MPTRAC

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Contents

1 Main Page

Massive-Parallel Trajectory Calculations (MPTRAC) is a Lagrangian particle dispersion model for the troposphere and stratosphere.This reference manual provides information on the algorithms and data structures used in the code. Further information can be found at:

https://github.com/slcs-jsc/mptrac

2 Data Structure Index

2.1 Data Structures

Here are the data structures with brief descriptions:

3 File Index

3.1 File List

Here is a list of all files with brief descriptions:

4 Data Structure Documentation

4.1 atm_t Struct Reference

Atmospheric data.

```
#include <libtrac.h>
```

Data Fields

- int np
  Number of air pacels.
- double time [NP]
  Time [s].
- double p [NP]
  Pressure [hPa].
- double lon [NP]
  Longitude [deg].
- double lat [NP]
  Latitude [deg].
- double q [NQ][NP]
  Quantity data (for various, user-defined attributes).

4.1.1 Detailed Description

Atmospheric data.

Definition at line 611 of file libtrac.h.

4.1.2 Field Documentation

4.1.2.1 int atm_t::np

Number of air pacels.

Definition at line 614 of file libtrac.h.

4.1.2.2 double atm_t::time[NP]

Time [s].

Definition at line 617 of file libtrac.h.

4.1.2.3 double atm_t::p[NP]

Pressure [hPa].

Definition at line 620 of file libtrac.h.

4.1.2.4 double atm_t::lon[NP]

Longitude [deg].

Definition at line 623 of file libtrac.h.

4.1.2.5 double atm_t::lat[NP]

Latitude [deg].

Definition at line 626 of file libtrac.h.

4.1.2.6 double atm_t::q[NQ][NP]

Quantity data (for various, user-defined attributes).

Definition at line 629 of file libtrac.h.

The documentation for this struct was generated from the following file:

- libtrac.h

4.2 cache_t Struct Reference

Cache data.

`#include <libtrac.h>`

Data Fields

- float up [NP]
  Zonal wind perturbation [m/s].
- float vp [NP]
  Meridional wind perturbation [m/s].
- float wp [NP]
  Vertical velocity perturbation [hPa/s].
- double iso_var [NP]
  Isosurface variables.
- double iso_ps [NP]
  Isosurface balloon pressure [hPa].
- double iso_ts [NP]
  Isosurface balloon time [s].
- int iso_n
  Isosurface balloon number of data points.
- double tsig [EX][EY][EP]
  Cache for reference time of wind standard deviations.
- float usig [EX][EY][EP]
  Cache for zonal wind standard deviations.
- float vsig [EX][EY][EP]
  Cache for meridional wind standard deviations.
- float wsig [EX][EY][EP]
  Cache for vertical velocity standard deviations.

4.2.1 Detailed Description

Cache data.

Definition at line 634 of file libtrac.h.

4.2.2 Field Documentation

4.2.2.1 float cache_t::up[NP]

Zonal wind perturbation [m/s].

Definition at line 637 of file libtrac.h.

4.2.2.2 float cache_t::vp[NP]

Meridional wind perturbation [m/s].

Definition at line 640 of file libtrac.h.

4.2.2.3 float cache_t::wp[NP]

Vertical velocity perturbation [hPa/s].

Definition at line 643 of file libtrac.h.

4.2.2.4 double cache_t::iso_var[NP]

Isosurface variables.

Definition at line 646 of file libtrac.h.

4.2.2.5 double cache_t::iso_ps[NP]

Isosurface balloon pressure [hPa].

Definition at line 649 of file libtrac.h.

4.2.2.6 double cache_t::iso_ts[NP]

Isosurface balloon time [s].

Definition at line 652 of file libtrac.h.

4.2.2.7 int cache_t::iso_n

Isosurface balloon number of data points.

Definition at line 655 of file libtrac.h.

4.2.2.8 double cache_t::tsig[EX][EY][EP]

Cache for reference time of wind standard deviations.

Definition at line 658 of file libtrac.h.

4.2.2.9 float cache_t::usig[EX][EY][EP]

Cache for zonal wind standard deviations.

Definition at line 661 of file libtrac.h.

4.2.2.10 float cache_t::vsig[EX][EY][EP]

Cache for meridional wind standard deviations.

Definition at line 664 of file libtrac.h.

4.2.2.11 float cache_t::wsig[EX][EY][EP]

Cache for vertical velocity standard deviations.

Definition at line 667 of file libtrac.h.

The documentation for this struct was generated from the following file:

- libtrac.h

4.3 ctl_t Struct Reference

Control parameters.

```
#include <libtrac.h>
```

Data Fields

- int nq
  Number of quantities.
- char qnt_name [NQ][LEN]
  Quantity names.
- char qnt_unit [NQ][LEN]
  Quantity units.
- char qnt_format [NQ][LEN]
  Quantity output format.
- int qnt_ens
  Quantity array index for ensemble IDs.
- int qnt_m
  Quantity array index for mass.
- int qnt_rho
  Quantity array index for particle density.
- int qnt_r
  Quantity array index for particle radius.
- int qnt_ps
  Quantity array index for surface pressure.
- int qnt_pt
  Quantity array index for tropopause pressure.
- int qnt_z
  Quantity array index for geopotential height.
- int qnt_p
  Quantity array index for pressure.
- int qnt_t
  Quantity array index for temperature.
- int qnt_u
  Quantity array index for zonal wind.
- int qnt_v
  Quantity array index for meridional wind.
- int qnt_w
  Quantity array index for vertical velocity.
- int qnt_h2o
  Quantity array index for water vapor vmr.
- int qnt_o3
  Quantity array index for ozone vmr.
- int qnt_theta
  Quantity array index for potential temperature.
- int qnt_vh
  Quantity array index for horizontal wind.
- int qnt_vz
  Quantity array index for vertical velocity.

- int qnt_pv

  Quantity array index for potential vorticity.
- int qnt_tice

  Quantity array index for T_ice.
- int qnt_tsts

  Quantity array index for T_STS.
- int qnt_tnat

  Quantity array index for T_NAT.
- int qnt_stat

  Quantity array index for station flag.
- int direction

  Direction flag (1=forward calculation, -1=backward calculation).
- double t_start

  Start time of simulation [s].
- double t_stop

  Stop time of simulation [s].
- double dt_mod

  Time step of simulation [s].
- double dt_met

  Time step of meteorological data [s].
- int met_dx

  Stride for longitudes.
- int met_dy

  Stride for latitudes.
- int met_dp

  Stride for pressure levels.
- int met_sx

  Smoothing for longitudes.
- int met_sy

  Smoothing for latitudes.
- int met_sp

  Smoothing for pressure levels.
- int met_np

  Number of target pressure levels.
- double met_p [EP]

  Target pressure levels [hPa].
- int met_tropo

  Tropopause definition (0=none, 1=clim, 2=cold point, 3=WMO_1st, 4=WMO_2nd).
- char met_geopot [LEN]

  Surface geopotential data file.
- double met_dt_out

  Time step for sampling of meteo data along trajectories [s].
- char met_stage [LEN]

  Command to stage meteo data.
- int isosurf

  Isosurface parameter (0=none, 1=pressure, 2=density, 3=theta, 4=balloon).
- char balloon [LEN]

  Balloon position filename.
- double turb_dx_trop

  Horizontal turbulent diffusion coefficient (troposphere) [m^2/s].
- double turb_dx_strat

Horizontal turbulent diffusion coefficient (stratosphere) [m^2/s].

- double turb_dz_trop

  Vertical turbulent diffusion coefficient (troposphere) [m^2/s].
- double turb_dz_strat

  Vertical turbulent diffusion coefficient (stratosphere) [m^2/s].
- double turb_mesox

  Horizontal scaling factor for mesoscale wind fluctuations.
- double turb_mesoz

  Vertical scaling factor for mesoscale wind fluctuations.
- double molmass

  Molar mass [g/mol].
- double tdec_trop

  Life time of particles (troposphere) [s].
- double tdec_strat

  Life time of particles (stratosphere) [s].
- double psc_h2o

  H2O volume mixing ratio for PSC analysis.
- double psc_hno3

  HNO3 volume mixing ratio for PSC analysis.
- char atm_basename [LEN]

  Basename of atmospheric data files.
- char atm_gpfile [LEN]

  Gnuplot file for atmospheric data.
- double atm_dt_out

  Time step for atmospheric data output [s].
- int atm_filter

  Time filter for atmospheric data output (0=no, 1=yes).
- int atm_stride

  Particle index stride for atmospheric data files.
- int atm_type

  Type of atmospheric data files (0=ASCII, 1=binary, 2=netCDF).
- char csi_basename [LEN]

  Basename of CSI data files.
- double csi_dt_out

  Time step for CSI data output [s].
- char csi_obsfile [LEN]

  Observation data file for CSI analysis.
- double csi_obsmin

  Minimum observation index to trigger detection.
- double csi_modmin

  Minimum column density to trigger detection [kg/m^2].
- int csi_nz

  Number of altitudes of gridded CSI data.
- double csi_z0

  Lower altitude of gridded CSI data [km].
- double csi_z1

  Upper altitude of gridded CSI data [km].
- int csi_nx

  Number of longitudes of gridded CSI data.
- double csi_lon0

  Lower longitude of gridded CSI data [deg].

- double csi_lon1
  Upper longitude of gridded CSI data [deg].
- int csi_ny
  Number of latitudes of gridded CSI data.
- double csi_lat0
  Lower latitude of gridded CSI data [deg].
- double csi_lat1
  Upper latitude of gridded CSI data [deg].
- char grid_basename [LEN]
  Basename of grid data files.
- char grid_gpfile [LEN]
  Gnuplot file for gridded data.
- double grid_dt_out
  Time step for gridded data output [s].
- int grid_sparse
  Sparse output in grid data files (0=no, 1=yes).
- int grid_nz
  Number of altitudes of gridded data.
- double grid_z0
  Lower altitude of gridded data [km].
- double grid_z1
  Upper altitude of gridded data [km].
- int grid_nx
  Number of longitudes of gridded data.
- double grid_lon0
  Lower longitude of gridded data [deg].
- double grid_lon1
  Upper longitude of gridded data [deg].
- int grid_ny
  Number of latitudes of gridded data.
- double grid_lat0
  Lower latitude of gridded data [deg].
- double grid_lat1
  Upper latitude of gridded data [deg].
- char prof_basename [LEN]
  Basename for profile output file.
- char prof_obsfile [LEN]
  Observation data file for profile output.
- int prof_nz
  Number of altitudes of gridded profile data.
- double prof_z0
  Lower altitude of gridded profile data [km].
- double prof_z1
  Upper altitude of gridded profile data [km].
- int prof_nx
  Number of longitudes of gridded profile data.
- double prof_lon0
  Lower longitude of gridded profile data [deg].
- double prof_lon1
  Upper longitude of gridded profile data [deg].
- int prof_ny

Number of latitudes of gridded profile data.

- double prof_lat0

  Lower latitude of gridded profile data [deg].

- double prof_lat1

  Upper latitude of gridded profile data [deg].

- char ens_basename [LEN]

  Basename of ensemble data file.

- char stat_basename [LEN]

  Basename of station data file.

- double stat_lon

  Longitude of station [deg].

- double stat_lat

  Latitude of station [deg].

- double stat_r

  Search radius around station [km].

4.3.1 Detailed Description

Control parameters.

Definition at line 289 of file libtrac.h.

4.3.2 Field Documentation

4.3.2.1 int ctl_t::nq

Number of quantities.

Definition at line 292 of file libtrac.h.

4.3.2.2 char ctl_t::qnt_name[NQ][LEN]

Quantity names.

Definition at line 295 of file libtrac.h.

4.3.2.3 char ctl_t::qnt_unit[NQ][LEN]

Quantity units.

Definition at line 298 of file libtrac.h.

4.3.2.4 char ctl_t::qnt_format[NQ][LEN]

Quantity output format.

Definition at line 301 of file libtrac.h.

4.3.2.5 int ctl_t::qnt_ens

Quantity array index for ensemble IDs.

Definition at line 304 of file libtrac.h.

4.3.2.6 int ctl_t::qnt_m

Quantity array index for mass.

Definition at line 307 of file libtrac.h.

4.3.2.7 int ctl_t::qnt_rho

Quantity array index for particle density.

Definition at line 310 of file libtrac.h.

4.3.2.8 int ctl_t::qnt_r

Quantity array index for particle radius.

Definition at line 313 of file libtrac.h.

4.3.2.9 int ctl_t::qnt_ps

Quantity array index for surface pressure.

Definition at line 316 of file libtrac.h.

4.3.2.10 int ctl_t::qnt_pt

Quantity array index for tropopause pressure.

Definition at line 319 of file libtrac.h.

4.3.2.11 int ctl_t::qnt_z

Quantity array index for geopotential height.

Definition at line 322 of file libtrac.h.

4.3.2.12 int ctl_t::qnt_p

Quantity array index for pressure.

Definition at line 325 of file libtrac.h.

4.3.2.13 int ctl_t::qnt_t

Quantity array index for temperature.

Definition at line 328 of file libtrac.h.

4.3.2.14 int ctl_t::qnt_u

Quantity array index for zonal wind.

Definition at line 331 of file libtrac.h.

4.3.2.15 int ctl_t::qnt_v

Quantity array index for meridional wind.

Definition at line 334 of file libtrac.h.

4.3.2.16 int ctl_t::qnt_w

Quantity array index for vertical velocity.

Definition at line 337 of file libtrac.h.

4.3.2.17 int ctl_t::qnt_h2o

Quantity array index for water vapor vmr.

Definition at line 340 of file libtrac.h.

4.3.2.18 int ctl_t::qnt_o3

Quantity array index for ozone vmr.

Definition at line 343 of file libtrac.h.

4.3.2.19 int ctl_t::qnt_theta

Quantity array index for potential temperature.

Definition at line 346 of file libtrac.h.

4.3.2.20 int ctl_t::qnt_vh

Quantity array index for horizontal wind.

Definition at line 349 of file libtrac.h.

4.3.2.21 int ctl_t::qnt_vz

Quantity array index for vertical velocity.

Definition at line 352 of file libtrac.h.

4.3.2.22 int ctl_t::qnt_pv

Quantity array index for potential vorticity.

Definition at line 355 of file libtrac.h.

4.3.2.23 int ctl_t::qnt_tice

Quantity array index for T_ice.

Definition at line 358 of file libtrac.h.

4.3.2.24 int ctl_t::qnt_tsts

Quantity array index for T_STS.

Definition at line 361 of file libtrac.h.

4.3.2.25 int ctl_t::qnt_tnat

Quantity array index for T_NAT.

Definition at line 364 of file libtrac.h.

4.3.2.26 int ctl_t::qnt_stat

Quantity array index for station flag.

Definition at line 367 of file libtrac.h.

4.3.2.27 int ctl_t::direction

Direction flag (1=forward calculation, -1=backward calculation).

Definition at line 370 of file libtrac.h.

4.3.2.28 double ctl_t::t_start

Start time of simulation [s].

Definition at line 373 of file libtrac.h.

4.3.2.29 double ctl_t::t_stop

Stop time of simulation [s].

Definition at line 376 of file libtrac.h.

4.3.2.30 double ctl_t::dt_mod

Time step of simulation [s].

Definition at line 379 of file libtrac.h.

4.3.2.31 double ctl_t::dt_met

Time step of meteorological data [s].

Definition at line 382 of file libtrac.h.

4.3.2.32 int ctl_t::met_dx

Stride for longitudes.

Definition at line 385 of file libtrac.h.

4.3.2.33 int ctl_t::met_dy

Stride for latitudes.

Definition at line 388 of file libtrac.h.

4.3.2.34 int ctl_t::met_dp

Stride for pressure levels.

Definition at line 391 of file libtrac.h.

4.3.2.35 int ctl_t::met_sx

Smoothing for longitudes.

Definition at line 394 of file libtrac.h.

4.3.2.36 int ctl_t::met_sy

Smoothing for latitudes.

Definition at line 397 of file libtrac.h.

4.3.2.37 int ctl_t::met_sp

Smoothing for pressure levels.

Definition at line 400 of file libtrac.h.

4.3.2.38 int ctl_t::met_np

Number of target pressure levels.

Definition at line 403 of file libtrac.h.

4.3.2.39 double ctl_t::met_p[EP]

Target pressure levels [hPa].

Definition at line 406 of file libtrac.h.

4.3.2.40 int ctl_t::met_tropo

Tropopause definition (0=none, 1=clim, 2=cold point, 3=WMO_1st, 4=WMO_2nd).

Definition at line 410 of file libtrac.h.

4.3.2.41 char ctl_t::met_geopot[LEN]

Surface geopotential data file.

Definition at line 413 of file libtrac.h.

4.3.2.42 double ctl_t::met_dt_out

Time step for sampling of meteo data along trajectories [s].

Definition at line 416 of file libtrac.h.

4.3.2.43 char ctl_t::met_stage[LEN]

Command to stage meteo data.

Definition at line 419 of file libtrac.h.

4.3.2.44 int ctl_t::isosurf

Isosurface parameter (0=none, 1=pressure, 2=density, 3=theta, 4=balloon).

Definition at line 423 of file libtrac.h.

4.3.2.45 char ctl_t::balloon[LEN]

Balloon position filename.

Definition at line 426 of file libtrac.h.

4.3.2.46 double ctl_t::turb_dx_trop

Horizontal turbulent diffusion coefficient (troposphere) [m^2/s].

Definition at line 429 of file libtrac.h.

4.3.2.47 double ctl_t::turb_dx_strat

Horizontal turbulent diffusion coefficient (stratosphere) [m^2/s].

Definition at line 432 of file libtrac.h.

4.3.2.48 double ctl_t::turb_dz_trop

Vertical turbulent diffusion coefficient (troposphere) [m^2/s].

Definition at line 435 of file libtrac.h.

4.3.2.49 double ctl_t::turb_dz_strat

Vertical turbulent diffusion coefficient (stratosphere) [m^2/s].

Definition at line 438 of file libtrac.h.

4.3.2.50 double ctl_t::turb_mesox

Horizontal scaling factor for mesoscale wind fluctuations.

Definition at line 441 of file libtrac.h.

4.3.2.51 double ctl_t::turb_mesoz

Vertical scaling factor for mesoscale wind fluctuations.

Definition at line 444 of file libtrac.h.

4.3.2.52 double ctl_t::molmass

Molar mass [g/mol].

Definition at line 447 of file libtrac.h.

4.3.2.53 double ctl_t::tdec_trop

Life time of particles (troposphere) [s].

Definition at line 450 of file libtrac.h.

4.3.2.54 double ctl_t::tdec_strat

Life time of particles (stratosphere) [s].

Definition at line 453 of file libtrac.h.

4.3.2.55 double ctl_t::psc_h2o

H2O volume mixing ratio for PSC analysis.

Definition at line 456 of file libtrac.h.

4.3.2.56 double ctl_t::psc_hno3

HNO3 volume mixing ratio for PSC analysis.

Definition at line 459 of file libtrac.h.

4.3.2.57 char ctl_t::atm_basename[LEN]

Basename of atmospheric data files.

Definition at line 462 of file libtrac.h.

4.3.2.58 char ctl_t::atm_gpfile[LEN]

Gnuplot file for atmospheric data.

Definition at line 465 of file libtrac.h.

4.3.2.59 double ctl_t::atm_dt_out

Time step for atmospheric data output [s].

Definition at line 468 of file libtrac.h.

4.3.2.60 int ctl_t::atm_filter

Time filter for atmospheric data output (0=no, 1=yes).

Definition at line 471 of file libtrac.h.

4.3.2.61 int ctl_t::atm_stride

Particle index stride for atmospheric data files.

Definition at line 474 of file libtrac.h.

4.3.2.62 int ctl_t::atm_type

Type of atmospheric data files (0=ASCII, 1=binary, 2=netCDF).

Definition at line 477 of file libtrac.h.

4.3.2.63 char ctl_t::csi_basename[LEN]

Basename of CSI data files.

Definition at line 480 of file libtrac.h.

4.3.2.64 double ctl_t::csi_dt_out

Time step for CSI data output [s].

Definition at line 483 of file libtrac.h.

4.3.2.65 char ctl_t::csi_obsfile[LEN]

Observation data file for CSI analysis.

Definition at line 486 of file libtrac.h.

4.3.2.66 double ctl_t::csi_obsmin

Minimum observation index to trigger detection.

Definition at line 489 of file libtrac.h.

4.3.2.67 double ctl_t::csi_modmin

Minimum column density to trigger detection [kg/m^2].

Definition at line 492 of file libtrac.h.

4.3.2.68 int ctl_t::csi_nz

Number of altitudes of gridded CSI data.

Definition at line 495 of file libtrac.h.

4.3.2.69 double ctl_t::csi_z0

Lower altitude of gridded CSI data [km].

Definition at line 498 of file libtrac.h.

4.3.2.70 double ctl_t::csi_z1

Upper altitude of gridded CSI data [km].

Definition at line 501 of file libtrac.h.

4.3.2.71 int ctl_t::csi_nx

Number of longitudes of gridded CSI data.

Definition at line 504 of file libtrac.h.

4.3.2.72 double ctl_t::csi_lon0

Lower longitude of gridded CSI data [deg].

Definition at line 507 of file libtrac.h.

4.3.2.73 double ctl_t::csi_lon1

Upper longitude of gridded CSI data [deg].

Definition at line 510 of file libtrac.h.

4.3.2.74 int ctl_t::csi_ny

Number of latitudes of gridded CSI data.

Definition at line 513 of file libtrac.h.

4.3.2.75 double ctl_t::csi_lat0

Lower latitude of gridded CSI data [deg].

Definition at line 516 of file libtrac.h.

4.3.2.76 double ctl_t::csi_lat1

Upper latitude of gridded CSI data [deg].

Definition at line 519 of file libtrac.h.

4.3.2.77 char ctl_t::grid_basename[LEN]

Basename of grid data files.

Definition at line 522 of file libtrac.h.

4.3.2.78 char ctl_t::grid_gpfile[LEN]

Gnuplot file for gridded data.

Definition at line 525 of file libtrac.h.

4.3.2.79 double ctl_t::grid_dt_out

Time step for gridded data output [s].

Definition at line 528 of file libtrac.h.

4.3.2.80 int ctl_t::grid_sparse

Sparse output in grid data files (0=no, 1=yes).

Definition at line 531 of file libtrac.h.

4.3.2.81 int ctl_t::grid_nz

Number of altitudes of gridded data.

Definition at line 534 of file libtrac.h.

4.3.2.82 double ctl_t::grid_z0

Lower altitude of gridded data [km].

Definition at line 537 of file libtrac.h.

4.3.2.83 double ctl_t::grid_z1

Upper altitude of gridded data [km].

Definition at line 540 of file libtrac.h.

4.3.2.84 int ctl_t::grid_nx

Number of longitudes of gridded data.

Definition at line 543 of file libtrac.h.

4.3.2.85 double ctl_t::grid_lon0

Lower longitude of gridded data [deg].

Definition at line 546 of file libtrac.h.

4.3.2.86 double ctl_t::grid_lon1

Upper longitude of gridded data [deg].

Definition at line 549 of file libtrac.h.

4.3.2.87 int ctl_t::grid_ny

Number of latitudes of gridded data.

Definition at line 552 of file libtrac.h.

4.3.2.88 double ctl_t::grid_lat0

Lower latitude of gridded data [deg].

Definition at line 555 of file libtrac.h.

4.3.2.89 double ctl_t::grid_lat1

Upper latitude of gridded data [deg].

Definition at line 558 of file libtrac.h.

4.3.2.90 char ctl_t::prof_basename[LEN]

Basename for profile output file.

Definition at line 561 of file libtrac.h.

4.3.2.91 char ctl_t::prof_obsfile[LEN]

Observation data file for profile output.

Definition at line 564 of file libtrac.h.

4.3.2.92 int ctl_t::prof_nz

Number of altitudes of gridded profile data.

Definition at line 567 of file libtrac.h.

4.3.2.93 double ctl_t::prof_z0

Lower altitude of gridded profile data [km].

Definition at line 570 of file libtrac.h.

4.3.2.94 double ctl_t::prof_z1

Upper altitude of gridded profile data [km].

Definition at line 573 of file libtrac.h.

4.3.2.95 int ctl_t::prof_nx

Number of longitudes of gridded profile data.

Definition at line 576 of file libtrac.h.

4.3.2.96 double ctl_t::prof_lon0

Lower longitude of gridded profile data [deg].

Definition at line 579 of file libtrac.h.

4.3.2.97 double ctl_t::prof_lon1

Upper longitude of gridded profile data [deg].

Definition at line 582 of file libtrac.h.

4.3.2.98 int ctl_t::prof_ny

Number of latitudes of gridded profile data.

Definition at line 585 of file libtrac.h.

4.3.2.99 double ctl_t::prof_lat0

Lower latitude of gridded profile data [deg].

Definition at line 588 of file libtrac.h.

4.3.2.100 double ctl_t::prof_lat1

Upper latitude of gridded profile data [deg].

Definition at line 591 of file libtrac.h.

4.3.2.101 char ctl_t::ens_basename[LEN]

Basename of ensemble data file.

Definition at line 594 of file libtrac.h.

4.3.2.102 char ctl_t::stat_basename[LEN]

Basename of station data file.

Definition at line 597 of file libtrac.h.

4.3.2.103 double ctl_t::stat_lon

Longitude of station [deg].

Definition at line 600 of file libtrac.h.

4.3.2.104 double ctl_t::stat_lat

Latitude of station [deg].

Definition at line 603 of file libtrac.h.

4.3.2.105 double ctl_t::stat_r

Search radius around station [km].

Definition at line 606 of file libtrac.h.

The documentation for this struct was generated from the following file:

- libtrac.h

4.4 met_t Struct Reference

Meteorological data.

```
#include <libtrac.h>
```

Data Fields

- double time
  Time [s].
- int nx
  Number of longitudes.
- int ny
  Number of latitudes.
- int np
  Number of pressure levels.
- double lon [EX]
  Longitude [deg].
- double lat [EY]
  Latitude [deg].
- double p [EP]
  Pressure [hPa].
- double ps [EX][EY]
  Surface pressure [hPa].
- double pt [EX][EY]
  Tropopause pressure [hPa].
- float z [EX][EY][EP]
  Geopotential height [km].
- float t [EX][EY][EP]
  Temperature [K].
- float u [EX][EY][EP]
  Zonal wind [m/s].
- float v [EX][EY][EP]
  Meridional wind [m/s].

- float w [EX][EY][EP]

  Vertical wind [hPa/s].
- float pv [EX][EY][EP]

  Potential vorticity [PVU].
- float h2o [EX][EY][EP]

  Water vapor volume mixing ratio [1].
- float o3 [EX][EY][EP]

  Ozone volume mixing ratio [1].
- float pl [EX][EY][EP]

  Pressure on model levels [hPa].

4.4.1 Detailed Description

Meteorological data.

Definition at line 672 of file libtrac.h.

4.4.2 Field Documentation

4.4.2.1 double met_t::time

Time [s].

Definition at line 675 of file libtrac.h.

4.4.2.2 int met_t::nx

Number of longitudes.

Definition at line 678 of file libtrac.h.

4.4.2.3 int met_t::ny

Number of latitudes.

Definition at line 681 of file libtrac.h.

4.4.2.4 int met_t::np

Number of pressure levels.

Definition at line 684 of file libtrac.h.

4.4.2.5 double met_t::lon[EX]

Longitude [deg].

Definition at line 687 of file libtrac.h.

4.4.2.6 double met_t::lat[EY]

Latitude [deg].

Definition at line 690 of file libtrac.h.

4.4.2.7 double met_t::p[EP]

Pressure [hPa].

Definition at line 693 of file libtrac.h.

4.4.2.8 double met_t::ps[EX][EY]

Surface pressure [hPa].

Definition at line 696 of file libtrac.h.

4.4.2.9 double met_t::pt[EX][EY]

Tropopause pressure [hPa].

Definition at line 699 of file libtrac.h.

4.4.2.10 float met_t::z[EX][EY][EP]

Geopotential height [km].

Definition at line 702 of file libtrac.h.

4.4.2.11 float met_t::t[EX][EY][EP]

Temperature [K].

Definition at line 705 of file libtrac.h.

4.4.2.12 float met_t::u[EX][EY][EP]

Zonal wind [m/s].

Definition at line 708 of file libtrac.h.

4.4.2.13 float met_t::v[EX][EY][EP]

Meridional wind [m/s].

Definition at line 711 of file libtrac.h.

4.4.2.14 float met_t::w[EX][EY][EP]

Vertical wind [hPa/s].

Definition at line 714 of file libtrac.h.

4.4.2.15 float met_t::pv[EX][EY][EP]

Potential vorticity [PVU].

Definition at line 717 of file libtrac.h.

4.4.2.16 float met_t::h2o[EX][EY][EP]

Water vapor volume mixing ratio [1].

Definition at line 720 of file libtrac.h.

4.4.2.17 float met_t::o3[EX][EY][EP]

Ozone volume mixing ratio [1].

Definition at line 723 of file libtrac.h.

4.4.2.18 float met_t::pl[EX][EY][EP]

Pressure on model levels [hPa].

Definition at line 726 of file libtrac.h.

The documentation for this struct was generated from the following file:

- libtrac.h

5 File Documentation

5.1 atm_conv.c File Reference

Convert file format of air parcel data files.

Functions

- int main (int argc, char ∗argv[ ])

5.1.1 Detailed Description

Convert file format of air parcel data files.

Definition in file atm_conv.c.

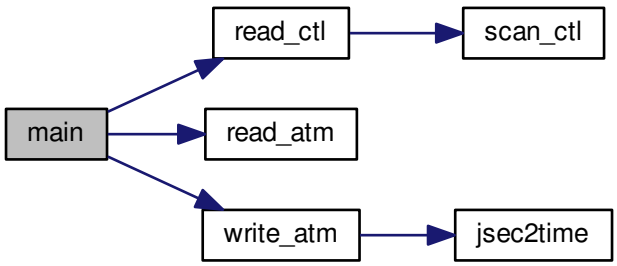
5.1.2 Function Documentation

5.1.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file atm_conv.c.

```
00029                 {
00030
00031   ctl_t ctl;
00032
00033   atm_t *atm;
00034
00035   /* Check arguments... */
00036   if (argc < 6)
00037     ERRMSG("Give parameters: <ctl> <atm_in> <atm_in_type>"
00038            " <atm_out> <atm_out_type>");
00039
00040   /* Allocate... */
00041   ALLOC(atm, atm_t, 1);
00042
00043   /* Read control parameters... */
00044   read_ctl(argv[1], argc, argv, &ctl);
00045
00046   /* Read atmospheric data... */
00047   ctl.atm_type = atoi(argv[3]);
00048   if (!read_atm(argv[2], &ctl, atm))
00049     ERRMSG("Cannot open file!");
00050
00051   /* Write atmospheric data... */
00052   ctl.atm_type = atoi(argv[5]);
00053   write_atm(argv[4], &ctl, atm, 0);
00054
00055   /* Free... */
00056   free(atm);
00057
00058   return EXIT_SUCCESS;
00059 }
```

Here is the call graph for this function:



5.2 atm_conv.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
```

```
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   ctl_t ctl;
00032
00033   atm_t *atm;
00034
00035   /* Check arguments... */
00036   if (argc < 6)
00037     ERRMSG("Give parameters: <ctl> <atm_in> <atm_in_type>"
00038            " <atm_out> <atm_out_type>");
00039
00040   /* Allocate... */
00041   ALLOC(atm, atm_t, 1);
00042
00043   /* Read control parameters... */
00044   read_ctl(argv[1], argc, argv, &ctl);
00045
00046   /* Read atmospheric data... */
00047   ctl.atm_type = atoi(argv[3]);
00048   if (!read_atm(argv[2], &ctl, atm))
00049     ERRMSG("Cannot open file!");
00050
00051   /* Write atmospheric data... */
00052   ctl.atm_type = atoi(argv[5]);
00053   write_atm(argv[4], &ctl, atm, 0);
00054
00055   /* Free... */
00056   free(atm);
00057
00058   return EXIT_SUCCESS;
00059 }
```

5.3 atm_dist.c File Reference

Calculate transport deviations of trajectories.

Functions

- int main (int argc, char *argv[])

5.3.1 Detailed Description

Calculate transport deviations of trajectories.

Definition in file atm_dist.c.

5.3.2 Function Documentation

5.3.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file atm_dist.c.

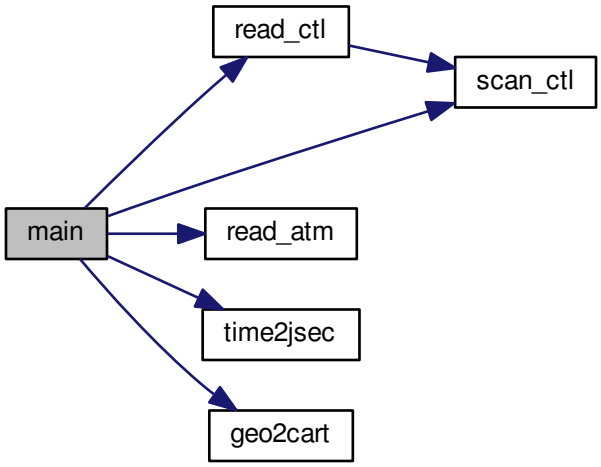
```
00029                {
00030
00031   ctl_t ctl;
00032
00033   atm_t *atm1, *atm2;
00034
00035   FILE *out;
00036
00037   char tstr[LEN];
00038
00039   double *ahtd, *aqtd, *avtd, ahtdm, aqtdm[NQ], avtdm, lat0, lat1,
00040     *lat1_old, *lat2_old, *lh1, *lh2, lon0, lon1, *lon1_old, *lon2_old,
00041     *lv1, *lv2, p0, p1, *rhtd, *rqtd, *rvtd, rhtdm, rqtdm[NQ], rvtdm,
00042     t, t0 = 0, x0[3], x1[3], x2[3], z1, *z1_old, z2, *z2_old, *work;
00043
00044   int ens, f, init = 0, ip, iq, np, year, mon, day, hour, min;
00045
00046   /* Allocate... */
00047   ALLOC(atm1, atm_t, 1);
00048   ALLOC(atm2, atm_t, 1);
00049   ALLOC(lon1_old, double,
00050         NP);
00051   ALLOC(lat1_old, double,
00052         NP);
00053   ALLOC(z1_old, double,
00054         NP);
00055   ALLOC(lh1, double,
00056         NP);
00057   ALLOC(lv1, double,
00058         NP);
00059   ALLOC(lon2_old, double,
00060         NP);
00061   ALLOC(lat2_old, double,
00062         NP);
00063   ALLOC(z2_old, double,
00064         NP);
00065   ALLOC(lh2, double,
00066         NP);
00067   ALLOC(lv2, double,
00068         NP);
00069   ALLOC(ahtd, double,
00070         NP);
00071   ALLOC(avtd, double,
00072         NP);
00073   ALLOC(aqtd, double,
00074         NP * NQ);
00075   ALLOC(rhtd, double,
00076         NP);
00077   ALLOC(rvtd, double,
00078         NP);
00079   ALLOC(rqtd, double,
00080         NP * NQ);
00081   ALLOC(work, double,
00082         NP);
00083
00084   /* Check arguments... */
00085   if (argc < 6)
00086     ERRMSG("Give parameters: <ctl> <dist.tab> <param> <atm1a> <atm1b>"
00087            " [<atm2a> <atm2b> ...]");
00088
00089   /* Read control parameters... */
00090   read_ctl(argv[1], argc, argv, &ctl);
00091   ens = (int) scan_ctl(argv[1], argc, argv, "DIST_ENS", -1, "-999", NULL);
00092   p0 = P(scan_ctl(argv[1], argc, argv, "DIST_Z0", -1, "-1000", NULL));
00093   p1 = P(scan_ctl(argv[1], argc, argv, "DIST_Z1", -1, "1000", NULL));
00094   lat0 = scan_ctl(argv[1], argc, argv, "DIST_LAT0", -1, "-1000", NULL);
00095   lat1 = scan_ctl(argv[1], argc, argv, "DIST_LAT1", -1, "1000", NULL);
00096   lon0 = scan_ctl(argv[1], argc, argv, "DIST_LON0", -1, "-1000", NULL);
00097   lon1 = scan_ctl(argv[1], argc, argv, "DIST_LON1", -1, "1000", NULL);
00098
00099   /* Write info... */
00100   printf("Write transport deviations: %s\n", argv[2]);
00101
00102   /* Create output file... */
00103   if (!(out = fopen(argv[2], "w")))
00104     ERRMSG("Cannot create file!");
00105
00106   /* Write header... */
00107   fprintf(out,
00108           "# $1 = time [s]\n"
00109           "# $2 = time difference [s]\n"
00110           "# $3 = absolute horizontal distance (%s) [km]\n"
00111           "# $4 = relative horizontal distance (%s) [%%]\n"
00112           "# $5 = absolute vertical distance (%s) [km]\n"
00113           "# $6 = relative vertical distance (%s) [%%]\n",
00114           argv[3], argv[3], argv[3], argv[3]);
00115   for (iq = 0; iq < ctl.nq; iq++)
```

```
00116     fprintf(out,
00117             "# $%d = %s absolute difference (%s) [%s]\n"
00118             "# $%d = %s relative difference (%s) [%%]\n",
00119             7 + 2 * iq, ctl.qnt_name[iq], argv[3], ctl.qnt_unit[iq],
00120             8 + 2 * iq, ctl.qnt_name[iq], argv[3]);
00121   fprintf(out, "# $%d = number of particles\n\n", 7 + 2 * ctl.nq);
00122
00123   /* Loop over file pairs... */
00124   for (f = 4; f < argc; f += 2) {
00125
00126     /* Read atmopheric data... */
00127     if (!read_atm(argv[f], &ctl, atm1) || !read_atm(argv[f + 1], &ctl, atm2))
00128       continue;
00129
00130     /* Check if structs match... */
00131     if (atm1->np != atm2->np)
00132       ERRMSG("Different numbers of particles!");
00133
00134     /* Get time from filename... */
00135     sprintf(tstr, "%.4s", &argv[f][strlen(argv[f]) - 20]);
00136     year = atoi(tstr);
00137     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 15]);
00138     mon = atoi(tstr);
00139     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 12]);
00140     day = atoi(tstr);
00141     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 9]);
00142     hour = atoi(tstr);
00143     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 6]);
00144     min = atoi(tstr);
00145     time2jsec(year, mon, day, hour, min, 0, 0, &t);
00146
00147     /* Save initial time... */
00148     if (!init) {
00149       init = 1;
00150       t0 = t;
00151     }
00152
00153     /* Init... */
00154     np = 0;
00155     for (ip = 0; ip < atm1->np; ip++) {
00156       ahtd[ip] = avtd[ip] = rhtd[ip] = rvtd[ip] = 0;
00157       for (iq = 0; iq < ctl.nq; iq++)
00158         aqtd[iq * NP + ip] = rqtd[iq * NP + ip] = 0;
00159     }
00160
00161     /* Loop over air parcels... */
00162     for (ip = 0; ip < atm1->np; ip++) {
00163
00164       /* Check data... */
00165       if (!gsl_finite(atm1->time[ip]) || !gsl_finite(atm2->time[ip]))
00166         continue;
00167
00168       /* Check ensemble index... */
00169       if (ctl.qnt_ens > 0
00170           && (atm1->q[ctl.qnt_ens][ip] != ens
00171               || atm2->q[ctl.qnt_ens][ip] != ens))
00172         continue;
00173
00174       /* Check spatial range... */
00175       if (atm1->p[ip] > p0 || atm1->p[ip] < p1
00176           || atm1->lon[ip] < lon0 || atm1->lon[ip] > lon1
00177           || atm1->lat[ip] < lat0 || atm1->lat[ip] > lat1)
00178         continue;
00179       if (atm2->p[ip] > p0 || atm2->p[ip] < p1
00180           || atm2->lon[ip] < lon0 || atm2->lon[ip] > lon1
00181           || atm2->lat[ip] < lat0 || atm2->lat[ip] > lat1)
00182         continue;
00183
00184       /* Convert coordinates... */
00185       geo2cart(0, atm1->lon[ip], atm1->lat[ip], x1);
00186       geo2cart(0, atm2->lon[ip], atm2->lat[ip], x2);
00187       z1 = Z(atm1->p[ip]);
00188       z2 = Z(atm2->p[ip]);
00189
00190       /* Calculate absolute transport deviations... */
00191       ahtd[np] = DIST(x1, x2);
00192       avtd[np] = z1 - z2;
00193       for (iq = 0; iq < ctl.nq; iq++)
00194         aqtd[iq * NP + np] = atm1->q[iq][ip] - atm2->q[iq][ip];
00195
00196       /* Calculate relative transport deviations... */
00197       if (f > 4) {
00198
00199         /* Get trajectory lengths... */
00200         geo2cart(0, lon1_old[ip], lat1_old[ip], x0);
00201         lh1[ip] += DIST(x0, x1);
00202         lv1[ip] += fabs(z1_old[ip] - z1);
```

```
00203
00204         geo2cart(0, lon2_old[ip], lat2_old[ip], x0);
00205         lh2[ip] += DIST(x0, x2);
00206         lv2[ip] += fabs(z2_old[ip] - z2);
00207
00208         /* Get relative transport deviations... */
00209         if (lh1[ip] + lh2[ip] > 0)
00210           rhtd[np] = 200. * DIST(x1, x2) / (lh1[ip] + lh2[ip]);
00211         if (lv1[ip] + lv2[ip] > 0)
00212           rvtd[np] = 200. * (z1 - z2) / (lv1[ip] + lv2[ip]);
00213       }
00214
00215       /* Get relative transport deviations... */
00216       for (iq = 0; iq < ctl.nq; iq++)
00217         rqtd[iq * NP + np] = 200. * (atm1->q[iq][ip] - atm2->q[iq][ip])
00218           / (fabs(atm1->q[iq][ip]) + fabs(atm2->q[iq][ip]));
00219
00220       /* Save positions of air parcels... */
00221       lon1_old[ip] = atm1->lon[ip];
00222       lat1_old[ip] = atm1->lat[ip];
00223       z1_old[ip] = z1;
00224
00225       lon2_old[ip] = atm2->lon[ip];
00226       lat2_old[ip] = atm2->lat[ip];
00227       z2_old[ip] = z2;
00228
00229       /* Increment air parcel counter... */
00230       np++;
00231     }
00232
00233     /* Get statistics... */
00234     if (strcasecmp(argv[3], "mean") == 0) {
00235       ahtdm = gsl_stats_mean(ahtd, 1, (size_t) np);
00236       rhtdm = gsl_stats_mean(rhtd, 1, (size_t) np);
00237       avtdm = gsl_stats_mean(avtd, 1, (size_t) np);
00238       rvtdm = gsl_stats_mean(rvtd, 1, (size_t) np);
00239       for (iq = 0; iq < ctl.nq; iq++) {
00240         aqtdm[iq] = gsl_stats_mean(&aqtd[iq * NP], 1, (size_t) np);
00241         rqtdm[iq] = gsl_stats_mean(&rqtd[iq * NP], 1, (size_t) np);
00242       }
00243     } else if (strcasecmp(argv[3], "stddev") == 0) {
00244       ahtdm = gsl_stats_sd(ahtd, 1, (size_t) np);
00245       rhtdm = gsl_stats_sd(rhtd, 1, (size_t) np);
00246       avtdm = gsl_stats_sd(avtd, 1, (size_t) np);
00247       rvtdm = gsl_stats_sd(rvtd, 1, (size_t) np);
00248       for (iq = 0; iq < ctl.nq; iq++) {
00249         aqtdm[iq] = gsl_stats_sd(&aqtd[iq * NP], 1, (size_t) np);
00250         rqtdm[iq] = gsl_stats_sd(&rqtd[iq * NP], 1, (size_t) np);
00251       }
00252     } else if (strcasecmp(argv[3], "min") == 0) {
00253       ahtdm = gsl_stats_min(ahtd, 1, (size_t) np);
00254       rhtdm = gsl_stats_min(rhtd, 1, (size_t) np);
00255       avtdm = gsl_stats_min(avtd, 1, (size_t) np);
00256       rvtdm = gsl_stats_min(rvtd, 1, (size_t) np);
00257       for (iq = 0; iq < ctl.nq; iq++) {
00258         aqtdm[iq] = gsl_stats_min(&aqtd[iq * NP], 1, (size_t) np);
00259         rqtdm[iq] = gsl_stats_min(&rqtd[iq * NP], 1, (size_t) np);
00260       }
00261     } else if (strcasecmp(argv[3], "max") == 0) {
00262       ahtdm = gsl_stats_max(ahtd, 1, (size_t) np);
00263       rhtdm = gsl_stats_max(rhtd, 1, (size_t) np);
00264       avtdm = gsl_stats_max(avtd, 1, (size_t) np);
00265       rvtdm = gsl_stats_max(rvtd, 1, (size_t) np);
00266       for (iq = 0; iq < ctl.nq; iq++) {
00267         aqtdm[iq] = gsl_stats_max(&aqtd[iq * NP], 1, (size_t) np);
00268         rqtdm[iq] = gsl_stats_max(&rqtd[iq * NP], 1, (size_t) np);
00269       }
00270     } else if (strcasecmp(argv[3], "skew") == 0) {
00271       ahtdm = gsl_stats_skew(ahtd, 1, (size_t) np);
00272       rhtdm = gsl_stats_skew(rhtd, 1, (size_t) np);
00273       avtdm = gsl_stats_skew(avtd, 1, (size_t) np);
00274       rvtdm = gsl_stats_skew(rvtd, 1, (size_t) np);
00275       for (iq = 0; iq < ctl.nq; iq++) {
00276         aqtdm[iq] = gsl_stats_skew(&aqtd[iq * NP], 1, (size_t) np);
00277         rqtdm[iq] = gsl_stats_skew(&rqtd[iq * NP], 1, (size_t) np);
00278       }
00279     } else if (strcasecmp(argv[3], "kurt") == 0) {
00280       ahtdm = gsl_stats_kurtosis(ahtd, 1, (size_t) np);
00281       rhtdm = gsl_stats_kurtosis(rhtd, 1, (size_t) np);
00282       avtdm = gsl_stats_kurtosis(avtd, 1, (size_t) np);
00283       rvtdm = gsl_stats_kurtosis(rvtd, 1, (size_t) np);
00284       for (iq = 0; iq < ctl.nq; iq++) {
00285         aqtdm[iq] = gsl_stats_kurtosis(&aqtd[iq * NP], 1, (size_t) np);
00286         rqtdm[iq] = gsl_stats_kurtosis(&rqtd[iq * NP], 1, (size_t) np);
00287       }
00288     } else if (strcasecmp(argv[3], "median") == 0) {
00289       ahtdm = gsl_stats_median(ahtd, 1, (size_t) np);
```

```
00290       rhtdm = gsl_stats_median(rhtd, 1, (size_t) np);
00291       avtdm = gsl_stats_median(avtd, 1, (size_t) np);
00292       rvtdm = gsl_stats_median(rvtd, 1, (size_t) np);
00293       for (iq = 0; iq < ctl.nq; iq++) {
00294         aqtdm[iq] = gsl_stats_median(&aqtd[iq * NP], 1, (size_t) np);
00295         rqtdm[iq] = gsl_stats_median(&rqtd[iq * NP], 1, (size_t) np);
00296       }
00297     } else if (strcasecmp(argv[3], "absdev") == 0) {
00298       ahtdm = gsl_stats_absdev(ahtd, 1, (size_t) np);
00299       rhtdm = gsl_stats_absdev(rhtd, 1, (size_t) np);
00300       avtdm = gsl_stats_absdev(avtd, 1, (size_t) np);
00301       rvtdm = gsl_stats_absdev(rvtd, 1, (size_t) np);
00302       for (iq = 0; iq < ctl.nq; iq++) {
00303         aqtdm[iq] = gsl_stats_absdev(&aqtd[iq * NP], 1, (size_t) np);
00304         rqtdm[iq] = gsl_stats_absdev(&rqtd[iq * NP], 1, (size_t) np);
00305       }
00306     } else if (strcasecmp(argv[3], "mad") == 0) {
00307       ahtdm = gsl_stats_mad0(ahtd, 1, (size_t) np, work);
00308       rhtdm = gsl_stats_mad0(rhtd, 1, (size_t) np, work);
00309       avtdm = gsl_stats_mad0(avtd, 1, (size_t) np, work);
00310       rvtdm = gsl_stats_mad0(rvtd, 1, (size_t) np, work);
00311       for (iq = 0; iq < ctl.nq; iq++) {
00312         aqtdm[iq] = gsl_stats_mad0(&aqtd[iq * NP], 1, (size_t) np, work);
00313         rqtdm[iq] = gsl_stats_mad0(&rqtd[iq * NP], 1, (size_t) np, work);
00314       }
00315     } else
00316       ERRMSG("Unknown parameter!");
00317
00318     /* Write output... */
00319     fprintf(out, "%.2f %.2f %g %g %g %g", t, t - t0,
00320             ahtdm, rhtdm, avtdm, rvtdm);
00321     for (iq = 0; iq < ctl.nq; iq++) {
00322       fprintf(out, " ");
00323       fprintf(out, ctl.qnt_format[iq], aqtdm[iq]);
00324       fprintf(out, " ");
00325       fprintf(out, ctl.qnt_format[iq], rqtdm[iq]);
00326     }
00327     fprintf(out, " %d\n", np);
00328   }
00329
00330   /* Close file... */
00331   fclose(out);
00332
00333   /* Free... */
00334   free(atm1);
00335   free(atm2);
00336   free(lon1_old);
00337   free(lat1_old);
00338   free(z1_old);
00339   free(lh1);
00340   free(lv1);
00341   free(lon2_old);
00342   free(lat2_old);
00343   free(z2_old);
00344   free(lh2);
00345   free(lv2);
00346   free(ahtd);
00347   free(avtd);
00348   free(aqtd);
00349   free(rhtd);
00350   free(rvtd);
00351   free(rqtd);
00352   free(work);
00353
00354   return EXIT_SUCCESS;
00355 }
```

Here is the call graph for this function:



5.4 atm_dist.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   ctl_t ctl;
00032
00033   atm_t *atm1, *atm2;
00034
00035   FILE *out;
00036
00037   char tstr[LEN];
00038
00039   double *ahtd, *aqtd, *avtd, ahtdm, aqtdm[NQ], avtdm, lat0, lat1,
00040     *lat1_old, *lat2_old, *lh1, *lh2, lon0, lon1, *lon1_old, *lon2_old,
00041     *lv1, *lv2, p0, p1, *rhtd, *rqtd, *rvtd, rhtdm, rqtdm[NQ], rvtdm,
00042     t, t0 = 0, x0[3], x1[3], x2[3], z1, *z1_old, z2, *z2_old, *work;
00043
00044   int ens, f, init = 0, ip, iq, np, year, mon, day, hour, min;
00045
00046   /* Allocate... */
00047   ALLOC(atm1, atm_t, 1);
00048   ALLOC(atm2, atm_t, 1);
00049   ALLOC(lon1_old, double,
```

```
00050         NP);
00051   ALLOC(lat1_old, double,
00052         NP);
00053   ALLOC(z1_old, double,
00054         NP);
00055   ALLOC(lh1, double,
00056         NP);
00057   ALLOC(lv1, double,
00058         NP);
00059   ALLOC(lon2_old, double,
00060         NP);
00061   ALLOC(lat2_old, double,
00062         NP);
00063   ALLOC(z2_old, double,
00064         NP);
00065   ALLOC(lh2, double,
00066         NP);
00067   ALLOC(lv2, double,
00068         NP);
00069   ALLOC(ahtd, double,
00070         NP);
00071   ALLOC(avtd, double,
00072         NP);
00073   ALLOC(aqtd, double,
00074         NP * NQ);
00075   ALLOC(rhtd, double,
00076         NP);
00077   ALLOC(rvtd, double,
00078         NP);
00079   ALLOC(rqtd, double,
00080         NP * NQ);
00081   ALLOC(work, double,
00082         NP);
00083
00084   /* Check arguments... */
00085   if (argc < 6)
00086     ERRMSG("Give parameters: <ctl> <dist.tab> <param> <atm1a> <atm1b>"
00087            " [<atm2a> <atm2b> ...]");
00088
00089   /* Read control parameters... */
00090   read_ctl(argv[1], argc, argv, &ctl);
00091   ens = (int) scan_ctl(argv[1], argc, argv, "DIST_ENS", -1, "-999", NULL);
00092   p0 = P(scan_ctl(argv[1], argc, argv, "DIST_Z0", -1, "-1000", NULL));
00093   p1 = P(scan_ctl(argv[1], argc, argv, "DIST_Z1", -1, "1000", NULL));
00094   lat0 = scan_ctl(argv[1], argc, argv, "DIST_LAT0", -1, "-1000", NULL);
00095   lat1 = scan_ctl(argv[1], argc, argv, "DIST_LAT1", -1, "1000", NULL);
00096   lon0 = scan_ctl(argv[1], argc, argv, "DIST_LON0", -1, "-1000", NULL);
00097   lon1 = scan_ctl(argv[1], argc, argv, "DIST_LON1", -1, "1000", NULL);
00098
00099   /* Write info... */
00100   printf("Write transport deviations: %s\n", argv[2]);
00101
00102   /* Create output file... */
00103   if (!(out = fopen(argv[2], "w")))
00104     ERRMSG("Cannot create file!");
00105
00106   /* Write header... */
00107   fprintf(out,
00108           "# $1 = time [s]\n"
00109           "# $2 = time difference [s]\n"
00110           "# $3 = absolute horizontal distance (%s) [km]\n"
00111           "# $4 = relative horizontal distance (%s) [%%]\n"
00112           "# $5 = absolute vertical distance (%s) [km]\n"
00113           "# $6 = relative vertical distance (%s) [%%]\n",
00114           argv[3], argv[3], argv[3], argv[3]);
00115   for (iq = 0; iq < ctl.nq; iq++)
00116     fprintf(out,
00117             "# $%d = %s absolute difference (%s) [%s]\n"
00118             "# $%d = %s relative difference (%s) [%%]\n",
00119             7 + 2 * iq, ctl.qnt_name[iq], argv[3], ctl.qnt_unit[iq],
00120             8 + 2 * iq, ctl.qnt_name[iq], argv[3]);
00121   fprintf(out, "# $%d = number of particles\n\n", 7 + 2 * ctl.nq);
00122
00123   /* Loop over file pairs... */
00124   for (f = 4; f < argc; f += 2) {
00125
00126     /* Read atmopheric data... */
00127     if (!read_atm(argv[f], &ctl, atm1) || !read_atm(argv[f + 1], &ctl, atm2))
00128       continue;
00129
00130     /* Check if structs match... */
00131     if (atm1->np != atm2->np)
00132       ERRMSG("Different numbers of particles!");
00133
00134     /* Get time from filename... */
00135     sprintf(tstr, "%.4s", &argv[f][strlen(argv[f]) - 20]);
00136     year = atoi(tstr);
```

```
00137     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 15]);
00138     mon = atoi(tstr);
00139     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 12]);
00140     day = atoi(tstr);
00141     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 9]);
00142     hour = atoi(tstr);
00143     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 6]);
00144     min = atoi(tstr);
00145     time2jsec(year, mon, day, hour, min, 0, 0, &t);
00146
00147     /* Save initial time... */
00148     if (!init) {
00149       init = 1;
00150       t0 = t;
00151     }
00152
00153     /* Init... */
00154     np = 0;
00155     for (ip = 0; ip < atm1->np; ip++) {
00156       ahtd[ip] = avtd[ip] = rhtd[ip] = rvtd[ip] = 0;
00157       for (iq = 0; iq < ctl.nq; iq++)
00158         aqtd[iq * NP + ip] = rqtd[iq * NP + ip] = 0;
00159     }
00160
00161     /* Loop over air parcels... */
00162     for (ip = 0; ip < atm1->np; ip++) {
00163
00164       /* Check data... */
00165       if (!gsl_finite(atm1->time[ip]) || !gsl_finite(atm2->time[ip]))
00166         continue;
00167
00168       /* Check ensemble index... */
00169       if (ctl.qnt_ens > 0
00170           && (atm1->q[ctl.qnt_ens][ip] != ens
00171               || atm2->q[ctl.qnt_ens][ip] != ens))
00172         continue;
00173
00174       /* Check spatial range... */
00175       if (atm1->p[ip] > p0 || atm1->p[ip] < p1
00176           || atm1->lon[ip] < lon0 || atm1->lon[ip] > lon1
00177           || atm1->lat[ip] < lat0 || atm1->lat[ip] > lat1)
00178         continue;
00179       if (atm2->p[ip] > p0 || atm2->p[ip] < p1
00180           || atm2->lon[ip] < lon0 || atm2->lon[ip] > lon1
00181           || atm2->lat[ip] < lat0 || atm2->lat[ip] > lat1)
00182         continue;
00183
00184       /* Convert coordinates... */
00185       geo2cart(0, atm1->lon[ip], atm1->lat[ip], x1);
00186       geo2cart(0, atm2->lon[ip], atm2->lat[ip], x2);
00187       z1 = Z(atm1->p[ip]);
00188       z2 = Z(atm2->p[ip]);
00189
00190       /* Calculate absolute transport deviations... */
00191       ahtd[np] = DIST(x1, x2);
00192       avtd[np] = z1 - z2;
00193       for (iq = 0; iq < ctl.nq; iq++)
00194         aqtd[iq * NP + np] = atm1->q[iq][ip] - atm2->q[iq][ip];
00195
00196       /* Calculate relative transport deviations... */
00197       if (f > 4) {
00198
00199         /* Get trajectory lengths... */
00200         geo2cart(0, lon1_old[ip], lat1_old[ip], x0);
00201         lh1[ip] += DIST(x0, x1);
00202         lv1[ip] += fabs(z1_old[ip] - z1);
00203
00204         geo2cart(0, lon2_old[ip], lat2_old[ip], x0);
00205         lh2[ip] += DIST(x0, x2);
00206         lv2[ip] += fabs(z2_old[ip] - z2);
00207
00208         /* Get relative transport deviations... */
00209         if (lh1[ip] + lh2[ip] > 0)
00210           rhtd[np] = 200. * DIST(x1, x2) / (lh1[ip] + lh2[ip]);
00211         if (lv1[ip] + lv2[ip] > 0)
00212           rvtd[np] = 200. * (z1 - z2) / (lv1[ip] + lv2[ip]);
00213       }
00214
00215       /* Get relative transport deviations... */
00216       for (iq = 0; iq < ctl.nq; iq++)
00217         rqtd[iq * NP + np] = 200. * (atm1->q[iq][ip] - atm2->q[iq][ip])
00218           / (fabs(atm1->q[iq][ip]) + fabs(atm2->q[iq][ip]));
00219
00220       /* Save positions of air parcels... */
00221       lon1_old[ip] = atm1->lon[ip];
00222       lat1_old[ip] = atm1->lat[ip];
00223       z1_old[ip] = z1;
```

```
00224
00225       lon2_old[ip] = atm2->lon[ip];
00226       lat2_old[ip] = atm2->lat[ip];
00227       z2_old[ip] = z2;
00228
00229       /* Increment air parcel counter... */
00230       np++;
00231     }
00232
00233     /* Get statistics... */
00234     if (strcasecmp(argv[3], "mean") == 0) {
00235       ahtdm = gsl_stats_mean(ahtd, 1, (size_t) np);
00236       rhtdm = gsl_stats_mean(rhtd, 1, (size_t) np);
00237       avtdm = gsl_stats_mean(avtd, 1, (size_t) np);
00238       rvtdm = gsl_stats_mean(rvtd, 1, (size_t) np);
00239       for (iq = 0; iq < ctl.nq; iq++) {
00240         aqtdm[iq] = gsl_stats_mean(&aqtd[iq * NP], 1, (size_t) np);
00241         rqtdm[iq] = gsl_stats_mean(&rqtd[iq * NP], 1, (size_t) np);
00242       }
00243     } else if (strcasecmp(argv[3], "stddev") == 0) {
00244       ahtdm = gsl_stats_sd(ahtd, 1, (size_t) np);
00245       rhtdm = gsl_stats_sd(rhtd, 1, (size_t) np);
00246       avtdm = gsl_stats_sd(avtd, 1, (size_t) np);
00247       rvtdm = gsl_stats_sd(rvtd, 1, (size_t) np);
00248       for (iq = 0; iq < ctl.nq; iq++) {
00249         aqtdm[iq] = gsl_stats_sd(&aqtd[iq * NP], 1, (size_t) np);
00250         rqtdm[iq] = gsl_stats_sd(&rqtd[iq * NP], 1, (size_t) np);
00251       }
00252     } else if (strcasecmp(argv[3], "min") == 0) {
00253       ahtdm = gsl_stats_min(ahtd, 1, (size_t) np);
00254       rhtdm = gsl_stats_min(rhtd, 1, (size_t) np);
00255       avtdm = gsl_stats_min(avtd, 1, (size_t) np);
00256       rvtdm = gsl_stats_min(rvtd, 1, (size_t) np);
00257       for (iq = 0; iq < ctl.nq; iq++) {
00258         aqtdm[iq] = gsl_stats_min(&aqtd[iq * NP], 1, (size_t) np);
00259         rqtdm[iq] = gsl_stats_min(&rqtd[iq * NP], 1, (size_t) np);
00260       }
00261     } else if (strcasecmp(argv[3], "max") == 0) {
00262       ahtdm = gsl_stats_max(ahtd, 1, (size_t) np);
00263       rhtdm = gsl_stats_max(rhtd, 1, (size_t) np);
00264       avtdm = gsl_stats_max(avtd, 1, (size_t) np);
00265       rvtdm = gsl_stats_max(rvtd, 1, (size_t) np);
00266       for (iq = 0; iq < ctl.nq; iq++) {
00267         aqtdm[iq] = gsl_stats_max(&aqtd[iq * NP], 1, (size_t) np);
00268         rqtdm[iq] = gsl_stats_max(&rqtd[iq * NP], 1, (size_t) np);
00269       }
00270     } else if (strcasecmp(argv[3], "skew") == 0) {
00271       ahtdm = gsl_stats_skew(ahtd, 1, (size_t) np);
00272       rhtdm = gsl_stats_skew(rhtd, 1, (size_t) np);
00273       avtdm = gsl_stats_skew(avtd, 1, (size_t) np);
00274       rvtdm = gsl_stats_skew(rvtd, 1, (size_t) np);
00275       for (iq = 0; iq < ctl.nq; iq++) {
00276         aqtdm[iq] = gsl_stats_skew(&aqtd[iq * NP], 1, (size_t) np);
00277         rqtdm[iq] = gsl_stats_skew(&rqtd[iq * NP], 1, (size_t) np);
00278       }
00279     } else if (strcasecmp(argv[3], "kurt") == 0) {
00280       ahtdm = gsl_stats_kurtosis(ahtd, 1, (size_t) np);
00281       rhtdm = gsl_stats_kurtosis(rhtd, 1, (size_t) np);
00282       avtdm = gsl_stats_kurtosis(avtd, 1, (size_t) np);
00283       rvtdm = gsl_stats_kurtosis(rvtd, 1, (size_t) np);
00284       for (iq = 0; iq < ctl.nq; iq++) {
00285         aqtdm[iq] = gsl_stats_kurtosis(&aqtd[iq * NP], 1, (size_t) np);
00286         rqtdm[iq] = gsl_stats_kurtosis(&rqtd[iq * NP], 1, (size_t) np);
00287       }
00288     } else if (strcasecmp(argv[3], "median") == 0) {
00289       ahtdm = gsl_stats_median(ahtd, 1, (size_t) np);
00290       rhtdm = gsl_stats_median(rhtd, 1, (size_t) np);
00291       avtdm = gsl_stats_median(avtd, 1, (size_t) np);
00292       rvtdm = gsl_stats_median(rvtd, 1, (size_t) np);
00293       for (iq = 0; iq < ctl.nq; iq++) {
00294         aqtdm[iq] = gsl_stats_median(&aqtd[iq * NP], 1, (size_t) np);
00295         rqtdm[iq] = gsl_stats_median(&rqtd[iq * NP], 1, (size_t) np);
00296       }
00297     } else if (strcasecmp(argv[3], "absdev") == 0) {
00298       ahtdm = gsl_stats_absdev(ahtd, 1, (size_t) np);
00299       rhtdm = gsl_stats_absdev(rhtd, 1, (size_t) np);
00300       avtdm = gsl_stats_absdev(avtd, 1, (size_t) np);
00301       rvtdm = gsl_stats_absdev(rvtd, 1, (size_t) np);
00302       for (iq = 0; iq < ctl.nq; iq++) {
00303         aqtdm[iq] = gsl_stats_absdev(&aqtd[iq * NP], 1, (size_t) np);
00304         rqtdm[iq] = gsl_stats_absdev(&rqtd[iq * NP], 1, (size_t) np);
00305       }
00306     } else if (strcasecmp(argv[3], "mad") == 0) {
00307       ahtdm = gsl_stats_mad0(ahtd, 1, (size_t) np, work);
00308       rhtdm = gsl_stats_mad0(rhtd, 1, (size_t) np, work);
00309       avtdm = gsl_stats_mad0(avtd, 1, (size_t) np, work);
00310       rvtdm = gsl_stats_mad0(rvtd, 1, (size_t) np, work);
```

```
00311       for (iq = 0; iq < ctl.nq; iq++) {
00312         aqtdm[iq] = gsl_stats_mad0(&aqtd[iq * NP], 1, (size_t) np, work);
00313         rqtdm[iq] = gsl_stats_mad0(&rqtd[iq * NP], 1, (size_t) np, work);
00314       }
00315     } else
00316       ERRMSG("Unknown parameter!");
00317
00318     /* Write output... */
00319     fprintf(out, "%.2f %.2f %g %g %g %g", t, t - t0,
00320             ahtdm, rhtdm, avtdm, rvtdm);
00321     for (iq = 0; iq < ctl.nq; iq++) {
00322       fprintf(out, " ");
00323       fprintf(out, ctl.qnt_format[iq], aqtdm[iq]);
00324       fprintf(out, " ");
00325       fprintf(out, ctl.qnt_format[iq], rqtdm[iq]);
00326     }
00327     fprintf(out, " %d\n", np);
00328   }
00329
00330   /* Close file... */
00331   fclose(out);
00332
00333   /* Free... */
00334   free(atm1);
00335   free(atm2);
00336   free(lon1_old);
00337   free(lat1_old);
00338   free(z1_old);
00339   free(lh1);
00340   free(lv1);
00341   free(lon2_old);
00342   free(lat2_old);
00343   free(z2_old);
00344   free(lh2);
00345   free(lv2);
00346   free(ahtd);
00347   free(avtd);
00348   free(aqtd);
00349   free(rhtd);
00350   free(rvtd);
00351   free(rqtd);
00352   free(work);
00353
00354   return EXIT_SUCCESS;
00355 }
```

5.5 atm_init.c File Reference

Create atmospheric data file with initial air parcel positions.

Functions

- int main (int argc, char ∗argv[ ])

5.5.1 Detailed Description

Create atmospheric data file with initial air parcel positions.

Definition in file atm_init.c.

5.5.2 Function Documentation

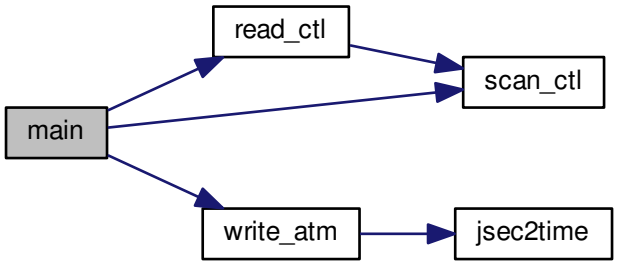
5.5.2.1 int main (int *argc*, char ∗ *argv[ ]*)

Definition at line 27 of file atm_init.c.

```
00029                {
00030
00031   atm_t *atm;
00032
00033   ctl_t ctl;
00034
00035   gsl_rng *rng;
00036
00037   double dt, dz, dlon, dlat, lat0, lat1, lon0, lon1, t0, t1, z0, z1,
00038     t, z, lon, lat, st, sz, slon, slat, sx, ut, uz, ulon, ulat, m;
00039
00040   int even, ip, irep, rep;
00041
00042   /* Allocate... */
00043   ALLOC(atm, atm_t, 1);
00044
00045   /* Check arguments... */
00046   if (argc < 3)
00047     ERRMSG("Give parameters: <ctl> <atm_out>");
00048
00049   /* Read control parameters... */
00050   read_ctl(argv[1], argc, argv, &ctl);
00051   t0 = scan_ctl(argv[1], argc, argv, "INIT_T0", -1, "0", NULL);
00052   t1 = scan_ctl(argv[1], argc, argv, "INIT_T1", -1, "0", NULL);
00053   dt = scan_ctl(argv[1], argc, argv, "INIT_DT", -1, "1", NULL);
00054   z0 = scan_ctl(argv[1], argc, argv, "INIT_Z0", -1, "0", NULL);
00055   z1 = scan_ctl(argv[1], argc, argv, "INIT_Z1", -1, "0", NULL);
00056   dz = scan_ctl(argv[1], argc, argv, "INIT_DZ", -1, "1", NULL);
00057   lon0 = scan_ctl(argv[1], argc, argv, "INIT_LON0", -1, "0", NULL);
00058   lon1 = scan_ctl(argv[1], argc, argv, "INIT_LON1", -1, "0", NULL);
00059   dlon = scan_ctl(argv[1], argc, argv, "INIT_DLON", -1, "1", NULL);
00060   lat0 = scan_ctl(argv[1], argc, argv, "INIT_LAT0", -1, "0", NULL);
00061   lat1 = scan_ctl(argv[1], argc, argv, "INIT_LAT1", -1, "0", NULL);
00062   dlat = scan_ctl(argv[1], argc, argv, "INIT_DLAT", -1, "1", NULL);
00063   st = scan_ctl(argv[1], argc, argv, "INIT_ST", -1, "0", NULL);
00064   sz = scan_ctl(argv[1], argc, argv, "INIT_SZ", -1, "0", NULL);
00065   slon = scan_ctl(argv[1], argc, argv, "INIT_SLON", -1, "0", NULL);
00066   slat = scan_ctl(argv[1], argc, argv, "INIT_SLAT", -1, "0", NULL);
00067   sx = scan_ctl(argv[1], argc, argv, "INIT_SX", -1, "0", NULL);
00068   ut = scan_ctl(argv[1], argc, argv, "INIT_UT", -1, "0", NULL);
00069   uz = scan_ctl(argv[1], argc, argv, "INIT_UZ", -1, "0", NULL);
00070   ulon = scan_ctl(argv[1], argc, argv, "INIT_ULON", -1, "0", NULL);
00071   ulat = scan_ctl(argv[1], argc, argv, "INIT_ULAT", -1, "0", NULL);
00072   even = (int) scan_ctl(argv[1], argc, argv, "INIT_EVENLY", -1, "1", NULL);
00073   rep = (int) scan_ctl(argv[1], argc, argv, "INIT_REP", -1, "1", NULL);
00074   m = scan_ctl(argv[1], argc, argv, "INIT_MASS", -1, "0", NULL);
00075
00076   /* Initialize random number generator... */
00077   gsl_rng_env_setup();
00078   rng = gsl_rng_alloc(gsl_rng_default);
00079
00080   /* Create grid... */
00081   for (t = t0; t <= t1; t += dt)
00082     for (z = z0; z <= z1; z += dz)
00083       for (lon = lon0; lon <= lon1; lon += dlon)
00084         for (lat = lat0; lat <= lat1; lat += dlat)
00085           for (irep = 0; irep < rep; irep++) {
00086
00087             /* Set position... */
00088             atm->time[atm->np]
00089               = (t + gsl_ran_gaussian_ziggurat(rng, st / 2.3548)
00090                  + ut * (gsl_rng_uniform(rng) - 0.5));
00091             atm->p[atm->np]
00092               = P(z + gsl_ran_gaussian_ziggurat(rng, sz / 2.3548)
00093                   + uz * (gsl_rng_uniform(rng) - 0.5));
00094             atm->lon[atm->np]
00095               = (lon + gsl_ran_gaussian_ziggurat(rng, slon / 2.3548)
00096                  + gsl_ran_gaussian_ziggurat(rng, DX2DEG(sx, lat) / 2.3548)
00097                  + ulon * (gsl_rng_uniform(rng) - 0.5));
00098             do {
00099               atm->lat[atm->np]
00100                 = (lat + gsl_ran_gaussian_ziggurat(rng, slat / 2.3548)
00101                    + gsl_ran_gaussian_ziggurat(rng, DY2DEG(sx) / 2.3548)
00102                    + ulat * (gsl_rng_uniform(rng) - 0.5));
00103             } while (even && gsl_rng_uniform(rng) >
00104                      fabs(cos(atm->lat[atm->np] * M_PI / 180.)));
00105
00106             /* Set particle counter... */
00107             if ((++atm->np) > NP)
00108               ERRMSG("Too many particles!");
00109           }
00110
00111   /* Check number of air parcels... */
00112   if (atm->np <= 0)
00113     ERRMSG("Did not create any air parcels!");
00114
00115   /* Initialize mass... */
```

```
00116   if (ctl.qnt_m >= 0)
00117     for (ip = 0; ip < atm->np; ip++)
00118       atm->q[ctl.qnt_m][ip] = m / atm->np;
00119
00120   /* Save data... */
00121   write_atm(argv[2], &ctl, atm, t0);
00122
00123   /* Free... */
00124   gsl_rng_free(rng);
00125   free(atm);
00126
00127   return EXIT_SUCCESS;
00128 }
```

Here is the call graph for this function:



5.6 atm_init.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   atm_t *atm;
00032
00033   ctl_t ctl;
00034
00035   gsl_rng *rng;
00036
00037   double dt, dz, dlon, dlat, lat0, lat1, lon0, lon1, t0, t1, z0, z1,
00038     t, z, lon, lat, st, sz, slon, slat, sx, ut, uz, ulon, ulat, m;
00039
00040   int even, ip, irep, rep;
00041
00042   /* Allocate... */
00043   ALLOC(atm, atm_t, 1);
```

```
00044
00045   /* Check arguments... */
00046   if (argc < 3)
00047     ERRMSG("Give parameters: <ctl> <atm_out>");
00048
00049   /* Read control parameters... */
00050   read_ctl(argv[1], argc, argv, &ctl);
00051   t0 = scan_ctl(argv[1], argc, argv, "INIT_T0", -1, "0", NULL);
00052   t1 = scan_ctl(argv[1], argc, argv, "INIT_T1", -1, "0", NULL);
00053   dt = scan_ctl(argv[1], argc, argv, "INIT_DT", -1, "1", NULL);
00054   z0 = scan_ctl(argv[1], argc, argv, "INIT_Z0", -1, "0", NULL);
00055   z1 = scan_ctl(argv[1], argc, argv, "INIT_Z1", -1, "0", NULL);
00056   dz = scan_ctl(argv[1], argc, argv, "INIT_DZ", -1, "1", NULL);
00057   lon0 = scan_ctl(argv[1], argc, argv, "INIT_LON0", -1, "0", NULL);
00058   lon1 = scan_ctl(argv[1], argc, argv, "INIT_LON1", -1, "0", NULL);
00059   dlon = scan_ctl(argv[1], argc, argv, "INIT_DLON", -1, "1", NULL);
00060   lat0 = scan_ctl(argv[1], argc, argv, "INIT_LAT0", -1, "0", NULL);
00061   lat1 = scan_ctl(argv[1], argc, argv, "INIT_LAT1", -1, "0", NULL);
00062   dlat = scan_ctl(argv[1], argc, argv, "INIT_DLAT", -1, "1", NULL);
00063   st = scan_ctl(argv[1], argc, argv, "INIT_ST", -1, "0", NULL);
00064   sz = scan_ctl(argv[1], argc, argv, "INIT_SZ", -1, "0", NULL);
00065   slon = scan_ctl(argv[1], argc, argv, "INIT_SLON", -1, "0", NULL);
00066   slat = scan_ctl(argv[1], argc, argv, "INIT_SLAT", -1, "0", NULL);
00067   sx = scan_ctl(argv[1], argc, argv, "INIT_SX", -1, "0", NULL);
00068   ut = scan_ctl(argv[1], argc, argv, "INIT_UT", -1, "0", NULL);
00069   uz = scan_ctl(argv[1], argc, argv, "INIT_UZ", -1, "0", NULL);
00070   ulon = scan_ctl(argv[1], argc, argv, "INIT_ULON", -1, "0", NULL);
00071   ulat = scan_ctl(argv[1], argc, argv, "INIT_ULAT", -1, "0", NULL);
00072   even = (int) scan_ctl(argv[1], argc, argv, "INIT_EVENLY", -1, "1", NULL);
00073   rep = (int) scan_ctl(argv[1], argc, argv, "INIT_REP", -1, "1", NULL);
00074   m = scan_ctl(argv[1], argc, argv, "INIT_MASS", -1, "0", NULL);
00075
00076   /* Initialize random number generator... */
00077   gsl_rng_env_setup();
00078   rng = gsl_rng_alloc(gsl_rng_default);
00079
00080   /* Create grid... */
00081   for (t = t0; t <= t1; t += dt)
00082     for (z = z0; z <= z1; z += dz)
00083       for (lon = lon0; lon <= lon1; lon += dlon)
00084         for (lat = lat0; lat <= lat1; lat += dlat)
00085           for (irep = 0; irep < rep; irep++) {
00086
00087             /* Set position... */
00088             atm->time[atm->np]
00089               = (t + gsl_ran_gaussian_ziggurat(rng, st / 2.3548)
00090                  + ut * (gsl_rng_uniform(rng) - 0.5));
00091             atm->p[atm->np]
00092               = P(z + gsl_ran_gaussian_ziggurat(rng, sz / 2.3548)
00093                   + uz * (gsl_rng_uniform(rng) - 0.5));
00094             atm->lon[atm->np]
00095               = (lon + gsl_ran_gaussian_ziggurat(rng, slon / 2.3548)
00096                  + gsl_ran_gaussian_ziggurat(rng, DX2DEG(sx, lat) / 2.3548)
00097                  + ulon * (gsl_rng_uniform(rng) - 0.5));
00098             do {
00099               atm->lat[atm->np]
00100                 = (lat + gsl_ran_gaussian_ziggurat(rng, slat / 2.3548)
00101                    + gsl_ran_gaussian_ziggurat(rng, DY2DEG(sx) / 2.3548)
00102                    + ulat * (gsl_rng_uniform(rng) - 0.5));
00103             } while (even && gsl_rng_uniform(rng) >
00104                      fabs(cos(atm->lat[atm->np] * M_PI / 180.)));
00105
00106             /* Set particle counter... */
00107             if ((++atm->np) > NP)
00108               ERRMSG("Too many particles!");
00109           }
00110
00111   /* Check number of air parcels... */
00112   if (atm->np <= 0)
00113     ERRMSG("Did not create any air parcels!");
00114
00115   /* Initialize mass... */
00116   if (ctl.qnt_m >= 0)
00117     for (ip = 0; ip < atm->np; ip++)
00118       atm->q[ctl.qnt_m][ip] = m / atm->np;
00119
00120   /* Save data... */
00121   write_atm(argv[2], &ctl, atm, t0);
00122
00123   /* Free... */
00124   gsl_rng_free(rng);
00125   free(atm);
00126
00127   return EXIT_SUCCESS;
00128 }
```

5.7 atm_split.c File Reference

Split air parcels into a larger number of parcels.

Functions

- int main (int argc, char ∗argv[ ])

5.7.1 Detailed Description

Split air parcels into a larger number of parcels.

Definition in file atm_split.c.

5.7.2 Function Documentation

5.7.2.1 int main (int *argc,* char ∗ *argv[ ]*)

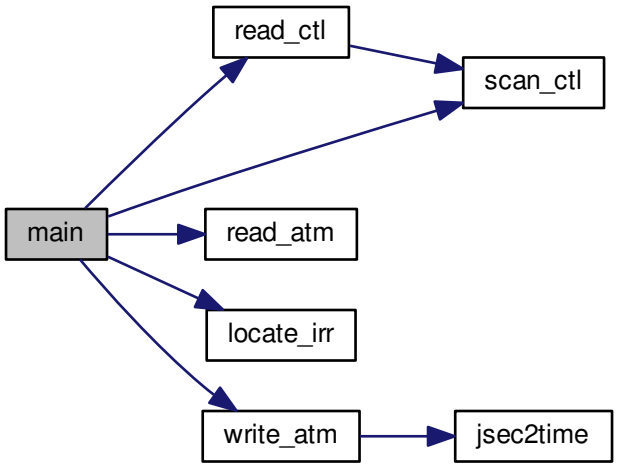
Definition at line 27 of file atm_split.c.

```
00029                {
00030
00031   atm_t *atm, *atm2;
00032
00033   ctl_t ctl;
00034
00035   gsl_rng *rng;
00036
00037   FILE *in;
00038
00039   char kernel[LEN], line[LEN];
00040
00041   double dt, dx, dz, k, kk[GZ], kz[GZ], kmin, kmax, m, mmax = 0, mtot = 0,
00042     t0, t1, z, z0, z1, lon0, lon1, lat0, lat1;
00043
00044   int i, ip, iq, iz, n, nz = 0;
00045
00046   /* Allocate... */
00047   ALLOC(atm, atm_t, 1);
00048   ALLOC(atm2, atm_t, 1);
00049
00050   /* Check arguments... */
00051   if (argc < 4)
00052     ERRMSG("Give parameters: <ctl> <atm_in> <atm_out>");
00053
00054   /* Read control parameters... */
00055   read_ctl(argv[1], argc, argv, &ctl);
00056   n = (int) scan_ctl(argv[1], argc, argv, "SPLIT_N", -1, "", NULL);
00057   m = scan_ctl(argv[1], argc, argv, "SPLIT_M", -1, "-999", NULL);
00058   dt = scan_ctl(argv[1], argc, argv, "SPLIT_DT", -1, "0", NULL);
00059   t0 = scan_ctl(argv[1], argc, argv, "SPLIT_T0", -1, "0", NULL);
00060   t1 = scan_ctl(argv[1], argc, argv, "SPLIT_T1", -1, "0", NULL);
00061   dz = scan_ctl(argv[1], argc, argv, "SPLIT_DZ", -1, "0", NULL);
00062   z0 = scan_ctl(argv[1], argc, argv, "SPLIT_Z0", -1, "0", NULL);
00063   z1 = scan_ctl(argv[1], argc, argv, "SPLIT_Z1", -1, "0", NULL);
00064   dx = scan_ctl(argv[1], argc, argv, "SPLIT_DX", -1, "0", NULL);
00065   lon0 = scan_ctl(argv[1], argc, argv, "SPLIT_LON0", -1, "0", NULL);
00066   lon1 = scan_ctl(argv[1], argc, argv, "SPLIT_LON1", -1, "0", NULL);
00067   lat0 = scan_ctl(argv[1], argc, argv, "SPLIT_LAT0", -1, "0", NULL);
00068   lat1 = scan_ctl(argv[1], argc, argv, "SPLIT_LAT1", -1, "0", NULL);
00069   scan_ctl(argv[1], argc, argv, "SPLIT_KERNEL", -1, "-", kernel);
00070
00071   /* Init random number generator... */
00072   gsl_rng_env_setup();
00073   rng = gsl_rng_alloc(gsl_rng_default);
00074
00075   /* Read atmospheric data... */
00076   if (!read_atm(argv[2], &ctl, atm))
```

```
00077     ERRMSG("Cannot open file!");
00078
00079   /* Read kernel function... */
00080   if (kernel[0] != '-') {
00081
00082     /* Write info... */
00083     printf("Read kernel function: %s\n", kernel);
00084
00085     /* Open file... */
00086     if (!(in = fopen(kernel, "r")))
00087       ERRMSG("Cannot open file!");
00088
00089     /* Read data... */
00090     while (fgets(line, LEN, in))
00091       if (sscanf(line, "%lg %lg", &kz[nz], &kk[nz]) == 2)
00092         if ((++nz) >= GZ)
00093           ERRMSG("Too many height levels!");
00094
00095     /* Close file... */
00096     fclose(in);
00097
00098     /* Normalize kernel function... */
00099     kmax = gsl_stats_max(kk, 1, (size_t) nz);
00100     kmin = gsl_stats_min(kk, 1, (size_t) nz);
00101     for (iz = 0; iz < nz; iz++)
00102       kk[iz] = (kk[iz] - kmin) / (kmax - kmin);
00103   }
00104
00105   /* Get total and maximum mass... */
00106   if (ctl.qnt_m >= 0)
00107     for (ip = 0; ip < atm->np; ip++) {
00108       mtot += atm->q[ctl.qnt_m][ip];
00109       mmax = GSL_MAX(mmax, atm->q[ctl.qnt_m][ip]);
00110     }
00111   if (m > 0)
00112     mtot = m;
00113
00114   /* Loop over air parcels... */
00115   for (i = 0; i < n; i++) {
00116
00117     /* Select air parcel... */
00118     if (ctl.qnt_m >= 0)
00119       do {
00120         ip = (int) gsl_rng_uniform_int(rng, (long unsigned int) atm->np);
00121       } while (gsl_rng_uniform(rng) > atm->q[ctl.qnt_m][ip] / mmax);
00122     else
00123       ip = (int) gsl_rng_uniform_int(rng, (long unsigned int) atm->np);
00124
00125     /* Set time... */
00126     if (t1 > t0)
00127       atm2->time[atm2->np] = t0 + (t1 - t0) * gsl_rng_uniform_pos(rng);
00128     else
00129       atm2->time[atm2->np] = atm->time[ip]
00130         + gsl_ran_gaussian_ziggurat(rng, dt / 2.3548);
00131
00132     /* Set vertical position... */
00133     if (nz > 0) {
00134       do {
00135         z = kmin + (kmax - kmin) * gsl_rng_uniform_pos(rng);
00136         iz = locate_irr(kz, nz, z);
00137         k = LIN(kz[iz], kk[iz], kz[iz + 1], kk[iz + 1], z);
00138       } while (gsl_rng_uniform(rng) > k);
00139       atm2->p[atm2->np] = P(z);
00140     } else if (z1 > z0)
00141       atm2->p[atm2->np] = P(z0 + (z1 - z0) * gsl_rng_uniform_pos(rng));
00142     else
00143       atm2->p[atm2->np] = atm->p[ip]
00144         + DZ2DP(gsl_ran_gaussian_ziggurat(rng, dz / 2.3548), atm->p[ip]);
00145
00146     /* Set horizontal position... */
00147     if (lon1 > lon0 && lat1 > lat0) {
00148       atm2->lon[atm2->np] = lon0 + (lon1 - lon0) * gsl_rng_uniform_pos(rng);
00149       atm2->lat[atm2->np] = lat0 + (lat1 - lat0) * gsl_rng_uniform_pos(rng);
00150     } else {
00151       atm2->lon[atm2->np] = atm->lon[ip]
00152         + gsl_ran_gaussian_ziggurat(rng, DX2DEG(dx, atm->lat[ip]) / 2.3548);
00153       atm2->lat[atm2->np] = atm->lat[ip]
00154         + gsl_ran_gaussian_ziggurat(rng, DY2DEG(dx) / 2.3548);
00155     }
00156
00157     /* Copy quantities... */
00158     for (iq = 0; iq < ctl.nq; iq++)
00159       atm2->q[iq][atm2->np] = atm->q[iq][ip];
00160
00161     /* Adjust mass... */
00162     if (ctl.qnt_m >= 0)
00163       atm2->q[ctl.qnt_m][atm2->np] = mtot / n;
```

```
00164
00165     /* Increment particle counter... */
00166     if ((++atm2->np) > NP)
00167       ERRMSG("Too many air parcels!");
00168   }
00169
00170   /* Save data and close file... */
00171   write_atm(argv[3], &ctl, atm2, atm->time[0]);
00172
00173   /* Free... */
00174   free(atm);
00175   free(atm2);
00176
00177   return EXIT_SUCCESS;
00178 }
```

Here is the call graph for this function:



5.8 atm_split.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   atm_t *atm, *atm2;
```

```
00032
00033   ctl_t ctl;
00034
00035   gsl_rng *rng;
00036
00037   FILE *in;
00038
00039   char kernel[LEN], line[LEN];
00040
00041   double dt, dx, dz, k, kk[GZ], kz[GZ], kmin, kmax, m, mmax = 0, mtot = 0,
00042     t0, t1, z, z0, z1, lon0, lon1, lat0, lat1;
00043
00044   int i, ip, iq, iz, n, nz = 0;
00045
00046   /* Allocate... */
00047   ALLOC(atm, atm_t, 1);
00048   ALLOC(atm2, atm_t, 1);
00049
00050   /* Check arguments... */
00051   if (argc < 4)
00052     ERRMSG("Give parameters: <ctl> <atm_in> <atm_out>");
00053
00054   /* Read control parameters... */
00055   read_ctl(argv[1], argc, argv, &ctl);
00056   n = (int) scan_ctl(argv[1], argc, argv, "SPLIT_N", -1, "", NULL);
00057   m = scan_ctl(argv[1], argc, argv, "SPLIT_M", -1, "-999", NULL);
00058   dt = scan_ctl(argv[1], argc, argv, "SPLIT_DT", -1, "0", NULL);
00059   t0 = scan_ctl(argv[1], argc, argv, "SPLIT_T0", -1, "0", NULL);
00060   t1 = scan_ctl(argv[1], argc, argv, "SPLIT_T1", -1, "0", NULL);
00061   dz = scan_ctl(argv[1], argc, argv, "SPLIT_DZ", -1, "0", NULL);
00062   z0 = scan_ctl(argv[1], argc, argv, "SPLIT_Z0", -1, "0", NULL);
00063   z1 = scan_ctl(argv[1], argc, argv, "SPLIT_Z1", -1, "0", NULL);
00064   dx = scan_ctl(argv[1], argc, argv, "SPLIT_DX", -1, "0", NULL);
00065   lon0 = scan_ctl(argv[1], argc, argv, "SPLIT_LON0", -1, "0", NULL);
00066   lon1 = scan_ctl(argv[1], argc, argv, "SPLIT_LON1", -1, "0", NULL);
00067   lat0 = scan_ctl(argv[1], argc, argv, "SPLIT_LAT0", -1, "0", NULL);
00068   lat1 = scan_ctl(argv[1], argc, argv, "SPLIT_LAT1", -1, "0", NULL);
00069   scan_ctl(argv[1], argc, argv, "SPLIT_KERNEL", -1, "-", kernel);
00070
00071   /* Init random number generator... */
00072   gsl_rng_env_setup();
00073   rng = gsl_rng_alloc(gsl_rng_default);
00074
00075   /* Read atmospheric data... */
00076   if (!read_atm(argv[2], &ctl, atm))
00077     ERRMSG("Cannot open file!");
00078
00079   /* Read kernel function... */
00080   if (kernel[0] != '-') {
00081
00082     /* Write info... */
00083     printf("Read kernel function: %s\n", kernel);
00084
00085     /* Open file... */
00086     if (!(in = fopen(kernel, "r")))
00087       ERRMSG("Cannot open file!");
00088
00089     /* Read data... */
00090     while (fgets(line, LEN, in))
00091       if (sscanf(line, "%lg %lg", &kz[nz], &kk[nz]) == 2)
00092         if ((++nz) >= GZ)
00093           ERRMSG("Too many height levels!");
00094
00095     /* Close file... */
00096     fclose(in);
00097
00098     /* Normalize kernel function... */
00099     kmax = gsl_stats_max(kk, 1, (size_t) nz);
00100    kmin = gsl_stats_min(kk, 1, (size_t) nz);
00101    for (iz = 0; iz < nz; iz++)
00102      kk[iz] = (kk[iz] - kmin) / (kmax - kmin);
00103  }
00104
00105  /* Get total and maximum mass... */
00106  if (ctl.qnt_m >= 0)
00107    for (ip = 0; ip < atm->np; ip++) {
00108      mtot += atm->q[ctl.qnt_m][ip];
00109      mmax = GSL_MAX(mmax, atm->q[ctl.qnt_m][ip]);
00110    }
00111  if (m > 0)
00112    mtot = m;
00113
00114  /* Loop over air parcels... */
00115  for (i = 0; i < n; i++) {
00116
00117    /* Select air parcel... */
00118    if (ctl.qnt_m >= 0)
```

```
00119       do {
00120         ip = (int) gsl_rng_uniform_int(rng, (long unsigned int) atm->np);
00121       } while (gsl_rng_uniform(rng) > atm->q[ctl.qnt_m][ip] / mmax);
00122     else
00123       ip = (int) gsl_rng_uniform_int(rng, (long unsigned int) atm->np);
00124
00125     /* Set time... */
00126     if (t1 > t0)
00127       atm2->time[atm2->np] = t0 + (t1 - t0) * gsl_rng_uniform_pos(rng);
00128     else
00129       atm2->time[atm2->np] = atm->time[ip]
00130         + gsl_ran_gaussian_ziggurat(rng, dt / 2.3548);
00131
00132     /* Set vertical position... */
00133     if (nz > 0) {
00134       do {
00135         z = kmin + (kmax - kmin) * gsl_rng_uniform_pos(rng);
00136         iz = locate_irr(kz, nz, z);
00137         k = LIN(kz[iz], kk[iz], kz[iz + 1], kk[iz + 1], z);
00138       } while (gsl_rng_uniform(rng) > k);
00139       atm2->p[atm2->np] = P(z);
00140     } else if (z1 > z0)
00141       atm2->p[atm2->np] = P(z0 + (z1 - z0) * gsl_rng_uniform_pos(rng));
00142     else
00143       atm2->p[atm2->np] = atm->p[ip]
00144         + DZ2DP(gsl_ran_gaussian_ziggurat(rng, dz / 2.3548), atm->p[ip]);
00145
00146     /* Set horizontal position... */
00147     if (lon1 > lon0 && lat1 > lat0) {
00148       atm2->lon[atm2->np] = lon0 + (lon1 - lon0) * gsl_rng_uniform_pos(rng);
00149       atm2->lat[atm2->np] = lat0 + (lat1 - lat0) * gsl_rng_uniform_pos(rng);
00150     } else {
00151       atm2->lon[atm2->np] = atm->lon[ip]
00152         + gsl_ran_gaussian_ziggurat(rng, DX2DEG(dx, atm->lat[ip]) / 2.3548);
00153       atm2->lat[atm2->np] = atm->lat[ip]
00154         + gsl_ran_gaussian_ziggurat(rng, DY2DEG(dx) / 2.3548);
00155     }
00156
00157     /* Copy quantities... */
00158     for (iq = 0; iq < ctl.nq; iq++)
00159       atm2->q[iq][atm2->np] = atm->q[iq][ip];
00160
00161     /* Adjust mass... */
00162     if (ctl.qnt_m >= 0)
00163       atm2->q[ctl.qnt_m][atm2->np] = mtot / n;
00164
00165     /* Increment particle counter... */
00166     if ((++atm2->np) > NP)
00167       ERRMSG("Too many air parcels!");
00168   }
00169
00170   /* Save data and close file... */
00171   write_atm(argv[3], &ctl, atm2, atm->time[0]);
00172
00173   /* Free... */
00174   free(atm);
00175   free(atm2);
00176
00177   return EXIT_SUCCESS;
00178 }
```

5.9 atm_stat.c File Reference

Calculate air parcel statistics.

Functions

- int main (int argc, char ∗argv[ ])

5.9.1 Detailed Description

Calculate air parcel statistics.

Definition in file atm_stat.c.

5.9.2 Function Documentation

5.9.2.1 int main (int *argc*, char * *argv[]*)

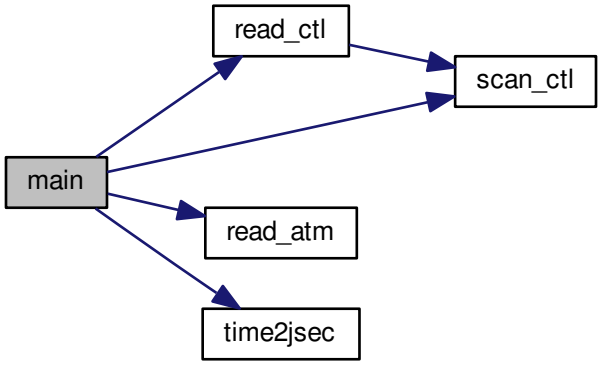
Definition at line 27 of file atm_stat.c.

```
00029                {
00030
00031   ctl_t ctl;
00032
00033   atm_t *atm, *atm_filt;
00034
00035   FILE *out;
00036
00037   char tstr[LEN];
00038
00039   double lat0, lat1, latm, lon0, lon1, lonm, p0, p1,
00040     t, t0, qm[NQ], *work, zm, *zs;
00041
00042   int ens, f, init = 0, ip, iq, year, mon, day, hour, min;
00043
00044   /* Allocate... */
00045   ALLOC(atm, atm_t, 1);
00046   ALLOC(atm_filt, atm_t, 1);
00047   ALLOC(work, double,
00048         NP);
00049   ALLOC(zs, double,
00050         NP);
00051
00052   /* Check arguments... */
00053   if (argc < 4)
00054     ERRMSG("Give parameters: <ctl> <stat.tab> <param> <atm1> [<atm2> ...]");
00055
00056   /* Read control parameters... */
00057   read_ctl(argv[1], argc, argv, &ctl);
00058   ens = (int) scan_ctl(argv[1], argc, argv, "STAT_ENS", -1, "-999", NULL);
00059   p0 = P(scan_ctl(argv[1], argc, argv, "STAT_Z0", -1, "-1000", NULL));
00060   p1 = P(scan_ctl(argv[1], argc, argv, "STAT_Z1", -1, "1000", NULL));
00061   lat0 = scan_ctl(argv[1], argc, argv, "STAT_LAT0", -1, "-1000", NULL);
00062   lat1 = scan_ctl(argv[1], argc, argv, "STAT_LAT1", -1, "1000", NULL);
00063   lon0 = scan_ctl(argv[1], argc, argv, "STAT_LON0", -1, "-1000", NULL);
00064   lon1 = scan_ctl(argv[1], argc, argv, "STAT_LON1", -1, "1000", NULL);
00065
00066   /* Write info... */
00067   printf("Write air parcel statistics: %s\n", argv[2]);
00068
00069   /* Create output file... */
00070   if (!(out = fopen(argv[2], "w")))
00071     ERRMSG("Cannot create file!");
00072
00073   /* Write header... */
00074   fprintf(out,
00075           "# $1 = time [s]\n"
00076           "# $2 = time difference [s]\n"
00077           "# $3 = altitude (%s) [km]\n"
00078           "# $4 = longitude (%s) [deg]\n"
00079           "# $5 = latitude (%s) [deg]\n", argv[3], argv[3], argv[3]);
00080   for (iq = 0; iq < ctl.nq; iq++)
00081     fprintf(out, "# $%d = %s (%s) [%s]\n", iq + 6,
00082             ctl.qnt_name[iq], argv[3], ctl.qnt_unit[iq]);
00083   fprintf(out, "# $%d = number of particles\n\n", ctl.nq + 6);
00084
00085   /* Loop over files... */
00086   for (f = 4; f < argc; f++) {
00087
00088     /* Read atmopheric data... */
00089     if (!read_atm(argv[f], &ctl, atm))
00090       continue;
00091
00092     /* Get time from filename... */
00093     sprintf(tstr, "%.4s", &argv[f][strlen(argv[f]) - 20]);
00094     year = atoi(tstr);
00095     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 15]);
00096     mon = atoi(tstr);
00097     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 12]);
00098     day = atoi(tstr);
00099     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 9]);
00100     hour = atoi(tstr);
00101     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 6]);
00102     min = atoi(tstr);
00103     time2jsec(year, mon, day, hour, min, 0, 0, &t);
00104
```

```
00105     /* Save intial time... */
00106     if (!init) {
00107       init = 1;
00108       t0 = t;
00109     }
00110
00111     /* Filter data... */
00112     atm_filt->np = 0;
00113     for (ip = 0; ip < atm->np; ip++) {
00114
00115       /* Check time... */
00116       if (!gsl_finite(atm->time[ip]))
00117         continue;
00118
00119       /* Check ensemble index... */
00120       if (ctl.qnt_ens > 0 && atm->q[ctl.qnt_ens][ip] != ens)
00121         continue;
00122
00123       /* Check spatial range... */
00124       if (atm->p[ip] > p0 || atm->p[ip] < p1
00125           || atm->lon[ip] < lon0 || atm->lon[ip] > lon1
00126           || atm->lat[ip] < lat0 || atm->lat[ip] > lat1)
00127         continue;
00128
00129       /* Save data... */
00130       atm_filt->time[atm_filt->np] = atm->time[ip];
00131       atm_filt->p[atm_filt->np] = atm->p[ip];
00132       atm_filt->lon[atm_filt->np] = atm->lon[ip];
00133       atm_filt->lat[atm_filt->np] = atm->lat[ip];
00134       for (iq = 0; iq < ctl.nq; iq++)
00135         atm_filt->q[iq][atm_filt->np] = atm->q[iq][ip];
00136       atm_filt->np++;
00137     }
00138
00139     /* Get heights... */
00140     for (ip = 0; ip < atm_filt->np; ip++)
00141       zs[ip] = Z(atm_filt->p[ip]);
00142
00143     /* Get statistics... */
00144     if (strcasecmp(argv[3], "mean") == 0) {
00145       zm = gsl_stats_mean(zs, 1, (size_t) atm_filt->np);
00146       lonm = gsl_stats_mean(atm_filt->lon, 1, (size_t) atm_filt->np);
00147       latm = gsl_stats_mean(atm_filt->lat, 1, (size_t) atm_filt->np);
00148       for (iq = 0; iq < ctl.nq; iq++)
00149         qm[iq] = gsl_stats_mean(atm_filt->q[iq], 1, (size_t) atm_filt->np);
00150     } else if (strcasecmp(argv[3], "stddev") == 0) {
00151       zm = gsl_stats_sd(zs, 1, (size_t) atm_filt->np);
00152       lonm = gsl_stats_sd(atm_filt->lon, 1, (size_t) atm_filt->np);
00153       latm = gsl_stats_sd(atm_filt->lat, 1, (size_t) atm_filt->np);
00154       for (iq = 0; iq < ctl.nq; iq++)
00155         qm[iq] = gsl_stats_sd(atm_filt->q[iq], 1, (size_t) atm_filt->np);
00156     } else if (strcasecmp(argv[3], "min") == 0) {
00157       zm = gsl_stats_min(zs, 1, (size_t) atm_filt->np);
00158       lonm = gsl_stats_min(atm_filt->lon, 1, (size_t) atm_filt->np);
00159       latm = gsl_stats_min(atm_filt->lat, 1, (size_t) atm_filt->np);
00160       for (iq = 0; iq < ctl.nq; iq++)
00161         qm[iq] = gsl_stats_min(atm_filt->q[iq], 1, (size_t) atm_filt->np);
00162     } else if (strcasecmp(argv[3], "max") == 0) {
00163       zm = gsl_stats_max(zs, 1, (size_t) atm_filt->np);
00164       lonm = gsl_stats_max(atm_filt->lon, 1, (size_t) atm_filt->np);
00165       latm = gsl_stats_max(atm_filt->lat, 1, (size_t) atm_filt->np);
00166       for (iq = 0; iq < ctl.nq; iq++)
00167         qm[iq] = gsl_stats_max(atm_filt->q[iq], 1, (size_t) atm_filt->np);
00168     } else if (strcasecmp(argv[3], "skew") == 0) {
00169       zm = gsl_stats_skew(zs, 1, (size_t) atm_filt->np);
00170       lonm = gsl_stats_skew(atm_filt->lon, 1, (size_t) atm_filt->np);
00171       latm = gsl_stats_skew(atm_filt->lat, 1, (size_t) atm_filt->np);
00172       for (iq = 0; iq < ctl.nq; iq++)
00173         qm[iq] = gsl_stats_skew(atm_filt->q[iq], 1, (size_t) atm_filt->np);
00174     } else if (strcasecmp(argv[3], "kurt") == 0) {
00175       zm = gsl_stats_kurtosis(zs, 1, (size_t) atm_filt->np);
00176       lonm = gsl_stats_kurtosis(atm_filt->lon, 1, (size_t) atm_filt->np);
00177       latm = gsl_stats_kurtosis(atm_filt->lat, 1, (size_t) atm_filt->np);
00178       for (iq = 0; iq < ctl.nq; iq++)
00179         qm[iq] =
00180           gsl_stats_kurtosis(atm_filt->q[iq], 1, (size_t) atm_filt->np);
00181     } else if (strcasecmp(argv[3], "median") == 0) {
00182       zm = gsl_stats_median(zs, 1, (size_t) atm_filt->np);
00183       lonm = gsl_stats_median(atm_filt->lon, 1, (size_t) atm_filt->np);
00184       latm = gsl_stats_median(atm_filt->lat, 1, (size_t) atm_filt->np);
00185       for (iq = 0; iq < ctl.nq; iq++)
00186         qm[iq] = gsl_stats_median(atm_filt->q[iq], 1, (size_t) atm_filt->np);
00187     } else if (strcasecmp(argv[3], "absdev") == 0) {
00188       zm = gsl_stats_absdev(zs, 1, (size_t) atm_filt->np);
00189       lonm = gsl_stats_absdev(atm_filt->lon, 1, (size_t) atm_filt->np);
00190       latm = gsl_stats_absdev(atm_filt->lat, 1, (size_t) atm_filt->np);
00191       for (iq = 0; iq < ctl.nq; iq++)
```

```
00192         qm[iq] = gsl_stats_absdev(atm_filt->q[iq], 1, (size_t) atm_filt->np);
00193       } else if (strcasecmp(argv[3], "mad") == 0) {
00194         zm = gsl_stats_mad0(zs, 1, (size_t) atm_filt->np, work);
00195         lonm = gsl_stats_mad0(atm_filt->lon, 1, (size_t) atm_filt->np, work);
00196         latm = gsl_stats_mad0(atm_filt->lat, 1, (size_t) atm_filt->np, work);
00197         for (iq = 0; iq < ctl.nq; iq++)
00198           qm[iq] =
00199             gsl_stats_mad0(atm_filt->q[iq], 1, (size_t) atm_filt->np, work);
00200       } else
00201         ERRMSG("Unknown parameter!");
00202
00203       /* Write data... */
00204       fprintf(out, "%.2f %.2f %g %g %g", t, t - t0, zm, lonm, latm);
00205       for (iq = 0; iq < ctl.nq; iq++) {
00206         fprintf(out, " ");
00207         fprintf(out, ctl.qnt_format[iq], qm[iq]);
00208       }
00209       fprintf(out, " %d\n", atm_filt->np);
00210     }
00211
00212     /* Close file... */
00213     fclose(out);
00214
00215     /* Free... */
00216     free(atm);
00217     free(atm_filt);
00218     free(work);
00219     free(zs);
00220
00221     return EXIT_SUCCESS;
00222   }
```

Here is the call graph for this function:



5.10 atm_stat.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
```

```
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   ctl_t ctl;
00032
00033   atm_t *atm, *atm_filt;
00034
00035   FILE *out;
00036
00037   char tstr[LEN];
00038
00039   double lat0, lat1, latm, lon0, lon1, lonm, p0, p1,
00040     t, t0, qm[NQ], *work, zm, *zs;
00041
00042   int ens, f, init = 0, ip, iq, year, mon, day, hour, min;
00043
00044   /* Allocate... */
00045   ALLOC(atm, atm_t, 1);
00046   ALLOC(atm_filt, atm_t, 1);
00047   ALLOC(work, double,
00048         NP);
00049   ALLOC(zs, double,
00050         NP);
00051
00052   /* Check arguments... */
00053   if (argc < 4)
00054     ERRMSG("Give parameters: <ctl> <stat.tab> <param> <atm1> [<atm2> ...]");
00055
00056   /* Read control parameters... */
00057   read_ctl(argv[1], argc, argv, &ctl);
00058   ens = (int) scan_ctl(argv[1], argc, argv, "STAT_ENS", -1, "-999", NULL);
00059   p0 = P(scan_ctl(argv[1], argc, argv, "STAT_Z0", -1, "-1000", NULL));
00060   p1 = P(scan_ctl(argv[1], argc, argv, "STAT_Z1", -1, "1000", NULL));
00061   lat0 = scan_ctl(argv[1], argc, argv, "STAT_LAT0", -1, "-1000", NULL);
00062   lat1 = scan_ctl(argv[1], argc, argv, "STAT_LAT1", -1, "1000", NULL);
00063   lon0 = scan_ctl(argv[1], argc, argv, "STAT_LON0", -1, "-1000", NULL);
00064   lon1 = scan_ctl(argv[1], argc, argv, "STAT_LON1", -1, "1000", NULL);
00065
00066   /* Write info... */
00067   printf("Write air parcel statistics: %s\n", argv[2]);
00068
00069   /* Create output file... */
00070   if (!(out = fopen(argv[2], "w")))
00071     ERRMSG("Cannot create file!");
00072
00073   /* Write header... */
00074   fprintf(out,
00075           "# $1 = time [s]\n"
00076           "# $2 = time difference [s]\n"
00077           "# $3 = altitude (%s) [km]\n"
00078           "# $4 = longitude (%s) [deg]\n"
00079           "# $5 = latitude (%s) [deg]\n", argv[3], argv[3], argv[3]);
00080   for (iq = 0; iq < ctl.nq; iq++)
00081     fprintf(out, "# $%d = %s (%s) [%s]\n", iq + 6,
00082             ctl.qnt_name[iq], argv[3], ctl.qnt_unit[iq]);
00083   fprintf(out, "# $%d = number of particles\n\n", ctl.nq + 6);
00084
00085   /* Loop over files... */
00086   for (f = 4; f < argc; f++) {
00087
00088     /* Read atmopheric data... */
00089     if (!read_atm(argv[f], &ctl, atm))
00090       continue;
00091
00092     /* Get time from filename... */
00093     sprintf(tstr, "%.4s", &argv[f][strlen(argv[f]) - 20]);
00094     year = atoi(tstr);
00095     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 15]);
00096     mon = atoi(tstr);
00097     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 12]);
00098     day = atoi(tstr);
00099     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 9]);
00100     hour = atoi(tstr);
00101     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 6]);
00102     min = atoi(tstr);
00103     time2jsec(year, mon, day, hour, min, 0, 0, &t);
00104
00105     /* Save intial time... */
00106     if (!init) {
00107       init = 1;
```

```
00108       t0 = t;
00109     }
00110
00111     /* Filter data... */
00112     atm_filt->np = 0;
00113     for (ip = 0; ip < atm->np; ip++) {
00114
00115       /* Check time... */
00116       if (!gsl_finite(atm->time[ip]))
00117         continue;
00118
00119       /* Check ensemble index... */
00120       if (ctl.qnt_ens > 0 && atm->q[ctl.qnt_ens][ip] != ens)
00121         continue;
00122
00123       /* Check spatial range... */
00124       if (atm->p[ip] > p0 || atm->p[ip] < p1
00125           || atm->lon[ip] < lon0 || atm->lon[ip] > lon1
00126           || atm->lat[ip] < lat0 || atm->lat[ip] > lat1)
00127         continue;
00128
00129       /* Save data... */
00130       atm_filt->time[atm_filt->np] = atm->time[ip];
00131       atm_filt->p[atm_filt->np] = atm->p[ip];
00132       atm_filt->lon[atm_filt->np] = atm->lon[ip];
00133       atm_filt->lat[atm_filt->np] = atm->lat[ip];
00134       for (iq = 0; iq < ctl.nq; iq++)
00135         atm_filt->q[iq][atm_filt->np] = atm->q[iq][ip];
00136       atm_filt->np++;
00137     }
00138
00139     /* Get heights... */
00140     for (ip = 0; ip < atm_filt->np; ip++)
00141       zs[ip] = Z(atm_filt->p[ip]);
00142
00143     /* Get statistics... */
00144     if (strcasecmp(argv[3], "mean") == 0) {
00145       zm = gsl_stats_mean(zs, 1, (size_t) atm_filt->np);
00146       lonm = gsl_stats_mean(atm_filt->lon, 1, (size_t) atm_filt->np);
00147       latm = gsl_stats_mean(atm_filt->lat, 1, (size_t) atm_filt->np);
00148       for (iq = 0; iq < ctl.nq; iq++)
00149         qm[iq] = gsl_stats_mean(atm_filt->q[iq], 1, (size_t) atm_filt->np);
00150     } else if (strcasecmp(argv[3], "stddev") == 0) {
00151       zm = gsl_stats_sd(zs, 1, (size_t) atm_filt->np);
00152       lonm = gsl_stats_sd(atm_filt->lon, 1, (size_t) atm_filt->np);
00153       latm = gsl_stats_sd(atm_filt->lat, 1, (size_t) atm_filt->np);
00154       for (iq = 0; iq < ctl.nq; iq++)
00155         qm[iq] = gsl_stats_sd(atm_filt->q[iq], 1, (size_t) atm_filt->np);
00156     } else if (strcasecmp(argv[3], "min") == 0) {
00157       zm = gsl_stats_min(zs, 1, (size_t) atm_filt->np);
00158       lonm = gsl_stats_min(atm_filt->lon, 1, (size_t) atm_filt->np);
00159       latm = gsl_stats_min(atm_filt->lat, 1, (size_t) atm_filt->np);
00160       for (iq = 0; iq < ctl.nq; iq++)
00161         qm[iq] = gsl_stats_min(atm_filt->q[iq], 1, (size_t) atm_filt->np);
00162     } else if (strcasecmp(argv[3], "max") == 0) {
00163       zm = gsl_stats_max(zs, 1, (size_t) atm_filt->np);
00164       lonm = gsl_stats_max(atm_filt->lon, 1, (size_t) atm_filt->np);
00165       latm = gsl_stats_max(atm_filt->lat, 1, (size_t) atm_filt->np);
00166       for (iq = 0; iq < ctl.nq; iq++)
00167         qm[iq] = gsl_stats_max(atm_filt->q[iq], 1, (size_t) atm_filt->np);
00168     } else if (strcasecmp(argv[3], "skew") == 0) {
00169       zm = gsl_stats_skew(zs, 1, (size_t) atm_filt->np);
00170       lonm = gsl_stats_skew(atm_filt->lon, 1, (size_t) atm_filt->np);
00171       latm = gsl_stats_skew(atm_filt->lat, 1, (size_t) atm_filt->np);
00172       for (iq = 0; iq < ctl.nq; iq++)
00173         qm[iq] = gsl_stats_skew(atm_filt->q[iq], 1, (size_t) atm_filt->np);
00174     } else if (strcasecmp(argv[3], "kurt") == 0) {
00175       zm = gsl_stats_kurtosis(zs, 1, (size_t) atm_filt->np);
00176       lonm = gsl_stats_kurtosis(atm_filt->lon, 1, (size_t) atm_filt->np);
00177       latm = gsl_stats_kurtosis(atm_filt->lat, 1, (size_t) atm_filt->np);
00178       for (iq = 0; iq < ctl.nq; iq++)
00179         qm[iq] =
00180           gsl_stats_kurtosis(atm_filt->q[iq], 1, (size_t) atm_filt->np);
00181     } else if (strcasecmp(argv[3], "median") == 0) {
00182       zm = gsl_stats_median(zs, 1, (size_t) atm_filt->np);
00183       lonm = gsl_stats_median(atm_filt->lon, 1, (size_t) atm_filt->np);
00184       latm = gsl_stats_median(atm_filt->lat, 1, (size_t) atm_filt->np);
00185       for (iq = 0; iq < ctl.nq; iq++)
00186         qm[iq] = gsl_stats_median(atm_filt->q[iq], 1, (size_t) atm_filt->np);
00187     } else if (strcasecmp(argv[3], "absdev") == 0) {
00188       zm = gsl_stats_absdev(zs, 1, (size_t) atm_filt->np);
00189       lonm = gsl_stats_absdev(atm_filt->lon, 1, (size_t) atm_filt->np);
00190       latm = gsl_stats_absdev(atm_filt->lat, 1, (size_t) atm_filt->np);
00191       for (iq = 0; iq < ctl.nq; iq++)
00192         qm[iq] = gsl_stats_absdev(atm_filt->q[iq], 1, (size_t) atm_filt->np);
00193     } else if (strcasecmp(argv[3], "mad") == 0) {
00194       zm = gsl_stats_mad0(zs, 1, (size_t) atm_filt->np, work);
```

```
00195       lonm = gsl_stats_mad0(atm_filt->lon, 1, (size_t) atm_filt->np, work);
00196       latm = gsl_stats_mad0(atm_filt->lat, 1, (size_t) atm_filt->np, work);
00197       for (iq = 0; iq < ctl.nq; iq++)
00198         qm[iq] =
00199           gsl_stats_mad0(atm_filt->q[iq], 1, (size_t) atm_filt->np, work);
00200     } else
00201       ERRMSG("Unknown parameter!");
00202
00203     /* Write data... */
00204     fprintf(out, "%.2f %.2f %g %g %g", t, t - t0, zm, lonm, latm);
00205     for (iq = 0; iq < ctl.nq; iq++) {
00206       fprintf(out, " ");
00207       fprintf(out, ctl.qnt_format[iq], qm[iq]);
00208     }
00209     fprintf(out, " %d\n", atm_filt->np);
00210   }
00211
00212   /* Close file... */
00213   fclose(out);
00214
00215   /* Free... */
00216   free(atm);
00217   free(atm_filt);
00218   free(work);
00219   free(zs);
00220
00221   return EXIT_SUCCESS;
00222 }
```

5.11 day2doy.c File Reference

Convert date to day of year.

Functions

- int main (int argc, char *argv[])

5.11.1 Detailed Description

Convert date to day of year.

Definition in file day2doy.c.

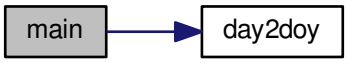
5.11.2 Function Documentation

5.11.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file day2doy.c.

```
00029                {
00030
00031   int day, doy, mon, year;
00032
00033   /* Check arguments... */
00034   if (argc < 4)
00035     ERRMSG("Give parameters: <year> <mon> <day>");
00036
00037   /* Read arguments... */
00038   year = atoi(argv[1]);
00039   mon = atoi(argv[2]);
00040   day = atoi(argv[3]);
00041
00042   /* Convert... */
00043   day2doy(year, mon, day, &doy);
00044   printf("%d %d\n", year, doy);
00045
00046   return EXIT_SUCCESS;
00047 }
```

Here is the call graph for this function:



5.12 day2doy.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   int day, doy, mon, year;
00032
00033   /* Check arguments... */
00034   if (argc < 4)
00035     ERRMSG("Give parameters: <year> <mon> <day>");
00036
00037   /* Read arguments... */
00038   year = atoi(argv[1]);
00039   mon = atoi(argv[2]);
00040   day = atoi(argv[3]);
00041
00042   /* Convert... */
00043   day2doy(year, mon, day, &doy);
00044   printf("%d %d\n", year, doy);
00045
00046   return EXIT_SUCCESS;
00047 }
```

5.13 doy2day.c File Reference

Convert day of year to date.

Functions

- int main (int argc, char *argv[])

5.13.1 Detailed Description

Convert day of year to date.

Definition in file doy2day.c.

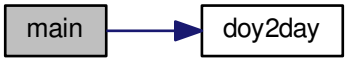
5.13.2 Function Documentation

5.13.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file doy2day.c.

```
00029                {
00030
00031   int day, doy, mon, year;
00032
00033   /* Check arguments... */
00034   if (argc < 3)
00035     ERRMSG("Give parameters: <year> <doy>");
00036
00037   /* Read arguments... */
00038   year = atoi(argv[1]);
00039   doy = atoi(argv[2]);
00040
00041   /* Convert... */
00042   doy2day(year, doy, &mon, &day);
00043   printf("%d %d %d\n", year, mon, day);
00044
00045   return EXIT_SUCCESS;
00046 }
```

Here is the call graph for this function:



5.14 doy2day.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
```

```
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   int day, doy, mon, year;
00032
00033   /* Check arguments... */
00034   if (argc < 3)
00035     ERRMSG("Give parameters: <year> <doy>");
00036
00037   /* Read arguments... */
00038   year = atoi(argv[1]);
00039   doy = atoi(argv[2]);
00040
00041   /* Convert... */
00042   doy2day(year, doy, &mon, &day);
00043   printf("%d %d %d\n", year, mon, day);
00044
00045   return EXIT_SUCCESS;
00046 }
```

5.15 extract.c File Reference

Extract single trajectory from atmospheric data files.

Functions

- int main (int argc, char *argv[])

5.15.1 Detailed Description

Extract single trajectory from atmospheric data files.

Definition in file extract.c.

5.15.2 Function Documentation

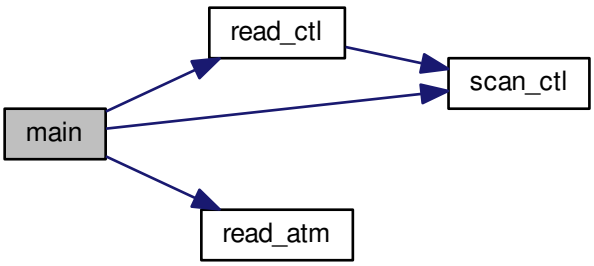
5.15.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file extract.c.

```
00029                {
00030
00031   ctl_t ctl;
00032
00033   atm_t *atm;
00034
00035   FILE *out;
00036
00037   int f, ip, iq;
00038
00039   /* Allocate... */
00040   ALLOC(atm, atm_t, 1);
00041
00042   /* Check arguments... */
00043   if (argc < 4)
00044     ERRMSG("Give parameters: <ctl> <trajec.tab> <atm1> [<atm2> ...]");
00045
00046   /* Read control parameters... */
00047   read_ctl(argv[1], argc, argv, &ctl);
00048   ip = (int) scan_ctl(argv[1], argc, argv, "EXTRACT_IP", -1, "", NULL);
00049
00050   /* Write info... */
00051   printf("Write trajectory data: %s\n", argv[2]);
```

```
00052
00053   /* Create output file... */
00054   if (!(out = fopen(argv[2], "w")))
00055     ERRMSG("Cannot create file!");
00056
00057   /* Write header... */
00058   fprintf(out,
00059           "# $1 = time [s]\n"
00060           "# $2 = altitude [km]\n"
00061           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
00062   for (iq = 0; iq < ctl.nq; iq++)
00063     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl.qnt_name[iq],
00064             ctl.qnt_unit[iq]);
00065   fprintf(out, "\n");
00066
00067   /* Loop over files... */
00068   for (f = 3; f < argc; f++) {
00069
00070     /* Read atmopheric data... */
00071     if (!read_atm(argv[f], &ctl, atm))
00072       continue;
00073
00074     /* Check air parcel index... */
00075     if (ip > atm->np)
00076       ERRMSG("Air parcel index out of range!");
00077
00078     /* Write data... */
00079     fprintf(out, "%.2f %g %g %g", atm->time[ip],
00080             Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
00081     for (iq = 0; iq < ctl.nq; iq++) {
00082       fprintf(out, " ");
00083       fprintf(out, ctl.qnt_format[iq], atm->q[iq][ip]);
00084     }
00085     fprintf(out, "\n");
00086   }
00087
00088   /* Close file... */
00089   fclose(out);
00090
00091   /* Free... */
00092   free(atm);
00093
00094   return EXIT_SUCCESS;
00095 }
```

Here is the call graph for this function:



5.16 extract.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
```

```
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   ctl_t ctl;
00032
00033   atm_t *atm;
00034
00035   FILE *out;
00036
00037   int f, ip, iq;
00038
00039   /* Allocate... */
00040   ALLOC(atm, atm_t, 1);
00041
00042   /* Check arguments... */
00043   if (argc < 4)
00044     ERRMSG("Give parameters: <ctl> <trajec.tab> <atm1> [<atm2> ...]");
00045
00046   /* Read control parameters... */
00047   read_ctl(argv[1], argc, argv, &ctl);
00048   ip = (int) scan_ctl(argv[1], argc, argv, "EXTRACT_IP", -1, "", NULL);
00049
00050   /* Write info... */
00051   printf("Write trajectory data: %s\n", argv[2]);
00052
00053   /* Create output file... */
00054   if (!(out = fopen(argv[2], "w")))
00055     ERRMSG("Cannot create file!");
00056
00057   /* Write header... */
00058   fprintf(out,
00059           "# $1 = time [s]\n"
00060           "# $2 = altitude [km]\n"
00061           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
00062   for (iq = 0; iq < ctl.nq; iq++)
00063     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl.qnt_name[iq],
00064             ctl.qnt_unit[iq]);
00065   fprintf(out, "\n");
00066
00067   /* Loop over files... */
00068   for (f = 3; f < argc; f++) {
00069
00070     /* Read atmopheric data... */
00071     if (!read_atm(argv[f], &ctl, atm))
00072       continue;
00073
00074     /* Check air parcel index... */
00075     if (ip > atm->np)
00076       ERRMSG("Air parcel index out of range!");
00077
00078     /* Write data... */
00079     fprintf(out, "%.2f %g %g %g", atm->time[ip],
00080             Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
00081     for (iq = 0; iq < ctl.nq; iq++) {
00082       fprintf(out, " ");
00083       fprintf(out, ctl.qnt_format[iq], atm->q[iq][ip]);
00084     }
00085     fprintf(out, "\n");
00086   }
00087
00088   /* Close file... */
00089   fclose(out);
00090
00091   /* Free... */
00092   free(atm);
00093
00094   return EXIT_SUCCESS;
00095 }
```

5.17 jsec2time.c File Reference

Convert Julian seconds to date.

Functions

- int main (int argc, char ∗argv[ ])

5.17.1 Detailed Description

Convert Julian seconds to date.

Definition in file jsec2time.c.

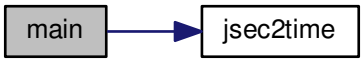
5.17.2 Function Documentation

5.17.2.1 int main (int *argc*, char ∗ *argv[ ]*)

Definition at line 27 of file jsec2time.c.

```
00029                {
00030
00031   double jsec, remain;
00032
00033   int day, hour, min, mon, sec, year;
00034
00035   /* Check arguments... */
00036   if (argc < 2)
00037     ERRMSG("Give parameters: <jsec>");
00038
00039   /* Read arguments... */
00040   jsec = atof(argv[1]);
00041
00042   /* Convert time... */
00043   jsec2time(jsec, &year, &mon, &day, &hour, &min, &sec, &remain);
00044   printf("%d %d %d %d %d %d %g\n", year, mon, day, hour, min, sec, remain);
00045
00046   return EXIT_SUCCESS;
00047 }
```

Here is the call graph for this function:



5.18 jsec2time.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   double jsec, remain;
00032
00033   int day, hour, min, mon, sec, year;
00034
00035   /* Check arguments... */
00036   if (argc < 2)
00037     ERRMSG("Give parameters: <jsec>");
00038
00039   /* Read arguments... */
00040   jsec = atof(argv[1]);
00041
00042   /* Convert time... */
00043   jsec2time(jsec, &year, &mon, &day, &hour, &min, &sec, &remain);
00044   printf("%d %d %d %d %d %d %g\n", year, mon, day, hour, min, sec, remain);
00045
00046   return EXIT_SUCCESS;
00047 }
```

5.19 libtrac.c File Reference

MPTRAC library definitions.

Functions

- void cart2geo (double *x, double *z, double *lon, double *lat)

  Convert Cartesian coordinates to geolocation.
- double clim_hno3 (double t, double lat, double p)

  Climatology of HNO3 volume mixing ratios.
- double clim_tropo (double t, double lat)

  Climatology of tropopause pressure.
- void day2doy (int year, int mon, int day, int *doy)

  Get day of year from date.
- void doy2day (int year, int doy, int *mon, int *day)

  Get date from day of year.
- void geo2cart (double z, double lon, double lat, double *x)

  Convert geolocation to Cartesian coordinates.
- void get_met (ctl_t *ctl, char *metbase, double t, met_t **met0, met_t **met1)

  Get meteorological data for given timestep.
- void get_met_help (double t, int direct, char *metbase, double dt_met, char *filename)

Get meteorological data for timestep.

- void get_met_replace (char *orig, char *search, char *repl)

  Replace template strings in filename.

- double intpol_met_2d (double array[EX][EY], int ix, int iy, double wx, double wy)

  Linear interpolation of 2-D meteorological data.

- double intpol_met_3d (float array[EX][EY][EP], int ip, int ix, int iy, double wp, double wx, double wy)

  Linear interpolation of 3-D meteorological data.

- void intpol_met_space (met_t *met, double p, double lon, double lat, double *ps, double *pt, double *z, double *t, double *u, double *v, double *w, double *pv, double *h2o, double *o3)

  Spatial interpolation of meteorological data.

- void intpol_met_time (met_t *met0, met_t *met1, double ts, double p, double lon, double lat, double *ps, double *pt, double *z, double *t, double *u, double *v, double *w, double *pv, double *h2o, double *o3)

  Temporal interpolation of meteorological data.

- void jsec2time (double jsec, int *year, int *mon, int *day, int *hour, int *min, int *sec, double *remain)

  Convert seconds to date.

- int locate_irr (double *xx, int n, double x)

  Find array index for irregular grid.

- int locate_reg (double *xx, int n, double x)

  Find array index for regular grid.

- int read_atm (const char *filename, ctl_t *ctl, atm_t *atm)

  Read atmospheric data.

- void read_ctl (const char *filename, int argc, char *argv[ ], ctl_t *ctl)

  Read control parameters.

- int read_met (ctl_t *ctl, char *filename, met_t *met)

  Read meteorological data file.

- void read_met_extrapolate (met_t *met)

  Extrapolate meteorological data at lower boundary.

- void read_met_geopot (ctl_t *ctl, met_t *met)

  Calculate geopotential heights.

- void read_met_help (int ncid, char *varname, char *varname2, met_t *met, float dest[EX][EY][EP], float scl)

  Read and convert variable from meteorological data file.

- void read_met_ml2pl (ctl_t *ctl, met_t *met, float var[EX][EY][EP])

  Convert meteorological data from model levels to pressure levels.

- void read_met_periodic (met_t *met)

  Create meteorological data with periodic boundary conditions.

- void read_met_pv (met_t *met)

  Calculate potential vorticity.

- void read_met_sample (ctl_t *ctl, met_t *met)

  Downsampling of meteorological data.

- void read_met_tropo (ctl_t *ctl, met_t *met)

  Calculate tropopause pressure.

- double scan_ctl (const char *filename, int argc, char *argv[ ], const char *varname, int arridx, const char *defvalue, char *value)

  Read a control parameter from file or command line.

- void spline (double *x, double *y, int n, double *x2, double *y2, int n2)

  Spline interpolation.

- double stddev (double *data, int n)

  Calculate standard deviation.

- void time2jsec (int year, int mon, int day, int hour, int min, int sec, double remain, double *jsec)

  Convert date to seconds.

- void timer (const char *name, int id, int mode)

Measure wall-clock time.

- void write_atm (const char *filename, ctl_t *ctl, atm_t *atm, double t)

  Write atmospheric data.
- void write_csi (const char *filename, ctl_t *ctl, atm_t *atm, double t)

  Write CSI data.
- void write_ens (const char *filename, ctl_t *ctl, atm_t *atm, double t)

  Write ensemble data.
- void write_grid (const char *filename, ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, double t)

  Write gridded data.
- void write_prof (const char *filename, ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, double t)

  Write profile data.
- void write_station (const char *filename, ctl_t *ctl, atm_t *atm, double t)

  Write station data.

5.19.1 Detailed Description

MPTRAC library definitions.

Definition in file libtrac.c.

5.19.2 Function Documentation

5.19.2.1 void cart2geo (double * *x*, double * *z*, double * *lon*, double * *lat*)

Convert Cartesian coordinates to geolocation.

Definition at line 29 of file libtrac.c.

```
00033                {
00034
00035   double radius = NORM(x);
00036   *lat = asin(x[2] / radius) * 180 / M_PI;
00037   *lon = atan2(x[1], x[0]) * 180 / M_PI;
00038   *z = radius - RE;
00039 }
```

5.19.2.2 double clim_hno3 (double *t*, double *lat*, double *p*)

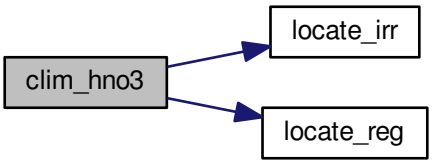
Climatology of HNO3 volume mixing ratios.

Definition at line 295 of file libtrac.c.

```
00298            {
00299
00300   /* Get seconds since begin of year... */
00301   double sec = FMOD(t, 365.25 * 86400.);
00302
00303   /* Get indices... */
00304   int isec = locate_irr(clim_hno3_secs, 12, sec);
00305   int ilat = locate_reg(clim_hno3_lats, 18, lat);
00306   int ip = locate_irr(clim_hno3_ps, 10, p);
00307
00308   /* Interpolate... */
00309   double aux00 = LIN(clim_hno3_ps[ip], clim_hno3_var[isec][ilat][ip],
00310                      clim_hno3_ps[ip + 1], clim_hno3_var[isec][ilat][ip + 1],
00311                      p);
00312   double aux01 = LIN(clim_hno3_ps[ip], clim_hno3_var[isec][ilat + 1][ip],
```

```
00313                     clim_hno3_ps[ip + 1],
00314                     clim_hno3_var[isec][ilat + 1][ip + 1], p);
00315   double aux10 = LIN(clim_hno3_ps[ip], clim_hno3_var[isec + 1][ilat][ip],
00316                     clim_hno3_ps[ip + 1],
00317                     clim_hno3_var[isec + 1][ilat][ip + 1], p);
00318   double aux11 = LIN(clim_hno3_ps[ip], clim_hno3_var[isec + 1][ilat + 1][ip],
00319                     clim_hno3_ps[ip + 1],
00320                     clim_hno3_var[isec + 1][ilat + 1][ip + 1],
00321                     p);
00322   aux00 =
00323     LIN(clim_hno3_lats[ilat], aux00, clim_hno3_lats[ilat + 1], aux01, lat);
00324   aux11 =
00325     LIN(clim_hno3_lats[ilat], aux10, clim_hno3_lats[ilat + 1], aux11, lat);
00326   return LIN(clim_hno3_secs[isec], aux00, clim_hno3_secs[isec + 1], aux11,
00327              sec);
00328 }
```

Here is the call graph for this function:



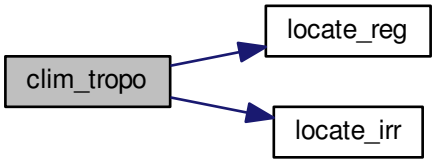
5.19.2.3 double clim_tropo (double *t*, double *lat*)

Climatology of tropopause pressure.

Definition at line 457 of file libtrac.c.

```
00459             {
00460
00461   /* Get day of year... */
00462   double doy = FMOD(t / 86400., 365.25);
00463   while (doy < 0)
00464     doy += 365.25;
00465
00466   /* Get indices... */
00467   int ilat = locate_reg(clim_tropo_lats, 73, lat);
00468   int imon = locate_irr(clim_tropo_doys, 12, doy);
00469
00470   /* Interpolate... */
00471   double p0 = LIN(clim_tropo_lats[ilat], clim_tropo_tps[imon][ilat],
00472                   clim_tropo_lats[ilat + 1], clim_tropo_tps[imon][ilat + 1],
00473                   lat);
00474   double p1 = LIN(clim_tropo_lats[ilat], clim_tropo_tps[imon + 1][ilat],
00475                   clim_tropo_lats[ilat + 1],
00476                   clim_tropo_tps[imon + 1][ilat + 1],
00477                   lat);
00478   return LIN(clim_tropo_doys[imon], p0, clim_tropo_doys[imon + 1], p1, doy);
00479 }
```

Here is the call graph for this function:



5.19.2.4 void day2doy (int *year*, int *mon*, int *day*, int * *doy*)

Get day of year from date.

Definition at line 483 of file libtrac.c.

```
00487             {
00488
00489   int d0[12] = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00490   int d01[12] = { 1, 32, 61, 92, 122, 153, 183, 214, 245, 275, 306, 336 };
00491
00492   /* Get day of year... */
00493   if (year % 400 == 0 || (year % 100 != 0 && year % 4 == 0))
00494     *doy = d01[mon - 1] + day - 1;
00495   else
00496     *doy = d0[mon - 1] + day - 1;
00497 }
```

5.19.2.5 void doy2day (int *year*, int *doy*, int * *mon*, int * *day*)

Get date from day of year.

Definition at line 501 of file libtrac.c.

```
00505             {
00506
00507   int d0[12] = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00508   int d01[12] = { 1, 32, 61, 92, 122, 153, 183, 214, 245, 275, 306, 336 };
00509   int i;
00510
00511   /* Get month and day... */
00512   if (year % 400 == 0 || (year % 100 != 0 && year % 4 == 0)) {
00513     for (i = 11; i >= 0; i--)
00514       if (d01[i] <= doy)
00515         break;
00516     *mon = i + 1;
00517     *day = doy - d01[i] + 1;
00518   } else {
00519     for (i = 11; i >= 0; i--)
00520       if (d0[i] <= doy)
00521         break;
00522     *mon = i + 1;
00523     *day = doy - d0[i] + 1;
00524   }
00525 }
```

5.19.2.6 void geo2cart (double *z*, double *lon*, double *lat*, double * *x*)

Convert geolocation to Cartesian coordinates.

Definition at line 529 of file libtrac.c.

```
00533             {
00534
00535   double radius = z + RE;
00536   x[0] = radius * cos(lat / 180 * M_PI) * cos(lon / 180 * M_PI);
00537   x[1] = radius * cos(lat / 180 * M_PI) * sin(lon / 180 * M_PI);
00538   x[2] = radius * sin(lat / 180 * M_PI);
00539 }
```

5.19.2.7 void get_met (ctl_t * *ctl*, char * *metbase*, double *t*, met_t ** *met0*, met_t ** *met1*)

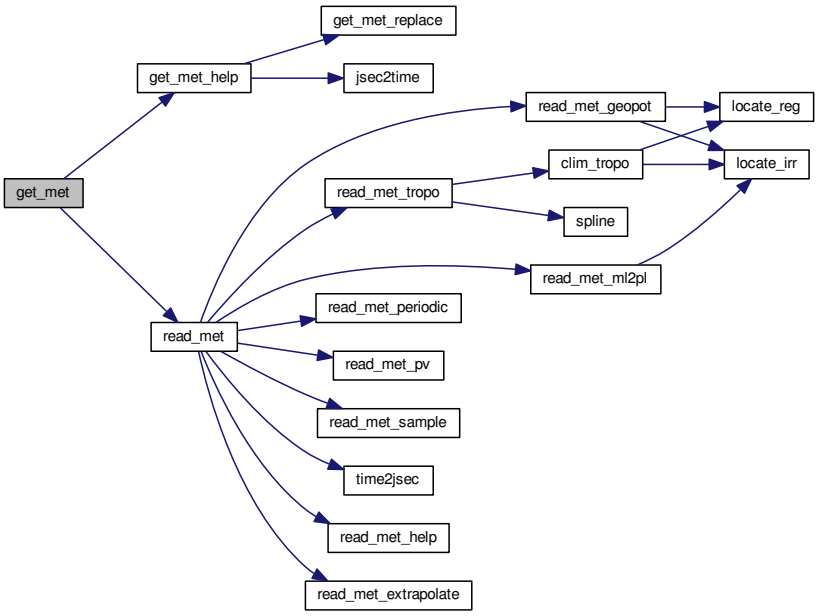
Get meteorological data for given timestep.

Definition at line 543 of file libtrac.c.

```
00548                 {
00549
00550   static int init, ip, ix, iy;
00551
00552   met_t *mets;
00553
00554   char filename[LEN];
00555
00556   /* Init... */
00557   if (t == ctl->t_start || !init) {
00558     init = 1;
00559
00560     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00561     if (!read_met(ctl, filename, *met0))
00562       ERRMSG("Cannot open file!");
00563
00564     get_met_help(t + 1.0 * ctl->direction, 1, metbase, ctl->
      dt_met, filename);
00565     if (!read_met(ctl, filename, *met1))
00566       ERRMSG("Cannot open file!");
00567 #ifdef _OPENACC
00568     met_t *met0up = *met0;
00569     met_t *met1up = *met1;
00570 #pragma acc update device(met0up[:1],met1up[:1])
00571 #endif
00572   }
00573
00574   /* Read new data for forward trajectories... */
00575   if (t > (*met1)->time && ctl->direction == 1) {
00576     mets = *met1;
00577     *met1 = *met0;
00578     *met0 = mets;
00579     get_met_help(t, 1, metbase, ctl->dt_met, filename);
00580     if (!read_met(ctl, filename, *met1))
00581       ERRMSG("Cannot open file!");
00582 #ifdef _OPENACC
00583     met_t *met1up = *met1;
00584 #pragma acc update device(met1up[:1])
00585 #endif
00586   }
00587
00588   /* Read new data for backward trajectories... */
00589   if (t < (*met0)->time && ctl->direction == -1) {
00590     mets = *met1;
00591     *met1 = *met0;
00592     *met0 = mets;
00593     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00594     if (!read_met(ctl, filename, *met0))
00595       ERRMSG("Cannot open file!");
00596 #ifdef _OPENACC
00597     met_t *met0up = *met0;
00598 #pragma acc update device(met0up[:1])
00599 #endif
00600   }
00601
00602   /* Check that grids are consistent... */
```

```
00603   if ((*met0)->nx != (*met1)->nx
00604       || (*met0)->ny != (*met1)->ny || (*met0)->np != (*met1)->np)
00605     ERRMSG("Meteo grid dimensions do not match!");
00606   for (ix = 0; ix < (*met0)->nx; ix++)
00607     if ((*met0)->lon[ix] != (*met1)->lon[ix])
00608       ERRMSG("Meteo grid longitudes do not match!");
00609   for (iy = 0; iy < (*met0)->ny; iy++)
00610     if ((*met0)->lat[iy] != (*met1)->lat[iy])
00611       ERRMSG("Meteo grid latitudes do not match!");
00612   for (ip = 0; ip < (*met0)->np; ip++)
00613     if ((*met0)->p[ip] != (*met1)->p[ip])
00614       ERRMSG("Meteo grid pressure levels do not match!");
00615 }
```

Here is the call graph for this function:



5.19.2.8 void get_met_help (double *t*, int *direct*, char * *metbase*, double *dt_met*, char * *filename*)

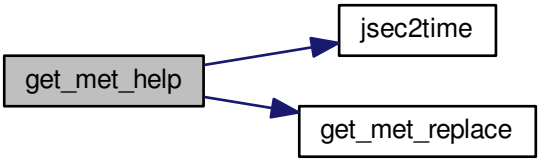
Get meteorological data for timestep.

Definition at line 619 of file libtrac.c.

```
00624                   {
00625
00626   char repl[LEN];
00627
00628   double t6, r;
00629
00630   int year, mon, day, hour, min, sec;
00631
00632   /* Round time to fixed intervals... */
00633   if (direct == -1)
00634     t6 = floor(t / dt_met) * dt_met;
00635   else
00636     t6 = ceil(t / dt_met) * dt_met;
00637
00638   /* Decode time... */
00639   jsec2time(t6, &year, &mon, &day, &hour, &min, &sec, &r);
00640
00641   /* Set filename... */
00642   sprintf(filename, "%s_YYYY_MM_DD_HH.nc", metbase);
```

```
00643   sprintf(repl, "%d", year);
00644   get_met_replace(filename, "YYYY", repl);
00645   sprintf(repl, "%02d", mon);
00646   get_met_replace(filename, "MM", repl);
00647   sprintf(repl, "%02d", day);
00648   get_met_replace(filename, "DD", repl);
00649   sprintf(repl, "%02d", hour);
00650   get_met_replace(filename, "HH", repl);
00651 }
```

Here is the call graph for this function:



5.19.2.9 void get_met_replace (char * *orig*, char * *search*, char * *repl*)

Replace template strings in filename.

Definition at line 655 of file libtrac.c.

```
00658               {
00659
00660   char buffer[LEN], *ch;
00661
00662   /* Iterate... */
00663   for (int i = 0; i < 3; i++) {
00664
00665     /* Replace substring... */
00666     if (!(ch = strstr(orig, search)))
00667       return;
00668     strncpy(buffer, orig, (size_t) (ch - orig));
00669     buffer[ch - orig] = 0;
00670     sprintf(buffer + (ch - orig), "%s%s", repl, ch + strlen(search));
00671     orig[0] = 0;
00672     strcpy(orig, buffer);
00673   }
00674 }
```

5.19.2.10 double intpol_met_2d (double *array[EX][EY]*, int *ix*, int *iy*, double *wx*, double *wy*)

Linear interpolation of 2-D meteorological data.

Definition at line 678 of file libtrac.c.

```
00683               {
00684
00685   /* Set variables... */
00686   double aux00 = array[ix][iy];
00687   double aux01 = array[ix][iy + 1];
00688   double aux10 = array[ix + 1][iy];
00689   double aux11 = array[ix + 1][iy + 1];
00690
00691   /* Interpolate horizontally... */
00692   aux00 = wy * (aux00 - aux01) + aux01;
00693   aux11 = wy * (aux10 - aux11) + aux11;
00694   return wx * (aux00 - aux11) + aux11;
00695 }
```

5.19.2.11 double intpol_met_3d (float *array[EX][EY][EP]*, int *ip*, int *ix*, int *iy*, double *wp*, double *wx*, double *wy*)

Linear interpolation of 3-D meteorological data.

Definition at line 699 of file libtrac.c.

```
00706             {
00707
00708   /* Interpolate vertically... */
00709   double aux00 = wp * (array[ix][iy][ip] - array[ix][iy][ip + 1])
00710     + array[ix][iy][ip + 1];
00711   double aux01 = wp * (array[ix][iy + 1][ip] - array[ix][iy + 1][ip + 1])
00712     + array[ix][iy + 1][ip + 1];
00713   double aux10 = wp * (array[ix + 1][iy][ip] - array[ix + 1][iy][ip + 1])
00714     + array[ix + 1][iy][ip + 1];
00715   double aux11 =
00716     wp * (array[ix + 1][iy + 1][ip] - array[ix + 1][iy + 1][ip + 1])
00717     + array[ix + 1][iy + 1][ip + 1];
00718
00719   /* Interpolate horizontally... */
00720   aux00 = wy * (aux00 - aux01) + aux01;
00721   aux11 = wy * (aux10 - aux11) + aux11;
00722   return wx * (aux00 - aux11) + aux11;
00723 }
```

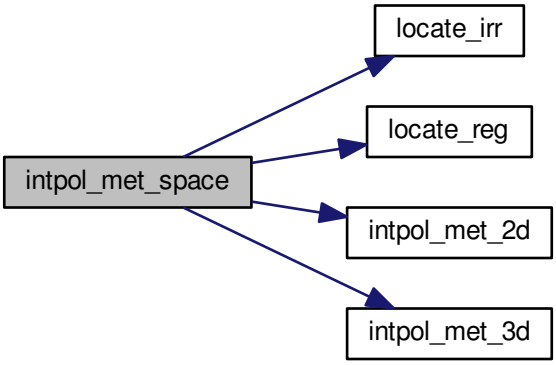
5.19.2.12 void intpol_met_space (met_t * *met*, double *p*, double *lon*, double *lat*, double * *ps*, double * *pt*, double * *z*, double * *t*, double * *u*, double * *v*, double * *w*, double * *pv*, double * *h2o*, double * *o3*)

Spatial interpolation of meteorological data.

Definition at line 727 of file libtrac.c.

```
00741              {
00742
00743   /* Check longitude... */
00744   if (met->lon[met->nx - 1] > 180 && lon < 0)
00745     lon += 360;
00746
00747   /* Get indices... */
00748   int ip = locate_irr(met->p, met->np, p);
00749   int ix = locate_reg(met->lon, met->nx, lon);
00750   int iy = locate_reg(met->lat, met->ny, lat);
00751
00752   /* Get weights... */
00753   double wp = (met->p[ip + 1] - p) / (met->p[ip + 1] - met->p[ip]);
00754   double wx = (met->lon[ix + 1] - lon) / (met->lon[ix + 1] - met->lon[ix]);
00755   double wy = (met->lat[iy + 1] - lat) / (met->lat[iy + 1] - met->lat[iy]);
00756
00757   /* Interpolate... */
00758   if (ps != NULL)
00759     *ps = intpol_met_2d(met->ps, ix, iy, wx, wy);
00760   if (pt != NULL)
00761     *pt = intpol_met_2d(met->pt, ix, iy, wx, wy);
00762   if (z != NULL)
00763     *z = intpol_met_3d(met->z, ip, ix, iy, wp, wx, wy);
00764   if (t != NULL)
00765     *t = intpol_met_3d(met->t, ip, ix, iy, wp, wx, wy);
00766   if (u != NULL)
00767     *u = intpol_met_3d(met->u, ip, ix, iy, wp, wx, wy);
00768   if (v != NULL)
00769     *v = intpol_met_3d(met->v, ip, ix, iy, wp, wx, wy);
00770   if (w != NULL)
00771     *w = intpol_met_3d(met->w, ip, ix, iy, wp, wx, wy);
00772   if (pv != NULL)
00773     *pv = intpol_met_3d(met->pv, ip, ix, iy, wp, wx, wy);
00774   if (h2o != NULL)
00775     *h2o = intpol_met_3d(met->h2o, ip, ix, iy, wp, wx, wy);
00776   if (o3 != NULL)
00777     *o3 = intpol_met_3d(met->o3, ip, ix, iy, wp, wx, wy);
00778 }
```

Here is the call graph for this function:



5.19.2.13 void intpol_met_time (met_t * *met0*, met_t * *met1*, double *ts*, double *p*, double *lon*, double *lat*, double * *ps*, double * *pt*, double * *z*, double * *t*, double * *u*, double * *v*, double * *w*, double * *pv*, double * *h2o*, double * *o3*)

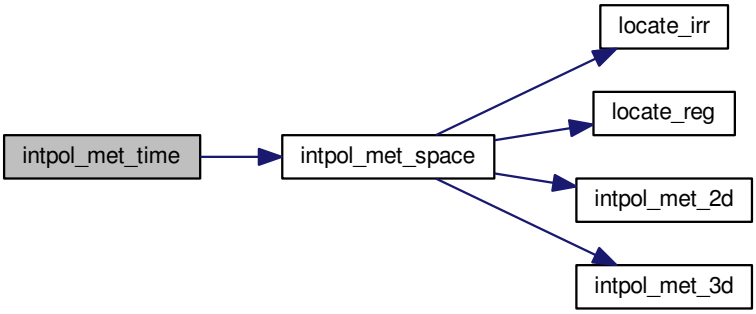
Temporal interpolation of meteorological data.

Definition at line 782 of file libtrac.c.

```
00798              {
00799
00800   double h2o0, h2o1, o30, o31, ps0, ps1, pt0, pt1, pv0, pv1, t0, t1, u0, u1,
00801     v0, v1, w0, w1, wt, z0, z1;
00802
00803   /* Spatial interpolation... */
00804   intpol_met_space(met0, p, lon, lat,
00805                    ps == NULL ? NULL : &ps0,
00806                    pt == NULL ? NULL : &pt0,
00807                    z == NULL ? NULL : &z0,
00808                    t == NULL ? NULL : &t0,
00809                    u == NULL ? NULL : &u0,
00810                    v == NULL ? NULL : &v0,
00811                    w == NULL ? NULL : &w0,
00812                    pv == NULL ? NULL : &pv0,
00813                    h2o == NULL ? NULL : &h2o0, o3 == NULL ? NULL : &o30);
00814   intpol_met_space(met1, p, lon, lat,
00815                    ps == NULL ? NULL : &ps1,
00816                    pt == NULL ? NULL : &pt1,
00817                    z == NULL ? NULL : &z1,
00818                    t == NULL ? NULL : &t1,
00819                    u == NULL ? NULL : &u1,
00820                    v == NULL ? NULL : &v1,
00821                    w == NULL ? NULL : &w1,
00822                    pv == NULL ? NULL : &pv1,
00823                    h2o == NULL ? NULL : &h2o1, o3 == NULL ? NULL : &o31);
00824
00825   /* Get weighting factor... */
00826   wt = (met1->time - ts) / (met1->time - met0->time);
00827
00828   /* Interpolate... */
00829   if (ps != NULL)
00830     *ps = wt * (ps0 - ps1) + ps1;
00831   if (pt != NULL)
00832     *pt = wt * (pt0 - pt1) + pt1;
00833   if (z != NULL)
00834     *z = wt * (z0 - z1) + z1;
00835   if (t != NULL)
00836     *t = wt * (t0 - t1) + t1;
00837   if (u != NULL)
00838     *u = wt * (u0 - u1) + u1;
```

```
00839   if (v != NULL)
00840     *v = wt * (v0 - v1) + v1;
00841   if (w != NULL)
00842     *w = wt * (w0 - w1) + w1;
00843   if (pv != NULL)
00844     *pv = wt * (pv0 - pv1) + pv1;
00845   if (h2o != NULL)
00846     *h2o = wt * (h2o0 - h2o1) + h2o1;
00847   if (o3 != NULL)
00848     *o3 = wt * (o30 - o31) + o31;
00849 }
```

Here is the call graph for this function:



5.19.2.14 void jsec2time (double *jsec*, int * *year*, int * *mon*, int * *day*, int * *hour*, int * *min*, int * *sec*, double * *remain*)

Convert seconds to date.

Definition at line 853 of file libtrac.c.

```
00861                   {
00862
00863   struct tm t0, *t1;
00864
00865   t0.tm_year = 100;
00866   t0.tm_mon = 0;
00867   t0.tm_mday = 1;
00868   t0.tm_hour = 0;
00869   t0.tm_min = 0;
00870   t0.tm_sec = 0;
00871
00872   time_t jsec0 = (time_t) jsec + timegm(&t0);
00873   t1 = gmtime(&jsec0);
00874
00875   *year = t1->tm_year + 1900;
00876   *mon = t1->tm_mon + 1;
00877   *day = t1->tm_mday;
00878   *hour = t1->tm_hour;
00879   *min = t1->tm_min;
00880   *sec = t1->tm_sec;
00881   *remain = jsec - floor(jsec);
00882 }
```

5.19.2.15 int locate_irr (double * *xx*, int *n*, double *x*)

Find array index for irregular grid.

Definition at line 886 of file libtrac.c.

```
00889             {
00890
00891   int ilo = 0;
00892   int ihi = n - 1;
00893   int i = (ihi + ilo) >> 1;
00894
00895   if (xx[i] < xx[i + 1])
00896     while (ihi > ilo + 1) {
00897       i = (ihi + ilo) >> 1;
00898       if (xx[i] > x)
00899         ihi = i;
00900       else
00901         ilo = i;
00902   } else
00903     while (ihi > ilo + 1) {
00904       i = (ihi + ilo) >> 1;
00905       if (xx[i] <= x)
00906         ihi = i;
00907       else
00908         ilo = i;
00909     }
00910
00911   return ilo;
00912 }
```

5.19.2.16 int locate_reg (double * *xx*, int *n*, double *x*)

Find array index for regular grid.

Definition at line 916 of file libtrac.c.

```
00919             {
00920
00921   /* Calculate index... */
00922   int i = (int) ((x - xx[0]) / (xx[1] - xx[0]));
00923
00924   /* Check range... */
00925   if (i < 0)
00926     i = 0;
00927   else if (i >= n - 2)
00928     i = n - 2;
00929
00930   return i;
00931 }
```

5.19.2.17 int read_atm (const char * *filename*, ctl_t * *ctl*, atm_t * *atm*)

Read atmospheric data.

Definition at line 935 of file libtrac.c.

```
00938               {
00939
00940   FILE *in;
00941
00942   char line[LEN], *tok;
00943
00944   double t0;
00945
00946   int dimid, ip, iq, ncid, varid;
00947
00948   size_t nparts;
00949
00950   /* Init... */
```

```
00951   atm->np = 0;
00952
00953   /* Write info... */
00954   printf("Read atmospheric data: %s\n", filename);
00955
00956   /* Read ASCII data... */
00957   if (ctl->atm_type == 0) {
00958
00959     /* Open file... */
00960     if (!(in = fopen(filename, "r"))) {
00961       WARN("File not found!");
00962       return 0;
00963     }
00964
00965     /* Read line... */
00966     while (fgets(line, LEN, in)) {
00967
00968       /* Read data... */
00969       TOK(line, tok, "%lg", atm->time[atm->np]);
00970       TOK(NULL, tok, "%lg", atm->p[atm->np]);
00971       TOK(NULL, tok, "%lg", atm->lon[atm->np]);
00972       TOK(NULL, tok, "%lg", atm->lat[atm->np]);
00973       for (iq = 0; iq < ctl->nq; iq++)
00974         TOK(NULL, tok, "%lg", atm->q[iq][atm->np]);
00975
00976       /* Convert altitude to pressure... */
00977       atm->p[atm->np] = P(atm->p[atm->np]);
00978
00979       /* Increment data point counter... */
00980       if ((++atm->np) > NP)
00981         ERRMSG("Too many data points!");
00982     }
00983
00984     /* Close file... */
00985     fclose(in);
00986   }
00987
00988   /* Read binary data... */
00989   else if (ctl->atm_type == 1) {
00990
00991     /* Open file... */
00992     if (!(in = fopen(filename, "r")))
00993       return 0;
00994
00995     /* Read data... */
00996     FREAD(&atm->np, int, 1, in);
00997     FREAD(atm->time, double,
00998           (size_t) atm->np,
00999           in);
01000     FREAD(atm->p, double,
01001           (size_t) atm->np,
01002           in);
01003     FREAD(atm->lon, double,
01004           (size_t) atm->np,
01005           in);
01006     FREAD(atm->lat, double,
01007           (size_t) atm->np,
01008           in);
01009     for (iq = 0; iq < ctl->nq; iq++)
01010       FREAD(atm->q[iq], double,
01011             (size_t) atm->np,
01012             in);
01013
01014     /* Close file... */
01015     fclose(in);
01016   }
01017
01018   /* Read netCDF data... */
01019   else if (ctl->atm_type == 2) {
01020
01021     /* Open file... */
01022     if (nc_open(filename, NC_NOWRITE, &ncid) != NC_NOERR)
01023       return 0;
01024
01025     /* Get dimensions... */
01026     NC(nc_inq_dimid(ncid, "NPARTS", &dimid));
01027     NC(nc_inq_dimlen(ncid, dimid, &nparts));
01028     atm->np = (int) nparts;
01029     if (atm->np > NP)
01030       ERRMSG("Too many particles!");
01031
01032     /* Get time... */
01033     NC(nc_inq_varid(ncid, "time", &varid));
01034     NC(nc_get_var_double(ncid, varid, &t0));
01035     for (ip = 0; ip < atm->np; ip++)
01036       atm->time[ip] = t0;
01037
```

```
01038     /* Read geolocations... */
01039     NC(nc_inq_varid(ncid, "PRESS", &varid));
01040     NC(nc_get_var_double(ncid, varid, atm->p));
01041     NC(nc_inq_varid(ncid, "LON", &varid));
01042     NC(nc_get_var_double(ncid, varid, atm->lon));
01043     NC(nc_inq_varid(ncid, "LAT", &varid));
01044     NC(nc_get_var_double(ncid, varid, atm->lat));
01045
01046     /* Read variables... */
01047     if (ctl->qnt_p >= 0)
01048       if (nc_inq_varid(ncid, "PRESS", &varid) == NC_NOERR)
01049         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_p]));
01050     if (ctl->qnt_t >= 0)
01051       if (nc_inq_varid(ncid, "TEMP", &varid) == NC_NOERR)
01052         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_t]));
01053     if (ctl->qnt_u >= 0)
01054       if (nc_inq_varid(ncid, "U", &varid) == NC_NOERR)
01055         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_u]));
01056     if (ctl->qnt_v >= 0)
01057       if (nc_inq_varid(ncid, "V", &varid) == NC_NOERR)
01058         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_v]));
01059     if (ctl->qnt_w >= 0)
01060       if (nc_inq_varid(ncid, "W", &varid) == NC_NOERR)
01061         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_w]));
01062     if (ctl->qnt_h2o >= 0)
01063       if (nc_inq_varid(ncid, "SH", &varid) == NC_NOERR)
01064         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_h2o]));
01065     if (ctl->qnt_o3 >= 0)
01066       if (nc_inq_varid(ncid, "O3", &varid) == NC_NOERR)
01067         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_o3]));
01068     if (ctl->qnt_theta >= 0)
01069       if (nc_inq_varid(ncid, "THETA", &varid) == NC_NOERR)
01070         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_theta]));
01071     if (ctl->qnt_pv >= 0)
01072       if (nc_inq_varid(ncid, "PV", &varid) == NC_NOERR)
01073         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_pv]));
01074
01075     /* Check data... */
01076     for (ip = 0; ip < atm->np; ip++)
01077       if (fabs(atm->lon[ip]) > 360 || fabs(atm->lat[ip]) > 90
01078           || (ctl->qnt_t >= 0 && fabs(atm->q[ctl->qnt_t][ip]) > 350)
01079           || (ctl->qnt_h2o >= 0 && fabs(atm->q[ctl->qnt_h2o][ip]) > 1)
01080           || (ctl->qnt_theta >= 0 && fabs(atm->q[ctl->qnt_theta][ip]) > 1e10)
01081           || (ctl->qnt_pv >= 0 && fabs(atm->q[ctl->qnt_pv][ip]) > 1e10)) {
01082         atm->time[ip] = GSL_NAN;
01083         atm->p[ip] = GSL_NAN;
01084         atm->lon[ip] = GSL_NAN;
01085         atm->lat[ip] = GSL_NAN;
01086         for (iq = 0; iq < ctl->nq; iq++)
01087           atm->q[iq][ip] = GSL_NAN;
01088       } else {
01089         if (ctl->qnt_h2o >= 0)
01090           atm->q[ctl->qnt_h2o][ip] *= 1.608;
01091         if (ctl->qnt_pv >= 0)
01092           atm->q[ctl->qnt_pv][ip] *= 1e6;
01093         if (atm->lon[ip] > 180)
01094           atm->lon[ip] -= 360;
01095       }
01096
01097     /* Close file... */
01098     NC(nc_close(ncid));
01099   }
01100
01101   /* Error... */
01102   else
01103     ERRMSG("Atmospheric data type not supported!");
01104
01105   /* Check number of points... */
01106   if (atm->np < 1)
01107     ERRMSG("Can not read any data!");
01108
01109   /* Return success... */
01110   return 1;
01111 }
```

5.19.2.18 void read_ctl (const char * *filename*, int *argc*, char * *argv[]*, ctl_t * *ctl*)

Read control parameters.

Definition at line 1115 of file libtrac.c.

```
01119               {
01120
01121   /* Write info... */
01122   printf("\nMassive-Parallel Trajectory Calculations (MPTRAC)\n"
01123          "(executable: %s | compiled: %s, %s)\n\n",
01124          argv[0], __DATE__, __TIME__);
01125
01126   /* Initialize quantity indices... */
01127   ctl->qnt_ens = -1;
01128   ctl->qnt_m = -1;
01129   ctl->qnt_r = -1;
01130   ctl->qnt_rho = -1;
01131   ctl->qnt_ps = -1;
01132   ctl->qnt_pt = -1;
01133   ctl->qnt_z = -1;
01134   ctl->qnt_p = -1;
01135   ctl->qnt_t = -1;
01136   ctl->qnt_u = -1;
01137   ctl->qnt_v = -1;
01138   ctl->qnt_w = -1;
01139   ctl->qnt_h2o = -1;
01140   ctl->qnt_o3 = -1;
01141   ctl->qnt_theta = -1;
01142   ctl->qnt_vh = -1;
01143   ctl->qnt_vz = -1;
01144   ctl->qnt_pv = -1;
01145   ctl->qnt_tice = -1;
01146   ctl->qnt_tsts = -1;
01147   ctl->qnt_tnat = -1;
01148   ctl->qnt_stat = -1;
01149
01150   /* Read quantities... */
01151   ctl->nq = (int) scan_ctl(filename, argc, argv, "NQ", -1, "0", NULL);
01152   if (ctl->nq > NQ)
01153     ERRMSG("Too many quantities!");
01154   for (int iq = 0; iq < ctl->nq; iq++) {
01155
01156     /* Read quantity name and format... */
01157     scan_ctl(filename, argc, argv, "QNT_NAME", iq, "", ctl->qnt_name[iq]);
01158     scan_ctl(filename, argc, argv, "QNT_FORMAT", iq, "%g",
01159              ctl->qnt_format[iq]);
01160
01161     /* Try to identify quantity... */
01162     if (strcmp(ctl->qnt_name[iq], "ens") == 0) {
01163       ctl->qnt_ens = iq;
01164       sprintf(ctl->qnt_unit[iq], "-");
01165     } else if (strcmp(ctl->qnt_name[iq], "m") == 0) {
01166       ctl->qnt_m = iq;
01167       sprintf(ctl->qnt_unit[iq], "kg");
01168     } else if (strcmp(ctl->qnt_name[iq], "r") == 0) {
01169       ctl->qnt_r = iq;
01170       sprintf(ctl->qnt_unit[iq], "m");
01171     } else if (strcmp(ctl->qnt_name[iq], "rho") == 0) {
01172       ctl->qnt_rho = iq;
01173       sprintf(ctl->qnt_unit[iq], "kg/m^3");
01174     } else if (strcmp(ctl->qnt_name[iq], "ps") == 0) {
01175       ctl->qnt_ps = iq;
01176       sprintf(ctl->qnt_unit[iq], "hPa");
01177     } else if (strcmp(ctl->qnt_name[iq], "pt") == 0) {
01178       ctl->qnt_pt = iq;
01179       sprintf(ctl->qnt_unit[iq], "hPa");
01180     } else if (strcmp(ctl->qnt_name[iq], "z") == 0) {
01181       ctl->qnt_z = iq;
01182       sprintf(ctl->qnt_unit[iq], "km");
01183     } else if (strcmp(ctl->qnt_name[iq], "p") == 0) {
01184       ctl->qnt_p = iq;
01185       sprintf(ctl->qnt_unit[iq], "hPa");
01186     } else if (strcmp(ctl->qnt_name[iq], "t") == 0) {
01187       ctl->qnt_t = iq;
01188       sprintf(ctl->qnt_unit[iq], "K");
01189     } else if (strcmp(ctl->qnt_name[iq], "u") == 0) {
01190       ctl->qnt_u = iq;
01191       sprintf(ctl->qnt_unit[iq], "m/s");
01192     } else if (strcmp(ctl->qnt_name[iq], "v") == 0) {
01193       ctl->qnt_v = iq;
01194       sprintf(ctl->qnt_unit[iq], "m/s");
01195     } else if (strcmp(ctl->qnt_name[iq], "w") == 0) {
01196       ctl->qnt_w = iq;
01197       sprintf(ctl->qnt_unit[iq], "hPa/s");
01198     } else if (strcmp(ctl->qnt_name[iq], "h2o") == 0) {
01199       ctl->qnt_h2o = iq;
01200       sprintf(ctl->qnt_unit[iq], "1");
01201     } else if (strcmp(ctl->qnt_name[iq], "o3") == 0) {
01202       ctl->qnt_o3 = iq;
01203       sprintf(ctl->qnt_unit[iq], "1");
01204     } else if (strcmp(ctl->qnt_name[iq], "theta") == 0) {
01205       ctl->qnt_theta = iq;
```

```
01206       sprintf(ctl->qnt_unit[iq], "K");
01207     } else if (strcmp(ctl->qnt_name[iq], "vh") == 0) {
01208       ctl->qnt_vh = iq;
01209       sprintf(ctl->qnt_unit[iq], "m/s");
01210     } else if (strcmp(ctl->qnt_name[iq], "vz") == 0) {
01211       ctl->qnt_vz = iq;
01212       sprintf(ctl->qnt_unit[iq], "m/s");
01213     } else if (strcmp(ctl->qnt_name[iq], "pv") == 0) {
01214       ctl->qnt_pv = iq;
01215       sprintf(ctl->qnt_unit[iq], "PVU");
01216     } else if (strcmp(ctl->qnt_name[iq], "tice") == 0) {
01217       ctl->qnt_tice = iq;
01218       sprintf(ctl->qnt_unit[iq], "K");
01219     } else if (strcmp(ctl->qnt_name[iq], "tsts") == 0) {
01220       ctl->qnt_tsts = iq;
01221       sprintf(ctl->qnt_unit[iq], "K");
01222     } else if (strcmp(ctl->qnt_name[iq], "tnat") == 0) {
01223       ctl->qnt_tnat = iq;
01224       sprintf(ctl->qnt_unit[iq], "K");
01225     } else if (strcmp(ctl->qnt_name[iq], "stat") == 0) {
01226       ctl->qnt_stat = iq;
01227       sprintf(ctl->qnt_unit[iq], "-");
01228     } else
01229       scan_ctl(filename, argc, argv, "QNT_UNIT", iq, "", ctl->qnt_unit[iq]);
01230   }
01231
01232   /* Check quantity flags... */
01233   if (ctl->qnt_tsts >= 0)
01234     if (ctl->qnt_tice < 0 || ctl->qnt_tnat < 0)
01235       ERRMSG("Need T_ice and T_NAT to calculate T_STS!");
01236
01237   /* Time steps of simulation... */
01238   ctl->direction =
01239     (int) scan_ctl(filename, argc, argv, "DIRECTION", -1, "1", NULL);
01240   if (ctl->direction != -1 && ctl->direction != 1)
01241     ERRMSG("Set DIRECTION to -1 or 1!");
01242   ctl->t_stop = scan_ctl(filename, argc, argv, "T_STOP", -1, "1e100", NULL);
01243   ctl->dt_mod = scan_ctl(filename, argc, argv, "DT_MOD", -1, "600", NULL);
01244
01245   /* Meteorological data... */
01246   ctl->dt_met = scan_ctl(filename, argc, argv, "DT_MET", -1, "21600", NULL);
01247   ctl->met_dx = (int) scan_ctl(filename, argc, argv, "MET_DX", -1, "1", NULL);
01248   ctl->met_dy = (int) scan_ctl(filename, argc, argv, "MET_DY", -1, "1", NULL);
01249   ctl->met_dp = (int) scan_ctl(filename, argc, argv, "MET_DP", -1, "1", NULL);
01250   ctl->met_sx = (int) scan_ctl(filename, argc, argv, "MET_SX", -1, "1", NULL);
01251   ctl->met_sy = (int) scan_ctl(filename, argc, argv, "MET_SY", -1, "1", NULL);
01252   ctl->met_sp = (int) scan_ctl(filename, argc, argv, "MET_SP", -1, "1", NULL);
01253   ctl->met_np = (int) scan_ctl(filename, argc, argv, "MET_NP", -1, "0", NULL);
01254   if (ctl->met_np > EP)
01255     ERRMSG("Too many levels!");
01256   for (int ip = 0; ip < ctl->met_np; ip++)
01257     ctl->met_p[ip] = scan_ctl(filename, argc, argv, "MET_P", ip, "", NULL);
01258   ctl->met_tropo
01259     = (int) scan_ctl(filename, argc, argv, "MET_TROPO", -1, "0", NULL);
01260   scan_ctl(filename, argc, argv, "MET_GEOPOT", -1, "-", ctl->met_geopot);
01261   scan_ctl(filename, argc, argv, "MET_STAGE", -1, "-", ctl->met_stage);
01262   ctl->met_dt_out =
01263     scan_ctl(filename, argc, argv, "MET_DT_OUT", -1, "0.1", NULL);
01264
01265   /* Isosurface parameters... */
01266   ctl->isosurf
01267     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
01268   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
01269
01270   /* Diffusion parameters... */
01271   ctl->turb_dx_trop
01272     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50", NULL);
01273   ctl->turb_dx_strat
01274     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0", NULL);
01275   ctl->turb_dz_trop
01276     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0", NULL);
01277   ctl->turb_dz_strat
01278     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
01279   ctl->turb_mesox =
01280     scan_ctl(filename, argc, argv, "TURB_MESOX", -1, "0.16", NULL);
01281   ctl->turb_mesoz =
01282     scan_ctl(filename, argc, argv, "TURB_MESOZ", -1, "0.16", NULL);
01283
01284   /* Mass and life time... */
01285   ctl->molmass = scan_ctl(filename, argc, argv, "MOLMASS", -1, "1", NULL);
01286   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
01287   ctl->tdec_strat =
01288     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
01289
01290   /* PSC analysis... */
01291   ctl->psc_h2o = scan_ctl(filename, argc, argv, "PSC_H2O", -1, "4e-6", NULL);
01292   ctl->psc_hno3 =
```

```
01293     scan_ctl(filename, argc, argv, "PSC_HNO3", -1, "9e-9", NULL);
01294
01295   /* Output of atmospheric data... */
01296   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
      atm_basename);
01297   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
01298   ctl->atm_dt_out =
01299     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
01300   ctl->atm_filter =
01301     (int) scan_ctl(filename, argc, argv, "ATM_FILTER", -1, "0", NULL);
01302   ctl->atm_stride =
01303     (int) scan_ctl(filename, argc, argv, "ATM_STRIDE", -1, "1", NULL);
01304   ctl->atm_type =
01305     (int) scan_ctl(filename, argc, argv, "ATM_TYPE", -1, "0", NULL);
01306
01307   /* Output of CSI data... */
01308   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
      csi_basename);
01309   ctl->csi_dt_out =
01310     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
01311   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "-", ctl->
      csi_obsfile);
01312   ctl->csi_obsmin =
01313     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
01314   ctl->csi_modmin =
01315     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
01316   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
01317   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
01318   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
01319   ctl->csi_lon0 =
01320     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
01321   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
01322   ctl->csi_nx =
01323     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
01324   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
01325   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
01326   ctl->csi_ny =
01327     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
01328
01329   /* Output of ensemble data... */
01330   scan_ctl(filename, argc, argv, "ENS_BASENAME", -1, "-", ctl->
      ens_basename);
01331
01332   /* Output of grid data... */
01333   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
01334            ctl->grid_basename);
01335   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
      grid_gpfile);
01336   ctl->grid_dt_out =
01337     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
01338   ctl->grid_sparse =
01339     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
01340   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
01341   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
01342   ctl->grid_nz =
01343     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
01344   ctl->grid_lon0 =
01345     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
01346   ctl->grid_lon1 =
01347     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
01348   ctl->grid_nx =
01349     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
01350   ctl->grid_lat0 =
01351     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
01352   ctl->grid_lat1 =
01353     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
01354   ctl->grid_ny =
01355     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
01356
01357   /* Output of profile data... */
01358   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
01359            ctl->prof_basename);
01360   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
      prof_obsfile);
01361   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
01362   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
01363   ctl->prof_nz =
01364     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
01365   ctl->prof_lon0 =
01366     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
01367   ctl->prof_lon1 =
01368     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
01369   ctl->prof_nx =
01370     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
01371   ctl->prof_lat0 =
01372     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
01373   ctl->prof_lat1 =
```

```
01374     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
01375   ctl->prof_ny =
01376     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
01377
01378   /* Output of station data... */
01379   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
01380            ctl->stat_basename);
01381   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
01382   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
01383   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
01384 }
```

Here is the call graph for this function:

5.19.2.19 int read_met (ctl_t * *ctl*, char * *filename*, met_t * *met*)

Read meteorological data file.

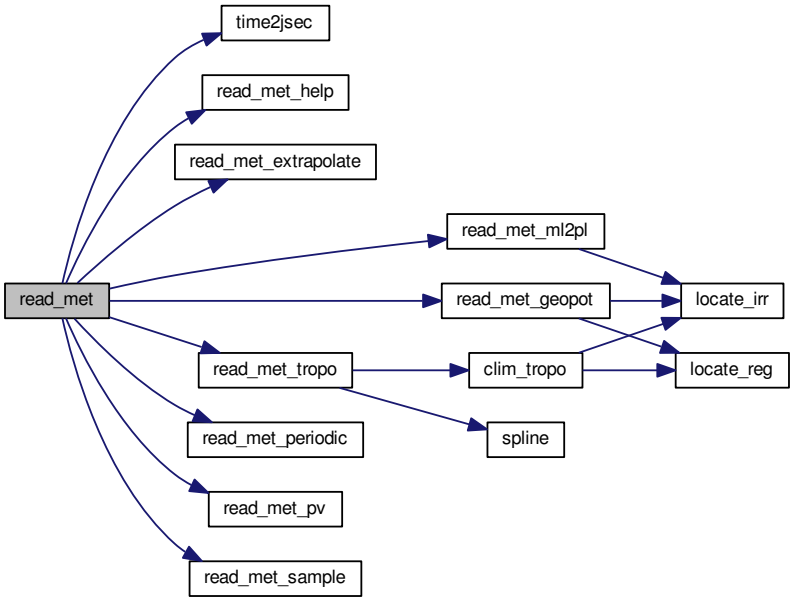
Definition at line 1388 of file libtrac.c.

```
01391               {
01392
01393   char cmd[2 * LEN], levname[LEN], tstr[10];
01394
01395   float help[EX * EY];
01396
01397   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
01398
01399   size_t np, nx, ny;
01400
01401   /* Write info... */
01402   printf("Read meteorological data: %s\n", filename);
01403
01404   /* Get time from filename... */
01405   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
01406   year = atoi(tstr);
01407   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
01408   mon = atoi(tstr);
01409   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
01410   day = atoi(tstr);
01411   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
01412   hour = atoi(tstr);
01413   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
01414
01415   /* Open netCDF file... */
01416   if (nc_open(filename, NC_NOWRITE, &ncid) != NC_NOERR) {
01417
01418     /* Try to stage meteo file... */
01419     if (ctl->met_stage[0] != '-') {
01420       sprintf(cmd, "%s %d %02d %02d %02d %s", ctl->met_stage,
01421               year, mon, day, hour, filename);
01422       if (system(cmd) != 0)
01423         ERRMSG("Error while staging meteo data!");
01424     }
01425
01426     /* Try to open again... */
01427     if (nc_open(filename, NC_NOWRITE, &ncid) != NC_NOERR) {
01428       WARN("File not found!");
01429       return 0;
01430     }
01431   }
01432
```

```
01433   /* Get dimensions... */
01434   NC(nc_inq_dimid(ncid, "lon", &dimid));
01435   NC(nc_inq_dimlen(ncid, dimid, &nx));
01436   if (nx < 2 || nx > EX)
01437     ERRMSG("Number of longitudes out of range!");
01438
01439   NC(nc_inq_dimid(ncid, "lat", &dimid));
01440   NC(nc_inq_dimlen(ncid, dimid, &ny));
01441   if (ny < 2 || ny > EY)
01442     ERRMSG("Number of latitudes out of range!");
01443
01444   sprintf(levname, "lev");
01445   NC(nc_inq_dimid(ncid, levname, &dimid));
01446   NC(nc_inq_dimlen(ncid, dimid, &np));
01447   if (np == 1) {
01448     sprintf(levname, "lev_2");
01449     NC(nc_inq_dimid(ncid, levname, &dimid));
01450     NC(nc_inq_dimlen(ncid, dimid, &np));
01451   }
01452   if (np < 2 || np > EP)
01453     ERRMSG("Number of levels out of range!");
01454
01455   /* Store dimensions... */
01456   met->np = (int) np;
01457   met->nx = (int) nx;
01458   met->ny = (int) ny;
01459
01460   /* Get horizontal grid... */
01461   NC(nc_inq_varid(ncid, "lon", &varid));
01462   NC(nc_get_var_double(ncid, varid, met->lon));
01463   NC(nc_inq_varid(ncid, "lat", &varid));
01464   NC(nc_get_var_double(ncid, varid, met->lat));
01465
01466   /* Read meteorological data... */
01467   read_met_help(ncid, "t", "T", met, met->t, 1.0);
01468   read_met_help(ncid, "u", "U", met, met->u, 1.0);
01469   read_met_help(ncid, "v", "V", met, met->v, 1.0);
01470   read_met_help(ncid, "w", "W", met, met->w, 0.01f);
01471   read_met_help(ncid, "q", "Q", met, met->h2o, (float) (MA / 18.01528));
01472   read_met_help(ncid, "o3", "O3", met, met->o3, (float) (MA / 48.00));
01473
01474   /* Meteo data on pressure levels... */
01475   if (ctl->met_np <= 0) {
01476
01477     /* Read pressure levels from file... */
01478     NC(nc_inq_varid(ncid, levname, &varid));
01479     NC(nc_get_var_double(ncid, varid, met->p));
01480     for (ip = 0; ip < met->np; ip++)
01481       met->p[ip] /= 100.;
01482
01483     /* Extrapolate data for lower boundary... */
01484     read_met_extrapolate(met);
01485   }
01486
01487   /* Meteo data on model levels... */
01488   else {
01489
01490     /* Read pressure data from file... */
01491     read_met_help(ncid, "pl", "PL", met, met->pl, 0.01f);
01492
01493     /* Interpolate from model levels to pressure levels... */
01494     read_met_ml2pl(ctl, met, met->t);
01495     read_met_ml2pl(ctl, met, met->u);
01496     read_met_ml2pl(ctl, met, met->v);
01497     read_met_ml2pl(ctl, met, met->w);
01498     read_met_ml2pl(ctl, met, met->h2o);
01499     read_met_ml2pl(ctl, met, met->o3);
01500
01501     /* Set pressure levels... */
01502     met->np = ctl->met_np;
01503     for (ip = 0; ip < met->np; ip++)
01504       met->p[ip] = ctl->met_p[ip];
01505   }
01506
01507   /* Check ordering of pressure levels... */
01508   for (ip = 1; ip < met->np; ip++)
01509     if (met->p[ip - 1] < met->p[ip])
01510       ERRMSG("Pressure levels must be descending!");
01511
01512   /* Read surface pressure... */
01513   if (nc_inq_varid(ncid, "ps", &varid) == NC_NOERR
01514       || nc_inq_varid(ncid, "PS", &varid) == NC_NOERR) {
01515     NC(nc_get_var_float(ncid, varid, help));
01516     for (iy = 0; iy < met->ny; iy++)
01517       for (ix = 0; ix < met->nx; ix++)
01518         met->ps[ix][iy] = help[iy * met->nx + ix] / 100.;
01519   } else if (nc_inq_varid(ncid, "lnsp", &varid) == NC_NOERR
```

```
01520             || nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
01521     NC(nc_get_var_float(ncid, varid, help));
01522     for (iy = 0; iy < met->ny; iy++)
01523       for (ix = 0; ix < met->nx; ix++)
01524         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
01525   } else
01526     for (ix = 0; ix < met->nx; ix++)
01527       for (iy = 0; iy < met->ny; iy++)
01528         met->ps[ix][iy] = met->p[0];
01529
01530   /* Create periodic boundary conditions... */
01531   read_met_periodic(met);
01532
01533   /* Calculate geopotential heights... */
01534   read_met_geopot(ctl, met);
01535
01536   /* Calculate potential vorticity... */
01537   read_met_pv(met);
01538
01539   /* Calculate tropopause pressure... */
01540   read_met_tropo(ctl, met);
01541
01542   /* Downsampling... */
01543   read_met_sample(ctl, met);
01544
01545   /* Close file... */
01546   NC(nc_close(ncid));
01547
01548   /* Return success... */
01549   return 1;
01550 }
```

Here is the call graph for this function:



5.19.2.20 void read_met_extrapolate (met_t * *met*)

Extrapolate meteorological data at lower boundary.

Definition at line 1554 of file libtrac.c.

```
01555                {
01556
01557   int ip, ip0, ix, iy;
01558
01559   /* Loop over columns... */
01560 #pragma omp parallel for default(shared) private(ix,iy,ip0,ip)
01561   for (ix = 0; ix < met->nx; ix++)
01562     for (iy = 0; iy < met->ny; iy++) {
01563
01564       /* Find lowest valid data point... */
01565       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
01566         if (!gsl_finite(met->t[ix][iy][ip0])
01567             || !gsl_finite(met->u[ix][iy][ip0])
01568             || !gsl_finite(met->v[ix][iy][ip0])
01569             || !gsl_finite(met->w[ix][iy][ip0]))
01570           break;
01571
01572       /* Extrapolate... */
01573       for (ip = ip0; ip >= 0; ip--) {
01574         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
01575         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
01576         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
01577         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
01578         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
01579         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
01580       }
01581     }
01582 }
```

5.19.2.21 void read_met_geopot (ctl_t * *ctl*, met_t * *met*)

Calculate geopotential heights.

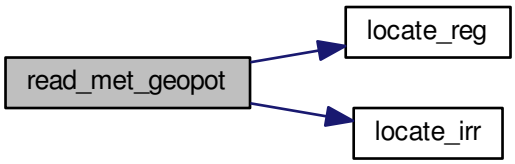
Definition at line 1586 of file libtrac.c.

```
01588                {
01589
01590   const int dx = 6, dy = 4;
01591
01592   static double logp[EP], topo_lat[EY], topo_lon[EX], topo_z[EX][EY];
01593
01594   static float help[EX][EY][EP];
01595
01596   static int init, topo_nx = -1, topo_ny;
01597
01598   FILE *in;
01599
01600   char line[LEN];
01601
01602   double lat, lon, rlat, rlon, rlon_old = -999, rz, ts, z0, z1;
01603
01604   int ip, ip0, ix, ix2, ix3, iy, iy2, n, tx, ty;
01605
01606   /* Initialize geopotential heights... */
01607 #pragma omp parallel for default(shared) private(ix,iy,ip)
01608   for (ix = 0; ix < met->nx; ix++)
01609     for (iy = 0; iy < met->ny; iy++)
01610       for (ip = 0; ip < met->np; ip++)
01611         met->z[ix][iy][ip] = GSL_NAN;
01612
01613   /* Check filename... */
01614   if (ctl->met_geopot[0] == '-')
01615     return;
01616
01617   /* Read surface geopotential... */
01618   if (!init) {
01619     init = 1;
01620
01621     /* Write info... */
01622     printf("Read surface geopotential: %s\n", ctl->met_geopot);
01623
01624     /* Open file... */
01625     if (!(in = fopen(ctl->met_geopot, "r")))
01626       ERRMSG("Cannot open file!");
01627
01628     /* Read data... */
01629     while (fgets(line, LEN, in))
01630       if (sscanf(line, "%lg %lg %lg", &rlon, &rlat, &rz) == 3) {
01631         if (rlon != rlon_old) {
01632           if ((++topo_nx) > EX)
```

```
01633             ERRMSG("Too many longitudes!");
01634           topo_ny = 0;
01635         }
01636         rlon_old = rlon;
01637         topo_lon[topo_nx] = rlon;
01638         topo_lat[topo_ny] = rlat;
01639         topo_z[topo_nx][topo_ny] = rz;
01640         if ((++topo_ny) > EY)
01641           ERRMSG("Too many latitudes!");
01642       }
01643     if ((++topo_nx) > EX)
01644       ERRMSG("Too many longitudes!");
01645
01646     /* Close file... */
01647     fclose(in);
01648
01649     /* Check grid spacing... */
01650     if (fabs(met->lon[0] - met->lon[1]) != fabs(topo_lon[0] - topo_lon[1])
01651         || fabs(met->lat[0] - met->lat[1]) != fabs(topo_lat[0] - topo_lat[1]))
01652       WARN("Grid spacing does not match!");
01653
01654     /* Calculate log pressure... */
01655     for (ip = 0; ip < met->np; ip++)
01656       logp[ip] = log(met->p[ip]);
01657   }
01658
01659   /* Apply hydrostatic equation to calculate geopotential heights... */
01660 #pragma omp parallel for default(shared) private(ix,iy,lon,lat,tx,ty,z0,z1,ip0,ts,ip)
01661   for (ix = 0; ix < met->nx; ix++) {
01662
01663     /* Get longitude index... */
01664     lon = met->lon[ix];
01665     if (lon < topo_lon[0])
01666       lon += 360;
01667     else if (lon > topo_lon[topo_nx - 1])
01668       lon -= 360;
01669     tx = locate_reg(topo_lon, topo_nx, lon);
01670
01671     /* Loop over latitudes... */
01672     for (iy = 0; iy < met->ny; iy++) {
01673
01674       /* Get latitude index... */
01675       lat = met->lat[iy];
01676       ty = locate_reg(topo_lat, topo_ny, lat);
01677
01678       /* Get surface height... */
01679       z0 = LIN(topo_lon[tx], topo_z[tx][ty],
01680                topo_lon[tx + 1], topo_z[tx + 1][ty], lon);
01681       z1 = LIN(topo_lon[tx], topo_z[tx][ty + 1],
01682                topo_lon[tx + 1], topo_z[tx + 1][ty + 1], lon);
01683       z0 = LIN(topo_lat[ty], z0, topo_lat[ty + 1], z1, lat);
01684
01685       /* Find surface pressure level... */
01686       ip0 = locate_irr(met->p, met->np, met->ps[ix][iy]);
01687
01688       /* Get surface data... */
01689       ts =
01690         LIN(met->p[ip0],
01691             TVIRT(met->t[ix][iy][ip0], met->h2o[ix][iy][ip0]),
01692             met->p[ip0 + 1],
01693             TVIRT(met->t[ix][iy][ip0 + 1], met->h2o[ix][iy][ip0 + 1]),
01694             met->ps[ix][iy]);
01695
01696       /* Upper part of profile... */
01697       met->z[ix][iy][ip0 + 1]
01698         = (float) (z0 + RI / MA / G0 * 0.5
01699                    * (ts + TVIRT(met->t[ix][iy][ip0 + 1],
01700                                  met->h2o[ix][iy][ip0 + 1]))
01701                    * (log(met->ps[ix][iy]) - logp[ip0 + 1]));
01702       for (ip = ip0 + 2; ip < met->np; ip++)
01703         met->z[ix][iy][ip]
01704           = (float) (met->z[ix][iy][ip - 1] + RI / MA / G0 * 0.5 *
01705                      (TVIRT(met->t[ix][iy][ip - 1], met->h2o[ix][iy][ip - 1])
01706                       + TVIRT(met->t[ix][iy][ip], met->h2o[ix][iy][ip]))
01707                      * (logp[ip - 1] - logp[ip]));
01708     }
01709   }
01710
01711   /* Smoothing... */
01712 #pragma omp parallel for default(shared) private(ix,iy,ip,n,ix2,ix3,iy2)
01713   for (ix = 0; ix < met->nx; ix++)
01714     for (iy = 0; iy < met->ny; iy++)
01715       for (ip = 0; ip < met->np; ip++) {
01716         n = 0;
01717         help[ix][iy][ip] = 0;
01718         for (ix2 = ix - dx; ix2 <= ix + dx; ix2++) {
01719           ix3 = ix2;
```

```
01720           if (ix3 < 0)
01721             ix3 += met->nx;
01722           else if (ix3 >= met->nx)
01723             ix3 -= met->nx;
01724           for (iy2 = GSL_MAX(iy - dy, 0);
01725                iy2 <= GSL_MIN(iy + dy, met->ny - 1); iy2++)
01726             if (gsl_finite(met->z[ix3][iy2][ip])) {
01727               help[ix][iy][ip] += met->z[ix3][iy2][ip];
01728               n++;
01729             }
01730         }
01731         if (n > 0)
01732           help[ix][iy][ip] /= (float) n;
01733         else
01734           help[ix][iy][ip] = GSL_NAN;
01735       }
01736
01737   /* Copy data... */
01738 #pragma omp parallel for default(shared) private(ix,iy,ip)
01739   for (ix = 0; ix < met->nx; ix++)
01740     for (iy = 0; iy < met->ny; iy++)
01741       for (ip = 0; ip < met->np; ip++)
01742         met->z[ix][iy][ip] = help[ix][iy][ip];
01743 }
```

Here is the call graph for this function:



5.19.2.22 void read_met_help (int *ncid*, char * *varname*, char * *varname2*, met_t * *met*, float *dest[EX][EY][EP]*, float *scl*)

Read and convert variable from meteorological data file.

Definition at line 1747 of file libtrac.c.

```
01753             {
01754
01755   float *help;
01756
01757   int ip, ix, iy, varid;
01758
01759   /* Check if variable exists... */
01760   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
01761     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
01762       return;
01763
01764   /* Allocate... */
01765   ALLOC(help, float, EX * EY * EP);
01766
01767   /* Read data... */
01768   NC(nc_get_var_float(ncid, varid, help));
01769
01770   /* Copy and check data... */
01771 #pragma omp parallel for default(shared) private(ix,iy,ip)
01772   for (ix = 0; ix < met->nx; ix++)
01773     for (iy = 0; iy < met->ny; iy++)
01774       for (ip = 0; ip < met->np; ip++) {
01775         dest[ix][iy][ip] = help[(ip * met->ny + iy) * met->nx + ix];
01776         if (fabsf(dest[ix][iy][ip]) < 1e14f)
01777           dest[ix][iy][ip] *= scl;
```

```
01778         else
01779           dest[ix][iy][ip] = GSL_NAN;
01780       }
01781
01782   /* Free... */
01783   free(help);
01784 }
```

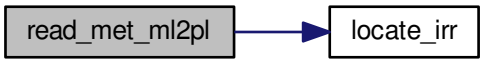
5.19.2.23 void read_met_ml2pl (ctl_t * *ctl*, met_t * *met*, float *var[EX][EY][EP]*)

Convert meteorological data from model levels to pressure levels.

Definition at line 1788 of file libtrac.c.

```
01791                           {
01792
01793   double aux[EP], p[EP], pt;
01794
01795   int ip, ip2, ix, iy;
01796
01797   /* Loop over columns... */
01798 #pragma omp parallel for default(shared) private(ix,iy,ip,p,pt,ip2,aux)
01799   for (ix = 0; ix < met->nx; ix++)
01800     for (iy = 0; iy < met->ny; iy++) {
01801
01802       /* Copy pressure profile... */
01803       for (ip = 0; ip < met->np; ip++)
01804         p[ip] = met->pl[ix][iy][ip];
01805
01806       /* Interpolate... */
01807       for (ip = 0; ip < ctl->met_np; ip++) {
01808         pt = ctl->met_p[ip];
01809         if ((pt > p[0] && p[0] > p[1]) || (pt < p[0] && p[0] < p[1]))
01810           pt = p[0];
01811         else if ((pt > p[met->np - 1] && p[1] > p[0])
01812                  || (pt < p[met->np - 1] && p[1] < p[0]))
01813           pt = p[met->np - 1];
01814         ip2 = locate_irr(p, met->np, pt);
01815         aux[ip] = LIN(p[ip2], var[ix][iy][ip2],
01816                       p[ip2 + 1], var[ix][iy][ip2 + 1], pt);
01817       }
01818
01819       /* Copy data... */
01820       for (ip = 0; ip < ctl->met_np; ip++)
01821         var[ix][iy][ip] = (float) aux[ip];
01822     }
01823 }
```

Here is the call graph for this function:



5.19.2.24 void read_met_periodic (met_t * *met*)

Create meteorological data with periodic boundary conditions.

Definition at line 1827 of file libtrac.c.

```
01828               {
01829
01830   /* Check longitudes... */
01831   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
01832              + met->lon[1] - met->lon[0] - 360) < 0.01))
01833     return;
01834
01835   /* Increase longitude counter... */
01836   if ((++met->nx) > EX)
01837     ERRMSG("Cannot create periodic boundary conditions!");
01838
01839   /* Set longitude... */
01840   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
01841
01842   /* Loop over latitudes and pressure levels... */
01843 #pragma omp parallel for default(shared)
01844   for (int iy = 0; iy < met->ny; iy++) {
01845     met->ps[met->nx - 1][iy] = met->ps[0][iy];
01846     met->pt[met->nx - 1][iy] = met->pt[0][iy];
01847     for (int ip = 0; ip < met->np; ip++) {
01848       met->z[met->nx - 1][iy][ip] = met->z[0][iy][ip];
01849       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
01850       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
01851       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
01852       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
01853       met->pv[met->nx - 1][iy][ip] = met->pv[0][iy][ip];
01854       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
01855       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
01856     }
01857   }
01858 }
```

5.19.2.25 void read_met_pv (met_t * *met*)

Calculate potential vorticity.

Definition at line 1862 of file libtrac.c.

```
01863               {
01864
01865   double c0, c1, cr, dx, dy, dp0, dp1, denom, dtdx, dvdx, dtdy, dudy,
01866     dtdp, dudp, dvdp, latr, vort, pows[EP];
01867
01868   int ip, ip0, ip1, ix, ix0, ix1, iy, iy0, iy1;
01869
01870   /* Set powers... */
01871   for (ip = 0; ip < met->np; ip++)
01872     pows[ip] = pow(1000. / met->p[ip], 0.286);
01873
01874   /* Loop over grid points... */
01875 #pragma omp parallel for default(shared)
       private(ix,ix0,ix1,iy,iy0,iy1,latr,dx,dy,c0,c1,cr,vort,ip,ip0,ip1,dp0,dp1,denom,dtdx,dvdx,dtdy,dudy,dtdp,dudp,dvdp)
01876   for (ix = 0; ix < met->nx; ix++) {
01877
01878     /* Set indices... */
01879     ix0 = GSL_MAX(ix - 1, 0);
01880     ix1 = GSL_MIN(ix + 1, met->nx - 1);
01881
01882     /* Loop over grid points... */
01883     for (iy = 0; iy < met->ny; iy++) {
01884
01885       /* Set indices... */
01886       iy0 = GSL_MAX(iy - 1, 0);
01887       iy1 = GSL_MIN(iy + 1, met->ny - 1);
01888
01889       /* Set auxiliary variables... */
01890       latr = 0.5 * (met->lat[iy1] + met->lat[iy0]);
01891       dx = 1000. * DEG2DX(met->lon[ix1] - met->lon[ix0], latr);
01892       dy = 1000. * DEG2DY(met->lat[iy1] - met->lat[iy0]);
01893       c0 = cos(met->lat[iy0] / 180. * M_PI);
01894       c1 = cos(met->lat[iy1] / 180. * M_PI);
01895       cr = cos(latr / 180. * M_PI);
01896       vort = 2 * 7.2921e-5 * sin(latr * M_PI / 180.);
01897
01898       /* Loop over grid points... */
01899       for (ip = 0; ip < met->np; ip++) {
01900
01901         /* Get gradients in longitude... */
01902         dtdx = (met->t[ix1][iy][ip] - met->t[ix0][iy][ip]) * pows[ip] / dx;
```

```
01903         dvdx = (met->v[ix1][iy][ip] - met->v[ix0][iy][ip]) / dx;
01904
01905         /* Get gradients in latitude... */
01906         dtdy = (met->t[ix][iy1][ip] - met->t[ix][iy0][ip]) * pows[ip] / dy;
01907         dudy = (met->u[ix][iy1][ip] * c1 - met->u[ix][iy0][ip] * c0) / dy;
01908
01909         /* Set indices... */
01910         ip0 = GSL_MAX(ip - 1, 0);
01911         ip1 = GSL_MIN(ip + 1, met->np - 1);
01912
01913         /* Get gradients in pressure... */
01914         dp0 = 100. * (met->p[ip] - met->p[ip0]);
01915         dp1 = 100. * (met->p[ip1] - met->p[ip]);
01916         if (ip != ip0 && ip != ip1) {
01917           denom = dp0 * dp1 * (dp0 + dp1);
01918           dtdp = (dp0 * dp0 * met->t[ix][iy][ip1] * pows[ip1]
01919                   - dp1 * dp1 * met->t[ix][iy][ip0] * pows[ip0]
01920                   + (dp1 * dp1 - dp0 * dp0) * met->t[ix][iy][ip] * pows[ip])
01921             / denom;
01922           dudp = (dp0 * dp0 * met->u[ix][iy][ip1]
01923                   - dp1 * dp1 * met->u[ix][iy][ip0]
01924                   + (dp1 * dp1 - dp0 * dp0) * met->u[ix][iy][ip])
01925             / denom;
01926           dvdp = (dp0 * dp0 * met->v[ix][iy][ip1]
01927                   - dp1 * dp1 * met->v[ix][iy][ip0]
01928                   + (dp1 * dp1 - dp0 * dp0) * met->v[ix][iy][ip])
01929             / denom;
01930         } else {
01931           denom = dp0 + dp1;
01932           dtdp =
01933             (met->t[ix][iy][ip1] * pows[ip1] -
01934              met->t[ix][iy][ip0] * pows[ip0]) / denom;
01935           dudp = (met->u[ix][iy][ip1] - met->u[ix][iy][ip0]) / denom;
01936           dvdp = (met->v[ix][iy][ip1] - met->v[ix][iy][ip0]) / denom;
01937         }
01938
01939         /* Calculate PV... */
01940         met->pv[ix][iy][ip] = (float)
01941           (1e6 * G0 *
01942            (-dtdp * (dvdx - dudy / cr + vort) + dvdp * dtdx - dudp * dtdy));
01943       }
01944     }
01945   }
01946
01947   /* Fix for polar regions... */
01948 #pragma omp parallel for default(shared) private(ix,ip)
01949   for (ix = 0; ix < met->nx; ix++)
01950     for (ip = 0; ip < met->np; ip++) {
01951       met->pv[ix][0][ip]
01952         = met->pv[ix][1][ip]
01953         = met->pv[ix][2][ip];
01954       met->pv[ix][met->ny - 1][ip]
01955         = met->pv[ix][met->ny - 2][ip]
01956         = met->pv[ix][met->ny - 3][ip];
01957     }
01958 }
```

5.19.2.26 void read_met_sample (ctl_t * *ctl*, met_t * *met*)

Downsampling of meteorological data.

Definition at line 1962 of file libtrac.c.

```
01964               {
01965
01966   met_t *help;
01967
01968   float w, wsum;
01969
01970   int ip, ip2, ix, ix2, ix3, iy, iy2;
01971
01972   /* Check parameters... */
01973   if (ctl->met_dp <= 1 && ctl->met_dx <= 1 && ctl->met_dy <= 1
01974       && ctl->met_sp <= 1 && ctl->met_sx <= 1 && ctl->met_sy <= 1)
01975     return;
01976
01977   /* Allocate... */
01978   ALLOC(help, met_t, 1);
01979
01980   /* Copy data... */
```

```
01981   help->nx = met->nx;
01982   help->ny = met->ny;
01983   help->np = met->np;
01984   memcpy(help->lon, met->lon, sizeof(met->lon));
01985   memcpy(help->lat, met->lat, sizeof(met->lat));
01986   memcpy(help->p, met->p, sizeof(met->p));
01987
01988   /* Smoothing... */
01989   for (ix = 0; ix < met->nx; ix += ctl->met_dx) {
01990     for (iy = 0; iy < met->ny; iy += ctl->met_dy) {
01991       for (ip = 0; ip < met->np; ip += ctl->met_dp) {
01992         help->ps[ix][iy] = 0;
01993         help->pt[ix][iy] = 0;
01994         help->z[ix][iy][ip] = 0;
01995         help->t[ix][iy][ip] = 0;
01996         help->u[ix][iy][ip] = 0;
01997         help->v[ix][iy][ip] = 0;
01998         help->w[ix][iy][ip] = 0;
01999         help->pv[ix][iy][ip] = 0;
02000         help->h2o[ix][iy][ip] = 0;
02001         help->o3[ix][iy][ip] = 0;
02002         wsum = 0;
02003         for (ix2 = ix - ctl->met_sx + 1; ix2 <= ix + ctl->met_sx - 1; ix2++) {
02004           ix3 = ix2;
02005           if (ix3 < 0)
02006             ix3 += met->nx;
02007           else if (ix3 >= met->nx)
02008             ix3 -= met->nx;
02009
02010           for (iy2 = GSL_MAX(iy - ctl->met_sy + 1, 0);
02011                iy2 <= GSL_MIN(iy + ctl->met_sy - 1, met->ny - 1); iy2++)
02012             for (ip2 = GSL_MAX(ip - ctl->met_sp + 1, 0);
02013                  ip2 <= GSL_MIN(ip + ctl->met_sp - 1, met->np - 1); ip2++) {
02014               w = (float) (1.0 - fabs(ix - ix2) / ctl->met_sx)
02015                 * (float) (1.0 - fabs(iy - iy2) / ctl->met_sy)
02016                 * (float) (1.0 - fabs(ip - ip2) / ctl->met_sp);
02017               help->ps[ix][iy] += w * met->ps[ix3][iy2];
02018               help->pt[ix][iy] += w * met->pt[ix3][iy2];
02019               help->z[ix][iy][ip] += w * met->z[ix3][iy2][ip2];
02020               help->t[ix][iy][ip] += w * met->t[ix3][iy2][ip2];
02021               help->u[ix][iy][ip] += w * met->u[ix3][iy2][ip2];
02022               help->v[ix][iy][ip] += w * met->v[ix3][iy2][ip2];
02023               help->w[ix][iy][ip] += w * met->w[ix3][iy2][ip2];
02024               help->pv[ix][iy][ip] += w * met->pv[ix3][iy2][ip2];
02025               help->h2o[ix][iy][ip] += w * met->h2o[ix3][iy2][ip2];
02026               help->o3[ix][iy][ip] += w * met->o3[ix3][iy2][ip2];
02027               wsum += w;
02028             }
02029         }
02030         help->ps[ix][iy] /= wsum;
02031         help->pt[ix][iy] /= wsum;
02032         help->t[ix][iy][ip] /= wsum;
02033         help->z[ix][iy][ip] /= wsum;
02034         help->u[ix][iy][ip] /= wsum;
02035         help->v[ix][iy][ip] /= wsum;
02036         help->w[ix][iy][ip] /= wsum;
02037         help->pv[ix][iy][ip] /= wsum;
02038         help->h2o[ix][iy][ip] /= wsum;
02039         help->o3[ix][iy][ip] /= wsum;
02040       }
02041     }
02042   }
02043
02044   /* Downsampling... */
02045   met->nx = 0;
02046   for (ix = 0; ix < help->nx; ix += ctl->met_dx) {
02047     met->lon[met->nx] = help->lon[ix];
02048     met->ny = 0;
02049     for (iy = 0; iy < help->ny; iy += ctl->met_dy) {
02050       met->lat[met->ny] = help->lat[iy];
02051       met->ps[met->nx][met->ny] = help->ps[ix][iy];
02052       met->pt[met->nx][met->ny] = help->pt[ix][iy];
02053       met->np = 0;
02054       for (ip = 0; ip < help->np; ip += ctl->met_dp) {
02055         met->p[met->np] = help->p[ip];
02056         met->z[met->nx][met->ny][met->np] = help->z[ix][iy][ip];
02057         met->t[met->nx][met->ny][met->np] = help->t[ix][iy][ip];
02058         met->u[met->nx][met->ny][met->np] = help->u[ix][iy][ip];
02059         met->v[met->nx][met->ny][met->np] = help->v[ix][iy][ip];
02060         met->w[met->nx][met->ny][met->np] = help->w[ix][iy][ip];
02061         met->pv[met->nx][met->ny][met->np] = help->pv[ix][iy][ip];
02062         met->h2o[met->nx][met->ny][met->np] = help->h2o[ix][iy][ip];
02063         met->o3[met->nx][met->ny][met->np] = help->o3[ix][iy][ip];
02064         met->np++;
02065       }
02066       met->ny++;
02067     }
```

```
02068     met->nx++;
02069   }
02070
02071   /* Free... */
02072   free(help);
02073 }
```

5.19.2.27 void read_met_tropo (ctl_t * *ctl*, met_t * *met*)

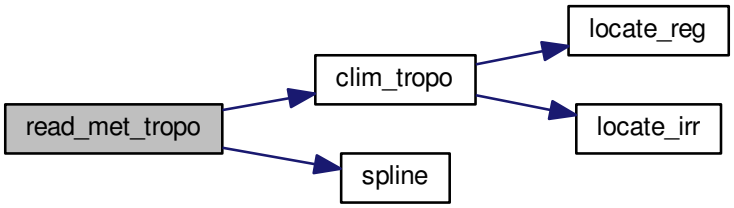
Calculate tropopause pressure.

Definition at line 2077 of file libtrac.c.

```
02079               {
02080
02081   double p2[200], pv[EP], pv2[200], t[EP], t2[200], th[EP],
02082     th2[200], z[EP], z2[200];
02083
02084   int found, ix, iy, iz, iz2;
02085
02086   /* Get altitude and pressure profiles... */
02087   for (iz = 0; iz < met->np; iz++)
02088     z[iz] = Z(met->p[iz]);
02089   for (iz = 0; iz <= 170; iz++) {
02090     z2[iz] = 4.5 + 0.1 * iz;
02091     p2[iz] = P(z2[iz]);
02092   }
02093
02094   /* Do not calculate tropopause... */
02095   if (ctl->met_tropo == 0)
02096     for (ix = 0; ix < met->nx; ix++)
02097       for (iy = 0; iy < met->ny; iy++)
02098         met->pt[ix][iy] = GSL_NAN;
02099
02100   /* Use tropopause climatology... */
02101   else if (ctl->met_tropo == 1) {
02102 #pragma omp parallel for default(shared) private(ix,iy)
02103     for (ix = 0; ix < met->nx; ix++)
02104       for (iy = 0; iy < met->ny; iy++)
02105         met->pt[ix][iy] = clim_tropo(met->time, met->lat[iy]);
02106   }
02107
02108   /* Use cold point... */
02109   else if (ctl->met_tropo == 2) {
02110
02111     /* Loop over grid points... */
02112 #pragma omp parallel for default(shared) private(ix,iy,iz,t,t2)
02113     for (ix = 0; ix < met->nx; ix++)
02114       for (iy = 0; iy < met->ny; iy++) {
02115
02116         /* Interpolate temperature profile... */
02117         for (iz = 0; iz < met->np; iz++)
02118           t[iz] = met->t[ix][iy][iz];
02119         spline(z, t, met->np, z2, t2, 171);
02120
02121         /* Find minimum... */
02122         iz = (int) gsl_stats_min_index(t2, 1, 171);
02123         if (iz <= 0 || iz >= 170)
02124           met->pt[ix][iy] = GSL_NAN;
02125         else
02126           met->pt[ix][iy] = p2[iz];
02127       }
02128   }
02129
02130   /* Use WMO definition... */
02131   else if (ctl->met_tropo == 3 || ctl->met_tropo == 4) {
02132
02133     /* Loop over grid points... */
02134 #pragma omp parallel for default(shared) private(ix,iy,iz,iz2,t,t2,found)
02135     for (ix = 0; ix < met->nx; ix++)
02136       for (iy = 0; iy < met->ny; iy++) {
02137
02138         /* Interpolate temperature profile... */
02139         for (iz = 0; iz < met->np; iz++)
02140           t[iz] = met->t[ix][iy][iz];
02141         spline(z, t, met->np, z2, t2, 161);
02142
02143         /* Find 1st tropopause... */
02144         met->pt[ix][iy] = GSL_NAN;
02145         for (iz = 0; iz <= 140; iz++) {
```

```
02146           found = 1;
02147           for (iz2 = iz + 1; iz2 <= iz + 20; iz2++)
02148             if (1e3 * G0 / RA * (t2[iz2] - t2[iz]) / (t2[iz2] + t2[iz])
02149                 * (p2[iz2] + p2[iz]) / (p2[iz2] - p2[iz]) > 2.0) {
02150               found = 0;
02151               break;
02152             }
02153           if (found) {
02154             if (iz > 0 && iz < 140)
02155               met->pt[ix][iy] = p2[iz];
02156             break;
02157           }
02158         }
02159
02160         /* Find 2nd tropopause... */
02161         if (ctl->met_tropo == 4) {
02162           met->pt[ix][iy] = GSL_NAN;
02163           for (; iz <= 140; iz++) {
02164             found = 1;
02165             for (iz2 = iz + 1; iz2 <= iz + 10; iz2++)
02166               if (1e3 * G0 / RA * (t2[iz2] - t2[iz]) / (t2[iz2] + t2[iz])
02167                   * (p2[iz2] + p2[iz]) / (p2[iz2] - p2[iz]) < 3.0) {
02168                 found = 0;
02169                 break;
02170               }
02171             if (found)
02172               break;
02173           }
02174           for (; iz <= 140; iz++) {
02175             found = 1;
02176             for (iz2 = iz + 1; iz2 <= iz + 20; iz2++)
02177               if (1e3 * G0 / RA * (t2[iz2] - t2[iz]) / (t2[iz2] + t2[iz])
02178                   * (p2[iz2] + p2[iz]) / (p2[iz2] - p2[iz]) > 2.0) {
02179                 found = 0;
02180                 break;
02181               }
02182             if (found) {
02183               if (iz > 0 && iz < 140)
02184                 met->pt[ix][iy] = p2[iz];
02185               break;
02186             }
02187           }
02188         }
02189       }
02190   }
02191
02192   /* Use dynamical tropopause... */
02193   else if (ctl->met_tropo == 5) {
02194
02195     /* Loop over grid points... */
02196 #pragma omp parallel for default(shared) private(ix,iy,iz,pv,pv2,th,th2)
02197     for (ix = 0; ix < met->nx; ix++)
02198       for (iy = 0; iy < met->ny; iy++) {
02199
02200         /* Interpolate potential vorticity profile... */
02201         for (iz = 0; iz < met->np; iz++)
02202           pv[iz] = met->pv[ix][iy][iz];
02203         spline(z, pv, met->np, z2, pv2, 161);
02204
02205         /* Interpolate potential temperature profile... */
02206         for (iz = 0; iz < met->np; iz++)
02207           th[iz] = THETA(met->p[iz], met->t[ix][iy][iz]);
02208         spline(z, th, met->np, z2, th2, 161);
02209
02210         /* Find dynamical tropopause 3.5 PVU + 380 K */
02211         met->pt[ix][iy] = GSL_NAN;
02212         for (iz = 0; iz <= 160; iz++)
02213           if (fabs(pv2[iz]) >= 3.5 || th2[iz] >= 380.) {
02214             if (iz > 0 && iz < 160)
02215               met->pt[ix][iy] = p2[iz];
02216             break;
02217           }
02218       }
02219   }
02220
02221   else
02222     ERRMSG("Cannot calculate tropopause!");
02223 }
```

Here is the call graph for this function:



5.19.2.28 double scan_ctl (const char * *filename*, int *argc*, char * *argv[]*, const char * *varname*, int *arridx*, const char * *defvalue*, char * *value*)

Read a control parameter from file or command line.

Definition at line 2227 of file libtrac.c.

```
02234               {
02235
02236   FILE *in = NULL;
02237
02238   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
02239     msg[2 * LEN], rvarname[LEN], rval[LEN];
02240
02241   int contain = 0, i;
02242
02243   /* Open file... */
02244   if (filename[strlen(filename) - 1] != '-')
02245     if (!(in = fopen(filename, "r")))
02246       ERRMSG("Cannot open file!");
02247
02248   /* Set full variable name... */
02249   if (arridx >= 0) {
02250     sprintf(fullname1, "%s[%d]", varname, arridx);
02251     sprintf(fullname2, "%s[*]", varname);
02252   } else {
02253     sprintf(fullname1, "%s", varname);
02254     sprintf(fullname2, "%s", varname);
02255   }
02256
02257   /* Read data... */
02258   if (in != NULL)
02259     while (fgets(line, LEN, in))
02260       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
02261         if (strcasecmp(rvarname, fullname1) == 0 ||
02262             strcasecmp(rvarname, fullname2) == 0) {
02263           contain = 1;
02264           break;
02265         }
02266   for (i = 1; i < argc - 1; i++)
02267     if (strcasecmp(argv[i], fullname1) == 0 ||
02268         strcasecmp(argv[i], fullname2) == 0) {
02269       sprintf(rval, "%s", argv[i + 1]);
02270       contain = 1;
02271       break;
02272     }
02273
02274   /* Close file... */
02275   if (in != NULL)
02276     fclose(in);
02277
02278   /* Check for missing variables... */
02279   if (!contain) {
02280     if (strlen(defvalue) > 0)
02281       sprintf(rval, "%s", defvalue);
```

```
02282     else {
02283       sprintf(msg, "Missing variable %s!\n", fullname1);
02284       ERRMSG(msg);
02285     }
02286   }
02287
02288   /* Write info... */
02289   printf("%s = %s\n", fullname1, rval);
02290
02291   /* Return values... */
02292   if (value != NULL)
02293     sprintf(value, "%s", rval);
02294   return atof(rval);
02295 }
```

5.19.2.29 void spline (double * *x*, double * *y*, int *n*, double * *x2*, double * *y2*, int *n2*)

Spline interpolation.

Definition at line 2299 of file libtrac.c.

```
02305           {
02306
02307   gsl_interp_accel *acc;
02308
02309   gsl_spline *s;
02310
02311   /* Allocate... */
02312   acc = gsl_interp_accel_alloc();
02313   s = gsl_spline_alloc(gsl_interp_cspline, (size_t) n);
02314
02315   /* Interpolate temperature profile... */
02316   gsl_spline_init(s, x, y, (size_t) n);
02317   for (int i = 0; i < n2; i++)
02318     y2[i] = gsl_spline_eval(s, x2[i], acc);
02319
02320   /* Free... */
02321   gsl_spline_free(s);
02322   gsl_interp_accel_free(acc);
02323 }
```

5.19.2.30 double stddev (double * *data*, int *n*)

Calculate standard deviation.

Definition at line 2327 of file libtrac.c.

```
02329           {
02330
02331   if (n <= 0)
02332     return 0;
02333
02334   double avg = 0, rms = 0;
02335
02336   for (int i = 0; i < n; ++i)
02337     avg += data[i];
02338   avg /= n;
02339
02340   for (int i = 0; i < n; ++i)
02341     rms += SQR(data[i] - avg);
02342
02343   return sqrt(rms / (n - 1));
02344 }
```

5.19.2.31 void time2jsec (int *year*, int *mon*, int *day*, int *hour*, int *min*, int *sec*, double *remain*, double * *jsec*)

Convert date to seconds.

Definition at line 2348 of file libtrac.c.

```
02356                 {
02357
02358   struct tm t0, t1;
02359
02360   t0.tm_year = 100;
02361   t0.tm_mon = 0;
02362   t0.tm_mday = 1;
02363   t0.tm_hour = 0;
02364   t0.tm_min = 0;
02365   t0.tm_sec = 0;
02366
02367   t1.tm_year = year - 1900;
02368   t1.tm_mon = mon - 1;
02369   t1.tm_mday = day;
02370   t1.tm_hour = hour;
02371   t1.tm_min = min;
02372   t1.tm_sec = sec;
02373
02374   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
02375 }
```

5.19.2.32 void timer (const char * *name*, int *id*, int *mode*)

Measure wall-clock time.

Definition at line 2379 of file libtrac.c.

```
02382             {
02383
02384   static double starttime[NTIMER], runtime[NTIMER];
02385
02386   /* Check id... */
02387   if (id < 0 || id >= NTIMER)
02388     ERRMSG("Too many timers!");
02389
02390   /* Start timer... */
02391   if (mode == 1) {
02392     if (starttime[id] <= 0)
02393       starttime[id] = omp_get_wtime();
02394     else
02395       ERRMSG("Timer already started!");
02396   }
02397
02398   /* Stop timer... */
02399   else if (mode == 2) {
02400     if (starttime[id] > 0) {
02401       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
02402       starttime[id] = -1;
02403     }
02404   }
02405
02406   /* Print timer... */
02407   else if (mode == 3) {
02408     printf("%s = %.3f s\n", name, runtime[id]);
02409     runtime[id] = 0;
02410   }
02411 }
```

5.19.2.33 void write_atm (const char * *filename*, ctl_t * *ctl*, atm_t * *atm*, double *t*)

Write atmospheric data.

Definition at line 2415 of file libtrac.c.

```
02419           {
02420
02421   FILE *in, *out;
02422
02423   char line[LEN];
02424
02425   double r, t0, t1;
02426
02427   int ip, iq, year, mon, day, hour, min, sec;
02428
02429   /* Set time interval for output... */
02430   t0 = t - 0.5 * ctl->dt_mod;
02431   t1 = t + 0.5 * ctl->dt_mod;
02432
02433   /* Write info... */
02434   printf("Write atmospheric data: %s\n", filename);
02435
02436   /* Write ASCII data... */
02437   if (ctl->atm_type == 0) {
02438
02439     /* Check if gnuplot output is requested... */
02440     if (ctl->atm_gpfile[0] != '-') {
02441
02442       /* Create gnuplot pipe... */
02443       if (!(out = popen("gnuplot", "w")))
02444         ERRMSG("Cannot create pipe to gnuplot!");
02445
02446       /* Set plot filename... */
02447       fprintf(out, "set out \"%s.png\"\n", filename);
02448
02449       /* Set time string... */
02450       jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
02451       fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
02452               year, mon, day, hour, min);
02453
02454       /* Dump gnuplot file to pipe... */
02455       if (!(in = fopen(ctl->atm_gpfile, "r")))
02456         ERRMSG("Cannot open file!");
02457       while (fgets(line, LEN, in))
02458         fprintf(out, "%s", line);
02459       fclose(in);
02460     }
02461
02462     else {
02463
02464       /* Create file... */
02465       if (!(out = fopen(filename, "w")))
02466         ERRMSG("Cannot create file!");
02467     }
02468
02469     /* Write header... */
02470     fprintf(out,
02471             "# $1 = time [s]\n"
02472             "# $2 = altitude [km]\n"
02473             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
02474     for (iq = 0; iq < ctl->nq; iq++)
02475       fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
02476               ctl->qnt_unit[iq]);
02477     fprintf(out, "\n");
02478
02479     /* Write data... */
02480     for (ip = 0; ip < atm->np; ip += ctl->atm_stride) {
02481
02482       /* Check time... */
02483       if (ctl->atm_filter && (atm->time[ip] < t0 || atm->time[ip] > t1))
02484         continue;
02485
02486       /* Write output... */
02487       fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
02488               atm->lon[ip], atm->lat[ip]);
02489       for (iq = 0; iq < ctl->nq; iq++) {
02490         fprintf(out, " ");
02491         fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
02492       }
02493       fprintf(out, "\n");
02494     }
02495
```

```
02496     /* Close file... */
02497     fclose(out);
02498   }
02499
02500   /* Write binary data... */
02501   else if (ctl->atm_type == 1) {
02502
02503     /* Create file... */
02504     if (!(out = fopen(filename, "w")))
02505       ERRMSG("Cannot create file!");
02506
02507     /* Write data... */
02508     FWRITE(&atm->np, int,
02509            1,
02510            out);
02511     FWRITE(atm->time, double,
02512              (size_t) atm->np,
02513            out);
02514     FWRITE(atm->p, double,
02515              (size_t) atm->np,
02516            out);
02517     FWRITE(atm->lon, double,
02518              (size_t) atm->np,
02519            out);
02520     FWRITE(atm->lat, double,
02521              (size_t) atm->np,
02522            out);
02523     for (iq = 0; iq < ctl->nq; iq++)
02524       FWRITE(atm->q[iq], double,
02525                (size_t) atm->np,
02526              out);
02527
02528     /* Close file... */
02529     fclose(out);
02530   }
02531
02532   /* Error... */
02533   else
02534     ERRMSG("Atmospheric data type not supported!");
02535 }
```

Here is the call graph for this function:

5.19.2.34 void write_csi (const char * *filename*, ctl_t * *ctl*, atm_t * *atm*, double *t*)

Write CSI data.

Definition at line 2539 of file libtrac.c.

```
02543             {
02544
02545   static FILE *in, *out;
02546
02547   static char line[LEN];
02548
02549   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
02550     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
02551
02552   static int obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
02553
02554   /* Init... */
02555   if (t == ctl->t_start) {
```

```
02556
02557     /* Check quantity index for mass... */
02558     if (ctl->qnt_m < 0)
02559       ERRMSG("Need quantity mass!");
02560
02561     /* Open observation data file... */
02562     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
02563     if (!(in = fopen(ctl->csi_obsfile, "r")))
02564       ERRMSG("Cannot open file!");
02565
02566     /* Create new file... */
02567     printf("Write CSI data: %s\n", filename);
02568     if (!(out = fopen(filename, "w")))
02569       ERRMSG("Cannot create file!");
02570
02571     /* Write header... */
02572     fprintf(out,
02573             "# $1 = time [s]\n"
02574             "# $2 = number of hits (cx)\n"
02575             "# $3 = number of misses (cy)\n"
02576             "# $4 = number of false alarms (cz)\n"
02577             "# $5 = number of observations (cx + cy)\n"
02578             "# $6 = number of forecasts (cx + cz)\n"
02579             "# $7 = bias (forecasts/observations) [%%]\n"
02580             "# $8 = probability of detection (POD) [%%]\n"
02581             "# $9 = false alarm rate (FAR) [%%]\n"
02582             "# $10 = critical success index (CSI) [%%]\n\n");
02583   }
02584
02585   /* Set time interval... */
02586   t0 = t - 0.5 * ctl->dt_mod;
02587   t1 = t + 0.5 * ctl->dt_mod;
02588
02589   /* Initialize grid cells... */
02590 #pragma omp parallel for default(shared) private(ix,iy,iz)
02591   for (ix = 0; ix < ctl->csi_nx; ix++)
02592     for (iy = 0; iy < ctl->csi_ny; iy++)
02593       for (iz = 0; iz < ctl->csi_nz; iz++)
02594         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
02595
02596   /* Read observation data... */
02597   while (fgets(line, LEN, in)) {
02598
02599     /* Read data... */
02600     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
02601         5)
02602       continue;
02603
02604     /* Check time... */
02605     if (rt < t0)
02606       continue;
02607     if (rt > t1)
02608       break;
02609
02610     /* Calculate indices... */
02611     ix = (int) ((rlon - ctl->csi_lon0)
02612                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
02613     iy = (int) ((rlat - ctl->csi_lat0)
02614                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
02615     iz = (int) ((rz - ctl->csi_z0)
02616                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
02617
02618     /* Check indices... */
02619     if (ix < 0 || ix >= ctl->csi_nx ||
02620         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
02621       continue;
02622
02623     /* Get mean observation index... */
02624     obsmean[ix][iy][iz] += robs;
02625     obscount[ix][iy][iz]++;
02626   }
02627
02628   /* Analyze model data... */
02629 #pragma omp parallel for default(shared) private(ip,ix,iy,iz)
02630   for (ip = 0; ip < atm->np; ip++) {
02631
02632     /* Check time... */
02633     if (atm->time[ip] < t0 || atm->time[ip] > t1)
02634       continue;
02635
02636     /* Get indices... */
02637     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
02638                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
02639     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
02640                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
02641     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
02642                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
```

```
02643
02644     /* Check indices... */
02645     if (ix < 0 || ix >= ctl->csi_nx ||
02646         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
02647       continue;
02648
02649     /* Get total mass in grid cell... */
02650     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
02651   }
02652
02653   /* Analyze all grid cells... */
02654 #pragma omp parallel for default(shared) private(ix,iy,iz,dlon,dlat,lat,area)
02655   for (ix = 0; ix < ctl->csi_nx; ix++)
02656     for (iy = 0; iy < ctl->csi_ny; iy++)
02657       for (iz = 0; iz < ctl->csi_nz; iz++) {
02658
02659         /* Calculate mean observation index... */
02660         if (obscount[ix][iy][iz] > 0)
02661           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
02662
02663         /* Calculate column density... */
02664         if (modmean[ix][iy][iz] > 0) {
02665           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
02666           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
02667           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
02668           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
02669             * cos(lat * M_PI / 180.);
02670           modmean[ix][iy][iz] /= (1e6 * area);
02671         }
02672
02673         /* Calculate CSI... */
02674         if (obscount[ix][iy][iz] > 0) {
02675           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
02676               modmean[ix][iy][iz] >= ctl->csi_modmin)
02677             cx++;
02678           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
02679                    modmean[ix][iy][iz] < ctl->csi_modmin)
02680             cy++;
02681           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
02682                    modmean[ix][iy][iz] >= ctl->csi_modmin)
02683             cz++;
02684         }
02685       }
02686
02687   /* Write output... */
02688   if (fmod(t, ctl->csi_dt_out) == 0) {
02689
02690     /* Write... */
02691     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
02692             t, cx, cy, cz, cx + cy, cx + cz,
02693             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
02694             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
02695             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
02696             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
02697
02698     /* Set counters to zero... */
02699     cx = cy = cz = 0;
02700   }
02701
02702   /* Close file... */
02703   if (t == ctl->t_stop)
02704     fclose(out);
02705 }
```

5.19.2.35 void write_ens (const char * *filename*, ctl_t * *ctl*, atm_t * *atm*, double *t*)

Write ensemble data.

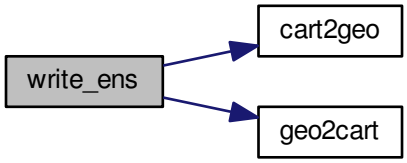
Definition at line 2709 of file libtrac.c.

```
02713             {
02714
02715   static FILE *out;
02716
02717   static double dummy, ens, lat, lon, p[NENS], q[NQ][NENS],
02718     t0, t1, x[NENS][3], xm[3];
02719
02720   static int ip, iq;
02721
02722   static size_t i, n;
```

```
02723
02724   /* Init... */
02725   if (t == ctl->t_start) {
02726
02727     /* Check quantities... */
02728     if (ctl->qnt_ens < 0)
02729       ERRMSG("Missing ensemble IDs!");
02730
02731     /* Create new file... */
02732     printf("Write ensemble data: %s\n", filename);
02733     if (!(out = fopen(filename, "w")))
02734       ERRMSG("Cannot create file!");
02735
02736     /* Write header... */
02737     fprintf(out,
02738             "# $1 = time [s]\n"
02739             "# $2 = altitude [km]\n"
02740             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
02741     for (iq = 0; iq < ctl->nq; iq++)
02742       fprintf(out, "# $%d = %s (mean) [%s]\n", 5 + iq,
02743               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
02744     for (iq = 0; iq < ctl->nq; iq++)
02745       fprintf(out, "# $%d = %s (sigma) [%s]\n", 5 + ctl->nq + iq,
02746               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
02747     fprintf(out, "# $%d = number of members\n\n", 5 + 2 * ctl->nq);
02748   }
02749
02750   /* Set time interval... */
02751   t0 = t - 0.5 * ctl->dt_mod;
02752   t1 = t + 0.5 * ctl->dt_mod;
02753
02754   /* Init... */
02755   ens = GSL_NAN;
02756   n = 0;
02757
02758   /* Loop over air parcels... */
02759   for (ip = 0; ip < atm->np; ip++) {
02760
02761     /* Check time... */
02762     if (atm->time[ip] < t0 || atm->time[ip] > t1)
02763       continue;
02764
02765     /* Check ensemble id... */
02766     if (atm->q[ctl->qnt_ens][ip] != ens) {
02767
02768       /* Write results... */
02769       if (n > 0) {
02770
02771         /* Get mean position... */
02772         xm[0] = xm[1] = xm[2] = 0;
02773         for (i = 0; i < n; i++) {
02774           xm[0] += x[i][0] / (double) n;
02775           xm[1] += x[i][1] / (double) n;
02776           xm[2] += x[i][2] / (double) n;
02777         }
02778         cart2geo(xm, &dummy, &lon, &lat);
02779         fprintf(out, "%.2f %g %g %g", t, Z(gsl_stats_mean(p, 1, n)), lon,
02780                 lat);
02781
02782         /* Get quantity statistics... */
02783         for (iq = 0; iq < ctl->nq; iq++) {
02784           fprintf(out, " ");
02785           fprintf(out, ctl->qnt_format[iq], gsl_stats_mean(q[iq], 1, n));
02786         }
02787         for (iq = 0; iq < ctl->nq; iq++) {
02788           fprintf(out, " ");
02789           fprintf(out, ctl->qnt_format[iq], gsl_stats_sd(q[iq], 1, n));
02790         }
02791         fprintf(out, " %lu\n", n);
02792       }
02793
02794       /* Init new ensemble... */
02795       ens = atm->q[ctl->qnt_ens][ip];
02796       n = 0;
02797     }
02798
02799     /* Save data... */
02800     p[n] = atm->p[ip];
02801     geo2cart(0, atm->lon[ip], atm->lat[ip], x[n]);
02802     for (iq = 0; iq < ctl->nq; iq++)
02803       q[iq][n] = atm->q[iq][ip];
02804     if ((++n) >= NENS)
02805       ERRMSG("Too many data points!");
02806   }
02807
02808   /* Write results... */
02809   if (n > 0) {
```

```
02810
02811     /* Get mean position... */
02812     xm[0] = xm[1] = xm[2] = 0;
02813     for (i = 0; i < n; i++) {
02814       xm[0] += x[i][0] / (double) n;
02815       xm[1] += x[i][1] / (double) n;
02816       xm[2] += x[i][2] / (double) n;
02817     }
02818     cart2geo(xm, &dummy, &lon, &lat);
02819     fprintf(out, "%.2f %g %g %g", t, Z(gsl_stats_mean(p, 1, n)), lon, lat);
02820
02821     /* Get quantity statistics... */
02822     for (iq = 0; iq < ctl->nq; iq++) {
02823       fprintf(out, " ");
02824       fprintf(out, ctl->qnt_format[iq], gsl_stats_mean(q[iq], 1, n));
02825     }
02826     for (iq = 0; iq < ctl->nq; iq++) {
02827       fprintf(out, " ");
02828       fprintf(out, ctl->qnt_format[iq], gsl_stats_sd(q[iq], 1, n));
02829     }
02830     fprintf(out, " %lu\n", n);
02831   }
02832
02833   /* Close file... */
02834   if (t == ctl->t_stop)
02835     fclose(out);
02836 }
```

Here is the call graph for this function:



5.19.2.36 void write_grid (const char * *filename*, ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, double *t*)

Write gridded data.

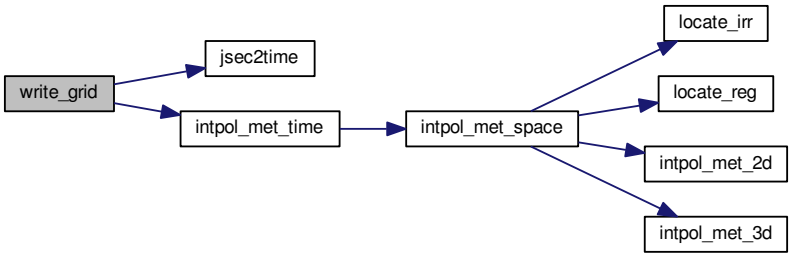
Definition at line 2840 of file libtrac.c.

```
02846             {
02847
02848   FILE *in, *out;
02849
02850   char line[LEN];
02851
02852   static double mass[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
02853     area, rho_air, press, temp, cd, vmr, t0, t1, r;
02854
02855   static int ip, ix, iy, iz, np[GX][GY][GZ], year, mon, day, hour, min, sec;
02856
02857   /* Check dimensions... */
02858   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
02859     ERRMSG("Grid dimensions too large!");
02860
02861   /* Set time interval for output... */
02862   t0 = t - 0.5 * ctl->dt_mod;
02863   t1 = t + 0.5 * ctl->dt_mod;
02864
02865   /* Set grid box size... */
02866   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
02867   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
```

```
02868   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
02869
02870   /* Initialize grid... */
02871 #pragma omp parallel for default(shared) private(ix,iy,iz)
02872   for (ix = 0; ix < ctl->grid_nx; ix++)
02873     for (iy = 0; iy < ctl->grid_ny; iy++)
02874       for (iz = 0; iz < ctl->grid_nz; iz++) {
02875         mass[ix][iy][iz] = 0;
02876         np[ix][iy][iz] = 0;
02877       }
02878
02879   /* Average data... */
02880 #pragma omp parallel for default(shared) private(ip,ix,iy,iz)
02881   for (ip = 0; ip < atm->np; ip++)
02882     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
02883
02884       /* Get index... */
02885       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
02886       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
02887       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
02888
02889       /* Check indices... */
02890       if (ix < 0 || ix >= ctl->grid_nx ||
02891           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
02892         continue;
02893
02894       /* Add mass... */
02895       if (ctl->qnt_m >= 0)
02896         mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
02897       np[ix][iy][iz]++;
02898     }
02899
02900   /* Check if gnuplot output is requested... */
02901   if (ctl->grid_gpfile[0] != '-') {
02902
02903     /* Write info... */
02904     printf("Plot grid data: %s.png\n", filename);
02905
02906     /* Create gnuplot pipe... */
02907     if (!(out = popen("gnuplot", "w")))
02908       ERRMSG("Cannot create pipe to gnuplot!");
02909
02910     /* Set plot filename... */
02911     fprintf(out, "set out \"%s.png\"\n", filename);
02912
02913     /* Set time string... */
02914     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
02915     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
02916             year, mon, day, hour, min);
02917
02918     /* Dump gnuplot file to pipe... */
02919     if (!(in = fopen(ctl->grid_gpfile, "r")))
02920       ERRMSG("Cannot open file!");
02921     while (fgets(line, LEN, in))
02922       fprintf(out, "%s", line);
02923     fclose(in);
02924   }
02925
02926   else {
02927
02928     /* Write info... */
02929     printf("Write grid data: %s\n", filename);
02930
02931     /* Create file... */
02932     if (!(out = fopen(filename, "w")))
02933       ERRMSG("Cannot create file!");
02934   }
02935
02936   /* Write header... */
02937   fprintf(out,
02938           "# $1 = time [s]\n"
02939           "# $2 = altitude [km]\n"
02940           "# $3 = longitude [deg]\n"
02941           "# $4 = latitude [deg]\n"
02942           "# $5 = surface area [km^2]\n"
02943           "# $6 = layer width [km]\n"
02944           "# $7 = number of particles [1]\n"
02945           "# $8 = column density [kg/m^2]\n"
02946           "# $9 = volume mixing ratio [1]\n\n");
02947
02948   /* Write data... */
02949   for (ix = 0; ix < ctl->grid_nx; ix++) {
02950     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
02951       fprintf(out, "\n");
02952     for (iy = 0; iy < ctl->grid_ny; iy++) {
02953       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
02954         fprintf(out, "\n");
```

```
02955       for (iz = 0; iz < ctl->grid_nz; iz++)
02956         if (!ctl->grid_sparse || mass[ix][iy][iz] > 0) {
02957
02958           /* Set coordinates... */
02959           z = ctl->grid_z0 + dz * (iz + 0.5);
02960           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
02961           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
02962
02963           /* Get pressure and temperature... */
02964           press = P(z);
02965           intpol_met_time(met0, met1, t, press, lon, lat, NULL, NULL,
02966                           NULL, &temp, NULL, NULL, NULL, NULL, NULL, NULL);
02967
02968           /* Calculate surface area... */
02969           area = dlat * dlon * SQR(RE * M_PI / 180.)
02970             * cos(lat * M_PI / 180.);
02971
02972           /* Calculate column density... */
02973           cd = mass[ix][iy][iz] / (1e6 * area);
02974
02975           /* Calculate volume mixing ratio... */
02976           rho_air = 100. * press / (RA * temp);
02977           vmr = MA / ctl->molmass * mass[ix][iy][iz]
02978             / (rho_air * 1e6 * area * 1e3 * dz);
02979
02980           /* Write output... */
02981           fprintf(out, "%.2f %g %g %g %g %g %d %g %g\n",
02982                   t, z, lon, lat, area, dz, np[ix][iy][iz], cd, vmr);
02983         }
02984     }
02985   }
02986
02987   /* Close file... */
02988   fclose(out);
02989 }
```

Here is the call graph for this function:



5.19.2.37 void write_prof (const char * *filename*, ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, double *t*)

Write profile data.

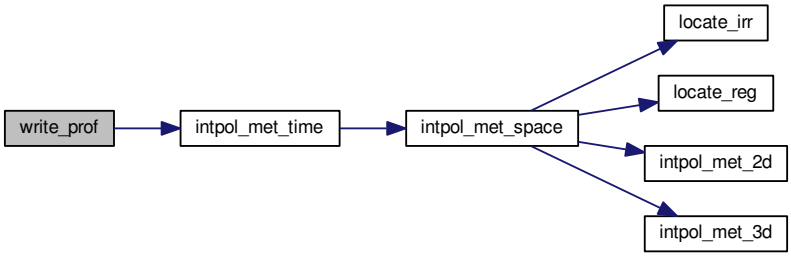
Definition at line 2993 of file libtrac.c.

```
02999           {
03000
03001   static FILE *in, *out;
03002
03003   static char line[LEN];
03004
03005   static double mass[GX][GY][GZ], obsmean[GX][GY], obsmean2[GX][GY], rt, rz,
03006     rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z, press, temp,
03007     rho_air, vmr, h2o, o3;
03008
03009   static int obscount[GX][GY], ip, ix, iy, iz, okay;
03010
```

```
03011   /* Init... */
03012   if (t == ctl->t_start) {
03013
03014     /* Check quantity index for mass... */
03015     if (ctl->qnt_m < 0)
03016       ERRMSG("Need quantity mass!");
03017
03018     /* Check dimensions... */
03019     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
03020       ERRMSG("Grid dimensions too large!");
03021
03022     /* Open observation data file... */
03023     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
03024     if (!(in = fopen(ctl->prof_obsfile, "r")))
03025       ERRMSG("Cannot open file!");
03026
03027     /* Create new output file... */
03028     printf("Write profile data: %s\n", filename);
03029     if (!(out = fopen(filename, "w")))
03030       ERRMSG("Cannot create file!");
03031
03032     /* Write header... */
03033     fprintf(out,
03034             "# $1 = time [s]\n"
03035             "# $2 = altitude [km]\n"
03036             "# $3 = longitude [deg]\n"
03037             "# $4 = latitude [deg]\n"
03038             "# $5 = pressure [hPa]\n"
03039             "# $6 = temperature [K]\n"
03040             "# $7 = volume mixing ratio [1]\n"
03041             "# $8 = H2O volume mixing ratio [1]\n"
03042             "# $9 = O3 volume mixing ratio [1]\n"
03043             "# $10 = observed BT index (mean) [K]\n"
03044             "# $11 = observed BT index (sigma) [K]\n");
03045
03046     /* Set grid box size... */
03047     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
03048     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
03049     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
03050   }
03051
03052   /* Set time interval... */
03053   t0 = t - 0.5 * ctl->dt_mod;
03054   t1 = t + 0.5 * ctl->dt_mod;
03055
03056   /* Initialize... */
03057 #pragma omp parallel for default(shared) private(ix,iy,iz)
03058   for (ix = 0; ix < ctl->prof_nx; ix++)
03059     for (iy = 0; iy < ctl->prof_ny; iy++) {
03060       obsmean[ix][iy] = 0;
03061       obsmean2[ix][iy] = 0;
03062       obscount[ix][iy] = 0;
03063       for (iz = 0; iz < ctl->prof_nz; iz++)
03064         mass[ix][iy][iz] = 0;
03065     }
03066
03067   /* Read observation data... */
03068   while (fgets(line, LEN, in)) {
03069
03070     /* Read data... */
03071     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
03072         5)
03073       continue;
03074
03075     /* Check time... */
03076     if (rt < t0)
03077       continue;
03078     if (rt > t1)
03079       break;
03080
03081     /* Calculate indices... */
03082     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
03083     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
03084
03085     /* Check indices... */
03086     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
03087       continue;
03088
03089     /* Get mean observation index... */
03090     obsmean[ix][iy] += robs;
03091     obsmean2[ix][iy] += SQR(robs);
03092     obscount[ix][iy]++;
03093   }
03094
03095   /* Analyze model data... */
03096 #pragma omp parallel for default(shared) private(ip,ix,iy,iz)
03097   for (ip = 0; ip < atm->np; ip++) {
```

```
03098
03099     /* Check time... */
03100     if (atm->time[ip] < t0 || atm->time[ip] > t1)
03101       continue;
03102
03103     /* Get indices... */
03104     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
03105     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
03106     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
03107
03108     /* Check indices... */
03109     if (ix < 0 || ix >= ctl->prof_nx ||
03110         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
03111       continue;
03112
03113     /* Get total mass in grid cell... */
03114     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
03115   }
03116
03117   /* Extract profiles... */
03118   for (ix = 0; ix < ctl->prof_nx; ix++)
03119     for (iy = 0; iy < ctl->prof_ny; iy++)
03120       if (obscount[ix][iy] > 0) {
03121
03122         /* Check profile... */
03123         okay = 0;
03124         for (iz = 0; iz < ctl->prof_nz; iz++)
03125           if (mass[ix][iy][iz] > 0) {
03126             okay = 1;
03127             break;
03128           }
03129         if (!okay)
03130           continue;
03131
03132         /* Write output... */
03133         fprintf(out, "\n");
03134
03135         /* Loop over altitudes... */
03136         for (iz = 0; iz < ctl->prof_nz; iz++) {
03137
03138           /* Set coordinates... */
03139           z = ctl->prof_z0 + dz * (iz + 0.5);
03140           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
03141           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
03142
03143           /* Get pressure and temperature... */
03144           press = P(z);
03145           intpol_met_time(met0, met1, t, press, lon, lat, NULL, NULL,
03146                           NULL, &temp, NULL, NULL, NULL, NULL, &h2o, &o3);
03147
03148           /* Calculate surface area... */
03149           area = dlat * dlon * SQR(M_PI * RE / 180.)
03150             * cos(lat * M_PI / 180.);
03151
03152           /* Calculate volume mixing ratio... */
03153           rho_air = 100. * press / (RA * temp);
03154           vmr = MA / ctl->molmass * mass[ix][iy][iz]
03155             / (rho_air * area * dz * 1e9);
03156
03157           /* Write output... */
03158           fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g\n",
03159                   t, z, lon, lat, press, temp, vmr, h2o, o3,
03160                   obsmean[ix][iy] / obscount[ix][iy],
03161                   sqrt(obsmean2[ix][iy] / obscount[ix][iy]
03162                        - SQR(obsmean[ix][iy] / obscount[ix][iy])));
03163         }
03164       }
03165
03166   /* Close file... */
03167   if (t == ctl->t_stop)
03168     fclose(out);
03169 }
```

Here is the call graph for this function:



5.19.2.38 void write_station (const char * *filename*, ctl_t * *ctl*, atm_t * *atm*, double *t*)

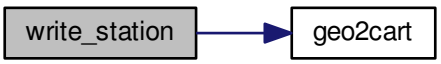
Write station data.

Definition at line 3173 of file libtrac.c.

```
03177           {
03178
03179   static FILE *out;
03180
03181   static double rmax2, t0, t1, x0[3], x1[3];
03182
03183   /* Init... */
03184   if (t == ctl->t_start) {
03185
03186     /* Write info... */
03187     printf("Write station data: %s\n", filename);
03188
03189     /* Create new file... */
03190     if (!(out = fopen(filename, "w")))
03191       ERRMSG("Cannot create file!");
03192
03193     /* Write header... */
03194     fprintf(out,
03195             "# $1 = time [s]\n"
03196             "# $2 = altitude [km]\n"
03197             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
03198     for (int iq = 0; iq < ctl->nq; iq++)
03199       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
03200               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
03201     fprintf(out, "\n");
03202
03203     /* Set geolocation and search radius... */
03204     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
03205     rmax2 = SQR(ctl->stat_r);
03206   }
03207
03208   /* Set time interval for output... */
03209   t0 = t - 0.5 * ctl->dt_mod;
03210   t1 = t + 0.5 * ctl->dt_mod;
03211
03212   /* Loop over air parcels... */
03213   for (int ip = 0; ip < atm->np; ip++) {
03214
03215     /* Check time... */
03216     if (atm->time[ip] < t0 || atm->time[ip] > t1)
03217       continue;
03218
03219     /* Check station flag... */
03220     if (ctl->qnt_stat >= 0)
03221       if (atm->q[ctl->qnt_stat][ip])
03222         continue;
03223
03224     /* Get Cartesian coordinates... */
03225     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
03226
```

```
03227     /* Check horizontal distance... */
03228     if (DIST2(x0, x1) > rmax2)
03229       continue;
03230
03231     /* Set station flag... */
03232     if (ctl->qnt_stat >= 0)
03233       atm->q[ctl->qnt_stat][ip] = 1;
03234
03235     /* Write data... */
03236     fprintf(out, "%.2f %g %g %g",
03237             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
03238     for (int iq = 0; iq < ctl->nq; iq++) {
03239       fprintf(out, " ");
03240       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
03241     }
03242     fprintf(out, "\n");
03243   }
03244
03245   /* Close file... */
03246   if (t == ctl->t_stop)
03247     fclose(out);
03248 }
```

Here is the call graph for this function:



5.20 libtrac.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 /*****************************************************************************/
00028
00029 void cart2geo(
00030   double *x,
00031   double *z,
00032   double *lon,
00033   double *lat) {
00034
00035   double radius = NORM(x);
00036   *lat = asin(x[2] / radius) * 180 / M_PI;
00037   *lon = atan2(x[1], x[0]) * 180 / M_PI;
00038   *z = radius - RE;
00039 }
00040
00041 /*****************************************************************************/
00042
00043 static double clim_hno3_secs[12] = {
```

```
00044   1209600.00, 3888000.00, 6393600.00,
00045   9072000.00, 11664000.00, 14342400.00,
00046   16934400.00, 19612800.00, 22291200.00,
00047   24883200.00, 27561600.00, 30153600.00
00048 };
00049
00050 #ifdef _OPENACC
00051 #pragma acc declare copyin(clim_hno3_secs)
00052 #endif
00053
00054 static double clim_hno3_lats[18] = {
00055   -85, -75, -65, -55, -45, -35, -25, -15, -5,
00056   5, 15, 25, 35, 45, 55, 65, 75, 85
00057 };
00058
00059 #ifdef _OPENACC
00060 #pragma acc declare copyin(clim_hno3_lats)
00061 #endif
00062
00063 static double clim_hno3_ps[10] = {
00064   4.64159, 6.81292, 10, 14.678, 21.5443,
00065   31.6228, 46.4159, 68.1292, 100, 146.78
00066 };
00067
00068 #ifdef _OPENACC
00069 #pragma acc declare copyin(clim_hno3_ps)
00070 #endif
00071
00072 static double clim_hno3_var[12][18][10] = {
00073   {{0.782, 1.65, 2.9, 4.59, 6.71, 8.25, 7.16, 5.75, 2.9, 1.74},
00074    {0.529, 1.64, 2.76, 4.55, 6.58, 8, 6.99, 5.55, 2.68, 1.57},
00075    {0.723, 1.55, 2.73, 4.48, 6.32, 7.58, 7.05, 5.16, 2.49, 1.54},
00076    {0.801, 1.56, 2.74, 4.52, 6.23, 7.35, 6.68, 4.4, 1.97, 1.23},
00077    {0.818, 1.62, 2.77, 4.38, 5.98, 6.84, 5.83, 3.05, 1.15, 0.709},
00078    {0.901, 1.73, 2.78, 4.21, 5.63, 6.16, 4.68, 1.87, 0.617, 0.37},
00079    {0.997, 1.8, 2.79, 4.09, 4.88, 4.96, 3.12, 1.22, 0.311, 0.244},
00080    {1, 1.71, 2.51, 3.4, 3.74, 3.39, 2.25, 0.845, 0.204, 0.222},
00081    {0.997, 1.7, 2.36, 2.88, 3.01, 2.25, 1.77, 0.608, 0.163, 0.181},
00082    {0.991, 1.79, 2.57, 3.06, 3.08, 2.15, 1.81, 0.59, 0.168, 0.104},
00083    {0.974, 1.86, 2.84, 3.8, 3.93, 3.79, 2.91, 1.02, 0.152, 0.0985},
00084    {0.85, 1.86, 3.3, 5.24, 6.55, 6.86, 5.12, 1.93, 0.378, 0.185},
00085    {0.783, 1.89, 3.85, 6.6, 8.56, 8.66, 6.95, 3.95, 1.47, 0.745},
00086    {0.883, 2.05, 4.34, 7.54, 9.68, 9.77, 8.19, 5.72, 3.15, 1.77},
00087    {1.4, 2.44, 4.72, 8.07, 10.5, 10.9, 9.28, 6.95, 4.47, 2.49},
00088    {1.7, 2.43, 4.24, 7.43, 10.4, 11.2, 9.72, 8.15, 5.7, 2.97},
00089    {2.06, 2.27, 3.68, 6.77, 10.3, 10.3, 9.05, 9.1, 6.73, 3.14},
00090    {2.33, 2.39, 3.51, 6.45, 10.3, 9.88, 8.57, 9.42, 7.22, 3.19}},
00091   {{0.947, 2.21, 3.81, 5.69, 7.55, 8.63, 7.53, 5.98, 3.03, 1.64},
00092    {0.642, 2, 3.4, 5.49, 7.5, 8.52, 7.53, 5.83, 2.74, 1.42},
00093    {0.756, 1.83, 3.18, 5.11, 7.24, 8.63, 7.66, 5.5, 2.45, 1.33},
00094    {0.837, 1.75, 3.06, 5, 6.79, 8.08, 7.05, 4.42, 1.81, 1.05},
00095    {0.86, 1.73, 2.96, 4.68, 6.38, 7.38, 6.09, 2.92, 1.06, 0.661},
00096    {0.926, 1.78, 2.89, 4.37, 5.74, 6.14, 4.59, 1.78, 0.561, 0.332},
00097    {0.988, 1.78, 2.75, 3.95, 4.64, 4.49, 2.85, 1.13, 0.271, 0.184},
00098    {0.999, 1.7, 2.44, 3.27, 3.57, 3.03, 2.06, 0.736, 0.181, 0.189},
00099    {0.971, 1.67, 2.23, 2.63, 2.83, 2.15, 1.74, 0.554, 0.157, 0.167},
00100    {0.985, 1.72, 2.34, 2.69, 2.81, 2.11, 1.78, 0.592, 0.152, 0.101},
00101    {0.95, 1.72, 2.57, 3.44, 3.84, 3.89, 2.91, 0.976, 0.135, 0.114},
00102    {0.819, 1.64, 2.93, 4.75, 6.02, 6.93, 5.2, 1.83, 0.347, 0.191},
00103    {0.731, 1.58, 3.3, 5.95, 7.81, 8.32, 6.93, 3.83, 1.47, 0.875},
00104    {0.77, 1.75, 3.74, 6.67, 8.76, 9.41, 8.19, 5.78, 3.32, 2.11},
00105    {1.08, 2.17, 4.24, 7.13, 9.2, 10.3, 9.03, 6.87, 4.65, 3.01},
00106    {1.43, 2.49, 4.31, 7, 9.14, 10.6, 9.34, 7.6, 5.86, 3.64},
00107    {1.5, 2.68, 4.32, 6.75, 8.78, 10.6, 9.05, 7.65, 6.27, 4.07},
00108    {1.73, 2.91, 4.33, 6.67, 8.73, 10.6, 8.5, 7.54, 6.63, 4.17}},
00109   {{1.43, 3.07, 5.22, 7.54, 9.78, 10.4, 10.1, 7.26, 3.61, 1.69},
00110    {0.989, 2.69, 4.76, 7.19, 9.44, 9.94, 9.5, 6.74, 3.24, 1.52},
00111    {0.908, 2.23, 4.11, 6.48, 8.74, 9.41, 8.58, 5.8, 2.66, 1.3},
00112    {0.923, 1.99, 3.61, 5.83, 7.84, 8.6, 7.55, 4.57, 1.87, 0.98},
00113    {0.933, 1.9, 3.31, 5.28, 7.1, 7.84, 6.44, 3.18, 1.1, 0.642},
00114    {0.982, 1.88, 3.1, 4.76, 6.16, 6.57, 5.16, 2.04, 0.598, 0.33},
00115    {1.02, 1.82, 2.88, 4.12, 4.71, 4.54, 3.03, 1.22, 0.268, 0.174},
00116    {0.992, 1.7, 2.51, 3.33, 3.62, 2.87, 2.05, 0.705, 0.161, 0.169},
00117    {0.969, 1.69, 2.2, 2.62, 2.84, 2.13, 1.78, 0.529, 0.146, 0.186},
00118    {0.945, 1.69, 2.27, 2.64, 2.83, 2.2, 1.83, 0.561, 0.139, 0.121},
00119    {0.922, 1.65, 2.48, 3.33, 3.83, 4.09, 2.92, 0.973, 0.117, 0.135},
00120    {0.886, 1.59, 2.66, 4.26, 5.51, 6.57, 5.09, 1.79, 0.342, 0.194},
00121    {0.786, 1.5, 2.78, 5.01, 6.8, 7.83, 6.65, 3.62, 1.45, 1},
00122    {0.745, 1.55, 3.05, 5.49, 7.44, 8.6, 7.8, 5.28, 2.95, 2.12},
00123    {0.938, 1.76, 3.4, 5.82, 7.8, 9.04, 8.43, 6.15, 3.85, 2.82},
00124    {0.999, 2, 3.66, 5.95, 7.94, 9.27, 8.8, 6.93, 4.87, 3.54},
00125    {1.13, 2.23, 3.86, 5.82, 7.65, 9, 8.82, 7.17, 5.72, 4.08},
00126    {1.23, 2.33, 3.94, 5.74, 7.48, 8.9, 8.84, 7.35, 6.3, 4.42}},
00127   {{1.55, 3.2, 6.25, 10, 12.9, 12.9, 11.9, 7.96, 3.96, 1.75},
00128    {1.32, 3.27, 6.32, 9.99, 12.7, 12.4, 11.3, 7.51, 3.66, 1.58},
00129    {1.25, 3.08, 5.77, 8.71, 11.2, 11.2, 9.84, 6.52, 3.23, 1.5},
00130    {1.18, 2.59, 4.76, 7.46, 9.61, 9.66, 8.42, 5.06, 2.25, 1.09},
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00131    {1.09, 2.24, 3.99, 6.4, 8.33, 8.54, 7.08, 3.69, 1.36, 0.727},
00132    {1.06, 2.07, 3.52, 5.52, 7.06, 7.26, 5.83, 2.46, 0.732, 0.409},
00133    {1.07, 1.91, 3.09, 4.63, 5.21, 4.9, 3.68, 1.43, 0.326, 0.198},
00134    {1.03, 1.74, 2.63, 3.54, 3.78, 2.89, 2.09, 0.743, 0.175, 0.12},
00135    {0.959, 1.71, 2.32, 2.77, 2.99, 2.24, 1.76, 0.519, 0.149, 0.172},
00136    {0.931, 1.68, 2.32, 2.74, 2.99, 2.46, 1.88, 0.578, 0.156, 0.157},
00137    {0.933, 1.66, 2.49, 3.42, 3.99, 4.12, 2.93, 1.02, 0.181, 0.138},
00138    {0.952, 1.64, 2.6, 4, 5.15, 6.07, 4.84, 1.78, 0.407, 0.286},
00139    {0.84, 1.54, 2.68, 4.47, 5.97, 7.13, 6.23, 3.25, 1.38, 1.02},
00140    {0.714, 1.44, 2.73, 4.68, 6.28, 7.68, 7.21, 4.82, 2.55, 1.96},
00141    {0.838, 1.57, 2.96, 4.93, 6.55, 8.08, 7.74, 5.77, 3.32, 2.52},
00142    {0.823, 1.65, 3.11, 5.09, 6.89, 8.36, 8.31, 6.59, 4.1, 3.04},
00143    {0.886, 1.83, 3.42, 5.33, 6.92, 8.36, 8.63, 7.21, 4.82, 3.46},
00144    {1.07, 2.12, 3.74, 5.54, 6.98, 8.41, 8.75, 7.41, 5.16, 3.62}},
00145   {{1.13, 2.59, 7.49, 13.5, 15.4, 12.9, 11.3, 8.62, 4.18, 1.63},
00146    {0.973, 2.79, 7.23, 12.8, 15.2, 13.3, 11.6, 8.42, 4.06, 1.57},
00147    {1.46, 3.44, 6.78, 10.4, 12.7, 12.1, 10.5, 7.04, 3.59, 1.63},
00148    {1.52, 3.38, 6.04, 9.08, 11, 10.3, 8.9, 5.7, 2.77, 1.37},
00149    {1.32, 2.65, 4.75, 7.49, 9.32, 8.89, 7.42, 4.27, 1.7, 0.88},
00150    {1.19, 2.2, 3.88, 6.36, 8.03, 7.81, 6.19, 2.94, 0.948, 0.527},
00151    {1.14, 1.96, 3.28, 5.26, 6.12, 5.8, 4.47, 1.66, 0.388, 0.229},
00152    {1.07, 1.82, 2.82, 3.92, 4.03, 3.15, 2.31, 0.871, 0.183, 0.0972},
00153    {0.978, 1.77, 2.53, 3.04, 3.1, 2.36, 1.76, 0.575, 0.16, 0.126},
00154    {0.962, 1.72, 2.49, 3.01, 3.22, 2.72, 2, 0.716, 0.162, 0.183},
00155    {0.968, 1.7, 2.6, 3.57, 4.28, 4.35, 3.09, 1.2, 0.262, 0.18},
00156    {0.977, 1.68, 2.71, 4.03, 5.17, 6.01, 4.81, 1.81, 0.473, 0.343},
00157    {0.819, 1.58, 2.75, 4.37, 5.8, 6.9, 5.96, 2.95, 1.19, 0.964},
00158    {0.672, 1.44, 2.69, 4.42, 5.92, 7.26, 6.79, 4.32, 2.22, 1.83},
00159    {0.783, 1.42, 2.65, 4.45, 6.04, 7.57, 7.39, 5.4, 2.94, 2.25},
00160    {0.757, 1.43, 2.7, 4.54, 6.14, 7.65, 7.51, 5.95, 3.42, 2.39},
00161    {0.758, 1.57, 3.04, 4.88, 6.24, 7.85, 7.58, 6.35, 3.81, 2.52},
00162    {0.835, 1.72, 3.35, 5.24, 6.5, 8.1, 7.67, 6.51, 4, 2.6}},
00163   {{1.5, 2.12, 7.64, 10.5, 5.59, 2.14, 2.2, 3.5, 4.71, 3.26},
00164    {1.32, 2.14, 7.23, 12, 9.3, 5.3, 5.11, 5.37, 5.12, 3.05},
00165    {1.53, 2.92, 6.9, 11.9, 13.5, 11.3, 9.91, 7.18, 4.75, 2.65},
00166    {1.66, 3.48, 6.25, 9.53, 11.3, 10.3, 9.01, 5.76, 2.99, 1.67},
00167    {1.54, 3.03, 5.21, 8.03, 9.66, 8.98, 7.5, 4.64, 2.11, 1.13},
00168    {1.32, 2.39, 4.03, 6.74, 8.52, 8.05, 6.4, 3.48, 1.2, 0.639},
00169    {1.17, 2.08, 3.35, 5.52, 6.86, 6.54, 5.08, 1.97, 0.462, 0.217},
00170    {1.07, 1.92, 3.01, 4.24, 4.47, 3.77, 2.77, 1.07, 0.213, 0.0694},
00171    {0.992, 1.88, 2.76, 3.39, 3.32, 2.52, 1.8, 0.713, 0.192, 0.136},
00172    {0.992, 1.8, 2.63, 3.34, 3.46, 2.95, 2.09, 0.9, 0.242, 0.194},
00173    {0.987, 1.77, 2.67, 3.64, 4.37, 4.36, 3, 1.27, 0.354, 0.229},
00174    {0.979, 1.74, 2.77, 3.99, 5.12, 5.75, 4.53, 1.75, 0.555, 0.302},
00175    {0.832, 1.6, 2.78, 4.32, 5.53, 6.67, 5.69, 2.59, 0.982, 0.66},
00176    {0.696, 1.41, 2.64, 4.31, 5.65, 7.14, 6.56, 3.8, 1.75, 1.41},
00177    {0.788, 1.36, 2.59, 4.3, 5.73, 7.35, 7.04, 4.82, 2.41, 1.8},
00178    {0.761, 1.43, 2.61, 4.28, 5.64, 7.37, 7.11, 5.37, 2.68, 1.9},
00179    {0.701, 1.44, 2.82, 4.64, 5.76, 7.63, 7.07, 5.74, 2.98, 1.88},
00180    {0.763, 1.5, 2.95, 4.97, 6.08, 7.88, 7.12, 5.98, 3.21, 1.91}},
00181   {{3.58, 2.59, 6.49, 5.84, 1.63, 0.282, 0.647, 0.371, 1.36, 2.33},
00182    {3.09, 2.38, 6.37, 7.66, 4.06, 1.23, 1.8, 1.65, 2.32, 2.78},
00183    {2.31, 2.84, 5.58, 9.63, 11, 9.02, 8.2, 6.23, 4.17, 3.08},
00184    {1.61, 3.16, 5.72, 9.13, 11.4, 10.4, 9.15, 6.18, 3.52, 2.3},
00185    {1.32, 2.8, 4.79, 7.44, 9.43, 8.83, 7.41, 4.9, 2.38, 1.38},
00186    {1.14, 2.36, 3.94, 6.41, 8.38, 8.17, 6.53, 3.76, 1.31, 0.656},
00187    {1.05, 2.1, 3.36, 5.45, 7.07, 6.98, 5.44, 2.22, 0.52, 0.176},
00188    {1.02, 2, 3.05, 4.33, 4.74, 4.21, 3.2, 1.26, 0.277, 0.0705},
00189    {1.01, 1.96, 2.9, 3.53, 3.46, 2.69, 1.89, 0.859, 0.254, 0.12},
00190    {1.01, 1.86, 2.7, 3.46, 3.59, 3.03, 2.14, 1, 0.34, 0.199},
00191    {1.02, 1.81, 2.67, 3.68, 4.39, 4.3, 2.93, 1.35, 0.477, 0.25},
00192    {0.991, 1.79, 2.82, 4.05, 5.08, 5.5, 4.21, 1.74, 0.605, 0.259},
00193    {0.844, 1.73, 2.87, 4.38, 5.49, 6.47, 5.5, 2.44, 0.85, 0.422},
00194    {0.729, 1.57, 2.76, 4.43, 5.73, 7.13, 6.43, 3.52, 1.38, 0.913},
00195    {0.819, 1.46, 2.69, 4.45, 5.92, 7.47, 7.05, 4.52, 2, 1.4},
00196    {0.783, 1.47, 2.71, 4.48, 5.92, 7.46, 7.16, 5.08, 2.35, 1.56},
00197    {0.735, 1.51, 2.96, 4.84, 5.92, 7.77, 7.2, 5.54, 2.56, 1.61},
00198    {0.8, 1.61, 3.14, 5.2, 6.26, 8.08, 7.27, 5.72, 2.75, 1.62}},
00199   {{5, 4.43, 5.53, 5.35, 2.33, 0.384, 0.663, 0.164, 0.692, 1.4},
00200    {3.62, 3.79, 4.77, 5.94, 4.12, 1.36, 1.3, 0.973, 1.37, 1.73},
00201    {2.11, 2.7, 4.12, 7.14, 9.03, 7.74, 7.12, 5.44, 3.73, 2.6},
00202    {1.13, 2.32, 4.12, 6.97, 9.86, 9.69, 8.85, 6.22, 3.59, 2.14},
00203    {0.957, 2.28, 4.11, 6.47, 8.66, 8.78, 7.33, 4.94, 2.44, 1.38},
00204    {0.881, 2.1, 3.65, 5.94, 7.98, 8.29, 6.69, 3.95, 1.36, 0.672},
00205    {0.867, 1.96, 3.26, 5.23, 6.94, 7.2, 5.63, 2.41, 0.578, 0.19},
00206    {0.953, 1.94, 2.98, 4.23, 4.83, 4.52, 3.38, 1.34, 0.293, 0.181},
00207    {1.01, 1.91, 2.77, 3.35, 3.3, 2.62, 1.99, 0.905, 0.245, 0.107},
00208    {1.03, 1.81, 2.57, 3.29, 3.43, 2.87, 2.13, 0.988, 0.306, 0.185},
00209    {1.02, 1.78, 2.58, 3.59, 4.19, 4, 2.72, 1.29, 0.389, 0.224},
00210    {1.01, 1.84, 2.84, 4.06, 4.9, 5.08, 3.71, 1.64, 0.529, 0.232},
00211    {0.902, 1.84, 2.98, 4.43, 5.5, 6.28, 5.18, 2.35, 0.734, 0.341},
00212    {0.785, 1.68, 2.93, 4.67, 5.95, 7.3, 6.52, 3.48, 1.24, 0.754},
00213    {0.847, 1.62, 2.94, 4.86, 6.38, 7.99, 7.5, 4.64, 1.93, 1.23},
00214    {0.8, 1.6, 2.94, 4.95, 6.62, 8.16, 7.91, 5.43, 2.43, 1.45},
00215    {0.82, 1.76, 3.37, 5.47, 6.82, 8.24, 7.73, 5.79, 2.69, 1.5},
00216    {0.988, 2.05, 3.87, 6.01, 7.18, 8.41, 7.7, 5.93, 2.89, 1.55}},
00217   {{1.52, 2.7, 3.79, 4.95, 3.8, 1.51, 1.11, 0.784, 1.1, 1.56},
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00218    {1.19, 2.16, 3.34, 4.76, 4.61, 2.93, 2.07, 1.65, 1.63, 1.74},
00219    {0.804, 1.65, 2.79, 4.63, 6.64, 6.95, 6.68, 5.11, 3.3, 2.09},
00220    {0.86, 1.8, 3.25, 5.3, 7.91, 8.76, 8.28, 6.01, 3.39, 1.83},
00221    {0.859, 1.95, 3.54, 5.64, 7.88, 8.55, 7.3, 4.88, 2.3, 1.22},
00222    {0.809, 1.88, 3.38, 5.45, 7.47, 8.02, 6.69, 3.98, 1.35, 0.646},
00223    {0.822, 1.81, 3.11, 4.9, 6.62, 6.96, 5.63, 2.47, 0.614, 0.169},
00224    {0.92, 1.83, 2.8, 3.93, 4.56, 4.4, 3.25, 1.31, 0.295, 0.0587},
00225    {0.986, 1.83, 2.6, 3.13, 3.08, 2.53, 1.94, 0.886, 0.244, 0.0815},
00226    {0.997, 1.74, 2.5, 3.16, 3.24, 2.67, 2.05, 0.939, 0.281, 0.147},
00227    {1.01, 1.75, 2.57, 3.55, 4.1, 3.81, 2.53, 1.21, 0.354, 0.197},
00228    {1.04, 1.88, 2.9, 4.16, 4.95, 4.96, 3.48, 1.63, 0.502, 0.163},
00229    {0.967, 1.95, 3.17, 4.72, 5.85, 6.5, 5.34, 2.53, 0.748, 0.303},
00230    {0.846, 1.83, 3.23, 5.15, 6.62, 7.82, 6.85, 3.79, 1.36, 0.714},
00231    {0.91, 1.81, 3.35, 5.55, 7.32, 8.55, 7.88, 5.03, 2.13, 1.1},
00232    {0.87, 1.94, 3.6, 5.97, 7.98, 9.14, 8.71, 6.04, 2.73, 1.41},
00233    {1.04, 2.36, 4.22, 6.57, 8.5, 9.53, 9.22, 6.71, 3.2, 1.56},
00234    {1.36, 2.84, 4.72, 6.94, 8.81, 9.87, 9.59, 7.1, 3.43, 1.65}},
00235   {{0.704, 1.4, 2.03, 3.08, 4.64, 4.24, 2.55, 1.57, 1.99, 1.91},
00236    {0.484, 1.38, 2.08, 3.54, 5.11, 4.98, 3.73, 2.57, 2.29, 1.84},
00237    {0.749, 1.57, 2.63, 4.17, 6.15, 6.97, 6.64, 5.11, 3.35, 1.97},
00238    {0.864, 1.69, 3.16, 4.87, 7.13, 8.33, 7.87, 5.9, 3.17, 1.56},
00239    {0.861, 1.79, 3.28, 5.2, 7.29, 8.32, 7.38, 4.9, 2.23, 1.11},
00240    {0.835, 1.79, 3.19, 4.99, 6.72, 7.58, 6.45, 3.68, 1.25, 0.616},
00241    {0.847, 1.8, 3.07, 4.66, 6.12, 6.6, 5.21, 2.18, 0.554, 0.21},
00242    {0.941, 1.78, 2.68, 3.68, 4.28, 4.18, 2.97, 1.15, 0.238, 0.0968},
00243    {0.98, 1.78, 2.48, 2.99, 2.96, 2.35, 1.88, 0.747, 0.207, 0.105},
00244    {0.978, 1.74, 2.51, 3.07, 3.12, 2.36, 1.95, 0.777, 0.216, 0.146},
00245    {1.01, 1.79, 2.63, 3.53, 3.95, 3.47, 2.38, 1.08, 0.265, 0.178},
00246    {1.06, 1.94, 3.02, 4.43, 5.19, 5.01, 3.68, 1.71, 0.429, 0.14},
00247    {0.99, 2.02, 3.38, 5.22, 6.56, 6.91, 5.56, 2.75, 0.816, 0.353},
00248    {0.923, 2.05, 3.66, 5.98, 7.78, 8.5, 7.23, 4.26, 1.67, 0.802},
00249    {1.08, 2.27, 4.17, 6.8, 8.89, 9.55, 8.59, 5.64, 2.58, 1.2},
00250    {1.12, 2.5, 4.52, 7.22, 9.76, 10.3, 9.72, 6.79, 3.32, 1.52},
00251    {1.2, 2.64, 4.81, 7.64, 10.5, 11.4, 10.6, 7.65, 3.87, 1.73},
00252    {1.4, 2.91, 5.01, 7.75, 10.7, 11.6, 11.1, 8.02, 4.04, 1.8}},
00253   {{0.75, 1.49, 2.39, 3.39, 4.93, 5.94, 5.03, 2.75, 2.27, 1.78},
00254    {0.508, 1.52, 2.38, 3.82, 5.34, 6.13, 5.6, 3.31, 2.42, 1.73},
00255    {0.715, 1.56, 2.7, 4.39, 6.18, 6.96, 7.1, 5.04, 3.01, 1.75},
00256    {0.813, 1.62, 2.94, 4.65, 6.53, 7.65, 7.52, 5.49, 2.75, 1.41},
00257    {0.802, 1.68, 2.97, 4.64, 6.37, 7.53, 7.01, 4.56, 1.9, 0.955},
00258    {0.816, 1.75, 3.01, 4.59, 6.15, 7.06, 6.15, 3.38, 1.11, 0.61},
00259    {0.867, 1.78, 2.92, 4.35, 5.69, 6.05, 4.73, 1.91, 0.519, 0.269},
00260    {0.932, 1.7, 2.55, 3.44, 4.03, 3.98, 2.74, 1.08, 0.247, 0.132},
00261    {0.937, 1.74, 2.51, 3.09, 3.11, 2.34, 1.84, 0.67, 0.189, 0.121},
00262    {0.942, 1.75, 2.63, 3.3, 3.27, 2.21, 1.87, 0.663, 0.171, 0.147},
00263    {0.959, 1.8, 2.82, 3.78, 4.03, 3.37, 2.53, 1.04, 0.199, 0.146},
00264    {1.01, 1.9, 3.13, 4.76, 5.63, 5.6, 4.31, 1.83, 0.367, 0.172},
00265    {0.989, 2.04, 3.64, 6, 7.62, 7.6, 6, 3.35, 1.05, 0.448},
00266    {1.02, 2.28, 4.32, 7.19, 9.21, 9.16, 7.64, 4.97, 2.2, 0.948},
00267    {1.26, 2.77, 5.2, 8.31, 10.5, 10.4, 9.01, 6.37, 3.46, 1.56},
00268    {1.31, 2.76, 5.23, 8.49, 11.2, 11.3, 10.1, 7.27, 3.98, 1.76},
00269    {1.26, 2.5, 5.14, 8.85, 12.3, 12.3, 11.2, 8.13, 4.45, 1.97},
00270    {1.35, 2.49, 5.26, 9.16, 13, 12.8, 11.8, 8.57, 4.72, 2.05}},
00271   {{0.759, 1.54, 2.54, 4.22, 6.26, 7.44, 7.14, 4.99, 2.84, 1.89},
00272    {0.508, 1.55, 2.5, 4.29, 6.29, 7.29, 7.07, 5.03, 2.77, 1.74},
00273    {0.699, 1.56, 2.62, 4.17, 6.08, 7.38, 7.04, 5.17, 2.81, 1.65},
00274    {0.778, 1.5, 2.65, 4.35, 6.07, 7.28, 6.84, 4.8, 2.28, 1.28},
00275    {0.772, 1.55, 2.71, 4.3, 5.76, 6.91, 6.2, 3.69, 1.45, 0.837},
00276    {0.836, 1.67, 2.78, 4.21, 5.56, 6.41, 5.33, 2.47, 0.807, 0.488},
00277    {0.937, 1.79, 2.78, 4.12, 5.17, 5.38, 3.89, 1.47, 0.392, 0.256},
00278    {0.97, 1.75, 2.52, 3.39, 3.83, 3.63, 2.48, 0.968, 0.212, 0.198},
00279    {0.968, 1.74, 2.5, 3.11, 3.2, 2.34, 1.79, 0.629, 0.169, 0.173},
00280    {0.98, 1.8, 2.69, 3.42, 3.4, 2.18, 1.81, 0.606, 0.164, 0.138},
00281    {0.975, 1.84, 2.96, 4.08, 4.12, 3.5, 2.79, 1.02, 0.145, 0.133},
00282    {0.96, 1.94, 3.27, 5.17, 6.26, 6.35, 4.88, 1.91, 0.329, 0.189},
00283    {0.954, 2.06, 3.8, 6.53, 8.46, 8.32, 6.53, 3.83, 1.32, 0.6},
00284    {1, 2.34, 4.58, 7.71, 9.68, 9.75, 7.96, 5.45, 2.84, 1.39},
00285    {1.24, 2.65, 5.14, 8.51, 10.7, 10.6, 8.96, 6.51, 3.83, 1.85},
00286    {1.34, 2.44, 4.99, 8.63, 11.6, 11.4, 10.1, 7.84, 4.77, 2.24},
00287    {1.33, 2.1, 4.76, 8.78, 12.2, 11.7, 10.8, 8.68, 5.15, 2.35},
00288    {1.42, 2.04, 4.68, 8.92, 12.7, 12, 11.2, 8.99, 5.32, 2.33}}
00289 };
00290
00291 #ifdef _OPENACC
00292 #pragma acc declare copyin(clim_hno3_var)
00293 #endif
00294
00295 double clim_hno3(
00296   double t,
00297   double lat,
00298   double p) {
00299
00300   /* Get seconds since begin of year... */
00301   double sec = FMOD(t, 365.25 * 86400.);
00302
00303   /* Get indices... */
00304   int isec = locate_irr(clim_hno3_secs, 12, sec);
```

```
00305   int ilat = locate_reg(clim_hno3_lats, 18, lat);
00306   int ip = locate_irr(clim_hno3_ps, 10, p);
00307
00308   /* Interpolate... */
00309   double aux00 = LIN(clim_hno3_ps[ip], clim_hno3_var[isec][ilat][ip],
00310                      clim_hno3_ps[ip + 1], clim_hno3_var[isec][ilat][ip + 1],
00311                      p);
00312   double aux01 = LIN(clim_hno3_ps[ip], clim_hno3_var[isec][ilat + 1][ip],
00313                      clim_hno3_ps[ip + 1],
00314                      clim_hno3_var[isec][ilat + 1][ip + 1], p);
00315   double aux10 = LIN(clim_hno3_ps[ip], clim_hno3_var[isec + 1][ilat][ip],
00316                      clim_hno3_ps[ip + 1],
00317                      clim_hno3_var[isec + 1][ilat][ip + 1], p);
00318   double aux11 = LIN(clim_hno3_ps[ip], clim_hno3_var[isec + 1][ilat + 1][ip],
00319                      clim_hno3_ps[ip + 1],
00320                      clim_hno3_var[isec + 1][ilat + 1][ip + 1],
00321                      p);
00322   aux00 =
00323     LIN(clim_hno3_lats[ilat], aux00, clim_hno3_lats[ilat + 1], aux01, lat);
00324   aux11 =
00325     LIN(clim_hno3_lats[ilat], aux10, clim_hno3_lats[ilat + 1], aux11, lat);
00326   return LIN(clim_hno3_secs[isec], aux00, clim_hno3_secs[isec + 1], aux11,
00327              sec);
00328 }
00329
00330 /*****************************************************************************/
00331
00332 static double clim_tropo_doys[12]
00333 = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00334
00335 #ifdef _OPENACC
00336 #pragma acc declare copyin(clim_tropo_doys)
00337 #endif
00338
00339 static double clim_tropo_lats[73]
00340   = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
00341   -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
00342   -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
00343   -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
00344   15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
00345   45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
00346   75, 77.5, 80, 82.5, 85, 87.5, 90
00347 };
00348
00349 #ifdef _OPENACC
00350 #pragma acc declare copyin(clim_tropo_lats)
00351 #endif
00352
00353 static double clim_tropo_tps[12][73]
00354   = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
00355        297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
00356        175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
00357        99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
00358        98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
00359        152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
00360        277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
00361        275.3, 275.6, 275.4, 274.1, 273.5},
00362 {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
00363  300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
00364  150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
00365  98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
00366  98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
00367  220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
00368  284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
00369  287.5, 286.2, 285.8},
00370 {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
00371  297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
00372  161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
00373  100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
00374  99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
00375  186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
00376  279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
00377  304.3, 304.9, 306, 306.6, 306.2, 306},
00378 {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
00379  290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
00380  195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
00381  102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
00382  99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
00383  148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
00384  263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
00385  315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
00386 {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
00387  260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
00388  205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
00389  101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
00390  102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
00391  165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
```

```
00392  273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
00393  325.3, 325.8, 325.8},
00394 {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
00395  222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
00396  228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
00397  105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
00398  106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
00399  127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
00400  251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
00401  308.5, 312.2, 313.1, 313.3},
00402 {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
00403  187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
00404  235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
00405  110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
00406  111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
00407  117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
00408  224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
00409  275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
00410 {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
00411  185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
00412  233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
00413  110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
00414  112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
00415  120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
00416  230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
00417  278.2, 282.6, 287.4, 290.9, 292.5, 293},
00418 {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
00419  183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
00420  243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
00421  114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
00422  110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
00423  114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
00424  203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
00425  276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
00426 {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
00427  215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
00428  237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
00429  111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
00430  106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
00431  112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
00432  206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
00433  279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
00434  305.1},
00435 {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
00436  253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
00437  223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
00438  108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
00439  102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
00440  109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
00441  241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
00442  286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
00443 {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
00444  284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
00445  175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
00446  100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
00447  100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
00448  186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
00449  280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
00450  281.7, 281.1, 281.2}
00451 };
00452
00453 #ifdef _OPENACC
00454 #pragma acc declare copyin(clim_tropo_tps)
00455 #endif
00456
00457 double clim_tropo(
00458   double t,
00459   double lat) {
00460
00461   /* Get day of year... */
00462   double doy = FMOD(t / 86400., 365.25);
00463   while (doy < 0)
00464     doy += 365.25;
00465
00466   /* Get indices... */
00467   int ilat = locate_reg(clim_tropo_lats, 73, lat);
00468   int imon = locate_irr(clim_tropo_doys, 12, doy);
00469
00470   /* Interpolate... */
00471   double p0 = LIN(clim_tropo_lats[ilat], clim_tropo_tps[imon][ilat],
00472                   clim_tropo_lats[ilat + 1], clim_tropo_tps[imon][ilat + 1],
00473                   lat);
00474   double p1 = LIN(clim_tropo_lats[ilat], clim_tropo_tps[imon + 1][ilat],
00475                   clim_tropo_lats[ilat + 1],
00476                   clim_tropo_tps[imon + 1][ilat + 1],
00477                   lat);
00478   return LIN(clim_tropo_doys[imon], p0, clim_tropo_doys[imon + 1], p1, doy);
```

```
00479 }
00480
00481 /*****************************************************************************/
00482
00483 void day2doy(
00484   int year,
00485   int mon,
00486   int day,
00487   int *doy) {
00488
00489   int d0[12] = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00490   int d0l[12] = { 1, 32, 61, 92, 122, 153, 183, 214, 245, 275, 306, 336 };
00491
00492   /* Get day of year... */
00493   if (year % 400 == 0 || (year % 100 != 0 && year % 4 == 0))
00494     *doy = d0l[mon - 1] + day - 1;
00495   else
00496     *doy = d0[mon - 1] + day - 1;
00497 }
00498
00499 /*****************************************************************************/
00500
00501 void doy2day(
00502   int year,
00503   int doy,
00504   int *mon,
00505   int *day) {
00506
00507   int d0[12] = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00508   int d0l[12] = { 1, 32, 61, 92, 122, 153, 183, 214, 245, 275, 306, 336 };
00509   int i;
00510
00511   /* Get month and day... */
00512   if (year % 400 == 0 || (year % 100 != 0 && year % 4 == 0)) {
00513     for (i = 11; i >= 0; i--)
00514       if (d0l[i] <= doy)
00515         break;
00516     *mon = i + 1;
00517     *day = doy - d0l[i] + 1;
00518   } else {
00519     for (i = 11; i >= 0; i--)
00520       if (d0[i] <= doy)
00521         break;
00522     *mon = i + 1;
00523     *day = doy - d0[i] + 1;
00524   }
00525 }
00526
00527 /*****************************************************************************/
00528
00529 void geo2cart(
00530   double z,
00531   double lon,
00532   double lat,
00533   double *x) {
00534
00535   double radius = z + RE;
00536   x[0] = radius * cos(lat / 180 * M_PI) * cos(lon / 180 * M_PI);
00537   x[1] = radius * cos(lat / 180 * M_PI) * sin(lon / 180 * M_PI);
00538   x[2] = radius * sin(lat / 180 * M_PI);
00539 }
00540
00541 /*****************************************************************************/
00542
00543 void get_met(
00544   ctl_t * ctl,
00545   char *metbase,
00546   double t,
00547   met_t ** met0,
00548   met_t ** met1) {
00549
00550   static int init, ip, ix, iy;
00551
00552   met_t *mets;
00553
00554   char filename[LEN];
00555
00556   /* Init... */
00557   if (t == ctl->t_start || !init) {
00558     init = 1;
00559
00560     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00561     if (!read_met(ctl, filename, *met0))
00562       ERRMSG("Cannot open file!");
00563
00564     get_met_help(t + 1.0 * ctl->direction, 1, metbase, ctl->
      dt_met, filename);
```

```
00565     if (!read_met(ctl, filename, *met1))
00566       ERRMSG("Cannot open file!");
00567 #ifdef _OPENACC
00568     met_t *met0up = *met0;
00569     met_t *met1up = *met1;
00570 #pragma acc update device(met0up[:1],met1up[:1])
00571 #endif
00572   }
00573
00574   /* Read new data for forward trajectories... */
00575   if (t > (*met1)->time && ctl->direction == 1) {
00576     mets = *met1;
00577     *met1 = *met0;
00578     *met0 = mets;
00579     get_met_help(t, 1, metbase, ctl->dt_met, filename);
00580     if (!read_met(ctl, filename, *met1))
00581       ERRMSG("Cannot open file!");
00582 #ifdef _OPENACC
00583     met_t *met1up = *met1;
00584 #pragma acc update device(met1up[:1])
00585 #endif
00586   }
00587
00588   /* Read new data for backward trajectories... */
00589   if (t < (*met0)->time && ctl->direction == -1) {
00590     mets = *met1;
00591     *met1 = *met0;
00592     *met0 = mets;
00593     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00594     if (!read_met(ctl, filename, *met0))
00595       ERRMSG("Cannot open file!");
00596 #ifdef _OPENACC
00597     met_t *met0up = *met0;
00598 #pragma acc update device(met0up[:1])
00599 #endif
00600   }
00601
00602   /* Check that grids are consistent... */
00603   if ((*met0)->nx != (*met1)->nx
00604       || (*met0)->ny != (*met1)->ny || (*met0)->np != (*met1)->np)
00605     ERRMSG("Meteo grid dimensions do not match!");
00606   for (ix = 0; ix < (*met0)->nx; ix++)
00607     if ((*met0)->lon[ix] != (*met1)->lon[ix])
00608       ERRMSG("Meteo grid longitudes do not match!");
00609   for (iy = 0; iy < (*met0)->ny; iy++)
00610     if ((*met0)->lat[iy] != (*met1)->lat[iy])
00611       ERRMSG("Meteo grid latitudes do not match!");
00612   for (ip = 0; ip < (*met0)->np; ip++)
00613     if ((*met0)->p[ip] != (*met1)->p[ip])
00614       ERRMSG("Meteo grid pressure levels do not match!");
00615 }
00616
00617 /*****************************************************************************/
00618
00619 void get_met_help(
00620   double t,
00621   int direct,
00622   char *metbase,
00623   double dt_met,
00624   char *filename) {
00625
00626   char repl[LEN];
00627
00628   double t6, r;
00629
00630   int year, mon, day, hour, min, sec;
00631
00632   /* Round time to fixed intervals... */
00633   if (direct == -1)
00634     t6 = floor(t / dt_met) * dt_met;
00635   else
00636     t6 = ceil(t / dt_met) * dt_met;
00637
00638   /* Decode time... */
00639   jsec2time(t6, &year, &mon, &day, &hour, &min, &sec, &r);
00640
00641   /* Set filename... */
00642   sprintf(filename, "%s_YYYY_MM_DD_HH.nc", metbase);
00643   sprintf(repl, "%d", year);
00644   get_met_replace(filename, "YYYY", repl);
00645   sprintf(repl, "%02d", mon);
00646   get_met_replace(filename, "MM", repl);
00647   sprintf(repl, "%02d", day);
00648   get_met_replace(filename, "DD", repl);
00649   sprintf(repl, "%02d", hour);
00650   get_met_replace(filename, "HH", repl);
00651 }
```

```
00652
00653 /*****************************************************************************/
00654
00655 void get_met_replace(
00656   char *orig,
00657   char *search,
00658   char *repl) {
00659
00660   char buffer[LEN], *ch;
00661
00662   /* Iterate... */
00663   for (int i = 0; i < 3; i++) {
00664
00665     /* Replace substring... */
00666     if (!(ch = strstr(orig, search)))
00667       return;
00668     strncpy(buffer, orig, (size_t) (ch - orig));
00669     buffer[ch - orig] = 0;
00670     sprintf(buffer + (ch - orig), "%s%s", repl, ch + strlen(search));
00671     orig[0] = 0;
00672     strcpy(orig, buffer);
00673   }
00674 }
00675
00676 /*****************************************************************************/
00677
00678 double intpol_met_2d(
00679   double array[EX][EY],
00680   int ix,
00681   int iy,
00682   double wx,
00683   double wy) {
00684
00685   /* Set variables... */
00686   double aux00 = array[ix][iy];
00687   double aux01 = array[ix][iy + 1];
00688   double aux10 = array[ix + 1][iy];
00689   double aux11 = array[ix + 1][iy + 1];
00690
00691   /* Interpolate horizontally... */
00692   aux00 = wy * (aux00 - aux01) + aux01;
00693   aux11 = wy * (aux10 - aux11) + aux11;
00694   return wx * (aux00 - aux11) + aux11;
00695 }
00696
00697 /*****************************************************************************/
00698
00699 double intpol_met_3d(
00700   float array[EX][EY][EP],
00701   int ip,
00702   int ix,
00703   int iy,
00704   double wp,
00705   double wx,
00706   double wy) {
00707
00708   /* Interpolate vertically... */
00709   double aux00 = wp * (array[ix][iy][ip] - array[ix][iy][ip + 1])
00710     + array[ix][iy][ip + 1];
00711   double aux01 = wp * (array[ix][iy + 1][ip] - array[ix][iy + 1][ip + 1])
00712     + array[ix][iy + 1][ip + 1];
00713   double aux10 = wp * (array[ix + 1][iy][ip] - array[ix + 1][iy][ip + 1])
00714     + array[ix + 1][iy][ip + 1];
00715   double aux11 =
00716     wp * (array[ix + 1][iy + 1][ip] - array[ix + 1][iy + 1][ip + 1])
00717     + array[ix + 1][iy + 1][ip + 1];
00718
00719   /* Interpolate horizontally... */
00720   aux00 = wy * (aux00 - aux01) + aux01;
00721   aux11 = wy * (aux10 - aux11) + aux11;
00722   return wx * (aux00 - aux11) + aux11;
00723 }
00724
00725 /*****************************************************************************/
00726
00727 void intpol_met_space(
00728   met_t * met,
00729   double p,
00730   double lon,
00731   double lat,
00732   double *ps,
00733   double *pt,
00734   double *z,
00735   double *t,
00736   double *u,
00737   double *v,
00738   double *w,
```

```
00739   double *pv,
00740   double *h2o,
00741   double *o3) {
00742
00743   /* Check longitude... */
00744   if (met->lon[met->nx - 1] > 180 && lon < 0)
00745     lon += 360;
00746
00747   /* Get indices... */
00748   int ip = locate_irr(met->p, met->np, p);
00749   int ix = locate_reg(met->lon, met->nx, lon);
00750   int iy = locate_reg(met->lat, met->ny, lat);
00751
00752   /* Get weights... */
00753   double wp = (met->p[ip + 1] - p) / (met->p[ip + 1] - met->p[ip]);
00754   double wx = (met->lon[ix + 1] - lon) / (met->lon[ix + 1] - met->lon[ix]);
00755   double wy = (met->lat[iy + 1] - lat) / (met->lat[iy + 1] - met->lat[iy]);
00756
00757   /* Interpolate... */
00758   if (ps != NULL)
00759     *ps = intpol_met_2d(met->ps, ix, iy, wx, wy);
00760   if (pt != NULL)
00761     *pt = intpol_met_2d(met->pt, ix, iy, wx, wy);
00762   if (z != NULL)
00763     *z = intpol_met_3d(met->z, ip, ix, iy, wp, wx, wy);
00764   if (t != NULL)
00765     *t = intpol_met_3d(met->t, ip, ix, iy, wp, wx, wy);
00766   if (u != NULL)
00767     *u = intpol_met_3d(met->u, ip, ix, iy, wp, wx, wy);
00768   if (v != NULL)
00769     *v = intpol_met_3d(met->v, ip, ix, iy, wp, wx, wy);
00770   if (w != NULL)
00771     *w = intpol_met_3d(met->w, ip, ix, iy, wp, wx, wy);
00772   if (pv != NULL)
00773     *pv = intpol_met_3d(met->pv, ip, ix, iy, wp, wx, wy);
00774   if (h2o != NULL)
00775     *h2o = intpol_met_3d(met->h2o, ip, ix, iy, wp, wx, wy);
00776   if (o3 != NULL)
00777     *o3 = intpol_met_3d(met->o3, ip, ix, iy, wp, wx, wy);
00778 }
00779
00780 /*****************************************************************************/
00781
00782 void intpol_met_time(
00783   met_t * met0,
00784   met_t * met1,
00785   double ts,
00786   double p,
00787   double lon,
00788   double lat,
00789   double *ps,
00790   double *pt,
00791   double *z,
00792   double *t,
00793   double *u,
00794   double *v,
00795   double *w,
00796   double *pv,
00797   double *h2o,
00798   double *o3) {
00799
00800   double h2o0, h2o1, o30, o31, ps0, ps1, pt0, pt1, pv0, pv1, t0, t1, u0, u1,
00801     v0, v1, w0, w1, wt, z0, z1;
00802
00803   /* Spatial interpolation... */
00804   intpol_met_space(met0, p, lon, lat,
00805                    ps == NULL ? NULL : &ps0,
00806                    pt == NULL ? NULL : &pt0,
00807                    z == NULL ? NULL : &z0,
00808                    t == NULL ? NULL : &t0,
00809                    u == NULL ? NULL : &u0,
00810                    v == NULL ? NULL : &v0,
00811                    w == NULL ? NULL : &w0,
00812                    pv == NULL ? NULL : &pv0,
00813                    h2o == NULL ? NULL : &h2o0, o3 == NULL ? NULL : &o30);
00814   intpol_met_space(met1, p, lon, lat,
00815                    ps == NULL ? NULL : &ps1,
00816                    pt == NULL ? NULL : &pt1,
00817                    z == NULL ? NULL : &z1,
00818                    t == NULL ? NULL : &t1,
00819                    u == NULL ? NULL : &u1,
00820                    v == NULL ? NULL : &v1,
00821                    w == NULL ? NULL : &w1,
00822                    pv == NULL ? NULL : &pv1,
00823                    h2o == NULL ? NULL : &h2o1, o3 == NULL ? NULL : &o31);
00824
00825   /* Get weighting factor... */
```

```
00826   wt = (met1->time - ts) / (met1->time - met0->time);
00827
00828   /* Interpolate... */
00829   if (ps != NULL)
00830     *ps = wt * (ps0 - ps1) + ps1;
00831   if (pt != NULL)
00832     *pt = wt * (pt0 - pt1) + pt1;
00833   if (z != NULL)
00834     *z = wt * (z0 - z1) + z1;
00835   if (t != NULL)
00836     *t = wt * (t0 - t1) + t1;
00837   if (u != NULL)
00838     *u = wt * (u0 - u1) + u1;
00839   if (v != NULL)
00840     *v = wt * (v0 - v1) + v1;
00841   if (w != NULL)
00842     *w = wt * (w0 - w1) + w1;
00843   if (pv != NULL)
00844     *pv = wt * (pv0 - pv1) + pv1;
00845   if (h2o != NULL)
00846     *h2o = wt * (h2o0 - h2o1) + h2o1;
00847   if (o3 != NULL)
00848     *o3 = wt * (o30 - o31) + o31;
00849 }
00850
00851 /*****************************************************************************/
00852
00853 void jsec2time(
00854   double jsec,
00855   int *year,
00856   int *mon,
00857   int *day,
00858   int *hour,
00859   int *min,
00860   int *sec,
00861   double *remain) {
00862
00863   struct tm t0, *t1;
00864
00865   t0.tm_year = 100;
00866   t0.tm_mon = 0;
00867   t0.tm_mday = 1;
00868   t0.tm_hour = 0;
00869   t0.tm_min = 0;
00870   t0.tm_sec = 0;
00871
00872   time_t jsec0 = (time_t) jsec + timegm(&t0);
00873   t1 = gmtime(&jsec0);
00874
00875   *year = t1->tm_year + 1900;
00876   *mon = t1->tm_mon + 1;
00877   *day = t1->tm_mday;
00878   *hour = t1->tm_hour;
00879   *min = t1->tm_min;
00880   *sec = t1->tm_sec;
00881   *remain = jsec - floor(jsec);
00882 }
00883
00884 /*****************************************************************************/
00885
00886 int locate_irr(
00887   double *xx,
00888   int n,
00889   double x) {
00890
00891   int ilo = 0;
00892   int ihi = n - 1;
00893   int i = (ihi + ilo) >> 1;
00894
00895   if (xx[i] < xx[i + 1])
00896     while (ihi > ilo + 1) {
00897       i = (ihi + ilo) >> 1;
00898       if (xx[i] > x)
00899         ihi = i;
00900       else
00901         ilo = i;
00902   } else
00903     while (ihi > ilo + 1) {
00904       i = (ihi + ilo) >> 1;
00905       if (xx[i] <= x)
00906         ihi = i;
00907       else
00908         ilo = i;
00909     }
00910
00911   return ilo;
00912 }
```

```
00913
00914 /*****************************************************************************/
00915
00916 int locate_reg(
00917   double *xx,
00918   int n,
00919   double x) {
00920
00921   /* Calculate index... */
00922   int i = (int) ((x - xx[0]) / (xx[1] - xx[0]));
00923
00924   /* Check range... */
00925   if (i < 0)
00926     i = 0;
00927   else if (i >= n - 2)
00928     i = n - 2;
00929
00930   return i;
00931 }
00932
00933 /*****************************************************************************/
00934
00935 int read_atm(
00936   const char *filename,
00937   ctl_t * ctl,
00938   atm_t * atm) {
00939
00940   FILE *in;
00941
00942   char line[LEN], *tok;
00943
00944   double t0;
00945
00946   int dimid, ip, iq, ncid, varid;
00947
00948   size_t nparts;
00949
00950   /* Init... */
00951   atm->np = 0;
00952
00953   /* Write info... */
00954   printf("Read atmospheric data: %s\n", filename);
00955
00956   /* Read ASCII data... */
00957   if (ctl->atm_type == 0) {
00958
00959     /* Open file... */
00960     if (!(in = fopen(filename, "r"))) {
00961       WARN("File not found!");
00962       return 0;
00963     }
00964
00965     /* Read line... */
00966     while (fgets(line, LEN, in)) {
00967
00968       /* Read data... */
00969       TOK(line, tok, "%lg", atm->time[atm->np]);
00970       TOK(NULL, tok, "%lg", atm->p[atm->np]);
00971       TOK(NULL, tok, "%lg", atm->lon[atm->np]);
00972       TOK(NULL, tok, "%lg", atm->lat[atm->np]);
00973       for (iq = 0; iq < ctl->nq; iq++)
00974         TOK(NULL, tok, "%lg", atm->q[iq][atm->np]);
00975
00976       /* Convert altitude to pressure... */
00977       atm->p[atm->np] = P(atm->p[atm->np]);
00978
00979       /* Increment data point counter... */
00980       if ((++atm->np) > NP)
00981         ERRMSG("Too many data points!");
00982     }
00983
00984     /* Close file... */
00985     fclose(in);
00986   }
00987
00988   /* Read binary data... */
00989   else if (ctl->atm_type == 1) {
00990
00991     /* Open file... */
00992     if (!(in = fopen(filename, "r")))
00993       return 0;
00994
00995     /* Read data... */
00996     FREAD(&atm->np, int, 1, in);
00997     FREAD(atm->time, double,
00998           (size_t) atm->np,
00999           in);
```

```
01000     FREAD(atm->p, double,
01001           (size_t) atm->np,
01002           in);
01003     FREAD(atm->lon, double,
01004           (size_t) atm->np,
01005           in);
01006     FREAD(atm->lat, double,
01007           (size_t) atm->np,
01008           in);
01009     for (iq = 0; iq < ctl->nq; iq++)
01010       FREAD(atm->q[iq], double,
01011             (size_t) atm->np,
01012             in);
01013
01014     /* Close file... */
01015     fclose(in);
01016   }
01017
01018   /* Read netCDF data... */
01019   else if (ctl->atm_type == 2) {
01020
01021     /* Open file... */
01022     if (nc_open(filename, NC_NOWRITE, &ncid) != NC_NOERR)
01023       return 0;
01024
01025     /* Get dimensions... */
01026     NC(nc_inq_dimid(ncid, "NPARTS", &dimid));
01027     NC(nc_inq_dimlen(ncid, dimid, &nparts));
01028     atm->np = (int) nparts;
01029     if (atm->np > NP)
01030       ERRMSG("Too many particles!");
01031
01032     /* Get time... */
01033     NC(nc_inq_varid(ncid, "time", &varid));
01034     NC(nc_get_var_double(ncid, varid, &t0));
01035     for (ip = 0; ip < atm->np; ip++)
01036       atm->time[ip] = t0;
01037
01038     /* Read geolocations... */
01039     NC(nc_inq_varid(ncid, "PRESS", &varid));
01040     NC(nc_get_var_double(ncid, varid, atm->p));
01041     NC(nc_inq_varid(ncid, "LON", &varid));
01042     NC(nc_get_var_double(ncid, varid, atm->lon));
01043     NC(nc_inq_varid(ncid, "LAT", &varid));
01044     NC(nc_get_var_double(ncid, varid, atm->lat));
01045
01046     /* Read variables... */
01047     if (ctl->qnt_p >= 0)
01048       if (nc_inq_varid(ncid, "PRESS", &varid) == NC_NOERR)
01049         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_p]));
01050     if (ctl->qnt_t >= 0)
01051       if (nc_inq_varid(ncid, "TEMP", &varid) == NC_NOERR)
01052         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_t]));
01053     if (ctl->qnt_u >= 0)
01054       if (nc_inq_varid(ncid, "U", &varid) == NC_NOERR)
01055         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_u]));
01056     if (ctl->qnt_v >= 0)
01057       if (nc_inq_varid(ncid, "V", &varid) == NC_NOERR)
01058         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_v]));
01059     if (ctl->qnt_w >= 0)
01060       if (nc_inq_varid(ncid, "W", &varid) == NC_NOERR)
01061         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_w]));
01062     if (ctl->qnt_h2o >= 0)
01063       if (nc_inq_varid(ncid, "SH", &varid) == NC_NOERR)
01064         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_h2o]));
01065     if (ctl->qnt_o3 >= 0)
01066       if (nc_inq_varid(ncid, "O3", &varid) == NC_NOERR)
01067         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_o3]));
01068     if (ctl->qnt_theta >= 0)
01069       if (nc_inq_varid(ncid, "THETA", &varid) == NC_NOERR)
01070         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_theta]));
01071     if (ctl->qnt_pv >= 0)
01072       if (nc_inq_varid(ncid, "PV", &varid) == NC_NOERR)
01073         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_pv]));
01074
01075     /* Check data... */
01076     for (ip = 0; ip < atm->np; ip++)
01077       if (fabs(atm->lon[ip]) > 360 || fabs(atm->lat[ip]) > 90
01078           || (ctl->qnt_t >= 0 && fabs(atm->q[ctl->qnt_t][ip]) > 350)
01079           || (ctl->qnt_h2o >= 0 && fabs(atm->q[ctl->qnt_h2o][ip]) > 1)
01080           || (ctl->qnt_theta >= 0 && fabs(atm->q[ctl->qnt_theta][ip]) > 1e10)
01081           || (ctl->qnt_pv >= 0 && fabs(atm->q[ctl->qnt_pv][ip]) > 1e10)) {
01082         atm->time[ip] = GSL_NAN;
01083         atm->p[ip] = GSL_NAN;
01084         atm->lon[ip] = GSL_NAN;
01085         atm->lat[ip] = GSL_NAN;
01086         for (iq = 0; iq < ctl->nq; iq++)
```

```
01087           atm->q[iq][ip] = GSL_NAN;
01088       } else {
01089         if (ctl->qnt_h2o >= 0)
01090           atm->q[ctl->qnt_h2o][ip] *= 1.608;
01091         if (ctl->qnt_pv >= 0)
01092           atm->q[ctl->qnt_pv][ip] *= 1e6;
01093         if (atm->lon[ip] > 180)
01094           atm->lon[ip] -= 360;
01095       }
01096
01097     /* Close file... */
01098     NC(nc_close(ncid));
01099   }
01100
01101   /* Error... */
01102   else
01103     ERRMSG("Atmospheric data type not supported!");
01104
01105   /* Check number of points... */
01106   if (atm->np < 1)
01107     ERRMSG("Can not read any data!");
01108
01109   /* Return success... */
01110   return 1;
01111 }
01112
01113 /*****************************************************************************/
01114
01115 void read_ctl(
01116   const char *filename,
01117   int argc,
01118   char *argv[],
01119   ctl_t * ctl) {
01120
01121   /* Write info... */
01122   printf("\nMassive-Parallel Trajectory Calculations (MPTRAC)\n"
01123          "(executable: %s | compiled: %s, %s)\n\n",
01124          argv[0], __DATE__, __TIME__);
01125
01126   /* Initialize quantity indices... */
01127   ctl->qnt_ens = -1;
01128   ctl->qnt_m = -1;
01129   ctl->qnt_r = -1;
01130   ctl->qnt_rho = -1;
01131   ctl->qnt_ps = -1;
01132   ctl->qnt_pt = -1;
01133   ctl->qnt_z = -1;
01134   ctl->qnt_p = -1;
01135   ctl->qnt_t = -1;
01136   ctl->qnt_u = -1;
01137   ctl->qnt_v = -1;
01138   ctl->qnt_w = -1;
01139   ctl->qnt_h2o = -1;
01140   ctl->qnt_o3 = -1;
01141   ctl->qnt_theta = -1;
01142   ctl->qnt_vh = -1;
01143   ctl->qnt_vz = -1;
01144   ctl->qnt_pv = -1;
01145   ctl->qnt_tice = -1;
01146   ctl->qnt_tsts = -1;
01147   ctl->qnt_tnat = -1;
01148   ctl->qnt_stat = -1;
01149
01150   /* Read quantities... */
01151   ctl->nq = (int) scan_ctl(filename, argc, argv, "NQ", -1, "0", NULL);
01152   if (ctl->nq > NQ)
01153     ERRMSG("Too many quantities!");
01154   for (int iq = 0; iq < ctl->nq; iq++) {
01155
01156     /* Read quantity name and format... */
01157     scan_ctl(filename, argc, argv, "QNT_NAME", iq, "", ctl->qnt_name[iq]);
01158     scan_ctl(filename, argc, argv, "QNT_FORMAT", iq, "%g",
01159              ctl->qnt_format[iq]);
01160
01161     /* Try to identify quantity... */
01162     if (strcmp(ctl->qnt_name[iq], "ens") == 0) {
01163       ctl->qnt_ens = iq;
01164       sprintf(ctl->qnt_unit[iq], "-");
01165     } else if (strcmp(ctl->qnt_name[iq], "m") == 0) {
01166       ctl->qnt_m = iq;
01167       sprintf(ctl->qnt_unit[iq], "kg");
01168     } else if (strcmp(ctl->qnt_name[iq], "r") == 0) {
01169       ctl->qnt_r = iq;
01170       sprintf(ctl->qnt_unit[iq], "m");
01171     } else if (strcmp(ctl->qnt_name[iq], "rho") == 0) {
01172       ctl->qnt_rho = iq;
01173       sprintf(ctl->qnt_unit[iq], "kg/m^3");
```

```
01174     } else if (strcmp(ctl->qnt_name[iq], "ps") == 0) {
01175       ctl->qnt_ps = iq;
01176       sprintf(ctl->qnt_unit[iq], "hPa");
01177     } else if (strcmp(ctl->qnt_name[iq], "pt") == 0) {
01178       ctl->qnt_pt = iq;
01179       sprintf(ctl->qnt_unit[iq], "hPa");
01180     } else if (strcmp(ctl->qnt_name[iq], "z") == 0) {
01181       ctl->qnt_z = iq;
01182       sprintf(ctl->qnt_unit[iq], "km");
01183     } else if (strcmp(ctl->qnt_name[iq], "p") == 0) {
01184       ctl->qnt_p = iq;
01185       sprintf(ctl->qnt_unit[iq], "hPa");
01186     } else if (strcmp(ctl->qnt_name[iq], "t") == 0) {
01187       ctl->qnt_t = iq;
01188       sprintf(ctl->qnt_unit[iq], "K");
01189     } else if (strcmp(ctl->qnt_name[iq], "u") == 0) {
01190       ctl->qnt_u = iq;
01191       sprintf(ctl->qnt_unit[iq], "m/s");
01192     } else if (strcmp(ctl->qnt_name[iq], "v") == 0) {
01193       ctl->qnt_v = iq;
01194       sprintf(ctl->qnt_unit[iq], "m/s");
01195     } else if (strcmp(ctl->qnt_name[iq], "w") == 0) {
01196       ctl->qnt_w = iq;
01197       sprintf(ctl->qnt_unit[iq], "hPa/s");
01198     } else if (strcmp(ctl->qnt_name[iq], "h2o") == 0) {
01199       ctl->qnt_h2o = iq;
01200       sprintf(ctl->qnt_unit[iq], "1");
01201     } else if (strcmp(ctl->qnt_name[iq], "o3") == 0) {
01202       ctl->qnt_o3 = iq;
01203       sprintf(ctl->qnt_unit[iq], "1");
01204     } else if (strcmp(ctl->qnt_name[iq], "theta") == 0) {
01205       ctl->qnt_theta = iq;
01206       sprintf(ctl->qnt_unit[iq], "K");
01207     } else if (strcmp(ctl->qnt_name[iq], "vh") == 0) {
01208       ctl->qnt_vh = iq;
01209       sprintf(ctl->qnt_unit[iq], "m/s");
01210     } else if (strcmp(ctl->qnt_name[iq], "vz") == 0) {
01211       ctl->qnt_vz = iq;
01212       sprintf(ctl->qnt_unit[iq], "m/s");
01213     } else if (strcmp(ctl->qnt_name[iq], "pv") == 0) {
01214       ctl->qnt_pv = iq;
01215       sprintf(ctl->qnt_unit[iq], "PVU");
01216     } else if (strcmp(ctl->qnt_name[iq], "tice") == 0) {
01217       ctl->qnt_tice = iq;
01218       sprintf(ctl->qnt_unit[iq], "K");
01219     } else if (strcmp(ctl->qnt_name[iq], "tsts") == 0) {
01220       ctl->qnt_tsts = iq;
01221       sprintf(ctl->qnt_unit[iq], "K");
01222     } else if (strcmp(ctl->qnt_name[iq], "tnat") == 0) {
01223       ctl->qnt_tnat = iq;
01224       sprintf(ctl->qnt_unit[iq], "K");
01225     } else if (strcmp(ctl->qnt_name[iq], "stat") == 0) {
01226       ctl->qnt_stat = iq;
01227       sprintf(ctl->qnt_unit[iq], "-");
01228     } else
01229       scan_ctl(filename, argc, argv, "QNT_UNIT", iq, "", ctl->qnt_unit[iq]);
01230   }
01231
01232   /* Check quantity flags... */
01233   if (ctl->qnt_tsts >= 0)
01234     if (ctl->qnt_tice < 0 || ctl->qnt_tnat < 0)
01235       ERRMSG("Need T_ice and T_NAT to calculate T_STS!");
01236
01237   /* Time steps of simulation... */
01238   ctl->direction =
01239     (int) scan_ctl(filename, argc, argv, "DIRECTION", -1, "1", NULL);
01240   if (ctl->direction != -1 && ctl->direction != 1)
01241     ERRMSG("Set DIRECTION to -1 or 1!");
01242   ctl->t_stop = scan_ctl(filename, argc, argv, "T_STOP", -1, "1e100", NULL);
01243   ctl->dt_mod = scan_ctl(filename, argc, argv, "DT_MOD", -1, "600", NULL);
01244
01245   /* Meteorological data... */
01246   ctl->dt_met = scan_ctl(filename, argc, argv, "DT_MET", -1, "21600", NULL);
01247   ctl->met_dx = (int) scan_ctl(filename, argc, argv, "MET_DX", -1, "1", NULL);
01248   ctl->met_dy = (int) scan_ctl(filename, argc, argv, "MET_DY", -1, "1", NULL);
01249   ctl->met_dp = (int) scan_ctl(filename, argc, argv, "MET_DP", -1, "1", NULL);
01250   ctl->met_sx = (int) scan_ctl(filename, argc, argv, "MET_SX", -1, "1", NULL);
01251   ctl->met_sy = (int) scan_ctl(filename, argc, argv, "MET_SY", -1, "1", NULL);
01252   ctl->met_sp = (int) scan_ctl(filename, argc, argv, "MET_SP", -1, "1", NULL);
01253   ctl->met_np = (int) scan_ctl(filename, argc, argv, "MET_NP", -1, "0", NULL);
01254   if (ctl->met_np > EP)
01255     ERRMSG("Too many levels!");
01256   for (int ip = 0; ip < ctl->met_np; ip++)
01257     ctl->met_p[ip] = scan_ctl(filename, argc, argv, "MET_P", ip, "", NULL);
01258   ctl->met_tropo
01259     = (int) scan_ctl(filename, argc, argv, "MET_TROPO", -1, "0", NULL);
01260   scan_ctl(filename, argc, argv, "MET_GEOPOT", -1, "-", ctl->met_geopot);
```

```
01261   scan_ctl(filename, argc, argv, "MET_STAGE", -1, "-", ctl->met_stage);
01262   ctl->met_dt_out =
01263     scan_ctl(filename, argc, argv, "MET_DT_OUT", -1, "0.1", NULL);
01264
01265   /* Isosurface parameters... */
01266   ctl->isosurf
01267     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
01268   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
01269
01270   /* Diffusion parameters... */
01271   ctl->turb_dx_trop
01272     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50", NULL);
01273   ctl->turb_dx_strat
01274     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0", NULL);
01275   ctl->turb_dz_trop
01276     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0", NULL);
01277   ctl->turb_dz_strat
01278     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
01279   ctl->turb_mesox =
01280     scan_ctl(filename, argc, argv, "TURB_MESOX", -1, "0.16", NULL);
01281   ctl->turb_mesoz =
01282     scan_ctl(filename, argc, argv, "TURB_MESOZ", -1, "0.16", NULL);
01283
01284   /* Mass and life time... */
01285   ctl->molmass = scan_ctl(filename, argc, argv, "MOLMASS", -1, "1", NULL);
01286   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
01287   ctl->tdec_strat =
01288     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
01289
01290   /* PSC analysis... */
01291   ctl->psc_h2o = scan_ctl(filename, argc, argv, "PSC_H2O", -1, "4e-6", NULL);
01292   ctl->psc_hno3 =
01293     scan_ctl(filename, argc, argv, "PSC_HNO3", -1, "9e-9", NULL);
01294
01295   /* Output of atmospheric data... */
01296   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
      atm_basename);
01297   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
01298   ctl->atm_dt_out =
01299     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
01300   ctl->atm_filter =
01301     (int) scan_ctl(filename, argc, argv, "ATM_FILTER", -1, "0", NULL);
01302   ctl->atm_stride =
01303     (int) scan_ctl(filename, argc, argv, "ATM_STRIDE", -1, "1", NULL);
01304   ctl->atm_type =
01305     (int) scan_ctl(filename, argc, argv, "ATM_TYPE", -1, "0", NULL);
01306
01307   /* Output of CSI data... */
01308   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
      csi_basename);
01309   ctl->csi_dt_out =
01310     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
01311   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "-", ctl->
      csi_obsfile);
01312   ctl->csi_obsmin =
01313     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
01314   ctl->csi_modmin =
01315     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
01316   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
01317   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
01318   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
01319   ctl->csi_lon0 =
01320     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
01321   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
01322   ctl->csi_nx =
01323     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
01324   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
01325   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
01326   ctl->csi_ny =
01327     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
01328
01329   /* Output of ensemble data... */
01330   scan_ctl(filename, argc, argv, "ENS_BASENAME", -1, "-", ctl->
      ens_basename);
01331
01332   /* Output of grid data... */
01333   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
01334            ctl->grid_basename);
01335   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
      grid_gpfile);
01336   ctl->grid_dt_out =
01337     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
01338   ctl->grid_sparse =
01339     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
01340   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
01341   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
01342   ctl->grid_nz =
```

```
01343     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
01344   ctl->grid_lon0 =
01345     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
01346   ctl->grid_lon1 =
01347     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
01348   ctl->grid_nx =
01349     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
01350   ctl->grid_lat0 =
01351     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
01352   ctl->grid_lat1 =
01353     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
01354   ctl->grid_ny =
01355     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
01356
01357   /* Output of profile data... */
01358   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
01359            ctl->prof_basename);
01360   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
      prof_obsfile);
01361   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
01362   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
01363   ctl->prof_nz =
01364     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
01365   ctl->prof_lon0 =
01366     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
01367   ctl->prof_lon1 =
01368     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
01369   ctl->prof_nx =
01370     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
01371   ctl->prof_lat0 =
01372     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
01373   ctl->prof_lat1 =
01374     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
01375   ctl->prof_ny =
01376     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
01377
01378   /* Output of station data... */
01379   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
01380            ctl->stat_basename);
01381   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
01382   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
01383   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
01384 }
01385
01386 /*****************************************************************************/
01387
01388 int read_met(
01389   ctl_t * ctl,
01390   char *filename,
01391   met_t * met) {
01392
01393   char cmd[2 * LEN], levname[LEN], tstr[10];
01394
01395   float help[EX * EY];
01396
01397   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
01398
01399   size_t np, nx, ny;
01400
01401   /* Write info... */
01402   printf("Read meteorological data: %s\n", filename);
01403
01404   /* Get time from filename... */
01405   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
01406   year = atoi(tstr);
01407   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
01408   mon = atoi(tstr);
01409   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
01410   day = atoi(tstr);
01411   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
01412   hour = atoi(tstr);
01413   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
01414
01415   /* Open netCDF file... */
01416   if (nc_open(filename, NC_NOWRITE, &ncid) != NC_NOERR) {
01417
01418     /* Try to stage meteo file... */
01419     if (ctl->met_stage[0] != '-') {
01420       sprintf(cmd, "%s %d %02d %02d %02d %s", ctl->met_stage,
01421               year, mon, day, hour, filename);
01422       if (system(cmd) != 0)
01423         ERRMSG("Error while staging meteo data!");
01424     }
01425
01426     /* Try to open again... */
01427     if (nc_open(filename, NC_NOWRITE, &ncid) != NC_NOERR) {
01428       WARN("File not found!");
```

```
01429       return 0;
01430     }
01431   }
01432
01433   /* Get dimensions... */
01434   NC(nc_inq_dimid(ncid, "lon", &dimid));
01435   NC(nc_inq_dimlen(ncid, dimid, &nx));
01436   if (nx < 2 || nx > EX)
01437     ERRMSG("Number of longitudes out of range!");
01438
01439   NC(nc_inq_dimid(ncid, "lat", &dimid));
01440   NC(nc_inq_dimlen(ncid, dimid, &ny));
01441   if (ny < 2 || ny > EY)
01442     ERRMSG("Number of latitudes out of range!");
01443
01444   sprintf(levname, "lev");
01445   NC(nc_inq_dimid(ncid, levname, &dimid));
01446   NC(nc_inq_dimlen(ncid, dimid, &np));
01447   if (np == 1) {
01448     sprintf(levname, "lev_2");
01449     NC(nc_inq_dimid(ncid, levname, &dimid));
01450     NC(nc_inq_dimlen(ncid, dimid, &np));
01451   }
01452   if (np < 2 || np > EP)
01453     ERRMSG("Number of levels out of range!");
01454
01455   /* Store dimensions... */
01456   met->np = (int) np;
01457   met->nx = (int) nx;
01458   met->ny = (int) ny;
01459
01460   /* Get horizontal grid... */
01461   NC(nc_inq_varid(ncid, "lon", &varid));
01462   NC(nc_get_var_double(ncid, varid, met->lon));
01463   NC(nc_inq_varid(ncid, "lat", &varid));
01464   NC(nc_get_var_double(ncid, varid, met->lat));
01465
01466   /* Read meteorological data... */
01467   read_met_help(ncid, "t", "T", met, met->t, 1.0);
01468   read_met_help(ncid, "u", "U", met, met->u, 1.0);
01469   read_met_help(ncid, "v", "V", met, met->v, 1.0);
01470   read_met_help(ncid, "w", "W", met, met->w, 0.01f);
01471   read_met_help(ncid, "q", "Q", met, met->h2o, (float) (MA / 18.01528));
01472   read_met_help(ncid, "o3", "O3", met, met->o3, (float) (MA / 48.00));
01473
01474   /* Meteo data on pressure levels... */
01475   if (ctl->met_np <= 0) {
01476
01477     /* Read pressure levels from file... */
01478     NC(nc_inq_varid(ncid, levname, &varid));
01479     NC(nc_get_var_double(ncid, varid, met->p));
01480     for (ip = 0; ip < met->np; ip++)
01481       met->p[ip] /= 100.;
01482
01483     /* Extrapolate data for lower boundary... */
01484     read_met_extrapolate(met);
01485   }
01486
01487   /* Meteo data on model levels... */
01488   else {
01489
01490     /* Read pressure data from file... */
01491     read_met_help(ncid, "pl", "PL", met, met->pl, 0.01f);
01492
01493     /* Interpolate from model levels to pressure levels... */
01494     read_met_ml2pl(ctl, met, met->t);
01495     read_met_ml2pl(ctl, met, met->u);
01496     read_met_ml2pl(ctl, met, met->v);
01497     read_met_ml2pl(ctl, met, met->w);
01498     read_met_ml2pl(ctl, met, met->h2o);
01499     read_met_ml2pl(ctl, met, met->o3);
01500
01501     /* Set pressure levels... */
01502     met->np = ctl->met_np;
01503     for (ip = 0; ip < met->np; ip++)
01504       met->p[ip] = ctl->met_p[ip];
01505   }
01506
01507   /* Check ordering of pressure levels... */
01508   for (ip = 1; ip < met->np; ip++)
01509     if (met->p[ip - 1] < met->p[ip])
01510       ERRMSG("Pressure levels must be descending!");
01511
01512   /* Read surface pressure... */
01513   if (nc_inq_varid(ncid, "ps", &varid) == NC_NOERR
01514       || nc_inq_varid(ncid, "PS", &varid) == NC_NOERR) {
01515     NC(nc_get_var_float(ncid, varid, help));
```

```
01516     for (iy = 0; iy < met->ny; iy++)
01517       for (ix = 0; ix < met->nx; ix++)
01518         met->ps[ix][iy] = help[iy * met->nx + ix] / 100.;
01519   } else if (nc_inq_varid(ncid, "lnsp", &varid) == NC_NOERR
01520              || nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
01521     NC(nc_get_var_float(ncid, varid, help));
01522     for (iy = 0; iy < met->ny; iy++)
01523       for (ix = 0; ix < met->nx; ix++)
01524         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
01525   } else
01526     for (ix = 0; ix < met->nx; ix++)
01527       for (iy = 0; iy < met->ny; iy++)
01528         met->ps[ix][iy] = met->p[0];
01529
01530   /* Create periodic boundary conditions... */
01531   read_met_periodic(met);
01532
01533   /* Calculate geopotential heights... */
01534   read_met_geopot(ctl, met);
01535
01536   /* Calculate potential vorticity... */
01537   read_met_pv(met);
01538
01539   /* Calculate tropopause pressure... */
01540   read_met_tropo(ctl, met);
01541
01542   /* Downsampling... */
01543   read_met_sample(ctl, met);
01544
01545   /* Close file... */
01546   NC(nc_close(ncid));
01547
01548   /* Return success... */
01549   return 1;
01550 }
01551
01552 /*****************************************************************************/
01553
01554 void read_met_extrapolate(
01555   met_t * met) {
01556
01557   int ip, ip0, ix, iy;
01558
01559   /* Loop over columns... */
01560 #pragma omp parallel for default(shared) private(ix,iy,ip0,ip)
01561   for (ix = 0; ix < met->nx; ix++)
01562     for (iy = 0; iy < met->ny; iy++) {
01563
01564       /* Find lowest valid data point... */
01565       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
01566         if (!gsl_finite(met->t[ix][iy][ip0])
01567             || !gsl_finite(met->u[ix][iy][ip0])
01568             || !gsl_finite(met->v[ix][iy][ip0])
01569             || !gsl_finite(met->w[ix][iy][ip0]))
01570           break;
01571
01572       /* Extrapolate... */
01573       for (ip = ip0; ip >= 0; ip--) {
01574         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
01575         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
01576         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
01577         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
01578         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
01579         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
01580       }
01581     }
01582 }
01583
01584 /*****************************************************************************/
01585
01586 void read_met_geopot(
01587   ctl_t * ctl,
01588   met_t * met) {
01589
01590   const int dx = 6, dy = 4;
01591
01592   static double logp[EP], topo_lat[EY], topo_lon[EX], topo_z[EX][EY];
01593
01594   static float help[EX][EY][EP];
01595
01596   static int init, topo_nx = -1, topo_ny;
01597
01598   FILE *in;
01599
01600   char line[LEN];
01601
01602   double lat, lon, rlat, rlon, rlon_old = -999, rz, ts, z0, z1;
```

```
01603
01604   int ip, ip0, ix, ix2, ix3, iy, iy2, n, tx, ty;
01605
01606   /* Initialize geopotential heights... */
01607 #pragma omp parallel for default(shared) private(ix,iy,ip)
01608   for (ix = 0; ix < met->nx; ix++)
01609     for (iy = 0; iy < met->ny; iy++)
01610       for (ip = 0; ip < met->np; ip++)
01611         met->z[ix][iy][ip] = GSL_NAN;
01612
01613   /* Check filename... */
01614   if (ctl->met_geopot[0] == '-')
01615     return;
01616
01617   /* Read surface geopotential... */
01618   if (!init) {
01619     init = 1;
01620
01621     /* Write info... */
01622     printf("Read surface geopotential: %s\n", ctl->met_geopot);
01623
01624     /* Open file... */
01625     if (!(in = fopen(ctl->met_geopot, "r")))
01626       ERRMSG("Cannot open file!");
01627
01628     /* Read data... */
01629     while (fgets(line, LEN, in))
01630       if (sscanf(line, "%lg %lg %lg", &rlon, &rlat, &rz) == 3) {
01631         if (rlon != rlon_old) {
01632           if ((++topo_nx) > EX)
01633             ERRMSG("Too many longitudes!");
01634           topo_ny = 0;
01635         }
01636         rlon_old = rlon;
01637         topo_lon[topo_nx] = rlon;
01638         topo_lat[topo_ny] = rlat;
01639         topo_z[topo_nx][topo_ny] = rz;
01640         if ((++topo_ny) > EY)
01641           ERRMSG("Too many latitudes!");
01642       }
01643     if ((++topo_nx) > EX)
01644       ERRMSG("Too many longitudes!");
01645
01646     /* Close file... */
01647     fclose(in);
01648
01649     /* Check grid spacing... */
01650     if (fabs(met->lon[0] - met->lon[1]) != fabs(topo_lon[0] - topo_lon[1])
01651         || fabs(met->lat[0] - met->lat[1]) != fabs(topo_lat[0] - topo_lat[1]))
01652       WARN("Grid spacing does not match!");
01653
01654     /* Calculate log pressure... */
01655     for (ip = 0; ip < met->np; ip++)
01656       logp[ip] = log(met->p[ip]);
01657   }
01658
01659   /* Apply hydrostatic equation to calculate geopotential heights... */
01660 #pragma omp parallel for default(shared) private(ix,iy,lon,lat,tx,ty,z0,z1,ip0,ts,ip)
01661   for (ix = 0; ix < met->nx; ix++) {
01662
01663     /* Get longitude index... */
01664     lon = met->lon[ix];
01665     if (lon < topo_lon[0])
01666       lon += 360;
01667     else if (lon > topo_lon[topo_nx - 1])
01668       lon -= 360;
01669     tx = locate_reg(topo_lon, topo_nx, lon);
01670
01671     /* Loop over latitudes... */
01672     for (iy = 0; iy < met->ny; iy++) {
01673
01674       /* Get latitude index... */
01675       lat = met->lat[iy];
01676       ty = locate_reg(topo_lat, topo_ny, lat);
01677
01678       /* Get surface height... */
01679       z0 = LIN(topo_lon[tx], topo_z[tx][ty],
01680                topo_lon[tx + 1], topo_z[tx + 1][ty], lon);
01681       z1 = LIN(topo_lon[tx], topo_z[tx][ty + 1],
01682                topo_lon[tx + 1], topo_z[tx + 1][ty + 1], lon);
01683       z0 = LIN(topo_lat[ty], z0, topo_lat[ty + 1], z1, lat);
01684
01685       /* Find surface pressure level... */
01686       ip0 = locate_irr(met->p, met->np, met->ps[ix][iy]);
01687
01688       /* Get surface data... */
01689       ts =
```

```
01690         LIN(met->p[ip0],
01691             TVIRT(met->t[ix][iy][ip0], met->h2o[ix][iy][ip0]),
01692             met->p[ip0 + 1],
01693             TVIRT(met->t[ix][iy][ip0 + 1], met->h2o[ix][iy][ip0 + 1]),
01694             met->ps[ix][iy]);
01695
01696       /* Upper part of profile... */
01697       met->z[ix][iy][ip0 + 1]
01698         = (float) (z0 + RI / MA / G0 * 0.5
01699                    * (ts + TVIRT(met->t[ix][iy][ip0 + 1],
01700                                  met->h2o[ix][iy][ip0 + 1]))
01701                    * (log(met->ps[ix][iy]) - logp[ip0 + 1]));
01702       for (ip = ip0 + 2; ip < met->np; ip++)
01703         met->z[ix][iy][ip]
01704           = (float) (met->z[ix][iy][ip - 1] + RI / MA / G0 * 0.5 *
01705                      (TVIRT(met->t[ix][iy][ip - 1], met->h2o[ix][iy][ip - 1])
01706                       + TVIRT(met->t[ix][iy][ip], met->h2o[ix][iy][ip]))
01707                      * (logp[ip - 1] - logp[ip]));
01708     }
01709   }
01710
01711   /* Smoothing... */
01712 #pragma omp parallel for default(shared) private(ix,iy,ip,n,ix2,ix3,iy2)
01713   for (ix = 0; ix < met->nx; ix++)
01714     for (iy = 0; iy < met->ny; iy++)
01715       for (ip = 0; ip < met->np; ip++) {
01716         n = 0;
01717         help[ix][iy][ip] = 0;
01718         for (ix2 = ix - dx; ix2 <= ix + dx; ix2++) {
01719           ix3 = ix2;
01720           if (ix3 < 0)
01721             ix3 += met->nx;
01722           else if (ix3 >= met->nx)
01723             ix3 -= met->nx;
01724           for (iy2 = GSL_MAX(iy - dy, 0);
01725                iy2 <= GSL_MIN(iy + dy, met->ny - 1); iy2++)
01726             if (gsl_finite(met->z[ix3][iy2][ip])) {
01727               help[ix][iy][ip] += met->z[ix3][iy2][ip];
01728               n++;
01729             }
01730         }
01731         if (n > 0)
01732           help[ix][iy][ip] /= (float) n;
01733         else
01734           help[ix][iy][ip] = GSL_NAN;
01735       }
01736
01737   /* Copy data... */
01738 #pragma omp parallel for default(shared) private(ix,iy,ip)
01739   for (ix = 0; ix < met->nx; ix++)
01740     for (iy = 0; iy < met->ny; iy++)
01741       for (ip = 0; ip < met->np; ip++)
01742         met->z[ix][iy][ip] = help[ix][iy][ip];
01743 }
01744
01745 /*****************************************************************************/
01746
01747 void read_met_help(
01748   int ncid,
01749   char *varname,
01750   char *varname2,
01751   met_t * met,
01752   float dest[EX][EY][EP],
01753   float scl) {
01754
01755   float *help;
01756
01757   int ip, ix, iy, varid;
01758
01759   /* Check if variable exists... */
01760   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
01761     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
01762       return;
01763
01764   /* Allocate... */
01765   ALLOC(help, float, EX * EY * EP);
01766
01767   /* Read data... */
01768   NC(nc_get_var_float(ncid, varid, help));
01769
01770   /* Copy and check data... */
01771 #pragma omp parallel for default(shared) private(ix,iy,ip)
01772   for (ix = 0; ix < met->nx; ix++)
01773     for (iy = 0; iy < met->ny; iy++)
01774       for (ip = 0; ip < met->np; ip++) {
01775         dest[ix][iy][ip] = help[(ip * met->ny + iy) * met->nx + ix];
01776         if (fabsf(dest[ix][iy][ip]) < 1e14f)
```

```
01777           dest[ix][iy][ip] *= scl;
01778         else
01779           dest[ix][iy][ip] = GSL_NAN;
01780       }
01781
01782   /* Free... */
01783   free(help);
01784 }
01785
01786 /*****************************************************************************/
01787
01788 void read_met_ml2pl(
01789   ctl_t * ctl,
01790   met_t * met,
01791   float var[EX][EY][EP]) {
01792
01793   double aux[EP], p[EP], pt;
01794
01795   int ip, ip2, ix, iy;
01796
01797   /* Loop over columns... */
01798 #pragma omp parallel for default(shared) private(ix,iy,ip,p,pt,ip2,aux)
01799   for (ix = 0; ix < met->nx; ix++)
01800     for (iy = 0; iy < met->ny; iy++) {
01801
01802       /* Copy pressure profile... */
01803       for (ip = 0; ip < met->np; ip++)
01804         p[ip] = met->pl[ix][iy][ip];
01805
01806       /* Interpolate... */
01807       for (ip = 0; ip < ctl->met_np; ip++) {
01808         pt = ctl->met_p[ip];
01809         if ((pt > p[0] && p[0] > p[1]) || (pt < p[0] && p[0] < p[1]))
01810           pt = p[0];
01811         else if ((pt > p[met->np - 1] && p[1] > p[0])
01812                  || (pt < p[met->np - 1] && p[1] < p[0]))
01813           pt = p[met->np - 1];
01814         ip2 = locate_irr(p, met->np, pt);
01815         aux[ip] = LIN(p[ip2], var[ix][iy][ip2],
01816                       p[ip2 + 1], var[ix][iy][ip2 + 1], pt);
01817       }
01818
01819       /* Copy data... */
01820       for (ip = 0; ip < ctl->met_np; ip++)
01821         var[ix][iy][ip] = (float) aux[ip];
01822     }
01823 }
01824
01825 /*****************************************************************************/
01826
01827 void read_met_periodic(
01828   met_t * met) {
01829
01830   /* Check longitudes... */
01831   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
01832              + met->lon[1] - met->lon[0] - 360) < 0.01))
01833     return;
01834
01835   /* Increase longitude counter... */
01836   if ((++met->nx) > EX)
01837     ERRMSG("Cannot create periodic boundary conditions!");
01838
01839   /* Set longitude... */
01840   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
01841
01842   /* Loop over latitudes and pressure levels... */
01843 #pragma omp parallel for default(shared)
01844   for (int iy = 0; iy < met->ny; iy++) {
01845     met->ps[met->nx - 1][iy] = met->ps[0][iy];
01846     met->pt[met->nx - 1][iy] = met->pt[0][iy];
01847     for (int ip = 0; ip < met->np; ip++) {
01848       met->z[met->nx - 1][iy][ip] = met->z[0][iy][ip];
01849       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
01850       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
01851       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
01852       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
01853       met->pv[met->nx - 1][iy][ip] = met->pv[0][iy][ip];
01854       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
01855       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
01856     }
01857   }
01858 }
01859
01860 /*****************************************************************************/
01861
01862 void read_met_pv(
```

```
01863   met_t * met) {
01864
01865   double c0, c1, cr, dx, dy, dp0, dp1, denom, dtdx, dvdx, dtdy, dudy,
01866     dtdp, dudp, dvdp, latr, vort, pows[EP];
01867
01868   int ip, ip0, ip1, ix, ix0, ix1, iy, iy0, iy1;
01869
01870   /* Set powers... */
01871   for (ip = 0; ip < met->np; ip++)
01872     pows[ip] = pow(1000. / met->p[ip], 0.286);
01873
01874   /* Loop over grid points... */
01875 #pragma omp parallel for default(shared)
       private(ix,ix0,ix1,iy,iy0,iy1,latr,dx,dy,c0,c1,cr,vort,ip,ip0,ip1,dp0,dp1,denom,dtdx,dvdx,dtdy,dudy,dtdp,dudp,dvdp)
01876   for (ix = 0; ix < met->nx; ix++) {
01877
01878     /* Set indices... */
01879     ix0 = GSL_MAX(ix - 1, 0);
01880     ix1 = GSL_MIN(ix + 1, met->nx - 1);
01881
01882     /* Loop over grid points... */
01883     for (iy = 0; iy < met->ny; iy++) {
01884
01885       /* Set indices... */
01886       iy0 = GSL_MAX(iy - 1, 0);
01887       iy1 = GSL_MIN(iy + 1, met->ny - 1);
01888
01889       /* Set auxiliary variables... */
01890       latr = 0.5 * (met->lat[iy1] + met->lat[iy0]);
01891       dx = 1000. * DEG2DX(met->lon[ix1] - met->lon[ix0], latr);
01892       dy = 1000. * DEG2DY(met->lat[iy1] - met->lat[iy0]);
01893       c0 = cos(met->lat[iy0] / 180. * M_PI);
01894       c1 = cos(met->lat[iy1] / 180. * M_PI);
01895       cr = cos(latr / 180. * M_PI);
01896       vort = 2 * 7.2921e-5 * sin(latr * M_PI / 180.);
01897
01898       /* Loop over grid points... */
01899       for (ip = 0; ip < met->np; ip++) {
01900
01901         /* Get gradients in longitude... */
01902         dtdx = (met->t[ix1][iy][ip] - met->t[ix0][iy][ip]) * pows[ip] / dx;
01903         dvdx = (met->v[ix1][iy][ip] - met->v[ix0][iy][ip]) / dx;
01904
01905         /* Get gradients in latitude... */
01906         dtdy = (met->t[ix][iy1][ip] - met->t[ix][iy0][ip]) * pows[ip] / dy;
01907         dudy = (met->u[ix][iy1][ip] * c1 - met->u[ix][iy0][ip] * c0) / dy;
01908
01909         /* Set indices... */
01910         ip0 = GSL_MAX(ip - 1, 0);
01911         ip1 = GSL_MIN(ip + 1, met->np - 1);
01912
01913         /* Get gradients in pressure... */
01914         dp0 = 100. * (met->p[ip] - met->p[ip0]);
01915         dp1 = 100. * (met->p[ip1] - met->p[ip]);
01916         if (ip != ip0 && ip != ip1) {
01917           denom = dp0 * dp1 * (dp0 + dp1);
01918           dtdp = (dp0 * dp0 * met->t[ix][iy][ip1] * pows[ip1]
01919                   - dp1 * dp1 * met->t[ix][iy][ip0] * pows[ip0]
01920                   + (dp1 * dp1 - dp0 * dp0) * met->t[ix][iy][ip] * pows[ip])
01921             / denom;
01922           dudp = (dp0 * dp0 * met->u[ix][iy][ip1]
01923                   - dp1 * dp1 * met->u[ix][iy][ip0]
01924                   + (dp1 * dp1 - dp0 * dp0) * met->u[ix][iy][ip])
01925             / denom;
01926           dvdp = (dp0 * dp0 * met->v[ix][iy][ip1]
01927                   - dp1 * dp1 * met->v[ix][iy][ip0]
01928                   + (dp1 * dp1 - dp0 * dp0) * met->v[ix][iy][ip])
01929             / denom;
01930         } else {
01931           denom = dp0 + dp1;
01932           dtdp =
01933             (met->t[ix][iy][ip1] * pows[ip1] -
01934              met->t[ix][iy][ip0] * pows[ip0]) / denom;
01935           dudp = (met->u[ix][iy][ip1] - met->u[ix][iy][ip0]) / denom;
01936           dvdp = (met->v[ix][iy][ip1] - met->v[ix][iy][ip0]) / denom;
01937         }
01938
01939         /* Calculate PV... */
01940         met->pv[ix][iy][ip] = (float)
01941           (1e6 * G0 *
01942            (-dtdp * (dvdx - dudy / cr + vort) + dvdp * dtdx - dudp * dtdy));
01943       }
01944     }
01945   }
01946
01947   /* Fix for polar regions... */
01948 #pragma omp parallel for default(shared) private(ix,ip)
```

```
01949   for (ix = 0; ix < met->nx; ix++)
01950     for (ip = 0; ip < met->np; ip++) {
01951       met->pv[ix][0][ip]
01952         = met->pv[ix][1][ip]
01953         = met->pv[ix][2][ip];
01954       met->pv[ix][met->ny - 1][ip]
01955         = met->pv[ix][met->ny - 2][ip]
01956         = met->pv[ix][met->ny - 3][ip];
01957     }
01958 }
01959
01960 /*****************************************************************************/
01961
01962 void read_met_sample(
01963   ctl_t * ctl,
01964   met_t * met) {
01965
01966   met_t *help;
01967
01968   float w, wsum;
01969
01970   int ip, ip2, ix, ix2, ix3, iy, iy2;
01971
01972   /* Check parameters... */
01973   if (ctl->met_dp <= 1 && ctl->met_dx <= 1 && ctl->met_dy <= 1
01974       && ctl->met_sp <= 1 && ctl->met_sx <= 1 && ctl->met_sy <= 1)
01975     return;
01976
01977   /* Allocate... */
01978   ALLOC(help, met_t, 1);
01979
01980   /* Copy data... */
01981   help->nx = met->nx;
01982   help->ny = met->ny;
01983   help->np = met->np;
01984   memcpy(help->lon, met->lon, sizeof(met->lon));
01985   memcpy(help->lat, met->lat, sizeof(met->lat));
01986   memcpy(help->p, met->p, sizeof(met->p));
01987
01988   /* Smoothing... */
01989   for (ix = 0; ix < met->nx; ix += ctl->met_dx) {
01990     for (iy = 0; iy < met->ny; iy += ctl->met_dy) {
01991       for (ip = 0; ip < met->np; ip += ctl->met_dp) {
01992         help->ps[ix][iy] = 0;
01993         help->pt[ix][iy] = 0;
01994         help->z[ix][iy][ip] = 0;
01995         help->t[ix][iy][ip] = 0;
01996         help->u[ix][iy][ip] = 0;
01997         help->v[ix][iy][ip] = 0;
01998         help->w[ix][iy][ip] = 0;
01999         help->pv[ix][iy][ip] = 0;
02000         help->h2o[ix][iy][ip] = 0;
02001         help->o3[ix][iy][ip] = 0;
02002         wsum = 0;
02003         for (ix2 = ix - ctl->met_sx + 1; ix2 <= ix + ctl->met_sx - 1; ix2++) {
02004           ix3 = ix2;
02005           if (ix3 < 0)
02006             ix3 += met->nx;
02007           else if (ix3 >= met->nx)
02008             ix3 -= met->nx;
02009
02010           for (iy2 = GSL_MAX(iy - ctl->met_sy + 1, 0);
02011                iy2 <= GSL_MIN(iy + ctl->met_sy - 1, met->ny - 1); iy2++)
02012             for (ip2 = GSL_MAX(ip - ctl->met_sp + 1, 0);
02013                  ip2 <= GSL_MIN(ip + ctl->met_sp - 1, met->np - 1); ip2++) {
02014               w = (float) (1.0 - fabs(ix - ix2) / ctl->met_sx)
02015                 * (float) (1.0 - fabs(iy - iy2) / ctl->met_sy)
02016                 * (float) (1.0 - fabs(ip - ip2) / ctl->met_sp);
02017               help->ps[ix][iy] += w * met->ps[ix3][iy2];
02018               help->pt[ix][iy] += w * met->pt[ix3][iy2];
02019               help->z[ix][iy][ip] += w * met->z[ix3][iy2][ip2];
02020               help->t[ix][iy][ip] += w * met->t[ix3][iy2][ip2];
02021               help->u[ix][iy][ip] += w * met->u[ix3][iy2][ip2];
02022               help->v[ix][iy][ip] += w * met->v[ix3][iy2][ip2];
02023               help->w[ix][iy][ip] += w * met->w[ix3][iy2][ip2];
02024               help->pv[ix][iy][ip] += w * met->pv[ix3][iy2][ip2];
02025               help->h2o[ix][iy][ip] += w * met->h2o[ix3][iy2][ip2];
02026               help->o3[ix][iy][ip] += w * met->o3[ix3][iy2][ip2];
02027               wsum += w;
02028             }
02029         }
02030         help->ps[ix][iy] /= wsum;
02031         help->pt[ix][iy] /= wsum;
02032         help->t[ix][iy][ip] /= wsum;
02033         help->z[ix][iy][ip] /= wsum;
02034         help->u[ix][iy][ip] /= wsum;
02035         help->v[ix][iy][ip] /= wsum;
```

```
02036         help->w[ix][iy][ip] /= wsum;
02037         help->pv[ix][iy][ip] /= wsum;
02038         help->h2o[ix][iy][ip] /= wsum;
02039         help->o3[ix][iy][ip] /= wsum;
02040       }
02041     }
02042   }
02043
02044   /* Downsampling... */
02045   met->nx = 0;
02046   for (ix = 0; ix < help->nx; ix += ctl->met_dx) {
02047     met->lon[met->nx] = help->lon[ix];
02048     met->ny = 0;
02049     for (iy = 0; iy < help->ny; iy += ctl->met_dy) {
02050       met->lat[met->ny] = help->lat[iy];
02051       met->ps[met->nx][met->ny] = help->ps[ix][iy];
02052       met->pt[met->nx][met->ny] = help->pt[ix][iy];
02053       met->np = 0;
02054       for (ip = 0; ip < help->np; ip += ctl->met_dp) {
02055         met->p[met->np] = help->p[ip];
02056         met->z[met->nx][met->ny][met->np] = help->z[ix][iy][ip];
02057         met->t[met->nx][met->ny][met->np] = help->t[ix][iy][ip];
02058         met->u[met->nx][met->ny][met->np] = help->u[ix][iy][ip];
02059         met->v[met->nx][met->ny][met->np] = help->v[ix][iy][ip];
02060         met->w[met->nx][met->ny][met->np] = help->w[ix][iy][ip];
02061         met->pv[met->nx][met->ny][met->np] = help->pv[ix][iy][ip];
02062         met->h2o[met->nx][met->ny][met->np] = help->h2o[ix][iy][ip];
02063         met->o3[met->nx][met->ny][met->np] = help->o3[ix][iy][ip];
02064         met->np++;
02065       }
02066       met->ny++;
02067     }
02068     met->nx++;
02069   }
02070
02071   /* Free... */
02072   free(help);
02073 }
02074
02075 /*****************************************************************************/
02076
02077 void read_met_tropo(
02078   ctl_t * ctl,
02079   met_t * met) {
02080
02081   double p2[200], pv[EP], pv2[200], t[EP], t2[200], th[EP],
02082     th2[200], z[EP], z2[200];
02083
02084   int found, ix, iy, iz, iz2;
02085
02086   /* Get altitude and pressure profiles... */
02087   for (iz = 0; iz < met->np; iz++)
02088     z[iz] = Z(met->p[iz]);
02089   for (iz = 0; iz <= 170; iz++) {
02090     z2[iz] = 4.5 + 0.1 * iz;
02091     p2[iz] = P(z2[iz]);
02092   }
02093
02094   /* Do not calculate tropopause... */
02095   if (ctl->met_tropo == 0)
02096     for (ix = 0; ix < met->nx; ix++)
02097       for (iy = 0; iy < met->ny; iy++)
02098         met->pt[ix][iy] = GSL_NAN;
02099
02100   /* Use tropopause climatology... */
02101   else if (ctl->met_tropo == 1) {
02102 #pragma omp parallel for default(shared) private(ix,iy)
02103     for (ix = 0; ix < met->nx; ix++)
02104       for (iy = 0; iy < met->ny; iy++)
02105         met->pt[ix][iy] = clim_tropo(met->time, met->lat[iy]);
02106   }
02107
02108   /* Use cold point... */
02109   else if (ctl->met_tropo == 2) {
02110
02111     /* Loop over grid points... */
02112 #pragma omp parallel for default(shared) private(ix,iy,iz,t,t2)
02113     for (ix = 0; ix < met->nx; ix++)
02114       for (iy = 0; iy < met->ny; iy++) {
02115
02116         /* Interpolate temperature profile... */
02117         for (iz = 0; iz < met->np; iz++)
02118           t[iz] = met->t[ix][iy][iz];
02119         spline(z, t, met->np, z2, t2, 171);
02120
02121         /* Find minimum... */
02122         iz = (int) gsl_stats_min_index(t2, 1, 171);
```

```
02123         if (iz <= 0 || iz >= 170)
02124           met->pt[ix][iy] = GSL_NAN;
02125         else
02126           met->pt[ix][iy] = p2[iz];
02127       }
02128   }
02129
02130   /* Use WMO definition... */
02131   else if (ctl->met_tropo == 3 || ctl->met_tropo == 4) {
02132
02133     /* Loop over grid points... */
02134 #pragma omp parallel for default(shared) private(ix,iy,iz,iz2,t,t2,found)
02135     for (ix = 0; ix < met->nx; ix++)
02136       for (iy = 0; iy < met->ny; iy++) {
02137
02138         /* Interpolate temperature profile... */
02139         for (iz = 0; iz < met->np; iz++)
02140           t[iz] = met->t[ix][iy][iz];
02141         spline(z, t, met->np, z2, t2, 161);
02142
02143         /* Find 1st tropopause... */
02144         met->pt[ix][iy] = GSL_NAN;
02145         for (iz = 0; iz <= 140; iz++) {
02146           found = 1;
02147           for (iz2 = iz + 1; iz2 <= iz + 20; iz2++)
02148             if (1e3 * G0 / RA * (t2[iz2] - t2[iz]) / (t2[iz2] + t2[iz])
02149                 * (p2[iz2] + p2[iz]) / (p2[iz2] - p2[iz]) > 2.0) {
02150               found = 0;
02151               break;
02152             }
02153           if (found) {
02154             if (iz > 0 && iz < 140)
02155               met->pt[ix][iy] = p2[iz];
02156             break;
02157           }
02158         }
02159
02160         /* Find 2nd tropopause... */
02161         if (ctl->met_tropo == 4) {
02162           met->pt[ix][iy] = GSL_NAN;
02163           for (; iz <= 140; iz++) {
02164             found = 1;
02165             for (iz2 = iz + 1; iz2 <= iz + 10; iz2++)
02166               if (1e3 * G0 / RA * (t2[iz2] - t2[iz]) / (t2[iz2] + t2[iz])
02167                   * (p2[iz2] + p2[iz]) / (p2[iz2] - p2[iz]) < 3.0) {
02168                 found = 0;
02169                 break;
02170               }
02171             if (found)
02172               break;
02173           }
02174           for (; iz <= 140; iz++) {
02175             found = 1;
02176             for (iz2 = iz + 1; iz2 <= iz + 20; iz2++)
02177               if (1e3 * G0 / RA * (t2[iz2] - t2[iz]) / (t2[iz2] + t2[iz])
02178                   * (p2[iz2] + p2[iz]) / (p2[iz2] - p2[iz]) > 2.0) {
02179                 found = 0;
02180                 break;
02181               }
02182             if (found) {
02183               if (iz > 0 && iz < 140)
02184                 met->pt[ix][iy] = p2[iz];
02185               break;
02186             }
02187           }
02188         }
02189       }
02190   }
02191
02192   /* Use dynamical tropopause... */
02193   else if (ctl->met_tropo == 5) {
02194
02195     /* Loop over grid points... */
02196 #pragma omp parallel for default(shared) private(ix,iy,iz,pv,pv2,th,th2)
02197     for (ix = 0; ix < met->nx; ix++)
02198       for (iy = 0; iy < met->ny; iy++) {
02199
02200         /* Interpolate potential vorticity profile... */
02201         for (iz = 0; iz < met->np; iz++)
02202           pv[iz] = met->pv[ix][iy][iz];
02203         spline(z, pv, met->np, z2, pv2, 161);
02204
02205         /* Interpolate potential temperature profile... */
02206         for (iz = 0; iz < met->np; iz++)
02207           th[iz] = THETA(met->p[iz], met->t[ix][iy][iz]);
02208         spline(z, th, met->np, z2, th2, 161);
02209
```

```
02210         /* Find dynamical tropopause 3.5 PVU + 380 K */
02211         met->pt[ix][iy] = GSL_NAN;
02212         for (iz = 0; iz <= 160; iz++)
02213           if (fabs(pv2[iz]) >= 3.5 || th2[iz] >= 380.) {
02214             if (iz > 0 && iz < 160)
02215               met->pt[ix][iy] = p2[iz];
02216             break;
02217           }
02218       }
02219   }
02220
02221   else
02222     ERRMSG("Cannot calculate tropopause!");
02223 }
02224
02225 /*****************************************************************************/
02226
02227 double scan_ctl(
02228   const char *filename,
02229   int argc,
02230   char *argv[],
02231   const char *varname,
02232   int arridx,
02233   const char *defvalue,
02234   char *value) {
02235
02236   FILE *in = NULL;
02237
02238   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
02239     msg[2 * LEN], rvarname[LEN], rval[LEN];
02240
02241   int contain = 0, i;
02242
02243   /* Open file... */
02244   if (filename[strlen(filename) - 1] != '-')
02245     if (!(in = fopen(filename, "r")))
02246       ERRMSG("Cannot open file!");
02247
02248   /* Set full variable name... */
02249   if (arridx >= 0) {
02250     sprintf(fullname1, "%s[%d]", varname, arridx);
02251     sprintf(fullname2, "%s[*]", varname);
02252   } else {
02253     sprintf(fullname1, "%s", varname);
02254     sprintf(fullname2, "%s", varname);
02255   }
02256
02257   /* Read data... */
02258   if (in != NULL)
02259     while (fgets(line, LEN, in))
02260       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
02261         if (strcasecmp(rvarname, fullname1) == 0 ||
02262             strcasecmp(rvarname, fullname2) == 0) {
02263           contain = 1;
02264           break;
02265         }
02266   for (i = 1; i < argc - 1; i++)
02267     if (strcasecmp(argv[i], fullname1) == 0 ||
02268         strcasecmp(argv[i], fullname2) == 0) {
02269       sprintf(rval, "%s", argv[i + 1]);
02270       contain = 1;
02271       break;
02272     }
02273
02274   /* Close file... */
02275   if (in != NULL)
02276     fclose(in);
02277
02278   /* Check for missing variables... */
02279   if (!contain) {
02280     if (strlen(defvalue) > 0)
02281       sprintf(rval, "%s", defvalue);
02282     else {
02283       sprintf(msg, "Missing variable %s!\n", fullname1);
02284       ERRMSG(msg);
02285     }
02286   }
02287
02288   /* Write info... */
02289   printf("%s = %s\n", fullname1, rval);
02290
02291   /* Return values... */
02292   if (value != NULL)
02293     sprintf(value, "%s", rval);
02294   return atof(rval);
02295 }
02296
```

```
02297 /*****************************************************************************/
02298
02299 void spline(
02300   double *x,
02301   double *y,
02302   int n,
02303   double *x2,
02304   double *y2,
02305   int n2) {
02306
02307   gsl_interp_accel *acc;
02308
02309   gsl_spline *s;
02310
02311   /* Allocate... */
02312   acc = gsl_interp_accel_alloc();
02313   s = gsl_spline_alloc(gsl_interp_cspline, (size_t) n);
02314
02315   /* Interpolate temperature profile... */
02316   gsl_spline_init(s, x, y, (size_t) n);
02317   for (int i = 0; i < n2; i++)
02318     y2[i] = gsl_spline_eval(s, x2[i], acc);
02319
02320   /* Free... */
02321   gsl_spline_free(s);
02322   gsl_interp_accel_free(acc);
02323 }
02324
02325 /*****************************************************************************/
02326
02327 double stddev(
02328   double *data,
02329   int n) {
02330
02331   if (n <= 0)
02332     return 0;
02333
02334   double avg = 0, rms = 0;
02335
02336   for (int i = 0; i < n; ++i)
02337     avg += data[i];
02338   avg /= n;
02339
02340   for (int i = 0; i < n; ++i)
02341     rms += SQR(data[i] - avg);
02342
02343   return sqrt(rms / (n - 1));
02344 }
02345
02346 /*****************************************************************************/
02347
02348 void time2jsec(
02349   int year,
02350   int mon,
02351   int day,
02352   int hour,
02353   int min,
02354   int sec,
02355   double remain,
02356   double *jsec) {
02357
02358   struct tm t0, t1;
02359
02360   t0.tm_year = 100;
02361   t0.tm_mon = 0;
02362   t0.tm_mday = 1;
02363   t0.tm_hour = 0;
02364   t0.tm_min = 0;
02365   t0.tm_sec = 0;
02366
02367   t1.tm_year = year - 1900;
02368   t1.tm_mon = mon - 1;
02369   t1.tm_mday = day;
02370   t1.tm_hour = hour;
02371   t1.tm_min = min;
02372   t1.tm_sec = sec;
02373
02374   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
02375 }
02376
02377 /*****************************************************************************/
02378
02379 void timer(
02380   const char *name,
02381   int id,
02382   int mode) {
02383
```

```
02384   static double starttime[NTIMER], runtime[NTIMER];
02385
02386   /* Check id... */
02387   if (id < 0 || id >= NTIMER)
02388     ERRMSG("Too many timers!");
02389
02390   /* Start timer... */
02391   if (mode == 1) {
02392     if (starttime[id] <= 0)
02393       starttime[id] = omp_get_wtime();
02394     else
02395       ERRMSG("Timer already started!");
02396   }
02397
02398   /* Stop timer... */
02399   else if (mode == 2) {
02400     if (starttime[id] > 0) {
02401       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
02402       starttime[id] = -1;
02403     }
02404   }
02405
02406   /* Print timer... */
02407   else if (mode == 3) {
02408     printf("%s = %.3f s\n", name, runtime[id]);
02409     runtime[id] = 0;
02410   }
02411 }
02412
02413 /*****************************************************************************/
02414
02415 void write_atm(
02416   const char *filename,
02417   ctl_t * ctl,
02418   atm_t * atm,
02419   double t) {
02420
02421   FILE *in, *out;
02422
02423   char line[LEN];
02424
02425   double r, t0, t1;
02426
02427   int ip, iq, year, mon, day, hour, min, sec;
02428
02429   /* Set time interval for output... */
02430   t0 = t - 0.5 * ctl->dt_mod;
02431   t1 = t + 0.5 * ctl->dt_mod;
02432
02433   /* Write info... */
02434   printf("Write atmospheric data: %s\n", filename);
02435
02436   /* Write ASCII data... */
02437   if (ctl->atm_type == 0) {
02438
02439     /* Check if gnuplot output is requested... */
02440     if (ctl->atm_gpfile[0] != '-') {
02441
02442       /* Create gnuplot pipe... */
02443       if (!(out = popen("gnuplot", "w")))
02444         ERRMSG("Cannot create pipe to gnuplot!");
02445
02446       /* Set plot filename... */
02447       fprintf(out, "set out \"%s.png\"\n", filename);
02448
02449       /* Set time string... */
02450       jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
02451       fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
02452               year, mon, day, hour, min);
02453
02454       /* Dump gnuplot file to pipe... */
02455       if (!(in = fopen(ctl->atm_gpfile, "r")))
02456         ERRMSG("Cannot open file!");
02457       while (fgets(line, LEN, in))
02458         fprintf(out, "%s", line);
02459       fclose(in);
02460     }
02461
02462     else {
02463
02464       /* Create file... */
02465       if (!(out = fopen(filename, "w")))
02466         ERRMSG("Cannot create file!");
02467     }
02468
02469     /* Write header... */
02470     fprintf(out,
```

```
02471             "# $1 = time [s]\n"
02472             "# $2 = altitude [km]\n"
02473             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
02474     for (iq = 0; iq < ctl->nq; iq++)
02475       fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
02476               ctl->qnt_unit[iq]);
02477     fprintf(out, "\n");
02478
02479     /* Write data... */
02480     for (ip = 0; ip < atm->np; ip += ctl->atm_stride) {
02481
02482       /* Check time... */
02483       if (ctl->atm_filter && (atm->time[ip] < t0 || atm->time[ip] > t1))
02484         continue;
02485
02486       /* Write output... */
02487       fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
02488               atm->lon[ip], atm->lat[ip]);
02489       for (iq = 0; iq < ctl->nq; iq++) {
02490         fprintf(out, " ");
02491         fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
02492       }
02493       fprintf(out, "\n");
02494     }
02495
02496     /* Close file... */
02497     fclose(out);
02498   }
02499
02500   /* Write binary data... */
02501   else if (ctl->atm_type == 1) {
02502
02503     /* Create file... */
02504     if (!(out = fopen(filename, "w")))
02505       ERRMSG("Cannot create file!");
02506
02507     /* Write data... */
02508     FWRITE(&atm->np, int,
02509            1,
02510            out);
02511     FWRITE(atm->time, double,
02512              (size_t) atm->np,
02513            out);
02514     FWRITE(atm->p, double,
02515              (size_t) atm->np,
02516            out);
02517     FWRITE(atm->lon, double,
02518              (size_t) atm->np,
02519            out);
02520     FWRITE(atm->lat, double,
02521              (size_t) atm->np,
02522            out);
02523     for (iq = 0; iq < ctl->nq; iq++)
02524       FWRITE(atm->q[iq], double,
02525                (size_t) atm->np,
02526              out);
02527
02528     /* Close file... */
02529     fclose(out);
02530   }
02531
02532   /* Error... */
02533   else
02534     ERRMSG("Atmospheric data type not supported!");
02535 }
02536
02537 /*****************************************************************************/
02538
02539 void write_csi(
02540   const char *filename,
02541   ctl_t * ctl,
02542   atm_t * atm,
02543   double t) {
02544
02545   static FILE *in, *out;
02546
02547   static char line[LEN];
02548
02549   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
02550     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
02551
02552   static int obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
02553
02554   /* Init... */
02555   if (t == ctl->t_start) {
02556
02557     /* Check quantity index for mass... */
```

```
02558     if (ctl->qnt_m < 0)
02559       ERRMSG("Need quantity mass!");
02560
02561     /* Open observation data file... */
02562     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
02563     if (!(in = fopen(ctl->csi_obsfile, "r")))
02564       ERRMSG("Cannot open file!");
02565
02566     /* Create new file... */
02567     printf("Write CSI data: %s\n", filename);
02568     if (!(out = fopen(filename, "w")))
02569       ERRMSG("Cannot create file!");
02570
02571     /* Write header... */
02572     fprintf(out,
02573             "# $1 = time [s]\n"
02574             "# $2 = number of hits (cx)\n"
02575             "# $3 = number of misses (cy)\n"
02576             "# $4 = number of false alarms (cz)\n"
02577             "# $5 = number of observations (cx + cy)\n"
02578             "# $6 = number of forecasts (cx + cz)\n"
02579             "# $7 = bias (forecasts/observations) [%%]\n"
02580             "# $8 = probability of detection (POD) [%%]\n"
02581             "# $9 = false alarm rate (FAR) [%%]\n"
02582             "# $10 = critical success index (CSI) [%%]\n\n");
02583   }
02584
02585   /* Set time interval... */
02586   t0 = t - 0.5 * ctl->dt_mod;
02587   t1 = t + 0.5 * ctl->dt_mod;
02588
02589   /* Initialize grid cells... */
02590 #pragma omp parallel for default(shared) private(ix,iy,iz)
02591   for (ix = 0; ix < ctl->csi_nx; ix++)
02592     for (iy = 0; iy < ctl->csi_ny; iy++)
02593       for (iz = 0; iz < ctl->csi_nz; iz++)
02594         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
02595
02596   /* Read observation data... */
02597   while (fgets(line, LEN, in)) {
02598
02599     /* Read data... */
02600     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
02601         5)
02602       continue;
02603
02604     /* Check time... */
02605     if (rt < t0)
02606       continue;
02607     if (rt > t1)
02608       break;
02609
02610     /* Calculate indices... */
02611     ix = (int) ((rlon - ctl->csi_lon0)
02612                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
02613     iy = (int) ((rlat - ctl->csi_lat0)
02614                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
02615     iz = (int) ((rz - ctl->csi_z0)
02616                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
02617
02618     /* Check indices... */
02619     if (ix < 0 || ix >= ctl->csi_nx ||
02620         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
02621       continue;
02622
02623     /* Get mean observation index... */
02624     obsmean[ix][iy][iz] += robs;
02625     obscount[ix][iy][iz]++;
02626   }
02627
02628   /* Analyze model data... */
02629 #pragma omp parallel for default(shared) private(ip,ix,iy,iz)
02630   for (ip = 0; ip < atm->np; ip++) {
02631
02632     /* Check time... */
02633     if (atm->time[ip] < t0 || atm->time[ip] > t1)
02634       continue;
02635
02636     /* Get indices... */
02637     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
02638                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
02639     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
02640                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
02641     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
02642                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
02643
02644     /* Check indices... */
```

```
02645     if (ix < 0 || ix >= ctl->csi_nx ||
02646         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
02647       continue;
02648
02649     /* Get total mass in grid cell... */
02650     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
02651   }
02652
02653   /* Analyze all grid cells... */
02654 #pragma omp parallel for default(shared) private(ix,iy,iz,dlon,dlat,lat,area)
02655   for (ix = 0; ix < ctl->csi_nx; ix++)
02656     for (iy = 0; iy < ctl->csi_ny; iy++)
02657       for (iz = 0; iz < ctl->csi_nz; iz++) {
02658
02659         /* Calculate mean observation index... */
02660         if (obscount[ix][iy][iz] > 0)
02661           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
02662
02663         /* Calculate column density... */
02664         if (modmean[ix][iy][iz] > 0) {
02665           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
02666           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
02667           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
02668           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
02669             * cos(lat * M_PI / 180.);
02670           modmean[ix][iy][iz] /= (1e6 * area);
02671         }
02672
02673         /* Calculate CSI... */
02674         if (obscount[ix][iy][iz] > 0) {
02675           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
02676               modmean[ix][iy][iz] >= ctl->csi_modmin)
02677             cx++;
02678           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
02679                    modmean[ix][iy][iz] < ctl->csi_modmin)
02680             cy++;
02681           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
02682                    modmean[ix][iy][iz] >= ctl->csi_modmin)
02683             cz++;
02684         }
02685       }
02686
02687   /* Write output... */
02688   if (fmod(t, ctl->csi_dt_out) == 0) {
02689
02690     /* Write... */
02691     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
02692             t, cx, cy, cz, cx + cy, cx + cz,
02693             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
02694             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
02695             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
02696             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
02697
02698     /* Set counters to zero... */
02699     cx = cy = cz = 0;
02700   }
02701
02702   /* Close file... */
02703   if (t == ctl->t_stop)
02704     fclose(out);
02705 }
02706
02707 /*****************************************************************************/
02708
02709 void write_ens(
02710   const char *filename,
02711   ctl_t * ctl,
02712   atm_t * atm,
02713   double t) {
02714
02715   static FILE *out;
02716
02717   static double dummy, ens, lat, lon, p[NENS], q[NQ][NENS],
02718     t0, t1, x[NENS][3], xm[3];
02719
02720   static int ip, iq;
02721
02722   static size_t i, n;
02723
02724   /* Init... */
02725   if (t == ctl->t_start) {
02726
02727     /* Check quantities... */
02728     if (ctl->qnt_ens < 0)
02729       ERRMSG("Missing ensemble IDs!");
02730
02731     /* Create new file... */
```

```
02732     printf("Write ensemble data: %s\n", filename);
02733     if (!(out = fopen(filename, "w")))
02734       ERRMSG("Cannot create file!");
02735
02736     /* Write header... */
02737     fprintf(out,
02738             "# $1 = time [s]\n"
02739             "# $2 = altitude [km]\n"
02740             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
02741     for (iq = 0; iq < ctl->nq; iq++)
02742       fprintf(out, "# $%d = %s (mean) [%s]\n", 5 + iq,
02743               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
02744     for (iq = 0; iq < ctl->nq; iq++)
02745       fprintf(out, "# $%d = %s (sigma) [%s]\n", 5 + ctl->nq + iq,
02746               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
02747     fprintf(out, "# $%d = number of members\n\n", 5 + 2 * ctl->nq);
02748   }
02749
02750   /* Set time interval... */
02751   t0 = t - 0.5 * ctl->dt_mod;
02752   t1 = t + 0.5 * ctl->dt_mod;
02753
02754   /* Init... */
02755   ens = GSL_NAN;
02756   n = 0;
02757
02758   /* Loop over air parcels... */
02759   for (ip = 0; ip < atm->np; ip++) {
02760
02761     /* Check time... */
02762     if (atm->time[ip] < t0 || atm->time[ip] > t1)
02763       continue;
02764
02765     /* Check ensemble id... */
02766     if (atm->q[ctl->qnt_ens][ip] != ens) {
02767
02768       /* Write results... */
02769       if (n > 0) {
02770
02771         /* Get mean position... */
02772         xm[0] = xm[1] = xm[2] = 0;
02773         for (i = 0; i < n; i++) {
02774           xm[0] += x[i][0] / (double) n;
02775           xm[1] += x[i][1] / (double) n;
02776           xm[2] += x[i][2] / (double) n;
02777         }
02778         cart2geo(xm, &dummy, &lon, &lat);
02779         fprintf(out, "%.2f %g %g %g", t, Z(gsl_stats_mean(p, 1, n)), lon,
02780                 lat);
02781
02782         /* Get quantity statistics... */
02783         for (iq = 0; iq < ctl->nq; iq++) {
02784           fprintf(out, " ");
02785           fprintf(out, ctl->qnt_format[iq], gsl_stats_mean(q[iq], 1, n));
02786         }
02787         for (iq = 0; iq < ctl->nq; iq++) {
02788           fprintf(out, " ");
02789           fprintf(out, ctl->qnt_format[iq], gsl_stats_sd(q[iq], 1, n));
02790         }
02791         fprintf(out, " %lu\n", n);
02792       }
02793
02794       /* Init new ensemble... */
02795       ens = atm->q[ctl->qnt_ens][ip];
02796       n = 0;
02797     }
02798
02799     /* Save data... */
02800     p[n] = atm->p[ip];
02801     geo2cart(0, atm->lon[ip], atm->lat[ip], x[n]);
02802     for (iq = 0; iq < ctl->nq; iq++)
02803       q[iq][n] = atm->q[iq][ip];
02804     if ((++n) >= NENS)
02805       ERRMSG("Too many data points!");
02806   }
02807
02808   /* Write results... */
02809   if (n > 0) {
02810
02811     /* Get mean position... */
02812     xm[0] = xm[1] = xm[2] = 0;
02813     for (i = 0; i < n; i++) {
02814       xm[0] += x[i][0] / (double) n;
02815       xm[1] += x[i][1] / (double) n;
02816       xm[2] += x[i][2] / (double) n;
02817     }
02818     cart2geo(xm, &dummy, &lon, &lat);
```

```
02819     fprintf(out, "%.2f %g %g %g", t, Z(gsl_stats_mean(p, 1, n)), lon, lat);
02820
02821     /* Get quantity statistics... */
02822     for (iq = 0; iq < ctl->nq; iq++) {
02823       fprintf(out, " ");
02824       fprintf(out, ctl->qnt_format[iq], gsl_stats_mean(q[iq], 1, n));
02825     }
02826     for (iq = 0; iq < ctl->nq; iq++) {
02827       fprintf(out, " ");
02828       fprintf(out, ctl->qnt_format[iq], gsl_stats_sd(q[iq], 1, n));
02829     }
02830     fprintf(out, " %lu\n", n);
02831   }
02832
02833   /* Close file... */
02834   if (t == ctl->t_stop)
02835     fclose(out);
02836 }
02837
02838 /*****************************************************************************/
02839
02840 void write_grid(
02841   const char *filename,
02842   ctl_t * ctl,
02843   met_t * met0,
02844   met_t * met1,
02845   atm_t * atm,
02846   double t) {
02847
02848   FILE *in, *out;
02849
02850   char line[LEN];
02851
02852   static double mass[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
02853     area, rho_air, press, temp, cd, vmr, t0, t1, r;
02854
02855   static int ip, ix, iy, iz, np[GX][GY][GZ], year, mon, day, hour, min, sec;
02856
02857   /* Check dimensions... */
02858   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
02859     ERRMSG("Grid dimensions too large!");
02860
02861   /* Set time interval for output... */
02862   t0 = t - 0.5 * ctl->dt_mod;
02863   t1 = t + 0.5 * ctl->dt_mod;
02864
02865   /* Set grid box size... */
02866   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
02867   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
02868   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
02869
02870   /* Initialize grid... */
02871 #pragma omp parallel for default(shared) private(ix,iy,iz)
02872   for (ix = 0; ix < ctl->grid_nx; ix++)
02873     for (iy = 0; iy < ctl->grid_ny; iy++)
02874       for (iz = 0; iz < ctl->grid_nz; iz++) {
02875         mass[ix][iy][iz] = 0;
02876         np[ix][iy][iz] = 0;
02877       }
02878
02879   /* Average data... */
02880 #pragma omp parallel for default(shared) private(ip,ix,iy,iz)
02881   for (ip = 0; ip < atm->np; ip++)
02882     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
02883
02884       /* Get index... */
02885       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
02886       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
02887       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
02888
02889       /* Check indices... */
02890       if (ix < 0 || ix >= ctl->grid_nx ||
02891           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
02892         continue;
02893
02894       /* Add mass... */
02895       if (ctl->qnt_m >= 0)
02896         mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
02897       np[ix][iy][iz]++;
02898     }
02899
02900   /* Check if gnuplot output is requested... */
02901   if (ctl->grid_gpfile[0] != '-') {
02902
02903     /* Write info... */
02904     printf("Plot grid data: %s.png\n", filename);
02905
```

```
02906     /* Create gnuplot pipe... */
02907     if (!(out = popen("gnuplot", "w")))
02908       ERRMSG("Cannot create pipe to gnuplot!");
02909
02910     /* Set plot filename... */
02911     fprintf(out, "set out \"%s.png\"\n", filename);
02912
02913     /* Set time string... */
02914     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
02915     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
02916             year, mon, day, hour, min);
02917
02918     /* Dump gnuplot file to pipe... */
02919     if (!(in = fopen(ctl->grid_gpfile, "r")))
02920       ERRMSG("Cannot open file!");
02921     while (fgets(line, LEN, in))
02922       fprintf(out, "%s", line);
02923     fclose(in);
02924   }
02925
02926   else {
02927
02928     /* Write info... */
02929     printf("Write grid data: %s\n", filename);
02930
02931     /* Create file... */
02932     if (!(out = fopen(filename, "w")))
02933       ERRMSG("Cannot create file!");
02934   }
02935
02936   /* Write header... */
02937   fprintf(out,
02938           "# $1 = time [s]\n"
02939           "# $2 = altitude [km]\n"
02940           "# $3 = longitude [deg]\n"
02941           "# $4 = latitude [deg]\n"
02942           "# $5 = surface area [km^2]\n"
02943           "# $6 = layer width [km]\n"
02944           "# $7 = number of particles [1]\n"
02945           "# $8 = column density [kg/m^2]\n"
02946           "# $9 = volume mixing ratio [1]\n\n");
02947
02948   /* Write data... */
02949   for (ix = 0; ix < ctl->grid_nx; ix++) {
02950     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
02951       fprintf(out, "\n");
02952     for (iy = 0; iy < ctl->grid_ny; iy++) {
02953       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
02954         fprintf(out, "\n");
02955       for (iz = 0; iz < ctl->grid_nz; iz++)
02956         if (!ctl->grid_sparse || mass[ix][iy][iz] > 0) {
02957
02958           /* Set coordinates... */
02959           z = ctl->grid_z0 + dz * (iz + 0.5);
02960           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
02961           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
02962
02963           /* Get pressure and temperature... */
02964           press = P(z);
02965           intpol_met_time(met0, met1, t, press, lon, lat, NULL, NULL,
02966                           NULL, &temp, NULL, NULL, NULL, NULL, NULL, NULL);
02967
02968           /* Calculate surface area... */
02969           area = dlat * dlon * SQR(RE * M_PI / 180.)
02970             * cos(lat * M_PI / 180.);
02971
02972           /* Calculate column density... */
02973           cd = mass[ix][iy][iz] / (1e6 * area);
02974
02975           /* Calculate volume mixing ratio... */
02976           rho_air = 100. * press / (RA * temp);
02977           vmr = MA / ctl->molmass * mass[ix][iy][iz]
02978             / (rho_air * 1e6 * area * 1e3 * dz);
02979
02980           /* Write output... */
02981           fprintf(out, "%.2f %g %g %g %g %g %d %g %g\n",
02982                   t, z, lon, lat, area, dz, np[ix][iy][iz], cd, vmr);
02983         }
02984     }
02985   }
02986
02987   /* Close file... */
02988   fclose(out);
02989 }
02990
02991 /*****************************************************************************/
02992
```

```
02993 void write_prof(
02994   const char *filename,
02995   ctl_t * ctl,
02996   met_t * met0,
02997   met_t * met1,
02998   atm_t * atm,
02999   double t) {
03000
03001   static FILE *in, *out;
03002
03003   static char line[LEN];
03004
03005   static double mass[GX][GY][GZ], obsmean[GX][GY], obsmean2[GX][GY], rt, rz,
03006     rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z, press, temp,
03007     rho_air, vmr, h2o, o3;
03008
03009   static int obscount[GX][GY], ip, ix, iy, iz, okay;
03010
03011   /* Init... */
03012   if (t == ctl->t_start) {
03013
03014     /* Check quantity index for mass... */
03015     if (ctl->qnt_m < 0)
03016       ERRMSG("Need quantity mass!");
03017
03018     /* Check dimensions... */
03019     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
03020       ERRMSG("Grid dimensions too large!");
03021
03022     /* Open observation data file... */
03023     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
03024     if (!(in = fopen(ctl->prof_obsfile, "r")))
03025       ERRMSG("Cannot open file!");
03026
03027     /* Create new output file... */
03028     printf("Write profile data: %s\n", filename);
03029     if (!(out = fopen(filename, "w")))
03030       ERRMSG("Cannot create file!");
03031
03032     /* Write header... */
03033     fprintf(out,
03034             "# $1 = time [s]\n"
03035             "# $2 = altitude [km]\n"
03036             "# $3 = longitude [deg]\n"
03037             "# $4 = latitude [deg]\n"
03038             "# $5 = pressure [hPa]\n"
03039             "# $6 = temperature [K]\n"
03040             "# $7 = volume mixing ratio [1]\n"
03041             "# $8 = H2O volume mixing ratio [1]\n"
03042             "# $9 = O3 volume mixing ratio [1]\n"
03043             "# $10 = observed BT index (mean) [K]\n"
03044             "# $11 = observed BT index (sigma) [K]\n");
03045
03046     /* Set grid box size... */
03047     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
03048     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
03049     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
03050   }
03051
03052   /* Set time interval... */
03053   t0 = t - 0.5 * ctl->dt_mod;
03054   t1 = t + 0.5 * ctl->dt_mod;
03055
03056   /* Initialize... */
03057 #pragma omp parallel for default(shared) private(ix,iy,iz)
03058   for (ix = 0; ix < ctl->prof_nx; ix++)
03059     for (iy = 0; iy < ctl->prof_ny; iy++) {
03060       obsmean[ix][iy] = 0;
03061       obsmean2[ix][iy] = 0;
03062       obscount[ix][iy] = 0;
03063       for (iz = 0; iz < ctl->prof_nz; iz++)
03064         mass[ix][iy][iz] = 0;
03065     }
03066
03067   /* Read observation data... */
03068   while (fgets(line, LEN, in)) {
03069
03070     /* Read data... */
03071     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
03072         5)
03073       continue;
03074
03075     /* Check time... */
03076     if (rt < t0)
03077       continue;
03078     if (rt > t1)
03079       break;
```

```
03080
03081     /* Calculate indices... */
03082     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
03083     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
03084
03085     /* Check indices... */
03086     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
03087       continue;
03088
03089     /* Get mean observation index... */
03090     obsmean[ix][iy] += robs;
03091     obsmean2[ix][iy] += SQR(robs);
03092     obscount[ix][iy]++;
03093   }
03094
03095   /* Analyze model data... */
03096 #pragma omp parallel for default(shared) private(ip,ix,iy,iz)
03097   for (ip = 0; ip < atm->np; ip++) {
03098
03099     /* Check time... */
03100     if (atm->time[ip] < t0 || atm->time[ip] > t1)
03101       continue;
03102
03103     /* Get indices... */
03104     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
03105     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
03106     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
03107
03108     /* Check indices... */
03109     if (ix < 0 || ix >= ctl->prof_nx ||
03110         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
03111       continue;
03112
03113     /* Get total mass in grid cell... */
03114     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
03115   }
03116
03117   /* Extract profiles... */
03118   for (ix = 0; ix < ctl->prof_nx; ix++)
03119     for (iy = 0; iy < ctl->prof_ny; iy++)
03120       if (obscount[ix][iy] > 0) {
03121
03122         /* Check profile... */
03123         okay = 0;
03124         for (iz = 0; iz < ctl->prof_nz; iz++)
03125           if (mass[ix][iy][iz] > 0) {
03126             okay = 1;
03127             break;
03128           }
03129         if (!okay)
03130           continue;
03131
03132         /* Write output... */
03133         fprintf(out, "\n");
03134
03135         /* Loop over altitudes... */
03136         for (iz = 0; iz < ctl->prof_nz; iz++) {
03137
03138           /* Set coordinates... */
03139           z = ctl->prof_z0 + dz * (iz + 0.5);
03140           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
03141           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
03142
03143           /* Get pressure and temperature... */
03144           press = P(z);
03145           intpol_met_time(met0, met1, t, press, lon, lat, NULL, NULL,
03146                           NULL, &temp, NULL, NULL, NULL, NULL, &h2o, &o3);
03147
03148           /* Calculate surface area... */
03149           area = dlat * dlon * SQR(M_PI * RE / 180.)
03150             * cos(lat * M_PI / 180.);
03151
03152           /* Calculate volume mixing ratio... */
03153           rho_air = 100. * press / (RA * temp);
03154           vmr = MA / ctl->molmass * mass[ix][iy][iz]
03155             / (rho_air * area * dz * 1e9);
03156
03157           /* Write output... */
03158           fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g\n",
03159                   t, z, lon, lat, press, temp, vmr, h2o, o3,
03160                   obsmean[ix][iy] / obscount[ix][iy],
03161                   sqrt(obsmean2[ix][iy] / obscount[ix][iy]
03162                        - SQR(obsmean[ix][iy] / obscount[ix][iy])));
03163         }
03164       }
03165
03166   /* Close file... */
```

```
03167   if (t == ctl->t_stop)
03168     fclose(out);
03169 }
03170
03171 /*****************************************************************************/
03172
03173 void write_station(
03174   const char *filename,
03175   ctl_t * ctl,
03176   atm_t * atm,
03177   double t) {
03178
03179   static FILE *out;
03180
03181   static double rmax2, t0, t1, x0[3], x1[3];
03182
03183   /* Init... */
03184   if (t == ctl->t_start) {
03185
03186     /* Write info... */
03187     printf("Write station data: %s\n", filename);
03188
03189     /* Create new file... */
03190     if (!(out = fopen(filename, "w")))
03191       ERRMSG("Cannot create file!");
03192
03193     /* Write header... */
03194     fprintf(out,
03195             "# $1 = time [s]\n"
03196             "# $2 = altitude [km]\n"
03197             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
03198     for (int iq = 0; iq < ctl->nq; iq++)
03199       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
03200               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
03201     fprintf(out, "\n");
03202
03203     /* Set geolocation and search radius... */
03204     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
03205     rmax2 = SQR(ctl->stat_r);
03206   }
03207
03208   /* Set time interval for output... */
03209   t0 = t - 0.5 * ctl->dt_mod;
03210   t1 = t + 0.5 * ctl->dt_mod;
03211
03212   /* Loop over air parcels... */
03213   for (int ip = 0; ip < atm->np; ip++) {
03214
03215     /* Check time... */
03216     if (atm->time[ip] < t0 || atm->time[ip] > t1)
03217       continue;
03218
03219     /* Check station flag... */
03220     if (ctl->qnt_stat >= 0)
03221       if (atm->q[ctl->qnt_stat][ip])
03222         continue;
03223
03224     /* Get Cartesian coordinates... */
03225     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
03226
03227     /* Check horizontal distance... */
03228     if (DIST2(x0, x1) > rmax2)
03229       continue;
03230
03231     /* Set station flag... */
03232     if (ctl->qnt_stat >= 0)
03233       atm->q[ctl->qnt_stat][ip] = 1;
03234
03235     /* Write data... */
03236     fprintf(out, "%.2f %g %g %g",
03237             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
03238     for (int iq = 0; iq < ctl->nq; iq++) {
03239       fprintf(out, " ");
03240       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
03241     }
03242     fprintf(out, "\n");
03243   }
03244
03245   /* Close file... */
03246   if (t == ctl->t_stop)
03247     fclose(out);
03248 }
```

5.21 libtrac.h File Reference

MPTRAC library declarations.

Data Structures

- struct ctl_t
  Control parameters.
- struct atm_t
  Atmospheric data.
- struct cache_t
  Cache data.
- struct met_t
  Meteorological data.

Functions

- void cart2geo (double *x, double *z, double *lon, double *lat)
  Convert Cartesian coordinates to geolocation.
- double clim_hno3 (double t, double lat, double p)
  Climatology of HNO3 volume mixing ratios.
- double clim_tropo (double t, double lat)
  Climatology of tropopause pressure.
- void day2doy (int year, int mon, int day, int *doy)
  Get day of year from date.
- void doy2day (int year, int doy, int *mon, int *day)
  Get date from day of year.
- void geo2cart (double z, double lon, double lat, double *x)
  Convert geolocation to Cartesian coordinates.
- void get_met (ctl_t *ctl, char *metbase, double t, met_t **met0, met_t **met1)
  Get meteorological data for given timestep.
- void get_met_help (double t, int direct, char *metbase, double dt_met, char *filename)
  Get meteorological data for timestep.
- void get_met_replace (char *orig, char *search, char *repl)
  Replace template strings in filename.
- double intpol_met_2d (double array[EX][EY], int ix, int iy, double wx, double wy)
  Linear interpolation of 2-D meteorological data.
- double intpol_met_3d (float array[EX][EY][EP], int ip, int ix, int iy, double wp, double wx, double wy)
  Linear interpolation of 3-D meteorological data.
- void intpol_met_space (met_t *met, double p, double lon, double lat, double *ps, double *pt, double *z, double *t, double *u, double *v, double *w, double *pv, double *h2o, double *o3)
  Spatial interpolation of meteorological data.
- void intpol_met_time (met_t *met0, met_t *met1, double ts, double p, double lon, double lat, double *ps, double *pt, double *z, double *t, double *u, double *v, double *w, double *pv, double *h2o, double *o3)
  Temporal interpolation of meteorological data.
- void jsec2time (double jsec, int *year, int *mon, int *day, int *hour, int *min, int *sec, double *remain)
  Convert seconds to date.
- int locate_irr (double *xx, int n, double x)
  Find array index for irregular grid.
- int locate_reg (double *xx, int n, double x)

Find array index for regular grid.

- int read_atm (const char *filename, ctl_t *ctl, atm_t *atm)

  Read atmospheric data.
- void read_ctl (const char *filename, int argc, char *argv[ ], ctl_t *ctl)

  Read control parameters.
- int read_met (ctl_t *ctl, char *filename, met_t *met)

  Read meteorological data file.
- void read_met_extrapolate (met_t *met)

  Extrapolate meteorological data at lower boundary.
- void read_met_geopot (ctl_t *ctl, met_t *met)

  Calculate geopotential heights.
- void read_met_help (int ncid, char *varname, char *varname2, met_t *met, float dest[EX][EY][EP], float scl)

  Read and convert variable from meteorological data file.
- void read_met_ml2pl (ctl_t *ctl, met_t *met, float var[EX][EY][EP])

  Convert meteorological data from model levels to pressure levels.
- void read_met_periodic (met_t *met)

  Create meteorological data with periodic boundary conditions.
- void read_met_pv (met_t *met)

  Calculate potential vorticity.
- void read_met_sample (ctl_t *ctl, met_t *met)

  Downsampling of meteorological data.
- void read_met_tropo (ctl_t *ctl, met_t *met)

  Calculate tropopause pressure.
- double scan_ctl (const char *filename, int argc, char *argv[ ], const char *varname, int arridx, const char *defvalue, char *value)

  Read a control parameter from file or command line.
- void spline (double *x, double *y, int n, double *x2, double *y2, int n2)

  Spline interpolation.
- double stddev (double *data, int n)

  Calculate standard deviation.
- void time2jsec (int year, int mon, int day, int hour, int min, int sec, double remain, double *jsec)

  Convert date to seconds.
- void timer (const char *name, int id, int mode)

  Measure wall-clock time.
- void write_atm (const char *filename, ctl_t *ctl, atm_t *atm, double t)

  Write atmospheric data.
- void write_csi (const char *filename, ctl_t *ctl, atm_t *atm, double t)

  Write CSI data.
- void write_ens (const char *filename, ctl_t *ctl, atm_t *atm, double t)

  Write ensemble data.
- void write_grid (const char *filename, ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, double t)

  Write gridded data.
- void write_prof (const char *filename, ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, double t)

  Write profile data.
- void write_station (const char *filename, ctl_t *ctl, atm_t *atm, double t)

  Write station data.

5.21.1 Detailed Description

MPTRAC library declarations.

Definition in file libtrac.h.

5.21.2 Function Documentation

5.21.2.1 void cart2geo (double * x, double * z, double * lon, double * lat)

Convert Cartesian coordinates to geolocation.

Definition at line 29 of file libtrac.c.

```
00033               {
00034
00035   double radius = NORM(x);
00036   *lat = asin(x[2] / radius) * 180 / M_PI;
00037   *lon = atan2(x[1], x[0]) * 180 / M_PI;
00038   *z = radius - RE;
00039 }
```

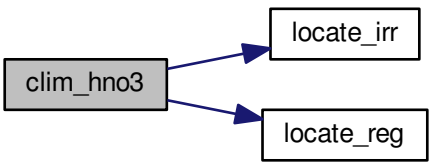
5.21.2.2 double clim_hno3 (double t, double lat, double p)

Climatology of HNO3 volume mixing ratios.

Definition at line 295 of file libtrac.c.

```
00298            {
00299
00300   /* Get seconds since begin of year... */
00301   double sec = FMOD(t, 365.25 * 86400.);
00302
00303   /* Get indices... */
00304   int isec = locate_irr(clim_hno3_secs, 12, sec);
00305   int ilat = locate_reg(clim_hno3_lats, 18, lat);
00306   int ip = locate_irr(clim_hno3_ps, 10, p);
00307
00308   /* Interpolate... */
00309   double aux00 = LIN(clim_hno3_ps[ip], clim_hno3_var[isec][ilat][ip],
00310                      clim_hno3_ps[ip + 1], clim_hno3_var[isec][ilat][ip + 1],
00311                      p);
00312   double aux01 = LIN(clim_hno3_ps[ip], clim_hno3_var[isec][ilat + 1][ip],
00313                      clim_hno3_ps[ip + 1],
00314                      clim_hno3_var[isec][ilat + 1][ip + 1], p);
00315   double aux10 = LIN(clim_hno3_ps[ip], clim_hno3_var[isec + 1][ilat][ip],
00316                      clim_hno3_ps[ip + 1],
00317                      clim_hno3_var[isec + 1][ilat][ip + 1], p);
00318   double aux11 = LIN(clim_hno3_ps[ip], clim_hno3_var[isec + 1][ilat + 1][ip],
00319                      clim_hno3_ps[ip + 1],
00320                      clim_hno3_var[isec + 1][ilat + 1][ip + 1],
00321                      p);
00322   aux00 =
00323     LIN(clim_hno3_lats[ilat], aux00, clim_hno3_lats[ilat + 1], aux01, lat);
00324   aux11 =
00325     LIN(clim_hno3_lats[ilat], aux10, clim_hno3_lats[ilat + 1], aux11, lat);
00326   return LIN(clim_hno3_secs[isec], aux00, clim_hno3_secs[isec + 1], aux11,
00327              sec);
00328 }
```

Here is the call graph for this function:



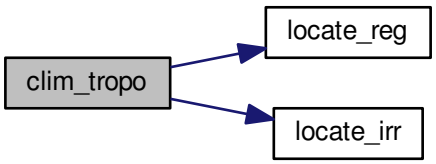
5.21.2.3 double clim_tropo (double *t*, double *lat*)

Climatology of tropopause pressure.

Definition at line 457 of file libtrac.c.

```
00459              {
00460
00461   /* Get day of year... */
00462   double doy = FMOD(t / 86400., 365.25);
00463   while (doy < 0)
00464     doy += 365.25;
00465
00466   /* Get indices... */
00467   int ilat = locate_reg(clim_tropo_lats, 73, lat);
00468   int imon = locate_irr(clim_tropo_doys, 12, doy);
00469
00470   /* Interpolate... */
00471   double p0 = LIN(clim_tropo_lats[ilat], clim_tropo_tps[imon][ilat],
00472                   clim_tropo_lats[ilat + 1], clim_tropo_tps[imon][ilat + 1],
00473                   lat);
00474   double p1 = LIN(clim_tropo_lats[ilat], clim_tropo_tps[imon + 1][ilat],
00475                   clim_tropo_lats[ilat + 1],
00476                   clim_tropo_tps[imon + 1][ilat + 1],
00477                   lat);
00478   return LIN(clim_tropo_doys[imon], p0, clim_tropo_doys[imon + 1], p1, doy);
00479 }
```

Here is the call graph for this function:



5.21.2.4 void day2doy (int *year*, int *mon*, int *day*, int * *doy*)

Get day of year from date.

Definition at line 483 of file libtrac.c.

```
00487              {
00488
00489   int d0[12] = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00490   int d01[12] = { 1, 32, 61, 92, 122, 153, 183, 214, 245, 275, 306, 336 };
00491
00492   /* Get day of year... */
00493   if (year % 400 == 0 || (year % 100 != 0 && year % 4 == 0))
00494     *doy = d01[mon - 1] + day - 1;
00495   else
00496     *doy = d0[mon - 1] + day - 1;
00497 }
```

5.21.2.5 void doy2day (int *year*, int *doy*, int * *mon*, int * *day*)

Get date from day of year.

Definition at line 501 of file libtrac.c.

```
00505             {
00506
00507   int d0[12] = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00508   int d0l[12] = { 1, 32, 61, 92, 122, 153, 183, 214, 245, 275, 306, 336 };
00509   int i;
00510
00511   /* Get month and day... */
00512   if (year % 400 == 0 || (year % 100 != 0 && year % 4 == 0)) {
00513     for (i = 11; i >= 0; i--)
00514       if (d0l[i] <= doy)
00515         break;
00516     *mon = i + 1;
00517     *day = doy - d0l[i] + 1;
00518   } else {
00519     for (i = 11; i >= 0; i--)
00520       if (d0[i] <= doy)
00521         break;
00522     *mon = i + 1;
00523     *day = doy - d0[i] + 1;
00524   }
00525 }
```

5.21.2.6 void geo2cart (double *z*, double *lon*, double *lat*, double * *x*)

Convert geolocation to Cartesian coordinates.

Definition at line 529 of file libtrac.c.

```
00533              {
00534
00535   double radius = z + RE;
00536   x[0] = radius * cos(lat / 180 * M_PI) * cos(lon / 180 * M_PI);
00537   x[1] = radius * cos(lat / 180 * M_PI) * sin(lon / 180 * M_PI);
00538   x[2] = radius * sin(lat / 180 * M_PI);
00539 }
```

5.21.2.7 void get_met (ctl_t * *ctl*, char * *metbase*, double *t*, met_t ** *met0*, met_t ** *met1*)

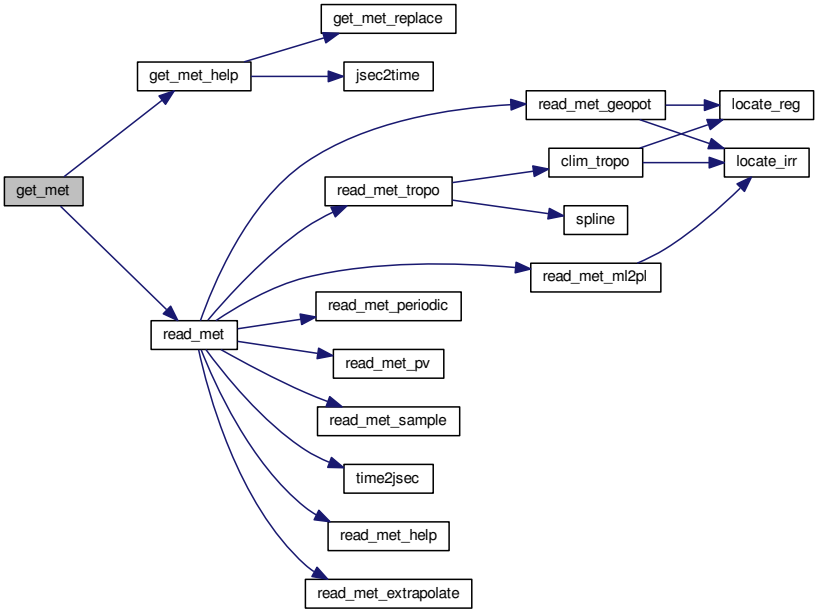
Get meteorological data for given timestep.

Definition at line 543 of file libtrac.c.

```
00548                  {
00549
00550   static int init, ip, ix, iy;
00551
00552   met_t *mets;
00553
00554   char filename[LEN];
00555
00556   /* Init... */
00557   if (t == ctl->t_start || !init) {
00558     init = 1;
00559
00560     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00561     if (!read_met(ctl, filename, *met0))
00562       ERRMSG("Cannot open file!");
00563
00564     get_met_help(t + 1.0 * ctl->direction, 1, metbase, ctl->
      dt_met, filename);
00565     if (!read_met(ctl, filename, *met1))
00566       ERRMSG("Cannot open file!");
00567 #ifdef _OPENACC
00568     met_t *met0up = *met0;
```

```
00569     met_t *met1up = *met1;
00570 #pragma acc update device(met0up[:1],met1up[:1])
00571 #endif
00572   }
00573
00574   /* Read new data for forward trajectories... */
00575   if (t > (*met1)->time && ctl->direction == 1) {
00576     mets = *met1;
00577     *met1 = *met0;
00578     *met0 = mets;
00579     get_met_help(t, 1, metbase, ctl->dt_met, filename);
00580     if (!read_met(ctl, filename, *met1))
00581       ERRMSG("Cannot open file!");
00582 #ifdef _OPENACC
00583     met_t *met1up = *met1;
00584 #pragma acc update device(met1up[:1])
00585 #endif
00586   }
00587
00588   /* Read new data for backward trajectories... */
00589   if (t < (*met0)->time && ctl->direction == -1) {
00590     mets = *met1;
00591     *met1 = *met0;
00592     *met0 = mets;
00593     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00594     if (!read_met(ctl, filename, *met0))
00595       ERRMSG("Cannot open file!");
00596 #ifdef _OPENACC
00597     met_t *met0up = *met0;
00598 #pragma acc update device(met0up[:1])
00599 #endif
00600   }
00601
00602   /* Check that grids are consistent... */
00603   if ((*met0)->nx != (*met1)->nx
00604       || (*met0)->ny != (*met1)->ny || (*met0)->np != (*met1)->np)
00605     ERRMSG("Meteo grid dimensions do not match!");
00606   for (ix = 0; ix < (*met0)->nx; ix++)
00607     if ((*met0)->lon[ix] != (*met1)->lon[ix])
00608       ERRMSG("Meteo grid longitudes do not match!");
00609   for (iy = 0; iy < (*met0)->ny; iy++)
00610     if ((*met0)->lat[iy] != (*met1)->lat[iy])
00611       ERRMSG("Meteo grid latitudes do not match!");
00612   for (ip = 0; ip < (*met0)->np; ip++)
00613     if ((*met0)->p[ip] != (*met1)->p[ip])
00614       ERRMSG("Meteo grid pressure levels do not match!");
00615 }
```

Here is the call graph for this function:



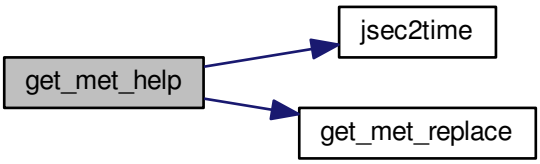
5.21.2.8 void get_met_help (double *t*, int *direct*, char * *metbase*, double *dt_met*, char * *filename*)

Get meteorological data for timestep.

Definition at line 619 of file libtrac.c.

```
00624                   {
00625
00626   char repl[LEN];
00627
00628   double t6, r;
00629
00630   int year, mon, day, hour, min, sec;
00631
00632   /* Round time to fixed intervals... */
00633   if (direct == -1)
00634     t6 = floor(t / dt_met) * dt_met;
00635   else
00636     t6 = ceil(t / dt_met) * dt_met;
00637
00638   /* Decode time... */
00639   jsec2time(t6, &year, &mon, &day, &hour, &min, &sec, &r);
00640
00641   /* Set filename... */
00642   sprintf(filename, "%s_YYYY_MM_DD_HH.nc", metbase);
00643   sprintf(repl, "%d", year);
00644   get_met_replace(filename, "YYYY", repl);
00645   sprintf(repl, "%02d", mon);
00646   get_met_replace(filename, "MM", repl);
00647   sprintf(repl, "%02d", day);
00648   get_met_replace(filename, "DD", repl);
00649   sprintf(repl, "%02d", hour);
00650   get_met_replace(filename, "HH", repl);
00651 }
```

Here is the call graph for this function:



5.21.2.9 void get_met_replace (char * *orig*, char * *search*, char * *repl*)

Replace template strings in filename.

Definition at line 655 of file libtrac.c.

```
00658               {
00659
00660   char buffer[LEN], *ch;
00661
00662   /* Iterate... */
00663   for (int i = 0; i < 3; i++) {
00664
00665     /* Replace substring... */
00666     if (!(ch = strstr(orig, search)))
00667       return;
00668     strncpy(buffer, orig, (size_t) (ch - orig));
00669     buffer[ch - orig] = 0;
00670     sprintf(buffer + (ch - orig), "%s%s", repl, ch + strlen(search));
00671     orig[0] = 0;
00672     strcpy(orig, buffer);
00673   }
00674 }
```

5.21.2.10 double intpol_met_2d (double *array[EX][EY]*, int *ix*, int *iy*, double *wx*, double *wy*)

Linear interpolation of 2-D meteorological data.

Definition at line 678 of file libtrac.c.

```
00683             {
00684
00685   /* Set variables... */
00686   double aux00 = array[ix][iy];
00687   double aux01 = array[ix][iy + 1];
00688   double aux10 = array[ix + 1][iy];
00689   double aux11 = array[ix + 1][iy + 1];
00690
00691   /* Interpolate horizontally... */
00692   aux00 = wy * (aux00 - aux01) + aux01;
00693   aux11 = wy * (aux10 - aux11) + aux11;
00694   return wx * (aux00 - aux11) + aux11;
00695 }
```

5.21.2.11 double intpol_met_3d (float *array[EX][EY][EP]*, int *ip*, int *ix*, int *iy*, double *wp*, double *wx*, double *wy*)

Linear interpolation of 3-D meteorological data.

Definition at line 699 of file libtrac.c.

```
00706             {
00707
00708   /* Interpolate vertically... */
00709   double aux00 = wp * (array[ix][iy][ip] - array[ix][iy][ip + 1])
00710     + array[ix][iy][ip + 1];
00711   double aux01 = wp * (array[ix][iy + 1][ip] - array[ix][iy + 1][ip + 1])
00712     + array[ix][iy + 1][ip + 1];
00713   double aux10 = wp * (array[ix + 1][iy][ip] - array[ix + 1][iy][ip + 1])
00714     + array[ix + 1][iy][ip + 1];
00715   double aux11 =
00716     wp * (array[ix + 1][iy + 1][ip] - array[ix + 1][iy + 1][ip + 1])
00717     + array[ix + 1][iy + 1][ip + 1];
00718
00719   /* Interpolate horizontally... */
00720   aux00 = wy * (aux00 - aux01) + aux01;
00721   aux11 = wy * (aux10 - aux11) + aux11;
00722   return wx * (aux00 - aux11) + aux11;
00723 }
```

5.21.2.12 void intpol_met_space (met_t * *met*, double *p*, double *lon*, double *lat*, double * *ps*, double * *pt*, double * *z*, double * *t*, double * *u*, double * *v*, double * *w*, double * *pv*, double * *h2o*, double * *o3*)

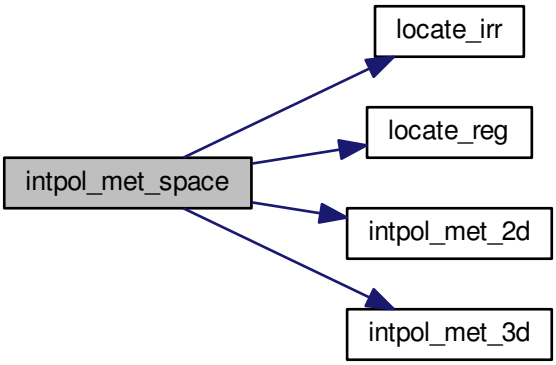
Spatial interpolation of meteorological data.

Definition at line 727 of file libtrac.c.

```
00741              {
00742
00743   /* Check longitude... */
00744   if (met->lon[met->nx - 1] > 180 && lon < 0)
00745     lon += 360;
00746
00747   /* Get indices... */
00748   int ip = locate_irr(met->p, met->np, p);
00749   int ix = locate_reg(met->lon, met->nx, lon);
00750   int iy = locate_reg(met->lat, met->ny, lat);
00751
00752   /* Get weights... */
00753   double wp = (met->p[ip + 1] - p) / (met->p[ip + 1] - met->p[ip]);
00754   double wx = (met->lon[ix + 1] - lon) / (met->lon[ix + 1] - met->lon[ix]);
00755   double wy = (met->lat[iy + 1] - lat) / (met->lat[iy + 1] - met->lat[iy]);
00756
00757   /* Interpolate... */
```

```
00758   if (ps != NULL)
00759     *ps = intpol_met_2d(met->ps, ix, iy, wx, wy);
00760   if (pt != NULL)
00761     *pt = intpol_met_2d(met->pt, ix, iy, wx, wy);
00762   if (z != NULL)
00763     *z = intpol_met_3d(met->z, ip, ix, iy, wp, wx, wy);
00764   if (t != NULL)
00765     *t = intpol_met_3d(met->t, ip, ix, iy, wp, wx, wy);
00766   if (u != NULL)
00767     *u = intpol_met_3d(met->u, ip, ix, iy, wp, wx, wy);
00768   if (v != NULL)
00769     *v = intpol_met_3d(met->v, ip, ix, iy, wp, wx, wy);
00770   if (w != NULL)
00771     *w = intpol_met_3d(met->w, ip, ix, iy, wp, wx, wy);
00772   if (pv != NULL)
00773     *pv = intpol_met_3d(met->pv, ip, ix, iy, wp, wx, wy);
00774   if (h2o != NULL)
00775     *h2o = intpol_met_3d(met->h2o, ip, ix, iy, wp, wx, wy);
00776   if (o3 != NULL)
00777     *o3 = intpol_met_3d(met->o3, ip, ix, iy, wp, wx, wy);
00778 }
```

Here is the call graph for this function:



5.21.2.13 void intpol_met_time (met_t * *met0*, met_t * *met1*, double *ts*, double *p*, double *lon*, double *lat*, double * *ps*, double * *pt*, double * *z*, double * *t*, double * *u*, double * *v*, double * *w*, double * *pv*, double * *h2o*, double * *o3*)

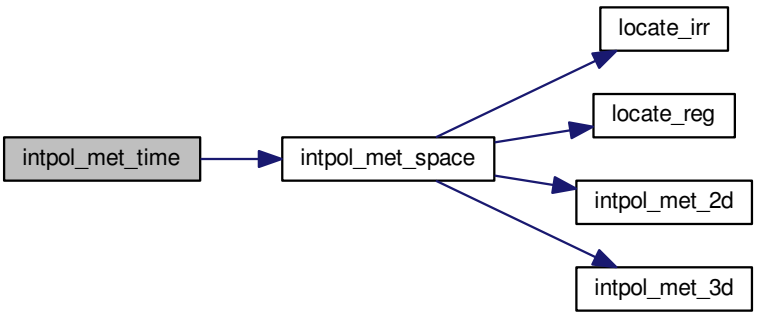
Temporal interpolation of meteorological data.

Definition at line 782 of file libtrac.c.

```
00798               {
00799
00800   double h2o0, h2o1, o30, o31, ps0, ps1, pt0, pt1, pv0, pv1, t0, t1, u0, u1,
00801     v0, v1, w0, w1, wt, z0, z1;
00802
00803   /* Spatial interpolation... */
00804   intpol_met_space(met0, p, lon, lat,
00805                    ps == NULL ? NULL : &ps0,
00806                    pt == NULL ? NULL : &pt0,
00807                    z == NULL ? NULL : &z0,
00808                    t == NULL ? NULL : &t0,
00809                    u == NULL ? NULL : &u0,
00810                    v == NULL ? NULL : &v0,
00811                    w == NULL ? NULL : &w0,
00812                    pv == NULL ? NULL : &pv0,
00813                    h2o == NULL ? NULL : &h2o0, o3 == NULL ? NULL : &o30);
00814   intpol_met_space(met1, p, lon, lat,
```

```
00815                   ps == NULL ? NULL : &ps1,
00816                   pt == NULL ? NULL : &pt1,
00817                   z == NULL ? NULL : &z1,
00818                   t == NULL ? NULL : &t1,
00819                   u == NULL ? NULL : &u1,
00820                   v == NULL ? NULL : &v1,
00821                   w == NULL ? NULL : &w1,
00822                   pv == NULL ? NULL : &pv1,
00823                   h2o == NULL ? NULL : &h2o1, o3 == NULL ? NULL : &o31);
00824
00825   /* Get weighting factor... */
00826   wt = (met1->time - ts) / (met1->time - met0->time);
00827
00828   /* Interpolate... */
00829   if (ps != NULL)
00830     *ps = wt * (ps0 - ps1) + ps1;
00831   if (pt != NULL)
00832     *pt = wt * (pt0 - pt1) + pt1;
00833   if (z != NULL)
00834     *z = wt * (z0 - z1) + z1;
00835   if (t != NULL)
00836     *t = wt * (t0 - t1) + t1;
00837   if (u != NULL)
00838     *u = wt * (u0 - u1) + u1;
00839   if (v != NULL)
00840     *v = wt * (v0 - v1) + v1;
00841   if (w != NULL)
00842     *w = wt * (w0 - w1) + w1;
00843   if (pv != NULL)
00844     *pv = wt * (pv0 - pv1) + pv1;
00845   if (h2o != NULL)
00846     *h2o = wt * (h2o0 - h2o1) + h2o1;
00847   if (o3 != NULL)
00848     *o3 = wt * (o30 - o31) + o31;
00849 }
```

Here is the call graph for this function:



5.21.2.14 void jsec2time (double *jsec*, int * *year*, int * *mon*, int * *day*, int * *hour*, int * *min*, int * *sec*, double * *remain*)

Convert seconds to date.

Definition at line 853 of file libtrac.c.

```
00861                   {
00862
00863   struct tm t0, *t1;
00864
00865   t0.tm_year = 100;
00866   t0.tm_mon = 0;
00867   t0.tm_mday = 1;
00868   t0.tm_hour = 0;
```

```
00869   t0.tm_min = 0;
00870   t0.tm_sec = 0;
00871
00872   time_t jsec0 = (time_t) jsec + timegm(&t0);
00873   t1 = gmtime(&jsec0);
00874
00875   *year = t1->tm_year + 1900;
00876   *mon = t1->tm_mon + 1;
00877   *day = t1->tm_mday;
00878   *hour = t1->tm_hour;
00879   *min = t1->tm_min;
00880   *sec = t1->tm_sec;
00881   *remain = jsec - floor(jsec);
00882 }
```

5.21.2.15 int locate_irr (double * *xx*, int *n*, double *x*)

Find array index for irregular grid.

Definition at line 886 of file libtrac.c.

```
00889             {
00890
00891   int ilo = 0;
00892   int ihi = n - 1;
00893   int i = (ihi + ilo) >> 1;
00894
00895   if (xx[i] < xx[i + 1])
00896     while (ihi > ilo + 1) {
00897       i = (ihi + ilo) >> 1;
00898       if (xx[i] > x)
00899         ihi = i;
00900       else
00901         ilo = i;
00902   } else
00903     while (ihi > ilo + 1) {
00904       i = (ihi + ilo) >> 1;
00905       if (xx[i] <= x)
00906         ihi = i;
00907       else
00908         ilo = i;
00909     }
00910
00911   return ilo;
00912 }
```

5.21.2.16 int locate_reg (double * *xx*, int *n*, double *x*)

Find array index for regular grid.

Definition at line 916 of file libtrac.c.

```
00919             {
00920
00921   /* Calculate index... */
00922   int i = (int) ((x - xx[0]) / (xx[1] - xx[0]));
00923
00924   /* Check range... */
00925   if (i < 0)
00926     i = 0;
00927   else if (i >= n - 2)
00928     i = n - 2;
00929
00930   return i;
00931 }
```

5.21.2.17 int read_atm (const char * *filename*, ctl_t * *ctl*, atm_t * *atm*)

Read atmospheric data.

Definition at line 935 of file libtrac.c.

```
00938               {
00939
00940   FILE *in;
00941
00942   char line[LEN], *tok;
00943
00944   double t0;
00945
00946   int dimid, ip, iq, ncid, varid;
00947
00948   size_t nparts;
00949
00950   /* Init... */
00951   atm->np = 0;
00952
00953   /* Write info... */
00954   printf("Read atmospheric data: %s\n", filename);
00955
00956   /* Read ASCII data... */
00957   if (ctl->atm_type == 0) {
00958
00959     /* Open file... */
00960     if (!(in = fopen(filename, "r"))) {
00961       WARN("File not found!");
00962       return 0;
00963     }
00964
00965     /* Read line... */
00966     while (fgets(line, LEN, in)) {
00967
00968       /* Read data... */
00969       TOK(line, tok, "%lg", atm->time[atm->np]);
00970       TOK(NULL, tok, "%lg", atm->p[atm->np]);
00971       TOK(NULL, tok, "%lg", atm->lon[atm->np]);
00972       TOK(NULL, tok, "%lg", atm->lat[atm->np]);
00973       for (iq = 0; iq < ctl->nq; iq++)
00974         TOK(NULL, tok, "%lg", atm->q[iq][atm->np]);
00975
00976       /* Convert altitude to pressure... */
00977       atm->p[atm->np] = P(atm->p[atm->np]);
00978
00979       /* Increment data point counter... */
00980       if ((++atm->np) > NP)
00981         ERRMSG("Too many data points!");
00982     }
00983
00984     /* Close file... */
00985     fclose(in);
00986   }
00987
00988   /* Read binary data... */
00989   else if (ctl->atm_type == 1) {
00990
00991     /* Open file... */
00992     if (!(in = fopen(filename, "r")))
00993       return 0;
00994
00995     /* Read data... */
00996     FREAD(&atm->np, int, 1, in);
00997     FREAD(atm->time, double,
00998           (size_t) atm->np,
00999           in);
01000     FREAD(atm->p, double,
01001           (size_t) atm->np,
01002           in);
01003     FREAD(atm->lon, double,
01004           (size_t) atm->np,
01005           in);
01006     FREAD(atm->lat, double,
01007           (size_t) atm->np,
01008           in);
01009     for (iq = 0; iq < ctl->nq; iq++)
01010       FREAD(atm->q[iq], double,
01011             (size_t) atm->np,
01012             in);
01013
01014     /* Close file... */
```

```
01015     fclose(in);
01016   }
01017
01018   /* Read netCDF data... */
01019   else if (ctl->atm_type == 2) {
01020
01021     /* Open file... */
01022     if (nc_open(filename, NC_NOWRITE, &ncid) != NC_NOERR)
01023       return 0;
01024
01025     /* Get dimensions... */
01026     NC(nc_inq_dimid(ncid, "NPARTS", &dimid));
01027     NC(nc_inq_dimlen(ncid, dimid, &nparts));
01028     atm->np = (int) nparts;
01029     if (atm->np > NP)
01030       ERRMSG("Too many particles!");
01031
01032     /* Get time... */
01033     NC(nc_inq_varid(ncid, "time", &varid));
01034     NC(nc_get_var_double(ncid, varid, &t0));
01035     for (ip = 0; ip < atm->np; ip++)
01036       atm->time[ip] = t0;
01037
01038     /* Read geolocations... */
01039     NC(nc_inq_varid(ncid, "PRESS", &varid));
01040     NC(nc_get_var_double(ncid, varid, atm->p));
01041     NC(nc_inq_varid(ncid, "LON", &varid));
01042     NC(nc_get_var_double(ncid, varid, atm->lon));
01043     NC(nc_inq_varid(ncid, "LAT", &varid));
01044     NC(nc_get_var_double(ncid, varid, atm->lat));
01045
01046     /* Read variables... */
01047     if (ctl->qnt_p >= 0)
01048       if (nc_inq_varid(ncid, "PRESS", &varid) == NC_NOERR)
01049         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_p]));
01050     if (ctl->qnt_t >= 0)
01051       if (nc_inq_varid(ncid, "TEMP", &varid) == NC_NOERR)
01052         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_t]));
01053     if (ctl->qnt_u >= 0)
01054       if (nc_inq_varid(ncid, "U", &varid) == NC_NOERR)
01055         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_u]));
01056     if (ctl->qnt_v >= 0)
01057       if (nc_inq_varid(ncid, "V", &varid) == NC_NOERR)
01058         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_v]));
01059     if (ctl->qnt_w >= 0)
01060       if (nc_inq_varid(ncid, "W", &varid) == NC_NOERR)
01061         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_w]));
01062     if (ctl->qnt_h2o >= 0)
01063       if (nc_inq_varid(ncid, "SH", &varid) == NC_NOERR)
01064         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_h2o]));
01065     if (ctl->qnt_o3 >= 0)
01066       if (nc_inq_varid(ncid, "O3", &varid) == NC_NOERR)
01067         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_o3]));
01068     if (ctl->qnt_theta >= 0)
01069       if (nc_inq_varid(ncid, "THETA", &varid) == NC_NOERR)
01070         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_theta]));
01071     if (ctl->qnt_pv >= 0)
01072       if (nc_inq_varid(ncid, "PV", &varid) == NC_NOERR)
01073         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_pv]));
01074
01075     /* Check data... */
01076     for (ip = 0; ip < atm->np; ip++)
01077       if (fabs(atm->lon[ip]) > 360 || fabs(atm->lat[ip]) > 90
01078           || (ctl->qnt_t >= 0 && fabs(atm->q[ctl->qnt_t][ip]) > 350)
01079           || (ctl->qnt_h2o >= 0 && fabs(atm->q[ctl->qnt_h2o][ip]) > 1)
01080           || (ctl->qnt_theta >= 0 && fabs(atm->q[ctl->qnt_theta][ip]) > 1e10)
01081           || (ctl->qnt_pv >= 0 && fabs(atm->q[ctl->qnt_pv][ip]) > 1e10)) {
01082         atm->time[ip] = GSL_NAN;
01083         atm->p[ip] = GSL_NAN;
01084         atm->lon[ip] = GSL_NAN;
01085         atm->lat[ip] = GSL_NAN;
01086         for (iq = 0; iq < ctl->nq; iq++)
01087           atm->q[iq][ip] = GSL_NAN;
01088       } else {
01089         if (ctl->qnt_h2o >= 0)
01090           atm->q[ctl->qnt_h2o][ip] *= 1.608;
01091         if (ctl->qnt_pv >= 0)
01092           atm->q[ctl->qnt_pv][ip] *= 1e6;
01093         if (atm->lon[ip] > 180)
01094           atm->lon[ip] -= 360;
01095       }
01096
01097     /* Close file... */
01098     NC(nc_close(ncid));
01099   }
01100
01101   /* Error... */
```

```
01102   else
01103     ERRMSG("Atmospheric data type not supported!");
01104
01105   /* Check number of points... */
01106   if (atm->np < 1)
01107     ERRMSG("Can not read any data!");
01108
01109   /* Return success... */
01110   return 1;
01111 }
```

5.21.2.18 void read_ctl (const char * *filename*, int *argc*, char * *argv[]*, ctl_t * *ctl*)

Read control parameters.

Definition at line 1115 of file libtrac.c.

```
01119               {
01120
01121   /* Write info... */
01122   printf("\nMassive-Parallel Trajectory Calculations (MPTRAC)\n"
01123          "(executable: %s | compiled: %s, %s)\n\n",
01124          argv[0], __DATE__, __TIME__);
01125
01126   /* Initialize quantity indices... */
01127   ctl->qnt_ens = -1;
01128   ctl->qnt_m = -1;
01129   ctl->qnt_r = -1;
01130   ctl->qnt_rho = -1;
01131   ctl->qnt_ps = -1;
01132   ctl->qnt_pt = -1;
01133   ctl->qnt_z = -1;
01134   ctl->qnt_p = -1;
01135   ctl->qnt_t = -1;
01136   ctl->qnt_u = -1;
01137   ctl->qnt_v = -1;
01138   ctl->qnt_w = -1;
01139   ctl->qnt_h2o = -1;
01140   ctl->qnt_o3 = -1;
01141   ctl->qnt_theta = -1;
01142   ctl->qnt_vh = -1;
01143   ctl->qnt_vz = -1;
01144   ctl->qnt_pv = -1;
01145   ctl->qnt_tice = -1;
01146   ctl->qnt_tsts = -1;
01147   ctl->qnt_tnat = -1;
01148   ctl->qnt_stat = -1;
01149
01150   /* Read quantities... */
01151   ctl->nq = (int) scan_ctl(filename, argc, argv, "NQ", -1, "0", NULL);
01152   if (ctl->nq > NQ)
01153     ERRMSG("Too many quantities!");
01154   for (int iq = 0; iq < ctl->nq; iq++) {
01155
01156     /* Read quantity name and format... */
01157     scan_ctl(filename, argc, argv, "QNT_NAME", iq, "", ctl->qnt_name[iq]);
01158     scan_ctl(filename, argc, argv, "QNT_FORMAT", iq, "%g",
01159              ctl->qnt_format[iq]);
01160
01161     /* Try to identify quantity... */
01162     if (strcmp(ctl->qnt_name[iq], "ens") == 0) {
01163       ctl->qnt_ens = iq;
01164       sprintf(ctl->qnt_unit[iq], "-");
01165     } else if (strcmp(ctl->qnt_name[iq], "m") == 0) {
01166       ctl->qnt_m = iq;
01167       sprintf(ctl->qnt_unit[iq], "kg");
01168     } else if (strcmp(ctl->qnt_name[iq], "r") == 0) {
01169       ctl->qnt_r = iq;
01170       sprintf(ctl->qnt_unit[iq], "m");
01171     } else if (strcmp(ctl->qnt_name[iq], "rho") == 0) {
01172       ctl->qnt_rho = iq;
01173       sprintf(ctl->qnt_unit[iq], "kg/m^3");
01174     } else if (strcmp(ctl->qnt_name[iq], "ps") == 0) {
01175       ctl->qnt_ps = iq;
01176       sprintf(ctl->qnt_unit[iq], "hPa");
01177     } else if (strcmp(ctl->qnt_name[iq], "pt") == 0) {
01178       ctl->qnt_pt = iq;
01179       sprintf(ctl->qnt_unit[iq], "hPa");
01180     } else if (strcmp(ctl->qnt_name[iq], "z") == 0) {
01181       ctl->qnt_z = iq;
```

```
01182       sprintf(ctl->qnt_unit[iq], "km");
01183     } else if (strcmp(ctl->qnt_name[iq], "p") == 0) {
01184       ctl->qnt_p = iq;
01185       sprintf(ctl->qnt_unit[iq], "hPa");
01186     } else if (strcmp(ctl->qnt_name[iq], "t") == 0) {
01187       ctl->qnt_t = iq;
01188       sprintf(ctl->qnt_unit[iq], "K");
01189     } else if (strcmp(ctl->qnt_name[iq], "u") == 0) {
01190       ctl->qnt_u = iq;
01191       sprintf(ctl->qnt_unit[iq], "m/s");
01192     } else if (strcmp(ctl->qnt_name[iq], "v") == 0) {
01193       ctl->qnt_v = iq;
01194       sprintf(ctl->qnt_unit[iq], "m/s");
01195     } else if (strcmp(ctl->qnt_name[iq], "w") == 0) {
01196       ctl->qnt_w = iq;
01197       sprintf(ctl->qnt_unit[iq], "hPa/s");
01198     } else if (strcmp(ctl->qnt_name[iq], "h2o") == 0) {
01199       ctl->qnt_h2o = iq;
01200       sprintf(ctl->qnt_unit[iq], "1");
01201     } else if (strcmp(ctl->qnt_name[iq], "o3") == 0) {
01202       ctl->qnt_o3 = iq;
01203       sprintf(ctl->qnt_unit[iq], "1");
01204     } else if (strcmp(ctl->qnt_name[iq], "theta") == 0) {
01205       ctl->qnt_theta = iq;
01206       sprintf(ctl->qnt_unit[iq], "K");
01207     } else if (strcmp(ctl->qnt_name[iq], "vh") == 0) {
01208       ctl->qnt_vh = iq;
01209       sprintf(ctl->qnt_unit[iq], "m/s");
01210     } else if (strcmp(ctl->qnt_name[iq], "vz") == 0) {
01211       ctl->qnt_vz = iq;
01212       sprintf(ctl->qnt_unit[iq], "m/s");
01213     } else if (strcmp(ctl->qnt_name[iq], "pv") == 0) {
01214       ctl->qnt_pv = iq;
01215       sprintf(ctl->qnt_unit[iq], "PVU");
01216     } else if (strcmp(ctl->qnt_name[iq], "tice") == 0) {
01217       ctl->qnt_tice = iq;
01218       sprintf(ctl->qnt_unit[iq], "K");
01219     } else if (strcmp(ctl->qnt_name[iq], "tsts") == 0) {
01220       ctl->qnt_tsts = iq;
01221       sprintf(ctl->qnt_unit[iq], "K");
01222     } else if (strcmp(ctl->qnt_name[iq], "tnat") == 0) {
01223       ctl->qnt_tnat = iq;
01224       sprintf(ctl->qnt_unit[iq], "K");
01225     } else if (strcmp(ctl->qnt_name[iq], "stat") == 0) {
01226       ctl->qnt_stat = iq;
01227       sprintf(ctl->qnt_unit[iq], "-");
01228     } else
01229       scan_ctl(filename, argc, argv, "QNT_UNIT", iq, "", ctl->qnt_unit[iq]);
01230   }
01231
01232   /* Check quantity flags... */
01233   if (ctl->qnt_tsts >= 0)
01234     if (ctl->qnt_tice < 0 || ctl->qnt_tnat < 0)
01235       ERRMSG("Need T_ice and T_NAT to calculate T_STS!");
01236
01237   /* Time steps of simulation... */
01238   ctl->direction =
01239     (int) scan_ctl(filename, argc, argv, "DIRECTION", -1, "1", NULL);
01240   if (ctl->direction != -1 && ctl->direction != 1)
01241     ERRMSG("Set DIRECTION to -1 or 1!");
01242   ctl->t_stop = scan_ctl(filename, argc, argv, "T_STOP", -1, "1e100", NULL);
01243   ctl->dt_mod = scan_ctl(filename, argc, argv, "DT_MOD", -1, "600", NULL);
01244
01245   /* Meteorological data... */
01246   ctl->dt_met = scan_ctl(filename, argc, argv, "DT_MET", -1, "21600", NULL);
01247   ctl->met_dx = (int) scan_ctl(filename, argc, argv, "MET_DX", -1, "1", NULL);
01248   ctl->met_dy = (int) scan_ctl(filename, argc, argv, "MET_DY", -1, "1", NULL);
01249   ctl->met_dp = (int) scan_ctl(filename, argc, argv, "MET_DP", -1, "1", NULL);
01250   ctl->met_sx = (int) scan_ctl(filename, argc, argv, "MET_SX", -1, "1", NULL);
01251   ctl->met_sy = (int) scan_ctl(filename, argc, argv, "MET_SY", -1, "1", NULL);
01252   ctl->met_sp = (int) scan_ctl(filename, argc, argv, "MET_SP", -1, "1", NULL);
01253   ctl->met_np = (int) scan_ctl(filename, argc, argv, "MET_NP", -1, "0", NULL);
01254   if (ctl->met_np > EP)
01255     ERRMSG("Too many levels!");
01256   for (int ip = 0; ip < ctl->met_np; ip++)
01257     ctl->met_p[ip] = scan_ctl(filename, argc, argv, "MET_P", ip, "", NULL);
01258   ctl->met_tropo
01259     = (int) scan_ctl(filename, argc, argv, "MET_TROPO", -1, "0", NULL);
01260   scan_ctl(filename, argc, argv, "MET_GEOPOT", -1, "-", ctl->met_geopot);
01261   scan_ctl(filename, argc, argv, "MET_STAGE", -1, "-", ctl->met_stage);
01262   ctl->met_dt_out =
01263     scan_ctl(filename, argc, argv, "MET_DT_OUT", -1, "0.1", NULL);
01264
01265   /* Isosurface parameters... */
01266   ctl->isosurf
01267     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
01268   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
```

```
01269
01270   /* Diffusion parameters... */
01271   ctl->turb_dx_trop
01272     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50", NULL);
01273   ctl->turb_dx_strat
01274     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0", NULL);
01275   ctl->turb_dz_trop
01276     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0", NULL);
01277   ctl->turb_dz_strat
01278     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
01279   ctl->turb_mesox =
01280     scan_ctl(filename, argc, argv, "TURB_MESOX", -1, "0.16", NULL);
01281   ctl->turb_mesoz =
01282     scan_ctl(filename, argc, argv, "TURB_MESOZ", -1, "0.16", NULL);
01283
01284   /* Mass and life time... */
01285   ctl->molmass = scan_ctl(filename, argc, argv, "MOLMASS", -1, "1", NULL);
01286   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
01287   ctl->tdec_strat =
01288     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
01289
01290   /* PSC analysis... */
01291   ctl->psc_h2o = scan_ctl(filename, argc, argv, "PSC_H2O", -1, "4e-6", NULL);
01292   ctl->psc_hno3 =
01293     scan_ctl(filename, argc, argv, "PSC_HNO3", -1, "9e-9", NULL);
01294
01295   /* Output of atmospheric data... */
01296   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
      atm_basename);
01297   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
01298   ctl->atm_dt_out =
01299     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
01300   ctl->atm_filter =
01301     (int) scan_ctl(filename, argc, argv, "ATM_FILTER", -1, "0", NULL);
01302   ctl->atm_stride =
01303     (int) scan_ctl(filename, argc, argv, "ATM_STRIDE", -1, "1", NULL);
01304   ctl->atm_type =
01305     (int) scan_ctl(filename, argc, argv, "ATM_TYPE", -1, "0", NULL);
01306
01307   /* Output of CSI data... */
01308   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
      csi_basename);
01309   ctl->csi_dt_out =
01310     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
01311   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "-", ctl->
      csi_obsfile);
01312   ctl->csi_obsmin =
01313     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
01314   ctl->csi_modmin =
01315     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
01316   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
01317   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
01318   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
01319   ctl->csi_lon0 =
01320     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
01321   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
01322   ctl->csi_nx =
01323     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
01324   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
01325   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
01326   ctl->csi_ny =
01327     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
01328
01329   /* Output of ensemble data... */
01330   scan_ctl(filename, argc, argv, "ENS_BASENAME", -1, "-", ctl->
      ens_basename);
01331
01332   /* Output of grid data... */
01333   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
01334            ctl->grid_basename);
01335   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
      grid_gpfile);
01336   ctl->grid_dt_out =
01337     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
01338   ctl->grid_sparse =
01339     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
01340   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
01341   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
01342   ctl->grid_nz =
01343     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
01344   ctl->grid_lon0 =
01345     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
01346   ctl->grid_lon1 =
01347     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
01348   ctl->grid_nx =
01349     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
01350   ctl->grid_lat0 =
```

```
01351     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
01352   ctl->grid_lat1 =
01353     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
01354   ctl->grid_ny =
01355     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
01356
01357   /* Output of profile data... */
01358   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
01359            ctl->prof_basename);
01360   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
      prof_obsfile);
01361   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
01362   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
01363   ctl->prof_nz =
01364     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
01365   ctl->prof_lon0 =
01366     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
01367   ctl->prof_lon1 =
01368     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
01369   ctl->prof_nx =
01370     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
01371   ctl->prof_lat0 =
01372     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
01373   ctl->prof_lat1 =
01374     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
01375   ctl->prof_ny =
01376     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
01377
01378   /* Output of station data... */
01379   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
01380            ctl->stat_basename);
01381   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
01382   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
01383   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
01384 }
```

Here is the call graph for this function:

5.21.2.19 int read_met (ctl_t * *ctl*, char * *filename*, met_t * *met*)

Read meteorological data file.

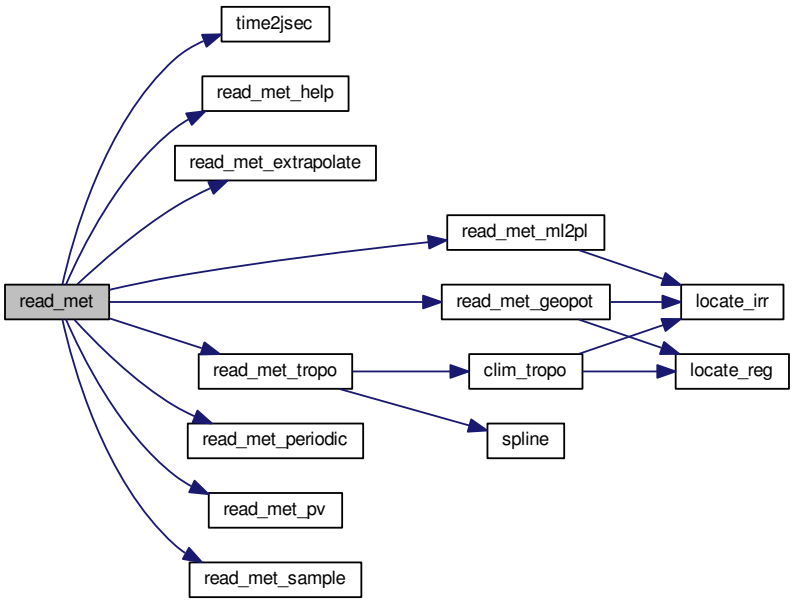
Definition at line 1388 of file libtrac.c.

```
01391               {
01392
01393   char cmd[2 * LEN], levname[LEN], tstr[10];
01394
01395   float help[EX * EY];
01396
01397   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
01398
01399   size_t np, nx, ny;
01400
01401   /* Write info... */
01402   printf("Read meteorological data: %s\n", filename);
01403
01404   /* Get time from filename... */
01405   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
01406   year = atoi(tstr);
01407   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
01408   mon = atoi(tstr);
```

```
01409   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
01410   day = atoi(tstr);
01411   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
01412   hour = atoi(tstr);
01413   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
01414
01415   /* Open netCDF file... */
01416   if (nc_open(filename, NC_NOWRITE, &ncid) != NC_NOERR) {
01417
01418     /* Try to stage meteo file... */
01419     if (ctl->met_stage[0] != '-') {
01420       sprintf(cmd, "%s %d %02d %02d %02d %s", ctl->met_stage,
01421               year, mon, day, hour, filename);
01422       if (system(cmd) != 0)
01423         ERRMSG("Error while staging meteo data!");
01424     }
01425
01426     /* Try to open again... */
01427     if (nc_open(filename, NC_NOWRITE, &ncid) != NC_NOERR) {
01428       WARN("File not found!");
01429       return 0;
01430     }
01431   }
01432
01433   /* Get dimensions... */
01434   NC(nc_inq_dimid(ncid, "lon", &dimid));
01435   NC(nc_inq_dimlen(ncid, dimid, &nx));
01436   if (nx < 2 || nx > EX)
01437     ERRMSG("Number of longitudes out of range!");
01438
01439   NC(nc_inq_dimid(ncid, "lat", &dimid));
01440   NC(nc_inq_dimlen(ncid, dimid, &ny));
01441   if (ny < 2 || ny > EY)
01442     ERRMSG("Number of latitudes out of range!");
01443
01444   sprintf(levname, "lev");
01445   NC(nc_inq_dimid(ncid, levname, &dimid));
01446   NC(nc_inq_dimlen(ncid, dimid, &np));
01447   if (np == 1) {
01448     sprintf(levname, "lev_2");
01449     NC(nc_inq_dimid(ncid, levname, &dimid));
01450     NC(nc_inq_dimlen(ncid, dimid, &np));
01451   }
01452   if (np < 2 || np > EP)
01453     ERRMSG("Number of levels out of range!");
01454
01455   /* Store dimensions... */
01456   met->np = (int) np;
01457   met->nx = (int) nx;
01458   met->ny = (int) ny;
01459
01460   /* Get horizontal grid... */
01461   NC(nc_inq_varid(ncid, "lon", &varid));
01462   NC(nc_get_var_double(ncid, varid, met->lon));
01463   NC(nc_inq_varid(ncid, "lat", &varid));
01464   NC(nc_get_var_double(ncid, varid, met->lat));
01465
01466   /* Read meteorological data... */
01467   read_met_help(ncid, "t", "T", met, met->t, 1.0);
01468   read_met_help(ncid, "u", "U", met, met->u, 1.0);
01469   read_met_help(ncid, "v", "V", met, met->v, 1.0);
01470   read_met_help(ncid, "w", "W", met, met->w, 0.01f);
01471   read_met_help(ncid, "q", "Q", met, met->h2o, (float) (MA / 18.01528));
01472   read_met_help(ncid, "o3", "O3", met, met->o3, (float) (MA / 48.00));
01473
01474   /* Meteo data on pressure levels... */
01475   if (ctl->met_np <= 0) {
01476
01477     /* Read pressure levels from file... */
01478     NC(nc_inq_varid(ncid, levname, &varid));
01479     NC(nc_get_var_double(ncid, varid, met->p));
01480     for (ip = 0; ip < met->np; ip++)
01481       met->p[ip] /= 100.;
01482
01483     /* Extrapolate data for lower boundary... */
01484     read_met_extrapolate(met);
01485   }
01486
01487   /* Meteo data on model levels... */
01488   else {
01489
01490     /* Read pressure data from file... */
01491     read_met_help(ncid, "pl", "PL", met, met->pl, 0.01f);
01492
01493     /* Interpolate from model levels to pressure levels... */
01494     read_met_ml2pl(ctl, met, met->t);
01495     read_met_ml2pl(ctl, met, met->u);
```

```
01496     read_met_ml2pl(ctl, met, met->v);
01497     read_met_ml2pl(ctl, met, met->w);
01498     read_met_ml2pl(ctl, met, met->h2o);
01499     read_met_ml2pl(ctl, met, met->o3);
01500
01501     /* Set pressure levels... */
01502     met->np = ctl->met_np;
01503     for (ip = 0; ip < met->np; ip++)
01504       met->p[ip] = ctl->met_p[ip];
01505   }
01506
01507   /* Check ordering of pressure levels... */
01508   for (ip = 1; ip < met->np; ip++)
01509     if (met->p[ip - 1] < met->p[ip])
01510       ERRMSG("Pressure levels must be descending!");
01511
01512   /* Read surface pressure... */
01513   if (nc_inq_varid(ncid, "ps", &varid) == NC_NOERR
01514       || nc_inq_varid(ncid, "PS", &varid) == NC_NOERR) {
01515     NC(nc_get_var_float(ncid, varid, help));
01516     for (iy = 0; iy < met->ny; iy++)
01517       for (ix = 0; ix < met->nx; ix++)
01518         met->ps[ix][iy] = help[iy * met->nx + ix] / 100.;
01519   } else if (nc_inq_varid(ncid, "lnsp", &varid) == NC_NOERR
01520              || nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
01521     NC(nc_get_var_float(ncid, varid, help));
01522     for (iy = 0; iy < met->ny; iy++)
01523       for (ix = 0; ix < met->nx; ix++)
01524         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
01525   } else
01526     for (ix = 0; ix < met->nx; ix++)
01527       for (iy = 0; iy < met->ny; iy++)
01528         met->ps[ix][iy] = met->p[0];
01529
01530   /* Create periodic boundary conditions... */
01531   read_met_periodic(met);
01532
01533   /* Calculate geopotential heights... */
01534   read_met_geopot(ctl, met);
01535
01536   /* Calculate potential vorticity... */
01537   read_met_pv(met);
01538
01539   /* Calculate tropopause pressure... */
01540   read_met_tropo(ctl, met);
01541
01542   /* Downsampling... */
01543   read_met_sample(ctl, met);
01544
01545   /* Close file... */
01546   NC(nc_close(ncid));
01547
01548   /* Return success... */
01549   return 1;
01550 }
```

Here is the call graph for this function:



5.21.2.20 void read_met_extrapolate (met_t * *met*)

Extrapolate meteorological data at lower boundary.

Definition at line 1554 of file libtrac.c.

```
01555                {
01556
01557   int ip, ip0, ix, iy;
01558
01559   /* Loop over columns... */
01560 #pragma omp parallel for default(shared) private(ix,iy,ip0,ip)
01561   for (ix = 0; ix < met->nx; ix++)
01562     for (iy = 0; iy < met->ny; iy++) {
01563
01564       /* Find lowest valid data point... */
01565       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
01566         if (!gsl_finite(met->t[ix][iy][ip0])
01567             || !gsl_finite(met->u[ix][iy][ip0])
01568             || !gsl_finite(met->v[ix][iy][ip0])
01569             || !gsl_finite(met->w[ix][iy][ip0]))
01570           break;
01571
01572       /* Extrapolate... */
01573       for (ip = ip0; ip >= 0; ip--) {
01574         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
01575         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
01576         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
01577         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
01578         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
01579         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
01580       }
01581     }
01582 }
```

5.21.2.21 void read_met_geopot (ctl_t * *ctl*, met_t * *met*)

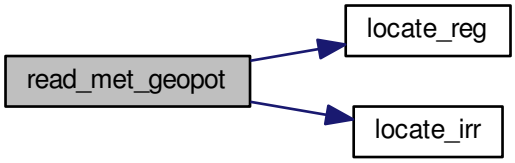
Calculate geopotential heights.

Definition at line 1586 of file libtrac.c.

```
01588                {
01589
01590   const int dx = 6, dy = 4;
01591
01592   static double logp[EP], topo_lat[EY], topo_lon[EX], topo_z[EX][EY];
01593
01594   static float help[EX][EY][EP];
01595
01596   static int init, topo_nx = -1, topo_ny;
01597
01598   FILE *in;
01599
01600   char line[LEN];
01601
01602   double lat, lon, rlat, rlon, rlon_old = -999, rz, ts, z0, z1;
01603
01604   int ip, ip0, ix, ix2, ix3, iy, iy2, n, tx, ty;
01605
01606   /* Initialize geopotential heights... */
01607 #pragma omp parallel for default(shared) private(ix,iy,ip)
01608   for (ix = 0; ix < met->nx; ix++)
01609     for (iy = 0; iy < met->ny; iy++)
01610       for (ip = 0; ip < met->np; ip++)
01611         met->z[ix][iy][ip] = GSL_NAN;
01612
01613   /* Check filename... */
01614   if (ctl->met_geopot[0] == '-')
01615     return;
01616
01617   /* Read surface geopotential... */
01618   if (!init) {
01619     init = 1;
01620
01621     /* Write info... */
01622     printf("Read surface geopotential: %s\n", ctl->met_geopot);
01623
01624     /* Open file... */
01625     if (!(in = fopen(ctl->met_geopot, "r")))
01626       ERRMSG("Cannot open file!");
01627
01628     /* Read data... */
01629     while (fgets(line, LEN, in))
01630       if (sscanf(line, "%lg %lg %lg", &rlon, &rlat, &rz) == 3) {
01631         if (rlon != rlon_old) {
01632           if ((++topo_nx) > EX)
01633             ERRMSG("Too many longitudes!");
01634           topo_ny = 0;
01635         }
01636         rlon_old = rlon;
01637         topo_lon[topo_nx] = rlon;
01638         topo_lat[topo_ny] = rlat;
01639         topo_z[topo_nx][topo_ny] = rz;
01640         if ((++topo_ny) > EY)
01641           ERRMSG("Too many latitudes!");
01642       }
01643     if ((++topo_nx) > EX)
01644       ERRMSG("Too many longitudes!");
01645
01646     /* Close file... */
01647     fclose(in);
01648
01649     /* Check grid spacing... */
01650     if (fabs(met->lon[0] - met->lon[1]) != fabs(topo_lon[0] - topo_lon[1])
01651         || fabs(met->lat[0] - met->lat[1]) != fabs(topo_lat[0] - topo_lat[1]))
01652       WARN("Grid spacing does not match!");
01653
01654     /* Calculate log pressure... */
01655     for (ip = 0; ip < met->np; ip++)
01656       logp[ip] = log(met->p[ip]);
01657   }
01658
01659   /* Apply hydrostatic equation to calculate geopotential heights... */
01660 #pragma omp parallel for default(shared) private(ix,iy,lon,lat,tx,ty,z0,z1,ip0,ts,ip)
01661   for (ix = 0; ix < met->nx; ix++) {
01662
01663     /* Get longitude index... */
01664     lon = met->lon[ix];
```

```
01665     if (lon < topo_lon[0])
01666       lon += 360;
01667     else if (lon > topo_lon[topo_nx - 1])
01668       lon -= 360;
01669     tx = locate_reg(topo_lon, topo_nx, lon);
01670
01671     /* Loop over latitudes... */
01672     for (iy = 0; iy < met->ny; iy++) {
01673
01674       /* Get latitude index... */
01675       lat = met->lat[iy];
01676       ty = locate_reg(topo_lat, topo_ny, lat);
01677
01678       /* Get surface height... */
01679       z0 = LIN(topo_lon[tx], topo_z[tx][ty],
01680                topo_lon[tx + 1], topo_z[tx + 1][ty], lon);
01681       z1 = LIN(topo_lon[tx], topo_z[tx][ty + 1],
01682                topo_lon[tx + 1], topo_z[tx + 1][ty + 1], lon);
01683       z0 = LIN(topo_lat[ty], z0, topo_lat[ty + 1], z1, lat);
01684
01685       /* Find surface pressure level... */
01686       ip0 = locate_irr(met->p, met->np, met->ps[ix][iy]);
01687
01688       /* Get surface data... */
01689       ts =
01690         LIN(met->p[ip0],
01691             TVIRT(met->t[ix][iy][ip0], met->h2o[ix][iy][ip0]),
01692             met->p[ip0 + 1],
01693             TVIRT(met->t[ix][iy][ip0 + 1], met->h2o[ix][iy][ip0 + 1]),
01694             met->ps[ix][iy]);
01695
01696       /* Upper part of profile... */
01697       met->z[ix][iy][ip0 + 1]
01698         = (float) (z0 + RI / MA / G0 * 0.5
01699                    * (ts + TVIRT(met->t[ix][iy][ip0 + 1],
01700                                  met->h2o[ix][iy][ip0 + 1]))
01701                    * (log(met->ps[ix][iy]) - logp[ip0 + 1]));
01702       for (ip = ip0 + 2; ip < met->np; ip++)
01703         met->z[ix][iy][ip]
01704           = (float) (met->z[ix][iy][ip - 1] + RI / MA / G0 * 0.5 *
01705                      (TVIRT(met->t[ix][iy][ip - 1], met->h2o[ix][iy][ip - 1])
01706                       + TVIRT(met->t[ix][iy][ip], met->h2o[ix][iy][ip]))
01707                      * (logp[ip - 1] - logp[ip]));
01708     }
01709   }
01710
01711   /* Smoothing... */
01712 #pragma omp parallel for default(shared) private(ix,iy,ip,n,ix2,ix3,iy2)
01713   for (ix = 0; ix < met->nx; ix++)
01714     for (iy = 0; iy < met->ny; iy++)
01715       for (ip = 0; ip < met->np; ip++) {
01716         n = 0;
01717         help[ix][iy][ip] = 0;
01718         for (ix2 = ix - dx; ix2 <= ix + dx; ix2++) {
01719           ix3 = ix2;
01720           if (ix3 < 0)
01721             ix3 += met->nx;
01722           else if (ix3 >= met->nx)
01723             ix3 -= met->nx;
01724           for (iy2 = GSL_MAX(iy - dy, 0);
01725                iy2 <= GSL_MIN(iy + dy, met->ny - 1); iy2++)
01726             if (gsl_finite(met->z[ix3][iy2][ip])) {
01727               help[ix][iy][ip] += met->z[ix3][iy2][ip];
01728               n++;
01729             }
01730         }
01731         if (n > 0)
01732           help[ix][iy][ip] /= (float) n;
01733         else
01734           help[ix][iy][ip] = GSL_NAN;
01735       }
01736
01737   /* Copy data... */
01738 #pragma omp parallel for default(shared) private(ix,iy,ip)
01739   for (ix = 0; ix < met->nx; ix++)
01740     for (iy = 0; iy < met->ny; iy++)
01741       for (ip = 0; ip < met->np; ip++)
01742         met->z[ix][iy][ip] = help[ix][iy][ip];
01743 }
```

Here is the call graph for this function:



5.21.2.22 void read_met_help (int *ncid*, char * *varname*, char * *varname2*, met_t * *met*, float *dest[EX][EY][EP]*, float *scl*)

Read and convert variable from meteorological data file.

Definition at line 1747 of file libtrac.c.

```
01753              {
01754
01755   float *help;
01756
01757   int ip, ix, iy, varid;
01758
01759   /* Check if variable exists... */
01760   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
01761     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
01762       return;
01763
01764   /* Allocate... */
01765   ALLOC(help, float, EX * EY * EP);
01766
01767   /* Read data... */
01768   NC(nc_get_var_float(ncid, varid, help));
01769
01770   /* Copy and check data... */
01771 #pragma omp parallel for default(shared) private(ix,iy,ip)
01772   for (ix = 0; ix < met->nx; ix++)
01773     for (iy = 0; iy < met->ny; iy++)
01774       for (ip = 0; ip < met->np; ip++) {
01775         dest[ix][iy][ip] = help[(ip * met->ny + iy) * met->nx + ix];
01776         if (fabsf(dest[ix][iy][ip]) < 1e14f)
01777           dest[ix][iy][ip] *= scl;
01778         else
01779           dest[ix][iy][ip] = GSL_NAN;
01780       }
01781
01782   /* Free... */
01783   free(help);
01784 }
```

5.21.2.23 void read_met_ml2pl (ctl_t * *ctl*, met_t * *met*, float *var[EX][EY][EP]*)

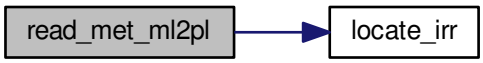
Convert meteorological data from model levels to pressure levels.

Definition at line 1788 of file libtrac.c.

```
01791                          {
01792
01793   double aux[EP], p[EP], pt;
01794
01795   int ip, ip2, ix, iy;
01796
```

```
01797   /* Loop over columns... */
01798 #pragma omp parallel for default(shared) private(ix,iy,ip,p,pt,ip2,aux)
01799   for (ix = 0; ix < met->nx; ix++)
01800     for (iy = 0; iy < met->ny; iy++) {
01801
01802       /* Copy pressure profile... */
01803       for (ip = 0; ip < met->np; ip++)
01804         p[ip] = met->pl[ix][iy][ip];
01805
01806       /* Interpolate... */
01807       for (ip = 0; ip < ctl->met_np; ip++) {
01808         pt = ctl->met_p[ip];
01809         if ((pt > p[0] && p[0] > p[1]) || (pt < p[0] && p[0] < p[1]))
01810           pt = p[0];
01811         else if ((pt > p[met->np - 1] && p[1] > p[0])
01812                  || (pt < p[met->np - 1] && p[1] < p[0]))
01813           pt = p[met->np - 1];
01814         ip2 = locate_irr(p, met->np, pt);
01815         aux[ip] = LIN(p[ip2], var[ix][iy][ip2],
01816                       p[ip2 + 1], var[ix][iy][ip2 + 1], pt);
01817       }
01818
01819       /* Copy data... */
01820       for (ip = 0; ip < ctl->met_np; ip++)
01821         var[ix][iy][ip] = (float) aux[ip];
01822     }
01823 }
```

Here is the call graph for this function:



5.21.2.24 void read_met_periodic (met_t * *met*)

Create meteorological data with periodic boundary conditions.

Definition at line 1827 of file libtrac.c.

```
01828               {
01829
01830   /* Check longitudes... */
01831   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
01832              + met->lon[1] - met->lon[0] - 360) < 0.01))
01833     return;
01834
01835   /* Increase longitude counter... */
01836   if ((++met->nx) > EX)
01837     ERRMSG("Cannot create periodic boundary conditions!");
01838
01839   /* Set longitude... */
01840   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
01841
01842   /* Loop over latitudes and pressure levels... */
01843 #pragma omp parallel for default(shared)
01844   for (int iy = 0; iy < met->ny; iy++) {
01845     met->ps[met->nx - 1][iy] = met->ps[0][iy];
01846     met->pt[met->nx - 1][iy] = met->pt[0][iy];
01847     for (int ip = 0; ip < met->np; ip++) {
01848       met->z[met->nx - 1][iy][ip] = met->z[0][iy][ip];
01849       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
01850       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
01851       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
01852       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
01853       met->pv[met->nx - 1][iy][ip] = met->pv[0][iy][ip];
01854       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
01855       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
01856     }
01857   }
01858 }
```

5.21.2.25 void read_met_pv (met_t * *met*)

Calculate potential vorticity.

Definition at line 1862 of file libtrac.c.

```
01863               {
01864
01865   double c0, c1, cr, dx, dy, dp0, dp1, denom, dtdx, dvdx, dtdy, dudy,
01866     dtdp, dudp, dvdp, latr, vort, pows[EP];
01867
01868   int ip, ip0, ip1, ix, ix0, ix1, iy, iy0, iy1;
01869
01870   /* Set powers... */
01871   for (ip = 0; ip < met->np; ip++)
01872     pows[ip] = pow(1000. / met->p[ip], 0.286);
01873
01874   /* Loop over grid points... */
01875 #pragma omp parallel for default(shared)
       private(ix,ix0,ix1,iy,iy0,iy1,latr,dx,dy,c0,c1,cr,vort,ip,ip0,ip1,dp0,dp1,denom,dtdx,dvdx,dtdy,dudy,dtdp,dudp,dvdp)
01876   for (ix = 0; ix < met->nx; ix++) {
01877
01878     /* Set indices... */
01879     ix0 = GSL_MAX(ix - 1, 0);
01880     ix1 = GSL_MIN(ix + 1, met->nx - 1);
01881
01882     /* Loop over grid points... */
01883     for (iy = 0; iy < met->ny; iy++) {
01884
01885       /* Set indices... */
01886       iy0 = GSL_MAX(iy - 1, 0);
01887       iy1 = GSL_MIN(iy + 1, met->ny - 1);
01888
01889       /* Set auxiliary variables... */
01890       latr = 0.5 * (met->lat[iy1] + met->lat[iy0]);
01891       dx = 1000. * DEG2DX(met->lon[ix1] - met->lon[ix0], latr);
01892       dy = 1000. * DEG2DY(met->lat[iy1] - met->lat[iy0]);
01893       c0 = cos(met->lat[iy0] / 180. * M_PI);
01894       c1 = cos(met->lat[iy1] / 180. * M_PI);
01895       cr = cos(latr / 180. * M_PI);
01896       vort = 2 * 7.2921e-5 * sin(latr * M_PI / 180.);
01897
01898       /* Loop over grid points... */
01899       for (ip = 0; ip < met->np; ip++) {
01900
01901         /* Get gradients in longitude... */
01902         dtdx = (met->t[ix1][iy][ip] - met->t[ix0][iy][ip]) * pows[ip] / dx;
01903         dvdx = (met->v[ix1][iy][ip] - met->v[ix0][iy][ip]) / dx;
01904
01905         /* Get gradients in latitude... */
01906         dtdy = (met->t[ix][iy1][ip] - met->t[ix][iy0][ip]) * pows[ip] / dy;
01907         dudy = (met->u[ix][iy1][ip] * c1 - met->u[ix][iy0][ip] * c0) / dy;
01908
01909         /* Set indices... */
01910         ip0 = GSL_MAX(ip - 1, 0);
01911         ip1 = GSL_MIN(ip + 1, met->np - 1);
01912
01913         /* Get gradients in pressure... */
01914         dp0 = 100. * (met->p[ip] - met->p[ip0]);
01915         dp1 = 100. * (met->p[ip1] - met->p[ip]);
01916         if (ip != ip0 && ip != ip1) {
01917           denom = dp0 * dp1 * (dp0 + dp1);
01918           dtdp = (dp0 * dp0 * met->t[ix][iy][ip1] * pows[ip1]
01919                   - dp1 * dp1 * met->t[ix][iy][ip0] * pows[ip0]
01920                   + (dp1 * dp1 - dp0 * dp0) * met->t[ix][iy][ip] * pows[ip])
01921             / denom;
01922           dudp = (dp0 * dp0 * met->u[ix][iy][ip1]
01923                   - dp1 * dp1 * met->u[ix][iy][ip0]
01924                   + (dp1 * dp1 - dp0 * dp0) * met->u[ix][iy][ip])
01925             / denom;
01926           dvdp = (dp0 * dp0 * met->v[ix][iy][ip1]
01927                   - dp1 * dp1 * met->v[ix][iy][ip0]
01928                   + (dp1 * dp1 - dp0 * dp0) * met->v[ix][iy][ip])
01929             / denom;
01930         } else {
01931           denom = dp0 + dp1;
01932           dtdp =
01933             (met->t[ix][iy][ip1] * pows[ip1] -
01934              met->t[ix][iy][ip0] * pows[ip0]) / denom;
01935           dudp = (met->u[ix][iy][ip1] - met->u[ix][iy][ip0]) / denom;
01936           dvdp = (met->v[ix][iy][ip1] - met->v[ix][iy][ip0]) / denom;
01937         }
01938
```

```
01939         /* Calculate PV... */
01940         met->pv[ix][iy][ip] = (float)
01941           (1e6 * G0 *
01942            (-dtdp * (dvdx - dudy / cr + vort) + dvdp * dtdx - dudp * dtdy));
01943       }
01944     }
01945   }
01946
01947   /* Fix for polar regions... */
01948 #pragma omp parallel for default(shared) private(ix,ip)
01949   for (ix = 0; ix < met->nx; ix++)
01950     for (ip = 0; ip < met->np; ip++) {
01951       met->pv[ix][0][ip]
01952         = met->pv[ix][1][ip]
01953         = met->pv[ix][2][ip];
01954       met->pv[ix][met->ny - 1][ip]
01955         = met->pv[ix][met->ny - 2][ip]
01956         = met->pv[ix][met->ny - 3][ip];
01957     }
01958 }
```

5.21.2.26 void read_met_sample (ctl_t * *ctl*, met_t * *met*)

Downsampling of meteorological data.

Definition at line 1962 of file libtrac.c.

```
01964               {
01965
01966   met_t *help;
01967
01968   float w, wsum;
01969
01970   int ip, ip2, ix, ix2, ix3, iy, iy2;
01971
01972   /* Check parameters... */
01973   if (ctl->met_dp <= 1 && ctl->met_dx <= 1 && ctl->met_dy <= 1
01974       && ctl->met_sp <= 1 && ctl->met_sx <= 1 && ctl->met_sy <= 1)
01975     return;
01976
01977   /* Allocate... */
01978   ALLOC(help, met_t, 1);
01979
01980   /* Copy data... */
01981   help->nx = met->nx;
01982   help->ny = met->ny;
01983   help->np = met->np;
01984   memcpy(help->lon, met->lon, sizeof(met->lon));
01985   memcpy(help->lat, met->lat, sizeof(met->lat));
01986   memcpy(help->p, met->p, sizeof(met->p));
01987
01988   /* Smoothing... */
01989   for (ix = 0; ix < met->nx; ix += ctl->met_dx) {
01990     for (iy = 0; iy < met->ny; iy += ctl->met_dy) {
01991       for (ip = 0; ip < met->np; ip += ctl->met_dp) {
01992         help->ps[ix][iy] = 0;
01993         help->pt[ix][iy] = 0;
01994         help->z[ix][iy][ip] = 0;
01995         help->t[ix][iy][ip] = 0;
01996         help->u[ix][iy][ip] = 0;
01997         help->v[ix][iy][ip] = 0;
01998         help->w[ix][iy][ip] = 0;
01999         help->pv[ix][iy][ip] = 0;
02000         help->h2o[ix][iy][ip] = 0;
02001         help->o3[ix][iy][ip] = 0;
02002         wsum = 0;
02003         for (ix2 = ix - ctl->met_sx + 1; ix2 <= ix + ctl->met_sx - 1; ix2++) {
02004           ix3 = ix2;
02005           if (ix3 < 0)
02006             ix3 += met->nx;
02007           else if (ix3 >= met->nx)
02008             ix3 -= met->nx;
02009
02010           for (iy2 = GSL_MAX(iy - ctl->met_sy + 1, 0);
02011                iy2 <= GSL_MIN(iy + ctl->met_sy - 1, met->ny - 1); iy2++)
02012             for (ip2 = GSL_MAX(ip - ctl->met_sp + 1, 0);
02013                  ip2 <= GSL_MIN(ip + ctl->met_sp - 1, met->np - 1); ip2++) {
02014               w = (float) (1.0 - fabs(ix - ix2) / ctl->met_sx)
02015                 * (float) (1.0 - fabs(iy - iy2) / ctl->met_sy)
02016                 * (float) (1.0 - fabs(ip - ip2) / ctl->met_sp);
```

```
02017               help->ps[ix][iy] += w * met->ps[ix3][iy2];
02018               help->pt[ix][iy] += w * met->pt[ix3][iy2];
02019               help->z[ix][iy][ip] += w * met->z[ix3][iy2][ip2];
02020               help->t[ix][iy][ip] += w * met->t[ix3][iy2][ip2];
02021               help->u[ix][iy][ip] += w * met->u[ix3][iy2][ip2];
02022               help->v[ix][iy][ip] += w * met->v[ix3][iy2][ip2];
02023               help->w[ix][iy][ip] += w * met->w[ix3][iy2][ip2];
02024               help->pv[ix][iy][ip] += w * met->pv[ix3][iy2][ip2];
02025               help->h2o[ix][iy][ip] += w * met->h2o[ix3][iy2][ip2];
02026               help->o3[ix][iy][ip] += w * met->o3[ix3][iy2][ip2];
02027               wsum += w;
02028             }
02029         }
02030         help->ps[ix][iy] /= wsum;
02031         help->pt[ix][iy] /= wsum;
02032         help->t[ix][iy][ip] /= wsum;
02033         help->z[ix][iy][ip] /= wsum;
02034         help->u[ix][iy][ip] /= wsum;
02035         help->v[ix][iy][ip] /= wsum;
02036         help->w[ix][iy][ip] /= wsum;
02037         help->pv[ix][iy][ip] /= wsum;
02038         help->h2o[ix][iy][ip] /= wsum;
02039         help->o3[ix][iy][ip] /= wsum;
02040       }
02041     }
02042   }
02043
02044   /* Downsampling... */
02045   met->nx = 0;
02046   for (ix = 0; ix < help->nx; ix += ctl->met_dx) {
02047     met->lon[met->nx] = help->lon[ix];
02048     met->ny = 0;
02049     for (iy = 0; iy < help->ny; iy += ctl->met_dy) {
02050       met->lat[met->ny] = help->lat[iy];
02051       met->ps[met->nx][met->ny] = help->ps[ix][iy];
02052       met->pt[met->nx][met->ny] = help->pt[ix][iy];
02053       met->np = 0;
02054       for (ip = 0; ip < help->np; ip += ctl->met_dp) {
02055         met->p[met->np] = help->p[ip];
02056         met->z[met->nx][met->ny][met->np] = help->z[ix][iy][ip];
02057         met->t[met->nx][met->ny][met->np] = help->t[ix][iy][ip];
02058         met->u[met->nx][met->ny][met->np] = help->u[ix][iy][ip];
02059         met->v[met->nx][met->ny][met->np] = help->v[ix][iy][ip];
02060         met->w[met->nx][met->ny][met->np] = help->w[ix][iy][ip];
02061         met->pv[met->nx][met->ny][met->np] = help->pv[ix][iy][ip];
02062         met->h2o[met->nx][met->ny][met->np] = help->h2o[ix][iy][ip];
02063         met->o3[met->nx][met->ny][met->np] = help->o3[ix][iy][ip];
02064         met->np++;
02065       }
02066       met->ny++;
02067     }
02068     met->nx++;
02069   }
02070
02071   /* Free... */
02072   free(help);
02073 }
```

5.21.2.27 void read_met_tropo (ctl_t * *ctl*, met_t * *met*)

Calculate tropopause pressure.

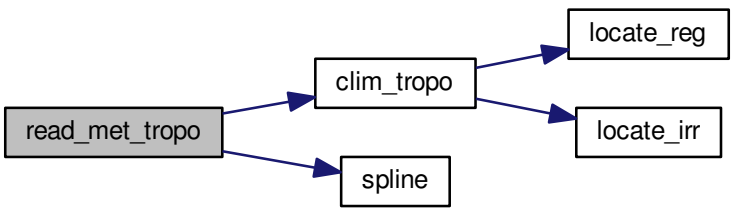
Definition at line 2077 of file libtrac.c.

```
02079               {
02080
02081   double p2[200], pv[EP], pv2[200], t[EP], t2[200], th[EP],
02082     th2[200], z[EP], z2[200];
02083
02084   int found, ix, iy, iz, iz2;
02085
02086   /* Get altitude and pressure profiles... */
02087   for (iz = 0; iz < met->np; iz++)
02088     z[iz] = Z(met->p[iz]);
02089   for (iz = 0; iz <= 170; iz++) {
02090     z2[iz] = 4.5 + 0.1 * iz;
02091     p2[iz] = P(z2[iz]);
02092   }
02093
02094   /* Do not calculate tropopause... */
```

```
02095   if (ctl->met_tropo == 0)
02096     for (ix = 0; ix < met->nx; ix++)
02097       for (iy = 0; iy < met->ny; iy++)
02098         met->pt[ix][iy] = GSL_NAN;
02099
02100   /* Use tropopause climatology... */
02101   else if (ctl->met_tropo == 1) {
02102 #pragma omp parallel for default(shared) private(ix,iy)
02103     for (ix = 0; ix < met->nx; ix++)
02104       for (iy = 0; iy < met->ny; iy++)
02105         met->pt[ix][iy] = clim_tropo(met->time, met->lat[iy]);
02106   }
02107
02108   /* Use cold point... */
02109   else if (ctl->met_tropo == 2) {
02110
02111     /* Loop over grid points... */
02112 #pragma omp parallel for default(shared) private(ix,iy,iz,t,t2)
02113     for (ix = 0; ix < met->nx; ix++)
02114       for (iy = 0; iy < met->ny; iy++) {
02115
02116         /* Interpolate temperature profile... */
02117         for (iz = 0; iz < met->np; iz++)
02118           t[iz] = met->t[ix][iy][iz];
02119         spline(z, t, met->np, z2, t2, 171);
02120
02121         /* Find minimum... */
02122         iz = (int) gsl_stats_min_index(t2, 1, 171);
02123         if (iz <= 0 || iz >= 170)
02124           met->pt[ix][iy] = GSL_NAN;
02125         else
02126           met->pt[ix][iy] = p2[iz];
02127       }
02128   }
02129
02130   /* Use WMO definition... */
02131   else if (ctl->met_tropo == 3 || ctl->met_tropo == 4) {
02132
02133     /* Loop over grid points... */
02134 #pragma omp parallel for default(shared) private(ix,iy,iz,iz2,t,t2,found)
02135     for (ix = 0; ix < met->nx; ix++)
02136       for (iy = 0; iy < met->ny; iy++) {
02137
02138         /* Interpolate temperature profile... */
02139         for (iz = 0; iz < met->np; iz++)
02140           t[iz] = met->t[ix][iy][iz];
02141         spline(z, t, met->np, z2, t2, 161);
02142
02143         /* Find 1st tropopause... */
02144         met->pt[ix][iy] = GSL_NAN;
02145         for (iz = 0; iz <= 140; iz++) {
02146           found = 1;
02147           for (iz2 = iz + 1; iz2 <= iz + 20; iz2++)
02148             if (1e3 * G0 / RA * (t2[iz2] - t2[iz]) / (t2[iz2] + t2[iz])
02149                 * (p2[iz2] + p2[iz]) / (p2[iz2] - p2[iz]) > 2.0) {
02150               found = 0;
02151               break;
02152             }
02153           if (found) {
02154             if (iz > 0 && iz < 140)
02155               met->pt[ix][iy] = p2[iz];
02156             break;
02157           }
02158         }
02159
02160         /* Find 2nd tropopause... */
02161         if (ctl->met_tropo == 4) {
02162           met->pt[ix][iy] = GSL_NAN;
02163           for (; iz <= 140; iz++) {
02164             found = 1;
02165             for (iz2 = iz + 1; iz2 <= iz + 10; iz2++)
02166               if (1e3 * G0 / RA * (t2[iz2] - t2[iz]) / (t2[iz2] + t2[iz])
02167                   * (p2[iz2] + p2[iz]) / (p2[iz2] - p2[iz]) < 3.0) {
02168                 found = 0;
02169                 break;
02170               }
02171             if (found)
02172               break;
02173           }
02174           for (; iz <= 140; iz++) {
02175             found = 1;
02176             for (iz2 = iz + 1; iz2 <= iz + 20; iz2++)
02177               if (1e3 * G0 / RA * (t2[iz2] - t2[iz]) / (t2[iz2] + t2[iz])
02178                   * (p2[iz2] + p2[iz]) / (p2[iz2] - p2[iz]) > 2.0) {
02179                 found = 0;
02180                 break;
02181               }
```

```
02182             if (found) {
02183               if (iz > 0 && iz < 140)
02184                 met->pt[ix][iy] = p2[iz];
02185               break;
02186             }
02187           }
02188         }
02189       }
02190   }
02191
02192   /* Use dynamical tropopause... */
02193   else if (ctl->met_tropo == 5) {
02194
02195     /* Loop over grid points... */
02196 #pragma omp parallel for default(shared) private(ix,iy,iz,pv,pv2,th,th2)
02197     for (ix = 0; ix < met->nx; ix++)
02198       for (iy = 0; iy < met->ny; iy++) {
02199
02200         /* Interpolate potential vorticity profile... */
02201         for (iz = 0; iz < met->np; iz++)
02202           pv[iz] = met->pv[ix][iy][iz];
02203         spline(z, pv, met->np, z2, pv2, 161);
02204
02205         /* Interpolate potential temperature profile... */
02206         for (iz = 0; iz < met->np; iz++)
02207           th[iz] = THETA(met->p[iz], met->t[ix][iy][iz]);
02208         spline(z, th, met->np, z2, th2, 161);
02209
02210         /* Find dynamical tropopause 3.5 PVU + 380 K */
02211         met->pt[ix][iy] = GSL_NAN;
02212         for (iz = 0; iz <= 160; iz++)
02213           if (fabs(pv2[iz]) >= 3.5 || th2[iz] >= 380.) {
02214             if (iz > 0 && iz < 160)
02215               met->pt[ix][iy] = p2[iz];
02216             break;
02217           }
02218       }
02219   }
02220
02221   else
02222     ERRMSG("Cannot calculate tropopause!");
02223 }
```

Here is the call graph for this function:



5.21.2.28 double scan_ctl (const char * *filename*, int *argc*, char * *argv[]*, const char * *varname*, int *arridx*, const char * *defvalue*, char * *value*)

Read a control parameter from file or command line.

Definition at line 2227 of file libtrac.c.

```
02234               {
02235
02236   FILE *in = NULL;
```

```
02237
02238   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
02239     msg[2 * LEN], rvarname[LEN], rval[LEN];
02240
02241   int contain = 0, i;
02242
02243   /* Open file... */
02244   if (filename[strlen(filename) - 1] != '-')
02245     if (!(in = fopen(filename, "r")))
02246       ERRMSG("Cannot open file!");
02247
02248   /* Set full variable name... */
02249   if (arridx >= 0) {
02250     sprintf(fullname1, "%s[%d]", varname, arridx);
02251     sprintf(fullname2, "%s[*]", varname);
02252   } else {
02253     sprintf(fullname1, "%s", varname);
02254     sprintf(fullname2, "%s", varname);
02255   }
02256
02257   /* Read data... */
02258   if (in != NULL)
02259     while (fgets(line, LEN, in))
02260       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
02261         if (strcasecmp(rvarname, fullname1) == 0 ||
02262             strcasecmp(rvarname, fullname2) == 0) {
02263           contain = 1;
02264           break;
02265         }
02266   for (i = 1; i < argc - 1; i++)
02267     if (strcasecmp(argv[i], fullname1) == 0 ||
02268         strcasecmp(argv[i], fullname2) == 0) {
02269       sprintf(rval, "%s", argv[i + 1]);
02270       contain = 1;
02271       break;
02272     }
02273
02274   /* Close file... */
02275   if (in != NULL)
02276     fclose(in);
02277
02278   /* Check for missing variables... */
02279   if (!contain) {
02280     if (strlen(defvalue) > 0)
02281       sprintf(rval, "%s", defvalue);
02282     else {
02283       sprintf(msg, "Missing variable %s!\n", fullname1);
02284       ERRMSG(msg);
02285     }
02286   }
02287
02288   /* Write info... */
02289   printf("%s = %s\n", fullname1, rval);
02290
02291   /* Return values... */
02292   if (value != NULL)
02293     sprintf(value, "%s", rval);
02294   return atof(rval);
02295 }
```

5.21.2.29 void spline (double * x, double * y, int n, double * x2, double * y2, int n2)

Spline interpolation.

Definition at line 2299 of file libtrac.c.

```
02305           {
02306
02307   gsl_interp_accel *acc;
02308
02309   gsl_spline *s;
02310
02311   /* Allocate... */
02312   acc = gsl_interp_accel_alloc();
02313   s = gsl_spline_alloc(gsl_interp_cspline, (size_t) n);
02314
02315   /* Interpolate temperature profile... */
02316   gsl_spline_init(s, x, y, (size_t) n);
02317   for (int i = 0; i < n2; i++)
02318     y2[i] = gsl_spline_eval(s, x2[i], acc);
```

```
02319
02320   /* Free... */
02321   gsl_spline_free(s);
02322   gsl_interp_accel_free(acc);
02323 }
```

5.21.2.30 double stddev (double * *data*, int *n*)

Calculate standard deviation.

Definition at line 2327 of file libtrac.c.

```
02329           {
02330
02331   if (n <= 0)
02332     return 0;
02333
02334   double avg = 0, rms = 0;
02335
02336   for (int i = 0; i < n; ++i)
02337     avg += data[i];
02338   avg /= n;
02339
02340   for (int i = 0; i < n; ++i)
02341     rms += SQR(data[i] - avg);
02342
02343   return sqrt(rms / (n - 1));
02344 }
```

5.21.2.31 void time2jsec (int *year*, int *mon*, int *day*, int *hour*, int *min*, int *sec*, double *remain*, double * *jsec*)

Convert date to seconds.

Definition at line 2348 of file libtrac.c.

```
02356                 {
02357
02358   struct tm t0, t1;
02359
02360   t0.tm_year = 100;
02361   t0.tm_mon = 0;
02362   t0.tm_mday = 1;
02363   t0.tm_hour = 0;
02364   t0.tm_min = 0;
02365   t0.tm_sec = 0;
02366
02367   t1.tm_year = year - 1900;
02368   t1.tm_mon = mon - 1;
02369   t1.tm_mday = day;
02370   t1.tm_hour = hour;
02371   t1.tm_min = min;
02372   t1.tm_sec = sec;
02373
02374   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
02375 }
```

5.21.2.32 void timer (const char * *name*, int *id*, int *mode*)

Measure wall-clock time.

Definition at line 2379 of file libtrac.c.

```
02382            {
02383
02384   static double starttime[NTIMER], runtime[NTIMER];
02385
02386   /* Check id... */
02387   if (id < 0 || id >= NTIMER)
02388     ERRMSG("Too many timers!");
02389
02390   /* Start timer... */
02391   if (mode == 1) {
02392     if (starttime[id] <= 0)
02393       starttime[id] = omp_get_wtime();
02394     else
02395       ERRMSG("Timer already started!");
02396   }
02397
02398   /* Stop timer... */
02399   else if (mode == 2) {
02400     if (starttime[id] > 0) {
02401       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
02402       starttime[id] = -1;
02403     }
02404   }
02405
02406   /* Print timer... */
02407   else if (mode == 3) {
02408     printf("%s = %.3f s\n", name, runtime[id]);
02409     runtime[id] = 0;
02410   }
02411 }
```

5.21.2.33 void write_atm (const char * *filename*, ctl_t * *ctl*, atm_t * *atm*, double *t*)

Write atmospheric data.

Definition at line 2415 of file libtrac.c.

```
02419            {
02420
02421   FILE *in, *out;
02422
02423   char line[LEN];
02424
02425   double r, t0, t1;
02426
02427   int ip, iq, year, mon, day, hour, min, sec;
02428
02429   /* Set time interval for output... */
02430   t0 = t - 0.5 * ctl->dt_mod;
02431   t1 = t + 0.5 * ctl->dt_mod;
02432
02433   /* Write info... */
02434   printf("Write atmospheric data: %s\n", filename);
02435
02436   /* Write ASCII data... */
02437   if (ctl->atm_type == 0) {
02438
02439     /* Check if gnuplot output is requested... */
02440     if (ctl->atm_gpfile[0] != '-') {
02441
02442       /* Create gnuplot pipe... */
02443       if (!(out = popen("gnuplot", "w")))
02444         ERRMSG("Cannot create pipe to gnuplot!");
02445
02446       /* Set plot filename... */
02447       fprintf(out, "set out \"%s.png\"\n", filename);
02448
02449       /* Set time string... */
02450       jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
02451       fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
02452               year, mon, day, hour, min);
02453
02454       /* Dump gnuplot file to pipe... */
02455       if (!(in = fopen(ctl->atm_gpfile, "r")))
02456         ERRMSG("Cannot open file!");
02457       while (fgets(line, LEN, in))
02458         fprintf(out, "%s", line);
02459       fclose(in);
02460     }
02461
```

```
02462     else {
02463
02464       /* Create file... */
02465       if (!(out = fopen(filename, "w")))
02466         ERRMSG("Cannot create file!");
02467     }
02468
02469     /* Write header... */
02470     fprintf(out,
02471             "# $1 = time [s]\n"
02472             "# $2 = altitude [km]\n"
02473             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
02474     for (iq = 0; iq < ctl->nq; iq++)
02475       fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
02476               ctl->qnt_unit[iq]);
02477     fprintf(out, "\n");
02478
02479     /* Write data... */
02480     for (ip = 0; ip < atm->np; ip += ctl->atm_stride) {
02481
02482       /* Check time... */
02483       if (ctl->atm_filter && (atm->time[ip] < t0 || atm->time[ip] > t1))
02484         continue;
02485
02486       /* Write output... */
02487       fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
02488               atm->lon[ip], atm->lat[ip]);
02489       for (iq = 0; iq < ctl->nq; iq++) {
02490         fprintf(out, " ");
02491         fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
02492       }
02493       fprintf(out, "\n");
02494     }
02495
02496     /* Close file... */
02497     fclose(out);
02498   }
02499
02500   /* Write binary data... */
02501   else if (ctl->atm_type == 1) {
02502
02503     /* Create file... */
02504     if (!(out = fopen(filename, "w")))
02505       ERRMSG("Cannot create file!");
02506
02507     /* Write data... */
02508     FWRITE(&atm->np, int,
02509            1,
02510            out);
02511     FWRITE(atm->time, double,
02512              (size_t) atm->np,
02513            out);
02514     FWRITE(atm->p, double,
02515              (size_t) atm->np,
02516            out);
02517     FWRITE(atm->lon, double,
02518              (size_t) atm->np,
02519            out);
02520     FWRITE(atm->lat, double,
02521              (size_t) atm->np,
02522            out);
02523     for (iq = 0; iq < ctl->nq; iq++)
02524       FWRITE(atm->q[iq], double,
02525                (size_t) atm->np,
02526              out);
02527
02528     /* Close file... */
02529     fclose(out);
02530   }
02531
02532   /* Error... */
02533   else
02534     ERRMSG("Atmospheric data type not supported!");
02535 }
```

Here is the call graph for this function:

5.21.2.34 void write_csi (const char * *filename*, ctl_t * *ctl*, atm_t * *atm*, double *t*)

Write CSI data.

Definition at line 2539 of file libtrac.c.

```
02543            {
02544
02545   static FILE *in, *out;
02546
02547   static char line[LEN];
02548
02549   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
02550     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
02551
02552   static int obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
02553
02554   /* Init... */
02555   if (t == ctl->t_start) {
02556
02557     /* Check quantity index for mass... */
02558     if (ctl->qnt_m < 0)
02559       ERRMSG("Need quantity mass!");
02560
02561     /* Open observation data file... */
02562     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
02563     if (!(in = fopen(ctl->csi_obsfile, "r")))
02564       ERRMSG("Cannot open file!");
02565
02566     /* Create new file... */
02567     printf("Write CSI data: %s\n", filename);
02568     if (!(out = fopen(filename, "w")))
02569       ERRMSG("Cannot create file!");
02570
02571     /* Write header... */
02572     fprintf(out,
02573             "# $1 = time [s]\n"
02574             "# $2 = number of hits (cx)\n"
02575             "# $3 = number of misses (cy)\n"
02576             "# $4 = number of false alarms (cz)\n"
02577             "# $5 = number of observations (cx + cy)\n"
02578             "# $6 = number of forecasts (cx + cz)\n"
02579             "# $7 = bias (forecasts/observations) [%%]\n"
02580             "# $8 = probability of detection (POD) [%%]\n"
02581             "# $9 = false alarm rate (FAR) [%%]\n"
02582             "# $10 = critical success index (CSI) [%%]\n\n");
02583   }
02584
02585   /* Set time interval... */
02586   t0 = t - 0.5 * ctl->dt_mod;
02587   t1 = t + 0.5 * ctl->dt_mod;
02588
02589   /* Initialize grid cells... */
02590 #pragma omp parallel for default(shared) private(ix,iy,iz)
02591   for (ix = 0; ix < ctl->csi_nx; ix++)
02592     for (iy = 0; iy < ctl->csi_ny; iy++)
02593       for (iz = 0; iz < ctl->csi_nz; iz++)
02594         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
02595
02596   /* Read observation data... */
02597   while (fgets(line, LEN, in)) {
02598
02599     /* Read data... */
```

```
02600     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
02601         5)
02602       continue;
02603
02604     /* Check time... */
02605     if (rt < t0)
02606       continue;
02607     if (rt > t1)
02608       break;
02609
02610     /* Calculate indices... */
02611     ix = (int) ((rlon - ctl->csi_lon0)
02612                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
02613     iy = (int) ((rlat - ctl->csi_lat0)
02614                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
02615     iz = (int) ((rz - ctl->csi_z0)
02616                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
02617
02618     /* Check indices... */
02619     if (ix < 0 || ix >= ctl->csi_nx ||
02620         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
02621       continue;
02622
02623     /* Get mean observation index... */
02624     obsmean[ix][iy][iz] += robs;
02625     obscount[ix][iy][iz]++;
02626   }
02627
02628   /* Analyze model data... */
02629 #pragma omp parallel for default(shared) private(ip,ix,iy,iz)
02630   for (ip = 0; ip < atm->np; ip++) {
02631
02632     /* Check time... */
02633     if (atm->time[ip] < t0 || atm->time[ip] > t1)
02634       continue;
02635
02636     /* Get indices... */
02637     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
02638                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
02639     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
02640                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
02641     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
02642                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
02643
02644     /* Check indices... */
02645     if (ix < 0 || ix >= ctl->csi_nx ||
02646         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
02647       continue;
02648
02649     /* Get total mass in grid cell... */
02650     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
02651   }
02652
02653   /* Analyze all grid cells... */
02654 #pragma omp parallel for default(shared) private(ix,iy,iz,dlon,dlat,lat,area)
02655   for (ix = 0; ix < ctl->csi_nx; ix++)
02656     for (iy = 0; iy < ctl->csi_ny; iy++)
02657       for (iz = 0; iz < ctl->csi_nz; iz++) {
02658
02659         /* Calculate mean observation index... */
02660         if (obscount[ix][iy][iz] > 0)
02661           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
02662
02663         /* Calculate column density... */
02664         if (modmean[ix][iy][iz] > 0) {
02665           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
02666           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
02667           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
02668           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
02669             * cos(lat * M_PI / 180.);
02670           modmean[ix][iy][iz] /= (1e6 * area);
02671         }
02672
02673         /* Calculate CSI... */
02674         if (obscount[ix][iy][iz] > 0) {
02675           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
02676               modmean[ix][iy][iz] >= ctl->csi_modmin)
02677             cx++;
02678           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
02679                    modmean[ix][iy][iz] < ctl->csi_modmin)
02680             cy++;
02681           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
02682                    modmean[ix][iy][iz] >= ctl->csi_modmin)
02683             cz++;
02684         }
02685       }
02686
```

```
02687   /* Write output... */
02688   if (fmod(t, ctl->csi_dt_out) == 0) {
02689
02690     /* Write... */
02691     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
02692             t, cx, cy, cz, cx + cy, cx + cz,
02693             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
02694             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
02695             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
02696             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
02697
02698     /* Set counters to zero... */
02699     cx = cy = cz = 0;
02700   }
02701
02702   /* Close file... */
02703   if (t == ctl->t_stop)
02704     fclose(out);
02705 }
```

5.21.2.35 void write_ens (const char * *filename*, ctl_t * *ctl*, atm_t * *atm*, double *t*)

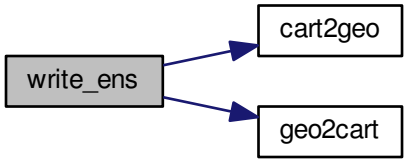
Write ensemble data.

Definition at line 2709 of file libtrac.c.

```
02713           {
02714
02715   static FILE *out;
02716
02717   static double dummy, ens, lat, lon, p[NENS], q[NQ][NENS],
02718     t0, t1, x[NENS][3], xm[3];
02719
02720   static int ip, iq;
02721
02722   static size_t i, n;
02723
02724   /* Init... */
02725   if (t == ctl->t_start) {
02726
02727     /* Check quantities... */
02728     if (ctl->qnt_ens < 0)
02729       ERRMSG("Missing ensemble IDs!");
02730
02731     /* Create new file... */
02732     printf("Write ensemble data: %s\n", filename);
02733     if (!(out = fopen(filename, "w")))
02734       ERRMSG("Cannot create file!");
02735
02736     /* Write header... */
02737     fprintf(out,
02738             "# $1 = time [s]\n"
02739             "# $2 = altitude [km]\n"
02740             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
02741     for (iq = 0; iq < ctl->nq; iq++)
02742       fprintf(out, "# $%d = %s (mean) [%s]\n", 5 + iq,
02743               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
02744     for (iq = 0; iq < ctl->nq; iq++)
02745       fprintf(out, "# $%d = %s (sigma) [%s]\n", 5 + ctl->nq + iq,
02746               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
02747     fprintf(out, "# $%d = number of members\n\n", 5 + 2 * ctl->nq);
02748   }
02749
02750   /* Set time interval... */
02751   t0 = t - 0.5 * ctl->dt_mod;
02752   t1 = t + 0.5 * ctl->dt_mod;
02753
02754   /* Init... */
02755   ens = GSL_NAN;
02756   n = 0;
02757
02758   /* Loop over air parcels... */
02759   for (ip = 0; ip < atm->np; ip++) {
02760
02761     /* Check time... */
02762     if (atm->time[ip] < t0 || atm->time[ip] > t1)
02763       continue;
02764
02765     /* Check ensemble id... */
02766     if (atm->q[ctl->qnt_ens][ip] != ens) {
```

```
02767
02768       /* Write results... */
02769       if (n > 0) {
02770
02771         /* Get mean position... */
02772         xm[0] = xm[1] = xm[2] = 0;
02773         for (i = 0; i < n; i++) {
02774           xm[0] += x[i][0] / (double) n;
02775           xm[1] += x[i][1] / (double) n;
02776           xm[2] += x[i][2] / (double) n;
02777         }
02778         cart2geo(xm, &dummy, &lon, &lat);
02779         fprintf(out, "%.2f %g %g %g", t, Z(gsl_stats_mean(p, 1, n)), lon,
02780                 lat);
02781
02782         /* Get quantity statistics... */
02783         for (iq = 0; iq < ctl->nq; iq++) {
02784           fprintf(out, " ");
02785           fprintf(out, ctl->qnt_format[iq], gsl_stats_mean(q[iq], 1, n));
02786         }
02787         for (iq = 0; iq < ctl->nq; iq++) {
02788           fprintf(out, " ");
02789           fprintf(out, ctl->qnt_format[iq], gsl_stats_sd(q[iq], 1, n));
02790         }
02791         fprintf(out, " %lu\n", n);
02792       }
02793
02794       /* Init new ensemble... */
02795       ens = atm->q[ctl->qnt_ens][ip];
02796       n = 0;
02797     }
02798
02799     /* Save data... */
02800     p[n] = atm->p[ip];
02801     geo2cart(0, atm->lon[ip], atm->lat[ip], x[n]);
02802     for (iq = 0; iq < ctl->nq; iq++)
02803       q[iq][n] = atm->q[iq][ip];
02804     if ((++n) >= NENS)
02805       ERRMSG("Too many data points!");
02806   }
02807
02808   /* Write results... */
02809   if (n > 0) {
02810
02811     /* Get mean position... */
02812     xm[0] = xm[1] = xm[2] = 0;
02813     for (i = 0; i < n; i++) {
02814       xm[0] += x[i][0] / (double) n;
02815       xm[1] += x[i][1] / (double) n;
02816       xm[2] += x[i][2] / (double) n;
02817     }
02818     cart2geo(xm, &dummy, &lon, &lat);
02819     fprintf(out, "%.2f %g %g %g", t, Z(gsl_stats_mean(p, 1, n)), lon, lat);
02820
02821     /* Get quantity statistics... */
02822     for (iq = 0; iq < ctl->nq; iq++) {
02823       fprintf(out, " ");
02824       fprintf(out, ctl->qnt_format[iq], gsl_stats_mean(q[iq], 1, n));
02825     }
02826     for (iq = 0; iq < ctl->nq; iq++) {
02827       fprintf(out, " ");
02828       fprintf(out, ctl->qnt_format[iq], gsl_stats_sd(q[iq], 1, n));
02829     }
02830     fprintf(out, " %lu\n", n);
02831   }
02832
02833   /* Close file... */
02834   if (t == ctl->t_stop)
02835     fclose(out);
02836 }
```

Here is the call graph for this function:



5.21.2.36 void write_grid (const char * *filename*, ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, double *t*)

Write gridded data.

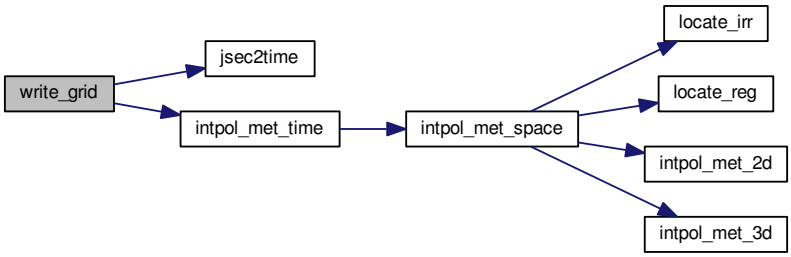
Definition at line 2840 of file libtrac.c.

```
02846            {
02847
02848   FILE *in, *out;
02849
02850   char line[LEN];
02851
02852   static double mass[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
02853     area, rho_air, press, temp, cd, vmr, t0, t1, r;
02854
02855   static int ip, ix, iy, iz, np[GX][GY][GZ], year, mon, day, hour, min, sec;
02856
02857   /* Check dimensions... */
02858   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
02859     ERRMSG("Grid dimensions too large!");
02860
02861   /* Set time interval for output... */
02862   t0 = t - 0.5 * ctl->dt_mod;
02863   t1 = t + 0.5 * ctl->dt_mod;
02864
02865   /* Set grid box size... */
02866   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
02867   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
02868   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
02869
02870   /* Initialize grid... */
02871 #pragma omp parallel for default(shared) private(ix,iy,iz)
02872   for (ix = 0; ix < ctl->grid_nx; ix++)
02873     for (iy = 0; iy < ctl->grid_ny; iy++)
02874       for (iz = 0; iz < ctl->grid_nz; iz++) {
02875         mass[ix][iy][iz] = 0;
02876         np[ix][iy][iz] = 0;
02877       }
02878
02879   /* Average data... */
02880 #pragma omp parallel for default(shared) private(ip,ix,iy,iz)
02881   for (ip = 0; ip < atm->np; ip++)
02882     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
02883
02884       /* Get index... */
02885       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
02886       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
02887       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
02888
02889       /* Check indices... */
02890       if (ix < 0 || ix >= ctl->grid_nx ||
02891           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
02892         continue;
02893
02894       /* Add mass... */
02895       if (ctl->qnt_m >= 0)
02896         mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
02897       np[ix][iy][iz]++;
```

```
02898     }
02899
02900   /* Check if gnuplot output is requested... */
02901   if (ctl->grid_gpfile[0] != '-') {
02902
02903     /* Write info... */
02904     printf("Plot grid data: %s.png\n", filename);
02905
02906     /* Create gnuplot pipe... */
02907     if (!(out = popen("gnuplot", "w")))
02908       ERRMSG("Cannot create pipe to gnuplot!");
02909
02910     /* Set plot filename... */
02911     fprintf(out, "set out \"%s.png\"\n", filename);
02912
02913     /* Set time string... */
02914     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
02915     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
02916             year, mon, day, hour, min);
02917
02918     /* Dump gnuplot file to pipe... */
02919     if (!(in = fopen(ctl->grid_gpfile, "r")))
02920       ERRMSG("Cannot open file!");
02921     while (fgets(line, LEN, in))
02922       fprintf(out, "%s", line);
02923     fclose(in);
02924   }
02925
02926   else {
02927
02928     /* Write info... */
02929     printf("Write grid data: %s\n", filename);
02930
02931     /* Create file... */
02932     if (!(out = fopen(filename, "w")))
02933       ERRMSG("Cannot create file!");
02934   }
02935
02936   /* Write header... */
02937   fprintf(out,
02938           "# $1 = time [s]\n"
02939           "# $2 = altitude [km]\n"
02940           "# $3 = longitude [deg]\n"
02941           "# $4 = latitude [deg]\n"
02942           "# $5 = surface area [km^2]\n"
02943           "# $6 = layer width [km]\n"
02944           "# $7 = number of particles [1]\n"
02945           "# $8 = column density [kg/m^2]\n"
02946           "# $9 = volume mixing ratio [1]\n\n");
02947
02948   /* Write data... */
02949   for (ix = 0; ix < ctl->grid_nx; ix++) {
02950     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
02951       fprintf(out, "\n");
02952     for (iy = 0; iy < ctl->grid_ny; iy++) {
02953       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
02954         fprintf(out, "\n");
02955       for (iz = 0; iz < ctl->grid_nz; iz++)
02956         if (!ctl->grid_sparse || mass[ix][iy][iz] > 0) {
02957
02958           /* Set coordinates... */
02959           z = ctl->grid_z0 + dz * (iz + 0.5);
02960           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
02961           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
02962
02963           /* Get pressure and temperature... */
02964           press = P(z);
02965           intpol_met_time(met0, met1, t, press, lon, lat, NULL, NULL,
02966                           NULL, &temp, NULL, NULL, NULL, NULL, NULL, NULL);
02967
02968           /* Calculate surface area... */
02969           area = dlat * dlon * SQR(RE * M_PI / 180.)
02970             * cos(lat * M_PI / 180.);
02971
02972           /* Calculate column density... */
02973           cd = mass[ix][iy][iz] / (1e6 * area);
02974
02975           /* Calculate volume mixing ratio... */
02976           rho_air = 100. * press / (RA * temp);
02977           vmr = MA / ctl->molmass * mass[ix][iy][iz]
02978             / (rho_air * 1e6 * area * 1e3 * dz);
02979
02980           /* Write output... */
02981           fprintf(out, "%.2f %g %g %g %g %g %d %g %g\n",
02982                   t, z, lon, lat, area, dz, np[ix][iy][iz], cd, vmr);
02983         }
02984     }
```

```
02985   }
02986
02987   /* Close file... */
02988   fclose(out);
02989 }
```

Here is the call graph for this function:



5.21.2.37 void write_prof (const char * *filename*, ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, double *t*)

Write profile data.

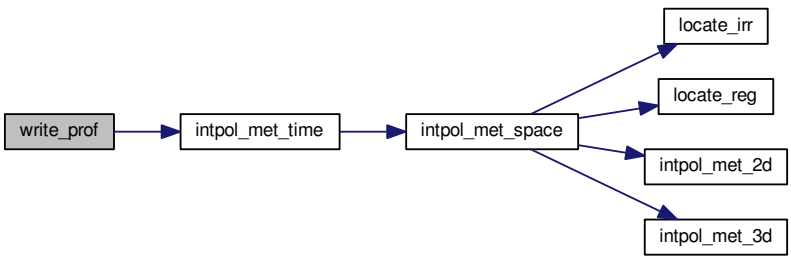
Definition at line 2993 of file libtrac.c.

```
02999           {
03000
03001   static FILE *in, *out;
03002
03003   static char line[LEN];
03004
03005   static double mass[GX][GY][GZ], obsmean[GX][GY], obsmean2[GX][GY], rt, rz,
03006     rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z, press, temp,
03007     rho_air, vmr, h2o, o3;
03008
03009   static int obscount[GX][GY], ip, ix, iy, iz, okay;
03010
03011   /* Init... */
03012   if (t == ctl->t_start) {
03013
03014     /* Check quantity index for mass... */
03015     if (ctl->qnt_m < 0)
03016       ERRMSG("Need quantity mass!");
03017
03018     /* Check dimensions... */
03019     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
03020       ERRMSG("Grid dimensions too large!");
03021
03022     /* Open observation data file... */
03023     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
03024     if (!(in = fopen(ctl->prof_obsfile, "r")))
03025       ERRMSG("Cannot open file!");
03026
03027     /* Create new output file... */
03028     printf("Write profile data: %s\n", filename);
03029     if (!(out = fopen(filename, "w")))
03030       ERRMSG("Cannot create file!");
03031
03032     /* Write header... */
03033     fprintf(out,
03034             "# $1 = time [s]\n"
03035             "# $2 = altitude [km]\n"
03036             "# $3 = longitude [deg]\n"
03037             "# $4 = latitude [deg]\n"
03038             "# $5 = pressure [hPa]\n"
03039             "# $6 = temperature [K]\n"
03040             "# $7 = volume mixing ratio [1]\n"
```

```
03041             "# $8 = H2O volume mixing ratio [1]\n"
03042             "# $9 = O3 volume mixing ratio [1]\n"
03043             "# $10 = observed BT index (mean) [K]\n"
03044             "# $11 = observed BT index (sigma) [K]\n");
03045
03046     /* Set grid box size... */
03047     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
03048     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
03049     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
03050   }
03051
03052   /* Set time interval... */
03053   t0 = t - 0.5 * ctl->dt_mod;
03054   t1 = t + 0.5 * ctl->dt_mod;
03055
03056   /* Initialize... */
03057 #pragma omp parallel for default(shared) private(ix,iy,iz)
03058   for (ix = 0; ix < ctl->prof_nx; ix++)
03059     for (iy = 0; iy < ctl->prof_ny; iy++) {
03060       obsmean[ix][iy] = 0;
03061       obsmean2[ix][iy] = 0;
03062       obscount[ix][iy] = 0;
03063       for (iz = 0; iz < ctl->prof_nz; iz++)
03064         mass[ix][iy][iz] = 0;
03065     }
03066
03067   /* Read observation data... */
03068   while (fgets(line, LEN, in)) {
03069
03070     /* Read data... */
03071     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
03072         5)
03073       continue;
03074
03075     /* Check time... */
03076     if (rt < t0)
03077       continue;
03078     if (rt > t1)
03079       break;
03080
03081     /* Calculate indices... */
03082     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
03083     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
03084
03085     /* Check indices... */
03086     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
03087       continue;
03088
03089     /* Get mean observation index... */
03090     obsmean[ix][iy] += robs;
03091     obsmean2[ix][iy] += SQR(robs);
03092     obscount[ix][iy]++;
03093   }
03094
03095   /* Analyze model data... */
03096 #pragma omp parallel for default(shared) private(ip,ix,iy,iz)
03097   for (ip = 0; ip < atm->np; ip++) {
03098
03099     /* Check time... */
03100     if (atm->time[ip] < t0 || atm->time[ip] > t1)
03101       continue;
03102
03103     /* Get indices... */
03104     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
03105     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
03106     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
03107
03108     /* Check indices... */
03109     if (ix < 0 || ix >= ctl->prof_nx ||
03110         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
03111       continue;
03112
03113     /* Get total mass in grid cell... */
03114     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
03115   }
03116
03117   /* Extract profiles... */
03118   for (ix = 0; ix < ctl->prof_nx; ix++)
03119     for (iy = 0; iy < ctl->prof_ny; iy++)
03120       if (obscount[ix][iy] > 0) {
03121
03122         /* Check profile... */
03123         okay = 0;
03124         for (iz = 0; iz < ctl->prof_nz; iz++)
03125           if (mass[ix][iy][iz] > 0) {
03126             okay = 1;
03127             break;
```

```
03128           }
03129         if (!okay)
03130           continue;
03131
03132         /* Write output... */
03133         fprintf(out, "\n");
03134
03135         /* Loop over altitudes... */
03136         for (iz = 0; iz < ctl->prof_nz; iz++) {
03137
03138           /* Set coordinates... */
03139           z = ctl->prof_z0 + dz * (iz + 0.5);
03140           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
03141           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
03142
03143           /* Get pressure and temperature... */
03144           press = P(z);
03145           intpol_met_time(met0, met1, t, press, lon, lat, NULL, NULL,
03146                           NULL, &temp, NULL, NULL, NULL, NULL, &h2o, &o3);
03147
03148           /* Calculate surface area... */
03149           area = dlat * dlon * SQR(M_PI * RE / 180.)
03150             * cos(lat * M_PI / 180.);
03151
03152           /* Calculate volume mixing ratio... */
03153           rho_air = 100. * press / (RA * temp);
03154           vmr = MA / ctl->molmass * mass[ix][iy][iz]
03155             / (rho_air * area * dz * 1e9);
03156
03157           /* Write output... */
03158           fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g\n",
03159                   t, z, lon, lat, press, temp, vmr, h2o, o3,
03160                   obsmean[ix][iy] / obscount[ix][iy],
03161                   sqrt(obsmean2[ix][iy] / obscount[ix][iy]
03162                        - SQR(obsmean[ix][iy] / obscount[ix][iy])));
03163         }
03164       }
03165
03166   /* Close file... */
03167   if (t == ctl->t_stop)
03168     fclose(out);
03169 }
```

Here is the call graph for this function:



5.21.2.38 void write_station (const char * *filename*, ctl_t * *ctl*, atm_t * *atm*, double *t*)

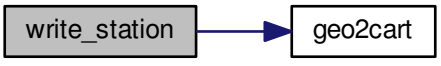
Write station data.

Definition at line 3173 of file libtrac.c.

```
03177             {
03178
03179   static FILE *out;
03180
03181   static double rmax2, t0, t1, x0[3], x1[3];
```

```
03182
03183   /* Init... */
03184   if (t == ctl->t_start) {
03185
03186     /* Write info... */
03187     printf("Write station data: %s\n", filename);
03188
03189     /* Create new file... */
03190     if (!(out = fopen(filename, "w")))
03191       ERRMSG("Cannot create file!");
03192
03193     /* Write header... */
03194     fprintf(out,
03195             "# $1 = time [s]\n"
03196             "# $2 = altitude [km]\n"
03197             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
03198     for (int iq = 0; iq < ctl->nq; iq++)
03199       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
03200               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
03201     fprintf(out, "\n");
03202
03203     /* Set geolocation and search radius... */
03204     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
03205     rmax2 = SQR(ctl->stat_r);
03206   }
03207
03208   /* Set time interval for output... */
03209   t0 = t - 0.5 * ctl->dt_mod;
03210   t1 = t + 0.5 * ctl->dt_mod;
03211
03212   /* Loop over air parcels... */
03213   for (int ip = 0; ip < atm->np; ip++) {
03214
03215     /* Check time... */
03216     if (atm->time[ip] < t0 || atm->time[ip] > t1)
03217       continue;
03218
03219     /* Check station flag... */
03220     if (ctl->qnt_stat >= 0)
03221       if (atm->q[ctl->qnt_stat][ip])
03222         continue;
03223
03224     /* Get Cartesian coordinates... */
03225     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
03226
03227     /* Check horizontal distance... */
03228     if (DIST2(x0, x1) > rmax2)
03229       continue;
03230
03231     /* Set station flag... */
03232     if (ctl->qnt_stat >= 0)
03233       atm->q[ctl->qnt_stat][ip] = 1;
03234
03235     /* Write data... */
03236     fprintf(out, "%.2f %g %g %g",
03237             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
03238     for (int iq = 0; iq < ctl->nq; iq++) {
03239       fprintf(out, " ");
03240       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
03241     }
03242     fprintf(out, "\n");
03243   }
03244
03245   /* Close file... */
03246   if (t == ctl->t_stop)
03247     fclose(out);
03248 }
```

Here is the call graph for this function:



5.22 libtrac.h

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00035 #include <ctype.h>
00036 #include <gsl/gsl_math.h>
00037 #include <gsl/gsl_randist.h>
00038 #include <gsl/gsl_rng.h>
00039 #include <gsl/gsl_sort.h>
00040 #include <gsl/gsl_spline.h>
00041 #include <gsl/gsl_statistics.h>
00042 #include <math.h>
00043 #include <netcdf.h>
00044 #include <omp.h>
00045 #include <stdio.h>
00046 #include <stdlib.h>
00047 #include <string.h>
00048 #include <time.h>
00049 #include <sys/time.h>
00050
00051 /* ------------------------------------------------------------
00052    Constants...
00053    ------------------------------------------------------------ */
00054
00056 #define G0 9.80665
00057
00059 #define H0 7.0
00060
00062 #define KB 1.3806504e-23
00063
00065 #define MA 28.9644
00066
00068 #define P0 1013.25
00069
00071 #define RA 287.058
00072
00074 #define RI 8.3144598
00075
00077 #define RE 6367.421
00078
00079 /* ------------------------------------------------------------
00080    Dimensions...
00081    ------------------------------------------------------------ */
00082
00084 #define LEN 5000
00085
00087 #define NP 10000000
00088
00090 #define NQ 12
00091
00093 #define EP 112
00094
00096 #define EX 1201
00097
00099 #define EY 601
00100
00102 #define GX 720
00103
00105 #define GY 360
00106
00108 #define GZ 100
00109
00111 #define NENS 2000
00112
00114 #define NTHREADS 512
00115
00116 /* ------------------------------------------------------------
00117    Macros...
00118    ------------------------------------------------------------ */
```

```
00119
00121 #define ALLOC(ptr, type, n)                                 \
00122   if((ptr=calloc((size_t)(n), sizeof(type)))==NULL)         \
00123     ERRMSG("Out of memory!");
00124
00126 #define DEG2DX(dlon, lat)                                           \
00127   ((dlon) * M_PI * RE / 180. * cos((lat) / 180. * M_PI))
00128
00130 #define DEG2DY(dlat)                                \
00131   ((dlat) * M_PI * RE / 180.)
00132
00134 #define DP2DZ(dp, p)                                \
00135   (- (dp) * H0 / (p))
00136
00138 #define DX2DEG(dx, lat)                                             \
00139   (((lat) < -89.999 || (lat) > 89.999) ? 0                          \
00140    : (dx) * 180. / (M_PI * RE * cos((lat) / 180. * M_PI)))
00141
00143 #define DY2DEG(dy)                                  \
00144   ((dy) * 180. / (M_PI * RE))
00145
00147 #define DZ2DP(dz, p)                                \
00148   (-(dz) * (p) / H0)
00149
00151 #define DIST(a, b) sqrt(DIST2(a, b))
00152
00154 #define DIST2(a, b)                                                         \
00155   ((a[0]-b[0])*(a[0]-b[0])+(a[1]-b[1])*(a[1]-b[1])+(a[2]-b[2])*(a[2]-b[2]))
00156
00158 #define DOTP(a, b) (a[0]*b[0]+a[1]*b[1]+a[2]*b[2])
00159
00161 #define ERRMSG(msg) {                                               \
00162     printf("\nError (%s, %s, l%d): %s\n\n",                         \
00163            __FILE__, __func__, __LINE__, msg);                      \
00164     exit(EXIT_FAILURE);                                             \
00165   }
00166
00168 #define FMOD(x, y)                                  \
00169   ((x) - (int) ((x) / (y)) * (y))
00170
00172 #define FREAD(ptr, type, size, out) {                               \
00173     if(fread(ptr, sizeof(type), size, out)!=size)                   \
00174       ERRMSG("Error while reading!");                               \
00175   }
00176
00178 #define FWRITE(ptr, type, size, out) {                              \
00179     if(fwrite(ptr, sizeof(type), size, out)!=size)                  \
00180       ERRMSG("Error while writing!");                               \
00181   }
00182
00184 #define LIN(x0, y0, x1, y1, x)                  \
00185   ((y0)+((y1)-(y0))/((x1)-(x0))*((x)-(x0)))
00186
00188 #define NC(cmd) {                                   \
00189     if((cmd)!=NC_NOERR)                             \
00190       ERRMSG(nc_strerror(cmd));                     \
00191   }
00192
00194 #define NORM(a) sqrt(DOTP(a, a))
00195
00197 #define PRINT(format, var)                                          \
00198   printf("Print (%s, %s, l%d): %s= "format"\n",                     \
00199          __FILE__, __func__, __LINE__, #var, var);
00200
00202 #define P(z) (P0*exp(-(z)/H0))
00203
00205 #define SQR(x) ((x)*(x))
00206
00208 #define THETA(p, t) ((t)*pow(1000./(p), 0.286))
00209
00211 #define TOK(line, tok, format, var) {                               \
00212     if(((tok)=strtok((line), " \t"))) {                             \
00213       if(sscanf(tok, format, &(var))!=1) continue;                  \
00214     } else ERRMSG("Error while reading!");                          \
00215   }
00216
00218 #define TVIRT(t, h2o) ((t)*(1.0 + 0.609133 * (h2o) * 18.01528 / MA))
00219
00221 #define WARN(msg) {                                                 \
00222     printf("\nWarning (%s, %s, l%d): %s\n\n",                       \
00223            __FILE__, __func__, __LINE__, msg);                      \
00224   }
00225
00227 #define Z(p) (H0*log(P0/(p)))
00228
00229 /* ------------------------------------------------------------
00230    Timers...
```

```
00231    ------------------------------------------------------------ */
00232
00234 #define START_TIMER(id) timer(#id, id, 1)
00235
00237 #define STOP_TIMER(id) timer(#id, id, 2)
00238
00240 #define PRINT_TIMER(id) timer(#id, id, 3)
00241
00243 #define NTIMER 20
00244
00246 #define TIMER_ZERO 0
00247
00249 #define TIMER_INIT 1
00250
00252 #define TIMER_INPUT 2
00253
00255 #define TIMER_OUTPUT 3
00256
00258 #define TIMER_ADVECT 4
00259
00261 #define TIMER_DECAY 5
00262
00264 #define TIMER_DIFFMESO 6
00265
00267 #define TIMER_DIFFTURB 7
00268
00270 #define TIMER_ISOSURF 8
00271
00273 #define TIMER_METEO 9
00274
00276 #define TIMER_POSITION 10
00277
00279 #define TIMER_SEDI 11
00280
00282 #define TIMER_TOTAL 12
00283
00284 /* ------------------------------------------------------------
00285    Structs...
00286    ------------------------------------------------------------ */
00287
00289 typedef struct {
00290
00292   int nq;
00293
00295   char qnt_name[NQ][LEN];
00296
00298   char qnt_unit[NQ][LEN];
00299
00301   char qnt_format[NQ][LEN];
00302
00304   int qnt_ens;
00305
00307   int qnt_m;
00308
00310   int qnt_rho;
00311
00313   int qnt_r;
00314
00316   int qnt_ps;
00317
00319   int qnt_pt;
00320
00322   int qnt_z;
00323
00325   int qnt_p;
00326
00328   int qnt_t;
00329
00331   int qnt_u;
00332
00334   int qnt_v;
00335
00337   int qnt_w;
00338
00340   int qnt_h2o;
00341
00343   int qnt_o3;
00344
00346   int qnt_theta;
00347
00349   int qnt_vh;
00350
00352   int qnt_vz;
00353
00355   int qnt_pv;
00356
00358   int qnt_tice;
```

```
00359
00361   int qnt_tsts;
00362
00364   int qnt_tnat;
00365
00367   int qnt_stat;
00368
00370   int direction;
00371
00373   double t_start;
00374
00376   double t_stop;
00377
00379   double dt_mod;
00380
00382   double dt_met;
00383
00385   int met_dx;
00386
00388   int met_dy;
00389
00391   int met_dp;
00392
00394   int met_sx;
00395
00397   int met_sy;
00398
00400   int met_sp;
00401
00403   int met_np;
00404
00406   double met_p[EP];
00407
00410   int met_tropo;
00411
00413   char met_geopot[LEN];
00414
00416   double met_dt_out;
00417
00419   char met_stage[LEN];
00420
00423   int isosurf;
00424
00426   char balloon[LEN];
00427
00429   double turb_dx_trop;
00430
00432   double turb_dx_strat;
00433
00435   double turb_dz_trop;
00436
00438   double turb_dz_strat;
00439
00441   double turb_mesox;
00442
00444   double turb_mesoz;
00445
00447   double molmass;
00448
00450   double tdec_trop;
00451
00453   double tdec_strat;
00454
00456   double psc_h2o;
00457
00459   double psc_hno3;
00460
00462   char atm_basename[LEN];
00463
00465   char atm_gpfile[LEN];
00466
00468   double atm_dt_out;
00469
00471   int atm_filter;
00472
00474   int atm_stride;
00475
00477   int atm_type;
00478
00480   char csi_basename[LEN];
00481
00483   double csi_dt_out;
00484
00486   char csi_obsfile[LEN];
00487
00489   double csi_obsmin;
00490
```

```
00492   double csi_modmin;
00493
00495   int csi_nz;
00496
00498   double csi_z0;
00499
00501   double csi_z1;
00502
00504   int csi_nx;
00505
00507   double csi_lon0;
00508
00510   double csi_lon1;
00511
00513   int csi_ny;
00514
00516   double csi_lat0;
00517
00519   double csi_lat1;
00520
00522   char grid_basename[LEN];
00523
00525   char grid_gpfile[LEN];
00526
00528   double grid_dt_out;
00529
00531   int grid_sparse;
00532
00534   int grid_nz;
00535
00537   double grid_z0;
00538
00540   double grid_z1;
00541
00543   int grid_nx;
00544
00546   double grid_lon0;
00547
00549   double grid_lon1;
00550
00552   int grid_ny;
00553
00555   double grid_lat0;
00556
00558   double grid_lat1;
00559
00561   char prof_basename[LEN];
00562
00564   char prof_obsfile[LEN];
00565
00567   int prof_nz;
00568
00570   double prof_z0;
00571
00573   double prof_z1;
00574
00576   int prof_nx;
00577
00579   double prof_lon0;
00580
00582   double prof_lon1;
00583
00585   int prof_ny;
00586
00588   double prof_lat0;
00589
00591   double prof_lat1;
00592
00594   char ens_basename[LEN];
00595
00597   char stat_basename[LEN];
00598
00600   double stat_lon;
00601
00603   double stat_lat;
00604
00606   double stat_r;
00607
00608 } ctl_t;
00609
00611 typedef struct {
00612
00614   int np;
00615
00617   double time[NP];
00618
00620   double p[NP];
```

```
00621
00623   double lon[NP];
00624
00626   double lat[NP];
00627
00629   double q[NQ][NP];
00630
00631 } atm_t;
00632
00634 typedef struct {
00635
00637   float up[NP];
00638
00640   float vp[NP];
00641
00643   float wp[NP];
00644
00646   double iso_var[NP];
00647
00649   double iso_ps[NP];
00650
00652   double iso_ts[NP];
00653
00655   int iso_n;
00656
00658   double tsig[EX][EY][EP];
00659
00661   float usig[EX][EY][EP];
00662
00664   float vsig[EX][EY][EP];
00665
00667   float wsig[EX][EY][EP];
00668
00669 } cache_t;
00670
00672 typedef struct {
00673
00675   double time;
00676
00678   int nx;
00679
00681   int ny;
00682
00684   int np;
00685
00687   double lon[EX];
00688
00690   double lat[EY];
00691
00693   double p[EP];
00694
00696   double ps[EX][EY];
00697
00699   double pt[EX][EY];
00700
00702   float z[EX][EY][EP];
00703
00705   float t[EX][EY][EP];
00706
00708   float u[EX][EY][EP];
00709
00711   float v[EX][EY][EP];
00712
00714   float w[EX][EY][EP];
00715
00717   float pv[EX][EY][EP];
00718
00720   float h2o[EX][EY][EP];
00721
00723   float o3[EX][EY][EP];
00724
00726   float pl[EX][EY][EP];
00727
00728 } met_t;
00729
00730 /* ------------------------------------------------------------
00731    Functions...
00732    ------------------------------------------------------------ */
00733
00735 void cart2geo(
00736   double *x,
00737   double *z,
00738   double *lon,
00739   double *lat);
00740
00742 #ifdef _OPENACC
00743 #pragma acc routine (clim_hno3)
```

```
00744 #endif
00745 double clim_hno3(
00746   double t,
00747   double lat,
00748   double p);
00749
00751 #ifdef _OPENACC
00752 #pragma acc routine (clim_tropo)
00753 #endif
00754 double clim_tropo(
00755   double t,
00756   double lat);
00757
00759 void day2doy(
00760   int year,
00761   int mon,
00762   int day,
00763   int *doy);
00764
00766 void doy2day(
00767   int year,
00768   int doy,
00769   int *mon,
00770   int *day);
00771
00773 void geo2cart(
00774   double z,
00775   double lon,
00776   double lat,
00777   double *x);
00778
00780 void get_met(
00781   ctl_t * ctl,
00782   char *metbase,
00783   double t,
00784   met_t ** met0,
00785   met_t ** met1);
00786
00788 void get_met_help(
00789   double t,
00790   int direct,
00791   char *metbase,
00792   double dt_met,
00793   char *filename);
00794
00796 void get_met_replace(
00797   char *orig,
00798   char *search,
00799   char *repl);
00800
00802 #ifdef _OPENACC
00803 #pragma acc routine (intpol_met_2d)
00804 #endif
00805 double intpol_met_2d(
00806   double array[EX][EY],
00807   int ix,
00808   int iy,
00809   double wx,
00810   double wy);
00811
00813 #ifdef _OPENACC
00814 #pragma acc routine (intpol_met_3d)
00815 #endif
00816 double intpol_met_3d(
00817   float array[EX][EY][EP],
00818   int ip,
00819   int ix,
00820   int iy,
00821   double wp,
00822   double wx,
00823   double wy);
00824
00826 #ifdef _OPENACC
00827 #pragma acc routine (intpol_met_space)
00828 #endif
00829 void intpol_met_space(
00830   met_t * met,
00831   double p,
00832   double lon,
00833   double lat,
00834   double *ps,
00835   double *pt,
00836   double *z,
00837   double *t,
00838   double *u,
00839   double *v,
00840   double *w,
```

```
00841   double *pv,
00842   double *h2o,
00843   double *o3);
00844
00846 #ifdef _OPENACC
00847 #pragma acc routine (intpol_met_time)
00848 #endif
00849 void intpol_met_time(
00850   met_t * met0,
00851   met_t * met1,
00852   double ts,
00853   double p,
00854   double lon,
00855   double lat,
00856   double *ps,
00857   double *pt,
00858   double *z,
00859   double *t,
00860   double *u,
00861   double *v,
00862   double *w,
00863   double *pv,
00864   double *h2o,
00865   double *o3);
00866
00868 void jsec2time(
00869   double jsec,
00870   int *year,
00871   int *mon,
00872   int *day,
00873   int *hour,
00874   int *min,
00875   int *sec,
00876   double *remain);
00877
00879 #ifdef _OPENACC
00880 #pragma acc routine (locate_irr)
00881 #endif
00882 int locate_irr(
00883   double *xx,
00884   int n,
00885   double x);
00886
00888 #ifdef _OPENACC
00889 #pragma acc routine (locate_reg)
00890 #endif
00891 int locate_reg(
00892   double *xx,
00893   int n,
00894   double x);
00895
00897 int read_atm(
00898   const char *filename,
00899   ctl_t * ctl,
00900   atm_t * atm);
00901
00903 void read_ctl(
00904   const char *filename,
00905   int argc,
00906   char *argv[],
00907   ctl_t * ctl);
00908
00910 int read_met(
00911   ctl_t * ctl,
00912   char *filename,
00913   met_t * met);
00914
00916 void read_met_extrapolate(
00917   met_t * met);
00918
00920 void read_met_geopot(
00921   ctl_t * ctl,
00922   met_t * met);
00923
00925 void read_met_help(
00926   int ncid,
00927   char *varname,
00928   char *varname2,
00929   met_t * met,
00930   float dest[EX][EY][EP],
00931   float scl);
00932
00934 void read_met_ml2pl(
00935   ctl_t * ctl,
00936   met_t * met,
00937   float var[EX][EY][EP]);
00938
```

```
00940 void read_met_periodic(
00941   met_t * met);
00942
00944 void read_met_pv(
00945   met_t * met);
00946
00948 void read_met_sample(
00949   ctl_t * ctl,
00950   met_t * met);
00951
00953 void read_met_tropo(
00954   ctl_t * ctl,
00955   met_t * met);
00956
00958 double scan_ctl(
00959   const char *filename,
00960   int argc,
00961   char *argv[],
00962   const char *varname,
00963   int arridx,
00964   const char *defvalue,
00965   char *value);
00966
00968 void spline(
00969   double *x,
00970   double *y,
00971   int n,
00972   double *x2,
00973   double *y2,
00974   int n2);
00975
00977 #ifdef _OPENACC
00978 #pragma acc routine (stddev)
00979 #endif
00980 double stddev(
00981   double *data,
00982   int n);
00983
00985 void time2jsec(
00986   int year,
00987   int mon,
00988   int day,
00989   int hour,
00990   int min,
00991   int sec,
00992   double remain,
00993   double *jsec);
00994
00996 void timer(
00997   const char *name,
00998   int id,
00999   int mode);
01000
01002 void write_atm(
01003   const char *filename,
01004   ctl_t * ctl,
01005   atm_t * atm,
01006   double t);
01007
01009 void write_csi(
01010   const char *filename,
01011   ctl_t * ctl,
01012   atm_t * atm,
01013   double t);
01014
01016 void write_ens(
01017   const char *filename,
01018   ctl_t * ctl,
01019   atm_t * atm,
01020   double t);
01021
01023 void write_grid(
01024   const char *filename,
01025   ctl_t * ctl,
01026   met_t * met0,
01027   met_t * met1,
01028   atm_t * atm,
01029   double t);
01030
01032 void write_prof(
01033   const char *filename,
01034   ctl_t * ctl,
01035   met_t * met0,
01036   met_t * met1,
01037   atm_t * atm,
01038   double t);
01039
```

```
01041 void write_station(
01042   const char *filename,
01043   ctl_t * ctl,
01044   atm_t * atm,
01045   double t);
```

5.23 met_map.c File Reference

Extract map from meteorological data.

Functions

- int main (int argc, char ∗argv[ ])

5.23.1 Detailed Description

Extract map from meteorological data.

Definition in file met_map.c.

5.23.2 Function Documentation

5.23.2.1 int main (int *argc*, char ∗ *argv[ ]*)

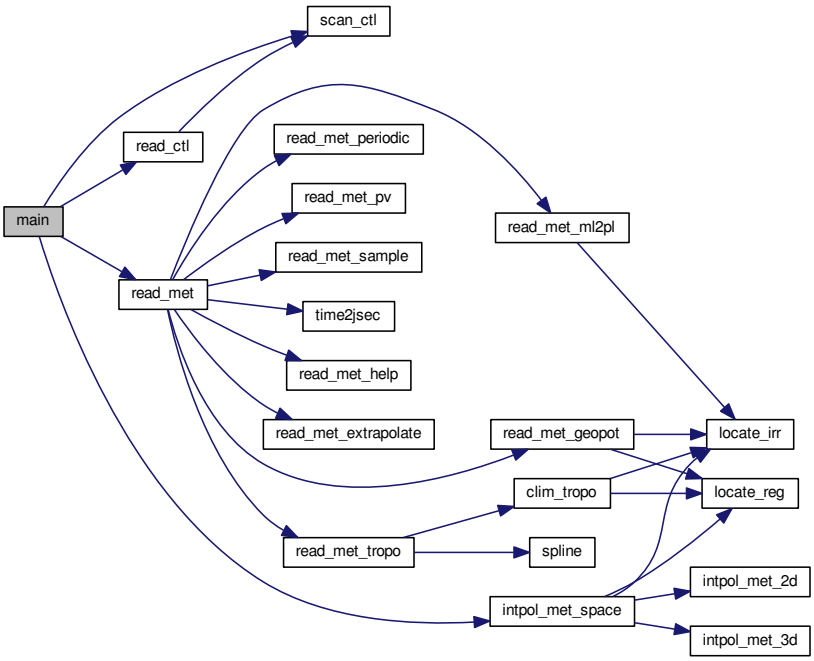
Definition at line 41 of file met_map.c.

```
00043                {
00044
00045   ctl_t ctl;
00046
00047   met_t *met;
00048
00049   FILE *out;
00050
00051   static double timem[NX][NY], p0, ps, psm[NX][NY], pt, ptm[NX][NY], t,
00052     tm[NX][NY], u, um[NX][NY], v, vm[NX][NY], w, wm[NX][NY], h2o,
00053     h2om[NX][NY], h2ot, h2otm[NX][NY], o3, o3m[NX][NY], z, zm[NX][NY], pv,
00054     pvm[NX][NY], zt, ztm[NX][NY], tt, ttm[NX][NY], lon, lon0, lon1, lons[NX],
00055     dlon, lat, lat0, lat1, lats[NY], dlat;
00056
00057   static int i, ix, iy, np[NX][NY], nx, ny;
00058
00059   /* Allocate... */
00060   ALLOC(met, met_t, 1);
00061
00062   /* Check arguments... */
00063   if (argc < 4)
00064     ERRMSG("Give parameters: <ctl> <map.tab> <met0> [ <met1> ... ]");
00065
00066   /* Read control parameters... */
00067   read_ctl(argv[1], argc, argv, &ctl);
00068   p0 = P(scan_ctl(argv[1], argc, argv, "MAP_Z0", -1, "", NULL));
00069   lon0 = scan_ctl(argv[1], argc, argv, "MAP_LON0", -1, "-180", NULL);
00070   lon1 = scan_ctl(argv[1], argc, argv, "MAP_LON1", -1, "180", NULL);
00071   dlon = scan_ctl(argv[1], argc, argv, "MAP_DLON", -1, "-999", NULL);
00072   lat0 = scan_ctl(argv[1], argc, argv, "MAP_LAT0", -1, "-90", NULL);
00073   lat1 = scan_ctl(argv[1], argc, argv, "MAP_LAT1", -1, "90", NULL);
00074   dlat = scan_ctl(argv[1], argc, argv, "MAP_DLAT", -1, "-999", NULL);
00075
00076   /* Loop over files... */
00077   for (i = 3; i < argc; i++) {
00078
00079     /* Read meteorological data... */
00080     if (!read_met(&ctl, argv[i], met))
00081       continue;
```

```
00082
00083     /* Set horizontal grid... */
00084     if (dlon <= 0)
00085       dlon = fabs(met->lon[1] - met->lon[0]);
00086     if (dlat <= 0)
00087       dlat = fabs(met->lat[1] - met->lat[0]);
00088     if (lon0 < -360 && lon1 > 360) {
00089       lon0 = gsl_stats_min(met->lon, 1, (size_t) met->nx);
00090       lon1 = gsl_stats_max(met->lon, 1, (size_t) met->nx);
00091     }
00092     nx = ny = 0;
00093     for (lon = lon0; lon <= lon1; lon += dlon) {
00094       lons[nx] = lon;
00095       if ((++nx) > NX)
00096         ERRMSG("Too many longitudes!");
00097     }
00098     if (lat0 < -90 && lat1 > 90) {
00099       lat0 = gsl_stats_min(met->lat, 1, (size_t) met->ny);
00100       lat1 = gsl_stats_max(met->lat, 1, (size_t) met->ny);
00101     }
00102     for (lat = lat0; lat <= lat1; lat += dlat) {
00103       lats[ny] = lat;
00104       if ((++ny) > NY)
00105         ERRMSG("Too many latitudes!");
00106     }
00107
00108     /* Average... */
00109     for (ix = 0; ix < nx; ix++)
00110       for (iy = 0; iy < ny; iy++) {
00111         intpol_met_space(met, p0, lons[ix], lats[iy], &ps, &pt,
00112                          &z, &t, &u, &v, &w, &pv, &h2o, &o3);
00113         intpol_met_space(met, pt, lons[ix], lats[iy], NULL, NULL,
00114                          &zt, &tt, NULL, NULL, NULL, NULL, &h2ot, NULL);
00115         timem[ix][iy] += met->time;
00116         zm[ix][iy] += z;
00117         tm[ix][iy] += t;
00118         um[ix][iy] += u;
00119         vm[ix][iy] += v;
00120         wm[ix][iy] += w;
00121         pvm[ix][iy] += pv;
00122         h2om[ix][iy] += h2o;
00123         o3m[ix][iy] += o3;
00124         psm[ix][iy] += ps;
00125         ptm[ix][iy] += pt;
00126         ztm[ix][iy] += zt;
00127         ttm[ix][iy] += tt;
00128         h2otm[ix][iy] += h2ot;
00129         np[ix][iy]++;
00130       }
00131   }
00132
00133   /* Create output file... */
00134   printf("Write meteorological data file: %s\n", argv[2]);
00135   if (!(out = fopen(argv[2], "w")))
00136     ERRMSG("Cannot create file!");
00137
00138   /* Write header... */
00139   fprintf(out,
00140           "# $1 = time [s]\n"
00141           "# $2 = altitude [km]\n"
00142           "# $3 = longitude [deg]\n"
00143           "# $4 = latitude [deg]\n"
00144           "# $5 = pressure [hPa]\n"
00145           "# $6 = temperature [K]\n"
00146           "# $7 = zonal wind [m/s]\n"
00147           "# $8 = meridional wind [m/s]\n" "# $9 = vertical wind [hPa/s]\n");
00148   fprintf(out,
00149           "# $10 = H2O volume mixing ratio [1]\n"
00150           "# $11 = O3 volume mixing ratio [1]\n"
00151           "# $12 = geopotential height [km]\n"
00152           "# $13 = potential vorticity [PVU]\n"
00153           "# $14 = surface pressure [hPa]\n"
00154           "# $15 = tropopause pressure [hPa]\n"
00155           "# $16 = tropopause geopotential height [km]\n"
00156           "# $17 = tropopause temperature [K]\n"
00157           "# $18 = tropopause water vapor [ppv]\n");
00158
00159   /* Write data... */
00160   for (iy = 0; iy < ny; iy++) {
00161     fprintf(out, "\n");
00162     for (ix = 0; ix < nx; ix++)
00163       fprintf(out,
00164               "%.2f %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00165               timem[ix][iy] / np[ix][iy], Z(p0), lons[ix], lats[iy], p0,
00166               tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00167               vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00168               h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
```

```
00169               zm[ix][iy] / np[ix][iy], pvm[ix][iy] / np[ix][iy],
00170               psm[ix][iy] / np[ix][iy], ptm[ix][iy] / np[ix][iy],
00171               ztm[ix][iy] / np[ix][iy], ttm[ix][iy] / np[ix][iy],
00172               h2otm[ix][iy] / np[ix][iy]);
00173   }
00174
00175   /* Close file... */
00176   fclose(out);
00177
00178   /* Free... */
00179   free(met);
00180
00181   return EXIT_SUCCESS;
00182 }
```

Here is the call graph for this function:



5.24 met_map.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 /* ------------------------------------------------------------
```

```
00028    Dimensions...
00029    ---------------------------------------------------------- */
00030
00032 #define NX 1441
00033
00035 #define NY 721
00036
00037 /* ----------------------------------------------------------
00038    Main...
00039    ---------------------------------------------------------- */
00040
00041 int main(
00042   int argc,
00043   char *argv[]) {
00044
00045   ctl_t ctl;
00046
00047   met_t *met;
00048
00049   FILE *out;
00050
00051   static double timem[NX][NY], p0, ps, psm[NX][NY], pt, ptm[NX][NY], t,
00052     tm[NX][NY], u, um[NX][NY], v, vm[NX][NY], w, wm[NX][NY], h2o,
00053     h2om[NX][NY], h2ot, h2otm[NX][NY], o3, o3m[NX][NY], z, zm[NX][NY], pv,
00054     pvm[NX][NY], zt, ztm[NX][NY], tt, ttm[NX][NY], lon, lon0, lon1, lons[NX],
00055     dlon, lat, lat0, lat1, lats[NY], dlat;
00056
00057   static int i, ix, iy, np[NX][NY], nx, ny;
00058
00059   /* Allocate... */
00060   ALLOC(met, met_t, 1);
00061
00062   /* Check arguments... */
00063   if (argc < 4)
00064     ERRMSG("Give parameters: <ctl> <map.tab> <met0> [ <met1> ... ]");
00065
00066   /* Read control parameters... */
00067   read_ctl(argv[1], argc, argv, &ctl);
00068   p0 = P(scan_ctl(argv[1], argc, argv, "MAP_Z0", -1, "", NULL));
00069   lon0 = scan_ctl(argv[1], argc, argv, "MAP_LON0", -1, "-180", NULL);
00070   lon1 = scan_ctl(argv[1], argc, argv, "MAP_LON1", -1, "180", NULL);
00071   dlon = scan_ctl(argv[1], argc, argv, "MAP_DLON", -1, "-999", NULL);
00072   lat0 = scan_ctl(argv[1], argc, argv, "MAP_LAT0", -1, "-90", NULL);
00073   lat1 = scan_ctl(argv[1], argc, argv, "MAP_LAT1", -1, "90", NULL);
00074   dlat = scan_ctl(argv[1], argc, argv, "MAP_DLAT", -1, "-999", NULL);
00075
00076   /* Loop over files... */
00077   for (i = 3; i < argc; i++) {
00078
00079     /* Read meteorological data... */
00080     if (!read_met(&ctl, argv[i], met))
00081       continue;
00082
00083     /* Set horizontal grid... */
00084     if (dlon <= 0)
00085       dlon = fabs(met->lon[1] - met->lon[0]);
00086     if (dlat <= 0)
00087       dlat = fabs(met->lat[1] - met->lat[0]);
00088     if (lon0 < -360 && lon1 > 360) {
00089       lon0 = gsl_stats_min(met->lon, 1, (size_t) met->nx);
00090       lon1 = gsl_stats_max(met->lon, 1, (size_t) met->nx);
00091     }
00092     nx = ny = 0;
00093     for (lon = lon0; lon <= lon1; lon += dlon) {
00094       lons[nx] = lon;
00095       if ((++nx) > NX)
00096         ERRMSG("Too many longitudes!");
00097     }
00098     if (lat0 < -90 && lat1 > 90) {
00099       lat0 = gsl_stats_min(met->lat, 1, (size_t) met->ny);
00100       lat1 = gsl_stats_max(met->lat, 1, (size_t) met->ny);
00101     }
00102     for (lat = lat0; lat <= lat1; lat += dlat) {
00103       lats[ny] = lat;
00104       if ((++ny) > NY)
00105         ERRMSG("Too many latitudes!");
00106     }
00107
00108     /* Average... */
00109     for (ix = 0; ix < nx; ix++)
00110       for (iy = 0; iy < ny; iy++) {
00111         intpol_met_space(met, p0, lons[ix], lats[iy], &ps, &pt,
00112                          &z, &t, &u, &v, &w, &pv, &h2o, &o3);
00113         intpol_met_space(met, pt, lons[ix], lats[iy], NULL, NULL,
00114                          &zt, &tt, NULL, NULL, NULL, NULL, &h2ot, NULL);
00115         timem[ix][iy] += met->time;
00116         zm[ix][iy] += z;
```

```
00117         tm[ix][iy] += t;
00118         um[ix][iy] += u;
00119         vm[ix][iy] += v;
00120         wm[ix][iy] += w;
00121         pvm[ix][iy] += pv;
00122         h2om[ix][iy] += h2o;
00123         o3m[ix][iy] += o3;
00124         psm[ix][iy] += ps;
00125         ptm[ix][iy] += pt;
00126         ztm[ix][iy] += zt;
00127         ttm[ix][iy] += tt;
00128         h2otm[ix][iy] += h2ot;
00129         np[ix][iy]++;
00130       }
00131   }
00132
00133   /* Create output file... */
00134   printf("Write meteorological data file: %s\n", argv[2]);
00135   if (!(out = fopen(argv[2], "w")))
00136     ERRMSG("Cannot create file!");
00137
00138   /* Write header... */
00139   fprintf(out,
00140           "# $1 = time [s]\n"
00141           "# $2 = altitude [km]\n"
00142           "# $3 = longitude [deg]\n"
00143           "# $4 = latitude [deg]\n"
00144           "# $5 = pressure [hPa]\n"
00145           "# $6 = temperature [K]\n"
00146           "# $7 = zonal wind [m/s]\n"
00147           "# $8 = meridional wind [m/s]\n" "# $9 = vertical wind [hPa/s]\n");
00148   fprintf(out,
00149           "# $10 = H2O volume mixing ratio [1]\n"
00150           "# $11 = O3 volume mixing ratio [1]\n"
00151           "# $12 = geopotential height [km]\n"
00152           "# $13 = potential vorticity [PVU]\n"
00153           "# $14 = surface pressure [hPa]\n"
00154           "# $15 = tropopause pressure [hPa]\n"
00155           "# $16 = tropopause geopotential height [km]\n"
00156           "# $17 = tropopause temperature [K]\n"
00157           "# $18 = tropopause water vapor [ppv]\n");
00158
00159   /* Write data... */
00160   for (iy = 0; iy < ny; iy++) {
00161     fprintf(out, "\n");
00162     for (ix = 0; ix < nx; ix++)
00163       fprintf(out,
00164               "%.2f %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00165               timem[ix][iy] / np[ix][iy], Z(p0), lons[ix], lats[iy], p0,
00166               tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00167               vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00168               h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00169               zm[ix][iy] / np[ix][iy], pvm[ix][iy] / np[ix][iy],
00170               psm[ix][iy] / np[ix][iy], ptm[ix][iy] / np[ix][iy],
00171               ztm[ix][iy] / np[ix][iy], ttm[ix][iy] / np[ix][iy],
00172               h2otm[ix][iy] / np[ix][iy]);
00173   }
00174
00175   /* Close file... */
00176   fclose(out);
00177
00178   /* Free... */
00179   free(met);
00180
00181   return EXIT_SUCCESS;
00182 }
```

5.25 met_prof.c File Reference

Extract vertical profile from meteorological data.

Functions

- int main (int argc, char *argv[])

5.25.1 Detailed Description

Extract vertical profile from meteorological data.

Definition in file met_prof.c.

5.25.2 Function Documentation

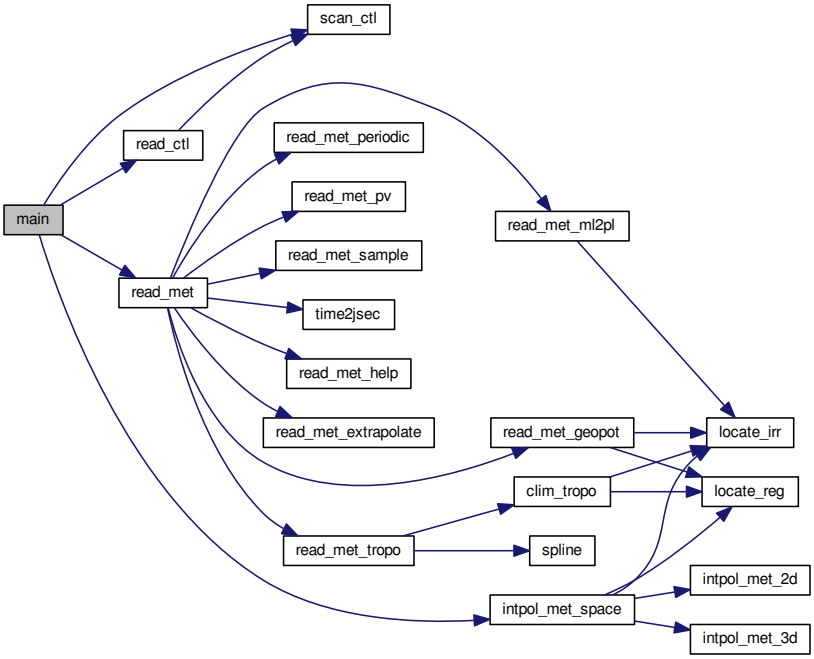
5.25.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 38 of file met_prof.c.

```
00040                {
00041
00042   ctl_t ctl;
00043
00044   met_t *met;
00045
00046   FILE *out;
00047
00048   static double timem[NZ], z, z0, z1, dz, lon, lon0, lon1, dlon, lonm[NZ],
00049     lat, lat0, lat1, dlat, latm[NZ], t, tm[NZ], u, um[NZ], v, vm[NZ], w,
00050     wm[NZ], h2o, h2om[NZ], h2ot, h2otm[NZ], o3, o3m[NZ], ps, psm[NZ], pt,
00051     ptm[NZ], tt, ttm[NZ], zm[NZ], zt, ztm[NZ], pv, pvm[NZ], plev[NZ];
00052
00053   static int i, iz, np[NZ], npt[NZ], nz;
00054
00055   /* Allocate... */
00056   ALLOC(met, met_t, 1);
00057
00058   /* Check arguments... */
00059   if (argc < 4)
00060     ERRMSG("Give parameters: <ctl> <prof.tab> <met0> [ <met1> ... ]");
00061
00062   /* Read control parameters... */
00063   read_ctl(argv[1], argc, argv, &ctl);
00064   z0 = scan_ctl(argv[1], argc, argv, "PROF_Z0", -1, "-999", NULL);
00065   z1 = scan_ctl(argv[1], argc, argv, "PROF_Z1", -1, "-999", NULL);
00066   dz = scan_ctl(argv[1], argc, argv, "PROF_DZ", -1, "-999", NULL);
00067   lon0 = scan_ctl(argv[1], argc, argv, "PROF_LON0", -1, "", NULL);
00068   lon1 = scan_ctl(argv[1], argc, argv, "PROF_LON1", -1, "", NULL);
00069   dlon = scan_ctl(argv[1], argc, argv, "PROF_DLON", -1, "-999", NULL);
00070   lat0 = scan_ctl(argv[1], argc, argv, "PROF_LAT0", -1, "", NULL);
00071   lat1 = scan_ctl(argv[1], argc, argv, "PROF_LAT1", -1, "", NULL);
00072   dlat = scan_ctl(argv[1], argc, argv, "PROF_DLAT", -1, "-999", NULL);
00073
00074   /* Loop over input files... */
00075   for (i = 3; i < argc; i++) {
00076
00077     /* Read meteorological data... */
00078     if (!read_met(&ctl, argv[i], met))
00079       continue;
00080
00081     /* Set vertical grid... */
00082     if (z0 < 0)
00083       z0 = Z(met->p[0]);
00084     if (z1 < 0)
00085       z1 = Z(met->p[met->np - 1]);
00086     nz = 0;
00087     if (dz < 0) {
00088       for (iz = 0; iz < met->np; iz++)
00089         if (Z(met->p[iz]) >= z0 && Z(met->p[iz]) <= z1) {
00090           plev[nz] = met->p[iz];
00091           if ((++nz) > NZ)
00092             ERRMSG("Too many pressure levels!");
00093         }
00094     } else
00095       for (z = z0; z <= z1; z += dz) {
00096         plev[nz] = P(z);
00097         if ((++nz) > NZ)
00098           ERRMSG("Too many pressure levels!");
00099       }
00100
00101     /* Set horizontal grid... */
00102     if (dlon <= 0)
00103       dlon = fabs(met->lon[1] - met->lon[0]);
00104     if (dlat <= 0)
```

```
00105       dlat = fabs(met->lat[1] - met->lat[0]);
00106
00107     /* Average... */
00108     for (iz = 0; iz < nz; iz++)
00109       for (lon = lon0; lon <= lon1; lon += dlon)
00110         for (lat = lat0; lat <= lat1; lat += dlat) {
00111           intpol_met_space(met, plev[iz], lon, lat, &ps, &pt, &z,
00112                            &t, &u, &v, &w, &pv, &h2o, &o3);
00113           intpol_met_space(met, pt, lon, lat, NULL, NULL, &zt,
00114                            &tt, NULL, NULL, NULL, &h2ot, NULL);
00115           if (gsl_finite(t) && gsl_finite(u)
00116               && gsl_finite(v) && gsl_finite(w)) {
00117             timem[iz] += met->time;
00118             lonm[iz] += lon;
00119             latm[iz] += lat;
00120             zm[iz] += z;
00121             tm[iz] += t;
00122             um[iz] += u;
00123             vm[iz] += v;
00124             wm[iz] += w;
00125             pvm[iz] += pv;
00126             h2om[iz] += h2o;
00127             o3m[iz] += o3;
00128             psm[iz] += ps;
00129             if (gsl_finite(pt)) {
00130               ptm[iz] += pt;
00131               ztm[iz] += zt;
00132               ttm[iz] += tt;
00133               h2otm[iz] += h2ot;
00134               npt[iz]++;
00135             }
00136             np[iz]++;
00137           }
00138         }
00139   }
00140
00141   /* Create output file... */
00142   printf("Write meteorological data file: %s\n", argv[2]);
00143   if (!(out = fopen(argv[2], "w")))
00144     ERRMSG("Cannot create file!");
00145
00146   /* Write header... */
00147   fprintf(out,
00148           "# $1 = time [s]\n"
00149           "# $2 = altitude [km]\n"
00150           "# $3 = longitude [deg]\n"
00151           "# $4 = latitude [deg]\n"
00152           "# $5 = pressure [hPa]\n"
00153           "# $6 = temperature [K]\n"
00154           "# $7 = zonal wind [m/s]\n"
00155           "# $8 = meridional wind [m/s]\n" "# $9 = vertical wind [hPa/s]\n");
00156   fprintf(out,
00157           "# $10 = H2O volume mixing ratio [1]\n"
00158           "# $11 = O3 volume mixing ratio [1]\n"
00159           "# $12 = geopotential height [km]\n"
00160           "# $13 = potential vorticity [PVU]\n"
00161           "# $14 = surface pressure [hPa]\n"
00162           "# $15 = tropopause pressure [hPa]\n"
00163           "# $16 = tropopause geopotential height [km]\n"
00164           "# $17 = tropopause temperature [K]\n"
00165           "# $18 = tropopause water vapor [ppv]\n\n");
00166
00167   /* Write data... */
00168   for (iz = 0; iz < nz; iz++)
00169     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00170             timem[iz] / np[iz], Z(plev[iz]), lonm[iz] / np[iz],
00171             latm[iz] / np[iz], plev[iz], tm[iz] / np[iz], um[iz] / np[iz],
00172             vm[iz] / np[iz], wm[iz] / np[iz], h2om[iz] / np[iz],
00173             o3m[iz] / np[iz], zm[iz] / np[iz], pvm[iz] / np[iz],
00174             psm[iz] / np[iz], ptm[iz] / npt[iz], ztm[iz] / npt[iz],
00175             ttm[iz] / npt[iz], h2otm[iz] / npt[iz]);
00176
00177   /* Close file... */
00178   fclose(out);
00179
00180   /* Free... */
00181   free(met);
00182
00183   return EXIT_SUCCESS;
00184 }
```

Here is the call graph for this function:



5.26 met_prof.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 /* ------------------------------------------------------------
00028    Dimensions...
00029    ------------------------------------------------------------ */
00030
00032 #define NZ 1000
00033
00034 /* ------------------------------------------------------------
00035    Main...
00036    ------------------------------------------------------------ */
00037
00038 int main(
00039   int argc,
00040   char *argv[]) {
00041
00042   ctl_t ctl;
00043
00044   met_t *met;
00045
```

```
00046   FILE *out;
00047
00048   static double timem[NZ], z, z0, z1, dz, lon, lon0, lon1, dlon, lonm[NZ],
00049     lat, lat0, lat1, dlat, latm[NZ], t, tm[NZ], u, um[NZ], v, vm[NZ], w,
00050     wm[NZ], h2o, h2om[NZ], h2ot, h2otm[NZ], o3, o3m[NZ], ps, psm[NZ], pt,
00051     ptm[NZ], tt, ttm[NZ], zm[NZ], zt, ztm[NZ], pv, pvm[NZ], plev[NZ];
00052
00053   static int i, iz, np[NZ], npt[NZ], nz;
00054
00055   /* Allocate... */
00056   ALLOC(met, met_t, 1);
00057
00058   /* Check arguments... */
00059   if (argc < 4)
00060     ERRMSG("Give parameters: <ctl> <prof.tab> <met0> [ <met1> ... ]");
00061
00062   /* Read control parameters... */
00063   read_ctl(argv[1], argc, argv, &ctl);
00064   z0 = scan_ctl(argv[1], argc, argv, "PROF_Z0", -1, "-999", NULL);
00065   z1 = scan_ctl(argv[1], argc, argv, "PROF_Z1", -1, "-999", NULL);
00066   dz = scan_ctl(argv[1], argc, argv, "PROF_DZ", -1, "-999", NULL);
00067   lon0 = scan_ctl(argv[1], argc, argv, "PROF_LON0", -1, "", NULL);
00068   lon1 = scan_ctl(argv[1], argc, argv, "PROF_LON1", -1, "", NULL);
00069   dlon = scan_ctl(argv[1], argc, argv, "PROF_DLON", -1, "-999", NULL);
00070   lat0 = scan_ctl(argv[1], argc, argv, "PROF_LAT0", -1, "", NULL);
00071   lat1 = scan_ctl(argv[1], argc, argv, "PROF_LAT1", -1, "", NULL);
00072   dlat = scan_ctl(argv[1], argc, argv, "PROF_DLAT", -1, "-999", NULL);
00073
00074   /* Loop over input files... */
00075   for (i = 3; i < argc; i++) {
00076
00077     /* Read meteorological data... */
00078     if (!read_met(&ctl, argv[i], met))
00079       continue;
00080
00081     /* Set vertical grid... */
00082     if (z0 < 0)
00083       z0 = Z(met->p[0]);
00084     if (z1 < 0)
00085       z1 = Z(met->p[met->np - 1]);
00086     nz = 0;
00087     if (dz < 0) {
00088       for (iz = 0; iz < met->np; iz++)
00089         if (Z(met->p[iz]) >= z0 && Z(met->p[iz]) <= z1) {
00090           plev[nz] = met->p[iz];
00091           if ((++nz) > NZ)
00092             ERRMSG("Too many pressure levels!");
00093         }
00094     } else
00095       for (z = z0; z <= z1; z += dz) {
00096         plev[nz] = P(z);
00097         if ((++nz) > NZ)
00098           ERRMSG("Too many pressure levels!");
00099       }
00100
00101     /* Set horizontal grid... */
00102     if (dlon <= 0)
00103       dlon = fabs(met->lon[1] - met->lon[0]);
00104     if (dlat <= 0)
00105       dlat = fabs(met->lat[1] - met->lat[0]);
00106
00107     /* Average... */
00108     for (iz = 0; iz < nz; iz++)
00109       for (lon = lon0; lon <= lon1; lon += dlon)
00110         for (lat = lat0; lat <= lat1; lat += dlat) {
00111           intpol_met_space(met, plev[iz], lon, lat, &ps, &pt, &z,
00112                            &t, &u, &v, &w, &pv, &h2o, &o3);
00113           intpol_met_space(met, pt, lon, lat, NULL, NULL, &zt,
00114                            &tt, NULL, NULL, NULL, &h2ot, NULL);
00115           if (gsl_finite(t) && gsl_finite(u)
00116               && gsl_finite(v) && gsl_finite(w)) {
00117             timem[iz] += met->time;
00118             lonm[iz] += lon;
00119             latm[iz] += lat;
00120             zm[iz] += z;
00121             tm[iz] += t;
00122             um[iz] += u;
00123             vm[iz] += v;
00124             wm[iz] += w;
00125             pvm[iz] += pv;
00126             h2om[iz] += h2o;
00127             o3m[iz] += o3;
00128             psm[iz] += ps;
00129             if (gsl_finite(pt)) {
00130               ptm[iz] += pt;
00131               ztm[iz] += zt;
00132               ttm[iz] += tt;
```

```
00133               h2otm[iz] += h2ot;
00134               npt[iz]++;
00135             }
00136             np[iz]++;
00137           }
00138         }
00139   }
00140
00141   /* Create output file... */
00142   printf("Write meteorological data file: %s\n", argv[2]);
00143   if (!(out = fopen(argv[2], "w")))
00144     ERRMSG("Cannot create file!");
00145
00146   /* Write header... */
00147   fprintf(out,
00148           "# $1 = time [s]\n"
00149           "# $2 = altitude [km]\n"
00150           "# $3 = longitude [deg]\n"
00151           "# $4 = latitude [deg]\n"
00152           "# $5 = pressure [hPa]\n"
00153           "# $6 = temperature [K]\n"
00154           "# $7 = zonal wind [m/s]\n"
00155           "# $8 = meridional wind [m/s]\n" "# $9 = vertical wind [hPa/s]\n");
00156   fprintf(out,
00157           "# $10 = H2O volume mixing ratio [1]\n"
00158           "# $11 = O3 volume mixing ratio [1]\n"
00159           "# $12 = geopotential height [km]\n"
00160           "# $13 = potential vorticity [PVU]\n"
00161           "# $14 = surface pressure [hPa]\n"
00162           "# $15 = tropopause pressure [hPa]\n"
00163           "# $16 = tropopause geopotential height [km]\n"
00164           "# $17 = tropopause temperature [K]\n"
00165           "# $18 = tropopause water vapor [ppv]\n\n");
00166
00167   /* Write data... */
00168   for (iz = 0; iz < nz; iz++)
00169     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00170             timem[iz] / np[iz], Z(plev[iz]), lonm[iz] / np[iz],
00171             latm[iz] / np[iz], plev[iz], tm[iz] / np[iz], um[iz] / np[iz],
00172             vm[iz] / np[iz], wm[iz] / np[iz], h2om[iz] / np[iz],
00173             o3m[iz] / np[iz], zm[iz] / np[iz], pvm[iz] / np[iz],
00174             psm[iz] / np[iz], ptm[iz] / npt[iz], ztm[iz] / npt[iz],
00175             ttm[iz] / npt[iz], h2otm[iz] / npt[iz]);
00176
00177   /* Close file... */
00178   fclose(out);
00179
00180   /* Free... */
00181   free(met);
00182
00183   return EXIT_SUCCESS;
00184 }
```

5.27 met_sample.c File Reference

Sample meteorological data at given geolocations.

Functions

- int main (int argc, char *argv[])

5.27.1 Detailed Description

Sample meteorological data at given geolocations.

Definition in file met_sample.c.

5.27.2 Function Documentation

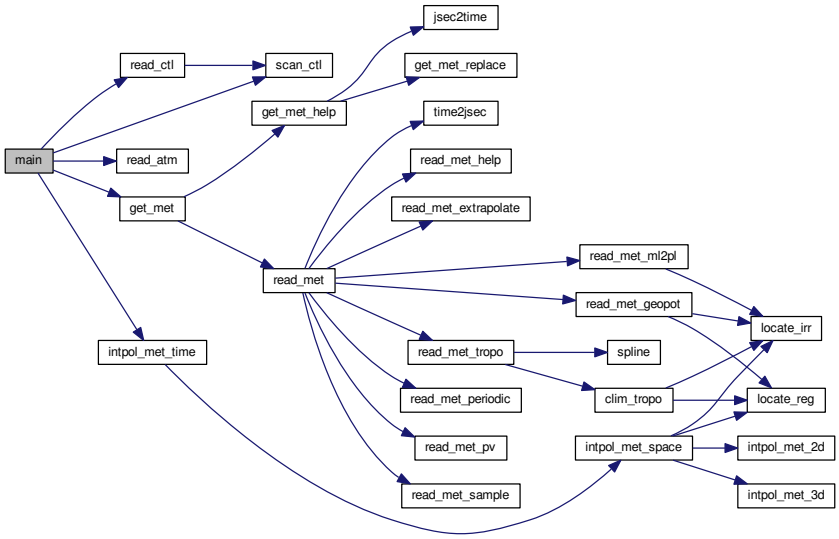
5.27.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 31 of file met_sample.c.

```
00033                {
00034
00035   ctl_t ctl;
00036
00037   atm_t *atm;
00038
00039   met_t *met0, *met1;
00040
00041   FILE *out;
00042
00043   double h2o, h2ot, o3, p0, p1, pref, ps, pt, pv, t, tt, u, v, w,
00044     z, zm, zref, zt;
00045
00046   int geopot, ip, it;
00047
00048   /* Check arguments... */
00049   if (argc < 4)
00050     ERRMSG("Give parameters: <ctl> <sample.tab> <metbase> <atm_in>");
00051
00052   /* Allocate... */
00053   ALLOC(atm, atm_t, 1);
00054   ALLOC(met0, met_t, 1);
00055   ALLOC(met1, met_t, 1);
00056
00057   /* Read control parameters... */
00058   read_ctl(argv[1], argc, argv, &ctl);
00059   geopot =
00060     (int) scan_ctl(argv[1], argc, argv, "SAMPLE_GEOPOT", -1, "0", NULL);
00061
00062   /* Read atmospheric data... */
00063   if (!read_atm(argv[4], &ctl, atm))
00064     ERRMSG("Cannot open file!");
00065
00066   /* Create output file... */
00067   printf("Write meteorological data file: %s\n", argv[2]);
00068   if (!(out = fopen(argv[2], "w")))
00069     ERRMSG("Cannot create file!");
00070
00071   /* Write header... */
00072   fprintf(out,
00073           "# $1  = time [s]\n"
00074           "# $2  = altitude [km]\n"
00075           "# $3  = longitude [deg]\n"
00076           "# $4  = latitude [deg]\n"
00077           "# $5  = pressure [hPa]\n"
00078           "# $6  = temperature [K]\n"
00079           "# $7  = zonal wind [m/s]\n"
00080           "# $8  = meridional wind [m/s]\n"
00081           "# $9  = vertical wind [hPa/s]\n");
00082   fprintf(out,
00083           "# $10 = H2O volume mixing ratio [1]\n"
00084           "# $11 = O3 volume mixing ratio [1]\n"
00085           "# $12 = geopotential height [km]\n"
00086           "# $13 = potential vorticity [PVU]\n"
00087           "# $14 = surface pressure [hPa]\n"
00088           "# $15 = tropopause pressure [hPa]\n"
00089           "# $16 = tropopause geopotential height [km]\n"
00090           "# $17 = tropopause temperature [K]\n"
00091           "# $18 = tropopause water vapor [ppv]\n\n");
00092
00093   /* Loop over air parcels... */
00094   for (ip = 0; ip < atm->np; ip++) {
00095
00096     /* Get meteorological data... */
00097     get_met(&ctl, argv[3], atm->time[ip], &met0, &met1);
00098
00099     /* Set reference pressure for interpolation... */
00100     pref = atm->p[ip];
00101     if (geopot) {
00102       zref = Z(pref);
00103       p0 = met0->p[0];
00104       p1 = met0->p[met0->np - 1];
00105       for (it = 0; it < 24; it++) {
00106         pref = 0.5 * (p0 + p1);
00107         intpol_met_time(met0, met1, atm->time[ip], pref, atm->
      lon[ip],
```

```
00108                         atm->lat[ip], NULL, NULL, &zm, NULL, NULL, NULL, NULL,
00109                         NULL, NULL, NULL);
00110         if (zref > zm || !gsl_finite(zm))
00111           p0 = pref;
00112         else
00113           p1 = pref;
00114       }
00115       pref = 0.5 * (p0 + p1);
00116     }
00117
00118     /* Interpolate meteorological data... */
00119     intpol_met_time(met0, met1, atm->time[ip], pref, atm->lon[ip],
00120                     atm->lat[ip], &ps, &pt, &z, &t, &u, &v, &w, &pv, &h2o,
00121                     &o3);
00122     intpol_met_time(met0, met1, atm->time[ip], pt, atm->lon[ip], atm->
    lat[ip],
00123                     NULL, NULL, &zt, &tt, NULL, NULL, NULL, NULL, &h2ot,
00124                     NULL);
00125
00126     /* Write data... */
00127     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00128             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip],
00129             atm->p[ip], t, u, v, w, h2o, o3, z, pv, ps, pt, zt, tt, h2ot);
00130   }
00131
00132   /* Close file... */
00133   fclose(out);
00134
00135   /* Free... */
00136   free(atm);
00137   free(met0);
00138   free(met1);
00139
00140   return EXIT_SUCCESS;
00141 }
```

Here is the call graph for this function:



5.28 met_sample.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
```

```
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 /* ------------------------------------------------------------
00028    Main...
00029    ------------------------------------------------------------ */
00030
00031 int main(
00032   int argc,
00033   char *argv[]) {
00034
00035   ctl_t ctl;
00036
00037   atm_t *atm;
00038
00039   met_t *met0, *met1;
00040
00041   FILE *out;
00042
00043   double h2o, h2ot, o3, p0, p1, pref, ps, pt, pv, t, tt, u, v, w,
00044     z, zm, zref, zt;
00045
00046   int geopot, ip, it;
00047
00048   /* Check arguments... */
00049   if (argc < 4)
00050     ERRMSG("Give parameters: <ctl> <sample.tab> <metbase> <atm_in>");
00051
00052   /* Allocate... */
00053   ALLOC(atm, atm_t, 1);
00054   ALLOC(met0, met_t, 1);
00055   ALLOC(met1, met_t, 1);
00056
00057   /* Read control parameters... */
00058   read_ctl(argv[1], argc, argv, &ctl);
00059   geopot =
00060     (int) scan_ctl(argv[1], argc, argv, "SAMPLE_GEOPOT", -1, "0", NULL);
00061
00062   /* Read atmospheric data... */
00063   if (!read_atm(argv[4], &ctl, atm))
00064     ERRMSG("Cannot open file!");
00065
00066   /* Create output file... */
00067   printf("Write meteorological data file: %s\n", argv[2]);
00068   if (!(out = fopen(argv[2], "w")))
00069     ERRMSG("Cannot create file!");
00070
00071   /* Write header... */
00072   fprintf(out,
00073           "# $1  = time [s]\n"
00074           "# $2  = altitude [km]\n"
00075           "# $3  = longitude [deg]\n"
00076           "# $4  = latitude [deg]\n"
00077           "# $5  = pressure [hPa]\n"
00078           "# $6  = temperature [K]\n"
00079           "# $7  = zonal wind [m/s]\n"
00080           "# $8  = meridional wind [m/s]\n"
00081           "# $9  = vertical wind [hPa/s]\n");
00082   fprintf(out,
00083           "# $10 = H2O volume mixing ratio [1]\n"
00084           "# $11 = O3 volume mixing ratio [1]\n"
00085           "# $12 = geopotential height [km]\n"
00086           "# $13 = potential vorticity [PVU]\n"
00087           "# $14 = surface pressure [hPa]\n"
00088           "# $15 = tropopause pressure [hPa]\n"
00089           "# $16 = tropopause geopotential height [km]\n"
00090           "# $17 = tropopause temperature [K]\n"
00091           "# $18 = tropopause water vapor [ppv]\n\n");
00092
00093   /* Loop over air parcels... */
00094   for (ip = 0; ip < atm->np; ip++) {
00095
00096     /* Get meteorological data... */
00097     get_met(&ctl, argv[3], atm->time[ip], &met0, &met1);
00098
00099     /* Set reference pressure for interpolation... */
00100     pref = atm->p[ip];
```

```
00101     if (geopot) {
00102       zref = Z(pref);
00103       p0 = met0->p[0];
00104       p1 = met0->p[met0->np - 1];
00105       for (it = 0; it < 24; it++) {
00106         pref = 0.5 * (p0 + p1);
00107         intpol_met_time(met0, met1, atm->time[ip], pref, atm->
      lon[ip],
00108                         atm->lat[ip], NULL, NULL, &zm, NULL, NULL, NULL, NULL,
00109                         NULL, NULL, NULL);
00110         if (zref > zm || !gsl_finite(zm))
00111           p0 = pref;
00112         else
00113           p1 = pref;
00114       }
00115       pref = 0.5 * (p0 + p1);
00116     }
00117
00118     /* Interpolate meteorological data... */
00119     intpol_met_time(met0, met1, atm->time[ip], pref, atm->lon[ip],
00120                     atm->lat[ip], &ps, &pt, &z, &t, &u, &v, &w, &pv, &h2o,
00121                     &o3);
00122     intpol_met_time(met0, met1, atm->time[ip], pt, atm->lon[ip], atm->
      lat[ip],
00123                     NULL, NULL, &zt, &tt, NULL, NULL, NULL, NULL, &h2ot,
00124                     NULL);
00125
00126     /* Write data... */
00127     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00128             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip],
00129             atm->p[ip], t, u, v, w, h2o, o3, z, pv, ps, pt, zt, tt, h2ot);
00130   }
00131
00132   /* Close file... */
00133   fclose(out);
00134
00135   /* Free... */
00136   free(atm);
00137   free(met0);
00138   free(met1);
00139
00140   return EXIT_SUCCESS;
00141 }
```

5.29 met_zm.c File Reference

Extract zonal mean from meteorological data.

Functions

- int main (int argc, char ∗argv[ ])

5.29.1 Detailed Description

Extract zonal mean from meteorological data.

Definition in file met_zm.c.

5.29.2 Function Documentation

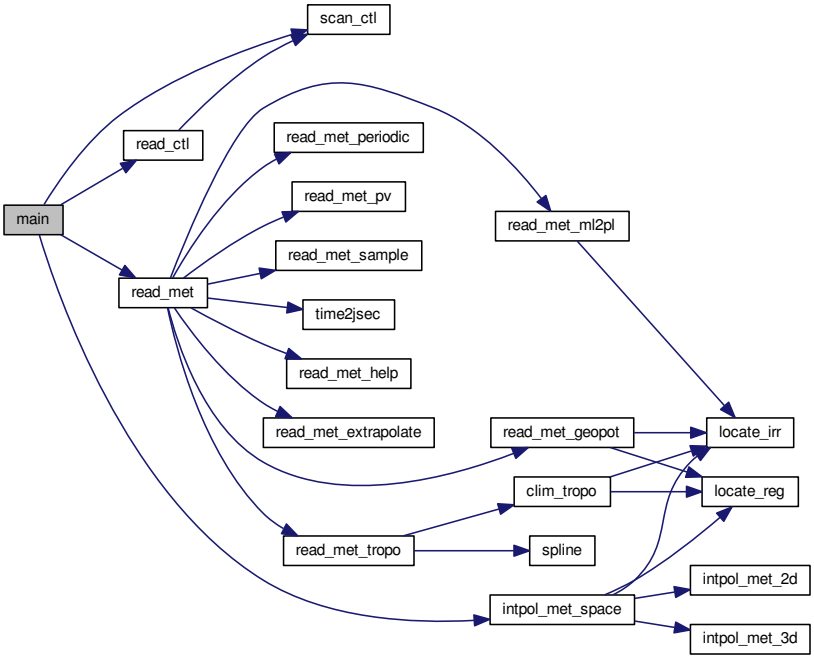
5.29.2.1 int main (int *argc*, char ∗ *argv[ ]*)

Definition at line 41 of file met_zm.c.

```
00043                {
00044
00045   ctl_t ctl;
00046
00047   met_t *met;
00048
00049   FILE *out;
00050
00051   static double timem[NZ][NY], psm[NZ][NY], ptm[NZ][NY], ttm[NZ][NY],
00052     ztm[NZ][NY], tm[NZ][NY], um[NZ][NY], vm[NZ][NY], wm[NZ][NY], h2om[NZ][NY],
00053     h2otm[NZ][NY], pvm[NZ][NY], o3m[NZ][NY], zm[NZ][NY], z, z0, z1, dz, zt,
00054     tt, plev[NZ], ps, pt, t, u, v, w, pv, h2o, h2ot, o3, lat, lat0, lat1,
00055     dlat, lats[NY];
00056
00057   static int i, ix, iy, iz, np[NZ][NY], npt[NZ][NY], ny, nz;
00058
00059   /* Allocate... */
00060   ALLOC(met, met_t, 1);
00061
00062   /* Check arguments... */
00063   if (argc < 4)
00064     ERRMSG("Give parameters: <ctl> <zm.tab> <met0> [ <met1> ... ]");
00065
00066   /* Read control parameters... */
00067   read_ctl(argv[1], argc, argv, &ctl);
00068   z0 = scan_ctl(argv[1], argc, argv, "ZM_Z0", -1, "-999", NULL);
00069   z1 = scan_ctl(argv[1], argc, argv, "ZM_Z1", -1, "-999", NULL);
00070   dz = scan_ctl(argv[1], argc, argv, "ZM_DZ", -1, "-999", NULL);
00071   lat0 = scan_ctl(argv[1], argc, argv, "ZM_LAT0", -1, "-90", NULL);
00072   lat1 = scan_ctl(argv[1], argc, argv, "ZM_LAT1", -1, "90", NULL);
00073   dlat = scan_ctl(argv[1], argc, argv, "ZM_DLAT", -1, "-999", NULL);
00074
00075   /* Loop over files... */
00076   for (i = 3; i < argc; i++) {
00077
00078     /* Read meteorological data... */
00079     if (!read_met(&ctl, argv[i], met))
00080       continue;
00081
00082     /* Set vertical grid... */
00083     if (z0 < 0)
00084       z0 = Z(met->p[0]);
00085     if (z1 < 0)
00086       z1 = Z(met->p[met->np - 1]);
00087     nz = 0;
00088     if (dz < 0) {
00089       for (iz = 0; iz < met->np; iz++)
00090         if (Z(met->p[iz]) >= z0 && Z(met->p[iz]) <= z1) {
00091           plev[nz] = met->p[iz];
00092           if ((++nz) > NZ)
00093             ERRMSG("Too many pressure levels!");
00094         }
00095     } else
00096       for (z = z0; z <= z1; z += dz) {
00097         plev[nz] = P(z);
00098         if ((++nz) > NZ)
00099           ERRMSG("Too many pressure levels!");
00100       }
00101
00102     /* Set horizontal grid... */
00103     if (dlat <= 0)
00104       dlat = fabs(met->lat[1] - met->lat[0]);
00105     ny = 0;
00106     if (lat0 < -90 && lat1 > 90) {
00107       lat0 = gsl_stats_min(met->lat, 1, (size_t) met->ny);
00108       lat1 = gsl_stats_max(met->lat, 1, (size_t) met->ny);
00109     }
00110     for (lat = lat0; lat <= lat1; lat += dlat) {
00111       lats[ny] = lat;
00112       if ((++ny) > NY)
00113         ERRMSG("Too many latitudes!");
00114     }
00115
00116     /* Average... */
00117     for (ix = 0; ix < met->nx; ix++)
00118       for (iy = 0; iy < ny; iy++)
00119         for (iz = 0; iz < nz; iz++) {
00120           intpol_met_space(met, plev[iz], met->lon[ix], lats[iy], &ps,
00121                            &pt, &z, &t, &u, &v, &w, &pv, &h2o, &o3);
00122           intpol_met_space(met, pt, met->lon[ix], lats[iy], NULL, NULL,
00123                            &zt, &tt, NULL, NULL, NULL, NULL, &h2ot, NULL);
00124           timem[iz][iy] += met->time;
00125           zm[iz][iy] += z;
00126           tm[iz][iy] += t;
00127           um[iz][iy] += u;
00128           vm[iz][iy] += v;
00129           wm[iz][iy] += w;
```

```
00130           pvm[iz][iy] += pv;
00131           h2om[iz][iy] += h2o;
00132           o3m[iz][iy] += o3;
00133           psm[iz][iy] += ps;
00134           if (gsl_finite(pt)) {
00135             ptm[iz][iy] += pt;
00136             ztm[iz][iy] += zt;
00137             ttm[iz][iy] += tt;
00138             h2otm[iz][iy] += h2ot;
00139             npt[iz][iy]++;
00140           }
00141           np[iz][iy]++;
00142         }
00143   }
00144
00145   /* Create output file... */
00146   printf("Write meteorological data file: %s\n", argv[2]);
00147   if (!(out = fopen(argv[2], "w")))
00148     ERRMSG("Cannot create file!");
00149
00150   /* Write header... */
00151   fprintf(out,
00152           "# $1 = time [s]\n"
00153           "# $2 = altitude [km]\n"
00154           "# $3 = longitude [deg]\n"
00155           "# $4 = latitude [deg]\n"
00156           "# $5 = pressure [hPa]\n"
00157           "# $6 = temperature [K]\n"
00158           "# $7 = zonal wind [m/s]\n"
00159           "# $8 = meridional wind [m/s]\n" "# $9 = vertical wind [hPa/s]\n");
00160   fprintf(out,
00161           "# $10 = H2O volume mixing ratio [1]\n"
00162           "# $11 = O3 volume mixing ratio [1]\n"
00163           "# $12 = geopotential height [km]\n"
00164           "# $13 = potential vorticity [PVU]\n"
00165           "# $14 = surface pressure [hPa]\n"
00166           "# $15 = tropopause pressure [hPa]\n"
00167           "# $16 = tropopause geopotential height [km]\n"
00168           "# $17 = tropopause temperature [K]\n"
00169           "# $18 = tropopause water vapor [ppv]\n");
00170
00171   /* Write data... */
00172   for (iz = 0; iz < nz; iz++) {
00173     fprintf(out, "\n");
00174     for (iy = 0; iy < ny; iy++)
00175       fprintf(out,
00176               "%.2f %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00177               timem[iz][iy] / np[iz][iy], Z(plev[iz]), 0.0, lats[iy],
00178               plev[iz], tm[iz][iy] / np[iz][iy], um[iz][iy] / np[iz][iy],
00179               vm[iz][iy] / np[iz][iy], wm[iz][iy] / np[iz][iy],
00180               h2om[iz][iy] / np[iz][iy], o3m[iz][iy] / np[iz][iy],
00181               zm[iz][iy] / np[iz][iy], pvm[iz][iy] / np[iz][iy],
00182               psm[iz][iy] / np[iz][iy], ptm[iz][iy] / npt[iz][iy],
00183               ztm[iz][iy] / npt[iz][iy], ttm[iz][iy] / npt[iz][iy],
00184               h2otm[iz][iy] / npt[iz][iy]);
00185   }
00186
00187   /* Close file... */
00188   fclose(out);
00189
00190   /* Free... */
00191   free(met);
00192
00193   return EXIT_SUCCESS;
00194 }
```

Here is the call graph for this function:



5.30 met_zm.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 /* ------------------------------------------------------------
00028    Dimensions...
00029    ------------------------------------------------------------ */
00030
00032 #define NZ 1000
00033
00035 #define NY 721
00036
00037 /* ------------------------------------------------------------
00038    Main...
00039    ------------------------------------------------------------ */
00040
00041 int main(
00042   int argc,
00043   char *argv[]) {
00044
00045   ctl_t ctl;
00046
```

```
00047   met_t *met;
00048
00049   FILE *out;
00050
00051   static double timem[NZ][NY], psm[NZ][NY], ptm[NZ][NY], ttm[NZ][NY],
00052     ztm[NZ][NY], tm[NZ][NY], um[NZ][NY], vm[NZ][NY], wm[NZ][NY], h2om[NZ][NY],
00053     h2otm[NZ][NY], pvm[NZ][NY], o3m[NZ][NY], zm[NZ][NY], z, z0, z1, dz, zt,
00054     tt, plev[NZ], ps, pt, t, u, v, w, pv, h2o, h2ot, o3, lat, lat0, lat1,
00055     dlat, lats[NY];
00056
00057   static int i, ix, iy, iz, np[NZ][NY], npt[NZ][NY], ny, nz;
00058
00059   /* Allocate... */
00060   ALLOC(met, met_t, 1);
00061
00062   /* Check arguments... */
00063   if (argc < 4)
00064     ERRMSG("Give parameters: <ctl> <zm.tab> <met0> [ <met1> ... ]");
00065
00066   /* Read control parameters... */
00067   read_ctl(argv[1], argc, argv, &ctl);
00068   z0 = scan_ctl(argv[1], argc, argv, "ZM_Z0", -1, "-999", NULL);
00069   z1 = scan_ctl(argv[1], argc, argv, "ZM_Z1", -1, "-999", NULL);
00070   dz = scan_ctl(argv[1], argc, argv, "ZM_DZ", -1, "-999", NULL);
00071   lat0 = scan_ctl(argv[1], argc, argv, "ZM_LAT0", -1, "-90", NULL);
00072   lat1 = scan_ctl(argv[1], argc, argv, "ZM_LAT1", -1, "90", NULL);
00073   dlat = scan_ctl(argv[1], argc, argv, "ZM_DLAT", -1, "-999", NULL);
00074
00075   /* Loop over files... */
00076   for (i = 3; i < argc; i++) {
00077
00078     /* Read meteorological data... */
00079     if (!read_met(&ctl, argv[i], met))
00080       continue;
00081
00082     /* Set vertical grid... */
00083     if (z0 < 0)
00084       z0 = Z(met->p[0]);
00085     if (z1 < 0)
00086       z1 = Z(met->p[met->np - 1]);
00087     nz = 0;
00088     if (dz < 0) {
00089       for (iz = 0; iz < met->np; iz++)
00090         if (Z(met->p[iz]) >= z0 && Z(met->p[iz]) <= z1) {
00091           plev[nz] = met->p[iz];
00092           if ((++nz) > NZ)
00093             ERRMSG("Too many pressure levels!");
00094         }
00095     } else
00096       for (z = z0; z <= z1; z += dz) {
00097         plev[nz] = P(z);
00098         if ((++nz) > NZ)
00099           ERRMSG("Too many pressure levels!");
00100       }
00101
00102     /* Set horizontal grid... */
00103     if (dlat <= 0)
00104       dlat = fabs(met->lat[1] - met->lat[0]);
00105     ny = 0;
00106     if (lat0 < -90 && lat1 > 90) {
00107       lat0 = gsl_stats_min(met->lat, 1, (size_t) met->ny);
00108       lat1 = gsl_stats_max(met->lat, 1, (size_t) met->ny);
00109     }
00110     for (lat = lat0; lat <= lat1; lat += dlat) {
00111       lats[ny] = lat;
00112       if ((++ny) > NY)
00113         ERRMSG("Too many latitudes!");
00114     }
00115
00116     /* Average... */
00117     for (ix = 0; ix < met->nx; ix++)
00118       for (iy = 0; iy < ny; iy++)
00119         for (iz = 0; iz < nz; iz++) {
00120           intpol_met_space(met, plev[iz], met->lon[ix], lats[iy], &ps,
00121                            &pt, &z, &t, &u, &v, &w, &pv, &h2o, &o3);
00122           intpol_met_space(met, pt, met->lon[ix], lats[iy], NULL, NULL,
00123                            &zt, &tt, NULL, NULL, NULL, NULL, &h2ot, NULL);
00124           timem[iz][iy] += met->time;
00125           zm[iz][iy] += z;
00126           tm[iz][iy] += t;
00127           um[iz][iy] += u;
00128           vm[iz][iy] += v;
00129           wm[iz][iy] += w;
00130           pvm[iz][iy] += pv;
00131           h2om[iz][iy] += h2o;
00132           o3m[iz][iy] += o3;
00133           psm[iz][iy] += ps;
```

```
00134           if (gsl_finite(pt)) {
00135             ptm[iz][iy] += pt;
00136             ztm[iz][iy] += zt;
00137             ttm[iz][iy] += tt;
00138             h2otm[iz][iy] += h2ot;
00139             npt[iz][iy]++;
00140           }
00141           np[iz][iy]++;
00142         }
00143   }
00144
00145   /* Create output file... */
00146   printf("Write meteorological data file: %s\n", argv[2]);
00147   if (!(out = fopen(argv[2], "w")))
00148     ERRMSG("Cannot create file!");
00149
00150   /* Write header... */
00151   fprintf(out,
00152           "# $1 = time [s]\n"
00153           "# $2 = altitude [km]\n"
00154           "# $3 = longitude [deg]\n"
00155           "# $4 = latitude [deg]\n"
00156           "# $5 = pressure [hPa]\n"
00157           "# $6 = temperature [K]\n"
00158           "# $7 = zonal wind [m/s]\n"
00159           "# $8 = meridional wind [m/s]\n" "# $9 = vertical wind [hPa/s]\n");
00160   fprintf(out,
00161           "# $10 = H2O volume mixing ratio [1]\n"
00162           "# $11 = O3 volume mixing ratio [1]\n"
00163           "# $12 = geopotential height [km]\n"
00164           "# $13 = potential vorticity [PVU]\n"
00165           "# $14 = surface pressure [hPa]\n"
00166           "# $15 = tropopause pressure [hPa]\n"
00167           "# $16 = tropopause geopotential height [km]\n"
00168           "# $17 = tropopause temperature [K]\n"
00169           "# $18 = tropopause water vapor [ppv]\n");
00170
00171   /* Write data... */
00172   for (iz = 0; iz < nz; iz++) {
00173     fprintf(out, "\n");
00174     for (iy = 0; iy < ny; iy++)
00175       fprintf(out,
00176               "%.2f %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00177               timem[iz][iy] / np[iz][iy], Z(plev[iz]), 0.0, lats[iy],
00178               plev[iz], tm[iz][iy] / np[iz][iy], um[iz][iy] / np[iz][iy],
00179               vm[iz][iy] / np[iz][iy], wm[iz][iy] / np[iz][iy],
00180               h2om[iz][iy] / np[iz][iy], o3m[iz][iy] / np[iz][iy],
00181               zm[iz][iy] / np[iz][iy], pvm[iz][iy] / np[iz][iy],
00182               psm[iz][iy] / np[iz][iy], ptm[iz][iy] / npt[iz][iy],
00183               ztm[iz][iy] / npt[iz][iy], ttm[iz][iy] / npt[iz][iy],
00184               h2otm[iz][iy] / npt[iz][iy]);
00185   }
00186
00187   /* Close file... */
00188   fclose(out);
00189
00190   /* Free... */
00191   free(met);
00192
00193   return EXIT_SUCCESS;
00194 }
```

5.31 time2jsec.c File Reference

Convert date to Julian seconds.

Functions

- int main (int argc, char *argv[])

5.31.1 Detailed Description

Convert date to Julian seconds.

Definition in file time2jsec.c.

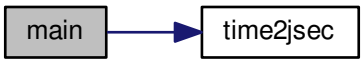
5.31.2 Function Documentation

5.31.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file time2jsec.c.

```
00029                {
00030
00031   double jsec, remain;
00032
00033   int day, hour, min, mon, sec, year;
00034
00035   /* Check arguments... */
00036   if (argc < 8)
00037     ERRMSG("Give parameters: <year> <mon> <day> <hour> <min> <sec> <remain>");
00038
00039   /* Read arguments... */
00040   year = atoi(argv[1]);
00041   mon = atoi(argv[2]);
00042   day = atoi(argv[3]);
00043   hour = atoi(argv[4]);
00044   min = atoi(argv[5]);
00045   sec = atoi(argv[6]);
00046   remain = atof(argv[7]);
00047
00048   /* Convert... */
00049   time2jsec(year, mon, day, hour, min, sec, remain, &jsec);
00050   printf("%.2f\n", jsec);
00051
00052   return EXIT_SUCCESS;
00053 }
```

Here is the call graph for this function:



5.32 time2jsec.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
```

```
00030
00031   double jsec, remain;
00032
00033   int day, hour, min, mon, sec, year;
00034
00035   /* Check arguments... */
00036   if (argc < 8)
00037     ERRMSG("Give parameters: <year> <mon> <day> <hour> <min> <sec> <remain>");
00038
00039   /* Read arguments... */
00040   year = atoi(argv[1]);
00041   mon = atoi(argv[2]);
00042   day = atoi(argv[3]);
00043   hour = atoi(argv[4]);
00044   min = atoi(argv[5]);
00045   sec = atoi(argv[6]);
00046   remain = atof(argv[7]);
00047
00048   /* Convert... */
00049   time2jsec(year, mon, day, hour, min, sec, remain, &jsec);
00050   printf("%.2f\n", jsec);
00051
00052   return EXIT_SUCCESS;
00053 }
```

5.33 trac.c File Reference

Lagrangian particle dispersion model.

Functions

- void module_advection (met_t *met0, met_t *met1, atm_t *atm, double *dt)

  Calculate advection of air parcels.
- void module_decay (ctl_t *ctl, atm_t *atm, double *dt)

  Calculate exponential decay of particle mass.
- void module_diffusion_init (void)

  Initialize random number generator...
- void module_diffusion_meso (ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, cache_t *cache, double *dt, double *rs)

  Calculate mesoscale diffusion.
- void module_diffusion_rng (double *rs, size_t n)

  Generate random numbers.
- void module_diffusion_turb (ctl_t *ctl, atm_t *atm, double *dt, double *rs)

  Calculate turbulent diffusion.
- void module_isosurf_init (ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, cache_t *cache)

  Initialize isosurface module.
- void module_isosurf (ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, cache_t *cache)

  Force air parcels to stay on isosurface.
- void module_meteo (ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm)

  Interpolate meteorological data for air parcel positions.
- void module_position (met_t *met0, met_t *met1, atm_t *atm, double *dt)

  Check position of air parcels.
- void module_sedi (ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, double *dt)

  Calculate sedimentation of air parcels.
- void write_output (const char *dirname, ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, double t)

  Write simulation output.
- int main (int argc, char *argv[])

Variables

- curandGenerator_t rng

5.33.1 Detailed Description

Lagrangian particle dispersion model.

Definition in file trac.c.

5.33.2 Function Documentation

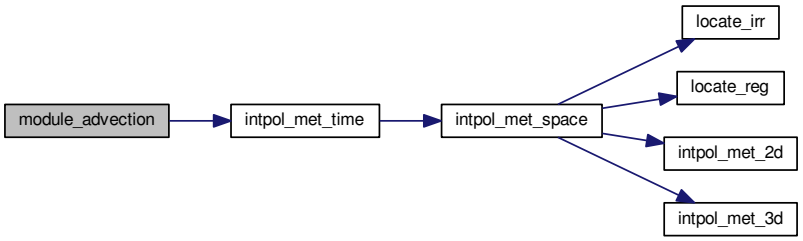
5.33.2.1 void module_advection (met_t * *met0*, met_t * *met1*, atm_t * *atm*, double * *dt*)

Calculate advection of air parcels.

Definition at line 419 of file trac.c.

```
00423               {
00424
00425 #ifdef _OPENACC
00426 #pragma acc data present(met0,met1,atm,dt)
00427 #pragma acc parallel loop independent gang vector
00428 #else
00429 #pragma omp parallel for default(shared)
00430 #endif
00431   for (int ip = 0; ip < atm->np; ip++)
00432     if (dt[ip] != 0) {
00433
00434       double v[3], xm[3];
00435
00436       /* Interpolate meteorological data... */
00437       intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00438                       atm->lon[ip], atm->lat[ip], NULL, NULL, NULL, NULL,
00439                       &v[0], &v[1], &v[2], NULL, NULL, NULL);
00440
00441       /* Get position of the mid point... */
00442       xm[0] =
00443         atm->lon[ip] + DX2DEG(0.5 * dt[ip] * v[0] / 1000., atm->lat[ip]);
00444       xm[1] = atm->lat[ip] + DY2DEG(0.5 * dt[ip] * v[1] / 1000.);
00445       xm[2] = atm->p[ip] + 0.5 * dt[ip] * v[2];
00446
00447       /* Interpolate meteorological data for mid point... */
00448       intpol_met_time(met0, met1, atm->time[ip] + 0.5 * dt[ip],
00449                       xm[2], xm[0], xm[1], NULL, NULL, NULL, NULL,
00450                       &v[0], &v[1], &v[2], NULL, NULL, NULL);
00451
00452       /* Save new position... */
00453       atm->time[ip] += dt[ip];
00454       atm->lon[ip] += DX2DEG(dt[ip] * v[0] / 1000., xm[1]);
00455       atm->lat[ip] += DY2DEG(dt[ip] * v[1] / 1000.);
00456       atm->p[ip] += dt[ip] * v[2];
00457     }
00458 }
```

Here is the call graph for this function:



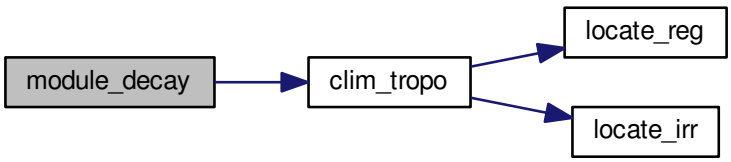
5.33.2.2 void module_decay (ctl_t * *ctl*, atm_t * *atm*, double * *dt*)

Calculate exponential decay of particle mass.

Definition at line 462 of file trac.c.

```
00465               {
00466
00467 #ifdef _OPENACC
00468 #pragma acc data present(ctl,atm,dt)
00469 #pragma acc parallel loop independent gang vector
00470 #else
00471 #pragma omp parallel for default(shared)
00472 #endif
00473   for (int ip = 0; ip < atm->np; ip++)
00474     if (dt[ip] != 0) {
00475
00476       double p0, p1, pt, tdec, w;
00477
00478       /* Get tropopause pressure... */
00479       pt = clim_tropo(atm->time[ip], atm->lat[ip]);
00480
00481       /* Get weighting factor... */
00482       p1 = pt * 0.866877899;
00483       p0 = pt / 0.866877899;
00484       if (atm->p[ip] > p0)
00485         w = 1;
00486       else if (atm->p[ip] < p1)
00487         w = 0;
00488       else
00489         w = LIN(p0, 1.0, p1, 0.0, atm->p[ip]);
00490
00491       /* Set lifetime... */
00492       tdec = w * ctl->tdec_trop + (1 - w) * ctl->tdec_strat;
00493
00494       /* Calculate exponential decay... */
00495       atm->q[ctl->qnt_m][ip] *= exp(-dt[ip] / tdec);
00496     }
00497 }
```

Here is the call graph for this function:



5.33.2.3 void module_diffusion_init (void)

Initialize random number generator...

Definition at line 501 of file trac.c.

```
00502         {
00503
00504   /* Initialize random number generator... */
00505 #ifdef _OPENACC
00506
00507   if (curandCreateGenerator(&rng, CURAND_RNG_PSEUDO_DEFAULT)
```

```
00508       != CURAND_STATUS_SUCCESS)
00509     ERRMSG("Cannot create random number generator!");
00510   if (curandSetStream(rng, (cudaStream_t) acc_get_cuda_stream(acc_async_sync))
00511       != CURAND_STATUS_SUCCESS)
00512     ERRMSG("Cannot set stream for random number generator!");
00513
00514 #else
00515
00516   gsl_rng_env_setup();
00517   if (omp_get_max_threads() > NTHREADS)
00518     ERRMSG("Too many threads!");
00519   for (int i = 0; i < NTHREADS; i++) {
00520     rng[i] = gsl_rng_alloc(gsl_rng_default);
00521     gsl_rng_set(rng[i], gsl_rng_default_seed + (long unsigned) i);
00522   }
00523
00524 #endif
00525 }
```

5.33.2.4 void module_diffusion_meso (ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, cache_t * *cache*, double * *dt*, double * *rs*)

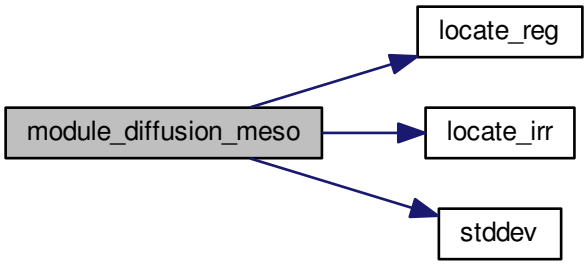
Calculate mesoscale diffusion.

Definition at line 529 of file trac.c.

```
00536               {
00537
00538 #ifdef _OPENACC
00539 #pragma acc data present(ctl,met0,met1,atm,cache,dt,rs)
00540 #pragma acc parallel loop independent gang vector
00541 #else
00542 #pragma omp parallel for default(shared)
00543 #endif
00544   for (int ip = 0; ip < atm->np; ip++)
00545     if (dt[ip] != 0) {
00546
00547       double u[16], v[16], w[16];
00548
00549       /* Get indices... */
00550       int ix = locate_reg(met0->lon, met0->nx, atm->lon[ip]);
00551       int iy = locate_reg(met0->lat, met0->ny, atm->lat[ip]);
00552       int iz = locate_irr(met0->p, met0->np, atm->p[ip]);
00553
00554       /* Caching of wind standard deviations... */
00555       if (cache->tsig[ix][iy][iz] != met0->time) {
00556
00557         /* Collect local wind data... */
00558         u[0] = met0->u[ix][iy][iz];
00559         u[1] = met0->u[ix + 1][iy][iz];
00560         u[2] = met0->u[ix][iy + 1][iz];
00561         u[3] = met0->u[ix + 1][iy + 1][iz];
00562         u[4] = met0->u[ix][iy][iz + 1];
00563         u[5] = met0->u[ix + 1][iy][iz + 1];
00564         u[6] = met0->u[ix][iy + 1][iz + 1];
00565         u[7] = met0->u[ix + 1][iy + 1][iz + 1];
00566
00567         v[0] = met0->v[ix][iy][iz];
00568         v[1] = met0->v[ix + 1][iy][iz];
00569         v[2] = met0->v[ix][iy + 1][iz];
00570         v[3] = met0->v[ix + 1][iy + 1][iz];
00571         v[4] = met0->v[ix][iy][iz + 1];
00572         v[5] = met0->v[ix + 1][iy][iz + 1];
00573         v[6] = met0->v[ix][iy + 1][iz + 1];
00574         v[7] = met0->v[ix + 1][iy + 1][iz + 1];
00575
00576         w[0] = met0->w[ix][iy][iz];
00577         w[1] = met0->w[ix + 1][iy][iz];
00578         w[2] = met0->w[ix][iy + 1][iz];
00579         w[3] = met0->w[ix + 1][iy + 1][iz];
00580         w[4] = met0->w[ix][iy][iz + 1];
00581         w[5] = met0->w[ix + 1][iy][iz + 1];
00582         w[6] = met0->w[ix][iy + 1][iz + 1];
00583         w[7] = met0->w[ix + 1][iy + 1][iz + 1];
00584
00585         /* Collect local wind data... */
00586         u[8] = met1->u[ix][iy][iz];
00587         u[9] = met1->u[ix + 1][iy][iz];
00588         u[10] = met1->u[ix][iy + 1][iz];
00589         u[11] = met1->u[ix + 1][iy + 1][iz];
```

```
00590         u[12] = met1->u[ix][iy][iz + 1];
00591         u[13] = met1->u[ix + 1][iy][iz + 1];
00592         u[14] = met1->u[ix][iy + 1][iz + 1];
00593         u[15] = met1->u[ix + 1][iy + 1][iz + 1];
00594
00595         v[8] = met1->v[ix][iy][iz];
00596         v[9] = met1->v[ix + 1][iy][iz];
00597         v[10] = met1->v[ix][iy + 1][iz];
00598         v[11] = met1->v[ix + 1][iy + 1][iz];
00599         v[12] = met1->v[ix][iy][iz + 1];
00600         v[13] = met1->v[ix + 1][iy][iz + 1];
00601         v[14] = met1->v[ix][iy + 1][iz + 1];
00602         v[15] = met1->v[ix + 1][iy + 1][iz + 1];
00603
00604         w[8] = met1->w[ix][iy][iz];
00605         w[9] = met1->w[ix + 1][iy][iz];
00606         w[10] = met1->w[ix][iy + 1][iz];
00607         w[11] = met1->w[ix + 1][iy + 1][iz];
00608         w[12] = met1->w[ix][iy][iz + 1];
00609         w[13] = met1->w[ix + 1][iy][iz + 1];
00610         w[14] = met1->w[ix][iy + 1][iz + 1];
00611         w[15] = met1->w[ix + 1][iy + 1][iz + 1];
00612
00613         /* Get standard deviations of local wind data... */
00614         cache->usig[ix][iy][iz] = (float) stddev(u, 16);
00615         cache->vsig[ix][iy][iz] = (float) stddev(v, 16);
00616         cache->wsig[ix][iy][iz] = (float) stddev(w, 16);
00617         cache->tsig[ix][iy][iz] = met0->time;
00618       }
00619
00620       /* Set temporal correlations for mesoscale fluctuations... */
00621       double r = 1 - 2 * fabs(dt[ip]) / ctl->dt_met;
00622       double r2 = sqrt(1 - r * r);
00623
00624       /* Calculate horizontal mesoscale wind fluctuations... */
00625       if (ctl->turb_mesox > 0) {
00626         cache->up[ip] = (float)
00627           (r * cache->up[ip]
00628            + r2 * rs[3 * ip] * ctl->turb_mesox * cache->usig[ix][iy][iz]);
00629         atm->lon[ip] += DX2DEG(cache->up[ip] * dt[ip] / 1000., atm->lat[ip]);
00630
00631         cache->vp[ip] = (float)
00632           (r * cache->vp[ip]
00633            + r2 * rs[3 * ip + 1] * ctl->turb_mesox * cache->vsig[ix][iy][iz]);
00634         atm->lat[ip] += DY2DEG(cache->vp[ip] * dt[ip] / 1000.);
00635       }
00636
00637       /* Calculate vertical mesoscale wind fluctuations... */
00638       if (ctl->turb_mesoz > 0) {
00639         cache->wp[ip] = (float)
00640           (r * cache->wp[ip]
00641            + r2 * rs[3 * ip + 2] * ctl->turb_mesoz * cache->wsig[ix][iy][iz]);
00642         atm->p[ip] += cache->wp[ip] * dt[ip];
00643       }
00644     }
00645 }
```

Here is the call graph for this function:



5.33.2.5 void module_diffusion_rng (double * *rs*, size_t *n*)

Generate random numbers.

Definition at line 649 of file trac.c.

```
00651             {
00652
00653 #ifdef _OPENACC
00654
00655 #pragma acc host_data use_device(rs)
00656   {
00657     if (curandGenerateNormalDouble(rng, rs, n, 0.0, 1.0)
00658         != CURAND_STATUS_SUCCESS)
00659       ERRMSG("Cannot create random numbers!");
00660   }
00661
00662 #else
00663
00664 #pragma omp parallel for default(shared)
00665   for (size_t i = 0; i < n; ++i)
00666     rs[i] = gsl_ran_gaussian_ziggurat(rng[omp_get_thread_num()], 1.0);
00667
00668 #endif
00669
00670 }
```

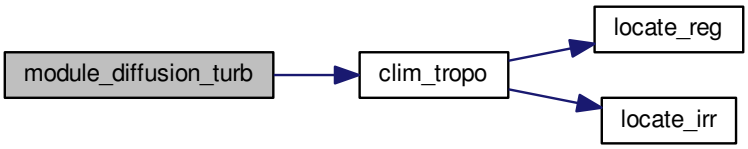
5.33.2.6 void module_diffusion_turb (ctl_t * *ctl*, atm_t * *atm*, double * *dt*, double * *rs*)

Calculate turbulent diffusion.

Definition at line 674 of file trac.c.

```
00678               {
00679
00680 #ifdef _OPENACC
00681 #pragma acc data present(ctl,atm,dt,rs)
00682 #pragma acc parallel loop independent gang vector
00683 #else
00684 #pragma omp parallel for default(shared)
00685 #endif
00686   for (int ip = 0; ip < atm->np; ip++)
00687     if (dt[ip] != 0) {
00688
00689       double w;
00690
00691       /* Get tropopause pressure... */
00692       double pt = clim_tropo(atm->time[ip], atm->lat[ip]);
00693
00694       /* Get weighting factor... */
00695       double p1 = pt * 0.866877899;
00696       double p0 = pt / 0.866877899;
00697       if (atm->p[ip] > p0)
00698         w = 1;
00699       else if (atm->p[ip] < p1)
00700         w = 0;
00701       else
00702         w = LIN(p0, 1.0, p1, 0.0, atm->p[ip]);
00703
00704       /* Set diffusivity... */
00705       double dx = w * ctl->turb_dx_trop + (1 - w) * ctl->
      turb_dx_strat;
00706       double dz = w * ctl->turb_dz_trop + (1 - w) * ctl->
      turb_dz_strat;
00707
00708       /* Horizontal turbulent diffusion... */
00709       if (dx > 0) {
00710         double sigma = sqrt(2.0 * dx * fabs(dt[ip]));
00711         atm->lon[ip] += DX2DEG(rs[3 * ip] * sigma / 1000., atm->lat[ip]);
00712         atm->lat[ip] += DY2DEG(rs[3 * ip + 1] * sigma / 1000.);
00713       }
00714
00715       /* Vertical turbulent diffusion... */
00716       if (dz > 0) {
00717         double sigma = sqrt(2.0 * dz * fabs(dt[ip]));
00718         atm->p[ip]
00719           += DZ2DP(rs[3 * ip + 2] * sigma / 1000., atm->p[ip]);
00720       }
00721     }
00722 }
```

Here is the call graph for this function:



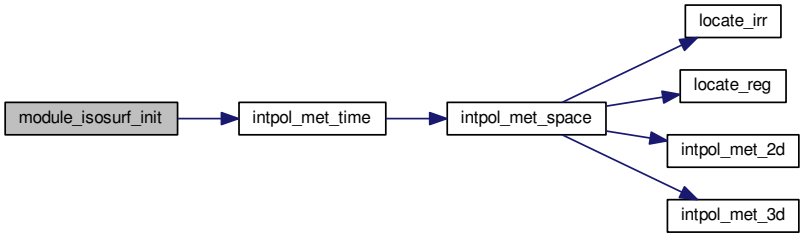
5.33.2.7 void module_isosurf_init (ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, cache_t * *cache*)

Initialize isosurface module.

Definition at line 726 of file trac.c.

```
00731                   {
00732
00733   FILE *in;
00734
00735   char line[LEN];
00736
00737   double t;
00738
00739   /* Save pressure... */
00740   if (ctl->isosurf == 1)
00741     for (int ip = 0; ip < atm->np; ip++)
00742       cache->iso_var[ip] = atm->p[ip];
00743
00744   /* Save density... */
00745   else if (ctl->isosurf == 2)
00746     for (int ip = 0; ip < atm->np; ip++) {
00747       intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00748                       atm->lon[ip], atm->lat[ip], NULL, NULL, NULL,
00749                       &t, NULL, NULL, NULL, NULL, NULL, NULL);
00750       cache->iso_var[ip] = atm->p[ip] / t;
00751     }
00752
00753   /* Save potential temperature... */
00754   else if (ctl->isosurf == 3)
00755     for (int ip = 0; ip < atm->np; ip++) {
00756       intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00757                       atm->lon[ip], atm->lat[ip], NULL, NULL, NULL,
00758                       &t, NULL, NULL, NULL, NULL, NULL, NULL);
00759       cache->iso_var[ip] = THETA(atm->p[ip], t);
00760     }
00761
00762   /* Read balloon pressure data... */
00763   else if (ctl->isosurf == 4) {
00764
00765     /* Write info... */
00766     printf("Read balloon pressure data: %s\n", ctl->balloon);
00767
00768     /* Open file... */
00769     if (!(in = fopen(ctl->balloon, "r")))
00770       ERRMSG("Cannot open file!");
00771
00772     /* Read pressure time series... */
00773     while (fgets(line, LEN, in))
00774       if (sscanf(line, "%lg %lg", &(cache->iso_ts[cache->iso_n]),
00775                  &(cache->iso_ps[cache->iso_n])) == 2)
00776         if ((++cache->iso_n) > NP)
00777           ERRMSG("Too many data points!");
00778
00779     /* Check number of points... */
00780     if (cache->iso_n < 1)
00781       ERRMSG("Could not read any data!");
00782
00783     /* Close file... */
00784     fclose(in);
00785   }
00786 }
```

Here is the call graph for this function:



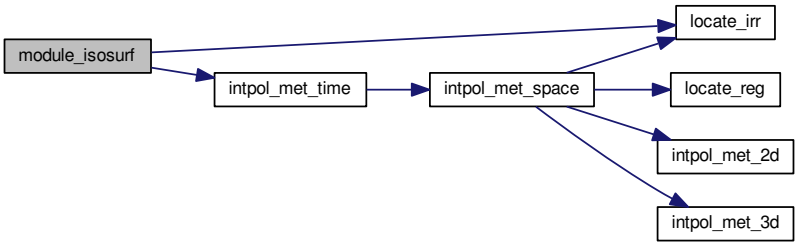
5.33.2.8 void module_isosurf (ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, cache_t * *cache*)

Force air parcels to stay on isosurface.

Definition at line 790 of file trac.c.

```
00795                   {
00796
00797 #ifdef _OPENACC
00798 #pragma acc data present(ctl,met0,met1,atm,cache)
00799 #pragma acc parallel loop independent gang vector
00800 #else
00801 #pragma omp parallel for default(shared)
00802 #endif
00803   for (int ip = 0; ip < atm->np; ip++) {
00804
00805     double t;
00806
00807     /* Restore pressure... */
00808     if (ctl->isosurf == 1)
00809       atm->p[ip] = cache->iso_var[ip];
00810
00811     /* Restore density... */
00812     else if (ctl->isosurf == 2) {
00813       intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
    lon[ip],
00814                       atm->lat[ip], NULL, NULL, NULL, &t,
00815                       NULL, NULL, NULL, NULL, NULL, NULL);
00816       atm->p[ip] = cache->iso_var[ip] * t;
00817     }
00818
00819     /* Restore potential temperature... */
00820     else if (ctl->isosurf == 3) {
00821       intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
    lon[ip],
00822                       atm->lat[ip], NULL, NULL, NULL, &t,
00823                       NULL, NULL, NULL, NULL, NULL, NULL);
00824       atm->p[ip] = 1000. * pow(cache->iso_var[ip] / t, -1. / 0.286);
00825     }
00826
00827     /* Interpolate pressure... */
00828     else if (ctl->isosurf == 4) {
00829       if (atm->time[ip] <= cache->iso_ts[0])
00830         atm->p[ip] = cache->iso_ps[0];
00831       else if (atm->time[ip] >= cache->iso_ts[cache->iso_n - 1])
00832         atm->p[ip] = cache->iso_ps[cache->iso_n - 1];
00833       else {
00834         int idx = locate_irr(cache->iso_ts, cache->iso_n, atm->
    time[ip]);
00835         atm->p[ip] = LIN(cache->iso_ts[idx], cache->iso_ps[idx],
00836                          cache->iso_ts[idx + 1], cache->iso_ps[idx + 1],
00837                          atm->time[ip]);
00838       }
00839     }
00840   }
00841 }
```

Here is the call graph for this function:



5.33.2.9 void module_meteo (ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*)

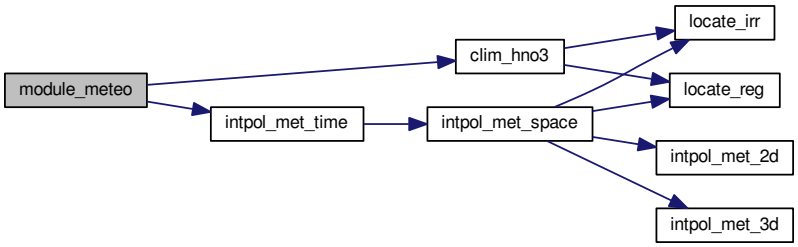
Interpolate meteorological data for air parcel positions.

Definition at line 845 of file trac.c.

```
00849               {
00850
00851 #ifdef _OPENACC
00852 #pragma acc data present(ctl,met0,met1,atm)
00853 #pragma acc parallel loop independent gang vector
00854 #else
00855 #pragma omp parallel for default(shared)
00856 #endif
00857   for (int ip = 0; ip < atm->np; ip++) {
00858
00859     double ps, pt, pv, t, u, v, w, h2o, o3, z;
00860
00861     /* Interpolate meteorological data... */
00862     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00863                     atm->lat[ip], &ps, &pt, &z, &t, &u, &v, &w, &pv, &h2o,
00864                     &o3);
00865
00866     /* Set surface pressure... */
00867     if (ctl->qnt_ps >= 0)
00868       atm->q[ctl->qnt_ps][ip] = ps;
00869
00870     /* Set tropopause pressure... */
00871     if (ctl->qnt_pt >= 0)
00872       atm->q[ctl->qnt_pt][ip] = pt;
00873
00874     /* Set pressure... */
00875     if (ctl->qnt_p >= 0)
00876       atm->q[ctl->qnt_p][ip] = atm->p[ip];
00877
00878     /* Set geopotential height... */
00879     if (ctl->qnt_z >= 0)
00880       atm->q[ctl->qnt_z][ip] = z;
00881
00882     /* Set temperature... */
00883     if (ctl->qnt_t >= 0)
00884       atm->q[ctl->qnt_t][ip] = t;
00885
00886     /* Set zonal wind... */
00887     if (ctl->qnt_u >= 0)
00888       atm->q[ctl->qnt_u][ip] = u;
00889
00890     /* Set meridional wind... */
00891     if (ctl->qnt_v >= 0)
00892       atm->q[ctl->qnt_v][ip] = v;
00893
00894     /* Set vertical velocity... */
00895     if (ctl->qnt_w >= 0)
00896       atm->q[ctl->qnt_w][ip] = w;
00897
00898     /* Set water vapor vmr... */
```

```
00899     if (ctl->qnt_h2o >= 0)
00900       atm->q[ctl->qnt_h2o][ip] = h2o;
00901
00902     /* Set ozone vmr... */
00903     if (ctl->qnt_o3 >= 0)
00904       atm->q[ctl->qnt_o3][ip] = o3;
00905
00906     /* Calculate horizontal wind... */
00907     if (ctl->qnt_vh >= 0)
00908       atm->q[ctl->qnt_vh][ip] = sqrt(u * u + v * v);
00909
00910     /* Calculate vertical velocity... */
00911     if (ctl->qnt_vz >= 0)
00912       atm->q[ctl->qnt_vz][ip] = -1e3 * H0 / atm->p[ip] * w;
00913
00914     /* Calculate potential temperature... */
00915     if (ctl->qnt_theta >= 0)
00916       atm->q[ctl->qnt_theta][ip] = THETA(atm->p[ip], t);
00917
00918     /* Set potential vorticity... */
00919     if (ctl->qnt_pv >= 0)
00920       atm->q[ctl->qnt_pv][ip] = pv;
00921
00922     /* Calculate T_ice (Marti and Mauersberger, 1993)... */
00923     if (ctl->qnt_tice >= 0)
00924       atm->q[ctl->qnt_tice][ip] =
00925         -2663.5 /
00926         (log10((ctl->psc_h2o > 0 ? ctl->psc_h2o : h2o) * atm->p[ip] * 100.) -
00927          12.537);
00928
00929     /* Calculate T_NAT (Hanson and Mauersberger, 1988)... */
00930     if (ctl->qnt_tnat >= 0) {
00931       double p_hno3;
00932       if (ctl->psc_hno3 > 0)
00933         p_hno3 = ctl->psc_hno3 * atm->p[ip] / 1.333224;
00934       else
00935         p_hno3 = clim_hno3(atm->time[ip], atm->lat[ip], atm->p[ip])
00936           * 1e-9 * atm->p[ip] / 1.333224;
00937       double p_h2o =
00938         (ctl->psc_h2o > 0 ? ctl->psc_h2o : h2o) * atm->p[ip] / 1.333224;
00939       double a = 0.009179 - 0.00088 * log10(p_h2o);
00940       double b = (38.9855 - log10(p_hno3) - 2.7836 * log10(p_h2o)) / a;
00941       double c = -11397.0 / a;
00942       double x1 = (-b + sqrt(b * b - 4. * c)) / 2.;
00943       double x2 = (-b - sqrt(b * b - 4. * c)) / 2.;
00944       if (x1 > 0)
00945         atm->q[ctl->qnt_tnat][ip] = x1;
00946       if (x2 > 0)
00947         atm->q[ctl->qnt_tnat][ip] = x2;
00948     }
00949
00950     /* Calculate T_STS (mean of T_ice and T_NAT)... */
00951     if (ctl->qnt_tsts >= 0) {
00952       atm->q[ctl->qnt_tsts][ip] = 0.5 * (atm->q[ctl->qnt_tice][ip]
00953                                          + atm->q[ctl->qnt_tnat][ip]);
00954     }
00955   }
00956 }
```

Here is the call graph for this function:



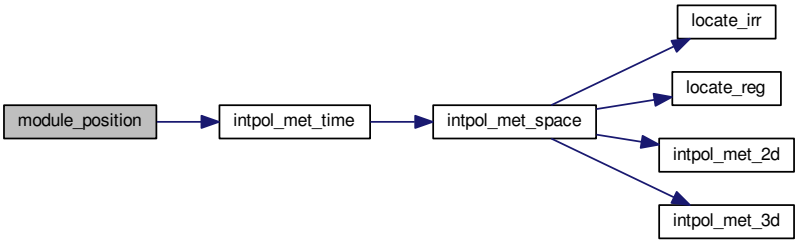
5.33.2.10 void module_position (met_t * *met0*, met_t * *met1*, atm_t * *atm*, double * *dt*)

Check position of air parcels.

Definition at line 960 of file trac.c.

```
00964               {
00965
00966 #ifdef _OPENACC
00967 #pragma acc data present(met0,met1,atm,dt)
00968 #pragma acc parallel loop independent gang vector
00969 #else
00970 #pragma omp parallel for default(shared)
00971 #endif
00972   for (int ip = 0; ip < atm->np; ip++)
00973     if (dt[ip] != 0) {
00974
00975       double ps;
00976
00977       /* Calculate modulo... */
00978       atm->lon[ip] = FMOD(atm->lon[ip], 360.);
00979       atm->lat[ip] = FMOD(atm->lat[ip], 360.);
00980
00981       /* Check latitude... */
00982       while (atm->lat[ip] < -90 || atm->lat[ip] > 90) {
00983         if (atm->lat[ip] > 90) {
00984           atm->lat[ip] = 180 - atm->lat[ip];
00985           atm->lon[ip] += 180;
00986         }
00987         if (atm->lat[ip] < -90) {
00988           atm->lat[ip] = -180 - atm->lat[ip];
00989           atm->lon[ip] += 180;
00990         }
00991       }
00992
00993       /* Check longitude... */
00994       while (atm->lon[ip] < -180)
00995         atm->lon[ip] += 360;
00996       while (atm->lon[ip] >= 180)
00997         atm->lon[ip] -= 360;
00998
00999       /* Check pressure... */
01000       if (atm->p[ip] < met0->p[met0->np - 1])
01001         atm->p[ip] = met0->p[met0->np - 1];
01002       else if (atm->p[ip] > 300.) {
01003         intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
01004                         atm->lon[ip], atm->lat[ip], &ps, NULL, NULL, NULL,
01005                         NULL, NULL, NULL, NULL, NULL, NULL);
01006         if (atm->p[ip] > ps)
01007           atm->p[ip] = ps;
01008       }
01009     }
01010 }
```

Here is the call graph for this function:



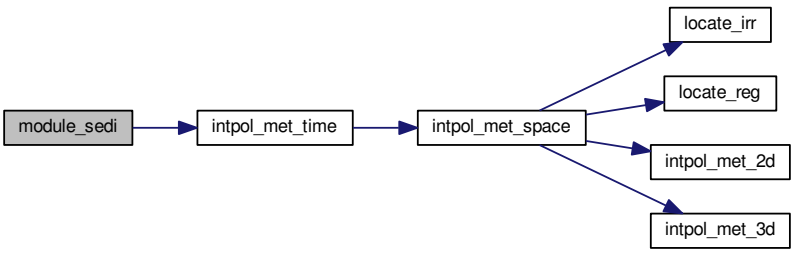
5.33.2.11 void module_sedi (ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, double * *dt*)

Calculate sedimentation of air parcels.

Definition at line 1014 of file trac.c.

```
01019              {
01020
01021 #ifdef _OPENACC
01022 #pragma acc data present(ctl,met0,met1,atm,dt)
01023 #pragma acc parallel loop independent gang vector
01024 #else
01025 #pragma omp parallel for default(shared)
01026 #endif
01027   for (int ip = 0; ip < atm->np; ip++)
01028     if (dt[ip] != 0) {
01029
01030       /* Coefficients for Cunningham slip-flow correction (Kasten, 1968): */
01031       const double A = 1.249, B = 0.42, C = 0.87;
01032
01033       /* Average mass of an air molecule [kg/molec]: */
01034       const double m = 4.8096e-26;
01035
01036       double G, K, eta, lambda, p, r_p, rho, rho_p, T, v, v_p;
01037
01038       /* Convert units... */
01039       p = 100 * atm->p[ip];
01040       r_p = 1e-6 * atm->q[ctl->qnt_r][ip];
01041       rho_p = atm->q[ctl->qnt_rho][ip];
01042
01043       /* Get temperature... */
01044       intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
01045                       atm->lat[ip], NULL, NULL, NULL, &T,
01046                       NULL, NULL, NULL, NULL, NULL, NULL);
01047
01048       /* Density of dry air... */
01049       rho = p / (RA * T);
01050
01051       /* Dynamic viscosity of air... */
01052       eta = 1.8325e-5 * (416.16 / (T + 120.)) * pow(T / 296.16, 1.5);
01053
01054       /* Thermal velocity of an air molecule... */
01055       v = sqrt(8 * KB * T / (M_PI * m));
01056
01057       /* Mean free path of an air molecule... */
01058       lambda = 2 * eta / (rho * v);
01059
01060       /* Knudsen number for air... */
01061       K = lambda / r_p;
01062
01063       /* Cunningham slip-flow correction... */
01064       G = 1 + K * (A + B * exp(-C / K));
01065
01066       /* Sedimentation (fall) velocity... */
01067       v_p = 2. * SQR(r_p) * (rho_p - rho) * G0 / (9. * eta) * G;
01068
01069       /* Calculate pressure change... */
01070       atm->p[ip] += DZ2DP(v_p * dt[ip] / 1000., atm->p[ip]);
01071     }
01072 }
```

Here is the call graph for this function:



5.33.2.12 void write_output (const char * *dirname*, ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, double *t*)

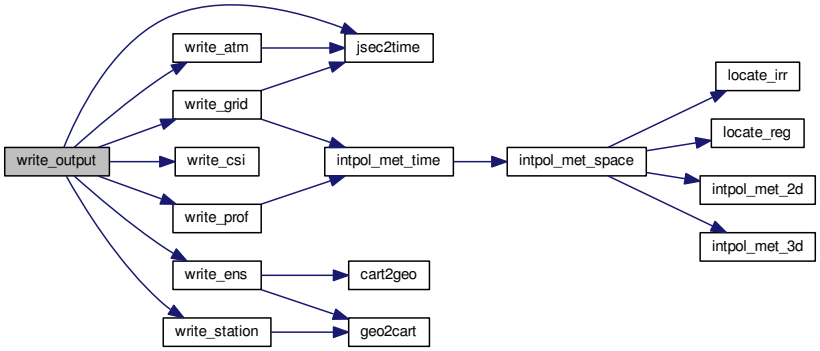
Write simulation output.

Definition at line 1076 of file trac.c.

```
01082             {
01083
01084   char filename[2 * LEN];
01085
01086   double r;
01087
01088   int year, mon, day, hour, min, sec, updated = 0;
01089
01090   /* Get time... */
01091   jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01092
01093   /* Write atmospheric data... */
01094   if (ctl->atm_basename[0] != '-' && fmod(t, ctl->atm_dt_out) == 0) {
01095     if (!updated) {
01096 #ifdef _OPENACC
01097 #pragma acc update host(atm[:1])
01098 #endif
01099       updated = 1;
01100     }
01101     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
01102             dirname, ctl->atm_basename, year, mon, day, hour, min);
01103     write_atm(filename, ctl, atm, t);
01104   }
01105
01106   /* Write gridded data... */
01107   if (ctl->grid_basename[0] != '-' && fmod(t, ctl->grid_dt_out) == 0) {
01108     if (!updated) {
01109 #ifdef _OPENACC
01110 #pragma acc update host(atm[:1])
01111 #endif
01112       updated = 1;
01113     }
01114     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
01115             dirname, ctl->grid_basename, year, mon, day, hour, min);
01116     write_grid(filename, ctl, met0, met1, atm, t);
01117   }
01118
01119   /* Write CSI data... */
01120   if (ctl->csi_basename[0] != '-') {
01121     if (!updated) {
01122 #ifdef _OPENACC
01123 #pragma acc update host(atm[:1])
01124 #endif
01125       updated = 1;
01126     }
01127     sprintf(filename, "%s/%s.tab", dirname, ctl->csi_basename);
01128     write_csi(filename, ctl, atm, t);
01129   }
01130
01131   /* Write ensemble data... */
01132   if (ctl->ens_basename[0] != '-') {
01133     if (!updated) {
01134 #ifdef _OPENACC
01135 #pragma acc update host(atm[:1])
01136 #endif
01137       updated = 1;
01138     }
01139     sprintf(filename, "%s/%s.tab", dirname, ctl->ens_basename);
01140     write_ens(filename, ctl, atm, t);
01141   }
01142
01143   /* Write profile data... */
01144   if (ctl->prof_basename[0] != '-') {
01145     if (!updated) {
01146 #ifdef _OPENACC
01147 #pragma acc update host(atm[:1])
01148 #endif
01149       updated = 1;
01150     }
01151     sprintf(filename, "%s/%s.tab", dirname, ctl->prof_basename);
01152     write_prof(filename, ctl, met0, met1, atm, t);
01153   }
01154
01155   /* Write station data... */
01156   if (ctl->stat_basename[0] != '-') {
01157     if (!updated) {
01158 #ifdef _OPENACC
```

```
01159 #pragma acc update host(atm[:1])
01160 #endif
01161       updated = 1;
01162     }
01163     sprintf(filename, "%s/%s.tab", dirname, ctl->stat_basename);
01164     write_station(filename, ctl, atm, t);
01165   }
01166 }
```

Here is the call graph for this function:



5.33.2.13 int main (int *argc*, char * *argv[ ]*)

Definition at line 140 of file trac.c.

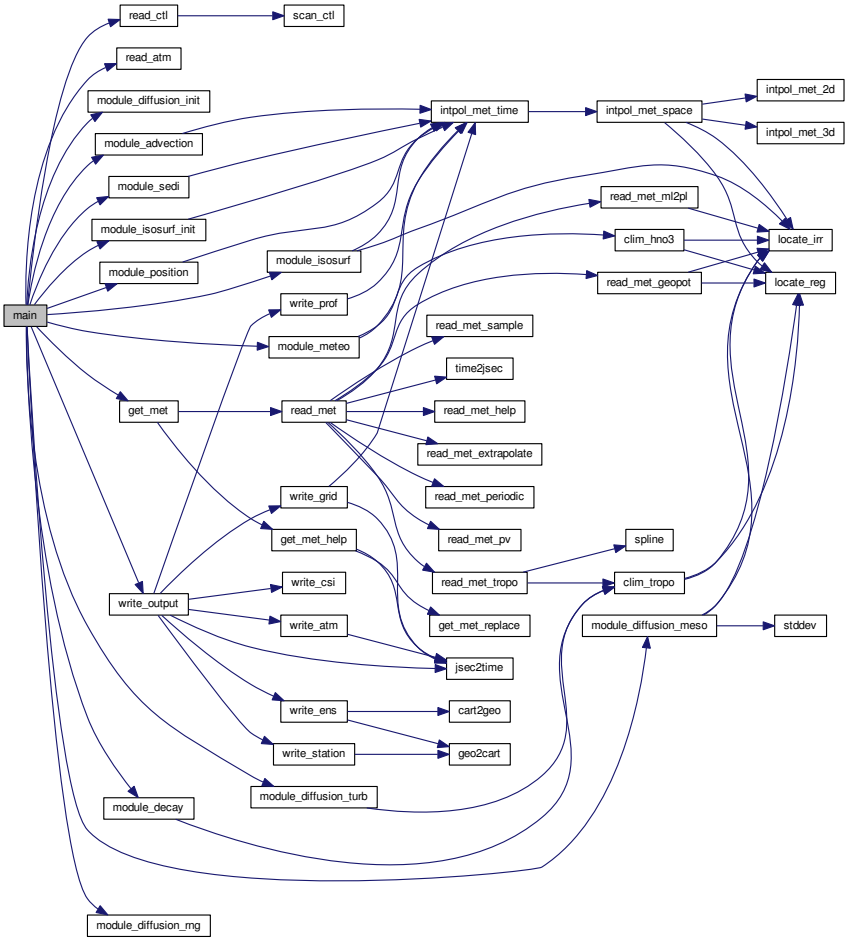
```
00142                {
00143
00144   ctl_t ctl;
00145
00146   atm_t *atm;
00147
00148   cache_t *cache;
00149
00150   met_t *met0, *met1;
00151
00152   FILE *dirlist;
00153
00154   char dirname[LEN], filename[2 * LEN];
00155
00156   double *dt, *rs, t;
00157
00158   int ntask = -1, rank = 0, size = 1;
00159
00160 #ifdef MPI
00161   /* Initialize MPI... */
00162   MPI_Init(&argc, &argv);
00163   MPI_Comm_rank(MPI_COMM_WORLD, &rank);
00164   MPI_Comm_size(MPI_COMM_WORLD, &size);
00165 #endif
00166
00167   /* Check arguments... */
00168   if (argc < 5)
00169     ERRMSG("Give parameters: <dirlist> <ctl> <atm_in> <metbase>");
00170
00171   /* Open directory list... */
00172   if (!(dirlist = fopen(argv[1], "r")))
00173     ERRMSG("Cannot open directory list!");
00174
00175   /* Loop over directories... */
00176   while (fscanf(dirlist, "%s", dirname) != EOF) {
00177
00178     /* MPI parallelization... */
00179     if ((++ntask) % size != rank)
00180       continue;
```

```
00181
00182     /* ------------------------------------------------------------
00183        Initialize model run...
00184        ------------------------------------------------------------ */
00185
00186     /* Set timers... */
00187     START_TIMER(TIMER_ZERO);
00188     START_TIMER(TIMER_TOTAL);
00189     START_TIMER(TIMER_INIT);
00190
00191     /* Allocate... */
00192     ALLOC(atm, atm_t, 1);
00193     ALLOC(cache, cache_t, 1);
00194     ALLOC(met0, met_t, 1);
00195     ALLOC(met1, met_t, 1);
00196     ALLOC(dt, double,
00197           NP);
00198     ALLOC(rs, double,
00199           3 * NP);
00200
00201     /* Read control parameters... */
00202     sprintf(filename, "%s/%s", dirname, argv[2]);
00203     read_ctl(filename, argc, argv, &ctl);
00204
00205     /* Read atmospheric data... */
00206     sprintf(filename, "%s/%s", dirname, argv[3]);
00207     if (!read_atm(filename, &ctl, atm))
00208       ERRMSG("Cannot open file!");
00209
00210     /* Copy to GPU... */
00211 #ifdef _OPENACC
00212 #pragma acc enter data copyin(ctl)
00213 #pragma acc enter data create(atm[:1],cache[:1],met0[:1],met1[:1],dt[:NP],rs[:3*NP])
00214 #pragma acc update device(atm[:1],cache[:1])
00215 #endif
00216
00217     /* Set start time... */
00218     if (ctl.direction == 1) {
00219       ctl.t_start = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00220       if (ctl.t_stop > 1e99)
00221         ctl.t_stop = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00222     } else {
00223       ctl.t_start = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00224       if (ctl.t_stop > 1e99)
00225         ctl.t_stop = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00226     }
00227
00228     /* Check time interval... */
00229     if (ctl.direction * (ctl.t_stop - ctl.t_start) <= 0)
00230       ERRMSG("Nothing to do!");
00231
00232     /* Round start time... */
00233     if (ctl.direction == 1)
00234       ctl.t_start = floor(ctl.t_start / ctl.dt_mod) * ctl.
      dt_mod;
00235     else
00236       ctl.t_start = ceil(ctl.t_start / ctl.dt_mod) * ctl.
      dt_mod;
00237
00238     /* Initialize random number generator... */
00239     module_diffusion_init();
00240
00241     /* Set timers... */
00242     STOP_TIMER(TIMER_INIT);
00243
00244     /* Initialize meteorological data... */
00245     START_TIMER(TIMER_INPUT);
00246     get_met(&ctl, argv[4], ctl.t_start, &met0, &met1);
00247     if (ctl.dt_mod > fabs(met0->lon[1] - met0->lon[0]) * 111132. / 150.)
00248       WARN("Violation of CFL criterion! Check DT_MOD!");
00249     STOP_TIMER(TIMER_INPUT);
00250
00251     /* Initialize isosurface... */
00252     START_TIMER(TIMER_ISOSURF);
00253     if (ctl.isosurf >= 1 && ctl.isosurf <= 4)
00254       module_isosurf_init(&ctl, met0, met1, atm, cache);
00255     STOP_TIMER(TIMER_ISOSURF);
00256
00257     /* ------------------------------------------------------------
00258        Loop over timesteps...
00259        ------------------------------------------------------------ */
00260
00261     /* Loop over timesteps... */
00262     for (t = ctl.t_start; ctl.direction * (t - ctl.t_stop) < ctl.
      dt_mod;
00263          t += ctl.direction * ctl.dt_mod) {
00264
```

```
00265       /* Adjust length of final time step... */
00266       if (ctl.direction * (t - ctl.t_stop) > 0)
00267         t = ctl.t_stop;
00268
00269       /* Set time steps for air parcels... */
00270 #ifdef _OPENACC
00271 #pragma acc parallel loop independent gang vector present(ctl,atm,atm->time,dt)
00272 #endif
00273       for (int ip = 0; ip < atm->np; ip++) {
00274         double atmtime = atm->time[ip];
00275         double tstart = ctl.t_start;
00276         double tstop = ctl.t_stop;
00277         int dir = ctl.direction;
00278         if ((dir * (atmtime - tstart) >= 0 && dir * (atmtime - tstop) <= 0
00279              && dir * (atmtime - t) < 0))
00280           dt[ip] = t - atmtime;
00281         else
00282           dt[ip] = 0;
00283       }
00284
00285       /* Get meteorological data... */
00286       START_TIMER(TIMER_INPUT);
00287       if (t != ctl.t_start)
00288         get_met(&ctl, argv[4], t, &met0, &met1);
00289       STOP_TIMER(TIMER_INPUT);
00290
00291       /* Check initial position... */
00292       START_TIMER(TIMER_POSITION);
00293       module_position(met0, met1, atm, dt);
00294       STOP_TIMER(TIMER_POSITION);
00295
00296       /* Advection... */
00297       START_TIMER(TIMER_ADVECT);
00298       module_advection(met0, met1, atm, dt);
00299       STOP_TIMER(TIMER_ADVECT);
00300
00301       /* Turbulent diffusion... */
00302       START_TIMER(TIMER_DIFFTURB);
00303       if (ctl.turb_dx_trop > 0 || ctl.turb_dz_trop > 0
00304           || ctl.turb_dx_strat > 0 || ctl.turb_dz_strat > 0) {
00305         module_diffusion_rng(rs, 3 * (size_t) atm->np);
00306         module_diffusion_turb(&ctl, atm, dt, rs);
00307       }
00308       STOP_TIMER(TIMER_DIFFTURB);
00309
00310       /* Mesoscale diffusion... */
00311       START_TIMER(TIMER_DIFFMESO);
00312       if (ctl.turb_mesox > 0 || ctl.turb_mesoz > 0) {
00313         module_diffusion_rng(rs, 3 * (size_t) atm->np);
00314         module_diffusion_meso(&ctl, met0, met1, atm, cache, dt, rs);
00315       }
00316       STOP_TIMER(TIMER_DIFFMESO);
00317
00318       /* Sedimentation... */
00319       START_TIMER(TIMER_SEDI);
00320       if (ctl.qnt_r >= 0 && ctl.qnt_rho >= 0)
00321         module_sedi(&ctl, met0, met1, atm, dt);
00322       STOP_TIMER(TIMER_SEDI);
00323
00324       /* Isosurface... */
00325       START_TIMER(TIMER_ISOSURF);
00326       if (ctl.isosurf >= 1 && ctl.isosurf <= 4)
00327         module_isosurf(&ctl, met0, met1, atm, cache);
00328       STOP_TIMER(TIMER_ISOSURF);
00329
00330       /* Check final position... */
00331       START_TIMER(TIMER_POSITION);
00332       module_position(met0, met1, atm, dt);
00333       STOP_TIMER(TIMER_POSITION);
00334
00335       /* Interpolate meteorological data... */
00336       START_TIMER(TIMER_METEO);
00337       if (ctl.met_dt_out > 0
00338           && (ctl.met_dt_out < ctl.dt_mod || fmod(t, ctl.
      met_dt_out) == 0))
00339         module_meteo(&ctl, met0, met1, atm);
00340       STOP_TIMER(TIMER_METEO);
00341
00342       /* Decay of particle mass... */
00343       START_TIMER(TIMER_DECAY);
00344       if (ctl.tdec_trop > 0 && ctl.tdec_strat > 0 && ctl.
      qnt_m >= 0)
00345         module_decay(&ctl, atm, dt);
00346       STOP_TIMER(TIMER_DECAY);
00347
00348       /* Write output... */
00349       START_TIMER(TIMER_OUTPUT);
```

```
00350       write_output(dirname, &ctl, met0, met1, atm, t);
00351       STOP_TIMER(TIMER_OUTPUT);
00352     }
00353
00354     /* ------------------------------------------------------------
00355        Finalize model run...
00356        ------------------------------------------------------------ */
00357
00358     /* Report problem size... */
00359     printf("SIZE_NP = %d\n", atm->np);
00360     printf("SIZE_TASKS = %d\n", size);
00361     printf("SIZE_THREADS = %d\n", omp_get_max_threads());
00362
00363     /* Report memory usage... */
00364     printf("MEMORY_ATM = %g MByte\n", sizeof(atm_t) / 1024. / 1024.);
00365     printf("MEMORY_CACHE = %g MByte\n", sizeof(cache_t) / 1024. / 1024.);
00366     printf("MEMORY_METEO = %g MByte\n", 2 * sizeof(met_t) / 1024. / 1024.);
00367     printf("MEMORY_DYNAMIC = %g MByte\n", (sizeof(met_t)
00368                                            + 4 * NP * sizeof(double)
00369                                            +
00370                                            EX * EY * EP * sizeof(float)) /
00371            1024. / 1024.);
00372     printf("MEMORY_STATIC = %g MByte\n", (EX * EY * sizeof(double)
00373                                           + EX * EY * EP * sizeof(float)
00374                                           + 4 * GX * GY * GZ * sizeof(double)
00375                                           + 2 * GX * GY * GZ * sizeof(int)
00376                                           + 2 * GX * GY * sizeof(double)
00377                                           +
00378                                           GX * GY * sizeof(int)) / 1024. /
00379            1024.);
00380
00381     /* Report timers... */
00382     STOP_TIMER(TIMER_ZERO);
00383     PRINT_TIMER(TIMER_INIT);
00384     PRINT_TIMER(TIMER_INPUT);
00385     PRINT_TIMER(TIMER_OUTPUT);
00386     PRINT_TIMER(TIMER_ADVECT);
00387     PRINT_TIMER(TIMER_DECAY);
00388     PRINT_TIMER(TIMER_DIFFMESO);
00389     PRINT_TIMER(TIMER_DIFFTURB);
00390     PRINT_TIMER(TIMER_ISOSURF);
00391     PRINT_TIMER(TIMER_METEO);
00392     PRINT_TIMER(TIMER_POSITION);
00393     PRINT_TIMER(TIMER_SEDI);
00394     STOP_TIMER(TIMER_TOTAL);
00395     PRINT_TIMER(TIMER_TOTAL);
00396
00397     /* Free... */
00398     free(atm);
00399     free(cache);
00400     free(met0);
00401     free(met1);
00402     free(dt);
00403     free(rs);
00404 #ifdef _OPENACC
00405 #pragma acc exit data delete(ctl,atm,cache,met0,met1,dt,rs)
00406 #endif
00407   }
00408
00409 #ifdef MPI
00410   /* Finalize MPI... */
00411   MPI_Finalize();
00412 #endif
00413
00414   return EXIT_SUCCESS;
00415 }
```

Here is the call graph for this function:



5.33.3 Variable Documentation

5.33.3.1 static gsl_rng * rng

Definition at line 41 of file trac.c.

5.34 trac.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
```

```
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 #ifdef MPI
00028 #include "mpi.h"
00029 #endif
00030
00031 #ifdef _OPENACC
00032 #include "openacc.h"
00033 #include "curand.h"
00034 #endif
00035
00036 /* ------------------------------------------------------------
00037    Global variables...
00038    ------------------------------------------------------------ */
00039
00040 #ifdef _OPENACC
00041 curandGenerator_t rng;
00042 #else
00043 static gsl_rng *rng[NTHREADS];
00044 #endif
00045
00046 /* ------------------------------------------------------------
00047    Functions...
00048    ------------------------------------------------------------ */
00049
00051 void module_advection(
00052   met_t * met0,
00053   met_t * met1,
00054   atm_t * atm,
00055   double *dt);
00056
00058 void module_decay(
00059   ctl_t * ctl,
00060   atm_t * atm,
00061   double *dt);
00062
00064 void module_diffusion_init(
00065   void);
00066
00068 void module_diffusion_meso(
00069   ctl_t * ctl,
00070   met_t * met0,
00071   met_t * met1,
00072   atm_t * atm,
00073   cache_t * cache,
00074   double *dt,
00075   double *rs);
00076
00078 void module_diffusion_rng(
00079   double *rs,
00080   size_t n);
00081
00083 void module_diffusion_turb(
00084   ctl_t * ctl,
00085   atm_t * atm,
00086   double *dt,
00087   double *rs);
00088
00090 void module_isosurf_init(
00091   ctl_t * ctl,
00092   met_t * met0,
00093   met_t * met1,
00094   atm_t * atm,
00095   cache_t * cache);
00096
00098 void module_isosurf(
00099   ctl_t * ctl,
00100   met_t * met0,
00101   met_t * met1,
00102   atm_t * atm,
00103   cache_t * cache);
00104
00106 void module_meteo(
00107   ctl_t * ctl,
00108   met_t * met0,
00109   met_t * met1,
00110   atm_t * atm);
00111
00113 void module_position(
00114   met_t * met0,
00115   met_t * met1,
00116   atm_t * atm,
00117   double *dt);
```

```
00118
00120 void module_sedi(
00121   ctl_t * ctl,
00122   met_t * met0,
00123   met_t * met1,
00124   atm_t * atm,
00125   double *dt);
00126
00128 void write_output(
00129   const char *dirname,
00130   ctl_t * ctl,
00131   met_t * met0,
00132   met_t * met1,
00133   atm_t * atm,
00134   double t);
00135
00136 /* ------------------------------------------------------------
00137    Main...
00138    ------------------------------------------------------------ */
00139
00140 int main(
00141   int argc,
00142   char *argv[]) {
00143
00144   ctl_t ctl;
00145
00146   atm_t *atm;
00147
00148   cache_t *cache;
00149
00150   met_t *met0, *met1;
00151
00152   FILE *dirlist;
00153
00154   char dirname[LEN], filename[2 * LEN];
00155
00156   double *dt, *rs, t;
00157
00158   int ntask = -1, rank = 0, size = 1;
00159
00160 #ifdef MPI
00161   /* Initialize MPI... */
00162   MPI_Init(&argc, &argv);
00163   MPI_Comm_rank(MPI_COMM_WORLD, &rank);
00164   MPI_Comm_size(MPI_COMM_WORLD, &size);
00165 #endif
00166
00167   /* Check arguments... */
00168   if (argc < 5)
00169     ERRMSG("Give parameters: <dirlist> <ctl> <atm_in> <metbase>");
00170
00171   /* Open directory list... */
00172   if (!(dirlist = fopen(argv[1], "r")))
00173     ERRMSG("Cannot open directory list!");
00174
00175   /* Loop over directories... */
00176   while (fscanf(dirlist, "%s", dirname) != EOF) {
00177
00178     /* MPI parallelization... */
00179     if ((++ntask) % size != rank)
00180       continue;
00181
00182     /* ------------------------------------------------------------
00183        Initialize model run...
00184        ------------------------------------------------------------ */
00185
00186     /* Set timers... */
00187     START_TIMER(TIMER_ZERO);
00188     START_TIMER(TIMER_TOTAL);
00189     START_TIMER(TIMER_INIT);
00190
00191     /* Allocate... */
00192     ALLOC(atm, atm_t, 1);
00193     ALLOC(cache, cache_t, 1);
00194     ALLOC(met0, met_t, 1);
00195     ALLOC(met1, met_t, 1);
00196     ALLOC(dt, double,
00197           NP);
00198     ALLOC(rs, double,
00199           3 * NP);
00200
00201     /* Read control parameters... */
00202     sprintf(filename, "%s/%s", dirname, argv[2]);
00203     read_ctl(filename, argc, argv, &ctl);
00204
00205     /* Read atmospheric data... */
00206     sprintf(filename, "%s/%s", dirname, argv[3]);
```

```
00207     if (!read_atm(filename, &ctl, atm))
00208       ERRMSG("Cannot open file!");
00209
00210     /* Copy to GPU... */
00211 #ifdef _OPENACC
00212 #pragma acc enter data copyin(ctl)
00213 #pragma acc enter data create(atm[:1],cache[:1],met0[:1],met1[:1],dt[:NP],rs[:3*NP])
00214 #pragma acc update device(atm[:1],cache[:1])
00215 #endif
00216
00217     /* Set start time... */
00218     if (ctl.direction == 1) {
00219       ctl.t_start = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00220       if (ctl.t_stop > 1e99)
00221         ctl.t_stop = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00222     } else {
00223       ctl.t_start = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00224       if (ctl.t_stop > 1e99)
00225         ctl.t_stop = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00226     }
00227
00228     /* Check time interval... */
00229     if (ctl.direction * (ctl.t_stop - ctl.t_start) <= 0)
00230       ERRMSG("Nothing to do!");
00231
00232     /* Round start time... */
00233     if (ctl.direction == 1)
00234       ctl.t_start = floor(ctl.t_start / ctl.dt_mod) * ctl.
    dt_mod;
00235     else
00236       ctl.t_start = ceil(ctl.t_start / ctl.dt_mod) * ctl.
    dt_mod;
00237
00238     /* Initialize random number generator... */
00239     module_diffusion_init();
00240
00241     /* Set timers... */
00242     STOP_TIMER(TIMER_INIT);
00243
00244     /* Initialize meteorological data... */
00245     START_TIMER(TIMER_INPUT);
00246     get_met(&ctl, argv[4], ctl.t_start, &met0, &met1);
00247     if (ctl.dt_mod > fabs(met0->lon[1] - met0->lon[0]) * 111132. / 150.)
00248       WARN("Violation of CFL criterion! Check DT_MOD!");
00249     STOP_TIMER(TIMER_INPUT);
00250
00251     /* Initialize isosurface... */
00252     START_TIMER(TIMER_ISOSURF);
00253     if (ctl.isosurf >= 1 && ctl.isosurf <= 4)
00254       module_isosurf_init(&ctl, met0, met1, atm, cache);
00255     STOP_TIMER(TIMER_ISOSURF);
00256
00257     /* ------------------------------------------------------------
00258        Loop over timesteps...
00259        ------------------------------------------------------------ */
00260
00261     /* Loop over timesteps... */
00262     for (t = ctl.t_start; ctl.direction * (t - ctl.t_stop) < ctl.
    dt_mod;
00263          t += ctl.direction * ctl.dt_mod) {
00264
00265       /* Adjust length of final time step... */
00266       if (ctl.direction * (t - ctl.t_stop) > 0)
00267         t = ctl.t_stop;
00268
00269       /* Set time steps for air parcels... */
00270 #ifdef _OPENACC
00271 #pragma acc parallel loop independent gang vector present(ctl,atm,atm->time,dt)
00272 #endif
00273       for (int ip = 0; ip < atm->np; ip++) {
00274         double atmtime = atm->time[ip];
00275         double tstart = ctl.t_start;
00276         double tstop = ctl.t_stop;
00277         int dir = ctl.direction;
00278         if ((dir * (atmtime - tstart) >= 0 && dir * (atmtime - tstop) <= 0
00279              && dir * (atmtime - t) < 0))
00280           dt[ip] = t - atmtime;
00281         else
00282           dt[ip] = 0;
00283       }
00284
00285       /* Get meteorological data... */
00286       START_TIMER(TIMER_INPUT);
00287       if (t != ctl.t_start)
00288         get_met(&ctl, argv[4], t, &met0, &met1);
00289       STOP_TIMER(TIMER_INPUT);
00290
```

```
00291       /* Check initial position... */
00292       START_TIMER(TIMER_POSITION);
00293       module_position(met0, met1, atm, dt);
00294       STOP_TIMER(TIMER_POSITION);
00295
00296       /* Advection... */
00297       START_TIMER(TIMER_ADVECT);
00298       module_advection(met0, met1, atm, dt);
00299       STOP_TIMER(TIMER_ADVECT);
00300
00301       /* Turbulent diffusion... */
00302       START_TIMER(TIMER_DIFFTURB);
00303       if (ctl.turb_dx_trop > 0 || ctl.turb_dz_trop > 0
00304           || ctl.turb_dx_strat > 0 || ctl.turb_dz_strat > 0) {
00305         module_diffusion_rng(rs, 3 * (size_t) atm->np);
00306         module_diffusion_turb(&ctl, atm, dt, rs);
00307       }
00308       STOP_TIMER(TIMER_DIFFTURB);
00309
00310       /* Mesoscale diffusion... */
00311       START_TIMER(TIMER_DIFFMESO);
00312       if (ctl.turb_mesox > 0 || ctl.turb_mesoz > 0) {
00313         module_diffusion_rng(rs, 3 * (size_t) atm->np);
00314         module_diffusion_meso(&ctl, met0, met1, atm, cache, dt, rs);
00315       }
00316       STOP_TIMER(TIMER_DIFFMESO);
00317
00318       /* Sedimentation... */
00319       START_TIMER(TIMER_SEDI);
00320       if (ctl.qnt_r >= 0 && ctl.qnt_rho >= 0)
00321         module_sedi(&ctl, met0, met1, atm, dt);
00322       STOP_TIMER(TIMER_SEDI);
00323
00324       /* Isosurface... */
00325       START_TIMER(TIMER_ISOSURF);
00326       if (ctl.isosurf >= 1 && ctl.isosurf <= 4)
00327         module_isosurf(&ctl, met0, met1, atm, cache);
00328       STOP_TIMER(TIMER_ISOSURF);
00329
00330       /* Check final position... */
00331       START_TIMER(TIMER_POSITION);
00332       module_position(met0, met1, atm, dt);
00333       STOP_TIMER(TIMER_POSITION);
00334
00335       /* Interpolate meteorological data... */
00336       START_TIMER(TIMER_METEO);
00337       if (ctl.met_dt_out > 0
00338           && (ctl.met_dt_out < ctl.dt_mod || fmod(t, ctl.
    met_dt_out) == 0))
00339         module_meteo(&ctl, met0, met1, atm);
00340       STOP_TIMER(TIMER_METEO);
00341
00342       /* Decay of particle mass... */
00343       START_TIMER(TIMER_DECAY);
00344       if (ctl.tdec_trop > 0 && ctl.tdec_strat > 0 && ctl.
    qnt_m >= 0)
00345         module_decay(&ctl, atm, dt);
00346       STOP_TIMER(TIMER_DECAY);
00347
00348       /* Write output... */
00349       START_TIMER(TIMER_OUTPUT);
00350       write_output(dirname, &ctl, met0, met1, atm, t);
00351       STOP_TIMER(TIMER_OUTPUT);
00352     }
00353
00354     /* ------------------------------------------------------------
00355        Finalize model run...
00356        ------------------------------------------------------------ */
00357
00358     /* Report problem size... */
00359     printf("SIZE_NP = %d\n", atm->np);
00360     printf("SIZE_TASKS = %d\n", size);
00361     printf("SIZE_THREADS = %d\n", omp_get_max_threads());
00362
00363     /* Report memory usage... */
00364     printf("MEMORY_ATM = %g MByte\n", sizeof(atm_t) / 1024. / 1024.);
00365     printf("MEMORY_CACHE = %g MByte\n", sizeof(cache_t) / 1024. / 1024.);
00366     printf("MEMORY_METEO = %g MByte\n", 2 * sizeof(met_t) / 1024. / 1024.);
00367     printf("MEMORY_DYNAMIC = %g MByte\n", (sizeof(met_t)
00368                                            + 4 * NP * sizeof(double)
00369                                            +
00370                                            EX * EY * EP * sizeof(float)) /
00371             1024. / 1024.);
00372     printf("MEMORY_STATIC = %g MByte\n", (EX * EY * sizeof(double)
00373                                           + EX * EY * EP * sizeof(float)
00374                                           + 4 * GX * GY * GZ * sizeof(double)
00375                                           + 2 * GX * GY * GZ * sizeof(int)
```

```
00376                                           + 2 * GX * GY * sizeof(double)
00377                                           +
00378                                           GX * GY * sizeof(int)) / 1024. /
00379             1024.);
00380
00381     /* Report timers... */
00382     STOP_TIMER(TIMER_ZERO);
00383     PRINT_TIMER(TIMER_INIT);
00384     PRINT_TIMER(TIMER_INPUT);
00385     PRINT_TIMER(TIMER_OUTPUT);
00386     PRINT_TIMER(TIMER_ADVECT);
00387     PRINT_TIMER(TIMER_DECAY);
00388     PRINT_TIMER(TIMER_DIFFMESO);
00389     PRINT_TIMER(TIMER_DIFFTURB);
00390     PRINT_TIMER(TIMER_ISOSURF);
00391     PRINT_TIMER(TIMER_METEO);
00392     PRINT_TIMER(TIMER_POSITION);
00393     PRINT_TIMER(TIMER_SEDI);
00394     STOP_TIMER(TIMER_TOTAL);
00395     PRINT_TIMER(TIMER_TOTAL);
00396
00397     /* Free... */
00398     free(atm);
00399     free(cache);
00400     free(met0);
00401     free(met1);
00402     free(dt);
00403     free(rs);
00404 #ifdef _OPENACC
00405 #pragma acc exit data delete(ctl,atm,cache,met0,met1,dt,rs)
00406 #endif
00407   }
00408
00409 #ifdef MPI
00410   /* Finalize MPI... */
00411   MPI_Finalize();
00412 #endif
00413
00414   return EXIT_SUCCESS;
00415 }
00416
00417 /*****************************************************************************/
00418
00419 void module_advection(
00420   met_t * met0,
00421   met_t * met1,
00422   atm_t * atm,
00423   double *dt) {
00424
00425 #ifdef _OPENACC
00426 #pragma acc data present(met0,met1,atm,dt)
00427 #pragma acc parallel loop independent gang vector
00428 #else
00429 #pragma omp parallel for default(shared)
00430 #endif
00431   for (int ip = 0; ip < atm->np; ip++)
00432     if (dt[ip] != 0) {
00433
00434       double v[3], xm[3];
00435
00436       /* Interpolate meteorological data... */
00437       intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00438                       atm->lon[ip], atm->lat[ip], NULL, NULL, NULL, NULL,
00439                       &v[0], &v[1], &v[2], NULL, NULL, NULL);
00440
00441       /* Get position of the mid point... */
00442       xm[0] =
00443         atm->lon[ip] + DX2DEG(0.5 * dt[ip] * v[0] / 1000., atm->lat[ip]);
00444       xm[1] = atm->lat[ip] + DY2DEG(0.5 * dt[ip] * v[1] / 1000.);
00445       xm[2] = atm->p[ip] + 0.5 * dt[ip] * v[2];
00446
00447       /* Interpolate meteorological data for mid point... */
00448       intpol_met_time(met0, met1, atm->time[ip] + 0.5 * dt[ip],
00449                       xm[2], xm[0], xm[1], NULL, NULL, NULL, NULL,
00450                       &v[0], &v[1], &v[2], NULL, NULL, NULL);
00451
00452       /* Save new position... */
00453       atm->time[ip] += dt[ip];
00454       atm->lon[ip] += DX2DEG(dt[ip] * v[0] / 1000., xm[1]);
00455       atm->lat[ip] += DY2DEG(dt[ip] * v[1] / 1000.);
00456       atm->p[ip] += dt[ip] * v[2];
00457     }
00458 }
00459
00460 /*****************************************************************************/
00461
00462 void module_decay(
```

```
00463   ctl_t * ctl,
00464   atm_t * atm,
00465   double *dt) {
00466
00467 #ifdef _OPENACC
00468 #pragma acc data present(ctl,atm,dt)
00469 #pragma acc parallel loop independent gang vector
00470 #else
00471 #pragma omp parallel for default(shared)
00472 #endif
00473   for (int ip = 0; ip < atm->np; ip++)
00474     if (dt[ip] != 0) {
00475
00476       double p0, p1, pt, tdec, w;
00477
00478       /* Get tropopause pressure... */
00479       pt = clim_tropo(atm->time[ip], atm->lat[ip]);
00480
00481       /* Get weighting factor... */
00482       p1 = pt * 0.866877899;
00483       p0 = pt / 0.866877899;
00484       if (atm->p[ip] > p0)
00485         w = 1;
00486       else if (atm->p[ip] < p1)
00487         w = 0;
00488       else
00489         w = LIN(p0, 1.0, p1, 0.0, atm->p[ip]);
00490
00491       /* Set lifetime... */
00492       tdec = w * ctl->tdec_trop + (1 - w) * ctl->tdec_strat;
00493
00494       /* Calculate exponential decay... */
00495       atm->q[ctl->qnt_m][ip] *= exp(-dt[ip] / tdec);
00496     }
00497 }
00498
00499 /*****************************************************************************/
00500
00501 void module_diffusion_init(
00502   void) {
00503
00504   /* Initialize random number generator... */
00505 #ifdef _OPENACC
00506
00507   if (curandCreateGenerator(&rng, CURAND_RNG_PSEUDO_DEFAULT)
00508       != CURAND_STATUS_SUCCESS)
00509     ERRMSG("Cannot create random number generator!");
00510   if (curandSetStream(rng, (cudaStream_t) acc_get_cuda_stream(acc_async_sync))
00511       != CURAND_STATUS_SUCCESS)
00512     ERRMSG("Cannot set stream for random number generator!");
00513
00514 #else
00515
00516   gsl_rng_env_setup();
00517   if (omp_get_max_threads() > NTHREADS)
00518     ERRMSG("Too many threads!");
00519   for (int i = 0; i < NTHREADS; i++) {
00520     rng[i] = gsl_rng_alloc(gsl_rng_default);
00521     gsl_rng_set(rng[i], gsl_rng_default_seed + (long unsigned) i);
00522   }
00523
00524 #endif
00525 }
00526
00527 /*****************************************************************************/
00528
00529 void module_diffusion_meso(
00530   ctl_t * ctl,
00531   met_t * met0,
00532   met_t * met1,
00533   atm_t * atm,
00534   cache_t * cache,
00535   double *dt,
00536   double *rs) {
00537
00538 #ifdef _OPENACC
00539 #pragma acc data present(ctl,met0,met1,atm,cache,dt,rs)
00540 #pragma acc parallel loop independent gang vector
00541 #else
00542 #pragma omp parallel for default(shared)
00543 #endif
00544   for (int ip = 0; ip < atm->np; ip++)
00545     if (dt[ip] != 0) {
00546
00547       double u[16], v[16], w[16];
00548
00549       /* Get indices... */
```

```
00550       int ix = locate_reg(met0->lon, met0->nx, atm->lon[ip]);
00551       int iy = locate_reg(met0->lat, met0->ny, atm->lat[ip]);
00552       int iz = locate_irr(met0->p, met0->np, atm->p[ip]);
00553
00554       /* Caching of wind standard deviations... */
00555       if (cache->tsig[ix][iy][iz] != met0->time) {
00556
00557         /* Collect local wind data... */
00558         u[0] = met0->u[ix][iy][iz];
00559         u[1] = met0->u[ix + 1][iy][iz];
00560         u[2] = met0->u[ix][iy + 1][iz];
00561         u[3] = met0->u[ix + 1][iy + 1][iz];
00562         u[4] = met0->u[ix][iy][iz + 1];
00563         u[5] = met0->u[ix + 1][iy][iz + 1];
00564         u[6] = met0->u[ix][iy + 1][iz + 1];
00565         u[7] = met0->u[ix + 1][iy + 1][iz + 1];
00566
00567         v[0] = met0->v[ix][iy][iz];
00568         v[1] = met0->v[ix + 1][iy][iz];
00569         v[2] = met0->v[ix][iy + 1][iz];
00570         v[3] = met0->v[ix + 1][iy + 1][iz];
00571         v[4] = met0->v[ix][iy][iz + 1];
00572         v[5] = met0->v[ix + 1][iy][iz + 1];
00573         v[6] = met0->v[ix][iy + 1][iz + 1];
00574         v[7] = met0->v[ix + 1][iy + 1][iz + 1];
00575
00576         w[0] = met0->w[ix][iy][iz];
00577         w[1] = met0->w[ix + 1][iy][iz];
00578         w[2] = met0->w[ix][iy + 1][iz];
00579         w[3] = met0->w[ix + 1][iy + 1][iz];
00580         w[4] = met0->w[ix][iy][iz + 1];
00581         w[5] = met0->w[ix + 1][iy][iz + 1];
00582         w[6] = met0->w[ix][iy + 1][iz + 1];
00583         w[7] = met0->w[ix + 1][iy + 1][iz + 1];
00584
00585         /* Collect local wind data... */
00586         u[8] = met1->u[ix][iy][iz];
00587         u[9] = met1->u[ix + 1][iy][iz];
00588         u[10] = met1->u[ix][iy + 1][iz];
00589         u[11] = met1->u[ix + 1][iy + 1][iz];
00590         u[12] = met1->u[ix][iy][iz + 1];
00591         u[13] = met1->u[ix + 1][iy][iz + 1];
00592         u[14] = met1->u[ix][iy + 1][iz + 1];
00593         u[15] = met1->u[ix + 1][iy + 1][iz + 1];
00594
00595         v[8] = met1->v[ix][iy][iz];
00596         v[9] = met1->v[ix + 1][iy][iz];
00597         v[10] = met1->v[ix][iy + 1][iz];
00598         v[11] = met1->v[ix + 1][iy + 1][iz];
00599         v[12] = met1->v[ix][iy][iz + 1];
00600         v[13] = met1->v[ix + 1][iy][iz + 1];
00601         v[14] = met1->v[ix][iy + 1][iz + 1];
00602         v[15] = met1->v[ix + 1][iy + 1][iz + 1];
00603
00604         w[8] = met1->w[ix][iy][iz];
00605         w[9] = met1->w[ix + 1][iy][iz];
00606         w[10] = met1->w[ix][iy + 1][iz];
00607         w[11] = met1->w[ix + 1][iy + 1][iz];
00608         w[12] = met1->w[ix][iy][iz + 1];
00609         w[13] = met1->w[ix + 1][iy][iz + 1];
00610         w[14] = met1->w[ix][iy + 1][iz + 1];
00611         w[15] = met1->w[ix + 1][iy + 1][iz + 1];
00612
00613         /* Get standard deviations of local wind data... */
00614         cache->usig[ix][iy][iz] = (float) stddev(u, 16);
00615         cache->vsig[ix][iy][iz] = (float) stddev(v, 16);
00616         cache->wsig[ix][iy][iz] = (float) stddev(w, 16);
00617         cache->tsig[ix][iy][iz] = met0->time;
00618       }
00619
00620       /* Set temporal correlations for mesoscale fluctuations... */
00621       double r = 1 - 2 * fabs(dt[ip]) / ctl->dt_met;
00622       double r2 = sqrt(1 - r * r);
00623
00624       /* Calculate horizontal mesoscale wind fluctuations... */
00625       if (ctl->turb_mesox > 0) {
00626         cache->up[ip] = (float)
00627           (r * cache->up[ip]
00628            + r2 * rs[3 * ip] * ctl->turb_mesox * cache->usig[ix][iy][iz]);
00629         atm->lon[ip] += DX2DEG(cache->up[ip] * dt[ip] / 1000., atm->lat[ip]);
00630
00631         cache->vp[ip] = (float)
00632           (r * cache->vp[ip]
00633            + r2 * rs[3 * ip + 1] * ctl->turb_mesox * cache->vsig[ix][iy][iz]);
00634         atm->lat[ip] += DY2DEG(cache->vp[ip] * dt[ip] / 1000.);
00635       }
00636
```

```
00637       /* Calculate vertical mesoscale wind fluctuations... */
00638       if (ctl->turb_mesoz > 0) {
00639         cache->wp[ip] = (float)
00640           (r * cache->wp[ip]
00641            + r2 * rs[3 * ip + 2] * ctl->turb_mesoz * cache->wsig[ix][iy][iz]);
00642         atm->p[ip] += cache->wp[ip] * dt[ip];
00643       }
00644     }
00645 }
00646
00647 /*****************************************************************************/
00648
00649 void module_diffusion_rng(
00650   double *rs,
00651   size_t n) {
00652
00653 #ifdef _OPENACC
00654
00655 #pragma acc host_data use_device(rs)
00656   {
00657     if (curandGenerateNormalDouble(rng, rs, n, 0.0, 1.0)
00658         != CURAND_STATUS_SUCCESS)
00659       ERRMSG("Cannot create random numbers!");
00660   }
00661
00662 #else
00663
00664 #pragma omp parallel for default(shared)
00665   for (size_t i = 0; i < n; ++i)
00666     rs[i] = gsl_ran_gaussian_ziggurat(rng[omp_get_thread_num()], 1.0);
00667
00668 #endif
00669
00670 }
00671
00672 /*****************************************************************************/
00673
00674 void module_diffusion_turb(
00675   ctl_t * ctl,
00676   atm_t * atm,
00677   double *dt,
00678   double *rs) {
00679
00680 #ifdef _OPENACC
00681 #pragma acc data present(ctl,atm,dt,rs)
00682 #pragma acc parallel loop independent gang vector
00683 #else
00684 #pragma omp parallel for default(shared)
00685 #endif
00686   for (int ip = 0; ip < atm->np; ip++)
00687     if (dt[ip] != 0) {
00688
00689       double w;
00690
00691       /* Get tropopause pressure... */
00692       double pt = clim_tropo(atm->time[ip], atm->lat[ip]);
00693
00694       /* Get weighting factor... */
00695       double p1 = pt * 0.866877899;
00696       double p0 = pt / 0.866877899;
00697       if (atm->p[ip] > p0)
00698         w = 1;
00699       else if (atm->p[ip] < p1)
00700         w = 0;
00701       else
00702         w = LIN(p0, 1.0, p1, 0.0, atm->p[ip]);
00703
00704       /* Set diffusivity... */
00705       double dx = w * ctl->turb_dx_trop + (1 - w) * ctl->
      turb_dx_strat;
00706       double dz = w * ctl->turb_dz_trop + (1 - w) * ctl->
      turb_dz_strat;
00707
00708       /* Horizontal turbulent diffusion... */
00709       if (dx > 0) {
00710         double sigma = sqrt(2.0 * dx * fabs(dt[ip]));
00711         atm->lon[ip] += DX2DEG(rs[3 * ip] * sigma / 1000., atm->lat[ip]);
00712         atm->lat[ip] += DY2DEG(rs[3 * ip + 1] * sigma / 1000.);
00713       }
00714
00715       /* Vertical turbulent diffusion... */
00716       if (dz > 0) {
00717         double sigma = sqrt(2.0 * dz * fabs(dt[ip]));
00718         atm->p[ip]
00719           += DZ2DP(rs[3 * ip + 2] * sigma / 1000., atm->p[ip]);
00720       }
00721     }
```

```
00722 }
00723
00724 /*****************************************************************************/
00725
00726 void module_isosurf_init(
00727   ctl_t * ctl,
00728   met_t * met0,
00729   met_t * met1,
00730   atm_t * atm,
00731   cache_t * cache) {
00732
00733   FILE *in;
00734
00735   char line[LEN];
00736
00737   double t;
00738
00739   /* Save pressure... */
00740   if (ctl->isosurf == 1)
00741     for (int ip = 0; ip < atm->np; ip++)
00742       cache->iso_var[ip] = atm->p[ip];
00743
00744   /* Save density... */
00745   else if (ctl->isosurf == 2)
00746     for (int ip = 0; ip < atm->np; ip++) {
00747       intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00748                       atm->lon[ip], atm->lat[ip], NULL, NULL, NULL,
00749                       &t, NULL, NULL, NULL, NULL, NULL, NULL);
00750       cache->iso_var[ip] = atm->p[ip] / t;
00751     }
00752
00753   /* Save potential temperature... */
00754   else if (ctl->isosurf == 3)
00755     for (int ip = 0; ip < atm->np; ip++) {
00756       intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00757                       atm->lon[ip], atm->lat[ip], NULL, NULL, NULL,
00758                       &t, NULL, NULL, NULL, NULL, NULL, NULL);
00759       cache->iso_var[ip] = THETA(atm->p[ip], t);
00760     }
00761
00762   /* Read balloon pressure data... */
00763   else if (ctl->isosurf == 4) {
00764
00765     /* Write info... */
00766     printf("Read balloon pressure data: %s\n", ctl->balloon);
00767
00768     /* Open file... */
00769     if (!(in = fopen(ctl->balloon, "r")))
00770       ERRMSG("Cannot open file!");
00771
00772     /* Read pressure time series... */
00773     while (fgets(line, LEN, in))
00774       if (sscanf(line, "%lg %lg", &(cache->iso_ts[cache->iso_n]),
00775                  &(cache->iso_ps[cache->iso_n])) == 2)
00776         if ((++cache->iso_n) > NP)
00777           ERRMSG("Too many data points!");
00778
00779     /* Check number of points... */
00780     if (cache->iso_n < 1)
00781       ERRMSG("Could not read any data!");
00782
00783     /* Close file... */
00784     fclose(in);
00785   }
00786 }
00787
00788 /*****************************************************************************/
00789
00790 void module_isosurf(
00791   ctl_t * ctl,
00792   met_t * met0,
00793   met_t * met1,
00794   atm_t * atm,
00795   cache_t * cache) {
00796
00797 #ifdef _OPENACC
00798 #pragma acc data present(ctl,met0,met1,atm,cache)
00799 #pragma acc parallel loop independent gang vector
00800 #else
00801 #pragma omp parallel for default(shared)
00802 #endif
00803   for (int ip = 0; ip < atm->np; ip++) {
00804
00805     double t;
00806
00807     /* Restore pressure... */
00808     if (ctl->isosurf == 1)
```

```
00809       atm->p[ip] = cache->iso_var[ip];
00810
00811     /* Restore density... */
00812     else if (ctl->isosurf == 2) {
00813       intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00814                       atm->lat[ip], NULL, NULL, NULL, &t,
00815                       NULL, NULL, NULL, NULL, NULL, NULL);
00816       atm->p[ip] = cache->iso_var[ip] * t;
00817     }
00818
00819     /* Restore potential temperature... */
00820     else if (ctl->isosurf == 3) {
00821       intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00822                       atm->lat[ip], NULL, NULL, NULL, &t,
00823                       NULL, NULL, NULL, NULL, NULL, NULL);
00824       atm->p[ip] = 1000. * pow(cache->iso_var[ip] / t, -1. / 0.286);
00825     }
00826
00827     /* Interpolate pressure... */
00828     else if (ctl->isosurf == 4) {
00829       if (atm->time[ip] <= cache->iso_ts[0])
00830         atm->p[ip] = cache->iso_ps[0];
00831       else if (atm->time[ip] >= cache->iso_ts[cache->iso_n - 1])
00832         atm->p[ip] = cache->iso_ps[cache->iso_n - 1];
00833       else {
00834         int idx = locate_irr(cache->iso_ts, cache->iso_n, atm->
      time[ip]);
00835         atm->p[ip] = LIN(cache->iso_ts[idx], cache->iso_ps[idx],
00836                          cache->iso_ts[idx + 1], cache->iso_ps[idx + 1],
00837                          atm->time[ip]);
00838       }
00839     }
00840   }
00841 }
00842
00843 /*****************************************************************************/
00844
00845 void module_meteo(
00846   ctl_t * ctl,
00847   met_t * met0,
00848   met_t * met1,
00849   atm_t * atm) {
00850
00851 #ifdef _OPENACC
00852 #pragma acc data present(ctl,met0,met1,atm)
00853 #pragma acc parallel loop independent gang vector
00854 #else
00855 #pragma omp parallel for default(shared)
00856 #endif
00857   for (int ip = 0; ip < atm->np; ip++) {
00858
00859     double ps, pt, pv, t, u, v, w, h2o, o3, z;
00860
00861     /* Interpolate meteorological data... */
00862     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00863                     atm->lat[ip], &ps, &pt, &z, &t, &u, &v, &w, &pv, &h2o,
00864                     &o3);
00865
00866     /* Set surface pressure... */
00867     if (ctl->qnt_ps >= 0)
00868       atm->q[ctl->qnt_ps][ip] = ps;
00869
00870     /* Set tropopause pressure... */
00871     if (ctl->qnt_pt >= 0)
00872       atm->q[ctl->qnt_pt][ip] = pt;
00873
00874     /* Set pressure... */
00875     if (ctl->qnt_p >= 0)
00876       atm->q[ctl->qnt_p][ip] = atm->p[ip];
00877
00878     /* Set geopotential height... */
00879     if (ctl->qnt_z >= 0)
00880       atm->q[ctl->qnt_z][ip] = z;
00881
00882     /* Set temperature... */
00883     if (ctl->qnt_t >= 0)
00884       atm->q[ctl->qnt_t][ip] = t;
00885
00886     /* Set zonal wind... */
00887     if (ctl->qnt_u >= 0)
00888       atm->q[ctl->qnt_u][ip] = u;
00889
00890     /* Set meridional wind... */
00891     if (ctl->qnt_v >= 0)
```

```
00892       atm->q[ctl->qnt_v][ip] = v;
00893
00894     /* Set vertical velocity... */
00895     if (ctl->qnt_w >= 0)
00896       atm->q[ctl->qnt_w][ip] = w;
00897
00898     /* Set water vapor vmr... */
00899     if (ctl->qnt_h2o >= 0)
00900       atm->q[ctl->qnt_h2o][ip] = h2o;
00901
00902     /* Set ozone vmr... */
00903     if (ctl->qnt_o3 >= 0)
00904       atm->q[ctl->qnt_o3][ip] = o3;
00905
00906     /* Calculate horizontal wind... */
00907     if (ctl->qnt_vh >= 0)
00908       atm->q[ctl->qnt_vh][ip] = sqrt(u * u + v * v);
00909
00910     /* Calculate vertical velocity... */
00911     if (ctl->qnt_vz >= 0)
00912       atm->q[ctl->qnt_vz][ip] = -1e3 * H0 / atm->p[ip] * w;
00913
00914     /* Calculate potential temperature... */
00915     if (ctl->qnt_theta >= 0)
00916       atm->q[ctl->qnt_theta][ip] = THETA(atm->p[ip], t);
00917
00918     /* Set potential vorticity... */
00919     if (ctl->qnt_pv >= 0)
00920       atm->q[ctl->qnt_pv][ip] = pv;
00921
00922     /* Calculate T_ice (Marti and Mauersberger, 1993)... */
00923     if (ctl->qnt_tice >= 0)
00924       atm->q[ctl->qnt_tice][ip] =
00925         -2663.5 /
00926         (log10((ctl->psc_h2o > 0 ? ctl->psc_h2o : h2o) * atm->p[ip] * 100.) -
00927          12.537);
00928
00929     /* Calculate T_NAT (Hanson and Mauersberger, 1988)... */
00930     if (ctl->qnt_tnat >= 0) {
00931       double p_hno3;
00932       if (ctl->psc_hno3 > 0)
00933         p_hno3 = ctl->psc_hno3 * atm->p[ip] / 1.333224;
00934       else
00935         p_hno3 = clim_hno3(atm->time[ip], atm->lat[ip], atm->p[ip])
00936           * 1e-9 * atm->p[ip] / 1.333224;
00937       double p_h2o =
00938         (ctl->psc_h2o > 0 ? ctl->psc_h2o : h2o) * atm->p[ip] / 1.333224;
00939       double a = 0.009179 - 0.00088 * log10(p_h2o);
00940       double b = (38.9855 - log10(p_hno3) - 2.7836 * log10(p_h2o)) / a;
00941       double c = -11397.0 / a;
00942       double x1 = (-b + sqrt(b * b - 4. * c)) / 2.;
00943       double x2 = (-b - sqrt(b * b - 4. * c)) / 2.;
00944       if (x1 > 0)
00945         atm->q[ctl->qnt_tnat][ip] = x1;
00946       if (x2 > 0)
00947         atm->q[ctl->qnt_tnat][ip] = x2;
00948     }
00949
00950     /* Calculate T_STS (mean of T_ice and T_NAT)... */
00951     if (ctl->qnt_tsts >= 0) {
00952       atm->q[ctl->qnt_tsts][ip] = 0.5 * (atm->q[ctl->qnt_tice][ip]
00953                                          + atm->q[ctl->qnt_tnat][ip]);
00954     }
00955   }
00956 }
00957
00958 /*****************************************************************************/
00959
00960 void module_position(
00961   met_t * met0,
00962   met_t * met1,
00963   atm_t * atm,
00964   double *dt) {
00965
00966 #ifdef _OPENACC
00967 #pragma acc data present(met0,met1,atm,dt)
00968 #pragma acc parallel loop independent gang vector
00969 #else
00970 #pragma omp parallel for default(shared)
00971 #endif
00972   for (int ip = 0; ip < atm->np; ip++)
00973     if (dt[ip] != 0) {
00974
00975       double ps;
00976
00977       /* Calculate modulo... */
00978       atm->lon[ip] = FMOD(atm->lon[ip], 360.);
```

```
00979       atm->lat[ip] = FMOD(atm->lat[ip], 360.);
00980
00981       /* Check latitude... */
00982       while (atm->lat[ip] < -90 || atm->lat[ip] > 90) {
00983         if (atm->lat[ip] > 90) {
00984           atm->lat[ip] = 180 - atm->lat[ip];
00985           atm->lon[ip] += 180;
00986         }
00987         if (atm->lat[ip] < -90) {
00988           atm->lat[ip] = -180 - atm->lat[ip];
00989           atm->lon[ip] += 180;
00990         }
00991       }
00992
00993       /* Check longitude... */
00994       while (atm->lon[ip] < -180)
00995         atm->lon[ip] += 360;
00996       while (atm->lon[ip] >= 180)
00997         atm->lon[ip] -= 360;
00998
00999       /* Check pressure... */
01000       if (atm->p[ip] < met0->p[met0->np - 1])
01001         atm->p[ip] = met0->p[met0->np - 1];
01002       else if (atm->p[ip] > 300.) {
01003         intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
01004                         atm->lon[ip], atm->lat[ip], &ps, NULL, NULL, NULL,
01005                         NULL, NULL, NULL, NULL, NULL, NULL);
01006         if (atm->p[ip] > ps)
01007           atm->p[ip] = ps;
01008       }
01009     }
01010 }
01011
01012 /*****************************************************************************/
01013
01014 void module_sedi(
01015   ctl_t * ctl,
01016   met_t * met0,
01017   met_t * met1,
01018   atm_t * atm,
01019   double *dt) {
01020
01021 #ifdef _OPENACC
01022 #pragma acc data present(ctl,met0,met1,atm,dt)
01023 #pragma acc parallel loop independent gang vector
01024 #else
01025 #pragma omp parallel for default(shared)
01026 #endif
01027   for (int ip = 0; ip < atm->np; ip++)
01028     if (dt[ip] != 0) {
01029
01030       /* Coefficients for Cunningham slip-flow correction (Kasten, 1968): */
01031       const double A = 1.249, B = 0.42, C = 0.87;
01032
01033       /* Average mass of an air molecule [kg/molec]: */
01034       const double m = 4.8096e-26;
01035
01036       double G, K, eta, lambda, p, r_p, rho, rho_p, T, v, v_p;
01037
01038       /* Convert units... */
01039       p = 100 * atm->p[ip];
01040       r_p = 1e-6 * atm->q[ctl->qnt_r][ip];
01041       rho_p = atm->q[ctl->qnt_rho][ip];
01042
01043       /* Get temperature... */
01044       intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
     lon[ip],
01045                       atm->lat[ip], NULL, NULL, NULL, &T,
01046                       NULL, NULL, NULL, NULL, NULL, NULL);
01047
01048       /* Density of dry air... */
01049       rho = p / (RA * T);
01050
01051       /* Dynamic viscosity of air... */
01052       eta = 1.8325e-5 * (416.16 / (T + 120.)) * pow(T / 296.16, 1.5);
01053
01054       /* Thermal velocity of an air molecule... */
01055       v = sqrt(8 * KB * T / (M_PI * m));
01056
01057       /* Mean free path of an air molecule... */
01058       lambda = 2 * eta / (rho * v);
01059
01060       /* Knudsen number for air... */
01061       K = lambda / r_p;
01062
01063       /* Cunningham slip-flow correction... */
01064       G = 1 + K * (A + B * exp(-C / K));
```

```
01065
01066       /* Sedimentation (fall) velocity... */
01067       v_p = 2. * SQR(r_p) * (rho_p - rho) * G0 / (9. * eta) * G;
01068
01069       /* Calculate pressure change... */
01070       atm->p[ip] += DZ2DP(v_p * dt[ip] / 1000., atm->p[ip]);
01071     }
01072 }
01073
01074 /*****************************************************************************/
01075
01076 void write_output(
01077   const char *dirname,
01078   ctl_t * ctl,
01079   met_t * met0,
01080   met_t * met1,
01081   atm_t * atm,
01082   double t) {
01083
01084   char filename[2 * LEN];
01085
01086   double r;
01087
01088   int year, mon, day, hour, min, sec, updated = 0;
01089
01090   /* Get time... */
01091   jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01092
01093   /* Write atmospheric data... */
01094   if (ctl->atm_basename[0] != '-' && fmod(t, ctl->atm_dt_out) == 0) {
01095     if (!updated) {
01096 #ifdef _OPENACC
01097 #pragma acc update host(atm[:1])
01098 #endif
01099       updated = 1;
01100     }
01101     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
01102             dirname, ctl->atm_basename, year, mon, day, hour, min);
01103     write_atm(filename, ctl, atm, t);
01104   }
01105
01106   /* Write gridded data... */
01107   if (ctl->grid_basename[0] != '-' && fmod(t, ctl->grid_dt_out) == 0) {
01108     if (!updated) {
01109 #ifdef _OPENACC
01110 #pragma acc update host(atm[:1])
01111 #endif
01112       updated = 1;
01113     }
01114     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
01115             dirname, ctl->grid_basename, year, mon, day, hour, min);
01116     write_grid(filename, ctl, met0, met1, atm, t);
01117   }
01118
01119   /* Write CSI data... */
01120   if (ctl->csi_basename[0] != '-') {
01121     if (!updated) {
01122 #ifdef _OPENACC
01123 #pragma acc update host(atm[:1])
01124 #endif
01125       updated = 1;
01126     }
01127     sprintf(filename, "%s/%s.tab", dirname, ctl->csi_basename);
01128     write_csi(filename, ctl, atm, t);
01129   }
01130
01131   /* Write ensemble data... */
01132   if (ctl->ens_basename[0] != '-') {
01133     if (!updated) {
01134 #ifdef _OPENACC
01135 #pragma acc update host(atm[:1])
01136 #endif
01137       updated = 1;
01138     }
01139     sprintf(filename, "%s/%s.tab", dirname, ctl->ens_basename);
01140     write_ens(filename, ctl, atm, t);
01141   }
01142
01143   /* Write profile data... */
01144   if (ctl->prof_basename[0] != '-') {
01145     if (!updated) {
01146 #ifdef _OPENACC
01147 #pragma acc update host(atm[:1])
01148 #endif
01149       updated = 1;
01150     }
01151     sprintf(filename, "%s/%s.tab", dirname, ctl->prof_basename);
```

```
01152     write_prof(filename, ctl, met0, met1, atm, t);
01153   }
01154
01155   /* Write station data... */
01156   if (ctl->stat_basename[0] != '-') {
01157     if (!updated) {
01158 #ifdef _OPENACC
01159 #pragma acc update host(atm[:1])
01160 #endif
01161       updated = 1;
01162     }
01163     sprintf(filename, "%s/%s.tab", dirname, ctl->stat_basename);
01164     write_station(filename, ctl, atm, t);
01165   }
01166 }
```

5.35 tropo.c File Reference

Create tropopause climatology from meteorological data.

Functions

- void add_text_attribute (int ncid, char *varname, char *attrname, char *text)
- int main (int argc, char *argv[ ])

5.35.1 Detailed Description

Create tropopause climatology from meteorological data.

Definition in file tropo.c.

5.35.2 Function Documentation

5.35.2.1 void add_text_attribute (int *ncid,* char * *varname,* char * *attrname,* char * *text*)

Definition at line 322 of file tropo.c.

```
00326               {
00327
00328   int varid;
00329
00330   NC(nc_inq_varid(ncid, varname, &varid));
00331   NC(nc_put_att_text(ncid, varid, attrname, strlen(text), text));
00332 }
```

5.35.2.2 int main (int *argc*, char * *argv[]*)

Definition at line 51 of file tropo.c.

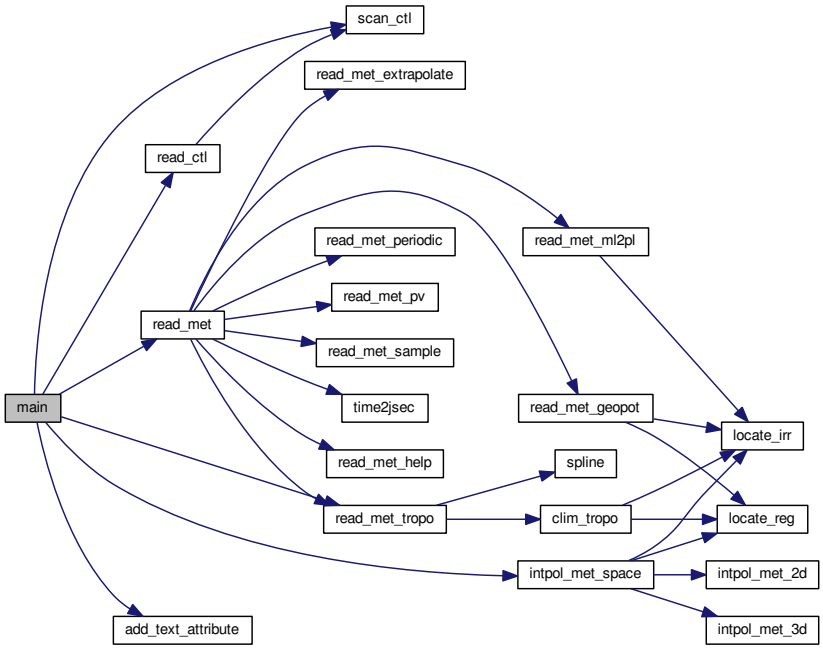
```
00053                {
00054
00055   ctl_t ctl;
00056
00057   met_t *met;
00058
00059   static double pt[NX * NY], qt[NX * NY], zt[NX * NY], tt[NX * NY], lon, lon0,
00060     lon1, lons[NX], dlon, lat, lat0, lat1, lats[NY], dlat;
00061
00062   static int init, i, ix, iy, nx, ny, nt, ncid, dims[3], timid, lonid, latid,
00063     clppid, clpqid, clptid, clpzid, dynpid, dynqid, dyntid, dynzid, wmo1pid,
00064     wmo1qid, wmo1tid, wmo1zid, wmo2pid, wmo2qid, wmo2tid, wmo2zid;
00065
00066   static size_t count[10], start[10];
00067
00068   /* Allocate... */
00069   ALLOC(met, met_t, 1);
00070
00071   /* Check arguments... */
00072   if (argc < 4)
00073     ERRMSG("Give parameters: <ctl> <tropo.nc> <met0> [ <met1> ... ]");
00074
00075   /* Read control parameters... */
00076   read_ctl(argv[1], argc, argv, &ctl);
00077   lon0 = scan_ctl(argv[1], argc, argv, "MAP_LON0", -1, "-180", NULL);
00078   lon1 = scan_ctl(argv[1], argc, argv, "MAP_LON1", -1, "180", NULL);
00079   dlon = scan_ctl(argv[1], argc, argv, "MAP_DLON", -1, "-999", NULL);
00080   lat0 = scan_ctl(argv[1], argc, argv, "MAP_LAT0", -1, "-90", NULL);
00081   lat1 = scan_ctl(argv[1], argc, argv, "MAP_LAT1", -1, "90", NULL);
00082   dlat = scan_ctl(argv[1], argc, argv, "MAP_DLAT", -1, "-999", NULL);
00083
00084   /* Loop over files... */
00085   for (i = 3; i < argc; i++) {
00086
00087     /* Read meteorological data... */
00088     ctl.met_tropo = 0;
00089     if (!read_met(&ctl, argv[i], met))
00090       continue;
00091
00092     /* Set horizontal grid... */
00093     if (!init) {
00094       init = 1;
00095
00096       /* get grid... */
00097       if (dlon <= 0)
00098         dlon = fabs(met->lon[1] - met->lon[0]);
00099       if (dlat <= 0)
00100         dlat = fabs(met->lat[1] - met->lat[0]);
00101       if (lon0 < -360 && lon1 > 360) {
00102         lon0 = gsl_stats_min(met->lon, 1, (size_t) met->nx);
00103         lon1 = gsl_stats_max(met->lon, 1, (size_t) met->nx);
00104       }
00105       nx = ny = 0;
00106       for (lon = lon0; lon <= lon1; lon += dlon) {
00107         lons[nx] = lon;
00108         if ((++nx) > NX)
00109           ERRMSG("Too many longitudes!");
00110       }
00111       if (lat0 < -90 && lat1 > 90) {
00112         lat0 = gsl_stats_min(met->lat, 1, (size_t) met->ny);
00113         lat1 = gsl_stats_max(met->lat, 1, (size_t) met->ny);
00114       }
00115       for (lat = lat0; lat <= lat1; lat += dlat) {
00116         lats[ny] = lat;
00117         if ((++ny) > NY)
00118           ERRMSG("Too many latitudes!");
00119       }
00120
00121       /* Create netCDF file... */
00122       printf("Write tropopause data file: %s\n", argv[2]);
00123       NC(nc_create(argv[2], NC_CLOBBER, &ncid));
00124
00125       /* Create dimensions... */
00126       NC(nc_def_dim(ncid, "time", (size_t) NC_UNLIMITED, &dims[0]));
00127       NC(nc_def_dim(ncid, "lat", (size_t) ny, &dims[1]));
00128       NC(nc_def_dim(ncid, "lon", (size_t) nx, &dims[2]));
00129
00130       /* Create variables... */
00131       NC(nc_def_var(ncid, "time", NC_DOUBLE, 1, &dims[0], &timid));
00132       NC(nc_def_var(ncid, "lat", NC_DOUBLE, 1, &dims[1], &latid));
```

```
00133       NC(nc_def_var(ncid, "lon", NC_DOUBLE, 1, &dims[2], &lonid));
00134       NC(nc_def_var(ncid, "clp_z", NC_FLOAT, 3, &dims[0], &clpzid));
00135       NC(nc_def_var(ncid, "clp_p", NC_FLOAT, 3, &dims[0], &clppid));
00136       NC(nc_def_var(ncid, "clp_t", NC_FLOAT, 3, &dims[0], &clptid));
00137       NC(nc_def_var(ncid, "clp_q", NC_FLOAT, 3, &dims[0], &clpqid));
00138       NC(nc_def_var(ncid, "dyn_z", NC_FLOAT, 3, &dims[0], &dynzid));
00139       NC(nc_def_var(ncid, "dyn_p", NC_FLOAT, 3, &dims[0], &dynpid));
00140       NC(nc_def_var(ncid, "dyn_t", NC_FLOAT, 3, &dims[0], &dyntid));
00141       NC(nc_def_var(ncid, "dyn_q", NC_FLOAT, 3, &dims[0], &dynqid));
00142       NC(nc_def_var(ncid, "wmo_1st_z", NC_FLOAT, 3, &dims[0], &wmo1zid));
00143       NC(nc_def_var(ncid, "wmo_1st_p", NC_FLOAT, 3, &dims[0], &wmo1pid));
00144       NC(nc_def_var(ncid, "wmo_1st_t", NC_FLOAT, 3, &dims[0], &wmo1tid));
00145       NC(nc_def_var(ncid, "wmo_1st_q", NC_FLOAT, 3, &dims[0], &wmo1qid));
00146       NC(nc_def_var(ncid, "wmo_2nd_z", NC_FLOAT, 3, &dims[0], &wmo2zid));
00147       NC(nc_def_var(ncid, "wmo_2nd_p", NC_FLOAT, 3, &dims[0], &wmo2pid));
00148       NC(nc_def_var(ncid, "wmo_2nd_t", NC_FLOAT, 3, &dims[0], &wmo2tid));
00149       NC(nc_def_var(ncid, "wmo_2nd_q", NC_FLOAT, 3, &dims[0], &wmo2qid));
00150
00151       /* Set attributes... */
00152       add_text_attribute(ncid, "time", "units", "s");
00153       add_text_attribute(ncid, "time", "long_name",
00154                          "seconds since 2000-01-01, 00:00 UTC");
00155       add_text_attribute(ncid, "lon", "units", "degrees_east");
00156       add_text_attribute(ncid, "lon", "long_name", "longitude");
00157       add_text_attribute(ncid, "lat", "units", "degrees_north");
00158       add_text_attribute(ncid, "lat", "long_name", "latitude");
00159
00160       add_text_attribute(ncid, "clp_z", "units", "km");
00161       add_text_attribute(ncid, "clp_z", "long_name", "cold point height");
00162       add_text_attribute(ncid, "clp_p", "units", "hPa");
00163       add_text_attribute(ncid, "clp_p", "long_name", "cold point pressure");
00164       add_text_attribute(ncid, "clp_t", "units", "K");
00165       add_text_attribute(ncid, "clp_t", "long_name",
00166                          "cold point temperature");
00167       add_text_attribute(ncid, "clp_q", "units", "ppv");
00168       add_text_attribute(ncid, "clp_q", "long_name",
00169                          "cold point water vapor");
00170
00171       add_text_attribute(ncid, "dyn_z", "units", "km");
00172       add_text_attribute(ncid, "dyn_z", "long_name",
00173                          "dynamical tropopause height");
00174       add_text_attribute(ncid, "dyn_p", "units", "hPa");
00175       add_text_attribute(ncid, "dyn_p", "long_name",
00176                          "dynamical tropopause pressure");
00177       add_text_attribute(ncid, "dyn_t", "units", "K");
00178       add_text_attribute(ncid, "dyn_t", "long_name",
00179                          "dynamical tropopause temperature");
00180       add_text_attribute(ncid, "dyn_q", "units", "ppv");
00181       add_text_attribute(ncid, "dyn_q", "long_name",
00182                          "dynamical tropopause water vapor");
00183
00184       add_text_attribute(ncid, "wmo_1st_z", "units", "km");
00185       add_text_attribute(ncid, "wmo_1st_z", "long_name",
00186                          "WMO 1st tropopause height");
00187       add_text_attribute(ncid, "wmo_1st_p", "units", "hPa");
00188       add_text_attribute(ncid, "wmo_1st_p", "long_name",
00189                          "WMO 1st tropopause pressure");
00190       add_text_attribute(ncid, "wmo_1st_t", "units", "K");
00191       add_text_attribute(ncid, "wmo_1st_t", "long_name",
00192                          "WMO 1st tropopause temperature");
00193       add_text_attribute(ncid, "wmo_1st_q", "units", "ppv");
00194       add_text_attribute(ncid, "wmo_1st_q", "long_name",
00195                          "WMO 1st tropopause water vapor");
00196
00197       add_text_attribute(ncid, "wmo_2nd_z", "units", "km");
00198       add_text_attribute(ncid, "wmo_2nd_z", "long_name",
00199                          "WMO 2nd tropopause height");
00200       add_text_attribute(ncid, "wmo_2nd_p", "units", "hPa");
00201       add_text_attribute(ncid, "wmo_2nd_p", "long_name",
00202                          "WMO 2nd tropopause pressure");
00203       add_text_attribute(ncid, "wmo_2nd_t", "units", "K");
00204       add_text_attribute(ncid, "wmo_2nd_t", "long_name",
00205                          "WMO 2nd tropopause temperature");
00206       add_text_attribute(ncid, "wmo_2nd_q", "units", "ppv");
00207       add_text_attribute(ncid, "wmo_2nd_q", "long_name",
00208                          "WMO 2nd tropopause water vapor");
00209
00210       /* End definition... */
00211       NC(nc_enddef(ncid));
00212
00213       /* Write longitude and latitude... */
00214       NC(nc_put_var_double(ncid, latid, lats));
00215       NC(nc_put_var_double(ncid, lonid, lons));
00216     }
00217
00218     /* Write time... */
00219     start[0] = (size_t) nt;
```

```
00220     count[0] = 1;
00221     start[1] = 0;
00222     count[1] = (size_t) ny;
00223     start[2] = 0;
00224     count[2] = (size_t) nx;
00225     NC(nc_put_vara_double(ncid, timid, start, count, &met->time));
00226
00227     /* Get cold point... */
00228     ctl.met_tropo = 2;
00229     read_met_tropo(&ctl, met);
00230 #pragma omp parallel for default(shared) private(ix,iy)
00231     for (ix = 0; ix < nx; ix++)
00232       for (iy = 0; iy < ny; iy++) {
00233         intpol_met_space(met, 100, lons[ix], lats[iy], NULL,
00234                          &pt[iy * nx + ix], NULL, NULL, NULL,
00235                          NULL, NULL, NULL, NULL, NULL);
00236         intpol_met_space(met, pt[iy * nx + ix], lons[ix], lats[iy],
00237                          NULL, NULL, &zt[iy * nx + ix], &tt[iy * nx + ix],
00238                          NULL, NULL, NULL, NULL, &qt[iy * nx + ix], NULL);
00239       }
00240
00241     /* Write data... */
00242     NC(nc_put_vara_double(ncid, clpzid, start, count, zt));
00243     NC(nc_put_vara_double(ncid, clppid, start, count, pt));
00244     NC(nc_put_vara_double(ncid, clptid, start, count, tt));
00245     NC(nc_put_vara_double(ncid, clpqid, start, count, qt));
00246
00247     /* Get dynamical tropopause... */
00248     ctl.met_tropo = 5;
00249     read_met_tropo(&ctl, met);
00250 #pragma omp parallel for default(shared) private(ix,iy)
00251     for (ix = 0; ix < nx; ix++)
00252       for (iy = 0; iy < ny; iy++) {
00253         intpol_met_space(met, 100, lons[ix], lats[iy], NULL,
00254                          &pt[iy * nx + ix], NULL, NULL, NULL,
00255                          NULL, NULL, NULL, NULL, NULL);
00256         intpol_met_space(met, pt[iy * nx + ix], lons[ix], lats[iy],
00257                          NULL, NULL, &zt[iy * nx + ix], &tt[iy * nx + ix],
00258                          NULL, NULL, NULL, NULL, &qt[iy * nx + ix], NULL);
00259       }
00260
00261     /* Write data... */
00262     NC(nc_put_vara_double(ncid, dynzid, start, count, zt));
00263     NC(nc_put_vara_double(ncid, dynpid, start, count, pt));
00264     NC(nc_put_vara_double(ncid, dyntid, start, count, tt));
00265     NC(nc_put_vara_double(ncid, dynqid, start, count, qt));
00266
00267     /* Get WMO 1st tropopause... */
00268     ctl.met_tropo = 3;
00269     read_met_tropo(&ctl, met);
00270 #pragma omp parallel for default(shared) private(ix,iy)
00271     for (ix = 0; ix < nx; ix++)
00272       for (iy = 0; iy < ny; iy++) {
00273         intpol_met_space(met, 100, lons[ix], lats[iy], NULL,
00274                          &pt[iy * nx + ix], NULL, NULL, NULL,
00275                          NULL, NULL, NULL, NULL, NULL);
00276         intpol_met_space(met, pt[iy * nx + ix], lons[ix], lats[iy],
00277                          NULL, NULL, &zt[iy * nx + ix], &tt[iy * nx + ix],
00278                          NULL, NULL, NULL, NULL, &qt[iy * nx + ix], NULL);
00279       }
00280
00281     /* Write data... */
00282     NC(nc_put_vara_double(ncid, wmo1zid, start, count, zt));
00283     NC(nc_put_vara_double(ncid, wmo1pid, start, count, pt));
00284     NC(nc_put_vara_double(ncid, wmo1tid, start, count, tt));
00285     NC(nc_put_vara_double(ncid, wmo1qid, start, count, qt));
00286
00287     /* Get WMO 2nd tropopause... */
00288     ctl.met_tropo = 4;
00289     read_met_tropo(&ctl, met);
00290 #pragma omp parallel for default(shared) private(ix,iy)
00291     for (ix = 0; ix < nx; ix++)
00292       for (iy = 0; iy < ny; iy++) {
00293         intpol_met_space(met, 100, lons[ix], lats[iy], NULL,
00294                          &pt[iy * nx + ix], NULL, NULL, NULL,
00295                          NULL, NULL, NULL, NULL, NULL);
00296         intpol_met_space(met, pt[iy * nx + ix], lons[ix], lats[iy],
00297                          NULL, NULL, &zt[iy * nx + ix], &tt[iy * nx + ix],
00298                          NULL, NULL, NULL, NULL, &qt[iy * nx + ix], NULL);
00299       }
00300
00301     /* Write data... */
00302     NC(nc_put_vara_double(ncid, wmo2zid, start, count, zt));
00303     NC(nc_put_vara_double(ncid, wmo2pid, start, count, pt));
00304     NC(nc_put_vara_double(ncid, wmo2tid, start, count, tt));
00305     NC(nc_put_vara_double(ncid, wmo2qid, start, count, qt));
00306
```

```
00307     /* Increment time step counter... */
00308     nt++;
00309   }
00310
00311   /* Close file... */
00312   NC(nc_close(ncid));
00313
00314   /* Free... */
00315   free(met);
00316
00317   return EXIT_SUCCESS;
00318 }
```

Here is the call graph for this function:



5.36 tropo.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 /* ------------------------------------------------------------
00028    Dimensions...
00029    ------------------------------------------------------------ */
00030
```

```
00032 #define NX 1441
00033
00035 #define NY 721
00036
00037 /* ------------------------------------------------------------
00038    Functions...
00039    ------------------------------------------------------------ */
00040
00041 void add_text_attribute(
00042   int ncid,
00043   char *varname,
00044   char *attrname,
00045   char *text);
00046
00047 /* ------------------------------------------------------------
00048    Main...
00049    ------------------------------------------------------------ */
00050
00051 int main(
00052   int argc,
00053   char *argv[]) {
00054
00055   ctl_t ctl;
00056
00057   met_t *met;
00058
00059   static double pt[NX * NY], qt[NX * NY], zt[NX * NY], tt[NX * NY], lon, lon0,
00060     lon1, lons[NX], dlon, lat, lat0, lat1, lats[NY], dlat;
00061
00062   static int init, i, ix, iy, nx, ny, nt, ncid, dims[3], timid, lonid, latid,
00063     clppid, clpqid, clptid, clpzid, dynpid, dynqid, dyntid, dynzid, wmo1pid,
00064     wmo1qid, wmo1tid, wmo1zid, wmo2pid, wmo2qid, wmo2tid, wmo2zid;
00065
00066   static size_t count[10], start[10];
00067
00068   /* Allocate... */
00069   ALLOC(met, met_t, 1);
00070
00071   /* Check arguments... */
00072   if (argc < 4)
00073     ERRMSG("Give parameters: <ctl> <tropo.nc> <met0> [ <met1> ... ]");
00074
00075   /* Read control parameters... */
00076   read_ctl(argv[1], argc, argv, &ctl);
00077   lon0 = scan_ctl(argv[1], argc, argv, "MAP_LON0", -1, "-180", NULL);
00078   lon1 = scan_ctl(argv[1], argc, argv, "MAP_LON1", -1, "180", NULL);
00079   dlon = scan_ctl(argv[1], argc, argv, "MAP_DLON", -1, "-999", NULL);
00080   lat0 = scan_ctl(argv[1], argc, argv, "MAP_LAT0", -1, "-90", NULL);
00081   lat1 = scan_ctl(argv[1], argc, argv, "MAP_LAT1", -1, "90", NULL);
00082   dlat = scan_ctl(argv[1], argc, argv, "MAP_DLAT", -1, "-999", NULL);
00083
00084   /* Loop over files... */
00085   for (i = 3; i < argc; i++) {
00086
00087     /* Read meteorological data... */
00088     ctl.met_tropo = 0;
00089     if (!read_met(&ctl, argv[i], met))
00090       continue;
00091
00092     /* Set horizontal grid... */
00093     if (!init) {
00094       init = 1;
00095
00096       /* get grid... */
00097       if (dlon <= 0)
00098         dlon = fabs(met->lon[1] - met->lon[0]);
00099       if (dlat <= 0)
00100         dlat = fabs(met->lat[1] - met->lat[0]);
00101       if (lon0 < -360 && lon1 > 360) {
00102         lon0 = gsl_stats_min(met->lon, 1, (size_t) met->nx);
00103         lon1 = gsl_stats_max(met->lon, 1, (size_t) met->nx);
00104       }
00105       nx = ny = 0;
00106       for (lon = lon0; lon <= lon1; lon += dlon) {
00107         lons[nx] = lon;
00108         if ((++nx) > NX)
00109           ERRMSG("Too many longitudes!");
00110       }
00111       if (lat0 < -90 && lat1 > 90) {
00112         lat0 = gsl_stats_min(met->lat, 1, (size_t) met->ny);
00113         lat1 = gsl_stats_max(met->lat, 1, (size_t) met->ny);
00114       }
00115       for (lat = lat0; lat <= lat1; lat += dlat) {
00116         lats[ny] = lat;
00117         if ((++ny) > NY)
00118           ERRMSG("Too many latitudes!");
00119       }
```

```
00120
00121       /* Create netCDF file... */
00122       printf("Write tropopause data file: %s\n", argv[2]);
00123       NC(nc_create(argv[2], NC_CLOBBER, &ncid));
00124
00125       /* Create dimensions... */
00126       NC(nc_def_dim(ncid, "time", (size_t) NC_UNLIMITED, &dims[0]));
00127       NC(nc_def_dim(ncid, "lat", (size_t) ny, &dims[1]));
00128       NC(nc_def_dim(ncid, "lon", (size_t) nx, &dims[2]));
00129
00130       /* Create variables... */
00131       NC(nc_def_var(ncid, "time", NC_DOUBLE, 1, &dims[0], &timid));
00132       NC(nc_def_var(ncid, "lat", NC_DOUBLE, 1, &dims[1], &latid));
00133       NC(nc_def_var(ncid, "lon", NC_DOUBLE, 1, &dims[2], &lonid));
00134       NC(nc_def_var(ncid, "clp_z", NC_FLOAT, 3, &dims[0], &clpzid));
00135       NC(nc_def_var(ncid, "clp_p", NC_FLOAT, 3, &dims[0], &clppid));
00136       NC(nc_def_var(ncid, "clp_t", NC_FLOAT, 3, &dims[0], &clptid));
00137       NC(nc_def_var(ncid, "clp_q", NC_FLOAT, 3, &dims[0], &clpqid));
00138       NC(nc_def_var(ncid, "dyn_z", NC_FLOAT, 3, &dims[0], &dynzid));
00139       NC(nc_def_var(ncid, "dyn_p", NC_FLOAT, 3, &dims[0], &dynpid));
00140       NC(nc_def_var(ncid, "dyn_t", NC_FLOAT, 3, &dims[0], &dyntid));
00141       NC(nc_def_var(ncid, "dyn_q", NC_FLOAT, 3, &dims[0], &dynqid));
00142       NC(nc_def_var(ncid, "wmo_1st_z", NC_FLOAT, 3, &dims[0], &wmo1zid));
00143       NC(nc_def_var(ncid, "wmo_1st_p", NC_FLOAT, 3, &dims[0], &wmo1pid));
00144       NC(nc_def_var(ncid, "wmo_1st_t", NC_FLOAT, 3, &dims[0], &wmo1tid));
00145       NC(nc_def_var(ncid, "wmo_1st_q", NC_FLOAT, 3, &dims[0], &wmo1qid));
00146       NC(nc_def_var(ncid, "wmo_2nd_z", NC_FLOAT, 3, &dims[0], &wmo2zid));
00147       NC(nc_def_var(ncid, "wmo_2nd_p", NC_FLOAT, 3, &dims[0], &wmo2pid));
00148       NC(nc_def_var(ncid, "wmo_2nd_t", NC_FLOAT, 3, &dims[0], &wmo2tid));
00149       NC(nc_def_var(ncid, "wmo_2nd_q", NC_FLOAT, 3, &dims[0], &wmo2qid));
00150
00151       /* Set attributes... */
00152       add_text_attribute(ncid, "time", "units", "s");
00153       add_text_attribute(ncid, "time", "long_name",
00154                          "seconds since 2000-01-01, 00:00 UTC");
00155       add_text_attribute(ncid, "lon", "units", "degrees_east");
00156       add_text_attribute(ncid, "lon", "long_name", "longitude");
00157       add_text_attribute(ncid, "lat", "units", "degrees_north");
00158       add_text_attribute(ncid, "lat", "long_name", "latitude");
00159
00160       add_text_attribute(ncid, "clp_z", "units", "km");
00161       add_text_attribute(ncid, "clp_z", "long_name", "cold point height");
00162       add_text_attribute(ncid, "clp_p", "units", "hPa");
00163       add_text_attribute(ncid, "clp_p", "long_name", "cold point pressure");
00164       add_text_attribute(ncid, "clp_t", "units", "K");
00165       add_text_attribute(ncid, "clp_t", "long_name",
00166                          "cold point temperature");
00167       add_text_attribute(ncid, "clp_q", "units", "ppv");
00168       add_text_attribute(ncid, "clp_q", "long_name",
00169                          "cold point water vapor");
00170
00171       add_text_attribute(ncid, "dyn_z", "units", "km");
00172       add_text_attribute(ncid, "dyn_z", "long_name",
00173                          "dynamical tropopause height");
00174       add_text_attribute(ncid, "dyn_p", "units", "hPa");
00175       add_text_attribute(ncid, "dyn_p", "long_name",
00176                          "dynamical tropopause pressure");
00177       add_text_attribute(ncid, "dyn_t", "units", "K");
00178       add_text_attribute(ncid, "dyn_t", "long_name",
00179                          "dynamical tropopause temperature");
00180       add_text_attribute(ncid, "dyn_q", "units", "ppv");
00181       add_text_attribute(ncid, "dyn_q", "long_name",
00182                          "dynamical tropopause water vapor");
00183
00184       add_text_attribute(ncid, "wmo_1st_z", "units", "km");
00185       add_text_attribute(ncid, "wmo_1st_z", "long_name",
00186                          "WMO 1st tropopause height");
00187       add_text_attribute(ncid, "wmo_1st_p", "units", "hPa");
00188       add_text_attribute(ncid, "wmo_1st_p", "long_name",
00189                          "WMO 1st tropopause pressure");
00190       add_text_attribute(ncid, "wmo_1st_t", "units", "K");
00191       add_text_attribute(ncid, "wmo_1st_t", "long_name",
00192                          "WMO 1st tropopause temperature");
00193       add_text_attribute(ncid, "wmo_1st_q", "units", "ppv");
00194       add_text_attribute(ncid, "wmo_1st_q", "long_name",
00195                          "WMO 1st tropopause water vapor");
00196
00197       add_text_attribute(ncid, "wmo_2nd_z", "units", "km");
00198       add_text_attribute(ncid, "wmo_2nd_z", "long_name",
00199                          "WMO 2nd tropopause height");
00200       add_text_attribute(ncid, "wmo_2nd_p", "units", "hPa");
00201       add_text_attribute(ncid, "wmo_2nd_p", "long_name",
00202                          "WMO 2nd tropopause pressure");
00203       add_text_attribute(ncid, "wmo_2nd_t", "units", "K");
00204       add_text_attribute(ncid, "wmo_2nd_t", "long_name",
00205                          "WMO 2nd tropopause temperature");
00206       add_text_attribute(ncid, "wmo_2nd_q", "units", "ppv");
```

```
00207       add_text_attribute(ncid, "wmo_2nd_q", "long_name",
00208                          "WMO 2nd tropopause water vapor");
00209
00210       /* End definition... */
00211       NC(nc_enddef(ncid));
00212
00213       /* Write longitude and latitude... */
00214       NC(nc_put_var_double(ncid, latid, lats));
00215       NC(nc_put_var_double(ncid, lonid, lons));
00216     }
00217
00218     /* Write time... */
00219     start[0] = (size_t) nt;
00220     count[0] = 1;
00221     start[1] = 0;
00222     count[1] = (size_t) ny;
00223     start[2] = 0;
00224     count[2] = (size_t) nx;
00225     NC(nc_put_vara_double(ncid, timid, start, count, &met->time));
00226
00227     /* Get cold point... */
00228     ctl.met_tropo = 2;
00229     read_met_tropo(&ctl, met);
00230 #pragma omp parallel for default(shared) private(ix,iy)
00231     for (ix = 0; ix < nx; ix++)
00232       for (iy = 0; iy < ny; iy++) {
00233         intpol_met_space(met, 100, lons[ix], lats[iy], NULL,
00234                          &pt[iy * nx + ix], NULL, NULL, NULL,
00235                          NULL, NULL, NULL, NULL, NULL);
00236         intpol_met_space(met, pt[iy * nx + ix], lons[ix], lats[iy],
00237                          NULL, NULL, &zt[iy * nx + ix], &tt[iy * nx + ix],
00238                          NULL, NULL, NULL, NULL, &qt[iy * nx + ix], NULL);
00239       }
00240
00241     /* Write data... */
00242     NC(nc_put_vara_double(ncid, clpzid, start, count, zt));
00243     NC(nc_put_vara_double(ncid, clppid, start, count, pt));
00244     NC(nc_put_vara_double(ncid, clptid, start, count, tt));
00245     NC(nc_put_vara_double(ncid, clpqid, start, count, qt));
00246
00247     /* Get dynamical tropopause... */
00248     ctl.met_tropo = 5;
00249     read_met_tropo(&ctl, met);
00250 #pragma omp parallel for default(shared) private(ix,iy)
00251     for (ix = 0; ix < nx; ix++)
00252       for (iy = 0; iy < ny; iy++) {
00253         intpol_met_space(met, 100, lons[ix], lats[iy], NULL,
00254                          &pt[iy * nx + ix], NULL, NULL, NULL,
00255                          NULL, NULL, NULL, NULL, NULL);
00256         intpol_met_space(met, pt[iy * nx + ix], lons[ix], lats[iy],
00257                          NULL, NULL, &zt[iy * nx + ix], &tt[iy * nx + ix],
00258                          NULL, NULL, NULL, NULL, &qt[iy * nx + ix], NULL);
00259       }
00260
00261     /* Write data... */
00262     NC(nc_put_vara_double(ncid, dynzid, start, count, zt));
00263     NC(nc_put_vara_double(ncid, dynpid, start, count, pt));
00264     NC(nc_put_vara_double(ncid, dyntid, start, count, tt));
00265     NC(nc_put_vara_double(ncid, dynqid, start, count, qt));
00266
00267     /* Get WMO 1st tropopause... */
00268     ctl.met_tropo = 3;
00269     read_met_tropo(&ctl, met);
00270 #pragma omp parallel for default(shared) private(ix,iy)
00271     for (ix = 0; ix < nx; ix++)
00272       for (iy = 0; iy < ny; iy++) {
00273         intpol_met_space(met, 100, lons[ix], lats[iy], NULL,
00274                          &pt[iy * nx + ix], NULL, NULL, NULL,
00275                          NULL, NULL, NULL, NULL, NULL);
00276         intpol_met_space(met, pt[iy * nx + ix], lons[ix], lats[iy],
00277                          NULL, NULL, &zt[iy * nx + ix], &tt[iy * nx + ix],
00278                          NULL, NULL, NULL, NULL, &qt[iy * nx + ix], NULL);
00279       }
00280
00281     /* Write data... */
00282     NC(nc_put_vara_double(ncid, wmo1zid, start, count, zt));
00283     NC(nc_put_vara_double(ncid, wmo1pid, start, count, pt));
00284     NC(nc_put_vara_double(ncid, wmo1tid, start, count, tt));
00285     NC(nc_put_vara_double(ncid, wmo1qid, start, count, qt));
00286
00287     /* Get WMO 2nd tropopause... */
00288     ctl.met_tropo = 4;
00289     read_met_tropo(&ctl, met);
00290 #pragma omp parallel for default(shared) private(ix,iy)
00291     for (ix = 0; ix < nx; ix++)
00292       for (iy = 0; iy < ny; iy++) {
00293         intpol_met_space(met, 100, lons[ix], lats[iy], NULL,
```

```
00294                         &pt[iy * nx + ix], NULL, NULL, NULL,
00295                         NULL, NULL, NULL, NULL, NULL);
00296         intpol_met_space(met, pt[iy * nx + ix], lons[ix], lats[iy],
00297                         NULL, NULL, &zt[iy * nx + ix], &tt[iy * nx + ix],
00298                         NULL, NULL, NULL, NULL, &qt[iy * nx + ix], NULL);
00299       }
00300
00301     /* Write data... */
00302     NC(nc_put_vara_double(ncid, wmo2zid, start, count, zt));
00303     NC(nc_put_vara_double(ncid, wmo2pid, start, count, pt));
00304     NC(nc_put_vara_double(ncid, wmo2tid, start, count, tt));
00305     NC(nc_put_vara_double(ncid, wmo2qid, start, count, qt));
00306
00307     /* Increment time step counter... */
00308     nt++;
00309   }
00310
00311   /* Close file... */
00312   NC(nc_close(ncid));
00313
00314   /* Free... */
00315   free(met);
00316
00317   return EXIT_SUCCESS;
00318 }
00319
00320 /*****************************************************************************/
00321
00322 void add_text_attribute(
00323   int ncid,
00324   char *varname,
00325   char *attrname,
00326   char *text) {
00327
00328   int varid;
00329
00330   NC(nc_inq_varid(ncid, varname, &varid));
00331   NC(nc_put_att_text(ncid, varid, attrname, strlen(text), text));
00332 }
```

5.37 tropo_sample.c File Reference

Sample tropopause climatology.

Functions

- double intpol_tropo_2d (float array[NX][NY], double lons[NX], double lats[NY], size_t nlon, size_t nlat, double lon, double lat)
- int main (int argc, char ∗argv[ ])

5.37.1 Detailed Description

Sample tropopause climatology.

Definition in file tropo_sample.c.

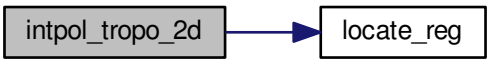
5.37.2 Function Documentation

5.37.2.1 double intpol_tropo_2d (float *array[NX][NY],* double *lons[NX],* double *lats[NY],* size_t *nlon,* size_t *nlat,* double *lon,* double *lat*)

Definition at line 256 of file tropo_sample.c.

```
00263             {
00264
00265   /* Get indices... */
00266   int ix = locate_reg(lons, (int) nlon, lon);
00267   int iy = locate_reg(lats, (int) nlat, lat);
00268
00269   /* Set variables... */
00270   double aux00 = array[ix][iy];
00271   double aux01 = array[ix][iy + 1];
00272   double aux10 = array[ix + 1][iy];
00273   double aux11 = array[ix + 1][iy + 1];
00274
00275   /* Interpolate horizontally... */
00276   aux00 = LIN(lats[iy], aux00, lats[iy + 1], aux01, lat);
00277   aux11 = LIN(lats[iy], aux10, lats[iy + 1], aux11, lat);
00278   return LIN(lons[ix], aux00, lons[ix + 1], aux11, lon);
00279 }
```

Here is the call graph for this function:



5.37.2.2 int main (int *argc*, char * *argv[]*)

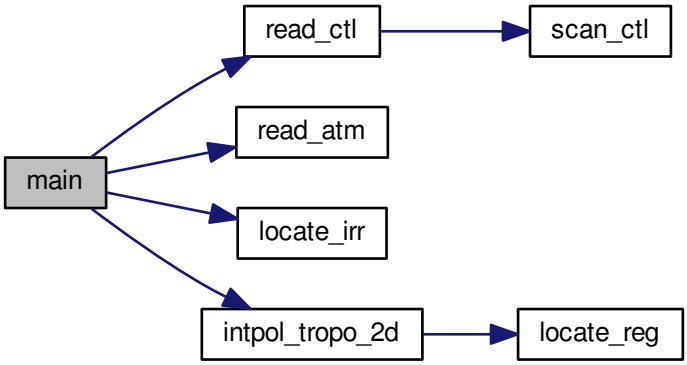
Definition at line 57 of file tropo_sample.c.

```
00059               {
00060
00061   ctl_t ctl;
00062
00063   atm_t *atm;
00064
00065   static FILE *out;
00066
00067   static char varname[LEN];
00068
00069   static double times[NT], lons[NX], lats[NY], time0, time1, z0, z1, p0, p1,
00070     t0, t1, q0, q1;
00071
00072   static float help[NX * NY], tropo_z0[NX][NY], tropo_z1[NX][NY],
00073     tropo_p0[NX][NY], tropo_p1[NX][NY], tropo_t0[NX][NY],
00074     tropo_t1[NX][NY], tropo_q0[NX][NY], tropo_q1[NX][NY];
00075
00076   static int ip, iq, it, it_old = -999, dimid[10], ncid,
00077     varid, varid_z, varid_p, varid_t, varid_q;
00078
00079   static size_t count[10], start[10], ntime, nlon, nlat, ilon, ilat;
00080
00081   /* Allocate... */
00082   ALLOC(atm, atm_t, 1);
00083
00084   /* Check arguments... */
00085   if (argc < 5)
00086     ERRMSG("Give parameters: <ctl> <sample.tab> <tropo.nc> <var> <atm_in>");
00087
00088   /* Read control parameters... */
00089   read_ctl(argv[1], argc, argv, &ctl);
00090
00091   /* Read atmospheric data... */
00092   if (!read_atm(argv[5], &ctl, atm))
00093     ERRMSG("Cannot open file!");
00094
00095   /* Open tropopause file... */
00096   printf("Read tropopause data: %s\n", argv[3]);
00097   if (nc_open(argv[3], NC_NOWRITE, &ncid) != NC_NOERR)
```

```
00098     ERRMSG("Cannot open file!");
00099
00100   /* Get dimensions... */
00101   NC(nc_inq_dimid(ncid, "time", &dimid[0]));
00102   NC(nc_inq_dimlen(ncid, dimid[0], &ntime));
00103   if (ntime > NT)
00104     ERRMSG("Too many times!");
00105   NC(nc_inq_dimid(ncid, "lat", &dimid[1]));
00106   NC(nc_inq_dimlen(ncid, dimid[1], &nlat));
00107   if (nlat > NY)
00108     ERRMSG("Too many latitudes!");
00109   NC(nc_inq_dimid(ncid, "lon", &dimid[2]));
00110   NC(nc_inq_dimlen(ncid, dimid[2], &nlon));
00111   if (nlon > NX)
00112     ERRMSG("Too many longitudes!");
00113
00114   /* Read coordinates... */
00115   NC(nc_inq_varid(ncid, "time", &varid));
00116   NC(nc_get_var_double(ncid, varid, times));
00117   NC(nc_inq_varid(ncid, "lat", &varid));
00118   NC(nc_get_var_double(ncid, varid, lats));
00119   NC(nc_inq_varid(ncid, "lon", &varid));
00120   NC(nc_get_var_double(ncid, varid, lons));
00121
00122   /* Get variable indices... */
00123   sprintf(varname, "%s_z", argv[4]);
00124   NC(nc_inq_varid(ncid, varname, &varid_z));
00125   sprintf(varname, "%s_p", argv[4]);
00126   NC(nc_inq_varid(ncid, varname, &varid_p));
00127   sprintf(varname, "%s_t", argv[4]);
00128   NC(nc_inq_varid(ncid, varname, &varid_t));
00129   sprintf(varname, "%s_q", argv[4]);
00130   NC(nc_inq_varid(ncid, varname, &varid_q));
00131
00132   /* Set dimensions... */
00133   count[0] = 1;
00134   count[1] = nlat;
00135   count[2] = nlon;
00136
00137   /* Create file... */
00138   printf("Write tropopause sample data: %s\n", argv[2]);
00139   if (!(out = fopen(argv[2], "w")))
00140     ERRMSG("Cannot create file!");
00141
00142   /* Write header... */
00143   fprintf(out,
00144           "# $1 = time [s]\n"
00145           "# $2 = altitude [km]\n"
00146           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
00147   for (iq = 0; iq < ctl.nq; iq++)
00148     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl.qnt_name[iq],
00149             ctl.qnt_unit[iq]);
00150   fprintf(out, "# $%d = tropopause height [km]\n", 5 + ctl.nq);
00151   fprintf(out, "# $%d = tropopause pressure [hPa]\n", 6 + ctl.nq);
00152   fprintf(out, "# $%d = tropopause temperature [K]\n", 7 + ctl.nq);
00153   fprintf(out, "# $%d = tropopause water vapor [ppv]\n\n", 8 + ctl.nq);
00154
00155   /* Loop over particles... */
00156   for (ip = 0; ip < atm->np; ip++) {
00157
00158     /* Check temporal ordering... */
00159     if (ip > 0 && atm->time[ip] < atm->time[ip - 1])
00160       ERRMSG("Time must be ascending!");
00161
00162     /* Check range... */
00163     if (atm->time[ip] < times[0] || atm->time[ip] > times[ntime - 1])
00164       continue;
00165
00166     /* Read data... */
00167     it = locate_irr(times, (int) ntime, atm->time[ip]);
00168     if (it != it_old) {
00169
00170       time0 = times[it];
00171       start[0] = (size_t) it;
00172       NC(nc_get_vara_float(ncid, varid_z, start, count, help));
00173       for (ilon = 0; ilon < nlon; ilon++)
00174         for (ilat = 0; ilat < nlat; ilat++)
00175           tropo_z0[ilon][ilat] = help[ilat * nlon + ilon];
00176       NC(nc_get_vara_float(ncid, varid_p, start, count, help));
00177       for (ilon = 0; ilon < nlon; ilon++)
00178         for (ilat = 0; ilat < nlat; ilat++)
00179           tropo_p0[ilon][ilat] = help[ilat * nlon + ilon];
00180       NC(nc_get_vara_float(ncid, varid_t, start, count, help));
00181       for (ilon = 0; ilon < nlon; ilon++)
00182         for (ilat = 0; ilat < nlat; ilat++)
00183           tropo_t0[ilon][ilat] = help[ilat * nlon + ilon];
00184       NC(nc_get_vara_float(ncid, varid_q, start, count, help));
```

```
00185       for (ilon = 0; ilon < nlon; ilon++)
00186         for (ilat = 0; ilat < nlat; ilat++)
00187           tropo_q0[ilon][ilat] = help[ilat * nlon + ilon];
00188
00189       time1 = times[it + 1];
00190       start[0] = (size_t) it + 1;
00191       NC(nc_get_vara_float(ncid, varid_z, start, count, help));
00192       for (ilon = 0; ilon < nlon; ilon++)
00193         for (ilat = 0; ilat < nlat; ilat++)
00194           tropo_z1[ilon][ilat] = help[ilat * nlon + ilon];
00195       NC(nc_get_vara_float(ncid, varid_p, start, count, help));
00196       for (ilon = 0; ilon < nlon; ilon++)
00197         for (ilat = 0; ilat < nlat; ilat++)
00198           tropo_p1[ilon][ilat] = help[ilat * nlon + ilon];
00199       NC(nc_get_vara_float(ncid, varid_t, start, count, help));
00200       for (ilon = 0; ilon < nlon; ilon++)
00201         for (ilat = 0; ilat < nlat; ilat++)
00202           tropo_t1[ilon][ilat] = help[ilat * nlon + ilon];
00203       NC(nc_get_vara_float(ncid, varid_q, start, count, help));
00204       for (ilon = 0; ilon < nlon; ilon++)
00205         for (ilat = 0; ilat < nlat; ilat++)
00206           tropo_q1[ilon][ilat] = help[ilat * nlon + ilon];
00207     }
00208     it_old = it;
00209
00210     /* Interpolate... */
00211     z0 = intpol_tropo_2d(tropo_z0, lons, lats, nlon, nlat,
00212                          atm->lon[ip], atm->lat[ip]);
00213     p0 = intpol_tropo_2d(tropo_p0, lons, lats, nlon, nlat,
00214                          atm->lon[ip], atm->lat[ip]);
00215     t0 = intpol_tropo_2d(tropo_t0, lons, lats, nlon, nlat,
00216                          atm->lon[ip], atm->lat[ip]);
00217     q0 = intpol_tropo_2d(tropo_q0, lons, lats, nlon, nlat,
00218                          atm->lon[ip], atm->lat[ip]);
00219
00220     z1 = intpol_tropo_2d(tropo_z1, lons, lats, nlon, nlat,
00221                          atm->lon[ip], atm->lat[ip]);
00222     p1 = intpol_tropo_2d(tropo_p1, lons, lats, nlon, nlat,
00223                          atm->lon[ip], atm->lat[ip]);
00224     t1 = intpol_tropo_2d(tropo_t1, lons, lats, nlon, nlat,
00225                          atm->lon[ip], atm->lat[ip]);
00226     q1 = intpol_tropo_2d(tropo_q1, lons, lats, nlon, nlat,
00227                          atm->lon[ip], atm->lat[ip]);
00228
00229     z0 = LIN(time0, z0, time1, z1, atm->time[ip]);
00230     p0 = LIN(time0, p0, time1, p1, atm->time[ip]);
00231     t0 = LIN(time0, t0, time1, t1, atm->time[ip]);
00232     q0 = LIN(time0, q0, time1, q1, atm->time[ip]);
00233
00234     /* Write output... */
00235     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
00236             atm->lon[ip], atm->lat[ip]);
00237     for (iq = 0; iq < ctl.nq; iq++) {
00238       fprintf(out, " ");
00239       fprintf(out, ctl.qnt_format[iq], atm->q[iq][ip]);
00240     }
00241     fprintf(out, " %g %g %g %g\n", z0, p0, t0, q0);
00242   }
00243
00244   /* Close files... */
00245   fclose(out);
00246   NC(nc_close(ncid));
00247
00248   /* Free... */
00249   free(atm);
00250
00251   return EXIT_SUCCESS;
00252 }
```

Here is the call graph for this function:



5.38 tropo_sample.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2019 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 /* ------------------------------------------------------------
00028    Dimensions...
00029    ------------------------------------------------------------ */
00030
00032 #define NT 744
00033
00035 #define NX 1441
00036
00038 #define NY 721
00039
00040 /* ------------------------------------------------------------
00041    Functions...
00042    ------------------------------------------------------------ */
00043
00044 double intpol_tropo_2d(
00045   float array[NX][NY],
00046   double lons[NX],
00047   double lats[NY],
00048   size_t nlon,
00049   size_t nlat,
00050   double lon,
00051   double lat);
00052
00053 /* ------------------------------------------------------------
00054    Main...
00055    ------------------------------------------------------------ */
00056
00057 int main(
```

```
00058   int argc,
00059   char *argv[]) {
00060
00061   ctl_t ctl;
00062
00063   atm_t *atm;
00064
00065   static FILE *out;
00066
00067   static char varname[LEN];
00068
00069   static double times[NT], lons[NX], lats[NY], time0, time1, z0, z1, p0, p1,
00070     t0, t1, q0, q1;
00071
00072   static float help[NX * NY], tropo_z0[NX][NY], tropo_z1[NX][NY],
00073     tropo_p0[NX][NY], tropo_p1[NX][NY], tropo_t0[NX][NY],
00074     tropo_t1[NX][NY], tropo_q0[NX][NY], tropo_q1[NX][NY];
00075
00076   static int ip, iq, it, it_old = -999, dimid[10], ncid,
00077     varid, varid_z, varid_p, varid_t, varid_q;
00078
00079   static size_t count[10], start[10], ntime, nlon, nlat, ilon, ilat;
00080
00081   /* Allocate... */
00082   ALLOC(atm, atm_t, 1);
00083
00084   /* Check arguments... */
00085   if (argc < 5)
00086     ERRMSG("Give parameters: <ctl> <sample.tab> <tropo.nc> <var> <atm_in>");
00087
00088   /* Read control parameters... */
00089   read_ctl(argv[1], argc, argv, &ctl);
00090
00091   /* Read atmospheric data... */
00092   if (!read_atm(argv[5], &ctl, atm))
00093     ERRMSG("Cannot open file!");
00094
00095   /* Open tropopause file... */
00096   printf("Read tropopause data: %s\n", argv[3]);
00097   if (nc_open(argv[3], NC_NOWRITE, &ncid) != NC_NOERR)
00098     ERRMSG("Cannot open file!");
00099
00100   /* Get dimensions... */
00101   NC(nc_inq_dimid(ncid, "time", &dimid[0]));
00102   NC(nc_inq_dimlen(ncid, dimid[0], &ntime));
00103   if (ntime > NT)
00104     ERRMSG("Too many times!");
00105   NC(nc_inq_dimid(ncid, "lat", &dimid[1]));
00106   NC(nc_inq_dimlen(ncid, dimid[1], &nlat));
00107   if (nlat > NY)
00108     ERRMSG("Too many latitudes!");
00109   NC(nc_inq_dimid(ncid, "lon", &dimid[2]));
00110   NC(nc_inq_dimlen(ncid, dimid[2], &nlon));
00111   if (nlon > NX)
00112     ERRMSG("Too many longitudes!");
00113
00114   /* Read coordinates... */
00115   NC(nc_inq_varid(ncid, "time", &varid));
00116   NC(nc_get_var_double(ncid, varid, times));
00117   NC(nc_inq_varid(ncid, "lat", &varid));
00118   NC(nc_get_var_double(ncid, varid, lats));
00119   NC(nc_inq_varid(ncid, "lon", &varid));
00120   NC(nc_get_var_double(ncid, varid, lons));
00121
00122   /* Get variable indices... */
00123   sprintf(varname, "%s_z", argv[4]);
00124   NC(nc_inq_varid(ncid, varname, &varid_z));
00125   sprintf(varname, "%s_p", argv[4]);
00126   NC(nc_inq_varid(ncid, varname, &varid_p));
00127   sprintf(varname, "%s_t", argv[4]);
00128   NC(nc_inq_varid(ncid, varname, &varid_t));
00129   sprintf(varname, "%s_q", argv[4]);
00130   NC(nc_inq_varid(ncid, varname, &varid_q));
00131
00132   /* Set dimensions... */
00133   count[0] = 1;
00134   count[1] = nlat;
00135   count[2] = nlon;
00136
00137   /* Create file... */
00138   printf("Write tropopause sample data: %s\n", argv[2]);
00139   if (!(out = fopen(argv[2], "w")))
00140     ERRMSG("Cannot create file!");
00141
00142   /* Write header... */
00143   fprintf(out,
00144           "# $1 = time [s]\n"
```

```
00145           "# $2 = altitude [km]\n"
00146           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
00147   for (iq = 0; iq < ctl.nq; iq++)
00148     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl.qnt_name[iq],
00149             ctl.qnt_unit[iq]);
00150   fprintf(out, "# $%d = tropopause height [km]\n", 5 + ctl.nq);
00151   fprintf(out, "# $%d = tropopause pressure [hPa]\n", 6 + ctl.nq);
00152   fprintf(out, "# $%d = tropopause temperature [K]\n", 7 + ctl.nq);
00153   fprintf(out, "# $%d = tropopause water vapor [ppv]\n\n", 8 + ctl.nq);
00154
00155   /* Loop over particles... */
00156   for (ip = 0; ip < atm->np; ip++) {
00157
00158     /* Check temporal ordering... */
00159     if (ip > 0 && atm->time[ip] < atm->time[ip - 1])
00160       ERRMSG("Time must be ascending!");
00161
00162     /* Check range... */
00163     if (atm->time[ip] < times[0] || atm->time[ip] > times[ntime - 1])
00164       continue;
00165
00166     /* Read data... */
00167     it = locate_irr(times, (int) ntime, atm->time[ip]);
00168     if (it != it_old) {
00169
00170       time0 = times[it];
00171       start[0] = (size_t) it;
00172       NC(nc_get_vara_float(ncid, varid_z, start, count, help));
00173       for (ilon = 0; ilon < nlon; ilon++)
00174         for (ilat = 0; ilat < nlat; ilat++)
00175           tropo_z0[ilon][ilat] = help[ilat * nlon + ilon];
00176       NC(nc_get_vara_float(ncid, varid_p, start, count, help));
00177       for (ilon = 0; ilon < nlon; ilon++)
00178         for (ilat = 0; ilat < nlat; ilat++)
00179           tropo_p0[ilon][ilat] = help[ilat * nlon + ilon];
00180       NC(nc_get_vara_float(ncid, varid_t, start, count, help));
00181       for (ilon = 0; ilon < nlon; ilon++)
00182         for (ilat = 0; ilat < nlat; ilat++)
00183           tropo_t0[ilon][ilat] = help[ilat * nlon + ilon];
00184       NC(nc_get_vara_float(ncid, varid_q, start, count, help));
00185       for (ilon = 0; ilon < nlon; ilon++)
00186         for (ilat = 0; ilat < nlat; ilat++)
00187           tropo_q0[ilon][ilat] = help[ilat * nlon + ilon];
00188
00189       time1 = times[it + 1];
00190       start[0] = (size_t) it + 1;
00191       NC(nc_get_vara_float(ncid, varid_z, start, count, help));
00192       for (ilon = 0; ilon < nlon; ilon++)
00193         for (ilat = 0; ilat < nlat; ilat++)
00194           tropo_z1[ilon][ilat] = help[ilat * nlon + ilon];
00195       NC(nc_get_vara_float(ncid, varid_p, start, count, help));
00196       for (ilon = 0; ilon < nlon; ilon++)
00197         for (ilat = 0; ilat < nlat; ilat++)
00198           tropo_p1[ilon][ilat] = help[ilat * nlon + ilon];
00199       NC(nc_get_vara_float(ncid, varid_t, start, count, help));
00200       for (ilon = 0; ilon < nlon; ilon++)
00201         for (ilat = 0; ilat < nlat; ilat++)
00202           tropo_t1[ilon][ilat] = help[ilat * nlon + ilon];
00203       NC(nc_get_vara_float(ncid, varid_q, start, count, help));
00204       for (ilon = 0; ilon < nlon; ilon++)
00205         for (ilat = 0; ilat < nlat; ilat++)
00206           tropo_q1[ilon][ilat] = help[ilat * nlon + ilon];
00207     }
00208     it_old = it;
00209
00210     /* Interpolate... */
00211     z0 = intpol_tropo_2d(tropo_z0, lons, lats, nlon, nlat,
00212                          atm->lon[ip], atm->lat[ip]);
00213     p0 = intpol_tropo_2d(tropo_p0, lons, lats, nlon, nlat,
00214                          atm->lon[ip], atm->lat[ip]);
00215     t0 = intpol_tropo_2d(tropo_t0, lons, lats, nlon, nlat,
00216                          atm->lon[ip], atm->lat[ip]);
00217     q0 = intpol_tropo_2d(tropo_q0, lons, lats, nlon, nlat,
00218                          atm->lon[ip], atm->lat[ip]);
00219
00220     z1 = intpol_tropo_2d(tropo_z1, lons, lats, nlon, nlat,
00221                          atm->lon[ip], atm->lat[ip]);
00222     p1 = intpol_tropo_2d(tropo_p1, lons, lats, nlon, nlat,
00223                          atm->lon[ip], atm->lat[ip]);
00224     t1 = intpol_tropo_2d(tropo_t1, lons, lats, nlon, nlat,
00225                          atm->lon[ip], atm->lat[ip]);
00226     q1 = intpol_tropo_2d(tropo_q1, lons, lats, nlon, nlat,
00227                          atm->lon[ip], atm->lat[ip]);
00228
00229     z0 = LIN(time0, z0, time1, z1, atm->time[ip]);
00230     p0 = LIN(time0, p0, time1, p1, atm->time[ip]);
00231     t0 = LIN(time0, t0, time1, t1, atm->time[ip]);
```

```
00232     q0 = LIN(time0, q0, time1, q1, atm->time[ip]);
00233
00234     /* Write output... */
00235     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
00236             atm->lon[ip], atm->lat[ip]);
00237     for (iq = 0; iq < ctl.nq; iq++) {
00238       fprintf(out, " ");
00239       fprintf(out, ctl.qnt_format[iq], atm->q[iq][ip]);
00240     }
00241     fprintf(out, " %g %g %g %g\n", z0, p0, t0, q0);
00242   }
00243
00244   /* Close files... */
00245   fclose(out);
00246   NC(nc_close(ncid));
00247
00248   /* Free... */
00249   free(atm);
00250
00251   return EXIT_SUCCESS;
00252 }
00253
00254 /*****************************************************************************/
00255
00256 double intpol_tropo_2d(
00257   float array[NX][NY],
00258   double lons[NX],
00259   double lats[NY],
00260   size_t nlon,
00261   size_t nlat,
00262   double lon,
00263   double lat) {
00264
00265   /* Get indices... */
00266   int ix = locate_reg(lons, (int) nlon, lon);
00267   int iy = locate_reg(lats, (int) nlat, lat);
00268
00269   /* Set variables... */
00270   double aux00 = array[ix][iy];
00271   double aux01 = array[ix][iy + 1];
00272   double aux10 = array[ix + 1][iy];
00273   double aux11 = array[ix + 1][iy + 1];
00274
00275   /* Interpolate horizontally... */
00276   aux00 = LIN(lats[iy], aux00, lats[iy + 1], aux01, lat);
00277   aux11 = LIN(lats[iy], aux10, lats[iy + 1], aux11, lat);
00278   return LIN(lons[ix], aux00, lons[ix + 1], aux11, lon);
00279 }
```

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