MPTRAC

Generated by Doxygen 1.8.11

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]

  Quantitiy data (for various, user-defined attributes).
- float up [NP]

  Zonal wind perturbation [m/s].
- float vp [NP]

  Meridional wind perturbation [m/s].
- float wp [NP]

  Vertical velocity perturbation [hPa/s].

4.1.1 Detailed Description

Atmospheric data.

Definition at line 561 of file libtrac.h.

4.1.2 Field Documentation

4.1.2.1 int atm_t::np

Number of air pacels.

Definition at line 564 of file libtrac.h.

4.1.2.2 double atm_t::time[NP]

Time [s].

Definition at line 567 of file libtrac.h.

4.1.2.3 double atm_t::p[NP]

Pressure [hPa].

Definition at line 570 of file libtrac.h.

4.1.2.4 double atm_t::lon[NP]

Longitude [deg].

Definition at line 573 of file libtrac.h.

4.1.2.5 double atm_t::lat[NP]

Latitude [deg].

Definition at line 576 of file libtrac.h.

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

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

Definition at line 579 of file libtrac.h.

4.1.2.7 float atm_t::up[NP]

Zonal wind perturbation [m/s].

Definition at line 582 of file libtrac.h.

4.1.2.8 float atm_t::vp[NP]

Meridional wind perturbation [m/s].

Definition at line 585 of file libtrac.h.

4.1.2.9 float atm_t::wp[NP]

Vertical velocity perturbation [hPa/s].

Definition at line 588 of file libtrac.h.

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

- libtrac.h

4.2 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.
- 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_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].

4.2.1 Detailed Description

Control parameters.

Definition at line 245 of file libtrac.h.

4.2.2 Field Documentation

4.2.2.1 int ctl_t::nq

Number of quantities.

Definition at line 248 of file libtrac.h.

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

Quantity names.

Definition at line 251 of file libtrac.h.

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

Quantity units.

Definition at line 254 of file libtrac.h.

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

Quantity output format.

Definition at line 257 of file libtrac.h.

4.2.2.5 int ctl_t::qnt_ens

Quantity array index for ensemble IDs.

Definition at line 260 of file libtrac.h.

4.2.2.6 int ctl_t::qnt_m

Quantity array index for mass.

Definition at line 263 of file libtrac.h.

4.2.2.7 int ctl_t::qnt_rho

Quantity array index for particle density.

Definition at line 266 of file libtrac.h.

4.2.2.8 int ctl_t::qnt_r

Quantity array index for particle radius.

Definition at line 269 of file libtrac.h.

4.2.2.9 int ctl_t::qnt_ps

Quantity array index for surface pressure.

Definition at line 272 of file libtrac.h.

4.2.2.10 int ctl_t::qnt_pt

Quantity array index for tropopause pressure.

Definition at line 275 of file libtrac.h.

4.2.2.11 int ctl_t::qnt_z

Quantity array index for geopotential height.

Definition at line 278 of file libtrac.h.

4.2.2.12 int ctl_t::qnt_p

Quantity array index for pressure.

Definition at line 281 of file libtrac.h.

4.2.2.13 int ctl_t::qnt_t

Quantity array index for temperature.

Definition at line 284 of file libtrac.h.

4.2.2.14 int ctl_t::qnt_u

Quantity array index for zonal wind.

Definition at line 287 of file libtrac.h.

4.2.2.15 int ctl_t::qnt_v

Quantity array index for meridional wind.

Definition at line 290 of file libtrac.h.

4.2.2.16 int ctl_t::qnt_w

Quantity array index for vertical velocity.

Definition at line 293 of file libtrac.h.

4.2.2.17 int ctl_t::qnt_h2o

Quantity array index for water vapor vmr.

Definition at line 296 of file libtrac.h.

4.2.2.18 int ctl_t::qnt_o3

Quantity array index for ozone vmr.

Definition at line 299 of file libtrac.h.

4.2.2.19 int ctl_t::qnt_theta

Quantity array index for potential temperature.

Definition at line 302 of file libtrac.h.

4.2.2.20 int ctl_t::qnt_vh

Quantity array index for horizontal wind.

Definition at line 305 of file libtrac.h.

4.2.2.21 int ctl_t::qnt_vz

Quantity array index for vertical velocity.

Definition at line 308 of file libtrac.h.

4.2.2.22 int ctl_t::qnt_pv

Quantity array index for potential vorticity.

Definition at line 311 of file libtrac.h.

4.2.2.23 int ctl_t::qnt_tice

Quantity array index for T_ice.

Definition at line 314 of file libtrac.h.

4.2.2.24 int ctl_t::qnt_tsts

Quantity array index for T_STS.

Definition at line 317 of file libtrac.h.

4.2.2.25 int ctl_t::qnt_tnat

Quantity array index for T_NAT.

Definition at line 320 of file libtrac.h.

4.2.2.26 int ctl_t::qnt_stat

Quantity array index for station flag.

Definition at line 323 of file libtrac.h.

4.2.2.27 int ctl_t::direction

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

Definition at line 326 of file libtrac.h.

4.2.2.28 double ctl_t::t_start

Start time of simulation [s].

Definition at line 329 of file libtrac.h.

4.2.2.29 double ctl_t::t_stop

Stop time of simulation [s].

Definition at line 332 of file libtrac.h.

4.2.2.30 double ctl_t::dt_mod

Time step of simulation [s].

Definition at line 335 of file libtrac.h.

4.2.2.31 double ctl_t::dt_met

Time step of meteorological data [s].

Definition at line 338 of file libtrac.h.

4.2.2.32 int ctl_t::met_dx

Stride for longitudes.

Definition at line 341 of file libtrac.h.

4.2.2.33 int ctl_t::met_dy

Stride for latitudes.

Definition at line 344 of file libtrac.h.

4.2.2.34 int ctl_t::met_dp

Stride for pressure levels.

Definition at line 347 of file libtrac.h.

4.2.2.35 int ctl_t::met_sx

Smoothing for longitudes.

Definition at line 350 of file libtrac.h.

4.2.2.36 int ctl_t::met_sy

Smoothing for latitudes.

Definition at line 353 of file libtrac.h.

4.2.2.37 int ctl_t::met_sp

Smoothing for pressure levels.

Definition at line 356 of file libtrac.h.

4.2.2.38 int ctl_t::met_np

Number of target pressure levels.

Definition at line 359 of file libtrac.h.

4.2.2.39 double ctl_t::met_p[EP]

Target pressure levels [hPa].

Definition at line 362 of file libtrac.h.

4.2.2.40 int ctl_t::met_tropo

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

Definition at line 366 of file libtrac.h.

4.2.2.41 char ctl_t::met_geopot[LEN]

Surface geopotential data file.

Definition at line 369 of file libtrac.h.

4.2.2.42 char ctl_t::met_stage[LEN]

Command to stage meteo data.

Definition at line 372 of file libtrac.h.

4.2.2.43 int ctl_t::isosurf

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

Definition at line 376 of file libtrac.h.

4.2.2.44 char ctl_t::balloon[LEN]

Balloon position filename.

Definition at line 379 of file libtrac.h.

4.2.2.45 double ctl_t::turb_dx_trop

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

Definition at line 382 of file libtrac.h.

4.2.2.46 double ctl_t::turb_dx_strat

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

Definition at line 385 of file libtrac.h.

4.2.2.47 double ctl_t::turb_dz_trop

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

Definition at line 388 of file libtrac.h.

4.2.2.48 double ctl_t::turb_dz_strat

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

Definition at line 391 of file libtrac.h.

4.2.2.49 double ctl_t::turb_mesox

Horizontal scaling factor for mesoscale wind fluctuations.

Definition at line 394 of file libtrac.h.

4.2.2.50 double ctl_t::turb_mesoz

Vertical scaling factor for mesoscale wind fluctuations.

Definition at line 397 of file libtrac.h.

4.2.2.51 double ctl_t::molmass

Molar mass [g/mol].

Definition at line 400 of file libtrac.h.

4.2.2.52 double ctl_t::tdec_trop

Life time of particles (troposphere) [s].

Definition at line 403 of file libtrac.h.

4.2.2.53 double ctl_t::tdec_strat

Life time of particles (stratosphere) [s].

Definition at line 406 of file libtrac.h.

4.2.2.54 double ctl_t::psc_h2o

H2O volume mixing ratio for PSC analysis.

Definition at line 409 of file libtrac.h.

4.2.2.55 double ctl_t::psc_hno3

HNO3 volume mixing ratio for PSC analysis.

Definition at line 412 of file libtrac.h.

4.2.2.56 char ctl_t::atm_basename[LEN]

Basename of atmospheric data files.

Definition at line 415 of file libtrac.h.

4.2.2.57 char ctl_t::atm_gpfile[LEN]

Gnuplot file for atmospheric data.

Definition at line 418 of file libtrac.h.

4.2.2.58 double ctl_t::atm_dt_out

Time step for atmospheric data output [s].

Definition at line 421 of file libtrac.h.

4.2.2.59 int ctl_t::atm_filter

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

Definition at line 424 of file libtrac.h.

4.2.2.60 int ctl_t::atm_type

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

Definition at line 427 of file libtrac.h.

4.2.2.61 char ctl_t::csi_basename[LEN]

Basename of CSI data files.

Definition at line 430 of file libtrac.h.

4.2.2.62 double ctl_t::csi_dt_out

Time step for CSI data output [s].

Definition at line 433 of file libtrac.h.

4.2.2.63 char ctl_t::csi_obsfile[LEN]

Observation data file for CSI analysis.

Definition at line 436 of file libtrac.h.

4.2.2.64 double ctl_t::csi_obsmin

Minimum observation index to trigger detection.

Definition at line 439 of file libtrac.h.

4.2.2.65 double ctl_t::csi_modmin

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

Definition at line 442 of file libtrac.h.

4.2.2.66 int ctl_t::csi_nz

Number of altitudes of gridded CSI data.

Definition at line 445 of file libtrac.h.

4.2.2.67 double ctl_t::csi_z0

Lower altitude of gridded CSI data [km].

Definition at line 448 of file libtrac.h.

4.2.2.68 double ctl_t::csi_z1

Upper altitude of gridded CSI data [km].

Definition at line 451 of file libtrac.h.

4.2.2.69 int ctl_t::csi_nx

Number of longitudes of gridded CSI data.

Definition at line 454 of file libtrac.h.

4.2.2.70 double ctl_t::csi_lon0

Lower longitude of gridded CSI data [deg].

Definition at line 457 of file libtrac.h.

4.2.2.71 double ctl_t::csi_lon1

Upper longitude of gridded CSI data [deg].

Definition at line 460 of file libtrac.h.

4.2.2.72 int ctl_t::csi_ny

Number of latitudes of gridded CSI data.

Definition at line 463 of file libtrac.h.

4.2.2.73 double ctl_t::csi_lat0

Lower latitude of gridded CSI data [deg].

Definition at line 466 of file libtrac.h.

4.2.2.74 double ctl_t::csi_lat1

Upper latitude of gridded CSI data [deg].

Definition at line 469 of file libtrac.h.

4.2.2.75 char ctl_t::grid_basename[LEN]

Basename of grid data files.

Definition at line 472 of file libtrac.h.

4.2.2.76 char ctl_t::grid_gpfile[LEN]

Gnuplot file for gridded data.

Definition at line 475 of file libtrac.h.

4.2.2.77 double ctl_t::grid_dt_out

Time step for gridded data output [s].

Definition at line 478 of file libtrac.h.

4.2.2.78 int ctl_t::grid_sparse

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

Definition at line 481 of file libtrac.h.

4.2.2.79 int ctl_t::grid_nz

Number of altitudes of gridded data.

Definition at line 484 of file libtrac.h.

4.2.2.80 double ctl_t::grid_z0

Lower altitude of gridded data [km].

Definition at line 487 of file libtrac.h.

4.2.2.81 double ctl_t::grid_z1

Upper altitude of gridded data [km].

Definition at line 490 of file libtrac.h.

4.2.2.82 int ctl_t::grid_nx

Number of longitudes of gridded data.

Definition at line 493 of file libtrac.h.

4.2.2.83 double ctl_t::grid_lon0

Lower longitude of gridded data [deg].

Definition at line 496 of file libtrac.h.

4.2.2.84 double ctl_t::grid_lon1

Upper longitude of gridded data [deg].

Definition at line 499 of file libtrac.h.

4.2.2.85 int ctl_t::grid_ny

Number of latitudes of gridded data.

Definition at line 502 of file libtrac.h.

4.2.2.86 double ctl_t::grid_lat0

Lower latitude of gridded data [deg].

Definition at line 505 of file libtrac.h.

4.2.2.87 double ctl_t::grid_lat1

Upper latitude of gridded data [deg].

Definition at line 508 of file libtrac.h.

4.2.2.88 char ctl_t::prof_basename[LEN]

Basename for profile output file.

Definition at line 511 of file libtrac.h.

4.2.2.89 char ctl_t::prof_obsfile[LEN]

Observation data file for profile output.

Definition at line 514 of file libtrac.h.

4.2.2.90 int ctl_t::prof_nz

Number of altitudes of gridded profile data.

Definition at line 517 of file libtrac.h.

4.2.2.91 double ctl_t::prof_z0

Lower altitude of gridded profile data [km].

Definition at line 520 of file libtrac.h.

4.2.2.92 double ctl_t::prof_z1

Upper altitude of gridded profile data [km].

Definition at line 523 of file libtrac.h.

4.2.2.93 int ctl_t::prof_nx

Number of longitudes of gridded profile data.

Definition at line 526 of file libtrac.h.

4.2.2.94 double ctl_t::prof_lon0

Lower longitude of gridded profile data [deg].

Definition at line 529 of file libtrac.h.

4.2.2.95 double ctl_t::prof_lon1

Upper longitude of gridded profile data [deg].

Definition at line 532 of file libtrac.h.

4.2.2.96 int ctl_t::prof_ny

Number of latitudes of gridded profile data.

Definition at line 535 of file libtrac.h.

4.2.2.97 double ctl_t::prof_lat0

Lower latitude of gridded profile data [deg].

Definition at line 538 of file libtrac.h.

4.2.2.98 double ctl_t::prof_lat1

Upper latitude of gridded profile data [deg].

Definition at line 541 of file libtrac.h.

4.2.2.99 char ctl_t::ens_basename[LEN]

Basename of ensemble data file.

Definition at line 544 of file libtrac.h.

4.2.2.100 char ctl_t::stat_basename[LEN]

Basename of station data file.

Definition at line 547 of file libtrac.h.

4.2.2.101 double ctl_t::stat_lon

Longitude of station [deg].

Definition at line 550 of file libtrac.h.

4.2.2.102 double ctl_t::stat_lat

Latitude of station [deg].

Definition at line 553 of file libtrac.h.

4.2.2.103 double ctl_t::stat_r

Search radius around station [km].

Definition at line 556 of file libtrac.h.

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

- libtrac.h

4.3 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].

4.3.1 Detailed Description

Meteorological data.

Definition at line 593 of file libtrac.h.

4.3.2 Field Documentation

4.3.2.1 double met_t::time

Time [s].

Definition at line 596 of file libtrac.h.

4.3.2.2 int met_t::nx

Number of longitudes.

Definition at line 599 of file libtrac.h.

4.3.2.3 int met_t::ny

Number of latitudes.

Definition at line 602 of file libtrac.h.

4.3.2.4 int met_t::np

Number of pressure levels.

Definition at line 605 of file libtrac.h.

4.3.2.5 double met_t::lon[EX]

Longitude [deg].

Definition at line 608 of file libtrac.h.

4.3.2.6 double met_t::lat[EY]

Latitude [deg].

Definition at line 611 of file libtrac.h.

4.3.2.7 double met_t::p[EP]

Pressure [hPa].

Definition at line 614 of file libtrac.h.

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

Surface pressure [hPa].

Definition at line 617 of file libtrac.h.

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

Tropopause pressure [hPa].

Definition at line 620 of file libtrac.h.

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

Geopotential height [km].

Definition at line 623 of file libtrac.h.

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

Temperature [K].

Definition at line 626 of file libtrac.h.

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

Zonal wind [m/s].

Definition at line 629 of file libtrac.h.

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

Meridional wind [m/s].

Definition at line 632 of file libtrac.h.

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

Vertical wind [hPa/s].

Definition at line 635 of file libtrac.h.

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

Potential vorticity [PVU].

Definition at line 638 of file libtrac.h.

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

Water vapor volume mixing ratio [1].

Definition at line 641 of file libtrac.h.

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

Ozone volume mixing ratio [1].

Definition at line 644 of file libtrac.h.

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

Pressure on model levels [hPa].

Definition at line 647 of file libtrac.h.

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

- libtrac.h

5 File Documentation

5.1 center.c File Reference

Calculate center of mass of air parcels.

Functions

- int main (int argc, char ∗argv[ ])

5.1.1 Detailed Description

Calculate center of mass of air parcels.

Definition in file center.c.

5.1.2 Function Documentation

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

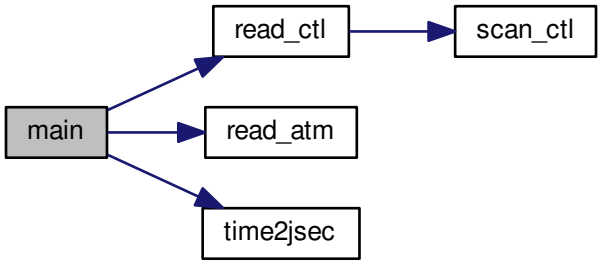
Definition at line 27 of file center.c.

```
00029                {
00030
00031   ctl_t ctl;
00032
00033   atm_t *atm;
00034
00035   FILE *out;
00036
00037   char tstr[LEN];
00038
00039   double latm, lats, lonm, lons, t, zm, zs;
00040
00041   int f, ip, year, mon, day, hour, min;
00042
00043   /* Allocate... */
00044   ALLOC(atm, atm_t, 1);
00045
00046   /* Check arguments... */
00047   if (argc < 4)
00048     ERRMSG("Give parameters: <ctl> <outfile> <atm1> [<atm2> ...]");
00049
00050   /* Read control parameters... */
00051   read_ctl(argv[1], argc, argv, &ctl);
00052
00053   /* Write info... */
00054   printf("Write center of mass data: %s\n", argv[2]);
00055
00056   /* Create output file... */
00057   if (!(out = fopen(argv[2], "w")))
00058     ERRMSG("Cannot create file!");
00059
00060   /* Write header... */
00061   fprintf(out,
00062           "# $1  = time [s]\n"
00063           "# $2  = altitude (mean) [km]\n"
00064           "# $3  = altitude (sigma) [km]\n"
00065           "# $4  = altitude (minimum) [km]\n"
00066           "# $5  = altitude (10%% percentile) [km]\n"
00067           "# $6  = altitude (1st quarter) [km]\n"
00068           "# $7  = altitude (median) [km]\n"
00069           "# $8  = altitude (3rd quarter) [km]\n"
00070           "# $9  = altitude (90%% percentile) [km]\n"
00071           "# $10 = altitude (maximum) [km]\n");
00072   fprintf(out,
```

```
00073           "# $11 = longitude (mean) [deg]\n"
00074           "# $12 = longitude (sigma) [deg]\n"
00075           "# $13 = longitude (minimum) [deg]\n"
00076           "# $14 = longitude (10%% percentile) [deg]\n"
00077           "# $15 = longitude (1st quarter) [deg]\n"
00078           "# $16 = longitude (median) [deg]\n"
00079           "# $17 = longitude (3rd quarter) [deg]\n"
00080           "# $18 = longitude (90%% percentile) [deg]\n"
00081           "# $19 = longitude (maximum) [deg]\n");
00082   fprintf(out,
00083           "# $20 = latitude (mean) [deg]\n"
00084           "# $21 = latitude (sigma) [deg]\n"
00085           "# $22 = latitude (minimum) [deg]\n"
00086           "# $23 = latitude (10%% percentile) [deg]\n"
00087           "# $24 = latitude (1st quarter) [deg]\n"
00088           "# $25 = latitude (median) [deg]\n"
00089           "# $26 = latitude (3rd quarter) [deg]\n"
00090           "# $27 = latitude (90%% percentile) [deg]\n"
00091           "# $28 = latitude (maximum) [deg]\n\n");
00092
00093   /* Loop over files... */
00094   for (f = 3; f < argc; f++) {
00095
00096     /* Read atmopheric data... */
00097     read_atm(argv[f], &ctl, atm);
00098
00099     /* Initialize... */
00100     zm = zs = 0;
00101     lonm = lons = 0;
00102     latm = lats = 0;
00103
00104     /* Calculate mean and standard deviation... */
00105     for (ip = 0; ip < atm->np; ip++) {
00106       zm += Z(atm->p[ip]) / atm->np;
00107       lonm += atm->lon[ip] / atm->np;
00108       latm += atm->lat[ip] / atm->np;
00109       zs += gsl_pow_2(Z(atm->p[ip])) / atm->np;
00110       lons += gsl_pow_2(atm->lon[ip]) / atm->np;
00111       lats += gsl_pow_2(atm->lat[ip]) / atm->np;
00112     }
00113
00114     /* Normalize... */
00115     zs = sqrt(zs - gsl_pow_2(zm));
00116     lons = sqrt(lons - gsl_pow_2(lonm));
00117     lats = sqrt(lats - gsl_pow_2(latm));
00118
00119     /* Sort arrays... */
00120     gsl_sort(atm->p, 1, (size_t) atm->np);
00121     gsl_sort(atm->lon, 1, (size_t) atm->np);
00122     gsl_sort(atm->lat, 1, (size_t) atm->np);
00123
00124     /* Get time from filename... */
00125     sprintf(tstr, "%.4s", &argv[f][strlen(argv[f]) - 20]);
00126     year = atoi(tstr);
00127     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 15]);
00128     mon = atoi(tstr);
00129     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 12]);
00130     day = atoi(tstr);
00131     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 9]);
00132     hour = atoi(tstr);
00133     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 6]);
00134     min = atoi(tstr);
00135     time2jsec(year, mon, day, hour, min, 0, 0, &t);
00136
00137     /* Write data... */
00138     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g "
00139             "%g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00140             t, zm, zs, Z(atm->p[atm->np - 1]),
00141             Z(atm->p[atm->np - atm->np / 10]),
00142             Z(atm->p[atm->np - atm->np / 4]),
00143             Z(atm->p[atm->np / 2]), Z(atm->p[atm->np / 4]),
00144             Z(atm->p[atm->np / 10]), Z(atm->p[0]),
00145             lonm, lons, atm->lon[0], atm->lon[atm->np / 10],
00146             atm->lon[atm->np / 4], atm->lon[atm->np / 2],
00147             atm->lon[atm->np - atm->np / 4],
00148             atm->lon[atm->np - atm->np / 10],
00149             atm->lon[atm->np - 1],
00150             latm, lats, atm->lat[0], atm->lat[atm->np / 10],
00151             atm->lat[atm->np / 4], atm->lat[atm->np / 2],
00152             atm->lat[atm->np - atm->np / 4],
00153             atm->lat[atm->np - atm->np / 10], atm->lat[atm->np - 1]);
00154   }
00155
00156   /* Close file... */
00157   fclose(out);
00158
00159   /* Free... */
```

```
00160   free(atm);
00161
00162   return EXIT_SUCCESS;
00163 }
```

Here is the call graph for this function:



5.2 center.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) 2013-2018 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   char tstr[LEN];
00038
00039   double latm, lats, lonm, lons, t, zm, zs;
00040
00041   int f, ip, year, mon, day, hour, min;
00042
00043   /* Allocate... */
00044   ALLOC(atm, atm_t, 1);
00045
00046   /* Check arguments... */
00047   if (argc < 4)
00048     ERRMSG("Give parameters: <ctl> <outfile> <atm1> [<atm2> ...]");
00049
00050   /* Read control parameters... */
00051   read_ctl(argv[1], argc, argv, &ctl);
00052
```

```
/* Write info... */
printf("Write center of mass data: %s\n", argv[2]);

/* Create output file... */
if (!(out = fopen(argv[2], "w")))
  ERRMSG("Cannot create file!");

/* Write header... */
fprintf(out,
        "# $1  = time [s]\n"
        "# $2  = altitude (mean) [km]\n"
        "# $3  = altitude (sigma) [km]\n"
        "# $4  = altitude (minimum) [km]\n"
        "# $5  = altitude (10%% percentile) [km]\n"
        "# $6  = altitude (1st quarter) [km]\n"
        "# $7  = altitude (median) [km]\n"
        "# $8  = altitude (3rd quarter) [km]\n"
        "# $9  = altitude (90%% percentile) [km]\n"
        "# $10 = altitude (maximum) [km]\n");
fprintf(out,
        "# $11 = longitude (mean) [deg]\n"
        "# $12 = longitude (sigma) [deg]\n"
        "# $13 = longitude (minimum) [deg]\n"
        "# $14 = longitude (10%% percentile) [deg]\n"
        "# $15 = longitude (1st quarter) [deg]\n"
        "# $16 = longitude (median) [deg]\n"
        "# $17 = longitude (3rd quarter) [deg]\n"
        "# $18 = longitude (90%% percentile) [deg]\n"
        "# $19 = longitude (maximum) [deg]\n");
fprintf(out,
        "# $20 = latitude (mean) [deg]\n"
        "# $21 = latitude (sigma) [deg]\n"
        "# $22 = latitude (minimum) [deg]\n"
        "# $23 = latitude (10%% percentile) [deg]\n"
        "# $24 = latitude (1st quarter) [deg]\n"
        "# $25 = latitude (median) [deg]\n"
        "# $26 = latitude (3rd quarter) [deg]\n"
        "# $27 = latitude (90%% percentile) [deg]\n"
        "# $28 = latitude (maximum) [deg]\n\n");

/* Loop over files... */
for (f = 3; f < argc; f++) {

  /* Read atmopheric data... */
  read_atm(argv[f], &ctl, atm);

  /* Initialize... */
  zm = zs = 0;
  lonm = lons = 0;
  latm = lats = 0;

  /* Calculate mean and standard deviation... */
  for (ip = 0; ip < atm->np; ip++) {
    zm += Z(atm->p[ip]) / atm->np;
    lonm += atm->lon[ip] / atm->np;
    latm += atm->lat[ip] / atm->np;
    zs += gsl_pow_2(Z(atm->p[ip])) / atm->np;
    lons += gsl_pow_2(atm->lon[ip]) / atm->np;
    lats += gsl_pow_2(atm->lat[ip]) / atm->np;
  }

  /* Normalize... */
  zs = sqrt(zs - gsl_pow_2(zm));
  lons = sqrt(lons - gsl_pow_2(lonm));
  lats = sqrt(lats - gsl_pow_2(latm));

  /* Sort arrays... */
  gsl_sort(atm->p, 1, (size_t) atm->np);
  gsl_sort(atm->lon, 1, (size_t) atm->np);
  gsl_sort(atm->lat, 1, (size_t) atm->np);

  /* Get time from filename... */
  sprintf(tstr, "%.4s", &argv[f][strlen(argv[f]) - 20]);
  year = atoi(tstr);
  sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 15]);
  mon = atoi(tstr);
  sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 12]);
  day = atoi(tstr);
  sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 9]);
  hour = atoi(tstr);
  sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 6]);
  min = atoi(tstr);
  time2jsec(year, mon, day, hour, min, 0, 0, &t);

  /* Write data... */
  fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g "
          "%g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
```

```
00140             t, zm, zs, Z(atm->p[atm->np - 1]),
00141             Z(atm->p[atm->np - atm->np / 10]),
00142             Z(atm->p[atm->np - atm->np / 4]),
00143             Z(atm->p[atm->np / 2]), Z(atm->p[atm->np / 4]),
00144             Z(atm->p[atm->np / 10]), Z(atm->p[0]),
00145             lonm, lons, atm->lon[0], atm->lon[atm->np / 10],
00146             atm->lon[atm->np / 4], atm->lon[atm->np / 2],
00147             atm->lon[atm->np - atm->np / 4],
00148             atm->lon[atm->np - atm->np / 10],
00149             atm->lon[atm->np - 1],
00150             latm, lats, atm->lat[0], atm->lat[atm->np / 10],
00151             atm->lat[atm->np / 4], atm->lat[atm->np / 2],
00152             atm->lat[atm->np - atm->np / 4],
00153             atm->lat[atm->np - atm->np / 10], atm->lat[atm->np - 1]);
00154   }
00155
00156   /* Close file... */
00157   fclose(out);
00158
00159   /* Free... */
00160   free(atm);
00161
00162   return EXIT_SUCCESS;
00163 }
```

5.3 cluster.c File Reference

Clustering of trajectories.

Functions

- int main (int argc, char ∗argv[ ])

5.3.1 Detailed Description

Clustering of trajectories.

Definition in file cluster.c.

5.3.2 Function Documentation

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

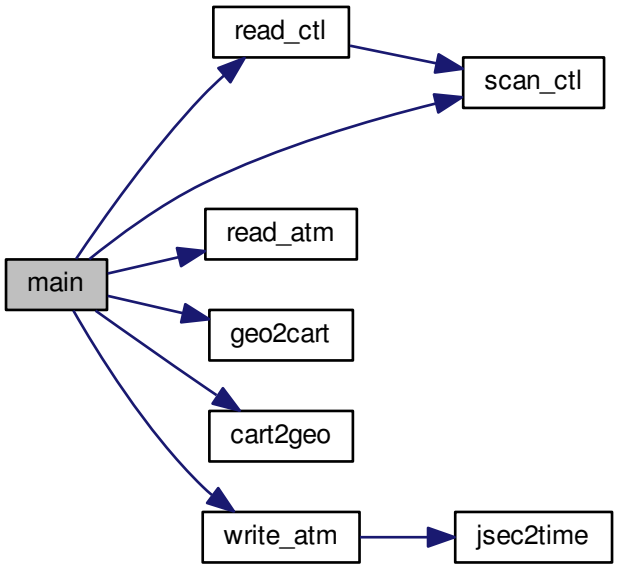
Definition at line 41 of file cluster.c.

```
00043                 {
00044
00045   ctl_t ctl;
00046
00047   atm_t *atm;
00048
00049   gsl_rng *rng;
00050
00051   FILE *out;
00052
00053   static double d2, *dist, lat, lon, rmsd[NS],
00054     x[3], xs[NT][NS][3], z, zs[NT][NS];
00055
00056   static int *cluster, f, idx[NS], ip, is, it, itmax, np[NS], ns;
00057
00058   /* Check arguments... */
00059   if (argc < 4)
00060     ERRMSG("Give parameters: <ctl> <cluster.log> <atm1> [<atm2> <atm3> ...]");
00061
00062   /* Read control parameters... */
```

```
00063   read_ctl(argv[1], argc, argv, &ctl);
00064   ns = (int) scan_ctl(argv[1], argc, argv, "CLUSTER_NS", -1, "7", NULL);
00065   if (ns > NS)
00066     ERRMSG("Too many seeds!");
00067   itmax =
00068     (int) scan_ctl(argv[1], argc, argv, "CLUSTER_ITMAX", -1, "10", NULL);
00069
00070   /* Initialize random number generator... */
00071   gsl_rng_env_setup();
00072   rng = gsl_rng_alloc(gsl_rng_default);
00073
00074   /* Allocate... */
00075   ALLOC(atm, atm_t, 1);
00076   ALLOC(cluster, int,
00077         NP);
00078   ALLOC(dist, double,
00079         NP * NS);
00080
00081   /* Create output file... */
00082   printf("Write cluster data: %s\n", argv[2]);
00083   if (!(out = fopen(argv[2], "w")))
00084     ERRMSG("Cannot create file!");
00085
00086   /* Write header... */
00087   fprintf(out,
00088           "# $1 = iteration index\n"
00089           "# $2 = seed index\n"
00090           "# $3 = time step index\n"
00091           "# $4 = mean altitude [km]\n"
00092           "# $5 = mean longitude [deg]\n"
00093           "# $6 = mean latitude [deg]\n"
00094           "# $7 = number of points\n" "# $8 = RMSD [km^2]\n");
00095
00096   /* Get seeds (random selection of trajectories)... */
00097   for (f = 3; f < argc; f++) {
00098
00099     /* Check number of timesteps... */
00100     if (f - 3 > NT)
00101       ERRMSG("Too many timesteps!");
00102
00103     /* Read atmopheric data... */
00104     read_atm(argv[f], &ctl, atm);
00105
00106     /* Pick seeds (random selection)... */
00107     if (f == 3)
00108       for (is = 0; is < ns; is++)
00109         idx[is] = (int) gsl_rng_uniform_int(rng, (long unsigned int) atm->np);
00110
00111     /* Save seeds... */
00112     for (is = 0; is < ns; is++) {
00113       geo2cart(0, atm->lon[idx[is]], atm->lat[idx[is]], xs[f - 3][is]);
00114       zs[f - 3][is] = Z(atm->p[idx[is]]);
00115     }
00116   }
00117
00118   /* Iterations... */
00119   for (it = 0; it < itmax; it++) {
00120
00121     /* Write output... */
00122     for (is = 0; is < ns; is++) {
00123       fprintf(out, "\n");
00124       for (f = 3; f < argc; f++) {
00125         cart2geo(xs[f - 3][is], &z, &lon, &lat);
00126         fprintf(out, "%d %d %d %g %g %g %d %g\n",
00127                 it, is, f - 3, zs[f - 3][is], lon, lat, np[is], rmsd[is]);
00128       }
00129     }
00130
00131     /* Init... */
00132     for (ip = 0; ip < atm->np; ip++)
00133       for (is = 0; is < ns; is++) {
00134         dist[ip * NS + is] = 0;
00135         rmsd[is] = 0;
00136       }
00137
00138     /* Get distances between seeds and trajectories... */
00139     for (f = 3; f < argc; f++) {
00140
00141       /* Read atmopheric data... */
00142       read_atm(argv[f], &ctl, atm);
00143
00144       /* Get distances... */
00145       for (ip = 0; ip < atm->np; ip++) {
00146         geo2cart(0, atm->lon[ip], atm->lat[ip], x);
00147         z = Z(atm->p[ip]);
00148         for (is = 0; is < ns; is++) {
00149           d2 =
```

```
00150             DIST2(x, xs[f - 3][is]) + gsl_pow_2((z - zs[f - 3][is]) * 200.);
00151           dist[ip * NS + is] += d2;
00152           rmsd[is] += d2;
00153         }
00154       }
00155     }
00156
00157     /* Assign clusters... */
00158     for (ip = 0; ip < atm->np; ip++)
00159       cluster[ip] = (int) gsl_stats_min_index(&dist[ip * NS], 1, (size_t) ns);
00160
00161     /* Recalculate seeds (mean trajectories)... */
00162     for (f = 3; f < argc; f++) {
00163
00164       /* Read atmopheric data... */
00165       read_atm(argv[f], &ctl, atm);
00166
00167       /* Calculate new seeds... */
00168       for (is = 0; is < ns; is++) {
00169         xs[f - 3][is][0] = 0;
00170         xs[f - 3][is][1] = 0;
00171         xs[f - 3][is][2] = 0;
00172         zs[f - 3][is] = 0;
00173         np[is] = 0;
00174       }
00175       for (ip = 0; ip < atm->np; ip++) {
00176         geo2cart(0, atm->lon[ip], atm->lat[ip], x);
00177         xs[f - 3][cluster[ip]][0] += x[0];
00178         xs[f - 3][cluster[ip]][1] += x[1];
00179         xs[f - 3][cluster[ip]][2] += x[2];
00180         zs[f - 3][cluster[ip]] += Z(atm->p[ip]);
00181         np[cluster[ip]]++;
00182       }
00183       for (is = 0; is < ns; is++) {
00184         xs[f - 3][is][0] /= np[is];
00185         xs[f - 3][is][1] /= np[is];
00186         xs[f - 3][is][2] /= np[is];
00187         zs[f - 3][is] /= np[is];
00188       }
00189     }
00190   }
00191
00192   /* Write output... */
00193   for (is = 0; is < ns; is++) {
00194     fprintf(out, "\n");
00195     for (f = 3; f < argc; f++) {
00196       cart2geo(xs[f - 3][is], &z, &lon, &lat);
00197       fprintf(out, "%d %d %d %g %g %g %d %g\n",
00198               it, is, f - 3, zs[f - 3][is], lon, lat, np[is], rmsd[is]);
00199     }
00200   }
00201
00202   /* Close output file... */
00203   fclose(out);
00204
00205   /* Write clustering results... */
00206   if (ctl.qnt_ens >= 0)
00207
00208     /* Recalculate seeds (mean trajectories)... */
00209     for (f = 3; f < argc; f++) {
00210
00211       /* Read atmopheric data... */
00212       read_atm(argv[f], &ctl, atm);
00213
00214       /* Set ensemble ID... */
00215       for (ip = 0; ip < atm->np; ip++)
00216         atm->q[ctl.qnt_ens][ip] = cluster[ip];
00217
00218       /* Write atmospheric data... */
00219       write_atm(argv[f], &ctl, atm, 0);
00220     }
00221
00222   /* Free... */
00223   gsl_rng_free(rng);
00224   free(atm);
00225   free(cluster);
00226   free(dist);
00227
00228   return EXIT_SUCCESS;
00229 }
```

Here is the call graph for this function:



5.4 cluster.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) 2013-2018 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 /* ------------------------------------------------------------
00028    Defines...
00029    ------------------------------------------------------------ */
00030
00032 #define NS 100
00033
00035 #define NT 1000
00036
00037 /* ------------------------------------------------------------
00038    Main...
00039    ------------------------------------------------------------ */
00040
00041 int main(
00042   int argc,
00043   char *argv[]) {
00044
00045   ctl_t ctl;
00046
```

```
00047   atm_t *atm;
00048
00049   gsl_rng *rng;
00050
00051   FILE *out;
00052
00053   static double d2, *dist, lat, lon, rmsd[NS],
00054     x[3], xs[NT][NS][3], z, zs[NT][NS];
00055
00056   static int *cluster, f, idx[NS], ip, is, it, itmax, np[NS], ns;
00057
00058   /* Check arguments... */
00059   if (argc < 4)
00060     ERRMSG("Give parameters: <ctl> <cluster.log> <atm1> [<atm2> <atm3> ...]");
00061
00062   /* Read control parameters... */
00063   read_ctl(argv[1], argc, argv, &ctl);
00064   ns = (int) scan_ctl(argv[1], argc, argv, "CLUSTER_NS", -1, "7", NULL);
00065   if (ns > NS)
00066     ERRMSG("Too many seeds!");
00067   itmax =
00068     (int) scan_ctl(argv[1], argc, argv, "CLUSTER_ITMAX", -1, "10", NULL);
00069
00070   /* Initialize random number generator... */
00071   gsl_rng_env_setup();
00072   rng = gsl_rng_alloc(gsl_rng_default);
00073
00074   /* Allocate... */
00075   ALLOC(atm, atm_t, 1);
00076   ALLOC(cluster, int,
00077         NP);
00078   ALLOC(dist, double,
00079         NP * NS);
00080
00081   /* Create output file... */
00082   printf("Write cluster data: %s\n", argv[2]);
00083   if (!(out = fopen(argv[2], "w")))
00084     ERRMSG("Cannot create file!");
00085
00086   /* Write header... */
00087   fprintf(out,
00088           "# $1 = iteration index\n"
00089           "# $2 = seed index\n"
00090           "# $3 = time step index\n"
00091           "# $4 = mean altitude [km]\n"
00092           "# $5 = mean longitude [deg]\n"
00093           "# $6 = mean latitude [deg]\n"
00094           "# $7 = number of points\n" "# $8 = RMSD [km^2]\n");
00095
00096   /* Get seeds (random selection of trajectories)... */
00097   for (f = 3; f < argc; f++) {
00098
00099     /* Check number of timesteps... */
00100     if (f - 3 > NT)
00101       ERRMSG("Too many timesteps!");
00102
00103     /* Read atmopheric data... */
00104     read_atm(argv[f], &ctl, atm);
00105
00106     /* Pick seeds (random selection)... */
00107     if (f == 3)
00108       for (is = 0; is < ns; is++)
00109         idx[is] = (int) gsl_rng_uniform_int(rng, (long unsigned int) atm->np);
00110
00111     /* Save seeds... */
00112     for (is = 0; is < ns; is++) {
00113       geo2cart(0, atm->lon[idx[is]], atm->lat[idx[is]], xs[f - 3][is]);
00114       zs[f - 3][is] = Z(atm->p[idx[is]]);
00115     }
00116   }
00117
00118   /* Iterations... */
00119   for (it = 0; it < itmax; it++) {
00120
00121     /* Write output... */
00122     for (is = 0; is < ns; is++) {
00123       fprintf(out, "\n");
00124       for (f = 3; f < argc; f++) {
00125         cart2geo(xs[f - 3][is], &z, &lon, &lat);
00126         fprintf(out, "%d %d %d %g %g %g %d %g\n",
00127                 it, is, f - 3, zs[f - 3][is], lon, lat, np[is], rmsd[is]);
00128       }
00129     }
00130
00131     /* Init... */
00132     for (ip = 0; ip < atm->np; ip++)
00133       for (is = 0; is < ns; is++) {
```

```
00134         dist[ip * NS + is] = 0;
00135         rmsd[is] = 0;
00136       }
00137
00138     /* Get distances between seeds and trajectories... */
00139     for (f = 3; f < argc; f++) {
00140
00141       /* Read atmopheric data... */
00142       read_atm(argv[f], &ctl, atm);
00143
00144       /* Get distances... */
00145       for (ip = 0; ip < atm->np; ip++) {
00146         geo2cart(0, atm->lon[ip], atm->lat[ip], x);
00147         z = Z(atm->p[ip]);
00148         for (is = 0; is < ns; is++) {
00149           d2 =
00150             DIST2(x, xs[f - 3][is]) + gsl_pow_2((z - zs[f - 3][is]) * 200.);
00151           dist[ip * NS + is] += d2;
00152           rmsd[is] += d2;
00153         }
00154       }
00155     }
00156
00157     /* Assign clusters... */
00158     for (ip = 0; ip < atm->np; ip++)
00159       cluster[ip] = (int) gsl_stats_min_index(&dist[ip * NS], 1, (size_t) ns);
00160
00161     /* Recalculate seeds (mean trajectories)... */
00162     for (f = 3; f < argc; f++) {
00163
00164       /* Read atmopheric data... */
00165       read_atm(argv[f], &ctl, atm);
00166
00167       /* Calculate new seeds... */
00168       for (is = 0; is < ns; is++) {
00169         xs[f - 3][is][0] = 0;
00170         xs[f - 3][is][1] = 0;
00171         xs[f - 3][is][2] = 0;
00172         zs[f - 3][is] = 0;
00173         np[is] = 0;
00174       }
00175       for (ip = 0; ip < atm->np; ip++) {
00176         geo2cart(0, atm->lon[ip], atm->lat[ip], x);
00177         xs[f - 3][cluster[ip]][0] += x[0];
00178         xs[f - 3][cluster[ip]][1] += x[1];
00179         xs[f - 3][cluster[ip]][2] += x[2];
00180         zs[f - 3][cluster[ip]] += Z(atm->p[ip]);
00181         np[cluster[ip]]++;
00182       }
00183       for (is = 0; is < ns; is++) {
00184         xs[f - 3][is][0] /= np[is];
00185         xs[f - 3][is][1] /= np[is];
00186         xs[f - 3][is][2] /= np[is];
00187         zs[f - 3][is] /= np[is];
00188       }
00189     }
00190   }
00191
00192   /* Write output... */
00193   for (is = 0; is < ns; is++) {
00194     fprintf(out, "\n");
00195     for (f = 3; f < argc; f++) {
00196       cart2geo(xs[f - 3][is], &z, &lon, &lat);
00197       fprintf(out, "%d %d %d %g %g %g %d %g\n",
00198               it, is, f - 3, zs[f - 3][is], lon, lat, np[is], rmsd[is]);
00199     }
00200   }
00201
00202   /* Close output file... */
00203   fclose(out);
00204
00205   /* Write clustering results... */
00206   if (ctl.qnt_ens >= 0)
00207
00208     /* Recalculate seeds (mean trajectories)... */
00209     for (f = 3; f < argc; f++) {
00210
00211       /* Read atmopheric data... */
00212       read_atm(argv[f], &ctl, atm);
00213
00214       /* Set ensemble ID... */
00215       for (ip = 0; ip < atm->np; ip++)
00216         atm->q[ctl.qnt_ens][ip] = cluster[ip];
00217
00218       /* Write atmospheric data... */
00219       write_atm(argv[f], &ctl, atm, 0);
00220     }
```

```
00221
00222   /* Free... */
00223   gsl_rng_free(rng);
00224   free(atm);
00225   free(cluster);
00226   free(dist);
00227
00228   return EXIT_SUCCESS;
00229 }
```

5.5 conv.c File Reference

Convert file format of atmospheric data files.

Functions

- int main (int argc, char ∗argv[ ])

5.5.1 Detailed Description

Convert file format of atmospheric data files.

Definition in file conv.c.

5.5.2 Function Documentation

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

Definition at line 27 of file 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   read_atm(argv[2], &ctl, atm);
00049
00050   /* Write atmospheric data... */
00051   ctl.atm_type = atoi(argv[5]);
00052   write_atm(argv[4], &ctl, atm, 0);
00053
00054   /* Free... */
00055   free(atm);
00056
00057   return EXIT_SUCCESS;
00058 }
```

Here is the call graph for this function:

5.6 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) 2013-2018 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   read_atm(argv[2], &ctl, atm);
00049
00050   /* Write atmospheric data... */
00051   ctl.atm_type = atoi(argv[5]);
00052   write_atm(argv[4], &ctl, atm, 0);
00053
00054   /* Free... */
00055   free(atm);
00056
00057   return EXIT_SUCCESS;
00058 }
```

5.7 day2doy.c File Reference

Convert date to day of year.

Functions

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

5.7.1 Detailed Description

Convert date to day of year.

Definition in file day2doy.c.

5.7.2 Function Documentation

5.7.2.1 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:

5.8 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 }
```

5.9 dist.c File Reference

Calculate transport deviations of trajectories.

Functions

- int main (int argc, char ∗argv[ ])

5.9.1 Detailed Description

Calculate transport deviations of trajectories.

Definition in file dist.c.

5.9.2 Function Documentation

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

Definition at line 27 of file dist.c.

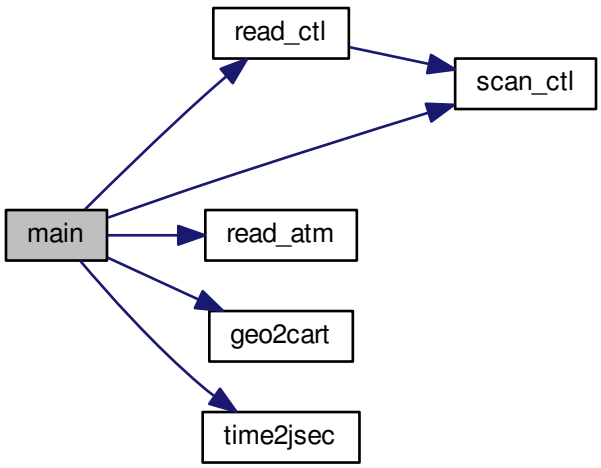
```
00029                {
00030
00031   ctl_t ctl;
00032
00033   atm_t *atm1, *atm2;
00034
00035   FILE *out;
00036
00037   char tstr[LEN];
00038
00039   double ahtd, aqtd[NQ], atce1[NQ], atce2[NQ], avtd, lat0, lat1,
00040     *lat1_old, *lat2_old, *lh1, *lh2, lon0, lon1, *lon1_old, *lon2_old,
00041     *lv1, *lv2, p0, p1, *q1, *q2, rhtd, rqtd[NQ], rtce1[NQ], rtce2[NQ], rvtd,
00042     t, t0 = 0, x0[3], x1[3], x2[3], z1, *z1_old, z2, *z2_old;
00043
00044   int ens, f, 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(q1, double,
00070         NQ * NP);
00071   ALLOC(q2, double,
00072         NQ * NP);
00073
00074   /* Check arguments... */
00075   if (argc < 5)
00076     ERRMSG("Give parameters: <ctl> <outfile> <atm1a> <atm1b>"
```

```
00077           " [<atm2a> <atm2b> ...]");
00078
00079   /* Read control parameters... */
00080   read_ctl(argv[1], argc, argv, &ctl);
00081   ens = (int) scan_ctl(argv[1], argc, argv, "DIST_ENS", -1, "-1", NULL);
00082   p0 = P(scan_ctl(argv[1], argc, argv, "DIST_Z0", -1, "-1000", NULL));
00083   p1 = P(scan_ctl(argv[1], argc, argv, "DIST_Z1", -1, "1000", NULL));
00084   lat0 = scan_ctl(argv[1], argc, argv, "DIST_LAT0", -1, "-1000", NULL);
00085   lat1 = scan_ctl(argv[1], argc, argv, "DIST_LAT1", -1, "1000", NULL);
00086   lon0 = scan_ctl(argv[1], argc, argv, "DIST_LON0", -1, "-1000", NULL);
00087   lon1 = scan_ctl(argv[1], argc, argv, "DIST_LON1", -1, "1000", NULL);
00088
00089   /* Write info... */
00090   printf("Write transport deviations: %s\n", argv[2]);
00091
00092   /* Create output file... */
00093   if (!(out = fopen(argv[2], "w")))
00094     ERRMSG("Cannot create file!");
00095
00096   /* Write header... */
00097   fprintf(out,
00098           "# $1 = time [s]\n"
00099           "# $2 = trajectory time [s]\n"
00100           "# $3 = AHTD [km]\n"
00101           "# $4 = RHTD [%%]\n" "# $5 = AVTD [km]\n" "# $6 = RVTD [%%]\n");
00102   for (iq = 0; iq < ctl.nq; iq++)
00103     fprintf(out,
00104             "# $%d = AQTD (%s) [%s]\n"
00105             "# $%d = RQTD (%s) [%%]\n",
00106             7 + 2 * iq, ctl.qnt_name[iq], ctl.qnt_unit[iq],
00107             8 + 2 * iq, ctl.qnt_name[iq]);
00108   for (iq = 0; iq < ctl.nq; iq++)
00109     fprintf(out,
00110             "# $%d = ATCE_1 (%s) [%s]\n"
00111             "# $%d = RTCE_1 (%s) [%%]\n",
00112             7 + 2 * ctl.nq + 2 * iq, ctl.qnt_name[iq], ctl.qnt_unit[iq],
00113             8 + 2 * ctl.nq + 2 * iq, ctl.qnt_name[iq]);
00114   for (iq = 0; iq < ctl.nq; iq++)
00115     fprintf(out,
00116             "# $%d = ATCE_2 (%s) [%s]\n"
00117             "# $%d = RTCE_2 (%s) [%%]\n",
00118             7 + 4 * ctl.nq + 2 * iq, ctl.qnt_name[iq], ctl.qnt_unit[iq],
00119             8 + 4 * ctl.nq + 2 * iq, ctl.qnt_name[iq]);
00120   fprintf(out, "# $%d = number of particles\n\n", 7 + 6 * ctl.nq);
00121
00122   /* Loop over file pairs... */
00123   for (f = 3; f < argc; f += 2) {
00124
00125     /* Read atmopheric data... */
00126     read_atm(argv[f], &ctl, atm1);
00127     read_atm(argv[f + 1], &ctl, atm2);
00128
00129     /* Check if structs match... */
00130     if (atm1->np != atm2->np)
00131       ERRMSG("Different numbers of parcels!");
00132     for (ip = 0; ip < atm1->np; ip++)
00133       if (gsl_finite(atm1->time[ip]) && gsl_finite(atm2->time[ip])
00134           && atm1->time[ip] != atm2->time[ip])
00135         ERRMSG("Times do not match!");
00136
00137     /* Get time from filename... */
00138     sprintf(tstr, "%.4s", &argv[f][strlen(argv[f]) - 20]);
00139     year = atoi(tstr);
00140     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 15]);
00141     mon = atoi(tstr);
00142     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 12]);
00143     day = atoi(tstr);
00144     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 9]);
00145     hour = atoi(tstr);
00146     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 6]);
00147     min = atoi(tstr);
00148     time2jsec(year, mon, day, hour, min, 0, 0, &t);
00149
00150     /* Save initial data... */
00151     if (f == 3) {
00152       t0 = t;
00153       for (iq = 0; iq < ctl.nq; iq++)
00154         for (ip = 0; ip < atm1->np; ip++) {
00155           q1[iq * NP + ip] = atm1->q[iq][ip];
00156           q2[iq * NP + ip] = atm2->q[iq][ip];
00157         }
00158     }
00159
00160     /* Init... */
00161     np = 0;
00162     ahtd = avtd = rhtd = rvtd = 0;
00163     for (iq = 0; iq < ctl.nq; iq++)
```

```
00164       aqtd[iq] = atce1[iq] = atce2[iq] = rqtd[iq] = rtce1[iq] = rtce2[iq] = 0;
00165
00166     /* Loop over air parcels... */
00167     for (ip = 0; ip < atm1->np; ip++) {
00168
00169       /* Check data... */
00170       if (!gsl_finite(atm1->time[ip]) || !gsl_finite(atm2->time[ip]))
00171         continue;
00172
00173       /* Check ensemble ID... */
00174       if (ens >= 0 && ctl.qnt_ens >= 0 && atm1->q[ctl.qnt_ens][ip] != ens)
00175         continue;
00176       if (ens >= 0 && ctl.qnt_ens >= 0 && atm2->q[ctl.qnt_ens][ip] != ens)
00177         continue;
00178
00179       /* Check spatial range... */
00180       if (atm1->p[ip] > p0 || atm1->p[ip] < p1
00181           || atm1->lon[ip] < lon0 || atm1->lon[ip] > lon1
00182           || atm1->lat[ip] < lat0 || atm1->lat[ip] > lat1)
00183         continue;
00184       if (atm2->p[ip] > p0 || atm2->p[ip] < p1
00185           || atm2->lon[ip] < lon0 || atm2->lon[ip] > lon1
00186           || atm2->lat[ip] < lat0 || atm2->lat[ip] > lat1)
00187         continue;
00188
00189       /* Convert coordinates... */
00190       geo2cart(0, atm1->lon[ip], atm1->lat[ip], x1);
00191       geo2cart(0, atm2->lon[ip], atm2->lat[ip], x2);
00192       z1 = Z(atm1->p[ip]);
00193       z2 = Z(atm2->p[ip]);
00194
00195       /* Calculate absolute transport deviations... */
00196       ahtd += DIST(x1, x2);
00197       avtd += fabs(z1 - z2);
00198       for (iq = 0; iq < ctl.nq; iq++)
00199         aqtd[iq] += fabs(atm1->q[iq][ip] - atm2->q[iq][ip]);
00200
00201       /* Calculate relative transport deviations... */
00202       if (f > 3) {
00203
00204         /* Get trajectory lengths... */
00205         geo2cart(0, lon1_old[ip], lat1_old[ip], x0);
00206         lh1[ip] += DIST(x0, x1);
00207         lv1[ip] += fabs(z1_old[ip] - z1);
00208
00209         geo2cart(0, lon2_old[ip], lat2_old[ip], x0);
00210         lh2[ip] += DIST(x0, x2);
00211         lv2[ip] += fabs(z2_old[ip] - z2);
00212
00213         /* Get relative transport deviations... */
00214         if (lh1[ip] + lh2[ip] > 0)
00215           rhtd += 200. * DIST(x1, x2) / (lh1[ip] + lh2[ip]);
00216         if (lv1[ip] + lv2[ip] > 0)
00217           rvtd += 200. * fabs(z1 - z2) / (lv1[ip] + lv2[ip]);
00218         for (iq = 0; iq < ctl.nq; iq++)
00219           rqtd[iq] += 200. * fabs(atm1->q[iq][ip] - atm2->q[iq][ip])
00220             / (fabs(atm1->q[iq][ip]) + fabs(atm2->q[iq][ip]));
00221
00222         /* Get tracer conservation errors... */
00223         for (iq = 0; iq < ctl.nq; iq++) {
00224           atce1[iq] += fabs(atm1->q[iq][ip] - q1[iq * NP + ip]);
00225           rtce1[iq] += 200. * fabs(atm1->q[iq][ip] - q1[iq * NP + ip])
00226             / (fabs(atm1->q[iq][ip]) + fabs(q1[iq * NP + ip]));
00227           atce2[iq] += fabs(atm2->q[iq][ip] - q2[iq * NP + ip]);
00228           rtce2[iq] += 200. * fabs(atm2->q[iq][ip] - q2[iq * NP + ip])
00229             / (fabs(atm2->q[iq][ip]) + fabs(q2[iq * NP + ip]));
00230         }
00231       }
00232
00233       /* Save positions of air parcels... */
00234       lon1_old[ip] = atm1->lon[ip];
00235       lat1_old[ip] = atm1->lat[ip];
00236       z1_old[ip] = z1;
00237
00238       lon2_old[ip] = atm2->lon[ip];
00239       lat2_old[ip] = atm2->lat[ip];
00240       z2_old[ip] = z2;
00241
00242       /* Increment air parcel counter... */
00243       np++;
00244     }
00245
00246     /* Write output... */
00247     fprintf(out, "%.2f %.2f %g %g %g %g", t, t - t0,
00248             ahtd / np, rhtd / np, avtd / np, rvtd / np);
00249     for (iq = 0; iq < ctl.nq; iq++) {
00250       fprintf(out, " ");
```

```
00251       fprintf(out, ctl.qnt_format[iq], aqtd[iq] / np);
00252       fprintf(out, " ");
00253       fprintf(out, ctl.qnt_format[iq], rqtd[iq] / np);
00254     }
00255     for (iq = 0; iq < ctl.nq; iq++) {
00256       fprintf(out, " ");
00257       fprintf(out, ctl.qnt_format[iq], atce1[iq] / np);
00258       fprintf(out, " ");
00259       fprintf(out, ctl.qnt_format[iq], rtce1[iq] / np);
00260     }
00261     for (iq = 0; iq < ctl.nq; iq++) {
00262       fprintf(out, " ");
00263       fprintf(out, ctl.qnt_format[iq], atce2[iq] / np);
00264       fprintf(out, " ");
00265       fprintf(out, ctl.qnt_format[iq], rtce2[iq] / np);
00266     }
00267     fprintf(out, " %d\n", np);
00268   }
00269
00270   /* Close file... */
00271   fclose(out);
00272
00273   /* Free... */
00274   free(atm1);
00275   free(atm2);
00276   free(lon1_old);
00277   free(lat1_old);
00278   free(z1_old);
00279   free(lh1);
00280   free(lv1);
00281   free(lon2_old);
00282   free(lat2_old);
00283   free(z2_old);
00284   free(lh2);
00285   free(lv2);
00286
00287   return EXIT_SUCCESS;
00288 }
```

Here is the call graph for this function:



5.10 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) 2013-2018 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[NQ], atce1[NQ], atce2[NQ], avtd, lat0, lat1,
00040     *lat1_old, *lat2_old, *lh1, *lh2, lon0, lon1, *lon1_old, *lon2_old,
00041     *lv1, *lv2, p0, p1, *q1, *q2, rhtd, rqtd[NQ], rtce1[NQ], rtce2[NQ], rvtd,
00042     t, t0 = 0, x0[3], x1[3], x2[3], z1, *z1_old, z2, *z2_old;
00043
00044   int ens, f, 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(q1, double,
00070         NQ * NP);
00071   ALLOC(q2, double,
00072         NQ * NP);
00073
00074   /* Check arguments... */
00075   if (argc < 5)
00076     ERRMSG("Give parameters: <ctl> <outfile> <atm1a> <atm1b>"
00077            " [<atm2a> <atm2b> ...]");
00078
00079   /* Read control parameters... */
00080   read_ctl(argv[1], argc, argv, &ctl);
00081   ens = (int) scan_ctl(argv[1], argc, argv, "DIST_ENS", -1, "-1", NULL);
00082   p0 = P(scan_ctl(argv[1], argc, argv, "DIST_Z0", -1, "-1000", NULL));
00083   p1 = P(scan_ctl(argv[1], argc, argv, "DIST_Z1", -1, "1000", NULL));
00084   lat0 = scan_ctl(argv[1], argc, argv, "DIST_LAT0", -1, "-1000", NULL);
00085   lat1 = scan_ctl(argv[1], argc, argv, "DIST_LAT1", -1, "1000", NULL);
00086   lon0 = scan_ctl(argv[1], argc, argv, "DIST_LON0", -1, "-1000", NULL);
00087   lon1 = scan_ctl(argv[1], argc, argv, "DIST_LON1", -1, "1000", NULL);
00088
00089   /* Write info... */
00090   printf("Write transport deviations: %s\n", argv[2]);
00091
00092   /* Create output file... */
00093   if (!(out = fopen(argv[2], "w")))
00094     ERRMSG("Cannot create file!");
00095
```

```
00096   /* Write header... */
00097   fprintf(out,
00098           "# $1 = time [s]\n"
00099           "# $2 = trajectory time [s]\n"
00100           "# $3 = AHTD [km]\n"
00101           "# $4 = RHTD [%%]\n" "# $5 = AVTD [km]\n" "# $6 = RVTD [%%]\n");
00102   for (iq = 0; iq < ctl.nq; iq++)
00103     fprintf(out,
00104             "# $%d = AQTD (%s) [%s]\n"
00105             "# $%d = RQTD (%s) [%%]\n",
00106             7 + 2 * iq, ctl.qnt_name[iq], ctl.qnt_unit[iq],
00107             8 + 2 * iq, ctl.qnt_name[iq]);
00108   for (iq = 0; iq < ctl.nq; iq++)
00109     fprintf(out,
00110             "# $%d = ATCE_1 (%s) [%s]\n"
00111             "# $%d = RTCE_1 (%s) [%%]\n",
00112             7 + 2 * ctl.nq + 2 * iq, ctl.qnt_name[iq], ctl.qnt_unit[iq],
00113             8 + 2 * ctl.nq + 2 * iq, ctl.qnt_name[iq]);
00114   for (iq = 0; iq < ctl.nq; iq++)
00115     fprintf(out,
00116             "# $%d = ATCE_2 (%s) [%s]\n"
00117             "# $%d = RTCE_2 (%s) [%%]\n",
00118             7 + 4 * ctl.nq + 2 * iq, ctl.qnt_name[iq], ctl.qnt_unit[iq],
00119             8 + 4 * ctl.nq + 2 * iq, ctl.qnt_name[iq]);
00120   fprintf(out, "# $%d = number of particles\n\n", 7 + 6 * ctl.nq);
00121
00122   /* Loop over file pairs... */
00123   for (f = 3; f < argc; f += 2) {
00124
00125     /* Read atmopheric data... */
00126     read_atm(argv[f], &ctl, atm1);
00127     read_atm(argv[f + 1], &ctl, atm2);
00128
00129     /* Check if structs match... */
00130     if (atm1->np != atm2->np)
00131       ERRMSG("Different numbers of parcels!");
00132     for (ip = 0; ip < atm1->np; ip++)
00133       if (gsl_finite(atm1->time[ip]) && gsl_finite(atm2->time[ip])
00134           && atm1->time[ip] != atm2->time[ip])
00135         ERRMSG("Times do not match!");
00136
00137     /* Get time from filename... */
00138     sprintf(tstr, "%.4s", &argv[f][strlen(argv[f]) - 20]);
00139     year = atoi(tstr);
00140     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 15]);
00141     mon = atoi(tstr);
00142     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 12]);
00143     day = atoi(tstr);
00144     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 9]);
00145     hour = atoi(tstr);
00146     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 6]);
00147     min = atoi(tstr);
00148     time2jsec(year, mon, day, hour, min, 0, 0, &t);
00149
00150     /* Save initial data... */
00151     if (f == 3) {
00152       t0 = t;
00153       for (iq = 0; iq < ctl.nq; iq++)
00154         for (ip = 0; ip < atm1->np; ip++) {
00155           q1[iq * NP + ip] = atm1->q[iq][ip];
00156           q2[iq * NP + ip] = atm2->q[iq][ip];
00157         }
00158     }
00159
00160     /* Init... */
00161     np = 0;
00162     ahtd = avtd = rhtd = rvtd = 0;
00163     for (iq = 0; iq < ctl.nq; iq++)
00164       aqtd[iq] = atce1[iq] = atce2[iq] = rqtd[iq] = rtce1[iq] = rtce2[iq] = 0;
00165
00166     /* Loop over air parcels... */
00167     for (ip = 0; ip < atm1->np; ip++) {
00168
00169       /* Check data... */
00170       if (!gsl_finite(atm1->time[ip]) || !gsl_finite(atm2->time[ip]))
00171         continue;
00172
00173       /* Check ensemble ID... */
00174       if (ens >= 0 && ctl.qnt_ens >= 0 && atm1->q[ctl.qnt_ens][ip] != ens)
00175         continue;
00176       if (ens >= 0 && ctl.qnt_ens >= 0 && atm2->q[ctl.qnt_ens][ip] != ens)
00177         continue;
00178
00179       /* Check spatial range... */
00180       if (atm1->p[ip] > p0 || atm1->p[ip] < p1
00181           || atm1->lon[ip] < lon0 || atm1->lon[ip] > lon1
00182           || atm1->lat[ip] < lat0 || atm1->lat[ip] > lat1)
```

```
00183         continue;
00184       if (atm2->p[ip] > p0 || atm2->p[ip] < p1
00185           || atm2->lon[ip] < lon0 || atm2->lon[ip] > lon1
00186           || atm2->lat[ip] < lat0 || atm2->lat[ip] > lat1)
00187         continue;
00188
00189       /* Convert coordinates... */
00190       geo2cart(0, atm1->lon[ip], atm1->lat[ip], x1);
00191       geo2cart(0, atm2->lon[ip], atm2->lat[ip], x2);
00192       z1 = Z(atm1->p[ip]);
00193       z2 = Z(atm2->p[ip]);
00194
00195       /* Calculate absolute transport deviations... */
00196       ahtd += DIST(x1, x2);
00197       avtd += fabs(z1 - z2);
00198       for (iq = 0; iq < ctl.nq; iq++)
00199         aqtd[iq] += fabs(atm1->q[iq][ip] - atm2->q[iq][ip]);
00200
00201       /* Calculate relative transport deviations... */
00202       if (f > 3) {
00203
00204         /* Get trajectory lengths... */
00205         geo2cart(0, lon1_old[ip], lat1_old[ip], x0);
00206         lh1[ip] += DIST(x0, x1);
00207         lv1[ip] += fabs(z1_old[ip] - z1);
00208
00209         geo2cart(0, lon2_old[ip], lat2_old[ip], x0);
00210         lh2[ip] += DIST(x0, x2);
00211         lv2[ip] += fabs(z2_old[ip] - z2);
00212
00213         /* Get relative transport deviations... */
00214         if (lh1[ip] + lh2[ip] > 0)
00215           rhtd += 200. * DIST(x1, x2) / (lh1[ip] + lh2[ip]);
00216         if (lv1[ip] + lv2[ip] > 0)
00217           rvtd += 200. * fabs(z1 - z2) / (lv1[ip] + lv2[ip]);
00218         for (iq = 0; iq < ctl.nq; iq++)
00219           rqtd[iq] += 200. * fabs(atm1->q[iq][ip] - atm2->q[iq][ip])
00220             / (fabs(atm1->q[iq][ip]) + fabs(atm2->q[iq][ip]));
00221
00222         /* Get tracer conservation errors... */
00223         for (iq = 0; iq < ctl.nq; iq++) {
00224           atce1[iq] += fabs(atm1->q[iq][ip] - q1[iq * NP + ip]);
00225           rtce1[iq] += 200. * fabs(atm1->q[iq][ip] - q1[iq * NP + ip])
00226             / (fabs(atm1->q[iq][ip]) + fabs(q1[iq * NP + ip]));
00227           atce2[iq] += fabs(atm2->q[iq][ip] - q2[iq * NP + ip]);
00228           rtce2[iq] += 200. * fabs(atm2->q[iq][ip] - q2[iq * NP + ip])
00229             / (fabs(atm2->q[iq][ip]) + fabs(q2[iq * NP + ip]));
00230         }
00231       }
00232
00233       /* Save positions of air parcels... */
00234       lon1_old[ip] = atm1->lon[ip];
00235       lat1_old[ip] = atm1->lat[ip];
00236       z1_old[ip] = z1;
00237
00238       lon2_old[ip] = atm2->lon[ip];
00239       lat2_old[ip] = atm2->lat[ip];
00240       z2_old[ip] = z2;
00241
00242       /* Increment air parcel counter... */
00243       np++;
00244     }
00245
00246     /* Write output... */
00247     fprintf(out, "%.2f %.2f %g %g %g %g", t, t - t0,
00248             ahtd / np, rhtd / np, avtd / np, rvtd / np);
00249     for (iq = 0; iq < ctl.nq; iq++) {
00250       fprintf(out, " ");
00251       fprintf(out, ctl.qnt_format[iq], aqtd[iq] / np);
00252       fprintf(out, " ");
00253       fprintf(out, ctl.qnt_format[iq], rqtd[iq] / np);
00254     }
00255     for (iq = 0; iq < ctl.nq; iq++) {
00256       fprintf(out, " ");
00257       fprintf(out, ctl.qnt_format[iq], atce1[iq] / np);
00258       fprintf(out, " ");
00259       fprintf(out, ctl.qnt_format[iq], rtce1[iq] / np);
00260     }
00261     for (iq = 0; iq < ctl.nq; iq++) {
00262       fprintf(out, " ");
00263       fprintf(out, ctl.qnt_format[iq], atce2[iq] / np);
00264       fprintf(out, " ");
00265       fprintf(out, ctl.qnt_format[iq], rtce2[iq] / np);
00266     }
00267     fprintf(out, " %d\n", np);
00268   }
00269
```

```
00270   /* Close file... */
00271   fclose(out);
00272
00273   /* Free... */
00274   free(atm1);
00275   free(atm2);
00276   free(lon1_old);
00277   free(lat1_old);
00278   free(z1_old);
00279   free(lh1);
00280   free(lv1);
00281   free(lon2_old);
00282   free(lat2_old);
00283   free(z2_old);
00284   free(lh2);
00285   free(lv2);
00286
00287   return EXIT_SUCCESS;
00288 }
```

5.11 doy2day.c File Reference

Convert day of year to date.

Functions

- int main (int argc, char ∗argv[ ])

5.11.1 Detailed Description

Convert day of year to date.

Definition in file doy2day.c.

5.11.2 Function Documentation

5.11.2.1 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:

5.12 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 }
```

5.13 extract.c File Reference

Extract single trajectory from atmospheric data files.

Functions

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

5.13.1 Detailed Description

Extract single trajectory from atmospheric data files.

Definition in file extract.c.

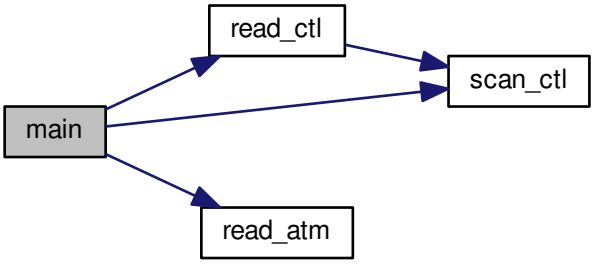
5.13.2 Function Documentation

5.13.2.1 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 *in, *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> <outfile> <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, "0", 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 (!(in = fopen(argv[f], "r")))
00072       continue;
00073     else
00074       fclose(in);
00075     read_atm(argv[f], &ctl, atm);
00076
00077     /* Write data... */
00078     fprintf(out, "%.2f %g %g %g", atm->time[ip],
00079             Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
00080     for (iq = 0; iq < ctl.nq; iq++) {
00081       fprintf(out, " ");
00082       fprintf(out, ctl.qnt_format[iq], atm->q[iq][ip]);
00083     }
00084     fprintf(out, "\n");
00085   }
00086
00087   /* Close file... */
00088   fclose(out);
00089
00090   /* Free... */
00091   free(atm);
00092
00093   return EXIT_SUCCESS;
00094 }
```

Here is the call graph for this function:



5.14 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) 2013-2018 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 *in, *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> <outfile> <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, "0", 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 (!(in = fopen(argv[f], "r")))
00072       continue;
00073     else
00074       fclose(in);
00075     read_atm(argv[f], &ctl, atm);
00076
00077     /* Write data... */
00078     fprintf(out, "%.2f %g %g %g", atm->time[ip],
00079             Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
00080     for (iq = 0; iq < ctl.nq; iq++) {
00081       fprintf(out, " ");
00082       fprintf(out, ctl.qnt_format[iq], atm->q[iq][ip]);
00083     }
00084     fprintf(out, "\n");
00085   }
00086
00087   /* Close file... */
00088   fclose(out);
00089
00090   /* Free... */
00091   free(atm);
00092
00093   return EXIT_SUCCESS;
00094 }
```

5.15 init.c File Reference

Create atmospheric data file with initial air parcel positions.

Functions

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

5.15.1 Detailed Description

Create atmospheric data file with initial air parcel positions.

Definition in file init.c.

5.15.2 Function Documentation

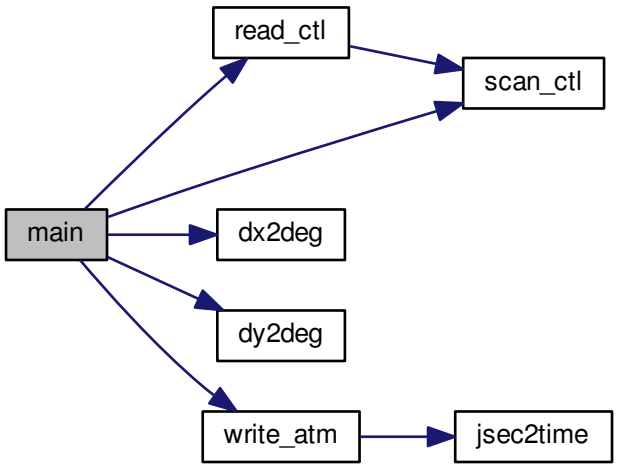
5.15.2.1 int main (int *argc*, char * *argv[ ]*)

Definition at line 27 of file 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:



5.16 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) 2013-2018 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 }
```

5.17 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.

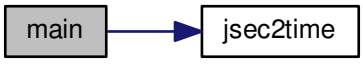
5.17.2 Function Documentation

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) 2013-2018 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.
- double deg2dx (double dlon, double lat)

  Convert degrees to horizontal distance.
- double deg2dy (double dlat)

  Convert degrees to horizontal distance.
- double dp2dz (double dp, double p)

Convert pressure to vertical distance.

- double dx2deg (double dx, double lat)

  Convert horizontal distance to degrees.

- double dy2deg (double dy)

  Convert horizontal distance to degrees.

- double dz2dp (double dz, double p)

  Convert vertical distance to pressure.

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

  Linear interpolation of 2-D meteorological data.

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

  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 (double *xx, int n, double x)

  Find array index.

- void 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.

- void 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 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;
00036
00037   radius = NORM(x);
00038   *lat = asin(x[2] / radius) * 180 / M_PI;
00039   *lon = atan2(x[1], x[0]) * 180 / M_PI;
00040   *z = radius - RE;
00041 }
```

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

Climatology of HNO3 volume mixing ratios.

Definition at line 45 of file libtrac.c.

```
00048             {
00049
00050   static double secs[12] = { 1209600.00, 3888000.00, 6393600.00,
00051     9072000.00, 11664000.00, 14342400.00,
00052     16934400.00, 19612800.00, 22291200.00,
00053     24883200.00, 27561600.00, 30153600.00
00054   };
00055
00056   static double lats[18] = { -85, -75, -65, -55, -45, -35, -25, -15, -5,
00057     5, 15, 25, 35, 45, 55, 65, 75, 85
00058   };
00059
00060   static double ps[10] = { 4.64159, 6.81292, 10, 14.678, 21.5443,
00061     31.6228, 46.4159, 68.1292, 100, 146.78
00062   };
00063
00064   static double hno3[12][18][10] = {
00065     {{0.782, 1.65, 2.9, 4.59, 6.71, 8.25, 7.16, 5.75, 2.9, 1.74},
00066      {0.529, 1.64, 2.76, 4.55, 6.58, 8, 6.99, 5.55, 2.68, 1.57},
00067      {0.723, 1.55, 2.73, 4.48, 6.32, 7.58, 7.05, 5.16, 2.49, 1.54},
00068      {0.801, 1.56, 2.74, 4.52, 6.23, 7.35, 6.68, 4.4, 1.97, 1.23},
00069      {0.818, 1.62, 2.77, 4.38, 5.98, 6.84, 5.83, 3.05, 1.15, 0.709},
00070      {0.901, 1.73, 2.78, 4.21, 5.63, 6.16, 4.68, 1.87, 0.617, 0.37},
00071      {0.997, 1.8, 2.79, 4.09, 4.88, 4.96, 3.12, 1.22, 0.311, 0.244},
00072      {1, 1.71, 2.51, 3.4, 3.74, 3.39, 2.25, 0.845, 0.204, 0.222},
00073      {0.997, 1.7, 2.36, 2.88, 3.01, 2.25, 1.77, 0.608, 0.163, 0.181},
00074      {0.991, 1.79, 2.57, 3.06, 3.08, 2.15, 1.81, 0.59, 0.168, 0.104},
00075      {0.974, 1.86, 2.84, 3.8, 3.93, 3.79, 2.91, 1.02, 0.152, 0.0985},
00076      {0.85, 1.86, 3.3, 5.24, 6.55, 6.86, 5.12, 1.93, 0.378, 0.185},
00077      {0.783, 1.89, 3.85, 6.6, 8.56, 8.66, 6.95, 3.95, 1.47, 0.745},
00078      {0.883, 2.05, 4.34, 7.54, 9.68, 9.77, 8.19, 5.72, 3.15, 1.77},
00079      {1.4, 2.44, 4.72, 8.07, 10.5, 10.9, 9.28, 6.95, 4.47, 2.49},
00080      {1.7, 2.43, 4.24, 7.43, 10.4, 11.2, 9.72, 8.15, 5.7, 2.97},
00081      {2.06, 2.27, 3.68, 6.77, 10.3, 10.3, 9.05, 9.1, 6.73, 3.14},
00082      {2.33, 2.39, 3.51, 6.45, 10.3, 9.88, 8.57, 9.42, 7.22, 3.19}},
00083     {{0.947, 2.21, 3.81, 5.69, 7.55, 8.63, 7.53, 5.98, 3.03, 1.64},
00084      {0.642, 2, 3.4, 5.49, 7.5, 8.52, 7.53, 5.83, 2.74, 1.42},
00085      {0.756, 1.83, 3.18, 5.11, 7.24, 8.63, 7.66, 5.5, 2.45, 1.33},
00086      {0.837, 1.75, 3.06, 5, 6.79, 8.08, 7.05, 4.42, 1.81, 1.05},
00087      {0.86, 1.73, 2.96, 4.68, 6.38, 7.38, 6.09, 2.92, 1.06, 0.661},
00088      {0.926, 1.78, 2.89, 4.37, 5.74, 6.14, 4.59, 1.78, 0.561, 0.332},
00089      {0.988, 1.78, 2.75, 3.95, 4.64, 4.49, 2.85, 1.13, 0.271, 0.184},
00090      {0.999, 1.7, 2.44, 3.27, 3.57, 3.03, 2.06, 0.736, 0.181, 0.189},
00091      {0.971, 1.67, 2.23, 2.63, 2.83, 2.15, 1.74, 0.554, 0.157, 0.167},
00092      {0.985, 1.72, 2.34, 2.69, 2.81, 2.11, 1.78, 0.592, 0.152, 0.101},
00093      {0.95, 1.72, 2.57, 3.44, 3.84, 3.89, 2.91, 0.976, 0.135, 0.114},
00094      {0.819, 1.64, 2.93, 4.75, 6.02, 6.93, 5.2, 1.83, 0.347, 0.191},
00095      {0.731, 1.58, 3.3, 5.95, 7.81, 8.32, 6.93, 3.83, 1.47, 0.875},
00096      {0.77, 1.75, 3.74, 6.67, 8.76, 9.41, 8.19, 5.78, 3.32, 2.11},
00097      {1.08, 2.17, 4.24, 7.13, 9.2, 10.3, 9.03, 6.87, 4.65, 3.01},
00098      {1.43, 2.49, 4.31, 7, 9.14, 10.6, 9.34, 7.6, 5.86, 3.64},
00099      {1.5, 2.68, 4.32, 6.75, 8.78, 10.6, 9.05, 7.65, 6.27, 4.07},
00100     {1.73, 2.91, 4.33, 6.67, 8.73, 10.6, 8.5, 7.54, 6.63, 4.17}},
00101    {{1.43, 3.07, 5.22, 7.54, 9.78, 10.4, 10.1, 7.26, 3.61, 1.69},
00102     {0.989, 2.69, 4.76, 7.19, 9.44, 9.94, 9.5, 6.74, 3.24, 1.52},
00103     {0.908, 2.23, 4.11, 6.48, 8.74, 9.41, 8.58, 5.8, 2.66, 1.3},
00104     {0.923, 1.99, 3.61, 5.83, 7.84, 8.6, 7.55, 4.57, 1.87, 0.98},
00105     {0.933, 1.9, 3.31, 5.28, 7.1, 7.84, 6.44, 3.18, 1.1, 0.642},
00106     {0.982, 1.88, 3.1, 4.76, 6.16, 6.57, 5.16, 2.04, 0.598, 0.33},
00107     {1.02, 1.82, 2.88, 4.12, 4.71, 4.54, 3.03, 1.22, 0.268, 0.174},
00108     {0.992, 1.7, 2.51, 3.33, 3.62, 2.87, 2.05, 0.705, 0.161, 0.169},
00109     {0.969, 1.69, 2.2, 2.62, 2.84, 2.13, 1.78, 0.529, 0.146, 0.186},
00110     {0.945, 1.69, 2.27, 2.64, 2.83, 2.2, 1.83, 0.561, 0.139, 0.121},
00111     {0.922, 1.65, 2.48, 3.33, 3.83, 4.09, 2.92, 0.973, 0.117, 0.135},
00112     {0.886, 1.59, 2.66, 4.26, 5.51, 6.57, 5.09, 1.79, 0.342, 0.194},
00113     {0.786, 1.5, 2.78, 5.01, 6.8, 7.83, 6.65, 3.62, 1.45, 1},
00114     {0.745, 1.55, 3.05, 5.49, 7.44, 8.6, 7.8, 5.28, 2.95, 2.12},
00115     {0.938, 1.76, 3.4, 5.82, 7.8, 9.04, 8.43, 6.15, 3.85, 2.82},
00116     {0.999, 2, 3.66, 5.95, 7.94, 9.27, 8.8, 6.93, 4.87, 3.54},
00117     {1.13, 2.23, 3.86, 5.82, 7.65, 9, 8.82, 7.17, 5.72, 4.08},
00118     {1.23, 2.33, 3.94, 5.74, 7.48, 8.9, 8.84, 7.35, 6.3, 4.42}},
00119    {{1.55, 3.2, 6.25, 10, 12.9, 12.9, 11.9, 7.96, 3.96, 1.75},
00120     {1.32, 3.27, 6.32, 9.99, 12.7, 12.4, 11.3, 7.51, 3.66, 1.58},
00121     {1.25, 3.08, 5.77, 8.71, 11.2, 11.2, 9.84, 6.52, 3.23, 1.5},
00122     {1.18, 2.59, 4.76, 7.46, 9.61, 9.66, 8.42, 5.06, 2.25, 1.09},
00123     {1.09, 2.24, 3.99, 6.4, 8.33, 8.54, 7.08, 3.69, 1.36, 0.727},
00124     {1.06, 2.07, 3.52, 5.52, 7.06, 7.26, 5.83, 2.46, 0.732, 0.409},
```

```
00125      {1.07, 1.91, 3.09, 4.63, 5.21, 4.9, 3.68, 1.43, 0.326, 0.198},
00126      {1.03, 1.74, 2.63, 3.54, 3.78, 2.89, 2.09, 0.743, 0.175, 0.12},
00127      {0.959, 1.71, 2.32, 2.77, 2.99, 2.24, 1.76, 0.519, 0.149, 0.172},
00128      {0.931, 1.68, 2.32, 2.74, 2.99, 2.46, 1.88, 0.578, 0.156, 0.157},
00129      {0.933, 1.66, 2.49, 3.42, 3.99, 4.12, 2.93, 1.02, 0.181, 0.138},
00130      {0.952, 1.64, 2.6, 4, 5.15, 6.07, 4.84, 1.78, 0.407, 0.286},
00131      {0.84, 1.54, 2.68, 4.47, 5.97, 7.13, 6.23, 3.25, 1.38, 1.02},
00132      {0.714, 1.44, 2.73, 4.68, 6.28, 7.68, 7.21, 4.82, 2.55, 1.96},
00133      {0.838, 1.57, 2.96, 4.93, 6.55, 8.08, 7.74, 5.77, 3.32, 2.52},
00134      {0.823, 1.65, 3.11, 5.09, 6.89, 8.36, 8.31, 6.59, 4.1, 3.04},
00135      {0.886, 1.83, 3.42, 5.33, 6.92, 8.36, 8.63, 7.21, 4.82, 3.46},
00136      {1.07, 2.12, 3.74, 5.54, 6.98, 8.41, 8.75, 7.41, 5.16, 3.62}},
00137     {{1.13, 2.59, 7.49, 13.5, 15.4, 12.9, 11.3, 8.62, 4.18, 1.63},
00138      {0.973, 2.79, 7.23, 12.8, 15.2, 13.3, 11.6, 8.42, 4.06, 1.57},
00139      {1.46, 3.44, 6.78, 10.4, 12.7, 12.1, 10.5, 7.04, 3.59, 1.63},
00140      {1.52, 3.38, 6.04, 9.08, 11, 10.3, 8.9, 5.7, 2.77, 1.37},
00141      {1.32, 2.65, 4.75, 7.49, 9.32, 8.89, 7.42, 4.27, 1.7, 0.88},
00142      {1.19, 2.2, 3.88, 6.36, 8.03, 7.81, 6.19, 2.94, 0.948, 0.527},
00143      {1.14, 1.96, 3.28, 5.26, 6.12, 5.8, 4.47, 1.66, 0.388, 0.229},
00144      {1.07, 1.82, 2.82, 3.92, 4.03, 3.15, 2.31, 0.871, 0.183, 0.0972},
00145      {0.978, 1.77, 2.53, 3.04, 3.1, 2.36, 1.76, 0.575, 0.16, 0.126},
00146      {0.962, 1.72, 2.49, 3.01, 3.22, 2.72, 2, 0.716, 0.162, 0.183},
00147      {0.968, 1.7, 2.6, 3.57, 4.28, 4.35, 3.09, 1.2, 0.262, 0.18},
00148      {0.977, 1.68, 2.71, 4.03, 5.17, 6.01, 4.81, 1.81, 0.473, 0.343},
00149      {0.819, 1.58, 2.75, 4.37, 5.8, 6.9, 5.96, 2.95, 1.19, 0.964},
00150      {0.672, 1.44, 2.69, 4.42, 5.92, 7.26, 6.79, 4.32, 2.22, 1.83},
00151      {0.783, 1.42, 2.65, 4.45, 6.04, 7.57, 7.39, 5.4, 2.94, 2.25},
00152      {0.757, 1.43, 2.7, 4.54, 6.14, 7.65, 7.51, 5.95, 3.42, 2.39},
00153      {0.758, 1.57, 3.04, 4.88, 6.24, 7.85, 7.58, 6.35, 3.81, 2.52},
00154      {0.835, 1.72, 3.35, 5.24, 6.5, 8.1, 7.67, 6.51, 4, 2.6}},
00155     {{1.5, 2.12, 7.64, 10.5, 5.59, 2.14, 2.2, 3.5, 4.71, 3.26},
00156      {1.32, 2.14, 7.23, 12, 9.3, 5.3, 5.11, 5.37, 5.12, 3.05},
00157      {1.53, 2.92, 6.9, 11.9, 13.5, 11.3, 9.91, 7.18, 4.75, 2.65},
00158      {1.66, 3.48, 6.25, 9.53, 11.3, 10.3, 9.01, 5.76, 2.99, 1.67},
00159      {1.54, 3.03, 5.21, 8.03, 9.66, 8.98, 7.5, 4.64, 2.11, 1.13},
00160      {1.32, 2.39, 4.03, 6.74, 8.52, 8.05, 6.4, 3.48, 1.2, 0.639},
00161      {1.17, 2.08, 3.35, 5.52, 6.86, 6.54, 5.08, 1.97, 0.462, 0.217},
00162      {1.07, 1.92, 3.01, 4.24, 4.47, 3.77, 2.77, 1.07, 0.213, 0.0694},
00163      {0.992, 1.88, 2.76, 3.39, 3.32, 2.52, 1.8, 0.713, 0.192, 0.136},
00164      {0.992, 1.8, 2.63, 3.34, 3.46, 2.95, 2.09, 0.9, 0.242, 0.194},
00165      {0.987, 1.77, 2.67, 3.64, 4.37, 4.36, 3, 1.27, 0.354, 0.229},
00166      {0.979, 1.74, 2.77, 3.99, 5.12, 5.75, 4.53, 1.75, 0.555, 0.302},
00167      {0.832, 1.6, 2.78, 4.32, 5.53, 6.67, 5.69, 2.59, 0.982, 0.66},
00168      {0.696, 1.41, 2.64, 4.31, 5.65, 7.14, 6.56, 3.8, 1.75, 1.41},
00169      {0.788, 1.36, 2.59, 4.3, 5.73, 7.35, 7.04, 4.82, 2.41, 1.8},
00170      {0.761, 1.43, 2.61, 4.28, 5.64, 7.37, 7.11, 5.37, 2.68, 1.9},
00171      {0.701, 1.44, 2.82, 4.64, 5.76, 7.63, 7.07, 5.74, 2.98, 1.88},
00172      {0.763, 1.5, 2.95, 4.97, 6.08, 7.88, 7.12, 5.98, 3.21, 1.91}},
00173     {{3.58, 2.59, 6.49, 5.84, 1.63, 0.282, 0.647, 0.371, 1.36, 2.33},
00174      {3.09, 2.38, 6.37, 7.66, 4.06, 1.23, 1.8, 1.65, 2.32, 2.78},
00175      {2.31, 2.84, 5.58, 9.63, 11, 9.02, 8.2, 6.23, 4.17, 3.08},
00176      {1.61, 3.16, 5.72, 9.13, 11.4, 10.4, 9.15, 6.18, 3.52, 2.3},
00177      {1.32, 2.8, 4.79, 7.44, 9.43, 8.83, 7.41, 4.9, 2.38, 1.38},
00178      {1.14, 2.36, 3.94, 6.41, 8.38, 8.17, 6.53, 3.76, 1.31, 0.656},
00179      {1.05, 2.1, 3.36, 5.45, 7.07, 6.98, 5.44, 2.22, 0.52, 0.176},
00180      {1.02, 2, 3.05, 4.33, 4.74, 4.21, 3.2, 1.26, 0.277, 0.0705},
00181      {1.01, 1.96, 2.9, 3.53, 3.46, 2.69, 1.89, 0.859, 0.254, 0.12},
00182      {1.01, 1.86, 2.7, 3.46, 3.59, 3.03, 2.14, 1, 0.34, 0.199},
00183      {1.02, 1.81, 2.67, 3.68, 4.39, 4.3, 2.93, 1.35, 0.477, 0.25},
00184      {0.991, 1.79, 2.82, 4.05, 5.08, 5.5, 4.21, 1.74, 0.605, 0.259},
00185      {0.844, 1.73, 2.87, 4.38, 5.49, 6.47, 5.5, 2.44, 0.85, 0.422},
00186      {0.729, 1.57, 2.76, 4.43, 5.73, 7.13, 6.43, 3.52, 1.38, 0.913},
00187      {0.819, 1.46, 2.69, 4.45, 5.92, 7.47, 7.05, 4.52, 2, 1.4},
00188      {0.783, 1.47, 2.71, 4.48, 5.92, 7.46, 7.16, 5.08, 2.35, 1.56},
00189      {0.735, 1.51, 2.96, 4.84, 5.92, 7.77, 7.2, 5.54, 2.56, 1.61},
00190      {0.8, 1.61, 3.14, 5.2, 6.26, 8.08, 7.27, 5.72, 2.75, 1.62}},
00191     {{5, 4.43, 5.53, 5.35, 2.33, 0.384, 0.663, 0.164, 0.692, 1.4},
00192      {3.62, 3.79, 4.77, 5.94, 4.12, 1.36, 1.3, 0.973, 1.37, 1.73},
00193      {2.11, 2.7, 4.12, 7.14, 9.03, 7.74, 7.12, 5.44, 3.73, 2.6},
00194      {1.13, 2.32, 4.12, 6.97, 9.86, 9.69, 8.85, 6.22, 3.59, 2.14},
00195      {0.957, 2.28, 4.11, 6.47, 8.66, 8.78, 7.33, 4.94, 2.44, 1.38},
00196      {0.881, 2.1, 3.65, 5.94, 7.98, 8.29, 6.69, 3.95, 1.36, 0.672},
00197      {0.867, 1.96, 3.26, 5.23, 6.94, 7.2, 5.63, 2.41, 0.578, 0.19},
00198      {0.953, 1.94, 2.98, 4.23, 4.83, 4.52, 3.38, 1.34, 0.293, 0.181},
00199      {1.01, 1.91, 2.77, 3.35, 3.3, 2.62, 1.99, 0.905, 0.245, 0.107},
00200      {1.03, 1.81, 2.57, 3.29, 3.43, 2.87, 2.13, 0.988, 0.306, 0.185},
00201      {1.02, 1.78, 2.58, 3.59, 4.19, 4, 2.72, 1.29, 0.389, 0.224},
00202      {1.01, 1.84, 2.84, 4.06, 4.9, 5.08, 3.71, 1.64, 0.529, 0.232},
00203      {0.902, 1.84, 2.98, 4.43, 5.5, 6.28, 5.18, 2.35, 0.734, 0.341},
00204      {0.785, 1.68, 2.93, 4.67, 5.95, 7.3, 6.52, 3.48, 1.24, 0.754},
00205      {0.847, 1.62, 2.94, 4.86, 6.38, 7.99, 7.5, 4.64, 1.93, 1.23},
00206      {0.8, 1.6, 2.94, 4.95, 6.62, 8.16, 7.91, 5.43, 2.43, 1.45},
00207      {0.82, 1.76, 3.37, 5.47, 6.82, 8.24, 7.73, 5.79, 2.69, 1.5},
00208      {0.988, 2.05, 3.87, 6.01, 7.18, 8.41, 7.7, 5.93, 2.89, 1.55}},
00209     {{1.52, 2.7, 3.79, 4.95, 3.8, 1.51, 1.11, 0.784, 1.1, 1.56},
00210      {1.19, 2.16, 3.34, 4.76, 4.61, 2.93, 2.07, 1.65, 1.63, 1.74},
00211      {0.804, 1.65, 2.79, 4.63, 6.64, 6.95, 6.68, 5.11, 3.3, 2.09},
```

```
00212     {0.86, 1.8, 3.25, 5.3, 7.91, 8.76, 8.28, 6.01, 3.39, 1.83},
00213     {0.859, 1.95, 3.54, 5.64, 7.88, 8.55, 7.3, 4.88, 2.3, 1.22},
00214     {0.809, 1.88, 3.38, 5.45, 7.47, 8.02, 6.69, 3.98, 1.35, 0.646},
00215     {0.822, 1.81, 3.11, 4.9, 6.62, 6.96, 5.63, 2.47, 0.614, 0.169},
00216     {0.92, 1.83, 2.8, 3.93, 4.56, 4.4, 3.25, 1.31, 0.295, 0.0587},
00217     {0.986, 1.83, 2.6, 3.13, 3.08, 2.53, 1.94, 0.886, 0.244, 0.0815},
00218     {0.997, 1.74, 2.5, 3.16, 3.24, 2.67, 2.05, 0.939, 0.281, 0.147},
00219     {1.01, 1.75, 2.57, 3.55, 4.1, 3.81, 2.53, 1.21, 0.354, 0.197},
00220     {1.04, 1.88, 2.9, 4.16, 4.95, 4.96, 3.48, 1.63, 0.502, 0.163},
00221     {0.967, 1.95, 3.17, 4.72, 5.85, 6.5, 5.34, 2.53, 0.748, 0.303},
00222     {0.846, 1.83, 3.23, 5.15, 6.62, 7.82, 6.85, 3.79, 1.36, 0.714},
00223     {0.91, 1.81, 3.35, 5.55, 7.32, 8.55, 7.88, 5.03, 2.13, 1.1},
00224     {0.87, 1.94, 3.6, 5.97, 7.98, 9.14, 8.71, 6.04, 2.73, 1.41},
00225     {1.04, 2.36, 4.22, 6.57, 8.5, 9.53, 9.22, 6.71, 3.2, 1.56},
00226     {1.36, 2.84, 4.72, 6.94, 8.81, 9.87, 9.59, 7.1, 3.43, 1.65}},
00227    {{0.704, 1.4, 2.03, 3.08, 4.64, 4.24, 2.55, 1.57, 1.99, 1.91},
00228     {0.484, 1.38, 2.08, 3.54, 5.11, 4.98, 3.73, 2.57, 2.29, 1.84},
00229     {0.749, 1.57, 2.63, 4.17, 6.15, 6.97, 6.64, 5.11, 3.35, 1.97},
00230     {0.864, 1.69, 3.16, 4.87, 7.13, 8.33, 7.87, 5.9, 3.17, 1.56},
00231     {0.861, 1.79, 3.28, 5.2, 7.29, 8.32, 7.38, 4.9, 2.23, 1.11},
00232     {0.835, 1.79, 3.19, 4.99, 6.72, 7.58, 6.45, 3.68, 1.25, 0.616},
00233     {0.847, 1.8, 3.07, 4.66, 6.12, 6.6, 5.21, 2.18, 0.554, 0.21},
00234     {0.941, 1.78, 2.68, 3.68, 4.28, 4.18, 2.97, 1.15, 0.238, 0.0968},
00235     {0.98, 1.78, 2.48, 2.99, 2.96, 2.35, 1.88, 0.747, 0.207, 0.105},
00236     {0.978, 1.74, 2.51, 3.07, 3.12, 2.36, 1.95, 0.777, 0.216, 0.146},
00237     {1.01, 1.79, 2.63, 3.53, 3.95, 3.47, 2.38, 1.08, 0.265, 0.178},
00238     {1.06, 1.94, 3.02, 4.43, 5.19, 5.01, 3.68, 1.71, 0.429, 0.14},
00239     {0.99, 2.02, 3.38, 5.22, 6.56, 6.91, 5.56, 2.75, 0.816, 0.353},
00240     {0.923, 2.05, 3.66, 5.98, 7.78, 8.5, 7.23, 4.26, 1.67, 0.802},
00241     {1.08, 2.27, 4.17, 6.8, 8.89, 9.55, 8.59, 5.64, 2.58, 1.2},
00242     {1.12, 2.5, 4.52, 7.22, 9.76, 10.3, 9.72, 6.79, 3.32, 1.52},
00243     {1.2, 2.64, 4.81, 7.64, 10.5, 11.4, 10.6, 7.65, 3.87, 1.73},
00244     {1.4, 2.91, 5.01, 7.75, 10.7, 11.6, 11.1, 8.02, 4.04, 1.8}},
00245    {{0.75, 1.49, 2.39, 3.39, 4.93, 5.94, 5.03, 2.75, 2.27, 1.78},
00246     {0.508, 1.52, 2.38, 3.82, 5.34, 6.13, 5.6, 3.31, 2.42, 1.73},
00247     {0.715, 1.56, 2.7, 4.39, 6.18, 6.96, 7.1, 5.04, 3.01, 1.75},
00248     {0.813, 1.62, 2.94, 4.65, 6.53, 7.65, 7.52, 5.49, 2.75, 1.41},
00249     {0.802, 1.68, 2.97, 4.64, 6.37, 7.53, 7.01, 4.56, 1.9, 0.955},
00250     {0.816, 1.75, 3.01, 4.59, 6.15, 7.06, 6.15, 3.38, 1.11, 0.61},
00251     {0.867, 1.78, 2.92, 4.35, 5.69, 6.05, 4.73, 1.91, 0.519, 0.269},
00252     {0.932, 1.7, 2.55, 3.44, 4.03, 3.98, 2.74, 1.08, 0.247, 0.132},
00253     {0.937, 1.74, 2.51, 3.09, 3.11, 2.34, 1.84, 0.67, 0.189, 0.121},
00254     {0.942, 1.75, 2.63, 3.3, 3.27, 2.21, 1.87, 0.663, 0.171, 0.147},
00255     {0.959, 1.8, 2.82, 3.78, 4.03, 3.37, 2.53, 1.04, 0.199, 0.146},
00256     {1.01, 1.9, 3.13, 4.76, 5.63, 5.6, 4.31, 1.83, 0.367, 0.172},
00257     {0.989, 2.04, 3.64, 6, 7.62, 7.6, 6, 3.35, 1.05, 0.448},
00258     {1.02, 2.28, 4.32, 7.19, 9.21, 9.16, 7.64, 4.97, 2.2, 0.948},
00259     {1.26, 2.77, 5.2, 8.31, 10.5, 10.4, 9.01, 6.37, 3.46, 1.56},
00260     {1.31, 2.76, 5.23, 8.49, 11.2, 11.3, 10.1, 7.27, 3.98, 1.76},
00261     {1.26, 2.5, 5.14, 8.85, 12.3, 12.3, 11.2, 8.13, 4.45, 1.97},
00262     {1.35, 2.49, 5.26, 9.16, 13, 12.8, 11.8, 8.57, 4.72, 2.05}},
00263    {{0.759, 1.54, 2.54, 4.22, 6.26, 7.44, 7.14, 4.99, 2.84, 1.89},
00264     {0.508, 1.55, 2.5, 4.29, 6.29, 7.29, 7.07, 5.03, 2.77, 1.74},
00265     {0.699, 1.56, 2.62, 4.17, 6.08, 7.38, 7.04, 5.17, 2.81, 1.65},
00266     {0.778, 1.5, 2.65, 4.35, 6.07, 7.28, 6.84, 4.8, 2.28, 1.28},
00267     {0.772, 1.55, 2.71, 4.3, 5.76, 6.91, 6.2, 3.69, 1.45, 0.837},
00268     {0.836, 1.67, 2.78, 4.21, 5.56, 6.41, 5.33, 2.47, 0.807, 0.488},
00269     {0.937, 1.79, 2.78, 4.12, 5.17, 5.38, 3.89, 1.47, 0.392, 0.256},
00270     {0.97, 1.75, 2.52, 3.39, 3.83, 3.63, 2.48, 0.968, 0.212, 0.198},
00271     {0.968, 1.74, 2.5, 3.11, 3.2, 2.34, 1.79, 0.629, 0.169, 0.173},
00272     {0.98, 1.8, 2.69, 3.42, 3.4, 2.18, 1.81, 0.606, 0.164, 0.138},
00273     {0.975, 1.84, 2.96, 4.08, 4.12, 3.5, 2.79, 1.02, 0.145, 0.133},
00274     {0.96, 1.94, 3.27, 5.17, 6.26, 6.35, 4.88, 1.91, 0.329, 0.189},
00275     {0.954, 2.06, 3.8, 6.53, 8.46, 8.32, 6.53, 3.83, 1.32, 0.6},
00276     {1, 2.34, 4.58, 7.71, 9.68, 9.75, 7.96, 5.45, 2.84, 1.39},
00277     {1.24, 2.65, 5.14, 8.51, 10.7, 10.6, 8.96, 6.51, 3.83, 1.85},
00278     {1.34, 2.44, 4.99, 8.63, 11.6, 11.4, 10.1, 7.84, 4.77, 2.24},
00279     {1.33, 2.1, 4.76, 8.78, 12.2, 11.7, 10.8, 8.68, 5.15, 2.35},
00280     {1.42, 2.04, 4.68, 8.92, 12.7, 12, 11.2, 8.99, 5.32, 2.33}}
00281   };
00282
00283   double aux00, aux01, aux10, aux11, sec;
00284
00285   int ilat, ip, isec;
00286
00287   /* Get seconds since begin of year... */
00288   sec = fmod(t, 365.25 * 86400.);
00289
00290   /* Get indices... */
00291   ilat = locate(lats, 18, lat);
00292   ip = locate(ps, 10, p);
00293   isec = locate(secs, 12, sec);
00294
00295   /* Interpolate... */
00296   aux00 = LIN(ps[ip], hno3[isec][ilat][ip],
00297               ps[ip + 1], hno3[isec][ilat][ip + 1], p);
00298   aux01 = LIN(ps[ip], hno3[isec][ilat + 1][ip],
```

```
00299                 ps[ip + 1], hno3[isec][ilat + 1][ip + 1], p);
00300    aux10 = LIN(ps[ip], hno3[isec + 1][ilat][ip],
00301                 ps[ip + 1], hno3[isec + 1][ilat][ip + 1], p);
00302    aux11 = LIN(ps[ip], hno3[isec + 1][ilat + 1][ip],
00303                 ps[ip + 1], hno3[isec + 1][ilat + 1][ip + 1], p);
00304    aux00 = LIN(lats[ilat], aux00, lats[ilat + 1], aux01, lat);
00305    aux11 = LIN(lats[ilat], aux10, lats[ilat + 1], aux11, lat);
00306    return LIN(secs[isec], aux00, secs[isec + 1], aux11, sec);
00307  }
```

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 311 of file libtrac.c.

```
00313                 {
00314
00315    static double doys[12]
00316    = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00317
00318    static double lats[73]
00319      = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
00320      -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
00321      -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
00322      -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
00323      15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
00324      45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
00325      75, 77.5, 80, 82.5, 85, 87.5, 90
00326    };
00327
00328    static double tps[12][73]
00329      = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
00330           297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
00331           175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
00332           99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
00333           98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
00334           152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
00335           277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
00336           275.3, 275.6, 275.4, 274.1, 273.5},
00337    {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
00338     300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
00339     150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
00340     98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
00341     98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
00342     220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
00343     284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
00344     287.5, 286.2, 285.8},
00345    {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
00346     297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
00347     161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
00348     100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
00349     99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
00350     186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
00351     279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
00352     304.3, 304.9, 306, 306.6, 306.2, 306},
00353    {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
00354     290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
00355     195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
00356     102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
00357     99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
00358     148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
00359     263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
00360     315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
00361    {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
00362     260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
00363     205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
00364     101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
00365     102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
00366     165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
00367     273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
00368     325.3, 325.8, 325.8},
00369    {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
00370     222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
00371     228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
00372     105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
00373     106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
```

```
00374    127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
00375    251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
00376    308.5, 312.2, 313.1, 313.3},
00377   {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
00378    187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
00379    235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
00380    110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
00381    111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
00382    117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
00383    224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
00384    275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
00385   {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
00386    185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
00387    233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
00388    110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
00389    112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
00390    120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
00391    230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
00392    278.2, 282.6, 287.4, 290.9, 292.5, 293},
00393   {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
00394    183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
00395    243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
00396    114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
00397    110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
00398    114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
00399    203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
00400    276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
00401   {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
00402    215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
00403    237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
00404    111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
00405    106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
00406    112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
00407    206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
00408    279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
00409    305.1},
00410   {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
00411    253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
00412    223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
00413    108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
00414    102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
00415    109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
00416    241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
00417    286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
00418   {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
00419    284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
00420    175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
00421    100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
00422    100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
00423    186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
00424    280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
00425    281.7, 281.1, 281.2}
00426   };
00427
00428   double doy, p0, p1, pt;
00429
00430   int imon, ilat;
00431
00432   /* Get day of year... */
00433   doy = fmod(t / 86400., 365.25);
00434   while (doy < 0)
00435     doy += 365.25;
00436
00437   /* Get indices... */
00438   imon = locate(doys, 12, doy);
00439   ilat = locate(lats, 73, lat);
00440
00441   /* Get tropopause pressure... */
00442   p0 = LIN(lats[ilat], tps[imon][ilat],
00443            lats[ilat + 1], tps[imon][ilat + 1], lat);
00444   p1 = LIN(lats[ilat], tps[imon + 1][ilat],
00445            lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
00446   pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
00447
00448   /* Return tropopause pressure... */
00449   return pt;
00450 }
```

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 454 of file libtrac.c.

```
00458             {
00459
00460   int d0[12] = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00461   int d01[12] = { 1, 32, 61, 92, 122, 153, 183, 214, 245, 275, 306, 336 };
00462
00463   /* Get day of year... */
00464   if (year % 400 == 0 || (year % 100 != 0 && year % 4 == 0))
00465     *doy = d01[mon - 1] + day - 1;
00466   else
00467     *doy = d0[mon - 1] + day - 1;
00468 }
```

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

Get date from day of year.

Definition at line 472 of file libtrac.c.

```
00476             {
00477
00478   int d0[12] = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00479   int d01[12] = { 1, 32, 61, 92, 122, 153, 183, 214, 245, 275, 306, 336 };
00480   int i;
00481
00482   /* Get month and day... */
00483   if (year % 400 == 0 || (year % 100 != 0 && year % 4 == 0)) {
00484     for (i = 11; i >= 0; i--)
00485       if (d01[i] <= doy)
00486         break;
00487     *mon = i + 1;
00488     *day = doy - d01[i] + 1;
00489   } else {
00490     for (i = 11; i >= 0; i--)
00491       if (d0[i] <= doy)
00492         break;
00493     *mon = i + 1;
00494     *day = doy - d0[i] + 1;
00495   }
00496 }
```

5.19.2.6 double deg2dx (double *dlon*, double *lat*)

Convert degrees to horizontal distance.

Definition at line 500 of file libtrac.c.

```
00502               {
00503
00504   return dlon * M_PI * RE / 180. * cos(lat / 180. * M_PI);
00505 }
```

5.19.2.7 double deg2dy (double *dlat*)

Convert degrees to horizontal distance.

Definition at line 509 of file libtrac.c.

```
00510                {
00511
00512   return dlat * M_PI * RE / 180.;
00513 }
```

5.19.2.8 double dp2dz (double *dp*, double *p*)

Convert pressure to vertical distance.

Definition at line 517 of file libtrac.c.

```
00519             {
00520
00521   return -dp * H0 / p;
00522 }
```

5.19.2.9 double dx2deg (double *dx*, double *lat*)

Convert horizontal distance to degrees.

Definition at line 526 of file libtrac.c.

```
00528               {
00529
00530   /* Avoid singularity at poles... */
00531   if (lat < -89.999 || lat > 89.999)
00532     return 0;
00533   else
00534     return dx * 180. / (M_PI * RE * cos(lat / 180. * M_PI));
00535 }
```

5.19.2.10 double dy2deg (double *dy*)

Convert horizontal distance to degrees.

Definition at line 539 of file libtrac.c.

```
00540              {
00541
00542   return dy * 180. / (M_PI * RE);
00543 }
```

5.19.2.11 double dz2dp (double *dz*, double *p*)

Convert vertical distance to pressure.

Definition at line 547 of file libtrac.c.

```
00549             {
00550
00551   return -dz * p / H0;
00552 }
```

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

Convert geolocation to Cartesian coordinates.

Definition at line 556 of file libtrac.c.

```
00560              {
00561
00562   double radius;
00563
00564   radius = z + RE;
00565   x[0] = radius * cos(lat / 180 * M_PI) * cos(lon / 180 * M_PI);
00566   x[1] = radius * cos(lat / 180 * M_PI) * sin(lon / 180 * M_PI);
00567   x[2] = radius * sin(lat / 180 * M_PI);
00568 }
```

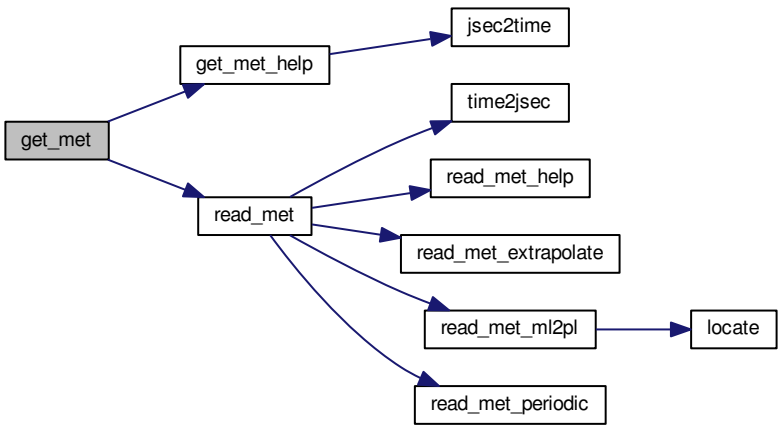
5.19.2.13 void get_met (ctl_t * *ctl*, char * *metbase*, double *t*, met_t * *met0*, met_t * *met1*)

Get meteorological data for given timestep.

Definition at line 572 of file libtrac.c.

```
00577                 {
00578
00579   static int init;
00580
00581   char filename[LEN];
00582
00583   /* Init... */
00584   if (t == ctl->t_start || !init) {
00585     init = 1;
00586
00587     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00588     read_met(ctl, filename, met0);
00589
00590     get_met_help(t + 1.0 * ctl->direction, 1, metbase, ctl->
      dt_met, filename);
00591     read_met(ctl, filename, met1);
00592   }
00593
00594   /* Read new data for forward trajectories... */
00595   if (t > met1->time && ctl->direction == 1) {
00596     memcpy(met0, met1, sizeof(met_t));
00597     get_met_help(t, 1, metbase, ctl->dt_met, filename);
00598     read_met(ctl, filename, met1);
00599   }
00600
00601   /* Read new data for backward trajectories... */
00602   if (t < met0->time && ctl->direction == -1) {
00603     memcpy(met1, met0, sizeof(met_t));
00604     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00605     read_met(ctl, filename, met0);
00606   }
00607 }
```

Here is the call graph for this function:



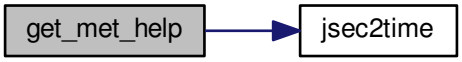
5.19.2.14 void get_met_help (double *t*, int *direct*, char * *metbase*, double *dt_met*, char * *filename*)

Get meteorological data for timestep.

Definition at line 611 of file libtrac.c.

```
00616                  {
00617
00618   double t6, r;
00619
00620   int year, mon, day, hour, min, sec;
00621
00622   /* Round time to fixed intervals... */
00623   if (direct == -1)
00624     t6 = floor(t / dt_met) * dt_met;
00625   else
00626     t6 = ceil(t / dt_met) * dt_met;
00627
00628   /* Decode time... */
00629   jsec2time(t6, &year, &mon, &day, &hour, &min, &sec, &r);
00630
00631   /* Set filename... */
00632   sprintf(filename, "%s_%d_%02d_%02d_%02d.nc", metbase, year, mon, day, hour);
00633 }
```

Here is the call graph for this function:



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

Linear interpolation of 2-D meteorological data.

Definition at line 637 of file libtrac.c.

```
00643                {
00644
00645   double aux00, aux01, aux10, aux11;
00646
00647   /* Set variables... */
00648   aux00 = array[ix][iy];
00649   aux01 = array[ix][iy + 1];
00650   aux10 = array[ix + 1][iy];
00651   aux11 = array[ix + 1][iy + 1];
00652
00653   /* Interpolate horizontally... */
00654   aux00 = wy * (aux00 - aux01) + aux01;
00655   aux11 = wy * (aux10 - aux11) + aux11;
00656   *var = wx * (aux00 - aux11) + aux11;
00657 }
```

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

Linear interpolation of 3-D meteorological data.

Definition at line 661 of file libtrac.c.

```
00669               {
00670
00671   double aux00, aux01, aux10, aux11;
00672
00673   /* Interpolate vertically... */
00674   aux00 = wp * (array[ix][iy][ip] - array[ix][iy][ip + 1])
00675     + array[ix][iy][ip + 1];
00676   aux01 = wp * (array[ix][iy + 1][ip] - array[ix][iy + 1][ip + 1])
00677     + array[ix][iy + 1][ip + 1];
00678   aux10 = wp * (array[ix + 1][iy][ip] - array[ix + 1][iy][ip + 1])
00679     + array[ix + 1][iy][ip + 1];
00680   aux11 = wp * (array[ix + 1][iy + 1][ip] - array[ix + 1][iy + 1][ip + 1])
00681     + array[ix + 1][iy + 1][ip + 1];
00682
00683   /* Interpolate horizontally... */
00684   aux00 = wy * (aux00 - aux01) + aux01;
00685   aux11 = wy * (aux10 - aux11) + aux11;
00686   *var = wx * (aux00 - aux11) + aux11;
00687 }
```

5.19.2.17 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 691 of file libtrac.c.

```
00705               {
00706
00707   double wp, wx, wy;
00708
00709   int ip, ix, iy;
00710
00711   /* Check longitude... */
00712   if (met->lon[met->nx - 1] > 180 && lon < 0)
00713     lon += 360;
00714
00715   /* Get indices... */
00716   ip = locate(met->p, met->np, p);
00717   ix = locate(met->lon, met->nx, lon);
00718   iy = locate(met->lat, met->ny, lat);
00719
00720   /* Get weights... */
00721   wp = (met->p[ip + 1] - p) / (met->p[ip + 1] - met->p[ip]);
00722   wx = (met->lon[ix + 1] - lon) / (met->lon[ix + 1] - met->lon[ix]);
00723   wy = (met->lat[iy + 1] - lat) / (met->lat[iy + 1] - met->lat[iy]);
00724
00725   /* Interpolate... */
00726   if (ps != NULL)
00727     intpol_met_2d(met->ps, ix, iy, wx, wy, ps);
00728   if (pt != NULL)
00729     intpol_met_2d(met->pt, ix, iy, wx, wy, pt);
00730   if (z != NULL)
00731     intpol_met_3d(met->z, ip, ix, iy, wp, wx, wy, z);
00732   if (t != NULL)
00733     intpol_met_3d(met->t, ip, ix, iy, wp, wx, wy, t);
00734   if (u != NULL)
00735     intpol_met_3d(met->u, ip, ix, iy, wp, wx, wy, u);
00736   if (v != NULL)
00737     intpol_met_3d(met->v, ip, ix, iy, wp, wx, wy, v);
00738   if (w != NULL)
00739     intpol_met_3d(met->w, ip, ix, iy, wp, wx, wy, w);
00740   if (pv != NULL)
00741     intpol_met_3d(met->pv, ip, ix, iy, wp, wx, wy, pv);
00742   if (h2o != NULL)
00743     intpol_met_3d(met->h2o, ip, ix, iy, wp, wx, wy, h2o);
00744   if (o3 != NULL)
00745     intpol_met_3d(met->o3, ip, ix, iy, wp, wx, wy, o3);
00746 }
```

Here is the call graph for this function:

5.19.2.18 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 750 of file libtrac.c.

```
00766              {
00767
00768   double h2o0, h2o1, o30, o31, ps0, ps1, pt0, pt1, pv0, pv1, t0, t1, u0, u1,
00769     v0, v1, w0, w1, wt, z0, z1;
00770
00771   /* Spatial interpolation... */
00772   intpol_met_space(met0, p, lon, lat,
00773                    ps == NULL ? NULL : &ps0,
00774                    pt == NULL ? NULL : &pt0,
00775                    z == NULL ? NULL : &z0,
00776                    t == NULL ? NULL : &t0,
00777                    u == NULL ? NULL : &u0,
00778                    v == NULL ? NULL : &v0,
00779                    w == NULL ? NULL : &w0,
00780                    pv == NULL ? NULL : &pv0,
00781                    h2o == NULL ? NULL : &h2o0, o3 == NULL ? NULL : &o30);
00782   intpol_met_space(met1, p, lon, lat,
00783                    ps == NULL ? NULL : &ps1,
00784                    pt == NULL ? NULL : &pt1,
00785                    z == NULL ? NULL : &z1,
00786                    t == NULL ? NULL : &t1,
00787                    u == NULL ? NULL : &u1,
00788                    v == NULL ? NULL : &v1,
00789                    w == NULL ? NULL : &w1,
00790                    pv == NULL ? NULL : &pv1,
00791                    h2o == NULL ? NULL : &h2o1, o3 == NULL ? NULL : &o31);
00792
00793   /* Get weighting factor... */
00794   wt = (met1->time - ts) / (met1->time - met0->time);
00795
00796   /* Interpolate... */
00797   if (ps != NULL)
00798     *ps = wt * (ps0 - ps1) + ps1;
00799   if (pt != NULL)
00800     *pt = wt * (pt0 - pt1) + pt1;
00801   if (z != NULL)
00802     *z = wt * (z0 - z1) + z1;
00803   if (t != NULL)
00804     *t = wt * (t0 - t1) + t1;
00805   if (u != NULL)
00806     *u = wt * (u0 - u1) + u1;
00807   if (v != NULL)
00808     *v = wt * (v0 - v1) + v1;
00809   if (w != NULL)
00810     *w = wt * (w0 - w1) + w1;
00811   if (pv != NULL)
00812     *pv = wt * (pv0 - pv1) + pv1;
00813   if (h2o != NULL)
00814     *h2o = wt * (h2o0 - h2o1) + h2o1;
00815   if (o3 != NULL)
00816     *o3 = wt * (o30 - o31) + o31;
00817 }
```

Here is the call graph for this function:

5.19.2.19 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 821 of file libtrac.c.

```
00829                   {
00830
00831   struct tm t0, *t1;
00832
00833   time_t jsec0;
00834
00835   t0.tm_year = 100;
```

```
00836   t0.tm_mon = 0;
00837   t0.tm_mday = 1;
00838   t0.tm_hour = 0;
00839   t0.tm_min = 0;
00840   t0.tm_sec = 0;
00841
00842   jsec0 = (time_t) jsec + timegm(&t0);
00843   t1 = gmtime(&jsec0);
00844
00845   *year = t1->tm_year + 1900;
00846   *mon = t1->tm_mon + 1;
00847   *day = t1->tm_mday;
00848   *hour = t1->tm_hour;
00849   *min = t1->tm_min;
00850   *sec = t1->tm_sec;
00851   *remain = jsec - floor(jsec);
00852 }
```

5.19.2.20 int locate (double * *xx*, int *n*, double *x*)

Find array index.

Definition at line 856 of file libtrac.c.

```
00859             {
00860
00861   int i, ilo, ihi;
00862
00863   ilo = 0;
00864   ihi = n - 1;
00865   i = (ihi + ilo) >> 1;
00866
00867   if (xx[i] < xx[i + 1])
00868     while (ihi > ilo + 1) {
00869       i = (ihi + ilo) >> 1;
00870       if (xx[i] > x)
00871         ihi = i;
00872       else
00873         ilo = i;
00874   } else
00875     while (ihi > ilo + 1) {
00876       i = (ihi + ilo) >> 1;
00877       if (xx[i] <= x)
00878         ihi = i;
00879       else
00880         ilo = i;
00881     }
00882
00883   return ilo;
00884 }
```

5.19.2.21 void read_atm (const char * *filename*, ctl_t * *ctl*, atm_t * *atm*)

Read atmospheric data.

Definition at line 888 of file libtrac.c.

```
00891                 {
00892
00893   FILE *in;
00894
00895   char line[LEN], *tok;
00896
00897   double t0;
00898
00899   int dimid, ip, iq, ncid, varid;
00900
00901   size_t nparts;
00902
00903   /* Init... */
00904   atm->np = 0;
00905
00906   /* Write info... */
00907   printf("Read atmospheric data: %s\n", filename);
```

```
00908
00909   /* Read ASCII data... */
00910   if (ctl->atm_type == 0) {
00911
00912     /* Open file... */
00913     if (!(in = fopen(filename, "r")))
00914       ERRMSG("Cannot open file!");
00915
00916     /* Read line... */
00917     while (fgets(line, LEN, in)) {
00918
00919       /* Read data... */
00920       TOK(line, tok, "%lg", atm->time[atm->np]);
00921       TOK(NULL, tok, "%lg", atm->p[atm->np]);
00922       TOK(NULL, tok, "%lg", atm->lon[atm->np]);
00923       TOK(NULL, tok, "%lg", atm->lat[atm->np]);
00924       for (iq = 0; iq < ctl->nq; iq++)
00925         TOK(NULL, tok, "%lg", atm->q[iq][atm->np]);
00926
00927       /* Convert altitude to pressure... */
00928       atm->p[atm->np] = P(atm->p[atm->np]);
00929
00930       /* Increment data point counter... */
00931       if ((++atm->np) > NP)
00932         ERRMSG("Too many data points!");
00933     }
00934
00935     /* Close file... */
00936     fclose(in);
00937   }
00938
00939   /* Read binary data... */
00940   else if (ctl->atm_type == 1) {
00941
00942     /* Open file... */
00943     if (!(in = fopen(filename, "r")))
00944       ERRMSG("Cannot open file!");
00945
00946     /* Read data... */
00947     FREAD(&atm->np, int,
00948           1,
00949           in);
00950     FREAD(atm->time, double,
00951             (size_t) atm->np,
00952           in);
00953     FREAD(atm->p, double,
00954             (size_t) atm->np,
00955           in);
00956     FREAD(atm->lon, double,
00957             (size_t) atm->np,
00958           in);
00959     FREAD(atm->lat, double,
00960             (size_t) atm->np,
00961           in);
00962     for (iq = 0; iq < ctl->nq; iq++)
00963       FREAD(atm->q[iq], double,
00964               (size_t) atm->np,
00965             in);
00966
00967     /* Close file... */
00968     fclose(in);
00969   }
00970
00971   /* Read netCDF data... */
00972   else if (ctl->atm_type == 2) {
00973
00974     /* Open file... */
00975     NC(nc_open(filename, NC_NOWRITE, &ncid));
00976
00977     /* Get dimensions... */
00978     NC(nc_inq_dimid(ncid, "NPARTS", &dimid));
00979     NC(nc_inq_dimlen(ncid, dimid, &nparts));
00980     atm->np = (int) nparts;
00981     if (atm->np > NP)
00982       ERRMSG("Too many particles!");
00983
00984     /* Get time... */
00985     NC(nc_inq_varid(ncid, "time", &varid));
00986     NC(nc_get_var_double(ncid, varid, &t0));
00987     for (ip = 0; ip < atm->np; ip++)
00988       atm->time[ip] = t0;
00989
00990     /* Read geolocations... */
00991     NC(nc_inq_varid(ncid, "PRESS", &varid));
00992     NC(nc_get_var_double(ncid, varid, atm->p));
00993     NC(nc_inq_varid(ncid, "LON", &varid));
00994     NC(nc_get_var_double(ncid, varid, atm->lon));
```

```
00995     NC(nc_inq_varid(ncid, "LAT", &varid));
00996     NC(nc_get_var_double(ncid, varid, atm->lat));
00997
00998     /* Read variables... */
00999     if (ctl->qnt_p >= 0)
01000       if (nc_inq_varid(ncid, "PRESS", &varid) == NC_NOERR)
01001         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_p]));
01002     if (ctl->qnt_t >= 0)
01003       if (nc_inq_varid(ncid, "TEMP", &varid) == NC_NOERR)
01004         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_t]));
01005     if (ctl->qnt_u >= 0)
01006       if (nc_inq_varid(ncid, "U", &varid) == NC_NOERR)
01007         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_u]));
01008     if (ctl->qnt_v >= 0)
01009       if (nc_inq_varid(ncid, "V", &varid) == NC_NOERR)
01010         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_v]));
01011     if (ctl->qnt_w >= 0)
01012       if (nc_inq_varid(ncid, "W", &varid) == NC_NOERR)
01013         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_w]));
01014     if (ctl->qnt_h2o >= 0)
01015       if (nc_inq_varid(ncid, "SH", &varid) == NC_NOERR)
01016         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_h2o]));
01017     if (ctl->qnt_o3 >= 0)
01018       if (nc_inq_varid(ncid, "O3", &varid) == NC_NOERR)
01019         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_o3]));
01020     if (ctl->qnt_theta >= 0)
01021       if (nc_inq_varid(ncid, "THETA", &varid) == NC_NOERR)
01022         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_theta]));
01023     if (ctl->qnt_pv >= 0)
01024       if (nc_inq_varid(ncid, "PV", &varid) == NC_NOERR)
01025         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_pv]));
01026
01027     /* Check data... */
01028     for (ip = 0; ip < atm->np; ip++)
01029       if (fabs(atm->lon[ip]) > 360 || fabs(atm->lat[ip]) > 90
01030           || (ctl->qnt_t >= 0 && fabs(atm->q[ctl->qnt_t][ip]) > 350)
01031           || (ctl->qnt_h2o >= 0 && fabs(atm->q[ctl->qnt_h2o][ip]) > 1)
01032           || (ctl->qnt_theta >= 0 && fabs(atm->q[ctl->qnt_theta][ip]) > 1e10)
01033           || (ctl->qnt_pv >= 0 && fabs(atm->q[ctl->qnt_pv][ip]) > 1e10)) {
01034         atm->time[ip] = GSL_NAN;
01035         atm->p[ip] = GSL_NAN;
01036         atm->lon[ip] = GSL_NAN;
01037         atm->lat[ip] = GSL_NAN;
01038         for (iq = 0; iq < ctl->nq; iq++)
01039           atm->q[iq][ip] = GSL_NAN;
01040       } else {
01041         if (ctl->qnt_h2o >= 0)
01042           atm->q[ctl->qnt_h2o][ip] *= 1.608;
01043         if (ctl->qnt_pv >= 0)
01044           atm->q[ctl->qnt_pv][ip] *= 1e6;
01045         if (atm->lon[ip] > 180)
01046           atm->lon[ip] -= 360;
01047       }
01048
01049     /* Close file... */
01050     NC(nc_close(ncid));
01051   }
01052
01053   /* Error... */
01054   else
01055     ERRMSG("Atmospheric data type not supported!");
01056
01057   /* Check number of points... */
01058   if (atm->np < 1)
01059     ERRMSG("Can not read any data!");
01060 }
```

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

Read control parameters.

Definition at line 1064 of file libtrac.c.

```
01068               {
01069
01070   int ip, iq;
01071
01072   /* Write info... */
01073   printf("\nMassive-Parallel Trajectory Calculations (MPTRAC)\n"
01074          "(executable: %s | compiled: %s, %s)\n\n",
```

```
01075          argv[0], __DATE__, __TIME__);
01076
01077    /* Initialize quantity indices... */
01078    ctl->qnt_ens = -1;
01079    ctl->qnt_m = -1;
01080    ctl->qnt_r = -1;
01081    ctl->qnt_rho = -1;
01082    ctl->qnt_ps = -1;
01083    ctl->qnt_pt = -1;
01084    ctl->qnt_z = -1;
01085    ctl->qnt_p = -1;
01086    ctl->qnt_t = -1;
01087    ctl->qnt_u = -1;
01088    ctl->qnt_v = -1;
01089    ctl->qnt_w = -1;
01090    ctl->qnt_h2o = -1;
01091    ctl->qnt_o3 = -1;
01092    ctl->qnt_theta = -1;
01093    ctl->qnt_vh = -1;
01094    ctl->qnt_vz = -1;
01095    ctl->qnt_pv = -1;
01096    ctl->qnt_tice = -1;
01097    ctl->qnt_tsts = -1;
01098    ctl->qnt_tnat = -1;
01099    ctl->qnt_stat = -1;
01100
01101    /* Read quantities... */
01102    ctl->nq = (int) scan_ctl(filename, argc, argv, "NQ", -1, "0", NULL);
01103    if (ctl->nq > NQ)
01104      ERRMSG("Too many quantities!");
01105    for (iq = 0; iq < ctl->nq; iq++) {
01106
01107      /* Read quantity name and format... */
01108      scan_ctl(filename, argc, argv, "QNT_NAME", iq, "", ctl->qnt_name[iq]);
01109      scan_ctl(filename, argc, argv, "QNT_FORMAT", iq, "%g",
01110               ctl->qnt_format[iq]);
01111
01112      /* Try to identify quantity... */
01113      if (strcmp(ctl->qnt_name[iq], "ens") == 0) {
01114        ctl->qnt_ens = iq;
01115        sprintf(ctl->qnt_unit[iq], "-");
01116      } else if (strcmp(ctl->qnt_name[iq], "m") == 0) {
01117        ctl->qnt_m = iq;
01118        sprintf(ctl->qnt_unit[iq], "kg");
01119      } else if (strcmp(ctl->qnt_name[iq], "r") == 0) {
01120        ctl->qnt_r = iq;
01121        sprintf(ctl->qnt_unit[iq], "m");
01122      } else if (strcmp(ctl->qnt_name[iq], "rho") == 0) {
01123        ctl->qnt_rho = iq;
01124        sprintf(ctl->qnt_unit[iq], "kg/m^3");
01125      } else if (strcmp(ctl->qnt_name[iq], "ps") == 0) {
01126        ctl->qnt_ps = iq;
01127        sprintf(ctl->qnt_unit[iq], "hPa");
01128      } else if (strcmp(ctl->qnt_name[iq], "pt") == 0) {
01129        ctl->qnt_pt = iq;
01130        sprintf(ctl->qnt_unit[iq], "hPa");
01131      } else if (strcmp(ctl->qnt_name[iq], "z") == 0) {
01132        ctl->qnt_z = iq;
01133        sprintf(ctl->qnt_unit[iq], "km");
01134      } else if (strcmp(ctl->qnt_name[iq], "p") == 0) {
01135        ctl->qnt_p = iq;
01136        sprintf(ctl->qnt_unit[iq], "hPa");
01137      } else if (strcmp(ctl->qnt_name[iq], "t") == 0) {
01138        ctl->qnt_t = iq;
01139        sprintf(ctl->qnt_unit[iq], "K");
01140      } else if (strcmp(ctl->qnt_name[iq], "u") == 0) {
01141        ctl->qnt_u = iq;
01142        sprintf(ctl->qnt_unit[iq], "m/s");
01143      } else if (strcmp(ctl->qnt_name[iq], "v") == 0) {
01144        ctl->qnt_v = iq;
01145        sprintf(ctl->qnt_unit[iq], "m/s");
01146      } else if (strcmp(ctl->qnt_name[iq], "w") == 0) {
01147        ctl->qnt_w = iq;
01148        sprintf(ctl->qnt_unit[iq], "hPa/s");
01149      } else if (strcmp(ctl->qnt_name[iq], "h2o") == 0) {
01150        ctl->qnt_h2o = iq;
01151        sprintf(ctl->qnt_unit[iq], "1");
01152      } else if (strcmp(ctl->qnt_name[iq], "o3") == 0) {
01153        ctl->qnt_o3 = iq;
01154        sprintf(ctl->qnt_unit[iq], "1");
01155      } else if (strcmp(ctl->qnt_name[iq], "theta") == 0) {
01156        ctl->qnt_theta = iq;
01157        sprintf(ctl->qnt_unit[iq], "K");
01158      } else if (strcmp(ctl->qnt_name[iq], "vh") == 0) {
01159        ctl->qnt_vh = iq;
01160        sprintf(ctl->qnt_unit[iq], "m/s");
01161      } else if (strcmp(ctl->qnt_name[iq], "vz") == 0) {
```

```
01162       ctl->qnt_vz = iq;
01163       sprintf(ctl->qnt_unit[iq], "m/s");
01164     } else if (strcmp(ctl->qnt_name[iq], "pv") == 0) {
01165       ctl->qnt_pv = iq;
01166       sprintf(ctl->qnt_unit[iq], "PVU");
01167     } else if (strcmp(ctl->qnt_name[iq], "tice") == 0) {
01168       ctl->qnt_tice = iq;
01169       sprintf(ctl->qnt_unit[iq], "K");
01170     } else if (strcmp(ctl->qnt_name[iq], "tsts") == 0) {
01171       ctl->qnt_tsts = iq;
01172       sprintf(ctl->qnt_unit[iq], "K");
01173     } else if (strcmp(ctl->qnt_name[iq], "tnat") == 0) {
01174       ctl->qnt_tnat = iq;
01175       sprintf(ctl->qnt_unit[iq], "K");
01176     } else if (strcmp(ctl->qnt_name[iq], "stat") == 0) {
01177       ctl->qnt_stat = iq;
01178       sprintf(ctl->qnt_unit[iq], "-");
01179     } else
01180       scan_ctl(filename, argc, argv, "QNT_UNIT", iq, "", ctl->qnt_unit[iq]);
01181   }
01182
01183   /* Time steps of simulation... */
01184   ctl->direction =
01185     (int) scan_ctl(filename, argc, argv, "DIRECTION", -1, "1", NULL);
01186   if (ctl->direction != -1 && ctl->direction != 1)
01187     ERRMSG("Set DIRECTION to -1 or 1!");
01188   ctl->t_stop = scan_ctl(filename, argc, argv, "T_STOP", -1, "1e100", NULL);
01189   ctl->dt_mod = scan_ctl(filename, argc, argv, "DT_MOD", -1, "600", NULL);
01190
01191   /* Meteorological data... */
01192   ctl->dt_met = scan_ctl(filename, argc, argv, "DT_MET", -1, "21600", NULL);
01193   ctl->met_dx = (int) scan_ctl(filename, argc, argv, "MET_DX", -1, "1", NULL);
01194   ctl->met_dy = (int) scan_ctl(filename, argc, argv, "MET_DY", -1, "1", NULL);
01195   ctl->met_dp = (int) scan_ctl(filename, argc, argv, "MET_DP", -1, "1", NULL);
01196   ctl->met_sx = (int) scan_ctl(filename, argc, argv, "MET_SX", -1, "1", NULL);
01197   ctl->met_sy = (int) scan_ctl(filename, argc, argv, "MET_SY", -1, "1", NULL);
01198   ctl->met_sp = (int) scan_ctl(filename, argc, argv, "MET_SP", -1, "1", NULL);
01199   ctl->met_np = (int) scan_ctl(filename, argc, argv, "MET_NP", -1, "0", NULL);
01200   if (ctl->met_np > EP)
01201     ERRMSG("Too many levels!");
01202   for (ip = 0; ip < ctl->met_np; ip++)
01203     ctl->met_p[ip] = scan_ctl(filename, argc, argv, "MET_P", ip, "", NULL);
01204   ctl->met_tropo
01205     = (int) scan_ctl(filename, argc, argv, "MET_TROPO", -1, "0", NULL);
01206   scan_ctl(filename, argc, argv, "MET_GEOPOT", -1, "-", ctl->met_geopot);
01207   scan_ctl(filename, argc, argv, "MET_STAGE", -1, "-", ctl->met_stage);
01208
01209   /* Isosurface parameters... */
01210   ctl->isosurf
01211     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
01212   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
01213
01214   /* Diffusion parameters... */
01215   ctl->turb_dx_trop
01216     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50", NULL);
01217   ctl->turb_dx_strat
01218     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0", NULL);
01219   ctl->turb_dz_trop
01220     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0", NULL);
01221   ctl->turb_dz_strat
01222     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
01223   ctl->turb_mesox =
01224     scan_ctl(filename, argc, argv, "TURB_MESOX", -1, "0.16", NULL);
01225   ctl->turb_mesoz =
01226     scan_ctl(filename, argc, argv, "TURB_MESOZ", -1, "0.16", NULL);
01227
01228   /* Mass and life time... */
01229   ctl->molmass = scan_ctl(filename, argc, argv, "MOLMASS", -1, "1", NULL);
01230   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
01231   ctl->tdec_strat =
01232     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
01233
01234   /* PSC analysis... */
01235   ctl->psc_h2o = scan_ctl(filename, argc, argv, "PSC_H2O", -1, "4e-6", NULL);
01236   ctl->psc_hno3 =
01237     scan_ctl(filename, argc, argv, "PSC_HNO3", -1, "9e-9", NULL);
01238
01239   /* Output of atmospheric data... */
01240   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
      atm_basename);
01241   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
01242   ctl->atm_dt_out =
01243     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
01244   ctl->atm_filter =
01245     (int) scan_ctl(filename, argc, argv, "ATM_FILTER", -1, "0", NULL);
01246   ctl->atm_type =
01247     (int) scan_ctl(filename, argc, argv, "ATM_TYPE", -1, "0", NULL);
```

```
01248
01249   /* Output of CSI data... */
01250   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
      csi_basename);
01251   ctl->csi_dt_out =
01252     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
01253   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "-", ctl->
      csi_obsfile);
01254   ctl->csi_obsmin =
01255     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
01256   ctl->csi_modmin =
01257     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
01258   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
01259   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
01260   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
01261   ctl->csi_lon0 =
01262     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
01263   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
01264   ctl->csi_nx =
01265     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
01266   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
01267   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
01268   ctl->csi_ny =
01269     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
01270
01271   /* Output of ensemble data... */
01272   scan_ctl(filename, argc, argv, "ENS_BASENAME", -1, "-", ctl->
      ens_basename);
01273
01274   /* Output of grid data... */
01275   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
01276            ctl->grid_basename);
01277   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
      grid_gpfile);
01278   ctl->grid_dt_out =
01279     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
01280   ctl->grid_sparse =
01281     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
01282   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
01283   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
01284   ctl->grid_nz =
01285     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
01286   ctl->grid_lon0 =
01287     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
01288   ctl->grid_lon1 =
01289     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
01290   ctl->grid_nx =
01291     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
01292   ctl->grid_lat0 =
01293     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
01294   ctl->grid_lat1 =
01295     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
01296   ctl->grid_ny =
01297     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
01298
01299   /* Output of profile data... */
01300   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
01301            ctl->prof_basename);
01302   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
      prof_obsfile);
01303   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
01304   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
01305   ctl->prof_nz =
01306     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
01307   ctl->prof_lon0 =
01308     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
01309   ctl->prof_lon1 =
01310     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
01311   ctl->prof_nx =
01312     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
01313   ctl->prof_lat0 =
01314     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
01315   ctl->prof_lat1 =
01316     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
01317   ctl->prof_ny =
01318     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
01319
01320   /* Output of station data... */
01321   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
01322            ctl->stat_basename);
01323   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
01324   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
01325   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
01326 }
```

Here is the call graph for this function:

5.19.2.23 void read_met (ctl_t * *ctl*, char * *filename*, met_t * *met*)

Read meteorological data file.

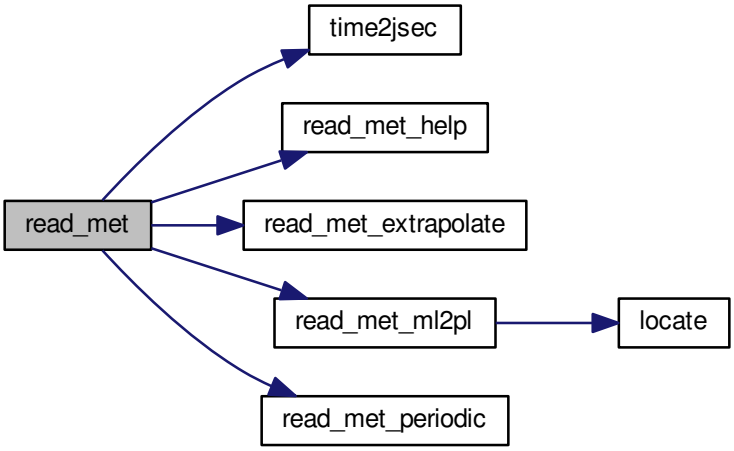
Definition at line 1330 of file libtrac.c.

```
01333               {
01334
01335   char cmd[2 * LEN], levname[LEN], tstr[10];
01336
01337   static float help[EX * EY];
01338
01339   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
01340
01341   size_t np, nx, ny;
01342
01343   /* Write info... */
01344   printf("Read meteorological data: %s\n", filename);
01345
01346   /* Get time from filename... */
01347   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
01348   year = atoi(tstr);
01349   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
01350   mon = atoi(tstr);
01351   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
01352   day = atoi(tstr);
01353   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
01354   hour = atoi(tstr);
01355   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
01356
01357   /* Open netCDF file... */
01358   if (nc_open(filename, NC_NOWRITE, &ncid) != NC_NOERR) {
01359
01360     /* Try to stage meteo file... */
01361     if (ctl->met_stage[0] != '-') {
01362       sprintf(cmd, "%s %d %02d %02d %02d %s", ctl->met_stage,
01363               year, mon, day, hour, filename);
01364       if (system(cmd) != 0)
01365         ERRMSG("Error while staging meteo data!");
01366     }
01367
01368     /* Try to open again... */
01369     NC(nc_open(filename, NC_NOWRITE, &ncid));
01370   }
01371
01372   /* Get dimensions... */
01373   NC(nc_inq_dimid(ncid, "lon", &dimid));
01374   NC(nc_inq_dimlen(ncid, dimid, &nx));
01375   if (nx < 2 || nx > EX)
01376     ERRMSG("Number of longitudes out of range!");
01377
01378   NC(nc_inq_dimid(ncid, "lat", &dimid));
01379   NC(nc_inq_dimlen(ncid, dimid, &ny));
01380   if (ny < 2 || ny > EY)
01381     ERRMSG("Number of latitudes out of range!");
01382
01383   sprintf(levname, "lev");
01384   NC(nc_inq_dimid(ncid, levname, &dimid));
01385   NC(nc_inq_dimlen(ncid, dimid, &np));
01386   if (np == 1) {
01387     sprintf(levname, "lev_2");
01388     NC(nc_inq_dimid(ncid, levname, &dimid));
01389     NC(nc_inq_dimlen(ncid, dimid, &np));
```

```
01390   }
01391   if (np < 2 || np > EP)
01392     ERRMSG("Number of levels out of range!");
01393
01394   /* Store dimensions... */
01395   met->np = (int) np;
01396   met->nx = (int) nx;
01397   met->ny = (int) ny;
01398
01399   /* Get horizontal grid... */
01400   NC(nc_inq_varid(ncid, "lon", &varid));
01401   NC(nc_get_var_double(ncid, varid, met->lon));
01402   NC(nc_inq_varid(ncid, "lat", &varid));
01403   NC(nc_get_var_double(ncid, varid, met->lat));
01404
01405   /* Read meteorological data... */
01406   read_met_help(ncid, "t", "T", met, met->t, 1.0);
01407   read_met_help(ncid, "u", "U", met, met->u, 1.0);
01408   read_met_help(ncid, "v", "V", met, met->v, 1.0);
01409   read_met_help(ncid, "w", "W", met, met->w, 0.01f);
01410   read_met_help(ncid, "q", "Q", met, met->h2o, (float) (MA / 18.01528));
01411   read_met_help(ncid, "o3", "O3", met, met->o3, (float) (MA / 48.00));
01412
01413   /* Meteo data on pressure levels... */
01414   if (ctl->met_np <= 0) {
01415
01416     /* Read pressure levels from file... */
01417     NC(nc_inq_varid(ncid, levname, &varid));
01418     NC(nc_get_var_double(ncid, varid, met->p));
01419     for (ip = 0; ip < met->np; ip++)
01420       met->p[ip] /= 100.;
01421
01422     /* Extrapolate data for lower boundary... */
01423     read_met_extrapolate(met);
01424   }
01425
01426   /* Meteo data on model levels... */
01427   else {
01428
01429     /* Read pressure data from file... */
01430     read_met_help(ncid, "pl", "PL", met, met->pl, 0.01f);
01431
01432     /* Interpolate from model levels to pressure levels... */
01433     read_met_ml2pl(ctl, met, met->t);
01434     read_met_ml2pl(ctl, met, met->u);
01435     read_met_ml2pl(ctl, met, met->v);
01436     read_met_ml2pl(ctl, met, met->w);
01437     read_met_ml2pl(ctl, met, met->h2o);
01438     read_met_ml2pl(ctl, met, met->o3);
01439
01440     /* Set pressure levels... */
01441     met->np = ctl->met_np;
01442     for (ip = 0; ip < met->np; ip++)
01443       met->p[ip] = ctl->met_p[ip];
01444   }
01445
01446   /* Check ordering of pressure levels... */
01447   for (ip = 1; ip < met->np; ip++)
01448     if (met->p[ip - 1] < met->p[ip])
01449       ERRMSG("Pressure levels must be descending!");
01450
01451   /* Read surface pressure... */
01452   if (nc_inq_varid(ncid, "ps", &varid) == NC_NOERR
01453       || nc_inq_varid(ncid, "PS", &varid) == NC_NOERR) {
01454     NC(nc_get_var_float(ncid, varid, help));
01455     for (iy = 0; iy < met->ny; iy++)
01456       for (ix = 0; ix < met->nx; ix++)
01457         met->ps[ix][iy] = help[iy * met->nx + ix] / 100.;
01458   } else if (nc_inq_varid(ncid, "lnsp", &varid) == NC_NOERR
01459              || nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
01460     NC(nc_get_var_float(ncid, varid, help));
01461     for (iy = 0; iy < met->ny; iy++)
01462       for (ix = 0; ix < met->nx; ix++)
01463         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
01464   } else
01465     for (ix = 0; ix < met->nx; ix++)
01466       for (iy = 0; iy < met->ny; iy++)
01467         met->ps[ix][iy] = met->p[0];
01468
01469   /* Create periodic boundary conditions... */
01470   read_met_periodic(met);
01471
01472   /* Calculate geopotential heights... */
01473   read_met_geopot(ctl, met);
01474
01475   /* Calculate potential vorticity... */
01476   read_met_pv(met);
```

```
01477
01478   /* Calculate tropopause pressure... */
01479   read_met_tropo(ctl, met);
01480
01481   /* Downsampling... */
01482   read_met_sample(ctl, met);
01483
01484   /* Close file... */
01485   NC(nc_close(ncid));
01486 }
```

Here is the call graph for this function:



5.19.2.24 void read_met_extrapolate (met_t * *met*)

Extrapolate meteorological data at lower boundary.

Definition at line 1490 of file libtrac.c.

```
01491               {
01492
01493   int ip, ip0, ix, iy;
01494
01495   /* Loop over columns... */
01496   for (ix = 0; ix < met->nx; ix++)
01497     for (iy = 0; iy < met->ny; iy++) {
01498
01499       /* Find lowest valid data point... */
01500       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
01501         if (!gsl_finite(met->t[ix][iy][ip0])
01502             || !gsl_finite(met->u[ix][iy][ip0])
01503             || !gsl_finite(met->v[ix][iy][ip0])
01504             || !gsl_finite(met->w[ix][iy][ip0]))
01505           break;
01506
01507       /* Extrapolate... */
01508       for (ip = ip0; ip >= 0; ip--) {
01509         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
01510         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
01511         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
01512         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
01513         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
01514         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
01515       }
01516     }
01517 }
```

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

Calculate geopotential heights.

Definition at line 1521 of file libtrac.c.

```
01523               {
01524
01525   static double topo_lat[EY], topo_lon[EX], topo_z[EX][EY];
01526
01527   static int init, topo_nx = -1, topo_ny;
01528
01529   FILE *in;
01530
01531   char line[LEN];
01532
01533   double data[30], lat, lon, rlat, rlon, rlon_old = -999, rz, ts, z0, z1;
01534
01535   float help[EX][EY];
01536
01537   int ip, ip0, ix, ix2, ix3, iy, iy2, n, tx, ty;
01538
01539   /* Initialize geopotential heights... */
01540   for (ix = 0; ix < met->nx; ix++)
01541     for (iy = 0; iy < met->ny; iy++)
01542       for (ip = 0; ip < met->np; ip++)
01543         met->z[ix][iy][ip] = GSL_NAN;
01544
01545   /* Check filename... */
01546   if (ctl->met_geopot[0] == '-')
01547     return;
01548
01549   /* Read surface geopotential... */
01550   if (!init) {
01551     init = 1;
01552
01553     /* Write info... */
01554     printf("Read surface geopotential: %s\n", ctl->met_geopot);
01555
01556     /* Open file... */
01557     if (!(in = fopen(ctl->met_geopot, "r")))
01558       ERRMSG("Cannot open file!");
01559
01560     /* Read data... */
01561     while (fgets(line, LEN, in))
01562       if (sscanf(line, "%lg %lg %lg", &rlon, &rlat, &rz) == 3) {
01563         if (rlon != rlon_old) {
01564           if ((++topo_nx) >= EX)
01565             ERRMSG("Too many longitudes!");
01566           topo_ny = 0;
01567         }
01568         rlon_old = rlon;
01569         topo_lon[topo_nx] = rlon;
01570         topo_lat[topo_ny] = rlat;
01571         topo_z[topo_nx][topo_ny] = rz;
01572         if ((++topo_ny) >= EY)
01573           ERRMSG("Too many latitudes!");
01574       }
01575     if ((++topo_nx) >= EX)
01576       ERRMSG("Too many longitudes!");
01577
01578     /* Close file... */
01579     fclose(in);
01580
01581     /* Check grid spacing... */
01582     if (fabs(met->lon[0] - met->lon[1]) != fabs(topo_lon[0] - topo_lon[1])
01583         || fabs(met->lat[0] - met->lat[1]) != fabs(topo_lat[0] - topo_lat[1]))
01584       printf("Warning: Grid spacing does not match!\n");
01585   }
01586
01587   /* Apply hydrostatic equation to calculate geopotential heights... */
01588   for (ix = 0; ix < met->nx; ix++)
01589     for (iy = 0; iy < met->ny; iy++) {
01590
01591       /* Get surface height... */
01592       lon = met->lon[ix];
01593       if (lon < topo_lon[0])
01594         lon += 360;
01595       else if (lon > topo_lon[topo_nx - 1])
01596         lon -= 360;
01597       lat = met->lat[iy];
01598       tx = locate(topo_lon, topo_nx, lon);
01599       ty = locate(topo_lat, topo_ny, lat);
```

```
01600       z0 = LIN(topo_lon[tx], topo_z[tx][ty],
01601                topo_lon[tx + 1], topo_z[tx + 1][ty], lon);
01602       z1 = LIN(topo_lon[tx], topo_z[tx][ty + 1],
01603                topo_lon[tx + 1], topo_z[tx + 1][ty + 1], lon);
01604       z0 = LIN(topo_lat[ty], z0, topo_lat[ty + 1], z1, lat);
01605
01606       /* Find surface pressure level... */
01607       ip0 = locate(met->p, met->np, met->ps[ix][iy]);
01608
01609       /* Get surface temperature... */
01610       ts = LIN(met->p[ip0], met->t[ix][iy][ip0],
01611                met->p[ip0 + 1], met->t[ix][iy][ip0 + 1], met->ps[ix][iy]);
01612
01613       /* Upper part of profile... */
01614       met->z[ix][iy][ip0 + 1]
01615         = (float) (z0 + RI / MA / G0 * 0.5 * (ts + met->t[ix][iy][ip0 + 1])
01616                    * log(met->ps[ix][iy] / met->p[ip0 + 1]));
01617       for (ip = ip0 + 2; ip < met->np; ip++)
01618         met->z[ix][iy][ip]
01619           = (float) (met->z[ix][iy][ip - 1] + RI / MA / G0
01620                      * 0.5 * (met->t[ix][iy][ip - 1] + met->t[ix][iy][ip])
01621                      * log(met->p[ip - 1] / met->p[ip]));
01622     }
01623
01624   /* Smooth fields... */
01625   for (ip = 0; ip < met->np; ip++) {
01626
01627     /* Median filter... */
01628     for (ix = 0; ix < met->nx; ix++)
01629       for (iy = 0; iy < met->nx; iy++) {
01630         n = 0;
01631         for (ix2 = ix - 2; ix2 <= ix + 2; ix2++) {
01632           ix3 = ix2;
01633           if (ix3 < 0)
01634             ix3 += met->nx;
01635           if (ix3 >= met->nx)
01636             ix3 -= met->nx;
01637           for (iy2 = GSL_MAX(iy - 2, 0); iy2 <= GSL_MIN(iy + 2, met->ny - 1);
01638                iy2++)
01639             if (gsl_finite(met->z[ix3][iy2][ip])) {
01640               data[n] = met->z[ix3][iy2][ip];
01641               n++;
01642             }
01643         }
01644         if (n > 0) {
01645           gsl_sort(data, 1, (size_t) n);
01646           help[ix][iy] = (float)
01647             gsl_stats_median_from_sorted_data(data, 1, (size_t) n);
01648         } else
01649           help[ix][iy] = GSL_NAN;
01650       }
01651
01652     /* Copy data... */
01653     for (ix = 0; ix < met->nx; ix++)
01654       for (iy = 0; iy < met->nx; iy++)
01655         met->z[ix][iy][ip] = help[ix][iy];
01656   }
01657 }
```

Here is the call graph for this function:

5.19.2.26 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 1661 of file libtrac.c.

```
01667             {
01668
01669   static float help[EX * EY * EP];
01670
01671   int ip, ix, iy, varid;
01672
01673   /* Check if variable exists... */
01674   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
01675     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
01676       return;
01677
01678   /* Read data... */
```

```
01679   NC(nc_get_var_float(ncid, varid, help));
01680
01681   /* Copy and check data... */
01682   for (ix = 0; ix < met->nx; ix++)
01683     for (iy = 0; iy < met->ny; iy++)
01684       for (ip = 0; ip < met->np; ip++) {
01685         dest[ix][iy][ip] = help[(ip * met->ny + iy) * met->nx + ix];
01686         if (fabsf(dest[ix][iy][ip]) < 1e14f)
01687           dest[ix][iy][ip] *= scl;
01688         else
01689           dest[ix][iy][ip] = GSL_NAN;
01690       }
01691 }
```

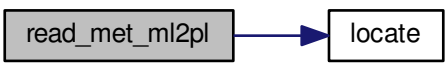
5.19.2.27 void read_met_ml2pl (ctl_t * *ctl*, met_t * *met*, float *var[EX][EY][EP]*)

Convert meteorological data from model levels to pressure levels.

Definition at line 1695 of file libtrac.c.

```
01698                           {
01699
01700   double aux[EP], p[EP], pt;
01701
01702   int ip, ip2, ix, iy;
01703
01704   /* Loop over columns... */
01705   for (ix = 0; ix < met->nx; ix++)
01706     for (iy = 0; iy < met->ny; iy++) {
01707
01708       /* Copy pressure profile... */
01709       for (ip = 0; ip < met->np; ip++)
01710         p[ip] = met->pl[ix][iy][ip];
01711
01712       /* Interpolate... */
01713       for (ip = 0; ip < ctl->met_np; ip++) {
01714         pt = ctl->met_p[ip];
01715         if ((pt > p[0] && p[0] > p[1]) || (pt < p[0] && p[0] < p[1]))
01716           pt = p[0];
01717         else if ((pt > p[met->np - 1] && p[1] > p[0])
01718                  || (pt < p[met->np - 1] && p[1] < p[0]))
01719           pt = p[met->np - 1];
01720         ip2 = locate(p, met->np, pt);
01721         aux[ip] = LIN(p[ip2], var[ix][iy][ip2],
01722                       p[ip2 + 1], var[ix][iy][ip2 + 1], pt);
01723       }
01724
01725       /* Copy data... */
01726       for (ip = 0; ip < ctl->met_np; ip++)
01727         var[ix][iy][ip] = (float) aux[ip];
01728     }
01729 }
```

Here is the call graph for this function:



5.19.2.28 void read_met_periodic (met_t * *met*)

Create meteorological data with periodic boundary conditions.

Definition at line 1733 of file libtrac.c.

```
01734               {
01735
01736   int ip, iy;
01737
01738   /* Check longitudes... */
01739   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
01740              + met->lon[1] - met->lon[0] - 360) < 0.01))
01741     return;
01742
01743   /* Increase longitude counter... */
01744   if ((++met->nx) > EX)
01745     ERRMSG("Cannot create periodic boundary conditions!");
01746
01747   /* Set longitude... */
01748   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
01749
01750   /* Loop over latitudes and pressure levels... */
01751   for (iy = 0; iy < met->ny; iy++)
01752     for (ip = 0; ip < met->np; ip++) {
01753       met->ps[met->nx - 1][iy] = met->ps[0][iy];
01754       met->pt[met->nx - 1][iy] = met->pt[0][iy];
01755       met->z[met->nx - 1][iy][ip] = met->z[0][iy][ip];
01756       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
01757       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
01758       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
01759       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
01760       met->pv[met->nx - 1][iy][ip] = met->pv[0][iy][ip];
01761       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
01762       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
01763     }
01764 }
```

5.19.2.29 void read_met_pv (met_t * *met*)

Calculate potential vorticity.

Definition at line 1768 of file libtrac.c.

```
01769               {
01770
01771   double c0, c1, cr, dx, dy, dp, dtdx, dvdx, dtdy, dudy, dtdp, dudp, dvdp,
01772     latr, vort, pows[EP];
01773
01774   int ip, ip0, ip1, ix, ix0, ix1, iy, iy0, iy1;
01775
01776   /* Set powers... */
01777   for (ip = 0; ip < met->np; ip++)
01778     pows[ip] = pow(1000. / met->p[ip], 0.286);
01779
01780   /* Loop over grid points... */
01781   for (ix = 0; ix < met->nx; ix++) {
01782
01783     /* Set indices... */
01784     ix0 = GSL_MAX(ix - 1, 0);
01785     ix1 = GSL_MIN(ix + 1, met->nx - 1);
01786
01787     /* Loop over grid points... */
01788     for (iy = 0; iy < met->ny; iy++) {
01789
01790       /* Set indices... */
01791       iy0 = GSL_MAX(iy - 1, 0);
01792       iy1 = GSL_MIN(iy + 1, met->ny - 1);
01793
01794       /* Set auxiliary variables... */
01795       latr = GSL_MIN(GSL_MAX(met->lat[iy], -89.), 89.);
01796       dx = 1000. * deg2dx(met->lon[ix1] - met->lon[ix0], latr);
01797       dy = 1000. * deg2dy(met->lat[iy1] - met->lat[iy0]);
01798       c0 = cos(met->lat[iy0] / 180. * M_PI);
01799       c1 = cos(met->lat[iy1] / 180. * M_PI);
```

```
01800       cr = cos(latr / 180. * M_PI);
01801       vort = 2 * 7.2921e-5 * sin(latr * M_PI / 180.);
01802
01803       /* Loop over grid points... */
01804       for (ip = 0; ip < met->np; ip++) {
01805
01806         /* Set indices... */
01807         ip0 = GSL_MAX(ip - 1, 0);
01808         ip1 = GSL_MIN(ip + 1, met->np - 1);
01809
01810         /* Set auxiliary variables... */
01811         dp = 100. * (met->p[ip1] - met->p[ip0]);
01812
01813         /* Get gradients in longitude... */
01814         dtdx = (met->t[ix1][iy][ip] - met->t[ix0][iy][ip]) * pows[ip] / dx;
01815         dvdx = (met->v[ix1][iy][ip] - met->v[ix0][iy][ip]) / dx;
01816
01817         /* Get gradients in latitude... */
01818         dtdy = (met->t[ix][iy1][ip] - met->t[ix][iy0][ip]) * pows[ip] / dy;
01819         dudy = (met->u[ix][iy1][ip] * c1 - met->u[ix][iy0][ip] * c0) / dy;
01820
01821         /* Get gradients in pressure... */
01822         dtdp =
01823           (met->t[ix][iy][ip1] * pows[ip1] -
01824            met->t[ix][iy][ip0] * pows[ip0]) / dp;
01825         dudp = (met->u[ix][iy][ip1] - met->u[ix][iy][ip0]) / dp;
01826         dvdp = (met->v[ix][iy][ip1] - met->v[ix][iy][ip0]) / dp;
01827
01828         /* Calculate PV... */
01829         met->pv[ix][iy][ip] = (float)
01830           (1e6 * G0 *
01831            (-dtdp * (dvdx - dudy / cr + vort) + dvdp * dtdx - dudp * dtdy));
01832       }
01833     }
01834   }
01835 }
```

Here is the call graph for this function:

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

Downsampling of meteorological data.

Definition at line 1839 of file libtrac.c.

```
01841               {
01842
01843   met_t *help;
01844
01845   float w, wsum;
01846
01847   int ip, ip2, ix, ix2, iy, iy2;
01848
01849   /* Check parameters... */
01850   if (ctl->met_dp <= 1 && ctl->met_dx <= 1 && ctl->met_dy <= 1)
01851     return;
01852
01853   /* Allocate... */
01854   ALLOC(help, met_t, 1);
01855
01856   /* Copy data... */
01857   help->nx = met->nx;
01858   help->ny = met->ny;
01859   help->np = met->np;
01860   memcpy(help->lon, met->lon, sizeof(met->lon));
01861   memcpy(help->lat, met->lat, sizeof(met->lat));
01862   memcpy(help->p, met->p, sizeof(met->p));
01863
01864   /* Smoothing... */
01865   for (ix = 0; ix < met->nx; ix += ctl->met_dx) {
01866     for (iy = 0; iy < met->ny; iy += ctl->met_dy) {
01867       for (ip = 0; ip < met->np; ip += ctl->met_dp) {
01868         help->ps[ix][iy] = 0;
01869         help->pt[ix][iy] = 0;
01870         help->z[ix][iy][ip] = 0;
01871         help->t[ix][iy][ip] = 0;
01872         help->u[ix][iy][ip] = 0;
01873         help->v[ix][iy][ip] = 0;
01874         help->w[ix][iy][ip] = 0;
```

```
01875         help->pv[ix][iy][ip] = 0;
01876         help->h2o[ix][iy][ip] = 0;
01877         help->o3[ix][iy][ip] = 0;
01878         wsum = 0;
01879         for (ix2 = GSL_MAX(ix - ctl->met_sx + 1, 0);
01880              ix2 <= GSL_MIN(ix + ctl->met_sx - 1, met->nx - 1); ix2++)
01881           for (iy2 = GSL_MAX(iy - ctl->met_sy + 1, 0);
01882                iy2 <= GSL_MIN(iy + ctl->met_sy - 1, met->ny - 1); iy2++)
01883             for (ip2 = GSL_MAX(ip - ctl->met_sp + 1, 0);
01884                  ip2 <= GSL_MIN(ip + ctl->met_sp - 1, met->np - 1); ip2++) {
01885               w = (float) (1.0 - fabs(ix - ix2) / ctl->met_sx)
01886                 * (float) (1.0 - fabs(iy - iy2) / ctl->met_sy)
01887                 * (float) (1.0 - fabs(ip - ip2) / ctl->met_sp);
01888               help->ps[ix][iy] += w * met->ps[ix2][iy2];
01889               help->pt[ix][iy] += w * met->pt[ix2][iy2];
01890               help->z[ix][iy][ip] += w * met->z[ix2][iy2][ip2];
01891               help->t[ix][iy][ip] += w * met->t[ix2][iy2][ip2];
01892               help->u[ix][iy][ip] += w * met->u[ix2][iy2][ip2];
01893               help->v[ix][iy][ip] += w * met->v[ix2][iy2][ip2];
01894               help->w[ix][iy][ip] += w * met->w[ix2][iy2][ip2];
01895               help->pv[ix][iy][ip] += w * met->pv[ix2][iy2][ip2];
01896               help->h2o[ix][iy][ip] += w * met->h2o[ix2][iy2][ip2];
01897               help->o3[ix][iy][ip] += w * met->o3[ix2][iy2][ip2];
01898               wsum += w;
01899             }
01900         help->ps[ix][iy] /= wsum;
01901         help->pt[ix][iy] /= wsum;
01902         help->t[ix][iy][ip] /= wsum;
01903         help->z[ix][iy][ip] /= wsum;
01904         help->u[ix][iy][ip] /= wsum;
01905         help->v[ix][iy][ip] /= wsum;
01906         help->w[ix][iy][ip] /= wsum;
01907         help->pv[ix][iy][ip] /= wsum;
01908         help->h2o[ix][iy][ip] /= wsum;
01909         help->o3[ix][iy][ip] /= wsum;
01910       }
01911     }
01912   }
01913
01914   /* Downsampling... */
01915   met->nx = 0;
01916   for (ix = 0; ix < help->nx; ix += ctl->met_dx) {
01917     met->lon[met->nx] = help->lon[ix];
01918     met->ny = 0;
01919     for (iy = 0; iy < help->ny; iy += ctl->met_dy) {
01920       met->lat[met->ny] = help->lat[iy];
01921       met->ps[met->nx][met->ny] = help->ps[ix][iy];
01922       met->pt[met->nx][met->ny] = help->pt[ix][iy];
01923       met->np = 0;
01924       for (ip = 0; ip < help->np; ip += ctl->met_dp) {
01925         met->p[met->np] = help->p[ip];
01926         met->z[met->nx][met->ny][met->np] = help->z[ix][iy][ip];
01927         met->t[met->nx][met->ny][met->np] = help->t[ix][iy][ip];
01928         met->u[met->nx][met->ny][met->np] = help->u[ix][iy][ip];
01929         met->v[met->nx][met->ny][met->np] = help->v[ix][iy][ip];
01930         met->w[met->nx][met->ny][met->np] = help->w[ix][iy][ip];
01931         met->pv[met->nx][met->ny][met->np] = help->pv[ix][iy][ip];
01932         met->h2o[met->nx][met->ny][met->np] = help->h2o[ix][iy][ip];
01933         met->o3[met->nx][met->ny][met->np] = help->o3[ix][iy][ip];
01934         met->np++;
01935       }
01936       met->ny++;
01937     }
01938     met->nx++;
01939   }
01940
01941   /* Free... */
01942   free(help);
01943 }
```

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

Calculate tropopause pressure.

Definition at line 1947 of file libtrac.c.

```
01949               {
01950
01951   gsl_interp_accel *acc;
01952
```

```
01953   gsl_spline *spline;
01954
01955   double p2[400], pv[400], pv2[400], t[400], t2[400], th[400], th2[400],
01956     z[400], z2[400];
01957
01958   int found, ix, iy, iz, iz2;
01959
01960   /* Allocate... */
01961   acc = gsl_interp_accel_alloc();
01962   spline = gsl_spline_alloc(gsl_interp_cspline, (size_t) met->np);
01963
01964   /* Get altitude and pressure profiles... */
01965   for (iz = 0; iz < met->np; iz++)
01966     z[iz] = Z(met->p[iz]);
01967   for (iz = 0; iz <= 170; iz++) {
01968     z2[iz] = 4.5 + 0.1 * iz;
01969     p2[iz] = P(z2[iz]);
01970   }
01971
01972   /* Do not calculate tropopause... */
01973   if (ctl->met_tropo == 0)
01974     for (ix = 0; ix < met->nx; ix++)
01975       for (iy = 0; iy < met->ny; iy++)
01976         met->pt[ix][iy] = GSL_NAN;
01977
01978   /* Use tropopause climatology... */
01979   else if (ctl->met_tropo == 1)
01980     for (ix = 0; ix < met->nx; ix++)
01981       for (iy = 0; iy < met->ny; iy++)
01982         met->pt[ix][iy] = clim_tropo(met->time, met->lat[iy]);
01983
01984   /* Use cold point... */
01985   else if (ctl->met_tropo == 2) {
01986
01987     /* Loop over grid points... */
01988     for (ix = 0; ix < met->nx; ix++)
01989       for (iy = 0; iy < met->ny; iy++) {
01990
01991         /* Interpolate temperature profile... */
01992         for (iz = 0; iz < met->np; iz++)
01993           t[iz] = met->t[ix][iy][iz];
01994         gsl_spline_init(spline, z, t, (size_t) met->np);
01995         for (iz = 0; iz <= 170; iz++)
01996           t2[iz] = gsl_spline_eval(spline, z2[iz], acc);
01997
01998         /* Find minimum... */
01999         iz = (int) gsl_stats_min_index(t2, 1, 171);
02000         if (iz <= 0 || iz >= 170)
02001           met->pt[ix][iy] = GSL_NAN;
02002         else
02003           met->pt[ix][iy] = p2[iz];
02004       }
02005   }
02006
02007   /* Use WMO definition... */
02008   else if (ctl->met_tropo == 3 || ctl->met_tropo == 4) {
02009
02010     /* Loop over grid points... */
02011     for (ix = 0; ix < met->nx; ix++)
02012       for (iy = 0; iy < met->ny; iy++) {
02013
02014         /* Interpolate temperature profile... */
02015         for (iz = 0; iz < met->np; iz++)
02016           t[iz] = met->t[ix][iy][iz];
02017         gsl_spline_init(spline, z, t, (size_t) met->np);
02018         for (iz = 0; iz <= 160; iz++)
02019           t2[iz] = gsl_spline_eval(spline, z2[iz], acc);
02020
02021         /* Find 1st tropopause... */
02022         met->pt[ix][iy] = GSL_NAN;
02023         for (iz = 0; iz <= 140; iz++) {
02024           found = 1;
02025           for (iz2 = iz + 1; iz2 <= iz + 20; iz2++)
02026             if (1000. * G0 / RA * log(t2[iz2] / t2[iz])
02027                 / log(p2[iz2] / p2[iz]) > 2.0) {
02028               found = 0;
02029               break;
02030             }
02031           if (found) {
02032             if (iz > 0 && iz < 140)
02033               met->pt[ix][iy] = p2[iz];
02034             break;
02035           }
02036         }
02037
02038         /* Find 2nd tropopause... */
02039         if (ctl->met_tropo == 4) {
```

```
02040           met->pt[ix][iy] = GSL_NAN;
02041           for (; iz <= 140; iz++) {
02042             found = 1;
02043             for (iz2 = iz + 1; iz2 <= iz + 10; iz2++)
02044               if (1000. * G0 / RA * log(t2[iz2] / t2[iz])
02045                   / log(p2[iz2] / p2[iz]) < 3.0) {
02046                 found = 0;
02047                 break;
02048               }
02049             if (found)
02050               break;
02051           }
02052           for (; iz <= 140; iz++) {
02053             found = 1;
02054             for (iz2 = iz + 1; iz2 <= iz + 20; iz2++)
02055               if (1000. * G0 / RA * log(t2[iz2] / t2[iz])
02056                   / log(p2[iz2] / p2[iz]) > 2.0) {
02057                 found = 0;
02058                 break;
02059               }
02060             if (found) {
02061               if (iz > 0 && iz < 140)
02062                 met->pt[ix][iy] = p2[iz];
02063               break;
02064             }
02065           }
02066         }
02067       }
02068   }
02069
02070   /* Use dynamical tropopause... */
02071   else if (ctl->met_tropo == 5) {
02072
02073     /* Loop over grid points... */
02074     for (ix = 0; ix < met->nx; ix++)
02075       for (iy = 0; iy < met->ny; iy++) {
02076
02077         /* Interpolate potential vorticity profile... */
02078         for (iz = 0; iz < met->np; iz++)
02079           pv[iz] = met->pv[ix][iy][iz];
02080         gsl_spline_init(spline, z, pv, (size_t) met->np);
02081         for (iz = 0; iz <= 160; iz++)
02082           pv2[iz] = gsl_spline_eval(spline, z2[iz], acc);
02083
02084         /* Interpolate potential temperature profile... */
02085         for (iz = 0; iz < met->np; iz++)
02086           th[iz] = THETA(met->p[iz], met->t[ix][iy][iz]);
02087         gsl_spline_init(spline, z, th, (size_t) met->np);
02088         for (iz = 0; iz <= 160; iz++)
02089           th2[iz] = gsl_spline_eval(spline, z2[iz], acc);
02090
02091         /* Find dynamical tropopause 3.5 PVU + 380 K */
02092         met->pt[ix][iy] = GSL_NAN;
02093         for (iz = 0; iz <= 160; iz++)
02094           if (fabs(pv2[iz]) >= 3.5 || th2[iz] >= 380.) {
02095             if (iz > 0 && iz < 160)
02096               met->pt[ix][iy] = p2[iz];
02097             break;
02098           }
02099       }
02100   }
02101
02102   else
02103     ERRMSG("Cannot calculate tropopause!");
02104
02105   /* Free... */
02106   gsl_spline_free(spline);
02107   gsl_interp_accel_free(acc);
02108 }
```

Here is the call graph for this function:

5.19.2.32 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 2112 of file libtrac.c.

```
02119               {
02120
02121   FILE *in = NULL;
02122
02123   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
02124     msg[2 * LEN], rvarname[LEN], rval[LEN];
02125
02126   int contain = 0, i;
02127
02128   /* Open file... */
02129   if (filename[strlen(filename) - 1] != '-')
02130     if (!(in = fopen(filename, "r")))
02131       ERRMSG("Cannot open file!");
02132
02133   /* Set full variable name... */
02134   if (arridx >= 0) {
02135     sprintf(fullname1, "%s[%d]", varname, arridx);
02136     sprintf(fullname2, "%s[*]", varname);
02137   } else {
02138     sprintf(fullname1, "%s", varname);
02139     sprintf(fullname2, "%s", varname);
02140   }
02141
02142   /* Read data... */
02143   if (in != NULL)
02144     while (fgets(line, LEN, in))
02145       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
02146         if (strcasecmp(rvarname, fullname1) == 0 ||
02147             strcasecmp(rvarname, fullname2) == 0) {
02148           contain = 1;
02149           break;
02150         }
02151   for (i = 1; i < argc - 1; i++)
02152     if (strcasecmp(argv[i], fullname1) == 0 ||
02153         strcasecmp(argv[i], fullname2) == 0) {
02154       sprintf(rval, "%s", argv[i + 1]);
02155       contain = 1;
02156       break;
02157     }
02158
02159   /* Close file... */
02160   if (in != NULL)
02161     fclose(in);
02162
02163   /* Check for missing variables... */
02164   if (!contain) {
02165     if (strlen(defvalue) > 0)
02166       sprintf(rval, "%s", defvalue);
02167     else {
02168       sprintf(msg, "Missing variable %s!\n", fullname1);
02169       ERRMSG(msg);
02170     }
02171   }
02172
02173   /* Write info... */
02174   printf("%s = %s\n", fullname1, rval);
02175
02176   /* Return values... */
02177   if (value != NULL)
02178     sprintf(value, "%s", rval);
02179   return atof(rval);
02180 }
```

5.19.2.33 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 2184 of file libtrac.c.

```
02192               {
02193
02194   struct tm t0, t1;
02195
02196   t0.tm_year = 100;
02197   t0.tm_mon = 0;
02198   t0.tm_mday = 1;
02199   t0.tm_hour = 0;
02200   t0.tm_min = 0;
02201   t0.tm_sec = 0;
02202
```

```
02203   t1.tm_year = year - 1900;
02204   t1.tm_mon = mon - 1;
02205   t1.tm_mday = day;
02206   t1.tm_hour = hour;
02207   t1.tm_min = min;
02208   t1.tm_sec = sec;
02209
02210   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
02211 }
```

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

Measure wall-clock time.

Definition at line 2215 of file libtrac.c.

```
02218            {
02219
02220   static double starttime[NTIMER], runtime[NTIMER];
02221
02222   /* Check id... */
02223   if (id < 0 || id >= NTIMER)
02224     ERRMSG("Too many timers!");
02225
02226   /* Start timer... */
02227   if (mode == 1) {
02228     if (starttime[id] <= 0)
02229       starttime[id] = omp_get_wtime();
02230     else
02231       ERRMSG("Timer already started!");
02232   }
02233
02234   /* Stop timer... */
02235   else if (mode == 2) {
02236     if (starttime[id] > 0) {
02237       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
02238       starttime[id] = -1;
02239     }
02240   }
02241
02242   /* Print timer... */
02243   else if (mode == 3) {
02244     printf("%s = %.3f s\n", name, runtime[id]);
02245     runtime[id] = 0;
02246   }
02247 }
```

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

Write atmospheric data.

Definition at line 2251 of file libtrac.c.

```
02255            {
02256
02257   FILE *in, *out;
02258
02259   char line[LEN];
02260
02261   double r, t0, t1;
02262
02263   int ip, iq, year, mon, day, hour, min, sec;
02264
02265   /* Set time interval for output... */
02266   t0 = t - 0.5 * ctl->dt_mod;
02267   t1 = t + 0.5 * ctl->dt_mod;
02268
02269   /* Write info... */
02270   printf("Write atmospheric data: %s\n", filename);
02271
02272   /* Write ASCII data... */
02273   if (ctl->atm_type == 0) {
02274
02275     /* Check if gnuplot output is requested... */
```

```
02276     if (ctl->atm_gpfile[0] != '-') {
02277
02278       /* Create gnuplot pipe... */
02279       if (!(out = popen("gnuplot", "w")))
02280         ERRMSG("Cannot create pipe to gnuplot!");
02281
02282       /* Set plot filename... */
02283       fprintf(out, "set out \"%s.png\"\n", filename);
02284
02285       /* Set time string... */
02286       jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
02287       fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
02288               year, mon, day, hour, min);
02289
02290       /* Dump gnuplot file to pipe... */
02291       if (!(in = fopen(ctl->atm_gpfile, "r")))
02292         ERRMSG("Cannot open file!");
02293       while (fgets(line, LEN, in))
02294         fprintf(out, "%s", line);
02295       fclose(in);
02296     }
02297
02298     else {
02299
02300       /* Create file... */
02301       if (!(out = fopen(filename, "w")))
02302         ERRMSG("Cannot create file!");
02303     }
02304
02305     /* Write header... */
02306     fprintf(out,
02307             "# $1 = time [s]\n"
02308             "# $2 = altitude [km]\n"
02309             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
02310     for (iq = 0; iq < ctl->nq; iq++)
02311       fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
02312               ctl->qnt_unit[iq]);
02313     fprintf(out, "\n");
02314
02315     /* Write data... */
02316     for (ip = 0; ip < atm->np; ip++) {
02317
02318       /* Check time... */
02319       if (ctl->atm_filter && (atm->time[ip] < t0 || atm->time[ip] > t1))
02320         continue;
02321
02322       /* Write output... */
02323       fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
02324               atm->lon[ip], atm->lat[ip]);
02325       for (iq = 0; iq < ctl->nq; iq++) {
02326         fprintf(out, " ");
02327         fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
02328       }
02329       fprintf(out, "\n");
02330     }
02331
02332     /* Close file... */
02333     fclose(out);
02334   }
02335
02336   /* Write binary data... */
02337   else if (ctl->atm_type == 1) {
02338
02339     /* Create file... */
02340     if (!(out = fopen(filename, "w")))
02341       ERRMSG("Cannot create file!");
02342
02343     /* Write data... */
02344     FWRITE(&atm->np, int,
02345            1,
02346            out);
02347     FWRITE(atm->time, double,
02348              (size_t) atm->np,
02349            out);
02350     FWRITE(atm->p, double,
02351              (size_t) atm->np,
02352            out);
02353     FWRITE(atm->lon, double,
02354              (size_t) atm->np,
02355            out);
02356     FWRITE(atm->lat, double,
02357              (size_t) atm->np,
02358            out);
02359     for (iq = 0; iq < ctl->nq; iq++)
02360       FWRITE(atm->q[iq], double,
02361                (size_t) atm->np,
02362              out);
```

```
02363
02364     /* Close file... */
02365     fclose(out);
02366   }
02367
02368   /* Error... */
02369   else
02370     ERRMSG("Atmospheric data type not supported!");
02371 }
```

Here is the call graph for this function:

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

Write CSI data.

Definition at line 2375 of file libtrac.c.

```
02379             {
02380
02381   static FILE *in, *out;
02382
02383   static char line[LEN];
02384
02385   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
02386     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
02387
02388   static int obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
02389
02390   /* Init... */
02391   if (t == ctl->t_start) {
02392
02393     /* Check quantity index for mass... */
02394     if (ctl->qnt_m < 0)
02395       ERRMSG("Need quantity mass!");
02396
02397     /* Open observation data file... */
02398     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
02399     if (!(in = fopen(ctl->csi_obsfile, "r")))
02400       ERRMSG("Cannot open file!");
02401
02402     /* Create new file... */
02403     printf("Write CSI data: %s\n", filename);
02404     if (!(out = fopen(filename, "w")))
02405       ERRMSG("Cannot create file!");
02406
02407     /* Write header... */
02408     fprintf(out,
02409             "# $1 = time [s]\n"
02410             "# $2 = number of hits (cx)\n"
02411             "# $3 = number of misses (cy)\n"
02412             "# $4 = number of false alarms (cz)\n"
02413             "# $5 = number of observations (cx + cy)\n"
02414             "# $6 = number of forecasts (cx + cz)\n"
02415             "# $7 = bias (forecasts/observations) [%%]\n"
02416             "# $8 = probability of detection (POD) [%%]\n"
02417             "# $9 = false alarm rate (FAR) [%%]\n"
02418             "# $10 = critical success index (CSI) [%%]\n\n");
02419   }
02420
02421   /* Set time interval... */
02422   t0 = t - 0.5 * ctl->dt_mod;
```

```
02423   t1 = t + 0.5 * ctl->dt_mod;
02424
02425   /* Initialize grid cells... */
02426   for (ix = 0; ix < ctl->csi_nx; ix++)
02427     for (iy = 0; iy < ctl->csi_ny; iy++)
02428       for (iz = 0; iz < ctl->csi_nz; iz++)
02429         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
02430
02431   /* Read observation data... */
02432   while (fgets(line, LEN, in)) {
02433
02434     /* Read data... */
02435     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
02436         5)
02437       continue;
02438
02439     /* Check time... */
02440     if (rt < t0)
02441       continue;
02442     if (rt > t1)
02443       break;
02444
02445     /* Calculate indices... */
02446     ix = (int) ((rlon - ctl->csi_lon0)
02447                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
02448     iy = (int) ((rlat - ctl->csi_lat0)
02449                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
02450     iz = (int) ((rz - ctl->csi_z0)
02451                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
02452
02453     /* Check indices... */
02454     if (ix < 0 || ix >= ctl->csi_nx ||
02455         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
02456       continue;
02457
02458     /* Get mean observation index... */
02459     obsmean[ix][iy][iz] += robs;
02460     obscount[ix][iy][iz]++;
02461   }
02462
02463   /* Analyze model data... */
02464   for (ip = 0; ip < atm->np; ip++) {
02465
02466     /* Check time... */
02467     if (atm->time[ip] < t0 || atm->time[ip] > t1)
02468       continue;
02469
02470     /* Get indices... */
02471     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
02472                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
02473     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
02474                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
02475     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
02476                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
02477
02478     /* Check indices... */
02479     if (ix < 0 || ix >= ctl->csi_nx ||
02480         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
02481       continue;
02482
02483     /* Get total mass in grid cell... */
02484     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
02485   }
02486
02487   /* Analyze all grid cells... */
02488   for (ix = 0; ix < ctl->csi_nx; ix++)
02489     for (iy = 0; iy < ctl->csi_ny; iy++)
02490       for (iz = 0; iz < ctl->csi_nz; iz++) {
02491
02492         /* Calculate mean observation index... */
02493         if (obscount[ix][iy][iz] > 0)
02494           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
02495
02496         /* Calculate column density... */
02497         if (modmean[ix][iy][iz] > 0) {
02498           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
02499           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
02500           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
02501           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
02502             * cos(lat * M_PI / 180.);
02503           modmean[ix][iy][iz] /= (1e6 * area);
02504         }
02505
02506         /* Calculate CSI... */
02507         if (obscount[ix][iy][iz] > 0) {
02508           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
02509               modmean[ix][iy][iz] >= ctl->csi_modmin)
```

```
02510             cx++;
02511           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
02512                    modmean[ix][iy][iz] < ctl->csi_modmin)
02513             cy++;
02514           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
02515                    modmean[ix][iy][iz] >= ctl->csi_modmin)
02516             cz++;
02517         }
02518       }
02519
02520   /* Write output... */
02521   if (fmod(t, ctl->csi_dt_out) == 0) {
02522
02523     /* Write... */
02524     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
02525             t, cx, cy, cz, cx + cy, cx + cz,
02526             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
02527             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
02528             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
02529             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
02530
02531     /* Set counters to zero... */
02532     cx = cy = cz = 0;
02533   }
02534
02535   /* Close file... */
02536   if (t == ctl->t_stop)
02537     fclose(out);
02538 }
```

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

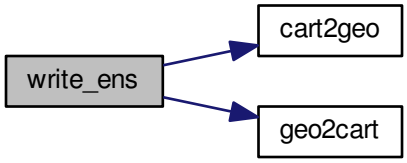
Write ensemble data.

Definition at line 2542 of file libtrac.c.

```
02546             {
02547
02548   static FILE *out;
02549
02550   static double dummy, ens, lat, lon, p[NENS], q[NQ][NENS],
02551     t0, t1, x[NENS][3], xm[3];
02552
02553   static int ip, iq;
02554
02555   static size_t i, n;
02556
02557   /* Init... */
02558   if (t == ctl->t_start) {
02559
02560     /* Check quantities... */
02561     if (ctl->qnt_ens < 0)
02562       ERRMSG("Missing ensemble IDs!");
02563
02564     /* Create new file... */
02565     printf("Write ensemble data: %s\n", filename);
02566     if (!(out = fopen(filename, "w")))
02567       ERRMSG("Cannot create file!");
02568
02569     /* Write header... */
02570     fprintf(out,
02571             "# $1 = time [s]\n"
02572             "# $2 = altitude [km]\n"
02573             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
02574     for (iq = 0; iq < ctl->nq; iq++)
02575       fprintf(out, "# $%d = %s (mean) [%s]\n", 5 + iq,
02576               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
02577     for (iq = 0; iq < ctl->nq; iq++)
02578       fprintf(out, "# $%d = %s (sigma) [%s]\n", 5 + ctl->nq + iq,
02579               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
02580     fprintf(out, "# $%d = number of members\n\n", 5 + 2 * ctl->nq);
02581   }
02582
02583   /* Set time interval... */
02584   t0 = t - 0.5 * ctl->dt_mod;
02585   t1 = t + 0.5 * ctl->dt_mod;
02586
02587   /* Init... */
02588   ens = GSL_NAN;
02589   n = 0;
```

```
02590
02591   /* Loop over air parcels... */
02592   for (ip = 0; ip < atm->np; ip++) {
02593
02594     /* Check time... */
02595     if (atm->time[ip] < t0 || atm->time[ip] > t1)
02596       continue;
02597
02598     /* Check ensemble id... */
02599     if (atm->q[ctl->qnt_ens][ip] != ens) {
02600
02601       /* Write results... */
02602       if (n > 0) {
02603
02604         /* Get mean position... */
02605         xm[0] = xm[1] = xm[2] = 0;
02606         for (i = 0; i < n; i++) {
02607           xm[0] += x[i][0] / (double) n;
02608           xm[1] += x[i][1] / (double) n;
02609           xm[2] += x[i][2] / (double) n;
02610         }
02611         cart2geo(xm, &dummy, &lon, &lat);
02612         fprintf(out, "%.2f %g %g %g", t, Z(gsl_stats_mean(p, 1, n)), lon,
02613                 lat);
02614
02615         /* Get quantity statistics... */
02616         for (iq = 0; iq < ctl->nq; iq++) {
02617           fprintf(out, " ");
02618           fprintf(out, ctl->qnt_format[iq], gsl_stats_mean(q[iq], 1, n));
02619         }
02620         for (iq = 0; iq < ctl->nq; iq++) {
02621           fprintf(out, " ");
02622           fprintf(out, ctl->qnt_format[iq], gsl_stats_sd(q[iq], 1, n));
02623         }
02624         fprintf(out, " %lu\n", n);
02625       }
02626
02627       /* Init new ensemble... */
02628       ens = atm->q[ctl->qnt_ens][ip];
02629       n = 0;
02630     }
02631
02632     /* Save data... */
02633     p[n] = atm->p[ip];
02634     geo2cart(0, atm->lon[ip], atm->lat[ip], x[n]);
02635     for (iq = 0; iq < ctl->nq; iq++)
02636       q[iq][n] = atm->q[iq][ip];
02637     if ((++n) >= NENS)
02638       ERRMSG("Too many data points!");
02639   }
02640
02641   /* Write results... */
02642   if (n > 0) {
02643
02644     /* Get mean position... */
02645     xm[0] = xm[1] = xm[2] = 0;
02646     for (i = 0; i < n; i++) {
02647       xm[0] += x[i][0] / (double) n;
02648       xm[1] += x[i][1] / (double) n;
02649       xm[2] += x[i][2] / (double) n;
02650     }
02651     cart2geo(xm, &dummy, &lon, &lat);
02652     fprintf(out, "%.2f %g %g %g", t, Z(gsl_stats_mean(p, 1, n)), lon, lat);
02653
02654     /* Get quantity statistics... */
02655     for (iq = 0; iq < ctl->nq; iq++) {
02656       fprintf(out, " ");
02657       fprintf(out, ctl->qnt_format[iq], gsl_stats_mean(q[iq], 1, n));
02658     }
02659     for (iq = 0; iq < ctl->nq; iq++) {
02660       fprintf(out, " ");
02661       fprintf(out, ctl->qnt_format[iq], gsl_stats_sd(q[iq], 1, n));
02662     }
02663     fprintf(out, " %lu\n", n);
02664   }
02665
02666   /* Close file... */
02667   if (t == ctl->t_stop)
02668     fclose(out);
02669 }
```

Here is the call graph for this function:



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

Write gridded data.

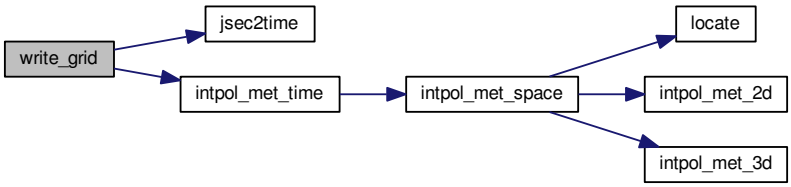
Definition at line 2673 of file libtrac.c.

```
02679            {
02680
02681   FILE *in, *out;
02682
02683   char line[LEN];
02684
02685   static double mass[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
02686     area, rho_air, press, temp, cd, vmr, t0, t1, r;
02687
02688   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
02689
02690   /* Check dimensions... */
02691   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
02692     ERRMSG("Grid dimensions too large!");
02693
02694   /* Check quantity index for mass... */
02695   if (ctl->qnt_m < 0)
02696     ERRMSG("Need quantity mass!");
02697
02698   /* Set time interval for output... */
02699   t0 = t - 0.5 * ctl->dt_mod;
02700   t1 = t + 0.5 * ctl->dt_mod;
02701
02702   /* Set grid box size... */
02703   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
02704   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
02705   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
02706
02707   /* Initialize grid... */
02708   for (ix = 0; ix < ctl->grid_nx; ix++)
02709     for (iy = 0; iy < ctl->grid_ny; iy++)
02710       for (iz = 0; iz < ctl->grid_nz; iz++)
02711         mass[ix][iy][iz] = 0;
02712
02713   /* Average data... */
02714   for (ip = 0; ip < atm->np; ip++)
02715     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
02716
02717       /* Get index... */
02718       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
02719       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
02720       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
02721
02722       /* Check indices... */
02723       if (ix < 0 || ix >= ctl->grid_nx ||
02724           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
02725         continue;
02726
02727       /* Add mass... */
02728       mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
02729     }
02730
```

```
02731   /* Check if gnuplot output is requested... */
02732   if (ctl->grid_gpfile[0] != '-') {
02733
02734     /* Write info... */
02735     printf("Plot grid data: %s.png\n", filename);
02736
02737     /* Create gnuplot pipe... */
02738     if (!(out = popen("gnuplot", "w")))
02739       ERRMSG("Cannot create pipe to gnuplot!");
02740
02741     /* Set plot filename... */
02742     fprintf(out, "set out \"%s.png\"\n", filename);
02743
02744     /* Set time string... */
02745     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
02746     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
02747             year, mon, day, hour, min);
02748
02749     /* Dump gnuplot file to pipe... */
02750     if (!(in = fopen(ctl->grid_gpfile, "r")))
02751       ERRMSG("Cannot open file!");
02752     while (fgets(line, LEN, in))
02753       fprintf(out, "%s", line);
02754     fclose(in);
02755   }
02756
02757   else {
02758
02759     /* Write info... */
02760     printf("Write grid data: %s\n", filename);
02761
02762     /* Create file... */
02763     if (!(out = fopen(filename, "w")))
02764       ERRMSG("Cannot create file!");
02765   }
02766
02767   /* Write header... */
02768   fprintf(out,
02769           "# $1 = time [s]\n"
02770           "# $2 = altitude [km]\n"
02771           "# $3 = longitude [deg]\n"
02772           "# $4 = latitude [deg]\n"
02773           "# $5 = surface area [km^2]\n"
02774           "# $6 = layer width [km]\n"
02775           "# $7 = temperature [K]\n"
02776           "# $8 = column density [kg/m^2]\n"
02777           "# $9 = volume mixing ratio [1]\n\n");
02778
02779   /* Write data... */
02780   for (ix = 0; ix < ctl->grid_nx; ix++) {
02781     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
02782       fprintf(out, "\n");
02783     for (iy = 0; iy < ctl->grid_ny; iy++) {
02784       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
02785         fprintf(out, "\n");
02786       for (iz = 0; iz < ctl->grid_nz; iz++)
02787         if (!ctl->grid_sparse || mass[ix][iy][iz] > 0) {
02788
02789           /* Set coordinates... */
02790           z = ctl->grid_z0 + dz * (iz + 0.5);
02791           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
02792           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
02793
02794           /* Get pressure and temperature... */
02795           press = P(z);
02796           intpol_met_time(met0, met1, t, press, lon, lat, NULL, NULL,
02797                           NULL, &temp, NULL, NULL, NULL, NULL, NULL, NULL);
02798
02799           /* Calculate surface area... */
02800           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
02801             * cos(lat * M_PI / 180.);
02802
02803           /* Calculate column density... */
02804           cd = mass[ix][iy][iz] / (1e6 * area);
02805
02806           /* Calculate volume mixing ratio... */
02807           rho_air = 100. * press / (RA * temp);
02808           vmr = MA / ctl->molmass * mass[ix][iy][iz]
02809             / (rho_air * 1e6 * area * 1e3 * dz);
02810
02811           /* Write output... */
02812           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
02813                   t, z, lon, lat, area, dz, temp, cd, vmr);
02814         }
02815     }
02816   }
02817
```

```
02818   /* Close file... */
02819   fclose(out);
02820 }
```

Here is the call graph for this function:



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

Write profile data.

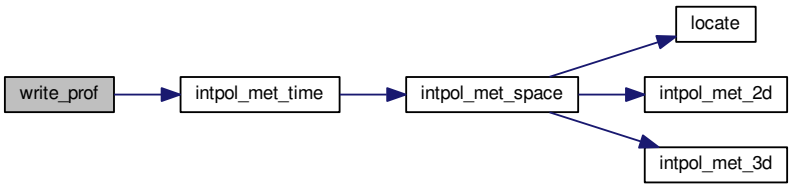
Definition at line 2824 of file libtrac.c.

```
02830             {
02831
02832   static FILE *in, *out;
02833
02834   static char line[LEN];
02835
02836   static double mass[GX][GY][GZ], obsmean[GX][GY], rt, rz, rlon, rlat, robs,
02837     t0, t1, area, dz, dlon, dlat, lon, lat, z, press, temp, rho_air, vmr, h2o,
02838     o3;
02839
02840   static int obscount[GX][GY], ip, ix, iy, iz, okay;
02841
02842   /* Init... */
02843   if (t == ctl->t_start) {
02844
02845     /* Check quantity index for mass... */
02846     if (ctl->qnt_m < 0)
02847       ERRMSG("Need quantity mass!");
02848
02849     /* Check dimensions... */
02850     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
02851       ERRMSG("Grid dimensions too large!");
02852
02853     /* Open observation data file... */
02854     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
02855     if (!(in = fopen(ctl->prof_obsfile, "r")))
02856       ERRMSG("Cannot open file!");
02857
02858     /* Create new output file... */
02859     printf("Write profile data: %s\n", filename);
02860     if (!(out = fopen(filename, "w")))
02861       ERRMSG("Cannot create file!");
02862
02863     /* Write header... */
02864     fprintf(out,
02865             "# $1  = time [s]\n"
02866             "# $2  = altitude [km]\n"
02867             "# $3  = longitude [deg]\n"
02868             "# $4  = latitude [deg]\n"
02869             "# $5  = pressure [hPa]\n"
02870             "# $6  = temperature [K]\n"
02871             "# $7  = volume mixing ratio [1]\n"
02872             "# $8  = H2O volume mixing ratio [1]\n"
02873             "# $9  = O3 volume mixing ratio [1]\n"
02874             "# $10 = mean BT index [K]\n");
02875
02876     /* Set grid box size... */
02877     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
```

```
02878     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
02879     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
02880   }
02881
02882   /* Set time interval... */
02883   t0 = t - 0.5 * ctl->dt_mod;
02884   t1 = t + 0.5 * ctl->dt_mod;
02885
02886   /* Initialize... */
02887   for (ix = 0; ix < ctl->prof_nx; ix++)
02888     for (iy = 0; iy < ctl->prof_ny; iy++) {
02889       obsmean[ix][iy] = 0;
02890       obscount[ix][iy] = 0;
02891       for (iz = 0; iz < ctl->prof_nz; iz++)
02892         mass[ix][iy][iz] = 0;
02893     }
02894
02895   /* Read observation data... */
02896   while (fgets(line, LEN, in)) {
02897
02898     /* Read data... */
02899     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
02900         5)
02901       continue;
02902
02903     /* Check time... */
02904     if (rt < t0)
02905       continue;
02906     if (rt > t1)
02907       break;
02908
02909     /* Calculate indices... */
02910     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
02911     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
02912
02913     /* Check indices... */
02914     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
02915       continue;
02916
02917     /* Get mean observation index... */
02918     obsmean[ix][iy] += robs;
02919     obscount[ix][iy]++;
02920   }
02921
02922   /* Analyze model data... */
02923   for (ip = 0; ip < atm->np; ip++) {
02924
02925     /* Check time... */
02926     if (atm->time[ip] < t0 || atm->time[ip] > t1)
02927       continue;
02928
02929     /* Get indices... */
02930     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
02931     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
02932     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
02933
02934     /* Check indices... */
02935     if (ix < 0 || ix >= ctl->prof_nx ||
02936         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
02937       continue;
02938
02939     /* Get total mass in grid cell... */
02940     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
02941   }
02942
02943   /* Extract profiles... */
02944   for (ix = 0; ix < ctl->prof_nx; ix++)
02945     for (iy = 0; iy < ctl->prof_ny; iy++)
02946       if (obscount[ix][iy] > 0) {
02947
02948         /* Check profile... */
02949         okay = 0;
02950         for (iz = 0; iz < ctl->prof_nz; iz++)
02951           if (mass[ix][iy][iz] > 0)
02952             okay = 1;
02953         if (!okay)
02954           continue;
02955
02956         /* Write output... */
02957         fprintf(out, "\n");
02958
02959         /* Loop over altitudes... */
02960         for (iz = 0; iz < ctl->prof_nz; iz++) {
02961
02962           /* Set coordinates... */
02963           z = ctl->prof_z0 + dz * (iz + 0.5);
02964           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
```

```
02965           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
02966
02967           /* Get pressure and temperature... */
02968           press = P(z);
02969           intpol_met_time(met0, met1, t, press, lon, lat, NULL, NULL,
02970                           NULL, &temp, NULL, NULL, NULL, NULL, &h2o, &o3);
02971
02972           /* Calculate surface area... */
02973           area = dlat * dlon * gsl_pow_2(M_PI * RE / 180.)
02974             * cos(lat * M_PI / 180.);
02975
02976           /* Calculate volume mixing ratio... */
02977           rho_air = 100. * press / (RA * temp);
02978           vmr = MA / ctl->molmass * mass[ix][iy][iz]
02979             / (rho_air * area * dz * 1e9);
02980
02981           /* Write output... */
02982           fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g\n",
02983                   t, z, lon, lat, press, temp, vmr, h2o, o3,
02984                   obsmean[ix][iy] / obscount[ix][iy]);
02985         }
02986       }
02987
02988   /* Close file... */
02989   if (t == ctl->t_stop)
02990     fclose(out);
02991 }
```

Here is the call graph for this function:



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

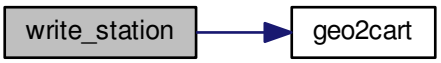
Write station data.

Definition at line 2995 of file libtrac.c.

```
02999           {
03000
03001   static FILE *out;
03002
03003   static double rmax2, t0, t1, x0[3], x1[3];
03004
03005   static int ip, iq;
03006
03007   /* Init... */
03008   if (t == ctl->t_start) {
03009
03010     /* Write info... */
03011     printf("Write station data: %s\n", filename);
03012
03013     /* Create new file... */
03014     if (!(out = fopen(filename, "w")))
03015       ERRMSG("Cannot create file!");
03016
03017     /* Write header... */
03018     fprintf(out,
03019             "# $1 = time [s]\n"
03020             "# $2 = altitude [km]\n"
03021             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
03022     for (iq = 0; iq < ctl->nq; iq++)
```

```
03023       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
03024               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
03025     fprintf(out, "\n");
03026
03027     /* Set geolocation and search radius... */
03028     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
03029     rmax2 = gsl_pow_2(ctl->stat_r);
03030   }
03031
03032   /* Set time interval for output... */
03033   t0 = t - 0.5 * ctl->dt_mod;
03034   t1 = t + 0.5 * ctl->dt_mod;
03035
03036   /* Loop over air parcels... */
03037   for (ip = 0; ip < atm->np; ip++) {
03038
03039     /* Check time... */
03040     if (atm->time[ip] < t0 || atm->time[ip] > t1)
03041       continue;
03042
03043     /* Check station flag... */
03044     if (ctl->qnt_stat >= 0)
03045       if (atm->q[ctl->qnt_stat][ip])
03046         continue;
03047
03048     /* Get Cartesian coordinates... */
03049     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
03050
03051     /* Check horizontal distance... */
03052     if (DIST2(x0, x1) > rmax2)
03053       continue;
03054
03055     /* Set station flag... */
03056     if (ctl->qnt_stat >= 0)
03057       atm->q[ctl->qnt_stat][ip] = 1;
03058
03059     /* Write data... */
03060     fprintf(out, "%.2f %g %g %g",
03061             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
03062     for (iq = 0; iq < ctl->nq; iq++) {
03063       fprintf(out, " ");
03064       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
03065     }
03066     fprintf(out, "\n");
03067   }
03068
03069   /* Close file... */
03070   if (t == ctl->t_stop)
03071     fclose(out);
03072 }
```

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) 2013-2018 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;
00036
00037   radius = NORM(x);
00038   *lat = asin(x[2] / radius) * 180 / M_PI;
00039   *lon = atan2(x[1], x[0]) * 180 / M_PI;
00040   *z = radius - RE;
00041 }
00042
00043 /*****************************************************************************/
00044
00045 double clim_hno3(
00046   double t,
00047   double lat,
00048   double p) {
00049
00050   static double secs[12] = { 1209600.00, 3888000.00, 6393600.00,
00051     9072000.00, 11664000.00, 14342400.00,
00052     16934400.00, 19612800.00, 22291200.00,
00053     24883200.00, 27561600.00, 30153600.00
00054   };
00055
00056   static double lats[18] = { -85, -75, -65, -55, -45, -35, -25, -15, -5,
00057     5, 15, 25, 35, 45, 55, 65, 75, 85
00058   };
00059
00060   static double ps[10] = { 4.64159, 6.81292, 10, 14.678, 21.5443,
00061     31.6228, 46.4159, 68.1292, 100, 146.78
00062   };
00063
00064   static double hno3[12][18][10] = {
00065     {{0.782, 1.65, 2.9, 4.59, 6.71, 8.25, 7.16, 5.75, 2.9, 1.74},
00066      {0.529, 1.64, 2.76, 4.55, 6.58, 8, 6.99, 5.55, 2.68, 1.57},
00067      {0.723, 1.55, 2.73, 4.48, 6.32, 7.58, 7.05, 5.16, 2.49, 1.54},
00068      {0.801, 1.56, 2.74, 4.52, 6.23, 7.35, 6.68, 4.4, 1.97, 1.23},
00069      {0.818, 1.62, 2.77, 4.38, 5.98, 6.84, 5.83, 3.05, 1.15, 0.709},
00070      {0.901, 1.73, 2.78, 4.21, 5.63, 6.16, 4.68, 1.87, 0.617, 0.37},
00071      {0.997, 1.8, 2.79, 4.09, 4.88, 4.96, 3.12, 1.22, 0.311, 0.244},
00072      {1, 1.71, 2.51, 3.4, 3.74, 3.39, 2.25, 0.845, 0.204, 0.222},
00073      {0.997, 1.7, 2.36, 2.88, 3.01, 2.25, 1.77, 0.608, 0.163, 0.181},
00074      {0.991, 1.79, 2.57, 3.06, 3.08, 2.15, 1.81, 0.59, 0.168, 0.104},
00075      {0.974, 1.86, 2.84, 3.8, 3.93, 3.79, 2.91, 1.02, 0.152, 0.0985},
00076      {0.85, 1.86, 3.3, 5.24, 6.55, 6.86, 5.12, 1.93, 0.378, 0.185},
00077      {0.783, 1.89, 3.85, 6.6, 8.56, 8.66, 6.95, 3.95, 1.47, 0.745},
00078      {0.883, 2.05, 4.34, 7.54, 9.68, 9.77, 8.19, 5.72, 3.15, 1.77},
00079      {1.4, 2.44, 4.72, 8.07, 10.5, 10.9, 9.28, 6.95, 4.47, 2.49},
00080      {1.7, 2.43, 4.24, 7.43, 10.4, 11.2, 9.72, 8.15, 5.7, 2.97},
00081      {2.06, 2.27, 3.68, 6.77, 10.3, 10.3, 9.05, 9.1, 6.73, 3.14},
00082      {2.33, 2.39, 3.51, 6.45, 10.3, 9.88, 8.57, 9.42, 7.22, 3.19}},
00083     {{0.947, 2.21, 3.81, 5.69, 7.55, 8.63, 7.53, 5.98, 3.03, 1.64},
00084      {0.642, 2, 3.4, 5.49, 7.5, 8.52, 7.53, 5.83, 2.74, 1.42},
00085      {0.756, 1.83, 3.18, 5.11, 7.24, 8.63, 7.66, 5.5, 2.45, 1.33},
00086      {0.837, 1.75, 3.06, 5, 6.79, 8.08, 7.05, 4.42, 1.81, 1.05},
00087      {0.86, 1.73, 2.96, 4.68, 6.38, 7.38, 6.09, 2.92, 1.06, 0.661},
00088      {0.926, 1.78, 2.89, 4.37, 5.74, 6.14, 4.59, 1.78, 0.561, 0.332},
00089      {0.988, 1.78, 2.75, 3.95, 4.64, 4.49, 2.85, 1.13, 0.271, 0.184},
00090      {0.999, 1.7, 2.44, 3.27, 3.57, 3.03, 2.06, 0.736, 0.181, 0.189},
00091      {0.971, 1.67, 2.23, 2.63, 2.83, 2.15, 1.74, 0.554, 0.157, 0.167},
00092      {0.985, 1.72, 2.34, 2.69, 2.81, 2.11, 1.78, 0.592, 0.152, 0.101},
00093      {0.95, 1.72, 2.57, 3.44, 3.84, 3.89, 2.91, 0.976, 0.135, 0.114},
00094      {0.819, 1.64, 2.93, 4.75, 6.02, 6.93, 5.2, 1.83, 0.347, 0.191},
00095      {0.731, 1.58, 3.3, 5.95, 7.81, 8.32, 6.93, 3.83, 1.47, 0.875},
00096      {0.77, 1.75, 3.74, 6.67, 8.76, 9.41, 8.19, 5.78, 3.32, 2.11},
00097      {1.08, 2.17, 4.24, 7.13, 9.2, 10.3, 9.03, 6.87, 4.65, 3.01},
00098      {1.43, 2.49, 4.31, 7, 9.14, 10.6, 9.34, 7.6, 5.86, 3.64},
00099      {1.5, 2.68, 4.32, 6.75, 8.78, 10.6, 9.05, 7.65, 6.27, 4.07},
00100      {1.73, 2.91, 4.33, 6.67, 8.73, 10.6, 8.5, 7.54, 6.63, 4.17}},
00101     {{1.43, 3.07, 5.22, 7.54, 9.78, 10.4, 10.1, 7.26, 3.61, 1.69},
00102      {0.989, 2.69, 4.76, 7.19, 9.44, 9.94, 9.5, 6.74, 3.24, 1.52},
```

```
00103       {0.908, 2.23, 4.11, 6.48, 8.74, 9.41, 8.58, 5.8, 2.66, 1.3},
00104       {0.923, 1.99, 3.61, 5.83, 7.84, 8.6, 7.55, 4.57, 1.87, 0.98},
00105       {0.933, 1.9, 3.31, 5.28, 7.1, 7.84, 6.44, 3.18, 1.1, 0.642},
00106       {0.982, 1.88, 3.1, 4.76, 6.16, 6.57, 5.16, 2.04, 0.598, 0.33},
00107       {1.02, 1.82, 2.88, 4.12, 4.71, 4.54, 3.03, 1.22, 0.268, 0.174},
00108       {0.992, 1.7, 2.51, 3.33, 3.62, 2.87, 2.05, 0.705, 0.161, 0.169},
00109       {0.969, 1.69, 2.2, 2.62, 2.84, 2.13, 1.78, 0.529, 0.146, 0.186},
00110       {0.945, 1.69, 2.27, 2.64, 2.83, 2.2, 1.83, 0.561, 0.139, 0.121},
00111       {0.922, 1.65, 2.48, 3.33, 3.83, 4.09, 2.92, 0.973, 0.117, 0.135},
00112       {0.886, 1.59, 2.66, 4.26, 5.51, 6.57, 5.09, 1.79, 0.342, 0.194},
00113       {0.786, 1.5, 2.78, 5.01, 6.8, 7.83, 6.65, 3.62, 1.45, 1},
00114       {0.745, 1.55, 3.05, 5.49, 7.44, 8.6, 7.8, 5.28, 2.95, 2.12},
00115       {0.938, 1.76, 3.4, 5.82, 7.8, 9.04, 8.43, 6.15, 3.85, 2.82},
00116       {0.999, 2, 3.66, 5.95, 7.94, 9.27, 8.8, 6.93, 4.87, 3.54},
00117       {1.13, 2.23, 3.86, 5.82, 7.65, 9, 8.82, 7.17, 5.72, 4.08},
00118       {1.23, 2.33, 3.94, 5.74, 7.48, 8.9, 8.84, 7.35, 6.3, 4.42}},
00119      {{1.55, 3.2, 6.25, 10, 12.9, 12.9, 11.9, 7.96, 3.96, 1.75},
00120       {1.32, 3.27, 6.32, 9.99, 12.7, 12.4, 11.3, 7.51, 3.66, 1.58},
00121       {1.25, 3.08, 5.77, 8.71, 11.2, 11.2, 9.84, 6.52, 3.23, 1.5},
00122       {1.18, 2.59, 4.76, 7.46, 9.61, 9.66, 8.42, 5.06, 2.25, 1.09},
00123       {1.09, 2.24, 3.99, 6.4, 8.33, 8.54, 7.08, 3.69, 1.36, 0.727},
00124       {1.06, 2.07, 3.52, 5.52, 7.06, 7.26, 5.83, 2.46, 0.732, 0.409},
00125       {1.07, 1.91, 3.09, 4.63, 5.21, 4.9, 3.68, 1.43, 0.326, 0.198},
00126       {1.03, 1.74, 2.63, 3.54, 3.78, 2.89, 2.09, 0.743, 0.175, 0.12},
00127       {0.959, 1.71, 2.32, 2.77, 2.99, 2.24, 1.76, 0.519, 0.149, 0.172},
00128       {0.931, 1.68, 2.32, 2.74, 2.99, 2.46, 1.88, 0.578, 0.156, 0.157},
00129       {0.933, 1.66, 2.49, 3.42, 3.99, 4.12, 2.93, 1.02, 0.181, 0.138},
00130       {0.952, 1.64, 2.6, 4, 5.15, 6.07, 4.84, 1.78, 0.407, 0.286},
00131       {0.84, 1.54, 2.68, 4.47, 5.97, 7.13, 6.23, 3.25, 1.38, 1.02},
00132       {0.714, 1.44, 2.73, 4.68, 6.28, 7.68, 7.21, 4.82, 2.55, 1.96},
00133       {0.838, 1.57, 2.96, 4.93, 6.55, 8.08, 7.74, 5.77, 3.32, 2.52},
00134       {0.823, 1.65, 3.11, 5.09, 6.89, 8.36, 8.31, 6.59, 4.1, 3.04},
00135       {0.886, 1.83, 3.42, 5.33, 6.92, 8.36, 8.63, 7.21, 4.82, 3.46},
00136       {1.07, 2.12, 3.74, 5.54, 6.98, 8.41, 8.75, 7.41, 5.16, 3.62}},
00137      {{1.13, 2.59, 7.49, 13.5, 15.4, 12.9, 11.3, 8.62, 4.18, 1.63},
00138       {0.973, 2.79, 7.23, 12.8, 15.2, 13.3, 11.6, 8.42, 4.06, 1.57},
00139       {1.46, 3.44, 6.78, 10.4, 12.7, 12.1, 10.5, 7.04, 3.59, 1.63},
00140       {1.52, 3.38, 6.04, 9.08, 11, 10.3, 8.9, 5.7, 2.77, 1.37},
00141       {1.32, 2.65, 4.75, 7.49, 9.32, 8.89, 7.42, 4.27, 1.7, 0.88},
00142       {1.19, 2.2, 3.88, 6.36, 8.03, 7.81, 6.19, 2.94, 0.948, 0.527},
00143       {1.14, 1.96, 3.28, 5.26, 6.12, 5.8, 4.47, 1.66, 0.388, 0.229},
00144       {1.07, 1.82, 2.82, 3.92, 4.03, 3.15, 2.31, 0.871, 0.183, 0.0972},
00145       {0.978, 1.77, 2.53, 3.04, 3.1, 2.36, 1.76, 0.575, 0.16, 0.126},
00146       {0.962, 1.72, 2.49, 3.01, 3.22, 2.72, 2, 0.716, 0.162, 0.183},
00147       {0.968, 1.7, 2.6, 3.57, 4.28, 4.35, 3.09, 1.2, 0.262, 0.18},
00148       {0.977, 1.68, 2.71, 4.03, 5.17, 6.01, 4.81, 1.81, 0.473, 0.343},
00149       {0.819, 1.58, 2.75, 4.37, 5.8, 6.9, 5.96, 2.95, 1.19, 0.964},
00150       {0.672, 1.44, 2.69, 4.42, 5.92, 7.26, 6.79, 4.32, 2.22, 1.83},
00151       {0.783, 1.42, 2.65, 4.45, 6.04, 7.57, 7.39, 5.4, 2.94, 2.25},
00152       {0.757, 1.43, 2.7, 4.54, 6.14, 7.65, 7.51, 5.95, 3.42, 2.39},
00153       {0.758, 1.57, 3.04, 4.88, 6.24, 7.85, 7.58, 6.35, 3.81, 2.52},
00154       {0.835, 1.72, 3.35, 5.24, 6.5, 8.1, 7.67, 6.51, 4, 2.6}},
00155      {{1.5, 2.12, 7.64, 10.5, 5.59, 2.14, 2.2, 3.5, 4.71, 3.26},
00156       {1.32, 2.14, 7.23, 12, 9.3, 5.3, 5.11, 5.37, 5.12, 3.05},
00157       {1.53, 2.92, 6.9, 11.9, 13.5, 11.3, 9.91, 7.18, 4.75, 2.65},
00158       {1.66, 3.48, 6.25, 9.53, 11.3, 10.3, 9.01, 5.76, 2.99, 1.67},
00159       {1.54, 3.03, 5.21, 8.03, 9.66, 8.98, 7.5, 4.64, 2.11, 1.13},
00160       {1.32, 2.39, 4.03, 6.74, 8.52, 8.05, 6.4, 3.48, 1.2, 0.639},
00161       {1.17, 2.08, 3.35, 5.52, 6.86, 6.54, 5.08, 1.97, 0.462, 0.217},
00162       {1.07, 1.92, 3.01, 4.24, 4.47, 3.77, 2.77, 1.07, 0.213, 0.0694},
00163       {0.992, 1.88, 2.76, 3.39, 3.32, 2.52, 1.8, 0.713, 0.192, 0.136},
00164       {0.992, 1.8, 2.63, 3.34, 3.46, 2.95, 2.09, 0.9, 0.242, 0.194},
00165       {0.987, 1.77, 2.67, 3.64, 4.37, 4.36, 3, 1.27, 0.354, 0.229},
00166       {0.979, 1.74, 2.77, 3.99, 5.12, 5.75, 4.53, 1.75, 0.555, 0.302},
00167       {0.832, 1.6, 2.78, 4.32, 5.53, 6.67, 5.69, 2.59, 0.982, 0.66},
00168       {0.696, 1.41, 2.64, 4.31, 5.65, 7.14, 6.56, 3.8, 1.75, 1.41},
00169       {0.788, 1.36, 2.59, 4.3, 5.73, 7.35, 7.04, 4.82, 2.41, 1.8},
00170       {0.761, 1.43, 2.61, 4.28, 5.64, 7.37, 7.11, 5.37, 2.68, 1.9},
00171       {0.701, 1.44, 2.82, 4.64, 5.76, 7.63, 7.07, 5.74, 2.98, 1.88},
00172       {0.763, 1.5, 2.95, 4.97, 6.08, 7.88, 7.12, 5.98, 3.21, 1.91}},
00173      {{3.58, 2.59, 6.49, 5.84, 1.63, 0.282, 0.647, 0.371, 1.36, 2.33},
00174       {3.09, 2.38, 6.37, 7.66, 4.06, 1.23, 1.8, 1.65, 2.32, 2.78},
00175       {2.31, 2.84, 5.58, 9.63, 11, 9.02, 8.2, 6.23, 4.17, 3.08},
00176       {1.61, 3.16, 5.72, 9.13, 11.4, 10.4, 9.15, 6.18, 3.52, 2.3},
00177       {1.32, 2.8, 4.79, 7.44, 9.43, 8.83, 7.41, 4.9, 2.38, 1.38},
00178       {1.14, 2.36, 3.94, 6.41, 8.38, 8.17, 6.53, 3.76, 1.31, 0.656},
00179       {1.05, 2.1, 3.36, 5.45, 7.07, 6.98, 5.44, 2.22, 0.52, 0.176},
00180       {1.02, 2, 3.05, 4.33, 4.74, 4.21, 3.2, 1.26, 0.277, 0.0705},
00181       {1.01, 1.96, 2.9, 3.53, 3.46, 2.69, 1.89, 0.859, 0.254, 0.12},
00182       {1.01, 1.86, 2.7, 3.46, 3.59, 3.03, 2.14, 1, 0.34, 0.199},
00183       {1.02, 1.81, 2.67, 3.68, 4.39, 4.3, 2.93, 1.35, 0.477, 0.25},
00184       {0.991, 1.79, 2.82, 4.05, 5.08, 5.5, 4.21, 1.74, 0.605, 0.259},
00185       {0.844, 1.73, 2.87, 4.38, 5.49, 6.47, 5.5, 2.44, 0.85, 0.422},
00186       {0.729, 1.57, 2.76, 4.43, 5.73, 7.13, 6.43, 3.52, 1.38, 0.913},
00187       {0.819, 1.46, 2.69, 4.45, 5.92, 7.47, 7.05, 4.52, 2, 1.4},
00188       {0.783, 1.47, 2.71, 4.48, 5.92, 7.46, 7.16, 5.08, 2.35, 1.56},
00189       {0.735, 1.51, 2.96, 4.84, 5.92, 7.77, 7.2, 5.54, 2.56, 1.61},
```

```
00190      {0.8, 1.61, 3.14, 5.2, 6.26, 8.08, 7.27, 5.72, 2.75, 1.62}},
00191     {{5, 4.43, 5.53, 5.35, 2.33, 0.384, 0.663, 0.164, 0.692, 1.4},
00192      {3.62, 3.79, 4.77, 5.94, 4.12, 1.36, 1.3, 0.973, 1.37, 1.73},
00193      {2.11, 2.7, 4.12, 7.14, 9.03, 7.74, 7.12, 5.44, 3.73, 2.6},
00194      {1.13, 2.32, 4.12, 6.97, 9.86, 9.69, 8.85, 6.22, 3.59, 2.14},
00195      {0.957, 2.28, 4.11, 6.47, 8.66, 8.78, 7.33, 4.94, 2.44, 1.38},
00196      {0.881, 2.1, 3.65, 5.94, 7.98, 8.29, 6.69, 3.95, 1.36, 0.672},
00197      {0.867, 1.96, 3.26, 5.23, 6.94, 7.2, 5.63, 2.41, 0.578, 0.19},
00198      {0.953, 1.94, 2.98, 4.23, 4.83, 4.52, 3.38, 1.34, 0.293, 0.181},
00199      {1.01, 1.91, 2.77, 3.35, 3.3, 2.62, 1.99, 0.905, 0.245, 0.107},
00200      {1.03, 1.81, 2.57, 3.29, 3.43, 2.87, 2.13, 0.988, 0.306, 0.185},
00201      {1.02, 1.78, 2.58, 3.59, 4.19, 4, 2.72, 1.29, 0.389, 0.224},
00202      {1.01, 1.84, 2.84, 4.06, 4.9, 5.08, 3.71, 1.64, 0.529, 0.232},
00203      {0.902, 1.84, 2.98, 4.43, 5.5, 6.28, 5.18, 2.35, 0.734, 0.341},
00204      {0.785, 1.68, 2.93, 4.67, 5.95, 7.3, 6.52, 3.48, 1.24, 0.754},
00205      {0.847, 1.62, 2.94, 4.86, 6.38, 7.99, 7.5, 4.64, 1.93, 1.23},
00206      {0.8, 1.6, 2.94, 4.95, 6.62, 8.16, 7.91, 5.43, 2.43, 1.45},
00207      {0.82, 1.76, 3.37, 5.47, 6.82, 8.24, 7.73, 5.79, 2.69, 1.5},
00208      {0.988, 2.05, 3.87, 6.01, 7.18, 8.41, 7.7, 5.93, 2.89, 1.55}},
00209     {{1.52, 2.7, 3.79, 4.95, 3.8, 1.51, 1.11, 0.784, 1.1, 1.56},
00210      {1.19, 2.16, 3.34, 4.76, 4.61, 2.93, 2.07, 1.65, 1.63, 1.74},
00211      {0.804, 1.65, 2.79, 4.63, 6.64, 6.95, 6.68, 5.11, 3.3, 2.09},
00212      {0.86, 1.8, 3.25, 5.3, 7.91, 8.76, 8.28, 6.01, 3.39, 1.83},
00213      {0.859, 1.95, 3.54, 5.64, 7.88, 8.55, 7.3, 4.88, 2.3, 1.22},
00214      {0.809, 1.88, 3.38, 5.45, 7.47, 8.02, 6.69, 3.98, 1.35, 0.646},
00215      {0.822, 1.81, 3.11, 4.9, 6.62, 6.96, 5.63, 2.47, 0.614, 0.169},
00216      {0.92, 1.83, 2.8, 3.93, 4.56, 4.4, 3.25, 1.31, 0.295, 0.0587},
00217      {0.986, 1.83, 2.6, 3.13, 3.08, 2.53, 1.94, 0.886, 0.244, 0.0815},
00218      {0.997, 1.74, 2.5, 3.16, 3.24, 2.67, 2.05, 0.939, 0.281, 0.147},
00219      {1.01, 1.75, 2.57, 3.55, 4.1, 3.81, 2.53, 1.21, 0.354, 0.197},
00220      {1.04, 1.88, 2.9, 4.16, 4.95, 4.96, 3.48, 1.63, 0.502, 0.163},
00221      {0.967, 1.95, 3.17, 4.72, 5.85, 6.5, 5.34, 2.53, 0.748, 0.303},
00222      {0.846, 1.83, 3.23, 5.15, 6.62, 7.82, 6.85, 3.79, 1.36, 0.714},
00223      {0.91, 1.81, 3.35, 5.55, 7.32, 8.55, 7.88, 5.03, 2.13, 1.1},
00224      {0.87, 1.94, 3.6, 5.97, 7.98, 9.14, 8.71, 6.04, 2.73, 1.41},
00225      {1.04, 2.36, 4.22, 6.57, 8.5, 9.53, 9.22, 6.71, 3.2, 1.56},
00226      {1.36, 2.84, 4.72, 6.94, 8.81, 9.87, 9.59, 7.1, 3.43, 1.65}},
00227     {{0.704, 1.4, 2.03, 3.08, 4.64, 4.24, 2.55, 1.57, 1.99, 1.91},
00228      {0.484, 1.38, 2.08, 3.54, 5.11, 4.98, 3.73, 2.57, 2.29, 1.84},
00229      {0.749, 1.57, 2.63, 4.17, 6.15, 6.97, 6.64, 5.11, 3.35, 1.97},
00230      {0.864, 1.69, 3.16, 4.87, 7.13, 8.33, 7.87, 5.9, 3.17, 1.56},
00231      {0.861, 1.79, 3.28, 5.2, 7.29, 8.32, 7.38, 4.9, 2.23, 1.11},
00232      {0.835, 1.79, 3.19, 4.99, 6.72, 7.58, 6.45, 3.68, 1.25, 0.616},
00233      {0.847, 1.8, 3.07, 4.66, 6.12, 6.6, 5.21, 2.18, 0.554, 0.21},
00234      {0.941, 1.78, 2.68, 3.68, 4.28, 4.18, 2.97, 1.15, 0.238, 0.0968},
00235      {0.98, 1.78, 2.48, 2.99, 2.96, 2.35, 1.88, 0.747, 0.207, 0.105},
00236      {0.978, 1.74, 2.51, 3.07, 3.12, 2.36, 1.95, 0.777, 0.216, 0.146},
00237      {1.01, 1.79, 2.63, 3.53, 3.95, 3.47, 2.38, 1.08, 0.265, 0.178},
00238      {1.06, 1.94, 3.02, 4.43, 5.19, 5.01, 3.68, 1.71, 0.429, 0.14},
00239      {0.99, 2.02, 3.38, 5.22, 6.56, 6.91, 5.56, 2.75, 0.816, 0.353},
00240      {0.923, 2.05, 3.66, 5.98, 7.78, 8.5, 7.23, 4.26, 1.67, 0.802},
00241      {1.08, 2.27, 4.17, 6.8, 8.89, 9.55, 8.59, 5.64, 2.58, 1.2},
00242      {1.12, 2.5, 4.52, 7.22, 9.76, 10.3, 9.72, 6.79, 3.32, 1.52},
00243      {1.2, 2.64, 4.81, 7.64, 10.5, 11.4, 10.6, 7.65, 3.87, 1.73},
00244      {1.4, 2.91, 5.01, 7.75, 10.7, 11.6, 11.1, 8.02, 4.04, 1.8}},
00245     {{0.75, 1.49, 2.39, 3.39, 4.93, 5.94, 5.03, 2.75, 2.27, 1.78},
00246      {0.508, 1.52, 2.38, 3.82, 5.34, 6.13, 5.6, 3.31, 2.42, 1.73},
00247      {0.715, 1.56, 2.7, 4.39, 6.18, 6.96, 7.1, 5.04, 3.01, 1.75},
00248      {0.813, 1.62, 2.94, 4.65, 6.53, 7.65, 7.52, 5.49, 2.75, 1.41},
00249      {0.802, 1.68, 2.97, 4.64, 6.37, 7.53, 7.01, 4.56, 1.9, 0.955},
00250      {0.816, 1.75, 3.01, 4.59, 6.15, 7.06, 6.15, 3.38, 1.11, 0.61},
00251      {0.867, 1.78, 2.92, 4.35, 5.69, 6.05, 4.73, 1.91, 0.519, 0.269},
00252      {0.932, 1.7, 2.55, 3.44, 4.03, 3.98, 2.74, 1.08, 0.247, 0.132},
00253      {0.937, 1.74, 2.51, 3.09, 3.11, 2.34, 1.84, 0.67, 0.189, 0.121},
00254      {0.942, 1.75, 2.63, 3.3, 3.27, 2.21, 1.87, 0.663, 0.171, 0.147},
00255      {0.959, 1.8, 2.82, 3.78, 4.03, 3.37, 2.53, 1.04, 0.199, 0.146},
00256      {1.01, 1.9, 3.13, 4.76, 5.63, 5.6, 4.31, 1.83, 0.367, 0.172},
00257      {0.989, 2.04, 3.64, 6, 7.62, 7.6, 6, 3.35, 1.05, 0.448},
00258      {1.02, 2.28, 4.32, 7.19, 9.21, 9.16, 7.64, 4.97, 2.2, 0.948},
00259      {1.26, 2.77, 5.2, 8.31, 10.5, 10.4, 9.01, 6.37, 3.46, 1.56},
00260      {1.31, 2.76, 5.23, 8.49, 11.2, 11.3, 10.1, 7.27, 3.98, 1.76},
00261      {1.26, 2.5, 5.14, 8.85, 12.3, 12.3, 11.2, 8.13, 4.45, 1.97},
00262      {1.35, 2.49, 5.26, 9.16, 13, 12.8, 11.8, 8.57, 4.72, 2.05}},
00263     {{0.759, 1.54, 2.54, 4.22, 6.26, 7.44, 7.14, 4.99, 2.84, 1.89},
00264      {0.508, 1.55, 2.5, 4.29, 6.29, 7.29, 7.07, 5.03, 2.77, 1.74},
00265      {0.699, 1.56, 2.62, 4.17, 6.08, 7.38, 7.04, 5.17, 2.81, 1.65},
00266      {0.778, 1.5, 2.65, 4.35, 6.07, 7.28, 6.84, 4.8, 2.28, 1.28},
00267      {0.772, 1.55, 2.71, 4.3, 5.76, 6.91, 6.2, 3.69, 1.45, 0.837},
00268      {0.836, 1.67, 2.78, 4.21, 5.56, 6.41, 5.33, 2.47, 0.807, 0.488},
00269      {0.937, 1.79, 2.78, 4.12, 5.17, 5.38, 3.89, 1.47, 0.392, 0.256},
00270      {0.97, 1.75, 2.52, 3.39, 3.83, 3.63, 2.48, 0.968, 0.212, 0.198},
00271      {0.968, 1.74, 2.5, 3.11, 3.2, 2.34, 1.79, 0.629, 0.169, 0.173},
00272      {0.98, 1.8, 2.69, 3.42, 3.4, 2.18, 1.81, 0.606, 0.164, 0.138},
00273      {0.975, 1.84, 2.96, 4.08, 4.12, 3.5, 2.79, 1.02, 0.145, 0.133},
00274      {0.96, 1.94, 3.27, 5.17, 6.26, 6.35, 4.88, 1.91, 0.329, 0.189},
00275      {0.954, 2.06, 3.8, 6.53, 8.46, 8.32, 6.53, 3.83, 1.32, 0.6},
00276      {1, 2.34, 4.58, 7.71, 9.68, 9.75, 7.96, 5.45, 2.84, 1.39},
```

```
00277       {1.24, 2.65, 5.14, 8.51, 10.7, 10.6, 8.96, 6.51, 3.83, 1.85},
00278       {1.34, 2.44, 4.99, 8.63, 11.6, 11.4, 10.1, 7.84, 4.77, 2.24},
00279       {1.33, 2.1, 4.76, 8.78, 12.2, 11.7, 10.8, 8.68, 5.15, 2.35},
00280       {1.42, 2.04, 4.68, 8.92, 12.7, 12, 11.2, 8.99, 5.32, 2.33}}
00281    };
00282
00283    double aux00, aux01, aux10, aux11, sec;
00284
00285    int ilat, ip, isec;
00286
00287    /* Get seconds since begin of year... */
00288    sec = fmod(t, 365.25 * 86400.);
00289
00290    /* Get indices... */
00291    ilat = locate(lats, 18, lat);
00292    ip = locate(ps, 10, p);
00293    isec = locate(secs, 12, sec);
00294
00295    /* Interpolate... */
00296    aux00 = LIN(ps[ip], hno3[isec][ilat][ip],
00297                ps[ip + 1], hno3[isec][ilat][ip + 1], p);
00298    aux01 = LIN(ps[ip], hno3[isec][ilat + 1][ip],
00299                ps[ip + 1], hno3[isec][ilat + 1][ip + 1], p);
00300    aux10 = LIN(ps[ip], hno3[isec + 1][ilat][ip],
00301                ps[ip + 1], hno3[isec + 1][ilat][ip + 1], p);
00302    aux11 = LIN(ps[ip], hno3[isec + 1][ilat + 1][ip],
00303                ps[ip + 1], hno3[isec + 1][ilat + 1][ip + 1], p);
00304    aux00 = LIN(lats[ilat], aux00, lats[ilat + 1], aux01, lat);
00305    aux11 = LIN(lats[ilat], aux10, lats[ilat + 1], aux11, lat);
00306    return LIN(secs[isec], aux00, secs[isec + 1], aux11, sec);
00307 }
00308
00309 /*****************************************************************************/
00310
00311 double clim_tropo(
00312    double t,
00313    double lat) {
00314
00315    static double doys[12]
00316    = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00317
00318    static double lats[73]
00319      = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
00320      -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
00321      -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
00322      -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
00323      15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
00324      45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
00325      75, 77.5, 80, 82.5, 85, 87.5, 90
00326    };
00327
00328    static double tps[12][73]
00329      = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
00330           297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
00331           175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
00332           99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
00333           98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
00334           152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
00335           277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
00336           275.3, 275.6, 275.4, 274.1, 273.5},
00337    {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
00338     300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
00339     150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
00340     98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
00341     98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
00342     220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
00343     284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
00344     287.5, 286.2, 285.8},
00345    {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
00346     297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
00347     161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
00348     100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
00349     99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
00350     186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
00351     279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
00352     304.3, 304.9, 306, 306.6, 306.2, 306},
00353    {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
00354     290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
00355     195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
00356     102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
00357     99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
00358     148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
00359     263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
00360     315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
00361    {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
00362     260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
00363     205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
```

```
00364    101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
00365    102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
00366    165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
00367    273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
00368    325.3, 325.8, 325.8},
00369   {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
00370    222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
00371    228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
00372    105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
00373    106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
00374    127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
00375    251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
00376    308.5, 312.2, 313.1, 313.3},
00377   {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
00378    187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
00379    235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
00380    110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
00381    111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
00382    117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
00383    224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
00384    275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
00385   {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
00386    185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
00387    233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
00388    110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
00389    112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
00390    120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
00391    230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
00392    278.2, 282.6, 287.4, 290.9, 292.5, 293},
00393   {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
00394    183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
00395    243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
00396    114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
00397    110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
00398    114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
00399    203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
00400    276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
00401   {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
00402    215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
00403    237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
00404    111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
00405    106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
00406    112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
00407    206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
00408    279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
00409    305.1},
00410   {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
00411    253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
00412    223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
00413    108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
00414    102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
00415    109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
00416    241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
00417    286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
00418   {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
00419    284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
00420    175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
00421    100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
00422    100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
00423    186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
00424    280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
00425    281.7, 281.1, 281.2}
00426   };
00427
00428   double doy, p0, p1, pt;
00429
00430   int imon, ilat;
00431
00432   /* Get day of year... */
00433   doy = fmod(t / 86400., 365.25);
00434   while (doy < 0)
00435     doy += 365.25;
00436
00437   /* Get indices... */
00438   imon = locate(doys, 12, doy);
00439   ilat = locate(lats, 73, lat);
00440
00441   /* Get tropopause pressure... */
00442   p0 = LIN(lats[ilat], tps[imon][ilat],
00443            lats[ilat + 1], tps[imon][ilat + 1], lat);
00444   p1 = LIN(lats[ilat], tps[imon + 1][ilat],
00445            lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
00446   pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
00447
00448   /* Return tropopause pressure... */
00449   return pt;
00450 }
```

```
00451
00452 /*****************************************************************************/
00453
00454 void day2doy(
00455   int year,
00456   int mon,
00457   int day,
00458   int *doy) {
00459
00460   int d0[12] = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00461   int d0l[12] = { 1, 32, 61, 92, 122, 153, 183, 214, 245, 275, 306, 336 };
00462
00463   /* Get day of year... */
00464   if (year % 400 == 0 || (year % 100 != 0 && year % 4 == 0))
00465     *doy = d0l[mon - 1] + day - 1;
00466   else
00467     *doy = d0[mon - 1] + day - 1;
00468 }
00469
00470 /*****************************************************************************/
00471
00472 void doy2day(
00473   int year,
00474   int doy,
00475   int *mon,
00476   int *day) {
00477
00478   int d0[12] = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00479   int d0l[12] = { 1, 32, 61, 92, 122, 153, 183, 214, 245, 275, 306, 336 };
00480   int i;
00481
00482   /* Get month and day... */
00483   if (year % 400 == 0 || (year % 100 != 0 && year % 4 == 0)) {
00484     for (i = 11; i >= 0; i--)
00485       if (d0l[i] <= doy)
00486         break;
00487     *mon = i + 1;
00488     *day = doy - d0l[i] + 1;
00489   } else {
00490     for (i = 11; i >= 0; i--)
00491       if (d0[i] <= doy)
00492         break;
00493     *mon = i + 1;
00494     *day = doy - d0[i] + 1;
00495   }
00496 }
00497
00498 /*****************************************************************************/
00499
00500 double deg2dx(
00501   double dlon,
00502   double lat) {
00503
00504   return dlon * M_PI * RE / 180. * cos(lat / 180. * M_PI);
00505 }
00506
00507 /*****************************************************************************/
00508
00509 double deg2dy(
00510   double dlat) {
00511
00512   return dlat * M_PI * RE / 180.;
00513 }
00514
00515 /*****************************************************************************/
00516
00517 double dp2dz(
00518   double dp,
00519   double p) {
00520
00521   return -dp * H0 / p;
00522 }
00523
00524 /*****************************************************************************/
00525
00526 double dx2deg(
00527   double dx,
00528   double lat) {
00529
00530   /* Avoid singularity at poles... */
00531   if (lat < -89.999 || lat > 89.999)
00532     return 0;
00533   else
00534     return dx * 180. / (M_PI * RE * cos(lat / 180. * M_PI));
00535 }
00536
00537 /*****************************************************************************/
```

```
00538
00539 double dy2deg(
00540   double dy) {
00541
00542   return dy * 180. / (M_PI * RE);
00543 }
00544
00545 /*****************************************************************************/
00546
00547 double dz2dp(
00548   double dz,
00549   double p) {
00550
00551   return -dz * p / H0;
00552 }
00553
00554 /*****************************************************************************/
00555
00556 void geo2cart(
00557   double z,
00558   double lon,
00559   double lat,
00560   double *x) {
00561
00562   double radius;
00563
00564   radius = z + RE;
00565   x[0] = radius * cos(lat / 180 * M_PI) * cos(lon / 180 * M_PI);
00566   x[1] = radius * cos(lat / 180 * M_PI) * sin(lon / 180 * M_PI);
00567   x[2] = radius * sin(lat / 180 * M_PI);
00568 }
00569
00570 /*****************************************************************************/
00571
00572 void get_met(
00573   ctl_t * ctl,
00574   char *metbase,
00575   double t,
00576   met_t * met0,
00577   met_t * met1) {
00578
00579   static int init;
00580
00581   char filename[LEN];
00582
00583   /* Init... */
00584   if (t == ctl->t_start || !init) {
00585     init = 1;
00586
00587     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00588     read_met(ctl, filename, met0);
00589
00590     get_met_help(t + 1.0 * ctl->direction, 1, metbase, ctl->
      dt_met, filename);
00591     read_met(ctl, filename, met1);
00592   }
00593
00594   /* Read new data for forward trajectories... */
00595   if (t > met1->time && ctl->direction == 1) {
00596     memcpy(met0, met1, sizeof(met_t));
00597     get_met_help(t, 1, metbase, ctl->dt_met, filename);
00598     read_met(ctl, filename, met1);
00599   }
00600
00601   /* Read new data for backward trajectories... */
00602   if (t < met0->time && ctl->direction == -1) {
00603     memcpy(met1, met0, sizeof(met_t));
00604     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00605     read_met(ctl, filename, met0);
00606   }
00607 }
00608
00609 /*****************************************************************************/
00610
00611 void get_met_help(
00612   double t,
00613   int direct,
00614   char *metbase,
00615   double dt_met,
00616   char *filename) {
00617
00618   double t6, r;
00619
00620   int year, mon, day, hour, min, sec;
00621
00622   /* Round time to fixed intervals... */
00623   if (direct == -1)
```

```
00624     t6 = floor(t / dt_met) * dt_met;
00625   else
00626     t6 = ceil(t / dt_met) * dt_met;
00627
00628   /* Decode time... */
00629   jsec2time(t6, &year, &mon, &day, &hour, &min, &sec, &r);
00630
00631   /* Set filename... */
00632   sprintf(filename, "%s_%d_%02d_%02d_%02d.nc", metbase, year, mon, day, hour);
00633 }
00634
00635 /*****************************************************************************/
00636
00637 void intpol_met_2d(
00638   double array[EX][EY],
00639   int ix,
00640   int iy,
00641   double wx,
00642   double wy,
00643   double *var) {
00644
00645   double aux00, aux01, aux10, aux11;
00646
00647   /* Set variables... */
00648   aux00 = array[ix][iy];
00649   aux01 = array[ix][iy + 1];
00650   aux10 = array[ix + 1][iy];
00651   aux11 = array[ix + 1][iy + 1];
00652
00653   /* Interpolate horizontally... */
00654   aux00 = wy * (aux00 - aux01) + aux01;
00655   aux11 = wy * (aux10 - aux11) + aux11;
00656   *var = wx * (aux00 - aux11) + aux11;
00657 }
00658
00659 /*****************************************************************************/
00660
00661 void intpol_met_3d(
00662   float array[EX][EY][EP],
00663   int ip,
00664   int ix,
00665   int iy,
00666   double wp,
00667   double wx,
00668   double wy,
00669   double *var) {
00670
00671   double aux00, aux01, aux10, aux11;
00672
00673   /* Interpolate vertically... */
00674   aux00 = wp * (array[ix][iy][ip] - array[ix][iy][ip + 1])
00675     + array[ix][iy][ip + 1];
00676   aux01 = wp * (array[ix][iy + 1][ip] - array[ix][iy + 1][ip + 1])
00677     + array[ix][iy + 1][ip + 1];
00678   aux10 = wp * (array[ix + 1][iy][ip] - array[ix + 1][iy][ip + 1])
00679     + array[ix + 1][iy][ip + 1];
00680   aux11 = wp * (array[ix + 1][iy + 1][ip] - array[ix + 1][iy + 1][ip + 1])
00681     + array[ix + 1][iy + 1][ip + 1];
00682
00683   /* Interpolate horizontally... */
00684   aux00 = wy * (aux00 - aux01) + aux01;
00685   aux11 = wy * (aux10 - aux11) + aux11;
00686   *var = wx * (aux00 - aux11) + aux11;
00687 }
00688
00689 /*****************************************************************************/
00690
00691 void intpol_met_space(
00692   met_t * met,
00693   double p,
00694   double lon,
00695   double lat,
00696   double *ps,
00697   double *pt,
00698   double *z,
00699   double *t,
00700   double *u,
00701   double *v,
00702   double *w,
00703   double *pv,
00704   double *h2o,
00705   double *o3) {
00706
00707   double wp, wx, wy;
00708
00709   int ip, ix, iy;
00710
```

```
00711   /* Check longitude... */
00712   if (met->lon[met->nx - 1] > 180 && lon < 0)
00713     lon += 360;
00714
00715   /* Get indices... */
00716   ip = locate(met->p, met->np, p);
00717   ix = locate(met->lon, met->nx, lon);
00718   iy = locate(met->lat, met->ny, lat);
00719
00720   /* Get weights... */
00721   wp = (met->p[ip + 1] - p) / (met->p[ip + 1] - met->p[ip]);
00722   wx = (met->lon[ix + 1] - lon) / (met->lon[ix + 1] - met->lon[ix]);
00723   wy = (met->lat[iy + 1] - lat) / (met->lat[iy + 1] - met->lat[iy]);
00724
00725   /* Interpolate... */
00726   if (ps != NULL)
00727     intpol_met_2d(met->ps, ix, iy, wx, wy, ps);
00728   if (pt != NULL)
00729     intpol_met_2d(met->pt, ix, iy, wx, wy, pt);
00730   if (z != NULL)
00731     intpol_met_3d(met->z, ip, ix, iy, wp, wx, wy, z);
00732   if (t != NULL)
00733     intpol_met_3d(met->t, ip, ix, iy, wp, wx, wy, t);
00734   if (u != NULL)
00735     intpol_met_3d(met->u, ip, ix, iy, wp, wx, wy, u);
00736   if (v != NULL)
00737     intpol_met_3d(met->v, ip, ix, iy, wp, wx, wy, v);
00738   if (w != NULL)
00739     intpol_met_3d(met->w, ip, ix, iy, wp, wx, wy, w);
00740   if (pv != NULL)
00741     intpol_met_3d(met->pv, ip, ix, iy, wp, wx, wy, pv);
00742   if (h2o != NULL)
00743     intpol_met_3d(met->h2o, ip, ix, iy, wp, wx, wy, h2o);
00744   if (o3 != NULL)
00745     intpol_met_3d(met->o3, ip, ix, iy, wp, wx, wy, o3);
00746 }
00747
00748 /*****************************************************************************/
00749
00750 void intpol_met_time(
00751   met_t * met0,
00752   met_t * met1,
00753   double ts,
00754   double p,
00755   double lon,
00756   double lat,
00757   double *ps,
00758   double *pt,
00759   double *z,
00760   double *t,
00761   double *u,
00762   double *v,
00763   double *w,
00764   double *pv,
00765   double *h2o,
00766   double *o3) {
00767
00768   double h2o0, h2o1, o30, o31, ps0, ps1, pt0, pt1, pv0, pv1, t0, t1, u0, u1,
00769     v0, v1, w0, w1, wt, z0, z1;
00770
00771   /* Spatial interpolation... */
00772   intpol_met_space(met0, p, lon, lat,
00773                    ps == NULL ? NULL : &ps0,
00774                    pt == NULL ? NULL : &pt0,
00775                    z == NULL ? NULL : &z0,
00776                    t == NULL ? NULL : &t0,
00777                    u == NULL ? NULL : &u0,
00778                    v == NULL ? NULL : &v0,
00779                    w == NULL ? NULL : &w0,
00780                    pv == NULL ? NULL : &pv0,
00781                    h2o == NULL ? NULL : &h2o0, o3 == NULL ? NULL : &o30);
00782   intpol_met_space(met1, p, lon, lat,
00783                    ps == NULL ? NULL : &ps1,
00784                    pt == NULL ? NULL : &pt1,
00785                    z == NULL ? NULL : &z1,
00786                    t == NULL ? NULL : &t1,
00787                    u == NULL ? NULL : &u1,
00788                    v == NULL ? NULL : &v1,
00789                    w == NULL ? NULL : &w1,
00790                    pv == NULL ? NULL : &pv1,
00791                    h2o == NULL ? NULL : &h2o1, o3 == NULL ? NULL : &o31);
00792
00793   /* Get weighting factor... */
00794   wt = (met1->time - ts) / (met1->time - met0->time);
00795
00796   /* Interpolate... */
00797   if (ps != NULL)
```

```
00798     *ps = wt * (ps0 - ps1) + ps1;
00799   if (pt != NULL)
00800     *pt = wt * (pt0 - pt1) + pt1;
00801   if (z != NULL)
00802     *z = wt * (z0 - z1) + z1;
00803   if (t != NULL)
00804     *t = wt * (t0 - t1) + t1;
00805   if (u != NULL)
00806     *u = wt * (u0 - u1) + u1;
00807   if (v != NULL)
00808     *v = wt * (v0 - v1) + v1;
00809   if (w != NULL)
00810     *w = wt * (w0 - w1) + w1;
00811   if (pv != NULL)
00812     *pv = wt * (pv0 - pv1) + pv1;
00813   if (h2o != NULL)
00814     *h2o = wt * (h2o0 - h2o1) + h2o1;
00815   if (o3 != NULL)
00816     *o3 = wt * (o30 - o31) + o31;
00817 }
00818
00819 /*****************************************************************************/
00820
00821 void jsec2time(
00822   double jsec,
00823   int *year,
00824   int *mon,
00825   int *day,
00826   int *hour,
00827   int *min,
00828   int *sec,
00829   double *remain) {
00830
00831   struct tm t0, *t1;
00832
00833   time_t jsec0;
00834
00835   t0.tm_year = 100;
00836   t0.tm_mon = 0;
00837   t0.tm_mday = 1;
00838   t0.tm_hour = 0;
00839   t0.tm_min = 0;
00840   t0.tm_sec = 0;
00841
00842   jsec0 = (time_t) jsec + timegm(&t0);
00843   t1 = gmtime(&jsec0);
00844
00845   *year = t1->tm_year + 1900;
00846   *mon = t1->tm_mon + 1;
00847   *day = t1->tm_mday;
00848   *hour = t1->tm_hour;
00849   *min = t1->tm_min;
00850   *sec = t1->tm_sec;
00851   *remain = jsec - floor(jsec);
00852 }
00853
00854 /*****************************************************************************/
00855
00856 int locate(
00857   double *xx,
00858   int n,
00859   double x) {
00860
00861   int i, ilo, ihi;
00862
00863   ilo = 0;
00864   ihi = n - 1;
00865   i = (ihi + ilo) >> 1;
00866
00867   if (xx[i] < xx[i + 1])
00868     while (ihi > ilo + 1) {
00869       i = (ihi + ilo) >> 1;
00870       if (xx[i] > x)
00871         ihi = i;
00872       else
00873         ilo = i;
00874   } else
00875     while (ihi > ilo + 1) {
00876       i = (ihi + ilo) >> 1;
00877       if (xx[i] <= x)
00878         ihi = i;
00879       else
00880         ilo = i;
00881     }
00882
00883   return ilo;
00884 }
```

```
00885
00886 /*****************************************************************************/
00887
00888 void read_atm(
00889   const char *filename,
00890   ctl_t * ctl,
00891   atm_t * atm) {
00892
00893   FILE *in;
00894
00895   char line[LEN], *tok;
00896
00897   double t0;
00898
00899   int dimid, ip, iq, ncid, varid;
00900
00901   size_t nparts;
00902
00903   /* Init... */
00904   atm->np = 0;
00905
00906   /* Write info... */
00907   printf("Read atmospheric data: %s\n", filename);
00908
00909   /* Read ASCII data... */
00910   if (ctl->atm_type == 0) {
00911
00912     /* Open file... */
00913     if (!(in = fopen(filename, "r")))
00914       ERRMSG("Cannot open file!");
00915
00916     /* Read line... */
00917     while (fgets(line, LEN, in)) {
00918
00919       /* Read data... */
00920       TOK(line, tok, "%lg", atm->time[atm->np]);
00921       TOK(NULL, tok, "%lg", atm->p[atm->np]);
00922       TOK(NULL, tok, "%lg", atm->lon[atm->np]);
00923       TOK(NULL, tok, "%lg", atm->lat[atm->np]);
00924       for (iq = 0; iq < ctl->nq; iq++)
00925         TOK(NULL, tok, "%lg", atm->q[iq][atm->np]);
00926
00927       /* Convert altitude to pressure... */
00928       atm->p[atm->np] = P(atm->p[atm->np]);
00929
00930       /* Increment data point counter... */
00931       if ((++atm->np) > NP)
00932         ERRMSG("Too many data points!");
00933     }
00934
00935     /* Close file... */
00936     fclose(in);
00937   }
00938
00939   /* Read binary data... */
00940   else if (ctl->atm_type == 1) {
00941
00942     /* Open file... */
00943     if (!(in = fopen(filename, "r")))
00944       ERRMSG("Cannot open file!");
00945
00946     /* Read data... */
00947     FREAD(&atm->np, int,
00948           1,
00949           in);
00950     FREAD(atm->time, double,
00951             (size_t) atm->np,
00952           in);
00953     FREAD(atm->p, double,
00954             (size_t) atm->np,
00955           in);
00956     FREAD(atm->lon, double,
00957             (size_t) atm->np,
00958           in);
00959     FREAD(atm->lat, double,
00960             (size_t) atm->np,
00961           in);
00962     for (iq = 0; iq < ctl->nq; iq++)
00963       FREAD(atm->q[iq], double,
00964               (size_t) atm->np,
00965             in);
00966
00967     /* Close file... */
00968     fclose(in);
00969   }
00970
00971   /* Read netCDF data... */
```

```
00972   else if (ctl->atm_type == 2) {
00973
00974     /* Open file... */
00975     NC(nc_open(filename, NC_NOWRITE, &ncid));
00976
00977     /* Get dimensions... */
00978     NC(nc_inq_dimid(ncid, "NPARTS", &dimid));
00979     NC(nc_inq_dimlen(ncid, dimid, &nparts));
00980     atm->np = (int) nparts;
00981     if (atm->np > NP)
00982       ERRMSG("Too many particles!");
00983
00984     /* Get time... */
00985     NC(nc_inq_varid(ncid, "time", &varid));
00986     NC(nc_get_var_double(ncid, varid, &t0));
00987     for (ip = 0; ip < atm->np; ip++)
00988       atm->time[ip] = t0;
00989
00990     /* Read geolocations... */
00991     NC(nc_inq_varid(ncid, "PRESS", &varid));
00992     NC(nc_get_var_double(ncid, varid, atm->p));
00993     NC(nc_inq_varid(ncid, "LON", &varid));
00994     NC(nc_get_var_double(ncid, varid, atm->lon));
00995     NC(nc_inq_varid(ncid, "LAT", &varid));
00996     NC(nc_get_var_double(ncid, varid, atm->lat));
00997
00998     /* Read variables... */
00999     if (ctl->qnt_p >= 0)
01000       if (nc_inq_varid(ncid, "PRESS", &varid) == NC_NOERR)
01001         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_p]));
01002     if (ctl->qnt_t >= 0)
01003       if (nc_inq_varid(ncid, "TEMP", &varid) == NC_NOERR)
01004         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_t]));
01005     if (ctl->qnt_u >= 0)
01006       if (nc_inq_varid(ncid, "U", &varid) == NC_NOERR)
01007         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_u]));
01008     if (ctl->qnt_v >= 0)
01009       if (nc_inq_varid(ncid, "V", &varid) == NC_NOERR)
01010         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_v]));
01011     if (ctl->qnt_w >= 0)
01012       if (nc_inq_varid(ncid, "W", &varid) == NC_NOERR)
01013         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_w]));
01014     if (ctl->qnt_h2o >= 0)
01015       if (nc_inq_varid(ncid, "SH", &varid) == NC_NOERR)
01016         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_h2o]));
01017     if (ctl->qnt_o3 >= 0)
01018       if (nc_inq_varid(ncid, "O3", &varid) == NC_NOERR)
01019         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_o3]));
01020     if (ctl->qnt_theta >= 0)
01021       if (nc_inq_varid(ncid, "THETA", &varid) == NC_NOERR)
01022         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_theta]));
01023     if (ctl->qnt_pv >= 0)
01024       if (nc_inq_varid(ncid, "PV", &varid) == NC_NOERR)
01025         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_pv]));
01026
01027     /* Check data... */
01028     for (ip = 0; ip < atm->np; ip++)
01029       if (fabs(atm->lon[ip]) > 360 || fabs(atm->lat[ip]) > 90
01030           || (ctl->qnt_t >= 0 && fabs(atm->q[ctl->qnt_t][ip]) > 350)
01031           || (ctl->qnt_h2o >= 0 && fabs(atm->q[ctl->qnt_h2o][ip]) > 1)
01032           || (ctl->qnt_theta >= 0 && fabs(atm->q[ctl->qnt_theta][ip]) > 1e10)
01033           || (ctl->qnt_pv >= 0 && fabs(atm->q[ctl->qnt_pv][ip]) > 1e10)) {
01034         atm->time[ip] = GSL_NAN;
01035         atm->p[ip] = GSL_NAN;
01036         atm->lon[ip] = GSL_NAN;
01037         atm->lat[ip] = GSL_NAN;
01038         for (iq = 0; iq < ctl->nq; iq++)
01039           atm->q[iq][ip] = GSL_NAN;
01040       } else {
01041         if (ctl->qnt_h2o >= 0)
01042           atm->q[ctl->qnt_h2o][ip] *= 1.608;
01043         if (ctl->qnt_pv >= 0)
01044           atm->q[ctl->qnt_pv][ip] *= 1e6;
01045         if (atm->lon[ip] > 180)
01046           atm->lon[ip] -= 360;
01047       }
01048
01049     /* Close file... */
01050     NC(nc_close(ncid));
01051   }
01052
01053   /* Error... */
01054   else
01055     ERRMSG("Atmospheric data type not supported!");
01056
01057   /* Check number of points... */
01058   if (atm->np < 1)
```

```
01059     ERRMSG("Can not read any data!");
01060 }
01061
01062 /*****************************************************************************/
01063
01064 void read_ctl(
01065   const char *filename,
01066   int argc,
01067   char *argv[],
01068   ctl_t * ctl) {
01069
01070   int ip, iq;
01071
01072   /* Write info... */
01073   printf("\nMassive-Parallel Trajectory Calculations (MPTRAC)\n"
01074          "(executable: %s | compiled: %s, %s)\n\n",
01075          argv[0], __DATE__, __TIME__);
01076
01077   /* Initialize quantity indices... */
01078   ctl->qnt_ens = -1;
01079   ctl->qnt_m = -1;
01080   ctl->qnt_r = -1;
01081   ctl->qnt_rho = -1;
01082   ctl->qnt_ps = -1;
01083   ctl->qnt_pt = -1;
01084   ctl->qnt_z = -1;
01085   ctl->qnt_p = -1;
01086   ctl->qnt_t = -1;
01087   ctl->qnt_u = -1;
01088   ctl->qnt_v = -1;
01089   ctl->qnt_w = -1;
01090   ctl->qnt_h2o = -1;
01091   ctl->qnt_o3 = -1;
01092   ctl->qnt_theta = -1;
01093   ctl->qnt_vh = -1;
01094   ctl->qnt_vz = -1;
01095   ctl->qnt_pv = -1;
01096   ctl->qnt_tice = -1;
01097   ctl->qnt_tsts = -1;
01098   ctl->qnt_tnat = -1;
01099   ctl->qnt_stat = -1;
01100
01101   /* Read quantities... */
01102   ctl->nq = (int) scan_ctl(filename, argc, argv, "NQ", -1, "0", NULL);
01103   if (ctl->nq > NQ)
01104     ERRMSG("Too many quantities!");
01105   for (iq = 0; iq < ctl->nq; iq++) {
01106
01107     /* Read quantity name and format... */
01108     scan_ctl(filename, argc, argv, "QNT_NAME", iq, "", ctl->qnt_name[iq]);
01109     scan_ctl(filename, argc, argv, "QNT_FORMAT", iq, "%g",
01110              ctl->qnt_format[iq]);
01111
01112     /* Try to identify quantity... */
01113     if (strcmp(ctl->qnt_name[iq], "ens") == 0) {
01114       ctl->qnt_ens = iq;
01115       sprintf(ctl->qnt_unit[iq], "-");
01116     } else if (strcmp(ctl->qnt_name[iq], "m") == 0) {
01117       ctl->qnt_m = iq;
01118       sprintf(ctl->qnt_unit[iq], "kg");
01119     } else if (strcmp(ctl->qnt_name[iq], "r") == 0) {
01120       ctl->qnt_r = iq;
01121       sprintf(ctl->qnt_unit[iq], "m");
01122     } else if (strcmp(ctl->qnt_name[iq], "rho") == 0) {
01123       ctl->qnt_rho = iq;
01124       sprintf(ctl->qnt_unit[iq], "kg/m^3");
01125     } else if (strcmp(ctl->qnt_name[iq], "ps") == 0) {
01126       ctl->qnt_ps = iq;
01127       sprintf(ctl->qnt_unit[iq], "hPa");
01128     } else if (strcmp(ctl->qnt_name[iq], "pt") == 0) {
01129       ctl->qnt_pt = iq;
01130       sprintf(ctl->qnt_unit[iq], "hPa");
01131     } else if (strcmp(ctl->qnt_name[iq], "z") == 0) {
01132       ctl->qnt_z = iq;
01133       sprintf(ctl->qnt_unit[iq], "km");
01134     } else if (strcmp(ctl->qnt_name[iq], "p") == 0) {
01135       ctl->qnt_p = iq;
01136       sprintf(ctl->qnt_unit[iq], "hPa");
01137     } else if (strcmp(ctl->qnt_name[iq], "t") == 0) {
01138       ctl->qnt_t = iq;
01139       sprintf(ctl->qnt_unit[iq], "K");
01140     } else if (strcmp(ctl->qnt_name[iq], "u") == 0) {
01141       ctl->qnt_u = iq;
01142       sprintf(ctl->qnt_unit[iq], "m/s");
01143     } else if (strcmp(ctl->qnt_name[iq], "v") == 0) {
01144       ctl->qnt_v = iq;
01145       sprintf(ctl->qnt_unit[iq], "m/s");
```

```
01146     } else if (strcmp(ctl->qnt_name[iq], "w") == 0) {
01147       ctl->qnt_w = iq;
01148       sprintf(ctl->qnt_unit[iq], "hPa/s");
01149     } else if (strcmp(ctl->qnt_name[iq], "h2o") == 0) {
01150       ctl->qnt_h2o = iq;
01151       sprintf(ctl->qnt_unit[iq], "1");
01152     } else if (strcmp(ctl->qnt_name[iq], "o3") == 0) {
01153       ctl->qnt_o3 = iq;
01154       sprintf(ctl->qnt_unit[iq], "1");
01155     } else if (strcmp(ctl->qnt_name[iq], "theta") == 0) {
01156       ctl->qnt_theta = iq;
01157       sprintf(ctl->qnt_unit[iq], "K");
01158     } else if (strcmp(ctl->qnt_name[iq], "vh") == 0) {
01159       ctl->qnt_vh = iq;
01160       sprintf(ctl->qnt_unit[iq], "m/s");
01161     } else if (strcmp(ctl->qnt_name[iq], "vz") == 0) {
01162       ctl->qnt_vz = iq;
01163       sprintf(ctl->qnt_unit[iq], "m/s");
01164     } else if (strcmp(ctl->qnt_name[iq], "pv") == 0) {
01165       ctl->qnt_pv = iq;
01166       sprintf(ctl->qnt_unit[iq], "PVU");
01167     } else if (strcmp(ctl->qnt_name[iq], "tice") == 0) {
01168       ctl->qnt_tice = iq;
01169       sprintf(ctl->qnt_unit[iq], "K");
01170     } else if (strcmp(ctl->qnt_name[iq], "tsts") == 0) {
01171       ctl->qnt_tsts = iq;
01172       sprintf(ctl->qnt_unit[iq], "K");
01173     } else if (strcmp(ctl->qnt_name[iq], "tnat") == 0) {
01174       ctl->qnt_tnat = iq;
01175       sprintf(ctl->qnt_unit[iq], "K");
01176     } else if (strcmp(ctl->qnt_name[iq], "stat") == 0) {
01177       ctl->qnt_stat = iq;
01178       sprintf(ctl->qnt_unit[iq], "-");
01179     } else
01180       scan_ctl(filename, argc, argv, "QNT_UNIT", iq, "", ctl->qnt_unit[iq]);
01181   }
01182
01183   /* Time steps of simulation... */
01184   ctl->direction =
01185     (int) scan_ctl(filename, argc, argv, "DIRECTION", -1, "1", NULL);
01186   if (ctl->direction != -1 && ctl->direction != 1)
01187     ERRMSG("Set DIRECTION to -1 or 1!");
01188   ctl->t_stop = scan_ctl(filename, argc, argv, "T_STOP", -1, "1e100", NULL);
01189   ctl->dt_mod = scan_ctl(filename, argc, argv, "DT_MOD", -1, "600", NULL);
01190
01191   /* Meteorological data... */
01192   ctl->dt_met = scan_ctl(filename, argc, argv, "DT_MET", -1, "21600", NULL);
01193   ctl->met_dx = (int) scan_ctl(filename, argc, argv, "MET_DX", -1, "1", NULL);
01194   ctl->met_dy = (int) scan_ctl(filename, argc, argv, "MET_DY", -1, "1", NULL);
01195   ctl->met_dp = (int) scan_ctl(filename, argc, argv, "MET_DP", -1, "1", NULL);
01196   ctl->met_sx = (int) scan_ctl(filename, argc, argv, "MET_SX", -1, "1", NULL);
01197   ctl->met_sy = (int) scan_ctl(filename, argc, argv, "MET_SY", -1, "1", NULL);
01198   ctl->met_sp = (int) scan_ctl(filename, argc, argv, "MET_SP", -1, "1", NULL);
01199   ctl->met_np = (int) scan_ctl(filename, argc, argv, "MET_NP", -1, "0", NULL);
01200   if (ctl->met_np > EP)
01201     ERRMSG("Too many levels!");
01202   for (ip = 0; ip < ctl->met_np; ip++)
01203     ctl->met_p[ip] = scan_ctl(filename, argc, argv, "MET_P", ip, "", NULL);
01204   ctl->met_tropo
01205     = (int) scan_ctl(filename, argc, argv, "MET_TROPO", -1, "0", NULL);
01206   scan_ctl(filename, argc, argv, "MET_GEOPOT", -1, "-", ctl->met_geopot);
01207   scan_ctl(filename, argc, argv, "MET_STAGE", -1, "-", ctl->met_stage);
01208
01209   /* Isosurface parameters... */
01210   ctl->isosurf
01211     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
01212   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
01213
01214   /* Diffusion parameters... */
01215   ctl->turb_dx_trop
01216     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50", NULL);
01217   ctl->turb_dx_strat
01218     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0", NULL);
01219   ctl->turb_dz_trop
01220     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0", NULL);
01221   ctl->turb_dz_strat
01222     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
01223   ctl->turb_mesox =
01224     scan_ctl(filename, argc, argv, "TURB_MESOX", -1, "0.16", NULL);
01225   ctl->turb_mesoz =
01226     scan_ctl(filename, argc, argv, "TURB_MESOZ", -1, "0.16", NULL);
01227
01228   /* Mass and life time... */
01229   ctl->molmass = scan_ctl(filename, argc, argv, "MOLMASS", -1, "1", NULL);
01230   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
01231   ctl->tdec_strat =
01232     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
```

```
01233
01234   /* PSC analysis... */
01235   ctl->psc_h2o = scan_ctl(filename, argc, argv, "PSC_H2O", -1, "4e-6", NULL);
01236   ctl->psc_hno3 =
01237     scan_ctl(filename, argc, argv, "PSC_HNO3", -1, "9e-9", NULL);
01238
01239   /* Output of atmospheric data... */
01240   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
      atm_basename);
01241   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
01242   ctl->atm_dt_out =
01243     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
01244   ctl->atm_filter =
01245     (int) scan_ctl(filename, argc, argv, "ATM_FILTER", -1, "0", NULL);
01246   ctl->atm_type =
01247     (int) scan_ctl(filename, argc, argv, "ATM_TYPE", -1, "0", NULL);
01248
01249   /* Output of CSI data... */
01250   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
      csi_basename);
01251   ctl->csi_dt_out =
01252     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
01253   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "-", ctl->
      csi_obsfile);
01254   ctl->csi_obsmin =
01255     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
01256   ctl->csi_modmin =
01257     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
01258   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
01259   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
01260   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
01261   ctl->csi_lon0 =
01262     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
01263   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
01264   ctl->csi_nx =
01265     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
01266   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
01267   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
01268   ctl->csi_ny =
01269     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
01270
01271   /* Output of ensemble data... */
01272   scan_ctl(filename, argc, argv, "ENS_BASENAME", -1, "-", ctl->
      ens_basename);
01273
01274   /* Output of grid data... */
01275   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
01276            ctl->grid_basename);
01277   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
      grid_gpfile);
01278   ctl->grid_dt_out =
01279     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
01280   ctl->grid_sparse =
01281     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
01282   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
01283   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
01284   ctl->grid_nz =
01285     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
01286   ctl->grid_lon0 =
01287     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
01288   ctl->grid_lon1 =
01289     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
01290   ctl->grid_nx =
01291     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
01292   ctl->grid_lat0 =
01293     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
01294   ctl->grid_lat1 =
01295     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
01296   ctl->grid_ny =
01297     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
01298
01299   /* Output of profile data... */
01300   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
01301            ctl->prof_basename);
01302   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
      prof_obsfile);
01303   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
01304   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
01305   ctl->prof_nz =
01306     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
01307   ctl->prof_lon0 =
01308     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
01309   ctl->prof_lon1 =
01310     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
01311   ctl->prof_nx =
01312     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
01313   ctl->prof_lat0 =
```

```
01314     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
01315   ctl->prof_lat1 =
01316     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
01317   ctl->prof_ny =
01318     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
01319
01320   /* Output of station data... */
01321   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
01322            ctl->stat_basename);
01323   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
01324   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
01325   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
01326 }
01327
01328 /*****************************************************************************/
01329
01330 void read_met(
01331   ctl_t * ctl,
01332   char *filename,
01333   met_t * met) {
01334
01335   char cmd[2 * LEN], levname[LEN], tstr[10];
01336
01337   static float help[EX * EY];
01338
01339   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
01340
01341   size_t np, nx, ny;
01342
01343   /* Write info... */
01344   printf("Read meteorological data: %s\n", filename);
01345
01346   /* Get time from filename... */
01347   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
01348   year = atoi(tstr);
01349   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
01350   mon = atoi(tstr);
01351   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
01352   day = atoi(tstr);
01353   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
01354   hour = atoi(tstr);
01355   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
01356
01357   /* Open netCDF file... */
01358   if (nc_open(filename, NC_NOWRITE, &ncid) != NC_NOERR) {
01359
01360     /* Try to stage meteo file... */
01361     if (ctl->met_stage[0] != '-') {
01362       sprintf(cmd, "%s %d %02d %02d %02d %s", ctl->met_stage,
01363               year, mon, day, hour, filename);
01364       if (system(cmd) != 0)
01365         ERRMSG("Error while staging meteo data!");
01366     }
01367
01368     /* Try to open again... */
01369     NC(nc_open(filename, NC_NOWRITE, &ncid));
01370   }
01371
01372   /* Get dimensions... */
01373   NC(nc_inq_dimid(ncid, "lon", &dimid));
01374   NC(nc_inq_dimlen(ncid, dimid, &nx));
01375   if (nx < 2 || nx > EX)
01376     ERRMSG("Number of longitudes out of range!");
01377
01378   NC(nc_inq_dimid(ncid, "lat", &dimid));
01379   NC(nc_inq_dimlen(ncid, dimid, &ny));
01380   if (ny < 2 || ny > EY)
01381     ERRMSG("Number of latitudes out of range!");
01382
01383   sprintf(levname, "lev");
01384   NC(nc_inq_dimid(ncid, levname, &dimid));
01385   NC(nc_inq_dimlen(ncid, dimid, &np));
01386   if (np == 1) {
01387     sprintf(levname, "lev_2");
01388     NC(nc_inq_dimid(ncid, levname, &dimid));
01389     NC(nc_inq_dimlen(ncid, dimid, &np));
01390   }
01391   if (np < 2 || np > EP)
01392     ERRMSG("Number of levels out of range!");
01393
01394   /* Store dimensions... */
01395   met->np = (int) np;
01396   met->nx = (int) nx;
01397   met->ny = (int) ny;
01398
01399   /* Get horizontal grid... */
01400   NC(nc_inq_varid(ncid, "lon", &varid));
```

```
01401   NC(nc_get_var_double(ncid, varid, met->lon));
01402   NC(nc_inq_varid(ncid, "lat", &varid));
01403   NC(nc_get_var_double(ncid, varid, met->lat));
01404
01405   /* Read meteorological data... */
01406   read_met_help(ncid, "t", "T", met, met->t, 1.0);
01407   read_met_help(ncid, "u", "U", met, met->u, 1.0);
01408   read_met_help(ncid, "v", "V", met, met->v, 1.0);
01409   read_met_help(ncid, "w", "W", met, met->w, 0.01f);
01410   read_met_help(ncid, "q", "Q", met, met->h2o, (float) (MA / 18.01528));
01411   read_met_help(ncid, "o3", "O3", met, met->o3, (float) (MA / 48.00));
01412
01413   /* Meteo data on pressure levels... */
01414   if (ctl->met_np <= 0) {
01415
01416     /* Read pressure levels from file... */
01417     NC(nc_inq_varid(ncid, levname, &varid));
01418     NC(nc_get_var_double(ncid, varid, met->p));
01419     for (ip = 0; ip < met->np; ip++)
01420       met->p[ip] /= 100.;
01421
01422     /* Extrapolate data for lower boundary... */
01423     read_met_extrapolate(met);
01424   }
01425
01426   /* Meteo data on model levels... */
01427   else {
01428
01429     /* Read pressure data from file... */
01430     read_met_help(ncid, "pl", "PL", met, met->pl, 0.01f);
01431
01432     /* Interpolate from model levels to pressure levels... */
01433     read_met_ml2pl(ctl, met, met->t);
01434     read_met_ml2pl(ctl, met, met->u);
01435     read_met_ml2pl(ctl, met, met->v);
01436     read_met_ml2pl(ctl, met, met->w);
01437     read_met_ml2pl(ctl, met, met->h2o);
01438     read_met_ml2pl(ctl, met, met->o3);
01439
01440     /* Set pressure levels... */
01441     met->np = ctl->met_np;
01442     for (ip = 0; ip < met->np; ip++)
01443       met->p[ip] = ctl->met_p[ip];
01444   }
01445
01446   /* Check ordering of pressure levels... */
01447   for (ip = 1; ip < met->np; ip++)
01448     if (met->p[ip - 1] < met->p[ip])
01449       ERRMSG("Pressure levels must be descending!");
01450
01451   /* Read surface pressure... */
01452   if (nc_inq_varid(ncid, "ps", &varid) == NC_NOERR
01453       || nc_inq_varid(ncid, "PS", &varid) == NC_NOERR) {
01454     NC(nc_get_var_float(ncid, varid, help));
01455     for (iy = 0; iy < met->ny; iy++)
01456       for (ix = 0; ix < met->nx; ix++)
01457         met->ps[ix][iy] = help[iy * met->nx + ix] / 100.;
01458   } else if (nc_inq_varid(ncid, "lnsp", &varid) == NC_NOERR
01459              || nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
01460     NC(nc_get_var_float(ncid, varid, help));
01461     for (iy = 0; iy < met->ny; iy++)
01462       for (ix = 0; ix < met->nx; ix++)
01463         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
01464   } else
01465     for (ix = 0; ix < met->nx; ix++)
01466       for (iy = 0; iy < met->ny; iy++)
01467         met->ps[ix][iy] = met->p[0];
01468
01469   /* Create periodic boundary conditions... */
01470   read_met_periodic(met);
01471
01472   /* Calculate geopotential heights... */
01473   read_met_geopot(ctl, met);
01474
01475   /* Calculate potential vorticity... */
01476   read_met_pv(met);
01477
01478   /* Calculate tropopause pressure... */
01479   read_met_tropo(ctl, met);
01480
01481   /* Downsampling... */
01482   read_met_sample(ctl, met);
01483
01484   /* Close file... */
01485   NC(nc_close(ncid));
01486 }
01487
```

```
01488 /*****************************************************************************/
01489
01490 void read_met_extrapolate(
01491   met_t * met) {
01492
01493   int ip, ip0, ix, iy;
01494
01495   /* Loop over columns... */
01496   for (ix = 0; ix < met->nx; ix++)
01497     for (iy = 0; iy < met->ny; iy++) {
01498
01499       /* Find lowest valid data point... */
01500       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
01501         if (!gsl_finite(met->t[ix][iy][ip0])
01502             || !gsl_finite(met->u[ix][iy][ip0])
01503             || !gsl_finite(met->v[ix][iy][ip0])
01504             || !gsl_finite(met->w[ix][iy][ip0]))
01505           break;
01506
01507       /* Extrapolate... */
01508       for (ip = ip0; ip >= 0; ip--) {
01509         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
01510         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
01511         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
01512         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
01513         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
01514         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
01515       }
01516     }
01517 }
01518
01519 /*****************************************************************************/
01520
01521 void read_met_geopot(
01522   ctl_t * ctl,
01523   met_t * met) {
01524
01525   static double topo_lat[EY], topo_lon[EX], topo_z[EX][EY];
01526
01527   static int init, topo_nx = -1, topo_ny;
01528
01529   FILE *in;
01530
01531   char line[LEN];
01532
01533   double data[30], lat, lon, rlat, rlon, rlon_old = -999, rz, ts, z0, z1;
01534
01535   float help[EX][EY];
01536
01537   int ip, ip0, ix, ix2, ix3, iy, iy2, n, tx, ty;
01538
01539   /* Initialize geopotential heights... */
01540   for (ix = 0; ix < met->nx; ix++)
01541     for (iy = 0; iy < met->ny; iy++)
01542       for (ip = 0; ip < met->np; ip++)
01543         met->z[ix][iy][ip] = GSL_NAN;
01544
01545   /* Check filename... */
01546   if (ctl->met_geopot[0] == '-')
01547     return;
01548
01549   /* Read surface geopotential... */
01550   if (!init) {
01551     init = 1;
01552
01553     /* Write info... */
01554     printf("Read surface geopotential: %s\n", ctl->met_geopot);
01555
01556     /* Open file... */
01557     if (!(in = fopen(ctl->met_geopot, "r")))
01558       ERRMSG("Cannot open file!");
01559
01560     /* Read data... */
01561     while (fgets(line, LEN, in))
01562       if (sscanf(line, "%lg %lg %lg", &rlon, &rlat, &rz) == 3) {
01563         if (rlon != rlon_old) {
01564           if ((++topo_nx) >= EX)
01565             ERRMSG("Too many longitudes!");
01566           topo_ny = 0;
01567         }
01568         rlon_old = rlon;
01569         topo_lon[topo_nx] = rlon;
01570         topo_lat[topo_ny] = rlat;
01571         topo_z[topo_nx][topo_ny] = rz;
01572         if ((++topo_ny) >= EY)
01573           ERRMSG("Too many latitudes!");
01574       }
```

```
01575     if ((++topo_nx) >= EX)
01576       ERRMSG("Too many longitudes!");
01577
01578     /* Close file... */
01579     fclose(in);
01580
01581     /* Check grid spacing... */
01582     if (fabs(met->lon[0] - met->lon[1]) != fabs(topo_lon[0] - topo_lon[1])
01583         || fabs(met->lat[0] - met->lat[1]) != fabs(topo_lat[0] - topo_lat[1]))
01584       printf("Warning: Grid spacing does not match!\n");
01585   }
01586
01587   /* Apply hydrostatic equation to calculate geopotential heights... */
01588   for (ix = 0; ix < met->nx; ix++)
01589     for (iy = 0; iy < met->ny; iy++) {
01590
01591       /* Get surface height... */
01592       lon = met->lon[ix];
01593       if (lon < topo_lon[0])
01594         lon += 360;
01595       else if (lon > topo_lon[topo_nx - 1])
01596         lon -= 360;
01597       lat = met->lat[iy];
01598       tx = locate(topo_lon, topo_nx, lon);
01599       ty = locate(topo_lat, topo_ny, lat);
01600       z0 = LIN(topo_lon[tx], topo_z[tx][ty],
01601                topo_lon[tx + 1], topo_z[tx + 1][ty], lon);
01602       z1 = LIN(topo_lon[tx], topo_z[tx][ty + 1],
01603                topo_lon[tx + 1], topo_z[tx + 1][ty + 1], lon);
01604       z0 = LIN(topo_lat[ty], z0, topo_lat[ty + 1], z1, lat);
01605
01606       /* Find surface pressure level... */
01607       ip0 = locate(met->p, met->np, met->ps[ix][iy]);
01608
01609       /* Get surface temperature... */
01610       ts = LIN(met->p[ip0], met->t[ix][iy][ip0],
01611                met->p[ip0 + 1], met->t[ix][iy][ip0 + 1], met->ps[ix][iy]);
01612
01613       /* Upper part of profile... */
01614       met->z[ix][iy][ip0 + 1]
01615         = (float) (z0 + RI / MA / G0 * 0.5 * (ts + met->t[ix][iy][ip0 + 1])
01616                    * log(met->ps[ix][iy] / met->p[ip0 + 1]));
01617       for (ip = ip0 + 2; ip < met->np; ip++)
01618         met->z[ix][iy][ip]
01619           = (float) (met->z[ix][iy][ip - 1] + RI / MA / G0
01620                      * 0.5 * (met->t[ix][iy][ip - 1] + met->t[ix][iy][ip])
01621                      * log(met->p[ip - 1] / met->p[ip]));
01622     }
01623
01624   /* Smooth fields... */
01625   for (ip = 0; ip < met->np; ip++) {
01626
01627     /* Median filter... */
01628     for (ix = 0; ix < met->nx; ix++)
01629       for (iy = 0; iy < met->nx; iy++) {
01630         n = 0;
01631         for (ix2 = ix - 2; ix2 <= ix + 2; ix2++) {
01632           ix3 = ix2;
01633           if (ix3 < 0)
01634             ix3 += met->nx;
01635           if (ix3 >= met->nx)
01636             ix3 -= met->nx;
01637           for (iy2 = GSL_MAX(iy - 2, 0); iy2 <= GSL_MIN(iy + 2, met->ny - 1);
01638                iy2++)
01639             if (gsl_finite(met->z[ix3][iy2][ip])) {
01640               data[n] = met->z[ix3][iy2][ip];
01641               n++;
01642             }
01643         }
01644         if (n > 0) {
01645           gsl_sort(data, 1, (size_t) n);
01646           help[ix][iy] = (float)
01647             gsl_stats_median_from_sorted_data(data, 1, (size_t) n);
01648         } else
01649           help[ix][iy] = GSL_NAN;
01650       }
01651
01652     /* Copy data... */
01653     for (ix = 0; ix < met->nx; ix++)
01654       for (iy = 0; iy < met->nx; iy++)
01655         met->z[ix][iy][ip] = help[ix][iy];
01656   }
01657 }
01658
01659 /*****************************************************************************/
01660
01661 void read_met_help(
```

```
01662   int ncid,
01663   char *varname,
01664   char *varname2,
01665   met_t * met,
01666   float dest[EX][EY][EP],
01667   float scl) {
01668
01669   static float help[EX * EY * EP];
01670
01671   int ip, ix, iy, varid;
01672
01673   /* Check if variable exists... */
01674   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
01675     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
01676       return;
01677
01678   /* Read data... */
01679   NC(nc_get_var_float(ncid, varid, help));
01680
01681   /* Copy and check data... */
01682   for (ix = 0; ix < met->nx; ix++)
01683     for (iy = 0; iy < met->ny; iy++)
01684       for (ip = 0; ip < met->np; ip++) {
01685         dest[ix][iy][ip] = help[(ip * met->ny + iy) * met->nx + ix];
01686         if (fabsf(dest[ix][iy][ip]) < 1e14f)
01687           dest[ix][iy][ip] *= scl;
01688         else
01689           dest[ix][iy][ip] = GSL_NAN;
01690       }
01691 }
01692
01693 /*****************************************************************************/
01694
01695 void read_met_ml2pl(
01696   ctl_t * ctl,
01697   met_t * met,
01698   float var[EX][EY][EP]) {
01699
01700   double aux[EP], p[EP], pt;
01701
01702   int ip, ip2, ix, iy;
01703
01704   /* Loop over columns... */
01705   for (ix = 0; ix < met->nx; ix++)
01706     for (iy = 0; iy < met->ny; iy++) {
01707
01708       /* Copy pressure profile... */
01709       for (ip = 0; ip < met->np; ip++)
01710         p[ip] = met->pl[ix][iy][ip];
01711
01712       /* Interpolate... */
01713       for (ip = 0; ip < ctl->met_np; ip++) {
01714         pt = ctl->met_p[ip];
01715         if ((pt > p[0] && p[0] > p[1]) || (pt < p[0] && p[0] < p[1]))
01716           pt = p[0];
01717         else if ((pt > p[met->np - 1] && p[1] > p[0])
01718                  || (pt < p[met->np - 1] && p[1] < p[0]))
01719           pt = p[met->np - 1];
01720         ip2 = locate(p, met->np, pt);
01721         aux[ip] = LIN(p[ip2], var[ix][iy][ip2],
01722                       p[ip2 + 1], var[ix][iy][ip2 + 1], pt);
01723       }
01724
01725       /* Copy data... */
01726       for (ip = 0; ip < ctl->met_np; ip++)
01727         var[ix][iy][ip] = (float) aux[ip];
01728     }
01729 }
01730
01731 /*****************************************************************************/
01732
01733 void read_met_periodic(
01734   met_t * met) {
01735
01736   int ip, iy;
01737
01738   /* Check longitudes... */
01739   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
01740              + met->lon[1] - met->lon[0] - 360) < 0.01))
01741     return;
01742
01743   /* Increase longitude counter... */
01744   if ((++met->nx) > EX)
01745     ERRMSG("Cannot create periodic boundary conditions!");
01746
01747   /* Set longitude... */
01748   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
```

```
      lon[0];
01749
01750   /* Loop over latitudes and pressure levels... */
01751   for (iy = 0; iy < met->ny; iy++)
01752     for (ip = 0; ip < met->np; ip++) {
01753       met->ps[met->nx - 1][iy] = met->ps[0][iy];
01754       met->pt[met->nx - 1][iy] = met->pt[0][iy];
01755       met->z[met->nx - 1][iy][ip] = met->z[0][iy][ip];
01756       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
01757       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
01758       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
01759       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
01760       met->pv[met->nx - 1][iy][ip] = met->pv[0][iy][ip];
01761       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
01762       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
01763     }
01764 }
01765
01766 /*****************************************************************************/
01767
01768 void read_met_pv(
01769   met_t * met) {
01770
01771   double c0, c1, cr, dx, dy, dp, dtdx, dvdx, dtdy, dudy, dtdp, dudp, dvdp,
01772     latr, vort, pows[EP];
01773
01774   int ip, ip0, ip1, ix, ix0, ix1, iy, iy0, iy1;
01775
01776   /* Set powers... */
01777   for (ip = 0; ip < met->np; ip++)
01778     pows[ip] = pow(1000. / met->p[ip], 0.286);
01779
01780   /* Loop over grid points... */
01781   for (ix = 0; ix < met->nx; ix++) {
01782
01783     /* Set indices... */
01784     ix0 = GSL_MAX(ix - 1, 0);
01785     ix1 = GSL_MIN(ix + 1, met->nx - 1);
01786
01787     /* Loop over grid points... */
01788     for (iy = 0; iy < met->ny; iy++) {
01789
01790       /* Set indices... */
01791       iy0 = GSL_MAX(iy - 1, 0);
01792       iy1 = GSL_MIN(iy + 1, met->ny - 1);
01793
01794       /* Set auxiliary variables... */
01795       latr = GSL_MIN(GSL_MAX(met->lat[iy], -89.), 89.);
01796       dx = 1000. * deg2dx(met->lon[ix1] - met->lon[ix0], latr);
01797       dy = 1000. * deg2dy(met->lat[iy1] - met->lat[iy0]);
01798       c0 = cos(met->lat[iy0] / 180. * M_PI);
01799       c1 = cos(met->lat[iy1] / 180. * M_PI);
01800       cr = cos(latr / 180. * M_PI);
01801       vort = 2 * 7.2921e-5 * sin(latr * M_PI / 180.);
01802
01803       /* Loop over grid points... */
01804       for (ip = 0; ip < met->np; ip++) {
01805
01806         /* Set indices... */
01807         ip0 = GSL_MAX(ip - 1, 0);
01808         ip1 = GSL_MIN(ip + 1, met->np - 1);
01809
01810         /* Set auxiliary variables... */
01811         dp = 100. * (met->p[ip1] - met->p[ip0]);
01812
01813         /* Get gradients in longitude... */
01814         dtdx = (met->t[ix1][iy][ip] - met->t[ix0][iy][ip]) * pows[ip] / dx;
01815         dvdx = (met->v[ix1][iy][ip] - met->v[ix0][iy][ip]) / dx;
01816
01817         /* Get gradients in latitude... */
01818         dtdy = (met->t[ix][iy1][ip] - met->t[ix][iy0][ip]) * pows[ip] / dy;
01819         dudy = (met->u[ix][iy1][ip] * c1 - met->u[ix][iy0][ip] * c0) / dy;
01820
01821         /* Get gradients in pressure... */
01822         dtdp =
01823           (met->t[ix][iy][ip1] * pows[ip1] -
01824            met->t[ix][iy][ip0] * pows[ip0]) / dp;
01825         dudp = (met->u[ix][iy][ip1] - met->u[ix][iy][ip0]) / dp;
01826         dvdp = (met->v[ix][iy][ip1] - met->v[ix][iy][ip0]) / dp;
01827
01828         /* Calculate PV... */
01829         met->pv[ix][iy][ip] = (float)
01830           (1e6 * G0 *
01831            (-dtdp * (dvdx - dudy / cr + vort) + dvdp * dtdx - dudp * dtdy));
01832       }
01833     }
01834   }
```

```
01835 }
01836
01837 /*****************************************************************************/
01838
01839 void read_met_sample(
01840   ctl_t * ctl,
01841   met_t * met) {
01842
01843   met_t *help;
01844
01845   float w, wsum;
01846
01847   int ip, ip2, ix, ix2, iy, iy2;
01848
01849   /* Check parameters... */
01850   if (ctl->met_dp <= 1 && ctl->met_dx <= 1 && ctl->met_dy <= 1)
01851     return;
01852
01853   /* Allocate... */
01854   ALLOC(help, met_t, 1);
01855
01856   /* Copy data... */
01857   help->nx = met->nx;
01858   help->ny = met->ny;
01859   help->np = met->np;
01860   memcpy(help->lon, met->lon, sizeof(met->lon));
01861   memcpy(help->lat, met->lat, sizeof(met->lat));
01862   memcpy(help->p, met->p, sizeof(met->p));
01863
01864   /* Smoothing... */
01865   for (ix = 0; ix < met->nx; ix += ctl->met_dx) {
01866     for (iy = 0; iy < met->ny; iy += ctl->met_dy) {
01867       for (ip = 0; ip < met->np; ip += ctl->met_dp) {
01868         help->ps[ix][iy] = 0;
01869         help->pt[ix][iy] = 0;
01870         help->z[ix][iy][ip] = 0;
01871         help->t[ix][iy][ip] = 0;
01872         help->u[ix][iy][ip] = 0;
01873         help->v[ix][iy][ip] = 0;
01874         help->w[ix][iy][ip] = 0;
01875         help->pv[ix][iy][ip] = 0;
01876         help->h2o[ix][iy][ip] = 0;
01877         help->o3[ix][iy][ip] = 0;
01878         wsum = 0;
01879         for (ix2 = GSL_MAX(ix - ctl->met_sx + 1, 0);
01880              ix2 <= GSL_MIN(ix + ctl->met_sx - 1, met->nx - 1); ix2++)
01881           for (iy2 = GSL_MAX(iy - ctl->met_sy + 1, 0);
01882                iy2 <= GSL_MIN(iy + ctl->met_sy - 1, met->ny - 1); iy2++)
01883             for (ip2 = GSL_MAX(ip - ctl->met_sp + 1, 0);
01884                  ip2 <= GSL_MIN(ip + ctl->met_sp - 1, met->np - 1); ip2++) {
01885               w = (float) (1.0 - fabs(ix - ix2) / ctl->met_sx)
01886                 * (float) (1.0 - fabs(iy - iy2) / ctl->met_sy)
01887                 * (float) (1.0 - fabs(ip - ip2) / ctl->met_sp);
01888               help->ps[ix][iy] += w * met->ps[ix2][iy2];
01889               help->pt[ix][iy] += w * met->pt[ix2][iy2];
01890               help->z[ix][iy][ip] += w * met->z[ix2][iy2][ip2];
01891               help->t[ix][iy][ip] += w * met->t[ix2][iy2][ip2];
01892               help->u[ix][iy][ip] += w * met->u[ix2][iy2][ip2];
01893               help->v[ix][iy][ip] += w * met->v[ix2][iy2][ip2];
01894               help->w[ix][iy][ip] += w * met->w[ix2][iy2][ip2];
01895               help->pv[ix][iy][ip] += w * met->pv[ix2][iy2][ip2];
01896               help->h2o[ix][iy][ip] += w * met->h2o[ix2][iy2][ip2];
01897               help->o3[ix][iy][ip] += w * met->o3[ix2][iy2][ip2];
01898               wsum += w;
01899             }
01900         help->ps[ix][iy] /= wsum;
01901         help->pt[ix][iy] /= wsum;
01902         help->t[ix][iy][ip] /= wsum;
01903         help->z[ix][iy][ip] /= wsum;
01904         help->u[ix][iy][ip] /= wsum;
01905         help->v[ix][iy][ip] /= wsum;
01906         help->w[ix][iy][ip] /= wsum;
01907         help->pv[ix][iy][ip] /= wsum;
01908         help->h2o[ix][iy][ip] /= wsum;
01909         help->o3[ix][iy][ip] /= wsum;
01910       }
01911     }
01912   }
01913
01914   /* Downsampling... */
01915   met->nx = 0;
01916   for (ix = 0; ix < help->nx; ix += ctl->met_dx) {
01917     met->lon[met->nx] = help->lon[ix];
01918     met->ny = 0;
01919     for (iy = 0; iy < help->ny; iy += ctl->met_dy) {
01920       met->lat[met->ny] = help->lat[iy];
01921       met->ps[met->nx][met->ny] = help->ps[ix][iy];
```

```
01922       met->pt[met->nx][met->ny] = help->pt[ix][iy];
01923       met->np = 0;
01924       for (ip = 0; ip < help->np; ip += ctl->met_dp) {
01925         met->p[met->np] = help->p[ip];
01926         met->z[met->nx][met->ny][met->np] = help->z[ix][iy][ip];
01927         met->t[met->nx][met->ny][met->np] = help->t[ix][iy][ip];
01928         met->u[met->nx][met->ny][met->np] = help->u[ix][iy][ip];
01929         met->v[met->nx][met->ny][met->np] = help->v[ix][iy][ip];
01930         met->w[met->nx][met->ny][met->np] = help->w[ix][iy][ip];
01931         met->pv[met->nx][met->ny][met->np] = help->pv[ix][iy][ip];
01932         met->h2o[met->nx][met->ny][met->np] = help->h2o[ix][iy][ip];
01933         met->o3[met->nx][met->ny][met->np] = help->o3[ix][iy][ip];
01934         met->np++;
01935       }
01936       met->ny++;
01937     }
01938     met->nx++;
01939   }
01940
01941   /* Free... */
01942   free(help);
01943 }
01944
01945 /*****************************************************************************/
01946
01947 void read_met_tropo(
01948   ctl_t * ctl,
01949   met_t * met) {
01950
01951   gsl_interp_accel *acc;
01952
01953   gsl_spline *spline;
01954
01955   double p2[400], pv[400], pv2[400], t[400], t2[400], th[400], th2[400],
01956     z[400], z2[400];
01957
01958   int found, ix, iy, iz, iz2;
01959
01960   /* Allocate... */
01961   acc = gsl_interp_accel_alloc();
01962   spline = gsl_spline_alloc(gsl_interp_cspline, (size_t) met->np);
01963
01964   /* Get altitude and pressure profiles... */
01965   for (iz = 0; iz < met->np; iz++)
01966     z[iz] = Z(met->p[iz]);
01967   for (iz = 0; iz <= 170; iz++) {
01968     z2[iz] = 4.5 + 0.1 * iz;
01969     p2[iz] = P(z2[iz]);
01970   }
01971
01972   /* Do not calculate tropopause... */
01973   if (ctl->met_tropo == 0)
01974     for (ix = 0; ix < met->nx; ix++)
01975       for (iy = 0; iy < met->ny; iy++)
01976         met->pt[ix][iy] = GSL_NAN;
01977
01978   /* Use tropopause climatology... */
01979   else if (ctl->met_tropo == 1)
01980     for (ix = 0; ix < met->nx; ix++)
01981       for (iy = 0; iy < met->ny; iy++)
01982         met->pt[ix][iy] = clim_tropo(met->time, met->lat[iy]);
01983
01984   /* Use cold point... */
01985   else if (ctl->met_tropo == 2) {
01986
01987     /* Loop over grid points... */
01988     for (ix = 0; ix < met->nx; ix++)
01989       for (iy = 0; iy < met->ny; iy++) {
01990
01991         /* Interpolate temperature profile... */
01992         for (iz = 0; iz < met->np; iz++)
01993           t[iz] = met->t[ix][iy][iz];
01994         gsl_spline_init(spline, z, t, (size_t) met->np);
01995         for (iz = 0; iz <= 170; iz++)
01996           t2[iz] = gsl_spline_eval(spline, z2[iz], acc);
01997
01998         /* Find minimum... */
01999         iz = (int) gsl_stats_min_index(t2, 1, 171);
02000         if (iz <= 0 || iz >= 170)
02001           met->pt[ix][iy] = GSL_NAN;
02002         else
02003           met->pt[ix][iy] = p2[iz];
02004       }
02005   }
02006
02007   /* Use WMO definition... */
02008   else if (ctl->met_tropo == 3 || ctl->met_tropo == 4) {
```

```
02009
02010     /* Loop over grid points... */
02011     for (ix = 0; ix < met->nx; ix++)
02012       for (iy = 0; iy < met->ny; iy++) {
02013
02014         /* Interpolate temperature profile... */
02015         for (iz = 0; iz < met->np; iz++)
02016           t[iz] = met->t[ix][iy][iz];
02017         gsl_spline_init(spline, z, t, (size_t) met->np);
02018         for (iz = 0; iz <= 160; iz++)
02019           t2[iz] = gsl_spline_eval(spline, z2[iz], acc);
02020
02021         /* Find 1st tropopause... */
02022         met->pt[ix][iy] = GSL_NAN;
02023         for (iz = 0; iz <= 140; iz++) {
02024           found = 1;
02025           for (iz2 = iz + 1; iz2 <= iz + 20; iz2++)
02026             if (1000. * G0 / RA * log(t2[iz2] / t2[iz])
02027                 / log(p2[iz2] / p2[iz]) > 2.0) {
02028               found = 0;
02029               break;
02030             }
02031           if (found) {
02032             if (iz > 0 && iz < 140)
02033               met->pt[ix][iy] = p2[iz];
02034             break;
02035           }
02036         }
02037
02038         /* Find 2nd tropopause... */
02039         if (ctl->met_tropo == 4) {
02040           met->pt[ix][iy] = GSL_NAN;
02041           for (; iz <= 140; iz++) {
02042             found = 1;
02043             for (iz2 = iz + 1; iz2 <= iz + 10; iz2++)
02044               if (1000. * G0 / RA * log(t2[iz2] / t2[iz])
02045                   / log(p2[iz2] / p2[iz]) < 3.0) {
02046                 found = 0;
02047                 break;
02048               }
02049             if (found)
02050               break;
02051           }
02052           for (; iz <= 140; iz++) {
02053             found = 1;
02054             for (iz2 = iz + 1; iz2 <= iz + 20; iz2++)
02055               if (1000. * G0 / RA * log(t2[iz2] / t2[iz])
02056                   / log(p2[iz2] / p2[iz]) > 2.0) {
02057                 found = 0;
02058                 break;
02059               }
02060             if (found) {
02061               if (iz > 0 && iz < 140)
02062                 met->pt[ix][iy] = p2[iz];
02063               break;
02064             }
02065           }
02066         }
02067       }
02068   }
02069
02070   /* Use dynamical tropopause... */
02071   else if (ctl->met_tropo == 5) {
02072
02073     /* Loop over grid points... */
02074     for (ix = 0; ix < met->nx; ix++)
02075       for (iy = 0; iy < met->ny; iy++) {
02076
02077         /* Interpolate potential vorticity profile... */
02078         for (iz = 0; iz < met->np; iz++)
02079           pv[iz] = met->pv[ix][iy][iz];
02080         gsl_spline_init(spline, z, pv, (size_t) met->np);
02081         for (iz = 0; iz <= 160; iz++)
02082           pv2[iz] = gsl_spline_eval(spline, z2[iz], acc);
02083
02084         /* Interpolate potential temperature profile... */
02085         for (iz = 0; iz < met->np; iz++)
02086           th[iz] = THETA(met->p[iz], met->t[ix][iy][iz]);
02087         gsl_spline_init(spline, z, th, (size_t) met->np);
02088         for (iz = 0; iz <= 160; iz++)
02089           th2[iz] = gsl_spline_eval(spline, z2[iz], acc);
02090
02091         /* Find dynamical tropopause 3.5 PVU + 380 K */
02092         met->pt[ix][iy] = GSL_NAN;
02093         for (iz = 0; iz <= 160; iz++)
02094           if (fabs(pv2[iz]) >= 3.5 || th2[iz] >= 380.) {
02095             if (iz > 0 && iz < 160)
```

```
02096               met->pt[ix][iy] = p2[iz];
02097             break;
02098           }
02099       }
02100   }
02101
02102   else
02103     ERRMSG("Cannot calculate tropopause!");
02104
02105   /* Free... */
02106   gsl_spline_free(spline);
02107   gsl_interp_accel_free(acc);
02108 }
02109
02110 /*****************************************************************************/
02111
02112 double scan_ctl(
02113   const char *filename,
02114   int argc,
02115   char *argv[],
02116   const char *varname,
02117   int arridx,
02118   const char *defvalue,
02119   char *value) {
02120
02121   FILE *in = NULL;
02122
02123   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
02124     msg[2 * LEN], rvarname[LEN], rval[LEN];
02125
02126   int contain = 0, i;
02127
02128   /* Open file... */
02129   if (filename[strlen(filename) - 1] != '-')
02130     if (!(in = fopen(filename, "r")))
02131       ERRMSG("Cannot open file!");
02132
02133   /* Set full variable name... */
02134   if (arridx >= 0) {
02135     sprintf(fullname1, "%s[%d]", varname, arridx);
02136     sprintf(fullname2, "%s[*]", varname);
02137   } else {
02138     sprintf(fullname1, "%s", varname);
02139     sprintf(fullname2, "%s", varname);
02140   }
02141
02142   /* Read data... */
02143   if (in != NULL)
02144     while (fgets(line, LEN, in))
02145       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
02146         if (strcasecmp(rvarname, fullname1) == 0 ||
02147             strcasecmp(rvarname, fullname2) == 0) {
02148           contain = 1;
02149           break;
02150         }
02151   for (i = 1; i < argc - 1; i++)
02152     if (strcasecmp(argv[i], fullname1) == 0 ||
02153         strcasecmp(argv[i], fullname2) == 0) {
02154       sprintf(rval, "%s", argv[i + 1]);
02155       contain = 1;
02156       break;
02157     }
02158
02159   /* Close file... */
02160   if (in != NULL)
02161     fclose(in);
02162
02163   /* Check for missing variables... */
02164   if (!contain) {
02165     if (strlen(defvalue) > 0)
02166       sprintf(rval, "%s", defvalue);
02167     else {
02168       sprintf(msg, "Missing variable %s!\n", fullname1);
02169       ERRMSG(msg);
02170     }
02171   }
02172
02173   /* Write info... */
02174   printf("%s = %s\n", fullname1, rval);
02175
02176   /* Return values... */
02177   if (value != NULL)
02178     sprintf(value, "%s", rval);
02179   return atof(rval);
02180 }
02181
02182 /*****************************************************************************/
```

```
02183
02184 void time2jsec(
02185   int year,
02186   int mon,
02187   int day,
02188   int hour,
02189   int min,
02190   int sec,
02191   double remain,
02192   double *jsec) {
02193
02194   struct tm t0, t1;
02195
02196   t0.tm_year = 100;
02197   t0.tm_mon = 0;
02198   t0.tm_mday = 1;
02199   t0.tm_hour = 0;
02200   t0.tm_min = 0;
02201   t0.tm_sec = 0;
02202
02203   t1.tm_year = year - 1900;
02204   t1.tm_mon = mon - 1;
02205   t1.tm_mday = day;
02206   t1.tm_hour = hour;
02207   t1.tm_min = min;
02208   t1.tm_sec = sec;
02209
02210   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
02211 }
02212
02213 /*****************************************************************************/
02214
02215 void timer(
02216   const char *name,
02217   int id,
02218   int mode) {
02219
02220   static double starttime[NTIMER], runtime[NTIMER];
02221
02222   /* Check id... */
02223   if (id < 0 || id >= NTIMER)
02224     ERRMSG("Too many timers!");
02225
02226   /* Start timer... */
02227   if (mode == 1) {
02228     if (starttime[id] <= 0)
02229       starttime[id] = omp_get_wtime();
02230     else
02231       ERRMSG("Timer already started!");
02232   }
02233
02234   /* Stop timer... */
02235   else if (mode == 2) {
02236     if (starttime[id] > 0) {
02237       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
02238       starttime[id] = -1;
02239     }
02240   }
02241
02242   /* Print timer... */
02243   else if (mode == 3) {
02244     printf("%s = %.3f s\n", name, runtime[id]);
02245     runtime[id] = 0;
02246   }
02247 }
02248
02249 /*****************************************************************************/
02250
02251 void write_atm(
02252   const char *filename,
02253   ctl_t * ctl,
02254   atm_t * atm,
02255   double t) {
02256
02257   FILE *in, *out;
02258
02259   char line[LEN];
02260
02261   double r, t0, t1;
02262
02263   int ip, iq, year, mon, day, hour, min, sec;
02264
02265   /* Set time interval for output... */
02266   t0 = t - 0.5 * ctl->dt_mod;
02267   t1 = t + 0.5 * ctl->dt_mod;
02268
02269   /* Write info... */
```

```
02270   printf("Write atmospheric data: %s\n", filename);
02271
02272   /* Write ASCII data... */
02273   if (ctl->atm_type == 0) {
02274
02275     /* Check if gnuplot output is requested... */
02276     if (ctl->atm_gpfile[0] != '-') {
02277
02278       /* Create gnuplot pipe... */
02279       if (!(out = popen("gnuplot", "w")))
02280         ERRMSG("Cannot create pipe to gnuplot!");
02281
02282       /* Set plot filename... */
02283       fprintf(out, "set out \"%s.png\"\n", filename);
02284
02285       /* Set time string... */
02286       jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
02287       fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
02288               year, mon, day, hour, min);
02289
02290       /* Dump gnuplot file to pipe... */
02291       if (!(in = fopen(ctl->atm_gpfile, "r")))
02292         ERRMSG("Cannot open file!");
02293       while (fgets(line, LEN, in))
02294         fprintf(out, "%s", line);
02295       fclose(in);
02296     }
02297
02298     else {
02299
02300       /* Create file... */
02301       if (!(out = fopen(filename, "w")))
02302         ERRMSG("Cannot create file!");
02303     }
02304
02305     /* Write header... */
02306     fprintf(out,
02307             "# $1 = time [s]\n"
02308             "# $2 = altitude [km]\n"
02309             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
02310     for (iq = 0; iq < ctl->nq; iq++)
02311       fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
02312               ctl->qnt_unit[iq]);
02313     fprintf(out, "\n");
02314
02315     /* Write data... */
02316     for (ip = 0; ip < atm->np; ip++) {
02317
02318       /* Check time... */
02319       if (ctl->atm_filter && (atm->time[ip] < t0 || atm->time[ip] > t1))
02320         continue;
02321
02322       /* Write output... */
02323       fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
02324               atm->lon[ip], atm->lat[ip]);
02325       for (iq = 0; iq < ctl->nq; iq++) {
02326         fprintf(out, " ");
02327         fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
02328       }
02329       fprintf(out, "\n");
02330     }
02331
02332     /* Close file... */
02333     fclose(out);
02334   }
02335
02336   /* Write binary data... */
02337   else if (ctl->atm_type == 1) {
02338
02339     /* Create file... */
02340     if (!(out = fopen(filename, "w")))
02341       ERRMSG("Cannot create file!");
02342
02343     /* Write data... */
02344     FWRITE(&atm->np, int,
02345            1,
02346            out);
02347     FWRITE(atm->time, double,
02348              (size_t) atm->np,
02349            out);
02350     FWRITE(atm->p, double,
02351              (size_t) atm->np,
02352            out);
02353     FWRITE(atm->lon, double,
02354              (size_t) atm->np,
02355            out);
02356     FWRITE(atm->lat, double,
```

```
02357             (size_t) atm->np,
02358           out);
02359     for (iq = 0; iq < ctl->nq; iq++)
02360       FWRITE(atm->q[iq], double,
02361              (size_t) atm->np,
02362            out);
02363
02364     /* Close file... */
02365     fclose(out);
02366   }
02367
02368   /* Error... */
02369   else
02370     ERRMSG("Atmospheric data type not supported!");
02371 }
02372
02373 /*****************************************************************************/
02374
02375 void write_csi(
02376   const char *filename,
02377   ctl_t * ctl,
02378   atm_t * atm,
02379   double t) {
02380
02381   static FILE *in, *out;
02382
02383   static char line[LEN];
02384
02385   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
02386     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
02387
02388   static int obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
02389
02390   /* Init... */
02391   if (t == ctl->t_start) {
02392
02393     /* Check quantity index for mass... */
02394     if (ctl->qnt_m < 0)
02395       ERRMSG("Need quantity mass!");
02396
02397     /* Open observation data file... */
02398     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
02399     if (!(in = fopen(ctl->csi_obsfile, "r")))
02400       ERRMSG("Cannot open file!");
02401
02402     /* Create new file... */
02403     printf("Write CSI data: %s\n", filename);
02404     if (!(out = fopen(filename, "w")))
02405       ERRMSG("Cannot create file!");
02406
02407     /* Write header... */
02408     fprintf(out,
02409             "# $1 = time [s]\n"
02410             "# $2 = number of hits (cx)\n"
02411             "# $3 = number of misses (cy)\n"
02412             "# $4 = number of false alarms (cz)\n"
02413             "# $5 = number of observations (cx + cy)\n"
02414             "# $6 = number of forecasts (cx + cz)\n"
02415             "# $7 = bias (forecasts/observations) [%%]\n"
02416             "# $8 = probability of detection (POD) [%%]\n"
02417             "# $9 = false alarm rate (FAR) [%%]\n"
02418             "# $10 = critical success index (CSI) [%%]\n\n");
02419   }
02420
02421   /* Set time interval... */
02422   t0 = t - 0.5 * ctl->dt_mod;
02423   t1 = t + 0.5 * ctl->dt_mod;
02424
02425   /* Initialize grid cells... */
02426   for (ix = 0; ix < ctl->csi_nx; ix++)
02427     for (iy = 0; iy < ctl->csi_ny; iy++)
02428       for (iz = 0; iz < ctl->csi_nz; iz++)
02429         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
02430
02431   /* Read observation data... */
02432   while (fgets(line, LEN, in)) {
02433
02434     /* Read data... */
02435     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
02436         5)
02437       continue;
02438
02439     /* Check time... */
02440     if (rt < t0)
02441       continue;
02442     if (rt > t1)
02443       break;
```

```
02444
02445     /* Calculate indices... */
02446     ix = (int) ((rlon - ctl->csi_lon0)
02447                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
02448     iy = (int) ((rlat - ctl->csi_lat0)
02449                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
02450     iz = (int) ((rz - ctl->csi_z0)
02451                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
02452
02453     /* Check indices... */
02454     if (ix < 0 || ix >= ctl->csi_nx ||
02455         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
02456       continue;
02457
02458     /* Get mean observation index... */
02459     obsmean[ix][iy][iz] += robs;
02460     obscount[ix][iy][iz]++;
02461   }
02462
02463   /* Analyze model data... */
02464   for (ip = 0; ip < atm->np; ip++) {
02465
02466     /* Check time... */
02467     if (atm->time[ip] < t0 || atm->time[ip] > t1)
02468       continue;
02469
02470     /* Get indices... */
02471     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
02472                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
02473     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
02474                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
02475     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
02476                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
02477
02478     /* Check indices... */
02479     if (ix < 0 || ix >= ctl->csi_nx ||
02480         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
02481       continue;
02482
02483     /* Get total mass in grid cell... */
02484     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
02485   }
02486
02487   /* Analyze all grid cells... */
02488   for (ix = 0; ix < ctl->csi_nx; ix++)
02489     for (iy = 0; iy < ctl->csi_ny; iy++)
02490       for (iz = 0; iz < ctl->csi_nz; iz++) {
02491
02492         /* Calculate mean observation index... */
02493         if (obscount[ix][iy][iz] > 0)
02494           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
02495
02496         /* Calculate column density... */
02497         if (modmean[ix][iy][iz] > 0) {
02498           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
02499           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
02500           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
02501           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
02502             * cos(lat * M_PI / 180.);
02503           modmean[ix][iy][iz] /= (1e6 * area);
02504         }
02505
02506         /* Calculate CSI... */
02507         if (obscount[ix][iy][iz] > 0) {
02508           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
02509               modmean[ix][iy][iz] >= ctl->csi_modmin)
02510             cx++;
02511           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
02512                    modmean[ix][iy][iz] < ctl->csi_modmin)
02513             cy++;
02514           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
02515                    modmean[ix][iy][iz] >= ctl->csi_modmin)
02516             cz++;
02517         }
02518       }
02519
02520   /* Write output... */
02521   if (fmod(t, ctl->csi_dt_out) == 0) {
02522
02523     /* Write... */
02524     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
02525             t, cx, cy, cz, cx + cy, cx + cz,
02526             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
02527             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
02528             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
02529             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
02530
```

```
02531     /* Set counters to zero... */
02532     cx = cy = cz = 0;
02533   }
02534
02535   /* Close file... */
02536   if (t == ctl->t_stop)
02537     fclose(out);
02538 }
02539
02540 /*****************************************************************************/
02541
02542 void write_ens(
02543   const char *filename,
02544   ctl_t * ctl,
02545   atm_t * atm,
02546   double t) {
02547
02548   static FILE *out;
02549
02550   static double dummy, ens, lat, lon, p[NENS], q[NQ][NENS],
02551     t0, t1, x[NENS][3], xm[3];
02552
02553   static int ip, iq;
02554
02555   static size_t i, n;
02556
02557   /* Init... */
02558   if (t == ctl->t_start) {
02559
02560     /* Check quantities... */
02561     if (ctl->qnt_ens < 0)
02562       ERRMSG("Missing ensemble IDs!");
02563
02564     /* Create new file... */
02565     printf("Write ensemble data: %s\n", filename);
02566     if (!(out = fopen(filename, "w")))
02567       ERRMSG("Cannot create file!");
02568
02569     /* Write header... */
02570     fprintf(out,
02571             "# $1 = time [s]\n"
02572             "# $2 = altitude [km]\n"
02573             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
02574     for (iq = 0; iq < ctl->nq; iq++)
02575       fprintf(out, "# $%d = %s (mean) [%s]\n", 5 + iq,
02576               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
02577     for (iq = 0; iq < ctl->nq; iq++)
02578       fprintf(out, "# $%d = %s (sigma) [%s]\n", 5 + ctl->nq + iq,
02579               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
02580     fprintf(out, "# $%d = number of members\n\n", 5 + 2 * ctl->nq);
02581   }
02582
02583   /* Set time interval... */
02584   t0 = t - 0.5 * ctl->dt_mod;
02585   t1 = t + 0.5 * ctl->dt_mod;
02586
02587   /* Init... */
02588   ens = GSL_NAN;
02589   n = 0;
02590
02591   /* Loop over air parcels... */
02592   for (ip = 0; ip < atm->np; ip++) {
02593
02594     /* Check time... */
02595     if (atm->time[ip] < t0 || atm->time[ip] > t1)
02596       continue;
02597
02598     /* Check ensemble id... */
02599     if (atm->q[ctl->qnt_ens][ip] != ens) {
02600
02601       /* Write results... */
02602       if (n > 0) {
02603
02604         /* Get mean position... */
02605         xm[0] = xm[1] = xm[2] = 0;
02606         for (i = 0; i < n; i++) {
02607           xm[0] += x[i][0] / (double) n;
02608           xm[1] += x[i][1] / (double) n;
02609           xm[2] += x[i][2] / (double) n;
02610         }
02611         cart2geo(xm, &dummy, &lon, &lat);
02612         fprintf(out, "%.2f %g %g %g", t, Z(gsl_stats_mean(p, 1, n)), lon,
02613                 lat);
02614
02615         /* Get quantity statistics... */
02616         for (iq = 0; iq < ctl->nq; iq++) {
02617           fprintf(out, " ");
```

```
02618           fprintf(out, ctl->qnt_format[iq], gsl_stats_mean(q[iq], 1, n));
02619         }
02620         for (iq = 0; iq < ctl->nq; iq++) {
02621           fprintf(out, " ");
02622           fprintf(out, ctl->qnt_format[iq], gsl_stats_sd(q[iq], 1, n));
02623         }
02624         fprintf(out, " %lu\n", n);
02625       }
02626
02627       /* Init new ensemble... */
02628       ens = atm->q[ctl->qnt_ens][ip];
02629       n = 0;
02630     }
02631
02632     /* Save data... */
02633     p[n] = atm->p[ip];
02634     geo2cart(0, atm->lon[ip], atm->lat[ip], x[n]);
02635     for (iq = 0; iq < ctl->nq; iq++)
02636       q[iq][n] = atm->q[iq][ip];
02637     if ((++n) >= NENS)
02638       ERRMSG("Too many data points!");
02639   }
02640
02641   /* Write results... */
02642   if (n > 0) {
02643
02644     /* Get mean position... */
02645     xm[0] = xm[1] = xm[2] = 0;
02646     for (i = 0; i < n; i++) {
02647       xm[0] += x[i][0] / (double) n;
02648       xm[1] += x[i][1] / (double) n;
02649       xm[2] += x[i][2] / (double) n;
02650     }
02651     cart2geo(xm, &dummy, &lon, &lat);
02652     fprintf(out, "%.2f %g %g %g", t, Z(gsl_stats_mean(p, 1, n)), lon, lat);
02653
02654     /* Get quantity statistics... */
02655     for (iq = 0; iq < ctl->nq; iq++) {
02656       fprintf(out, " ");
02657       fprintf(out, ctl->qnt_format[iq], gsl_stats_mean(q[iq], 1, n));
02658     }
02659     for (iq = 0; iq < ctl->nq; iq++) {
02660       fprintf(out, " ");
02661       fprintf(out, ctl->qnt_format[iq], gsl_stats_sd(q[iq], 1, n));
02662     }
02663     fprintf(out, " %lu\n", n);
02664   }
02665
02666   /* Close file... */
02667   if (t == ctl->t_stop)
02668     fclose(out);
02669 }
02670
02671 /*****************************************************************************/
02672
02673 void write_grid(
02674   const char *filename,
02675   ctl_t * ctl,
02676   met_t * met0,
02677   met_t * met1,
02678   atm_t * atm,
02679   double t) {
02680
02681   FILE *in, *out;
02682
02683   char line[LEN];
02684
02685   static double mass[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
02686     area, rho_air, press, temp, cd, vmr, t0, t1, r;
02687
02688   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
02689
02690   /* Check dimensions... */
02691   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
02692     ERRMSG("Grid dimensions too large!");
02693
02694   /* Check quantity index for mass... */
02695   if (ctl->qnt_m < 0)
02696     ERRMSG("Need quantity mass!");
02697
02698   /* Set time interval for output... */
02699   t0 = t - 0.5 * ctl->dt_mod;
02700   t1 = t + 0.5 * ctl->dt_mod;
02701
02702   /* Set grid box size... */
02703   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
02704   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
```

```
02705   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
02706
02707   /* Initialize grid... */
02708   for (ix = 0; ix < ctl->grid_nx; ix++)
02709     for (iy = 0; iy < ctl->grid_ny; iy++)
02710       for (iz = 0; iz < ctl->grid_nz; iz++)
02711         mass[ix][iy][iz] = 0;
02712
02713   /* Average data... */
02714   for (ip = 0; ip < atm->np; ip++)
02715     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
02716
02717       /* Get index... */
02718       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
02719       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
02720       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
02721
02722       /* Check indices... */
02723       if (ix < 0 || ix >= ctl->grid_nx ||
02724           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
02725         continue;
02726
02727       /* Add mass... */
02728       mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
02729     }
02730
02731   /* Check if gnuplot output is requested... */
02732   if (ctl->grid_gpfile[0] != '-') {
02733
02734     /* Write info... */
02735     printf("Plot grid data: %s.png\n", filename);
02736
02737     /* Create gnuplot pipe... */
02738     if (!(out = popen("gnuplot", "w")))
02739       ERRMSG("Cannot create pipe to gnuplot!");
02740
02741     /* Set plot filename... */
02742     fprintf(out, "set out \"%s.png\"\n", filename);
02743
02744     /* Set time string... */
02745     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
02746     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
02747             year, mon, day, hour, min);
02748
02749     /* Dump gnuplot file to pipe... */
02750     if (!(in = fopen(ctl->grid_gpfile, "r")))
02751       ERRMSG("Cannot open file!");
02752     while (fgets(line, LEN, in))
02753       fprintf(out, "%s", line);
02754     fclose(in);
02755   }
02756
02757   else {
02758
02759     /* Write info... */
02760     printf("Write grid data: %s\n", filename);
02761
02762     /* Create file... */
02763     if (!(out = fopen(filename, "w")))
02764       ERRMSG("Cannot create file!");
02765   }
02766
02767   /* Write header... */
02768   fprintf(out,
02769           "# $1 = time [s]\n"
02770           "# $2 = altitude [km]\n"
02771           "# $3 = longitude [deg]\n"
02772           "# $4 = latitude [deg]\n"
02773           "# $5 = surface area [km^2]\n"
02774           "# $6 = layer width [km]\n"
02775           "# $7 = temperature [K]\n"
02776           "# $8 = column density [kg/m^2]\n"
02777           "# $9 = volume mixing ratio [1]\n\n");
02778
02779   /* Write data... */
02780   for (ix = 0; ix < ctl->grid_nx; ix++) {
02781     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
02782       fprintf(out, "\n");
02783     for (iy = 0; iy < ctl->grid_ny; iy++) {
02784       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
02785         fprintf(out, "\n");
02786       for (iz = 0; iz < ctl->grid_nz; iz++)
02787         if (!ctl->grid_sparse || mass[ix][iy][iz] > 0) {
02788
02789           /* Set coordinates... */
02790           z = ctl->grid_z0 + dz * (iz + 0.5);
02791           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
```

```
02792           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
02793
02794           /* Get pressure and temperature... */
02795           press = P(z);
02796           intpol_met_time(met0, met1, t, press, lon, lat, NULL, NULL,
02797                           NULL, &temp, NULL, NULL, NULL, NULL, NULL, NULL);
02798
02799           /* Calculate surface area... */
02800           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
02801             * cos(lat * M_PI / 180.);
02802
02803           /* Calculate column density... */
02804           cd = mass[ix][iy][iz] / (1e6 * area);
02805
02806           /* Calculate volume mixing ratio... */
02807           rho_air = 100. * press / (RA * temp);
02808           vmr = MA / ctl->molmass * mass[ix][iy][iz]
02809             / (rho_air * 1e6 * area * 1e3 * dz);
02810
02811           /* Write output... */
02812           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
02813                   t, z, lon, lat, area, dz, temp, cd, vmr);
02814         }
02815     }
02816   }
02817
02818   /* Close file... */
02819   fclose(out);
02820 }
02821
02822 /*****************************************************************************/
02823
02824 void write_prof(
02825   const char *filename,
02826   ctl_t * ctl,
02827   met_t * met0,
02828   met_t * met1,
02829   atm_t * atm,
02830   double t) {
02831
02832   static FILE *in, *out;
02833
02834   static char line[LEN];
02835
02836   static double mass[GX][GY][GZ], obsmean[GX][GY], rt, rz, rlon, rlat, robs,
02837     t0, t1, area, dz, dlon, dlat, lon, lat, z, press, temp, rho_air, vmr, h2o,
02838     o3;
02839
02840   static int obscount[GX][GY], ip, ix, iy, iz, okay;
02841
02842   /* Init... */
02843   if (t == ctl->t_start) {
02844
02845     /* Check quantity index for mass... */
02846     if (ctl->qnt_m < 0)
02847       ERRMSG("Need quantity mass!");
02848
02849     /* Check dimensions... */
02850     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
02851       ERRMSG("Grid dimensions too large!");
02852
02853     /* Open observation data file... */
02854     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
02855     if (!(in = fopen(ctl->prof_obsfile, "r")))
02856       ERRMSG("Cannot open file!");
02857
02858     /* Create new output file... */
02859     printf("Write profile data: %s\n", filename);
02860     if (!(out = fopen(filename, "w")))
02861       ERRMSG("Cannot create file!");
02862
02863     /* Write header... */
02864     fprintf(out,
02865             "# $1  = time [s]\n"
02866             "# $2  = altitude [km]\n"
02867             "# $3  = longitude [deg]\n"
02868             "# $4  = latitude [deg]\n"
02869             "# $5  = pressure [hPa]\n"
02870             "# $6  = temperature [K]\n"
02871             "# $7  = volume mixing ratio [1]\n"
02872             "# $8  = H2O volume mixing ratio [1]\n"
02873             "# $9  = O3 volume mixing ratio [1]\n"
02874             "# $10 = mean BT index [K]\n");
02875
02876     /* Set grid box size... */
02877     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
02878     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
```

```
02879     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
02880   }
02881
02882   /* Set time interval... */
02883   t0 = t - 0.5 * ctl->dt_mod;
02884   t1 = t + 0.5 * ctl->dt_mod;
02885
02886   /* Initialize... */
02887   for (ix = 0; ix < ctl->prof_nx; ix++)
02888     for (iy = 0; iy < ctl->prof_ny; iy++) {
02889       obsmean[ix][iy] = 0;
02890       obscount[ix][iy] = 0;
02891       for (iz = 0; iz < ctl->prof_nz; iz++)
02892         mass[ix][iy][iz] = 0;
02893     }
02894
02895   /* Read observation data... */
02896   while (fgets(line, LEN, in)) {
02897
02898     /* Read data... */
02899     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
02900         5)
02901       continue;
02902
02903     /* Check time... */
02904     if (rt < t0)
02905       continue;
02906     if (rt > t1)
02907       break;
02908
02909     /* Calculate indices... */
02910     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
02911     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
02912
02913     /* Check indices... */
02914     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
02915       continue;
02916
02917     /* Get mean observation index... */
02918     obsmean[ix][iy] += robs;
02919     obscount[ix][iy]++;
02920   }
02921
02922   /* Analyze model data... */
02923   for (ip = 0; ip < atm->np; ip++) {
02924
02925     /* Check time... */
02926     if (atm->time[ip] < t0 || atm->time[ip] > t1)
02927       continue;
02928
02929     /* Get indices... */
02930     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
02931     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
02932     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
02933
02934     /* Check indices... */
02935     if (ix < 0 || ix >= ctl->prof_nx ||
02936         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
02937       continue;
02938
02939     /* Get total mass in grid cell... */
02940     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
02941   }
02942
02943   /* Extract profiles... */
02944   for (ix = 0; ix < ctl->prof_nx; ix++)
02945     for (iy = 0; iy < ctl->prof_ny; iy++)
02946       if (obscount[ix][iy] > 0) {
02947
02948         /* Check profile... */
02949         okay = 0;
02950         for (iz = 0; iz < ctl->prof_nz; iz++)
02951           if (mass[ix][iy][iz] > 0)
02952             okay = 1;
02953         if (!okay)
02954           continue;
02955
02956         /* Write output... */
02957         fprintf(out, "\n");
02958
02959         /* Loop over altitudes... */
02960         for (iz = 0; iz < ctl->prof_nz; iz++) {
02961
02962           /* Set coordinates... */
02963           z = ctl->prof_z0 + dz * (iz + 0.5);
02964           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
02965           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
```

```
02966
02967           /* Get pressure and temperature... */
02968           press = P(z);
02969           intpol_met_time(met0, met1, t, press, lon, lat, NULL, NULL,
02970                           NULL, &temp, NULL, NULL, NULL, NULL, &h2o, &o3);
02971
02972           /* Calculate surface area... */
02973           area = dlat * dlon * gsl_pow_2(M_PI * RE / 180.)
02974             * cos(lat * M_PI / 180.);
02975
02976           /* Calculate volume mixing ratio... */
02977           rho_air = 100. * press / (RA * temp);
02978           vmr = MA / ctl->molmass * mass[ix][iy][iz]
02979             / (rho_air * area * dz * 1e9);
02980
02981           /* Write output... */
02982           fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g\n",
02983                   t, z, lon, lat, press, temp, vmr, h2o, o3,
02984                   obsmean[ix][iy] / obscount[ix][iy]);
02985         }
02986       }
02987
02988   /* Close file... */
02989   if (t == ctl->t_stop)
02990     fclose(out);
02991 }
02992
02993 /*****************************************************************************/
02994
02995 void write_station(
02996   const char *filename,
02997   ctl_t * ctl,
02998   atm_t * atm,
02999   double t) {
03000
03001   static FILE *out;
03002
03003   static double rmax2, t0, t1, x0[3], x1[3];
03004
03005   static int ip, iq;
03006
03007   /* Init... */
03008   if (t == ctl->t_start) {
03009
03010     /* Write info... */
03011     printf("Write station data: %s\n", filename);
03012
03013     /* Create new file... */
03014     if (!(out = fopen(filename, "w")))
03015       ERRMSG("Cannot create file!");
03016
03017     /* Write header... */
03018     fprintf(out,
03019             "# $1 = time [s]\n"
03020             "# $2 = altitude [km]\n"
03021             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
03022     for (iq = 0; iq < ctl->nq; iq++)
03023       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
03024               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
03025     fprintf(out, "\n");
03026
03027     /* Set geolocation and search radius... */
03028     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
03029     rmax2 = gsl_pow_2(ctl->stat_r);
03030   }
03031
03032   /* Set time interval for output... */
03033   t0 = t - 0.5 * ctl->dt_mod;
03034   t1 = t + 0.5 * ctl->dt_mod;
03035
03036   /* Loop over air parcels... */
03037   for (ip = 0; ip < atm->np; ip++) {
03038
03039     /* Check time... */
03040     if (atm->time[ip] < t0 || atm->time[ip] > t1)
03041       continue;
03042
03043     /* Check station flag... */
03044     if (ctl->qnt_stat >= 0)
03045       if (atm->q[ctl->qnt_stat][ip])
03046         continue;
03047
03048     /* Get Cartesian coordinates... */
03049     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
03050
03051     /* Check horizontal distance... */
03052     if (DIST2(x0, x1) > rmax2)
```

```
03053       continue;
03054
03055     /* Set station flag... */
03056     if (ctl->qnt_stat >= 0)
03057       atm->q[ctl->qnt_stat][ip] = 1;
03058
03059     /* Write data... */
03060     fprintf(out, "%.2f %g %g %g",
03061             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
03062     for (iq = 0; iq < ctl->nq; iq++) {
03063       fprintf(out, " ");
03064       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
03065     }
03066     fprintf(out, "\n");
03067   }
03068
03069   /* Close file... */
03070   if (t == ctl->t_stop)
03071     fclose(out);
03072 }
```

5.21 libtrac.h File Reference

MPTRAC library declarations.

Data Structures

- struct ctl_t

  Control parameters.
- struct atm_t

  Atmospheric 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.
- double deg2dx (double dlon, double lat)

  Convert degrees to horizontal distance.
- double deg2dy (double dlat)

  Convert degrees to horizontal distance.
- double dp2dz (double dp, double p)

  Convert pressure to vertical distance.
- double dx2deg (double dx, double lat)

  Convert horizontal distance to degrees.
- double dy2deg (double dy)

  Convert horizontal distance to degrees.

- 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;
00036
00037   radius = NORM(x);
00038   *lat = asin(x[2] / radius) * 180 / M_PI;
00039   *lon = atan2(x[1], x[0]) * 180 / M_PI;
00040   *z = radius - RE;
00041 }
```

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

Climatology of HNO3 volume mixing ratios.

Definition at line 45 of file libtrac.c.

```
00048            {
00049
00050   static double secs[12] = { 1209600.00, 3888000.00, 6393600.00,
00051     9072000.00, 11664000.00, 14342400.00,
00052     16934400.00, 19612800.00, 22291200.00,
00053     24883200.00, 27561600.00, 30153600.00
00054   };
00055
00056   static double lats[18] = { -85, -75, -65, -55, -45, -35, -25, -15, -5,
00057     5, 15, 25, 35, 45, 55, 65, 75, 85
00058   };
00059
00060   static double ps[10] = { 4.64159, 6.81292, 10, 14.678, 21.5443,
00061     31.6228, 46.4159, 68.1292, 100, 146.78
00062   };
```

```
00063
00064   static double hno3[12][18][10] = {
00065     {{0.782, 1.65, 2.9, 4.59, 6.71, 8.25, 7.16, 5.75, 2.9, 1.74},
00066      {0.529, 1.64, 2.76, 4.55, 6.58, 8, 6.99, 5.55, 2.68, 1.57},
00067      {0.723, 1.55, 2.73, 4.48, 6.32, 7.58, 7.05, 5.16, 2.49, 1.54},
00068      {0.801, 1.56, 2.74, 4.52, 6.23, 7.35, 6.68, 4.4, 1.97, 1.23},
00069      {0.818, 1.62, 2.77, 4.38, 5.98, 6.84, 5.83, 3.05, 1.15, 0.709},
00070      {0.901, 1.73, 2.78, 4.21, 5.63, 6.16, 4.68, 1.87, 0.617, 0.37},
00071      {0.997, 1.8, 2.79, 4.09, 4.88, 4.96, 3.12, 1.22, 0.311, 0.244},
00072      {1, 1.71, 2.51, 3.4, 3.74, 3.39, 2.25, 0.845, 0.204, 0.222},
00073      {0.997, 1.7, 2.36, 2.88, 3.01, 2.25, 1.77, 0.608, 0.163, 0.181},
00074      {0.991, 1.79, 2.57, 3.06, 3.08, 2.15, 1.81, 0.59, 0.168, 0.104},
00075      {0.974, 1.86, 2.84, 3.8, 3.93, 3.79, 2.91, 1.02, 0.152, 0.0985},
00076      {0.85, 1.86, 3.3, 5.24, 6.55, 6.86, 5.12, 1.93, 0.378, 0.185},
00077      {0.783, 1.89, 3.85, 6.6, 8.56, 8.66, 6.95, 3.95, 1.47, 0.745},
00078      {0.883, 2.05, 4.34, 7.54, 9.68, 9.77, 8.19, 5.72, 3.15, 1.77},
00079      {1.4, 2.44, 4.72, 8.07, 10.5, 10.9, 9.28, 6.95, 4.47, 2.49},
00080      {1.7, 2.43, 4.24, 7.43, 10.4, 11.2, 9.72, 8.15, 5.7, 2.97},
00081      {2.06, 2.27, 3.68, 6.77, 10.3, 10.3, 9.05, 9.1, 6.73, 3.14},
00082      {2.33, 2.39, 3.51, 6.45, 10.3, 9.88, 8.57, 9.42, 7.22, 3.19}},
00083     {{0.947, 2.21, 3.81, 5.69, 7.55, 8.63, 7.53, 5.98, 3.03, 1.64},
00084      {0.642, 2, 3.4, 5.49, 7.5, 8.52, 7.53, 5.83, 2.74, 1.42},
00085      {0.756, 1.83, 3.18, 5.11, 7.24, 8.63, 7.66, 5.5, 2.45, 1.33},
00086      {0.837, 1.75, 3.06, 5, 6.79, 8.08, 7.05, 4.42, 1.81, 1.05},
00087      {0.86, 1.73, 2.96, 4.68, 6.38, 7.38, 6.09, 2.92, 1.06, 0.661},
00088      {0.926, 1.78, 2.89, 4.37, 5.74, 6.14, 4.59, 1.78, 0.561, 0.332},
00089      {0.988, 1.78, 2.75, 3.95, 4.64, 4.49, 2.85, 1.13, 0.271, 0.184},
00090      {0.999, 1.7, 2.44, 3.27, 3.57, 3.03, 2.06, 0.736, 0.181, 0.189},
00091      {0.971, 1.67, 2.23, 2.63, 2.83, 2.15, 1.74, 0.554, 0.157, 0.167},
00092      {0.985, 1.72, 2.34, 2.69, 2.81, 2.11, 1.78, 0.592, 0.152, 0.101},
00093      {0.95, 1.72, 2.57, 3.44, 3.84, 3.89, 2.91, 0.976, 0.135, 0.114},
00094      {0.819, 1.64, 2.93, 4.75, 6.02, 6.93, 5.2, 1.83, 0.347, 0.191},
00095      {0.731, 1.58, 3.3, 5.95, 7.81, 8.32, 6.93, 3.83, 1.47, 0.875},
00096      {0.77, 1.75, 3.74, 6.67, 8.76, 9.41, 8.19, 5.78, 3.32, 2.11},
00097      {1.08, 2.17, 4.24, 7.13, 9.2, 10.3, 9.03, 6.87, 4.65, 3.01},
00098      {1.43, 2.49, 4.31, 7, 9.14, 10.6, 9.34, 7.6, 5.86, 3.64},
00099      {1.5, 2.68, 4.32, 6.75, 8.78, 10.6, 9.05, 7.65, 6.27, 4.07},
00100      {1.73, 2.91, 4.33, 6.67, 8.73, 10.6, 8.5, 7.54, 6.63, 4.17}},
00101     {{1.43, 3.07, 5.22, 7.54, 9.78, 10.4, 10.1, 7.26, 3.61, 1.69},
00102      {0.989, 2.69, 4.76, 7.19, 9.44, 9.94, 9.5, 6.74, 3.24, 1.52},
00103      {0.908, 2.23, 4.11, 6.48, 8.74, 9.41, 8.58, 5.8, 2.66, 1.3},
00104      {0.923, 1.99, 3.61, 5.83, 7.84, 8.6, 7.55, 4.57, 1.87, 0.98},
00105      {0.933, 1.9, 3.31, 5.28, 7.1, 7.84, 6.44, 3.18, 1.1, 0.642},
00106      {0.982, 1.88, 3.1, 4.76, 6.16, 6.57, 5.16, 2.04, 0.598, 0.33},
00107      {1.02, 1.82, 2.88, 4.12, 4.71, 4.54, 3.03, 1.22, 0.268, 0.174},
00108      {0.992, 1.7, 2.51, 3.33, 3.62, 2.87, 2.05, 0.705, 0.161, 0.169},
00109      {0.969, 1.69, 2.2, 2.62, 2.84, 2.13, 1.78, 0.529, 0.146, 0.186},
00110      {0.945, 1.69, 2.27, 2.64, 2.83, 2.2, 1.83, 0.561, 0.139, 0.121},
00111      {0.922, 1.65, 2.48, 3.33, 3.83, 4.09, 2.92, 0.973, 0.117, 0.135},
00112      {0.886, 1.59, 2.66, 4.26, 5.51, 6.57, 5.09, 1.79, 0.342, 0.194},
00113      {0.786, 1.5, 2.78, 5.01, 6.8, 7.83, 6.65, 3.62, 1.45, 1},
00114      {0.745, 1.55, 3.05, 5.49, 7.44, 8.6, 7.8, 5.28, 2.95, 2.12},
00115      {0.938, 1.76, 3.4, 5.82, 7.8, 9.04, 8.43, 6.15, 3.85, 2.82},
00116      {0.999, 2, 3.66, 5.95, 7.94, 9.27, 8.8, 6.93, 4.87, 3.54},
00117      {1.13, 2.23, 3.86, 5.82, 7.65, 9, 8.82, 7.17, 5.72, 4.08},
00118      {1.23, 2.33, 3.94, 5.74, 7.48, 8.9, 8.84, 7.35, 6.3, 4.42}},
00119     {{1.55, 3.2, 6.25, 10, 12.9, 12.9, 11.9, 7.96, 3.96, 1.75},
00120      {1.32, 3.27, 6.32, 9.99, 12.7, 12.4, 11.3, 7.51, 3.66, 1.58},
00121      {1.25, 3.08, 5.77, 8.71, 11.2, 11.2, 9.84, 6.52, 3.23, 1.5},
00122      {1.18, 2.59, 4.76, 7.46, 9.61, 9.66, 8.42, 5.06, 2.25, 1.09},
00123      {1.09, 2.24, 3.99, 6.4, 8.33, 8.54, 7.08, 3.69, 1.36, 0.727},
00124      {1.06, 2.07, 3.52, 5.52, 7.06, 7.26, 5.83, 2.46, 0.732, 0.409},
00125      {1.07, 1.91, 3.09, 4.63, 5.21, 4.9, 3.68, 1.43, 0.326, 0.198},
00126      {1.03, 1.74, 2.63, 3.54, 3.78, 2.89, 2.09, 0.743, 0.175, 0.12},
00127      {0.959, 1.71, 2.32, 2.77, 2.99, 2.24, 1.76, 0.519, 0.149, 0.172},
00128      {0.931, 1.68, 2.32, 2.74, 2.99, 2.46, 1.88, 0.578, 0.156, 0.157},
00129      {0.933, 1.66, 2.49, 3.42, 3.99, 4.12, 2.93, 1.02, 0.181, 0.138},
00130      {0.952, 1.64, 2.6, 4, 5.15, 6.07, 4.84, 1.78, 0.407, 0.286},
00131      {0.84, 1.54, 2.68, 4.47, 5.97, 7.13, 6.23, 3.25, 1.38, 1.02},
00132      {0.714, 1.44, 2.73, 4.68, 6.28, 7.68, 7.21, 4.82, 2.55, 1.96},
00133      {0.838, 1.57, 2.96, 4.93, 6.55, 8.08, 7.74, 5.77, 3.32, 2.52},
00134      {0.823, 1.65, 3.11, 5.09, 6.89, 8.36, 8.31, 6.59, 4.1, 3.04},
00135      {0.886, 1.83, 3.42, 5.33, 6.92, 8.36, 8.63, 7.21, 4.82, 3.46},
00136      {1.07, 2.12, 3.74, 5.54, 6.98, 8.41, 8.75, 7.41, 5.16, 3.62}},
00137     {{1.13, 2.59, 7.49, 13.5, 15.4, 12.9, 11.3, 8.62, 4.18, 1.63},
00138      {0.973, 2.79, 7.23, 12.8, 15.2, 13.3, 11.6, 8.42, 4.06, 1.57},
00139      {1.46, 3.44, 6.78, 10.4, 12.7, 12.1, 10.5, 7.04, 3.59, 1.63},
00140      {1.52, 3.38, 6.04, 9.08, 11, 10.3, 8.9, 5.7, 2.77, 1.37},
00141      {1.32, 2.65, 4.75, 7.49, 9.32, 8.89, 7.42, 4.27, 1.7, 0.88},
00142      {1.19, 2.2, 3.88, 6.36, 8.03, 7.81, 6.19, 2.94, 0.948, 0.527},
00143      {1.14, 1.96, 3.28, 5.26, 6.12, 5.8, 4.47, 1.66, 0.388, 0.229},
00144      {1.07, 1.82, 2.82, 3.92, 4.03, 3.15, 2.31, 0.871, 0.183, 0.0972},
00145      {0.978, 1.77, 2.53, 3.04, 3.1, 2.36, 1.76, 0.575, 0.16, 0.126},
00146      {0.962, 1.72, 2.49, 3.01, 3.22, 2.72, 2, 0.716, 0.162, 0.183},
00147      {0.968, 1.7, 2.6, 3.57, 4.28, 4.35, 3.09, 1.2, 0.262, 0.18},
00148      {0.977, 1.68, 2.71, 4.03, 5.17, 6.01, 4.81, 1.81, 0.473, 0.343},
00149      {0.819, 1.58, 2.75, 4.37, 5.8, 6.9, 5.96, 2.95, 1.19, 0.964},
```

```
00150       {0.672, 1.44, 2.69, 4.42, 5.92, 7.26, 6.79, 4.32, 2.22, 1.83},
00151       {0.783, 1.42, 2.65, 4.45, 6.04, 7.57, 7.39, 5.4, 2.94, 2.25},
00152       {0.757, 1.43, 2.7, 4.54, 6.14, 7.65, 7.51, 5.95, 3.42, 2.39},
00153       {0.758, 1.57, 3.04, 4.88, 6.24, 7.85, 7.58, 6.35, 3.81, 2.52},
00154       {0.835, 1.72, 3.35, 5.24, 6.5, 8.1, 7.67, 6.51, 4, 2.6}},
00155      {{1.5, 2.12, 7.64, 10.5, 5.59, 2.14, 2.2, 3.5, 4.71, 3.26},
00156       {1.32, 2.14, 7.23, 12, 9.3, 5.3, 5.11, 5.37, 5.12, 3.05},
00157       {1.53, 2.92, 6.9, 11.9, 13.5, 11.3, 9.91, 7.18, 4.75, 2.65},
00158       {1.66, 3.48, 6.25, 9.53, 11.3, 10.3, 9.01, 5.76, 2.99, 1.67},
00159       {1.54, 3.03, 5.21, 8.03, 9.66, 8.98, 7.5, 4.64, 2.11, 1.13},
00160       {1.32, 2.39, 4.03, 6.74, 8.52, 8.05, 6.4, 3.48, 1.2, 0.639},
00161       {1.17, 2.08, 3.35, 5.52, 6.86, 6.54, 5.08, 1.97, 0.462, 0.217},
00162       {1.07, 1.92, 3.01, 4.24, 4.47, 3.77, 2.77, 1.07, 0.213, 0.0694},
00163       {0.992, 1.88, 2.76, 3.39, 3.32, 2.52, 1.8, 0.713, 0.192, 0.136},
00164       {0.992, 1.8, 2.63, 3.34, 3.46, 2.95, 2.09, 0.9, 0.242, 0.194},
00165       {0.987, 1.77, 2.67, 3.64, 4.37, 4.36, 3, 1.27, 0.354, 0.229},
00166       {0.979, 1.74, 2.77, 3.99, 5.12, 5.75, 4.53, 1.75, 0.555, 0.302},
00167       {0.832, 1.6, 2.78, 4.32, 5.53, 6.67, 5.69, 2.59, 0.982, 0.66},
00168       {0.696, 1.41, 2.64, 4.31, 5.65, 7.14, 6.56, 3.8, 1.75, 1.41},
00169       {0.788, 1.36, 2.59, 4.3, 5.73, 7.35, 7.04, 4.82, 2.41, 1.8},
00170       {0.761, 1.43, 2.61, 4.28, 5.64, 7.37, 7.11, 5.37, 2.68, 1.9},
00171       {0.701, 1.44, 2.82, 4.64, 5.76, 7.63, 7.07, 5.74, 2.98, 1.88},
00172       {0.763, 1.5, 2.95, 4.97, 6.08, 7.88, 7.12, 5.98, 3.21, 1.91}},
00173      {{3.58, 2.59, 6.49, 5.84, 1.63, 0.282, 0.647, 0.371, 1.36, 2.33},
00174       {3.09, 2.38, 6.37, 7.66, 4.06, 1.23, 1.8, 1.65, 2.32, 2.78},
00175       {2.31, 2.84, 5.58, 9.63, 11, 9.02, 8.2, 6.23, 4.17, 3.08},
00176       {1.61, 3.16, 5.72, 9.13, 11.4, 10.4, 9.15, 6.18, 3.52, 2.3},
00177       {1.32, 2.8, 4.79, 7.44, 9.43, 8.83, 7.41, 4.9, 2.38, 1.38},
00178       {1.14, 2.36, 3.94, 6.41, 8.38, 8.17, 6.53, 3.76, 1.31, 0.656},
00179       {1.05, 2.1, 3.36, 5.45, 7.07, 6.98, 5.44, 2.22, 0.52, 0.176},
00180       {1.02, 2, 3.05, 4.33, 4.74, 4.21, 3.2, 1.26, 0.277, 0.0705},
00181       {1.01, 1.96, 2.9, 3.53, 3.46, 2.69, 1.89, 0.859, 0.254, 0.12},
00182       {1.01, 1.86, 2.7, 3.46, 3.59, 3.03, 2.14, 1, 0.34, 0.199},
00183       {1.02, 1.81, 2.67, 3.68, 4.39, 4.3, 2.93, 1.35, 0.477, 0.25},
00184       {0.991, 1.79, 2.82, 4.05, 5.08, 5.5, 4.21, 1.74, 0.605, 0.259},
00185       {0.844, 1.73, 2.87, 4.38, 5.49, 6.47, 5.5, 2.44, 0.85, 0.422},
00186       {0.729, 1.57, 2.76, 4.43, 5.73, 7.13, 6.43, 3.52, 1.38, 0.913},
00187       {0.819, 1.46, 2.69, 4.45, 5.92, 7.47, 7.05, 4.52, 2, 1.4},
00188       {0.783, 1.47, 2.71, 4.48, 5.92, 7.46, 7.16, 5.08, 2.35, 1.56},
00189       {0.735, 1.51, 2.96, 4.84, 5.92, 7.77, 7.2, 5.54, 2.56, 1.61},
00190       {0.8, 1.61, 3.14, 5.2, 6.26, 8.08, 7.27, 5.72, 2.75, 1.62}},
00191      {{5, 4.43, 5.53, 5.35, 2.33, 0.384, 0.663, 0.164, 0.692, 1.4},
00192       {3.62, 3.79, 4.77, 5.94, 4.12, 1.36, 1.3, 0.973, 1.37, 1.73},
00193       {2.11, 2.7, 4.12, 7.14, 9.03, 7.74, 7.12, 5.44, 3.73, 2.6},
00194       {1.13, 2.32, 4.12, 6.97, 9.86, 9.69, 8.85, 6.22, 3.59, 2.14},
00195       {0.957, 2.28, 4.11, 6.47, 8.66, 8.78, 7.33, 4.94, 2.44, 1.38},
00196       {0.881, 2.1, 3.65, 5.94, 7.98, 8.29, 6.69, 3.95, 1.36, 0.672},
00197       {0.867, 1.96, 3.26, 5.23, 6.94, 7.2, 5.63, 2.41, 0.578, 0.19},
00198       {0.953, 1.94, 2.98, 4.23, 4.83, 4.52, 3.38, 1.34, 0.293, 0.181},
00199       {1.01, 1.91, 2.77, 3.35, 3.3, 2.62, 1.99, 0.905, 0.245, 0.107},
00200       {1.03, 1.81, 2.57, 3.29, 3.43, 2.87, 2.13, 0.988, 0.306, 0.185},
00201       {1.02, 1.78, 2.58, 3.59, 4.19, 4, 2.72, 1.29, 0.389, 0.224},
00202       {1.01, 1.84, 2.84, 4.06, 4.9, 5.08, 3.71, 1.64, 0.529, 0.232},
00203       {0.902, 1.84, 2.98, 4.43, 5.5, 6.28, 5.18, 2.35, 0.734, 0.341},
00204       {0.785, 1.68, 2.93, 4.67, 5.95, 7.3, 6.52, 3.48, 1.24, 0.754},
00205       {0.847, 1.62, 2.94, 4.86, 6.38, 7.99, 7.5, 4.64, 1.93, 1.23},
00206       {0.8, 1.6, 2.94, 4.95, 6.62, 8.16, 7.91, 5.43, 2.43, 1.45},
00207       {0.82, 1.76, 3.37, 5.47, 6.82, 8.24, 7.73, 5.79, 2.69, 1.5},
00208       {0.988, 2.05, 3.87, 6.01, 7.18, 8.41, 7.7, 5.93, 2.89, 1.55}},
00209      {{1.52, 2.7, 3.79, 4.95, 3.8, 1.51, 1.11, 0.784, 1.1, 1.56},
00210       {1.19, 2.16, 3.34, 4.76, 4.61, 2.93, 2.07, 1.65, 1.63, 1.74},
00211       {0.804, 1.65, 2.79, 4.63, 6.64, 6.95, 6.68, 5.11, 3.3, 2.09},
00212       {0.86, 1.8, 3.25, 5.3, 7.91, 8.76, 8.28, 6.01, 3.39, 1.83},
00213       {0.859, 1.95, 3.54, 5.64, 7.88, 8.55, 7.3, 4.88, 2.3, 1.22},
00214       {0.809, 1.88, 3.38, 5.45, 7.47, 8.02, 6.69, 3.98, 1.35, 0.646},
00215       {0.822, 1.81, 3.11, 4.9, 6.62, 6.96, 5.63, 2.47, 0.614, 0.169},
00216       {0.92, 1.83, 2.8, 3.93, 4.56, 4.4, 3.25, 1.31, 0.295, 0.0587},
00217       {0.986, 1.83, 2.6, 3.13, 3.08, 2.53, 1.94, 0.886, 0.244, 0.0815},
00218       {0.997, 1.74, 2.5, 3.16, 3.24, 2.67, 2.05, 0.939, 0.281, 0.147},
00219       {1.01, 1.75, 2.57, 3.55, 4.1, 3.81, 2.53, 1.21, 0.354, 0.197},
00220       {1.04, 1.88, 2.9, 4.16, 4.95, 4.96, 3.48, 1.63, 0.502, 0.163},
00221       {0.967, 1.95, 3.17, 4.72, 5.85, 6.5, 5.34, 2.53, 0.748, 0.303},
00222       {0.846, 1.83, 3.23, 5.15, 6.62, 7.82, 6.85, 3.79, 1.36, 0.714},
00223       {0.91, 1.81, 3.35, 5.55, 7.32, 8.55, 7.88, 5.03, 2.13, 1.1},
00224       {0.87, 1.94, 3.6, 5.97, 7.98, 9.14, 8.71, 6.04, 2.73, 1.41},
00225       {1.04, 2.36, 4.22, 6.57, 8.5, 9.53, 9.22, 6.71, 3.2, 1.56},
00226       {1.36, 2.84, 4.72, 6.94, 8.81, 9.87, 9.59, 7.1, 3.43, 1.65}},
00227      {{0.704, 1.4, 2.03, 3.08, 4.64, 4.24, 2.55, 1.57, 1.99, 1.91},
00228       {0.484, 1.38, 2.08, 3.54, 5.11, 4.98, 3.73, 2.57, 2.29, 1.84},
00229       {0.749, 1.57, 2.63, 4.17, 6.15, 6.97, 6.64, 5.11, 3.35, 1.97},
00230       {0.864, 1.69, 3.16, 4.87, 7.13, 8.33, 7.87, 5.9, 3.17, 1.56},
00231       {0.861, 1.79, 3.28, 5.2, 7.29, 8.32, 7.38, 4.9, 2.23, 1.11},
00232       {0.835, 1.79, 3.19, 4.99, 6.72, 7.58, 6.45, 3.68, 1.25, 0.616},
00233       {0.847, 1.8, 3.07, 4.66, 6.12, 6.6, 5.21, 2.18, 0.554, 0.21},
00234       {0.941, 1.78, 2.68, 3.68, 4.28, 4.18, 2.97, 1.15, 0.238, 0.0968},
00235       {0.98, 1.78, 2.48, 2.99, 2.96, 2.35, 1.88, 0.747, 0.207, 0.105},
00236       {0.978, 1.74, 2.51, 3.07, 3.12, 2.36, 1.95, 0.777, 0.216, 0.146},
```

```
00237       {1.01, 1.79, 2.63, 3.53, 3.95, 3.47, 2.38, 1.08, 0.265, 0.178},
00238       {1.06, 1.94, 3.02, 4.43, 5.19, 5.01, 3.68, 1.71, 0.429, 0.14},
00239       {0.99, 2.02, 3.38, 5.22, 6.56, 6.91, 5.56, 2.75, 0.816, 0.353},
00240       {0.923, 2.05, 3.66, 5.98, 7.78, 8.5, 7.23, 4.26, 1.67, 0.802},
00241       {1.08, 2.27, 4.17, 6.8, 8.89, 9.55, 8.59, 5.64, 2.58, 1.2},
00242       {1.12, 2.5, 4.52, 7.22, 9.76, 10.3, 9.72, 6.79, 3.32, 1.52},
00243       {1.2, 2.64, 4.81, 7.64, 10.5, 11.4, 10.6, 7.65, 3.87, 1.73},
00244       {1.4, 2.91, 5.01, 7.75, 10.7, 11.6, 11.1, 8.02, 4.04, 1.8}},
00245     {{0.75, 1.49, 2.39, 3.39, 4.93, 5.94, 5.03, 2.75, 2.27, 1.78},
00246       {0.508, 1.52, 2.38, 3.82, 5.34, 6.13, 5.6, 3.31, 2.42, 1.73},
00247       {0.715, 1.56, 2.7, 4.39, 6.18, 6.96, 7.1, 5.04, 3.01, 1.75},
00248       {0.813, 1.62, 2.94, 4.65, 6.53, 7.65, 7.52, 5.49, 2.75, 1.41},
00249       {0.802, 1.68, 2.97, 4.64, 6.37, 7.53, 7.01, 4.56, 1.9, 0.955},
00250       {0.816, 1.75, 3.01, 4.59, 6.15, 7.06, 6.15, 3.38, 1.11, 0.61},
00251       {0.867, 1.78, 2.92, 4.35, 5.69, 6.05, 4.73, 1.91, 0.519, 0.269},
00252       {0.932, 1.7, 2.55, 3.44, 4.03, 3.98, 2.74, 1.08, 0.247, 0.132},
00253       {0.937, 1.74, 2.51, 3.09, 3.11, 2.34, 1.84, 0.67, 0.189, 0.121},
00254       {0.942, 1.75, 2.63, 3.3, 3.27, 2.21, 1.87, 0.663, 0.171, 0.147},
00255       {0.959, 1.8, 2.82, 3.78, 4.03, 3.37, 2.53, 1.04, 0.199, 0.146},
00256       {1.01, 1.9, 3.13, 4.76, 5.63, 5.6, 4.31, 1.83, 0.367, 0.172},
00257       {0.989, 2.04, 3.64, 6, 7.62, 7.6, 6, 3.35, 1.05, 0.448},
00258       {1.02, 2.28, 4.32, 7.19, 9.21, 9.16, 7.64, 4.97, 2.2, 0.948},
00259       {1.26, 2.77, 5.2, 8.31, 10.5, 10.4, 9.01, 6.37, 3.46, 1.56},
00260       {1.31, 2.76, 5.23, 8.49, 11.2, 11.3, 10.1, 7.27, 3.98, 1.76},
00261       {1.26, 2.5, 5.14, 8.85, 12.3, 12.3, 11.2, 8.13, 4.45, 1.97},
00262       {1.35, 2.49, 5.26, 9.16, 13, 12.8, 11.8, 8.57, 4.72, 2.05}},
00263     {{0.759, 1.54, 2.54, 4.22, 6.26, 7.44, 7.14, 4.99, 2.84, 1.89},
00264       {0.508, 1.55, 2.5, 4.29, 6.29, 7.29, 7.07, 5.03, 2.77, 1.74},
00265       {0.699, 1.56, 2.62, 4.17, 6.08, 7.38, 7.04, 5.17, 2.81, 1.65},
00266       {0.778, 1.5, 2.65, 4.35, 6.07, 7.28, 6.84, 4.8, 2.28, 1.28},
00267       {0.772, 1.55, 2.71, 4.3, 5.76, 6.91, 6.2, 3.69, 1.45, 0.837},
00268       {0.836, 1.67, 2.78, 4.21, 5.56, 6.41, 5.33, 2.47, 0.807, 0.488},
00269       {0.937, 1.79, 2.78, 4.12, 5.17, 5.38, 3.89, 1.47, 0.392, 0.256},
00270       {0.97, 1.75, 2.52, 3.39, 3.83, 3.63, 2.48, 0.968, 0.212, 0.198},
00271       {0.968, 1.74, 2.5, 3.11, 3.2, 2.34, 1.79, 0.629, 0.169, 0.173},
00272       {0.98, 1.8, 2.69, 3.42, 3.4, 2.18, 1.81, 0.606, 0.164, 0.138},
00273       {0.975, 1.84, 2.96, 4.08, 4.12, 3.5, 2.79, 1.02, 0.145, 0.133},
00274       {0.96, 1.94, 3.27, 5.17, 6.26, 6.35, 4.88, 1.91, 0.329, 0.189},
00275       {0.954, 2.06, 3.8, 6.53, 8.46, 8.32, 6.53, 3.83, 1.32, 0.6},
00276       {1, 2.34, 4.58, 7.71, 9.68, 9.75, 7.96, 5.45, 2.84, 1.39},
00277       {1.24, 2.65, 5.14, 8.51, 10.7, 10.6, 8.96, 6.51, 3.83, 1.85},
00278       {1.34, 2.44, 4.99, 8.63, 11.6, 11.4, 10.1, 7.84, 4.77, 2.24},
00279       {1.33, 2.1, 4.76, 8.78, 12.2, 11.7, 10.8, 8.68, 5.15, 2.35},
00280       {1.42, 2.04, 4.68, 8.92, 12.7, 12, 11.2, 8.99, 5.32, 2.33}}
00281   };
00282
00283   double aux00, aux01, aux10, aux11, sec;
00284
00285   int ilat, ip, isec;
00286
00287   /* Get seconds since begin of year... */
00288   sec = fmod(t, 365.25 * 86400.);
00289
00290   /* Get indices... */
00291   ilat = locate(lats, 18, lat);
00292   ip = locate(ps, 10, p);
00293   isec = locate(secs, 12, sec);
00294
00295   /* Interpolate... */
00296   aux00 = LIN(ps[ip], hno3[isec][ilat][ip],
00297               ps[ip + 1], hno3[isec][ilat][ip + 1], p);
00298   aux01 = LIN(ps[ip], hno3[isec][ilat + 1][ip],
00299               ps[ip + 1], hno3[isec][ilat + 1][ip + 1], p);
00300   aux10 = LIN(ps[ip], hno3[isec + 1][ilat][ip],
00301               ps[ip + 1], hno3[isec + 1][ilat][ip + 1], p);
00302   aux11 = LIN(ps[ip], hno3[isec + 1][ilat + 1][ip],
00303               ps[ip + 1], hno3[isec + 1][ilat + 1][ip + 1], p);
00304   aux00 = LIN(lats[ilat], aux00, lats[ilat + 1], aux01, lat);
00305   aux11 = LIN(lats[ilat], aux10, lats[ilat + 1], aux11, lat);
00306   return LIN(secs[isec], aux00, secs[isec + 1], aux11, sec);
00307 }
```

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 311 of file libtrac.c.

```
00313             {
00314
00315   static double doys[12]
00316   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00317
00318   static double lats[73]
00319     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
00320     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
00321     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
00322     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
00323     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
00324     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
00325     75, 77.5, 80, 82.5, 85, 87.5, 90
00326   };
00327
00328   static double tps[12][73]
00329     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
00330          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
00331          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
00332          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
00333          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
00334          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
00335          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
00336          275.3, 275.6, 275.4, 274.1, 273.5},
00337   {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
00338    300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
00339    150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
00340    98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
00341    98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
00342    220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
00343    284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
00344    287.5, 286.2, 285.8},
00345   {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
00346    297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
00347    161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
00348    100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
00349    99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
00350    186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
00351    279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
00352    304.3, 304.9, 306, 306.6, 306.2, 306},
00353   {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
00354    290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
00355    195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
00356    102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
00357    99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
00358    148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
00359    263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
00360    315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
00361   {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
00362    260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
00363    205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
00364    101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
00365    102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
00366    165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
00367    273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
00368    325.3, 325.8, 325.8},
00369   {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
00370    222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
00371    228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
00372    105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
00373    106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
00374    127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
00375    251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
00376    308.5, 312.2, 313.1, 313.3},
00377   {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
00378    187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
00379    235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
00380    110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
00381    111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
00382    117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
00383    224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
00384    275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
00385   {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
00386    185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
00387    233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
00388    110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
00389    112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
00390    120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
00391    230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
00392    278.2, 282.6, 287.4, 290.9, 292.5, 293},
00393   {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
00394    183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
00395    243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
00396    114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
00397    110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
00398    114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
00399    203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
```

```
00400    276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
00401   {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
00402    215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
00403    237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
00404    111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
00405    106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
00406    112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
00407    206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
00408    279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
00409    305.1},
00410   {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
00411    253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
00412    223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
00413    108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
00414    102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
00415    109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
00416    241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
00417    286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
00418   {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
00419    284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
00420    175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
00421    100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
00422    100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
00423    186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
00424    280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
00425    281.7, 281.1, 281.2}
00426   };
00427
00428   double doy, p0, p1, pt;
00429
00430   int imon, ilat;
00431
00432   /* Get day of year... */
00433   doy = fmod(t / 86400., 365.25);
00434   while (doy < 0)
00435     doy += 365.25;
00436
00437   /* Get indices... */
00438   imon = locate(doys, 12, doy);
00439   ilat = locate(lats, 73, lat);
00440
00441   /* Get tropopause pressure... */
00442   p0 = LIN(lats[ilat], tps[imon][ilat],
00443            lats[ilat + 1], tps[imon][ilat + 1], lat);
00444   p1 = LIN(lats[ilat], tps[imon + 1][ilat],
00445            lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
00446   pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
00447
00448   /* Return tropopause pressure... */
00449   return pt;
00450 }
```

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 454 of file libtrac.c.

```
00458            {
00459
00460   int d0[12] = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00461   int d01[12] = { 1, 32, 61, 92, 122, 153, 183, 214, 245, 275, 306, 336 };
00462
00463   /* Get day of year... */
00464   if (year % 400 == 0 || (year % 100 != 0 && year % 4 == 0))
00465     *doy = d01[mon - 1] + day - 1;
00466   else
00467     *doy = d0[mon - 1] + day - 1;
00468 }
```

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

Get date from day of year.

Definition at line 472 of file libtrac.c.

```
00476             {
00477
00478   int d0[12] = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00479   int d01[12] = { 1, 32, 61, 92, 122, 153, 183, 214, 245, 275, 306, 336 };
00480   int i;
00481
00482   /* Get month and day... */
00483   if (year % 400 == 0 || (year % 100 != 0 && year % 4 == 0)) {
00484     for (i = 11; i >= 0; i--)
00485       if (d01[i] <= doy)
00486         break;
00487     *mon = i + 1;
00488     *day = doy - d01[i] + 1;
00489   } else {
00490     for (i = 11; i >= 0; i--)
00491       if (d0[i] <= doy)
00492         break;
00493     *mon = i + 1;
00494     *day = doy - d0[i] + 1;
00495   }
00496 }
```

5.21.2.6 double deg2dx (double *dlon*, double *lat*)

Convert degrees to horizontal distance.

Definition at line 500 of file libtrac.c.

```
00502               {
00503
00504   return dlon * M_PI * RE / 180. * cos(lat / 180. * M_PI);
00505 }
```

5.21.2.7 double deg2dy (double *dlat*)

Convert degrees to horizontal distance.

Definition at line 509 of file libtrac.c.

```
00510                {
00511
00512   return dlat * M_PI * RE / 180.;
00513 }
```

5.21.2.8 double dp2dz (double *dp*, double *p*)

Convert pressure to vertical distance.

Definition at line 517 of file libtrac.c.

```
00519             {
00520
00521   return -dp * H0 / p;
00522 }
```

5.21.2.9 double dx2deg (double *dx*, double *lat*)

Convert horizontal distance to degrees.

Definition at line 526 of file libtrac.c.

```
00528                {
00529
00530   /* Avoid singularity at poles... */
00531   if (lat < -89.999 || lat > 89.999)
00532     return 0;
00533   else
00534     return dx * 180. / (M_PI * RE * cos(lat / 180. * M_PI));
00535 }
```

5.21.2.10 double dy2deg (double *dy*)

Convert horizontal distance to degrees.

Definition at line 539 of file libtrac.c.

```
00540               {
00541
00542   return dy * 180. / (M_PI * RE);
00543 }
```

5.21.2.11 double dz2dp (double *dz*, double *p*)

Convert vertical distance to pressure.

Definition at line 547 of file libtrac.c.

```
00549              {
00550
00551   return -dz * p / H0;
00552 }
```

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

Convert geolocation to Cartesian coordinates.

Definition at line 556 of file libtrac.c.

```
00560              {
00561
00562   double radius;
00563
00564   radius = z + RE;
00565   x[0] = radius * cos(lat / 180 * M_PI) * cos(lon / 180 * M_PI);
00566   x[1] = radius * cos(lat / 180 * M_PI) * sin(lon / 180 * M_PI);
00567   x[2] = radius * sin(lat / 180 * M_PI);
00568 }
```

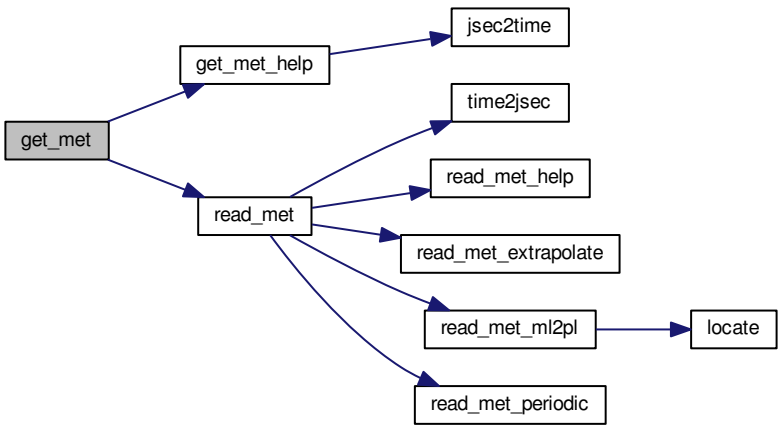
5.21.2.13 void get_met (ctl_t * *ctl,* char * *metbase,* double *t,* met_t * *met0,* met_t * *met1*)

Get meteorological data for given timestep.

Definition at line 572 of file libtrac.c.

```
00577                 {
00578
00579   static int init;
00580
00581   char filename[LEN];
00582
00583   /* Init... */
00584   if (t == ctl->t_start || !init) {
00585     init = 1;
00586
00587     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00588     read_met(ctl, filename, met0);
00589
00590     get_met_help(t + 1.0 * ctl->direction, 1, metbase, ctl->
      dt_met, filename);
00591     read_met(ctl, filename, met1);
00592   }
00593
00594   /* Read new data for forward trajectories... */
00595   if (t > met1->time && ctl->direction == 1) {
00596     memcpy(met0, met1, sizeof(met_t));
00597     get_met_help(t, 1, metbase, ctl->dt_met, filename);
00598     read_met(ctl, filename, met1);
00599   }
00600
00601   /* Read new data for backward trajectories... */
00602   if (t < met0->time && ctl->direction == -1) {
00603     memcpy(met1, met0, sizeof(met_t));
00604     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00605     read_met(ctl, filename, met0);
00606   }
00607 }
```

Here is the call graph for this function:



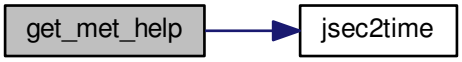
5.21.2.14 void get_met_help (double *t,* int *direct,* char * *metbase,* double *dt_met,* char * *filename*)

Get meteorological data for timestep.

Definition at line 611 of file libtrac.c.

```
00616                   {
00617
00618   double t6, r;
00619
00620   int year, mon, day, hour, min, sec;
00621
00622   /* Round time to fixed intervals... */
00623   if (direct == -1)
00624     t6 = floor(t / dt_met) * dt_met;
00625   else
00626     t6 = ceil(t / dt_met) * dt_met;
00627
00628   /* Decode time... */
00629   jsec2time(t6, &year, &mon, &day, &hour, &min, &sec, &r);
00630
00631   /* Set filename... */
00632   sprintf(filename, "%s_%d_%02d_%02d_%02d.nc", metbase, year, mon, day, hour);
00633 }
```

Here is the call graph for this function:



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

Linear interpolation of 2-D meteorological data.

Definition at line 637 of file libtrac.c.

```
00643               {
00644
00645   double aux00, aux01, aux10, aux11;
00646
00647   /* Set variables... */
00648   aux00 = array[ix][iy];
00649   aux01 = array[ix][iy + 1];
00650   aux10 = array[ix + 1][iy];
00651   aux11 = array[ix + 1][iy + 1];
00652
00653   /* Interpolate horizontally... */
00654   aux00 = wy * (aux00 - aux01) + aux01;
00655   aux11 = wy * (aux10 - aux11) + aux11;
00656   *var = wx * (aux00 - aux11) + aux11;
00657 }
```

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

Linear interpolation of 3-D meteorological data.

Definition at line 661 of file libtrac.c.

```
00669               {
00670
00671   double aux00, aux01, aux10, aux11;
00672
00673   /* Interpolate vertically... */
00674   aux00 = wp * (array[ix][iy][ip] - array[ix][iy][ip + 1])
00675     + array[ix][iy][ip + 1];
00676   aux01 = wp * (array[ix][iy + 1][ip] - array[ix][iy + 1][ip + 1])
00677     + array[ix][iy + 1][ip + 1];
00678   aux10 = wp * (array[ix + 1][iy][ip] - array[ix + 1][iy][ip + 1])
00679     + array[ix + 1][iy][ip + 1];
00680   aux11 = wp * (array[ix + 1][iy + 1][ip] - array[ix + 1][iy + 1][ip + 1])
00681     + array[ix + 1][iy + 1][ip + 1];
00682
00683   /* Interpolate horizontally... */
00684   aux00 = wy * (aux00 - aux01) + aux01;
00685   aux11 = wy * (aux10 - aux11) + aux11;
00686   *var = wx * (aux00 - aux11) + aux11;
00687 }
```

5.21.2.17 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 691 of file libtrac.c.

```
00705               {
00706
00707   double wp, wx, wy;
00708
00709   int ip, ix, iy;
00710
00711   /* Check longitude... */
00712   if (met->lon[met->nx - 1] > 180 && lon < 0)
00713     lon += 360;
00714
00715   /* Get indices... */
00716   ip = locate(met->p, met->np, p);
00717   ix = locate(met->lon, met->nx, lon);
00718   iy = locate(met->lat, met->ny, lat);
00719
00720   /* Get weights... */
00721   wp = (met->p[ip + 1] - p) / (met->p[ip + 1] - met->p[ip]);
00722   wx = (met->lon[ix + 1] - lon) / (met->lon[ix + 1] - met->lon[ix]);
00723   wy = (met->lat[iy + 1] - lat) / (met->lat[iy + 1] - met->lat[iy]);
00724
00725   /* Interpolate... */
00726   if (ps != NULL)
00727     intpol_met_2d(met->ps, ix, iy, wx, wy, ps);
00728   if (pt != NULL)
00729     intpol_met_2d(met->pt, ix, iy, wx, wy, pt);
00730   if (z != NULL)
00731     intpol_met_3d(met->z, ip, ix, iy, wp, wx, wy, z);
00732   if (t != NULL)
00733     intpol_met_3d(met->t, ip, ix, iy, wp, wx, wy, t);
00734   if (u != NULL)
00735     intpol_met_3d(met->u, ip, ix, iy, wp, wx, wy, u);
00736   if (v != NULL)
00737     intpol_met_3d(met->v, ip, ix, iy, wp, wx, wy, v);
00738   if (w != NULL)
00739     intpol_met_3d(met->w, ip, ix, iy, wp, wx, wy, w);
00740   if (pv != NULL)
00741     intpol_met_3d(met->pv, ip, ix, iy, wp, wx, wy, pv);
00742   if (h2o != NULL)
00743     intpol_met_3d(met->h2o, ip, ix, iy, wp, wx, wy, h2o);
00744   if (o3 != NULL)
00745     intpol_met_3d(met->o3, ip, ix, iy, wp, wx, wy, o3);
00746 }
```

Here is the call graph for this function:

5.21.2.18 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 750 of file libtrac.c.

```
00766              {
00767
00768   double h2o0, h2o1, o30, o31, ps0, ps1, pt0, pt1, pv0, pv1, t0, t1, u0, u1,
00769     v0, v1, w0, w1, wt, z0, z1;
00770
00771   /* Spatial interpolation... */
00772   intpol_met_space(met0, p, lon, lat,
00773                    ps == NULL ? NULL : &ps0,
00774                    pt == NULL ? NULL : &pt0,
00775                    z == NULL ? NULL : &z0,
00776                    t == NULL ? NULL : &t0,
00777                    u == NULL ? NULL : &u0,
00778                    v == NULL ? NULL : &v0,
00779                    w == NULL ? NULL : &w0,
00780                    pv == NULL ? NULL : &pv0,
00781                    h2o == NULL ? NULL : &h2o0, o3 == NULL ? NULL : &o30);
00782   intpol_met_space(met1, p, lon, lat,
00783                    ps == NULL ? NULL : &ps1,
00784                    pt == NULL ? NULL : &pt1,
00785                    z == NULL ? NULL : &z1,
00786                    t == NULL ? NULL : &t1,
00787                    u == NULL ? NULL : &u1,
00788                    v == NULL ? NULL : &v1,
00789                    w == NULL ? NULL : &w1,
00790                    pv == NULL ? NULL : &pv1,
00791                    h2o == NULL ? NULL : &h2o1, o3 == NULL ? NULL : &o31);
00792
00793   /* Get weighting factor... */
00794   wt = (met1->time - ts) / (met1->time - met0->time);
00795
00796   /* Interpolate... */
00797   if (ps != NULL)
00798     *ps = wt * (ps0 - ps1) + ps1;
00799   if (pt != NULL)
00800     *pt = wt * (pt0 - pt1) + pt1;
00801   if (z != NULL)
00802     *z = wt * (z0 - z1) + z1;
00803   if (t != NULL)
00804     *t = wt * (t0 - t1) + t1;
00805   if (u != NULL)
00806     *u = wt * (u0 - u1) + u1;
00807   if (v != NULL)
00808     *v = wt * (v0 - v1) + v1;
00809   if (w != NULL)
00810     *w = wt * (w0 - w1) + w1;
00811   if (pv != NULL)
00812     *pv = wt * (pv0 - pv1) + pv1;
00813   if (h2o != NULL)
00814     *h2o = wt * (h2o0 - h2o1) + h2o1;
00815   if (o3 != NULL)
00816     *o3 = wt * (o30 - o31) + o31;
00817 }
```

Here is the call graph for this function:

5.21.2.19 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 821 of file libtrac.c.

```
00829                  {
00830
00831   struct tm t0, *t1;
00832
00833   time_t jsec0;
00834
00835   t0.tm_year = 100;
```

```
00836   t0.tm_mon = 0;
00837   t0.tm_mday = 1;
00838   t0.tm_hour = 0;
00839   t0.tm_min = 0;
00840   t0.tm_sec = 0;
00841
00842   jsec0 = (time_t) jsec + timegm(&t0);
00843   t1 = gmtime(&jsec0);
00844
00845   *year = t1->tm_year + 1900;
00846   *mon = t1->tm_mon + 1;
00847   *day = t1->tm_mday;
00848   *hour = t1->tm_hour;
00849   *min = t1->tm_min;
00850   *sec = t1->tm_sec;
00851   *remain = jsec - floor(jsec);
00852 }
```

5.21.2.20 int locate (double * *xx*, int *n*, double *x*)

Find array index.

Definition at line 856 of file libtrac.c.

```
00859             {
00860
00861   int i, ilo, ihi;
00862
00863   ilo = 0;
00864   ihi = n - 1;
00865   i = (ihi + ilo) >> 1;
00866
00867   if (xx[i] < xx[i + 1])
00868     while (ihi > ilo + 1) {
00869       i = (ihi + ilo) >> 1;
00870       if (xx[i] > x)
00871         ihi = i;
00872       else
00873         ilo = i;
00874   } else
00875     while (ihi > ilo + 1) {
00876       i = (ihi + ilo) >> 1;
00877       if (xx[i] <= x)
00878         ihi = i;
00879       else
00880         ilo = i;
00881     }
00882
00883   return ilo;
00884 }
```

5.21.2.21 void read_atm (const char * *filename*, ctl_t * *ctl*, atm_t * *atm*)

Read atmospheric data.

Definition at line 888 of file libtrac.c.

```
00891                 {
00892
00893   FILE *in;
00894
00895   char line[LEN], *tok;
00896
00897   double t0;
00898
00899   int dimid, ip, iq, ncid, varid;
00900
00901   size_t nparts;
00902
00903   /* Init... */
00904   atm->np = 0;
00905
00906   /* Write info... */
00907   printf("Read atmospheric data: %s\n", filename);
```

```
00908
00909   /* Read ASCII data... */
00910   if (ctl->atm_type == 0) {
00911
00912     /* Open file... */
00913     if (!(in = fopen(filename, "r")))
00914       ERRMSG("Cannot open file!");
00915
00916     /* Read line... */
00917     while (fgets(line, LEN, in)) {
00918
00919       /* Read data... */
00920       TOK(line, tok, "%lg", atm->time[atm->np]);
00921       TOK(NULL, tok, "%lg", atm->p[atm->np]);
00922       TOK(NULL, tok, "%lg", atm->lon[atm->np]);
00923       TOK(NULL, tok, "%lg", atm->lat[atm->np]);
00924       for (iq = 0; iq < ctl->nq; iq++)
00925         TOK(NULL, tok, "%lg", atm->q[iq][atm->np]);
00926
00927       /* Convert altitude to pressure... */
00928       atm->p[atm->np] = P(atm->p[atm->np]);
00929
00930       /* Increment data point counter... */
00931       if ((++atm->np) > NP)
00932         ERRMSG("Too many data points!");
00933     }
00934
00935     /* Close file... */
00936     fclose(in);
00937   }
00938
00939   /* Read binary data... */
00940   else if (ctl->atm_type == 1) {
00941
00942     /* Open file... */
00943     if (!(in = fopen(filename, "r")))
00944       ERRMSG("Cannot open file!");
00945
00946     /* Read data... */
00947     FREAD(&atm->np, int,
00948           1,
00949           in);
00950     FREAD(atm->time, double,
00951             (size_t) atm->np,
00952           in);
00953     FREAD(atm->p, double,
00954             (size_t) atm->np,
00955           in);
00956     FREAD(atm->lon, double,
00957             (size_t) atm->np,
00958           in);
00959     FREAD(atm->lat, double,
00960             (size_t) atm->np,
00961           in);
00962     for (iq = 0; iq < ctl->nq; iq++)
00963       FREAD(atm->q[iq], double,
00964               (size_t) atm->np,
00965             in);
00966
00967     /* Close file... */
00968     fclose(in);
00969   }
00970
00971   /* Read netCDF data... */
00972   else if (ctl->atm_type == 2) {
00973
00974     /* Open file... */
00975     NC(nc_open(filename, NC_NOWRITE, &ncid));
00976
00977     /* Get dimensions... */
00978     NC(nc_inq_dimid(ncid, "NPARTS", &dimid));
00979     NC(nc_inq_dimlen(ncid, dimid, &nparts));
00980     atm->np = (int) nparts;
00981     if (atm->np > NP)
00982       ERRMSG("Too many particles!");
00983
00984     /* Get time... */
00985     NC(nc_inq_varid(ncid, "time", &varid));
00986     NC(nc_get_var_double(ncid, varid, &t0));
00987     for (ip = 0; ip < atm->np; ip++)
00988       atm->time[ip] = t0;
00989
00990     /* Read geolocations... */
00991     NC(nc_inq_varid(ncid, "PRESS", &varid));
00992     NC(nc_get_var_double(ncid, varid, atm->p));
00993     NC(nc_inq_varid(ncid, "LON", &varid));
00994     NC(nc_get_var_double(ncid, varid, atm->lon));
```

```
00995     NC(nc_inq_varid(ncid, "LAT", &varid));
00996     NC(nc_get_var_double(ncid, varid, atm->lat));
00997
00998     /* Read variables... */
00999     if (ctl->qnt_p >= 0)
01000       if (nc_inq_varid(ncid, "PRESS", &varid) == NC_NOERR)
01001         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_p]));
01002     if (ctl->qnt_t >= 0)
01003       if (nc_inq_varid(ncid, "TEMP", &varid) == NC_NOERR)
01004         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_t]));
01005     if (ctl->qnt_u >= 0)
01006       if (nc_inq_varid(ncid, "U", &varid) == NC_NOERR)
01007         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_u]));
01008     if (ctl->qnt_v >= 0)
01009       if (nc_inq_varid(ncid, "V", &varid) == NC_NOERR)
01010         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_v]));
01011     if (ctl->qnt_w >= 0)
01012       if (nc_inq_varid(ncid, "W", &varid) == NC_NOERR)
01013         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_w]));
01014     if (ctl->qnt_h2o >= 0)
01015       if (nc_inq_varid(ncid, "SH", &varid) == NC_NOERR)
01016         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_h2o]));
01017     if (ctl->qnt_o3 >= 0)
01018       if (nc_inq_varid(ncid, "O3", &varid) == NC_NOERR)
01019         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_o3]));
01020     if (ctl->qnt_theta >= 0)
01021       if (nc_inq_varid(ncid, "THETA", &varid) == NC_NOERR)
01022         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_theta]));
01023     if (ctl->qnt_pv >= 0)
01024       if (nc_inq_varid(ncid, "PV", &varid) == NC_NOERR)
01025         NC(nc_get_var_double(ncid, varid, atm->q[ctl->qnt_pv]));
01026
01027     /* Check data... */
01028     for (ip = 0; ip < atm->np; ip++)
01029       if (fabs(atm->lon[ip]) > 360 || fabs(atm->lat[ip]) > 90
01030           || (ctl->qnt_t >= 0 && fabs(atm->q[ctl->qnt_t][ip]) > 350)
01031           || (ctl->qnt_h2o >= 0 && fabs(atm->q[ctl->qnt_h2o][ip]) > 1)
01032           || (ctl->qnt_theta >= 0 && fabs(atm->q[ctl->qnt_theta][ip]) > 1e10)
01033           || (ctl->qnt_pv >= 0 && fabs(atm->q[ctl->qnt_pv][ip]) > 1e10)) {
01034         atm->time[ip] = GSL_NAN;
01035         atm->p[ip] = GSL_NAN;
01036         atm->lon[ip] = GSL_NAN;
01037         atm->lat[ip] = GSL_NAN;
01038         for (iq = 0; iq < ctl->nq; iq++)
01039           atm->q[iq][ip] = GSL_NAN;
01040       } else {
01041         if (ctl->qnt_h2o >= 0)
01042           atm->q[ctl->qnt_h2o][ip] *= 1.608;
01043         if (ctl->qnt_pv >= 0)
01044           atm->q[ctl->qnt_pv][ip] *= 1e6;
01045         if (atm->lon[ip] > 180)
01046           atm->lon[ip] -= 360;
01047       }
01048
01049     /* Close file... */
01050     NC(nc_close(ncid));
01051   }
01052
01053   /* Error... */
01054   else
01055     ERRMSG("Atmospheric data type not supported!");
01056
01057   /* Check number of points... */
01058   if (atm->np < 1)
01059     ERRMSG("Can not read any data!");
01060 }
```

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

Read control parameters.

Definition at line 1064 of file libtrac.c.

```
01068               {
01069
01070   int ip, iq;
01071
01072   /* Write info... */
01073   printf("\nMassive-Parallel Trajectory Calculations (MPTRAC)\n"
01074          "(executable: %s | compiled: %s, %s)\n\n",
```

```
01075          argv[0], __DATE__, __TIME__);
01076
01077   /* Initialize quantity indices... */
01078   ctl->qnt_ens = -1;
01079   ctl->qnt_m = -1;
01080   ctl->qnt_r = -1;
01081   ctl->qnt_rho = -1;
01082   ctl->qnt_ps = -1;
01083   ctl->qnt_pt = -1;
01084   ctl->qnt_z = -1;
01085   ctl->qnt_p = -1;
01086   ctl->qnt_t = -1;
01087   ctl->qnt_u = -1;
01088   ctl->qnt_v = -1;
01089   ctl->qnt_w = -1;
01090   ctl->qnt_h2o = -1;
01091   ctl->qnt_o3 = -1;
01092   ctl->qnt_theta = -1;
01093   ctl->qnt_vh = -1;
01094   ctl->qnt_vz = -1;
01095   ctl->qnt_pv = -1;
01096   ctl->qnt_tice = -1;
01097   ctl->qnt_tsts = -1;
01098   ctl->qnt_tnat = -1;
01099   ctl->qnt_stat = -1;
01100
01101   /* Read quantities... */
01102   ctl->nq = (int) scan_ctl(filename, argc, argv, "NQ", -1, "0", NULL);
01103   if (ctl->nq > NQ)
01104     ERRMSG("Too many quantities!");
01105   for (iq = 0; iq < ctl->nq; iq++) {
01106
01107     /* Read quantity name and format... */
01108     scan_ctl(filename, argc, argv, "QNT_NAME", iq, "", ctl->qnt_name[iq]);
01109     scan_ctl(filename, argc, argv, "QNT_FORMAT", iq, "%g",
01110              ctl->qnt_format[iq]);
01111
01112     /* Try to identify quantity... */
01113     if (strcmp(ctl->qnt_name[iq], "ens") == 0) {
01114       ctl->qnt_ens = iq;
01115       sprintf(ctl->qnt_unit[iq], "-");
01116     } else if (strcmp(ctl->qnt_name[iq], "m") == 0) {
01117       ctl->qnt_m = iq;
01118       sprintf(ctl->qnt_unit[iq], "kg");
01119     } else if (strcmp(ctl->qnt_name[iq], "r") == 0) {
01120       ctl->qnt_r = iq;
01121       sprintf(ctl->qnt_unit[iq], "m");
01122     } else if (strcmp(ctl->qnt_name[iq], "rho") == 0) {
01123       ctl->qnt_rho = iq;
01124       sprintf(ctl->qnt_unit[iq], "kg/m^3");
01125     } else if (strcmp(ctl->qnt_name[iq], "ps") == 0) {
01126       ctl->qnt_ps = iq;
01127       sprintf(ctl->qnt_unit[iq], "hPa");
01128     } else if (strcmp(ctl->qnt_name[iq], "pt") == 0) {
01129       ctl->qnt_pt = iq;
01130       sprintf(ctl->qnt_unit[iq], "hPa");
01131     } else if (strcmp(ctl->qnt_name[iq], "z") == 0) {
01132       ctl->qnt_z = iq;
01133       sprintf(ctl->qnt_unit[iq], "km");
01134     } else if (strcmp(ctl->qnt_name[iq], "p") == 0) {
01135       ctl->qnt_p = iq;
01136       sprintf(ctl->qnt_unit[iq], "hPa");
01137     } else if (strcmp(ctl->qnt_name[iq], "t") == 0) {
01138       ctl->qnt_t = iq;
01139       sprintf(ctl->qnt_unit[iq], "K");
01140     } else if (strcmp(ctl->qnt_name[iq], "u") == 0) {
01141       ctl->qnt_u = iq;
01142       sprintf(ctl->qnt_unit[iq], "m/s");
01143     } else if (strcmp(ctl->qnt_name[iq], "v") == 0) {
01144       ctl->qnt_v = iq;
01145       sprintf(ctl->qnt_unit[iq], "m/s");
01146     } else if (strcmp(ctl->qnt_name[iq], "w") == 0) {
01147       ctl->qnt_w = iq;
01148       sprintf(ctl->qnt_unit[iq], "hPa/s");
01149     } else if (strcmp(ctl->qnt_name[iq], "h2o") == 0) {
01150       ctl->qnt_h2o = iq;
01151       sprintf(ctl->qnt_unit[iq], "1");
01152     } else if (strcmp(ctl->qnt_name[iq], "o3") == 0) {
01153       ctl->qnt_o3 = iq;
01154       sprintf(ctl->qnt_unit[iq], "1");
01155     } else if (strcmp(ctl->qnt_name[iq], "theta") == 0) {
01156       ctl->qnt_theta = iq;
01157       sprintf(ctl->qnt_unit[iq], "K");
01158     } else if (strcmp(ctl->qnt_name[iq], "vh") == 0) {
01159       ctl->qnt_vh = iq;
01160       sprintf(ctl->qnt_unit[iq], "m/s");
01161     } else if (strcmp(ctl->qnt_name[iq], "vz") == 0) {
```

```
01162       ctl->qnt_vz = iq;
01163       sprintf(ctl->qnt_unit[iq], "m/s");
01164     } else if (strcmp(ctl->qnt_name[iq], "pv") == 0) {
01165       ctl->qnt_pv = iq;
01166       sprintf(ctl->qnt_unit[iq], "PVU");
01167     } else if (strcmp(ctl->qnt_name[iq], "tice") == 0) {
01168       ctl->qnt_tice = iq;
01169       sprintf(ctl->qnt_unit[iq], "K");
01170     } else if (strcmp(ctl->qnt_name[iq], "tsts") == 0) {
01171       ctl->qnt_tsts = iq;
01172       sprintf(ctl->qnt_unit[iq], "K");
01173     } else if (strcmp(ctl->qnt_name[iq], "tnat") == 0) {
01174       ctl->qnt_tnat = iq;
01175       sprintf(ctl->qnt_unit[iq], "K");
01176     } else if (strcmp(ctl->qnt_name[iq], "stat") == 0) {
01177       ctl->qnt_stat = iq;
01178       sprintf(ctl->qnt_unit[iq], "-");
01179     } else
01180       scan_ctl(filename, argc, argv, "QNT_UNIT", iq, "", ctl->qnt_unit[iq]);
01181   }
01182
01183   /* Time steps of simulation... */
01184   ctl->direction =
01185     (int) scan_ctl(filename, argc, argv, "DIRECTION", -1, "1", NULL);
01186   if (ctl->direction != -1 && ctl->direction != 1)
01187     ERRMSG("Set DIRECTION to -1 or 1!");
01188   ctl->t_stop = scan_ctl(filename, argc, argv, "T_STOP", -1, "1e100", NULL);
01189   ctl->dt_mod = scan_ctl(filename, argc, argv, "DT_MOD", -1, "600", NULL);
01190
01191   /* Meteorological data... */
01192   ctl->dt_met = scan_ctl(filename, argc, argv, "DT_MET", -1, "21600", NULL);
01193   ctl->met_dx = (int) scan_ctl(filename, argc, argv, "MET_DX", -1, "1", NULL);
01194   ctl->met_dy = (int) scan_ctl(filename, argc, argv, "MET_DY", -1, "1", NULL);
01195   ctl->met_dp = (int) scan_ctl(filename, argc, argv, "MET_DP", -1, "1", NULL);
01196   ctl->met_sx = (int) scan_ctl(filename, argc, argv, "MET_SX", -1, "1", NULL);
01197   ctl->met_sy = (int) scan_ctl(filename, argc, argv, "MET_SY", -1, "1", NULL);
01198   ctl->met_sp = (int) scan_ctl(filename, argc, argv, "MET_SP", -1, "1", NULL);
01199   ctl->met_np = (int) scan_ctl(filename, argc, argv, "MET_NP", -1, "0", NULL);
01200   if (ctl->met_np > EP)
01201     ERRMSG("Too many levels!");
01202   for (ip = 0; ip < ctl->met_np; ip++)
01203     ctl->met_p[ip] = scan_ctl(filename, argc, argv, "MET_P", ip, "", NULL);
01204   ctl->met_tropo
01205     = (int) scan_ctl(filename, argc, argv, "MET_TROPO", -1, "0", NULL);
01206   scan_ctl(filename, argc, argv, "MET_GEOPOT", -1, "-", ctl->met_geopot);
01207   scan_ctl(filename, argc, argv, "MET_STAGE", -1, "-", ctl->met_stage);
01208
01209   /* Isosurface parameters... */
01210   ctl->isosurf
01211     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
01212   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
01213
01214   /* Diffusion parameters... */
01215   ctl->turb_dx_trop
01216     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50", NULL);
01217   ctl->turb_dx_strat
01218     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0", NULL);
01219   ctl->turb_dz_trop
01220     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0", NULL);
01221   ctl->turb_dz_strat
01222     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
01223   ctl->turb_mesox =
01224     scan_ctl(filename, argc, argv, "TURB_MESOX", -1, "0.16", NULL);
01225   ctl->turb_mesoz =
01226     scan_ctl(filename, argc, argv, "TURB_MESOZ", -1, "0.16", NULL);
01227
01228   /* Mass and life time... */
01229   ctl->molmass = scan_ctl(filename, argc, argv, "MOLMASS", -1, "1", NULL);
01230   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
01231   ctl->tdec_strat =
01232     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
01233
01234   /* PSC analysis... */
01235   ctl->psc_h2o = scan_ctl(filename, argc, argv, "PSC_H2O", -1, "4e-6", NULL);
01236   ctl->psc_hno3 =
01237     scan_ctl(filename, argc, argv, "PSC_HNO3", -1, "9e-9", NULL);
01238
01239   /* Output of atmospheric data... */
01240   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
      atm_basename);
01241   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
01242   ctl->atm_dt_out =
01243     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
01244   ctl->atm_filter =
01245     (int) scan_ctl(filename, argc, argv, "ATM_FILTER", -1, "0", NULL);
01246   ctl->atm_type =
01247     (int) scan_ctl(filename, argc, argv, "ATM_TYPE", -1, "0", NULL);
```

```
01248
01249   /* Output of CSI data... */
01250   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
      csi_basename);
01251   ctl->csi_dt_out =
01252     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
01253   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "-", ctl->
      csi_obsfile);
01254   ctl->csi_obsmin =
01255     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
01256   ctl->csi_modmin =
01257     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
01258   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
01259   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
01260   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
01261   ctl->csi_lon0 =
01262     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
01263   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
01264   ctl->csi_nx =
01265     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
01266   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
01267   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
01268   ctl->csi_ny =
01269     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
01270
01271   /* Output of ensemble data... */
01272   scan_ctl(filename, argc, argv, "ENS_BASENAME", -1, "-", ctl->
      ens_basename);
01273
01274   /* Output of grid data... */
01275   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
01276            ctl->grid_basename);
01277   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
      grid_gpfile);
01278   ctl->grid_dt_out =
01279     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
01280   ctl->grid_sparse =
01281     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
01282   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
01283   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
01284   ctl->grid_nz =
01285     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
01286   ctl->grid_lon0 =
01287     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
01288   ctl->grid_lon1 =
01289     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
01290   ctl->grid_nx =
01291     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
01292   ctl->grid_lat0 =
01293     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
01294   ctl->grid_lat1 =
01295     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
01296   ctl->grid_ny =
01297     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
01298
01299   /* Output of profile data... */
01300   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
01301            ctl->prof_basename);
01302   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
      prof_obsfile);
01303   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
01304   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
01305   ctl->prof_nz =
01306     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
01307   ctl->prof_lon0 =
01308     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
01309   ctl->prof_lon1 =
01310     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
01311   ctl->prof_nx =
01312     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
01313   ctl->prof_lat0 =
01314     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
01315   ctl->prof_lat1 =
01316     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
01317   ctl->prof_ny =
01318     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
01319
01320   /* Output of station data... */
01321   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
01322            ctl->stat_basename);
01323   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
01324   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
01325   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
01326 }
```

Here is the call graph for this function:

5.21.2.23 void read_met (ctl_t * *ctl*, char * *filename*, met_t * *met*)

Read meteorological data file.

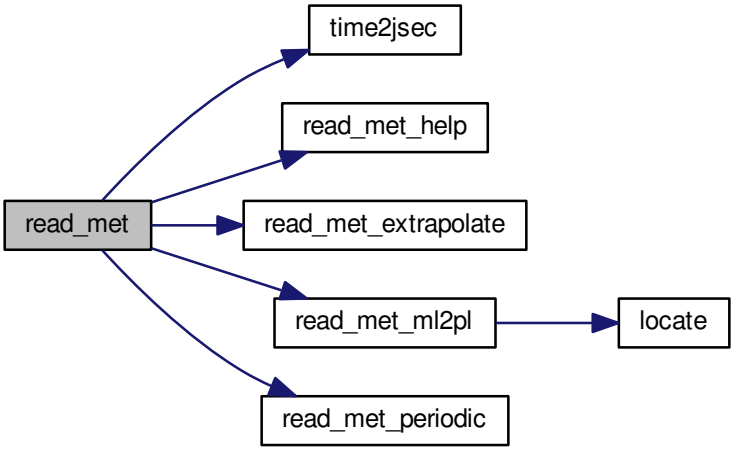
Definition at line 1330 of file libtrac.c.

```
01333               {
01334
01335   char cmd[2 * LEN], levname[LEN], tstr[10];
01336
01337   static float help[EX * EY];
01338
01339   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
01340
01341   size_t np, nx, ny;
01342
01343   /* Write info... */
01344   printf("Read meteorological data: %s\n", filename);
01345
01346   /* Get time from filename... */
01347   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
01348   year = atoi(tstr);
01349   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
01350   mon = atoi(tstr);
01351   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
01352   day = atoi(tstr);
01353   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
01354   hour = atoi(tstr);
01355   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
01356
01357   /* Open netCDF file... */
01358   if (nc_open(filename, NC_NOWRITE, &ncid) != NC_NOERR) {
01359
01360     /* Try to stage meteo file... */
01361     if (ctl->met_stage[0] != '-') {
01362       sprintf(cmd, "%s %d %02d %02d %02d %s", ctl->met_stage,
01363               year, mon, day, hour, filename);
01364       if (system(cmd) != 0)
01365         ERRMSG("Error while staging meteo data!");
01366     }
01367
01368     /* Try to open again... */
01369     NC(nc_open(filename, NC_NOWRITE, &ncid));
01370   }
01371
01372   /* Get dimensions... */
01373   NC(nc_inq_dimid(ncid, "lon", &dimid));
01374   NC(nc_inq_dimlen(ncid, dimid, &nx));
01375   if (nx < 2 || nx > EX)
01376     ERRMSG("Number of longitudes out of range!");
01377
01378   NC(nc_inq_dimid(ncid, "lat", &dimid));
01379   NC(nc_inq_dimlen(ncid, dimid, &ny));
01380   if (ny < 2 || ny > EY)
01381     ERRMSG("Number of latitudes out of range!");
01382
01383   sprintf(levname, "lev");
01384   NC(nc_inq_dimid(ncid, levname, &dimid));
01385   NC(nc_inq_dimlen(ncid, dimid, &np));
01386   if (np == 1) {
01387     sprintf(levname, "lev_2");
01388     NC(nc_inq_dimid(ncid, levname, &dimid));
01389     NC(nc_inq_dimlen(ncid, dimid, &np));
```

```
01390   }
01391   if (np < 2 || np > EP)
01392     ERRMSG("Number of levels out of range!");
01393
01394   /* Store dimensions... */
01395   met->np = (int) np;
01396   met->nx = (int) nx;
01397   met->ny = (int) ny;
01398
01399   /* Get horizontal grid... */
01400   NC(nc_inq_varid(ncid, "lon", &varid));
01401   NC(nc_get_var_double(ncid, varid, met->lon));
01402   NC(nc_inq_varid(ncid, "lat", &varid));
01403   NC(nc_get_var_double(ncid, varid, met->lat));
01404
01405   /* Read meteorological data... */
01406   read_met_help(ncid, "t", "T", met, met->t, 1.0);
01407   read_met_help(ncid, "u", "U", met, met->u, 1.0);
01408   read_met_help(ncid, "v", "V", met, met->v, 1.0);
01409   read_met_help(ncid, "w", "W", met, met->w, 0.01f);
01410   read_met_help(ncid, "q", "Q", met, met->h2o, (float) (MA / 18.01528));
01411   read_met_help(ncid, "o3", "O3", met, met->o3, (float) (MA / 48.00));
01412
01413   /* Meteo data on pressure levels... */
01414   if (ctl->met_np <= 0) {
01415
01416     /* Read pressure levels from file... */
01417     NC(nc_inq_varid(ncid, levname, &varid));
01418     NC(nc_get_var_double(ncid, varid, met->p));
01419     for (ip = 0; ip < met->np; ip++)
01420       met->p[ip] /= 100.;
01421
01422     /* Extrapolate data for lower boundary... */
01423     read_met_extrapolate(met);
01424   }
01425
01426   /* Meteo data on model levels... */
01427   else {
01428
01429     /* Read pressure data from file... */
01430     read_met_help(ncid, "pl", "PL", met, met->pl, 0.01f);
01431
01432     /* Interpolate from model levels to pressure levels... */
01433     read_met_ml2pl(ctl, met, met->t);
01434     read_met_ml2pl(ctl, met, met->u);
01435     read_met_ml2pl(ctl, met, met->v);
01436     read_met_ml2pl(ctl, met, met->w);
01437     read_met_ml2pl(ctl, met, met->h2o);
01438     read_met_ml2pl(ctl, met, met->o3);
01439
01440     /* Set pressure levels... */
01441     met->np = ctl->met_np;
01442     for (ip = 0; ip < met->np; ip++)
01443       met->p[ip] = ctl->met_p[ip];
01444   }
01445
01446   /* Check ordering of pressure levels... */
01447   for (ip = 1; ip < met->np; ip++)
01448     if (met->p[ip - 1] < met->p[ip])
01449       ERRMSG("Pressure levels must be descending!");
01450
01451   /* Read surface pressure... */
01452   if (nc_inq_varid(ncid, "ps", &varid) == NC_NOERR
01453       || nc_inq_varid(ncid, "PS", &varid) == NC_NOERR) {
01454     NC(nc_get_var_float(ncid, varid, help));
01455     for (iy = 0; iy < met->ny; iy++)
01456       for (ix = 0; ix < met->nx; ix++)
01457         met->ps[ix][iy] = help[iy * met->nx + ix] / 100.;
01458   } else if (nc_inq_varid(ncid, "lnsp", &varid) == NC_NOERR
01459              || nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
01460     NC(nc_get_var_float(ncid, varid, help));
01461     for (iy = 0; iy < met->ny; iy++)
01462       for (ix = 0; ix < met->nx; ix++)
01463         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
01464   } else
01465     for (ix = 0; ix < met->nx; ix++)
01466       for (iy = 0; iy < met->ny; iy++)
01467         met->ps[ix][iy] = met->p[0];
01468
01469   /* Create periodic boundary conditions... */
01470   read_met_periodic(met);
01471
01472   /* Calculate geopotential heights... */
01473   read_met_geopot(ctl, met);
01474
01475   /* Calculate potential vorticity... */
01476   read_met_pv(met);
```

```
01477
01478   /* Calculate tropopause pressure... */
01479   read_met_tropo(ctl, met);
01480
01481   /* Downsampling... */
01482   read_met_sample(ctl, met);
01483
01484   /* Close file... */
01485   NC(nc_close(ncid));
01486 }
```

Here is the call graph for this function:



5.21.2.24 void read_met_extrapolate (met_t * *met*)

Extrapolate meteorological data at lower boundary.

Definition at line 1490 of file libtrac.c.

```
01491               {
01492
01493   int ip, ip0, ix, iy;
01494
01495   /* Loop over columns... */
01496   for (ix = 0; ix < met->nx; ix++)
01497     for (iy = 0; iy < met->ny; iy++) {
01498
01499       /* Find lowest valid data point... */
01500       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
01501         if (!gsl_finite(met->t[ix][iy][ip0])
01502             || !gsl_finite(met->u[ix][iy][ip0])
01503             || !gsl_finite(met->v[ix][iy][ip0])
01504             || !gsl_finite(met->w[ix][iy][ip0]))
01505           break;
01506
01507       /* Extrapolate... */
01508       for (ip = ip0; ip >= 0; ip--) {
01509         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
01510         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
01511         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
01512         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
01513         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
01514         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
01515       }
01516     }
01517 }
```

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

Calculate geopotential heights.

Definition at line 1521 of file libtrac.c.

```
01523                {
01524
01525   static double topo_lat[EY], topo_lon[EX], topo_z[EX][EY];
01526
01527   static int init, topo_nx = -1, topo_ny;
01528
01529   FILE *in;
01530
01531   char line[LEN];
01532
01533   double data[30], lat, lon, rlat, rlon, rlon_old = -999, rz, ts, z0, z1;
01534
01535   float help[EX][EY];
01536
01537   int ip, ip0, ix, ix2, ix3, iy, iy2, n, tx, ty;
01538
01539   /* Initialize geopotential heights... */
01540   for (ix = 0; ix < met->nx; ix++)
01541     for (iy = 0; iy < met->ny; iy++)
01542       for (ip = 0; ip < met->np; ip++)
01543         met->z[ix][iy][ip] = GSL_NAN;
01544
01545   /* Check filename... */
01546   if (ctl->met_geopot[0] == '-')
01547     return;
01548
01549   /* Read surface geopotential... */
01550   if (!init) {
01551     init = 1;
01552
01553     /* Write info... */
01554     printf("Read surface geopotential: %s\n", ctl->met_geopot);
01555
01556     /* Open file... */
01557     if (!(in = fopen(ctl->met_geopot, "r")))
01558       ERRMSG("Cannot open file!");
01559
01560     /* Read data... */
01561     while (fgets(line, LEN, in))
01562       if (sscanf(line, "%lg %lg %lg", &rlon, &rlat, &rz) == 3) {
01563         if (rlon != rlon_old) {
01564           if ((++topo_nx) >= EX)
01565             ERRMSG("Too many longitudes!");
01566           topo_ny = 0;
01567         }
01568         rlon_old = rlon;
01569         topo_lon[topo_nx] = rlon;
01570         topo_lat[topo_ny] = rlat;
01571         topo_z[topo_nx][topo_ny] = rz;
01572         if ((++topo_ny) >= EY)
01573           ERRMSG("Too many latitudes!");
01574       }
01575     if ((++topo_nx) >= EX)
01576       ERRMSG("Too many longitudes!");
01577
01578     /* Close file... */
01579     fclose(in);
01580
01581     /* Check grid spacing... */
01582     if (fabs(met->lon[0] - met->lon[1]) != fabs(topo_lon[0] - topo_lon[1])
01583         || fabs(met->lat[0] - met->lat[1]) != fabs(topo_lat[0] - topo_lat[1]))
01584       printf("Warning: Grid spacing does not match!\n");
01585   }
01586
01587   /* Apply hydrostatic equation to calculate geopotential heights... */
01588   for (ix = 0; ix < met->nx; ix++)
01589     for (iy = 0; iy < met->ny; iy++) {
01590
01591       /* Get surface height... */
01592       lon = met->lon[ix];
01593       if (lon < topo_lon[0])
01594         lon += 360;
01595       else if (lon > topo_lon[topo_nx - 1])
01596         lon -= 360;
01597       lat = met->lat[iy];
01598       tx = locate(topo_lon, topo_nx, lon);
01599       ty = locate(topo_lat, topo_ny, lat);
```

```
01600       z0 = LIN(topo_lon[tx], topo_z[tx][ty],
01601                topo_lon[tx + 1], topo_z[tx + 1][ty], lon);
01602       z1 = LIN(topo_lon[tx], topo_z[tx][ty + 1],
01603                topo_lon[tx + 1], topo_z[tx + 1][ty + 1], lon);
01604       z0 = LIN(topo_lat[ty], z0, topo_lat[ty + 1], z1, lat);
01605
01606       /* Find surface pressure level... */
01607       ip0 = locate(met->p, met->np, met->ps[ix][iy]);
01608
01609       /* Get surface temperature... */
01610       ts = LIN(met->p[ip0], met->t[ix][iy][ip0],
01611                met->p[ip0 + 1], met->t[ix][iy][ip0 + 1], met->ps[ix][iy]);
01612
01613       /* Upper part of profile... */
01614       met->z[ix][iy][ip0 + 1]
01615         = (float) (z0 + RI / MA / G0 * 0.5 * (ts + met->t[ix][iy][ip0 + 1])
01616                    * log(met->ps[ix][iy] / met->p[ip0 + 1]));
01617       for (ip = ip0 + 2; ip < met->np; ip++)
01618         met->z[ix][iy][ip]
01619           = (float) (met->z[ix][iy][ip - 1] + RI / MA / G0
01620                      * 0.5 * (met->t[ix][iy][ip - 1] + met->t[ix][iy][ip])
01621                      * log(met->p[ip - 1] / met->p[ip]));
01622     }
01623
01624   /* Smooth fields... */
01625   for (ip = 0; ip < met->np; ip++) {
01626
01627     /* Median filter... */
01628     for (ix = 0; ix < met->nx; ix++)
01629       for (iy = 0; iy < met->nx; iy++) {
01630         n = 0;
01631         for (ix2 = ix - 2; ix2 <= ix + 2; ix2++) {
01632           ix3 = ix2;
01633           if (ix3 < 0)
01634             ix3 += met->nx;
01635           if (ix3 >= met->nx)
01636             ix3 -= met->nx;
01637           for (iy2 = GSL_MAX(iy - 2, 0); iy2 <= GSL_MIN(iy + 2, met->ny - 1);
01638                iy2++)
01639             if (gsl_finite(met->z[ix3][iy2][ip])) {
01640               data[n] = met->z[ix3][iy2][ip];
01641               n++;
01642             }
01643         }
01644         if (n > 0) {
01645           gsl_sort(data, 1, (size_t) n);
01646           help[ix][iy] = (float)
01647             gsl_stats_median_from_sorted_data(data, 1, (size_t) n);
01648         } else
01649           help[ix][iy] = GSL_NAN;
01650       }
01651
01652     /* Copy data... */
01653     for (ix = 0; ix < met->nx; ix++)
01654       for (iy = 0; iy < met->nx; iy++)
01655         met->z[ix][iy][ip] = help[ix][iy];
01656   }
01657 }
```

Here is the call graph for this function:

5.21.2.26 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 1661 of file libtrac.c.

```
01667             {
01668
01669   static float help[EX * EY * EP];
01670
01671   int ip, ix, iy, varid;
01672
01673   /* Check if variable exists... */
01674   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
01675     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
01676       return;
01677
01678   /* Read data... */
```

```
01679   NC(nc_get_var_float(ncid, varid, help));
01680
01681   /* Copy and check data... */
01682   for (ix = 0; ix < met->nx; ix++)
01683     for (iy = 0; iy < met->ny; iy++)
01684       for (ip = 0; ip < met->np; ip++) {
01685         dest[ix][iy][ip] = help[(ip * met->ny + iy) * met->nx + ix];
01686         if (fabsf(dest[ix][iy][ip]) < 1e14f)
01687           dest[ix][iy][ip] *= scl;
01688         else
01689           dest[ix][iy][ip] = GSL_NAN;
01690       }
01691 }
```

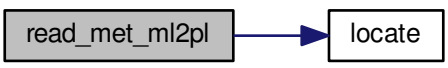
5.21.2.27 void read_met_ml2pl (ctl_t * *ctl*, met_t * *met*, float *var[EX][EY][EP]*)

Convert meteorological data from model levels to pressure levels.

Definition at line 1695 of file libtrac.c.

```
01698                           {
01699
01700   double aux[EP], p[EP], pt;
01701
01702   int ip, ip2, ix, iy;
01703
01704   /* Loop over columns... */
01705   for (ix = 0; ix < met->nx; ix++)
01706     for (iy = 0; iy < met->ny; iy++) {
01707
01708       /* Copy pressure profile... */
01709       for (ip = 0; ip < met->np; ip++)
01710         p[ip] = met->pl[ix][iy][ip];
01711
01712       /* Interpolate... */
01713       for (ip = 0; ip < ctl->met_np; ip++) {
01714         pt = ctl->met_p[ip];
01715         if ((pt > p[0] && p[0] > p[1]) || (pt < p[0] && p[0] < p[1]))
01716           pt = p[0];
01717         else if ((pt > p[met->np - 1] && p[1] > p[0])
01718                  || (pt < p[met->np - 1] && p[1] < p[0]))
01719           pt = p[met->np - 1];
01720         ip2 = locate(p, met->np, pt);
01721         aux[ip] = LIN(p[ip2], var[ix][iy][ip2],
01722                       p[ip2 + 1], var[ix][iy][ip2 + 1], pt);
01723       }
01724
01725       /* Copy data... */
01726       for (ip = 0; ip < ctl->met_np; ip++)
01727         var[ix][iy][ip] = (float) aux[ip];
01728     }
01729 }
```

Here is the call graph for this function:



5.21.2.28 void read_met_periodic (met_t * *met*)

Create meteorological data with periodic boundary conditions.

Definition at line 1733 of file libtrac.c.

```
01734               {
01735
01736   int ip, iy;
01737
01738   /* Check longitudes... */
01739   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
01740              + met->lon[1] - met->lon[0] - 360) < 0.01))
01741     return;
01742
01743   /* Increase longitude counter... */
01744   if ((++met->nx) > EX)
01745     ERRMSG("Cannot create periodic boundary conditions!");
01746
01747   /* Set longitude... */
01748   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
01749
01750   /* Loop over latitudes and pressure levels... */
01751   for (iy = 0; iy < met->ny; iy++)
01752     for (ip = 0; ip < met->np; ip++) {
01753       met->ps[met->nx - 1][iy] = met->ps[0][iy];
01754       met->pt[met->nx - 1][iy] = met->pt[0][iy];
01755       met->z[met->nx - 1][iy][ip] = met->z[0][iy][ip];
01756       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
01757       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
01758       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
01759       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
01760       met->pv[met->nx - 1][iy][ip] = met->pv[0][iy][ip];
01761       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
01762       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
01763     }
01764 }
```

5.21.2.29 void read_met_pv (met_t * *met*)

Calculate potential vorticity.

Definition at line 1768 of file libtrac.c.

```
01769               {
01770
01771   double c0, c1, cr, dx, dy, dp, dtdx, dvdx, dtdy, dudy, dtdp, dudp, dvdp,
01772     latr, vort, pows[EP];
01773
01774   int ip, ip0, ip1, ix, ix0, ix1, iy, iy0, iy1;
01775
01776   /* Set powers... */
01777   for (ip = 0; ip < met->np; ip++)
01778     pows[ip] = pow(1000. / met->p[ip], 0.286);
01779
01780   /* Loop over grid points... */
01781   for (ix = 0; ix < met->nx; ix++) {
01782
01783     /* Set indices... */
01784     ix0 = GSL_MAX(ix - 1, 0);
01785     ix1 = GSL_MIN(ix + 1, met->nx - 1);
01786
01787     /* Loop over grid points... */
01788     for (iy = 0; iy < met->ny; iy++) {
01789
01790       /* Set indices... */
01791       iy0 = GSL_MAX(iy - 1, 0);
01792       iy1 = GSL_MIN(iy + 1, met->ny - 1);
01793
01794       /* Set auxiliary variables... */
01795       latr = GSL_MIN(GSL_MAX(met->lat[iy], -89.), 89.);
01796       dx = 1000. * deg2dx(met->lon[ix1] - met->lon[ix0], latr);
01797       dy = 1000. * deg2dy(met->lat[iy1] - met->lat[iy0]);
01798       c0 = cos(met->lat[iy0] / 180. * M_PI);
01799       c1 = cos(met->lat[iy1] / 180. * M_PI);
```

```
01800       cr = cos(latr / 180. * M_PI);
01801       vort = 2 * 7.2921e-5 * sin(latr * M_PI / 180.);
01802
01803       /* Loop over grid points... */
01804       for (ip = 0; ip < met->np; ip++) {
01805
01806         /* Set indices... */
01807         ip0 = GSL_MAX(ip - 1, 0);
01808         ip1 = GSL_MIN(ip + 1, met->np - 1);
01809
01810         /* Set auxiliary variables... */
01811         dp = 100. * (met->p[ip1] - met->p[ip0]);
01812
01813         /* Get gradients in longitude... */
01814         dtdx = (met->t[ix1][iy][ip] - met->t[ix0][iy][ip]) * pows[ip] / dx;
01815         dvdx = (met->v[ix1][iy][ip] - met->v[ix0][iy][ip]) / dx;
01816
01817         /* Get gradients in latitude... */
01818         dtdy = (met->t[ix][iy1][ip] - met->t[ix][iy0][ip]) * pows[ip] / dy;
01819         dudy = (met->u[ix][iy1][ip] * c1 - met->u[ix][iy0][ip] * c0) / dy;
01820
01821         /* Get gradients in pressure... */
01822         dtdp =
01823           (met->t[ix][iy][ip1] * pows[ip1] -
01824            met->t[ix][iy][ip0] * pows[ip0]) / dp;
01825         dudp = (met->u[ix][iy][ip1] - met->u[ix][iy][ip0]) / dp;
01826         dvdp = (met->v[ix][iy][ip1] - met->v[ix][iy][ip0]) / dp;
01827
01828         /* Calculate PV... */
01829         met->pv[ix][iy][ip] = (float)
01830           (1e6 * G0 *
01831            (-dtdp * (dvdx - dudy / cr + vort) + dvdp * dtdx - dudp * dtdy));
01832       }
01833     }
01834   }
01835 }
```

Here is the call graph for this function:

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

Downsampling of meteorological data.

Definition at line 1839 of file libtrac.c.

```
01841               {
01842
01843   met_t *help;
01844
01845   float w, wsum;
01846
01847   int ip, ip2, ix, ix2, iy, iy2;
01848
01849   /* Check parameters... */
01850   if (ctl->met_dp <= 1 && ctl->met_dx <= 1 && ctl->met_dy <= 1)
01851     return;
01852
01853   /* Allocate... */
01854   ALLOC(help, met_t, 1);
01855
01856   /* Copy data... */
01857   help->nx = met->nx;
01858   help->ny = met->ny;
01859   help->np = met->np;
01860   memcpy(help->lon, met->lon, sizeof(met->lon));
01861   memcpy(help->lat, met->lat, sizeof(met->lat));
01862   memcpy(help->p, met->p, sizeof(met->p));
01863
01864   /* Smoothing... */
01865   for (ix = 0; ix < met->nx; ix += ctl->met_dx) {
01866     for (iy = 0; iy < met->ny; iy += ctl->met_dy) {
01867       for (ip = 0; ip < met->np; ip += ctl->met_dp) {
01868         help->ps[ix][iy] = 0;
01869         help->pt[ix][iy] = 0;
01870         help->z[ix][iy][ip] = 0;
01871         help->t[ix][iy][ip] = 0;
01872         help->u[ix][iy][ip] = 0;
01873         help->v[ix][iy][ip] = 0;
01874         help->w[ix][iy][ip] = 0;
```

```
01875         help->pv[ix][iy][ip] = 0;
01876         help->h2o[ix][iy][ip] = 0;
01877         help->o3[ix][iy][ip] = 0;
01878         wsum = 0;
01879         for (ix2 = GSL_MAX(ix - ctl->met_sx + 1, 0);
01880              ix2 <= GSL_MIN(ix + ctl->met_sx - 1, met->nx - 1); ix2++)
01881           for (iy2 = GSL_MAX(iy - ctl->met_sy + 1, 0);
01882                iy2 <= GSL_MIN(iy + ctl->met_sy - 1, met->ny - 1); iy2++)
01883             for (ip2 = GSL_MAX(ip - ctl->met_sp + 1, 0);
01884                  ip2 <= GSL_MIN(ip + ctl->met_sp - 1, met->np - 1); ip2++) {
01885               w = (float) (1.0 - fabs(ix - ix2) / ctl->met_sx)
01886                 * (float) (1.0 - fabs(iy - iy2) / ctl->met_sy)
01887                 * (float) (1.0 - fabs(ip - ip2) / ctl->met_sp);
01888               help->ps[ix][iy] += w * met->ps[ix2][iy2];
01889               help->pt[ix][iy] += w * met->pt[ix2][iy2];
01890               help->z[ix][iy][ip] += w * met->z[ix2][iy2][ip2];
01891               help->t[ix][iy][ip] += w * met->t[ix2][iy2][ip2];
01892               help->u[ix][iy][ip] += w * met->u[ix2][iy2][ip2];
01893               help->v[ix][iy][ip] += w * met->v[ix2][iy2][ip2];
01894               help->w[ix][iy][ip] += w * met->w[ix2][iy2][ip2];
01895               help->pv[ix][iy][ip] += w * met->pv[ix2][iy2][ip2];
01896               help->h2o[ix][iy][ip] += w * met->h2o[ix2][iy2][ip2];
01897               help->o3[ix][iy][ip] += w * met->o3[ix2][iy2][ip2];
01898               wsum += w;
01899             }
01900         help->ps[ix][iy] /= wsum;
01901         help->pt[ix][iy] /= wsum;
01902         help->t[ix][iy][ip] /= wsum;
01903         help->z[ix][iy][ip] /= wsum;
01904         help->u[ix][iy][ip] /= wsum;
01905         help->v[ix][iy][ip] /= wsum;
01906         help->w[ix][iy][ip] /= wsum;
01907         help->pv[ix][iy][ip] /= wsum;
01908         help->h2o[ix][iy][ip] /= wsum;
01909         help->o3[ix][iy][ip] /= wsum;
01910       }
01911     }
01912   }
01913
01914   /* Downsampling... */
01915   met->nx = 0;
01916   for (ix = 0; ix < help->nx; ix += ctl->met_dx) {
01917     met->lon[met->nx] = help->lon[ix];
01918     met->ny = 0;
01919     for (iy = 0; iy < help->ny; iy += ctl->met_dy) {
01920       met->lat[met->ny] = help->lat[iy];
01921       met->ps[met->nx][met->ny] = help->ps[ix][iy];
01922       met->pt[met->nx][met->ny] = help->pt[ix][iy];
01923       met->np = 0;
01924       for (ip = 0; ip < help->np; ip += ctl->met_dp) {
01925         met->p[met->np] = help->p[ip];
01926         met->z[met->nx][met->ny][met->np] = help->z[ix][iy][ip];
01927         met->t[met->nx][met->ny][met->np] = help->t[ix][iy][ip];
01928         met->u[met->nx][met->ny][met->np] = help->u[ix][iy][ip];
01929         met->v[met->nx][met->ny][met->np] = help->v[ix][iy][ip];
01930         met->w[met->nx][met->ny][met->np] = help->w[ix][iy][ip];
01931         met->pv[met->nx][met->ny][met->np] = help->pv[ix][iy][ip];
01932         met->h2o[met->nx][met->ny][met->np] = help->h2o[ix][iy][ip];
01933         met->o3[met->nx][met->ny][met->np] = help->o3[ix][iy][ip];
01934         met->np++;
01935       }
01936       met->ny++;
01937     }
01938     met->nx++;
01939   }
01940
01941   /* Free... */
01942   free(help);
01943 }
```

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

Calculate tropopause pressure.

Definition at line 1947 of file libtrac.c.

```
01949               {
01950
01951   gsl_interp_accel *acc;
01952
```

```
01953   gsl_spline *spline;
01954
01955   double p2[400], pv[400], pv2[400], t[400], t2[400], th[400], th2[400],
01956     z[400], z2[400];
01957
01958   int found, ix, iy, iz, iz2;
01959
01960   /* Allocate... */
01961   acc = gsl_interp_accel_alloc();
01962   spline = gsl_spline_alloc(gsl_interp_cspline, (size_t) met->np);
01963
01964   /* Get altitude and pressure profiles... */
01965   for (iz = 0; iz < met->np; iz++)
01966     z[iz] = Z(met->p[iz]);
01967   for (iz = 0; iz <= 170; iz++) {
01968     z2[iz] = 4.5 + 0.1 * iz;
01969     p2[iz] = P(z2[iz]);
01970   }
01971
01972   /* Do not calculate tropopause... */
01973   if (ctl->met_tropo == 0)
01974     for (ix = 0; ix < met->nx; ix++)
01975       for (iy = 0; iy < met->ny; iy++)
01976         met->pt[ix][iy] = GSL_NAN;
01977
01978   /* Use tropopause climatology... */
01979   else if (ctl->met_tropo == 1)
01980     for (ix = 0; ix < met->nx; ix++)
01981       for (iy = 0; iy < met->ny; iy++)
01982         met->pt[ix][iy] = clim_tropo(met->time, met->lat[iy]);
01983
01984   /* Use cold point... */
01985   else if (ctl->met_tropo == 2) {
01986
01987     /* Loop over grid points... */
01988     for (ix = 0; ix < met->nx; ix++)
01989       for (iy = 0; iy < met->ny; iy++) {
01990
01991         /* Interpolate temperature profile... */
01992         for (iz = 0; iz < met->np; iz++)
01993           t[iz] = met->t[ix][iy][iz];
01994         gsl_spline_init(spline, z, t, (size_t) met->np);
01995         for (iz = 0; iz <= 170; iz++)
01996           t2[iz] = gsl_spline_eval(spline, z2[iz], acc);
01997
01998         /* Find minimum... */
01999         iz = (int) gsl_stats_min_index(t2, 1, 171);
02000         if (iz <= 0 || iz >= 170)
02001           met->pt[ix][iy] = GSL_NAN;
02002         else
02003           met->pt[ix][iy] = p2[iz];
02004       }
02005   }
02006
02007   /* Use WMO definition... */
02008   else if (ctl->met_tropo == 3 || ctl->met_tropo == 4) {
02009
02010     /* Loop over grid points... */
02011     for (ix = 0; ix < met->nx; ix++)
02012       for (iy = 0; iy < met->ny; iy++) {
02013
02014         /* Interpolate temperature profile... */
02015         for (iz = 0; iz < met->np; iz++)
02016           t[iz] = met->t[ix][iy][iz];
02017         gsl_spline_init(spline, z, t, (size_t) met->np);
02018         for (iz = 0; iz <= 160; iz++)
02019           t2[iz] = gsl_spline_eval(spline, z2[iz], acc);
02020
02021         /* Find 1st tropopause... */
02022         met->pt[ix][iy] = GSL_NAN;
02023         for (iz = 0; iz <= 140; iz++) {
02024           found = 1;
02025           for (iz2 = iz + 1; iz2 <= iz + 20; iz2++)
02026             if (1000. * G0 / RA * log(t2[iz2] / t2[iz])
02027                 / log(p2[iz2] / p2[iz]) > 2.0) {
02028               found = 0;
02029               break;
02030             }
02031           if (found) {
02032             if (iz > 0 && iz < 140)
02033               met->pt[ix][iy] = p2[iz];
02034             break;
02035           }
02036         }
02037
02038         /* Find 2nd tropopause... */
02039         if (ctl->met_tropo == 4) {
```

```
02040           met->pt[ix][iy] = GSL_NAN;
02041           for (; iz <= 140; iz++) {
02042             found = 1;
02043             for (iz2 = iz + 1; iz2 <= iz + 10; iz2++)
02044               if (1000. * G0 / RA * log(t2[iz2] / t2[iz])
02045                   / log(p2[iz2] / p2[iz]) < 3.0) {
02046                 found = 0;
02047                 break;
02048               }
02049             if (found)
02050               break;
02051           }
02052           for (; iz <= 140; iz++) {
02053             found = 1;
02054             for (iz2 = iz + 1; iz2 <= iz + 20; iz2++)
02055               if (1000. * G0 / RA * log(t2[iz2] / t2[iz])
02056                   / log(p2[iz2] / p2[iz]) > 2.0) {
02057                 found = 0;
02058                 break;
02059               }
02060             if (found) {
02061               if (iz > 0 && iz < 140)
02062                 met->pt[ix][iy] = p2[iz];
02063               break;
02064             }
02065           }
02066         }
02067       }
02068   }
02069
02070   /* Use dynamical tropopause... */
02071   else if (ctl->met_tropo == 5) {
02072
02073     /* Loop over grid points... */
02074     for (ix = 0; ix < met->nx; ix++)
02075       for (iy = 0; iy < met->ny; iy++) {
02076
02077         /* Interpolate potential vorticity profile... */
02078         for (iz = 0; iz < met->np; iz++)
02079           pv[iz] = met->pv[ix][iy][iz];
02080         gsl_spline_init(spline, z, pv, (size_t) met->np);
02081         for (iz = 0; iz <= 160; iz++)
02082           pv2[iz] = gsl_spline_eval(spline, z2[iz], acc);
02083
02084         /* Interpolate potential temperature profile... */
02085         for (iz = 0; iz < met->np; iz++)
02086           th[iz] = THETA(met->p[iz], met->t[ix][iy][iz]);
02087         gsl_spline_init(spline, z, th, (size_t) met->np);
02088         for (iz = 0; iz <= 160; iz++)
02089           th2[iz] = gsl_spline_eval(spline, z2[iz], acc);
02090
02091         /* Find dynamical tropopause 3.5 PVU + 380 K */
02092         met->pt[ix][iy] = GSL_NAN;
02093         for (iz = 0; iz <= 160; iz++)
02094           if (fabs(pv2[iz]) >= 3.5 || th2[iz] >= 380.) {
02095             if (iz > 0 && iz < 160)
02096               met->pt[ix][iy] = p2[iz];
02097             break;
02098           }
02099       }
02100   }
02101
02102   else
02103     ERRMSG("Cannot calculate tropopause!");
02104
02105   /* Free... */
02106   gsl_spline_free(spline);
02107   gsl_interp_accel_free(acc);
02108 }
```

Here is the call graph for this function:

5.21.2.32 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 2112 of file libtrac.c.

```
02119               {
02120
02121   FILE *in = NULL;
02122
02123   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
02124     msg[2 * LEN], rvarname[LEN], rval[LEN];
02125
02126   int contain = 0, i;
02127
02128   /* Open file... */
02129   if (filename[strlen(filename) - 1] != '-')
02130     if (!(in = fopen(filename, "r")))
02131       ERRMSG("Cannot open file!");
02132
02133   /* Set full variable name... */
02134   if (arridx >= 0) {
02135     sprintf(fullname1, "%s[%d]", varname, arridx);
02136     sprintf(fullname2, "%s[*]", varname);
02137   } else {
02138     sprintf(fullname1, "%s", varname);
02139     sprintf(fullname2, "%s", varname);
02140   }
02141
02142   /* Read data... */
02143   if (in != NULL)
02144     while (fgets(line, LEN, in))
02145       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
02146         if (strcasecmp(rvarname, fullname1) == 0 ||
02147             strcasecmp(rvarname, fullname2) == 0) {
02148           contain = 1;
02149           break;
02150         }
02151   for (i = 1; i < argc - 1; i++)
02152     if (strcasecmp(argv[i], fullname1) == 0 ||
02153         strcasecmp(argv[i], fullname2) == 0) {
02154       sprintf(rval, "%s", argv[i + 1]);
02155       contain = 1;
02156       break;
02157     }
02158
02159   /* Close file... */
02160   if (in != NULL)
02161     fclose(in);
02162
02163   /* Check for missing variables... */
02164   if (!contain) {
02165     if (strlen(defvalue) > 0)
02166       sprintf(rval, "%s", defvalue);
02167     else {
02168       sprintf(msg, "Missing variable %s!\n", fullname1);
02169       ERRMSG(msg);
02170     }
02171   }
02172
02173   /* Write info... */
02174   printf("%s = %s\n", fullname1, rval);
02175
02176   /* Return values... */
02177   if (value != NULL)
02178     sprintf(value, "%s", rval);
02179   return atof(rval);
02180 }
```

5.21.2.33 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 2184 of file libtrac.c.

```
02192               {
02193
02194   struct tm t0, t1;
02195
02196   t0.tm_year = 100;
02197   t0.tm_mon = 0;
02198   t0.tm_mday = 1;
02199   t0.tm_hour = 0;
02200   t0.tm_min = 0;
02201   t0.tm_sec = 0;
02202
```

```
02203   t1.tm_year = year - 1900;
02204   t1.tm_mon = mon - 1;
02205   t1.tm_mday = day;
02206   t1.tm_hour = hour;
02207   t1.tm_min = min;
02208   t1.tm_sec = sec;
02209
02210   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
02211 }
```

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

Measure wall-clock time.

Definition at line 2215 of file libtrac.c.

```
02218           {
02219
02220   static double starttime[NTIMER], runtime[NTIMER];
02221
02222   /* Check id... */
02223   if (id < 0 || id >= NTIMER)
02224     ERRMSG("Too many timers!");
02225
02226   /* Start timer... */
02227   if (mode == 1) {
02228     if (starttime[id] <= 0)
02229       starttime[id] = omp_get_wtime();
02230     else
02231       ERRMSG("Timer already started!");
02232   }
02233
02234   /* Stop timer... */
02235   else if (mode == 2) {
02236     if (starttime[id] > 0) {
02237       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
02238       starttime[id] = -1;
02239     }
02240   }
02241
02242   /* Print timer... */
02243   else if (mode == 3) {
02244     printf("%s = %.3f s\n", name, runtime[id]);
02245     runtime[id] = 0;
02246   }
02247 }
```

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

Write atmospheric data.

Definition at line 2251 of file libtrac.c.

```
02255           {
02256
02257   FILE *in, *out;
02258
02259   char line[LEN];
02260
02261   double r, t0, t1;
02262
02263   int ip, iq, year, mon, day, hour, min, sec;
02264
02265   /* Set time interval for output... */
02266   t0 = t - 0.5 * ctl->dt_mod;
02267   t1 = t + 0.5 * ctl->dt_mod;
02268
02269   /* Write info... */
02270   printf("Write atmospheric data: %s\n", filename);
02271
02272   /* Write ASCII data... */
02273   if (ctl->atm_type == 0) {
02274
02275     /* Check if gnuplot output is requested... */
```

```
02276     if (ctl->atm_gpfile[0] != '-') {
02277
02278       /* Create gnuplot pipe... */
02279       if (!(out = popen("gnuplot", "w")))
02280         ERRMSG("Cannot create pipe to gnuplot!");
02281
02282       /* Set plot filename... */
02283       fprintf(out, "set out \"%s.png\"\n", filename);
02284
02285       /* Set time string... */
02286       jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
02287       fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
02288               year, mon, day, hour, min);
02289
02290       /* Dump gnuplot file to pipe... */
02291       if (!(in = fopen(ctl->atm_gpfile, "r")))
02292         ERRMSG("Cannot open file!");
02293       while (fgets(line, LEN, in))
02294         fprintf(out, "%s", line);
02295       fclose(in);
02296     }
02297
02298     else {
02299
02300       /* Create file... */
02301       if (!(out = fopen(filename, "w")))
02302         ERRMSG("Cannot create file!");
02303     }
02304
02305     /* Write header... */
02306     fprintf(out,
02307             "# $1 = time [s]\n"
02308             "# $2 = altitude [km]\n"
02309             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
02310     for (iq = 0; iq < ctl->nq; iq++)
02311       fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
02312               ctl->qnt_unit[iq]);
02313     fprintf(out, "\n");
02314
02315     /* Write data... */
02316     for (ip = 0; ip < atm->np; ip++) {
02317
02318       /* Check time... */
02319       if (ctl->atm_filter && (atm->time[ip] < t0 || atm->time[ip] > t1))
02320         continue;
02321
02322       /* Write output... */
02323       fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
02324               atm->lon[ip], atm->lat[ip]);
02325       for (iq = 0; iq < ctl->nq; iq++) {
02326         fprintf(out, " ");
02327         fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
02328       }
02329       fprintf(out, "\n");
02330     }
02331
02332     /* Close file... */
02333     fclose(out);
02334   }
02335
02336   /* Write binary data... */
02337   else if (ctl->atm_type == 1) {
02338
02339     /* Create file... */
02340     if (!(out = fopen(filename, "w")))
02341       ERRMSG("Cannot create file!");
02342
02343     /* Write data... */
02344     FWRITE(&atm->np, int,
02345            1,
02346            out);
02347     FWRITE(atm->time, double,
02348              (size_t) atm->np,
02349            out);
02350     FWRITE(atm->p, double,
02351              (size_t) atm->np,
02352            out);
02353     FWRITE(atm->lon, double,
02354              (size_t) atm->np,
02355            out);
02356     FWRITE(atm->lat, double,
02357              (size_t) atm->np,
02358            out);
02359     for (iq = 0; iq < ctl->nq; iq++)
02360       FWRITE(atm->q[iq], double,
02361                (size_t) atm->np,
02362              out);
```

```
02363
02364     /* Close file... */
02365     fclose(out);
02366   }
02367
02368   /* Error... */
02369   else
02370     ERRMSG("Atmospheric data type not supported!");
02371 }
```

Here is the call graph for this function:

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

Write CSI data.

Definition at line 2375 of file libtrac.c.

```
02379             {
02380
02381   static FILE *in, *out;
02382
02383   static char line[LEN];
02384
02385   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
02386     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
02387
02388   static int obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
02389
02390   /* Init... */
02391   if (t == ctl->t_start) {
02392
02393     /* Check quantity index for mass... */
02394     if (ctl->qnt_m < 0)
02395       ERRMSG("Need quantity mass!");
02396
02397     /* Open observation data file... */
02398     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
02399     if (!(in = fopen(ctl->csi_obsfile, "r")))
02400       ERRMSG("Cannot open file!");
02401
02402     /* Create new file... */
02403     printf("Write CSI data: %s\n", filename);
02404     if (!(out = fopen(filename, "w")))
02405       ERRMSG("Cannot create file!");
02406
02407     /* Write header... */
02408     fprintf(out,
02409             "# $1 = time [s]\n"
02410             "# $2 = number of hits (cx)\n"
02411             "# $3 = number of misses (cy)\n"
02412             "# $4 = number of false alarms (cz)\n"
02413             "# $5 = number of observations (cx + cy)\n"
02414             "# $6 = number of forecasts (cx + cz)\n"
02415             "# $7 = bias (forecasts/observations) [%%]\n"
02416             "# $8 = probability of detection (POD) [%%]\n"
02417             "# $9 = false alarm rate (FAR) [%%]\n"
02418             "# $10 = critical success index (CSI) [%%]\n\n");
02419   }
02420
02421   /* Set time interval... */
02422   t0 = t - 0.5 * ctl->dt_mod;
```

```
02423   t1 = t + 0.5 * ctl->dt_mod;
02424
02425   /* Initialize grid cells... */
02426   for (ix = 0; ix < ctl->csi_nx; ix++)
02427     for (iy = 0; iy < ctl->csi_ny; iy++)
02428       for (iz = 0; iz < ctl->csi_nz; iz++)
02429         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
02430
02431   /* Read observation data... */
02432   while (fgets(line, LEN, in)) {
02433
02434     /* Read data... */
02435     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
02436         5)
02437       continue;
02438
02439     /* Check time... */
02440     if (rt < t0)
02441       continue;
02442     if (rt > t1)
02443       break;
02444
02445     /* Calculate indices... */
02446     ix = (int) ((rlon - ctl->csi_lon0)
02447                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
02448     iy = (int) ((rlat - ctl->csi_lat0)
02449                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
02450     iz = (int) ((rz - ctl->csi_z0)
02451                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
02452
02453     /* Check indices... */
02454     if (ix < 0 || ix >= ctl->csi_nx ||
02455         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
02456       continue;
02457
02458     /* Get mean observation index... */
02459     obsmean[ix][iy][iz] += robs;
02460     obscount[ix][iy][iz]++;
02461   }
02462
02463   /* Analyze model data... */
02464   for (ip = 0; ip < atm->np; ip++) {
02465
02466     /* Check time... */
02467     if (atm->time[ip] < t0 || atm->time[ip] > t1)
02468       continue;
02469
02470     /* Get indices... */
02471     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
02472                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
02473     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
02474                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
02475     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
02476                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
02477
02478     /* Check indices... */
02479     if (ix < 0 || ix >= ctl->csi_nx ||
02480         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
02481       continue;
02482
02483     /* Get total mass in grid cell... */
02484     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
02485   }
02486
02487   /* Analyze all grid cells... */
02488   for (ix = 0; ix < ctl->csi_nx; ix++)
02489     for (iy = 0; iy < ctl->csi_ny; iy++)
02490       for (iz = 0; iz < ctl->csi_nz; iz++) {
02491
02492         /* Calculate mean observation index... */
02493         if (obscount[ix][iy][iz] > 0)
02494           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
02495
02496         /* Calculate column density... */
02497         if (modmean[ix][iy][iz] > 0) {
02498           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
02499           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
02500           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
02501           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
02502             * cos(lat * M_PI / 180.);
02503           modmean[ix][iy][iz] /= (1e6 * area);
02504         }
02505
02506         /* Calculate CSI... */
02507         if (obscount[ix][iy][iz] > 0) {
02508           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
02509               modmean[ix][iy][iz] >= ctl->csi_modmin)
```

```
02510             cx++;
02511           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
02512                    modmean[ix][iy][iz] < ctl->csi_modmin)
02513             cy++;
02514           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
02515                    modmean[ix][iy][iz] >= ctl->csi_modmin)
02516             cz++;
02517         }
02518       }
02519
02520   /* Write output... */
02521   if (fmod(t, ctl->csi_dt_out) == 0) {
02522
02523     /* Write... */
02524     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
02525             t, cx, cy, cz, cx + cy, cx + cz,
02526             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
02527             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
02528             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
02529             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
02530
02531     /* Set counters to zero... */
02532     cx = cy = cz = 0;
02533   }
02534
02535   /* Close file... */
02536   if (t == ctl->t_stop)
02537     fclose(out);
02538 }
```

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

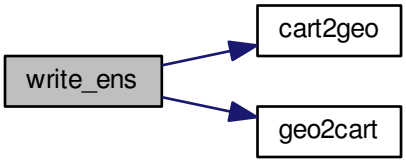
Write ensemble data.

Definition at line 2542 of file libtrac.c.

```
02546             {
02547
02548   static FILE *out;
02549
02550   static double dummy, ens, lat, lon, p[NENS], q[NQ][NENS],
02551     t0, t1, x[NENS][3], xm[3];
02552
02553   static int ip, iq;
02554
02555   static size_t i, n;
02556
02557   /* Init... */
02558   if (t == ctl->t_start) {
02559
02560     /* Check quantities... */
02561     if (ctl->qnt_ens < 0)
02562       ERRMSG("Missing ensemble IDs!");
02563
02564     /* Create new file... */
02565     printf("Write ensemble data: %s\n", filename);
02566     if (!(out = fopen(filename, "w")))
02567       ERRMSG("Cannot create file!");
02568
02569     /* Write header... */
02570     fprintf(out,
02571             "# $1 = time [s]\n"
02572             "# $2 = altitude [km]\n"
02573             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
02574     for (iq = 0; iq < ctl->nq; iq++)
02575       fprintf(out, "# $%d = %s (mean) [%s]\n", 5 + iq,
02576               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
02577     for (iq = 0; iq < ctl->nq; iq++)
02578       fprintf(out, "# $%d = %s (sigma) [%s]\n", 5 + ctl->nq + iq,
02579               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
02580     fprintf(out, "# $%d = number of members\n\n", 5 + 2 * ctl->nq);
02581   }
02582
02583   /* Set time interval... */
02584   t0 = t - 0.5 * ctl->dt_mod;
02585   t1 = t + 0.5 * ctl->dt_mod;
02586
02587   /* Init... */
02588   ens = GSL_NAN;
02589   n = 0;
```

```
02590
02591   /* Loop over air parcels... */
02592   for (ip = 0; ip < atm->np; ip++) {
02593
02594     /* Check time... */
02595     if (atm->time[ip] < t0 || atm->time[ip] > t1)
02596       continue;
02597
02598     /* Check ensemble id... */
02599     if (atm->q[ctl->qnt_ens][ip] != ens) {
02600
02601       /* Write results... */
02602       if (n > 0) {
02603
02604         /* Get mean position... */
02605         xm[0] = xm[1] = xm[2] = 0;
02606         for (i = 0; i < n; i++) {
02607           xm[0] += x[i][0] / (double) n;
02608           xm[1] += x[i][1] / (double) n;
02609           xm[2] += x[i][2] / (double) n;
02610         }
02611         cart2geo(xm, &dummy, &lon, &lat);
02612         fprintf(out, "%.2f %g %g %g", t, Z(gsl_stats_mean(p, 1, n)), lon,
02613                 lat);
02614
02615         /* Get quantity statistics... */
02616         for (iq = 0; iq < ctl->nq; iq++) {
02617           fprintf(out, " ");
02618           fprintf(out, ctl->qnt_format[iq], gsl_stats_mean(q[iq], 1, n));
02619         }
02620         for (iq = 0; iq < ctl->nq; iq++) {
02621           fprintf(out, " ");
02622           fprintf(out, ctl->qnt_format[iq], gsl_stats_sd(q[iq], 1, n));
02623         }
02624         fprintf(out, " %lu\n", n);
02625       }
02626
02627       /* Init new ensemble... */
02628       ens = atm->q[ctl->qnt_ens][ip];
02629       n = 0;
02630     }
02631
02632     /* Save data... */
02633     p[n] = atm->p[ip];
02634     geo2cart(0, atm->lon[ip], atm->lat[ip], x[n]);
02635     for (iq = 0; iq < ctl->nq; iq++)
02636       q[iq][n] = atm->q[iq][ip];
02637     if ((++n) >= NENS)
02638       ERRMSG("Too many data points!");
02639   }
02640
02641   /* Write results... */
02642   if (n > 0) {
02643
02644     /* Get mean position... */
02645     xm[0] = xm[1] = xm[2] = 0;
02646     for (i = 0; i < n; i++) {
02647       xm[0] += x[i][0] / (double) n;
02648       xm[1] += x[i][1] / (double) n;
02649       xm[2] += x[i][2] / (double) n;
02650     }
02651     cart2geo(xm, &dummy, &lon, &lat);
02652     fprintf(out, "%.2f %g %g %g", t, Z(gsl_stats_mean(p, 1, n)), lon, lat);
02653
02654     /* Get quantity statistics... */
02655     for (iq = 0; iq < ctl->nq; iq++) {
02656       fprintf(out, " ");
02657       fprintf(out, ctl->qnt_format[iq], gsl_stats_mean(q[iq], 1, n));
02658     }
02659     for (iq = 0; iq < ctl->nq; iq++) {
02660       fprintf(out, " ");
02661       fprintf(out, ctl->qnt_format[iq], gsl_stats_sd(q[iq], 1, n));
02662     }
02663     fprintf(out, " %lu\n", n);
02664   }
02665
02666   /* Close file... */
02667   if (t == ctl->t_stop)
02668     fclose(out);
02669 }
```

Here is the call graph for this function:



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

Write gridded data.

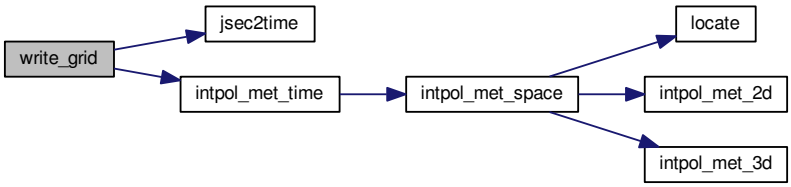
Definition at line 2673 of file libtrac.c.

```
02679           {
02680
02681   FILE *in, *out;
02682
02683   char line[LEN];
02684
02685   static double mass[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
02686     area, rho_air, press, temp, cd, vmr, t0, t1, r;
02687
02688   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
02689
02690   /* Check dimensions... */
02691   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
02692     ERRMSG("Grid dimensions too large!");
02693
02694   /* Check quantity index for mass... */
02695   if (ctl->qnt_m < 0)
02696     ERRMSG("Need quantity mass!");
02697
02698   /* Set time interval for output... */
02699   t0 = t - 0.5 * ctl->dt_mod;
02700   t1 = t + 0.5 * ctl->dt_mod;
02701
02702   /* Set grid box size... */
02703   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
02704   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
02705   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
02706
02707   /* Initialize grid... */
02708   for (ix = 0; ix < ctl->grid_nx; ix++)
02709     for (iy = 0; iy < ctl->grid_ny; iy++)
02710       for (iz = 0; iz < ctl->grid_nz; iz++)
02711         mass[ix][iy][iz] = 0;
02712
02713   /* Average data... */
02714   for (ip = 0; ip < atm->np; ip++)
02715     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
02716
02717       /* Get index... */
02718       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
02719       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
02720       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
02721
02722       /* Check indices... */
02723       if (ix < 0 || ix >= ctl->grid_nx ||
02724           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
02725         continue;
02726
02727       /* Add mass... */
02728       mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
02729     }
02730
```

```
02731   /* Check if gnuplot output is requested... */
02732   if (ctl->grid_gpfile[0] != '-') {
02733
02734     /* Write info... */
02735     printf("Plot grid data: %s.png\n", filename);
02736
02737     /* Create gnuplot pipe... */
02738     if (!(out = popen("gnuplot", "w")))
02739       ERRMSG("Cannot create pipe to gnuplot!");
02740
02741     /* Set plot filename... */
02742     fprintf(out, "set out \"%s.png\"\n", filename);
02743
02744     /* Set time string... */
02745     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
02746     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
02747             year, mon, day, hour, min);
02748
02749     /* Dump gnuplot file to pipe... */
02750     if (!(in = fopen(ctl->grid_gpfile, "r")))
02751       ERRMSG("Cannot open file!");
02752     while (fgets(line, LEN, in))
02753       fprintf(out, "%s", line);
02754     fclose(in);
02755   }
02756
02757   else {
02758
02759     /* Write info... */
02760     printf("Write grid data: %s\n", filename);
02761
02762     /* Create file... */
02763     if (!(out = fopen(filename, "w")))
02764       ERRMSG("Cannot create file!");
02765   }
02766
02767   /* Write header... */
02768   fprintf(out,
02769           "# $1 = time [s]\n"
02770           "# $2 = altitude [km]\n"
02771           "# $3 = longitude [deg]\n"
02772           "# $4 = latitude [deg]\n"
02773           "# $5 = surface area [km^2]\n"
02774           "# $6 = layer width [km]\n"
02775           "# $7 = temperature [K]\n"
02776           "# $8 = column density [kg/m^2]\n"
02777           "# $9 = volume mixing ratio [1]\n\n");
02778
02779   /* Write data... */
02780   for (ix = 0; ix < ctl->grid_nx; ix++) {
02781     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
02782       fprintf(out, "\n");
02783     for (iy = 0; iy < ctl->grid_ny; iy++) {
02784       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
02785         fprintf(out, "\n");
02786       for (iz = 0; iz < ctl->grid_nz; iz++)
02787         if (!ctl->grid_sparse || mass[ix][iy][iz] > 0) {
02788
02789           /* Set coordinates... */
02790           z = ctl->grid_z0 + dz * (iz + 0.5);
02791           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
02792           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
02793
02794           /* Get pressure and temperature... */
02795           press = P(z);
02796           intpol_met_time(met0, met1, t, press, lon, lat, NULL, NULL,
02797                           NULL, &temp, NULL, NULL, NULL, NULL, NULL, NULL);
02798
02799           /* Calculate surface area... */
02800           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
02801             * cos(lat * M_PI / 180.);
02802
02803           /* Calculate column density... */
02804           cd = mass[ix][iy][iz] / (1e6 * area);
02805
02806           /* Calculate volume mixing ratio... */
02807           rho_air = 100. * press / (RA * temp);
02808           vmr = MA / ctl->molmass * mass[ix][iy][iz]
02809             / (rho_air * 1e6 * area * 1e3 * dz);
02810
02811           /* Write output... */
02812           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
02813                   t, z, lon, lat, area, dz, temp, cd, vmr);
02814         }
02815     }
02816   }
02817
```

```
02818   /* Close file... */
02819   fclose(out);
02820 }
```

Here is the call graph for this function:



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

Write profile data.

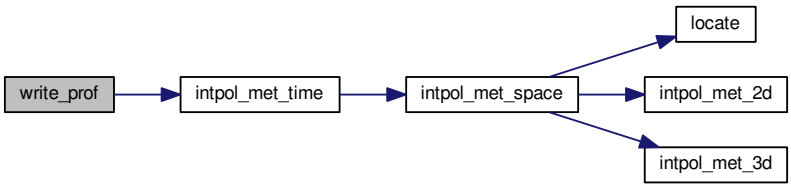
Definition at line 2824 of file libtrac.c.

```
02830             {
02831
02832   static FILE *in, *out;
02833
02834   static char line[LEN];
02835
02836   static double mass[GX][GY][GZ], obsmean[GX][GY], rt, rz, rlon, rlat, robs,
02837     t0, t1, area, dz, dlon, dlat, lon, lat, z, press, temp, rho_air, vmr, h2o,
02838     o3;
02839
02840   static int obscount[GX][GY], ip, ix, iy, iz, okay;
02841
02842   /* Init... */
02843   if (t == ctl->t_start) {
02844
02845     /* Check quantity index for mass... */
02846     if (ctl->qnt_m < 0)
02847       ERRMSG("Need quantity mass!");
02848
02849     /* Check dimensions... */
02850     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
02851       ERRMSG("Grid dimensions too large!");
02852
02853     /* Open observation data file... */
02854     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
02855     if (!(in = fopen(ctl->prof_obsfile, "r")))
02856       ERRMSG("Cannot open file!");
02857
02858     /* Create new output file... */
02859     printf("Write profile data: %s\n", filename);
02860     if (!(out = fopen(filename, "w")))
02861       ERRMSG("Cannot create file!");
02862
02863     /* Write header... */
02864     fprintf(out,
02865             "# $1  = time [s]\n"
02866             "# $2  = altitude [km]\n"
02867             "# $3  = longitude [deg]\n"
02868             "# $4  = latitude [deg]\n"
02869             "# $5  = pressure [hPa]\n"
02870             "# $6  = temperature [K]\n"
02871             "# $7  = volume mixing ratio [1]\n"
02872             "# $8  = H2O volume mixing ratio [1]\n"
02873             "# $9  = O3 volume mixing ratio [1]\n"
02874             "# $10 = mean BT index [K]\n");
02875
02876     /* Set grid box size... */
02877     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
```

```
02878     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
02879     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
02880   }
02881
02882   /* Set time interval... */
02883   t0 = t - 0.5 * ctl->dt_mod;
02884   t1 = t + 0.5 * ctl->dt_mod;
02885
02886   /* Initialize... */
02887   for (ix = 0; ix < ctl->prof_nx; ix++)
02888     for (iy = 0; iy < ctl->prof_ny; iy++) {
02889       obsmean[ix][iy] = 0;
02890       obscount[ix][iy] = 0;
02891       for (iz = 0; iz < ctl->prof_nz; iz++)
02892         mass[ix][iy][iz] = 0;
02893     }
02894
02895   /* Read observation data... */
02896   while (fgets(line, LEN, in)) {
02897
02898     /* Read data... */
02899     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
02900         5)
02901       continue;
02902
02903     /* Check time... */
02904     if (rt < t0)
02905       continue;
02906     if (rt > t1)
02907       break;
02908
02909     /* Calculate indices... */
02910     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
02911     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
02912
02913     /* Check indices... */
02914     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
02915       continue;
02916
02917     /* Get mean observation index... */
02918     obsmean[ix][iy] += robs;
02919     obscount[ix][iy]++;
02920   }
02921
02922   /* Analyze model data... */
02923   for (ip = 0; ip < atm->np; ip++) {
02924
02925     /* Check time... */
02926     if (atm->time[ip] < t0 || atm->time[ip] > t1)
02927       continue;
02928
02929     /* Get indices... */
02930     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
02931     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
02932     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
02933
02934     /* Check indices... */
02935     if (ix < 0 || ix >= ctl->prof_nx ||
02936         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
02937       continue;
02938
02939     /* Get total mass in grid cell... */
02940     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
02941   }
02942
02943   /* Extract profiles... */
02944   for (ix = 0; ix < ctl->prof_nx; ix++)
02945     for (iy = 0; iy < ctl->prof_ny; iy++)
02946       if (obscount[ix][iy] > 0) {
02947
02948         /* Check profile... */
02949         okay = 0;
02950         for (iz = 0; iz < ctl->prof_nz; iz++)
02951           if (mass[ix][iy][iz] > 0)
02952             okay = 1;
02953         if (!okay)
02954           continue;
02955
02956         /* Write output... */
02957         fprintf(out, "\n");
02958
02959         /* Loop over altitudes... */
02960         for (iz = 0; iz < ctl->prof_nz; iz++) {
02961
02962           /* Set coordinates... */
02963           z = ctl->prof_z0 + dz * (iz + 0.5);
02964           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
```

```
02965           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
02966
02967           /* Get pressure and temperature... */
02968           press = P(z);
02969           intpol_met_time(met0, met1, t, press, lon, lat, NULL, NULL,
02970                           NULL, &temp, NULL, NULL, NULL, NULL, &h2o, &o3);
02971
02972           /* Calculate surface area... */
02973           area = dlat * dlon * gsl_pow_2(M_PI * RE / 180.)
02974             * cos(lat * M_PI / 180.);
02975
02976           /* Calculate volume mixing ratio... */
02977           rho_air = 100. * press / (RA * temp);
02978           vmr = MA / ctl->molmass * mass[ix][iy][iz]
02979             / (rho_air * area * dz * 1e9);
02980
02981           /* Write output... */
02982           fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g\n",
02983                   t, z, lon, lat, press, temp, vmr, h2o, o3,
02984                   obsmean[ix][iy] / obscount[ix][iy]);
02985         }
02986       }
02987
02988   /* Close file... */
02989   if (t == ctl->t_stop)
02990     fclose(out);
02991 }
```

Here is the call graph for this function:



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

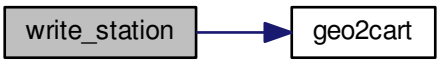
Write station data.

Definition at line 2995 of file libtrac.c.

```
02999           {
03000
03001   static FILE *out;
03002
03003   static double rmax2, t0, t1, x0[3], x1[3];
03004
03005   static int ip, iq;
03006
03007   /* Init... */
03008   if (t == ctl->t_start) {
03009
03010     /* Write info... */
03011     printf("Write station data: %s\n", filename);
03012
03013     /* Create new file... */
03014     if (!(out = fopen(filename, "w")))
03015       ERRMSG("Cannot create file!");
03016
03017     /* Write header... */
03018     fprintf(out,
03019             "# $1 = time [s]\n"
03020             "# $2 = altitude [km]\n"
03021             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
03022     for (iq = 0; iq < ctl->nq; iq++)
```

```
03023       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
03024               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
03025     fprintf(out, "\n");
03026
03027     /* Set geolocation and search radius... */
03028     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
03029     rmax2 = gsl_pow_2(ctl->stat_r);
03030   }
03031
03032   /* Set time interval for output... */
03033   t0 = t - 0.5 * ctl->dt_mod;
03034   t1 = t + 0.5 * ctl->dt_mod;
03035
03036   /* Loop over air parcels... */
03037   for (ip = 0; ip < atm->np; ip++) {
03038
03039     /* Check time... */
03040     if (atm->time[ip] < t0 || atm->time[ip] > t1)
03041       continue;
03042
03043     /* Check station flag... */
03044     if (ctl->qnt_stat >= 0)
03045       if (atm->q[ctl->qnt_stat][ip])
03046         continue;
03047
03048     /* Get Cartesian coordinates... */
03049     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
03050
03051     /* Check horizontal distance... */
03052     if (DIST2(x0, x1) > rmax2)
03053       continue;
03054
03055     /* Set station flag... */
03056     if (ctl->qnt_stat >= 0)
03057       atm->q[ctl->qnt_stat][ip] = 1;
03058
03059     /* Write data... */
03060     fprintf(out, "%.2f %g %g %g",
03061             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
03062     for (iq = 0; iq < ctl->nq; iq++) {
03063       fprintf(out, " ");
03064       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
03065     }
03066     fprintf(out, "\n");
03067   }
03068
03069   /* Close file... */
03070   if (t == ctl->t_stop)
03071     fclose(out);
03072 }
```

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) 2013-2018 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 111
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 DIST(a, b) sqrt(DIST2(a, b))
00127
00129 #define DIST2(a, b)                                                     \
00130   ((a[0]-b[0])*(a[0]-b[0])+(a[1]-b[1])*(a[1]-b[1])+(a[2]-b[2])*(a[2]-b[2]))
00131
00133 #define DOTP(a, b) (a[0]*b[0]+a[1]*b[1]+a[2]*b[2])
00134
00136 #define ERRMSG(msg) {                                               \
```

```
00137     printf("\nError (%s, %s, l%d): %s\n\n",                              \
00138            __FILE__, __func__, __LINE__, msg);                           \
00139     exit(EXIT_FAILURE);                                                  \
00140   }
00141
00143 #define FREAD(ptr, type, size, out) {                                    \
00144     if(fread(ptr, sizeof(type), size, out)!=size)                        \
00145       ERRMSG("Error while reading!");                                    \
00146   }
00147
00149 #define FWRITE(ptr, type, size, out) {                                   \
00150     if(fwrite(ptr, sizeof(type), size, out)!=size)                       \
00151       ERRMSG("Error while writing!");                                    \
00152   }
00153
00155 #define LIN(x0, y0, x1, y1, x)                  \
00156   ((y0)+((y1)-(y0))/((x1)-(x0))*((x)-(x0)))
00157
00159 #define NC(cmd) {                                   \
00160     if((cmd)!=NC_NOERR)                             \
00161       ERRMSG(nc_strerror(cmd));                     \
00162   }
00163
00165 #define NORM(a) sqrt(DOTP(a, a))
00166
00168 #define PRINT(format, var)                                               \
00169   printf("Print (%s, %s, l%d): %s= "format"\n",                          \
00170          __FILE__, __func__, __LINE__, #var, var);
00171
00173 #define P(z) (P0*exp(-(z)/H0))
00174
00176 #define THETA(p, t) ((t)*pow(1000./(p), 0.286))
00177
00179 #define TOK(line, tok, format, var) {                                    \
00180     if(((tok)=strtok((line), " \t"))) {                                  \
00181       if(sscanf(tok, format, &(var))!=1) continue;                       \
00182     } else ERRMSG("Error while reading!");                               \
00183   }
00184
00186 #define Z(p) (H0*log(P0/(p)))
00187
00188 /* ------------------------------------------------------------
00189    Timers...
00190    ------------------------------------------------------------ */
00191
00193 #define START_TIMER(id) timer(#id, id, 1)
00194
00196 #define STOP_TIMER(id) timer(#id, id, 2)
00197
00199 #define PRINT_TIMER(id) timer(#id, id, 3)
00200
00202 #define NTIMER 12
00203
00205 #define TIMER_TOTAL 0
00206
00208 #define TIMER_INIT 1
00209
00211 #define TIMER_INPUT 2
00212
00214 #define TIMER_OUTPUT 3
00215
00217 #define TIMER_ADVECT 4
00218
00220 #define TIMER_DECAY 5
00221
00223 #define TIMER_DIFFMESO 6
00224
00226 #define TIMER_DIFFTURB 7
00227
00229 #define TIMER_ISOSURF 8
00230
00232 #define TIMER_METEO 9
00233
00235 #define TIMER_POSITION 10
00236
00238 #define TIMER_SEDI 11
00239
00240 /* ------------------------------------------------------------
00241    Structs...
00242    ------------------------------------------------------------ */
00243
00245 typedef struct {
00246
00248   int nq;
00249
00251   char qnt_name[NQ][LEN];
00252
```

```
00254   char qnt_unit[NQ][LEN];
00255
00257   char qnt_format[NQ][LEN];
00258
00260   int qnt_ens;
00261
00263   int qnt_m;
00264
00266   int qnt_rho;
00267
00269   int qnt_r;
00270
00272   int qnt_ps;
00273
00275   int qnt_pt;
00276
00278   int qnt_z;
00279
00281   int qnt_p;
00282
00284   int qnt_t;
00285
00287   int qnt_u;
00288
00290   int qnt_v;
00291
00293   int qnt_w;
00294
00296   int qnt_h2o;
00297
00299   int qnt_o3;
00300
00302   int qnt_theta;
00303
00305   int qnt_vh;
00306
00308   int qnt_vz;
00309
00311   int qnt_pv;
00312
00314   int qnt_tice;
00315
00317   int qnt_tsts;
00318
00320   int qnt_tnat;
00321
00323   int qnt_stat;
00324
00326   int direction;
00327
00329   double t_start;
00330
00332   double t_stop;
00333
00335   double dt_mod;
00336
00338   double dt_met;
00339
00341   int met_dx;
00342
00344   int met_dy;
00345
00347   int met_dp;
00348
00350   int met_sx;
00351
00353   int met_sy;
00354
00356   int met_sp;
00357
00359   int met_np;
00360
00362   double met_p[EP];
00363
00366   int met_tropo;
00367
00369   char met_geopot[LEN];
00370
00372   char met_stage[LEN];
00373
00376   int isosurf;
00377
00379   char balloon[LEN];
00380
00382   double turb_dx_trop;
00383
00385   double turb_dx_strat;
```

```
00386
00388   double turb_dz_trop;
00389
00391   double turb_dz_strat;
00392
00394   double turb_mesox;
00395
00397   double turb_mesoz;
00398
00400   double molmass;
00401
00403   double tdec_trop;
00404
00406   double tdec_strat;
00407
00409   double psc_h2o;
00410
00412   double psc_hno3;
00413
00415   char atm_basename[LEN];
00416
00418   char atm_gpfile[LEN];
00419
00421   double atm_dt_out;
00422
00424   int atm_filter;
00425
00427   int atm_type;
00428
00430   char csi_basename[LEN];
00431
00433   double csi_dt_out;
00434
00436   char csi_obsfile[LEN];
00437
00439   double csi_obsmin;
00440
00442   double csi_modmin;
00443
00445   int csi_nz;
00446
00448   double csi_z0;
00449
00451   double csi_z1;
00452
00454   int csi_nx;
00455
00457   double csi_lon0;
00458
00460   double csi_lon1;
00461
00463   int csi_ny;
00464
00466   double csi_lat0;
00467
00469   double csi_lat1;
00470
00472   char grid_basename[LEN];
00473
00475   char grid_gpfile[LEN];
00476
00478   double grid_dt_out;
00479
00481   int grid_sparse;
00482
00484   int grid_nz;
00485
00487   double grid_z0;
00488
00490   double grid_z1;
00491
00493   int grid_nx;
00494
00496   double grid_lon0;
00497
00499   double grid_lon1;
00500
00502   int grid_ny;
00503
00505   double grid_lat0;
00506
00508   double grid_lat1;
00509
00511   char prof_basename[LEN];
00512
00514   char prof_obsfile[LEN];
00515
```

```
00517   int prof_nz;
00518
00520   double prof_z0;
00521
00523   double prof_z1;
00524
00526   int prof_nx;
00527
00529   double prof_lon0;
00530
00532   double prof_lon1;
00533
00535   int prof_ny;
00536
00538   double prof_lat0;
00539
00541   double prof_lat1;
00542
00544   char ens_basename[LEN];
00545
00547   char stat_basename[LEN];
00548
00550   double stat_lon;
00551
00553   double stat_lat;
00554
00556   double stat_r;
00557
00558 } ctl_t;
00559
00561 typedef struct {
00562
00564   int np;
00565
00567   double time[NP];
00568
00570   double p[NP];
00571
00573   double lon[NP];
00574
00576   double lat[NP];
00577
00579   double q[NQ][NP];
00580
00582   float up[NP];
00583
00585   float vp[NP];
00586
00588   float wp[NP];
00589
00590 } atm_t;
00591
00593 typedef struct {
00594
00596   double time;
00597
00599   int nx;
00600
00602   int ny;
00603
00605   int np;
00606
00608   double lon[EX];
00609
00611   double lat[EY];
00612
00614   double p[EP];
00615
00617   double ps[EX][EY];
00618
00620   double pt[EX][EY];
00621
00623   float z[EX][EY][EP];
00624
00626   float t[EX][EY][EP];
00627
00629   float u[EX][EY][EP];
00630
00632   float v[EX][EY][EP];
00633
00635   float w[EX][EY][EP];
00636
00638   float pv[EX][EY][EP];
00639
00641   float h2o[EX][EY][EP];
00642
00644   float o3[EX][EY][EP];
```

```
00645
00647   float pl[EX][EY][EP];
00648
00649 } met_t;
00650
00651 /* ------------------------------------------------------------
00652    Functions...
00653    ------------------------------------------------------------ */
00654
00656 void cart2geo(
00657   double *x,
00658   double *z,
00659   double *lon,
00660   double *lat);
00661
00663 double clim_hno3(
00664   double t,
00665   double lat,
00666   double p);
00667
00669 double clim_tropo(
00670   double t,
00671   double lat);
00672
00674 void day2doy(
00675   int year,
00676   int mon,
00677   int day,
00678   int *doy);
00679
00681 void doy2day(
00682   int year,
00683   int doy,
00684   int *mon,
00685   int *day);
00686
00688 double deg2dx(
00689   double dlon,
00690   double lat);
00691
00693 double deg2dy(
00694   double dlat);
00695
00697 double dp2dz(
00698   double dp,
00699   double p);
00700
00702 double dx2deg(
00703   double dx,
00704   double lat);
00705
00707 double dy2deg(
00708   double dy);
00709
00711 double dz2dp(
00712   double dz,
00713   double p);
00714
00716 void geo2cart(
00717   double z,
00718   double lon,
00719   double lat,
00720   double *x);
00721
00723 void get_met(
00724   ctl_t * ctl,
00725   char *metbase,
00726   double t,
00727   met_t * met0,
00728   met_t * met1);
00729
00731 void get_met_help(
00732   double t,
00733   int direct,
00734   char *metbase,
00735   double dt_met,
00736   char *filename);
00737
00739 void intpol_met_2d(
00740   double array[EX][EY],
00741   int ix,
00742   int iy,
00743   double wx,
00744   double wy,
00745   double *var);
00746
00748 void intpol_met_3d(
```

```
00749   float array[EX][EY][EP],
00750   int ip,
00751   int ix,
00752   int iy,
00753   double wp,
00754   double wx,
00755   double wy,
00756   double *var);
00757
00759 void intpol_met_space(
00760   met_t * met,
00761   double p,
00762   double lon,
00763   double lat,
00764   double *ps,
00765   double *pt,
00766   double *z,
00767   double *t,
00768   double *u,
00769   double *v,
00770   double *w,
00771   double *pv,
00772   double *h2o,
00773   double *o3);
00774
00776 void intpol_met_time(
00777   met_t * met0,
00778   met_t * met1,
00779   double ts,
00780   double p,
00781   double lon,
00782   double lat,
00783   double *ps,
00784   double *pt,
00785   double *z,
00786   double *t,
00787   double *u,
00788   double *v,
00789   double *w,
00790   double *pv,
00791   double *h2o,
00792   double *o3);
00793
00795 void jsec2time(
00796   double jsec,
00797   int *year,
00798   int *mon,
00799   int *day,
00800   int *hour,
00801   int *min,
00802   int *sec,
00803   double *remain);
00804
00806 int locate(
00807   double *xx,
00808   int n,
00809   double x);
00810
00812 void read_atm(
00813   const char *filename,
00814   ctl_t * ctl,
00815   atm_t * atm);
00816
00818 void read_ctl(
00819   const char *filename,
00820   int argc,
00821   char *argv[],
00822   ctl_t * ctl);
00823
00825 void read_met(
00826   ctl_t * ctl,
00827   char *filename,
00828   met_t * met);
00829
00831 void read_met_extrapolate(
00832   met_t * met);
00833
00835 void read_met_geopot(
00836   ctl_t * ctl,
00837   met_t * met);
00838
00840 void read_met_help(
00841   int ncid,
00842   char *varname,
00843   char *varname2,
00844   met_t * met,
00845   float dest[EX][EY][EP],
```

```
00846   float scl);
00847
00849 void read_met_ml2pl(
00850   ctl_t * ctl,
00851   met_t * met,
00852   float var[EX][EY][EP]);
00853
00855 void read_met_periodic(
00856   met_t * met);
00857
00859 void read_met_pv(
00860   met_t * met);
00861
00863 void read_met_sample(
00864   ctl_t * ctl,
00865   met_t * met);
00866
00868 void read_met_tropo(
00869   ctl_t * ctl,
00870   met_t * met);
00871
00873 double scan_ctl(
00874   const char *filename,
00875   int argc,
00876   char *argv[],
00877   const char *varname,
00878   int arridx,
00879   const char *defvalue,
00880   char *value);
00881
00883 void time2jsec(
00884   int year,
00885   int mon,
00886   int day,
00887   int hour,
00888   int min,
00889   int sec,
00890   double remain,
00891   double *jsec);
00892
00894 void timer(
00895   const char *name,
00896   int id,
00897   int mode);
00898
00900 void write_atm(
00901   const char *filename,
00902   ctl_t * ctl,
00903   atm_t * atm,
00904   double t);
00905
00907 void write_csi(
00908   const char *filename,
00909   ctl_t * ctl,
00910   atm_t * atm,
00911   double t);
00912
00914 void write_ens(
00915   const char *filename,
00916   ctl_t * ctl,
00917   atm_t * atm,
00918   double t);
00919
00921 void write_grid(
00922   const char *filename,
00923   ctl_t * ctl,
00924   met_t * met0,
00925   met_t * met1,
00926   atm_t * atm,
00927   double t);
00928
00930 void write_prof(
00931   const char *filename,
00932   ctl_t * ctl,
00933   met_t * met0,
00934   met_t * met1,
00935   atm_t * atm,
00936   double t);
00937
00939 void write_station(
00940   const char *filename,
00941   ctl_t * ctl,
00942   atm_t * atm,
00943   double t);
```

5.23 match.c File Reference

Calculate deviations between two trajectories.

Functions

- int main (int argc, char ∗argv[ ])

5.23.1 Detailed Description

Calculate deviations between two trajectories.

Definition in file match.c.

5.23.2 Function Documentation

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

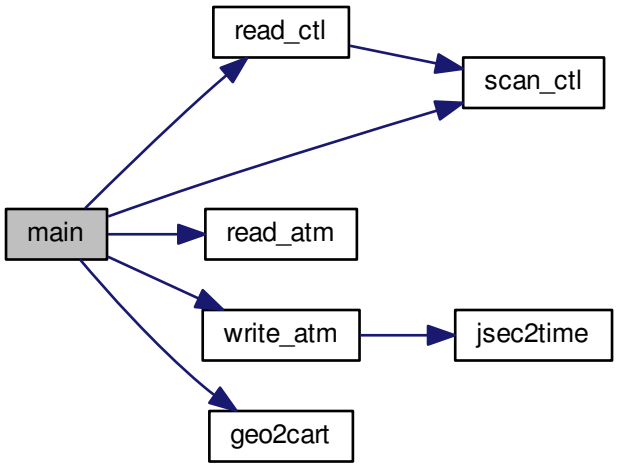
Definition at line 27 of file match.c.

```
00029                {
00030
00031   ctl_t ctl;
00032
00033   atm_t *atm1, *atm2, *atm3;
00034
00035   FILE *out;
00036
00037   char filename[LEN];
00038
00039   double filter_dt, x1[3], x2[3], dh, dq[NQ], dv, lh = 0, lt = 0, lv = 0;
00040
00041   int filter, ip1, ip2, iq, n;
00042
00043   /* Allocate... */
00044   ALLOC(atm1, atm_t, 1);
00045   ALLOC(atm2, atm_t, 1);
00046   ALLOC(atm3, atm_t, 1);
00047
00048   /* Check arguments... */
00049   if (argc < 5)
00050     ERRMSG("Give parameters: <ctl> <atm_test> <atm_ref> <outfile>");
00051
00052   /* Read control parameters... */
00053   read_ctl(argv[1], argc, argv, &ctl);
00054   filter = (int) scan_ctl(argv[1], argc, argv, "FILTER", -1, "0", NULL);
00055   filter_dt = scan_ctl(argv[1], argc, argv, "FILTER_DT", -1, "0", NULL);
00056
00057   /* Read atmospheric data... */
00058   read_atm(argv[2], &ctl, atm1);
00059   read_atm(argv[3], &ctl, atm2);
00060
00061   /* Write info... */
00062   printf("Write transport deviations: %s\n", argv[4]);
00063
00064   /* Create output file... */
00065   if (!(out = fopen(argv[4], "w")))
00066     ERRMSG("Cannot create file!");
00067
00068   /* Write header... */
00069   fprintf(out,
00070           "# $1 = time [s]\n"
00071           "# $2 = altitude [km]\n"
00072           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
00073   for (iq = 0; iq < ctl.nq; iq++)
00074     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl.qnt_name[iq],
00075             ctl.qnt_unit[iq]);
00076   fprintf(out,
```

```
00077           "# $%d = trajectory time [s]\n"
00078           "# $%d = vertical length of trajectory [km]\n"
00079           "# $%d = horizontal length of trajectory [km]\n"
00080           "# $%d = vertical deviation [km]\n"
00081           "# $%d = horizontal deviation [km]\n",
00082           5 + ctl.nq, 6 + ctl.nq, 7 + ctl.nq, 8 + ctl.nq, 9 + ctl.nq);
00083   for (iq = 0; iq < ctl.nq; iq++)
00084     fprintf(out, "# $%d = %s deviation [%s]\n", ctl.nq + iq + 10,
00085             ctl.qnt_name[iq], ctl.qnt_unit[iq]);
00086   fprintf(out, "\n");
00087
00088   /* Filtering of reference time series... */
00089   if (filter) {
00090
00091     /* Copy data... */
00092     memcpy(atm3, atm2, sizeof(atm_t));
00093
00094     /* Loop over data points... */
00095     for (ip1 = 0; ip1 < atm2->np; ip1++) {
00096       n = 0;
00097       atm2->p[ip1] = 0;
00098       for (iq = 0; iq < ctl.nq; iq++)
00099         atm2->q[iq][ip1] = 0;
00100       for (ip2 = 0; ip2 < atm2->np; ip2++)
00101         if (fabs(atm2->time[ip1] - atm2->time[ip2]) < filter_dt) {
00102           atm2->p[ip1] += atm3->p[ip2];
00103           for (iq = 0; iq < ctl.nq; iq++)
00104             atm2->q[iq][ip1] += atm3->q[iq][ip2];
00105           n++;
00106         }
00107       atm2->p[ip1] /= n;
00108       for (iq = 0; iq < ctl.nq; iq++)
00109         atm2->q[iq][ip1] /= n;
00110     }
00111
00112     /* Write filtered data... */
00113     sprintf(filename, "%s.filt", argv[3]);
00114     write_atm(filename, &ctl, atm2, 0);
00115   }
00116
00117   /* Loop over air parcels (reference data)... */
00118   for (ip2 = 0; ip2 < atm2->np; ip2++) {
00119
00120     /* Get trajectory length... */
00121     if (ip2 > 0) {
00122       geo2cart(0, atm2->lon[ip2 - 1], atm2->lat[ip2 - 1], x1);
00123       geo2cart(0, atm2->lon[ip2], atm2->lat[ip2], x2);
00124       lh += DIST(x1, x2);
00125       lv += fabs(Z(atm2->p[ip2 - 1]) - Z(atm2->p[ip2]));
00126       lt = fabs(atm2->time[ip2] - atm2->time[0]);
00127     }
00128
00129     /* Init... */
00130     n = 0;
00131     dh = 0;
00132     dv = 0;
00133     for (iq = 0; iq < ctl.nq; iq++)
00134       dq[iq] = 0;
00135     geo2cart(0, atm2->lon[ip2], atm2->lat[ip2], x2);
00136
00137     /* Find corresponding time step (test data)... */
00138     for (ip1 = 0; ip1 < atm1->np; ip1++)
00139       if (fabs(atm1->time[ip1] - atm2->time[ip2])
00140           < (filter ? filter_dt : 0.1)) {
00141
00142         /* Calculate deviations... */
00143         geo2cart(0, atm1->lon[ip1], atm1->lat[ip1], x1);
00144         dh += DIST(x1, x2);
00145         dv += Z(atm1->p[ip1]) - Z(atm2->p[ip2]);
00146         for (iq = 0; iq < ctl.nq; iq++)
00147           dq[iq] += atm1->q[iq][ip1] - atm2->q[iq][ip2];
00148         n++;
00149       }
00150
00151     /* Write output... */
00152     if (n > 0) {
00153       fprintf(out, "%.2f %.4f %.4f %.4f",
00154               atm2->time[ip2], Z(atm2->p[ip2]),
00155               atm2->lon[ip2], atm2->lat[ip2]);
00156       for (iq = 0; iq < ctl.nq; iq++) {
00157         fprintf(out, " ");
00158         fprintf(out, ctl.qnt_format[iq], atm2->q[iq][ip2]);
00159       }
00160       fprintf(out, " %.2f %g %g %g %g", lt, lv, lh, dv / n, dh / n);
00161       for (iq = 0; iq < ctl.nq; iq++) {
00162         fprintf(out, " ");
00163         fprintf(out, ctl.qnt_format[iq], dq[iq] / n);
```

```
00164       }
00165       fprintf(out, "\n");
00166     }
00167   }
00168
00169   /* Close file... */
00170   fclose(out);
00171
00172   /* Free... */
00173   free(atm1);
00174   free(atm2);
00175   free(atm3);
00176
00177   return EXIT_SUCCESS;
00178 }
```

Here is the call graph for this function:



5.24 match.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) 2013-2018 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, *atm3;
00034
00035   FILE *out;
00036
00037   char filename[LEN];
00038
00039   double filter_dt, x1[3], x2[3], dh, dq[NQ], dv, lh = 0, lt = 0, lv = 0;
00040
00041   int filter, ip1, ip2, iq, n;
00042
00043   /* Allocate... */
00044   ALLOC(atm1, atm_t, 1);
00045   ALLOC(atm2, atm_t, 1);
00046   ALLOC(atm3, atm_t, 1);
00047
00048   /* Check arguments... */
00049   if (argc < 5)
00050     ERRMSG("Give parameters: <ctl> <atm_test> <atm_ref> <outfile>");
00051
00052   /* Read control parameters... */
00053   read_ctl(argv[1], argc, argv, &ctl);
00054   filter = (int) scan_ctl(argv[1], argc, argv, "FILTER", -1, "0", NULL);
00055   filter_dt = scan_ctl(argv[1], argc, argv, "FILTER_DT", -1, "0", NULL);
00056
00057   /* Read atmospheric data... */
00058   read_atm(argv[2], &ctl, atm1);
00059   read_atm(argv[3], &ctl, atm2);
00060
00061   /* Write info... */
00062   printf("Write transport deviations: %s\n", argv[4]);
00063
00064   /* Create output file... */
00065   if (!(out = fopen(argv[4], "w")))
00066     ERRMSG("Cannot create file!");
00067
00068   /* Write header... */
00069   fprintf(out,
00070           "# $1 = time [s]\n"
00071           "# $2 = altitude [km]\n"
00072           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
00073   for (iq = 0; iq < ctl.nq; iq++)
00074     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl.qnt_name[iq],
00075             ctl.qnt_unit[iq]);
00076   fprintf(out,
00077           "# $%d = trajectory time [s]\n"
00078           "# $%d = vertical length of trajectory [km]\n"
00079           "# $%d = horizontal length of trajectory [km]\n"
00080           "# $%d = vertical deviation [km]\n"
00081           "# $%d = horizontal deviation [km]\n",
00082           5 + ctl.nq, 6 + ctl.nq, 7 + ctl.nq, 8 + ctl.nq, 9 + ctl.nq);
00083   for (iq = 0; iq < ctl.nq; iq++)
00084     fprintf(out, "# $%d = %s deviation [%s]\n", ctl.nq + iq + 10,
00085             ctl.qnt_name[iq], ctl.qnt_unit[iq]);
00086   fprintf(out, "\n");
00087
00088   /* Filtering of reference time series... */
00089   if (filter) {
00090
00091     /* Copy data... */
00092     memcpy(atm3, atm2, sizeof(atm_t));
00093
00094     /* Loop over data points... */
00095     for (ip1 = 0; ip1 < atm2->np; ip1++) {
00096       n = 0;
00097       atm2->p[ip1] = 0;
00098       for (iq = 0; iq < ctl.nq; iq++)
00099         atm2->q[iq][ip1] = 0;
00100       for (ip2 = 0; ip2 < atm2->np; ip2++)
00101         if (fabs(atm2->time[ip1] - atm2->time[ip2]) < filter_dt) {
00102           atm2->p[ip1] += atm3->p[ip2];
00103           for (iq = 0; iq < ctl.nq; iq++)
00104             atm2->q[iq][ip1] += atm3->q[iq][ip2];
00105           n++;
00106         }
00107       atm2->p[ip1] /= n;
00108       for (iq = 0; iq < ctl.nq; iq++)
00109         atm2->q[iq][ip1] /= n;
00110     }
00111
00112     /* Write filtered data... */
00113     sprintf(filename, "%s.filt", argv[3]);
00114     write_atm(filename, &ctl, atm2, 0);
00115   }
00116
00117   /* Loop over air parcels (reference data)... */
00118   for (ip2 = 0; ip2 < atm2->np; ip2++) {
```

```
00119
00120     /* Get trajectory length... */
00121     if (ip2 > 0) {
00122       geo2cart(0, atm2->lon[ip2 - 1], atm2->lat[ip2 - 1], x1);
00123       geo2cart(0, atm2->lon[ip2], atm2->lat[ip2], x2);
00124       lh += DIST(x1, x2);
00125       lv += fabs(Z(atm2->p[ip2 - 1]) - Z(atm2->p[ip2]));
00126       lt = fabs(atm2->time[ip2] - atm2->time[0]);
00127     }
00128
00129     /* Init... */
00130     n = 0;
00131     dh = 0;
00132     dv = 0;
00133     for (iq = 0; iq < ctl.nq; iq++)
00134       dq[iq] = 0;
00135     geo2cart(0, atm2->lon[ip2], atm2->lat[ip2], x2);
00136
00137     /* Find corresponding time step (test data)... */
00138     for (ip1 = 0; ip1 < atm1->np; ip1++)
00139       if (fabs(atm1->time[ip1] - atm2->time[ip2])
00140           < (filter ? filter_dt : 0.1)) {
00141
00142         /* Calculate deviations... */
00143         geo2cart(0, atm1->lon[ip1], atm1->lat[ip1], x1);
00144         dh += DIST(x1, x2);
00145         dv += Z(atm1->p[ip1]) - Z(atm2->p[ip2]);
00146         for (iq = 0; iq < ctl.nq; iq++)
00147           dq[iq] += atm1->q[iq][ip1] - atm2->q[iq][ip2];
00148         n++;
00149       }
00150
00151     /* Write output... */
00152     if (n > 0) {
00153       fprintf(out, "%.2f %.4f %.4f %.4f",
00154               atm2->time[ip2], Z(atm2->p[ip2]),
00155               atm2->lon[ip2], atm2->lat[ip2]);
00156       for (iq = 0; iq < ctl.nq; iq++) {
00157         fprintf(out, " ");
00158         fprintf(out, ctl.qnt_format[iq], atm2->q[iq][ip2]);
00159       }
00160       fprintf(out, " %.2f %g %g %g %g", lt, lv, lh, dv / n, dh / n);
00161       for (iq = 0; iq < ctl.nq; iq++) {
00162         fprintf(out, " ");
00163         fprintf(out, ctl.qnt_format[iq], dq[iq] / n);
00164       }
00165       fprintf(out, "\n");
00166     }
00167   }
00168
00169   /* Close file... */
00170   fclose(out);
00171
00172   /* Free... */
00173   free(atm1);
00174   free(atm2);
00175   free(atm3);
00176
00177   return EXIT_SUCCESS;
00178 }
```

5.25 met_map.c File Reference

Extract global map from meteorological data.

Functions

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

5.25.1 Detailed Description

Extract global map from meteorological data.

Definition in file met_map.c.

5.25.2 Function Documentation

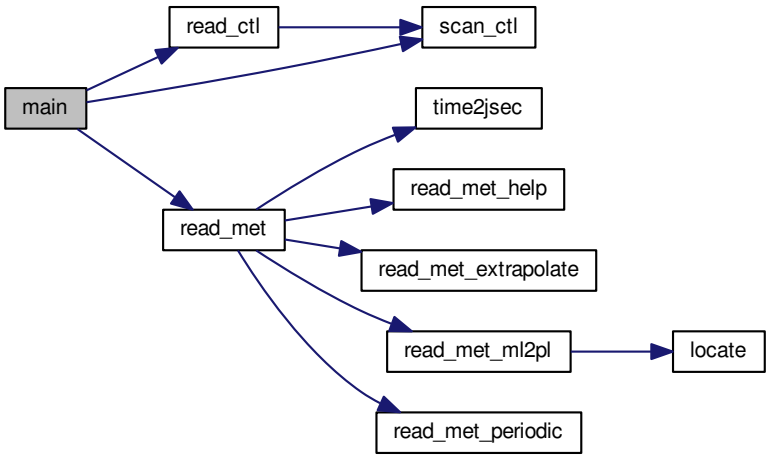
5.25.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file met_map.c.

```
00029                {
00030
00031   ctl_t ctl;
00032
00033   met_t *met;
00034
00035   FILE *out;
00036
00037   static double dz, dzmin = 1e10, z, timem[EX][EY], psm[EX][EY], ptm[EX][EY],
00038     tm[EX][EY], um[EX][EY], vm[EX][EY], wm[EX][EY], h2om[EX][EY], o3m[EX][EY],
00039     zm[EX][EY], pvm[EX][EY], zt, ztm[EX][EY], tt, ttm[EX][EY];
00040
00041   static int i, ip, ip2, ix, iy, np[EX][EY];
00042
00043   /* Allocate... */
00044   ALLOC(met, met_t, 1);
00045
00046   /* Check arguments... */
00047   if (argc < 4)
00048     ERRMSG("Give parameters: <ctl> <map.tab> <met0> [ <met1> ... ]");
00049
00050   /* Read control parameters... */
00051   read_ctl(argv[1], argc, argv, &ctl);
00052   z = scan_ctl(argv[1], argc, argv, "Z", -1, "", NULL);
00053
00054   /* Loop over files... */
00055   for (i = 3; i < argc; i++) {
00056
00057     /* Read meteorological data... */
00058     read_met(&ctl, argv[i], met);
00059
00060     /* Find nearest pressure level... */
00061     for (ip2 = 0; ip2 < met->np; ip2++) {
00062       dz = fabs(Z(met->p[ip2]) - z);
00063       if (dz < dzmin) {
00064         dzmin = dz;
00065         ip = ip2;
00066       }
00067     }
00068
00069     /* Average data... */
00070     for (ix = 0; ix < met->nx; ix++)
00071       for (iy = 0; iy < met->ny; iy++) {
00072         intpol_met_space(met, met->pt[ix][iy], met->lon[ix], met->
      lat[iy],
00073                          NULL, NULL, &zt, &tt, NULL, NULL, NULL, NULL, NULL,
00074                          NULL);
00075         timem[ix][iy] += met->time;
00076         zm[ix][iy] += met->z[ix][iy][ip];
00077         tm[ix][iy] += met->t[ix][iy][ip];
00078         um[ix][iy] += met->u[ix][iy][ip];
00079         vm[ix][iy] += met->v[ix][iy][ip];
00080         wm[ix][iy] += met->w[ix][iy][ip];
00081         pvm[ix][iy] += met->pv[ix][iy][ip];
00082         h2om[ix][iy] += met->h2o[ix][iy][ip];
00083         o3m[ix][iy] += met->o3[ix][iy][ip];
00084         psm[ix][iy] += met->ps[ix][iy];
00085         ptm[ix][iy] += met->pt[ix][iy];
00086         ztm[ix][iy] += zt;
00087         ttm[ix][iy] += tt;
00088         np[ix][iy]++;
00089       }
00090   }
00091
00092   /* Create output file... */
00093   printf("Write meteorological data file: %s\n", argv[2]);
00094   if (!(out = fopen(argv[2], "w")))
00095     ERRMSG("Cannot create file!");
00096
00097   /* Write header... */
00098   fprintf(out,
00099           "# $1  = time [s]\n"
00100           "# $2  = altitude [km]\n"
00101           "# $3  = longitude [deg]\n"
00102           "# $4  = latitude [deg]\n"
00103           "# $5  = pressure [hPa]\n"
```

```
00104           "# $6  = temperature [K]\n"
00105           "# $7  = zonal wind [m/s]\n"
00106           "# $8  = meridional wind [m/s]\n"
00107           "# $9  = vertical wind [hPa/s]\n"
00108           "# $10 = H2O volume mixing ratio [1]\n");
00109   fprintf(out,
00110           "# $11 = O3 volume mixing ratio [1]\n"
00111           "# $12 = geopotential height [km]\n"
00112           "# $13 = potential vorticity [PVU]\n"
00113           "# $14 = surface pressure [hPa]\n"
00114           "# $15 = tropopause pressure [hPa]\n"
00115           "# $16 = tropopause geopotential height [km]\n"
00116           "# $17 = tropopause temperature [K]\n");
00117
00118   /* Write data... */
00119   for (iy = 0; iy < met->ny; iy++) {
00120     fprintf(out, "\n");
00121     for (ix = 0; ix < met->nx; ix++)
00122       if (met->lon[ix] >= 180)
00123         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00124                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00125                 met->lon[ix] - 360.0, met->lat[iy], met->p[ip],
00126                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00127                 vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00128                 h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00129                 zm[ix][iy] / np[ix][iy], pvm[ix][iy] / np[ix][iy],
00130                 psm[ix][iy] / np[ix][iy], ptm[ix][iy] / np[ix][iy],
00131                 ztm[ix][iy] / np[ix][iy], ttm[ix][iy] / np[ix][iy]);
00132     for (ix = 0; ix < met->nx; ix++)
00133       if (met->lon[ix] <= 180)
00134         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00135                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00136                 met->lon[ix], met->lat[iy], met->p[ip],
00137                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00138                 vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00139                 h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00140                 zm[ix][iy] / np[ix][iy], pvm[ix][iy] / np[ix][iy],
00141                 psm[ix][iy] / np[ix][iy], ptm[ix][iy] / np[ix][iy],
00142                 ztm[ix][iy] / np[ix][iy], ttm[ix][iy] / np[ix][iy]);
00143   }
00144
00145   /* Close file... */
00146   fclose(out);
00147
00148   /* Free... */
00149   free(met);
00150
00151   return EXIT_SUCCESS;
00152 }
```

Here is the call graph for this function:



5.26 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) 2013-2018 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   met_t *met;
00034
00035   FILE *out;
00036
00037   static double dz, dzmin = 1e10, z, timem[EX][EY], psm[EX][EY], ptm[EX][EY],
00038     tm[EX][EY], um[EX][EY], vm[EX][EY], wm[EX][EY], h2om[EX][EY], o3m[EX][EY],
00039     zm[EX][EY], pvm[EX][EY], zt, ztm[EX][EY], tt, ttm[EX][EY];
00040
00041   static int i, ip, ip2, ix, iy, np[EX][EY];
00042
00043   /* Allocate... */
00044   ALLOC(met, met_t, 1);
00045
00046   /* Check arguments... */
00047   if (argc < 4)
00048     ERRMSG("Give parameters: <ctl> <map.tab> <met0> [ <met1> ... ]");
00049
00050   /* Read control parameters... */
00051   read_ctl(argv[1], argc, argv, &ctl);
00052   z = scan_ctl(argv[1], argc, argv, "Z", -1, "", NULL);
00053
00054   /* Loop over files... */
00055   for (i = 3; i < argc; i++) {
00056
00057     /* Read meteorological data... */
00058     read_met(&ctl, argv[i], met);
00059
00060     /* Find nearest pressure level... */
00061     for (ip2 = 0; ip2 < met->np; ip2++) {
00062       dz = fabs(Z(met->p[ip2]) - z);
00063       if (dz < dzmin) {
00064         dzmin = dz;
00065         ip = ip2;
00066       }
00067     }
00068
00069     /* Average data... */
00070     for (ix = 0; ix < met->nx; ix++)
00071       for (iy = 0; iy < met->ny; iy++) {
00072         intpol_met_space(met, met->pt[ix][iy], met->lon[ix], met->
      lat[iy],
00073                          NULL, NULL, &zt, &tt, NULL, NULL, NULL, NULL, NULL,
00074                          NULL);
00075         timem[ix][iy] += met->time;
00076         zm[ix][iy] += met->z[ix][iy][ip];
00077         tm[ix][iy] += met->t[ix][iy][ip];
00078         um[ix][iy] += met->u[ix][iy][ip];
00079         vm[ix][iy] += met->v[ix][iy][ip];
00080         wm[ix][iy] += met->w[ix][iy][ip];
00081         pvm[ix][iy] += met->pv[ix][iy][ip];
00082         h2om[ix][iy] += met->h2o[ix][iy][ip];
00083         o3m[ix][iy] += met->o3[ix][iy][ip];
00084         psm[ix][iy] += met->ps[ix][iy];
00085         ptm[ix][iy] += met->pt[ix][iy];
00086         ztm[ix][iy] += zt;
00087         ttm[ix][iy] += tt;
00088         np[ix][iy]++;
```

```
00089       }
00090   }
00091
00092   /* Create output file... */
00093   printf("Write meteorological data file: %s\n", argv[2]);
00094   if (!(out = fopen(argv[2], "w")))
00095     ERRMSG("Cannot create file!");
00096
00097   /* Write header... */
00098   fprintf(out,
00099           "# $1  = time [s]\n"
00100           "# $2  = altitude [km]\n"
00101           "# $3  = longitude [deg]\n"
00102           "# $4  = latitude [deg]\n"
00103           "# $5  = pressure [hPa]\n"
00104           "# $6  = temperature [K]\n"
00105           "# $7  = zonal wind [m/s]\n"
00106           "# $8  = meridional wind [m/s]\n"
00107           "# $9  = vertical wind [hPa/s]\n"
00108           "# $10 = H2O volume mixing ratio [1]\n");
00109   fprintf(out,
00110           "# $11 = O3 volume mixing ratio [1]\n"
00111           "# $12 = geopotential height [km]\n"
00112           "# $13 = potential vorticity [PVU]\n"
00113           "# $14 = surface pressure [hPa]\n"
00114           "# $15 = tropopause pressure [hPa]\n"
00115           "# $16 = tropopause geopotential height [km]\n"
00116           "# $17 = tropopause temperature [K]\n");
00117
00118   /* Write data... */
00119   for (iy = 0; iy < met->ny; iy++) {
00120     fprintf(out, "\n");
00121     for (ix = 0; ix < met->nx; ix++)
00122       if (met->lon[ix] >= 180)
00123         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00124                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00125                 met->lon[ix] - 360.0, met->lat[iy], met->p[ip],
00126                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00127                 vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00128                 h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00129                 zm[ix][iy] / np[ix][iy], pvm[ix][iy] / np[ix][iy],
00130                 psm[ix][iy] / np[ix][iy], ptm[ix][iy] / np[ix][iy],
00131                 ztm[ix][iy] / np[ix][iy], ttm[ix][iy] / np[ix][iy]);
00132     for (ix = 0; ix < met->nx; ix++)
00133       if (met->lon[ix] <= 180)
00134         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00135                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00136                 met->lon[ix], met->lat[iy], met->p[ip],
00137                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00138                 vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00139                 h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00140                 zm[ix][iy] / np[ix][iy], pvm[ix][iy] / np[ix][iy],
00141                 psm[ix][iy] / np[ix][iy], ptm[ix][iy] / np[ix][iy],
00142                 ztm[ix][iy] / np[ix][iy], ttm[ix][iy] / np[ix][iy]);
00143   }
00144
00145   /* Close file... */
00146   fclose(out);
00147
00148   /* Free... */
00149   free(met);
00150
00151   return EXIT_SUCCESS;
00152 }
```

5.27 met_prof.c File Reference

Extract vertical profile from meteorological data.

Functions

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

5.27.1 Detailed Description

Extract vertical profile from meteorological data.

Definition in file met_prof.c.

5.27.2 Function Documentation

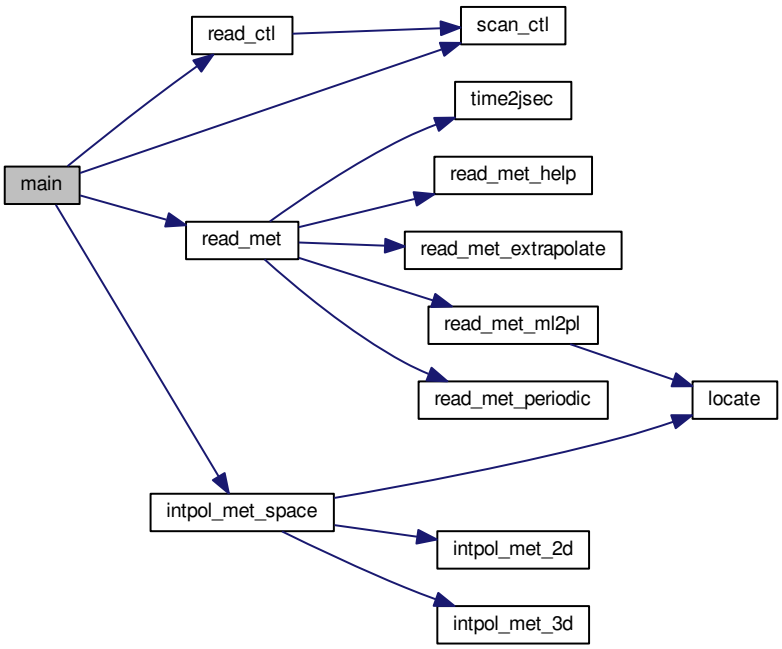
5.27.2.1 int main (int *argc*, char * *argv[]*)

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], o3, o3m[NZ], ps, psm[NZ], pt, ptm[NZ], tt, ttm[NZ],
00051     zg, zgm[NZ], zt, ztm[NZ], pv, pvm[NZ];
00052
00053   static int i, iz, np[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, "Z0", -1, "0", NULL);
00065   z1 = scan_ctl(argv[1], argc, argv, "Z1", -1, "60", NULL);
00066   dz = scan_ctl(argv[1], argc, argv, "DZ", -1, "1", NULL);
00067   lon0 = scan_ctl(argv[1], argc, argv, "LON0", -1, "0", NULL);
00068   lon1 = scan_ctl(argv[1], argc, argv, "LON1", -1, "0", NULL);
00069   dlon = scan_ctl(argv[1], argc, argv, "DLON", -1, "1", NULL);
00070   lat0 = scan_ctl(argv[1], argc, argv, "LAT0", -1, "0", NULL);
00071   lat1 = scan_ctl(argv[1], argc, argv, "LAT1", -1, "0", NULL);
00072   dlat = scan_ctl(argv[1], argc, argv, "DLAT", -1, "1", NULL);
00073
00074   /* Loop over input files... */
00075   for (i = 3; i < argc; i++) {
00076
00077     /* Read meteorological data... */
00078     read_met(&ctl, argv[i], met);
00079
00080     /* Average... */
00081     for (z = z0; z <= z1; z += dz) {
00082       iz = (int) ((z - z0) / dz);
00083       if (iz < 0 || iz > NZ)
00084         ERRMSG("Too many altitudes!");
00085       for (lon = lon0; lon <= lon1; lon += dlon)
00086         for (lat = lat0; lat <= lat1; lat += dlat) {
00087           intpol_met_space(met, P(z), lon, lat, &ps, &pt, &zg,
00088                            &t, &u, &v, &w, &pv, &h2o, &o3);
00089           intpol_met_space(met, pt, lon, lat, NULL, NULL, &zt,
00090                            &tt, NULL, NULL, NULL, NULL, NULL);
00091           if (gsl_finite(t) && gsl_finite(u)
00092               && gsl_finite(v) && gsl_finite(w)) {
00093             timem[iz] += met->time;
00094             lonm[iz] += lon;
00095             latm[iz] += lat;
00096             zgm[iz] += zg;
00097             tm[iz] += t;
00098             um[iz] += u;
00099             vm[iz] += v;
00100            wm[iz] += w;
00101            pvm[iz] += pv;
00102            h2om[iz] += h2o;
00103            o3m[iz] += o3;
00104            psm[iz] += ps;
00105            ptm[iz] += pt;
00106            ztm[iz] += zt;
00107            ttm[iz] += tt;
00108            np[iz]++;
00109          }
00110       }
00111   }
00112 }
00113
00114 /* Create output file... */
00115 printf("Write meteorological data file: %s\n", argv[2]);
```

```
00116   if (!(out = fopen(argv[2], "w")))
00117     ERRMSG("Cannot create file!");
00118
00119   /* Write header... */
00120   fprintf(out,
00121           "# $1  = time [s]\n"
00122           "# $2  = altitude [km]\n"
00123           "# $3  = longitude [deg]\n"
00124           "# $4  = latitude [deg]\n"
00125           "# $5  = pressure [hPa]\n"
00126           "# $6  = temperature [K]\n"
00127           "# $7  = zonal wind [m/s]\n"
00128           "# $8  = meridional wind [m/s]\n"
00129           "# $9  = vertical wind [hPa/s]\n");
00130   fprintf(out,
00131           "# $10 = H2O volume mixing ratio [1]\n"
00132           "# $11 = O3 volume mixing ratio [1]\n"
00133           "# $12 = geopotential height [km]\n"
00134           "# $13 = potential vorticity [PVU]\n"
00135           "# $14 = surface pressure [hPa]\n"
00136           "# $15 = tropopause pressure [hPa]\n"
00137           "# $16 = tropopause geopotential height [km]\n"
00138           "# $17 = tropopause temperature [K]\n\n");
00139
00140   /* Write data... */
00141   for (z = z0; z <= z1; z += dz) {
00142     iz = (int) ((z - z0) / dz);
00143     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00144             timem[iz] / np[iz], z, lonm[iz] / np[iz], latm[iz] / np[iz], P(z),
00145             tm[iz] / np[iz], um[iz] / np[iz], vm[iz] / np[iz],
00146             wm[iz] / np[iz], h2om[iz] / np[iz], o3m[iz] / np[iz],
00147             zgm[iz] / np[iz], pvm[iz] / np[iz], psm[iz] / np[iz],
00148             ptm[iz] / np[iz], ztm[iz] / np[iz], ttm[iz] / np[iz]);
00149   }
00150
00151   /* Close file... */
00152   fclose(out);
00153
00154   /* Free... */
00155   free(met);
00156
00157   return EXIT_SUCCESS;
00158 }
```

Here is the call graph for this function:



5.28 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) 2013-2018 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 /* ------------------------------------------------------------
00028    Dimensions...
00029    ------------------------------------------------------------ */
00030
00031 /* Maximum number of altitudes. */
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], o3, o3m[NZ], ps, psm[NZ], pt, ptm[NZ], tt, ttm[NZ],
00051     zg, zgm[NZ], zt, ztm[NZ], pv, pvm[NZ];
00052
00053   static int i, iz, np[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, "Z0", -1, "0", NULL);
00065   z1 = scan_ctl(argv[1], argc, argv, "Z1", -1, "60", NULL);
00066   dz = scan_ctl(argv[1], argc, argv, "DZ", -1, "1", NULL);
00067   lon0 = scan_ctl(argv[1], argc, argv, "LON0", -1, "0", NULL);
00068   lon1 = scan_ctl(argv[1], argc, argv, "LON1", -1, "0", NULL);
00069   dlon = scan_ctl(argv[1], argc, argv, "DLON", -1, "1", NULL);
00070   lat0 = scan_ctl(argv[1], argc, argv, "LAT0", -1, "0", NULL);
00071   lat1 = scan_ctl(argv[1], argc, argv, "LAT1", -1, "0", NULL);
00072   dlat = scan_ctl(argv[1], argc, argv, "DLAT", -1, "1", NULL);
00073
00074   /* Loop over input files... */
00075   for (i = 3; i < argc; i++) {
00076
00077     /* Read meteorological data... */
00078     read_met(&ctl, argv[i], met);
00079
00080     /* Average... */
00081     for (z = z0; z <= z1; z += dz) {
00082       iz = (int) ((z - z0) / dz);
00083       if (iz < 0 || iz > NZ)
00084         ERRMSG("Too many altitudes!");
00085       for (lon = lon0; lon <= lon1; lon += dlon)
00086         for (lat = lat0; lat <= lat1; lat += dlat) {
00087           intpol_met_space(met, P(z), lon, lat, &ps, &pt, &zg,
00088                            &t, &u, &v, &w, &pv, &h2o, &o3);
00089           intpol_met_space(met, pt, lon, lat, NULL, NULL, &zt,
```

```
00090                           &tt, NULL, NULL, NULL, NULL, NULL, NULL);
00091           if (gsl_finite(t) && gsl_finite(u)
00092               && gsl_finite(v) && gsl_finite(w)) {
00093             timem[iz] += met->time;
00094             lonm[iz] += lon;
00095             latm[iz] += lat;
00096             zgm[iz] += zg;
00097             tm[iz] += t;
00098             um[iz] += u;
00099             vm[iz] += v;
00100            wm[iz] += w;
00101            pvm[iz] += pv;
00102            h2om[iz] += h2o;
00103            o3m[iz] += o3;
00104            psm[iz] += ps;
00105            ptm[iz] += pt;
00106            ztm[iz] += zt;
00107            ttm[iz] += tt;
00108            np[iz]++;
00109          }
00110        }
00111    }
00112  }
00113
00114  /* Create output file... */
00115  printf("Write meteorological data file: %s\n", argv[2]);
00116  if (!(out = fopen(argv[2], "w")))
00117    ERRMSG("Cannot create file!");
00118
00119  /* Write header... */
00120  fprintf(out,
00121          "# $1  = time [s]\n"
00122          "# $2  = altitude [km]\n"
00123          "# $3  = longitude [deg]\n"
00124          "# $4  = latitude [deg]\n"
00125          "# $5  = pressure [hPa]\n"
00126          "# $6  = temperature [K]\n"
00127          "# $7  = zonal wind [m/s]\n"
00128          "# $8  = meridional wind [m/s]\n"
00129          "# $9  = vertical wind [hPa/s]\n");
00130  fprintf(out,
00131          "# $10 = H2O volume mixing ratio [1]\n"
00132          "# $11 = O3 volume mixing ratio [1]\n"
00133          "# $12 = geopotential height [km]\n"
00134          "# $13 = potential vorticity [PVU]\n"
00135          "# $14 = surface pressure [hPa]\n"
00136          "# $15 = tropopause pressure [hPa]\n"
00137          "# $16 = tropopause geopotential height [km]\n"
00138          "# $17 = tropopause temperature [K]\n\n");
00139
00140  /* Write data... */
00141  for (z = z0; z <= z1; z += dz) {
00142    iz = (int) ((z - z0) / dz);
00143    fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00144            timem[iz] / np[iz], z, lonm[iz] / np[iz], latm[iz] / np[iz], P(z),
00145            tm[iz] / np[iz], um[iz] / np[iz], vm[iz] / np[iz],
00146            wm[iz] / np[iz], h2om[iz] / np[iz], o3m[iz] / np[iz],
00147            zgm[iz] / np[iz], pvm[iz] / np[iz], psm[iz] / np[iz],
00148            ptm[iz] / np[iz], ztm[iz] / np[iz], ttm[iz] / np[iz]);
00149  }
00150
00151  /* Close file... */
00152  fclose(out);
00153
00154  /* Free... */
00155  free(met);
00156
00157  return EXIT_SUCCESS;
00158 }
```

5.29 met_sample.c File Reference

Sample meteorological data at given geolocations.

Functions

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

5.29.1 Detailed Description

Sample meteorological data at given geolocations.

Definition in file met_sample.c.

5.29.2 Function Documentation

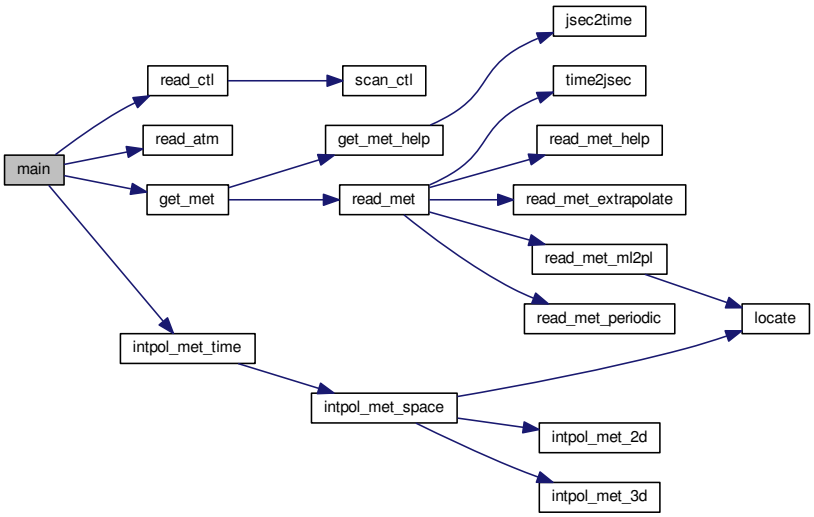
5.29.2.1 int main (int *argc*, char * *argv[]*)

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

```
00098     if (geopot) {
00099       zref = Z(pref);
00100       p0 = met0->p[0];
00101       p1 = met0->p[met0->np - 1];
00102       for (it = 0; it < 24; it++) {
00103         pref = 0.5 * (p0 + p1);
00104         intpol_met_time(met0, met1, atm->time[ip], pref, atm->
      lon[ip],
00105                         atm->lat[ip], NULL, NULL, &zm, NULL, NULL, NULL, NULL,
00106                         NULL, NULL, NULL);
00107         if (zref > zm || !gsl_finite(zm))
00108           p0 = pref;
00109         else
00110           p1 = pref;
00111       }
00112       pref = 0.5 * (p0 + p1);
00113     }
00114
00115     /* Interpolate meteorological data... */
00116     intpol_met_time(met0, met1, atm->time[ip], pref, atm->lon[ip],
00117                     atm->lat[ip], &ps, &pt, &z, &t, &u, &v, &w, &pv, &h2o,
00118                     &o3);
00119     intpol_met_time(met0, met1, atm->time[ip], pt, atm->lon[ip], atm->
      lat[ip],
00120                     NULL, NULL, &zt, &tt, NULL, NULL, NULL, NULL, NULL, NULL);
00121
00122     /* Write data... */
00123     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00124             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip],
00125             atm->p[ip], t, u, v, w, h2o, o3, z, pv, ps, pt, zt, tt);
00126   }
00127
00128   /* Close file... */
00129   fclose(out);
00130
00131   /* Free... */
00132   free(atm);
00133   free(met0);
00134   free(met1);
00135
00136   return EXIT_SUCCESS;
00137 }
```

Here is the call graph for this function:



5.30 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) 2013-2018 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, o3, p0, p1, pref, ps, pt, pv, t, tt, u, v, w, z, zm, zref, zt;
00044
00045   int geopot, ip, it;
00046
00047   /* Check arguments... */
00048   if (argc < 4)
00049     ERRMSG("Give parameters: <ctl> <metbase> <atm_in> <sample.tab>");
00050
00051   /* Allocate... */
00052   ALLOC(atm, atm_t, 1);
00053   ALLOC(met0, met_t, 1);
00054   ALLOC(met1, met_t, 1);
00055
00056   /* Read control parameters... */
00057   read_ctl(argv[1], argc, argv, &ctl);
00058   geopot =
00059     (int) scan_ctl(argv[1], argc, argv, "MET_SAMPLE_GEOPOT", -1, "0", NULL);
00060
00061   /* Read atmospheric data... */
00062   read_atm(argv[3], &ctl, atm);
00063
00064   /* Create output file... */
00065   printf("Write meteorological data file: %s\n", argv[4]);
00066   if (!(out = fopen(argv[4], "w")))
00067     ERRMSG("Cannot create file!");
00068
00069   /* Write header... */
00070   fprintf(out,
00071           "# $1  = time [s]\n"
00072           "# $2  = altitude [km]\n"
00073           "# $3  = longitude [deg]\n"
00074           "# $4  = latitude [deg]\n"
00075           "# $5  = pressure [hPa]\n"
00076           "# $6  = temperature [K]\n"
00077           "# $7  = zonal wind [m/s]\n"
00078           "# $8  = meridional wind [m/s]\n"
00079           "# $9  = vertical wind [hPa/s]\n");
00080   fprintf(out,
00081           "# $10 = H2O volume mixing ratio [1]\n"
00082           "# $11 = O3 volume mixing ratio [1]\n"
00083           "# $12 = geopotential height [km]\n"
00084           "# $13 = potential vorticity [PVU]\n"
00085           "# $14 = surface pressure [hPa]\n"
00086           "# $15 = tropopause pressure [hPa]\n"
00087           "# $16 = tropopause geopotential height [km]\n"
00088           "# $17 = tropopause temperature [K]\n\n");
00089
00090   /* Loop over air parcels... */
00091   for (ip = 0; ip < atm->np; ip++) {
00092
00093     /* Get meteorological data... */
```

```
00094     get_met(&ctl, argv[2], atm->time[ip], met0, met1);
00095
00096     /* Set reference pressure for interpolation... */
00097     pref = atm->p[ip];
00098     if (geopot) {
00099       zref = Z(pref);
00100       p0 = met0->p[0];
00101       p1 = met0->p[met0->np - 1];
00102       for (it = 0; it < 24; it++) {
00103         pref = 0.5 * (p0 + p1);
00104         intpol_met_time(met0, met1, atm->time[ip], pref, atm->
      lon[ip],
00105                         atm->lat[ip], NULL, NULL, &zm, NULL, NULL, NULL, NULL,
00106                         NULL, NULL, NULL);
00107         if (zref > zm || !gsl_finite(zm))
00108           p0 = pref;
00109         else
00110           p1 = pref;
00111       }
00112       pref = 0.5 * (p0 + p1);
00113     }
00114
00115     /* Interpolate meteorological data... */
00116     intpol_met_time(met0, met1, atm->time[ip], pref, atm->lon[ip],
00117                     atm->lat[ip], &ps, &pt, &z, &t, &u, &v, &w, &pv, &h2o,
00118                     &o3);
00119     intpol_met_time(met0, met1, atm->time[ip], pt, atm->lon[ip], atm->
      lat[ip],
00120                     NULL, NULL, &zt, &tt, NULL, NULL, NULL, NULL, NULL, NULL);
00121
00122     /* Write data... */
00123     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00124             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip],
00125             atm->p[ip], t, u, v, w, h2o, o3, z, pv, ps, pt, zt, tt);
00126   }
00127
00128   /* Close file... */
00129   fclose(out);
00130
00131   /* Free... */
00132   free(atm);
00133   free(met0);
00134   free(met1);
00135
00136   return EXIT_SUCCESS;
00137 }
```

5.31 met_zm.c File Reference

Extract zonal mean from meteorological data.

Functions

- int main (int argc, char ∗argv[ ])

5.31.1 Detailed Description

Extract zonal mean from meteorological data.

Definition in file met_zm.c.

5.31.2 Function Documentation

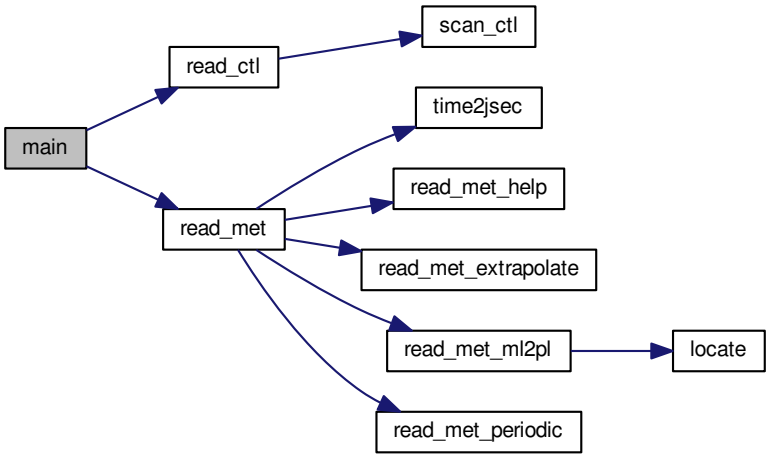
5.31.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file met_zm.c.

```
00029                {
00030
00031   ctl_t ctl;
00032
00033   met_t *met;
00034
00035   FILE *out;
00036
00037   static double timem[EP][EY], psm[EP][EY], ptm[EP][EY], ttm[EP][EY],
00038     ztm[EP][EY], tm[EP][EY], um[EP][EY], vm[EP][EY], wm[EP][EY], h2om[EP][EY],
00039     pvm[EP][EY], o3m[EP][EY], zm[EP][EY], zt, tt;
00040
00041   static int i, ip, ix, iy, np[EP][EY];
00042
00043   /* Allocate... */
00044   ALLOC(met, met_t, 1);
00045
00046   /* Check arguments... */
00047   if (argc < 4)
00048     ERRMSG("Give parameters: <ctl> <zm.tab> <met0> [ <met1> ... ]");
00049
00050   /* Read control parameters... */
00051   read_ctl(argv[1], argc, argv, &ctl);
00052
00053   /* Loop over files... */
00054   for (i = 3; i < argc; i++) {
00055
00056     /* Read meteorological data... */
00057     read_met(&ctl, argv[i], met);
00058
00059     /* Average data... */
00060     for (ix = 0; ix < met->nx; ix++)
00061       for (iy = 0; iy < met->ny; iy++)
00062         for (ip = 0; ip < met->np; ip++) {
00063           intpol_met_space(met, met->pt[ix][iy], met->lon[ix], met->
      lat[iy],
00064                            NULL, NULL, &zt, &tt, NULL, NULL, NULL, NULL, NULL,
00065                            NULL);
00066           timem[ip][iy] += met->time;
00067           zm[ip][iy] += met->z[ix][iy][ip];
00068           tm[ip][iy] += met->t[ix][iy][ip];
00069           um[ip][iy] += met->u[ix][iy][ip];
00070           vm[ip][iy] += met->v[ix][iy][ip];
00071           wm[ip][iy] += met->w[ix][iy][ip];
00072           pvm[ip][iy] += met->pv[ix][iy][ip];
00073           h2om[ip][iy] += met->h2o[ix][iy][ip];
00074           o3m[ip][iy] += met->o3[ix][iy][ip];
00075           psm[ip][iy] += met->ps[ix][iy];
00076           ptm[ip][iy] += met->pt[ix][iy];
00077           ztm[ip][iy] += zt;
00078           ttm[ip][iy] += tt;
00079           np[ip][iy]++;
00080         }
00081   }
00082
00083   /* Create output file... */
00084   printf("Write meteorological data file: %s\n", argv[2]);
00085   if (!(out = fopen(argv[2], "w")))
00086     ERRMSG("Cannot create file!");
00087
00088   /* Write header... */
00089   fprintf(out,
00090           "# $1  = time [s]\n"
00091           "# $2  = altitude [km]\n"
00092           "# $3  = longitude [deg]\n"
00093           "# $4  = latitude [deg]\n"
00094           "# $5  = pressure [hPa]\n"
00095           "# $6  = temperature [K]\n"
00096           "# $7  = zonal wind [m/s]\n"
00097           "# $8  = meridional wind [m/s]\n"
00098           "# $9  = vertical wind [hPa/s]\n"
00099           "# $10 = H2O volume mixing ratio [1]\n");
00100   fprintf(out,
00101           "# $11 = O3 volume mixing ratio [1]\n"
00102           "# $12 = geopotential height [km]\n"
00103           "# $13 = potential vorticity [PVU]\n"
```

```
00104           "# $14 = surface pressure [hPa]\n"
00105           "# $15 = tropopause pressure [hPa]\n"
00106           "# $16 = tropopause geopotential height [km]\n"
00107           "# $17 = tropopause temperature [K]\n");
00108
00109   /* Write data... */
00110   for (ip = 0; ip < met->np; ip++) {
00111     fprintf(out, "\n");
00112     for (iy = 0; iy < met->ny; iy++)
00113       fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00114               timem[ip][iy] / np[ip][iy], Z(met->p[ip]), 0.0, met->lat[iy],
00115               met->p[ip], tm[ip][iy] / np[ip][iy], um[ip][iy] / np[ip][iy],
00116               vm[ip][iy] / np[ip][iy], wm[ip][iy] / np[ip][iy],
00117               h2om[ip][iy] / np[ip][iy], o3m[ip][iy] / np[ip][iy],
00118               zm[ip][iy] / np[ip][iy], pvm[ip][iy] / np[ip][iy],
00119               psm[ip][iy] / np[ip][iy], ptm[ip][iy] / np[ip][iy],
00120               ztm[ip][iy] / np[ip][iy], ttm[ip][iy] / np[ip][iy]);
00121   }
00122
00123   /* Close file... */
00124   fclose(out);
00125
00126   /* Free... */
00127   free(met);
00128
00129   return EXIT_SUCCESS;
00130 }
```

Here is the call graph for this function:



5.32 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) 2013-2018 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   met_t *met;
00034
00035   FILE *out;
00036
00037   static double timem[EP][EY], psm[EP][EY], ptm[EP][EY], ttm[EP][EY],
00038     ztm[EP][EY], tm[EP][EY], um[EP][EY], vm[EP][EY], wm[EP][EY], h2om[EP][EY],
00039     pvm[EP][EY], o3m[EP][EY], zm[EP][EY], zt, tt;
00040
00041   static int i, ip, ix, iy, np[EP][EY];
00042
00043   /* Allocate... */
00044   ALLOC(met, met_t, 1);
00045
00046   /* Check arguments... */
00047   if (argc < 4)
00048     ERRMSG("Give parameters: <ctl> <zm.tab> <met0> [ <met1> ... ]");
00049
00050   /* Read control parameters... */
00051   read_ctl(argv[1], argc, argv, &ctl);
00052
00053   /* Loop over files... */
00054   for (i = 3; i < argc; i++) {
00055
00056     /* Read meteorological data... */
00057     read_met(&ctl, argv[i], met);
00058
00059     /* Average data... */
00060     for (ix = 0; ix < met->nx; ix++)
00061       for (iy = 0; iy < met->ny; iy++)
00062         for (ip = 0; ip < met->np; ip++) {
00063           intpol_met_space(met, met->pt[ix][iy], met->lon[ix], met->
      lat[iy],
00064                            NULL, NULL, &zt, &tt, NULL, NULL, NULL, NULL, NULL,
00065                            NULL);
00066           timem[ip][iy] += met->time;
00067           zm[ip][iy] += met->z[ix][iy][ip];
00068           tm[ip][iy] += met->t[ix][iy][ip];
00069           um[ip][iy] += met->u[ix][iy][ip];
00070           vm[ip][iy] += met->v[ix][iy][ip];
00071           wm[ip][iy] += met->w[ix][iy][ip];
00072           pvm[ip][iy] += met->pv[ix][iy][ip];
00073           h2om[ip][iy] += met->h2o[ix][iy][ip];
00074           o3m[ip][iy] += met->o3[ix][iy][ip];
00075           psm[ip][iy] += met->ps[ix][iy];
00076           ptm[ip][iy] += met->pt[ix][iy];
00077           ztm[ip][iy] += zt;
00078           ttm[ip][iy] += tt;
00079           np[ip][iy]++;
00080         }
00081   }
00082
00083   /* Create output file... */
00084   printf("Write meteorological data file: %s\n", argv[2]);
00085   if (!(out = fopen(argv[2], "w")))
00086     ERRMSG("Cannot create file!");
00087
00088   /* Write header... */
00089   fprintf(out,
00090           "# $1  = time [s]\n"
00091           "# $2  = altitude [km]\n"
00092           "# $3  = longitude [deg]\n"
00093           "# $4  = latitude [deg]\n"
00094           "# $5  = pressure [hPa]\n"
00095           "# $6  = temperature [K]\n"
00096           "# $7  = zonal wind [m/s]\n"
00097           "# $8  = meridional wind [m/s]\n"
00098           "# $9  = vertical wind [hPa/s]\n"
00099           "# $10 = H2O volume mixing ratio [1]\n");
00100   fprintf(out,
00101           "# $11 = O3 volume mixing ratio [1]\n"
00102           "# $12 = geopotential height [km]\n"
00103           "# $13 = potential vorticity [PVU]\n"
00104           "# $14 = surface pressure [hPa]\n"
00105           "# $15 = tropopause pressure [hPa]\n"
00106           "# $16 = tropopause geopotential height [km]\n"
00107           "# $17 = tropopause temperature [K]\n");
```

```
00108
00109   /* Write data... */
00110   for (ip = 0; ip < met->np; ip++) {
00111     fprintf(out, "\n");
00112     for (iy = 0; iy < met->ny; iy++)
00113       fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00114               timem[ip][iy] / np[ip][iy], Z(met->p[ip]), 0.0, met->lat[iy],
00115               met->p[ip], tm[ip][iy] / np[ip][iy], um[ip][iy] / np[ip][iy],
00116               vm[ip][iy] / np[ip][iy], wm[ip][iy] / np[ip][iy],
00117               h2om[ip][iy] / np[ip][iy], o3m[ip][iy] / np[ip][iy],
00118               zm[ip][iy] / np[ip][iy], pvm[ip][iy] / np[ip][iy],
00119               psm[ip][iy] / np[ip][iy], ptm[ip][iy] / np[ip][iy],
00120               ztm[ip][iy] / np[ip][iy], ttm[ip][iy] / np[ip][iy]);
00121   }
00122
00123   /* Close file... */
00124   fclose(out);
00125
00126   /* Free... */
00127   free(met);
00128
00129   return EXIT_SUCCESS;
00130 }
```

5.33 smago.c File Reference

Estimate horizontal diffusivity based on Smagorinsky theory.

Functions

- int main (int argc, char ∗argv[ ])

5.33.1 Detailed Description

Estimate horizontal diffusivity based on Smagorinsky theory.

Definition in file smago.c.

5.33.2 Function Documentation

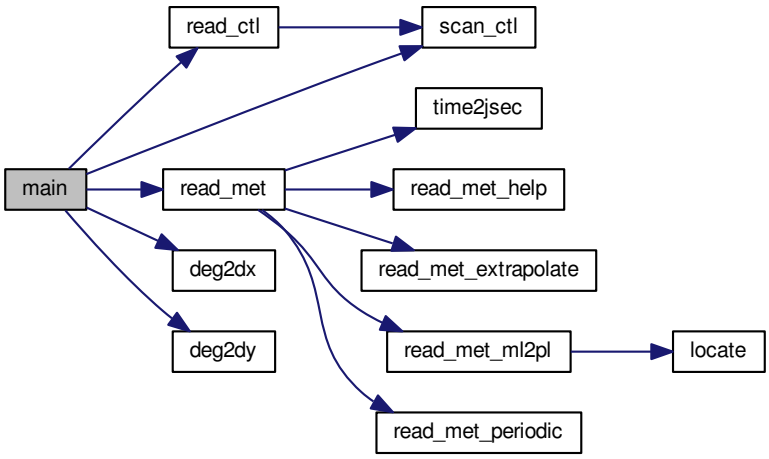
5.33.2.1 int main (int *argc*, char ∗ *argv[ ]*)

Definition at line 8 of file smago.c.

```
00010                {
00011
00012   ctl_t ctl;
00013
00014   met_t *met;
00015
00016   FILE *out;
00017
00018   static double dz, dzmin = 1e10, z, t, s, ls2, k[EX][EY], c = 0.15;
00019
00020   static int ip, ip2, ix, iy;
00021
00022   /* Allocate... */
00023   ALLOC(met, met_t, 1);
00024
00025   /* Check arguments... */
00026   if (argc < 4)
00027     ERRMSG("Give parameters: <ctl> <map.tab> <met>");
00028
00029   /* Read control parameters... */
00030   read_ctl(argv[1], argc, argv, &ctl);
```

```
00031   z = scan_ctl(argv[1], argc, argv, "Z", -1, "", NULL);
00032
00033   /* Read meteorological data... */
00034   read_met(&ctl, argv[3], met);
00035
00036   /* Find nearest pressure level... */
00037   for (ip2 = 0; ip2 < met->np; ip2++) {
00038     dz = fabs(Z(met->p[ip2]) - z);
00039     if (dz < dzmin) {
00040       dzmin = dz;
00041       ip = ip2;
00042     }
00043   }
00044
00045   /* Write info... */
00046   printf("Analyze %g hPa...\n", met->p[ip]);
00047
00048   /* Calculate horizontal diffusion coefficients... */
00049   for (ix = 1; ix < met->nx - 1; ix++)
00050     for (iy = 1; iy < met->ny - 1; iy++) {
00051       t = 0.5 * ((met->u[ix + 1][iy][ip] - met->u[ix - 1][iy][ip])
00052                  / (1000. *
00053                     deg2dx(met->lon[ix + 1] - met->lon[ix - 1], met->
    lat[iy]))
00054                  - (met->v[ix][iy + 1][ip] - met->v[ix][iy - 1][ip])
00055                  / (1000. * deg2dy(met->lat[iy + 1] - met->lat[iy - 1])));
00056       s = 0.5 * ((met->u[ix][iy + 1][ip] - met->u[ix][iy - 1][ip])
00057                  / (1000. * deg2dy(met->lat[iy + 1] - met->lat[iy - 1]))
00058                  + (met->v[ix + 1][iy][ip] - met->v[ix - 1][iy][ip])
00059                  / (1000. *
00060                     deg2dx(met->lon[ix + 1] - met->lon[ix - 1],
00061                            met->lat[iy])));
00062       ls2 = gsl_pow_2(c * 500. * deg2dy(met->lat[iy + 1] - met->lat[iy - 1]));
00063       if (fabs(met->lat[iy]) > 80)
00064         ls2 *= (90. - fabs(met->lat[iy])) / 10.;
00065       k[ix][iy] = ls2 * sqrt(2.0 * (gsl_pow_2(t) + gsl_pow_2(s)));
00066     }
00067
00068   /* Create output file... */
00069   printf("Write data file: %s\n", argv[2]);
00070   if (!(out = fopen(argv[2], "w")))
00071     ERRMSG("Cannot create file!");
00072
00073   /* Write header... */
00074   fprintf(out,
00075           "# $1 = longitude [deg]\n"
00076           "# $2 = latitude [deg]\n"
00077           "# $3 = zonal wind [m/s]\n"
00078           "# $4 = meridional wind [m/s]\n"
00079           "# $5 = horizontal diffusivity [m^2/s]\n");
00080
00081   /* Write data... */
00082   for (iy = 0; iy < met->ny; iy++) {
00083     fprintf(out, "\n");
00084     for (ix = 0; ix < met->nx; ix++)
00085       if (met->lon[ix] >= 180)
00086         fprintf(out, "%g %g %g %g %g\n",
00087                 met->lon[ix] - 360.0, met->lat[iy],
00088                 met->u[ix][iy][ip], met->v[ix][iy][ip], k[ix][iy]);
00089     for (ix = 0; ix < met->nx; ix++)
00090       if (met->lon[ix] <= 180)
00091         fprintf(out, "%g %g %g %g %g\n",
00092                 met->lon[ix], met->lat[iy],
00093                 met->u[ix][iy][ip], met->v[ix][iy][ip], k[ix][iy]);
00094   }
00095
00096   /* Close file... */
00097   fclose(out);
00098
00099   /* Free... */
00100   free(met);
00101
00102   return EXIT_SUCCESS;
00103 }
```

Here is the call graph for this function:



5.34 smago.c

```
00001
00006 #include "libtrac.h"
00007
00008 int main(
00009   int argc,
00010   char *argv[]) {
00011
00012   ctl_t ctl;
00013
00014   met_t *met;
00015
00016   FILE *out;
00017
00018   static double dz, dzmin = 1e10, z, t, s, ls2, k[EX][EY], c = 0.15;
00019
00020   static int ip, ip2, ix, iy;
00021
00022   /* Allocate... */
00023   ALLOC(met, met_t, 1);
00024
00025   /* Check arguments... */
00026   if (argc < 4)
00027     ERRMSG("Give parameters: <ctl> <map.tab> <met>");
00028
00029   /* Read control parameters... */
00030   read_ctl(argv[1], argc, argv, &ctl);
00031   z = scan_ctl(argv[1], argc, argv, "Z", -1, "", NULL);
00032
00033   /* Read meteorological data... */
00034   read_met(&ctl, argv[3], met);
00035
00036   /* Find nearest pressure level... */
00037   for (ip2 = 0; ip2 < met->np; ip2++) {
00038     dz = fabs(Z(met->p[ip2]) - z);
00039     if (dz < dzmin) {
00040       dzmin = dz;
00041       ip = ip2;
00042     }
00043   }
00044
00045   /* Write info... */
00046   printf("Analyze %g hPa...\n", met->p[ip]);
00047
00048   /* Calculate horizontal diffusion coefficients... */
00049   for (ix = 1; ix < met->nx - 1; ix++)
00050     for (iy = 1; iy < met->ny - 1; iy++) {
00051       t = 0.5 * ((met->u[ix + 1][iy][ip] - met->u[ix - 1][iy][ip])
```

```
00052                   / (1000. *
00053                      deg2dx(met->lon[ix + 1] - met->lon[ix - 1], met->
    lat[iy]))
00054                   - (met->v[ix][iy + 1][ip] - met->v[ix][iy - 1][ip])
00055                   / (1000. * deg2dy(met->lat[iy + 1] - met->lat[iy - 1])));
00056       s = 0.5 * ((met->u[ix][iy + 1][ip] - met->u[ix][iy - 1][ip])
00057                  / (1000. * deg2dy(met->lat[iy + 1] - met->lat[iy - 1]))
00058                  + (met->v[ix + 1][iy][ip] - met->v[ix - 1][iy][ip])
00059                  / (1000. *
00060                     deg2dx(met->lon[ix + 1] - met->lon[ix - 1],
00061                            met->lat[iy])));
00062       ls2 = gsl_pow_2(c * 500. * deg2dy(met->lat[iy + 1] - met->lat[iy - 1]));
00063       if (fabs(met->lat[iy]) > 80)
00064         ls2 *= (90. - fabs(met->lat[iy])) / 10.;
00065       k[ix][iy] = ls2 * sqrt(2.0 * (gsl_pow_2(t) + gsl_pow_2(s)));
00066     }
00067
00068   /* Create output file... */
00069   printf("Write data file: %s\n", argv[2]);
00070   if (!(out = fopen(argv[2], "w")))
00071     ERRMSG("Cannot create file!");
00072
00073   /* Write header... */
00074   fprintf(out,
00075           "# $1 = longitude [deg]\n"
00076           "# $2 = latitude [deg]\n"
00077           "# $3 = zonal wind [m/s]\n"
00078           "# $4 = meridional wind [m/s]\n"
00079           "# $5 = horizontal diffusivity [m^2/s]\n");
00080
00081   /* Write data... */
00082   for (iy = 0; iy < met->ny; iy++) {
00083     fprintf(out, "\n");
00084     for (ix = 0; ix < met->nx; ix++)
00085       if (met->lon[ix] >= 180)
00086         fprintf(out, "%g %g %g %g %g\n",
00087                 met->lon[ix] - 360.0, met->lat[iy],
00088                 met->u[ix][iy][ip], met->v[ix][iy][ip], k[ix][iy]);
00089     for (ix = 0; ix < met->nx; ix++)
00090       if (met->lon[ix] <= 180)
00091         fprintf(out, "%g %g %g %g %g\n",
00092                 met->lon[ix], met->lat[iy],
00093                 met->u[ix][iy][ip], met->v[ix][iy][ip], k[ix][iy]);
00094   }
00095
00096   /* Close file... */
00097   fclose(out);
00098
00099   /* Free... */
00100   free(met);
00101
00102   return EXIT_SUCCESS;
00103 }
```

5.35 split.c File Reference

Split air parcels into a larger number of parcels.

Functions

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

5.35.1 Detailed Description

Split air parcels into a larger number of parcels.

Definition in file split.c.

5.35.2 Function Documentation

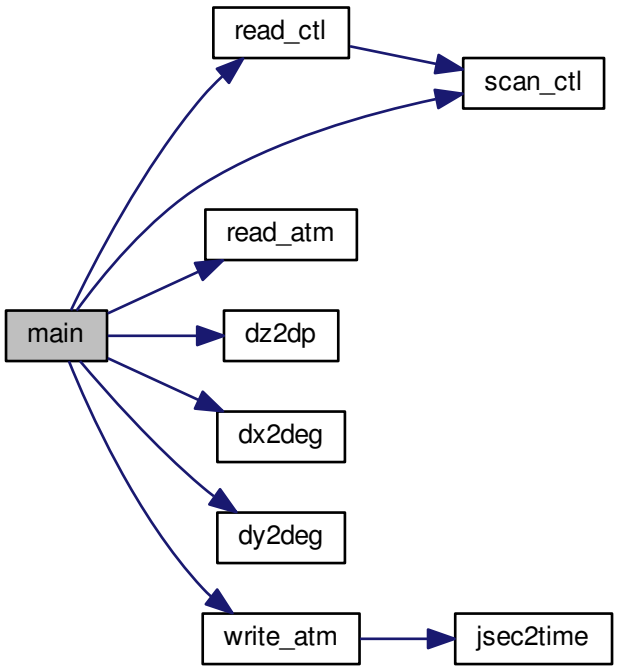
5.35.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file split.c.

```
00029                {
00030
00031   atm_t *atm, *atm2;
00032
00033   ctl_t ctl;
00034
00035   gsl_rng *rng;
00036
00037   double m, mtot = 0, dt, dx, dz, mmax = 0,
00038     t0, t1, z0, z1, lon0, lon1, lat0, lat1;
00039
00040   int i, ip, iq, n;
00041
00042   /* Allocate... */
00043   ALLOC(atm, atm_t, 1);
00044   ALLOC(atm2, atm_t, 1);
00045
00046   /* Check arguments... */
00047   if (argc < 4)
00048     ERRMSG("Give parameters: <ctl> <atm_in> <atm_out>");
00049
00050   /* Read control parameters... */
00051   read_ctl(argv[1], argc, argv, &ctl);
00052   n = (int) scan_ctl(argv[1], argc, argv, "SPLIT_N", -1, "", NULL);
00053   m = scan_ctl(argv[1], argc, argv, "SPLIT_M", -1, "-999", NULL);
00054   dt = scan_ctl(argv[1], argc, argv, "SPLIT_DT", -1, "0", NULL);
00055   t0 = scan_ctl(argv[1], argc, argv, "SPLIT_T0", -1, "0", NULL);
00056   t1 = scan_ctl(argv[1], argc, argv, "SPLIT_T1", -1, "0", NULL);
00057   dz = scan_ctl(argv[1], argc, argv, "SPLIT_DZ", -1, "0", NULL);
00058   z0 = scan_ctl(argv[1], argc, argv, "SPLIT_Z0", -1, "0", NULL);
00059   z1 = scan_ctl(argv[1], argc, argv, "SPLIT_Z1", -1, "0", NULL);
00060   dx = scan_ctl(argv[1], argc, argv, "SPLIT_DX", -1, "0", NULL);
00061   lon0 = scan_ctl(argv[1], argc, argv, "SPLIT_LON0", -1, "0", NULL);
00062   lon1 = scan_ctl(argv[1], argc, argv, "SPLIT_LON1", -1, "0", NULL);
00063   lat0 = scan_ctl(argv[1], argc, argv, "SPLIT_LAT0", -1, "0", NULL);
00064   lat1 = scan_ctl(argv[1], argc, argv, "SPLIT_LAT1", -1, "0", NULL);
00065
00066   /* Init random number generator... */
00067   gsl_rng_env_setup();
00068   rng = gsl_rng_alloc(gsl_rng_default);
00069
00070   /* Read atmospheric data... */
00071   read_atm(argv[2], &ctl, atm);
00072
00073   /* Get total and maximum mass... */
00074   if (ctl.qnt_m >= 0)
00075     for (ip = 0; ip < atm->np; ip++) {
00076       mtot += atm->q[ctl.qnt_m][ip];
00077       mmax = GSL_MAX(mmax, atm->q[ctl.qnt_m][ip]);
00078     }
00079   if (m > 0)
00080     mtot = m;
00081
00082   /* Loop over air parcels... */
00083   for (i = 0; i < n; i++) {
00084
00085     /* Select air parcel... */
00086     if (ctl.qnt_m >= 0)
00087       do {
00088         ip = (int) gsl_rng_uniform_int(rng, (long unsigned int) atm->np);
00089       } while (gsl_rng_uniform(rng) > atm->q[ctl.qnt_m][ip] / mmax);
00090     else
00091       ip = (int) gsl_rng_uniform_int(rng, (long unsigned int) atm->np);
00092
00093     /* Set time... */
00094     if (t1 > t0)
00095       atm2->time[atm2->np] = t0 + (t1 - t0) * gsl_rng_uniform_pos(rng);
00096     else
00097       atm2->time[atm2->np] = atm->time[ip]
00098         + gsl_ran_gaussian_ziggurat(rng, dt / 2.3548);
00099
00100    /* Set vertical position... */
00101    if (z1 > z0)
00102      atm2->p[atm2->np] = P(z0 + (z1 - z0) * gsl_rng_uniform_pos(rng));
00103    else
00104      atm2->p[atm2->np] = atm->p[ip]
```

```
00105         + dz2dp(gsl_ran_gaussian_ziggurat(rng, dz / 2.3548), atm->p[ip]);
00106
00107     /* Set horizontal position... */
00108     if (lon1 > lon0 && lat1 > lat0) {
00109       atm2->lon[atm2->np] = lon0 + (lon1 - lon0) * gsl_rng_uniform_pos(rng);
00110       atm2->lat[atm2->np] = lat0 + (lat1 - lat0) * gsl_rng_uniform_pos(rng);
00111     } else {
00112       atm2->lon[atm2->np] = atm->lon[ip]
00113         + gsl_ran_gaussian_ziggurat(rng, dx2deg(dx, atm->lat[ip]) / 2.3548);
00114       atm2->lat[atm2->np] = atm->lat[ip]
00115         + gsl_ran_gaussian_ziggurat(rng, dy2deg(dx) / 2.3548);
00116     }
00117
00118     /* Copy quantities... */
00119     for (iq = 0; iq < ctl.nq; iq++)
00120       atm2->q[iq][atm2->np] = atm->q[iq][ip];
00121
00122     /* Adjust mass... */
00123     if (ctl.qnt_m >= 0)
00124       atm2->q[ctl.qnt_m][atm2->np] = mtot / n;
00125
00126     /* Increment particle counter... */
00127     if ((++atm2->np) >= NP)
00128       ERRMSG("Too many air parcels!");
00129   }
00130
00131   /* Save data and close file... */
00132   write_atm(argv[3], &ctl, atm2, atm->time[0]);
00133
00134   /* Free... */
00135   free(atm);
00136   free(atm2);
00137
00138   return EXIT_SUCCESS;
00139 }
```

Here is the call graph for this function:



5.36 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) 2013-2018 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   double m, mtot = 0, dt, dx, dz, mmax = 0,
00038     t0, t1, z0, z1, lon0, lon1, lat0, lat1;
00039
00040   int i, ip, iq, n;
00041
00042   /* Allocate... */
00043   ALLOC(atm, atm_t, 1);
00044   ALLOC(atm2, atm_t, 1);
00045
00046   /* Check arguments... */
00047   if (argc < 4)
00048     ERRMSG("Give parameters: <ctl> <atm_in> <atm_out>");
00049
00050   /* Read control parameters... */
00051   read_ctl(argv[1], argc, argv, &ctl);
00052   n = (int) scan_ctl(argv[1], argc, argv, "SPLIT_N", -1, "", NULL);
00053   m = scan_ctl(argv[1], argc, argv, "SPLIT_M", -1, "-999", NULL);
00054   dt = scan_ctl(argv[1], argc, argv, "SPLIT_DT", -1, "0", NULL);
00055   t0 = scan_ctl(argv[1], argc, argv, "SPLIT_T0", -1, "0", NULL);
00056   t1 = scan_ctl(argv[1], argc, argv, "SPLIT_T1", -1, "0", NULL);
00057   dz = scan_ctl(argv[1], argc, argv, "SPLIT_DZ", -1, "0", NULL);
00058   z0 = scan_ctl(argv[1], argc, argv, "SPLIT_Z0", -1, "0", NULL);
00059   z1 = scan_ctl(argv[1], argc, argv, "SPLIT_Z1", -1, "0", NULL);
00060   dx = scan_ctl(argv[1], argc, argv, "SPLIT_DX", -1, "0", NULL);
00061   lon0 = scan_ctl(argv[1], argc, argv, "SPLIT_LON0", -1, "0", NULL);
00062   lon1 = scan_ctl(argv[1], argc, argv, "SPLIT_LON1", -1, "0", NULL);
00063   lat0 = scan_ctl(argv[1], argc, argv, "SPLIT_LAT0", -1, "0", NULL);
00064   lat1 = scan_ctl(argv[1], argc, argv, "SPLIT_LAT1", -1, "0", NULL);
00065
00066   /* Init random number generator... */
00067   gsl_rng_env_setup();
00068   rng = gsl_rng_alloc(gsl_rng_default);
00069
00070   /* Read atmospheric data... */
00071   read_atm(argv[2], &ctl, atm);
00072
00073   /* Get total and maximum mass... */
00074   if (ctl.qnt_m >= 0)
00075     for (ip = 0; ip < atm->np; ip++) {
00076       mtot += atm->q[ctl.qnt_m][ip];
00077       mmax = GSL_MAX(mmax, atm->q[ctl.qnt_m][ip]);
00078     }
00079   if (m > 0)
00080     mtot = m;
00081
00082   /* Loop over air parcels... */
00083   for (i = 0; i < n; i++) {
00084
00085     /* Select air parcel... */
00086     if (ctl.qnt_m >= 0)
00087       do {
00088         ip = (int) gsl_rng_uniform_int(rng, (long unsigned int) atm->np);
00089       } while (gsl_rng_uniform(rng) > atm->q[ctl.qnt_m][ip] / mmax);
```

```
00090     else
00091       ip = (int) gsl_rng_uniform_int(rng, (long unsigned int) atm->np);
00092
00093     /* Set time... */
00094     if (t1 > t0)
00095       atm2->time[atm2->np] = t0 + (t1 - t0) * gsl_rng_uniform_pos(rng);
00096     else
00097       atm2->time[atm2->np] = atm->time[ip]
00098         + gsl_ran_gaussian_ziggurat(rng, dt / 2.3548);
00099
00100    /* Set vertical position... */
00101    if (z1 > z0)
00102      atm2->p[atm2->np] = P(z0 + (z1 - z0) * gsl_rng_uniform_pos(rng));
00103    else
00104      atm2->p[atm2->np] = atm->p[ip]
00105        + dz2dp(gsl_ran_gaussian_ziggurat(rng, dz / 2.3548), atm->p[ip]);
00106
00107    /* Set horizontal position... */
00108    if (lon1 > lon0 && lat1 > lat0) {
00109      atm2->lon[atm2->np] = lon0 + (lon1 - lon0) * gsl_rng_uniform_pos(rng);
00110      atm2->lat[atm2->np] = lat0 + (lat1 - lat0) * gsl_rng_uniform_pos(rng);
00111    } else {
00112      atm2->lon[atm2->np] = atm->lon[ip]
00113        + gsl_ran_gaussian_ziggurat(rng, dx2deg(dx, atm->lat[ip]) / 2.3548);
00114      atm2->lat[atm2->np] = atm->lat[ip]
00115        + gsl_ran_gaussian_ziggurat(rng, dy2deg(dx) / 2.3548);
00116    }
00117
00118    /* Copy quantities... */
00119    for (iq = 0; iq < ctl.nq; iq++)
00120      atm2->q[iq][atm2->np] = atm->q[iq][ip];
00121
00122    /* Adjust mass... */
00123    if (ctl.qnt_m >= 0)
00124      atm2->q[ctl.qnt_m][atm2->np] = mtot / n;
00125
00126    /* Increment particle counter... */
00127    if ((++atm2->np) >= NP)
00128      ERRMSG("Too many air parcels!");
00129  }
00130
00131  /* Save data and close file... */
00132  write_atm(argv[3], &ctl, atm2, atm->time[0]);
00133
00134  /* Free... */
00135  free(atm);
00136  free(atm2);
00137
00138  return EXIT_SUCCESS;
00139 }
```

5.37 time2jsec.c File Reference

Convert date to Julian seconds.

Functions

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

5.37.1 Detailed Description

Convert date to Julian seconds.

Definition in file time2jsec.c.

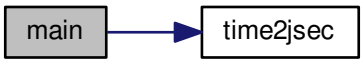
5.37.2 Function Documentation

5.37.2.1 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:



5.38 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) 2013-2018 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 }
```

5.39 trac.c File Reference

Lagrangian particle dispersion model.

Functions

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

  Calculate advection of air parcels.
- void module_decay (ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, int ip, double dt)

  Calculate exponential decay of particle mass.
- void module_diffusion_meso (ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, int ip, double dt, gsl_rng *rng)

  Calculate mesoscale diffusion.
- void module_diffusion_turb (ctl_t *ctl, atm_t *atm, int ip, double dt, gsl_rng *rng)

  Calculate turbulent diffusion.
- void module_isosurf (ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, int ip)

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

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

  Check position of air parcels.
- void module_sedi (ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, int ip, 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[])

5.39.1 Detailed Description

Lagrangian particle dispersion model.

Definition in file trac.c.

5.39.2 Function Documentation

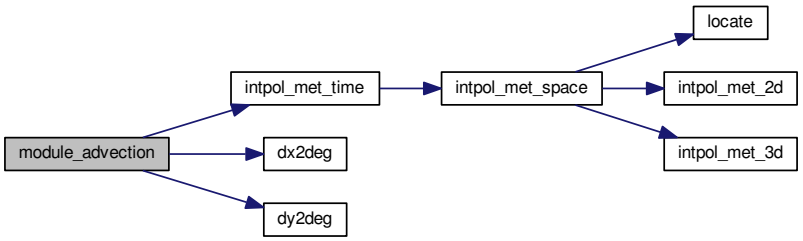
5.39.2.1 void module_advection (met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt*)

Calculate advection of air parcels.

Definition at line 383 of file trac.c.

```
00388             {
00389
00390   double v[3], xm[3];
00391
00392   /* Interpolate meteorological data... */
00393   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00394                   atm->lon[ip], atm->lat[ip], NULL, NULL, NULL, NULL,
00395                   &v[0], &v[1], &v[2], NULL, NULL, NULL);
00396
00397   /* Get position of the mid point... */
00398   xm[0] = atm->lon[ip] + dx2deg(0.5 * dt * v[0] / 1000., atm->lat[ip]);
00399   xm[1] = atm->lat[ip] + dy2deg(0.5 * dt * v[1] / 1000.);
00400   xm[2] = atm->p[ip] + 0.5 * dt * v[2];
00401
00402   /* Interpolate meteorological data for mid point... */
00403   intpol_met_time(met0, met1, atm->time[ip] + 0.5 * dt,
00404                   xm[2], xm[0], xm[1], NULL, NULL, NULL, NULL,
00405                   &v[0], &v[1], &v[2], NULL, NULL, NULL);
00406
00407   /* Save new position... */
00408   atm->time[ip] += dt;
00409   atm->lon[ip] += dx2deg(dt * v[0] / 1000., xm[1]);
00410   atm->lat[ip] += dy2deg(dt * v[1] / 1000.);
00411   atm->p[ip] += dt * v[2];
00412 }
```

Here is the call graph for this function:



5.39.2.2 void module_decay (ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt*)

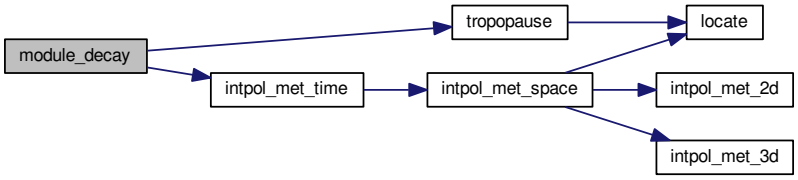
Calculate exponential decay of particle mass.

Definition at line 416 of file trac.c.

```
00422             {
00423
00424   double ps, pt, tdec;
00425
00426   /* Set constant lifetime... */
00427   if (ctl->tdec_trop == ctl->tdec_strat)
00428     tdec = ctl->tdec_trop;
00429
00430   /* Set altitude-dependent lifetime... */
00431   else {
```

```
00432
00433     /* Get surface pressure... */
00434     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00435                     atm->lon[ip], atm->lat[ip], &ps, NULL, NULL, NULL,
00436                     NULL, NULL, NULL, NULL, NULL, NULL);
00437
00438     /* Get tropopause pressure... */
00439     pt = clim_tropo(atm->time[ip], atm->lat[ip]);
00440
00441     /* Set lifetime... */
00442     if (atm->p[ip] <= pt)
00443       tdec = ctl->tdec_strat;
00444     else
00445       tdec = LIN(ps, ctl->tdec_trop, pt, ctl->tdec_strat, atm->
      p[ip]);
00446   }
00447
00448   /* Calculate exponential decay... */
00449   atm->q[ctl->qnt_m][ip] *= exp(-dt / tdec);
00450 }
```

Here is the call graph for this function:



5.39.2.3 void module_diffusion_meso (ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt*, gsl_rng * *rng*)

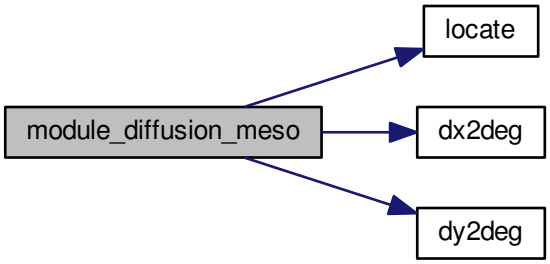
Calculate mesoscale diffusion.

Definition at line 454 of file trac.c.

```
00461                 {
00462
00463   double r, rs, u[16], v[16], w[16], usig, vsig, wsig;
00464
00465   int ix, iy, iz;
00466
00467   /* Get indices... */
00468   ix = locate(met0->lon, met0->nx, atm->lon[ip]);
00469   iy = locate(met0->lat, met0->ny, atm->lat[ip]);
00470   iz = locate(met0->p, met0->np, atm->p[ip]);
00471
00472   /* Collect local wind data... */
00473   u[0] = met0->u[ix][iy][iz];
00474   u[1] = met0->u[ix + 1][iy][iz];
00475   u[2] = met0->u[ix][iy + 1][iz];
00476   u[3] = met0->u[ix + 1][iy + 1][iz];
00477   u[4] = met0->u[ix][iy][iz + 1];
00478   u[5] = met0->u[ix + 1][iy][iz + 1];
00479   u[6] = met0->u[ix][iy + 1][iz + 1];
00480   u[7] = met0->u[ix + 1][iy + 1][iz + 1];
00481
00482   v[0] = met0->v[ix][iy][iz];
00483   v[1] = met0->v[ix + 1][iy][iz];
00484   v[2] = met0->v[ix][iy + 1][iz];
00485   v[3] = met0->v[ix + 1][iy + 1][iz];
00486   v[4] = met0->v[ix][iy][iz + 1];
00487   v[5] = met0->v[ix + 1][iy][iz + 1];
00488   v[6] = met0->v[ix][iy + 1][iz + 1];
00489   v[7] = met0->v[ix + 1][iy + 1][iz + 1];
00490
```

```
00491   w[0] = met0->w[ix][iy][iz];
00492   w[1] = met0->w[ix + 1][iy][iz];
00493   w[2] = met0->w[ix][iy + 1][iz];
00494   w[3] = met0->w[ix + 1][iy + 1][iz];
00495   w[4] = met0->w[ix][iy][iz + 1];
00496   w[5] = met0->w[ix + 1][iy][iz + 1];
00497   w[6] = met0->w[ix][iy + 1][iz + 1];
00498   w[7] = met0->w[ix + 1][iy + 1][iz + 1];
00499
00500   /* Get indices... */
00501   ix = locate(met1->lon, met1->nx, atm->lon[ip]);
00502   iy = locate(met1->lat, met1->ny, atm->lat[ip]);
00503   iz = locate(met1->p, met1->np, atm->p[ip]);
00504
00505   /* Collect local wind data... */
00506   u[8] = met1->u[ix][iy][iz];
00507   u[9] = met1->u[ix + 1][iy][iz];
00508   u[10] = met1->u[ix][iy + 1][iz];
00509   u[11] = met1->u[ix + 1][iy + 1][iz];
00510   u[12] = met1->u[ix][iy][iz + 1];
00511   u[13] = met1->u[ix + 1][iy][iz + 1];
00512   u[14] = met1->u[ix][iy + 1][iz + 1];
00513   u[15] = met1->u[ix + 1][iy + 1][iz + 1];
00514
00515   v[8] = met1->v[ix][iy][iz];
00516   v[9] = met1->v[ix + 1][iy][iz];
00517   v[10] = met1->v[ix][iy + 1][iz];
00518   v[11] = met1->v[ix + 1][iy + 1][iz];
00519   v[12] = met1->v[ix][iy][iz + 1];
00520   v[13] = met1->v[ix + 1][iy][iz + 1];
00521   v[14] = met1->v[ix][iy + 1][iz + 1];
00522   v[15] = met1->v[ix + 1][iy + 1][iz + 1];
00523
00524   w[8] = met1->w[ix][iy][iz];
00525   w[9] = met1->w[ix + 1][iy][iz];
00526   w[10] = met1->w[ix][iy + 1][iz];
00527   w[11] = met1->w[ix + 1][iy + 1][iz];
00528   w[12] = met1->w[ix][iy][iz + 1];
00529   w[13] = met1->w[ix + 1][iy][iz + 1];
00530   w[14] = met1->w[ix][iy + 1][iz + 1];
00531   w[15] = met1->w[ix + 1][iy + 1][iz + 1];
00532
00533   /* Get standard deviations of local wind data... */
00534   usig = gsl_stats_sd(u, 1, 16);
00535   vsig = gsl_stats_sd(v, 1, 16);
00536   wsig = gsl_stats_sd(w, 1, 16);
00537
00538   /* Set temporal correlations for mesoscale fluctuations... */
00539   r = 1 - 2 * fabs(dt) / ctl->dt_met;
00540   rs = sqrt(1 - r * r);
00541
00542   /* Calculate horizontal mesoscale wind fluctuations... */
00543   if (ctl->turb_mesox > 0) {
00544     atm->up[ip] = (float)
00545       (r * atm->up[ip]
00546        + rs * gsl_ran_gaussian_ziggurat(rng, ctl->turb_mesox * usig));
00547     atm->lon[ip] += dx2deg(atm->up[ip] * dt / 1000., atm->lat[ip]);
00548
00549     atm->vp[ip] = (float)
00550       (r * atm->vp[ip]
00551        + rs * gsl_ran_gaussian_ziggurat(rng, ctl->turb_mesox * vsig));
00552     atm->lat[ip] += dy2deg(atm->vp[ip] * dt / 1000.);
00553   }
00554
00555   /* Calculate vertical mesoscale wind fluctuations... */
00556   if (ctl->turb_mesoz > 0) {
00557     atm->wp[ip] = (float)
00558       (r * atm->wp[ip]
00559        + rs * gsl_ran_gaussian_ziggurat(rng, ctl->turb_mesoz * wsig));
00560     atm->p[ip] += atm->wp[ip] * dt;
00561   }
00562 }
```

Here is the call graph for this function:



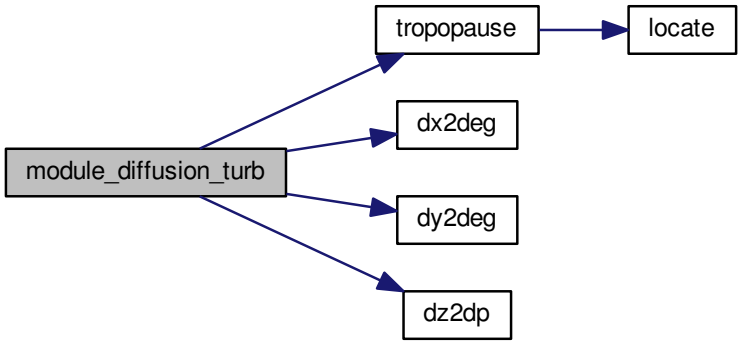
5.39.2.4 void module_diffusion_turb (ctl_t * *ctl*, atm_t * *atm*, int *ip*, double *dt*, gsl_rng * *rng*)

Calculate turbulent diffusion.

Definition at line 566 of file trac.c.

```
00571                 {
00572
00573   double dx, dz, pt, p0, p1, w;
00574
00575   /* Get tropopause pressure... */
00576   pt = clim_tropo(atm->time[ip], atm->lat[ip]);
00577
00578   /* Get weighting factor... */
00579   p1 = pt * 0.866877899;
00580   p0 = pt / 0.866877899;
00581   if (atm->p[ip] > p0)
00582     w = 1;
00583   else if (atm->p[ip] < p1)
00584     w = 0;
00585   else
00586     w = LIN(p0, 1.0, p1, 0.0, atm->p[ip]);
00587
00588   /* Set diffusivitiy... */
00589   dx = w * ctl->turb_dx_trop + (1 - w) * ctl->turb_dx_strat;
00590   dz = w * ctl->turb_dz_trop + (1 - w) * ctl->turb_dz_strat;
00591
00592   /* Horizontal turbulent diffusion... */
00593   if (dx > 0) {
00594     atm->lon[ip]
00595       += dx2deg(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dx * fabs(dt)))
00596                 / 1000., atm->lat[ip]);
00597     atm->lat[ip]
00598       += dy2deg(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dx * fabs(dt)))
00599                 / 1000.);
00600   }
00601
00602   /* Vertical turbulent diffusion... */
00603   if (dz > 0)
00604     atm->p[ip]
00605       += dz2dp(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dz * fabs(dt)))
00606                / 1000., atm->p[ip]);
00607 }
```

Here is the call graph for this function:



5.39.2.5 void module_isosurf (ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*)

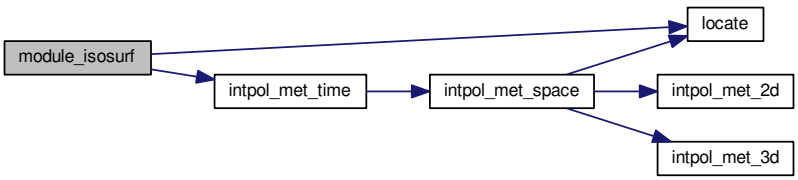
Force air parcels to stay on isosurface.

Definition at line 611 of file trac.c.

```
00616           {
00617
00618     static double *iso, *ps, t, *ts;
00619
00620     static int idx, ip2, n;
00621
00622     FILE *in;
00623
00624     char line[LEN];
00625
00626     /* Initialize... */
00627     if (ip < 0) {
00628
00629       /* Allocate... */
00630       ALLOC(iso, double,
00631             NP);
00632       ALLOC(ps, double,
00633             NP);
00634       ALLOC(ts, double,
00635             NP);
00636
00637       /* Save pressure... */
00638       if (ctl->isosurf == 1)
00639         for (ip2 = 0; ip2 < atm->np; ip2++)
00640           iso[ip2] = atm->p[ip2];
00641
00642       /* Save density... */
00643       else if (ctl->isosurf == 2)
00644         for (ip2 = 0; ip2 < atm->np; ip2++) {
00645           intpol_met_time(met0, met1, atm->time[ip2], atm->p[ip2],
00646                           atm->lon[ip2], atm->lat[ip2], NULL, NULL, NULL,
00647                           &t, NULL, NULL, NULL, NULL, NULL, NULL);
00648           iso[ip2] = atm->p[ip2] / t;
00649         }
00650
00651       /* Save potential temperature... */
00652       else if (ctl->isosurf == 3)
00653         for (ip2 = 0; ip2 < atm->np; ip2++) {
00654           intpol_met_time(met0, met1, atm->time[ip2], atm->p[ip2],
00655                           atm->lon[ip2], atm->lat[ip2], NULL, NULL, NULL,
00656                           &t, NULL, NULL, NULL, NULL, NULL, NULL);
00657           iso[ip2] = THETA(atm->p[ip2], t);
00658         }
00659
```

```
00660     /* Read balloon pressure data... */
00661     else if (ctl->isosurf == 4) {
00662
00663       /* Write info... */
00664       printf("Read balloon pressure data: %s\n", ctl->balloon);
00665
00666       /* Open file... */
00667       if (!(in = fopen(ctl->balloon, "r")))
00668         ERRMSG("Cannot open file!");
00669
00670       /* Read pressure time series... */
00671       while (fgets(line, LEN, in))
00672         if (sscanf(line, "%lg %lg", &ts[n], &ps[n]) == 2)
00673           if ((++n) > NP)
00674             ERRMSG("Too many data points!");
00675
00676       /* Check number of points... */
00677       if (n < 1)
00678         ERRMSG("Could not read any data!");
00679
00680       /* Close file... */
00681       fclose(in);
00682     }
00683
00684     /* Leave initialization... */
00685     return;
00686   }
00687
00688   /* Restore pressure... */
00689   if (ctl->isosurf == 1)
00690     atm->p[ip] = iso[ip];
00691
00692   /* Restore density... */
00693   else if (ctl->isosurf == 2) {
00694     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00695                     atm->lat[ip], NULL, NULL, NULL, &t,
00696                     NULL, NULL, NULL, NULL, NULL, NULL);
00697     atm->p[ip] = iso[ip] * t;
00698   }
00699
00700   /* Restore potential temperature... */
00701   else if (ctl->isosurf == 3) {
00702     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00703                     atm->lat[ip], NULL, NULL, NULL, &t,
00704                     NULL, NULL, NULL, NULL, NULL, NULL);
00705     atm->p[ip] = 1000. * pow(iso[ip] / t, -1. / 0.286);
00706   }
00707
00708   /* Interpolate pressure... */
00709   else if (ctl->isosurf == 4) {
00710     if (atm->time[ip] <= ts[0])
00711       atm->p[ip] = ps[0];
00712     else if (atm->time[ip] >= ts[n - 1])
00713       atm->p[ip] = ps[n - 1];
00714     else {
00715       idx = locate(ts, n, atm->time[ip]);
00716       atm->p[ip] = LIN(ts[idx], ps[idx],
00717                        ts[idx + 1], ps[idx + 1], atm->time[ip]);
00718     }
00719   }
00720 }
```

Here is the call graph for this function:



5.39.2.6 void module_meteo (ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*)

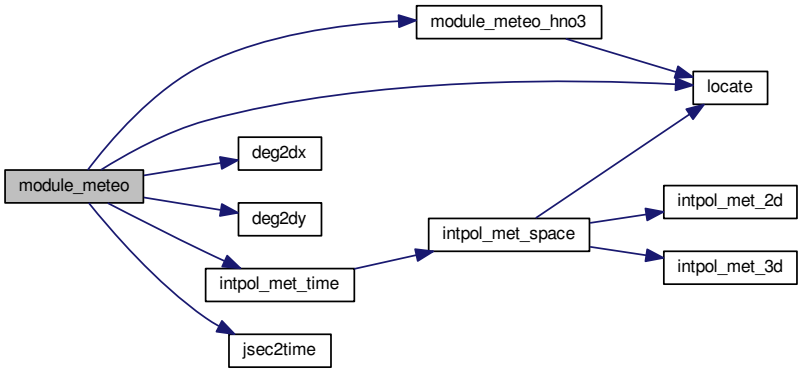
Interpolate meteorological data for air parcel positions.

Definition at line 724 of file trac.c.

```
00729           {
00730
00731   double a, b, c, ps, pt, pv, p_hno3, p_h2o, t, u, v, w, x1, x2, h2o, o3, z;
00732
00733   /* Interpolate meteorological data... */
00734   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00735                   atm->lat[ip], &ps, &pt, &z, &t, &u, &v, &w, &pv, &h2o, &o3);
00736
00737   /* Set surface pressure... */
00738   if (ctl->qnt_ps >= 0)
00739     atm->q[ctl->qnt_ps][ip] = ps;
00740
00741   /* Set tropopause pressure... */
00742   if (ctl->qnt_pt >= 0)
00743     atm->q[ctl->qnt_pt][ip] = pt;
00744
00745   /* Set pressure... */
00746   if (ctl->qnt_p >= 0)
00747     atm->q[ctl->qnt_p][ip] = atm->p[ip];
00748
00749   /* Set geopotential height... */
00750   if (ctl->qnt_z >= 0)
00751     atm->q[ctl->qnt_z][ip] = z;
00752
00753   /* Set temperature... */
00754   if (ctl->qnt_t >= 0)
00755     atm->q[ctl->qnt_t][ip] = t;
00756
00757   /* Set zonal wind... */
00758   if (ctl->qnt_u >= 0)
00759     atm->q[ctl->qnt_u][ip] = u;
00760
00761   /* Set meridional wind... */
00762   if (ctl->qnt_v >= 0)
00763     atm->q[ctl->qnt_v][ip] = v;
00764
00765   /* Set vertical velocity... */
00766   if (ctl->qnt_w >= 0)
00767     atm->q[ctl->qnt_w][ip] = w;
00768
00769   /* Set water vapor vmr... */
00770   if (ctl->qnt_h2o >= 0)
00771     atm->q[ctl->qnt_h2o][ip] = h2o;
00772
00773   /* Set ozone vmr... */
00774   if (ctl->qnt_o3 >= 0)
00775     atm->q[ctl->qnt_o3][ip] = o3;
00776
00777   /* Calculate horizontal wind... */
00778   if (ctl->qnt_vh >= 0)
00779     atm->q[ctl->qnt_vh][ip] = sqrt(u * u + v * v);
00780
00781   /* Calculate vertical velocity... */
00782   if (ctl->qnt_vz >= 0)
00783     atm->q[ctl->qnt_vz][ip] = -1e3 * H0 / atm->p[ip] * w;
00784
00785   /* Calculate potential temperature... */
00786   if (ctl->qnt_theta >= 0)
00787     atm->q[ctl->qnt_theta][ip] = THETA(atm->p[ip], t);
00788
00789   /* Set potential vorticity... */
00790   if (ctl->qnt_pv >= 0)
00791     atm->q[ctl->qnt_pv][ip] = pv;
00792
00793   /* Calculate T_ice (Marti and Mauersberger, 1993)... */
00794   if (ctl->qnt_tice >= 0)
00795     atm->q[ctl->qnt_tice][ip] =
00796       -2663.5 /
00797       (log10((ctl->psc_h2o > 0 ? ctl->psc_h2o : h2o) * atm->p[ip] * 100.) -
00798        12.537);
00799
00800   /* Calculate T_NAT (Hanson and Mauersberger, 1988)... */
00801   if (ctl->qnt_tnat >= 0) {
00802     if (ctl->psc_hno3 > 0)
00803       p_hno3 = ctl->psc_hno3 * atm->p[ip] / 1.333224;
00804     else
```

```
00805       p_hno3 = clim_hno3(atm->time[ip], atm->lat[ip], atm->p[ip])
00806         * 1e-9 * atm->p[ip] / 1.333224;
00807     p_h2o = (ctl->psc_h2o > 0 ? ctl->psc_h2o : h2o) * atm->p[ip] / 1.333224;
00808     a = 0.009179 - 0.00088 * log10(p_h2o);
00809     b = (38.9855 - log10(p_hno3) - 2.7836 * log10(p_h2o)) / a;
00810     c = -11397.0 / a;
00811     x1 = (-b + sqrt(b * b - 4. * c)) / 2.;
00812     x2 = (-b - sqrt(b * b - 4. * c)) / 2.;
00813     if (x1 > 0)
00814       atm->q[ctl->qnt_tnat][ip] = x1;
00815     if (x2 > 0)
00816       atm->q[ctl->qnt_tnat][ip] = x2;
00817   }
00818
00819   /* Calculate T_STS (mean of T_ice and T_NAT)... */
00820   if (ctl->qnt_tsts >= 0) {
00821     if (ctl->qnt_tice < 0 || ctl->qnt_tnat < 0)
00822       ERRMSG("Need T_ice and T_NAT to calculate T_STS!");
00823     atm->q[ctl->qnt_tsts][ip] = 0.5 * (atm->q[ctl->qnt_tice][ip]
00824                                        + atm->q[ctl->qnt_tnat][ip]);
00825   }
00826 }
```

Here is the call graph for this function:



5.39.2.7 void module_position (met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*)

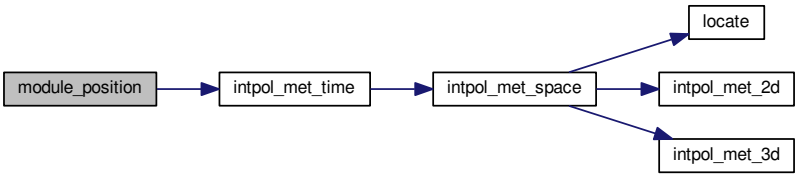
Check position of air parcels.

Definition at line 830 of file trac.c.

```
00834           {
00835
00836   double ps;
00837
00838   /* Calculate modulo... */
00839   atm->lon[ip] = fmod(atm->lon[ip], 360);
00840   atm->lat[ip] = fmod(atm->lat[ip], 360);
00841
00842   /* Check latitude... */
00843   while (atm->lat[ip] < -90 || atm->lat[ip] > 90) {
00844     if (atm->lat[ip] > 90) {
00845       atm->lat[ip] = 180 - atm->lat[ip];
00846       atm->lon[ip] += 180;
00847     }
00848     if (atm->lat[ip] < -90) {
00849       atm->lat[ip] = -180 - atm->lat[ip];
00850       atm->lon[ip] += 180;
00851     }
00852   }
00853
```

```
00854   /* Check longitude... */
00855   while (atm->lon[ip] < -180)
00856     atm->lon[ip] += 360;
00857   while (atm->lon[ip] >= 180)
00858     atm->lon[ip] -= 360;
00859
00860   /* Get surface pressure... */
00861   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00862                   atm->lon[ip], atm->lat[ip], &ps, NULL, NULL, NULL,
00863                   NULL, NULL, NULL, NULL, NULL, NULL);
00864
00865   /* Check pressure... */
00866   if (atm->p[ip] > ps)
00867     atm->p[ip] = ps;
00868   else if (atm->p[ip] < met0->p[met0->np - 1])
00869     atm->p[ip] = met0->p[met0->np - 1];
00870 }
```

Here is the call graph for this function:



5.39.2.8 void module_sedi (ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt*)

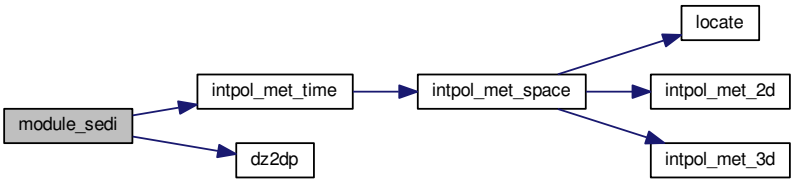
Calculate sedimentation of air parcels.

Definition at line 874 of file trac.c.

```
00880             {
00881
00882   /* Coefficients for Cunningham slip-flow correction (Kasten, 1968): */
00883   const double A = 1.249, B = 0.42, C = 0.87;
00884
00885   /* Average mass of an air molecule [kg/molec]: */
00886   const double m = 4.8096e-26;
00887
00888   double G, K, eta, lambda, p, r_p, rho, rho_p, T, v, v_p;
00889
00890   /* Convert units... */
00891   p = 100 * atm->p[ip];
00892   r_p = 1e-6 * atm->q[ctl->qnt_r][ip];
00893   rho_p = atm->q[ctl->qnt_rho][ip];
00894
00895   /* Get temperature... */
00896   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00897                   atm->lat[ip], NULL, NULL, NULL, &T,
00898                   NULL, NULL, NULL, NULL, NULL, NULL);
00899
00900   /* Density of dry air... */
00901   rho = p / (RA * T);
00902
00903   /* Dynamic viscosity of air... */
00904   eta = 1.8325e-5 * (416.16 / (T + 120.)) * pow(T / 296.16, 1.5);
00905
00906   /* Thermal velocity of an air molecule... */
00907   v = sqrt(8 * KB * T / (M_PI * m));
00908
00909   /* Mean free path of an air molecule... */
00910   lambda = 2 * eta / (rho * v);
00911
00912   /* Knudsen number for air... */
```

```
00913   K = lambda / r_p;
00914
00915   /* Cunningham slip-flow correction... */
00916   G = 1 + K * (A + B * exp(-C / K));
00917
00918   /* Sedimentation (fall) velocity... */
00919   v_p = 2. * gsl_pow_2(r_p) * (rho_p - rho) * G0 / (9. * eta) * G;
00920
00921   /* Calculate pressure change... */
00922   atm->p[ip] += dz2dp(v_p * dt / 1000., atm->p[ip]);
00923 }
```

Here is the call graph for this function:



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

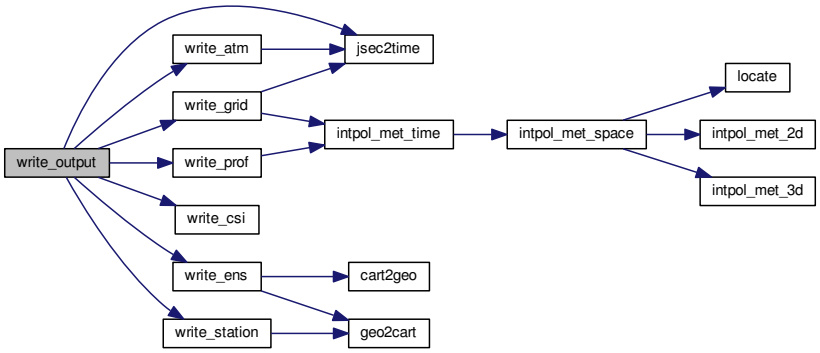
Write simulation output.

Definition at line 927 of file trac.c.

```
00933           {
00934
00935   char filename[2 * LEN];
00936
00937   double r;
00938
00939   int year, mon, day, hour, min, sec;
00940
00941   /* Get time... */
00942   jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
00943
00944   /* Write atmospheric data... */
00945   if (ctl->atm_basename[0] != '-' && fmod(t, ctl->atm_dt_out) == 0) {
00946     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
00947             dirname, ctl->atm_basename, year, mon, day, hour, min);
00948     write_atm(filename, ctl, atm, t);
00949   }
00950
00951   /* Write CSI data... */
00952   if (ctl->csi_basename[0] != '-') {
00953     sprintf(filename, "%s/%s.tab", dirname, ctl->csi_basename);
00954     write_csi(filename, ctl, atm, t);
00955   }
00956
00957   /* Write ensemble data... */
00958   if (ctl->ens_basename[0] != '-') {
00959     sprintf(filename, "%s/%s.tab", dirname, ctl->ens_basename);
00960     write_ens(filename, ctl, atm, t);
00961   }
00962
00963   /* Write gridded data... */
00964   if (ctl->grid_basename[0] != '-' && fmod(t, ctl->grid_dt_out) == 0) {
00965     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
00966             dirname, ctl->grid_basename, year, mon, day, hour, min);
00967     write_grid(filename, ctl, met0, met1, atm, t);
00968   }
00969
00970   /* Write profile data... */
00971   if (ctl->prof_basename[0] != '-') {
00972     sprintf(filename, "%s/%s.tab", dirname, ctl->prof_basename);
```

```
00973     write_prof(filename, ctl, met0, met1, atm, t);
00974   }
00975
00976   /* Write station data... */
00977   if (ctl->stat_basename[0] != '-') {
00978     sprintf(filename, "%s/%s.tab", dirname, ctl->stat_basename);
00979     write_station(filename, ctl, atm, t);
00980   }
00981 }
```

Here is the call graph for this function:



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

Definition at line 115 of file trac.c.

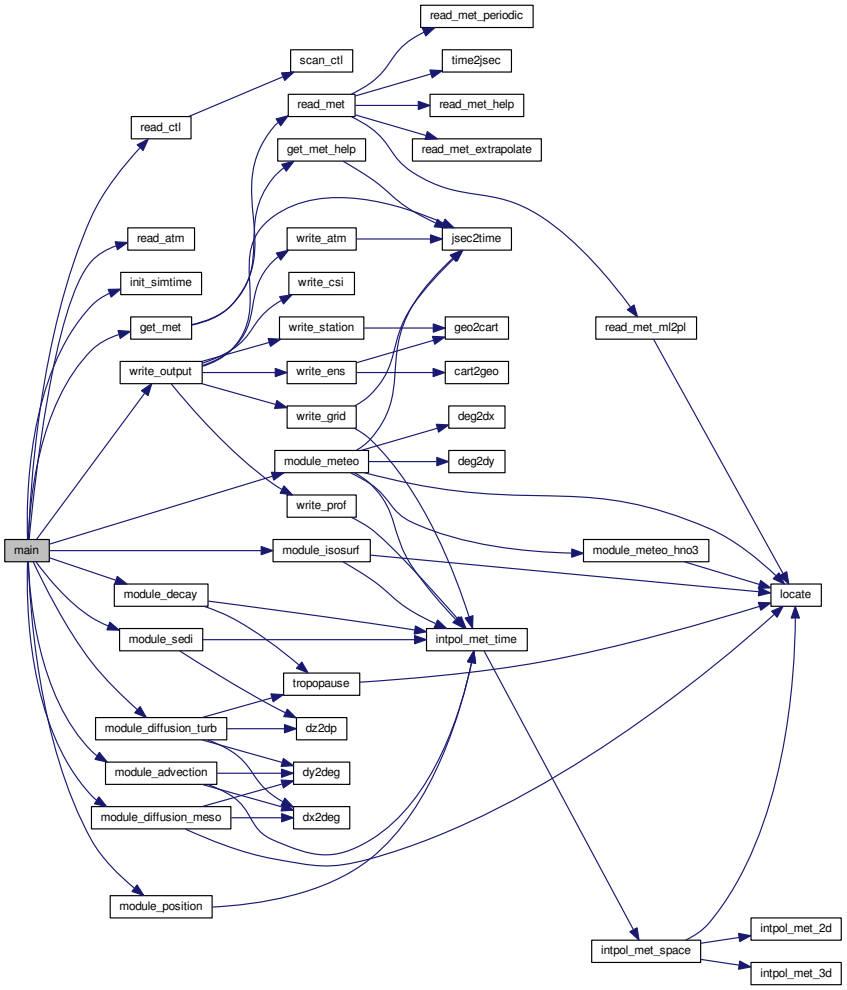
```
00117                {
00118
00119   ctl_t ctl;
00120
00121   atm_t *atm;
00122
00123   met_t *met0, *met1;
00124
00125   gsl_rng *rng[NTHREADS];
00126
00127   FILE *dirlist;
00128
00129   char dirname[LEN], filename[2 * LEN];
00130
00131   double *dt, t;
00132
00133   int i, ip, ntask = -1, rank = 0, size = 1;
00134
00135 #ifdef MPI
00136   /* Initialize MPI... */
00137   MPI_Init(&argc, &argv);
00138   MPI_Comm_rank(MPI_COMM_WORLD, &rank);
00139   MPI_Comm_size(MPI_COMM_WORLD, &size);
00140 #endif
00141
00142   /* Check arguments... */
00143   if (argc < 5)
00144     ERRMSG("Give parameters: <dirlist> <ctl> <atm_in> <metbase>");
00145
00146   /* Open directory list... */
00147   if (!(dirlist = fopen(argv[1], "r")))
00148     ERRMSG("Cannot open directory list!");
00149
00150   /* Loop over directories... */
00151   while (fscanf(dirlist, "%s", dirname) != EOF) {
00152
00153     /* MPI parallelization... */
00154     if ((++ntask) % size != rank)
```

```
00155       continue;
00156
00157     /* ------------------------------------------------------------
00158        Initialize model run...
00159        ------------------------------------------------------------ */
00160
00161     /* Set timers... */
00162     START_TIMER(TIMER_TOTAL);
00163     START_TIMER(TIMER_INIT);
00164
00165     /* Allocate... */
00166     ALLOC(atm, atm_t, 1);
00167     ALLOC(met0, met_t, 1);
00168     ALLOC(met1, met_t, 1);
00169     ALLOC(dt, double,
00170           NP);
00171
00172     /* Initialize random number generators... */
00173     gsl_rng_env_setup();
00174     if (omp_get_max_threads() > NTHREADS)
00175       ERRMSG("Too many threads!");
00176     for (i = 0; i < NTHREADS; i++) {
00177       rng[i] = gsl_rng_alloc(gsl_rng_default);
00178       gsl_rng_set(rng[i], gsl_rng_default_seed + (long unsigned) i);
00179     }
00180
00181     /* Read control parameters... */
00182     sprintf(filename, "%s/%s", dirname, argv[2]);
00183     read_ctl(filename, argc, argv, &ctl);
00184
00185     /* Read atmospheric data... */
00186     sprintf(filename, "%s/%s", dirname, argv[3]);
00187     read_atm(filename, &ctl, atm);
00188
00189     /* Set start time... */
00190     if (ctl.direction == 1) {
00191       ctl.t_start = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00192       if (ctl.t_stop > 1e99)
00193         ctl.t_stop = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00194     } else {
00195       ctl.t_start = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00196       if (ctl.t_stop > 1e99)
00197         ctl.t_stop = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00198     }
00199
00200     /* Check time interval... */
00201     if (ctl.direction * (ctl.t_stop - ctl.t_start) <= 0)
00202       ERRMSG("Nothing to do!");
00203
00204     /* Round start time... */
00205     if (ctl.direction == 1)
00206       ctl.t_start = floor(ctl.t_start / ctl.dt_mod) * ctl.
    dt_mod;
00207     else
00208       ctl.t_start = ceil(ctl.t_start / ctl.dt_mod) * ctl.
    dt_mod;
00209
00210     /* Set timers... */
00211     STOP_TIMER(TIMER_INIT);
00212
00213     /* ------------------------------------------------------------
00214        Loop over timesteps...
00215        ------------------------------------------------------------ */
00216
00217     /* Loop over timesteps... */
00218     for (t = ctl.t_start; ctl.direction * (t - ctl.t_stop) < ctl.
    dt_mod;
00219          t += ctl.direction * ctl.dt_mod) {
00220
00221       /* Adjust length of final time step... */
00222       if (ctl.direction * (t - ctl.t_stop) > 0)
00223         t = ctl.t_stop;
00224
00225       /* Set time steps for air parcels... */
00226       for (ip = 0; ip < atm->np; ip++)
00227         if ((ctl.direction * (atm->time[ip] - ctl.t_start) >= 0
00228              && ctl.direction * (atm->time[ip] - ctl.t_stop) <= 0
00229              && ctl.direction * (atm->time[ip] - t) < 0))
00230           dt[ip] = t - atm->time[ip];
00231         else
00232           dt[ip] = GSL_NAN;
00233
00234       /* Get meteorological data... */
00235       START_TIMER(TIMER_INPUT);
00236       get_met(&ctl, argv[4], t, met0, met1);
00237       if (ctl.dt_mod > fabs(met0->lon[1] - met0->lon[0]) * 111132. / 150.)
00238         printf("Warning: Violation of CFL criterion! Set DT_MOD <= %g s!\n",
```

```
00239                fabs(met0->lon[1] - met0->lon[0]) * 111132. / 150.);
00240       STOP_TIMER(TIMER_INPUT);
00241
00242       /* Initialize isosurface... */
00243       START_TIMER(TIMER_ISOSURF);
00244       if (ctl.isosurf >= 1 && ctl.isosurf <= 4 && t == ctl.t_start)
00245         module_isosurf(&ctl, met0, met1, atm, -1);
00246       STOP_TIMER(TIMER_ISOSURF);
00247
00248       /* Advection... */
00249       START_TIMER(TIMER_ADVECT);
00250 #pragma omp parallel for default(shared) private(ip)
00251       for (ip = 0; ip < atm->np; ip++)
00252         if (gsl_finite(dt[ip]))
00253           module_advection(met0, met1, atm, ip, dt[ip]);
00254       STOP_TIMER(TIMER_ADVECT);
00255
00256       /* Turbulent diffusion... */
00257       START_TIMER(TIMER_DIFFTURB);
00258       if (ctl.turb_dx_trop > 0 || ctl.turb_dz_trop > 0
00259           || ctl.turb_dx_strat > 0 || ctl.turb_dz_strat > 0) {
00260 #pragma omp parallel for default(shared) private(ip)
00261         for (ip = 0; ip < atm->np; ip++)
00262           if (gsl_finite(dt[ip]))
00263             module_diffusion_turb(&ctl, atm, ip, dt[ip],
00264                                   rng[omp_get_thread_num()]);
00265       }
00266       STOP_TIMER(TIMER_DIFFTURB);
00267
00268       /* Mesoscale diffusion... */
00269       START_TIMER(TIMER_DIFFMESO);
00270       if (ctl.turb_mesox > 0 || ctl.turb_mesoz > 0) {
00271 #pragma omp parallel for default(shared) private(ip)
00272         for (ip = 0; ip < atm->np; ip++)
00273           if (gsl_finite(dt[ip]))
00274             module_diffusion_meso(&ctl, met0, met1, atm, ip, dt[ip],
00275                                   rng[omp_get_thread_num()]);
00276       }
00277       STOP_TIMER(TIMER_DIFFMESO);
00278
00279       /* Sedimentation... */
00280       START_TIMER(TIMER_SEDI);
00281       if (ctl.qnt_r >= 0 && ctl.qnt_rho >= 0) {
00282 #pragma omp parallel for default(shared) private(ip)
00283         for (ip = 0; ip < atm->np; ip++)
00284           if (gsl_finite(dt[ip]))
00285             module_sedi(&ctl, met0, met1, atm, ip, dt[ip]);
00286       }
00287       STOP_TIMER(TIMER_SEDI);
00288
00289       /* Isosurface... */
00290       START_TIMER(TIMER_ISOSURF);
00291       if (ctl.isosurf >= 1 && ctl.isosurf <= 4) {
00292 #pragma omp parallel for default(shared) private(ip)
00293         for (ip = 0; ip < atm->np; ip++)
00294           module_isosurf(&ctl, met0, met1, atm, ip);
00295       }
00296       STOP_TIMER(TIMER_ISOSURF);
00297
00298       /* Position... */
00299       START_TIMER(TIMER_POSITION);
00300 #pragma omp parallel for default(shared) private(ip)
00301       for (ip = 0; ip < atm->np; ip++)
00302         module_position(met0, met1, atm, ip);
00303       STOP_TIMER(TIMER_POSITION);
00304
00305       /* Meteorological data... */
00306       START_TIMER(TIMER_METEO);
00307 #pragma omp parallel for default(shared) private(ip)
00308       for (ip = 0; ip < atm->np; ip++)
00309         module_meteo(&ctl, met0, met1, atm, ip);
00310       STOP_TIMER(TIMER_METEO);
00311
00312       /* Decay... */
00313       START_TIMER(TIMER_DECAY);
00314       if ((ctl.tdec_trop > 0 || ctl.tdec_strat > 0) && ctl.
      qnt_m >= 0) {
00315 #pragma omp parallel for default(shared) private(ip)
00316         for (ip = 0; ip < atm->np; ip++)
00317           if (gsl_finite(dt[ip]))
00318             module_decay(&ctl, met0, met1, atm, ip, dt[ip]);
00319       }
00320       STOP_TIMER(TIMER_DECAY);
00321
00322       /* Write output... */
00323       START_TIMER(TIMER_OUTPUT);
00324       write_output(dirname, &ctl, met0, met1, atm, t);
```

```
00325       STOP_TIMER(TIMER_OUTPUT);
00326     }
00327
00328     /* ------------------------------------------------------------
00329        Finalize model run...
00330        ------------------------------------------------------------ */
00331
00332     /* Report memory usage... */
00333     printf("MEMORY_ATM = %g MByte\n", sizeof(atm_t) / 1024. / 1024.);
00334     printf("MEMORY_METEO = %g MByte\n", 2. * sizeof(met_t) / 1024. / 1024.);
00335     printf("MEMORY_DYNAMIC = %g MByte\n",
00336            4 * NP * sizeof(double) / 1024. / 1024.);
00337     printf("MEMORY_STATIC = %g MByte\n",
00338            ((3 * GX * GY + 4 * GX * GY * GZ) * sizeof(double)
00339             + (EX * EY + EX * EY * EP) * sizeof(float)
00340             + (GX * GY + GX * GY * GZ) * sizeof(int)) / 1024. / 1024.);
00341
00342     /* Report problem size... */
00343     printf("SIZE_NP = %d\n", atm->np);
00344     printf("SIZE_TASKS = %d\n", size);
00345     printf("SIZE_THREADS = %d\n", omp_get_max_threads());
00346
00347     /* Report timers... */
00348     STOP_TIMER(TIMER_TOTAL);
00349     PRINT_TIMER(TIMER_TOTAL);
00350     PRINT_TIMER(TIMER_INIT);
00351     PRINT_TIMER(TIMER_INPUT);
00352     PRINT_TIMER(TIMER_OUTPUT);
00353     PRINT_TIMER(TIMER_ADVECT);
00354     PRINT_TIMER(TIMER_DECAY);
00355     PRINT_TIMER(TIMER_DIFFMESO);
00356     PRINT_TIMER(TIMER_DIFFTURB);
00357     PRINT_TIMER(TIMER_ISOSURF);
00358     PRINT_TIMER(TIMER_METEO);
00359     PRINT_TIMER(TIMER_POSITION);
00360     PRINT_TIMER(TIMER_SEDI);
00361
00362     /* Free random number generators... */
00363     for (i = 0; i < NTHREADS; i++)
00364       gsl_rng_free(rng[i]);
00365
00366     /* Free... */
00367     free(atm);
00368     free(met0);
00369     free(met1);
00370     free(dt);
00371   }
00372
00373 #ifdef MPI
00374   /* Finalize MPI... */
00375   MPI_Finalize();
00376 #endif
00377
00378   return EXIT_SUCCESS;
00379 }
```

Here is the call graph for this function:



5.40 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) 2013-2018 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 #ifdef MPI
00028 #include "mpi.h"
00029 #endif
00030
```

```
00031 /* ------------------------------------------------------------
00032    Functions...
00033    ------------------------------------------------------------ */
00034
00036 void module_advection(
00037   met_t * met0,
00038   met_t * met1,
00039   atm_t * atm,
00040   int ip,
00041   double dt);
00042
00044 void module_decay(
00045   ctl_t * ctl,
00046   met_t * met0,
00047   met_t * met1,
00048   atm_t * atm,
00049   int ip,
00050   double dt);
00051
00053 void module_diffusion_meso(
00054   ctl_t * ctl,
00055   met_t * met0,
00056   met_t * met1,
00057   atm_t * atm,
00058   int ip,
00059   double dt,
00060   gsl_rng * rng);
00061
00063 void module_diffusion_turb(
00064   ctl_t * ctl,
00065   atm_t * atm,
00066   int ip,
00067   double dt,
00068   gsl_rng * rng);
00069
00071 void module_isosurf(
00072   ctl_t * ctl,
00073   met_t * met0,
00074   met_t * met1,
00075   atm_t * atm,
00076   int ip);
00077
00079 void module_meteo(
00080   ctl_t * ctl,
00081   met_t * met0,
00082   met_t * met1,
00083   atm_t * atm,
00084   int ip);
00085
00087 void module_position(
00088   met_t * met0,
00089   met_t * met1,
00090   atm_t * atm,
00091   int ip);
00092
00094 void module_sedi(
00095   ctl_t * ctl,
00096   met_t * met0,
00097   met_t * met1,
00098   atm_t * atm,
00099   int ip,
00100   double dt);
00101
00103 void write_output(
00104   const char *dirname,
00105   ctl_t * ctl,
00106   met_t * met0,
00107   met_t * met1,
00108   atm_t * atm,
00109   double t);
00110
00111 /* ------------------------------------------------------------
00112    Main...
00113    ------------------------------------------------------------ */
00114
00115 int main(
00116   int argc,
00117   char *argv[]) {
00118
00119   ctl_t ctl;
00120
00121   atm_t *atm;
00122
00123   met_t *met0, *met1;
00124
00125   gsl_rng *rng[NTHREADS];
00126
```

```
00127   FILE *dirlist;
00128
00129   char dirname[LEN], filename[2 * LEN];
00130
00131   double *dt, t;
00132
00133   int i, ip, ntask = -1, rank = 0, size = 1;
00134
00135 #ifdef MPI
00136   /* Initialize MPI... */
00137   MPI_Init(&argc, &argv);
00138   MPI_Comm_rank(MPI_COMM_WORLD, &rank);
00139   MPI_Comm_size(MPI_COMM_WORLD, &size);
00140 #endif
00141
00142   /* Check arguments... */
00143   if (argc < 5)
00144     ERRMSG("Give parameters: <dirlist> <ctl> <atm_in> <metbase>");
00145
00146   /* Open directory list... */
00147   if (!(dirlist = fopen(argv[1], "r")))
00148     ERRMSG("Cannot open directory list!");
00149
00150   /* Loop over directories... */
00151   while (fscanf(dirlist, "%s", dirname) != EOF) {
00152
00153     /* MPI parallelization... */
00154     if ((++ntask) % size != rank)
00155       continue;
00156
00157     /* ------------------------------------------------------------
00158        Initialize model run...
00159        ------------------------------------------------------------ */
00160
00161     /* Set timers... */
00162     START_TIMER(TIMER_TOTAL);
00163     START_TIMER(TIMER_INIT);
00164
00165     /* Allocate... */
00166     ALLOC(atm, atm_t, 1);
00167     ALLOC(met0, met_t, 1);
00168     ALLOC(met1, met_t, 1);
00169     ALLOC(dt, double,
00170           NP);
00171
00172     /* Initialize random number generators... */
00173     gsl_rng_env_setup();
00174     if (omp_get_max_threads() > NTHREADS)
00175       ERRMSG("Too many threads!");
00176     for (i = 0; i < NTHREADS; i++) {
00177       rng[i] = gsl_rng_alloc(gsl_rng_default);
00178       gsl_rng_set(rng[i], gsl_rng_default_seed + (long unsigned) i);
00179     }
00180
00181     /* Read control parameters... */
00182     sprintf(filename, "%s/%s", dirname, argv[2]);
00183     read_ctl(filename, argc, argv, &ctl);
00184
00185     /* Read atmospheric data... */
00186     sprintf(filename, "%s/%s", dirname, argv[3]);
00187     read_atm(filename, &ctl, atm);
00188
00189     /* Set start time... */
00190     if (ctl.direction == 1) {
00191       ctl.t_start = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00192       if (ctl.t_stop > 1e99)
00193         ctl.t_stop = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00194     } else {
00195       ctl.t_start = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00196       if (ctl.t_stop > 1e99)
00197         ctl.t_stop = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00198     }
00199
00200     /* Check time interval... */
00201     if (ctl.direction * (ctl.t_stop - ctl.t_start) <= 0)
00202       ERRMSG("Nothing to do!");
00203
00204     /* Round start time... */
00205     if (ctl.direction == 1)
00206       ctl.t_start = floor(ctl.t_start / ctl.dt_mod) * ctl.
      dt_mod;
00207     else
00208       ctl.t_start = ceil(ctl.t_start / ctl.dt_mod) * ctl.
      dt_mod;
00209
00210     /* Set timers... */
00211     STOP_TIMER(TIMER_INIT);
```

```
00212
00213     /* ----------------------------------------------------------
00214        Loop over timesteps...
00215        ---------------------------------------------------------- */
00216
00217     /* Loop over timesteps... */
00218     for (t = ctl.t_start; ctl.direction * (t - ctl.t_stop) < ctl.
      dt_mod;
00219          t += ctl.direction * ctl.dt_mod) {
00220
00221       /* Adjust length of final time step... */
00222       if (ctl.direction * (t - ctl.t_stop) > 0)
00223         t = ctl.t_stop;
00224
00225       /* Set time steps for air parcels... */
00226       for (ip = 0; ip < atm->np; ip++)
00227         if ((ctl.direction * (atm->time[ip] - ctl.t_start) >= 0
00228              && ctl.direction * (atm->time[ip] - ctl.t_stop) <= 0
00229              && ctl.direction * (atm->time[ip] - t) < 0))
00230           dt[ip] = t - atm->time[ip];
00231         else
00232           dt[ip] = GSL_NAN;
00233
00234       /* Get meteorological data... */
00235       START_TIMER(TIMER_INPUT);
00236       get_met(&ctl, argv[4], t, met0, met1);
00237       if (ctl.dt_mod > fabs(met0->lon[1] - met0->lon[0]) * 111132. / 150.)
00238         printf("Warning: Violation of CFL criterion! Set DT_MOD <= %g s!\n",
00239                fabs(met0->lon[1] - met0->lon[0]) * 111132. / 150.);
00240       STOP_TIMER(TIMER_INPUT);
00241
00242       /* Initialize isosurface... */
00243       START_TIMER(TIMER_ISOSURF);
00244       if (ctl.isosurf >= 1 && ctl.isosurf <= 4 && t == ctl.t_start)
00245         module_isosurf(&ctl, met0, met1, atm, -1);
00246       STOP_TIMER(TIMER_ISOSURF);
00247
00248       /* Advection... */
00249       START_TIMER(TIMER_ADVECT);
00250 #pragma omp parallel for default(shared) private(ip)
00251       for (ip = 0; ip < atm->np; ip++)
00252         if (gsl_finite(dt[ip]))
00253           module_advection(met0, met1, atm, ip, dt[ip]);
00254       STOP_TIMER(TIMER_ADVECT);
00255
00256       /* Turbulent diffusion... */
00257       START_TIMER(TIMER_DIFFTURB);
00258       if (ctl.turb_dx_trop > 0 || ctl.turb_dz_trop > 0
00259           || ctl.turb_dx_strat > 0 || ctl.turb_dz_strat > 0) {
00260 #pragma omp parallel for default(shared) private(ip)
00261         for (ip = 0; ip < atm->np; ip++)
00262           if (gsl_finite(dt[ip]))
00263             module_diffusion_turb(&ctl, atm, ip, dt[ip],
00264                                   rng[omp_get_thread_num()]);
00265       }
00266       STOP_TIMER(TIMER_DIFFTURB);
00267
00268       /* Mesoscale diffusion... */
00269       START_TIMER(TIMER_DIFFMESO);
00270       if (ctl.turb_mesox > 0 || ctl.turb_mesoz > 0) {
00271 #pragma omp parallel for default(shared) private(ip)
00272         for (ip = 0; ip < atm->np; ip++)
00273           if (gsl_finite(dt[ip]))
00274             module_diffusion_meso(&ctl, met0, met1, atm, ip, dt[ip],
00275                                   rng[omp_get_thread_num()]);
00276       }
00277       STOP_TIMER(TIMER_DIFFMESO);
00278
00279       /* Sedimentation... */
00280       START_TIMER(TIMER_SEDI);
00281       if (ctl.qnt_r >= 0 && ctl.qnt_rho >= 0) {
00282 #pragma omp parallel for default(shared) private(ip)
00283         for (ip = 0; ip < atm->np; ip++)
00284           if (gsl_finite(dt[ip]))
00285             module_sedi(&ctl, met0, met1, atm, ip, dt[ip]);
00286       }
00287       STOP_TIMER(TIMER_SEDI);
00288
00289       /* Isosurface... */
00290       START_TIMER(TIMER_ISOSURF);
00291       if (ctl.isosurf >= 1 && ctl.isosurf <= 4) {
00292 #pragma omp parallel for default(shared) private(ip)
00293         for (ip = 0; ip < atm->np; ip++)
00294           module_isosurf(&ctl, met0, met1, atm, ip);
00295       }
00296       STOP_TIMER(TIMER_ISOSURF);
00297
```

```
00298       /* Position... */
00299       START_TIMER(TIMER_POSITION);
00300 #pragma omp parallel for default(shared) private(ip)
00301       for (ip = 0; ip < atm->np; ip++)
00302         module_position(met0, met1, atm, ip);
00303       STOP_TIMER(TIMER_POSITION);
00304
00305       /* Meteorological data... */
00306       START_TIMER(TIMER_METEO);
00307 #pragma omp parallel for default(shared) private(ip)
00308       for (ip = 0; ip < atm->np; ip++)
00309         module_meteo(&ctl, met0, met1, atm, ip);
00310       STOP_TIMER(TIMER_METEO);
00311
00312       /* Decay... */
00313       START_TIMER(TIMER_DECAY);
00314       if ((ctl.tdec_trop > 0 || ctl.tdec_strat > 0) && ctl.
      qnt_m >= 0) {
00315 #pragma omp parallel for default(shared) private(ip)
00316         for (ip = 0; ip < atm->np; ip++)
00317           if (gsl_finite(dt[ip]))
00318             module_decay(&ctl, met0, met1, atm, ip, dt[ip]);
00319       }
00320       STOP_TIMER(TIMER_DECAY);
00321
00322       /* Write output... */
00323       START_TIMER(TIMER_OUTPUT);
00324       write_output(dirname, &ctl, met0, met1, atm, t);
00325       STOP_TIMER(TIMER_OUTPUT);
00326     }
00327
00328     /* ------------------------------------------------------------
00329        Finalize model run...
00330        ------------------------------------------------------------ */
00331
00332     /* Report memory usage... */
00333     printf("MEMORY_ATM = %g MByte\n", sizeof(atm_t) / 1024. / 1024.);
00334     printf("MEMORY_METEO = %g MByte\n", 2. * sizeof(met_t) / 1024. / 1024.);
00335     printf("MEMORY_DYNAMIC = %g MByte\n",
00336            4 * NP * sizeof(double) / 1024. / 1024.);
00337     printf("MEMORY_STATIC = %g MByte\n",
00338            ((3 * GX * GY + 4 * GX * GY * GZ) * sizeof(double)
00339             + (EX * EY + EX * EY * EP) * sizeof(float)
00340             + (GX * GY + GX * GY * GZ) * sizeof(int)) / 1024. / 1024.);
00341
00342     /* Report problem size... */
00343     printf("SIZE_NP = %d\n", atm->np);
00344     printf("SIZE_TASKS = %d\n", size);
00345     printf("SIZE_THREADS = %d\n", omp_get_max_threads());
00346
00347     /* Report timers... */
00348     STOP_TIMER(TIMER_TOTAL);
00349     PRINT_TIMER(TIMER_TOTAL);
00350     PRINT_TIMER(TIMER_INIT);
00351     PRINT_TIMER(TIMER_INPUT);
00352     PRINT_TIMER(TIMER_OUTPUT);
00353     PRINT_TIMER(TIMER_ADVECT);
00354     PRINT_TIMER(TIMER_DECAY);
00355     PRINT_TIMER(TIMER_DIFFMESO);
00356     PRINT_TIMER(TIMER_DIFFTURB);
00357     PRINT_TIMER(TIMER_ISOSURF);
00358     PRINT_TIMER(TIMER_METEO);
00359     PRINT_TIMER(TIMER_POSITION);
00360     PRINT_TIMER(TIMER_SEDI);
00361
00362     /* Free random number generators... */
00363     for (i = 0; i < NTHREADS; i++)
00364       gsl_rng_free(rng[i]);
00365
00366     /* Free... */
00367     free(atm);
00368     free(met0);
00369     free(met1);
00370     free(dt);
00371   }
00372
00373 #ifdef MPI
00374   /* Finalize MPI... */
00375   MPI_Finalize();
00376 #endif
00377
00378   return EXIT_SUCCESS;
00379 }
00380
00381 /*****************************************************************************/
00382
00383 void module_advection(
```

```
00384   met_t * met0,
00385   met_t * met1,
00386   atm_t * atm,
00387   int ip,
00388   double dt) {
00389
00390   double v[3], xm[3];
00391
00392   /* Interpolate meteorological data... */
00393   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00394                   atm->lon[ip], atm->lat[ip], NULL, NULL, NULL, NULL,
00395                   &v[0], &v[1], &v[2], NULL, NULL, NULL);
00396
00397   /* Get position of the mid point... */
00398   xm[0] = atm->lon[ip] + dx2deg(0.5 * dt * v[0] / 1000., atm->lat[ip]);
00399   xm[1] = atm->lat[ip] + dy2deg(0.5 * dt * v[1] / 1000.);
00400   xm[2] = atm->p[ip] + 0.5 * dt * v[2];
00401
00402   /* Interpolate meteorological data for mid point... */
00403   intpol_met_time(met0, met1, atm->time[ip] + 0.5 * dt,
00404                   xm[2], xm[0], xm[1], NULL, NULL, NULL, NULL,
00405                   &v[0], &v[1], &v[2], NULL, NULL, NULL);
00406
00407   /* Save new position... */
00408   atm->time[ip] += dt;
00409   atm->lon[ip] += dx2deg(dt * v[0] / 1000., xm[1]);
00410   atm->lat[ip] += dy2deg(dt * v[1] / 1000.);
00411   atm->p[ip] += dt * v[2];
00412 }
00413
00414 /*****************************************************************************/
00415
00416 void module_decay(
00417   ctl_t * ctl,
00418   met_t * met0,
00419   met_t * met1,
00420   atm_t * atm,
00421   int ip,
00422   double dt) {
00423
00424   double ps, pt, tdec;
00425
00426   /* Set constant lifetime... */
00427   if (ctl->tdec_trop == ctl->tdec_strat)
00428     tdec = ctl->tdec_trop;
00429
00430   /* Set altitude-dependent lifetime... */
00431   else {
00432
00433     /* Get surface pressure... */
00434     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00435                     atm->lon[ip], atm->lat[ip], &ps, NULL, NULL, NULL,
00436                     NULL, NULL, NULL, NULL, NULL, NULL);
00437
00438     /* Get tropopause pressure... */
00439     pt = clim_tropo(atm->time[ip], atm->lat[ip]);
00440
00441     /* Set lifetime... */
00442     if (atm->p[ip] <= pt)
00443       tdec = ctl->tdec_strat;
00444     else
00445       tdec = LIN(ps, ctl->tdec_trop, pt, ctl->tdec_strat, atm->
      p[ip]);
00446   }
00447
00448   /* Calculate exponential decay... */
00449   atm->q[ctl->qnt_m][ip] *= exp(-dt / tdec);
00450 }
00451
00452 /*****************************************************************************/
00453
00454 void module_diffusion_meso(
00455   ctl_t * ctl,
00456   met_t * met0,
00457   met_t * met1,
00458   atm_t * atm,
00459   int ip,
00460   double dt,
00461   gsl_rng * rng) {
00462
00463   double r, rs, u[16], v[16], w[16], usig, vsig, wsig;
00464
00465   int ix, iy, iz;
00466
00467   /* Get indices... */
00468   ix = locate(met0->lon, met0->nx, atm->lon[ip]);
00469   iy = locate(met0->lat, met0->ny, atm->lat[ip]);
```

```
00470   iz = locate(met0->p, met0->np, atm->p[ip]);
00471
00472   /* Collect local wind data... */
00473   u[0] = met0->u[ix][iy][iz];
00474   u[1] = met0->u[ix + 1][iy][iz];
00475   u[2] = met0->u[ix][iy + 1][iz];
00476   u[3] = met0->u[ix + 1][iy + 1][iz];
00477   u[4] = met0->u[ix][iy][iz + 1];
00478   u[5] = met0->u[ix + 1][iy][iz + 1];
00479   u[6] = met0->u[ix][iy + 1][iz + 1];
00480   u[7] = met0->u[ix + 1][iy + 1][iz + 1];
00481
00482   v[0] = met0->v[ix][iy][iz];
00483   v[1] = met0->v[ix + 1][iy][iz];
00484   v[2] = met0->v[ix][iy + 1][iz];
00485   v[3] = met0->v[ix + 1][iy + 1][iz];
00486   v[4] = met0->v[ix][iy][iz + 1];
00487   v[5] = met0->v[ix + 1][iy][iz + 1];
00488   v[6] = met0->v[ix][iy + 1][iz + 1];
00489   v[7] = met0->v[ix + 1][iy + 1][iz + 1];
00490
00491   w[0] = met0->w[ix][iy][iz];
00492   w[1] = met0->w[ix + 1][iy][iz];
00493   w[2] = met0->w[ix][iy + 1][iz];
00494   w[3] = met0->w[ix + 1][iy + 1][iz];
00495   w[4] = met0->w[ix][iy][iz + 1];
00496   w[5] = met0->w[ix + 1][iy][iz + 1];
00497   w[6] = met0->w[ix][iy + 1][iz + 1];
00498   w[7] = met0->w[ix + 1][iy + 1][iz + 1];
00499
00500   /* Get indices... */
00501   ix = locate(met1->lon, met1->nx, atm->lon[ip]);
00502   iy = locate(met1->lat, met1->ny, atm->lat[ip]);
00503   iz = locate(met1->p, met1->np, atm->p[ip]);
00504
00505   /* Collect local wind data... */
00506   u[8] = met1->u[ix][iy][iz];
00507   u[9] = met1->u[ix + 1][iy][iz];
00508   u[10] = met1->u[ix][iy + 1][iz];
00509   u[11] = met1->u[ix + 1][iy + 1][iz];
00510   u[12] = met1->u[ix][iy][iz + 1];
00511   u[13] = met1->u[ix + 1][iy][iz + 1];
00512   u[14] = met1->u[ix][iy + 1][iz + 1];
00513   u[15] = met1->u[ix + 1][iy + 1][iz + 1];
00514
00515   v[8] = met1->v[ix][iy][iz];
00516   v[9] = met1->v[ix + 1][iy][iz];
00517   v[10] = met1->v[ix][iy + 1][iz];
00518   v[11] = met1->v[ix + 1][iy + 1][iz];
00519   v[12] = met1->v[ix][iy][iz + 1];
00520   v[13] = met1->v[ix + 1][iy][iz + 1];
00521   v[14] = met1->v[ix][iy + 1][iz + 1];
00522   v[15] = met1->v[ix + 1][iy + 1][iz + 1];
00523
00524   w[8] = met1->w[ix][iy][iz];
00525   w[9] = met1->w[ix + 1][iy][iz];
00526   w[10] = met1->w[ix][iy + 1][iz];
00527   w[11] = met1->w[ix + 1][iy + 1][iz];
00528   w[12] = met1->w[ix][iy][iz + 1];
00529   w[13] = met1->w[ix + 1][iy][iz + 1];
00530   w[14] = met1->w[ix][iy + 1][iz + 1];
00531   w[15] = met1->w[ix + 1][iy + 1][iz + 1];
00532
00533   /* Get standard deviations of local wind data... */
00534   usig = gsl_stats_sd(u, 1, 16);
00535   vsig = gsl_stats_sd(v, 1, 16);
00536   wsig = gsl_stats_sd(w, 1, 16);
00537
00538   /* Set temporal correlations for mesoscale fluctuations... */
00539   r = 1 - 2 * fabs(dt) / ctl->dt_met;
00540   rs = sqrt(1 - r * r);
00541
00542   /* Calculate horizontal mesoscale wind fluctuations... */
00543   if (ctl->turb_mesox > 0) {
00544     atm->up[ip] = (float)
00545       (r * atm->up[ip]
00546        + rs * gsl_ran_gaussian_ziggurat(rng, ctl->turb_mesox * usig));
00547     atm->lon[ip] += dx2deg(atm->up[ip] * dt / 1000., atm->lat[ip]);
00548
00549     atm->vp[ip] = (float)
00550       (r * atm->vp[ip]
00551        + rs * gsl_ran_gaussian_ziggurat(rng, ctl->turb_mesox * vsig));
00552     atm->lat[ip] += dy2deg(atm->vp[ip] * dt / 1000.);
00553   }
00554
00555   /* Calculate vertical mesoscale wind fluctuations... */
00556   if (ctl->turb_mesoz > 0) {
```

```
00557     atm->wp[ip] = (float)
00558       (r * atm->wp[ip]
00559        + rs * gsl_ran_gaussian_ziggurat(rng, ctl->turb_mesoz * wsig));
00560     atm->p[ip] += atm->wp[ip] * dt;
00561   }
00562 }
00563
00564 /*****************************************************************************/
00565
00566 void module_diffusion_turb(
00567   ctl_t * ctl,
00568   atm_t * atm,
00569   int ip,
00570   double dt,
00571   gsl_rng * rng) {
00572
00573   double dx, dz, pt, p0, p1, w;
00574
00575   /* Get tropopause pressure... */
00576   pt = clim_tropo(atm->time[ip], atm->lat[ip]);
00577
00578   /* Get weighting factor... */
00579   p1 = pt * 0.866877899;
00580   p0 = pt / 0.866877899;
00581   if (atm->p[ip] > p0)
00582     w = 1;
00583   else if (atm->p[ip] < p1)
00584     w = 0;
00585   else
00586     w = LIN(p0, 1.0, p1, 0.0, atm->p[ip]);
00587
00588   /* Set diffusivitiy... */
00589   dx = w * ctl->turb_dx_trop + (1 - w) * ctl->turb_dx_strat;
00590   dz = w * ctl->turb_dz_trop + (1 - w) * ctl->turb_dz_strat;
00591
00592   /* Horizontal turbulent diffusion... */
00593   if (dx > 0) {
00594     atm->lon[ip]
00595       += dx2deg(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dx * fabs(dt)))
00596                 / 1000., atm->lat[ip]);
00597     atm->lat[ip]
00598       += dy2deg(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dx * fabs(dt)))
00599                 / 1000.);
00600   }
00601
00602   /* Vertical turbulent diffusion... */
00603   if (dz > 0)
00604     atm->p[ip]
00605       += dz2dp(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dz * fabs(dt)))
00606                / 1000., atm->p[ip]);
00607 }
00608
00609 /*****************************************************************************/
00610
00611 void module_isosurf(
00612   ctl_t * ctl,
00613   met_t * met0,
00614   met_t * met1,
00615   atm_t * atm,
00616   int ip) {
00617
00618   static double *iso, *ps, t, *ts;
00619
00620   static int idx, ip2, n;
00621
00622   FILE *in;
00623
00624   char line[LEN];
00625
00626   /* Initialize... */
00627   if (ip < 0) {
00628
00629     /* Allocate... */
00630     ALLOC(iso, double,
00631           NP);
00632     ALLOC(ps, double,
00633           NP);
00634     ALLOC(ts, double,
00635           NP);
00636
00637     /* Save pressure... */
00638     if (ctl->isosurf == 1)
00639       for (ip2 = 0; ip2 < atm->np; ip2++)
00640         iso[ip2] = atm->p[ip2];
00641
00642     /* Save density... */
00643     else if (ctl->isosurf == 2)
```

```
00644       for (ip2 = 0; ip2 < atm->np; ip2++) {
00645         intpol_met_time(met0, met1, atm->time[ip2], atm->p[ip2],
00646                         atm->lon[ip2], atm->lat[ip2], NULL, NULL, NULL,
00647                         &t, NULL, NULL, NULL, NULL, NULL, NULL);
00648         iso[ip2] = atm->p[ip2] / t;
00649       }
00650
00651     /* Save potential temperature... */
00652     else if (ctl->isosurf == 3)
00653       for (ip2 = 0; ip2 < atm->np; ip2++) {
00654         intpol_met_time(met0, met1, atm->time[ip2], atm->p[ip2],
00655                         atm->lon[ip2], atm->lat[ip2], NULL, NULL, NULL,
00656                         &t, NULL, NULL, NULL, NULL, NULL, NULL);
00657         iso[ip2] = THETA(atm->p[ip2], t);
00658       }
00659
00660     /* Read balloon pressure data... */
00661     else if (ctl->isosurf == 4) {
00662
00663       /* Write info... */
00664       printf("Read balloon pressure data: %s\n", ctl->balloon);
00665
00666       /* Open file... */
00667       if (!(in = fopen(ctl->balloon, "r")))
00668         ERRMSG("Cannot open file!");
00669
00670       /* Read pressure time series... */
00671       while (fgets(line, LEN, in))
00672         if (sscanf(line, "%lg %lg", &ts[n], &ps[n]) == 2)
00673           if ((++n) > NP)
00674             ERRMSG("Too many data points!");
00675
00676       /* Check number of points... */
00677       if (n < 1)
00678         ERRMSG("Could not read any data!");
00679
00680       /* Close file... */
00681       fclose(in);
00682     }
00683
00684     /* Leave initialization... */
00685     return;
00686   }
00687
00688   /* Restore pressure... */
00689   if (ctl->isosurf == 1)
00690     atm->p[ip] = iso[ip];
00691
00692   /* Restore density... */
00693   else if (ctl->isosurf == 2) {
00694     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00695                     atm->lat[ip], NULL, NULL, NULL, &t,
00696                     NULL, NULL, NULL, NULL, NULL, NULL);
00697     atm->p[ip] = iso[ip] * t;
00698   }
00699
00700   /* Restore potential temperature... */
00701   else if (ctl->isosurf == 3) {
00702     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00703                     atm->lat[ip], NULL, NULL, NULL, &t,
00704                     NULL, NULL, NULL, NULL, NULL, NULL);
00705     atm->p[ip] = 1000. * pow(iso[ip] / t, -1. / 0.286);
00706   }
00707
00708   /* Interpolate pressure... */
00709   else if (ctl->isosurf == 4) {
00710     if (atm->time[ip] <= ts[0])
00711       atm->p[ip] = ps[0];
00712     else if (atm->time[ip] >= ts[n - 1])
00713       atm->p[ip] = ps[n - 1];
00714     else {
00715       idx = locate(ts, n, atm->time[ip]);
00716       atm->p[ip] = LIN(ts[idx], ps[idx],
00717                        ts[idx + 1], ps[idx + 1], atm->time[ip]);
00718     }
00719   }
00720 }
00721
00722 /*****************************************************************************/
00723
00724 void module_meteo(
00725   ctl_t * ctl,
00726   met_t * met0,
00727   met_t * met1,
00728   atm_t * atm,
```

```
00729   int ip) {
00730
00731   double a, b, c, ps, pt, pv, p_hno3, p_h2o, t, u, v, w, x1, x2, h2o, o3, z;
00732
00733   /* Interpolate meteorological data... */
00734   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
     lon[ip],
00735                   atm->lat[ip], &ps, &pt, &z, &t, &u, &v, &w, &pv, &h2o, &o3);
00736
00737   /* Set surface pressure... */
00738   if (ctl->qnt_ps >= 0)
00739     atm->q[ctl->qnt_ps][ip] = ps;
00740
00741   /* Set tropopause pressure... */
00742   if (ctl->qnt_pt >= 0)
00743     atm->q[ctl->qnt_pt][ip] = pt;
00744
00745   /* Set pressure... */
00746   if (ctl->qnt_p >= 0)
00747     atm->q[ctl->qnt_p][ip] = atm->p[ip];
00748
00749   /* Set geopotential height... */
00750   if (ctl->qnt_z >= 0)
00751     atm->q[ctl->qnt_z][ip] = z;
00752
00753   /* Set temperature... */
00754   if (ctl->qnt_t >= 0)
00755     atm->q[ctl->qnt_t][ip] = t;
00756
00757   /* Set zonal wind... */
00758   if (ctl->qnt_u >= 0)
00759     atm->q[ctl->qnt_u][ip] = u;
00760
00761   /* Set meridional wind... */
00762   if (ctl->qnt_v >= 0)
00763     atm->q[ctl->qnt_v][ip] = v;
00764
00765   /* Set vertical velocity... */
00766   if (ctl->qnt_w >= 0)
00767     atm->q[ctl->qnt_w][ip] = w;
00768
00769   /* Set water vapor vmr... */
00770   if (ctl->qnt_h2o >= 0)
00771     atm->q[ctl->qnt_h2o][ip] = h2o;
00772
00773   /* Set ozone vmr... */
00774   if (ctl->qnt_o3 >= 0)
00775     atm->q[ctl->qnt_o3][ip] = o3;
00776
00777   /* Calculate horizontal wind... */
00778   if (ctl->qnt_vh >= 0)
00779     atm->q[ctl->qnt_vh][ip] = sqrt(u * u + v * v);
00780
00781   /* Calculate vertical velocity... */
00782   if (ctl->qnt_vz >= 0)
00783     atm->q[ctl->qnt_vz][ip] = -1e3 * H0 / atm->p[ip] * w;
00784
00785   /* Calculate potential temperature... */
00786   if (ctl->qnt_theta >= 0)
00787     atm->q[ctl->qnt_theta][ip] = THETA(atm->p[ip], t);
00788
00789   /* Set potential vorticity... */
00790   if (ctl->qnt_pv >= 0)
00791     atm->q[ctl->qnt_pv][ip] = pv;
00792
00793   /* Calculate T_ice (Marti and Mauersberger, 1993)... */
00794   if (ctl->qnt_tice >= 0)
00795     atm->q[ctl->qnt_tice][ip] =
00796       -2663.5 /
00797       (log10((ctl->psc_h2o > 0 ? ctl->psc_h2o : h2o) * atm->p[ip] * 100.) -
00798        12.537);
00799
00800   /* Calculate T_NAT (Hanson and Mauersberger, 1988)... */
00801   if (ctl->qnt_tnat >= 0) {
00802     if (ctl->psc_hno3 > 0)
00803       p_hno3 = ctl->psc_hno3 * atm->p[ip] / 1.333224;
00804     else
00805       p_hno3 = clim_hno3(atm->time[ip], atm->lat[ip], atm->p[ip])
00806         * 1e-9 * atm->p[ip] / 1.333224;
00807     p_h2o = (ctl->psc_h2o > 0 ? ctl->psc_h2o : h2o) * atm->p[ip] / 1.333224;
00808     a = 0.009179 - 0.00088 * log10(p_h2o);
00809     b = (38.9855 - log10(p_hno3) - 2.7836 * log10(p_h2o)) / a;
00810     c = -11397.0 / a;
00811     x1 = (-b + sqrt(b * b - 4. * c)) / 2.;
00812     x2 = (-b - sqrt(b * b - 4. * c)) / 2.;
00813     if (x1 > 0)
00814       atm->q[ctl->qnt_tnat][ip] = x1;
```

```
00815     if (x2 > 0)
00816       atm->q[ctl->qnt_tnat][ip] = x2;
00817   }
00818
00819   /* Calculate T_STS (mean of T_ice and T_NAT)... */
00820   if (ctl->qnt_tsts >= 0) {
00821     if (ctl->qnt_tice < 0 || ctl->qnt_tnat < 0)
00822       ERRMSG("Need T_ice and T_NAT to calculate T_STS!");
00823     atm->q[ctl->qnt_tsts][ip] = 0.5 * (atm->q[ctl->qnt_tice][ip]
00824                                        + atm->q[ctl->qnt_tnat][ip]);
00825   }
00826 }
00827
00828 /*****************************************************************************/
00829
00830 void module_position(
00831   met_t * met0,
00832   met_t * met1,
00833   atm_t * atm,
00834   int ip) {
00835
00836   double ps;
00837
00838   /* Calculate modulo... */
00839   atm->lon[ip] = fmod(atm->lon[ip], 360);
00840   atm->lat[ip] = fmod(atm->lat[ip], 360);
00841
00842   /* Check latitude... */
00843   while (atm->lat[ip] < -90 || atm->lat[ip] > 90) {
00844     if (atm->lat[ip] > 90) {
00845       atm->lat[ip] = 180 - atm->lat[ip];
00846       atm->lon[ip] += 180;
00847     }
00848     if (atm->lat[ip] < -90) {
00849       atm->lat[ip] = -180 - atm->lat[ip];
00850       atm->lon[ip] += 180;
00851     }
00852   }
00853
00854   /* Check longitude... */
00855   while (atm->lon[ip] < -180)
00856     atm->lon[ip] += 360;
00857   while (atm->lon[ip] >= 180)
00858     atm->lon[ip] -= 360;
00859
00860   /* Get surface pressure... */
00861   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00862                   atm->lon[ip], atm->lat[ip], &ps, NULL, NULL, NULL,
00863                   NULL, NULL, NULL, NULL, NULL, NULL);
00864
00865   /* Check pressure... */
00866   if (atm->p[ip] > ps)
00867     atm->p[ip] = ps;
00868   else if (atm->p[ip] < met0->p[met0->np - 1])
00869     atm->p[ip] = met0->p[met0->np - 1];
00870 }
00871
00872 /*****************************************************************************/
00873
00874 void module_sedi(
00875   ctl_t * ctl,
00876   met_t * met0,
00877   met_t * met1,
00878   atm_t * atm,
00879   int ip,
00880   double dt) {
00881
00882   /* Coefficients for Cunningham slip-flow correction (Kasten, 1968): */
00883   const double A = 1.249, B = 0.42, C = 0.87;
00884
00885   /* Average mass of an air molecule [kg/molec]: */
00886   const double m = 4.8096e-26;
00887
00888   double G, K, eta, lambda, p, r_p, rho, rho_p, T, v, v_p;
00889
00890   /* Convert units... */
00891   p = 100 * atm->p[ip];
00892   r_p = 1e-6 * atm->q[ctl->qnt_r][ip];
00893   rho_p = atm->q[ctl->qnt_rho][ip];
00894
00895   /* Get temperature... */
00896   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00897                   atm->lat[ip], NULL, NULL, NULL, &T,
00898                   NULL, NULL, NULL, NULL, NULL, NULL);
00899
00900   /* Density of dry air... */
```

```
00901   rho = p / (RA * T);
00902
00903   /* Dynamic viscosity of air... */
00904   eta = 1.8325e-5 * (416.16 / (T + 120.)) * pow(T / 296.16, 1.5);
00905
00906   /* Thermal velocity of an air molecule... */
00907   v = sqrt(8 * KB * T / (M_PI * m));
00908
00909   /* Mean free path of an air molecule... */
00910   lambda = 2 * eta / (rho * v);
00911
00912   /* Knudsen number for air... */
00913   K = lambda / r_p;
00914
00915   /* Cunningham slip-flow correction... */
00916   G = 1 + K * (A + B * exp(-C / K));
00917
00918   /* Sedimentation (fall) velocity... */
00919   v_p = 2. * gsl_pow_2(r_p) * (rho_p - rho) * G0 / (9. * eta) * G;
00920
00921   /* Calculate pressure change... */
00922   atm->p[ip] += dz2dp(v_p * dt / 1000., atm->p[ip]);
00923 }
00924
00925 /*****************************************************************************/
00926
00927 void write_output(
00928   const char *dirname,
00929   ctl_t * ctl,
00930   met_t * met0,
00931   met_t * met1,
00932   atm_t * atm,
00933   double t) {
00934
00935   char filename[2 * LEN];
00936
00937   double r;
00938
00939   int year, mon, day, hour, min, sec;
00940
00941   /* Get time... */
00942   jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
00943
00944   /* Write atmospheric data... */
00945   if (ctl->atm_basename[0] != '-' && fmod(t, ctl->atm_dt_out) == 0) {
00946     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
00947             dirname, ctl->atm_basename, year, mon, day, hour, min);
00948     write_atm(filename, ctl, atm, t);
00949   }
00950
00951   /* Write CSI data... */
00952   if (ctl->csi_basename[0] != '-') {
00953     sprintf(filename, "%s/%s.tab", dirname, ctl->csi_basename);
00954     write_csi(filename, ctl, atm, t);
00955   }
00956
00957   /* Write ensemble data... */
00958   if (ctl->ens_basename[0] != '-') {
00959     sprintf(filename, "%s/%s.tab", dirname, ctl->ens_basename);
00960     write_ens(filename, ctl, atm, t);
00961   }
00962
00963   /* Write gridded data... */
00964   if (ctl->grid_basename[0] != '-' && fmod(t, ctl->grid_dt_out) == 0) {
00965     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
00966             dirname, ctl->grid_basename, year, mon, day, hour, min);
00967     write_grid(filename, ctl, met0, met1, atm, t);
00968   }
00969
00970   /* Write profile data... */
00971   if (ctl->prof_basename[0] != '-') {
00972     sprintf(filename, "%s/%s.tab", dirname, ctl->prof_basename);
00973     write_prof(filename, ctl, met0, met1, atm, t);
00974   }
00975
00976   /* Write station data... */
00977   if (ctl->stat_basename[0] != '-') {
00978     sprintf(filename, "%s/%s.tab", dirname, ctl->stat_basename);
00979     write_station(filename, ctl, atm, t);
00980   }
00981 }
```

5.41 wind.c File Reference

Create meteorological data files with synthetic wind fields.

Functions

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

5.41.1 Detailed Description

Create meteorological data files with synthetic wind fields.

Definition in file wind.c.

5.41.2 Function Documentation

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

Definition at line 188 of file wind.c.

```
00192               {
00193
00194   int varid;
00195
00196   NC(nc_inq_varid(ncid, varname, &varid));
00197   NC(nc_put_att_text(ncid, varid, attrname, strlen(text), text));
00198 }
```

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

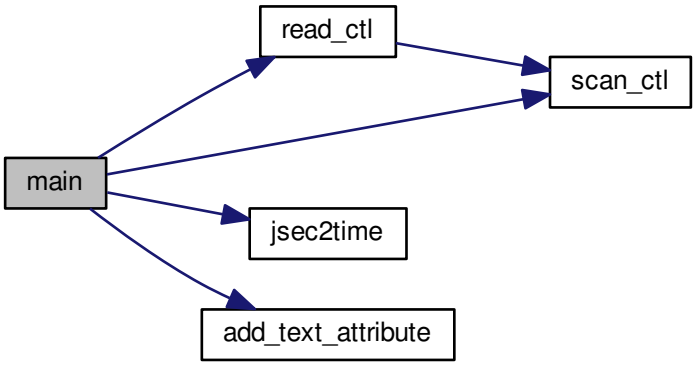
Definition at line 41 of file wind.c.

```
00043                 {
00044
00045   ctl_t ctl;
00046
00047   static char filename[LEN];
00048
00049   static double r, t0, z0, z1, dataLon[EX], dataLat[EY], dataZ[EP],
00050     u0, u1, alpha;
00051
00052   static float *dataT, *dataU, *dataV, *dataW;
00053
00054   static int ncid, dims[4], timid, levid, latid, lonid, tid, uid, vid, wid,
00055     idx, ix, iy, iz, nx, ny, nz, year, mon, day, hour, min, sec;
00056
00057   /* Allocate... */
00058   ALLOC(dataT, float,
00059         EP * EY * EX);
00060   ALLOC(dataU, float,
00061         EP * EY * EX);
00062   ALLOC(dataV, float,
00063         EP * EY * EX);
00064   ALLOC(dataW, float,
00065         EP * EY * EX);
00066
00067   /* Check arguments... */
00068   if (argc < 3)
00069     ERRMSG("Give parameters: <ctl> <metbase>");
00070
00071   /* Read control parameters... */
```

```
00072   read_ctl(argv[1], argc, argv, &ctl);
00073   t0 = scan_ctl(argv[1], argc, argv, "WIND_T0", -1, "0", NULL);
00074   nx = (int) scan_ctl(argv[1], argc, argv, "WIND_NX", -1, "360", NULL);
00075   ny = (int) scan_ctl(argv[1], argc, argv, "WIND_NY", -1, "181", NULL);
00076   nz = (int) scan_ctl(argv[1], argc, argv, "WIND_NZ", -1, "61", NULL);
00077   z0 = scan_ctl(argv[1], argc, argv, "WIND_Z0", -1, "0", NULL);
00078   z1 = scan_ctl(argv[1], argc, argv, "WIND_Z1", -1, "60", NULL);
00079   u0 = scan_ctl(argv[1], argc, argv, "WIND_U0", -1, "38.587660177302", NULL);
00080   u1 = scan_ctl(argv[1], argc, argv, "WIND_U1", -1, "38.587660177302", NULL);
00081   alpha = scan_ctl(argv[1], argc, argv, "WIND_ALPHA", -1, "0.0", NULL);
00082
00083   /* Check dimensions... */
00084   if (nx < 1 || nx > EX)
00085     ERRMSG("Set 1 <= NX <= MAX!");
00086   if (ny < 1 || ny > EY)
00087     ERRMSG("Set 1 <= NY <= MAX!");
00088   if (nz < 1 || nz > EP)
00089     ERRMSG("Set 1 <= NZ <= MAX!");
00090
00091   /* Get time... */
00092   jsec2time(t0, &year, &mon, &day, &hour, &min, &sec, &r);
00093   t0 = year * 10000. + mon * 100. + day + hour / 24.;
00094
00095   /* Set filename... */
00096   sprintf(filename, "%s_%d_%02d_%02d_%02d.nc", argv[2], year, mon, day, hour);
00097
00098   /* Create netCDF file... */
00099   NC(nc_create(filename, NC_CLOBBER, &ncid));
00100
00101   /* Create dimensions... */
00102   NC(nc_def_dim(ncid, "time", 1, &dims[0]));
00103   NC(nc_def_dim(ncid, "lev", (size_t) nz, &dims[1]));
00104   NC(nc_def_dim(ncid, "lat", (size_t) ny, &dims[2]));
00105   NC(nc_def_dim(ncid, "lon", (size_t) nx, &dims[3]));
00106
00107   /* Create variables... */
00108   NC(nc_def_var(ncid, "time", NC_DOUBLE, 1, &dims[0], &timid));
00109   NC(nc_def_var(ncid, "lev", NC_DOUBLE, 1, &dims[1], &levid));
00110   NC(nc_def_var(ncid, "lat", NC_DOUBLE, 1, &dims[2], &latid));
00111   NC(nc_def_var(ncid, "lon", NC_DOUBLE, 1, &dims[3], &lonid));
00112   NC(nc_def_var(ncid, "T", NC_FLOAT, 4, &dims[0], &tid));
00113   NC(nc_def_var(ncid, "U", NC_FLOAT, 4, &dims[0], &uid));
00114   NC(nc_def_var(ncid, "V", NC_FLOAT, 4, &dims[0], &vid));
00115   NC(nc_def_var(ncid, "W", NC_FLOAT, 4, &dims[0], &wid));
00116
00117   /* Set attributes... */
00118   add_text_attribute(ncid, "time", "long_name", "time");
00119   add_text_attribute(ncid, "time", "units", "day as %Y%m%d.%f");
00120   add_text_attribute(ncid, "lon", "long_name", "longitude");
00121   add_text_attribute(ncid, "lon", "units", "degrees_east");
00122   add_text_attribute(ncid, "lat", "long_name", "latitude");
00123   add_text_attribute(ncid, "lat", "units", "degrees_north");
00124   add_text_attribute(ncid, "lev", "long_name", "air_pressure");
00125   add_text_attribute(ncid, "lev", "units", "Pa");
00126   add_text_attribute(ncid, "T", "long_name", "Temperature");
00127   add_text_attribute(ncid, "T", "units", "K");
00128   add_text_attribute(ncid, "U", "long_name", "U velocity");
00129   add_text_attribute(ncid, "U", "units", "m s**-1");
00130   add_text_attribute(ncid, "V", "long_name", "V velocity");
00131   add_text_attribute(ncid, "V", "units", "m s**-1");
00132   add_text_attribute(ncid, "W", "long_name", "Vertical velocity");
00133   add_text_attribute(ncid, "W", "units", "Pa s**-1");
00134
00135   /* End definition... */
00136   NC(nc_enddef(ncid));
00137
00138   /* Set coordinates... */
00139   for (ix = 0; ix < nx; ix++)
00140     dataLon[ix] = 360.0 / nx * (double) ix;
00141   for (iy = 0; iy < ny; iy++)
00142     dataLat[iy] = 180.0 / (ny - 1) * (double) iy - 90;
00143   for (iz = 0; iz < nz; iz++)
00144     dataZ[iz] = 100. * P(LIN(0.0, z0, nz - 1.0, z1, iz));
00145
00146   /* Write coordinates... */
00147   NC(nc_put_var_double(ncid, timid, &t0));
00148   NC(nc_put_var_double(ncid, levid, dataZ));
00149   NC(nc_put_var_double(ncid, lonid, dataLon));
00150   NC(nc_put_var_double(ncid, latid, dataLat));
00151
00152   /* Create wind fields (Williamson et al., 1992)... */
00153   for (ix = 0; ix < nx; ix++)
00154     for (iy = 0; iy < ny; iy++)
00155       for (iz = 0; iz < nz; iz++) {
00156         idx = (iz * ny + iy) * nx + ix;
00157         dataU[idx] = (float) (LIN(0.0, u0, nz - 1.0, u1, iz)
00158                               * (cos(dataLat[iy] * M_PI / 180.0)
```

```
00159                                 * cos(alpha * M_PI / 180.0)
00160                                 + sin(dataLat[iy] * M_PI / 180.0)
00161                                 * cos(dataLon[ix] * M_PI / 180.0)
00162                                 * sin(alpha * M_PI / 180.0)));
00163         dataV[idx] = (float) (-LIN(0.0, u0, nz - 1.0, u1, iz)
00164                               * sin(dataLon[ix] * M_PI / 180.0)
00165                               * sin(alpha * M_PI / 180.0));
00166       }
00167
00168   /* Write wind data... */
00169   NC(nc_put_var_float(ncid, tid, dataT));
00170   NC(nc_put_var_float(ncid, uid, dataU));
00171   NC(nc_put_var_float(ncid, vid, dataV));
00172   NC(nc_put_var_float(ncid, wid, dataW));
00173
00174   /* Close file... */
00175   NC(nc_close(ncid));
00176
00177   /* Free... */
00178   free(dataT);
00179   free(dataU);
00180   free(dataV);
00181   free(dataW);
00182
00183   return EXIT_SUCCESS;
00184 }
```

Here is the call graph for this function:



5.42 wind.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) 2013-2018 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
```

```
00026
00027 /* ------------------------------------------------------------
00028    Functions...
00029    ------------------------------------------------------------ */
00030
00031 void add_text_attribute(
00032   int ncid,
00033   char *varname,
00034   char *attrname,
00035   char *text);
00036
00037 /* ------------------------------------------------------------
00038    Main...
00039    ------------------------------------------------------------ */
00040
00041 int main(
00042   int argc,
00043   char *argv[]) {
00044
00045   ctl_t ctl;
00046
00047   static char filename[LEN];
00048
00049   static double r, t0, z0, z1, dataLon[EX], dataLat[EY], dataZ[EP],
00050     u0, u1, alpha;
00051
00052   static float *dataT, *dataU, *dataV, *dataW;
00053
00054   static int ncid, dims[4], timid, levid, latid, lonid, tid, uid, vid, wid,
00055     idx, ix, iy, iz, nx, ny, nz, year, mon, day, hour, min, sec;
00056
00057   /* Allocate... */
00058   ALLOC(dataT, float,
00059         EP * EY * EX);
00060   ALLOC(dataU, float,
00061         EP * EY * EX);
00062   ALLOC(dataV, float,
00063         EP * EY * EX);
00064   ALLOC(dataW, float,
00065         EP * EY * EX);
00066
00067   /* Check arguments... */
00068   if (argc < 3)
00069     ERRMSG("Give parameters: <ctl> <metbase>");
00070
00071   /* Read control parameters... */
00072   read_ctl(argv[1], argc, argv, &ctl);
00073   t0 = scan_ctl(argv[1], argc, argv, "WIND_T0", -1, "0", NULL);
00074   nx = (int) scan_ctl(argv[1], argc, argv, "WIND_NX", -1, "360", NULL);
00075   ny = (int) scan_ctl(argv[1], argc, argv, "WIND_NY", -1, "181", NULL);
00076   nz = (int) scan_ctl(argv[1], argc, argv, "WIND_NZ", -1, "61", NULL);
00077   z0 = scan_ctl(argv[1], argc, argv, "WIND_Z0", -1, "0", NULL);
00078   z1 = scan_ctl(argv[1], argc, argv, "WIND_Z1", -1, "60", NULL);
00079   u0 = scan_ctl(argv[1], argc, argv, "WIND_U0", -1, "38.587660177302", NULL);
00080   u1 = scan_ctl(argv[1], argc, argv, "WIND_U1", -1, "38.587660177302", NULL);
00081   alpha = scan_ctl(argv[1], argc, argv, "WIND_ALPHA", -1, "0.0", NULL);
00082
00083   /* Check dimensions... */
00084   if (nx < 1 || nx > EX)
00085     ERRMSG("Set 1 <= NX <= MAX!");
00086   if (ny < 1 || ny > EY)
00087     ERRMSG("Set 1 <= NY <= MAX!");
00088   if (nz < 1 || nz > EP)
00089     ERRMSG("Set 1 <= NZ <= MAX!");
00090
00091   /* Get time... */
00092   jsec2time(t0, &year, &mon, &day, &hour, &min, &sec, &r);
00093   t0 = year * 10000. + mon * 100. + day + hour / 24.;
00094
00095   /* Set filename... */
00096   sprintf(filename, "%s_%d_%02d_%02d_%02d.nc", argv[2], year, mon, day, hour);
00097
00098   /* Create netCDF file... */
00099   NC(nc_create(filename, NC_CLOBBER, &ncid));
00100
00101   /* Create dimensions... */
00102   NC(nc_def_dim(ncid, "time", 1, &dims[0]));
00103   NC(nc_def_dim(ncid, "lev", (size_t) nz, &dims[1]));
00104   NC(nc_def_dim(ncid, "lat", (size_t) ny, &dims[2]));
00105   NC(nc_def_dim(ncid, "lon", (size_t) nx, &dims[3]));
00106
00107   /* Create variables... */
00108   NC(nc_def_var(ncid, "time", NC_DOUBLE, 1, &dims[0], &timid));
00109   NC(nc_def_var(ncid, "lev", NC_DOUBLE, 1, &dims[1], &levid));
00110   NC(nc_def_var(ncid, "lat", NC_DOUBLE, 1, &dims[2], &latid));
00111   NC(nc_def_var(ncid, "lon", NC_DOUBLE, 1, &dims[3], &lonid));
00112   NC(nc_def_var(ncid, "T", NC_FLOAT, 4, &dims[0], &tid));
```

```
00113   NC(nc_def_var(ncid, "U", NC_FLOAT, 4, &dims[0], &uid));
00114   NC(nc_def_var(ncid, "V", NC_FLOAT, 4, &dims[0], &vid));
00115   NC(nc_def_var(ncid, "W", NC_FLOAT, 4, &dims[0], &wid));
00116
00117   /* Set attributes... */
00118   add_text_attribute(ncid, "time", "long_name", "time");
00119   add_text_attribute(ncid, "time", "units", "day as %Y%m%d.%f");
00120   add_text_attribute(ncid, "lon", "long_name", "longitude");
00121   add_text_attribute(ncid, "lon", "units", "degrees_east");
00122   add_text_attribute(ncid, "lat", "long_name", "latitude");
00123   add_text_attribute(ncid, "lat", "units", "degrees_north");
00124   add_text_attribute(ncid, "lev", "long_name", "air_pressure");
00125   add_text_attribute(ncid, "lev", "units", "Pa");
00126   add_text_attribute(ncid, "T", "long_name", "Temperature");
00127   add_text_attribute(ncid, "T", "units", "K");
00128   add_text_attribute(ncid, "U", "long_name", "U velocity");
00129   add_text_attribute(ncid, "U", "units", "m s**-1");
00130   add_text_attribute(ncid, "V", "long_name", "V velocity");
00131   add_text_attribute(ncid, "V", "units", "m s**-1");
00132   add_text_attribute(ncid, "W", "long_name", "Vertical velocity");
00133   add_text_attribute(ncid, "W", "units", "Pa s**-1");
00134
00135   /* End definition... */
00136   NC(nc_enddef(ncid));
00137
00138   /* Set coordinates... */
00139   for (ix = 0; ix < nx; ix++)
00140     dataLon[ix] = 360.0 / nx * (double) ix;
00141   for (iy = 0; iy < ny; iy++)
00142     dataLat[iy] = 180.0 / (ny - 1) * (double) iy - 90;
00143   for (iz = 0; iz < nz; iz++)
00144     dataZ[iz] = 100. * P(LIN(0.0, z0, nz - 1.0, z1, iz));
00145
00146   /* Write coordinates... */
00147   NC(nc_put_var_double(ncid, timid, &t0));
00148   NC(nc_put_var_double(ncid, levid, dataZ));
00149   NC(nc_put_var_double(ncid, lonid, dataLon));
00150   NC(nc_put_var_double(ncid, latid, dataLat));
00151
00152   /* Create wind fields (Williamson et al., 1992)... */
00153   for (ix = 0; ix < nx; ix++)
00154     for (iy = 0; iy < ny; iy++)
00155       for (iz = 0; iz < nz; iz++) {
00156         idx = (iz * ny + iy) * nx + ix;
00157         dataU[idx] = (float) (LIN(0.0, u0, nz - 1.0, u1, iz)
00158                               * (cos(dataLat[iy] * M_PI / 180.0)
00159                                  * cos(alpha * M_PI / 180.0)
00160                                  + sin(dataLat[iy] * M_PI / 180.0)
00161                                  * cos(dataLon[ix] * M_PI / 180.0)
00162                                  * sin(alpha * M_PI / 180.0)));
00163         dataV[idx] = (float) (-LIN(0.0, u0, nz - 1.0, u1, iz)
00164                               * sin(dataLon[ix] * M_PI / 180.0)
00165                               * sin(alpha * M_PI / 180.0));
00166       }
00167
00168   /* Write wind data... */
00169   NC(nc_put_var_float(ncid, tid, dataT));
00170   NC(nc_put_var_float(ncid, uid, dataU));
00171   NC(nc_put_var_float(ncid, vid, dataV));
00172   NC(nc_put_var_float(ncid, wid, dataW));
00173
00174   /* Close file... */
00175   NC(nc_close(ncid));
00176
00177   /* Free... */
00178   free(dataT);
00179   free(dataU);
00180   free(dataV);
00181   free(dataW);
00182
00183   return EXIT_SUCCESS;
00184 }
00185
00186 /*****************************************************************************/
00187
00188 void add_text_attribute(
00189   int ncid,
00190   char *varname,
00191   char *attrname,
00192   char *text) {
00193
00194   int varid;
00195
00196   NC(nc_inq_varid(ncid, varname, &varid));
00197   NC(nc_put_att_text(ncid, varid, attrname, strlen(text), text));
00198 }
```

Index