MPTRAC

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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: http://www.fz-juelich.de/ias/jsc/mptrac

2 Data Structure Index

2.1 Data Structures

Here are the data structures with brief descriptions:

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3.1 File List

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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).
- double up [NP]
  Zonal wind perturbation [m/s].
- double vp [NP]
  Meridional wind perturbation [m/s].
- double wp [NP]
  Vertical velocity perturbation [hPa/s].

4.1.1 Detailed Description

Atmospheric data.

Definition at line 505 of file libtrac.h.

4.1.2 Field Documentation

4.1.2.1 int atm_t::np

Number of air pacels.

Definition at line 508 of file libtrac.h.

4.1.2.2 double atm_t::time[NP]

Time [s].

Definition at line 511 of file libtrac.h.

4.1.2.3 double atm_t::p[NP]

Pressure [hPa].

Definition at line 514 of file libtrac.h.

4.1.2.4 double atm_t::lon[NP]

Longitude [deg].

Definition at line 517 of file libtrac.h.

4.1.2.5 double atm_t::lat[NP]

Latitude [deg].

Definition at line 520 of file libtrac.h.

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

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

Definition at line 523 of file libtrac.h.

4.1.2.7 double atm_t::up[NP]

Zonal wind perturbation [m/s].

Definition at line 526 of file libtrac.h.

4.1.2.8 double atm_t::vp[NP]

Meridional wind perturbation [m/s].

Definition at line 529 of file libtrac.h.

4.1.2.9 double atm_t::wp[NP]

Vertical velocity perturbation [hPa/s].

Definition at line 532 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_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_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 qnt_gw_u750
  Quantity array index for low-level zonal wind.
- int qnt_gw_v750
  Quantity array index for low-level meridional wind.
- int qnt_gw_sso
  Quantity array index for subgrid-scale orography.
- int qnt_gw_var
  Quantity array index for gravity wave variances.
- 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_np
  Number of target pressure levels.
- double met_p [EP]
  Target pressure levels [hPa].
- 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_meso

  Scaling factor for mesoscale wind fluctuations.
- 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 gw_basename [LEN]

  Basename for gravity wave variance data.
- 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).
- 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 220 of file libtrac.h.

4.2.2 Field Documentation

4.2.2.1 int ctl_t::nq

Number of quantities.

Definition at line 223 of file libtrac.h.

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

Quantity names.

Definition at line 226 of file libtrac.h.

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

Quantity units.

Definition at line 229 of file libtrac.h.

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

Quantity output format.

Definition at line 232 of file libtrac.h.

4.2.2.5 int ctl_t::qnt_ens

Quantity array index for ensemble IDs.

Definition at line 235 of file libtrac.h.

4.2.2.6 int ctl_t::qnt_m

Quantity array index for mass.

Definition at line 238 of file libtrac.h.

4.2.2.7 int ctl_t::qnt_rho

Quantity array index for particle density.

Definition at line 241 of file libtrac.h.

4.2.2.8 int ctl_t::qnt_r

Quantity array index for particle radius.

Definition at line 244 of file libtrac.h.

4.2.2.9 int ctl_t::qnt_ps

Quantity array index for surface pressure.

Definition at line 247 of file libtrac.h.

4.2.2.10 int ctl_t::qnt_p

Quantity array index for pressure.

Definition at line 250 of file libtrac.h.

4.2.2.11 int ctl_t::qnt_t

Quantity array index for temperature.

Definition at line 253 of file libtrac.h.

4.2.2.12 int ctl_t::qnt_u

Quantity array index for zonal wind.

Definition at line 256 of file libtrac.h.

4.2.2.13 int ctl_t::qnt_v

Quantity array index for meridional wind.

Definition at line 259 of file libtrac.h.

4.2.2.14 int ctl_t::qnt_w

Quantity array index for vertical velocity.

Definition at line 262 of file libtrac.h.

4.2.2.15 int ctl_t::qnt_h2o

Quantity array index for water vapor vmr.

Definition at line 265 of file libtrac.h.

4.2.2.16 int ctl_t::qnt_o3

Quantity array index for ozone vmr.

Definition at line 268 of file libtrac.h.

4.2.2.17 int ctl_t::qnt_theta

Quantity array index for potential temperature.

Definition at line 271 of file libtrac.h.

4.2.2.18 int ctl_t::qnt_pv

Quantity array index for potential vorticity.

Definition at line 274 of file libtrac.h.

4.2.2.19 int ctl_t::qnt_tice

Quantity array index for T_ice.

Definition at line 277 of file libtrac.h.

4.2.2.20 int ctl_t::qnt_tsts

Quantity array index for T_STS.

Definition at line 280 of file libtrac.h.

4.2.2.21 int ctl_t::qnt_tnat

Quantity array index for T_NAT.

Definition at line 283 of file libtrac.h.

4.2.2.22 int ctl_t::qnt_stat

Quantity array index for station flag.

Definition at line 286 of file libtrac.h.

4.2.2.23 int ctl_t::qnt_gw_u750

Quantity array index for low-level zonal wind.

Definition at line 289 of file libtrac.h.

4.2.2.24 int ctl_t::qnt_gw_v750

Quantity array index for low-level meridional wind.

Definition at line 292 of file libtrac.h.

4.2.2.25 int ctl_t::qnt_gw_sso

Quantity array index for subgrid-scale orography.

Definition at line 295 of file libtrac.h.

4.2.2.26 int ctl_t::qnt_gw_var

Quantity array index for gravity wave variances.

Definition at line 298 of file libtrac.h.

4.2.2.27 int ctl_t::direction

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

Definition at line 301 of file libtrac.h.

4.2.2.28 double ctl_t::t_start

Start time of simulation [s].

Definition at line 304 of file libtrac.h.

4.2.2.29 double ctl_t::t_stop

Stop time of simulation [s].

Definition at line 307 of file libtrac.h.

4.2.2.30 double ctl_t::dt_mod

Time step of simulation [s].

Definition at line 310 of file libtrac.h.

4.2.2.31 double ctl_t::dt_met

Time step of meteorological data [s].

Definition at line 313 of file libtrac.h.

4.2.2.32 int ctl_t::met_np

Number of target pressure levels.

Definition at line 316 of file libtrac.h.

4.2.2.33 double ctl_t::met_p[EP]

Target pressure levels [hPa].

Definition at line 319 of file libtrac.h.

4.2.2.34 char ctl_t::met_stage[LEN]

Command to stage meteo data.

Definition at line 322 of file libtrac.h.

4.2.2.35 int ctl_t::isosurf

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

Definition at line 326 of file libtrac.h.

4.2.2.36 char ctl_t::balloon[LEN]

Balloon position filename.

Definition at line 329 of file libtrac.h.

4.2.2.37 double ctl_t::turb_dx_trop

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

Definition at line 332 of file libtrac.h.

4.2.2.38 double ctl_t::turb_dx_strat

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

Definition at line 335 of file libtrac.h.

4.2.2.39 double ctl_t::turb_dz_trop

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

Definition at line 338 of file libtrac.h.

4.2.2.40 double ctl_t::turb_dz_strat

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

Definition at line 341 of file libtrac.h.

4.2.2.41 double ctl_t::turb_meso

Scaling factor for mesoscale wind fluctuations.

Definition at line 344 of file libtrac.h.

4.2.2.42 double ctl_t::tdec_trop

Life time of particles (troposphere) [s].

Definition at line 347 of file libtrac.h.

4.2.2.43 double ctl_t::tdec_strat

Life time of particles (stratosphere) [s].

Definition at line 350 of file libtrac.h.

4.2.2.44 double ctl_t::psc_h2o

H2O volume mixing ratio for PSC analysis.

Definition at line 353 of file libtrac.h.

4.2.2.45 double ctl_t::psc_hno3

HNO3 volume mixing ratio for PSC analysis.

Definition at line 356 of file libtrac.h.

4.2.2.46 char ctl_t::gw_basename[LEN]

Basename for gravity wave variance data.

Definition at line 359 of file libtrac.h.

4.2.2.47 char ctl_t::atm_basename[LEN]

Basename of atmospheric data files.

Definition at line 362 of file libtrac.h.

4.2.2.48 char ctl_t::atm_gpfile[LEN]

Gnuplot file for atmospheric data.

Definition at line 365 of file libtrac.h.

4.2.2.49 double ctl_t::atm_dt_out

Time step for atmospheric data output [s].

Definition at line 368 of file libtrac.h.

4.2.2.50 int ctl_t::atm_filter

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

Definition at line 371 of file libtrac.h.

4.2.2.51 char ctl_t::csi_basename[LEN]

Basename of CSI data files.

Definition at line 374 of file libtrac.h.

4.2.2.52 double ctl_t::csi_dt_out

Time step for CSI data output [s].

Definition at line 377 of file libtrac.h.

4.2.2.53 char ctl_t::csi_obsfile[LEN]

Observation data file for CSI analysis.

Definition at line 380 of file libtrac.h.

4.2.2.54 double ctl_t::csi_obsmin

Minimum observation index to trigger detection.

Definition at line 383 of file libtrac.h.

4.2.2.55 double ctl_t::csi_modmin

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

Definition at line 386 of file libtrac.h.

4.2.2.56 int ctl_t::csi_nz

Number of altitudes of gridded CSI data.

Definition at line 389 of file libtrac.h.

4.2.2.57 double ctl_t::csi_z0

Lower altitude of gridded CSI data [km].

Definition at line 392 of file libtrac.h.

4.2.2.58 double ctl_t::csi_z1

Upper altitude of gridded CSI data [km].

Definition at line 395 of file libtrac.h.

4.2.2.59 int ctl_t::csi_nx

Number of longitudes of gridded CSI data.

Definition at line 398 of file libtrac.h.

4.2.2.60 double ctl_t::csi_lon0

Lower longitude of gridded CSI data [deg].

Definition at line 401 of file libtrac.h.

4.2.2.61 double ctl_t::csi_lon1

Upper longitude of gridded CSI data [deg].

Definition at line 404 of file libtrac.h.

4.2.2.62 int ctl_t::csi_ny

Number of latitudes of gridded CSI data.

Definition at line 407 of file libtrac.h.

4.2.2.63 double ctl_t::csi_lat0

Lower latitude of gridded CSI data [deg].

Definition at line 410 of file libtrac.h.

4.2.2.64 double ctl_t::csi_lat1

Upper latitude of gridded CSI data [deg].

Definition at line 413 of file libtrac.h.

4.2.2.65 char ctl_t::grid_basename[LEN]

Basename of grid data files.

Definition at line 416 of file libtrac.h.

4.2.2.66 char ctl_t::grid_gpfile[LEN]

Gnuplot file for gridded data.

Definition at line 419 of file libtrac.h.

4.2.2.67 double ctl_t::grid_dt_out

Time step for gridded data output [s].

Definition at line 422 of file libtrac.h.

4.2.2.68 int ctl_t::grid_sparse

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

Definition at line 425 of file libtrac.h.

4.2.2.69 int ctl_t::grid_nz

Number of altitudes of gridded data.

Definition at line 428 of file libtrac.h.

4.2.2.70 double ctl_t::grid_z0

Lower altitude of gridded data [km].

Definition at line 431 of file libtrac.h.

4.2.2.71 double ctl_t::grid_z1

Upper altitude of gridded data [km].

Definition at line 434 of file libtrac.h.

4.2.2.72 int ctl_t::grid_nx

Number of longitudes of gridded data.

Definition at line 437 of file libtrac.h.

4.2.2.73 double ctl_t::grid_lon0

Lower longitude of gridded data [deg].

Definition at line 440 of file libtrac.h.

4.2.2.74 double ctl_t::grid_lon1

Upper longitude of gridded data [deg].

Definition at line 443 of file libtrac.h.

4.2.2.75 int ctl_t::grid_ny

Number of latitudes of gridded data.

Definition at line 446 of file libtrac.h.

4.2.2.76 double ctl_t::grid_lat0

Lower latitude of gridded data [deg].

Definition at line 449 of file libtrac.h.

4.2.2.77 double ctl_t::grid_lat1

Upper latitude of gridded data [deg].

Definition at line 452 of file libtrac.h.

4.2.2.78 char ctl_t::prof_basename[LEN]

Basename for profile output file.

Definition at line 455 of file libtrac.h.

4.2.2.79 char ctl_t::prof_obsfile[LEN]

Observation data file for profile output.

Definition at line 458 of file libtrac.h.

4.2.2.80 int ctl_t::prof_nz

Number of altitudes of gridded profile data.

Definition at line 461 of file libtrac.h.

4.2.2.81 double ctl_t::prof_z0

Lower altitude of gridded profile data [km].

Definition at line 464 of file libtrac.h.

4.2.2.82 double ctl_t::prof_z1

Upper altitude of gridded profile data [km].

Definition at line 467 of file libtrac.h.

4.2.2.83 int ctl_t::prof_nx

Number of longitudes of gridded profile data.

Definition at line 470 of file libtrac.h.

4.2.2.84 double ctl_t::prof_lon0

Lower longitude of gridded profile data [deg].

Definition at line 473 of file libtrac.h.

4.2.2.85 double ctl_t::prof_lon1

Upper longitude of gridded profile data [deg].

Definition at line 476 of file libtrac.h.

4.2.2.86 int ctl_t::prof_ny

Number of latitudes of gridded profile data.

Definition at line 479 of file libtrac.h.

4.2.2.87 double ctl_t::prof_lat0

Lower latitude of gridded profile data [deg].

Definition at line 482 of file libtrac.h.

4.2.2.88 double ctl_t::prof_lat1

Upper latitude of gridded profile data [deg].

Definition at line 485 of file libtrac.h.

4.2.2.89 char ctl_t::ens_basename[LEN]

Basename of ensemble data file.

Definition at line 488 of file libtrac.h.

4.2.2.90 char ctl_t::stat_basename[LEN]

Basename of station data file.

Definition at line 491 of file libtrac.h.

4.2.2.91 double ctl_t::stat_lon

Longitude of station [deg].

Definition at line 494 of file libtrac.h.

4.2.2.92 double ctl_t::stat_lat

Latitude of station [deg].

Definition at line 497 of file libtrac.h.

4.2.2.93 double ctl_t::stat_r

Search radius around station [km].

Definition at line 500 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].
- float pl [EX][EY][EP]
  Pressure on model levels [hPa].
- 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 h2o [EX][EY][EP]
  Water vapor volume mixing ratio [1].
- float o3 [EX][EY][EP]
  Ozone volume mixing ratio [1].

4.3.1 Detailed Description

Meteorological data.

Definition at line 537 of file libtrac.h.

4.3.2 Field Documentation

4.3.2.1 double met_t::time

Time [s].

Definition at line 540 of file libtrac.h.

4.3.2.2 int met_t::nx

Number of longitudes.

Definition at line 543 of file libtrac.h.

4.3.2.3 int met_t::ny

Number of latitudes.

Definition at line 546 of file libtrac.h.

4.3.2.4 int met_t::np

Number of pressure levels.

Definition at line 549 of file libtrac.h.

4.3.2.5 double met_t::lon[EX]

Longitude [deg].

Definition at line 552 of file libtrac.h.

4.3.2.6 double met_t::lat[EY]

Latitude [deg].

Definition at line 555 of file libtrac.h.

4.3.2.7 double met_t::p[EP]

Pressure [hPa].

Definition at line 558 of file libtrac.h.

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

Surface pressure [hPa].

Definition at line 561 of file libtrac.h.

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

Pressure on model levels [hPa].

Definition at line 564 of file libtrac.h.

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

Temperature [K].

Definition at line 567 of file libtrac.h.

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

Zonal wind [m/s].

Definition at line 570 of file libtrac.h.

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

Meridional wind [m/s].

Definition at line 573 of file libtrac.h.

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

Vertical wind [hPa/s].

Definition at line 576 of file libtrac.h.

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

Water vapor volume mixing ratio [1].

Definition at line 579 of file libtrac.h.

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

Ozone volume mixing ratio [1].

Definition at line 582 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

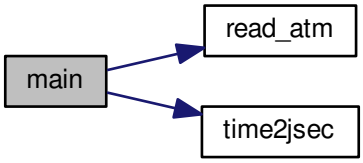
5.1.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 28 of file center.c.

```
00030                {
00031
00032   ctl_t ctl;
00033
00034   atm_t *atm;
00035
00036   FILE *out;
00037
00038   char tstr[LEN];
00039
00040   double latm, lats, lonm, lons, t, zm, zs;
00041
00042   int f, ip, year, mon, day, hour, min;
00043
00044   /* Allocate... */
00045   ALLOC(atm, atm_t, 1);
00046
00047   /* Check arguments... */
00048   if (argc < 3)
00049     ERRMSG("Give parameters: <outfile> <atm1> [<atm2> ...]");
00050
00051   /* Write info... */
00052   printf("Write center of mass data: %s\n", argv[1]);
00053
00054   /* Create output file... */
00055   if (!(out = fopen(argv[1], "w")))
00056     ERRMSG("Cannot create file!");
00057
00058   /* Write header... */
00059   fprintf(out,
00060           "# $1  = time [s]\n"
00061           "# $2  = altitude (mean) [km]\n"
00062           "# $3  = altitude (sigma) [km]\n"
00063           "# $4  = altitude (minimum) [km]\n"
00064           "# $5  = altitude (10%% percentile) [km]\n"
00065           "# $6  = altitude (1st quarter) [km]\n"
00066           "# $7  = altitude (median) [km]\n"
00067           "# $8  = altitude (3rd quarter) [km]\n"
00068           "# $9  = altitude (90%% percentile) [km]\n"
00069           "# $10 = altitude (maximum) [km]\n");
00070   fprintf(out,
00071           "# $11 = longitude (mean) [deg]\n"
00072           "# $12 = longitude (sigma) [deg]\n"
00073           "# $13 = longitude (minimum) [deg]\n"
00074           "# $14 = longitude (10%% percentile) [deg]\n"
00075           "# $15 = longitude (1st quarter) [deg]\n"
00076           "# $16 = longitude (median) [deg]\n"
00077           "# $17 = longitude (3rd quarter) [deg]\n"
00078           "# $18 = longitude (90%% percentile) [deg]\n"
00079           "# $19 = longitude (maximum) [deg]\n");
00080   fprintf(out,
00081           "# $20 = latitude (mean) [deg]\n"
00082           "# $21 = latitude (sigma) [deg]\n"
00083           "# $22 = latitude (minimum) [deg]\n"
00084           "# $23 = latitude (10%% percentile) [deg]\n"
00085           "# $24 = latitude (1st quarter) [deg]\n"
00086           "# $25 = latitude (median) [deg]\n"
00087           "# $26 = latitude (3rd quarter) [deg]\n"
00088           "# $27 = latitude (90%% percentile) [deg]\n"
00089           "# $28 = latitude (maximum) [deg]\n\n");
00090
00091   /* Loop over files... */
00092   for (f = 2; f < argc; f++) {
00093
00094     /* Read atmopheric data... */
00095     read_atm(argv[f], &ctl, atm);
00096
00097     /* Initialize... */
00098     zm = zs = 0;
00099     lonm = lons = 0;
00100     latm = lats = 0;
00101
00102     /* Calculate mean and standard deviation... */
00103     for (ip = 0; ip < atm->np; ip++) {
00104       zm += Z(atm->p[ip]) / atm->np;
00105       lonm += atm->lon[ip] / atm->np;
```

```
00106       latm += atm->lat[ip] / atm->np;
00107       zs += gsl_pow_2(Z(atm->p[ip])) / atm->np;
00108       lons += gsl_pow_2(atm->lon[ip]) / atm->np;
00109       lats += gsl_pow_2(atm->lat[ip]) / atm->np;
00110     }
00111
00112     /* Normalize... */
00113     zs = sqrt(zs - gsl_pow_2(zm));
00114     lons = sqrt(lons - gsl_pow_2(lonm));
00115     lats = sqrt(lats - gsl_pow_2(latm));
00116
00117     /* Sort arrays... */
00118     gsl_sort(atm->p, 1, (size_t) atm->np);
00119     gsl_sort(atm->lon, 1, (size_t) atm->np);
00120     gsl_sort(atm->lat, 1, (size_t) atm->np);
00121
00122     /* Get time from filename... */
00123     sprintf(tstr, "%.4s", &argv[f][strlen(argv[f]) - 20]);
00124     year = atoi(tstr);
00125     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 15]);
00126     mon = atoi(tstr);
00127     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 12]);
00128     day = atoi(tstr);
00129     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 9]);
00130     hour = atoi(tstr);
00131     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 6]);
00132     min = atoi(tstr);
00133     time2jsec(year, mon, day, hour, min, 0, 0, &t);
00134
00135     /* Write data... */
00136     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g "
00137             "%g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00138             t, zm, zs, Z(atm->p[atm->np - 1]),
00139             Z(atm->p[atm->np - atm->np / 10]),
00140             Z(atm->p[atm->np - atm->np / 4]),
00141             Z(atm->p[atm->np / 2]), Z(atm->p[atm->np / 4]),
00142             Z(atm->p[atm->np / 10]), Z(atm->p[0]),
00143             lonm, lons, atm->lon[0], atm->lon[atm->np / 10],
00144             atm->lon[atm->np / 4], atm->lon[atm->np / 2],
00145             atm->lon[atm->np - atm->np / 4],
00146             atm->lon[atm->np - atm->np / 10],
00147             atm->lon[atm->np - 1],
00148             latm, lats, atm->lat[0], atm->lat[atm->np / 10],
00149             atm->lat[atm->np / 4], atm->lat[atm->np / 2],
00150             atm->lat[atm->np - atm->np / 4],
00151             atm->lat[atm->np - atm->np / 10], atm->lat[atm->np - 1]);
00152   }
00153
00154   /* Close file... */
00155   fclose(out);
00156
00157   /* Free... */
00158   free(atm);
00159
00160   return EXIT_SUCCESS;
00161 }
```

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   Copright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026 #include <gsl/gsl_sort.h>
00027
00028 int main(
00029   int argc,
00030   char *argv[]) {
00031
00032   ctl_t ctl;
00033
00034   atm_t *atm;
00035
00036   FILE *out;
00037
00038   char tstr[LEN];
00039
00040   double latm, lats, lonm, lons, t, zm, zs;
00041
00042   int f, ip, year, mon, day, hour, min;
00043
00044   /* Allocate... */
00045   ALLOC(atm, atm_t, 1);
00046
00047   /* Check arguments... */
00048   if (argc < 3)
00049     ERRMSG("Give parameters: <outfile> <atm1> [<atm2> ...]");
00050
00051   /* Write info... */
00052   printf("Write center of mass data: %s\n", argv[1]);
00053
00054   /* Create output file... */
00055   if (!(out = fopen(argv[1], "w")))
00056     ERRMSG("Cannot create file!");
00057
00058   /* Write header... */
00059   fprintf(out,
00060           "# $1  = time [s]\n"
00061           "# $2  = altitude (mean) [km]\n"
00062           "# $3  = altitude (sigma) [km]\n"
00063           "# $4  = altitude (minimum) [km]\n"
00064           "# $5  = altitude (10%% percentile) [km]\n"
00065           "# $6  = altitude (1st quarter) [km]\n"
00066           "# $7  = altitude (median) [km]\n"
00067           "# $8  = altitude (3rd quarter) [km]\n"
00068           "# $9  = altitude (90%% percentile) [km]\n"
00069           "# $10 = altitude (maximum) [km]\n");
00070   fprintf(out,
00071           "# $11 = longitude (mean) [deg]\n"
00072           "# $12 = longitude (sigma) [deg]\n"
00073           "# $13 = longitude (minimum) [deg]\n"
00074           "# $14 = longitude (10%% percentile) [deg]\n"
00075           "# $15 = longitude (1st quarter) [deg]\n"
00076           "# $16 = longitude (median) [deg]\n"
00077           "# $17 = longitude (3rd quarter) [deg]\n"
00078           "# $18 = longitude (90%% percentile) [deg]\n"
00079           "# $19 = longitude (maximum) [deg]\n");
00080   fprintf(out,
00081           "# $20 = latitude (mean) [deg]\n"
00082           "# $21 = latitude (sigma) [deg]\n"
00083           "# $22 = latitude (minimum) [deg]\n"
00084           "# $23 = latitude (10%% percentile) [deg]\n"
00085           "# $24 = latitude (1st quarter) [deg]\n"
00086           "# $25 = latitude (median) [deg]\n"
00087           "# $26 = latitude (3rd quarter) [deg]\n"
00088           "# $27 = latitude (90%% percentile) [deg]\n"
00089           "# $28 = latitude (maximum) [deg]\n\n");
00090
00091   /* Loop over files... */
00092   for (f = 2; f < argc; f++) {
00093
```

```
    /* 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",
            t, zm, zs, Z(atm->p[atm->np - 1]),
            Z(atm->p[atm->np - atm->np / 10]),
            Z(atm->p[atm->np - atm->np / 4]),
            Z(atm->p[atm->np / 2]), Z(atm->p[atm->np / 4]),
            Z(atm->p[atm->np / 10]), Z(atm->p[0]),
            lonm, lons, atm->lon[0], atm->lon[atm->np / 10],
            atm->lon[atm->np / 4], atm->lon[atm->np / 2],
            atm->lon[atm->np - atm->np / 4],
            atm->lon[atm->np - atm->np / 10],
            atm->lon[atm->np - 1],
            latm, lats, atm->lat[0], atm->lat[atm->np / 10],
            atm->lat[atm->np / 4], atm->lat[atm->np / 2],
            atm->lat[atm->np - atm->np / 4],
            atm->lat[atm->np - atm->np / 10], atm->lat[atm->np - 1]);
  }

  /* Close file... */
  fclose(out);

  /* Free... */
  free(atm);

  return EXIT_SUCCESS;
}
```

5.3 dist.c File Reference

Calculate transport deviations of trajectories.

Functions

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

5.3.1 Detailed Description

Calculate transport deviations of trajectories.

Definition in file dist.c.

5.3.2 Function Documentation

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

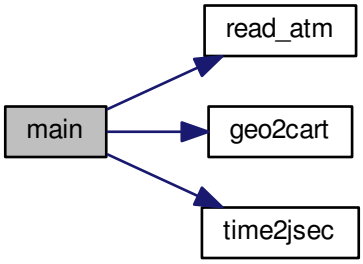
Definition at line 28 of file dist.c.

```
00030                {
00031
00032   ctl_t ctl;
00033
00034   atm_t *atm1, *atm2;
00035
00036   FILE *out;
00037
00038   char tstr[LEN];
00039
00040   double aux, x0[3], x1[3], x2[3], *lon1, *lat1, *p1, *lh1, *lv1,
00041     *lon2, *lat2, *p2, *lh2, *lv2, ahtd, avtd, ahtd2, avtd2,
00042     rhtd, rvtd, rhtd2, rvtd2, t, *dh, *dv;
00043
00044   int f, ip, iph, ipv, year, mon, day, hour, min;
00045
00046   /* Allocate... */
00047   ALLOC(atm1, atm_t, 1);
00048   ALLOC(atm2, atm_t, 1);
00049   ALLOC(lon1, double,
00050         NP);
00051   ALLOC(lat1, double,
00052         NP);
00053   ALLOC(p1, double,
00054         NP);
00055   ALLOC(lh1, double,
00056         NP);
00057   ALLOC(lv1, double,
00058         NP);
00059   ALLOC(lon2, double,
00060         NP);
00061   ALLOC(lat2, double,
00062         NP);
00063   ALLOC(p2, double,
00064         NP);
00065   ALLOC(lh2, double,
00066         NP);
00067   ALLOC(lv2, double,
00068         NP);
00069   ALLOC(dh, double,
00070         NP);
00071   ALLOC(dv, double,
00072         NP);
00073
00074   /* Check arguments... */
00075   if (argc < 4)
00076     ERRMSG
00077       ("Give parameters: <outfile> <atm1a> <atm1b> [<atm2a> <atm2b> ...]");
00078
00079   /* Write info... */
00080   printf("Write transport deviations: %s\n", argv[1]);
00081
00082   /* Create output file... */
00083   if (!(out = fopen(argv[1], "w")))
00084     ERRMSG("Cannot create file!");
00085
00086   /* Write header... */
00087   fprintf(out,
00088           "# $1  = time [s]\n"
00089           "# $2  = AHTD (mean) [km]\n"
00090           "# $3  = AHTD (sigma) [km]\n"
00091           "# $4  = AHTD (minimum) [km]\n"
00092           "# $5  = AHTD (10%% percentile) [km]\n"
00093           "# $6  = AHTD (1st quartile) [km]\n"
00094           "# $7  = AHTD (median) [km]\n"
```

```
00095           "# $8  = AHTD (3rd quartile) [km]\n"
00096           "# $9  = AHTD (90%% percentile) [km]\n"
00097           "# $10 = AHTD (maximum) [km]\n"
00098           "# $11 = AHTD (maximum trajectory index)\n"
00099           "# $12 = RHTD (mean) [%%]\n" "# $13 = RHTD (sigma) [%%]\n");
00100   fprintf(out,
00101           "# $14 = AVTD (mean) [km]\n"
00102           "# $15 = AVTD (sigma) [km]\n"
00103           "# $16 = AVTD (minimum) [km]\n"
00104           "# $17 = AVTD (10%% percentile) [km]\n"
00105           "# $18 = AVTD (1st quartile) [km]\n"
00106           "# $19 = AVTD (median) [km]\n"
00107           "# $20 = AVTD (3rd quartile) [km]\n"
00108           "# $21 = AVTD (90%% percentile) [km]\n"
00109           "# $22 = AVTD (maximum) [km]\n"
00110           "# $23 = AVTD (maximum trajectory index)\n"
00111           "# $24 = RVTD (mean) [%%]\n" "# $25 = RVTD (sigma) [%%]\n\n");
00112
00113   /* Loop over file pairs... */
00114   for (f = 2; f < argc; f += 2) {
00115
00116     /* Read atmopheric data... */
00117     read_atm(argv[f], &ctl, atm1);
00118     read_atm(argv[f + 1], &ctl, atm2);
00119
00120     /* Check if structs match... */
00121     if (atm1->np != atm2->np)
00122       ERRMSG("Different numbers of parcels!");
00123     for (ip = 0; ip < atm1->np; ip++)
00124       if (atm1->time[ip] != atm2->time[ip])
00125         ERRMSG("Times do not match!");
00126
00127     /* Init... */
00128     ahtd = ahtd2 = 0;
00129     avtd = avtd2 = 0;
00130     rhtd = rhtd2 = 0;
00131     rvtd = rvtd2 = 0;
00132
00133     /* Loop over air parcels... */
00134     for (ip = 0; ip < atm1->np; ip++) {
00135
00136       /* Get Cartesian coordinates... */
00137       geo2cart(0, atm1->lon[ip], atm1->lat[ip], x1);
00138       geo2cart(0, atm2->lon[ip], atm2->lat[ip], x2);
00139
00140       /* Calculate absolute transport deviations... */
00141       dh[ip] = DIST(x1, x2);
00142       ahtd += dh[ip];
00143       ahtd2 += gsl_pow_2(dh[ip]);
00144
00145       dv[ip] = fabs(Z(atm1->p[ip]) - Z(atm2->p[ip]));
00146       avtd += dv[ip];
00147       avtd2 += gsl_pow_2(dv[ip]);
00148
00149       /* Calculate relative transport deviations... */
00150       if (f > 2) {
00151
00152         /* Get trajectory lengths... */
00153         geo2cart(0, lon1[ip], lat1[ip], x0);
00154         lh1[ip] += DIST(x0, x1);
00155         lv1[ip] += fabs(Z(p1[ip]) - Z(atm1->p[ip]));
00156
00157         geo2cart(0, lon2[ip], lat2[ip], x0);
00158         lh2[ip] += DIST(x0, x2);
00159         lv2[ip] += fabs(Z(p2[ip]) - Z(atm2->p[ip]));
00160
00161         /* Get relative transport devations... */
00162         if (lh1[ip] + lh2[ip] > 0) {
00163           aux = 200. * DIST(x1, x2) / (lh1[ip] + lh2[ip]);
00164           rhtd += aux;
00165           rhtd2 += gsl_pow_2(aux);
00166         }
00167         if (lv1[ip] + lv2[ip] > 0) {
00168           aux =
00169             200. * fabs(Z(atm1->p[ip]) - Z(atm2->p[ip])) / (lv1[ip] +
00170                                                             lv2[ip]);
00171           rvtd += aux;
00172           rvtd2 += gsl_pow_2(aux);
00173         }
00174       }
00175
00176       /* Save positions of air parcels... */
00177       lon1[ip] = atm1->lon[ip];
00178       lat1[ip] = atm1->lat[ip];
00179       p1[ip] = atm1->p[ip];
00180
00181       lon2[ip] = atm2->lon[ip];
```

```
00182       lat2[ip] = atm2->lat[ip];
00183       p2[ip] = atm2->p[ip];
00184     }
00185
00186     /* Get indices of trajectories with maximum errors... */
00187     iph = (int) gsl_stats_max_index(dh, 1, (size_t) atm1->np);
00188     ipv = (int) gsl_stats_max_index(dv, 1, (size_t) atm1->np);
00189
00190     /* Sort distances to calculate percentiles... */
00191     gsl_sort(dh, 1, (size_t) atm1->np);
00192     gsl_sort(dv, 1, (size_t) atm1->np);
00193
00194     /* Get time from filename... */
00195     sprintf(tstr, "%.4s", &argv[f][strlen(argv[f]) - 20]);
00196     year = atoi(tstr);
00197     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 15]);
00198     mon = atoi(tstr);
00199     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 12]);
00200     day = atoi(tstr);
00201     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 9]);
00202     hour = atoi(tstr);
00203     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 6]);
00204     min = atoi(tstr);
00205     time2jsec(year, mon, day, hour, min, 0, 0, &t);
00206
00207     /* Write output... */
00208     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %d %g %g"
00209             " %g %g %g %g %g %g %g %g %g %d %g %g\n", t,
00210             ahtd / atm1->np,
00211             sqrt(ahtd2 / atm1->np - gsl_pow_2(ahtd / atm1->np)),
00212             dh[0], dh[atm1->np / 10], dh[atm1->np / 4], dh[atm1->np / 2],
00213             dh[atm1->np - atm1->np / 4], dh[atm1->np - atm1->np / 10],
00214             dh[atm1->np - 1], iph, rhtd / atm1->np,
00215             sqrt(rhtd2 / atm1->np - gsl_pow_2(rhtd / atm1->np)),
00216             avtd / atm1->np,
00217             sqrt(avtd2 / atm1->np - gsl_pow_2(avtd / atm1->np)),
00218             dv[0], dv[atm1->np / 10], dv[atm1->np / 4], dv[atm1->np / 2],
00219             dv[atm1->np - atm1->np / 4], dv[atm1->np - atm1->np / 10],
00220             dv[atm1->np - 1], ipv, rvtd / atm1->np,
00221             sqrt(rvtd2 / atm1->np - gsl_pow_2(rvtd / atm1->np)));
00222   }
00223
00224   /* Close file... */
00225   fclose(out);
00226
00227   /* Free... */
00228   free(atm1);
00229   free(atm2);
00230   free(lon1);
00231   free(lat1);
00232   free(p1);
00233   free(lh1);
00234   free(lv1);
00235   free(lon2);
00236   free(lat2);
00237   free(p2);
00238   free(lh2);
00239   free(lv2);
00240   free(dh);
00241   free(dv);
00242
00243   return EXIT_SUCCESS;
00244 }
```

Here is the call graph for this function:



5.4 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   Copright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026 #include <gsl/gsl_sort.h>
00027
00028 int main(
00029   int argc,
00030   char *argv[]) {
00031
00032   ctl_t ctl;
00033
00034   atm_t *atm1, *atm2;
00035
00036   FILE *out;
00037
00038   char tstr[LEN];
00039
00040   double aux, x0[3], x1[3], x2[3], *lon1, *lat1, *p1, *lh1, *lv1,
00041     *lon2, *lat2, *p2, *lh2, *lv2, ahtd, avtd, ahtd2, avtd2,
00042     rhtd, rvtd, rhtd2, rvtd2, t, *dh, *dv;
00043
00044   int f, ip, iph, ipv, year, mon, day, hour, min;
00045
00046   /* Allocate... */
00047   ALLOC(atm1, atm_t, 1);
00048   ALLOC(atm2, atm_t, 1);
00049   ALLOC(lon1, double,
00050         NP);
00051   ALLOC(lat1, double,
00052         NP);
00053   ALLOC(p1, double,
00054         NP);
00055   ALLOC(lh1, double,
00056         NP);
00057   ALLOC(lv1, double,
00058         NP);
00059   ALLOC(lon2, double,
```

```
00060         NP);
00061   ALLOC(lat2, double,
00062         NP);
00063   ALLOC(p2, double,
00064         NP);
00065   ALLOC(lh2, double,
00066         NP);
00067   ALLOC(lv2, double,
00068         NP);
00069   ALLOC(dh, double,
00070         NP);
00071   ALLOC(dv, double,
00072         NP);
00073
00074   /* Check arguments... */
00075   if (argc < 4)
00076     ERRMSG
00077       ("Give parameters: <outfile> <atm1a> <atm1b> [<atm2a> <atm2b> ...]");
00078
00079   /* Write info... */
00080   printf("Write transport deviations: %s\n", argv[1]);
00081
00082   /* Create output file... */
00083   if (!(out = fopen(argv[1], "w")))
00084     ERRMSG("Cannot create file!");
00085
00086   /* Write header... */
00087   fprintf(out,
00088           "# $1  = time [s]\n"
00089           "# $2  = AHTD (mean) [km]\n"
00090           "# $3  = AHTD (sigma) [km]\n"
00091           "# $4  = AHTD (minimum) [km]\n"
00092           "# $5  = AHTD (10%% percentile) [km]\n"
00093           "# $6  = AHTD (1st quartile) [km]\n"
00094           "# $7  = AHTD (median) [km]\n"
00095           "# $8  = AHTD (3rd quartile) [km]\n"
00096           "# $9  = AHTD (90%% percentile) [km]\n"
00097           "# $10 = AHTD (maximum) [km]\n"
00098           "# $11 = AHTD (maximum trajectory index)\n"
00099           "# $12 = RHTD (mean) [%%]\n" "# $13 = RHTD (sigma) [%%]\n");
00100   fprintf(out,
00101           "# $14 = AVTD (mean) [km]\n"
00102           "# $15 = AVTD (sigma) [km]\n"
00103           "# $16 = AVTD (minimum) [km]\n"
00104           "# $17 = AVTD (10%% percentile) [km]\n"
00105           "# $18 = AVTD (1st quartile) [km]\n"
00106           "# $19 = AVTD (median) [km]\n"
00107           "# $20 = AVTD (3rd quartile) [km]\n"
00108           "# $21 = AVTD (90%% percentile) [km]\n"
00109           "# $22 = AVTD (maximum) [km]\n"
00110           "# $23 = AVTD (maximum trajectory index)\n"
00111           "# $24 = RVTD (mean) [%%]\n" "# $25 = RVTD (sigma) [%%]\n\n");
00112
00113   /* Loop over file pairs... */
00114   for (f = 2; f < argc; f += 2) {
00115
00116     /* Read atmopheric data... */
00117     read_atm(argv[f], &ctl, atm1);
00118     read_atm(argv[f + 1], &ctl, atm2);
00119
00120     /* Check if structs match... */
00121     if (atm1->np != atm2->np)
00122       ERRMSG("Different numbers of parcels!");
00123     for (ip = 0; ip < atm1->np; ip++)
00124       if (atm1->time[ip] != atm2->time[ip])
00125         ERRMSG("Times do not match!");
00126
00127     /* Init... */
00128     ahtd = ahtd2 = 0;
00129     avtd = avtd2 = 0;
00130     rhtd = rhtd2 = 0;
00131     rvtd = rvtd2 = 0;
00132
00133     /* Loop over air parcels... */
00134     for (ip = 0; ip < atm1->np; ip++) {
00135
00136       /* Get Cartesian coordinates... */
00137       geo2cart(0, atm1->lon[ip], atm1->lat[ip], x1);
00138       geo2cart(0, atm2->lon[ip], atm2->lat[ip], x2);
00139
00140       /* Calculate absolute transport deviations... */
00141       dh[ip] = DIST(x1, x2);
00142       ahtd += dh[ip];
00143       ahtd2 += gsl_pow_2(dh[ip]);
00144
00145       dv[ip] = fabs(Z(atm1->p[ip]) - Z(atm2->p[ip]));
00146       avtd += dv[ip];
```

```
00147       avtd2 += gsl_pow_2(dv[ip]);
00148
00149       /* Calculate relative transport deviations... */
00150       if (f > 2) {
00151
00152         /* Get trajectory lengths... */
00153         geo2cart(0, lon1[ip], lat1[ip], x0);
00154         lh1[ip] += DIST(x0, x1);
00155         lv1[ip] += fabs(Z(p1[ip]) - Z(atm1->p[ip]));
00156
00157         geo2cart(0, lon2[ip], lat2[ip], x0);
00158         lh2[ip] += DIST(x0, x2);
00159         lv2[ip] += fabs(Z(p2[ip]) - Z(atm2->p[ip]));
00160
00161         /* Get relative transport devations... */
00162         if (lh1[ip] + lh2[ip] > 0) {
00163           aux = 200. * DIST(x1, x2) / (lh1[ip] + lh2[ip]);
00164           rhtd += aux;
00165           rhtd2 += gsl_pow_2(aux);
00166         }
00167         if (lv1[ip] + lv2[ip] > 0) {
00168           aux =
00169             200. * fabs(Z(atm1->p[ip]) - Z(atm2->p[ip])) / (lv1[ip] +
00170                                                             lv2[ip]);
00171           rvtd += aux;
00172           rvtd2 += gsl_pow_2(aux);
00173         }
00174       }
00175
00176       /* Save positions of air parcels... */
00177       lon1[ip] = atm1->lon[ip];
00178       lat1[ip] = atm1->lat[ip];
00179       p1[ip] = atm1->p[ip];
00180
00181       lon2[ip] = atm2->lon[ip];
00182       lat2[ip] = atm2->lat[ip];
00183       p2[ip] = atm2->p[ip];
00184     }
00185
00186     /* Get indices of trajectories with maximum errors... */
00187     iph = (int) gsl_stats_max_index(dh, 1, (size_t) atm1->np);
00188     ipv = (int) gsl_stats_max_index(dv, 1, (size_t) atm1->np);
00189
00190     /* Sort distances to calculate percentiles... */
00191     gsl_sort(dh, 1, (size_t) atm1->np);
00192     gsl_sort(dv, 1, (size_t) atm1->np);
00193
00194     /* Get time from filename... */
00195     sprintf(tstr, "%.4s", &argv[f][strlen(argv[f]) - 20]);
00196     year = atoi(tstr);
00197     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 15]);
00198     mon = atoi(tstr);
00199     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 12]);
00200     day = atoi(tstr);
00201     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 9]);
00202     hour = atoi(tstr);
00203     sprintf(tstr, "%.2s", &argv[f][strlen(argv[f]) - 6]);
00204     min = atoi(tstr);
00205     time2jsec(year, mon, day, hour, min, 0, 0, &t);
00206
00207     /* Write output... */
00208     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %d %g %g"
00209             " %g %g %g %g %g %g %g %g %g %d %g %g\n", t,
00210             ahtd / atm1->np,
00211             sqrt(ahtd2 / atm1->np - gsl_pow_2(ahtd / atm1->np)),
00212             dh[0], dh[atm1->np / 10], dh[atm1->np / 4], dh[atm1->np / 2],
00213             dh[atm1->np - atm1->np / 4], dh[atm1->np - atm1->np / 10],
00214             dh[atm1->np - 1], iph, rhtd / atm1->np,
00215             sqrt(rhtd2 / atm1->np - gsl_pow_2(rhtd / atm1->np)),
00216             avtd / atm1->np,
00217             sqrt(avtd2 / atm1->np - gsl_pow_2(avtd / atm1->np)),
00218             dv[0], dv[atm1->np / 10], dv[atm1->np / 4], dv[atm1->np / 2],
00219             dv[atm1->np - atm1->np / 4], dv[atm1->np - atm1->np / 10],
00220             dv[atm1->np - 1], ipv, rvtd / atm1->np,
00221             sqrt(rvtd2 / atm1->np - gsl_pow_2(rvtd / atm1->np)));
00222   }
00223
00224   /* Close file... */
00225   fclose(out);
00226
00227   /* Free... */
00228   free(atm1);
00229   free(atm2);
00230   free(lon1);
00231   free(lat1);
00232   free(p1);
00233   free(lh1);
```

```
00234   free(lv1);
00235   free(lon2);
00236   free(lat2);
00237   free(p2);
00238   free(lh2);
00239   free(lv2);
00240   free(dh);
00241   free(dv);
00242
00243   return EXIT_SUCCESS;
00244 }
```

5.5 extract.c File Reference

Extract single trajectory from atmospheric data files.

Functions

- int main (int argc, char ∗argv[ ])

5.5.1 Detailed Description

Extract single trajectory from atmospheric data files.

Definition in file extract.c.

5.5.2 Function Documentation

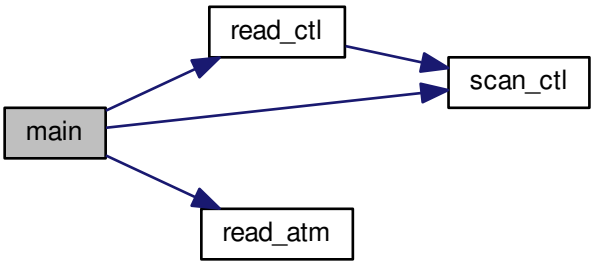
5.5.2.1 int main (int *argc,* char ∗ *argv[ ]*)

Definition at line 28 of file extract.c.

```
00030                {
00031
00032   ctl_t ctl;
00033
00034   atm_t *atm;
00035
00036   FILE *in, *out;
00037
00038   int f, ip, iq;
00039
00040   /* Allocate... */
00041   ALLOC(atm, atm_t, 1);
00042
00043   /* Check arguments... */
00044   if (argc < 4)
00045     ERRMSG("Give parameters: <ctl> <outfile> <atm1> [<atm2> ...]");
00046
00047   /* Read control parameters... */
00048   read_ctl(argv[1], argc, argv, &ctl);
00049   ip = (int) scan_ctl(argv[1], argc, argv, "EXTRACT_IP", -1, "0", NULL);
00050
00051   /* Write info... */
00052   printf("Write trajectory data: %s\n", argv[2]);
00053
00054   /* Create output file... */
00055   if (!(out = fopen(argv[2], "w")))
00056     ERRMSG("Cannot create file!");
00057
00058   /* Write header... */
00059   fprintf(out,
00060           "# $1 = time [s]\n"
00061           "# $2 = altitude [km]\n"
00062           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
```

```
00063   for (iq = 0; iq < ctl.nq; iq++)
00064     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl.qnt_name[iq],
00065             ctl.qnt_unit[iq]);
00066   fprintf(out, "\n");
00067
00068   /* Loop over files... */
00069   for (f = 3; f < argc; f++) {
00070
00071     /* Read atmopheric data... */
00072     if (!(in = fopen(argv[f], "r")))
00073       continue;
00074     else
00075       fclose(in);
00076     read_atm(argv[f], &ctl, atm);
00077
00078     /* Write data... */
00079     fprintf(out, "%.2f %g %g %g", atm->time[ip],
00080             Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
00081     for (iq = 0; iq < ctl.nq; iq++) {
00082       fprintf(out, " ");
00083       fprintf(out, ctl.qnt_format[iq], atm->q[iq][ip]);
00084     }
00085     fprintf(out, "\n");
00086   }
00087
00088   /* Close file... */
00089   fclose(out);
00090
00091   /* Free... */
00092   free(atm);
00093
00094   return EXIT_SUCCESS;
00095 }
```

Here is the call graph for this function:



5.6 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) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
```

```
00019
00025 #include "libtrac.h"
00026 #include <gsl/gsl_sort.h>
00027
00028 int main(
00029   int argc,
00030   char *argv[]) {
00031
00032   ctl_t ctl;
00033
00034   atm_t *atm;
00035
00036   FILE *in, *out;
00037
00038   int f, ip, iq;
00039
00040   /* Allocate... */
00041   ALLOC(atm, atm_t, 1);
00042
00043   /* Check arguments... */
00044   if (argc < 4)
00045     ERRMSG("Give parameters: <ctl> <outfile> <atm1> [<atm2> ...]");
00046
00047   /* Read control parameters... */
00048   read_ctl(argv[1], argc, argv, &ctl);
00049   ip = (int) scan_ctl(argv[1], argc, argv, "EXTRACT_IP", -1, "0", NULL);
00050
00051   /* Write info... */
00052   printf("Write trajectory data: %s\n", argv[2]);
00053
00054   /* Create output file... */
00055   if (!(out = fopen(argv[2], "w")))
00056     ERRMSG("Cannot create file!");
00057
00058   /* Write header... */
00059   fprintf(out,
00060           "# $1 = time [s]\n"
00061           "# $2 = altitude [km]\n"
00062           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
00063   for (iq = 0; iq < ctl.nq; iq++)
00064     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl.qnt_name[iq],
00065             ctl.qnt_unit[iq]);
00066   fprintf(out, "\n");
00067
00068   /* Loop over files... */
00069   for (f = 3; f < argc; f++) {
00070
00071     /* Read atmopheric data... */
00072     if (!(in = fopen(argv[f], "r")))
00073       continue;
00074     else
00075       fclose(in);
00076     read_atm(argv[f], &ctl, atm);
00077
00078     /* Write data... */
00079     fprintf(out, "%.2f %g %g %g", atm->time[ip],
00080             Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
00081     for (iq = 0; iq < ctl.nq; iq++) {
00082       fprintf(out, " ");
00083       fprintf(out, ctl.qnt_format[iq], atm->q[iq][ip]);
00084     }
00085     fprintf(out, "\n");
00086   }
00087
00088   /* Close file... */
00089   fclose(out);
00090
00091   /* Free... */
00092   free(atm);
00093
00094   return EXIT_SUCCESS;
00095 }
```

5.7 init.c File Reference

Create atmospheric data file with initial air parcel positions.

Functions

- int main (int argc, char ∗argv[ ])

5.7.1 Detailed Description

Create atmospheric data file with initial air parcel positions.

Definition in file init.c.

5.7.2 Function Documentation

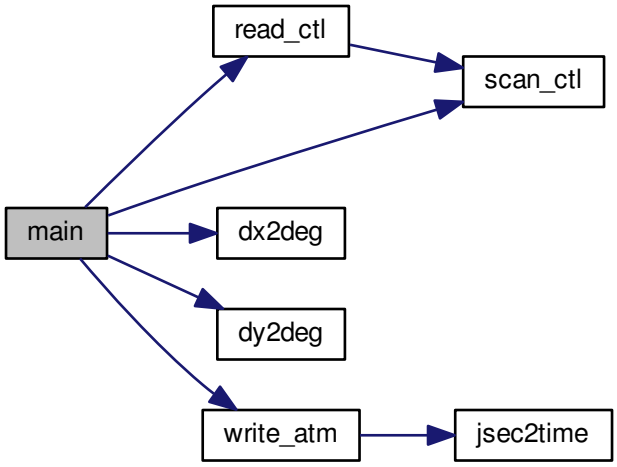
5.7.2.1 int main (int *argc*, char * *argv[]*)

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             do {
00092               atm->p[atm->np]
00093                 = P(z + gsl_ran_gaussian_ziggurat(rng, sz / 2.3548)
```

```
00094                     + uz * (gsl_rng_uniform(rng) - 0.5));
00095             } while (atm->p[atm->np] < 0);
00096             do {
00097               atm->lon[atm->np]
00098                 = (lon + gsl_ran_gaussian_ziggurat(rng, slon / 2.3548)
00099                    + gsl_ran_gaussian_ziggurat(rng, dx2deg(sx, lat) / 2.3548)
00100                    + ulon * (gsl_rng_uniform(rng) - 0.5));
00101             } while (atm->lon[atm->np] < -180 || atm->lon[atm->np] >= 180);
00102             do {
00103               do {
00104                 atm->lat[atm->np]
00105                   = (lat + gsl_ran_gaussian_ziggurat(rng, slat / 2.3548)
00106                      + gsl_ran_gaussian_ziggurat(rng, dy2deg(sx) / 2.3548)
00107                      + ulat * (gsl_rng_uniform(rng) - 0.5));
00108               } while (atm->lat[atm->np] < -90 || atm->lat[atm->np] >= 90);
00109             } while (even && gsl_rng_uniform(rng) >
00110                      fabs(cos(atm->lat[atm->np] * M_PI / 180.)));
00111
00112             /* Set particle counter... */
00113             if ((++atm->np) >= NP)
00114               ERRMSG("Too many particles!");
00115           }
00116
00117   /* Check number of air parcels... */
00118   if (atm->np <= 0)
00119     ERRMSG("Did not create any air parcels!");
00120
00121   /* Initialize mass... */
00122   if (ctl.qnt_m >= 0)
00123     for (ip = 0; ip < atm->np; ip++)
00124       atm->q[ctl.qnt_m][ip] = m / atm->np;
00125
00126   /* Save data... */
00127   write_atm(argv[2], &ctl, atm, t0);
00128
00129   /* Free... */
00130   gsl_rng_free(rng);
00131   free(atm);
00132
00133   return EXIT_SUCCESS;
00134 }
```

Here is the call graph for this function:



5.8 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   Copright (C) 2013-2015 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             do {
00092               atm->p[atm->np]
00093                 = P(z + gsl_ran_gaussian_ziggurat(rng, sz / 2.3548)
```

```
00094                     + uz * (gsl_rng_uniform(rng) - 0.5));
00095             } while (atm->p[atm->np] < 0);
00096             do {
00097               atm->lon[atm->np]
00098                 = (lon + gsl_ran_gaussian_ziggurat(rng, slon / 2.3548)
00099                    + gsl_ran_gaussian_ziggurat(rng, dx2deg(sx, lat) / 2.3548)
00100                    + ulon * (gsl_rng_uniform(rng) - 0.5));
00101             } while (atm->lon[atm->np] < -180 || atm->lon[atm->np] >= 180);
00102             do {
00103               do {
00104                 atm->lat[atm->np]
00105                   = (lat + gsl_ran_gaussian_ziggurat(rng, slat / 2.3548)
00106                      + gsl_ran_gaussian_ziggurat(rng, dy2deg(sx) / 2.3548)
00107                      + ulat * (gsl_rng_uniform(rng) - 0.5));
00108               } while (atm->lat[atm->np] < -90 || atm->lat[atm->np] >= 90);
00109             } while (even && gsl_rng_uniform(rng) >
00110                      fabs(cos(atm->lat[atm->np] * M_PI / 180.)));
00111
00112             /* Set particle counter... */
00113             if ((++atm->np) >= NP)
00114               ERRMSG("Too many particles!");
00115           }
00116
00117   /* Check number of air parcels... */
00118   if (atm->np <= 0)
00119     ERRMSG("Did not create any air parcels!");
00120
00121   /* Initialize mass... */
00122   if (ctl.qnt_m >= 0)
00123     for (ip = 0; ip < atm->np; ip++)
00124       atm->q[ctl.qnt_m][ip] = m / atm->np;
00125
00126   /* Save data... */
00127   write_atm(argv[2], &ctl, atm, t0);
00128
00129   /* Free... */
00130   gsl_rng_free(rng);
00131   free(atm);
00132
00133   return EXIT_SUCCESS;
00134 }
```

5.9 jsec2time.c File Reference

Convert Julian seconds to date.

Functions

- int main (int argc, char ∗argv[ ])

5.9.1 Detailed Description

Convert Julian seconds to date.

Definition in file jsec2time.c.

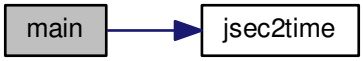
5.9.2 Function Documentation

5.9.2.1 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:



5.10 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) 2013-2015 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 }
```

5.11 libtrac.c File Reference

MPTRAC library definitions.

Functions

- void cart2geo (double *x, double *z, double *lon, double *lat)
  Convert Cartesian coordinates to geolocation.
- 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 *t, double *u, double *v, double *w, 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 *t, double *u, double *v, double *w, 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_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.
- 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.
- double tropopause (double t, double lat)
- 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.

5.11.1 Detailed Description

MPTRAC library definitions.

Definition in file libtrac.c.

5.11.2 Function Documentation

5.11.2.1 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 }
```

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

Convert degrees to horizontal distance.

Definition at line 45 of file libtrac.c.

```
00047               {
00048
00049   return dlon * M_PI * RE / 180. * cos(lat / 180. * M_PI);
00050 }
```

5.11.2.3 double deg2dy (double *dlat*)

Convert degrees to horizontal distance.

Definition at line 54 of file libtrac.c.

```
00055                {
00056
00057   return dlat * M_PI * RE / 180.;
00058 }
```

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

Convert pressure to vertical distance.

Definition at line 62 of file libtrac.c.

```
00064             {
00065
00066   return -dp * H0 / p;
00067 }
```

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

Convert horizontal distance to degrees.

Definition at line 71 of file libtrac.c.

```
00073               {
00074
00075   /* Avoid singularity at poles... */
00076   if (lat < -89.999 || lat > 89.999)
00077     return 0;
00078   else
00079     return dx * 180. / (M_PI * RE * cos(lat / 180. * M_PI));
00080 }
```

5.11.2.6 double dy2deg (double *dy*)

Convert horizontal distance to degrees.

Definition at line 84 of file libtrac.c.

```
00085               {
00086
00087   return dy * 180. / (M_PI * RE);
00088 }
```

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

Convert vertical distance to pressure.

Definition at line 92 of file libtrac.c.

```
00094             {
00095
00096   return -dz * p / H0;
00097 }
```

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

Convert geolocation to Cartesian coordinates.

Definition at line 101 of file libtrac.c.

```
00105              {
00106
00107   double radius;
00108
00109   radius = z + RE;
00110   x[0] = radius * cos(lat / 180 * M_PI) * cos(lon / 180 * M_PI);
00111   x[1] = radius * cos(lat / 180 * M_PI) * sin(lon / 180 * M_PI);
00112   x[2] = radius * sin(lat / 180 * M_PI);
00113 }
```

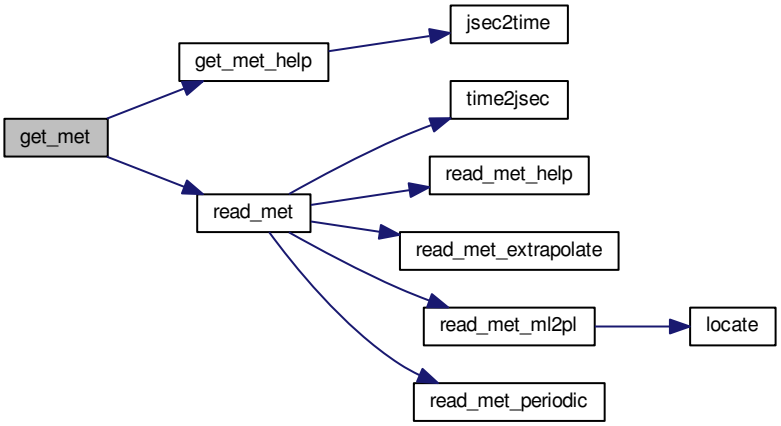
5.11.2.9 void get_met (ctl_t * *ctl*, char * *metbase*, double *t*, met_t * *met0*, met_t * *met1*)

Get meteorological data for given timestep.

Definition at line 117 of file libtrac.c.

```
00122                {
00123
00124   char filename[LEN];
00125
00126   static int init;
00127
00128   /* Init... */
00129   if (!init) {
00130     init = 1;
00131
00132     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00133     read_met(ctl, filename, met0);
00134
00135     get_met_help(t + 1.0 * ctl->direction, 1, metbase, ctl->
      dt_met, filename);
00136     read_met(ctl, filename, met1);
00137   }
00138
00139   /* Read new data for forward trajectories... */
00140   if (t > met1->time && ctl->direction == 1) {
00141     memcpy(met0, met1, sizeof(met_t));
00142     get_met_help(t, 1, metbase, ctl->dt_met, filename);
00143     read_met(ctl, filename, met1);
00144   }
00145
00146   /* Read new data for backward trajectories... */
00147   if (t < met0->time && ctl->direction == -1) {
00148     memcpy(met1, met0, sizeof(met_t));
00149     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00150     read_met(ctl, filename, met0);
00151   }
00152 }
```

Here is the call graph for this function:



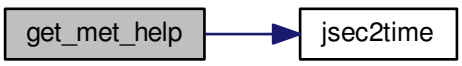
5.11.2.10 void get_met_help (double *t*, int *direct*, char * *metbase*, double *dt_met*, char * *filename*)

Get meteorological data for timestep.

Definition at line 156 of file libtrac.c.

```
00161                   {
00162
00163   double t6, r;
00164
00165   int year, mon, day, hour, min, sec;
00166
00167   /* Round time to fixed intervals... */
00168   if (direct == -1)
00169     t6 = floor(t / dt_met) * dt_met;
00170   else
00171     t6 = ceil(t / dt_met) * dt_met;
00172
00173   /* Decode time... */
00174   jsec2time(t6, &year, &mon, &day, &hour, &min, &sec, &r);
00175
00176   /* Set filename... */
00177   sprintf(filename, "%s_%d_%02d_%02d_%02d.nc", metbase, year, mon, day, hour);
00178 }
```

Here is the call graph for this function:



5.11.2.11 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 182 of file libtrac.c.

```
00188                {
00189
00190   double aux00, aux01, aux10, aux11;
00191
00192   /* Set variables... */
00193   aux00 = array[ix][iy];
00194   aux01 = array[ix][iy + 1];
00195   aux10 = array[ix + 1][iy];
00196   aux11 = array[ix + 1][iy + 1];
00197
00198   /* Interpolate horizontally... */
00199   aux00 = wy * (aux00 - aux01) + aux01;
00200   aux11 = wy * (aux10 - aux11) + aux11;
00201   *var = wx * (aux00 - aux11) + aux11;
00202 }
```

5.11.2.12 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 206 of file libtrac.c.

```
00214                {
00215
00216   double aux00, aux01, aux10, aux11;
00217
00218   /* Interpolate vertically... */
00219   aux00 = wp * (array[ix][iy][ip] - array[ix][iy][ip + 1])
00220     + array[ix][iy][ip + 1];
00221   aux01 = wp * (array[ix][iy + 1][ip] - array[ix][iy + 1][ip + 1])
00222     + array[ix][iy + 1][ip + 1];
00223   aux10 = wp * (array[ix + 1][iy][ip] - array[ix + 1][iy][ip + 1])
00224     + array[ix + 1][iy][ip + 1];
00225   aux11 = wp * (array[ix + 1][iy + 1][ip] - array[ix + 1][iy + 1][ip + 1])
00226     + array[ix + 1][iy + 1][ip + 1];
00227
00228   /* Interpolate horizontally... */
00229   aux00 = wy * (aux00 - aux01) + aux01;
00230   aux11 = wy * (aux10 - aux11) + aux11;
00231   *var = wx * (aux00 - aux11) + aux11;
00232 }
```

5.11.2.13 void intpol_met_space (met_t * *met*, double *p*, double *lon*, double *lat*, double * *ps*, double * *t*, double * *u*, double * *v*, double * *w*, double * *h2o*, double * *o3*)

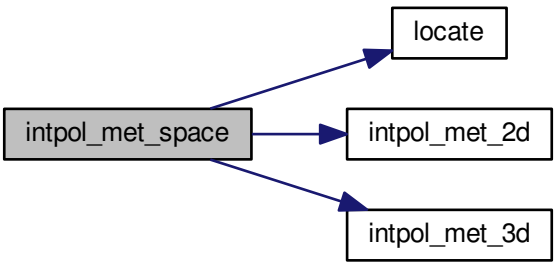
Spatial interpolation of meteorological data.

Definition at line 236 of file libtrac.c.

```
00247                {
00248
00249   double wp, wx, wy;
00250
00251   int ip, ix, iy;
00252
00253   /* Check longitude... */
00254   if (met->lon[met->nx - 1] > 180 && lon < 0)
00255     lon += 360;
00256
00257   /* Get indices... */
00258   ip = locate(met->p, met->np, p);
00259   ix = locate(met->lon, met->nx, lon);
00260   iy = locate(met->lat, met->ny, lat);
```

```
00261
00262   /* Get weights... */
00263   wp = (met->p[ip + 1] - p) / (met->p[ip + 1] - met->p[ip]);
00264   wx = (met->lon[ix + 1] - lon) / (met->lon[ix + 1] - met->lon[ix]);
00265   wy = (met->lat[iy + 1] - lat) / (met->lat[iy + 1] - met->lat[iy]);
00266
00267   /* Interpolate... */
00268   if (ps != NULL)
00269     intpol_met_2d(met->ps, ix, iy, wx, wy, ps);
00270   if (t != NULL)
00271     intpol_met_3d(met->t, ip, ix, iy, wp, wx, wy, t);
00272   if (u != NULL)
00273     intpol_met_3d(met->u, ip, ix, iy, wp, wx, wy, u);
00274   if (v != NULL)
00275     intpol_met_3d(met->v, ip, ix, iy, wp, wx, wy, v);
00276   if (w != NULL)
00277     intpol_met_3d(met->w, ip, ix, iy, wp, wx, wy, w);
00278   if (h2o != NULL)
00279     intpol_met_3d(met->h2o, ip, ix, iy, wp, wx, wy, h2o);
00280   if (o3 != NULL)
00281     intpol_met_3d(met->o3, ip, ix, iy, wp, wx, wy, o3);
00282 }
```

Here is the call graph for this function:



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

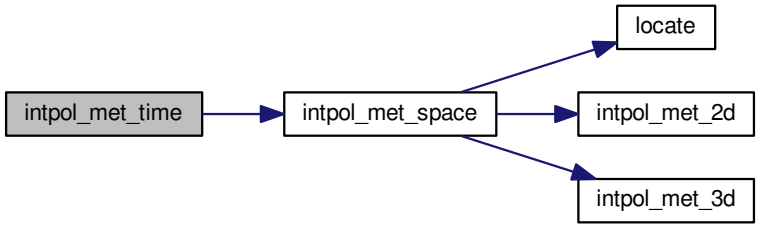
Temporal interpolation of meteorological data.

Definition at line 286 of file libtrac.c.

```
00299             {
00300
00301   double h2o0, h2o1, o30, o31, ps0, ps1, t0, t1, u0, u1, v0, v1, w0, w1, wt;
00302
00303   /* Spatial interpolation... */
00304   intpol_met_space(met0, p, lon, lat,
00305                    ps == NULL ? NULL : &ps0,
00306                    t == NULL ? NULL : &t0,
00307                    u == NULL ? NULL : &u0,
00308                    v == NULL ? NULL : &v0,
00309                    w == NULL ? NULL : &w0,
00310                    h2o == NULL ? NULL : &h2o0, o3 == NULL ? NULL : &o30);
00311   intpol_met_space(met1, p, lon, lat,
00312                    ps == NULL ? NULL : &ps1,
00313                    t == NULL ? NULL : &t1,
00314                    u == NULL ? NULL : &u1,
00315                    v == NULL ? NULL : &v1,
00316                    w == NULL ? NULL : &w1,
00317                    h2o == NULL ? NULL : &h2o1, o3 == NULL ? NULL : &o31);
00318
```

```
00319   /* Get weighting factor... */
00320   wt = (met1->time - ts) / (met1->time - met0->time);
00321
00322   /* Interpolate... */
00323   if (ps != NULL)
00324     *ps = wt * (ps0 - ps1) + ps1;
00325   if (t != NULL)
00326     *t = wt * (t0 - t1) + t1;
00327   if (u != NULL)
00328     *u = wt * (u0 - u1) + u1;
00329   if (v != NULL)
00330     *v = wt * (v0 - v1) + v1;
00331   if (w != NULL)
00332     *w = wt * (w0 - w1) + w1;
00333   if (h2o != NULL)
00334     *h2o = wt * (h2o0 - h2o1) + h2o1;
00335   if (o3 != NULL)
00336     *o3 = wt * (o30 - o31) + o31;
00337 }
```

Here is the call graph for this function:



5.11.2.15 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 341 of file libtrac.c.

```
00349                   {
00350
00351   struct tm t0, *t1;
00352
00353   time_t jsec0;
00354
00355   t0.tm_year = 100;
00356   t0.tm_mon = 0;
00357   t0.tm_mday = 1;
00358   t0.tm_hour = 0;
00359   t0.tm_min = 0;
00360   t0.tm_sec = 0;
00361
00362   jsec0 = (time_t) jsec + timegm(&t0);
00363   t1 = gmtime(&jsec0);
00364
00365   *year = t1->tm_year + 1900;
00366   *mon = t1->tm_mon + 1;
00367   *day = t1->tm_mday;
00368   *hour = t1->tm_hour;
00369   *min = t1->tm_min;
00370   *sec = t1->tm_sec;
00371   *remain = jsec - floor(jsec);
00372 }
```

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

Find array index.

Definition at line 376 of file libtrac.c.

```
00379            {
00380
00381   int i, ilo, ihi;
00382
00383   ilo = 0;
00384   ihi = n - 1;
00385   i = (ihi + ilo) >> 1;
00386
00387   if (xx[i] < xx[i + 1])
00388     while (ihi > ilo + 1) {
00389       i = (ihi + ilo) >> 1;
00390       if (xx[i] > x)
00391         ihi = i;
00392       else
00393         ilo = i;
00394   } else
00395     while (ihi > ilo + 1) {
00396       i = (ihi + ilo) >> 1;
00397       if (xx[i] <= x)
00398         ihi = i;
00399       else
00400         ilo = i;
00401     }
00402
00403   return ilo;
00404 }
```

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

Read atmospheric data.

Definition at line 408 of file libtrac.c.

```
00411               {
00412
00413   FILE *in;
00414
00415   char line[LEN], *tok;
00416
00417   int iq;
00418
00419   /* Init... */
00420   atm->np = 0;
00421
00422   /* Write info... */
00423   printf("Read atmospheric data: %s\n", filename);
00424
00425   /* Open file... */
00426   if (!(in = fopen(filename, "r")))
00427     ERRMSG("Cannot open file!");
00428
00429   /* Read line... */
00430   while (fgets(line, LEN, in)) {
00431
00432     /* Read data... */
00433     TOK(line, tok, "%lg", atm->time[atm->np]);
00434     TOK(NULL, tok, "%lg", atm->p[atm->np]);
00435     TOK(NULL, tok, "%lg", atm->lon[atm->np]);
00436     TOK(NULL, tok, "%lg", atm->lat[atm->np]);
00437     for (iq = 0; iq < ctl->nq; iq++)
00438       TOK(NULL, tok, "%lg", atm->q[iq][atm->np]);
00439
00440     /* Convert altitude to pressure... */
00441     atm->p[atm->np] = P(atm->p[atm->np]);
00442
00443     /* Increment data point counter... */
00444     if ((++atm->np) > NP)
00445       ERRMSG("Too many data points!");
00446   }
00447
00448   /* Close file... */
00449   fclose(in);
00450
00451   /* Check number of points... */
00452   if (atm->np < 1)
00453     ERRMSG("Can not read any data!");
00454 }
```

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

Read control parameters.

Definition at line 458 of file libtrac.c.

```
00462               {
00463
00464   int ip, iq;
00465
00466   /* Write info... */
00467   printf("\nMassive-Parallel Trajectory Calculations (MPTRAC)\n"
00468          "(executable: %s | compiled: %s, %s)\n\n",
00469          argv[0], __DATE__, __TIME__);
00470
00471   /* Initialize quantity indices... */
00472   ctl->qnt_ens = -1;
00473   ctl->qnt_m = -1;
00474   ctl->qnt_r = -1;
00475   ctl->qnt_rho = -1;
00476   ctl->qnt_ps = -1;
00477   ctl->qnt_p = -1;
00478   ctl->qnt_t = -1;
00479   ctl->qnt_u = -1;
00480   ctl->qnt_v = -1;
00481   ctl->qnt_w = -1;
00482   ctl->qnt_h2o = -1;
00483   ctl->qnt_o3 = -1;
00484   ctl->qnt_theta = -1;
00485   ctl->qnt_pv = -1;
00486   ctl->qnt_tice = -1;
00487   ctl->qnt_tsts = -1;
00488   ctl->qnt_tnat = -1;
00489   ctl->qnt_gw_var = -1;
00490   ctl->qnt_stat = -1;
00491
00492   /* Read quantities... */
00493   ctl->nq = (int) scan_ctl(filename, argc, argv, "NQ", -1, "0", NULL);
00494   if (ctl->nq > NQ)
00495     ERRMSG("Too many quantities!");
00496   for (iq = 0; iq < ctl->nq; iq++) {
00497
00498     /* Read quantity name and format... */
00499     scan_ctl(filename, argc, argv, "QNT_NAME", iq, "", ctl->qnt_name[iq]);
00500     scan_ctl(filename, argc, argv, "QNT_FORMAT", iq, "%g",
00501              ctl->qnt_format[iq]);
00502
00503     /* Try to identify quantity... */
00504     if (strcmp(ctl->qnt_name[iq], "ens") == 0) {
00505       ctl->qnt_ens = iq;
00506       sprintf(ctl->qnt_unit[iq], "-");
00507     } else if (strcmp(ctl->qnt_name[iq], "m") == 0) {
00508       ctl->qnt_m = iq;
00509       sprintf(ctl->qnt_unit[iq], "kg");
00510     } else if (strcmp(ctl->qnt_name[iq], "r") == 0) {
00511       ctl->qnt_r = iq;
00512       sprintf(ctl->qnt_unit[iq], "m");
00513     } else if (strcmp(ctl->qnt_name[iq], "rho") == 0) {
00514       ctl->qnt_rho = iq;
00515       sprintf(ctl->qnt_unit[iq], "kg/m^3");
00516     } else if (strcmp(ctl->qnt_name[iq], "ps") == 0) {
00517       ctl->qnt_ps = iq;
00518       sprintf(ctl->qnt_unit[iq], "hPa");
00519     } else if (strcmp(ctl->qnt_name[iq], "p") == 0) {
00520       ctl->qnt_p = iq;
00521       sprintf(ctl->qnt_unit[iq], "hPa");
00522     } else if (strcmp(ctl->qnt_name[iq], "t") == 0) {
00523       ctl->qnt_t = iq;
00524       sprintf(ctl->qnt_unit[iq], "K");
00525     } else if (strcmp(ctl->qnt_name[iq], "u") == 0) {
00526       ctl->qnt_u = iq;
00527       sprintf(ctl->qnt_unit[iq], "m/s");
00528     } else if (strcmp(ctl->qnt_name[iq], "v") == 0) {
00529       ctl->qnt_v = iq;
00530       sprintf(ctl->qnt_unit[iq], "m/s");
00531     } else if (strcmp(ctl->qnt_name[iq], "w") == 0) {
00532       ctl->qnt_w = iq;
00533       sprintf(ctl->qnt_unit[iq], "hPa/s");
00534     } else if (strcmp(ctl->qnt_name[iq], "h2o") == 0) {
00535       ctl->qnt_h2o = iq;
00536       sprintf(ctl->qnt_unit[iq], "1");
00537     } else if (strcmp(ctl->qnt_name[iq], "o3") == 0) {
00538       ctl->qnt_o3 = iq;
```

```
00539       sprintf(ctl->qnt_unit[iq], "1");
00540     } else if (strcmp(ctl->qnt_name[iq], "theta") == 0) {
00541       ctl->qnt_theta = iq;
00542       sprintf(ctl->qnt_unit[iq], "K");
00543     } else if (strcmp(ctl->qnt_name[iq], "pv") == 0) {
00544       ctl->qnt_pv = iq;
00545       sprintf(ctl->qnt_unit[iq], "PVU");
00546     } else if (strcmp(ctl->qnt_name[iq], "tice") == 0) {
00547       ctl->qnt_tice = iq;
00548       sprintf(ctl->qnt_unit[iq], "K");
00549     } else if (strcmp(ctl->qnt_name[iq], "tsts") == 0) {
00550       ctl->qnt_tsts = iq;
00551       sprintf(ctl->qnt_unit[iq], "K");
00552     } else if (strcmp(ctl->qnt_name[iq], "tnat") == 0) {
00553       ctl->qnt_tnat = iq;
00554       sprintf(ctl->qnt_unit[iq], "K");
00555     } else if (strcmp(ctl->qnt_name[iq], "gw_var") == 0) {
00556       ctl->qnt_gw_var = iq;
00557       sprintf(ctl->qnt_unit[iq], "K^2");
00558     } else if (strcmp(ctl->qnt_name[iq], "stat") == 0) {
00559       ctl->qnt_stat = iq;
00560       sprintf(ctl->qnt_unit[iq], "-");
00561     } else
00562       scan_ctl(filename, argc, argv, "QNT_UNIT", iq, "", ctl->qnt_unit[iq]);
00563   }
00564
00565   /* Time steps of simulation... */
00566   ctl->direction =
00567     (int) scan_ctl(filename, argc, argv, "DIRECTION", -1, "1", NULL);
00568   if (ctl->direction != -1 && ctl->direction != 1)
00569     ERRMSG("Set DIRECTION to -1 or 1!");
00570   ctl->t_start =
00571     scan_ctl(filename, argc, argv, "T_START", -1, "-1e100", NULL);
00572   ctl->t_stop = scan_ctl(filename, argc, argv, "T_STOP", -1, "-1e100", NULL);
00573   ctl->dt_mod = scan_ctl(filename, argc, argv, "DT_MOD", -1, "600", NULL);
00574
00575   /* Meteorological data... */
00576   ctl->dt_met = scan_ctl(filename, argc, argv, "DT_MET", -1, "21600", NULL);
00577   ctl->met_np = (int) scan_ctl(filename, argc, argv, "MET_NP", -1, "0", NULL);
00578   if (ctl->met_np > EP)
00579     ERRMSG("Too many levels!");
00580   for (ip = 0; ip < ctl->met_np; ip++)
00581     ctl->met_p[ip] = scan_ctl(filename, argc, argv, "MET_P", ip, "", NULL);
00582   scan_ctl(filename, argc, argv, "MET_STAGE", -1, "-", ctl->met_stage);
00583
00584   /* Isosurface parameters... */
00585   ctl->isosurf
00586     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
00587   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
00588
00589   /* Diffusion parameters... */
00590   ctl->turb_dx_trop
00591     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50.0", NULL);
00592   ctl->turb_dx_strat
00593     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0.0", NULL);
00594   ctl->turb_dz_trop
00595     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0.0", NULL);
00596   ctl->turb_dz_strat
00597     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
00598   ctl->turb_meso =
00599     scan_ctl(filename, argc, argv, "TURB_MESO", -1, "0.16", NULL);
00600
00601   /* Life time of particles... */
00602   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
00603   ctl->tdec_strat =
00604     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
00605
00606   /* PSC analysis... */
00607   ctl->psc_h2o = scan_ctl(filename, argc, argv, "PSC_H2O", -1, "4e-6", NULL);
00608   ctl->psc_hno3 =
00609     scan_ctl(filename, argc, argv, "PSC_HNO3", -1, "9e-9", NULL);
00610
00611   /* Gravity wave analysis... */
00612   scan_ctl(filename, argc, argv, "GW_BASENAME", -1, "-", ctl->
      gw_basename);
00613
00614   /* Output of atmospheric data... */
00615   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
      atm_basename);
00616   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
00617   ctl->atm_dt_out =
00618     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
00619   ctl->atm_filter =
00620     (int) scan_ctl(filename, argc, argv, "ATM_FILTER", -1, "0", NULL);
00621
00622   /* Output of CSI data... */
00623   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
```

```
      csi_basename);
00624   ctl->csi_dt_out =
00625     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
00626   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "obs.tab",
00627            ctl->csi_obsfile);
00628   ctl->csi_obsmin =
00629     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
00630   ctl->csi_modmin =
00631     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
00632   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
00633   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
00634   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
00635   ctl->csi_lon0 =
00636     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
00637   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
00638   ctl->csi_nx =
00639     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
00640   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
00641   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
00642   ctl->csi_ny =
00643     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
00644
00645   /* Output of ensemble data... */
00646   scan_ctl(filename, argc, argv, "ENS_BASENAME", -1, "-", ctl->
      ens_basename);
00647
00648   /* Output of grid data... */
00649   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
00650            ctl->grid_basename);
00651   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
      grid_gpfile);
00652   ctl->grid_dt_out =
00653     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
00654   ctl->grid_sparse =
00655     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
00656   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
00657   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
00658   ctl->grid_nz =
00659     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
00660   ctl->grid_lon0 =
00661     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
00662   ctl->grid_lon1 =
00663     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
00664   ctl->grid_nx =
00665     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
00666   ctl->grid_lat0 =
00667     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
00668   ctl->grid_lat1 =
00669     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
00670   ctl->grid_ny =
00671     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
00672
00673   /* Output of profile data... */
00674   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
00675            ctl->prof_basename);
00676   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
      prof_obsfile);
00677   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
00678   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
00679   ctl->prof_nz =
00680     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
00681   ctl->prof_lon0 =
00682     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
00683   ctl->prof_lon1 =
00684     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
00685   ctl->prof_nx =
00686     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
00687   ctl->prof_lat0 =
00688     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
00689   ctl->prof_lat1 =
00690     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
00691   ctl->prof_ny =
00692     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
00693
00694   /* Output of station data... */
00695   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
00696            ctl->stat_basename);
00697   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
00698   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
00699   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
00700 }
```

Here is the call graph for this function:

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

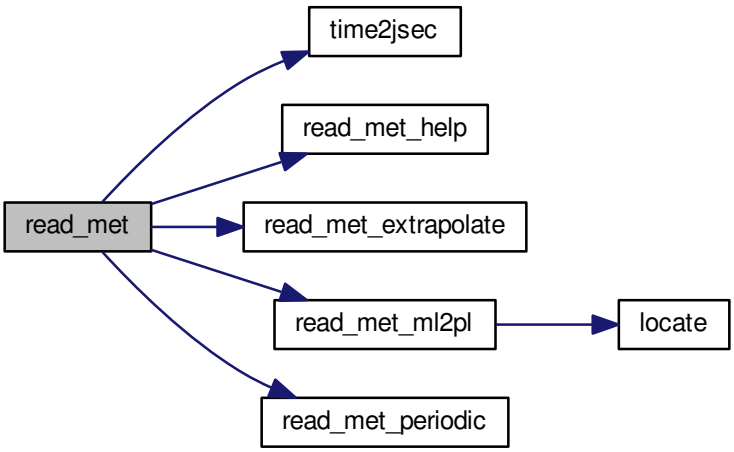
Read meteorological data file.

Definition at line 704 of file libtrac.c.

```
00707               {
00708
00709   char cmd[LEN], levname[LEN], tstr[10];
00710
00711   static float help[EX * EY];
00712
00713   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
00714
00715   size_t np, nx, ny;
00716
00717   /* Write info... */
00718   printf("Read meteorological data: %s\n", filename);
00719
00720   /* Get time from filename... */
00721   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
00722   year = atoi(tstr);
00723   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
00724   mon = atoi(tstr);
00725   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
00726   day = atoi(tstr);
00727   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
00728   hour = atoi(tstr);
00729   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
00730
00731   /* Open netCDF file... */
00732   if (nc_open(filename, NC_NOWRITE, &ncid) != NC_NOERR) {
00733
00734     /* Try to stage meteo file... */
00735     START_TIMER(TIMER_STAGE);
00736     if (ctl->met_stage[0] != '-') {
00737       sprintf(cmd, "%s %d %02d %02d %02d %s", ctl->met_stage,
00738               year, mon, day, hour, filename);
00739       if (system(cmd) != 0)
00740         ERRMSG("Error while staging meteo data!");
00741     }
00742     STOP_TIMER(TIMER_STAGE);
00743
00744     /* Try to open again... */
00745     NC(nc_open(filename, NC_NOWRITE, &ncid));
00746   }
00747
00748   /* Get dimensions... */
00749   NC(nc_inq_dimid(ncid, "lon", &dimid));
00750   NC(nc_inq_dimlen(ncid, dimid, &nx));
00751   if (nx < 2 || nx > EX)
00752     ERRMSG("Number of longitudes out of range!");
00753
00754   NC(nc_inq_dimid(ncid, "lat", &dimid));
00755   NC(nc_inq_dimlen(ncid, dimid, &ny));
00756   if (ny < 2 || ny > EY)
00757     ERRMSG("Number of latitudes out of range!");
00758
00759   sprintf(levname, "lev");
00760   NC(nc_inq_dimid(ncid, levname, &dimid));
00761   NC(nc_inq_dimlen(ncid, dimid, &np));
00762   if (np == 1) {
00763     sprintf(levname, "lev_2");
```

```
00764     NC(nc_inq_dimid(ncid, levname, &dimid));
00765     NC(nc_inq_dimlen(ncid, dimid, &np));
00766   }
00767   if (np < 2 || np > EP)
00768     ERRMSG("Number of levels out of range!");
00769
00770   /* Store dimensions... */
00771   met->np = (int) np;
00772   met->nx = (int) nx;
00773   met->ny = (int) ny;
00774
00775   /* Get horizontal grid... */
00776   NC(nc_inq_varid(ncid, "lon", &varid));
00777   NC(nc_get_var_double(ncid, varid, met->lon));
00778   NC(nc_inq_varid(ncid, "lat", &varid));
00779   NC(nc_get_var_double(ncid, varid, met->lat));
00780
00781   /* Read meteorological data... */
00782   read_met_help(ncid, "t", "T", met, met->t, 1.0);
00783   read_met_help(ncid, "u", "U", met, met->u, 1.0);
00784   read_met_help(ncid, "v", "V", met, met->v, 1.0);
00785   read_met_help(ncid, "w", "W", met, met->w, 0.01f);
00786   read_met_help(ncid, "q", "Q", met, met->h2o, 1.608f);
00787   read_met_help(ncid, "o3", "O3", met, met->o3, 0.602f);
00788
00789   /* Meteo data on pressure levels... */
00790   if (ctl->met_np <= 0) {
00791
00792     /* Read pressure levels from file... */
00793     NC(nc_inq_varid(ncid, levname, &varid));
00794     NC(nc_get_var_double(ncid, varid, met->p));
00795     for (ip = 0; ip < met->np; ip++)
00796       met->p[ip] /= 100.;
00797
00798     /* Extrapolate data for lower boundary... */
00799     read_met_extrapolate(met);
00800   }
00801
00802   /* Meteo data on model levels... */
00803   else {
00804
00805     /* Read pressure data from file... */
00806     read_met_help(ncid, "pl", "PL", met, met->pl, 0.01f);
00807
00808     /* Interpolate from model levels to pressure levels... */
00809     read_met_ml2pl(ctl, met, met->t);
00810     read_met_ml2pl(ctl, met, met->u);
00811     read_met_ml2pl(ctl, met, met->v);
00812     read_met_ml2pl(ctl, met, met->w);
00813     read_met_ml2pl(ctl, met, met->h2o);
00814     read_met_ml2pl(ctl, met, met->o3);
00815
00816     /* Set pressure levels... */
00817     met->np = ctl->met_np;
00818     for (ip = 0; ip < met->np; ip++)
00819       met->p[ip] = ctl->met_p[ip];
00820   }
00821
00822   /* Check ordering of pressure levels... */
00823   for (ip = 1; ip < met->np; ip++)
00824     if (met->p[ip - 1] < met->p[ip])
00825       ERRMSG("Pressure levels must be descending!");
00826
00827   /* Read surface pressure... */
00828   if (nc_inq_varid(ncid, "ps", &varid) == NC_NOERR
00829       || nc_inq_varid(ncid, "PS", &varid) == NC_NOERR) {
00830     NC(nc_get_var_float(ncid, varid, help));
00831     for (iy = 0; iy < met->ny; iy++)
00832       for (ix = 0; ix < met->nx; ix++)
00833         met->ps[ix][iy] = help[iy * met->nx + ix] / 100.;
00834   } else if (nc_inq_varid(ncid, "lnsp", &varid) == NC_NOERR
00835              || nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
00836     NC(nc_get_var_float(ncid, varid, help));
00837     for (iy = 0; iy < met->ny; iy++)
00838       for (ix = 0; ix < met->nx; ix++)
00839         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
00840   } else
00841     for (ix = 0; ix < met->nx; ix++)
00842       for (iy = 0; iy < met->ny; iy++)
00843         met->ps[ix][iy] = met->p[0];
00844
00845   /* Create periodic boundary conditions... */
00846   read_met_periodic(met);
00847
00848   /* Close file... */
00849   NC(nc_close(ncid));
00850 }
```

Here is the call graph for this function:



5.11.2.20 void read_met_extrapolate (met_t * *met*)

Extrapolate meteorological data at lower boundary.

Definition at line 854 of file libtrac.c.

```
00855                {
00856
00857   int ip, ip0, ix, iy;
00858
00859   /* Loop over columns... */
00860   for (ix = 0; ix < met->nx; ix++)
00861     for (iy = 0; iy < met->ny; iy++) {
00862
00863       /* Find lowest valid data point... */
00864       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
00865         if (!gsl_finite(met->t[ix][iy][ip0])
00866             || !gsl_finite(met->u[ix][iy][ip0])
00867             || !gsl_finite(met->v[ix][iy][ip0])
00868             || !gsl_finite(met->w[ix][iy][ip0]))
00869           break;
00870
00871       /* Extrapolate... */
00872       for (ip = ip0; ip >= 0; ip--) {
00873         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
00874         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
00875         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
00876         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
00877         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
00878         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
00879       }
00880     }
00881 }
```

5.11.2.21 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 885 of file libtrac.c.

```
00891             {
00892
00893   static float help[EX * EY * EP];
00894
00895   int ip, ix, iy, n = 0, varid;
00896
00897   /* Check if variable exists... */
00898   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
00899     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
00900       return;
00901
00902   /* Read data... */
00903   NC(nc_get_var_float(ncid, varid, help));
00904
00905   /* Copy and check data... */
00906   for (ip = 0; ip < met->np; ip++)
00907     for (iy = 0; iy < met->ny; iy++)
00908       for (ix = 0; ix < met->nx; ix++) {
00909         dest[ix][iy][ip] = scl * help[n++];
00910         if (fabs(dest[ix][iy][ip] / scl) > 1e14)
00911           dest[ix][iy][ip] = GSL_NAN;
00912       }
00913 }
```

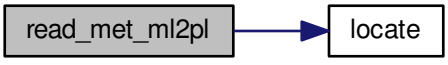
5.11.2.22 void read_met_ml2pl (ctl_t * *ctl*, met_t * *met*, float *var[EX][EY][EP]*)

Convert meteorological data from model levels to pressure levels.

Definition at line 917 of file libtrac.c.

```
00920                         {
00921
00922   double aux[EP], p[EP], pt;
00923
00924   int ip, ip2, ix, iy;
00925
00926   /* Loop over columns... */
00927   for (ix = 0; ix < met->nx; ix++)
00928     for (iy = 0; iy < met->ny; iy++) {
00929
00930       /* Copy pressure profile... */
00931       for (ip = 0; ip < met->np; ip++)
00932         p[ip] = met->pl[ix][iy][ip];
00933
00934       /* Interpolate... */
00935       for (ip = 0; ip < ctl->met_np; ip++) {
00936         pt = ctl->met_p[ip];
00937         if ((pt > p[0] && p[0] > p[1]) || (pt < p[0] && p[0] < p[1]))
00938           pt = p[0];
00939         else if ((pt > p[met->np - 1] && p[1] > p[0])
00940                  || (pt < p[met->np - 1] && p[1] < p[0]))
00941           pt = p[met->np - 1];
00942         ip2 = locate(p, met->np, pt);
00943         aux[ip] = LIN(p[ip2], var[ix][iy][ip2],
00944                       p[ip2 + 1], var[ix][iy][ip2 + 1], pt);
00945       }
00946
00947       /* Copy data... */
00948       for (ip = 0; ip < ctl->met_np; ip++)
00949         var[ix][iy][ip] = (float) aux[ip];
00950     }
00951 }
```

Here is the call graph for this function:



5.11.2.23 void read_met_periodic (met_t * *met*)

Create meteorological data with periodic boundary conditions.

Definition at line 955 of file libtrac.c.

```
00956                {
00957
00958   int ip, iy;
00959
00960   /* Check longitudes... */
00961   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
00962              + met->lon[1] - met->lon[0] - 360) < 0.01))
00963     return;
00964
00965   /* Increase longitude counter... */
00966   if ((++met->nx) > EX)
00967     ERRMSG("Cannot create periodic boundary conditions!");
00968
00969   /* Set longitude... */
00970   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
00971
00972   /* Loop over latitudes and pressure levels... */
00973   for (iy = 0; iy < met->ny; iy++)
00974     for (ip = 0; ip < met->np; ip++) {
00975       met->ps[met->nx - 1][iy] = met->ps[0][iy];
00976       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
00977       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
00978       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
00979       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
00980       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
00981       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
00982     }
00983 }
```

5.11.2.24 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 987 of file libtrac.c.

```
00994                {
00995
00996   FILE *in = NULL;
00997
00998   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
00999     msg[LEN], rvarname[LEN], rval[LEN];
01000
01001   int contain = 0, i;
01002
01003   /* Open file... */
01004   if (filename[strlen(filename) - 1] != '-')
01005     if (!(in = fopen(filename, "r")))
01006       ERRMSG("Cannot open file!");
01007
01008   /* Set full variable name... */
01009   if (arridx >= 0) {
01010     sprintf(fullname1, "%s[%d]", varname, arridx);
01011     sprintf(fullname2, "%s[*]", varname);
01012   } else {
01013     sprintf(fullname1, "%s", varname);
01014     sprintf(fullname2, "%s", varname);
01015   }
01016
01017   /* Read data... */
01018   if (in != NULL)
01019     while (fgets(line, LEN, in))
01020       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
01021         if (strcasecmp(rvarname, fullname1) == 0 ||
01022             strcasecmp(rvarname, fullname2) == 0) {
01023           contain = 1;
01024           break;
01025         }
01026   for (i = 1; i < argc - 1; i++)
```

```
01027     if (strcasecmp(argv[i], fullname1) == 0 ||
01028         strcasecmp(argv[i], fullname2) == 0) {
01029       sprintf(rval, "%s", argv[i + 1]);
01030       contain = 1;
01031       break;
01032     }
01033
01034   /* Close file... */
01035   if (in != NULL)
01036     fclose(in);
01037
01038   /* Check for missing variables... */
01039   if (!contain) {
01040     if (strlen(defvalue) > 0)
01041       sprintf(rval, "%s", defvalue);
01042     else {
01043       sprintf(msg, "Missing variable %s!\n", fullname1);
01044       ERRMSG(msg);
01045     }
01046   }
01047
01048   /* Write info... */
01049   printf("%s = %s\n", fullname1, rval);
01050
01051   /* Return values... */
01052   if (value != NULL)
01053     sprintf(value, "%s", rval);
01054   return atof(rval);
01055 }
```

5.11.2.25 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 1059 of file libtrac.c.

```
01067                 {
01068
01069   struct tm t0, t1;
01070
01071   t0.tm_year = 100;
01072   t0.tm_mon = 0;
01073   t0.tm_mday = 1;
01074   t0.tm_hour = 0;
01075   t0.tm_min = 0;
01076   t0.tm_sec = 0;
01077
01078   t1.tm_year = year - 1900;
01079   t1.tm_mon = mon - 1;
01080   t1.tm_mday = day;
01081   t1.tm_hour = hour;
01082   t1.tm_min = min;
01083   t1.tm_sec = sec;
01084
01085   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
01086 }
```

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

Measure wall-clock time.

Definition at line 1090 of file libtrac.c.

```
01093             {
01094
01095   static double starttime[NTIMER], runtime[NTIMER];
01096
01097   /* Check id... */
01098   if (id < 0 || id >= NTIMER)
01099     ERRMSG("Too many timers!");
01100
01101   /* Start timer... */
01102   if (mode == 1) {
01103     if (starttime[id] <= 0)
```

```
01104       starttime[id] = omp_get_wtime();
01105     else
01106       ERRMSG("Timer already started!");
01107   }
01108
01109   /* Stop timer... */
01110   else if (mode == 2) {
01111     if (starttime[id] > 0) {
01112       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
01113       starttime[id] = -1;
01114     } else
01115       ERRMSG("Timer not started!");
01116   }
01117
01118   /* Print timer... */
01119   else if (mode == 3)
01120     printf("%s = %g s\n", name, runtime[id]);
01121 }
```

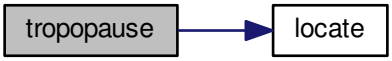
5.11.2.27 double tropopause (double *t*, double *lat*)

Definition at line 1125 of file libtrac.c.

```
01127               {
01128
01129   static double doys[12]
01130   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
01131
01132   static double lats[73]
01133     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
01134     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
01135     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
01136     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
01137     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
01138     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
01139     75, 77.5, 80, 82.5, 85, 87.5, 90
01140   };
01141
01142   static double tps[12][73]
01143     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
01144          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
01145          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
01146          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
01147          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
01148          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
01149          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
01150          275.3, 275.6, 275.4, 274.1, 273.5},
01151   {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
01152    300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
01153    150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
01154    98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
01155    98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
01156    220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
01157    284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
01158    287.5, 286.2, 285.8},
01159   {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
01160    297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
01161    161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
01162    100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
01163    99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
01164    186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
01165    279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
01166    304.3, 304.9, 306, 306.6, 306.2, 306},
01167   {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
01168    290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
01169    195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
01170    102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
01171    99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
01172    148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
01173    263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
01174    315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
01175   {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
01176    260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
01177    205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
01178    101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
01179    102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
01180    165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
01181    273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
01182    325.3, 325.8, 325.8},
01183   {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
01184    222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
```

```
01185     228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
01186     105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
01187     106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
01188     127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
01189     251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
01190     308.5, 312.2, 313.1, 313.3},
01191    {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
01192     187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
01193     235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
01194     110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
01195     111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
01196     117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
01197     224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
01198     275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
01199    {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
01200     185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
01201     233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
01202     110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
01203     112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
01204     120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
01205     230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
01206     278.2, 282.6, 287.4, 290.9, 292.5, 293},
01207    {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
01208     183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
01209     243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
01210     114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
01211     110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
01212     114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
01213     203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
01214     276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
01215    {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
01216     215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
01217     237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
01218     111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
01219     106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
01220     112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
01221     206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
01222     279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
01223     305.1},
01224    {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
01225     253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
01226     223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
01227     108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
01228     102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
01229     109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
01230     241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
01231     286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
01232    {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
01233     284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
01234     175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
01235     100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
01236     100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
01237     186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
01238     280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
01239     281.7, 281.1, 281.2}
01240    };
01241
01242    double doy, p0, p1, pt;
01243
01244    int imon, ilat;
01245
01246    /* Get day of year... */
01247    doy = fmod(t / 86400., 365.25);
01248    while (doy < 0)
01249      doy += 365.25;
01250
01251    /* Get indices... */
01252    imon = locate(doys, 12, doy);
01253    ilat = locate(lats, 73, lat);
01254
01255    /* Get tropopause pressure... */
01256    p0 = LIN(lats[ilat], tps[imon][ilat],
01257             lats[ilat + 1], tps[imon][ilat + 1], lat);
01258    p1 = LIN(lats[ilat], tps[imon + 1][ilat],
01259             lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
01260    pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
01261
01262    /* Return tropopause pressure... */
01263    return pt;
01264  }
```

Here is the call graph for this function:



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

Write atmospheric data.

Definition at line 1268 of file libtrac.c.

```
01272            {
01273
01274   FILE *in, *out;
01275
01276   char line[LEN];
01277
01278   double r, t0, t1;
01279
01280   int ip, iq, year, mon, day, hour, min, sec;
01281
01282   /* Set time interval for output... */
01283   t0 = t - 0.5 * ctl->dt_mod;
01284   t1 = t + 0.5 * ctl->dt_mod;
01285
01286   /* Check if gnuplot output is requested... */
01287   if (ctl->atm_gpfile[0] != '-') {
01288
01289     /* Write info... */
01290     printf("Plot atmospheric data: %s.png\n", filename);
01291
01292     /* Create gnuplot pipe... */
01293     if (!(out = popen("gnuplot", "w")))
01294       ERRMSG("Cannot create pipe to gnuplot!");
01295
01296     /* Set plot filename... */
01297     fprintf(out, "set out \"%s.png\"\n", filename);
01298
01299     /* Set time string... */
01300     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01301     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01302             year, mon, day, hour, min);
01303
01304     /* Dump gnuplot file to pipe... */
01305     if (!(in = fopen(ctl->atm_gpfile, "r")))
01306       ERRMSG("Cannot open file!");
01307     while (fgets(line, LEN, in))
01308       fprintf(out, "%s", line);
01309     fclose(in);
01310   }
01311
01312   else {
01313
01314     /* Write info... */
01315     printf("Write atmospheric data: %s\n", filename);
01316
01317     /* Create file... */
01318     if (!(out = fopen(filename, "w")))
01319       ERRMSG("Cannot create file!");
01320   }
01321
01322   /* Write header... */
01323   fprintf(out,
01324           "# $1 = time [s]\n"
01325           "# $2 = altitude [km]\n"
01326           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01327   for (iq = 0; iq < ctl->nq; iq++)
01328     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
```

```
01329             ctl->qnt_unit[iq]);
01330   fprintf(out, "\n");
01331
01332   /* Write data... */
01333   for (ip = 0; ip < atm->np; ip++) {
01334
01335     /* Check time... */
01336     if (ctl->atm_filter && (atm->time[ip] < t0 || atm->time[ip] > t1))
01337       continue;
01338
01339     /* Write output... */
01340     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
01341             atm->lon[ip], atm->lat[ip]);
01342     for (iq = 0; iq < ctl->nq; iq++) {
01343       fprintf(out, " ");
01344       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01345     }
01346     fprintf(out, "\n");
01347   }
01348
01349   /* Close file... */
01350   fclose(out);
01351 }
```

Here is the call graph for this function:

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

Write CSI data.

Definition at line 1355 of file libtrac.c.

```
01359             {
01360
01361   static FILE *in, *out;
01362
01363   static char line[LEN];
01364
01365   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
01366     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
01367
01368   static int init, obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
01369
01370   /* Init... */
01371   if (!init) {
01372     init = 1;
01373
01374     /* Check quantity index for mass... */
01375     if (ctl->qnt_m < 0)
01376       ERRMSG("Need quantity mass to analyze CSI!");
01377
01378     /* Open observation data file... */
01379     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
01380     if (!(in = fopen(ctl->csi_obsfile, "r")))
01381       ERRMSG("Cannot open file!");
01382
01383     /* Create new file... */
01384     printf("Write CSI data: %s\n", filename);
01385     if (!(out = fopen(filename, "w")))
01386       ERRMSG("Cannot create file!");
01387
01388     /* Write header... */
```

```
01389     fprintf(out,
01390             "# $1 = time [s]\n"
01391             "# $2 = number of hits (cx)\n"
01392             "# $3 = number of misses (cy)\n"
01393             "# $4 = number of false alarms (cz)\n"
01394             "# $5 = number of observations (cx + cy)\n"
01395             "# $6 = number of forecasts (cx + cz)\n"
01396             "# $7 = bias (forecasts/observations) [%%]\n"
01397             "# $8 = probability of detection (POD) [%%]\n"
01398             "# $9 = false alarm rate (FAR) [%%]\n"
01399             "# $10 = critical success index (CSI) [%%]\n\n");
01400   }
01401
01402   /* Set time interval... */
01403   t0 = t - 0.5 * ctl->dt_mod;
01404   t1 = t + 0.5 * ctl->dt_mod;
01405
01406   /* Initialize grid cells... */
01407   for (ix = 0; ix < ctl->csi_nx; ix++)
01408     for (iy = 0; iy < ctl->csi_ny; iy++)
01409       for (iz = 0; iz < ctl->csi_nz; iz++)
01410         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
01411
01412   /* Read data... */
01413   while (fgets(line, LEN, in)) {
01414
01415     /* Read data... */
01416     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
01417         5)
01418       continue;
01419
01420     /* Check time... */
01421     if (rt < t0)
01422       continue;
01423     if (rt > t1)
01424       break;
01425
01426     /* Calculate indices... */
01427     ix = (int) ((rlon - ctl->csi_lon0)
01428                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01429     iy = (int) ((rlat - ctl->csi_lat0)
01430                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01431     iz = (int) ((rz - ctl->csi_z0)
01432                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01433
01434     /* Check indices... */
01435     if (ix < 0 || ix >= ctl->csi_nx ||
01436         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01437       continue;
01438
01439     /* Get mean observation index... */
01440     obsmean[ix][iy][iz] += robs;
01441     obscount[ix][iy][iz]++;
01442   }
01443
01444   /* Analyze model data... */
01445   for (ip = 0; ip < atm->np; ip++) {
01446
01447     /* Check time... */
01448     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01449       continue;
01450
01451     /* Get indices... */
01452     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
01453                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01454     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
01455                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01456     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
01457                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01458
01459     /* Check indices... */
01460     if (ix < 0 || ix >= ctl->csi_nx ||
01461         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01462       continue;
01463
01464     /* Get total mass in grid cell... */
01465     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01466   }
01467
01468   /* Analyze all grid cells... */
01469   for (ix = 0; ix < ctl->csi_nx; ix++)
01470     for (iy = 0; iy < ctl->csi_ny; iy++)
01471       for (iz = 0; iz < ctl->csi_nz; iz++) {
01472
01473         /* Calculate mean observation index... */
01474         if (obscount[ix][iy][iz] > 0)
01475           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
```

```
01476
01477         /* Calculate column density... */
01478         if (modmean[ix][iy][iz] > 0) {
01479           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
01480           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
01481           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
01482           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
01483             * cos(lat * M_PI / 180.);
01484           modmean[ix][iy][iz] /= (1e6 * area);
01485         }
01486
01487         /* Calculate CSI... */
01488         if (obscount[ix][iy][iz] > 0) {
01489           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01490               modmean[ix][iy][iz] >= ctl->csi_modmin)
01491             cx++;
01492           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01493                    modmean[ix][iy][iz] < ctl->csi_modmin)
01494             cy++;
01495           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
01496                    modmean[ix][iy][iz] >= ctl->csi_modmin)
01497             cz++;
01498         }
01499       }
01500
01501   /* Write output... */
01502   if (fmod(t, ctl->csi_dt_out) == 0) {
01503
01504     /* Write... */
01505     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
01506             t, cx, cy, cz, cx + cy, cx + cz,
01507             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
01508             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
01509             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
01510             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
01511
01512     /* Set counters to zero... */
01513     cx = cy = cz = 0;
01514   }
01515
01516   /* Close file... */
01517   if (t == ctl->t_stop)
01518     fclose(out);
01519 }
```

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

Write ensemble data.

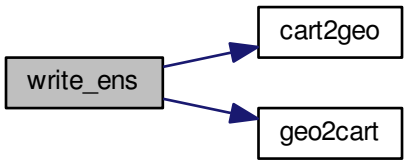
Definition at line 1523 of file libtrac.c.

```
01527             {
01528
01529   static FILE *out;
01530
01531   static double dummy, ens, lat, lon, p[NENS], q[NQ][NENS],
01532     t0, t1, x[NENS][3], xm[3];
01533
01534   static int init, ip, iq;
01535
01536   static size_t i, n;
01537
01538   /* Init... */
01539   if (!init) {
01540     init = 1;
01541
01542     /* Check quantities... */
01543     if (ctl->qnt_ens < 0)
01544       ERRMSG("Missing ensemble IDs!");
01545
01546     /* Create new file... */
01547     printf("Write ensemble data: %s\n", filename);
01548     if (!(out = fopen(filename, "w")))
01549       ERRMSG("Cannot create file!");
01550
01551     /* Write header... */
01552     fprintf(out,
01553             "# $1 = time [s]\n"
01554             "# $2 = altitude [km]\n"
01555             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
```

```
01556     for (iq = 0; iq < ctl->nq; iq++)
01557       fprintf(out, "# $%d = %s (mean) [%s]\n", 5 + iq,
01558               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
01559     for (iq = 0; iq < ctl->nq; iq++)
01560       fprintf(out, "# $%d = %s (sigma) [%s]\n", 5 + ctl->nq + iq,
01561               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
01562     fprintf(out, "# $%d = number of members\n\n", 5 + 2 * ctl->nq);
01563   }
01564
01565   /* Set time interval... */
01566   t0 = t - 0.5 * ctl->dt_mod;
01567   t1 = t + 0.5 * ctl->dt_mod;
01568
01569   /* Init... */
01570   ens = GSL_NAN;
01571   n = 0;
01572
01573   /* Loop over air parcels... */
01574   for (ip = 0; ip < atm->np; ip++) {
01575
01576     /* Check time... */
01577     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01578       continue;
01579
01580     /* Check ensemble id... */
01581     if (atm->q[ctl->qnt_ens][ip] != ens) {
01582
01583       /* Write results... */
01584       if (n > 0) {
01585
01586         /* Get mean position... */
01587         xm[0] = xm[1] = xm[2] = 0;
01588         for (i = 0; i < n; i++) {
01589           xm[0] += x[i][0] / (double) n;
01590           xm[1] += x[i][1] / (double) n;
01591           xm[2] += x[i][2] / (double) n;
01592         }
01593         cart2geo(xm, &dummy, &lon, &lat);
01594         fprintf(out, "%.2f %g %g %g", t, Z(gsl_stats_mean(p, 1, n)), lon,
01595                 lat);
01596
01597         /* Get quantity statistics... */
01598         for (iq = 0; iq < ctl->nq; iq++) {
01599           fprintf(out, " ");
01600           fprintf(out, ctl->qnt_format[iq], gsl_stats_mean(q[iq], 1, n));
01601         }
01602         for (iq = 0; iq < ctl->nq; iq++) {
01603           fprintf(out, " ");
01604           fprintf(out, ctl->qnt_format[iq], gsl_stats_sd(q[iq], 1, n));
01605         }
01606         fprintf(out, " %lu\n", n);
01607       }
01608
01609       /* Init new ensemble... */
01610       ens = atm->q[ctl->qnt_ens][ip];
01611       n = 0;
01612     }
01613
01614     /* Save data... */
01615     p[n] = atm->p[ip];
01616     geo2cart(0, atm->lon[ip], atm->lat[ip], x[n]);
01617     for (iq = 0; iq < ctl->nq; iq++)
01618       q[iq][n] = atm->q[iq][ip];
01619     if ((++n) >= NENS)
01620       ERRMSG("Too many data points!");
01621   }
01622
01623   /* Write results... */
01624   if (n > 0) {
01625
01626     /* Get mean position... */
01627     xm[0] = xm[1] = xm[2] = 0;
01628     for (i = 0; i < n; i++) {
01629       xm[0] += x[i][0] / (double) n;
01630       xm[1] += x[i][1] / (double) n;
01631       xm[2] += x[i][2] / (double) n;
01632     }
01633     cart2geo(xm, &dummy, &lon, &lat);
01634     fprintf(out, "%.2f %g %g %g", t, Z(gsl_stats_mean(p, 1, n)), lon, lat);
01635
01636     /* Get quantity statistics... */
01637     for (iq = 0; iq < ctl->nq; iq++) {
01638       fprintf(out, " ");
01639       fprintf(out, ctl->qnt_format[iq], gsl_stats_mean(q[iq], 1, n));
01640     }
01641     for (iq = 0; iq < ctl->nq; iq++) {
01642       fprintf(out, " ");
```

```
01643       fprintf(out, ctl->qnt_format[iq], gsl_stats_sd(q[iq], 1, n));
01644     }
01645     fprintf(out, " %lu\n", n);
01646   }
01647
01648   /* Close file... */
01649   if (t == ctl->t_stop)
01650     fclose(out);
01651 }
```

Here is the call graph for this function:



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

Write gridded data.

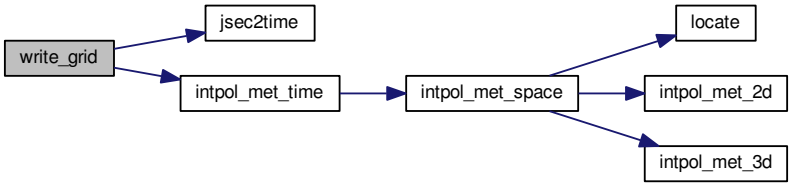
Definition at line 1655 of file libtrac.c.

```
01661             {
01662
01663   FILE *in, *out;
01664
01665   char line[LEN];
01666
01667   static double grid_m[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
01668     area, rho_air, press, temp, cd, mmr, t0, t1, r;
01669
01670   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
01671
01672   /* Check dimensions... */
01673   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
01674     ERRMSG("Grid dimensions too large!");
01675
01676   /* Check quantity index for mass... */
01677   if (ctl->qnt_m < 0)
01678     ERRMSG("Need quantity mass to write grid data!");
01679
01680   /* Set time interval for output... */
01681   t0 = t - 0.5 * ctl->dt_mod;
01682   t1 = t + 0.5 * ctl->dt_mod;
01683
01684   /* Set grid box size... */
01685   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
01686   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
01687   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
01688
01689   /* Initialize grid... */
01690   for (ix = 0; ix < ctl->grid_nx; ix++)
01691     for (iy = 0; iy < ctl->grid_ny; iy++)
01692       for (iz = 0; iz < ctl->grid_nz; iz++)
01693         grid_m[ix][iy][iz] = 0;
01694
01695   /* Average data... */
01696   for (ip = 0; ip < atm->np; ip++)
01697     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
01698
01699       /* Get index... */
01700       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
```

```
01701       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
01702       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
01703
01704       /* Check indices... */
01705       if (ix < 0 || ix >= ctl->grid_nx ||
01706           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
01707         continue;
01708
01709       /* Add mass... */
01710       grid_m[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01711     }
01712
01713   /* Check if gnuplot output is requested... */
01714   if (ctl->grid_gpfile[0] != '-') {
01715
01716     /* Write info... */
01717     printf("Plot grid data: %s.png\n", filename);
01718
01719     /* Create gnuplot pipe... */
01720     if (!(out = popen("gnuplot", "w")))
01721       ERRMSG("Cannot create pipe to gnuplot!");
01722
01723     /* Set plot filename... */
01724     fprintf(out, "set out \"%s.png\"\n", filename);
01725
01726     /* Set time string... */
01727     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01728     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01729             year, mon, day, hour, min);
01730
01731     /* Dump gnuplot file to pipe... */
01732     if (!(in = fopen(ctl->grid_gpfile, "r")))
01733       ERRMSG("Cannot open file!");
01734     while (fgets(line, LEN, in))
01735       fprintf(out, "%s", line);
01736     fclose(in);
01737   }
01738
01739   else {
01740
01741     /* Write info... */
01742     printf("Write grid data: %s\n", filename);
01743
01744     /* Create file... */
01745     if (!(out = fopen(filename, "w")))
01746       ERRMSG("Cannot create file!");
01747   }
01748
01749   /* Write header... */
01750   fprintf(out,
01751           "# $1 = time [s]\n"
01752           "# $2 = altitude [km]\n"
01753           "# $3 = longitude [deg]\n"
01754           "# $4 = latitude [deg]\n"
01755           "# $5 = surface area [km^2]\n"
01756           "# $6 = layer width [km]\n"
01757           "# $7 = temperature [K]\n"
01758           "# $8 = column density [kg/m^2]\n"
01759           "# $9 = mass mixing ratio [1]\n\n");
01760
01761   /* Write data... */
01762   for (ix = 0; ix < ctl->grid_nx; ix++) {
01763     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
01764       fprintf(out, "\n");
01765     for (iy = 0; iy < ctl->grid_ny; iy++) {
01766       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
01767         fprintf(out, "\n");
01768       for (iz = 0; iz < ctl->grid_nz; iz++)
01769         if (!ctl->grid_sparse
01770             || ix == 0 || iy == 0 || iz == 0 || grid_m[ix][iy][iz] > 0) {
01771
01772           /* Set coordinates... */
01773           z = ctl->grid_z0 + dz * (iz + 0.5);
01774           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
01775           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
01776
01777           /* Get pressure and temperature... */
01778           press = P(z);
01779           intpol_met_time(met0, met1, t, press, lon, lat,
01780                           NULL, &temp, NULL, NULL, NULL, NULL, NULL);
01781
01782           /* Calculate surface area... */
01783           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
01784             * cos(lat * M_PI / 180.);
01785
01786           /* Calculate column density... */
01787           cd = grid_m[ix][iy][iz] / (1e6 * area);
```

```
01788
01789           /* Calculate mass mixing ratio... */
01790           rho_air = 100. * press / (287.058 * temp);
01791           mmr = grid_m[ix][iy][iz] / (rho_air * 1e6 * area * 1e3 * dz);
01792
01793           /* Write output... */
01794           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01795                   t, z, lon, lat, area, dz, temp, cd, mmr);
01796         }
01797     }
01798   }
01799
01800   /* Close file... */
01801   fclose(out);
01802 }
```

Here is the call graph for this function:



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

Write profile data.

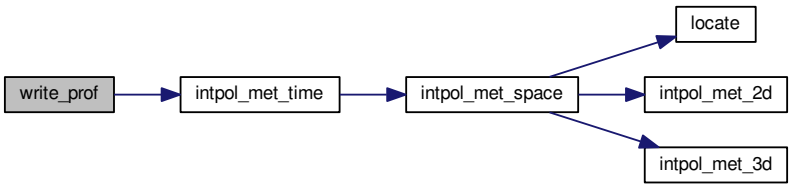
Definition at line 1806 of file libtrac.c.

```
01812             {
01813
01814   static FILE *in, *out;
01815
01816   static char line[LEN];
01817
01818   static double mass[GX][GY][GZ], obsmean[GX][GY], tmean[GX][GY],
01819     rt, rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z,
01820     press, temp, rho_air, mmr, h2o, o3;
01821
01822   static int init, obscount[GX][GY], ip, ix, iy, iz;
01823
01824   /* Init... */
01825   if (!init) {
01826     init = 1;
01827
01828     /* Check quantity index for mass... */
01829     if (ctl->qnt_m < 0)
01830       ERRMSG("Need quantity mass!");
01831
01832     /* Check dimensions... */
01833     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
01834       ERRMSG("Grid dimensions too large!");
01835
01836     /* Open observation data file... */
01837     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
01838     if (!(in = fopen(ctl->prof_obsfile, "r")))
01839       ERRMSG("Cannot open file!");
01840
01841     /* Create new file... */
01842     printf("Write profile data: %s\n", filename);
01843     if (!(out = fopen(filename, "w")))
01844       ERRMSG("Cannot create file!");
01845
01846     /* Write header... */
01847     fprintf(out,
```

```
01848             "# $1  = time [s]\n"
01849             "# $2  = altitude [km]\n"
01850             "# $3  = longitude [deg]\n"
01851             "# $4  = latitude [deg]\n"
01852             "# $5  = pressure [hPa]\n"
01853             "# $6  = temperature [K]\n"
01854             "# $7  = mass mixing ratio [1]\n"
01855             "# $8  = H2O volume mixing ratio [1]\n"
01856             "# $9  = O3 volume mixing ratio [1]\n"
01857             "# $10 = mean BT index [K]\n");
01858
01859     /* Set grid box size... */
01860     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
01861     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
01862     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
01863   }
01864
01865   /* Set time interval... */
01866   t0 = t - 0.5 * ctl->dt_mod;
01867   t1 = t + 0.5 * ctl->dt_mod;
01868
01869   /* Initialize... */
01870   for (ix = 0; ix < ctl->prof_nx; ix++)
01871     for (iy = 0; iy < ctl->prof_ny; iy++) {
01872       obsmean[ix][iy] = 0;
01873       obscount[ix][iy] = 0;
01874       tmean[ix][iy] = 0;
01875       for (iz = 0; iz < ctl->prof_nz; iz++)
01876         mass[ix][iy][iz] = 0;
01877     }
01878
01879   /* Read data... */
01880   while (fgets(line, LEN, in)) {
01881
01882     /* Read data... */
01883     if (sscanf(line, "%lg %lg %lg %lg", &rt, &rlon, &rlat, &robs) != 4)
01884       continue;
01885
01886     /* Check time... */
01887     if (rt < t0)
01888       continue;
01889     if (rt > t1)
01890       break;
01891
01892     /* Calculate indices... */
01893     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
01894     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
01895
01896     /* Check indices... */
01897     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
01898       continue;
01899
01900     /* Get mean observation index... */
01901     obsmean[ix][iy] += robs;
01902     tmean[ix][iy] += rt;
01903     obscount[ix][iy]++;
01904   }
01905
01906   /* Analyze model data... */
01907   for (ip = 0; ip < atm->np; ip++) {
01908
01909     /* Check time... */
01910     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01911       continue;
01912
01913     /* Get indices... */
01914     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
01915     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
01916     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
01917
01918     /* Check indices... */
01919     if (ix < 0 || ix >= ctl->prof_nx ||
01920         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
01921       continue;
01922
01923     /* Get total mass in grid cell... */
01924     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01925   }
01926
01927   /* Extract profiles... */
01928   for (ix = 0; ix < ctl->prof_nx; ix++)
01929     for (iy = 0; iy < ctl->prof_ny; iy++)
01930       if (obscount[ix][iy] > 0) {
01931
01932         /* Write output... */
01933         fprintf(out, "\n");
01934
```

```
01935         /* Loop over altitudes... */
01936         for (iz = 0; iz < ctl->prof_nz; iz++) {
01937
01938           /* Set coordinates... */
01939           z = ctl->prof_z0 + dz * (iz + 0.5);
01940           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
01941           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
01942
01943           /* Get meteorological data... */
01944           press = P(z);
01945           intpol_met_time(met0, met1, t, press, lon, lat,
01946                           NULL, &temp, NULL, NULL, NULL, &h2o, &o3);
01947
01948           /* Calculate mass mixing ratio... */
01949           rho_air = 100. * press / (287.058 * temp);
01950           area = dlat * dlon * gsl_pow_2(M_PI * RE / 180.)
01951             * cos(lat * M_PI / 180.);
01952           mmr = mass[ix][iy][iz] / (rho_air * area * dz * 1e9);
01953
01954           /* Write output... */
01955           fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g\n",
01956                   tmean[ix][iy] / obscount[ix][iy],
01957                   z, lon, lat, press, temp, mmr, h2o, o3,
01958                   obsmean[ix][iy] / obscount[ix][iy]);
01959         }
01960       }
01961
01962   /* Close file... */
01963   if (t == ctl->t_stop)
01964     fclose(out);
01965 }
```

Here is the call graph for this function:



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

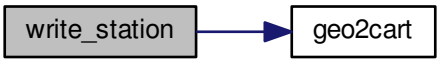
Write station data.

Definition at line 1969 of file libtrac.c.

```
01973             {
01974
01975   static FILE *out;
01976
01977   static double rmax2, t0, t1, x0[3], x1[3];
01978
01979   static int init, ip, iq;
01980
01981   /* Init... */
01982   if (!init) {
01983     init = 1;
01984
01985     /* Write info... */
01986     printf("Write station data: %s\n", filename);
01987
01988     /* Create new file... */
01989     if (!(out = fopen(filename, "w")))
01990       ERRMSG("Cannot create file!");
01991
01992     /* Write header... */
```

```
01993     fprintf(out,
01994             "# $1 = time [s]\n"
01995             "# $2 = altitude [km]\n"
01996             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01997     for (iq = 0; iq < ctl->nq; iq++)
01998       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
01999               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
02000     fprintf(out, "\n");
02001
02002     /* Set geolocation and search radius... */
02003     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
02004     rmax2 = gsl_pow_2(ctl->stat_r);
02005   }
02006
02007   /* Set time interval for output... */
02008   t0 = t - 0.5 * ctl->dt_mod;
02009   t1 = t + 0.5 * ctl->dt_mod;
02010
02011   /* Loop over air parcels... */
02012   for (ip = 0; ip < atm->np; ip++) {
02013
02014     /* Check time... */
02015     if (atm->time[ip] < t0 || atm->time[ip] > t1)
02016       continue;
02017
02018     /* Check station flag... */
02019     if (ctl->qnt_stat >= 0)
02020       if (atm->q[ctl->qnt_stat][ip])
02021         continue;
02022
02023     /* Get Cartesian coordinates... */
02024     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
02025
02026     /* Check horizontal distance... */
02027     if (DIST2(x0, x1) > rmax2)
02028       continue;
02029
02030     /* Set station flag... */
02031     if (ctl->qnt_stat >= 0)
02032       atm->q[ctl->qnt_stat][ip] = 1;
02033
02034     /* Write data... */
02035     fprintf(out, "%.2f %g %g %g",
02036             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
02037     for (iq = 0; iq < ctl->nq; iq++) {
02038       fprintf(out, " ");
02039       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
02040     }
02041     fprintf(out, "\n");
02042   }
02043
02044   /* Close file... */
02045   if (t == ctl->t_stop)
02046     fclose(out);
02047 }
```

Here is the call graph for this function:



5.12 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   Copright (C) 2013-2015 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 deg2dx(
00046   double dlon,
00047   double lat) {
00048
00049   return dlon * M_PI * RE / 180. * cos(lat / 180. * M_PI);
00050 }
00051
00052 /*****************************************************************************/
00053
00054 double deg2dy(
00055   double dlat) {
00056
00057   return dlat * M_PI * RE / 180.;
00058 }
00059
00060 /*****************************************************************************/
00061
00062 double dp2dz(
00063   double dp,
00064   double p) {
00065
00066   return -dp * H0 / p;
00067 }
00068
00069 /*****************************************************************************/
00070
00071 double dx2deg(
00072   double dx,
00073   double lat) {
00074
00075   /* Avoid singularity at poles... */
00076   if (lat < -89.999 || lat > 89.999)
00077     return 0;
00078   else
00079     return dx * 180. / (M_PI * RE * cos(lat / 180. * M_PI));
00080 }
00081
00082 /*****************************************************************************/
00083
00084 double dy2deg(
00085   double dy) {
00086
00087   return dy * 180. / (M_PI * RE);
00088 }
00089
00090 /*****************************************************************************/
00091
00092 double dz2dp(
00093   double dz,
00094   double p) {
00095
00096   return -dz * p / H0;
00097 }
```

```
00098
00099 /*****************************************************************************/
00100
00101 void geo2cart(
00102   double z,
00103   double lon,
00104   double lat,
00105   double *x) {
00106
00107   double radius;
00108
00109   radius = z + RE;
00110   x[0] = radius * cos(lat / 180 * M_PI) * cos(lon / 180 * M_PI);
00111   x[1] = radius * cos(lat / 180 * M_PI) * sin(lon / 180 * M_PI);
00112   x[2] = radius * sin(lat / 180 * M_PI);
00113 }
00114
00115 /*****************************************************************************/
00116
00117 void get_met(
00118   ctl_t * ctl,
00119   char *metbase,
00120   double t,
00121   met_t * met0,
00122   met_t * met1) {
00123
00124   char filename[LEN];
00125
00126   static int init;
00127
00128   /* Init... */
00129   if (!init) {
00130     init = 1;
00131
00132     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00133     read_met(ctl, filename, met0);
00134
00135     get_met_help(t + 1.0 * ctl->direction, 1, metbase, ctl->
      dt_met, filename);
00136     read_met(ctl, filename, met1);
00137   }
00138
00139   /* Read new data for forward trajectories... */
00140   if (t > met1->time && ctl->direction == 1) {
00141     memcpy(met0, met1, sizeof(met_t));
00142     get_met_help(t, 1, metbase, ctl->dt_met, filename);
00143     read_met(ctl, filename, met1);
00144   }
00145
00146   /* Read new data for backward trajectories... */
00147   if (t < met0->time && ctl->direction == -1) {
00148     memcpy(met1, met0, sizeof(met_t));
00149     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00150     read_met(ctl, filename, met0);
00151   }
00152 }
00153
00154 /*****************************************************************************/
00155
00156 void get_met_help(
00157   double t,
00158   int direct,
00159   char *metbase,
00160   double dt_met,
00161   char *filename) {
00162
00163   double t6, r;
00164
00165   int year, mon, day, hour, min, sec;
00166
00167   /* Round time to fixed intervals... */
00168   if (direct == -1)
00169     t6 = floor(t / dt_met) * dt_met;
00170   else
00171     t6 = ceil(t / dt_met) * dt_met;
00172
00173   /* Decode time... */
00174   jsec2time(t6, &year, &mon, &day, &hour, &min, &sec, &r);
00175
00176   /* Set filename... */
00177   sprintf(filename, "%s_%d_%02d_%02d_%02d.nc", metbase, year, mon, day, hour);
00178 }
00179
00180 /*****************************************************************************/
00181
00182 void intpol_met_2d(
00183   double array[EX][EY],
```

```
00184   int ix,
00185   int iy,
00186   double wx,
00187   double wy,
00188   double *var) {
00189
00190   double aux00, aux01, aux10, aux11;
00191
00192   /* Set variables... */
00193   aux00 = array[ix][iy];
00194   aux01 = array[ix][iy + 1];
00195   aux10 = array[ix + 1][iy];
00196   aux11 = array[ix + 1][iy + 1];
00197
00198   /* Interpolate horizontally... */
00199   aux00 = wy * (aux00 - aux01) + aux01;
00200   aux11 = wy * (aux10 - aux11) + aux11;
00201   *var = wx * (aux00 - aux11) + aux11;
00202 }
00203
00204 /*****************************************************************************/
00205
00206 void intpol_met_3d(
00207   float array[EX][EY][EP],
00208   int ip,
00209   int ix,
00210   int iy,
00211   double wp,
00212   double wx,
00213   double wy,
00214   double *var) {
00215
00216   double aux00, aux01, aux10, aux11;
00217
00218   /* Interpolate vertically... */
00219   aux00 = wp * (array[ix][iy][ip] - array[ix][iy][ip + 1])
00220     + array[ix][iy][ip + 1];
00221   aux01 = wp * (array[ix][iy + 1][ip] - array[ix][iy + 1][ip + 1])
00222     + array[ix][iy + 1][ip + 1];
00223   aux10 = wp * (array[ix + 1][iy][ip] - array[ix + 1][iy][ip + 1])
00224     + array[ix + 1][iy][ip + 1];
00225   aux11 = wp * (array[ix + 1][iy + 1][ip] - array[ix + 1][iy + 1][ip + 1])
00226     + array[ix + 1][iy + 1][ip + 1];
00227
00228   /* Interpolate horizontally... */
00229   aux00 = wy * (aux00 - aux01) + aux01;
00230   aux11 = wy * (aux10 - aux11) + aux11;
00231   *var = wx * (aux00 - aux11) + aux11;
00232 }
00233
00234 /*****************************************************************************/
00235
00236 void intpol_met_space(
00237   met_t * met,
00238   double p,
00239   double lon,
00240   double lat,
00241   double *ps,
00242   double *t,
00243   double *u,
00244   double *v,
00245   double *w,
00246   double *h2o,
00247   double *o3) {
00248
00249   double wp, wx, wy;
00250
00251   int ip, ix, iy;
00252
00253   /* Check longitude... */
00254   if (met->lon[met->nx - 1] > 180 && lon < 0)
00255     lon += 360;
00256
00257   /* Get indices... */
00258   ip = locate(met->p, met->np, p);
00259   ix = locate(met->lon, met->nx, lon);
00260   iy = locate(met->lat, met->ny, lat);
00261
00262   /* Get weights... */
00263   wp = (met->p[ip + 1] - p) / (met->p[ip + 1] - met->p[ip]);
00264   wx = (met->lon[ix + 1] - lon) / (met->lon[ix + 1] - met->lon[ix]);
00265   wy = (met->lat[iy + 1] - lat) / (met->lat[iy + 1] - met->lat[iy]);
00266
00267   /* Interpolate... */
00268   if (ps != NULL)
00269     intpol_met_2d(met->ps, ix, iy, wx, wy, ps);
00270   if (t != NULL)
```

```
00271     intpol_met_3d(met->t, ip, ix, iy, wp, wx, wy, t);
00272   if (u != NULL)
00273     intpol_met_3d(met->u, ip, ix, iy, wp, wx, wy, u);
00274   if (v != NULL)
00275     intpol_met_3d(met->v, ip, ix, iy, wp, wx, wy, v);
00276   if (w != NULL)
00277     intpol_met_3d(met->w, ip, ix, iy, wp, wx, wy, w);
00278   if (h2o != NULL)
00279     intpol_met_3d(met->h2o, ip, ix, iy, wp, wx, wy, h2o);
00280   if (o3 != NULL)
00281     intpol_met_3d(met->o3, ip, ix, iy, wp, wx, wy, o3);
00282 }
00283
00284 /*****************************************************************************/
00285
00286 void intpol_met_time(
00287   met_t * met0,
00288   met_t * met1,
00289   double ts,
00290   double p,
00291   double lon,
00292   double lat,
00293   double *ps,
00294   double *t,
00295   double *u,
00296   double *v,
00297   double *w,
00298   double *h2o,
00299   double *o3) {
00300
00301   double h2o0, h2o1, o30, o31, ps0, ps1, t0, t1, u0, u1, v0, v1, w0, w1, wt;
00302
00303   /* Spatial interpolation... */
00304   intpol_met_space(met0, p, lon, lat,
00305                    ps == NULL ? NULL : &ps0,
00306                    t == NULL ? NULL : &t0,
00307                    u == NULL ? NULL : &u0,
00308                    v == NULL ? NULL : &v0,
00309                    w == NULL ? NULL : &w0,
00310                    h2o == NULL ? NULL : &h2o0, o3 == NULL ? NULL : &o30);
00311   intpol_met_space(met1, p, lon, lat,
00312                    ps == NULL ? NULL : &ps1,
00313                    t == NULL ? NULL : &t1,
00314                    u == NULL ? NULL : &u1,
00315                    v == NULL ? NULL : &v1,
00316                    w == NULL ? NULL : &w1,
00317                    h2o == NULL ? NULL : &h2o1, o3 == NULL ? NULL : &o31);
00318
00319   /* Get weighting factor... */
00320   wt = (met1->time - ts) / (met1->time - met0->time);
00321
00322   /* Interpolate... */
00323   if (ps != NULL)
00324     *ps = wt * (ps0 - ps1) + ps1;
00325   if (t != NULL)
00326     *t = wt * (t0 - t1) + t1;
00327   if (u != NULL)
00328     *u = wt * (u0 - u1) + u1;
00329   if (v != NULL)
00330     *v = wt * (v0 - v1) + v1;
00331   if (w != NULL)
00332     *w = wt * (w0 - w1) + w1;
00333   if (h2o != NULL)
00334     *h2o = wt * (h2o0 - h2o1) + h2o1;
00335   if (o3 != NULL)
00336     *o3 = wt * (o30 - o31) + o31;
00337 }
00338
00339 /*****************************************************************************/
00340
00341 void jsec2time(
00342   double jsec,
00343   int *year,
00344   int *mon,
00345   int *day,
00346   int *hour,
00347   int *min,
00348   int *sec,
00349   double *remain) {
00350
00351   struct tm t0, *t1;
00352
00353   time_t jsec0;
00354
00355   t0.tm_year = 100;
00356   t0.tm_mon = 0;
00357   t0.tm_mday = 1;
```

```
00358   t0.tm_hour = 0;
00359   t0.tm_min = 0;
00360   t0.tm_sec = 0;
00361
00362   jsec0 = (time_t) jsec + timegm(&t0);
00363   t1 = gmtime(&jsec0);
00364
00365   *year = t1->tm_year + 1900;
00366   *mon = t1->tm_mon + 1;
00367   *day = t1->tm_mday;
00368   *hour = t1->tm_hour;
00369   *min = t1->tm_min;
00370   *sec = t1->tm_sec;
00371   *remain = jsec - floor(jsec);
00372 }
00373
00374 /*****************************************************************************/
00375
00376 int locate(
00377   double *xx,
00378   int n,
00379   double x) {
00380
00381   int i, ilo, ihi;
00382
00383   ilo = 0;
00384   ihi = n - 1;
00385   i = (ihi + ilo) >> 1;
00386
00387   if (xx[i] < xx[i + 1])
00388     while (ihi > ilo + 1) {
00389       i = (ihi + ilo) >> 1;
00390       if (xx[i] > x)
00391         ihi = i;
00392       else
00393         ilo = i;
00394   } else
00395     while (ihi > ilo + 1) {
00396       i = (ihi + ilo) >> 1;
00397       if (xx[i] <= x)
00398         ihi = i;
00399       else
00400         ilo = i;
00401     }
00402
00403   return ilo;
00404 }
00405
00406 /*****************************************************************************/
00407
00408 void read_atm(
00409   const char *filename,
00410   ctl_t * ctl,
00411   atm_t * atm) {
00412
00413   FILE *in;
00414
00415   char line[LEN], *tok;
00416
00417   int iq;
00418
00419   /* Init... */
00420   atm->np = 0;
00421
00422   /* Write info... */
00423   printf("Read atmospheric data: %s\n", filename);
00424
00425   /* Open file... */
00426   if (!(in = fopen(filename, "r")))
00427     ERRMSG("Cannot open file!");
00428
00429   /* Read line... */
00430   while (fgets(line, LEN, in)) {
00431
00432     /* Read data... */
00433     TOK(line, tok, "%lg", atm->time[atm->np]);
00434     TOK(NULL, tok, "%lg", atm->p[atm->np]);
00435     TOK(NULL, tok, "%lg", atm->lon[atm->np]);
00436     TOK(NULL, tok, "%lg", atm->lat[atm->np]);
00437     for (iq = 0; iq < ctl->nq; iq++)
00438       TOK(NULL, tok, "%lg", atm->q[iq][atm->np]);
00439
00440     /* Convert altitude to pressure... */
00441     atm->p[atm->np] = P(atm->p[atm->np]);
00442
00443     /* Increment data point counter... */
00444     if ((++atm->np) > NP)
```

```
00445       ERRMSG("Too many data points!");
00446   }
00447
00448   /* Close file... */
00449   fclose(in);
00450
00451   /* Check number of points... */
00452   if (atm->np < 1)
00453     ERRMSG("Can not read any data!");
00454 }
00455
00456 /*****************************************************************************/
00457
00458 void read_ctl(
00459   const char *filename,
00460   int argc,
00461   char *argv[],
00462   ctl_t * ctl) {
00463
00464   int ip, iq;
00465
00466   /* Write info... */
00467   printf("\nMassive-Parallel Trajectory Calculations (MPTRAC)\n"
00468          "(executable: %s | compiled: %s, %s)\n\n",
00469          argv[0], __DATE__, __TIME__);
00470
00471   /* Initialize quantity indices... */
00472   ctl->qnt_ens = -1;
00473   ctl->qnt_m = -1;
00474   ctl->qnt_r = -1;
00475   ctl->qnt_rho = -1;
00476   ctl->qnt_ps = -1;
00477   ctl->qnt_p = -1;
00478   ctl->qnt_t = -1;
00479   ctl->qnt_u = -1;
00480   ctl->qnt_v = -1;
00481   ctl->qnt_w = -1;
00482   ctl->qnt_h2o = -1;
00483   ctl->qnt_o3 = -1;
00484   ctl->qnt_theta = -1;
00485   ctl->qnt_pv = -1;
00486   ctl->qnt_tice = -1;
00487   ctl->qnt_tsts = -1;
00488   ctl->qnt_tnat = -1;
00489   ctl->qnt_gw_var = -1;
00490   ctl->qnt_stat = -1;
00491
00492   /* Read quantities... */
00493   ctl->nq = (int) scan_ctl(filename, argc, argv, "NQ", -1, "0", NULL);
00494   if (ctl->nq > NQ)
00495     ERRMSG("Too many quantities!");
00496   for (iq = 0; iq < ctl->nq; iq++) {
00497
00498     /* Read quantity name and format... */
00499     scan_ctl(filename, argc, argv, "QNT_NAME", iq, "", ctl->qnt_name[iq]);
00500     scan_ctl(filename, argc, argv, "QNT_FORMAT", iq, "%g",
00501              ctl->qnt_format[iq]);
00502
00503     /* Try to identify quantity... */
00504     if (strcmp(ctl->qnt_name[iq], "ens") == 0) {
00505       ctl->qnt_ens = iq;
00506       sprintf(ctl->qnt_unit[iq], "-");
00507     } else if (strcmp(ctl->qnt_name[iq], "m") == 0) {
00508       ctl->qnt_m = iq;
00509       sprintf(ctl->qnt_unit[iq], "kg");
00510     } else if (strcmp(ctl->qnt_name[iq], "r") == 0) {
00511       ctl->qnt_r = iq;
00512       sprintf(ctl->qnt_unit[iq], "m");
00513     } else if (strcmp(ctl->qnt_name[iq], "rho") == 0) {
00514       ctl->qnt_rho = iq;
00515       sprintf(ctl->qnt_unit[iq], "kg/m^3");
00516     } else if (strcmp(ctl->qnt_name[iq], "ps") == 0) {
00517       ctl->qnt_ps = iq;
00518       sprintf(ctl->qnt_unit[iq], "hPa");
00519     } else if (strcmp(ctl->qnt_name[iq], "p") == 0) {
00520       ctl->qnt_p = iq;
00521       sprintf(ctl->qnt_unit[iq], "hPa");
00522     } else if (strcmp(ctl->qnt_name[iq], "t") == 0) {
00523       ctl->qnt_t = iq;
00524       sprintf(ctl->qnt_unit[iq], "K");
00525     } else if (strcmp(ctl->qnt_name[iq], "u") == 0) {
00526       ctl->qnt_u = iq;
00527       sprintf(ctl->qnt_unit[iq], "m/s");
00528     } else if (strcmp(ctl->qnt_name[iq], "v") == 0) {
00529       ctl->qnt_v = iq;
00530       sprintf(ctl->qnt_unit[iq], "m/s");
00531     } else if (strcmp(ctl->qnt_name[iq], "w") == 0) {
```

```
00532       ctl->qnt_w = iq;
00533       sprintf(ctl->qnt_unit[iq], "hPa/s");
00534     } else if (strcmp(ctl->qnt_name[iq], "h2o") == 0) {
00535       ctl->qnt_h2o = iq;
00536       sprintf(ctl->qnt_unit[iq], "1");
00537     } else if (strcmp(ctl->qnt_name[iq], "o3") == 0) {
00538       ctl->qnt_o3 = iq;
00539       sprintf(ctl->qnt_unit[iq], "1");
00540     } else if (strcmp(ctl->qnt_name[iq], "theta") == 0) {
00541       ctl->qnt_theta = iq;
00542       sprintf(ctl->qnt_unit[iq], "K");
00543     } else if (strcmp(ctl->qnt_name[iq], "pv") == 0) {
00544       ctl->qnt_pv = iq;
00545       sprintf(ctl->qnt_unit[iq], "PVU");
00546     } else if (strcmp(ctl->qnt_name[iq], "tice") == 0) {
00547       ctl->qnt_tice = iq;
00548       sprintf(ctl->qnt_unit[iq], "K");
00549     } else if (strcmp(ctl->qnt_name[iq], "tsts") == 0) {
00550       ctl->qnt_tsts = iq;
00551       sprintf(ctl->qnt_unit[iq], "K");
00552     } else if (strcmp(ctl->qnt_name[iq], "tnat") == 0) {
00553       ctl->qnt_tnat = iq;
00554       sprintf(ctl->qnt_unit[iq], "K");
00555     } else if (strcmp(ctl->qnt_name[iq], "gw_var") == 0) {
00556       ctl->qnt_gw_var = iq;
00557       sprintf(ctl->qnt_unit[iq], "K^2");
00558     } else if (strcmp(ctl->qnt_name[iq], "stat") == 0) {
00559       ctl->qnt_stat = iq;
00560       sprintf(ctl->qnt_unit[iq], "-");
00561     } else
00562       scan_ctl(filename, argc, argv, "QNT_UNIT", iq, "", ctl->qnt_unit[iq]);
00563   }
00564
00565   /* Time steps of simulation... */
00566   ctl->direction =
00567     (int) scan_ctl(filename, argc, argv, "DIRECTION", -1, "1", NULL);
00568   if (ctl->direction != -1 && ctl->direction != 1)
00569     ERRMSG("Set DIRECTION to -1 or 1!");
00570   ctl->t_start =
00571     scan_ctl(filename, argc, argv, "T_START", -1, "-1e100", NULL);
00572   ctl->t_stop = scan_ctl(filename, argc, argv, "T_STOP", -1, "-1e100", NULL);
00573   ctl->dt_mod = scan_ctl(filename, argc, argv, "DT_MOD", -1, "600", NULL);
00574
00575   /* Meteorological data... */
00576   ctl->dt_met = scan_ctl(filename, argc, argv, "DT_MET", -1, "21600", NULL);
00577   ctl->met_np = (int) scan_ctl(filename, argc, argv, "MET_NP", -1, "0", NULL);
00578   if (ctl->met_np > EP)
00579     ERRMSG("Too many levels!");
00580   for (ip = 0; ip < ctl->met_np; ip++)
00581     ctl->met_p[ip] = scan_ctl(filename, argc, argv, "MET_P", ip, "", NULL);
00582   scan_ctl(filename, argc, argv, "MET_STAGE", -1, "-", ctl->met_stage);
00583
00584   /* Isosurface parameters... */
00585   ctl->isosurf
00586     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
00587   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
00588
00589   /* Diffusion parameters... */
00590   ctl->turb_dx_trop
00591     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50.0", NULL);
00592   ctl->turb_dx_strat
00593     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0.0", NULL);
00594   ctl->turb_dz_trop
00595     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0.0", NULL);
00596   ctl->turb_dz_strat
00597     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
00598   ctl->turb_meso =
00599     scan_ctl(filename, argc, argv, "TURB_MESO", -1, "0.16", NULL);
00600
00601   /* Life time of particles... */
00602   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
00603   ctl->tdec_strat =
00604     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
00605
00606   /* PSC analysis... */
00607   ctl->psc_h2o = scan_ctl(filename, argc, argv, "PSC_H2O", -1, "4e-6", NULL);
00608   ctl->psc_hno3 =
00609     scan_ctl(filename, argc, argv, "PSC_HNO3", -1, "9e-9", NULL);
00610
00611   /* Gravity wave analysis... */
00612   scan_ctl(filename, argc, argv, "GW_BASENAME", -1, "-", ctl->
     gw_basename);
00613
00614   /* Output of atmospheric data... */
00615   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
     atm_basename);
00616   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
```

```
00617   ctl->atm_dt_out =
00618     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
00619   ctl->atm_filter =
00620     (int) scan_ctl(filename, argc, argv, "ATM_FILTER", -1, "0", NULL);
00621
00622   /* Output of CSI data... */
00623   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
      csi_basename);
00624   ctl->csi_dt_out =
00625     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
00626   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "obs.tab",
00627            ctl->csi_obsfile);
00628   ctl->csi_obsmin =
00629     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
00630   ctl->csi_modmin =
00631     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
00632   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
00633   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
00634   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
00635   ctl->csi_lon0 =
00636     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
00637   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
00638   ctl->csi_nx =
00639     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
00640   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
00641   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
00642   ctl->csi_ny =
00643     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
00644
00645   /* Output of ensemble data... */
00646   scan_ctl(filename, argc, argv, "ENS_BASENAME", -1, "-", ctl->
      ens_basename);
00647
00648   /* Output of grid data... */
00649   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
00650            ctl->grid_basename);
00651   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
      grid_gpfile);
00652   ctl->grid_dt_out =
00653     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
00654   ctl->grid_sparse =
00655     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
00656   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
00657   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
00658   ctl->grid_nz =
00659     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
00660   ctl->grid_lon0 =
00661     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
00662   ctl->grid_lon1 =
00663     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
00664   ctl->grid_nx =
00665     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
00666   ctl->grid_lat0 =
00667     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
00668   ctl->grid_lat1 =
00669     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
00670   ctl->grid_ny =
00671     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
00672
00673   /* Output of profile data... */
00674   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
00675            ctl->prof_basename);
00676   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
      prof_obsfile);
00677   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
00678   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
00679   ctl->prof_nz =
00680     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
00681   ctl->prof_lon0 =
00682     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
00683   ctl->prof_lon1 =
00684     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
00685   ctl->prof_nx =
00686     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
00687   ctl->prof_lat0 =
00688     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
00689   ctl->prof_lat1 =
00690     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
00691   ctl->prof_ny =
00692     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
00693
00694   /* Output of station data... */
00695   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
00696            ctl->stat_basename);
00697   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
00698   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
00699   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
```

```
00700 }
00701
00702 /*****************************************************************************/
00703
00704 void read_met(
00705   ctl_t * ctl,
00706   char *filename,
00707   met_t * met) {
00708
00709   char cmd[LEN], levname[LEN], tstr[10];
00710
00711   static float help[EX * EY];
00712
00713   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
00714
00715   size_t np, nx, ny;
00716
00717   /* Write info... */
00718   printf("Read meteorological data: %s\n", filename);
00719
00720   /* Get time from filename... */
00721   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
00722   year = atoi(tstr);
00723   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
00724   mon = atoi(tstr);
00725   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
00726   day = atoi(tstr);
00727   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
00728   hour = atoi(tstr);
00729   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
00730
00731   /* Open netCDF file... */
00732   if (nc_open(filename, NC_NOWRITE, &ncid) != NC_NOERR) {
00733
00734     /* Try to stage meteo file... */
00735     START_TIMER(TIMER_STAGE);
00736     if (ctl->met_stage[0] != '-') {
00737       sprintf(cmd, "%s %d %02d %02d %02d %s", ctl->met_stage,
00738               year, mon, day, hour, filename);
00739       if (system(cmd) != 0)
00740         ERRMSG("Error while staging meteo data!");
00741     }
00742     STOP_TIMER(TIMER_STAGE);
00743
00744     /* Try to open again... */
00745     NC(nc_open(filename, NC_NOWRITE, &ncid));
00746   }
00747
00748   /* Get dimensions... */
00749   NC(nc_inq_dimid(ncid, "lon", &dimid));
00750   NC(nc_inq_dimlen(ncid, dimid, &nx));
00751   if (nx < 2 || nx > EX)
00752     ERRMSG("Number of longitudes out of range!");
00753
00754   NC(nc_inq_dimid(ncid, "lat", &dimid));
00755   NC(nc_inq_dimlen(ncid, dimid, &ny));
00756   if (ny < 2 || ny > EY)
00757     ERRMSG("Number of latitudes out of range!");
00758
00759   sprintf(levname, "lev");
00760   NC(nc_inq_dimid(ncid, levname, &dimid));
00761   NC(nc_inq_dimlen(ncid, dimid, &np));
00762   if (np == 1) {
00763     sprintf(levname, "lev_2");
00764     NC(nc_inq_dimid(ncid, levname, &dimid));
00765     NC(nc_inq_dimlen(ncid, dimid, &np));
00766   }
00767   if (np < 2 || np > EP)
00768     ERRMSG("Number of levels out of range!");
00769
00770   /* Store dimensions... */
00771   met->np = (int) np;
00772   met->nx = (int) nx;
00773   met->ny = (int) ny;
00774
00775   /* Get horizontal grid... */
00776   NC(nc_inq_varid(ncid, "lon", &varid));
00777   NC(nc_get_var_double(ncid, varid, met->lon));
00778   NC(nc_inq_varid(ncid, "lat", &varid));
00779   NC(nc_get_var_double(ncid, varid, met->lat));
00780
00781   /* Read meteorological data... */
00782   read_met_help(ncid, "t", "T", met, met->t, 1.0);
00783   read_met_help(ncid, "u", "U", met, met->u, 1.0);
00784   read_met_help(ncid, "v", "V", met, met->v, 1.0);
00785   read_met_help(ncid, "w", "W", met, met->w, 0.01f);
00786   read_met_help(ncid, "q", "Q", met, met->h2o, 1.608f);
```

```
00787   read_met_help(ncid, "o3", "O3", met, met->o3, 0.602f);
00788
00789   /* Meteo data on pressure levels... */
00790   if (ctl->met_np <= 0) {
00791
00792     /* Read pressure levels from file... */
00793     NC(nc_inq_varid(ncid, levname, &varid));
00794     NC(nc_get_var_double(ncid, varid, met->p));
00795     for (ip = 0; ip < met->np; ip++)
00796       met->p[ip] /= 100.;
00797
00798     /* Extrapolate data for lower boundary... */
00799     read_met_extrapolate(met);
00800   }
00801
00802   /* Meteo data on model levels... */
00803   else {
00804
00805     /* Read pressure data from file... */
00806     read_met_help(ncid, "pl", "PL", met, met->pl, 0.01f);
00807
00808     /* Interpolate from model levels to pressure levels... */
00809     read_met_ml2pl(ctl, met, met->t);
00810     read_met_ml2pl(ctl, met, met->u);
00811     read_met_ml2pl(ctl, met, met->v);
00812     read_met_ml2pl(ctl, met, met->w);
00813     read_met_ml2pl(ctl, met, met->h2o);
00814     read_met_ml2pl(ctl, met, met->o3);
00815
00816     /* Set pressure levels... */
00817     met->np = ctl->met_np;
00818     for (ip = 0; ip < met->np; ip++)
00819       met->p[ip] = ctl->met_p[ip];
00820   }
00821
00822   /* Check ordering of pressure levels... */
00823   for (ip = 1; ip < met->np; ip++)
00824     if (met->p[ip - 1] < met->p[ip])
00825       ERRMSG("Pressure levels must be descending!");
00826
00827   /* Read surface pressure... */
00828   if (nc_inq_varid(ncid, "ps", &varid) == NC_NOERR
00829       || nc_inq_varid(ncid, "PS", &varid) == NC_NOERR) {
00830     NC(nc_get_var_float(ncid, varid, help));
00831     for (iy = 0; iy < met->ny; iy++)
00832       for (ix = 0; ix < met->nx; ix++)
00833         met->ps[ix][iy] = help[iy * met->nx + ix] / 100.;
00834   } else if (nc_inq_varid(ncid, "lnsp", &varid) == NC_NOERR
00835              || nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
00836     NC(nc_get_var_float(ncid, varid, help));
00837     for (iy = 0; iy < met->ny; iy++)
00838       for (ix = 0; ix < met->nx; ix++)
00839         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
00840   } else
00841     for (ix = 0; ix < met->nx; ix++)
00842       for (iy = 0; iy < met->ny; iy++)
00843         met->ps[ix][iy] = met->p[0];
00844
00845   /* Create periodic boundary conditions... */
00846   read_met_periodic(met);
00847
00848   /* Close file... */
00849   NC(nc_close(ncid));
00850 }
00851
00852 /*****************************************************************************/
00853
00854 void read_met_extrapolate(
00855   met_t * met) {
00856
00857   int ip, ip0, ix, iy;
00858
00859   /* Loop over columns... */
00860   for (ix = 0; ix < met->nx; ix++)
00861     for (iy = 0; iy < met->ny; iy++) {
00862
00863       /* Find lowest valid data point... */
00864       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
00865         if (!gsl_finite(met->t[ix][iy][ip0])
00866             || !gsl_finite(met->u[ix][iy][ip0])
00867             || !gsl_finite(met->v[ix][iy][ip0])
00868             || !gsl_finite(met->w[ix][iy][ip0]))
00869           break;
00870
00871       /* Extrapolate... */
00872       for (ip = ip0; ip >= 0; ip--) {
00873         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
```

```
00874         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
00875         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
00876         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
00877         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
00878         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
00879       }
00880     }
00881 }
00882
00883 /*****************************************************************************/
00884
00885 void read_met_help(
00886   int ncid,
00887   char *varname,
00888   char *varname2,
00889   met_t * met,
00890   float dest[EX][EY][EP],
00891   float scl) {
00892
00893   static float help[EX * EY * EP];
00894
00895   int ip, ix, iy, n = 0, varid;
00896
00897   /* Check if variable exists... */
00898   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
00899     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
00900       return;
00901
00902   /* Read data... */
00903   NC(nc_get_var_float(ncid, varid, help));
00904
00905   /* Copy and check data... */
00906   for (ip = 0; ip < met->np; ip++)
00907     for (iy = 0; iy < met->ny; iy++)
00908       for (ix = 0; ix < met->nx; ix++) {
00909         dest[ix][iy][ip] = scl * help[n++];
00910         if (fabs(dest[ix][iy][ip] / scl) > 1e14)
00911           dest[ix][iy][ip] = GSL_NAN;
00912       }
00913 }
00914
00915 /*****************************************************************************/
00916
00917 void read_met_ml2pl(
00918   ctl_t * ctl,
00919   met_t * met,
00920   float var[EX][EY][EP]) {
00921
00922   double aux[EP], p[EP], pt;
00923
00924   int ip, ip2, ix, iy;
00925
00926   /* Loop over columns... */
00927   for (ix = 0; ix < met->nx; ix++)
00928     for (iy = 0; iy < met->ny; iy++) {
00929
00930       /* Copy pressure profile... */
00931       for (ip = 0; ip < met->np; ip++)
00932         p[ip] = met->pl[ix][iy][ip];
00933
00934       /* Interpolate... */
00935       for (ip = 0; ip < ctl->met_np; ip++) {
00936         pt = ctl->met_p[ip];
00937         if ((pt > p[0] && p[0] > p[1]) || (pt < p[0] && p[0] < p[1]))
00938           pt = p[0];
00939         else if ((pt > p[met->np - 1] && p[1] > p[0])
00940                  || (pt < p[met->np - 1] && p[1] < p[0]))
00941           pt = p[met->np - 1];
00942         ip2 = locate(p, met->np, pt);
00943         aux[ip] = LIN(p[ip2], var[ix][iy][ip2],
00944                       p[ip2 + 1], var[ix][iy][ip2 + 1], pt);
00945       }
00946
00947       /* Copy data... */
00948       for (ip = 0; ip < ctl->met_np; ip++)
00949         var[ix][iy][ip] = (float) aux[ip];
00950     }
00951 }
00952
00953 /*****************************************************************************/
00954
00955 void read_met_periodic(
00956   met_t * met) {
00957
00958   int ip, iy;
00959
00960   /* Check longitudes... */
```

```
00961   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
00962              + met->lon[1] - met->lon[0] - 360) < 0.01))
00963     return;
00964
00965   /* Increase longitude counter... */
00966   if ((++met->nx) > EX)
00967     ERRMSG("Cannot create periodic boundary conditions!");
00968
00969   /* Set longitude... */
00970   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
00971
00972   /* Loop over latitudes and pressure levels... */
00973   for (iy = 0; iy < met->ny; iy++)
00974     for (ip = 0; ip < met->np; ip++) {
00975       met->ps[met->nx - 1][iy] = met->ps[0][iy];
00976       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
00977       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
00978       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
00979       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
00980       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
00981       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
00982     }
00983 }
00984
00985 /*****************************************************************************/
00986
00987 double scan_ctl(
00988   const char *filename,
00989   int argc,
00990   char *argv[],
00991   const char *varname,
00992   int arridx,
00993   const char *defvalue,
00994   char *value) {
00995
00996   FILE *in = NULL;
00997
00998   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
00999     msg[LEN], rvarname[LEN], rval[LEN];
01000
01001   int contain = 0, i;
01002
01003   /* Open file... */
01004   if (filename[strlen(filename) - 1] != '-')
01005     if (!(in = fopen(filename, "r")))
01006       ERRMSG("Cannot open file!");
01007
01008   /* Set full variable name... */
01009   if (arridx >= 0) {
01010     sprintf(fullname1, "%s[%d]", varname, arridx);
01011     sprintf(fullname2, "%s[*]", varname);
01012   } else {
01013     sprintf(fullname1, "%s", varname);
01014     sprintf(fullname2, "%s", varname);
01015   }
01016
01017   /* Read data... */
01018   if (in != NULL)
01019     while (fgets(line, LEN, in))
01020       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
01021         if (strcasecmp(rvarname, fullname1) == 0 ||
01022             strcasecmp(rvarname, fullname2) == 0) {
01023           contain = 1;
01024           break;
01025         }
01026   for (i = 1; i < argc - 1; i++)
01027     if (strcasecmp(argv[i], fullname1) == 0 ||
01028         strcasecmp(argv[i], fullname2) == 0) {
01029       sprintf(rval, "%s", argv[i + 1]);
01030       contain = 1;
01031       break;
01032     }
01033
01034   /* Close file... */
01035   if (in != NULL)
01036     fclose(in);
01037
01038   /* Check for missing variables... */
01039   if (!contain) {
01040     if (strlen(defvalue) > 0)
01041       sprintf(rval, "%s", defvalue);
01042     else {
01043       sprintf(msg, "Missing variable %s!\n", fullname1);
01044       ERRMSG(msg);
01045     }
01046   }
```

```
01047
01048   /* Write info... */
01049   printf("%s = %s\n", fullname1, rval);
01050
01051   /* Return values... */
01052   if (value != NULL)
01053     sprintf(value, "%s", rval);
01054   return atof(rval);
01055 }
01056
01057 /*****************************************************************************/
01058
01059 void time2jsec(
01060   int year,
01061   int mon,
01062   int day,
01063   int hour,
01064   int min,
01065   int sec,
01066   double remain,
01067   double *jsec) {
01068
01069   struct tm t0, t1;
01070
01071   t0.tm_year = 100;
01072   t0.tm_mon = 0;
01073   t0.tm_mday = 1;
01074   t0.tm_hour = 0;
01075   t0.tm_min = 0;
01076   t0.tm_sec = 0;
01077
01078   t1.tm_year = year - 1900;
01079   t1.tm_mon = mon - 1;
01080   t1.tm_mday = day;
01081   t1.tm_hour = hour;
01082   t1.tm_min = min;
01083   t1.tm_sec = sec;
01084
01085   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
01086 }
01087
01088 /*****************************************************************************/
01089
01090 void timer(
01091   const char *name,
01092   int id,
01093   int mode) {
01094
01095   static double starttime[NTIMER], runtime[NTIMER];
01096
01097   /* Check id... */
01098   if (id < 0 || id >= NTIMER)
01099     ERRMSG("Too many timers!");
01100
01101   /* Start timer... */
01102   if (mode == 1) {
01103     if (starttime[id] <= 0)
01104       starttime[id] = omp_get_wtime();
01105     else
01106       ERRMSG("Timer already started!");
01107   }
01108
01109   /* Stop timer... */
01110   else if (mode == 2) {
01111     if (starttime[id] > 0) {
01112       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
01113       starttime[id] = -1;
01114     } else
01115       ERRMSG("Timer not started!");
01116   }
01117
01118   /* Print timer... */
01119   else if (mode == 3)
01120     printf("%s = %g s\n", name, runtime[id]);
01121 }
01122
01123 /*****************************************************************************/
01124
01125 double tropopause(
01126   double t,
01127   double lat) {
01128
01129   static double doys[12]
01130   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
01131
01132   static double lats[73]
01133     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
```

```
01134     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
01135     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
01136     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
01137     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
01138     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
01139     75, 77.5, 80, 82.5, 85, 87.5, 90
01140   };
01141
01142   static double tps[12][73]
01143     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
01144          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
01145          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
01146          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
01147          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
01148          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
01149          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
01150          275.3, 275.6, 275.4, 274.1, 273.5},
01151   {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
01152    300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
01153    150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
01154    98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
01155    98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
01156    220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
01157    284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
01158    287.5, 286.2, 285.8},
01159   {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
01160    297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
01161    161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
01162    100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
01163    99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
01164    186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
01165    279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
01166    304.3, 304.9, 306, 306.6, 306.2, 306},
01167   {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
01168    290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
01169    195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
01170    102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
01171    99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
01172    148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
01173    263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
01174    315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
01175   {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
01176    260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
01177    205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
01178    101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
01179    102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
01180    165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
01181    273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
01182    325.3, 325.8, 325.8},
01183   {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
01184    222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
01185    228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
01186    105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
01187    106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
01188    127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
01189    251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
01190    308.5, 312.2, 313.1, 313.3},
01191   {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
01192    187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
01193    235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
01194    110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
01195    111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
01196    117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
01197    224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
01198    275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
01199   {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
01200    185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
01201    233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
01202    110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
01203    112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
01204    120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
01205    230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
01206    278.2, 282.6, 287.4, 290.9, 292.5, 293},
01207   {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
01208    183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
01209    243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
01210    114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
01211    110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
01212    114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
01213    203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
01214    276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
01215   {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
01216    215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
01217    237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
01218    111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
01219    106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
01220    112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
```

```
01221    206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
01222    279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
01223    305.1},
01224   {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
01225    253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
01226    223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
01227    108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
01228    102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
01229    109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
01230    241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
01231    286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
01232   {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
01233    284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
01234    175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
01235    100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
01236    100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
01237    186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
01238    280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
01239    281.7, 281.1, 281.2}
01240   };
01241
01242   double doy, p0, p1, pt;
01243
01244   int imon, ilat;
01245
01246   /* Get day of year... */
01247   doy = fmod(t / 86400., 365.25);
01248   while (doy < 0)
01249     doy += 365.25;
01250
01251   /* Get indices... */
01252   imon = locate(doys, 12, doy);
01253   ilat = locate(lats, 73, lat);
01254
01255   /* Get tropopause pressure... */
01256   p0 = LIN(lats[ilat], tps[imon][ilat],
01257            lats[ilat + 1], tps[imon][ilat + 1], lat);
01258   p1 = LIN(lats[ilat], tps[imon + 1][ilat],
01259            lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
01260   pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
01261
01262   /* Return tropopause pressure... */
01263   return pt;
01264 }
01265
01266 /*****************************************************************************/
01267
01268 void write_atm(
01269   const char *filename,
01270   ctl_t * ctl,
01271   atm_t * atm,
01272   double t) {
01273
01274   FILE *in, *out;
01275
01276   char line[LEN];
01277
01278   double r, t0, t1;
01279
01280   int ip, iq, year, mon, day, hour, min, sec;
01281
01282   /* Set time interval for output... */
01283   t0 = t - 0.5 * ctl->dt_mod;
01284   t1 = t + 0.5 * ctl->dt_mod;
01285
01286   /* Check if gnuplot output is requested... */
01287   if (ctl->atm_gpfile[0] != '-') {
01288
01289     /* Write info... */
01290     printf("Plot atmospheric data: %s.png\n", filename);
01291
01292     /* Create gnuplot pipe... */
01293     if (!(out = popen("gnuplot", "w")))
01294       ERRMSG("Cannot create pipe to gnuplot!");
01295
01296     /* Set plot filename... */
01297     fprintf(out, "set out \"%s.png\"\n", filename);
01298
01299     /* Set time string... */
01300     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01301     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01302             year, mon, day, hour, min);
01303
01304     /* Dump gnuplot file to pipe... */
01305     if (!(in = fopen(ctl->atm_gpfile, "r")))
01306       ERRMSG("Cannot open file!");
01307     while (fgets(line, LEN, in))
```

```
01308       fprintf(out, "%s", line);
01309     fclose(in);
01310   }
01311
01312   else {
01313
01314     /* Write info... */
01315     printf("Write atmospheric data: %s\n", filename);
01316
01317     /* Create file... */
01318     if (!(out = fopen(filename, "w")))
01319       ERRMSG("Cannot create file!");
01320   }
01321
01322   /* Write header... */
01323   fprintf(out,
01324           "# $1 = time [s]\n"
01325           "# $2 = altitude [km]\n"
01326           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01327   for (iq = 0; iq < ctl->nq; iq++)
01328     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
01329             ctl->qnt_unit[iq]);
01330   fprintf(out, "\n");
01331
01332   /* Write data... */
01333   for (ip = 0; ip < atm->np; ip++) {
01334
01335     /* Check time... */
01336     if (ctl->atm_filter && (atm->time[ip] < t0 || atm->time[ip] > t1))
01337       continue;
01338
01339     /* Write output... */
01340     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
01341             atm->lon[ip], atm->lat[ip]);
01342     for (iq = 0; iq < ctl->nq; iq++) {
01343       fprintf(out, " ");
01344       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01345     }
01346     fprintf(out, "\n");
01347   }
01348
01349   /* Close file... */
01350   fclose(out);
01351 }
01352
01353 /*****************************************************************************/
01354
01355 void write_csi(
01356   const char *filename,
01357   ctl_t * ctl,
01358   atm_t * atm,
01359   double t) {
01360
01361   static FILE *in, *out;
01362
01363   static char line[LEN];
01364
01365   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
01366     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
01367
01368   static int init, obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
01369
01370   /* Init... */
01371   if (!init) {
01372     init = 1;
01373
01374     /* Check quantity index for mass... */
01375     if (ctl->qnt_m < 0)
01376       ERRMSG("Need quantity mass to analyze CSI!");
01377
01378     /* Open observation data file... */
01379     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
01380     if (!(in = fopen(ctl->csi_obsfile, "r")))
01381       ERRMSG("Cannot open file!");
01382
01383     /* Create new file... */
01384     printf("Write CSI data: %s\n", filename);
01385     if (!(out = fopen(filename, "w")))
01386       ERRMSG("Cannot create file!");
01387
01388     /* Write header... */
01389     fprintf(out,
01390             "# $1 = time [s]\n"
01391             "# $2 = number of hits (cx)\n"
01392             "# $3 = number of misses (cy)\n"
01393             "# $4 = number of false alarms (cz)\n"
01394             "# $5 = number of observations (cx + cy)\n"
```

```
01395             "# $6 = number of forecasts (cx + cz)\n"
01396             "# $7 = bias (forecasts/observations) [%%]\n"
01397             "# $8 = probability of detection (POD) [%%]\n"
01398             "# $9 = false alarm rate (FAR) [%%]\n"
01399             "# $10 = critical success index (CSI) [%%]\n\n");
01400   }
01401
01402   /* Set time interval... */
01403   t0 = t - 0.5 * ctl->dt_mod;
01404   t1 = t + 0.5 * ctl->dt_mod;
01405
01406   /* Initialize grid cells... */
01407   for (ix = 0; ix < ctl->csi_nx; ix++)
01408     for (iy = 0; iy < ctl->csi_ny; iy++)
01409       for (iz = 0; iz < ctl->csi_nz; iz++)
01410         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
01411
01412   /* Read data... */
01413   while (fgets(line, LEN, in)) {
01414
01415     /* Read data... */
01416     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
01417         5)
01418       continue;
01419
01420     /* Check time... */
01421     if (rt < t0)
01422       continue;
01423     if (rt > t1)
01424       break;
01425
01426     /* Calculate indices... */
01427     ix = (int) ((rlon - ctl->csi_lon0)
01428                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01429     iy = (int) ((rlat - ctl->csi_lat0)
01430                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01431     iz = (int) ((rz - ctl->csi_z0)
01432                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01433
01434     /* Check indices... */
01435     if (ix < 0 || ix >= ctl->csi_nx ||
01436         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01437       continue;
01438
01439     /* Get mean observation index... */
01440     obsmean[ix][iy][iz] += robs;
01441     obscount[ix][iy][iz]++;
01442   }
01443
01444   /* Analyze model data... */
01445   for (ip = 0; ip < atm->np; ip++) {
01446
01447     /* Check time... */
01448     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01449       continue;
01450
01451     /* Get indices... */
01452     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
01453                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01454     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
01455                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01456     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
01457                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01458
01459     /* Check indices... */
01460     if (ix < 0 || ix >= ctl->csi_nx ||
01461         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01462       continue;
01463
01464     /* Get total mass in grid cell... */
01465     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01466   }
01467
01468   /* Analyze all grid cells... */
01469   for (ix = 0; ix < ctl->csi_nx; ix++)
01470     for (iy = 0; iy < ctl->csi_ny; iy++)
01471       for (iz = 0; iz < ctl->csi_nz; iz++) {
01472
01473         /* Calculate mean observation index... */
01474         if (obscount[ix][iy][iz] > 0)
01475           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
01476
01477         /* Calculate column density... */
01478         if (modmean[ix][iy][iz] > 0) {
01479           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
01480           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
01481           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
```

```
01482           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
01483             * cos(lat * M_PI / 180.);
01484           modmean[ix][iy][iz] /= (1e6 * area);
01485         }
01486
01487         /* Calculate CSI... */
01488         if (obscount[ix][iy][iz] > 0) {
01489           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01490               modmean[ix][iy][iz] >= ctl->csi_modmin)
01491             cx++;
01492           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01493                    modmean[ix][iy][iz] < ctl->csi_modmin)
01494             cy++;
01495           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
01496                    modmean[ix][iy][iz] >= ctl->csi_modmin)
01497             cz++;
01498         }
01499       }
01500
01501   /* Write output... */
01502   if (fmod(t, ctl->csi_dt_out) == 0) {
01503
01504     /* Write... */
01505     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
01506             t, cx, cy, cz, cx + cy, cx + cz,
01507             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
01508             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
01509             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
01510             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
01511
01512     /* Set counters to zero... */
01513     cx = cy = cz = 0;
01514   }
01515
01516   /* Close file... */
01517   if (t == ctl->t_stop)
01518     fclose(out);
01519 }
01520
01521 /*****************************************************************************/
01522
01523 void write_ens(
01524   const char *filename,
01525   ctl_t * ctl,
01526   atm_t * atm,
01527   double t) {
01528
01529   static FILE *out;
01530
01531   static double dummy, ens, lat, lon, p[NENS], q[NQ][NENS],
01532     t0, t1, x[NENS][3], xm[3];
01533
01534   static int init, ip, iq;
01535
01536   static size_t i, n;
01537
01538   /* Init... */
01539   if (!init) {
01540     init = 1;
01541
01542     /* Check quantities... */
01543     if (ctl->qnt_ens < 0)
01544       ERRMSG("Missing ensemble IDs!");
01545
01546     /* Create new file... */
01547     printf("Write ensemble data: %s\n", filename);
01548     if (!(out = fopen(filename, "w")))
01549       ERRMSG("Cannot create file!");
01550
01551     /* Write header... */
01552     fprintf(out,
01553             "# $1 = time [s]\n"
01554             "# $2 = altitude [km]\n"
01555             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01556     for (iq = 0; iq < ctl->nq; iq++)
01557       fprintf(out, "# $%d = %s (mean) [%s]\n", 5 + iq,
01558               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
01559     for (iq = 0; iq < ctl->nq; iq++)
01560       fprintf(out, "# $%d = %s (sigma) [%s]\n", 5 + ctl->nq + iq,
01561               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
01562     fprintf(out, "# $%d = number of members\n\n", 5 + 2 * ctl->nq);
01563   }
01564
01565   /* Set time interval... */
01566   t0 = t - 0.5 * ctl->dt_mod;
01567   t1 = t + 0.5 * ctl->dt_mod;
01568
```

```
01569   /* Init... */
01570   ens = GSL_NAN;
01571   n = 0;
01572
01573   /* Loop over air parcels... */
01574   for (ip = 0; ip < atm->np; ip++) {
01575
01576     /* Check time... */
01577     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01578       continue;
01579
01580     /* Check ensemble id... */
01581     if (atm->q[ctl->qnt_ens][ip] != ens) {
01582
01583       /* Write results... */
01584       if (n > 0) {
01585
01586         /* Get mean position... */
01587         xm[0] = xm[1] = xm[2] = 0;
01588         for (i = 0; i < n; i++) {
01589           xm[0] += x[i][0] / (double) n;
01590           xm[1] += x[i][1] / (double) n;
01591           xm[2] += x[i][2] / (double) n;
01592         }
01593         cart2geo(xm, &dummy, &lon, &lat);
01594         fprintf(out, "%.2f %g %g %g", t, Z(gsl_stats_mean(p, 1, n)), lon,
01595                 lat);
01596
01597         /* Get quantity statistics... */
01598         for (iq = 0; iq < ctl->nq; iq++) {
01599           fprintf(out, " ");
01600           fprintf(out, ctl->qnt_format[iq], gsl_stats_mean(q[iq], 1, n));
01601         }
01602         for (iq = 0; iq < ctl->nq; iq++) {
01603           fprintf(out, " ");
01604           fprintf(out, ctl->qnt_format[iq], gsl_stats_sd(q[iq], 1, n));
01605         }
01606         fprintf(out, " %lu\n", n);
01607       }
01608
01609       /* Init new ensemble... */
01610       ens = atm->q[ctl->qnt_ens][ip];
01611       n = 0;
01612     }
01613
01614     /* Save data... */
01615     p[n] = atm->p[ip];
01616     geo2cart(0, atm->lon[ip], atm->lat[ip], x[n]);
01617     for (iq = 0; iq < ctl->nq; iq++)
01618       q[iq][n] = atm->q[iq][ip];
01619     if ((++n) >= NENS)
01620       ERRMSG("Too many data points!");
01621   }
01622
01623   /* Write results... */
01624   if (n > 0) {
01625
01626     /* Get mean position... */
01627     xm[0] = xm[1] = xm[2] = 0;
01628     for (i = 0; i < n; i++) {
01629       xm[0] += x[i][0] / (double) n;
01630       xm[1] += x[i][1] / (double) n;
01631       xm[2] += x[i][2] / (double) n;
01632     }
01633     cart2geo(xm, &dummy, &lon, &lat);
01634     fprintf(out, "%.2f %g %g %g", t, Z(gsl_stats_mean(p, 1, n)), lon, lat);
01635
01636     /* Get quantity statistics... */
01637     for (iq = 0; iq < ctl->nq; iq++) {
01638       fprintf(out, " ");
01639       fprintf(out, ctl->qnt_format[iq], gsl_stats_mean(q[iq], 1, n));
01640     }
01641     for (iq = 0; iq < ctl->nq; iq++) {
01642       fprintf(out, " ");
01643       fprintf(out, ctl->qnt_format[iq], gsl_stats_sd(q[iq], 1, n));
01644     }
01645     fprintf(out, " %lu\n", n);
01646   }
01647
01648   /* Close file... */
01649   if (t == ctl->t_stop)
01650     fclose(out);
01651 }
01652
01653 /*****************************************************************************/
01654
01655 void write_grid(
```

```
01656   const char *filename,
01657   ctl_t * ctl,
01658   met_t * met0,
01659   met_t * met1,
01660   atm_t * atm,
01661   double t) {
01662
01663   FILE *in, *out;
01664
01665   char line[LEN];
01666
01667   static double grid_m[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
01668     area, rho_air, press, temp, cd, mmr, t0, t1, r;
01669
01670   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
01671
01672   /* Check dimensions... */
01673   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
01674     ERRMSG("Grid dimensions too large!");
01675
01676   /* Check quantity index for mass... */
01677   if (ctl->qnt_m < 0)
01678     ERRMSG("Need quantity mass to write grid data!");
01679
01680   /* Set time interval for output... */
01681   t0 = t - 0.5 * ctl->dt_mod;
01682   t1 = t + 0.5 * ctl->dt_mod;
01683
01684   /* Set grid box size... */
01685   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
01686   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
01687   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
01688
01689   /* Initialize grid... */
01690   for (ix = 0; ix < ctl->grid_nx; ix++)
01691     for (iy = 0; iy < ctl->grid_ny; iy++)
01692       for (iz = 0; iz < ctl->grid_nz; iz++)
01693         grid_m[ix][iy][iz] = 0;
01694
01695   /* Average data... */
01696   for (ip = 0; ip < atm->np; ip++)
01697     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
01698
01699       /* Get index... */
01700       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
01701       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
01702       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
01703
01704       /* Check indices... */
01705       if (ix < 0 || ix >= ctl->grid_nx ||
01706           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
01707         continue;
01708
01709       /* Add mass... */
01710       grid_m[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01711     }
01712
01713   /* Check if gnuplot output is requested... */
01714   if (ctl->grid_gpfile[0] != '-') {
01715
01716     /* Write info... */
01717     printf("Plot grid data: %s.png\n", filename);
01718
01719     /* Create gnuplot pipe... */
01720     if (!(out = popen("gnuplot", "w")))
01721       ERRMSG("Cannot create pipe to gnuplot!");
01722
01723     /* Set plot filename... */
01724     fprintf(out, "set out \"%s.png\"\n", filename);
01725
01726     /* Set time string... */
01727     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01728     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01729             year, mon, day, hour, min);
01730
01731     /* Dump gnuplot file to pipe... */
01732     if (!(in = fopen(ctl->grid_gpfile, "r")))
01733       ERRMSG("Cannot open file!");
01734     while (fgets(line, LEN, in))
01735       fprintf(out, "%s", line);
01736     fclose(in);
01737   }
01738
01739   else {
01740
01741     /* Write info... */
01742     printf("Write grid data: %s\n", filename);
```

```
01743
01744     /* Create file... */
01745     if (!(out = fopen(filename, "w")))
01746       ERRMSG("Cannot create file!");
01747   }
01748
01749   /* Write header... */
01750   fprintf(out,
01751           "# $1 = time [s]\n"
01752           "# $2 = altitude [km]\n"
01753           "# $3 = longitude [deg]\n"
01754           "# $4 = latitude [deg]\n"
01755           "# $5 = surface area [km^2]\n"
01756           "# $6 = layer width [km]\n"
01757           "# $7 = temperature [K]\n"
01758           "# $8 = column density [kg/m^2]\n"
01759           "# $9 = mass mixing ratio [1]\n\n");
01760
01761   /* Write data... */
01762   for (ix = 0; ix < ctl->grid_nx; ix++) {
01763     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
01764       fprintf(out, "\n");
01765     for (iy = 0; iy < ctl->grid_ny; iy++) {
01766       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
01767         fprintf(out, "\n");
01768       for (iz = 0; iz < ctl->grid_nz; iz++)
01769         if (!ctl->grid_sparse
01770             || ix == 0 || iy == 0 || iz == 0 || grid_m[ix][iy][iz] > 0) {
01771
01772           /* Set coordinates... */
01773           z = ctl->grid_z0 + dz * (iz + 0.5);
01774           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
01775           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
01776
01777           /* Get pressure and temperature... */
01778           press = P(z);
01779           intpol_met_time(met0, met1, t, press, lon, lat,
01780                           NULL, &temp, NULL, NULL, NULL, NULL, NULL);
01781
01782           /* Calculate surface area... */
01783           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
01784             * cos(lat * M_PI / 180.);
01785
01786           /* Calculate column density... */
01787           cd = grid_m[ix][iy][iz] / (1e6 * area);
01788
01789           /* Calculate mass mixing ratio... */
01790           rho_air = 100. * press / (287.058 * temp);
01791           mmr = grid_m[ix][iy][iz] / (rho_air * 1e6 * area * 1e3 * dz);
01792
01793           /* Write output... */
01794           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01795                   t, z, lon, lat, area, dz, temp, cd, mmr);
01796         }
01797     }
01798   }
01799
01800   /* Close file... */
01801   fclose(out);
01802 }
01803
01804 /*****************************************************************************/
01805
01806 void write_prof(
01807   const char *filename,
01808   ctl_t * ctl,
01809   met_t * met0,
01810   met_t * met1,
01811   atm_t * atm,
01812   double t) {
01813
01814   static FILE *in, *out;
01815
01816   static char line[LEN];
01817
01818   static double mass[GX][GY][GZ], obsmean[GX][GY], tmean[GX][GY],
01819     rt, rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z,
01820     press, temp, rho_air, mmr, h2o, o3;
01821
01822   static int init, obscount[GX][GY], ip, ix, iy, iz;
01823
01824   /* Init... */
01825   if (!init) {
01826     init = 1;
01827
01828     /* Check quantity index for mass... */
01829     if (ctl->qnt_m < 0)
```

```
01830       ERRMSG("Need quantity mass!");
01831
01832     /* Check dimensions... */
01833     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
01834       ERRMSG("Grid dimensions too large!");
01835
01836     /* Open observation data file... */
01837     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
01838     if (!(in = fopen(ctl->prof_obsfile, "r")))
01839       ERRMSG("Cannot open file!");
01840
01841     /* Create new file... */
01842     printf("Write profile data: %s\n", filename);
01843     if (!(out = fopen(filename, "w")))
01844       ERRMSG("Cannot create file!");
01845
01846     /* Write header... */
01847     fprintf(out,
01848             "# $1  = time [s]\n"
01849             "# $2  = altitude [km]\n"
01850             "# $3  = longitude [deg]\n"
01851             "# $4  = latitude [deg]\n"
01852             "# $5  = pressure [hPa]\n"
01853             "# $6  = temperature [K]\n"
01854             "# $7  = mass mixing ratio [1]\n"
01855             "# $8  = H2O volume mixing ratio [1]\n"
01856             "# $9  = O3 volume mixing ratio [1]\n"
01857             "# $10 = mean BT index [K]\n");
01858
01859     /* Set grid box size... */
01860     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
01861     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
01862     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
01863   }
01864
01865   /* Set time interval... */
01866   t0 = t - 0.5 * ctl->dt_mod;
01867   t1 = t + 0.5 * ctl->dt_mod;
01868
01869   /* Initialize... */
01870   for (ix = 0; ix < ctl->prof_nx; ix++)
01871     for (iy = 0; iy < ctl->prof_ny; iy++) {
01872       obsmean[ix][iy] = 0;
01873       obscount[ix][iy] = 0;
01874       tmean[ix][iy] = 0;
01875       for (iz = 0; iz < ctl->prof_nz; iz++)
01876         mass[ix][iy][iz] = 0;
01877     }
01878
01879   /* Read data... */
01880   while (fgets(line, LEN, in)) {
01881
01882     /* Read data... */
01883     if (sscanf(line, "%lg %lg %lg %lg", &rt, &rlon, &rlat, &robs) != 4)
01884       continue;
01885
01886     /* Check time... */
01887     if (rt < t0)
01888       continue;
01889     if (rt > t1)
01890       break;
01891
01892     /* Calculate indices... */
01893     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
01894     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
01895
01896     /* Check indices... */
01897     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
01898       continue;
01899
01900     /* Get mean observation index... */
01901     obsmean[ix][iy] += robs;
01902     tmean[ix][iy] += rt;
01903     obscount[ix][iy]++;
01904   }
01905
01906   /* Analyze model data... */
01907   for (ip = 0; ip < atm->np; ip++) {
01908
01909     /* Check time... */
01910     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01911       continue;
01912
01913     /* Get indices... */
01914     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
01915     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
01916     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
```

```
01917
01918     /* Check indices... */
01919     if (ix < 0 || ix >= ctl->prof_nx ||
01920         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
01921       continue;
01922
01923     /* Get total mass in grid cell... */
01924     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01925   }
01926
01927   /* Extract profiles... */
01928   for (ix = 0; ix < ctl->prof_nx; ix++)
01929     for (iy = 0; iy < ctl->prof_ny; iy++)
01930       if (obscount[ix][iy] > 0) {
01931
01932         /* Write output... */
01933         fprintf(out, "\n");
01934
01935         /* Loop over altitudes... */
01936         for (iz = 0; iz < ctl->prof_nz; iz++) {
01937
01938           /* Set coordinates... */
01939           z = ctl->prof_z0 + dz * (iz + 0.5);
01940           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
01941           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
01942
01943           /* Get meteorological data... */
01944           press = P(z);
01945           intpol_met_time(met0, met1, t, press, lon, lat,
01946                           NULL, &temp, NULL, NULL, NULL, &h2o, &o3);
01947
01948           /* Calculate mass mixing ratio... */
01949           rho_air = 100. * press / (287.058 * temp);
01950           area = dlat * dlon * gsl_pow_2(M_PI * RE / 180.)
01951             * cos(lat * M_PI / 180.);
01952           mmr = mass[ix][iy][iz] / (rho_air * area * dz * 1e9);
01953
01954           /* Write output... */
01955           fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g\n",
01956                   tmean[ix][iy] / obscount[ix][iy],
01957                   z, lon, lat, press, temp, mmr, h2o, o3,
01958                   obsmean[ix][iy] / obscount[ix][iy]);
01959         }
01960       }
01961
01962   /* Close file... */
01963   if (t == ctl->t_stop)
01964     fclose(out);
01965 }
01966
01967 /*****************************************************************************/
01968
01969 void write_station(
01970   const char *filename,
01971   ctl_t * ctl,
01972   atm_t * atm,
01973   double t) {
01974
01975   static FILE *out;
01976
01977   static double rmax2, t0, t1, x0[3], x1[3];
01978
01979   static int init, ip, iq;
01980
01981   /* Init... */
01982   if (!init) {
01983     init = 1;
01984
01985     /* Write info... */
01986     printf("Write station data: %s\n", filename);
01987
01988     /* Create new file... */
01989     if (!(out = fopen(filename, "w")))
01990       ERRMSG("Cannot create file!");
01991
01992     /* Write header... */
01993     fprintf(out,
01994             "# $1 = time [s]\n"
01995             "# $2 = altitude [km]\n"
01996             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01997     for (iq = 0; iq < ctl->nq; iq++)
01998       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
01999               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
02000     fprintf(out, "\n");
02001
02002     /* Set geolocation and search radius... */
02003     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
```

```
02004     rmax2 = gsl_pow_2(ctl->stat_r);
02005   }
02006
02007   /* Set time interval for output... */
02008   t0 = t - 0.5 * ctl->dt_mod;
02009   t1 = t + 0.5 * ctl->dt_mod;
02010
02011   /* Loop over air parcels... */
02012   for (ip = 0; ip < atm->np; ip++) {
02013
02014     /* Check time... */
02015     if (atm->time[ip] < t0 || atm->time[ip] > t1)
02016       continue;
02017
02018     /* Check station flag... */
02019     if (ctl->qnt_stat >= 0)
02020       if (atm->q[ctl->qnt_stat][ip])
02021         continue;
02022
02023     /* Get Cartesian coordinates... */
02024     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
02025
02026     /* Check horizontal distance... */
02027     if (DIST2(x0, x1) > rmax2)
02028       continue;
02029
02030     /* Set station flag... */
02031     if (ctl->qnt_stat >= 0)
02032       atm->q[ctl->qnt_stat][ip] = 1;
02033
02034     /* Write data... */
02035     fprintf(out, "%.2f %g %g %g",
02036             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
02037     for (iq = 0; iq < ctl->nq; iq++) {
02038       fprintf(out, " ");
02039       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
02040     }
02041     fprintf(out, "\n");
02042   }
02043
02044   /* Close file... */
02045   if (t == ctl->t_stop)
02046     fclose(out);
02047 }
```

5.13 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 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 *t, double *u, double *v, double *w, 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 *t, double *u, double *v, double *w, 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_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.
- 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.
- double tropopause (double t, double lat)
- 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.

5.13.1 Detailed Description

MPTRAC library declarations.

Definition in file libtrac.h.

5.13.2 Function Documentation

5.13.2.1 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 }
```

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

Convert degrees to horizontal distance.

Definition at line 45 of file libtrac.c.

```
00047               {
00048
00049   return dlon * M_PI * RE / 180. * cos(lat / 180. * M_PI);
00050 }
```

5.13.2.3 double deg2dy (double *dlat*)

Convert degrees to horizontal distance.

Definition at line 54 of file libtrac.c.

```
00055                {
00056
00057   return dlat * M_PI * RE / 180.;
00058 }
```

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

Convert pressure to vertical distance.

Definition at line 62 of file libtrac.c.

```
00064             {
00065
00066   return -dp * H0 / p;
00067 }
```

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

Convert horizontal distance to degrees.

Definition at line 71 of file libtrac.c.

```
00073               {
00074
00075   /* Avoid singularity at poles... */
00076   if (lat < -89.999 || lat > 89.999)
00077     return 0;
00078   else
00079     return dx * 180. / (M_PI * RE * cos(lat / 180. * M_PI));
00080 }
```

5.13.2.6 double dy2deg (double *dy*)

Convert horizontal distance to degrees.

Definition at line 84 of file libtrac.c.

```
00085              {
00086
00087   return dy * 180. / (M_PI * RE);
00088 }
```

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

Convert vertical distance to pressure.

Definition at line 92 of file libtrac.c.

```
00094             {
00095
00096   return -dz * p / H0;
00097 }
```

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

Convert geolocation to Cartesian coordinates.

Definition at line 101 of file libtrac.c.

```
00105              {
00106
00107   double radius;
00108
00109   radius = z + RE;
00110   x[0] = radius * cos(lat / 180 * M_PI) * cos(lon / 180 * M_PI);
00111   x[1] = radius * cos(lat / 180 * M_PI) * sin(lon / 180 * M_PI);
00112   x[2] = radius * sin(lat / 180 * M_PI);
00113 }
```

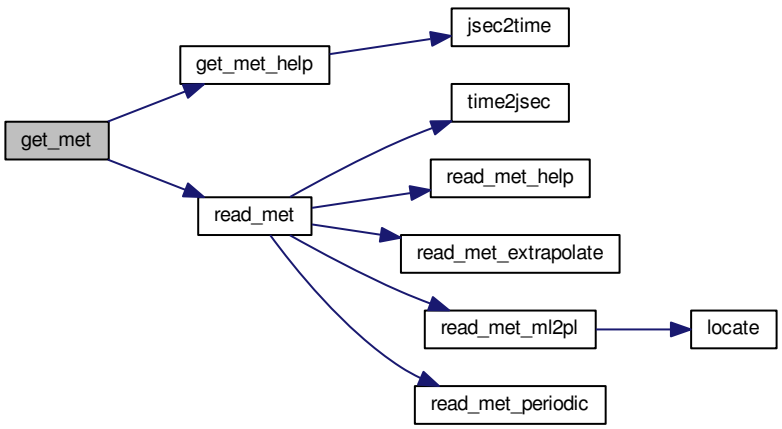
5.13.2.9 void get_met (ctl_t * *ctl,* char * *metbase,* double *t,* met_t * *met0,* met_t * *met1*)

Get meteorological data for given timestep.

Definition at line 117 of file libtrac.c.

```
00122                 {
00123
00124   char filename[LEN];
00125
00126   static int init;
00127
00128   /* Init... */
00129   if (!init) {
00130     init = 1;
00131
00132     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00133     read_met(ctl, filename, met0);
00134
00135     get_met_help(t + 1.0 * ctl->direction, 1, metbase, ctl->
      dt_met, filename);
00136     read_met(ctl, filename, met1);
00137   }
00138
00139   /* Read new data for forward trajectories... */
00140   if (t > met1->time && ctl->direction == 1) {
00141     memcpy(met0, met1, sizeof(met_t));
00142     get_met_help(t, 1, metbase, ctl->dt_met, filename);
00143     read_met(ctl, filename, met1);
00144   }
00145
00146   /* Read new data for backward trajectories... */
00147   if (t < met0->time && ctl->direction == -1) {
00148     memcpy(met1, met0, sizeof(met_t));
00149     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00150     read_met(ctl, filename, met0);
00151   }
00152 }
```

Here is the call graph for this function:



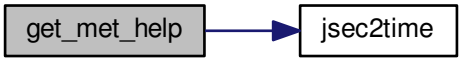
5.13.2.10 void get_met_help (double *t,* int *direct,* char * *metbase,* double *dt_met,* char * *filename*)

Get meteorological data for timestep.

Definition at line 156 of file libtrac.c.

```
00161                   {
00162
00163   double t6, r;
00164
00165   int year, mon, day, hour, min, sec;
00166
00167   /* Round time to fixed intervals... */
00168   if (direct == -1)
00169     t6 = floor(t / dt_met) * dt_met;
00170   else
00171     t6 = ceil(t / dt_met) * dt_met;
00172
00173   /* Decode time... */
00174   jsec2time(t6, &year, &mon, &day, &hour, &min, &sec, &r);
00175
00176   /* Set filename... */
00177   sprintf(filename, "%s_%d_%02d_%02d_%02d.nc", metbase, year, mon, day, hour);
00178 }
```

Here is the call graph for this function:



5.13.2.11 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 182 of file libtrac.c.

```
00188               {
00189
00190   double aux00, aux01, aux10, aux11;
00191
00192   /* Set variables... */
00193   aux00 = array[ix][iy];
00194   aux01 = array[ix][iy + 1];
00195   aux10 = array[ix + 1][iy];
00196   aux11 = array[ix + 1][iy + 1];
00197
00198   /* Interpolate horizontally... */
00199   aux00 = wy * (aux00 - aux01) + aux01;
00200   aux11 = wy * (aux10 - aux11) + aux11;
00201   *var = wx * (aux00 - aux11) + aux11;
00202 }
```

5.13.2.12 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 206 of file libtrac.c.

```
00214               {
00215
00216   double aux00, aux01, aux10, aux11;
00217
00218   /* Interpolate vertically... */
00219   aux00 = wp * (array[ix][iy][ip] - array[ix][iy][ip + 1])
00220     + array[ix][iy][ip + 1];
00221   aux01 = wp * (array[ix][iy + 1][ip] - array[ix][iy + 1][ip + 1])
00222     + array[ix][iy + 1][ip + 1];
00223   aux10 = wp * (array[ix + 1][iy][ip] - array[ix + 1][iy][ip + 1])
00224     + array[ix + 1][iy][ip + 1];
00225   aux11 = wp * (array[ix + 1][iy + 1][ip] - array[ix + 1][iy + 1][ip + 1])
00226     + array[ix + 1][iy + 1][ip + 1];
00227
00228   /* Interpolate horizontally... */
00229   aux00 = wy * (aux00 - aux01) + aux01;
00230   aux11 = wy * (aux10 - aux11) + aux11;
00231   *var = wx * (aux00 - aux11) + aux11;
00232 }
```

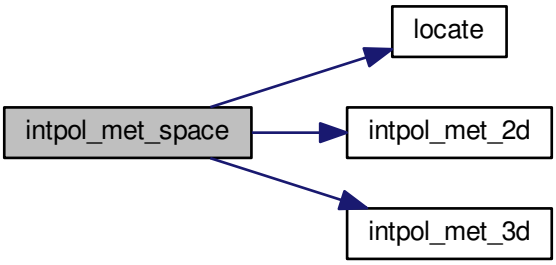
5.13.2.13 void intpol_met_space (met_t * *met*, double *p*, double *lon*, double *lat*, double * *ps*, double * *t*, double * *u*, double * *v*, double * *w*, double * *h2o*, double * *o3*)

Spatial interpolation of meteorological data.

Definition at line 236 of file libtrac.c.

```
00247               {
00248
00249   double wp, wx, wy;
00250
00251   int ip, ix, iy;
00252
00253   /* Check longitude... */
00254   if (met->lon[met->nx - 1] > 180 && lon < 0)
00255     lon += 360;
00256
00257   /* Get indices... */
00258   ip = locate(met->p, met->np, p);
00259   ix = locate(met->lon, met->nx, lon);
00260   iy = locate(met->lat, met->ny, lat);
00261
00262   /* Get weights... */
00263   wp = (met->p[ip + 1] - p) / (met->p[ip + 1] - met->p[ip]);
00264   wx = (met->lon[ix + 1] - lon) / (met->lon[ix + 1] - met->lon[ix]);
00265   wy = (met->lat[iy + 1] - lat) / (met->lat[iy + 1] - met->lat[iy]);
00266
00267   /* Interpolate... */
00268   if (ps != NULL)
00269     intpol_met_2d(met->ps, ix, iy, wx, wy, ps);
00270   if (t != NULL)
00271     intpol_met_3d(met->t, ip, ix, iy, wp, wx, wy, t);
00272   if (u != NULL)
00273     intpol_met_3d(met->u, ip, ix, iy, wp, wx, wy, u);
00274   if (v != NULL)
00275     intpol_met_3d(met->v, ip, ix, iy, wp, wx, wy, v);
00276   if (w != NULL)
00277     intpol_met_3d(met->w, ip, ix, iy, wp, wx, wy, w);
00278   if (h2o != NULL)
00279     intpol_met_3d(met->h2o, ip, ix, iy, wp, wx, wy, h2o);
00280   if (o3 != NULL)
00281     intpol_met_3d(met->o3, ip, ix, iy, wp, wx, wy, o3);
00282 }
```

Here is the call graph for this function:



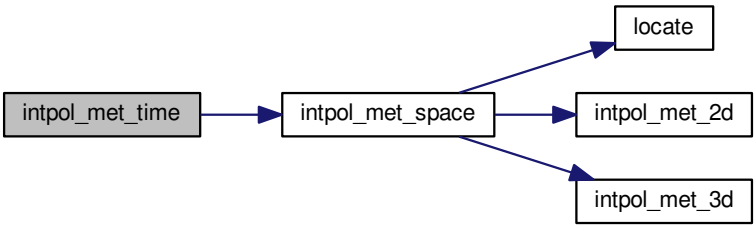
5.13.2.14 void intpol_met_time (met_t * *met0*, met_t * *met1*, double *ts*, double *p*, double *lon*, double *lat*, double * *ps*, double * *t*, double * *u*, double * *v*, double * *w*, double * *h2o*, double * *o3*)

Temporal interpolation of meteorological data.

Definition at line 286 of file libtrac.c.

```
00299              {
00300
00301   double h2o0, h2o1, o30, o31, ps0, ps1, t0, t1, u0, u1, v0, v1, w0, w1, wt;
00302
00303   /* Spatial interpolation... */
00304   intpol_met_space(met0, p, lon, lat,
00305                    ps == NULL ? NULL : &ps0,
00306                    t == NULL ? NULL : &t0,
00307                    u == NULL ? NULL : &u0,
00308                    v == NULL ? NULL : &v0,
00309                    w == NULL ? NULL : &w0,
00310                    h2o == NULL ? NULL : &h2o0, o3 == NULL ? NULL : &o30);
00311   intpol_met_space(met1, p, lon, lat,
00312                    ps == NULL ? NULL : &ps1,
00313                    t == NULL ? NULL : &t1,
00314                    u == NULL ? NULL : &u1,
00315                    v == NULL ? NULL : &v1,
00316                    w == NULL ? NULL : &w1,
00317                    h2o == NULL ? NULL : &h2o1, o3 == NULL ? NULL : &o31);
00318
00319   /* Get weighting factor... */
00320   wt = (met1->time - ts) / (met1->time - met0->time);
00321
00322   /* Interpolate... */
00323   if (ps != NULL)
00324     *ps = wt * (ps0 - ps1) + ps1;
00325   if (t != NULL)
00326     *t = wt * (t0 - t1) + t1;
00327   if (u != NULL)
00328     *u = wt * (u0 - u1) + u1;
00329   if (v != NULL)
00330     *v = wt * (v0 - v1) + v1;
00331   if (w != NULL)
00332     *w = wt * (w0 - w1) + w1;
00333   if (h2o != NULL)
00334     *h2o = wt * (h2o0 - h2o1) + h2o1;
00335   if (o3 != NULL)
00336     *o3 = wt * (o30 - o31) + o31;
00337 }
```

Here is the call graph for this function:



5.13.2.15 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 341 of file libtrac.c.

```
00349                   {
00350
00351   struct tm t0, *t1;
00352
00353   time_t jsec0;
00354
00355   t0.tm_year = 100;
00356   t0.tm_mon = 0;
00357   t0.tm_mday = 1;
00358   t0.tm_hour = 0;
00359   t0.tm_min = 0;
00360   t0.tm_sec = 0;
00361
00362   jsec0 = (time_t) jsec + timegm(&t0);
00363   t1 = gmtime(&jsec0);
00364
00365   *year = t1->tm_year + 1900;
00366   *mon = t1->tm_mon + 1;
00367   *day = t1->tm_mday;
00368   *hour = t1->tm_hour;
00369   *min = t1->tm_min;
00370   *sec = t1->tm_sec;
00371   *remain = jsec - floor(jsec);
00372 }
```

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

Find array index.

Definition at line 376 of file libtrac.c.

```
00379             {
00380
00381   int i, ilo, ihi;
00382
00383   ilo = 0;
00384   ihi = n - 1;
00385   i = (ihi + ilo) >> 1;
00386
00387   if (xx[i] < xx[i + 1])
00388     while (ihi > ilo + 1) {
00389       i = (ihi + ilo) >> 1;
00390       if (xx[i] > x)
```

```
00391         ihi = i;
00392       else
00393         ilo = i;
00394     } else
00395       while (ihi > ilo + 1) {
00396         i = (ihi + ilo) >> 1;
00397         if (xx[i] <= x)
00398           ihi = i;
00399         else
00400           ilo = i;
00401       }
00402
00403     return ilo;
00404   }
```

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

Read atmospheric data.

Definition at line 408 of file libtrac.c.

```
00411                 {
00412
00413     FILE *in;
00414
00415     char line[LEN], *tok;
00416
00417     int iq;
00418
00419     /* Init... */
00420     atm->np = 0;
00421
00422     /* Write info... */
00423     printf("Read atmospheric data: %s\n", filename);
00424
00425     /* Open file... */
00426     if (!(in = fopen(filename, "r")))
00427       ERRMSG("Cannot open file!");
00428
00429     /* Read line... */
00430     while (fgets(line, LEN, in)) {
00431
00432       /* Read data... */
00433       TOK(line, tok, "%lg", atm->time[atm->np]);
00434       TOK(NULL, tok, "%lg", atm->p[atm->np]);
00435       TOK(NULL, tok, "%lg", atm->lon[atm->np]);
00436       TOK(NULL, tok, "%lg", atm->lat[atm->np]);
00437       for (iq = 0; iq < ctl->nq; iq++)
00438         TOK(NULL, tok, "%lg", atm->q[iq][atm->np]);
00439
00440       /* Convert altitude to pressure... */
00441       atm->p[atm->np] = P(atm->p[atm->np]);
00442
00443       /* Increment data point counter... */
00444       if ((++atm->np) > NP)
00445         ERRMSG("Too many data points!");
00446     }
00447
00448     /* Close file... */
00449     fclose(in);
00450
00451     /* Check number of points... */
00452     if (atm->np < 1)
00453       ERRMSG("Can not read any data!");
00454   }
```

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

Read control parameters.

Definition at line 458 of file libtrac.c.

```
00462               {
00463
00464   int ip, iq;
00465
00466   /* Write info... */
00467   printf("\nMassive-Parallel Trajectory Calculations (MPTRAC)\n"
00468          "(executable: %s | compiled: %s, %s)\n\n",
00469          argv[0], __DATE__, __TIME__);
00470
00471   /* Initialize quantity indices... */
00472   ctl->qnt_ens = -1;
00473   ctl->qnt_m = -1;
00474   ctl->qnt_r = -1;
00475   ctl->qnt_rho = -1;
00476   ctl->qnt_ps = -1;
00477   ctl->qnt_p = -1;
00478   ctl->qnt_t = -1;
00479   ctl->qnt_u = -1;
00480   ctl->qnt_v = -1;
00481   ctl->qnt_w = -1;
00482   ctl->qnt_h2o = -1;
00483   ctl->qnt_o3 = -1;
00484   ctl->qnt_theta = -1;
00485   ctl->qnt_pv = -1;
00486   ctl->qnt_tice = -1;
00487   ctl->qnt_tsts = -1;
00488   ctl->qnt_tnat = -1;
00489   ctl->qnt_gw_var = -1;
00490   ctl->qnt_stat = -1;
00491
00492   /* Read quantities... */
00493   ctl->nq = (int) scan_ctl(filename, argc, argv, "NQ", -1, "0", NULL);
00494   if (ctl->nq > NQ)
00495     ERRMSG("Too many quantities!");
00496   for (iq = 0; iq < ctl->nq; iq++) {
00497
00498     /* Read quantity name and format... */
00499     scan_ctl(filename, argc, argv, "QNT_NAME", iq, "", ctl->qnt_name[iq]);
00500     scan_ctl(filename, argc, argv, "QNT_FORMAT", iq, "%g",
00501              ctl->qnt_format[iq]);
00502
00503     /* Try to identify quantity... */
00504     if (strcmp(ctl->qnt_name[iq], "ens") == 0) {
00505       ctl->qnt_ens = iq;
00506       sprintf(ctl->qnt_unit[iq], "-");
00507     } else if (strcmp(ctl->qnt_name[iq], "m") == 0) {
00508       ctl->qnt_m = iq;
00509       sprintf(ctl->qnt_unit[iq], "kg");
00510     } else if (strcmp(ctl->qnt_name[iq], "r") == 0) {
00511       ctl->qnt_r = iq;
00512       sprintf(ctl->qnt_unit[iq], "m");
00513     } else if (strcmp(ctl->qnt_name[iq], "rho") == 0) {
00514       ctl->qnt_rho = iq;
00515       sprintf(ctl->qnt_unit[iq], "kg/m^3");
00516     } else if (strcmp(ctl->qnt_name[iq], "ps") == 0) {
00517       ctl->qnt_ps = iq;
00518       sprintf(ctl->qnt_unit[iq], "hPa");
00519     } else if (strcmp(ctl->qnt_name[iq], "p") == 0) {
00520       ctl->qnt_p = iq;
00521       sprintf(ctl->qnt_unit[iq], "hPa");
00522     } else if (strcmp(ctl->qnt_name[iq], "t") == 0) {
00523       ctl->qnt_t = iq;
00524       sprintf(ctl->qnt_unit[iq], "K");
00525     } else if (strcmp(ctl->qnt_name[iq], "u") == 0) {
00526       ctl->qnt_u = iq;
00527       sprintf(ctl->qnt_unit[iq], "m/s");
00528     } else if (strcmp(ctl->qnt_name[iq], "v") == 0) {
00529       ctl->qnt_v = iq;
00530       sprintf(ctl->qnt_unit[iq], "m/s");
00531     } else if (strcmp(ctl->qnt_name[iq], "w") == 0) {
00532       ctl->qnt_w = iq;
00533       sprintf(ctl->qnt_unit[iq], "hPa/s");
00534     } else if (strcmp(ctl->qnt_name[iq], "h2o") == 0) {
00535       ctl->qnt_h2o = iq;
00536       sprintf(ctl->qnt_unit[iq], "1");
00537     } else if (strcmp(ctl->qnt_name[iq], "o3") == 0) {
00538       ctl->qnt_o3 = iq;
00539       sprintf(ctl->qnt_unit[iq], "1");
00540     } else if (strcmp(ctl->qnt_name[iq], "theta") == 0) {
00541       ctl->qnt_theta = iq;
00542       sprintf(ctl->qnt_unit[iq], "K");
00543     } else if (strcmp(ctl->qnt_name[iq], "pv") == 0) {
00544       ctl->qnt_pv = iq;
00545       sprintf(ctl->qnt_unit[iq], "PVU");
00546     } else if (strcmp(ctl->qnt_name[iq], "tice") == 0) {
00547       ctl->qnt_tice = iq;
00548       sprintf(ctl->qnt_unit[iq], "K");
```

```
00549     } else if (strcmp(ctl->qnt_name[iq], "tsts") == 0) {
00550       ctl->qnt_tsts = iq;
00551       sprintf(ctl->qnt_unit[iq], "K");
00552     } else if (strcmp(ctl->qnt_name[iq], "tnat") == 0) {
00553       ctl->qnt_tnat = iq;
00554       sprintf(ctl->qnt_unit[iq], "K");
00555     } else if (strcmp(ctl->qnt_name[iq], "gw_var") == 0) {
00556       ctl->qnt_gw_var = iq;
00557       sprintf(ctl->qnt_unit[iq], "K^2");
00558     } else if (strcmp(ctl->qnt_name[iq], "stat") == 0) {
00559       ctl->qnt_stat = iq;
00560       sprintf(ctl->qnt_unit[iq], "-");
00561     } else
00562       scan_ctl(filename, argc, argv, "QNT_UNIT", iq, "", ctl->qnt_unit[iq]);
00563   }
00564
00565   /* Time steps of simulation... */
00566   ctl->direction =
00567     (int) scan_ctl(filename, argc, argv, "DIRECTION", -1, "1", NULL);
00568   if (ctl->direction != -1 && ctl->direction != 1)
00569     ERRMSG("Set DIRECTION to -1 or 1!");
00570   ctl->t_start =
00571     scan_ctl(filename, argc, argv, "T_START", -1, "-1e100", NULL);
00572   ctl->t_stop = scan_ctl(filename, argc, argv, "T_STOP", -1, "-1e100", NULL);
00573   ctl->dt_mod = scan_ctl(filename, argc, argv, "DT_MOD", -1, "600", NULL);
00574
00575   /* Meteorological data... */
00576   ctl->dt_met = scan_ctl(filename, argc, argv, "DT_MET", -1, "21600", NULL);
00577   ctl->met_np = (int) scan_ctl(filename, argc, argv, "MET_NP", -1, "0", NULL);
00578   if (ctl->met_np > EP)
00579     ERRMSG("Too many levels!");
00580   for (ip = 0; ip < ctl->met_np; ip++)
00581     ctl->met_p[ip] = scan_ctl(filename, argc, argv, "MET_P", ip, "", NULL);
00582   scan_ctl(filename, argc, argv, "MET_STAGE", -1, "-", ctl->met_stage);
00583
00584   /* Isosurface parameters... */
00585   ctl->isosurf
00586     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
00587   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
00588
00589   /* Diffusion parameters... */
00590   ctl->turb_dx_trop
00591     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50.0", NULL);
00592   ctl->turb_dx_strat
00593     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0.0", NULL);
00594   ctl->turb_dz_trop
00595     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0.0", NULL);
00596   ctl->turb_dz_strat
00597     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
00598   ctl->turb_meso =
00599     scan_ctl(filename, argc, argv, "TURB_MESO", -1, "0.16", NULL);
00600
00601   /* Life time of particles... */
00602   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
00603   ctl->tdec_strat =
00604     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
00605
00606   /* PSC analysis... */
00607   ctl->psc_h2o = scan_ctl(filename, argc, argv, "PSC_H2O", -1, "4e-6", NULL);
00608   ctl->psc_hno3 =
00609     scan_ctl(filename, argc, argv, "PSC_HNO3", -1, "9e-9", NULL);
00610
00611   /* Gravity wave analysis... */
00612   scan_ctl(filename, argc, argv, "GW_BASENAME", -1, "-", ctl->
      gw_basename);
00613
00614   /* Output of atmospheric data... */
00615   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
      atm_basename);
00616   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
00617   ctl->atm_dt_out =
00618     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
00619   ctl->atm_filter =
00620     (int) scan_ctl(filename, argc, argv, "ATM_FILTER", -1, "0", NULL);
00621
00622   /* Output of CSI data... */
00623   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
      csi_basename);
00624   ctl->csi_dt_out =
00625     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
00626   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "obs.tab",
00627            ctl->csi_obsfile);
00628   ctl->csi_obsmin =
00629     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
00630   ctl->csi_modmin =
00631     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
00632   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
```

```
00633   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
00634   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
00635   ctl->csi_lon0 =
00636     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
00637   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
00638   ctl->csi_nx =
00639     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
00640   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
00641   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
00642   ctl->csi_ny =
00643     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
00644
00645   /* Output of ensemble data... */
00646   scan_ctl(filename, argc, argv, "ENS_BASENAME", -1, "-", ctl->
      ens_basename);
00647
00648   /* Output of grid data... */
00649   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
00650            ctl->grid_basename);
00651   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
      grid_gpfile);
00652   ctl->grid_dt_out =
00653     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
00654   ctl->grid_sparse =
00655     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
00656   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
00657   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
00658   ctl->grid_nz =
00659     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
00660   ctl->grid_lon0 =
00661     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
00662   ctl->grid_lon1 =
00663     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
00664   ctl->grid_nx =
00665     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
00666   ctl->grid_lat0 =
00667     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
00668   ctl->grid_lat1 =
00669     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
00670   ctl->grid_ny =
00671     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
00672
00673   /* Output of profile data... */
00674   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
00675            ctl->prof_basename);
00676   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
      prof_obsfile);
00677   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
00678   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
00679   ctl->prof_nz =
00680     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
00681   ctl->prof_lon0 =
00682     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
00683   ctl->prof_lon1 =
00684     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
00685   ctl->prof_nx =
00686     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
00687   ctl->prof_lat0 =
00688     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
00689   ctl->prof_lat1 =
00690     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
00691   ctl->prof_ny =
00692     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
00693
00694   /* Output of station data... */
00695   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
00696            ctl->stat_basename);
00697   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
00698   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
00699   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
00700 }
```

Here is the call graph for this function:

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

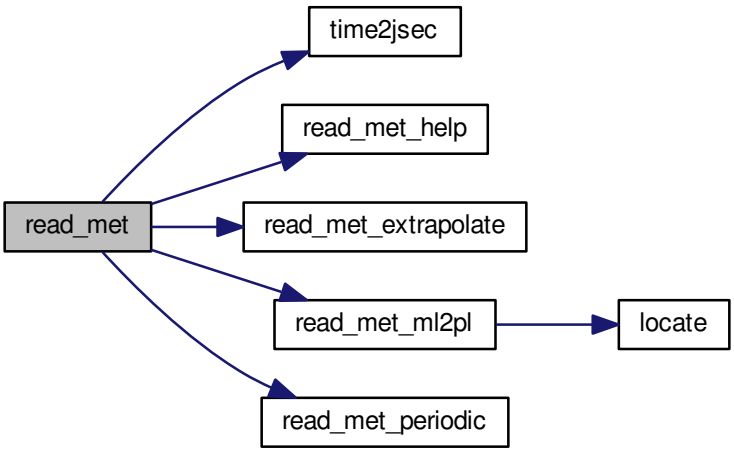
Read meteorological data file.

Definition at line 704 of file libtrac.c.

```
00707               {
00708
00709   char cmd[LEN], levname[LEN], tstr[10];
00710
00711   static float help[EX * EY];
00712
00713   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
00714
00715   size_t np, nx, ny;
00716
00717   /* Write info... */
00718   printf("Read meteorological data: %s\n", filename);
00719
00720   /* Get time from filename... */
00721   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
00722   year = atoi(tstr);
00723   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
00724   mon = atoi(tstr);
00725   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
00726   day = atoi(tstr);
00727   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
00728   hour = atoi(tstr);
00729   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
00730
00731   /* Open netCDF file... */
00732   if (nc_open(filename, NC_NOWRITE, &ncid) != NC_NOERR) {
00733
00734     /* Try to stage meteo file... */
00735     START_TIMER(TIMER_STAGE);
00736     if (ctl->met_stage[0] != '-') {
00737       sprintf(cmd, "%s %d %02d %02d %02d %s", ctl->met_stage,
00738               year, mon, day, hour, filename);
00739       if (system(cmd) != 0)
00740         ERRMSG("Error while staging meteo data!");
00741     }
00742     STOP_TIMER(TIMER_STAGE);
00743
00744     /* Try to open again... */
00745     NC(nc_open(filename, NC_NOWRITE, &ncid));
00746   }
00747
00748   /* Get dimensions... */
00749   NC(nc_inq_dimid(ncid, "lon", &dimid));
00750   NC(nc_inq_dimlen(ncid, dimid, &nx));
00751   if (nx < 2 || nx > EX)
00752     ERRMSG("Number of longitudes out of range!");
00753
00754   NC(nc_inq_dimid(ncid, "lat", &dimid));
00755   NC(nc_inq_dimlen(ncid, dimid, &ny));
00756   if (ny < 2 || ny > EY)
00757     ERRMSG("Number of latitudes out of range!");
00758
00759   sprintf(levname, "lev");
00760   NC(nc_inq_dimid(ncid, levname, &dimid));
00761   NC(nc_inq_dimlen(ncid, dimid, &np));
00762   if (np == 1) {
00763     sprintf(levname, "lev_2");
```

```
00764     NC(nc_inq_dimid(ncid, levname, &dimid));
00765     NC(nc_inq_dimlen(ncid, dimid, &np));
00766   }
00767   if (np < 2 || np > EP)
00768     ERRMSG("Number of levels out of range!");
00769
00770   /* Store dimensions... */
00771   met->np = (int) np;
00772   met->nx = (int) nx;
00773   met->ny = (int) ny;
00774
00775   /* Get horizontal grid... */
00776   NC(nc_inq_varid(ncid, "lon", &varid));
00777   NC(nc_get_var_double(ncid, varid, met->lon));
00778   NC(nc_inq_varid(ncid, "lat", &varid));
00779   NC(nc_get_var_double(ncid, varid, met->lat));
00780
00781   /* Read meteorological data... */
00782   read_met_help(ncid, "t", "T", met, met->t, 1.0);
00783   read_met_help(ncid, "u", "U", met, met->u, 1.0);
00784   read_met_help(ncid, "v", "V", met, met->v, 1.0);
00785   read_met_help(ncid, "w", "W", met, met->w, 0.01f);
00786   read_met_help(ncid, "q", "Q", met, met->h2o, 1.608f);
00787   read_met_help(ncid, "o3", "O3", met, met->o3, 0.602f);
00788
00789   /* Meteo data on pressure levels... */
00790   if (ctl->met_np <= 0) {
00791
00792     /* Read pressure levels from file... */
00793     NC(nc_inq_varid(ncid, levname, &varid));
00794     NC(nc_get_var_double(ncid, varid, met->p));
00795     for (ip = 0; ip < met->np; ip++)
00796       met->p[ip] /= 100.;
00797
00798     /* Extrapolate data for lower boundary... */
00799     read_met_extrapolate(met);
00800   }
00801
00802   /* Meteo data on model levels... */
00803   else {
00804
00805     /* Read pressure data from file... */
00806     read_met_help(ncid, "pl", "PL", met, met->pl, 0.01f);
00807
00808     /* Interpolate from model levels to pressure levels... */
00809     read_met_ml2pl(ctl, met, met->t);
00810     read_met_ml2pl(ctl, met, met->u);
00811     read_met_ml2pl(ctl, met, met->v);
00812     read_met_ml2pl(ctl, met, met->w);
00813     read_met_ml2pl(ctl, met, met->h2o);
00814     read_met_ml2pl(ctl, met, met->o3);
00815
00816     /* Set pressure levels... */
00817     met->np = ctl->met_np;
00818     for (ip = 0; ip < met->np; ip++)
00819       met->p[ip] = ctl->met_p[ip];
00820   }
00821
00822   /* Check ordering of pressure levels... */
00823   for (ip = 1; ip < met->np; ip++)
00824     if (met->p[ip - 1] < met->p[ip])
00825       ERRMSG("Pressure levels must be descending!");
00826
00827   /* Read surface pressure... */
00828   if (nc_inq_varid(ncid, "ps", &varid) == NC_NOERR
00829       || nc_inq_varid(ncid, "PS", &varid) == NC_NOERR) {
00830     NC(nc_get_var_float(ncid, varid, help));
00831     for (iy = 0; iy < met->ny; iy++)
00832       for (ix = 0; ix < met->nx; ix++)
00833         met->ps[ix][iy] = help[iy * met->nx + ix] / 100.;
00834   } else if (nc_inq_varid(ncid, "lnsp", &varid) == NC_NOERR
00835              || nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
00836     NC(nc_get_var_float(ncid, varid, help));
00837     for (iy = 0; iy < met->ny; iy++)
00838       for (ix = 0; ix < met->nx; ix++)
00839         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
00840   } else
00841     for (ix = 0; ix < met->nx; ix++)
00842       for (iy = 0; iy < met->ny; iy++)
00843         met->ps[ix][iy] = met->p[0];
00844
00845   /* Create periodic boundary conditions... */
00846   read_met_periodic(met);
00847
00848   /* Close file... */
00849   NC(nc_close(ncid));
00850 }
```

Here is the call graph for this function:



5.13.2.20 void read_met_extrapolate (met_t * *met*)

Extrapolate meteorological data at lower boundary.

Definition at line 854 of file libtrac.c.

```
00855                {
00856
00857   int ip, ip0, ix, iy;
00858
00859   /* Loop over columns... */
00860   for (ix = 0; ix < met->nx; ix++)
00861     for (iy = 0; iy < met->ny; iy++) {
00862
00863       /* Find lowest valid data point... */
00864       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
00865         if (!gsl_finite(met->t[ix][iy][ip0])
00866             || !gsl_finite(met->u[ix][iy][ip0])
00867             || !gsl_finite(met->v[ix][iy][ip0])
00868             || !gsl_finite(met->w[ix][iy][ip0]))
00869           break;
00870
00871       /* Extrapolate... */
00872       for (ip = ip0; ip >= 0; ip--) {
00873         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
00874         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
00875         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
00876         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
00877         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
00878         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
00879       }
00880     }
00881 }
```

5.13.2.21 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 885 of file libtrac.c.

```
00891             {
00892
00893   static float help[EX * EY * EP];
00894
00895   int ip, ix, iy, n = 0, varid;
00896
00897   /* Check if variable exists... */
00898   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
00899     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
00900       return;
00901
00902   /* Read data... */
00903   NC(nc_get_var_float(ncid, varid, help));
00904
00905   /* Copy and check data... */
00906   for (ip = 0; ip < met->np; ip++)
00907     for (iy = 0; iy < met->ny; iy++)
00908       for (ix = 0; ix < met->nx; ix++) {
00909         dest[ix][iy][ip] = scl * help[n++];
00910         if (fabs(dest[ix][iy][ip] / scl) > 1e14)
00911           dest[ix][iy][ip] = GSL_NAN;
00912       }
00913 }
```

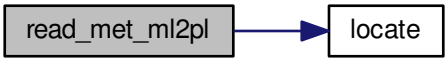
5.13.2.22 void read_met_ml2pl (ctl_t * *ctl*, met_t * *met*, float *var[EX][EY][EP]*)

Convert meteorological data from model levels to pressure levels.

Definition at line 917 of file libtrac.c.

```
00920                         {
00921
00922   double aux[EP], p[EP], pt;
00923
00924   int ip, ip2, ix, iy;
00925
00926   /* Loop over columns... */
00927   for (ix = 0; ix < met->nx; ix++)
00928     for (iy = 0; iy < met->ny; iy++) {
00929
00930       /* Copy pressure profile... */
00931       for (ip = 0; ip < met->np; ip++)
00932         p[ip] = met->pl[ix][iy][ip];
00933
00934       /* Interpolate... */
00935       for (ip = 0; ip < ctl->met_np; ip++) {
00936         pt = ctl->met_p[ip];
00937         if ((pt > p[0] && p[0] > p[1]) || (pt < p[0] && p[0] < p[1]))
00938           pt = p[0];
00939         else if ((pt > p[met->np - 1] && p[1] > p[0])
00940                  || (pt < p[met->np - 1] && p[1] < p[0]))
00941           pt = p[met->np - 1];
00942         ip2 = locate(p, met->np, pt);
00943         aux[ip] = LIN(p[ip2], var[ix][iy][ip2],
00944                       p[ip2 + 1], var[ix][iy][ip2 + 1], pt);
00945       }
00946
00947       /* Copy data... */
00948       for (ip = 0; ip < ctl->met_np; ip++)
00949         var[ix][iy][ip] = (float) aux[ip];
00950     }
00951 }
```

Here is the call graph for this function:



5.13.2.23 void read_met_periodic (met_t * *met*)

Create meteorological data with periodic boundary conditions.

Definition at line 955 of file libtrac.c.

```
00956                {
00957
00958   int ip, iy;
00959
00960   /* Check longitudes... */
00961   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
00962              + met->lon[1] - met->lon[0] - 360) < 0.01))
00963     return;
00964
00965   /* Increase longitude counter... */
00966   if ((++met->nx) > EX)
00967     ERRMSG("Cannot create periodic boundary conditions!");
00968
00969   /* Set longitude... */
00970   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
00971
00972   /* Loop over latitudes and pressure levels... */
00973   for (iy = 0; iy < met->ny; iy++)
00974     for (ip = 0; ip < met->np; ip++) {
00975       met->ps[met->nx - 1][iy] = met->ps[0][iy];
00976       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
00977       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
00978       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
00979       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
00980       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
00981       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
00982     }
00983 }
```

5.13.2.24 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 987 of file libtrac.c.

```
00994                {
00995
00996   FILE *in = NULL;
00997
00998   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
00999     msg[LEN], rvarname[LEN], rval[LEN];
01000
01001   int contain = 0, i;
01002
01003   /* Open file... */
01004   if (filename[strlen(filename) - 1] != '-')
01005     if (!(in = fopen(filename, "r")))
01006       ERRMSG("Cannot open file!");
01007
01008   /* Set full variable name... */
01009   if (arridx >= 0) {
01010     sprintf(fullname1, "%s[%d]", varname, arridx);
01011     sprintf(fullname2, "%s[*]", varname);
01012   } else {
01013     sprintf(fullname1, "%s", varname);
01014     sprintf(fullname2, "%s", varname);
01015   }
01016
01017   /* Read data... */
01018   if (in != NULL)
01019     while (fgets(line, LEN, in))
01020       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
01021         if (strcasecmp(rvarname, fullname1) == 0 ||
01022             strcasecmp(rvarname, fullname2) == 0) {
01023           contain = 1;
01024           break;
01025         }
01026   for (i = 1; i < argc - 1; i++)
```

```
01027     if (strcasecmp(argv[i], fullname1) == 0 ||
01028         strcasecmp(argv[i], fullname2) == 0) {
01029       sprintf(rval, "%s", argv[i + 1]);
01030       contain = 1;
01031       break;
01032     }
01033
01034   /* Close file... */
01035   if (in != NULL)
01036     fclose(in);
01037
01038   /* Check for missing variables... */
01039   if (!contain) {
01040     if (strlen(defvalue) > 0)
01041       sprintf(rval, "%s", defvalue);
01042     else {
01043       sprintf(msg, "Missing variable %s!\n", fullname1);
01044       ERRMSG(msg);
01045     }
01046   }
01047
01048   /* Write info... */
01049   printf("%s = %s\n", fullname1, rval);
01050
01051   /* Return values... */
01052   if (value != NULL)
01053     sprintf(value, "%s", rval);
01054   return atof(rval);
01055 }
```

5.13.2.25 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 1059 of file libtrac.c.

```
01067                 {
01068
01069   struct tm t0, t1;
01070
01071   t0.tm_year = 100;
01072   t0.tm_mon = 0;
01073   t0.tm_mday = 1;
01074   t0.tm_hour = 0;
01075   t0.tm_min = 0;
01076   t0.tm_sec = 0;
01077
01078   t1.tm_year = year - 1900;
01079   t1.tm_mon = mon - 1;
01080   t1.tm_mday = day;
01081   t1.tm_hour = hour;
01082   t1.tm_min = min;
01083   t1.tm_sec = sec;
01084
01085   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
01086 }
```

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

Measure wall-clock time.

Definition at line 1090 of file libtrac.c.

```
01093             {
01094
01095   static double starttime[NTIMER], runtime[NTIMER];
01096
01097   /* Check id... */
01098   if (id < 0 || id >= NTIMER)
01099     ERRMSG("Too many timers!");
01100
01101   /* Start timer... */
01102   if (mode == 1) {
01103     if (starttime[id] <= 0)
```

```
01104       starttime[id] = omp_get_wtime();
01105     else
01106       ERRMSG("Timer already started!");
01107   }
01108
01109   /* Stop timer... */
01110   else if (mode == 2) {
01111     if (starttime[id] > 0) {
01112       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
01113       starttime[id] = -1;
01114     } else
01115       ERRMSG("Timer not started!");
01116   }
01117
01118   /* Print timer... */
01119   else if (mode == 3)
01120     printf("%s = %g s\n", name, runtime[id]);
01121 }
```

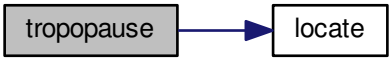
5.13.2.27 double tropopause (double *t*, double *lat*)

Definition at line 1125 of file libtrac.c.

```
01127               {
01128
01129   static double doys[12]
01130   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
01131
01132   static double lats[73]
01133     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
01134     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
01135     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
01136     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
01137     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
01138     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
01139     75, 77.5, 80, 82.5, 85, 87.5, 90
01140   };
01141
01142   static double tps[12][73]
01143     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
01144          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
01145          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
01146          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
01147          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
01148          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
01149          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
01150          275.3, 275.6, 275.4, 274.1, 273.5},
01151   {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
01152    300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
01153    150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
01154    98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
01155    98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
01156    220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
01157    284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
01158    287.5, 286.2, 285.8},
01159   {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
01160    297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
01161    161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
01162    100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
01163    99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
01164    186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
01165    279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
01166    304.3, 304.9, 306, 306.6, 306.2, 306},
01167   {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
01168    290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
01169    195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
01170    102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
01171    99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
01172    148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
01173    263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
01174    315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
01175   {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
01176    260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
01177    205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
01178    101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
01179    102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
01180    165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
01181    273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
01182    325.3, 325.8, 325.8},
01183   {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
01184    222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
```

```
01185     228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
01186     105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
01187     106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
01188     127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
01189     251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
01190     308.5, 312.2, 313.1, 313.3},
01191    {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
01192     187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
01193     235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
01194     110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
01195     111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
01196     117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
01197     224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
01198     275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
01199    {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
01200     185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
01201     233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
01202     110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
01203     112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
01204     120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
01205     230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
01206     278.2, 282.6, 287.4, 290.9, 292.5, 293},
01207    {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
01208     183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
01209     243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
01210     114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
01211     110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
01212     114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
01213     203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
01214     276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
01215    {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
01216     215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
01217     237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
01218     111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
01219     106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
01220     112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
01221     206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
01222     279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
01223     305.1},
01224    {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
01225     253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
01226     223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
01227     108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
01228     102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
01229     109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
01230     241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
01231     286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
01232    {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
01233     284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
01234     175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
01235     100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
01236     100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
01237     186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
01238     280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
01239     281.7, 281.1, 281.2}
01240    };
01241
01242    double doy, p0, p1, pt;
01243
01244    int imon, ilat;
01245
01246    /* Get day of year... */
01247    doy = fmod(t / 86400., 365.25);
01248    while (doy < 0)
01249      doy += 365.25;
01250
01251    /* Get indices... */
01252    imon = locate(doys, 12, doy);
01253    ilat = locate(lats, 73, lat);
01254
01255    /* Get tropopause pressure... */
01256    p0 = LIN(lats[ilat], tps[imon][ilat],
01257             lats[ilat + 1], tps[imon][ilat + 1], lat);
01258    p1 = LIN(lats[ilat], tps[imon + 1][ilat],
01259             lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
01260    pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
01261
01262    /* Return tropopause pressure... */
01263    return pt;
01264 }
```

Here is the call graph for this function:



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

Write atmospheric data.

Definition at line 1268 of file libtrac.c.

```
01272            {
01273
01274   FILE *in, *out;
01275
01276   char line[LEN];
01277
01278   double r, t0, t1;
01279
01280   int ip, iq, year, mon, day, hour, min, sec;
01281
01282   /* Set time interval for output... */
01283   t0 = t - 0.5 * ctl->dt_mod;
01284   t1 = t + 0.5 * ctl->dt_mod;
01285
01286   /* Check if gnuplot output is requested... */
01287   if (ctl->atm_gpfile[0] != '-') {
01288
01289     /* Write info... */
01290     printf("Plot atmospheric data: %s.png\n", filename);
01291
01292     /* Create gnuplot pipe... */
01293     if (!(out = popen("gnuplot", "w")))
01294       ERRMSG("Cannot create pipe to gnuplot!");
01295
01296     /* Set plot filename... */
01297     fprintf(out, "set out \"%s.png\"\n", filename);
01298
01299     /* Set time string... */
01300     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01301     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01302             year, mon, day, hour, min);
01303
01304     /* Dump gnuplot file to pipe... */
01305     if (!(in = fopen(ctl->atm_gpfile, "r")))
01306       ERRMSG("Cannot open file!");
01307     while (fgets(line, LEN, in))
01308       fprintf(out, "%s", line);
01309     fclose(in);
01310   }
01311
01312   else {
01313
01314     /* Write info... */
01315     printf("Write atmospheric data: %s\n", filename);
01316
01317     /* Create file... */
01318     if (!(out = fopen(filename, "w")))
01319       ERRMSG("Cannot create file!");
01320   }
01321
01322   /* Write header... */
01323   fprintf(out,
01324           "# $1 = time [s]\n"
01325           "# $2 = altitude [km]\n"
01326           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01327   for (iq = 0; iq < ctl->nq; iq++)
01328     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
```

```
01329             ctl->qnt_unit[iq]);
01330   fprintf(out, "\n");
01331
01332   /* Write data... */
01333   for (ip = 0; ip < atm->np; ip++) {
01334
01335     /* Check time... */
01336     if (ctl->atm_filter && (atm->time[ip] < t0 || atm->time[ip] > t1))
01337       continue;
01338
01339     /* Write output... */
01340     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
01341             atm->lon[ip], atm->lat[ip]);
01342     for (iq = 0; iq < ctl->nq; iq++) {
01343       fprintf(out, " ");
01344       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01345     }
01346     fprintf(out, "\n");
01347   }
01348
01349   /* Close file... */
01350   fclose(out);
01351 }
```

Here is the call graph for this function:

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

Write CSI data.

Definition at line 1355 of file libtrac.c.

```
01359             {
01360
01361   static FILE *in, *out;
01362
01363   static char line[LEN];
01364
01365   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
01366     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
01367
01368   static int init, obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
01369
01370   /* Init... */
01371   if (!init) {
01372     init = 1;
01373
01374     /* Check quantity index for mass... */
01375     if (ctl->qnt_m < 0)
01376       ERRMSG("Need quantity mass to analyze CSI!");
01377
01378     /* Open observation data file... */
01379     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
01380     if (!(in = fopen(ctl->csi_obsfile, "r")))
01381       ERRMSG("Cannot open file!");
01382
01383     /* Create new file... */
01384     printf("Write CSI data: %s\n", filename);
01385     if (!(out = fopen(filename, "w")))
01386       ERRMSG("Cannot create file!");
01387
01388     /* Write header... */
```

```
01389     fprintf(out,
01390             "# $1 = time [s]\n"
01391             "# $2 = number of hits (cx)\n"
01392             "# $3 = number of misses (cy)\n"
01393             "# $4 = number of false alarms (cz)\n"
01394             "# $5 = number of observations (cx + cy)\n"
01395             "# $6 = number of forecasts (cx + cz)\n"
01396             "# $7 = bias (forecasts/observations) [%%]\n"
01397             "# $8 = probability of detection (POD) [%%]\n"
01398             "# $9 = false alarm rate (FAR) [%%]\n"
01399             "# $10 = critical success index (CSI) [%%]\n\n");
01400   }
01401
01402   /* Set time interval... */
01403   t0 = t - 0.5 * ctl->dt_mod;
01404   t1 = t + 0.5 * ctl->dt_mod;
01405
01406   /* Initialize grid cells... */
01407   for (ix = 0; ix < ctl->csi_nx; ix++)
01408     for (iy = 0; iy < ctl->csi_ny; iy++)
01409       for (iz = 0; iz < ctl->csi_nz; iz++)
01410         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
01411
01412   /* Read data... */
01413   while (fgets(line, LEN, in)) {
01414
01415     /* Read data... */
01416     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
01417         5)
01418       continue;
01419
01420     /* Check time... */
01421     if (rt < t0)
01422       continue;
01423     if (rt > t1)
01424       break;
01425
01426     /* Calculate indices... */
01427     ix = (int) ((rlon - ctl->csi_lon0)
01428                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01429     iy = (int) ((rlat - ctl->csi_lat0)
01430                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01431     iz = (int) ((rz - ctl->csi_z0)
01432                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01433
01434     /* Check indices... */
01435     if (ix < 0 || ix >= ctl->csi_nx ||
01436         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01437       continue;
01438
01439     /* Get mean observation index... */
01440     obsmean[ix][iy][iz] += robs;
01441     obscount[ix][iy][iz]++;
01442   }
01443
01444   /* Analyze model data... */
01445   for (ip = 0; ip < atm->np; ip++) {
01446
01447     /* Check time... */
01448     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01449       continue;
01450
01451     /* Get indices... */
01452     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
01453                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01454     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
01455                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01456     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
01457                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01458
01459     /* Check indices... */
01460     if (ix < 0 || ix >= ctl->csi_nx ||
01461         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01462       continue;
01463
01464     /* Get total mass in grid cell... */
01465     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01466   }
01467
01468   /* Analyze all grid cells... */
01469   for (ix = 0; ix < ctl->csi_nx; ix++)
01470     for (iy = 0; iy < ctl->csi_ny; iy++)
01471       for (iz = 0; iz < ctl->csi_nz; iz++) {
01472
01473         /* Calculate mean observation index... */
01474         if (obscount[ix][iy][iz] > 0)
01475           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
```

```
01476
01477         /* Calculate column density... */
01478         if (modmean[ix][iy][iz] > 0) {
01479           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
01480           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
01481           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
01482           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
01483             * cos(lat * M_PI / 180.);
01484           modmean[ix][iy][iz] /= (1e6 * area);
01485         }
01486
01487         /* Calculate CSI... */
01488         if (obscount[ix][iy][iz] > 0) {
01489           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01490               modmean[ix][iy][iz] >= ctl->csi_modmin)
01491             cx++;
01492           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01493                    modmean[ix][iy][iz] < ctl->csi_modmin)
01494             cy++;
01495           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
01496                    modmean[ix][iy][iz] >= ctl->csi_modmin)
01497             cz++;
01498         }
01499       }
01500
01501   /* Write output... */
01502   if (fmod(t, ctl->csi_dt_out) == 0) {
01503
01504     /* Write... */
01505     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
01506             t, cx, cy, cz, cx + cy, cx + cz,
01507             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
01508             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
01509             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
01510             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
01511
01512     /* Set counters to zero... */
01513     cx = cy = cz = 0;
01514   }
01515
01516   /* Close file... */
01517   if (t == ctl->t_stop)
01518     fclose(out);
01519 }
```

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

Write ensemble data.

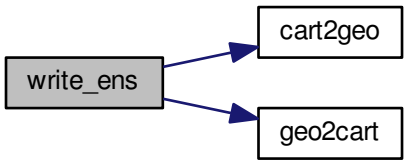
Definition at line 1523 of file libtrac.c.

```
01527             {
01528
01529   static FILE *out;
01530
01531   static double dummy, ens, lat, lon, p[NENS], q[NQ][NENS],
01532     t0, t1, x[NENS][3], xm[3];
01533
01534   static int init, ip, iq;
01535
01536   static size_t i, n;
01537
01538   /* Init... */
01539   if (!init) {
01540     init = 1;
01541
01542     /* Check quantities... */
01543     if (ctl->qnt_ens < 0)
01544       ERRMSG("Missing ensemble IDs!");
01545
01546     /* Create new file... */
01547     printf("Write ensemble data: %s\n", filename);
01548     if (!(out = fopen(filename, "w")))
01549       ERRMSG("Cannot create file!");
01550
01551     /* Write header... */
01552     fprintf(out,
01553             "# $1 = time [s]\n"
01554             "# $2 = altitude [km]\n"
01555             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
```

```
01556     for (iq = 0; iq < ctl->nq; iq++)
01557       fprintf(out, "# $%d = %s (mean) [%s]\n", 5 + iq,
01558               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
01559     for (iq = 0; iq < ctl->nq; iq++)
01560       fprintf(out, "# $%d = %s (sigma) [%s]\n", 5 + ctl->nq + iq,
01561               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
01562     fprintf(out, "# $%d = number of members\n\n", 5 + 2 * ctl->nq);
01563   }
01564
01565   /* Set time interval... */
01566   t0 = t - 0.5 * ctl->dt_mod;
01567   t1 = t + 0.5 * ctl->dt_mod;
01568
01569   /* Init... */
01570   ens = GSL_NAN;
01571   n = 0;
01572
01573   /* Loop over air parcels... */
01574   for (ip = 0; ip < atm->np; ip++) {
01575
01576     /* Check time... */
01577     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01578       continue;
01579
01580     /* Check ensemble id... */
01581     if (atm->q[ctl->qnt_ens][ip] != ens) {
01582
01583       /* Write results... */
01584       if (n > 0) {
01585
01586         /* Get mean position... */
01587         xm[0] = xm[1] = xm[2] = 0;
01588         for (i = 0; i < n; i++) {
01589           xm[0] += x[i][0] / (double) n;
01590           xm[1] += x[i][1] / (double) n;
01591           xm[2] += x[i][2] / (double) n;
01592         }
01593         cart2geo(xm, &dummy, &lon, &lat);
01594         fprintf(out, "%.2f %g %g %g", t, Z(gsl_stats_mean(p, 1, n)), lon,
01595                 lat);
01596
01597         /* Get quantity statistics... */
01598         for (iq = 0; iq < ctl->nq; iq++) {
01599           fprintf(out, " ");
01600           fprintf(out, ctl->qnt_format[iq], gsl_stats_mean(q[iq], 1, n));
01601         }
01602         for (iq = 0; iq < ctl->nq; iq++) {
01603           fprintf(out, " ");
01604           fprintf(out, ctl->qnt_format[iq], gsl_stats_sd(q[iq], 1, n));
01605         }
01606         fprintf(out, " %lu\n", n);
01607       }
01608
01609       /* Init new ensemble... */
01610       ens = atm->q[ctl->qnt_ens][ip];
01611       n = 0;
01612     }
01613
01614     /* Save data... */
01615     p[n] = atm->p[ip];
01616     geo2cart(0, atm->lon[ip], atm->lat[ip], x[n]);
01617     for (iq = 0; iq < ctl->nq; iq++)
01618       q[iq][n] = atm->q[iq][ip];
01619     if ((++n) >= NENS)
01620       ERRMSG("Too many data points!");
01621   }
01622
01623   /* Write results... */
01624   if (n > 0) {
01625
01626     /* Get mean position... */
01627     xm[0] = xm[1] = xm[2] = 0;
01628     for (i = 0; i < n; i++) {
01629       xm[0] += x[i][0] / (double) n;
01630       xm[1] += x[i][1] / (double) n;
01631       xm[2] += x[i][2] / (double) n;
01632     }
01633     cart2geo(xm, &dummy, &lon, &lat);
01634     fprintf(out, "%.2f %g %g %g", t, Z(gsl_stats_mean(p, 1, n)), lon, lat);
01635
01636     /* Get quantity statistics... */
01637     for (iq = 0; iq < ctl->nq; iq++) {
01638       fprintf(out, " ");
01639       fprintf(out, ctl->qnt_format[iq], gsl_stats_mean(q[iq], 1, n));
01640     }
01641     for (iq = 0; iq < ctl->nq; iq++) {
01642       fprintf(out, " ");
```

```
01643       fprintf(out, ctl->qnt_format[iq], gsl_stats_sd(q[iq], 1, n));
01644     }
01645     fprintf(out, " %lu\n", n);
01646   }
01647
01648   /* Close file... */
01649   if (t == ctl->t_stop)
01650     fclose(out);
01651 }
```

Here is the call graph for this function:



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

Write gridded data.

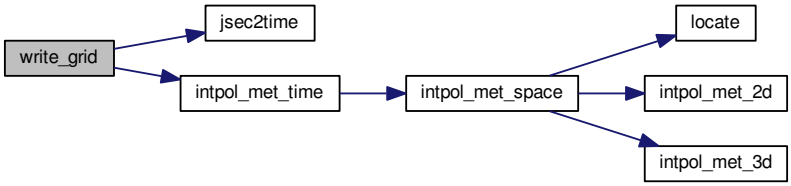
Definition at line 1655 of file libtrac.c.

```
01661             {
01662
01663   FILE *in, *out;
01664
01665   char line[LEN];
01666
01667   static double grid_m[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
01668     area, rho_air, press, temp, cd, mmr, t0, t1, r;
01669
01670   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
01671
01672   /* Check dimensions... */
01673   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
01674     ERRMSG("Grid dimensions too large!");
01675
01676   /* Check quantity index for mass... */
01677   if (ctl->qnt_m < 0)
01678     ERRMSG("Need quantity mass to write grid data!");
01679
01680   /* Set time interval for output... */
01681   t0 = t - 0.5 * ctl->dt_mod;
01682   t1 = t + 0.5 * ctl->dt_mod;
01683
01684   /* Set grid box size... */
01685   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
01686   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
01687   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
01688
01689   /* Initialize grid... */
01690   for (ix = 0; ix < ctl->grid_nx; ix++)
01691     for (iy = 0; iy < ctl->grid_ny; iy++)
01692       for (iz = 0; iz < ctl->grid_nz; iz++)
01693         grid_m[ix][iy][iz] = 0;
01694
01695   /* Average data... */
01696   for (ip = 0; ip < atm->np; ip++)
01697     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
01698
01699       /* Get index... */
01700       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
```

```
01701       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
01702       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
01703
01704       /* Check indices... */
01705       if (ix < 0 || ix >= ctl->grid_nx ||
01706           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
01707         continue;
01708
01709       /* Add mass... */
01710       grid_m[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01711     }
01712
01713   /* Check if gnuplot output is requested... */
01714   if (ctl->grid_gpfile[0] != '-') {
01715
01716     /* Write info... */
01717     printf("Plot grid data: %s.png\n", filename);
01718
01719     /* Create gnuplot pipe... */
01720     if (!(out = popen("gnuplot", "w")))
01721       ERRMSG("Cannot create pipe to gnuplot!");
01722
01723     /* Set plot filename... */
01724     fprintf(out, "set out \"%s.png\"\n", filename);
01725
01726     /* Set time string... */
01727     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01728     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01729             year, mon, day, hour, min);
01730
01731     /* Dump gnuplot file to pipe... */
01732     if (!(in = fopen(ctl->grid_gpfile, "r")))
01733       ERRMSG("Cannot open file!");
01734     while (fgets(line, LEN, in))
01735       fprintf(out, "%s", line);
01736     fclose(in);
01737   }
01738
01739   else {
01740
01741     /* Write info... */
01742     printf("Write grid data: %s\n", filename);
01743
01744     /* Create file... */
01745     if (!(out = fopen(filename, "w")))
01746       ERRMSG("Cannot create file!");
01747   }
01748
01749   /* Write header... */
01750   fprintf(out,
01751           "# $1 = time [s]\n"
01752           "# $2 = altitude [km]\n"
01753           "# $3 = longitude [deg]\n"
01754           "# $4 = latitude [deg]\n"
01755           "# $5 = surface area [km^2]\n"
01756           "# $6 = layer width [km]\n"
01757           "# $7 = temperature [K]\n"
01758           "# $8 = column density [kg/m^2]\n"
01759           "# $9 = mass mixing ratio [1]\n\n");
01760
01761   /* Write data... */
01762   for (ix = 0; ix < ctl->grid_nx; ix++) {
01763     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
01764       fprintf(out, "\n");
01765     for (iy = 0; iy < ctl->grid_ny; iy++) {
01766       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
01767         fprintf(out, "\n");
01768       for (iz = 0; iz < ctl->grid_nz; iz++)
01769         if (!ctl->grid_sparse
01770             || ix == 0 || iy == 0 || iz == 0 || grid_m[ix][iy][iz] > 0) {
01771
01772           /* Set coordinates... */
01773           z = ctl->grid_z0 + dz * (iz + 0.5);
01774           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
01775           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
01776
01777           /* Get pressure and temperature... */
01778           press = P(z);
01779           intpol_met_time(met0, met1, t, press, lon, lat,
01780                           NULL, &temp, NULL, NULL, NULL, NULL, NULL);
01781
01782           /* Calculate surface area... */
01783           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
01784             * cos(lat * M_PI / 180.);
01785
01786           /* Calculate column density... */
01787           cd = grid_m[ix][iy][iz] / (1e6 * area);
```

```
01788
01789           /* Calculate mass mixing ratio... */
01790           rho_air = 100. * press / (287.058 * temp);
01791           mmr = grid_m[ix][iy][iz] / (rho_air * 1e6 * area * 1e3 * dz);
01792
01793           /* Write output... */
01794           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01795                   t, z, lon, lat, area, dz, temp, cd, mmr);
01796         }
01797     }
01798   }
01799
01800   /* Close file... */
01801   fclose(out);
01802 }
```

Here is the call graph for this function:



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

Write profile data.

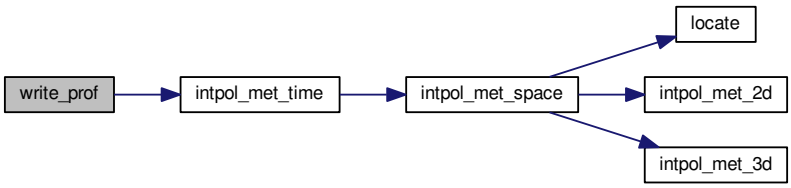
Definition at line 1806 of file libtrac.c.

```
01812           {
01813
01814   static FILE *in, *out;
01815
01816   static char line[LEN];
01817
01818   static double mass[GX][GY][GZ], obsmean[GX][GY], tmean[GX][GY],
01819     rt, rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z,
01820     press, temp, rho_air, mmr, h2o, o3;
01821
01822   static int init, obscount[GX][GY], ip, ix, iy, iz;
01823
01824   /* Init... */
01825   if (!init) {
01826     init = 1;
01827
01828     /* Check quantity index for mass... */
01829     if (ctl->qnt_m < 0)
01830       ERRMSG("Need quantity mass!");
01831
01832     /* Check dimensions... */
01833     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
01834       ERRMSG("Grid dimensions too large!");
01835
01836     /* Open observation data file... */
01837     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
01838     if (!(in = fopen(ctl->prof_obsfile, "r")))
01839       ERRMSG("Cannot open file!");
01840
01841     /* Create new file... */
01842     printf("Write profile data: %s\n", filename);
01843     if (!(out = fopen(filename, "w")))
01844       ERRMSG("Cannot create file!");
01845
01846     /* Write header... */
01847     fprintf(out,
```

```
01848             "# $1  = time [s]\n"
01849             "# $2  = altitude [km]\n"
01850             "# $3  = longitude [deg]\n"
01851             "# $4  = latitude [deg]\n"
01852             "# $5  = pressure [hPa]\n"
01853             "# $6  = temperature [K]\n"
01854             "# $7  = mass mixing ratio [1]\n"
01855             "# $8  = H2O volume mixing ratio [1]\n"
01856             "# $9  = O3 volume mixing ratio [1]\n"
01857             "# $10 = mean BT index [K]\n");
01858
01859     /* Set grid box size... */
01860     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
01861     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
01862     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
01863   }
01864
01865   /* Set time interval... */
01866   t0 = t - 0.5 * ctl->dt_mod;
01867   t1 = t + 0.5 * ctl->dt_mod;
01868
01869   /* Initialize... */
01870   for (ix = 0; ix < ctl->prof_nx; ix++)
01871     for (iy = 0; iy < ctl->prof_ny; iy++) {
01872       obsmean[ix][iy] = 0;
01873       obscount[ix][iy] = 0;
01874       tmean[ix][iy] = 0;
01875       for (iz = 0; iz < ctl->prof_nz; iz++)
01876         mass[ix][iy][iz] = 0;
01877     }
01878
01879   /* Read data... */
01880   while (fgets(line, LEN, in)) {
01881
01882     /* Read data... */
01883     if (sscanf(line, "%lg %lg %lg %lg", &rt, &rlon, &rlat, &robs) != 4)
01884       continue;
01885
01886     /* Check time... */
01887     if (rt < t0)
01888       continue;
01889     if (rt > t1)
01890       break;
01891
01892     /* Calculate indices... */
01893     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
01894     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
01895
01896     /* Check indices... */
01897     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
01898       continue;
01899
01900     /* Get mean observation index... */
01901     obsmean[ix][iy] += robs;
01902     tmean[ix][iy] += rt;
01903     obscount[ix][iy]++;
01904   }
01905
01906   /* Analyze model data... */
01907   for (ip = 0; ip < atm->np; ip++) {
01908
01909     /* Check time... */
01910     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01911       continue;
01912
01913     /* Get indices... */
01914     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
01915     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
01916     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
01917
01918     /* Check indices... */
01919     if (ix < 0 || ix >= ctl->prof_nx ||
01920         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
01921       continue;
01922
01923     /* Get total mass in grid cell... */
01924     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01925   }
01926
01927   /* Extract profiles... */
01928   for (ix = 0; ix < ctl->prof_nx; ix++)
01929     for (iy = 0; iy < ctl->prof_ny; iy++)
01930       if (obscount[ix][iy] > 0) {
01931
01932         /* Write output... */
01933         fprintf(out, "\n");
01934
```

```
01935         /* Loop over altitudes... */
01936         for (iz = 0; iz < ctl->prof_nz; iz++) {
01937
01938           /* Set coordinates... */
01939           z = ctl->prof_z0 + dz * (iz + 0.5);
01940           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
01941           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
01942
01943           /* Get meteorological data... */
01944           press = P(z);
01945           intpol_met_time(met0, met1, t, press, lon, lat,
01946                           NULL, &temp, NULL, NULL, NULL, &h2o, &o3);
01947
01948           /* Calculate mass mixing ratio... */
01949           rho_air = 100. * press / (287.058 * temp);
01950           area = dlat * dlon * gsl_pow_2(M_PI * RE / 180.)
01951             * cos(lat * M_PI / 180.);
01952           mmr = mass[ix][iy][iz] / (rho_air * area * dz * 1e9);
01953
01954           /* Write output... */
01955           fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g\n",
01956                   tmean[ix][iy] / obscount[ix][iy],
01957                   z, lon, lat, press, temp, mmr, h2o, o3,
01958                   obsmean[ix][iy] / obscount[ix][iy]);
01959         }
01960       }
01961
01962   /* Close file... */
01963   if (t == ctl->t_stop)
01964     fclose(out);
01965 }
```

Here is the call graph for this function:



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

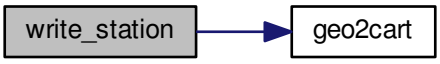
Write station data.

Definition at line 1969 of file libtrac.c.

```
01973             {
01974
01975   static FILE *out;
01976
01977   static double rmax2, t0, t1, x0[3], x1[3];
01978
01979   static int init, ip, iq;
01980
01981   /* Init... */
01982   if (!init) {
01983     init = 1;
01984
01985     /* Write info... */
01986     printf("Write station data: %s\n", filename);
01987
01988     /* Create new file... */
01989     if (!(out = fopen(filename, "w")))
01990       ERRMSG("Cannot create file!");
01991
01992     /* Write header... */
```

```
01993     fprintf(out,
01994             "# $1 = time [s]\n"
01995             "# $2 = altitude [km]\n"
01996             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01997     for (iq = 0; iq < ctl->nq; iq++)
01998       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
01999               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
02000     fprintf(out, "\n");
02001
02002     /* Set geolocation and search radius... */
02003     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
02004     rmax2 = gsl_pow_2(ctl->stat_r);
02005   }
02006
02007   /* Set time interval for output... */
02008   t0 = t - 0.5 * ctl->dt_mod;
02009   t1 = t + 0.5 * ctl->dt_mod;
02010
02011   /* Loop over air parcels... */
02012   for (ip = 0; ip < atm->np; ip++) {
02013
02014     /* Check time... */
02015     if (atm->time[ip] < t0 || atm->time[ip] > t1)
02016       continue;
02017
02018     /* Check station flag... */
02019     if (ctl->qnt_stat >= 0)
02020       if (atm->q[ctl->qnt_stat][ip])
02021         continue;
02022
02023     /* Get Cartesian coordinates... */
02024     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
02025
02026     /* Check horizontal distance... */
02027     if (DIST2(x0, x1) > rmax2)
02028       continue;
02029
02030     /* Set station flag... */
02031     if (ctl->qnt_stat >= 0)
02032       atm->q[ctl->qnt_stat][ip] = 1;
02033
02034     /* Write data... */
02035     fprintf(out, "%.2f %g %g %g",
02036             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
02037     for (iq = 0; iq < ctl->nq; iq++) {
02038       fprintf(out, " ");
02039       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
02040     }
02041     fprintf(out, "\n");
02042   }
02043
02044   /* Close file... */
02045   if (t == ctl->t_stop)
02046     fclose(out);
02047 }
```

Here is the call graph for this function:



5.14 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   Copright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00034 #include <ctype.h>
00035 #include <gsl/gsl_const_mksa.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_statistics.h>
00041 #include <math.h>
00042 #include <netcdf.h>
00043 #include <omp.h>
00044 #include <stdio.h>
00045 #include <stdlib.h>
00046 #include <string.h>
00047 #include <time.h>
00048 #include <sys/time.h>
00049
00050 /* ------------------------------------------------------------
00051    Constants...
00052    ------------------------------------------------------------ */
00053
00055 #define G0 9.80665
00056
00058 #define H0 7.0
00059
00061 #define P0 1013.25
00062
00064 #define RE 6367.421
00065
00066 /* ------------------------------------------------------------
00067    Dimensions...
00068    ------------------------------------------------------------ */
00069
00071 #define LEN 5000
00072
00074 #define NP 10000000
00075
00077 #define NQ 12
00078
00080 #define EP 137
00081
00083 #define EX 1201
00084
00086 #define EY 601
00087
00089 #define GX 720
00090
00092 #define GY 360
00093
00095 #define GZ 100
00096
00098 #define NENS 2000
00099
00101 #define NTHREADS 128
00102
00103 /* ------------------------------------------------------------
00104    Macros...
00105    ------------------------------------------------------------ */
00106
00108 #define ALLOC(ptr, type, n)                             \
00109   if((ptr=calloc((size_t)(n), sizeof(type)))==NULL)     \
00110     ERRMSG("Out of memory!");
00111
00113 #define DIST(a, b) sqrt(DIST2(a, b))
00114
00116 #define DIST2(a, b)                                                     \
00117   ((a[0]-b[0])*(a[0]-b[0])+(a[1]-b[1])*(a[1]-b[1])+(a[2]-b[2])*(a[2]-b[2]))
00118
00120 #define DOTP(a, b) (a[0]*b[0]+a[1]*b[1]+a[2]*b[2])
00121
00123 #define ERRMSG(msg) {                                                   \
00124     printf("\nError (%s, %s, l%d): %s\n\n",                             \
00125            __FILE__, __func__, __LINE__, msg);                          \
00126     exit(EXIT_FAILURE);                                                 \
```

```
00127   }
00128
00130 #define LIN(x0, y0, x1, y1, x)                  \
00131   ((y0)+((y1)-(y0))/((x1)-(x0))*((x)-(x0)))
00132
00134 #define NC(cmd) {                                \
00135     if((cmd)!=NC_NOERR)                          \
00136       ERRMSG(nc_strerror(cmd));                  \
00137   }
00138
00140 #define NORM(a) sqrt(DOTP(a, a))
00141
00143 #define PRINT(format, var)                                          \
00144   printf("Print (%s, %s, l%d): %s= "format"\n",                     \
00145          __FILE__, __func__, __LINE__, #var, var);
00146
00148 #define P(z) (P0*exp(-(z)/H0))
00149
00151 #define TOK(line, tok, format, var) {                               \
00152     if(((tok)=strtok((line), " \t"))) {                             \
00153       if(sscanf(tok, format, &(var))!=1) continue;                  \
00154     } else ERRMSG("Error while reading!");                          \
00155   }
00156
00158 #define Z(p) (H0*log(P0/(p)))
00159
00160 /* ------------------------------------------------------------
00161    Timers...
00162    ------------------------------------------------------------ */
00163
00165 #define START_TIMER(id) timer(#id, id, 1)
00166
00168 #define STOP_TIMER(id) timer(#id, id, 2)
00169
00171 #define PRINT_TIMER(id) timer(#id, id, 3)
00172
00174 #define NTIMER 13
00175
00177 #define TIMER_TOTAL 0
00178
00180 #define TIMER_INIT 1
00181
00183 #define TIMER_STAGE 2
00184
00186 #define TIMER_INPUT 3
00187
00189 #define TIMER_OUTPUT 4
00190
00192 #define TIMER_ADVECT 5
00193
00195 #define TIMER_DECAY 6
00196
00198 #define TIMER_DIFFMESO 7
00199
00201 #define TIMER_DIFFTURB 8
00202
00204 #define TIMER_ISOSURF 9
00205
00207 #define TIMER_METEO 10
00208
00210 #define TIMER_POSITION 11
00211
00213 #define TIMER_SEDI 12
00214
00215 /* ------------------------------------------------------------
00216    Structs...
00217    ------------------------------------------------------------ */
00218
00220 typedef struct {
00221
00223   int nq;
00224
00226   char qnt_name[NQ][LEN];
00227
00229   char qnt_unit[NQ][LEN];
00230
00232   char qnt_format[NQ][LEN];
00233
00235   int qnt_ens;
00236
00238   int qnt_m;
00239
00241   int qnt_rho;
00242
00244   int qnt_r;
00245
00247   int qnt_ps;
```

```
00248
00250   int qnt_p;
00251
00253   int qnt_t;
00254
00256   int qnt_u;
00257
00259   int qnt_v;
00260
00262   int qnt_w;
00263
00265   int qnt_h2o;
00266
00268   int qnt_o3;
00269
00271   int qnt_theta;
00272
00274   int qnt_pv;
00275
00277   int qnt_tice;
00278
00280   int qnt_tsts;
00281
00283   int qnt_tnat;
00284
00286   int qnt_stat;
00287
00289   int qnt_gw_u750;
00290
00292   int qnt_gw_v750;
00293
00295   int qnt_gw_sso;
00296
00298   int qnt_gw_var;
00299
00301   int direction;
00302
00304   double t_start;
00305
00307   double t_stop;
00308
00310   double dt_mod;
00311
00313   double dt_met;
00314
00316   int met_np;
00317
00319   double met_p[EP];
00320
00322   char met_stage[LEN];
00323
00326   int isosurf;
00327
00329   char balloon[LEN];
00330
00332   double turb_dx_trop;
00333
00335   double turb_dx_strat;
00336
00338   double turb_dz_trop;
00339
00341   double turb_dz_strat;
00342
00344   double turb_meso;
00345
00347   double tdec_trop;
00348
00350   double tdec_strat;
00351
00353   double psc_h2o;
00354
00356   double psc_hno3;
00357
00359   char gw_basename[LEN];
00360
00362   char atm_basename[LEN];
00363
00365   char atm_gpfile[LEN];
00366
00368   double atm_dt_out;
00369
00371   int atm_filter;
00372
00374   char csi_basename[LEN];
00375
00377   double csi_dt_out;
00378
```

```
00380   char csi_obsfile[LEN];
00381
00383   double csi_obsmin;
00384
00386   double csi_modmin;
00387
00389   int csi_nz;
00390
00392   double csi_z0;
00393
00395   double csi_z1;
00396
00398   int csi_nx;
00399
00401   double csi_lon0;
00402
00404   double csi_lon1;
00405
00407   int csi_ny;
00408
00410   double csi_lat0;
00411
00413   double csi_lat1;
00414
00416   char grid_basename[LEN];
00417
00419   char grid_gpfile[LEN];
00420
00422   double grid_dt_out;
00423
00425   int grid_sparse;
00426
00428   int grid_nz;
00429
00431   double grid_z0;
00432
00434   double grid_z1;
00435
00437   int grid_nx;
00438
00440   double grid_lon0;
00441
00443   double grid_lon1;
00444
00446   int grid_ny;
00447
00449   double grid_lat0;
00450
00452   double grid_lat1;
00453
00455   char prof_basename[LEN];
00456
00458   char prof_obsfile[LEN];
00459
00461   int prof_nz;
00462
00464   double prof_z0;
00465
00467   double prof_z1;
00468
00470   int prof_nx;
00471
00473   double prof_lon0;
00474
00476   double prof_lon1;
00477
00479   int prof_ny;
00480
00482   double prof_lat0;
00483
00485   double prof_lat1;
00486
00488   char ens_basename[LEN];
00489
00491   char stat_basename[LEN];
00492
00494   double stat_lon;
00495
00497   double stat_lat;
00498
00500   double stat_r;
00501
00502 } ctl_t;
00503
00505 typedef struct {
00506
00508   int np;
```

```
00509
00511   double time[NP];
00512
00514   double p[NP];
00515
00517   double lon[NP];
00518
00520   double lat[NP];
00521
00523   double q[NQ][NP];
00524
00526   double up[NP];
00527
00529   double vp[NP];
00530
00532   double wp[NP];
00533
00534 } atm_t;
00535
00537 typedef struct {
00538
00540   double time;
00541
00543   int nx;
00544
00546   int ny;
00547
00549   int np;
00550
00552   double lon[EX];
00553
00555   double lat[EY];
00556
00558   double p[EP];
00559
00561   double ps[EX][EY];
00562
00564   float pl[EX][EY][EP];
00565
00567   float t[EX][EY][EP];
00568
00570   float u[EX][EY][EP];
00571
00573   float v[EX][EY][EP];
00574
00576   float w[EX][EY][EP];
00577
00579   float h2o[EX][EY][EP];
00580
00582   float o3[EX][EY][EP];
00583
00584 } met_t;
00585
00586 /* ------------------------------------------------------------
00587    Functions...
00588    ------------------------------------------------------------ */
00589
00591 void cart2geo(
00592   double *x,
00593   double *z,
00594   double *lon,
00595   double *lat);
00596
00598 double deg2dx(
00599   double dlon,
00600   double lat);
00601
00603 double deg2dy(
00604   double dlat);
00605
00607 double dp2dz(
00608   double dp,
00609   double p);
00610
00612 double dx2deg(
00613   double dx,
00614   double lat);
00615
00617 double dy2deg(
00618   double dy);
00619
00621 double dz2dp(
00622   double dz,
00623   double p);
00624
00626 void geo2cart(
00627   double z,
```

```
00628   double lon,
00629   double lat,
00630   double *x);
00631
00633 void get_met(
00634   ctl_t * ctl,
00635   char *metbase,
00636   double t,
00637   met_t * met0,
00638   met_t * met1);
00639
00641 void get_met_help(
00642   double t,
00643   int direct,
00644   char *metbase,
00645   double dt_met,
00646   char *filename);
00647
00649 void intpol_met_2d(
00650   double array[EX][EY],
00651   int ix,
00652   int iy,
00653   double wx,
00654   double wy,
00655   double *var);
00656
00658 void intpol_met_3d(
00659   float array[EX][EY][EP],
00660   int ip,
00661   int ix,
00662   int iy,
00663   double wp,
00664   double wx,
00665   double wy,
00666   double *var);
00667
00669 void intpol_met_space(
00670   met_t * met,
00671   double p,
00672   double lon,
00673   double lat,
00674   double *ps,
00675   double *t,
00676   double *u,
00677   double *v,
00678   double *w,
00679   double *h2o,
00680   double *o3);
00681
00683 void intpol_met_time(
00684   met_t * met0,
00685   met_t * met1,
00686   double ts,
00687   double p,
00688   double lon,
00689   double lat,
00690   double *ps,
00691   double *t,
00692   double *u,
00693   double *v,
00694   double *w,
00695   double *h2o,
00696   double *o3);
00697
00699 void jsec2time(
00700   double jsec,
00701   int *year,
00702   int *mon,
00703   int *day,
00704   int *hour,
00705   int *min,
00706   int *sec,
00707   double *remain);
00708
00710 int locate(
00711   double *xx,
00712   int n,
00713   double x);
00714
00716 void read_atm(
00717   const char *filename,
00718   ctl_t * ctl,
00719   atm_t * atm);
00720
00722 void read_ctl(
00723   const char *filename,
00724   int argc,
```

```
00725   char *argv[],
00726   ctl_t * ctl);
00727
00729 void read_met(
00730   ctl_t * ctl,
00731   char *filename,
00732   met_t * met);
00733
00735 void read_met_extrapolate(
00736   met_t * met);
00737
00739 void read_met_help(
00740   int ncid,
00741   char *varname,
00742   char *varname2,
00743   met_t * met,
00744   float dest[EX][EY][EP],
00745   float scl);
00746
00748 void read_met_ml2pl(
00749   ctl_t * ctl,
00750   met_t * met,
00751   float var[EX][EY][EP]);
00752
00754 void read_met_periodic(
00755   met_t * met);
00756
00758 double scan_ctl(
00759   const char *filename,
00760   int argc,
00761   char *argv[],
00762   const char *varname,
00763   int arridx,
00764   const char *defvalue,
00765   char *value);
00766
00768 void time2jsec(
00769   int year,
00770   int mon,
00771   int day,
00772   int hour,
00773   int min,
00774   int sec,
00775   double remain,
00776   double *jsec);
00777
00779 void timer(
00780   const char *name,
00781   int id,
00782   int mode);
00783
00784 /* Get tropopause pressure... */
00785 double tropopause(
00786   double t,
00787   double lat);
00788
00790 void write_atm(
00791   const char *filename,
00792   ctl_t * ctl,
00793   atm_t * atm,
00794   double t);
00795
00797 void write_csi(
00798   const char *filename,
00799   ctl_t * ctl,
00800   atm_t * atm,
00801   double t);
00802
00804 void write_ens(
00805   const char *filename,
00806   ctl_t * ctl,
00807   atm_t * atm,
00808   double t);
00809
00811 void write_grid(
00812   const char *filename,
00813   ctl_t * ctl,
00814   met_t * met0,
00815   met_t * met1,
00816   atm_t * atm,
00817   double t);
00818
00820 void write_prof(
00821   const char *filename,
00822   ctl_t * ctl,
00823   met_t * met0,
00824   met_t * met1,
```

```
00825   atm_t * atm,
00826   double t);
00827
00829 void write_station(
00830   const char *filename,
00831   ctl_t * ctl,
00832   atm_t * atm,
00833   double t);
```

5.15 match.c File Reference

Calculate deviations between two trajectories.

Functions

- int main (int argc, char ∗argv[ ])

5.15.1 Detailed Description

Calculate deviations between two trajectories.

Definition in file match.c.

5.15.2 Function Documentation

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

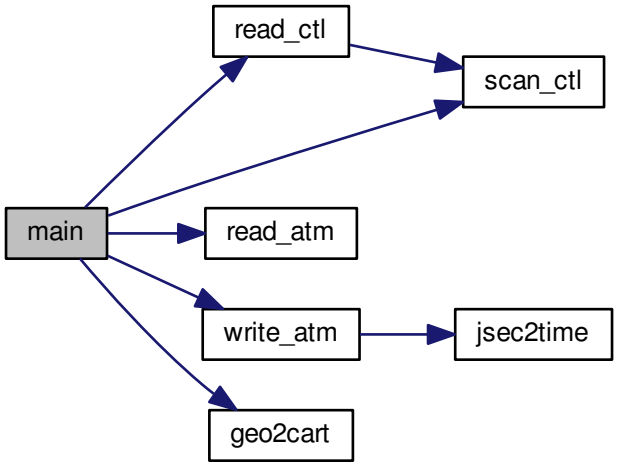
Definition at line 28 of file match.c.

```
00030                {
00031
00032   ctl_t ctl;
00033
00034   atm_t *atm1, *atm2, *atm3;
00035
00036   FILE *out;
00037
00038   char filename[LEN];
00039
00040   double filter_dt, x1[3], x2[3], dh, dq[NQ], dv, lh = 0, lt = 0, lv = 0;
00041
00042   int filter, ip1, ip2, iq, n;
00043
00044   /* Allocate... */
00045   ALLOC(atm1, atm_t, 1);
00046   ALLOC(atm2, atm_t, 1);
00047   ALLOC(atm3, atm_t, 1);
00048
00049   /* Check arguments... */
00050   if (argc < 5)
00051     ERRMSG("Give parameters: <ctl> <atm_test> <atm_ref> <outfile>");
00052
00053   /* Read control parameters... */
00054   read_ctl(argv[1], argc, argv, &ctl);
00055   filter = (int) scan_ctl(argv[1], argc, argv, "FILTER", -1, "0", NULL);
00056   filter_dt = scan_ctl(argv[1], argc, argv, "FILTER_DT", -1, "0", NULL);
00057
00058   /* Read atmospheric data... */
00059   read_atm(argv[2], &ctl, atm1);
00060   read_atm(argv[3], &ctl, atm2);
00061
00062   /* Write info... */
00063   printf("Write transport deviations: %s\n", argv[4]);
00064
00065   /* Create output file... */
```

```
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" "# $4 = latitude [deg]\n");
00074   for (iq = 0; iq < ctl.nq; iq++)
00075     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl.qnt_name[iq],
00076             ctl.qnt_unit[iq]);
00077   fprintf(out,
00078           "# $%d = trajectory time [s]\n"
00079           "# $%d = vertical length of trajectory [km]\n"
00080           "# $%d = horizontal length of trajectory [km]\n"
00081           "# $%d = vertical deviation [km]\n"
00082           "# $%d = horizontal deviation [km]\n",
00083           5 + ctl.nq, 6 + ctl.nq, 7 + ctl.nq, 8 + ctl.nq, 9 + ctl.nq);
00084   for (iq = 0; iq < ctl.nq; iq++)
00085     fprintf(out, "# $%d = %s deviation [%s]\n", ctl.nq + iq + 10,
00086             ctl.qnt_name[iq], ctl.qnt_unit[iq]);
00087   fprintf(out, "\n");
00088
00089   /* Filtering of reference time series... */
00090   if (filter) {
00091
00092     /* Copy data... */
00093     memcpy(atm3, atm2, sizeof(atm_t));
00094
00095     /* Loop over data points... */
00096     for (ip1 = 0; ip1 < atm2->np; ip1++) {
00097       n = 0;
00098       atm2->p[ip1] = 0;
00099       for (iq = 0; iq < ctl.nq; iq++)
00100         atm2->q[iq][ip1] = 0;
00101       for (ip2 = 0; ip2 < atm2->np; ip2++)
00102         if (fabs(atm2->time[ip1] - atm2->time[ip2]) < filter_dt) {
00103           atm2->p[ip1] += atm3->p[ip2];
00104           for (iq = 0; iq < ctl.nq; iq++)
00105             atm2->q[iq][ip1] += atm3->q[iq][ip2];
00106           n++;
00107         }
00108       atm2->p[ip1] /= n;
00109       for (iq = 0; iq < ctl.nq; iq++)
00110         atm2->q[iq][ip1] /= n;
00111     }
00112
00113     /* Write filtered data... */
00114     sprintf(filename, "%s.filt", argv[3]);
00115     write_atm(filename, &ctl, atm2, 0);
00116   }
00117
00118   /* Loop over air parcels (reference data)... */
00119   for (ip2 = 0; ip2 < atm2->np; ip2++) {
00120
00121     /* Get trajectory length... */
00122     if (ip2 > 0) {
00123       geo2cart(0, atm2->lon[ip2 - 1], atm2->lat[ip2 - 1], x1);
00124       geo2cart(0, atm2->lon[ip2], atm2->lat[ip2], x2);
00125       lh += DIST(x1, x2);
00126       lv += fabs(Z(atm2->p[ip2 - 1]) - Z(atm2->p[ip2]));
00127       lt = fabs(atm2->time[ip2] - atm2->time[0]);
00128     }
00129
00130     /* Init... */
00131     n = 0;
00132     dh = 0;
00133     dv = 0;
00134     for (iq = 0; iq < ctl.nq; iq++)
00135       dq[iq] = 0;
00136     geo2cart(0, atm2->lon[ip2], atm2->lat[ip2], x2);
00137
00138     /* Find corresponding time step (test data)... */
00139     for (ip1 = 0; ip1 < atm1->np; ip1++)
00140       if (fabs(atm1->time[ip1] - atm2->time[ip2])
00141           < (filter ? filter_dt : 0.1)) {
00142
00143         /* Calculate deviations... */
00144         geo2cart(0, atm1->lon[ip1], atm1->lat[ip1], x1);
00145         dh += DIST(x1, x2);
00146         dv += Z(atm1->p[ip1]) - Z(atm2->p[ip2]);
00147         for (iq = 0; iq < ctl.nq; iq++)
00148           dq[iq] += atm1->q[iq][ip1] - atm2->q[iq][ip2];
00149         n++;
00150       }
00151
00152     /* Write output... */
```

```
00153     if (n > 0) {
00154       fprintf(out, "%.2f %.4f %.4f %.4f",
00155               atm2->time[ip2], Z(atm2->p[ip2]),
00156               atm2->lon[ip2], atm2->lat[ip2]);
00157       for (iq = 0; iq < ctl.nq; iq++) {
00158         fprintf(out, " ");
00159         fprintf(out, ctl.qnt_format[iq], atm2->q[iq][ip2]);
00160       }
00161       fprintf(out, " %.2f %g %g %g %g", lt, lv, lh, dv / n, dh / n);
00162       for (iq = 0; iq < ctl.nq; iq++) {
00163         fprintf(out, " ");
00164         fprintf(out, ctl.qnt_format[iq], dq[iq] / n);
00165       }
00166       fprintf(out, "\n");
00167     }
00168   }
00169
00170   /* Close file... */
00171   fclose(out);
00172
00173   /* Free... */
00174   free(atm1);
00175   free(atm2);
00176   free(atm3);
00177
00178   return EXIT_SUCCESS;
00179 }
```

Here is the call graph for this function:



5.16 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   Copright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026 #include <gsl/gsl_sort.h>
00027
00028 int main(
00029   int argc,
00030   char *argv[]) {
00031
00032   ctl_t ctl;
00033
00034   atm_t *atm1, *atm2, *atm3;
00035
00036   FILE *out;
00037
00038   char filename[LEN];
00039
00040   double filter_dt, x1[3], x2[3], dh, dq[NQ], dv, lh = 0, lt = 0, lv = 0;
00041
00042   int filter, ip1, ip2, iq, n;
00043
00044   /* Allocate... */
00045   ALLOC(atm1, atm_t, 1);
00046   ALLOC(atm2, atm_t, 1);
00047   ALLOC(atm3, atm_t, 1);
00048
00049   /* Check arguments... */
00050   if (argc < 5)
00051     ERRMSG("Give parameters: <ctl> <atm_test> <atm_ref> <outfile>");
00052
00053   /* Read control parameters... */
00054   read_ctl(argv[1], argc, argv, &ctl);
00055   filter = (int) scan_ctl(argv[1], argc, argv, "FILTER", -1, "0", NULL);
00056   filter_dt = scan_ctl(argv[1], argc, argv, "FILTER_DT", -1, "0", NULL);
00057
00058   /* Read atmospheric data... */
00059   read_atm(argv[2], &ctl, atm1);
00060   read_atm(argv[3], &ctl, atm2);
00061
00062   /* Write info... */
00063   printf("Write transport deviations: %s\n", argv[4]);
00064
00065   /* Create output file... */
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" "# $4 = latitude [deg]\n");
00074   for (iq = 0; iq < ctl.nq; iq++)
00075     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl.qnt_name[iq],
00076             ctl.qnt_unit[iq]);
00077   fprintf(out,
00078           "# $%d = trajectory time [s]\n"
00079           "# $%d = vertical length of trajectory [km]\n"
00080           "# $%d = horizontal length of trajectory [km]\n"
00081           "# $%d = vertical deviation [km]\n"
00082           "# $%d = horizontal deviation [km]\n",
00083           5 + ctl.nq, 6 + ctl.nq, 7 + ctl.nq, 8 + ctl.nq, 9 + ctl.nq);
00084   for (iq = 0; iq < ctl.nq; iq++)
00085     fprintf(out, "# $%d = %s deviation [%s]\n", ctl.nq + iq + 10,
00086             ctl.qnt_name[iq], ctl.qnt_unit[iq]);
00087   fprintf(out, "\n");
00088
00089   /* Filtering of reference time series... */
00090   if (filter) {
00091
00092     /* Copy data... */
00093     memcpy(atm3, atm2, sizeof(atm_t));
00094
00095     /* Loop over data points... */
00096     for (ip1 = 0; ip1 < atm2->np; ip1++) {
00097       n = 0;
00098       atm2->p[ip1] = 0;
00099       for (iq = 0; iq < ctl.nq; iq++)
00100         atm2->q[iq][ip1] = 0;
00101       for (ip2 = 0; ip2 < atm2->np; ip2++)
00102         if (fabs(atm2->time[ip1] - atm2->time[ip2]) < filter_dt) {
00103           atm2->p[ip1] += atm3->p[ip2];
00104           for (iq = 0; iq < ctl.nq; iq++)
00105             atm2->q[iq][ip1] += atm3->q[iq][ip2];
00106           n++;
```

```
00107         }
00108       atm2->p[ip1] /= n;
00109       for (iq = 0; iq < ctl.nq; iq++)
00110         atm2->q[iq][ip1] /= n;
00111     }
00112
00113     /* Write filtered data... */
00114     sprintf(filename, "%s.filt", argv[3]);
00115     write_atm(filename, &ctl, atm2, 0);
00116   }
00117
00118   /* Loop over air parcels (reference data)... */
00119   for (ip2 = 0; ip2 < atm2->np; ip2++) {
00120
00121     /* Get trajectory length... */
00122     if (ip2 > 0) {
00123       geo2cart(0, atm2->lon[ip2 - 1], atm2->lat[ip2 - 1], x1);
00124       geo2cart(0, atm2->lon[ip2], atm2->lat[ip2], x2);
00125       lh += DIST(x1, x2);
00126       lv += fabs(Z(atm2->p[ip2 - 1]) - Z(atm2->p[ip2]));
00127       lt = fabs(atm2->time[ip2] - atm2->time[0]);
00128     }
00129
00130     /* Init... */
00131     n = 0;
00132     dh = 0;
00133     dv = 0;
00134     for (iq = 0; iq < ctl.nq; iq++)
00135       dq[iq] = 0;
00136     geo2cart(0, atm2->lon[ip2], atm2->lat[ip2], x2);
00137
00138     /* Find corresponding time step (test data)... */
00139     for (ip1 = 0; ip1 < atm1->np; ip1++)
00140       if (fabs(atm1->time[ip1] - atm2->time[ip2])
00141           < (filter ? filter_dt : 0.1)) {
00142
00143         /* Calculate deviations... */
00144         geo2cart(0, atm1->lon[ip1], atm1->lat[ip1], x1);
00145         dh += DIST(x1, x2);
00146         dv += Z(atm1->p[ip1]) - Z(atm2->p[ip2]);
00147         for (iq = 0; iq < ctl.nq; iq++)
00148           dq[iq] += atm1->q[iq][ip1] - atm2->q[iq][ip2];
00149         n++;
00150       }
00151
00152     /* Write output... */
00153     if (n > 0) {
00154       fprintf(out, "%.2f %.4f %.4f %.4f",
00155               atm2->time[ip2], Z(atm2->p[ip2]),
00156               atm2->lon[ip2], atm2->lat[ip2]);
00157       for (iq = 0; iq < ctl.nq; iq++) {
00158         fprintf(out, " ");
00159         fprintf(out, ctl.qnt_format[iq], atm2->q[iq][ip2]);
00160       }
00161       fprintf(out, " %.2f %g %g %g %g", lt, lv, lh, dv / n, dh / n);
00162       for (iq = 0; iq < ctl.nq; iq++) {
00163         fprintf(out, " ");
00164         fprintf(out, ctl.qnt_format[iq], dq[iq] / n);
00165       }
00166       fprintf(out, "\n");
00167     }
00168   }
00169
00170   /* Close file... */
00171   fclose(out);
00172
00173   /* Free... */
00174   free(atm1);
00175   free(atm2);
00176   free(atm3);
00177
00178   return EXIT_SUCCESS;
00179 }
```

5.17 met_map.c File Reference

Extract global map from meteorological data.

Functions

- int main (int argc, char ∗argv[ ])

5.17.1 Detailed Description

Extract global map from meteorological data.

Definition in file met_map.c.

5.17.2 Function Documentation

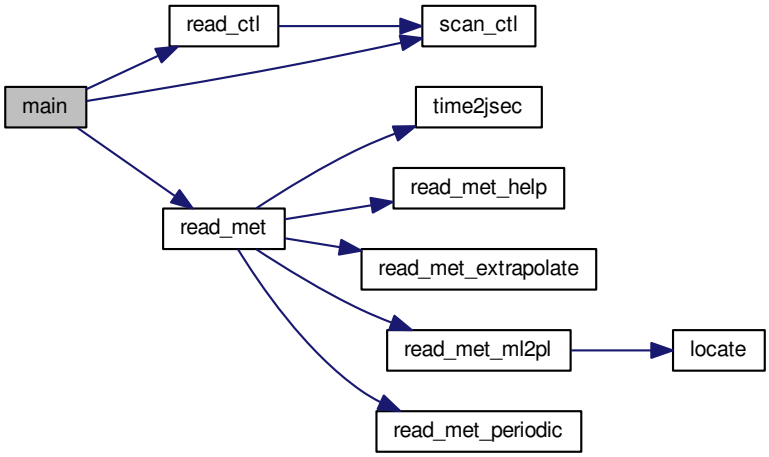
5.17.2.1 int main (int *argc*, char * *argv[]*)

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], tm[EX][EY],
00038     um[EX][EY], vm[EX][EY], wm[EX][EY], h2om[EX][EY], o3m[EX][EY];
00039
00040   static int i, ip, ip2, ix, iy, np[EX][EY];
00041
00042   /* Allocate... */
00043   ALLOC(met, met_t, 1);
00044
00045   /* Check arguments... */
00046   if (argc < 4)
00047     ERRMSG("Give parameters: <ctl> <map.tab> <met0> [ <met1> ... ]");
00048
00049   /* Read control parameters... */
00050   read_ctl(argv[1], argc, argv, &ctl);
00051   z = scan_ctl(argv[1], argc, argv, "Z", -1, "", NULL);
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     /* Find nearest pressure level... */
00060     for (ip2 = 0; ip2 < met->np; ip2++) {
00061       dz = fabs(Z(met->p[ip2]) - z);
00062       if (dz < dzmin) {
00063         dzmin = dz;
00064         ip = ip2;
00065       }
00066     }
00067
00068     /* Average data... */
00069     for (ix = 0; ix < met->nx; ix++)
00070       for (iy = 0; iy < met->ny; iy++) {
00071         timem[ix][iy] += met->time;
00072         tm[ix][iy] += met->t[ix][iy][ip];
00073         um[ix][iy] += met->u[ix][iy][ip];
00074         vm[ix][iy] += met->v[ix][iy][ip];
00075         wm[ix][iy] += met->w[ix][iy][ip];
00076         h2om[ix][iy] += met->h2o[ix][iy][ip];
00077         o3m[ix][iy] += met->o3[ix][iy][ip];
00078         psm[ix][iy] += met->ps[ix][iy];
00079         np[ix][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           "# $11 = O3 volume mixing ratio [1]\n"
00101           "# $12 = surface pressure [hPa]\n");
00102
00103   /* Write data... */
00104   for (iy = 0; iy < met->ny; iy++) {
00105     fprintf(out, "\n");
00106     for (ix = 0; ix < met->nx; ix++)
00107       if (met->lon[ix] >= 180)
00108         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g\n",
00109                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00110                 met->lon[ix] - 360.0, met->lat[iy], met->p[ip],
00111                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00112                 vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00113                 h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00114                 psm[ix][iy] / np[ix][iy]);
00115     for (ix = 0; ix < met->nx; ix++)
00116       if (met->lon[ix] <= 180)
00117         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g\n",
00118                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00119                 met->lon[ix], met->lat[iy], met->p[ip],
00120                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00121                 vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00122                 h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00123                 psm[ix][iy] / np[ix][iy]);
00124   }
00125
00126   /* Close file... */
00127   fclose(out);
00128
00129   /* Free... */
00130   free(met);
00131
00132   return EXIT_SUCCESS;
00133 }
```

Here is the call graph for this function:



5.18 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) 2013-2015 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], tm[EX][EY],
00038     um[EX][EY], vm[EX][EY], wm[EX][EY], h2om[EX][EY], o3m[EX][EY];
00039
00040   static int i, ip, ip2, ix, iy, np[EX][EY];
00041
00042   /* Allocate... */
00043   ALLOC(met, met_t, 1);
00044
00045   /* Check arguments... */
00046   if (argc < 4)
00047     ERRMSG("Give parameters: <ctl> <map.tab> <met0> [ <met1> ... ]");
00048
00049   /* Read control parameters... */
00050   read_ctl(argv[1], argc, argv, &ctl);
00051   z = scan_ctl(argv[1], argc, argv, "Z", -1, "", NULL);
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     /* Find nearest pressure level... */
00060     for (ip2 = 0; ip2 < met->np; ip2++) {
00061       dz = fabs(Z(met->p[ip2]) - z);
00062       if (dz < dzmin) {
00063         dzmin = dz;
00064         ip = ip2;
00065       }
00066     }
00067
00068     /* Average data... */
00069     for (ix = 0; ix < met->nx; ix++)
00070       for (iy = 0; iy < met->ny; iy++) {
00071         timem[ix][iy] += met->time;
00072         tm[ix][iy] += met->t[ix][iy][ip];
00073         um[ix][iy] += met->u[ix][iy][ip];
00074         vm[ix][iy] += met->v[ix][iy][ip];
00075         wm[ix][iy] += met->w[ix][iy][ip];
00076         h2om[ix][iy] += met->h2o[ix][iy][ip];
00077         o3m[ix][iy] += met->o3[ix][iy][ip];
00078         psm[ix][iy] += met->ps[ix][iy];
00079         np[ix][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           "# $11 = O3 volume mixing ratio [1]\n"
00101           "# $12 = surface pressure [hPa]\n");
00102
00103   /* Write data... */
00104   for (iy = 0; iy < met->ny; iy++) {
00105     fprintf(out, "\n");
00106     for (ix = 0; ix < met->nx; ix++)
00107       if (met->lon[ix] >= 180)
00108         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g\n",
00109                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00110                 met->lon[ix] - 360.0, met->lat[iy], met->p[ip],
00111                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00112                 vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00113                 h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00114                 psm[ix][iy] / np[ix][iy]);
00115     for (ix = 0; ix < met->nx; ix++)
00116       if (met->lon[ix] <= 180)
00117         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g\n",
00118                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00119                 met->lon[ix], met->lat[iy], met->p[ip],
00120                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00121                 vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00122                 h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00123                 psm[ix][iy] / np[ix][iy]);
00124   }
00125
00126   /* Close file... */
00127   fclose(out);
00128
00129   /* Free... */
00130   free(met);
00131
00132   return EXIT_SUCCESS;
00133 }
```

5.19 met_prof.c File Reference

Extract vertical profile from meteorological data.

Functions

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

5.19.1 Detailed Description

Extract vertical profile from meteorological data.

Definition in file met_prof.c.

5.19.2 Function Documentation

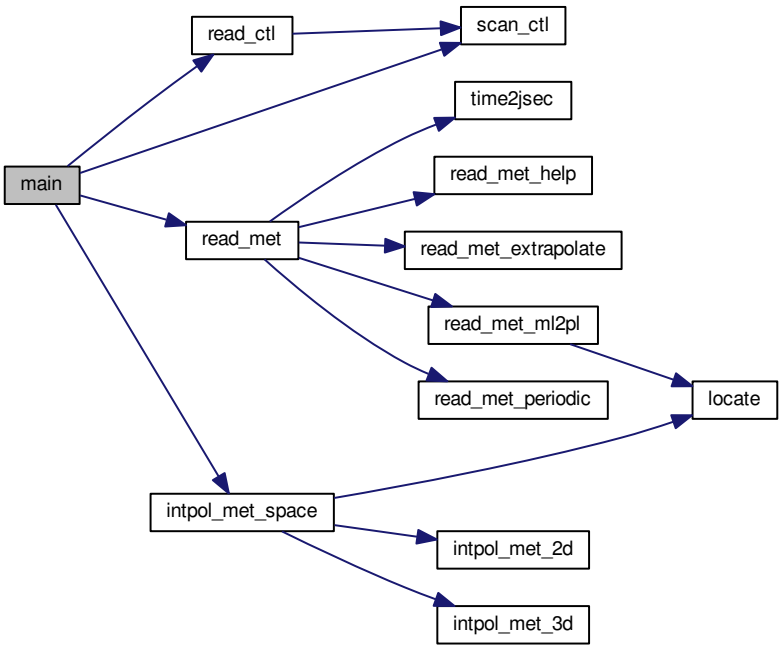
5.19.2.1 int main (int *argc*, char * *argv[]*)

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],
00050     w, wm[NZ], h2o, h2om[NZ], o3, o3m[NZ], ps, psm[NZ];
00051
00052   static int i, iz, np[NZ];
00053
00054   /* Allocate... */
00055   ALLOC(met, met_t, 1);
00056
00057   /* Check arguments... */
00058   if (argc < 4)
00059     ERRMSG("Give parameters: <ctl> <prof.tab> <met0> [ <met1> ... ]");
00060
00061   /* Read control parameters... */
00062   read_ctl(argv[1], argc, argv, &ctl);
00063   z0 = scan_ctl(argv[1], argc, argv, "Z0", -1, "0", NULL);
00064   z1 = scan_ctl(argv[1], argc, argv, "Z1", -1, "60", NULL);
00065   dz = scan_ctl(argv[1], argc, argv, "DZ", -1, "1", NULL);
00066   lon0 = scan_ctl(argv[1], argc, argv, "LON0", -1, "0", NULL);
00067   lon1 = scan_ctl(argv[1], argc, argv, "LON1", -1, "0", NULL);
00068   dlon = scan_ctl(argv[1], argc, argv, "DLON", -1, "1", NULL);
00069   lat0 = scan_ctl(argv[1], argc, argv, "LAT0", -1, "0", NULL);
00070   lat1 = scan_ctl(argv[1], argc, argv, "LAT1", -1, "0", NULL);
00071   dlat = scan_ctl(argv[1], argc, argv, "DLAT", -1, "1", NULL);
00072
00073   /* Loop over input files... */
00074   for (i = 3; i < argc; i++) {
00075
00076     /* Read meteorological data... */
00077     read_met(&ctl, argv[i], met);
00078
00079     /* Average... */
00080     for (z = z0; z <= z1; z += dz) {
00081       iz = (int) ((z - z0) / dz);
00082       if (iz < 0 || iz > NZ)
00083         ERRMSG("Too many altitudes!");
00084       for (lon = lon0; lon <= lon1; lon += dlon)
00085         for (lat = lat0; lat <= lat1; lat += dlat) {
00086           intpol_met_space(met, P(z), lon, lat, &ps,
00087                            &t, &u, &v, &w, &h2o, &o3);
00088           if (gsl_finite(t) && gsl_finite(u)
00089               && gsl_finite(v) && gsl_finite(w)) {
00090             timem[iz] += met->time;
00091             lonm[iz] += lon;
00092             latm[iz] += lat;
00093             tm[iz] += t;
00094             um[iz] += u;
00095             vm[iz] += v;
00096             wm[iz] += w;
00097             h2om[iz] += h2o;
00098             o3m[iz] += o3;
00099             psm[iz] += ps;
00100             np[iz]++;
00101           }
00102         }
00103     }
00104   }
00105
00106   /* Normalize... */
00107   for (z = z0; z <= z1; z += dz) {
00108     iz = (int) ((z - z0) / dz);
00109     if (np[iz] > 0) {
00110       timem[iz] /= np[iz];
00111       lonm[iz] /= np[iz];
00112       latm[iz] /= np[iz];
00113       tm[iz] /= np[iz];
00114       um[iz] /= np[iz];
00115       vm[iz] /= np[iz];
00116       wm[iz] /= np[iz];
00117       h2om[iz] /= np[iz];
00118       o3m[iz] /= np[iz];
00119       psm[iz] /= np[iz];
00120     } else {
00121       timem[iz] = GSL_NAN;
00122       lonm[iz] = GSL_NAN;
00123       latm[iz] = GSL_NAN;
00124       tm[iz] = GSL_NAN;
00125       um[iz] = GSL_NAN;
00126       vm[iz] = GSL_NAN;
```

```
00127       wm[iz] = GSL_NAN;
00128       h2om[iz] = GSL_NAN;
00129       o3m[iz] = GSL_NAN;
00130       psm[iz] = GSL_NAN;
00131     }
00132   }
00133
00134   /* Create output file... */
00135   printf("Write meteorological data file: %s\n", argv[2]);
00136   if (!(out = fopen(argv[2], "w")))
00137     ERRMSG("Cannot create file!");
00138
00139   /* Write header... */
00140   fprintf(out,
00141           "# $1  = time [s]\n"
00142           "# $2  = altitude [km]\n"
00143           "# $3  = longitude [deg]\n"
00144           "# $4  = latitude [deg]\n"
00145           "# $5  = pressure [hPa]\n"
00146           "# $6  = temperature [K]\n"
00147           "# $7  = zonal wind [m/s]\n"
00148           "# $8  = meridional wind [m/s]\n"
00149           "# $9  = vertical wind [hPa/s]\n"
00150           "# $10 = H2O volume mixing ratio [1]\n"
00151           "# $11 = O3 volume mixing ratio [1]\n"
00152           "# $12 = surface pressure [hPa]\n\n");
00153
00154   /* Write data... */
00155   for (z = z0; z <= z1; z += dz) {
00156     iz = (int) ((z - z0) / dz);
00157     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g\n",
00158             timem[iz], z, lonm[iz], latm[iz], P(z), tm[iz],
00159             um[iz], vm[iz], wm[iz], h2om[iz], o3m[iz], psm[iz]);
00160   }
00161
00162   /* Close file... */
00163   fclose(out);
00164
00165   /* Free... */
00166   free(met);
00167
00168   return EXIT_SUCCESS;
00169 }
```

Here is the call graph for this function:



5.20 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) 2013-2015 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],
00050     w, wm[NZ], h2o, h2om[NZ], o3, o3m[NZ], ps, psm[NZ];
00051
00052   static int i, iz, np[NZ];
00053
00054   /* Allocate... */
00055   ALLOC(met, met_t, 1);
00056
00057   /* Check arguments... */
00058   if (argc < 4)
00059     ERRMSG("Give parameters: <ctl> <prof.tab> <met0> [ <met1> ... ]");
00060
00061   /* Read control parameters... */
00062   read_ctl(argv[1], argc, argv, &ctl);
00063   z0 = scan_ctl(argv[1], argc, argv, "Z0", -1, "0", NULL);
00064   z1 = scan_ctl(argv[1], argc, argv, "Z1", -1, "60", NULL);
00065   dz = scan_ctl(argv[1], argc, argv, "DZ", -1, "1", NULL);
00066   lon0 = scan_ctl(argv[1], argc, argv, "LON0", -1, "0", NULL);
00067   lon1 = scan_ctl(argv[1], argc, argv, "LON1", -1, "0", NULL);
00068   dlon = scan_ctl(argv[1], argc, argv, "DLON", -1, "1", NULL);
00069   lat0 = scan_ctl(argv[1], argc, argv, "LAT0", -1, "0", NULL);
00070   lat1 = scan_ctl(argv[1], argc, argv, "LAT1", -1, "0", NULL);
00071   dlat = scan_ctl(argv[1], argc, argv, "DLAT", -1, "1", NULL);
00072
00073   /* Loop over input files... */
00074   for (i = 3; i < argc; i++) {
00075
00076     /* Read meteorological data... */
00077     read_met(&ctl, argv[i], met);
00078
00079     /* Average... */
00080     for (z = z0; z <= z1; z += dz) {
00081       iz = (int) ((z - z0) / dz);
00082       if (iz < 0 || iz > NZ)
00083         ERRMSG("Too many altitudes!");
00084       for (lon = lon0; lon <= lon1; lon += dlon)
00085         for (lat = lat0; lat <= lat1; lat += dlat) {
00086           intpol_met_space(met, P(z), lon, lat, &ps,
00087                            &t, &u, &v, &w, &h2o, &o3);
00088           if (gsl_finite(t) && gsl_finite(u)
00089               && gsl_finite(v) && gsl_finite(w)) {
```

```
00090             timem[iz] += met->time;
00091             lonm[iz] += lon;
00092             latm[iz] += lat;
00093             tm[iz] += t;
00094             um[iz] += u;
00095             vm[iz] += v;
00096             wm[iz] += w;
00097             h2om[iz] += h2o;
00098             o3m[iz] += o3;
00099             psm[iz] += ps;
00100             np[iz]++;
00101           }
00102         }
00103     }
00104   }
00105
00106   /* Normalize... */
00107   for (z = z0; z <= z1; z += dz) {
00108     iz = (int) ((z - z0) / dz);
00109     if (np[iz] > 0) {
00110       timem[iz] /= np[iz];
00111       lonm[iz] /= np[iz];
00112       latm[iz] /= np[iz];
00113       tm[iz] /= np[iz];
00114       um[iz] /= np[iz];
00115       vm[iz] /= np[iz];
00116       wm[iz] /= np[iz];
00117       h2om[iz] /= np[iz];
00118       o3m[iz] /= np[iz];
00119       psm[iz] /= np[iz];
00120     } else {
00121       timem[iz] = GSL_NAN;
00122       lonm[iz] = GSL_NAN;
00123       latm[iz] = GSL_NAN;
00124       tm[iz] = GSL_NAN;
00125       um[iz] = GSL_NAN;
00126       vm[iz] = GSL_NAN;
00127       wm[iz] = GSL_NAN;
00128       h2om[iz] = GSL_NAN;
00129       o3m[iz] = GSL_NAN;
00130       psm[iz] = GSL_NAN;
00131     }
00132   }
00133
00134   /* Create output file... */
00135   printf("Write meteorological data file: %s\n", argv[2]);
00136   if (!(out = fopen(argv[2], "w")))
00137     ERRMSG("Cannot create file!");
00138
00139   /* Write header... */
00140   fprintf(out,
00141           "# $1  = time [s]\n"
00142           "# $2  = altitude [km]\n"
00143           "# $3  = longitude [deg]\n"
00144           "# $4  = latitude [deg]\n"
00145           "# $5  = pressure [hPa]\n"
00146           "# $6  = temperature [K]\n"
00147           "# $7  = zonal wind [m/s]\n"
00148           "# $8  = meridional wind [m/s]\n"
00149           "# $9  = vertical wind [hPa/s]\n"
00150           "# $10 = H2O volume mixing ratio [1]\n"
00151           "# $11 = O3 volume mixing ratio [1]\n"
00152           "# $12 = surface pressure [hPa]\n\n");
00153
00154   /* Write data... */
00155   for (z = z0; z <= z1; z += dz) {
00156     iz = (int) ((z - z0) / dz);
00157     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g\n",
00158             timem[iz], z, lonm[iz], latm[iz], P(z), tm[iz],
00159             um[iz], vm[iz], wm[iz], h2om[iz], o3m[iz], psm[iz]);
00160   }
00161
00162   /* Close file... */
00163   fclose(out);
00164
00165   /* Free... */
00166   free(met);
00167
00168   return EXIT_SUCCESS;
00169 }
```

5.21 met_sample.c File Reference

Sample meteorological data at given geolocations.

Functions

- int main (int argc, char ∗argv[ ])

5.21.1 Detailed Description

Sample meteorological data at given geolocations.

Definition in file met_sample.c.

5.21.2 Function Documentation

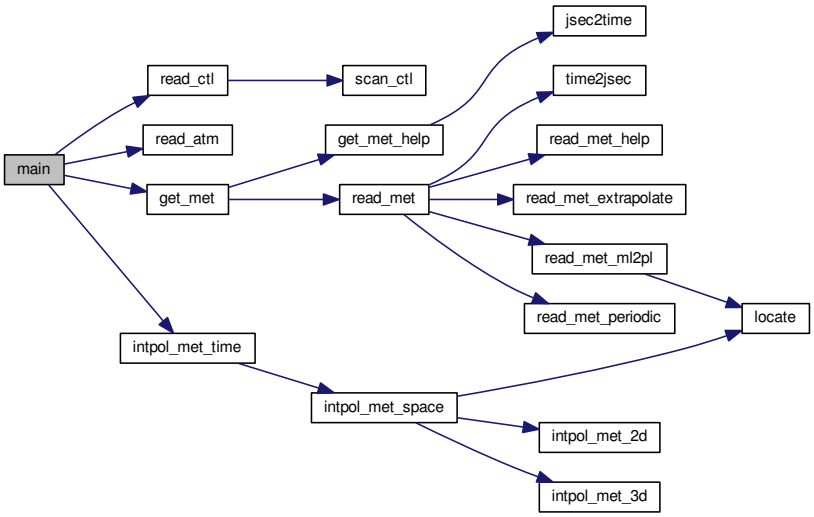
5.21.2.1 int main (int *argc*, char ∗ *argv[ ]*)

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 t, u, v, w, h2o, o3;
00044
00045   int ip;
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
00059   /* Read atmospheric data... */
00060   read_atm(argv[3], &ctl, atm);
00061
00062   /* Create output file... */
00063   printf("Write meteorological data file: %s\n", argv[4]);
00064   if (!(out = fopen(argv[4], "w")))
00065     ERRMSG("Cannot create file!");
00066
00067   /* Write header... */
00068   fprintf(out,
00069           "# $1  = time [s]\n"
00070           "# $2  = altitude [km]\n"
00071           "# $3  = longitude [deg]\n"
00072           "# $4  = latitude [deg]\n"
00073           "# $5  = pressure [hPa]\n"
00074           "# $6  = temperature [K]\n"
00075           "# $7  = zonal wind [m/s]\n"
00076           "# $8  = meridional wind [m/s]\n"
00077           "# $9  = vertical wind [hPa/s]\n"
00078           "# $10 = H2O volume mixing ratio [1]\n"
00079           "# $11 = O3 volume mixing ratio [1]\n\n");
00080
00081   /* Loop over air parcels... */
00082   for (ip = 0; ip < atm->np; ip++) {
00083
00084     /* Get meteorological data... */
00085     get_met(&ctl, argv[2], atm->time[ip], met0, met1);
00086
00087     /* Interpolate meteorological data... */
00088     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
```

```
00089                     atm->lat[ip], NULL, &t, &u, &v, &w, &h2o, &o3);
00090
00091     /* Write data... */
00092     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g\n",
00093             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip],
00094             atm->p[ip], t, u, v, w, h2o, o3);
00095   }
00096
00097   /* Close file... */
00098   fclose(out);
00099
00100   /* Free... */
00101   free(atm);
00102   free(met0);
00103   free(met1);
00104
00105   return EXIT_SUCCESS;
00106 }
```

Here is the call graph for this function:



5.22 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   Copright (C) 2013-2015 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 t, u, v, w, h2o, o3;
00044
00045   int ip;
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
00059   /* Read atmospheric data... */
00060   read_atm(argv[3], &ctl, atm);
00061
00062   /* Create output file... */
00063   printf("Write meteorological data file: %s\n", argv[4]);
00064   if (!(out = fopen(argv[4], "w")))
00065     ERRMSG("Cannot create file!");
00066
00067   /* Write header... */
00068   fprintf(out,
00069           "# $1  = time [s]\n"
00070           "# $2  = altitude [km]\n"
00071           "# $3  = longitude [deg]\n"
00072           "# $4  = latitude [deg]\n"
00073           "# $5  = pressure [hPa]\n"
00074           "# $6  = temperature [K]\n"
00075           "# $7  = zonal wind [m/s]\n"
00076           "# $8  = meridional wind [m/s]\n"
00077           "# $9  = vertical wind [hPa/s]\n"
00078           "# $10 = H2O volume mixing ratio [1]\n"
00079           "# $11 = O3 volume mixing ratio [1]\n\n");
00080
00081   /* Loop over air parcels... */
00082   for (ip = 0; ip < atm->np; ip++) {
00083
00084     /* Get meteorological data... */
00085     get_met(&ctl, argv[2], atm->time[ip], met0, met1);
00086
00087     /* Interpolate meteorological data... */
00088     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
    lon[ip],
00089                     atm->lat[ip], NULL, &t, &u, &v, &w, &h2o, &o3);
00090
00091     /* Write data... */
00092     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g\n",
00093             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip],
00094             atm->p[ip], t, u, v, w, h2o, o3);
00095   }
00096
00097   /* Close file... */
00098   fclose(out);
00099
00100   /* Free... */
00101   free(atm);
00102   free(met0);
00103   free(met1);
00104
00105   return EXIT_SUCCESS;
00106 }
```

5.23 met_zm.c File Reference

Extract zonal mean from meteorological data.

Functions

- int main (int argc, char ∗argv[ ])

5.23.1 Detailed Description

Extract zonal mean from meteorological data.

Definition in file met_zm.c.

5.23.2 Function Documentation

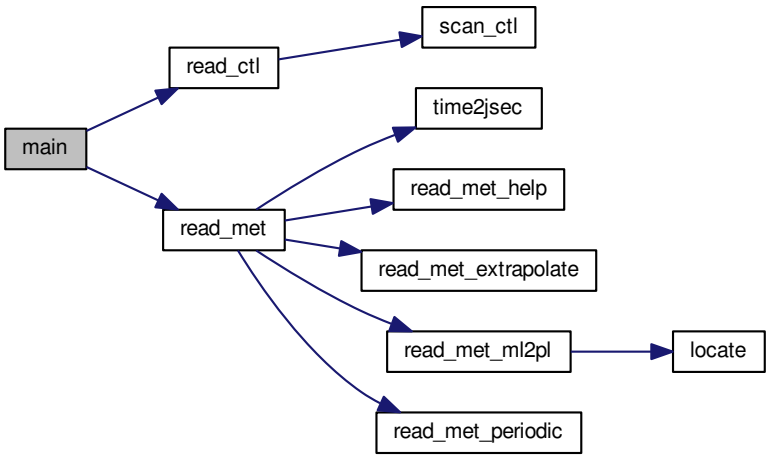
5.23.2.1 int main (int *argc,* char ∗ *argv[ ]*)

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], tm[EP][EY], um[EP][EY],
00038     vm[EP][EY], vhm[EP][EY], wm[EP][EY], h2om[EP][EY], o3m[EP][EY],
00039     psm2[EP][EY], tm2[EP][EY], um2[EP][EY], vm2[EP][EY], vhm2[EP][EY],
00040     wm2[EP][EY], h2om2[EP][EY], o3m2[EP][EY];
00041
00042   static int i, ip, ix, iy, np[EP][EY];
00043
00044   /* Allocate... */
00045   ALLOC(met, met_t, 1);
00046
00047   /* Check arguments... */
00048   if (argc < 4)
00049     ERRMSG("Give parameters: <ctl> <zm.tab> <met0> [ <met1> ... ]");
00050
00051   /* Read control parameters... */
00052   read_ctl(argv[1], argc, argv, &ctl);
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     /* Average data... */
00061     for (ix = 0; ix < met->nx; ix++)
00062       for (iy = 0; iy < met->ny; iy++)
00063         for (ip = 0; ip < met->np; ip++) {
00064           timem[ip][iy] += met->time;
00065           tm[ip][iy] += met->t[ix][iy][ip];
00066           um[ip][iy] += met->u[ix][iy][ip];
00067           vm[ip][iy] += met->v[ix][iy][ip];
00068           vhm[ip][iy] += sqrt(gsl_pow_2(met->u[ix][iy][ip])
00069                               + gsl_pow_2(met->v[ix][iy][ip]));
00070           wm[ip][iy] += met->w[ix][iy][ip];
00071           h2om[ip][iy] += met->h2o[ix][iy][ip];
00072           o3m[ip][iy] += met->o3[ix][iy][ip];
00073           psm[ip][iy] += met->ps[ix][iy];
00074           tm2[ip][iy] += gsl_pow_2(met->t[ix][iy][ip]);
00075           um2[ip][iy] += gsl_pow_2(met->u[ix][iy][ip]);
00076           vm2[ip][iy] += gsl_pow_2(met->v[ix][iy][ip]);
00077           vhm2[ip][iy] += gsl_pow_2(met->u[ix][iy][ip])
00078             + gsl_pow_2(met->v[ix][iy][ip]);
00079           wm2[ip][iy] += gsl_pow_2(met->w[ix][iy][ip]);
00080           h2om2[ip][iy] += gsl_pow_2(met->h2o[ix][iy][ip]);
00081           o3m2[ip][iy] += gsl_pow_2(met->o3[ix][iy][ip]);
00082           psm2[ip][iy] += gsl_pow_2(met->ps[ix][iy]);
00083           np[ip][iy]++;
00084         }
00085   }
```

```
00086
00087   /* Create output file... */
00088   printf("Write meteorological data file: %s\n", argv[2]);
00089   if (!(out = fopen(argv[2], "w")))
00090     ERRMSG("Cannot create file!");
00091
00092   /* Write header... */
00093   fprintf(out,
00094           "# $1  = time [s]\n"
00095           "# $2  = altitude [km]\n"
00096           "# $3  = latitude [deg]\n"
00097           "# $4  = temperature mean [K]\n"
00098           "# $5  = temperature standard deviation [K]\n"
00099           "# $6  = zonal wind mean [m/s]\n"
00100           "# $7  = zonal wind standard deviation [m/s]\n"
00101           "# $8  = meridional wind mean [m/s]\n"
00102           "# $9  = meridional wind standard deviation [m/s]\n"
00103           "# $10 = horizontal wind mean [m/s]\n"
00104           "# $11 = horizontal wind standard deviation [m/s]\n"
00105           "# $12 = vertical wind mean [hPa/s]\n"
00106           "# $13 = vertical wind standard deviation [hPa/s]\n"
00107           "# $14 = H2O vmr mean [1]\n"
00108           "# $15 = H2O vmr standard deviation [1]\n"
00109           "# $16 = O3 vmr mean [1]\n"
00110           "# $17 = O3 vmr standard deviation [1]\n"
00111           "# $18 = surface pressure mean [hPa]\n"
00112           "# $19 = surface pressure standard deviation [hPa]\n");
00113
00114   /* Write data... */
00115   for (iy = 0; iy < met->ny; iy++) {
00116     fprintf(out, "\n");
00117     for (ip = 0; ip < met->np; ip++)
00118       fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g"
00119               " %g %g %g %g %g %g %g %g\n",
00120               timem[ip][iy] / np[ip][iy], Z(met->p[ip]), met->lat[iy],
00121               tm[ip][iy] / np[ip][iy],
00122               sqrt(tm2[ip][iy] / np[ip][iy] -
00123                    gsl_pow_2(tm[ip][iy] / np[ip][iy])),
00124               um[ip][iy] / np[ip][iy],
00125               sqrt(um2[ip][iy] / np[ip][iy] -
00126                    gsl_pow_2(um[ip][iy] / np[ip][iy])),
00127               vm[ip][iy] / np[ip][iy],
00128               sqrt(vm2[ip][iy] / np[ip][iy] -
00129                    gsl_pow_2(vm[ip][iy] / np[ip][iy])),
00130               vhm[ip][iy] / np[ip][iy],
00131               sqrt(vhm2[ip][iy] / np[ip][iy] -
00132                    gsl_pow_2(vhm[ip][iy] / np[ip][iy])),
00133               wm[ip][iy] / np[ip][iy],
00134               sqrt(wm2[ip][iy] / np[ip][iy] -
00135                    gsl_pow_2(wm[ip][iy] / np[ip][iy])),
00136               h2om[ip][iy] / np[ip][iy],
00137               sqrt(h2om2[ip][iy] / np[ip][iy] -
00138                    gsl_pow_2(h2om[ip][iy] / np[ip][iy])),
00139               o3m[ip][iy] / np[ip][iy],
00140               sqrt(o3m2[ip][iy] / np[ip][iy] -
00141                    gsl_pow_2(o3m[ip][iy] / np[ip][iy])),
00142               psm[ip][iy] / np[ip][iy],
00143               sqrt(psm2[ip][iy] / np[ip][iy] -
00144                    gsl_pow_2(psm[ip][iy] / np[ip][iy])));
00145   }
00146
00147   /* Close file... */
00148   fclose(out);
00149
00150   /* Free... */
00151   free(met);
00152
00153   return EXIT_SUCCESS;
00154 }
```

Here is the call graph for this function:



5.24 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   Copright (C) 2013-2015 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], tm[EP][EY], um[EP][EY],
00038     vm[EP][EY], vhm[EP][EY], wm[EP][EY], h2om[EP][EY], o3m[EP][EY],
00039     psm2[EP][EY], tm2[EP][EY], um2[EP][EY], vm2[EP][EY], vhm2[EP][EY],
00040     wm2[EP][EY], h2om2[EP][EY], o3m2[EP][EY];
00041
00042   static int i, ip, ix, iy, np[EP][EY];
00043
00044   /* Allocate... */
00045   ALLOC(met, met_t, 1);
00046
00047   /* Check arguments... */
00048   if (argc < 4)
00049     ERRMSG("Give parameters: <ctl> <zm.tab> <met0> [ <met1> ... ]");
00050
00051   /* Read control parameters... */
00052   read_ctl(argv[1], argc, argv, &ctl);
```

```
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     /* Average data... */
00061     for (ix = 0; ix < met->nx; ix++)
00062       for (iy = 0; iy < met->ny; iy++)
00063         for (ip = 0; ip < met->np; ip++) {
00064           timem[ip][iy] += met->time;
00065           tm[ip][iy] += met->t[ix][iy][ip];
00066           um[ip][iy] += met->u[ix][iy][ip];
00067           vm[ip][iy] += met->v[ix][iy][ip];
00068           vhm[ip][iy] += sqrt(gsl_pow_2(met->u[ix][iy][ip])
00069                               + gsl_pow_2(met->v[ix][iy][ip]));
00070           wm[ip][iy] += met->w[ix][iy][ip];
00071           h2om[ip][iy] += met->h2o[ix][iy][ip];
00072           o3m[ip][iy] += met->o3[ix][iy][ip];
00073           psm[ip][iy] += met->ps[ix][iy];
00074           tm2[ip][iy] += gsl_pow_2(met->t[ix][iy][ip]);
00075           um2[ip][iy] += gsl_pow_2(met->u[ix][iy][ip]);
00076           vm2[ip][iy] += gsl_pow_2(met->v[ix][iy][ip]);
00077           vhm2[ip][iy] += gsl_pow_2(met->u[ix][iy][ip])
00078             + gsl_pow_2(met->v[ix][iy][ip]);
00079           wm2[ip][iy] += gsl_pow_2(met->w[ix][iy][ip]);
00080           h2om2[ip][iy] += gsl_pow_2(met->h2o[ix][iy][ip]);
00081           o3m2[ip][iy] += gsl_pow_2(met->o3[ix][iy][ip]);
00082           psm2[ip][iy] += gsl_pow_2(met->ps[ix][iy]);
00083           np[ip][iy]++;
00084         }
00085   }
00086
00087   /* Create output file... */
00088   printf("Write meteorological data file: %s\n", argv[2]);
00089   if (!(out = fopen(argv[2], "w")))
00090     ERRMSG("Cannot create file!");
00091
00092   /* Write header... */
00093   fprintf(out,
00094           "# $1  = time [s]\n"
00095           "# $2  = altitude [km]\n"
00096           "# $3  = latitude [deg]\n"
00097           "# $4  = temperature mean [K]\n"
00098           "# $5  = temperature standard deviation [K]\n"
00099           "# $6  = zonal wind mean [m/s]\n"
00100          "# $7  = zonal wind standard deviation [m/s]\n"
00101          "# $8  = meridional wind mean [m/s]\n"
00102          "# $9  = meridional wind standard deviation [m/s]\n"
00103          "# $10 = horizontal wind mean [m/s]\n"
00104          "# $11 = horizontal wind standard deviation [m/s]\n"
00105          "# $12 = vertical wind mean [hPa/s]\n"
00106          "# $13 = vertical wind standard deviation [hPa/s]\n"
00107          "# $14 = H2O vmr mean [1]\n"
00108          "# $15 = H2O vmr standard deviation [1]\n"
00109          "# $16 = O3 vmr mean [1]\n"
00110          "# $17 = O3 vmr standard deviation [1]\n"
00111          "# $18 = surface pressure mean [hPa]\n"
00112          "# $19 = surface pressure standard deviation [hPa]\n");
00113
00114   /* Write data... */
00115   for (iy = 0; iy < met->ny; iy++) {
00116     fprintf(out, "\n");
00117     for (ip = 0; ip < met->np; ip++)
00118       fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g"
00119               " %g %g %g %g %g %g %g %g\n",
00120               timem[ip][iy] / np[ip][iy], Z(met->p[ip]), met->lat[iy],
00121               tm[ip][iy] / np[ip][iy],
00122               sqrt(tm2[ip][iy] / np[ip][iy] -
00123                    gsl_pow_2(tm[ip][iy] / np[ip][iy])),
00124               um[ip][iy] / np[ip][iy],
00125               sqrt(um2[ip][iy] / np[ip][iy] -
00126                    gsl_pow_2(um[ip][iy] / np[ip][iy])),
00127               vm[ip][iy] / np[ip][iy],
00128               sqrt(vm2[ip][iy] / np[ip][iy] -
00129                    gsl_pow_2(vm[ip][iy] / np[ip][iy])),
00130               vhm[ip][iy] / np[ip][iy],
00131               sqrt(vhm2[ip][iy] / np[ip][iy] -
00132                    gsl_pow_2(vhm[ip][iy] / np[ip][iy])),
00133               wm[ip][iy] / np[ip][iy],
00134               sqrt(wm2[ip][iy] / np[ip][iy] -
00135                    gsl_pow_2(wm[ip][iy] / np[ip][iy])),
00136               h2om[ip][iy] / np[ip][iy],
00137               sqrt(h2om2[ip][iy] / np[ip][iy] -
00138                    gsl_pow_2(h2om[ip][iy] / np[ip][iy])),
00139               o3m[ip][iy] / np[ip][iy],
```

```
00140               sqrt(o3m2[ip][iy] / np[ip][iy] -
00141                    gsl_pow_2(o3m[ip][iy] / np[ip][iy])),
00142               psm[ip][iy] / np[ip][iy],
00143               sqrt(psm2[ip][iy] / np[ip][iy] -
00144                    gsl_pow_2(psm[ip][iy] / np[ip][iy])));
00145   }
00146
00147   /* Close file... */
00148   fclose(out);
00149
00150   /* Free... */
00151   free(met);
00152
00153   return EXIT_SUCCESS;
00154 }
```

5.25 smago.c File Reference

Estimate horizontal diffusivity based on Smagorinsky theory.

Functions

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

5.25.1 Detailed Description

Estimate horizontal diffusivity based on Smagorinsky theory.

Definition in file smago.c.

5.25.2 Function Documentation

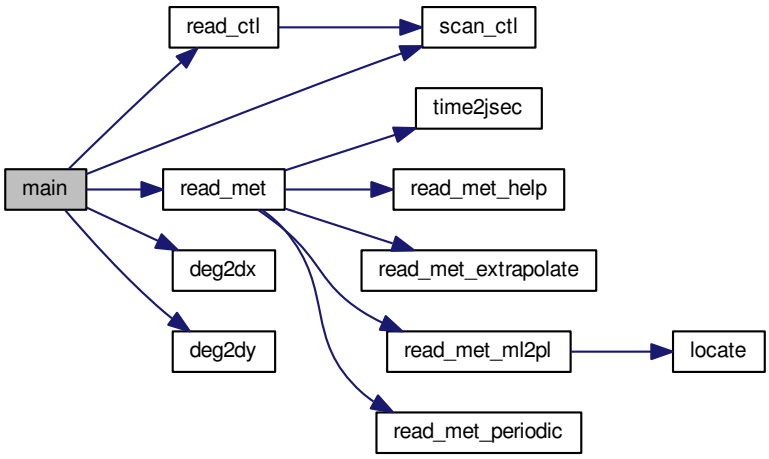
5.25.2.1 int main (int *argc*, char * *argv[]*)

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:



5.26 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 }
```

5.27 split.c File Reference

Split air parcels into a larger number of parcels.

Functions

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

5.27.1 Detailed Description

Split air parcels into a larger number of parcels.

Definition in file split.c.

5.27.2 Function Documentation

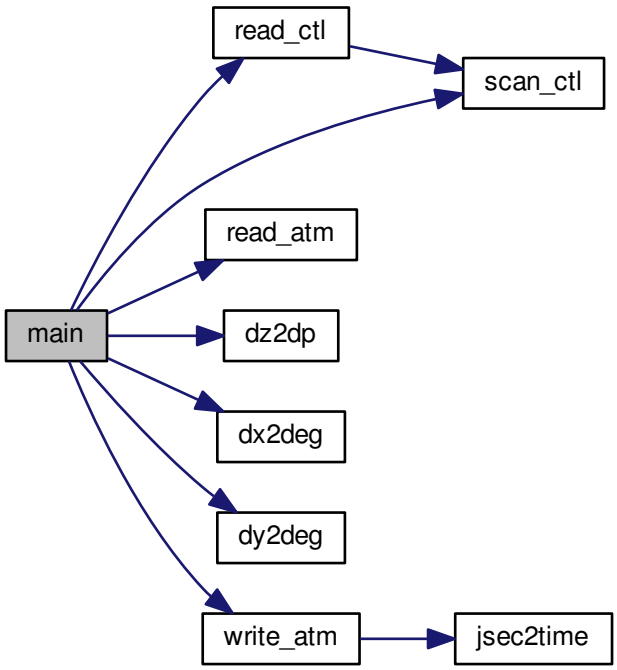
5.27.2.1 int main (int *argc*, char * *argv[]*)

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:



5.28 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) 2013-2015 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 }
```

5.29 time2jsec.c File Reference

Convert date to Julian seconds.

Functions

- int main (int argc, char ∗argv[ ])

5.29.1 Detailed Description

Convert date to Julian seconds.

Definition in file time2jsec.c.

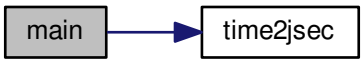
5.29.2 Function Documentation

5.29.2.1 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:



5.30 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) 2013-2015 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 }
```

5.31 trac.c File Reference

Lagrangian particle dispersion model.

Functions

- void init_simtime (ctl_t *ctl, atm_t *atm)
  Set simulation time interval.
- 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.
- double module_meteo_hno3 (double t, double lat, double p)
  Auxiliary function for meteo module.
- 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[])

5.31.1 Detailed Description

Lagrangian particle dispersion model.

Definition in file trac.c.

5.31.2 Function Documentation

5.31.2.1 void init_simtime (ctl_t * *ctl*, atm_t * *atm*)

Set simulation time interval.

Definition at line 371 of file trac.c.

```
00373                {
00374
00375   /* Set inital and final time... */
00376   if (ctl->direction == 1) {
00377     if (ctl->t_start < -1e99)
00378       ctl->t_start = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00379     if (ctl->t_stop < -1e99)
00380       ctl->t_stop = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00381   } else if (ctl->direction == -1) {
00382     if (ctl->t_stop < -1e99)
00383       ctl->t_stop = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00384     if (ctl->t_start < -1e99)
00385       ctl->t_start = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00386   }
00387
00388   /* Check time... */
00389   if (ctl->direction * (ctl->t_stop - ctl->t_start) <= 0)
00390     ERRMSG("Nothing to do!");
00391 }
```

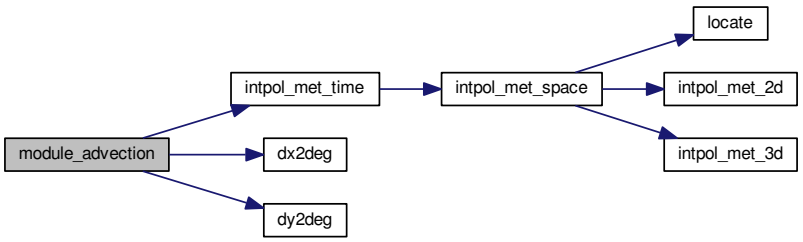
5.31.2.2 void module_advection (met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt*)

Calculate advection of air parcels.

Definition at line 395 of file trac.c.

```
00400              {
00401
00402   double v[3], xm[3];
00403
00404   /* Interpolate meteorological data... */
00405   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00406                   atm->lon[ip], atm->lat[ip], NULL, NULL,
00407                   &v[0], &v[1], &v[2], NULL, NULL);
00408
00409   /* Get position of the mid point... */
00410   xm[0] = atm->lon[ip] + dx2deg(0.5 * dt * v[0] / 1000., atm->lat[ip]);
00411   xm[1] = atm->lat[ip] + dy2deg(0.5 * dt * v[1] / 1000.);
00412   xm[2] = atm->p[ip] + 0.5 * dt * v[2];
00413
00414   /* Interpolate meteorological data for mid point... */
00415   intpol_met_time(met0, met1, atm->time[ip] + 0.5 * dt,
00416                   xm[2], xm[0], xm[1], NULL, NULL,
00417                   &v[0], &v[1], &v[2], NULL, NULL);
00418
00419   /* Save new position... */
00420   atm->time[ip] += dt;
00421   atm->lon[ip] += dx2deg(dt * v[0] / 1000., xm[1]);
00422   atm->lat[ip] += dy2deg(dt * v[1] / 1000.);
00423   atm->p[ip] += dt * v[2];
00424 }
```

Here is the call graph for this function:



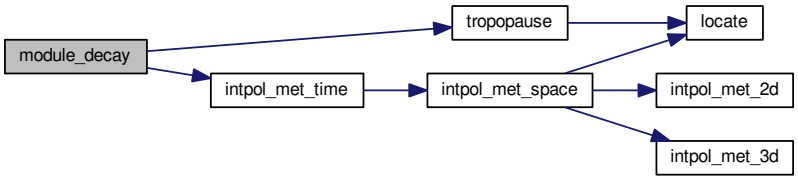
5.31.2.3 void module_decay (ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt*)

Calculate exponential decay of particle mass.

Definition at line 428 of file trac.c.

```
00434             {
00435
00436   double ps, pt, tdec;
00437
00438   /* Check lifetime values... */
00439   if ((ctl->tdec_trop <= 0 && ctl->tdec_strat <= 0) || ctl->
      qnt_m < 0)
00440     return;
00441
00442   /* Set constant lifetime... */
00443   if (ctl->tdec_trop == ctl->tdec_strat)
00444     tdec = ctl->tdec_trop;
00445
00446   /* Set altitude-dependent lifetime... */
00447   else {
00448
00449     /* Get surface pressure... */
00450     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00451                     atm->lon[ip], atm->lat[ip], &ps, NULL,
00452                     NULL, NULL, NULL, NULL, NULL);
00453
00454     /* Get tropopause pressure... */
00455     pt = tropopause(atm->time[ip], atm->lat[ip]);
00456
00457     /* Set lifetime... */
00458     if (atm->p[ip] <= pt)
00459       tdec = ctl->tdec_strat;
00460     else
00461       tdec = LIN(ps, ctl->tdec_trop, pt, ctl->tdec_strat, atm->
      p[ip]);
00462   }
00463
00464   /* Calculate exponential decay... */
00465   atm->q[ctl->qnt_m][ip] *= exp(-dt / tdec);
00466 }
```

Here is the call graph for this function:



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

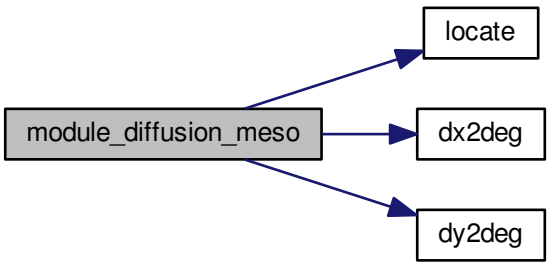
Calculate mesoscale diffusion.

Definition at line 470 of file trac.c.

```
00477                 {
00478
00479   double r, rs, u[16], v[16], w[16], usig, vsig, wsig;
00480
00481   int ix, iy, iz;
00482
00483   /* Calculate mesoscale velocity fluctuations... */
00484   if (ctl->turb_meso > 0) {
00485
00486     /* Get indices... */
00487     ix = locate(met0->lon, met0->nx, atm->lon[ip]);
00488     iy = locate(met0->lat, met0->ny, atm->lat[ip]);
00489     iz = locate(met0->p, met0->np, atm->p[ip]);
00490
00491     /* Collect local wind data... */
00492     u[0] = met0->u[ix][iy][iz];
00493     u[1] = met0->u[ix + 1][iy][iz];
00494     u[2] = met0->u[ix][iy + 1][iz];
00495     u[3] = met0->u[ix + 1][iy + 1][iz];
00496     u[4] = met0->u[ix][iy][iz + 1];
00497     u[5] = met0->u[ix + 1][iy][iz + 1];
00498     u[6] = met0->u[ix][iy + 1][iz + 1];
00499     u[7] = met0->u[ix + 1][iy + 1][iz + 1];
00500
00501     v[0] = met0->v[ix][iy][iz];
00502     v[1] = met0->v[ix + 1][iy][iz];
00503     v[2] = met0->v[ix][iy + 1][iz];
00504     v[3] = met0->v[ix + 1][iy + 1][iz];
00505     v[4] = met0->v[ix][iy][iz + 1];
00506     v[5] = met0->v[ix + 1][iy][iz + 1];
00507     v[6] = met0->v[ix][iy + 1][iz + 1];
00508     v[7] = met0->v[ix + 1][iy + 1][iz + 1];
00509
00510     w[0] = met0->w[ix][iy][iz];
00511     w[1] = met0->w[ix + 1][iy][iz];
00512     w[2] = met0->w[ix][iy + 1][iz];
00513     w[3] = met0->w[ix + 1][iy + 1][iz];
00514     w[4] = met0->w[ix][iy][iz + 1];
00515     w[5] = met0->w[ix + 1][iy][iz + 1];
00516     w[6] = met0->w[ix][iy + 1][iz + 1];
00517     w[7] = met0->w[ix + 1][iy + 1][iz + 1];
00518
00519     /* Get indices... */
00520     ix = locate(met1->lon, met1->nx, atm->lon[ip]);
00521     iy = locate(met1->lat, met1->ny, atm->lat[ip]);
00522     iz = locate(met1->p, met1->np, atm->p[ip]);
00523
00524     /* Collect local wind data... */
00525     u[8] = met1->u[ix][iy][iz];
00526     u[9] = met1->u[ix + 1][iy][iz];
00527     u[10] = met1->u[ix][iy + 1][iz];
00528     u[11] = met1->u[ix + 1][iy + 1][iz];
00529     u[12] = met1->u[ix][iy][iz + 1];
00530     u[13] = met1->u[ix + 1][iy][iz + 1];
00531     u[14] = met1->u[ix][iy + 1][iz + 1];
00532     u[15] = met1->u[ix + 1][iy + 1][iz + 1];
00533
00534     v[8] = met1->v[ix][iy][iz];
00535     v[9] = met1->v[ix + 1][iy][iz];
00536     v[10] = met1->v[ix][iy + 1][iz];
00537     v[11] = met1->v[ix + 1][iy + 1][iz];
00538     v[12] = met1->v[ix][iy][iz + 1];
00539     v[13] = met1->v[ix + 1][iy][iz + 1];
00540     v[14] = met1->v[ix][iy + 1][iz + 1];
00541     v[15] = met1->v[ix + 1][iy + 1][iz + 1];
00542
00543     w[8] = met1->w[ix][iy][iz];
00544     w[9] = met1->w[ix + 1][iy][iz];
00545     w[10] = met1->w[ix][iy + 1][iz];
00546     w[11] = met1->w[ix + 1][iy + 1][iz];
00547     w[12] = met1->w[ix][iy][iz + 1];
00548     w[13] = met1->w[ix + 1][iy][iz + 1];
00549     w[14] = met1->w[ix][iy + 1][iz + 1];
00550     w[15] = met1->w[ix + 1][iy + 1][iz + 1];
00551
00552     /* Get standard deviations of local wind data... */
00553     usig = gsl_stats_sd(u, 1, 16);
00554     vsig = gsl_stats_sd(v, 1, 16);
00555     wsig = gsl_stats_sd(w, 1, 16);
00556
00557     /* Set temporal correlations for mesoscale fluctuations... */
00558     r = 1 - 2 * fabs(dt) / ctl->dt_met;
00559     rs = sqrt(1 - r * r);
00560
00561     /* Calculate mesoscale wind fluctuations... */
00562     atm->up[ip] =
00563       r * atm->up[ip] + rs * gsl_ran_gaussian_ziggurat(rng,
```

```
00564                                                   ctl->turb_meso * usig);
00565     atm->vp[ip] =
00566       r * atm->vp[ip] + rs * gsl_ran_gaussian_ziggurat(rng,
00567                                                   ctl->turb_meso * vsig);
00568     atm->wp[ip] =
00569       r * atm->wp[ip] + rs * gsl_ran_gaussian_ziggurat(rng,
00570                                                   ctl->turb_meso * wsig);
00571
00572     /* Calculate air parcel displacement... */
00573     atm->lon[ip] += dx2deg(atm->up[ip] * dt / 1000., atm->lat[ip]);
00574     atm->lat[ip] += dy2deg(atm->vp[ip] * dt / 1000.);
00575     atm->p[ip] += atm->wp[ip] * dt;
00576   }
00577 }
```

Here is the call graph for this function:



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

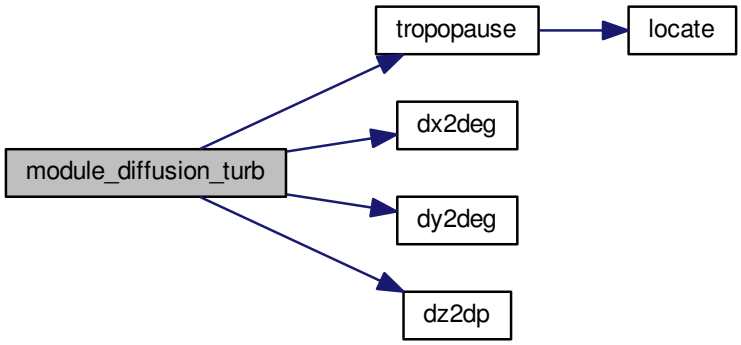
Calculate turbulent diffusion.

Definition at line 581 of file trac.c.

```
00586                 {
00587
00588   double dx, dz, pt, p0, p1, w;
00589
00590   /* Get tropopause pressure... */
00591   pt = tropopause(atm->time[ip], atm->lat[ip]);
00592
00593   /* Get weighting factor... */
00594   p1 = pt * 0.866877899;
00595   p0 = pt / 0.866877899;
00596   if (atm->p[ip] > p0)
00597     w = 1;
00598   else if (atm->p[ip] < p1)
00599     w = 0;
00600   else
00601     w = LIN(p0, 1.0, p1, 0.0, atm->p[ip]);
00602
00603   /* Set diffusivitiy... */
00604   dx = w * ctl->turb_dx_trop + (1 - w) * ctl->turb_dx_strat;
00605   dz = w * ctl->turb_dz_trop + (1 - w) * ctl->turb_dz_strat;
00606
00607   /* Horizontal turbulent diffusion... */
00608   if (dx > 0) {
00609     atm->lon[ip]
00610       += dx2deg(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dx * fabs(dt)))
00611                 / 1000., atm->lat[ip]);
00612     atm->lat[ip]
00613       += dy2deg(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dx * fabs(dt)))
00614                 / 1000.);
00615   }
```

```
00616
00617   /* Vertical turbulent diffusion... */
00618   if (dz > 0)
00619     atm->p[ip]
00620       += dz2dp(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dz * fabs(dt)))
00621                / 1000., atm->p[ip]);
00622 }
```

Here is the call graph for this function:



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

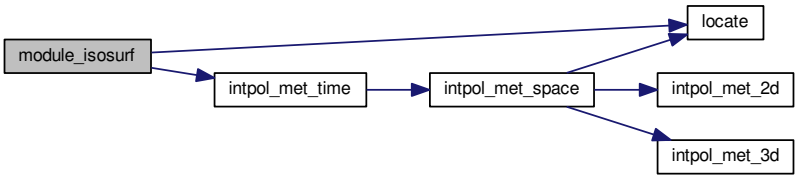
Force air parcels to stay on isosurface.

Definition at line 626 of file trac.c.

```
00631           {
00632
00633   static double *iso, *ps, t, *ts;
00634
00635   static int idx, ip2, n, nb = 100000;
00636
00637   FILE *in;
00638
00639   char line[LEN];
00640
00641   /* Check control parameter... */
00642   if (ctl->isosurf < 1 || ctl->isosurf > 4)
00643     return;
00644
00645   /* Initialize... */
00646   if (ip < 0) {
00647
00648     /* Allocate... */
00649     ALLOC(iso, double,
00650           NP);
00651     ALLOC(ps, double,
00652           nb);
00653     ALLOC(ts, double,
00654           nb);
00655
00656     /* Save pressure... */
00657     if (ctl->isosurf == 1)
00658       for (ip2 = 0; ip2 < atm->np; ip2++)
00659         iso[ip2] = atm->p[ip2];
00660
00661     /* Save density... */
00662     else if (ctl->isosurf == 2)
00663       for (ip2 = 0; ip2 < atm->np; ip2++) {
00664         intpol_met_time(met0, met1, atm->time[ip2], atm->p[ip2],
```

```
00665                         atm->lon[ip2], atm->lat[ip2], NULL, &t, NULL, NULL,
00666                         NULL, NULL, NULL);
00667         iso[ip2] = atm->p[ip2] / t;
00668       }
00669
00670     /* Save potential temperature... */
00671     else if (ctl->isosurf == 3)
00672       for (ip2 = 0; ip2 < atm->np; ip2++) {
00673         intpol_met_time(met0, met1, atm->time[ip2], atm->p[ip2],
00674                         atm->lon[ip2], atm->lat[ip2], NULL, &t, NULL, NULL,
00675                         NULL, NULL, NULL);
00676         iso[ip2] = t * pow(P0 / atm->p[ip2], 0.286);
00677       }
00678
00679     /* Read balloon pressure data... */
00680     else if (ctl->isosurf == 4) {
00681
00682       /* Write info... */
00683       printf("Read balloon pressure data: %s\n", ctl->balloon);
00684
00685       /* Open file... */
00686       if (!(in = fopen(ctl->balloon, "r")))
00687         ERRMSG("Cannot open file!");
00688
00689       /* Read pressure time series... */
00690       while (fgets(line, LEN, in))
00691         if (sscanf(line, "%lg %lg", &ts[n], &ps[n]) == 2)
00692           if ((++n) > 100000)
00693             ERRMSG("Too many data points!");
00694
00695       /* Check number of points... */
00696       if (n < 1)
00697         ERRMSG("Could not read any data!");
00698
00699       /* Close file... */
00700       fclose(in);
00701     }
00702
00703     /* Leave initialization... */
00704     return;
00705   }
00706
00707   /* Restore pressure... */
00708   if (ctl->isosurf == 1)
00709     atm->p[ip] = iso[ip];
00710
00711   /* Restore density... */
00712   else if (ctl->isosurf == 2) {
00713     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00714                     atm->lat[ip], NULL, &t, NULL, NULL, NULL, NULL, NULL);
00715     atm->p[ip] = iso[ip] * t;
00716   }
00717
00718   /* Restore potential temperature... */
00719   else if (ctl->isosurf == 3) {
00720     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00721                     atm->lat[ip], NULL, &t, NULL, NULL, NULL, NULL, NULL);
00722     atm->p[ip] = P0 * pow(iso[ip] / t, -1. / 0.286);
00723   }
00724
00725   /* Interpolate pressure... */
00726   else if (ctl->isosurf == 4) {
00727     if (atm->time[ip] <= ts[0])
00728       atm->p[ip] = ps[0];
00729     else if (atm->time[ip] >= ts[n - 1])
00730       atm->p[ip] = ps[n - 1];
00731     else {
00732       idx = locate(ts, n, atm->time[ip]);
00733       atm->p[ip] = LIN(ts[idx], ps[idx],
00734                        ts[idx + 1], ps[idx + 1], atm->time[ip]);
00735     }
00736   }
00737 }
```

Here is the call graph for this function:



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

Interpolate meteorological data for air parcel positions.

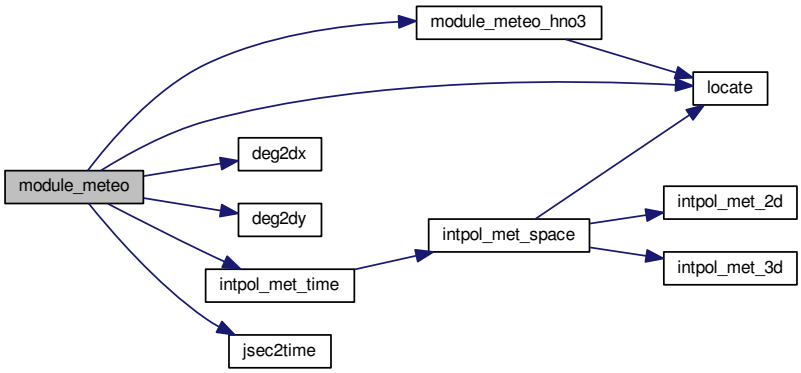
Definition at line 741 of file trac.c.

```
00746           {
00747
00748   static FILE *in;
00749
00750   static char filename[LEN], line[LEN];
00751
00752   static double lon[GX], lat[GY], var[GX][GY],
00753     rdum, rlat, rlat_old = -999, rlon, rvar;
00754
00755   static int year_old, mon_old, day_old, nlon, nlat;
00756
00757   double a, b, c, ps, p1, p_hno3, p_h2o, t, t1, u, u1, v, v1, w,
00758     x1, x2, h2o, o3, grad, vort, var0, var1;
00759
00760   int day, mon, year, idum, ilat, ilon;
00761
00762   /* Interpolate meteorological data... */
00763   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00764                   atm->lat[ip], &ps, &t, &u, &v, &w, &h2o, &o3);
00765
00766   /* Set surface pressure... */
00767   if (ctl->qnt_ps >= 0)
00768     atm->q[ctl->qnt_ps][ip] = ps;
00769
00770   /* Set pressure... */
00771   if (ctl->qnt_p >= 0)
00772     atm->q[ctl->qnt_p][ip] = atm->p[ip];
00773
00774   /* Set temperature... */
00775   if (ctl->qnt_t >= 0)
00776     atm->q[ctl->qnt_t][ip] = t;
00777
00778   /* Set zonal wind... */
00779   if (ctl->qnt_u >= 0)
00780     atm->q[ctl->qnt_u][ip] = u;
00781
00782   /* Set meridional wind... */
00783   if (ctl->qnt_v >= 0)
00784     atm->q[ctl->qnt_v][ip] = v;
00785
00786   /* Set vertical velocity... */
00787   if (ctl->qnt_w >= 0)
00788     atm->q[ctl->qnt_w][ip] = w;
00789
00790   /* Set water vapor vmr... */
00791   if (ctl->qnt_h2o >= 0)
00792     atm->q[ctl->qnt_h2o][ip] = h2o;
00793
00794   /* Set ozone vmr... */
00795   if (ctl->qnt_o3 >= 0)
00796     atm->q[ctl->qnt_o3][ip] = o3;
00797
00798   /* Calculate potential temperature... */
```

```
00799   if (ctl->qnt_theta >= 0)
00800     atm->q[ctl->qnt_theta][ip] = t * pow(P0 / atm->p[ip], 0.286);
00801
00802   /* Calculate potential vorticity... */
00803   if (ctl->qnt_pv >= 0) {
00804
00805     /* Absolute vorticity... */
00806     vort = 2 * 7.2921e-5 * sin(atm->lat[ip] * M_PI / 180.);
00807     if (fabs(atm->lat[ip]) < 89.) {
00808       intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00809                       (atm->lon[ip] >=
00810                        0 ? atm->lon[ip] - 1. : atm->lon[ip] + 1.),
00811                       atm->lat[ip], NULL, NULL, NULL, &v1, NULL, NULL, NULL);
00812       vort += (v1 - v) / 1000.
00813         / ((atm->lon[ip] >= 0 ? -1 : 1) * deg2dx(1., atm->lat[ip]));
00814     }
00815     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00816                     (atm->lat[ip] >=
00817                      0 ? atm->lat[ip] - 1. : atm->lat[ip] + 1.), NULL, NULL,
00818                     &u1, NULL, NULL, NULL, NULL);
00819     vort += (u1 - u) / 1000. / ((atm->lat[ip] >= 0 ? -1 : 1) * deg2dy(1.));
00820
00821     /* Potential temperature gradient... */
00822     p1 = 0.85 * atm->p[ip];
00823     intpol_met_time(met0, met1, atm->time[ip], p1, atm->lon[ip],
00824                     atm->lat[ip], NULL, &t1, NULL, NULL, NULL, NULL, NULL);
00825     grad = (t1 * pow(P0 / p1, 0.286) - t * pow(P0 / atm->p[ip], 0.286))
00826       / (100. * (p1 - atm->p[ip]));
00827
00828     /* Calculate PV... */
00829     atm->q[ctl->qnt_pv][ip] = -1e6 * G0 * vort * grad;
00830   }
00831
00832   /* Calculate T_ice (Marti and Mauersberger, 1993)... */
00833   if (ctl->qnt_tice >= 0 || ctl->qnt_tsts >= 0)
00834     atm->q[ctl->qnt_tice][ip] =
00835       -2663.5 /
00836       (log10((ctl->psc_h2o > 0 ? ctl->psc_h2o : h2o) * atm->p[ip] * 100.) -
00837        12.537);
00838
00839   /* Calculate T_NAT (Hanson and Mauersberger, 1988)... */
00840   if (ctl->qnt_tnat >= 0 || ctl->qnt_tsts >= 0) {
00841     if (ctl->psc_hno3 > 0)
00842       p_hno3 = ctl->psc_hno3 * atm->p[ip] / 1.333224;
00843     else
00844       p_hno3 = module_meteo_hno3(atm->time[ip], atm->lat[ip], atm->
      p[ip])
00845         * 1e-9 * atm->p[ip] / 1.333224;
00846     p_h2o = (ctl->psc_h2o > 0 ? ctl->psc_h2o : h2o) * atm->p[ip] / 1.333224;
00847     a = 0.009179 - 0.00088 * log10(p_h2o);
00848     b = (38.9855 - log10(p_hno3) - 2.7836 * log10(p_h2o)) / a;
00849     c = -11397.0 / a;
00850     x1 = (-b + sqrt(b * b - 4. * c)) / 2.;
00851     x2 = (-b - sqrt(b * b - 4. * c)) / 2.;
00852     if (x1 > 0)
00853       atm->q[ctl->qnt_tnat][ip] = x1;
00854     if (x2 > 0)
00855       atm->q[ctl->qnt_tnat][ip] = x2;
00856   }
00857
00858   /* Calculate T_STS (mean of T_ice and T_NAT)... */
00859   if (ctl->qnt_tsts >= 0) {
00860     if (ctl->qnt_tice < 0 || ctl->qnt_tnat < 0)
00861       ERRMSG("Need T_ice and T_NAT to calculate T_STS!");
00862     atm->q[ctl->qnt_tsts][ip] = 0.5 * (atm->q[ctl->qnt_tice][ip]
00863                                        + atm->q[ctl->qnt_tnat][ip]);
00864   }
00865
00866   /* Read variance data for current day... */
00867   if (ip == 0 && ctl->qnt_gw_var >= 0) {
00868     jsec2time(atm->time[ip], &year, &mon, &day, &idum, &idum, &idum, &rdum);
00869     if (year != year_old || mon != mon_old || day != day_old) {
00870       year_old = year;
00871       mon_old = mon;
00872       day_old = day;
00873       nlon = nlat = -1;
00874       sprintf(filename, "%s_%d_%02d_%02d.tab",
00875               ctl->gw_basename, year, mon, day);
00876       if ((in = fopen(filename, "r"))) {
00877         printf("Read gravity wave data: %s\n", filename);
00878         while (fgets(line, LEN, in)) {
00879           if (sscanf(line, "%lg %lg %lg", &rlon, &rlat, &rvar) != 3)
00880             continue;
00881           if (rlat != rlat_old) {
00882             rlat_old = rlat;
00883             if ((++nlat) > GY)
```

```
00884               ERRMSG("Too many latitudes!");
00885             nlon = -1;
00886           }
00887           if ((++nlon) > GX)
00888             ERRMSG("Too many longitudes!");
00889           lon[nlon] = rlon;
00890           lat[nlat] = rlat;
00891           var[nlon][nlat] = GSL_MAX(0, rvar);
00892         }
00893         fclose(in);
00894         nlat++;
00895         nlon++;
00896       } else
00897         printf("Missing gravity wave data: %s\n", filename);
00898     }
00899   }
00900
00901   /* Interpolate variance data... */
00902   if (ctl->qnt_gw_var >= 0) {
00903     if (nlat >= 2 && nlon >= 2) {
00904       ilat = locate(lat, nlat, atm->lat[ip]);
00905       ilon = locate(lon, nlon, atm->lon[ip]);
00906       var0 = LIN(lat[ilat], var[ilon][ilat],
00907                  lat[ilat + 1], var[ilon][ilat + 1], atm->lat[ip]);
00908       var1 = LIN(lat[ilat], var[ilon + 1][ilat],
00909                  lat[ilat + 1], var[ilon + 1][ilat + 1], atm->lat[ip]);
00910       atm->q[ctl->qnt_gw_var][ip]
00911         = LIN(lon[ilon], var0, lon[ilon + 1], var1, atm->lon[ip]);
00912     } else
00913       atm->q[ctl->qnt_gw_var][ip] = GSL_NAN;
00914   }
00915 }
```

Here is the call graph for this function:



5.31.2.8 double module_meteo_hno3 (double *t*, double *lat*, double *p*)

Auxiliary function for meteo module.

Definition at line 919 of file trac.c.

```
00922             {
00923
00924   static double secs[12] = { 1209600.00, 3888000.00, 6393600.00,
00925     9072000.00, 11664000.00, 14342400.00,
00926     16934400.00, 19612800.00, 22291200.00,
00927     24883200.00, 27561600.00, 30153600.00
00928   };
00929
00930   static double lats[18] = { -85, -75, -65, -55, -45, -35, -25, -15, -5,
00931     5, 15, 25, 35, 45, 55, 65, 75, 85
```

```
00932   };
00933
00934   static double ps[10] = { 4.64159, 6.81292, 10, 14.678, 21.5443,
00935     31.6228, 46.4159, 68.1292, 100, 146.78
00936   };
00937
00938   static double hno3[12][18][10] = {
00939     {{0.782, 1.65, 2.9, 4.59, 6.71, 8.25, 7.16, 5.75, 2.9, 1.74},
00940      {0.529, 1.64, 2.76, 4.55, 6.58, 8, 6.99, 5.55, 2.68, 1.57},
00941      {0.723, 1.55, 2.73, 4.48, 6.32, 7.58, 7.05, 5.16, 2.49, 1.54},
00942      {0.801, 1.56, 2.74, 4.52, 6.23, 7.35, 6.68, 4.4, 1.97, 1.23},
00943      {0.818, 1.62, 2.77, 4.38, 5.98, 6.84, 5.83, 3.05, 1.15, 0.709},
00944      {0.901, 1.73, 2.78, 4.21, 5.63, 6.16, 4.68, 1.87, 0.617, 0.37},
00945      {0.997, 1.8, 2.79, 4.09, 4.88, 4.96, 3.12, 1.22, 0.311, 0.244},
00946      {1, 1.71, 2.51, 3.4, 3.74, 3.39, 2.25, 0.845, 0.204, 0.222},
00947      {0.997, 1.7, 2.36, 2.88, 3.01, 2.25, 1.77, 0.608, 0.163, 0.181},
00948      {0.991, 1.79, 2.57, 3.06, 3.08, 2.15, 1.81, 0.59, 0.168, 0.104},
00949      {0.974, 1.86, 2.84, 3.8, 3.93, 3.79, 2.91, 1.02, 0.152, 0.0985},
00950      {0.85, 1.86, 3.3, 5.24, 6.55, 6.86, 5.12, 1.93, 0.378, 0.185},
00951      {0.783, 1.89, 3.85, 6.6, 8.56, 8.66, 6.95, 3.95, 1.47, 0.745},
00952      {0.883, 2.05, 4.34, 7.54, 9.68, 9.77, 8.19, 5.72, 3.15, 1.77},
00953      {1.4, 2.44, 4.72, 8.07, 10.5, 10.9, 9.28, 6.95, 4.47, 2.49},
00954      {1.7, 2.43, 4.24, 7.43, 10.4, 11.2, 9.72, 8.15, 5.7, 2.97},
00955      {2.06, 2.27, 3.68, 6.77, 10.3, 10.3, 9.05, 9.1, 6.73, 3.14},
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00982      {0.992, 1.7, 2.51, 3.33, 3.62, 2.87, 2.05, 0.705, 0.161, 0.169},
00983      {0.969, 1.69, 2.2, 2.62, 2.84, 2.13, 1.78, 0.529, 0.146, 0.186},
00984      {0.945, 1.69, 2.27, 2.64, 2.83, 2.2, 1.83, 0.561, 0.139, 0.121},
00985      {0.922, 1.65, 2.48, 3.33, 3.83, 4.09, 2.92, 0.973, 0.117, 0.135},
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01001      {0.959, 1.71, 2.32, 2.77, 2.99, 2.24, 1.76, 0.519, 0.149, 0.172},
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01015      {1.32, 2.65, 4.75, 7.49, 9.32, 8.89, 7.42, 4.27, 1.7, 0.88},
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01022       {0.977, 1.68, 2.71, 4.03, 5.17, 6.01, 4.81, 1.81, 0.473, 0.343},
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01085       {0.804, 1.65, 2.79, 4.63, 6.64, 6.95, 6.68, 5.11, 3.3, 2.09},
01086       {0.86, 1.8, 3.25, 5.3, 7.91, 8.76, 8.28, 6.01, 3.39, 1.83},
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01127       {0.937, 1.74, 2.51, 3.09, 3.11, 2.34, 1.84, 0.67, 0.189, 0.121},
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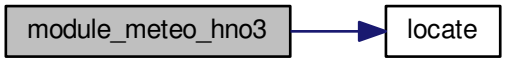
01129       {0.959, 1.8, 2.82, 3.78, 4.03, 3.37, 2.53, 1.04, 0.199, 0.146},
01130       {1.01, 1.9, 3.13, 4.76, 5.63, 5.6, 4.31, 1.83, 0.367, 0.172},
01131       {0.989, 2.04, 3.64, 6, 7.62, 7.6, 6, 3.35, 1.05, 0.448},
01132       {1.02, 2.28, 4.32, 7.19, 9.21, 9.16, 7.64, 4.97, 2.2, 0.948},
01133       {1.26, 2.77, 5.2, 8.31, 10.5, 10.4, 9.01, 6.37, 3.46, 1.56},
01134       {1.31, 2.76, 5.23, 8.49, 11.2, 11.3, 10.1, 7.27, 3.98, 1.76},
01135       {1.26, 2.5, 5.14, 8.85, 12.3, 12.3, 11.2, 8.13, 4.45, 1.97},
01136       {1.35, 2.49, 5.26, 9.16, 13, 12.8, 11.8, 8.57, 4.72, 2.05}},
01137     {{0.759, 1.54, 2.54, 4.22, 6.26, 7.44, 7.14, 4.99, 2.84, 1.89},
01138       {0.508, 1.55, 2.5, 4.29, 6.29, 7.29, 7.07, 5.03, 2.77, 1.74},
01139       {0.699, 1.56, 2.62, 4.17, 6.08, 7.38, 7.04, 5.17, 2.81, 1.65},
01140       {0.778, 1.5, 2.65, 4.35, 6.07, 7.28, 6.84, 4.8, 2.28, 1.28},
01141       {0.772, 1.55, 2.71, 4.3, 5.76, 6.91, 6.2, 3.69, 1.45, 0.837},
01142       {0.836, 1.67, 2.78, 4.21, 5.56, 6.41, 5.33, 2.47, 0.807, 0.488},
01143       {0.937, 1.79, 2.78, 4.12, 5.17, 5.38, 3.89, 1.47, 0.392, 0.256},
01144       {0.97, 1.75, 2.52, 3.39, 3.83, 3.63, 2.48, 0.968, 0.212, 0.198},
01145       {0.968, 1.74, 2.5, 3.11, 3.2, 2.34, 1.79, 0.629, 0.169, 0.173},
01146       {0.98, 1.8, 2.69, 3.42, 3.4, 2.18, 1.81, 0.606, 0.164, 0.138},
01147       {0.975, 1.84, 2.96, 4.08, 4.12, 3.5, 2.79, 1.02, 0.145, 0.133},
01148       {0.96, 1.94, 3.27, 5.17, 6.26, 6.35, 4.88, 1.91, 0.329, 0.189},
01149       {0.954, 2.06, 3.8, 6.53, 8.46, 8.32, 6.53, 3.83, 1.32, 0.6},
01150       {1, 2.34, 4.58, 7.71, 9.68, 9.75, 7.96, 5.45, 2.84, 1.39},
01151       {1.24, 2.65, 5.14, 8.51, 10.7, 10.6, 8.96, 6.51, 3.83, 1.85},
01152       {1.34, 2.44, 4.99, 8.63, 11.6, 11.4, 10.1, 7.84, 4.77, 2.24},
01153       {1.33, 2.1, 4.76, 8.78, 12.2, 11.7, 10.8, 8.68, 5.15, 2.35},
01154       {1.42, 2.04, 4.68, 8.92, 12.7, 12, 11.2, 8.99, 5.32, 2.33}}
01155   };
01156
01157   double aux00, aux01, aux10, aux11, sec;
01158
01159   int ilat, ip, isec;
01160
01161   /* Get seconds since begin of year... */
01162   sec = fmod(t, 365.25 * 86400.);
01163
01164   /* Get indices... */
01165   ilat = locate(lats, 18, lat);
01166   ip = locate(ps, 10, p);
01167   isec = locate(secs, 12, sec);
01168
01169   /* Interpolate... */
01170   aux00 = LIN(ps[ip], hno3[isec][ilat][ip],
01171               ps[ip + 1], hno3[isec][ilat][ip + 1], p);
01172   aux01 = LIN(ps[ip], hno3[isec][ilat + 1][ip],
01173               ps[ip + 1], hno3[isec][ilat + 1][ip + 1], p);
01174   aux10 = LIN(ps[ip], hno3[isec + 1][ilat][ip],
01175               ps[ip + 1], hno3[isec + 1][ilat][ip + 1], p);
01176   aux11 = LIN(ps[ip], hno3[isec + 1][ilat + 1][ip],
01177               ps[ip + 1], hno3[isec + 1][ilat + 1][ip + 1], p);
01178   aux00 = LIN(lats[ilat], aux00, lats[ilat + 1], aux01, lat);
01179   aux11 = LIN(lats[ilat], aux10, lats[ilat + 1], aux11, lat);
01180   return LIN(secs[isec], aux00, secs[isec + 1], aux11, sec);
01181 }
```

Here is the call graph for this function:



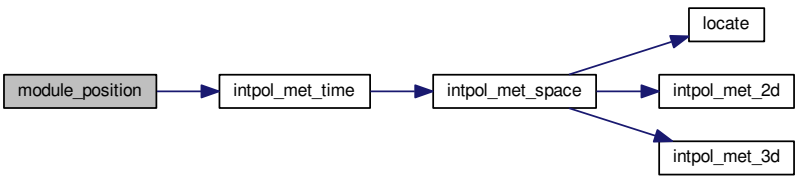
5.31.2.9 void module_position (met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*)

Check position of air parcels.

Definition at line 1185 of file trac.c.

```
01189           {
01190
01191   double ps;
01192
01193   /* Calculate modulo... */
01194   atm->lon[ip] = fmod(atm->lon[ip], 360);
01195   atm->lat[ip] = fmod(atm->lat[ip], 360);
01196
01197   /* Check latitude... */
01198   while (atm->lat[ip] < -90 || atm->lat[ip] > 90) {
01199     if (atm->lat[ip] > 90) {
01200       atm->lat[ip] = 180 - atm->lat[ip];
01201       atm->lon[ip] += 180;
01202     }
01203     if (atm->lat[ip] < -90) {
01204       atm->lat[ip] = -180 - atm->lat[ip];
01205       atm->lon[ip] += 180;
01206     }
01207   }
01208
01209   /* Check longitude... */
01210   while (atm->lon[ip] < -180)
01211     atm->lon[ip] += 360;
01212   while (atm->lon[ip] >= 180)
01213     atm->lon[ip] -= 360;
01214
01215   /* Get surface pressure... */
01216   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
01217                   atm->lon[ip], atm->lat[ip], &ps, NULL,
01218                   NULL, NULL, NULL, NULL, NULL);
01219
01220   /* Check pressure... */
01221   if (atm->p[ip] > ps)
01222     atm->p[ip] = ps;
01223   else if (atm->p[ip] < met0->p[met0->np - 1])
01224     atm->p[ip] = met0->p[met0->np - 1];
01225 }
```

Here is the call graph for this function:



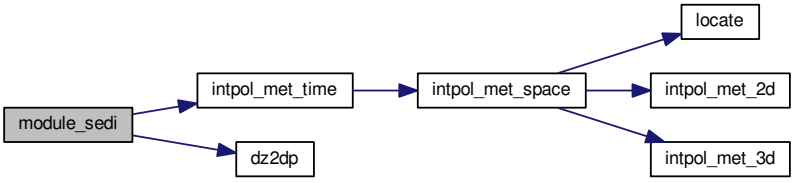
5.31.2.10 void module_sedi (ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt*)

Calculate sedimentation of air parcels.

Definition at line 1229 of file trac.c.

```
01235             {
01236
01237   /* Coefficients for Cunningham slip-flow correction (Kasten, 1968): */
01238   const double A = 1.249, B = 0.42, C = 0.87;
01239
01240   /* Specific gas constant for dry air [J/(kg K)]: */
01241   const double R = 287.058;
01242
01243   /* Average mass of an air molecule [kg/molec]: */
01244   const double m = 4.8096e-26;
01245
01246   double G, K, eta, lambda, p, r_p, rho, rho_p, T, v, v_p;
01247
01248   /* Check if parameters are available... */
01249   if (ctl->qnt_r < 0 || ctl->qnt_rho < 0)
01250     return;
01251
01252   /* Convert units... */
01253   p = 100 * atm->p[ip];
01254   r_p = 1e-6 * atm->q[ctl->qnt_r][ip];
01255   rho_p = atm->q[ctl->qnt_rho][ip];
01256
01257   /* Get temperature... */
01258   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
01259                   atm->lat[ip], NULL, &T, NULL, NULL, NULL, NULL, NULL);
01260
01261   /* Density of dry air... */
01262   rho = p / (R * T);
01263
01264   /* Dynamic viscosity of air... */
01265   eta = 1.8325e-5 * (416.16 / (T + 120.)) * pow(T / 296.16, 1.5);
01266
01267   /* Thermal velocity of an air molecule... */
01268   v = sqrt(8 * GSL_CONST_MKSA_BOLTZMANN * T / (M_PI * m));
01269
01270   /* Mean free path of an air molecule... */
01271   lambda = 2 * eta / (rho * v);
01272
01273   /* Knudsen number for air... */
01274   K = lambda / r_p;
01275
01276   /* Cunningham slip-flow correction... */
01277   G = 1 + K * (A + B * exp(-C / K));
01278
01279   /* Sedimentation (fall) velocity... */
01280   v_p =
01281     2. * gsl_pow_2(r_p) * (rho_p -
01282                            rho) * GSL_CONST_MKSA_GRAV_ACCEL / (9. * eta) * G;
01283
01284   /* Calculate pressure change... */
01285   atm->p[ip] += dz2dp(v_p * dt / 1000., atm->p[ip]);
01286 }
```

Here is the call graph for this function:



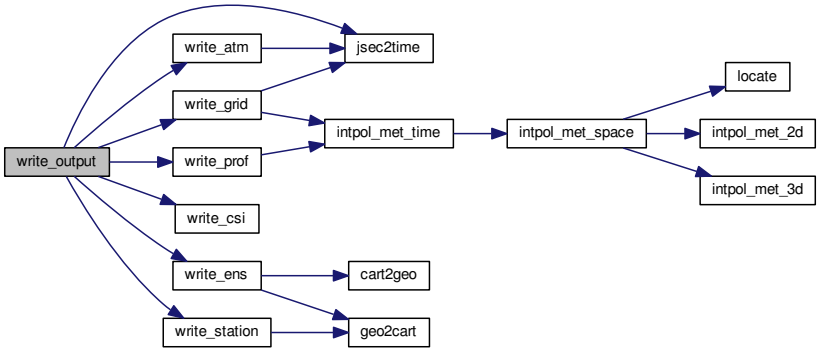
5.31.2.11 void write_output (const char * *dirname*, ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, double *t*)

Write simulation output.

Definition at line 1290 of file trac.c.

```
01296             {
01297
01298   char filename[LEN];
01299
01300   double r;
01301
01302   int year, mon, day, hour, min, sec;
01303
01304   /* Get time... */
01305   jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01306
01307   /* Write atmospheric data... */
01308   if (ctl->atm_basename[0] != '-' && fmod(t, ctl->atm_dt_out) == 0) {
01309     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
01310             dirname, ctl->atm_basename, year, mon, day, hour, min);
01311     write_atm(filename, ctl, atm, t);
01312   }
01313
01314   /* Write CSI data... */
01315   if (ctl->csi_basename[0] != '-') {
01316     sprintf(filename, "%s/%s.tab", dirname, ctl->csi_basename);
01317     write_csi(filename, ctl, atm, t);
01318   }
01319
01320   /* Write ensemble data... */
01321   if (ctl->ens_basename[0] != '-') {
01322     sprintf(filename, "%s/%s.tab", dirname, ctl->ens_basename);
01323     write_ens(filename, ctl, atm, t);
01324   }
01325
01326   /* Write gridded data... */
01327   if (ctl->grid_basename[0] != '-' && fmod(t, ctl->grid_dt_out) == 0) {
01328     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
01329             dirname, ctl->grid_basename, year, mon, day, hour, min);
01330     write_grid(filename, ctl, met0, met1, atm, t);
01331   }
01332
01333   /* Write profile data... */
01334   if (ctl->prof_basename[0] != '-') {
01335     sprintf(filename, "%s/%s.tab", dirname, ctl->prof_basename);
01336     write_prof(filename, ctl, met0, met1, atm, t);
01337   }
01338
01339   /* Write station data... */
01340   if (ctl->stat_basename[0] != '-') {
01341     sprintf(filename, "%s/%s.tab", dirname, ctl->stat_basename);
01342     write_station(filename, ctl, atm, t);
01343   }
01344 }
```

Here is the call graph for this function:



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

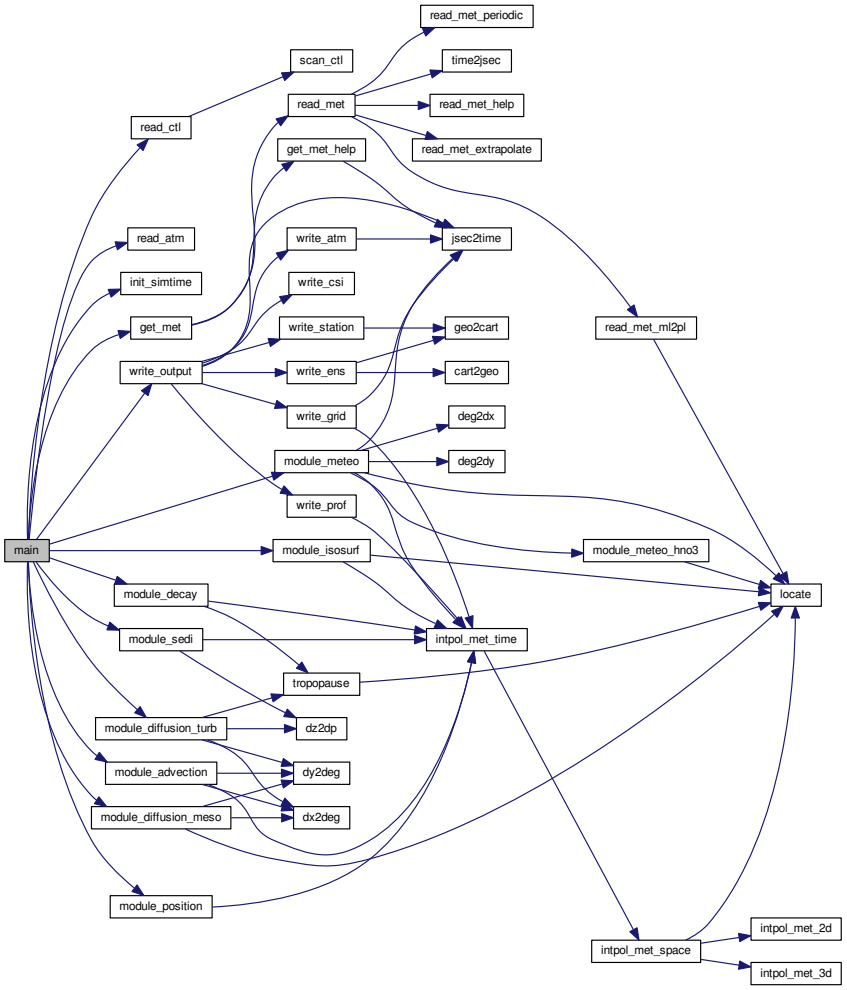
Definition at line 126 of file trac.c.

```
00128                {
00129
00130   ctl_t ctl;
00131
00132   atm_t *atm;
00133
00134   met_t *met0, *met1;
00135
00136   gsl_rng *rng[NTHREADS];
00137
00138   FILE *dirlist;
00139
00140   char dirname[LEN], filename[LEN];
00141
00142   double *dt, t, t0;
00143
00144   int i, ip, ntask = 0, rank = 0, size = 1;
00145
00146 #ifdef MPI
00147   /* Initialize MPI... */
00148   MPI_Init(&argc, &argv);
00149   MPI_Comm_rank(MPI_COMM_WORLD, &rank);
00150   MPI_Comm_size(MPI_COMM_WORLD, &size);
00151 #endif
00152
00153   /* Check arguments... */
00154   if (argc < 5)
00155     ERRMSG("Give parameters: <dirlist> <ctl> <atm_in> <metbase>");
00156
00157   /* Open directory list... */
00158   if (!(dirlist = fopen(argv[1], "r")))
00159     ERRMSG("Cannot open directory list!");
00160
00161   /* Loop over directories... */
00162   while (fscanf(dirlist, "%s", dirname) != EOF) {
00163
00164     /* MPI parallelization... */
00165     if ((++ntask) % size != rank)
00166       continue;
00167
00168     /* ------------------------------------------------------------
00169        Initialize model run...
00170        ------------------------------------------------------------ */
00171
00172     /* Set timers... */
00173     START_TIMER(TIMER_TOTAL);
00174     START_TIMER(TIMER_INIT);
00175
00176     /* Allocate... */
00177     ALLOC(atm, atm_t, 1);
00178     ALLOC(met0, met_t, 1);
00179     ALLOC(met1, met_t, 1);
00180     ALLOC(dt, double,
00181           NP);
00182
00183     /* Read control parameters... */
00184     sprintf(filename, "%s/%s", dirname, argv[2]);
00185     read_ctl(filename, argc, argv, &ctl);
00186
00187     /* Initialize random number generators... */
00188     gsl_rng_env_setup();
00189     if (omp_get_max_threads() > NTHREADS)
00190       ERRMSG("Too many threads!");
00191     for (i = 0; i < NTHREADS; i++)
00192       rng[i] = gsl_rng_alloc(gsl_rng_default);
00193
00194     /* Read atmospheric data... */
00195     sprintf(filename, "%s/%s", dirname, argv[3]);
00196     read_atm(filename, &ctl, atm);
00197
00198     /* Get simulation time interval... */
00199     init_simtime(&ctl, atm);
00200
00201     /* Get rounded start time... */
00202     if (ctl.direction == 1)
00203       t0 = floor(ctl.t_start / ctl.dt_mod) * ctl.dt_mod;
00204     else
00205       t0 = ceil(ctl.t_start / ctl.dt_mod) * ctl.dt_mod;
00206
00207     /* Set timers... */
```

```
00208     STOP_TIMER(TIMER_INIT);
00209
00210     /* ------------------------------------------------------------
00211        Loop over timesteps...
00212        ------------------------------------------------------------ */
00213
00214     /* Loop over timesteps... */
00215     for (t = t0; ctl.direction * (t - ctl.t_stop) < ctl.dt_mod;
00216          t += ctl.direction * ctl.dt_mod) {
00217
00218       /* Adjust length of final time step... */
00219       if (ctl.direction * (t - ctl.t_stop) > 0)
00220         t = ctl.t_stop;
00221
00222       /* Set time steps for air parcels... */
00223       for (ip = 0; ip < atm->np; ip++)
00224         if ((ctl.direction * (atm->time[ip] - ctl.t_start) >= 0
00225              && ctl.direction * (atm->time[ip] - ctl.t_stop) <= 0
00226              && ctl.direction * (atm->time[ip] - t) < 0))
00227           dt[ip] = t - atm->time[ip];
00228         else
00229           dt[ip] = GSL_NAN;
00230
00231       /* Get meteorological data... */
00232       START_TIMER(TIMER_INPUT);
00233       get_met(&ctl, argv[4], t, met0, met1);
00234       if (ctl.dt_mod > fabs(met0->lon[1] - met0->lon[1]) * 111132. / 150.
00235           || ctl.dt_mod > fabs(met1->lon[1] - met1->lon[1]) * 111132. / 150.)
00236         printf("Warning: Time step DT_MOD violates the CFL criterion!\n");
00237       STOP_TIMER(TIMER_INPUT);
00238
00239       /* Initialize isosurface... */
00240       START_TIMER(TIMER_ISOSURF);
00241       if (t == t0)
00242         module_isosurf(&ctl, met0, met1, atm, -1);
00243       STOP_TIMER(TIMER_ISOSURF);
00244
00245       /* Advection... */
00246       START_TIMER(TIMER_ADVECT);
00247 #pragma omp parallel for default(shared) private(ip)
00248       for (ip = 0; ip < atm->np; ip++)
00249         if (gsl_finite(dt[ip]))
00250           module_advection(met0, met1, atm, ip, dt[ip]);
00251       STOP_TIMER(TIMER_ADVECT);
00252
00253       /* Turbulent diffusion... */
00254       START_TIMER(TIMER_DIFFTURB);
00255 #pragma omp parallel for default(shared) private(ip)
00256       for (ip = 0; ip < atm->np; ip++)
00257         if (gsl_finite(dt[ip]))
00258           module_diffusion_turb(&ctl, atm, ip, dt[ip],
00259                                 rng[omp_get_thread_num()]);
00260       STOP_TIMER(TIMER_DIFFTURB);
00261
00262       /* Mesoscale diffusion... */
00263       START_TIMER(TIMER_DIFFMESO);
00264 #pragma omp parallel for default(shared) private(ip)
00265       for (ip = 0; ip < atm->np; ip++)
00266         if (gsl_finite(dt[ip]))
00267           module_diffusion_meso(&ctl, met0, met1, atm, ip, dt[ip],
00268                                 rng[omp_get_thread_num()]);
00269       STOP_TIMER(TIMER_DIFFMESO);
00270
00271       /* Sedimentation... */
00272       START_TIMER(TIMER_SEDI);
00273 #pragma omp parallel for default(shared) private(ip)
00274       for (ip = 0; ip < atm->np; ip++)
00275         if (gsl_finite(dt[ip]))
00276           module_sedi(&ctl, met0, met1, atm, ip, dt[ip]);
00277       STOP_TIMER(TIMER_SEDI);
00278
00279       /* Isosurface... */
00280       START_TIMER(TIMER_ISOSURF);
00281 #pragma omp parallel for default(shared) private(ip)
00282       for (ip = 0; ip < atm->np; ip++)
00283         module_isosurf(&ctl, met0, met1, atm, ip);
00284       STOP_TIMER(TIMER_ISOSURF);
00285
00286       /* Position... */
00287       START_TIMER(TIMER_POSITION);
00288 #pragma omp parallel for default(shared) private(ip)
00289       for (ip = 0; ip < atm->np; ip++)
00290         module_position(met0, met1, atm, ip);
00291       STOP_TIMER(TIMER_POSITION);
00292
00293       /* Meteorological data... */
00294       START_TIMER(TIMER_METEO);
```

```
00295       module_meteo(&ctl, met0, met1, atm, 0);
00296 #pragma omp parallel for default(shared) private(ip)
00297       for (ip = 1; ip < atm->np; ip++)
00298         module_meteo(&ctl, met0, met1, atm, ip);
00299       STOP_TIMER(TIMER_METEO);
00300
00301       /* Decay... */
00302       START_TIMER(TIMER_DECAY);
00303 #pragma omp parallel for default(shared) private(ip)
00304       for (ip = 0; ip < atm->np; ip++)
00305         if (gsl_finite(dt[ip]))
00306           module_decay(&ctl, met0, met1, atm, ip, dt[ip]);
00307       STOP_TIMER(TIMER_DECAY);
00308
00309       /* Write output... */
00310       START_TIMER(TIMER_OUTPUT);
00311       write_output(dirname, &ctl, met0, met1, atm, t);
00312       STOP_TIMER(TIMER_OUTPUT);
00313     }
00314
00315     /* ------------------------------------------------------------
00316        Finalize model run...
00317        ------------------------------------------------------------ */
00318
00319     /* Report timers... */
00320     STOP_TIMER(TIMER_TOTAL);
00321     PRINT_TIMER(TIMER_TOTAL);
00322     PRINT_TIMER(TIMER_INIT);
00323     PRINT_TIMER(TIMER_STAGE);
00324     PRINT_TIMER(TIMER_INPUT);
00325     PRINT_TIMER(TIMER_OUTPUT);
00326     PRINT_TIMER(TIMER_ADVECT);
00327     PRINT_TIMER(TIMER_DECAY);
00328     PRINT_TIMER(TIMER_DIFFMESO);
00329     PRINT_TIMER(TIMER_DIFFTURB);
00330     PRINT_TIMER(TIMER_ISOSURF);
00331     PRINT_TIMER(TIMER_METEO);
00332     PRINT_TIMER(TIMER_POSITION);
00333     PRINT_TIMER(TIMER_SEDI);
00334
00335     /* Report memory usage... */
00336     printf("MEMORY_ATM = %g MByte\n", 2. * sizeof(atm_t) / 1024. / 1024.);
00337     printf("MEMORY_METEO = %g MByte\n", 2. * sizeof(met_t) / 1024. / 1024.);
00338     printf("MEMORY_DYNAMIC = %g MByte\n",
00339            NP * sizeof(double) / 1024. / 1024.);
00340     printf("MEMORY_STATIC = %g MByte\n",
00341            (((EX + EY) + (2 + NQ) * GX * GY * GZ) * sizeof(double)
00342             + (EX * EY + EX * EY * EP) * sizeof(float)
00343             + (2 * GX * GY * GZ) * sizeof(int)) / 1024. / 1024.);
00344
00345     /* Report problem size... */
00346     printf("SIZE_NP = %d\n", atm->np);
00347     printf("SIZE_TASKS = %d\n", size);
00348     printf("SIZE_THREADS = %d\n", omp_get_max_threads());
00349
00350     /* Free random number generators... */
00351     for (i = 0; i < NTHREADS; i++)
00352       gsl_rng_free(rng[i]);
00353
00354     /* Free... */
00355     free(atm);
00356     free(met0);
00357     free(met1);
00358     free(dt);
00359   }
00360
00361 #ifdef MPI
00362   /* Finalize MPI... */
00363   MPI_Finalize();
00364 #endif
00365
00366   return EXIT_SUCCESS;
00367 }
```

Here is the call graph for this function:



5.32 trac.c

```
00001 /*
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00003
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00017   Copyright (C) 2013-2015 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 init_simtime(
00037   ctl_t * ctl,
00038   atm_t * atm);
00039
00041 void module_advection(
00042   met_t * met0,
00043   met_t * met1,
00044   atm_t * atm,
00045   int ip,
00046   double dt);
00047
00049 void module_decay(
00050   ctl_t * ctl,
00051   met_t * met0,
00052   met_t * met1,
00053   atm_t * atm,
00054   int ip,
00055   double dt);
00056
00058 void module_diffusion_meso(
00059   ctl_t * ctl,
00060   met_t * met0,
00061   met_t * met1,
00062   atm_t * atm,
00063   int ip,
00064   double dt,
00065   gsl_rng * rng);
00066
00068 void module_diffusion_turb(
00069   ctl_t * ctl,
00070   atm_t * atm,
00071   int ip,
00072   double dt,
00073   gsl_rng * rng);
00074
00076 void module_isosurf(
00077   ctl_t * ctl,
00078   met_t * met0,
00079   met_t * met1,
00080   atm_t * atm,
00081   int ip);
00082
00084 void module_meteo(
00085   ctl_t * ctl,
00086   met_t * met0,
00087   met_t * met1,
00088   atm_t * atm,
00089   int ip);
00090
00092 double module_meteo_hno3(
00093   double t,
00094   double lat,
00095   double p);
00096
00098 void module_position(
00099   met_t * met0,
00100   met_t * met1,
00101   atm_t * atm,
00102   int ip);
00103
00105 void module_sedi(
00106   ctl_t * ctl,
00107   met_t * met0,
00108   met_t * met1,
00109   atm_t * atm,
00110   int ip,
00111   double dt);
00112
00114 void write_output(
00115   const char *dirname,
00116   ctl_t * ctl,
00117   met_t * met0,
00118   met_t * met1,
00119   atm_t * atm,
00120   double t);
00121
00122 /* ------------------------------------------------------------
00123    Main...
00124    ------------------------------------------------------------ */
00125
00126 int main(
00127   int argc,
00128   char *argv[]) {
```

```
00129
00130   ctl_t ctl;
00131
00132   atm_t *atm;
00133
00134   met_t *met0, *met1;
00135
00136   gsl_rng *rng[NTHREADS];
00137
00138   FILE *dirlist;
00139
00140   char dirname[LEN], filename[LEN];
00141
00142   double *dt, t, t0;
00143
00144   int i, ip, ntask = 0, rank = 0, size = 1;
00145
00146 #ifdef MPI
00147   /* Initialize MPI... */
00148   MPI_Init(&argc, &argv);
00149   MPI_Comm_rank(MPI_COMM_WORLD, &rank);
00150   MPI_Comm_size(MPI_COMM_WORLD, &size);
00151 #endif
00152
00153   /* Check arguments... */
00154   if (argc < 5)
00155     ERRMSG("Give parameters: <dirlist> <ctl> <atm_in> <metbase>");
00156
00157   /* Open directory list... */
00158   if (!(dirlist = fopen(argv[1], "r")))
00159     ERRMSG("Cannot open directory list!");
00160
00161   /* Loop over directories... */
00162   while (fscanf(dirlist, "%s", dirname) != EOF) {
00163
00164     /* MPI parallelization... */
00165     if ((++ntask) % size != rank)
00166       continue;
00167
00168     /* ------------------------------------------------------------
00169        Initialize model run...
00170        ------------------------------------------------------------ */
00171
00172     /* Set timers... */
00173     START_TIMER(TIMER_TOTAL);
00174     START_TIMER(TIMER_INIT);
00175
00176     /* Allocate... */
00177     ALLOC(atm, atm_t, 1);
00178     ALLOC(met0, met_t, 1);
00179     ALLOC(met1, met_t, 1);
00180     ALLOC(dt, double,
00181           NP);
00182
00183     /* Read control parameters... */
00184     sprintf(filename, "%s/%s", dirname, argv[2]);
00185     read_ctl(filename, argc, argv, &ctl);
00186
00187     /* Initialize random number generators... */
00188     gsl_rng_env_setup();
00189     if (omp_get_max_threads() > NTHREADS)
00190       ERRMSG("Too many threads!");
00191     for (i = 0; i < NTHREADS; i++)
00192       rng[i] = gsl_rng_alloc(gsl_rng_default);
00193
00194     /* Read atmospheric data... */
00195     sprintf(filename, "%s/%s", dirname, argv[3]);
00196     read_atm(filename, &ctl, atm);
00197
00198     /* Get simulation time interval... */
00199     init_simtime(&ctl, atm);
00200
00201     /* Get rounded start time... */
00202     if (ctl.direction == 1)
00203       t0 = floor(ctl.t_start / ctl.dt_mod) * ctl.dt_mod;
00204     else
00205       t0 = ceil(ctl.t_start / ctl.dt_mod) * ctl.dt_mod;
00206
00207     /* Set timers... */
00208     STOP_TIMER(TIMER_INIT);
00209
00210     /* ------------------------------------------------------------
00211        Loop over timesteps...
00212        ------------------------------------------------------------ */
00213
00214     /* Loop over timesteps... */
00215     for (t = t0; ctl.direction * (t - ctl.t_stop) < ctl.dt_mod;
```

```
00216          t += ctl.direction * ctl.dt_mod) {
00217
00218       /* Adjust length of final time step... */
00219       if (ctl.direction * (t - ctl.t_stop) > 0)
00220         t = ctl.t_stop;
00221
00222       /* Set time steps for air parcels... */
00223       for (ip = 0; ip < atm->np; ip++)
00224         if ((ctl.direction * (atm->time[ip] - ctl.t_start) >= 0
00225              && ctl.direction * (atm->time[ip] - ctl.t_stop) <= 0
00226              && ctl.direction * (atm->time[ip] - t) < 0))
00227           dt[ip] = t - atm->time[ip];
00228         else
00229           dt[ip] = GSL_NAN;
00230
00231       /* Get meteorological data... */
00232       START_TIMER(TIMER_INPUT);
00233       get_met(&ctl, argv[4], t, met0, met1);
00234       if (ctl.dt_mod > fabs(met0->lon[1] - met0->lon[1]) * 111132. / 150.
00235           || ctl.dt_mod > fabs(met1->lon[1] - met1->lon[1]) * 111132. / 150.)
00236         printf("Warning: Time step DT_MOD violates the CFL criterion!\n");
00237       STOP_TIMER(TIMER_INPUT);
00238
00239       /* Initialize isosurface... */
00240       START_TIMER(TIMER_ISOSURF);
00241       if (t == t0)
00242         module_isosurf(&ctl, met0, met1, atm, -1);
00243       STOP_TIMER(TIMER_ISOSURF);
00244
00245       /* Advection... */
00246       START_TIMER(TIMER_ADVECT);
00247 #pragma omp parallel for default(shared) private(ip)
00248       for (ip = 0; ip < atm->np; ip++)
00249         if (gsl_finite(dt[ip]))
00250           module_advection(met0, met1, atm, ip, dt[ip]);
00251       STOP_TIMER(TIMER_ADVECT);
00252
00253       /* Turbulent diffusion... */
00254       START_TIMER(TIMER_DIFFTURB);
00255 #pragma omp parallel for default(shared) private(ip)
00256       for (ip = 0; ip < atm->np; ip++)
00257         if (gsl_finite(dt[ip]))
00258           module_diffusion_turb(&ctl, atm, ip, dt[ip],
00259                                 rng[omp_get_thread_num()]);
00260       STOP_TIMER(TIMER_DIFFTURB);
00261
00262       /* Mesoscale diffusion... */
00263       START_TIMER(TIMER_DIFFMESO);
00264 #pragma omp parallel for default(shared) private(ip)
00265       for (ip = 0; ip < atm->np; ip++)
00266         if (gsl_finite(dt[ip]))
00267           module_diffusion_meso(&ctl, met0, met1, atm, ip, dt[ip],
00268                                 rng[omp_get_thread_num()]);
00269       STOP_TIMER(TIMER_DIFFMESO);
00270
00271       /* Sedimentation... */
00272       START_TIMER(TIMER_SEDI);
00273 #pragma omp parallel for default(shared) private(ip)
00274       for (ip = 0; ip < atm->np; ip++)
00275         if (gsl_finite(dt[ip]))
00276           module_sedi(&ctl, met0, met1, atm, ip, dt[ip]);
00277       STOP_TIMER(TIMER_SEDI);
00278
00279       /* Isosurface... */
00280       START_TIMER(TIMER_ISOSURF);
00281 #pragma omp parallel for default(shared) private(ip)
00282       for (ip = 0; ip < atm->np; ip++)
00283         module_isosurf(&ctl, met0, met1, atm, ip);
00284       STOP_TIMER(TIMER_ISOSURF);
00285
00286       /* Position... */
00287       START_TIMER(TIMER_POSITION);
00288 #pragma omp parallel for default(shared) private(ip)
00289       for (ip = 0; ip < atm->np; ip++)
00290         module_position(met0, met1, atm, ip);
00291       STOP_TIMER(TIMER_POSITION);
00292
00293       /* Meteorological data... */
00294       START_TIMER(TIMER_METEO);
00295       module_meteo(&ctl, met0, met1, atm, 0);
00296 #pragma omp parallel for default(shared) private(ip)
00297       for (ip = 1; ip < atm->np; ip++)
00298         module_meteo(&ctl, met0, met1, atm, ip);
00299       STOP_TIMER(TIMER_METEO);
00300
00301       /* Decay... */
00302       START_TIMER(TIMER_DECAY);
```

```
00303 #pragma omp parallel for default(shared) private(ip)
00304       for (ip = 0; ip < atm->np; ip++)
00305         if (gsl_finite(dt[ip]))
00306           module_decay(&ctl, met0, met1, atm, ip, dt[ip]);
00307       STOP_TIMER(TIMER_DECAY);
00308
00309       /* Write output... */
00310       START_TIMER(TIMER_OUTPUT);
00311       write_output(dirname, &ctl, met0, met1, atm, t);
00312       STOP_TIMER(TIMER_OUTPUT);
00313     }
00314
00315     /* ------------------------------------------------------------
00316        Finalize model run...
00317        ------------------------------------------------------------ */
00318
00319     /* Report timers... */
00320     STOP_TIMER(TIMER_TOTAL);
00321     PRINT_TIMER(TIMER_TOTAL);
00322     PRINT_TIMER(TIMER_INIT);
00323     PRINT_TIMER(TIMER_STAGE);
00324     PRINT_TIMER(TIMER_INPUT);
00325     PRINT_TIMER(TIMER_OUTPUT);
00326     PRINT_TIMER(TIMER_ADVECT);
00327     PRINT_TIMER(TIMER_DECAY);
00328     PRINT_TIMER(TIMER_DIFFMESO);
00329     PRINT_TIMER(TIMER_DIFFTURB);
00330     PRINT_TIMER(TIMER_ISOSURF);
00331     PRINT_TIMER(TIMER_METEO);
00332     PRINT_TIMER(TIMER_POSITION);
00333     PRINT_TIMER(TIMER_SEDI);
00334
00335     /* Report memory usage... */
00336     printf("MEMORY_ATM = %g MByte\n", 2. * sizeof(atm_t) / 1024. / 1024.);
00337     printf("MEMORY_METEO = %g MByte\n", 2. * sizeof(met_t) / 1024. / 1024.);
00338     printf("MEMORY_DYNAMIC = %g MByte\n",
00339            NP * sizeof(double) / 1024. / 1024.);
00340     printf("MEMORY_STATIC = %g MByte\n",
00341            (((EX + EY) + (2 + NQ) * GX * GY * GZ) * sizeof(double)
00342             + (EX * EY + EX * EY * EP) * sizeof(float)
00343             + (2 * GX * GY * GZ) * sizeof(int)) / 1024. / 1024.);
00344
00345     /* Report problem size... */
00346     printf("SIZE_NP = %d\n", atm->np);
00347     printf("SIZE_TASKS = %d\n", size);
00348     printf("SIZE_THREADS = %d\n", omp_get_max_threads());
00349
00350     /* Free random number generators... */
00351     for (i = 0; i < NTHREADS; i++)
00352       gsl_rng_free(rng[i]);
00353
00354     /* Free... */
00355     free(atm);
00356     free(met0);
00357     free(met1);
00358     free(dt);
00359   }
00360
00361 #ifdef MPI
00362   /* Finalize MPI... */
00363   MPI_Finalize();
00364 #endif
00365
00366   return EXIT_SUCCESS;
00367 }
00368
00369 /*****************************************************************************/
00370
00371 void init_simtime(
00372   ctl_t * ctl,
00373   atm_t * atm) {
00374
00375   /* Set inital and final time... */
00376   if (ctl->direction == 1) {
00377     if (ctl->t_start < -1e99)
00378       ctl->t_start = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00379     if (ctl->t_stop < -1e99)
00380       ctl->t_stop = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00381   } else if (ctl->direction == -1) {
00382     if (ctl->t_stop < -1e99)
00383       ctl->t_stop = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00384     if (ctl->t_start < -1e99)
00385       ctl->t_start = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00386   }
00387
00388   /* Check time... */
00389   if (ctl->direction * (ctl->t_stop - ctl->t_start) <= 0)
```

```
00390     ERRMSG("Nothing to do!");
00391 }
00392
00393 /*****************************************************************************/
00394
00395 void module_advection(
00396   met_t * met0,
00397   met_t * met1,
00398   atm_t * atm,
00399   int ip,
00400   double dt) {
00401
00402   double v[3], xm[3];
00403
00404   /* Interpolate meteorological data... */
00405   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00406                   atm->lon[ip], atm->lat[ip], NULL, NULL,
00407                   &v[0], &v[1], &v[2], NULL, NULL);
00408
00409   /* Get position of the mid point... */
00410   xm[0] = atm->lon[ip] + dx2deg(0.5 * dt * v[0] / 1000., atm->lat[ip]);
00411   xm[1] = atm->lat[ip] + dy2deg(0.5 * dt * v[1] / 1000.);
00412   xm[2] = atm->p[ip] + 0.5 * dt * v[2];
00413
00414   /* Interpolate meteorological data for mid point... */
00415   intpol_met_time(met0, met1, atm->time[ip] + 0.5 * dt,
00416                   xm[2], xm[0], xm[1], NULL, NULL,
00417                   &v[0], &v[1], &v[2], NULL, NULL);
00418
00419   /* Save new position... */
00420   atm->time[ip] += dt;
00421   atm->lon[ip] += dx2deg(dt * v[0] / 1000., xm[1]);
00422   atm->lat[ip] += dy2deg(dt * v[1] / 1000.);
00423   atm->p[ip] += dt * v[2];
00424 }
00425
00426 /*****************************************************************************/
00427
00428 void module_decay(
00429   ctl_t * ctl,
00430   met_t * met0,
00431   met_t * met1,
00432   atm_t * atm,
00433   int ip,
00434   double dt) {
00435
00436   double ps, pt, tdec;
00437
00438   /* Check lifetime values... */
00439   if ((ctl->tdec_trop <= 0 && ctl->tdec_strat <= 0) || ctl->
      qnt_m < 0)
00440     return;
00441
00442   /* Set constant lifetime... */
00443   if (ctl->tdec_trop == ctl->tdec_strat)
00444     tdec = ctl->tdec_trop;
00445
00446   /* Set altitude-dependent lifetime... */
00447   else {
00448
00449     /* Get surface pressure... */
00450     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00451                     atm->lon[ip], atm->lat[ip], &ps, NULL,
00452                     NULL, NULL, NULL, NULL, NULL);
00453
00454     /* Get tropopause pressure... */
00455     pt = tropopause(atm->time[ip], atm->lat[ip]);
00456
00457     /* Set lifetime... */
00458     if (atm->p[ip] <= pt)
00459       tdec = ctl->tdec_strat;
00460     else
00461       tdec = LIN(ps, ctl->tdec_trop, pt, ctl->tdec_strat, atm->
      p[ip]);
00462   }
00463
00464   /* Calculate exponential decay... */
00465   atm->q[ctl->qnt_m][ip] *= exp(-dt / tdec);
00466 }
00467
00468 /*****************************************************************************/
00469
00470 void module_diffusion_meso(
00471   ctl_t * ctl,
00472   met_t * met0,
00473   met_t * met1,
00474   atm_t * atm,
```

```
00475   int ip,
00476   double dt,
00477   gsl_rng * rng) {
00478
00479   double r, rs, u[16], v[16], w[16], usig, vsig, wsig;
00480
00481   int ix, iy, iz;
00482
00483   /* Calculate mesoscale velocity fluctuations... */
00484   if (ctl->turb_meso > 0) {
00485
00486     /* Get indices... */
00487     ix = locate(met0->lon, met0->nx, atm->lon[ip]);
00488     iy = locate(met0->lat, met0->ny, atm->lat[ip]);
00489     iz = locate(met0->p, met0->np, atm->p[ip]);
00490
00491     /* Collect local wind data... */
00492     u[0] = met0->u[ix][iy][iz];
00493     u[1] = met0->u[ix + 1][iy][iz];
00494     u[2] = met0->u[ix][iy + 1][iz];
00495     u[3] = met0->u[ix + 1][iy + 1][iz];
00496     u[4] = met0->u[ix][iy][iz + 1];
00497     u[5] = met0->u[ix + 1][iy][iz + 1];
00498     u[6] = met0->u[ix][iy + 1][iz + 1];
00499     u[7] = met0->u[ix + 1][iy + 1][iz + 1];
00500
00501     v[0] = met0->v[ix][iy][iz];
00502     v[1] = met0->v[ix + 1][iy][iz];
00503     v[2] = met0->v[ix][iy + 1][iz];
00504     v[3] = met0->v[ix + 1][iy + 1][iz];
00505     v[4] = met0->v[ix][iy][iz + 1];
00506     v[5] = met0->v[ix + 1][iy][iz + 1];
00507     v[6] = met0->v[ix][iy + 1][iz + 1];
00508     v[7] = met0->v[ix + 1][iy + 1][iz + 1];
00509
00510     w[0] = met0->w[ix][iy][iz];
00511     w[1] = met0->w[ix + 1][iy][iz];
00512     w[2] = met0->w[ix][iy + 1][iz];
00513     w[3] = met0->w[ix + 1][iy + 1][iz];
00514     w[4] = met0->w[ix][iy][iz + 1];
00515     w[5] = met0->w[ix + 1][iy][iz + 1];
00516     w[6] = met0->w[ix][iy + 1][iz + 1];
00517     w[7] = met0->w[ix + 1][iy + 1][iz + 1];
00518
00519     /* Get indices... */
00520     ix = locate(met1->lon, met1->nx, atm->lon[ip]);
00521     iy = locate(met1->lat, met1->ny, atm->lat[ip]);
00522     iz = locate(met1->p, met1->np, atm->p[ip]);
00523
00524     /* Collect local wind data... */
00525     u[8] = met1->u[ix][iy][iz];
00526     u[9] = met1->u[ix + 1][iy][iz];
00527     u[10] = met1->u[ix][iy + 1][iz];
00528     u[11] = met1->u[ix + 1][iy + 1][iz];
00529     u[12] = met1->u[ix][iy][iz + 1];
00530     u[13] = met1->u[ix + 1][iy][iz + 1];
00531     u[14] = met1->u[ix][iy + 1][iz + 1];
00532     u[15] = met1->u[ix + 1][iy + 1][iz + 1];
00533
00534     v[8] = met1->v[ix][iy][iz];
00535     v[9] = met1->v[ix + 1][iy][iz];
00536     v[10] = met1->v[ix][iy + 1][iz];
00537     v[11] = met1->v[ix + 1][iy + 1][iz];
00538     v[12] = met1->v[ix][iy][iz + 1];
00539     v[13] = met1->v[ix + 1][iy][iz + 1];
00540     v[14] = met1->v[ix][iy + 1][iz + 1];
00541     v[15] = met1->v[ix + 1][iy + 1][iz + 1];
00542
00543     w[8] = met1->w[ix][iy][iz];
00544     w[9] = met1->w[ix + 1][iy][iz];
00545     w[10] = met1->w[ix][iy + 1][iz];
00546     w[11] = met1->w[ix + 1][iy + 1][iz];
00547     w[12] = met1->w[ix][iy][iz + 1];
00548     w[13] = met1->w[ix + 1][iy][iz + 1];
00549     w[14] = met1->w[ix][iy + 1][iz + 1];
00550     w[15] = met1->w[ix + 1][iy + 1][iz + 1];
00551
00552     /* Get standard deviations of local wind data... */
00553     usig = gsl_stats_sd(u, 1, 16);
00554     vsig = gsl_stats_sd(v, 1, 16);
00555     wsig = gsl_stats_sd(w, 1, 16);
00556
00557     /* Set temporal correlations for mesoscale fluctuations... */
00558     r = 1 - 2 * fabs(dt) / ctl->dt_met;
00559     rs = sqrt(1 - r * r);
00560
00561     /* Calculate mesoscale wind fluctuations... */
```

```
00562     atm->up[ip] =
00563       r * atm->up[ip] + rs * gsl_ran_gaussian_ziggurat(rng,
00564                                                        ctl->turb_meso * usig);
00565     atm->vp[ip] =
00566       r * atm->vp[ip] + rs * gsl_ran_gaussian_ziggurat(rng,
00567                                                        ctl->turb_meso * vsig);
00568     atm->wp[ip] =
00569       r * atm->wp[ip] + rs * gsl_ran_gaussian_ziggurat(rng,
00570                                                        ctl->turb_meso * wsig);
00571
00572     /* Calculate air parcel displacement... */
00573     atm->lon[ip] += dx2deg(atm->up[ip] * dt / 1000., atm->lat[ip]);
00574     atm->lat[ip] += dy2deg(atm->vp[ip] * dt / 1000.);
00575     atm->p[ip] += atm->wp[ip] * dt;
00576   }
00577 }
00578
00579 /*****************************************************************************/
00580
00581 void module_diffusion_turb(
00582   ctl_t * ctl,
00583   atm_t * atm,
00584   int ip,
00585   double dt,
00586   gsl_rng * rng) {
00587
00588   double dx, dz, pt, p0, p1, w;
00589
00590   /* Get tropopause pressure... */
00591   pt = tropopause(atm->time[ip], atm->lat[ip]);
00592
00593   /* Get weighting factor... */
00594   p1 = pt * 0.866877899;
00595   p0 = pt / 0.866877899;
00596   if (atm->p[ip] > p0)
00597     w = 1;
00598   else if (atm->p[ip] < p1)
00599     w = 0;
00600   else
00601     w = LIN(p0, 1.0, p1, 0.0, atm->p[ip]);
00602
00603   /* Set diffusivitiy... */
00604   dx = w * ctl->turb_dx_trop + (1 - w) * ctl->turb_dx_strat;
00605   dz = w * ctl->turb_dz_trop + (1 - w) * ctl->turb_dz_strat;
00606
00607   /* Horizontal turbulent diffusion... */
00608   if (dx > 0) {
00609     atm->lon[ip]
00610       += dx2deg(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dx * fabs(dt)))
00611                 / 1000., atm->lat[ip]);
00612     atm->lat[ip]
00613       += dy2deg(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dx * fabs(dt)))
00614                 / 1000.);
00615   }
00616
00617   /* Vertical turbulent diffusion... */
00618   if (dz > 0)
00619     atm->p[ip]
00620       += dz2dp(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dz * fabs(dt)))
00621                / 1000., atm->p[ip]);
00622 }
00623
00624 /*****************************************************************************/
00625
00626 void module_isosurf(
00627   ctl_t * ctl,
00628   met_t * met0,
00629   met_t * met1,
00630   atm_t * atm,
00631   int ip) {
00632
00633   static double *iso, *ps, t, *ts;
00634
00635   static int idx, ip2, n, nb = 100000;
00636
00637   FILE *in;
00638
00639   char line[LEN];
00640
00641   /* Check control parameter... */
00642   if (ctl->isosurf < 1 || ctl->isosurf > 4)
00643     return;
00644
00645   /* Initialize... */
00646   if (ip < 0) {
00647
00648     /* Allocate... */
```

```
00649     ALLOC(iso, double,
00650           NP);
00651     ALLOC(ps, double,
00652           nb);
00653     ALLOC(ts, double,
00654           nb);
00655
00656     /* Save pressure... */
00657     if (ctl->isosurf == 1)
00658       for (ip2 = 0; ip2 < atm->np; ip2++)
00659         iso[ip2] = atm->p[ip2];
00660
00661     /* Save density... */
00662     else if (ctl->isosurf == 2)
00663       for (ip2 = 0; ip2 < atm->np; ip2++) {
00664         intpol_met_time(met0, met1, atm->time[ip2], atm->p[ip2],
00665                         atm->lon[ip2], atm->lat[ip2], NULL, &t, NULL, NULL,
00666                         NULL, NULL, NULL);
00667         iso[ip2] = atm->p[ip2] / t;
00668       }
00669
00670     /* Save potential temperature... */
00671     else if (ctl->isosurf == 3)
00672       for (ip2 = 0; ip2 < atm->np; ip2++) {
00673         intpol_met_time(met0, met1, atm->time[ip2], atm->p[ip2],
00674                         atm->lon[ip2], atm->lat[ip2], NULL, &t, NULL, NULL,
00675                         NULL, NULL, NULL);
00676         iso[ip2] = t * pow(P0 / atm->p[ip2], 0.286);
00677       }
00678
00679     /* Read balloon pressure data... */
00680     else if (ctl->isosurf == 4) {
00681
00682       /* Write info... */
00683       printf("Read balloon pressure data: %s\n", ctl->balloon);
00684
00685       /* Open file... */
00686       if (!(in = fopen(ctl->balloon, "r")))
00687         ERRMSG("Cannot open file!");
00688
00689       /* Read pressure time series... */
00690       while (fgets(line, LEN, in))
00691         if (sscanf(line, "%lg %lg", &ts[n], &ps[n]) == 2)
00692           if ((++n) > 100000)
00693             ERRMSG("Too many data points!");
00694
00695       /* Check number of points... */
00696       if (n < 1)
00697         ERRMSG("Could not read any data!");
00698
00699       /* Close file... */
00700       fclose(in);
00701     }
00702
00703     /* Leave initialization... */
00704     return;
00705   }
00706
00707   /* Restore pressure... */
00708   if (ctl->isosurf == 1)
00709     atm->p[ip] = iso[ip];
00710
00711   /* Restore density... */
00712   else if (ctl->isosurf == 2) {
00713     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00714                     atm->lat[ip], NULL, &t, NULL, NULL, NULL, NULL, NULL);
00715     atm->p[ip] = iso[ip] * t;
00716   }
00717
00718   /* Restore potential temperature... */
00719   else if (ctl->isosurf == 3) {
00720     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00721                     atm->lat[ip], NULL, &t, NULL, NULL, NULL, NULL, NULL);
00722     atm->p[ip] = P0 * pow(iso[ip] / t, -1. / 0.286);
00723   }
00724
00725   /* Interpolate pressure... */
00726   else if (ctl->isosurf == 4) {
00727     if (atm->time[ip] <= ts[0])
00728       atm->p[ip] = ps[0];
00729     else if (atm->time[ip] >= ts[n - 1])
00730       atm->p[ip] = ps[n - 1];
00731     else {
00732       idx = locate(ts, n, atm->time[ip]);
00733       atm->p[ip] = LIN(ts[idx], ps[idx],
```

```
00734                         ts[idx + 1], ps[idx + 1], atm->time[ip]);
00735     }
00736   }
00737 }
00738
00739 /*****************************************************************************/
00740
00741 void module_meteo(
00742   ctl_t * ctl,
00743   met_t * met0,
00744   met_t * met1,
00745   atm_t * atm,
00746   int ip) {
00747
00748   static FILE *in;
00749
00750   static char filename[LEN], line[LEN];
00751
00752   static double lon[GX], lat[GY], var[GX][GY],
00753     rdum, rlat, rlat_old = -999, rlon, rvar;
00754
00755   static int year_old, mon_old, day_old, nlon, nlat;
00756
00757   double a, b, c, ps, p1, p_hno3, p_h2o, t, t1, u, u1, v, v1, w,
00758     x1, x2, h2o, o3, grad, vort, var0, var1;
00759
00760   int day, mon, year, idum, ilat, ilon;
00761
00762   /* Interpolate meteorological data... */
00763   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00764                   atm->lat[ip], &ps, &t, &u, &v, &w, &h2o, &o3);
00765
00766   /* Set surface pressure... */
00767   if (ctl->qnt_ps >= 0)
00768     atm->q[ctl->qnt_ps][ip] = ps;
00769
00770   /* Set pressure... */
00771   if (ctl->qnt_p >= 0)
00772     atm->q[ctl->qnt_p][ip] = atm->p[ip];
00773
00774   /* Set temperature... */
00775   if (ctl->qnt_t >= 0)
00776     atm->q[ctl->qnt_t][ip] = t;
00777
00778   /* Set zonal wind... */
00779   if (ctl->qnt_u >= 0)
00780     atm->q[ctl->qnt_u][ip] = u;
00781
00782   /* Set meridional wind... */
00783   if (ctl->qnt_v >= 0)
00784     atm->q[ctl->qnt_v][ip] = v;
00785
00786   /* Set vertical velocity... */
00787   if (ctl->qnt_w >= 0)
00788     atm->q[ctl->qnt_w][ip] = w;
00789
00790   /* Set water vapor vmr... */
00791   if (ctl->qnt_h2o >= 0)
00792     atm->q[ctl->qnt_h2o][ip] = h2o;
00793
00794   /* Set ozone vmr... */
00795   if (ctl->qnt_o3 >= 0)
00796     atm->q[ctl->qnt_o3][ip] = o3;
00797
00798   /* Calculate potential temperature... */
00799   if (ctl->qnt_theta >= 0)
00800     atm->q[ctl->qnt_theta][ip] = t * pow(P0 / atm->p[ip], 0.286);
00801
00802   /* Calculate potential vorticity... */
00803   if (ctl->qnt_pv >= 0) {
00804
00805     /* Absolute vorticity... */
00806     vort = 2 * 7.2921e-5 * sin(atm->lat[ip] * M_PI / 180.);
00807     if (fabs(atm->lat[ip]) < 89.) {
00808       intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00809                       (atm->lon[ip] >=
00810                        0 ? atm->lon[ip] - 1. : atm->lon[ip] + 1.),
00811                       atm->lat[ip], NULL, NULL, NULL, &v1, NULL, NULL, NULL);
00812       vort += (v1 - v) / 1000.
00813         / ((atm->lon[ip] >= 0 ? -1 : 1) * deg2dx(1., atm->lat[ip]));
00814     }
00815     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00816                     (atm->lat[ip] >=
00817                      0 ? atm->lat[ip] - 1. : atm->lat[ip] + 1.), NULL, NULL,
00818                     &u1, NULL, NULL, NULL, NULL);
```

```
00819     vort += (u1 - u) / 1000. / ((atm->lat[ip] >= 0 ? -1 : 1) * deg2dy(1.));
00820
00821     /* Potential temperature gradient... */
00822     p1 = 0.85 * atm->p[ip];
00823     intpol_met_time(met0, met1, atm->time[ip], p1, atm->lon[ip],
00824                     atm->lat[ip], NULL, &t1, NULL, NULL, NULL, NULL, NULL);
00825     grad = (t1 * pow(P0 / p1, 0.286) - t * pow(P0 / atm->p[ip], 0.286))
00826       / (100. * (p1 - atm->p[ip]));
00827
00828     /* Calculate PV... */
00829     atm->q[ctl->qnt_pv][ip] = -1e6 * G0 * vort * grad;
00830   }
00831
00832   /* Calculate T_ice (Marti and Mauersberger, 1993)... */
00833   if (ctl->qnt_tice >= 0 || ctl->qnt_tsts >= 0)
00834     atm->q[ctl->qnt_tice][ip] =
00835       -2663.5 /
00836       (log10((ctl->psc_h2o > 0 ? ctl->psc_h2o : h2o) * atm->p[ip] * 100.) -
00837        12.537);
00838
00839   /* Calculate T_NAT (Hanson and Mauersberger, 1988)... */
00840   if (ctl->qnt_tnat >= 0 || ctl->qnt_tsts >= 0) {
00841     if (ctl->psc_hno3 > 0)
00842       p_hno3 = ctl->psc_hno3 * atm->p[ip] / 1.333224;
00843     else
00844       p_hno3 = module_meteo_hno3(atm->time[ip], atm->lat[ip], atm->
      p[ip])
00845         * 1e-9 * atm->p[ip] / 1.333224;
00846     p_h2o = (ctl->psc_h2o > 0 ? ctl->psc_h2o : h2o) * atm->p[ip] / 1.333224;
00847     a = 0.009179 - 0.00088 * log10(p_h2o);
00848     b = (38.9855 - log10(p_hno3) - 2.7836 * log10(p_h2o)) / a;
00849     c = -11397.0 / a;
00850     x1 = (-b + sqrt(b * b - 4. * c)) / 2.;
00851     x2 = (-b - sqrt(b * b - 4. * c)) / 2.;
00852     if (x1 > 0)
00853       atm->q[ctl->qnt_tnat][ip] = x1;
00854     if (x2 > 0)
00855       atm->q[ctl->qnt_tnat][ip] = x2;
00856   }
00857
00858   /* Calculate T_STS (mean of T_ice and T_NAT)... */
00859   if (ctl->qnt_tsts >= 0) {
00860     if (ctl->qnt_tice < 0 || ctl->qnt_tnat < 0)
00861       ERRMSG("Need T_ice and T_NAT to calculate T_STS!");
00862     atm->q[ctl->qnt_tsts][ip] = 0.5 * (atm->q[ctl->qnt_tice][ip]
00863                                        + atm->q[ctl->qnt_tnat][ip]);
00864   }
00865
00866   /* Read variance data for current day... */
00867   if (ip == 0 && ctl->qnt_gw_var >= 0) {
00868     jsec2time(atm->time[ip], &year, &mon, &day, &idum, &idum, &idum, &rdum);
00869     if (year != year_old || mon != mon_old || day != day_old) {
00870       year_old = year;
00871       mon_old = mon;
00872       day_old = day;
00873       nlon = nlat = -1;
00874       sprintf(filename, "%s_%d_%02d_%02d.tab",
00875               ctl->gw_basename, year, mon, day);
00876       if ((in = fopen(filename, "r"))) {
00877         printf("Read gravity wave data: %s\n", filename);
00878         while (fgets(line, LEN, in)) {
00879           if (sscanf(line, "%lg %lg %lg", &rlon, &rlat, &rvar) != 3)
00880             continue;
00881           if (rlat != rlat_old) {
00882             rlat_old = rlat;
00883             if ((++nlat) > GY)
00884               ERRMSG("Too many latitudes!");
00885             nlon = -1;
00886           }
00887           if ((++nlon) > GX)
00888             ERRMSG("Too many longitudes!");
00889           lon[nlon] = rlon;
00890           lat[nlat] = rlat;
00891           var[nlon][nlat] = GSL_MAX(0, rvar);
00892         }
00893         fclose(in);
00894         nlat++;
00895         nlon++;
00896       } else
00897         printf("Missing gravity wave data: %s\n", filename);
00898     }
00899   }
00900
00901   /* Interpolate variance data... */
00902   if (ctl->qnt_gw_var >= 0) {
00903     if (nlat >= 2 && nlon >= 2) {
00904       ilat = locate(lat, nlat, atm->lat[ip]);
```

```
00905       ilon = locate(lon, nlon, atm->lon[ip]);
00906       var0 = LIN(lat[ilat], var[ilon][ilat],
00907                  lat[ilat + 1], var[ilon][ilat + 1], atm->lat[ip]);
00908       var1 = LIN(lat[ilat], var[ilon + 1][ilat],
00909                  lat[ilat + 1], var[ilon + 1][ilat + 1], atm->lat[ip]);
00910       atm->q[ctl->qnt_gw_var][ip]
00911         = LIN(lon[ilon], var0, lon[ilon + 1], var1, atm->lon[ip]);
00912     } else
00913       atm->q[ctl->qnt_gw_var][ip] = GSL_NAN;
00914   }
00915 }
00916
00917 /*****************************************************************************/
00918
00919 double module_meteo_hno3(
00920   double t,
00921   double lat,
00922   double p) {
00923
00924   static double secs[12] = { 1209600.00, 3888000.00, 6393600.00,
00925     9072000.00, 11664000.00, 14342400.00,
00926     16934400.00, 19612800.00, 22291200.00,
00927     24883200.00, 27561600.00, 30153600.00
00928   };
00929
00930   static double lats[18] = { -85, -75, -65, -55, -45, -35, -25, -15, -5,
00931     5, 15, 25, 35, 45, 55, 65, 75, 85
00932   };
00933
00934   static double ps[10] = { 4.64159, 6.81292, 10, 14.678, 21.5443,
00935     31.6228, 46.4159, 68.1292, 100, 146.78
00936   };
00937
00938   static double hno3[12][18][10] = {
00939     {{0.782, 1.65, 2.9, 4.59, 6.71, 8.25, 7.16, 5.75, 2.9, 1.74},
00940      {0.529, 1.64, 2.76, 4.55, 6.58, 8, 6.99, 5.55, 2.68, 1.57},
00941      {0.723, 1.55, 2.73, 4.48, 6.32, 7.58, 7.05, 5.16, 2.49, 1.54},
00942      {0.801, 1.56, 2.74, 4.52, 6.23, 7.35, 6.68, 4.4, 1.97, 1.23},
00943      {0.818, 1.62, 2.77, 4.38, 5.98, 6.84, 5.83, 3.05, 1.15, 0.709},
00944      {0.901, 1.73, 2.78, 4.21, 5.63, 6.16, 4.68, 1.87, 0.617, 0.37},
00945      {0.997, 1.8, 2.79, 4.09, 4.88, 4.96, 3.12, 1.22, 0.311, 0.244},
00946      {1, 1.71, 2.51, 3.4, 3.74, 3.39, 2.25, 0.845, 0.204, 0.222},
00947      {0.997, 1.7, 2.36, 2.88, 3.01, 2.25, 1.77, 0.608, 0.163, 0.181},
00948      {0.991, 1.79, 2.57, 3.06, 3.08, 2.15, 1.81, 0.59, 0.168, 0.104},
00949      {0.974, 1.86, 2.84, 3.8, 3.93, 3.79, 2.91, 1.02, 0.152, 0.0985},
00950      {0.85, 1.86, 3.3, 5.24, 6.55, 6.86, 5.12, 1.93, 0.378, 0.185},
00951      {0.783, 1.89, 3.85, 6.6, 8.56, 8.66, 6.95, 3.95, 1.47, 0.745},
00952      {0.883, 2.05, 4.34, 7.54, 9.68, 9.77, 8.19, 5.72, 3.15, 1.77},
00953      {1.4, 2.44, 4.72, 8.07, 10.5, 10.9, 9.28, 6.95, 4.47, 2.49},
00954      {1.7, 2.43, 4.24, 7.43, 10.4, 11.2, 9.72, 8.15, 5.7, 2.97},
00955      {2.06, 2.27, 3.68, 6.77, 10.3, 10.3, 9.05, 9.1, 6.73, 3.14},
00956      {2.33, 2.39, 3.51, 6.45, 10.3, 9.88, 8.57, 9.42, 7.22, 3.19}},
00957     {{0.947, 2.21, 3.81, 5.69, 7.55, 8.63, 7.53, 5.98, 3.03, 1.64},
00958      {0.642, 2, 3.4, 5.49, 7.5, 8.52, 7.53, 5.83, 2.74, 1.42},
00959      {0.756, 1.83, 3.18, 5.11, 7.24, 8.63, 7.66, 5.5, 2.45, 1.33},
00960      {0.837, 1.75, 3.06, 5, 6.79, 8.08, 7.05, 4.42, 1.81, 1.05},
00961      {0.86, 1.73, 2.96, 4.68, 6.38, 7.38, 6.09, 2.92, 1.06, 0.661},
00962      {0.926, 1.78, 2.89, 4.37, 5.74, 6.14, 4.59, 1.78, 0.561, 0.332},
00963      {0.988, 1.78, 2.75, 3.95, 4.64, 4.49, 2.85, 1.13, 0.271, 0.184},
00964      {0.999, 1.7, 2.44, 3.27, 3.57, 3.03, 2.06, 0.736, 0.181, 0.189},
00965      {0.971, 1.67, 2.23, 2.63, 2.83, 2.15, 1.74, 0.554, 0.157, 0.167},
00966      {0.985, 1.72, 2.34, 2.69, 2.81, 2.11, 1.78, 0.592, 0.152, 0.101},
00967      {0.95, 1.72, 2.57, 3.44, 3.84, 3.89, 2.91, 0.976, 0.135, 0.114},
00968      {0.819, 1.64, 2.93, 4.75, 6.02, 6.93, 5.2, 1.83, 0.347, 0.191},
00969      {0.731, 1.58, 3.3, 5.95, 7.81, 8.32, 6.93, 3.83, 1.47, 0.875},
00970      {0.77, 1.75, 3.74, 6.67, 8.76, 9.41, 8.19, 5.78, 3.32, 2.11},
00971      {1.08, 2.17, 4.24, 7.13, 9.2, 10.3, 9.03, 6.87, 4.65, 3.01},
00972      {1.43, 2.49, 4.31, 7, 9.14, 10.6, 9.34, 7.6, 5.86, 3.64},
00973      {1.5, 2.68, 4.32, 6.75, 8.78, 10.6, 9.05, 7.65, 6.27, 4.07},
00974      {1.73, 2.91, 4.33, 6.67, 8.73, 10.6, 8.5, 7.54, 6.63, 4.17}},
00975     {{1.43, 3.07, 5.22, 7.54, 9.78, 10.4, 10.1, 7.26, 3.61, 1.69},
00976      {0.989, 2.69, 4.76, 7.19, 9.44, 9.94, 9.5, 6.74, 3.24, 1.52},
00977      {0.908, 2.23, 4.11, 6.48, 8.74, 9.41, 8.58, 5.8, 2.66, 1.3},
00978      {0.923, 1.99, 3.61, 5.83, 7.84, 8.6, 7.55, 4.57, 1.87, 0.98},
00979      {0.933, 1.9, 3.31, 5.28, 7.1, 7.84, 6.44, 3.18, 1.1, 0.642},
00980      {0.982, 1.88, 3.1, 4.76, 6.16, 6.57, 5.16, 2.04, 0.598, 0.33},
00981      {1.02, 1.82, 2.88, 4.12, 4.71, 4.54, 3.03, 1.22, 0.268, 0.174},
00982      {0.992, 1.7, 2.51, 3.33, 3.62, 2.87, 2.05, 0.705, 0.161, 0.169},
00983      {0.969, 1.69, 2.2, 2.62, 2.84, 2.13, 1.78, 0.529, 0.146, 0.186},
00984      {0.945, 1.69, 2.27, 2.64, 2.83, 2.2, 1.83, 0.561, 0.139, 0.121},
00985      {0.922, 1.65, 2.48, 3.33, 3.83, 4.09, 2.92, 0.973, 0.117, 0.135},
00986      {0.886, 1.59, 2.66, 4.26, 5.51, 6.57, 5.09, 1.79, 0.342, 0.194},
00987      {0.786, 1.5, 2.78, 5.01, 6.8, 7.83, 6.65, 3.62, 1.45, 1},
00988      {0.745, 1.55, 3.05, 5.49, 7.44, 8.6, 7.8, 5.28, 2.95, 2.12},
00989      {0.938, 1.76, 3.4, 5.82, 7.8, 9.04, 8.43, 6.15, 3.85, 2.82},
00990      {0.999, 2, 3.66, 5.95, 7.94, 9.27, 8.8, 6.93, 4.87, 3.54},
00991      {1.13, 2.23, 3.86, 5.82, 7.65, 9, 8.82, 7.17, 5.72, 4.08},
```

```
00992       {1.23, 2.33, 3.94, 5.74, 7.48, 8.9, 8.84, 7.35, 6.3, 4.42}},
00993      {{1.55, 3.2, 6.25, 10, 12.9, 12.9, 11.9, 7.96, 3.96, 1.75},
00994       {1.32, 3.27, 6.32, 9.99, 12.7, 12.4, 11.3, 7.51, 3.66, 1.58},
00995       {1.25, 3.08, 5.77, 8.71, 11.2, 11.2, 9.84, 6.52, 3.23, 1.5},
00996       {1.18, 2.59, 4.76, 7.46, 9.61, 9.66, 8.42, 5.06, 2.25, 1.09},
00997       {1.09, 2.24, 3.99, 6.4, 8.33, 8.54, 7.08, 3.69, 1.36, 0.727},
00998       {1.06, 2.07, 3.52, 5.52, 7.06, 7.26, 5.83, 2.46, 0.732, 0.409},
00999       {1.07, 1.91, 3.09, 4.63, 5.21, 4.9, 3.68, 1.43, 0.326, 0.198},
01000       {1.03, 1.74, 2.63, 3.54, 3.78, 2.89, 2.09, 0.743, 0.175, 0.12},
01001       {0.959, 1.71, 2.32, 2.77, 2.99, 2.24, 1.76, 0.519, 0.149, 0.172},
01002       {0.931, 1.68, 2.32, 2.74, 2.99, 2.46, 1.88, 0.578, 0.156, 0.157},
01003       {0.933, 1.66, 2.49, 3.42, 3.99, 4.12, 2.93, 1.02, 0.181, 0.138},
01004       {0.952, 1.64, 2.6, 4, 5.15, 6.07, 4.84, 1.78, 0.407, 0.286},
01005       {0.84, 1.54, 2.68, 4.47, 5.97, 7.13, 6.23, 3.25, 1.38, 1.02},
01006       {0.714, 1.44, 2.73, 4.68, 6.28, 7.68, 7.21, 4.82, 2.55, 1.96},
01007       {0.838, 1.57, 2.96, 4.93, 6.55, 8.08, 7.74, 5.77, 3.32, 2.52},
01008       {0.823, 1.65, 3.11, 5.09, 6.89, 8.36, 8.31, 6.59, 4.1, 3.04},
01009       {0.886, 1.83, 3.42, 5.33, 6.92, 8.36, 8.63, 7.21, 4.82, 3.46},
01010       {1.07, 2.12, 3.74, 5.54, 6.98, 8.41, 8.75, 7.41, 5.16, 3.62}},
01011      {{1.13, 2.59, 7.49, 13.5, 15.4, 12.9, 11.3, 8.62, 4.18, 1.63},
01012       {0.973, 2.79, 7.23, 12.8, 15.2, 13.3, 11.6, 8.42, 4.06, 1.57},
01013       {1.46, 3.44, 6.78, 10.4, 12.7, 12.1, 10.5, 7.04, 3.59, 1.63},
01014       {1.52, 3.38, 6.04, 9.08, 11, 10.3, 8.9, 5.7, 2.77, 1.37},
01015       {1.32, 2.65, 4.75, 7.49, 9.32, 8.89, 7.42, 4.27, 1.7, 0.88},
01016       {1.19, 2.2, 3.88, 6.36, 8.03, 7.81, 6.19, 2.94, 0.948, 0.527},
01017       {1.14, 1.96, 3.28, 5.26, 6.12, 5.8, 4.47, 1.66, 0.388, 0.229},
01018       {1.07, 1.82, 2.82, 3.92, 4.03, 3.15, 2.31, 0.871, 0.183, 0.0972},
01019       {0.978, 1.77, 2.53, 3.04, 3.1, 2.36, 1.76, 0.575, 0.16, 0.126},
01020       {0.962, 1.72, 2.49, 3.01, 3.22, 2.72, 2, 0.716, 0.162, 0.183},
01021       {0.968, 1.7, 2.6, 3.57, 4.28, 4.35, 3.09, 1.2, 0.262, 0.18},
01022       {0.977, 1.68, 2.71, 4.03, 5.17, 6.01, 4.81, 1.81, 0.473, 0.343},
01023       {0.819, 1.58, 2.75, 4.37, 5.8, 6.9, 5.96, 2.95, 1.19, 0.964},
01024       {0.672, 1.44, 2.69, 4.42, 5.92, 7.26, 6.79, 4.32, 2.22, 1.83},
01025       {0.783, 1.42, 2.65, 4.45, 6.04, 7.57, 7.39, 5.4, 2.94, 2.25},
01026       {0.757, 1.43, 2.7, 4.54, 6.14, 7.65, 7.51, 5.95, 3.42, 2.39},
01027       {0.758, 1.57, 3.04, 4.88, 6.24, 7.85, 7.58, 6.35, 3.81, 2.52},
01028       {0.835, 1.72, 3.35, 5.24, 6.5, 8.1, 7.67, 6.51, 4, 2.6}},
01029      {{1.5, 2.12, 7.64, 10.5, 5.59, 2.14, 2.2, 3.5, 4.71, 3.26},
01030       {1.32, 2.14, 7.23, 12, 9.3, 5.3, 5.11, 5.37, 5.12, 3.05},
01031       {1.53, 2.92, 6.9, 11.9, 13.5, 11.3, 9.91, 7.18, 4.75, 2.65},
01032       {1.66, 3.48, 6.25, 9.53, 11.3, 10.3, 9.01, 5.76, 2.99, 1.67},
01033       {1.54, 3.03, 5.21, 8.03, 9.66, 8.98, 7.5, 4.64, 2.11, 1.13},
01034       {1.32, 2.39, 4.03, 6.74, 8.52, 8.05, 6.4, 3.48, 1.2, 0.639},
01035       {1.17, 2.08, 3.35, 5.52, 6.86, 6.54, 5.08, 1.97, 0.462, 0.217},
01036       {1.07, 1.92, 3.01, 4.24, 4.47, 3.77, 2.77, 1.07, 0.213, 0.0694},
01037       {0.992, 1.88, 2.76, 3.39, 3.32, 2.52, 1.8, 0.713, 0.192, 0.136},
01038       {0.992, 1.8, 2.63, 3.34, 3.46, 2.95, 2.09, 0.9, 0.242, 0.194},
01039       {0.987, 1.77, 2.67, 3.64, 4.37, 4.36, 3, 1.27, 0.354, 0.229},
01040       {0.979, 1.74, 2.77, 3.99, 5.12, 5.75, 4.53, 1.75, 0.555, 0.302},
01041       {0.832, 1.6, 2.78, 4.32, 5.53, 6.67, 5.69, 2.59, 0.982, 0.66},
01042       {0.696, 1.41, 2.64, 4.31, 5.65, 7.14, 6.56, 3.8, 1.75, 1.41},
01043       {0.788, 1.36, 2.59, 4.3, 5.73, 7.35, 7.04, 4.82, 2.41, 1.8},
01044       {0.761, 1.43, 2.61, 4.28, 5.64, 7.37, 7.11, 5.37, 2.68, 1.9},
01045       {0.701, 1.44, 2.82, 4.64, 5.76, 7.63, 7.07, 5.74, 2.98, 1.88},
01046       {0.763, 1.5, 2.95, 4.97, 6.08, 7.88, 7.12, 5.98, 3.21, 1.91}},
01047      {{3.58, 2.59, 6.49, 5.84, 1.63, 0.282, 0.647, 0.371, 1.36, 2.33},
01048       {3.09, 2.38, 6.37, 7.66, 4.06, 1.23, 1.8, 1.65, 2.32, 2.78},
01049       {2.31, 2.84, 5.58, 9.63, 11, 9.02, 8.2, 6.23, 4.17, 3.08},
01050       {1.61, 3.16, 5.72, 9.13, 11.4, 10.4, 9.15, 6.18, 3.52, 2.3},
01051       {1.32, 2.8, 4.79, 7.44, 9.43, 8.83, 7.41, 4.9, 2.38, 1.38},
01052       {1.14, 2.36, 3.94, 6.41, 8.38, 8.17, 6.53, 3.76, 1.31, 0.656},
01053       {1.05, 2.1, 3.36, 5.45, 7.07, 6.98, 5.44, 2.22, 0.52, 0.176},
01054       {1.02, 2, 3.05, 4.33, 4.74, 4.21, 3.2, 1.26, 0.277, 0.0705},
01055       {1.01, 1.96, 2.9, 3.53, 3.46, 2.69, 1.89, 0.859, 0.254, 0.12},
01056       {1.01, 1.86, 2.7, 3.46, 3.59, 3.03, 2.14, 1, 0.34, 0.199},
01057       {1.02, 1.81, 2.67, 3.68, 4.39, 4.3, 2.93, 1.35, 0.477, 0.25},
01058       {0.991, 1.79, 2.82, 4.05, 5.08, 5.5, 4.21, 1.74, 0.605, 0.259},
01059       {0.844, 1.73, 2.87, 4.38, 5.49, 6.47, 5.5, 2.44, 0.85, 0.422},
01060       {0.729, 1.57, 2.76, 4.43, 5.73, 7.13, 6.43, 3.52, 1.38, 0.913},
01061       {0.819, 1.46, 2.69, 4.45, 5.92, 7.47, 7.05, 4.52, 2, 1.4},
01062       {0.783, 1.47, 2.71, 4.48, 5.92, 7.46, 7.16, 5.08, 2.35, 1.56},
01063       {0.735, 1.51, 2.96, 4.84, 5.92, 7.77, 7.2, 5.54, 2.56, 1.61},
01064       {0.8, 1.61, 3.14, 5.2, 6.26, 8.08, 7.27, 5.72, 2.75, 1.62}},
01065      {{5, 4.43, 5.53, 5.35, 2.33, 0.384, 0.663, 0.164, 0.692, 1.4},
01066       {3.62, 3.79, 4.77, 5.94, 4.12, 1.36, 1.3, 0.973, 1.37, 1.73},
01067       {2.11, 2.7, 4.12, 7.14, 9.03, 7.74, 7.12, 5.44, 3.73, 2.6},
01068       {1.13, 2.32, 4.12, 6.97, 9.86, 9.69, 8.85, 6.22, 3.59, 2.14},
01069       {0.957, 2.28, 4.11, 6.47, 8.66, 8.78, 7.33, 4.94, 2.44, 1.38},
01070       {0.881, 2.1, 3.65, 5.94, 7.98, 8.29, 6.69, 3.95, 1.36, 0.672},
01071       {0.867, 1.96, 3.26, 5.23, 6.94, 7.2, 5.63, 2.41, 0.578, 0.19},
01072       {0.953, 1.94, 2.98, 4.23, 4.83, 4.52, 3.38, 1.34, 0.293, 0.181},
01073       {1.01, 1.91, 2.77, 3.35, 3.3, 2.62, 1.99, 0.905, 0.245, 0.107},
01074       {1.03, 1.81, 2.57, 3.29, 3.43, 2.87, 2.13, 0.988, 0.306, 0.185},
01075       {1.02, 1.78, 2.58, 3.59, 4.19, 4, 2.72, 1.29, 0.389, 0.224},
01076       {1.01, 1.84, 2.84, 4.06, 4.9, 5.08, 3.71, 1.64, 0.529, 0.232},
01077       {0.902, 1.84, 2.98, 4.43, 5.5, 6.28, 5.18, 2.35, 0.734, 0.341},
01078       {0.785, 1.68, 2.93, 4.67, 5.95, 7.3, 6.52, 3.48, 1.24, 0.754},
```

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01079       {0.847, 1.62, 2.94, 4.86, 6.38, 7.99, 7.5, 4.64, 1.93, 1.23},
01080       {0.8, 1.6, 2.94, 4.95, 6.62, 8.16, 7.91, 5.43, 2.43, 1.45},
01081       {0.82, 1.76, 3.37, 5.47, 6.82, 8.24, 7.73, 5.79, 2.69, 1.5},
01082       {0.988, 2.05, 3.87, 6.01, 7.18, 8.41, 7.7, 5.93, 2.89, 1.55}},
01083     {{1.52, 2.7, 3.79, 4.95, 3.8, 1.51, 1.11, 0.784, 1.1, 1.56},
01084       {1.19, 2.16, 3.34, 4.76, 4.61, 2.93, 2.07, 1.65, 1.63, 1.74},
01085       {0.804, 1.65, 2.79, 4.63, 6.64, 6.95, 6.68, 5.11, 3.3, 2.09},
01086       {0.86, 1.8, 3.25, 5.3, 7.91, 8.76, 8.28, 6.01, 3.39, 1.83},
01087       {0.859, 1.95, 3.54, 5.64, 7.88, 8.55, 7.3, 4.88, 2.3, 1.22},
01088       {0.809, 1.88, 3.38, 5.45, 7.47, 8.02, 6.69, 3.98, 1.35, 0.646},
01089       {0.822, 1.81, 3.11, 4.9, 6.62, 6.96, 5.63, 2.47, 0.614, 0.169},
01090       {0.92, 1.83, 2.8, 3.93, 4.56, 4.4, 3.25, 1.31, 0.295, 0.0587},
01091       {0.986, 1.83, 2.6, 3.13, 3.08, 2.53, 1.94, 0.886, 0.244, 0.0815},
01092       {0.997, 1.74, 2.5, 3.16, 3.24, 2.67, 2.05, 0.939, 0.281, 0.147},
01093       {1.01, 1.75, 2.57, 3.55, 4.1, 3.81, 2.53, 1.21, 0.354, 0.197},
01094       {1.04, 1.88, 2.9, 4.16, 4.95, 4.96, 3.48, 1.63, 0.502, 0.163},
01095       {0.967, 1.95, 3.17, 4.72, 5.85, 6.5, 5.34, 2.53, 0.748, 0.303},
01096       {0.846, 1.83, 3.23, 5.15, 6.62, 7.82, 6.85, 3.79, 1.36, 0.714},
01097       {0.91, 1.81, 3.35, 5.55, 7.32, 8.55, 7.88, 5.03, 2.13, 1.1},
01098       {0.87, 1.94, 3.6, 5.97, 7.98, 9.14, 8.71, 6.04, 2.73, 1.41},
01099       {1.04, 2.36, 4.22, 6.57, 8.5, 9.53, 9.22, 6.71, 3.2, 1.56},
01100       {1.36, 2.84, 4.72, 6.94, 8.81, 9.87, 9.59, 7.1, 3.43, 1.65}},
01101     {{0.704, 1.4, 2.03, 3.08, 4.64, 4.24, 2.55, 1.57, 1.99, 1.91},
01102       {0.484, 1.38, 2.08, 3.54, 5.11, 4.98, 3.73, 2.57, 2.29, 1.84},
01103       {0.749, 1.57, 2.63, 4.17, 6.15, 6.97, 6.64, 5.11, 3.35, 1.97},
01104       {0.864, 1.69, 3.16, 4.87, 7.13, 8.33, 7.87, 5.9, 3.17, 1.56},
01105       {0.861, 1.79, 3.28, 5.2, 7.29, 8.32, 7.38, 4.9, 2.23, 1.11},
01106       {0.835, 1.79, 3.19, 4.99, 6.72, 7.58, 6.45, 3.68, 1.25, 0.616},
01107       {0.847, 1.8, 3.07, 4.66, 6.12, 6.6, 5.21, 2.18, 0.554, 0.21},
01108       {0.941, 1.78, 2.68, 3.68, 4.28, 4.18, 2.97, 1.15, 0.238, 0.0968},
01109       {0.98, 1.78, 2.48, 2.99, 2.96, 2.35, 1.88, 0.747, 0.207, 0.105},
01110       {0.978, 1.74, 2.51, 3.07, 3.12, 2.36, 1.95, 0.777, 0.216, 0.146},
01111       {1.01, 1.79, 2.63, 3.53, 3.95, 3.47, 2.38, 1.08, 0.265, 0.178},
01112       {1.06, 1.94, 3.02, 4.43, 5.19, 5.01, 3.68, 1.71, 0.429, 0.14},
01113       {0.99, 2.02, 3.38, 5.22, 6.56, 6.91, 5.56, 2.75, 0.816, 0.353},
01114       {0.923, 2.05, 3.66, 5.98, 7.78, 8.5, 7.23, 4.26, 1.67, 0.802},
01115       {1.08, 2.27, 4.17, 6.8, 8.89, 9.55, 8.59, 5.64, 2.58, 1.2},
01116       {1.12, 2.5, 4.52, 7.22, 9.76, 10.3, 9.72, 6.79, 3.32, 1.52},
01117       {1.2, 2.64, 4.81, 7.64, 10.5, 11.4, 10.6, 7.65, 3.87, 1.73},
01118       {1.4, 2.91, 5.01, 7.75, 10.7, 11.6, 11.1, 8.02, 4.04, 1.8}},
01119     {{0.75, 1.49, 2.39, 3.39, 4.93, 5.94, 5.03, 2.75, 2.27, 1.78},
01120       {0.508, 1.52, 2.38, 3.82, 5.34, 6.13, 5.6, 3.31, 2.42, 1.73},
01121       {0.715, 1.56, 2.7, 4.39, 6.18, 6.96, 7.1, 5.04, 3.01, 1.75},
01122       {0.813, 1.62, 2.94, 4.65, 6.53, 7.65, 7.52, 5.49, 2.75, 1.41},
01123       {0.802, 1.68, 2.97, 4.64, 6.37, 7.53, 7.01, 4.56, 1.9, 0.955},
01124       {0.816, 1.75, 3.01, 4.59, 6.15, 7.06, 6.15, 3.38, 1.11, 0.61},
01125       {0.867, 1.78, 2.92, 4.35, 5.69, 6.05, 4.73, 1.91, 0.519, 0.269},
01126       {0.932, 1.7, 2.55, 3.44, 4.03, 3.98, 2.74, 1.08, 0.247, 0.132},
01127       {0.937, 1.74, 2.51, 3.09, 3.11, 2.34, 1.84, 0.67, 0.189, 0.121},
01128       {0.942, 1.75, 2.63, 3.3, 3.27, 2.21, 1.87, 0.663, 0.171, 0.147},
01129       {0.959, 1.8, 2.82, 3.78, 4.03, 3.37, 2.53, 1.04, 0.199, 0.146},
01130       {1.01, 1.9, 3.13, 4.76, 5.63, 5.6, 4.31, 1.83, 0.367, 0.172},
01131       {0.989, 2.04, 3.64, 6, 7.62, 7.6, 6, 3.35, 1.05, 0.448},
01132       {1.02, 2.28, 4.32, 7.19, 9.21, 9.16, 7.64, 4.97, 2.2, 0.948},
01133       {1.26, 2.77, 5.2, 8.31, 10.5, 10.4, 9.01, 6.37, 3.46, 1.56},
01134       {1.31, 2.76, 5.23, 8.49, 11.2, 11.3, 10.1, 7.27, 3.98, 1.76},
01135       {1.26, 2.5, 5.14, 8.85, 12.3, 12.3, 11.2, 8.13, 4.45, 1.97},
01136       {1.35, 2.49, 5.26, 9.16, 13, 12.8, 11.8, 8.57, 4.72, 2.05}},
01137     {{0.759, 1.54, 2.54, 4.22, 6.26, 7.44, 7.14, 4.99, 2.84, 1.89},
01138       {0.508, 1.55, 2.5, 4.29, 6.29, 7.29, 7.07, 5.03, 2.77, 1.74},
01139       {0.699, 1.56, 2.62, 4.17, 6.08, 7.38, 7.04, 5.17, 2.81, 1.65},
01140       {0.778, 1.5, 2.65, 4.35, 6.07, 7.28, 6.84, 4.8, 2.28, 1.28},
01141       {0.772, 1.55, 2.71, 4.3, 5.76, 6.91, 6.2, 3.69, 1.45, 0.837},
01142       {0.836, 1.67, 2.78, 4.21, 5.56, 6.41, 5.33, 2.47, 0.807, 0.488},
01143       {0.937, 1.79, 2.78, 4.12, 5.17, 5.38, 3.89, 1.47, 0.392, 0.256},
01144       {0.97, 1.75, 2.52, 3.39, 3.83, 3.63, 2.48, 0.968, 0.212, 0.198},
01145       {0.968, 1.74, 2.5, 3.11, 3.2, 2.34, 1.79, 0.629, 0.169, 0.173},
01146       {0.98, 1.8, 2.69, 3.42, 3.4, 2.18, 1.81, 0.606, 0.164, 0.138},
01147       {0.975, 1.84, 2.96, 4.08, 4.12, 3.5, 2.79, 1.02, 0.145, 0.133},
01148       {0.96, 1.94, 3.27, 5.17, 6.26, 6.35, 4.88, 1.91, 0.329, 0.189},
01149       {0.954, 2.06, 3.8, 6.53, 8.46, 8.32, 6.53, 3.83, 1.32, 0.6},
01150       {1, 2.34, 4.58, 7.71, 9.68, 9.75, 7.96, 5.45, 2.84, 1.39},
01151       {1.24, 2.65, 5.14, 8.51, 10.7, 10.6, 8.96, 6.51, 3.83, 1.85},
01152       {1.34, 2.44, 4.99, 8.63, 11.6, 11.4, 10.1, 7.84, 4.77, 2.24},
01153       {1.33, 2.1, 4.76, 8.78, 12.2, 11.7, 10.8, 8.68, 5.15, 2.35},
01154       {1.42, 2.04, 4.68, 8.92, 12.7, 12, 11.2, 8.99, 5.32, 2.33}}
01155   };
01156
01157   double aux00, aux01, aux10, aux11, sec;
01158
01159   int ilat, ip, isec;
01160
01161   /* Get seconds since begin of year... */
01162   sec = fmod(t, 365.25 * 86400.);
01163
01164   /* Get indices... */
01165   ilat = locate(lats, 18, lat);
```

```
01166   ip = locate(ps, 10, p);
01167   isec = locate(secs, 12, sec);
01168
01169   /* Interpolate... */
01170   aux00 = LIN(ps[ip], hno3[isec][ilat][ip],
01171               ps[ip + 1], hno3[isec][ilat][ip + 1], p);
01172   aux01 = LIN(ps[ip], hno3[isec][ilat + 1][ip],
01173               ps[ip + 1], hno3[isec][ilat + 1][ip + 1], p);
01174   aux10 = LIN(ps[ip], hno3[isec + 1][ilat][ip],
01175               ps[ip + 1], hno3[isec + 1][ilat][ip + 1], p);
01176   aux11 = LIN(ps[ip], hno3[isec + 1][ilat + 1][ip],
01177               ps[ip + 1], hno3[isec + 1][ilat + 1][ip + 1], p);
01178   aux00 = LIN(lats[ilat], aux00, lats[ilat + 1], aux01, lat);
01179   aux11 = LIN(lats[ilat], aux10, lats[ilat + 1], aux11, lat);
01180   return LIN(secs[isec], aux00, secs[isec + 1], aux11, sec);
01181 }
01182
01183 /*****************************************************************************/
01184
01185 void module_position(
01186   met_t * met0,
01187   met_t * met1,
01188   atm_t * atm,
01189   int ip) {
01190
01191   double ps;
01192
01193   /* Calculate modulo... */
01194   atm->lon[ip] = fmod(atm->lon[ip], 360);
01195   atm->lat[ip] = fmod(atm->lat[ip], 360);
01196
01197   /* Check latitude... */
01198   while (atm->lat[ip] < -90 || atm->lat[ip] > 90) {
01199     if (atm->lat[ip] > 90) {
01200       atm->lat[ip] = 180 - atm->lat[ip];
01201       atm->lon[ip] += 180;
01202     }
01203     if (atm->lat[ip] < -90) {
01204       atm->lat[ip] = -180 - atm->lat[ip];
01205       atm->lon[ip] += 180;
01206     }
01207   }
01208
01209   /* Check longitude... */
01210   while (atm->lon[ip] < -180)
01211     atm->lon[ip] += 360;
01212   while (atm->lon[ip] >= 180)
01213     atm->lon[ip] -= 360;
01214
01215   /* Get surface pressure... */
01216   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
01217                   atm->lon[ip], atm->lat[ip], &ps, NULL,
01218                   NULL, NULL, NULL, NULL, NULL);
01219
01220   /* Check pressure... */
01221   if (atm->p[ip] > ps)
01222     atm->p[ip] = ps;
01223   else if (atm->p[ip] < met0->p[met0->np - 1])
01224     atm->p[ip] = met0->p[met0->np - 1];
01225 }
01226
01227 /*****************************************************************************/
01228
01229 void module_sedi(
01230   ctl_t * ctl,
01231   met_t * met0,
01232   met_t * met1,
01233   atm_t * atm,
01234   int ip,
01235   double dt) {
01236
01237   /* Coefficients for Cunningham slip-flow correction (Kasten, 1968): */
01238   const double A = 1.249, B = 0.42, C = 0.87;
01239
01240   /* Specific gas constant for dry air [J/(kg K)]: */
01241   const double R = 287.058;
01242
01243   /* Average mass of an air molecule [kg/molec]: */
01244   const double m = 4.8096e-26;
01245
01246   double G, K, eta, lambda, p, r_p, rho, rho_p, T, v, v_p;
01247
01248   /* Check if parameters are available... */
01249   if (ctl->qnt_r < 0 || ctl->qnt_rho < 0)
01250     return;
01251
01252   /* Convert units... */
```

```
01253   p = 100 * atm->p[ip];
01254   r_p = 1e-6 * atm->q[ctl->qnt_r][ip];
01255   rho_p = atm->q[ctl->qnt_rho][ip];
01256
01257   /* Get temperature... */
01258   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
    lon[ip],
01259                   atm->lat[ip], NULL, &T, NULL, NULL, NULL, NULL, NULL);
01260
01261   /* Density of dry air... */
01262   rho = p / (R * T);
01263
01264   /* Dynamic viscosity of air... */
01265   eta = 1.8325e-5 * (416.16 / (T + 120.)) * pow(T / 296.16, 1.5);
01266
01267   /* Thermal velocity of an air molecule... */
01268   v = sqrt(8 * GSL_CONST_MKSA_BOLTZMANN * T / (M_PI * m));
01269
01270   /* Mean free path of an air molecule... */
01271   lambda = 2 * eta / (rho * v);
01272
01273   /* Knudsen number for air... */
01274   K = lambda / r_p;
01275
01276   /* Cunningham slip-flow correction... */
01277   G = 1 + K * (A + B * exp(-C / K));
01278
01279   /* Sedimentation (fall) velocity... */
01280   v_p =
01281     2. * gsl_pow_2(r_p) * (rho_p -
01282                            rho) * GSL_CONST_MKSA_GRAV_ACCEL / (9. * eta) * G;
01283
01284   /* Calculate pressure change... */
01285   atm->p[ip] += dz2dp(v_p * dt / 1000., atm->p[ip]);
01286 }
01287
01288 /*****************************************************************************/
01289
01290 void write_output(
01291   const char *dirname,
01292   ctl_t * ctl,
01293   met_t * met0,
01294   met_t * met1,
01295   atm_t * atm,
01296   double t) {
01297
01298   char filename[LEN];
01299
01300   double r;
01301
01302   int year, mon, day, hour, min, sec;
01303
01304   /* Get time... */
01305   jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01306
01307   /* Write atmospheric data... */
01308   if (ctl->atm_basename[0] != '-' && fmod(t, ctl->atm_dt_out) == 0) {
01309     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
01310             dirname, ctl->atm_basename, year, mon, day, hour, min);
01311     write_atm(filename, ctl, atm, t);
01312   }
01313
01314   /* Write CSI data... */
01315   if (ctl->csi_basename[0] != '-') {
01316     sprintf(filename, "%s/%s.tab", dirname, ctl->csi_basename);
01317     write_csi(filename, ctl, atm, t);
01318   }
01319
01320   /* Write ensemble data... */
01321   if (ctl->ens_basename[0] != '-') {
01322     sprintf(filename, "%s/%s.tab", dirname, ctl->ens_basename);
01323     write_ens(filename, ctl, atm, t);
01324   }
01325
01326   /* Write gridded data... */
01327   if (ctl->grid_basename[0] != '-' && fmod(t, ctl->grid_dt_out) == 0) {
01328     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
01329             dirname, ctl->grid_basename, year, mon, day, hour, min);
01330     write_grid(filename, ctl, met0, met1, atm, t);
01331   }
01332
01333   /* Write profile data... */
01334   if (ctl->prof_basename[0] != '-') {
01335     sprintf(filename, "%s/%s.tab", dirname, ctl->prof_basename);
01336     write_prof(filename, ctl, met0, met1, atm, t);
01337   }
01338
```

```
01339   /* Write station data... */
01340   if (ctl->stat_basename[0] != '-') {
01341     sprintf(filename, "%s/%s.tab", dirname, ctl->stat_basename);
01342     write_station(filename, ctl, atm, t);
01343   }
01344 }
```

5.33 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[])

5.33.1 Detailed Description

Create meteorological data files with synthetic wind fields.

Definition in file wind.c.

5.33.2 Function Documentation

5.33.2.1 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 }
```

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

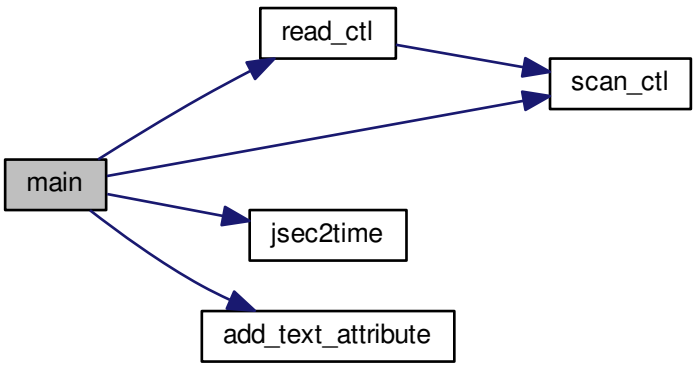
Definition at line 41 of file wind.c.

```
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:



5.34 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   Copright (C) 2013-2015 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 }
```

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