MPTRAC

Generated by Doxygen 1.8.11

Contents

1 Main Page

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

2 Data Structure Index

2.1 Data Structures

Here are the data structures with brief descriptions:

3 File Index

3.1 File List

Here is a list of all files with brief descriptions:

4 Data Structure Documentation

4.1 atm_t Struct Reference

Atmospheric data.

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

Data Fields

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

4.1.2 Field Documentation

4.1.2.1 int atm_t::np

Number of air pacels.

Definition at line 438 of file libtrac.h.

4.1.2.2 double atm_t::time[NP]

Time [s].

Definition at line 441 of file libtrac.h.

4.1.2.3 double atm_t::p[NP]

Pressure [hPa].

Definition at line 444 of file libtrac.h.

4.1.2.4 double atm_t::lon[NP]

Longitude [deg].

Definition at line 447 of file libtrac.h.

4.1.2.5 double atm_t::lat[NP]

Latitude [deg].

Definition at line 450 of file libtrac.h.

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

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

Definition at line 453 of file libtrac.h.

4.1.2.7 double atm_t::up[NP]

Zonal wind perturbation [m/s].

Definition at line 456 of file libtrac.h.

4.1.2.8 double atm_t::vp[NP]

Meridional wind perturbation [m/s].

Definition at line 459 of file libtrac.h.

4.1.2.9 double atm_t::wp[NP]

Vertical velocity perturbation [hPa/s].

Definition at line 462 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_t0
  Quantity array index for trajectory start time.
- 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_tnat
  Quantity array index for T_NAT.
- int qnt_stat
  Quantity array index for station flag.
- int direction
  Direction flag (1=forward calculation, -1=backward calculation).
- double t_start
  Start time of simulation [s].
- double t_stop
  Stop time of simulation [s].
- double dt_mod
  Time step of simulation [s].
- double dt_met
  Time step of meteorological data [s].
- int met_np
  Number of target pressure levels.
- double met_p [EP]
  Target pressure levels [hPa].
- 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].
- 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 psc_basename [LEN]

  Basename of PSC 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 177 of file libtrac.h.

4.2.2 Field Documentation

4.2.2.1 int ctl_t::nq

Number of quantities.

Definition at line 180 of file libtrac.h.

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

Quantity names.

Definition at line 183 of file libtrac.h.

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

Quantity units.

Definition at line 186 of file libtrac.h.

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

Quantity output format.

Definition at line 189 of file libtrac.h.

4.2.2.5 int ctl_t::qnt_t0

Quantity array index for trajectory start time.

Definition at line 192 of file libtrac.h.

4.2.2.6 int ctl_t::qnt_m

Quantity array index for mass.

Definition at line 195 of file libtrac.h.

4.2.2.7 int ctl_t::qnt_rho

Quantity array index for particle density.

Definition at line 198 of file libtrac.h.

4.2.2.8 int ctl_t::qnt_r

Quantity array index for particle radius.

Definition at line 201 of file libtrac.h.

4.2.2.9 int ctl_t::qnt_ps

Quantity array index for surface pressure.

Definition at line 204 of file libtrac.h.

4.2.2.10 int ctl_t::qnt_p

Quantity array index for pressure.

Definition at line 207 of file libtrac.h.

4.2.2.11 int ctl_t::qnt_t

Quantity array index for temperature.

Definition at line 210 of file libtrac.h.

4.2.2.12 int ctl_t::qnt_u

Quantity array index for zonal wind.

Definition at line 213 of file libtrac.h.

4.2.2.13 int ctl_t::qnt_v

Quantity array index for meridional wind.

Definition at line 216 of file libtrac.h.

4.2.2.14 int ctl_t::qnt_w

Quantity array index for vertical velocity.

Definition at line 219 of file libtrac.h.

4.2.2.15 int ctl_t::qnt_h2o

Quantity array index for water vapor vmr.

Definition at line 222 of file libtrac.h.

4.2.2.16 int ctl_t::qnt_o3

Quantity array index for ozone vmr.

Definition at line 225 of file libtrac.h.

4.2.2.17 int ctl_t::qnt_theta

Quantity array index for potential temperature.

Definition at line 228 of file libtrac.h.

4.2.2.18 int ctl_t::qnt_pv

Quantity array index for potential vorticity.

Definition at line 231 of file libtrac.h.

4.2.2.19 int ctl_t::qnt_tice

Quantity array index for T_ice.

Definition at line 234 of file libtrac.h.

4.2.2.20 int ctl_t::qnt_tnat

Quantity array index for T_NAT.

Definition at line 237 of file libtrac.h.

4.2.2.21 int ctl_t::qnt_stat

Quantity array index for station flag.

Definition at line 240 of file libtrac.h.

4.2.2.22 int ctl_t::direction

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

Definition at line 243 of file libtrac.h.

4.2.2.23 double ctl_t::t_start

Start time of simulation [s].

Definition at line 246 of file libtrac.h.

4.2.2.24 double ctl_t::t_stop

Stop time of simulation [s].

Definition at line 249 of file libtrac.h.

4.2.2.25 double ctl_t::dt_mod

Time step of simulation [s].

Definition at line 252 of file libtrac.h.

4.2.2.26 double ctl_t::dt_met

Time step of meteorological data [s].

Definition at line 255 of file libtrac.h.

4.2.2.27 int ctl_t::met_np

Number of target pressure levels.

Definition at line 258 of file libtrac.h.

4.2.2.28 double ctl_t::met_p[EP]

Target pressure levels [hPa].

Definition at line 261 of file libtrac.h.

4.2.2.29 int ctl_t::isosurf

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

Definition at line 265 of file libtrac.h.

4.2.2.30 char ctl_t::balloon[LEN]

Balloon position filename.

Definition at line 268 of file libtrac.h.

4.2.2.31 double ctl_t::turb_dx_trop

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

Definition at line 271 of file libtrac.h.

4.2.2.32 double ctl_t::turb_dx_strat

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

Definition at line 274 of file libtrac.h.

4.2.2.33 double ctl_t::turb_dz_trop

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

Definition at line 277 of file libtrac.h.

4.2.2.34 double ctl_t::turb_dz_strat

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

Definition at line 280 of file libtrac.h.

4.2.2.35 double ctl_t::turb_meso

Scaling factor for mesoscale wind fluctuations.

Definition at line 283 of file libtrac.h.

4.2.2.36 double ctl_t::tdec_trop

Life time of particles (troposphere) [s].

Definition at line 286 of file libtrac.h.

4.2.2.37 double ctl_t::tdec_strat

Life time of particles (stratosphere) [s].

Definition at line 289 of file libtrac.h.

4.2.2.38 char ctl_t::atm_basename[LEN]

Basename of atmospheric data files.

Definition at line 292 of file libtrac.h.

4.2.2.39 char ctl_t::atm_gpfile[LEN]

Gnuplot file for atmospheric data.

Definition at line 295 of file libtrac.h.

4.2.2.40 double ctl_t::atm_dt_out

Time step for atmospheric data output [s].

Definition at line 298 of file libtrac.h.

4.2.2.41 int ctl_t::atm_filter

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

Definition at line 301 of file libtrac.h.

4.2.2.42 char ctl_t::csi_basename[LEN]

Basename of CSI data files.

Definition at line 304 of file libtrac.h.

4.2.2.43 double ctl_t::csi_dt_out

Time step for CSI data output [s].

Definition at line 307 of file libtrac.h.

4.2.2.44 char ctl_t::csi_obsfile[LEN]

Observation data file for CSI analysis.

Definition at line 310 of file libtrac.h.

4.2.2.45 double ctl_t::csi_obsmin

Minimum observation index to trigger detection.

Definition at line 313 of file libtrac.h.

4.2.2.46 double ctl_t::csi_modmin

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

Definition at line 316 of file libtrac.h.

4.2.2.47 int ctl_t::csi_nz

Number of altitudes of gridded CSI data.

Definition at line 319 of file libtrac.h.

4.2.2.48 double ctl_t::csi_z0

Lower altitude of gridded CSI data [km].

Definition at line 322 of file libtrac.h.

4.2.2.49 double ctl_t::csi_z1

Upper altitude of gridded CSI data [km].

Definition at line 325 of file libtrac.h.

4.2.2.50 int ctl_t::csi_nx

Number of longitudes of gridded CSI data.

Definition at line 328 of file libtrac.h.

4.2.2.51 double ctl_t::csi_lon0

Lower longitude of gridded CSI data [deg].

Definition at line 331 of file libtrac.h.

4.2.2.52 double ctl_t::csi_lon1

Upper longitude of gridded CSI data [deg].

Definition at line 334 of file libtrac.h.

4.2.2.53 int ctl_t::csi_ny

Number of latitudes of gridded CSI data.

Definition at line 337 of file libtrac.h.

4.2.2.54 double ctl_t::csi_lat0

Lower latitude of gridded CSI data [deg].

Definition at line 340 of file libtrac.h.

4.2.2.55 double ctl_t::csi_lat1

Upper latitude of gridded CSI data [deg].

Definition at line 343 of file libtrac.h.

4.2.2.56 char ctl_t::grid_basename[LEN]

Basename of grid data files.

Definition at line 346 of file libtrac.h.

4.2.2.57 char ctl_t::grid_gpfile[LEN]

Gnuplot file for gridded data.

Definition at line 349 of file libtrac.h.

4.2.2.58 double ctl_t::grid_dt_out

Time step for gridded data output [s].

Definition at line 352 of file libtrac.h.

4.2.2.59 int ctl_t::grid_sparse

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

Definition at line 355 of file libtrac.h.

4.2.2.60 int ctl_t::grid_nz

Number of altitudes of gridded data.

Definition at line 358 of file libtrac.h.

4.2.2.61 double ctl_t::grid_z0

Lower altitude of gridded data [km].

Definition at line 361 of file libtrac.h.

4.2.2.62 double ctl_t::grid_z1

Upper altitude of gridded data [km].

Definition at line 364 of file libtrac.h.

4.2.2.63 int ctl_t::grid_nx

Number of longitudes of gridded data.

Definition at line 367 of file libtrac.h.

4.2.2.64 double ctl_t::grid_lon0

Lower longitude of gridded data [deg].

Definition at line 370 of file libtrac.h.

4.2.2.65 double ctl_t::grid_lon1

Upper longitude of gridded data [deg].

Definition at line 373 of file libtrac.h.

4.2.2.66 int ctl_t::grid_ny

Number of latitudes of gridded data.

Definition at line 376 of file libtrac.h.

4.2.2.67 double ctl_t::grid_lat0

Lower latitude of gridded data [deg].

Definition at line 379 of file libtrac.h.

4.2.2.68 double ctl_t::grid_lat1

Upper latitude of gridded data [deg].

Definition at line 382 of file libtrac.h.

4.2.2.69 char ctl_t::prof_basename[LEN]

Basename for profile output file.

Definition at line 385 of file libtrac.h.

4.2.2.70 char ctl_t::prof_obsfile[LEN]

Observation data file for profile output.

Definition at line 388 of file libtrac.h.

4.2.2.71 int ctl_t::prof_nz

Number of altitudes of gridded profile data.

Definition at line 391 of file libtrac.h.

4.2.2.72 double ctl_t::prof_z0

Lower altitude of gridded profile data [km].

Definition at line 394 of file libtrac.h.

4.2.2.73 double ctl_t::prof_z1

Upper altitude of gridded profile data [km].

Definition at line 397 of file libtrac.h.

4.2.2.74 int ctl_t::prof_nx

Number of longitudes of gridded profile data.

Definition at line 400 of file libtrac.h.

4.2.2.75 double ctl_t::prof_lon0

Lower longitude of gridded profile data [deg].

Definition at line 403 of file libtrac.h.

4.2.2.76 double ctl_t::prof_lon1

Upper longitude of gridded profile data [deg].

Definition at line 406 of file libtrac.h.

4.2.2.77 int ctl_t::prof_ny

Number of latitudes of gridded profile data.

Definition at line 409 of file libtrac.h.

4.2.2.78 double ctl_t::prof_lat0

Lower latitude of gridded profile data [deg].

Definition at line 412 of file libtrac.h.

4.2.2.79 double ctl_t::prof_lat1

Upper latitude of gridded profile data [deg].

Definition at line 415 of file libtrac.h.

4.2.2.80 char ctl_t::psc_basename[LEN]

Basename of PSC data file.

Definition at line 418 of file libtrac.h.

4.2.2.81 char ctl_t::stat_basename[LEN]

Basename of station data file.

Definition at line 421 of file libtrac.h.

4.2.2.82 double ctl_t::stat_lon

Longitude of station [deg].

Definition at line 424 of file libtrac.h.

4.2.2.83 double ctl_t::stat_lat

Latitude of station [deg].

Definition at line 427 of file libtrac.h.

4.2.2.84 double ctl_t::stat_r

Search radius around station [km].

Definition at line 430 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 467 of file libtrac.h.

4.3.2 Field Documentation

4.3.2.1 double met_t::time

Time [s].

Definition at line 470 of file libtrac.h.

4.3.2.2 int met_t::nx

Number of longitudes.

Definition at line 473 of file libtrac.h.

4.3.2.3 int met_t::ny

Number of latitudes.

Definition at line 476 of file libtrac.h.

4.3.2.4 int met_t::np

Number of pressure levels.

Definition at line 479 of file libtrac.h.

4.3.2.5 double met_t::lon[EX]

Longitude [deg].

Definition at line 482 of file libtrac.h.

4.3.2.6 double met_t::lat[EY]

Latitude [deg].

Definition at line 485 of file libtrac.h.

4.3.2.7 double met_t::p[EP]

Pressure [hPa].

Definition at line 488 of file libtrac.h.

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

Surface pressure [hPa].

Definition at line 491 of file libtrac.h.

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

Pressure on model levels [hPa].

Definition at line 494 of file libtrac.h.

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

Temperature [K].

Definition at line 497 of file libtrac.h.

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

Zonal wind [m/s].

Definition at line 500 of file libtrac.h.

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

Meridional wind [m/s].

Definition at line 503 of file libtrac.h.

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

Vertical wind [hPa/s].

Definition at line 506 of file libtrac.h.

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

Water vapor volume mixing ratio [1].

Definition at line 509 of file libtrac.h.

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

Ozone volume mixing ratio [1].

Definition at line 512 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

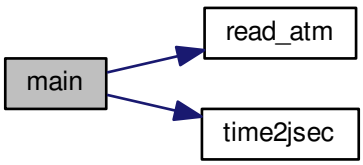
5.1.2.1 int main (int *argc,* char ∗ *argv[ ]*)

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 *name, *year, *mon, *day, *hour, *min;
00039
00040   double latm, lats, lonm, lons, t, zm, zs;
00041
00042   int i, f, ip;
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 date from filename... */
00123     for (i = (int) strlen(argv[f]) - 1; argv[f][i] != '/' || i == 0; i--);
00124     name = strtok(&(argv[f][i]), "_");
00125     year = strtok(NULL, "_");
00126     mon = strtok(NULL, "_");
00127     day = strtok(NULL, "_");
00128     hour = strtok(NULL, "_");
00129     name = strtok(NULL, "_");   /* TODO: Why another "name" here? */
00130     min = strtok(name, ".");
00131     time2jsec(atoi(year), atoi(mon), atoi(day), atoi(hour), atoi(min), 0, 0,
00132               &t);
00133
00134     /* Write data... */
00135     fprintf(out, "%.2f %g %g %g %g %g %g %g %g "
00136             "%g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00137             t, zm, zs, Z(atm->p[atm->np - 1]),
00138             Z(atm->p[atm->np - atm->np / 10]),
00139             Z(atm->p[atm->np - atm->np / 4]),
00140             Z(atm->p[atm->np / 2]), Z(atm->p[atm->np / 4]),
00141             Z(atm->p[atm->np / 10]), Z(atm->p[0]),
00142             lonm, lons, atm->lon[0], atm->lon[atm->np / 10],
00143             atm->lon[atm->np / 4], atm->lon[atm->np / 2],
00144             atm->lon[atm->np - atm->np / 4],
00145             atm->lon[atm->np - atm->np / 10],
00146             atm->lon[atm->np - 1],
00147             latm, lats, atm->lat[0], atm->lat[atm->np / 10],
00148             atm->lat[atm->np / 4], atm->lat[atm->np / 2],
00149             atm->lat[atm->np - atm->np / 4],
00150             atm->lat[atm->np - atm->np / 10], atm->lat[atm->np - 1]);
00151   }
00152
00153   /* Close file... */
00154   fclose(out);
00155
00156   /* Free... */
00157   free(atm);
00158
00159   return EXIT_SUCCESS;
00160 }
```

Here is the call graph for this function:



5.2 center.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
```

```
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2015 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 *name, *year, *mon, *day, *hour, *min;
00039
00040   double latm, lats, lonm, lons, t, zm, zs;
00041
00042   int i, f, ip;
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 date from filename... */
00123     for (i = (int) strlen(argv[f]) - 1; argv[f][i] != '/' || i == 0; i--);
00124     name = strtok(&(argv[f][i]), "_");
00125     year = strtok(NULL, "_");
00126     mon = strtok(NULL, "_");
00127     day = strtok(NULL, "_");
00128     hour = strtok(NULL, "_");
00129     name = strtok(NULL, "_");   /* TODO: Why another "name" here? */
00130     min = strtok(name, ".");
00131     time2jsec(atoi(year), atoi(mon), atoi(day), atoi(hour), atoi(min), 0, 0,
00132               &t);
00133
00134     /* Write data... */
00135     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g "
00136             "%g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
00137             t, zm, zs, Z(atm->p[atm->np - 1]),
00138             Z(atm->p[atm->np - atm->np / 10]),
00139             Z(atm->p[atm->np - atm->np / 4]),
00140             Z(atm->p[atm->np / 2]), Z(atm->p[atm->np / 4]),
00141             Z(atm->p[atm->np / 10]), Z(atm->p[0]),
00142             lonm, lons, atm->lon[0], atm->lon[atm->np / 10],
00143             atm->lon[atm->np / 4], atm->lon[atm->np / 2],
00144             atm->lon[atm->np - atm->np / 4],
00145             atm->lon[atm->np - atm->np / 10],
00146             atm->lon[atm->np - 1],
00147             latm, lats, atm->lat[0], atm->lat[atm->np / 10],
00148             atm->lat[atm->np / 4], atm->lat[atm->np / 2],
00149             atm->lat[atm->np - atm->np / 4],
00150             atm->lat[atm->np - atm->np / 10], atm->lat[atm->np - 1]);
00151   }
00152
00153   /* Close file... */
00154   fclose(out);
00155
00156   /* Free... */
00157   free(atm);
00158
00159   return EXIT_SUCCESS;
00160 }
```

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[]*)

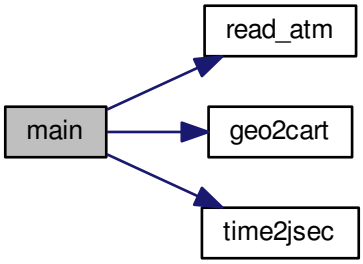
Definition at line 28 of file dist.c.

```
00030                {
00031
00032   ctl_t ctl;
00033
00034   atm_t *atm1, *atm2;
00035
00036   FILE *out;
00037
00038   char *name, *year, *mon, *day, *hour, *min;
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, i, ip, iph, ipv;
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 date from filename... */
00195     for (i = (int) strlen(argv[f]) - 1; argv[f][i] != '/' || i == 0; i--);
00196     name = strtok(&(argv[f][i]), "_");
00197     year = strtok(NULL, "_");
00198     mon = strtok(NULL, "_");
00199     day = strtok(NULL, "_");
00200     hour = strtok(NULL, "_");
00201     name = strtok(NULL, "_");   /* TODO: Why another "name" here? */
00202     min = strtok(name, ".");
00203     time2jsec(atoi(year), atoi(mon), atoi(day), atoi(hour), atoi(min), 0, 0,
00204               &t);
00205
00206     /* Write output... */
00207     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %d %g %g"
00208             " %g %g %g %g %g %g %g %g %g %d %g %g\n", t,
00209             ahtd / atm1->np,
00210             sqrt(ahtd2 / atm1->np - gsl_pow_2(ahtd / atm1->np)),
00211             dh[0], dh[atm1->np / 10], dh[atm1->np / 4], dh[atm1->np / 2],
00212             dh[atm1->np - atm1->np / 4], dh[atm1->np - atm1->np / 10],
00213             dh[atm1->np - 1], iph, rhtd / atm1->np,
00214             sqrt(rhtd2 / atm1->np - gsl_pow_2(rhtd / atm1->np)),
00215             avtd / atm1->np,
00216             sqrt(avtd2 / atm1->np - gsl_pow_2(avtd / atm1->np)),
00217             dv[0], dv[atm1->np / 10], dv[atm1->np / 4], dv[atm1->np / 2],
00218             dv[atm1->np - atm1->np / 4], dv[atm1->np - atm1->np / 10],
00219             dv[atm1->np - 1], ipv, rvtd / atm1->np,
00220             sqrt(rvtd2 / atm1->np - gsl_pow_2(rvtd / atm1->np)));
00221   }
00222
00223   /* Close file... */
00224   fclose(out);
00225
00226   /* Free... */
00227   free(atm1);
00228   free(atm2);
00229   free(lon1);
00230   free(lat1);
00231   free(p1);
00232   free(lh1);
00233   free(lv1);
00234   free(lon2);
00235   free(lat2);
00236   free(p2);
00237   free(lh2);
00238   free(lv2);
00239   free(dh);
00240   free(dv);
00241
00242   return EXIT_SUCCESS;
00243 }
```

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 *name, *year, *mon, *day, *hour, *min;
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, i, ip, iph, ipv;
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 date from filename... */
00195     for (i = (int) strlen(argv[f]) - 1; argv[f][i] != '/' || i == 0; i--);
00196     name = strtok(&(argv[f][i]), "_");
00197     year = strtok(NULL, "_");
00198     mon = strtok(NULL, "_");
00199     day = strtok(NULL, "_");
00200     hour = strtok(NULL, "_");
00201     name = strtok(NULL, "_");   /* TODO: Why another "name" here? */
00202     min = strtok(name, ".");
00203     time2jsec(atoi(year), atoi(mon), atoi(day), atoi(hour), atoi(min), 0, 0,
00204               &t);
00205
00206     /* Write output... */
00207     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %d %g %g"
00208             " %g %g %g %g %g %g %g %g %g %d %g %g\n", t,
00209             ahtd / atm1->np,
00210             sqrt(ahtd2 / atm1->np - gsl_pow_2(ahtd / atm1->np)),
00211             dh[0], dh[atm1->np / 10], dh[atm1->np / 4], dh[atm1->np / 2],
00212             dh[atm1->np - atm1->np / 4], dh[atm1->np - atm1->np / 10],
00213             dh[atm1->np - 1], iph, rhtd / atm1->np,
00214             sqrt(rhtd2 / atm1->np - gsl_pow_2(rhtd / atm1->np)),
00215             avtd / atm1->np,
00216             sqrt(avtd2 / atm1->np - gsl_pow_2(avtd / atm1->np)),
00217             dv[0], dv[atm1->np / 10], dv[atm1->np / 4], dv[atm1->np / 2],
00218             dv[atm1->np - atm1->np / 4], dv[atm1->np - atm1->np / 10],
00219             dv[atm1->np - 1], ipv, rvtd / atm1->np,
00220             sqrt(rvtd2 / atm1->np - gsl_pow_2(rvtd / atm1->np)));
00221   }
00222
00223   /* Close file... */
00224   fclose(out);
00225
00226   /* Free... */
00227   free(atm1);
00228   free(atm2);
00229   free(lon1);
00230   free(lat1);
00231   free(p1);
00232   free(lh1);
00233   free(lv1);
00234   free(lon2);
00235   free(lat2);
00236   free(p2);
00237   free(lh2);
00238   free(lv2);
00239   free(dh);
00240   free(dv);
00241
00242   return EXIT_SUCCESS;
00243 }
```

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.

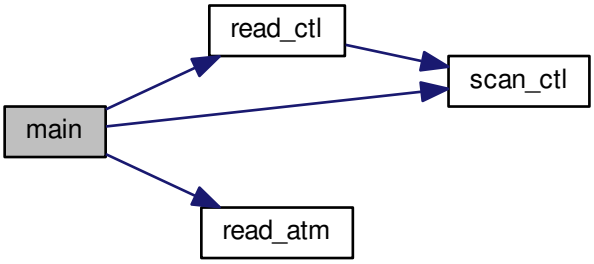
5.5.2 Function Documentation

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

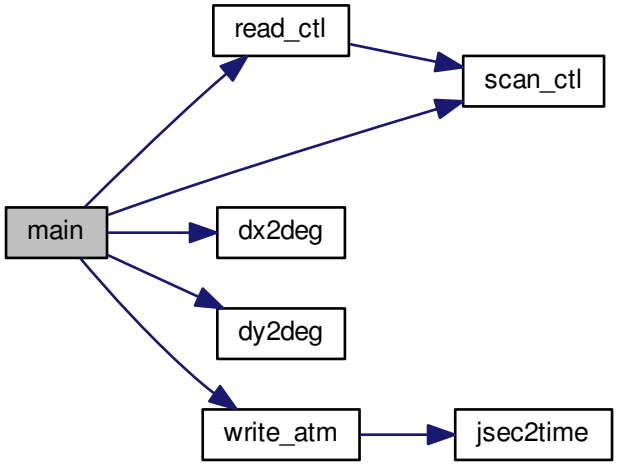
5.7.2.1 int main (int *argc,* char ∗ *argv[ ]*)

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 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   rep = (int) scan_ctl(argv[1], argc, argv, "INIT_REP", -1, "1", NULL);
00073   m = scan_ctl(argv[1], argc, argv, "INIT_MASS", -1, "0", NULL);
00074
00075   /* Initialize random number generator... */
00076   gsl_rng_env_setup();
00077   rng = gsl_rng_alloc(gsl_rng_default);
00078
00079   /* Create grid... */
00080   for (t = t0; t <= t1; t += dt)
00081     for (z = z0; z <= z1; z += dz)
00082       for (lon = lon0; lon <= lon1; lon += dlon)
00083         for (lat = lat0; lat <= lat1; lat += dlat)
00084           for (irep = 0; irep < rep; irep++) {
00085
00086             /* Set position... */
00087             atm->time[atm->np]
00088               = (t + gsl_ran_gaussian_ziggurat(rng, st / 2.3548)
00089                  + ut * (gsl_rng_uniform(rng) - 0.5));
00090             atm->p[atm->np]
00091               = P(z + gsl_ran_gaussian_ziggurat(rng, sz / 2.3548)
00092                   + uz * (gsl_rng_uniform(rng) - 0.5));
00093             atm->lon[atm->np]
00094               = (lon + gsl_ran_gaussian_ziggurat(rng, slon / 2.3548)
00095                  + gsl_ran_gaussian_ziggurat(rng, dx2deg(sx, lat) / 2.3548)
00096                  + ulon * (gsl_rng_uniform(rng) - 0.5));
00097             atm->lat[atm->np]
00098               = (lat + gsl_ran_gaussian_ziggurat(rng, slat / 2.3548)
00099                  + gsl_ran_gaussian_ziggurat(rng, dy2deg(sx) / 2.3548)
00100                  + ulat * (gsl_rng_uniform(rng) - 0.5));
00101
00102             /* Set particle counter... */
00103             if ((++atm->np) >= NP)
00104               ERRMSG("Too many particles!");
00105           }
00106
00107   /* Check number of air parcels... */
00108   if (atm->np <= 0)
00109     ERRMSG("Did not create any air parcels!");
00110
00111   /* Initialize mass... */
00112   if (ctl.qnt_m >= 0)
00113     for (ip = 0; ip < atm->np; ip++)
00114       atm->q[ctl.qnt_m][ip] = m / atm->np;
00115
```

```
00116   /* Save data... */
00117   write_atm(argv[2], &ctl, atm, t0);
00118
00119   /* Free... */
00120   gsl_rng_free(rng);
00121   free(atm);
00122
00123   return EXIT_SUCCESS;
00124 }
```

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   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;
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 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   rep = (int) scan_ctl(argv[1], argc, argv, "INIT_REP", -1, "1", NULL);
00073   m = scan_ctl(argv[1], argc, argv, "INIT_MASS", -1, "0", NULL);
00074
00075   /* Initialize random number generator... */
00076   gsl_rng_env_setup();
00077   rng = gsl_rng_alloc(gsl_rng_default);
00078
00079   /* Create grid... */
00080   for (t = t0; t <= t1; t += dt)
00081     for (z = z0; z <= z1; z += dz)
00082       for (lon = lon0; lon <= lon1; lon += dlon)
00083         for (lat = lat0; lat <= lat1; lat += dlat)
00084           for (irep = 0; irep < rep; irep++) {
00085
00086             /* Set position... */
00087             atm->time[atm->np]
00088               = (t + gsl_ran_gaussian_ziggurat(rng, st / 2.3548)
00089                  + ut * (gsl_rng_uniform(rng) - 0.5));
00090             atm->p[atm->np]
00091               = P(z + gsl_ran_gaussian_ziggurat(rng, sz / 2.3548)
00092                   + uz * (gsl_rng_uniform(rng) - 0.5));
00093             atm->lon[atm->np]
00094               = (lon + gsl_ran_gaussian_ziggurat(rng, slon / 2.3548)
00095                  + gsl_ran_gaussian_ziggurat(rng, dx2deg(sx, lat) / 2.3548)
00096                  + ulon * (gsl_rng_uniform(rng) - 0.5));
00097             atm->lat[atm->np]
00098               = (lat + gsl_ran_gaussian_ziggurat(rng, slat / 2.3548)
00099                  + gsl_ran_gaussian_ziggurat(rng, dy2deg(sx) / 2.3548)
00100                  + ulat * (gsl_rng_uniform(rng) - 0.5));
00101
00102             /* Set particle counter... */
00103             if ((++atm->np) >= NP)
00104               ERRMSG("Too many particles!");
00105           }
00106
00107   /* Check number of air parcels... */
00108   if (atm->np <= 0)
00109     ERRMSG("Did not create any air parcels!");
00110
00111   /* Initialize mass... */
00112   if (ctl.qnt_m >= 0)
00113     for (ip = 0; ip < atm->np; ip++)
00114       atm->q[ctl.qnt_m][ip] = m / atm->np;
00115
00116   /* Save data... */
00117   write_atm(argv[2], &ctl, atm, t0);
00118
00119   /* Free... */
00120   gsl_rng_free(rng);
00121   free(atm);
00122
00123   return EXIT_SUCCESS;
00124 }
```

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.

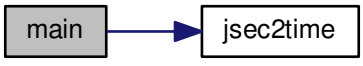
5.9.2 Function Documentation

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   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   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_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_psc (const char *filename, ctl_t *ctl, atm_t *atm, double t)

  Write PSC 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 }
```

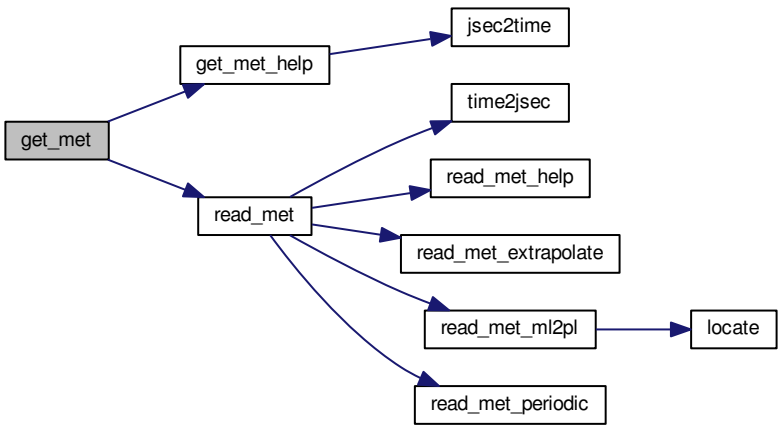
5.11.2.9 void get_met (ctl_t * *ctl,* char * *metbase,* double *t,* met_t * *met0,* met_t * *met1*)

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:



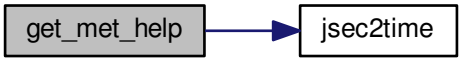
5.11.2.10 void get_met_help (double *t,* int *direct,* char * *metbase,* double *dt_met,* char * *filename*)

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 }
```

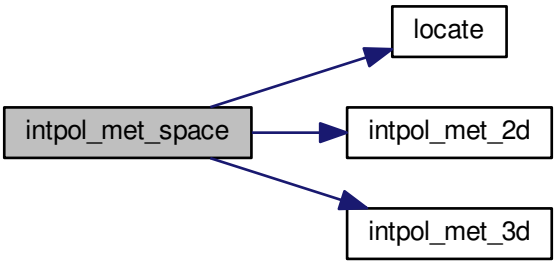
5.11.2.13 void intpol_met_space (met_t * *met*, double *p*, double *lon*, double *lat*, double * *ps*, double * *t*, double * *u*, double * *v*, double * *w*, double * *h2o*, double * *o3*)

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:



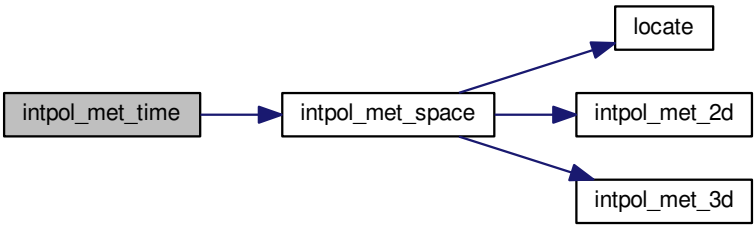
5.11.2.14 void intpol_met_time (met_t * *met0*, met_t * *met1*, double *ts*, double *p*, double *lon*, double *lat*, double * *ps*, double * *t*, double * *u*, double * *v*, double * *w*, double * *h2o*, double * *o3*)

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_t0 = -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_tnat = -1;
00488   ctl->qnt_stat = -1;
00489
00490   /* Read quantities... */
00491   ctl->nq = (int) scan_ctl(filename, argc, argv, "NQ", -1, "0", NULL);
00492   for (iq = 0; iq < ctl->nq; iq++) {
00493
00494     /* Read quantity name and format... */
00495     scan_ctl(filename, argc, argv, "QNT_NAME", iq, "", ctl->qnt_name[iq]);
00496     scan_ctl(filename, argc, argv, "QNT_FORMAT", iq, "%g",
00497              ctl->qnt_format[iq]);
00498
00499     /* Try to identify quantity... */
00500     if (strcmp(ctl->qnt_name[iq], "t0") == 0) {
00501       ctl->qnt_t0 = iq;
00502       sprintf(ctl->qnt_unit[iq], "s");
00503     } else if (strcmp(ctl->qnt_name[iq], "m") == 0) {
00504       ctl->qnt_m = iq;
00505       sprintf(ctl->qnt_unit[iq], "kg");
00506     } else if (strcmp(ctl->qnt_name[iq], "r") == 0) {
00507       ctl->qnt_r = iq;
00508       sprintf(ctl->qnt_unit[iq], "m");
00509     } else if (strcmp(ctl->qnt_name[iq], "rho") == 0) {
00510       ctl->qnt_rho = iq;
00511       sprintf(ctl->qnt_unit[iq], "kg/m^3");
00512     } else if (strcmp(ctl->qnt_name[iq], "ps") == 0) {
00513       ctl->qnt_ps = iq;
00514       sprintf(ctl->qnt_unit[iq], "hPa");
00515     } else if (strcmp(ctl->qnt_name[iq], "p") == 0) {
00516       ctl->qnt_p = iq;
00517       sprintf(ctl->qnt_unit[iq], "hPa");
00518     } else if (strcmp(ctl->qnt_name[iq], "t") == 0) {
00519       ctl->qnt_t = iq;
00520       sprintf(ctl->qnt_unit[iq], "K");
00521     } else if (strcmp(ctl->qnt_name[iq], "u") == 0) {
00522       ctl->qnt_u = iq;
00523       sprintf(ctl->qnt_unit[iq], "m/s");
00524     } else if (strcmp(ctl->qnt_name[iq], "v") == 0) {
00525       ctl->qnt_v = iq;
00526       sprintf(ctl->qnt_unit[iq], "m/s");
00527     } else if (strcmp(ctl->qnt_name[iq], "w") == 0) {
00528       ctl->qnt_w = iq;
00529       sprintf(ctl->qnt_unit[iq], "hPa/s");
00530     } else if (strcmp(ctl->qnt_name[iq], "h2o") == 0) {
00531       ctl->qnt_h2o = iq;
00532       sprintf(ctl->qnt_unit[iq], "1");
00533     } else if (strcmp(ctl->qnt_name[iq], "o3") == 0) {
00534       ctl->qnt_o3 = iq;
00535       sprintf(ctl->qnt_unit[iq], "1");
00536     } else if (strcmp(ctl->qnt_name[iq], "theta") == 0) {
00537       ctl->qnt_theta = iq;
00538       sprintf(ctl->qnt_unit[iq], "K");
00539     } else if (strcmp(ctl->qnt_name[iq], "pv") == 0) {
00540       ctl->qnt_pv = iq;
00541       sprintf(ctl->qnt_unit[iq], "PVU");
00542     } else if (strcmp(ctl->qnt_name[iq], "tice") == 0) {
00543       ctl->qnt_tice = iq;
00544       sprintf(ctl->qnt_unit[iq], "K");
00545     } else if (strcmp(ctl->qnt_name[iq], "tnat") == 0) {
00546       ctl->qnt_tnat = iq;
00547       sprintf(ctl->qnt_unit[iq], "K");
00548     } else if (strcmp(ctl->qnt_name[iq], "stat") == 0) {
```

```
00549       ctl->qnt_stat = iq;
00550       sprintf(ctl->qnt_unit[iq], "-");
00551     } else
00552       scan_ctl(filename, argc, argv, "QNT_UNIT", iq, "", ctl->qnt_unit[iq]);
00553   }
00554
00555   /* Time steps of simulation... */
00556   ctl->direction =
00557     (int) scan_ctl(filename, argc, argv, "DIRECTION", -1, "1", NULL);
00558   if (ctl->direction != -1 && ctl->direction != 1)
00559     ERRMSG("Set DIRECTION to -1 or 1!");
00560   ctl->t_start =
00561     scan_ctl(filename, argc, argv, "T_START", -1, "-1e100", NULL);
00562   ctl->t_stop = scan_ctl(filename, argc, argv, "T_STOP", -1, "-1e100", NULL);
00563   ctl->dt_mod = scan_ctl(filename, argc, argv, "DT_MOD", -1, "600", NULL);
00564
00565   /* Meteorological data... */
00566   ctl->dt_met = scan_ctl(filename, argc, argv, "DT_MET", -1, "21600", NULL);
00567   ctl->met_np = (int) scan_ctl(filename, argc, argv, "MET_NP", -1, "0", NULL);
00568   if (ctl->met_np > EP)
00569     ERRMSG("Too many levels!");
00570   for (ip = 0; ip < ctl->met_np; ip++)
00571     ctl->met_p[ip] = scan_ctl(filename, argc, argv, "MET_P", ip, "", NULL);
00572
00573   /* Isosurface parameters... */
00574   ctl->isosurf
00575     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
00576   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
00577
00578   /* Diffusion parameters... */
00579   ctl->turb_dx_trop
00580     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50.0", NULL);
00581   ctl->turb_dx_strat
00582     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0.0", NULL);
00583   ctl->turb_dz_trop
00584     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0.0", NULL);
00585   ctl->turb_dz_strat
00586     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
00587   ctl->turb_meso =
00588     scan_ctl(filename, argc, argv, "TURB_MESO", -1, "0.16", NULL);
00589
00590   /* Life time of particles... */
00591   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
00592   ctl->tdec_strat =
00593     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
00594
00595   /* Output of atmospheric data... */
00596   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
     atm_basename);
00597   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
00598   ctl->atm_dt_out =
00599     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
00600   ctl->atm_filter =
00601     (int) scan_ctl(filename, argc, argv, "ATM_FILTER", -1, "0", NULL);
00602
00603   /* Output of CSI data... */
00604   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
     csi_basename);
00605   ctl->csi_dt_out =
00606     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
00607   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "obs.tab",
00608            ctl->csi_obsfile);
00609   ctl->csi_obsmin =
00610     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
00611   ctl->csi_modmin =
00612     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
00613   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
00614   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
00615   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
00616   ctl->csi_lon0 =
00617     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
00618   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
00619   ctl->csi_nx =
00620     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
00621   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
00622   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
00623   ctl->csi_ny =
00624     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
00625
00626   /* Output of grid data... */
00627   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
00628            ctl->grid_basename);
00629   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
     grid_gpfile);
00630   ctl->grid_dt_out =
00631     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
00632   ctl->grid_sparse =
```

```
00633     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
00634   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
00635   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
00636   ctl->grid_nz =
00637     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
00638   ctl->grid_lon0 =
00639     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
00640   ctl->grid_lon1 =
00641     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
00642   ctl->grid_nx =
00643     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
00644   ctl->grid_lat0 =
00645     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
00646   ctl->grid_lat1 =
00647     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
00648   ctl->grid_ny =
00649     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
00650
00651   /* Output of profile data... */
00652   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
00653            ctl->prof_basename);
00654   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
      prof_obsfile);
00655   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
00656   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
00657   ctl->prof_nz =
00658     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
00659   ctl->prof_lon0 =
00660     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
00661   ctl->prof_lon1 =
00662     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
00663   ctl->prof_nx =
00664     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
00665   ctl->prof_lat0 =
00666     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
00667   ctl->prof_lat1 =
00668     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
00669   ctl->prof_ny =
00670     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
00671
00672   /* Output of PSC data... */
00673   scan_ctl(filename, argc, argv, "PSC_BASENAME", -1, "-", ctl->
      psc_basename);
00674
00675   /* Output of station data... */
00676   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
00677            ctl->stat_basename);
00678   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
00679   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
00680   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
00681 }
```

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.

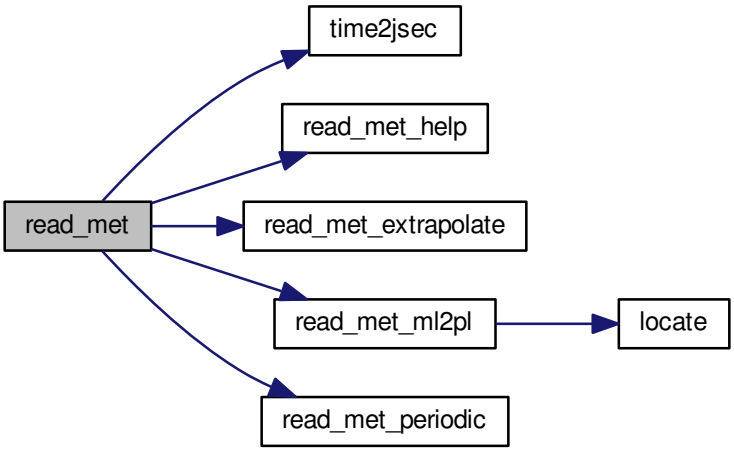
Definition at line 685 of file libtrac.c.

```
00688                {
00689
```

```
00690   char tstr[10];
00691
00692   static float help[EX * EY];
00693
00694   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
00695
00696   size_t np, nx, ny;
00697
00698   /* Write info... */
00699   printf("Read meteorological data: %s\n", filename);
00700
00701   /* Get time from filename... */
00702   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
00703   year = atoi(tstr);
00704   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
00705   mon = atoi(tstr);
00706   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
00707   day = atoi(tstr);
00708   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
00709   hour = atoi(tstr);
00710   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
00711
00712   /* Open netCDF file... */
00713   NC(nc_open(filename, NC_NOWRITE, &ncid));
00714
00715   /* Get dimensions... */
00716   NC(nc_inq_dimid(ncid, "lon", &dimid));
00717   NC(nc_inq_dimlen(ncid, dimid, &nx));
00718   if (nx > EX)
00719     ERRMSG("Too many longitudes!");
00720
00721   NC(nc_inq_dimid(ncid, "lat", &dimid));
00722   NC(nc_inq_dimlen(ncid, dimid, &ny));
00723   if (ny > EY)
00724     ERRMSG("Too many latitudes!");
00725
00726   NC(nc_inq_dimid(ncid, "lev", &dimid));
00727   NC(nc_inq_dimlen(ncid, dimid, &np));
00728   if (np > EP)
00729     ERRMSG("Too many levels!");
00730
00731   /* Store dimensions... */
00732   met->np = (int) np;
00733   met->nx = (int) nx;
00734   met->ny = (int) ny;
00735
00736   /* Get horizontal grid... */
00737   NC(nc_inq_varid(ncid, "lon", &varid));
00738   NC(nc_get_var_double(ncid, varid, met->lon));
00739   NC(nc_inq_varid(ncid, "lat", &varid));
00740   NC(nc_get_var_double(ncid, varid, met->lat));
00741
00742   /* Read meteorological data... */
00743   read_met_help(ncid, "t", "T", met, met->t, 1.0);
00744   read_met_help(ncid, "u", "U", met, met->u, 1.0);
00745   read_met_help(ncid, "v", "V", met, met->v, 1.0);
00746   read_met_help(ncid, "w", "W", met, met->w, 0.01f);
00747   read_met_help(ncid, "q", "Q", met, met->h2o, 1.608f);
00748   read_met_help(ncid, "o3", "O3", met, met->o3, 0.602f);
00749
00750   /* Meteo data on pressure levels... */
00751   if (ctl->met_np <= 0) {
00752
00753     /* Read pressure levels from file... */
00754     NC(nc_inq_varid(ncid, "lev", &varid));
00755     NC(nc_get_var_double(ncid, varid, met->p));
00756     for (ip = 0; ip < met->np; ip++)
00757       met->p[ip] /= 100.;
00758
00759     /* Extrapolate data for lower boundary... */
00760     read_met_extrapolate(met);
00761   }
00762
00763   /* Meteo data on model levels... */
00764   else {
00765
00766     /* Read pressure data from file... */
00767     read_met_help(ncid, "pl", "PL", met, met->pl, 0.01f);
00768
00769     /* Interpolate from model levels to pressure levels... */
00770     read_met_ml2pl(ctl, met, met->t);
00771     read_met_ml2pl(ctl, met, met->u);
00772     read_met_ml2pl(ctl, met, met->v);
00773     read_met_ml2pl(ctl, met, met->w);
00774     read_met_ml2pl(ctl, met, met->h2o);
00775     read_met_ml2pl(ctl, met, met->o3);
00776
```

```
00777     /* Set pressure levels... */
00778     met->np = ctl->met_np;
00779     for (ip = 0; ip < met->np; ip++)
00780       met->p[ip] = ctl->met_p[ip];
00781   }
00782
00783   /* Check ordering of pressure levels... */
00784   for (ip = 1; ip < met->np; ip++)
00785     if (met->p[ip - 1] < met->p[ip])
00786       ERRMSG("Pressure levels must be descending!");
00787
00788   /* Read surface pressure... */
00789   if (nc_inq_varid(ncid, "PS", &varid) == NC_NOERR) {
00790     NC(nc_get_var_float(ncid, varid, help));
00791     for (iy = 0; iy < met->ny; iy++)
00792       for (ix = 0; ix < met->nx; ix++)
00793         met->ps[ix][iy] = help[iy * met->nx + ix] / 100.;
00794   } else if (nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
00795     NC(nc_get_var_float(ncid, varid, help));
00796     for (iy = 0; iy < met->ny; iy++)
00797       for (ix = 0; ix < met->nx; ix++)
00798         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
00799   } else
00800     for (ix = 0; ix < met->nx; ix++)
00801       for (iy = 0; iy < met->ny; iy++)
00802         met->ps[ix][iy] = met->p[0];
00803
00804   /* Create periodic boundary conditions... */
00805   read_met_periodic(met);
00806
00807   /* Close file... */
00808   NC(nc_close(ncid));
00809 }
```

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 813 of file libtrac.c.

```
00814               {
00815
```

```
00816   int ip, ip0, ix, iy;
00817
00818   /* Loop over columns... */
00819   for (ix = 0; ix < met->nx; ix++)
00820     for (iy = 0; iy < met->ny; iy++) {
00821
00822       /* Find lowest valid data point... */
00823       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
00824         if (!gsl_finite(met->t[ix][iy][ip0])
00825             || !gsl_finite(met->u[ix][iy][ip0])
00826             || !gsl_finite(met->v[ix][iy][ip0])
00827             || !gsl_finite(met->w[ix][iy][ip0]))
00828           break;
00829
00830       /* Extrapolate... */
00831       for (ip = ip0; ip >= 0; ip--) {
00832         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
00833         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
00834         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
00835         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
00836         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
00837         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
00838       }
00839     }
00840 }
```

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 844 of file libtrac.c.

```
00850             {
00851
00852   static float help[EX * EY * EP];
00853
00854   int ip, ix, iy, n = 0, varid;
00855
00856   /* Check if variable exists... */
00857   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
00858     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
00859       return;
00860
00861   /* Read data... */
00862   NC(nc_get_var_float(ncid, varid, help));
00863
00864   /* Copy and check data... */
00865   for (ip = 0; ip < met->np; ip++)
00866     for (iy = 0; iy < met->ny; iy++)
00867       for (ix = 0; ix < met->nx; ix++) {
00868         dest[ix][iy][ip] = scl * help[n++];
00869         if (fabs(dest[ix][iy][ip] / scl) > 1e14)
00870           dest[ix][iy][ip] = GSL_NAN;
00871       }
00872 }
```

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

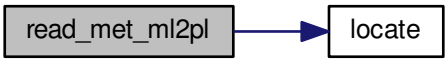
Convert meteorological data from model levels to pressure levels.

Definition at line 876 of file libtrac.c.

```
00879                         {
00880
00881   double aux[EP], p[EP], pt;
00882
00883   int ip, ip2, ix, iy;
00884
00885   /* Loop over columns... */
00886   for (ix = 0; ix < met->nx; ix++)
00887     for (iy = 0; iy < met->ny; iy++) {
00888
00889       /* Copy pressure profile... */
00890       for (ip = 0; ip < met->np; ip++)
```

```
00891         p[ip] = met->pl[ix][iy][ip];
00892
00893       /* Interpolate... */
00894       for (ip = 0; ip < ctl->met_np; ip++) {
00895         pt = ctl->met_p[ip];
00896         if ((pt > p[0] && p[0] > p[1]) || (pt < p[0] && p[0] < p[1]))
00897           pt = p[0];
00898         else if ((pt > p[met->np - 1] && p[1] > p[0])
00899                  || (pt < p[met->np - 1] && p[1] < p[0]))
00900           pt = p[met->np - 1];
00901         ip2 = locate(p, met->np, pt);
00902         aux[ip] = LIN(p[ip2], var[ix][iy][ip2],
00903                       p[ip2 + 1], var[ix][iy][ip2 + 1], pt);
00904       }
00905
00906       /* Copy data... */
00907       for (ip = 0; ip < ctl->met_np; ip++)
00908         var[ix][iy][ip] = (float) aux[ip];
00909     }
00910 }
```

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 914 of file libtrac.c.

```
00915               {
00916
00917   int ip, iy;
00918
00919   /* Check longitudes... */
00920   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
00921              + met->lon[1] - met->lon[0] - 360) < 0.01))
00922     return;
00923
00924   /* Increase longitude counter... */
00925   if ((++met->nx) > EX)
00926     ERRMSG("Cannot create periodic boundary conditions!");
00927
00928   /* Set longitude... */
00929   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
00930
00931   /* Loop over latitudes and pressure levels... */
00932   for (iy = 0; iy < met->ny; iy++)
00933     for (ip = 0; ip < met->np; ip++) {
00934       met->ps[met->nx - 1][iy] = met->ps[0][iy];
00935       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
00936       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
00937       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
00938       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
00939       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
00940       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
00941     }
00942 }
```

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 946 of file libtrac.c.

```
00953               {
00954
00955   FILE *in = NULL;
00956
00957   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
00958     msg[LEN], rvarname[LEN], rval[LEN];
00959
00960   int contain = 0, i;
00961
00962   /* Open file... */
00963   if (filename[strlen(filename) - 1] != '-')
00964     if (!(in = fopen(filename, "r")))
00965       ERRMSG("Cannot open file!");
00966
00967   /* Set full variable name... */
00968   if (arridx >= 0) {
00969     sprintf(fullname1, "%s[%d]", varname, arridx);
00970     sprintf(fullname2, "%s[*]", varname);
00971   } else {
00972     sprintf(fullname1, "%s", varname);
00973     sprintf(fullname2, "%s", varname);
00974   }
00975
00976   /* Read data... */
00977   if (in != NULL)
00978     while (fgets(line, LEN, in))
00979       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
00980         if (strcasecmp(rvarname, fullname1) == 0 ||
00981             strcasecmp(rvarname, fullname2) == 0) {
00982           contain = 1;
00983           break;
00984         }
00985   for (i = 1; i < argc - 1; i++)
00986     if (strcasecmp(argv[i], fullname1) == 0 ||
00987         strcasecmp(argv[i], fullname2) == 0) {
00988       sprintf(rval, "%s", argv[i + 1]);
00989       contain = 1;
00990       break;
00991     }
00992
00993   /* Close file... */
00994   if (in != NULL)
00995     fclose(in);
00996
00997   /* Check for missing variables... */
00998   if (!contain) {
00999     if (strlen(defvalue) > 0)
01000       sprintf(rval, "%s", defvalue);
01001     else {
01002       sprintf(msg, "Missing variable %s!\n", fullname1);
01003       ERRMSG(msg);
01004     }
01005   }
01006
01007   /* Write info... */
01008   printf("%s = %s\n", fullname1, rval);
01009
01010   /* Return values... */
01011   if (value != NULL)
01012     sprintf(value, "%s", rval);
01013   return atof(rval);
01014 }
```

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 1018 of file libtrac.c.

```
01026                {
01027
01028   struct tm t0, t1;
01029
01030   t0.tm_year = 100;
01031   t0.tm_mon = 0;
01032   t0.tm_mday = 1;
01033   t0.tm_hour = 0;
01034   t0.tm_min = 0;
01035   t0.tm_sec = 0;
01036
01037   t1.tm_year = year - 1900;
01038   t1.tm_mon = mon - 1;
01039   t1.tm_mday = day;
01040   t1.tm_hour = hour;
01041   t1.tm_min = min;
01042   t1.tm_sec = sec;
01043
01044   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
01045 }
```

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

Measure wall-clock time.

Definition at line 1049 of file libtrac.c.

```
01052            {
01053
01054   static double starttime[NTIMER], runtime[NTIMER];
01055
01056   /* Check id... */
01057   if (id < 0 || id >= NTIMER)
01058     ERRMSG("Too many timers!");
01059
01060   /* Start timer... */
01061   if (mode == 1) {
01062     if (starttime[id] <= 0)
01063       starttime[id] = omp_get_wtime();
01064     else
01065       ERRMSG("Timer already started!");
01066   }
01067
01068   /* Stop timer... */
01069   else if (mode == 2) {
01070     if (starttime[id] > 0) {
01071       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
01072       starttime[id] = -1;
01073     } else
01074       ERRMSG("Timer not started!");
01075   }
01076
01077   /* Print timer... */
01078   else if (mode == 3)
01079     printf("%s = %g s\n", name, runtime[id]);
01080 }
```

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

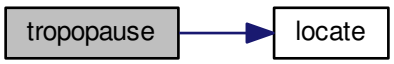
Definition at line 1084 of file libtrac.c.

```
01086              {
01087
01088   static double doys[12]
01089   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
01090
01091   static double lats[73]
01092     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
01093     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
01094     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
01095     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
01096     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
01097     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
01098     75, 77.5, 80, 82.5, 85, 87.5, 90
01099   };
```

```
01100
01101   static double tps[12][73]
01102     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
01103          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
01104          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
01105          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
01106          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
01107          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
01108          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
01109          275.3, 275.6, 275.4, 274.1, 273.5},
01110   {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
01111    300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
01112    150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
01113    98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
01114    98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
01115    220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
01116    284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
01117    287.5, 286.2, 285.8},
01118   {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
01119    297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
01120    161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
01121    100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
01122    99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
01123    186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
01124    279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
01125    304.3, 304.9, 306, 306.6, 306.2, 306},
01126   {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
01127    290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
01128    195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
01129    102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
01130    99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
01131    148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
01132    263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
01133    315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
01134   {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
01135    260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
01136    205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
01137    101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
01138    102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
01139    165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
01140    273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
01141    325.3, 325.8, 325.8},
01142   {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
01143    222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
01144    228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
01145    105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
01146    106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
01147    127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
01148    251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
01149    308.5, 312.2, 313.1, 313.3},
01150   {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
01151    187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
01152    235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
01153    110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
01154    111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
01155    117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
01156    224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
01157    275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
01158   {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
01159    185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
01160    233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
01161    110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
01162    112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
01163    120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
01164    230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
01165    278.2, 282.6, 287.4, 290.9, 292.5, 293},
01166   {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
01167    183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
01168    243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
01169    114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
01170    110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
01171    114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
01172    203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
01173    276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
01174   {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
01175    215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
01176    237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
01177    111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
01178    106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
01179    112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
01180    206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
01181    279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
01182    305.1},
01183   {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
01184    253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
01185    223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
01186    108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
```

```
01187     102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
01188     109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
01189     241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
01190     286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
01191    {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
01192     284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
01193     175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
01194     100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
01195     100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
01196     186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
01197     280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
01198     281.7, 281.1, 281.2}
01199    };
01200
01201    double doy, p0, p1, pt;
01202
01203    int imon, ilat;
01204
01205    /* Get day of year... */
01206    doy = fmod(t / 86400., 365.25);
01207    while (doy < 0)
01208      doy += 365.25;
01209
01210    /* Get indices... */
01211    imon = locate(doys, 12, doy);
01212    ilat = locate(lats, 73, lat);
01213
01214    /* Get tropopause pressure... */
01215    p0 = LIN(lats[ilat], tps[imon][ilat],
01216             lats[ilat + 1], tps[imon][ilat + 1], lat);
01217    p1 = LIN(lats[ilat], tps[imon + 1][ilat],
01218             lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
01219    pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
01220
01221    /* Return tropopause pressure... */
01222    return pt;
01223  }
```

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 1227 of file libtrac.c.

```
01231             {
01232
01233    FILE *in, *out;
01234
01235    char line[LEN];
01236
01237    double r, t0, t1;
01238
01239    int ip, iq, year, mon, day, hour, min, sec;
01240
01241    /* Set time interval for output... */
01242    t0 = t - 0.5 * ctl->dt_mod;
01243    t1 = t + 0.5 * ctl->dt_mod;
01244
01245    /* Check if gnuplot output is requested... */
01246    if (ctl->atm_gpfile[0] != '-') {
```

```
01247
01248     /* Write info... */
01249     printf("Plot atmospheric data: %s.png\n", filename);
01250
01251     /* Create gnuplot pipe... */
01252     if (!(out = popen("gnuplot", "w")))
01253       ERRMSG("Cannot create pipe to gnuplot!");
01254
01255     /* Set plot filename... */
01256     fprintf(out, "set out \"%s.png\"\n", filename);
01257
01258     /* Set time string... */
01259     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01260     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01261             year, mon, day, hour, min);
01262
01263     /* Dump gnuplot file to pipe... */
01264     if (!(in = fopen(ctl->atm_gpfile, "r")))
01265       ERRMSG("Cannot open file!");
01266     while (fgets(line, LEN, in))
01267       fprintf(out, "%s", line);
01268     fclose(in);
01269   }
01270
01271   else {
01272
01273     /* Write info... */
01274     printf("Write atmospheric data: %s\n", filename);
01275
01276     /* Create file... */
01277     if (!(out = fopen(filename, "w")))
01278       ERRMSG("Cannot create file!");
01279   }
01280
01281   /* Write header... */
01282   fprintf(out,
01283           "# $1 = time [s]\n"
01284           "# $2 = altitude [km]\n"
01285           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01286   for (iq = 0; iq < ctl->nq; iq++)
01287     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
01288             ctl->qnt_unit[iq]);
01289   fprintf(out, "\n");
01290
01291   /* Write data... */
01292   for (ip = 0; ip < atm->np; ip++) {
01293
01294     /* Check time... */
01295     if (ctl->atm_filter && (atm->time[ip] < t0 || atm->time[ip] > t1))
01296       continue;
01297
01298     /* Write output... */
01299     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
01300             atm->lon[ip], atm->lat[ip]);
01301     for (iq = 0; iq < ctl->nq; iq++) {
01302       fprintf(out, " ");
01303       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01304     }
01305     fprintf(out, "\n");
01306   }
01307
01308   /* Close file... */
01309   fclose(out);
01310 }
```

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 1314 of file libtrac.c.

```
01318           {
01319
01320   static FILE *in, *out;
01321
01322   static char line[LEN];
01323
01324   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
01325     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
01326
01327   static int init, obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
01328
01329   /* Init... */
01330   if (!init) {
01331     init = 1;
01332
01333     /* Check quantity index for mass... */
01334     if (ctl->qnt_m < 0)
01335       ERRMSG("Need quantity mass to analyze CSI!");
01336
01337     /* Open observation data file... */
01338     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
01339     if (!(in = fopen(ctl->csi_obsfile, "r")))
01340       ERRMSG("Cannot open file!");
01341
01342     /* Create new file... */
01343     printf("Write CSI data: %s\n", filename);
01344     if (!(out = fopen(filename, "w")))
01345       ERRMSG("Cannot create file!");
01346
01347     /* Write header... */
01348     fprintf(out,
01349             "# $1 = time [s]\n"
01350             "# $2 = number of hits (cx)\n"
01351             "# $3 = number of misses (cy)\n"
01352             "# $4 = number of false alarms (cz)\n"
01353             "# $5 = number of observations (cx + cy)\n"
01354             "# $6 = number of forecasts (cx + cz)\n"
01355             "# $7 = bias (forecasts/observations) [%%]\n"
01356             "# $8 = probability of detection (POD) [%%]\n"
01357             "# $9 = false alarm rate (FAR) [%%]\n"
01358             "# $10 = critical success index (CSI) [%%]\n\n");
01359   }
01360
01361   /* Set time interval... */
01362   t0 = t - 0.5 * ctl->dt_mod;
01363   t1 = t + 0.5 * ctl->dt_mod;
01364
01365   /* Initialize grid cells... */
01366   for (ix = 0; ix < ctl->csi_nx; ix++)
01367     for (iy = 0; iy < ctl->csi_ny; iy++)
01368       for (iz = 0; iz < ctl->csi_nz; iz++)
01369         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
01370
01371   /* Read data... */
01372   while (fgets(line, LEN, in)) {
01373
01374     /* Read data... */
01375     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
01376         5)
01377       continue;
01378
01379     /* Check time... */
01380     if (rt < t0)
01381       continue;
01382     if (rt > t1)
01383       break;
01384
01385     /* Calculate indices... */
01386     ix = (int) ((rlon - ctl->csi_lon0)
01387                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01388     iy = (int) ((rlat - ctl->csi_lat0)
01389                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01390     iz = (int) ((rz - ctl->csi_z0)
01391                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01392
01393     /* Check indices... */
01394     if (ix < 0 || ix >= ctl->csi_nx ||
```

```
01395         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01396       continue;
01397
01398     /* Get mean observation index... */
01399     obsmean[ix][iy][iz] += robs;
01400     obscount[ix][iy][iz]++;
01401   }
01402
01403   /* Analyze model data... */
01404   for (ip = 0; ip < atm->np; ip++) {
01405
01406     /* Check time... */
01407     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01408       continue;
01409
01410     /* Get indices... */
01411     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
01412                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01413     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
01414                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01415     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
01416                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01417
01418     /* Check indices... */
01419     if (ix < 0 || ix >= ctl->csi_nx ||
01420         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01421       continue;
01422
01423     /* Get total mass in grid cell... */
01424     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01425   }
01426
01427   /* Analyze all grid cells... */
01428   for (ix = 0; ix < ctl->csi_nx; ix++)
01429     for (iy = 0; iy < ctl->csi_ny; iy++)
01430       for (iz = 0; iz < ctl->csi_nz; iz++) {
01431
01432         /* Calculate mean observation index... */
01433         if (obscount[ix][iy][iz] > 0)
01434           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
01435
01436         /* Calculate column density... */
01437         if (modmean[ix][iy][iz] > 0) {
01438           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
01439           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
01440           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
01441           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
01442             * cos(lat * M_PI / 180.);
01443           modmean[ix][iy][iz] /= (1e6 * area);
01444         }
01445
01446         /* Calculate CSI... */
01447         if (obscount[ix][iy][iz] > 0) {
01448           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01449               modmean[ix][iy][iz] >= ctl->csi_modmin)
01450             cx++;
01451           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01452                    modmean[ix][iy][iz] < ctl->csi_modmin)
01453             cy++;
01454           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
01455                    modmean[ix][iy][iz] >= ctl->csi_modmin)
01456             cz++;
01457         }
01458       }
01459
01460   /* Write output... */
01461   if (fmod(t, ctl->csi_dt_out) == 0) {
01462
01463     /* Write... */
01464     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
01465             t, cx, cy, cz, cx + cy, cx + cz,
01466             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
01467             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
01468             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
01469             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
01470
01471     /* Set counters to zero... */
01472     cx = cy = cz = 0;
01473   }
01474
01475   /* Close file... */
01476   if (t == ctl->t_stop)
01477     fclose(out);
01478 }
```

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

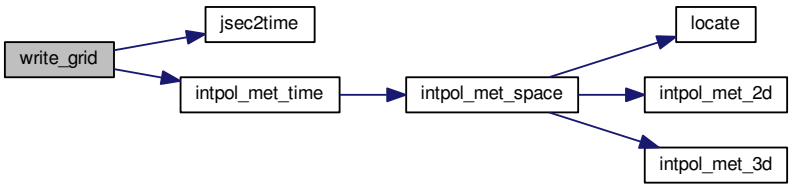
Write gridded data.

Definition at line 1482 of file libtrac.c.

```
01488            {
01489
01490   FILE *in, *out;
01491
01492   char line[LEN];
01493
01494   static double grid_m[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
01495     area, rho_air, press, temp, cd, mmr, t0, t1, r;
01496
01497   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
01498
01499   /* Check dimensions... */
01500   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
01501     ERRMSG("Grid dimensions too large!");
01502
01503   /* Check quantity index for mass... */
01504   if (ctl->qnt_m < 0)
01505     ERRMSG("Need quantity mass to write grid data!");
01506
01507   /* Set time interval for output... */
01508   t0 = t - 0.5 * ctl->dt_mod;
01509   t1 = t + 0.5 * ctl->dt_mod;
01510
01511   /* Set grid box size... */
01512   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
01513   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
01514   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
01515
01516   /* Initialize grid... */
01517   for (ix = 0; ix < ctl->grid_nx; ix++)
01518     for (iy = 0; iy < ctl->grid_ny; iy++)
01519       for (iz = 0; iz < ctl->grid_nz; iz++)
01520         grid_m[ix][iy][iz] = 0;
01521
01522   /* Average data... */
01523   for (ip = 0; ip < atm->np; ip++)
01524     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
01525
01526       /* Get index... */
01527       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
01528       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
01529       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
01530
01531       /* Check indices... */
01532       if (ix < 0 || ix >= ctl->grid_nx ||
01533           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
01534         continue;
01535
01536       /* Add mass... */
01537       grid_m[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01538     }
01539
01540   /* Check if gnuplot output is requested... */
01541   if (ctl->grid_gpfile[0] != '-') {
01542
01543     /* Write info... */
01544     printf("Plot grid data: %s.png\n", filename);
01545
01546     /* Create gnuplot pipe... */
01547     if (!(out = popen("gnuplot", "w")))
01548       ERRMSG("Cannot create pipe to gnuplot!");
01549
01550     /* Set plot filename... */
01551     fprintf(out, "set out \"%s.png\"\n", filename);
01552
01553     /* Set time string... */
01554     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01555     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01556             year, mon, day, hour, min);
01557
01558     /* Dump gnuplot file to pipe... */
01559     if (!(in = fopen(ctl->grid_gpfile, "r")))
01560       ERRMSG("Cannot open file!");
01561     while (fgets(line, LEN, in))
01562       fprintf(out, "%s", line);
01563     fclose(in);
01564   }
```

```
01565
01566   else {
01567
01568     /* Write info... */
01569     printf("Write grid data: %s\n", filename);
01570
01571     /* Create file... */
01572     if (!(out = fopen(filename, "w")))
01573       ERRMSG("Cannot create file!");
01574   }
01575
01576   /* Write header... */
01577   fprintf(out,
01578           "# $1 = time [s]\n"
01579           "# $2 = altitude [km]\n"
01580           "# $3 = longitude [deg]\n"
01581           "# $4 = latitude [deg]\n"
01582           "# $5 = surface area [km^2]\n"
01583           "# $6 = layer width [km]\n"
01584           "# $7 = temperature [K]\n"
01585           "# $8 = column density [kg/m^2]\n"
01586           "# $9 = mass mixing ratio [1]\n\n");
01587
01588   /* Write data... */
01589   for (ix = 0; ix < ctl->grid_nx; ix++) {
01590     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
01591       fprintf(out, "\n");
01592     for (iy = 0; iy < ctl->grid_ny; iy++) {
01593       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
01594         fprintf(out, "\n");
01595       for (iz = 0; iz < ctl->grid_nz; iz++)
01596         if (!ctl->grid_sparse
01597             || ix == 0 || iy == 0 || iz == 0 || grid_m[ix][iy][iz] > 0) {
01598
01599           /* Set coordinates... */
01600           z = ctl->grid_z0 + dz * (iz + 0.5);
01601           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
01602           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
01603
01604           /* Get pressure and temperature... */
01605           press = P(z);
01606           intpol_met_time(met0, met1, t, press, lon, lat,
01607                           NULL, &temp, NULL, NULL, NULL, NULL, NULL);
01608
01609           /* Calculate surface area... */
01610           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
01611             * cos(lat * M_PI / 180.);
01612
01613           /* Calculate column density... */
01614           cd = grid_m[ix][iy][iz] / (1e6 * area);
01615
01616           /* Calculate mass mixing ratio... */
01617           rho_air = 100. * press / (287.058 * temp);
01618           mmr = grid_m[ix][iy][iz] / (rho_air * 1e6 * area * 1e3 * dz);
01619
01620           /* Write output... */
01621           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01622                   t, z, lon, lat, area, dz, temp, cd, mmr);
01623         }
01624     }
01625   }
01626
01627   /* Close file... */
01628   fclose(out);
01629 }
```

Here is the call graph for this function:



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

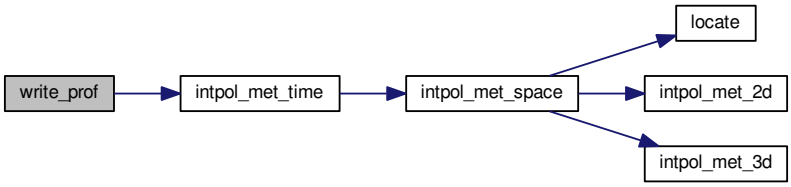
Write profile data.

Definition at line 1633 of file libtrac.c.

```
01639           {
01640
01641   static FILE *in, *out;
01642
01643   static char line[LEN];
01644
01645   static double mass[GX][GY][GZ], obsmean[GX][GY], tmean[GX][GY],
01646     rt, rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z,
01647     press, temp, rho_air, mmr, h2o, o3;
01648
01649   static int init, obscount[GX][GY], ip, ix, iy, iz;
01650
01651   /* Init... */
01652   if (!init) {
01653     init = 1;
01654
01655     /* Check quantity index for mass... */
01656     if (ctl->qnt_m < 0)
01657       ERRMSG("Need quantity mass!");
01658
01659     /* Check dimensions... */
01660     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
01661       ERRMSG("Grid dimensions too large!");
01662
01663     /* Open observation data file... */
01664     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
01665     if (!(in = fopen(ctl->prof_obsfile, "r")))
01666       ERRMSG("Cannot open file!");
01667
01668     /* Create new file... */
01669     printf("Write profile data: %s\n", filename);
01670     if (!(out = fopen(filename, "w")))
01671       ERRMSG("Cannot create file!");
01672
01673     /* Write header... */
01674     fprintf(out,
01675             "# $1  = time [s]\n"
01676             "# $2  = altitude [km]\n"
01677             "# $3  = longitude [deg]\n"
01678             "# $4  = latitude [deg]\n"
01679             "# $5  = pressure [hPa]\n"
01680             "# $6  = temperature [K]\n"
01681             "# $7  = mass mixing ratio [1]\n"
01682             "# $8  = H2O volume mixing ratio [1]\n"
01683             "# $9  = O3 volume mixing ratio [1]\n"
01684             "# $10 = mean BT index [K]\n");
01685
01686     /* Set grid box size... */
01687     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
01688     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
01689     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
01690   }
01691
01692   /* Set time interval... */
01693   t0 = t - 0.5 * ctl->dt_mod;
01694   t1 = t + 0.5 * ctl->dt_mod;
01695
01696   /* Initialize... */
01697   for (ix = 0; ix < ctl->prof_nx; ix++)
01698     for (iy = 0; iy < ctl->prof_ny; iy++) {
01699       obsmean[ix][iy] = 0;
01700       obscount[ix][iy] = 0;
01701       tmean[ix][iy] = 0;
01702       for (iz = 0; iz < ctl->prof_nz; iz++)
01703         mass[ix][iy][iz] = 0;
01704     }
01705
01706   /* Read data... */
01707   while (fgets(line, LEN, in)) {
01708
01709     /* Read data... */
01710     if (sscanf(line, "%lg %lg %lg %lg", &rt, &rlon, &rlat, &robs) != 4)
01711       continue;
01712
01713     /* Check time... */
01714     if (rt < t0)
01715       continue;
```

```
01716     if (rt > t1)
01717       break;
01718
01719     /* Calculate indices... */
01720     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
01721     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
01722
01723     /* Check indices... */
01724     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
01725       continue;
01726
01727     /* Get mean observation index... */
01728     obsmean[ix][iy] += robs;
01729     tmean[ix][iy] += rt;
01730     obscount[ix][iy]++;
01731   }
01732
01733   /* Analyze model data... */
01734   for (ip = 0; ip < atm->np; ip++) {
01735
01736     /* Check time... */
01737     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01738       continue;
01739
01740     /* Get indices... */
01741     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
01742     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
01743     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
01744
01745     /* Check indices... */
01746     if (ix < 0 || ix >= ctl->prof_nx ||
01747         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
01748       continue;
01749
01750     /* Get total mass in grid cell... */
01751     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01752   }
01753
01754   /* Extract profiles... */
01755   for (ix = 0; ix < ctl->prof_nx; ix++)
01756     for (iy = 0; iy < ctl->prof_ny; iy++)
01757       if (obscount[ix][iy] > 0) {
01758
01759         /* Write output... */
01760         fprintf(out, "\n");
01761
01762         /* Loop over altitudes... */
01763         for (iz = 0; iz < ctl->prof_nz; iz++) {
01764
01765           /* Set coordinates... */
01766           z = ctl->prof_z0 + dz * (iz + 0.5);
01767           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
01768           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
01769
01770           /* Get meteorological data... */
01771           press = P(z);
01772           intpol_met_time(met0, met1, t, press, lon, lat,
01773                           NULL, &temp, NULL, NULL, NULL, &h2o, &o3);
01774
01775           /* Calculate mass mixing ratio... */
01776           rho_air = 100. * press / (287.058 * temp);
01777           area = dlat * dlon * gsl_pow_2(M_PI * RE / 180.)
01778             * cos(lat * M_PI / 180.);
01779           mmr = mass[ix][iy][iz] / (rho_air * area * dz * 1e9);
01780
01781           /* Write output... */
01782           fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g\n",
01783                   tmean[ix][iy] / obscount[ix][iy],
01784                   z, lon, lat, press, temp, mmr, h2o, o3,
01785                   obsmean[ix][iy] / obscount[ix][iy]);
01786         }
01787       }
01788
01789   /* Close file... */
01790   if (t == ctl->t_stop)
01791     fclose(out);
01792 }
```

Here is the call graph for this function:



5.11.2.32 void write_psc (const char * *filename*, ctl_t * *ctl*, atm_t * *atm*, double *t*)

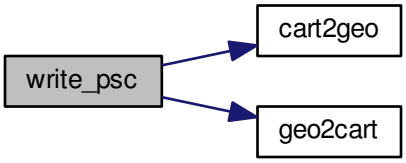
Write PSC data.

Definition at line 1796 of file libtrac.c.

```
01800           {
01801
01802   static FILE *out;
01803
01804   static double dtice[NPSC], dtsts[NPSC], dtnat[NPSC], dummy,
01805     latm, lonm, p[NPSC], pv[NPSC], t0, t1, ts, x[NPSC][3], xm[3];
01806
01807   static int init, ip;
01808
01809   static size_t i, n;
01810
01811   /* Init... */
01812   if (!init) {
01813     init = 1;
01814
01815     /* Check quantity indices... */
01816     if (ctl->qnt_t0 < 0 || ctl->qnt_pv < 0 || ctl->qnt_t < 0 ||
01817         ctl->qnt_tice < 0 || ctl->qnt_tnat < 0)
01818       ERRMSG("Missing quantities for PSC analysis!");
01819
01820     /* Create new file... */
01821     printf("Write PSC data: %s\n", filename);
01822     if (!(out = fopen(filename, "w")))
01823       ERRMSG("Cannot create file!");
01824
01825     /* Write header... */
01826     fprintf(out,
01827             "# $1 = time [s]\n"
01828             "# $2 = altitude [km]\n"
01829             "# $3 = longitude [deg]\n"
01830             "# $4 = latitude [deg]\n"
01831             "# $5 = start time [s]\n"
01832             "# $6 = potential vorticity [PVU]\n"
01833             "# $7 = T - T_ice (mean) [K]\n"
01834             "# $8 = T - T_ice (sigma) [K]\n"
01835             "# $9 = T - T_STS (mean) [K]\n"
01836             "# $10 = T - T_STS (sigma) [K]\n"
01837             "# $11 = T - T_NAT (mean) [K]\n"
01838             "# $12 = T - T_NAT (sigma) [K]\n\n");
01839   }
01840
01841   /* Set time interval... */
01842   t0 = t - 0.5 * ctl->dt_mod;
01843   t1 = t + 0.5 * ctl->dt_mod;
01844
01845   /* Init... */
01846   ts = GSL_NAN;
01847   n = 0;
01848
01849   /* Loop over air parcels... */
01850   for (ip = 0; ip < atm->np; ip++) {
01851
01852     /* Check time... */
01853     if (atm->time[ip] < t0 || atm->time[ip] > t1)
```

```
01854       continue;
01855
01856     /* Check trajectory start time... */
01857     if (atm->q[ctl->qnt_t0][ip] != ts) {
01858
01859       /* Write results... */
01860       if (n > 0) {
01861
01862         /* Get mean position... */
01863         xm[0] = xm[1] = xm[2] = 0;
01864         for (i = 0; i < n; i++) {
01865           xm[0] += x[i][0] / (double) n;
01866           xm[1] += x[i][1] / (double) n;
01867           xm[2] += x[i][2] / (double) n;
01868         }
01869         cart2geo(xm, &dummy, &lonm, &latm);
01870
01871         /* Get statistics... */
01872         fprintf(out, "%.2f %g %g %g %.2f %g %.2f %.2f %.2f %.2f %.2f %.2f\n",
01873                 t, Z(gsl_stats_mean(p, 1, n)), lonm, latm, ts,
01874                 gsl_stats_mean(pv, 1, n),
01875                 gsl_stats_mean(dtice, 1, n), gsl_stats_sd(dtice, 1, n),
01876                 gsl_stats_mean(dtsts, 1, n), gsl_stats_sd(dtsts, 1, n),
01877                 gsl_stats_mean(dtnat, 1, n), gsl_stats_sd(dtnat, 1, n));
01878       }
01879
01880       /* Save new start time... */
01881       ts = atm->q[ctl->qnt_t0][ip];
01882       n = 0;
01883     }
01884
01885     /* Save data... */
01886     p[n] = atm->p[ip];
01887     geo2cart(0, atm->lon[ip], atm->lat[ip], x[n]);
01888     pv[n] = atm->q[ctl->qnt_pv][ip];
01889     dtice[n] = atm->q[ctl->qnt_t][ip] - atm->q[ctl->qnt_tice][ip];
01890     dtsts[n] = atm->q[ctl->qnt_t][ip]
01891       - 0.5 * (atm->q[ctl->qnt_tice][ip] + atm->q[ctl->qnt_tnat][ip]);
01892     dtnat[n] = atm->q[ctl->qnt_t][ip] - atm->q[ctl->qnt_tnat][ip];
01893     if ((++n) >= NPSC)
01894       ERRMSG("Too many data points!");
01895   }
01896
01897   /* Write results... */
01898   if (n > 0) {
01899
01900     /* Get mean position... */
01901     xm[0] = xm[1] = xm[2] = 0;
01902     for (i = 0; i < n; i++) {
01903       xm[0] += x[i][0] / (double) n;
01904       xm[1] += x[i][1] / (double) n;
01905       xm[2] += x[i][2] / (double) n;
01906     }
01907     cart2geo(xm, &dummy, &lonm, &latm);
01908
01909     /* Get statistics... */
01910     fprintf(out, "%.2f %g %g %g %.2f %g %.2f %.2f %.2f %.2f %.2f %.2f\n",
01911             t, Z(gsl_stats_mean(p, 1, n)), lonm, latm, ts,
01912             gsl_stats_mean(pv, 1, n),
01913             gsl_stats_mean(dtice, 1, n), gsl_stats_sd(dtice, 1, n),
01914             gsl_stats_mean(dtsts, 1, n), gsl_stats_sd(dtsts, 1, n),
01915             gsl_stats_mean(dtnat, 1, n), gsl_stats_sd(dtnat, 1, n));
01916   }
01917
01918   /* Close file... */
01919   if (t == ctl->t_stop)
01920     fclose(out);
01921 }
```

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*)

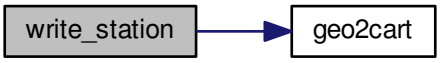
Write station data.

Definition at line 1925 of file libtrac.c.

```
01929            {
01930
01931   static FILE *out;
01932
01933   static double rmax2, t0, t1, x0[3], x1[3];
01934
01935   static int init, ip, iq;
01936
01937   /* Init... */
01938   if (!init) {
01939     init = 1;
01940
01941     /* Write info... */
01942     printf("Write station data: %s\n", filename);
01943
01944     /* Create new file... */
01945     if (!(out = fopen(filename, "w")))
01946       ERRMSG("Cannot create file!");
01947
01948     /* Write header... */
01949     fprintf(out,
01950             "# $1 = time [s]\n"
01951             "# $2 = altitude [km]\n"
01952             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01953     for (iq = 0; iq < ctl->nq; iq++)
01954       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
01955               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
01956     fprintf(out, "\n");
01957
01958     /* Set geolocation and search radius... */
01959     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
01960     rmax2 = gsl_pow_2(ctl->stat_r);
01961   }
01962
01963   /* Set time interval for output... */
01964   t0 = t - 0.5 * ctl->dt_mod;
01965   t1 = t + 0.5 * ctl->dt_mod;
01966
01967   /* Loop over air parcels... */
01968   for (ip = 0; ip < atm->np; ip++) {
01969
01970     /* Check time... */
01971     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01972       continue;
01973
01974     /* Check station flag... */
01975     if (ctl->qnt_stat >= 0)
01976       if (atm->q[ctl->qnt_stat][ip])
01977         continue;
01978
01979     /* Get Cartesian coordinates... */
01980     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
```

```
01981
01982     /* Check horizontal distance... */
01983     if (DIST2(x0, x1) > rmax2)
01984       continue;
01985
01986     /* Set station flag... */
01987     if (ctl->qnt_stat >= 0)
01988       atm->q[ctl->qnt_stat][ip] = 1;
01989
01990     /* Write data... */
01991     fprintf(out, "%.2f %g %g %g",
01992             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
01993     for (iq = 0; iq < ctl->nq; iq++) {
01994       fprintf(out, " ");
01995       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01996     }
01997     fprintf(out, "\n");
01998   }
01999
02000   /* Close file... */
02001   if (t == ctl->t_stop)
02002     fclose(out);
02003 }
```

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_t0 = -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_tnat = -1;
00488   ctl->qnt_stat = -1;
00489
00490   /* Read quantities... */
00491   ctl->nq = (int) scan_ctl(filename, argc, argv, "NQ", -1, "0", NULL);
00492   for (iq = 0; iq < ctl->nq; iq++) {
00493
00494     /* Read quantity name and format... */
00495     scan_ctl(filename, argc, argv, "QNT_NAME", iq, "", ctl->qnt_name[iq]);
00496     scan_ctl(filename, argc, argv, "QNT_FORMAT", iq, "%g",
00497              ctl->qnt_format[iq]);
00498
00499     /* Try to identify quantity... */
00500     if (strcmp(ctl->qnt_name[iq], "t0") == 0) {
00501       ctl->qnt_t0 = iq;
00502       sprintf(ctl->qnt_unit[iq], "s");
00503     } else if (strcmp(ctl->qnt_name[iq], "m") == 0) {
00504       ctl->qnt_m = iq;
00505       sprintf(ctl->qnt_unit[iq], "kg");
00506     } else if (strcmp(ctl->qnt_name[iq], "r") == 0) {
00507       ctl->qnt_r = iq;
00508       sprintf(ctl->qnt_unit[iq], "m");
00509     } else if (strcmp(ctl->qnt_name[iq], "rho") == 0) {
00510       ctl->qnt_rho = iq;
00511       sprintf(ctl->qnt_unit[iq], "kg/m^3");
00512     } else if (strcmp(ctl->qnt_name[iq], "ps") == 0) {
00513       ctl->qnt_ps = iq;
00514       sprintf(ctl->qnt_unit[iq], "hPa");
00515     } else if (strcmp(ctl->qnt_name[iq], "p") == 0) {
00516       ctl->qnt_p = iq;
00517       sprintf(ctl->qnt_unit[iq], "hPa");
00518     } else if (strcmp(ctl->qnt_name[iq], "t") == 0) {
00519       ctl->qnt_t = iq;
00520       sprintf(ctl->qnt_unit[iq], "K");
00521     } else if (strcmp(ctl->qnt_name[iq], "u") == 0) {
00522       ctl->qnt_u = iq;
00523       sprintf(ctl->qnt_unit[iq], "m/s");
00524     } else if (strcmp(ctl->qnt_name[iq], "v") == 0) {
00525       ctl->qnt_v = iq;
00526       sprintf(ctl->qnt_unit[iq], "m/s");
00527     } else if (strcmp(ctl->qnt_name[iq], "w") == 0) {
00528       ctl->qnt_w = iq;
00529       sprintf(ctl->qnt_unit[iq], "hPa/s");
00530     } else if (strcmp(ctl->qnt_name[iq], "h2o") == 0) {
00531       ctl->qnt_h2o = iq;
00532       sprintf(ctl->qnt_unit[iq], "1");
00533     } else if (strcmp(ctl->qnt_name[iq], "o3") == 0) {
00534       ctl->qnt_o3 = iq;
00535       sprintf(ctl->qnt_unit[iq], "1");
00536     } else if (strcmp(ctl->qnt_name[iq], "theta") == 0) {
00537       ctl->qnt_theta = iq;
00538       sprintf(ctl->qnt_unit[iq], "K");
00539     } else if (strcmp(ctl->qnt_name[iq], "pv") == 0) {
00540       ctl->qnt_pv = iq;
00541       sprintf(ctl->qnt_unit[iq], "PVU");
00542     } else if (strcmp(ctl->qnt_name[iq], "tice") == 0) {
00543       ctl->qnt_tice = iq;
00544       sprintf(ctl->qnt_unit[iq], "K");
00545     } else if (strcmp(ctl->qnt_name[iq], "tnat") == 0) {
00546       ctl->qnt_tnat = iq;
00547       sprintf(ctl->qnt_unit[iq], "K");
00548     } else if (strcmp(ctl->qnt_name[iq], "stat") == 0) {
00549       ctl->qnt_stat = iq;
00550       sprintf(ctl->qnt_unit[iq], "-");
00551     } else
00552       scan_ctl(filename, argc, argv, "QNT_UNIT", iq, "", ctl->qnt_unit[iq]);
00553   }
00554
00555   /* Time steps of simulation... */
00556   ctl->direction =
00557     (int) scan_ctl(filename, argc, argv, "DIRECTION", -1, "1", NULL);
00558   if (ctl->direction != -1 && ctl->direction != 1)
00559     ERRMSG("Set DIRECTION to -1 or 1!");
00560   ctl->t_start =
00561     scan_ctl(filename, argc, argv, "T_START", -1, "-1e100", NULL);
00562   ctl->t_stop = scan_ctl(filename, argc, argv, "T_STOP", -1, "-1e100", NULL);
00563   ctl->dt_mod = scan_ctl(filename, argc, argv, "DT_MOD", -1, "600", NULL);
```

```
00564
00565   /* Meteorological data... */
00566   ctl->dt_met = scan_ctl(filename, argc, argv, "DT_MET", -1, "21600", NULL);
00567   ctl->met_np = (int) scan_ctl(filename, argc, argv, "MET_NP", -1, "0", NULL);
00568   if (ctl->met_np > EP)
00569     ERRMSG("Too many levels!");
00570   for (ip = 0; ip < ctl->met_np; ip++)
00571     ctl->met_p[ip] = scan_ctl(filename, argc, argv, "MET_P", ip, "", NULL);
00572
00573   /* Isosurface parameters... */
00574   ctl->isosurf
00575     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
00576   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
00577
00578   /* Diffusion parameters... */
00579   ctl->turb_dx_trop
00580     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50.0", NULL);
00581   ctl->turb_dx_strat
00582     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0.0", NULL);
00583   ctl->turb_dz_trop
00584     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0.0", NULL);
00585   ctl->turb_dz_strat
00586     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
00587   ctl->turb_meso =
00588     scan_ctl(filename, argc, argv, "TURB_MESO", -1, "0.16", NULL);
00589
00590   /* Life time of particles... */
00591   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
00592   ctl->tdec_strat =
00593     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
00594
00595   /* Output of atmospheric data... */
00596   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
    atm_basename);
00597   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
00598   ctl->atm_dt_out =
00599     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
00600   ctl->atm_filter =
00601     (int) scan_ctl(filename, argc, argv, "ATM_FILTER", -1, "0", NULL);
00602
00603   /* Output of CSI data... */
00604   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
    csi_basename);
00605   ctl->csi_dt_out =
00606     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
00607   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "obs.tab",
00608            ctl->csi_obsfile);
00609   ctl->csi_obsmin =
00610     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
00611   ctl->csi_modmin =
00612     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
00613   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
00614   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
00615   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
00616   ctl->csi_lon0 =
00617     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
00618   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
00619   ctl->csi_nx =
00620     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
00621   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
00622   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
00623   ctl->csi_ny =
00624     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
00625
00626   /* Output of grid data... */
00627   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
00628            ctl->grid_basename);
00629   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
    grid_gpfile);
00630   ctl->grid_dt_out =
00631     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
00632   ctl->grid_sparse =
00633     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
00634   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
00635   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
00636   ctl->grid_nz =
00637     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
00638   ctl->grid_lon0 =
00639     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
00640   ctl->grid_lon1 =
00641     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
00642   ctl->grid_nx =
00643     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
00644   ctl->grid_lat0 =
00645     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
00646   ctl->grid_lat1 =
00647     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
```

```
00648   ctl->grid_ny =
00649     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
00650
00651   /* Output of profile data... */
00652   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
00653            ctl->prof_basename);
00654   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
      prof_obsfile);
00655   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
00656   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
00657   ctl->prof_nz =
00658     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
00659   ctl->prof_lon0 =
00660     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
00661   ctl->prof_lon1 =
00662     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
00663   ctl->prof_nx =
00664     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
00665   ctl->prof_lat0 =
00666     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
00667   ctl->prof_lat1 =
00668     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
00669   ctl->prof_ny =
00670     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
00671
00672   /* Output of PSC data... */
00673   scan_ctl(filename, argc, argv, "PSC_BASENAME", -1, "-", ctl->
      psc_basename);
00674
00675   /* Output of station data... */
00676   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
00677            ctl->stat_basename);
00678   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
00679   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
00680   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
00681 }
00682
00683 /*****************************************************************************/
00684
00685 void read_met(
00686   ctl_t * ctl,
00687   char *filename,
00688   met_t * met) {
00689
00690   char tstr[10];
00691
00692   static float help[EX * EY];
00693
00694   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
00695
00696   size_t np, nx, ny;
00697
00698   /* Write info... */
00699   printf("Read meteorological data: %s\n", filename);
00700
00701   /* Get time from filename... */
00702   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
00703   year = atoi(tstr);
00704   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
00705   mon = atoi(tstr);
00706   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
00707   day = atoi(tstr);
00708   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
00709   hour = atoi(tstr);
00710   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
00711
00712   /* Open netCDF file... */
00713   NC(nc_open(filename, NC_NOWRITE, &ncid));
00714
00715   /* Get dimensions... */
00716   NC(nc_inq_dimid(ncid, "lon", &dimid));
00717   NC(nc_inq_dimlen(ncid, dimid, &nx));
00718   if (nx > EX)
00719     ERRMSG("Too many longitudes!");
00720
00721   NC(nc_inq_dimid(ncid, "lat", &dimid));
00722   NC(nc_inq_dimlen(ncid, dimid, &ny));
00723   if (ny > EY)
00724     ERRMSG("Too many latitudes!");
00725
00726   NC(nc_inq_dimid(ncid, "lev", &dimid));
00727   NC(nc_inq_dimlen(ncid, dimid, &np));
00728   if (np > EP)
00729     ERRMSG("Too many levels!");
00730
00731   /* Store dimensions... */
00732   met->np = (int) np;
```

```
00733   met->nx = (int) nx;
00734   met->ny = (int) ny;
00735
00736   /* Get horizontal grid... */
00737   NC(nc_inq_varid(ncid, "lon", &varid));
00738   NC(nc_get_var_double(ncid, varid, met->lon));
00739   NC(nc_inq_varid(ncid, "lat", &varid));
00740   NC(nc_get_var_double(ncid, varid, met->lat));
00741
00742   /* Read meteorological data... */
00743   read_met_help(ncid, "t", "T", met, met->t, 1.0);
00744   read_met_help(ncid, "u", "U", met, met->u, 1.0);
00745   read_met_help(ncid, "v", "V", met, met->v, 1.0);
00746   read_met_help(ncid, "w", "W", met, met->w, 0.01f);
00747   read_met_help(ncid, "q", "Q", met, met->h2o, 1.608f);
00748   read_met_help(ncid, "o3", "O3", met, met->o3, 0.602f);
00749
00750   /* Meteo data on pressure levels... */
00751   if (ctl->met_np <= 0) {
00752
00753     /* Read pressure levels from file... */
00754     NC(nc_inq_varid(ncid, "lev", &varid));
00755     NC(nc_get_var_double(ncid, varid, met->p));
00756     for (ip = 0; ip < met->np; ip++)
00757       met->p[ip] /= 100.;
00758
00759     /* Extrapolate data for lower boundary... */
00760     read_met_extrapolate(met);
00761   }
00762
00763   /* Meteo data on model levels... */
00764   else {
00765
00766     /* Read pressure data from file... */
00767     read_met_help(ncid, "pl", "PL", met, met->pl, 0.01f);
00768
00769     /* Interpolate from model levels to pressure levels... */
00770     read_met_ml2pl(ctl, met, met->t);
00771     read_met_ml2pl(ctl, met, met->u);
00772     read_met_ml2pl(ctl, met, met->v);
00773     read_met_ml2pl(ctl, met, met->w);
00774     read_met_ml2pl(ctl, met, met->h2o);
00775     read_met_ml2pl(ctl, met, met->o3);
00776
00777     /* Set pressure levels... */
00778     met->np = ctl->met_np;
00779     for (ip = 0; ip < met->np; ip++)
00780       met->p[ip] = ctl->met_p[ip];
00781   }
00782
00783   /* Check ordering of pressure levels... */
00784   for (ip = 1; ip < met->np; ip++)
00785     if (met->p[ip - 1] < met->p[ip])
00786       ERRMSG("Pressure levels must be descending!");
00787
00788   /* Read surface pressure... */
00789   if (nc_inq_varid(ncid, "PS", &varid) == NC_NOERR) {
00790     NC(nc_get_var_float(ncid, varid, help));
00791     for (iy = 0; iy < met->ny; iy++)
00792       for (ix = 0; ix < met->nx; ix++)
00793         met->ps[ix][iy] = help[iy * met->nx + ix] / 100.;
00794   } else if (nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
00795     NC(nc_get_var_float(ncid, varid, help));
00796     for (iy = 0; iy < met->ny; iy++)
00797       for (ix = 0; ix < met->nx; ix++)
00798         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
00799   } else
00800     for (ix = 0; ix < met->nx; ix++)
00801       for (iy = 0; iy < met->ny; iy++)
00802         met->ps[ix][iy] = met->p[0];
00803
00804   /* Create periodic boundary conditions... */
00805   read_met_periodic(met);
00806
00807   /* Close file... */
00808   NC(nc_close(ncid));
00809 }
00810
00811 /*****************************************************************************/
00812
00813 void read_met_extrapolate(
00814   met_t * met) {
00815
00816   int ip, ip0, ix, iy;
00817
00818   /* Loop over columns... */
00819   for (ix = 0; ix < met->nx; ix++)
```

```
00820     for (iy = 0; iy < met->ny; iy++) {
00821
00822       /* Find lowest valid data point... */
00823       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
00824         if (!gsl_finite(met->t[ix][iy][ip0])
00825             || !gsl_finite(met->u[ix][iy][ip0])
00826             || !gsl_finite(met->v[ix][iy][ip0])
00827             || !gsl_finite(met->w[ix][iy][ip0]))
00828           break;
00829
00830       /* Extrapolate... */
00831       for (ip = ip0; ip >= 0; ip--) {
00832         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
00833         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
00834         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
00835         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
00836         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
00837         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
00838       }
00839     }
00840 }
00841
00842 /*****************************************************************************/
00843
00844 void read_met_help(
00845   int ncid,
00846   char *varname,
00847   char *varname2,
00848   met_t * met,
00849   float dest[EX][EY][EP],
00850   float scl) {
00851
00852   static float help[EX * EY * EP];
00853
00854   int ip, ix, iy, n = 0, varid;
00855
00856   /* Check if variable exists... */
00857   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
00858     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
00859       return;
00860
00861   /* Read data... */
00862   NC(nc_get_var_float(ncid, varid, help));
00863
00864   /* Copy and check data... */
00865   for (ip = 0; ip < met->np; ip++)
00866     for (iy = 0; iy < met->ny; iy++)
00867       for (ix = 0; ix < met->nx; ix++) {
00868         dest[ix][iy][ip] = scl * help[n++];
00869         if (fabs(dest[ix][iy][ip] / scl) > 1e14)
00870           dest[ix][iy][ip] = GSL_NAN;
00871       }
00872 }
00873
00874 /*****************************************************************************/
00875
00876 void read_met_ml2pl(
00877   ctl_t * ctl,
00878   met_t * met,
00879   float var[EX][EY][EP]) {
00880
00881   double aux[EP], p[EP], pt;
00882
00883   int ip, ip2, ix, iy;
00884
00885   /* Loop over columns... */
00886   for (ix = 0; ix < met->nx; ix++)
00887     for (iy = 0; iy < met->ny; iy++) {
00888
00889       /* Copy pressure profile... */
00890       for (ip = 0; ip < met->np; ip++)
00891         p[ip] = met->pl[ix][iy][ip];
00892
00893       /* Interpolate... */
00894       for (ip = 0; ip < ctl->met_np; ip++) {
00895         pt = ctl->met_p[ip];
00896         if ((pt > p[0] && p[0] > p[1]) || (pt < p[0] && p[0] < p[1]))
00897           pt = p[0];
00898         else if ((pt > p[met->np - 1] && p[1] > p[0])
00899                  || (pt < p[met->np - 1] && p[1] < p[0]))
00900           pt = p[met->np - 1];
00901         ip2 = locate(p, met->np, pt);
00902         aux[ip] = LIN(p[ip2], var[ix][iy][ip2],
00903                       p[ip2 + 1], var[ix][iy][ip2 + 1], pt);
00904       }
00905
00906       /* Copy data... */
```

```
00907       for (ip = 0; ip < ctl->met_np; ip++)
00908         var[ix][iy][ip] = (float) aux[ip];
00909     }
00910 }
00911
00912 /*****************************************************************************/
00913
00914 void read_met_periodic(
00915   met_t * met) {
00916
00917   int ip, iy;
00918
00919   /* Check longitudes... */
00920   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
00921              + met->lon[1] - met->lon[0] - 360) < 0.01))
00922     return;
00923
00924   /* Increase longitude counter... */
00925   if ((++met->nx) > EX)
00926     ERRMSG("Cannot create periodic boundary conditions!");
00927
00928   /* Set longitude... */
00929   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
    lon[0];
00930
00931   /* Loop over latitudes and pressure levels... */
00932   for (iy = 0; iy < met->ny; iy++)
00933     for (ip = 0; ip < met->np; ip++) {
00934       met->ps[met->nx - 1][iy] = met->ps[0][iy];
00935       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
00936       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
00937       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
00938       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
00939       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
00940       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
00941     }
00942 }
00943
00944 /*****************************************************************************/
00945
00946 double scan_ctl(
00947   const char *filename,
00948   int argc,
00949   char *argv[],
00950   const char *varname,
00951   int arridx,
00952   const char *defvalue,
00953   char *value) {
00954
00955   FILE *in = NULL;
00956
00957   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
00958     msg[LEN], rvarname[LEN], rval[LEN];
00959
00960   int contain = 0, i;
00961
00962   /* Open file... */
00963   if (filename[strlen(filename) - 1] != '-')
00964     if (!(in = fopen(filename, "r")))
00965       ERRMSG("Cannot open file!");
00966
00967   /* Set full variable name... */
00968   if (arridx >= 0) {
00969     sprintf(fullname1, "%s[%d]", varname, arridx);
00970     sprintf(fullname2, "%s[*]", varname);
00971   } else {
00972     sprintf(fullname1, "%s", varname);
00973     sprintf(fullname2, "%s", varname);
00974   }
00975
00976   /* Read data... */
00977   if (in != NULL)
00978     while (fgets(line, LEN, in))
00979       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
00980         if (strcasecmp(rvarname, fullname1) == 0 ||
00981             strcasecmp(rvarname, fullname2) == 0) {
00982           contain = 1;
00983           break;
00984         }
00985   for (i = 1; i < argc - 1; i++)
00986     if (strcasecmp(argv[i], fullname1) == 0 ||
00987         strcasecmp(argv[i], fullname2) == 0) {
00988       sprintf(rval, "%s", argv[i + 1]);
00989       contain = 1;
00990       break;
00991     }
00992
```

```
00993   /* Close file... */
00994   if (in != NULL)
00995     fclose(in);
00996
00997   /* Check for missing variables... */
00998   if (!contain) {
00999     if (strlen(defvalue) > 0)
01000       sprintf(rval, "%s", defvalue);
01001     else {
01002       sprintf(msg, "Missing variable %s!\n", fullname1);
01003       ERRMSG(msg);
01004     }
01005   }
01006
01007   /* Write info... */
01008   printf("%s = %s\n", fullname1, rval);
01009
01010   /* Return values... */
01011   if (value != NULL)
01012     sprintf(value, "%s", rval);
01013   return atof(rval);
01014 }
01015
01016 /*****************************************************************************/
01017
01018 void time2jsec(
01019   int year,
01020   int mon,
01021   int day,
01022   int hour,
01023   int min,
01024   int sec,
01025   double remain,
01026   double *jsec) {
01027
01028   struct tm t0, t1;
01029
01030   t0.tm_year = 100;
01031   t0.tm_mon = 0;
01032   t0.tm_mday = 1;
01033   t0.tm_hour = 0;
01034   t0.tm_min = 0;
01035   t0.tm_sec = 0;
01036
01037   t1.tm_year = year - 1900;
01038   t1.tm_mon = mon - 1;
01039   t1.tm_mday = day;
01040   t1.tm_hour = hour;
01041   t1.tm_min = min;
01042   t1.tm_sec = sec;
01043
01044   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
01045 }
01046
01047 /*****************************************************************************/
01048
01049 void timer(
01050   const char *name,
01051   int id,
01052   int mode) {
01053
01054   static double starttime[NTIMER], runtime[NTIMER];
01055
01056   /* Check id... */
01057   if (id < 0 || id >= NTIMER)
01058     ERRMSG("Too many timers!");
01059
01060   /* Start timer... */
01061   if (mode == 1) {
01062     if (starttime[id] <= 0)
01063       starttime[id] = omp_get_wtime();
01064     else
01065       ERRMSG("Timer already started!");
01066   }
01067
01068   /* Stop timer... */
01069   else if (mode == 2) {
01070     if (starttime[id] > 0) {
01071       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
01072       starttime[id] = -1;
01073     } else
01074       ERRMSG("Timer not started!");
01075   }
01076
01077   /* Print timer... */
01078   else if (mode == 3)
01079     printf("%s = %g s\n", name, runtime[id]);
```

```
01080 }
01081
01082 /*****************************************************************************/
01083
01084 double tropopause(
01085   double t,
01086   double lat) {
01087
01088   static double doys[12]
01089   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
01090
01091   static double lats[73]
01092     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
01093     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
01094     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
01095     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
01096     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
01097     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
01098     75, 77.5, 80, 82.5, 85, 87.5, 90
01099   };
01100
01101   static double tps[12][73]
01102     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
01103          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
01104          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
01105          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
01106          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
01107          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
01108          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
01109          275.3, 275.6, 275.4, 274.1, 273.5},
01110   {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
01111    300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
01112    150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
01113    98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
01114    98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
01115    220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
01116    284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
01117    287.5, 286.2, 285.8},
01118   {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
01119    297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
01120    161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
01121    100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
01122    99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
01123    186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
01124    279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
01125    304.3, 304.9, 306, 306.6, 306.2, 306},
01126   {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
01127    290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
01128    195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
01129    102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
01130    99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
01131    148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
01132    263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
01133    315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
01134   {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
01135    260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
01136    205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
01137    101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
01138    102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
01139    165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
01140    273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
01141    325.3, 325.8, 325.8},
01142   {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
01143    222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
01144    228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
01145    105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
01146    106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
01147    127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
01148    251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
01149    308.5, 312.2, 313.1, 313.3},
01150   {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
01151    187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
01152    235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
01153    110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
01154    111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
01155    117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
01156    224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
01157    275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
01158   {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
01159    185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
01160    233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
01161    110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
01162    112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
01163    120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
01164    230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
01165    278.2, 282.6, 287.4, 290.9, 292.5, 293},
01166   {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
```

```
01167     183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
01168     243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
01169     114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
01170     110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
01171     114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
01172     203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
01173     276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
01174    {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
01175     215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
01176     237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
01177     111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
01178     106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
01179     112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
01180     206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
01181     279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
01182     305.1},
01183    {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
01184     253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
01185     223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
01186     108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
01187     102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
01188     109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
01189     241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
01190     286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
01191    {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
01192     284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
01193     175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
01194     100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
01195     100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
01196     186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
01197     280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
01198     281.7, 281.1, 281.2}
01199    };
01200
01201    double doy, p0, p1, pt;
01202
01203    int imon, ilat;
01204
01205    /* Get day of year... */
01206    doy = fmod(t / 86400., 365.25);
01207    while (doy < 0)
01208      doy += 365.25;
01209
01210    /* Get indices... */
01211    imon = locate(doys, 12, doy);
01212    ilat = locate(lats, 73, lat);
01213
01214    /* Get tropopause pressure... */
01215    p0 = LIN(lats[ilat], tps[imon][ilat],
01216             lats[ilat + 1], tps[imon][ilat + 1], lat);
01217    p1 = LIN(lats[ilat], tps[imon + 1][ilat],
01218             lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
01219    pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
01220
01221    /* Return tropopause pressure... */
01222    return pt;
01223  }
01224
01225  /*****************************************************************************/
01226
01227  void write_atm(
01228    const char *filename,
01229    ctl_t * ctl,
01230    atm_t * atm,
01231    double t) {
01232
01233    FILE *in, *out;
01234
01235    char line[LEN];
01236
01237    double r, t0, t1;
01238
01239    int ip, iq, year, mon, day, hour, min, sec;
01240
01241    /* Set time interval for output... */
01242    t0 = t - 0.5 * ctl->dt_mod;
01243    t1 = t + 0.5 * ctl->dt_mod;
01244
01245    /* Check if gnuplot output is requested... */
01246    if (ctl->atm_gpfile[0] != '-') {
01247
01248      /* Write info... */
01249      printf("Plot atmospheric data: %s.png\n", filename);
01250
01251      /* Create gnuplot pipe... */
01252      if (!(out = popen("gnuplot", "w")))
01253        ERRMSG("Cannot create pipe to gnuplot!");
```

```
01254
01255     /* Set plot filename... */
01256     fprintf(out, "set out \"%s.png\"\n", filename);
01257
01258     /* Set time string... */
01259     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01260     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01261             year, mon, day, hour, min);
01262
01263     /* Dump gnuplot file to pipe... */
01264     if (!(in = fopen(ctl->atm_gpfile, "r")))
01265       ERRMSG("Cannot open file!");
01266     while (fgets(line, LEN, in))
01267       fprintf(out, "%s", line);
01268     fclose(in);
01269   }
01270
01271   else {
01272
01273     /* Write info... */
01274     printf("Write atmospheric data: %s\n", filename);
01275
01276     /* Create file... */
01277     if (!(out = fopen(filename, "w")))
01278       ERRMSG("Cannot create file!");
01279   }
01280
01281   /* Write header... */
01282   fprintf(out,
01283           "# $1 = time [s]\n"
01284           "# $2 = altitude [km]\n"
01285           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01286   for (iq = 0; iq < ctl->nq; iq++)
01287     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
01288             ctl->qnt_unit[iq]);
01289   fprintf(out, "\n");
01290
01291   /* Write data... */
01292   for (ip = 0; ip < atm->np; ip++) {
01293
01294     /* Check time... */
01295     if (ctl->atm_filter && (atm->time[ip] < t0 || atm->time[ip] > t1))
01296       continue;
01297
01298     /* Write output... */
01299     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
01300             atm->lon[ip], atm->lat[ip]);
01301     for (iq = 0; iq < ctl->nq; iq++) {
01302       fprintf(out, " ");
01303       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01304     }
01305     fprintf(out, "\n");
01306   }
01307
01308   /* Close file... */
01309   fclose(out);
01310 }
01311
01312 /*****************************************************************************/
01313
01314 void write_csi(
01315   const char *filename,
01316   ctl_t * ctl,
01317   atm_t * atm,
01318   double t) {
01319
01320   static FILE *in, *out;
01321
01322   static char line[LEN];
01323
01324   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
01325     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
01326
01327   static int init, obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
01328
01329   /* Init... */
01330   if (!init) {
01331     init = 1;
01332
01333     /* Check quantity index for mass... */
01334     if (ctl->qnt_m < 0)
01335       ERRMSG("Need quantity mass to analyze CSI!");
01336
01337     /* Open observation data file... */
01338     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
01339     if (!(in = fopen(ctl->csi_obsfile, "r")))
01340       ERRMSG("Cannot open file!");
```

```
01341
01342     /* Create new file... */
01343     printf("Write CSI data: %s\n", filename);
01344     if (!(out = fopen(filename, "w")))
01345       ERRMSG("Cannot create file!");
01346
01347     /* Write header... */
01348     fprintf(out,
01349             "# $1 = time [s]\n"
01350             "# $2 = number of hits (cx)\n"
01351             "# $3 = number of misses (cy)\n"
01352             "# $4 = number of false alarms (cz)\n"
01353             "# $5 = number of observations (cx + cy)\n"
01354             "# $6 = number of forecasts (cx + cz)\n"
01355             "# $7 = bias (forecasts/observations) [%%]\n"
01356             "# $8 = probability of detection (POD) [%%]\n"
01357             "# $9 = false alarm rate (FAR) [%%]\n"
01358             "# $10 = critical success index (CSI) [%%]\n\n");
01359   }
01360
01361   /* Set time interval... */
01362   t0 = t - 0.5 * ctl->dt_mod;
01363   t1 = t + 0.5 * ctl->dt_mod;
01364
01365   /* Initialize grid cells... */
01366   for (ix = 0; ix < ctl->csi_nx; ix++)
01367     for (iy = 0; iy < ctl->csi_ny; iy++)
01368       for (iz = 0; iz < ctl->csi_nz; iz++)
01369         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
01370
01371   /* Read data... */
01372   while (fgets(line, LEN, in)) {
01373
01374     /* Read data... */
01375     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
01376         5)
01377       continue;
01378
01379     /* Check time... */
01380     if (rt < t0)
01381       continue;
01382     if (rt > t1)
01383       break;
01384
01385     /* Calculate indices... */
01386     ix = (int) ((rlon - ctl->csi_lon0)
01387                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01388     iy = (int) ((rlat - ctl->csi_lat0)
01389                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01390     iz = (int) ((rz - ctl->csi_z0)
01391                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01392
01393     /* Check indices... */
01394     if (ix < 0 || ix >= ctl->csi_nx ||
01395         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01396       continue;
01397
01398     /* Get mean observation index... */
01399     obsmean[ix][iy][iz] += robs;
01400     obscount[ix][iy][iz]++;
01401   }
01402
01403   /* Analyze model data... */
01404   for (ip = 0; ip < atm->np; ip++) {
01405
01406     /* Check time... */
01407     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01408       continue;
01409
01410     /* Get indices... */
01411     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
01412                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01413     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
01414                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01415     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
01416                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01417
01418     /* Check indices... */
01419     if (ix < 0 || ix >= ctl->csi_nx ||
01420         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01421       continue;
01422
01423     /* Get total mass in grid cell... */
01424     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01425   }
01426
01427   /* Analyze all grid cells... */
```

```
01428   for (ix = 0; ix < ctl->csi_nx; ix++)
01429     for (iy = 0; iy < ctl->csi_ny; iy++)
01430       for (iz = 0; iz < ctl->csi_nz; iz++) {
01431
01432         /* Calculate mean observation index... */
01433         if (obscount[ix][iy][iz] > 0)
01434           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
01435
01436         /* Calculate column density... */
01437         if (modmean[ix][iy][iz] > 0) {
01438           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
01439           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
01440           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
01441           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
01442             * cos(lat * M_PI / 180.);
01443           modmean[ix][iy][iz] /= (1e6 * area);
01444         }
01445
01446         /* Calculate CSI... */
01447         if (obscount[ix][iy][iz] > 0) {
01448           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01449               modmean[ix][iy][iz] >= ctl->csi_modmin)
01450             cx++;
01451           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01452                    modmean[ix][iy][iz] < ctl->csi_modmin)
01453             cy++;
01454           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
01455                    modmean[ix][iy][iz] >= ctl->csi_modmin)
01456             cz++;
01457         }
01458       }
01459
01460   /* Write output... */
01461   if (fmod(t, ctl->csi_dt_out) == 0) {
01462
01463     /* Write... */
01464     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
01465             t, cx, cy, cz, cx + cy, cx + cz,
01466             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
01467             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
01468             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
01469             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
01470
01471     /* Set counters to zero... */
01472     cx = cy = cz = 0;
01473   }
01474
01475   /* Close file... */
01476   if (t == ctl->t_stop)
01477     fclose(out);
01478 }
01479
01480 /*****************************************************************************/
01481
01482 void write_grid(
01483   const char *filename,
01484   ctl_t * ctl,
01485   met_t * met0,
01486   met_t * met1,
01487   atm_t * atm,
01488   double t) {
01489
01490   FILE *in, *out;
01491
01492   char line[LEN];
01493
01494   static double grid_m[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
01495     area, rho_air, press, temp, cd, mmr, t0, t1, r;
01496
01497   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
01498
01499   /* Check dimensions... */
01500   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
01501     ERRMSG("Grid dimensions too large!");
01502
01503   /* Check quantity index for mass... */
01504   if (ctl->qnt_m < 0)
01505     ERRMSG("Need quantity mass to write grid data!");
01506
01507   /* Set time interval for output... */
01508   t0 = t - 0.5 * ctl->dt_mod;
01509   t1 = t + 0.5 * ctl->dt_mod;
01510
01511   /* Set grid box size... */
01512   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
01513   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
01514   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
```

```
01515
01516   /* Initialize grid... */
01517   for (ix = 0; ix < ctl->grid_nx; ix++)
01518     for (iy = 0; iy < ctl->grid_ny; iy++)
01519       for (iz = 0; iz < ctl->grid_nz; iz++)
01520         grid_m[ix][iy][iz] = 0;
01521
01522   /* Average data... */
01523   for (ip = 0; ip < atm->np; ip++)
01524     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
01525
01526       /* Get index... */
01527       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
01528       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
01529       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
01530
01531       /* Check indices... */
01532       if (ix < 0 || ix >= ctl->grid_nx ||
01533           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
01534         continue;
01535
01536       /* Add mass... */
01537       grid_m[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01538     }
01539
01540   /* Check if gnuplot output is requested... */
01541   if (ctl->grid_gpfile[0] != '-') {
01542
01543     /* Write info... */
01544     printf("Plot grid data: %s.png\n", filename);
01545
01546     /* Create gnuplot pipe... */
01547     if (!(out = popen("gnuplot", "w")))
01548       ERRMSG("Cannot create pipe to gnuplot!");
01549
01550     /* Set plot filename... */
01551     fprintf(out, "set out \"%s.png\"\n", filename);
01552
01553     /* Set time string... */
01554     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01555     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01556             year, mon, day, hour, min);
01557
01558     /* Dump gnuplot file to pipe... */
01559     if (!(in = fopen(ctl->grid_gpfile, "r")))
01560       ERRMSG("Cannot open file!");
01561     while (fgets(line, LEN, in))
01562       fprintf(out, "%s", line);
01563     fclose(in);
01564   }
01565
01566   else {
01567
01568     /* Write info... */
01569     printf("Write grid data: %s\n", filename);
01570
01571     /* Create file... */
01572     if (!(out = fopen(filename, "w")))
01573       ERRMSG("Cannot create file!");
01574   }
01575
01576   /* Write header... */
01577   fprintf(out,
01578           "# $1 = time [s]\n"
01579           "# $2 = altitude [km]\n"
01580           "# $3 = longitude [deg]\n"
01581           "# $4 = latitude [deg]\n"
01582           "# $5 = surface area [km^2]\n"
01583           "# $6 = layer width [km]\n"
01584           "# $7 = temperature [K]\n"
01585           "# $8 = column density [kg/m^2]\n"
01586           "# $9 = mass mixing ratio [1]\n\n");
01587
01588   /* Write data... */
01589   for (ix = 0; ix < ctl->grid_nx; ix++) {
01590     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
01591       fprintf(out, "\n");
01592     for (iy = 0; iy < ctl->grid_ny; iy++) {
01593       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
01594         fprintf(out, "\n");
01595       for (iz = 0; iz < ctl->grid_nz; iz++)
01596         if (!ctl->grid_sparse
01597             || ix == 0 || iy == 0 || iz == 0 || grid_m[ix][iy][iz] > 0) {
01598
01599           /* Set coordinates... */
01600           z = ctl->grid_z0 + dz * (iz + 0.5);
01601           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
```

```
01602           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
01603
01604           /* Get pressure and temperature... */
01605           press = P(z);
01606           intpol_met_time(met0, met1, t, press, lon, lat,
01607                           NULL, &temp, NULL, NULL, NULL, NULL, NULL);
01608
01609           /* Calculate surface area... */
01610           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
01611             * cos(lat * M_PI / 180.);
01612
01613           /* Calculate column density... */
01614           cd = grid_m[ix][iy][iz] / (1e6 * area);
01615
01616           /* Calculate mass mixing ratio... */
01617           rho_air = 100. * press / (287.058 * temp);
01618           mmr = grid_m[ix][iy][iz] / (rho_air * 1e6 * area * 1e3 * dz);
01619
01620           /* Write output... */
01621           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01622                   t, z, lon, lat, area, dz, temp, cd, mmr);
01623         }
01624     }
01625   }
01626
01627   /* Close file... */
01628   fclose(out);
01629 }
01630
01631 /*****************************************************************************/
01632
01633 void write_prof(
01634   const char *filename,
01635   ctl_t * ctl,
01636   met_t * met0,
01637   met_t * met1,
01638   atm_t * atm,
01639   double t) {
01640
01641   static FILE *in, *out;
01642
01643   static char line[LEN];
01644
01645   static double mass[GX][GY][GZ], obsmean[GX][GY], tmean[GX][GY],
01646     rt, rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z,
01647     press, temp, rho_air, mmr, h2o, o3;
01648
01649   static int init, obscount[GX][GY], ip, ix, iy, iz;
01650
01651   /* Init... */
01652   if (!init) {
01653     init = 1;
01654
01655     /* Check quantity index for mass... */
01656     if (ctl->qnt_m < 0)
01657       ERRMSG("Need quantity mass!");
01658
01659     /* Check dimensions... */
01660     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
01661       ERRMSG("Grid dimensions too large!");
01662
01663     /* Open observation data file... */
01664     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
01665     if (!(in = fopen(ctl->prof_obsfile, "r")))
01666       ERRMSG("Cannot open file!");
01667
01668     /* Create new file... */
01669     printf("Write profile data: %s\n", filename);
01670     if (!(out = fopen(filename, "w")))
01671       ERRMSG("Cannot create file!");
01672
01673     /* Write header... */
01674     fprintf(out,
01675             "# $1  = time [s]\n"
01676             "# $2  = altitude [km]\n"
01677             "# $3  = longitude [deg]\n"
01678             "# $4  = latitude [deg]\n"
01679             "# $5  = pressure [hPa]\n"
01680             "# $6  = temperature [K]\n"
01681             "# $7  = mass mixing ratio [1]\n"
01682             "# $8  = H2O volume mixing ratio [1]\n"
01683             "# $9  = O3 volume mixing ratio [1]\n"
01684             "# $10 = mean BT index [K]\n");
01685
01686     /* Set grid box size... */
01687     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
01688     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
```

```
01689     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
01690   }
01691
01692   /* Set time interval... */
01693   t0 = t - 0.5 * ctl->dt_mod;
01694   t1 = t + 0.5 * ctl->dt_mod;
01695
01696   /* Initialize... */
01697   for (ix = 0; ix < ctl->prof_nx; ix++)
01698     for (iy = 0; iy < ctl->prof_ny; iy++) {
01699       obsmean[ix][iy] = 0;
01700       obscount[ix][iy] = 0;
01701       tmean[ix][iy] = 0;
01702       for (iz = 0; iz < ctl->prof_nz; iz++)
01703         mass[ix][iy][iz] = 0;
01704     }
01705
01706   /* Read data... */
01707   while (fgets(line, LEN, in)) {
01708
01709     /* Read data... */
01710     if (sscanf(line, "%lg %lg %lg %lg", &rt, &rlon, &rlat, &robs) != 4)
01711       continue;
01712
01713     /* Check time... */
01714     if (rt < t0)
01715       continue;
01716     if (rt > t1)
01717       break;
01718
01719     /* Calculate indices... */
01720     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
01721     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
01722
01723     /* Check indices... */
01724     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
01725       continue;
01726
01727     /* Get mean observation index... */
01728     obsmean[ix][iy] += robs;
01729     tmean[ix][iy] += rt;
01730     obscount[ix][iy]++;
01731   }
01732
01733   /* Analyze model data... */
01734   for (ip = 0; ip < atm->np; ip++) {
01735
01736     /* Check time... */
01737     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01738       continue;
01739
01740     /* Get indices... */
01741     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
01742     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
01743     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
01744
01745     /* Check indices... */
01746     if (ix < 0 || ix >= ctl->prof_nx ||
01747         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
01748       continue;
01749
01750     /* Get total mass in grid cell... */
01751     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01752   }
01753
01754   /* Extract profiles... */
01755   for (ix = 0; ix < ctl->prof_nx; ix++)
01756     for (iy = 0; iy < ctl->prof_ny; iy++)
01757       if (obscount[ix][iy] > 0) {
01758
01759         /* Write output... */
01760         fprintf(out, "\n");
01761
01762         /* Loop over altitudes... */
01763         for (iz = 0; iz < ctl->prof_nz; iz++) {
01764
01765           /* Set coordinates... */
01766           z = ctl->prof_z0 + dz * (iz + 0.5);
01767           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
01768           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
01769
01770           /* Get meteorological data... */
01771           press = P(z);
01772           intpol_met_time(met0, met1, t, press, lon, lat,
01773                           NULL, &temp, NULL, NULL, NULL, &h2o, &o3);
01774
01775           /* Calculate mass mixing ratio... */
```

```
01776           rho_air = 100. * press / (287.058 * temp);
01777           area = dlat * dlon * gsl_pow_2(M_PI * RE / 180.)
01778             * cos(lat * M_PI / 180.);
01779           mmr = mass[ix][iy][iz] / (rho_air * area * dz * 1e9);
01780
01781           /* Write output... */
01782           fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g\n",
01783                   tmean[ix][iy] / obscount[ix][iy],
01784                   z, lon, lat, press, temp, mmr, h2o, o3,
01785                   obsmean[ix][iy] / obscount[ix][iy]);
01786         }
01787       }
01788
01789   /* Close file... */
01790   if (t == ctl->t_stop)
01791     fclose(out);
01792 }
01793
01794 /*****************************************************************************/
01795
01796 void write_psc(
01797   const char *filename,
01798   ctl_t * ctl,
01799   atm_t * atm,
01800   double t) {
01801
01802   static FILE *out;
01803
01804   static double dtice[NPSC], dtsts[NPSC], dtnat[NPSC], dummy,
01805     latm, lonm, p[NPSC], pv[NPSC], t0, t1, ts, x[NPSC][3], xm[3];
01806
01807   static int init, ip;
01808
01809   static size_t i, n;
01810
01811   /* Init... */
01812   if (!init) {
01813     init = 1;
01814
01815     /* Check quantity indices... */
01816     if (ctl->qnt_t0 < 0 || ctl->qnt_pv < 0 || ctl->qnt_t < 0 ||
01817         ctl->qnt_tice < 0 || ctl->qnt_tnat < 0)
01818       ERRMSG("Missing quantities for PSC analysis!");
01819
01820     /* Create new file... */
01821     printf("Write PSC data: %s\n", filename);
01822     if (!(out = fopen(filename, "w")))
01823       ERRMSG("Cannot create file!");
01824
01825     /* Write header... */
01826     fprintf(out,
01827             "# $1 = time [s]\n"
01828             "# $2 = altitude [km]\n"
01829             "# $3 = longitude [deg]\n"
01830             "# $4 = latitude [deg]\n"
01831             "# $5 = start time [s]\n"
01832             "# $6 = potential vorticity [PVU]\n"
01833             "# $7 = T - T_ice (mean) [K]\n"
01834             "# $8 = T - T_ice (sigma) [K]\n"
01835             "# $9 = T - T_STS (mean) [K]\n"
01836             "# $10 = T - T_STS (sigma) [K]\n"
01837             "# $11 = T - T_NAT (mean) [K]\n"
01838             "# $12 = T - T_NAT (sigma) [K]\n\n");
01839   }
01840
01841   /* Set time interval... */
01842   t0 = t - 0.5 * ctl->dt_mod;
01843   t1 = t + 0.5 * ctl->dt_mod;
01844
01845   /* Init... */
01846   ts = GSL_NAN;
01847   n = 0;
01848
01849   /* Loop over air parcels... */
01850   for (ip = 0; ip < atm->np; ip++) {
01851
01852     /* Check time... */
01853     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01854       continue;
01855
01856     /* Check trajectory start time... */
01857     if (atm->q[ctl->qnt_t0][ip] != ts) {
01858
01859       /* Write results... */
01860       if (n > 0) {
01861
01862         /* Get mean position... */
```

```
01863         xm[0] = xm[1] = xm[2] = 0;
01864         for (i = 0; i < n; i++) {
01865           xm[0] += x[i][0] / (double) n;
01866           xm[1] += x[i][1] / (double) n;
01867           xm[2] += x[i][2] / (double) n;
01868         }
01869         cart2geo(xm, &dummy, &lonm, &latm);
01870
01871         /* Get statistics... */
01872         fprintf(out, "%.2f %g %g %g %.2f %g %.2f %.2f %.2f %.2f %.2f %.2f\n",
01873                 t, Z(gsl_stats_mean(p, 1, n)), lonm, latm, ts,
01874                 gsl_stats_mean(pv, 1, n),
01875                 gsl_stats_mean(dtice, 1, n), gsl_stats_sd(dtice, 1, n),
01876                 gsl_stats_mean(dtsts, 1, n), gsl_stats_sd(dtsts, 1, n),
01877                 gsl_stats_mean(dtnat, 1, n), gsl_stats_sd(dtnat, 1, n));
01878       }
01879
01880       /* Save new start time... */
01881       ts = atm->q[ctl->qnt_t0][ip];
01882       n = 0;
01883     }
01884
01885     /* Save data... */
01886     p[n] = atm->p[ip];
01887     geo2cart(0, atm->lon[ip], atm->lat[ip], x[n]);
01888     pv[n] = atm->q[ctl->qnt_pv][ip];
01889     dtice[n] = atm->q[ctl->qnt_t][ip] - atm->q[ctl->qnt_tice][ip];
01890     dtsts[n] = atm->q[ctl->qnt_t][ip]
01891       - 0.5 * (atm->q[ctl->qnt_tice][ip] + atm->q[ctl->qnt_tnat][ip]);
01892     dtnat[n] = atm->q[ctl->qnt_t][ip] - atm->q[ctl->qnt_tnat][ip];
01893     if ((++n) >= NPSC)
01894       ERRMSG("Too many data points!");
01895   }
01896
01897   /* Write results... */
01898   if (n > 0) {
01899
01900     /* Get mean position... */
01901     xm[0] = xm[1] = xm[2] = 0;
01902     for (i = 0; i < n; i++) {
01903       xm[0] += x[i][0] / (double) n;
01904       xm[1] += x[i][1] / (double) n;
01905       xm[2] += x[i][2] / (double) n;
01906     }
01907     cart2geo(xm, &dummy, &lonm, &latm);
01908
01909     /* Get statistics... */
01910     fprintf(out, "%.2f %g %g %g %.2f %g %.2f %.2f %.2f %.2f %.2f %.2f\n",
01911             t, Z(gsl_stats_mean(p, 1, n)), lonm, latm, ts,
01912             gsl_stats_mean(pv, 1, n),
01913             gsl_stats_mean(dtice, 1, n), gsl_stats_sd(dtice, 1, n),
01914             gsl_stats_mean(dtsts, 1, n), gsl_stats_sd(dtsts, 1, n),
01915             gsl_stats_mean(dtnat, 1, n), gsl_stats_sd(dtnat, 1, n));
01916   }
01917
01918   /* Close file... */
01919   if (t == ctl->t_stop)
01920     fclose(out);
01921 }
01922
01923 /*****************************************************************************/
01924
01925 void write_station(
01926   const char *filename,
01927   ctl_t * ctl,
01928   atm_t * atm,
01929   double t) {
01930
01931   static FILE *out;
01932
01933   static double rmax2, t0, t1, x0[3], x1[3];
01934
01935   static int init, ip, iq;
01936
01937   /* Init... */
01938   if (!init) {
01939     init = 1;
01940
01941     /* Write info... */
01942     printf("Write station data: %s\n", filename);
01943
01944     /* Create new file... */
01945     if (!(out = fopen(filename, "w")))
01946       ERRMSG("Cannot create file!");
01947
01948     /* Write header... */
01949     fprintf(out,
```

```
01950             "# $1 = time [s]\n"
01951             "# $2 = altitude [km]\n"
01952             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01953     for (iq = 0; iq < ctl->nq; iq++)
01954       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
01955               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
01956     fprintf(out, "\n");
01957
01958     /* Set geolocation and search radius... */
01959     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
01960     rmax2 = gsl_pow_2(ctl->stat_r);
01961   }
01962
01963   /* Set time interval for output... */
01964   t0 = t - 0.5 * ctl->dt_mod;
01965   t1 = t + 0.5 * ctl->dt_mod;
01966
01967   /* Loop over air parcels... */
01968   for (ip = 0; ip < atm->np; ip++) {
01969
01970     /* Check time... */
01971     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01972       continue;
01973
01974     /* Check station flag... */
01975     if (ctl->qnt_stat >= 0)
01976       if (atm->q[ctl->qnt_stat][ip])
01977         continue;
01978
01979     /* Get Cartesian coordinates... */
01980     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
01981
01982     /* Check horizontal distance... */
01983     if (DIST2(x0, x1) > rmax2)
01984       continue;
01985
01986     /* Set station flag... */
01987     if (ctl->qnt_stat >= 0)
01988       atm->q[ctl->qnt_stat][ip] = 1;
01989
01990     /* Write data... */
01991     fprintf(out, "%.2f %g %g %g",
01992             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
01993     for (iq = 0; iq < ctl->nq; iq++) {
01994       fprintf(out, " ");
01995       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01996     }
01997     fprintf(out, "\n");
01998   }
01999
02000   /* Close file... */
02001   if (t == ctl->t_stop)
02002     fclose(out);
02003 }
```

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_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_psc (const char *filename, ctl_t *ctl, atm_t *atm, double t)

  Write PSC 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 }
```

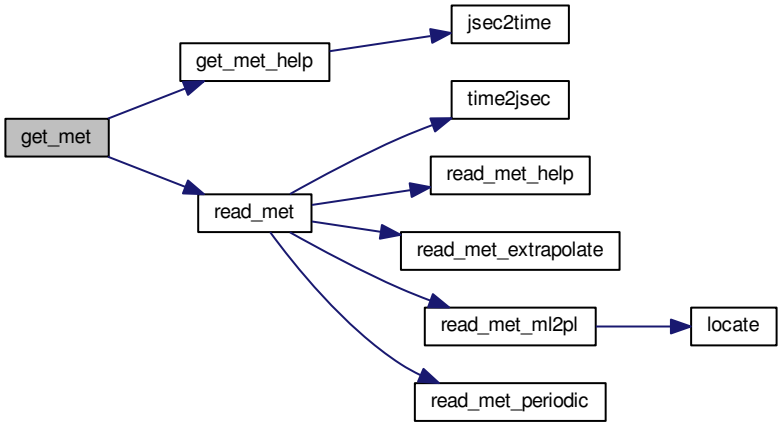
5.13.2.9 void get_met (ctl_t * *ctl*, char * *metbase*, double *t*, met_t * *met0*, met_t * *met1*)

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:



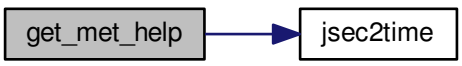
5.13.2.10 void get_met_help (double *t*, int *direct*, char * *metbase*, double *dt_met*, char * *filename*)

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*)

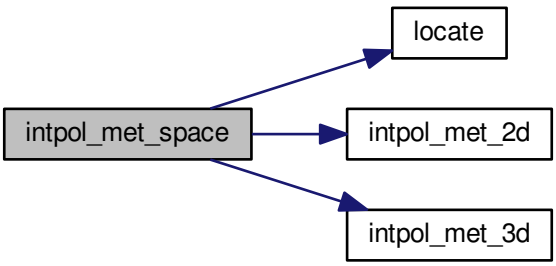
Spatial interpolation of meteorological data.

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*)

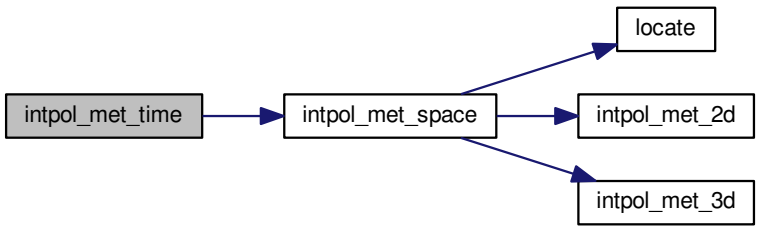
Temporal interpolation of meteorological data.

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_t0 = -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_tnat = -1;
00488   ctl->qnt_stat = -1;
00489
00490   /* Read quantities... */
00491   ctl->nq = (int) scan_ctl(filename, argc, argv, "NQ", -1, "0", NULL);
00492   for (iq = 0; iq < ctl->nq; iq++) {
00493
00494     /* Read quantity name and format... */
00495     scan_ctl(filename, argc, argv, "QNT_NAME", iq, "", ctl->qnt_name[iq]);
00496     scan_ctl(filename, argc, argv, "QNT_FORMAT", iq, "%g",
00497              ctl->qnt_format[iq]);
00498
00499     /* Try to identify quantity... */
00500     if (strcmp(ctl->qnt_name[iq], "t0") == 0) {
00501       ctl->qnt_t0 = iq;
00502       sprintf(ctl->qnt_unit[iq], "s");
00503     } else if (strcmp(ctl->qnt_name[iq], "m") == 0) {
00504       ctl->qnt_m = iq;
00505       sprintf(ctl->qnt_unit[iq], "kg");
00506     } else if (strcmp(ctl->qnt_name[iq], "r") == 0) {
00507       ctl->qnt_r = iq;
00508       sprintf(ctl->qnt_unit[iq], "m");
00509     } else if (strcmp(ctl->qnt_name[iq], "rho") == 0) {
00510       ctl->qnt_rho = iq;
00511       sprintf(ctl->qnt_unit[iq], "kg/m^3");
00512     } else if (strcmp(ctl->qnt_name[iq], "ps") == 0) {
00513       ctl->qnt_ps = iq;
00514       sprintf(ctl->qnt_unit[iq], "hPa");
00515     } else if (strcmp(ctl->qnt_name[iq], "p") == 0) {
00516       ctl->qnt_p = iq;
00517       sprintf(ctl->qnt_unit[iq], "hPa");
00518     } else if (strcmp(ctl->qnt_name[iq], "t") == 0) {
00519       ctl->qnt_t = iq;
00520       sprintf(ctl->qnt_unit[iq], "K");
00521     } else if (strcmp(ctl->qnt_name[iq], "u") == 0) {
00522       ctl->qnt_u = iq;
00523       sprintf(ctl->qnt_unit[iq], "m/s");
00524     } else if (strcmp(ctl->qnt_name[iq], "v") == 0) {
00525       ctl->qnt_v = iq;
00526       sprintf(ctl->qnt_unit[iq], "m/s");
00527     } else if (strcmp(ctl->qnt_name[iq], "w") == 0) {
00528       ctl->qnt_w = iq;
00529       sprintf(ctl->qnt_unit[iq], "hPa/s");
00530     } else if (strcmp(ctl->qnt_name[iq], "h2o") == 0) {
00531       ctl->qnt_h2o = iq;
00532       sprintf(ctl->qnt_unit[iq], "1");
00533     } else if (strcmp(ctl->qnt_name[iq], "o3") == 0) {
00534       ctl->qnt_o3 = iq;
00535       sprintf(ctl->qnt_unit[iq], "1");
00536     } else if (strcmp(ctl->qnt_name[iq], "theta") == 0) {
00537       ctl->qnt_theta = iq;
00538       sprintf(ctl->qnt_unit[iq], "K");
```

```
00539     } else if (strcmp(ctl->qnt_name[iq], "pv") == 0) {
00540       ctl->qnt_pv = iq;
00541       sprintf(ctl->qnt_unit[iq], "PVU");
00542     } else if (strcmp(ctl->qnt_name[iq], "tice") == 0) {
00543       ctl->qnt_tice = iq;
00544       sprintf(ctl->qnt_unit[iq], "K");
00545     } else if (strcmp(ctl->qnt_name[iq], "tnat") == 0) {
00546       ctl->qnt_tnat = iq;
00547       sprintf(ctl->qnt_unit[iq], "K");
00548     } else if (strcmp(ctl->qnt_name[iq], "stat") == 0) {
00549       ctl->qnt_stat = iq;
00550       sprintf(ctl->qnt_unit[iq], "-");
00551     } else
00552       scan_ctl(filename, argc, argv, "QNT_UNIT", iq, "", ctl->qnt_unit[iq]);
00553   }
00554
00555   /* Time steps of simulation... */
00556   ctl->direction =
00557     (int) scan_ctl(filename, argc, argv, "DIRECTION", -1, "1", NULL);
00558   if (ctl->direction != -1 && ctl->direction != 1)
00559     ERRMSG("Set DIRECTION to -1 or 1!");
00560   ctl->t_start =
00561     scan_ctl(filename, argc, argv, "T_START", -1, "-1e100", NULL);
00562   ctl->t_stop = scan_ctl(filename, argc, argv, "T_STOP", -1, "-1e100", NULL);
00563   ctl->dt_mod = scan_ctl(filename, argc, argv, "DT_MOD", -1, "600", NULL);
00564
00565   /* Meteorological data... */
00566   ctl->dt_met = scan_ctl(filename, argc, argv, "DT_MET", -1, "21600", NULL);
00567   ctl->met_np = (int) scan_ctl(filename, argc, argv, "MET_NP", -1, "0", NULL);
00568   if (ctl->met_np > EP)
00569     ERRMSG("Too many levels!");
00570   for (ip = 0; ip < ctl->met_np; ip++)
00571     ctl->met_p[ip] = scan_ctl(filename, argc, argv, "MET_P", ip, "", NULL);
00572
00573   /* Isosurface parameters... */
00574   ctl->isosurf
00575     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
00576   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
00577
00578   /* Diffusion parameters... */
00579   ctl->turb_dx_trop
00580     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50.0", NULL);
00581   ctl->turb_dx_strat
00582     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0.0", NULL);
00583   ctl->turb_dz_trop
00584     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0.0", NULL);
00585   ctl->turb_dz_strat
00586     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
00587   ctl->turb_meso =
00588     scan_ctl(filename, argc, argv, "TURB_MESO", -1, "0.16", NULL);
00589
00590   /* Life time of particles... */
00591   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
00592   ctl->tdec_strat =
00593     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
00594
00595   /* Output of atmospheric data... */
00596   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
      atm_basename);
00597   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
00598   ctl->atm_dt_out =
00599     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
00600   ctl->atm_filter =
00601     (int) scan_ctl(filename, argc, argv, "ATM_FILTER", -1, "0", NULL);
00602
00603   /* Output of CSI data... */
00604   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
      csi_basename);
00605   ctl->csi_dt_out =
00606     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
00607   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "obs.tab",
00608            ctl->csi_obsfile);
00609   ctl->csi_obsmin =
00610     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
00611   ctl->csi_modmin =
00612     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
00613   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
00614   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
00615   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
00616   ctl->csi_lon0 =
00617     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
00618   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
00619   ctl->csi_nx =
00620     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
00621   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
00622   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
00623   ctl->csi_ny =
```

```
00624     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
00625
00626   /* Output of grid data... */
00627   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
00628            ctl->grid_basename);
00629   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
      grid_gpfile);
00630   ctl->grid_dt_out =
00631     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
00632   ctl->grid_sparse =
00633     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
00634   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
00635   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
00636   ctl->grid_nz =
00637     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
00638   ctl->grid_lon0 =
00639     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
00640   ctl->grid_lon1 =
00641     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
00642   ctl->grid_nx =
00643     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
00644   ctl->grid_lat0 =
00645     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
00646   ctl->grid_lat1 =
00647     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
00648   ctl->grid_ny =
00649     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
00650
00651   /* Output of profile data... */
00652   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
00653            ctl->prof_basename);
00654   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
      prof_obsfile);
00655   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
00656   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
00657   ctl->prof_nz =
00658     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
00659   ctl->prof_lon0 =
00660     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
00661   ctl->prof_lon1 =
00662     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
00663   ctl->prof_nx =
00664     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
00665   ctl->prof_lat0 =
00666     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
00667   ctl->prof_lat1 =
00668     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
00669   ctl->prof_ny =
00670     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
00671
00672   /* Output of PSC data... */
00673   scan_ctl(filename, argc, argv, "PSC_BASENAME", -1, "-", ctl->
      psc_basename);
00674
00675   /* Output of station data... */
00676   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
00677            ctl->stat_basename);
00678   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
00679   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
00680   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
00681 }
```

Here is the call graph for this function:

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

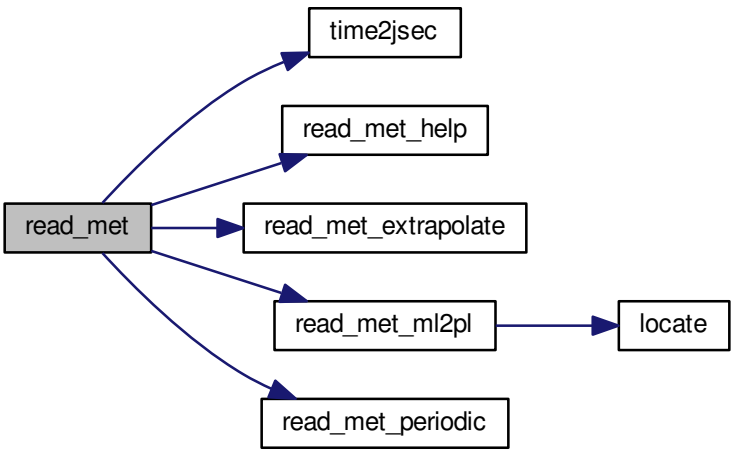
Read meteorological data file.

Definition at line 685 of file libtrac.c.

```
00688               {
00689
00690   char tstr[10];
00691
00692   static float help[EX * EY];
00693
00694   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
00695
00696   size_t np, nx, ny;
00697
00698   /* Write info... */
00699   printf("Read meteorological data: %s\n", filename);
00700
00701   /* Get time from filename... */
00702   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
00703   year = atoi(tstr);
00704   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
00705   mon = atoi(tstr);
00706   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
00707   day = atoi(tstr);
00708   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
00709   hour = atoi(tstr);
00710   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
00711
00712   /* Open netCDF file... */
00713   NC(nc_open(filename, NC_NOWRITE, &ncid));
00714
00715   /* Get dimensions... */
00716   NC(nc_inq_dimid(ncid, "lon", &dimid));
00717   NC(nc_inq_dimlen(ncid, dimid, &nx));
00718   if (nx > EX)
00719     ERRMSG("Too many longitudes!");
00720
00721   NC(nc_inq_dimid(ncid, "lat", &dimid));
00722   NC(nc_inq_dimlen(ncid, dimid, &ny));
00723   if (ny > EY)
00724     ERRMSG("Too many latitudes!");
00725
00726   NC(nc_inq_dimid(ncid, "lev", &dimid));
00727   NC(nc_inq_dimlen(ncid, dimid, &np));
00728   if (np > EP)
00729     ERRMSG("Too many levels!");
00730
00731   /* Store dimensions... */
00732   met->np = (int) np;
00733   met->nx = (int) nx;
00734   met->ny = (int) ny;
00735
00736   /* Get horizontal grid... */
00737   NC(nc_inq_varid(ncid, "lon", &varid));
00738   NC(nc_get_var_double(ncid, varid, met->lon));
00739   NC(nc_inq_varid(ncid, "lat", &varid));
00740   NC(nc_get_var_double(ncid, varid, met->lat));
00741
00742   /* Read meteorological data... */
00743   read_met_help(ncid, "t", "T", met, met->t, 1.0);
00744   read_met_help(ncid, "u", "U", met, met->u, 1.0);
00745   read_met_help(ncid, "v", "V", met, met->v, 1.0);
00746   read_met_help(ncid, "w", "W", met, met->w, 0.01f);
00747   read_met_help(ncid, "q", "Q", met, met->h2o, 1.608f);
00748   read_met_help(ncid, "o3", "O3", met, met->o3, 0.602f);
00749
00750   /* Meteo data on pressure levels... */
00751   if (ctl->met_np <= 0) {
00752
00753     /* Read pressure levels from file... */
00754     NC(nc_inq_varid(ncid, "lev", &varid));
00755     NC(nc_get_var_double(ncid, varid, met->p));
00756     for (ip = 0; ip < met->np; ip++)
00757       met->p[ip] /= 100.;
00758
00759     /* Extrapolate data for lower boundary... */
00760     read_met_extrapolate(met);
00761   }
00762
00763   /* Meteo data on model levels... */
00764   else {
00765
00766     /* Read pressure data from file... */
00767     read_met_help(ncid, "pl", "PL", met, met->pl, 0.01f);
00768
00769     /* Interpolate from model levels to pressure levels... */
00770     read_met_ml2pl(ctl, met, met->t);
00771     read_met_ml2pl(ctl, met, met->u);
```

```
00772     read_met_ml2pl(ctl, met, met->v);
00773     read_met_ml2pl(ctl, met, met->w);
00774     read_met_ml2pl(ctl, met, met->h2o);
00775     read_met_ml2pl(ctl, met, met->o3);
00776
00777     /* Set pressure levels... */
00778     met->np = ctl->met_np;
00779     for (ip = 0; ip < met->np; ip++)
00780       met->p[ip] = ctl->met_p[ip];
00781   }
00782
00783   /* Check ordering of pressure levels... */
00784   for (ip = 1; ip < met->np; ip++)
00785     if (met->p[ip - 1] < met->p[ip])
00786       ERRMSG("Pressure levels must be descending!");
00787
00788   /* Read surface pressure... */
00789   if (nc_inq_varid(ncid, "PS", &varid) == NC_NOERR) {
00790     NC(nc_get_var_float(ncid, varid, help));
00791     for (iy = 0; iy < met->ny; iy++)
00792       for (ix = 0; ix < met->nx; ix++)
00793         met->ps[ix][iy] = help[iy * met->nx + ix] / 100.;
00794   } else if (nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
00795     NC(nc_get_var_float(ncid, varid, help));
00796     for (iy = 0; iy < met->ny; iy++)
00797       for (ix = 0; ix < met->nx; ix++)
00798         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
00799   } else
00800     for (ix = 0; ix < met->nx; ix++)
00801       for (iy = 0; iy < met->ny; iy++)
00802         met->ps[ix][iy] = met->p[0];
00803
00804   /* Create periodic boundary conditions... */
00805   read_met_periodic(met);
00806
00807   /* Close file... */
00808   NC(nc_close(ncid));
00809 }
```

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 813 of file libtrac.c.

```
00814               {
00815
00816   int ip, ip0, ix, iy;
00817
00818   /* Loop over columns... */
00819   for (ix = 0; ix < met->nx; ix++)
00820     for (iy = 0; iy < met->ny; iy++) {
00821
00822       /* Find lowest valid data point... */
00823       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
00824         if (!gsl_finite(met->t[ix][iy][ip0])
00825             || !gsl_finite(met->u[ix][iy][ip0])
00826             || !gsl_finite(met->v[ix][iy][ip0])
00827             || !gsl_finite(met->w[ix][iy][ip0]))
00828           break;
00829
00830       /* Extrapolate... */
00831       for (ip = ip0; ip >= 0; ip--) {
00832         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
00833         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
00834         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
00835         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
00836         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
00837         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
00838       }
00839     }
00840 }
```

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 844 of file libtrac.c.

```
00850             {
00851
00852   static float help[EX * EY * EP];
00853
00854   int ip, ix, iy, n = 0, varid;
00855
00856   /* Check if variable exists... */
00857   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
00858     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
00859       return;
00860
00861   /* Read data... */
00862   NC(nc_get_var_float(ncid, varid, help));
00863
00864   /* Copy and check data... */
00865   for (ip = 0; ip < met->np; ip++)
00866     for (iy = 0; iy < met->ny; iy++)
00867       for (ix = 0; ix < met->nx; ix++) {
00868         dest[ix][iy][ip] = scl * help[n++];
00869         if (fabs(dest[ix][iy][ip] / scl) > 1e14)
00870           dest[ix][iy][ip] = GSL_NAN;
00871       }
00872 }
```

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

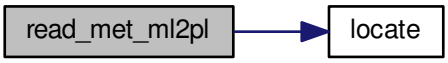
Convert meteorological data from model levels to pressure levels.

Definition at line 876 of file libtrac.c.

```
00879                         {
00880
00881   double aux[EP], p[EP], pt;
00882
00883   int ip, ip2, ix, iy;
00884
00885   /* Loop over columns... */
00886   for (ix = 0; ix < met->nx; ix++)
00887     for (iy = 0; iy < met->ny; iy++) {
00888
```

```
00889       /* Copy pressure profile... */
00890       for (ip = 0; ip < met->np; ip++)
00891         p[ip] = met->pl[ix][iy][ip];
00892
00893       /* Interpolate... */
00894       for (ip = 0; ip < ctl->met_np; ip++) {
00895         pt = ctl->met_p[ip];
00896         if ((pt > p[0] && p[0] > p[1]) || (pt < p[0] && p[0] < p[1]))
00897           pt = p[0];
00898         else if ((pt > p[met->np - 1] && p[1] > p[0])
00899                  || (pt < p[met->np - 1] && p[1] < p[0]))
00900           pt = p[met->np - 1];
00901         ip2 = locate(p, met->np, pt);
00902         aux[ip] = LIN(p[ip2], var[ix][iy][ip2],
00903                       p[ip2 + 1], var[ix][iy][ip2 + 1], pt);
00904       }
00905
00906       /* Copy data... */
00907       for (ip = 0; ip < ctl->met_np; ip++)
00908         var[ix][iy][ip] = (float) aux[ip];
00909     }
00910 }
```

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 914 of file libtrac.c.

```
00915               {
00916
00917   int ip, iy;
00918
00919   /* Check longitudes... */
00920   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
00921              + met->lon[1] - met->lon[0] - 360) < 0.01))
00922     return;
00923
00924   /* Increase longitude counter... */
00925   if ((++met->nx) > EX)
00926     ERRMSG("Cannot create periodic boundary conditions!");
00927
00928   /* Set longitude... */
00929   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
00930
00931   /* Loop over latitudes and pressure levels... */
00932   for (iy = 0; iy < met->ny; iy++)
00933     for (ip = 0; ip < met->np; ip++) {
00934       met->ps[met->nx - 1][iy] = met->ps[0][iy];
00935       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
00936       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
00937       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
00938       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
00939       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
00940       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
00941     }
00942 }
```

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 946 of file libtrac.c.

```
00953                {
00954
00955   FILE *in = NULL;
00956
00957   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
00958     msg[LEN], rvarname[LEN], rval[LEN];
00959
00960   int contain = 0, i;
00961
00962   /* Open file... */
00963   if (filename[strlen(filename) - 1] != '-')
00964     if (!(in = fopen(filename, "r")))
00965       ERRMSG("Cannot open file!");
00966
00967   /* Set full variable name... */
00968   if (arridx >= 0) {
00969     sprintf(fullname1, "%s[%d]", varname, arridx);
00970     sprintf(fullname2, "%s[*]", varname);
00971   } else {
00972     sprintf(fullname1, "%s", varname);
00973     sprintf(fullname2, "%s", varname);
00974   }
00975
00976   /* Read data... */
00977   if (in != NULL)
00978     while (fgets(line, LEN, in))
00979       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
00980         if (strcasecmp(rvarname, fullname1) == 0 ||
00981             strcasecmp(rvarname, fullname2) == 0) {
00982           contain = 1;
00983           break;
00984         }
00985   for (i = 1; i < argc - 1; i++)
00986     if (strcasecmp(argv[i], fullname1) == 0 ||
00987         strcasecmp(argv[i], fullname2) == 0) {
00988       sprintf(rval, "%s", argv[i + 1]);
00989       contain = 1;
00990       break;
00991     }
00992
00993   /* Close file... */
00994   if (in != NULL)
00995     fclose(in);
00996
00997   /* Check for missing variables... */
00998   if (!contain) {
00999     if (strlen(defvalue) > 0)
01000       sprintf(rval, "%s", defvalue);
01001     else {
01002       sprintf(msg, "Missing variable %s!\n", fullname1);
01003       ERRMSG(msg);
01004     }
01005   }
01006
01007   /* Write info... */
01008   printf("%s = %s\n", fullname1, rval);
01009
01010   /* Return values... */
01011   if (value != NULL)
01012     sprintf(value, "%s", rval);
01013   return atof(rval);
01014 }
```

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 1018 of file libtrac.c.

```
01026                {
01027
01028   struct tm t0, t1;
01029
01030   t0.tm_year = 100;
01031   t0.tm_mon = 0;
01032   t0.tm_mday = 1;
01033   t0.tm_hour = 0;
01034   t0.tm_min = 0;
01035   t0.tm_sec = 0;
01036
01037   t1.tm_year = year - 1900;
01038   t1.tm_mon = mon - 1;
01039   t1.tm_mday = day;
01040   t1.tm_hour = hour;
01041   t1.tm_min = min;
01042   t1.tm_sec = sec;
01043
01044   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
01045 }
```

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

Measure wall-clock time.

Definition at line 1049 of file libtrac.c.

```
01052            {
01053
01054   static double starttime[NTIMER], runtime[NTIMER];
01055
01056   /* Check id... */
01057   if (id < 0 || id >= NTIMER)
01058     ERRMSG("Too many timers!");
01059
01060   /* Start timer... */
01061   if (mode == 1) {
01062     if (starttime[id] <= 0)
01063       starttime[id] = omp_get_wtime();
01064     else
01065       ERRMSG("Timer already started!");
01066   }
01067
01068   /* Stop timer... */
01069   else if (mode == 2) {
01070     if (starttime[id] > 0) {
01071       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
01072       starttime[id] = -1;
01073     } else
01074       ERRMSG("Timer not started!");
01075   }
01076
01077   /* Print timer... */
01078   else if (mode == 3)
01079     printf("%s = %g s\n", name, runtime[id]);
01080 }
```

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

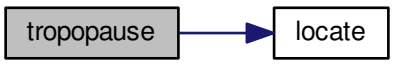
Definition at line 1084 of file libtrac.c.

```
01086              {
01087
01088   static double doys[12]
01089   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
01090
01091   static double lats[73]
01092     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
01093     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
01094     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
01095     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
01096     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
01097     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
01098     75, 77.5, 80, 82.5, 85, 87.5, 90
01099   };
```

```
01100
01101   static double tps[12][73]
01102     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
01103          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
01104          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
01105          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
01106          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
01107          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
01108          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
01109          275.3, 275.6, 275.4, 274.1, 273.5},
01110    {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
01111     300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
01112     150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
01113     98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
01114     98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
01115     220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
01116     284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
01117     287.5, 286.2, 285.8},
01118    {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
01119     297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
01120     161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
01121     100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
01122     99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
01123     186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
01124     279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
01125     304.3, 304.9, 306, 306.6, 306.2, 306},
01126    {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
01127     290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
01128     195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
01129     102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
01130     99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
01131     148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
01132     263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
01133     315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
01134    {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
01135     260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
01136     205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
01137     101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
01138     102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
01139     165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
01140     273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
01141     325.3, 325.8, 325.8},
01142    {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
01143     222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
01144     228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
01145     105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
01146     106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
01147     127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
01148     251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
01149     308.5, 312.2, 313.1, 313.3},
01150    {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
01151     187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
01152     235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
01153     110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
01154     111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
01155     117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
01156     224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
01157     275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
01158    {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
01159     185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
01160     233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
01161     110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
01162     112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
01163     120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
01164     230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
01165     278.2, 282.6, 287.4, 290.9, 292.5, 293},
01166    {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
01167     183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
01168     243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
01169     114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
01170     110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
01171     114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
01172     203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
01173     276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
01174    {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
01175     215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
01176     237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
01177     111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
01178     106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
01179     112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
01180     206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
01181     279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
01182     305.1},
01183    {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
01184     253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
01185     223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
01186     108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
```

```
01187     102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
01188     109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
01189     241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
01190     286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
01191    {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
01192     284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
01193     175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
01194     100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
01195     100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
01196     186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
01197     280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
01198     281.7, 281.1, 281.2}
01199    };
01200
01201    double doy, p0, p1, pt;
01202
01203    int imon, ilat;
01204
01205    /* Get day of year... */
01206    doy = fmod(t / 86400., 365.25);
01207    while (doy < 0)
01208      doy += 365.25;
01209
01210    /* Get indices... */
01211    imon = locate(doys, 12, doy);
01212    ilat = locate(lats, 73, lat);
01213
01214    /* Get tropopause pressure... */
01215    p0 = LIN(lats[ilat], tps[imon][ilat],
01216             lats[ilat + 1], tps[imon][ilat + 1], lat);
01217    p1 = LIN(lats[ilat], tps[imon + 1][ilat],
01218             lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
01219    pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
01220
01221    /* Return tropopause pressure... */
01222    return pt;
01223  }
```

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 1227 of file libtrac.c.

```
01231             {
01232
01233    FILE *in, *out;
01234
01235    char line[LEN];
01236
01237    double r, t0, t1;
01238
01239    int ip, iq, year, mon, day, hour, min, sec;
01240
01241    /* Set time interval for output... */
01242    t0 = t - 0.5 * ctl->dt_mod;
01243    t1 = t + 0.5 * ctl->dt_mod;
01244
01245    /* Check if gnuplot output is requested... */
01246    if (ctl->atm_gpfile[0] != '-') {
```

```
01247
01248     /* Write info... */
01249     printf("Plot atmospheric data: %s.png\n", filename);
01250
01251     /* Create gnuplot pipe... */
01252     if (!(out = popen("gnuplot", "w")))
01253       ERRMSG("Cannot create pipe to gnuplot!");
01254
01255     /* Set plot filename... */
01256     fprintf(out, "set out \"%s.png\"\n", filename);
01257
01258     /* Set time string... */
01259     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01260     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01261             year, mon, day, hour, min);
01262
01263     /* Dump gnuplot file to pipe... */
01264     if (!(in = fopen(ctl->atm_gpfile, "r")))
01265       ERRMSG("Cannot open file!");
01266     while (fgets(line, LEN, in))
01267       fprintf(out, "%s", line);
01268     fclose(in);
01269   }
01270
01271   else {
01272
01273     /* Write info... */
01274     printf("Write atmospheric data: %s\n", filename);
01275
01276     /* Create file... */
01277     if (!(out = fopen(filename, "w")))
01278       ERRMSG("Cannot create file!");
01279   }
01280
01281   /* Write header... */
01282   fprintf(out,
01283           "# $1 = time [s]\n"
01284           "# $2 = altitude [km]\n"
01285           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01286   for (iq = 0; iq < ctl->nq; iq++)
01287     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
01288             ctl->qnt_unit[iq]);
01289   fprintf(out, "\n");
01290
01291   /* Write data... */
01292   for (ip = 0; ip < atm->np; ip++) {
01293
01294     /* Check time... */
01295     if (ctl->atm_filter && (atm->time[ip] < t0 || atm->time[ip] > t1))
01296       continue;
01297
01298     /* Write output... */
01299     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
01300             atm->lon[ip], atm->lat[ip]);
01301     for (iq = 0; iq < ctl->nq; iq++) {
01302       fprintf(out, " ");
01303       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01304     }
01305     fprintf(out, "\n");
01306   }
01307
01308   /* Close file... */
01309   fclose(out);
01310 }
```

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 1314 of file libtrac.c.

```
01318            {
01319
01320   static FILE *in, *out;
01321
01322   static char line[LEN];
01323
01324   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
01325     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
01326
01327   static int init, obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
01328
01329   /* Init... */
01330   if (!init) {
01331     init = 1;
01332
01333     /* Check quantity index for mass... */
01334     if (ctl->qnt_m < 0)
01335       ERRMSG("Need quantity mass to analyze CSI!");
01336
01337     /* Open observation data file... */
01338     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
01339     if (!(in = fopen(ctl->csi_obsfile, "r")))
01340       ERRMSG("Cannot open file!");
01341
01342     /* Create new file... */
01343     printf("Write CSI data: %s\n", filename);
01344     if (!(out = fopen(filename, "w")))
01345       ERRMSG("Cannot create file!");
01346
01347     /* Write header... */
01348     fprintf(out,
01349             "# $1 = time [s]\n"
01350             "# $2 = number of hits (cx)\n"
01351             "# $3 = number of misses (cy)\n"
01352             "# $4 = number of false alarms (cz)\n"
01353             "# $5 = number of observations (cx + cy)\n"
01354             "# $6 = number of forecasts (cx + cz)\n"
01355             "# $7 = bias (forecasts/observations) [%%]\n"
01356             "# $8 = probability of detection (POD) [%%]\n"
01357             "# $9 = false alarm rate (FAR) [%%]\n"
01358             "# $10 = critical success index (CSI) [%%]\n\n");
01359   }
01360
01361   /* Set time interval... */
01362   t0 = t - 0.5 * ctl->dt_mod;
01363   t1 = t + 0.5 * ctl->dt_mod;
01364
01365   /* Initialize grid cells... */
01366   for (ix = 0; ix < ctl->csi_nx; ix++)
01367     for (iy = 0; iy < ctl->csi_ny; iy++)
01368       for (iz = 0; iz < ctl->csi_nz; iz++)
01369         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
01370
01371   /* Read data... */
01372   while (fgets(line, LEN, in)) {
01373
01374     /* Read data... */
01375     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
01376         5)
01377       continue;
01378
01379     /* Check time... */
01380     if (rt < t0)
01381       continue;
01382     if (rt > t1)
01383       break;
01384
01385     /* Calculate indices... */
01386     ix = (int) ((rlon - ctl->csi_lon0)
01387                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01388     iy = (int) ((rlat - ctl->csi_lat0)
01389                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01390     iz = (int) ((rz - ctl->csi_z0)
01391                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01392
01393     /* Check indices... */
01394     if (ix < 0 || ix >= ctl->csi_nx ||
```

```
01395         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01396       continue;
01397
01398     /* Get mean observation index... */
01399     obsmean[ix][iy][iz] += robs;
01400     obscount[ix][iy][iz]++;
01401   }
01402
01403   /* Analyze model data... */
01404   for (ip = 0; ip < atm->np; ip++) {
01405
01406     /* Check time... */
01407     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01408       continue;
01409
01410     /* Get indices... */
01411     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
01412                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01413     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
01414                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01415     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
01416                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01417
01418     /* Check indices... */
01419     if (ix < 0 || ix >= ctl->csi_nx ||
01420         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01421       continue;
01422
01423     /* Get total mass in grid cell... */
01424     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01425   }
01426
01427   /* Analyze all grid cells... */
01428   for (ix = 0; ix < ctl->csi_nx; ix++)
01429     for (iy = 0; iy < ctl->csi_ny; iy++)
01430       for (iz = 0; iz < ctl->csi_nz; iz++) {
01431
01432         /* Calculate mean observation index... */
01433         if (obscount[ix][iy][iz] > 0)
01434           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
01435
01436         /* Calculate column density... */
01437         if (modmean[ix][iy][iz] > 0) {
01438           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
01439           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
01440           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
01441           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
01442             * cos(lat * M_PI / 180.);
01443           modmean[ix][iy][iz] /= (1e6 * area);
01444         }
01445
01446         /* Calculate CSI... */
01447         if (obscount[ix][iy][iz] > 0) {
01448           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01449               modmean[ix][iy][iz] >= ctl->csi_modmin)
01450             cx++;
01451           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01452                    modmean[ix][iy][iz] < ctl->csi_modmin)
01453             cy++;
01454           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
01455                    modmean[ix][iy][iz] >= ctl->csi_modmin)
01456             cz++;
01457         }
01458       }
01459
01460   /* Write output... */
01461   if (fmod(t, ctl->csi_dt_out) == 0) {
01462
01463     /* Write... */
01464     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
01465             t, cx, cy, cz, cx + cy, cx + cz,
01466             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
01467             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
01468             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
01469             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
01470
01471     /* Set counters to zero... */
01472     cx = cy = cz = 0;
01473   }
01474
01475   /* Close file... */
01476   if (t == ctl->t_stop)
01477     fclose(out);
01478 }
```

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

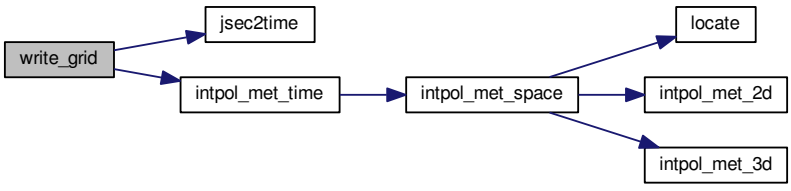
Write gridded data.

Definition at line 1482 of file libtrac.c.

```
01488            {
01489
01490   FILE *in, *out;
01491
01492   char line[LEN];
01493
01494   static double grid_m[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
01495     area, rho_air, press, temp, cd, mmr, t0, t1, r;
01496
01497   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
01498
01499   /* Check dimensions... */
01500   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
01501     ERRMSG("Grid dimensions too large!");
01502
01503   /* Check quantity index for mass... */
01504   if (ctl->qnt_m < 0)
01505     ERRMSG("Need quantity mass to write grid data!");
01506
01507   /* Set time interval for output... */
01508   t0 = t - 0.5 * ctl->dt_mod;
01509   t1 = t + 0.5 * ctl->dt_mod;
01510
01511   /* Set grid box size... */
01512   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
01513   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
01514   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
01515
01516   /* Initialize grid... */
01517   for (ix = 0; ix < ctl->grid_nx; ix++)
01518     for (iy = 0; iy < ctl->grid_ny; iy++)
01519       for (iz = 0; iz < ctl->grid_nz; iz++)
01520         grid_m[ix][iy][iz] = 0;
01521
01522   /* Average data... */
01523   for (ip = 0; ip < atm->np; ip++)
01524     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
01525
01526       /* Get index... */
01527       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
01528       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
01529       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
01530
01531       /* Check indices... */
01532       if (ix < 0 || ix >= ctl->grid_nx ||
01533           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
01534         continue;
01535
01536       /* Add mass... */
01537       grid_m[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01538     }
01539
01540   /* Check if gnuplot output is requested... */
01541   if (ctl->grid_gpfile[0] != '-') {
01542
01543     /* Write info... */
01544     printf("Plot grid data: %s.png\n", filename);
01545
01546     /* Create gnuplot pipe... */
01547     if (!(out = popen("gnuplot", "w")))
01548       ERRMSG("Cannot create pipe to gnuplot!");
01549
01550     /* Set plot filename... */
01551     fprintf(out, "set out \"%s.png\"\n", filename);
01552
01553     /* Set time string... */
01554     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01555     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01556             year, mon, day, hour, min);
01557
01558     /* Dump gnuplot file to pipe... */
01559     if (!(in = fopen(ctl->grid_gpfile, "r")))
01560       ERRMSG("Cannot open file!");
01561     while (fgets(line, LEN, in))
01562       fprintf(out, "%s", line);
01563     fclose(in);
01564   }
```

```
01565
01566   else {
01567
01568     /* Write info... */
01569     printf("Write grid data: %s\n", filename);
01570
01571     /* Create file... */
01572     if (!(out = fopen(filename, "w")))
01573       ERRMSG("Cannot create file!");
01574   }
01575
01576   /* Write header... */
01577   fprintf(out,
01578           "# $1 = time [s]\n"
01579           "# $2 = altitude [km]\n"
01580           "# $3 = longitude [deg]\n"
01581           "# $4 = latitude [deg]\n"
01582           "# $5 = surface area [km^2]\n"
01583           "# $6 = layer width [km]\n"
01584           "# $7 = temperature [K]\n"
01585           "# $8 = column density [kg/m^2]\n"
01586           "# $9 = mass mixing ratio [1]\n\n");
01587
01588   /* Write data... */
01589   for (ix = 0; ix < ctl->grid_nx; ix++) {
01590     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
01591       fprintf(out, "\n");
01592     for (iy = 0; iy < ctl->grid_ny; iy++) {
01593       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
01594         fprintf(out, "\n");
01595       for (iz = 0; iz < ctl->grid_nz; iz++)
01596         if (!ctl->grid_sparse
01597             || ix == 0 || iy == 0 || iz == 0 || grid_m[ix][iy][iz] > 0) {
01598
01599           /* Set coordinates... */
01600           z = ctl->grid_z0 + dz * (iz + 0.5);
01601           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
01602           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
01603
01604           /* Get pressure and temperature... */
01605           press = P(z);
01606           intpol_met_time(met0, met1, t, press, lon, lat,
01607                           NULL, &temp, NULL, NULL, NULL, NULL, NULL);
01608
01609           /* Calculate surface area... */
01610           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
01611             * cos(lat * M_PI / 180.);
01612
01613           /* Calculate column density... */
01614           cd = grid_m[ix][iy][iz] / (1e6 * area);
01615
01616           /* Calculate mass mixing ratio... */
01617           rho_air = 100. * press / (287.058 * temp);
01618           mmr = grid_m[ix][iy][iz] / (rho_air * 1e6 * area * 1e3 * dz);
01619
01620           /* Write output... */
01621           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01622                   t, z, lon, lat, area, dz, temp, cd, mmr);
01623         }
01624     }
01625   }
01626
01627   /* Close file... */
01628   fclose(out);
01629 }
```

Here is the call graph for this function:



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

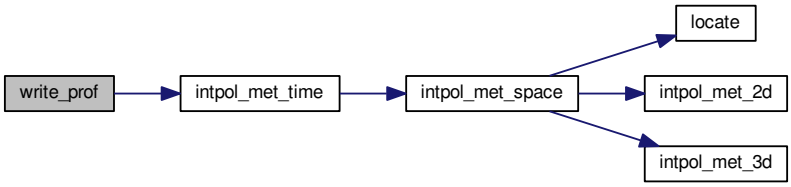
Write profile data.

Definition at line 1633 of file libtrac.c.

```
01639           {
01640
01641   static FILE *in, *out;
01642
01643   static char line[LEN];
01644
01645   static double mass[GX][GY][GZ], obsmean[GX][GY], tmean[GX][GY],
01646     rt, rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z,
01647     press, temp, rho_air, mmr, h2o, o3;
01648
01649   static int init, obscount[GX][GY], ip, ix, iy, iz;
01650
01651   /* Init... */
01652   if (!init) {
01653     init = 1;
01654
01655     /* Check quantity index for mass... */
01656     if (ctl->qnt_m < 0)
01657       ERRMSG("Need quantity mass!");
01658
01659     /* Check dimensions... */
01660     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
01661       ERRMSG("Grid dimensions too large!");
01662
01663     /* Open observation data file... */
01664     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
01665     if (!(in = fopen(ctl->prof_obsfile, "r")))
01666       ERRMSG("Cannot open file!");
01667
01668     /* Create new file... */
01669     printf("Write profile data: %s\n", filename);
01670     if (!(out = fopen(filename, "w")))
01671       ERRMSG("Cannot create file!");
01672
01673     /* Write header... */
01674     fprintf(out,
01675             "# $1  = time [s]\n"
01676             "# $2  = altitude [km]\n"
01677             "# $3  = longitude [deg]\n"
01678             "# $4  = latitude [deg]\n"
01679             "# $5  = pressure [hPa]\n"
01680             "# $6  = temperature [K]\n"
01681             "# $7  = mass mixing ratio [1]\n"
01682             "# $8  = H2O volume mixing ratio [1]\n"
01683             "# $9  = O3 volume mixing ratio [1]\n"
01684             "# $10 = mean BT index [K]\n");
01685
01686     /* Set grid box size... */
01687     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
01688     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
01689     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
01690   }
01691
01692   /* Set time interval... */
01693   t0 = t - 0.5 * ctl->dt_mod;
01694   t1 = t + 0.5 * ctl->dt_mod;
01695
01696   /* Initialize... */
01697   for (ix = 0; ix < ctl->prof_nx; ix++)
01698     for (iy = 0; iy < ctl->prof_ny; iy++) {
01699       obsmean[ix][iy] = 0;
01700       obscount[ix][iy] = 0;
01701       tmean[ix][iy] = 0;
01702       for (iz = 0; iz < ctl->prof_nz; iz++)
01703         mass[ix][iy][iz] = 0;
01704     }
01705
01706   /* Read data... */
01707   while (fgets(line, LEN, in)) {
01708
01709     /* Read data... */
01710     if (sscanf(line, "%lg %lg %lg %lg", &rt, &rlon, &rlat, &robs) != 4)
01711       continue;
01712
01713     /* Check time... */
01714     if (rt < t0)
01715       continue;
```

```
01716     if (rt > t1)
01717       break;
01718
01719     /* Calculate indices... */
01720     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
01721     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
01722
01723     /* Check indices... */
01724     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
01725       continue;
01726
01727     /* Get mean observation index... */
01728     obsmean[ix][iy] += robs;
01729     tmean[ix][iy] += rt;
01730     obscount[ix][iy]++;
01731   }
01732
01733   /* Analyze model data... */
01734   for (ip = 0; ip < atm->np; ip++) {
01735
01736     /* Check time... */
01737     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01738       continue;
01739
01740     /* Get indices... */
01741     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
01742     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
01743     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
01744
01745     /* Check indices... */
01746     if (ix < 0 || ix >= ctl->prof_nx ||
01747         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
01748       continue;
01749
01750     /* Get total mass in grid cell... */
01751     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01752   }
01753
01754   /* Extract profiles... */
01755   for (ix = 0; ix < ctl->prof_nx; ix++)
01756     for (iy = 0; iy < ctl->prof_ny; iy++)
01757       if (obscount[ix][iy] > 0) {
01758
01759         /* Write output... */
01760         fprintf(out, "\n");
01761
01762         /* Loop over altitudes... */
01763         for (iz = 0; iz < ctl->prof_nz; iz++) {
01764
01765           /* Set coordinates... */
01766           z = ctl->prof_z0 + dz * (iz + 0.5);
01767           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
01768           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
01769
01770           /* Get meteorological data... */
01771           press = P(z);
01772           intpol_met_time(met0, met1, t, press, lon, lat,
01773                           NULL, &temp, NULL, NULL, NULL, &h2o, &o3);
01774
01775           /* Calculate mass mixing ratio... */
01776           rho_air = 100. * press / (287.058 * temp);
01777           area = dlat * dlon * gsl_pow_2(M_PI * RE / 180.)
01778             * cos(lat * M_PI / 180.);
01779           mmr = mass[ix][iy][iz] / (rho_air * area * dz * 1e9);
01780
01781           /* Write output... */
01782           fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g\n",
01783                   tmean[ix][iy] / obscount[ix][iy],
01784                   z, lon, lat, press, temp, mmr, h2o, o3,
01785                   obsmean[ix][iy] / obscount[ix][iy]);
01786         }
01787       }
01788
01789   /* Close file... */
01790   if (t == ctl->t_stop)
01791     fclose(out);
01792 }
```

Here is the call graph for this function:



5.13.2.32 void write_psc (const char * *filename*, ctl_t * *ctl*, atm_t * *atm*, double *t*)

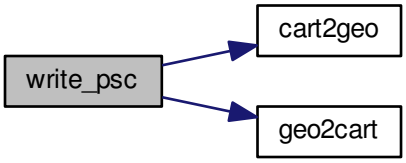
Write PSC data.

Definition at line 1796 of file libtrac.c.

```
01800           {
01801
01802   static FILE *out;
01803
01804   static double dtice[NPSC], dtsts[NPSC], dtnat[NPSC], dummy,
01805     latm, lonm, p[NPSC], pv[NPSC], t0, t1, ts, x[NPSC][3], xm[3];
01806
01807   static int init, ip;
01808
01809   static size_t i, n;
01810
01811   /* Init... */
01812   if (!init) {
01813     init = 1;
01814
01815     /* Check quantity indices... */
01816     if (ctl->qnt_t0 < 0 || ctl->qnt_pv < 0 || ctl->qnt_t < 0 ||
01817         ctl->qnt_tice < 0 || ctl->qnt_tnat < 0)
01818       ERRMSG("Missing quantities for PSC analysis!");
01819
01820     /* Create new file... */
01821     printf("Write PSC data: %s\n", filename);
01822     if (!(out = fopen(filename, "w")))
01823       ERRMSG("Cannot create file!");
01824
01825     /* Write header... */
01826     fprintf(out,
01827             "# $1 = time [s]\n"
01828             "# $2 = altitude [km]\n"
01829             "# $3 = longitude [deg]\n"
01830             "# $4 = latitude [deg]\n"
01831             "# $5 = start time [s]\n"
01832             "# $6 = potential vorticity [PVU]\n"
01833             "# $7 = T - T_ice (mean) [K]\n"
01834             "# $8 = T - T_ice (sigma) [K]\n"
01835             "# $9 = T - T_STS (mean) [K]\n"
01836             "# $10 = T - T_STS (sigma) [K]\n"
01837             "# $11 = T - T_NAT (mean) [K]\n"
01838             "# $12 = T - T_NAT (sigma) [K]\n\n");
01839   }
01840
01841   /* Set time interval... */
01842   t0 = t - 0.5 * ctl->dt_mod;
01843   t1 = t + 0.5 * ctl->dt_mod;
01844
01845   /* Init... */
01846   ts = GSL_NAN;
01847   n = 0;
01848
01849   /* Loop over air parcels... */
01850   for (ip = 0; ip < atm->np; ip++) {
01851
01852     /* Check time... */
01853     if (atm->time[ip] < t0 || atm->time[ip] > t1)
```

```
01854       continue;
01855
01856     /* Check trajectory start time... */
01857     if (atm->q[ctl->qnt_t0][ip] != ts) {
01858
01859       /* Write results... */
01860       if (n > 0) {
01861
01862         /* Get mean position... */
01863         xm[0] = xm[1] = xm[2] = 0;
01864         for (i = 0; i < n; i++) {
01865           xm[0] += x[i][0] / (double) n;
01866           xm[1] += x[i][1] / (double) n;
01867           xm[2] += x[i][2] / (double) n;
01868         }
01869         cart2geo(xm, &dummy, &lonm, &latm);
01870
01871         /* Get statistics... */
01872         fprintf(out, "%.2f %g %g %g %.2f %g %.2f %.2f %.2f %.2f %.2f %.2f\n",
01873                 t, Z(gsl_stats_mean(p, 1, n)), lonm, latm, ts,
01874                 gsl_stats_mean(pv, 1, n),
01875                 gsl_stats_mean(dtice, 1, n), gsl_stats_sd(dtice, 1, n),
01876                 gsl_stats_mean(dtsts, 1, n), gsl_stats_sd(dtsts, 1, n),
01877                 gsl_stats_mean(dtnat, 1, n), gsl_stats_sd(dtnat, 1, n));
01878       }
01879
01880       /* Save new start time... */
01881       ts = atm->q[ctl->qnt_t0][ip];
01882       n = 0;
01883     }
01884
01885     /* Save data... */
01886     p[n] = atm->p[ip];
01887     geo2cart(0, atm->lon[ip], atm->lat[ip], x[n]);
01888     pv[n] = atm->q[ctl->qnt_pv][ip];
01889     dtice[n] = atm->q[ctl->qnt_t][ip] - atm->q[ctl->qnt_tice][ip];
01890     dtsts[n] = atm->q[ctl->qnt_t][ip]
01891       - 0.5 * (atm->q[ctl->qnt_tice][ip] + atm->q[ctl->qnt_tnat][ip]);
01892     dtnat[n] = atm->q[ctl->qnt_t][ip] - atm->q[ctl->qnt_tnat][ip];
01893     if ((++n) >= NPSC)
01894       ERRMSG("Too many data points!");
01895   }
01896
01897   /* Write results... */
01898   if (n > 0) {
01899
01900     /* Get mean position... */
01901     xm[0] = xm[1] = xm[2] = 0;
01902     for (i = 0; i < n; i++) {
01903       xm[0] += x[i][0] / (double) n;
01904       xm[1] += x[i][1] / (double) n;
01905       xm[2] += x[i][2] / (double) n;
01906     }
01907     cart2geo(xm, &dummy, &lonm, &latm);
01908
01909     /* Get statistics... */
01910     fprintf(out, "%.2f %g %g %g %.2f %g %.2f %.2f %.2f %.2f %.2f %.2f\n",
01911             t, Z(gsl_stats_mean(p, 1, n)), lonm, latm, ts,
01912             gsl_stats_mean(pv, 1, n),
01913             gsl_stats_mean(dtice, 1, n), gsl_stats_sd(dtice, 1, n),
01914             gsl_stats_mean(dtsts, 1, n), gsl_stats_sd(dtsts, 1, n),
01915             gsl_stats_mean(dtnat, 1, n), gsl_stats_sd(dtnat, 1, n));
01916   }
01917
01918   /* Close file... */
01919   if (t == ctl->t_stop)
01920     fclose(out);
01921 }
```

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*)

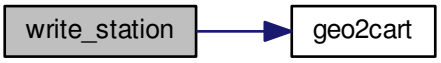
Write station data.

Definition at line 1925 of file libtrac.c.

```
01929            {
01930
01931   static FILE *out;
01932
01933   static double rmax2, t0, t1, x0[3], x1[3];
01934
01935   static int init, ip, iq;
01936
01937   /* Init... */
01938   if (!init) {
01939     init = 1;
01940
01941     /* Write info... */
01942     printf("Write station data: %s\n", filename);
01943
01944     /* Create new file... */
01945     if (!(out = fopen(filename, "w")))
01946       ERRMSG("Cannot create file!");
01947
01948     /* Write header... */
01949     fprintf(out,
01950             "# $1 = time [s]\n"
01951             "# $2 = altitude [km]\n"
01952             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01953     for (iq = 0; iq < ctl->nq; iq++)
01954       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
01955               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
01956     fprintf(out, "\n");
01957
01958     /* Set geolocation and search radius... */
01959     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
01960     rmax2 = gsl_pow_2(ctl->stat_r);
01961   }
01962
01963   /* Set time interval for output... */
01964   t0 = t - 0.5 * ctl->dt_mod;
01965   t1 = t + 0.5 * ctl->dt_mod;
01966
01967   /* Loop over air parcels... */
01968   for (ip = 0; ip < atm->np; ip++) {
01969
01970     /* Check time... */
01971     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01972       continue;
01973
01974     /* Check station flag... */
01975     if (ctl->qnt_stat >= 0)
01976       if (atm->q[ctl->qnt_stat][ip])
01977         continue;
01978
01979     /* Get Cartesian coordinates... */
01980     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
```

```
01981
01982     /* Check horizontal distance... */
01983     if (DIST2(x0, x1) > rmax2)
01984       continue;
01985
01986     /* Set station flag... */
01987     if (ctl->qnt_stat >= 0)
01988       atm->q[ctl->qnt_stat][ip] = 1;
01989
01990     /* Write data... */
01991     fprintf(out, "%.2f %g %g %g",
01992             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
01993     for (iq = 0; iq < ctl->nq; iq++) {
01994       fprintf(out, " ");
01995       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01996     }
01997     fprintf(out, "\n");
01998   }
01999
02000   /* Close file... */
02001   if (t == ctl->t_stop)
02002     fclose(out);
02003 }
```

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    Macros...
```

```
00052    ---------------------------------------------------------- */
00053
00055 #define ALLOC(ptr, type, n)                                  \
00056   if((ptr=calloc((size_t)(n), sizeof(type)))==NULL)       \
00057     ERRMSG("Out of memory!");
00058
00060 #define DIST(a, b) sqrt(DIST2(a, b))
00061
00063 #define DIST2(a, b)                                                    \
00064   ((a[0]-b[0])*(a[0]-b[0])+(a[1]-b[1])*(a[1]-b[1])+(a[2]-b[2])*(a[2]-b[2]))
00065
00067 #define DOTP(a, b) (a[0]*b[0]+a[1]*b[1]+a[2]*b[2])
00068
00070 #define ERRMSG(msg) {                                                  \
00071     printf("\nError (%s, %s, l%d): %s\n\n",                            \
00072            __FILE__, __func__, __LINE__, msg);                         \
00073     exit(EXIT_FAILURE);                                                \
00074   }
00075
00077 #define LIN(x0, y0, x1, y1, x)                  \
00078   ((y0)+((y1)-(y0))/((x1)-(x0))*((x)-(x0)))
00079
00081 #define NC(cmd) {                                    \
00082     if((cmd)!=NC_NOERR)                              \
00083       ERRMSG(nc_strerror(cmd));                      \
00084   }
00085
00087 #define NORM(a) sqrt(DOTP(a, a))
00088
00090 #define PRINT(format, var)                                             \
00091   printf("Print (%s, %s, l%d): %s= "format"\n",                        \
00092          __FILE__, __func__, __LINE__, #var, var);
00093
00095 #define P(z) (P0*exp(-(z)/H0))
00096
00098 #define TOK(line, tok, format, var) {                                  \
00099     if(((tok)=strtok((line), " \t"))) {                                \
00100       if(sscanf(tok, format, &(var))!=1) continue;                     \
00101     } else ERRMSG("Error while reading!");                             \
00102   }
00103
00105 #define Z(p) (H0*log(P0/(p)))
00106
00108 #define START_TIMER(id) timer(#id, id, 1)
00109
00111 #define STOP_TIMER(id) timer(#id, id, 2)
00112
00114 #define PRINT_TIMER(id) timer(#id, id, 3)
00115
00116 /* ------------------------------------------------------------
00117    Constants...
00118    ------------------------------------------------------------ */
00119
00121 #define G0 9.80665
00122
00124 #define H0 7.0
00125
00127 #define P0 1013.25
00128
00130 #define RE 6367.421
00131
00132 /* ------------------------------------------------------------
00133    Dimensions...
00134    ------------------------------------------------------------ */
00135
00137 #define LEN 5000
00138
00140 #define NP 10000000
00141
00143 #define NQ 10
00144
00146 #define EP 73
00147
00149 #define EX 721
00150
00152 #define EY 361
00153
00155 #define GX 720
00156
00158 #define GY 360
00159
00161 #define GZ 100
00162
00164 #define NPSC 2000
00165
00167 #define NTHREADS 128
00168
```

```
00170 #define NTIMER 20
00171
00172 /* ------------------------------------------------------------
00173    Structs...
00174    ------------------------------------------------------------ */
00175
00177 typedef struct {
00178
00180   int nq;
00181
00183   char qnt_name[NQ][LEN];
00184
00186   char qnt_unit[NQ][LEN];
00187
00189   char qnt_format[NQ][LEN];
00190
00192   int qnt_t0;
00193
00195   int qnt_m;
00196
00198   int qnt_rho;
00199
00201   int qnt_r;
00202
00204   int qnt_ps;
00205
00207   int qnt_p;
00208
00210   int qnt_t;
00211
00213   int qnt_u;
00214
00216   int qnt_v;
00217
00219   int qnt_w;
00220
00222   int qnt_h2o;
00223
00225   int qnt_o3;
00226
00228   int qnt_theta;
00229
00231   int qnt_pv;
00232
00234   int qnt_tice;
00235
00237   int qnt_tnat;
00238
00240   int qnt_stat;
00241
00243   int direction;
00244
00246   double t_start;
00247
00249   double t_stop;
00250
00252   double dt_mod;
00253
00255   double dt_met;
00256
00258   int met_np;
00259
00261   double met_p[EP];
00262
00265   int isosurf;
00266
00268   char balloon[LEN];
00269
00271   double turb_dx_trop;
00272
00274   double turb_dx_strat;
00275
00277   double turb_dz_trop;
00278
00280   double turb_dz_strat;
00281
00283   double turb_meso;
00284
00286   double tdec_trop;
00287
00289   double tdec_strat;
00290
00292   char atm_basename[LEN];
00293
00295   char atm_gpfile[LEN];
00296
00298   double atm_dt_out;
```

```
00299
00301   int atm_filter;
00302
00304   char csi_basename[LEN];
00305
00307   double csi_dt_out;
00308
00310   char csi_obsfile[LEN];
00311
00313   double csi_obsmin;
00314
00316   double csi_modmin;
00317
00319   int csi_nz;
00320
00322   double csi_z0;
00323
00325   double csi_z1;
00326
00328   int csi_nx;
00329
00331   double csi_lon0;
00332
00334   double csi_lon1;
00335
00337   int csi_ny;
00338
00340   double csi_lat0;
00341
00343   double csi_lat1;
00344
00346   char grid_basename[LEN];
00347
00349   char grid_gpfile[LEN];
00350
00352   double grid_dt_out;
00353
00355   int grid_sparse;
00356
00358   int grid_nz;
00359
00361   double grid_z0;
00362
00364   double grid_z1;
00365
00367   int grid_nx;
00368
00370   double grid_lon0;
00371
00373   double grid_lon1;
00374
00376   int grid_ny;
00377
00379   double grid_lat0;
00380
00382   double grid_lat1;
00383
00385   char prof_basename[LEN];
00386
00388   char prof_obsfile[LEN];
00389
00391   int prof_nz;
00392
00394   double prof_z0;
00395
00397   double prof_z1;
00398
00400   int prof_nx;
00401
00403   double prof_lon0;
00404
00406   double prof_lon1;
00407
00409   int prof_ny;
00410
00412   double prof_lat0;
00413
00415   double prof_lat1;
00416
00418   char psc_basename[LEN];
00419
00421   char stat_basename[LEN];
00422
00424   double stat_lon;
00425
00427   double stat_lat;
00428
```

```
00430   double stat_r;
00431
00432 } ctl_t;
00433
00435 typedef struct {
00436
00438   int np;
00439
00441   double time[NP];
00442
00444   double p[NP];
00445
00447   double lon[NP];
00448
00450   double lat[NP];
00451
00453   double q[NQ][NP];
00454
00456   double up[NP];
00457
00459   double vp[NP];
00460
00462   double wp[NP];
00463
00464 } atm_t;
00465
00467 typedef struct {
00468
00470   double time;
00471
00473   int nx;
00474
00476   int ny;
00477
00479   int np;
00480
00482   double lon[EX];
00483
00485   double lat[EY];
00486
00488   double p[EP];
00489
00491   double ps[EX][EY];
00492
00494   float pl[EX][EY][EP];
00495
00497   float t[EX][EY][EP];
00498
00500   float u[EX][EY][EP];
00501
00503   float v[EX][EY][EP];
00504
00506   float w[EX][EY][EP];
00507
00509   float h2o[EX][EY][EP];
00510
00512   float o3[EX][EY][EP];
00513
00514 } met_t;
00515
00516 /* ------------------------------------------------------------
00517    Functions...
00518    ------------------------------------------------------------ */
00519
00521 void cart2geo(
00522   double *x,
00523   double *z,
00524   double *lon,
00525   double *lat);
00526
00528 double deg2dx(
00529   double dlon,
00530   double lat);
00531
00533 double deg2dy(
00534   double dlat);
00535
00537 double dp2dz(
00538   double dp,
00539   double p);
00540
00542 double dx2deg(
00543   double dx,
00544   double lat);
00545
00547 double dy2deg(
00548   double dy);
```

```
00549
00551 double dz2dp(
00552   double dz,
00553   double p);
00554
00556 void geo2cart(
00557   double z,
00558   double lon,
00559   double lat,
00560   double *x);
00561
00563 void get_met(
00564   ctl_t * ctl,
00565   char *metbase,
00566   double t,
00567   met_t * met0,
00568   met_t * met1);
00569
00571 void get_met_help(
00572   double t,
00573   int direct,
00574   char *metbase,
00575   double dt_met,
00576   char *filename);
00577
00579 void intpol_met_2d(
00580   double array[EX][EY],
00581   int ix,
00582   int iy,
00583   double wx,
00584   double wy,
00585   double *var);
00586
00588 void intpol_met_3d(
00589   float array[EX][EY][EP],
00590   int ip,
00591   int ix,
00592   int iy,
00593   double wp,
00594   double wx,
00595   double wy,
00596   double *var);
00597
00599 void intpol_met_space(
00600   met_t * met,
00601   double p,
00602   double lon,
00603   double lat,
00604   double *ps,
00605   double *t,
00606   double *u,
00607   double *v,
00608   double *w,
00609   double *h2o,
00610   double *o3);
00611
00613 void intpol_met_time(
00614   met_t * met0,
00615   met_t * met1,
00616   double ts,
00617   double p,
00618   double lon,
00619   double lat,
00620   double *ps,
00621   double *t,
00622   double *u,
00623   double *v,
00624   double *w,
00625   double *h2o,
00626   double *o3);
00627
00629 void jsec2time(
00630   double jsec,
00631   int *year,
00632   int *mon,
00633   int *day,
00634   int *hour,
00635   int *min,
00636   int *sec,
00637   double *remain);
00638
00640 int locate(
00641   double *xx,
00642   int n,
00643   double x);
00644
00646 void read_atm(
```

```
00647   const char *filename,
00648   ctl_t * ctl,
00649   atm_t * atm);
00650
00652 void read_ctl(
00653   const char *filename,
00654   int argc,
00655   char *argv[],
00656   ctl_t * ctl);
00657
00659 void read_met(
00660   ctl_t * ctl,
00661   char *filename,
00662   met_t * met);
00663
00665 void read_met_extrapolate(
00666   met_t * met);
00667
00669 void read_met_help(
00670   int ncid,
00671   char *varname,
00672   char *varname2,
00673   met_t * met,
00674   float dest[EX][EY][EP],
00675   float scl);
00676
00678 void read_met_ml2pl(
00679   ctl_t * ctl,
00680   met_t * met,
00681   float var[EX][EY][EP]);
00682
00684 void read_met_periodic(
00685   met_t * met);
00686
00688 double scan_ctl(
00689   const char *filename,
00690   int argc,
00691   char *argv[],
00692   const char *varname,
00693   int arridx,
00694   const char *defvalue,
00695   char *value);
00696
00698 void time2jsec(
00699   int year,
00700   int mon,
00701   int day,
00702   int hour,
00703   int min,
00704   int sec,
00705   double remain,
00706   double *jsec);
00707
00709 void timer(
00710   const char *name,
00711   int id,
00712   int mode);
00713
00714 /* Get tropopause pressure... */
00715 double tropopause(
00716   double t,
00717   double lat);
00718
00720 void write_atm(
00721   const char *filename,
00722   ctl_t * ctl,
00723   atm_t * atm,
00724   double t);
00725
00727 void write_csi(
00728   const char *filename,
00729   ctl_t * ctl,
00730   atm_t * atm,
00731   double t);
00732
00734 void write_grid(
00735   const char *filename,
00736   ctl_t * ctl,
00737   met_t * met0,
00738   met_t * met1,
00739   atm_t * atm,
00740   double t);
00741
00743 void write_prof(
00744   const char *filename,
00745   ctl_t * ctl,
00746   met_t * met0,
```

```
00747   met_t * met1,
00748   atm_t * atm,
00749   double t);
00750
00752 void write_psc(
00753   const char *filename,
00754   ctl_t * ctl,
00755   atm_t * atm,
00756   double t);
00757
00759 void write_station(
00760   const char *filename,
00761   ctl_t * ctl,
00762   atm_t * atm,
00763   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[ ]*)

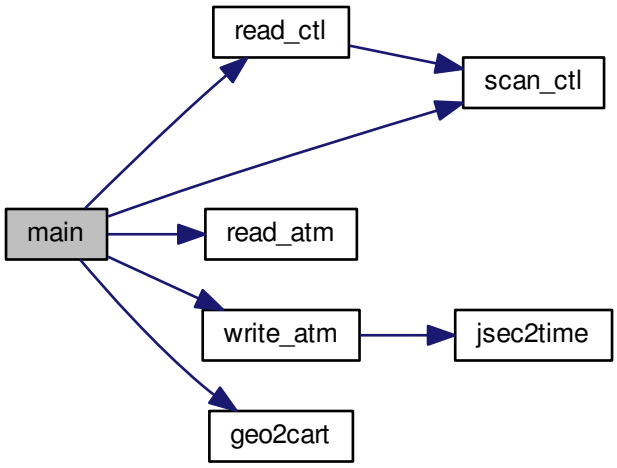
Definition at line 28 of file match.c.

```
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   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 *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

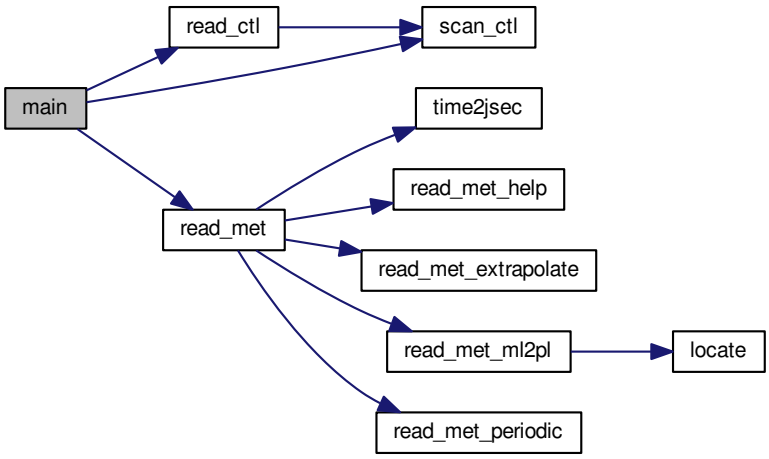
5.17.2.1 int main (int *argc,* char ∗ *argv[ ]*)

Definition at line 27 of file met_map.c.

```
00029                {
00030
00031   ctl_t ctl;
00032
00033   met_t *met;
00034
00035   FILE *in, *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     if (!(in = fopen(argv[i], "r")))
00058       continue;
00059     else
00060       fclose(in);
00061     read_met(&ctl, argv[i], met);
00062
00063     /* Find nearest pressure level... */
00064     for (ip2 = 0; ip2 < met->np; ip2++) {
00065       dz = fabs(Z(met->p[ip2]) - z);
00066       if (dz < dzmin) {
00067         dzmin = dz;
00068         ip = ip2;
00069       }
00070     }
00071
00072     /* Average data... */
00073     for (ix = 0; ix < met->nx; ix++)
00074       for (iy = 0; iy < met->ny; iy++) {
00075         timem[ix][iy] += met->time;
00076         tm[ix][iy] += met->t[ix][iy][ip];
00077         um[ix][iy] += met->u[ix][iy][ip];
00078         vm[ix][iy] += met->v[ix][iy][ip];
00079         wm[ix][iy] += met->w[ix][iy][ip];
00080         h2om[ix][iy] += met->h2o[ix][iy][ip];
00081         o3m[ix][iy] += met->o3[ix][iy][ip];
00082         psm[ix][iy] += met->ps[ix][iy];
00083         np[ix][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  = longitude [deg]\n"
00097           "# $4  = latitude [deg]\n"
00098           "# $5  = pressure [hPa]\n"
00099           "# $6  = temperature [K]\n"
00100           "# $7  = zonal wind [m/s]\n"
00101           "# $8  = meridional wind [m/s]\n"
00102           "# $9  = vertical wind [hPa/s]\n"
00103           "# $10 = H2O volume mixing ratio [1]\n"
00104           "# $11 = O3 volume mixing ratio [1]\n"
00105           "# $12 = surface pressure [hPa]\n");
00106
00107   /* Write data... */
00108   for (iy = 0; iy < met->ny; iy++) {
00109     fprintf(out, "\n");
00110     for (ix = 0; ix < met->nx; ix++)
00111       if (met->lon[ix] >= 180)
00112         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g\n",
00113                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00114                 met->lon[ix] - 360.0, met->lat[iy], met->p[ip],
00115                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00116                 vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00117                 h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00118                 psm[ix][iy] / np[ix][iy]);
00119     for (ix = 0; ix < met->nx; ix++)
00120       if (met->lon[ix] <= 180)
00121         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g\n",
00122                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00123                 met->lon[ix], met->lat[iy], met->p[ip],
00124                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00125                 vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00126                 h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00127                 psm[ix][iy] / np[ix][iy]);
00128   }
00129
00130   /* Close file... */
00131   fclose(out);
00132
00133   /* Free... */
00134   free(met);
00135
00136   return EXIT_SUCCESS;
00137 }
```

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   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 *in, *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     if (!(in = fopen(argv[i], "r")))
00058       continue;
00059     else
00060       fclose(in);
00061     read_met(&ctl, argv[i], met);
00062
00063     /* Find nearest pressure level... */
00064     for (ip2 = 0; ip2 < met->np; ip2++) {
00065       dz = fabs(Z(met->p[ip2]) - z);
00066       if (dz < dzmin) {
00067         dzmin = dz;
00068         ip = ip2;
00069       }
00070     }
00071
00072     /* Average data... */
00073     for (ix = 0; ix < met->nx; ix++)
00074       for (iy = 0; iy < met->ny; iy++) {
00075         timem[ix][iy] += met->time;
00076         tm[ix][iy] += met->t[ix][iy][ip];
00077         um[ix][iy] += met->u[ix][iy][ip];
00078         vm[ix][iy] += met->v[ix][iy][ip];
00079         wm[ix][iy] += met->w[ix][iy][ip];
00080         h2om[ix][iy] += met->h2o[ix][iy][ip];
00081         o3m[ix][iy] += met->o3[ix][iy][ip];
00082         psm[ix][iy] += met->ps[ix][iy];
00083         np[ix][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  = longitude [deg]\n"
00097           "# $4  = latitude [deg]\n"
00098           "# $5  = pressure [hPa]\n"
00099           "# $6  = temperature [K]\n"
00100           "# $7  = zonal wind [m/s]\n"
00101           "# $8  = meridional wind [m/s]\n"
00102           "# $9  = vertical wind [hPa/s]\n"
00103           "# $10 = H2O volume mixing ratio [1]\n"
00104           "# $11 = O3 volume mixing ratio [1]\n"
00105           "# $12 = surface pressure [hPa]\n");
00106
00107   /* Write data... */
00108   for (iy = 0; iy < met->ny; iy++) {
00109     fprintf(out, "\n");
00110     for (ix = 0; ix < met->nx; ix++)
00111       if (met->lon[ix] >= 180)
00112         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g\n",
00113                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00114                 met->lon[ix] - 360.0, met->lat[iy], met->p[ip],
00115                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00116                 vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00117                 h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00118                 psm[ix][iy] / np[ix][iy]);
00119     for (ix = 0; ix < met->nx; ix++)
00120       if (met->lon[ix] <= 180)
00121         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g\n",
00122                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00123                 met->lon[ix], met->lat[iy], met->p[ip],
00124                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00125                 vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00126                 h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00127                 psm[ix][iy] / np[ix][iy]);
00128   }
00129
00130   /* Close file... */
00131   fclose(out);
00132
00133   /* Free... */
00134   free(met);
00135
00136   return EXIT_SUCCESS;
00137 }
```

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

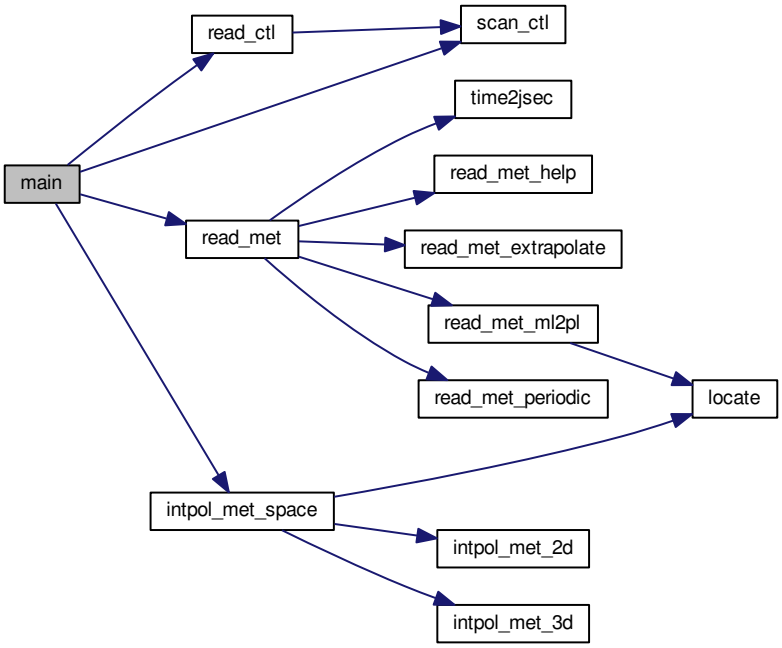
5.19.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 38 of file met_prof.c.

```
00040                {
00041
00042   ctl_t ctl;
00043
00044   met_t *met;
00045
00046   FILE *in, *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     if (!(in = fopen(argv[i], "r")))
00078       continue;
00079     else
00080       fclose(in);
00081     read_met(&ctl, argv[i], met);
00082
00083     /* Average... */
00084     for (z = z0; z <= z1; z += dz) {
00085       iz = (int) ((z - z0) / dz);
00086       if (iz < 0 || iz > NZ)
00087         ERRMSG("Too many altitudes!");
00088       for (lon = lon0; lon <= lon1; lon += dlon)
00089         for (lat = lat0; lat <= lat1; lat += dlat) {
00090           intpol_met_space(met, P(z), lon, lat, &ps,
00091                            &t, &u, &v, &w, &h2o, &o3);
00092           if (gsl_finite(t) && gsl_finite(u)
00093               && gsl_finite(v) && gsl_finite(w)) {
00094             timem[iz] += met->time;
00095             lonm[iz] += lon;
00096             latm[iz] += lat;
00097             tm[iz] += t;
00098             um[iz] += u;
00099             vm[iz] += v;
00100             wm[iz] += w;
00101             h2om[iz] += h2o;
00102             o3m[iz] += o3;
00103             psm[iz] += ps;
00104             np[iz]++;
00105           }
00106         }
00107     }
00108   }
00109
00110   /* Normalize... */
00111   for (z = z0; z <= z1; z += dz) {
00112     iz = (int) ((z - z0) / dz);
00113     if (np[iz] > 0) {
00114       timem[iz] /= np[iz];
00115       lonm[iz] /= np[iz];
```

```
00116       latm[iz] /= np[iz];
00117       tm[iz] /= np[iz];
00118       um[iz] /= np[iz];
00119       vm[iz] /= np[iz];
00120       wm[iz] /= np[iz];
00121       h2om[iz] /= np[iz];
00122       o3m[iz] /= np[iz];
00123       psm[iz] /= np[iz];
00124     } else {
00125       timem[iz] = GSL_NAN;
00126       lonm[iz] = GSL_NAN;
00127       latm[iz] = GSL_NAN;
00128       tm[iz] = GSL_NAN;
00129       um[iz] = GSL_NAN;
00130       vm[iz] = GSL_NAN;
00131       wm[iz] = GSL_NAN;
00132       h2om[iz] = GSL_NAN;
00133       o3m[iz] = GSL_NAN;
00134       psm[iz] = GSL_NAN;
00135     }
00136   }
00137
00138   /* Create output file... */
00139   printf("Write meteorological data file: %s\n", argv[2]);
00140   if (!(out = fopen(argv[2], "w")))
00141     ERRMSG("Cannot create file!");
00142
00143   /* Write header... */
00144   fprintf(out,
00145           "# $1  = time [s]\n"
00146           "# $2  = altitude [km]\n"
00147           "# $3  = longitude [deg]\n"
00148           "# $4  = latitude [deg]\n"
00149           "# $5  = pressure [hPa]\n"
00150           "# $6  = temperature [K]\n"
00151           "# $7  = zonal wind [m/s]\n"
00152           "# $8  = meridional wind [m/s]\n"
00153           "# $9  = vertical wind [hPa/s]\n"
00154           "# $10 = H2O volume mixing ratio [1]\n"
00155           "# $11 = O3 volume mixing ratio [1]\n"
00156           "# $12 = surface pressure [hPa]\n\n");
00157
00158   /* Write data... */
00159   for (z = z0; z <= z1; z += dz) {
00160     iz = (int) ((z - z0) / dz);
00161     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g\n",
00162             timem[iz], z, lonm[iz], latm[iz], P(z), tm[iz],
00163             um[iz], vm[iz], wm[iz], h2om[iz], o3m[iz], psm[iz]);
00164   }
00165
00166   /* Close file... */
00167   fclose(out);
00168
00169   /* Free... */
00170   free(met);
00171
00172   return EXIT_SUCCESS;
00173 }
```

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   Copright (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 *in, *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     if (!(in = fopen(argv[i], "r")))
00078       continue;
00079     else
00080       fclose(in);
00081     read_met(&ctl, argv[i], met);
00082
00083     /* Average... */
00084     for (z = z0; z <= z1; z += dz) {
00085       iz = (int) ((z - z0) / dz);
00086       if (iz < 0 || iz > NZ)
00087         ERRMSG("Too many altitudes!");
00088       for (lon = lon0; lon <= lon1; lon += dlon)
00089         for (lat = lat0; lat <= lat1; lat += dlat) {
00090           intpol_met_space(met, P(z), lon, lat, &ps,
00091                            &t, &u, &v, &w, &h2o, &o3);
00092           if (gsl_finite(t) && gsl_finite(u)
00093               && gsl_finite(v) && gsl_finite(w)) {
00094             timem[iz] += met->time;
00095             lonm[iz] += lon;
00096             latm[iz] += lat;
00097             tm[iz] += t;
00098             um[iz] += u;
00099             vm[iz] += v;
00100             wm[iz] += w;
00101             h2om[iz] += h2o;
00102             o3m[iz] += o3;
00103             psm[iz] += ps;
00104             np[iz]++;
00105           }
00106         }
00107     }
00108   }
00109
00110   /* Normalize... */
00111   for (z = z0; z <= z1; z += dz) {
00112     iz = (int) ((z - z0) / dz);
00113     if (np[iz] > 0) {
00114       timem[iz] /= np[iz];
00115       lonm[iz] /= np[iz];
00116       latm[iz] /= np[iz];
00117       tm[iz] /= np[iz];
00118       um[iz] /= np[iz];
00119       vm[iz] /= np[iz];
00120       wm[iz] /= np[iz];
00121       h2om[iz] /= np[iz];
00122       o3m[iz] /= np[iz];
00123       psm[iz] /= np[iz];
00124     } else {
00125       timem[iz] = GSL_NAN;
00126       lonm[iz] = GSL_NAN;
00127       latm[iz] = GSL_NAN;
00128       tm[iz] = GSL_NAN;
00129       um[iz] = GSL_NAN;
00130       vm[iz] = GSL_NAN;
```

```
00131       wm[iz] = GSL_NAN;
00132       h2om[iz] = GSL_NAN;
00133       o3m[iz] = GSL_NAN;
00134       psm[iz] = GSL_NAN;
00135     }
00136   }
00137
00138   /* Create output file... */
00139   printf("Write meteorological data file: %s\n", argv[2]);
00140   if (!(out = fopen(argv[2], "w")))
00141     ERRMSG("Cannot create file!");
00142
00143   /* Write header... */
00144   fprintf(out,
00145           "# $1  = time [s]\n"
00146           "# $2  = altitude [km]\n"
00147           "# $3  = longitude [deg]\n"
00148           "# $4  = latitude [deg]\n"
00149           "# $5  = pressure [hPa]\n"
00150           "# $6  = temperature [K]\n"
00151           "# $7  = zonal wind [m/s]\n"
00152           "# $8  = meridional wind [m/s]\n"
00153           "# $9  = vertical wind [hPa/s]\n"
00154           "# $10 = H2O volume mixing ratio [1]\n"
00155           "# $11 = O3 volume mixing ratio [1]\n"
00156           "# $12 = surface pressure [hPa]\n\n");
00157
00158   /* Write data... */
00159   for (z = z0; z <= z1; z += dz) {
00160     iz = (int) ((z - z0) / dz);
00161     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g\n",
00162             timem[iz], z, lonm[iz], latm[iz], P(z), tm[iz],
00163             um[iz], vm[iz], wm[iz], h2om[iz], o3m[iz], psm[iz]);
00164   }
00165
00166   /* Close file... */
00167   fclose(out);
00168
00169   /* Free... */
00170   free(met);
00171
00172   return EXIT_SUCCESS;
00173 }
```

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.

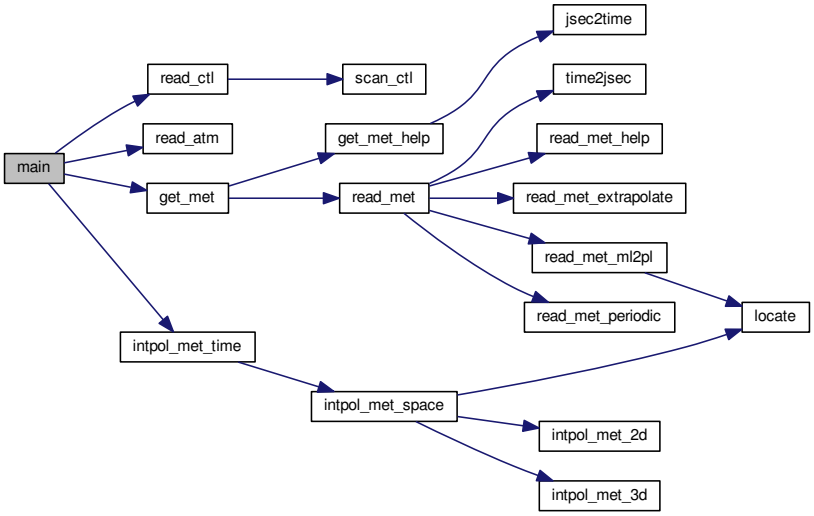
5.21.2 Function Documentation

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   Copyright (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

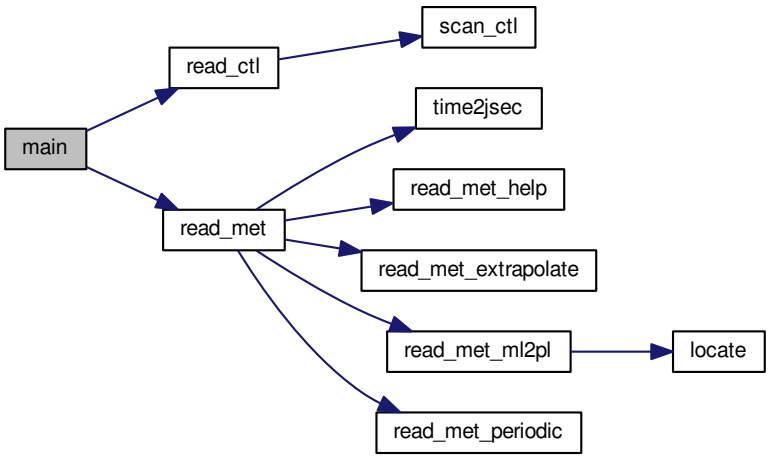
5.23.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file met_zm.c.

```
00029                {
00030
00031   ctl_t ctl;
00032
00033   met_t *met;
00034
00035   FILE *in, *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     if (!(in = fopen(argv[i], "r")))
00059       continue;
00060     else
00061       fclose(in);
00062     read_met(&ctl, argv[i], met);
00063
00064     /* Average data... */
00065     for (ix = 0; ix < met->nx; ix++)
00066       for (iy = 0; iy < met->ny; iy++)
00067         for (ip = 0; ip < met->np; ip++) {
00068           timem[ip][iy] += met->time;
00069           tm[ip][iy] += met->t[ix][iy][ip];
00070           um[ip][iy] += met->u[ix][iy][ip];
00071           vm[ip][iy] += met->v[ix][iy][ip];
00072           vhm[ip][iy] += sqrt(gsl_pow_2(met->u[ix][iy][ip])
00073                               + gsl_pow_2(met->v[ix][iy][ip]));
00074           wm[ip][iy] += met->w[ix][iy][ip];
00075           h2om[ip][iy] += met->h2o[ix][iy][ip];
00076           o3m[ip][iy] += met->o3[ix][iy][ip];
00077           psm[ip][iy] += met->ps[ix][iy];
00078           tm2[ip][iy] += gsl_pow_2(met->t[ix][iy][ip]);
00079           um2[ip][iy] += gsl_pow_2(met->u[ix][iy][ip]);
00080           vm2[ip][iy] += gsl_pow_2(met->v[ix][iy][ip]);
00081           vhm2[ip][iy] += gsl_pow_2(met->u[ix][iy][ip])
00082             + gsl_pow_2(met->v[ix][iy][ip]);
00083           wm2[ip][iy] += gsl_pow_2(met->w[ix][iy][ip]);
00084           h2om2[ip][iy] += gsl_pow_2(met->h2o[ix][iy][ip]);
00085           o3m2[ip][iy] += gsl_pow_2(met->o3[ix][iy][ip]);
00086           psm2[ip][iy] += gsl_pow_2(met->ps[ix][iy]);
00087           np[ip][iy]++;
00088         }
00089   }
00090
00091   /* Create output file... */
00092   printf("Write meteorological data file: %s\n", argv[2]);
00093   if (!(out = fopen(argv[2], "w")))
00094     ERRMSG("Cannot create file!");
00095
00096   /* Write header... */
00097   fprintf(out,
00098           "# $1  = time [s]\n"
00099           "# $2  = altitude [km]\n"
00100           "# $3  = latitude [deg]\n"
00101           "# $4  = temperature mean [K]\n"
00102           "# $5  = temperature standard deviation [K]\n"
00103           "# $6  = zonal wind mean [m/s]\n"
00104           "# $7  = zonal wind standard deviation [m/s]\n"
```

```
00105           "# $8  = meridional wind mean [m/s]\n"
00106           "# $9  = meridional wind standard deviation [m/s]\n"
00107           "# $10 = horizontal wind mean [m/s]\n"
00108           "# $11 = horizontal wind standard deviation [m/s]\n"
00109           "# $12 = vertical wind mean [hPa/s]\n"
00110           "# $13 = vertical wind standard deviation [hPa/s]\n"
00111           "# $14 = H2O vmr mean [1]\n"
00112           "# $15 = H2O vmr standard deviation [1]\n"
00113           "# $16 = O3 vmr mean [1]\n"
00114           "# $17 = O3 vmr standard deviation [1]\n"
00115           "# $18 = surface pressure mean [hPa]\n"
00116           "# $19 = surface pressure standard deviation [hPa]\n");
00117
00118   /* Write data... */
00119   for (iy = 0; iy < met->ny; iy++) {
00120     fprintf(out, "\n");
00121     for (ip = 0; ip < met->np; ip++)
00122       fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g"
00123               " %g %g %g %g %g %g %g %g\n",
00124               timem[ip][iy] / np[ip][iy], Z(met->p[ip]), met->lat[iy],
00125               tm[ip][iy] / np[ip][iy],
00126               sqrt(tm2[ip][iy] / np[ip][iy] -
00127                    gsl_pow_2(tm[ip][iy] / np[ip][iy])),
00128               um[ip][iy] / np[ip][iy],
00129               sqrt(um2[ip][iy] / np[ip][iy] -
00130                    gsl_pow_2(um[ip][iy] / np[ip][iy])),
00131               vm[ip][iy] / np[ip][iy],
00132               sqrt(vm2[ip][iy] / np[ip][iy] -
00133                    gsl_pow_2(vm[ip][iy] / np[ip][iy])),
00134               vhm[ip][iy] / np[ip][iy],
00135               sqrt(vhm2[ip][iy] / np[ip][iy] -
00136                    gsl_pow_2(vhm[ip][iy] / np[ip][iy])),
00137               wm[ip][iy] / np[ip][iy],
00138               sqrt(wm2[ip][iy] / np[ip][iy] -
00139                    gsl_pow_2(wm[ip][iy] / np[ip][iy])),
00140               h2om[ip][iy] / np[ip][iy],
00141               sqrt(h2om2[ip][iy] / np[ip][iy] -
00142                    gsl_pow_2(h2om[ip][iy] / np[ip][iy])),
00143               o3m[ip][iy] / np[ip][iy],
00144               sqrt(o3m2[ip][iy] / np[ip][iy] -
00145                    gsl_pow_2(o3m[ip][iy] / np[ip][iy])),
00146               psm[ip][iy] / np[ip][iy],
00147               sqrt(psm2[ip][iy] / np[ip][iy] -
00148                    gsl_pow_2(psm[ip][iy] / np[ip][iy])));
00149   }
00150
00151   /* Close file... */
00152   fclose(out);
00153
00154   /* Free... */
00155   free(met);
00156
00157   return EXIT_SUCCESS;
00158 }
```

Here is the call graph for this function:



5.24 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 *in, *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     if (!(in = fopen(argv[i], "r")))
00059       continue;
00060     else
00061       fclose(in);
00062     read_met(&ctl, argv[i], met);
00063
00064     /* Average data... */
00065     for (ix = 0; ix < met->nx; ix++)
00066       for (iy = 0; iy < met->ny; iy++)
00067         for (ip = 0; ip < met->np; ip++) {
00068           timem[ip][iy] += met->time;
00069           tm[ip][iy] += met->t[ix][iy][ip];
00070           um[ip][iy] += met->u[ix][iy][ip];
00071           vm[ip][iy] += met->v[ix][iy][ip];
00072           vhm[ip][iy] += sqrt(gsl_pow_2(met->u[ix][iy][ip])
00073                               + gsl_pow_2(met->v[ix][iy][ip]));
00074           wm[ip][iy] += met->w[ix][iy][ip];
00075           h2om[ip][iy] += met->h2o[ix][iy][ip];
00076           o3m[ip][iy] += met->o3[ix][iy][ip];
00077           psm[ip][iy] += met->ps[ix][iy];
00078           tm2[ip][iy] += gsl_pow_2(met->t[ix][iy][ip]);
00079           um2[ip][iy] += gsl_pow_2(met->u[ix][iy][ip]);
00080           vm2[ip][iy] += gsl_pow_2(met->v[ix][iy][ip]);
00081           vhm2[ip][iy] += gsl_pow_2(met->u[ix][iy][ip])
00082             + gsl_pow_2(met->v[ix][iy][ip]);
00083           wm2[ip][iy] += gsl_pow_2(met->w[ix][iy][ip]);
00084           h2om2[ip][iy] += gsl_pow_2(met->h2o[ix][iy][ip]);
00085           o3m2[ip][iy] += gsl_pow_2(met->o3[ix][iy][ip]);
00086           psm2[ip][iy] += gsl_pow_2(met->ps[ix][iy]);
00087           np[ip][iy]++;
00088         }
00089   }
00090
00091   /* Create output file... */
00092   printf("Write meteorological data file: %s\n", argv[2]);
00093   if (!(out = fopen(argv[2], "w")))
00094     ERRMSG("Cannot create file!");
00095
00096   /* Write header... */
00097   fprintf(out,
00098           "# $1  = time [s]\n"
00099           "# $2  = altitude [km]\n"
00100           "# $3  = latitude [deg]\n"
00101           "# $4  = temperature mean [K]\n"
00102           "# $5  = temperature standard deviation [K]\n"
00103           "# $6  = zonal wind mean [m/s]\n"
00104           "# $7  = zonal wind standard deviation [m/s]\n"
00105           "# $8  = meridional wind mean [m/s]\n"
00106           "# $9  = meridional wind standard deviation [m/s]\n"
00107           "# $10 = horizontal wind mean [m/s]\n"
00108           "# $11 = horizontal wind standard deviation [m/s]\n"
00109           "# $12 = vertical wind mean [hPa/s]\n"
00110           "# $13 = vertical wind standard deviation [hPa/s]\n"
00111           "# $14 = H2O vmr mean [1]\n"
00112           "# $15 = H2O vmr standard deviation [1]\n"
00113           "# $16 = O3 vmr mean [1]\n"
00114           "# $17 = O3 vmr standard deviation [1]\n"
00115           "# $18 = surface pressure mean [hPa]\n"
00116           "# $19 = surface pressure standard deviation [hPa]\n");
00117
00118   /* Write data... */
00119   for (iy = 0; iy < met->ny; iy++) {
00120     fprintf(out, "\n");
00121     for (ip = 0; ip < met->np; ip++)
00122       fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g"
00123               " %g %g %g %g %g %g %g %g\n",
00124               timem[ip][iy] / np[ip][iy], Z(met->p[ip]), met->lat[iy],
00125               tm[ip][iy] / np[ip][iy],
00126               sqrt(tm2[ip][iy] / np[ip][iy] -
00127                    gsl_pow_2(tm[ip][iy] / np[ip][iy])),
00128               um[ip][iy] / np[ip][iy],
00129               sqrt(um2[ip][iy] / np[ip][iy] -
00130                    gsl_pow_2(um[ip][iy] / np[ip][iy])),
00131               vm[ip][iy] / np[ip][iy],
00132               sqrt(vm2[ip][iy] / np[ip][iy] -
00133                    gsl_pow_2(vm[ip][iy] / np[ip][iy])),
00134               vhm[ip][iy] / np[ip][iy],
00135               sqrt(vhm2[ip][iy] / np[ip][iy] -
00136                    gsl_pow_2(vhm[ip][iy] / np[ip][iy])),
00137               wm[ip][iy] / np[ip][iy],
00138               sqrt(wm2[ip][iy] / np[ip][iy] -
00139                    gsl_pow_2(wm[ip][iy] / np[ip][iy])),
```

```
00140               h2om[ip][iy] / np[ip][iy],
00141               sqrt(h2om2[ip][iy] / np[ip][iy] -
00142                    gsl_pow_2(h2om[ip][iy] / np[ip][iy])),
00143               o3m[ip][iy] / np[ip][iy],
00144               sqrt(o3m2[ip][iy] / np[ip][iy] -
00145                    gsl_pow_2(o3m[ip][iy] / np[ip][iy])),
00146               psm[ip][iy] / np[ip][iy],
00147               sqrt(psm2[ip][iy] / np[ip][iy] -
00148                    gsl_pow_2(psm[ip][iy] / np[ip][iy])));
00149   }
00150
00151   /* Close file... */
00152   fclose(out);
00153
00154   /* Free... */
00155   free(met);
00156
00157   return EXIT_SUCCESS;
00158 }
```

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

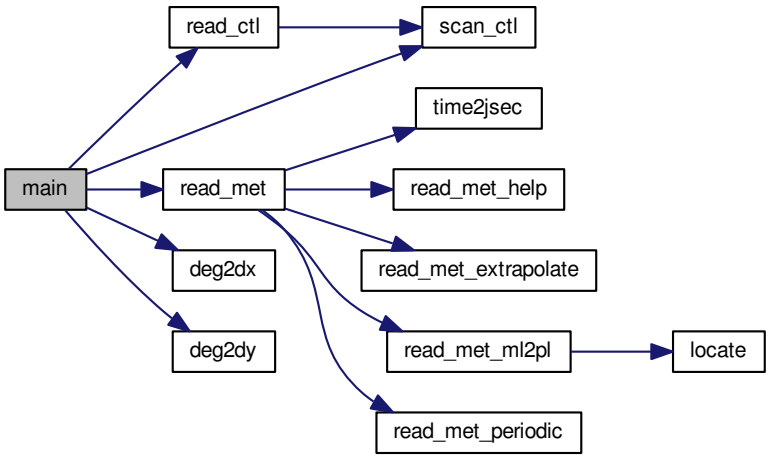
5.25.2.1 int main (int *argc*, char ∗ *argv[ ]*)

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

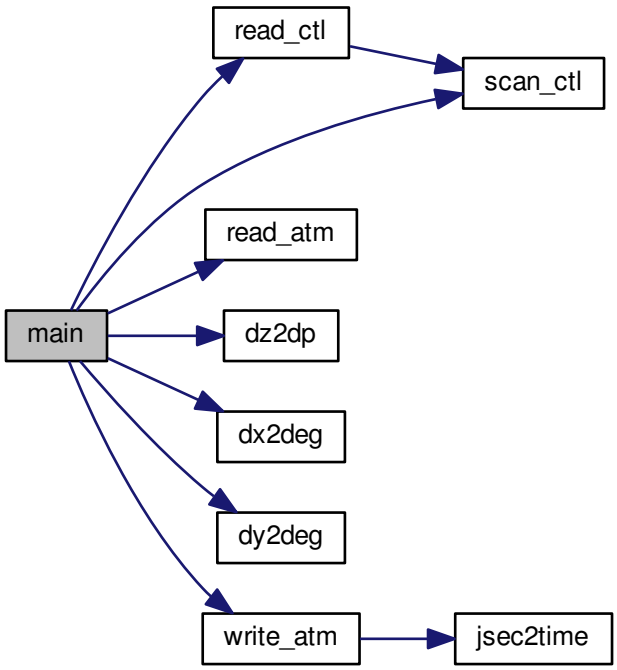
5.27.2.1 int main (int *argc*, char * *argv[]*)

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.

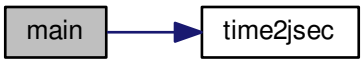
5.29.2 Function Documentation

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.
- 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 398 of file trac.c.

```
00400                {
00401
00402   /* Set inital and final time... */
00403   if (ctl->direction == 1) {
00404     if (ctl->t_start < -1e99)
00405       ctl->t_start = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00406     if (ctl->t_stop < -1e99)
00407       ctl->t_stop = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00408   } else if (ctl->direction == -1) {
00409     if (ctl->t_stop < -1e99)
00410       ctl->t_stop = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00411     if (ctl->t_start < -1e99)
00412       ctl->t_start = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00413   }
00414
00415   /* Check time... */
00416   if (ctl->direction * (ctl->t_stop - ctl->t_start) <= 0)
00417     ERRMSG("Nothing to do!");
00418 }
```

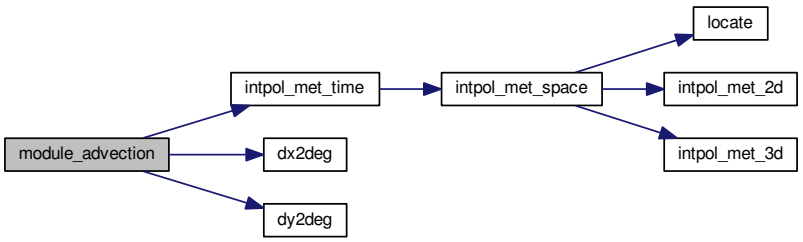
5.31.2.2 void module_advection (met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt*)

Calculate advection of air parcels.

Definition at line 422 of file trac.c.

```
00427              {
00428
00429   double v[3], xm[3];
00430
00431   /* Interpolate meteorological data... */
00432   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00433                   atm->lon[ip], atm->lat[ip], NULL, NULL,
00434                   &v[0], &v[1], &v[2], NULL, NULL);
00435
00436   /* Get position of the mid point... */
00437   xm[0] = atm->lon[ip] + dx2deg(0.5 * dt * v[0] / 1000., atm->lat[ip]);
00438   xm[1] = atm->lat[ip] + dy2deg(0.5 * dt * v[1] / 1000.);
00439   xm[2] = atm->p[ip] + 0.5 * dt * v[2];
00440
00441   /* Interpolate meteorological data for mid point... */
00442   intpol_met_time(met0, met1, atm->time[ip] + 0.5 * dt,
00443                   xm[2], xm[0], xm[1], NULL, NULL,
00444                   &v[0], &v[1], &v[2], NULL, NULL);
00445
00446   /* Save new position... */
00447   atm->time[ip] += dt;
00448   atm->lon[ip] += dx2deg(dt * v[0] / 1000., xm[1]);
00449   atm->lat[ip] += dy2deg(dt * v[1] / 1000.);
00450   atm->p[ip] += dt * v[2];
00451 }
```

Here is the call graph for this function:



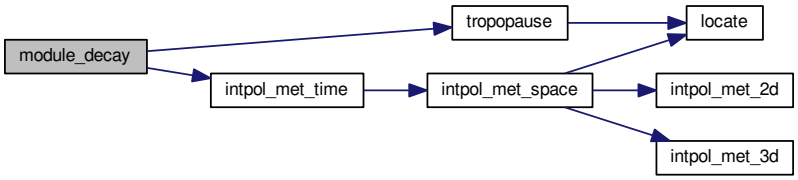
5.31.2.3 void module_decay (ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt*)

Calculate exponential decay of particle mass.

Definition at line 455 of file trac.c.

```
00461             {
00462
00463   double ps, pt, tdec;
00464
00465   /* Check lifetime values... */
00466   if ((ctl->tdec_trop <= 0 && ctl->tdec_strat <= 0) || ctl->
      qnt_m < 0)
00467     return;
00468
00469   /* Set constant lifetime... */
00470   if (ctl->tdec_trop == ctl->tdec_strat)
00471     tdec = ctl->tdec_trop;
00472
00473   /* Set altitude-dependent lifetime... */
00474   else {
00475
00476     /* Get surface pressure... */
00477     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00478                     atm->lon[ip], atm->lat[ip], &ps, NULL,
00479                     NULL, NULL, NULL, NULL, NULL);
00480
00481     /* Get tropopause pressure... */
00482     pt = tropopause(atm->time[ip], atm->lat[ip]);
00483
00484     /* Set lifetime... */
00485     if (atm->p[ip] <= pt)
00486       tdec = ctl->tdec_strat;
00487     else
00488       tdec = LIN(ps, ctl->tdec_trop, pt, ctl->tdec_strat, atm->
      p[ip]);
00489   }
00490
00491   /* Calculate exponential decay... */
00492   atm->q[ctl->qnt_m][ip] *= exp(-dt / tdec);
00493 }
```

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*)

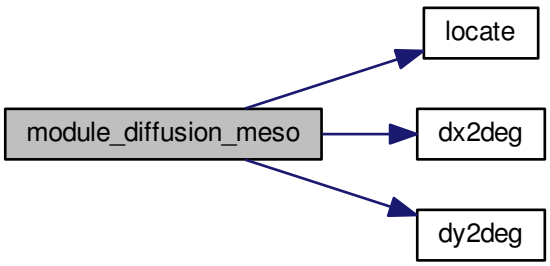
Calculate mesoscale diffusion.

Definition at line 497 of file trac.c.

```
00504                 {
00505
00506   double r, rs, u[16], v[16], w[16], usig, vsig, wsig;
00507
00508   int ix, iy, iz;
00509
00510   /* Calculate mesoscale velocity fluctuations... */
00511   if (ctl->turb_meso > 0) {
00512
00513     /* Get indices... */
00514     ix = locate(met0->lon, met0->nx, atm->lon[ip]);
00515     iy = locate(met0->lat, met0->ny, atm->lat[ip]);
00516     iz = locate(met0->p, met0->np, atm->p[ip]);
00517
00518     /* Collect local wind data... */
00519     u[0] = met0->u[ix][iy][iz];
00520     u[1] = met0->u[ix + 1][iy][iz];
00521     u[2] = met0->u[ix][iy + 1][iz];
00522     u[3] = met0->u[ix + 1][iy + 1][iz];
00523     u[4] = met0->u[ix][iy][iz + 1];
00524     u[5] = met0->u[ix + 1][iy][iz + 1];
00525     u[6] = met0->u[ix][iy + 1][iz + 1];
00526     u[7] = met0->u[ix + 1][iy + 1][iz + 1];
00527
00528     v[0] = met0->v[ix][iy][iz];
00529     v[1] = met0->v[ix + 1][iy][iz];
00530     v[2] = met0->v[ix][iy + 1][iz];
00531     v[3] = met0->v[ix + 1][iy + 1][iz];
00532     v[4] = met0->v[ix][iy][iz + 1];
00533     v[5] = met0->v[ix + 1][iy][iz + 1];
00534     v[6] = met0->v[ix][iy + 1][iz + 1];
00535     v[7] = met0->v[ix + 1][iy + 1][iz + 1];
00536
00537     w[0] = met0->w[ix][iy][iz];
00538     w[1] = met0->w[ix + 1][iy][iz];
00539     w[2] = met0->w[ix][iy + 1][iz];
00540     w[3] = met0->w[ix + 1][iy + 1][iz];
00541     w[4] = met0->w[ix][iy][iz + 1];
00542     w[5] = met0->w[ix + 1][iy][iz + 1];
00543     w[6] = met0->w[ix][iy + 1][iz + 1];
00544     w[7] = met0->w[ix + 1][iy + 1][iz + 1];
00545
00546     /* Get indices... */
00547     ix = locate(met1->lon, met1->nx, atm->lon[ip]);
00548     iy = locate(met1->lat, met1->ny, atm->lat[ip]);
00549     iz = locate(met1->p, met1->np, atm->p[ip]);
00550
00551     /* Collect local wind data... */
00552     u[8] = met1->u[ix][iy][iz];
00553     u[9] = met1->u[ix + 1][iy][iz];
00554     u[10] = met1->u[ix][iy + 1][iz];
00555     u[11] = met1->u[ix + 1][iy + 1][iz];
00556     u[12] = met1->u[ix][iy][iz + 1];
00557     u[13] = met1->u[ix + 1][iy][iz + 1];
00558     u[14] = met1->u[ix][iy + 1][iz + 1];
00559     u[15] = met1->u[ix + 1][iy + 1][iz + 1];
00560
00561     v[8] = met1->v[ix][iy][iz];
00562     v[9] = met1->v[ix + 1][iy][iz];
00563     v[10] = met1->v[ix][iy + 1][iz];
00564     v[11] = met1->v[ix + 1][iy + 1][iz];
00565     v[12] = met1->v[ix][iy][iz + 1];
00566     v[13] = met1->v[ix + 1][iy][iz + 1];
00567     v[14] = met1->v[ix][iy + 1][iz + 1];
00568     v[15] = met1->v[ix + 1][iy + 1][iz + 1];
00569
00570     w[8] = met1->w[ix][iy][iz];
00571     w[9] = met1->w[ix + 1][iy][iz];
00572     w[10] = met1->w[ix][iy + 1][iz];
00573     w[11] = met1->w[ix + 1][iy + 1][iz];
00574     w[12] = met1->w[ix][iy][iz + 1];
00575     w[13] = met1->w[ix + 1][iy][iz + 1];
00576     w[14] = met1->w[ix][iy + 1][iz + 1];
00577     w[15] = met1->w[ix + 1][iy + 1][iz + 1];
00578
00579     /* Get standard deviations of local wind data... */
00580     usig = gsl_stats_sd(u, 1, 16);
00581     vsig = gsl_stats_sd(v, 1, 16);
00582     wsig = gsl_stats_sd(w, 1, 16);
00583
00584     /* Set temporal correlations for mesoscale fluctuations... */
00585     r = 1 - 2 * fabs(dt) / ctl->dt_met;
00586     rs = sqrt(1 - r * r);
00587
00588     /* Calculate mesoscale wind fluctuations... */
00589     atm->up[ip] =
00590       r * atm->up[ip] + rs * gsl_ran_gaussian_ziggurat(rng,
```

```
00591                                                   ctl->turb_meso * usig);
00592     atm->vp[ip] =
00593       r * atm->vp[ip] + rs * gsl_ran_gaussian_ziggurat(rng,
00594                                                   ctl->turb_meso * vsig);
00595     atm->wp[ip] =
00596       r * atm->wp[ip] + rs * gsl_ran_gaussian_ziggurat(rng,
00597                                                   ctl->turb_meso * wsig);
00598
00599     /* Calculate air parcel displacement... */
00600     atm->lon[ip] += dx2deg(atm->up[ip] * dt / 1000., atm->lat[ip]);
00601     atm->lat[ip] += dy2deg(atm->vp[ip] * dt / 1000.);
00602     atm->p[ip] += atm->wp[ip] * dt;
00603   }
00604 }
```

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*)

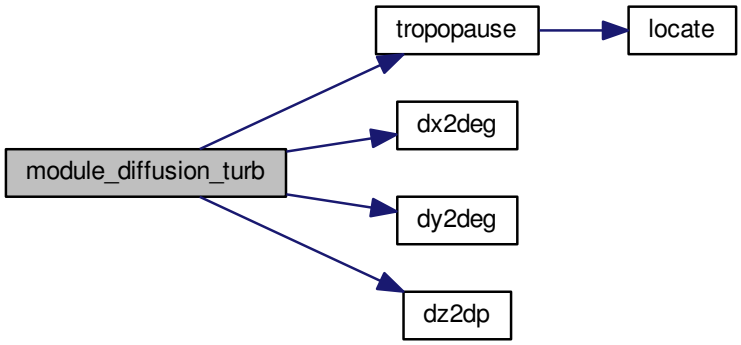
Calculate turbulent diffusion.

Definition at line 608 of file trac.c.

```
00613                 {
00614
00615   double dx, dz, pt, p0, p1, w;
00616
00617   /* Get tropopause pressure... */
00618   pt = tropopause(atm->time[ip], atm->lat[ip]);
00619
00620   /* Get weighting factor... */
00621   p1 = pt * 0.866877899;
00622   p0 = pt / 0.866877899;
00623   if (atm->p[ip] > p0)
00624     w = 1;
00625   else if (atm->p[ip] < p1)
00626     w = 0;
00627   else
00628     w = LIN(p0, 1.0, p1, 0.0, atm->p[ip]);
00629
00630   /* Set diffusivitiy... */
00631   dx = w * ctl->turb_dx_trop + (1 - w) * ctl->turb_dx_strat;
00632   dz = w * ctl->turb_dz_trop + (1 - w) * ctl->turb_dz_strat;
00633
00634   /* Horizontal turbulent diffusion... */
00635   if (dx > 0) {
00636     atm->lon[ip]
00637       += dx2deg(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dx * fabs(dt)))
00638                 / 1000., atm->lat[ip]);
00639     atm->lat[ip]
00640       += dy2deg(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dx * fabs(dt)))
00641                 / 1000.);
00642   }
```

```
00643
00644   /* Vertical turbulent diffusion... */
00645   if (dz > 0)
00646     atm->p[ip]
00647       += dz2dp(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dz * fabs(dt)))
00648                / 1000., atm->p[ip]);
00649 }
```

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*)

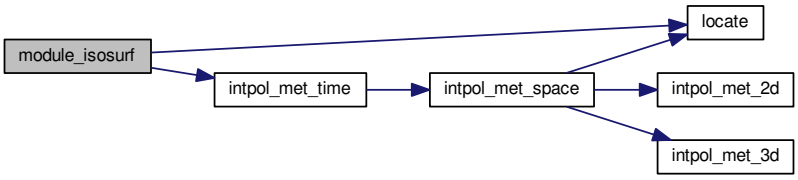
Force air parcels to stay on isosurface.

Definition at line 653 of file trac.c.

```
00658           {
00659
00660   static double *iso, *ps, t, *ts;
00661
00662   static int idx, ip2, n, nb = 100000;
00663
00664   FILE *in;
00665
00666   char line[LEN];
00667
00668   /* Check control parameter... */
00669   if (ctl->isosurf < 1 || ctl->isosurf > 4)
00670     return;
00671
00672   /* Initialize... */
00673   if (ip < 0) {
00674
00675     /* Allocate... */
00676     ALLOC(iso, double,
00677           NP);
00678     ALLOC(ps, double,
00679           nb);
00680     ALLOC(ts, double,
00681           nb);
00682
00683     /* Save pressure... */
00684     if (ctl->isosurf == 1)
00685       for (ip2 = 0; ip2 < atm->np; ip2++)
00686         iso[ip2] = atm->p[ip2];
00687
00688     /* Save density... */
00689     else if (ctl->isosurf == 2)
00690       for (ip2 = 0; ip2 < atm->np; ip2++) {
00691         intpol_met_time(met0, met1, atm->time[ip2], atm->p[ip2],
```

```
00692                         atm->lon[ip2], atm->lat[ip2], NULL, &t, NULL, NULL,
00693                         NULL, NULL, NULL);
00694         iso[ip2] = atm->p[ip2] / t;
00695       }
00696
00697     /* Save potential temperature... */
00698     else if (ctl->isosurf == 3)
00699       for (ip2 = 0; ip2 < atm->np; ip2++) {
00700         intpol_met_time(met0, met1, atm->time[ip2], atm->p[ip2],
00701                         atm->lon[ip2], atm->lat[ip2], NULL, &t, NULL, NULL,
00702                         NULL, NULL, NULL);
00703         iso[ip2] = t * pow(P0 / atm->p[ip2], 0.286);
00704       }
00705
00706     /* Read balloon pressure data... */
00707     else if (ctl->isosurf == 4) {
00708
00709       /* Write info... */
00710       printf("Read balloon pressure data: %s\n", ctl->balloon);
00711
00712       /* Open file... */
00713       if (!(in = fopen(ctl->balloon, "r")))
00714         ERRMSG("Cannot open file!");
00715
00716       /* Read pressure time series... */
00717       while (fgets(line, LEN, in))
00718         if (sscanf(line, "%lg %lg", &ts[n], &ps[n]) == 2)
00719           if ((++n) > 100000)
00720             ERRMSG("Too many data points!");
00721
00722       /* Check number of points... */
00723       if (n < 1)
00724         ERRMSG("Could not read any data!");
00725
00726       /* Close file... */
00727       fclose(in);
00728     }
00729
00730     /* Leave initialization... */
00731     return;
00732   }
00733
00734   /* Restore pressure... */
00735   if (ctl->isosurf == 1)
00736     atm->p[ip] = iso[ip];
00737
00738   /* Restore density... */
00739   else if (ctl->isosurf == 2) {
00740     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00741                     atm->lat[ip], NULL, &t, NULL, NULL, NULL, NULL, NULL);
00742     atm->p[ip] = iso[ip] * t;
00743   }
00744
00745   /* Restore potential temperature... */
00746   else if (ctl->isosurf == 3) {
00747     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00748                     atm->lat[ip], NULL, &t, NULL, NULL, NULL, NULL, NULL);
00749     atm->p[ip] = P0 * pow(iso[ip] / t, -1. / 0.286);
00750   }
00751
00752   /* Interpolate pressure... */
00753   else if (ctl->isosurf == 4) {
00754     if (atm->time[ip] <= ts[0])
00755       atm->p[ip] = ps[0];
00756     else if (atm->time[ip] >= ts[n - 1])
00757       atm->p[ip] = ps[n - 1];
00758     else {
00759       idx = locate(ts, n, atm->time[ip]);
00760       atm->p[ip] = LIN(ts[idx], ps[idx],
00761                        ts[idx + 1], ps[idx + 1], atm->time[ip]);
00762     }
00763   }
00764 }
```

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*)

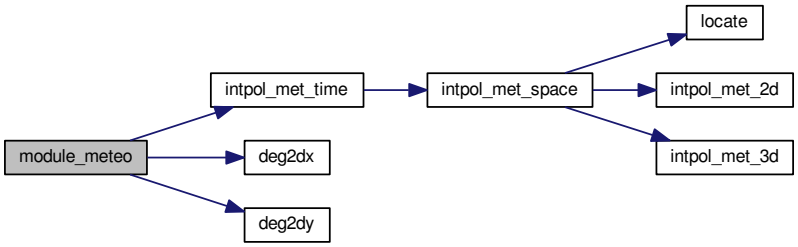
Interpolate meteorological data for air parcel positions.

Definition at line 768 of file trac.c.

```
00773           {
00774
00775   double b, c, ps, p1, p_hno3, p_h2o, t, t1, term1, term2,
00776     u, u1, v, v1, w, x1, x2, h2o, o3, grad, vort;
00777
00778   /* Interpolate meteorological data... */
00779   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00780                   atm->lat[ip], &ps, &t, &u, &v, &w, &h2o, &o3);
00781
00782   /* Set surface pressure... */
00783   if (ctl->qnt_ps >= 0)
00784     atm->q[ctl->qnt_ps][ip] = ps;
00785
00786   /* Set pressure... */
00787   if (ctl->qnt_p >= 0)
00788     atm->q[ctl->qnt_p][ip] = atm->p[ip];
00789
00790   /* Set temperature... */
00791   if (ctl->qnt_t >= 0)
00792     atm->q[ctl->qnt_t][ip] = t;
00793
00794   /* Set zonal wind... */
00795   if (ctl->qnt_u >= 0)
00796     atm->q[ctl->qnt_u][ip] = u;
00797
00798   /* Set meridional wind... */
00799   if (ctl->qnt_v >= 0)
00800     atm->q[ctl->qnt_v][ip] = v;
00801
00802   /* Set vertical velocity... */
00803   if (ctl->qnt_w >= 0)
00804     atm->q[ctl->qnt_w][ip] = w;
00805
00806   /* Set water vapor vmr... */
00807   if (ctl->qnt_h2o >= 0)
00808     atm->q[ctl->qnt_h2o][ip] = h2o;
00809
00810   /* Set ozone vmr... */
00811   if (ctl->qnt_o3 >= 0)
00812     atm->q[ctl->qnt_o3][ip] = o3;
00813
00814   /* Calculate potential temperature... */
00815   if (ctl->qnt_theta >= 0)
00816     atm->q[ctl->qnt_theta][ip] = t * pow(P0 / atm->p[ip], 0.286);
00817
00818   /* Calculate potential vorticity... */
00819   if (ctl->qnt_pv >= 0) {
00820
00821     /* Absolute vorticity... */
00822     vort = 2 * 7.2921e-5 * sin(atm->lat[ip] * M_PI / 180.);
00823     if (fabs(atm->lat[ip]) < 89.) {
00824       intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00825                       (atm->lon[ip] >=
```

```
00826                        0 ? atm->lon[ip] - 1. : atm->lon[ip] + 1.),
00827                       atm->lat[ip], NULL, NULL, NULL, &v1, NULL, NULL, NULL);
00828       vort += (v1 - v) / 1000.
00829         / ((atm->lon[ip] >= 0 ? -1 : 1) * deg2dx(1., atm->lat[ip]));
00830     }
00831     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
    lon[ip],
00832                     (atm->lat[ip] >=
00833                      0 ? atm->lat[ip] - 1. : atm->lat[ip] + 1.), NULL, NULL,
00834                     &u1, NULL, NULL, NULL, NULL);
00835     vort += (u1 - u) / 1000. / ((atm->lat[ip] >= 0 ? -1 : 1) * deg2dy(1.));
00836
00837     /* Potential temperature gradient... */
00838     p1 = 0.85 * atm->p[ip];
00839     intpol_met_time(met0, met1, atm->time[ip], p1, atm->lon[ip],
00840                     atm->lat[ip], NULL, &t1, NULL, NULL, NULL, NULL, NULL);
00841     grad = (t1 * pow(P0 / p1, 0.286) - t * pow(P0 / atm->p[ip], 0.286))
00842       / (100. * (p1 - atm->p[ip]));
00843
00844     /* Calculate PV... */
00845     atm->q[ctl->qnt_pv][ip] = -1e6 * G0 * vort * grad;
00846   }
00847
00848   /* Calculate T_ice (Marti and Mauersberger, 1993)... */
00849   if (ctl->qnt_tice >= 0)
00850     atm->q[ctl->qnt_tice][ip] = -2663.5
00851       / (log10(4e-6 * atm->p[ip] * 100.) - 12.537);
00852
00853   /* Calculate T_NAT (Hanson and Mauersberger, 1988)... */
00854   if (ctl->qnt_tnat >= 0) {
00855     p_hno3 = 9e-9 * atm->p[ip] / 1.333224;
00856     p_h2o = 4e-6 * atm->p[ip] / 1.333224;
00857     term1 = 38.9855 - log10(p_hno3) - 2.7836 * log10(p_h2o);
00858     term2 = 0.009179 - 0.00088 * log10(p_h2o);
00859     b = term1 / term2;
00860     c = -11397.0 / term2;
00861     x1 = (-b + sqrt(b * b - 4. * c)) / 2.;
00862     x2 = (-b - sqrt(b * b - 4. * c)) / 2.;
00863     if (x1 > 0)
00864       atm->q[ctl->qnt_tnat][ip] = x1;
00865     if (x2 > 0)
00866       atm->q[ctl->qnt_tnat][ip] = x2;
00867   }
00868 }
```

Here is the call graph for this function:



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

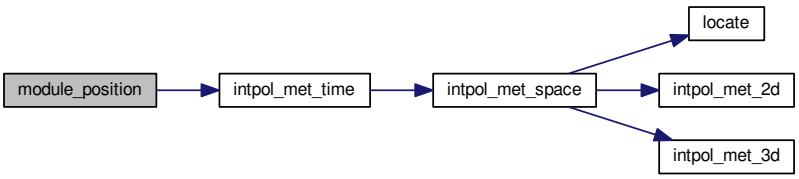
Check position of air parcels.

Definition at line 872 of file trac.c.

```
00876           {
00877
00878   double ps;
00879
```

```
00880   /* Calculate modulo... */
00881   atm->lon[ip] = fmod(atm->lon[ip], 360);
00882   atm->lat[ip] = fmod(atm->lat[ip], 360);
00883
00884   /* Check latitude... */
00885   while (atm->lat[ip] < -90 || atm->lat[ip] > 90) {
00886     if (atm->lat[ip] > 90) {
00887       atm->lat[ip] = 180 - atm->lat[ip];
00888       atm->lon[ip] += 180;
00889     }
00890     if (atm->lat[ip] < -90) {
00891       atm->lat[ip] = -180 - atm->lat[ip];
00892       atm->lon[ip] += 180;
00893     }
00894   }
00895
00896   /* Check longitude... */
00897   while (atm->lon[ip] < -180)
00898     atm->lon[ip] += 360;
00899   while (atm->lon[ip] >= 180)
00900     atm->lon[ip] -= 360;
00901
00902   /* Get surface pressure... */
00903   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00904                   atm->lon[ip], atm->lat[ip], &ps, NULL,
00905                   NULL, NULL, NULL, NULL, NULL);
00906
00907   /* Check pressure... */
00908   if (atm->p[ip] > ps)
00909     atm->p[ip] = ps;
00910   else if (atm->p[ip] < met0->p[met0->np - 1])
00911     atm->p[ip] = met0->p[met0->np - 1];
00912 }
```

Here is the call graph for this function:



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

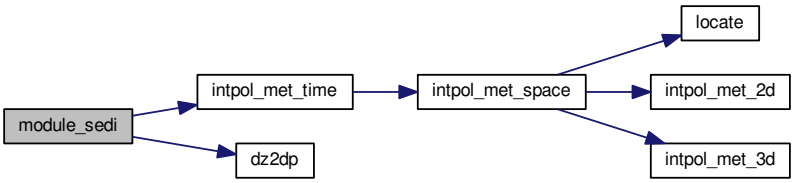
Calculate sedimentation of air parcels.

Definition at line 916 of file trac.c.

```
00922             {
00923
00924   /* Coefficients for Cunningham slip-flow correction (Kasten, 1968): */
00925   const double A = 1.249, B = 0.42, C = 0.87;
00926
00927   /* Specific gas constant for dry air [J/(kg K)]: */
00928   const double R = 287.058;
00929
00930   /* Average mass of an air molecule [kg/molec]: */
00931   const double m = 4.8096e-26;
00932
00933   double G, K, eta, lambda, p, r_p, rho, rho_p, T, v, v_p;
00934
00935   /* Check if parameters are available... */
00936   if (ctl->qnt_r < 0 || ctl->qnt_rho < 0)
00937     return;
00938
00939   /* Convert units... */
```

```
00940   p = 100 * atm->p[ip];
00941   r_p = 1e-6 * atm->q[ctl->qnt_r][ip];
00942   rho_p = atm->q[ctl->qnt_rho][ip];
00943
00944   /* Get temperature... */
00945   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
    lon[ip],
00946                   atm->lat[ip], NULL, &T, NULL, NULL, NULL, NULL, NULL);
00947
00948   /* Density of dry air... */
00949   rho = p / (R * T);
00950
00951   /* Dynamic viscosity of air... */
00952   eta = 1.8325e-5 * (416.16 / (T + 120.)) * pow(T / 296.16, 1.5);
00953
00954   /* Thermal velocity of an air molecule... */
00955   v = sqrt(8 * GSL_CONST_MKSA_BOLTZMANN * T / (M_PI * m));
00956
00957   /* Mean free path of an air molecule... */
00958   lambda = 2 * eta / (rho * v);
00959
00960   /* Knudsen number for air... */
00961   K = lambda / r_p;
00962
00963   /* Cunningham slip-flow correction... */
00964   G = 1 + K * (A + B * exp(-C / K));
00965
00966   /* Sedimentation (fall) velocity... */
00967   v_p =
00968     2. * gsl_pow_2(r_p) * (rho_p -
00969                            rho) * GSL_CONST_MKSA_GRAV_ACCEL / (9. * eta) * G;
00970
00971   /* Calculate pressure change... */
00972   atm->p[ip] += dz2dp(v_p * dt / 1000., atm->p[ip]);
00973 }
```

Here is the call graph for this function:



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

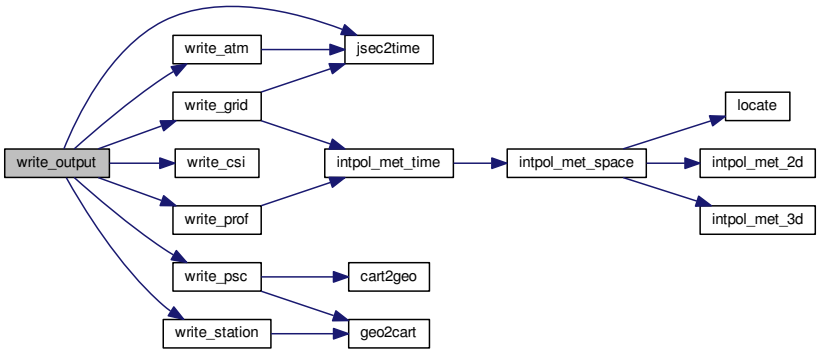
Write simulation output.

Definition at line 977 of file trac.c.

```
00983           {
00984
00985   char filename[LEN];
00986
00987   double r;
00988
00989   int year, mon, day, hour, min, sec;
00990
00991   /* Get time... */
00992   jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
00993
00994   /* Write atmospheric data... */
00995   if (ctl->atm_basename[0] != '-' && fmod(t, ctl->atm_dt_out) == 0) {
00996     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
00997             dirname, ctl->atm_basename, year, mon, day, hour, min);
00998     write_atm(filename, ctl, atm, t);
```

```
00999   }
01000
01001   /* Write gridded data... */
01002   if (ctl->grid_basename[0] != '-' && fmod(t, ctl->grid_dt_out) == 0) {
01003     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
01004             dirname, ctl->grid_basename, year, mon, day, hour, min);
01005     write_grid(filename, ctl, met0, met1, atm, t);
01006   }
01007
01008   /* Write CSI data... */
01009   if (ctl->csi_basename[0] != '-') {
01010     sprintf(filename, "%s/%s.tab", dirname, ctl->csi_basename);
01011     write_csi(filename, ctl, atm, t);
01012   }
01013
01014   /* Write profile data... */
01015   if (ctl->prof_basename[0] != '-') {
01016     sprintf(filename, "%s/%s.tab", dirname, ctl->prof_basename);
01017     write_prof(filename, ctl, met0, met1, atm, t);
01018   }
01019
01020   /* Write PSC data... */
01021   if (ctl->psc_basename[0] != '-') {
01022     sprintf(filename, "%s/%s.tab", dirname, ctl->psc_basename);
01023     write_psc(filename, ctl, atm, t);
01024   }
01025
01026   /* Write station data... */
01027   if (ctl->stat_basename[0] != '-') {
01028     sprintf(filename, "%s/%s.tab", dirname, ctl->stat_basename);
01029     write_station(filename, ctl, atm, t);
01030   }
01031 }
```

Here is the call graph for this function:



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

Definition at line 160 of file trac.c.

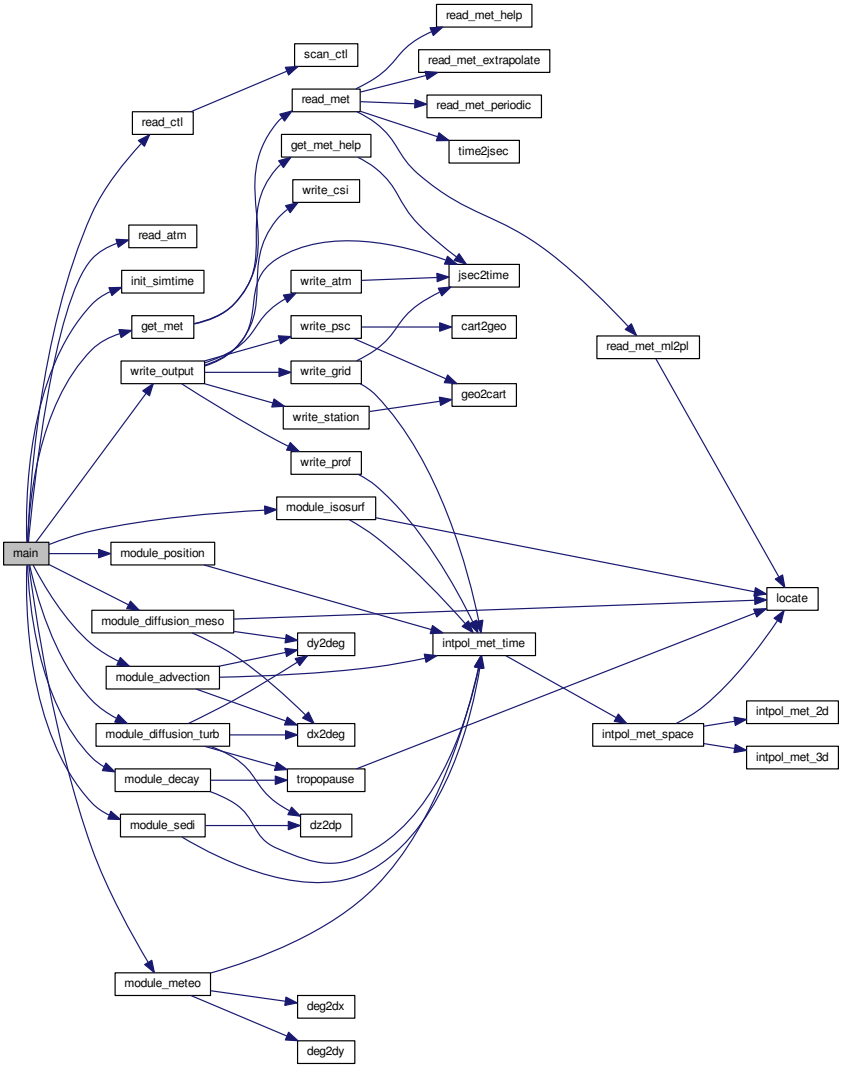
```
00162                {
00163
00164   ctl_t ctl;
00165
00166   atm_t *atm;
00167
00168   met_t *met0, *met1;
00169
00170   gsl_rng *rng[NTHREADS];
00171
00172   FILE *dirlist;
00173
00174   char dirname[LEN], filename[LEN];
00175
```

```
00176   double *dt, t, t0;
00177
00178   int i, ip, ntask = 0, rank = 0, size = 1;
00179
00180 #ifdef MPI
00181   /* Initialize MPI... */
00182   MPI_Init(&argc, &argv);
00183   MPI_Comm_rank(MPI_COMM_WORLD, &rank);
00184   MPI_Comm_size(MPI_COMM_WORLD, &size);
00185 #endif
00186
00187   /* Check arguments... */
00188   if (argc < 5)
00189     ERRMSG("Give parameters: <dirlist> <ctl> <atm_in> <metbase>");
00190
00191   /* Open directory list... */
00192   if (!(dirlist = fopen(argv[1], "r")))
00193     ERRMSG("Cannot open directory list!");
00194
00195   /* Loop over directories... */
00196   while (fscanf(dirlist, "%s", dirname) != EOF) {
00197
00198     /* MPI parallelization... */
00199     if ((++ntask) % size != rank)
00200       continue;
00201
00202     /* ------------------------------------------------------------
00203        Initialize model run...
00204        ------------------------------------------------------------ */
00205
00206     /* Set timers... */
00207     START_TIMER(TIMER_TOTAL);
00208     START_TIMER(TIMER_INIT);
00209
00210     /* Allocate... */
00211     ALLOC(atm, atm_t, 1);
00212     ALLOC(met0, met_t, 1);
00213     ALLOC(met1, met_t, 1);
00214     ALLOC(dt, double,
00215           NP);
00216
00217     /* Read control parameters... */
00218     sprintf(filename, "%s/%s", dirname, argv[2]);
00219     read_ctl(filename, argc, argv, &ctl);
00220
00221     /* Initialize random number generators... */
00222     gsl_rng_env_setup();
00223     for (i = 0; i < NTHREADS; i++)
00224       rng[i] = gsl_rng_alloc(gsl_rng_default);
00225
00226     /* Read atmospheric data... */
00227     sprintf(filename, "%s/%s", dirname, argv[3]);
00228     read_atm(filename, &ctl, atm);
00229
00230     /* Get simulation time interval... */
00231     init_simtime(&ctl, atm);
00232
00233     /* Get rounded start time... */
00234     if (ctl.direction == 1)
00235       t0 = floor(ctl.t_start / ctl.dt_mod) * ctl.dt_mod;
00236     else
00237       t0 = ceil(ctl.t_start / ctl.dt_mod) * ctl.dt_mod;
00238
00239     /* Set timers... */
00240     STOP_TIMER(TIMER_INIT);
00241
00242     /* ------------------------------------------------------------
00243        Loop over timesteps...
00244        ------------------------------------------------------------ */
00245
00246     /* Loop over timesteps... */
00247     for (t = t0; ctl.direction * (t - ctl.t_stop) < ctl.dt_mod;
00248          t += ctl.direction * ctl.dt_mod) {
00249
00250       /* Adjust length of final time step... */
00251       if (ctl.direction * (t - ctl.t_stop) > 0)
00252         t = ctl.t_stop;
00253
00254       /* Set time steps for air parcels... */
00255       for (ip = 0; ip < atm->np; ip++)
00256         if ((ctl.direction * (atm->time[ip] - ctl.t_start) >= 0
00257              && ctl.direction * (atm->time[ip] - ctl.t_stop) <= 0
00258              && ctl.direction * (atm->time[ip] - t) < 0))
00259           dt[ip] = t - atm->time[ip];
00260         else
00261           dt[ip] = GSL_NAN;
00262
```

```
00263       /* Get meteorological data... */
00264       START_TIMER(TIMER_INPUT);
00265       get_met(&ctl, argv[4], t, met0, met1);
00266       STOP_TIMER(TIMER_INPUT);
00267
00268       /* Initialize isosurface... */
00269       START_TIMER(TIMER_ISOSURF);
00270       if (t == t0)
00271         module_isosurf(&ctl, met0, met1, atm, -1);
00272       STOP_TIMER(TIMER_ISOSURF);
00273
00274       /* Advection... */
00275       START_TIMER(TIMER_ADVECT);
00276 #pragma omp parallel for default(shared) private(ip)
00277       for (ip = 0; ip < atm->np; ip++)
00278         if (gsl_finite(dt[ip]))
00279           module_advection(met0, met1, atm, ip, dt[ip]);
00280       STOP_TIMER(TIMER_ADVECT);
00281
00282       /* Turbulent diffusion... */
00283       START_TIMER(TIMER_DIFFTURB);
00284 #pragma omp parallel for default(shared) private(ip)
00285       for (ip = 0; ip < atm->np; ip++)
00286         if (gsl_finite(dt[ip]))
00287           module_diffusion_turb(&ctl, atm, ip, dt[ip],
00288                                 rng[omp_get_thread_num()]);
00289       STOP_TIMER(TIMER_DIFFTURB);
00290
00291       /* Mesoscale diffusion... */
00292       START_TIMER(TIMER_DIFFMESO);
00293 #pragma omp parallel for default(shared) private(ip)
00294       for (ip = 0; ip < atm->np; ip++)
00295         if (gsl_finite(dt[ip]))
00296           module_diffusion_meso(&ctl, met0, met1, atm, ip, dt[ip],
00297                                 rng[omp_get_thread_num()]);
00298       STOP_TIMER(TIMER_DIFFMESO);
00299
00300       /* Sedimentation... */
00301       START_TIMER(TIMER_SEDI);
00302 #pragma omp parallel for default(shared) private(ip)
00303       for (ip = 0; ip < atm->np; ip++)
00304         if (gsl_finite(dt[ip]))
00305           module_sedi(&ctl, met0, met1, atm, ip, dt[ip]);
00306       STOP_TIMER(TIMER_SEDI);
00307
00308       /* Isosurface... */
00309       START_TIMER(TIMER_ISOSURF);
00310 #pragma omp parallel for default(shared) private(ip)
00311       for (ip = 0; ip < atm->np; ip++)
00312         module_isosurf(&ctl, met0, met1, atm, ip);
00313       STOP_TIMER(TIMER_ISOSURF);
00314
00315       /* Position... */
00316       START_TIMER(TIMER_POSITION);
00317 #pragma omp parallel for default(shared) private(ip)
00318       for (ip = 0; ip < atm->np; ip++)
00319         module_position(met0, met1, atm, ip);
00320       STOP_TIMER(TIMER_POSITION);
00321
00322       /* Meteorological data... */
00323       START_TIMER(TIMER_METEO);
00324 #pragma omp parallel for default(shared) private(ip)
00325       for (ip = 0; ip < atm->np; ip++)
00326         module_meteo(&ctl, met0, met1, atm, ip);
00327       STOP_TIMER(TIMER_METEO);
00328
00329       /* Decay... */
00330       START_TIMER(TIMER_DECAY);
00331 #pragma omp parallel for default(shared) private(ip)
00332       for (ip = 0; ip < atm->np; ip++)
00333         if (gsl_finite(dt[ip]))
00334           module_decay(&ctl, met0, met1, atm, ip, dt[ip]);
00335       STOP_TIMER(TIMER_DECAY);
00336
00337       /* Write output... */
00338       START_TIMER(TIMER_OUTPUT);
00339       write_output(dirname, &ctl, met0, met1, atm, t);
00340       STOP_TIMER(TIMER_OUTPUT);
00341     }
00342
00343     /* ------------------------------------------------------------
00344        Finalize model run...
00345        ------------------------------------------------------------ */
00346
00347     /* Report timers... */
00348     STOP_TIMER(TIMER_TOTAL);
00349     PRINT_TIMER(TIMER_TOTAL);
```

```
00350     PRINT_TIMER(TIMER_INIT);
00351     PRINT_TIMER(TIMER_INPUT);
00352     PRINT_TIMER(TIMER_OUTPUT);
00353     PRINT_TIMER(TIMER_ADVECT);
00354     PRINT_TIMER(TIMER_DECAY);
00355     PRINT_TIMER(TIMER_DIFFMESO);
00356     PRINT_TIMER(TIMER_DIFFTURB);
00357     PRINT_TIMER(TIMER_ISOSURF);
00358     PRINT_TIMER(TIMER_METEO);
00359     PRINT_TIMER(TIMER_POSITION);
00360     PRINT_TIMER(TIMER_SEDI);
00361
00362     /* Report memory usage... */
00363     printf("MEMORY_ATM = %g MByte\n", 2. * sizeof(atm_t) / 1024. / 1024.);
00364     printf("MEMORY_METEO = %g MByte\n", 2. * sizeof(met_t) / 1024. / 1024.);
00365     printf("MEMORY_DYNAMIC = %g MByte\n",
00366            NP * sizeof(double) / 1024. / 1024.);
00367     printf("MEMORY_STATIC = %g MByte\n",
00368            (((EX + EY) + (2 + NQ) * GX * GY * GZ) * sizeof(double)
00369             + (EX * EY + EX * EY * EP) * sizeof(float)
00370             + (2 * GX * GY * GZ) * sizeof(int)) / 1024. / 1024.);
00371
00372     /* Report problem size... */
00373     printf("SIZE_NP = %d\n", atm->np);
00374     printf("SIZE_TASKS = %d\n", size);
00375     printf("SIZE_THREADS = %d\n", omp_get_max_threads());
00376
00377     /* Free random number generators... */
00378     for (i = 0; i < NTHREADS; i++)
00379       gsl_rng_free(rng[i]);
00380
00381     /* Free... */
00382     free(atm);
00383     free(met0);
00384     free(met1);
00385     free(dt);
00386   }
00387
00388 #ifdef MPI
00389   /* Finalize MPI... */
00390   MPI_Finalize();
00391 #endif
00392
00393   return EXIT_SUCCESS;
00394 }
```

Here is the call graph for this function:



5.32 trac.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
```

```
00027 #ifdef MPI
00028 #include "mpi.h"
00029 #endif
00030
00031 /* ------------------------------------------------------------
00032    Defines...
00033    ------------------------------------------------------------ */
00034
00036 #define TIMER_TOTAL 0
00037
00039 #define TIMER_INIT 1
00040
00042 #define TIMER_INPUT 2
00043
00045 #define TIMER_OUTPUT 3
00046
00048 #define TIMER_ADVECT 4
00049
00051 #define TIMER_DECAY 5
00052
00054 #define TIMER_DIFFMESO 6
00055
00057 #define TIMER_DIFFTURB 7
00058
00060 #define TIMER_ISOSURF 8
00061
00063 #define TIMER_METEO 9
00064
00066 #define TIMER_POSITION 10
00067
00069 #define TIMER_SEDI 11
00070
00071 /* ------------------------------------------------------------
00072    Functions...
00073    ------------------------------------------------------------ */
00074
00076 void init_simtime(
00077   ctl_t * ctl,
00078   atm_t * atm);
00079
00081 void module_advection(
00082   met_t * met0,
00083   met_t * met1,
00084   atm_t * atm,
00085   int ip,
00086   double dt);
00087
00089 void module_decay(
00090   ctl_t * ctl,
00091   met_t * met0,
00092   met_t * met1,
00093   atm_t * atm,
00094   int ip,
00095   double dt);
00096
00098 void module_diffusion_meso(
00099   ctl_t * ctl,
00100   met_t * met0,
00101   met_t * met1,
00102   atm_t * atm,
00103   int ip,
00104   double dt,
00105   gsl_rng * rng);
00106
00108 void module_diffusion_turb(
00109   ctl_t * ctl,
00110   atm_t * atm,
00111   int ip,
00112   double dt,
00113   gsl_rng * rng);
00114
00116 void module_isosurf(
00117   ctl_t * ctl,
00118   met_t * met0,
00119   met_t * met1,
00120   atm_t * atm,
00121   int ip);
00122
00124 void module_meteo(
00125   ctl_t * ctl,
00126   met_t * met0,
00127   met_t * met1,
00128   atm_t * atm,
00129   int ip);
00130
00132 void module_position(
00133   met_t * met0,
```

```
00134   met_t * met1,
00135   atm_t * atm,
00136   int ip);
00137
00139 void module_sedi(
00140   ctl_t * ctl,
00141   met_t * met0,
00142   met_t * met1,
00143   atm_t * atm,
00144   int ip,
00145   double dt);
00146
00148 void write_output(
00149   const char *dirname,
00150   ctl_t * ctl,
00151   met_t * met0,
00152   met_t * met1,
00153   atm_t * atm,
00154   double t);
00155
00156 /* ------------------------------------------------------------
00157    Main...
00158    ------------------------------------------------------------ */
00159
00160 int main(
00161   int argc,
00162   char *argv[]) {
00163
00164   ctl_t ctl;
00165
00166   atm_t *atm;
00167
00168   met_t *met0, *met1;
00169
00170   gsl_rng *rng[NTHREADS];
00171
00172   FILE *dirlist;
00173
00174   char dirname[LEN], filename[LEN];
00175
00176   double *dt, t, t0;
00177
00178   int i, ip, ntask = 0, rank = 0, size = 1;
00179
00180 #ifdef MPI
00181   /* Initialize MPI... */
00182   MPI_Init(&argc, &argv);
00183   MPI_Comm_rank(MPI_COMM_WORLD, &rank);
00184   MPI_Comm_size(MPI_COMM_WORLD, &size);
00185 #endif
00186
00187   /* Check arguments... */
00188   if (argc < 5)
00189     ERRMSG("Give parameters: <dirlist> <ctl> <atm_in> <metbase>");
00190
00191   /* Open directory list... */
00192   if (!(dirlist = fopen(argv[1], "r")))
00193     ERRMSG("Cannot open directory list!");
00194
00195   /* Loop over directories... */
00196   while (fscanf(dirlist, "%s", dirname) != EOF) {
00197
00198     /* MPI parallelization... */
00199     if ((++ntask) % size != rank)
00200       continue;
00201
00202     /* ------------------------------------------------------------
00203        Initialize model run...
00204        ------------------------------------------------------------ */
00205
00206     /* Set timers... */
00207     START_TIMER(TIMER_TOTAL);
00208     START_TIMER(TIMER_INIT);
00209
00210     /* Allocate... */
00211     ALLOC(atm, atm_t, 1);
00212     ALLOC(met0, met_t, 1);
00213     ALLOC(met1, met_t, 1);
00214     ALLOC(dt, double,
00215           NP);
00216
00217     /* Read control parameters... */
00218     sprintf(filename, "%s/%s", dirname, argv[2]);
00219     read_ctl(filename, argc, argv, &ctl);
00220
00221     /* Initialize random number generators... */
00222     gsl_rng_env_setup();
```

```
00223     for (i = 0; i < NTHREADS; i++)
00224       rng[i] = gsl_rng_alloc(gsl_rng_default);
00225
00226     /* Read atmospheric data... */
00227     sprintf(filename, "%s/%s", dirname, argv[3]);
00228     read_atm(filename, &ctl, atm);
00229
00230     /* Get simulation time interval... */
00231     init_simtime(&ctl, atm);
00232
00233     /* Get rounded start time... */
00234     if (ctl.direction == 1)
00235       t0 = floor(ctl.t_start / ctl.dt_mod) * ctl.dt_mod;
00236     else
00237       t0 = ceil(ctl.t_start / ctl.dt_mod) * ctl.dt_mod;
00238
00239     /* Set timers... */
00240     STOP_TIMER(TIMER_INIT);
00241
00242     /* ------------------------------------------------------------
00243        Loop over timesteps...
00244        ------------------------------------------------------------ */
00245
00246     /* Loop over timesteps... */
00247     for (t = t0; ctl.direction * (t - ctl.t_stop) < ctl.dt_mod;
00248          t += ctl.direction * ctl.dt_mod) {
00249
00250       /* Adjust length of final time step... */
00251       if (ctl.direction * (t - ctl.t_stop) > 0)
00252         t = ctl.t_stop;
00253
00254       /* Set time steps for air parcels... */
00255       for (ip = 0; ip < atm->np; ip++)
00256         if ((ctl.direction * (atm->time[ip] - ctl.t_start) >= 0
00257              && ctl.direction * (atm->time[ip] - ctl.t_stop) <= 0
00258              && ctl.direction * (atm->time[ip] - t) < 0))
00259           dt[ip] = t - atm->time[ip];
00260         else
00261           dt[ip] = GSL_NAN;
00262
00263       /* Get meteorological data... */
00264       START_TIMER(TIMER_INPUT);
00265       get_met(&ctl, argv[4], t, met0, met1);
00266       STOP_TIMER(TIMER_INPUT);
00267
00268       /* Initialize isosurface... */
00269       START_TIMER(TIMER_ISOSURF);
00270       if (t == t0)
00271         module_isosurf(&ctl, met0, met1, atm, -1);
00272       STOP_TIMER(TIMER_ISOSURF);
00273
00274       /* Advection... */
00275       START_TIMER(TIMER_ADVECT);
00276 #pragma omp parallel for default(shared) private(ip)
00277       for (ip = 0; ip < atm->np; ip++)
00278         if (gsl_finite(dt[ip]))
00279           module_advection(met0, met1, atm, ip, dt[ip]);
00280       STOP_TIMER(TIMER_ADVECT);
00281
00282       /* Turbulent diffusion... */
00283       START_TIMER(TIMER_DIFFTURB);
00284 #pragma omp parallel for default(shared) private(ip)
00285       for (ip = 0; ip < atm->np; ip++)
00286         if (gsl_finite(dt[ip]))
00287           module_diffusion_turb(&ctl, atm, ip, dt[ip],
00288                                 rng[omp_get_thread_num()]);
00289       STOP_TIMER(TIMER_DIFFTURB);
00290
00291       /* Mesoscale diffusion... */
00292       START_TIMER(TIMER_DIFFMESO);
00293 #pragma omp parallel for default(shared) private(ip)
00294       for (ip = 0; ip < atm->np; ip++)
00295         if (gsl_finite(dt[ip]))
00296           module_diffusion_meso(&ctl, met0, met1, atm, ip, dt[ip],
00297                                 rng[omp_get_thread_num()]);
00298       STOP_TIMER(TIMER_DIFFMESO);
00299
00300       /* Sedimentation... */
00301       START_TIMER(TIMER_SEDI);
00302 #pragma omp parallel for default(shared) private(ip)
00303       for (ip = 0; ip < atm->np; ip++)
00304         if (gsl_finite(dt[ip]))
00305           module_sedi(&ctl, met0, met1, atm, ip, dt[ip]);
00306       STOP_TIMER(TIMER_SEDI);
00307
00308       /* Isosurface... */
00309       START_TIMER(TIMER_ISOSURF);
```

```
00310 #pragma omp parallel for default(shared) private(ip)
00311       for (ip = 0; ip < atm->np; ip++)
00312         module_isosurf(&ctl, met0, met1, atm, ip);
00313       STOP_TIMER(TIMER_ISOSURF);
00314
00315       /* Position... */
00316       START_TIMER(TIMER_POSITION);
00317 #pragma omp parallel for default(shared) private(ip)
00318       for (ip = 0; ip < atm->np; ip++)
00319         module_position(met0, met1, atm, ip);
00320       STOP_TIMER(TIMER_POSITION);
00321
00322       /* Meteorological data... */
00323       START_TIMER(TIMER_METEO);
00324 #pragma omp parallel for default(shared) private(ip)
00325       for (ip = 0; ip < atm->np; ip++)
00326         module_meteo(&ctl, met0, met1, atm, ip);
00327       STOP_TIMER(TIMER_METEO);
00328
00329       /* Decay... */
00330       START_TIMER(TIMER_DECAY);
00331 #pragma omp parallel for default(shared) private(ip)
00332       for (ip = 0; ip < atm->np; ip++)
00333         if (gsl_finite(dt[ip]))
00334           module_decay(&ctl, met0, met1, atm, ip, dt[ip]);
00335       STOP_TIMER(TIMER_DECAY);
00336
00337       /* Write output... */
00338       START_TIMER(TIMER_OUTPUT);
00339       write_output(dirname, &ctl, met0, met1, atm, t);
00340       STOP_TIMER(TIMER_OUTPUT);
00341     }
00342
00343     /* ------------------------------------------------------------
00344        Finalize model run...
00345        ------------------------------------------------------------ */
00346
00347     /* Report timers... */
00348     STOP_TIMER(TIMER_TOTAL);
00349     PRINT_TIMER(TIMER_TOTAL);
00350     PRINT_TIMER(TIMER_INIT);
00351     PRINT_TIMER(TIMER_INPUT);
00352     PRINT_TIMER(TIMER_OUTPUT);
00353     PRINT_TIMER(TIMER_ADVECT);
00354     PRINT_TIMER(TIMER_DECAY);
00355     PRINT_TIMER(TIMER_DIFFMESO);
00356     PRINT_TIMER(TIMER_DIFFTURB);
00357     PRINT_TIMER(TIMER_ISOSURF);
00358     PRINT_TIMER(TIMER_METEO);
00359     PRINT_TIMER(TIMER_POSITION);
00360     PRINT_TIMER(TIMER_SEDI);
00361
00362     /* Report memory usage... */
00363     printf("MEMORY_ATM = %g MByte\n", 2. * sizeof(atm_t) / 1024. / 1024.);
00364     printf("MEMORY_METEO = %g MByte\n", 2. * sizeof(met_t) / 1024. / 1024.);
00365     printf("MEMORY_DYNAMIC = %g MByte\n",
00366            NP * sizeof(double) / 1024. / 1024.);
00367     printf("MEMORY_STATIC = %g MByte\n",
00368            (((EX + EY) + (2 + NQ) * GX * GY * GZ) * sizeof(double)
00369             + (EX * EY + EX * EY * EP) * sizeof(float)
00370             + (2 * GX * GY * GZ) * sizeof(int)) / 1024. / 1024.);
00371
00372     /* Report problem size... */
00373     printf("SIZE_NP = %d\n", atm->np);
00374     printf("SIZE_TASKS = %d\n", size);
00375     printf("SIZE_THREADS = %d\n", omp_get_max_threads());
00376
00377     /* Free random number generators... */
00378     for (i = 0; i < NTHREADS; i++)
00379       gsl_rng_free(rng[i]);
00380
00381     /* Free... */
00382     free(atm);
00383     free(met0);
00384     free(met1);
00385     free(dt);
00386   }
00387
00388 #ifdef MPI
00389   /* Finalize MPI... */
00390   MPI_Finalize();
00391 #endif
00392
00393   return EXIT_SUCCESS;
00394 }
00395
00396 /*****************************************************************************/
```

```
00397
00398 void init_simtime(
00399   ctl_t * ctl,
00400   atm_t * atm) {
00401
00402   /* Set inital and final time... */
00403   if (ctl->direction == 1) {
00404     if (ctl->t_start < -1e99)
00405       ctl->t_start = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00406     if (ctl->t_stop < -1e99)
00407       ctl->t_stop = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00408   } else if (ctl->direction == -1) {
00409     if (ctl->t_stop < -1e99)
00410       ctl->t_stop = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00411     if (ctl->t_start < -1e99)
00412       ctl->t_start = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00413   }
00414
00415   /* Check time... */
00416   if (ctl->direction * (ctl->t_stop - ctl->t_start) <= 0)
00417     ERRMSG("Nothing to do!");
00418 }
00419
00420 /*****************************************************************************/
00421
00422 void module_advection(
00423   met_t * met0,
00424   met_t * met1,
00425   atm_t * atm,
00426   int ip,
00427   double dt) {
00428
00429   double v[3], xm[3];
00430
00431   /* Interpolate meteorological data... */
00432   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00433                   atm->lon[ip], atm->lat[ip], NULL, NULL,
00434                   &v[0], &v[1], &v[2], NULL, NULL);
00435
00436   /* Get position of the mid point... */
00437   xm[0] = atm->lon[ip] + dx2deg(0.5 * dt * v[0] / 1000., atm->lat[ip]);
00438   xm[1] = atm->lat[ip] + dy2deg(0.5 * dt * v[1] / 1000.);
00439   xm[2] = atm->p[ip] + 0.5 * dt * v[2];
00440
00441   /* Interpolate meteorological data for mid point... */
00442   intpol_met_time(met0, met1, atm->time[ip] + 0.5 * dt,
00443                   xm[2], xm[0], xm[1], NULL, NULL,
00444                   &v[0], &v[1], &v[2], NULL, NULL);
00445
00446   /* Save new position... */
00447   atm->time[ip] += dt;
00448   atm->lon[ip] += dx2deg(dt * v[0] / 1000., xm[1]);
00449   atm->lat[ip] += dy2deg(dt * v[1] / 1000.);
00450   atm->p[ip] += dt * v[2];
00451 }
00452
00453 /*****************************************************************************/
00454
00455 void module_decay(
00456   ctl_t * ctl,
00457   met_t * met0,
00458   met_t * met1,
00459   atm_t * atm,
00460   int ip,
00461   double dt) {
00462
00463   double ps, pt, tdec;
00464
00465   /* Check lifetime values... */
00466   if ((ctl->tdec_trop <= 0 && ctl->tdec_strat <= 0) || ctl->
      qnt_m < 0)
00467     return;
00468
00469   /* Set constant lifetime... */
00470   if (ctl->tdec_trop == ctl->tdec_strat)
00471     tdec = ctl->tdec_trop;
00472
00473   /* Set altitude-dependent lifetime... */
00474   else {
00475
00476     /* Get surface pressure... */
00477     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00478                     atm->lon[ip], atm->lat[ip], &ps, NULL,
00479                     NULL, NULL, NULL, NULL, NULL);
00480
00481     /* Get tropopause pressure... */
00482     pt = tropopause(atm->time[ip], atm->lat[ip]);
```

```
00483
00484     /* Set lifetime... */
00485     if (atm->p[ip] <= pt)
00486       tdec = ctl->tdec_strat;
00487     else
00488       tdec = LIN(ps, ctl->tdec_trop, pt, ctl->tdec_strat, atm->
      p[ip]);
00489   }
00490
00491   /* Calculate exponential decay... */
00492   atm->q[ctl->qnt_m][ip] *= exp(-dt / tdec);
00493 }
00494
00495 /*****************************************************************************/
00496
00497 void module_diffusion_meso(
00498   ctl_t * ctl,
00499   met_t * met0,
00500   met_t * met1,
00501   atm_t * atm,
00502   int ip,
00503   double dt,
00504   gsl_rng * rng) {
00505
00506   double r, rs, u[16], v[16], w[16], usig, vsig, wsig;
00507
00508   int ix, iy, iz;
00509
00510   /* Calculate mesoscale velocity fluctuations... */
00511   if (ctl->turb_meso > 0) {
00512
00513     /* Get indices... */
00514     ix = locate(met0->lon, met0->nx, atm->lon[ip]);
00515     iy = locate(met0->lat, met0->ny, atm->lat[ip]);
00516     iz = locate(met0->p, met0->np, atm->p[ip]);
00517
00518     /* Collect local wind data... */
00519     u[0] = met0->u[ix][iy][iz];
00520     u[1] = met0->u[ix + 1][iy][iz];
00521     u[2] = met0->u[ix][iy + 1][iz];
00522     u[3] = met0->u[ix + 1][iy + 1][iz];
00523     u[4] = met0->u[ix][iy][iz + 1];
00524     u[5] = met0->u[ix + 1][iy][iz + 1];
00525     u[6] = met0->u[ix][iy + 1][iz + 1];
00526     u[7] = met0->u[ix + 1][iy + 1][iz + 1];
00527
00528     v[0] = met0->v[ix][iy][iz];
00529     v[1] = met0->v[ix + 1][iy][iz];
00530     v[2] = met0->v[ix][iy + 1][iz];
00531     v[3] = met0->v[ix + 1][iy + 1][iz];
00532     v[4] = met0->v[ix][iy][iz + 1];
00533     v[5] = met0->v[ix + 1][iy][iz + 1];
00534     v[6] = met0->v[ix][iy + 1][iz + 1];
00535     v[7] = met0->v[ix + 1][iy + 1][iz + 1];
00536
00537     w[0] = met0->w[ix][iy][iz];
00538     w[1] = met0->w[ix + 1][iy][iz];
00539     w[2] = met0->w[ix][iy + 1][iz];
00540     w[3] = met0->w[ix + 1][iy + 1][iz];
00541     w[4] = met0->w[ix][iy][iz + 1];
00542     w[5] = met0->w[ix + 1][iy][iz + 1];
00543     w[6] = met0->w[ix][iy + 1][iz + 1];
00544     w[7] = met0->w[ix + 1][iy + 1][iz + 1];
00545
00546     /* Get indices... */
00547     ix = locate(met1->lon, met1->nx, atm->lon[ip]);
00548     iy = locate(met1->lat, met1->ny, atm->lat[ip]);
00549     iz = locate(met1->p, met1->np, atm->p[ip]);
00550
00551     /* Collect local wind data... */
00552     u[8] = met1->u[ix][iy][iz];
00553     u[9] = met1->u[ix + 1][iy][iz];
00554     u[10] = met1->u[ix][iy + 1][iz];
00555     u[11] = met1->u[ix + 1][iy + 1][iz];
00556     u[12] = met1->u[ix][iy][iz + 1];
00557     u[13] = met1->u[ix + 1][iy][iz + 1];
00558     u[14] = met1->u[ix][iy + 1][iz + 1];
00559     u[15] = met1->u[ix + 1][iy + 1][iz + 1];
00560
00561     v[8] = met1->v[ix][iy][iz];
00562     v[9] = met1->v[ix + 1][iy][iz];
00563     v[10] = met1->v[ix][iy + 1][iz];
00564     v[11] = met1->v[ix + 1][iy + 1][iz];
00565     v[12] = met1->v[ix][iy][iz + 1];
00566     v[13] = met1->v[ix + 1][iy][iz + 1];
00567     v[14] = met1->v[ix][iy + 1][iz + 1];
00568     v[15] = met1->v[ix + 1][iy + 1][iz + 1];
```

```
00569
00570     w[8] = met1->w[ix][iy][iz];
00571     w[9] = met1->w[ix + 1][iy][iz];
00572     w[10] = met1->w[ix][iy + 1][iz];
00573     w[11] = met1->w[ix + 1][iy + 1][iz];
00574     w[12] = met1->w[ix][iy][iz + 1];
00575     w[13] = met1->w[ix + 1][iy][iz + 1];
00576     w[14] = met1->w[ix][iy + 1][iz + 1];
00577     w[15] = met1->w[ix + 1][iy + 1][iz + 1];
00578
00579     /* Get standard deviations of local wind data... */
00580     usig = gsl_stats_sd(u, 1, 16);
00581     vsig = gsl_stats_sd(v, 1, 16);
00582     wsig = gsl_stats_sd(w, 1, 16);
00583
00584     /* Set temporal correlations for mesoscale fluctuations... */
00585     r = 1 - 2 * fabs(dt) / ctl->dt_met;
00586     rs = sqrt(1 - r * r);
00587
00588     /* Calculate mesoscale wind fluctuations... */
00589     atm->up[ip] =
00590       r * atm->up[ip] + rs * gsl_ran_gaussian_ziggurat(rng,
00591                                                        ctl->turb_meso * usig);
00592     atm->vp[ip] =
00593       r * atm->vp[ip] + rs * gsl_ran_gaussian_ziggurat(rng,
00594                                                        ctl->turb_meso * vsig);
00595     atm->wp[ip] =
00596       r * atm->wp[ip] + rs * gsl_ran_gaussian_ziggurat(rng,
00597                                                        ctl->turb_meso * wsig);
00598
00599     /* Calculate air parcel displacement... */
00600     atm->lon[ip] += dx2deg(atm->up[ip] * dt / 1000., atm->lat[ip]);
00601     atm->lat[ip] += dy2deg(atm->vp[ip] * dt / 1000.);
00602     atm->p[ip] += atm->wp[ip] * dt;
00603   }
00604 }
00605
00606 /*****************************************************************************/
00607
00608 void module_diffusion_turb(
00609   ctl_t * ctl,
00610   atm_t * atm,
00611   int ip,
00612   double dt,
00613   gsl_rng * rng) {
00614
00615   double dx, dz, pt, p0, p1, w;
00616
00617   /* Get tropopause pressure... */
00618   pt = tropopause(atm->time[ip], atm->lat[ip]);
00619
00620   /* Get weighting factor... */
00621   p1 = pt * 0.866877899;
00622   p0 = pt / 0.866877899;
00623   if (atm->p[ip] > p0)
00624     w = 1;
00625   else if (atm->p[ip] < p1)
00626     w = 0;
00627   else
00628     w = LIN(p0, 1.0, p1, 0.0, atm->p[ip]);
00629
00630   /* Set diffusivitiy... */
00631   dx = w * ctl->turb_dx_trop + (1 - w) * ctl->turb_dx_strat;
00632   dz = w * ctl->turb_dz_trop + (1 - w) * ctl->turb_dz_strat;
00633
00634   /* Horizontal turbulent diffusion... */
00635   if (dx > 0) {
00636     atm->lon[ip]
00637       += dx2deg(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dx * fabs(dt)))
00638                 / 1000., atm->lat[ip]);
00639     atm->lat[ip]
00640       += dy2deg(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dx * fabs(dt)))
00641                 / 1000.);
00642   }
00643
00644   /* Vertical turbulent diffusion... */
00645   if (dz > 0)
00646     atm->p[ip]
00647       += dz2dp(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dz * fabs(dt)))
00648                / 1000., atm->p[ip]);
00649 }
00650
00651 /*****************************************************************************/
00652
00653 void module_isosurf(
00654   ctl_t * ctl,
00655   met_t * met0,
```

```
00656   met_t * met1,
00657   atm_t * atm,
00658   int ip) {
00659
00660   static double *iso, *ps, t, *ts;
00661
00662   static int idx, ip2, n, nb = 100000;
00663
00664   FILE *in;
00665
00666   char line[LEN];
00667
00668   /* Check control parameter... */
00669   if (ctl->isosurf < 1 || ctl->isosurf > 4)
00670     return;
00671
00672   /* Initialize... */
00673   if (ip < 0) {
00674
00675     /* Allocate... */
00676     ALLOC(iso, double,
00677           NP);
00678     ALLOC(ps, double,
00679           nb);
00680     ALLOC(ts, double,
00681           nb);
00682
00683     /* Save pressure... */
00684     if (ctl->isosurf == 1)
00685       for (ip2 = 0; ip2 < atm->np; ip2++)
00686         iso[ip2] = atm->p[ip2];
00687
00688     /* Save density... */
00689     else if (ctl->isosurf == 2)
00690       for (ip2 = 0; ip2 < atm->np; ip2++) {
00691         intpol_met_time(met0, met1, atm->time[ip2], atm->p[ip2],
00692                         atm->lon[ip2], atm->lat[ip2], NULL, &t, NULL, NULL,
00693                         NULL, NULL, NULL);
00694         iso[ip2] = atm->p[ip2] / t;
00695       }
00696
00697     /* Save potential temperature... */
00698     else if (ctl->isosurf == 3)
00699       for (ip2 = 0; ip2 < atm->np; ip2++) {
00700         intpol_met_time(met0, met1, atm->time[ip2], atm->p[ip2],
00701                         atm->lon[ip2], atm->lat[ip2], NULL, &t, NULL, NULL,
00702                         NULL, NULL, NULL);
00703         iso[ip2] = t * pow(P0 / atm->p[ip2], 0.286);
00704       }
00705
00706     /* Read balloon pressure data... */
00707     else if (ctl->isosurf == 4) {
00708
00709       /* Write info... */
00710       printf("Read balloon pressure data: %s\n", ctl->balloon);
00711
00712       /* Open file... */
00713       if (!(in = fopen(ctl->balloon, "r")))
00714         ERRMSG("Cannot open file!");
00715
00716       /* Read pressure time series... */
00717       while (fgets(line, LEN, in))
00718         if (sscanf(line, "%lg %lg", &ts[n], &ps[n]) == 2)
00719           if ((++n) > 100000)
00720             ERRMSG("Too many data points!");
00721
00722       /* Check number of points... */
00723       if (n < 1)
00724         ERRMSG("Could not read any data!");
00725
00726       /* Close file... */
00727       fclose(in);
00728     }
00729
00730     /* Leave initialization... */
00731     return;
00732   }
00733
00734   /* Restore pressure... */
00735   if (ctl->isosurf == 1)
00736     atm->p[ip] = iso[ip];
00737
00738   /* Restore density... */
00739   else if (ctl->isosurf == 2) {
00740     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
    lon[ip],
00741                     atm->lat[ip], NULL, &t, NULL, NULL, NULL, NULL, NULL);
```

```
00742     atm->p[ip] = iso[ip] * t;
00743   }
00744
00745   /* Restore potential temperature... */
00746   else if (ctl->isosurf == 3) {
00747     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00748                     atm->lat[ip], NULL, &t, NULL, NULL, NULL, NULL, NULL);
00749     atm->p[ip] = P0 * pow(iso[ip] / t, -1. / 0.286);
00750   }
00751
00752   /* Interpolate pressure... */
00753   else if (ctl->isosurf == 4) {
00754     if (atm->time[ip] <= ts[0])
00755       atm->p[ip] = ps[0];
00756     else if (atm->time[ip] >= ts[n - 1])
00757       atm->p[ip] = ps[n - 1];
00758     else {
00759       idx = locate(ts, n, atm->time[ip]);
00760       atm->p[ip] = LIN(ts[idx], ps[idx],
00761                        ts[idx + 1], ps[idx + 1], atm->time[ip]);
00762     }
00763   }
00764 }
00765
00766 /*****************************************************************************/
00767
00768 void module_meteo(
00769   ctl_t * ctl,
00770   met_t * met0,
00771   met_t * met1,
00772   atm_t * atm,
00773   int ip) {
00774
00775   double b, c, ps, p1, p_hno3, p_h2o, t, t1, term1, term2,
00776     u, u1, v, v1, w, x1, x2, h2o, o3, grad, vort;
00777
00778   /* Interpolate meteorological data... */
00779   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00780                   atm->lat[ip], &ps, &t, &u, &v, &w, &h2o, &o3);
00781
00782   /* Set surface pressure... */
00783   if (ctl->qnt_ps >= 0)
00784     atm->q[ctl->qnt_ps][ip] = ps;
00785
00786   /* Set pressure... */
00787   if (ctl->qnt_p >= 0)
00788     atm->q[ctl->qnt_p][ip] = atm->p[ip];
00789
00790   /* Set temperature... */
00791   if (ctl->qnt_t >= 0)
00792     atm->q[ctl->qnt_t][ip] = t;
00793
00794   /* Set zonal wind... */
00795   if (ctl->qnt_u >= 0)
00796     atm->q[ctl->qnt_u][ip] = u;
00797
00798   /* Set meridional wind... */
00799   if (ctl->qnt_v >= 0)
00800     atm->q[ctl->qnt_v][ip] = v;
00801
00802   /* Set vertical velocity... */
00803   if (ctl->qnt_w >= 0)
00804     atm->q[ctl->qnt_w][ip] = w;
00805
00806   /* Set water vapor vmr... */
00807   if (ctl->qnt_h2o >= 0)
00808     atm->q[ctl->qnt_h2o][ip] = h2o;
00809
00810   /* Set ozone vmr... */
00811   if (ctl->qnt_o3 >= 0)
00812     atm->q[ctl->qnt_o3][ip] = o3;
00813
00814   /* Calculate potential temperature... */
00815   if (ctl->qnt_theta >= 0)
00816     atm->q[ctl->qnt_theta][ip] = t * pow(P0 / atm->p[ip], 0.286);
00817
00818   /* Calculate potential vorticity... */
00819   if (ctl->qnt_pv >= 0) {
00820
00821     /* Absolute vorticity... */
00822     vort = 2 * 7.2921e-5 * sin(atm->lat[ip] * M_PI / 180.);
00823     if (fabs(atm->lat[ip]) < 89.) {
00824       intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00825                       (atm->lon[ip] >=
00826                        0 ? atm->lon[ip] - 1. : atm->lon[ip] + 1.),
```

```
00827                       atm->lat[ip], NULL, NULL, NULL, &v1, NULL, NULL, NULL);
00828       vort += (v1 - v) / 1000.
00829         / ((atm->lon[ip] >= 0 ? -1 : 1) * deg2dx(1., atm->lat[ip]));
00830     }
00831     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00832                     (atm->lat[ip] >=
00833                      0 ? atm->lat[ip] - 1. : atm->lat[ip] + 1.), NULL, NULL,
00834                     &u1, NULL, NULL, NULL, NULL);
00835     vort += (u1 - u) / 1000. / ((atm->lat[ip] >= 0 ? -1 : 1) * deg2dy(1.));
00836
00837     /* Potential temperature gradient... */
00838     p1 = 0.85 * atm->p[ip];
00839     intpol_met_time(met0, met1, atm->time[ip], p1, atm->lon[ip],
00840                     atm->lat[ip], NULL, &t1, NULL, NULL, NULL, NULL);
00841     grad = (t1 * pow(P0 / p1, 0.286) - t * pow(P0 / atm->p[ip], 0.286))
00842       / (100. * (p1 - atm->p[ip]));
00843
00844     /* Calculate PV... */
00845     atm->q[ctl->qnt_pv][ip] = -1e6 * G0 * vort * grad;
00846   }
00847
00848   /* Calculate T_ice (Marti and Mauersberger, 1993)... */
00849   if (ctl->qnt_tice >= 0)
00850     atm->q[ctl->qnt_tice][ip] = -2663.5
00851       / (log10(4e-6 * atm->p[ip] * 100.) - 12.537);
00852
00853   /* Calculate T_NAT (Hanson and Mauersberger, 1988)... */
00854   if (ctl->qnt_tnat >= 0) {
00855     p_hno3 = 9e-9 * atm->p[ip] / 1.333224;
00856     p_h2o = 4e-6 * atm->p[ip] / 1.333224;
00857     term1 = 38.9855 - log10(p_hno3) - 2.7836 * log10(p_h2o);
00858     term2 = 0.009179 - 0.00088 * log10(p_h2o);
00859     b = term1 / term2;
00860     c = -11397.0 / term2;
00861     x1 = (-b + sqrt(b * b - 4. * c)) / 2.;
00862     x2 = (-b - sqrt(b * b - 4. * c)) / 2.;
00863     if (x1 > 0)
00864       atm->q[ctl->qnt_tnat][ip] = x1;
00865     if (x2 > 0)
00866       atm->q[ctl->qnt_tnat][ip] = x2;
00867   }
00868 }
00869
00870 /*****************************************************************************/
00871
00872 void module_position(
00873   met_t * met0,
00874   met_t * met1,
00875   atm_t * atm,
00876   int ip) {
00877
00878   double ps;
00879
00880   /* Calculate modulo... */
00881   atm->lon[ip] = fmod(atm->lon[ip], 360);
00882   atm->lat[ip] = fmod(atm->lat[ip], 360);
00883
00884   /* Check latitude... */
00885   while (atm->lat[ip] < -90 || atm->lat[ip] > 90) {
00886     if (atm->lat[ip] > 90) {
00887       atm->lat[ip] = 180 - atm->lat[ip];
00888       atm->lon[ip] += 180;
00889     }
00890     if (atm->lat[ip] < -90) {
00891       atm->lat[ip] = -180 - atm->lat[ip];
00892       atm->lon[ip] += 180;
00893     }
00894   }
00895
00896   /* Check longitude... */
00897   while (atm->lon[ip] < -180)
00898     atm->lon[ip] += 360;
00899   while (atm->lon[ip] >= 180)
00900     atm->lon[ip] -= 360;
00901
00902   /* Get surface pressure... */
00903   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00904                   atm->lon[ip], atm->lat[ip], &ps, NULL,
00905                   NULL, NULL, NULL, NULL, NULL);
00906
00907   /* Check pressure... */
00908   if (atm->p[ip] > ps)
00909     atm->p[ip] = ps;
00910   else if (atm->p[ip] < met0->p[met0->np - 1])
00911     atm->p[ip] = met0->p[met0->np - 1];
00912 }
```

```
00913
00914 /*****************************************************************************/
00915
00916 void module_sedi(
00917   ctl_t * ctl,
00918   met_t * met0,
00919   met_t * met1,
00920   atm_t * atm,
00921   int ip,
00922   double dt) {
00923
00924   /* Coefficients for Cunningham slip-flow correction (Kasten, 1968): */
00925   const double A = 1.249, B = 0.42, C = 0.87;
00926
00927   /* Specific gas constant for dry air [J/(kg K)]: */
00928   const double R = 287.058;
00929
00930   /* Average mass of an air molecule [kg/molec]: */
00931   const double m = 4.8096e-26;
00932
00933   double G, K, eta, lambda, p, r_p, rho, rho_p, T, v, v_p;
00934
00935   /* Check if parameters are available... */
00936   if (ctl->qnt_r < 0 || ctl->qnt_rho < 0)
00937     return;
00938
00939   /* Convert units... */
00940   p = 100 * atm->p[ip];
00941   r_p = 1e-6 * atm->q[ctl->qnt_r][ip];
00942   rho_p = atm->q[ctl->qnt_rho][ip];
00943
00944   /* Get temperature... */
00945   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
    lon[ip],
00946                   atm->lat[ip], NULL, &T, NULL, NULL, NULL, NULL, NULL);
00947
00948   /* Density of dry air... */
00949   rho = p / (R * T);
00950
00951   /* Dynamic viscosity of air... */
00952   eta = 1.8325e-5 * (416.16 / (T + 120.)) * pow(T / 296.16, 1.5);
00953
00954   /* Thermal velocity of an air molecule... */
00955   v = sqrt(8 * GSL_CONST_MKSA_BOLTZMANN * T / (M_PI * m));
00956
00957   /* Mean free path of an air molecule... */
00958   lambda = 2 * eta / (rho * v);
00959
00960   /* Knudsen number for air... */
00961   K = lambda / r_p;
00962
00963   /* Cunningham slip-flow correction... */
00964   G = 1 + K * (A + B * exp(-C / K));
00965
00966   /* Sedimentation (fall) velocity... */
00967   v_p =
00968     2. * gsl_pow_2(r_p) * (rho_p -
00969                            rho) * GSL_CONST_MKSA_GRAV_ACCEL / (9. * eta) * G;
00970
00971   /* Calculate pressure change... */
00972   atm->p[ip] += dz2dp(v_p * dt / 1000., atm->p[ip]);
00973 }
00974
00975 /*****************************************************************************/
00976
00977 void write_output(
00978   const char *dirname,
00979   ctl_t * ctl,
00980   met_t * met0,
00981   met_t * met1,
00982   atm_t * atm,
00983   double t) {
00984
00985   char filename[LEN];
00986
00987   double r;
00988
00989   int year, mon, day, hour, min, sec;
00990
00991   /* Get time... */
00992   jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
00993
00994   /* Write atmospheric data... */
00995   if (ctl->atm_basename[0] != '-' && fmod(t, ctl->atm_dt_out) == 0) {
00996     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
00997             dirname, ctl->atm_basename, year, mon, day, hour, min);
00998     write_atm(filename, ctl, atm, t);
```

```
00999   }
01000
01001   /* Write gridded data... */
01002   if (ctl->grid_basename[0] != '-' && fmod(t, ctl->grid_dt_out) == 0) {
01003     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
01004             dirname, ctl->grid_basename, year, mon, day, hour, min);
01005     write_grid(filename, ctl, met0, met1, atm, t);
01006   }
01007
01008   /* Write CSI data... */
01009   if (ctl->csi_basename[0] != '-') {
01010     sprintf(filename, "%s/%s.tab", dirname, ctl->csi_basename);
01011     write_csi(filename, ctl, atm, t);
01012   }
01013
01014   /* Write profile data... */
01015   if (ctl->prof_basename[0] != '-') {
01016     sprintf(filename, "%s/%s.tab", dirname, ctl->prof_basename);
01017     write_prof(filename, ctl, met0, met1, atm, t);
01018   }
01019
01020   /* Write PSC data... */
01021   if (ctl->psc_basename[0] != '-') {
01022     sprintf(filename, "%s/%s.tab", dirname, ctl->psc_basename);
01023     write_psc(filename, ctl, atm, t);
01024   }
01025
01026   /* Write station data... */
01027   if (ctl->stat_basename[0] != '-') {
01028     sprintf(filename, "%s/%s.tab", dirname, ctl->stat_basename);
01029     write_station(filename, ctl, atm, t);
01030   }
01031 }
```

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 173 of file wind.c.

```
00177               {
00178
00179   int varid;
00180
00181   NC(nc_inq_varid(ncid, varname, &varid));
00182   NC(nc_put_att_text(ncid, varid, attrname, strlen(text), text));
00183 }
```

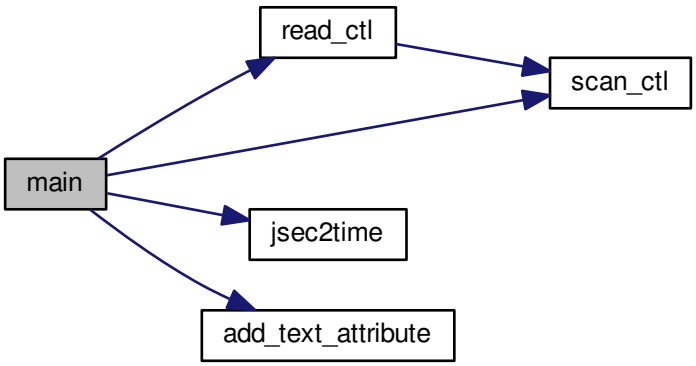
5.33.2.2 int main (int *argc*, char * *argv[]*)

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[EP * EY * EX], dataU[EP * EY * EX], dataV[EP * EY * EX],
00053     dataW[EP * EY * EX];
00054
00055   static int ncid, dims[4], timid, levid, latid, lonid, tid, uid, vid, wid,
00056     idx, ix, iy, iz, nx, ny, nz, year, mon, day, hour, min, sec;
00057
00058   /* Check arguments... */
00059   if (argc < 3)
00060     ERRMSG("Give parameters: <ctl> <metbase>");
00061
00062   /* Read control parameters... */
00063   read_ctl(argv[1], argc, argv, &ctl);
00064   t0 = scan_ctl(argv[1], argc, argv, "WIND_T0", -1, "0", NULL);
00065   nx = (int) scan_ctl(argv[1], argc, argv, "WIND_NX", -1, "360", NULL);
00066   ny = (int) scan_ctl(argv[1], argc, argv, "WIND_NY", -1, "181", NULL);
00067   nz = (int) scan_ctl(argv[1], argc, argv, "WIND_NZ", -1, "61", NULL);
00068   z0 = scan_ctl(argv[1], argc, argv, "WIND_Z0", -1, "0", NULL);
00069   z1 = scan_ctl(argv[1], argc, argv, "WIND_Z1", -1, "60", NULL);
00070   u0 = scan_ctl(argv[1], argc, argv, "WIND_U0", -1, "38.587660177302", NULL);
00071   u1 = scan_ctl(argv[1], argc, argv, "WIND_U1", -1, "38.587660177302", NULL);
00072   alpha = scan_ctl(argv[1], argc, argv, "WIND_ALPHA", -1, "0.0", NULL);
00073
00074   /* Check dimensions... */
00075   if (nx < 1 || nx > EX)
00076     ERRMSG("Set 1 <= NX <= MAX!");
00077   if (ny < 1 || ny > EY)
00078     ERRMSG("Set 1 <= NY <= MAX!");
00079   if (nz < 1 || nz > EP)
00080     ERRMSG("Set 1 <= NZ <= MAX!");
00081
00082   /* Get time... */
00083   jsec2time(t0, &year, &mon, &day, &hour, &min, &sec, &r);
00084   t0 = year * 10000. + mon * 100. + day + hour / 24.;
00085
00086   /* Set filename... */
00087   sprintf(filename, "%s_%d_%02d_%02d_%02d.nc", argv[2], year, mon, day, hour);
00088
00089   /* Create netCDF file... */
00090   NC(nc_create(filename, NC_CLOBBER, &ncid));
00091
00092   /* Create dimensions... */
00093   NC(nc_def_dim(ncid, "time", 1, &dims[0]));
00094   NC(nc_def_dim(ncid, "lev", (size_t) nz, &dims[1]));
00095   NC(nc_def_dim(ncid, "lat", (size_t) ny, &dims[2]));
00096   NC(nc_def_dim(ncid, "lon", (size_t) nx, &dims[3]));
00097
00098   /* Create variables... */
00099   NC(nc_def_var(ncid, "time", NC_DOUBLE, 1, &dims[0], &timid));
00100   NC(nc_def_var(ncid, "lev", NC_DOUBLE, 1, &dims[1], &levid));
00101   NC(nc_def_var(ncid, "lat", NC_DOUBLE, 1, &dims[2], &latid));
00102   NC(nc_def_var(ncid, "lon", NC_DOUBLE, 1, &dims[3], &lonid));
00103   NC(nc_def_var(ncid, "T", NC_FLOAT, 4, &dims[0], &tid));
00104   NC(nc_def_var(ncid, "U", NC_FLOAT, 4, &dims[0], &uid));
00105   NC(nc_def_var(ncid, "V", NC_FLOAT, 4, &dims[0], &vid));
00106   NC(nc_def_var(ncid, "W", NC_FLOAT, 4, &dims[0], &wid));
00107
00108   /* Set attributes... */
00109   add_text_attribute(ncid, "time", "long_name", "time");
00110   add_text_attribute(ncid, "time", "units", "day as %Y%m%d.%f");
00111   add_text_attribute(ncid, "lon", "long_name", "longitude");
00112   add_text_attribute(ncid, "lon", "units", "degrees_east");
00113   add_text_attribute(ncid, "lat", "long_name", "latitude");
00114   add_text_attribute(ncid, "lat", "units", "degrees_north");
00115   add_text_attribute(ncid, "lev", "long_name", "air_pressure");
00116   add_text_attribute(ncid, "lev", "units", "Pa");
00117   add_text_attribute(ncid, "T", "long_name", "Temperature");
00118   add_text_attribute(ncid, "T", "units", "K");
00119   add_text_attribute(ncid, "U", "long_name", "U velocity");
00120   add_text_attribute(ncid, "U", "units", "m s**-1");
00121   add_text_attribute(ncid, "V", "long_name", "V velocity");
00122   add_text_attribute(ncid, "V", "units", "m s**-1");
```

```
00123   add_text_attribute(ncid, "W", "long_name", "Vertical velocity");
00124   add_text_attribute(ncid, "W", "units", "Pa s**-1");
00125
00126   /* End definition... */
00127   NC(nc_enddef(ncid));
00128
00129   /* Set coordinates... */
00130   for (ix = 0; ix < nx; ix++)
00131     dataLon[ix] = 360.0 / nx * (double) ix;
00132   for (iy = 0; iy < ny; iy++)
00133     dataLat[iy] = 180.0 / (ny - 1) * (double) iy - 90;
00134   for (iz = 0; iz < nz; iz++)
00135     dataZ[iz] = 100. * P(LIN(0.0, z0, nz - 1.0, z1, iz));
00136
00137   /* Write coordinates... */
00138   NC(nc_put_var_double(ncid, timid, &t0));
00139   NC(nc_put_var_double(ncid, levid, dataZ));
00140   NC(nc_put_var_double(ncid, lonid, dataLon));
00141   NC(nc_put_var_double(ncid, latid, dataLat));
00142
00143   /* Create wind fields (Williamson et al., 1992)... */
00144   for (ix = 0; ix < nx; ix++)
00145     for (iy = 0; iy < ny; iy++)
00146       for (iz = 0; iz < nz; iz++) {
00147         idx = (iz * ny + iy) * nx + ix;
00148         dataU[idx] = (float) (LIN(0.0, u0, nz - 1.0, u1, iz)
00149                               * (cos(dataLat[iy] * M_PI / 180.0)
00150                                  * cos(alpha * M_PI / 180.0)
00151                                  + sin(dataLat[iy] * M_PI / 180.0)
00152                                  * cos(dataLon[ix] * M_PI / 180.0)
00153                                  * sin(alpha * M_PI / 180.0)));
00154         dataV[idx] = (float) (-LIN(0.0, u0, nz - 1.0, u1, iz)
00155                               * sin(dataLon[ix] * M_PI / 180.0)
00156                               * sin(alpha * M_PI / 180.0));
00157       }
00158
00159   /* Write wind data... */
00160   NC(nc_put_var_float(ncid, tid, dataT));
00161   NC(nc_put_var_float(ncid, uid, dataU));
00162   NC(nc_put_var_float(ncid, vid, dataV));
00163   NC(nc_put_var_float(ncid, wid, dataW));
00164
00165   /* Close file... */
00166   NC(nc_close(ncid));
00167
00168   return EXIT_SUCCESS;
00169 }
```

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   Copyright (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[EP * EY * EX], dataU[EP * EY * EX], dataV[EP * EY * EX],
00053     dataW[EP * EY * EX];
00054
00055   static int ncid, dims[4], timid, levid, latid, lonid, tid, uid, vid, wid,
00056     idx, ix, iy, iz, nx, ny, nz, year, mon, day, hour, min, sec;
00057
00058   /* Check arguments... */
00059   if (argc < 3)
00060     ERRMSG("Give parameters: <ctl> <metbase>");
00061
00062   /* Read control parameters... */
00063   read_ctl(argv[1], argc, argv, &ctl);
00064   t0 = scan_ctl(argv[1], argc, argv, "WIND_T0", -1, "0", NULL);
00065   nx = (int) scan_ctl(argv[1], argc, argv, "WIND_NX", -1, "360", NULL);
00066   ny = (int) scan_ctl(argv[1], argc, argv, "WIND_NY", -1, "181", NULL);
00067   nz = (int) scan_ctl(argv[1], argc, argv, "WIND_NZ", -1, "61", NULL);
00068   z0 = scan_ctl(argv[1], argc, argv, "WIND_Z0", -1, "0", NULL);
00069   z1 = scan_ctl(argv[1], argc, argv, "WIND_Z1", -1, "60", NULL);
00070   u0 = scan_ctl(argv[1], argc, argv, "WIND_U0", -1, "38.587660177302", NULL);
00071   u1 = scan_ctl(argv[1], argc, argv, "WIND_U1", -1, "38.587660177302", NULL);
00072   alpha = scan_ctl(argv[1], argc, argv, "WIND_ALPHA", -1, "0.0", NULL);
00073
00074   /* Check dimensions... */
00075   if (nx < 1 || nx > EX)
00076     ERRMSG("Set 1 <= NX <= MAX!");
00077   if (ny < 1 || ny > EY)
00078     ERRMSG("Set 1 <= NY <= MAX!");
00079   if (nz < 1 || nz > EP)
00080     ERRMSG("Set 1 <= NZ <= MAX!");
00081
00082   /* Get time... */
00083   jsec2time(t0, &year, &mon, &day, &hour, &min, &sec, &r);
00084   t0 = year * 10000. + mon * 100. + day + hour / 24.;
00085
00086   /* Set filename... */
00087   sprintf(filename, "%s_%d_%02d_%02d_%02d.nc", argv[2], year, mon, day, hour);
00088
00089   /* Create netCDF file... */
00090   NC(nc_create(filename, NC_CLOBBER, &ncid));
00091
00092   /* Create dimensions... */
00093   NC(nc_def_dim(ncid, "time", 1, &dims[0]));
```

```
00094   NC(nc_def_dim(ncid, "lev", (size_t) nz, &dims[1]));
00095   NC(nc_def_dim(ncid, "lat", (size_t) ny, &dims[2]));
00096   NC(nc_def_dim(ncid, "lon", (size_t) nx, &dims[3]));
00097
00098   /* Create variables... */
00099   NC(nc_def_var(ncid, "time", NC_DOUBLE, 1, &dims[0], &timid));
00100   NC(nc_def_var(ncid, "lev", NC_DOUBLE, 1, &dims[1], &levid));
00101   NC(nc_def_var(ncid, "lat", NC_DOUBLE, 1, &dims[2], &latid));
00102   NC(nc_def_var(ncid, "lon", NC_DOUBLE, 1, &dims[3], &lonid));
00103   NC(nc_def_var(ncid, "T", NC_FLOAT, 4, &dims[0], &tid));
00104   NC(nc_def_var(ncid, "U", NC_FLOAT, 4, &dims[0], &uid));
00105   NC(nc_def_var(ncid, "V", NC_FLOAT, 4, &dims[0], &vid));
00106   NC(nc_def_var(ncid, "W", NC_FLOAT, 4, &dims[0], &wid));
00107
00108   /* Set attributes... */
00109   add_text_attribute(ncid, "time", "long_name", "time");
00110   add_text_attribute(ncid, "time", "units", "day as %Y%m%d.%f");
00111   add_text_attribute(ncid, "lon", "long_name", "longitude");
00112   add_text_attribute(ncid, "lon", "units", "degrees_east");
00113   add_text_attribute(ncid, "lat", "long_name", "latitude");
00114   add_text_attribute(ncid, "lat", "units", "degrees_north");
00115   add_text_attribute(ncid, "lev", "long_name", "air_pressure");
00116   add_text_attribute(ncid, "lev", "units", "Pa");
00117   add_text_attribute(ncid, "T", "long_name", "Temperature");
00118   add_text_attribute(ncid, "T", "units", "K");
00119   add_text_attribute(ncid, "U", "long_name", "U velocity");
00120   add_text_attribute(ncid, "U", "units", "m s**-1");
00121   add_text_attribute(ncid, "V", "long_name", "V velocity");
00122   add_text_attribute(ncid, "V", "units", "m s**-1");
00123   add_text_attribute(ncid, "W", "long_name", "Vertical velocity");
00124   add_text_attribute(ncid, "W", "units", "Pa s**-1");
00125
00126   /* End definition... */
00127   NC(nc_enddef(ncid));
00128
00129   /* Set coordinates... */
00130   for (ix = 0; ix < nx; ix++)
00131     dataLon[ix] = 360.0 / nx * (double) ix;
00132   for (iy = 0; iy < ny; iy++)
00133     dataLat[iy] = 180.0 / (ny - 1) * (double) iy - 90;
00134   for (iz = 0; iz < nz; iz++)
00135     dataZ[iz] = 100. * P(LIN(0.0, z0, nz - 1.0, z1, iz));
00136
00137   /* Write coordinates... */
00138   NC(nc_put_var_double(ncid, timid, &t0));
00139   NC(nc_put_var_double(ncid, levid, dataZ));
00140   NC(nc_put_var_double(ncid, lonid, dataLon));
00141   NC(nc_put_var_double(ncid, latid, dataLat));
00142
00143   /* Create wind fields (Williamson et al., 1992)... */
00144   for (ix = 0; ix < nx; ix++)
00145     for (iy = 0; iy < ny; iy++)
00146       for (iz = 0; iz < nz; iz++) {
00147         idx = (iz * ny + iy) * nx + ix;
00148         dataU[idx] = (float) (LIN(0.0, u0, nz - 1.0, u1, iz)
00149                               * (cos(dataLat[iy] * M_PI / 180.0)
00150                                  * cos(alpha * M_PI / 180.0)
00151                                  + sin(dataLat[iy] * M_PI / 180.0)
00152                                  * cos(dataLon[ix] * M_PI / 180.0)
00153                                  * sin(alpha * M_PI / 180.0)));
00154         dataV[idx] = (float) (-LIN(0.0, u0, nz - 1.0, u1, iz)
00155                               * sin(dataLon[ix] * M_PI / 180.0)
00156                               * sin(alpha * M_PI / 180.0));
00157       }
00158
00159   /* Write wind data... */
00160   NC(nc_put_var_float(ncid, tid, dataT));
00161   NC(nc_put_var_float(ncid, uid, dataU));
00162   NC(nc_put_var_float(ncid, vid, dataV));
00163   NC(nc_put_var_float(ncid, wid, dataW));
00164
00165   /* Close file... */
00166   NC(nc_close(ncid));
00167
00168   return EXIT_SUCCESS;
00169 }
00170
00171 /*****************************************************************************/
00172
00173 void add_text_attribute(
00174   int ncid,
00175   char *varname,
00176   char *attrname,
00177   char *text) {
00178
00179   int varid;
00180
```

```
00181   NC(nc_inq_varid(ncid, varname, &varid));
00182   NC(nc_put_att_text(ncid, varid, attrname, strlen(text), text));
00183 }
```

Index