MPTRAC

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Contents

1 Main Page

Massive-Parallel Trajectory Calculations (MPTRAC) is a Lagrangian particle dispersion model for the troposphere and stratosphere.This reference manual provides information on the algorithms and data structures used in the code. Further information can be found at: 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 425 of file libtrac.h.

4.1.2 Field Documentation

4.1.2.1 int atm_t::np

Number of air pacels.

Definition at line 428 of file libtrac.h.

4.1.2.2 double atm_t::time[NP]

Time [s].

Definition at line 431 of file libtrac.h.

4.1.2.3 double atm_t::p[NP]

Pressure [hPa].

Definition at line 434 of file libtrac.h.

4.1.2.4 double atm_t::lon[NP]

Longitude [deg].

Definition at line 437 of file libtrac.h.

4.1.2.5 double atm_t::lat[NP]

Latitude [deg].

Definition at line 440 of file libtrac.h.

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

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

Definition at line 443 of file libtrac.h.

4.1.2.7 double atm_t::up[NP]

Zonal wind perturbation [m/s].

Definition at line 446 of file libtrac.h.

4.1.2.8 double atm_t::vp[NP]

Meridional wind perturbation [m/s].

Definition at line 449 of file libtrac.h.

4.1.2.9 double atm_t::wp[NP]

Vertical velocity perturbation [hPa/s].

Definition at line 452 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_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 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 173 of file libtrac.h.

4.2.2 Field Documentation

4.2.2.1 int ctl_t::nq

Number of quantities.

Definition at line 176 of file libtrac.h.

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

Quantity names.

Definition at line 179 of file libtrac.h.

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

Quantity units.

Definition at line 182 of file libtrac.h.

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

Quantity output format.

Definition at line 185 of file libtrac.h.

4.2.2.5 int ctl_t::qnt_m

Quantity array index for mass.

Definition at line 188 of file libtrac.h.

4.2.2.6 int ctl_t::qnt_rho

Quantity array index for particle density.

Definition at line 191 of file libtrac.h.

4.2.2.7 int ctl_t::qnt_r

Quantity array index for particle radius.

Definition at line 194 of file libtrac.h.

4.2.2.8 int ctl_t::qnt_ps

Quantity array index for surface pressure.

Definition at line 197 of file libtrac.h.

4.2.2.9 int ctl_t::qnt_p

Quantity array index for pressure.

Definition at line 200 of file libtrac.h.

4.2.2.10 int ctl_t::qnt_t

Quantity array index for temperature.

Definition at line 203 of file libtrac.h.

4.2.2.11 int ctl_t::qnt_u

Quantity array index for zonal wind.

Definition at line 206 of file libtrac.h.

4.2.2.12 int ctl_t::qnt_v

Quantity array index for meridional wind.

Definition at line 209 of file libtrac.h.

4.2.2.13 int ctl_t::qnt_w

Quantity array index for vertical velocity.

Definition at line 212 of file libtrac.h.

4.2.2.14 int ctl_t::qnt_h2o

Quantity array index for water vapor vmr.

Definition at line 215 of file libtrac.h.

4.2.2.15 int ctl_t::qnt_o3

Quantity array index for ozone vmr.

Definition at line 218 of file libtrac.h.

4.2.2.16 int ctl_t::qnt_theta

Quantity array index for potential temperature.

Definition at line 221 of file libtrac.h.

4.2.2.17 int ctl_t::qnt_pv

Quantity array index for potential vorticity.

Definition at line 224 of file libtrac.h.

4.2.2.18 int ctl_t::qnt_tice

Quantity array index for T_ice.

Definition at line 227 of file libtrac.h.

4.2.2.19 int ctl_t::qnt_tnat

Quantity array index for T_NAT.

Definition at line 230 of file libtrac.h.

4.2.2.20 int ctl_t::qnt_stat

Quantity array index for station flag.

Definition at line 233 of file libtrac.h.

4.2.2.21 int ctl_t::direction

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

Definition at line 236 of file libtrac.h.

4.2.2.22 double ctl_t::t_start

Start time of simulation [s].

Definition at line 239 of file libtrac.h.

4.2.2.23 double ctl_t::t_stop

Stop time of simulation [s].

Definition at line 242 of file libtrac.h.

4.2.2.24 double ctl_t::dt_mod

Time step of simulation [s].

Definition at line 245 of file libtrac.h.

4.2.2.25 double ctl_t::dt_met

Time step of meteorological data [s].

Definition at line 248 of file libtrac.h.

4.2.2.26 int ctl_t::met_np

Number of target pressure levels.

Definition at line 251 of file libtrac.h.

4.2.2.27 double ctl_t::met_p[EP]

Target pressure levels [hPa].

Definition at line 254 of file libtrac.h.

4.2.2.28 int ctl_t::isosurf

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

Definition at line 258 of file libtrac.h.

4.2.2.29 char ctl_t::balloon[LEN]

Balloon position filename.

Definition at line 261 of file libtrac.h.

4.2.2.30 double ctl_t::turb_dx_trop

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

Definition at line 264 of file libtrac.h.

4.2.2.31 double ctl_t::turb_dx_strat

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

Definition at line 267 of file libtrac.h.

4.2.2.32 double ctl_t::turb_dz_trop

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

Definition at line 270 of file libtrac.h.

4.2.2.33 double ctl_t::turb_dz_strat

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

Definition at line 273 of file libtrac.h.

4.2.2.34 double ctl_t::turb_meso

Scaling factor for mesoscale wind fluctuations.

Definition at line 276 of file libtrac.h.

4.2.2.35 double ctl_t::tdec_trop

Life time of particles (troposphere) [s].

Definition at line 279 of file libtrac.h.

4.2.2.36 double ctl_t::tdec_strat

Life time of particles (stratosphere) [s].

Definition at line 282 of file libtrac.h.

4.2.2.37 char ctl_t::atm_basename[LEN]

Basename of atmospheric data files.

Definition at line 285 of file libtrac.h.

4.2.2.38 char ctl_t::atm_gpfile[LEN]

Gnuplot file for atmospheric data.

Definition at line 288 of file libtrac.h.

4.2.2.39 double ctl_t::atm_dt_out

Time step for atmospheric data output [s].

Definition at line 291 of file libtrac.h.

4.2.2.40 int ctl_t::atm_filter

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

Definition at line 294 of file libtrac.h.

4.2.2.41 char ctl_t::csi_basename[LEN]

Basename of CSI data files.

Definition at line 297 of file libtrac.h.

4.2.2.42 double ctl_t::csi_dt_out

Time step for CSI data output [s].

Definition at line 300 of file libtrac.h.

4.2.2.43 char ctl_t::csi_obsfile[LEN]

Observation data file for CSI analysis.

Definition at line 303 of file libtrac.h.

4.2.2.44 double ctl_t::csi_obsmin

Minimum observation index to trigger detection.

Definition at line 306 of file libtrac.h.

4.2.2.45 double ctl_t::csi_modmin

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

Definition at line 309 of file libtrac.h.

4.2.2.46 int ctl_t::csi_nz

Number of altitudes of gridded CSI data.

Definition at line 312 of file libtrac.h.

4.2.2.47 double ctl_t::csi_z0

Lower altitude of gridded CSI data [km].

Definition at line 315 of file libtrac.h.

4.2.2.48 double ctl_t::csi_z1

Upper altitude of gridded CSI data [km].

Definition at line 318 of file libtrac.h.

4.2.2.49 int ctl_t::csi_nx

Number of longitudes of gridded CSI data.

Definition at line 321 of file libtrac.h.

4.2.2.50 double ctl_t::csi_lon0

Lower longitude of gridded CSI data [deg].

Definition at line 324 of file libtrac.h.

4.2.2.51 double ctl_t::csi_lon1

Upper longitude of gridded CSI data [deg].

Definition at line 327 of file libtrac.h.

4.2.2.52 int ctl_t::csi_ny

Number of latitudes of gridded CSI data.

Definition at line 330 of file libtrac.h.

4.2.2.53 double ctl_t::csi_lat0

Lower latitude of gridded CSI data [deg].

Definition at line 333 of file libtrac.h.

4.2.2.54 double ctl_t::csi_lat1

Upper latitude of gridded CSI data [deg].

Definition at line 336 of file libtrac.h.

4.2.2.55 char ctl_t::grid_basename[LEN]

Basename of grid data files.

Definition at line 339 of file libtrac.h.

4.2.2.56 char ctl_t::grid_gpfile[LEN]

Gnuplot file for gridded data.

Definition at line 342 of file libtrac.h.

4.2.2.57 double ctl_t::grid_dt_out

Time step for gridded data output [s].

Definition at line 345 of file libtrac.h.

4.2.2.58 int ctl_t::grid_sparse

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

Definition at line 348 of file libtrac.h.

4.2.2.59 int ctl_t::grid_nz

Number of altitudes of gridded data.

Definition at line 351 of file libtrac.h.

4.2.2.60 double ctl_t::grid_z0

Lower altitude of gridded data [km].

Definition at line 354 of file libtrac.h.

4.2.2.61 double ctl_t::grid_z1

Upper altitude of gridded data [km].

Definition at line 357 of file libtrac.h.

4.2.2.62 int ctl_t::grid_nx

Number of longitudes of gridded data.

Definition at line 360 of file libtrac.h.

4.2.2.63 double ctl_t::grid_lon0

Lower longitude of gridded data [deg].

Definition at line 363 of file libtrac.h.

4.2.2.64 double ctl_t::grid_lon1

Upper longitude of gridded data [deg].

Definition at line 366 of file libtrac.h.

4.2.2.65 int ctl_t::grid_ny

Number of latitudes of gridded data.

Definition at line 369 of file libtrac.h.

4.2.2.66 double ctl_t::grid_lat0

Lower latitude of gridded data [deg].

Definition at line 372 of file libtrac.h.

4.2.2.67 double ctl_t::grid_lat1

Upper latitude of gridded data [deg].

Definition at line 375 of file libtrac.h.

4.2.2.68 char ctl_t::prof_basename[LEN]

Basename for profile output file.

Definition at line 378 of file libtrac.h.

4.2.2.69 char ctl_t::prof_obsfile[LEN]

Observation data file for profile output.

Definition at line 381 of file libtrac.h.

4.2.2.70 int ctl_t::prof_nz

Number of altitudes of gridded profile data.

Definition at line 384 of file libtrac.h.

4.2.2.71 double ctl_t::prof_z0

Lower altitude of gridded profile data [km].

Definition at line 387 of file libtrac.h.

4.2.2.72 double ctl_t::prof_z1

Upper altitude of gridded profile data [km].

Definition at line 390 of file libtrac.h.

4.2.2.73 int ctl_t::prof_nx

Number of longitudes of gridded profile data.

Definition at line 393 of file libtrac.h.

4.2.2.74 double ctl_t::prof_lon0

Lower longitude of gridded profile data [deg].

Definition at line 396 of file libtrac.h.

4.2.2.75 double ctl_t::prof_lon1

Upper longitude of gridded profile data [deg].

Definition at line 399 of file libtrac.h.

4.2.2.76 int ctl_t::prof_ny

Number of latitudes of gridded profile data.

Definition at line 402 of file libtrac.h.

4.2.2.77 double ctl_t::prof_lat0

Lower latitude of gridded profile data [deg].

Definition at line 405 of file libtrac.h.

4.2.2.78 double ctl_t::prof_lat1

Upper latitude of gridded profile data [deg].

Definition at line 408 of file libtrac.h.

4.2.2.79 char ctl_t::stat_basename[LEN]

Basename of station data file.

Definition at line 411 of file libtrac.h.

4.2.2.80 double ctl_t::stat_lon

Longitude of station [deg].

Definition at line 414 of file libtrac.h.

4.2.2.81 double ctl_t::stat_lat

Latitude of station [deg].

Definition at line 417 of file libtrac.h.

4.2.2.82 double ctl_t::stat_r

Search radius around station [km].

Definition at line 420 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 457 of file libtrac.h.

4.3.2 Field Documentation

4.3.2.1 double met_t::time

Time [s].

Definition at line 460 of file libtrac.h.

4.3.2.2 int met_t::nx

Number of longitudes.

Definition at line 463 of file libtrac.h.

4.3.2.3 int met_t::ny

Number of latitudes.

Definition at line 466 of file libtrac.h.

4.3.2.4 int met_t::np

Number of pressure levels.

Definition at line 469 of file libtrac.h.

4.3.2.5 double met_t::lon[EX]

Longitude [deg].

Definition at line 472 of file libtrac.h.

4.3.2.6 double met_t::lat[EY]

Latitude [deg].

Definition at line 475 of file libtrac.h.

4.3.2.7 double met_t::p[EP]

Pressure [hPa].

Definition at line 478 of file libtrac.h.

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

Surface pressure [hPa].

Definition at line 481 of file libtrac.h.

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

Pressure on model levels [hPa].

Definition at line 484 of file libtrac.h.

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

Temperature [K].

Definition at line 487 of file libtrac.h.

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

Zonal wind [m/s].

Definition at line 490 of file libtrac.h.

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

Meridional wind [m/s].

Definition at line 493 of file libtrac.h.

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

Vertical wind [hPa/s].

Definition at line 496 of file libtrac.h.

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

Water vapor volume mixing ratio [1].

Definition at line 499 of file libtrac.h.

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

Ozone volume mixing ratio [1].

Definition at line 502 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

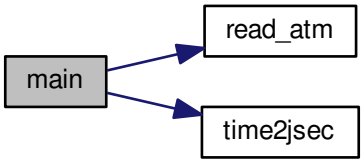
5.1.2.1 int main (int *argc,* char ∗ *argv[ ]*)

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 %g "
00136             "%g %g %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"
```

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

/* Loop over files... */
for (f = 2; f < argc; f++) {

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

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

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

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

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

  /* Get date from filename... */
  for (i = (int) strlen(argv[f]) - 1; argv[f][i] != '/' || i == 0; i--);
  name = strtok(&(argv[f][i]), "_");
  year = strtok(NULL, "_");
  mon = strtok(NULL, "_");
  day = strtok(NULL, "_");
  hour = strtok(NULL, "_");
  name = strtok(NULL, "_");    /* TODO: Why another "name" here? */
  min = strtok(name, ".");
  time2jsec(atoi(year), atoi(mon), atoi(day), atoi(hour), atoi(min), 0, 0,
            &t);

  /* Write data... */
  fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g "
          "%g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\n",
          t, zm, zs, Z(atm->p[atm->np - 1]),
          Z(atm->p[atm->np - atm->np / 10]),
          Z(atm->p[atm->np - atm->np / 4]),
          Z(atm->p[atm->np / 2]), Z(atm->p[atm->np / 4]),
          Z(atm->p[atm->np / 10]), Z(atm->p[0]),
          lonm, lons, atm->lon[0], atm->lon[atm->np / 10],
          atm->lon[atm->np / 4], atm->lon[atm->np / 2],
          atm->lon[atm->np - atm->np / 4],
          atm->lon[atm->np - atm->np / 10],
          atm->lon[atm->np - 1],
          latm, lats, atm->lat[0], atm->lat[atm->np / 10],
          atm->lat[atm->np / 4], atm->lat[atm->np / 2],
          atm->lat[atm->np - atm->np / 4],
          atm->lat[atm->np - atm->np / 10], atm->lat[atm->np - 1]);
```

```
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.

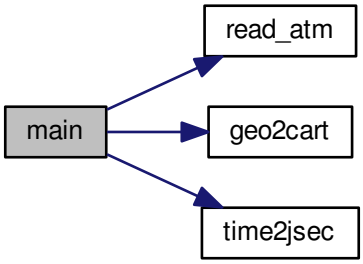
```
00030                {
00031
00032   ctl_t ctl;
00033
00034   atm_t *atm1, *atm2;
00035
00036   FILE *out;
00037
00038   char *name, *year, *mon, *day, *hour, *min;
00039
00040   double aux, x0[3], x1[3], x2[3], *lon1, *lat1, *p1, *lh1, *lv1,
00041     *lon2, *lat2, *p2, *lh2, *lv2, ahtd, avtd, ahtd2, 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 %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

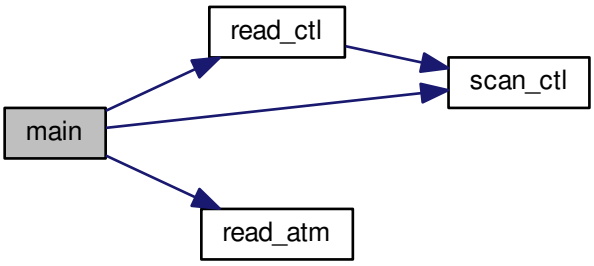
5.5.2.1 int main (int *argc,* char ∗ *argv[ ]*)

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   Copright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026 #include <gsl/gsl_sort.h>
00027
00028 int main(
00029   int argc,
00030   char *argv[]) {
00031
00032   ctl_t ctl;
00033
00034   atm_t *atm;
00035
00036   FILE *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

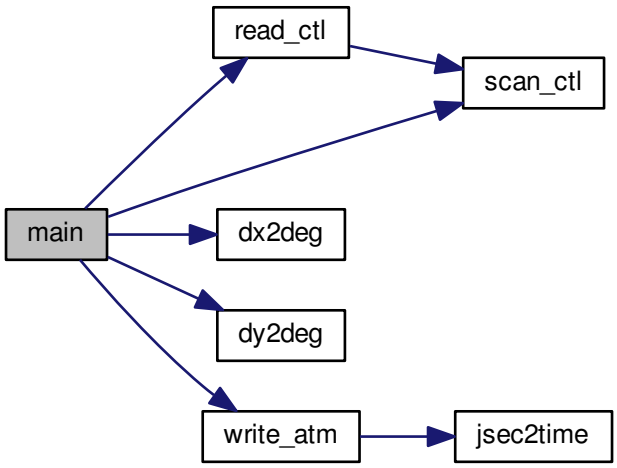
5.7.2.1 int main (int *argc,* char ∗ *argv[ ]*)

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   Copright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   atm_t *atm;
00032
00033   ctl_t ctl;
00034
00035   gsl_rng *rng;
00036
00037   double dt, dz, dlon, dlat, lat0, lat1, lon0, lon1, t0, t1, z0, z1,
00038     t, z, lon, lat, st, sz, slon, slat, sx, ut, uz, ulon, ulat, m;
00039
00040   int 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.

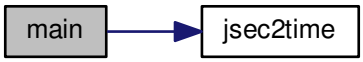
5.9.2 Function Documentation

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_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 }
```

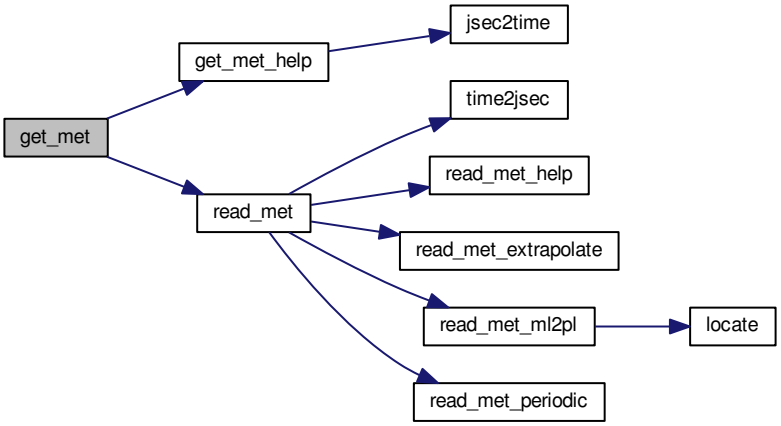
5.11.2.9 void get_met (ctl_t * *ctl*, char * *metbase*, double *t*, met_t * *met0*, met_t * *met1*)

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:



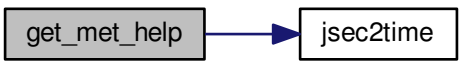
5.11.2.10 void get_met_help (double *t*, int *direct*, char * *metbase*, double *dt_met*, char * *filename*)

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*)

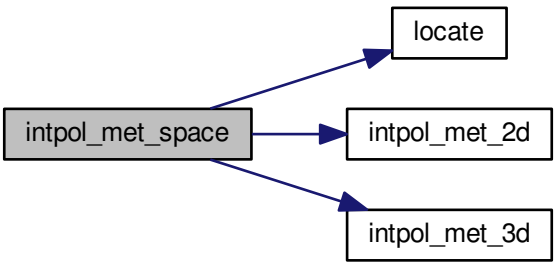
Spatial interpolation of meteorological data.

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*)

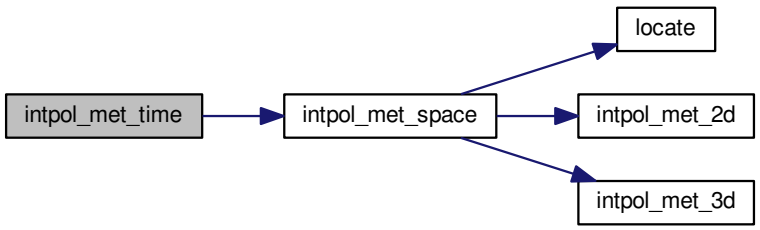
Temporal interpolation of meteorological data.

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_m = -1;
00473   ctl->qnt_r = -1;
00474   ctl->qnt_rho = -1;
00475   ctl->qnt_ps = -1;
00476   ctl->qnt_p = -1;
00477   ctl->qnt_t = -1;
00478   ctl->qnt_u = -1;
00479   ctl->qnt_v = -1;
00480   ctl->qnt_w = -1;
00481   ctl->qnt_h2o = -1;
00482   ctl->qnt_o3 = -1;
00483   ctl->qnt_theta = -1;
00484   ctl->qnt_pv = -1;
00485   ctl->qnt_tice = -1;
00486   ctl->qnt_tnat = -1;
00487   ctl->qnt_stat = -1;
00488
00489   /* Read quantities... */
00490   ctl->nq = (int) scan_ctl(filename, argc, argv, "NQ", -1, "0", NULL);
00491   for (iq = 0; iq < ctl->nq; iq++) {
00492
00493     /* Read quantity name and format... */
00494     scan_ctl(filename, argc, argv, "QNT_NAME", iq, "", ctl->qnt_name[iq]);
00495     scan_ctl(filename, argc, argv, "QNT_FORMAT", iq, "%g",
00496              ctl->qnt_format[iq]);
00497
00498     /* Try to identify quantity... */
00499     if (strcmp(ctl->qnt_name[iq], "m") == 0) {
00500       ctl->qnt_m = iq;
00501       sprintf(ctl->qnt_unit[iq], "kg");
00502     } else if (strcmp(ctl->qnt_name[iq], "r") == 0) {
00503       ctl->qnt_r = iq;
00504       sprintf(ctl->qnt_unit[iq], "m");
00505     } else if (strcmp(ctl->qnt_name[iq], "rho") == 0) {
00506       ctl->qnt_rho = iq;
00507       sprintf(ctl->qnt_unit[iq], "kg/m^3");
00508     } else if (strcmp(ctl->qnt_name[iq], "ps") == 0) {
00509       ctl->qnt_ps = iq;
00510       sprintf(ctl->qnt_unit[iq], "hPa");
00511     } else if (strcmp(ctl->qnt_name[iq], "p") == 0) {
00512       ctl->qnt_p = iq;
00513       sprintf(ctl->qnt_unit[iq], "hPa");
00514     } else if (strcmp(ctl->qnt_name[iq], "t") == 0) {
00515       ctl->qnt_t = iq;
00516       sprintf(ctl->qnt_unit[iq], "K");
00517     } else if (strcmp(ctl->qnt_name[iq], "u") == 0) {
00518       ctl->qnt_u = iq;
00519       sprintf(ctl->qnt_unit[iq], "m/s");
00520     } else if (strcmp(ctl->qnt_name[iq], "v") == 0) {
00521       ctl->qnt_v = iq;
00522       sprintf(ctl->qnt_unit[iq], "m/s");
00523     } else if (strcmp(ctl->qnt_name[iq], "w") == 0) {
00524       ctl->qnt_w = iq;
00525       sprintf(ctl->qnt_unit[iq], "hPa/s");
00526     } else if (strcmp(ctl->qnt_name[iq], "h2o") == 0) {
00527       ctl->qnt_h2o = iq;
00528       sprintf(ctl->qnt_unit[iq], "1");
00529     } else if (strcmp(ctl->qnt_name[iq], "o3") == 0) {
00530       ctl->qnt_o3 = iq;
00531       sprintf(ctl->qnt_unit[iq], "1");
00532     } else if (strcmp(ctl->qnt_name[iq], "theta") == 0) {
00533       ctl->qnt_theta = iq;
00534       sprintf(ctl->qnt_unit[iq], "K");
00535     } else if (strcmp(ctl->qnt_name[iq], "pv") == 0) {
00536       ctl->qnt_pv = iq;
00537       sprintf(ctl->qnt_unit[iq], "PVU");
00538     } else if (strcmp(ctl->qnt_name[iq], "tice") == 0) {
```

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

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

Here is the call graph for this function:

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

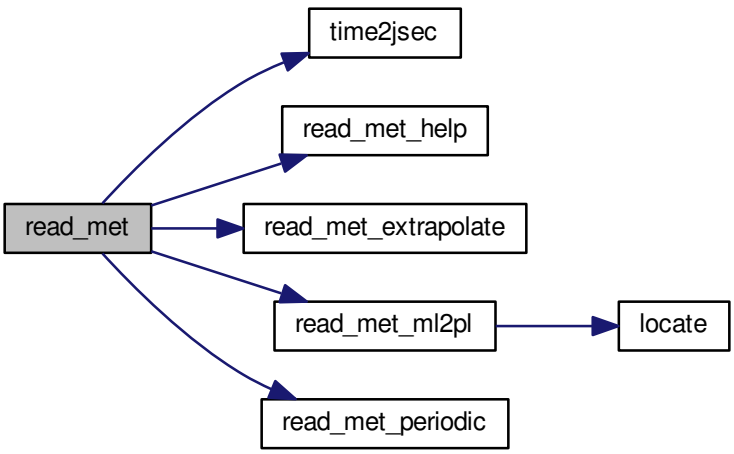
Read meteorological data file.

Definition at line 678 of file libtrac.c.

```
00681               {
00682
00683   char tstr[10];
00684
00685   static float help[EX * EY];
00686
00687   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
00688
00689   size_t np, nx, ny;
00690
00691   /* Write info... */
00692   printf("Read meteorological data: %s\n", filename);
00693
00694   /* Get time from filename... */
00695   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
00696   year = atoi(tstr);
00697   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
00698   mon = atoi(tstr);
00699   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
00700   day = atoi(tstr);
00701   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
00702   hour = atoi(tstr);
00703   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
00704
00705   /* Open netCDF file... */
00706   NC(nc_open(filename, NC_NOWRITE, &ncid));
00707
00708   /* Get dimensions... */
00709   NC(nc_inq_dimid(ncid, "lon", &dimid));
00710   NC(nc_inq_dimlen(ncid, dimid, &nx));
00711   if (nx > EX)
00712     ERRMSG("Too many longitudes!");
00713
00714   NC(nc_inq_dimid(ncid, "lat", &dimid));
00715   NC(nc_inq_dimlen(ncid, dimid, &ny));
00716   if (ny > EY)
00717     ERRMSG("Too many latitudes!");
00718
00719   NC(nc_inq_dimid(ncid, "lev", &dimid));
00720   NC(nc_inq_dimlen(ncid, dimid, &np));
00721   if (np > EP)
00722     ERRMSG("Too many levels!");
00723
00724   /* Store dimensions... */
00725   met->np = (int) np;
00726   met->nx = (int) nx;
00727   met->ny = (int) ny;
00728
00729   /* Get horizontal grid... */
00730   NC(nc_inq_varid(ncid, "lon", &varid));
00731   NC(nc_get_var_double(ncid, varid, met->lon));
00732   NC(nc_inq_varid(ncid, "lat", &varid));
00733   NC(nc_get_var_double(ncid, varid, met->lat));
00734
00735   /* Read meteorological data... */
00736   read_met_help(ncid, "t", "T", met, met->t, 1.0);
00737   read_met_help(ncid, "u", "U", met, met->u, 1.0);
00738   read_met_help(ncid, "v", "V", met, met->v, 1.0);
00739   read_met_help(ncid, "w", "W", met, met->w, 0.01f);
00740   read_met_help(ncid, "q", "Q", met, met->h2o, 1.608f);
00741   read_met_help(ncid, "o3", "O3", met, met->o3, 0.602f);
00742
00743   /* Meteo data on pressure levels... */
00744   if (ctl->met_np <= 0) {
00745
00746     /* Read pressure levels from file... */
00747     NC(nc_inq_varid(ncid, "lev", &varid));
00748     NC(nc_get_var_double(ncid, varid, met->p));
00749     for (ip = 0; ip < met->np; ip++)
00750       met->p[ip] /= 100.;
00751
00752     /* Extrapolate data for lower boundary... */
00753     read_met_extrapolate(met);
00754   }
00755
00756   /* Meteo data on model levels... */
00757   else {
00758
00759     /* Read pressure data from file... */
00760     read_met_help(ncid, "pl", "PL", met, met->pl, 0.01f);
00761
00762     /* Interpolate from model levels to pressure levels... */
00763     read_met_ml2pl(ctl, met, met->t);
00764     read_met_ml2pl(ctl, met, met->u);
00765     read_met_ml2pl(ctl, met, met->v);
00766     read_met_ml2pl(ctl, met, met->w);
00767     read_met_ml2pl(ctl, met, met->h2o);
```

```
00768     read_met_ml2pl(ctl, met, met->o3);
00769
00770     /* Set pressure levels... */
00771     met->np = ctl->met_np;
00772     for (ip = 0; ip < met->np; ip++)
00773       met->p[ip] = ctl->met_p[ip];
00774   }
00775
00776   /* Check ordering of pressure levels... */
00777   for (ip = 1; ip < met->np; ip++)
00778     if (met->p[ip - 1] < met->p[ip])
00779       ERRMSG("Pressure levels must be descending!");
00780
00781   /* Read surface pressure... */
00782   if (nc_inq_varid(ncid, "PS", &varid) == NC_NOERR) {
00783     NC(nc_get_var_float(ncid, varid, help));
00784     for (iy = 0; iy < met->ny; iy++)
00785       for (ix = 0; ix < met->nx; ix++)
00786         met->ps[ix][iy] = help[iy * met->nx + ix] / 100.;
00787   } else if (nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
00788     NC(nc_get_var_float(ncid, varid, help));
00789     for (iy = 0; iy < met->ny; iy++)
00790       for (ix = 0; ix < met->nx; ix++)
00791         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
00792   } else
00793     for (ix = 0; ix < met->nx; ix++)
00794       for (iy = 0; iy < met->ny; iy++)
00795         met->ps[ix][iy] = met->p[0];
00796
00797   /* Create periodic boundary conditions... */
00798   read_met_periodic(met);
00799
00800   /* Close file... */
00801   NC(nc_close(ncid));
00802 }
```

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 806 of file libtrac.c.

```
00807               {
00808
00809   int ip, ip0, ix, iy;
00810
00811   /* Loop over columns... */
00812   for (ix = 0; ix < met->nx; ix++)
00813     for (iy = 0; iy < met->ny; iy++) {
00814
00815       /* Find lowest valid data point... */
00816       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
00817         if (!gsl_finite(met->t[ix][iy][ip0])
00818             || !gsl_finite(met->u[ix][iy][ip0])
00819             || !gsl_finite(met->v[ix][iy][ip0])
00820             || !gsl_finite(met->w[ix][iy][ip0]))
00821           break;
00822
00823       /* Extrapolate... */
00824       for (ip = ip0; ip >= 0; ip--) {
00825         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
00826         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
00827         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
00828         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
00829         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
00830         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
00831       }
00832     }
00833 }
```

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 837 of file libtrac.c.

```
00843             {
00844
00845   static float help[EX * EY * EP];
00846
00847   int ip, ix, iy, n = 0, varid;
00848
00849   /* Check if variable exists... */
00850   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
00851     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
00852       return;
00853
00854   /* Read data... */
00855   NC(nc_get_var_float(ncid, varid, help));
00856
00857   /* Copy and check data... */
00858   for (ip = 0; ip < met->np; ip++)
00859     for (iy = 0; iy < met->ny; iy++)
00860       for (ix = 0; ix < met->nx; ix++) {
00861         dest[ix][iy][ip] = scl * help[n++];
00862         if (fabs(dest[ix][iy][ip] / scl) > 1e14)
00863           dest[ix][iy][ip] = GSL_NAN;
00864       }
00865 }
```

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

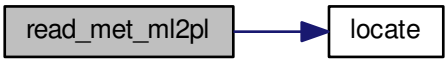
Convert meteorological data from model levels to pressure levels.

Definition at line 869 of file libtrac.c.

```
00872                         {
00873
00874   double aux[EP], p[EP], pt;
00875
00876   int ip, ip2, ix, iy;
00877
00878   /* Loop over columns... */
00879   for (ix = 0; ix < met->nx; ix++)
00880     for (iy = 0; iy < met->ny; iy++) {
00881
```

```
00882       /* Copy pressure profile... */
00883       for (ip = 0; ip < met->np; ip++)
00884         p[ip] = met->pl[ix][iy][ip];
00885
00886       /* Interpolate... */
00887       for (ip = 0; ip < ctl->met_np; ip++) {
00888         pt = ctl->met_p[ip];
00889         if ((pt > p[0] && p[0] > p[1]) || (pt < p[0] && p[0] < p[1]))
00890           pt = p[0];
00891         else if ((pt > p[met->np - 1] && p[1] > p[0])
00892                  || (pt < p[met->np - 1] && p[1] < p[0]))
00893           pt = p[met->np - 1];
00894         ip2 = locate(p, met->np, pt);
00895         aux[ip] = LIN(p[ip2], var[ix][iy][ip2],
00896                       p[ip2 + 1], var[ix][iy][ip2 + 1], pt);
00897       }
00898
00899       /* Copy data... */
00900       for (ip = 0; ip < ctl->met_np; ip++)
00901         var[ix][iy][ip] = (float) aux[ip];
00902     }
00903 }
```

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 907 of file libtrac.c.

```
00908               {
00909
00910   int ip, iy;
00911
00912   /* Check longitudes... */
00913   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
00914              + met->lon[1] - met->lon[0] - 360) < 0.01))
00915     return;
00916
00917   /* Increase longitude counter... */
00918   if ((++met->nx) > EX)
00919     ERRMSG("Cannot create periodic boundary conditions!");
00920
00921   /* Set longitude... */
00922   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
00923
00924   /* Loop over latitudes and pressure levels... */
00925   for (iy = 0; iy < met->ny; iy++)
00926     for (ip = 0; ip < met->np; ip++) {
00927       met->ps[met->nx - 1][iy] = met->ps[0][iy];
00928       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
00929       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
00930       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
00931       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
00932       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
00933       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
00934     }
00935 }
```

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 939 of file libtrac.c.

```
00946                {
00947
00948   FILE *in = NULL;
00949
00950   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
00951     msg[LEN], rvarname[LEN], rval[LEN];
00952
00953   int contain = 0, i;
00954
00955   /* Open file... */
00956   if (filename[strlen(filename) - 1] != '-')
00957     if (!(in = fopen(filename, "r")))
00958       ERRMSG("Cannot open file!");
00959
00960   /* Set full variable name... */
00961   if (arridx >= 0) {
00962     sprintf(fullname1, "%s[%d]", varname, arridx);
00963     sprintf(fullname2, "%s[*]", varname);
00964   } else {
00965     sprintf(fullname1, "%s", varname);
00966     sprintf(fullname2, "%s", varname);
00967   }
00968
00969   /* Read data... */
00970   if (in != NULL)
00971     while (fgets(line, LEN, in))
00972       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
00973         if (strcasecmp(rvarname, fullname1) == 0 ||
00974             strcasecmp(rvarname, fullname2) == 0) {
00975           contain = 1;
00976           break;
00977         }
00978   for (i = 1; i < argc - 1; i++)
00979     if (strcasecmp(argv[i], fullname1) == 0 ||
00980         strcasecmp(argv[i], fullname2) == 0) {
00981       sprintf(rval, "%s", argv[i + 1]);
00982       contain = 1;
00983       break;
00984     }
00985
00986   /* Close file... */
00987   if (in != NULL)
00988     fclose(in);
00989
00990   /* Check for missing variables... */
00991   if (!contain) {
00992     if (strlen(defvalue) > 0)
00993       sprintf(rval, "%s", defvalue);
00994     else {
00995       sprintf(msg, "Missing variable %s!\n", fullname1);
00996       ERRMSG(msg);
00997     }
00998   }
00999
01000   /* Write info... */
01001   printf("%s = %s\n", fullname1, rval);
01002
01003   /* Return values... */
01004   if (value != NULL)
01005     sprintf(value, "%s", rval);
01006   return atof(rval);
01007 }
```

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 1011 of file libtrac.c.

```
01019                {
01020
01021   struct tm t0, t1;
01022
01023   t0.tm_year = 100;
01024   t0.tm_mon = 0;
01025   t0.tm_mday = 1;
01026   t0.tm_hour = 0;
01027   t0.tm_min = 0;
01028   t0.tm_sec = 0;
01029
01030   t1.tm_year = year - 1900;
01031   t1.tm_mon = mon - 1;
01032   t1.tm_mday = day;
01033   t1.tm_hour = hour;
01034   t1.tm_min = min;
01035   t1.tm_sec = sec;
01036
01037   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
01038 }
```

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

Measure wall-clock time.

Definition at line 1042 of file libtrac.c.

```
01045            {
01046
01047   static double starttime[NTIMER], runtime[NTIMER];
01048
01049   /* Check id... */
01050   if (id < 0 || id >= NTIMER)
01051     ERRMSG("Too many timers!");
01052
01053   /* Start timer... */
01054   if (mode == 1) {
01055     if (starttime[id] <= 0)
01056       starttime[id] = omp_get_wtime();
01057     else
01058       ERRMSG("Timer already started!");
01059   }
01060
01061   /* Stop timer... */
01062   else if (mode == 2) {
01063     if (starttime[id] > 0) {
01064       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
01065       starttime[id] = -1;
01066     } else
01067       ERRMSG("Timer not started!");
01068   }
01069
01070   /* Print timer... */
01071   else if (mode == 3)
01072     printf("%s = %g s\n", name, runtime[id]);
01073 }
```

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

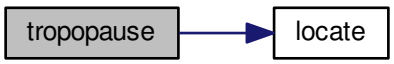
Definition at line 1077 of file libtrac.c.

```
01079              {
01080
01081   static double doys[12]
01082   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
01083
01084   static double lats[73]
01085     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
01086     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
01087     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
01088     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
01089     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
01090     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
01091     75, 77.5, 80, 82.5, 85, 87.5, 90
01092   };
```

```
01093
01094   static double tps[12][73]
01095     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
01096          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
01097          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
01098          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
01099          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
01100          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
01101          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
01102          275.3, 275.6, 275.4, 274.1, 273.5},
01103    {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
01104     300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
01105     150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
01106     98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
01107     98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
01108     220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
01109     284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
01110     287.5, 286.2, 285.8},
01111    {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
01112     297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
01113     161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
01114     100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
01115     99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
01116     186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
01117     279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
01118     304.3, 304.9, 306, 306.6, 306.2, 306},
01119    {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
01120     290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
01121     195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
01122     102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
01123     99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
01124     148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
01125     263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
01126     315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
01127    {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
01128     260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
01129     205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
01130     101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
01131     102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
01132     165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
01133     273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
01134     325.3, 325.8, 325.8},
01135    {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
01136     222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
01137     228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
01138     105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
01139     106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
01140     127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
01141     251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
01142     308.5, 312.2, 313.1, 313.3},
01143    {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
01144     187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
01145     235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
01146     110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
01147     111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
01148     117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
01149     224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
01150     275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
01151    {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
01152     185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
01153     233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
01154     110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
01155     112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
01156     120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
01157     230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
01158     278.2, 282.6, 287.4, 290.9, 292.5, 293},
01159    {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
01160     183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
01161     243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
01162     114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
01163     110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
01164     114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
01165     203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
01166     276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
01167    {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
01168     215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
01169     237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
01170     111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
01171     106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
01172     112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
01173     206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
01174     279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
01175     305.1},
01176    {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
01177     253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
01178     223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
01179     108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
```

```
01180     102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
01181     109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
01182     241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
01183     286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
01184    {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
01185     284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
01186     175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
01187     100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
01188     100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
01189     186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
01190     280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
01191     281.7, 281.1, 281.2}
01192    };
01193
01194    double doy, p0, p1, pt;
01195
01196    int imon, ilat;
01197
01198    /* Get day of year... */
01199    doy = fmod(t / 86400., 365.25);
01200    while (doy < 0)
01201      doy += 365.25;
01202
01203    /* Get indices... */
01204    imon = locate(doys, 12, doy);
01205    ilat = locate(lats, 73, lat);
01206
01207    /* Get tropopause pressure... */
01208    p0 = LIN(lats[ilat], tps[imon][ilat],
01209             lats[ilat + 1], tps[imon][ilat + 1], lat);
01210    p1 = LIN(lats[ilat], tps[imon + 1][ilat],
01211             lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
01212    pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
01213
01214    /* Return tropopause pressure... */
01215    return pt;
01216  }
```

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 1220 of file libtrac.c.

```
01224             {
01225
01226    FILE *in, *out;
01227
01228    char line[LEN];
01229
01230    double r, t0, t1;
01231
01232    int ip, iq, year, mon, day, hour, min, sec;
01233
01234    /* Set time interval for output... */
01235    t0 = t - 0.5 * ctl->dt_mod;
01236    t1 = t + 0.5 * ctl->dt_mod;
01237
01238    /* Check if gnuplot output is requested... */
01239    if (ctl->atm_gpfile[0] != '-') {
```

```
01240
01241     /* Write info... */
01242     printf("Plot atmospheric data: %s.png\n", filename);
01243
01244     /* Create gnuplot pipe... */
01245     if (!(out = popen("gnuplot", "w")))
01246       ERRMSG("Cannot create pipe to gnuplot!");
01247
01248     /* Set plot filename... */
01249     fprintf(out, "set out \"%s.png\"\n", filename);
01250
01251     /* Set time string... */
01252     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01253     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01254             year, mon, day, hour, min);
01255
01256     /* Dump gnuplot file to pipe... */
01257     if (!(in = fopen(ctl->atm_gpfile, "r")))
01258       ERRMSG("Cannot open file!");
01259     while (fgets(line, LEN, in))
01260       fprintf(out, "%s", line);
01261     fclose(in);
01262   }
01263
01264   else {
01265
01266     /* Write info... */
01267     printf("Write atmospheric data: %s\n", filename);
01268
01269     /* Create file... */
01270     if (!(out = fopen(filename, "w")))
01271       ERRMSG("Cannot create file!");
01272   }
01273
01274   /* Write header... */
01275   fprintf(out,
01276           "# $1 = time [s]\n"
01277           "# $2 = altitude [km]\n"
01278           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01279   for (iq = 0; iq < ctl->nq; iq++)
01280     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
01281             ctl->qnt_unit[iq]);
01282   fprintf(out, "\n");
01283
01284   /* Write data... */
01285   for (ip = 0; ip < atm->np; ip++) {
01286
01287     /* Check time... */
01288     if (ctl->atm_filter && (atm->time[ip] < t0 || atm->time[ip] > t1))
01289       continue;
01290
01291     /* Write output... */
01292     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
01293             atm->lon[ip], atm->lat[ip]);
01294     for (iq = 0; iq < ctl->nq; iq++) {
01295       fprintf(out, " ");
01296       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01297     }
01298     fprintf(out, "\n");
01299   }
01300
01301   /* Close file... */
01302   fclose(out);
01303 }
```

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 1307 of file libtrac.c.

```
01311           {
01312
01313   static FILE *in, *out;
01314
01315   static char line[LEN];
01316
01317   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
01318     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
01319
01320   static int init, obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
01321
01322   /* Init... */
01323   if (!init) {
01324     init = 1;
01325
01326     /* Check quantity index for mass... */
01327     if (ctl->qnt_m < 0)
01328       ERRMSG("Need quantity mass to analyze CSI!");
01329
01330     /* Open observation data file... */
01331     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
01332     if (!(in = fopen(ctl->csi_obsfile, "r")))
01333       ERRMSG("Cannot open file!");
01334
01335     /* Create new file... */
01336     printf("Write CSI data: %s\n", filename);
01337     if (!(out = fopen(filename, "w")))
01338       ERRMSG("Cannot create file!");
01339
01340     /* Write header... */
01341     fprintf(out,
01342             "# $1 = time [s]\n"
01343             "# $2 = number of hits (cx)\n"
01344             "# $3 = number of misses (cy)\n"
01345             "# $4 = number of false alarms (cz)\n"
01346             "# $5 = number of observations (cx + cy)\n"
01347             "# $6 = number of forecasts (cx + cz)\n"
01348             "# $7 = bias (forecasts/observations) [%%]\n"
01349             "# $8 = probability of detection (POD) [%%]\n"
01350             "# $9 = false alarm rate (FAR) [%%]\n"
01351             "# $10 = critical success index (CSI) [%%]\n\n");
01352   }
01353
01354   /* Set time interval... */
01355   t0 = t - 0.5 * ctl->dt_mod;
01356   t1 = t + 0.5 * ctl->dt_mod;
01357
01358   /* Initialize grid cells... */
01359   for (ix = 0; ix < ctl->csi_nx; ix++)
01360     for (iy = 0; iy < ctl->csi_ny; iy++)
01361       for (iz = 0; iz < ctl->csi_nz; iz++)
01362         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
01363
01364   /* Read data... */
01365   while (fgets(line, LEN, in)) {
01366
01367     /* Read data... */
01368     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
01369         5)
01370       continue;
01371
01372     /* Check time... */
01373     if (rt < t0)
01374       continue;
01375     if (rt > t1)
01376       break;
01377
01378     /* Calculate indices... */
01379     ix = (int) ((rlon - ctl->csi_lon0)
01380                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01381     iy = (int) ((rlat - ctl->csi_lat0)
01382                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01383     iz = (int) ((rz - ctl->csi_z0)
01384                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01385
01386     /* Check indices... */
01387     if (ix < 0 || ix >= ctl->csi_nx ||
```

```
01388         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01389       continue;
01390
01391     /* Get mean observation index... */
01392     obsmean[ix][iy][iz] += robs;
01393     obscount[ix][iy][iz]++;
01394   }
01395
01396   /* Analyze model data... */
01397   for (ip = 0; ip < atm->np; ip++) {
01398
01399     /* Check time... */
01400     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01401       continue;
01402
01403     /* Get indices... */
01404     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
01405                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01406     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
01407                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01408     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
01409                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01410
01411     /* Check indices... */
01412     if (ix < 0 || ix >= ctl->csi_nx ||
01413         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01414       continue;
01415
01416     /* Get total mass in grid cell... */
01417     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01418   }
01419
01420   /* Analyze all grid cells... */
01421   for (ix = 0; ix < ctl->csi_nx; ix++)
01422     for (iy = 0; iy < ctl->csi_ny; iy++)
01423       for (iz = 0; iz < ctl->csi_nz; iz++) {
01424
01425         /* Calculate mean observation index... */
01426         if (obscount[ix][iy][iz] > 0)
01427           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
01428
01429         /* Calculate column density... */
01430         if (modmean[ix][iy][iz] > 0) {
01431           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
01432           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
01433           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
01434           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
01435             * cos(lat * M_PI / 180.);
01436           modmean[ix][iy][iz] /= (1e6 * area);
01437         }
01438
01439         /* Calculate CSI... */
01440         if (obscount[ix][iy][iz] > 0) {
01441           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01442               modmean[ix][iy][iz] >= ctl->csi_modmin)
01443             cx++;
01444           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01445                    modmean[ix][iy][iz] < ctl->csi_modmin)
01446             cy++;
01447           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
01448                    modmean[ix][iy][iz] >= ctl->csi_modmin)
01449             cz++;
01450         }
01451       }
01452
01453   /* Write output... */
01454   if (fmod(t, ctl->csi_dt_out) == 0) {
01455
01456     /* Write... */
01457     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
01458             t, cx, cy, cz, cx + cy, cx + cz,
01459             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
01460             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
01461             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
01462             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
01463
01464     /* Set counters to zero... */
01465     cx = cy = cz = 0;
01466   }
01467
01468   /* Close file... */
01469   if (t == ctl->t_stop)
01470     fclose(out);
01471 }
```

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

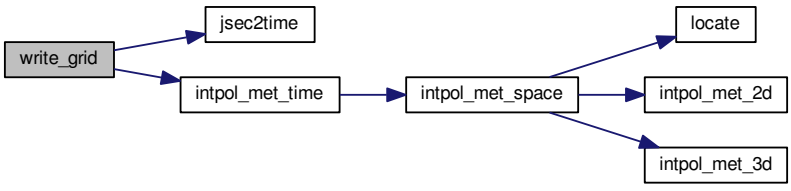
Write gridded data.

Definition at line 1475 of file libtrac.c.

```
01481            {
01482
01483   FILE *in, *out;
01484
01485   char line[LEN];
01486
01487   static double grid_m[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
01488     area, rho_air, press, temp, cd, mmr, t0, t1, r;
01489
01490   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
01491
01492   /* Check dimensions... */
01493   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
01494     ERRMSG("Grid dimensions too large!");
01495
01496   /* Check quantity index for mass... */
01497   if (ctl->qnt_m < 0)
01498     ERRMSG("Need quantity mass to write grid data!");
01499
01500   /* Set time interval for output... */
01501   t0 = t - 0.5 * ctl->dt_mod;
01502   t1 = t + 0.5 * ctl->dt_mod;
01503
01504   /* Set grid box size... */
01505   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
01506   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
01507   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
01508
01509   /* Initialize grid... */
01510   for (ix = 0; ix < ctl->grid_nx; ix++)
01511     for (iy = 0; iy < ctl->grid_ny; iy++)
01512       for (iz = 0; iz < ctl->grid_nz; iz++)
01513         grid_m[ix][iy][iz] = 0;
01514
01515   /* Average data... */
01516   for (ip = 0; ip < atm->np; ip++)
01517     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
01518
01519       /* Get index... */
01520       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
01521       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
01522       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
01523
01524       /* Check indices... */
01525       if (ix < 0 || ix >= ctl->grid_nx ||
01526           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
01527         continue;
01528
01529       /* Add mass... */
01530       grid_m[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01531     }
01532
01533   /* Check if gnuplot output is requested... */
01534   if (ctl->grid_gpfile[0] != '-') {
01535
01536     /* Write info... */
01537     printf("Plot grid data: %s.png\n", filename);
01538
01539     /* Create gnuplot pipe... */
01540     if (!(out = popen("gnuplot", "w")))
01541       ERRMSG("Cannot create pipe to gnuplot!");
01542
01543     /* Set plot filename... */
01544     fprintf(out, "set out \"%s.png\"\n", filename);
01545
01546     /* Set time string... */
01547     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01548     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01549             year, mon, day, hour, min);
01550
01551     /* Dump gnuplot file to pipe... */
01552     if (!(in = fopen(ctl->grid_gpfile, "r")))
01553       ERRMSG("Cannot open file!");
01554     while (fgets(line, LEN, in))
01555       fprintf(out, "%s", line);
01556     fclose(in);
01557   }
```

```
01558
01559   else {
01560
01561     /* Write info... */
01562     printf("Write grid data: %s\n", filename);
01563
01564     /* Create file... */
01565     if (!(out = fopen(filename, "w")))
01566       ERRMSG("Cannot create file!");
01567   }
01568
01569   /* Write header... */
01570   fprintf(out,
01571           "# $1 = time [s]\n"
01572           "# $2 = altitude [km]\n"
01573           "# $3 = longitude [deg]\n"
01574           "# $4 = latitude [deg]\n"
01575           "# $5 = surface area [km^2]\n"
01576           "# $6 = layer width [km]\n"
01577           "# $7 = temperature [K]\n"
01578           "# $8 = column density [kg/m^2]\n"
01579           "# $9 = mass mixing ratio [1]\n\n");
01580
01581   /* Write data... */
01582   for (ix = 0; ix < ctl->grid_nx; ix++) {
01583     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
01584       fprintf(out, "\n");
01585     for (iy = 0; iy < ctl->grid_ny; iy++) {
01586       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
01587         fprintf(out, "\n");
01588       for (iz = 0; iz < ctl->grid_nz; iz++)
01589         if (!ctl->grid_sparse
01590             || ix == 0 || iy == 0 || iz == 0 || grid_m[ix][iy][iz] > 0) {
01591
01592           /* Set coordinates... */
01593           z = ctl->grid_z0 + dz * (iz + 0.5);
01594           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
01595           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
01596
01597           /* Get pressure and temperature... */
01598           press = P(z);
01599           intpol_met_time(met0, met1, t, press, lon, lat,
01600                           NULL, &temp, NULL, NULL, NULL, NULL, NULL);
01601
01602           /* Calculate surface area... */
01603           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
01604             * cos(lat * M_PI / 180.);
01605
01606           /* Calculate column density... */
01607           cd = grid_m[ix][iy][iz] / (1e6 * area);
01608
01609           /* Calculate mass mixing ratio... */
01610           rho_air = 100. * press / (287.058 * temp);
01611           mmr = grid_m[ix][iy][iz] / (rho_air * 1e6 * area * 1e3 * dz);
01612
01613           /* Write output... */
01614           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01615                   t, z, lon, lat, area, dz, temp, cd, mmr);
01616         }
01617     }
01618   }
01619
01620   /* Close file... */
01621   fclose(out);
01622 }
```

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*)

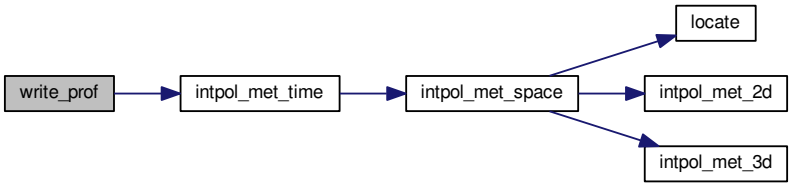
Write profile data.

Definition at line 1626 of file libtrac.c.

```
01632           {
01633
01634   static FILE *in, *out;
01635
01636   static char line[LEN];
01637
01638   static double mass[GX][GY][GZ], obsmean[GX][GY], tmean[GX][GY],
01639     rt, rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z,
01640     press, temp, rho_air, mmr, h2o, o3;
01641
01642   static int init, obscount[GX][GY], ip, ix, iy, iz;
01643
01644   /* Init... */
01645   if (!init) {
01646     init = 1;
01647
01648     /* Check quantity index for mass... */
01649     if (ctl->qnt_m < 0)
01650       ERRMSG("Need quantity mass!");
01651
01652     /* Check dimensions... */
01653     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
01654       ERRMSG("Grid dimensions too large!");
01655
01656     /* Open observation data file... */
01657     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
01658     if (!(in = fopen(ctl->prof_obsfile, "r")))
01659       ERRMSG("Cannot open file!");
01660
01661     /* Create new file... */
01662     printf("Write profile data: %s\n", filename);
01663     if (!(out = fopen(filename, "w")))
01664       ERRMSG("Cannot create file!");
01665
01666     /* Write header... */
01667     fprintf(out,
01668             "# $1  = time [s]\n"
01669             "# $2  = altitude [km]\n"
01670             "# $3  = longitude [deg]\n"
01671             "# $4  = latitude [deg]\n"
01672             "# $5  = pressure [hPa]\n"
01673             "# $6  = temperature [K]\n"
01674             "# $7  = mass mixing ratio [1]\n"
01675             "# $8  = H2O volume mixing ratio [1]\n"
01676             "# $9  = O3 volume mixing ratio [1]\n"
01677             "# $10 = mean BT index [K]\n");
01678
01679     /* Set grid box size... */
01680     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
01681     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
01682     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
01683   }
01684
01685   /* Set time interval... */
01686   t0 = t - 0.5 * ctl->dt_mod;
01687   t1 = t + 0.5 * ctl->dt_mod;
01688
01689   /* Initialize... */
01690   for (ix = 0; ix < ctl->prof_nx; ix++)
01691     for (iy = 0; iy < ctl->prof_ny; iy++) {
01692       obsmean[ix][iy] = 0;
01693       obscount[ix][iy] = 0;
01694       tmean[ix][iy] = 0;
01695       for (iz = 0; iz < ctl->prof_nz; iz++)
01696         mass[ix][iy][iz] = 0;
01697     }
01698
01699   /* Read data... */
01700   while (fgets(line, LEN, in)) {
01701
01702     /* Read data... */
01703     if (sscanf(line, "%lg %lg %lg %lg", &rt, &rlon, &rlat, &robs) != 4)
01704       continue;
01705
01706     /* Check time... */
01707     if (rt < t0)
01708       continue;
```

```
01709     if (rt > t1)
01710       break;
01711
01712     /* Calculate indices... */
01713     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
01714     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
01715
01716     /* Check indices... */
01717     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
01718       continue;
01719
01720     /* Get mean observation index... */
01721     obsmean[ix][iy] += robs;
01722     tmean[ix][iy] += rt;
01723     obscount[ix][iy]++;
01724   }
01725
01726   /* Analyze model data... */
01727   for (ip = 0; ip < atm->np; ip++) {
01728
01729     /* Check time... */
01730     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01731       continue;
01732
01733     /* Get indices... */
01734     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
01735     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
01736     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
01737
01738     /* Check indices... */
01739     if (ix < 0 || ix >= ctl->prof_nx ||
01740         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
01741       continue;
01742
01743     /* Get total mass in grid cell... */
01744     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01745   }
01746
01747   /* Extract profiles... */
01748   for (ix = 0; ix < ctl->prof_nx; ix++)
01749     for (iy = 0; iy < ctl->prof_ny; iy++)
01750       if (obscount[ix][iy] > 0) {
01751
01752         /* Write output... */
01753         fprintf(out, "\n");
01754
01755         /* Loop over altitudes... */
01756         for (iz = 0; iz < ctl->prof_nz; iz++) {
01757
01758           /* Set coordinates... */
01759           z = ctl->prof_z0 + dz * (iz + 0.5);
01760           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
01761           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
01762
01763           /* Get meteorological data... */
01764           press = P(z);
01765           intpol_met_time(met0, met1, t, press, lon, lat,
01766                           NULL, &temp, NULL, NULL, NULL, &h2o, &o3);
01767
01768           /* Calculate mass mixing ratio... */
01769           rho_air = 100. * press / (287.058 * temp);
01770           area = dlat * dlon * gsl_pow_2(M_PI * RE / 180.)
01771             * cos(lat * M_PI / 180.);
01772           mmr = mass[ix][iy][iz] / (rho_air * area * dz * 1e9);
01773
01774           /* Write output... */
01775           fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g\n",
01776                   tmean[ix][iy] / obscount[ix][iy],
01777                   z, lon, lat, press, temp, mmr, h2o, o3,
01778                   obsmean[ix][iy] / obscount[ix][iy]);
01779         }
01780       }
01781
01782   /* Close file... */
01783   if (t == ctl->t_stop)
01784     fclose(out);
01785 }
```

Here is the call graph for this function:



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

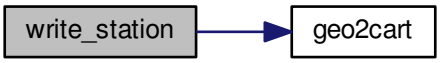
Write station data.

Definition at line 1789 of file libtrac.c.

```
01793           {
01794
01795   static FILE *out;
01796
01797   static double rmax2, t0, t1, x0[3], x1[3];
01798
01799   static int init, ip, iq;
01800
01801   /* Init... */
01802   if (!init) {
01803     init = 1;
01804
01805     /* Write info... */
01806     printf("Write station data: %s\n", filename);
01807
01808     /* Create new file... */
01809     if (!(out = fopen(filename, "w")))
01810       ERRMSG("Cannot create file!");
01811
01812     /* Write header... */
01813     fprintf(out,
01814             "# $1 = time [s]\n"
01815             "# $2 = altitude [km]\n"
01816             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01817     for (iq = 0; iq < ctl->nq; iq++)
01818       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
01819               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
01820     fprintf(out, "\n");
01821
01822     /* Set geolocation and search radius... */
01823     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
01824     rmax2 = gsl_pow_2(ctl->stat_r);
01825   }
01826
01827   /* Set time interval for output... */
01828   t0 = t - 0.5 * ctl->dt_mod;
01829   t1 = t + 0.5 * ctl->dt_mod;
01830
01831   /* Loop over air parcels... */
01832   for (ip = 0; ip < atm->np; ip++) {
01833
01834     /* Check time... */
01835     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01836       continue;
01837
01838     /* Check station flag... */
01839     if (ctl->qnt_stat >= 0)
01840       if (atm->q[ctl->qnt_stat][ip])
01841         continue;
01842
01843     /* Get Cartesian coordinates... */
01844     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
01845
01846     /* Check horizontal distance... */
```

```
01847     if (DIST2(x0, x1) > rmax2)
01848       continue;
01849
01850     /* Set station flag... */
01851     if (ctl->qnt_stat >= 0)
01852       atm->q[ctl->qnt_stat][ip] = 1;
01853
01854     /* Write data... */
01855     fprintf(out, "%.2f %g %g %g",
01856             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
01857     for (iq = 0; iq < ctl->nq; iq++) {
01858       fprintf(out, " ");
01859       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01860     }
01861     fprintf(out, "\n");
01862   }
01863
01864   /* Close file... */
01865   if (t == ctl->t_stop)
01866     fclose(out);
01867 }
```

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_m = -1;
00473     ctl->qnt_r = -1;
00474     ctl->qnt_rho = -1;
00475     ctl->qnt_ps = -1;
00476     ctl->qnt_p = -1;
00477     ctl->qnt_t = -1;
00478     ctl->qnt_u = -1;
```

```
00479   ctl->qnt_v = -1;
00480   ctl->qnt_w = -1;
00481   ctl->qnt_h2o = -1;
00482   ctl->qnt_o3 = -1;
00483   ctl->qnt_theta = -1;
00484   ctl->qnt_pv = -1;
00485   ctl->qnt_tice = -1;
00486   ctl->qnt_tnat = -1;
00487   ctl->qnt_stat = -1;
00488
00489   /* Read quantities... */
00490   ctl->nq = (int) scan_ctl(filename, argc, argv, "NQ", -1, "0", NULL);
00491   for (iq = 0; iq < ctl->nq; iq++) {
00492
00493     /* Read quantity name and format... */
00494     scan_ctl(filename, argc, argv, "QNT_NAME", iq, "", ctl->qnt_name[iq]);
00495     scan_ctl(filename, argc, argv, "QNT_FORMAT", iq, "%g",
00496              ctl->qnt_format[iq]);
00497
00498     /* Try to identify quantity... */
00499     if (strcmp(ctl->qnt_name[iq], "m") == 0) {
00500       ctl->qnt_m = iq;
00501       sprintf(ctl->qnt_unit[iq], "kg");
00502     } else if (strcmp(ctl->qnt_name[iq], "r") == 0) {
00503       ctl->qnt_r = iq;
00504       sprintf(ctl->qnt_unit[iq], "m");
00505     } else if (strcmp(ctl->qnt_name[iq], "rho") == 0) {
00506       ctl->qnt_rho = iq;
00507       sprintf(ctl->qnt_unit[iq], "kg/m^3");
00508     } else if (strcmp(ctl->qnt_name[iq], "ps") == 0) {
00509       ctl->qnt_ps = iq;
00510       sprintf(ctl->qnt_unit[iq], "hPa");
00511     } else if (strcmp(ctl->qnt_name[iq], "p") == 0) {
00512       ctl->qnt_p = iq;
00513       sprintf(ctl->qnt_unit[iq], "hPa");
00514     } else if (strcmp(ctl->qnt_name[iq], "t") == 0) {
00515       ctl->qnt_t = iq;
00516       sprintf(ctl->qnt_unit[iq], "K");
00517     } else if (strcmp(ctl->qnt_name[iq], "u") == 0) {
00518       ctl->qnt_u = iq;
00519       sprintf(ctl->qnt_unit[iq], "m/s");
00520     } else if (strcmp(ctl->qnt_name[iq], "v") == 0) {
00521       ctl->qnt_v = iq;
00522       sprintf(ctl->qnt_unit[iq], "m/s");
00523     } else if (strcmp(ctl->qnt_name[iq], "w") == 0) {
00524       ctl->qnt_w = iq;
00525       sprintf(ctl->qnt_unit[iq], "hPa/s");
00526     } else if (strcmp(ctl->qnt_name[iq], "h2o") == 0) {
00527       ctl->qnt_h2o = iq;
00528       sprintf(ctl->qnt_unit[iq], "1");
00529     } else if (strcmp(ctl->qnt_name[iq], "o3") == 0) {
00530       ctl->qnt_o3 = iq;
00531       sprintf(ctl->qnt_unit[iq], "1");
00532     } else if (strcmp(ctl->qnt_name[iq], "theta") == 0) {
00533       ctl->qnt_theta = iq;
00534       sprintf(ctl->qnt_unit[iq], "K");
00535     } else if (strcmp(ctl->qnt_name[iq], "pv") == 0) {
00536       ctl->qnt_pv = iq;
00537       sprintf(ctl->qnt_unit[iq], "PVU");
00538     } else if (strcmp(ctl->qnt_name[iq], "tice") == 0) {
00539       ctl->qnt_tice = iq;
00540       sprintf(ctl->qnt_unit[iq], "K");
00541     } else if (strcmp(ctl->qnt_name[iq], "tnat") == 0) {
00542       ctl->qnt_tnat = iq;
00543       sprintf(ctl->qnt_unit[iq], "K");
00544     } else if (strcmp(ctl->qnt_name[iq], "stat") == 0) {
00545       ctl->qnt_stat = iq;
00546       sprintf(ctl->qnt_unit[iq], "-");
00547     } else
00548       scan_ctl(filename, argc, argv, "QNT_UNIT", iq, "", ctl->qnt_unit[iq]);
00549   }
00550
00551   /* Time steps of simulation... */
00552   ctl->direction =
00553     (int) scan_ctl(filename, argc, argv, "DIRECTION", -1, "1", NULL);
00554   if (ctl->direction != -1 && ctl->direction != 1)
00555     ERRMSG("Set DIRECTION to -1 or 1!");
00556   ctl->t_start =
00557     scan_ctl(filename, argc, argv, "T_START", -1, "-1e100", NULL);
00558   ctl->t_stop = scan_ctl(filename, argc, argv, "T_STOP", -1, "-1e100", NULL);
00559   ctl->dt_mod = scan_ctl(filename, argc, argv, "DT_MOD", -1, "600", NULL);
00560
00561   /* Meteorological data... */
00562   ctl->dt_met = scan_ctl(filename, argc, argv, "DT_MET", -1, "21600", NULL);
00563   ctl->met_np = (int) scan_ctl(filename, argc, argv, "MET_NP", -1, "0", NULL);
00564   if (ctl->met_np > EP)
00565     ERRMSG("Too many levels!");
```

```
00566   for (ip = 0; ip < ctl->met_np; ip++)
00567     ctl->met_p[ip] = scan_ctl(filename, argc, argv, "MET_P", ip, "", NULL);
00568
00569   /* Isosurface parameters... */
00570   ctl->isosurf
00571     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
00572   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
00573
00574   /* Diffusion parameters... */
00575   ctl->turb_dx_trop
00576     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50.0", NULL);
00577   ctl->turb_dx_strat
00578     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0.0", NULL);
00579   ctl->turb_dz_trop
00580     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0.0", NULL);
00581   ctl->turb_dz_strat
00582     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
00583   ctl->turb_meso =
00584     scan_ctl(filename, argc, argv, "TURB_MESO", -1, "0.16", NULL);
00585
00586   /* Life time of particles... */
00587   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
00588   ctl->tdec_strat =
00589     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
00590
00591   /* Output of atmospheric data... */
00592   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
    atm_basename);
00593   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
00594   ctl->atm_dt_out =
00595     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
00596   ctl->atm_filter =
00597     (int) scan_ctl(filename, argc, argv, "ATM_FILTER", -1, "0", NULL);
00598
00599   /* Output of CSI data... */
00600   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
    csi_basename);
00601   ctl->csi_dt_out =
00602     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
00603   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "obs.tab",
00604            ctl->csi_obsfile);
00605   ctl->csi_obsmin =
00606     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
00607   ctl->csi_modmin =
00608     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
00609   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
00610   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
00611   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
00612   ctl->csi_lon0 =
00613     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
00614   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
00615   ctl->csi_nx =
00616     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
00617   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
00618   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
00619   ctl->csi_ny =
00620     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
00621
00622   /* Output of grid data... */
00623   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
00624            ctl->grid_basename);
00625   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
    grid_gpfile);
00626   ctl->grid_dt_out =
00627     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
00628   ctl->grid_sparse =
00629     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
00630   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
00631   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
00632   ctl->grid_nz =
00633     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
00634   ctl->grid_lon0 =
00635     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
00636   ctl->grid_lon1 =
00637     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
00638   ctl->grid_nx =
00639     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
00640   ctl->grid_lat0 =
00641     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
00642   ctl->grid_lat1 =
00643     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
00644   ctl->grid_ny =
00645     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
00646
00647   /* Output of profile data... */
00648   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
00649            ctl->prof_basename);
```

```
00650   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
      prof_obsfile);
00651   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
00652   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
00653   ctl->prof_nz =
00654     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
00655   ctl->prof_lon0 =
00656     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
00657   ctl->prof_lon1 =
00658     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
00659   ctl->prof_nx =
00660     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
00661   ctl->prof_lat0 =
00662     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
00663   ctl->prof_lat1 =
00664     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
00665   ctl->prof_ny =
00666     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
00667
00668   /* Output of station data... */
00669   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
00670            ctl->stat_basename);
00671   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
00672   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
00673   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
00674 }
00675
00676 /*****************************************************************************/
00677
00678 void read_met(
00679   ctl_t * ctl,
00680   char *filename,
00681   met_t * met) {
00682
00683   char tstr[10];
00684
00685   static float help[EX * EY];
00686
00687   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
00688
00689   size_t np, nx, ny;
00690
00691   /* Write info... */
00692   printf("Read meteorological data: %s\n", filename);
00693
00694   /* Get time from filename... */
00695   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
00696   year = atoi(tstr);
00697   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
00698   mon = atoi(tstr);
00699   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
00700   day = atoi(tstr);
00701   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
00702   hour = atoi(tstr);
00703   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
00704
00705   /* Open netCDF file... */
00706   NC(nc_open(filename, NC_NOWRITE, &ncid));
00707
00708   /* Get dimensions... */
00709   NC(nc_inq_dimid(ncid, "lon", &dimid));
00710   NC(nc_inq_dimlen(ncid, dimid, &nx));
00711   if (nx > EX)
00712     ERRMSG("Too many longitudes!");
00713
00714   NC(nc_inq_dimid(ncid, "lat", &dimid));
00715   NC(nc_inq_dimlen(ncid, dimid, &ny));
00716   if (ny > EY)
00717     ERRMSG("Too many latitudes!");
00718
00719   NC(nc_inq_dimid(ncid, "lev", &dimid));
00720   NC(nc_inq_dimlen(ncid, dimid, &np));
00721   if (np > EP)
00722     ERRMSG("Too many levels!");
00723
00724   /* Store dimensions... */
00725   met->np = (int) np;
00726   met->nx = (int) nx;
00727   met->ny = (int) ny;
00728
00729   /* Get horizontal grid... */
00730   NC(nc_inq_varid(ncid, "lon", &varid));
00731   NC(nc_get_var_double(ncid, varid, met->lon));
00732   NC(nc_inq_varid(ncid, "lat", &varid));
00733   NC(nc_get_var_double(ncid, varid, met->lat));
00734
00735   /* Read meteorological data... */
```

```
00736   read_met_help(ncid, "t", "T", met, met->t, 1.0);
00737   read_met_help(ncid, "u", "U", met, met->u, 1.0);
00738   read_met_help(ncid, "v", "V", met, met->v, 1.0);
00739   read_met_help(ncid, "w", "W", met, met->w, 0.01f);
00740   read_met_help(ncid, "q", "Q", met, met->h2o, 1.608f);
00741   read_met_help(ncid, "o3", "O3", met, met->o3, 0.602f);
00742
00743   /* Meteo data on pressure levels... */
00744   if (ctl->met_np <= 0) {
00745
00746     /* Read pressure levels from file... */
00747     NC(nc_inq_varid(ncid, "lev", &varid));
00748     NC(nc_get_var_double(ncid, varid, met->p));
00749     for (ip = 0; ip < met->np; ip++)
00750       met->p[ip] /= 100.;
00751
00752     /* Extrapolate data for lower boundary... */
00753     read_met_extrapolate(met);
00754   }
00755
00756   /* Meteo data on model levels... */
00757   else {
00758
00759     /* Read pressure data from file... */
00760     read_met_help(ncid, "pl", "PL", met, met->pl, 0.01f);
00761
00762     /* Interpolate from model levels to pressure levels... */
00763     read_met_ml2pl(ctl, met, met->t);
00764     read_met_ml2pl(ctl, met, met->u);
00765     read_met_ml2pl(ctl, met, met->v);
00766     read_met_ml2pl(ctl, met, met->w);
00767     read_met_ml2pl(ctl, met, met->h2o);
00768     read_met_ml2pl(ctl, met, met->o3);
00769
00770     /* Set pressure levels... */
00771     met->np = ctl->met_np;
00772     for (ip = 0; ip < met->np; ip++)
00773       met->p[ip] = ctl->met_p[ip];
00774   }
00775
00776   /* Check ordering of pressure levels... */
00777   for (ip = 1; ip < met->np; ip++)
00778     if (met->p[ip - 1] < met->p[ip])
00779       ERRMSG("Pressure levels must be descending!");
00780
00781   /* Read surface pressure... */
00782   if (nc_inq_varid(ncid, "PS", &varid) == NC_NOERR) {
00783     NC(nc_get_var_float(ncid, varid, help));
00784     for (iy = 0; iy < met->ny; iy++)
00785       for (ix = 0; ix < met->nx; ix++)
00786         met->ps[ix][iy] = help[iy * met->nx + ix] / 100.;
00787   } else if (nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
00788     NC(nc_get_var_float(ncid, varid, help));
00789     for (iy = 0; iy < met->ny; iy++)
00790       for (ix = 0; ix < met->nx; ix++)
00791         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
00792   } else
00793     for (ix = 0; ix < met->nx; ix++)
00794       for (iy = 0; iy < met->ny; iy++)
00795         met->ps[ix][iy] = met->p[0];
00796
00797   /* Create periodic boundary conditions... */
00798   read_met_periodic(met);
00799
00800   /* Close file... */
00801   NC(nc_close(ncid));
00802 }
00803
00804 /*****************************************************************************/
00805
00806 void read_met_extrapolate(
00807   met_t * met) {
00808
00809   int ip, ip0, ix, iy;
00810
00811   /* Loop over columns... */
00812   for (ix = 0; ix < met->nx; ix++)
00813     for (iy = 0; iy < met->ny; iy++) {
00814
00815       /* Find lowest valid data point... */
00816       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
00817         if (!gsl_finite(met->t[ix][iy][ip0])
00818             || !gsl_finite(met->u[ix][iy][ip0])
00819             || !gsl_finite(met->v[ix][iy][ip0])
00820             || !gsl_finite(met->w[ix][iy][ip0]))
00821           break;
00822
```

```
00823       /* Extrapolate... */
00824       for (ip = ip0; ip >= 0; ip--) {
00825         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
00826         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
00827         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
00828         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
00829         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
00830         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
00831       }
00832     }
00833 }
00834
00835 /*****************************************************************************/
00836
00837 void read_met_help(
00838   int ncid,
00839   char *varname,
00840   char *varname2,
00841   met_t * met,
00842   float dest[EX][EY][EP],
00843   float scl) {
00844
00845   static float help[EX * EY * EP];
00846
00847   int ip, ix, iy, n = 0, varid;
00848
00849   /* Check if variable exists... */
00850   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
00851     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
00852       return;
00853
00854   /* Read data... */
00855   NC(nc_get_var_float(ncid, varid, help));
00856
00857   /* Copy and check data... */
00858   for (ip = 0; ip < met->np; ip++)
00859     for (iy = 0; iy < met->ny; iy++)
00860       for (ix = 0; ix < met->nx; ix++) {
00861         dest[ix][iy][ip] = scl * help[n++];
00862         if (fabs(dest[ix][iy][ip] / scl) > 1e14)
00863           dest[ix][iy][ip] = GSL_NAN;
00864       }
00865 }
00866
00867 /*****************************************************************************/
00868
00869 void read_met_ml2pl(
00870   ctl_t * ctl,
00871   met_t * met,
00872   float var[EX][EY][EP]) {
00873
00874   double aux[EP], p[EP], pt;
00875
00876   int ip, ip2, ix, iy;
00877
00878   /* Loop over columns... */
00879   for (ix = 0; ix < met->nx; ix++)
00880     for (iy = 0; iy < met->ny; iy++) {
00881
00882       /* Copy pressure profile... */
00883       for (ip = 0; ip < met->np; ip++)
00884         p[ip] = met->pl[ix][iy][ip];
00885
00886       /* Interpolate... */
00887       for (ip = 0; ip < ctl->met_np; ip++) {
00888         pt = ctl->met_p[ip];
00889         if ((pt > p[0] && p[0] > p[1]) || (pt < p[0] && p[0] < p[1]))
00890           pt = p[0];
00891         else if ((pt > p[met->np - 1] && p[1] > p[0])
00892                  || (pt < p[met->np - 1] && p[1] < p[0]))
00893           pt = p[met->np - 1];
00894         ip2 = locate(p, met->np, pt);
00895         aux[ip] = LIN(p[ip2], var[ix][iy][ip2],
00896                       p[ip2 + 1], var[ix][iy][ip2 + 1], pt);
00897       }
00898
00899       /* Copy data... */
00900       for (ip = 0; ip < ctl->met_np; ip++)
00901         var[ix][iy][ip] = (float) aux[ip];
00902     }
00903 }
00904
00905 /*****************************************************************************/
00906
00907 void read_met_periodic(
00908   met_t * met) {
00909
```

```
00910   int ip, iy;
00911
00912   /* Check longitudes... */
00913   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
00914              + met->lon[1] - met->lon[0] - 360) < 0.01))
00915     return;
00916
00917   /* Increase longitude counter... */
00918   if ((++met->nx) > EX)
00919     ERRMSG("Cannot create periodic boundary conditions!");
00920
00921   /* Set longitude... */
00922   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
00923
00924   /* Loop over latitudes and pressure levels... */
00925   for (iy = 0; iy < met->ny; iy++)
00926     for (ip = 0; ip < met->np; ip++) {
00927       met->ps[met->nx - 1][iy] = met->ps[0][iy];
00928       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
00929       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
00930       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
00931       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
00932       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
00933       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
00934     }
00935 }
00936
00937 /*****************************************************************************/
00938
00939 double scan_ctl(
00940   const char *filename,
00941   int argc,
00942   char *argv[],
00943   const char *varname,
00944   int arridx,
00945   const char *defvalue,
00946   char *value) {
00947
00948   FILE *in = NULL;
00949
00950   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
00951     msg[LEN], rvarname[LEN], rval[LEN];
00952
00953   int contain = 0, i;
00954
00955   /* Open file... */
00956   if (filename[strlen(filename) - 1] != '-')
00957     if (!(in = fopen(filename, "r")))
00958       ERRMSG("Cannot open file!");
00959
00960   /* Set full variable name... */
00961   if (arridx >= 0) {
00962     sprintf(fullname1, "%s[%d]", varname, arridx);
00963     sprintf(fullname2, "%s[*]", varname);
00964   } else {
00965     sprintf(fullname1, "%s", varname);
00966     sprintf(fullname2, "%s", varname);
00967   }
00968
00969   /* Read data... */
00970   if (in != NULL)
00971     while (fgets(line, LEN, in))
00972       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
00973         if (strcasecmp(rvarname, fullname1) == 0 ||
00974             strcasecmp(rvarname, fullname2) == 0) {
00975           contain = 1;
00976           break;
00977         }
00978   for (i = 1; i < argc - 1; i++)
00979     if (strcasecmp(argv[i], fullname1) == 0 ||
00980         strcasecmp(argv[i], fullname2) == 0) {
00981       sprintf(rval, "%s", argv[i + 1]);
00982       contain = 1;
00983       break;
00984     }
00985
00986   /* Close file... */
00987   if (in != NULL)
00988     fclose(in);
00989
00990   /* Check for missing variables... */
00991   if (!contain) {
00992     if (strlen(defvalue) > 0)
00993       sprintf(rval, "%s", defvalue);
00994     else {
00995       sprintf(msg, "Missing variable %s!\n", fullname1);
```

```
00996       ERRMSG(msg);
00997     }
00998   }
00999
01000   /* Write info... */
01001   printf("%s = %s\n", fullname1, rval);
01002
01003   /* Return values... */
01004   if (value != NULL)
01005     sprintf(value, "%s", rval);
01006   return atof(rval);
01007 }
01008
01009 /*****************************************************************************/
01010
01011 void time2jsec(
01012   int year,
01013   int mon,
01014   int day,
01015   int hour,
01016   int min,
01017   int sec,
01018   double remain,
01019   double *jsec) {
01020
01021   struct tm t0, t1;
01022
01023   t0.tm_year = 100;
01024   t0.tm_mon = 0;
01025   t0.tm_mday = 1;
01026   t0.tm_hour = 0;
01027   t0.tm_min = 0;
01028   t0.tm_sec = 0;
01029
01030   t1.tm_year = year - 1900;
01031   t1.tm_mon = mon - 1;
01032   t1.tm_mday = day;
01033   t1.tm_hour = hour;
01034   t1.tm_min = min;
01035   t1.tm_sec = sec;
01036
01037   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
01038 }
01039
01040 /*****************************************************************************/
01041
01042 void timer(
01043   const char *name,
01044   int id,
01045   int mode) {
01046
01047   static double starttime[NTIMER], runtime[NTIMER];
01048
01049   /* Check id... */
01050   if (id < 0 || id >= NTIMER)
01051     ERRMSG("Too many timers!");
01052
01053   /* Start timer... */
01054   if (mode == 1) {
01055     if (starttime[id] <= 0)
01056       starttime[id] = omp_get_wtime();
01057     else
01058       ERRMSG("Timer already started!");
01059   }
01060
01061   /* Stop timer... */
01062   else if (mode == 2) {
01063     if (starttime[id] > 0) {
01064       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
01065       starttime[id] = -1;
01066     } else
01067       ERRMSG("Timer not started!");
01068   }
01069
01070   /* Print timer... */
01071   else if (mode == 3)
01072     printf("%s = %g s\n", name, runtime[id]);
01073 }
01074
01075 /*****************************************************************************/
01076
01077 double tropopause(
01078   double t,
01079   double lat) {
01080
01081   static double doys[12]
01082   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
```

```
01083
01084   static double lats[73]
01085     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
01086     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
01087     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
01088     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
01089     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
01090     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
01091     75, 77.5, 80, 82.5, 85, 87.5, 90
01092   };
01093
01094   static double tps[12][73]
01095     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
01096          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
01097          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
01098          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
01099          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
01100          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
01101          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
01102          275.3, 275.6, 275.4, 274.1, 273.5},
01103   {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
01104    300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
01105    150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
01106    98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
01107    98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
01108    220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
01109    284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
01110    287.5, 286.2, 285.8},
01111   {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
01112    297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
01113    161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
01114    100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
01115    99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
01116    186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
01117    279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
01118    304.3, 304.9, 306, 306.6, 306.2, 306},
01119   {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
01120    290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
01121    195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
01122    102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
01123    99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
01124    148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
01125    263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
01126    315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
01127   {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
01128    260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
01129    205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
01130    101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
01131    102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
01132    165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
01133    273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
01134    325.3, 325.8, 325.8},
01135   {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
01136    222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
01137    228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
01138    105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
01139    106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
01140    127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
01141    251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
01142    308.5, 312.2, 313.1, 313.3},
01143   {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
01144    187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
01145    235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
01146    110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
01147    111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
01148    117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
01149    224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
01150    275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
01151   {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
01152    185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
01153    233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
01154    110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
01155    112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
01156    120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
01157    230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
01158    278.2, 282.6, 287.4, 290.9, 292.5, 293},
01159   {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
01160    183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
01161    243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
01162    114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
01163    110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
01164    114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
01165    203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
01166    276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
01167   {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
01168    215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
01169    237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
```

```
01170    111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
01171    106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
01172    112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
01173    206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
01174    279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
01175    305.1},
01176   {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
01177    253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
01178    223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
01179    108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
01180    102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
01181    109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
01182    241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
01183    286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
01184   {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
01185    284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
01186    175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
01187    100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
01188    100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
01189    186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
01190    280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
01191    281.7, 281.1, 281.2}
01192   };
01193
01194   double doy, p0, p1, pt;
01195
01196   int imon, ilat;
01197
01198   /* Get day of year... */
01199   doy = fmod(t / 86400., 365.25);
01200   while (doy < 0)
01201     doy += 365.25;
01202
01203   /* Get indices... */
01204   imon = locate(doys, 12, doy);
01205   ilat = locate(lats, 73, lat);
01206
01207   /* Get tropopause pressure... */
01208   p0 = LIN(lats[ilat], tps[imon][ilat],
01209            lats[ilat + 1], tps[imon][ilat + 1], lat);
01210   p1 = LIN(lats[ilat], tps[imon + 1][ilat],
01211            lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
01212   pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
01213
01214   /* Return tropopause pressure... */
01215   return pt;
01216 }
01217
01218 /*****************************************************************************/
01219
01220 void write_atm(
01221   const char *filename,
01222   ctl_t * ctl,
01223   atm_t * atm,
01224   double t) {
01225
01226   FILE *in, *out;
01227
01228   char line[LEN];
01229
01230   double r, t0, t1;
01231
01232   int ip, iq, year, mon, day, hour, min, sec;
01233
01234   /* Set time interval for output... */
01235   t0 = t - 0.5 * ctl->dt_mod;
01236   t1 = t + 0.5 * ctl->dt_mod;
01237
01238   /* Check if gnuplot output is requested... */
01239   if (ctl->atm_gpfile[0] != '-') {
01240
01241     /* Write info... */
01242     printf("Plot atmospheric data: %s.png\n", filename);
01243
01244     /* Create gnuplot pipe... */
01245     if (!(out = popen("gnuplot", "w")))
01246       ERRMSG("Cannot create pipe to gnuplot!");
01247
01248     /* Set plot filename... */
01249     fprintf(out, "set out \"%s.png\"\n", filename);
01250
01251     /* Set time string... */
01252     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01253     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01254             year, mon, day, hour, min);
01255
01256     /* Dump gnuplot file to pipe... */
```

```
01257     if (!(in = fopen(ctl->atm_gpfile, "r")))
01258       ERRMSG("Cannot open file!");
01259     while (fgets(line, LEN, in))
01260       fprintf(out, "%s", line);
01261     fclose(in);
01262   }
01263
01264   else {
01265
01266     /* Write info... */
01267     printf("Write atmospheric data: %s\n", filename);
01268
01269     /* Create file... */
01270     if (!(out = fopen(filename, "w")))
01271       ERRMSG("Cannot create file!");
01272   }
01273
01274   /* Write header... */
01275   fprintf(out,
01276           "# $1 = time [s]\n"
01277           "# $2 = altitude [km]\n"
01278           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01279   for (iq = 0; iq < ctl->nq; iq++)
01280     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
01281             ctl->qnt_unit[iq]);
01282   fprintf(out, "\n");
01283
01284   /* Write data... */
01285   for (ip = 0; ip < atm->np; ip++) {
01286
01287     /* Check time... */
01288     if (ctl->atm_filter && (atm->time[ip] < t0 || atm->time[ip] > t1))
01289       continue;
01290
01291     /* Write output... */
01292     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
01293             atm->lon[ip], atm->lat[ip]);
01294     for (iq = 0; iq < ctl->nq; iq++) {
01295       fprintf(out, " ");
01296       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01297     }
01298     fprintf(out, "\n");
01299   }
01300
01301   /* Close file... */
01302   fclose(out);
01303 }
01304
01305 /*****************************************************************************/
01306
01307 void write_csi(
01308   const char *filename,
01309   ctl_t * ctl,
01310   atm_t * atm,
01311   double t) {
01312
01313   static FILE *in, *out;
01314
01315   static char line[LEN];
01316
01317   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
01318     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
01319
01320   static int init, obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
01321
01322   /* Init... */
01323   if (!init) {
01324     init = 1;
01325
01326     /* Check quantity index for mass... */
01327     if (ctl->qnt_m < 0)
01328       ERRMSG("Need quantity mass to analyze CSI!");
01329
01330     /* Open observation data file... */
01331     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
01332     if (!(in = fopen(ctl->csi_obsfile, "r")))
01333       ERRMSG("Cannot open file!");
01334
01335     /* Create new file... */
01336     printf("Write CSI data: %s\n", filename);
01337     if (!(out = fopen(filename, "w")))
01338       ERRMSG("Cannot create file!");
01339
01340     /* Write header... */
01341     fprintf(out,
01342             "# $1 = time [s]\n"
01343             "# $2 = number of hits (cx)\n"
```

```
01344             "# $3 = number of misses (cy)\n"
01345             "# $4 = number of false alarms (cz)\n"
01346             "# $5 = number of observations (cx + cy)\n"
01347             "# $6 = number of forecasts (cx + cz)\n"
01348             "# $7 = bias (forecasts/observations) [%%]\n"
01349             "# $8 = probability of detection (POD) [%%]\n"
01350             "# $9 = false alarm rate (FAR) [%%]\n"
01351             "# $10 = critical success index (CSI) [%%]\n\n");
01352   }
01353
01354   /* Set time interval... */
01355   t0 = t - 0.5 * ctl->dt_mod;
01356   t1 = t + 0.5 * ctl->dt_mod;
01357
01358   /* Initialize grid cells... */
01359   for (ix = 0; ix < ctl->csi_nx; ix++)
01360     for (iy = 0; iy < ctl->csi_ny; iy++)
01361       for (iz = 0; iz < ctl->csi_nz; iz++)
01362         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
01363
01364   /* Read data... */
01365   while (fgets(line, LEN, in)) {
01366
01367     /* Read data... */
01368     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
01369         5)
01370       continue;
01371
01372     /* Check time... */
01373     if (rt < t0)
01374       continue;
01375     if (rt > t1)
01376       break;
01377
01378     /* Calculate indices... */
01379     ix = (int) ((rlon - ctl->csi_lon0)
01380                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01381     iy = (int) ((rlat - ctl->csi_lat0)
01382                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01383     iz = (int) ((rz - ctl->csi_z0)
01384                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01385
01386     /* Check indices... */
01387     if (ix < 0 || ix >= ctl->csi_nx ||
01388         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01389       continue;
01390
01391     /* Get mean observation index... */
01392     obsmean[ix][iy][iz] += robs;
01393     obscount[ix][iy][iz]++;
01394   }
01395
01396   /* Analyze model data... */
01397   for (ip = 0; ip < atm->np; ip++) {
01398
01399     /* Check time... */
01400     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01401       continue;
01402
01403     /* Get indices... */
01404     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
01405                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01406     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
01407                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01408     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
01409                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01410
01411     /* Check indices... */
01412     if (ix < 0 || ix >= ctl->csi_nx ||
01413         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01414       continue;
01415
01416     /* Get total mass in grid cell... */
01417     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01418   }
01419
01420   /* Analyze all grid cells... */
01421   for (ix = 0; ix < ctl->csi_nx; ix++)
01422     for (iy = 0; iy < ctl->csi_ny; iy++)
01423       for (iz = 0; iz < ctl->csi_nz; iz++) {
01424
01425         /* Calculate mean observation index... */
01426         if (obscount[ix][iy][iz] > 0)
01427           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
01428
01429         /* Calculate column density... */
01430         if (modmean[ix][iy][iz] > 0) {
```

```
01431           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
01432           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
01433           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
01434           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
01435             * cos(lat * M_PI / 180.);
01436           modmean[ix][iy][iz] /= (1e6 * area);
01437         }
01438
01439         /* Calculate CSI... */
01440         if (obscount[ix][iy][iz] > 0) {
01441           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01442               modmean[ix][iy][iz] >= ctl->csi_modmin)
01443             cx++;
01444           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01445                    modmean[ix][iy][iz] < ctl->csi_modmin)
01446             cy++;
01447           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
01448                    modmean[ix][iy][iz] >= ctl->csi_modmin)
01449             cz++;
01450         }
01451       }
01452
01453   /* Write output... */
01454   if (fmod(t, ctl->csi_dt_out) == 0) {
01455
01456     /* Write... */
01457     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
01458             t, cx, cy, cz, cx + cy, cx + cz,
01459             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
01460             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
01461             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
01462             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
01463
01464     /* Set counters to zero... */
01465     cx = cy = cz = 0;
01466   }
01467
01468   /* Close file... */
01469   if (t == ctl->t_stop)
01470     fclose(out);
01471 }
01472
01473 /*****************************************************************************/
01474
01475 void write_grid(
01476   const char *filename,
01477   ctl_t * ctl,
01478   met_t * met0,
01479   met_t * met1,
01480   atm_t * atm,
01481   double t) {
01482
01483   FILE *in, *out;
01484
01485   char line[LEN];
01486
01487   static double grid_m[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
01488     area, rho_air, press, temp, cd, mmr, t0, t1, r;
01489
01490   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
01491
01492   /* Check dimensions... */
01493   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
01494     ERRMSG("Grid dimensions too large!");
01495
01496   /* Check quantity index for mass... */
01497   if (ctl->qnt_m < 0)
01498     ERRMSG("Need quantity mass to write grid data!");
01499
01500   /* Set time interval for output... */
01501   t0 = t - 0.5 * ctl->dt_mod;
01502   t1 = t + 0.5 * ctl->dt_mod;
01503
01504   /* Set grid box size... */
01505   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
01506   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
01507   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
01508
01509   /* Initialize grid... */
01510   for (ix = 0; ix < ctl->grid_nx; ix++)
01511     for (iy = 0; iy < ctl->grid_ny; iy++)
01512       for (iz = 0; iz < ctl->grid_nz; iz++)
01513         grid_m[ix][iy][iz] = 0;
01514
01515   /* Average data... */
01516   for (ip = 0; ip < atm->np; ip++)
01517     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
```

```
01518
01519       /* Get index... */
01520       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
01521       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
01522       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
01523
01524       /* Check indices... */
01525       if (ix < 0 || ix >= ctl->grid_nx ||
01526           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
01527         continue;
01528
01529       /* Add mass... */
01530       grid_m[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01531     }
01532
01533   /* Check if gnuplot output is requested... */
01534   if (ctl->grid_gpfile[0] != '-') {
01535
01536     /* Write info... */
01537     printf("Plot grid data: %s.png\n", filename);
01538
01539     /* Create gnuplot pipe... */
01540     if (!(out = popen("gnuplot", "w")))
01541       ERRMSG("Cannot create pipe to gnuplot!");
01542
01543     /* Set plot filename... */
01544     fprintf(out, "set out \"%s.png\"\n", filename);
01545
01546     /* Set time string... */
01547     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01548     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01549             year, mon, day, hour, min);
01550
01551     /* Dump gnuplot file to pipe... */
01552     if (!(in = fopen(ctl->grid_gpfile, "r")))
01553       ERRMSG("Cannot open file!");
01554     while (fgets(line, LEN, in))
01555       fprintf(out, "%s", line);
01556     fclose(in);
01557   }
01558
01559   else {
01560
01561     /* Write info... */
01562     printf("Write grid data: %s\n", filename);
01563
01564     /* Create file... */
01565     if (!(out = fopen(filename, "w")))
01566       ERRMSG("Cannot create file!");
01567   }
01568
01569   /* Write header... */
01570   fprintf(out,
01571           "# $1 = time [s]\n"
01572           "# $2 = altitude [km]\n"
01573           "# $3 = longitude [deg]\n"
01574           "# $4 = latitude [deg]\n"
01575           "# $5 = surface area [km^2]\n"
01576           "# $6 = layer width [km]\n"
01577           "# $7 = temperature [K]\n"
01578           "# $8 = column density [kg/m^2]\n"
01579           "# $9 = mass mixing ratio [1]\n\n");
01580
01581   /* Write data... */
01582   for (ix = 0; ix < ctl->grid_nx; ix++) {
01583     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
01584       fprintf(out, "\n");
01585     for (iy = 0; iy < ctl->grid_ny; iy++) {
01586       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
01587         fprintf(out, "\n");
01588       for (iz = 0; iz < ctl->grid_nz; iz++)
01589         if (!ctl->grid_sparse
01590             || ix == 0 || iy == 0 || iz == 0 || grid_m[ix][iy][iz] > 0) {
01591
01592           /* Set coordinates... */
01593           z = ctl->grid_z0 + dz * (iz + 0.5);
01594           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
01595           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
01596
01597           /* Get pressure and temperature... */
01598           press = P(z);
01599           intpol_met_time(met0, met1, t, press, lon, lat,
01600                           NULL, &temp, NULL, NULL, NULL, NULL, NULL);
01601
01602           /* Calculate surface area... */
01603           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
01604             * cos(lat * M_PI / 180.);
```

```
01605
01606           /* Calculate column density... */
01607           cd = grid_m[ix][iy][iz] / (1e6 * area);
01608
01609           /* Calculate mass mixing ratio... */
01610           rho_air = 100. * press / (287.058 * temp);
01611           mmr = grid_m[ix][iy][iz] / (rho_air * 1e6 * area * 1e3 * dz);
01612
01613           /* Write output... */
01614           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01615                   t, z, lon, lat, area, dz, temp, cd, mmr);
01616         }
01617     }
01618   }
01619
01620   /* Close file... */
01621   fclose(out);
01622 }
01623
01624 /*****************************************************************************/
01625
01626 void write_prof(
01627   const char *filename,
01628   ctl_t * ctl,
01629   met_t * met0,
01630   met_t * met1,
01631   atm_t * atm,
01632   double t) {
01633
01634   static FILE *in, *out;
01635
01636   static char line[LEN];
01637
01638   static double mass[GX][GY][GZ], obsmean[GX][GY], tmean[GX][GY],
01639     rt, rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z,
01640     press, temp, rho_air, mmr, h2o, o3;
01641
01642   static int init, obscount[GX][GY], ip, ix, iy, iz;
01643
01644   /* Init... */
01645   if (!init) {
01646     init = 1;
01647
01648     /* Check quantity index for mass... */
01649     if (ctl->qnt_m < 0)
01650       ERRMSG("Need quantity mass!");
01651
01652     /* Check dimensions... */
01653     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
01654       ERRMSG("Grid dimensions too large!");
01655
01656     /* Open observation data file... */
01657     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
01658     if (!(in = fopen(ctl->prof_obsfile, "r")))
01659       ERRMSG("Cannot open file!");
01660
01661     /* Create new file... */
01662     printf("Write profile data: %s\n", filename);
01663     if (!(out = fopen(filename, "w")))
01664       ERRMSG("Cannot create file!");
01665
01666     /* Write header... */
01667     fprintf(out,
01668             "# $1  = time [s]\n"
01669             "# $2  = altitude [km]\n"
01670             "# $3  = longitude [deg]\n"
01671             "# $4  = latitude [deg]\n"
01672             "# $5  = pressure [hPa]\n"
01673             "# $6  = temperature [K]\n"
01674             "# $7  = mass mixing ratio [1]\n"
01675             "# $8  = H2O volume mixing ratio [1]\n"
01676             "# $9  = O3 volume mixing ratio [1]\n"
01677             "# $10 = mean BT index [K]\n");
01678
01679     /* Set grid box size... */
01680     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
01681     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
01682     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
01683   }
01684
01685   /* Set time interval... */
01686   t0 = t - 0.5 * ctl->dt_mod;
01687   t1 = t + 0.5 * ctl->dt_mod;
01688
01689   /* Initialize... */
01690   for (ix = 0; ix < ctl->prof_nx; ix++)
01691     for (iy = 0; iy < ctl->prof_ny; iy++) {
```

```
01692       obsmean[ix][iy] = 0;
01693       obscount[ix][iy] = 0;
01694       tmean[ix][iy] = 0;
01695       for (iz = 0; iz < ctl->prof_nz; iz++)
01696         mass[ix][iy][iz] = 0;
01697     }
01698
01699   /* Read data... */
01700   while (fgets(line, LEN, in)) {
01701
01702     /* Read data... */
01703     if (sscanf(line, "%lg %lg %lg %lg", &rt, &rlon, &rlat, &robs) != 4)
01704       continue;
01705
01706     /* Check time... */
01707     if (rt < t0)
01708       continue;
01709     if (rt > t1)
01710       break;
01711
01712     /* Calculate indices... */
01713     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
01714     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
01715
01716     /* Check indices... */
01717     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
01718       continue;
01719
01720     /* Get mean observation index... */
01721     obsmean[ix][iy] += robs;
01722     tmean[ix][iy] += rt;
01723     obscount[ix][iy]++;
01724   }
01725
01726   /* Analyze model data... */
01727   for (ip = 0; ip < atm->np; ip++) {
01728
01729     /* Check time... */
01730     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01731       continue;
01732
01733     /* Get indices... */
01734     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
01735     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
01736     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
01737
01738     /* Check indices... */
01739     if (ix < 0 || ix >= ctl->prof_nx ||
01740         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
01741       continue;
01742
01743     /* Get total mass in grid cell... */
01744     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01745   }
01746
01747   /* Extract profiles... */
01748   for (ix = 0; ix < ctl->prof_nx; ix++)
01749     for (iy = 0; iy < ctl->prof_ny; iy++)
01750       if (obscount[ix][iy] > 0) {
01751
01752         /* Write output... */
01753         fprintf(out, "\n");
01754
01755         /* Loop over altitudes... */
01756         for (iz = 0; iz < ctl->prof_nz; iz++) {
01757
01758           /* Set coordinates... */
01759           z = ctl->prof_z0 + dz * (iz + 0.5);
01760           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
01761           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
01762
01763           /* Get meteorological data... */
01764           press = P(z);
01765           intpol_met_time(met0, met1, t, press, lon, lat,
01766                           NULL, &temp, NULL, NULL, NULL, &h2o, &o3);
01767
01768           /* Calculate mass mixing ratio... */
01769           rho_air = 100. * press / (287.058 * temp);
01770           area = dlat * dlon * gsl_pow_2(M_PI * RE / 180.)
01771             * cos(lat * M_PI / 180.);
01772           mmr = mass[ix][iy][iz] / (rho_air * area * dz * 1e9);
01773
01774           /* Write output... */
01775           fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g\n",
01776                   tmean[ix][iy] / obscount[ix][iy],
01777                   z, lon, lat, press, temp, mmr, h2o, o3,
01778                   obsmean[ix][iy] / obscount[ix][iy]);
```

```
01779         }
01780       }
01781
01782   /* Close file... */
01783   if (t == ctl->t_stop)
01784     fclose(out);
01785 }
01786
01787 /*****************************************************************************/
01788
01789 void write_station(
01790   const char *filename,
01791   ctl_t * ctl,
01792   atm_t * atm,
01793   double t) {
01794
01795   static FILE *out;
01796
01797   static double rmax2, t0, t1, x0[3], x1[3];
01798
01799   static int init, ip, iq;
01800
01801   /* Init... */
01802   if (!init) {
01803     init = 1;
01804
01805     /* Write info... */
01806     printf("Write station data: %s\n", filename);
01807
01808     /* Create new file... */
01809     if (!(out = fopen(filename, "w")))
01810       ERRMSG("Cannot create file!");
01811
01812     /* Write header... */
01813     fprintf(out,
01814             "# $1 = time [s]\n"
01815             "# $2 = altitude [km]\n"
01816             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01817     for (iq = 0; iq < ctl->nq; iq++)
01818       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
01819               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
01820     fprintf(out, "\n");
01821
01822     /* Set geolocation and search radius... */
01823     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
01824     rmax2 = gsl_pow_2(ctl->stat_r);
01825   }
01826
01827   /* Set time interval for output... */
01828   t0 = t - 0.5 * ctl->dt_mod;
01829   t1 = t + 0.5 * ctl->dt_mod;
01830
01831   /* Loop over air parcels... */
01832   for (ip = 0; ip < atm->np; ip++) {
01833
01834     /* Check time... */
01835     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01836       continue;
01837
01838     /* Check station flag... */
01839     if (ctl->qnt_stat >= 0)
01840       if (atm->q[ctl->qnt_stat][ip])
01841         continue;
01842
01843     /* Get Cartesian coordinates... */
01844     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
01845
01846     /* Check horizontal distance... */
01847     if (DIST2(x0, x1) > rmax2)
01848       continue;
01849
01850     /* Set station flag... */
01851     if (ctl->qnt_stat >= 0)
01852       atm->q[ctl->qnt_stat][ip] = 1;
01853
01854     /* Write data... */
01855     fprintf(out, "%.2f %g %g %g",
01856             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
01857     for (iq = 0; iq < ctl->nq; iq++) {
01858       fprintf(out, " ");
01859       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01860     }
01861     fprintf(out, "\n");
01862   }
01863
01864   /* Close file... */
01865   if (t == ctl->t_stop)
```

```
01866     fclose(out);
01867 }
```

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_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 }
```

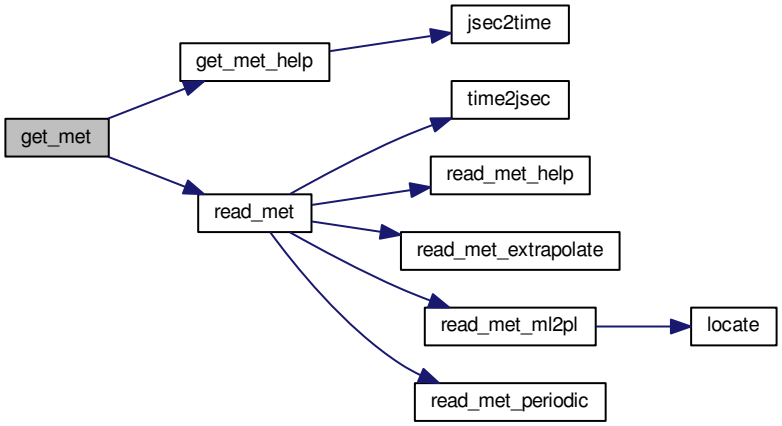
5.13.2.9 void get_met (ctl_t * *ctl*, char * *metbase*, double *t*, met_t * *met0*, met_t * *met1*)

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:



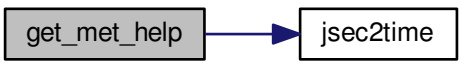
5.13.2.10 void get_met_help (double *t*, int *direct*, char * *metbase*, double *dt_met*, char * *filename*)

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*)

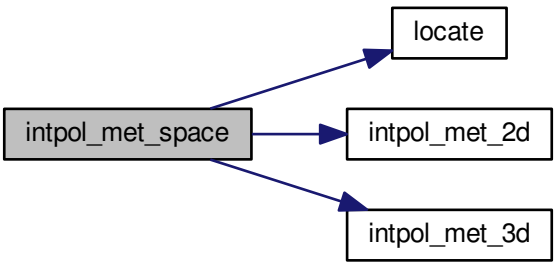
Spatial interpolation of meteorological data.

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*)

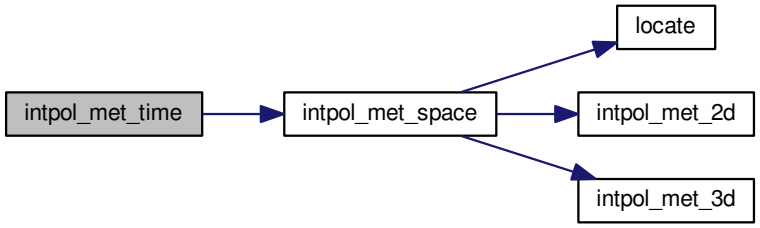
Temporal interpolation of meteorological data.

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_m = -1;
00473   ctl->qnt_r = -1;
00474   ctl->qnt_rho = -1;
00475   ctl->qnt_ps = -1;
00476   ctl->qnt_p = -1;
00477   ctl->qnt_t = -1;
00478   ctl->qnt_u = -1;
00479   ctl->qnt_v = -1;
00480   ctl->qnt_w = -1;
00481   ctl->qnt_h2o = -1;
00482   ctl->qnt_o3 = -1;
00483   ctl->qnt_theta = -1;
00484   ctl->qnt_pv = -1;
00485   ctl->qnt_tice = -1;
00486   ctl->qnt_tnat = -1;
00487   ctl->qnt_stat = -1;
00488
00489   /* Read quantities... */
00490   ctl->nq = (int) scan_ctl(filename, argc, argv, "NQ", -1, "0", NULL);
00491   for (iq = 0; iq < ctl->nq; iq++) {
00492
00493     /* Read quantity name and format... */
00494     scan_ctl(filename, argc, argv, "QNT_NAME", iq, "", ctl->qnt_name[iq]);
00495     scan_ctl(filename, argc, argv, "QNT_FORMAT", iq, "%g",
00496              ctl->qnt_format[iq]);
00497
00498     /* Try to identify quantity... */
00499     if (strcmp(ctl->qnt_name[iq], "m") == 0) {
00500       ctl->qnt_m = iq;
00501       sprintf(ctl->qnt_unit[iq], "kg");
00502     } else if (strcmp(ctl->qnt_name[iq], "r") == 0) {
00503       ctl->qnt_r = iq;
00504       sprintf(ctl->qnt_unit[iq], "m");
00505     } else if (strcmp(ctl->qnt_name[iq], "rho") == 0) {
00506       ctl->qnt_rho = iq;
00507       sprintf(ctl->qnt_unit[iq], "kg/m^3");
00508     } else if (strcmp(ctl->qnt_name[iq], "ps") == 0) {
00509       ctl->qnt_ps = iq;
00510       sprintf(ctl->qnt_unit[iq], "hPa");
00511     } else if (strcmp(ctl->qnt_name[iq], "p") == 0) {
00512       ctl->qnt_p = iq;
00513       sprintf(ctl->qnt_unit[iq], "hPa");
00514     } else if (strcmp(ctl->qnt_name[iq], "t") == 0) {
00515       ctl->qnt_t = iq;
00516       sprintf(ctl->qnt_unit[iq], "K");
00517     } else if (strcmp(ctl->qnt_name[iq], "u") == 0) {
00518       ctl->qnt_u = iq;
00519       sprintf(ctl->qnt_unit[iq], "m/s");
00520     } else if (strcmp(ctl->qnt_name[iq], "v") == 0) {
00521       ctl->qnt_v = iq;
00522       sprintf(ctl->qnt_unit[iq], "m/s");
00523     } else if (strcmp(ctl->qnt_name[iq], "w") == 0) {
00524       ctl->qnt_w = iq;
00525       sprintf(ctl->qnt_unit[iq], "hPa/s");
00526     } else if (strcmp(ctl->qnt_name[iq], "h2o") == 0) {
00527       ctl->qnt_h2o = iq;
00528       sprintf(ctl->qnt_unit[iq], "1");
00529     } else if (strcmp(ctl->qnt_name[iq], "o3") == 0) {
00530       ctl->qnt_o3 = iq;
00531       sprintf(ctl->qnt_unit[iq], "1");
00532     } else if (strcmp(ctl->qnt_name[iq], "theta") == 0) {
00533       ctl->qnt_theta = iq;
00534       sprintf(ctl->qnt_unit[iq], "K");
00535     } else if (strcmp(ctl->qnt_name[iq], "pv") == 0) {
00536       ctl->qnt_pv = iq;
00537       sprintf(ctl->qnt_unit[iq], "PVU");
00538     } else if (strcmp(ctl->qnt_name[iq], "tice") == 0) {
```

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

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

Here is the call graph for this function:

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

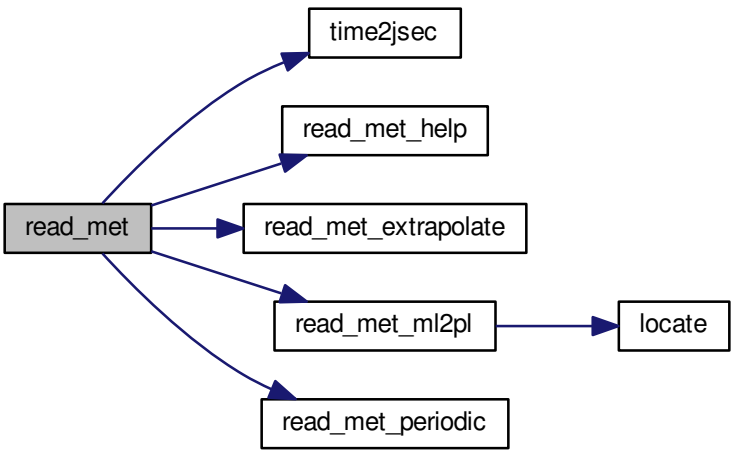
Read meteorological data file.

Definition at line 678 of file libtrac.c.

```
00681               {
00682
00683   char tstr[10];
00684
00685   static float help[EX * EY];
00686
00687   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
00688
00689   size_t np, nx, ny;
00690
00691   /* Write info... */
00692   printf("Read meteorological data: %s\n", filename);
00693
00694   /* Get time from filename... */
00695   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
00696   year = atoi(tstr);
00697   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
00698   mon = atoi(tstr);
00699   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
00700   day = atoi(tstr);
00701   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
00702   hour = atoi(tstr);
00703   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
00704
00705   /* Open netCDF file... */
00706   NC(nc_open(filename, NC_NOWRITE, &ncid));
00707
00708   /* Get dimensions... */
00709   NC(nc_inq_dimid(ncid, "lon", &dimid));
00710   NC(nc_inq_dimlen(ncid, dimid, &nx));
00711   if (nx > EX)
00712     ERRMSG("Too many longitudes!");
00713
00714   NC(nc_inq_dimid(ncid, "lat", &dimid));
00715   NC(nc_inq_dimlen(ncid, dimid, &ny));
00716   if (ny > EY)
00717     ERRMSG("Too many latitudes!");
00718
00719   NC(nc_inq_dimid(ncid, "lev", &dimid));
00720   NC(nc_inq_dimlen(ncid, dimid, &np));
00721   if (np > EP)
00722     ERRMSG("Too many levels!");
00723
00724   /* Store dimensions... */
00725   met->np = (int) np;
00726   met->nx = (int) nx;
00727   met->ny = (int) ny;
00728
00729   /* Get horizontal grid... */
00730   NC(nc_inq_varid(ncid, "lon", &varid));
00731   NC(nc_get_var_double(ncid, varid, met->lon));
00732   NC(nc_inq_varid(ncid, "lat", &varid));
00733   NC(nc_get_var_double(ncid, varid, met->lat));
00734
00735   /* Read meteorological data... */
00736   read_met_help(ncid, "t", "T", met, met->t, 1.0);
00737   read_met_help(ncid, "u", "U", met, met->u, 1.0);
00738   read_met_help(ncid, "v", "V", met, met->v, 1.0);
00739   read_met_help(ncid, "w", "W", met, met->w, 0.01f);
00740   read_met_help(ncid, "q", "Q", met, met->h2o, 1.608f);
00741   read_met_help(ncid, "o3", "O3", met, met->o3, 0.602f);
00742
00743   /* Meteo data on pressure levels... */
00744   if (ctl->met_np <= 0) {
00745
00746     /* Read pressure levels from file... */
00747     NC(nc_inq_varid(ncid, "lev", &varid));
00748     NC(nc_get_var_double(ncid, varid, met->p));
00749     for (ip = 0; ip < met->np; ip++)
00750       met->p[ip] /= 100.;
00751
00752     /* Extrapolate data for lower boundary... */
00753     read_met_extrapolate(met);
00754   }
00755
00756   /* Meteo data on model levels... */
00757   else {
00758
00759     /* Read pressure data from file... */
00760     read_met_help(ncid, "pl", "PL", met, met->pl, 0.01f);
00761
00762     /* Interpolate from model levels to pressure levels... */
00763     read_met_ml2pl(ctl, met, met->t);
00764     read_met_ml2pl(ctl, met, met->u);
00765     read_met_ml2pl(ctl, met, met->v);
00766     read_met_ml2pl(ctl, met, met->w);
00767     read_met_ml2pl(ctl, met, met->h2o);
```

```
00768     read_met_ml2pl(ctl, met, met->o3);
00769
00770     /* Set pressure levels... */
00771     met->np = ctl->met_np;
00772     for (ip = 0; ip < met->np; ip++)
00773       met->p[ip] = ctl->met_p[ip];
00774   }
00775
00776   /* Check ordering of pressure levels... */
00777   for (ip = 1; ip < met->np; ip++)
00778     if (met->p[ip - 1] < met->p[ip])
00779       ERRMSG("Pressure levels must be descending!");
00780
00781   /* Read surface pressure... */
00782   if (nc_inq_varid(ncid, "PS", &varid) == NC_NOERR) {
00783     NC(nc_get_var_float(ncid, varid, help));
00784     for (iy = 0; iy < met->ny; iy++)
00785       for (ix = 0; ix < met->nx; ix++)
00786         met->ps[ix][iy] = help[iy * met->nx + ix] / 100.;
00787   } else if (nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
00788     NC(nc_get_var_float(ncid, varid, help));
00789     for (iy = 0; iy < met->ny; iy++)
00790       for (ix = 0; ix < met->nx; ix++)
00791         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
00792   } else
00793     for (ix = 0; ix < met->nx; ix++)
00794       for (iy = 0; iy < met->ny; iy++)
00795         met->ps[ix][iy] = met->p[0];
00796
00797   /* Create periodic boundary conditions... */
00798   read_met_periodic(met);
00799
00800   /* Close file... */
00801   NC(nc_close(ncid));
00802 }
```

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 806 of file libtrac.c.

```
00807               {
00808
00809   int ip, ip0, ix, iy;
00810
00811   /* Loop over columns... */
00812   for (ix = 0; ix < met->nx; ix++)
00813     for (iy = 0; iy < met->ny; iy++) {
00814
00815       /* Find lowest valid data point... */
00816       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
00817         if (!gsl_finite(met->t[ix][iy][ip0])
00818             || !gsl_finite(met->u[ix][iy][ip0])
00819             || !gsl_finite(met->v[ix][iy][ip0])
00820             || !gsl_finite(met->w[ix][iy][ip0]))
00821           break;
00822
00823       /* Extrapolate... */
00824       for (ip = ip0; ip >= 0; ip--) {
00825         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
00826         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
00827         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
00828         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
00829         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
00830         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
00831       }
00832     }
00833 }
```

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 837 of file libtrac.c.

```
00843             {
00844
00845   static float help[EX * EY * EP];
00846
00847   int ip, ix, iy, n = 0, varid;
00848
00849   /* Check if variable exists... */
00850   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
00851     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
00852       return;
00853
00854   /* Read data... */
00855   NC(nc_get_var_float(ncid, varid, help));
00856
00857   /* Copy and check data... */
00858   for (ip = 0; ip < met->np; ip++)
00859     for (iy = 0; iy < met->ny; iy++)
00860       for (ix = 0; ix < met->nx; ix++) {
00861         dest[ix][iy][ip] = scl * help[n++];
00862         if (fabs(dest[ix][iy][ip] / scl) > 1e14)
00863           dest[ix][iy][ip] = GSL_NAN;
00864       }
00865 }
```

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

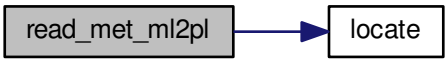
Convert meteorological data from model levels to pressure levels.

Definition at line 869 of file libtrac.c.

```
00872                         {
00873
00874   double aux[EP], p[EP], pt;
00875
00876   int ip, ip2, ix, iy;
00877
00878   /* Loop over columns... */
00879   for (ix = 0; ix < met->nx; ix++)
00880     for (iy = 0; iy < met->ny; iy++) {
00881
```

```
00882       /* Copy pressure profile... */
00883       for (ip = 0; ip < met->np; ip++)
00884         p[ip] = met->pl[ix][iy][ip];
00885
00886       /* Interpolate... */
00887       for (ip = 0; ip < ctl->met_np; ip++) {
00888         pt = ctl->met_p[ip];
00889         if ((pt > p[0] && p[0] > p[1]) || (pt < p[0] && p[0] < p[1]))
00890           pt = p[0];
00891         else if ((pt > p[met->np - 1] && p[1] > p[0])
00892                  || (pt < p[met->np - 1] && p[1] < p[0]))
00893           pt = p[met->np - 1];
00894         ip2 = locate(p, met->np, pt);
00895         aux[ip] = LIN(p[ip2], var[ix][iy][ip2],
00896                       p[ip2 + 1], var[ix][iy][ip2 + 1], pt);
00897       }
00898
00899       /* Copy data... */
00900       for (ip = 0; ip < ctl->met_np; ip++)
00901         var[ix][iy][ip] = (float) aux[ip];
00902     }
00903 }
```

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 907 of file libtrac.c.

```
00908               {
00909
00910   int ip, iy;
00911
00912   /* Check longitudes... */
00913   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
00914              + met->lon[1] - met->lon[0] - 360) < 0.01))
00915     return;
00916
00917   /* Increase longitude counter... */
00918   if ((++met->nx) > EX)
00919     ERRMSG("Cannot create periodic boundary conditions!");
00920
00921   /* Set longitude... */
00922   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
00923
00924   /* Loop over latitudes and pressure levels... */
00925   for (iy = 0; iy < met->ny; iy++)
00926     for (ip = 0; ip < met->np; ip++) {
00927       met->ps[met->nx - 1][iy] = met->ps[0][iy];
00928       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
00929       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
00930       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
00931       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
00932       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
00933       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
00934     }
00935 }
```

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 939 of file libtrac.c.

```
00946                {
00947
00948   FILE *in = NULL;
00949
00950   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
00951     msg[LEN], rvarname[LEN], rval[LEN];
00952
00953   int contain = 0, i;
00954
00955   /* Open file... */
00956   if (filename[strlen(filename) - 1] != '-')
00957     if (!(in = fopen(filename, "r")))
00958       ERRMSG("Cannot open file!");
00959
00960   /* Set full variable name... */
00961   if (arridx >= 0) {
00962     sprintf(fullname1, "%s[%d]", varname, arridx);
00963     sprintf(fullname2, "%s[*]", varname);
00964   } else {
00965     sprintf(fullname1, "%s", varname);
00966     sprintf(fullname2, "%s", varname);
00967   }
00968
00969   /* Read data... */
00970   if (in != NULL)
00971     while (fgets(line, LEN, in))
00972       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
00973         if (strcasecmp(rvarname, fullname1) == 0 ||
00974             strcasecmp(rvarname, fullname2) == 0) {
00975           contain = 1;
00976           break;
00977         }
00978   for (i = 1; i < argc - 1; i++)
00979     if (strcasecmp(argv[i], fullname1) == 0 ||
00980         strcasecmp(argv[i], fullname2) == 0) {
00981       sprintf(rval, "%s", argv[i + 1]);
00982       contain = 1;
00983       break;
00984     }
00985
00986   /* Close file... */
00987   if (in != NULL)
00988     fclose(in);
00989
00990   /* Check for missing variables... */
00991   if (!contain) {
00992     if (strlen(defvalue) > 0)
00993       sprintf(rval, "%s", defvalue);
00994     else {
00995       sprintf(msg, "Missing variable %s!\n", fullname1);
00996       ERRMSG(msg);
00997     }
00998   }
00999
01000   /* Write info... */
01001   printf("%s = %s\n", fullname1, rval);
01002
01003   /* Return values... */
01004   if (value != NULL)
01005     sprintf(value, "%s", rval);
01006   return atof(rval);
01007 }
```

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 1011 of file libtrac.c.

```
01019                {
01020
01021   struct tm t0, t1;
01022
01023   t0.tm_year = 100;
01024   t0.tm_mon = 0;
01025   t0.tm_mday = 1;
01026   t0.tm_hour = 0;
01027   t0.tm_min = 0;
01028   t0.tm_sec = 0;
01029
01030   t1.tm_year = year - 1900;
01031   t1.tm_mon = mon - 1;
01032   t1.tm_mday = day;
01033   t1.tm_hour = hour;
01034   t1.tm_min = min;
01035   t1.tm_sec = sec;
01036
01037   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
01038 }
```

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

Measure wall-clock time.

Definition at line 1042 of file libtrac.c.

```
01045            {
01046
01047   static double starttime[NTIMER], runtime[NTIMER];
01048
01049   /* Check id... */
01050   if (id < 0 || id >= NTIMER)
01051     ERRMSG("Too many timers!");
01052
01053   /* Start timer... */
01054   if (mode == 1) {
01055     if (starttime[id] <= 0)
01056       starttime[id] = omp_get_wtime();
01057     else
01058       ERRMSG("Timer already started!");
01059   }
01060
01061   /* Stop timer... */
01062   else if (mode == 2) {
01063     if (starttime[id] > 0) {
01064       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
01065       starttime[id] = -1;
01066     } else
01067       ERRMSG("Timer not started!");
01068   }
01069
01070   /* Print timer... */
01071   else if (mode == 3)
01072     printf("%s = %g s\n", name, runtime[id]);
01073 }
```

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

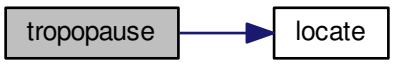
Definition at line 1077 of file libtrac.c.

```
01079              {
01080
01081   static double doys[12]
01082   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
01083
01084   static double lats[73]
01085     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
01086     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
01087     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
01088     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
01089     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
01090     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
01091     75, 77.5, 80, 82.5, 85, 87.5, 90
01092   };
```

```
01093
01094   static double tps[12][73]
01095     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
01096          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
01097          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
01098          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
01099          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
01100          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
01101          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
01102          275.3, 275.6, 275.4, 274.1, 273.5},
01103    {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
01104     300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
01105     150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
01106     98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
01107     98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
01108     220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
01109     284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
01110     287.5, 286.2, 285.8},
01111    {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
01112     297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
01113     161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
01114     100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
01115     99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
01116     186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
01117     279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
01118     304.3, 304.9, 306, 306.6, 306.2, 306},
01119    {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
01120     290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
01121     195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
01122     102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
01123     99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
01124     148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
01125     263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
01126     315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
01127    {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
01128     260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
01129     205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
01130     101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
01131     102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
01132     165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
01133     273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
01134     325.3, 325.8, 325.8},
01135    {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
01136     222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
01137     228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
01138     105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
01139     106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
01140     127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
01141     251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
01142     308.5, 312.2, 313.1, 313.3},
01143    {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
01144     187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
01145     235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
01146     110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
01147     111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
01148     117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
01149     224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
01150     275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
01151    {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
01152     185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
01153     233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
01154     110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
01155     112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
01156     120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
01157     230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
01158     278.2, 282.6, 287.4, 290.9, 292.5, 293},
01159    {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
01160     183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
01161     243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
01162     114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
01163     110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
01164     114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
01165     203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
01166     276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
01167    {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
01168     215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
01169     237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
01170     111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
01171     106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
01172     112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
01173     206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
01174     279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
01175     305.1},
01176    {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
01177     253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
01178     223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
01179     108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
```

```
01180     102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
01181     109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
01182     241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
01183     286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
01184    {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
01185     284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
01186     175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
01187     100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
01188     100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
01189     186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
01190     280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
01191     281.7, 281.1, 281.2}
01192    };
01193
01194    double doy, p0, p1, pt;
01195
01196    int imon, ilat;
01197
01198    /* Get day of year... */
01199    doy = fmod(t / 86400., 365.25);
01200    while (doy < 0)
01201      doy += 365.25;
01202
01203    /* Get indices... */
01204    imon = locate(doys, 12, doy);
01205    ilat = locate(lats, 73, lat);
01206
01207    /* Get tropopause pressure... */
01208    p0 = LIN(lats[ilat], tps[imon][ilat],
01209             lats[ilat + 1], tps[imon][ilat + 1], lat);
01210    p1 = LIN(lats[ilat], tps[imon + 1][ilat],
01211             lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
01212    pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
01213
01214    /* Return tropopause pressure... */
01215    return pt;
01216  }
```

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 1220 of file libtrac.c.

```
01224             {
01225
01226    FILE *in, *out;
01227
01228    char line[LEN];
01229
01230    double r, t0, t1;
01231
01232    int ip, iq, year, mon, day, hour, min, sec;
01233
01234    /* Set time interval for output... */
01235    t0 = t - 0.5 * ctl->dt_mod;
01236    t1 = t + 0.5 * ctl->dt_mod;
01237
01238    /* Check if gnuplot output is requested... */
01239    if (ctl->atm_gpfile[0] != '-') {
```

```
01240
01241     /* Write info... */
01242     printf("Plot atmospheric data: %s.png\n", filename);
01243
01244     /* Create gnuplot pipe... */
01245     if (!(out = popen("gnuplot", "w")))
01246       ERRMSG("Cannot create pipe to gnuplot!");
01247
01248     /* Set plot filename... */
01249     fprintf(out, "set out \"%s.png\"\n", filename);
01250
01251     /* Set time string... */
01252     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01253     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01254             year, mon, day, hour, min);
01255
01256     /* Dump gnuplot file to pipe... */
01257     if (!(in = fopen(ctl->atm_gpfile, "r")))
01258       ERRMSG("Cannot open file!");
01259     while (fgets(line, LEN, in))
01260       fprintf(out, "%s", line);
01261     fclose(in);
01262   }
01263
01264   else {
01265
01266     /* Write info... */
01267     printf("Write atmospheric data: %s\n", filename);
01268
01269     /* Create file... */
01270     if (!(out = fopen(filename, "w")))
01271       ERRMSG("Cannot create file!");
01272   }
01273
01274   /* Write header... */
01275   fprintf(out,
01276           "# $1 = time [s]\n"
01277           "# $2 = altitude [km]\n"
01278           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01279   for (iq = 0; iq < ctl->nq; iq++)
01280     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
01281             ctl->qnt_unit[iq]);
01282   fprintf(out, "\n");
01283
01284   /* Write data... */
01285   for (ip = 0; ip < atm->np; ip++) {
01286
01287     /* Check time... */
01288     if (ctl->atm_filter && (atm->time[ip] < t0 || atm->time[ip] > t1))
01289       continue;
01290
01291     /* Write output... */
01292     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
01293             atm->lon[ip], atm->lat[ip]);
01294     for (iq = 0; iq < ctl->nq; iq++) {
01295       fprintf(out, " ");
01296       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01297     }
01298     fprintf(out, "\n");
01299   }
01300
01301   /* Close file... */
01302   fclose(out);
01303 }
```

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 1307 of file libtrac.c.

```
01311           {
01312
01313   static FILE *in, *out;
01314
01315   static char line[LEN];
01316
01317   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
01318     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
01319
01320   static int init, obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
01321
01322   /* Init... */
01323   if (!init) {
01324     init = 1;
01325
01326     /* Check quantity index for mass... */
01327     if (ctl->qnt_m < 0)
01328       ERRMSG("Need quantity mass to analyze CSI!");
01329
01330     /* Open observation data file... */
01331     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
01332     if (!(in = fopen(ctl->csi_obsfile, "r")))
01333       ERRMSG("Cannot open file!");
01334
01335     /* Create new file... */
01336     printf("Write CSI data: %s\n", filename);
01337     if (!(out = fopen(filename, "w")))
01338       ERRMSG("Cannot create file!");
01339
01340     /* Write header... */
01341     fprintf(out,
01342             "# $1 = time [s]\n"
01343             "# $2 = number of hits (cx)\n"
01344             "# $3 = number of misses (cy)\n"
01345             "# $4 = number of false alarms (cz)\n"
01346             "# $5 = number of observations (cx + cy)\n"
01347             "# $6 = number of forecasts (cx + cz)\n"
01348             "# $7 = bias (forecasts/observations) [%%]\n"
01349             "# $8 = probability of detection (POD) [%%]\n"
01350             "# $9 = false alarm rate (FAR) [%%]\n"
01351             "# $10 = critical success index (CSI) [%%]\n\n");
01352   }
01353
01354   /* Set time interval... */
01355   t0 = t - 0.5 * ctl->dt_mod;
01356   t1 = t + 0.5 * ctl->dt_mod;
01357
01358   /* Initialize grid cells... */
01359   for (ix = 0; ix < ctl->csi_nx; ix++)
01360     for (iy = 0; iy < ctl->csi_ny; iy++)
01361       for (iz = 0; iz < ctl->csi_nz; iz++)
01362         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
01363
01364   /* Read data... */
01365   while (fgets(line, LEN, in)) {
01366
01367     /* Read data... */
01368     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
01369         5)
01370       continue;
01371
01372     /* Check time... */
01373     if (rt < t0)
01374       continue;
01375     if (rt > t1)
01376       break;
01377
01378     /* Calculate indices... */
01379     ix = (int) ((rlon - ctl->csi_lon0)
01380                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01381     iy = (int) ((rlat - ctl->csi_lat0)
01382                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01383     iz = (int) ((rz - ctl->csi_z0)
01384                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01385
01386     /* Check indices... */
01387     if (ix < 0 || ix >= ctl->csi_nx ||
```

```
01388         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01389       continue;
01390
01391     /* Get mean observation index... */
01392     obsmean[ix][iy][iz] += robs;
01393     obscount[ix][iy][iz]++;
01394   }
01395
01396   /* Analyze model data... */
01397   for (ip = 0; ip < atm->np; ip++) {
01398
01399     /* Check time... */
01400     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01401       continue;
01402
01403     /* Get indices... */
01404     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
01405                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01406     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
01407                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01408     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
01409                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01410
01411     /* Check indices... */
01412     if (ix < 0 || ix >= ctl->csi_nx ||
01413         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01414       continue;
01415
01416     /* Get total mass in grid cell... */
01417     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01418   }
01419
01420   /* Analyze all grid cells... */
01421   for (ix = 0; ix < ctl->csi_nx; ix++)
01422     for (iy = 0; iy < ctl->csi_ny; iy++)
01423       for (iz = 0; iz < ctl->csi_nz; iz++) {
01424
01425         /* Calculate mean observation index... */
01426         if (obscount[ix][iy][iz] > 0)
01427           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
01428
01429         /* Calculate column density... */
01430         if (modmean[ix][iy][iz] > 0) {
01431           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
01432           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
01433           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
01434           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
01435             * cos(lat * M_PI / 180.);
01436           modmean[ix][iy][iz] /= (1e6 * area);
01437         }
01438
01439         /* Calculate CSI... */
01440         if (obscount[ix][iy][iz] > 0) {
01441           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01442               modmean[ix][iy][iz] >= ctl->csi_modmin)
01443             cx++;
01444           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01445                    modmean[ix][iy][iz] < ctl->csi_modmin)
01446             cy++;
01447           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
01448                    modmean[ix][iy][iz] >= ctl->csi_modmin)
01449             cz++;
01450         }
01451       }
01452
01453   /* Write output... */
01454   if (fmod(t, ctl->csi_dt_out) == 0) {
01455
01456     /* Write... */
01457     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
01458             t, cx, cy, cz, cx + cy, cx + cz,
01459             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
01460             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
01461             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
01462             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
01463
01464     /* Set counters to zero... */
01465     cx = cy = cz = 0;
01466   }
01467
01468   /* Close file... */
01469   if (t == ctl->t_stop)
01470     fclose(out);
01471 }
```

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

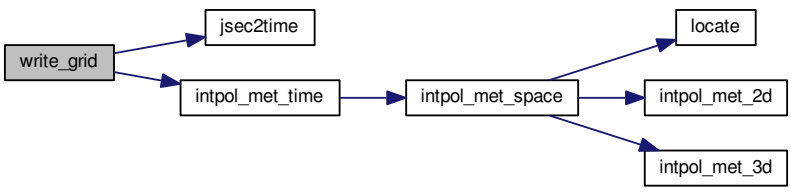
Write gridded data.

Definition at line 1475 of file libtrac.c.

```
01481            {
01482
01483   FILE *in, *out;
01484
01485   char line[LEN];
01486
01487   static double grid_m[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
01488     area, rho_air, press, temp, cd, mmr, t0, t1, r;
01489
01490   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
01491
01492   /* Check dimensions... */
01493   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
01494     ERRMSG("Grid dimensions too large!");
01495
01496   /* Check quantity index for mass... */
01497   if (ctl->qnt_m < 0)
01498     ERRMSG("Need quantity mass to write grid data!");
01499
01500   /* Set time interval for output... */
01501   t0 = t - 0.5 * ctl->dt_mod;
01502   t1 = t + 0.5 * ctl->dt_mod;
01503
01504   /* Set grid box size... */
01505   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
01506   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
01507   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
01508
01509   /* Initialize grid... */
01510   for (ix = 0; ix < ctl->grid_nx; ix++)
01511     for (iy = 0; iy < ctl->grid_ny; iy++)
01512       for (iz = 0; iz < ctl->grid_nz; iz++)
01513         grid_m[ix][iy][iz] = 0;
01514
01515   /* Average data... */
01516   for (ip = 0; ip < atm->np; ip++)
01517     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
01518
01519       /* Get index... */
01520       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
01521       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
01522       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
01523
01524       /* Check indices... */
01525       if (ix < 0 || ix >= ctl->grid_nx ||
01526           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
01527         continue;
01528
01529       /* Add mass... */
01530       grid_m[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01531     }
01532
01533   /* Check if gnuplot output is requested... */
01534   if (ctl->grid_gpfile[0] != '-') {
01535
01536     /* Write info... */
01537     printf("Plot grid data: %s.png\n", filename);
01538
01539     /* Create gnuplot pipe... */
01540     if (!(out = popen("gnuplot", "w")))
01541       ERRMSG("Cannot create pipe to gnuplot!");
01542
01543     /* Set plot filename... */
01544     fprintf(out, "set out \"%s.png\"\n", filename);
01545
01546     /* Set time string... */
01547     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01548     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01549             year, mon, day, hour, min);
01550
01551     /* Dump gnuplot file to pipe... */
01552     if (!(in = fopen(ctl->grid_gpfile, "r")))
01553       ERRMSG("Cannot open file!");
01554     while (fgets(line, LEN, in))
01555       fprintf(out, "%s", line);
01556     fclose(in);
01557   }
```

```
01558
01559   else {
01560
01561     /* Write info... */
01562     printf("Write grid data: %s\n", filename);
01563
01564     /* Create file... */
01565     if (!(out = fopen(filename, "w")))
01566       ERRMSG("Cannot create file!");
01567   }
01568
01569   /* Write header... */
01570   fprintf(out,
01571           "# $1 = time [s]\n"
01572           "# $2 = altitude [km]\n"
01573           "# $3 = longitude [deg]\n"
01574           "# $4 = latitude [deg]\n"
01575           "# $5 = surface area [km^2]\n"
01576           "# $6 = layer width [km]\n"
01577           "# $7 = temperature [K]\n"
01578           "# $8 = column density [kg/m^2]\n"
01579           "# $9 = mass mixing ratio [1]\n\n");
01580
01581   /* Write data... */
01582   for (ix = 0; ix < ctl->grid_nx; ix++) {
01583     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
01584       fprintf(out, "\n");
01585     for (iy = 0; iy < ctl->grid_ny; iy++) {
01586       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
01587         fprintf(out, "\n");
01588       for (iz = 0; iz < ctl->grid_nz; iz++)
01589         if (!ctl->grid_sparse
01590             || ix == 0 || iy == 0 || iz == 0 || grid_m[ix][iy][iz] > 0) {
01591
01592           /* Set coordinates... */
01593           z = ctl->grid_z0 + dz * (iz + 0.5);
01594           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
01595           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
01596
01597           /* Get pressure and temperature... */
01598           press = P(z);
01599           intpol_met_time(met0, met1, t, press, lon, lat,
01600                           NULL, &temp, NULL, NULL, NULL, NULL, NULL);
01601
01602           /* Calculate surface area... */
01603           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
01604             * cos(lat * M_PI / 180.);
01605
01606           /* Calculate column density... */
01607           cd = grid_m[ix][iy][iz] / (1e6 * area);
01608
01609           /* Calculate mass mixing ratio... */
01610           rho_air = 100. * press / (287.058 * temp);
01611           mmr = grid_m[ix][iy][iz] / (rho_air * 1e6 * area * 1e3 * dz);
01612
01613           /* Write output... */
01614           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01615                   t, z, lon, lat, area, dz, temp, cd, mmr);
01616         }
01617     }
01618   }
01619
01620   /* Close file... */
01621   fclose(out);
01622 }
```

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*)

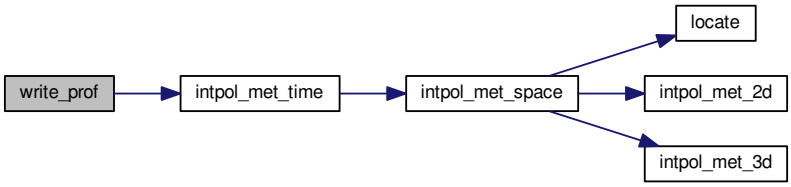
Write profile data.

Definition at line 1626 of file libtrac.c.

```
01632           {
01633
01634   static FILE *in, *out;
01635
01636   static char line[LEN];
01637
01638   static double mass[GX][GY][GZ], obsmean[GX][GY], tmean[GX][GY],
01639     rt, rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z,
01640     press, temp, rho_air, mmr, h2o, o3;
01641
01642   static int init, obscount[GX][GY], ip, ix, iy, iz;
01643
01644   /* Init... */
01645   if (!init) {
01646     init = 1;
01647
01648     /* Check quantity index for mass... */
01649     if (ctl->qnt_m < 0)
01650       ERRMSG("Need quantity mass!");
01651
01652     /* Check dimensions... */
01653     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
01654       ERRMSG("Grid dimensions too large!");
01655
01656     /* Open observation data file... */
01657     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
01658     if (!(in = fopen(ctl->prof_obsfile, "r")))
01659       ERRMSG("Cannot open file!");
01660
01661     /* Create new file... */
01662     printf("Write profile data: %s\n", filename);
01663     if (!(out = fopen(filename, "w")))
01664       ERRMSG("Cannot create file!");
01665
01666     /* Write header... */
01667     fprintf(out,
01668             "# $1  = time [s]\n"
01669             "# $2  = altitude [km]\n"
01670             "# $3  = longitude [deg]\n"
01671             "# $4  = latitude [deg]\n"
01672             "# $5  = pressure [hPa]\n"
01673             "# $6  = temperature [K]\n"
01674             "# $7  = mass mixing ratio [1]\n"
01675             "# $8  = H2O volume mixing ratio [1]\n"
01676             "# $9  = O3 volume mixing ratio [1]\n"
01677             "# $10 = mean BT index [K]\n");
01678
01679     /* Set grid box size... */
01680     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
01681     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
01682     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
01683   }
01684
01685   /* Set time interval... */
01686   t0 = t - 0.5 * ctl->dt_mod;
01687   t1 = t + 0.5 * ctl->dt_mod;
01688
01689   /* Initialize... */
01690   for (ix = 0; ix < ctl->prof_nx; ix++)
01691     for (iy = 0; iy < ctl->prof_ny; iy++) {
01692       obsmean[ix][iy] = 0;
01693       obscount[ix][iy] = 0;
01694       tmean[ix][iy] = 0;
01695       for (iz = 0; iz < ctl->prof_nz; iz++)
01696         mass[ix][iy][iz] = 0;
01697     }
01698
01699   /* Read data... */
01700   while (fgets(line, LEN, in)) {
01701
01702     /* Read data... */
01703     if (sscanf(line, "%lg %lg %lg %lg", &rt, &rlon, &rlat, &robs) != 4)
01704       continue;
01705
01706     /* Check time... */
01707     if (rt < t0)
01708       continue;
```

```
01709     if (rt > t1)
01710       break;
01711
01712     /* Calculate indices... */
01713     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
01714     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
01715
01716     /* Check indices... */
01717     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
01718       continue;
01719
01720     /* Get mean observation index... */
01721     obsmean[ix][iy] += robs;
01722     tmean[ix][iy] += rt;
01723     obscount[ix][iy]++;
01724   }
01725
01726   /* Analyze model data... */
01727   for (ip = 0; ip < atm->np; ip++) {
01728
01729     /* Check time... */
01730     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01731       continue;
01732
01733     /* Get indices... */
01734     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
01735     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
01736     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
01737
01738     /* Check indices... */
01739     if (ix < 0 || ix >= ctl->prof_nx ||
01740         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
01741       continue;
01742
01743     /* Get total mass in grid cell... */
01744     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01745   }
01746
01747   /* Extract profiles... */
01748   for (ix = 0; ix < ctl->prof_nx; ix++)
01749     for (iy = 0; iy < ctl->prof_ny; iy++)
01750       if (obscount[ix][iy] > 0) {
01751
01752         /* Write output... */
01753         fprintf(out, "\n");
01754
01755         /* Loop over altitudes... */
01756         for (iz = 0; iz < ctl->prof_nz; iz++) {
01757
01758           /* Set coordinates... */
01759           z = ctl->prof_z0 + dz * (iz + 0.5);
01760           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
01761           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
01762
01763           /* Get meteorological data... */
01764           press = P(z);
01765           intpol_met_time(met0, met1, t, press, lon, lat,
01766                           NULL, &temp, NULL, NULL, NULL, &h2o, &o3);
01767
01768           /* Calculate mass mixing ratio... */
01769           rho_air = 100. * press / (287.058 * temp);
01770           area = dlat * dlon * gsl_pow_2(M_PI * RE / 180.)
01771             * cos(lat * M_PI / 180.);
01772           mmr = mass[ix][iy][iz] / (rho_air * area * dz * 1e9);
01773
01774           /* Write output... */
01775           fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g\n",
01776                   tmean[ix][iy] / obscount[ix][iy],
01777                   z, lon, lat, press, temp, mmr, h2o, o3,
01778                   obsmean[ix][iy] / obscount[ix][iy]);
01779         }
01780       }
01781
01782   /* Close file... */
01783   if (t == ctl->t_stop)
01784     fclose(out);
01785 }
```

Here is the call graph for this function:



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

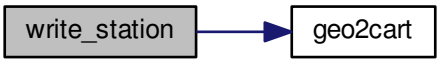
Write station data.

Definition at line 1789 of file libtrac.c.

```
01793           {
01794
01795   static FILE *out;
01796
01797   static double rmax2, t0, t1, x0[3], x1[3];
01798
01799   static int init, ip, iq;
01800
01801   /* Init... */
01802   if (!init) {
01803     init = 1;
01804
01805     /* Write info... */
01806     printf("Write station data: %s\n", filename);
01807
01808     /* Create new file... */
01809     if (!(out = fopen(filename, "w")))
01810       ERRMSG("Cannot create file!");
01811
01812     /* Write header... */
01813     fprintf(out,
01814             "# $1 = time [s]\n"
01815             "# $2 = altitude [km]\n"
01816             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01817     for (iq = 0; iq < ctl->nq; iq++)
01818       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
01819               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
01820     fprintf(out, "\n");
01821
01822     /* Set geolocation and search radius... */
01823     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
01824     rmax2 = gsl_pow_2(ctl->stat_r);
01825   }
01826
01827   /* Set time interval for output... */
01828   t0 = t - 0.5 * ctl->dt_mod;
01829   t1 = t + 0.5 * ctl->dt_mod;
01830
01831   /* Loop over air parcels... */
01832   for (ip = 0; ip < atm->np; ip++) {
01833
01834     /* Check time... */
01835     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01836       continue;
01837
01838     /* Check station flag... */
01839     if (ctl->qnt_stat >= 0)
01840       if (atm->q[ctl->qnt_stat][ip])
01841         continue;
01842
01843     /* Get Cartesian coordinates... */
01844     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
01845
01846     /* Check horizontal distance... */
```

```
01847     if (DIST2(x0, x1) > rmax2)
01848       continue;
01849
01850     /* Set station flag... */
01851     if (ctl->qnt_stat >= 0)
01852       atm->q[ctl->qnt_stat][ip] = 1;
01853
01854     /* Write data... */
01855     fprintf(out, "%.2f %g %g %g",
01856             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
01857     for (iq = 0; iq < ctl->nq; iq++) {
01858       fprintf(out, " ");
01859       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01860     }
01861     fprintf(out, "\n");
01862   }
01863
01864   /* Close file... */
01865   if (t == ctl->t_stop)
01866     fclose(out);
01867 }
```

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_statistics.h>
00040 #include <math.h>
00041 #include <netcdf.h>
00042 #include <omp.h>
00043 #include <stdio.h>
00044 #include <stdlib.h>
00045 #include <string.h>
00046 #include <time.h>
00047 #include <sys/time.h>
00048
00049 /* ------------------------------------------------------------
00050    Macros...
00051    ------------------------------------------------------------ */
00052
00054 #define ALLOC(ptr, type, n)                             \
```

```
00055   if((ptr=calloc((size_t)(n), sizeof(type)))==NULL)      \
00056     ERRMSG("Out of memory!");
00057
00059 #define DIST(a, b) sqrt(DIST2(a, b))
00060
00062 #define DIST2(a, b)                                                  \
00063   ((a[0]-b[0])*(a[0]-b[0])+(a[1]-b[1])*(a[1]-b[1])+(a[2]-b[2])*(a[2]-b[2]))
00064
00066 #define DOTP(a, b) (a[0]*b[0]+a[1]*b[1]+a[2]*b[2])
00067
00069 #define ERRMSG(msg) {                                                \
00070     printf("\nError (%s, %s, l%d): %s\n\n",                          \
00071            __FILE__, __func__, __LINE__, msg);                       \
00072     exit(EXIT_FAILURE);                                              \
00073   }
00074
00076 #define LIN(x0, y0, x1, y1, x)                  \
00077   ((y0)+((y1)-(y0))/((x1)-(x0))*((x)-(x0)))
00078
00080 #define NC(cmd) {                                   \
00081     if((cmd)!=NC_NOERR)                             \
00082       ERRMSG(nc_strerror(cmd));                     \
00083   }
00084
00086 #define NORM(a) sqrt(DOTP(a, a))
00087
00089 #define PRINT(format, var)                                           \
00090   printf("Print (%s, %s, l%d): %s= "format"\n",                      \
00091          __FILE__, __func__, __LINE__, #var, var);
00092
00094 #define P(z) (P0*exp(-(z)/H0))
00095
00097 #define TOK(line, tok, format, var) {                                \
00098     if(((tok)=strtok((line), " \t"))) {                              \
00099       if(sscanf(tok, format, &(var))!=1) continue;                   \
00100     } else ERRMSG("Error while reading!");                           \
00101   }
00102
00104 #define Z(p) (H0*log(P0/(p)))
00105
00107 #define START_TIMER(id) timer(#id, id, 1)
00108
00110 #define STOP_TIMER(id) timer(#id, id, 2)
00111
00113 #define PRINT_TIMER(id) timer(#id, id, 3)
00114
00115 /* ------------------------------------------------------------
00116    Constants...
00117    ------------------------------------------------------------ */
00118
00120 #define G0 9.80665
00121
00123 #define H0 7.0
00124
00126 #define P0 1013.25
00127
00129 #define RE 6367.421
00130
00131 /* ------------------------------------------------------------
00132    Dimensions...
00133    ------------------------------------------------------------ */
00134
00136 #define LEN 5000
00137
00139 #define NP 10000000
00140
00142 #define NQ 10
00143
00145 #define EP 73
00146
00148 #define EX 721
00149
00151 #define EY 361
00152
00154 #define GX 720
00155
00157 #define GY 360
00158
00160 #define GZ 100
00161
00163 #define NTHREADS 128
00164
00166 #define NTIMER 20
00167
00168 /* ------------------------------------------------------------
00169    Structs...
00170    ------------------------------------------------------------ */
```

```
00171
00173 typedef struct {
00174
00176   int nq;
00177
00179   char qnt_name[NQ][LEN];
00180
00182   char qnt_unit[NQ][LEN];
00183
00185   char qnt_format[NQ][LEN];
00186
00188   int qnt_m;
00189
00191   int qnt_rho;
00192
00194   int qnt_r;
00195
00197   int qnt_ps;
00198
00200   int qnt_p;
00201
00203   int qnt_t;
00204
00206   int qnt_u;
00207
00209   int qnt_v;
00210
00212   int qnt_w;
00213
00215   int qnt_h2o;
00216
00218   int qnt_o3;
00219
00221   int qnt_theta;
00222
00224   int qnt_pv;
00225
00227   int qnt_tice;
00228
00230   int qnt_tnat;
00231
00233   int qnt_stat;
00234
00236   int direction;
00237
00239   double t_start;
00240
00242   double t_stop;
00243
00245   double dt_mod;
00246
00248   double dt_met;
00249
00251   int met_np;
00252
00254   double met_p[EP];
00255
00258   int isosurf;
00259
00261   char balloon[LEN];
00262
00264   double turb_dx_trop;
00265
00267   double turb_dx_strat;
00268
00270   double turb_dz_trop;
00271
00273   double turb_dz_strat;
00274
00276   double turb_meso;
00277
00279   double tdec_trop;
00280
00282   double tdec_strat;
00283
00285   char atm_basename[LEN];
00286
00288   char atm_gpfile[LEN];
00289
00291   double atm_dt_out;
00292
00294   int atm_filter;
00295
00297   char csi_basename[LEN];
00298
00300   double csi_dt_out;
00301
```

```
00303   char csi_obsfile[LEN];
00304
00306   double csi_obsmin;
00307
00309   double csi_modmin;
00310
00312   int csi_nz;
00313
00315   double csi_z0;
00316
00318   double csi_z1;
00319
00321   int csi_nx;
00322
00324   double csi_lon0;
00325
00327   double csi_lon1;
00328
00330   int csi_ny;
00331
00333   double csi_lat0;
00334
00336   double csi_lat1;
00337
00339   char grid_basename[LEN];
00340
00342   char grid_gpfile[LEN];
00343
00345   double grid_dt_out;
00346
00348   int grid_sparse;
00349
00351   int grid_nz;
00352
00354   double grid_z0;
00355
00357   double grid_z1;
00358
00360   int grid_nx;
00361
00363   double grid_lon0;
00364
00366   double grid_lon1;
00367
00369   int grid_ny;
00370
00372   double grid_lat0;
00373
00375   double grid_lat1;
00376
00378   char prof_basename[LEN];
00379
00381   char prof_obsfile[LEN];
00382
00384   int prof_nz;
00385
00387   double prof_z0;
00388
00390   double prof_z1;
00391
00393   int prof_nx;
00394
00396   double prof_lon0;
00397
00399   double prof_lon1;
00400
00402   int prof_ny;
00403
00405   double prof_lat0;
00406
00408   double prof_lat1;
00409
00411   char stat_basename[LEN];
00412
00414   double stat_lon;
00415
00417   double stat_lat;
00418
00420   double stat_r;
00421
00422 } ctl_t;
00423
00425 typedef struct {
00426
00428   int np;
00429
00431   double time[NP];
```

```
00432
00434   double p[NP];
00435
00437   double lon[NP];
00438
00440   double lat[NP];
00441
00443   double q[NQ][NP];
00444
00446   double up[NP];
00447
00449   double vp[NP];
00450
00452   double wp[NP];
00453
00454 } atm_t;
00455
00457 typedef struct {
00458
00460   double time;
00461
00463   int nx;
00464
00466   int ny;
00467
00469   int np;
00470
00472   double lon[EX];
00473
00475   double lat[EY];
00476
00478   double p[EP];
00479
00481   double ps[EX][EY];
00482
00484   float pl[EX][EY][EP];
00485
00487   float t[EX][EY][EP];
00488
00490   float u[EX][EY][EP];
00491
00493   float v[EX][EY][EP];
00494
00496   float w[EX][EY][EP];
00497
00499   float h2o[EX][EY][EP];
00500
00502   float o3[EX][EY][EP];
00503
00504 } met_t;
00505
00506 /* ------------------------------------------------------------
00507    Functions...
00508    ------------------------------------------------------------ */
00509
00511 void cart2geo(
00512   double *x,
00513   double *z,
00514   double *lon,
00515   double *lat);
00516
00518 double deg2dx(
00519   double dlon,
00520   double lat);
00521
00523 double deg2dy(
00524   double dlat);
00525
00527 double dp2dz(
00528   double dp,
00529   double p);
00530
00532 double dx2deg(
00533   double dx,
00534   double lat);
00535
00537 double dy2deg(
00538   double dy);
00539
00541 double dz2dp(
00542   double dz,
00543   double p);
00544
00546 void geo2cart(
00547   double z,
00548   double lon,
00549   double lat,
```

```
00550   double *x);
00551
00553 void get_met(
00554   ctl_t * ctl,
00555   char *metbase,
00556   double t,
00557   met_t * met0,
00558   met_t * met1);
00559
00561 void get_met_help(
00562   double t,
00563   int direct,
00564   char *metbase,
00565   double dt_met,
00566   char *filename);
00567
00569 void intpol_met_2d(
00570   double array[EX][EY],
00571   int ix,
00572   int iy,
00573   double wx,
00574   double wy,
00575   double *var);
00576
00578 void intpol_met_3d(
00579   float array[EX][EY][EP],
00580   int ip,
00581   int ix,
00582   int iy,
00583   double wp,
00584   double wx,
00585   double wy,
00586   double *var);
00587
00589 void intpol_met_space(
00590   met_t * met,
00591   double p,
00592   double lon,
00593   double lat,
00594   double *ps,
00595   double *t,
00596   double *u,
00597   double *v,
00598   double *w,
00599   double *h2o,
00600   double *o3);
00601
00603 void intpol_met_time(
00604   met_t * met0,
00605   met_t * met1,
00606   double ts,
00607   double p,
00608   double lon,
00609   double lat,
00610   double *ps,
00611   double *t,
00612   double *u,
00613   double *v,
00614   double *w,
00615   double *h2o,
00616   double *o3);
00617
00619 void jsec2time(
00620   double jsec,
00621   int *year,
00622   int *mon,
00623   int *day,
00624   int *hour,
00625   int *min,
00626   int *sec,
00627   double *remain);
00628
00630 int locate(
00631   double *xx,
00632   int n,
00633   double x);
00634
00636 void read_atm(
00637   const char *filename,
00638   ctl_t * ctl,
00639   atm_t * atm);
00640
00642 void read_ctl(
00643   const char *filename,
00644   int argc,
00645   char *argv[],
00646   ctl_t * ctl);
```

```
00647
00649 void read_met(
00650   ctl_t * ctl,
00651   char *filename,
00652   met_t * met);
00653
00655 void read_met_extrapolate(
00656   met_t * met);
00657
00659 void read_met_help(
00660   int ncid,
00661   char *varname,
00662   char *varname2,
00663   met_t * met,
00664   float dest[EX][EY][EP],
00665   float scl);
00666
00668 void read_met_ml2pl(
00669   ctl_t * ctl,
00670   met_t * met,
00671   float var[EX][EY][EP]);
00672
00674 void read_met_periodic(
00675   met_t * met);
00676
00678 double scan_ctl(
00679   const char *filename,
00680   int argc,
00681   char *argv[],
00682   const char *varname,
00683   int arridx,
00684   const char *defvalue,
00685   char *value);
00686
00688 void time2jsec(
00689   int year,
00690   int mon,
00691   int day,
00692   int hour,
00693   int min,
00694   int sec,
00695   double remain,
00696   double *jsec);
00697
00699 void timer(
00700   const char *name,
00701   int id,
00702   int mode);
00703
00704 /* Get tropopause pressure... */
00705 double tropopause(
00706   double t,
00707   double lat);
00708
00710 void write_atm(
00711   const char *filename,
00712   ctl_t * ctl,
00713   atm_t * atm,
00714   double t);
00715
00717 void write_csi(
00718   const char *filename,
00719   ctl_t * ctl,
00720   atm_t * atm,
00721   double t);
00722
00724 void write_grid(
00725   const char *filename,
00726   ctl_t * ctl,
00727   met_t * met0,
00728   met_t * met1,
00729   atm_t * atm,
00730   double t);
00731
00733 void write_prof(
00734   const char *filename,
00735   ctl_t * ctl,
00736   met_t * met0,
00737   met_t * met1,
00738   atm_t * atm,
00739   double t);
00740
00742 void write_station(
00743   const char *filename,
00744   ctl_t * ctl,
00745   atm_t * atm,
00746   double t);
```

5.15 match.c File Reference

Calculate deviations between two trajectories.

Functions

- int main (int argc, char ∗argv[ ])

5.15.1 Detailed Description

Calculate deviations between two trajectories.

Definition in file match.c.

5.15.2 Function Documentation

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

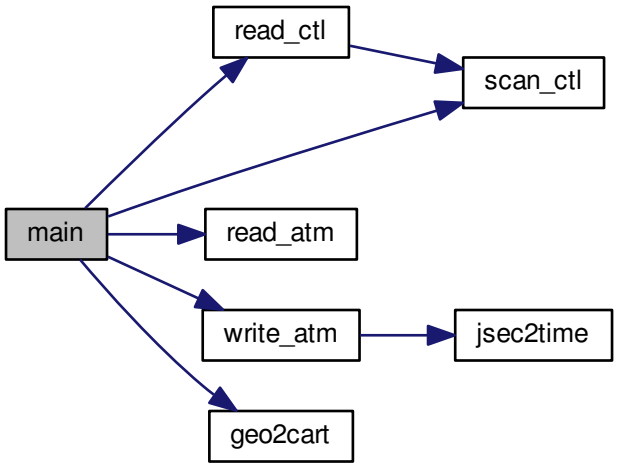
Definition at line 28 of file match.c.

```
00030                {
00031
00032   ctl_t ctl;
00033
00034   atm_t *atm1, *atm2, *atm3;
00035
00036   FILE *out;
00037
00038   char filename[LEN];
00039
00040   double filter_dt, x1[3], x2[3], dh, dq[NQ], dv, lh = 0, lt = 0, lv = 0;
00041
00042   int filter, ip1, ip2, iq, n;
00043
00044   /* Allocate... */
00045   ALLOC(atm1, atm_t, 1);
00046   ALLOC(atm2, atm_t, 1);
00047   ALLOC(atm3, atm_t, 1);
00048
00049   /* Check arguments... */
00050   if (argc < 5)
00051     ERRMSG("Give parameters: <ctl> <atm_test> <atm_ref> <outfile>");
00052
00053   /* Read control parameters... */
00054   read_ctl(argv[1], argc, argv, &ctl);
00055   filter = (int) scan_ctl(argv[1], argc, argv, "FILTER", -1, "0", NULL);
00056   filter_dt = scan_ctl(argv[1], argc, argv, "FILTER_DT", -1, "0", NULL);
00057
00058   /* Read atmospheric data... */
00059   read_atm(argv[2], &ctl, atm1);
00060   read_atm(argv[3], &ctl, atm2);
00061
00062   /* Write info... */
00063   printf("Write transport deviations: %s\n", argv[4]);
00064
00065   /* Create output file... */
00066   if (!(out = fopen(argv[4], "w")))
00067     ERRMSG("Cannot create file!");
00068
00069   /* Write header... */
00070   fprintf(out,
00071           "# $1 = time [s]\n"
00072           "# $2 = altitude [km]\n"
00073           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
00074   for (iq = 0; iq < ctl.nq; iq++)
00075     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl.qnt_name[iq],
00076             ctl.qnt_unit[iq]);
00077   fprintf(out,
```

```
00078           "# $%d = trajectory time [s]\n"
00079           "# $%d = vertical length of trajectory [km]\n"
00080           "# $%d = horizontal length of trajectory [km]\n"
00081           "# $%d = vertical deviation [km]\n"
00082           "# $%d = horizontal deviation [km]\n",
00083           5 + ctl.nq, 6 + ctl.nq, 7 + ctl.nq, 8 + ctl.nq, 9 + ctl.nq);
00084   for (iq = 0; iq < ctl.nq; iq++)
00085     fprintf(out, "# $%d = %s deviation [%s]\n", ctl.nq + iq + 10,
00086             ctl.qnt_name[iq], ctl.qnt_unit[iq]);
00087   fprintf(out, "\n");
00088
00089   /* Filtering of reference time series... */
00090   if (filter) {
00091
00092     /* Copy data... */
00093     memcpy(atm3, atm2, sizeof(atm_t));
00094
00095     /* Loop over data points... */
00096     for (ip1 = 0; ip1 < atm2->np; ip1++) {
00097       n = 0;
00098       atm2->p[ip1] = 0;
00099       for (iq = 0; iq < ctl.nq; iq++)
00100         atm2->q[iq][ip1] = 0;
00101       for (ip2 = 0; ip2 < atm2->np; ip2++)
00102         if (fabs(atm2->time[ip1] - atm2->time[ip2]) < filter_dt) {
00103           atm2->p[ip1] += atm3->p[ip2];
00104           for (iq = 0; iq < ctl.nq; iq++)
00105             atm2->q[iq][ip1] += atm3->q[iq][ip2];
00106           n++;
00107         }
00108       atm2->p[ip1] /= n;
00109       for (iq = 0; iq < ctl.nq; iq++)
00110         atm2->q[iq][ip1] /= n;
00111     }
00112
00113     /* Write filtered data... */
00114     sprintf(filename, "%s.filt", argv[3]);
00115     write_atm(filename, &ctl, atm2, 0);
00116   }
00117
00118   /* Loop over air parcels (reference data)... */
00119   for (ip2 = 0; ip2 < atm2->np; ip2++) {
00120
00121     /* Get trajectory length... */
00122     if (ip2 > 0) {
00123       geo2cart(0, atm2->lon[ip2 - 1], atm2->lat[ip2 - 1], x1);
00124       geo2cart(0, atm2->lon[ip2], atm2->lat[ip2], x2);
00125       lh += DIST(x1, x2);
00126       lv += fabs(Z(atm2->p[ip2 - 1]) - Z(atm2->p[ip2]));
00127       lt = fabs(atm2->time[ip2] - atm2->time[0]);
00128     }
00129
00130     /* Init... */
00131     n = 0;
00132     dh = 0;
00133     dv = 0;
00134     for (iq = 0; iq < ctl.nq; iq++)
00135       dq[iq] = 0;
00136     geo2cart(0, atm2->lon[ip2], atm2->lat[ip2], x2);
00137
00138     /* Find corresponding time step (test data)... */
00139     for (ip1 = 0; ip1 < atm1->np; ip1++)
00140       if (fabs(atm1->time[ip1] - atm2->time[ip2])
00141           < (filter ? filter_dt : 0.1)) {
00142
00143         /* Calculate deviations... */
00144         geo2cart(0, atm1->lon[ip1], atm1->lat[ip1], x1);
00145         dh += DIST(x1, x2);
00146         dv += Z(atm1->p[ip1]) - Z(atm2->p[ip2]);
00147         for (iq = 0; iq < ctl.nq; iq++)
00148           dq[iq] += atm1->q[iq][ip1] - atm2->q[iq][ip2];
00149         n++;
00150       }
00151
00152     /* Write output... */
00153     if (n > 0) {
00154       fprintf(out, "%.2f %.4f %.4f %.4f",
00155               atm2->time[ip2], Z(atm2->p[ip2]),
00156               atm2->lon[ip2], atm2->lat[ip2]);
00157       for (iq = 0; iq < ctl.nq; iq++) {
00158         fprintf(out, " ");
00159         fprintf(out, ctl.qnt_format[iq], atm2->q[iq][ip2]);
00160       }
00161       fprintf(out, " %.2f %g %g %g %g", lt, lv, lh, dv / n, dh / n);
00162       for (iq = 0; iq < ctl.nq; iq++) {
00163         fprintf(out, " ");
00164         fprintf(out, ctl.qnt_format[iq], dq[iq] / n);
```

```
00165       }
00166       fprintf(out, "\n");
00167     }
00168   }
00169
00170   /* Close file... */
00171   fclose(out);
00172
00173   /* Free... */
00174   free(atm1);
00175   free(atm2);
00176   free(atm3);
00177
00178   return EXIT_SUCCESS;
00179 }
```

Here is the call graph for this function:



5.16 match.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026 #include <gsl/gsl_sort.h>
00027
00028 int main(
00029   int argc,
00030   char *argv[]) {
00031
```

```
00032   ctl_t ctl;
00033
00034   atm_t *atm1, *atm2, *atm3;
00035
00036   FILE *out;
00037
00038   char filename[LEN];
00039
00040   double filter_dt, x1[3], x2[3], dh, dq[NQ], dv, lh = 0, lt = 0, lv = 0;
00041
00042   int filter, ip1, ip2, iq, n;
00043
00044   /* Allocate... */
00045   ALLOC(atm1, atm_t, 1);
00046   ALLOC(atm2, atm_t, 1);
00047   ALLOC(atm3, atm_t, 1);
00048
00049   /* Check arguments... */
00050   if (argc < 5)
00051     ERRMSG("Give parameters: <ctl> <atm_test> <atm_ref> <outfile>");
00052
00053   /* Read control parameters... */
00054   read_ctl(argv[1], argc, argv, &ctl);
00055   filter = (int) scan_ctl(argv[1], argc, argv, "FILTER", -1, "0", NULL);
00056   filter_dt = scan_ctl(argv[1], argc, argv, "FILTER_DT", -1, "0", NULL);
00057
00058   /* Read atmospheric data... */
00059   read_atm(argv[2], &ctl, atm1);
00060   read_atm(argv[3], &ctl, atm2);
00061
00062   /* Write info... */
00063   printf("Write transport deviations: %s\n", argv[4]);
00064
00065   /* Create output file... */
00066   if (!(out = fopen(argv[4], "w")))
00067     ERRMSG("Cannot create file!");
00068
00069   /* Write header... */
00070   fprintf(out,
00071           "# $1 = time [s]\n"
00072           "# $2 = altitude [km]\n"
00073           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
00074   for (iq = 0; iq < ctl.nq; iq++)
00075     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl.qnt_name[iq],
00076             ctl.qnt_unit[iq]);
00077   fprintf(out,
00078           "# $%d = trajectory time [s]\n"
00079           "# $%d = vertical length of trajectory [km]\n"
00080           "# $%d = horizontal length of trajectory [km]\n"
00081           "# $%d = vertical deviation [km]\n"
00082           "# $%d = horizontal deviation [km]\n",
00083           5 + ctl.nq, 6 + ctl.nq, 7 + ctl.nq, 8 + ctl.nq, 9 + ctl.nq);
00084   for (iq = 0; iq < ctl.nq; iq++)
00085     fprintf(out, "# $%d = %s deviation [%s]\n", ctl.nq + iq + 10,
00086             ctl.qnt_name[iq], ctl.qnt_unit[iq]);
00087   fprintf(out, "\n");
00088
00089   /* Filtering of reference time series... */
00090   if (filter) {
00091
00092     /* Copy data... */
00093     memcpy(atm3, atm2, sizeof(atm_t));
00094
00095     /* Loop over data points... */
00096     for (ip1 = 0; ip1 < atm2->np; ip1++) {
00097       n = 0;
00098       atm2->p[ip1] = 0;
00099       for (iq = 0; iq < ctl.nq; iq++)
00100         atm2->q[iq][ip1] = 0;
00101       for (ip2 = 0; ip2 < atm2->np; ip2++)
00102         if (fabs(atm2->time[ip1] - atm2->time[ip2]) < filter_dt) {
00103           atm2->p[ip1] += atm3->p[ip2];
00104           for (iq = 0; iq < ctl.nq; iq++)
00105             atm2->q[iq][ip1] += atm3->q[iq][ip2];
00106           n++;
00107         }
00108       atm2->p[ip1] /= n;
00109       for (iq = 0; iq < ctl.nq; iq++)
00110         atm2->q[iq][ip1] /= n;
00111     }
00112
00113     /* Write filtered data... */
00114     sprintf(filename, "%s.filt", argv[3]);
00115     write_atm(filename, &ctl, atm2, 0);
00116   }
00117
00118   /* Loop over air parcels (reference data)... */
```

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

5.17 met_map.c File Reference

Extract global map from meteorological data.

Functions

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

5.17.1 Detailed Description

Extract global map from meteorological data.

Definition in file met_map.c.

5.17.2 Function Documentation

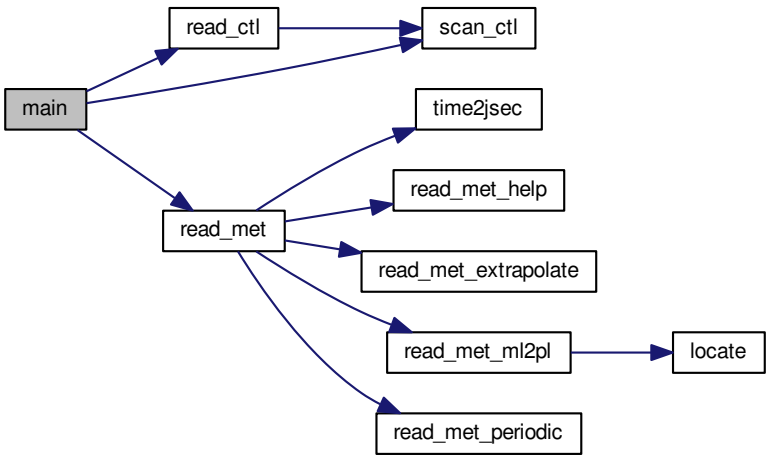
5.17.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file met_map.c.

```
00029                {
00030
00031   ctl_t ctl;
00032
00033   met_t *met;
00034
00035   FILE *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\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\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

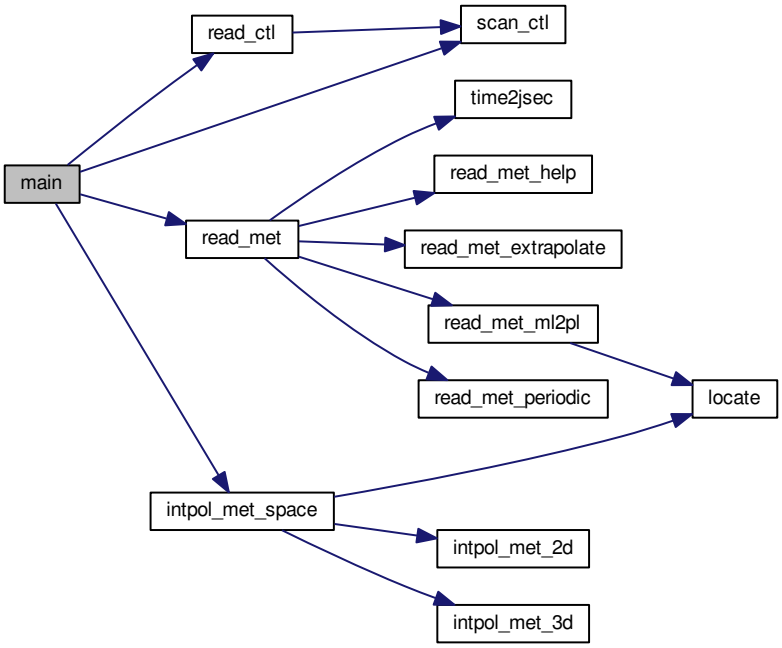
5.19.2.1 int main (int *argc*, char * *argv[]*)

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 %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.

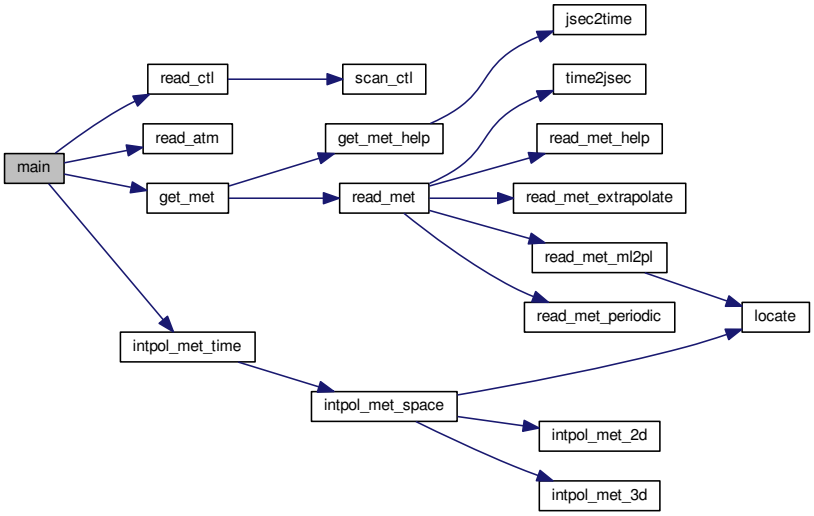
5.21.2 Function Documentation

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

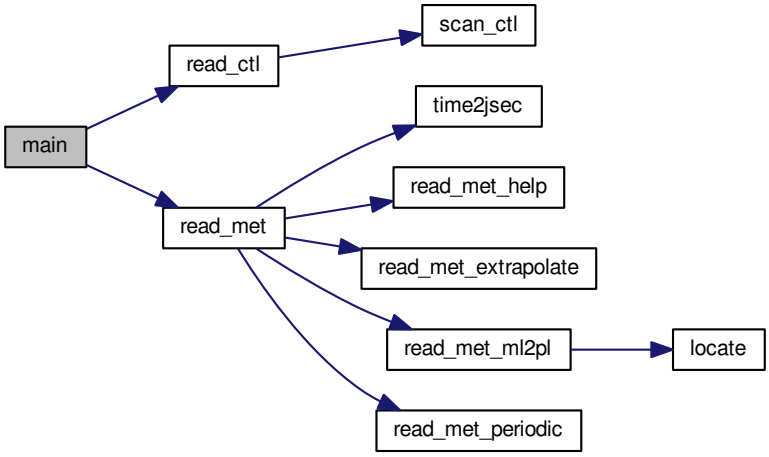
5.23.2.1 int main (int *argc*, char * *argv[]*)

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   Copyright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   ctl_t ctl;
00032
00033   met_t *met;
00034
00035   FILE *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

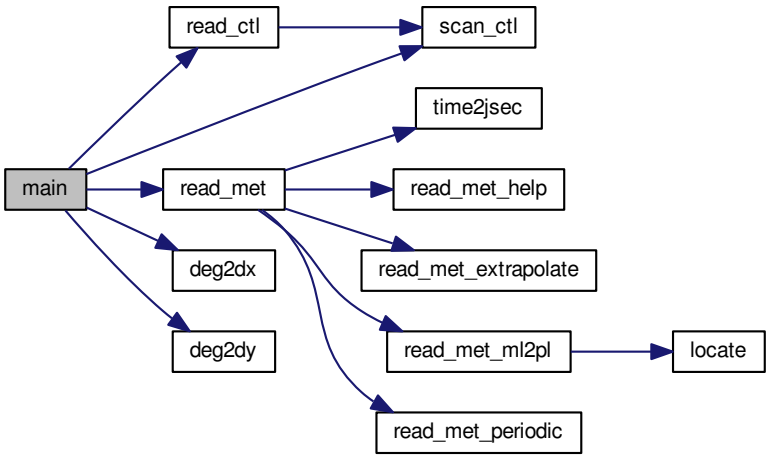
5.25.2.1 int main (int *argc*, char ∗ *argv[ ]*)

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

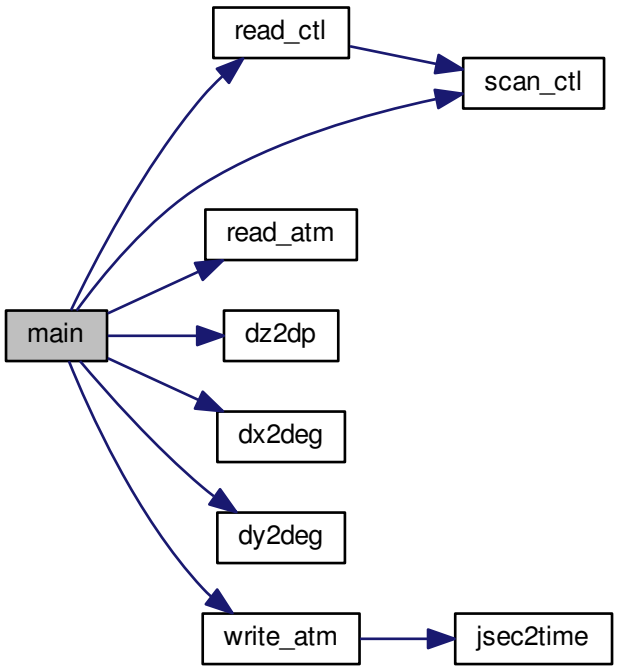
5.27.2.1 int main (int *argc*, char * *argv[]*)

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.

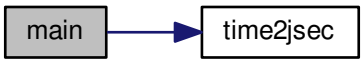
5.29.2 Function Documentation

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 }
```

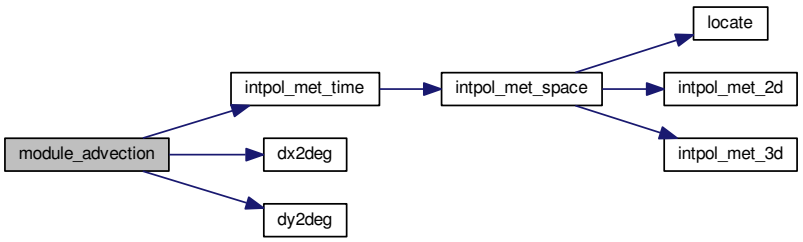
5.31.2.2 void module_advection (met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt*)

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:



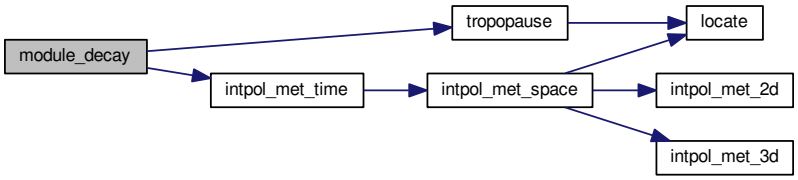
5.31.2.3 void module_decay (ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt*)

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*)

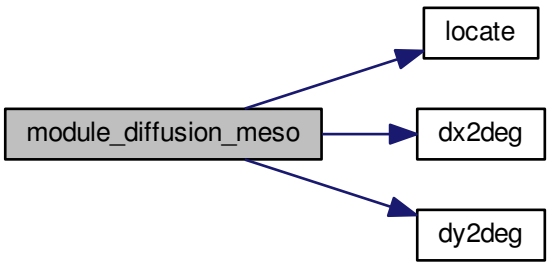
Calculate mesoscale diffusion.

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*)

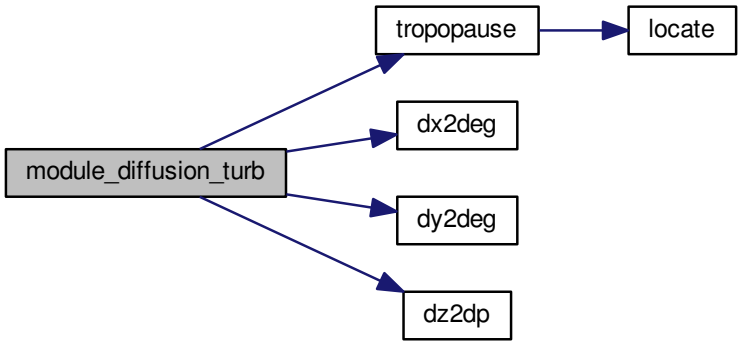
Calculate turbulent diffusion.

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*)

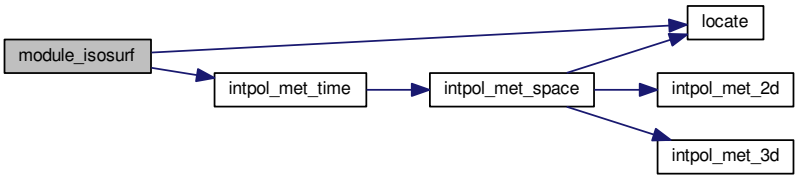
Force air parcels to stay on isosurface.

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*)

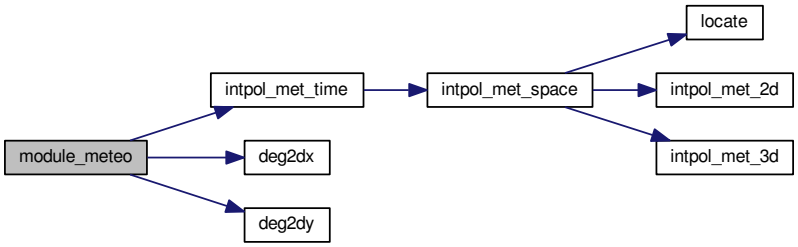
Interpolate meteorological data for air parcel positions.

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*)

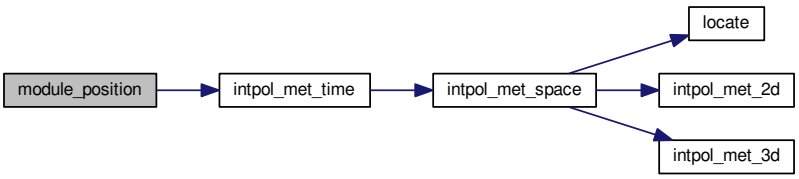
Check position of air parcels.

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*)

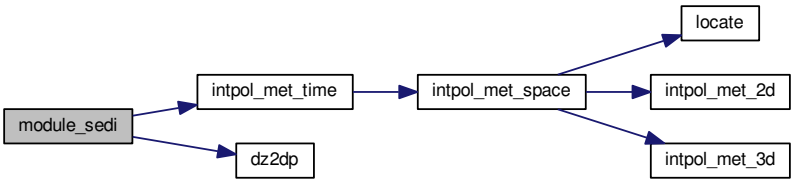
Calculate sedimentation of air parcels.

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*)

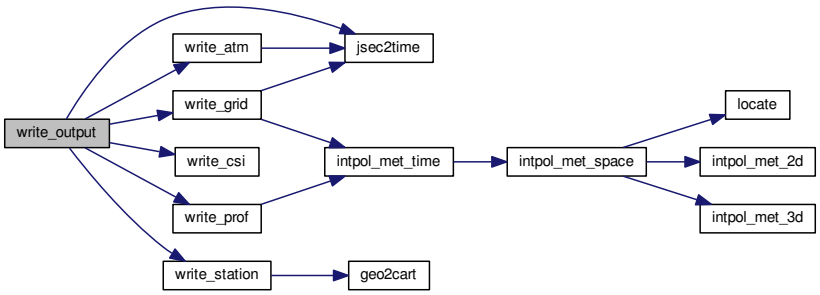
Write simulation output.

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 station data... */
01021   if (ctl->stat_basename[0] != '-') {
01022     sprintf(filename, "%s/%s.tab", dirname, ctl->stat_basename);
01023     write_station(filename, ctl, atm, t);
01024   }
01025 }
```

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.

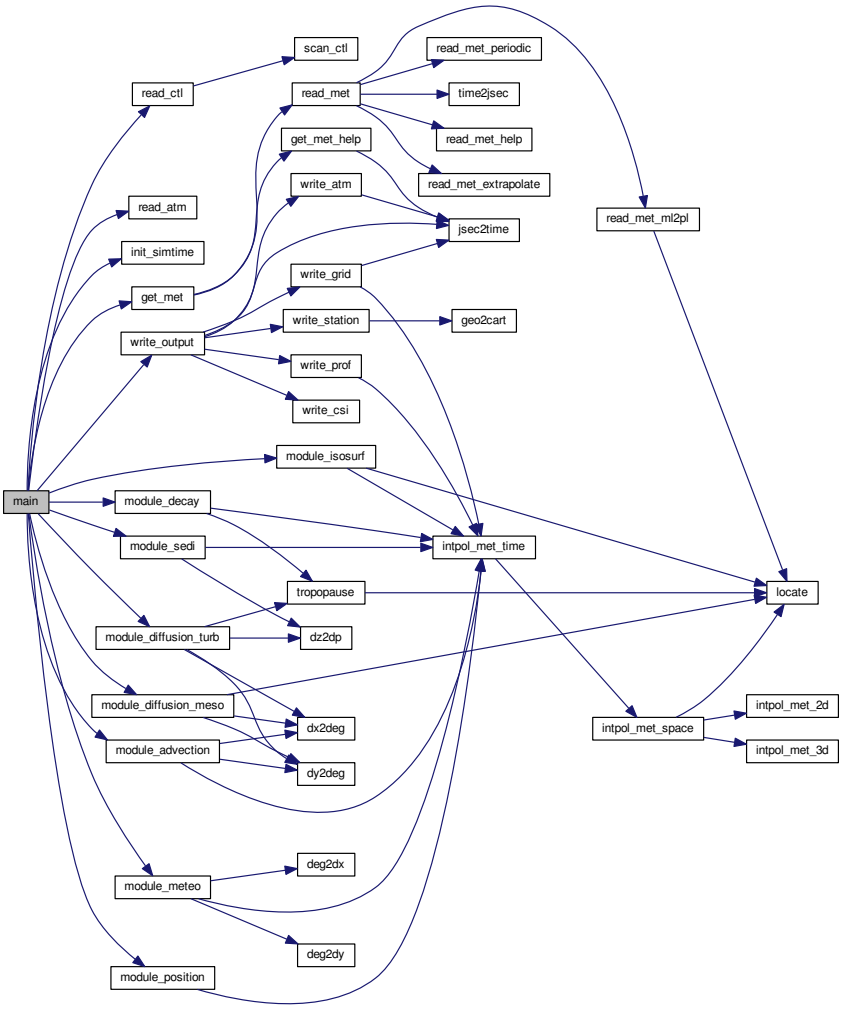
```
00162                {
00163
00164   ctl_t ctl;
00165
00166   atm_t *atm;
00167
00168   met_t *met0, *met1;
00169
00170   gsl_rng *rng[NTHREADS];
00171
00172   FILE *dirlist;
00173
00174   char dirname[LEN], filename[LEN];
00175
00176   double *dt, t, t0;
00177
00178   int i, ip, ntask = 0, rank = 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   Copright (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, 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 station data... */
01021   if (ctl->stat_basename[0] != '-') {
01022     sprintf(filename, "%s/%s.tab", dirname, ctl->stat_basename);
01023     write_station(filename, ctl, atm, t);
01024   }
01025 }
```

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 }
```

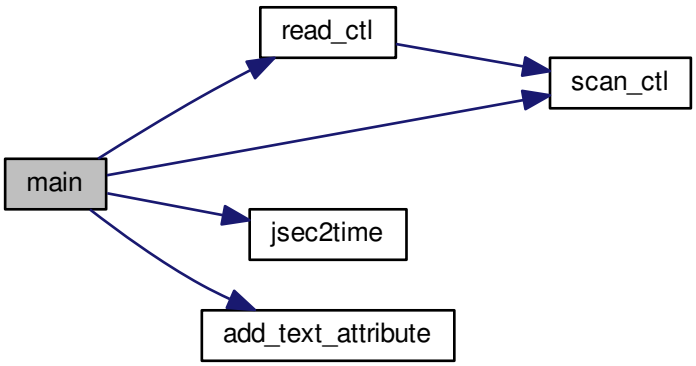
5.33.2.2 int main (int *argc*, char * *argv[]*)

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
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00012   GNU General Public License for more details.
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00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 /* ------------------------------------------------------------
00028    Functions...
00029    ------------------------------------------------------------ */
00030
00031 void add_text_attribute(
00032   int ncid,
00033   char *varname,
00034   char *attrname,
00035   char *text);
00036
00037 /* ------------------------------------------------------------
00038    Main...
00039    ------------------------------------------------------------ */
00040
00041 int main(
00042   int argc,
00043   char *argv[]) {
00044
00045   ctl_t ctl;
00046
00047   static char filename[LEN];
00048
00049   static double r, t0, z0, z1, dataLon[EX], dataLat[EY], dataZ[EP],
00050     u0, u1, alpha;
00051
00052   static float dataT[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 }
```

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