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 404 of file libtrac.h.

4.1.2 Field Documentation

4.1.2.1 int atm_t::np

Number of air pacels.

Definition at line 407 of file libtrac.h.

4.1.2.2 double atm_t::time[NP]

Time [s].

Definition at line 410 of file libtrac.h.

4.1.2.3 double atm_t::p[NP]

Pressure [hPa].

Definition at line 413 of file libtrac.h.

4.1.2.4 double atm_t::lon[NP]

Longitude [deg].

Definition at line 416 of file libtrac.h.

4.1.2.5 double atm_t::lat[NP]

Latitude [deg].

Definition at line 419 of file libtrac.h.

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

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

Definition at line 422 of file libtrac.h.

4.1.2.7 double atm_t::up[NP]

Zonal wind perturbation [m/s].

Definition at line 425 of file libtrac.h.

4.1.2.8 double atm_t::vp[NP]

Meridional wind perturbation [m/s].

Definition at line 428 of file libtrac.h.

4.1.2.9 double atm_t::wp[NP]

Vertical velocity perturbation [hPa/s].

Definition at line 431 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_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_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 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].
- 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_t

Quantity array index for temperature.

Definition at line 200 of file libtrac.h.

4.2.2.10 int ctl_t::qnt_u

Quantity array index for zonal wind.

Definition at line 203 of file libtrac.h.

4.2.2.11 int ctl_t::qnt_v

Quantity array index for meridional wind.

Definition at line 206 of file libtrac.h.

4.2.2.12 int ctl_t::qnt_w

Quantity array index for vertical velocity.

Definition at line 209 of file libtrac.h.

4.2.2.13 int ctl_t::qnt_h2o

Quantity array index for water vapor vmr.

Definition at line 212 of file libtrac.h.

4.2.2.14 int ctl_t::qnt_o3

Quantity array index for ozone vmr.

Definition at line 215 of file libtrac.h.

4.2.2.15 int ctl_t::qnt_theta

Quantity array index for potential temperature.

Definition at line 218 of file libtrac.h.

4.2.2.16 int ctl_t::qnt_stat

Quantity array index for station flag.

Definition at line 221 of file libtrac.h.

4.2.2.17 int ctl_t::direction

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

Definition at line 224 of file libtrac.h.

4.2.2.18 double ctl_t::t_start

Start time of simulation [s].

Definition at line 227 of file libtrac.h.

4.2.2.19 double ctl_t::t_stop

Stop time of simulation [s].

Definition at line 230 of file libtrac.h.

4.2.2.20 double ctl_t::dt_mod

Time step of simulation [s].

Definition at line 233 of file libtrac.h.

4.2.2.21 double ctl_t::dt_met

Time step of meteorological data [s].

Definition at line 236 of file libtrac.h.

4.2.2.22 int ctl_t::isosurf

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

Definition at line 240 of file libtrac.h.

4.2.2.23 char ctl_t::balloon[LEN]

Balloon position filename.

Definition at line 243 of file libtrac.h.

4.2.2.24 double ctl_t::turb_dx_trop

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

Definition at line 246 of file libtrac.h.

4.2.2.25 double ctl_t::turb_dx_strat

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

Definition at line 249 of file libtrac.h.

4.2.2.26 double ctl_t::turb_dz_trop

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

Definition at line 252 of file libtrac.h.

4.2.2.27 double ctl_t::turb_dz_strat

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

Definition at line 255 of file libtrac.h.

4.2.2.28 double ctl_t::turb_meso

Scaling factor for mesoscale wind fluctuations.

Definition at line 258 of file libtrac.h.

4.2.2.29 double ctl_t::tdec_trop

Life time of particles (troposphere) [s].

Definition at line 261 of file libtrac.h.

4.2.2.30 double ctl_t::tdec_strat

Life time of particles (stratosphere) [s].

Definition at line 264 of file libtrac.h.

4.2.2.31 char ctl_t::atm_basename[LEN]

Basename of atmospheric data files.

Definition at line 267 of file libtrac.h.

4.2.2.32 char ctl_t::atm_gpfile[LEN]

Gnuplot file for atmospheric data.

Definition at line 270 of file libtrac.h.

4.2.2.33 double ctl_t::atm_dt_out

Time step for atmospheric data output [s].

Definition at line 273 of file libtrac.h.

4.2.2.34 char ctl_t::csi_basename[LEN]

Basename of CSI data files.

Definition at line 276 of file libtrac.h.

4.2.2.35 double ctl_t::csi_dt_out

Time step for CSI data output [s].

Definition at line 279 of file libtrac.h.

4.2.2.36 char ctl_t::csi_obsfile[LEN]

Observation data file for CSI analysis.

Definition at line 282 of file libtrac.h.

4.2.2.37 double ctl_t::csi_obsmin

Minimum observation index to trigger detection.

Definition at line 285 of file libtrac.h.

4.2.2.38 double ctl_t::csi_modmin

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

Definition at line 288 of file libtrac.h.

4.2.2.39 int ctl_t::csi_nz

Number of altitudes of gridded CSI data.

Definition at line 291 of file libtrac.h.

4.2.2.40 double ctl_t::csi_z0

Lower altitude of gridded CSI data [km].

Definition at line 294 of file libtrac.h.

4.2.2.41 double ctl_t::csi_z1

Upper altitude of gridded CSI data [km].

Definition at line 297 of file libtrac.h.

4.2.2.42 int ctl_t::csi_nx

Number of longitudes of gridded CSI data.

Definition at line 300 of file libtrac.h.

4.2.2.43 double ctl_t::csi_lon0

Lower longitude of gridded CSI data [deg].

Definition at line 303 of file libtrac.h.

4.2.2.44 double ctl_t::csi_lon1

Upper longitude of gridded CSI data [deg].

Definition at line 306 of file libtrac.h.

4.2.2.45 int ctl_t::csi_ny

Number of latitudes of gridded CSI data.

Definition at line 309 of file libtrac.h.

4.2.2.46 double ctl_t::csi_lat0

Lower latitude of gridded CSI data [deg].

Definition at line 312 of file libtrac.h.

4.2.2.47 double ctl_t::csi_lat1

Upper latitude of gridded CSI data [deg].

Definition at line 315 of file libtrac.h.

4.2.2.48 char ctl_t::grid_basename[LEN]

Basename of grid data files.

Definition at line 318 of file libtrac.h.

4.2.2.49 char ctl_t::grid_gpfile[LEN]

Gnuplot file for gridded data.

Definition at line 321 of file libtrac.h.

4.2.2.50 double ctl_t::grid_dt_out

Time step for gridded data output [s].

Definition at line 324 of file libtrac.h.

4.2.2.51 int ctl_t::grid_sparse

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

Definition at line 327 of file libtrac.h.

4.2.2.52 int ctl_t::grid_nz

Number of altitudes of gridded data.

Definition at line 330 of file libtrac.h.

4.2.2.53 double ctl_t::grid_z0

Lower altitude of gridded data [km].

Definition at line 333 of file libtrac.h.

4.2.2.54 double ctl_t::grid_z1

Upper altitude of gridded data [km].

Definition at line 336 of file libtrac.h.

4.2.2.55 int ctl_t::grid_nx

Number of longitudes of gridded data.

Definition at line 339 of file libtrac.h.

4.2.2.56 double ctl_t::grid_lon0

Lower longitude of gridded data [deg].

Definition at line 342 of file libtrac.h.

4.2.2.57 double ctl_t::grid_lon1

Upper longitude of gridded data [deg].

Definition at line 345 of file libtrac.h.

4.2.2.58 int ctl_t::grid_ny

Number of latitudes of gridded data.

Definition at line 348 of file libtrac.h.

4.2.2.59 double ctl_t::grid_lat0

Lower latitude of gridded data [deg].

Definition at line 351 of file libtrac.h.

4.2.2.60 double ctl_t::grid_lat1

Upper latitude of gridded data [deg].

Definition at line 354 of file libtrac.h.

4.2.2.61 char ctl_t::prof_basename[LEN]

Basename for profile output file.

Definition at line 357 of file libtrac.h.

4.2.2.62 char ctl_t::prof_obsfile[LEN]

Observation data file for profile output.

Definition at line 360 of file libtrac.h.

4.2.2.63 int ctl_t::prof_nz

Number of altitudes of gridded profile data.

Definition at line 363 of file libtrac.h.

4.2.2.64 double ctl_t::prof_z0

Lower altitude of gridded profile data [km].

Definition at line 366 of file libtrac.h.

4.2.2.65 double ctl_t::prof_z1

Upper altitude of gridded profile data [km].

Definition at line 369 of file libtrac.h.

4.2.2.66 int ctl_t::prof_nx

Number of longitudes of gridded profile data.

Definition at line 372 of file libtrac.h.

4.2.2.67 double ctl_t::prof_lon0

Lower longitude of gridded profile data [deg].

Definition at line 375 of file libtrac.h.

4.2.2.68 double ctl_t::prof_lon1

Upper longitude of gridded profile data [deg].

Definition at line 378 of file libtrac.h.

4.2.2.69 int ctl_t::prof_ny

Number of latitudes of gridded profile data.

Definition at line 381 of file libtrac.h.

4.2.2.70 double ctl_t::prof_lat0

Lower latitude of gridded profile data [deg].

Definition at line 384 of file libtrac.h.

4.2.2.71 double ctl_t::prof_lat1

Upper latitude of gridded profile data [deg].

Definition at line 387 of file libtrac.h.

4.2.2.72 char ctl_t::stat_basename[LEN]

Basename of station data file.

Definition at line 390 of file libtrac.h.

4.2.2.73 double ctl_t::stat_lon

Longitude of station [deg].

Definition at line 393 of file libtrac.h.

4.2.2.74 double ctl_t::stat_lat

Latitude of station [deg].

Definition at line 396 of file libtrac.h.

4.2.2.75 double ctl_t::stat_r

Search radius around station [km].

Definition at line 399 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 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 436 of file libtrac.h.

4.3.2 Field Documentation

4.3.2.1 double met_t::time

Time [s].

Definition at line 439 of file libtrac.h.

4.3.2.2 int met_t::nx

Number of longitudes.

Definition at line 442 of file libtrac.h.

4.3.2.3 int met_t::ny

Number of latitudes.

Definition at line 445 of file libtrac.h.

4.3.2.4 int met_t::np

Number of pressure levels.

Definition at line 448 of file libtrac.h.

4.3.2.5 double met_t::lon[EX]

Longitude [deg].

Definition at line 451 of file libtrac.h.

4.3.2.6 double met_t::lat[EY]

Latitude [deg].

Definition at line 454 of file libtrac.h.

4.3.2.7 double met_t::p[EP]

Pressure [hPa].

Definition at line 457 of file libtrac.h.

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

Surface pressure [hPa].

Definition at line 460 of file libtrac.h.

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

Temperature [K].

Definition at line 463 of file libtrac.h.

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

Zonal wind [m/s].

Definition at line 466 of file libtrac.h.

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

Meridional wind [m/s].

Definition at line 469 of file libtrac.h.

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

Vertical wind [hPa/s].

Definition at line 472 of file libtrac.h.

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

Water vapor volume mixing ratio [1].

Definition at line 475 of file libtrac.h.

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

Ozone volume mixing ratio [1].

Definition at line 478 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

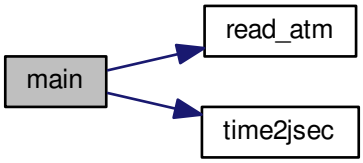
5.1.2.1 int main (int *argc*, char ∗ *argv[ ]*)

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\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   Copright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026 #include <gsl/gsl_sort.h>
00027
00028 int main(
00029   int argc,
00030   char *argv[]) {
00031
00032   ctl_t ctl;
00033
00034   atm_t *atm;
00035
00036   FILE *out;
00037
00038   char *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.

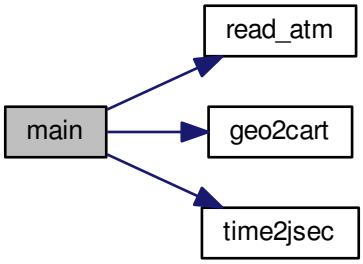
```
00030                {
00031
00032   ctl_t ctl;
00033
00034   atm_t *atm1, *atm2;
00035
00036   FILE *out;
00037
00038   char *name, *year, *mon, *day, *hour, *min;
00039
00040   double aux, x0[3], x1[3], x2[3], *lon1, *lat1, *p1, *lh1, *lv1,
00041     *lon2, *lat2, *p2, *lh2, *lv2, ahtd, avtd, ahtd2,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

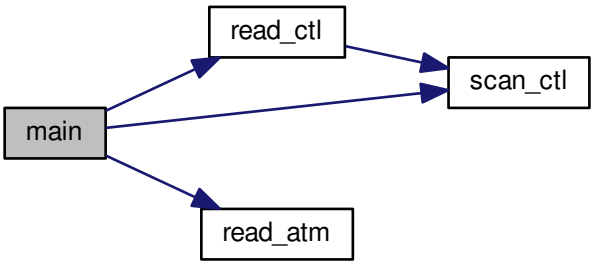
5.5.2.1 int main (int *argc,* char ∗ *argv[ ]*)

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

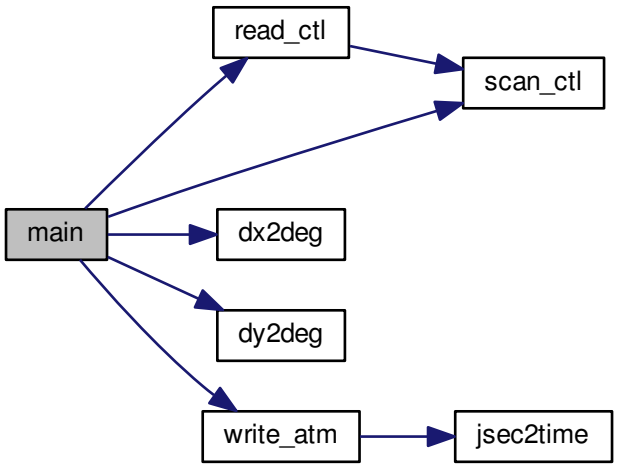
5.7.2.1 int main (int *argc,* char ∗ *argv[ ]*)

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   Copyright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   atm_t *atm;
00032
00033   ctl_t ctl;
00034
00035   gsl_rng *rng;
00036
00037   double dt, dz, dlon, dlat, lat0, lat1, lon0, lon1, t0, t1, z0, z1,
00038     t, z, lon, lat, st, sz, slon, slat, sx, ut, uz, ulon, ulat, m;
00039
00040   int ip, irep, rep;
00041
00042   /* Allocate... */
00043   ALLOC(atm, atm_t, 1);
00044
00045   /* Check arguments... */
00046   if (argc < 3)
00047     ERRMSG("Give parameters: <ctl> <atm_out>");
00048
00049   /* Read control parameters... */
00050   read_ctl(argv[1], argc, argv, &ctl);
00051   t0 = scan_ctl(argv[1], argc, argv, "INIT_T0", -1, "0", NULL);
00052   t1 = scan_ctl(argv[1], argc, argv, "INIT_T1", -1, "0", NULL);
00053   dt = scan_ctl(argv[1], argc, argv, "INIT_DT", -1, "1", NULL);
00054   z0 = scan_ctl(argv[1], argc, argv, "INIT_Z0", -1, "0", NULL);
00055   z1 = scan_ctl(argv[1], argc, argv, "INIT_Z1", -1, "0", NULL);
00056   dz = scan_ctl(argv[1], argc, argv, "INIT_DZ", -1, "1", NULL);
00057   lon0 = scan_ctl(argv[1], argc, argv, "INIT_LON0", -1, "0", NULL);
00058   lon1 = scan_ctl(argv[1], argc, argv, "INIT_LON1", -1, "0", NULL);
00059   dlon = scan_ctl(argv[1], argc, argv, "INIT_DLON", -1, "1", NULL);
00060   lat0 = scan_ctl(argv[1], argc, argv, "INIT_LAT0", -1, "0", NULL);
00061   lat1 = scan_ctl(argv[1], argc, argv, "INIT_LAT1", -1, "0", NULL);
00062   dlat = scan_ctl(argv[1], argc, argv, "INIT_DLAT", -1, "1", NULL);
00063   st = scan_ctl(argv[1], argc, argv, "INIT_ST", -1, "0", NULL);
00064   sz = scan_ctl(argv[1], argc, argv, "INIT_SZ", -1, "0", NULL);
00065   slon = scan_ctl(argv[1], argc, argv, "INIT_SLON", -1, "0", NULL);
00066   slat = scan_ctl(argv[1], argc, argv, "INIT_SLAT", -1, "0", NULL);
00067   sx = scan_ctl(argv[1], argc, argv, "INIT_SX", -1, "0", NULL);
00068   ut = scan_ctl(argv[1], argc, argv, "INIT_UT", -1, "0", NULL);
00069   uz = scan_ctl(argv[1], argc, argv, "INIT_UZ", -1, "0", NULL);
00070   ulon = scan_ctl(argv[1], argc, argv, "INIT_ULON", -1, "0", NULL);
00071   ulat = scan_ctl(argv[1], argc, argv, "INIT_ULAT", -1, "0", NULL);
00072   rep = (int) scan_ctl(argv[1], argc, argv, "INIT_REP", -1, "1", NULL);
00073   m = scan_ctl(argv[1], argc, argv, "INIT_MASS", -1, "0", NULL);
00074
00075   /* Initialize random number generator... */
00076   gsl_rng_env_setup();
00077   rng = gsl_rng_alloc(gsl_rng_default);
00078
00079   /* Create grid... */
00080   for (t = t0; t <= t1; t += dt)
00081     for (z = z0; z <= z1; z += dz)
00082       for (lon = lon0; lon <= lon1; lon += dlon)
00083         for (lat = lat0; lat <= lat1; lat += dlat)
00084           for (irep = 0; irep < rep; irep++) {
00085
00086             /* Set position... */
00087             atm->time[atm->np]
00088               = (t + gsl_ran_gaussian_ziggurat(rng, st / 2.3548)
00089                  + ut * (gsl_rng_uniform(rng) - 0.5));
00090             atm->p[atm->np]
00091               = P(z + gsl_ran_gaussian_ziggurat(rng, sz / 2.3548)
00092                   + uz * (gsl_rng_uniform(rng) - 0.5));
00093             atm->lon[atm->np]
00094               = (lon + gsl_ran_gaussian_ziggurat(rng, slon / 2.3548)
```

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

5.9 jsec2time.c File Reference

Convert Julian seconds to date.

Functions

- int main (int argc, char ∗argv[ ])

5.9.1 Detailed Description

Convert Julian seconds to date.

Definition in file jsec2time.c.

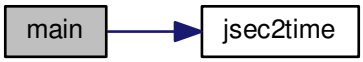
5.9.2 Function Documentation

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

Definition at line 27 of file jsec2time.c.

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

Here is the call graph for this function:



5.10 jsec2time.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   double jsec, remain;
00032
00033   int day, hour, min, mon, sec, year;
00034
00035   /* Check arguments... */
00036   if (argc < 2)
00037     ERRMSG("Give parameters: <jsec>");
00038
00039   /* Read arguments... */
00040   jsec = atof(argv[1]);
00041
00042   /* Convert time... */
00043   jsec2time(jsec, &year, &mon, &day, &hour, &min, &sec, &remain);
00044   printf("%d %d %d %d %d %d %g\n", year, mon, day, hour, min, sec, remain);
00045
00046   return EXIT_SUCCESS;
00047 }
```

5.11 libtrac.c File Reference

MPTRAC library definitions.

Functions

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

  Convert Cartesian coordinates to geolocation.
- double deg2dx (double dlon, double lat)

- 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 }
```

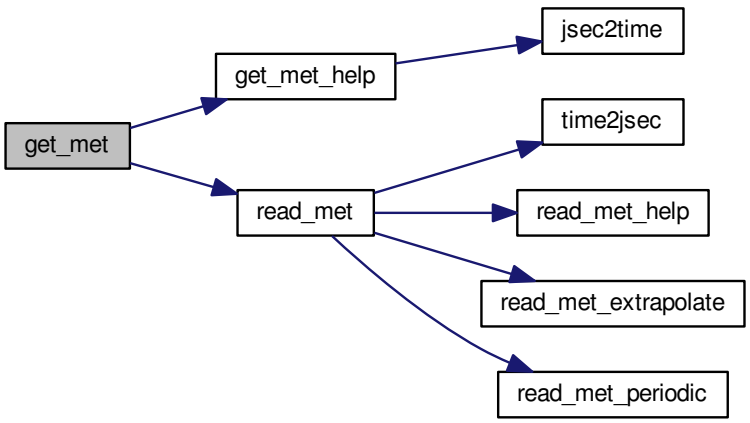
5.11.2.9 void get_met (ctl_t * *ctl,* char * *metbase,* double *t,* met_t * *met0,* met_t * *met1*)

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(filename, met0);
00134
00135     get_met_help(t + 1.0 * ctl->direction, 1, metbase, ctl->
      dt_met, filename);
00136     read_met(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(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(filename, met0);
00151   }
00152 }
```

Here is the call graph for this function:



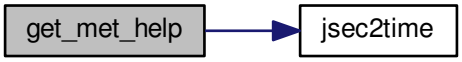
5.11.2.10 void get_met_help (double *t,* int *direct,* char * *metbase,* double *dt_met,* char * *filename*)

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 }
```

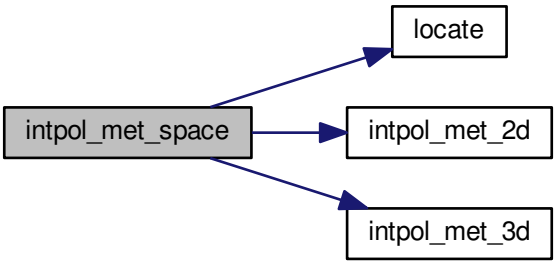
5.11.2.13 void intpol_met_space (met_t * *met*, double *p*, double *lon*, double *lat*, double * *ps*, double * *t*, double * *u*, double * *v*, double * *w*, double * *h2o*, double * *o3*)

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 (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:



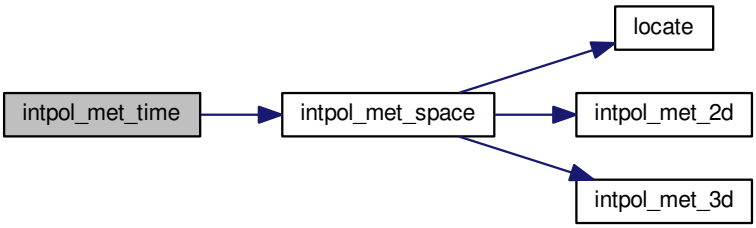
5.11.2.14 void intpol_met_time (met_t * *met0*, met_t * *met1*, double *ts*, double *p*, double *lon*, double *lat*, double * *ps*, double * *t*, double * *u*, double * *v*, double * *w*, double * *h2o*, double * *o3*)

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 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_t = -1;
00477   ctl->qnt_u = -1;
00478   ctl->qnt_v = -1;
00479   ctl->qnt_w = -1;
00480   ctl->qnt_h2o = -1;
00481   ctl->qnt_o3 = -1;
00482   ctl->qnt_theta = -1;
00483   ctl->qnt_stat = -1;
00484
00485   /* Read quantities... */
00486   ctl->nq = (int) scan_ctl(filename, argc, argv, "NQ", -1, "0", NULL);
00487   for (iq = 0; iq < ctl->nq; iq++) {
00488
00489     /* Read quantity name and format... */
00490     scan_ctl(filename, argc, argv, "QNT_NAME", iq, "", ctl->qnt_name[iq]);
00491     scan_ctl(filename, argc, argv, "QNT_FORMAT", iq, "%g",
00492              ctl->qnt_format[iq]);
00493
00494     /* Try to identify quantity... */
00495     if (strcmp(ctl->qnt_name[iq], "m") == 0) {
00496       ctl->qnt_m = iq;
00497       sprintf(ctl->qnt_unit[iq], "kg");
00498     } else if (strcmp(ctl->qnt_name[iq], "r") == 0) {
00499       ctl->qnt_r = iq;
00500       sprintf(ctl->qnt_unit[iq], "m");
00501     } else if (strcmp(ctl->qnt_name[iq], "rho") == 0) {
00502       ctl->qnt_rho = iq;
00503       sprintf(ctl->qnt_unit[iq], "kg/m^3");
00504     } else if (strcmp(ctl->qnt_name[iq], "ps") == 0) {
00505       ctl->qnt_ps = iq;
00506       sprintf(ctl->qnt_unit[iq], "hPa");
00507     } else if (strcmp(ctl->qnt_name[iq], "t") == 0) {
00508       ctl->qnt_t = iq;
00509       sprintf(ctl->qnt_unit[iq], "K");
00510     } else if (strcmp(ctl->qnt_name[iq], "u") == 0) {
00511       ctl->qnt_u = iq;
00512       sprintf(ctl->qnt_unit[iq], "m/s");
00513     } else if (strcmp(ctl->qnt_name[iq], "v") == 0) {
00514       ctl->qnt_v = iq;
00515       sprintf(ctl->qnt_unit[iq], "m/s");
00516     } else if (strcmp(ctl->qnt_name[iq], "w") == 0) {
00517       ctl->qnt_w = iq;
00518       sprintf(ctl->qnt_unit[iq], "hPa/s");
00519     } else if (strcmp(ctl->qnt_name[iq], "h2o") == 0) {
00520       ctl->qnt_h2o = iq;
00521       sprintf(ctl->qnt_unit[iq], "1");
00522     } else if (strcmp(ctl->qnt_name[iq], "o3") == 0) {
00523       ctl->qnt_o3 = iq;
00524       sprintf(ctl->qnt_unit[iq], "1");
00525     } else if (strcmp(ctl->qnt_name[iq], "theta") == 0) {
00526       ctl->qnt_theta = iq;
00527       sprintf(ctl->qnt_unit[iq], "K");
00528     } else if (strcmp(ctl->qnt_name[iq], "stat") == 0) {
00529       ctl->qnt_stat = iq;
00530       sprintf(ctl->qnt_unit[iq], "-");
00531     } else
00532       scan_ctl(filename, argc, argv, "QNT_UNIT", iq, "", ctl->qnt_unit[iq]);
00533   }
00534
00535   /* Time steps of simulation... */
00536   ctl->direction =
00537     (int) scan_ctl(filename, argc, argv, "DIRECTION", -1, "1", NULL);
00538   if (ctl->direction != -1 && ctl->direction != 1)
00539     ERRMSG("Set DIRECTION to -1 or 1!");
00540   ctl->t_start =
00541     scan_ctl(filename, argc, argv, "T_START", -1, "-1e100", NULL);
00542   ctl->t_stop = scan_ctl(filename, argc, argv, "T_STOP", -1, "-1e100", NULL);
00543   ctl->dt_mod = scan_ctl(filename, argc, argv, "DT_MOD", -1, "600", NULL);
00544
00545   /* Meteorological data... */
00546   ctl->dt_met = scan_ctl(filename, argc, argv, "DT_MET", -1, "21600", NULL);
00547
00548   /* Isosurface parameters... */
```

```
00549   ctl->isosurf
00550     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
00551   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
00552
00553   /* Diffusion parameters... */
00554   ctl->turb_dx_trop
00555     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50.0", NULL);
00556   ctl->turb_dx_strat
00557     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0.0", NULL);
00558   ctl->turb_dz_trop
00559     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0.0", NULL);
00560   ctl->turb_dz_strat
00561     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
00562   ctl->turb_meso =
00563     scan_ctl(filename, argc, argv, "TURB_MESO", -1, "0.16", NULL);
00564
00565   /* Life time of particles... */
00566   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
00567   ctl->tdec_strat =
00568     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
00569
00570   /* Output of atmospheric data... */
00571   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
    atm_basename);
00572   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
00573   ctl->atm_dt_out =
00574     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
00575
00576   /* Output of CSI data... */
00577   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
    csi_basename);
00578   ctl->csi_dt_out =
00579     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
00580   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "obs.tab",
00581            ctl->csi_obsfile);
00582   ctl->csi_obsmin =
00583     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
00584   ctl->csi_modmin =
00585     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
00586   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
00587   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
00588   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
00589   ctl->csi_lon0 =
00590     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
00591   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
00592   ctl->csi_nx =
00593     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
00594   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
00595   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
00596   ctl->csi_ny =
00597     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
00598
00599   /* Output of grid data... */
00600   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
00601            ctl->grid_basename);
00602   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
    grid_gpfile);
00603   ctl->grid_dt_out =
00604     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
00605   ctl->grid_sparse =
00606     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
00607   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
00608   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
00609   ctl->grid_nz =
00610     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
00611   ctl->grid_lon0 =
00612     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
00613   ctl->grid_lon1 =
00614     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
00615   ctl->grid_nx =
00616     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
00617   ctl->grid_lat0 =
00618     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
00619   ctl->grid_lat1 =
00620     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
00621   ctl->grid_ny =
00622     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
00623
00624   /* Output of profile data... */
00625   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
00626            ctl->prof_basename);
00627   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
    prof_obsfile);
00628   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
00629   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
00630   ctl->prof_nz =
00631     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
```

```
00632   ctl->prof_lon0 =
00633     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
00634   ctl->prof_lon1 =
00635     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
00636   ctl->prof_nx =
00637     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
00638   ctl->prof_lat0 =
00639     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
00640   ctl->prof_lat1 =
00641     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
00642   ctl->prof_ny =
00643     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
00644
00645   /* Output of station data... */
00646   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
00647            ctl->stat_basename);
00648   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
00649   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
00650   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
00651 }
```

Here is the call graph for this function:

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

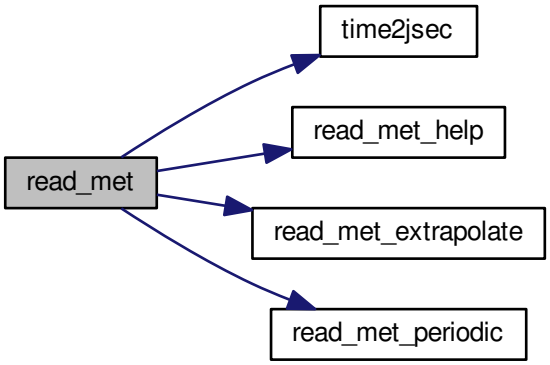
Read meteorological data file.

Definition at line 655 of file libtrac.c.

```
00657               {
00658
00659   char tstr[10];
00660
00661   static float help[EX * EY];
00662
00663   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
00664
00665   size_t np, nx, ny;
00666
00667   /* Write info... */
00668   printf("Read meteorological data: %s\n", filename);
00669
00670   /* Get time from filename... */
00671   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
00672   year = atoi(tstr);
00673   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
00674   mon = atoi(tstr);
00675   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
00676   day = atoi(tstr);
00677   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
00678   hour = atoi(tstr);
00679   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
00680
00681   /* Open netCDF file... */
00682   NC(nc_open(filename, NC_NOWRITE, &ncid));
00683
00684   /* Get dimensions... */
00685   NC(nc_inq_dimid(ncid, "lon", &dimid));
00686   NC(nc_inq_dimlen(ncid, dimid, &nx));
00687   if (nx > EX)
00688     ERRMSG("Too many longitudes!");
00689
```

```
00690   NC(nc_inq_dimid(ncid, "lat", &dimid));
00691   NC(nc_inq_dimlen(ncid, dimid, &ny));
00692   if (ny > EY)
00693     ERRMSG("Too many latitudes!");
00694
00695   NC(nc_inq_dimid(ncid, "lev", &dimid));
00696   NC(nc_inq_dimlen(ncid, dimid, &np));
00697   if (np > EP)
00698     ERRMSG("Too many pressure levels!");
00699
00700   /* Store dimensions... */
00701   met->np = (int) np;
00702   met->nx = (int) nx;
00703   met->ny = (int) ny;
00704
00705   /* Read geolocations... */
00706   NC(nc_inq_varid(ncid, "lev", &varid));
00707   NC(nc_get_var_double(ncid, varid, met->p));
00708
00709   NC(nc_inq_varid(ncid, "lon", &varid));
00710   NC(nc_get_var_double(ncid, varid, met->lon));
00711
00712   NC(nc_inq_varid(ncid, "lat", &varid));
00713   NC(nc_get_var_double(ncid, varid, met->lat));
00714
00715   /* Check and convert pressure levels... */
00716   for (ip = 0; ip < met->np; ip++) {
00717     if (ip > 0 && met->p[ip - 1] > met->p[ip])
00718       ERRMSG("Pressure levels must be descending!");
00719     met->p[ip] /= 100.;
00720   }
00721
00722   /* Read surface pressure... */
00723   if (nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
00724     NC(nc_get_var_float(ncid, varid, help));
00725     for (iy = 0; iy < met->ny; iy++)
00726       for (ix = 0; ix < met->nx; ix++)
00727         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
00728   } else {
00729     for (ix = 0; ix < met->nx; ix++)
00730       for (iy = 0; iy < met->ny; iy++)
00731         met->ps[ix][iy] = met->p[0];
00732   }
00733
00734   /* Read meteorological data... */
00735   read_met_help(ncid, "t", "T", met, met->np, met->t, 1.0);
00736   read_met_help(ncid, "u", "U", met, met->np, met->u, 1.0);
00737   read_met_help(ncid, "v", "V", met, met->np, met->v, 1.0);
00738   read_met_help(ncid, "w", "W", met, met->np, met->w, 0.01f);
00739   read_met_help(ncid, "q", "Q", met, met->np, met->h2o, 1.608f);
00740   read_met_help(ncid, "o3", "O3", met, met->np, met->o3, 0.602f);
00741
00742   /* Extrapolate data for lower boundary... */
00743   read_met_extrapolate(met);
00744
00745   /* Copy data to obtain periodic boundary conditions... */
00746   read_met_periodic(met);
00747
00748   /* Close file... */
00749   NC(nc_close(ncid));
00750 }
```

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 754 of file libtrac.c.

```
00755                {
00756
00757   int ip, ip0, ix, iy;
00758
00759   /* Loop over columns... */
00760   for (ix = 0; ix < met->nx; ix++)
00761     for (iy = 0; iy < met->ny; iy++) {
00762
00763       /* Find lowest valid data point... */
00764       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
00765         if (!gsl_finite(met->t[ix][iy][ip0])
00766             || !gsl_finite(met->u[ix][iy][ip0])
00767             || !gsl_finite(met->v[ix][iy][ip0])
00768             || !gsl_finite(met->w[ix][iy][ip0]))
00769           break;
00770
00771       /* Extrapolate... */
00772       for (ip = ip0; ip >= 0; ip--) {
00773         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
00774         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
00775         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
00776         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
00777         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
00778         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
00779       }
00780     }
00781 }
```

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

Read and convert variable from meteorological data file.

Definition at line 785 of file libtrac.c.

```
00792             {
00793
00794   static float help[EX * EY * EP];
00795
00796   int ip, ix, iy, n = 0, varid;
00797
00798   /* Check if variable exists... */
00799   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
00800     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
00801       return;
00802
00803   /* Read data... */
00804   NC(nc_get_var_float(ncid, varid, help));
00805
00806   /* Copy and check data... */
00807   for (ip = 0; ip < np; ip++)
00808     for (iy = 0; iy < met->ny; iy++)
00809       for (ix = 0; ix < met->nx; ix++) {
00810         dest[ix][iy][ip] = scl * help[n++];
00811         if (dest[ix][iy][ip] < -1e10 || dest[ix][iy][ip] > 1e10)
00812           dest[ix][iy][ip] = GSL_NAN;
00813       }
00814 }
```

5.11.2.22 void read_met_periodic (met_t * *met*)

Create meteorological data with periodic boundary conditions.

Definition at line 818 of file libtrac.c.

```
00819               {
00820
00821   int ip, iy;
00822
00823   /* Check longitudes... */
00824   if (fabs(met->lon[met->nx - 1] - met->lon[0] - 360) < 0.01)
00825     return;
00826
00827   /* Increase longitude counter... */
00828   if ((++met->nx) > EX)
00829     ERRMSG("Cannot create periodic boundary conditions!");
00830
00831   /* Set longitude... */
00832   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
00833
00834   /* Loop over latitudes and pressure levels... */
00835   for (iy = 0; iy < met->ny; iy++)
00836     for (ip = 0; ip < met->np; ip++) {
00837       met->ps[met->nx - 1][iy] = met->ps[0][iy];
00838       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
00839       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
00840       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
00841       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
00842       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
00843       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
00844     }
00845 }
```

5.11.2.23 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 849 of file libtrac.c.

```
00856               {
00857
00858   FILE *in = NULL;
00859
00860   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
00861     msg[LEN], rvarname[LEN], rval[LEN];
00862
```

```
00863   int contain = 0, i;
00864
00865   /* Open file... */
00866   if (filename[strlen(filename) - 1] != '-')
00867     if (!(in = fopen(filename, "r")))
00868       ERRMSG("Cannot open file!");
00869
00870   /* Set full variable name... */
00871   if (arridx >= 0) {
00872     sprintf(fullname1, "%s[%d]", varname, arridx);
00873     sprintf(fullname2, "%s[*]", varname);
00874   } else {
00875     sprintf(fullname1, "%s", varname);
00876     sprintf(fullname2, "%s", varname);
00877   }
00878
00879   /* Read data... */
00880   if (in != NULL)
00881     while (fgets(line, LEN, in))
00882       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
00883         if (strcasecmp(rvarname, fullname1) == 0 ||
00884             strcasecmp(rvarname, fullname2) == 0) {
00885           contain = 1;
00886           break;
00887         }
00888   for (i = 1; i < argc - 1; i++)
00889     if (strcasecmp(argv[i], fullname1) == 0 ||
00890         strcasecmp(argv[i], fullname2) == 0) {
00891       sprintf(rval, "%s", argv[i + 1]);
00892       contain = 1;
00893       break;
00894     }
00895
00896   /* Close file... */
00897   if (in != NULL)
00898     fclose(in);
00899
00900   /* Check for missing variables... */
00901   if (!contain) {
00902     if (strlen(defvalue) > 0)
00903       sprintf(rval, "%s", defvalue);
00904     else {
00905       sprintf(msg, "Missing variable %s!\n", fullname1);
00906       ERRMSG(msg);
00907     }
00908   }
00909
00910   /* Write info... */
00911   printf("%s = %s\n", fullname1, rval);
00912
00913   /* Return values... */
00914   if (value != NULL)
00915     sprintf(value, "%s", rval);
00916   return atof(rval);
00917 }
```

5.11.2.24 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 921 of file libtrac.c.

```
00929                 {
00930
00931   struct tm t0, t1;
00932
00933   t0.tm_year = 100;
00934   t0.tm_mon = 0;
00935   t0.tm_mday = 1;
00936   t0.tm_hour = 0;
00937   t0.tm_min = 0;
00938   t0.tm_sec = 0;
00939
00940   t1.tm_year = year - 1900;
00941   t1.tm_mon = mon - 1;
00942   t1.tm_mday = day;
00943   t1.tm_hour = hour;
00944   t1.tm_min = min;
00945   t1.tm_sec = sec;
00946
00947   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
00948 }
```

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

Measure wall-clock time.

Definition at line 952 of file libtrac.c.

```
00955             {
00956
00957   static double starttime[NTIMER], runtime[NTIMER];
00958
00959   /* Check id... */
00960   if (id < 0 || id >= NTIMER)
00961     ERRMSG("Too many timers!");
00962
00963   /* Start timer... */
00964   if (mode == 1) {
00965     if (starttime[id] <= 0)
00966       starttime[id] = omp_get_wtime();
00967     else
00968       ERRMSG("Timer already started!");
00969   }
00970
00971   /* Stop timer... */
00972   else if (mode == 2) {
00973     if (starttime[id] > 0) {
00974       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
00975       starttime[id] = -1;
00976     } else
00977       ERRMSG("Timer not started!");
00978   }
00979
00980   /* Print timer... */
00981   else if (mode == 3)
00982     printf("%s = %g s\n", name, runtime[id]);
00983 }
```

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

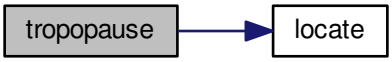
Definition at line 987 of file libtrac.c.

```
00989               {
00990
00991   static double doys[12]
00992   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00993
00994   static double lats[73]
00995     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
00996     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
00997     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
00998     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
00999     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
01000     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
01001     75, 77.5, 80, 82.5, 85, 87.5, 90
01002   };
01003
01004   static double tps[12][73]
01005     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
01006          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
01007          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
01008          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
01009          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
01010          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
01011          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
01012          275.3, 275.6, 275.4, 274.1, 273.5},
01013   {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
01014    300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
01015    150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
01016    98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
01017    98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
01018    220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
01019    284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
01020    287.5, 286.2, 285.8},
01021   {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
01022    297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
01023    161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
01024    100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
01025    99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
```

```
01026    186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
01027    279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
01028    304.3, 304.9, 306, 306.6, 306.2, 306},
01029   {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
01030    290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
01031    195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
01032    102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
01033    99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
01034    148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
01035    263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
01036    315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
01037   {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
01038    260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
01039    205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
01040    101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
01041    102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
01042    165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
01043    273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
01044    325.3, 325.8, 325.8},
01045   {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
01046    222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
01047    228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
01048    105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
01049    106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
01050    127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
01051    251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
01052    308.5, 312.2, 313.1, 313.3},
01053   {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
01054    187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
01055    235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
01056    110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
01057    111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
01058    117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
01059    224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
01060    275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
01061   {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
01062    185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
01063    233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
01064    110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
01065    112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
01066    120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
01067    230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
01068    278.2, 282.6, 287.4, 290.9, 292.5, 293},
01069   {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
01070    183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
01071    243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
01072    114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
01073    110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
01074    114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
01075    203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
01076    276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
01077   {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
01078    215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
01079    237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
01080    111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
01081    106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
01082    112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
01083    206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
01084    279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
01085    305.1},
01086   {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
01087    253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
01088    223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
01089    108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
01090    102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
01091    109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
01092    241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
01093    286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
01094   {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
01095    284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
01096    175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
01097    100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
01098    100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
01099    186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
01100    280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
01101    281.7, 281.1, 281.2}
01102   };
01103
01104   double doy, p0, p1, pt;
01105
01106   int imon, ilat;
01107
01108   /* Get day of year... */
01109   doy = fmod(t / 86400., 365.25);
01110   while (doy < 0)
01111     doy += 365.25;
01112
```

```
01113   /* Get indices... */
01114   imon = locate(doys, 12, doy);
01115   ilat = locate(lats, 73, lat);
01116
01117   /* Get tropopause pressure... */
01118   p0 = LIN(lats[ilat], tps[imon][ilat],
01119            lats[ilat + 1], tps[imon][ilat + 1], lat);
01120   p1 = LIN(lats[ilat], tps[imon + 1][ilat],
01121            lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
01122   pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
01123
01124   /* Return tropopause pressure... */
01125   return pt;
01126 }
```

Here is the call graph for this function:



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

Write atmospheric data.

Definition at line 1130 of file libtrac.c.

```
01134             {
01135
01136   FILE *in, *out;
01137
01138   char line[LEN];
01139
01140   double r;
01141
01142   int ip, iq, year, mon, day, hour, min, sec;
01143
01144   /* Check if gnuplot output is requested... */
01145   if (ctl->atm_gpfile[0] != '-') {
01146
01147     /* Write info... */
01148     printf("Plot atmospheric data: %s.png\n", filename);
01149
01150     /* Create gnuplot pipe... */
01151     if (!(out = popen("gnuplot", "w")))
01152       ERRMSG("Cannot create pipe to gnuplot!");
01153
01154     /* Set plot filename... */
01155     fprintf(out, "set out \"%s.png\"\n", filename);
01156
01157     /* Set time string... */
01158     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01159     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01160             year, mon, day, hour, min);
01161
01162     /* Dump gnuplot file to pipe... */
01163     if (!(in = fopen(ctl->atm_gpfile, "r")))
01164       ERRMSG("Cannot open file!");
01165     while (fgets(line, LEN, in))
01166       fprintf(out, "%s", line);
01167     fclose(in);
01168   }
01169
01170   else {
01171
01172     /* Write info... */
```

```
01173     printf("Write atmospheric data: %s\n", filename);
01174
01175     /* Create file... */
01176     if (!(out = fopen(filename, "w")))
01177       ERRMSG("Cannot create file!");
01178   }
01179
01180   /* Write header... */
01181   fprintf(out,
01182           "# $1 = time [s]\n"
01183           "# $2 = altitude [km]\n"
01184           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01185   for (iq = 0; iq < ctl->nq; iq++)
01186     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
01187             ctl->qnt_unit[iq]);
01188   fprintf(out, "\n");
01189
01190   /* Write data... */
01191   for (ip = 0; ip < atm->np; ip++) {
01192     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
01193             atm->lon[ip], atm->lat[ip]);
01194     for (iq = 0; iq < ctl->nq; iq++) {
01195       fprintf(out, " ");
01196       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01197     }
01198     fprintf(out, "\n");
01199   }
01200
01201   /* Close file... */
01202   fclose(out);
01203 }
```

Here is the call graph for this function:

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

Write CSI data.

Definition at line 1207 of file libtrac.c.

```
01211             {
01212
01213   static FILE *in, *out;
01214
01215   static char line[LEN];
01216
01217   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
01218     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
01219
01220   static int init, obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
01221
01222   /* Init... */
01223   if (!init) {
01224     init = 1;
01225
01226     /* Check quantity index for mass... */
01227     if (ctl->qnt_m < 0)
01228       ERRMSG("Need quantity mass to analyze CSI!");
01229
01230     /* Open observation data file... */
01231     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
01232     if (!(in = fopen(ctl->csi_obsfile, "r")))
```

```
01233       ERRMSG("Cannot open file!");
01234
01235     /* Create new file... */
01236     printf("Write CSI data: %s\n", filename);
01237     if (!(out = fopen(filename, "w")))
01238       ERRMSG("Cannot create file!");
01239
01240     /* Write header... */
01241     fprintf(out,
01242             "# $1 = time [s]\n"
01243             "# $2 = number of hits (cx)\n"
01244             "# $3 = number of misses (cy)\n"
01245             "# $4 = number of false alarms (cz)\n"
01246             "# $5 = number of observations (cx + cy)\n"
01247             "# $6 = number of forecasts (cx + cz)\n"
01248             "# $7 = bias (forecasts/observations) [%%]\n"
01249             "# $8 = probability of detection (POD) [%%]\n"
01250             "# $9 = false alarm rate (FAR) [%%]\n"
01251             "# $10 = critical success index (CSI) [%%]\n\n");
01252   }
01253
01254   /* Set time interval... */
01255   t0 = t - 0.5 * ctl->dt_mod;
01256   t1 = t + 0.5 * ctl->dt_mod;
01257
01258   /* Initialize grid cells... */
01259   for (ix = 0; ix < ctl->csi_nx; ix++)
01260     for (iy = 0; iy < ctl->csi_ny; iy++)
01261       for (iz = 0; iz < ctl->csi_nz; iz++)
01262         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
01263
01264   /* Read data... */
01265   while (fgets(line, LEN, in)) {
01266
01267     /* Read data... */
01268     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
01269         5)
01270       continue;
01271
01272     /* Check time... */
01273     if (rt < t0)
01274       continue;
01275     if (rt > t1)
01276       break;
01277
01278     /* Calculate indices... */
01279     ix = (int) ((rlon - ctl->csi_lon0)
01280                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01281     iy = (int) ((rlat - ctl->csi_lat0)
01282                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01283     iz = (int) ((rz - ctl->csi_z0)
01284                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01285
01286     /* Check indices... */
01287     if (ix < 0 || ix >= ctl->csi_nx ||
01288         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01289       continue;
01290
01291     /* Get mean observation index... */
01292     obsmean[ix][iy][iz] += robs;
01293     obscount[ix][iy][iz]++;
01294   }
01295
01296   /* Analyze model data... */
01297   for (ip = 0; ip < atm->np; ip++) {
01298
01299     /* Check time... */
01300     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01301       continue;
01302
01303     /* Get indices... */
01304     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
01305                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01306     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
01307                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01308     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
01309                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01310
01311     /* Check indices... */
01312     if (ix < 0 || ix >= ctl->csi_nx ||
01313         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01314       continue;
01315
01316     /* Get total mass in grid cell... */
01317     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01318   }
01319
```

```
01320   /* Analyze all grid cells... */
01321   for (ix = 0; ix < ctl->csi_nx; ix++)
01322     for (iy = 0; iy < ctl->csi_ny; iy++)
01323       for (iz = 0; iz < ctl->csi_nz; iz++) {
01324
01325         /* Calculate mean observation index... */
01326         if (obscount[ix][iy][iz] > 0)
01327           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
01328
01329         /* Calculate column density... */
01330         if (modmean[ix][iy][iz] > 0) {
01331           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
01332           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
01333           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
01334           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
01335             * cos(lat * M_PI / 180.);
01336           modmean[ix][iy][iz] /= (1e6 * area);
01337         }
01338
01339         /* Calculate CSI... */
01340         if (obscount[ix][iy][iz] > 0) {
01341           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01342               modmean[ix][iy][iz] >= ctl->csi_modmin)
01343             cx++;
01344           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01345                    modmean[ix][iy][iz] < ctl->csi_modmin)
01346             cy++;
01347           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
01348                    modmean[ix][iy][iz] >= ctl->csi_modmin)
01349             cz++;
01350         }
01351       }
01352
01353   /* Write output... */
01354   if (fmod(t, ctl->csi_dt_out) == 0) {
01355
01356     /* Write... */
01357     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
01358             t, cx, cy, cz, cx + cy, cx + cz,
01359             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
01360             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
01361             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
01362             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
01363
01364     /* Set counters to zero... */
01365     cx = cy = cz = 0;
01366   }
01367
01368   /* Close file... */
01369   if (t == ctl->t_stop)
01370     fclose(out);
01371 }
```

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

Write gridded data.

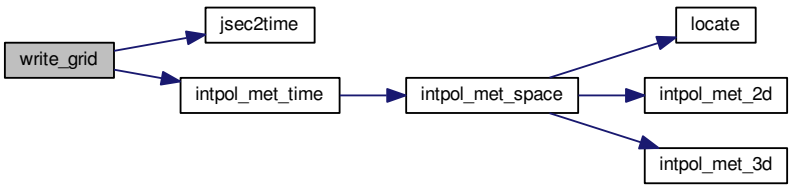
Definition at line 1375 of file libtrac.c.

```
01381             {
01382
01383   FILE *in, *out;
01384
01385   char line[LEN];
01386
01387   static double grid_m[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
01388     area, rho_air, press, temp, cd, mmr, t0, t1, r;
01389
01390   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
01391
01392   /* Check dimensions... */
01393   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
01394     ERRMSG("Grid dimensions too large!");
01395
01396   /* Check quantity index for mass... */
01397   if (ctl->qnt_m < 0)
01398     ERRMSG("Need quantity mass to write grid data!");
01399
01400   /* Set time interval for output... */
01401   t0 = t - 0.5 * ctl->dt_mod;
```

```
01402   t1 = t + 0.5 * ctl->dt_mod;
01403
01404   /* Set grid box size... */
01405   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
01406   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
01407   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
01408
01409   /* Initialize grid... */
01410   for (ix = 0; ix < ctl->grid_nx; ix++)
01411     for (iy = 0; iy < ctl->grid_ny; iy++)
01412       for (iz = 0; iz < ctl->grid_nz; iz++)
01413         grid_m[ix][iy][iz] = 0;
01414
01415   /* Average data... */
01416   for (ip = 0; ip < atm->np; ip++)
01417     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
01418
01419       /* Get index... */
01420       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
01421       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
01422       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
01423
01424       /* Check indices... */
01425       if (ix < 0 || ix >= ctl->grid_nx ||
01426           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
01427         continue;
01428
01429       /* Add mass... */
01430       grid_m[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01431     }
01432
01433   /* Check if gnuplot output is requested... */
01434   if (ctl->grid_gpfile[0] != '-') {
01435
01436     /* Write info... */
01437     printf("Plot grid data: %s.png\n", filename);
01438
01439     /* Create gnuplot pipe... */
01440     if (!(out = popen("gnuplot", "w")))
01441       ERRMSG("Cannot create pipe to gnuplot!");
01442
01443     /* Set plot filename... */
01444     fprintf(out, "set out \"%s.png\"\n", filename);
01445
01446     /* Set time string... */
01447     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01448     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01449             year, mon, day, hour, min);
01450
01451     /* Dump gnuplot file to pipe... */
01452     if (!(in = fopen(ctl->grid_gpfile, "r")))
01453       ERRMSG("Cannot open file!");
01454     while (fgets(line, LEN, in))
01455       fprintf(out, "%s", line);
01456     fclose(in);
01457   }
01458
01459   else {
01460
01461     /* Write info... */
01462     printf("Write grid data: %s\n", filename);
01463
01464     /* Create file... */
01465     if (!(out = fopen(filename, "w")))
01466       ERRMSG("Cannot create file!");
01467   }
01468
01469   /* Write header... */
01470   fprintf(out,
01471           "# $1 = time [s]\n"
01472           "# $2 = altitude [km]\n"
01473           "# $3 = longitude [deg]\n"
01474           "# $4 = latitude [deg]\n"
01475           "# $5 = surface area [km^2]\n"
01476           "# $6 = layer width [km]\n"
01477           "# $7 = temperature [K]\n"
01478           "# $8 = column density [kg/m^2]\n"
01479           "# $9 = mass mixing ratio [1]\n\n");
01480
01481   /* Write data... */
01482   for (ix = 0; ix < ctl->grid_nx; ix++) {
01483     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
01484       fprintf(out, "\n");
01485     for (iy = 0; iy < ctl->grid_ny; iy++) {
01486       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
01487         fprintf(out, "\n");
01488       for (iz = 0; iz < ctl->grid_nz; iz++)
```

```
01489         if (!ctl->grid_sparse
01490             || ix == 0 || iy == 0 || iz == 0 || grid_m[ix][iy][iz] > 0) {
01491
01492           /* Set coordinates... */
01493           z = ctl->grid_z0 + dz * (iz + 0.5);
01494           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
01495           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
01496
01497           /* Get pressure and temperature... */
01498           press = P(z);
01499           intpol_met_time(met0, met1, t, press, lon, lat,
01500                           NULL, &temp, NULL, NULL, NULL, NULL, NULL);
01501
01502           /* Calculate surface area... */
01503           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
01504             * cos(lat * M_PI / 180.);
01505
01506           /* Calculate column density... */
01507           cd = grid_m[ix][iy][iz] / (1e6 * area);
01508
01509           /* Calculate mass mixing ratio... */
01510           rho_air = 100. * press / (287.058 * temp);
01511           mmr = grid_m[ix][iy][iz] / (rho_air * 1e6 * area * 1e3 * dz);
01512
01513           /* Write output... */
01514           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01515                   t, z, lon, lat, area, dz, temp, cd, mmr);
01516         }
01517     }
01518   }
01519
01520   /* Close file... */
01521   fclose(out);
01522 }
```

Here is the call graph for this function:



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

Write profile data.

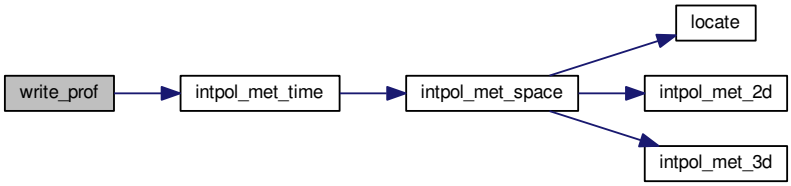
Definition at line 1526 of file libtrac.c.

```
01532             {
01533
01534   static FILE *in, *out;
01535
01536   static char line[LEN];
01537
01538   static double mass[GX][GY][GZ], obsmean[GX][GY], tmean[GX][GY],
01539     rt, rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z,
01540     press, temp, rho_air, mmr, h2o, o3;
01541
01542   static int init, obscount[GX][GY], ip, ix, iy, iz;
01543
01544   /* Init... */
01545   if (!init) {
01546     init = 1;
01547
01548     /* Check quantity index for mass... */
```

```
01549     if (ctl->qnt_m < 0)
01550       ERRMSG("Need quantity mass!");
01551
01552     /* Check dimensions... */
01553     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
01554       ERRMSG("Grid dimensions too large!");
01555
01556     /* Open observation data file... */
01557     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
01558     if (!(in = fopen(ctl->prof_obsfile, "r")))
01559       ERRMSG("Cannot open file!");
01560
01561     /* Create new file... */
01562     printf("Write profile data: %s\n", filename);
01563     if (!(out = fopen(filename, "w")))
01564       ERRMSG("Cannot create file!");
01565
01566     /* Write header... */
01567     fprintf(out,
01568             "# $1  = time [s]\n"
01569             "# $2  = altitude [km]\n"
01570             "# $3  = longitude [deg]\n"
01571             "# $4  = latitude [deg]\n"
01572             "# $5  = pressure [hPa]\n"
01573             "# $6  = temperature [K]\n"
01574             "# $7  = mass mixing ratio [1]\n"
01575             "# $8  = H2O volume mixing ratio [1]\n"
01576             "# $9  = O3 volume mixing ratio [1]\n"
01577             "# $10 = mean BT index [K]\n");
01578
01579     /* Set grid box size... */
01580     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
01581     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
01582     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
01583   }
01584
01585   /* Set time interval... */
01586   t0 = t - 0.5 * ctl->dt_mod;
01587   t1 = t + 0.5 * ctl->dt_mod;
01588
01589   /* Initialize... */
01590   for (ix = 0; ix < ctl->prof_nx; ix++)
01591     for (iy = 0; iy < ctl->prof_ny; iy++) {
01592       obsmean[ix][iy] = 0;
01593       obscount[ix][iy] = 0;
01594       tmean[ix][iy] = 0;
01595       for (iz = 0; iz < ctl->prof_nz; iz++)
01596         mass[ix][iy][iz] = 0;
01597     }
01598
01599   /* Read data... */
01600   while (fgets(line, LEN, in)) {
01601
01602     /* Read data... */
01603     if (sscanf(line, "%lg %lg %lg %lg", &rt, &rlon, &rlat, &robs) != 4)
01604       continue;
01605
01606     /* Check time... */
01607     if (rt < t0)
01608       continue;
01609     if (rt > t1)
01610       break;
01611
01612     /* Calculate indices... */
01613     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
01614     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
01615
01616     /* Check indices... */
01617     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
01618       continue;
01619
01620     /* Get mean observation index... */
01621     obsmean[ix][iy] += robs;
01622     tmean[ix][iy] += rt;
01623     obscount[ix][iy]++;
01624   }
01625
01626   /* Analyze model data... */
01627   for (ip = 0; ip < atm->np; ip++) {
01628
01629     /* Check time... */
01630     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01631       continue;
01632
01633     /* Get indices... */
01634     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
01635     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
```

```
01636     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
01637
01638     /* Check indices... */
01639     if (ix < 0 || ix >= ctl->prof_nx ||
01640         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
01641       continue;
01642
01643     /* Get total mass in grid cell... */
01644     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01645   }
01646
01647   /* Extract profiles... */
01648   for (ix = 0; ix < ctl->prof_nx; ix++)
01649     for (iy = 0; iy < ctl->prof_ny; iy++)
01650       if (obscount[ix][iy] > 0) {
01651
01652         /* Write output... */
01653         fprintf(out, "\n");
01654
01655         /* Loop over altitudes... */
01656         for (iz = 0; iz < ctl->prof_nz; iz++) {
01657
01658           /* Set coordinates... */
01659           z = ctl->prof_z0 + dz * (iz + 0.5);
01660           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
01661           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
01662
01663           /* Get meteorological data... */
01664           press = P(z);
01665           intpol_met_time(met0, met1, t, press, lon, lat,
01666                           NULL, &temp, NULL, NULL, NULL, &h2o, &o3);
01667
01668           /* Calculate mass mixing ratio... */
01669           rho_air = 100. * press / (287.058 * temp);
01670           area = dlat * dlon * gsl_pow_2(M_PI * RE / 180.)
01671             * cos(lat * M_PI / 180.);
01672           mmr = mass[ix][iy][iz] / (rho_air * area * dz * 1e9);
01673
01674           /* Write output... */
01675           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01676                   tmean[ix][iy] / obscount[ix][iy],
01677                   z, lon, lat, press, temp, mmr, h2o, o3,
01678                   obsmean[ix][iy] / obscount[ix][iy]);
01679         }
01680       }
01681
01682   /* Close file... */
01683   if (t == ctl->t_stop)
01684     fclose(out);
01685 }
```

Here is the call graph for this function:



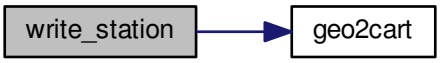
5.11.2.31 void write_station (const char * *filename*, ctl_t * *ctl*, atm_t * *atm*, double *t*)

Write station data.

Definition at line 1689 of file libtrac.c.

```
01693             {
01694
01695   static FILE *out;
01696
01697   static double rmax2, t0, t1, x0[3], x1[3];
01698
01699   static int init, ip, iq;
01700
01701   /* Init... */
01702   if (!init) {
01703     init = 1;
01704
01705     /* Write info... */
01706     printf("Write station data: %s\n", filename);
01707
01708     /* Create new file... */
01709     if (!(out = fopen(filename, "w")))
01710       ERRMSG("Cannot create file!");
01711
01712     /* Write header... */
01713     fprintf(out,
01714             "# $1 = time [s]\n"
01715             "# $2 = altitude [km]\n"
01716             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01717     for (iq = 0; iq < ctl->nq; iq++)
01718       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
01719               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
01720     fprintf(out, "\n");
01721
01722     /* Set geolocation and search radius... */
01723     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
01724     rmax2 = gsl_pow_2(ctl->stat_r);
01725   }
01726
01727   /* Set time interval for output... */
01728   t0 = t - 0.5 * ctl->dt_mod;
01729   t1 = t + 0.5 * ctl->dt_mod;
01730
01731   /* Loop over air parcels... */
01732   for (ip = 0; ip < atm->np; ip++) {
01733
01734     /* Check time... */
01735     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01736       continue;
01737
01738     /* Check station flag... */
01739     if (ctl->qnt_stat >= 0)
01740       if (atm->q[ctl->qnt_stat][ip])
01741         continue;
01742
01743     /* Get Cartesian coordinates... */
01744     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
01745
01746     /* Check horizontal distance... */
01747     if (DIST2(x0, x1) > rmax2)
01748       continue;
01749
01750     /* Set station flag... */
01751     if (ctl->qnt_stat >= 0)
01752       atm->q[ctl->qnt_stat][ip] = 1;
01753
01754     /* Write data... */
01755     fprintf(out, "%.2f %g %g %g",
01756             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
01757     for (iq = 0; iq < ctl->nq; iq++) {
01758       fprintf(out, " ");
01759       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01760     }
01761     fprintf(out, "\n");
01762   }
01763
01764   /* Close file... */
01765   if (t == ctl->t_stop)
01766     fclose(out);
01767 }
```

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   Copyright (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(filename, met0);
00134
00135     get_met_help(t + 1.0 * ctl->direction, 1, metbase, ctl->
      dt_met, filename);
00136     read_met(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(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(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 (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 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_t = -1;
00477   ctl->qnt_u = -1;
00478   ctl->qnt_v = -1;
00479   ctl->qnt_w = -1;
00480   ctl->qnt_h2o = -1;
00481   ctl->qnt_o3 = -1;
00482   ctl->qnt_theta = -1;
00483   ctl->qnt_stat = -1;
00484
00485   /* Read quantities... */
00486   ctl->nq = (int) scan_ctl(filename, argc, argv, "NQ", -1, "0", NULL);
00487   for (iq = 0; iq < ctl->nq; iq++) {
00488
00489     /* Read quantity name and format... */
00490     scan_ctl(filename, argc, argv, "QNT_NAME", iq, "", ctl->qnt_name[iq]);
00491     scan_ctl(filename, argc, argv, "QNT_FORMAT", iq, "%g",
00492              ctl->qnt_format[iq]);
00493
00494     /* Try to identify quantity... */
00495     if (strcmp(ctl->qnt_name[iq], "m") == 0) {
00496       ctl->qnt_m = iq;
00497       sprintf(ctl->qnt_unit[iq], "kg");
00498     } else if (strcmp(ctl->qnt_name[iq], "r") == 0) {
00499       ctl->qnt_r = iq;
00500       sprintf(ctl->qnt_unit[iq], "m");
00501     } else if (strcmp(ctl->qnt_name[iq], "rho") == 0) {
00502       ctl->qnt_rho = iq;
```

```
00503       sprintf(ctl->qnt_unit[iq], "kg/m^3");
00504     } else if (strcmp(ctl->qnt_name[iq], "ps") == 0) {
00505       ctl->qnt_ps = iq;
00506       sprintf(ctl->qnt_unit[iq], "hPa");
00507     } else if (strcmp(ctl->qnt_name[iq], "t") == 0) {
00508       ctl->qnt_t = iq;
00509       sprintf(ctl->qnt_unit[iq], "K");
00510     } else if (strcmp(ctl->qnt_name[iq], "u") == 0) {
00511       ctl->qnt_u = iq;
00512       sprintf(ctl->qnt_unit[iq], "m/s");
00513     } else if (strcmp(ctl->qnt_name[iq], "v") == 0) {
00514       ctl->qnt_v = iq;
00515       sprintf(ctl->qnt_unit[iq], "m/s");
00516     } else if (strcmp(ctl->qnt_name[iq], "w") == 0) {
00517       ctl->qnt_w = iq;
00518       sprintf(ctl->qnt_unit[iq], "hPa/s");
00519     } else if (strcmp(ctl->qnt_name[iq], "h2o") == 0) {
00520       ctl->qnt_h2o = iq;
00521       sprintf(ctl->qnt_unit[iq], "1");
00522     } else if (strcmp(ctl->qnt_name[iq], "o3") == 0) {
00523       ctl->qnt_o3 = iq;
00524       sprintf(ctl->qnt_unit[iq], "1");
00525     } else if (strcmp(ctl->qnt_name[iq], "theta") == 0) {
00526       ctl->qnt_theta = iq;
00527       sprintf(ctl->qnt_unit[iq], "K");
00528     } else if (strcmp(ctl->qnt_name[iq], "stat") == 0) {
00529       ctl->qnt_stat = iq;
00530       sprintf(ctl->qnt_unit[iq], "-");
00531     } else
00532       scan_ctl(filename, argc, argv, "QNT_UNIT", iq, "", ctl->qnt_unit[iq]);
00533   }
00534
00535   /* Time steps of simulation... */
00536   ctl->direction =
00537     (int) scan_ctl(filename, argc, argv, "DIRECTION", -1, "1", NULL);
00538   if (ctl->direction != -1 && ctl->direction != 1)
00539     ERRMSG("Set DIRECTION to -1 or 1!");
00540   ctl->t_start =
00541     scan_ctl(filename, argc, argv, "T_START", -1, "-1e100", NULL);
00542   ctl->t_stop = scan_ctl(filename, argc, argv, "T_STOP", -1, "-1e100", NULL);
00543   ctl->dt_mod = scan_ctl(filename, argc, argv, "DT_MOD", -1, "600", NULL);
00544
00545   /* Meteorological data... */
00546   ctl->dt_met = scan_ctl(filename, argc, argv, "DT_MET", -1, "21600", NULL);
00547
00548   /* Isosurface parameters... */
00549   ctl->isosurf
00550     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
00551   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
00552
00553   /* Diffusion parameters... */
00554   ctl->turb_dx_trop
00555     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50.0", NULL);
00556   ctl->turb_dx_strat
00557     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0.0", NULL);
00558   ctl->turb_dz_trop
00559     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0.0", NULL);
00560   ctl->turb_dz_strat
00561     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
00562   ctl->turb_meso =
00563     scan_ctl(filename, argc, argv, "TURB_MESO", -1, "0.16", NULL);
00564
00565   /* Life time of particles... */
00566   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
00567   ctl->tdec_strat =
00568     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
00569
00570   /* Output of atmospheric data... */
00571   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
      atm_basename);
00572   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
00573   ctl->atm_dt_out =
00574     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
00575
00576   /* Output of CSI data... */
00577   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
      csi_basename);
00578   ctl->csi_dt_out =
00579     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
00580   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "obs.tab",
00581            ctl->csi_obsfile);
00582   ctl->csi_obsmin =
00583     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
00584   ctl->csi_modmin =
00585     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
00586   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
00587   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
```

```
00588   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
00589   ctl->csi_lon0 =
00590     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
00591   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
00592   ctl->csi_nx =
00593     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
00594   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
00595   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
00596   ctl->csi_ny =
00597     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
00598
00599   /* Output of grid data... */
00600   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
00601            ctl->grid_basename);
00602   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
      grid_gpfile);
00603   ctl->grid_dt_out =
00604     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
00605   ctl->grid_sparse =
00606     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
00607   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
00608   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
00609   ctl->grid_nz =
00610     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
00611   ctl->grid_lon0 =
00612     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
00613   ctl->grid_lon1 =
00614     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
00615   ctl->grid_nx =
00616     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
00617   ctl->grid_lat0 =
00618     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
00619   ctl->grid_lat1 =
00620     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
00621   ctl->grid_ny =
00622     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
00623
00624   /* Output of profile data... */
00625   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
00626            ctl->prof_basename);
00627   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
      prof_obsfile);
00628   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
00629   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
00630   ctl->prof_nz =
00631     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
00632   ctl->prof_lon0 =
00633     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
00634   ctl->prof_lon1 =
00635     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
00636   ctl->prof_nx =
00637     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
00638   ctl->prof_lat0 =
00639     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
00640   ctl->prof_lat1 =
00641     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
00642   ctl->prof_ny =
00643     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
00644
00645   /* Output of station data... */
00646   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
00647            ctl->stat_basename);
00648   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
00649   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
00650   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
00651 }
00652
00653 /*****************************************************************************/
00654
00655 void read_met(
00656   char *filename,
00657   met_t * met) {
00658
00659   char tstr[10];
00660
00661   static float help[EX * EY];
00662
00663   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
00664
00665   size_t np, nx, ny;
00666
00667   /* Write info... */
00668   printf("Read meteorological data: %s\n", filename);
00669
00670   /* Get time from filename... */
00671   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
00672   year = atoi(tstr);
```

```
00673   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
00674   mon = atoi(tstr);
00675   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
00676   day = atoi(tstr);
00677   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
00678   hour = atoi(tstr);
00679   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
00680
00681   /* Open netCDF file... */
00682   NC(nc_open(filename, NC_NOWRITE, &ncid));
00683
00684   /* Get dimensions... */
00685   NC(nc_inq_dimid(ncid, "lon", &dimid));
00686   NC(nc_inq_dimlen(ncid, dimid, &nx));
00687   if (nx > EX)
00688     ERRMSG("Too many longitudes!");
00689
00690   NC(nc_inq_dimid(ncid, "lat", &dimid));
00691   NC(nc_inq_dimlen(ncid, dimid, &ny));
00692   if (ny > EY)
00693     ERRMSG("Too many latitudes!");
00694
00695   NC(nc_inq_dimid(ncid, "lev", &dimid));
00696   NC(nc_inq_dimlen(ncid, dimid, &np));
00697   if (np > EP)
00698     ERRMSG("Too many pressure levels!");
00699
00700   /* Store dimensions... */
00701   met->np = (int) np;
00702   met->nx = (int) nx;
00703   met->ny = (int) ny;
00704
00705   /* Read geolocations... */
00706   NC(nc_inq_varid(ncid, "lev", &varid));
00707   NC(nc_get_var_double(ncid, varid, met->p));
00708
00709   NC(nc_inq_varid(ncid, "lon", &varid));
00710   NC(nc_get_var_double(ncid, varid, met->lon));
00711
00712   NC(nc_inq_varid(ncid, "lat", &varid));
00713   NC(nc_get_var_double(ncid, varid, met->lat));
00714
00715   /* Check and convert pressure levels... */
00716   for (ip = 0; ip < met->np; ip++) {
00717     if (ip > 0 && met->p[ip - 1] > met->p[ip])
00718       ERRMSG("Pressure levels must be descending!");
00719     met->p[ip] /= 100.;
00720   }
00721
00722   /* Read surface pressure... */
00723   if (nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
00724     NC(nc_get_var_float(ncid, varid, help));
00725     for (iy = 0; iy < met->ny; iy++)
00726       for (ix = 0; ix < met->nx; ix++)
00727         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
00728   } else {
00729     for (ix = 0; ix < met->nx; ix++)
00730       for (iy = 0; iy < met->ny; iy++)
00731         met->ps[ix][iy] = met->p[0];
00732   }
00733
00734   /* Read meteorological data... */
00735   read_met_help(ncid, "t", "T", met, met->np, met->t, 1.0);
00736   read_met_help(ncid, "u", "U", met, met->np, met->u, 1.0);
00737   read_met_help(ncid, "v", "V", met, met->np, met->v, 1.0);
00738   read_met_help(ncid, "w", "W", met, met->np, met->w, 0.01f);
00739   read_met_help(ncid, "q", "Q", met, met->np, met->h2o, 1.608f);
00740   read_met_help(ncid, "o3", "O3", met, met->np, met->o3, 0.602f);
00741
00742   /* Extrapolate data for lower boundary... */
00743   read_met_extrapolate(met);
00744
00745   /* Copy data to obtain periodic boundary conditions... */
00746   read_met_periodic(met);
00747
00748   /* Close file... */
00749   NC(nc_close(ncid));
00750 }
00751
00752 /*****************************************************************************/
00753
00754 void read_met_extrapolate(
00755   met_t * met) {
00756
00757   int ip, ip0, ix, iy;
00758
00759   /* Loop over columns... */
```

```
00760   for (ix = 0; ix < met->nx; ix++)
00761     for (iy = 0; iy < met->ny; iy++) {
00762
00763       /* Find lowest valid data point... */
00764       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
00765         if (!gsl_finite(met->t[ix][iy][ip0])
00766             || !gsl_finite(met->u[ix][iy][ip0])
00767             || !gsl_finite(met->v[ix][iy][ip0])
00768             || !gsl_finite(met->w[ix][iy][ip0]))
00769           break;
00770
00771       /* Extrapolate... */
00772       for (ip = ip0; ip >= 0; ip--) {
00773         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
00774         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
00775         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
00776         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
00777         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
00778         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
00779       }
00780     }
00781 }
00782
00783 /*****************************************************************************/
00784
00785 void read_met_help(
00786   int ncid,
00787   char *varname,
00788   char *varname2,
00789   met_t * met,
00790   int np,
00791   float dest[EX][EY][EP],
00792   float scl) {
00793
00794   static float help[EX * EY * EP];
00795
00796   int ip, ix, iy, n = 0, varid;
00797
00798   /* Check if variable exists... */
00799   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
00800     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
00801       return;
00802
00803   /* Read data... */
00804   NC(nc_get_var_float(ncid, varid, help));
00805
00806   /* Copy and check data... */
00807   for (ip = 0; ip < np; ip++)
00808     for (iy = 0; iy < met->ny; iy++)
00809       for (ix = 0; ix < met->nx; ix++) {
00810         dest[ix][iy][ip] = scl * help[n++];
00811         if (dest[ix][iy][ip] < -1e10 || dest[ix][iy][ip] > 1e10)
00812           dest[ix][iy][ip] = GSL_NAN;
00813       }
00814 }
00815
00816 /*****************************************************************************/
00817
00818 void read_met_periodic(
00819   met_t * met) {
00820
00821   int ip, iy;
00822
00823   /* Check longitudes... */
00824   if (fabs(met->lon[met->nx - 1] - met->lon[0] - 360) < 0.01)
00825     return;
00826
00827   /* Increase longitude counter... */
00828   if ((++met->nx) > EX)
00829     ERRMSG("Cannot create periodic boundary conditions!");
00830
00831   /* Set longitude... */
00832   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
00833
00834   /* Loop over latitudes and pressure levels... */
00835   for (iy = 0; iy < met->ny; iy++)
00836     for (ip = 0; ip < met->np; ip++) {
00837       met->ps[met->nx - 1][iy] = met->ps[0][iy];
00838       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
00839       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
00840       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
00841       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
00842       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
00843       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
00844     }
00845 }
```

```
00846
00847 /*****************************************************************************/
00848
00849 double scan_ctl(
00850   const char *filename,
00851   int argc,
00852   char *argv[],
00853   const char *varname,
00854   int arridx,
00855   const char *defvalue,
00856   char *value) {
00857
00858   FILE *in = NULL;
00859
00860   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
00861     msg[LEN], rvarname[LEN], rval[LEN];
00862
00863   int contain = 0, i;
00864
00865   /* Open file... */
00866   if (filename[strlen(filename) - 1] != '-')
00867     if (!(in = fopen(filename, "r")))
00868       ERRMSG("Cannot open file!");
00869
00870   /* Set full variable name... */
00871   if (arridx >= 0) {
00872     sprintf(fullname1, "%s[%d]", varname, arridx);
00873     sprintf(fullname2, "%s[*]", varname);
00874   } else {
00875     sprintf(fullname1, "%s", varname);
00876     sprintf(fullname2, "%s", varname);
00877   }
00878
00879   /* Read data... */
00880   if (in != NULL)
00881     while (fgets(line, LEN, in))
00882       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
00883         if (strcasecmp(rvarname, fullname1) == 0 ||
00884             strcasecmp(rvarname, fullname2) == 0) {
00885           contain = 1;
00886           break;
00887         }
00888   for (i = 1; i < argc - 1; i++)
00889     if (strcasecmp(argv[i], fullname1) == 0 ||
00890         strcasecmp(argv[i], fullname2) == 0) {
00891       sprintf(rval, "%s", argv[i + 1]);
00892       contain = 1;
00893       break;
00894     }
00895
00896   /* Close file... */
00897   if (in != NULL)
00898     fclose(in);
00899
00900   /* Check for missing variables... */
00901   if (!contain) {
00902     if (strlen(defvalue) > 0)
00903       sprintf(rval, "%s", defvalue);
00904     else {
00905       sprintf(msg, "Missing variable %s!\n", fullname1);
00906       ERRMSG(msg);
00907     }
00908   }
00909
00910   /* Write info... */
00911   printf("%s = %s\n", fullname1, rval);
00912
00913   /* Return values... */
00914   if (value != NULL)
00915     sprintf(value, "%s", rval);
00916   return atof(rval);
00917 }
00918
00919 /*****************************************************************************/
00920
00921 void time2jsec(
00922   int year,
00923   int mon,
00924   int day,
00925   int hour,
00926   int min,
00927   int sec,
00928   double remain,
00929   double *jsec) {
00930
00931   struct tm t0, t1;
00932
```

```
00933   t0.tm_year = 100;
00934   t0.tm_mon = 0;
00935   t0.tm_mday = 1;
00936   t0.tm_hour = 0;
00937   t0.tm_min = 0;
00938   t0.tm_sec = 0;
00939
00940   t1.tm_year = year - 1900;
00941   t1.tm_mon = mon - 1;
00942   t1.tm_mday = day;
00943   t1.tm_hour = hour;
00944   t1.tm_min = min;
00945   t1.tm_sec = sec;
00946
00947   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
00948 }
00949
00950 /*****************************************************************************/
00951
00952 void timer(
00953   const char *name,
00954   int id,
00955   int mode) {
00956
00957   static double starttime[NTIMER], runtime[NTIMER];
00958
00959   /* Check id... */
00960   if (id < 0 || id >= NTIMER)
00961     ERRMSG("Too many timers!");
00962
00963   /* Start timer... */
00964   if (mode == 1) {
00965     if (starttime[id] <= 0)
00966       starttime[id] = omp_get_wtime();
00967     else
00968       ERRMSG("Timer already started!");
00969   }
00970
00971   /* Stop timer... */
00972   else if (mode == 2) {
00973     if (starttime[id] > 0) {
00974       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
00975       starttime[id] = -1;
00976     } else
00977       ERRMSG("Timer not started!");
00978   }
00979
00980   /* Print timer... */
00981   else if (mode == 3)
00982     printf("%s = %g s\n", name, runtime[id]);
00983 }
00984
00985 /*****************************************************************************/
00986
00987 double tropopause(
00988   double t,
00989   double lat) {
00990
00991   static double doys[12]
00992   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00993
00994   static double lats[73]
00995     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
00996     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
00997     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
00998     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
00999     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
01000     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
01001     75, 77.5, 80, 82.5, 85, 87.5, 90
01002   };
01003
01004   static double tps[12][73]
01005     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
01006          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
01007          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
01008          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
01009          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
01010          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
01011          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
01012          275.3, 275.6, 275.4, 274.1, 273.5},
01013   {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
01014    300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
01015    150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
01016    98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
01017    98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
01018    220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
01019    284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
```

```
01020    287.5, 286.2, 285.8},
01021   {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
01022    297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
01023    161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
01024    100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
01025    99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
01026    186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
01027    279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
01028    304.3, 304.9, 306, 306.6, 306.2, 306},
01029   {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
01030    290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
01031    195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
01032    102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
01033    99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
01034    148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
01035    263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
01036    315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
01037   {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
01038    260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
01039    205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
01040    101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
01041    102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
01042    165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
01043    273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
01044    325.3, 325.8, 325.8},
01045   {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
01046    222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
01047    228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
01048    105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
01049    106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
01050    127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
01051    251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
01052    308.5, 312.2, 313.1, 313.3},
01053   {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
01054    187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
01055    235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
01056    110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
01057    111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
01058    117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
01059    224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
01060    275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
01061   {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
01062    185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
01063    233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
01064    110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
01065    112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
01066    120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
01067    230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
01068    278.2, 282.6, 287.4, 290.9, 292.5, 293},
01069   {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
01070    183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
01071    243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
01072    114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
01073    110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
01074    114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
01075    203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
01076    276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
01077   {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
01078    215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
01079    237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
01080    111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
01081    106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
01082    112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
01083    206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
01084    279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
01085    305.1},
01086   {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
01087    253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
01088    223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
01089    108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
01090    102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
01091    109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
01092    241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
01093    286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
01094   {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
01095    284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
01096    175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
01097    100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
01098    100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
01099    186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
01100    280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
01101    281.7, 281.1, 281.2}
01102   };
01103
01104   double doy, p0, p1, pt;
01105
01106   int imon, ilat;
```

```
01107
01108   /* Get day of year... */
01109   doy = fmod(t / 86400., 365.25);
01110   while (doy < 0)
01111     doy += 365.25;
01112
01113   /* Get indices... */
01114   imon = locate(doys, 12, doy);
01115   ilat = locate(lats, 73, lat);
01116
01117   /* Get tropopause pressure... */
01118   p0 = LIN(lats[ilat], tps[imon][ilat],
01119            lats[ilat + 1], tps[imon][ilat + 1], lat);
01120   p1 = LIN(lats[ilat], tps[imon + 1][ilat],
01121            lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
01122   pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
01123
01124   /* Return tropopause pressure... */
01125   return pt;
01126 }
01127
01128 /*****************************************************************************/
01129
01130 void write_atm(
01131   const char *filename,
01132   ctl_t * ctl,
01133   atm_t * atm,
01134   double t) {
01135
01136   FILE *in, *out;
01137
01138   char line[LEN];
01139
01140   double r;
01141
01142   int ip, iq, year, mon, day, hour, min, sec;
01143
01144   /* Check if gnuplot output is requested... */
01145   if (ctl->atm_gpfile[0] != '-') {
01146
01147     /* Write info... */
01148     printf("Plot atmospheric data: %s.png\n", filename);
01149
01150     /* Create gnuplot pipe... */
01151     if (!(out = popen("gnuplot", "w")))
01152       ERRMSG("Cannot create pipe to gnuplot!");
01153
01154     /* Set plot filename... */
01155     fprintf(out, "set out \"%s.png\"\n", filename);
01156
01157     /* Set time string... */
01158     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01159     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01160             year, mon, day, hour, min);
01161
01162     /* Dump gnuplot file to pipe... */
01163     if (!(in = fopen(ctl->atm_gpfile, "r")))
01164       ERRMSG("Cannot open file!");
01165     while (fgets(line, LEN, in))
01166       fprintf(out, "%s", line);
01167     fclose(in);
01168   }
01169
01170   else {
01171
01172     /* Write info... */
01173     printf("Write atmospheric data: %s\n", filename);
01174
01175     /* Create file... */
01176     if (!(out = fopen(filename, "w")))
01177       ERRMSG("Cannot create file!");
01178   }
01179
01180   /* Write header... */
01181   fprintf(out,
01182           "# $1 = time [s]\n"
01183           "# $2 = altitude [km]\n"
01184           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01185   for (iq = 0; iq < ctl->nq; iq++)
01186     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
01187             ctl->qnt_unit[iq]);
01188   fprintf(out, "\n");
01189
01190   /* Write data... */
01191   for (ip = 0; ip < atm->np; ip++) {
01192     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
01193             atm->lon[ip], atm->lat[ip]);
```

```
01194     for (iq = 0; iq < ctl->nq; iq++) {
01195       fprintf(out, " ");
01196       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01197     }
01198     fprintf(out, "\n");
01199   }
01200
01201   /* Close file... */
01202   fclose(out);
01203 }
01204
01205 /*****************************************************************************/
01206
01207 void write_csi(
01208   const char *filename,
01209   ctl_t * ctl,
01210   atm_t * atm,
01211   double t) {
01212
01213   static FILE *in, *out;
01214
01215   static char line[LEN];
01216
01217   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
01218     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
01219
01220   static int init, obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
01221
01222   /* Init... */
01223   if (!init) {
01224     init = 1;
01225
01226     /* Check quantity index for mass... */
01227     if (ctl->qnt_m < 0)
01228       ERRMSG("Need quantity mass to analyze CSI!");
01229
01230     /* Open observation data file... */
01231     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
01232     if (!(in = fopen(ctl->csi_obsfile, "r")))
01233       ERRMSG("Cannot open file!");
01234
01235     /* Create new file... */
01236     printf("Write CSI data: %s\n", filename);
01237     if (!(out = fopen(filename, "w")))
01238       ERRMSG("Cannot create file!");
01239
01240     /* Write header... */
01241     fprintf(out,
01242             "# $1 = time [s]\n"
01243             "# $2 = number of hits (cx)\n"
01244             "# $3 = number of misses (cy)\n"
01245             "# $4 = number of false alarms (cz)\n"
01246             "# $5 = number of observations (cx + cy)\n"
01247             "# $6 = number of forecasts (cx + cz)\n"
01248             "# $7 = bias (forecasts/observations) [%%]\n"
01249             "# $8 = probability of detection (POD) [%%]\n"
01250             "# $9 = false alarm rate (FAR) [%%]\n"
01251             "# $10 = critical success index (CSI) [%%]\n\n");
01252   }
01253
01254   /* Set time interval... */
01255   t0 = t - 0.5 * ctl->dt_mod;
01256   t1 = t + 0.5 * ctl->dt_mod;
01257
01258   /* Initialize grid cells... */
01259   for (ix = 0; ix < ctl->csi_nx; ix++)
01260     for (iy = 0; iy < ctl->csi_ny; iy++)
01261       for (iz = 0; iz < ctl->csi_nz; iz++)
01262         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
01263
01264   /* Read data... */
01265   while (fgets(line, LEN, in)) {
01266
01267     /* Read data... */
01268     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
01269         5)
01270       continue;
01271
01272     /* Check time... */
01273     if (rt < t0)
01274       continue;
01275     if (rt > t1)
01276       break;
01277
01278     /* Calculate indices... */
01279     ix = (int) ((rlon - ctl->csi_lon0)
01280                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
```

```
01281     iy = (int) ((rlat - ctl->csi_lat0)
01282                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01283     iz = (int) ((rz - ctl->csi_z0)
01284                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01285
01286     /* Check indices... */
01287     if (ix < 0 || ix >= ctl->csi_nx ||
01288         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01289       continue;
01290
01291     /* Get mean observation index... */
01292     obsmean[ix][iy][iz] += robs;
01293     obscount[ix][iy][iz]++;
01294   }
01295
01296   /* Analyze model data... */
01297   for (ip = 0; ip < atm->np; ip++) {
01298
01299     /* Check time... */
01300     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01301       continue;
01302
01303     /* Get indices... */
01304     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
01305                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01306     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
01307                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01308     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
01309                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01310
01311     /* Check indices... */
01312     if (ix < 0 || ix >= ctl->csi_nx ||
01313         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01314       continue;
01315
01316     /* Get total mass in grid cell... */
01317     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01318   }
01319
01320   /* Analyze all grid cells... */
01321   for (ix = 0; ix < ctl->csi_nx; ix++)
01322     for (iy = 0; iy < ctl->csi_ny; iy++)
01323       for (iz = 0; iz < ctl->csi_nz; iz++) {
01324
01325         /* Calculate mean observation index... */
01326         if (obscount[ix][iy][iz] > 0)
01327           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
01328
01329         /* Calculate column density... */
01330         if (modmean[ix][iy][iz] > 0) {
01331           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
01332           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
01333           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
01334           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
01335             * cos(lat * M_PI / 180.);
01336           modmean[ix][iy][iz] /= (1e6 * area);
01337         }
01338
01339         /* Calculate CSI... */
01340         if (obscount[ix][iy][iz] > 0) {
01341           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01342               modmean[ix][iy][iz] >= ctl->csi_modmin)
01343             cx++;
01344           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01345                    modmean[ix][iy][iz] < ctl->csi_modmin)
01346             cy++;
01347           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
01348                    modmean[ix][iy][iz] >= ctl->csi_modmin)
01349             cz++;
01350         }
01351       }
01352
01353   /* Write output... */
01354   if (fmod(t, ctl->csi_dt_out) == 0) {
01355
01356     /* Write... */
01357     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
01358             t, cx, cy, cz, cx + cy, cx + cz,
01359             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
01360             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
01361             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
01362             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
01363
01364     /* Set counters to zero... */
01365     cx = cy = cz = 0;
01366   }
01367
```

```
01368   /* Close file... */
01369   if (t == ctl->t_stop)
01370     fclose(out);
01371 }
01372
01373 /*****************************************************************************/
01374
01375 void write_grid(
01376   const char *filename,
01377   ctl_t * ctl,
01378   met_t * met0,
01379   met_t * met1,
01380   atm_t * atm,
01381   double t) {
01382
01383   FILE *in, *out;
01384
01385   char line[LEN];
01386
01387   static double grid_m[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
01388     area, rho_air, press, temp, cd, mmr, t0, t1, r;
01389
01390   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
01391
01392   /* Check dimensions... */
01393   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
01394     ERRMSG("Grid dimensions too large!");
01395
01396   /* Check quantity index for mass... */
01397   if (ctl->qnt_m < 0)
01398     ERRMSG("Need quantity mass to write grid data!");
01399
01400   /* Set time interval for output... */
01401   t0 = t - 0.5 * ctl->dt_mod;
01402   t1 = t + 0.5 * ctl->dt_mod;
01403
01404   /* Set grid box size... */
01405   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
01406   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
01407   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
01408
01409   /* Initialize grid... */
01410   for (ix = 0; ix < ctl->grid_nx; ix++)
01411     for (iy = 0; iy < ctl->grid_ny; iy++)
01412       for (iz = 0; iz < ctl->grid_nz; iz++)
01413         grid_m[ix][iy][iz] = 0;
01414
01415   /* Average data... */
01416   for (ip = 0; ip < atm->np; ip++)
01417     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
01418
01419       /* Get index... */
01420       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
01421       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
01422       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
01423
01424       /* Check indices... */
01425       if (ix < 0 || ix >= ctl->grid_nx ||
01426           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
01427         continue;
01428
01429       /* Add mass... */
01430       grid_m[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01431     }
01432
01433   /* Check if gnuplot output is requested... */
01434   if (ctl->grid_gpfile[0] != '-') {
01435
01436     /* Write info... */
01437     printf("Plot grid data: %s.png\n", filename);
01438
01439     /* Create gnuplot pipe... */
01440     if (!(out = popen("gnuplot", "w")))
01441       ERRMSG("Cannot create pipe to gnuplot!");
01442
01443     /* Set plot filename... */
01444     fprintf(out, "set out \"%s.png\"\n", filename);
01445
01446     /* Set time string... */
01447     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01448     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01449             year, mon, day, hour, min);
01450
01451     /* Dump gnuplot file to pipe... */
01452     if (!(in = fopen(ctl->grid_gpfile, "r")))
01453       ERRMSG("Cannot open file!");
01454     while (fgets(line, LEN, in))
```

```
01455       fprintf(out, "%s", line);
01456     fclose(in);
01457   }
01458
01459   else {
01460
01461     /* Write info... */
01462     printf("Write grid data: %s\n", filename);
01463
01464     /* Create file... */
01465     if (!(out = fopen(filename, "w")))
01466       ERRMSG("Cannot create file!");
01467   }
01468
01469   /* Write header... */
01470   fprintf(out,
01471           "# $1 = time [s]\n"
01472           "# $2 = altitude [km]\n"
01473           "# $3 = longitude [deg]\n"
01474           "# $4 = latitude [deg]\n"
01475           "# $5 = surface area [km^2]\n"
01476           "# $6 = layer width [km]\n"
01477           "# $7 = temperature [K]\n"
01478           "# $8 = column density [kg/m^2]\n"
01479           "# $9 = mass mixing ratio [1]\n\n");
01480
01481   /* Write data... */
01482   for (ix = 0; ix < ctl->grid_nx; ix++) {
01483     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
01484       fprintf(out, "\n");
01485     for (iy = 0; iy < ctl->grid_ny; iy++) {
01486       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
01487         fprintf(out, "\n");
01488       for (iz = 0; iz < ctl->grid_nz; iz++)
01489         if (!ctl->grid_sparse
01490             || ix == 0 || iy == 0 || iz == 0 || grid_m[ix][iy][iz] > 0) {
01491
01492           /* Set coordinates... */
01493           z = ctl->grid_z0 + dz * (iz + 0.5);
01494           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
01495           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
01496
01497           /* Get pressure and temperature... */
01498           press = P(z);
01499           intpol_met_time(met0, met1, t, press, lon, lat,
01500                           NULL, &temp, NULL, NULL, NULL, NULL, NULL);
01501
01502           /* Calculate surface area... */
01503           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
01504             * cos(lat * M_PI / 180.);
01505
01506           /* Calculate column density... */
01507           cd = grid_m[ix][iy][iz] / (1e6 * area);
01508
01509           /* Calculate mass mixing ratio... */
01510           rho_air = 100. * press / (287.058 * temp);
01511           mmr = grid_m[ix][iy][iz] / (rho_air * 1e6 * area * 1e3 * dz);
01512
01513           /* Write output... */
01514           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01515                   t, z, lon, lat, area, dz, temp, cd, mmr);
01516         }
01517     }
01518   }
01519
01520   /* Close file... */
01521   fclose(out);
01522 }
01523
01524 /*****************************************************************************/
01525
01526 void write_prof(
01527   const char *filename,
01528   ctl_t * ctl,
01529   met_t * met0,
01530   met_t * met1,
01531   atm_t * atm,
01532   double t) {
01533
01534   static FILE *in, *out;
01535
01536   static char line[LEN];
01537
01538   static double mass[GX][GY][GZ], obsmean[GX][GY], tmean[GX][GY],
01539     rt, rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z,
01540     press, temp, rho_air, mmr, h2o, o3;
01541
```

```
01542   static int init, obscount[GX][GY], ip, ix, iy, iz;
01543
01544   /* Init... */
01545   if (!init) {
01546     init = 1;
01547
01548     /* Check quantity index for mass... */
01549     if (ctl->qnt_m < 0)
01550       ERRMSG("Need quantity mass!");
01551
01552     /* Check dimensions... */
01553     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
01554       ERRMSG("Grid dimensions too large!");
01555
01556     /* Open observation data file... */
01557     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
01558     if (!(in = fopen(ctl->prof_obsfile, "r")))
01559       ERRMSG("Cannot open file!");
01560
01561     /* Create new file... */
01562     printf("Write profile data: %s\n", filename);
01563     if (!(out = fopen(filename, "w")))
01564       ERRMSG("Cannot create file!");
01565
01566     /* Write header... */
01567     fprintf(out,
01568             "# $1  = time [s]\n"
01569             "# $2  = altitude [km]\n"
01570             "# $3  = longitude [deg]\n"
01571             "# $4  = latitude [deg]\n"
01572             "# $5  = pressure [hPa]\n"
01573             "# $6  = temperature [K]\n"
01574             "# $7  = mass mixing ratio [1]\n"
01575             "# $8  = H2O volume mixing ratio [1]\n"
01576             "# $9  = O3 volume mixing ratio [1]\n"
01577             "# $10 = mean BT index [K]\n");
01578
01579     /* Set grid box size... */
01580     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
01581     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
01582     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
01583   }
01584
01585   /* Set time interval... */
01586   t0 = t - 0.5 * ctl->dt_mod;
01587   t1 = t + 0.5 * ctl->dt_mod;
01588
01589   /* Initialize... */
01590   for (ix = 0; ix < ctl->prof_nx; ix++)
01591     for (iy = 0; iy < ctl->prof_ny; iy++) {
01592       obsmean[ix][iy] = 0;
01593       obscount[ix][iy] = 0;
01594       tmean[ix][iy] = 0;
01595       for (iz = 0; iz < ctl->prof_nz; iz++)
01596         mass[ix][iy][iz] = 0;
01597     }
01598
01599   /* Read data... */
01600   while (fgets(line, LEN, in)) {
01601
01602     /* Read data... */
01603     if (sscanf(line, "%lg %lg %lg %lg", &rt, &rlon, &rlat, &robs) != 4)
01604       continue;
01605
01606     /* Check time... */
01607     if (rt < t0)
01608       continue;
01609     if (rt > t1)
01610       break;
01611
01612     /* Calculate indices... */
01613     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
01614     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
01615
01616     /* Check indices... */
01617     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
01618       continue;
01619
01620     /* Get mean observation index... */
01621     obsmean[ix][iy] += robs;
01622     tmean[ix][iy] += rt;
01623     obscount[ix][iy]++;
01624   }
01625
01626   /* Analyze model data... */
01627   for (ip = 0; ip < atm->np; ip++) {
01628
```

```
01629     /* Check time... */
01630     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01631       continue;
01632
01633     /* Get indices... */
01634     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
01635     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
01636     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
01637
01638     /* Check indices... */
01639     if (ix < 0 || ix >= ctl->prof_nx ||
01640         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
01641       continue;
01642
01643     /* Get total mass in grid cell... */
01644     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01645   }
01646
01647   /* Extract profiles... */
01648   for (ix = 0; ix < ctl->prof_nx; ix++)
01649     for (iy = 0; iy < ctl->prof_ny; iy++)
01650       if (obscount[ix][iy] > 0) {
01651
01652         /* Write output... */
01653         fprintf(out, "\n");
01654
01655         /* Loop over altitudes... */
01656         for (iz = 0; iz < ctl->prof_nz; iz++) {
01657
01658           /* Set coordinates... */
01659           z = ctl->prof_z0 + dz * (iz + 0.5);
01660           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
01661           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
01662
01663           /* Get meteorological data... */
01664           press = P(z);
01665           intpol_met_time(met0, met1, t, press, lon, lat,
01666                           NULL, &temp, NULL, NULL, NULL, &h2o, &o3);
01667
01668           /* Calculate mass mixing ratio... */
01669           rho_air = 100. * press / (287.058 * temp);
01670           area = dlat * dlon * gsl_pow_2(M_PI * RE / 180.)
01671             * cos(lat * M_PI / 180.);
01672           mmr = mass[ix][iy][iz] / (rho_air * area * dz * 1e9);
01673
01674           /* Write output... */
01675           fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g\n",
01676                   tmean[ix][iy] / obscount[ix][iy],
01677                   z, lon, lat, press, temp, mmr, h2o, o3,
01678                   obsmean[ix][iy] / obscount[ix][iy]);
01679         }
01680       }
01681
01682   /* Close file... */
01683   if (t == ctl->t_stop)
01684     fclose(out);
01685 }
01686
01687 /*****************************************************************************/
01688
01689 void write_station(
01690   const char *filename,
01691   ctl_t * ctl,
01692   atm_t * atm,
01693   double t) {
01694
01695   static FILE *out;
01696
01697   static double rmax2, t0, t1, x0[3], x1[3];
01698
01699   static int init, ip, iq;
01700
01701   /* Init... */
01702   if (!init) {
01703     init = 1;
01704
01705     /* Write info... */
01706     printf("Write station data: %s\n", filename);
01707
01708     /* Create new file... */
01709     if (!(out = fopen(filename, "w")))
01710       ERRMSG("Cannot create file!");
01711
01712     /* Write header... */
01713     fprintf(out,
01714             "# $1 = time [s]\n"
01715             "# $2 = altitude [km]\n"
```

```
01716             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01717     for (iq = 0; iq < ctl->nq; iq++)
01718       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
01719               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
01720     fprintf(out, "\n");
01721
01722     /* Set geolocation and search radius... */
01723     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
01724     rmax2 = gsl_pow_2(ctl->stat_r);
01725   }
01726
01727   /* Set time interval for output... */
01728   t0 = t - 0.5 * ctl->dt_mod;
01729   t1 = t + 0.5 * ctl->dt_mod;
01730
01731   /* Loop over air parcels... */
01732   for (ip = 0; ip < atm->np; ip++) {
01733
01734     /* Check time... */
01735     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01736       continue;
01737
01738     /* Check station flag... */
01739     if (ctl->qnt_stat >= 0)
01740       if (atm->q[ctl->qnt_stat][ip])
01741         continue;
01742
01743     /* Get Cartesian coordinates... */
01744     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
01745
01746     /* Check horizontal distance... */
01747     if (DIST2(x0, x1) > rmax2)
01748       continue;
01749
01750     /* Set station flag... */
01751     if (ctl->qnt_stat >= 0)
01752       atm->q[ctl->qnt_stat][ip] = 1;
01753
01754     /* Write data... */
01755     fprintf(out, "%.2f %g %g %g",
01756             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
01757     for (iq = 0; iq < ctl->nq; iq++) {
01758       fprintf(out, " ");
01759       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01760     }
01761     fprintf(out, "\n");
01762   }
01763
01764   /* Close file... */
01765   if (t == ctl->t_stop)
01766     fclose(out);
01767 }
```

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 (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, int np, float dest[EX][EY][EP], float scl)

  Read and convert variable from meteorological data file.
- 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 }
```

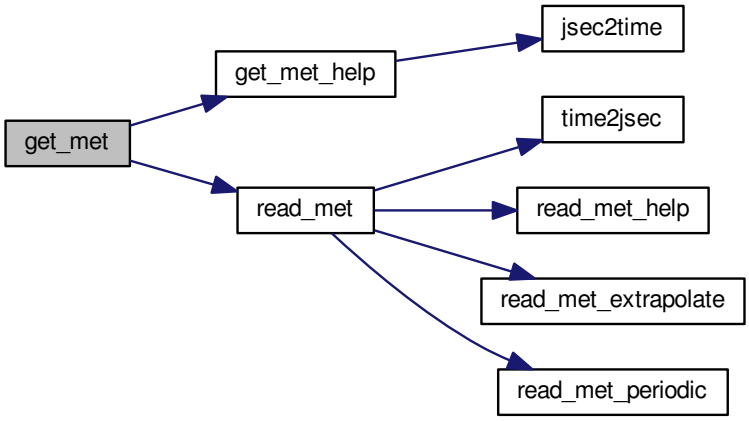
5.13.2.9 void get_met (ctl_t * *ctl*, char * *metbase*, double *t*, met_t * *met0*, met_t * *met1*)

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(filename, met0);
00134
00135     get_met_help(t + 1.0 * ctl->direction, 1, metbase, ctl->
      dt_met, filename);
00136     read_met(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(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(filename, met0);
00151   }
00152 }
```

Here is the call graph for this function:



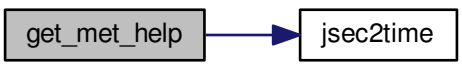
5.13.2.10 void get_met_help (double *t*, int *direct*, char * *metbase*, double *dt_met*, char * *filename*)

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*)

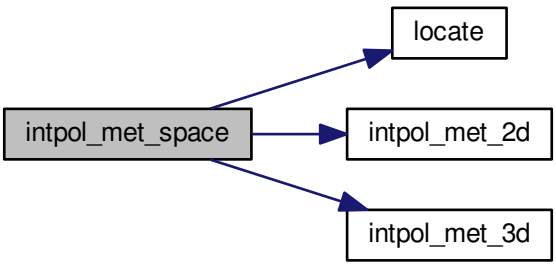
Spatial interpolation of meteorological data.

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 (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*)

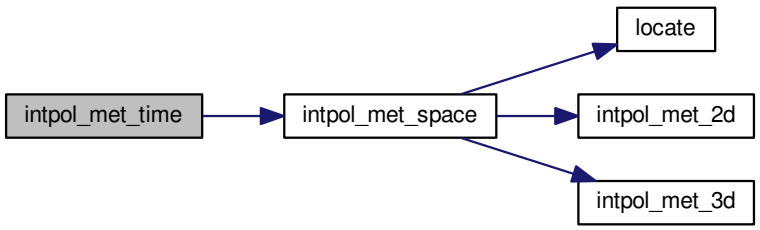
Temporal interpolation of meteorological data.

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

```
00539     ERRMSG("Set DIRECTION to -1 or 1!");
00540   ctl->t_start =
00541     scan_ctl(filename, argc, argv, "T_START", -1, "-1e100", NULL);
00542   ctl->t_stop = scan_ctl(filename, argc, argv, "T_STOP", -1, "-1e100", NULL);
00543   ctl->dt_mod = scan_ctl(filename, argc, argv, "DT_MOD", -1, "600", NULL);
00544
00545   /* Meteorological data... */
00546   ctl->dt_met = scan_ctl(filename, argc, argv, "DT_MET", -1, "21600", NULL);
00547
00548   /* Isosurface parameters... */
00549   ctl->isosurf
00550     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
00551   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
00552
00553   /* Diffusion parameters... */
00554   ctl->turb_dx_trop
00555     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50.0", NULL);
00556   ctl->turb_dx_strat
00557     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0.0", NULL);
00558   ctl->turb_dz_trop
00559     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0.0", NULL);
00560   ctl->turb_dz_strat
00561     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
00562   ctl->turb_meso =
00563     scan_ctl(filename, argc, argv, "TURB_MESO", -1, "0.16", NULL);
00564
00565   /* Life time of particles... */
00566   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
00567   ctl->tdec_strat =
00568     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
00569
00570   /* Output of atmospheric data... */
00571   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
      atm_basename);
00572   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
00573   ctl->atm_dt_out =
00574     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
00575
00576   /* Output of CSI data... */
00577   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
      csi_basename);
00578   ctl->csi_dt_out =
00579     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
00580   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "obs.tab",
00581            ctl->csi_obsfile);
00582   ctl->csi_obsmin =
00583     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
00584   ctl->csi_modmin =
00585     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
00586   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
00587   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
00588   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
00589   ctl->csi_lon0 =
00590     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
00591   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
00592   ctl->csi_nx =
00593     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
00594   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
00595   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
00596   ctl->csi_ny =
00597     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
00598
00599   /* Output of grid data... */
00600   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
00601            ctl->grid_basename);
00602   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
      grid_gpfile);
00603   ctl->grid_dt_out =
00604     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
00605   ctl->grid_sparse =
00606     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
00607   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
00608   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
00609   ctl->grid_nz =
00610     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
00611   ctl->grid_lon0 =
00612     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
00613   ctl->grid_lon1 =
00614     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
00615   ctl->grid_nx =
00616     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
00617   ctl->grid_lat0 =
00618     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
00619   ctl->grid_lat1 =
00620     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
00621   ctl->grid_ny =
00622     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
```

```
00623
00624   /* Output of profile data... */
00625   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
00626            ctl->prof_basename);
00627   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
      prof_obsfile);
00628   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
00629   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
00630   ctl->prof_nz =
00631     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
00632   ctl->prof_lon0 =
00633     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
00634   ctl->prof_lon1 =
00635     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
00636   ctl->prof_nx =
00637     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
00638   ctl->prof_lat0 =
00639     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
00640   ctl->prof_lat1 =
00641     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
00642   ctl->prof_ny =
00643     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
00644
00645   /* Output of station data... */
00646   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
00647            ctl->stat_basename);
00648   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
00649   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
00650   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
00651 }
```

Here is the call graph for this function:

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

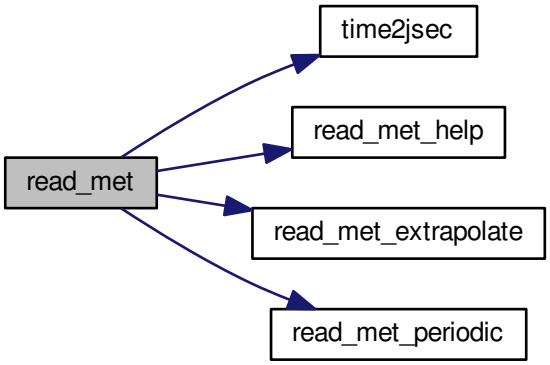
Read meteorological data file.

Definition at line 655 of file libtrac.c.

```
00657               {
00658
00659   char tstr[10];
00660
00661   static float help[EX * EY];
00662
00663   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
00664
00665   size_t np, nx, ny;
00666
00667   /* Write info... */
00668   printf("Read meteorological data: %s\n", filename);
00669
00670   /* Get time from filename... */
00671   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
00672   year = atoi(tstr);
00673   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
00674   mon = atoi(tstr);
00675   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
00676   day = atoi(tstr);
00677   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
00678   hour = atoi(tstr);
00679   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
```

```
00680
00681   /* Open netCDF file... */
00682   NC(nc_open(filename, NC_NOWRITE, &ncid));
00683
00684   /* Get dimensions... */
00685   NC(nc_inq_dimid(ncid, "lon", &dimid));
00686   NC(nc_inq_dimlen(ncid, dimid, &nx));
00687   if (nx > EX)
00688     ERRMSG("Too many longitudes!");
00689
00690   NC(nc_inq_dimid(ncid, "lat", &dimid));
00691   NC(nc_inq_dimlen(ncid, dimid, &ny));
00692   if (ny > EY)
00693     ERRMSG("Too many latitudes!");
00694
00695   NC(nc_inq_dimid(ncid, "lev", &dimid));
00696   NC(nc_inq_dimlen(ncid, dimid, &np));
00697   if (np > EP)
00698     ERRMSG("Too many pressure levels!");
00699
00700   /* Store dimensions... */
00701   met->np = (int) np;
00702   met->nx = (int) nx;
00703   met->ny = (int) ny;
00704
00705   /* Read geolocations... */
00706   NC(nc_inq_varid(ncid, "lev", &varid));
00707   NC(nc_get_var_double(ncid, varid, met->p));
00708
00709   NC(nc_inq_varid(ncid, "lon", &varid));
00710   NC(nc_get_var_double(ncid, varid, met->lon));
00711
00712   NC(nc_inq_varid(ncid, "lat", &varid));
00713   NC(nc_get_var_double(ncid, varid, met->lat));
00714
00715   /* Check and convert pressure levels... */
00716   for (ip = 0; ip < met->np; ip++) {
00717     if (ip > 0 && met->p[ip - 1] > met->p[ip])
00718       ERRMSG("Pressure levels must be descending!");
00719     met->p[ip] /= 100.;
00720   }
00721
00722   /* Read surface pressure... */
00723   if (nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
00724     NC(nc_get_var_float(ncid, varid, help));
00725     for (iy = 0; iy < met->ny; iy++)
00726       for (ix = 0; ix < met->nx; ix++)
00727         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
00728   } else {
00729     for (ix = 0; ix < met->nx; ix++)
00730       for (iy = 0; iy < met->ny; iy++)
00731         met->ps[ix][iy] = met->p[0];
00732   }
00733
00734   /* Read meteorological data... */
00735   read_met_help(ncid, "t", "T", met, met->np, met->t, 1.0);
00736   read_met_help(ncid, "u", "U", met, met->np, met->u, 1.0);
00737   read_met_help(ncid, "v", "V", met, met->np, met->v, 1.0);
00738   read_met_help(ncid, "w", "W", met, met->np, met->w, 0.01f);
00739   read_met_help(ncid, "q", "Q", met, met->np, met->h2o, 1.608f);
00740   read_met_help(ncid, "o3", "O3", met, met->np, met->o3, 0.602f);
00741
00742   /* Extrapolate data for lower boundary... */
00743   read_met_extrapolate(met);
00744
00745   /* Copy data to obtain periodic boundary conditions... */
00746   read_met_periodic(met);
00747
00748   /* Close file... */
00749   NC(nc_close(ncid));
00750 }
```

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 754 of file libtrac.c.

```
00755                {
00756
00757   int ip, ip0, ix, iy;
00758
00759   /* Loop over columns... */
00760   for (ix = 0; ix < met->nx; ix++)
00761     for (iy = 0; iy < met->ny; iy++) {
00762
00763       /* Find lowest valid data point... */
00764       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
00765         if (!gsl_finite(met->t[ix][iy][ip0])
00766             || !gsl_finite(met->u[ix][iy][ip0])
00767             || !gsl_finite(met->v[ix][iy][ip0])
00768             || !gsl_finite(met->w[ix][iy][ip0]))
00769           break;
00770
00771       /* Extrapolate... */
00772       for (ip = ip0; ip >= 0; ip--) {
00773         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
00774         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
00775         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
00776         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
00777         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
00778         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
00779       }
00780     }
00781 }
```

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

Read and convert variable from meteorological data file.

Definition at line 785 of file libtrac.c.

```
00792             {
00793
00794   static float help[EX * EY * EP];
00795
00796   int ip, ix, iy, n = 0, varid;
00797
00798   /* Check if variable exists... */
00799   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
00800     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
00801       return;
00802
00803   /* Read data... */
00804   NC(nc_get_var_float(ncid, varid, help));
00805
00806   /* Copy and check data... */
00807   for (ip = 0; ip < np; ip++)
00808     for (iy = 0; iy < met->ny; iy++)
00809       for (ix = 0; ix < met->nx; ix++) {
00810         dest[ix][iy][ip] = scl * help[n++];
00811         if (dest[ix][iy][ip] < -1e10 || dest[ix][iy][ip] > 1e10)
00812           dest[ix][iy][ip] = GSL_NAN;
00813       }
00814 }
```

5.13.2.22 void read_met_periodic (met_t * *met*)

Create meteorological data with periodic boundary conditions.

Definition at line 818 of file libtrac.c.

```
00819               {
00820
00821   int ip, iy;
00822
00823   /* Check longitudes... */
00824   if (fabs(met->lon[met->nx - 1] - met->lon[0] - 360) < 0.01)
00825     return;
00826
00827   /* Increase longitude counter... */
00828   if ((++met->nx) > EX)
00829     ERRMSG("Cannot create periodic boundary conditions!");
00830
00831   /* Set longitude... */
00832   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
00833
00834   /* Loop over latitudes and pressure levels... */
00835   for (iy = 0; iy < met->ny; iy++)
00836     for (ip = 0; ip < met->np; ip++) {
00837       met->ps[met->nx - 1][iy] = met->ps[0][iy];
00838       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
00839       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
00840       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
00841       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
00842       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
00843       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
00844     }
00845 }
```

5.13.2.23 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 849 of file libtrac.c.

```
00856               {
00857
00858   FILE *in = NULL;
00859
00860   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
00861     msg[LEN], rvarname[LEN], rval[LEN];
00862
```

```
00863   int contain = 0, i;
00864
00865   /* Open file... */
00866   if (filename[strlen(filename) - 1] != '-')
00867     if (!(in = fopen(filename, "r")))
00868       ERRMSG("Cannot open file!");
00869
00870   /* Set full variable name... */
00871   if (arridx >= 0) {
00872     sprintf(fullname1, "%s[%d]", varname, arridx);
00873     sprintf(fullname2, "%s[*]", varname);
00874   } else {
00875     sprintf(fullname1, "%s", varname);
00876     sprintf(fullname2, "%s", varname);
00877   }
00878
00879   /* Read data... */
00880   if (in != NULL)
00881     while (fgets(line, LEN, in))
00882       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
00883         if (strcasecmp(rvarname, fullname1) == 0 ||
00884             strcasecmp(rvarname, fullname2) == 0) {
00885           contain = 1;
00886           break;
00887         }
00888   for (i = 1; i < argc - 1; i++)
00889     if (strcasecmp(argv[i], fullname1) == 0 ||
00890         strcasecmp(argv[i], fullname2) == 0) {
00891       sprintf(rval, "%s", argv[i + 1]);
00892       contain = 1;
00893       break;
00894     }
00895
00896   /* Close file... */
00897   if (in != NULL)
00898     fclose(in);
00899
00900   /* Check for missing variables... */
00901   if (!contain) {
00902     if (strlen(defvalue) > 0)
00903       sprintf(rval, "%s", defvalue);
00904     else {
00905       sprintf(msg, "Missing variable %s!\n", fullname1);
00906       ERRMSG(msg);
00907     }
00908   }
00909
00910   /* Write info... */
00911   printf("%s = %s\n", fullname1, rval);
00912
00913   /* Return values... */
00914   if (value != NULL)
00915     sprintf(value, "%s", rval);
00916   return atof(rval);
00917 }
```

5.13.2.24 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 921 of file libtrac.c.

```
00929                 {
00930
00931   struct tm t0, t1;
00932
00933   t0.tm_year = 100;
00934   t0.tm_mon = 0;
00935   t0.tm_mday = 1;
00936   t0.tm_hour = 0;
00937   t0.tm_min = 0;
00938   t0.tm_sec = 0;
00939
00940   t1.tm_year = year - 1900;
00941   t1.tm_mon = mon - 1;
00942   t1.tm_mday = day;
00943   t1.tm_hour = hour;
00944   t1.tm_min = min;
00945   t1.tm_sec = sec;
00946
00947   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
00948 }
```

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

Measure wall-clock time.

Definition at line 952 of file libtrac.c.

```
00955            {
00956
00957   static double starttime[NTIMER], runtime[NTIMER];
00958
00959   /* Check id... */
00960   if (id < 0 || id >= NTIMER)
00961     ERRMSG("Too many timers!");
00962
00963   /* Start timer... */
00964   if (mode == 1) {
00965     if (starttime[id] <= 0)
00966       starttime[id] = omp_get_wtime();
00967     else
00968       ERRMSG("Timer already started!");
00969   }
00970
00971   /* Stop timer... */
00972   else if (mode == 2) {
00973     if (starttime[id] > 0) {
00974       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
00975       starttime[id] = -1;
00976     } else
00977       ERRMSG("Timer not started!");
00978   }
00979
00980   /* Print timer... */
00981   else if (mode == 3)
00982     printf("%s = %g s\n", name, runtime[id]);
00983 }
```

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

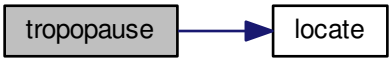
Definition at line 987 of file libtrac.c.

```
00989              {
00990
00991   static double doys[12]
00992   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
00993
00994   static double lats[73]
00995     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
00996     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
00997     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
00998     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
00999     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
01000     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
01001     75, 77.5, 80, 82.5, 85, 87.5, 90
01002   };
01003
01004   static double tps[12][73]
01005     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
01006          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
01007          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
01008          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
01009          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
01010          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
01011          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
01012          275.3, 275.6, 275.4, 274.1, 273.5},
01013   {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
01014    300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
01015    150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
01016    98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
01017    98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
01018    220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
01019    284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
01020    287.5, 286.2, 285.8},
01021   {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
01022    297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
01023    161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
01024    100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
01025    99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
```

```
01026    186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
01027    279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
01028    304.3, 304.9, 306, 306.6, 306.2, 306},
01029   {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
01030    290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
01031    195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
01032    102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
01033    99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
01034    148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
01035    263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
01036    315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
01037   {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
01038    260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
01039    205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
01040    101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
01041    102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
01042    165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
01043    273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
01044    325.3, 325.8, 325.8},
01045   {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
01046    222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
01047    228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
01048    105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
01049    106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
01050    127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
01051    251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
01052    308.5, 312.2, 313.1, 313.3},
01053   {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
01054    187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
01055    235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
01056    110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
01057    111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
01058    117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
01059    224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
01060    275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
01061   {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
01062    185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
01063    233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
01064    110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
01065    112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
01066    120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
01067    230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
01068    278.2, 282.6, 287.4, 290.9, 292.5, 293},
01069   {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
01070    183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
01071    243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
01072    114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
01073    110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
01074    114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
01075    203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
01076    276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
01077   {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
01078    215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
01079    237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
01080    111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
01081    106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
01082    112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
01083    206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
01084    279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
01085    305.1},
01086   {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
01087    253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
01088    223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
01089    108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
01090    102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
01091    109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
01092    241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
01093    286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
01094   {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
01095    284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
01096    175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
01097    100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
01098    100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
01099    186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
01100    280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
01101    281.7, 281.1, 281.2}
01102   };
01103
01104   double doy, p0, p1, pt;
01105
01106   int imon, ilat;
01107
01108   /* Get day of year... */
01109   doy = fmod(t / 86400., 365.25);
01110   while (doy < 0)
01111     doy += 365.25;
01112
```

```
01113   /* Get indices... */
01114   imon = locate(doys, 12, doy);
01115   ilat = locate(lats, 73, lat);
01116
01117   /* Get tropopause pressure... */
01118   p0 = LIN(lats[ilat], tps[imon][ilat],
01119            lats[ilat + 1], tps[imon][ilat + 1], lat);
01120   p1 = LIN(lats[ilat], tps[imon + 1][ilat],
01121            lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
01122   pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
01123
01124   /* Return tropopause pressure... */
01125   return pt;
01126 }
```

Here is the call graph for this function:



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

Write atmospheric data.

Definition at line 1130 of file libtrac.c.

```
01134            {
01135
01136   FILE *in, *out;
01137
01138   char line[LEN];
01139
01140   double r;
01141
01142   int ip, iq, year, mon, day, hour, min, sec;
01143
01144   /* Check if gnuplot output is requested... */
01145   if (ctl->atm_gpfile[0] != '-') {
01146
01147     /* Write info... */
01148     printf("Plot atmospheric data: %s.png\n", filename);
01149
01150     /* Create gnuplot pipe... */
01151     if (!(out = popen("gnuplot", "w")))
01152       ERRMSG("Cannot create pipe to gnuplot!");
01153
01154     /* Set plot filename... */
01155     fprintf(out, "set out \"%s.png\"\n", filename);
01156
01157     /* Set time string... */
01158     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01159     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01160             year, mon, day, hour, min);
01161
01162     /* Dump gnuplot file to pipe... */
01163     if (!(in = fopen(ctl->atm_gpfile, "r")))
01164       ERRMSG("Cannot open file!");
01165     while (fgets(line, LEN, in))
01166       fprintf(out, "%s", line);
01167     fclose(in);
01168   }
01169
01170   else {
01171
01172     /* Write info... */
```

```
01173     printf("Write atmospheric data: %s\n", filename);
01174
01175     /* Create file... */
01176     if (!(out = fopen(filename, "w")))
01177       ERRMSG("Cannot create file!");
01178   }
01179
01180   /* Write header... */
01181   fprintf(out,
01182           "# $1 = time [s]\n"
01183           "# $2 = altitude [km]\n"
01184           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01185   for (iq = 0; iq < ctl->nq; iq++)
01186     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
01187             ctl->qnt_unit[iq]);
01188   fprintf(out, "\n");
01189
01190   /* Write data... */
01191   for (ip = 0; ip < atm->np; ip++) {
01192     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
01193             atm->lon[ip], atm->lat[ip]);
01194     for (iq = 0; iq < ctl->nq; iq++) {
01195       fprintf(out, " ");
01196       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01197     }
01198     fprintf(out, "\n");
01199   }
01200
01201   /* Close file... */
01202   fclose(out);
01203 }
```

Here is the call graph for this function:

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

Write CSI data.

Definition at line 1207 of file libtrac.c.

```
01211             {
01212
01213   static FILE *in, *out;
01214
01215   static char line[LEN];
01216
01217   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
01218     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
01219
01220   static int init, obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
01221
01222   /* Init... */
01223   if (!init) {
01224     init = 1;
01225
01226     /* Check quantity index for mass... */
01227     if (ctl->qnt_m < 0)
01228       ERRMSG("Need quantity mass to analyze CSI!");
01229
01230     /* Open observation data file... */
01231     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
01232     if (!(in = fopen(ctl->csi_obsfile, "r")))
```

```
01233       ERRMSG("Cannot open file!");
01234
01235     /* Create new file... */
01236     printf("Write CSI data: %s\n", filename);
01237     if (!(out = fopen(filename, "w")))
01238       ERRMSG("Cannot create file!");
01239
01240     /* Write header... */
01241     fprintf(out,
01242             "# $1 = time [s]\n"
01243             "# $2 = number of hits (cx)\n"
01244             "# $3 = number of misses (cy)\n"
01245             "# $4 = number of false alarms (cz)\n"
01246             "# $5 = number of observations (cx + cy)\n"
01247             "# $6 = number of forecasts (cx + cz)\n"
01248             "# $7 = bias (forecasts/observations) [%%]\n"
01249             "# $8 = probability of detection (POD) [%%]\n"
01250             "# $9 = false alarm rate (FAR) [%%]\n"
01251             "# $10 = critical success index (CSI) [%%]\n\n");
01252   }
01253
01254   /* Set time interval... */
01255   t0 = t - 0.5 * ctl->dt_mod;
01256   t1 = t + 0.5 * ctl->dt_mod;
01257
01258   /* Initialize grid cells... */
01259   for (ix = 0; ix < ctl->csi_nx; ix++)
01260     for (iy = 0; iy < ctl->csi_ny; iy++)
01261       for (iz = 0; iz < ctl->csi_nz; iz++)
01262         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
01263
01264   /* Read data... */
01265   while (fgets(line, LEN, in)) {
01266
01267     /* Read data... */
01268     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
01269         5)
01270       continue;
01271
01272     /* Check time... */
01273     if (rt < t0)
01274       continue;
01275     if (rt > t1)
01276       break;
01277
01278     /* Calculate indices... */
01279     ix = (int) ((rlon - ctl->csi_lon0)
01280                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01281     iy = (int) ((rlat - ctl->csi_lat0)
01282                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01283     iz = (int) ((rz - ctl->csi_z0)
01284                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01285
01286     /* Check indices... */
01287     if (ix < 0 || ix >= ctl->csi_nx ||
01288         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01289       continue;
01290
01291     /* Get mean observation index... */
01292     obsmean[ix][iy][iz] += robs;
01293     obscount[ix][iy][iz]++;
01294   }
01295
01296   /* Analyze model data... */
01297   for (ip = 0; ip < atm->np; ip++) {
01298
01299     /* Check time... */
01300     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01301       continue;
01302
01303     /* Get indices... */
01304     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
01305                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01306     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
01307                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01308     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
01309                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01310
01311     /* Check indices... */
01312     if (ix < 0 || ix >= ctl->csi_nx ||
01313         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01314       continue;
01315
01316     /* Get total mass in grid cell... */
01317     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01318   }
01319
```

```
01320   /* Analyze all grid cells... */
01321   for (ix = 0; ix < ctl->csi_nx; ix++)
01322     for (iy = 0; iy < ctl->csi_ny; iy++)
01323       for (iz = 0; iz < ctl->csi_nz; iz++) {
01324
01325         /* Calculate mean observation index... */
01326         if (obscount[ix][iy][iz] > 0)
01327           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
01328
01329         /* Calculate column density... */
01330         if (modmean[ix][iy][iz] > 0) {
01331           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
01332           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
01333           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
01334           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
01335             * cos(lat * M_PI / 180.);
01336           modmean[ix][iy][iz] /= (1e6 * area);
01337         }
01338
01339         /* Calculate CSI... */
01340         if (obscount[ix][iy][iz] > 0) {
01341           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01342               modmean[ix][iy][iz] >= ctl->csi_modmin)
01343             cx++;
01344           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01345                    modmean[ix][iy][iz] < ctl->csi_modmin)
01346             cy++;
01347           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
01348                    modmean[ix][iy][iz] >= ctl->csi_modmin)
01349             cz++;
01350         }
01351       }
01352
01353   /* Write output... */
01354   if (fmod(t, ctl->csi_dt_out) == 0) {
01355
01356     /* Write... */
01357     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
01358             t, cx, cy, cz, cx + cy, cx + cz,
01359             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
01360             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
01361             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
01362             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
01363
01364     /* Set counters to zero... */
01365     cx = cy = cz = 0;
01366   }
01367
01368   /* Close file... */
01369   if (t == ctl->t_stop)
01370     fclose(out);
01371 }
```

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

Write gridded data.

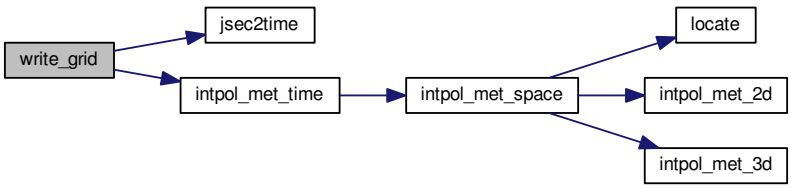
Definition at line 1375 of file libtrac.c.

```
01381             {
01382
01383   FILE *in, *out;
01384
01385   char line[LEN];
01386
01387   static double grid_m[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
01388     area, rho_air, press, temp, cd, mmr, t0, t1, r;
01389
01390   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
01391
01392   /* Check dimensions... */
01393   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
01394     ERRMSG("Grid dimensions too large!");
01395
01396   /* Check quantity index for mass... */
01397   if (ctl->qnt_m < 0)
01398     ERRMSG("Need quantity mass to write grid data!");
01399
01400   /* Set time interval for output... */
01401   t0 = t - 0.5 * ctl->dt_mod;
```

```
01402   t1 = t + 0.5 * ctl->dt_mod;
01403
01404   /* Set grid box size... */
01405   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
01406   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
01407   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
01408
01409   /* Initialize grid... */
01410   for (ix = 0; ix < ctl->grid_nx; ix++)
01411     for (iy = 0; iy < ctl->grid_ny; iy++)
01412       for (iz = 0; iz < ctl->grid_nz; iz++)
01413         grid_m[ix][iy][iz] = 0;
01414
01415   /* Average data... */
01416   for (ip = 0; ip < atm->np; ip++)
01417     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
01418
01419       /* Get index... */
01420       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
01421       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
01422       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
01423
01424       /* Check indices... */
01425       if (ix < 0 || ix >= ctl->grid_nx ||
01426           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
01427         continue;
01428
01429       /* Add mass... */
01430       grid_m[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01431     }
01432
01433   /* Check if gnuplot output is requested... */
01434   if (ctl->grid_gpfile[0] != '-') {
01435
01436     /* Write info... */
01437     printf("Plot grid data: %s.png\n", filename);
01438
01439     /* Create gnuplot pipe... */
01440     if (!(out = popen("gnuplot", "w")))
01441       ERRMSG("Cannot create pipe to gnuplot!");
01442
01443     /* Set plot filename... */
01444     fprintf(out, "set out \"%s.png\"\n", filename);
01445
01446     /* Set time string... */
01447     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01448     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01449             year, mon, day, hour, min);
01450
01451     /* Dump gnuplot file to pipe... */
01452     if (!(in = fopen(ctl->grid_gpfile, "r")))
01453       ERRMSG("Cannot open file!");
01454     while (fgets(line, LEN, in))
01455       fprintf(out, "%s", line);
01456     fclose(in);
01457   }
01458
01459   else {
01460
01461     /* Write info... */
01462     printf("Write grid data: %s\n", filename);
01463
01464     /* Create file... */
01465     if (!(out = fopen(filename, "w")))
01466       ERRMSG("Cannot create file!");
01467   }
01468
01469   /* Write header... */
01470   fprintf(out,
01471           "# $1 = time [s]\n"
01472           "# $2 = altitude [km]\n"
01473           "# $3 = longitude [deg]\n"
01474           "# $4 = latitude [deg]\n"
01475           "# $5 = surface area [km^2]\n"
01476           "# $6 = layer width [km]\n"
01477           "# $7 = temperature [K]\n"
01478           "# $8 = column density [kg/m^2]\n"
01479           "# $9 = mass mixing ratio [1]\n\n");
01480
01481   /* Write data... */
01482   for (ix = 0; ix < ctl->grid_nx; ix++) {
01483     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
01484       fprintf(out, "\n");
01485     for (iy = 0; iy < ctl->grid_ny; iy++) {
01486       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
01487         fprintf(out, "\n");
01488       for (iz = 0; iz < ctl->grid_nz; iz++)
```

```
01489         if (!ctl->grid_sparse
01490             || ix == 0 || iy == 0 || iz == 0 || grid_m[ix][iy][iz] > 0) {
01491
01492           /* Set coordinates... */
01493           z = ctl->grid_z0 + dz * (iz + 0.5);
01494           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
01495           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
01496
01497           /* Get pressure and temperature... */
01498           press = P(z);
01499           intpol_met_time(met0, met1, t, press, lon, lat,
01500                           NULL, &temp, NULL, NULL, NULL, NULL, NULL);
01501
01502           /* Calculate surface area... */
01503           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
01504             * cos(lat * M_PI / 180.);
01505
01506           /* Calculate column density... */
01507           cd = grid_m[ix][iy][iz] / (1e6 * area);
01508
01509           /* Calculate mass mixing ratio... */
01510           rho_air = 100. * press / (287.058 * temp);
01511           mmr = grid_m[ix][iy][iz] / (rho_air * 1e6 * area * 1e3 * dz);
01512
01513           /* Write output... */
01514           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01515                   t, z, lon, lat, area, dz, temp, cd, mmr);
01516         }
01517     }
01518   }
01519
01520   /* Close file... */
01521   fclose(out);
01522 }
```

Here is the call graph for this function:



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

Write profile data.

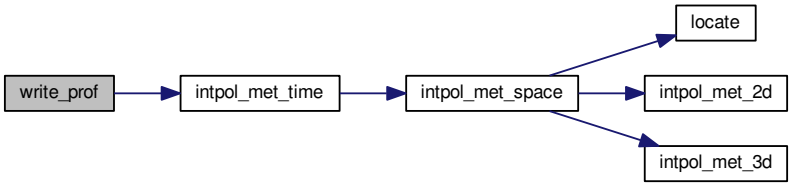
Definition at line 1526 of file libtrac.c.

```
01532             {
01533
01534   static FILE *in, *out;
01535
01536   static char line[LEN];
01537
01538   static double mass[GX][GY][GZ], obsmean[GX][GY], tmean[GX][GY],
01539     rt, rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z,
01540     press, temp, rho_air, mmr, h2o, o3;
01541
01542   static int init, obscount[GX][GY], ip, ix, iy, iz;
01543
01544   /* Init... */
01545   if (!init) {
01546     init = 1;
01547
01548     /* Check quantity index for mass... */
```

```
01549     if (ctl->qnt_m < 0)
01550       ERRMSG("Need quantity mass!");
01551
01552     /* Check dimensions... */
01553     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
01554       ERRMSG("Grid dimensions too large!");
01555
01556     /* Open observation data file... */
01557     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
01558     if (!(in = fopen(ctl->prof_obsfile, "r")))
01559       ERRMSG("Cannot open file!");
01560
01561     /* Create new file... */
01562     printf("Write profile data: %s\n", filename);
01563     if (!(out = fopen(filename, "w")))
01564       ERRMSG("Cannot create file!");
01565
01566     /* Write header... */
01567     fprintf(out,
01568             "# $1  = time [s]\n"
01569             "# $2  = altitude [km]\n"
01570             "# $3  = longitude [deg]\n"
01571             "# $4  = latitude [deg]\n"
01572             "# $5  = pressure [hPa]\n"
01573             "# $6  = temperature [K]\n"
01574             "# $7  = mass mixing ratio [1]\n"
01575             "# $8  = H2O volume mixing ratio [1]\n"
01576             "# $9  = O3 volume mixing ratio [1]\n"
01577             "# $10 = mean BT index [K]\n");
01578
01579     /* Set grid box size... */
01580     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
01581     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
01582     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
01583   }
01584
01585   /* Set time interval... */
01586   t0 = t - 0.5 * ctl->dt_mod;
01587   t1 = t + 0.5 * ctl->dt_mod;
01588
01589   /* Initialize... */
01590   for (ix = 0; ix < ctl->prof_nx; ix++)
01591     for (iy = 0; iy < ctl->prof_ny; iy++) {
01592       obsmean[ix][iy] = 0;
01593       obscount[ix][iy] = 0;
01594       tmean[ix][iy] = 0;
01595       for (iz = 0; iz < ctl->prof_nz; iz++)
01596         mass[ix][iy][iz] = 0;
01597     }
01598
01599   /* Read data... */
01600   while (fgets(line, LEN, in)) {
01601
01602     /* Read data... */
01603     if (sscanf(line, "%lg %lg %lg %lg", &rt, &rlon, &rlat, &robs) != 4)
01604       continue;
01605
01606     /* Check time... */
01607     if (rt < t0)
01608       continue;
01609     if (rt > t1)
01610       break;
01611
01612     /* Calculate indices... */
01613     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
01614     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
01615
01616     /* Check indices... */
01617     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
01618       continue;
01619
01620     /* Get mean observation index... */
01621     obsmean[ix][iy] += robs;
01622     tmean[ix][iy] += rt;
01623     obscount[ix][iy]++;
01624   }
01625
01626   /* Analyze model data... */
01627   for (ip = 0; ip < atm->np; ip++) {
01628
01629     /* Check time... */
01630     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01631       continue;
01632
01633     /* Get indices... */
01634     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
01635     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
```

```
01636     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
01637
01638     /* Check indices... */
01639     if (ix < 0 || ix >= ctl->prof_nx ||
01640         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
01641       continue;
01642
01643     /* Get total mass in grid cell... */
01644     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01645   }
01646
01647   /* Extract profiles... */
01648   for (ix = 0; ix < ctl->prof_nx; ix++)
01649     for (iy = 0; iy < ctl->prof_ny; iy++)
01650       if (obscount[ix][iy] > 0) {
01651
01652         /* Write output... */
01653         fprintf(out, "\n");
01654
01655         /* Loop over altitudes... */
01656         for (iz = 0; iz < ctl->prof_nz; iz++) {
01657
01658           /* Set coordinates... */
01659           z = ctl->prof_z0 + dz * (iz + 0.5);
01660           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
01661           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
01662
01663           /* Get meteorological data... */
01664           press = P(z);
01665           intpol_met_time(met0, met1, t, press, lon, lat,
01666                           NULL, &temp, NULL, NULL, NULL, &h2o, &o3);
01667
01668           /* Calculate mass mixing ratio... */
01669           rho_air = 100. * press / (287.058 * temp);
01670           area = dlat * dlon * gsl_pow_2(M_PI * RE / 180.)
01671             * cos(lat * M_PI / 180.);
01672           mmr = mass[ix][iy][iz] / (rho_air * area * dz * 1e9);
01673
01674           /* Write output... */
01675           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01676                   tmean[ix][iy] / obscount[ix][iy],
01677                   z, lon, lat, press, temp, mmr, h2o, o3,
01678                   obsmean[ix][iy] / obscount[ix][iy]);
01679         }
01680       }
01681
01682   /* Close file... */
01683   if (t == ctl->t_stop)
01684     fclose(out);
01685 }
```

Here is the call graph for this function:



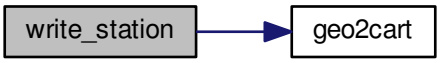
5.13.2.31 void write_station (const char * *filename*, ctl_t * *ctl*, atm_t * *atm*, double *t*)

Write station data.

Definition at line 1689 of file libtrac.c.

```
01693             {
01694
01695   static FILE *out;
01696
01697   static double rmax2, t0, t1, x0[3], x1[3];
01698
01699   static int init, ip, iq;
01700
01701   /* Init... */
01702   if (!init) {
01703     init = 1;
01704
01705     /* Write info... */
01706     printf("Write station data: %s\n", filename);
01707
01708     /* Create new file... */
01709     if (!(out = fopen(filename, "w")))
01710       ERRMSG("Cannot create file!");
01711
01712     /* Write header... */
01713     fprintf(out,
01714             "# $1 = time [s]\n"
01715             "# $2 = altitude [km]\n"
01716             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01717     for (iq = 0; iq < ctl->nq; iq++)
01718       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
01719               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
01720     fprintf(out, "\n");
01721
01722     /* Set geolocation and search radius... */
01723     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
01724     rmax2 = gsl_pow_2(ctl->stat_r);
01725   }
01726
01727   /* Set time interval for output... */
01728   t0 = t - 0.5 * ctl->dt_mod;
01729   t1 = t + 0.5 * ctl->dt_mod;
01730
01731   /* Loop over air parcels... */
01732   for (ip = 0; ip < atm->np; ip++) {
01733
01734     /* Check time... */
01735     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01736       continue;
01737
01738     /* Check station flag... */
01739     if (ctl->qnt_stat >= 0)
01740       if (atm->q[ctl->qnt_stat][ip])
01741         continue;
01742
01743     /* Get Cartesian coordinates... */
01744     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
01745
01746     /* Check horizontal distance... */
01747     if (DIST2(x0, x1) > rmax2)
01748       continue;
01749
01750     /* Set station flag... */
01751     if (ctl->qnt_stat >= 0)
01752       atm->q[ctl->qnt_stat][ip] = 1;
01753
01754     /* Write data... */
01755     fprintf(out, "%.2f %g %g %g",
01756             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
01757     for (iq = 0; iq < ctl->nq; iq++) {
01758       fprintf(out, " ");
01759       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01760     }
01761     fprintf(out, "\n");
01762   }
01763
01764   /* Close file... */
01765   if (t == ctl->t_stop)
01766     fclose(out);
01767 }
```

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 5
00143
00145 #define EP 66
00146
00148 #define EX 361
00149
00151 #define EY 181
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_t;
00201
00203   int qnt_u;
00204
00206   int qnt_v;
```

```
00207
00209   int qnt_w;
00210
00212   int qnt_h2o;
00213
00215   int qnt_o3;
00216
00218   int qnt_theta;
00219
00221   int qnt_stat;
00222
00224   int direction;
00225
00227   double t_start;
00228
00230   double t_stop;
00231
00233   double dt_mod;
00234
00236   double dt_met;
00237
00240   int isosurf;
00241
00243   char balloon[LEN];
00244
00246   double turb_dx_trop;
00247
00249   double turb_dx_strat;
00250
00252   double turb_dz_trop;
00253
00255   double turb_dz_strat;
00256
00258   double turb_meso;
00259
00261   double tdec_trop;
00262
00264   double tdec_strat;
00265
00267   char atm_basename[LEN];
00268
00270   char atm_gpfile[LEN];
00271
00273   double atm_dt_out;
00274
00276   char csi_basename[LEN];
00277
00279   double csi_dt_out;
00280
00282   char csi_obsfile[LEN];
00283
00285   double csi_obsmin;
00286
00288   double csi_modmin;
00289
00291   int csi_nz;
00292
00294   double csi_z0;
00295
00297   double csi_z1;
00298
00300   int csi_nx;
00301
00303   double csi_lon0;
00304
00306   double csi_lon1;
00307
00309   int csi_ny;
00310
00312   double csi_lat0;
00313
00315   double csi_lat1;
00316
00318   char grid_basename[LEN];
00319
00321   char grid_gpfile[LEN];
00322
00324   double grid_dt_out;
00325
00327   int grid_sparse;
00328
00330   int grid_nz;
00331
00333   double grid_z0;
00334
00336   double grid_z1;
00337
```

```
00339   int grid_nx;
00340
00342   double grid_lon0;
00343
00345   double grid_lon1;
00346
00348   int grid_ny;
00349
00351   double grid_lat0;
00352
00354   double grid_lat1;
00355
00357   char prof_basename[LEN];
00358
00360   char prof_obsfile[LEN];
00361
00363   int prof_nz;
00364
00366   double prof_z0;
00367
00369   double prof_z1;
00370
00372   int prof_nx;
00373
00375   double prof_lon0;
00376
00378   double prof_lon1;
00379
00381   int prof_ny;
00382
00384   double prof_lat0;
00385
00387   double prof_lat1;
00388
00390   char stat_basename[LEN];
00391
00393   double stat_lon;
00394
00396   double stat_lat;
00397
00399   double stat_r;
00400
00401 } ctl_t;
00402
00404 typedef struct {
00405
00407   int np;
00408
00410   double time[NP];
00411
00413   double p[NP];
00414
00416   double lon[NP];
00417
00419   double lat[NP];
00420
00422   double q[NQ][NP];
00423
00425   double up[NP];
00426
00428   double vp[NP];
00429
00431   double wp[NP];
00432
00433 } atm_t;
00434
00436 typedef struct {
00437
00439   double time;
00440
00442   int nx;
00443
00445   int ny;
00446
00448   int np;
00449
00451   double lon[EX];
00452
00454   double lat[EY];
00455
00457   double p[EP];
00458
00460   double ps[EX][EY];
00461
00463   float t[EX][EY][EP];
00464
00466   float u[EX][EY][EP];
```

```
00467
00469   float v[EX][EY][EP];
00470
00472   float w[EX][EY][EP];
00473
00475   float h2o[EX][EY][EP];
00476
00478   float o3[EX][EY][EP];
00479
00480 } met_t;
00481
00482 /* ------------------------------------------------------------
00483    Functions...
00484    ------------------------------------------------------------ */
00485
00487 void cart2geo(
00488   double *x,
00489   double *z,
00490   double *lon,
00491   double *lat);
00492
00494 double deg2dx(
00495   double dlon,
00496   double lat);
00497
00499 double deg2dy(
00500   double dlat);
00501
00503 double dp2dz(
00504   double dp,
00505   double p);
00506
00508 double dx2deg(
00509   double dx,
00510   double lat);
00511
00513 double dy2deg(
00514   double dy);
00515
00517 double dz2dp(
00518   double dz,
00519   double p);
00520
00522 void geo2cart(
00523   double z,
00524   double lon,
00525   double lat,
00526   double *x);
00527
00529 void get_met(
00530   ctl_t * ctl,
00531   char *metbase,
00532   double t,
00533   met_t * met0,
00534   met_t * met1);
00535
00537 void get_met_help(
00538   double t,
00539   int direct,
00540   char *metbase,
00541   double dt_met,
00542   char *filename);
00543
00545 void intpol_met_2d(
00546   double array[EX][EY],
00547   int ix,
00548   int iy,
00549   double wx,
00550   double wy,
00551   double *var);
00552
00554 void intpol_met_3d(
00555   float array[EX][EY][EP],
00556   int ip,
00557   int ix,
00558   int iy,
00559   double wp,
00560   double wx,
00561   double wy,
00562   double *var);
00563
00565 void intpol_met_space(
00566   met_t * met,
00567   double p,
00568   double lon,
00569   double lat,
00570   double *ps,
```

```
00571   double *t,
00572   double *u,
00573   double *v,
00574   double *w,
00575   double *h2o,
00576   double *o3);
00577
00579 void intpol_met_time(
00580   met_t * met0,
00581   met_t * met1,
00582   double ts,
00583   double p,
00584   double lon,
00585   double lat,
00586   double *ps,
00587   double *t,
00588   double *u,
00589   double *v,
00590   double *w,
00591   double *h2o,
00592   double *o3);
00593
00595 void jsec2time(
00596   double jsec,
00597   int *year,
00598   int *mon,
00599   int *day,
00600   int *hour,
00601   int *min,
00602   int *sec,
00603   double *remain);
00604
00606 int locate(
00607   double *xx,
00608   int n,
00609   double x);
00610
00612 void read_atm(
00613   const char *filename,
00614   ctl_t * ctl,
00615   atm_t * atm);
00616
00618 void read_ctl(
00619   const char *filename,
00620   int argc,
00621   char *argv[],
00622   ctl_t * ctl);
00623
00625 void read_met(
00626   char *filename,
00627   met_t * met);
00628
00630 void read_met_extrapolate(
00631   met_t * met);
00632
00634 void read_met_help(
00635   int ncid,
00636   char *varname,
00637   char *varname2,
00638   met_t * met,
00639   int np,
00640   float dest[EX][EY][EP],
00641   float scl);
00642
00644 void read_met_periodic(
00645   met_t * met);
00646
00648 double scan_ctl(
00649   const char *filename,
00650   int argc,
00651   char *argv[],
00652   const char *varname,
00653   int arridx,
00654   const char *defvalue,
00655   char *value);
00656
00658 void time2jsec(
00659   int year,
00660   int mon,
00661   int day,
00662   int hour,
00663   int min,
00664   int sec,
00665   double remain,
00666   double *jsec);
00667
00669 void timer(
```

```
00670   const char *name,
00671   int id,
00672   int mode);
00673
00674 /* Get tropopause pressure... */
00675 double tropopause(
00676   double t,
00677   double lat);
00678
00680 void write_atm(
00681   const char *filename,
00682   ctl_t * ctl,
00683   atm_t * atm,
00684   double t);
00685
00687 void write_csi(
00688   const char *filename,
00689   ctl_t * ctl,
00690   atm_t * atm,
00691   double t);
00692
00694 void write_grid(
00695   const char *filename,
00696   ctl_t * ctl,
00697   met_t * met0,
00698   met_t * met1,
00699   atm_t * atm,
00700   double t);
00701
00703 void write_prof(
00704   const char *filename,
00705   ctl_t * ctl,
00706   met_t * met0,
00707   met_t * met1,
00708   atm_t * atm,
00709   double t);
00710
00712 void write_station(
00713   const char *filename,
00714   ctl_t * ctl,
00715   atm_t * atm,
00716   double t);
```

5.15 match.c File Reference

Calculate deviations between two trajectories.

Functions

- int main (int argc, char ∗argv[ ])

5.15.1 Detailed Description

Calculate deviations between two trajectories.

Definition in file match.c.

5.15.2 Function Documentation

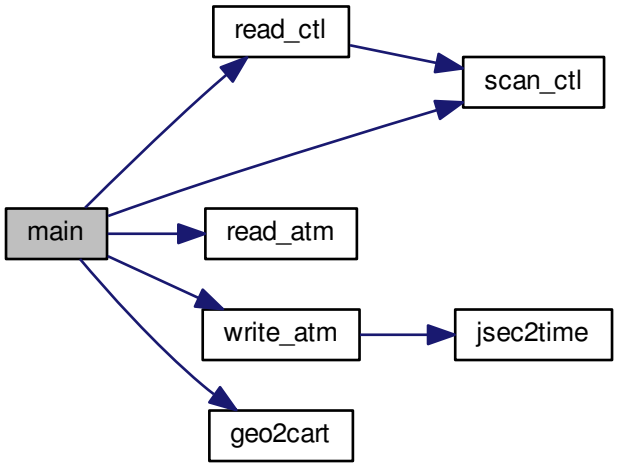
5.15.2.1 int main (int *argc,* char ∗ *argv[ ]*)

Definition at line 28 of file match.c.

```
00030                {
00031
00032   ctl_t ctl;
00033
00034   atm_t *atm1, *atm2, *atm3;
00035
00036   FILE *out;
00037
00038   char filename[LEN];
00039
00040   double filter_dt, x1[3], x2[3], dh, dq[NQ], dv, lh = 0, lt = 0, lv = 0;
00041
00042   int filter, ip1, ip2, iq, n;
00043
00044   /* Allocate... */
00045   ALLOC(atm1, atm_t, 1);
00046   ALLOC(atm2, atm_t, 1);
00047   ALLOC(atm3, atm_t, 1);
00048
00049   /* Check arguments... */
00050   if (argc < 5)
00051     ERRMSG("Give parameters: <ctl> <atm_test> <atm_ref> <outfile>");
00052
00053   /* Read control parameters... */
00054   read_ctl(argv[1], argc, argv, &ctl);
00055   filter = (int) scan_ctl(argv[1], argc, argv, "FILTER", -1, "0", NULL);
00056   filter_dt = scan_ctl(argv[1], argc, argv, "FILTER_DT", -1, "0", NULL);
00057
00058   /* Read atmospheric data... */
00059   read_atm(argv[2], &ctl, atm1);
00060   read_atm(argv[3], &ctl, atm2);
00061
00062   /* Write info... */
00063   printf("Write transport deviations: %s\n", argv[4]);
00064
00065   /* Create output file... */
00066   if (!(out = fopen(argv[4], "w")))
00067     ERRMSG("Cannot create file!");
00068
00069   /* Write header... */
00070   fprintf(out,
00071           "# $1 = time [s]\n"
00072           "# $2 = altitude [km]\n"
00073           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
00074   for (iq = 0; iq < ctl.nq; iq++)
00075     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl.qnt_name[iq],
00076             ctl.qnt_unit[iq]);
00077   fprintf(out,
00078           "# $%d = trajectory time [s]\n"
00079           "# $%d = vertical length of trajectory [km]\n"
00080           "# $%d = horizontal length of trajectory [km]\n"
00081           "# $%d = vertical deviation [km]\n"
00082           "# $%d = horizontal deviation [km]\n",
00083           5 + ctl.nq, 6 + ctl.nq, 7 + ctl.nq, 8 + ctl.nq, 9 + ctl.nq);
00084   for (iq = 0; iq < ctl.nq; iq++)
00085     fprintf(out, "# $%d = %s deviation [%s]\n", ctl.nq + iq + 10,
00086             ctl.qnt_name[iq], ctl.qnt_unit[iq]);
00087   fprintf(out, "\n");
00088
00089   /* Filtering of reference time series... */
00090   if (filter) {
00091
00092     /* Copy data... */
00093     memcpy(atm3, atm2, sizeof(atm_t));
00094
00095     /* Loop over data points... */
00096     for (ip1 = 0; ip1 < atm2->np; ip1++) {
00097       n = 0;
00098       atm2->p[ip1] = 0;
00099       for (iq = 0; iq < ctl.nq; iq++)
00100         atm2->q[iq][ip1] = 0;
00101       for (ip2 = 0; ip2 < atm2->np; ip2++)
00102         if (fabs(atm2->time[ip1] - atm2->time[ip2]) < filter_dt) {
00103           atm2->p[ip1] += atm3->p[ip2];
00104           for (iq = 0; iq < ctl.nq; iq++)
00105             atm2->q[iq][ip1] += atm3->q[iq][ip2];
00106           n++;
00107         }
00108       atm2->p[ip1] /= n;
00109       for (iq = 0; iq < ctl.nq; iq++)
00110         atm2->q[iq][ip1] /= n;
00111     }
00112
00113     /* Write filtered data... */
00114     sprintf(filename, "%s.filt", argv[3]);
00115     write_atm(filename, &ctl, atm2, 0);
00116   }
```

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

Here is the call graph for this function:



5.16 match.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026 #include <gsl/gsl_sort.h>
00027
00028 int main(
00029   int argc,
00030   char *argv[]) {
00031
00032   ctl_t ctl;
00033
00034   atm_t *atm1, *atm2, *atm3;
00035
00036   FILE *out;
00037
00038   char filename[LEN];
00039
00040   double filter_dt, x1[3], x2[3], dh, dq[NQ], dv, lh = 0, lt = 0, lv = 0;
00041
00042   int filter, ip1, ip2, iq, n;
00043
00044   /* Allocate... */
00045   ALLOC(atm1, atm_t, 1);
00046   ALLOC(atm2, atm_t, 1);
00047   ALLOC(atm3, atm_t, 1);
00048
00049   /* Check arguments... */
```

```
00050   if (argc < 5)
00051     ERRMSG("Give parameters: <ctl> <atm_test> <atm_ref> <outfile>");
00052
00053   /* Read control parameters... */
00054   read_ctl(argv[1], argc, argv, &ctl);
00055   filter = (int) scan_ctl(argv[1], argc, argv, "FILTER", -1, "0", NULL);
00056   filter_dt = scan_ctl(argv[1], argc, argv, "FILTER_DT", -1, "0", NULL);
00057
00058   /* Read atmospheric data... */
00059   read_atm(argv[2], &ctl, atm1);
00060   read_atm(argv[3], &ctl, atm2);
00061
00062   /* Write info... */
00063   printf("Write transport deviations: %s\n", argv[4]);
00064
00065   /* Create output file... */
00066   if (!(out = fopen(argv[4], "w")))
00067     ERRMSG("Cannot create file!");
00068
00069   /* Write header... */
00070   fprintf(out,
00071           "# $1 = time [s]\n"
00072           "# $2 = altitude [km]\n"
00073           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
00074   for (iq = 0; iq < ctl.nq; iq++)
00075     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl.qnt_name[iq],
00076             ctl.qnt_unit[iq]);
00077   fprintf(out,
00078           "# $%d = trajectory time [s]\n"
00079           "# $%d = vertical length of trajectory [km]\n"
00080           "# $%d = horizontal length of trajectory [km]\n"
00081           "# $%d = vertical deviation [km]\n"
00082           "# $%d = horizontal deviation [km]\n",
00083           5 + ctl.nq, 6 + ctl.nq, 7 + ctl.nq, 8 + ctl.nq, 9 + ctl.nq);
00084   for (iq = 0; iq < ctl.nq; iq++)
00085     fprintf(out, "# $%d = %s deviation [%s]\n", ctl.nq + iq + 10,
00086             ctl.qnt_name[iq], ctl.qnt_unit[iq]);
00087   fprintf(out, "\n");
00088
00089   /* Filtering of reference time series... */
00090   if (filter) {
00091
00092     /* Copy data... */
00093     memcpy(atm3, atm2, sizeof(atm_t));
00094
00095     /* Loop over data points... */
00096     for (ip1 = 0; ip1 < atm2->np; ip1++) {
00097       n = 0;
00098       atm2->p[ip1] = 0;
00099       for (iq = 0; iq < ctl.nq; iq++)
00100         atm2->q[iq][ip1] = 0;
00101       for (ip2 = 0; ip2 < atm2->np; ip2++)
00102         if (fabs(atm2->time[ip1] - atm2->time[ip2]) < filter_dt) {
00103           atm2->p[ip1] += atm3->p[ip2];
00104           for (iq = 0; iq < ctl.nq; iq++)
00105             atm2->q[iq][ip1] += atm3->q[iq][ip2];
00106           n++;
00107         }
00108       atm2->p[ip1] /= n;
00109       for (iq = 0; iq < ctl.nq; iq++)
00110         atm2->q[iq][ip1] /= n;
00111     }
00112
00113     /* Write filtered data... */
00114     sprintf(filename, "%s.filt", argv[3]);
00115     write_atm(filename, &ctl, atm2, 0);
00116   }
00117
00118   /* Loop over air parcels (reference data)... */
00119   for (ip2 = 0; ip2 < atm2->np; ip2++) {
00120
00121     /* Get trajectory length... */
00122     if (ip2 > 0) {
00123       geo2cart(0, atm2->lon[ip2 - 1], atm2->lat[ip2 - 1], x1);
00124       geo2cart(0, atm2->lon[ip2], atm2->lat[ip2], x2);
00125       lh += DIST(x1, x2);
00126       lv += fabs(Z(atm2->p[ip2 - 1]) - Z(atm2->p[ip2]));
00127       lt = fabs(atm2->time[ip2] - atm2->time[0]);
00128     }
00129
00130     /* Init... */
00131     n = 0;
00132     dh = 0;
00133     dv = 0;
00134     for (iq = 0; iq < ctl.nq; iq++)
00135       dq[iq] = 0;
00136     geo2cart(0, atm2->lon[ip2], atm2->lat[ip2], x2);
```

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

5.17 met_map.c File Reference

Extract global map from meteorological data.

Functions

- int main (int argc, char ∗argv[ ])

5.17.1 Detailed Description

Extract global map from meteorological data.

Definition in file met_map.c.

5.17.2 Function Documentation

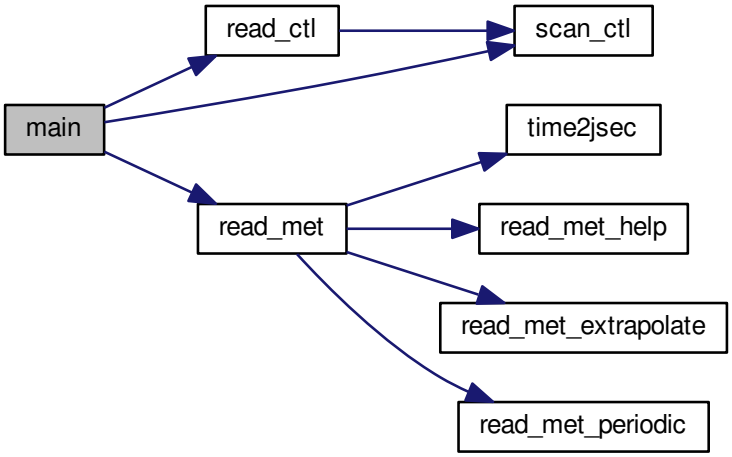
5.17.2.1 int main (int *argc*, char ∗ *argv[ ]*)

Definition at line 27 of file met_map.c.

```
00029                {
00030
00031   ctl_t ctl;
00032
00033   met_t *met;
00034
00035   FILE *in, *out;
00036
00037   static double dz, dzmin = 1e10, z, timem[EX][EY], psm[EX][EY], tm[EX][EY],
00038     um[EX][EY], vm[EX][EY], wm[EX][EY], h2om[EX][EY], o3m[EX][EY];
00039
00040   static int i, ip, ip2, ix, iy, np[EX][EY];
00041
00042   /* Allocate... */
00043   ALLOC(met, met_t, 1);
00044
00045   /* Check arguments... */
00046   if (argc < 4)
00047     ERRMSG("Give parameters: <ctl> <map.tab> <met0> [ <met1> ... ]");
00048
00049   /* Read control parameters... */
00050   read_ctl(argv[1], argc, argv, &ctl);
00051   z = scan_ctl(argv[1], argc, argv, "Z", -1, "", NULL);
00052
00053   /* Loop over files... */
00054   for (i = 3; i < argc; i++) {
00055
00056     /* Read meteorological data... */
00057     if (!(in = fopen(argv[i], "r")))
00058       continue;
00059     else
00060       fclose(in);
00061     read_met(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(argv[i], met);
00062
00063     /* Find nearest pressure level... */
00064     for (ip2 = 0; ip2 < met->np; ip2++) {
00065       dz = fabs(Z(met->p[ip2]) - z);
00066       if (dz < dzmin) {
00067         dzmin = dz;
00068         ip = ip2;
00069       }
00070     }
00071
00072     /* Average data... */
00073     for (ix = 0; ix < met->nx; ix++)
00074       for (iy = 0; iy < met->ny; iy++) {
00075         timem[ix][iy] += met->time;
00076         tm[ix][iy] += met->t[ix][iy][ip];
00077         um[ix][iy] += met->u[ix][iy][ip];
00078         vm[ix][iy] += met->v[ix][iy][ip];
00079         wm[ix][iy] += met->w[ix][iy][ip];
00080         h2om[ix][iy] += met->h2o[ix][iy][ip];
00081         o3m[ix][iy] += met->o3[ix][iy][ip];
00082         psm[ix][iy] += met->ps[ix][iy];
00083         np[ix][iy]++;
00084       }
00085   }
00086
00087   /* Create output file... */
00088   printf("Write meteorological data file: %s\n", argv[2]);
00089   if (!(out = fopen(argv[2], "w")))
00090     ERRMSG("Cannot create file!");
00091
00092   /* Write header... */
00093   fprintf(out,
00094           "# $1  = time [s]\n"
00095           "# $2  = altitude [km]\n"
00096           "# $3  = longitude [deg]\n"
00097           "# $4  = latitude [deg]\n"
00098           "# $5  = pressure [hPa]\n"
00099           "# $6  = temperature [K]\n"
00100           "# $7  = zonal wind [m/s]\n"
00101           "# $8  = meridional wind [m/s]\n"
00102           "# $9  = vertical wind [hPa/s]\n"
00103           "# $10 = H2O volume mixing ratio [1]\n"
00104           "# $11 = O3 volume mixing ratio [1]\n"
00105           "# $12 = surface pressure [hPa]\n");
00106
00107   /* Write data... */
00108   for (iy = 0; iy < met->ny; iy++) {
00109     fprintf(out, "\n");
00110     for (ix = 0; ix < met->nx; ix++)
00111       if (met->lon[ix] >= 180)
00112         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g\n",
```

```
00113                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00114                 met->lon[ix] - 360.0, met->lat[iy], met->p[ip],
00115                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00116                 vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00117                 h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00118                 psm[ix][iy] / np[ix][iy]);
00119     for (ix = 0; ix < met->nx; ix++)
00120       if (met->lon[ix] <= 180)
00121         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g\n",
00122                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00123                 met->lon[ix], met->lat[iy], met->p[ip],
00124                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00125                 vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00126                 h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00127                 psm[ix][iy] / np[ix][iy]);
00128   }
00129
00130   /* Close file... */
00131   fclose(out);
00132
00133   /* Free... */
00134   free(met);
00135
00136   return EXIT_SUCCESS;
00137 }
```

5.19 met_prof.c File Reference

Extract vertical profile from meteorological data.

Functions

- int main (int argc, char ∗argv[ ])

5.19.1 Detailed Description

Extract vertical profile from meteorological data.

Definition in file met_prof.c.

5.19.2 Function Documentation

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

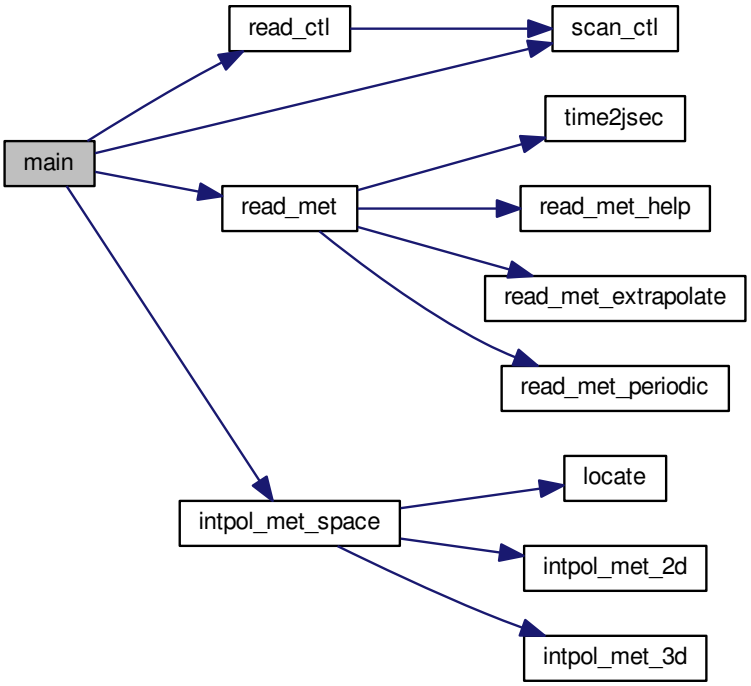
Definition at line 38 of file met_prof.c.

```
00040                 {
00041
00042   ctl_t ctl;
00043
00044   met_t *met;
00045
00046   FILE *in, *out;
00047
00048   static double timem[NZ], z, z0, z1, dz, lon, lon0, lon1, dlon, lonm[NZ],
00049     lat, lat0, lat1, dlat, latm[NZ], t, tm[NZ],
00050     u, um[NZ], v, vm[NZ], w, wm[NZ], h2o, h2om[NZ], o3, o3m[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(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, NULL,
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            np[iz]++;
00104          }
00105       }
00106   }
00107 }
00108
00109 /* Normalize... */
00110 for (z = z0; z <= z1; z += dz) {
00111   iz = (int) ((z - z0) / dz);
00112   if (np[iz] > 0) {
00113     timem[iz] /= np[iz];
00114     lonm[iz] /= np[iz];
00115     latm[iz] /= np[iz];
00116     tm[iz] /= np[iz];
00117     um[iz] /= np[iz];
00118     vm[iz] /= np[iz];
00119     wm[iz] /= np[iz];
00120     h2om[iz] /= np[iz];
00121     o3m[iz] /= np[iz];
00122   } else {
00123     timem[iz] = GSL_NAN;
00124     lonm[iz] = GSL_NAN;
00125     latm[iz] = GSL_NAN;
00126     tm[iz] = GSL_NAN;
00127     um[iz] = GSL_NAN;
00128     vm[iz] = GSL_NAN;
00129     wm[iz] = GSL_NAN;
00130     h2om[iz] = GSL_NAN;
00131     o3m[iz] = GSL_NAN;
00132   }
00133 }
00134
00135 /* Create output file... */
00136 printf("Write meteorological data file: %s\n", argv[2]);
00137 if (!(out = fopen(argv[2], "w")))
00138   ERRMSG("Cannot create file!");
00139
00140 /* Write header... */
00141 fprintf(out,
00142         "# $1  = time [s]\n"
00143         "# $2  = altitude [km]\n"
00144         "# $3  = longitude [deg]\n"
00145         "# $4  = latitude [deg]\n"
```

```
00146           "# $5  = pressure [hPa]\n"
00147           "# $6  = temperature [K]\n"
00148           "# $7  = zonal wind [m/s]\n"
00149           "# $8  = meridional wind [m/s]\n"
00150           "# $9  = vertical wind [hPa/s]\n"
00151           "# $10 = H2O volume mixing ratio [1]\n"
00152           "# $11 = O3 volume mixing ratio [1]\n\n");
00153
00154   /* Write data... */
00155   for (z = z0; z <= z1; z += dz) {
00156     iz = (int) ((z - z0) / dz);
00157     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g\n",
00158             timem[iz], z, lonm[iz], latm[iz], P(z),
00159             tm[iz], um[iz], vm[iz], wm[iz], h2om[iz], o3m[iz]);
00160   }
00161
00162   /* Close file... */
00163   fclose(out);
00164
00165   /* Free... */
00166   free(met);
00167
00168   return EXIT_SUCCESS;
00169 }
```

Here is the call graph for this function:



5.20 met_prof.c

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

```
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   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],
00050     u, um[NZ], v, vm[NZ], w, wm[NZ], h2o, h2om[NZ], o3, o3m[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(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, NULL,
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             np[iz]++;
00104           }
00105         }
00106     }
00107   }
00108
00109   /* Normalize... */
00110   for (z = z0; z <= z1; z += dz) {
00111     iz = (int) ((z - z0) / dz);
00112     if (np[iz] > 0) {
00113       timem[iz] /= np[iz];
00114       lonm[iz] /= np[iz];
00115       latm[iz] /= np[iz];
00116       tm[iz] /= np[iz];
00117       um[iz] /= np[iz];
00118       vm[iz] /= np[iz];
00119       wm[iz] /= np[iz];
00120       h2om[iz] /= np[iz];
00121       o3m[iz] /= np[iz];
00122     } else {
00123       timem[iz] = GSL_NAN;
00124       lonm[iz] = GSL_NAN;
00125       latm[iz] = GSL_NAN;
00126       tm[iz] = GSL_NAN;
00127       um[iz] = GSL_NAN;
00128       vm[iz] = GSL_NAN;
00129       wm[iz] = GSL_NAN;
00130       h2om[iz] = GSL_NAN;
00131       o3m[iz] = GSL_NAN;
00132     }
00133   }
00134
00135   /* Create output file... */
00136   printf("Write meteorological data file: %s\n", argv[2]);
00137   if (!(out = fopen(argv[2], "w")))
00138     ERRMSG("Cannot create file!");
00139
00140   /* Write header... */
00141   fprintf(out,
00142           "# $1  = time [s]\n"
00143           "# $2  = altitude [km]\n"
00144           "# $3  = longitude [deg]\n"
00145           "# $4  = latitude [deg]\n"
00146           "# $5  = pressure [hPa]\n"
00147           "# $6  = temperature [K]\n"
00148           "# $7  = zonal wind [m/s]\n"
00149           "# $8  = meridional wind [m/s]\n"
00150           "# $9  = vertical wind [hPa/s]\n"
00151           "# $10 = H2O volume mixing ratio [1]\n"
00152           "# $11 = O3 volume mixing ratio [1]\n\n");
00153
00154   /* Write data... */
00155   for (z = z0; z <= z1; z += dz) {
00156     iz = (int) ((z - z0) / dz);
00157     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g\n",
00158             timem[iz], z, lonm[iz], latm[iz], P(z),
00159             tm[iz], um[iz], vm[iz], wm[iz], h2om[iz], o3m[iz]);
00160   }
00161
00162   /* Close file... */
00163   fclose(out);
00164
00165   /* Free... */
00166   free(met);
00167
00168   return EXIT_SUCCESS;
00169 }
```

5.21 met_sample.c File Reference

Sample meteorological data at given geolocations.

Functions

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

5.21.1 Detailed Description

Sample meteorological data at given geolocations.

Definition in file met_sample.c.

5.21.2 Function Documentation

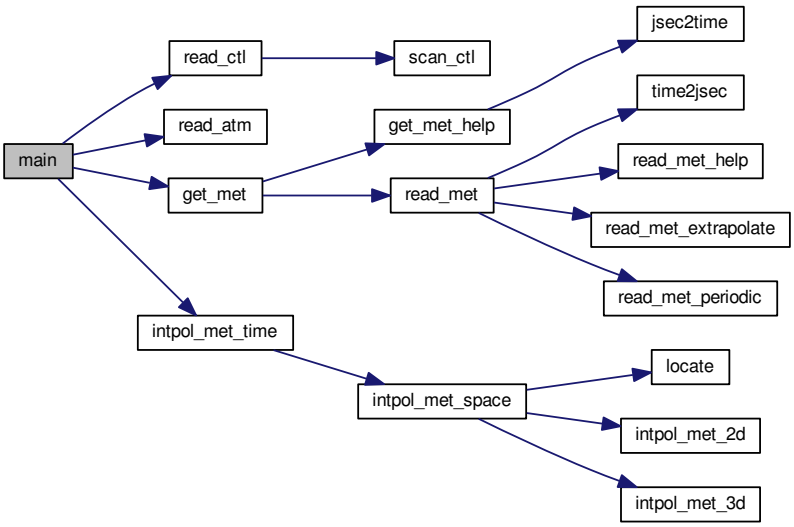
5.21.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 31 of file met_sample.c.

```
00033                {
00034
00035   ctl_t ctl;
00036
00037   atm_t *atm;
00038
00039   met_t *met0, *met1;
00040
00041   FILE *out;
00042
00043   double t, u, v, w, h2o, o3;
00044
00045   int ip;
00046
00047   /* Check arguments... */
00048   if (argc < 4)
00049     ERRMSG("Give parameters: <ctl> <metbase> <atm_in> <sample.tab>");
00050
00051   /* Allocate... */
00052   ALLOC(atm, atm_t, 1);
00053   ALLOC(met0, met_t, 1);
00054   ALLOC(met1, met_t, 1);
00055
00056   /* Read control parameters... */
00057   read_ctl(argv[1], argc, argv, &ctl);
00058
00059   /* Read atmospheric data... */
00060   read_atm(argv[3], &ctl, atm);
00061
00062   /* Create output file... */
00063   printf("Write meteorological data file: %s\n", argv[4]);
00064   if (!(out = fopen(argv[4], "w")))
00065     ERRMSG("Cannot create file!");
00066
00067   /* Write header... */
00068   fprintf(out,
00069           "# $1  = time [s]\n"
00070           "# $2  = altitude [km]\n"
00071           "# $3  = longitude [deg]\n"
00072           "# $4  = latitude [deg]\n"
00073           "# $5  = pressure [hPa]\n"
00074           "# $6  = temperature [K]\n"
00075           "# $7  = zonal wind [m/s]\n"
00076           "# $8  = meridional wind [m/s]\n"
00077           "# $9  = vertical wind [hPa/s]\n"
00078           "# $10 = H2O volume mixing ratio [1]\n"
00079           "# $11 = O3 volume mixing ratio [1]\n\n");
00080
00081   /* Loop over air parcels... */
00082   for (ip = 0; ip < atm->np; ip++) {
00083
00084     /* Get meteorological data... */
00085     get_met(&ctl, argv[2], atm->time[ip], met0, met1);
00086
00087     /* Interpolate meteorological data... */
00088     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00089                     atm->lat[ip], NULL, &t, &u, &v, &w, &h2o, &o3);
00090
00091     /* Write data... */
00092     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g\n",
00093             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip],
00094             atm->p[ip], t, u, v, w, h2o, o3);
00095   }
00096
```

```
00097   /* Close file... */
00098   fclose(out);
00099
00100   /* Free... */
00101   free(atm);
00102   free(met0);
00103   free(met1);
00104
00105   return EXIT_SUCCESS;
00106 }
```

Here is the call graph for this function:



5.22 met_sample.c

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

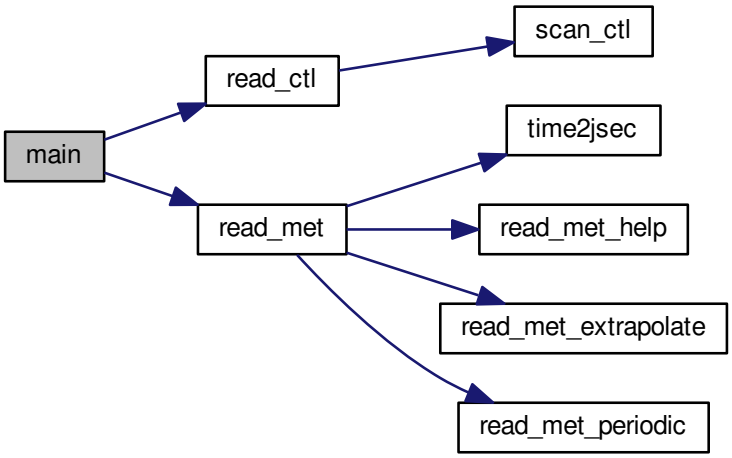
5.23.2.1 int main (int *argc*, char * *argv[]*)

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> <map.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(argv[i], met);
00063
00064     /* Average data... */
00065     for (ix = 0; ix < met->nx; ix++)
00066       for (iy = 0; iy < met->ny; iy++)
00067         for (ip = 0; ip < met->np; ip++) {
00068           timem[ip][iy] += met->time;
00069           tm[ip][iy] += met->t[ix][iy][ip];
00070           um[ip][iy] += met->u[ix][iy][ip];
00071           vm[ip][iy] += met->v[ix][iy][ip];
00072           vhm[ip][iy] += sqrt(gsl_pow_2(met->u[ix][iy][ip])
00073                               + gsl_pow_2(met->v[ix][iy][ip]));
00074           wm[ip][iy] += met->w[ix][iy][ip];
00075           h2om[ip][iy] += met->h2o[ix][iy][ip];
00076           o3m[ip][iy] += met->o3[ix][iy][ip];
00077           psm[ip][iy] += met->ps[ix][iy];
00078           tm2[ip][iy] += gsl_pow_2(met->t[ix][iy][ip]);
00079           um2[ip][iy] += gsl_pow_2(met->u[ix][iy][ip]);
00080           vm2[ip][iy] += gsl_pow_2(met->v[ix][iy][ip]);
00081           vhm2[ip][iy] += gsl_pow_2(met->u[ix][iy][ip])
00082             + gsl_pow_2(met->v[ix][iy][ip]);
00083           wm2[ip][iy] += gsl_pow_2(met->w[ix][iy][ip]);
00084           h2om2[ip][iy] += gsl_pow_2(met->h2o[ix][iy][ip]);
00085           o3m2[ip][iy] += gsl_pow_2(met->o3[ix][iy][ip]);
00086           psm2[ip][iy] += gsl_pow_2(met->ps[ix][iy]);
00087           np[ip][iy]++;
00088         }
00089   }
00090
00091   /* Create output file... */
00092   printf("Write meteorological data file: %s\n", argv[2]);
00093   if (!(out = fopen(argv[2], "w")))
```

```
00094     ERRMSG("Cannot create file!");
00095
00096   /* Write header... */
00097   fprintf(out,
00098           "# $1  = time [s]\n"
00099           "# $2  = altitude [km]\n"
00100           "# $3  = latitude [deg]\n"
00101           "# $4  = temperature mean [K]\n"
00102           "# $5  = temperature standard deviation [K]\n"
00103           "# $6  = zonal wind mean [m/s]\n"
00104           "# $7  = zonal wind standard deviation [m/s]\n"
00105           "# $8  = meridional wind mean [m/s]\n"
00106           "# $9  = meridional wind standard deviation [m/s]\n"
00107           "# $10 = horizontal wind mean [m/s]\n"
00108           "# $11 = horizontal wind standard deviation [m/s]\n"
00109           "# $12 = vertical wind mean [hPa/s]\n"
00110           "# $13 = vertical wind standard deviation [hPa/s]\n"
00111           "# $14 = H2O vmr mean [1]\n"
00112           "# $15 = H2O vmr standard deviation [1]\n"
00113           "# $16 = O3 vmr mean [1]\n"
00114           "# $17 = O3 vmr standard deviation [1]\n"
00115           "# $18 = surface pressure mean [hPa]\n"
00116           "# $19 = surface pressure standard deviation [hPa]\n");
00117
00118   /* Write data... */
00119   for (iy = 0; iy < met->ny; iy++) {
00120     fprintf(out, "\n");
00121     for (ip = 0; ip < met->np; ip++)
00122       fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g"
00123               " %g %g %g %g %g %g %g %g\n",
00124               timem[ip][iy] / np[ip][iy], Z(met->p[ip]), met->lat[iy],
00125               tm[ip][iy] / np[ip][iy],
00126               sqrt(tm2[ip][iy] / np[ip][iy] -
00127                    gsl_pow_2(tm[ip][iy] / np[ip][iy])),
00128               um[ip][iy] / np[ip][iy],
00129               sqrt(um2[ip][iy] / np[ip][iy] -
00130                    gsl_pow_2(um[ip][iy] / np[ip][iy])),
00131               vm[ip][iy] / np[ip][iy],
00132               sqrt(vm2[ip][iy] / np[ip][iy] -
00133                    gsl_pow_2(vm[ip][iy] / np[ip][iy])),
00134               vhm[ip][iy] / np[ip][iy],
00135               sqrt(vhm2[ip][iy] / np[ip][iy] -
00136                    gsl_pow_2(vhm[ip][iy] / np[ip][iy])),
00137               wm[ip][iy] / np[ip][iy],
00138               sqrt(wm2[ip][iy] / np[ip][iy] -
00139                    gsl_pow_2(wm[ip][iy] / np[ip][iy])),
00140               h2om[ip][iy] / np[ip][iy],
00141               sqrt(h2om2[ip][iy] / np[ip][iy] -
00142                    gsl_pow_2(h2om[ip][iy] / np[ip][iy])),
00143               o3m[ip][iy] / np[ip][iy],
00144               sqrt(o3m2[ip][iy] / np[ip][iy] -
00145                    gsl_pow_2(o3m[ip][iy] / np[ip][iy])),
00146               psm[ip][iy] / np[ip][iy],
00147               sqrt(psm2[ip][iy] / np[ip][iy] -
00148                    gsl_pow_2(psm[ip][iy] / np[ip][iy])));
00149   }
00150
00151   /* Close file... */
00152   fclose(out);
00153
00154   /* Free... */
00155   free(met);
00156
00157   return EXIT_SUCCESS;
00158 }
```

Here is the call graph for this function:



5.24 met_zm.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   ctl_t ctl;
00032
00033   met_t *met;
00034
00035   FILE *in, *out;
00036
00037   static double timem[EP][EY], psm[EP][EY], tm[EP][EY], um[EP][EY],
00038     vm[EP][EY], vhm[EP][EY], wm[EP][EY], h2om[EP][EY], o3m[EP][EY],
00039     psm2[EP][EY], tm2[EP][EY], um2[EP][EY], vm2[EP][EY], vhm2[EP][EY],
00040     wm2[EP][EY], h2om2[EP][EY], o3m2[EP][EY];
00041
00042   static int i, ip, ix, iy, np[EP][EY];
00043
00044   /* Allocate... */
00045   ALLOC(met, met_t, 1);
00046
00047   /* Check arguments... */
00048   if (argc < 4)
00049     ERRMSG("Give parameters: <ctl> <map.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(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 %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

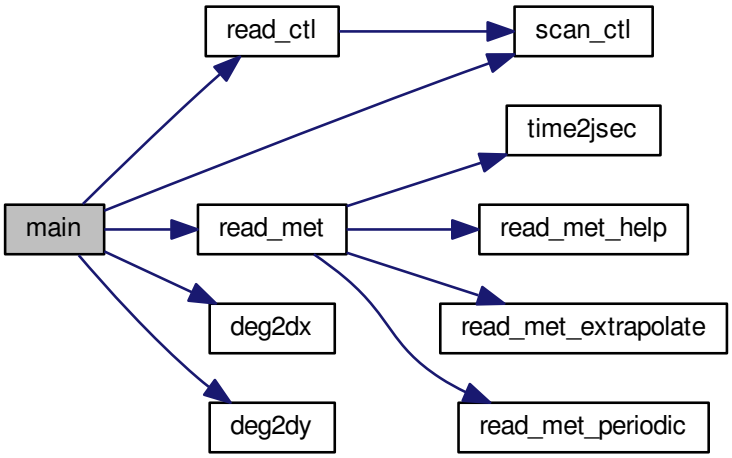
5.25.2.1 int main (int *argc*, char ∗ *argv[ ]*)

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(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 && met->lon[ix] < 360)
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 && met->lon[ix] > 0)
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(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 && met->lon[ix] < 360)
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 && met->lon[ix] > 0)
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

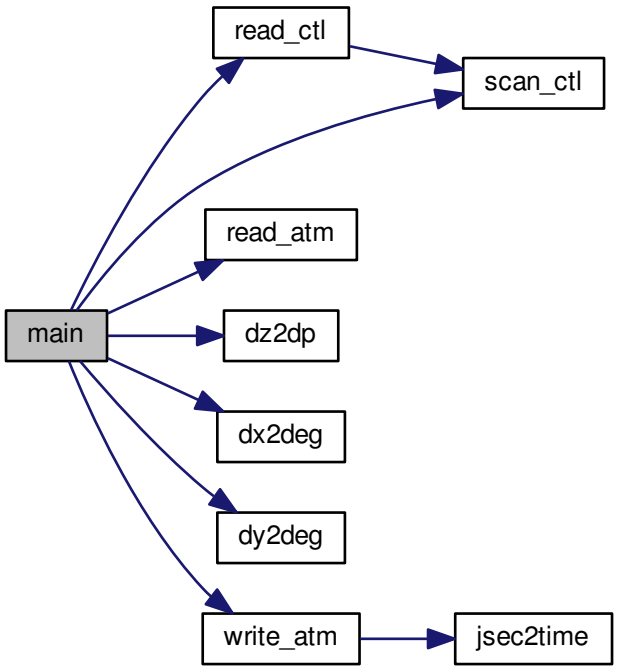
5.27.2.1 int main (int *argc*, char * *argv[]*)

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.

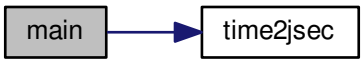
5.29.2 Function Documentation

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 }
```

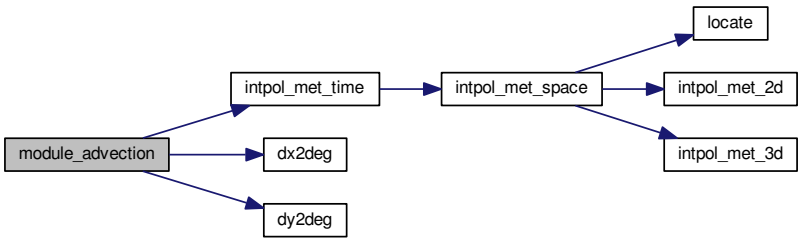
5.31.2.2 void module_advection (met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt*)

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:



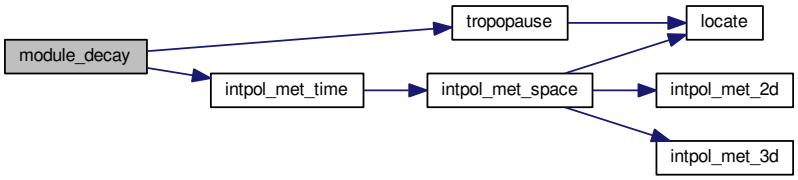
5.31.2.3 void module_decay (ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt*)

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*)

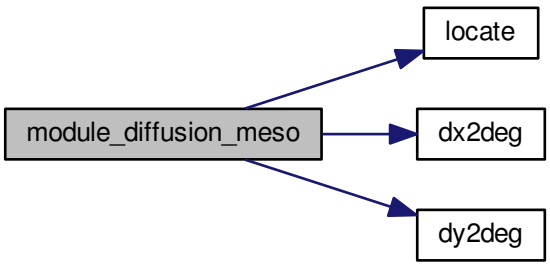
Calculate mesoscale diffusion.

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*)

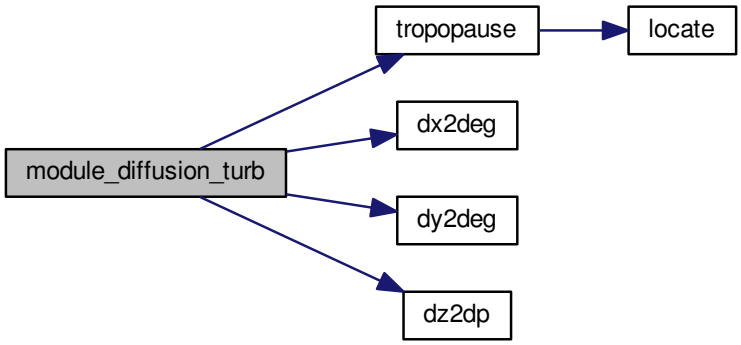
Calculate turbulent diffusion.

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*)

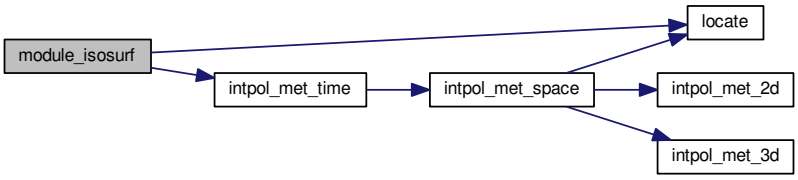
Force air parcels to stay on isosurface.

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*)

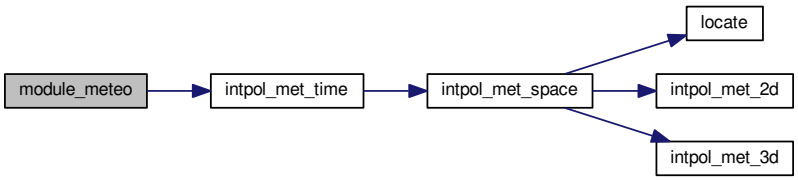
Interpolate meteorological data for air parcel positions.

Definition at line 768 of file trac.c.

```
00773           {
00774
00775   /* Interpolate surface pressure... */
00776   if (ctl->qnt_ps >= 0)
00777     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00778                     atm->lat[ip], &atm->q[ctl->qnt_ps][ip], NULL,
00779                     NULL, NULL, NULL, NULL, NULL);
00780
00781   /* Interpolate temperature... */
00782   if (ctl->qnt_t >= 0)
00783     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00784                     atm->lat[ip], NULL, &atm->q[ctl->qnt_t][ip],
00785                     NULL, NULL, NULL, NULL, NULL);
00786
00787   /* Interpolate zonal wind... */
00788   if (ctl->qnt_u >= 0)
00789     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00790                     atm->lat[ip], NULL, NULL, &atm->q[ctl->qnt_u][ip],
00791                     NULL, NULL, NULL, NULL);
00792
00793   /* Interpolate meridional wind... */
00794   if (ctl->qnt_v >= 0)
00795     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00796                     atm->lat[ip], NULL, NULL, NULL,
00797                     &atm->q[ctl->qnt_v][ip], NULL, NULL, NULL);
00798
00799   /* Interpolate vertical velocity... */
00800   if (ctl->qnt_w >= 0)
00801     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00802                     atm->lat[ip], NULL, NULL, NULL, NULL,
00803                     &atm->q[ctl->qnt_w][ip], NULL, NULL);
00804
00805   /* Interpolate water vapor vmr... */
00806   if (ctl->qnt_h2o >= 0)
00807     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00808                     atm->lat[ip], NULL, NULL, NULL, NULL, NULL,
00809                     &atm->q[ctl->qnt_h2o][ip], NULL);
00810
00811   /* Interpolate ozone... */
00812   if (ctl->qnt_o3 >= 0)
00813     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00814                     atm->lat[ip], NULL, NULL, NULL, NULL, NULL, NULL,
00815                     &atm->q[ctl->qnt_o3][ip]);
00816
00817   /* Calculate potential temperature... */
00818   if (ctl->qnt_theta >= 0) {
00819     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
```

```
      lon[ip],
00820                     atm->lat[ip], NULL, &atm->q[ctl->qnt_theta][ip],
00821                     NULL, NULL, NULL, NULL, NULL);
00822     atm->q[ctl->qnt_theta][ip] *= pow(P0 / atm->p[ip], 0.286);
00823   }
00824 }
```

Here is the call graph for this function:



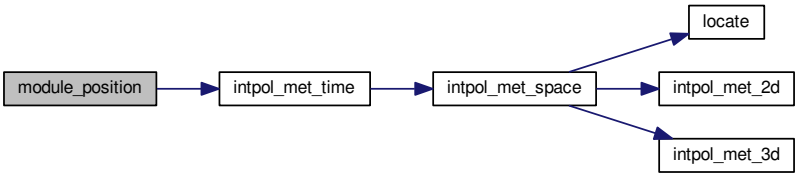
5.31.2.8 void module_position (met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*)

Check position of air parcels.

Definition at line 828 of file trac.c.

```
00832           {
00833
00834   double ps;
00835
00836   /* Calculate modulo... */
00837   atm->lon[ip] = fmod(atm->lon[ip], 360);
00838   atm->lat[ip] = fmod(atm->lat[ip], 360);
00839
00840   /* Check latitude... */
00841   while (atm->lat[ip] < -90 || atm->lat[ip] > 90) {
00842     if (atm->lat[ip] > 90) {
00843       atm->lat[ip] = 180 - atm->lat[ip];
00844       atm->lon[ip] += 180;
00845     }
00846     if (atm->lat[ip] < -90) {
00847       atm->lat[ip] = -180 - atm->lat[ip];
00848       atm->lon[ip] += 180;
00849     }
00850   }
00851
00852   /* Check longitude... */
00853   while (atm->lon[ip] < -180)
00854     atm->lon[ip] += 360;
00855   while (atm->lon[ip] >= 180)
00856     atm->lon[ip] -= 360;
00857
00858   /* Get surface pressure... */
00859   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00860                   atm->lon[ip], atm->lat[ip], &ps, NULL,
00861                   NULL, NULL, NULL, NULL, NULL);
00862
00863   /* Check pressure... */
00864   if (atm->p[ip] > ps)
00865     atm->p[ip] = ps;
00866   else if (atm->p[ip] < met0->p[met0->np - 1])
00867     atm->p[ip] = met0->p[met0->np - 1];
00868 }
```

Here is the call graph for this function:



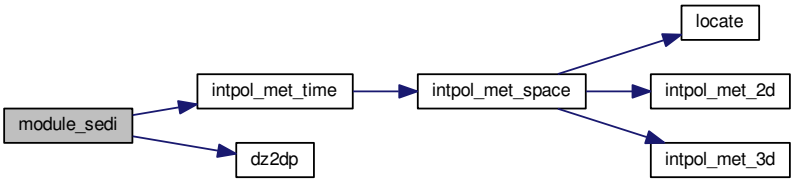
5.31.2.9 void module_sedi (ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt*)

Calculate sedimentation of air parcels.

Definition at line 872 of file trac.c.

```
00878             {
00879
00880   /* Coefficients for Cunningham slip-flow correction (Kasten, 1968): */
00881   const double A = 1.249, B = 0.42, C = 0.87;
00882
00883   /* Specific gas constant for dry air [J/(kg K)]: */
00884   const double R = 287.058;
00885
00886   /* Average mass of an air molecule [kg/molec]: */
00887   const double m = 4.8096e-26;
00888
00889   double G, K, eta, lambda, p, r_p, rho, rho_p, T, v, v_p;
00890
00891   /* Check if parameters are available... */
00892   if (ctl->qnt_r < 0 || ctl->qnt_rho < 0)
00893     return;
00894
00895   /* Convert units... */
00896   p = 100 * atm->p[ip];
00897   r_p = 1e-6 * atm->q[ctl->qnt_r][ip];
00898   rho_p = atm->q[ctl->qnt_rho][ip];
00899
00900   /* Get temperature... */
00901   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
    lon[ip],
00902                   atm->lat[ip], NULL, &T, NULL, NULL, NULL, NULL, NULL);
00903
00904   /* Density of dry air... */
00905   rho = p / (R * T);
00906
00907   /* Dynamic viscosity of air... */
00908   eta = 1.8325e-5 * (416.16 / (T + 120.)) * pow(T / 296.16, 1.5);
00909
00910   /* Thermal velocity of an air molecule... */
00911   v = sqrt(8 * GSL_CONST_MKSA_BOLTZMANN * T / (M_PI * m));
00912
00913   /* Mean free path of an air molecule... */
00914   lambda = 2 * eta / (rho * v);
00915
00916   /* Knudsen number for air... */
00917   K = lambda / r_p;
00918
00919   /* Cunningham slip-flow correction... */
00920   G = 1 + K * (A + B * exp(-C / K));
00921
00922   /* Sedimentation (fall) velocity... */
00923   v_p =
00924     2. * gsl_pow_2(r_p) * (rho_p -
00925                            rho) * GSL_CONST_MKSA_GRAV_ACCEL / (9. * eta) * G;
00926
00927   /* Calculate pressure change... */
00928   atm->p[ip] += dz2dp(v_p * dt / 1000., atm->p[ip]);
00929 }
```

Here is the call graph for this function:



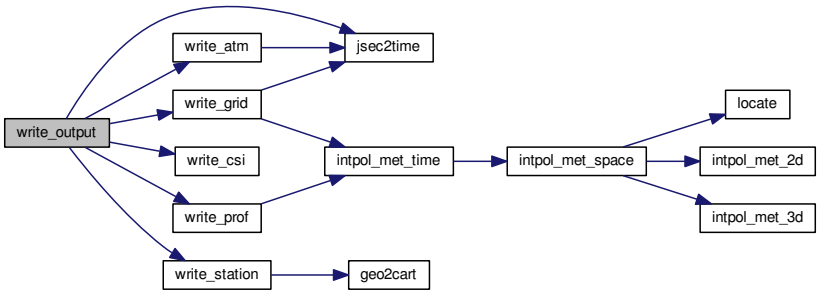
5.31.2.10 void write_output (const char * *dirname*, ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, double *t*)

Write simulation output.

Definition at line 933 of file trac.c.

```
00939            {
00940
00941   char filename[LEN];
00942
00943   double r;
00944
00945   int year, mon, day, hour, min, sec;
00946
00947   /* Get time... */
00948   jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
00949
00950   /* Write atmospheric data... */
00951   if (ctl->atm_basename[0] != '-' && fmod(t, ctl->atm_dt_out) == 0) {
00952     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
00953             dirname, ctl->atm_basename, year, mon, day, hour, min);
00954     write_atm(filename, ctl, atm, t);
00955   }
00956
00957   /* Write gridded data... */
00958   if (ctl->grid_basename[0] != '-' && fmod(t, ctl->grid_dt_out) == 0) {
00959     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
00960             dirname, ctl->grid_basename, year, mon, day, hour, min);
00961     write_grid(filename, ctl, met0, met1, atm, t);
00962   }
00963
00964   /* Write CSI data... */
00965   if (ctl->csi_basename[0] != '-') {
00966     sprintf(filename, "%s/%s.tab", dirname, ctl->csi_basename);
00967     write_csi(filename, ctl, atm, t);
00968   }
00969
00970   /* Write profile data... */
00971   if (ctl->prof_basename[0] != '-') {
00972     sprintf(filename, "%s/%s.tab", dirname, ctl->prof_basename);
00973     write_prof(filename, ctl, met0, met1, atm, t);
00974   }
00975
00976   /* Write station data... */
00977   if (ctl->stat_basename[0] != '-') {
00978     sprintf(filename, "%s/%s.tab", dirname, ctl->stat_basename);
00979     write_station(filename, ctl, atm, t);
00980   }
00981 }
```

Here is the call graph for this function:



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

Definition at line 160 of file trac.c.

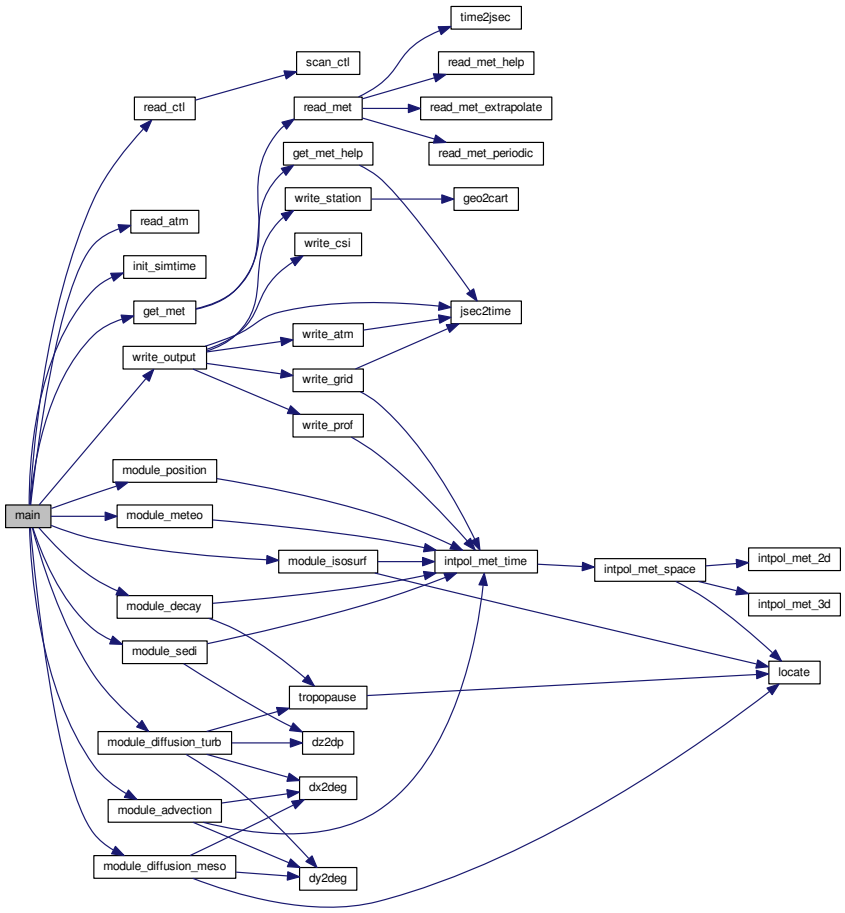
```
00162                {
00163
00164   ctl_t ctl;
00165
00166   atm_t *atm;
00167
00168   met_t *met0, *met1;
00169
00170   gsl_rng *rng[NTHREADS];
00171
00172   FILE *dirlist;
00173
00174   char dirname[LEN], filename[LEN];
00175
00176   double *dt, t, t0;
00177
00178   int i, ip, ntask = 0, rank = 0, size = 1;
00179
00180 #ifdef MPI
00181   /* Initialize MPI... */
00182   MPI_Init(&argc, &argv);
00183   MPI_Comm_rank(MPI_COMM_WORLD, &rank);
00184   MPI_Comm_size(MPI_COMM_WORLD, &size);
00185 #endif
00186
00187   /* Check arguments... */
00188   if (argc < 5)
00189     ERRMSG("Give parameters: <dirlist> <ctl> <atm_in> <metbase>");
00190
00191   /* Open directory list... */
00192   if (!(dirlist = fopen(argv[1], "r")))
00193     ERRMSG("Cannot open directory list!");
00194
00195   /* Loop over directories... */
00196   while (fscanf(dirlist, "%s", dirname) != EOF) {
00197
00198     /* MPI parallelization... */
00199     if ((++ntask) % size != rank)
00200       continue;
00201
00202     /* ------------------------------------------------------------
00203        Initialize model run...
00204        ------------------------------------------------------------ */
00205
00206     /* Set timers... */
00207     START_TIMER(TIMER_TOTAL);
00208     START_TIMER(TIMER_INIT);
00209
00210     /* Allocate... */
00211     ALLOC(atm, atm_t, 1);
00212     ALLOC(met0, met_t, 1);
00213     ALLOC(met1, met_t, 1);
00214     ALLOC(dt, double,
```

```
00215           NP);
00216
00217     /* Read control parameters... */
00218     sprintf(filename, "%s/%s", dirname, argv[2]);
00219     read_ctl(filename, argc, argv, &ctl);
00220
00221     /* Initialize random number generators... */
00222     gsl_rng_env_setup();
00223     for (i = 0; i < NTHREADS; i++)
00224       rng[i] = gsl_rng_alloc(gsl_rng_default);
00225
00226     /* Read atmospheric data... */
00227     sprintf(filename, "%s/%s", dirname, argv[3]);
00228     read_atm(filename, &ctl, atm);
00229
00230     /* Get simulation time interval... */
00231     init_simtime(&ctl, atm);
00232
00233     /* Get rounded start time... */
00234     if (ctl.direction == 1)
00235       t0 = floor(ctl.t_start / ctl.dt_mod) * ctl.dt_mod;
00236     else
00237       t0 = ceil(ctl.t_start / ctl.dt_mod) * ctl.dt_mod;
00238
00239     /* Set timers... */
00240     STOP_TIMER(TIMER_INIT);
00241
00242     /* ------------------------------------------------------------
00243        Loop over timesteps...
00244        ------------------------------------------------------------ */
00245
00246     /* Loop over timesteps... */
00247     for (t = t0; ctl.direction * (t - ctl.t_stop) < ctl.dt_mod;
00248          t += ctl.direction * ctl.dt_mod) {
00249
00250       /* Adjust length of final time step... */
00251       if (ctl.direction * (t - ctl.t_stop) > 0)
00252         t = ctl.t_stop;
00253
00254       /* Set time steps for air parcels... */
00255       for (ip = 0; ip < atm->np; ip++)
00256         if ((ctl.direction * (atm->time[ip] - ctl.t_start) >= 0
00257              && ctl.direction * (atm->time[ip] - ctl.t_stop) <= 0
00258              && ctl.direction * (atm->time[ip] - t) < 0))
00259           dt[ip] = t - atm->time[ip];
00260         else
00261           dt[ip] = GSL_NAN;
00262
00263       /* Get meteorological data... */
00264       START_TIMER(TIMER_INPUT);
00265       get_met(&ctl, argv[4], t, met0, met1);
00266       STOP_TIMER(TIMER_INPUT);
00267
00268       /* Initialize isosurface... */
00269       START_TIMER(TIMER_ISOSURF);
00270       if (t == t0)
00271         module_isosurf(&ctl, met0, met1, atm, -1);
00272       STOP_TIMER(TIMER_ISOSURF);
00273
00274       /* Advection... */
00275       START_TIMER(TIMER_ADVECT);
00276 #pragma omp parallel for default(shared) private(ip)
00277       for (ip = 0; ip < atm->np; ip++)
00278         if (gsl_finite(dt[ip]))
00279           module_advection(met0, met1, atm, ip, dt[ip]);
00280       STOP_TIMER(TIMER_ADVECT);
00281
00282       /* Turbulent diffusion... */
00283       START_TIMER(TIMER_DIFFTURB);
00284 #pragma omp parallel for default(shared) private(ip)
00285       for (ip = 0; ip < atm->np; ip++)
00286         if (gsl_finite(dt[ip]))
00287           module_diffusion_turb(&ctl, atm, ip, dt[ip],
00288                                 rng[omp_get_thread_num()]);
00289       STOP_TIMER(TIMER_DIFFTURB);
00290
00291       /* Mesoscale diffusion... */
00292       START_TIMER(TIMER_DIFFMESO);
00293 #pragma omp parallel for default(shared) private(ip)
00294       for (ip = 0; ip < atm->np; ip++)
00295         if (gsl_finite(dt[ip]))
00296           module_diffusion_meso(&ctl, met0, met1, atm, ip, dt[ip],
00297                                 rng[omp_get_thread_num()]);
00298       STOP_TIMER(TIMER_DIFFMESO);
00299
00300       /* Sedimentation... */
00301       START_TIMER(TIMER_SEDI);
```

```
00302 #pragma omp parallel for default(shared) private(ip)
00303       for (ip = 0; ip < atm->np; ip++)
00304         if (gsl_finite(dt[ip]))
00305           module_sedi(&ctl, met0, met1, atm, ip, dt[ip]);
00306       STOP_TIMER(TIMER_SEDI);
00307
00308       /* Isosurface... */
00309       START_TIMER(TIMER_ISOSURF);
00310 #pragma omp parallel for default(shared) private(ip)
00311       for (ip = 0; ip < atm->np; ip++)
00312         module_isosurf(&ctl, met0, met1, atm, ip);
00313       STOP_TIMER(TIMER_ISOSURF);
00314
00315       /* Position... */
00316       START_TIMER(TIMER_POSITION);
00317 #pragma omp parallel for default(shared) private(ip)
00318       for (ip = 0; ip < atm->np; ip++)
00319         module_position(met0, met1, atm, ip);
00320       STOP_TIMER(TIMER_POSITION);
00321
00322       /* Meteorological data... */
00323       START_TIMER(TIMER_METEO);
00324 #pragma omp parallel for default(shared) private(ip)
00325       for (ip = 0; ip < atm->np; ip++)
00326         module_meteo(&ctl, met0, met1, atm, ip);
00327       STOP_TIMER(TIMER_METEO);
00328
00329       /* Decay... */
00330       START_TIMER(TIMER_DECAY);
00331 #pragma omp parallel for default(shared) private(ip)
00332       for (ip = 0; ip < atm->np; ip++)
00333         if (gsl_finite(dt[ip]))
00334           module_decay(&ctl, met0, met1, atm, ip, dt[ip]);
00335       STOP_TIMER(TIMER_DECAY);
00336
00337       /* Write output... */
00338       START_TIMER(TIMER_OUTPUT);
00339       write_output(dirname, &ctl, met0, met1, atm, t);
00340       STOP_TIMER(TIMER_OUTPUT);
00341     }
00342
00343     /* ------------------------------------------------------------
00344        Finalize model run...
00345        ------------------------------------------------------------ */
00346
00347     /* Report timers... */
00348     STOP_TIMER(TIMER_TOTAL);
00349     PRINT_TIMER(TIMER_TOTAL);
00350     PRINT_TIMER(TIMER_INIT);
00351     PRINT_TIMER(TIMER_INPUT);
00352     PRINT_TIMER(TIMER_OUTPUT);
00353     PRINT_TIMER(TIMER_ADVECT);
00354     PRINT_TIMER(TIMER_DECAY);
00355     PRINT_TIMER(TIMER_DIFFMESO);
00356     PRINT_TIMER(TIMER_DIFFTURB);
00357     PRINT_TIMER(TIMER_ISOSURF);
00358     PRINT_TIMER(TIMER_METEO);
00359     PRINT_TIMER(TIMER_POSITION);
00360     PRINT_TIMER(TIMER_SEDI);
00361
00362     /* Report memory usage... */
00363     printf("MEMORY_ATM = %g MByte\n", 2. * sizeof(atm_t) / 1024. / 1024.);
00364     printf("MEMORY_METEO = %g MByte\n", 2. * sizeof(met_t) / 1024. / 1024.);
00365     printf("MEMORY_DYNAMIC = %g MByte\n",
00366            NP * sizeof(double) / 1024. / 1024.);
00367     printf("MEMORY_STATIC = %g MByte\n",
00368            (((EX + EY) + (2 + NQ) * GX * GY * GZ) * sizeof(double)
00369             + (EX * EY + EX * EY * EP) * sizeof(float)
00370             + (2 * GX * GY * GZ) * sizeof(int)) / 1024. / 1024.);
00371
00372     /* Report problem size... */
00373     printf("SIZE_NP = %d\n", atm->np);
00374     printf("SIZE_TASKS = %d\n", size);
00375     printf("SIZE_THREADS = %d\n", omp_get_max_threads());
00376
00377     /* Free random number generators... */
00378     for (i = 0; i < NTHREADS; i++)
00379       gsl_rng_free(rng[i]);
00380
00381     /* Free... */
00382     free(atm);
00383     free(met0);
00384     free(met1);
00385     free(dt);
00386   }
00387
00388 #ifdef MPI
```

```
00389   /* Finalize MPI... */
00390   MPI_Finalize();
00391 #endif
00392
00393   return EXIT_SUCCESS;
00394 }
```

Here is the call graph for this function:



5.32 trac.c

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

```
00026
00027 #ifdef MPI
00028 #include "mpi.h"
00029 #endif
00030
00031 /* ------------------------------------------------------------
00032    Defines...
00033    ------------------------------------------------------------ */
00034
00036 #define TIMER_TOTAL 0
00037
00039 #define TIMER_INIT 1
00040
00042 #define TIMER_INPUT 2
00043
00045 #define TIMER_OUTPUT 3
00046
00048 #define TIMER_ADVECT 4
00049
00051 #define TIMER_DECAY 5
00052
00054 #define TIMER_DIFFMESO 6
00055
00057 #define TIMER_DIFFTURB 7
00058
00060 #define TIMER_ISOSURF 8
00061
00063 #define TIMER_METEO 9
00064
00066 #define TIMER_POSITION 10
00067
00069 #define TIMER_SEDI 11
00070
00071 /* ------------------------------------------------------------
00072    Functions...
00073    ------------------------------------------------------------ */
00074
00076 void init_simtime(
00077   ctl_t * ctl,
00078   atm_t * atm);
00079
00081 void module_advection(
00082   met_t * met0,
00083   met_t * met1,
00084   atm_t * atm,
00085   int ip,
00086   double dt);
00087
00089 void module_decay(
00090   ctl_t * ctl,
00091   met_t * met0,
00092   met_t * met1,
00093   atm_t * atm,
00094   int ip,
00095   double dt);
00096
00098 void module_diffusion_meso(
00099   ctl_t * ctl,
00100   met_t * met0,
00101   met_t * met1,
00102   atm_t * atm,
00103   int ip,
00104   double dt,
00105   gsl_rng * rng);
00106
00108 void module_diffusion_turb(
00109   ctl_t * ctl,
00110   atm_t * atm,
00111   int ip,
00112   double dt,
00113   gsl_rng * rng);
00114
00116 void module_isosurf(
00117   ctl_t * ctl,
00118   met_t * met0,
00119   met_t * met1,
00120   atm_t * atm,
00121   int ip);
00122
00124 void module_meteo(
00125   ctl_t * ctl,
00126   met_t * met0,
00127   met_t * met1,
00128   atm_t * atm,
00129   int ip);
00130
00132 void module_position(
```

```
00133   met_t * met0,
00134   met_t * met1,
00135   atm_t * atm,
00136   int ip);
00137
00139 void module_sedi(
00140   ctl_t * ctl,
00141   met_t * met0,
00142   met_t * met1,
00143   atm_t * atm,
00144   int ip,
00145   double dt);
00146
00148 void write_output(
00149   const char *dirname,
00150   ctl_t * ctl,
00151   met_t * met0,
00152   met_t * met1,
00153   atm_t * atm,
00154   double t);
00155
00156 /* ------------------------------------------------------------
00157    Main...
00158    ------------------------------------------------------------ */
00159
00160 int main(
00161   int argc,
00162   char *argv[]) {
00163
00164   ctl_t ctl;
00165
00166   atm_t *atm;
00167
00168   met_t *met0, *met1;
00169
00170   gsl_rng *rng[NTHREADS];
00171
00172   FILE *dirlist;
00173
00174   char dirname[LEN], filename[LEN];
00175
00176   double *dt, t, t0;
00177
00178   int i, ip, ntask = 0, rank = 0, size = 1;
00179
00180 #ifdef MPI
00181   /* Initialize MPI... */
00182   MPI_Init(&argc, &argv);
00183   MPI_Comm_rank(MPI_COMM_WORLD, &rank);
00184   MPI_Comm_size(MPI_COMM_WORLD, &size);
00185 #endif
00186
00187   /* Check arguments... */
00188   if (argc < 5)
00189     ERRMSG("Give parameters: <dirlist> <ctl> <atm_in> <metbase>");
00190
00191   /* Open directory list... */
00192   if (!(dirlist = fopen(argv[1], "r")))
00193     ERRMSG("Cannot open directory list!");
00194
00195   /* Loop over directories... */
00196   while (fscanf(dirlist, "%s", dirname) != EOF) {
00197
00198     /* MPI parallelization... */
00199     if ((++ntask) % size != rank)
00200       continue;
00201
00202     /* ------------------------------------------------------------
00203        Initialize model run...
00204        ------------------------------------------------------------ */
00205
00206     /* Set timers... */
00207     START_TIMER(TIMER_TOTAL);
00208     START_TIMER(TIMER_INIT);
00209
00210     /* Allocate... */
00211     ALLOC(atm, atm_t, 1);
00212     ALLOC(met0, met_t, 1);
00213     ALLOC(met1, met_t, 1);
00214     ALLOC(dt, double,
00215           NP);
00216
00217     /* Read control parameters... */
00218     sprintf(filename, "%s/%s", dirname, argv[2]);
00219     read_ctl(filename, argc, argv, &ctl);
00220
00221     /* Initialize random number generators... */
```

```
00222     gsl_rng_env_setup();
00223     for (i = 0; i < NTHREADS; i++)
00224       rng[i] = gsl_rng_alloc(gsl_rng_default);
00225
00226     /* Read atmospheric data... */
00227     sprintf(filename, "%s/%s", dirname, argv[3]);
00228     read_atm(filename, &ctl, atm);
00229
00230     /* Get simulation time interval... */
00231     init_simtime(&ctl, atm);
00232
00233     /* Get rounded start time... */
00234     if (ctl.direction == 1)
00235       t0 = floor(ctl.t_start / ctl.dt_mod) * ctl.dt_mod;
00236     else
00237       t0 = ceil(ctl.t_start / ctl.dt_mod) * ctl.dt_mod;
00238
00239     /* Set timers... */
00240     STOP_TIMER(TIMER_INIT);
00241
00242     /* ------------------------------------------------------------
00243        Loop over timesteps...
00244        ------------------------------------------------------------ */
00245
00246     /* Loop over timesteps... */
00247     for (t = t0; ctl.direction * (t - ctl.t_stop) < ctl.dt_mod;
00248          t += ctl.direction * ctl.dt_mod) {
00249
00250       /* Adjust length of final time step... */
00251       if (ctl.direction * (t - ctl.t_stop) > 0)
00252         t = ctl.t_stop;
00253
00254       /* Set time steps for air parcels... */
00255       for (ip = 0; ip < atm->np; ip++)
00256         if ((ctl.direction * (atm->time[ip] - ctl.t_start) >= 0
00257              && ctl.direction * (atm->time[ip] - ctl.t_stop) <= 0
00258              && ctl.direction * (atm->time[ip] - t) < 0))
00259           dt[ip] = t - atm->time[ip];
00260         else
00261           dt[ip] = GSL_NAN;
00262
00263       /* Get meteorological data... */
00264       START_TIMER(TIMER_INPUT);
00265       get_met(&ctl, argv[4], t, met0, met1);
00266       STOP_TIMER(TIMER_INPUT);
00267
00268       /* Initialize isosurface... */
00269       START_TIMER(TIMER_ISOSURF);
00270       if (t == t0)
00271         module_isosurf(&ctl, met0, met1, atm, -1);
00272       STOP_TIMER(TIMER_ISOSURF);
00273
00274       /* Advection... */
00275       START_TIMER(TIMER_ADVECT);
00276 #pragma omp parallel for default(shared) private(ip)
00277       for (ip = 0; ip < atm->np; ip++)
00278         if (gsl_finite(dt[ip]))
00279           module_advection(met0, met1, atm, ip, dt[ip]);
00280       STOP_TIMER(TIMER_ADVECT);
00281
00282       /* Turbulent diffusion... */
00283       START_TIMER(TIMER_DIFFTURB);
00284 #pragma omp parallel for default(shared) private(ip)
00285       for (ip = 0; ip < atm->np; ip++)
00286         if (gsl_finite(dt[ip]))
00287           module_diffusion_turb(&ctl, atm, ip, dt[ip],
00288                                 rng[omp_get_thread_num()]);
00289       STOP_TIMER(TIMER_DIFFTURB);
00290
00291       /* Mesoscale diffusion... */
00292       START_TIMER(TIMER_DIFFMESO);
00293 #pragma omp parallel for default(shared) private(ip)
00294       for (ip = 0; ip < atm->np; ip++)
00295         if (gsl_finite(dt[ip]))
00296           module_diffusion_meso(&ctl, met0, met1, atm, ip, dt[ip],
00297                                 rng[omp_get_thread_num()]);
00298       STOP_TIMER(TIMER_DIFFMESO);
00299
00300       /* Sedimentation... */
00301       START_TIMER(TIMER_SEDI);
00302 #pragma omp parallel for default(shared) private(ip)
00303       for (ip = 0; ip < atm->np; ip++)
00304         if (gsl_finite(dt[ip]))
00305           module_sedi(&ctl, met0, met1, atm, ip, dt[ip]);
00306       STOP_TIMER(TIMER_SEDI);
00307
00308       /* Isosurface... */
```

```
00309       START_TIMER(TIMER_ISOSURF);
00310 #pragma omp parallel for default(shared) private(ip)
00311       for (ip = 0; ip < atm->np; ip++)
00312         module_isosurf(&ctl, met0, met1, atm, ip);
00313       STOP_TIMER(TIMER_ISOSURF);
00314
00315       /* Position... */
00316       START_TIMER(TIMER_POSITION);
00317 #pragma omp parallel for default(shared) private(ip)
00318       for (ip = 0; ip < atm->np; ip++)
00319         module_position(met0, met1, atm, ip);
00320       STOP_TIMER(TIMER_POSITION);
00321
00322       /* Meteorological data... */
00323       START_TIMER(TIMER_METEO);
00324 #pragma omp parallel for default(shared) private(ip)
00325       for (ip = 0; ip < atm->np; ip++)
00326         module_meteo(&ctl, met0, met1, atm, ip);
00327       STOP_TIMER(TIMER_METEO);
00328
00329       /* Decay... */
00330       START_TIMER(TIMER_DECAY);
00331 #pragma omp parallel for default(shared) private(ip)
00332       for (ip = 0; ip < atm->np; ip++)
00333         if (gsl_finite(dt[ip]))
00334           module_decay(&ctl, met0, met1, atm, ip, dt[ip]);
00335       STOP_TIMER(TIMER_DECAY);
00336
00337       /* Write output... */
00338       START_TIMER(TIMER_OUTPUT);
00339       write_output(dirname, &ctl, met0, met1, atm, t);
00340       STOP_TIMER(TIMER_OUTPUT);
00341     }
00342
00343     /* ------------------------------------------------------------
00344        Finalize model run...
00345        ------------------------------------------------------------ */
00346
00347     /* Report timers... */
00348     STOP_TIMER(TIMER_TOTAL);
00349     PRINT_TIMER(TIMER_TOTAL);
00350     PRINT_TIMER(TIMER_INIT);
00351     PRINT_TIMER(TIMER_INPUT);
00352     PRINT_TIMER(TIMER_OUTPUT);
00353     PRINT_TIMER(TIMER_ADVECT);
00354     PRINT_TIMER(TIMER_DECAY);
00355     PRINT_TIMER(TIMER_DIFFMESO);
00356     PRINT_TIMER(TIMER_DIFFTURB);
00357     PRINT_TIMER(TIMER_ISOSURF);
00358     PRINT_TIMER(TIMER_METEO);
00359     PRINT_TIMER(TIMER_POSITION);
00360     PRINT_TIMER(TIMER_SEDI);
00361
00362     /* Report memory usage... */
00363     printf("MEMORY_ATM = %g MByte\n", 2. * sizeof(atm_t) / 1024. / 1024.);
00364     printf("MEMORY_METEO = %g MByte\n", 2. * sizeof(met_t) / 1024. / 1024.);
00365     printf("MEMORY_DYNAMIC = %g MByte\n",
00366            NP * sizeof(double) / 1024. / 1024.);
00367     printf("MEMORY_STATIC = %g MByte\n",
00368            (((EX + EY) + (2 + NQ) * GX * GY * GZ) * sizeof(double)
00369             + (EX * EY + EX * EY * EP) * sizeof(float)
00370             + (2 * GX * GY * GZ) * sizeof(int)) / 1024. / 1024.);
00371
00372     /* Report problem size... */
00373     printf("SIZE_NP = %d\n", atm->np);
00374     printf("SIZE_TASKS = %d\n", size);
00375     printf("SIZE_THREADS = %d\n", omp_get_max_threads());
00376
00377     /* Free random number generators... */
00378     for (i = 0; i < NTHREADS; i++)
00379       gsl_rng_free(rng[i]);
00380
00381     /* Free... */
00382     free(atm);
00383     free(met0);
00384     free(met1);
00385     free(dt);
00386   }
00387
00388 #ifdef MPI
00389   /* Finalize MPI... */
00390   MPI_Finalize();
00391 #endif
00392
00393   return EXIT_SUCCESS;
00394 }
00395
```

```
00396 /*****************************************************************************/
00397
00398 void init_simtime(
00399   ctl_t * ctl,
00400   atm_t * atm) {
00401
00402   /* Set inital and final time... */
00403   if (ctl->direction == 1) {
00404     if (ctl->t_start < -1e99)
00405       ctl->t_start = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00406     if (ctl->t_stop < -1e99)
00407       ctl->t_stop = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00408   } else if (ctl->direction == -1) {
00409     if (ctl->t_stop < -1e99)
00410       ctl->t_stop = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00411     if (ctl->t_start < -1e99)
00412       ctl->t_start = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00413   }
00414
00415   /* Check time... */
00416   if (ctl->direction * (ctl->t_stop - ctl->t_start) <= 0)
00417     ERRMSG("Nothing to do!");
00418 }
00419
00420 /*****************************************************************************/
00421
00422 void module_advection(
00423   met_t * met0,
00424   met_t * met1,
00425   atm_t * atm,
00426   int ip,
00427   double dt) {
00428
00429   double v[3], xm[3];
00430
00431   /* Interpolate meteorological data... */
00432   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00433                   atm->lon[ip], atm->lat[ip], NULL, NULL,
00434                   &v[0], &v[1], &v[2], NULL, NULL);
00435
00436   /* Get position of the mid point... */
00437   xm[0] = atm->lon[ip] + dx2deg(0.5 * dt * v[0] / 1000., atm->lat[ip]);
00438   xm[1] = atm->lat[ip] + dy2deg(0.5 * dt * v[1] / 1000.);
00439   xm[2] = atm->p[ip] + 0.5 * dt * v[2];
00440
00441   /* Interpolate meteorological data for mid point... */
00442   intpol_met_time(met0, met1, atm->time[ip] + 0.5 * dt,
00443                   xm[2], xm[0], xm[1], NULL, NULL,
00444                   &v[0], &v[1], &v[2], NULL, NULL);
00445
00446   /* Save new position... */
00447   atm->time[ip] += dt;
00448   atm->lon[ip] += dx2deg(dt * v[0] / 1000., xm[1]);
00449   atm->lat[ip] += dy2deg(dt * v[1] / 1000.);
00450   atm->p[ip] += dt * v[2];
00451 }
00452
00453 /*****************************************************************************/
00454
00455 void module_decay(
00456   ctl_t * ctl,
00457   met_t * met0,
00458   met_t * met1,
00459   atm_t * atm,
00460   int ip,
00461   double dt) {
00462
00463   double ps, pt, tdec;
00464
00465   /* Check lifetime values... */
00466   if ((ctl->tdec_trop <= 0 && ctl->tdec_strat <= 0) || ctl->
      qnt_m < 0)
00467     return;
00468
00469   /* Set constant lifetime... */
00470   if (ctl->tdec_trop == ctl->tdec_strat)
00471     tdec = ctl->tdec_trop;
00472
00473   /* Set altitude-dependent lifetime... */
00474   else {
00475
00476     /* Get surface pressure... */
00477     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00478                     atm->lon[ip], atm->lat[ip], &ps, NULL,
00479                     NULL, NULL, NULL, NULL, NULL);
00480
00481     /* Get tropopause pressure... */
```

```
00482     pt = tropopause(atm->time[ip], atm->lat[ip]);
00483
00484     /* Set lifetime... */
00485     if (atm->p[ip] <= pt)
00486       tdec = ctl->tdec_strat;
00487     else
00488       tdec = LIN(ps, ctl->tdec_trop, pt, ctl->tdec_strat, atm->
      p[ip]);
00489   }
00490
00491   /* Calculate exponential decay... */
00492   atm->q[ctl->qnt_m][ip] *= exp(-dt / tdec);
00493 }
00494
00495 /*****************************************************************************/
00496
00497 void module_diffusion_meso(
00498   ctl_t * ctl,
00499   met_t * met0,
00500   met_t * met1,
00501   atm_t * atm,
00502   int ip,
00503   double dt,
00504   gsl_rng * rng) {
00505
00506   double r, rs, u[16], v[16], w[16], usig, vsig, wsig;
00507
00508   int ix, iy, iz;
00509
00510   /* Calculate mesoscale velocity fluctuations... */
00511   if (ctl->turb_meso > 0) {
00512
00513     /* Get indices... */
00514     ix = locate(met0->lon, met0->nx, atm->lon[ip]);
00515     iy = locate(met0->lat, met0->ny, atm->lat[ip]);
00516     iz = locate(met0->p, met0->np, atm->p[ip]);
00517
00518     /* Collect local wind data... */
00519     u[0] = met0->u[ix][iy][iz];
00520     u[1] = met0->u[ix + 1][iy][iz];
00521     u[2] = met0->u[ix][iy + 1][iz];
00522     u[3] = met0->u[ix + 1][iy + 1][iz];
00523     u[4] = met0->u[ix][iy][iz + 1];
00524     u[5] = met0->u[ix + 1][iy][iz + 1];
00525     u[6] = met0->u[ix][iy + 1][iz + 1];
00526     u[7] = met0->u[ix + 1][iy + 1][iz + 1];
00527
00528     v[0] = met0->v[ix][iy][iz];
00529     v[1] = met0->v[ix + 1][iy][iz];
00530     v[2] = met0->v[ix][iy + 1][iz];
00531     v[3] = met0->v[ix + 1][iy + 1][iz];
00532     v[4] = met0->v[ix][iy][iz + 1];
00533     v[5] = met0->v[ix + 1][iy][iz + 1];
00534     v[6] = met0->v[ix][iy + 1][iz + 1];
00535     v[7] = met0->v[ix + 1][iy + 1][iz + 1];
00536
00537     w[0] = met0->w[ix][iy][iz];
00538     w[1] = met0->w[ix + 1][iy][iz];
00539     w[2] = met0->w[ix][iy + 1][iz];
00540     w[3] = met0->w[ix + 1][iy + 1][iz];
00541     w[4] = met0->w[ix][iy][iz + 1];
00542     w[5] = met0->w[ix + 1][iy][iz + 1];
00543     w[6] = met0->w[ix][iy + 1][iz + 1];
00544     w[7] = met0->w[ix + 1][iy + 1][iz + 1];
00545
00546     /* Get indices... */
00547     ix = locate(met1->lon, met1->nx, atm->lon[ip]);
00548     iy = locate(met1->lat, met1->ny, atm->lat[ip]);
00549     iz = locate(met1->p, met1->np, atm->p[ip]);
00550
00551     /* Collect local wind data... */
00552     u[8] = met1->u[ix][iy][iz];
00553     u[9] = met1->u[ix + 1][iy][iz];
00554     u[10] = met1->u[ix][iy + 1][iz];
00555     u[11] = met1->u[ix + 1][iy + 1][iz];
00556     u[12] = met1->u[ix][iy][iz + 1];
00557     u[13] = met1->u[ix + 1][iy][iz + 1];
00558     u[14] = met1->u[ix][iy + 1][iz + 1];
00559     u[15] = met1->u[ix + 1][iy + 1][iz + 1];
00560
00561     v[8] = met1->v[ix][iy][iz];
00562     v[9] = met1->v[ix + 1][iy][iz];
00563     v[10] = met1->v[ix][iy + 1][iz];
00564     v[11] = met1->v[ix + 1][iy + 1][iz];
00565     v[12] = met1->v[ix][iy][iz + 1];
00566     v[13] = met1->v[ix + 1][iy][iz + 1];
00567     v[14] = met1->v[ix][iy + 1][iz + 1];
```

```
00568     v[15] = met1->v[ix + 1][iy + 1][iz + 1];
00569
00570     w[8] = met1->w[ix][iy][iz];
00571     w[9] = met1->w[ix + 1][iy][iz];
00572     w[10] = met1->w[ix][iy + 1][iz];
00573     w[11] = met1->w[ix + 1][iy + 1][iz];
00574     w[12] = met1->w[ix][iy][iz + 1];
00575     w[13] = met1->w[ix + 1][iy][iz + 1];
00576     w[14] = met1->w[ix][iy + 1][iz + 1];
00577     w[15] = met1->w[ix + 1][iy + 1][iz + 1];
00578
00579     /* Get standard deviations of local wind data... */
00580     usig = gsl_stats_sd(u, 1, 16);
00581     vsig = gsl_stats_sd(v, 1, 16);
00582     wsig = gsl_stats_sd(w, 1, 16);
00583
00584     /* Set temporal correlations for mesoscale fluctuations... */
00585     r = 1 - 2 * fabs(dt) / ctl->dt_met;
00586     rs = sqrt(1 - r * r);
00587
00588     /* Calculate mesoscale wind fluctuations... */
00589     atm->up[ip] =
00590       r * atm->up[ip] + rs * gsl_ran_gaussian_ziggurat(rng,
00591                                                        ctl->turb_meso * usig);
00592     atm->vp[ip] =
00593       r * atm->vp[ip] + rs * gsl_ran_gaussian_ziggurat(rng,
00594                                                        ctl->turb_meso * vsig);
00595     atm->wp[ip] =
00596       r * atm->wp[ip] + rs * gsl_ran_gaussian_ziggurat(rng,
00597                                                        ctl->turb_meso * wsig);
00598
00599     /* Calculate air parcel displacement... */
00600     atm->lon[ip] += dx2deg(atm->up[ip] * dt / 1000., atm->lat[ip]);
00601     atm->lat[ip] += dy2deg(atm->vp[ip] * dt / 1000.);
00602     atm->p[ip] += atm->wp[ip] * dt;
00603   }
00604 }
00605
00606 /*****************************************************************************/
00607
00608 void module_diffusion_turb(
00609   ctl_t * ctl,
00610   atm_t * atm,
00611   int ip,
00612   double dt,
00613   gsl_rng * rng) {
00614
00615   double dx, dz, pt, p0, p1, w;
00616
00617   /* Get tropopause pressure... */
00618   pt = tropopause(atm->time[ip], atm->lat[ip]);
00619
00620   /* Get weighting factor... */
00621   p1 = pt * 0.866877899;
00622   p0 = pt / 0.866877899;
00623   if (atm->p[ip] > p0)
00624     w = 1;
00625   else if (atm->p[ip] < p1)
00626     w = 0;
00627   else
00628     w = LIN(p0, 1.0, p1, 0.0, atm->p[ip]);
00629
00630   /* Set diffusivitiy... */
00631   dx = w * ctl->turb_dx_trop + (1 - w) * ctl->turb_dx_strat;
00632   dz = w * ctl->turb_dz_trop + (1 - w) * ctl->turb_dz_strat;
00633
00634   /* Horizontal turbulent diffusion... */
00635   if (dx > 0) {
00636     atm->lon[ip]
00637       += dx2deg(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dx * fabs(dt)))
00638                 / 1000., atm->lat[ip]);
00639     atm->lat[ip]
00640       += dy2deg(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dx * fabs(dt)))
00641                 / 1000.);
00642   }
00643
00644   /* Vertical turbulent diffusion... */
00645   if (dz > 0)
00646     atm->p[ip]
00647       += dz2dp(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dz * fabs(dt)))
00648                / 1000., atm->p[ip]);
00649 }
00650
00651 /*****************************************************************************/
00652
00653 void module_isosurf(
00654   ctl_t * ctl,
```

```
00655   met_t * met0,
00656   met_t * met1,
00657   atm_t * atm,
00658   int ip) {
00659
00660   static double *iso, *ps, t, *ts;
00661
00662   static int idx, ip2, n, nb = 100000;
00663
00664   FILE *in;
00665
00666   char line[LEN];
00667
00668   /* Check control parameter... */
00669   if (ctl->isosurf < 1 || ctl->isosurf > 4)
00670     return;
00671
00672   /* Initialize... */
00673   if (ip < 0) {
00674
00675     /* Allocate... */
00676     ALLOC(iso, double,
00677           NP);
00678     ALLOC(ps, double,
00679           nb);
00680     ALLOC(ts, double,
00681           nb);
00682
00683     /* Save pressure... */
00684     if (ctl->isosurf == 1)
00685       for (ip2 = 0; ip2 < atm->np; ip2++)
00686         iso[ip2] = atm->p[ip2];
00687
00688     /* Save density... */
00689     else if (ctl->isosurf == 2)
00690       for (ip2 = 0; ip2 < atm->np; ip2++) {
00691         intpol_met_time(met0, met1, atm->time[ip2], atm->p[ip2],
00692                         atm->lon[ip2], atm->lat[ip2], NULL, &t, NULL, NULL,
00693                         NULL, NULL, NULL);
00694         iso[ip2] = atm->p[ip2] / t;
00695       }
00696
00697     /* Save potential temperature... */
00698     else if (ctl->isosurf == 3)
00699       for (ip2 = 0; ip2 < atm->np; ip2++) {
00700         intpol_met_time(met0, met1, atm->time[ip2], atm->p[ip2],
00701                         atm->lon[ip2], atm->lat[ip2], NULL, &t, NULL, NULL,
00702                         NULL, NULL, NULL);
00703         iso[ip2] = t * pow(P0 / atm->p[ip2], 0.286);
00704       }
00705
00706     /* Read balloon pressure data... */
00707     else if (ctl->isosurf == 4) {
00708
00709       /* Write info... */
00710       printf("Read balloon pressure data: %s\n", ctl->balloon);
00711
00712       /* Open file... */
00713       if (!(in = fopen(ctl->balloon, "r")))
00714         ERRMSG("Cannot open file!");
00715
00716       /* Read pressure time series... */
00717       while (fgets(line, LEN, in))
00718         if (sscanf(line, "%lg %lg", &ts[n], &ps[n]) == 2)
00719           if ((++n) > 100000)
00720             ERRMSG("Too many data points!");
00721
00722       /* Check number of points... */
00723       if (n < 1)
00724         ERRMSG("Could not read any data!");
00725
00726       /* Close file... */
00727       fclose(in);
00728     }
00729
00730     /* Leave initialization... */
00731     return;
00732   }
00733
00734   /* Restore pressure... */
00735   if (ctl->isosurf == 1)
00736     atm->p[ip] = iso[ip];
00737
00738   /* Restore density... */
00739   else if (ctl->isosurf == 2) {
00740     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
```

```
00741                     atm->lat[ip], NULL, &t, NULL, NULL, NULL, NULL, NULL);
00742     atm->p[ip] = iso[ip] * t;
00743   }
00744
00745   /* Restore potential temperature... */
00746   else if (ctl->isosurf == 3) {
00747     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00748                     atm->lat[ip], NULL, &t, NULL, NULL, NULL, NULL, NULL);
00749     atm->p[ip] = P0 * pow(iso[ip] / t, -1. / 0.286);
00750   }
00751
00752   /* Interpolate pressure... */
00753   else if (ctl->isosurf == 4) {
00754     if (atm->time[ip] <= ts[0])
00755       atm->p[ip] = ps[0];
00756     else if (atm->time[ip] >= ts[n - 1])
00757       atm->p[ip] = ps[n - 1];
00758     else {
00759       idx = locate(ts, n, atm->time[ip]);
00760       atm->p[ip] = LIN(ts[idx], ps[idx],
00761                        ts[idx + 1], ps[idx + 1], atm->time[ip]);
00762     }
00763   }
00764 }
00765
00766 /*****************************************************************************/
00767
00768 void module_meteo(
00769   ctl_t * ctl,
00770   met_t * met0,
00771   met_t * met1,
00772   atm_t * atm,
00773   int ip) {
00774
00775   /* Interpolate surface pressure... */
00776   if (ctl->qnt_ps >= 0)
00777     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00778                     atm->lat[ip], &atm->q[ctl->qnt_ps][ip], NULL,
00779                     NULL, NULL, NULL, NULL, NULL);
00780
00781   /* Interpolate temperature... */
00782   if (ctl->qnt_t >= 0)
00783     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00784                     atm->lat[ip], NULL, &atm->q[ctl->qnt_t][ip],
00785                     NULL, NULL, NULL, NULL, NULL);
00786
00787   /* Interpolate zonal wind... */
00788   if (ctl->qnt_u >= 0)
00789     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00790                     atm->lat[ip], NULL, NULL, &atm->q[ctl->qnt_u][ip],
00791                     NULL, NULL, NULL, NULL);
00792
00793   /* Interpolate meridional wind... */
00794   if (ctl->qnt_v >= 0)
00795     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00796                     atm->lat[ip], NULL, NULL, NULL,
00797                     &atm->q[ctl->qnt_v][ip], NULL, NULL, NULL);
00798
00799   /* Interpolate vertical velocity... */
00800   if (ctl->qnt_w >= 0)
00801     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00802                     atm->lat[ip], NULL, NULL, NULL, NULL,
00803                     &atm->q[ctl->qnt_w][ip], NULL, NULL);
00804
00805   /* Interpolate water vapor vmr... */
00806   if (ctl->qnt_h2o >= 0)
00807     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00808                     atm->lat[ip], NULL, NULL, NULL, NULL, NULL,
00809                     &atm->q[ctl->qnt_h2o][ip], NULL);
00810
00811   /* Interpolate ozone... */
00812   if (ctl->qnt_o3 >= 0)
00813     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00814                     atm->lat[ip], NULL, NULL, NULL, NULL, NULL, NULL,
00815                     &atm->q[ctl->qnt_o3][ip]);
00816
00817   /* Calculate potential temperature... */
00818   if (ctl->qnt_theta >= 0) {
00819     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
```

```
    lon[ip],
00820                     atm->lat[ip], NULL, &atm->q[ctl->qnt_theta][ip],
00821                     NULL, NULL, NULL, NULL, NULL);
00822     atm->q[ctl->qnt_theta][ip] *= pow(P0 / atm->p[ip], 0.286);
00823   }
00824 }
00825
00826 /*****************************************************************************/
00827
00828 void module_position(
00829   met_t * met0,
00830   met_t * met1,
00831   atm_t * atm,
00832   int ip) {
00833
00834   double ps;
00835
00836   /* Calculate modulo... */
00837   atm->lon[ip] = fmod(atm->lon[ip], 360);
00838   atm->lat[ip] = fmod(atm->lat[ip], 360);
00839
00840   /* Check latitude... */
00841   while (atm->lat[ip] < -90 || atm->lat[ip] > 90) {
00842     if (atm->lat[ip] > 90) {
00843       atm->lat[ip] = 180 - atm->lat[ip];
00844       atm->lon[ip] += 180;
00845     }
00846     if (atm->lat[ip] < -90) {
00847       atm->lat[ip] = -180 - atm->lat[ip];
00848       atm->lon[ip] += 180;
00849     }
00850   }
00851
00852   /* Check longitude... */
00853   while (atm->lon[ip] < -180)
00854     atm->lon[ip] += 360;
00855   while (atm->lon[ip] >= 180)
00856     atm->lon[ip] -= 360;
00857
00858   /* Get surface pressure... */
00859   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00860                   atm->lon[ip], atm->lat[ip], &ps, NULL,
00861                   NULL, NULL, NULL, NULL, NULL);
00862
00863   /* Check pressure... */
00864   if (atm->p[ip] > ps)
00865     atm->p[ip] = ps;
00866   else if (atm->p[ip] < met0->p[met0->np - 1])
00867     atm->p[ip] = met0->p[met0->np - 1];
00868 }
00869
00870 /*****************************************************************************/
00871
00872 void module_sedi(
00873   ctl_t * ctl,
00874   met_t * met0,
00875   met_t * met1,
00876   atm_t * atm,
00877   int ip,
00878   double dt) {
00879
00880   /* Coefficients for Cunningham slip-flow correction (Kasten, 1968): */
00881   const double A = 1.249, B = 0.42, C = 0.87;
00882
00883   /* Specific gas constant for dry air [J/(kg K)]: */
00884   const double R = 287.058;
00885
00886   /* Average mass of an air molecule [kg/molec]: */
00887   const double m = 4.8096e-26;
00888
00889   double G, K, eta, lambda, p, r_p, rho, rho_p, T, v, v_p;
00890
00891   /* Check if parameters are available... */
00892   if (ctl->qnt_r < 0 || ctl->qnt_rho < 0)
00893     return;
00894
00895   /* Convert units... */
00896   p = 100 * atm->p[ip];
00897   r_p = 1e-6 * atm->q[ctl->qnt_r][ip];
00898   rho_p = atm->q[ctl->qnt_rho][ip];
00899
00900   /* Get temperature... */
00901   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
    lon[ip],
00902                   atm->lat[ip], NULL, &T, NULL, NULL, NULL, NULL, NULL);
00903
00904   /* Density of dry air... */
```

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

5.33 wind.c File Reference

Create meteorological data files with synthetic wind fields.

Functions

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

5.33.1 Detailed Description

Create meteorological data files with synthetic wind fields.

Definition in file wind.c.

5.33.2 Function Documentation

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

Definition at line 173 of file wind.c.

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

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

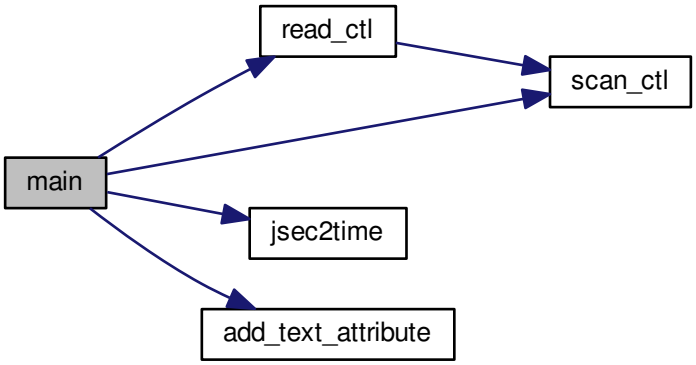
Definition at line 41 of file wind.c.

```
00043                 {
00044
00045   ctl_t ctl;
00046
00047   static char filename[LEN];
00048
00049   static double r, t0, z0, z1, dataLon[EX], dataLat[EY], dataZ[EP],
00050     u0, u1, alpha;
00051
00052   static float dataT[EP * EY * EX], dataU[EP * EY * EX], dataV[EP * EY * EX],
00053     dataW[EP * EY * EX];
00054
00055   static int ncid, dims[4], timid, levid, latid, lonid, tid, uid, vid, wid,
00056     idx, ix, iy, iz, nx, ny, nz, year, mon, day, hour, min, sec;
00057
00058   /* Check arguments... */
00059   if (argc < 3)
00060     ERRMSG("Give parameters: <ctl> <metbase>");
00061
00062   /* Read control parameters... */
00063   read_ctl(argv[1], argc, argv, &ctl);
00064   t0 = scan_ctl(argv[1], argc, argv, "WIND_T0", -1, "0", NULL);
00065   nx = (int) scan_ctl(argv[1], argc, argv, "WIND_NX", -1, "360", NULL);
00066   ny = (int) scan_ctl(argv[1], argc, argv, "WIND_NY", -1, "181", NULL);
00067   nz = (int) scan_ctl(argv[1], argc, argv, "WIND_NZ", -1, "61", NULL);
00068   z0 = scan_ctl(argv[1], argc, argv, "WIND_Z0", -1, "0", NULL);
00069   z1 = scan_ctl(argv[1], argc, argv, "WIND_Z1", -1, "60", NULL);
00070   u0 = scan_ctl(argv[1], argc, argv, "WIND_U0", -1, "38.587660177302", NULL);
00071   u1 = scan_ctl(argv[1], argc, argv, "WIND_U1", -1, "38.587660177302", NULL);
00072   alpha = scan_ctl(argv[1], argc, argv, "WIND_ALPHA", -1, "0.0", NULL);
00073
00074   /* Check dimensions... */
00075   if (nx < 1 || nx > EX)
00076     ERRMSG("Set 1 <= NX <= MAX!");
00077   if (ny < 1 || ny > EY)
00078     ERRMSG("Set 1 <= NY <= MAX!");
00079   if (nz < 1 || nz > EP)
00080     ERRMSG("Set 1 <= NZ <= MAX!");
```

```
00081
00082   /* Get time... */
00083   jsec2time(t0, &year, &mon, &day, &hour, &min, &sec, &r);
00084   t0 = year * 10000. + mon * 100. + day + hour / 24.;
00085
00086   /* Set filename... */
00087   sprintf(filename, "%s_%d_%02d_%02d_%02d.nc", argv[2], year, mon, day, hour);
00088
00089   /* Create netCDF file... */
00090   NC(nc_create(filename, NC_CLOBBER, &ncid));
00091
00092   /* Create dimensions... */
00093   NC(nc_def_dim(ncid, "time", 1, &dims[0]));
00094   NC(nc_def_dim(ncid, "lev", (size_t) nz, &dims[1]));
00095   NC(nc_def_dim(ncid, "lat", (size_t) ny, &dims[2]));
00096   NC(nc_def_dim(ncid, "lon", (size_t) nx, &dims[3]));
00097
00098   /* Create variables... */
00099   NC(nc_def_var(ncid, "time", NC_DOUBLE, 1, &dims[0], &timid));
00100   NC(nc_def_var(ncid, "lev", NC_DOUBLE, 1, &dims[1], &levid));
00101   NC(nc_def_var(ncid, "lat", NC_DOUBLE, 1, &dims[2], &latid));
00102   NC(nc_def_var(ncid, "lon", NC_DOUBLE, 1, &dims[3], &lonid));
00103   NC(nc_def_var(ncid, "T", NC_FLOAT, 4, &dims[0], &tid));
00104   NC(nc_def_var(ncid, "U", NC_FLOAT, 4, &dims[0], &uid));
00105   NC(nc_def_var(ncid, "V", NC_FLOAT, 4, &dims[0], &vid));
00106   NC(nc_def_var(ncid, "W", NC_FLOAT, 4, &dims[0], &wid));
00107
00108   /* Set attributes... */
00109   add_text_attribute(ncid, "time", "long_name", "time");
00110   add_text_attribute(ncid, "time", "units", "day as %Y%m%d.%f");
00111   add_text_attribute(ncid, "lon", "long_name", "longitude");
00112   add_text_attribute(ncid, "lon", "units", "degrees_east");
00113   add_text_attribute(ncid, "lat", "long_name", "latitude");
00114   add_text_attribute(ncid, "lat", "units", "degrees_north");
00115   add_text_attribute(ncid, "lev", "long_name", "air_pressure");
00116   add_text_attribute(ncid, "lev", "units", "Pa");
00117   add_text_attribute(ncid, "T", "long_name", "Temperature");
00118   add_text_attribute(ncid, "T", "units", "K");
00119   add_text_attribute(ncid, "U", "long_name", "U velocity");
00120   add_text_attribute(ncid, "U", "units", "m s**-1");
00121   add_text_attribute(ncid, "V", "long_name", "V velocity");
00122   add_text_attribute(ncid, "V", "units", "m s**-1");
00123   add_text_attribute(ncid, "W", "long_name", "Vertical velocity");
00124   add_text_attribute(ncid, "W", "units", "Pa s**-1");
00125
00126   /* End definition... */
00127   NC(nc_enddef(ncid));
00128
00129   /* Set coordinates... */
00130   for (ix = 0; ix < nx; ix++)
00131     dataLon[ix] = 360.0 / nx * (double) ix;
00132   for (iy = 0; iy < ny; iy++)
00133     dataLat[iy] = 180.0 / (ny - 1) * (double) iy - 90;
00134   for (iz = 0; iz < nz; iz++)
00135     dataZ[iz] = 100. * P(LIN(0.0, z0, nz - 1.0, z1, iz));
00136
00137   /* Write coordinates... */
00138   NC(nc_put_var_double(ncid, timid, &t0));
00139   NC(nc_put_var_double(ncid, levid, dataZ));
00140   NC(nc_put_var_double(ncid, lonid, dataLon));
00141   NC(nc_put_var_double(ncid, latid, dataLat));
00142
00143   /* Create wind fields (Williamson et al., 1992)... */
00144   for (ix = 0; ix < nx; ix++)
00145     for (iy = 0; iy < ny; iy++)
00146       for (iz = 0; iz < nz; iz++) {
00147         idx = (iz * ny + iy) * nx + ix;
00148         dataU[idx] = (float) (LIN(0.0, u0, nz - 1.0, u1, iz)
00149                               * (cos(dataLat[iy] * M_PI / 180.0)
00150                                  * cos(alpha * M_PI / 180.0)
00151                                  + sin(dataLat[iy] * M_PI / 180.0)
00152                                  * cos(dataLon[ix] * M_PI / 180.0)
00153                                  * sin(alpha * M_PI / 180.0)));
00154         dataV[idx] = (float) (-LIN(0.0, u0, nz - 1.0, u1, iz)
00155                               * sin(dataLon[ix] * M_PI / 180.0)
00156                               * sin(alpha * M_PI / 180.0));
00157       }
00158
00159   /* Write wind data... */
00160   NC(nc_put_var_float(ncid, tid, dataT));
00161   NC(nc_put_var_float(ncid, uid, dataU));
00162   NC(nc_put_var_float(ncid, vid, dataV));
00163   NC(nc_put_var_float(ncid, wid, dataW));
00164
00165   /* Close file... */
00166   NC(nc_close(ncid));
00167
```

```
00168   return EXIT_SUCCESS;
00169 }
```

Here is the call graph for this function:



5.34 wind.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 /* ------------------------------------------------------------
00028    Functions...
00029    ------------------------------------------------------------ */
00030
00031 void add_text_attribute(
00032   int ncid,
00033   char *varname,
00034   char *attrname,
00035   char *text);
00036
00037 /* ------------------------------------------------------------
00038    Main...
00039    ------------------------------------------------------------ */
00040
00041 int main(
00042   int argc,
00043   char *argv[]) {
00044
00045   ctl_t ctl;
00046
00047   static char filename[LEN];
00048
00049   static double r, t0, z0, z1, dataLon[EX], dataLat[EY], dataZ[EP],
```

```
00050     u0, u1, alpha;
00051
00052   static float dataT[EP * EY * EX], dataU[EP * EY * EX], dataV[EP * EY * EX],
00053     dataW[EP * EY * EX];
00054
00055   static int ncid, dims[4], timid, levid, latid, lonid, tid, uid, vid, wid,
00056     idx, ix, iy, iz, nx, ny, nz, year, mon, day, hour, min, sec;
00057
00058   /* Check arguments... */
00059   if (argc < 3)
00060     ERRMSG("Give parameters: <ctl> <metbase>");
00061
00062   /* Read control parameters... */
00063   read_ctl(argv[1], argc, argv, &ctl);
00064   t0 = scan_ctl(argv[1], argc, argv, "WIND_T0", -1, "0", NULL);
00065   nx = (int) scan_ctl(argv[1], argc, argv, "WIND_NX", -1, "360", NULL);
00066   ny = (int) scan_ctl(argv[1], argc, argv, "WIND_NY", -1, "181", NULL);
00067   nz = (int) scan_ctl(argv[1], argc, argv, "WIND_NZ", -1, "61", NULL);
00068   z0 = scan_ctl(argv[1], argc, argv, "WIND_Z0", -1, "0", NULL);
00069   z1 = scan_ctl(argv[1], argc, argv, "WIND_Z1", -1, "60", NULL);
00070   u0 = scan_ctl(argv[1], argc, argv, "WIND_U0", -1, "38.587660177302", NULL);
00071   u1 = scan_ctl(argv[1], argc, argv, "WIND_U1", -1, "38.587660177302", NULL);
00072   alpha = scan_ctl(argv[1], argc, argv, "WIND_ALPHA", -1, "0.0", NULL);
00073
00074   /* Check dimensions... */
00075   if (nx < 1 || nx > EX)
00076     ERRMSG("Set 1 <= NX <= MAX!");
00077   if (ny < 1 || ny > EY)
00078     ERRMSG("Set 1 <= NY <= MAX!");
00079   if (nz < 1 || nz > EP)
00080     ERRMSG("Set 1 <= NZ <= MAX!");
00081
00082   /* Get time... */
00083   jsec2time(t0, &year, &mon, &day, &hour, &min, &sec, &r);
00084   t0 = year * 10000. + mon * 100. + day + hour / 24.;
00085
00086   /* Set filename... */
00087   sprintf(filename, "%s_%d_%02d_%02d_%02d.nc", argv[2], year, mon, day, hour);
00088
00089   /* Create netCDF file... */
00090   NC(nc_create(filename, NC_CLOBBER, &ncid));
00091
00092   /* Create dimensions... */
00093   NC(nc_def_dim(ncid, "time", 1, &dims[0]));
00094   NC(nc_def_dim(ncid, "lev", (size_t) nz, &dims[1]));
00095   NC(nc_def_dim(ncid, "lat", (size_t) ny, &dims[2]));
00096   NC(nc_def_dim(ncid, "lon", (size_t) nx, &dims[3]));
00097
00098   /* Create variables... */
00099   NC(nc_def_var(ncid, "time", NC_DOUBLE, 1, &dims[0], &timid));
00100   NC(nc_def_var(ncid, "lev", NC_DOUBLE, 1, &dims[1], &levid));
00101   NC(nc_def_var(ncid, "lat", NC_DOUBLE, 1, &dims[2], &latid));
00102   NC(nc_def_var(ncid, "lon", NC_DOUBLE, 1, &dims[3], &lonid));
00103   NC(nc_def_var(ncid, "T", NC_FLOAT, 4, &dims[0], &tid));
00104   NC(nc_def_var(ncid, "U", NC_FLOAT, 4, &dims[0], &uid));
00105   NC(nc_def_var(ncid, "V", NC_FLOAT, 4, &dims[0], &vid));
00106   NC(nc_def_var(ncid, "W", NC_FLOAT, 4, &dims[0], &wid));
00107
00108   /* Set attributes... */
00109   add_text_attribute(ncid, "time", "long_name", "time");
00110   add_text_attribute(ncid, "time", "units", "day as %Y%m%d.%f");
00111   add_text_attribute(ncid, "lon", "long_name", "longitude");
00112   add_text_attribute(ncid, "lon", "units", "degrees_east");
00113   add_text_attribute(ncid, "lat", "long_name", "latitude");
00114   add_text_attribute(ncid, "lat", "units", "degrees_north");
00115   add_text_attribute(ncid, "lev", "long_name", "air_pressure");
00116   add_text_attribute(ncid, "lev", "units", "Pa");
00117   add_text_attribute(ncid, "T", "long_name", "Temperature");
00118   add_text_attribute(ncid, "T", "units", "K");
00119   add_text_attribute(ncid, "U", "long_name", "U velocity");
00120   add_text_attribute(ncid, "U", "units", "m s**-1");
00121   add_text_attribute(ncid, "V", "long_name", "V velocity");
00122   add_text_attribute(ncid, "V", "units", "m s**-1");
00123   add_text_attribute(ncid, "W", "long_name", "Vertical velocity");
00124   add_text_attribute(ncid, "W", "units", "Pa s**-1");
00125
00126   /* End definition... */
00127   NC(nc_enddef(ncid));
00128
00129   /* Set coordinates... */
00130   for (ix = 0; ix < nx; ix++)
00131     dataLon[ix] = 360.0 / nx * (double) ix;
00132   for (iy = 0; iy < ny; iy++)
00133     dataLat[iy] = 180.0 / (ny - 1) * (double) iy - 90;
00134   for (iz = 0; iz < nz; iz++)
00135     dataZ[iz] = 100. * P(LIN(0.0, z0, nz - 1.0, z1, iz));
00136
```

```
00137   /* Write coordinates... */
00138   NC(nc_put_var_double(ncid, timid, &t0));
00139   NC(nc_put_var_double(ncid, levid, dataZ));
00140   NC(nc_put_var_double(ncid, lonid, dataLon));
00141   NC(nc_put_var_double(ncid, latid, dataLat));
00142
00143   /* Create wind fields (Williamson et al., 1992)... */
00144   for (ix = 0; ix < nx; ix++)
00145     for (iy = 0; iy < ny; iy++)
00146       for (iz = 0; iz < nz; iz++) {
00147         idx = (iz * ny + iy) * nx + ix;
00148         dataU[idx] = (float) (LIN(0.0, u0, nz - 1.0, u1, iz)
00149                               * (cos(dataLat[iy] * M_PI / 180.0)
00150                                  * cos(alpha * M_PI / 180.0)
00151                                  + sin(dataLat[iy] * M_PI / 180.0)
00152                                  * cos(dataLon[ix] * M_PI / 180.0)
00153                                  * sin(alpha * M_PI / 180.0)));
00154         dataV[idx] = (float) (-LIN(0.0, u0, nz - 1.0, u1, iz)
00155                               * sin(dataLon[ix] * M_PI / 180.0)
00156                               * sin(alpha * M_PI / 180.0));
00157       }
00158
00159   /* Write wind data... */
00160   NC(nc_put_var_float(ncid, tid, dataT));
00161   NC(nc_put_var_float(ncid, uid, dataU));
00162   NC(nc_put_var_float(ncid, vid, dataV));
00163   NC(nc_put_var_float(ncid, wid, dataW));
00164
00165   /* Close file... */
00166   NC(nc_close(ncid));
00167
00168   return EXIT_SUCCESS;
00169 }
00170
00171 /*****************************************************************************/
00172
00173 void add_text_attribute(
00174   int ncid,
00175   char *varname,
00176   char *attrname,
00177   char *text) {
00178
00179   int varid;
00180
00181   NC(nc_inq_varid(ncid, varname, &varid));
00182   NC(nc_put_att_text(ncid, varid, attrname, strlen(text), text));
00183 }
```

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