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 410 of file libtrac.h.

4.1.2 Field Documentation

4.1.2.1 int atm_t::np

Number of air pacels.

Definition at line 413 of file libtrac.h.

4.1.2.2 double atm_t::time[NP]

Time [s].

Definition at line 416 of file libtrac.h.

4.1.2.3 double atm_t::p[NP]

Pressure [hPa].

Definition at line 419 of file libtrac.h.

4.1.2.4 double atm_t::lon[NP]

Longitude [deg].

Definition at line 422 of file libtrac.h.

4.1.2.5 double atm_t::lat[NP]

Latitude [deg].

Definition at line 425 of file libtrac.h.

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

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

Definition at line 428 of file libtrac.h.

4.1.2.7 double atm_t::up[NP]

Zonal wind perturbation [m/s].

Definition at line 431 of file libtrac.h.

4.1.2.8 double atm_t::vp[NP]

Meridional wind perturbation [m/s].

Definition at line 434 of file libtrac.h.

4.1.2.9 double atm_t::wp[NP]

Vertical velocity perturbation [hPa/s].

Definition at line 437 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 met_np

  Number of target pressure levels.
- double met_p [EP]

  Target pressure levels [hPa].
- int isosurf

  Isosurface parameter (0=none, 1=pressure, 2=density, 3=theta, 4=balloon).
- char balloon [LEN]

  Balloon position filename.
- double turb_dx_trop

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

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

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

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

  Scaling factor for mesoscale wind fluctuations.
- double tdec_trop

  Life time of particles (troposphere) [s].
- double tdec_strat

  Life time of particles (stratosphere) [s].
- char atm_basename [LEN]

  Basename of atmospheric data files.
- char atm_gpfile [LEN]

  Gnuplot file for atmospheric data.
- double atm_dt_out

  Time step for atmospheric data output [s].
- 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::met_np

Number of target pressure levels.

Definition at line 239 of file libtrac.h.

4.2.2.23 double ctl_t::met_p[EP]

Target pressure levels [hPa].

Definition at line 242 of file libtrac.h.

4.2.2.24 int ctl_t::isosurf

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

Definition at line 246 of file libtrac.h.

4.2.2.25 char ctl_t::balloon[LEN]

Balloon position filename.

Definition at line 249 of file libtrac.h.

4.2.2.26 double ctl_t::turb_dx_trop

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

Definition at line 252 of file libtrac.h.

4.2.2.27 double ctl_t::turb_dx_strat

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

Definition at line 255 of file libtrac.h.

4.2.2.28 double ctl_t::turb_dz_trop

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

Definition at line 258 of file libtrac.h.

4.2.2.29 double ctl_t::turb_dz_strat

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

Definition at line 261 of file libtrac.h.

4.2.2.30 double ctl_t::turb_meso

Scaling factor for mesoscale wind fluctuations.

Definition at line 264 of file libtrac.h.

4.2.2.31 double ctl_t::tdec_trop

Life time of particles (troposphere) [s].

Definition at line 267 of file libtrac.h.

4.2.2.32 double ctl_t::tdec_strat

Life time of particles (stratosphere) [s].

Definition at line 270 of file libtrac.h.

4.2.2.33 char ctl_t::atm_basename[LEN]

Basename of atmospheric data files.

Definition at line 273 of file libtrac.h.

4.2.2.34 char ctl_t::atm_gpfile[LEN]

Gnuplot file for atmospheric data.

Definition at line 276 of file libtrac.h.

4.2.2.35 double ctl_t::atm_dt_out

Time step for atmospheric data output [s].

Definition at line 279 of file libtrac.h.

4.2.2.36 char ctl_t::csi_basename[LEN]

Basename of CSI data files.

Definition at line 282 of file libtrac.h.

4.2.2.37 double ctl_t::csi_dt_out

Time step for CSI data output [s].

Definition at line 285 of file libtrac.h.

4.2.2.38 char ctl_t::csi_obsfile[LEN]

Observation data file for CSI analysis.

Definition at line 288 of file libtrac.h.

4.2.2.39 double ctl_t::csi_obsmin

Minimum observation index to trigger detection.

Definition at line 291 of file libtrac.h.

4.2.2.40 double ctl_t::csi_modmin

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

Definition at line 294 of file libtrac.h.

4.2.2.41 int ctl_t::csi_nz

Number of altitudes of gridded CSI data.

Definition at line 297 of file libtrac.h.

4.2.2.42 double ctl_t::csi_z0

Lower altitude of gridded CSI data [km].

Definition at line 300 of file libtrac.h.

4.2.2.43 double ctl_t::csi_z1

Upper altitude of gridded CSI data [km].

Definition at line 303 of file libtrac.h.

4.2.2.44 int ctl_t::csi_nx

Number of longitudes of gridded CSI data.

Definition at line 306 of file libtrac.h.

4.2.2.45 double ctl_t::csi_lon0

Lower longitude of gridded CSI data [deg].

Definition at line 309 of file libtrac.h.

4.2.2.46 double ctl_t::csi_lon1

Upper longitude of gridded CSI data [deg].

Definition at line 312 of file libtrac.h.

4.2.2.47 int ctl_t::csi_ny

Number of latitudes of gridded CSI data.

Definition at line 315 of file libtrac.h.

4.2.2.48 double ctl_t::csi_lat0

Lower latitude of gridded CSI data [deg].

Definition at line 318 of file libtrac.h.

4.2.2.49 double ctl_t::csi_lat1

Upper latitude of gridded CSI data [deg].

Definition at line 321 of file libtrac.h.

4.2.2.50 char ctl_t::grid_basename[LEN]

Basename of grid data files.

Definition at line 324 of file libtrac.h.

4.2.2.51 char ctl_t::grid_gpfile[LEN]

Gnuplot file for gridded data.

Definition at line 327 of file libtrac.h.

4.2.2.52 double ctl_t::grid_dt_out

Time step for gridded data output [s].

Definition at line 330 of file libtrac.h.

4.2.2.53 int ctl_t::grid_sparse

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

Definition at line 333 of file libtrac.h.

4.2.2.54 int ctl_t::grid_nz

Number of altitudes of gridded data.

Definition at line 336 of file libtrac.h.

4.2.2.55 double ctl_t::grid_z0

Lower altitude of gridded data [km].

Definition at line 339 of file libtrac.h.

4.2.2.56 double ctl_t::grid_z1

Upper altitude of gridded data [km].

Definition at line 342 of file libtrac.h.

4.2.2.57 int ctl_t::grid_nx

Number of longitudes of gridded data.

Definition at line 345 of file libtrac.h.

4.2.2.58 double ctl_t::grid_lon0

Lower longitude of gridded data [deg].

Definition at line 348 of file libtrac.h.

4.2.2.59 double ctl_t::grid_lon1

Upper longitude of gridded data [deg].

Definition at line 351 of file libtrac.h.

4.2.2.60 int ctl_t::grid_ny

Number of latitudes of gridded data.

Definition at line 354 of file libtrac.h.

4.2.2.61 double ctl_t::grid_lat0

Lower latitude of gridded data [deg].

Definition at line 357 of file libtrac.h.

4.2.2.62 double ctl_t::grid_lat1

Upper latitude of gridded data [deg].

Definition at line 360 of file libtrac.h.

4.2.2.63 char ctl_t::prof_basename[LEN]

Basename for profile output file.

Definition at line 363 of file libtrac.h.

4.2.2.64 char ctl_t::prof_obsfile[LEN]

Observation data file for profile output.

Definition at line 366 of file libtrac.h.

4.2.2.65 int ctl_t::prof_nz

Number of altitudes of gridded profile data.

Definition at line 369 of file libtrac.h.

4.2.2.66 double ctl_t::prof_z0

Lower altitude of gridded profile data [km].

Definition at line 372 of file libtrac.h.

4.2.2.67 double ctl_t::prof_z1

Upper altitude of gridded profile data [km].

Definition at line 375 of file libtrac.h.

4.2.2.68 int ctl_t::prof_nx

Number of longitudes of gridded profile data.

Definition at line 378 of file libtrac.h.

4.2.2.69 double ctl_t::prof_lon0

Lower longitude of gridded profile data [deg].

Definition at line 381 of file libtrac.h.

4.2.2.70 double ctl_t::prof_lon1

Upper longitude of gridded profile data [deg].

Definition at line 384 of file libtrac.h.

4.2.2.71 int ctl_t::prof_ny

Number of latitudes of gridded profile data.

Definition at line 387 of file libtrac.h.

4.2.2.72 double ctl_t::prof_lat0

Lower latitude of gridded profile data [deg].

Definition at line 390 of file libtrac.h.

4.2.2.73 double ctl_t::prof_lat1

Upper latitude of gridded profile data [deg].

Definition at line 393 of file libtrac.h.

4.2.2.74 char ctl_t::stat_basename[LEN]

Basename of station data file.

Definition at line 396 of file libtrac.h.

4.2.2.75 double ctl_t::stat_lon

Longitude of station [deg].

Definition at line 399 of file libtrac.h.

4.2.2.76 double ctl_t::stat_lat

Latitude of station [deg].

Definition at line 402 of file libtrac.h.

4.2.2.77 double ctl_t::stat_r

Search radius around station [km].

Definition at line 405 of file libtrac.h.

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

- libtrac.h

4.3 met_t Struct Reference

Meteorological data.

`#include <libtrac.h>`

Data Fields

- double time
  Time [s].
- int nx
  Number of longitudes.
- int ny
  Number of latitudes.
- int np
  Number of pressure levels.
- double lon [EX]
  Longitude [deg].
- double lat [EY]
  Latitude [deg].
- double p [EP]
  Pressure [hPa].
- double ps [EX][EY]
  Surface pressure [hPa].
- float pl [EX][EY][EP]
  Pressure on model levels [hPa].
- float t [EX][EY][EP]
  Temperature [K].
- float u [EX][EY][EP]
  Zonal wind [m/s].
- float v [EX][EY][EP]
  Meridional wind [m/s].
- float w [EX][EY][EP]
  Vertical wind [hPa/s].
- float h2o [EX][EY][EP]
  Water vapor volume mixing ratio [1].
- float o3 [EX][EY][EP]
  Ozone volume mixing ratio [1].

4.3.1 Detailed Description

Meteorological data.

Definition at line 442 of file libtrac.h.

4.3.2 Field Documentation

4.3.2.1 double met_t::time

Time [s].

Definition at line 445 of file libtrac.h.

4.3.2.2 int met_t::nx

Number of longitudes.

Definition at line 448 of file libtrac.h.

4.3.2.3 int met_t::ny

Number of latitudes.

Definition at line 451 of file libtrac.h.

4.3.2.4 int met_t::np

Number of pressure levels.

Definition at line 454 of file libtrac.h.

4.3.2.5 double met_t::lon[EX]

Longitude [deg].

Definition at line 457 of file libtrac.h.

4.3.2.6 double met_t::lat[EY]

Latitude [deg].

Definition at line 460 of file libtrac.h.

4.3.2.7 double met_t::p[EP]

Pressure [hPa].

Definition at line 463 of file libtrac.h.

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

Surface pressure [hPa].

Definition at line 466 of file libtrac.h.

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

Pressure on model levels [hPa].

Definition at line 469 of file libtrac.h.

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

Temperature [K].

Definition at line 472 of file libtrac.h.

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

Zonal wind [m/s].

Definition at line 475 of file libtrac.h.

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

Meridional wind [m/s].

Definition at line 478 of file libtrac.h.

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

Vertical wind [hPa/s].

Definition at line 481 of file libtrac.h.

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

Water vapor volume mixing ratio [1].

Definition at line 484 of file libtrac.h.

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

Ozone volume mixing ratio [1].

Definition at line 487 of file libtrac.h.

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

- libtrac.h

5 File Documentation

5.1 center.c File Reference

Calculate center of mass of air parcels.

Functions

- int main (int argc, char ∗argv[ ])

5.1.1 Detailed Description

Calculate center of mass of air parcels.

Definition in file center.c.

5.1.2 Function Documentation

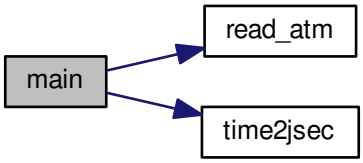
5.1.2.1 int main (int *argc,* char ∗ *argv[ ]*)

Definition at line 28 of file center.c.

```
00030                {
00031
00032   ctl_t ctl;
00033
00034   atm_t *atm;
00035
00036   FILE *out;
00037
00038   char *name, *year, *mon, *day, *hour, *min;
00039
00040   double latm, lats, lonm, lons, t, zm, zs;
00041
00042   int i, f, ip;
00043
00044   /* Allocate... */
00045   ALLOC(atm, atm_t, 1);
00046
00047   /* Check arguments... */
00048   if (argc < 3)
00049     ERRMSG("Give parameters: <outfile> <atm1> [<atm2> ...]");
00050
00051   /* Write info... */
00052   printf("Write center of mass data: %s\n", argv[1]);
00053
00054   /* Create output file... */
00055   if (!(out = fopen(argv[1], "w")))
00056     ERRMSG("Cannot create file!");
00057
00058   /* Write header... */
00059   fprintf(out,
00060           "# $1  = time [s]\n"
00061           "# $2  = altitude (mean) [km]\n"
00062           "# $3  = altitude (sigma) [km]\n"
00063           "# $4  = altitude (minimum) [km]\n"
00064           "# $5  = altitude (10%% percentile) [km]\n"
00065           "# $6  = altitude (1st quarter) [km]\n"
00066           "# $7  = altitude (median) [km]\n"
00067           "# $8  = altitude (3rd quarter) [km]\n"
00068           "# $9  = altitude (90%% percentile) [km]\n"
00069           "# $10 = altitude (maximum) [km]\n");
00070   fprintf(out,
00071           "# $11 = longitude (mean) [deg]\n"
00072           "# $12 = longitude (sigma) [deg]\n"
00073           "# $13 = longitude (minimum) [deg]\n"
```

```
00074           "# $14 = longitude (10%% percentile) [deg]\n"
00075           "# $15 = longitude (1st quarter) [deg]\n"
00076           "# $16 = longitude (median) [deg]\n"
00077           "# $17 = longitude (3rd quarter) [deg]\n"
00078           "# $18 = longitude (90%% percentile) [deg]\n"
00079           "# $19 = longitude (maximum) [deg]\n");
00080   fprintf(out,
00081           "# $20 = latitude (mean) [deg]\n"
00082           "# $21 = latitude (sigma) [deg]\n"
00083           "# $22 = latitude (minimum) [deg]\n"
00084           "# $23 = latitude (10%% percentile) [deg]\n"
00085           "# $24 = latitude (1st quarter) [deg]\n"
00086           "# $25 = latitude (median) [deg]\n"
00087           "# $26 = latitude (3rd quarter) [deg]\n"
00088           "# $27 = latitude (90%% percentile) [deg]\n"
00089           "# $28 = latitude (maximum) [deg]\n\n");
00090
00091   /* Loop over files... */
00092   for (f = 2; f < argc; f++) {
00093
00094     /* Read atmopheric data... */
00095     read_atm(argv[f], &ctl, atm);
00096
00097     /* Initialize... */
00098     zm = zs = 0;
00099     lonm = lons = 0;
00100     latm = lats = 0;
00101
00102     /* Calculate mean and standard deviation... */
00103     for (ip = 0; ip < atm->np; ip++) {
00104       zm += Z(atm->p[ip]) / atm->np;
00105       lonm += atm->lon[ip] / atm->np;
00106       latm += atm->lat[ip] / atm->np;
00107       zs += gsl_pow_2(Z(atm->p[ip])) / atm->np;
00108       lons += gsl_pow_2(atm->lon[ip]) / atm->np;
00109       lats += gsl_pow_2(atm->lat[ip]) / atm->np;
00110     }
00111
00112     /* Normalize... */
00113     zs = sqrt(zs - gsl_pow_2(zm));
00114     lons = sqrt(lons - gsl_pow_2(lonm));
00115     lats = sqrt(lats - gsl_pow_2(latm));
00116
00117     /* Sort arrays... */
00118     gsl_sort(atm->p, 1, (size_t) atm->np);
00119     gsl_sort(atm->lon, 1, (size_t) atm->np);
00120     gsl_sort(atm->lat, 1, (size_t) atm->np);
00121
00122     /* Get date from filename... */
00123     for (i = (int) strlen(argv[f]) - 1; argv[f][i] != '/' || i == 0; i--);
00124     name = strtok(&(argv[f][i]), "_");
00125     year = strtok(NULL, "_");
00126     mon = strtok(NULL, "_");
00127     day = strtok(NULL, "_");
00128     hour = strtok(NULL, "_");
00129     name = strtok(NULL, "_");   /* TODO: Why another "name" here? */
00130     min = strtok(name, ".");
00131     time2jsec(atoi(year), atoi(mon), atoi(day), atoi(hour), atoi(min), 0, 0,
00132               &t);
00133
00134     /* Write data... */
00135     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g "
00136             "%g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g %g\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.

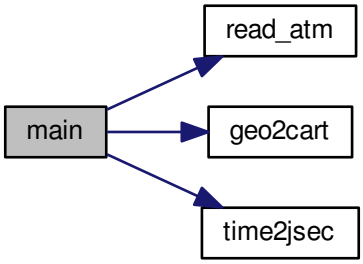
```
00030                {
00031
00032   ctl_t ctl;
00033
00034   atm_t *atm1, *atm2;
00035
00036   FILE *out;
00037
00038   char *name, *year, *mon, *day, *hour, *min;
00039
00040   double aux, x0[3], x1[3], x2[3], *lon1, *lat1, *p1, *lh1, *lv1,
00041     *lon2, *lat2, *p2, *lh2, *lv2, ahtd, avtd, ahtd2,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

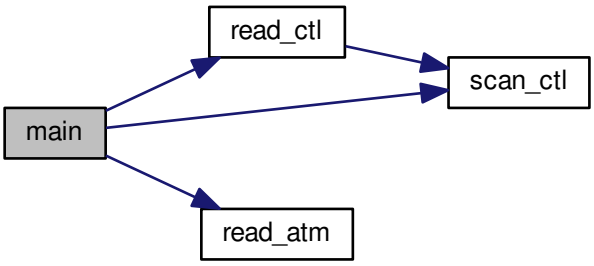
5.5.2.1 int main (int *argc,* char ∗ *argv[ ]*)

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

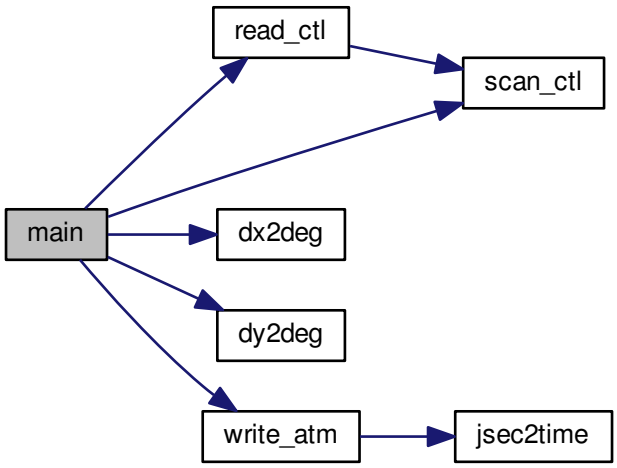
5.7.2.1 int main (int *argc,* char ∗ *argv[ ]*)

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.

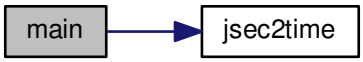
5.9.2 Function Documentation

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)

Convert degrees to horizontal distance.

- double deg2dy (double dlat)

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

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

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

  Convert horizontal distance to degrees.
- double dz2dp (double dz, double p)

  Convert vertical distance to pressure.
- void geo2cart (double z, double lon, double lat, double *x)

  Convert geolocation to Cartesian coordinates.
- void get_met (ctl_t *ctl, char *metbase, double t, met_t *met0, met_t *met1)

  Get meteorological data for given timestep.
- void get_met_help (double t, int direct, char *metbase, double dt_met, char *filename)

  Get meteorological data for timestep.
- void intpol_met_2d (double array[EX][EY], int ix, int iy, double wx, double wy, double *var)

  Linear interpolation of 2-D meteorological data.
- void intpol_met_3d (float array[EX][EY][EP], int ip, int ix, int iy, double wp, double wx, double wy, double *var)

  Linear interpolation of 3-D meteorological data.
- void intpol_met_space (met_t *met, double p, double lon, double lat, double *ps, double *t, double *u, double *v, double *w, double *h2o, double *o3)

  Spatial interpolation of meteorological data.
- void intpol_met_time (met_t *met0, met_t *met1, double ts, double p, double lon, double lat, double *ps, double *t, double *u, double *v, double *w, double *h2o, double *o3)

  Temporal interpolation of meteorological data.
- void jsec2time (double jsec, int *year, int *mon, int *day, int *hour, int *min, int *sec, double *remain)

  Convert seconds to date.
- int locate (double *xx, int n, double x)

  Find array index.
- void read_atm (const char *filename, ctl_t *ctl, atm_t *atm)

  Read atmospheric data.
- void read_ctl (const char *filename, int argc, char *argv[ ], ctl_t *ctl)

  Read control parameters.
- void read_met (ctl_t *ctl, char *filename, met_t *met)

  Read meteorological data file.
- void read_met_extrapolate (met_t *met)

  Extrapolate meteorological data at lower boundary.
- void read_met_help (int ncid, char *varname, char *varname2, met_t *met, float dest[EX][EY][EP], float scl)

  Read and convert variable from meteorological data file.
- void read_met_ml2pl (ctl_t *ctl, met_t *met, float var[EX][EY][EP])

  Convert meteorological data from model levels to pressure levels.
- void read_met_periodic (met_t *met)

  Create meteorological data with periodic boundary conditions.
- double scan_ctl (const char *filename, int argc, char *argv[ ], const char *varname, int arridx, const char *defvalue, char *value)

  Read a control parameter from file or command line.
- void time2jsec (int year, int mon, int day, int hour, int min, int sec, double remain, double *jsec)

  Convert date to seconds.
- void timer (const char *name, int id, int mode)

Measure wall-clock time.

- double tropopause (double t, double lat)
- void write_atm (const char *filename, ctl_t *ctl, atm_t *atm, double t)

  Write atmospheric data.
- void write_csi (const char *filename, ctl_t *ctl, atm_t *atm, double t)

  Write CSI data.
- void write_grid (const char *filename, ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, double t)

  Write gridded data.
- void write_prof (const char *filename, ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, double t)

  Write profile data.
- void write_station (const char *filename, ctl_t *ctl, atm_t *atm, double t)

  Write station data.

5.11.1 Detailed Description

MPTRAC library definitions.

Definition in file libtrac.c.

5.11.2 Function Documentation

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

Convert Cartesian coordinates to geolocation.

Definition at line 29 of file libtrac.c.

```
00033                {
00034
00035   double radius;
00036
00037   radius = NORM(x);
00038   *lat = asin(x[2] / radius) * 180 / M_PI;
00039   *lon = atan2(x[1], x[0]) * 180 / M_PI;
00040   *z = radius - RE;
00041 }
```

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

Convert degrees to horizontal distance.

Definition at line 45 of file libtrac.c.

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

5.11.2.3 double deg2dy (double *dlat*)

Convert degrees to horizontal distance.

Definition at line 54 of file libtrac.c.

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

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

Convert pressure to vertical distance.

Definition at line 62 of file libtrac.c.

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

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

Convert horizontal distance to degrees.

Definition at line 71 of file libtrac.c.

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

5.11.2.6 double dy2deg (double *dy*)

Convert horizontal distance to degrees.

Definition at line 84 of file libtrac.c.

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

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

Convert vertical distance to pressure.

Definition at line 92 of file libtrac.c.

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

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

Convert geolocation to Cartesian coordinates.

Definition at line 101 of file libtrac.c.

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

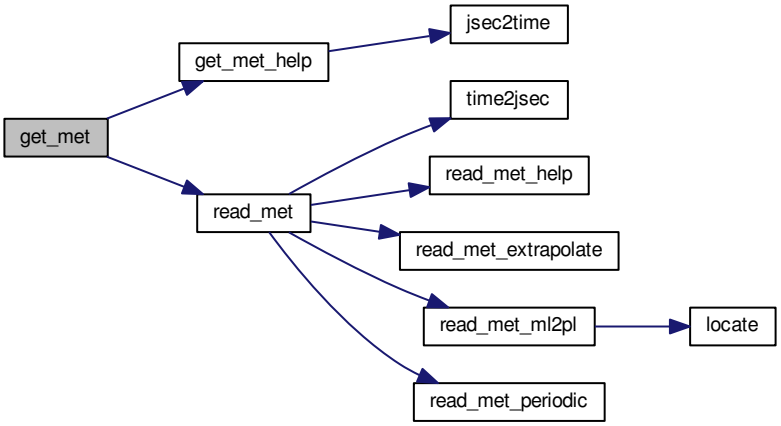
5.11.2.9 void get_met (ctl_t * *ctl*, char * *metbase*, double *t*, met_t * *met0*, met_t * *met1*)

Get meteorological data for given timestep.

Definition at line 117 of file libtrac.c.

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

Here is the call graph for this function:



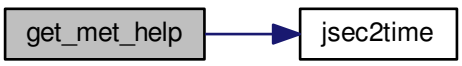
5.11.2.10 void get_met_help (double *t*, int *direct*, char * *metbase*, double *dt_met*, char * *filename*)

Get meteorological data for timestep.

Definition at line 156 of file libtrac.c.

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

Here is the call graph for this function:



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

Linear interpolation of 2-D meteorological data.

Definition at line 182 of file libtrac.c.

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

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

Linear interpolation of 3-D meteorological data.

Definition at line 206 of file libtrac.c.

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

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

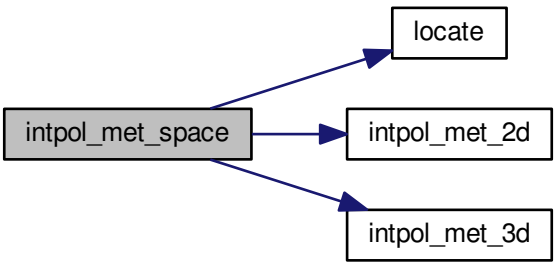
Spatial interpolation of meteorological data.

Definition at line 236 of file libtrac.c.

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

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

Here is the call graph for this function:



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

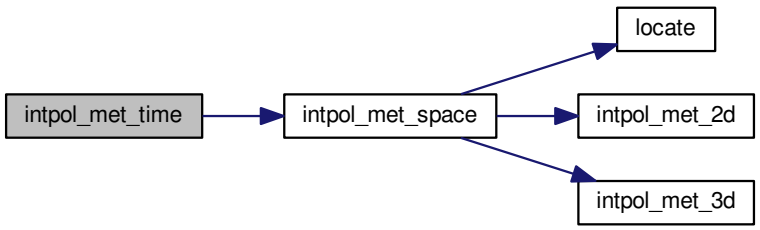
Temporal interpolation of meteorological data.

Definition at line 286 of file libtrac.c.

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

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

Here is the call graph for this function:



5.11.2.15 void jsec2time (double *jsec*, int * *year*, int * *mon*, int * *day*, int * *hour*, int * *min*, int * *sec*, double * *remain*)

Convert seconds to date.

Definition at line 341 of file libtrac.c.

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

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

Find array index.

Definition at line 376 of file libtrac.c.

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

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

Read atmospheric data.

Definition at line 408 of file libtrac.c.

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

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

Read control parameters.

Definition at line 458 of file libtrac.c.

```
00462               {
00463
00464   int ip, iq;
00465
00466   /* Write info... */
00467   printf("\nMassive-Parallel Trajectory Calculations (MPTRAC)\n"
00468          "(executable: %s | compiled: %s, %s)\n\n",
00469          argv[0], __DATE__, __TIME__);
00470
00471   /* Initialize quantity indices... */
00472   ctl->qnt_m = -1;
00473   ctl->qnt_r = -1;
00474   ctl->qnt_rho = -1;
00475   ctl->qnt_ps = -1;
00476   ctl->qnt_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   ctl->met_np = (int) scan_ctl(filename, argc, argv, "MET_NP", -1, "0", NULL);
00548   if (ctl->met_np > EP)
00549     ERRMSG("Too many levels!");
00550   for (ip = 0; ip < ctl->met_np; ip++)
00551     ctl->met_p[ip] = scan_ctl(filename, argc, argv, "MET_P", ip, "", NULL);
00552
00553   /* Isosurface parameters... */
00554   ctl->isosurf
00555     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
00556   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
00557
00558   /* Diffusion parameters... */
00559   ctl->turb_dx_trop
00560     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50.0", NULL);
00561   ctl->turb_dx_strat
00562     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0.0", NULL);
00563   ctl->turb_dz_trop
00564     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0.0", NULL);
00565   ctl->turb_dz_strat
00566     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
00567   ctl->turb_meso =
00568     scan_ctl(filename, argc, argv, "TURB_MESO", -1, "0.16", NULL);
00569
00570   /* Life time of particles... */
00571   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
00572   ctl->tdec_strat =
00573     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
00574
00575   /* Output of atmospheric data... */
00576   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
      atm_basename);
00577   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
00578   ctl->atm_dt_out =
00579     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
00580
00581   /* Output of CSI data... */
00582   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
      csi_basename);
00583   ctl->csi_dt_out =
00584     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
00585   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "obs.tab",
00586            ctl->csi_obsfile);
00587   ctl->csi_obsmin =
00588     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
00589   ctl->csi_modmin =
00590     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
00591   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
00592   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
00593   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
00594   ctl->csi_lon0 =
00595     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
00596   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
00597   ctl->csi_nx =
00598     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
00599   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
00600   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
00601   ctl->csi_ny =
00602     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
00603
00604   /* Output of grid data... */
00605   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
00606            ctl->grid_basename);
00607   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
      grid_gpfile);
00608   ctl->grid_dt_out =
00609     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
00610   ctl->grid_sparse =
00611     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
00612   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
00613   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
00614   ctl->grid_nz =
00615     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
00616   ctl->grid_lon0 =
00617     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
00618   ctl->grid_lon1 =
00619     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
00620   ctl->grid_nx =
00621     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
00622   ctl->grid_lat0 =
```

```
00623     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
00624   ctl->grid_lat1 =
00625     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
00626   ctl->grid_ny =
00627     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
00628
00629   /* Output of profile data... */
00630   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
00631            ctl->prof_basename);
00632   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
      prof_obsfile);
00633   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
00634   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
00635   ctl->prof_nz =
00636     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
00637   ctl->prof_lon0 =
00638     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
00639   ctl->prof_lon1 =
00640     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
00641   ctl->prof_nx =
00642     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
00643   ctl->prof_lat0 =
00644     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
00645   ctl->prof_lat1 =
00646     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
00647   ctl->prof_ny =
00648     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
00649
00650   /* Output of station data... */
00651   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
00652            ctl->stat_basename);
00653   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
00654   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
00655   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
00656 }
```

Here is the call graph for this function:

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

Read meteorological data file.

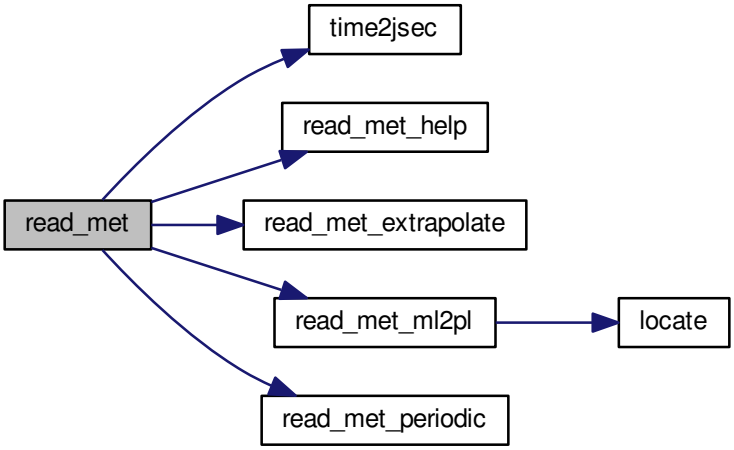
Definition at line 660 of file libtrac.c.

```
00663               {
00664
00665   char tstr[10];
00666
00667   static float help[EX * EY];
00668
00669   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
00670
00671   size_t np, nx, ny;
00672
00673   /* Write info... */
00674   printf("Read meteorological data: %s\n", filename);
00675
00676   /* Get time from filename... */
00677   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
00678   year = atoi(tstr);
00679   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
00680   mon = atoi(tstr);
```

```
00681   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
00682   day = atoi(tstr);
00683   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
00684   hour = atoi(tstr);
00685   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
00686
00687   /* Open netCDF file... */
00688   NC(nc_open(filename, NC_NOWRITE, &ncid));
00689
00690   /* Get dimensions... */
00691   NC(nc_inq_dimid(ncid, "lon", &dimid));
00692   NC(nc_inq_dimlen(ncid, dimid, &nx));
00693   if (nx > EX)
00694     ERRMSG("Too many longitudes!");
00695
00696   NC(nc_inq_dimid(ncid, "lat", &dimid));
00697   NC(nc_inq_dimlen(ncid, dimid, &ny));
00698   if (ny > EY)
00699     ERRMSG("Too many latitudes!");
00700
00701   NC(nc_inq_dimid(ncid, "lev", &dimid));
00702   NC(nc_inq_dimlen(ncid, dimid, &np));
00703   if (np > EP)
00704     ERRMSG("Too many levels!");
00705
00706   /* Store dimensions... */
00707   met->np = (int) np;
00708   met->nx = (int) nx;
00709   met->ny = (int) ny;
00710
00711   /* Get horizontal grid... */
00712   NC(nc_inq_varid(ncid, "lon", &varid));
00713   NC(nc_get_var_double(ncid, varid, met->lon));
00714   NC(nc_inq_varid(ncid, "lat", &varid));
00715   NC(nc_get_var_double(ncid, varid, met->lat));
00716
00717   /* Read meteorological data... */
00718   read_met_help(ncid, "t", "T", met, met->t, 1.0);
00719   read_met_help(ncid, "u", "U", met, met->u, 1.0);
00720   read_met_help(ncid, "v", "V", met, met->v, 1.0);
00721   read_met_help(ncid, "w", "W", met, met->w, 0.01f);
00722   read_met_help(ncid, "q", "Q", met, met->h2o, 1.608f);
00723   read_met_help(ncid, "o3", "O3", met, met->o3, 0.602f);
00724
00725   /* Meteo data on pressure levels... */
00726   if (ctl->met_np <= 0) {
00727
00728     /* Read pressure levels from file... */
00729     NC(nc_inq_varid(ncid, "lev", &varid));
00730     NC(nc_get_var_double(ncid, varid, met->p));
00731     for (ip = 0; ip < met->np; ip++)
00732       met->p[ip] /= 100.;
00733
00734     /* Extrapolate data for lower boundary... */
00735     read_met_extrapolate(met);
00736   }
00737
00738   /* Meteo data on model levels... */
00739   else {
00740
00741     /* Read pressure data from file... */
00742     read_met_help(ncid, "pl", "PL", met, met->pl, 0.01f);
00743
00744     /* Interpolate from model levels to pressure levels... */
00745     read_met_ml2pl(ctl, met, met->t);
00746     read_met_ml2pl(ctl, met, met->u);
00747     read_met_ml2pl(ctl, met, met->v);
00748     read_met_ml2pl(ctl, met, met->w);
00749     read_met_ml2pl(ctl, met, met->h2o);
00750     read_met_ml2pl(ctl, met, met->o3);
00751
00752     /* Set pressure levels... */
00753     met->np = ctl->met_np;
00754     for (ip = 0; ip < met->np; ip++)
00755       met->p[ip] = ctl->met_p[ip];
00756   }
00757
00758   /* Check ordering of pressure levels... */
00759   for (ip = 1; ip < met->np; ip++)
00760     if (met->p[ip - 1] < met->p[ip])
00761       ERRMSG("Pressure levels must be descending!");
00762
00763   /* Read surface pressure... */
00764   if (nc_inq_varid(ncid, "PS", &varid) == NC_NOERR) {
00765     NC(nc_get_var_float(ncid, varid, help));
00766     for (iy = 0; iy < met->ny; iy++)
00767       for (ix = 0; ix < met->nx; ix++)
```

```
00768         met->ps[ix][iy] = help[iy * met->nx + ix] / 100.;
00769     } else if (nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
00770       NC(nc_get_var_float(ncid, varid, help));
00771       for (iy = 0; iy < met->ny; iy++)
00772         for (ix = 0; ix < met->nx; ix++)
00773           met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
00774     } else
00775       for (ix = 0; ix < met->nx; ix++)
00776         for (iy = 0; iy < met->ny; iy++)
00777           met->ps[ix][iy] = met->p[0];
00778
00779     /* Create periodic boundary conditions... */
00780     read_met_periodic(met);
00781
00782     /* Close file... */
00783     NC(nc_close(ncid));
00784   }
```

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 788 of file libtrac.c.

```
00789                 {
00790
00791     int ip, ip0, ix, iy;
00792
00793     /* Loop over columns... */
00794     for (ix = 0; ix < met->nx; ix++)
00795       for (iy = 0; iy < met->ny; iy++) {
00796
00797         /* Find lowest valid data point... */
00798         for (ip0 = met->np - 1; ip0 >= 0; ip0--)
00799           if (!gsl_finite(met->t[ix][iy][ip0])
00800               || !gsl_finite(met->u[ix][iy][ip0])
00801               || !gsl_finite(met->v[ix][iy][ip0])
00802               || !gsl_finite(met->w[ix][iy][ip0]))
00803             break;
00804
00805         /* Extrapolate... */
00806         for (ip = ip0; ip >= 0; ip--) {
```

```
00807         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
00808         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
00809         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
00810         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
00811         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
00812         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
00813       }
00814     }
00815 }
```

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

Read and convert variable from meteorological data file.

Definition at line 819 of file libtrac.c.

```
00825             {
00826
00827   static float help[EX * EY * EP];
00828
00829   int ip, ix, iy, n = 0, varid;
00830
00831   /* Check if variable exists... */
00832   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
00833     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
00834       return;
00835
00836   /* Read data... */
00837   NC(nc_get_var_float(ncid, varid, help));
00838
00839   /* Copy and check data... */
00840   for (ip = 0; ip < met->np; ip++)
00841     for (iy = 0; iy < met->ny; iy++)
00842       for (ix = 0; ix < met->nx; ix++) {
00843         dest[ix][iy][ip] = scl * help[n++];
00844         if (fabs(dest[ix][iy][ip] / scl) > 1e14)
00845           dest[ix][iy][ip] = GSL_NAN;
00846       }
00847 }
```

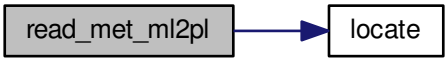
5.11.2.22 void read_met_ml2pl (ctl_t * *ctl*, met_t * *met*, float *var[EX][EY][EP]*)

Convert meteorological data from model levels to pressure levels.

Definition at line 851 of file libtrac.c.

```
00854                         {
00855
00856   double aux[EP], p[EP], pt;
00857
00858   int ip, ip2, ix, iy;
00859
00860   /* Loop over columns... */
00861   for (ix = 0; ix < met->nx; ix++)
00862     for (iy = 0; iy < met->ny; iy++) {
00863
00864       /* Copy pressure profile... */
00865       for (ip = 0; ip < met->np; ip++)
00866         p[ip] = met->pl[ix][iy][ip];
00867
00868       /* Interpolate... */
00869       for (ip = 0; ip < ctl->met_np; ip++) {
00870         pt = ctl->met_p[ip];
00871         if ((pt > p[0] && p[0] > p[1]) || (pt < p[0] && p[0] < p[1]))
00872           pt = p[0];
00873         else if ((pt > p[met->np - 1] && p[1] > p[0])
00874                  || (pt < p[met->np - 1] && p[1] < p[0]))
00875           pt = p[met->np - 1];
00876         ip2 = locate(p, met->np, pt);
00877         aux[ip] = LIN(p[ip2], var[ix][iy][ip2],
00878                       p[ip2 + 1], var[ix][iy][ip2 + 1], pt);
00879       }
00880
00881       /* Copy data... */
00882       for (ip = 0; ip < ctl->met_np; ip++)
00883         var[ix][iy][ip] = (float) aux[ip];
00884     }
00885 }
```

Here is the call graph for this function:



5.11.2.23 void read_met_periodic (met_t * *met*)

Create meteorological data with periodic boundary conditions.

Definition at line 889 of file libtrac.c.

```
00890                {
00891
00892   int ip, iy;
00893
00894   /* Check longitudes... */
00895   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
00896              + met->lon[1] - met->lon[0] - 360) < 0.01))
00897     return;
00898
00899   /* Increase longitude counter... */
00900   if ((++met->nx) > EX)
00901     ERRMSG("Cannot create periodic boundary conditions!");
00902
00903   /* Set longitude... */
00904   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
00905
00906   /* Loop over latitudes and pressure levels... */
00907   for (iy = 0; iy < met->ny; iy++)
00908     for (ip = 0; ip < met->np; ip++) {
00909       met->ps[met->nx - 1][iy] = met->ps[0][iy];
00910       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
00911       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
00912       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
00913       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
00914       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
00915       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
00916     }
00917 }
```

5.11.2.24 double scan_ctl (const char * *filename*, int *argc*, char * *argv[]*, const char * *varname*, int *arridx*, const char * *defvalue*, char * *value*)

Read a control parameter from file or command line.

Definition at line 921 of file libtrac.c.

```
00928                {
00929
00930   FILE *in = NULL;
00931
00932   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
00933     msg[LEN], rvarname[LEN], rval[LEN];
00934
00935   int contain = 0, i;
00936
00937   /* Open file... */
00938   if (filename[strlen(filename) - 1] != '-')
00939     if (!(in = fopen(filename, "r")))
```

```
00940       ERRMSG("Cannot open file!");
00941
00942   /* Set full variable name... */
00943   if (arridx >= 0) {
00944     sprintf(fullname1, "%s[%d]", varname, arridx);
00945     sprintf(fullname2, "%s[*]", varname);
00946   } else {
00947     sprintf(fullname1, "%s", varname);
00948     sprintf(fullname2, "%s", varname);
00949   }
00950
00951   /* Read data... */
00952   if (in != NULL)
00953     while (fgets(line, LEN, in))
00954       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
00955         if (strcasecmp(rvarname, fullname1) == 0 ||
00956             strcasecmp(rvarname, fullname2) == 0) {
00957           contain = 1;
00958           break;
00959         }
00960   for (i = 1; i < argc - 1; i++)
00961     if (strcasecmp(argv[i], fullname1) == 0 ||
00962         strcasecmp(argv[i], fullname2) == 0) {
00963       sprintf(rval, "%s", argv[i + 1]);
00964       contain = 1;
00965       break;
00966     }
00967
00968   /* Close file... */
00969   if (in != NULL)
00970     fclose(in);
00971
00972   /* Check for missing variables... */
00973   if (!contain) {
00974     if (strlen(defvalue) > 0)
00975       sprintf(rval, "%s", defvalue);
00976     else {
00977       sprintf(msg, "Missing variable %s!\n", fullname1);
00978       ERRMSG(msg);
00979     }
00980   }
00981
00982   /* Write info... */
00983   printf("%s = %s\n", fullname1, rval);
00984
00985   /* Return values... */
00986   if (value != NULL)
00987     sprintf(value, "%s", rval);
00988   return atof(rval);
00989 }
```

5.11.2.25 void time2jsec (int *year*, int *mon*, int *day*, int *hour*, int *min*, int *sec*, double *remain*, double * *jsec*)

Convert date to seconds.

Definition at line 993 of file libtrac.c.

```
01001                 {
01002
01003   struct tm t0, t1;
01004
01005   t0.tm_year = 100;
01006   t0.tm_mon = 0;
01007   t0.tm_mday = 1;
01008   t0.tm_hour = 0;
01009   t0.tm_min = 0;
01010   t0.tm_sec = 0;
01011
01012   t1.tm_year = year - 1900;
01013   t1.tm_mon = mon - 1;
01014   t1.tm_mday = day;
01015   t1.tm_hour = hour;
01016   t1.tm_min = min;
01017   t1.tm_sec = sec;
01018
01019   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
01020 }
```

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

Measure wall-clock time.

Definition at line 1024 of file libtrac.c.

```
01027            {
01028
01029   static double starttime[NTIMER], runtime[NTIMER];
01030
01031   /* Check id... */
01032   if (id < 0 || id >= NTIMER)
01033     ERRMSG("Too many timers!");
01034
01035   /* Start timer... */
01036   if (mode == 1) {
01037     if (starttime[id] <= 0)
01038       starttime[id] = omp_get_wtime();
01039     else
01040       ERRMSG("Timer already started!");
01041   }
01042
01043   /* Stop timer... */
01044   else if (mode == 2) {
01045     if (starttime[id] > 0) {
01046       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
01047       starttime[id] = -1;
01048     } else
01049       ERRMSG("Timer not started!");
01050   }
01051
01052   /* Print timer... */
01053   else if (mode == 3)
01054     printf("%s = %g s\n", name, runtime[id]);
01055 }
```

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

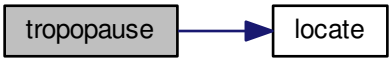
Definition at line 1059 of file libtrac.c.

```
01061              {
01062
01063   static double doys[12]
01064   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
01065
01066   static double lats[73]
01067     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
01068     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
01069     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
01070     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
01071     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
01072     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
01073     75, 77.5, 80, 82.5, 85, 87.5, 90
01074   };
01075
01076   static double tps[12][73]
01077     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
01078          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
01079          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
01080          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
01081          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
01082          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
01083          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
01084          275.3, 275.6, 275.4, 274.1, 273.5},
01085   {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
01086    300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
01087    150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
01088    98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
01089    98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
01090    220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
01091    284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
01092    287.5, 286.2, 285.8},
01093   {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
01094    297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
01095    161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
01096    100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
01097    99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
```

```
01098    186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
01099    279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
01100    304.3, 304.9, 306, 306.6, 306.2, 306},
01101   {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
01102    290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
01103    195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
01104    102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
01105    99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
01106    148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
01107    263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
01108    315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
01109   {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
01110    260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
01111    205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
01112    101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
01113    102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
01114    165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
01115    273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
01116    325.3, 325.8, 325.8},
01117   {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
01118    222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
01119    228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
01120    105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
01121    106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
01122    127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
01123    251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
01124    308.5, 312.2, 313.1, 313.3},
01125   {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
01126    187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
01127    235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
01128    110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
01129    111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
01130    117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
01131    224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
01132    275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
01133   {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
01134    185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
01135    233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
01136    110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
01137    112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
01138    120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
01139    230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
01140    278.2, 282.6, 287.4, 290.9, 292.5, 293},
01141   {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
01142    183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
01143    243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
01144    114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
01145    110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
01146    114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
01147    203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
01148    276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
01149   {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
01150    215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
01151    237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
01152    111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
01153    106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
01154    112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
01155    206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
01156    279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
01157    305.1},
01158   {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
01159    253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
01160    223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
01161    108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
01162    102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
01163    109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
01164    241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
01165    286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
01166   {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
01167    284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
01168    175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
01169    100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
01170    100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
01171    186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
01172    280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
01173    281.7, 281.1, 281.2}
01174   };
01175
01176   double doy, p0, p1, pt;
01177
01178   int imon, ilat;
01179
01180   /* Get day of year... */
01181   doy = fmod(t / 86400., 365.25);
01182   while (doy < 0)
01183     doy += 365.25;
01184
```

```
01185   /* Get indices... */
01186   imon = locate(doys, 12, doy);
01187   ilat = locate(lats, 73, lat);
01188
01189   /* Get tropopause pressure... */
01190   p0 = LIN(lats[ilat], tps[imon][ilat],
01191            lats[ilat + 1], tps[imon][ilat + 1], lat);
01192   p1 = LIN(lats[ilat], tps[imon + 1][ilat],
01193            lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
01194   pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
01195
01196   /* Return tropopause pressure... */
01197   return pt;
01198 }
```

Here is the call graph for this function:



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

Write atmospheric data.

Definition at line 1202 of file libtrac.c.

```
01206            {
01207
01208   FILE *in, *out;
01209
01210   char line[LEN];
01211
01212   double r;
01213
01214   int ip, iq, year, mon, day, hour, min, sec;
01215
01216   /* Check if gnuplot output is requested... */
01217   if (ctl->atm_gpfile[0] != '-') {
01218
01219     /* Write info... */
01220     printf("Plot atmospheric data: %s.png\n", filename);
01221
01222     /* Create gnuplot pipe... */
01223     if (!(out = popen("gnuplot", "w")))
01224       ERRMSG("Cannot create pipe to gnuplot!");
01225
01226     /* Set plot filename... */
01227     fprintf(out, "set out \"%s.png\"\n", filename);
01228
01229     /* Set time string... */
01230     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01231     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01232             year, mon, day, hour, min);
01233
01234     /* Dump gnuplot file to pipe... */
01235     if (!(in = fopen(ctl->atm_gpfile, "r")))
01236       ERRMSG("Cannot open file!");
01237     while (fgets(line, LEN, in))
01238       fprintf(out, "%s", line);
01239     fclose(in);
01240   }
01241
01242   else {
01243
01244     /* Write info... */
```

```
01245     printf("Write atmospheric data: %s\n", filename);
01246
01247     /* Create file... */
01248     if (!(out = fopen(filename, "w")))
01249       ERRMSG("Cannot create file!");
01250   }
01251
01252   /* Write header... */
01253   fprintf(out,
01254           "# $1 = time [s]\n"
01255           "# $2 = altitude [km]\n"
01256           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01257   for (iq = 0; iq < ctl->nq; iq++)
01258     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
01259             ctl->qnt_unit[iq]);
01260   fprintf(out, "\n");
01261
01262   /* Write data... */
01263   for (ip = 0; ip < atm->np; ip++) {
01264     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
01265             atm->lon[ip], atm->lat[ip]);
01266     for (iq = 0; iq < ctl->nq; iq++) {
01267       fprintf(out, " ");
01268       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01269     }
01270     fprintf(out, "\n");
01271   }
01272
01273   /* Close file... */
01274   fclose(out);
01275 }
```

Here is the call graph for this function:

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

Write CSI data.

Definition at line 1279 of file libtrac.c.

```
01283             {
01284
01285   static FILE *in, *out;
01286
01287   static char line[LEN];
01288
01289   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
01290     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
01291
01292   static int init, obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
01293
01294   /* Init... */
01295   if (!init) {
01296     init = 1;
01297
01298     /* Check quantity index for mass... */
01299     if (ctl->qnt_m < 0)
01300       ERRMSG("Need quantity mass to analyze CSI!");
01301
01302     /* Open observation data file... */
01303     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
01304     if (!(in = fopen(ctl->csi_obsfile, "r")))
```

```
01305       ERRMSG("Cannot open file!");
01306
01307     /* Create new file... */
01308     printf("Write CSI data: %s\n", filename);
01309     if (!(out = fopen(filename, "w")))
01310       ERRMSG("Cannot create file!");
01311
01312     /* Write header... */
01313     fprintf(out,
01314             "# $1 = time [s]\n"
01315             "# $2 = number of hits (cx)\n"
01316             "# $3 = number of misses (cy)\n"
01317             "# $4 = number of false alarms (cz)\n"
01318             "# $5 = number of observations (cx + cy)\n"
01319             "# $6 = number of forecasts (cx + cz)\n"
01320             "# $7 = bias (forecasts/observations) [%%]\n"
01321             "# $8 = probability of detection (POD) [%%]\n"
01322             "# $9 = false alarm rate (FAR) [%%]\n"
01323             "# $10 = critical success index (CSI) [%%]\n\n");
01324   }
01325
01326   /* Set time interval... */
01327   t0 = t - 0.5 * ctl->dt_mod;
01328   t1 = t + 0.5 * ctl->dt_mod;
01329
01330   /* Initialize grid cells... */
01331   for (ix = 0; ix < ctl->csi_nx; ix++)
01332     for (iy = 0; iy < ctl->csi_ny; iy++)
01333       for (iz = 0; iz < ctl->csi_nz; iz++)
01334         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
01335
01336   /* Read data... */
01337   while (fgets(line, LEN, in)) {
01338
01339     /* Read data... */
01340     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
01341         5)
01342       continue;
01343
01344     /* Check time... */
01345     if (rt < t0)
01346       continue;
01347     if (rt > t1)
01348       break;
01349
01350     /* Calculate indices... */
01351     ix = (int) ((rlon - ctl->csi_lon0)
01352                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01353     iy = (int) ((rlat - ctl->csi_lat0)
01354                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01355     iz = (int) ((rz - ctl->csi_z0)
01356                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01357
01358     /* Check indices... */
01359     if (ix < 0 || ix >= ctl->csi_nx ||
01360         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01361       continue;
01362
01363     /* Get mean observation index... */
01364     obsmean[ix][iy][iz] += robs;
01365     obscount[ix][iy][iz]++;
01366   }
01367
01368   /* Analyze model data... */
01369   for (ip = 0; ip < atm->np; ip++) {
01370
01371     /* Check time... */
01372     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01373       continue;
01374
01375     /* Get indices... */
01376     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
01377                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01378     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
01379                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01380     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
01381                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01382
01383     /* Check indices... */
01384     if (ix < 0 || ix >= ctl->csi_nx ||
01385         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01386       continue;
01387
01388     /* Get total mass in grid cell... */
01389     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01390   }
01391
```

```
01392   /* Analyze all grid cells... */
01393   for (ix = 0; ix < ctl->csi_nx; ix++)
01394     for (iy = 0; iy < ctl->csi_ny; iy++)
01395       for (iz = 0; iz < ctl->csi_nz; iz++) {
01396
01397         /* Calculate mean observation index... */
01398         if (obscount[ix][iy][iz] > 0)
01399           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
01400
01401         /* Calculate column density... */
01402         if (modmean[ix][iy][iz] > 0) {
01403           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
01404           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
01405           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
01406           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
01407             * cos(lat * M_PI / 180.);
01408           modmean[ix][iy][iz] /= (1e6 * area);
01409         }
01410
01411         /* Calculate CSI... */
01412         if (obscount[ix][iy][iz] > 0) {
01413           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01414               modmean[ix][iy][iz] >= ctl->csi_modmin)
01415             cx++;
01416           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01417                    modmean[ix][iy][iz] < ctl->csi_modmin)
01418             cy++;
01419           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
01420                    modmean[ix][iy][iz] >= ctl->csi_modmin)
01421             cz++;
01422         }
01423       }
01424
01425   /* Write output... */
01426   if (fmod(t, ctl->csi_dt_out) == 0) {
01427
01428     /* Write... */
01429     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
01430             t, cx, cy, cz, cx + cy, cx + cz,
01431             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
01432             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
01433             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
01434             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
01435
01436     /* Set counters to zero... */
01437     cx = cy = cz = 0;
01438   }
01439
01440   /* Close file... */
01441   if (t == ctl->t_stop)
01442     fclose(out);
01443 }
```

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

Write gridded data.

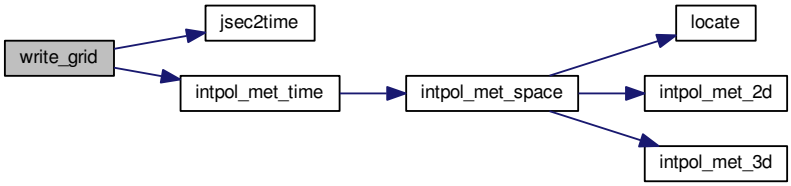
Definition at line 1447 of file libtrac.c.

```
01453             {
01454
01455   FILE *in, *out;
01456
01457   char line[LEN];
01458
01459   static double grid_m[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
01460     area, rho_air, press, temp, cd, mmr, t0, t1, r;
01461
01462   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
01463
01464   /* Check dimensions... */
01465   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
01466     ERRMSG("Grid dimensions too large!");
01467
01468   /* Check quantity index for mass... */
01469   if (ctl->qnt_m < 0)
01470     ERRMSG("Need quantity mass to write grid data!");
01471
01472   /* Set time interval for output... */
01473   t0 = t - 0.5 * ctl->dt_mod;
```

```
01474   t1 = t + 0.5 * ctl->dt_mod;
01475
01476   /* Set grid box size... */
01477   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
01478   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
01479   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
01480
01481   /* Initialize grid... */
01482   for (ix = 0; ix < ctl->grid_nx; ix++)
01483     for (iy = 0; iy < ctl->grid_ny; iy++)
01484       for (iz = 0; iz < ctl->grid_nz; iz++)
01485         grid_m[ix][iy][iz] = 0;
01486
01487   /* Average data... */
01488   for (ip = 0; ip < atm->np; ip++)
01489     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
01490
01491       /* Get index... */
01492       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
01493       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
01494       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
01495
01496       /* Check indices... */
01497       if (ix < 0 || ix >= ctl->grid_nx ||
01498           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
01499         continue;
01500
01501       /* Add mass... */
01502       grid_m[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01503     }
01504
01505   /* Check if gnuplot output is requested... */
01506   if (ctl->grid_gpfile[0] != '-') {
01507
01508     /* Write info... */
01509     printf("Plot grid data: %s.png\n", filename);
01510
01511     /* Create gnuplot pipe... */
01512     if (!(out = popen("gnuplot", "w")))
01513       ERRMSG("Cannot create pipe to gnuplot!");
01514
01515     /* Set plot filename... */
01516     fprintf(out, "set out \"%s.png\"\n", filename);
01517
01518     /* Set time string... */
01519     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01520     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01521             year, mon, day, hour, min);
01522
01523     /* Dump gnuplot file to pipe... */
01524     if (!(in = fopen(ctl->grid_gpfile, "r")))
01525       ERRMSG("Cannot open file!");
01526     while (fgets(line, LEN, in))
01527       fprintf(out, "%s", line);
01528     fclose(in);
01529   }
01530
01531   else {
01532
01533     /* Write info... */
01534     printf("Write grid data: %s\n", filename);
01535
01536     /* Create file... */
01537     if (!(out = fopen(filename, "w")))
01538       ERRMSG("Cannot create file!");
01539   }
01540
01541   /* Write header... */
01542   fprintf(out,
01543           "# $1 = time [s]\n"
01544           "# $2 = altitude [km]\n"
01545           "# $3 = longitude [deg]\n"
01546           "# $4 = latitude [deg]\n"
01547           "# $5 = surface area [km^2]\n"
01548           "# $6 = layer width [km]\n"
01549           "# $7 = temperature [K]\n"
01550           "# $8 = column density [kg/m^2]\n"
01551           "# $9 = mass mixing ratio [1]\n\n");
01552
01553   /* Write data... */
01554   for (ix = 0; ix < ctl->grid_nx; ix++) {
01555     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
01556       fprintf(out, "\n");
01557     for (iy = 0; iy < ctl->grid_ny; iy++) {
01558       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
01559         fprintf(out, "\n");
01560       for (iz = 0; iz < ctl->grid_nz; iz++)
```

```
01561         if (!ctl->grid_sparse
01562             || ix == 0 || iy == 0 || iz == 0 || grid_m[ix][iy][iz] > 0) {
01563
01564           /* Set coordinates... */
01565           z = ctl->grid_z0 + dz * (iz + 0.5);
01566           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
01567           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
01568
01569           /* Get pressure and temperature... */
01570           press = P(z);
01571           intpol_met_time(met0, met1, t, press, lon, lat,
01572                           NULL, &temp, NULL, NULL, NULL, NULL, NULL);
01573
01574           /* Calculate surface area... */
01575           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
01576             * cos(lat * M_PI / 180.);
01577
01578           /* Calculate column density... */
01579           cd = grid_m[ix][iy][iz] / (1e6 * area);
01580
01581           /* Calculate mass mixing ratio... */
01582           rho_air = 100. * press / (287.058 * temp);
01583           mmr = grid_m[ix][iy][iz] / (rho_air * 1e6 * area * 1e3 * dz);
01584
01585           /* Write output... */
01586           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01587                   t, z, lon, lat, area, dz, temp, cd, mmr);
01588         }
01589       }
01590     }
01591
01592     /* Close file... */
01593     fclose(out);
01594   }
```

Here is the call graph for this function:



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

Write profile data.

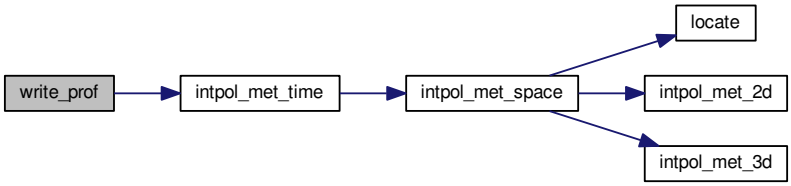
Definition at line 1598 of file libtrac.c.

```
01604             {
01605
01606     static FILE *in, *out;
01607
01608     static char line[LEN];
01609
01610     static double mass[GX][GY][GZ], obsmean[GX][GY], tmean[GX][GY],
01611       rt, rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z,
01612       press, temp, rho_air, mmr, h2o, o3;
01613
01614     static int init, obscount[GX][GY], ip, ix, iy, iz;
01615
01616     /* Init... */
01617     if (!init) {
01618       init = 1;
01619
01620       /* Check quantity index for mass... */
```

```
01621     if (ctl->qnt_m < 0)
01622       ERRMSG("Need quantity mass!");
01623
01624     /* Check dimensions... */
01625     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
01626       ERRMSG("Grid dimensions too large!");
01627
01628     /* Open observation data file... */
01629     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
01630     if (!(in = fopen(ctl->prof_obsfile, "r")))
01631       ERRMSG("Cannot open file!");
01632
01633     /* Create new file... */
01634     printf("Write profile data: %s\n", filename);
01635     if (!(out = fopen(filename, "w")))
01636       ERRMSG("Cannot create file!");
01637
01638     /* Write header... */
01639     fprintf(out,
01640             "# $1  = time [s]\n"
01641             "# $2  = altitude [km]\n"
01642             "# $3  = longitude [deg]\n"
01643             "# $4  = latitude [deg]\n"
01644             "# $5  = pressure [hPa]\n"
01645             "# $6  = temperature [K]\n"
01646             "# $7  = mass mixing ratio [1]\n"
01647             "# $8  = H2O volume mixing ratio [1]\n"
01648             "# $9  = O3 volume mixing ratio [1]\n"
01649             "# $10 = mean BT index [K]\n");
01650
01651     /* Set grid box size... */
01652     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
01653     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
01654     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
01655   }
01656
01657   /* Set time interval... */
01658   t0 = t - 0.5 * ctl->dt_mod;
01659   t1 = t + 0.5 * ctl->dt_mod;
01660
01661   /* Initialize... */
01662   for (ix = 0; ix < ctl->prof_nx; ix++)
01663     for (iy = 0; iy < ctl->prof_ny; iy++) {
01664       obsmean[ix][iy] = 0;
01665       obscount[ix][iy] = 0;
01666       tmean[ix][iy] = 0;
01667       for (iz = 0; iz < ctl->prof_nz; iz++)
01668         mass[ix][iy][iz] = 0;
01669     }
01670
01671   /* Read data... */
01672   while (fgets(line, LEN, in)) {
01673
01674     /* Read data... */
01675     if (sscanf(line, "%lg %lg %lg %lg", &rt, &rlon, &rlat, &robs) != 4)
01676       continue;
01677
01678     /* Check time... */
01679     if (rt < t0)
01680       continue;
01681     if (rt > t1)
01682       break;
01683
01684     /* Calculate indices... */
01685     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
01686     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
01687
01688     /* Check indices... */
01689     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
01690       continue;
01691
01692     /* Get mean observation index... */
01693     obsmean[ix][iy] += robs;
01694     tmean[ix][iy] += rt;
01695     obscount[ix][iy]++;
01696   }
01697
01698   /* Analyze model data... */
01699   for (ip = 0; ip < atm->np; ip++) {
01700
01701     /* Check time... */
01702     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01703       continue;
01704
01705     /* Get indices... */
01706     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
01707     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
```

```
01708     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
01709
01710     /* Check indices... */
01711     if (ix < 0 || ix >= ctl->prof_nx ||
01712         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
01713       continue;
01714
01715     /* Get total mass in grid cell... */
01716     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01717   }
01718
01719   /* Extract profiles... */
01720   for (ix = 0; ix < ctl->prof_nx; ix++)
01721     for (iy = 0; iy < ctl->prof_ny; iy++)
01722       if (obscount[ix][iy] > 0) {
01723
01724         /* Write output... */
01725         fprintf(out, "\n");
01726
01727         /* Loop over altitudes... */
01728         for (iz = 0; iz < ctl->prof_nz; iz++) {
01729
01730           /* Set coordinates... */
01731           z = ctl->prof_z0 + dz * (iz + 0.5);
01732           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
01733           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
01734
01735           /* Get meteorological data... */
01736           press = P(z);
01737           intpol_met_time(met0, met1, t, press, lon, lat,
01738                           NULL, &temp, NULL, NULL, NULL, &h2o, &o3);
01739
01740           /* Calculate mass mixing ratio... */
01741           rho_air = 100. * press / (287.058 * temp);
01742           area = dlat * dlon * gsl_pow_2(M_PI * RE / 180.)
01743             * cos(lat * M_PI / 180.);
01744           mmr = mass[ix][iy][iz] / (rho_air * area * dz * 1e9);
01745
01746           /* Write output... */
01747           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01748                   tmean[ix][iy] / obscount[ix][iy],
01749                   z, lon, lat, press, temp, mmr, h2o, o3,
01750                   obsmean[ix][iy] / obscount[ix][iy]);
01751         }
01752       }
01753
01754   /* Close file... */
01755   if (t == ctl->t_stop)
01756     fclose(out);
01757 }
```

Here is the call graph for this function:



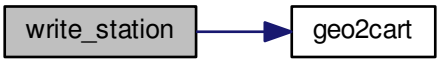
5.11.2.32 void write_station (const char * *filename*, ctl_t * *ctl*, atm_t * *atm*, double *t*)

Write station data.

Definition at line 1761 of file libtrac.c.

```
01765             {
01766
01767   static FILE *out;
01768
01769   static double rmax2, t0, t1, x0[3], x1[3];
01770
01771   static int init, ip, iq;
01772
01773   /* Init... */
01774   if (!init) {
01775     init = 1;
01776
01777     /* Write info... */
01778     printf("Write station data: %s\n", filename);
01779
01780     /* Create new file... */
01781     if (!(out = fopen(filename, "w")))
01782       ERRMSG("Cannot create file!");
01783
01784     /* Write header... */
01785     fprintf(out,
01786             "# $1 = time [s]\n"
01787             "# $2 = altitude [km]\n"
01788             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01789     for (iq = 0; iq < ctl->nq; iq++)
01790       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
01791               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
01792     fprintf(out, "\n");
01793
01794     /* Set geolocation and search radius... */
01795     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
01796     rmax2 = gsl_pow_2(ctl->stat_r);
01797   }
01798
01799   /* Set time interval for output... */
01800   t0 = t - 0.5 * ctl->dt_mod;
01801   t1 = t + 0.5 * ctl->dt_mod;
01802
01803   /* Loop over air parcels... */
01804   for (ip = 0; ip < atm->np; ip++) {
01805
01806     /* Check time... */
01807     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01808       continue;
01809
01810     /* Check station flag... */
01811     if (ctl->qnt_stat >= 0)
01812       if (atm->q[ctl->qnt_stat][ip])
01813         continue;
01814
01815     /* Get Cartesian coordinates... */
01816     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
01817
01818     /* Check horizontal distance... */
01819     if (DIST2(x0, x1) > rmax2)
01820       continue;
01821
01822     /* Set station flag... */
01823     if (ctl->qnt_stat >= 0)
01824       atm->q[ctl->qnt_stat][ip] = 1;
01825
01826     /* Write data... */
01827     fprintf(out, "%.2f %g %g %g",
01828             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
01829     for (iq = 0; iq < ctl->nq; iq++) {
01830       fprintf(out, " ");
01831       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01832     }
01833     fprintf(out, "\n");
01834   }
01835
01836   /* Close file... */
01837   if (t == ctl->t_stop)
01838     fclose(out);
01839 }
```

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(ctl, filename, met0);
00134
00135     get_met_help(t + 1.0 * ctl->direction, 1, metbase, ctl->
      dt_met, filename);
00136     read_met(ctl, filename, met1);
00137   }
00138
00139   /* Read new data for forward trajectories... */
00140   if (t > met1->time && ctl->direction == 1) {
00141     memcpy(met0, met1, sizeof(met_t));
00142     get_met_help(t, 1, metbase, ctl->dt_met, filename);
00143     read_met(ctl, filename, met1);
00144   }
00145
00146   /* Read new data for backward trajectories... */
00147   if (t < met0->time && ctl->direction == -1) {
00148     memcpy(met1, met0, sizeof(met_t));
00149     get_met_help(t, -1, metbase, ctl->dt_met, filename);
00150     read_met(ctl, filename, met0);
00151   }
00152 }
00153
00154 /*****************************************************************************/
```

```
00155
00156 void get_met_help(
00157   double t,
00158   int direct,
00159   char *metbase,
00160   double dt_met,
00161   char *filename) {
00162
00163   double t6, r;
00164
00165   int year, mon, day, hour, min, sec;
00166
00167   /* Round time to fixed intervals... */
00168   if (direct == -1)
00169     t6 = floor(t / dt_met) * dt_met;
00170   else
00171     t6 = ceil(t / dt_met) * dt_met;
00172
00173   /* Decode time... */
00174   jsec2time(t6, &year, &mon, &day, &hour, &min, &sec, &r);
00175
00176   /* Set filename... */
00177   sprintf(filename, "%s_%d_%02d_%02d_%02d.nc", metbase, year, mon, day, hour);
00178 }
00179
00180 /*****************************************************************************/
00181
00182 void intpol_met_2d(
00183   double array[EX][EY],
00184   int ix,
00185   int iy,
00186   double wx,
00187   double wy,
00188   double *var) {
00189
00190   double aux00, aux01, aux10, aux11;
00191
00192   /* Set variables... */
00193   aux00 = array[ix][iy];
00194   aux01 = array[ix][iy + 1];
00195   aux10 = array[ix + 1][iy];
00196   aux11 = array[ix + 1][iy + 1];
00197
00198   /* Interpolate horizontally... */
00199   aux00 = wy * (aux00 - aux01) + aux01;
00200   aux11 = wy * (aux10 - aux11) + aux11;
00201   *var = wx * (aux00 - aux11) + aux11;
00202 }
00203
00204 /*****************************************************************************/
00205
00206 void intpol_met_3d(
00207   float array[EX][EY][EP],
00208   int ip,
00209   int ix,
00210   int iy,
00211   double wp,
00212   double wx,
00213   double wy,
00214   double *var) {
00215
00216   double aux00, aux01, aux10, aux11;
00217
00218   /* Interpolate vertically... */
00219   aux00 = wp * (array[ix][iy][ip] - array[ix][iy][ip + 1])
00220     + array[ix][iy][ip + 1];
00221   aux01 = wp * (array[ix][iy + 1][ip] - array[ix][iy + 1][ip + 1])
00222     + array[ix][iy + 1][ip + 1];
00223   aux10 = wp * (array[ix + 1][iy][ip] - array[ix + 1][iy][ip + 1])
00224     + array[ix + 1][iy][ip + 1];
00225   aux11 = wp * (array[ix + 1][iy + 1][ip] - array[ix + 1][iy + 1][ip + 1])
00226     + array[ix + 1][iy + 1][ip + 1];
00227
00228   /* Interpolate horizontally... */
00229   aux00 = wy * (aux00 - aux01) + aux01;
00230   aux11 = wy * (aux10 - aux11) + aux11;
00231   *var = wx * (aux00 - aux11) + aux11;
00232 }
00233
00234 /*****************************************************************************/
00235
00236 void intpol_met_space(
00237   met_t * met,
00238   double p,
00239   double lon,
00240   double lat,
00241   double *ps,
```

```
00242   double *t,
00243   double *u,
00244   double *v,
00245   double *w,
00246   double *h2o,
00247   double *o3) {
00248
00249   double wp, wx, wy;
00250
00251   int ip, ix, iy;
00252
00253   /* Check longitude... */
00254   if (met->lon[met->nx - 1] > 180 && lon < 0)
00255     lon += 360;
00256
00257   /* Get indices... */
00258   ip = locate(met->p, met->np, p);
00259   ix = locate(met->lon, met->nx, lon);
00260   iy = locate(met->lat, met->ny, lat);
00261
00262   /* Get weights... */
00263   wp = (met->p[ip + 1] - p) / (met->p[ip + 1] - met->p[ip]);
00264   wx = (met->lon[ix + 1] - lon) / (met->lon[ix + 1] - met->lon[ix]);
00265   wy = (met->lat[iy + 1] - lat) / (met->lat[iy + 1] - met->lat[iy]);
00266
00267   /* Interpolate... */
00268   if (ps != NULL)
00269     intpol_met_2d(met->ps, ix, iy, wx, wy, ps);
00270   if (t != NULL)
00271     intpol_met_3d(met->t, ip, ix, iy, wp, wx, wy, t);
00272   if (u != NULL)
00273     intpol_met_3d(met->u, ip, ix, iy, wp, wx, wy, u);
00274   if (v != NULL)
00275     intpol_met_3d(met->v, ip, ix, iy, wp, wx, wy, v);
00276   if (w != NULL)
00277     intpol_met_3d(met->w, ip, ix, iy, wp, wx, wy, w);
00278   if (h2o != NULL)
00279     intpol_met_3d(met->h2o, ip, ix, iy, wp, wx, wy, h2o);
00280   if (o3 != NULL)
00281     intpol_met_3d(met->o3, ip, ix, iy, wp, wx, wy, o3);
00282 }
00283
00284 /*****************************************************************************/
00285
00286 void intpol_met_time(
00287   met_t * met0,
00288   met_t * met1,
00289   double ts,
00290   double p,
00291   double lon,
00292   double lat,
00293   double *ps,
00294   double *t,
00295   double *u,
00296   double *v,
00297   double *w,
00298   double *h2o,
00299   double *o3) {
00300
00301   double h2o0, h2o1, o30, o31, ps0, ps1, t0, t1, u0, u1, v0, v1, w0, w1, wt;
00302
00303   /* Spatial interpolation... */
00304   intpol_met_space(met0, p, lon, lat,
00305                    ps == NULL ? NULL : &ps0,
00306                    t == NULL ? NULL : &t0,
00307                    u == NULL ? NULL : &u0,
00308                    v == NULL ? NULL : &v0,
00309                    w == NULL ? NULL : &w0,
00310                    h2o == NULL ? NULL : &h2o0, o3 == NULL ? NULL : &o30);
00311   intpol_met_space(met1, p, lon, lat,
00312                    ps == NULL ? NULL : &ps1,
00313                    t == NULL ? NULL : &t1,
00314                    u == NULL ? NULL : &u1,
00315                    v == NULL ? NULL : &v1,
00316                    w == NULL ? NULL : &w1,
00317                    h2o == NULL ? NULL : &h2o1, o3 == NULL ? NULL : &o31);
00318
00319   /* Get weighting factor... */
00320   wt = (met1->time - ts) / (met1->time - met0->time);
00321
00322   /* Interpolate... */
00323   if (ps != NULL)
00324     *ps = wt * (ps0 - ps1) + ps1;
00325   if (t != NULL)
00326     *t = wt * (t0 - t1) + t1;
00327   if (u != NULL)
00328     *u = wt * (u0 - u1) + u1;
```

```
00329   if (v != NULL)
00330     *v = wt * (v0 - v1) + v1;
00331   if (w != NULL)
00332     *w = wt * (w0 - w1) + w1;
00333   if (h2o != NULL)
00334     *h2o = wt * (h2o0 - h2o1) + h2o1;
00335   if (o3 != NULL)
00336     *o3 = wt * (o30 - o31) + o31;
00337 }
00338
00339 /*****************************************************************************/
00340
00341 void jsec2time(
00342   double jsec,
00343   int *year,
00344   int *mon,
00345   int *day,
00346   int *hour,
00347   int *min,
00348   int *sec,
00349   double *remain) {
00350
00351   struct tm t0, *t1;
00352
00353   time_t jsec0;
00354
00355   t0.tm_year = 100;
00356   t0.tm_mon = 0;
00357   t0.tm_mday = 1;
00358   t0.tm_hour = 0;
00359   t0.tm_min = 0;
00360   t0.tm_sec = 0;
00361
00362   jsec0 = (time_t) jsec + timegm(&t0);
00363   t1 = gmtime(&jsec0);
00364
00365   *year = t1->tm_year + 1900;
00366   *mon = t1->tm_mon + 1;
00367   *day = t1->tm_mday;
00368   *hour = t1->tm_hour;
00369   *min = t1->tm_min;
00370   *sec = t1->tm_sec;
00371   *remain = jsec - floor(jsec);
00372 }
00373
00374 /*****************************************************************************/
00375
00376 int locate(
00377   double *xx,
00378   int n,
00379   double x) {
00380
00381   int i, ilo, ihi;
00382
00383   ilo = 0;
00384   ihi = n - 1;
00385   i = (ihi + ilo) >> 1;
00386
00387   if (xx[i] < xx[i + 1])
00388     while (ihi > ilo + 1) {
00389       i = (ihi + ilo) >> 1;
00390       if (xx[i] > x)
00391         ihi = i;
00392       else
00393         ilo = i;
00394   } else
00395     while (ihi > ilo + 1) {
00396       i = (ihi + ilo) >> 1;
00397       if (xx[i] <= x)
00398         ihi = i;
00399       else
00400         ilo = i;
00401     }
00402
00403   return ilo;
00404 }
00405
00406 /*****************************************************************************/
00407
00408 void read_atm(
00409   const char *filename,
00410   ctl_t * ctl,
00411   atm_t * atm) {
00412
00413   FILE *in;
00414
00415   char line[LEN], *tok;
```

```
00416
00417   int iq;
00418
00419   /* Init... */
00420   atm->np = 0;
00421
00422   /* Write info... */
00423   printf("Read atmospheric data: %s\n", filename);
00424
00425   /* Open file... */
00426   if (!(in = fopen(filename, "r")))
00427     ERRMSG("Cannot open file!");
00428
00429   /* Read line... */
00430   while (fgets(line, LEN, in)) {
00431
00432     /* Read data... */
00433     TOK(line, tok, "%lg", atm->time[atm->np]);
00434     TOK(NULL, tok, "%lg", atm->p[atm->np]);
00435     TOK(NULL, tok, "%lg", atm->lon[atm->np]);
00436     TOK(NULL, tok, "%lg", atm->lat[atm->np]);
00437     for (iq = 0; iq < ctl->nq; iq++)
00438       TOK(NULL, tok, "%lg", atm->q[iq][atm->np]);
00439
00440     /* Convert altitude to pressure... */
00441     atm->p[atm->np] = P(atm->p[atm->np]);
00442
00443     /* Increment data point counter... */
00444     if ((++atm->np) > NP)
00445       ERRMSG("Too many data points!");
00446   }
00447
00448   /* Close file... */
00449   fclose(in);
00450
00451   /* Check number of points... */
00452   if (atm->np < 1)
00453     ERRMSG("Can not read any data!");
00454 }
00455
00456 /*****************************************************************************/
00457
00458 void read_ctl(
00459   const char *filename,
00460   int argc,
00461   char *argv[],
00462   ctl_t * ctl) {
00463
00464   int ip, iq;
00465
00466   /* Write info... */
00467   printf("\nMassive-Parallel Trajectory Calculations (MPTRAC)\n"
00468          "(executable: %s | compiled: %s, %s)\n\n",
00469          argv[0], __DATE__, __TIME__);
00470
00471   /* Initialize quantity indices... */
00472   ctl->qnt_m = -1;
00473   ctl->qnt_r = -1;
00474   ctl->qnt_rho = -1;
00475   ctl->qnt_ps = -1;
00476   ctl->qnt_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   ctl->met_np = (int) scan_ctl(filename, argc, argv, "MET_NP", -1, "0", NULL);
00548   if (ctl->met_np > EP)
00549     ERRMSG("Too many levels!");
00550   for (ip = 0; ip < ctl->met_np; ip++)
00551     ctl->met_p[ip] = scan_ctl(filename, argc, argv, "MET_P", ip, "", NULL);
00552
00553   /* Isosurface parameters... */
00554   ctl->isosurf
00555     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
00556   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
00557
00558   /* Diffusion parameters... */
00559   ctl->turb_dx_trop
00560     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50.0", NULL);
00561   ctl->turb_dx_strat
00562     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0.0", NULL);
00563   ctl->turb_dz_trop
00564     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0.0", NULL);
00565   ctl->turb_dz_strat
00566     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
00567   ctl->turb_meso =
00568     scan_ctl(filename, argc, argv, "TURB_MESO", -1, "0.16", NULL);
00569
00570   /* Life time of particles... */
00571   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
00572   ctl->tdec_strat =
00573     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
00574
00575   /* Output of atmospheric data... */
00576   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
      atm_basename);
00577   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
00578   ctl->atm_dt_out =
00579     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
00580
00581   /* Output of CSI data... */
00582   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
      csi_basename);
00583   ctl->csi_dt_out =
00584     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
00585   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "obs.tab",
00586            ctl->csi_obsfile);
00587   ctl->csi_obsmin =
```

```
00588     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
00589   ctl->csi_modmin =
00590     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
00591   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
00592   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
00593   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
00594   ctl->csi_lon0 =
00595     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
00596   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
00597   ctl->csi_nx =
00598     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
00599   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
00600   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
00601   ctl->csi_ny =
00602     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
00603
00604   /* Output of grid data... */
00605   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
00606            ctl->grid_basename);
00607   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
      grid_gpfile);
00608   ctl->grid_dt_out =
00609     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
00610   ctl->grid_sparse =
00611     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
00612   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
00613   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
00614   ctl->grid_nz =
00615     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
00616   ctl->grid_lon0 =
00617     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
00618   ctl->grid_lon1 =
00619     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
00620   ctl->grid_nx =
00621     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
00622   ctl->grid_lat0 =
00623     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
00624   ctl->grid_lat1 =
00625     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
00626   ctl->grid_ny =
00627     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
00628
00629   /* Output of profile data... */
00630   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
00631            ctl->prof_basename);
00632   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
      prof_obsfile);
00633   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
00634   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
00635   ctl->prof_nz =
00636     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
00637   ctl->prof_lon0 =
00638     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
00639   ctl->prof_lon1 =
00640     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
00641   ctl->prof_nx =
00642     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
00643   ctl->prof_lat0 =
00644     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
00645   ctl->prof_lat1 =
00646     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
00647   ctl->prof_ny =
00648     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
00649
00650   /* Output of station data... */
00651   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
00652            ctl->stat_basename);
00653   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
00654   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
00655   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
00656 }
00657
00658 /*****************************************************************************/
00659
00660 void read_met(
00661   ctl_t * ctl,
00662   char *filename,
00663   met_t * met) {
00664
00665   char tstr[10];
00666
00667   static float help[EX * EY];
00668
00669   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
00670
00671   size_t np, nx, ny;
00672
```

```
00673   /* Write info... */
00674   printf("Read meteorological data: %s\n", filename);
00675
00676   /* Get time from filename... */
00677   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
00678   year = atoi(tstr);
00679   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
00680   mon = atoi(tstr);
00681   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
00682   day = atoi(tstr);
00683   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
00684   hour = atoi(tstr);
00685   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
00686
00687   /* Open netCDF file... */
00688   NC(nc_open(filename, NC_NOWRITE, &ncid));
00689
00690   /* Get dimensions... */
00691   NC(nc_inq_dimid(ncid, "lon", &dimid));
00692   NC(nc_inq_dimlen(ncid, dimid, &nx));
00693   if (nx > EX)
00694     ERRMSG("Too many longitudes!");
00695
00696   NC(nc_inq_dimid(ncid, "lat", &dimid));
00697   NC(nc_inq_dimlen(ncid, dimid, &ny));
00698   if (ny > EY)
00699     ERRMSG("Too many latitudes!");
00700
00701   NC(nc_inq_dimid(ncid, "lev", &dimid));
00702   NC(nc_inq_dimlen(ncid, dimid, &np));
00703   if (np > EP)
00704     ERRMSG("Too many levels!");
00705
00706   /* Store dimensions... */
00707   met->np = (int) np;
00708   met->nx = (int) nx;
00709   met->ny = (int) ny;
00710
00711   /* Get horizontal grid... */
00712   NC(nc_inq_varid(ncid, "lon", &varid));
00713   NC(nc_get_var_double(ncid, varid, met->lon));
00714   NC(nc_inq_varid(ncid, "lat", &varid));
00715   NC(nc_get_var_double(ncid, varid, met->lat));
00716
00717   /* Read meteorological data... */
00718   read_met_help(ncid, "t", "T", met, met->t, 1.0);
00719   read_met_help(ncid, "u", "U", met, met->u, 1.0);
00720   read_met_help(ncid, "v", "V", met, met->v, 1.0);
00721   read_met_help(ncid, "w", "W", met, met->w, 0.01f);
00722   read_met_help(ncid, "q", "Q", met, met->h2o, 1.608f);
00723   read_met_help(ncid, "o3", "O3", met, met->o3, 0.602f);
00724
00725   /* Meteo data on pressure levels... */
00726   if (ctl->met_np <= 0) {
00727
00728     /* Read pressure levels from file... */
00729     NC(nc_inq_varid(ncid, "lev", &varid));
00730     NC(nc_get_var_double(ncid, varid, met->p));
00731     for (ip = 0; ip < met->np; ip++)
00732       met->p[ip] /= 100.;
00733
00734     /* Extrapolate data for lower boundary... */
00735     read_met_extrapolate(met);
00736   }
00737
00738   /* Meteo data on model levels... */
00739   else {
00740
00741     /* Read pressure data from file... */
00742     read_met_help(ncid, "pl", "PL", met, met->pl, 0.01f);
00743
00744     /* Interpolate from model levels to pressure levels... */
00745     read_met_ml2pl(ctl, met, met->t);
00746     read_met_ml2pl(ctl, met, met->u);
00747     read_met_ml2pl(ctl, met, met->v);
00748     read_met_ml2pl(ctl, met, met->w);
00749     read_met_ml2pl(ctl, met, met->h2o);
00750     read_met_ml2pl(ctl, met, met->o3);
00751
00752     /* Set pressure levels... */
00753     met->np = ctl->met_np;
00754     for (ip = 0; ip < met->np; ip++)
00755       met->p[ip] = ctl->met_p[ip];
00756   }
00757
00758   /* Check ordering of pressure levels... */
00759   for (ip = 1; ip < met->np; ip++)
```

```
00760     if (met->p[ip - 1] < met->p[ip])
00761       ERRMSG("Pressure levels must be descending!");
00762
00763   /* Read surface pressure... */
00764   if (nc_inq_varid(ncid, "PS", &varid) == NC_NOERR) {
00765     NC(nc_get_var_float(ncid, varid, help));
00766     for (iy = 0; iy < met->ny; iy++)
00767       for (ix = 0; ix < met->nx; ix++)
00768         met->ps[ix][iy] = help[iy * met->nx + ix] / 100.;
00769   } else if (nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
00770     NC(nc_get_var_float(ncid, varid, help));
00771     for (iy = 0; iy < met->ny; iy++)
00772       for (ix = 0; ix < met->nx; ix++)
00773         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
00774   } else
00775     for (ix = 0; ix < met->nx; ix++)
00776       for (iy = 0; iy < met->ny; iy++)
00777         met->ps[ix][iy] = met->p[0];
00778
00779   /* Create periodic boundary conditions... */
00780   read_met_periodic(met);
00781
00782   /* Close file... */
00783   NC(nc_close(ncid));
00784 }
00785
00786 /*****************************************************************************/
00787
00788 void read_met_extrapolate(
00789   met_t * met) {
00790
00791   int ip, ip0, ix, iy;
00792
00793   /* Loop over columns... */
00794   for (ix = 0; ix < met->nx; ix++)
00795     for (iy = 0; iy < met->ny; iy++) {
00796
00797       /* Find lowest valid data point... */
00798       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
00799         if (!gsl_finite(met->t[ix][iy][ip0])
00800             || !gsl_finite(met->u[ix][iy][ip0])
00801             || !gsl_finite(met->v[ix][iy][ip0])
00802             || !gsl_finite(met->w[ix][iy][ip0]))
00803           break;
00804
00805       /* Extrapolate... */
00806       for (ip = ip0; ip >= 0; ip--) {
00807         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
00808         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
00809         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
00810         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
00811         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
00812         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
00813       }
00814     }
00815 }
00816
00817 /*****************************************************************************/
00818
00819 void read_met_help(
00820   int ncid,
00821   char *varname,
00822   char *varname2,
00823   met_t * met,
00824   float dest[EX][EY][EP],
00825   float scl) {
00826
00827   static float help[EX * EY * EP];
00828
00829   int ip, ix, iy, n = 0, varid;
00830
00831   /* Check if variable exists... */
00832   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
00833     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
00834       return;
00835
00836   /* Read data... */
00837   NC(nc_get_var_float(ncid, varid, help));
00838
00839   /* Copy and check data... */
00840   for (ip = 0; ip < met->np; ip++)
00841     for (iy = 0; iy < met->ny; iy++)
00842       for (ix = 0; ix < met->nx; ix++) {
00843         dest[ix][iy][ip] = scl * help[n++];
00844         if (fabs(dest[ix][iy][ip] / scl) > 1e14)
00845           dest[ix][iy][ip] = GSL_NAN;
00846       }
```

```
00847 }
00848
00849 /*****************************************************************************/
00850
00851 void read_met_ml2pl(
00852   ctl_t * ctl,
00853   met_t * met,
00854   float var[EX][EY][EP]) {
00855
00856   double aux[EP], p[EP], pt;
00857
00858   int ip, ip2, ix, iy;
00859
00860   /* Loop over columns... */
00861   for (ix = 0; ix < met->nx; ix++)
00862     for (iy = 0; iy < met->ny; iy++) {
00863
00864       /* Copy pressure profile... */
00865       for (ip = 0; ip < met->np; ip++)
00866         p[ip] = met->pl[ix][iy][ip];
00867
00868       /* Interpolate... */
00869       for (ip = 0; ip < ctl->met_np; ip++) {
00870         pt = ctl->met_p[ip];
00871         if ((pt > p[0] && p[0] > p[1]) || (pt < p[0] && p[0] < p[1]))
00872           pt = p[0];
00873         else if ((pt > p[met->np - 1] && p[1] > p[0])
00874                  || (pt < p[met->np - 1] && p[1] < p[0]))
00875           pt = p[met->np - 1];
00876         ip2 = locate(p, met->np, pt);
00877         aux[ip] = LIN(p[ip2], var[ix][iy][ip2],
00878                       p[ip2 + 1], var[ix][iy][ip2 + 1], pt);
00879       }
00880
00881       /* Copy data... */
00882       for (ip = 0; ip < ctl->met_np; ip++)
00883         var[ix][iy][ip] = (float) aux[ip];
00884     }
00885 }
00886
00887 /*****************************************************************************/
00888
00889 void read_met_periodic(
00890   met_t * met) {
00891
00892   int ip, iy;
00893
00894   /* Check longitudes... */
00895   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
00896              + met->lon[1] - met->lon[0] - 360) < 0.01))
00897     return;
00898
00899   /* Increase longitude counter... */
00900   if ((++met->nx) > EX)
00901     ERRMSG("Cannot create periodic boundary conditions!");
00902
00903   /* Set longitude... */
00904   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
00905
00906   /* Loop over latitudes and pressure levels... */
00907   for (iy = 0; iy < met->ny; iy++)
00908     for (ip = 0; ip < met->np; ip++) {
00909       met->ps[met->nx - 1][iy] = met->ps[0][iy];
00910       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
00911       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
00912       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
00913       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
00914       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
00915       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
00916     }
00917 }
00918
00919 /*****************************************************************************/
00920
00921 double scan_ctl(
00922   const char *filename,
00923   int argc,
00924   char *argv[],
00925   const char *varname,
00926   int arridx,
00927   const char *defvalue,
00928   char *value) {
00929
00930   FILE *in = NULL;
00931
00932   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
```

```
00933     msg[LEN], rvarname[LEN], rval[LEN];
00934
00935   int contain = 0, i;
00936
00937   /* Open file... */
00938   if (filename[strlen(filename) - 1] != '-')
00939     if (!(in = fopen(filename, "r")))
00940       ERRMSG("Cannot open file!");
00941
00942   /* Set full variable name... */
00943   if (arridx >= 0) {
00944     sprintf(fullname1, "%s[%d]", varname, arridx);
00945     sprintf(fullname2, "%s[*]", varname);
00946   } else {
00947     sprintf(fullname1, "%s", varname);
00948     sprintf(fullname2, "%s", varname);
00949   }
00950
00951   /* Read data... */
00952   if (in != NULL)
00953     while (fgets(line, LEN, in))
00954       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
00955         if (strcasecmp(rvarname, fullname1) == 0 ||
00956             strcasecmp(rvarname, fullname2) == 0) {
00957           contain = 1;
00958           break;
00959         }
00960   for (i = 1; i < argc - 1; i++)
00961     if (strcasecmp(argv[i], fullname1) == 0 ||
00962         strcasecmp(argv[i], fullname2) == 0) {
00963       sprintf(rval, "%s", argv[i + 1]);
00964       contain = 1;
00965       break;
00966     }
00967
00968   /* Close file... */
00969   if (in != NULL)
00970     fclose(in);
00971
00972   /* Check for missing variables... */
00973   if (!contain) {
00974     if (strlen(defvalue) > 0)
00975       sprintf(rval, "%s", defvalue);
00976     else {
00977       sprintf(msg, "Missing variable %s!\n", fullname1);
00978       ERRMSG(msg);
00979     }
00980   }
00981
00982   /* Write info... */
00983   printf("%s = %s\n", fullname1, rval);
00984
00985   /* Return values... */
00986   if (value != NULL)
00987     sprintf(value, "%s", rval);
00988   return atof(rval);
00989 }
00990
00991 /*****************************************************************************/
00992
00993 void time2jsec(
00994   int year,
00995   int mon,
00996   int day,
00997   int hour,
00998   int min,
00999   int sec,
01000   double remain,
01001   double *jsec) {
01002
01003   struct tm t0, t1;
01004
01005   t0.tm_year = 100;
01006   t0.tm_mon = 0;
01007   t0.tm_mday = 1;
01008   t0.tm_hour = 0;
01009   t0.tm_min = 0;
01010   t0.tm_sec = 0;
01011
01012   t1.tm_year = year - 1900;
01013   t1.tm_mon = mon - 1;
01014   t1.tm_mday = day;
01015   t1.tm_hour = hour;
01016   t1.tm_min = min;
01017   t1.tm_sec = sec;
01018
01019   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
```

```
01020 }
01021
01022 /*****************************************************************************/
01023
01024 void timer(
01025   const char *name,
01026   int id,
01027   int mode) {
01028
01029   static double starttime[NTIMER], runtime[NTIMER];
01030
01031   /* Check id... */
01032   if (id < 0 || id >= NTIMER)
01033     ERRMSG("Too many timers!");
01034
01035   /* Start timer... */
01036   if (mode == 1) {
01037     if (starttime[id] <= 0)
01038       starttime[id] = omp_get_wtime();
01039     else
01040       ERRMSG("Timer already started!");
01041   }
01042
01043   /* Stop timer... */
01044   else if (mode == 2) {
01045     if (starttime[id] > 0) {
01046       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
01047       starttime[id] = -1;
01048     } else
01049       ERRMSG("Timer not started!");
01050   }
01051
01052   /* Print timer... */
01053   else if (mode == 3)
01054     printf("%s = %g s\n", name, runtime[id]);
01055 }
01056
01057 /*****************************************************************************/
01058
01059 double tropopause(
01060   double t,
01061   double lat) {
01062
01063   static double doys[12]
01064   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
01065
01066   static double lats[73]
01067     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
01068     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
01069     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
01070     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
01071     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
01072     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
01073     75, 77.5, 80, 82.5, 85, 87.5, 90
01074   };
01075
01076   static double tps[12][73]
01077     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
01078          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
01079          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
01080          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
01081          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
01082          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
01083          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
01084          275.3, 275.6, 275.4, 274.1, 273.5},
01085   {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
01086    300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
01087    150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
01088    98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
01089    98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
01090    220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
01091    284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
01092    287.5, 286.2, 285.8},
01093   {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
01094    297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
01095    161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
01096    100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
01097    99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
01098    186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
01099    279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
01100    304.3, 304.9, 306, 306.6, 306.2, 306},
01101   {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
01102    290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
01103    195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
01104    102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
01105    99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
01106    148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
```

```
01107     263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
01108     315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
01109    {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
01110     260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
01111     205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
01112     101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
01113     102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
01114     165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
01115     273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
01116     325.3, 325.8, 325.8},
01117    {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
01118     222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
01119     228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
01120     105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
01121     106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
01122     127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
01123     251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
01124     308.5, 312.2, 313.1, 313.3},
01125    {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
01126     187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
01127     235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
01128     110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
01129     111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
01130     117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
01131     224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
01132     275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
01133    {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
01134     185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
01135     233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
01136     110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
01137     112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
01138     120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
01139     230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
01140     278.2, 282.6, 287.4, 290.9, 292.5, 293},
01141    {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
01142     183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
01143     243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
01144     114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
01145     110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
01146     114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
01147     203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
01148     276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
01149    {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
01150     215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
01151     237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
01152     111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
01153     106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
01154     112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
01155     206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
01156     279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
01157     305.1},
01158    {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
01159     253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
01160     223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
01161     108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
01162     102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
01163     109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
01164     241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
01165     286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
01166    {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
01167     284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
01168     175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
01169     100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
01170     100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
01171     186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
01172     280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
01173     281.7, 281.1, 281.2}
01174    };
01175
01176    double doy, p0, p1, pt;
01177
01178    int imon, ilat;
01179
01180    /* Get day of year... */
01181    doy = fmod(t / 86400., 365.25);
01182    while (doy < 0)
01183      doy += 365.25;
01184
01185    /* Get indices... */
01186    imon = locate(doys, 12, doy);
01187    ilat = locate(lats, 73, lat);
01188
01189    /* Get tropopause pressure... */
01190    p0 = LIN(lats[ilat], tps[imon][ilat],
01191             lats[ilat + 1], tps[imon][ilat + 1], lat);
01192    p1 = LIN(lats[ilat], tps[imon + 1][ilat],
01193             lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
```

```
01194   pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
01195
01196   /* Return tropopause pressure... */
01197   return pt;
01198 }
01199
01200 /*****************************************************************************/
01201
01202 void write_atm(
01203   const char *filename,
01204   ctl_t * ctl,
01205   atm_t * atm,
01206   double t) {
01207
01208   FILE *in, *out;
01209
01210   char line[LEN];
01211
01212   double r;
01213
01214   int ip, iq, year, mon, day, hour, min, sec;
01215
01216   /* Check if gnuplot output is requested... */
01217   if (ctl->atm_gpfile[0] != '-') {
01218
01219     /* Write info... */
01220     printf("Plot atmospheric data: %s.png\n", filename);
01221
01222     /* Create gnuplot pipe... */
01223     if (!(out = popen("gnuplot", "w")))
01224       ERRMSG("Cannot create pipe to gnuplot!");
01225
01226     /* Set plot filename... */
01227     fprintf(out, "set out \"%s.png\"\n", filename);
01228
01229     /* Set time string... */
01230     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01231     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01232             year, mon, day, hour, min);
01233
01234     /* Dump gnuplot file to pipe... */
01235     if (!(in = fopen(ctl->atm_gpfile, "r")))
01236       ERRMSG("Cannot open file!");
01237     while (fgets(line, LEN, in))
01238       fprintf(out, "%s", line);
01239     fclose(in);
01240   }
01241
01242   else {
01243
01244     /* Write info... */
01245     printf("Write atmospheric data: %s\n", filename);
01246
01247     /* Create file... */
01248     if (!(out = fopen(filename, "w")))
01249       ERRMSG("Cannot create file!");
01250   }
01251
01252   /* Write header... */
01253   fprintf(out,
01254           "# $1 = time [s]\n"
01255           "# $2 = altitude [km]\n"
01256           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01257   for (iq = 0; iq < ctl->nq; iq++)
01258     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
01259             ctl->qnt_unit[iq]);
01260   fprintf(out, "\n");
01261
01262   /* Write data... */
01263   for (ip = 0; ip < atm->np; ip++) {
01264     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
01265             atm->lon[ip], atm->lat[ip]);
01266     for (iq = 0; iq < ctl->nq; iq++) {
01267       fprintf(out, " ");
01268       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01269     }
01270     fprintf(out, "\n");
01271   }
01272
01273   /* Close file... */
01274   fclose(out);
01275 }
01276
01277 /*****************************************************************************/
01278
01279 void write_csi(
01280   const char *filename,
```

```
01281   ctl_t * ctl,
01282   atm_t * atm,
01283   double t) {
01284
01285   static FILE *in, *out;
01286
01287   static char line[LEN];
01288
01289   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
01290     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
01291
01292   static int init, obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
01293
01294   /* Init... */
01295   if (!init) {
01296     init = 1;
01297
01298     /* Check quantity index for mass... */
01299     if (ctl->qnt_m < 0)
01300       ERRMSG("Need quantity mass to analyze CSI!");
01301
01302     /* Open observation data file... */
01303     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
01304     if (!(in = fopen(ctl->csi_obsfile, "r")))
01305       ERRMSG("Cannot open file!");
01306
01307     /* Create new file... */
01308     printf("Write CSI data: %s\n", filename);
01309     if (!(out = fopen(filename, "w")))
01310       ERRMSG("Cannot create file!");
01311
01312     /* Write header... */
01313     fprintf(out,
01314             "# $1 = time [s]\n"
01315             "# $2 = number of hits (cx)\n"
01316             "# $3 = number of misses (cy)\n"
01317             "# $4 = number of false alarms (cz)\n"
01318             "# $5 = number of observations (cx + cy)\n"
01319             "# $6 = number of forecasts (cx + cz)\n"
01320             "# $7 = bias (forecasts/observations) [%%]\n"
01321             "# $8 = probability of detection (POD) [%%]\n"
01322             "# $9 = false alarm rate (FAR) [%%]\n"
01323             "# $10 = critical success index (CSI) [%%]\n\n");
01324   }
01325
01326   /* Set time interval... */
01327   t0 = t - 0.5 * ctl->dt_mod;
01328   t1 = t + 0.5 * ctl->dt_mod;
01329
01330   /* Initialize grid cells... */
01331   for (ix = 0; ix < ctl->csi_nx; ix++)
01332     for (iy = 0; iy < ctl->csi_ny; iy++)
01333       for (iz = 0; iz < ctl->csi_nz; iz++)
01334         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
01335
01336   /* Read data... */
01337   while (fgets(line, LEN, in)) {
01338
01339     /* Read data... */
01340     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
01341         5)
01342       continue;
01343
01344     /* Check time... */
01345     if (rt < t0)
01346       continue;
01347     if (rt > t1)
01348       break;
01349
01350     /* Calculate indices... */
01351     ix = (int) ((rlon - ctl->csi_lon0)
01352                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01353     iy = (int) ((rlat - ctl->csi_lat0)
01354                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01355     iz = (int) ((rz - ctl->csi_z0)
01356                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01357
01358     /* Check indices... */
01359     if (ix < 0 || ix >= ctl->csi_nx ||
01360         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01361       continue;
01362
01363     /* Get mean observation index... */
01364     obsmean[ix][iy][iz] += robs;
01365     obscount[ix][iy][iz]++;
01366   }
01367
```

```
01368   /* Analyze model data... */
01369   for (ip = 0; ip < atm->np; ip++) {
01370
01371     /* Check time... */
01372     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01373       continue;
01374
01375     /* Get indices... */
01376     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
01377                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01378     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
01379                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01380     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
01381                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01382
01383     /* Check indices... */
01384     if (ix < 0 || ix >= ctl->csi_nx ||
01385         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01386       continue;
01387
01388     /* Get total mass in grid cell... */
01389     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01390   }
01391
01392   /* Analyze all grid cells... */
01393   for (ix = 0; ix < ctl->csi_nx; ix++)
01394     for (iy = 0; iy < ctl->csi_ny; iy++)
01395       for (iz = 0; iz < ctl->csi_nz; iz++) {
01396
01397         /* Calculate mean observation index... */
01398         if (obscount[ix][iy][iz] > 0)
01399           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
01400
01401         /* Calculate column density... */
01402         if (modmean[ix][iy][iz] > 0) {
01403           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
01404           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
01405           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
01406           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
01407             * cos(lat * M_PI / 180.);
01408           modmean[ix][iy][iz] /= (1e6 * area);
01409         }
01410
01411         /* Calculate CSI... */
01412         if (obscount[ix][iy][iz] > 0) {
01413           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01414               modmean[ix][iy][iz] >= ctl->csi_modmin)
01415             cx++;
01416           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01417                    modmean[ix][iy][iz] < ctl->csi_modmin)
01418             cy++;
01419           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
01420                    modmean[ix][iy][iz] >= ctl->csi_modmin)
01421             cz++;
01422         }
01423       }
01424
01425   /* Write output... */
01426   if (fmod(t, ctl->csi_dt_out) == 0) {
01427
01428     /* Write... */
01429     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
01430             t, cx, cy, cz, cx + cy, cx + cz,
01431             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
01432             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
01433             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
01434             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
01435
01436     /* Set counters to zero... */
01437     cx = cy = cz = 0;
01438   }
01439
01440   /* Close file... */
01441   if (t == ctl->t_stop)
01442     fclose(out);
01443 }
01444
01445 /*****************************************************************************/
01446
01447 void write_grid(
01448   const char *filename,
01449   ctl_t * ctl,
01450   met_t * met0,
01451   met_t * met1,
01452   atm_t * atm,
01453   double t) {
01454
```

```
01455   FILE *in, *out;
01456
01457   char line[LEN];
01458
01459   static double grid_m[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
01460     area, rho_air, press, temp, cd, mmr, t0, t1, r;
01461
01462   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
01463
01464   /* Check dimensions... */
01465   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
01466     ERRMSG("Grid dimensions too large!");
01467
01468   /* Check quantity index for mass... */
01469   if (ctl->qnt_m < 0)
01470     ERRMSG("Need quantity mass to write grid data!");
01471
01472   /* Set time interval for output... */
01473   t0 = t - 0.5 * ctl->dt_mod;
01474   t1 = t + 0.5 * ctl->dt_mod;
01475
01476   /* Set grid box size... */
01477   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
01478   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
01479   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
01480
01481   /* Initialize grid... */
01482   for (ix = 0; ix < ctl->grid_nx; ix++)
01483     for (iy = 0; iy < ctl->grid_ny; iy++)
01484       for (iz = 0; iz < ctl->grid_nz; iz++)
01485         grid_m[ix][iy][iz] = 0;
01486
01487   /* Average data... */
01488   for (ip = 0; ip < atm->np; ip++)
01489     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
01490
01491       /* Get index... */
01492       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
01493       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
01494       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
01495
01496       /* Check indices... */
01497       if (ix < 0 || ix >= ctl->grid_nx ||
01498           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
01499         continue;
01500
01501       /* Add mass... */
01502       grid_m[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01503     }
01504
01505   /* Check if gnuplot output is requested... */
01506   if (ctl->grid_gpfile[0] != '-') {
01507
01508     /* Write info... */
01509     printf("Plot grid data: %s.png\n", filename);
01510
01511     /* Create gnuplot pipe... */
01512     if (!(out = popen("gnuplot", "w")))
01513       ERRMSG("Cannot create pipe to gnuplot!");
01514
01515     /* Set plot filename... */
01516     fprintf(out, "set out \"%s.png\"\n", filename);
01517
01518     /* Set time string... */
01519     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01520     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01521             year, mon, day, hour, min);
01522
01523     /* Dump gnuplot file to pipe... */
01524     if (!(in = fopen(ctl->grid_gpfile, "r")))
01525       ERRMSG("Cannot open file!");
01526     while (fgets(line, LEN, in))
01527       fprintf(out, "%s", line);
01528     fclose(in);
01529   }
01530
01531   else {
01532
01533     /* Write info... */
01534     printf("Write grid data: %s\n", filename);
01535
01536     /* Create file... */
01537     if (!(out = fopen(filename, "w")))
01538       ERRMSG("Cannot create file!");
01539   }
01540
01541   /* Write header... */
```

```
01542   fprintf(out,
01543           "# $1 = time [s]\n"
01544           "# $2 = altitude [km]\n"
01545           "# $3 = longitude [deg]\n"
01546           "# $4 = latitude [deg]\n"
01547           "# $5 = surface area [km^2]\n"
01548           "# $6 = layer width [km]\n"
01549           "# $7 = temperature [K]\n"
01550           "# $8 = column density [kg/m^2]\n"
01551           "# $9 = mass mixing ratio [1]\n\n");
01552
01553   /* Write data... */
01554   for (ix = 0; ix < ctl->grid_nx; ix++) {
01555     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
01556       fprintf(out, "\n");
01557     for (iy = 0; iy < ctl->grid_ny; iy++) {
01558       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
01559         fprintf(out, "\n");
01560       for (iz = 0; iz < ctl->grid_nz; iz++)
01561         if (!ctl->grid_sparse
01562             || ix == 0 || iy == 0 || iz == 0 || grid_m[ix][iy][iz] > 0) {
01563
01564           /* Set coordinates... */
01565           z = ctl->grid_z0 + dz * (iz + 0.5);
01566           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
01567           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
01568
01569           /* Get pressure and temperature... */
01570           press = P(z);
01571           intpol_met_time(met0, met1, t, press, lon, lat,
01572                           NULL, &temp, NULL, NULL, NULL, NULL, NULL);
01573
01574           /* Calculate surface area... */
01575           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
01576             * cos(lat * M_PI / 180.);
01577
01578           /* Calculate column density... */
01579           cd = grid_m[ix][iy][iz] / (1e6 * area);
01580
01581           /* Calculate mass mixing ratio... */
01582           rho_air = 100. * press / (287.058 * temp);
01583           mmr = grid_m[ix][iy][iz] / (rho_air * 1e6 * area * 1e3 * dz);
01584
01585           /* Write output... */
01586           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01587                   t, z, lon, lat, area, dz, temp, cd, mmr);
01588         }
01589     }
01590   }
01591
01592   /* Close file... */
01593   fclose(out);
01594 }
01595
01596 /*****************************************************************************/
01597
01598 void write_prof(
01599   const char *filename,
01600   ctl_t * ctl,
01601   met_t * met0,
01602   met_t * met1,
01603   atm_t * atm,
01604   double t) {
01605
01606   static FILE *in, *out;
01607
01608   static char line[LEN];
01609
01610   static double mass[GX][GY][GZ], obsmean[GX][GY], tmean[GX][GY],
01611     rt, rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z,
01612     press, temp, rho_air, mmr, h2o, o3;
01613
01614   static int init, obscount[GX][GY], ip, ix, iy, iz;
01615
01616   /* Init... */
01617   if (!init) {
01618     init = 1;
01619
01620     /* Check quantity index for mass... */
01621     if (ctl->qnt_m < 0)
01622       ERRMSG("Need quantity mass!");
01623
01624     /* Check dimensions... */
01625     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
01626       ERRMSG("Grid dimensions too large!");
01627
01628     /* Open observation data file... */
```

```
01629     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
01630     if (!(in = fopen(ctl->prof_obsfile, "r")))
01631       ERRMSG("Cannot open file!");
01632
01633     /* Create new file... */
01634     printf("Write profile data: %s\n", filename);
01635     if (!(out = fopen(filename, "w")))
01636       ERRMSG("Cannot create file!");
01637
01638     /* Write header... */
01639     fprintf(out,
01640             "# $1  = time [s]\n"
01641             "# $2  = altitude [km]\n"
01642             "# $3  = longitude [deg]\n"
01643             "# $4  = latitude [deg]\n"
01644             "# $5  = pressure [hPa]\n"
01645             "# $6  = temperature [K]\n"
01646             "# $7  = mass mixing ratio [1]\n"
01647             "# $8  = H2O volume mixing ratio [1]\n"
01648             "# $9  = O3 volume mixing ratio [1]\n"
01649             "# $10 = mean BT index [K]\n");
01650
01651     /* Set grid box size... */
01652     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
01653     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
01654     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
01655   }
01656
01657   /* Set time interval... */
01658   t0 = t - 0.5 * ctl->dt_mod;
01659   t1 = t + 0.5 * ctl->dt_mod;
01660
01661   /* Initialize... */
01662   for (ix = 0; ix < ctl->prof_nx; ix++)
01663     for (iy = 0; iy < ctl->prof_ny; iy++) {
01664       obsmean[ix][iy] = 0;
01665       obscount[ix][iy] = 0;
01666       tmean[ix][iy] = 0;
01667       for (iz = 0; iz < ctl->prof_nz; iz++)
01668         mass[ix][iy][iz] = 0;
01669     }
01670
01671   /* Read data... */
01672   while (fgets(line, LEN, in)) {
01673
01674     /* Read data... */
01675     if (sscanf(line, "%lg %lg %lg %lg", &rt, &rlon, &rlat, &robs) != 4)
01676       continue;
01677
01678     /* Check time... */
01679     if (rt < t0)
01680       continue;
01681     if (rt > t1)
01682       break;
01683
01684     /* Calculate indices... */
01685     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
01686     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
01687
01688     /* Check indices... */
01689     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
01690       continue;
01691
01692     /* Get mean observation index... */
01693     obsmean[ix][iy] += robs;
01694     tmean[ix][iy] += rt;
01695     obscount[ix][iy]++;
01696   }
01697
01698   /* Analyze model data... */
01699   for (ip = 0; ip < atm->np; ip++) {
01700
01701     /* Check time... */
01702     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01703       continue;
01704
01705     /* Get indices... */
01706     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
01707     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
01708     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
01709
01710     /* Check indices... */
01711     if (ix < 0 || ix >= ctl->prof_nx ||
01712         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
01713       continue;
01714
01715     /* Get total mass in grid cell... */
```

```
01716     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01717   }
01718
01719   /* Extract profiles... */
01720   for (ix = 0; ix < ctl->prof_nx; ix++)
01721     for (iy = 0; iy < ctl->prof_ny; iy++)
01722       if (obscount[ix][iy] > 0) {
01723
01724         /* Write output... */
01725         fprintf(out, "\n");
01726
01727         /* Loop over altitudes... */
01728         for (iz = 0; iz < ctl->prof_nz; iz++) {
01729
01730           /* Set coordinates... */
01731           z = ctl->prof_z0 + dz * (iz + 0.5);
01732           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
01733           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
01734
01735           /* Get meteorological data... */
01736           press = P(z);
01737           intpol_met_time(met0, met1, t, press, lon, lat,
01738                           NULL, &temp, NULL, NULL, NULL, &h2o, &o3);
01739
01740           /* Calculate mass mixing ratio... */
01741           rho_air = 100. * press / (287.058 * temp);
01742           area = dlat * dlon * gsl_pow_2(M_PI * RE / 180.)
01743             * cos(lat * M_PI / 180.);
01744           mmr = mass[ix][iy][iz] / (rho_air * area * dz * 1e9);
01745
01746           /* Write output... */
01747           fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g\n",
01748                   tmean[ix][iy] / obscount[ix][iy],
01749                   z, lon, lat, press, temp, mmr, h2o, o3,
01750                   obsmean[ix][iy] / obscount[ix][iy]);
01751         }
01752       }
01753
01754   /* Close file... */
01755   if (t == ctl->t_stop)
01756     fclose(out);
01757 }
01758
01759 /*****************************************************************************/
01760
01761 void write_station(
01762   const char *filename,
01763   ctl_t * ctl,
01764   atm_t * atm,
01765   double t) {
01766
01767   static FILE *out;
01768
01769   static double rmax2, t0, t1, x0[3], x1[3];
01770
01771   static int init, ip, iq;
01772
01773   /* Init... */
01774   if (!init) {
01775     init = 1;
01776
01777     /* Write info... */
01778     printf("Write station data: %s\n", filename);
01779
01780     /* Create new file... */
01781     if (!(out = fopen(filename, "w")))
01782       ERRMSG("Cannot create file!");
01783
01784     /* Write header... */
01785     fprintf(out,
01786             "# $1 = time [s]\n"
01787             "# $2 = altitude [km]\n"
01788             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01789     for (iq = 0; iq < ctl->nq; iq++)
01790       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
01791               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
01792     fprintf(out, "\n");
01793
01794     /* Set geolocation and search radius... */
01795     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
01796     rmax2 = gsl_pow_2(ctl->stat_r);
01797   }
01798
01799   /* Set time interval for output... */
01800   t0 = t - 0.5 * ctl->dt_mod;
01801   t1 = t + 0.5 * ctl->dt_mod;
01802
```

```
01803   /* Loop over air parcels... */
01804   for (ip = 0; ip < atm->np; ip++) {
01805
01806     /* Check time... */
01807     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01808       continue;
01809
01810     /* Check station flag... */
01811     if (ctl->qnt_stat >= 0)
01812       if (atm->q[ctl->qnt_stat][ip])
01813         continue;
01814
01815     /* Get Cartesian coordinates... */
01816     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
01817
01818     /* Check horizontal distance... */
01819     if (DIST2(x0, x1) > rmax2)
01820       continue;
01821
01822     /* Set station flag... */
01823     if (ctl->qnt_stat >= 0)
01824       atm->q[ctl->qnt_stat][ip] = 1;
01825
01826     /* Write data... */
01827     fprintf(out, "%.2f %g %g %g",
01828             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
01829     for (iq = 0; iq < ctl->nq; iq++) {
01830       fprintf(out, " ");
01831       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01832     }
01833     fprintf(out, "\n");
01834   }
01835
01836   /* Close file... */
01837   if (t == ctl->t_stop)
01838     fclose(out);
01839 }
```

5.13 libtrac.h File Reference

MPTRAC library declarations.

Data Structures

- struct ctl_t

  Control parameters.
- struct atm_t

  Atmospheric data.
- struct met_t

  Meteorological data.

Functions

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

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

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

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

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

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

Convert horizontal distance to degrees.

- double dz2dp (double dz, double p)

  Convert vertical distance to pressure.
- void geo2cart (double z, double lon, double lat, double *x)

  Convert geolocation to Cartesian coordinates.
- void get_met (ctl_t *ctl, char *metbase, double t, met_t *met0, met_t *met1)

  Get meteorological data for given timestep.
- void get_met_help (double t, int direct, char *metbase, double dt_met, char *filename)

  Get meteorological data for timestep.
- void intpol_met_2d (double array[EX][EY], int ix, int iy, double wx, double wy, double *var)

  Linear interpolation of 2-D meteorological data.
- void intpol_met_3d (float array[EX][EY][EP], int ip, int ix, int iy, double wp, double wx, double wy, double *var)

  Linear interpolation of 3-D meteorological data.
- void intpol_met_space (met_t *met, double p, double lon, double lat, double *ps, double *t, double *u, double *v, double *w, double *h2o, double *o3)

  Spatial interpolation of meteorological data.
- void intpol_met_time (met_t *met0, met_t *met1, double ts, double p, double lon, double lat, double *ps, double *t, double *u, double *v, double *w, double *h2o, double *o3)

  Temporal interpolation of meteorological data.
- void jsec2time (double jsec, int *year, int *mon, int *day, int *hour, int *min, int *sec, double *remain)

  Convert seconds to date.
- int locate (double *xx, int n, double x)

  Find array index.
- void read_atm (const char *filename, ctl_t *ctl, atm_t *atm)

  Read atmospheric data.
- void read_ctl (const char *filename, int argc, char *argv[ ], ctl_t *ctl)

  Read control parameters.
- void read_met (ctl_t *ctl, char *filename, met_t *met)

  Read meteorological data file.
- void read_met_extrapolate (met_t *met)

  Extrapolate meteorological data at lower boundary.
- void read_met_help (int ncid, char *varname, char *varname2, met_t *met, float dest[EX][EY][EP], float scl)

  Read and convert variable from meteorological data file.
- void read_met_ml2pl (ctl_t *ctl, met_t *met, float var[EX][EY][EP])

  Convert meteorological data from model levels to pressure levels.
- void read_met_periodic (met_t *met)

  Create meteorological data with periodic boundary conditions.
- double scan_ctl (const char *filename, int argc, char *argv[ ], const char *varname, int arridx, const char *defvalue, char *value)

  Read a control parameter from file or command line.
- void time2jsec (int year, int mon, int day, int hour, int min, int sec, double remain, double *jsec)

  Convert date to seconds.
- void timer (const char *name, int id, int mode)

  Measure wall-clock time.
- double tropopause (double t, double lat)
- void write_atm (const char *filename, ctl_t *ctl, atm_t *atm, double t)

  Write atmospheric data.
- void write_csi (const char *filename, ctl_t *ctl, atm_t *atm, double t)

  Write CSI data.
- void write_grid (const char *filename, ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, double t)

  Write gridded data.

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

  Write profile data.
- void write_station (const char *filename, ctl_t *ctl, atm_t *atm, double t)

  Write station data.

5.13.1 Detailed Description

MPTRAC library declarations.

Definition in file libtrac.h.

5.13.2 Function Documentation

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

Convert Cartesian coordinates to geolocation.

Definition at line 29 of file libtrac.c.

```
00033                {
00034
00035   double radius;
00036
00037   radius = NORM(x);
00038   *lat = asin(x[2] / radius) * 180 / M_PI;
00039   *lon = atan2(x[1], x[0]) * 180 / M_PI;
00040   *z = radius - RE;
00041 }
```

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

Convert degrees to horizontal distance.

Definition at line 45 of file libtrac.c.

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

5.13.2.3 double deg2dy (double *dlat*)

Convert degrees to horizontal distance.

Definition at line 54 of file libtrac.c.

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

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

Convert pressure to vertical distance.

Definition at line 62 of file libtrac.c.

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

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

Convert horizontal distance to degrees.

Definition at line 71 of file libtrac.c.

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

5.13.2.6 double dy2deg (double *dy*)

Convert horizontal distance to degrees.

Definition at line 84 of file libtrac.c.

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

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

Convert vertical distance to pressure.

Definition at line 92 of file libtrac.c.

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

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

Convert geolocation to Cartesian coordinates.

Definition at line 101 of file libtrac.c.

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

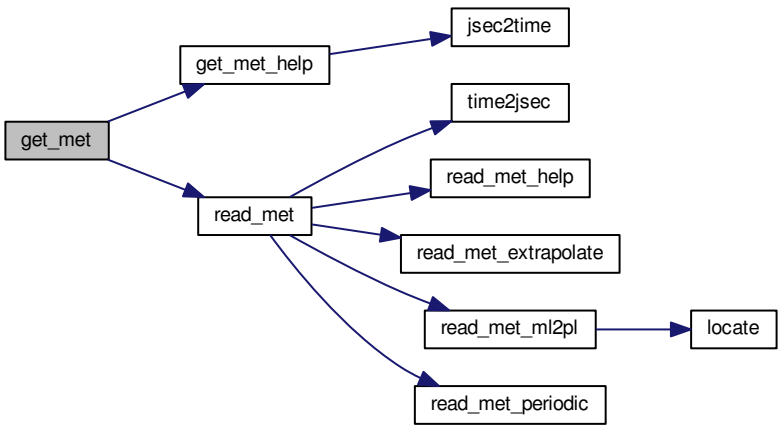
5.13.2.9 void get_met (ctl_t * *ctl,* char * *metbase,* double *t,* met_t * *met0,* met_t * *met1*)

Get meteorological data for given timestep.

Definition at line 117 of file libtrac.c.

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

Here is the call graph for this function:



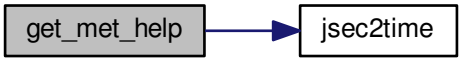
5.13.2.10 void get_met_help (double *t,* int *direct,* char * *metbase,* double *dt_met,* char * *filename*)

Get meteorological data for timestep.

Definition at line 156 of file libtrac.c.

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

Here is the call graph for this function:



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

Linear interpolation of 2-D meteorological data.

Definition at line 182 of file libtrac.c.

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

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

Linear interpolation of 3-D meteorological data.

Definition at line 206 of file libtrac.c.

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

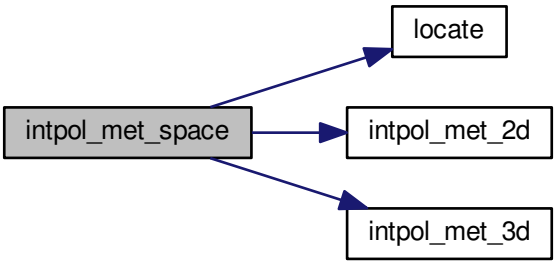
5.13.2.13 void intpol_met_space (met_t * *met*, double *p*, double *lon*, double *lat*, double * *ps*, double * *t*, double * *u*, double * *v*, double * *w*, double * *h2o*, double * *o3*)

Spatial interpolation of meteorological data.

Definition at line 236 of file libtrac.c.

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

Here is the call graph for this function:



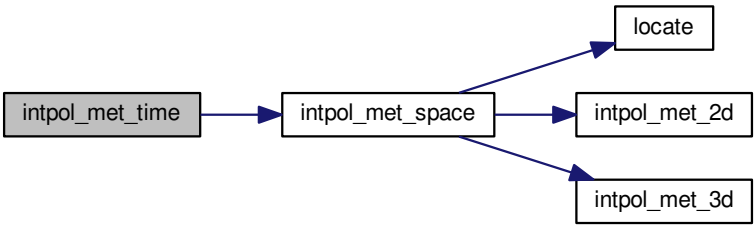
5.13.2.14 void intpol_met_time (met_t * *met0*, met_t * *met1*, double *ts*, double *p*, double *lon*, double *lat*, double * *ps*, double * *t*, double * *u*, double * *v*, double * *w*, double * *h2o*, double * *o3*)

Temporal interpolation of meteorological data.

Definition at line 286 of file libtrac.c.

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

Here is the call graph for this function:



5.13.2.15 void jsec2time (double *jsec*, int * *year*, int * *mon*, int * *day*, int * *hour*, int * *min*, int * *sec*, double * *remain*)

Convert seconds to date.

Definition at line 341 of file libtrac.c.

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

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

Find array index.

Definition at line 376 of file libtrac.c.

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

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

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

Read atmospheric data.

Definition at line 408 of file libtrac.c.

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

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

Read control parameters.

Definition at line 458 of file libtrac.c.

```
00462               {
00463
00464   int ip, iq;
00465
00466   /* Write info... */
00467   printf("\nMassive-Parallel Trajectory Calculations (MPTRAC)\n"
00468          "(executable: %s | compiled: %s, %s)\n\n",
00469          argv[0], __DATE__, __TIME__);
00470
00471   /* Initialize quantity indices... */
00472   ctl->qnt_m = -1;
00473   ctl->qnt_r = -1;
00474   ctl->qnt_rho = -1;
00475   ctl->qnt_ps = -1;
00476   ctl->qnt_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   ctl->met_np = (int) scan_ctl(filename, argc, argv, "MET_NP", -1, "0", NULL);
00548   if (ctl->met_np > EP)
```

```
00549     ERRMSG("Too many levels!");
00550   for (ip = 0; ip < ctl->met_np; ip++)
00551     ctl->met_p[ip] = scan_ctl(filename, argc, argv, "MET_P", ip, "", NULL);
00552
00553   /* Isosurface parameters... */
00554   ctl->isosurf
00555     = (int) scan_ctl(filename, argc, argv, "ISOSURF", -1, "0", NULL);
00556   scan_ctl(filename, argc, argv, "BALLOON", -1, "-", ctl->balloon);
00557
00558   /* Diffusion parameters... */
00559   ctl->turb_dx_trop
00560     = scan_ctl(filename, argc, argv, "TURB_DX_TROP", -1, "50.0", NULL);
00561   ctl->turb_dx_strat
00562     = scan_ctl(filename, argc, argv, "TURB_DX_STRAT", -1, "0.0", NULL);
00563   ctl->turb_dz_trop
00564     = scan_ctl(filename, argc, argv, "TURB_DZ_TROP", -1, "0.0", NULL);
00565   ctl->turb_dz_strat
00566     = scan_ctl(filename, argc, argv, "TURB_DZ_STRAT", -1, "0.1", NULL);
00567   ctl->turb_meso =
00568     scan_ctl(filename, argc, argv, "TURB_MESO", -1, "0.16", NULL);
00569
00570   /* Life time of particles... */
00571   ctl->tdec_trop = scan_ctl(filename, argc, argv, "TDEC_TROP", -1, "0", NULL);
00572   ctl->tdec_strat =
00573     scan_ctl(filename, argc, argv, "TDEC_STRAT", -1, "0", NULL);
00574
00575   /* Output of atmospheric data... */
00576   scan_ctl(filename, argc, argv, "ATM_BASENAME", -1, "-", ctl->
      atm_basename);
00577   scan_ctl(filename, argc, argv, "ATM_GPFILE", -1, "-", ctl->atm_gpfile);
00578   ctl->atm_dt_out =
00579     scan_ctl(filename, argc, argv, "ATM_DT_OUT", -1, "86400", NULL);
00580
00581   /* Output of CSI data... */
00582   scan_ctl(filename, argc, argv, "CSI_BASENAME", -1, "-", ctl->
      csi_basename);
00583   ctl->csi_dt_out =
00584     scan_ctl(filename, argc, argv, "CSI_DT_OUT", -1, "86400", NULL);
00585   scan_ctl(filename, argc, argv, "CSI_OBSFILE", -1, "obs.tab",
00586            ctl->csi_obsfile);
00587   ctl->csi_obsmin =
00588     scan_ctl(filename, argc, argv, "CSI_OBSMIN", -1, "0", NULL);
00589   ctl->csi_modmin =
00590     scan_ctl(filename, argc, argv, "CSI_MODMIN", -1, "0", NULL);
00591   ctl->csi_z0 = scan_ctl(filename, argc, argv, "CSI_Z0", -1, "0", NULL);
00592   ctl->csi_z1 = scan_ctl(filename, argc, argv, "CSI_Z1", -1, "100", NULL);
00593   ctl->csi_nz = (int) scan_ctl(filename, argc, argv, "CSI_NZ", -1, "1", NULL);
00594   ctl->csi_lon0 =
00595     scan_ctl(filename, argc, argv, "CSI_LON0", -1, "-180", NULL);
00596   ctl->csi_lon1 = scan_ctl(filename, argc, argv, "CSI_LON1", -1, "180", NULL);
00597   ctl->csi_nx =
00598     (int) scan_ctl(filename, argc, argv, "CSI_NX", -1, "360", NULL);
00599   ctl->csi_lat0 = scan_ctl(filename, argc, argv, "CSI_LAT0", -1, "-90", NULL);
00600   ctl->csi_lat1 = scan_ctl(filename, argc, argv, "CSI_LAT1", -1, "90", NULL);
00601   ctl->csi_ny =
00602     (int) scan_ctl(filename, argc, argv, "CSI_NY", -1, "180", NULL);
00603
00604   /* Output of grid data... */
00605   scan_ctl(filename, argc, argv, "GRID_BASENAME", -1, "-",
00606            ctl->grid_basename);
00607   scan_ctl(filename, argc, argv, "GRID_GPFILE", -1, "-", ctl->
      grid_gpfile);
00608   ctl->grid_dt_out =
00609     scan_ctl(filename, argc, argv, "GRID_DT_OUT", -1, "86400", NULL);
00610   ctl->grid_sparse =
00611     (int) scan_ctl(filename, argc, argv, "GRID_SPARSE", -1, "0", NULL);
00612   ctl->grid_z0 = scan_ctl(filename, argc, argv, "GRID_Z0", -1, "0", NULL);
00613   ctl->grid_z1 = scan_ctl(filename, argc, argv, "GRID_Z1", -1, "100", NULL);
00614   ctl->grid_nz =
00615     (int) scan_ctl(filename, argc, argv, "GRID_NZ", -1, "1", NULL);
00616   ctl->grid_lon0 =
00617     scan_ctl(filename, argc, argv, "GRID_LON0", -1, "-180", NULL);
00618   ctl->grid_lon1 =
00619     scan_ctl(filename, argc, argv, "GRID_LON1", -1, "180", NULL);
00620   ctl->grid_nx =
00621     (int) scan_ctl(filename, argc, argv, "GRID_NX", -1, "360", NULL);
00622   ctl->grid_lat0 =
00623     scan_ctl(filename, argc, argv, "GRID_LAT0", -1, "-90", NULL);
00624   ctl->grid_lat1 =
00625     scan_ctl(filename, argc, argv, "GRID_LAT1", -1, "90", NULL);
00626   ctl->grid_ny =
00627     (int) scan_ctl(filename, argc, argv, "GRID_NY", -1, "180", NULL);
00628
00629   /* Output of profile data... */
00630   scan_ctl(filename, argc, argv, "PROF_BASENAME", -1, "-",
00631            ctl->prof_basename);
00632   scan_ctl(filename, argc, argv, "PROF_OBSFILE", -1, "-", ctl->
```

```
      prof_obsfile);
00633   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
00634   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
00635   ctl->prof_nz =
00636     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
00637   ctl->prof_lon0 =
00638     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
00639   ctl->prof_lon1 =
00640     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
00641   ctl->prof_nx =
00642     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
00643   ctl->prof_lat0 =
00644     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
00645   ctl->prof_lat1 =
00646     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
00647   ctl->prof_ny =
00648     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
00649
00650   /* Output of station data... */
00651   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
00652            ctl->stat_basename);
00653   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
00654   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
00655   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
00656 }
```

Here is the call graph for this function:

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

Read meteorological data file.

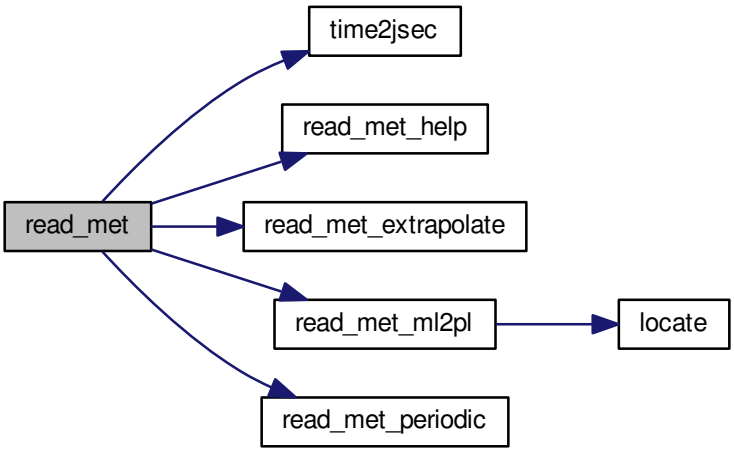
Definition at line 660 of file libtrac.c.

```
00663               {
00664
00665   char tstr[10];
00666
00667   static float help[EX * EY];
00668
00669   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
00670
00671   size_t np, nx, ny;
00672
00673   /* Write info... */
00674   printf("Read meteorological data: %s\n", filename);
00675
00676   /* Get time from filename... */
00677   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
00678   year = atoi(tstr);
00679   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
00680   mon = atoi(tstr);
00681   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
00682   day = atoi(tstr);
00683   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
00684   hour = atoi(tstr);
00685   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
00686
00687   /* Open netCDF file... */
00688   NC(nc_open(filename, NC_NOWRITE, &ncid));
00689
00690   /* Get dimensions... */
```

```
00691   NC(nc_inq_dimid(ncid, "lon", &dimid));
00692   NC(nc_inq_dimlen(ncid, dimid, &nx));
00693   if (nx > EX)
00694     ERRMSG("Too many longitudes!");
00695
00696   NC(nc_inq_dimid(ncid, "lat", &dimid));
00697   NC(nc_inq_dimlen(ncid, dimid, &ny));
00698   if (ny > EY)
00699     ERRMSG("Too many latitudes!");
00700
00701   NC(nc_inq_dimid(ncid, "lev", &dimid));
00702   NC(nc_inq_dimlen(ncid, dimid, &np));
00703   if (np > EP)
00704     ERRMSG("Too many levels!");
00705
00706   /* Store dimensions... */
00707   met->np = (int) np;
00708   met->nx = (int) nx;
00709   met->ny = (int) ny;
00710
00711   /* Get horizontal grid... */
00712   NC(nc_inq_varid(ncid, "lon", &varid));
00713   NC(nc_get_var_double(ncid, varid, met->lon));
00714   NC(nc_inq_varid(ncid, "lat", &varid));
00715   NC(nc_get_var_double(ncid, varid, met->lat));
00716
00717   /* Read meteorological data... */
00718   read_met_help(ncid, "t", "T", met, met->t, 1.0);
00719   read_met_help(ncid, "u", "U", met, met->u, 1.0);
00720   read_met_help(ncid, "v", "V", met, met->v, 1.0);
00721   read_met_help(ncid, "w", "W", met, met->w, 0.01f);
00722   read_met_help(ncid, "q", "Q", met, met->h2o, 1.608f);
00723   read_met_help(ncid, "o3", "O3", met, met->o3, 0.602f);
00724
00725   /* Meteo data on pressure levels... */
00726   if (ctl->met_np <= 0) {
00727
00728     /* Read pressure levels from file... */
00729     NC(nc_inq_varid(ncid, "lev", &varid));
00730     NC(nc_get_var_double(ncid, varid, met->p));
00731     for (ip = 0; ip < met->np; ip++)
00732       met->p[ip] /= 100.;
00733
00734     /* Extrapolate data for lower boundary... */
00735     read_met_extrapolate(met);
00736   }
00737
00738   /* Meteo data on model levels... */
00739   else {
00740
00741     /* Read pressure data from file... */
00742     read_met_help(ncid, "pl", "PL", met, met->pl, 0.01f);
00743
00744     /* Interpolate from model levels to pressure levels... */
00745     read_met_ml2pl(ctl, met, met->t);
00746     read_met_ml2pl(ctl, met, met->u);
00747     read_met_ml2pl(ctl, met, met->v);
00748     read_met_ml2pl(ctl, met, met->w);
00749     read_met_ml2pl(ctl, met, met->h2o);
00750     read_met_ml2pl(ctl, met, met->o3);
00751
00752     /* Set pressure levels... */
00753     met->np = ctl->met_np;
00754     for (ip = 0; ip < met->np; ip++)
00755       met->p[ip] = ctl->met_p[ip];
00756   }
00757
00758   /* Check ordering of pressure levels... */
00759   for (ip = 1; ip < met->np; ip++)
00760     if (met->p[ip - 1] < met->p[ip])
00761       ERRMSG("Pressure levels must be descending!");
00762
00763   /* Read surface pressure... */
00764   if (nc_inq_varid(ncid, "PS", &varid) == NC_NOERR) {
00765     NC(nc_get_var_float(ncid, varid, help));
00766     for (iy = 0; iy < met->ny; iy++)
00767       for (ix = 0; ix < met->nx; ix++)
00768         met->ps[ix][iy] = help[iy * met->nx + ix] / 100.;
00769   } else if (nc_inq_varid(ncid, "LNSP", &varid) == NC_NOERR) {
00770     NC(nc_get_var_float(ncid, varid, help));
00771     for (iy = 0; iy < met->ny; iy++)
00772       for (ix = 0; ix < met->nx; ix++)
00773         met->ps[ix][iy] = exp(help[iy * met->nx + ix]) / 100.;
00774   } else
00775     for (ix = 0; ix < met->nx; ix++)
00776       for (iy = 0; iy < met->ny; iy++)
00777         met->ps[ix][iy] = met->p[0];
```

```
00778
00779   /* Create periodic boundary conditions... */
00780   read_met_periodic(met);
00781
00782   /* Close file... */
00783   NC(nc_close(ncid));
00784 }
```

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 788 of file libtrac.c.

```
00789                {
00790
00791   int ip, ip0, ix, iy;
00792
00793   /* Loop over columns... */
00794   for (ix = 0; ix < met->nx; ix++)
00795     for (iy = 0; iy < met->ny; iy++) {
00796
00797       /* Find lowest valid data point... */
00798       for (ip0 = met->np - 1; ip0 >= 0; ip0--)
00799         if (!gsl_finite(met->t[ix][iy][ip0])
00800             || !gsl_finite(met->u[ix][iy][ip0])
00801             || !gsl_finite(met->v[ix][iy][ip0])
00802             || !gsl_finite(met->w[ix][iy][ip0]))
00803           break;
00804
00805       /* Extrapolate... */
00806       for (ip = ip0; ip >= 0; ip--) {
00807         met->t[ix][iy][ip] = met->t[ix][iy][ip + 1];
00808         met->u[ix][iy][ip] = met->u[ix][iy][ip + 1];
00809         met->v[ix][iy][ip] = met->v[ix][iy][ip + 1];
00810         met->w[ix][iy][ip] = met->w[ix][iy][ip + 1];
00811         met->h2o[ix][iy][ip] = met->h2o[ix][iy][ip + 1];
00812         met->o3[ix][iy][ip] = met->o3[ix][iy][ip + 1];
00813       }
00814     }
00815 }
```

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

Read and convert variable from meteorological data file.

Definition at line 819 of file libtrac.c.

```
00825             {
00826
00827   static float help[EX * EY * EP];
00828
00829   int ip, ix, iy, n = 0, varid;
00830
00831   /* Check if variable exists... */
00832   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
00833     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
00834       return;
00835
00836   /* Read data... */
00837   NC(nc_get_var_float(ncid, varid, help));
00838
00839   /* Copy and check data... */
00840   for (ip = 0; ip < met->np; ip++)
00841     for (iy = 0; iy < met->ny; iy++)
00842       for (ix = 0; ix < met->nx; ix++) {
00843         dest[ix][iy][ip] = scl * help[n++];
00844         if (fabs(dest[ix][iy][ip] / scl) > 1e14)
00845           dest[ix][iy][ip] = GSL_NAN;
00846       }
00847 }
```

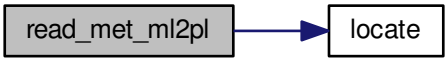
5.13.2.22 void read_met_ml2pl (ctl_t * *ctl*, met_t * *met*, float *var[EX][EY][EP]*)

Convert meteorological data from model levels to pressure levels.

Definition at line 851 of file libtrac.c.

```
00854                         {
00855
00856   double aux[EP], p[EP], pt;
00857
00858   int ip, ip2, ix, iy;
00859
00860   /* Loop over columns... */
00861   for (ix = 0; ix < met->nx; ix++)
00862     for (iy = 0; iy < met->ny; iy++) {
00863
00864       /* Copy pressure profile... */
00865       for (ip = 0; ip < met->np; ip++)
00866         p[ip] = met->pl[ix][iy][ip];
00867
00868       /* Interpolate... */
00869       for (ip = 0; ip < ctl->met_np; ip++) {
00870         pt = ctl->met_p[ip];
00871         if ((pt > p[0] && p[0] > p[1]) || (pt < p[0] && p[0] < p[1]))
00872           pt = p[0];
00873         else if ((pt > p[met->np - 1] && p[1] > p[0])
00874                  || (pt < p[met->np - 1] && p[1] < p[0]))
00875           pt = p[met->np - 1];
00876         ip2 = locate(p, met->np, pt);
00877         aux[ip] = LIN(p[ip2], var[ix][iy][ip2],
00878                       p[ip2 + 1], var[ix][iy][ip2 + 1], pt);
00879       }
00880
00881       /* Copy data... */
00882       for (ip = 0; ip < ctl->met_np; ip++)
00883         var[ix][iy][ip] = (float) aux[ip];
00884     }
00885 }
```

Here is the call graph for this function:



5.13.2.23 void read_met_periodic (met_t * *met*)

Create meteorological data with periodic boundary conditions.

Definition at line 889 of file libtrac.c.

```
00890                {
00891
00892   int ip, iy;
00893
00894   /* Check longitudes... */
00895   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
00896              + met->lon[1] - met->lon[0] - 360) < 0.01))
00897     return;
00898
00899   /* Increase longitude counter... */
00900   if ((++met->nx) > EX)
00901     ERRMSG("Cannot create periodic boundary conditions!");
00902
00903   /* Set longitude... */
00904   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
00905
00906   /* Loop over latitudes and pressure levels... */
00907   for (iy = 0; iy < met->ny; iy++)
00908     for (ip = 0; ip < met->np; ip++) {
00909       met->ps[met->nx - 1][iy] = met->ps[0][iy];
00910       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
00911       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
00912       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
00913       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
00914       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
00915       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
00916     }
00917 }
```

5.13.2.24 double scan_ctl (const char * *filename*, int *argc*, char * *argv[]*, const char * *varname*, int *arridx*, const char * *defvalue*, char * *value*)

Read a control parameter from file or command line.

Definition at line 921 of file libtrac.c.

```
00928                {
00929
00930   FILE *in = NULL;
00931
00932   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
00933     msg[LEN], rvarname[LEN], rval[LEN];
00934
00935   int contain = 0, i;
00936
00937   /* Open file... */
00938   if (filename[strlen(filename) - 1] != '-')
00939     if (!(in = fopen(filename, "r")))
```

```
00940       ERRMSG("Cannot open file!");
00941
00942   /* Set full variable name... */
00943   if (arridx >= 0) {
00944     sprintf(fullname1, "%s[%d]", varname, arridx);
00945     sprintf(fullname2, "%s[*]", varname);
00946   } else {
00947     sprintf(fullname1, "%s", varname);
00948     sprintf(fullname2, "%s", varname);
00949   }
00950
00951   /* Read data... */
00952   if (in != NULL)
00953     while (fgets(line, LEN, in))
00954       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
00955         if (strcasecmp(rvarname, fullname1) == 0 ||
00956             strcasecmp(rvarname, fullname2) == 0) {
00957           contain = 1;
00958           break;
00959         }
00960   for (i = 1; i < argc - 1; i++)
00961     if (strcasecmp(argv[i], fullname1) == 0 ||
00962         strcasecmp(argv[i], fullname2) == 0) {
00963       sprintf(rval, "%s", argv[i + 1]);
00964       contain = 1;
00965       break;
00966     }
00967
00968   /* Close file... */
00969   if (in != NULL)
00970     fclose(in);
00971
00972   /* Check for missing variables... */
00973   if (!contain) {
00974     if (strlen(defvalue) > 0)
00975       sprintf(rval, "%s", defvalue);
00976     else {
00977       sprintf(msg, "Missing variable %s!\n", fullname1);
00978       ERRMSG(msg);
00979     }
00980   }
00981
00982   /* Write info... */
00983   printf("%s = %s\n", fullname1, rval);
00984
00985   /* Return values... */
00986   if (value != NULL)
00987     sprintf(value, "%s", rval);
00988   return atof(rval);
00989 }
```

5.13.2.25 void time2jsec (int *year*, int *mon*, int *day*, int *hour*, int *min*, int *sec*, double *remain*, double * *jsec*)

Convert date to seconds.

Definition at line 993 of file libtrac.c.

```
01001                 {
01002
01003   struct tm t0, t1;
01004
01005   t0.tm_year = 100;
01006   t0.tm_mon = 0;
01007   t0.tm_mday = 1;
01008   t0.tm_hour = 0;
01009   t0.tm_min = 0;
01010   t0.tm_sec = 0;
01011
01012   t1.tm_year = year - 1900;
01013   t1.tm_mon = mon - 1;
01014   t1.tm_mday = day;
01015   t1.tm_hour = hour;
01016   t1.tm_min = min;
01017   t1.tm_sec = sec;
01018
01019   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
01020 }
```

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

Measure wall-clock time.

Definition at line 1024 of file libtrac.c.

```
01027            {
01028
01029   static double starttime[NTIMER], runtime[NTIMER];
01030
01031   /* Check id... */
01032   if (id < 0 || id >= NTIMER)
01033     ERRMSG("Too many timers!");
01034
01035   /* Start timer... */
01036   if (mode == 1) {
01037     if (starttime[id] <= 0)
01038       starttime[id] = omp_get_wtime();
01039     else
01040       ERRMSG("Timer already started!");
01041   }
01042
01043   /* Stop timer... */
01044   else if (mode == 2) {
01045     if (starttime[id] > 0) {
01046       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
01047       starttime[id] = -1;
01048     } else
01049       ERRMSG("Timer not started!");
01050   }
01051
01052   /* Print timer... */
01053   else if (mode == 3)
01054     printf("%s = %g s\n", name, runtime[id]);
01055 }
```

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

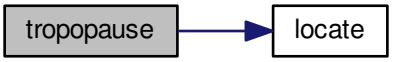
Definition at line 1059 of file libtrac.c.

```
01061              {
01062
01063   static double doys[12]
01064   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
01065
01066   static double lats[73]
01067     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
01068     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
01069     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
01070     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
01071     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
01072     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
01073     75, 77.5, 80, 82.5, 85, 87.5, 90
01074   };
01075
01076   static double tps[12][73]
01077     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
01078          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
01079          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
01080          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
01081          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
01082          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
01083          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
01084          275.3, 275.6, 275.4, 274.1, 273.5},
01085   {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
01086    300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
01087    150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
01088    98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
01089    98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
01090    220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
01091    284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
01092    287.5, 286.2, 285.8},
01093   {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
01094    297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
01095    161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
01096    100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
01097    99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
```

```
01098    186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
01099    279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
01100    304.3, 304.9, 306, 306.6, 306.2, 306},
01101   {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
01102    290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
01103    195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
01104    102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
01105    99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
01106    148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
01107    263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
01108    315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
01109   {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
01110    260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
01111    205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
01112    101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
01113    102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
01114    165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
01115    273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
01116    325.3, 325.8, 325.8},
01117   {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
01118    222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
01119    228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
01120    105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
01121    106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
01122    127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
01123    251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
01124    308.5, 312.2, 313.1, 313.3},
01125   {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
01126    187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
01127    235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
01128    110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
01129    111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
01130    117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
01131    224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
01132    275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
01133   {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
01134    185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
01135    233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
01136    110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
01137    112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
01138    120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
01139    230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
01140    278.2, 282.6, 287.4, 290.9, 292.5, 293},
01141   {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
01142    183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
01143    243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
01144    114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
01145    110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
01146    114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
01147    203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
01148    276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
01149   {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
01150    215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
01151    237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
01152    111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
01153    106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
01154    112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
01155    206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
01156    279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
01157    305.1},
01158   {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
01159    253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
01160    223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
01161    108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
01162    102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
01163    109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
01164    241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
01165    286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
01166   {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
01167    284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
01168    175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
01169    100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
01170    100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
01171    186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
01172    280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
01173    281.7, 281.1, 281.2}
01174   };
01175
01176   double doy, p0, p1, pt;
01177
01178   int imon, ilat;
01179
01180   /* Get day of year... */
01181   doy = fmod(t / 86400., 365.25);
01182   while (doy < 0)
01183     doy += 365.25;
01184
```

```
01185   /* Get indices... */
01186   imon = locate(doys, 12, doy);
01187   ilat = locate(lats, 73, lat);
01188
01189   /* Get tropopause pressure... */
01190   p0 = LIN(lats[ilat], tps[imon][ilat],
01191            lats[ilat + 1], tps[imon][ilat + 1], lat);
01192   p1 = LIN(lats[ilat], tps[imon + 1][ilat],
01193            lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
01194   pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
01195
01196   /* Return tropopause pressure... */
01197   return pt;
01198 }
```

Here is the call graph for this function:



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

Write atmospheric data.

Definition at line 1202 of file libtrac.c.

```
01206             {
01207
01208   FILE *in, *out;
01209
01210   char line[LEN];
01211
01212   double r;
01213
01214   int ip, iq, year, mon, day, hour, min, sec;
01215
01216   /* Check if gnuplot output is requested... */
01217   if (ctl->atm_gpfile[0] != '-') {
01218
01219     /* Write info... */
01220     printf("Plot atmospheric data: %s.png\n", filename);
01221
01222     /* Create gnuplot pipe... */
01223     if (!(out = popen("gnuplot", "w")))
01224       ERRMSG("Cannot create pipe to gnuplot!");
01225
01226     /* Set plot filename... */
01227     fprintf(out, "set out \"%s.png\"\n", filename);
01228
01229     /* Set time string... */
01230     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01231     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01232             year, mon, day, hour, min);
01233
01234     /* Dump gnuplot file to pipe... */
01235     if (!(in = fopen(ctl->atm_gpfile, "r")))
01236       ERRMSG("Cannot open file!");
01237     while (fgets(line, LEN, in))
01238       fprintf(out, "%s", line);
01239     fclose(in);
01240   }
01241
01242   else {
01243
01244     /* Write info... */
```

```
01245     printf("Write atmospheric data: %s\n", filename);
01246
01247     /* Create file... */
01248     if (!(out = fopen(filename, "w")))
01249       ERRMSG("Cannot create file!");
01250   }
01251
01252   /* Write header... */
01253   fprintf(out,
01254           "# $1 = time [s]\n"
01255           "# $2 = altitude [km]\n"
01256           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01257   for (iq = 0; iq < ctl->nq; iq++)
01258     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
01259             ctl->qnt_unit[iq]);
01260   fprintf(out, "\n");
01261
01262   /* Write data... */
01263   for (ip = 0; ip < atm->np; ip++) {
01264     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
01265             atm->lon[ip], atm->lat[ip]);
01266     for (iq = 0; iq < ctl->nq; iq++) {
01267       fprintf(out, " ");
01268       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01269     }
01270     fprintf(out, "\n");
01271   }
01272
01273   /* Close file... */
01274   fclose(out);
01275 }
```

Here is the call graph for this function:

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

Write CSI data.

Definition at line 1279 of file libtrac.c.

```
01283             {
01284
01285   static FILE *in, *out;
01286
01287   static char line[LEN];
01288
01289   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
01290     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
01291
01292   static int init, obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
01293
01294   /* Init... */
01295   if (!init) {
01296     init = 1;
01297
01298     /* Check quantity index for mass... */
01299     if (ctl->qnt_m < 0)
01300       ERRMSG("Need quantity mass to analyze CSI!");
01301
01302     /* Open observation data file... */
01303     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
01304     if (!(in = fopen(ctl->csi_obsfile, "r")))
```

```
01305       ERRMSG("Cannot open file!");
01306
01307     /* Create new file... */
01308     printf("Write CSI data: %s\n", filename);
01309     if (!(out = fopen(filename, "w")))
01310       ERRMSG("Cannot create file!");
01311
01312     /* Write header... */
01313     fprintf(out,
01314             "# $1 = time [s]\n"
01315             "# $2 = number of hits (cx)\n"
01316             "# $3 = number of misses (cy)\n"
01317             "# $4 = number of false alarms (cz)\n"
01318             "# $5 = number of observations (cx + cy)\n"
01319             "# $6 = number of forecasts (cx + cz)\n"
01320             "# $7 = bias (forecasts/observations) [%%]\n"
01321             "# $8 = probability of detection (POD) [%%]\n"
01322             "# $9 = false alarm rate (FAR) [%%]\n"
01323             "# $10 = critical success index (CSI) [%%]\n\n");
01324   }
01325
01326   /* Set time interval... */
01327   t0 = t - 0.5 * ctl->dt_mod;
01328   t1 = t + 0.5 * ctl->dt_mod;
01329
01330   /* Initialize grid cells... */
01331   for (ix = 0; ix < ctl->csi_nx; ix++)
01332     for (iy = 0; iy < ctl->csi_ny; iy++)
01333       for (iz = 0; iz < ctl->csi_nz; iz++)
01334         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
01335
01336   /* Read data... */
01337   while (fgets(line, LEN, in)) {
01338
01339     /* Read data... */
01340     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
01341         5)
01342       continue;
01343
01344     /* Check time... */
01345     if (rt < t0)
01346       continue;
01347     if (rt > t1)
01348       break;
01349
01350     /* Calculate indices... */
01351     ix = (int) ((rlon - ctl->csi_lon0)
01352                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01353     iy = (int) ((rlat - ctl->csi_lat0)
01354                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01355     iz = (int) ((rz - ctl->csi_z0)
01356                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01357
01358     /* Check indices... */
01359     if (ix < 0 || ix >= ctl->csi_nx ||
01360         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01361       continue;
01362
01363     /* Get mean observation index... */
01364     obsmean[ix][iy][iz] += robs;
01365     obscount[ix][iy][iz]++;
01366   }
01367
01368   /* Analyze model data... */
01369   for (ip = 0; ip < atm->np; ip++) {
01370
01371     /* Check time... */
01372     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01373       continue;
01374
01375     /* Get indices... */
01376     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
01377                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01378     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
01379                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01380     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
01381                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01382
01383     /* Check indices... */
01384     if (ix < 0 || ix >= ctl->csi_nx ||
01385         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01386       continue;
01387
01388     /* Get total mass in grid cell... */
01389     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01390   }
01391
```

```
01392   /* Analyze all grid cells... */
01393   for (ix = 0; ix < ctl->csi_nx; ix++)
01394     for (iy = 0; iy < ctl->csi_ny; iy++)
01395       for (iz = 0; iz < ctl->csi_nz; iz++) {
01396
01397         /* Calculate mean observation index... */
01398         if (obscount[ix][iy][iz] > 0)
01399           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
01400
01401         /* Calculate column density... */
01402         if (modmean[ix][iy][iz] > 0) {
01403           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
01404           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
01405           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
01406           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
01407             * cos(lat * M_PI / 180.);
01408           modmean[ix][iy][iz] /= (1e6 * area);
01409         }
01410
01411         /* Calculate CSI... */
01412         if (obscount[ix][iy][iz] > 0) {
01413           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01414               modmean[ix][iy][iz] >= ctl->csi_modmin)
01415             cx++;
01416           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01417                    modmean[ix][iy][iz] < ctl->csi_modmin)
01418             cy++;
01419           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
01420                    modmean[ix][iy][iz] >= ctl->csi_modmin)
01421             cz++;
01422         }
01423       }
01424
01425   /* Write output... */
01426   if (fmod(t, ctl->csi_dt_out) == 0) {
01427
01428     /* Write... */
01429     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
01430             t, cx, cy, cz, cx + cy, cx + cz,
01431             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
01432             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
01433             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
01434             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
01435
01436     /* Set counters to zero... */
01437     cx = cy = cz = 0;
01438   }
01439
01440   /* Close file... */
01441   if (t == ctl->t_stop)
01442     fclose(out);
01443 }
```

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

Write gridded data.

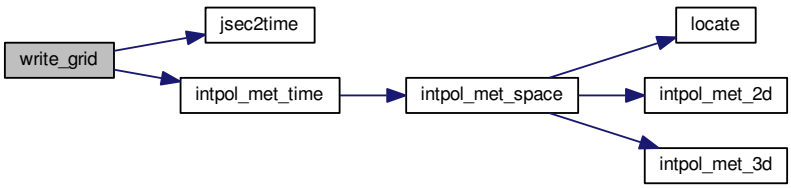
Definition at line 1447 of file libtrac.c.

```
01453             {
01454
01455   FILE *in, *out;
01456
01457   char line[LEN];
01458
01459   static double grid_m[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
01460     area, rho_air, press, temp, cd, mmr, t0, t1, r;
01461
01462   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
01463
01464   /* Check dimensions... */
01465   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
01466     ERRMSG("Grid dimensions too large!");
01467
01468   /* Check quantity index for mass... */
01469   if (ctl->qnt_m < 0)
01470     ERRMSG("Need quantity mass to write grid data!");
01471
01472   /* Set time interval for output... */
01473   t0 = t - 0.5 * ctl->dt_mod;
```

```
01474   t1 = t + 0.5 * ctl->dt_mod;
01475
01476   /* Set grid box size... */
01477   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
01478   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
01479   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
01480
01481   /* Initialize grid... */
01482   for (ix = 0; ix < ctl->grid_nx; ix++)
01483     for (iy = 0; iy < ctl->grid_ny; iy++)
01484       for (iz = 0; iz < ctl->grid_nz; iz++)
01485         grid_m[ix][iy][iz] = 0;
01486
01487   /* Average data... */
01488   for (ip = 0; ip < atm->np; ip++)
01489     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
01490
01491       /* Get index... */
01492       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
01493       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
01494       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
01495
01496       /* Check indices... */
01497       if (ix < 0 || ix >= ctl->grid_nx ||
01498           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
01499         continue;
01500
01501       /* Add mass... */
01502       grid_m[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01503     }
01504
01505   /* Check if gnuplot output is requested... */
01506   if (ctl->grid_gpfile[0] != '-') {
01507
01508     /* Write info... */
01509     printf("Plot grid data: %s.png\n", filename);
01510
01511     /* Create gnuplot pipe... */
01512     if (!(out = popen("gnuplot", "w")))
01513       ERRMSG("Cannot create pipe to gnuplot!");
01514
01515     /* Set plot filename... */
01516     fprintf(out, "set out \"%s.png\"\n", filename);
01517
01518     /* Set time string... */
01519     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01520     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01521             year, mon, day, hour, min);
01522
01523     /* Dump gnuplot file to pipe... */
01524     if (!(in = fopen(ctl->grid_gpfile, "r")))
01525       ERRMSG("Cannot open file!");
01526     while (fgets(line, LEN, in))
01527       fprintf(out, "%s", line);
01528     fclose(in);
01529   }
01530
01531   else {
01532
01533     /* Write info... */
01534     printf("Write grid data: %s\n", filename);
01535
01536     /* Create file... */
01537     if (!(out = fopen(filename, "w")))
01538       ERRMSG("Cannot create file!");
01539   }
01540
01541   /* Write header... */
01542   fprintf(out,
01543           "# $1 = time [s]\n"
01544           "# $2 = altitude [km]\n"
01545           "# $3 = longitude [deg]\n"
01546           "# $4 = latitude [deg]\n"
01547           "# $5 = surface area [km^2]\n"
01548           "# $6 = layer width [km]\n"
01549           "# $7 = temperature [K]\n"
01550           "# $8 = column density [kg/m^2]\n"
01551           "# $9 = mass mixing ratio [1]\n\n");
01552
01553   /* Write data... */
01554   for (ix = 0; ix < ctl->grid_nx; ix++) {
01555     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
01556       fprintf(out, "\n");
01557     for (iy = 0; iy < ctl->grid_ny; iy++) {
01558       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
01559         fprintf(out, "\n");
01560       for (iz = 0; iz < ctl->grid_nz; iz++)
```

```
01561         if (!ctl->grid_sparse
01562             || ix == 0 || iy == 0 || iz == 0 || grid_m[ix][iy][iz] > 0) {
01563
01564           /* Set coordinates... */
01565           z = ctl->grid_z0 + dz * (iz + 0.5);
01566           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
01567           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
01568
01569           /* Get pressure and temperature... */
01570           press = P(z);
01571           intpol_met_time(met0, met1, t, press, lon, lat,
01572                           NULL, &temp, NULL, NULL, NULL, NULL, NULL);
01573
01574           /* Calculate surface area... */
01575           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
01576             * cos(lat * M_PI / 180.);
01577
01578           /* Calculate column density... */
01579           cd = grid_m[ix][iy][iz] / (1e6 * area);
01580
01581           /* Calculate mass mixing ratio... */
01582           rho_air = 100. * press / (287.058 * temp);
01583           mmr = grid_m[ix][iy][iz] / (rho_air * 1e6 * area * 1e3 * dz);
01584
01585           /* Write output... */
01586           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01587                   t, z, lon, lat, area, dz, temp, cd, mmr);
01588         }
01589       }
01590     }
01591
01592     /* Close file... */
01593     fclose(out);
01594   }
```

Here is the call graph for this function:



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

Write profile data.

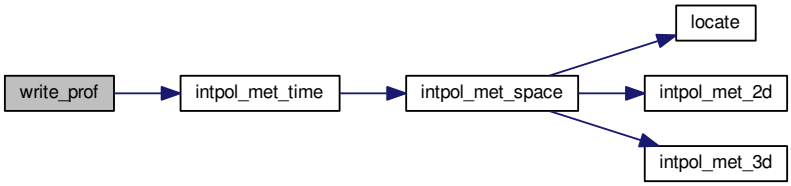
Definition at line 1598 of file libtrac.c.

```
01604             {
01605
01606     static FILE *in, *out;
01607
01608     static char line[LEN];
01609
01610     static double mass[GX][GY][GZ], obsmean[GX][GY], tmean[GX][GY],
01611       rt, rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z,
01612       press, temp, rho_air, mmr, h2o, o3;
01613
01614     static int init, obscount[GX][GY], ip, ix, iy, iz;
01615
01616     /* Init... */
01617     if (!init) {
01618       init = 1;
01619
01620       /* Check quantity index for mass... */
```

```
01621     if (ctl->qnt_m < 0)
01622       ERRMSG("Need quantity mass!");
01623
01624     /* Check dimensions... */
01625     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
01626       ERRMSG("Grid dimensions too large!");
01627
01628     /* Open observation data file... */
01629     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
01630     if (!(in = fopen(ctl->prof_obsfile, "r")))
01631       ERRMSG("Cannot open file!");
01632
01633     /* Create new file... */
01634     printf("Write profile data: %s\n", filename);
01635     if (!(out = fopen(filename, "w")))
01636       ERRMSG("Cannot create file!");
01637
01638     /* Write header... */
01639     fprintf(out,
01640             "# $1  = time [s]\n"
01641             "# $2  = altitude [km]\n"
01642             "# $3  = longitude [deg]\n"
01643             "# $4  = latitude [deg]\n"
01644             "# $5  = pressure [hPa]\n"
01645             "# $6  = temperature [K]\n"
01646             "# $7  = mass mixing ratio [1]\n"
01647             "# $8  = H2O volume mixing ratio [1]\n"
01648             "# $9  = O3 volume mixing ratio [1]\n"
01649             "# $10 = mean BT index [K]\n");
01650
01651     /* Set grid box size... */
01652     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
01653     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
01654     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
01655   }
01656
01657   /* Set time interval... */
01658   t0 = t - 0.5 * ctl->dt_mod;
01659   t1 = t + 0.5 * ctl->dt_mod;
01660
01661   /* Initialize... */
01662   for (ix = 0; ix < ctl->prof_nx; ix++)
01663     for (iy = 0; iy < ctl->prof_ny; iy++) {
01664       obsmean[ix][iy] = 0;
01665       obscount[ix][iy] = 0;
01666       tmean[ix][iy] = 0;
01667       for (iz = 0; iz < ctl->prof_nz; iz++)
01668         mass[ix][iy][iz] = 0;
01669     }
01670
01671   /* Read data... */
01672   while (fgets(line, LEN, in)) {
01673
01674     /* Read data... */
01675     if (sscanf(line, "%lg %lg %lg %lg", &rt, &rlon, &rlat, &robs) != 4)
01676       continue;
01677
01678     /* Check time... */
01679     if (rt < t0)
01680       continue;
01681     if (rt > t1)
01682       break;
01683
01684     /* Calculate indices... */
01685     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
01686     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
01687
01688     /* Check indices... */
01689     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
01690       continue;
01691
01692     /* Get mean observation index... */
01693     obsmean[ix][iy] += robs;
01694     tmean[ix][iy] += rt;
01695     obscount[ix][iy]++;
01696   }
01697
01698   /* Analyze model data... */
01699   for (ip = 0; ip < atm->np; ip++) {
01700
01701     /* Check time... */
01702     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01703       continue;
01704
01705     /* Get indices... */
01706     ix = (int) ((atm->lon[ip] - ctl->prof_lon0) / dlon);
01707     iy = (int) ((atm->lat[ip] - ctl->prof_lat0) / dlat);
```

```
01708     iz = (int) ((Z(atm->p[ip]) - ctl->prof_z0) / dz);
01709
01710     /* Check indices... */
01711     if (ix < 0 || ix >= ctl->prof_nx ||
01712         iy < 0 || iy >= ctl->prof_ny || iz < 0 || iz >= ctl->prof_nz)
01713       continue;
01714
01715     /* Get total mass in grid cell... */
01716     mass[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01717   }
01718
01719   /* Extract profiles... */
01720   for (ix = 0; ix < ctl->prof_nx; ix++)
01721     for (iy = 0; iy < ctl->prof_ny; iy++)
01722       if (obscount[ix][iy] > 0) {
01723
01724         /* Write output... */
01725         fprintf(out, "\n");
01726
01727         /* Loop over altitudes... */
01728         for (iz = 0; iz < ctl->prof_nz; iz++) {
01729
01730           /* Set coordinates... */
01731           z = ctl->prof_z0 + dz * (iz + 0.5);
01732           lon = ctl->prof_lon0 + dlon * (ix + 0.5);
01733           lat = ctl->prof_lat0 + dlat * (iy + 0.5);
01734
01735           /* Get meteorological data... */
01736           press = P(z);
01737           intpol_met_time(met0, met1, t, press, lon, lat,
01738                           NULL, &temp, NULL, NULL, NULL, &h2o, &o3);
01739
01740           /* Calculate mass mixing ratio... */
01741           rho_air = 100. * press / (287.058 * temp);
01742           area = dlat * dlon * gsl_pow_2(M_PI * RE / 180.)
01743             * cos(lat * M_PI / 180.);
01744           mmr = mass[ix][iy][iz] / (rho_air * area * dz * 1e9);
01745
01746           /* Write output... */
01747           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01748                   tmean[ix][iy] / obscount[ix][iy],
01749                   z, lon, lat, press, temp, mmr, h2o, o3,
01750                   obsmean[ix][iy] / obscount[ix][iy]);
01751         }
01752       }
01753
01754   /* Close file... */
01755   if (t == ctl->t_stop)
01756     fclose(out);
01757 }
```

Here is the call graph for this function:



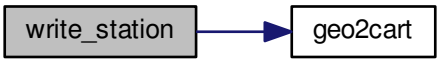
5.13.2.32 void write_station (const char * *filename*, ctl_t * *ctl*, atm_t * *atm*, double *t*)

Write station data.

Definition at line 1761 of file libtrac.c.

```
01765             {
01766
01767   static FILE *out;
01768
01769   static double rmax2, t0, t1, x0[3], x1[3];
01770
01771   static int init, ip, iq;
01772
01773   /* Init... */
01774   if (!init) {
01775     init = 1;
01776
01777     /* Write info... */
01778     printf("Write station data: %s\n", filename);
01779
01780     /* Create new file... */
01781     if (!(out = fopen(filename, "w")))
01782       ERRMSG("Cannot create file!");
01783
01784     /* Write header... */
01785     fprintf(out,
01786             "# $1 = time [s]\n"
01787             "# $2 = altitude [km]\n"
01788             "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01789     for (iq = 0; iq < ctl->nq; iq++)
01790       fprintf(out, "# $%i = %s [%s]\n", (iq + 5),
01791               ctl->qnt_name[iq], ctl->qnt_unit[iq]);
01792     fprintf(out, "\n");
01793
01794     /* Set geolocation and search radius... */
01795     geo2cart(0, ctl->stat_lon, ctl->stat_lat, x0);
01796     rmax2 = gsl_pow_2(ctl->stat_r);
01797   }
01798
01799   /* Set time interval for output... */
01800   t0 = t - 0.5 * ctl->dt_mod;
01801   t1 = t + 0.5 * ctl->dt_mod;
01802
01803   /* Loop over air parcels... */
01804   for (ip = 0; ip < atm->np; ip++) {
01805
01806     /* Check time... */
01807     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01808       continue;
01809
01810     /* Check station flag... */
01811     if (ctl->qnt_stat >= 0)
01812       if (atm->q[ctl->qnt_stat][ip])
01813         continue;
01814
01815     /* Get Cartesian coordinates... */
01816     geo2cart(0, atm->lon[ip], atm->lat[ip], x1);
01817
01818     /* Check horizontal distance... */
01819     if (DIST2(x0, x1) > rmax2)
01820       continue;
01821
01822     /* Set station flag... */
01823     if (ctl->qnt_stat >= 0)
01824       atm->q[ctl->qnt_stat][ip] = 1;
01825
01826     /* Write data... */
01827     fprintf(out, "%.2f %g %g %g",
01828             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
01829     for (iq = 0; iq < ctl->nq; iq++) {
01830       fprintf(out, " ");
01831       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01832     }
01833     fprintf(out, "\n");
01834   }
01835
01836   /* Close file... */
01837   if (t == ctl->t_stop)
01838     fclose(out);
01839 }
```

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 73
00146
00148 #define EX 721
00149
00151 #define EY 361
00152
00154 #define GX 720
00155
00157 #define GY 360
00158
00160 #define GZ 100
00161
00163 #define NTHREADS 128
00164
00166 #define NTIMER 20
00167
00168 /* ------------------------------------------------------------
00169    Structs...
00170    ------------------------------------------------------------ */
00171
00173 typedef struct {
00174
00176   int nq;
00177
00179   char qnt_name[NQ][LEN];
00180
00182   char qnt_unit[NQ][LEN];
00183
00185   char qnt_format[NQ][LEN];
00186
00188   int qnt_m;
00189
00191   int qnt_rho;
00192
00194   int qnt_r;
00195
00197   int qnt_ps;
00198
00200   int qnt_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
00239   int met_np;
00240
00242   double met_p[EP];
00243
00246   int isosurf;
00247
00249   char balloon[LEN];
00250
00252   double turb_dx_trop;
00253
00255   double turb_dx_strat;
00256
00258   double turb_dz_trop;
00259
00261   double turb_dz_strat;
00262
00264   double turb_meso;
00265
00267   double tdec_trop;
00268
00270   double tdec_strat;
00271
00273   char atm_basename[LEN];
00274
00276   char atm_gpfile[LEN];
00277
00279   double atm_dt_out;
00280
00282   char csi_basename[LEN];
00283
00285   double csi_dt_out;
00286
00288   char csi_obsfile[LEN];
00289
00291   double csi_obsmin;
00292
00294   double csi_modmin;
00295
00297   int csi_nz;
00298
00300   double csi_z0;
00301
00303   double csi_z1;
00304
00306   int csi_nx;
00307
00309   double csi_lon0;
00310
00312   double csi_lon1;
00313
00315   int csi_ny;
00316
00318   double csi_lat0;
00319
00321   double csi_lat1;
00322
00324   char grid_basename[LEN];
00325
00327   char grid_gpfile[LEN];
00328
00330   double grid_dt_out;
00331
00333   int grid_sparse;
00334
00336   int grid_nz;
00337
```

```
00339   double grid_z0;
00340
00342   double grid_z1;
00343
00345   int grid_nx;
00346
00348   double grid_lon0;
00349
00351   double grid_lon1;
00352
00354   int grid_ny;
00355
00357   double grid_lat0;
00358
00360   double grid_lat1;
00361
00363   char prof_basename[LEN];
00364
00366   char prof_obsfile[LEN];
00367
00369   int prof_nz;
00370
00372   double prof_z0;
00373
00375   double prof_z1;
00376
00378   int prof_nx;
00379
00381   double prof_lon0;
00382
00384   double prof_lon1;
00385
00387   int prof_ny;
00388
00390   double prof_lat0;
00391
00393   double prof_lat1;
00394
00396   char stat_basename[LEN];
00397
00399   double stat_lon;
00400
00402   double stat_lat;
00403
00405   double stat_r;
00406
00407 } ctl_t;
00408
00410 typedef struct {
00411
00413   int np;
00414
00416   double time[NP];
00417
00419   double p[NP];
00420
00422   double lon[NP];
00423
00425   double lat[NP];
00426
00428   double q[NQ][NP];
00429
00431   double up[NP];
00432
00434   double vp[NP];
00435
00437   double wp[NP];
00438
00439 } atm_t;
00440
00442 typedef struct {
00443
00445   double time;
00446
00448   int nx;
00449
00451   int ny;
00452
00454   int np;
00455
00457   double lon[EX];
00458
00460   double lat[EY];
00461
00463   double p[EP];
00464
00466   double ps[EX][EY];
```

```
00467
00469   float pl[EX][EY][EP];
00470
00472   float t[EX][EY][EP];
00473
00475   float u[EX][EY][EP];
00476
00478   float v[EX][EY][EP];
00479
00481   float w[EX][EY][EP];
00482
00484   float h2o[EX][EY][EP];
00485
00487   float o3[EX][EY][EP];
00488
00489 } met_t;
00490
00491 /* ------------------------------------------------------------
00492    Functions...
00493    ------------------------------------------------------------ */
00494
00496 void cart2geo(
00497   double *x,
00498   double *z,
00499   double *lon,
00500   double *lat);
00501
00503 double deg2dx(
00504   double dlon,
00505   double lat);
00506
00508 double deg2dy(
00509   double dlat);
00510
00512 double dp2dz(
00513   double dp,
00514   double p);
00515
00517 double dx2deg(
00518   double dx,
00519   double lat);
00520
00522 double dy2deg(
00523   double dy);
00524
00526 double dz2dp(
00527   double dz,
00528   double p);
00529
00531 void geo2cart(
00532   double z,
00533   double lon,
00534   double lat,
00535   double *x);
00536
00538 void get_met(
00539   ctl_t * ctl,
00540   char *metbase,
00541   double t,
00542   met_t * met0,
00543   met_t * met1);
00544
00546 void get_met_help(
00547   double t,
00548   int direct,
00549   char *metbase,
00550   double dt_met,
00551   char *filename);
00552
00554 void intpol_met_2d(
00555   double array[EX][EY],
00556   int ix,
00557   int iy,
00558   double wx,
00559   double wy,
00560   double *var);
00561
00563 void intpol_met_3d(
00564   float array[EX][EY][EP],
00565   int ip,
00566   int ix,
00567   int iy,
00568   double wp,
00569   double wx,
00570   double wy,
00571   double *var);
00572
```

```
00574 void intpol_met_space(
00575   met_t * met,
00576   double p,
00577   double lon,
00578   double lat,
00579   double *ps,
00580   double *t,
00581   double *u,
00582   double *v,
00583   double *w,
00584   double *h2o,
00585   double *o3);
00586
00588 void intpol_met_time(
00589   met_t * met0,
00590   met_t * met1,
00591   double ts,
00592   double p,
00593   double lon,
00594   double lat,
00595   double *ps,
00596   double *t,
00597   double *u,
00598   double *v,
00599   double *w,
00600   double *h2o,
00601   double *o3);
00602
00604 void jsec2time(
00605   double jsec,
00606   int *year,
00607   int *mon,
00608   int *day,
00609   int *hour,
00610   int *min,
00611   int *sec,
00612   double *remain);
00613
00615 int locate(
00616   double *xx,
00617   int n,
00618   double x);
00619
00621 void read_atm(
00622   const char *filename,
00623   ctl_t * ctl,
00624   atm_t * atm);
00625
00627 void read_ctl(
00628   const char *filename,
00629   int argc,
00630   char *argv[],
00631   ctl_t * ctl);
00632
00634 void read_met(
00635   ctl_t * ctl,
00636   char *filename,
00637   met_t * met);
00638
00640 void read_met_extrapolate(
00641   met_t * met);
00642
00644 void read_met_help(
00645   int ncid,
00646   char *varname,
00647   char *varname2,
00648   met_t * met,
00649   float dest[EX][EY][EP],
00650   float scl);
00651
00653 void read_met_ml2pl(
00654   ctl_t * ctl,
00655   met_t * met,
00656   float var[EX][EY][EP]);
00657
00659 void read_met_periodic(
00660   met_t * met);
00661
00663 double scan_ctl(
00664   const char *filename,
00665   int argc,
00666   char *argv[],
00667   const char *varname,
00668   int arridx,
00669   const char *defvalue,
00670   char *value);
00671
```

```
00673 void time2jsec(
00674   int year,
00675   int mon,
00676   int day,
00677   int hour,
00678   int min,
00679   int sec,
00680   double remain,
00681   double *jsec);
00682
00684 void timer(
00685   const char *name,
00686   int id,
00687   int mode);
00688
00689 /* Get tropopause pressure... */
00690 double tropopause(
00691   double t,
00692   double lat);
00693
00695 void write_atm(
00696   const char *filename,
00697   ctl_t * ctl,
00698   atm_t * atm,
00699   double t);
00700
00702 void write_csi(
00703   const char *filename,
00704   ctl_t * ctl,
00705   atm_t * atm,
00706   double t);
00707
00709 void write_grid(
00710   const char *filename,
00711   ctl_t * ctl,
00712   met_t * met0,
00713   met_t * met1,
00714   atm_t * atm,
00715   double t);
00716
00718 void write_prof(
00719   const char *filename,
00720   ctl_t * ctl,
00721   met_t * met0,
00722   met_t * met1,
00723   atm_t * atm,
00724   double t);
00725
00727 void write_station(
00728   const char *filename,
00729   ctl_t * ctl,
00730   atm_t * atm,
00731   double t);
```

5.15 match.c File Reference

Calculate deviations between two trajectories.

Functions

- int main (int argc, char ∗argv[ ])

5.15.1 Detailed Description

Calculate deviations between two trajectories.

Definition in file match.c.

5.15.2 Function Documentation

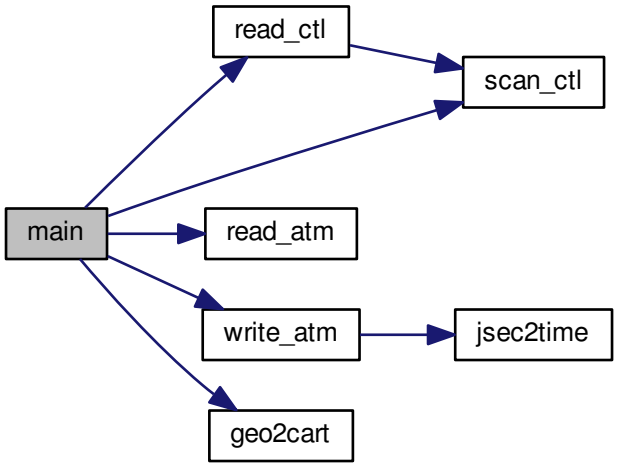
5.15.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 28 of file match.c.

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

```
00106           n++;
00107         }
00108       atm2->p[ip1] /= n;
00109       for (iq = 0; iq < ctl.nq; iq++)
00110         atm2->q[iq][ip1] /= n;
00111     }
00112
00113     /* Write filtered data... */
00114     sprintf(filename, "%s.filt", argv[3]);
00115     write_atm(filename, &ctl, atm2, 0);
00116   }
00117
00118   /* Loop over air parcels (reference data)... */
00119   for (ip2 = 0; ip2 < atm2->np; ip2++) {
00120
00121     /* Get trajectory length... */
00122     if (ip2 > 0) {
00123       geo2cart(0, atm2->lon[ip2 - 1], atm2->lat[ip2 - 1], x1);
00124       geo2cart(0, atm2->lon[ip2], atm2->lat[ip2], x2);
00125       lh += DIST(x1, x2);
00126       lv += fabs(Z(atm2->p[ip2 - 1]) - Z(atm2->p[ip2]));
00127       lt = fabs(atm2->time[ip2] - atm2->time[0]);
00128     }
00129
00130     /* Init... */
00131     n = 0;
00132     dh = 0;
00133     dv = 0;
00134     for (iq = 0; iq < ctl.nq; iq++)
00135       dq[iq] = 0;
00136     geo2cart(0, atm2->lon[ip2], atm2->lat[ip2], x2);
00137
00138     /* Find corresponding time step (test data)... */
00139     for (ip1 = 0; ip1 < atm1->np; ip1++)
00140       if (fabs(atm1->time[ip1] - atm2->time[ip2])
00141           < (filter ? filter_dt : 0.1)) {
00142
00143         /* Calculate deviations... */
00144         geo2cart(0, atm1->lon[ip1], atm1->lat[ip1], x1);
00145         dh += DIST(x1, x2);
00146         dv += Z(atm1->p[ip1]) - Z(atm2->p[ip2]);
00147         for (iq = 0; iq < ctl.nq; iq++)
00148           dq[iq] += atm1->q[iq][ip1] - atm2->q[iq][ip2];
00149         n++;
00150       }
00151
00152     /* Write output... */
00153     if (n > 0) {
00154       fprintf(out, "%.2f %.4f %.4f %.4f",
00155               atm2->time[ip2], Z(atm2->p[ip2]),
00156               atm2->lon[ip2], atm2->lat[ip2]);
00157       for (iq = 0; iq < ctl.nq; iq++) {
00158         fprintf(out, " ");
00159         fprintf(out, ctl.qnt_format[iq], atm2->q[iq][ip2]);
00160       }
00161       fprintf(out, " %.2f %g %g %g %g", lt, lv, lh, dv / n, dh / n);
00162       for (iq = 0; iq < ctl.nq; iq++) {
00163         fprintf(out, " ");
00164         fprintf(out, ctl.qnt_format[iq], dq[iq] / n);
00165       }
00166       fprintf(out, "\n");
00167     }
00168   }
00169
00170   /* Close file... */
00171   fclose(out);
00172
00173   /* Free... */
00174   free(atm1);
00175   free(atm2);
00176   free(atm3);
00177
00178   return EXIT_SUCCESS;
00179 }
```

Here is the call graph for this function:



5.16 match.c

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

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

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

5.17 met_map.c File Reference

Extract global map from meteorological data.

Functions

- int main (int argc, char ∗argv[ ])

5.17.1 Detailed Description

Extract global map from meteorological data.

Definition in file met_map.c.

5.17.2 Function Documentation

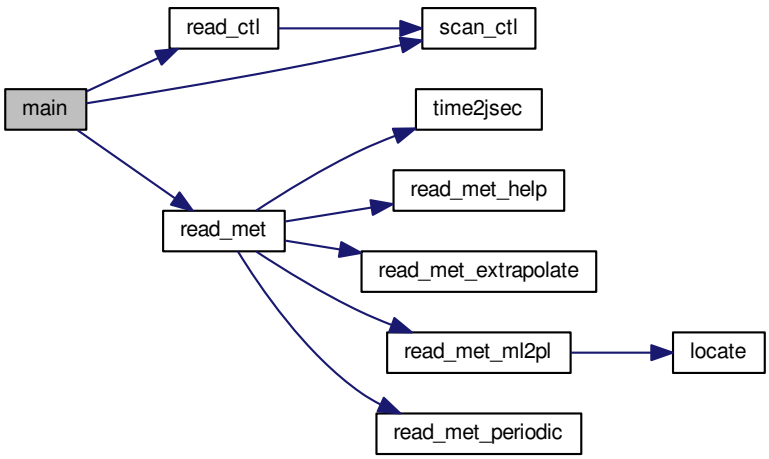
5.17.2.1 int main (int *argc*, char ∗ *argv[ ]*)

Definition at line 27 of file met_map.c.

```
00029                {
00030
00031   ctl_t ctl;
00032
00033   met_t *met;
00034
00035   FILE *in, *out;
00036
00037   static double dz, dzmin = 1e10, z, timem[EX][EY], psm[EX][EY], tm[EX][EY],
00038     um[EX][EY], vm[EX][EY], wm[EX][EY], h2om[EX][EY], o3m[EX][EY];
00039
00040   static int i, ip, ip2, ix, iy, np[EX][EY];
00041
00042   /* Allocate... */
00043   ALLOC(met, met_t, 1);
00044
00045   /* Check arguments... */
00046   if (argc < 4)
00047     ERRMSG("Give parameters: <ctl> <map.tab> <met0> [ <met1> ... ]");
00048
00049   /* Read control parameters... */
00050   read_ctl(argv[1], argc, argv, &ctl);
00051   z = scan_ctl(argv[1], argc, argv, "Z", -1, "", NULL);
00052
00053   /* Loop over files... */
00054   for (i = 3; i < argc; i++) {
00055
00056     /* Read meteorological data... */
00057     if (!(in = fopen(argv[i], "r")))
00058       continue;
00059     else
00060       fclose(in);
00061     read_met(&ctl, argv[i], met);
00062
00063     /* Find nearest pressure level... */
00064     for (ip2 = 0; ip2 < met->np; ip2++) {
00065       dz = fabs(Z(met->p[ip2]) - z);
00066       if (dz < dzmin) {
00067         dzmin = dz;
00068         ip = ip2;
00069       }
00070     }
00071
00072     /* Average data... */
00073     for (ix = 0; ix < met->nx; ix++)
00074       for (iy = 0; iy < met->ny; iy++) {
00075         timem[ix][iy] += met->time;
00076         tm[ix][iy] += met->t[ix][iy][ip];
00077         um[ix][iy] += met->u[ix][iy][ip];
00078         vm[ix][iy] += met->v[ix][iy][ip];
00079         wm[ix][iy] += met->w[ix][iy][ip];
00080         h2om[ix][iy] += met->h2o[ix][iy][ip];
00081         o3m[ix][iy] += met->o3[ix][iy][ip];
00082         psm[ix][iy] += met->ps[ix][iy];
00083         np[ix][iy]++;
00084       }
00085   }
00086
00087   /* Create output file... */
00088   printf("Write meteorological data file: %s\n", argv[2]);
00089   if (!(out = fopen(argv[2], "w")))
00090     ERRMSG("Cannot create file!");
00091
00092   /* Write header... */
00093   fprintf(out,
00094           "# $1  = time [s]\n"
00095           "# $2  = altitude [km]\n"
00096           "# $3  = longitude [deg]\n"
00097           "# $4  = latitude [deg]\n"
00098           "# $5  = pressure [hPa]\n"
00099           "# $6  = temperature [K]\n"
00100           "# $7  = zonal wind [m/s]\n"
00101           "# $8  = meridional wind [m/s]\n"
00102           "# $9  = vertical wind [hPa/s]\n"
00103           "# $10 = H2O volume mixing ratio [1]\n"
00104           "# $11 = O3 volume mixing ratio [1]\n"
00105           "# $12 = surface pressure [hPa]\n");
00106
00107   /* Write data... */
00108   for (iy = 0; iy < met->ny; iy++) {
00109     fprintf(out, "\n");
00110     for (ix = 0; ix < met->nx; ix++)
00111       if (met->lon[ix] >= 180)
00112         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g\n",
00113                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00114                 met->lon[ix] - 360.0, met->lat[iy], met->p[ip],
00115                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
```

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

Here is the call graph for this function:



5.18 met_map.c

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

```
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   ctl_t ctl;
00032
00033   met_t *met;
00034
00035   FILE *in, *out;
00036
00037   static double dz, dzmin = 1e10, z, timem[EX][EY], psm[EX][EY], tm[EX][EY],
00038     um[EX][EY], vm[EX][EY], wm[EX][EY], h2om[EX][EY], o3m[EX][EY];
00039
00040   static int i, ip, ip2, ix, iy, np[EX][EY];
00041
00042   /* Allocate... */
00043   ALLOC(met, met_t, 1);
00044
00045   /* Check arguments... */
00046   if (argc < 4)
00047     ERRMSG("Give parameters: <ctl> <map.tab> <met0> [ <met1> ... ]");
00048
00049   /* Read control parameters... */
00050   read_ctl(argv[1], argc, argv, &ctl);
00051   z = scan_ctl(argv[1], argc, argv, "Z", -1, "", NULL);
00052
00053   /* Loop over files... */
00054   for (i = 3; i < argc; i++) {
00055
00056     /* Read meteorological data... */
00057     if (!(in = fopen(argv[i], "r")))
00058       continue;
00059     else
00060       fclose(in);
00061     read_met(&ctl, argv[i], met);
00062
00063     /* Find nearest pressure level... */
00064     for (ip2 = 0; ip2 < met->np; ip2++) {
00065       dz = fabs(Z(met->p[ip2]) - z);
00066       if (dz < dzmin) {
00067         dzmin = dz;
00068         ip = ip2;
00069       }
00070     }
00071
00072     /* Average data... */
00073     for (ix = 0; ix < met->nx; ix++)
00074       for (iy = 0; iy < met->ny; iy++) {
00075         timem[ix][iy] += met->time;
00076         tm[ix][iy] += met->t[ix][iy][ip];
00077         um[ix][iy] += met->u[ix][iy][ip];
00078         vm[ix][iy] += met->v[ix][iy][ip];
00079         wm[ix][iy] += met->w[ix][iy][ip];
00080         h2om[ix][iy] += met->h2o[ix][iy][ip];
00081         o3m[ix][iy] += met->o3[ix][iy][ip];
00082         psm[ix][iy] += met->ps[ix][iy];
00083         np[ix][iy]++;
00084       }
00085   }
00086
00087   /* Create output file... */
00088   printf("Write meteorological data file: %s\n", argv[2]);
00089   if (!(out = fopen(argv[2], "w")))
00090     ERRMSG("Cannot create file!");
00091
00092   /* Write header... */
00093   fprintf(out,
00094           "# $1  = time [s]\n"
00095           "# $2  = altitude [km]\n"
00096           "# $3  = longitude [deg]\n"
00097           "# $4  = latitude [deg]\n"
00098           "# $5  = pressure [hPa]\n"
00099           "# $6  = temperature [K]\n"
00100           "# $7  = zonal wind [m/s]\n"
00101           "# $8  = meridional wind [m/s]\n"
00102           "# $9  = vertical wind [hPa/s]\n"
00103           "# $10 = H2O volume mixing ratio [1]\n"
00104           "# $11 = O3 volume mixing ratio [1]\n"
00105           "# $12 = surface pressure [hPa]\n");
00106
00107   /* Write data... */
00108   for (iy = 0; iy < met->ny; iy++) {
00109     fprintf(out, "\n");
00110     for (ix = 0; ix < met->nx; ix++)
00111       if (met->lon[ix] >= 180)
00112         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g %g\n",
00113                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
```

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

5.19 met_prof.c File Reference

Extract vertical profile from meteorological data.

Functions

- int main (int argc, char ∗argv[ ])

5.19.1 Detailed Description

Extract vertical profile from meteorological data.

Definition in file met_prof.c.

5.19.2 Function Documentation

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

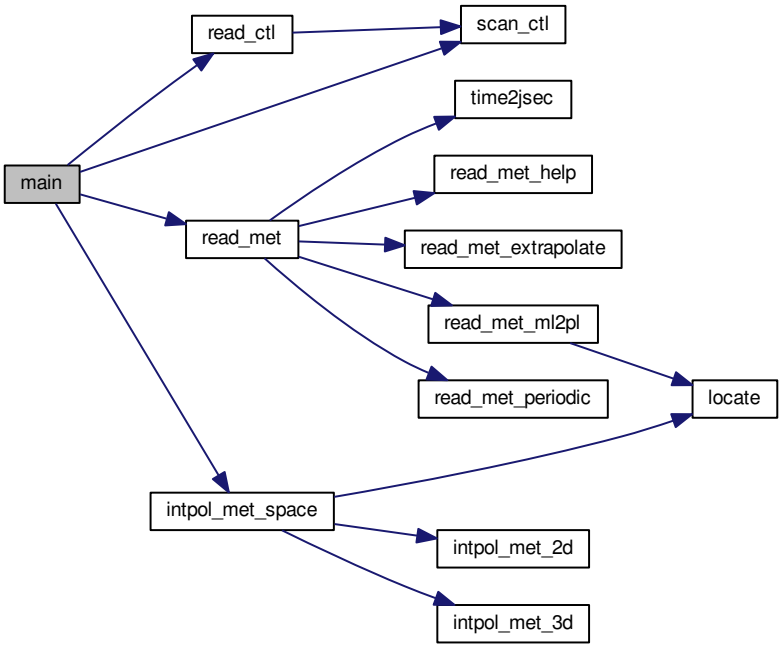
Definition at line 38 of file met_prof.c.

```
00040                 {
00041
00042   ctl_t ctl;
00043
00044   met_t *met;
00045
00046   FILE *in, *out;
00047
00048   static double timem[NZ], z, z0, z1, dz, lon, lon0, lon1, dlon, lonm[NZ],
00049     lat, lat0, lat1, dlat, latm[NZ], t, tm[NZ], u, um[NZ], v, vm[NZ],
00050     w, wm[NZ], h2o, h2om[NZ], o3, o3m[NZ], ps, psm[NZ];
00051
00052   static int i, iz, np[NZ];
00053
00054   /* Allocate... */
00055   ALLOC(met, met_t, 1);
00056
00057   /* Check arguments... */
00058   if (argc < 4)
00059     ERRMSG("Give parameters: <ctl> <prof.tab> <met0> [ <met1> ... ]");
```

```
00060
00061   /* Read control parameters... */
00062   read_ctl(argv[1], argc, argv, &ctl);
00063   z0 = scan_ctl(argv[1], argc, argv, "Z0", -1, "0", NULL);
00064   z1 = scan_ctl(argv[1], argc, argv, "Z1", -1, "60", NULL);
00065   dz = scan_ctl(argv[1], argc, argv, "DZ", -1, "1", NULL);
00066   lon0 = scan_ctl(argv[1], argc, argv, "LON0", -1, "0", NULL);
00067   lon1 = scan_ctl(argv[1], argc, argv, "LON1", -1, "0", NULL);
00068   dlon = scan_ctl(argv[1], argc, argv, "DLON", -1, "1", NULL);
00069   lat0 = scan_ctl(argv[1], argc, argv, "LAT0", -1, "0", NULL);
00070   lat1 = scan_ctl(argv[1], argc, argv, "LAT1", -1, "0", NULL);
00071   dlat = scan_ctl(argv[1], argc, argv, "DLAT", -1, "1", NULL);
00072
00073   /* Loop over input files... */
00074   for (i = 3; i < argc; i++) {
00075
00076     /* Read meteorological data... */
00077     if (!(in = fopen(argv[i], "r")))
00078       continue;
00079     else
00080       fclose(in);
00081     read_met(&ctl, argv[i], met);
00082
00083     /* Average... */
00084     for (z = z0; z <= z1; z += dz) {
00085       iz = (int) ((z - z0) / dz);
00086       if (iz < 0 || iz > NZ)
00087         ERRMSG("Too many altitudes!");
00088       for (lon = lon0; lon <= lon1; lon += dlon)
00089         for (lat = lat0; lat <= lat1; lat += dlat) {
00090           intpol_met_space(met, P(z), lon, lat, &ps,
00091                            &t, &u, &v, &w, &h2o, &o3);
00092           if (gsl_finite(t) && gsl_finite(u)
00093               && gsl_finite(v) && gsl_finite(w)) {
00094             timem[iz] += met->time;
00095             lonm[iz] += lon;
00096             latm[iz] += lat;
00097             tm[iz] += t;
00098             um[iz] += u;
00099             vm[iz] += v;
00100             wm[iz] += w;
00101             h2om[iz] += h2o;
00102             o3m[iz] += o3;
00103             psm[iz] += ps;
00104             np[iz]++;
00105           }
00106         }
00107     }
00108   }
00109
00110   /* Normalize... */
00111   for (z = z0; z <= z1; z += dz) {
00112     iz = (int) ((z - z0) / dz);
00113     if (np[iz] > 0) {
00114       timem[iz] /= np[iz];
00115       lonm[iz] /= np[iz];
00116       latm[iz] /= np[iz];
00117       tm[iz] /= np[iz];
00118       um[iz] /= np[iz];
00119       vm[iz] /= np[iz];
00120       wm[iz] /= np[iz];
00121       h2om[iz] /= np[iz];
00122       o3m[iz] /= np[iz];
00123       psm[iz] /= np[iz];
00124     } else {
00125       timem[iz] = GSL_NAN;
00126       lonm[iz] = GSL_NAN;
00127       latm[iz] = GSL_NAN;
00128       tm[iz] = GSL_NAN;
00129       um[iz] = GSL_NAN;
00130       vm[iz] = GSL_NAN;
00131       wm[iz] = GSL_NAN;
00132       h2om[iz] = GSL_NAN;
00133       o3m[iz] = GSL_NAN;
00134       psm[iz] = GSL_NAN;
00135     }
00136   }
00137
00138   /* Create output file... */
00139   printf("Write meteorological data file: %s\n", argv[2]);
00140   if (!(out = fopen(argv[2], "w")))
00141     ERRMSG("Cannot create file!");
00142
00143   /* Write header... */
00144   fprintf(out,
00145           "# $1  = time [s]\n"
00146           "# $2  = altitude [km]\n"
```

```
00147           "# $3  = longitude [deg]\n"
00148           "# $4  = latitude [deg]\n"
00149           "# $5  = pressure [hPa]\n"
00150           "# $6  = temperature [K]\n"
00151           "# $7  = zonal wind [m/s]\n"
00152           "# $8  = meridional wind [m/s]\n"
00153           "# $9  = vertical wind [hPa/s]\n"
00154           "# $10 = H2O volume mixing ratio [1]\n"
00155           "# $11 = O3 volume mixing ratio [1]\n"
00156           "# $12 = surface pressure [hPa]\n\n");
00157
00158   /* Write data... */
00159   for (z = z0; z <= z1; z += dz) {
00160     iz = (int) ((z - z0) / dz);
00161     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g\n",
00162             timem[iz], z, lonm[iz], latm[iz], P(z), tm[iz],
00163             um[iz], vm[iz], wm[iz], h2om[iz], o3m[iz], psm[iz]);
00164   }
00165
00166   /* Close file... */
00167   fclose(out);
00168
00169   /* Free... */
00170   free(met);
00171
00172   return EXIT_SUCCESS;
00173 }
```

Here is the call graph for this function:



5.20 met_prof.c

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

```
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 /* ------------------------------------------------------------
00028    Dimensions...
00029    ------------------------------------------------------------ */
00030
00031 /* Maximum number of altitudes. */
00032 #define NZ 1000
00033
00034 /* ------------------------------------------------------------
00035    Main...
00036    ------------------------------------------------------------ */
00037
00038 int main(
00039   int argc,
00040   char *argv[]) {
00041
00042   ctl_t ctl;
00043
00044   met_t *met;
00045
00046   FILE *in, *out;
00047
00048   static double timem[NZ], z, z0, z1, dz, lon, lon0, lon1, dlon, lonm[NZ],
00049     lat, lat0, lat1, dlat, latm[NZ], t, tm[NZ], u, um[NZ], v, vm[NZ],
00050     w, wm[NZ], h2o, h2om[NZ], o3, o3m[NZ], ps, psm[NZ];
00051
00052   static int i, iz, np[NZ];
00053
00054   /* Allocate... */
00055   ALLOC(met, met_t, 1);
00056
00057   /* Check arguments... */
00058   if (argc < 4)
00059     ERRMSG("Give parameters: <ctl> <prof.tab> <met0> [ <met1> ... ]");
00060
00061   /* Read control parameters... */
00062   read_ctl(argv[1], argc, argv, &ctl);
00063   z0 = scan_ctl(argv[1], argc, argv, "Z0", -1, "0", NULL);
00064   z1 = scan_ctl(argv[1], argc, argv, "Z1", -1, "60", NULL);
00065   dz = scan_ctl(argv[1], argc, argv, "DZ", -1, "1", NULL);
00066   lon0 = scan_ctl(argv[1], argc, argv, "LON0", -1, "0", NULL);
00067   lon1 = scan_ctl(argv[1], argc, argv, "LON1", -1, "0", NULL);
00068   dlon = scan_ctl(argv[1], argc, argv, "DLON", -1, "1", NULL);
00069   lat0 = scan_ctl(argv[1], argc, argv, "LAT0", -1, "0", NULL);
00070   lat1 = scan_ctl(argv[1], argc, argv, "LAT1", -1, "0", NULL);
00071   dlat = scan_ctl(argv[1], argc, argv, "DLAT", -1, "1", NULL);
00072
00073   /* Loop over input files... */
00074   for (i = 3; i < argc; i++) {
00075
00076     /* Read meteorological data... */
00077     if (!(in = fopen(argv[i], "r")))
00078       continue;
00079     else
00080       fclose(in);
00081     read_met(&ctl, argv[i], met);
00082
00083     /* Average... */
00084     for (z = z0; z <= z1; z += dz) {
00085       iz = (int) ((z - z0) / dz);
00086       if (iz < 0 || iz > NZ)
00087         ERRMSG("Too many altitudes!");
00088       for (lon = lon0; lon <= lon1; lon += dlon)
00089         for (lat = lat0; lat <= lat1; lat += dlat) {
00090           intpol_met_space(met, P(z), lon, lat, &ps,
00091                            &t, &u, &v, &w, &h2o, &o3);
00092           if (gsl_finite(t) && gsl_finite(u)
00093               && gsl_finite(v) && gsl_finite(w)) {
00094             timem[iz] += met->time;
00095             lonm[iz] += lon;
00096             latm[iz] += lat;
00097             tm[iz] += t;
00098             um[iz] += u;
00099             vm[iz] += v;
00100             wm[iz] += w;
```

```
00101             h2om[iz] += h2o;
00102             o3m[iz] += o3;
00103             psm[iz] += ps;
00104             np[iz]++;
00105           }
00106         }
00107     }
00108   }
00109
00110   /* Normalize... */
00111   for (z = z0; z <= z1; z += dz) {
00112     iz = (int) ((z - z0) / dz);
00113     if (np[iz] > 0) {
00114       timem[iz] /= np[iz];
00115       lonm[iz] /= np[iz];
00116       latm[iz] /= np[iz];
00117       tm[iz] /= np[iz];
00118       um[iz] /= np[iz];
00119       vm[iz] /= np[iz];
00120       wm[iz] /= np[iz];
00121       h2om[iz] /= np[iz];
00122       o3m[iz] /= np[iz];
00123       psm[iz] /= np[iz];
00124     } else {
00125       timem[iz] = GSL_NAN;
00126       lonm[iz] = GSL_NAN;
00127       latm[iz] = GSL_NAN;
00128       tm[iz] = GSL_NAN;
00129       um[iz] = GSL_NAN;
00130       vm[iz] = GSL_NAN;
00131       wm[iz] = GSL_NAN;
00132       h2om[iz] = GSL_NAN;
00133       o3m[iz] = GSL_NAN;
00134       psm[iz] = GSL_NAN;
00135     }
00136   }
00137
00138   /* Create output file... */
00139   printf("Write meteorological data file: %s\n", argv[2]);
00140   if (!(out = fopen(argv[2], "w")))
00141     ERRMSG("Cannot create file!");
00142
00143   /* Write header... */
00144   fprintf(out,
00145           "# $1  = time [s]\n"
00146           "# $2  = altitude [km]\n"
00147           "# $3  = longitude [deg]\n"
00148           "# $4  = latitude [deg]\n"
00149           "# $5  = pressure [hPa]\n"
00150           "# $6  = temperature [K]\n"
00151           "# $7  = zonal wind [m/s]\n"
00152           "# $8  = meridional wind [m/s]\n"
00153           "# $9  = vertical wind [hPa/s]\n"
00154           "# $10 = H2O volume mixing ratio [1]\n"
00155           "# $11 = O3 volume mixing ratio [1]\n"
00156           "# $12 = surface pressure [hPa]\n\n");
00157
00158   /* Write data... */
00159   for (z = z0; z <= z1; z += dz) {
00160     iz = (int) ((z - z0) / dz);
00161     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g\n",
00162             timem[iz], z, lonm[iz], latm[iz], P(z), tm[iz],
00163             um[iz], vm[iz], wm[iz], h2om[iz], o3m[iz], psm[iz]);
00164   }
00165
00166   /* Close file... */
00167   fclose(out);
00168
00169   /* Free... */
00170   free(met);
00171
00172   return EXIT_SUCCESS;
00173 }
```

5.21 met_sample.c File Reference

Sample meteorological data at given geolocations.

Functions

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

5.21.1 Detailed Description

Sample meteorological data at given geolocations.

Definition in file met_sample.c.

5.21.2 Function Documentation

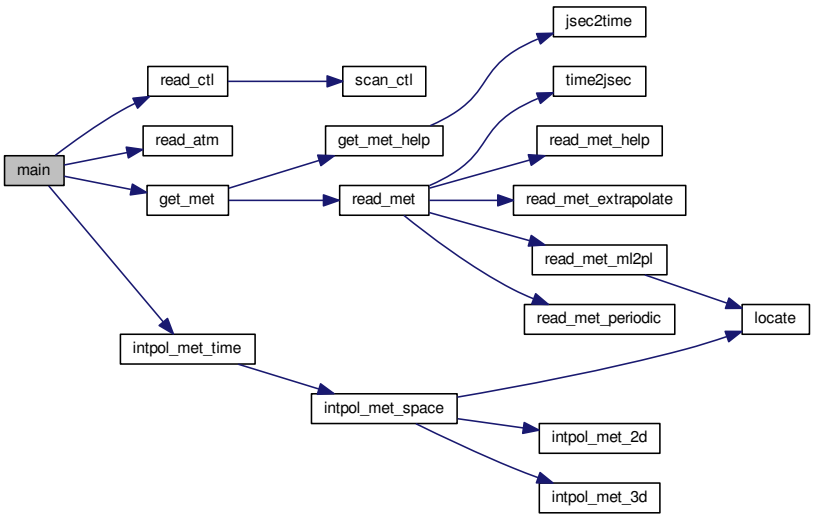
5.21.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 31 of file met_sample.c.

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

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

Here is the call graph for this function:



5.22 met_sample.c

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

```
00039   met_t *met0, *met1;
00040
00041   FILE *out;
00042
00043   double t, u, v, w, h2o, o3;
00044
00045   int ip;
00046
00047   /* Check arguments... */
00048   if (argc < 4)
00049     ERRMSG("Give parameters: <ctl> <metbase> <atm_in> <sample.tab>");
00050
00051   /* Allocate... */
00052   ALLOC(atm, atm_t, 1);
00053   ALLOC(met0, met_t, 1);
00054   ALLOC(met1, met_t, 1);
00055
00056   /* Read control parameters... */
00057   read_ctl(argv[1], argc, argv, &ctl);
00058
00059   /* Read atmospheric data... */
00060   read_atm(argv[3], &ctl, atm);
00061
00062   /* Create output file... */
00063   printf("Write meteorological data file: %s\n", argv[4]);
00064   if (!(out = fopen(argv[4], "w")))
00065     ERRMSG("Cannot create file!");
00066
00067   /* Write header... */
00068   fprintf(out,
00069           "# $1  = time [s]\n"
00070           "# $2  = altitude [km]\n"
00071           "# $3  = longitude [deg]\n"
00072           "# $4  = latitude [deg]\n"
00073           "# $5  = pressure [hPa]\n"
00074           "# $6  = temperature [K]\n"
00075           "# $7  = zonal wind [m/s]\n"
00076           "# $8  = meridional wind [m/s]\n"
00077           "# $9  = vertical wind [hPa/s]\n"
00078           "# $10 = H2O volume mixing ratio [1]\n"
00079           "# $11 = O3 volume mixing ratio [1]\n\n");
00080
00081   /* Loop over air parcels... */
00082   for (ip = 0; ip < atm->np; ip++) {
00083
00084     /* Get meteorological data... */
00085     get_met(&ctl, argv[2], atm->time[ip], met0, met1);
00086
00087     /* Interpolate meteorological data... */
00088     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00089                     atm->lat[ip], NULL, &t, &u, &v, &w, &h2o, &o3);
00090
00091     /* Write data... */
00092     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g\n",
00093             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip],
00094             atm->p[ip], t, u, v, w, h2o, o3);
00095   }
00096
00097   /* Close file... */
00098   fclose(out);
00099
00100   /* Free... */
00101   free(atm);
00102   free(met0);
00103   free(met1);
00104
00105   return EXIT_SUCCESS;
00106 }
```

5.23 met_zm.c File Reference

Extract zonal mean from meteorological data.

Functions

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

5.23.1 Detailed Description

Extract zonal mean from meteorological data.

Definition in file met_zm.c.

5.23.2 Function Documentation

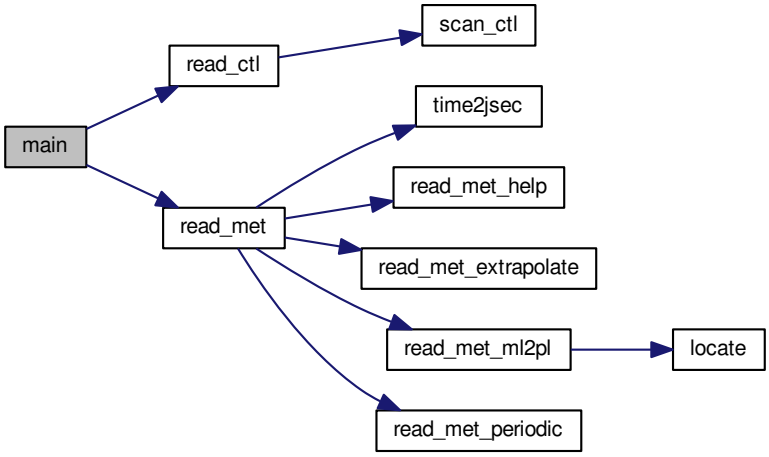
5.23.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file met_zm.c.

```
00029                {
00030
00031   ctl_t ctl;
00032
00033   met_t *met;
00034
00035   FILE *in, *out;
00036
00037   static double timem[EP][EY], psm[EP][EY], tm[EP][EY], um[EP][EY],
00038     vm[EP][EY], vhm[EP][EY], wm[EP][EY], h2om[EP][EY], o3m[EP][EY],
00039     psm2[EP][EY], tm2[EP][EY], um2[EP][EY], vm2[EP][EY], vhm2[EP][EY],
00040     wm2[EP][EY], h2om2[EP][EY], o3m2[EP][EY];
00041
00042   static int i, ip, ix, iy, np[EP][EY];
00043
00044   /* Allocate... */
00045   ALLOC(met, met_t, 1);
00046
00047   /* Check arguments... */
00048   if (argc < 4)
00049     ERRMSG("Give parameters: <ctl> <zm.tab> <met0> [ <met1> ... ]");
00050
00051   /* Read control parameters... */
00052   read_ctl(argv[1], argc, argv, &ctl);
00053
00054   /* Loop over files... */
00055   for (i = 3; i < argc; i++) {
00056
00057     /* Read meteorological data... */
00058     if (!(in = fopen(argv[i], "r")))
00059       continue;
00060     else
00061       fclose(in);
00062     read_met(&ctl, argv[i], met);
00063
00064     /* Average data... */
00065     for (ix = 0; ix < met->nx; ix++)
00066       for (iy = 0; iy < met->ny; iy++)
00067         for (ip = 0; ip < met->np; ip++) {
00068           timem[ip][iy] += met->time;
00069           tm[ip][iy] += met->t[ix][iy][ip];
00070           um[ip][iy] += met->u[ix][iy][ip];
00071           vm[ip][iy] += met->v[ix][iy][ip];
00072           vhm[ip][iy] += sqrt(gsl_pow_2(met->u[ix][iy][ip])
00073                               + gsl_pow_2(met->v[ix][iy][ip]));
00074           wm[ip][iy] += met->w[ix][iy][ip];
00075           h2om[ip][iy] += met->h2o[ix][iy][ip];
00076           o3m[ip][iy] += met->o3[ix][iy][ip];
00077           psm[ip][iy] += met->ps[ix][iy];
00078           tm2[ip][iy] += gsl_pow_2(met->t[ix][iy][ip]);
00079           um2[ip][iy] += gsl_pow_2(met->u[ix][iy][ip]);
00080           vm2[ip][iy] += gsl_pow_2(met->v[ix][iy][ip]);
00081           vhm2[ip][iy] += gsl_pow_2(met->u[ix][iy][ip])
00082             + gsl_pow_2(met->v[ix][iy][ip]);
00083           wm2[ip][iy] += gsl_pow_2(met->w[ix][iy][ip]);
00084           h2om2[ip][iy] += gsl_pow_2(met->h2o[ix][iy][ip]);
00085           o3m2[ip][iy] += gsl_pow_2(met->o3[ix][iy][ip]);
00086           psm2[ip][iy] += gsl_pow_2(met->ps[ix][iy]);
00087           np[ip][iy]++;
00088         }
00089   }
00090
00091   /* Create output file... */
00092   printf("Write meteorological data file: %s\n", argv[2]);
00093   if (!(out = fopen(argv[2], "w")))
```

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

Here is the call graph for this function:



5.24 met_zm.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   ctl_t ctl;
00032
00033   met_t *met;
00034
00035   FILE *in, *out;
00036
00037   static double timem[EP][EY], psm[EP][EY], tm[EP][EY], um[EP][EY],
00038     vm[EP][EY], vhm[EP][EY], wm[EP][EY], h2om[EP][EY], o3m[EP][EY],
00039     psm2[EP][EY], tm2[EP][EY], um2[EP][EY], vm2[EP][EY], vhm2[EP][EY],
00040     wm2[EP][EY], h2om2[EP][EY], o3m2[EP][EY];
00041
00042   static int i, ip, ix, iy, np[EP][EY];
00043
00044   /* Allocate... */
00045   ALLOC(met, met_t, 1);
00046
00047   /* Check arguments... */
00048   if (argc < 4)
00049     ERRMSG("Give parameters: <ctl> <zm.tab> <met0> [ <met1> ... ]");
00050
00051   /* Read control parameters... */
00052   read_ctl(argv[1], argc, argv, &ctl);
```

```
00053
00054   /* Loop over files... */
00055   for (i = 3; i < argc; i++) {
00056
00057     /* Read meteorological data... */
00058     if (!(in = fopen(argv[i], "r")))
00059       continue;
00060     else
00061       fclose(in);
00062     read_met(&ctl, argv[i], met);
00063
00064     /* Average data... */
00065     for (ix = 0; ix < met->nx; ix++)
00066       for (iy = 0; iy < met->ny; iy++)
00067         for (ip = 0; ip < met->np; ip++) {
00068           timem[ip][iy] += met->time;
00069           tm[ip][iy] += met->t[ix][iy][ip];
00070           um[ip][iy] += met->u[ix][iy][ip];
00071           vm[ip][iy] += met->v[ix][iy][ip];
00072           vhm[ip][iy] += sqrt(gsl_pow_2(met->u[ix][iy][ip])
00073                               + gsl_pow_2(met->v[ix][iy][ip]));
00074           wm[ip][iy] += met->w[ix][iy][ip];
00075           h2om[ip][iy] += met->h2o[ix][iy][ip];
00076           o3m[ip][iy] += met->o3[ix][iy][ip];
00077           psm[ip][iy] += met->ps[ix][iy];
00078           tm2[ip][iy] += gsl_pow_2(met->t[ix][iy][ip]);
00079           um2[ip][iy] += gsl_pow_2(met->u[ix][iy][ip]);
00080           vm2[ip][iy] += gsl_pow_2(met->v[ix][iy][ip]);
00081           vhm2[ip][iy] += gsl_pow_2(met->u[ix][iy][ip])
00082             + gsl_pow_2(met->v[ix][iy][ip]);
00083           wm2[ip][iy] += gsl_pow_2(met->w[ix][iy][ip]);
00084           h2om2[ip][iy] += gsl_pow_2(met->h2o[ix][iy][ip]);
00085           o3m2[ip][iy] += gsl_pow_2(met->o3[ix][iy][ip]);
00086           psm2[ip][iy] += gsl_pow_2(met->ps[ix][iy]);
00087           np[ip][iy]++;
00088         }
00089   }
00090
00091   /* Create output file... */
00092   printf("Write meteorological data file: %s\n", argv[2]);
00093   if (!(out = fopen(argv[2], "w")))
00094     ERRMSG("Cannot create file!");
00095
00096   /* Write header... */
00097   fprintf(out,
00098           "# $1  = time [s]\n"
00099           "# $2  = altitude [km]\n"
00100           "# $3  = latitude [deg]\n"
00101           "# $4  = temperature mean [K]\n"
00102           "# $5  = temperature standard deviation [K]\n"
00103           "# $6  = zonal wind mean [m/s]\n"
00104           "# $7  = zonal wind standard deviation [m/s]\n"
00105           "# $8  = meridional wind mean [m/s]\n"
00106           "# $9  = meridional wind standard deviation [m/s]\n"
00107           "# $10 = horizontal wind mean [m/s]\n"
00108           "# $11 = horizontal wind standard deviation [m/s]\n"
00109           "# $12 = vertical wind mean [hPa/s]\n"
00110           "# $13 = vertical wind standard deviation [hPa/s]\n"
00111           "# $14 = H2O vmr mean [1]\n"
00112           "# $15 = H2O vmr standard deviation [1]\n"
00113           "# $16 = O3 vmr mean [1]\n"
00114           "# $17 = O3 vmr standard deviation [1]\n"
00115           "# $18 = surface pressure mean [hPa]\n"
00116           "# $19 = surface pressure standard deviation [hPa]\n");
00117
00118   /* Write data... */
00119   for (iy = 0; iy < met->ny; iy++) {
00120     fprintf(out, "\n");
00121     for (ip = 0; ip < met->np; ip++)
00122       fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g"
00123               " %g %g %g %g %g %g %g %g\n",
00124               timem[ip][iy] / np[ip][iy], Z(met->p[ip]), met->lat[iy],
00125               tm[ip][iy] / np[ip][iy],
00126               sqrt(tm2[ip][iy] / np[ip][iy] -
00127                    gsl_pow_2(tm[ip][iy] / np[ip][iy])),
00128               um[ip][iy] / np[ip][iy],
00129               sqrt(um2[ip][iy] / np[ip][iy] -
00130                    gsl_pow_2(um[ip][iy] / np[ip][iy])),
00131               vm[ip][iy] / np[ip][iy],
00132               sqrt(vm2[ip][iy] / np[ip][iy] -
00133                    gsl_pow_2(vm[ip][iy] / np[ip][iy])),
00134               vhm[ip][iy] / np[ip][iy],
00135               sqrt(vhm2[ip][iy] / np[ip][iy] -
00136                    gsl_pow_2(vhm[ip][iy] / np[ip][iy])),
00137               wm[ip][iy] / np[ip][iy],
00138               sqrt(wm2[ip][iy] / np[ip][iy] -
00139                    gsl_pow_2(wm[ip][iy] / np[ip][iy])),
```

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

5.25 smago.c File Reference

Estimate horizontal diffusivity based on Smagorinsky theory.

Functions

- int main (int argc, char ∗argv[ ])

5.25.1 Detailed Description

Estimate horizontal diffusivity based on Smagorinsky theory.

Definition in file smago.c.

5.25.2 Function Documentation

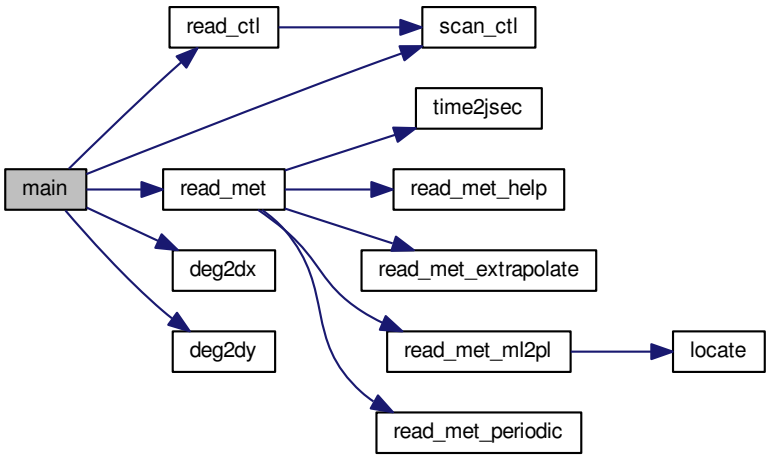
5.25.2.1 int main (int *argc*, char ∗ *argv[ ]*)

Definition at line 8 of file smago.c.

```
00010                {
00011
00012   ctl_t ctl;
00013
00014   met_t *met;
00015
00016   FILE *out;
00017
00018   static double dz, dzmin = 1e10, z, t, s, ls2, k[EX][EY], c = 0.15;
00019
00020   static int ip, ip2, ix, iy;
00021
00022   /* Allocate... */
00023   ALLOC(met, met_t, 1);
00024
00025   /* Check arguments... */
00026   if (argc < 4)
00027     ERRMSG("Give parameters: <ctl> <map.tab> <met>");
00028
00029   /* Read control parameters... */
00030   read_ctl(argv[1], argc, argv, &ctl);
00031   z = scan_ctl(argv[1], argc, argv, "Z", -1, "", NULL);
00032
00033   /* Read meteorological data... */
00034   read_met(&ctl, argv[3], met);
```

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

Here is the call graph for this function:



5.26 smago.c

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

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

5.27 split.c File Reference

Split air parcels into a larger number of parcels.

Functions

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

5.27.1 Detailed Description

Split air parcels into a larger number of parcels.

Definition in file split.c.

5.27.2 Function Documentation

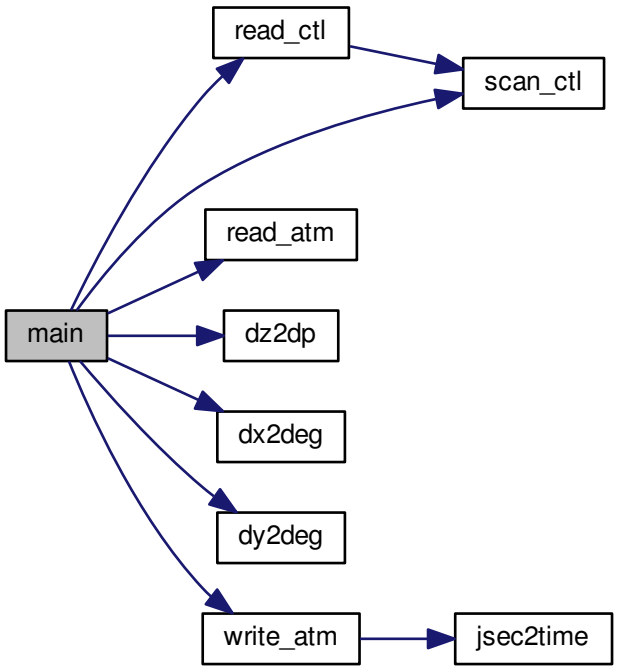
5.27.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file split.c.

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

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

Here is the call graph for this function:



5.28 split.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   atm_t *atm, *atm2;
00032
00033   ctl_t ctl;
00034
00035   gsl_rng *rng;
00036
00037   double m, mtot = 0, dt, dx, dz, mmax = 0,
00038     t0, t1, z0, z1, lon0, lon1, lat0, lat1;
00039
00040   int i, ip, iq, n;
00041
00042   /* Allocate... */
00043   ALLOC(atm, atm_t, 1);
00044   ALLOC(atm2, atm_t, 1);
00045
00046   /* Check arguments... */
00047   if (argc < 4)
00048     ERRMSG("Give parameters: <ctl> <atm_in> <atm_out>");
00049
00050   /* Read control parameters... */
00051   read_ctl(argv[1], argc, argv, &ctl);
00052   n = (int) scan_ctl(argv[1], argc, argv, "SPLIT_N", -1, "", NULL);
00053   m = scan_ctl(argv[1], argc, argv, "SPLIT_M", -1, "-999", NULL);
00054   dt = scan_ctl(argv[1], argc, argv, "SPLIT_DT", -1, "0", NULL);
00055   t0 = scan_ctl(argv[1], argc, argv, "SPLIT_T0", -1, "0", NULL);
00056   t1 = scan_ctl(argv[1], argc, argv, "SPLIT_T1", -1, "0", NULL);
00057   dz = scan_ctl(argv[1], argc, argv, "SPLIT_DZ", -1, "0", NULL);
00058   z0 = scan_ctl(argv[1], argc, argv, "SPLIT_Z0", -1, "0", NULL);
00059   z1 = scan_ctl(argv[1], argc, argv, "SPLIT_Z1", -1, "0", NULL);
00060   dx = scan_ctl(argv[1], argc, argv, "SPLIT_DX", -1, "0", NULL);
00061   lon0 = scan_ctl(argv[1], argc, argv, "SPLIT_LON0", -1, "0", NULL);
00062   lon1 = scan_ctl(argv[1], argc, argv, "SPLIT_LON1", -1, "0", NULL);
00063   lat0 = scan_ctl(argv[1], argc, argv, "SPLIT_LAT0", -1, "0", NULL);
00064   lat1 = scan_ctl(argv[1], argc, argv, "SPLIT_LAT1", -1, "0", NULL);
00065
00066   /* Init random number generator... */
00067   gsl_rng_env_setup();
00068   rng = gsl_rng_alloc(gsl_rng_default);
00069
00070   /* Read atmospheric data... */
00071   read_atm(argv[2], &ctl, atm);
00072
00073   /* Get total and maximum mass... */
00074   if (ctl.qnt_m >= 0)
00075     for (ip = 0; ip < atm->np; ip++) {
00076       mtot += atm->q[ctl.qnt_m][ip];
00077       mmax = GSL_MAX(mmax, atm->q[ctl.qnt_m][ip]);
00078     }
00079   if (m > 0)
00080     mtot = m;
00081
00082   /* Loop over air parcels... */
00083   for (i = 0; i < n; i++) {
00084
00085     /* Select air parcel... */
00086     if (ctl.qnt_m >= 0)
00087       do {
00088         ip = (int) gsl_rng_uniform_int(rng, (long unsigned int) atm->np);
00089       } while (gsl_rng_uniform(rng) > atm->q[ctl.qnt_m][ip] / mmax);
```

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

5.29 time2jsec.c File Reference

Convert date to Julian seconds.

Functions

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

5.29.1 Detailed Description

Convert date to Julian seconds.

Definition in file time2jsec.c.

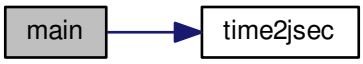
5.29.2 Function Documentation

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

Definition at line 27 of file time2jsec.c.

```
00029                {
00030
00031   double jsec, remain;
00032
00033   int day, hour, min, mon, sec, year;
00034
00035   /* Check arguments... */
00036   if (argc < 8)
00037     ERRMSG("Give parameters: <year> <mon> <day> <hour> <min> <sec> <remain>");
00038
00039   /* Read arguments... */
00040   year = atoi(argv[1]);
00041   mon = atoi(argv[2]);
00042   day = atoi(argv[3]);
00043   hour = atoi(argv[4]);
00044   min = atoi(argv[5]);
00045   sec = atoi(argv[6]);
00046   remain = atof(argv[7]);
00047
00048   /* Convert... */
00049   time2jsec(year, mon, day, hour, min, sec, remain, &jsec);
00050   printf("%.2f\n", jsec);
00051
00052   return EXIT_SUCCESS;
00053 }
```

Here is the call graph for this function:



5.30 time2jsec.c

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

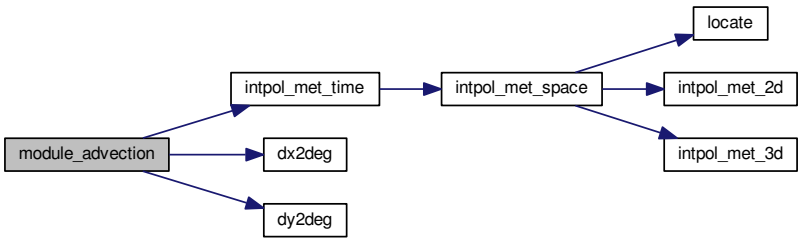
5.31.2.2 void module_advection (met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt*)

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:



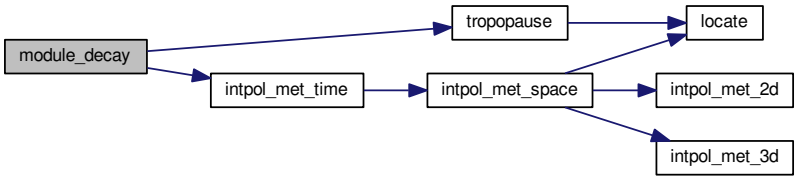
5.31.2.3 void module_decay (ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt*)

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*)

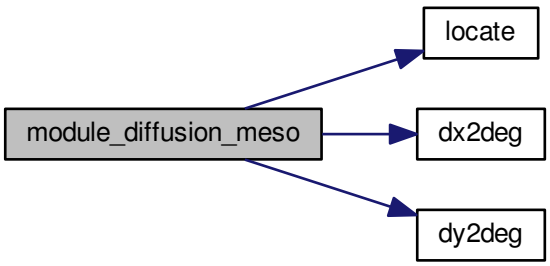
Calculate mesoscale diffusion.

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*)

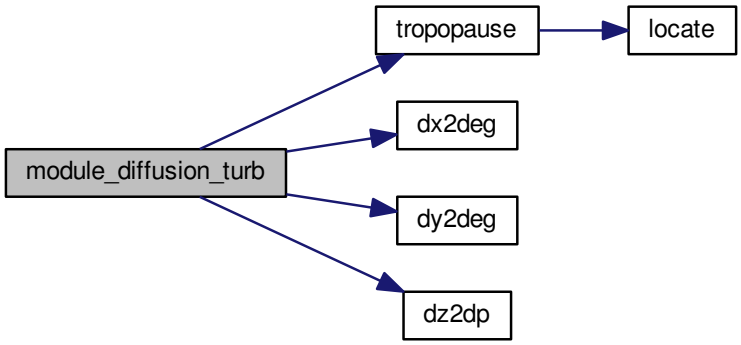
Calculate turbulent diffusion.

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*)

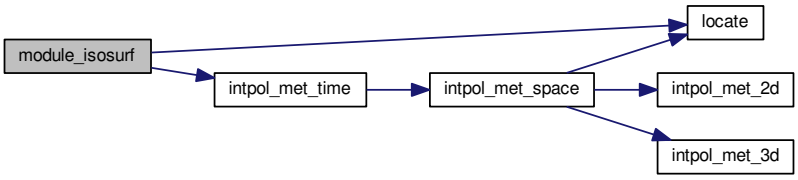
Force air parcels to stay on isosurface.

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*)

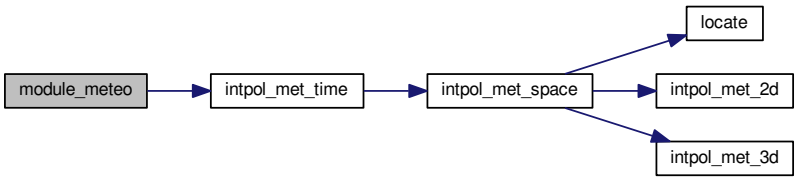
Interpolate meteorological data for air parcel positions.

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:



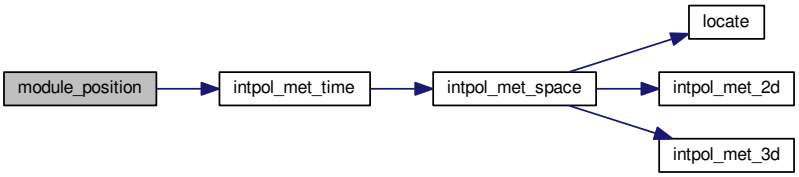
5.31.2.8 void module_position (met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*)

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:



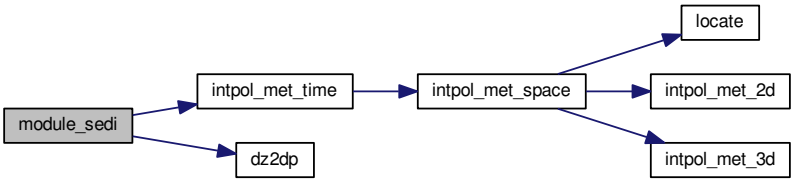
5.31.2.9 void module_sedi (ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt*)

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:



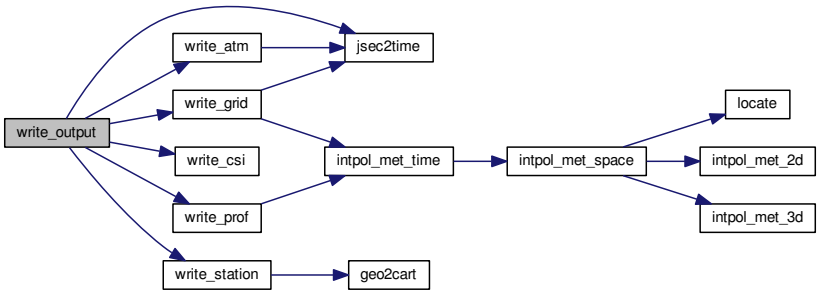
5.31.2.10 void write_output (const char * *dirname*, ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, double *t*)

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.

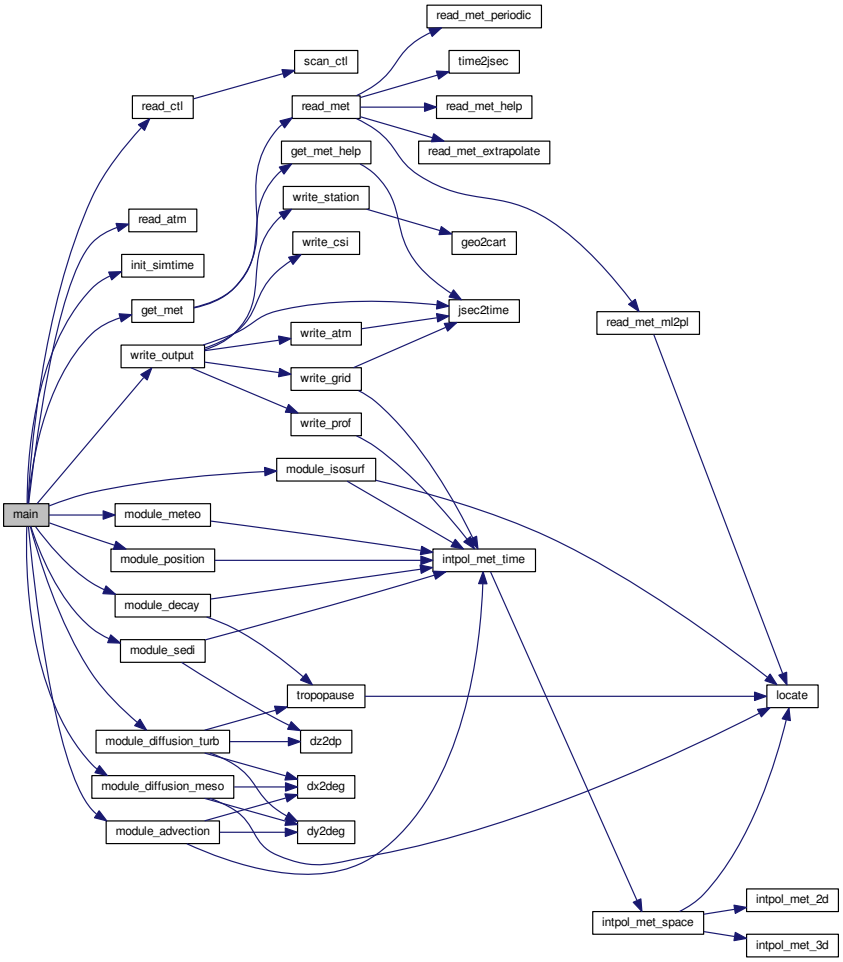
```
00162                {
00163
00164   ctl_t ctl;
00165
00166   atm_t *atm;
00167
00168   met_t *met0, *met1;
00169
00170   gsl_rng *rng[NTHREADS];
00171
00172   FILE *dirlist;
00173
00174   char dirname[LEN], filename[LEN];
00175
00176   double *dt, t, t0;
00177
00178   int i, ip, ntask = 0, rank = 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[]*)

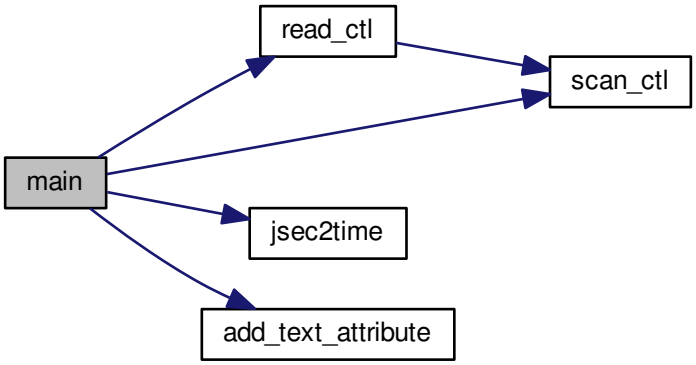
Definition at line 41 of file wind.c.

```
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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