# 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 422 of file libtrac.h.

#### 4.1.2 Field Documentation

##### 4.1.2.1 int atm_t::np

Number of air pacels.

Definition at line 425 of file libtrac.h.

##### 4.1.2.2 double atm_t::time[NP]

Time [s].

Definition at line 428 of file libtrac.h.

##### 4.1.2.3 double atm_t::p[NP]

Pressure [hPa].

Definition at line 431 of file libtrac.h.

##### 4.1.2.4 double atm_t::lon[NP]

Longitude [deg].

Definition at line 434 of file libtrac.h.

##### 4.1.2.5 double atm_t::lat[NP]

Latitude [deg].

Definition at line 437 of file libtrac.h.

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

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

Definition at line 440 of file libtrac.h.

##### 4.1.2.7 double atm_t::up[NP]

Zonal wind perturbation [m/s].

Definition at line 443 of file libtrac.h.

#### 4.1.2.8 double atm_t::vp[NP]

Meridional wind perturbation [m/s].

Definition at line 446 of file libtrac.h.

#### 4.1.2.9 double atm_t::wp[NP]

Vertical velocity perturbation [hPa/s].

Definition at line 449 of file libtrac.h.

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

- libtrac.h

## 4.2 ctl_t Struct Reference

Control parameters.

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

### Data Fields

- int nq
  *Number of quantities.*
- char qnt_name [NQ][LEN]
  *Quantity names.*
- char qnt_unit [NQ][LEN]
  *Quantity units.*
- char qnt_format [NQ][LEN]
  *Quantity output format.*
- int qnt_m
  *Quantity array index for mass.*
- int qnt_rho
  *Quantity array index for particle density.*
- int qnt_r
  *Quantity array index for particle radius.*
- int qnt_ps
  *Quantity array index for surface pressure.*
- int qnt_p
  *Quantity array index for pressure.*
- int qnt_t
  *Quantity array index for temperature.*
- int qnt_u
  *Quantity array index for zonal wind.*
- int qnt_v
  *Quantity array index for meridional wind.*
- int qnt_w
  *Quantity array index for vertical velocity.*

- int qnt_h2o
  *Quantity array index for water vapor vmr.*
- int qnt_o3
  *Quantity array index for ozone vmr.*
- int qnt_theta
  *Quantity array index for potential temperature.*
- int qnt_pv
  *Quantity array index for potential vorticity.*
- int qnt_tice
  *Quantity array index for T_ice.*
- int qnt_tnat
  *Quantity array index for T_NAT.*
- int qnt_stat
  *Quantity array index for station flag.*
- int direction
  *Direction flag (1=forward calculation, -1=backward calculation).*
- double t_start
  *Start time of simulation [s].*
- double t_stop
  *Stop time of simulation [s].*
- double dt_mod
  *Time step of simulation [s].*
- double dt_met
  *Time step of meteorological data [s].*
- int met_np
  *Number of target pressure levels.*
- double met_p [EP]
  *Target pressure levels [hPa].*
- int isosurf
  *Isosurface parameter (0=none, 1=pressure, 2=density, 3=theta, 4=balloon).*
- char balloon [LEN]
  *Balloon position filename.*
- double turb_dx_trop
  *Horizontal turbulent diffusion coefficient (troposphere) [m^2/s].*
- double turb_dx_strat
  *Horizontal turbulent diffusion coefficient (stratosphere) [m^2/s].*
- double turb_dz_trop
  *Vertical turbulent diffusion coefficient (troposphere) [m^2/s].*
- double turb_dz_strat
  *Vertical turbulent diffusion coefficient (stratosphere) [m^2/s].*
- double turb_meso
  *Scaling factor for mesoscale wind fluctuations.*
- double tdec_trop
  *Life time of particles (troposphere) [s].*
- double tdec_strat
  *Life time of particles (stratosphere) [s].*
- char atm_basename [LEN]
  *Basename of atmospheric data files.*
- char atm_gpfile [LEN]
  *Gnuplot file for atmospheric data.*
- double atm_dt_out

*Time step for atmospheric data output [s].*

- char csi_basename [LEN]

  *Basename of CSI data files.*
- double csi_dt_out

  *Time step for CSI data output [s].*
- char csi_obsfile [LEN]

  *Observation data file for CSI analysis.*
- double csi_obsmin

  *Minimum observation index to trigger detection.*
- double csi_modmin

  *Minimum column density to trigger detection [kg/m^2].*
- int csi_nz

  *Number of altitudes of gridded CSI data.*
- double csi_z0

  *Lower altitude of gridded CSI data [km].*
- double csi_z1

  *Upper altitude of gridded CSI data [km].*
- int csi_nx

  *Number of longitudes of gridded CSI data.*
- double csi_lon0

  *Lower longitude of gridded CSI data [deg].*
- double csi_lon1

  *Upper longitude of gridded CSI data [deg].*
- int csi_ny

  *Number of latitudes of gridded CSI data.*
- double csi_lat0

  *Lower latitude of gridded CSI data [deg].*
- double csi_lat1

  *Upper latitude of gridded CSI data [deg].*
- char grid_basename [LEN]

  *Basename of grid data files.*
- char grid_gpfile [LEN]

  *Gnuplot file for gridded data.*
- double grid_dt_out

  *Time step for gridded data output [s].*
- int grid_sparse

  *Sparse output in grid data files (0=no, 1=yes).*
- int grid_nz

  *Number of altitudes of gridded data.*
- double grid_z0

  *Lower altitude of gridded data [km].*
- double grid_z1

  *Upper altitude of gridded data [km].*
- int grid_nx

  *Number of longitudes of gridded data.*
- double grid_lon0

  *Lower longitude of gridded data [deg].*
- double grid_lon1

  *Upper longitude of gridded data [deg].*
- int grid_ny

  *Number of latitudes of gridded data.*

- double grid_lat0

  *Lower latitude of gridded data [deg].*
- double grid_lat1

  *Upper latitude of gridded data [deg].*
- char prof_basename [LEN]

  *Basename for profile output file.*
- char prof_obsfile [LEN]

  *Observation data file for profile output.*
- int prof_nz

  *Number of altitudes of gridded profile data.*
- double prof_z0

  *Lower altitude of gridded profile data [km].*
- double prof_z1

  *Upper altitude of gridded profile data [km].*
- int prof_nx

  *Number of longitudes of gridded profile data.*
- double prof_lon0

  *Lower longitude of gridded profile data [deg].*
- double prof_lon1

  *Upper longitude of gridded profile data [deg].*
- int prof_ny

  *Number of latitudes of gridded profile data.*
- double prof_lat0

  *Lower latitude of gridded profile data [deg].*
- double prof_lat1

  *Upper latitude of gridded profile data [deg].*
- char stat_basename [LEN]

  *Basename of station data file.*
- double stat_lon

  *Longitude of station [deg].*
- double stat_lat

  *Latitude of station [deg].*
- double stat_r

  *Search radius around station [km].*

#### 4.2.1 Detailed Description

Control parameters.

Definition at line 173 of file libtrac.h.

#### 4.2.2 Field Documentation

##### 4.2.2.1 int ctl_t::nq

Number of quantities.

Definition at line 176 of file libtrac.h.

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

Quantity names.

Definition at line 179 of file libtrac.h.

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

Quantity units.

Definition at line 182 of file libtrac.h.

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

Quantity output format.

Definition at line 185 of file libtrac.h.

#### 4.2.2.5 int ctl_t::qnt_m

Quantity array index for mass.

Definition at line 188 of file libtrac.h.

#### 4.2.2.6 int ctl_t::qnt_rho

Quantity array index for particle density.

Definition at line 191 of file libtrac.h.

#### 4.2.2.7 int ctl_t::qnt_r

Quantity array index for particle radius.

Definition at line 194 of file libtrac.h.

#### 4.2.2.8 int ctl_t::qnt_ps

Quantity array index for surface pressure.

Definition at line 197 of file libtrac.h.

#### 4.2.2.9 int ctl_t::qnt_p

Quantity array index for pressure.

Definition at line 200 of file libtrac.h.

#### 4.2.2.10 int ctl_t::qnt_t

Quantity array index for temperature.

Definition at line 203 of file libtrac.h.

#### 4.2.2.11 int ctl_t::qnt_u

Quantity array index for zonal wind.

Definition at line 206 of file libtrac.h.

#### 4.2.2.12 int ctl_t::qnt_v

Quantity array index for meridional wind.

Definition at line 209 of file libtrac.h.

#### 4.2.2.13 int ctl_t::qnt_w

Quantity array index for vertical velocity.

Definition at line 212 of file libtrac.h.

#### 4.2.2.14 int ctl_t::qnt_h2o

Quantity array index for water vapor vmr.

Definition at line 215 of file libtrac.h.

#### 4.2.2.15 int ctl_t::qnt_o3

Quantity array index for ozone vmr.

Definition at line 218 of file libtrac.h.

#### 4.2.2.16 int ctl_t::qnt_theta

Quantity array index for potential temperature.

Definition at line 221 of file libtrac.h.

#### 4.2.2.17 int ctl_t::qnt_pv

Quantity array index for potential vorticity.

Definition at line 224 of file libtrac.h.

#### 4.2.2.18 int ctl_t::qnt_tice

Quantity array index for T_ice.

Definition at line 227 of file libtrac.h.

#### 4.2.2.19 int ctl_t::qnt_tnat

Quantity array index for T_NAT.

Definition at line 230 of file libtrac.h.

#### 4.2.2.20 int ctl_t::qnt_stat

Quantity array index for station flag.

Definition at line 233 of file libtrac.h.

#### 4.2.2.21 int ctl_t::direction

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

Definition at line 236 of file libtrac.h.

#### 4.2.2.22 double ctl_t::t_start

Start time of simulation [s].

Definition at line 239 of file libtrac.h.

#### 4.2.2.23 double ctl_t::t_stop

Stop time of simulation [s].

Definition at line 242 of file libtrac.h.

#### 4.2.2.24 double ctl_t::dt_mod

Time step of simulation [s].

Definition at line 245 of file libtrac.h.

#### 4.2.2.25 double ctl_t::dt_met

Time step of meteorological data [s].

Definition at line 248 of file libtrac.h.

#### 4.2.2.26 int ctl_t::met_np

Number of target pressure levels.

Definition at line 251 of file libtrac.h.

#### 4.2.2.27 double ctl_t::met_p[EP]

Target pressure levels [hPa].

Definition at line 254 of file libtrac.h.

#### 4.2.2.28 int ctl_t::isosurf

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

Definition at line 258 of file libtrac.h.

#### 4.2.2.29 char ctl_t::balloon[LEN]

Balloon position filename.

Definition at line 261 of file libtrac.h.

#### 4.2.2.30 double ctl_t::turb_dx_trop

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

Definition at line 264 of file libtrac.h.

#### 4.2.2.31 double ctl_t::turb_dx_strat

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

Definition at line 267 of file libtrac.h.

#### 4.2.2.32 double ctl_t::turb_dz_trop

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

Definition at line 270 of file libtrac.h.

#### 4.2.2.33 double ctl_t::turb_dz_strat

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

Definition at line 273 of file libtrac.h.

#### 4.2.2.34 double ctl_t::turb_meso

Scaling factor for mesoscale wind fluctuations.

Definition at line 276 of file libtrac.h.

#### 4.2.2.35 double ctl_t::tdec_trop

Life time of particles (troposphere) [s].

Definition at line 279 of file libtrac.h.

#### 4.2.2.36 double ctl_t::tdec_strat

Life time of particles (stratosphere) [s].

Definition at line 282 of file libtrac.h.

#### 4.2.2.37 char ctl_t::atm_basename[LEN]

Basename of atmospheric data files.

Definition at line 285 of file libtrac.h.

#### 4.2.2.38 char ctl_t::atm_gpfile[LEN]

Gnuplot file for atmospheric data.

Definition at line 288 of file libtrac.h.

#### 4.2.2.39 double ctl_t::atm_dt_out

Time step for atmospheric data output [s].

Definition at line 291 of file libtrac.h.

#### 4.2.2.40 char ctl_t::csi_basename[LEN]

Basename of CSI data files.

Definition at line 294 of file libtrac.h.

#### 4.2.2.41 double ctl_t::csi_dt_out

Time step for CSI data output [s].

Definition at line 297 of file libtrac.h.

#### 4.2.2.42 char ctl_t::csi_obsfile[LEN]

Observation data file for CSI analysis.

Definition at line 300 of file libtrac.h.

#### 4.2.2.43 double ctl_t::csi_obsmin

Minimum observation index to trigger detection.

Definition at line 303 of file libtrac.h.

#### 4.2.2.44 double ctl_t::csi_modmin

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

Definition at line 306 of file libtrac.h.

#### 4.2.2.45 int ctl_t::csi_nz

Number of altitudes of gridded CSI data.

Definition at line 309 of file libtrac.h.

#### 4.2.2.46 double ctl_t::csi_z0

Lower altitude of gridded CSI data [km].

Definition at line 312 of file libtrac.h.

#### 4.2.2.47 double ctl_t::csi_z1

Upper altitude of gridded CSI data [km].

Definition at line 315 of file libtrac.h.

#### 4.2.2.48 int ctl_t::csi_nx

Number of longitudes of gridded CSI data.

Definition at line 318 of file libtrac.h.

#### 4.2.2.49 double ctl_t::csi_lon0

Lower longitude of gridded CSI data [deg].

Definition at line 321 of file libtrac.h.

#### 4.2.2.50 double ctl_t::csi_lon1

Upper longitude of gridded CSI data [deg].

Definition at line 324 of file libtrac.h.

#### 4.2.2.51 int ctl_t::csi_ny

Number of latitudes of gridded CSI data.

Definition at line 327 of file libtrac.h.

#### 4.2.2.52 double ctl_t::csi_lat0

Lower latitude of gridded CSI data [deg].

Definition at line 330 of file libtrac.h.

#### 4.2.2.53 double ctl_t::csi_lat1

Upper latitude of gridded CSI data [deg].

Definition at line 333 of file libtrac.h.

#### 4.2.2.54 char ctl_t::grid_basename[LEN]

Basename of grid data files.

Definition at line 336 of file libtrac.h.

#### 4.2.2.55 char ctl_t::grid_gpfile[LEN]

Gnuplot file for gridded data.

Definition at line 339 of file libtrac.h.

#### 4.2.2.56 double ctl_t::grid_dt_out

Time step for gridded data output [s].

Definition at line 342 of file libtrac.h.

#### 4.2.2.57 int ctl_t::grid_sparse

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

Definition at line 345 of file libtrac.h.

#### 4.2.2.58 int ctl_t::grid_nz

Number of altitudes of gridded data.

Definition at line 348 of file libtrac.h.

#### 4.2.2.59 double ctl_t::grid_z0

Lower altitude of gridded data [km].

Definition at line 351 of file libtrac.h.

#### 4.2.2.60 double ctl_t::grid_z1

Upper altitude of gridded data [km].

Definition at line 354 of file libtrac.h.

#### 4.2.2.61 int ctl_t::grid_nx

Number of longitudes of gridded data.

Definition at line 357 of file libtrac.h.

#### 4.2.2.62 double ctl_t::grid_lon0

Lower longitude of gridded data [deg].

Definition at line 360 of file libtrac.h.

#### 4.2.2.63 double ctl_t::grid_lon1

Upper longitude of gridded data [deg].

Definition at line 363 of file libtrac.h.

#### 4.2.2.64 int ctl_t::grid_ny

Number of latitudes of gridded data.

Definition at line 366 of file libtrac.h.

#### 4.2.2.65 double ctl_t::grid_lat0

Lower latitude of gridded data [deg].

Definition at line 369 of file libtrac.h.

#### 4.2.2.66 double ctl_t::grid_lat1

Upper latitude of gridded data [deg].

Definition at line 372 of file libtrac.h.

#### 4.2.2.67 char ctl_t::prof_basename[LEN]

Basename for profile output file.

Definition at line 375 of file libtrac.h.

#### 4.2.2.68 char ctl_t::prof_obsfile[LEN]

Observation data file for profile output.

Definition at line 378 of file libtrac.h.

#### 4.2.2.69 int ctl_t::prof_nz

Number of altitudes of gridded profile data.

Definition at line 381 of file libtrac.h.

#### 4.2.2.70 double ctl_t::prof_z0

Lower altitude of gridded profile data [km].

Definition at line 384 of file libtrac.h.

#### 4.2.2.71 double ctl_t::prof_z1

Upper altitude of gridded profile data [km].

Definition at line 387 of file libtrac.h.

#### 4.2.2.72 int ctl_t::prof_nx

Number of longitudes of gridded profile data.

Definition at line 390 of file libtrac.h.

#### 4.2.2.73 double ctl_t::prof_lon0

Lower longitude of gridded profile data [deg].

Definition at line 393 of file libtrac.h.

#### 4.2.2.74 double ctl_t::prof_lon1

Upper longitude of gridded profile data [deg].

Definition at line 396 of file libtrac.h.

#### 4.2.2.75 int ctl_t::prof_ny

Number of latitudes of gridded profile data.

Definition at line 399 of file libtrac.h.

#### 4.2.2.76 double ctl_t::prof_lat0

Lower latitude of gridded profile data [deg].

Definition at line 402 of file libtrac.h.

#### 4.2.2.77 double ctl_t::prof_lat1

Upper latitude of gridded profile data [deg].

Definition at line 405 of file libtrac.h.

#### 4.2.2.78 char ctl_t::stat_basename[LEN]

Basename of station data file.

Definition at line 408 of file libtrac.h.

#### 4.2.2.79 double ctl_t::stat_lon

Longitude of station [deg].

Definition at line 411 of file libtrac.h.

#### 4.2.2.80 double ctl_t::stat_lat

Latitude of station [deg].

Definition at line 414 of file libtrac.h.

#### 4.2.2.81 double ctl_t::stat_r

Search radius around station [km].

Definition at line 417 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 454 of file libtrac.h.

### 4.3.2 Field Documentation

#### 4.3.2.1 double met_t::time

Time [s].

Definition at line 457 of file libtrac.h.

#### 4.3.2.2 int met_t::nx

Number of longitudes.

Definition at line 460 of file libtrac.h.

#### 4.3.2.3 int met_t::ny

Number of latitudes.

Definition at line 463 of file libtrac.h.

#### 4.3.2.4 int met_t::np

Number of pressure levels.

Definition at line 466 of file libtrac.h.

#### 4.3.2.5 double met_t::lon[EX]

Longitude [deg].

Definition at line 469 of file libtrac.h.

#### 4.3.2.6 double met_t::lat[EY]

Latitude [deg].

Definition at line 472 of file libtrac.h.

#### 4.3.2.7 double met_t::p[EP]

Pressure [hPa].

Definition at line 475 of file libtrac.h.

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

Surface pressure [hPa].

Definition at line 478 of file libtrac.h.

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

Pressure on model levels [hPa].

Definition at line 481 of file libtrac.h.

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

Temperature [K].

Definition at line 484 of file libtrac.h.

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

Zonal wind [m/s].

Definition at line 487 of file libtrac.h.

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

Meridional wind [m/s].

Definition at line 490 of file libtrac.h.

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

Vertical wind [hPa/s].

Definition at line 493 of file libtrac.h.

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

Water vapor volume mixing ratio [1].

Definition at line 496 of file libtrac.h.

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

Ozone volume mixing ratio [1].

Definition at line 499 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

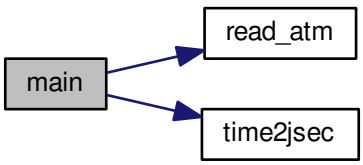
#### 5.1.2.1 int main ( int *argc*, char * *argv[]* )

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\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"
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 }
```

## 5.3 dist.c File Reference

Calculate transport deviations of trajectories.

### Functions

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

### 5.3.1 Detailed Description

Calculate transport deviations of trajectories.

Definition in file dist.c.

### 5.3.2 Function Documentation

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

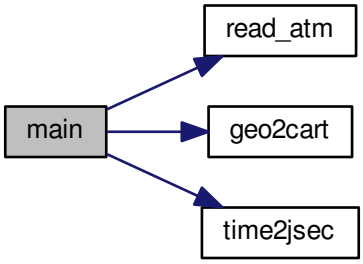
Definition at line 28 of file dist.c.

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

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

```
00182       lat2[ip] = atm2->lat[ip];
00183       p2[ip] = atm2->p[ip];
00184     }
00185
00186     /* Get indices of trajectories with maximum errors... */
00187     iph = (int) gsl_stats_max_index(dh, 1, (size_t) atm1->np);
00188     ipv = (int) gsl_stats_max_index(dv, 1, (size_t) atm1->np);
00189
00190     /* Sort distances to calculate percentiles... */
00191     gsl_sort(dh, 1, (size_t) atm1->np);
00192     gsl_sort(dv, 1, (size_t) atm1->np);
00193
00194     /* Get date from filename... */
00195     for (i = (int) strlen(argv[f]) - 1; argv[f][i] != '/' || i == 0; i--);
00196     name = strtok(&(argv[f][i]), "_");
00197     year = strtok(NULL, "_");
00198     mon = strtok(NULL, "_");
00199     day = strtok(NULL, "_");
00200     hour = strtok(NULL, "_");
00201     name = strtok(NULL, "_");   /* TODO: Why another "name" here? */
00202     min = strtok(name, ".");
00203     time2jsec(atoi(year), atoi(mon), atoi(day), atoi(hour), atoi(min), 0, 0,
00204               &t);
00205
00206     /* Write output... */
00207     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %d %g %g"
00208             " %g %g %g %g %g %g %g %g %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

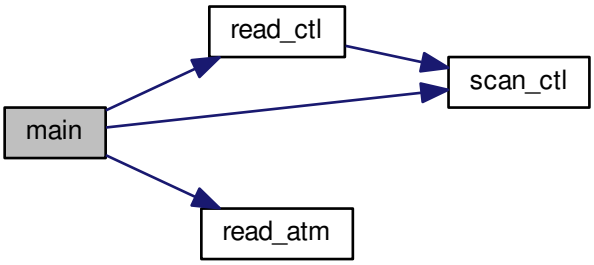
#### 5.5.2.1 int main ( int *argc,* char ∗ *argv[ ]* )

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   Copyright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
```

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

## 5.7 init.c File Reference

Create atmospheric data file with initial air parcel positions.

### Functions

- int main (int argc, char ∗argv[ ])

### 5.7.1 Detailed Description

Create atmospheric data file with initial air parcel positions.

Definition in file init.c.

### 5.7.2 Function Documentation

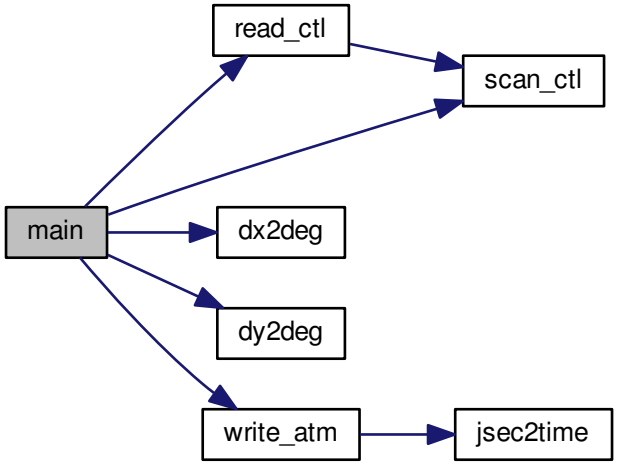
#### 5.7.2.1 int main ( int *argc*, char * *argv[ ]* )

Definition at line 27 of file init.c.

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

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

Here is the call graph for this function:




## 5.8 init.c

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

```
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   atm_t *atm;
00032
00033   ctl_t ctl;
00034
00035   gsl_rng *rng;
00036
00037   double dt, dz, dlon, dlat, lat0, lat1, lon0, lon1, t0, t1, z0, z1,
00038     t, z, lon, lat, st, sz, slon, slat, sx, ut, uz, ulon, ulat, m;
00039
00040   int ip, irep, rep;
00041
00042   /* Allocate... */
00043   ALLOC(atm, atm_t, 1);
00044
00045   /* Check arguments... */
00046   if (argc < 3)
00047     ERRMSG("Give parameters: <ctl> <atm_out>");
00048
00049   /* Read control parameters... */
00050   read_ctl(argv[1], argc, argv, &ctl);
00051   t0 = scan_ctl(argv[1], argc, argv, "INIT_T0", -1, "0", NULL);
00052   t1 = scan_ctl(argv[1], argc, argv, "INIT_T1", -1, "0", NULL);
00053   dt = scan_ctl(argv[1], argc, argv, "INIT_DT", -1, "1", NULL);
00054   z0 = scan_ctl(argv[1], argc, argv, "INIT_Z0", -1, "0", NULL);
00055   z1 = scan_ctl(argv[1], argc, argv, "INIT_Z1", -1, "0", NULL);
00056   dz = scan_ctl(argv[1], argc, argv, "INIT_DZ", -1, "1", NULL);
00057   lon0 = scan_ctl(argv[1], argc, argv, "INIT_LON0", -1, "0", NULL);
00058   lon1 = scan_ctl(argv[1], argc, argv, "INIT_LON1", -1, "0", NULL);
00059   dlon = scan_ctl(argv[1], argc, argv, "INIT_DLON", -1, "1", NULL);
00060   lat0 = scan_ctl(argv[1], argc, argv, "INIT_LAT0", -1, "0", NULL);
00061   lat1 = scan_ctl(argv[1], argc, argv, "INIT_LAT1", -1, "0", NULL);
00062   dlat = scan_ctl(argv[1], argc, argv, "INIT_DLAT", -1, "1", NULL);
00063   st = scan_ctl(argv[1], argc, argv, "INIT_ST", -1, "0", NULL);
00064   sz = scan_ctl(argv[1], argc, argv, "INIT_SZ", -1, "0", NULL);
00065   slon = scan_ctl(argv[1], argc, argv, "INIT_SLON", -1, "0", NULL);
00066   slat = scan_ctl(argv[1], argc, argv, "INIT_SLAT", -1, "0", NULL);
00067   sx = scan_ctl(argv[1], argc, argv, "INIT_SX", -1, "0", NULL);
00068   ut = scan_ctl(argv[1], argc, argv, "INIT_UT", -1, "0", NULL);
00069   uz = scan_ctl(argv[1], argc, argv, "INIT_UZ", -1, "0", NULL);
00070   ulon = scan_ctl(argv[1], argc, argv, "INIT_ULON", -1, "0", NULL);
00071   ulat = scan_ctl(argv[1], argc, argv, "INIT_ULAT", -1, "0", NULL);
00072   rep = (int) scan_ctl(argv[1], argc, argv, "INIT_REP", -1, "1", NULL);
00073   m = scan_ctl(argv[1], argc, argv, "INIT_MASS", -1, "0", NULL);
00074
00075   /* Initialize random number generator... */
00076   gsl_rng_env_setup();
00077   rng = gsl_rng_alloc(gsl_rng_default);
00078
00079   /* Create grid... */
00080   for (t = t0; t <= t1; t += dt)
00081     for (z = z0; z <= z1; z += dz)
00082       for (lon = lon0; lon <= lon1; lon += dlon)
00083         for (lat = lat0; lat <= lat1; lat += dlat)
00084           for (irep = 0; irep < rep; irep++) {
00085
00086             /* Set position... */
00087             atm->time[atm->np]
00088               = (t + gsl_ran_gaussian_ziggurat(rng, st / 2.3548)
00089                  + ut * (gsl_rng_uniform(rng) - 0.5));
00090             atm->p[atm->np]
00091               = P(z + gsl_ran_gaussian_ziggurat(rng, sz / 2.3548)
00092                   + uz * (gsl_rng_uniform(rng) - 0.5));
00093             atm->lon[atm->np]
00094               = (lon + gsl_ran_gaussian_ziggurat(rng, slon / 2.3548)
00095                  + gsl_ran_gaussian_ziggurat(rng, dx2deg(sx, lat) / 2.3548)
00096                  + ulon * (gsl_rng_uniform(rng) - 0.5));
00097             atm->lat[atm->np]
00098               = (lat + gsl_ran_gaussian_ziggurat(rng, slat / 2.3548)
00099                  + gsl_ran_gaussian_ziggurat(rng, dy2deg(sx) / 2.3548)
00100                 + ulat * (gsl_rng_uniform(rng) - 0.5));
00101
00102             /* Set particle counter... */
```

```
00103             if ((++atm->np) >= NP)
00104               ERRMSG("Too many particles!");
00105           }
00106
00107   /* Check number of air parcels... */
00108   if (atm->np <= 0)
00109     ERRMSG("Did not create any air parcels!");
00110
00111   /* Initialize mass... */
00112   if (ctl.qnt_m >= 0)
00113     for (ip = 0; ip < atm->np; ip++)
00114       atm->q[ctl.qnt_m][ip] = m / atm->np;
00115
00116   /* Save data... */
00117   write_atm(argv[2], &ctl, atm, t0);
00118
00119   /* Free... */
00120   gsl_rng_free(rng);
00121   free(atm);
00122
00123   return EXIT_SUCCESS;
00124 }
```

## 5.9 jsec2time.c File Reference

Convert Julian seconds to date.

### Functions

- int main (int argc, char ∗argv[ ])

### 5.9.1 Detailed Description

Convert Julian seconds to date.

Definition in file jsec2time.c.

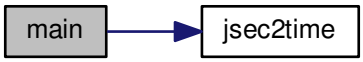
### 5.9.2 Function Documentation

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

Definition at line 27 of file jsec2time.c.

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

Here is the call graph for this function:




## 5.10 jsec2time.c

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

## 5.11 libtrac.c File Reference

MPTRAC library definitions.

### Functions

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

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

*Convert degrees to horizontal distance.*

- double deg2dy (double dlat)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

*Measure wall-clock time.*

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

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

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

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

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

  *Write station data.*

#### 5.11.1 Detailed Description

MPTRAC library definitions.

Definition in file libtrac.c.

#### 5.11.2 Function Documentation

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

Convert Cartesian coordinates to geolocation.

Definition at line 29 of file libtrac.c.

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

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

Convert degrees to horizontal distance.

Definition at line 45 of file libtrac.c.

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

#### 5.11.2.3 double deg2dy ( double *dlat* )

Convert degrees to horizontal distance.

Definition at line 54 of file libtrac.c.

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

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

Convert pressure to vertical distance.

Definition at line 62 of file libtrac.c.

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

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

Convert horizontal distance to degrees.

Definition at line 71 of file libtrac.c.

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

#### 5.11.2.6 double dy2deg ( double *dy* )

Convert horizontal distance to degrees.

Definition at line 84 of file libtrac.c.

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

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

Convert vertical distance to pressure.

Definition at line 92 of file libtrac.c.

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

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

Convert geolocation to Cartesian coordinates.

Definition at line 101 of file libtrac.c.

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

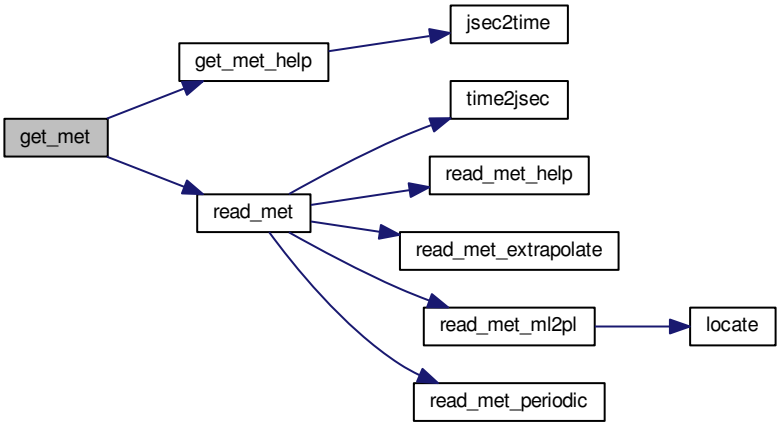
#### 5.11.2.9 void get_met ( ctl_t * *ctl*, char * *metbase*, double *t*, met_t * *met0*, met_t * *met1* )

Get meteorological data for given timestep.

Definition at line 117 of file libtrac.c.

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

Here is the call graph for this function:



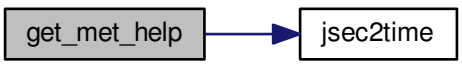

#### 5.11.2.10 void get_met_help ( double *t*, int *direct*, char * *metbase*, double *dt_met*, char * *filename* )

Get meteorological data for timestep.

Definition at line 156 of file libtrac.c.

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

Here is the call graph for this function:



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

Linear interpolation of 2-D meteorological data.

Definition at line 182 of file libtrac.c.

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

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

Linear interpolation of 3-D meteorological data.

Definition at line 206 of file libtrac.c.

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

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

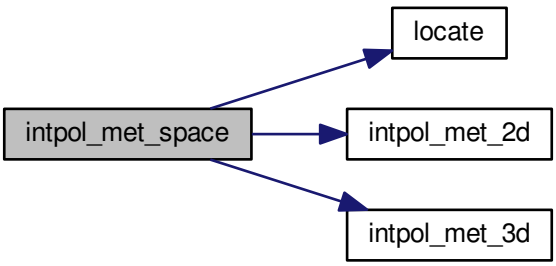
Spatial interpolation of meteorological data.

Definition at line 236 of file libtrac.c.

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

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

Here is the call graph for this function:




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

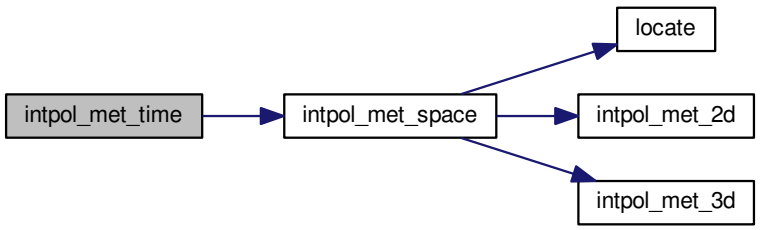
Temporal interpolation of meteorological data.

Definition at line 286 of file libtrac.c.

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

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

Here is the call graph for this function:




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

Convert seconds to date.

Definition at line 341 of file libtrac.c.

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

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

Find array index.

Definition at line 376 of file libtrac.c.

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

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

Read atmospheric data.

Definition at line 408 of file libtrac.c.

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

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

Read control parameters.

Definition at line 458 of file libtrac.c.

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

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

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

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.

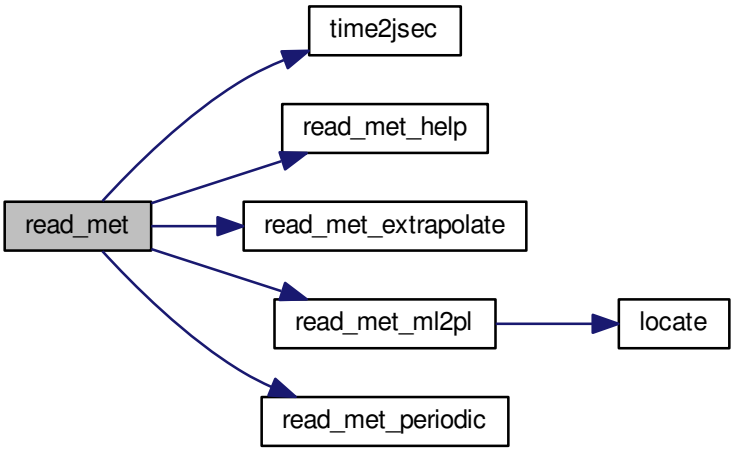
Definition at line 676 of file libtrac.c.

```
00679                {
00680
```

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

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

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 804 of file libtrac.c.

```
00805               {
00806
```

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

#### 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 835 of file libtrac.c.

```
00841             {
00842
00843   static float help[EX * EY * EP];
00844
00845   int ip, ix, iy, n = 0, varid;
00846
00847   /* Check if variable exists... */
00848   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
00849     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
00850       return;
00851
00852   /* Read data... */
00853   NC(nc_get_var_float(ncid, varid, help));
00854
00855   /* Copy and check data... */
00856   for (ip = 0; ip < met->np; ip++)
00857     for (iy = 0; iy < met->ny; iy++)
00858       for (ix = 0; ix < met->nx; ix++) {
00859         dest[ix][iy][ip] = scl * help[n++];
00860         if (fabs(dest[ix][iy][ip] / scl) > 1e14)
00861           dest[ix][iy][ip] = GSL_NAN;
00862       }
00863 }
```

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

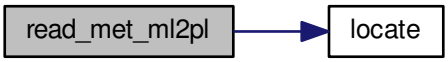
Convert meteorological data from model levels to pressure levels.

Definition at line 867 of file libtrac.c.

```
00870                         {
00871
00872   double aux[EP], p[EP], pt;
00873
00874   int ip, ip2, ix, iy;
00875
00876   /* Loop over columns... */
00877   for (ix = 0; ix < met->nx; ix++)
00878     for (iy = 0; iy < met->ny; iy++) {
00879
00880       /* Copy pressure profile... */
00881       for (ip = 0; ip < met->np; ip++)
```

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

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 905 of file libtrac.c.

```
00906               {
00907
00908   int ip, iy;
00909
00910   /* Check longitudes... */
00911   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
00912              + met->lon[1] - met->lon[0] - 360) < 0.01))
00913     return;
00914
00915   /* Increase longitude counter... */
00916   if ((++met->nx) > EX)
00917     ERRMSG("Cannot create periodic boundary conditions!");
00918
00919   /* Set longitude... */
00920   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
00921
00922   /* Loop over latitudes and pressure levels... */
00923   for (iy = 0; iy < met->ny; iy++)
00924     for (ip = 0; ip < met->np; ip++) {
00925       met->ps[met->nx - 1][iy] = met->ps[0][iy];
00926       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
00927       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
00928       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
00929       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
00930       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
00931       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
00932     }
00933 }
```

#### 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 937 of file libtrac.c.

```
00944                {
00945
00946   FILE *in = NULL;
00947
00948   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
00949     msg[LEN], rvarname[LEN], rval[LEN];
00950
00951   int contain = 0, i;
00952
00953   /* Open file... */
00954   if (filename[strlen(filename) - 1] != '-')
00955     if (!(in = fopen(filename, "r")))
00956       ERRMSG("Cannot open file!");
00957
00958   /* Set full variable name... */
00959   if (arridx >= 0) {
00960     sprintf(fullname1, "%s[%d]", varname, arridx);
00961     sprintf(fullname2, "%s[*]", varname);
00962   } else {
00963     sprintf(fullname1, "%s", varname);
00964     sprintf(fullname2, "%s", varname);
00965   }
00966
00967   /* Read data... */
00968   if (in != NULL)
00969     while (fgets(line, LEN, in))
00970       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
00971         if (strcasecmp(rvarname, fullname1) == 0 ||
00972             strcasecmp(rvarname, fullname2) == 0) {
00973           contain = 1;
00974           break;
00975         }
00976   for (i = 1; i < argc - 1; i++)
00977     if (strcasecmp(argv[i], fullname1) == 0 ||
00978         strcasecmp(argv[i], fullname2) == 0) {
00979       sprintf(rval, "%s", argv[i + 1]);
00980       contain = 1;
00981       break;
00982     }
00983
00984   /* Close file... */
00985   if (in != NULL)
00986     fclose(in);
00987
00988   /* Check for missing variables... */
00989   if (!contain) {
00990     if (strlen(defvalue) > 0)
00991       sprintf(rval, "%s", defvalue);
00992     else {
00993       sprintf(msg, "Missing variable %s!\n", fullname1);
00994       ERRMSG(msg);
00995     }
00996   }
00997
00998   /* Write info... */
00999   printf("%s = %s\n", fullname1, rval);
01000
01001   /* Return values... */
01002   if (value != NULL)
01003     sprintf(value, "%s", rval);
01004   return atof(rval);
01005 }
```

#### 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 1009 of file libtrac.c.

```
01017                {
01018
01019   struct tm t0, t1;
01020
01021   t0.tm_year = 100;
01022   t0.tm_mon = 0;
01023   t0.tm_mday = 1;
01024   t0.tm_hour = 0;
01025   t0.tm_min = 0;
01026   t0.tm_sec = 0;
01027
01028   t1.tm_year = year - 1900;
01029   t1.tm_mon = mon - 1;
01030   t1.tm_mday = day;
01031   t1.tm_hour = hour;
01032   t1.tm_min = min;
01033   t1.tm_sec = sec;
01034
01035   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
01036 }
```

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

Measure wall-clock time.

Definition at line 1040 of file libtrac.c.

```
01043            {
01044
01045   static double starttime[NTIMER], runtime[NTIMER];
01046
01047   /* Check id... */
01048   if (id < 0 || id >= NTIMER)
01049     ERRMSG("Too many timers!");
01050
01051   /* Start timer... */
01052   if (mode == 1) {
01053     if (starttime[id] <= 0)
01054       starttime[id] = omp_get_wtime();
01055     else
01056       ERRMSG("Timer already started!");
01057   }
01058
01059   /* Stop timer... */
01060   else if (mode == 2) {
01061     if (starttime[id] > 0) {
01062       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
01063       starttime[id] = -1;
01064     } else
01065       ERRMSG("Timer not started!");
01066   }
01067
01068   /* Print timer... */
01069   else if (mode == 3)
01070     printf("%s = %g s\n", name, runtime[id]);
01071 }
```

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

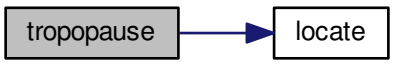
Definition at line 1075 of file libtrac.c.

```
01077              {
01078
01079   static double doys[12]
01080   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
01081
01082   static double lats[73]
01083     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
01084     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
01085     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
01086     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
01087     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
01088     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
01089     75, 77.5, 80, 82.5, 85, 87.5, 90
01090   };
```

```
01091
01092   static double tps[12][73]
01093     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
01094          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
01095          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
01096          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
01097          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
01098          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
01099          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
01100          275.3, 275.6, 275.4, 274.1, 273.5},
01101    {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
01102     300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
01103     150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
01104     98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
01105     98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
01106     220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
01107     284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
01108     287.5, 286.2, 285.8},
01109    {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
01110     297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
01111     161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
01112     100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
01113     99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
01114     186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
01115     279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
01116     304.3, 304.9, 306, 306.6, 306.2, 306},
01117    {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
01118     290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
01119     195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
01120     102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
01121     99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
01122     148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
01123     263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
01124     315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
01125    {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
01126     260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
01127     205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
01128     101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
01129     102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
01130     165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
01131     273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
01132     325.3, 325.8, 325.8},
01133    {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
01134     222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
01135     228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
01136     105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
01137     106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
01138     127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
01139     251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
01140     308.5, 312.2, 313.1, 313.3},
01141    {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
01142     187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
01143     235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
01144     110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
01145     111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
01146     117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
01147     224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
01148     275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
01149    {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
01150     185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
01151     233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
01152     110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
01153     112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
01154     120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
01155     230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
01156     278.2, 282.6, 287.4, 290.9, 292.5, 293},
01157    {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
01158     183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
01159     243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
01160     114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
01161     110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
01162     114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
01163     203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
01164     276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
01165    {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
01166     215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
01167     237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
01168     111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
01169     106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
01170     112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
01171     206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
01172     279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
01173     305.1},
01174    {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
01175     253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
01176     223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
01177     108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
```

```
01178    102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
01179    109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
01180    241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
01181    286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
01182   {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
01183    284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
01184    175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
01185    100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
01186    100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
01187    186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
01188    280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
01189    281.7, 281.1, 281.2}
01190   };
01191
01192   double doy, p0, p1, pt;
01193
01194   int imon, ilat;
01195
01196   /* Get day of year... */
01197   doy = fmod(t / 86400., 365.25);
01198   while (doy < 0)
01199     doy += 365.25;
01200
01201   /* Get indices... */
01202   imon = locate(doys, 12, doy);
01203   ilat = locate(lats, 73, lat);
01204
01205   /* Get tropopause pressure... */
01206   p0 = LIN(lats[ilat], tps[imon][ilat],
01207            lats[ilat + 1], tps[imon][ilat + 1], lat);
01208   p1 = LIN(lats[ilat], tps[imon + 1][ilat],
01209            lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
01210   pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
01211
01212   /* Return tropopause pressure... */
01213   return pt;
01214 }
```

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 1218 of file libtrac.c.

```
01222            {
01223
01224   FILE *in, *out;
01225
01226   char line[LEN];
01227
01228   double r;
01229
01230   int ip, iq, year, mon, day, hour, min, sec;
01231
01232   /* Check if gnuplot output is requested... */
01233   if (ctl->atm_gpfile[0] != '-') {
01234
01235     /* Write info... */
01236     printf("Plot atmospheric data: %s.png\n", filename);
01237
```

```
01238     /* Create gnuplot pipe... */
01239     if (!(out = popen("gnuplot", "w")))
01240       ERRMSG("Cannot create pipe to gnuplot!");
01241
01242     /* Set plot filename... */
01243     fprintf(out, "set out \"%s.png\"\n", filename);
01244
01245     /* Set time string... */
01246     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01247     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01248             year, mon, day, hour, min);
01249
01250     /* Dump gnuplot file to pipe... */
01251     if (!(in = fopen(ctl->atm_gpfile, "r")))
01252       ERRMSG("Cannot open file!");
01253     while (fgets(line, LEN, in))
01254       fprintf(out, "%s", line);
01255     fclose(in);
01256   }
01257
01258   else {
01259
01260     /* Write info... */
01261     printf("Write atmospheric data: %s\n", filename);
01262
01263     /* Create file... */
01264     if (!(out = fopen(filename, "w")))
01265       ERRMSG("Cannot create file!");
01266   }
01267
01268   /* Write header... */
01269   fprintf(out,
01270           "# $1 = time [s]\n"
01271           "# $2 = altitude [km]\n"
01272           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01273   for (iq = 0; iq < ctl->nq; iq++)
01274     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
01275             ctl->qnt_unit[iq]);
01276   fprintf(out, "\n");
01277
01278   /* Write data... */
01279   for (ip = 0; ip < atm->np; ip++) {
01280     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
01281             atm->lon[ip], atm->lat[ip]);
01282     for (iq = 0; iq < ctl->nq; iq++) {
01283       fprintf(out, " ");
01284       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01285     }
01286     fprintf(out, "\n");
01287   }
01288
01289   /* Close file... */
01290   fclose(out);
01291 }
```

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 1295 of file libtrac.c.

```
01299           {
01300
01301   static FILE *in, *out;
01302
01303   static char line[LEN];
01304
01305   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
01306     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
01307
01308   static int init, obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
01309
01310   /* Init... */
01311   if (!init) {
01312     init = 1;
01313
01314     /* Check quantity index for mass... */
01315     if (ctl->qnt_m < 0)
01316       ERRMSG("Need quantity mass to analyze CSI!");
01317
01318     /* Open observation data file... */
01319     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
01320     if (!(in = fopen(ctl->csi_obsfile, "r")))
01321       ERRMSG("Cannot open file!");
01322
01323     /* Create new file... */
01324     printf("Write CSI data: %s\n", filename);
01325     if (!(out = fopen(filename, "w")))
01326       ERRMSG("Cannot create file!");
01327
01328     /* Write header... */
01329     fprintf(out,
01330             "# $1 = time [s]\n"
01331             "# $2 = number of hits (cx)\n"
01332             "# $3 = number of misses (cy)\n"
01333             "# $4 = number of false alarms (cz)\n"
01334             "# $5 = number of observations (cx + cy)\n"
01335             "# $6 = number of forecasts (cx + cz)\n"
01336             "# $7 = bias (forecasts/observations) [%%]\n"
01337             "# $8 = probability of detection (POD) [%%]\n"
01338             "# $9 = false alarm rate (FAR) [%%]\n"
01339             "# $10 = critical success index (CSI) [%%]\n\n");
01340   }
01341
01342   /* Set time interval... */
01343   t0 = t - 0.5 * ctl->dt_mod;
01344   t1 = t + 0.5 * ctl->dt_mod;
01345
01346   /* Initialize grid cells... */
01347   for (ix = 0; ix < ctl->csi_nx; ix++)
01348     for (iy = 0; iy < ctl->csi_ny; iy++)
01349       for (iz = 0; iz < ctl->csi_nz; iz++)
01350         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
01351
01352   /* Read data... */
01353   while (fgets(line, LEN, in)) {
01354
01355     /* Read data... */
01356     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
01357         5)
01358       continue;
01359
01360     /* Check time... */
01361     if (rt < t0)
01362       continue;
01363     if (rt > t1)
01364       break;
01365
01366     /* Calculate indices... */
01367     ix = (int) ((rlon - ctl->csi_lon0)
01368                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01369     iy = (int) ((rlat - ctl->csi_lat0)
01370                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01371     iz = (int) ((rz - ctl->csi_z0)
01372                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01373
01374     /* Check indices... */
01375     if (ix < 0 || ix >= ctl->csi_nx ||
01376         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01377       continue;
01378
01379     /* Get mean observation index... */
01380     obsmean[ix][iy][iz] += robs;
01381     obscount[ix][iy][iz]++;
01382   }
01383
01384   /* Analyze model data... */
01385   for (ip = 0; ip < atm->np; ip++) {
```

```
01386
01387     /* Check time... */
01388     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01389       continue;
01390
01391     /* Get indices... */
01392     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
01393                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01394     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
01395                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01396     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
01397                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01398
01399     /* Check indices... */
01400     if (ix < 0 || ix >= ctl->csi_nx ||
01401         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01402       continue;
01403
01404     /* Get total mass in grid cell... */
01405     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01406   }
01407
01408   /* Analyze all grid cells... */
01409   for (ix = 0; ix < ctl->csi_nx; ix++)
01410     for (iy = 0; iy < ctl->csi_ny; iy++)
01411       for (iz = 0; iz < ctl->csi_nz; iz++) {
01412
01413         /* Calculate mean observation index... */
01414         if (obscount[ix][iy][iz] > 0)
01415           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
01416
01417         /* Calculate column density... */
01418         if (modmean[ix][iy][iz] > 0) {
01419           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
01420           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
01421           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
01422           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
01423             * cos(lat * M_PI / 180.);
01424           modmean[ix][iy][iz] /= (1e6 * area);
01425         }
01426
01427         /* Calculate CSI... */
01428         if (obscount[ix][iy][iz] > 0) {
01429           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01430               modmean[ix][iy][iz] >= ctl->csi_modmin)
01431             cx++;
01432           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01433                    modmean[ix][iy][iz] < ctl->csi_modmin)
01434             cy++;
01435           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
01436                    modmean[ix][iy][iz] >= ctl->csi_modmin)
01437             cz++;
01438         }
01439       }
01440
01441   /* Write output... */
01442   if (fmod(t, ctl->csi_dt_out) == 0) {
01443
01444     /* Write... */
01445     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
01446             t, cx, cy, cz, cx + cy, cx + cz,
01447             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
01448             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
01449             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
01450             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
01451
01452     /* Set counters to zero... */
01453     cx = cy = cz = 0;
01454   }
01455
01456   /* Close file... */
01457   if (t == ctl->t_stop)
01458     fclose(out);
01459 }
```

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

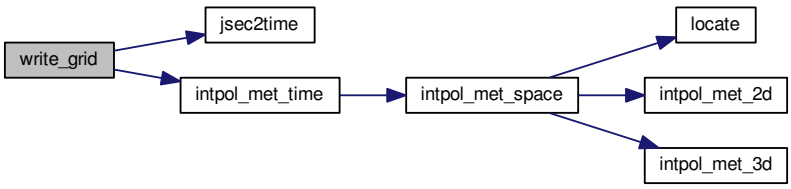
Write gridded data.

Definition at line 1463 of file libtrac.c.

```
01469           {
01470
01471   FILE *in, *out;
01472
01473   char line[LEN];
01474
01475   static double grid_m[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
01476     area, rho_air, press, temp, cd, mmr, t0, t1, r;
01477
01478   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
01479
01480   /* Check dimensions... */
01481   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
01482     ERRMSG("Grid dimensions too large!");
01483
01484   /* Check quantity index for mass... */
01485   if (ctl->qnt_m < 0)
01486     ERRMSG("Need quantity mass to write grid data!");
01487
01488   /* Set time interval for output... */
01489   t0 = t - 0.5 * ctl->dt_mod;
01490   t1 = t + 0.5 * ctl->dt_mod;
01491
01492   /* Set grid box size... */
01493   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
01494   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
01495   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
01496
01497   /* Initialize grid... */
01498   for (ix = 0; ix < ctl->grid_nx; ix++)
01499     for (iy = 0; iy < ctl->grid_ny; iy++)
01500       for (iz = 0; iz < ctl->grid_nz; iz++)
01501         grid_m[ix][iy][iz] = 0;
01502
01503   /* Average data... */
01504   for (ip = 0; ip < atm->np; ip++)
01505     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
01506
01507       /* Get index... */
01508       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
01509       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
01510       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
01511
01512       /* Check indices... */
01513       if (ix < 0 || ix >= ctl->grid_nx ||
01514           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
01515         continue;
01516
01517       /* Add mass... */
01518       grid_m[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01519     }
01520
01521   /* Check if gnuplot output is requested... */
01522   if (ctl->grid_gpfile[0] != '-') {
01523
01524     /* Write info... */
01525     printf("Plot grid data: %s.png\n", filename);
01526
01527     /* Create gnuplot pipe... */
01528     if (!(out = popen("gnuplot", "w")))
01529       ERRMSG("Cannot create pipe to gnuplot!");
01530
01531     /* Set plot filename... */
01532     fprintf(out, "set out \"%s.png\"\n", filename);
01533
01534     /* Set time string... */
01535     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01536     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01537             year, mon, day, hour, min);
01538
01539     /* Dump gnuplot file to pipe... */
01540     if (!(in = fopen(ctl->grid_gpfile, "r")))
01541       ERRMSG("Cannot open file!");
01542     while (fgets(line, LEN, in))
01543       fprintf(out, "%s", line);
01544     fclose(in);
01545   }
01546
01547   else {
01548
01549     /* Write info... */
01550     printf("Write grid data: %s\n", filename);
01551
01552     /* Create file... */
01553     if (!(out = fopen(filename, "w")))
01554       ERRMSG("Cannot create file!");
01555   }
```

```
01556
01557   /* Write header... */
01558   fprintf(out,
01559           "# $1 = time [s]\n"
01560           "# $2 = altitude [km]\n"
01561           "# $3 = longitude [deg]\n"
01562           "# $4 = latitude [deg]\n"
01563           "# $5 = surface area [km^2]\n"
01564           "# $6 = layer width [km]\n"
01565           "# $7 = temperature [K]\n"
01566           "# $8 = column density [kg/m^2]\n"
01567           "# $9 = mass mixing ratio [1]\n\n");
01568
01569   /* Write data... */
01570   for (ix = 0; ix < ctl->grid_nx; ix++) {
01571     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
01572       fprintf(out, "\n");
01573     for (iy = 0; iy < ctl->grid_ny; iy++) {
01574       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
01575         fprintf(out, "\n");
01576       for (iz = 0; iz < ctl->grid_nz; iz++)
01577         if (!ctl->grid_sparse
01578             || ix == 0 || iy == 0 || iz == 0 || grid_m[ix][iy][iz] > 0) {
01579
01580           /* Set coordinates... */
01581           z = ctl->grid_z0 + dz * (iz + 0.5);
01582           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
01583           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
01584
01585           /* Get pressure and temperature... */
01586           press = P(z);
01587           intpol_met_time(met0, met1, t, press, lon, lat,
01588                           NULL, &temp, NULL, NULL, NULL, NULL, NULL);
01589
01590           /* Calculate surface area... */
01591           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
01592             * cos(lat * M_PI / 180.);
01593
01594           /* Calculate column density... */
01595           cd = grid_m[ix][iy][iz] / (1e6 * area);
01596
01597           /* Calculate mass mixing ratio... */
01598           rho_air = 100. * press / (287.058 * temp);
01599           mmr = grid_m[ix][iy][iz] / (rho_air * 1e6 * area * 1e3 * dz);
01600
01601           /* Write output... */
01602           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01603                   t, z, lon, lat, area, dz, temp, cd, mmr);
01604         }
01605     }
01606   }
01607
01608   /* Close file... */
01609   fclose(out);
01610 }
```

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* )

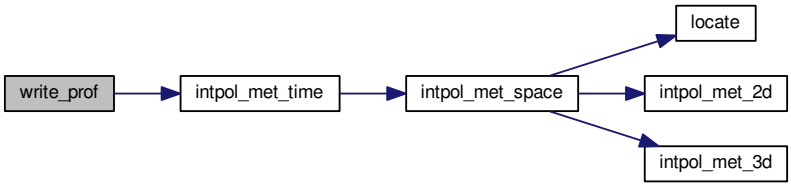
Write profile data.

Definition at line 1614 of file libtrac.c.

```
01620           {
01621
01622   static FILE *in, *out;
01623
01624   static char line[LEN];
01625
01626   static double mass[GX][GY][GZ], obsmean[GX][GY], tmean[GX][GY],
01627     rt, rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z,
01628     press, temp, rho_air, mmr, h2o, o3;
01629
01630   static int init, obscount[GX][GY], ip, ix, iy, iz;
01631
01632   /* Init... */
01633   if (!init) {
01634     init = 1;
01635
01636     /* Check quantity index for mass... */
01637     if (ctl->qnt_m < 0)
01638       ERRMSG("Need quantity mass!");
01639
01640     /* Check dimensions... */
01641     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
01642       ERRMSG("Grid dimensions too large!");
01643
01644     /* Open observation data file... */
01645     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
01646     if (!(in = fopen(ctl->prof_obsfile, "r")))
01647       ERRMSG("Cannot open file!");
01648
01649     /* Create new file... */
01650     printf("Write profile data: %s\n", filename);
01651     if (!(out = fopen(filename, "w")))
01652       ERRMSG("Cannot create file!");
01653
01654     /* Write header... */
01655     fprintf(out,
01656             "# $1  = time [s]\n"
01657             "# $2  = altitude [km]\n"
01658             "# $3  = longitude [deg]\n"
01659             "# $4  = latitude [deg]\n"
01660             "# $5  = pressure [hPa]\n"
01661             "# $6  = temperature [K]\n"
01662             "# $7  = mass mixing ratio [1]\n"
01663             "# $8  = H2O volume mixing ratio [1]\n"
01664             "# $9  = O3 volume mixing ratio [1]\n"
01665             "# $10 = mean BT index [K]\n");
01666
01667     /* Set grid box size... */
01668     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
01669     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
01670     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
01671   }
01672
01673   /* Set time interval... */
01674   t0 = t - 0.5 * ctl->dt_mod;
01675   t1 = t + 0.5 * ctl->dt_mod;
01676
01677   /* Initialize... */
01678   for (ix = 0; ix < ctl->prof_nx; ix++)
01679     for (iy = 0; iy < ctl->prof_ny; iy++) {
01680       obsmean[ix][iy] = 0;
01681       obscount[ix][iy] = 0;
01682       tmean[ix][iy] = 0;
01683       for (iz = 0; iz < ctl->prof_nz; iz++)
01684         mass[ix][iy][iz] = 0;
01685     }
01686
01687   /* Read data... */
01688   while (fgets(line, LEN, in)) {
01689
01690     /* Read data... */
01691     if (sscanf(line, "%lg %lg %lg %lg", &rt, &rlon, &rlat, &robs) != 4)
01692       continue;
01693
01694     /* Check time... */
01695     if (rt < t0)
01696       continue;
01697     if (rt > t1)
01698       break;
01699
01700     /* Calculate indices... */
01701     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
01702     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
01703
01704     /* Check indices... */
01705     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
01706       continue;
```

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

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* )

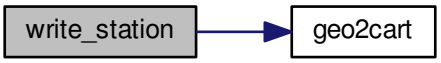
Write station data.

Definition at line 1777 of file libtrac.c.

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

```
01835     if (DIST2(x0, x1) > rmax2)
01836       continue;
01837
01838     /* Set station flag... */
01839     if (ctl->qnt_stat >= 0)
01840       atm->q[ctl->qnt_stat][ip] = 1;
01841
01842     /* Write data... */
01843     fprintf(out, "%.2f %g %g %g",
01844             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
01845     for (iq = 0; iq < ctl->nq; iq++) {
01846       fprintf(out, " ");
01847       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01848     }
01849     fprintf(out, "\n");
01850   }
01851
01852   /* Close file... */
01853   if (t == ctl->t_stop)
01854     fclose(out);
01855 }
```

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_p = -1;
00477     ctl->qnt_t = -1;
00478     ctl->qnt_u = -1;
```

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

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

```
00649   ctl->prof_z0 = scan_ctl(filename, argc, argv, "PROF_Z0", -1, "0", NULL);
00650   ctl->prof_z1 = scan_ctl(filename, argc, argv, "PROF_Z1", -1, "60", NULL);
00651   ctl->prof_nz =
00652     (int) scan_ctl(filename, argc, argv, "PROF_NZ", -1, "60", NULL);
00653   ctl->prof_lon0 =
00654     scan_ctl(filename, argc, argv, "PROF_LON0", -1, "-180", NULL);
00655   ctl->prof_lon1 =
00656     scan_ctl(filename, argc, argv, "PROF_LON1", -1, "180", NULL);
00657   ctl->prof_nx =
00658     (int) scan_ctl(filename, argc, argv, "PROF_NX", -1, "360", NULL);
00659   ctl->prof_lat0 =
00660     scan_ctl(filename, argc, argv, "PROF_LAT0", -1, "-90", NULL);
00661   ctl->prof_lat1 =
00662     scan_ctl(filename, argc, argv, "PROF_LAT1", -1, "90", NULL);
00663   ctl->prof_ny =
00664     (int) scan_ctl(filename, argc, argv, "PROF_NY", -1, "180", NULL);
00665
00666   /* Output of station data... */
00667   scan_ctl(filename, argc, argv, "STAT_BASENAME", -1, "-",
00668            ctl->stat_basename);
00669   ctl->stat_lon = scan_ctl(filename, argc, argv, "STAT_LON", -1, "0", NULL);
00670   ctl->stat_lat = scan_ctl(filename, argc, argv, "STAT_LAT", -1, "0", NULL);
00671   ctl->stat_r = scan_ctl(filename, argc, argv, "STAT_R", -1, "50", NULL);
00672 }
00673
00674 /*****************************************************************************/
00675
00676 void read_met(
00677   ctl_t * ctl,
00678   char *filename,
00679   met_t * met) {
00680
00681   char tstr[10];
00682
00683   static float help[EX * EY];
00684
00685   int ix, iy, ip, dimid, ncid, varid, year, mon, day, hour;
00686
00687   size_t np, nx, ny;
00688
00689   /* Write info... */
00690   printf("Read meteorological data: %s\n", filename);
00691
00692   /* Get time from filename... */
00693   sprintf(tstr, "%.4s", &filename[strlen(filename) - 16]);
00694   year = atoi(tstr);
00695   sprintf(tstr, "%.2s", &filename[strlen(filename) - 11]);
00696   mon = atoi(tstr);
00697   sprintf(tstr, "%.2s", &filename[strlen(filename) - 8]);
00698   day = atoi(tstr);
00699   sprintf(tstr, "%.2s", &filename[strlen(filename) - 5]);
00700   hour = atoi(tstr);
00701   time2jsec(year, mon, day, hour, 0, 0, 0, &met->time);
00702
00703   /* Open netCDF file... */
00704   NC(nc_open(filename, NC_NOWRITE, &ncid));
00705
00706   /* Get dimensions... */
00707   NC(nc_inq_dimid(ncid, "lon", &dimid));
00708   NC(nc_inq_dimlen(ncid, dimid, &nx));
00709   if (nx > EX)
00710     ERRMSG("Too many longitudes!");
00711
00712   NC(nc_inq_dimid(ncid, "lat", &dimid));
00713   NC(nc_inq_dimlen(ncid, dimid, &ny));
00714   if (ny > EY)
00715     ERRMSG("Too many latitudes!");
00716
00717   NC(nc_inq_dimid(ncid, "lev", &dimid));
00718   NC(nc_inq_dimlen(ncid, dimid, &np));
00719   if (np > EP)
00720     ERRMSG("Too many levels!");
00721
00722   /* Store dimensions... */
00723   met->np = (int) np;
00724   met->nx = (int) nx;
00725   met->ny = (int) ny;
00726
00727   /* Get horizontal grid... */
00728   NC(nc_inq_varid(ncid, "lon", &varid));
00729   NC(nc_get_var_double(ncid, varid, met->lon));
00730   NC(nc_inq_varid(ncid, "lat", &varid));
00731   NC(nc_get_var_double(ncid, varid, met->lat));
00732
00733   /* Read meteorological data... */
00734   read_met_help(ncid, "t", "T", met, met->t, 1.0);
00735   read_met_help(ncid, "u", "U", met, met->u, 1.0);
```

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

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

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

```
00996   }
00997
00998   /* Write info... */
00999   printf("%s = %s\n", fullname1, rval);
01000
01001   /* Return values... */
01002   if (value != NULL)
01003     sprintf(value, "%s", rval);
01004   return atof(rval);
01005 }
01006
01007 /*****************************************************************************/
01008
01009 void time2jsec(
01010   int year,
01011   int mon,
01012   int day,
01013   int hour,
01014   int min,
01015   int sec,
01016   double remain,
01017   double *jsec) {
01018
01019   struct tm t0, t1;
01020
01021   t0.tm_year = 100;
01022   t0.tm_mon = 0;
01023   t0.tm_mday = 1;
01024   t0.tm_hour = 0;
01025   t0.tm_min = 0;
01026   t0.tm_sec = 0;
01027
01028   t1.tm_year = year - 1900;
01029   t1.tm_mon = mon - 1;
01030   t1.tm_mday = day;
01031   t1.tm_hour = hour;
01032   t1.tm_min = min;
01033   t1.tm_sec = sec;
01034
01035   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
01036 }
01037
01038 /*****************************************************************************/
01039
01040 void timer(
01041   const char *name,
01042   int id,
01043   int mode) {
01044
01045   static double starttime[NTIMER], runtime[NTIMER];
01046
01047   /* Check id... */
01048   if (id < 0 || id >= NTIMER)
01049     ERRMSG("Too many timers!");
01050
01051   /* Start timer... */
01052   if (mode == 1) {
01053     if (starttime[id] <= 0)
01054       starttime[id] = omp_get_wtime();
01055     else
01056       ERRMSG("Timer already started!");
01057   }
01058
01059   /* Stop timer... */
01060   else if (mode == 2) {
01061     if (starttime[id] > 0) {
01062       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
01063       starttime[id] = -1;
01064     } else
01065       ERRMSG("Timer not started!");
01066   }
01067
01068   /* Print timer... */
01069   else if (mode == 3)
01070     printf("%s = %g s\n", name, runtime[id]);
01071 }
01072
01073 /*****************************************************************************/
01074
01075 double tropopause(
01076   double t,
01077   double lat) {
01078
01079   static double doys[12]
01080   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
01081
01082   static double lats[73]
```

```
01083     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
01084     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
01085     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
01086     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
01087     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
01088     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
01089     75, 77.5, 80, 82.5, 85, 87.5, 90
01090   };
01091
01092   static double tps[12][73]
01093     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
01094          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
01095          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
01096          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
01097          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
01098          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
01099          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
01100          275.3, 275.6, 275.4, 274.1, 273.5},
01101    {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
01102     300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
01103     150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
01104     98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
01105     98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
01106     220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
01107     284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
01108     287.5, 286.2, 285.8},
01109    {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
01110     297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
01111     161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
01112     100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
01113     99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
01114     186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
01115     279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
01116     304.3, 304.9, 306, 306.6, 306.2, 306},
01117    {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
01118     290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
01119     195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
01120     102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
01121     99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
01122     148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
01123     263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
01124     315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
01125    {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
01126     260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
01127     205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
01128     101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
01129     102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
01130     165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
01131     273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
01132     325.3, 325.8, 325.8},
01133    {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
01134     222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
01135     228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
01136     105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
01137     106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
01138     127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
01139     251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
01140     308.5, 312.2, 313.1, 313.3},
01141    {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
01142     187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
01143     235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
01144     110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
01145     111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
01146     117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
01147     224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
01148     275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
01149    {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
01150     185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
01151     233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
01152     110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
01153     112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
01154     120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
01155     230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
01156     278.2, 282.6, 287.4, 290.9, 292.5, 293},
01157    {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
01158     183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
01159     243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
01160     114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
01161     110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
01162     114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
01163     203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
01164     276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
01165    {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
01166     215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
01167     237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
01168     111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
01169     106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
```

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

```
01257
01258   else {
01259
01260     /* Write info... */
01261     printf("Write atmospheric data: %s\n", filename);
01262
01263     /* Create file... */
01264     if (!(out = fopen(filename, "w")))
01265       ERRMSG("Cannot create file!");
01266   }
01267
01268   /* Write header... */
01269   fprintf(out,
01270           "# $1 = time [s]\n"
01271           "# $2 = altitude [km]\n"
01272           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01273   for (iq = 0; iq < ctl->nq; iq++)
01274     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
01275             ctl->qnt_unit[iq]);
01276   fprintf(out, "\n");
01277
01278   /* Write data... */
01279   for (ip = 0; ip < atm->np; ip++) {
01280     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
01281             atm->lon[ip], atm->lat[ip]);
01282     for (iq = 0; iq < ctl->nq; iq++) {
01283       fprintf(out, " ");
01284       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01285     }
01286     fprintf(out, "\n");
01287   }
01288
01289   /* Close file... */
01290   fclose(out);
01291 }
01292
01293 /*****************************************************************************/
01294
01295 void write_csi(
01296   const char *filename,
01297   ctl_t * ctl,
01298   atm_t * atm,
01299   double t) {
01300
01301   static FILE *in, *out;
01302
01303   static char line[LEN];
01304
01305   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
01306     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
01307
01308   static int init, obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
01309
01310   /* Init... */
01311   if (!init) {
01312     init = 1;
01313
01314     /* Check quantity index for mass... */
01315     if (ctl->qnt_m < 0)
01316       ERRMSG("Need quantity mass to analyze CSI!");
01317
01318     /* Open observation data file... */
01319     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
01320     if (!(in = fopen(ctl->csi_obsfile, "r")))
01321       ERRMSG("Cannot open file!");
01322
01323     /* Create new file... */
01324     printf("Write CSI data: %s\n", filename);
01325     if (!(out = fopen(filename, "w")))
01326       ERRMSG("Cannot create file!");
01327
01328     /* Write header... */
01329     fprintf(out,
01330             "# $1 = time [s]\n"
01331             "# $2 = number of hits (cx)\n"
01332             "# $3 = number of misses (cy)\n"
01333             "# $4 = number of false alarms (cz)\n"
01334             "# $5 = number of observations (cx + cy)\n"
01335             "# $6 = number of forecasts (cx + cz)\n"
01336             "# $7 = bias (forecasts/observations) [%%]\n"
01337             "# $8 = probability of detection (POD) [%%]\n"
01338             "# $9 = false alarm rate (FAR) [%%]\n"
01339             "# $10 = critical success index (CSI) [%%]\n\n");
01340   }
01341
01342   /* Set time interval... */
01343   t0 = t - 0.5 * ctl->dt_mod;
```

```
01344   t1 = t + 0.5 * ctl->dt_mod;
01345
01346   /* Initialize grid cells... */
01347   for (ix = 0; ix < ctl->csi_nx; ix++)
01348     for (iy = 0; iy < ctl->csi_ny; iy++)
01349       for (iz = 0; iz < ctl->csi_nz; iz++)
01350         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
01351
01352   /* Read data... */
01353   while (fgets(line, LEN, in)) {
01354
01355     /* Read data... */
01356     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
01357         5)
01358       continue;
01359
01360     /* Check time... */
01361     if (rt < t0)
01362       continue;
01363     if (rt > t1)
01364       break;
01365
01366     /* Calculate indices... */
01367     ix = (int) ((rlon - ctl->csi_lon0)
01368                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01369     iy = (int) ((rlat - ctl->csi_lat0)
01370                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01371     iz = (int) ((rz - ctl->csi_z0)
01372                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01373
01374     /* Check indices... */
01375     if (ix < 0 || ix >= ctl->csi_nx ||
01376         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01377       continue;
01378
01379     /* Get mean observation index... */
01380     obsmean[ix][iy][iz] += robs;
01381     obscount[ix][iy][iz]++;
01382   }
01383
01384   /* Analyze model data... */
01385   for (ip = 0; ip < atm->np; ip++) {
01386
01387     /* Check time... */
01388     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01389       continue;
01390
01391     /* Get indices... */
01392     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
01393                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01394     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
01395                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01396     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
01397                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01398
01399     /* Check indices... */
01400     if (ix < 0 || ix >= ctl->csi_nx ||
01401         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01402       continue;
01403
01404     /* Get total mass in grid cell... */
01405     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01406   }
01407
01408   /* Analyze all grid cells... */
01409   for (ix = 0; ix < ctl->csi_nx; ix++)
01410     for (iy = 0; iy < ctl->csi_ny; iy++)
01411       for (iz = 0; iz < ctl->csi_nz; iz++) {
01412
01413         /* Calculate mean observation index... */
01414         if (obscount[ix][iy][iz] > 0)
01415           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
01416
01417         /* Calculate column density... */
01418         if (modmean[ix][iy][iz] > 0) {
01419           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
01420           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
01421           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
01422           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
01423             * cos(lat * M_PI / 180.);
01424           modmean[ix][iy][iz] /= (1e6 * area);
01425         }
01426
01427         /* Calculate CSI... */
01428         if (obscount[ix][iy][iz] > 0) {
01429           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01430               modmean[ix][iy][iz] >= ctl->csi_modmin)
```

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

```
01518       grid_m[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01519     }
01520
01521   /* Check if gnuplot output is requested... */
01522   if (ctl->grid_gpfile[0] != '-') {
01523
01524     /* Write info... */
01525     printf("Plot grid data: %s.png\n", filename);
01526
01527     /* Create gnuplot pipe... */
01528     if (!(out = popen("gnuplot", "w")))
01529       ERRMSG("Cannot create pipe to gnuplot!");
01530
01531     /* Set plot filename... */
01532     fprintf(out, "set out \"%s.png\"\n", filename);
01533
01534     /* Set time string... */
01535     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01536     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01537             year, mon, day, hour, min);
01538
01539     /* Dump gnuplot file to pipe... */
01540     if (!(in = fopen(ctl->grid_gpfile, "r")))
01541       ERRMSG("Cannot open file!");
01542     while (fgets(line, LEN, in))
01543       fprintf(out, "%s", line);
01544     fclose(in);
01545   }
01546
01547   else {
01548
01549     /* Write info... */
01550     printf("Write grid data: %s\n", filename);
01551
01552     /* Create file... */
01553     if (!(out = fopen(filename, "w")))
01554       ERRMSG("Cannot create file!");
01555   }
01556
01557   /* Write header... */
01558   fprintf(out,
01559           "# $1 = time [s]\n"
01560           "# $2 = altitude [km]\n"
01561           "# $3 = longitude [deg]\n"
01562           "# $4 = latitude [deg]\n"
01563           "# $5 = surface area [km^2]\n"
01564           "# $6 = layer width [km]\n"
01565           "# $7 = temperature [K]\n"
01566           "# $8 = column density [kg/m^2]\n"
01567           "# $9 = mass mixing ratio [1]\n\n");
01568
01569   /* Write data... */
01570   for (ix = 0; ix < ctl->grid_nx; ix++) {
01571     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
01572       fprintf(out, "\n");
01573     for (iy = 0; iy < ctl->grid_ny; iy++) {
01574       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
01575         fprintf(out, "\n");
01576       for (iz = 0; iz < ctl->grid_nz; iz++)
01577         if (!ctl->grid_sparse
01578             || ix == 0 || iy == 0 || iz == 0 || grid_m[ix][iy][iz] > 0) {
01579
01580           /* Set coordinates... */
01581           z = ctl->grid_z0 + dz * (iz + 0.5);
01582           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
01583           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
01584
01585           /* Get pressure and temperature... */
01586           press = P(z);
01587           intpol_met_time(met0, met1, t, press, lon, lat,
01588                           NULL, &temp, NULL, NULL, NULL, NULL, NULL);
01589
01590           /* Calculate surface area... */
01591           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
01592             * cos(lat * M_PI / 180.);
01593
01594           /* Calculate column density... */
01595           cd = grid_m[ix][iy][iz] / (1e6 * area);
01596
01597           /* Calculate mass mixing ratio... */
01598           rho_air = 100. * press / (287.058 * temp);
01599           mmr = grid_m[ix][iy][iz] / (rho_air * 1e6 * area * 1e3 * dz);
01600
01601           /* Write output... */
01602           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01603                   t, z, lon, lat, area, dz, temp, cd, mmr);
01604         }
```

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

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

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

## 5.13 libtrac.h File Reference

MPTRAC library declarations.

### Data Structures

- struct ctl_t

  *Control parameters.*
- struct atm_t

  *Atmospheric data.*
- struct met_t

  *Meteorological data.*

### Functions

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

  *Read meteorological data file.*

- void read_met_extrapolate (met_t *met)

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

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

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

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

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

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

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

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

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

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

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

  *Write station data.*

### 5.13.1 Detailed Description

MPTRAC library declarations.

Definition in file libtrac.h.

### 5.13.2 Function Documentation

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

Convert Cartesian coordinates to geolocation.

Definition at line 29 of file libtrac.c.

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

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

Convert degrees to horizontal distance.

Definition at line 45 of file libtrac.c.

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

#### 5.13.2.3 double deg2dy ( double *dlat* )

Convert degrees to horizontal distance.

Definition at line 54 of file libtrac.c.

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

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

Convert pressure to vertical distance.

Definition at line 62 of file libtrac.c.

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

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

Convert horizontal distance to degrees.

Definition at line 71 of file libtrac.c.

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

#### 5.13.2.6 double dy2deg ( double *dy* )

Convert horizontal distance to degrees.

Definition at line 84 of file libtrac.c.

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

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

Convert vertical distance to pressure.

Definition at line 92 of file libtrac.c.

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

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

Convert geolocation to Cartesian coordinates.

Definition at line 101 of file libtrac.c.

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

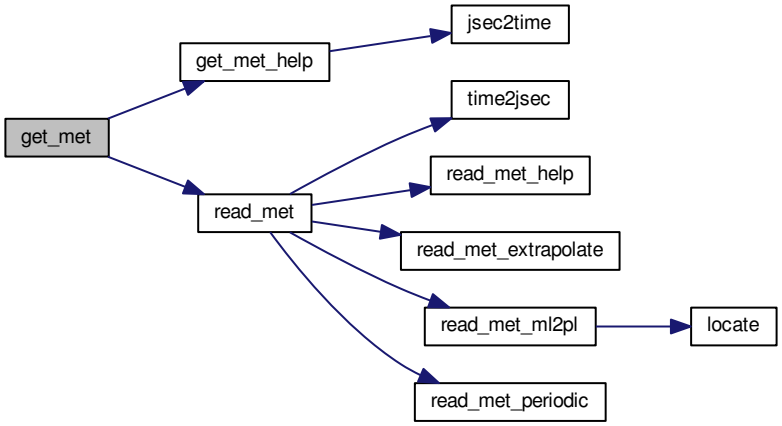
#### 5.13.2.9 void get_met ( ctl_t * *ctl*, char * *metbase*, double *t*, met_t * *met0*, met_t * *met1* )

Get meteorological data for given timestep.

Definition at line 117 of file libtrac.c.

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

Here is the call graph for this function:



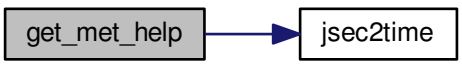

#### 5.13.2.10 void get_met_help ( double *t*, int *direct*, char * *metbase*, double *dt_met*, char * *filename* )

Get meteorological data for timestep.

Definition at line 156 of file libtrac.c.

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

Here is the call graph for this function:



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

Linear interpolation of 2-D meteorological data.

Definition at line 182 of file libtrac.c.

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

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

Linear interpolation of 3-D meteorological data.

Definition at line 206 of file libtrac.c.

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

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

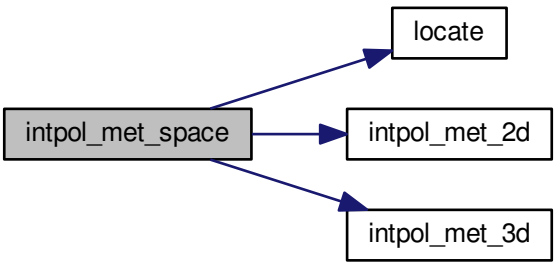
Spatial interpolation of meteorological data.

Definition at line 236 of file libtrac.c.

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

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

Here is the call graph for this function:




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

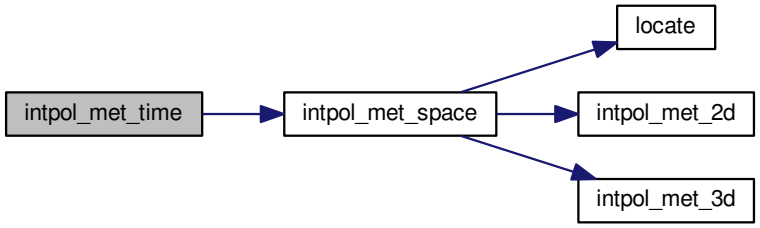
Temporal interpolation of meteorological data.

Definition at line 286 of file libtrac.c.

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

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

Here is the call graph for this function:




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

Convert seconds to date.

Definition at line 341 of file libtrac.c.

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

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

Find array index.

Definition at line 376 of file libtrac.c.

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

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

Read atmospheric data.

Definition at line 408 of file libtrac.c.

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

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

Read control parameters.

Definition at line 458 of file libtrac.c.

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

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

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

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.

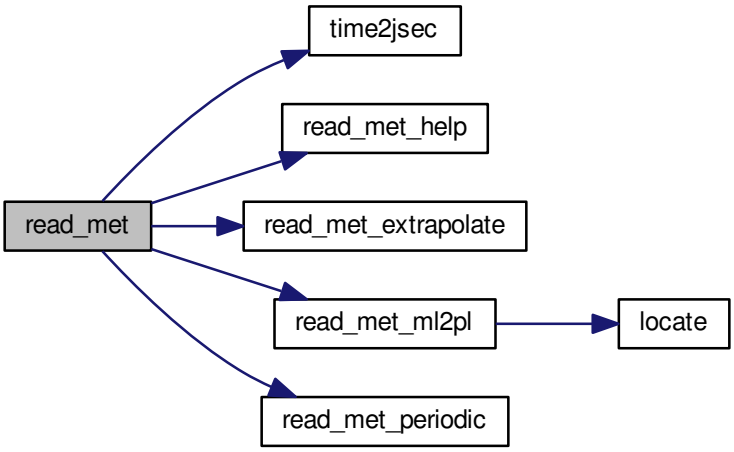
Definition at line 676 of file libtrac.c.

```
00679                {
00680
```

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

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

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 804 of file libtrac.c.

```
00805               {
00806
```

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

#### 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 835 of file libtrac.c.

```
00841             {
00842
00843   static float help[EX * EY * EP];
00844
00845   int ip, ix, iy, n = 0, varid;
00846
00847   /* Check if variable exists... */
00848   if (nc_inq_varid(ncid, varname, &varid) != NC_NOERR)
00849     if (nc_inq_varid(ncid, varname2, &varid) != NC_NOERR)
00850       return;
00851
00852   /* Read data... */
00853   NC(nc_get_var_float(ncid, varid, help));
00854
00855   /* Copy and check data... */
00856   for (ip = 0; ip < met->np; ip++)
00857     for (iy = 0; iy < met->ny; iy++)
00858       for (ix = 0; ix < met->nx; ix++) {
00859         dest[ix][iy][ip] = scl * help[n++];
00860         if (fabs(dest[ix][iy][ip] / scl) > 1e14)
00861           dest[ix][iy][ip] = GSL_NAN;
00862       }
00863 }
```

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

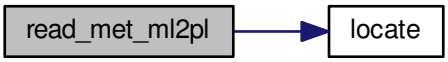
Convert meteorological data from model levels to pressure levels.

Definition at line 867 of file libtrac.c.

```
00870                         {
00871
00872   double aux[EP], p[EP], pt;
00873
00874   int ip, ip2, ix, iy;
00875
00876   /* Loop over columns... */
00877   for (ix = 0; ix < met->nx; ix++)
00878     for (iy = 0; iy < met->ny; iy++) {
00879
00880       /* Copy pressure profile... */
00881       for (ip = 0; ip < met->np; ip++)
```

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

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 905 of file libtrac.c.

```
00906               {
00907
00908   int ip, iy;
00909
00910   /* Check longitudes... */
00911   if (!(fabs(met->lon[met->nx - 1] - met->lon[0]
00912              + met->lon[1] - met->lon[0] - 360) < 0.01))
00913     return;
00914
00915   /* Increase longitude counter... */
00916   if ((++met->nx) > EX)
00917     ERRMSG("Cannot create periodic boundary conditions!");
00918
00919   /* Set longitude... */
00920   met->lon[met->nx - 1] = met->lon[met->nx - 2] + met->lon[1] - met->
      lon[0];
00921
00922   /* Loop over latitudes and pressure levels... */
00923   for (iy = 0; iy < met->ny; iy++)
00924     for (ip = 0; ip < met->np; ip++) {
00925       met->ps[met->nx - 1][iy] = met->ps[0][iy];
00926       met->u[met->nx - 1][iy][ip] = met->u[0][iy][ip];
00927       met->v[met->nx - 1][iy][ip] = met->v[0][iy][ip];
00928       met->w[met->nx - 1][iy][ip] = met->w[0][iy][ip];
00929       met->t[met->nx - 1][iy][ip] = met->t[0][iy][ip];
00930       met->h2o[met->nx - 1][iy][ip] = met->h2o[0][iy][ip];
00931       met->o3[met->nx - 1][iy][ip] = met->o3[0][iy][ip];
00932     }
00933 }
```

#### 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 937 of file libtrac.c.

```
00944                {
00945
00946   FILE *in = NULL;
00947
00948   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
00949     msg[LEN], rvarname[LEN], rval[LEN];
00950
00951   int contain = 0, i;
00952
00953   /* Open file... */
00954   if (filename[strlen(filename) - 1] != '-')
00955     if (!(in = fopen(filename, "r")))
00956       ERRMSG("Cannot open file!");
00957
00958   /* Set full variable name... */
00959   if (arridx >= 0) {
00960     sprintf(fullname1, "%s[%d]", varname, arridx);
00961     sprintf(fullname2, "%s[*]", varname);
00962   } else {
00963     sprintf(fullname1, "%s", varname);
00964     sprintf(fullname2, "%s", varname);
00965   }
00966
00967   /* Read data... */
00968   if (in != NULL)
00969     while (fgets(line, LEN, in))
00970       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
00971         if (strcasecmp(rvarname, fullname1) == 0 ||
00972             strcasecmp(rvarname, fullname2) == 0) {
00973           contain = 1;
00974           break;
00975         }
00976   for (i = 1; i < argc - 1; i++)
00977     if (strcasecmp(argv[i], fullname1) == 0 ||
00978         strcasecmp(argv[i], fullname2) == 0) {
00979       sprintf(rval, "%s", argv[i + 1]);
00980       contain = 1;
00981       break;
00982     }
00983
00984   /* Close file... */
00985   if (in != NULL)
00986     fclose(in);
00987
00988   /* Check for missing variables... */
00989   if (!contain) {
00990     if (strlen(defvalue) > 0)
00991       sprintf(rval, "%s", defvalue);
00992     else {
00993       sprintf(msg, "Missing variable %s!\n", fullname1);
00994       ERRMSG(msg);
00995     }
00996   }
00997
00998   /* Write info... */
00999   printf("%s = %s\n", fullname1, rval);
01000
01001   /* Return values... */
01002   if (value != NULL)
01003     sprintf(value, "%s", rval);
01004   return atof(rval);
01005 }
```

#### 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 1009 of file libtrac.c.

```
01017                {
01018
01019   struct tm t0, t1;
01020
01021   t0.tm_year = 100;
01022   t0.tm_mon = 0;
01023   t0.tm_mday = 1;
01024   t0.tm_hour = 0;
01025   t0.tm_min = 0;
01026   t0.tm_sec = 0;
01027
01028   t1.tm_year = year - 1900;
01029   t1.tm_mon = mon - 1;
01030   t1.tm_mday = day;
01031   t1.tm_hour = hour;
01032   t1.tm_min = min;
01033   t1.tm_sec = sec;
01034
01035   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
01036 }
```

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

Measure wall-clock time.

Definition at line 1040 of file libtrac.c.

```
01043            {
01044
01045   static double starttime[NTIMER], runtime[NTIMER];
01046
01047   /* Check id... */
01048   if (id < 0 || id >= NTIMER)
01049     ERRMSG("Too many timers!");
01050
01051   /* Start timer... */
01052   if (mode == 1) {
01053     if (starttime[id] <= 0)
01054       starttime[id] = omp_get_wtime();
01055     else
01056       ERRMSG("Timer already started!");
01057   }
01058
01059   /* Stop timer... */
01060   else if (mode == 2) {
01061     if (starttime[id] > 0) {
01062       runtime[id] = runtime[id] + omp_get_wtime() - starttime[id];
01063       starttime[id] = -1;
01064     } else
01065       ERRMSG("Timer not started!");
01066   }
01067
01068   /* Print timer... */
01069   else if (mode == 3)
01070     printf("%s = %g s\n", name, runtime[id]);
01071 }
```

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

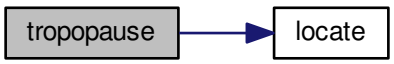
Definition at line 1075 of file libtrac.c.

```
01077              {
01078
01079   static double doys[12]
01080   = { 1, 32, 60, 91, 121, 152, 182, 213, 244, 274, 305, 335 };
01081
01082   static double lats[73]
01083     = { -90, -87.5, -85, -82.5, -80, -77.5, -75, -72.5, -70, -67.5,
01084     -65, -62.5, -60, -57.5, -55, -52.5, -50, -47.5, -45, -42.5,
01085     -40, -37.5, -35, -32.5, -30, -27.5, -25, -22.5, -20, -17.5,
01086     -15, -12.5, -10, -7.5, -5, -2.5, 0, 2.5, 5, 7.5, 10, 12.5,
01087     15, 17.5, 20, 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5,
01088     45, 47.5, 50, 52.5, 55, 57.5, 60, 62.5, 65, 67.5, 70, 72.5,
01089     75, 77.5, 80, 82.5, 85, 87.5, 90
01090   };
```

```
01091
01092   static double tps[12][73]
01093     = { {324.1, 325.6, 325, 324.3, 322.5, 319.7, 314, 307.2, 301.8, 299.6,
01094          297.1, 292.2, 285.6, 276.1, 264, 248.9, 231.9, 213.5, 194.4,
01095          175.3, 157, 140.4, 126.7, 116.3, 109.5, 105.4, 103, 101.4, 100.4,
01096          99.69, 99.19, 98.84, 98.56, 98.39, 98.39, 98.42, 98.44, 98.54,
01097          98.68, 98.81, 98.89, 98.96, 99.12, 99.65, 101.4, 105.4, 113.5, 128,
01098          152.1, 184.7, 214, 234.1, 247.3, 255.8, 262.6, 267.7, 271.7, 275,
01099          277.2, 279, 280.1, 280.4, 280.6, 280.1, 279.3, 278.3, 276.8, 275.8,
01100          275.3, 275.6, 275.4, 274.1, 273.5},
01101    {337.3, 338.7, 337.8, 336.4, 333, 328.8, 321.1, 312.6, 306.6, 303.7,
01102     300.2, 293.8, 285.4, 273.8, 259.6, 242.7, 224.4, 205.2, 186, 167.5,
01103     150.3, 135, 122.8, 113.9, 108.2, 104.7, 102.5, 101.1, 100.2, 99.42,
01104     98.88, 98.52, 98.25, 98.09, 98.07, 98.1, 98.12, 98.2, 98.25, 98.27,
01105     98.26, 98.27, 98.36, 98.79, 100.2, 104.2, 113.7, 131.2, 159.5, 193,
01106     220.4, 238.1, 250.2, 258.1, 264.7, 269.7, 273.7, 277.3, 280.2, 282.8,
01107     284.9, 286.5, 288.1, 288.8, 289, 288.5, 287.2, 286.3, 286.1, 287.2,
01108     287.5, 286.2, 285.8},
01109    {335, 336, 335.7, 335.1, 332.3, 328.1, 320.6, 311.8, 305.1, 301.9,
01110     297.6, 290, 280.4, 268.3, 254.6, 239.6, 223.9, 207.9, 192.2, 176.9,
01111     161.7, 146.4, 132.2, 120.6, 112.3, 107.2, 104.3, 102.4, 101.3,
01112     100.4, 99.86, 99.47, 99.16, 98.97, 98.94, 98.97, 99, 99.09, 99.2,
01113     99.31, 99.35, 99.41, 99.51, 99.86, 101.1, 104.9, 114.3, 131, 156.8,
01114     186.3, 209.3, 224.6, 236.8, 246.3, 254.9, 262.3, 268.8, 274.8,
01115     279.9, 284.6, 288.6, 291.6, 294.9, 297.5, 299.8, 301.8, 303.1,
01116     304.3, 304.9, 306, 306.6, 306.2, 306},
01117    {306.2, 306.7, 305.7, 307.1, 307.3, 306.4, 301.8, 296.2, 292.4,
01118     290.3, 287.1, 280.9, 273.4, 264.3, 254.1, 242.8, 231, 219, 207.2,
01119     195.5, 183.3, 169.7, 154.7, 138.7, 124.1, 113.6, 107.8, 104.7,
01120     102.8, 101.7, 100.9, 100.4, 100, 99.79, 99.7, 99.66, 99.68, 99.79,
01121     99.94, 100.2, 100.5, 100.9, 101.4, 102.1, 103.4, 107, 115.2, 129.1,
01122     148.7, 171, 190.8, 205.6, 218.4, 229.4, 239.6, 248.6, 256.5,
01123     263.7, 270.3, 276.6, 282.6, 288.1, 294.5, 300.4, 306.3, 311.4,
01124     315.1, 318.3, 320.3, 322.2, 322.8, 321.5, 321.1},
01125    {266.5, 264.9, 260.8, 261, 262, 263, 261.3, 259.7, 259.2, 259.8,
01126     260.1, 258.6, 256.7, 253.6, 249.5, 243.9, 237.4, 230, 222.1, 213.9,
01127     205, 194.4, 180.4, 161.8, 140.7, 122.9, 112.1, 106.7, 104.1, 102.7,
01128     101.8, 101.4, 101.1, 101, 101, 101, 101.1, 101.2, 101.5, 101.9,
01129     102.4, 103, 103.8, 104.9, 106.8, 110.1, 115.6, 124, 135.2, 148.9,
01130     165.2, 181.3, 198, 211.8, 223.5, 233.8, 242.9, 251.5, 259, 266.2,
01131     273.1, 279.2, 286.2, 292.8, 299.6, 306, 311.1, 315.5, 318.8, 322.6,
01132     325.3, 325.8, 325.8},
01133    {220.1, 218.1, 210.8, 207.2, 207.6, 210.5, 211.4, 213.5, 217.3,
01134     222.4, 227.9, 232.8, 237.4, 240.8, 242.8, 243, 241.5, 238.6, 234.2,
01135     228.5, 221, 210.7, 195.1, 172.9, 147.8, 127.6, 115.6, 109.9, 107.1,
01136     105.7, 105, 104.8, 104.8, 104.9, 105, 105.1, 105.3, 105.5, 105.8,
01137     106.4, 107, 107.6, 108.1, 108.8, 110, 111.8, 114.2, 117.4, 121.6,
01138     127.9, 137.3, 151.2, 169.5, 189, 205.8, 218.9, 229.1, 237.8, 245,
01139     251.5, 257.1, 262.3, 268.2, 274, 280.4, 286.7, 292.4, 297.9, 302.9,
01140     308.5, 312.2, 313.1, 313.3},
01141    {187.4, 184.5, 173.3, 166.1, 165.4, 167.8, 169.6, 173.6, 179.6,
01142     187.9, 198.9, 210, 220.5, 229.2, 235.7, 239.9, 241.8, 241.6, 239.6,
01143     235.8, 229.4, 218.6, 200.9, 175.9, 149.4, 129.4, 118.3, 113.1,
01144     110.8, 109.7, 109.3, 109.4, 109.7, 110, 110.2, 110.4, 110.5, 110.7,
01145     111, 111.4, 111.8, 112.1, 112.3, 112.7, 113.2, 113.9, 115, 116.4,
01146     117.9, 120.4, 124.1, 130.9, 142.2, 159.6, 179.6, 198.5, 212.9,
01147     224.2, 232.7, 239.1, 243.8, 247.7, 252.4, 257.3, 263.2, 269.5,
01148     275.4, 281.1, 286.3, 292, 296.3, 298.2, 298.8},
01149    {166, 166.4, 155.7, 148.3, 147.1, 149, 152.1, 157, 163.6, 172.4,
01150     185.3, 199.2, 212.6, 224, 233.2, 239.6, 243.3, 244.6, 243.6, 240.3,
01151     233.9, 222.6, 203.7, 177, 149.5, 129.7, 119, 114, 111.7, 110.7,
01152     110.3, 110.3, 110.6, 110.9, 111.1, 111.3, 111.5, 111.6, 111.9,
01153     112.2, 112.5, 112.6, 112.8, 113, 113.4, 114, 115.1, 116.5, 118.3,
01154     120.9, 124.4, 130.2, 139.4, 154.6, 173.8, 193.1, 208.1, 220.4,
01155     230.1, 238.2, 244.7, 249.5, 254.5, 259.3, 264.5, 269.4, 273.7,
01156     278.2, 282.6, 287.4, 290.9, 292.5, 293},
01157    {171.9, 172.8, 166.2, 162.3, 161.4, 162.5, 165.2, 169.6, 175.3,
01158     183.1, 193.8, 205.9, 218.3, 229.6, 238.5, 244.3, 246.9, 246.7,
01159     243.8, 238.4, 230.2, 217.9, 199.6, 174.9, 148.9, 129.8, 119.5,
01160     114.8, 112.3, 110.9, 110.3, 110.1, 110.2, 110.3, 110.4, 110.5,
01161     110.6, 110.8, 111, 111.4, 111.8, 112, 112.2, 112.4, 112.9, 113.6,
01162     114.7, 116.3, 118.4, 121.9, 127.1, 136.1, 149.8, 168.4, 186.9,
01163     203.3, 217, 229.1, 238.7, 247, 254, 259.3, 264.3, 268.3, 272.5,
01164     276.6, 280.4, 284.4, 288.4, 293.3, 297.2, 298.7, 299.1},
01165    {191.6, 192.2, 189, 188.1, 190.2, 193.7, 197.8, 202.9, 208.5,
01166     215.6, 224.2, 233.1, 241.2, 247.3, 250.8, 251.3, 248.9, 244.2,
01167     237.3, 228.4, 217.2, 202.9, 184.5, 162.5, 140.7, 124.8, 116.2,
01168     111.8, 109.4, 107.9, 107, 106.7, 106.6, 106.6, 106.7, 106.7,
01169     106.8, 107, 107.4, 108, 108.7, 109.3, 109.8, 110.4, 111.2,
01170     112.4, 114.2, 116.9, 121.1, 127.9, 139.3, 155.2, 173.6, 190.7,
01171     206.1, 220.1, 232.3, 243, 251.8, 259.2, 265.7, 270.6, 275.3,
01172     279.3, 283.3, 286.9, 289.7, 292.8, 296.1, 300.5, 303.9, 304.8,
01173     305.1},
01174    {241.5, 239.6, 236.8, 237.4, 239.4, 242.3, 244.2, 246.4, 249.2,
01175     253.6, 258.6, 262.7, 264.8, 264.2, 260.6, 254.1, 245.5, 235.3,
01176     223.9, 211.7, 198.3, 183.1, 165.6, 147.1, 130.5, 118.7, 111.9,
01177     108.1, 105.8, 104.3, 103.4, 102.8, 102.5, 102.4, 102.5, 102.5,
```

```
01178    102.5, 102.7, 103.1, 103.8, 104.6, 105.4, 106.1, 107, 108.2,
01179    109.9, 112.8, 117.5, 126, 140.4, 161, 181.9, 201.2, 216.8, 230.4,
01180    241.8, 251.4, 259.9, 266.9, 272.8, 277.4, 280.4, 282.9, 284.6,
01181    286.1, 287.4, 288.3, 289.5, 290.9, 294.2, 296.9, 297.5, 297.6},
01182   {301.2, 300.3, 296.6, 295.4, 295, 294.3, 291.2, 287.4, 284.9, 284.7,
01183    284.1, 281.5, 277.1, 270.4, 261.7, 250.6, 237.6, 223.1, 207.9, 192,
01184    175.8, 158.8, 142.1, 127.6, 116.8, 109.9, 106, 103.6, 102.1, 101.1,
01185    100.4, 99.96, 99.6, 99.37, 99.32, 99.32, 99.31, 99.46, 99.77, 100.2,
01186    100.7, 101.3, 101.8, 102.7, 104.1, 106.8, 111.9, 121, 136.7, 160,
01187    186.9, 209.9, 228.1, 241.2, 251.5, 259.5, 265.7, 270.9, 274.8, 278,
01188    280.3, 281.8, 283, 283.3, 283.7, 283.8, 283, 282.2, 281.2, 281.4,
01189    281.7, 281.1, 281.2}
01190   };
01191
01192   double doy, p0, p1, pt;
01193
01194   int imon, ilat;
01195
01196   /* Get day of year... */
01197   doy = fmod(t / 86400., 365.25);
01198   while (doy < 0)
01199     doy += 365.25;
01200
01201   /* Get indices... */
01202   imon = locate(doys, 12, doy);
01203   ilat = locate(lats, 73, lat);
01204
01205   /* Get tropopause pressure... */
01206   p0 = LIN(lats[ilat], tps[imon][ilat],
01207            lats[ilat + 1], tps[imon][ilat + 1], lat);
01208   p1 = LIN(lats[ilat], tps[imon + 1][ilat],
01209            lats[ilat + 1], tps[imon + 1][ilat + 1], lat);
01210   pt = LIN(doys[imon], p0, doys[imon + 1], p1, doy);
01211
01212   /* Return tropopause pressure... */
01213   return pt;
01214 }
```

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 1218 of file libtrac.c.

```
01222            {
01223
01224   FILE *in, *out;
01225
01226   char line[LEN];
01227
01228   double r;
01229
01230   int ip, iq, year, mon, day, hour, min, sec;
01231
01232   /* Check if gnuplot output is requested... */
01233   if (ctl->atm_gpfile[0] != '-') {
01234
01235     /* Write info... */
01236     printf("Plot atmospheric data: %s.png\n", filename);
01237
```

```
01238     /* Create gnuplot pipe... */
01239     if (!(out = popen("gnuplot", "w")))
01240       ERRMSG("Cannot create pipe to gnuplot!");
01241
01242     /* Set plot filename... */
01243     fprintf(out, "set out \"%s.png\"\n", filename);
01244
01245     /* Set time string... */
01246     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01247     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01248             year, mon, day, hour, min);
01249
01250     /* Dump gnuplot file to pipe... */
01251     if (!(in = fopen(ctl->atm_gpfile, "r")))
01252       ERRMSG("Cannot open file!");
01253     while (fgets(line, LEN, in))
01254       fprintf(out, "%s", line);
01255     fclose(in);
01256   }
01257
01258   else {
01259
01260     /* Write info... */
01261     printf("Write atmospheric data: %s\n", filename);
01262
01263     /* Create file... */
01264     if (!(out = fopen(filename, "w")))
01265       ERRMSG("Cannot create file!");
01266   }
01267
01268   /* Write header... */
01269   fprintf(out,
01270           "# $1 = time [s]\n"
01271           "# $2 = altitude [km]\n"
01272           "# $3 = longitude [deg]\n" "# $4 = latitude [deg]\n");
01273   for (iq = 0; iq < ctl->nq; iq++)
01274     fprintf(out, "# $%i = %s [%s]\n", iq + 5, ctl->qnt_name[iq],
01275             ctl->qnt_unit[iq]);
01276   fprintf(out, "\n");
01277
01278   /* Write data... */
01279   for (ip = 0; ip < atm->np; ip++) {
01280     fprintf(out, "%.2f %g %g %g", atm->time[ip], Z(atm->p[ip]),
01281             atm->lon[ip], atm->lat[ip]);
01282     for (iq = 0; iq < ctl->nq; iq++) {
01283       fprintf(out, " ");
01284       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01285     }
01286     fprintf(out, "\n");
01287   }
01288
01289   /* Close file... */
01290   fclose(out);
01291 }
```

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 1295 of file libtrac.c.

```
01299           {
01300
01301   static FILE *in, *out;
01302
01303   static char line[LEN];
01304
01305   static double modmean[GX][GY][GZ], obsmean[GX][GY][GZ],
01306     rt, rz, rlon, rlat, robs, t0, t1, area, dlon, dlat, lat;
01307
01308   static int init, obscount[GX][GY][GZ], cx, cy, cz, ip, ix, iy, iz;
01309
01310   /* Init... */
01311   if (!init) {
01312     init = 1;
01313
01314     /* Check quantity index for mass... */
01315     if (ctl->qnt_m < 0)
01316       ERRMSG("Need quantity mass to analyze CSI!");
01317
01318     /* Open observation data file... */
01319     printf("Read CSI observation data: %s\n", ctl->csi_obsfile);
01320     if (!(in = fopen(ctl->csi_obsfile, "r")))
01321       ERRMSG("Cannot open file!");
01322
01323     /* Create new file... */
01324     printf("Write CSI data: %s\n", filename);
01325     if (!(out = fopen(filename, "w")))
01326       ERRMSG("Cannot create file!");
01327
01328     /* Write header... */
01329     fprintf(out,
01330             "# $1 = time [s]\n"
01331             "# $2 = number of hits (cx)\n"
01332             "# $3 = number of misses (cy)\n"
01333             "# $4 = number of false alarms (cz)\n"
01334             "# $5 = number of observations (cx + cy)\n"
01335             "# $6 = number of forecasts (cx + cz)\n"
01336             "# $7 = bias (forecasts/observations) [%%]\n"
01337             "# $8 = probability of detection (POD) [%%]\n"
01338             "# $9 = false alarm rate (FAR) [%%]\n"
01339             "# $10 = critical success index (CSI) [%%]\n\n");
01340   }
01341
01342   /* Set time interval... */
01343   t0 = t - 0.5 * ctl->dt_mod;
01344   t1 = t + 0.5 * ctl->dt_mod;
01345
01346   /* Initialize grid cells... */
01347   for (ix = 0; ix < ctl->csi_nx; ix++)
01348     for (iy = 0; iy < ctl->csi_ny; iy++)
01349       for (iz = 0; iz < ctl->csi_nz; iz++)
01350         modmean[ix][iy][iz] = obsmean[ix][iy][iz] = obscount[ix][iy][iz] = 0;
01351
01352   /* Read data... */
01353   while (fgets(line, LEN, in)) {
01354
01355     /* Read data... */
01356     if (sscanf(line, "%lg %lg %lg %lg %lg", &rt, &rz, &rlon, &rlat, &robs) !=
01357         5)
01358       continue;
01359
01360     /* Check time... */
01361     if (rt < t0)
01362       continue;
01363     if (rt > t1)
01364       break;
01365
01366     /* Calculate indices... */
01367     ix = (int) ((rlon - ctl->csi_lon0)
01368                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01369     iy = (int) ((rlat - ctl->csi_lat0)
01370                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01371     iz = (int) ((rz - ctl->csi_z0)
01372                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01373
01374     /* Check indices... */
01375     if (ix < 0 || ix >= ctl->csi_nx ||
01376         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01377       continue;
01378
01379     /* Get mean observation index... */
01380     obsmean[ix][iy][iz] += robs;
01381     obscount[ix][iy][iz]++;
01382   }
01383
01384   /* Analyze model data... */
01385   for (ip = 0; ip < atm->np; ip++) {
```

```
01386
01387     /* Check time... */
01388     if (atm->time[ip] < t0 || atm->time[ip] > t1)
01389       continue;
01390
01391     /* Get indices... */
01392     ix = (int) ((atm->lon[ip] - ctl->csi_lon0)
01393                 / (ctl->csi_lon1 - ctl->csi_lon0) * ctl->csi_nx);
01394     iy = (int) ((atm->lat[ip] - ctl->csi_lat0)
01395                 / (ctl->csi_lat1 - ctl->csi_lat0) * ctl->csi_ny);
01396     iz = (int) ((Z(atm->p[ip]) - ctl->csi_z0)
01397                 / (ctl->csi_z1 - ctl->csi_z0) * ctl->csi_nz);
01398
01399     /* Check indices... */
01400     if (ix < 0 || ix >= ctl->csi_nx ||
01401         iy < 0 || iy >= ctl->csi_ny || iz < 0 || iz >= ctl->csi_nz)
01402       continue;
01403
01404     /* Get total mass in grid cell... */
01405     modmean[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01406   }
01407
01408   /* Analyze all grid cells... */
01409   for (ix = 0; ix < ctl->csi_nx; ix++)
01410     for (iy = 0; iy < ctl->csi_ny; iy++)
01411       for (iz = 0; iz < ctl->csi_nz; iz++) {
01412
01413         /* Calculate mean observation index... */
01414         if (obscount[ix][iy][iz] > 0)
01415           obsmean[ix][iy][iz] /= obscount[ix][iy][iz];
01416
01417         /* Calculate column density... */
01418         if (modmean[ix][iy][iz] > 0) {
01419           dlon = (ctl->csi_lon1 - ctl->csi_lon0) / ctl->csi_nx;
01420           dlat = (ctl->csi_lat1 - ctl->csi_lat0) / ctl->csi_ny;
01421           lat = ctl->csi_lat0 + dlat * (iy + 0.5);
01422           area = dlat * M_PI * RE / 180. * dlon * M_PI * RE / 180.
01423             * cos(lat * M_PI / 180.);
01424           modmean[ix][iy][iz] /= (1e6 * area);
01425         }
01426
01427         /* Calculate CSI... */
01428         if (obscount[ix][iy][iz] > 0) {
01429           if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01430               modmean[ix][iy][iz] >= ctl->csi_modmin)
01431             cx++;
01432           else if (obsmean[ix][iy][iz] >= ctl->csi_obsmin &&
01433                    modmean[ix][iy][iz] < ctl->csi_modmin)
01434             cy++;
01435           else if (obsmean[ix][iy][iz] < ctl->csi_obsmin &&
01436                    modmean[ix][iy][iz] >= ctl->csi_modmin)
01437             cz++;
01438         }
01439       }
01440
01441   /* Write output... */
01442   if (fmod(t, ctl->csi_dt_out) == 0) {
01443
01444     /* Write... */
01445     fprintf(out, "%.2f %d %d %d %d %d %g %g %g %g\n",
01446             t, cx, cy, cz, cx + cy, cx + cz,
01447             (cx + cy > 0) ? 100. * (cx + cz) / (cx + cy) : GSL_NAN,
01448             (cx + cy > 0) ? (100. * cx) / (cx + cy) : GSL_NAN,
01449             (cx + cz > 0) ? (100. * cz) / (cx + cz) : GSL_NAN,
01450             (cx + cy + cz > 0) ? (100. * cx) / (cx + cy + cz) : GSL_NAN);
01451
01452     /* Set counters to zero... */
01453     cx = cy = cz = 0;
01454   }
01455
01456   /* Close file... */
01457   if (t == ctl->t_stop)
01458     fclose(out);
01459 }
```

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

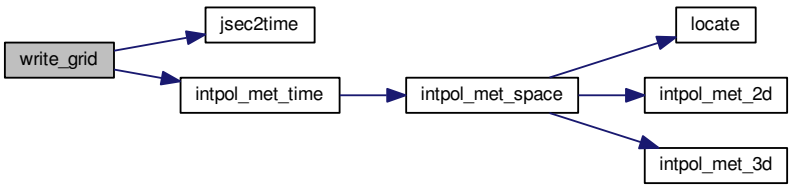
Write gridded data.

Definition at line 1463 of file libtrac.c.

```
01469           {
01470
01471   FILE *in, *out;
01472
01473   char line[LEN];
01474
01475   static double grid_m[GX][GY][GZ], z, dz, lon, dlon, lat, dlat,
01476     area, rho_air, press, temp, cd, mmr, t0, t1, r;
01477
01478   static int ip, ix, iy, iz, year, mon, day, hour, min, sec;
01479
01480   /* Check dimensions... */
01481   if (ctl->grid_nx > GX || ctl->grid_ny > GY || ctl->grid_nz > GZ)
01482     ERRMSG("Grid dimensions too large!");
01483
01484   /* Check quantity index for mass... */
01485   if (ctl->qnt_m < 0)
01486     ERRMSG("Need quantity mass to write grid data!");
01487
01488   /* Set time interval for output... */
01489   t0 = t - 0.5 * ctl->dt_mod;
01490   t1 = t + 0.5 * ctl->dt_mod;
01491
01492   /* Set grid box size... */
01493   dz = (ctl->grid_z1 - ctl->grid_z0) / ctl->grid_nz;
01494   dlon = (ctl->grid_lon1 - ctl->grid_lon0) / ctl->grid_nx;
01495   dlat = (ctl->grid_lat1 - ctl->grid_lat0) / ctl->grid_ny;
01496
01497   /* Initialize grid... */
01498   for (ix = 0; ix < ctl->grid_nx; ix++)
01499     for (iy = 0; iy < ctl->grid_ny; iy++)
01500       for (iz = 0; iz < ctl->grid_nz; iz++)
01501         grid_m[ix][iy][iz] = 0;
01502
01503   /* Average data... */
01504   for (ip = 0; ip < atm->np; ip++)
01505     if (atm->time[ip] >= t0 && atm->time[ip] <= t1) {
01506
01507       /* Get index... */
01508       ix = (int) ((atm->lon[ip] - ctl->grid_lon0) / dlon);
01509       iy = (int) ((atm->lat[ip] - ctl->grid_lat0) / dlat);
01510       iz = (int) ((Z(atm->p[ip]) - ctl->grid_z0) / dz);
01511
01512       /* Check indices... */
01513       if (ix < 0 || ix >= ctl->grid_nx ||
01514           iy < 0 || iy >= ctl->grid_ny || iz < 0 || iz >= ctl->grid_nz)
01515         continue;
01516
01517       /* Add mass... */
01518       grid_m[ix][iy][iz] += atm->q[ctl->qnt_m][ip];
01519     }
01520
01521   /* Check if gnuplot output is requested... */
01522   if (ctl->grid_gpfile[0] != '-') {
01523
01524     /* Write info... */
01525     printf("Plot grid data: %s.png\n", filename);
01526
01527     /* Create gnuplot pipe... */
01528     if (!(out = popen("gnuplot", "w")))
01529       ERRMSG("Cannot create pipe to gnuplot!");
01530
01531     /* Set plot filename... */
01532     fprintf(out, "set out \"%s.png\"\n", filename);
01533
01534     /* Set time string... */
01535     jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
01536     fprintf(out, "timestr=\"%d-%02d-%02d, %02d:%02d UTC\"\n",
01537             year, mon, day, hour, min);
01538
01539     /* Dump gnuplot file to pipe... */
01540     if (!(in = fopen(ctl->grid_gpfile, "r")))
01541       ERRMSG("Cannot open file!");
01542     while (fgets(line, LEN, in))
01543       fprintf(out, "%s", line);
01544     fclose(in);
01545   }
01546
01547   else {
01548
01549     /* Write info... */
01550     printf("Write grid data: %s\n", filename);
01551
01552     /* Create file... */
01553     if (!(out = fopen(filename, "w")))
01554       ERRMSG("Cannot create file!");
01555   }
```

```
01556
01557   /* Write header... */
01558   fprintf(out,
01559           "# $1 = time [s]\n"
01560           "# $2 = altitude [km]\n"
01561           "# $3 = longitude [deg]\n"
01562           "# $4 = latitude [deg]\n"
01563           "# $5 = surface area [km^2]\n"
01564           "# $6 = layer width [km]\n"
01565           "# $7 = temperature [K]\n"
01566           "# $8 = column density [kg/m^2]\n"
01567           "# $9 = mass mixing ratio [1]\n\n");
01568
01569   /* Write data... */
01570   for (ix = 0; ix < ctl->grid_nx; ix++) {
01571     if (ix > 0 && ctl->grid_ny > 1 && !ctl->grid_sparse)
01572       fprintf(out, "\n");
01573     for (iy = 0; iy < ctl->grid_ny; iy++) {
01574       if (iy > 0 && ctl->grid_nz > 1 && !ctl->grid_sparse)
01575         fprintf(out, "\n");
01576       for (iz = 0; iz < ctl->grid_nz; iz++)
01577         if (!ctl->grid_sparse
01578             || ix == 0 || iy == 0 || iz == 0 || grid_m[ix][iy][iz] > 0) {
01579
01580           /* Set coordinates... */
01581           z = ctl->grid_z0 + dz * (iz + 0.5);
01582           lon = ctl->grid_lon0 + dlon * (ix + 0.5);
01583           lat = ctl->grid_lat0 + dlat * (iy + 0.5);
01584
01585           /* Get pressure and temperature... */
01586           press = P(z);
01587           intpol_met_time(met0, met1, t, press, lon, lat,
01588                           NULL, &temp, NULL, NULL, NULL, NULL, NULL);
01589
01590           /* Calculate surface area... */
01591           area = dlat * dlon * gsl_pow_2(RE * M_PI / 180.)
01592             * cos(lat * M_PI / 180.);
01593
01594           /* Calculate column density... */
01595           cd = grid_m[ix][iy][iz] / (1e6 * area);
01596
01597           /* Calculate mass mixing ratio... */
01598           rho_air = 100. * press / (287.058 * temp);
01599           mmr = grid_m[ix][iy][iz] / (rho_air * 1e6 * area * 1e3 * dz);
01600
01601           /* Write output... */
01602           fprintf(out, "%.2f %g %g %g %g %g %g %g %g\n",
01603                   t, z, lon, lat, area, dz, temp, cd, mmr);
01604         }
01605     }
01606   }
01607
01608   /* Close file... */
01609   fclose(out);
01610 }
```

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* )

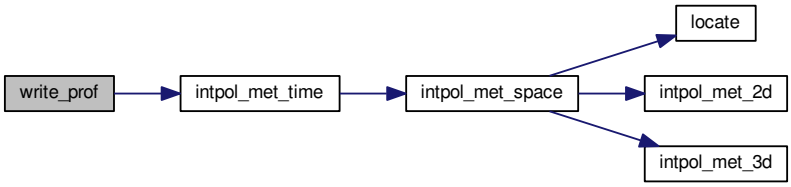
Write profile data.

Definition at line 1614 of file libtrac.c.

```
01620           {
01621
01622   static FILE *in, *out;
01623
01624   static char line[LEN];
01625
01626   static double mass[GX][GY][GZ], obsmean[GX][GY], tmean[GX][GY],
01627     rt, rlon, rlat, robs, t0, t1, area, dz, dlon, dlat, lon, lat, z,
01628     press, temp, rho_air, mmr, h2o, o3;
01629
01630   static int init, obscount[GX][GY], ip, ix, iy, iz;
01631
01632   /* Init... */
01633   if (!init) {
01634     init = 1;
01635
01636     /* Check quantity index for mass... */
01637     if (ctl->qnt_m < 0)
01638       ERRMSG("Need quantity mass!");
01639
01640     /* Check dimensions... */
01641     if (ctl->prof_nx > GX || ctl->prof_ny > GY || ctl->prof_nz > GZ)
01642       ERRMSG("Grid dimensions too large!");
01643
01644     /* Open observation data file... */
01645     printf("Read profile observation data: %s\n", ctl->prof_obsfile);
01646     if (!(in = fopen(ctl->prof_obsfile, "r")))
01647       ERRMSG("Cannot open file!");
01648
01649     /* Create new file... */
01650     printf("Write profile data: %s\n", filename);
01651     if (!(out = fopen(filename, "w")))
01652       ERRMSG("Cannot create file!");
01653
01654     /* Write header... */
01655     fprintf(out,
01656             "# $1  = time [s]\n"
01657             "# $2  = altitude [km]\n"
01658             "# $3  = longitude [deg]\n"
01659             "# $4  = latitude [deg]\n"
01660             "# $5  = pressure [hPa]\n"
01661             "# $6  = temperature [K]\n"
01662             "# $7  = mass mixing ratio [1]\n"
01663             "# $8  = H2O volume mixing ratio [1]\n"
01664             "# $9  = O3 volume mixing ratio [1]\n"
01665             "# $10 = mean BT index [K]\n");
01666
01667     /* Set grid box size... */
01668     dz = (ctl->prof_z1 - ctl->prof_z0) / ctl->prof_nz;
01669     dlon = (ctl->prof_lon1 - ctl->prof_lon0) / ctl->prof_nx;
01670     dlat = (ctl->prof_lat1 - ctl->prof_lat0) / ctl->prof_ny;
01671   }
01672
01673   /* Set time interval... */
01674   t0 = t - 0.5 * ctl->dt_mod;
01675   t1 = t + 0.5 * ctl->dt_mod;
01676
01677   /* Initialize... */
01678   for (ix = 0; ix < ctl->prof_nx; ix++)
01679     for (iy = 0; iy < ctl->prof_ny; iy++) {
01680       obsmean[ix][iy] = 0;
01681       obscount[ix][iy] = 0;
01682       tmean[ix][iy] = 0;
01683       for (iz = 0; iz < ctl->prof_nz; iz++)
01684         mass[ix][iy][iz] = 0;
01685     }
01686
01687   /* Read data... */
01688   while (fgets(line, LEN, in)) {
01689
01690     /* Read data... */
01691     if (sscanf(line, "%lg %lg %lg %lg", &rt, &rlon, &rlat, &robs) != 4)
01692       continue;
01693
01694     /* Check time... */
01695     if (rt < t0)
01696       continue;
01697     if (rt > t1)
01698       break;
01699
01700     /* Calculate indices... */
01701     ix = (int) ((rlon - ctl->prof_lon0) / dlon);
01702     iy = (int) ((rlat - ctl->prof_lat0) / dlat);
01703
01704     /* Check indices... */
01705     if (ix < 0 || ix >= ctl->prof_nx || iy < 0 || iy >= ctl->prof_ny)
01706       continue;
```

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

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* )

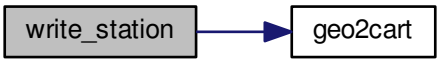
Write station data.

Definition at line 1777 of file libtrac.c.

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

```
01835     if (DIST2(x0, x1) > rmax2)
01836       continue;
01837
01838     /* Set station flag... */
01839     if (ctl->qnt_stat >= 0)
01840       atm->q[ctl->qnt_stat][ip] = 1;
01841
01842     /* Write data... */
01843     fprintf(out, "%.2f %g %g %g",
01844             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip]);
01845     for (iq = 0; iq < ctl->nq; iq++) {
01846       fprintf(out, " ");
01847       fprintf(out, ctl->qnt_format[iq], atm->q[iq][ip]);
01848     }
01849     fprintf(out, "\n");
01850   }
01851
01852   /* Close file... */
01853   if (t == ctl->t_stop)
01854     fclose(out);
01855 }
```

Here is the call graph for this function:




## 5.14 libtrac.h

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00034 #include <ctype.h>
00035 #include <gsl/gsl_const_mksa.h>
00036 #include <gsl/gsl_math.h>
00037 #include <gsl/gsl_randist.h>
00038 #include <gsl/gsl_rng.h>
00039 #include <gsl/gsl_statistics.h>
00040 #include <math.h>
00041 #include <netcdf.h>
00042 #include <omp.h>
00043 #include <stdio.h>
00044 #include <stdlib.h>
00045 #include <string.h>
00046 #include <time.h>
00047 #include <sys/time.h>
00048
00049 /* ------------------------------------------------------------
00050    Macros...
00051    ------------------------------------------------------------ */
00052
00054 #define ALLOC(ptr, type, n)                             \
```

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

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

```
00303   double csi_obsmin;
00304
00306   double csi_modmin;
00307
00309   int csi_nz;
00310
00312   double csi_z0;
00313
00315   double csi_z1;
00316
00318   int csi_nx;
00319
00321   double csi_lon0;
00322
00324   double csi_lon1;
00325
00327   int csi_ny;
00328
00330   double csi_lat0;
00331
00333   double csi_lat1;
00334
00336   char grid_basename[LEN];
00337
00339   char grid_gpfile[LEN];
00340
00342   double grid_dt_out;
00343
00345   int grid_sparse;
00346
00348   int grid_nz;
00349
00351   double grid_z0;
00352
00354   double grid_z1;
00355
00357   int grid_nx;
00358
00360   double grid_lon0;
00361
00363   double grid_lon1;
00364
00366   int grid_ny;
00367
00369   double grid_lat0;
00370
00372   double grid_lat1;
00373
00375   char prof_basename[LEN];
00376
00378   char prof_obsfile[LEN];
00379
00381   int prof_nz;
00382
00384   double prof_z0;
00385
00387   double prof_z1;
00388
00390   int prof_nx;
00391
00393   double prof_lon0;
00394
00396   double prof_lon1;
00397
00399   int prof_ny;
00400
00402   double prof_lat0;
00403
00405   double prof_lat1;
00406
00408   char stat_basename[LEN];
00409
00411   double stat_lon;
00412
00414   double stat_lat;
00415
00417   double stat_r;
00418
00419 } ctl_t;
00420
00422 typedef struct {
00423
00425   int np;
00426
00428   double time[NP];
00429
00431   double p[NP];
```

```
00432
00434   double lon[NP];
00435
00437   double lat[NP];
00438
00440   double q[NQ][NP];
00441
00443   double up[NP];
00444
00446   double vp[NP];
00447
00449   double wp[NP];
00450
00451 } atm_t;
00452
00454 typedef struct {
00455
00457   double time;
00458
00460   int nx;
00461
00463   int ny;
00464
00466   int np;
00467
00469   double lon[EX];
00470
00472   double lat[EY];
00473
00475   double p[EP];
00476
00478   double ps[EX][EY];
00479
00481   float pl[EX][EY][EP];
00482
00484   float t[EX][EY][EP];
00485
00487   float u[EX][EY][EP];
00488
00490   float v[EX][EY][EP];
00491
00493   float w[EX][EY][EP];
00494
00496   float h2o[EX][EY][EP];
00497
00499   float o3[EX][EY][EP];
00500
00501 } met_t;
00502
00503 /* ------------------------------------------------------------
00504    Functions...
00505    ------------------------------------------------------------ */
00506
00508 void cart2geo(
00509   double *x,
00510   double *z,
00511   double *lon,
00512   double *lat);
00513
00515 double deg2dx(
00516   double dlon,
00517   double lat);
00518
00520 double deg2dy(
00521   double dlat);
00522
00524 double dp2dz(
00525   double dp,
00526   double p);
00527
00529 double dx2deg(
00530   double dx,
00531   double lat);
00532
00534 double dy2deg(
00535   double dy);
00536
00538 double dz2dp(
00539   double dz,
00540   double p);
00541
00543 void geo2cart(
00544   double z,
00545   double lon,
00546   double lat,
00547   double *x);
00548
```

```
00550 void get_met(
00551   ctl_t * ctl,
00552   char *metbase,
00553   double t,
00554   met_t * met0,
00555   met_t * met1);
00556
00558 void get_met_help(
00559   double t,
00560   int direct,
00561   char *metbase,
00562   double dt_met,
00563   char *filename);
00564
00566 void intpol_met_2d(
00567   double array[EX][EY],
00568   int ix,
00569   int iy,
00570   double wx,
00571   double wy,
00572   double *var);
00573
00575 void intpol_met_3d(
00576   float array[EX][EY][EP],
00577   int ip,
00578   int ix,
00579   int iy,
00580   double wp,
00581   double wx,
00582   double wy,
00583   double *var);
00584
00586 void intpol_met_space(
00587   met_t * met,
00588   double p,
00589   double lon,
00590   double lat,
00591   double *ps,
00592   double *t,
00593   double *u,
00594   double *v,
00595   double *w,
00596   double *h2o,
00597   double *o3);
00598
00600 void intpol_met_time(
00601   met_t * met0,
00602   met_t * met1,
00603   double ts,
00604   double p,
00605   double lon,
00606   double lat,
00607   double *ps,
00608   double *t,
00609   double *u,
00610   double *v,
00611   double *w,
00612   double *h2o,
00613   double *o3);
00614
00616 void jsec2time(
00617   double jsec,
00618   int *year,
00619   int *mon,
00620   int *day,
00621   int *hour,
00622   int *min,
00623   int *sec,
00624   double *remain);
00625
00627 int locate(
00628   double *xx,
00629   int n,
00630   double x);
00631
00633 void read_atm(
00634   const char *filename,
00635   ctl_t * ctl,
00636   atm_t * atm);
00637
00639 void read_ctl(
00640   const char *filename,
00641   int argc,
00642   char *argv[],
00643   ctl_t * ctl);
00644
00646 void read_met(
```

```
00647   ctl_t * ctl,
00648   char *filename,
00649   met_t * met);
00650
00652 void read_met_extrapolate(
00653   met_t * met);
00654
00656 void read_met_help(
00657   int ncid,
00658   char *varname,
00659   char *varname2,
00660   met_t * met,
00661   float dest[EX][EY][EP],
00662   float scl);
00663
00665 void read_met_ml2pl(
00666   ctl_t * ctl,
00667   met_t * met,
00668   float var[EX][EY][EP]);
00669
00671 void read_met_periodic(
00672   met_t * met);
00673
00675 double scan_ctl(
00676   const char *filename,
00677   int argc,
00678   char *argv[],
00679   const char *varname,
00680   int arridx,
00681   const char *defvalue,
00682   char *value);
00683
00685 void time2jsec(
00686   int year,
00687   int mon,
00688   int day,
00689   int hour,
00690   int min,
00691   int sec,
00692   double remain,
00693   double *jsec);
00694
00696 void timer(
00697   const char *name,
00698   int id,
00699   int mode);
00700
00701 /* Get tropopause pressure... */
00702 double tropopause(
00703   double t,
00704   double lat);
00705
00707 void write_atm(
00708   const char *filename,
00709   ctl_t * ctl,
00710   atm_t * atm,
00711   double t);
00712
00714 void write_csi(
00715   const char *filename,
00716   ctl_t * ctl,
00717   atm_t * atm,
00718   double t);
00719
00721 void write_grid(
00722   const char *filename,
00723   ctl_t * ctl,
00724   met_t * met0,
00725   met_t * met1,
00726   atm_t * atm,
00727   double t);
00728
00730 void write_prof(
00731   const char *filename,
00732   ctl_t * ctl,
00733   met_t * met0,
00734   met_t * met1,
00735   atm_t * atm,
00736   double t);
00737
00739 void write_station(
00740   const char *filename,
00741   ctl_t * ctl,
00742   atm_t * atm,
00743   double t);
```

## 5.15 match.c File Reference

Calculate deviations between two trajectories.

### Functions

- int main (int argc, char ∗argv[ ])

### 5.15.1 Detailed Description

Calculate deviations between two trajectories.

Definition in file match.c.

### 5.15.2 Function Documentation

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

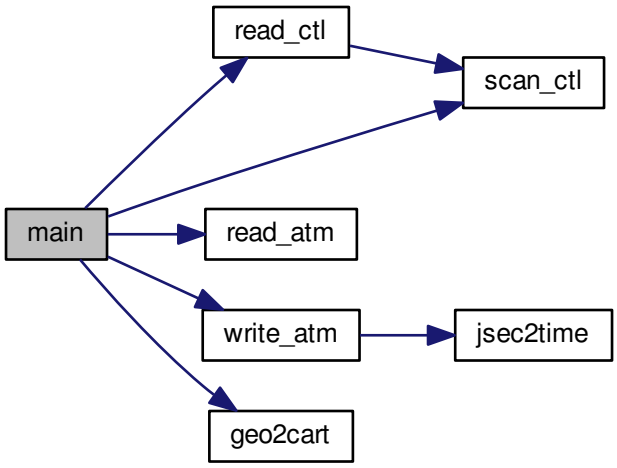
Definition at line 28 of file match.c.

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

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

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

Here is the call graph for this function:




## 5.16 match.c

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

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

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

## 5.17 met_map.c File Reference

Extract global map from meteorological data.

### Functions

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

### 5.17.1 Detailed Description

Extract global map from meteorological data.

Definition in file met_map.c.

### 5.17.2 Function Documentation

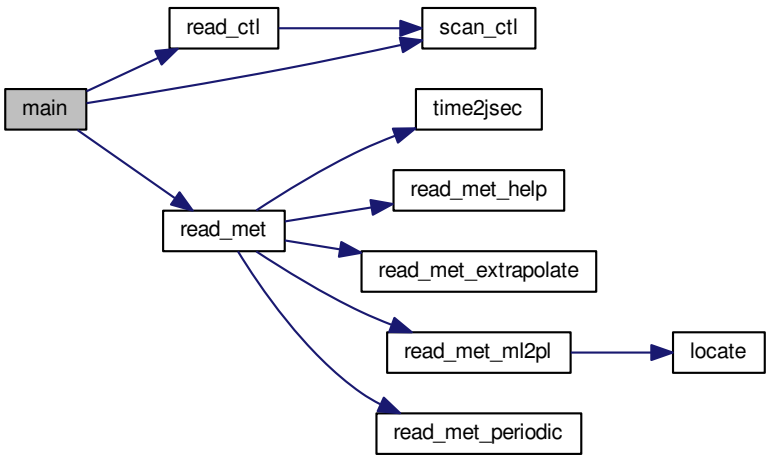
#### 5.17.2.1 int main ( int *argc*, char * *argv[]* )

Definition at line 27 of file met_map.c.

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

```
00105           "# $12 = surface pressure [hPa]\n");
00106
00107   /* Write data... */
00108   for (iy = 0; iy < met->ny; iy++) {
00109     fprintf(out, "\n");
00110     for (ix = 0; ix < met->nx; ix++)
00111       if (met->lon[ix] >= 180)
00112         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g\n",
00113                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00114                 met->lon[ix] - 360.0, met->lat[iy], met->p[ip],
00115                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00116                 vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00117                 h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00118                 psm[ix][iy] / np[ix][iy]);
00119     for (ix = 0; ix < met->nx; ix++)
00120       if (met->lon[ix] <= 180)
00121         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g %g\n",
00122                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00123                 met->lon[ix], met->lat[iy], met->p[ip],
00124                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00125                 vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00126                 h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00127                 psm[ix][iy] / np[ix][iy]);
00128   }
00129
00130   /* Close file... */
00131   fclose(out);
00132
00133   /* Free... */
00134   free(met);
00135
00136   return EXIT_SUCCESS;
00137 }
```

Here is the call graph for this function:




## 5.18 met_map.c

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

```
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   ctl_t ctl;
00032
00033   met_t *met;
00034
00035   FILE *in, *out;
00036
00037   static double dz, dzmin = 1e10, z, timem[EX][EY], psm[EX][EY], tm[EX][EY],
00038     um[EX][EY], vm[EX][EY], wm[EX][EY], h2om[EX][EY], o3m[EX][EY];
00039
00040   static int i, ip, ip2, ix, iy, np[EX][EY];
00041
00042   /* Allocate... */
00043   ALLOC(met, met_t, 1);
00044
00045   /* Check arguments... */
00046   if (argc < 4)
00047     ERRMSG("Give parameters: <ctl> <map.tab> <met0> [ <met1> ... ]");
00048
00049   /* Read control parameters... */
00050   read_ctl(argv[1], argc, argv, &ctl);
00051   z = scan_ctl(argv[1], argc, argv, "Z", -1, "", NULL);
00052
00053   /* Loop over files... */
00054   for (i = 3; i < argc; i++) {
00055
00056     /* Read meteorological data... */
00057     if (!(in = fopen(argv[i], "r")))
00058       continue;
00059     else
00060       fclose(in);
00061     read_met(&ctl, argv[i], met);
00062
00063     /* Find nearest pressure level... */
00064     for (ip2 = 0; ip2 < met->np; ip2++) {
00065       dz = fabs(Z(met->p[ip2]) - z);
00066       if (dz < dzmin) {
00067         dzmin = dz;
00068         ip = ip2;
00069       }
00070     }
00071
00072     /* Average data... */
00073     for (ix = 0; ix < met->nx; ix++)
00074       for (iy = 0; iy < met->ny; iy++) {
00075         timem[ix][iy] += met->time;
00076         tm[ix][iy] += met->t[ix][iy][ip];
00077         um[ix][iy] += met->u[ix][iy][ip];
00078         vm[ix][iy] += met->v[ix][iy][ip];
00079         wm[ix][iy] += met->w[ix][iy][ip];
00080         h2om[ix][iy] += met->h2o[ix][iy][ip];
00081         o3m[ix][iy] += met->o3[ix][iy][ip];
00082         psm[ix][iy] += met->ps[ix][iy];
00083         np[ix][iy]++;
00084       }
00085   }
00086
00087   /* Create output file... */
00088   printf("Write meteorological data file: %s\n", argv[2]);
00089   if (!(out = fopen(argv[2], "w")))
00090     ERRMSG("Cannot create file!");
00091
00092   /* Write header... */
00093   fprintf(out,
00094           "# $1  = time [s]\n"
00095           "# $2  = altitude [km]\n"
00096           "# $3  = longitude [deg]\n"
00097           "# $4  = latitude [deg]\n"
00098           "# $5  = pressure [hPa]\n"
00099           "# $6  = temperature [K]\n"
00100          "# $7  = zonal wind [m/s]\n"
00101          "# $8  = meridional wind [m/s]\n"
00102          "# $9  = vertical wind [hPa/s]\n"
```

```
00103           "# $10 = H2O volume mixing ratio [1]\n"
00104           "# $11 = O3 volume mixing ratio [1]\n"
00105           "# $12 = surface pressure [hPa]\n");
00106
00107   /* Write data... */
00108   for (iy = 0; iy < met->ny; iy++) {
00109     fprintf(out, "\n");
00110     for (ix = 0; ix < met->nx; ix++)
00111       if (met->lon[ix] >= 180)
00112         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g\n",
00113                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00114                 met->lon[ix] - 360.0, met->lat[iy], met->p[ip],
00115                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00116                 vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00117                 h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00118                 psm[ix][iy] / np[ix][iy]);
00119     for (ix = 0; ix < met->nx; ix++)
00120       if (met->lon[ix] <= 180)
00121         fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g\n",
00122                 timem[ix][iy] / np[ix][iy], Z(met->p[ip]),
00123                 met->lon[ix], met->lat[iy], met->p[ip],
00124                 tm[ix][iy] / np[ix][iy], um[ix][iy] / np[ix][iy],
00125                 vm[ix][iy] / np[ix][iy], wm[ix][iy] / np[ix][iy],
00126                 h2om[ix][iy] / np[ix][iy], o3m[ix][iy] / np[ix][iy],
00127                 psm[ix][iy] / np[ix][iy]);
00128   }
00129
00130   /* Close file... */
00131   fclose(out);
00132
00133   /* Free... */
00134   free(met);
00135
00136   return EXIT_SUCCESS;
00137 }
```

## 5.19 met_prof.c File Reference

Extract vertical profile from meteorological data.

### Functions

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

#### 5.19.1 Detailed Description

Extract vertical profile from meteorological data.

Definition in file met_prof.c.

#### 5.19.2 Function Documentation

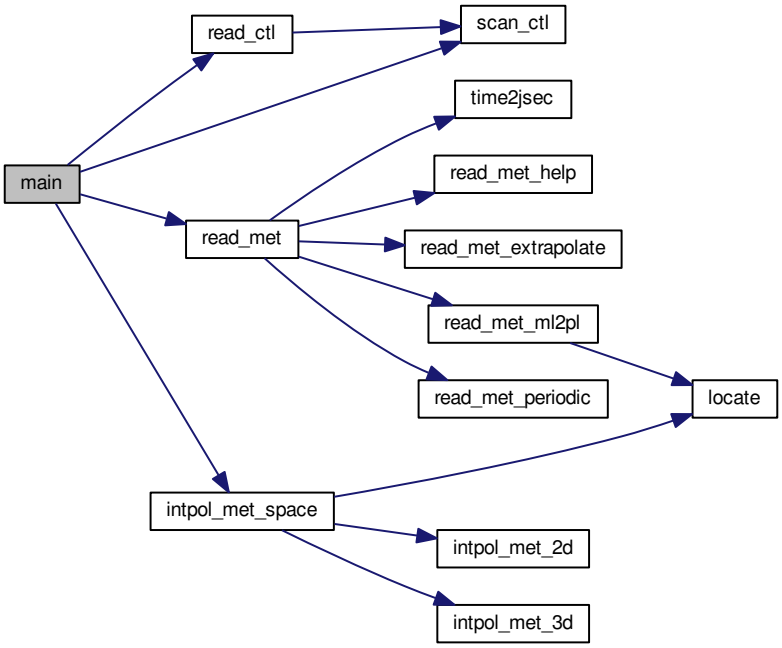
##### 5.19.2.1 int main ( int *argc*, char * *argv[]* )

Definition at line 38 of file met_prof.c.

```
00040                {
00041
00042   ctl_t ctl;
00043
00044   met_t *met;
00045
00046   FILE *in, *out;
00047
00048   static double timem[NZ], z, z0, z1, dz, lon, lon0, lon1, dlon, lonm[NZ],
00049     lat, lat0, lat1, dlat, latm[NZ], t, tm[NZ], u, um[NZ], v, vm[NZ],
00050     w, wm[NZ], h2o, h2om[NZ], o3, o3m[NZ], ps, psm[NZ];
00051
00052   static int i, iz, np[NZ];
00053
00054   /* Allocate... */
00055   ALLOC(met, met_t, 1);
00056
00057   /* Check arguments... */
00058   if (argc < 4)
00059     ERRMSG("Give parameters: <ctl> <prof.tab> <met0> [ <met1> ... ]");
00060
00061   /* Read control parameters... */
00062   read_ctl(argv[1], argc, argv, &ctl);
00063   z0 = scan_ctl(argv[1], argc, argv, "Z0", -1, "0", NULL);
00064   z1 = scan_ctl(argv[1], argc, argv, "Z1", -1, "60", NULL);
00065   dz = scan_ctl(argv[1], argc, argv, "DZ", -1, "1", NULL);
00066   lon0 = scan_ctl(argv[1], argc, argv, "LON0", -1, "0", NULL);
00067   lon1 = scan_ctl(argv[1], argc, argv, "LON1", -1, "0", NULL);
00068   dlon = scan_ctl(argv[1], argc, argv, "DLON", -1, "1", NULL);
00069   lat0 = scan_ctl(argv[1], argc, argv, "LAT0", -1, "0", NULL);
00070   lat1 = scan_ctl(argv[1], argc, argv, "LAT1", -1, "0", NULL);
00071   dlat = scan_ctl(argv[1], argc, argv, "DLAT", -1, "1", NULL);
00072
00073   /* Loop over input files... */
00074   for (i = 3; i < argc; i++) {
00075
00076     /* Read meteorological data... */
00077     if (!(in = fopen(argv[i], "r")))
00078       continue;
00079     else
00080       fclose(in);
00081     read_met(&ctl, argv[i], met);
00082
00083     /* Average... */
00084     for (z = z0; z <= z1; z += dz) {
00085       iz = (int) ((z - z0) / dz);
00086       if (iz < 0 || iz > NZ)
00087         ERRMSG("Too many altitudes!");
00088       for (lon = lon0; lon <= lon1; lon += dlon)
00089         for (lat = lat0; lat <= lat1; lat += dlat) {
00090           intpol_met_space(met, P(z), lon, lat, &ps,
00091                            &t, &u, &v, &w, &h2o, &o3);
00092           if (gsl_finite(t) && gsl_finite(u)
00093               && gsl_finite(v) && gsl_finite(w)) {
00094             timem[iz] += met->time;
00095             lonm[iz] += lon;
00096             latm[iz] += lat;
00097             tm[iz] += t;
00098             um[iz] += u;
00099             vm[iz] += v;
00100            wm[iz] += w;
00101            h2om[iz] += h2o;
00102            o3m[iz] += o3;
00103            psm[iz] += ps;
00104            np[iz]++;
00105          }
00106        }
00107     }
00108   }
00109
00110   /* Normalize... */
00111   for (z = z0; z <= z1; z += dz) {
00112     iz = (int) ((z - z0) / dz);
00113     if (np[iz] > 0) {
00114       timem[iz] /= np[iz];
00115       lonm[iz] /= np[iz];
00116       latm[iz] /= np[iz];
00117       tm[iz] /= np[iz];
00118       um[iz] /= np[iz];
00119       vm[iz] /= np[iz];
00120       wm[iz] /= np[iz];
00121       h2om[iz] /= np[iz];
00122       o3m[iz] /= np[iz];
00123       psm[iz] /= np[iz];
00124     } else {
00125       timem[iz] = GSL_NAN;
00126       lonm[iz] = GSL_NAN;
```

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

Here is the call graph for this function:




## 5.20 met_prof.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 /* ------------------------------------------------------------
00028    Dimensions...
00029    ------------------------------------------------------------ */
00030
00031 /* Maximum number of altitudes. */
00032 #define NZ 1000
00033
00034 /* ------------------------------------------------------------
00035    Main...
00036    ------------------------------------------------------------ */
00037
00038 int main(
00039   int argc,
00040   char *argv[]) {
00041
00042   ctl_t ctl;
00043
```

```
00044   met_t *met;
00045
00046   FILE *in, *out;
00047
00048   static double timem[NZ], z, z0, z1, dz, lon, lon0, lon1, dlon, lonm[NZ],
00049     lat, lat0, lat1, dlat, latm[NZ], t, tm[NZ], u, um[NZ], v, vm[NZ],
00050     w, wm[NZ], h2o, h2om[NZ], o3, o3m[NZ], ps, psm[NZ];
00051
00052   static int i, iz, np[NZ];
00053
00054   /* Allocate... */
00055   ALLOC(met, met_t, 1);
00056
00057   /* Check arguments... */
00058   if (argc < 4)
00059     ERRMSG("Give parameters: <ctl> <prof.tab> <met0> [ <met1> ... ]");
00060
00061   /* Read control parameters... */
00062   read_ctl(argv[1], argc, argv, &ctl);
00063   z0 = scan_ctl(argv[1], argc, argv, "Z0", -1, "0", NULL);
00064   z1 = scan_ctl(argv[1], argc, argv, "Z1", -1, "60", NULL);
00065   dz = scan_ctl(argv[1], argc, argv, "DZ", -1, "1", NULL);
00066   lon0 = scan_ctl(argv[1], argc, argv, "LON0", -1, "0", NULL);
00067   lon1 = scan_ctl(argv[1], argc, argv, "LON1", -1, "0", NULL);
00068   dlon = scan_ctl(argv[1], argc, argv, "DLON", -1, "1", NULL);
00069   lat0 = scan_ctl(argv[1], argc, argv, "LAT0", -1, "0", NULL);
00070   lat1 = scan_ctl(argv[1], argc, argv, "LAT1", -1, "0", NULL);
00071   dlat = scan_ctl(argv[1], argc, argv, "DLAT", -1, "1", NULL);
00072
00073   /* Loop over input files... */
00074   for (i = 3; i < argc; i++) {
00075
00076     /* Read meteorological data... */
00077     if (!(in = fopen(argv[i], "r")))
00078       continue;
00079     else
00080       fclose(in);
00081     read_met(&ctl, argv[i], met);
00082
00083     /* Average... */
00084     for (z = z0; z <= z1; z += dz) {
00085       iz = (int) ((z - z0) / dz);
00086       if (iz < 0 || iz > NZ)
00087         ERRMSG("Too many altitudes!");
00088       for (lon = lon0; lon <= lon1; lon += dlon)
00089         for (lat = lat0; lat <= lat1; lat += dlat) {
00090           intpol_met_space(met, P(z), lon, lat, &ps,
00091                            &t, &u, &v, &w, &h2o, &o3);
00092           if (gsl_finite(t) && gsl_finite(u)
00093               && gsl_finite(v) && gsl_finite(w)) {
00094             timem[iz] += met->time;
00095             lonm[iz] += lon;
00096             latm[iz] += lat;
00097             tm[iz] += t;
00098             um[iz] += u;
00099             vm[iz] += v;
00100             wm[iz] += w;
00101             h2om[iz] += h2o;
00102             o3m[iz] += o3;
00103             psm[iz] += ps;
00104             np[iz]++;
00105           }
00106         }
00107     }
00108   }
00109
00110   /* Normalize... */
00111   for (z = z0; z <= z1; z += dz) {
00112     iz = (int) ((z - z0) / dz);
00113     if (np[iz] > 0) {
00114       timem[iz] /= np[iz];
00115       lonm[iz] /= np[iz];
00116       latm[iz] /= np[iz];
00117       tm[iz] /= np[iz];
00118       um[iz] /= np[iz];
00119       vm[iz] /= np[iz];
00120       wm[iz] /= np[iz];
00121       h2om[iz] /= np[iz];
00122       o3m[iz] /= np[iz];
00123       psm[iz] /= np[iz];
00124     } else {
00125       timem[iz] = GSL_NAN;
00126       lonm[iz] = GSL_NAN;
00127       latm[iz] = GSL_NAN;
00128       tm[iz] = GSL_NAN;
00129       um[iz] = GSL_NAN;
00130       vm[iz] = GSL_NAN;
```

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

## 5.21 met_sample.c File Reference

Sample meteorological data at given geolocations.

### Functions

- int main (int argc, char ∗argv[ ])

### 5.21.1 Detailed Description

Sample meteorological data at given geolocations.

Definition in file met_sample.c.

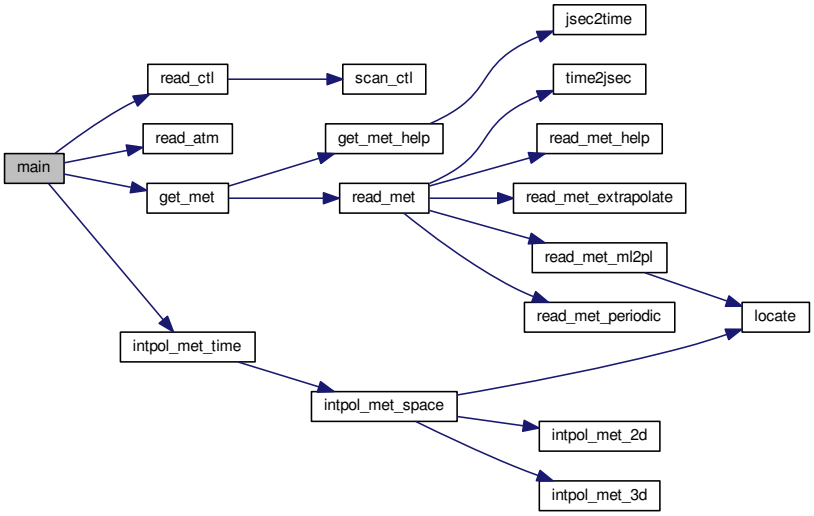
### 5.21.2 Function Documentation

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

Definition at line 31 of file met_sample.c.

```
00033                {
00034
00035   ctl_t ctl;
00036
00037   atm_t *atm;
00038
00039   met_t *met0, *met1;
00040
00041   FILE *out;
00042
00043   double t, u, v, w, h2o, o3;
00044
00045   int ip;
00046
00047   /* Check arguments... */
00048   if (argc < 4)
00049     ERRMSG("Give parameters: <ctl> <metbase> <atm_in> <sample.tab>");
00050
00051   /* Allocate... */
00052   ALLOC(atm, atm_t, 1);
00053   ALLOC(met0, met_t, 1);
00054   ALLOC(met1, met_t, 1);
00055
00056   /* Read control parameters... */
00057   read_ctl(argv[1], argc, argv, &ctl);
00058
00059   /* Read atmospheric data... */
00060   read_atm(argv[3], &ctl, atm);
00061
00062   /* Create output file... */
00063   printf("Write meteorological data file: %s\n", argv[4]);
00064   if (!(out = fopen(argv[4], "w")))
00065     ERRMSG("Cannot create file!");
00066
00067   /* Write header... */
00068   fprintf(out,
00069           "# $1  = time [s]\n"
00070           "# $2  = altitude [km]\n"
00071           "# $3  = longitude [deg]\n"
00072           "# $4  = latitude [deg]\n"
00073           "# $5  = pressure [hPa]\n"
00074           "# $6  = temperature [K]\n"
00075           "# $7  = zonal wind [m/s]\n"
00076           "# $8  = meridional wind [m/s]\n"
00077           "# $9  = vertical wind [hPa/s]\n"
00078           "# $10 = H2O volume mixing ratio [1]\n"
00079           "# $11 = O3 volume mixing ratio [1]\n\n");
00080
00081   /* Loop over air parcels... */
00082   for (ip = 0; ip < atm->np; ip++) {
00083
00084     /* Get meteorological data... */
00085     get_met(&ctl, argv[2], atm->time[ip], met0, met1);
00086
00087     /* Interpolate meteorological data... */
00088     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
    lon[ip],
00089                     atm->lat[ip], NULL, &t, &u, &v, &w, &h2o, &o3);
00090
00091     /* Write data... */
00092     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g %g\n",
00093             atm->time[ip], Z(atm->p[ip]), atm->lon[ip], atm->lat[ip],
00094             atm->p[ip], t, u, v, w, h2o, o3);
00095   }
00096
00097   /* Close file... */
00098   fclose(out);
00099
00100   /* Free... */
00101   free(atm);
00102   free(met0);
00103   free(met1);
00104
00105   return EXIT_SUCCESS;
00106 }
```

Here is the call graph for this function:




## 5.22 met_sample.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 /* ------------------------------------------------------------
00028    Main...
00029    ------------------------------------------------------------ */
00030
00031 int main(
00032   int argc,
00033   char *argv[]) {
00034
00035   ctl_t ctl;
00036
00037   atm_t *atm;
00038
00039   met_t *met0, *met1;
00040
00041   FILE *out;
00042
00043   double t, u, v, w, h2o, o3;
00044
00045   int ip;
00046
00047   /* Check arguments... */
00048   if (argc < 4)
00049     ERRMSG("Give parameters: <ctl> <metbase> <atm_in> <sample.tab>");
00050
00051   /* Allocate... */
```

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

## 5.23 met_zm.c File Reference

Extract zonal mean from meteorological data.

### Functions

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

#### 5.23.1 Detailed Description

Extract zonal mean from meteorological data.

Definition in file met_zm.c.

### 5.23.2 Function Documentation

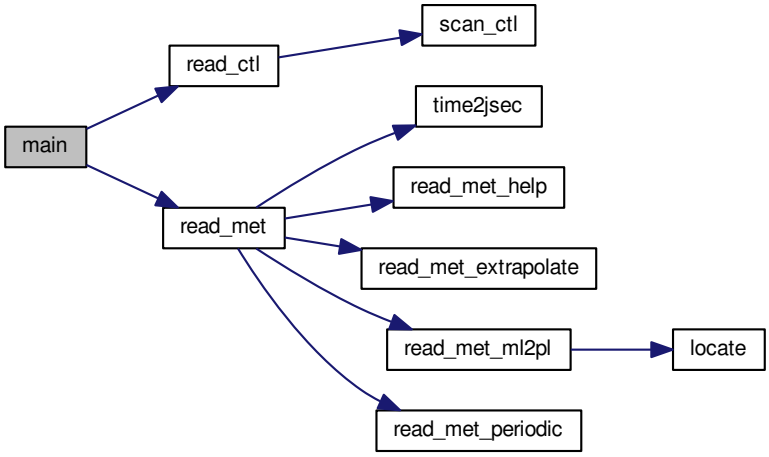
#### 5.23.2.1 int main ( int *argc*, char * *argv[]* )

Definition at line 27 of file met_zm.c.

```
00029                {
00030
00031   ctl_t ctl;
00032
00033   met_t *met;
00034
00035   FILE *in, *out;
00036
00037   static double timem[EP][EY], psm[EP][EY], tm[EP][EY], um[EP][EY],
00038     vm[EP][EY], vhm[EP][EY], wm[EP][EY], h2om[EP][EY], o3m[EP][EY],
00039     psm2[EP][EY], tm2[EP][EY], um2[EP][EY], vm2[EP][EY], vhm2[EP][EY],
00040     wm2[EP][EY], h2om2[EP][EY], o3m2[EP][EY];
00041
00042   static int i, ip, ix, iy, np[EP][EY];
00043
00044   /* Allocate... */
00045   ALLOC(met, met_t, 1);
00046
00047   /* Check arguments... */
00048   if (argc < 4)
00049     ERRMSG("Give parameters: <ctl> <zm.tab> <met0> [ <met1> ... ]");
00050
00051   /* Read control parameters... */
00052   read_ctl(argv[1], argc, argv, &ctl);
00053
00054   /* Loop over files... */
00055   for (i = 3; i < argc; i++) {
00056
00057     /* Read meteorological data... */
00058     if (!(in = fopen(argv[i], "r")))
00059       continue;
00060     else
00061       fclose(in);
00062     read_met(&ctl, argv[i], met);
00063
00064     /* Average data... */
00065     for (ix = 0; ix < met->nx; ix++)
00066       for (iy = 0; iy < met->ny; iy++)
00067         for (ip = 0; ip < met->np; ip++) {
00068           timem[ip][iy] += met->time;
00069           tm[ip][iy] += met->t[ix][iy][ip];
00070           um[ip][iy] += met->u[ix][iy][ip];
00071           vm[ip][iy] += met->v[ix][iy][ip];
00072           vhm[ip][iy] += sqrt(gsl_pow_2(met->u[ix][iy][ip])
00073                               + gsl_pow_2(met->v[ix][iy][ip]));
00074           wm[ip][iy] += met->w[ix][iy][ip];
00075           h2om[ip][iy] += met->h2o[ix][iy][ip];
00076           o3m[ip][iy] += met->o3[ix][iy][ip];
00077           psm[ip][iy] += met->ps[ix][iy];
00078           tm2[ip][iy] += gsl_pow_2(met->t[ix][iy][ip]);
00079           um2[ip][iy] += gsl_pow_2(met->u[ix][iy][ip]);
00080           vm2[ip][iy] += gsl_pow_2(met->v[ix][iy][ip]);
00081           vhm2[ip][iy] += gsl_pow_2(met->u[ix][iy][ip])
00082             + gsl_pow_2(met->v[ix][iy][ip]);
00083           wm2[ip][iy] += gsl_pow_2(met->w[ix][iy][ip]);
00084           h2om2[ip][iy] += gsl_pow_2(met->h2o[ix][iy][ip]);
00085           o3m2[ip][iy] += gsl_pow_2(met->o3[ix][iy][ip]);
00086           psm2[ip][iy] += gsl_pow_2(met->ps[ix][iy]);
00087           np[ip][iy]++;
00088         }
00089   }
00090
00091   /* Create output file... */
00092   printf("Write meteorological data file: %s\n", argv[2]);
00093   if (!(out = fopen(argv[2], "w")))
00094     ERRMSG("Cannot create file!");
00095
00096   /* Write header... */
00097   fprintf(out,
00098           "# $1  = time [s]\n"
00099           "# $2  = altitude [km]\n"
00100           "# $3  = latitude [deg]\n"
00101           "# $4  = temperature mean [K]\n"
00102           "# $5  = temperature standard deviation [K]\n"
00103           "# $6  = zonal wind mean [m/s]\n"
00104           "# $7  = zonal wind standard deviation [m/s]\n"
```

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

Here is the call graph for this function:




## 5.24 met_zm.c

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

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

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

## 5.25 smago.c File Reference

Estimate horizontal diffusivity based on Smagorinsky theory.

### Functions

- int main (int argc, char ∗argv[ ])

### 5.25.1 Detailed Description

Estimate horizontal diffusivity based on Smagorinsky theory.

Definition in file smago.c.

### 5.25.2 Function Documentation

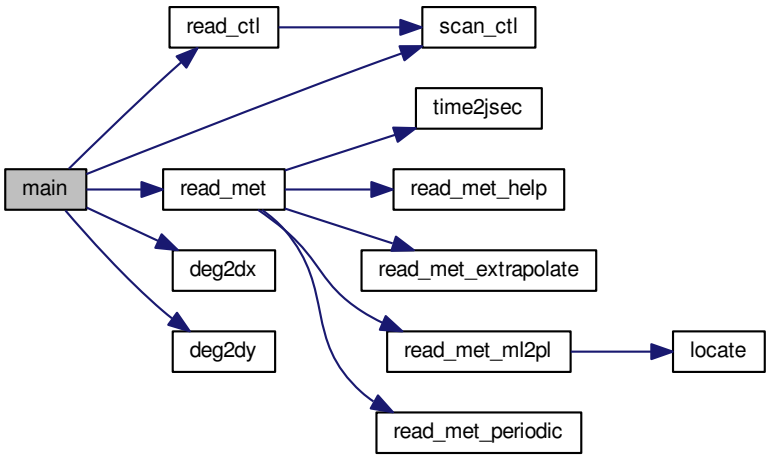
#### 5.25.2.1 int main ( int *argc*, char ∗ *argv[ ]* )

Definition at line 8 of file smago.c.

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

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

Here is the call graph for this function:




## 5.26 smago.c

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

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

## 5.27 split.c File Reference

Split air parcels into a larger number of parcels.

### Functions

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

### 5.27.1 Detailed Description

Split air parcels into a larger number of parcels.

Definition in file split.c.

### 5.27.2 Function Documentation

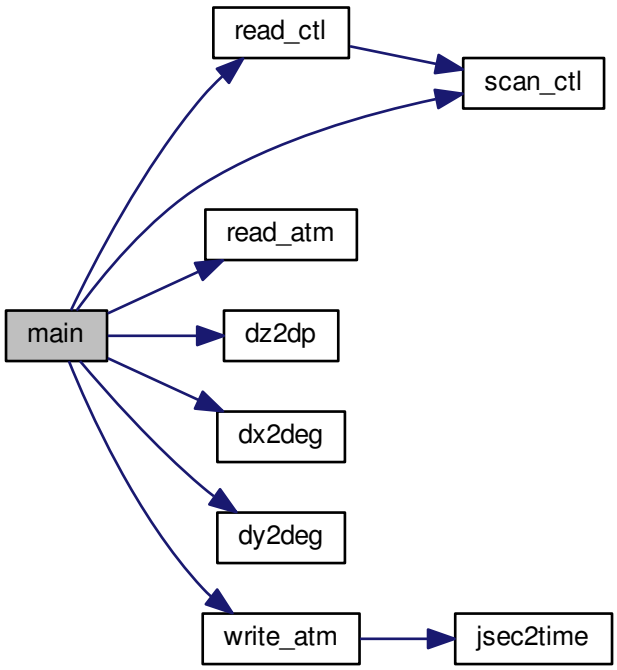
#### 5.27.2.1 int main ( int *argc*, char * *argv[]* )

Definition at line 27 of file split.c.

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

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

Here is the call graph for this function:



## 5.28 split.c

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

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

## 5.29 time2jsec.c File Reference

Convert date to Julian seconds.

### Functions

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

#### 5.29.1 Detailed Description

Convert date to Julian seconds.

Definition in file time2jsec.c.

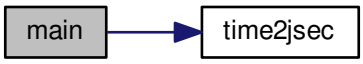
### 5.29.2 Function Documentation

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

Definition at line 27 of file time2jsec.c.

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

Here is the call graph for this function:




## 5.30 time2jsec.c

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

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

## 5.31 trac.c File Reference

Lagrangian particle dispersion model.

### Functions

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

  *Set simulation time interval.*
- void module_advection (met_t *met0, met_t *met1, atm_t *atm, int ip, double dt)

  *Calculate advection of air parcels.*
- void module_decay (ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, int ip, double dt)

  *Calculate exponential decay of particle mass.*
- void module_diffusion_meso (ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, int ip, double dt, gsl_rng *rng)

  *Calculate mesoscale diffusion.*
- void module_diffusion_turb (ctl_t *ctl, atm_t *atm, int ip, double dt, gsl_rng *rng)

  *Calculate turbulent diffusion.*
- void module_isosurf (ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, int ip)

  *Force air parcels to stay on isosurface.*
- void module_meteo (ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, int ip)

  *Interpolate meteorological data for air parcel positions.*
- void module_position (met_t *met0, met_t *met1, atm_t *atm, int ip)

  *Check position of air parcels.*
- void module_sedi (ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, int ip, double dt)

  *Calculate sedimentation of air parcels.*
- void write_output (const char *dirname, ctl_t *ctl, met_t *met0, met_t *met1, atm_t *atm, double t)

  *Write simulation output.*
- int main (int argc, char *argv[])

### 5.31.1 Detailed Description

Lagrangian particle dispersion model.

Definition in file trac.c.

### 5.31.2 Function Documentation

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

Set simulation time interval.

Definition at line 398 of file trac.c.

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

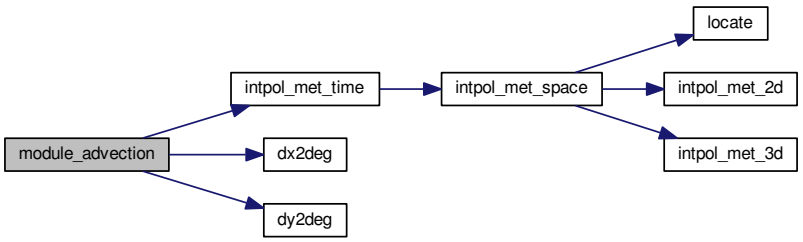
#### 5.31.2.2 void module_advection ( met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt* )

Calculate advection of air parcels.

Definition at line 422 of file trac.c.

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

Here is the call graph for this function:



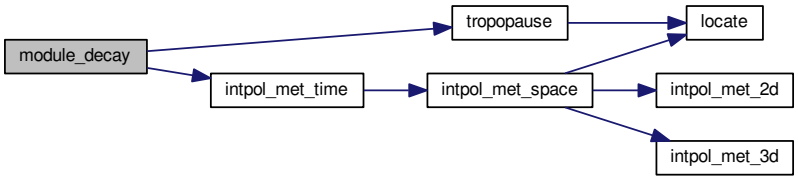
#### 5.31.2.3 void module_decay ( ctl_t * *ctl*, met_t * *met0*, met_t * *met1*, atm_t * *atm*, int *ip*, double *dt* )

Calculate exponential decay of particle mass.

Definition at line 455 of file trac.c.

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

Here is the call graph for this function:




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

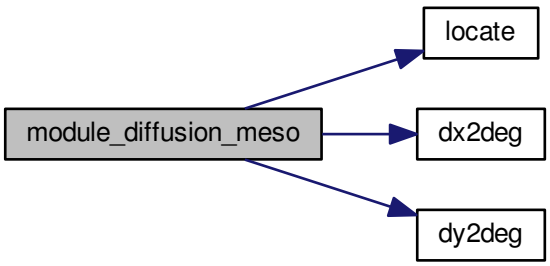
Calculate mesoscale diffusion.

Definition at line 497 of file trac.c.

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

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

Here is the call graph for this function:




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

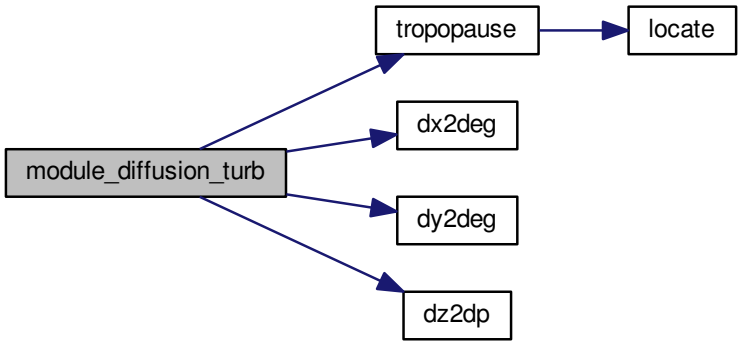
Calculate turbulent diffusion.

Definition at line 608 of file trac.c.

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

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

Here is the call graph for this function:




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

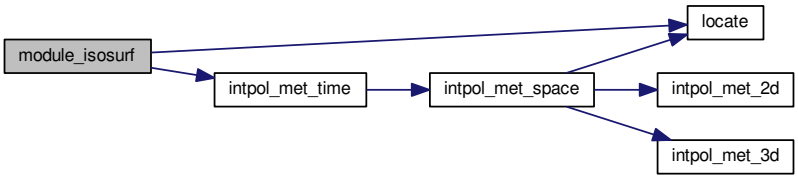
Force air parcels to stay on isosurface.

Definition at line 653 of file trac.c.

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

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

Here is the call graph for this function:




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

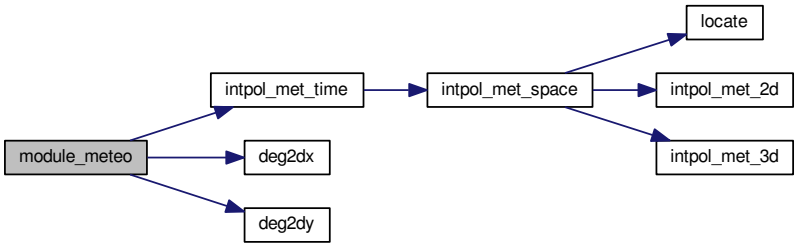
Interpolate meteorological data for air parcel positions.

Definition at line 768 of file trac.c.

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

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

Here is the call graph for this function:




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

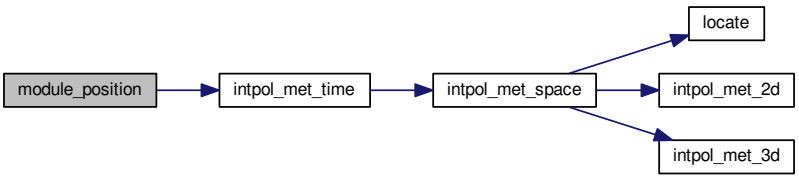
Check position of air parcels.

Definition at line 872 of file trac.c.

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

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

Here is the call graph for this function:




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

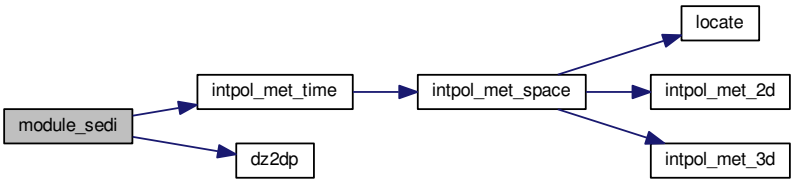
Calculate sedimentation of air parcels.

Definition at line 916 of file trac.c.

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

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

Here is the call graph for this function:




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

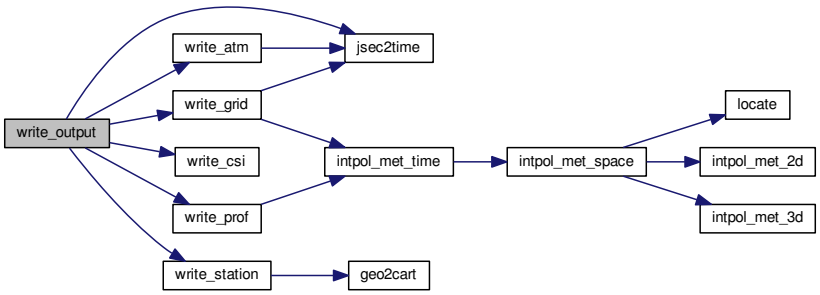
Write simulation output.

Definition at line 977 of file trac.c.

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

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

Here is the call graph for this function:




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

Definition at line 160 of file trac.c.

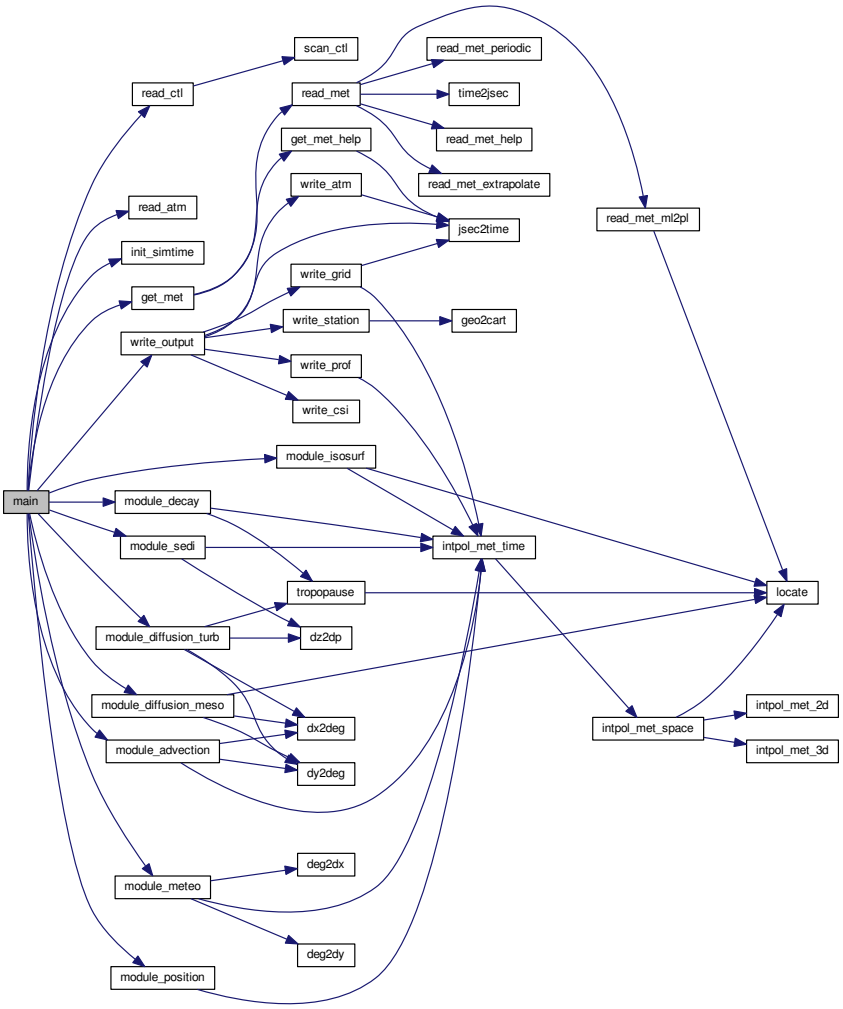
```
00162                {
00163
00164   ctl_t ctl;
00165
00166   atm_t *atm;
00167
00168   met_t *met0, *met1;
00169
00170   gsl_rng *rng[NTHREADS];
00171
00172   FILE *dirlist;
00173
00174   char dirname[LEN], filename[LEN];
00175
00176   double *dt, t, t0;
00177
00178   int i, ip, ntask = 0, rank = 0, size = 1;
00179
00180 #ifdef MPI
00181   /* Initialize MPI... */
00182   MPI_Init(&argc, &argv);
00183   MPI_Comm_rank(MPI_COMM_WORLD, &rank);
00184   MPI_Comm_size(MPI_COMM_WORLD, &size);
```

```
00185 #endif
00186
00187   /* Check arguments... */
00188   if (argc < 5)
00189     ERRMSG("Give parameters: <dirlist> <ctl> <atm_in> <metbase>");
00190
00191   /* Open directory list... */
00192   if (!(dirlist = fopen(argv[1], "r")))
00193     ERRMSG("Cannot open directory list!");
00194
00195   /* Loop over directories... */
00196   while (fscanf(dirlist, "%s", dirname) != EOF) {
00197
00198     /* MPI parallelization... */
00199     if ((++ntask) % size != rank)
00200       continue;
00201
00202     /* ------------------------------------------------------------
00203        Initialize model run...
00204        ------------------------------------------------------------ */
00205
00206     /* Set timers... */
00207     START_TIMER(TIMER_TOTAL);
00208     START_TIMER(TIMER_INIT);
00209
00210     /* Allocate... */
00211     ALLOC(atm, atm_t, 1);
00212     ALLOC(met0, met_t, 1);
00213     ALLOC(met1, met_t, 1);
00214     ALLOC(dt, double,
00215           NP);
00216
00217     /* Read control parameters... */
00218     sprintf(filename, "%s/%s", dirname, argv[2]);
00219     read_ctl(filename, argc, argv, &ctl);
00220
00221     /* Initialize random number generators... */
00222     gsl_rng_env_setup();
00223     for (i = 0; i < NTHREADS; i++)
00224       rng[i] = gsl_rng_alloc(gsl_rng_default);
00225
00226     /* Read atmospheric data... */
00227     sprintf(filename, "%s/%s", dirname, argv[3]);
00228     read_atm(filename, &ctl, atm);
00229
00230     /* Get simulation time interval... */
00231     init_simtime(&ctl, atm);
00232
00233     /* Get rounded start time... */
00234     if (ctl.direction == 1)
00235       t0 = floor(ctl.t_start / ctl.dt_mod) * ctl.dt_mod;
00236     else
00237       t0 = ceil(ctl.t_start / ctl.dt_mod) * ctl.dt_mod;
00238
00239     /* Set timers... */
00240     STOP_TIMER(TIMER_INIT);
00241
00242     /* ------------------------------------------------------------
00243        Loop over timesteps...
00244        ------------------------------------------------------------ */
00245
00246     /* Loop over timesteps... */
00247     for (t = t0; ctl.direction * (t - ctl.t_stop) < ctl.dt_mod;
00248          t += ctl.direction * ctl.dt_mod) {
00249
00250       /* Adjust length of final time step... */
00251       if (ctl.direction * (t - ctl.t_stop) > 0)
00252         t = ctl.t_stop;
00253
00254       /* Set time steps for air parcels... */
00255       for (ip = 0; ip < atm->np; ip++)
00256         if ((ctl.direction * (atm->time[ip] - ctl.t_start) >= 0
00257              && ctl.direction * (atm->time[ip] - ctl.t_stop) <= 0
00258              && ctl.direction * (atm->time[ip] - t) < 0))
00259           dt[ip] = t - atm->time[ip];
00260         else
00261           dt[ip] = GSL_NAN;
00262
00263       /* Get meteorological data... */
00264       START_TIMER(TIMER_INPUT);
00265       get_met(&ctl, argv[4], t, met0, met1);
00266       STOP_TIMER(TIMER_INPUT);
00267
00268       /* Initialize isosurface... */
00269       START_TIMER(TIMER_ISOSURF);
00270       if (t == t0)
00271         module_isosurf(&ctl, met0, met1, atm, -1);
```

```
00272       STOP_TIMER(TIMER_ISOSURF);
00273
00274       /* Advection... */
00275       START_TIMER(TIMER_ADVECT);
00276 #pragma omp parallel for default(shared) private(ip)
00277       for (ip = 0; ip < atm->np; ip++)
00278         if (gsl_finite(dt[ip]))
00279           module_advection(met0, met1, atm, ip, dt[ip]);
00280       STOP_TIMER(TIMER_ADVECT);
00281
00282       /* Turbulent diffusion... */
00283       START_TIMER(TIMER_DIFFTURB);
00284 #pragma omp parallel for default(shared) private(ip)
00285       for (ip = 0; ip < atm->np; ip++)
00286         if (gsl_finite(dt[ip]))
00287           module_diffusion_turb(&ctl, atm, ip, dt[ip],
00288                                 rng[omp_get_thread_num()]);
00289       STOP_TIMER(TIMER_DIFFTURB);
00290
00291       /* Mesoscale diffusion... */
00292       START_TIMER(TIMER_DIFFMESO);
00293 #pragma omp parallel for default(shared) private(ip)
00294       for (ip = 0; ip < atm->np; ip++)
00295         if (gsl_finite(dt[ip]))
00296           module_diffusion_meso(&ctl, met0, met1, atm, ip, dt[ip],
00297                                 rng[omp_get_thread_num()]);
00298       STOP_TIMER(TIMER_DIFFMESO);
00299
00300       /* Sedimentation... */
00301       START_TIMER(TIMER_SEDI);
00302 #pragma omp parallel for default(shared) private(ip)
00303       for (ip = 0; ip < atm->np; ip++)
00304         if (gsl_finite(dt[ip]))
00305           module_sedi(&ctl, met0, met1, atm, ip, dt[ip]);
00306       STOP_TIMER(TIMER_SEDI);
00307
00308       /* Isosurface... */
00309       START_TIMER(TIMER_ISOSURF);
00310 #pragma omp parallel for default(shared) private(ip)
00311       for (ip = 0; ip < atm->np; ip++)
00312         module_isosurf(&ctl, met0, met1, atm, ip);
00313       STOP_TIMER(TIMER_ISOSURF);
00314
00315       /* Position... */
00316       START_TIMER(TIMER_POSITION);
00317 #pragma omp parallel for default(shared) private(ip)
00318       for (ip = 0; ip < atm->np; ip++)
00319         module_position(met0, met1, atm, ip);
00320       STOP_TIMER(TIMER_POSITION);
00321
00322       /* Meteorological data... */
00323       START_TIMER(TIMER_METEO);
00324 #pragma omp parallel for default(shared) private(ip)
00325       for (ip = 0; ip < atm->np; ip++)
00326         module_meteo(&ctl, met0, met1, atm, ip);
00327       STOP_TIMER(TIMER_METEO);
00328
00329       /* Decay... */
00330       START_TIMER(TIMER_DECAY);
00331 #pragma omp parallel for default(shared) private(ip)
00332       for (ip = 0; ip < atm->np; ip++)
00333         if (gsl_finite(dt[ip]))
00334           module_decay(&ctl, met0, met1, atm, ip, dt[ip]);
00335       STOP_TIMER(TIMER_DECAY);
00336
00337       /* Write output... */
00338       START_TIMER(TIMER_OUTPUT);
00339       write_output(dirname, &ctl, met0, met1, atm, t);
00340       STOP_TIMER(TIMER_OUTPUT);
00341     }
00342
00343     /* ------------------------------------------------------------
00344        Finalize model run...
00345        ------------------------------------------------------------ */
00346
00347     /* Report timers... */
00348     STOP_TIMER(TIMER_TOTAL);
00349     PRINT_TIMER(TIMER_TOTAL);
00350     PRINT_TIMER(TIMER_INIT);
00351     PRINT_TIMER(TIMER_INPUT);
00352     PRINT_TIMER(TIMER_OUTPUT);
00353     PRINT_TIMER(TIMER_ADVECT);
00354     PRINT_TIMER(TIMER_DECAY);
00355     PRINT_TIMER(TIMER_DIFFMESO);
00356     PRINT_TIMER(TIMER_DIFFTURB);
00357     PRINT_TIMER(TIMER_ISOSURF);
00358     PRINT_TIMER(TIMER_METEO);
```

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

Here is the call graph for this function:




## 5.32 trac.c

```
00001 /*
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
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00016
00017   Copright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 #ifdef MPI
00028 #include "mpi.h"
00029 #endif
```

```
00030
00031 /* ------------------------------------------------------------
00032    Defines...
00033    ------------------------------------------------------------ */
00034
00036 #define TIMER_TOTAL 0
00037
00039 #define TIMER_INIT 1
00040
00042 #define TIMER_INPUT 2
00043
00045 #define TIMER_OUTPUT 3
00046
00048 #define TIMER_ADVECT 4
00049
00051 #define TIMER_DECAY 5
00052
00054 #define TIMER_DIFFMESO 6
00055
00057 #define TIMER_DIFFTURB 7
00058
00060 #define TIMER_ISOSURF 8
00061
00063 #define TIMER_METEO 9
00064
00066 #define TIMER_POSITION 10
00067
00069 #define TIMER_SEDI 11
00070
00071 /* ------------------------------------------------------------
00072    Functions...
00073    ------------------------------------------------------------ */
00074
00076 void init_simtime(
00077   ctl_t * ctl,
00078   atm_t * atm);
00079
00081 void module_advection(
00082   met_t * met0,
00083   met_t * met1,
00084   atm_t * atm,
00085   int ip,
00086   double dt);
00087
00089 void module_decay(
00090   ctl_t * ctl,
00091   met_t * met0,
00092   met_t * met1,
00093   atm_t * atm,
00094   int ip,
00095   double dt);
00096
00098 void module_diffusion_meso(
00099   ctl_t * ctl,
00100   met_t * met0,
00101   met_t * met1,
00102   atm_t * atm,
00103   int ip,
00104   double dt,
00105   gsl_rng * rng);
00106
00108 void module_diffusion_turb(
00109   ctl_t * ctl,
00110   atm_t * atm,
00111   int ip,
00112   double dt,
00113   gsl_rng * rng);
00114
00116 void module_isosurf(
00117   ctl_t * ctl,
00118   met_t * met0,
00119   met_t * met1,
00120   atm_t * atm,
00121   int ip);
00122
00124 void module_meteo(
00125   ctl_t * ctl,
00126   met_t * met0,
00127   met_t * met1,
00128   atm_t * atm,
00129   int ip);
00130
00132 void module_position(
00133   met_t * met0,
00134   met_t * met1,
00135   atm_t * atm,
00136   int ip);
```

```
00137
00139 void module_sedi(
00140   ctl_t * ctl,
00141   met_t * met0,
00142   met_t * met1,
00143   atm_t * atm,
00144   int ip,
00145   double dt);
00146
00148 void write_output(
00149   const char *dirname,
00150   ctl_t * ctl,
00151   met_t * met0,
00152   met_t * met1,
00153   atm_t * atm,
00154   double t);
00155
00156 /* ------------------------------------------------------------
00157    Main...
00158    ------------------------------------------------------------ */
00159
00160 int main(
00161   int argc,
00162   char *argv[]) {
00163
00164   ctl_t ctl;
00165
00166   atm_t *atm;
00167
00168   met_t *met0, *met1;
00169
00170   gsl_rng *rng[NTHREADS];
00171
00172   FILE *dirlist;
00173
00174   char dirname[LEN], filename[LEN];
00175
00176   double *dt, t, t0;
00177
00178   int i, ip, ntask = 0, rank = 0, size = 1;
00179
00180 #ifdef MPI
00181   /* Initialize MPI... */
00182   MPI_Init(&argc, &argv);
00183   MPI_Comm_rank(MPI_COMM_WORLD, &rank);
00184   MPI_Comm_size(MPI_COMM_WORLD, &size);
00185 #endif
00186
00187   /* Check arguments... */
00188   if (argc < 5)
00189     ERRMSG("Give parameters: <dirlist> <ctl> <atm_in> <metbase>");
00190
00191   /* Open directory list... */
00192   if (!(dirlist = fopen(argv[1], "r")))
00193     ERRMSG("Cannot open directory list!");
00194
00195   /* Loop over directories... */
00196   while (fscanf(dirlist, "%s", dirname) != EOF) {
00197
00198     /* MPI parallelization... */
00199     if ((++ntask) % size != rank)
00200       continue;
00201
00202     /* ------------------------------------------------------------
00203        Initialize model run...
00204        ------------------------------------------------------------ */
00205
00206     /* Set timers... */
00207     START_TIMER(TIMER_TOTAL);
00208     START_TIMER(TIMER_INIT);
00209
00210     /* Allocate... */
00211     ALLOC(atm, atm_t, 1);
00212     ALLOC(met0, met_t, 1);
00213     ALLOC(met1, met_t, 1);
00214     ALLOC(dt, double,
00215           NP);
00216
00217     /* Read control parameters... */
00218     sprintf(filename, "%s/%s", dirname, argv[2]);
00219     read_ctl(filename, argc, argv, &ctl);
00220
00221     /* Initialize random number generators... */
00222     gsl_rng_env_setup();
00223     for (i = 0; i < NTHREADS; i++)
00224       rng[i] = gsl_rng_alloc(gsl_rng_default);
00225
```

```
00226     /* Read atmospheric data... */
00227     sprintf(filename, "%s/%s", dirname, argv[3]);
00228     read_atm(filename, &ctl, atm);
00229
00230     /* Get simulation time interval... */
00231     init_simtime(&ctl, atm);
00232
00233     /* Get rounded start time... */
00234     if (ctl.direction == 1)
00235       t0 = floor(ctl.t_start / ctl.dt_mod) * ctl.dt_mod;
00236     else
00237       t0 = ceil(ctl.t_start / ctl.dt_mod) * ctl.dt_mod;
00238
00239     /* Set timers... */
00240     STOP_TIMER(TIMER_INIT);
00241
00242     /* ------------------------------------------------------------
00243        Loop over timesteps...
00244        ------------------------------------------------------------ */
00245
00246     /* Loop over timesteps... */
00247     for (t = t0; ctl.direction * (t - ctl.t_stop) < ctl.dt_mod;
00248          t += ctl.direction * ctl.dt_mod) {
00249
00250       /* Adjust length of final time step... */
00251       if (ctl.direction * (t - ctl.t_stop) > 0)
00252         t = ctl.t_stop;
00253
00254       /* Set time steps for air parcels... */
00255       for (ip = 0; ip < atm->np; ip++)
00256         if ((ctl.direction * (atm->time[ip] - ctl.t_start) >= 0
00257              && ctl.direction * (atm->time[ip] - ctl.t_stop) <= 0
00258              && ctl.direction * (atm->time[ip] - t) < 0))
00259           dt[ip] = t - atm->time[ip];
00260         else
00261           dt[ip] = GSL_NAN;
00262
00263       /* Get meteorological data... */
00264       START_TIMER(TIMER_INPUT);
00265       get_met(&ctl, argv[4], t, met0, met1);
00266       STOP_TIMER(TIMER_INPUT);
00267
00268       /* Initialize isosurface... */
00269       START_TIMER(TIMER_ISOSURF);
00270       if (t == t0)
00271         module_isosurf(&ctl, met0, met1, atm, -1);
00272       STOP_TIMER(TIMER_ISOSURF);
00273
00274       /* Advection... */
00275       START_TIMER(TIMER_ADVECT);
00276 #pragma omp parallel for default(shared) private(ip)
00277       for (ip = 0; ip < atm->np; ip++)
00278         if (gsl_finite(dt[ip]))
00279           module_advection(met0, met1, atm, ip, dt[ip]);
00280       STOP_TIMER(TIMER_ADVECT);
00281
00282       /* Turbulent diffusion... */
00283       START_TIMER(TIMER_DIFFTURB);
00284 #pragma omp parallel for default(shared) private(ip)
00285       for (ip = 0; ip < atm->np; ip++)
00286         if (gsl_finite(dt[ip]))
00287           module_diffusion_turb(&ctl, atm, ip, dt[ip],
00288                                 rng[omp_get_thread_num()]);
00289       STOP_TIMER(TIMER_DIFFTURB);
00290
00291       /* Mesoscale diffusion... */
00292       START_TIMER(TIMER_DIFFMESO);
00293 #pragma omp parallel for default(shared) private(ip)
00294       for (ip = 0; ip < atm->np; ip++)
00295         if (gsl_finite(dt[ip]))
00296           module_diffusion_meso(&ctl, met0, met1, atm, ip, dt[ip],
00297                                 rng[omp_get_thread_num()]);
00298       STOP_TIMER(TIMER_DIFFMESO);
00299
00300       /* Sedimentation... */
00301       START_TIMER(TIMER_SEDI);
00302 #pragma omp parallel for default(shared) private(ip)
00303       for (ip = 0; ip < atm->np; ip++)
00304         if (gsl_finite(dt[ip]))
00305           module_sedi(&ctl, met0, met1, atm, ip, dt[ip]);
00306       STOP_TIMER(TIMER_SEDI);
00307
00308       /* Isosurface... */
00309       START_TIMER(TIMER_ISOSURF);
00310 #pragma omp parallel for default(shared) private(ip)
00311       for (ip = 0; ip < atm->np; ip++)
00312         module_isosurf(&ctl, met0, met1, atm, ip);
```

```
00313       STOP_TIMER(TIMER_ISOSURF);
00314
00315       /* Position... */
00316       START_TIMER(TIMER_POSITION);
00317 #pragma omp parallel for default(shared) private(ip)
00318       for (ip = 0; ip < atm->np; ip++)
00319         module_position(met0, met1, atm, ip);
00320       STOP_TIMER(TIMER_POSITION);
00321
00322       /* Meteorological data... */
00323       START_TIMER(TIMER_METEO);
00324 #pragma omp parallel for default(shared) private(ip)
00325       for (ip = 0; ip < atm->np; ip++)
00326         module_meteo(&ctl, met0, met1, atm, ip);
00327       STOP_TIMER(TIMER_METEO);
00328
00329       /* Decay... */
00330       START_TIMER(TIMER_DECAY);
00331 #pragma omp parallel for default(shared) private(ip)
00332       for (ip = 0; ip < atm->np; ip++)
00333         if (gsl_finite(dt[ip]))
00334           module_decay(&ctl, met0, met1, atm, ip, dt[ip]);
00335       STOP_TIMER(TIMER_DECAY);
00336
00337       /* Write output... */
00338       START_TIMER(TIMER_OUTPUT);
00339       write_output(dirname, &ctl, met0, met1, atm, t);
00340       STOP_TIMER(TIMER_OUTPUT);
00341     }
00342
00343     /* ------------------------------------------------------------
00344        Finalize model run...
00345        ------------------------------------------------------------ */
00346
00347     /* Report timers... */
00348     STOP_TIMER(TIMER_TOTAL);
00349     PRINT_TIMER(TIMER_TOTAL);
00350     PRINT_TIMER(TIMER_INIT);
00351     PRINT_TIMER(TIMER_INPUT);
00352     PRINT_TIMER(TIMER_OUTPUT);
00353     PRINT_TIMER(TIMER_ADVECT);
00354     PRINT_TIMER(TIMER_DECAY);
00355     PRINT_TIMER(TIMER_DIFFMESO);
00356     PRINT_TIMER(TIMER_DIFFTURB);
00357     PRINT_TIMER(TIMER_ISOSURF);
00358     PRINT_TIMER(TIMER_METEO);
00359     PRINT_TIMER(TIMER_POSITION);
00360     PRINT_TIMER(TIMER_SEDI);
00361
00362     /* Report memory usage... */
00363     printf("MEMORY_ATM = %g MByte\n", 2. * sizeof(atm_t) / 1024. / 1024.);
00364     printf("MEMORY_METEO = %g MByte\n", 2. * sizeof(met_t) / 1024. / 1024.);
00365     printf("MEMORY_DYNAMIC = %g MByte\n",
00366            NP * sizeof(double) / 1024. / 1024.);
00367     printf("MEMORY_STATIC = %g MByte\n",
00368            (((EX + EY) + (2 + NQ) * GX * GY * GZ) * sizeof(double)
00369             + (EX * EY + EX * EY * EP) * sizeof(float)
00370             + (2 * GX * GY * GZ) * sizeof(int)) / 1024. / 1024.);
00371
00372     /* Report problem size... */
00373     printf("SIZE_NP = %d\n", atm->np);
00374     printf("SIZE_TASKS = %d\n", size);
00375     printf("SIZE_THREADS = %d\n", omp_get_max_threads());
00376
00377     /* Free random number generators... */
00378     for (i = 0; i < NTHREADS; i++)
00379       gsl_rng_free(rng[i]);
00380
00381     /* Free... */
00382     free(atm);
00383     free(met0);
00384     free(met1);
00385     free(dt);
00386   }
00387
00388 #ifdef MPI
00389   /* Finalize MPI... */
00390   MPI_Finalize();
00391 #endif
00392
00393   return EXIT_SUCCESS;
00394 }
00395
00396 /*****************************************************************************/
00397
00398 void init_simtime(
00399   ctl_t * ctl,
```

```
00400   atm_t * atm) {
00401
00402   /* Set inital and final time... */
00403   if (ctl->direction == 1) {
00404     if (ctl->t_start < -1e99)
00405       ctl->t_start = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00406     if (ctl->t_stop < -1e99)
00407       ctl->t_stop = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00408   } else if (ctl->direction == -1) {
00409     if (ctl->t_stop < -1e99)
00410       ctl->t_stop = gsl_stats_min(atm->time, 1, (size_t) atm->np);
00411     if (ctl->t_start < -1e99)
00412       ctl->t_start = gsl_stats_max(atm->time, 1, (size_t) atm->np);
00413   }
00414
00415   /* Check time... */
00416   if (ctl->direction * (ctl->t_stop - ctl->t_start) <= 0)
00417     ERRMSG("Nothing to do!");
00418 }
00419
00420 /*****************************************************************************/
00421
00422 void module_advection(
00423   met_t * met0,
00424   met_t * met1,
00425   atm_t * atm,
00426   int ip,
00427   double dt) {
00428
00429   double v[3], xm[3];
00430
00431   /* Interpolate meteorological data... */
00432   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00433                   atm->lon[ip], atm->lat[ip], NULL, NULL,
00434                   &v[0], &v[1], &v[2], NULL, NULL);
00435
00436   /* Get position of the mid point... */
00437   xm[0] = atm->lon[ip] + dx2deg(0.5 * dt * v[0] / 1000., atm->lat[ip]);
00438   xm[1] = atm->lat[ip] + dy2deg(0.5 * dt * v[1] / 1000.);
00439   xm[2] = atm->p[ip] + 0.5 * dt * v[2];
00440
00441   /* Interpolate meteorological data for mid point... */
00442   intpol_met_time(met0, met1, atm->time[ip] + 0.5 * dt,
00443                   xm[2], xm[0], xm[1], NULL, NULL,
00444                   &v[0], &v[1], &v[2], NULL, NULL);
00445
00446   /* Save new position... */
00447   atm->time[ip] += dt;
00448   atm->lon[ip] += dx2deg(dt * v[0] / 1000., xm[1]);
00449   atm->lat[ip] += dy2deg(dt * v[1] / 1000.);
00450   atm->p[ip] += dt * v[2];
00451 }
00452
00453 /*****************************************************************************/
00454
00455 void module_decay(
00456   ctl_t * ctl,
00457   met_t * met0,
00458   met_t * met1,
00459   atm_t * atm,
00460   int ip,
00461   double dt) {
00462
00463   double ps, pt, tdec;
00464
00465   /* Check lifetime values... */
00466   if ((ctl->tdec_trop <= 0 && ctl->tdec_strat <= 0) || ctl->
      qnt_m < 0)
00467     return;
00468
00469   /* Set constant lifetime... */
00470   if (ctl->tdec_trop == ctl->tdec_strat)
00471     tdec = ctl->tdec_trop;
00472
00473   /* Set altitude-dependent lifetime... */
00474   else {
00475
00476     /* Get surface pressure... */
00477     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00478                     atm->lon[ip], atm->lat[ip], &ps, NULL,
00479                     NULL, NULL, NULL, NULL, NULL);
00480
00481     /* Get tropopause pressure... */
00482     pt = tropopause(atm->time[ip], atm->lat[ip]);
00483
00484     /* Set lifetime... */
00485     if (atm->p[ip] <= pt)
```

```
00486       tdec = ctl->tdec_strat;
00487     else
00488       tdec = LIN(ps, ctl->tdec_trop, pt, ctl->tdec_strat, atm->
      p[ip]);
00489   }
00490
00491   /* Calculate exponential decay... */
00492   atm->q[ctl->qnt_m][ip] *= exp(-dt / tdec);
00493 }
00494
00495 /*****************************************************************************/
00496
00497 void module_diffusion_meso(
00498   ctl_t * ctl,
00499   met_t * met0,
00500   met_t * met1,
00501   atm_t * atm,
00502   int ip,
00503   double dt,
00504   gsl_rng * rng) {
00505
00506   double r, rs, u[16], v[16], w[16], usig, vsig, wsig;
00507
00508   int ix, iy, iz;
00509
00510   /* Calculate mesoscale velocity fluctuations... */
00511   if (ctl->turb_meso > 0) {
00512
00513     /* Get indices... */
00514     ix = locate(met0->lon, met0->nx, atm->lon[ip]);
00515     iy = locate(met0->lat, met0->ny, atm->lat[ip]);
00516     iz = locate(met0->p, met0->np, atm->p[ip]);
00517
00518     /* Collect local wind data... */
00519     u[0] = met0->u[ix][iy][iz];
00520     u[1] = met0->u[ix + 1][iy][iz];
00521     u[2] = met0->u[ix][iy + 1][iz];
00522     u[3] = met0->u[ix + 1][iy + 1][iz];
00523     u[4] = met0->u[ix][iy][iz + 1];
00524     u[5] = met0->u[ix + 1][iy][iz + 1];
00525     u[6] = met0->u[ix][iy + 1][iz + 1];
00526     u[7] = met0->u[ix + 1][iy + 1][iz + 1];
00527
00528     v[0] = met0->v[ix][iy][iz];
00529     v[1] = met0->v[ix + 1][iy][iz];
00530     v[2] = met0->v[ix][iy + 1][iz];
00531     v[3] = met0->v[ix + 1][iy + 1][iz];
00532     v[4] = met0->v[ix][iy][iz + 1];
00533     v[5] = met0->v[ix + 1][iy][iz + 1];
00534     v[6] = met0->v[ix][iy + 1][iz + 1];
00535     v[7] = met0->v[ix + 1][iy + 1][iz + 1];
00536
00537     w[0] = met0->w[ix][iy][iz];
00538     w[1] = met0->w[ix + 1][iy][iz];
00539     w[2] = met0->w[ix][iy + 1][iz];
00540     w[3] = met0->w[ix + 1][iy + 1][iz];
00541     w[4] = met0->w[ix][iy][iz + 1];
00542     w[5] = met0->w[ix + 1][iy][iz + 1];
00543     w[6] = met0->w[ix][iy + 1][iz + 1];
00544     w[7] = met0->w[ix + 1][iy + 1][iz + 1];
00545
00546     /* Get indices... */
00547     ix = locate(met1->lon, met1->nx, atm->lon[ip]);
00548     iy = locate(met1->lat, met1->ny, atm->lat[ip]);
00549     iz = locate(met1->p, met1->np, atm->p[ip]);
00550
00551     /* Collect local wind data... */
00552     u[8] = met1->u[ix][iy][iz];
00553     u[9] = met1->u[ix + 1][iy][iz];
00554     u[10] = met1->u[ix][iy + 1][iz];
00555     u[11] = met1->u[ix + 1][iy + 1][iz];
00556     u[12] = met1->u[ix][iy][iz + 1];
00557     u[13] = met1->u[ix + 1][iy][iz + 1];
00558     u[14] = met1->u[ix][iy + 1][iz + 1];
00559     u[15] = met1->u[ix + 1][iy + 1][iz + 1];
00560
00561     v[8] = met1->v[ix][iy][iz];
00562     v[9] = met1->v[ix + 1][iy][iz];
00563     v[10] = met1->v[ix][iy + 1][iz];
00564     v[11] = met1->v[ix + 1][iy + 1][iz];
00565     v[12] = met1->v[ix][iy][iz + 1];
00566     v[13] = met1->v[ix + 1][iy][iz + 1];
00567     v[14] = met1->v[ix][iy + 1][iz + 1];
00568     v[15] = met1->v[ix + 1][iy + 1][iz + 1];
00569
00570     w[8] = met1->w[ix][iy][iz];
00571     w[9] = met1->w[ix + 1][iy][iz];
```

```
00572     w[10] = met1->w[ix][iy + 1][iz];
00573     w[11] = met1->w[ix + 1][iy + 1][iz];
00574     w[12] = met1->w[ix][iy][iz + 1];
00575     w[13] = met1->w[ix + 1][iy][iz + 1];
00576     w[14] = met1->w[ix][iy + 1][iz + 1];
00577     w[15] = met1->w[ix + 1][iy + 1][iz + 1];
00578
00579     /* Get standard deviations of local wind data... */
00580     usig = gsl_stats_sd(u, 1, 16);
00581     vsig = gsl_stats_sd(v, 1, 16);
00582     wsig = gsl_stats_sd(w, 1, 16);
00583
00584     /* Set temporal correlations for mesoscale fluctuations... */
00585     r = 1 - 2 * fabs(dt) / ctl->dt_met;
00586     rs = sqrt(1 - r * r);
00587
00588     /* Calculate mesoscale wind fluctuations... */
00589     atm->up[ip] =
00590       r * atm->up[ip] + rs * gsl_ran_gaussian_ziggurat(rng,
00591                                                        ctl->turb_meso * usig);
00592     atm->vp[ip] =
00593       r * atm->vp[ip] + rs * gsl_ran_gaussian_ziggurat(rng,
00594                                                        ctl->turb_meso * vsig);
00595     atm->wp[ip] =
00596       r * atm->wp[ip] + rs * gsl_ran_gaussian_ziggurat(rng,
00597                                                        ctl->turb_meso * wsig);
00598
00599     /* Calculate air parcel displacement... */
00600     atm->lon[ip] += dx2deg(atm->up[ip] * dt / 1000., atm->lat[ip]);
00601     atm->lat[ip] += dy2deg(atm->vp[ip] * dt / 1000.);
00602     atm->p[ip] += atm->wp[ip] * dt;
00603   }
00604 }
00605
00606 /*****************************************************************************/
00607
00608 void module_diffusion_turb(
00609   ctl_t * ctl,
00610   atm_t * atm,
00611   int ip,
00612   double dt,
00613   gsl_rng * rng) {
00614
00615   double dx, dz, pt, p0, p1, w;
00616
00617   /* Get tropopause pressure... */
00618   pt = tropopause(atm->time[ip], atm->lat[ip]);
00619
00620   /* Get weighting factor... */
00621   p1 = pt * 0.866877899;
00622   p0 = pt / 0.866877899;
00623   if (atm->p[ip] > p0)
00624     w = 1;
00625   else if (atm->p[ip] < p1)
00626     w = 0;
00627   else
00628     w = LIN(p0, 1.0, p1, 0.0, atm->p[ip]);
00629
00630   /* Set diffusivitiy... */
00631   dx = w * ctl->turb_dx_trop + (1 - w) * ctl->turb_dx_strat;
00632   dz = w * ctl->turb_dz_trop + (1 - w) * ctl->turb_dz_strat;
00633
00634   /* Horizontal turbulent diffusion... */
00635   if (dx > 0) {
00636     atm->lon[ip]
00637       += dx2deg(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dx * fabs(dt)))
00638                 / 1000., atm->lat[ip]);
00639     atm->lat[ip]
00640       += dy2deg(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dx * fabs(dt)))
00641                 / 1000.);
00642   }
00643
00644   /* Vertical turbulent diffusion... */
00645   if (dz > 0)
00646     atm->p[ip]
00647       += dz2dp(gsl_ran_gaussian_ziggurat(rng, sqrt(2.0 * dz * fabs(dt)))
00648                / 1000., atm->p[ip]);
00649 }
00650
00651 /*****************************************************************************/
00652
00653 void module_isosurf(
00654   ctl_t * ctl,
00655   met_t * met0,
00656   met_t * met1,
00657   atm_t * atm,
00658   int ip) {
```

```
00659
00660   static double *iso, *ps, t, *ts;
00661
00662   static int idx, ip2, n, nb = 100000;
00663
00664   FILE *in;
00665
00666   char line[LEN];
00667
00668   /* Check control parameter... */
00669   if (ctl->isosurf < 1 || ctl->isosurf > 4)
00670     return;
00671
00672   /* Initialize... */
00673   if (ip < 0) {
00674
00675     /* Allocate... */
00676     ALLOC(iso, double,
00677           NP);
00678     ALLOC(ps, double,
00679           nb);
00680     ALLOC(ts, double,
00681           nb);
00682
00683     /* Save pressure... */
00684     if (ctl->isosurf == 1)
00685       for (ip2 = 0; ip2 < atm->np; ip2++)
00686         iso[ip2] = atm->p[ip2];
00687
00688     /* Save density... */
00689     else if (ctl->isosurf == 2)
00690       for (ip2 = 0; ip2 < atm->np; ip2++) {
00691         intpol_met_time(met0, met1, atm->time[ip2], atm->p[ip2],
00692                         atm->lon[ip2], atm->lat[ip2], NULL, &t, NULL, NULL,
00693                         NULL, NULL, NULL);
00694         iso[ip2] = atm->p[ip2] / t;
00695       }
00696
00697     /* Save potential temperature... */
00698     else if (ctl->isosurf == 3)
00699       for (ip2 = 0; ip2 < atm->np; ip2++) {
00700         intpol_met_time(met0, met1, atm->time[ip2], atm->p[ip2],
00701                         atm->lon[ip2], atm->lat[ip2], NULL, &t, NULL, NULL,
00702                         NULL, NULL, NULL);
00703         iso[ip2] = t * pow(P0 / atm->p[ip2], 0.286);
00704       }
00705
00706     /* Read balloon pressure data... */
00707     else if (ctl->isosurf == 4) {
00708
00709       /* Write info... */
00710       printf("Read balloon pressure data: %s\n", ctl->balloon);
00711
00712       /* Open file... */
00713       if (!(in = fopen(ctl->balloon, "r")))
00714         ERRMSG("Cannot open file!");
00715
00716       /* Read pressure time series... */
00717       while (fgets(line, LEN, in))
00718         if (sscanf(line, "%lg %lg", &ts[n], &ps[n]) == 2)
00719           if ((++n) > 100000)
00720             ERRMSG("Too many data points!");
00721
00722       /* Check number of points... */
00723       if (n < 1)
00724         ERRMSG("Could not read any data!");
00725
00726       /* Close file... */
00727       fclose(in);
00728     }
00729
00730     /* Leave initialization... */
00731     return;
00732   }
00733
00734   /* Restore pressure... */
00735   if (ctl->isosurf == 1)
00736     atm->p[ip] = iso[ip];
00737
00738   /* Restore density... */
00739   else if (ctl->isosurf == 2) {
00740     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00741                     atm->lat[ip], NULL, &t, NULL, NULL, NULL, NULL, NULL);
00742     atm->p[ip] = iso[ip] * t;
00743   }
00744
```

```
00745   /* Restore potential temperature... */
00746   else if (ctl->isosurf == 3) {
00747     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00748                     atm->lat[ip], NULL, &t, NULL, NULL, NULL, NULL, NULL);
00749     atm->p[ip] = P0 * pow(iso[ip] / t, -1. / 0.286);
00750   }
00751
00752   /* Interpolate pressure... */
00753   else if (ctl->isosurf == 4) {
00754     if (atm->time[ip] <= ts[0])
00755       atm->p[ip] = ps[0];
00756     else if (atm->time[ip] >= ts[n - 1])
00757       atm->p[ip] = ps[n - 1];
00758     else {
00759       idx = locate(ts, n, atm->time[ip]);
00760       atm->p[ip] = LIN(ts[idx], ps[idx],
00761                        ts[idx + 1], ps[idx + 1], atm->time[ip]);
00762     }
00763   }
00764 }
00765
00766 /*****************************************************************************/
00767
00768 void module_meteo(
00769   ctl_t * ctl,
00770   met_t * met0,
00771   met_t * met1,
00772   atm_t * atm,
00773   int ip) {
00774
00775   double b, c, ps, p1, p_hno3, p_h2o, t, t1, term1, term2,
00776     u, u1, v, v1, w, x1, x2, h2o, o3, grad, vort;
00777
00778   /* Interpolate meteorological data... */
00779   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00780                   atm->lat[ip], &ps, &t, &u, &v, &w, &h2o, &o3);
00781
00782   /* Set surface pressure... */
00783   if (ctl->qnt_ps >= 0)
00784     atm->q[ctl->qnt_ps][ip] = ps;
00785
00786   /* Set pressure... */
00787   if (ctl->qnt_p >= 0)
00788     atm->q[ctl->qnt_p][ip] = atm->p[ip];
00789
00790   /* Set temperature... */
00791   if (ctl->qnt_t >= 0)
00792     atm->q[ctl->qnt_t][ip] = t;
00793
00794   /* Set zonal wind... */
00795   if (ctl->qnt_u >= 0)
00796     atm->q[ctl->qnt_u][ip] = u;
00797
00798   /* Set meridional wind... */
00799   if (ctl->qnt_v >= 0)
00800     atm->q[ctl->qnt_v][ip] = v;
00801
00802   /* Set vertical velocity... */
00803   if (ctl->qnt_w >= 0)
00804     atm->q[ctl->qnt_w][ip] = w;
00805
00806   /* Set water vapor vmr... */
00807   if (ctl->qnt_h2o >= 0)
00808     atm->q[ctl->qnt_h2o][ip] = h2o;
00809
00810   /* Set ozone vmr... */
00811   if (ctl->qnt_o3 >= 0)
00812     atm->q[ctl->qnt_o3][ip] = o3;
00813
00814   /* Calculate potential temperature... */
00815   if (ctl->qnt_theta >= 0)
00816     atm->q[ctl->qnt_theta][ip] = t * pow(P0 / atm->p[ip], 0.286);
00817
00818   /* Calculate potential vorticity... */
00819   if (ctl->qnt_pv >= 0) {
00820
00821     /* Absolute vorticity... */
00822     vort = 2 * 7.2921e-5 * sin(atm->lat[ip] * M_PI / 180.);
00823     if (fabs(atm->lat[ip]) < 89.) {
00824       intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00825                       (atm->lon[ip] >=
00826                        0 ? atm->lon[ip] - 1. : atm->lon[ip] + 1.),
00827                       atm->lat[ip], NULL, NULL, NULL, &v1, NULL, NULL, NULL);
00828       vort += (v1 - v) / 1000.
00829         / ((atm->lon[ip] >= 0 ? -1 : 1) * deg2dx(1., atm->lat[ip]));
```

```
00830     }
00831     intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
    lon[ip],
00832                     (atm->lat[ip] >=
00833                      0 ? atm->lat[ip] - 1. : atm->lat[ip] + 1.), NULL, NULL,
00834                     &u1, NULL, NULL, NULL, NULL);
00835     vort += (u1 - u) / 1000. / ((atm->lat[ip] >= 0 ? -1 : 1) * deg2dy(1.));
00836
00837     /* Potential temperature gradient... */
00838     p1 = 0.85 * atm->p[ip];
00839     intpol_met_time(met0, met1, atm->time[ip], p1, atm->lon[ip],
00840                     atm->lat[ip], NULL, &t1, NULL, NULL, NULL, NULL, NULL);
00841     grad = (t1 * pow(P0 / p1, 0.286) - t * pow(P0 / atm->p[ip], 0.286))
00842       / (100. * (p1 - atm->p[ip]));
00843
00844     /* Calculate PV... */
00845     atm->q[ctl->qnt_pv][ip] = -1e6 * G0 * vort * grad;
00846   }
00847
00848   /* Calculate T_ice (Marti and Mauersberger, 1993)... */
00849   if (ctl->qnt_tice >= 0)
00850     atm->q[ctl->qnt_tice][ip] = -2663.5
00851       / (log10(4e-6 * atm->p[ip] * 100.) - 12.537);
00852
00853   /* Calculate T_NAT (Hanson and Mauersberger, 1988)... */
00854   if (ctl->qnt_tnat >= 0) {
00855     p_hno3 = 9e-9 * atm->p[ip] / 1.333224;
00856     p_h2o = 4e-6 * atm->p[ip] / 1.333224;
00857     term1 = 38.9855 - log10(p_hno3) - 2.7836 * log10(p_h2o);
00858     term2 = 0.009179 - 0.00088 * log10(p_h2o);
00859     b = term1 / term2;
00860     c = -11397.0 / term2;
00861     x1 = (-b + sqrt(b * b - 4. * c)) / 2.;
00862     x2 = (-b - sqrt(b * b - 4. * c)) / 2.;
00863     if (x1 > 0)
00864       atm->q[ctl->qnt_tnat][ip] = x1;
00865     if (x2 > 0)
00866       atm->q[ctl->qnt_tnat][ip] = x2;
00867   }
00868 }
00869
00870 /*****************************************************************************/
00871
00872 void module_position(
00873   met_t * met0,
00874   met_t * met1,
00875   atm_t * atm,
00876   int ip) {
00877
00878   double ps;
00879
00880   /* Calculate modulo... */
00881   atm->lon[ip] = fmod(atm->lon[ip], 360);
00882   atm->lat[ip] = fmod(atm->lat[ip], 360);
00883
00884   /* Check latitude... */
00885   while (atm->lat[ip] < -90 || atm->lat[ip] > 90) {
00886     if (atm->lat[ip] > 90) {
00887       atm->lat[ip] = 180 - atm->lat[ip];
00888       atm->lon[ip] += 180;
00889     }
00890     if (atm->lat[ip] < -90) {
00891       atm->lat[ip] = -180 - atm->lat[ip];
00892       atm->lon[ip] += 180;
00893     }
00894   }
00895
00896   /* Check longitude... */
00897   while (atm->lon[ip] < -180)
00898     atm->lon[ip] += 360;
00899   while (atm->lon[ip] >= 180)
00900     atm->lon[ip] -= 360;
00901
00902   /* Get surface pressure... */
00903   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip],
00904                   atm->lon[ip], atm->lat[ip], &ps, NULL,
00905                   NULL, NULL, NULL, NULL, NULL);
00906
00907   /* Check pressure... */
00908   if (atm->p[ip] > ps)
00909     atm->p[ip] = ps;
00910   else if (atm->p[ip] < met0->p[met0->np - 1])
00911     atm->p[ip] = met0->p[met0->np - 1];
00912 }
00913
00914 /*****************************************************************************/
00915
```

```
00916 void module_sedi(
00917   ctl_t * ctl,
00918   met_t * met0,
00919   met_t * met1,
00920   atm_t * atm,
00921   int ip,
00922   double dt) {
00923
00924   /* Coefficients for Cunningham slip-flow correction (Kasten, 1968): */
00925   const double A = 1.249, B = 0.42, C = 0.87;
00926
00927   /* Specific gas constant for dry air [J/(kg K)]: */
00928   const double R = 287.058;
00929
00930   /* Average mass of an air molecule [kg/molec]: */
00931   const double m = 4.8096e-26;
00932
00933   double G, K, eta, lambda, p, r_p, rho, rho_p, T, v, v_p;
00934
00935   /* Check if parameters are available... */
00936   if (ctl->qnt_r < 0 || ctl->qnt_rho < 0)
00937     return;
00938
00939   /* Convert units... */
00940   p = 100 * atm->p[ip];
00941   r_p = 1e-6 * atm->q[ctl->qnt_r][ip];
00942   rho_p = atm->q[ctl->qnt_rho][ip];
00943
00944   /* Get temperature... */
00945   intpol_met_time(met0, met1, atm->time[ip], atm->p[ip], atm->
      lon[ip],
00946                   atm->lat[ip], NULL, &T, NULL, NULL, NULL, NULL, NULL);
00947
00948   /* Density of dry air... */
00949   rho = p / (R * T);
00950
00951   /* Dynamic viscosity of air... */
00952   eta = 1.8325e-5 * (416.16 / (T + 120.)) * pow(T / 296.16, 1.5);
00953
00954   /* Thermal velocity of an air molecule... */
00955   v = sqrt(8 * GSL_CONST_MKSA_BOLTZMANN * T / (M_PI * m));
00956
00957   /* Mean free path of an air molecule... */
00958   lambda = 2 * eta / (rho * v);
00959
00960   /* Knudsen number for air... */
00961   K = lambda / r_p;
00962
00963   /* Cunningham slip-flow correction... */
00964   G = 1 + K * (A + B * exp(-C / K));
00965
00966   /* Sedimentation (fall) velocity... */
00967   v_p =
00968     2. * gsl_pow_2(r_p) * (rho_p -
00969                            rho) * GSL_CONST_MKSA_GRAV_ACCEL / (9. * eta) * G;
00970
00971   /* Calculate pressure change... */
00972   atm->p[ip] += dz2dp(v_p * dt / 1000., atm->p[ip]);
00973 }
00974
00975 /*****************************************************************************/
00976
00977 void write_output(
00978   const char *dirname,
00979   ctl_t * ctl,
00980   met_t * met0,
00981   met_t * met1,
00982   atm_t * atm,
00983   double t) {
00984
00985   char filename[LEN];
00986
00987   double r;
00988
00989   int year, mon, day, hour, min, sec;
00990
00991   /* Get time... */
00992   jsec2time(t, &year, &mon, &day, &hour, &min, &sec, &r);
00993
00994   /* Write atmospheric data... */
00995   if (ctl->atm_basename[0] != '-' && fmod(t, ctl->atm_dt_out) == 0) {
00996     sprintf(filename, "%s/%s_%04d_%02d_%02d_%02d_%02d.tab",
00997             dirname, ctl->atm_basename, year, mon, day, hour, min);
00998     write_atm(filename, ctl, atm, t);
00999   }
01000
01001   /* Write gridded data... */
```

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

## 5.33 wind.c File Reference

Create meteorological data files with synthetic wind fields.

### Functions

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

### 5.33.1 Detailed Description

Create meteorological data files with synthetic wind fields.

Definition in file wind.c.

### 5.33.2 Function Documentation

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

Definition at line 173 of file wind.c.

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

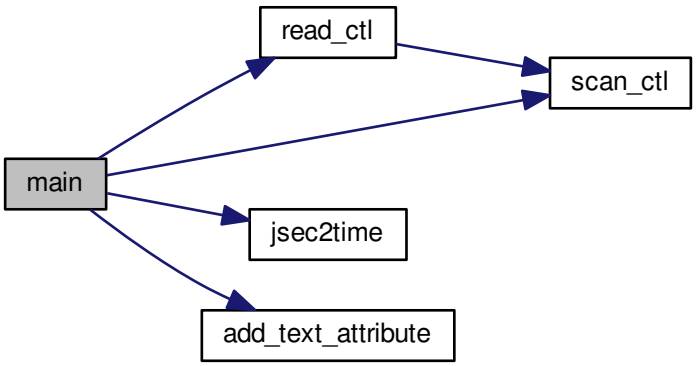
#### 5.33.2.2 int main ( int *argc*, char * *argv[]* )

Definition at line 41 of file wind.c.

```
00043                {
00044
00045   ctl_t ctl;
00046
00047   static char filename[LEN];
00048
00049   static double r, t0, z0, z1, dataLon[EX], dataLat[EY], dataZ[EP],
00050     u0, u1, alpha;
00051
00052   static float dataT[EP * EY * EX], dataU[EP * EY * EX], dataV[EP * EY * EX],
00053     dataW[EP * EY * EX];
00054
00055   static int ncid, dims[4], timid, levid, latid, lonid, tid, uid, vid, wid,
00056     idx, ix, iy, iz, nx, ny, nz, year, mon, day, hour, min, sec;
00057
00058   /* Check arguments... */
00059   if (argc < 3)
00060     ERRMSG("Give parameters: <ctl> <metbase>");
00061
00062   /* Read control parameters... */
00063   read_ctl(argv[1], argc, argv, &ctl);
00064   t0 = scan_ctl(argv[1], argc, argv, "WIND_T0", -1, "0", NULL);
00065   nx = (int) scan_ctl(argv[1], argc, argv, "WIND_NX", -1, "360", NULL);
00066   ny = (int) scan_ctl(argv[1], argc, argv, "WIND_NY", -1, "181", NULL);
00067   nz = (int) scan_ctl(argv[1], argc, argv, "WIND_NZ", -1, "61", NULL);
00068   z0 = scan_ctl(argv[1], argc, argv, "WIND_Z0", -1, "0", NULL);
00069   z1 = scan_ctl(argv[1], argc, argv, "WIND_Z1", -1, "60", NULL);
00070   u0 = scan_ctl(argv[1], argc, argv, "WIND_U0", -1, "38.587660177302", NULL);
00071   u1 = scan_ctl(argv[1], argc, argv, "WIND_U1", -1, "38.587660177302", NULL);
00072   alpha = scan_ctl(argv[1], argc, argv, "WIND_ALPHA", -1, "0.0", NULL);
00073
00074   /* Check dimensions... */
00075   if (nx < 1 || nx > EX)
00076     ERRMSG("Set 1 <= NX <= MAX!");
00077   if (ny < 1 || ny > EY)
00078     ERRMSG("Set 1 <= NY <= MAX!");
00079   if (nz < 1 || nz > EP)
00080     ERRMSG("Set 1 <= NZ <= MAX!");
00081
00082   /* Get time... */
00083   jsec2time(t0, &year, &mon, &day, &hour, &min, &sec, &r);
00084   t0 = year * 10000. + mon * 100. + day + hour / 24.;
00085
00086   /* Set filename... */
00087   sprintf(filename, "%s_%d_%02d_%02d_%02d.nc", argv[2], year, mon, day, hour);
00088
00089   /* Create netCDF file... */
00090   NC(nc_create(filename, NC_CLOBBER, &ncid));
00091
00092   /* Create dimensions... */
00093   NC(nc_def_dim(ncid, "time", 1, &dims[0]));
00094   NC(nc_def_dim(ncid, "lev", (size_t) nz, &dims[1]));
00095   NC(nc_def_dim(ncid, "lat", (size_t) ny, &dims[2]));
00096   NC(nc_def_dim(ncid, "lon", (size_t) nx, &dims[3]));
00097
00098   /* Create variables... */
00099   NC(nc_def_var(ncid, "time", NC_DOUBLE, 1, &dims[0], &timid));
00100   NC(nc_def_var(ncid, "lev", NC_DOUBLE, 1, &dims[1], &levid));
00101   NC(nc_def_var(ncid, "lat", NC_DOUBLE, 1, &dims[2], &latid));
00102   NC(nc_def_var(ncid, "lon", NC_DOUBLE, 1, &dims[3], &lonid));
00103   NC(nc_def_var(ncid, "T", NC_FLOAT, 4, &dims[0], &tid));
00104   NC(nc_def_var(ncid, "U", NC_FLOAT, 4, &dims[0], &uid));
00105   NC(nc_def_var(ncid, "V", NC_FLOAT, 4, &dims[0], &vid));
00106   NC(nc_def_var(ncid, "W", NC_FLOAT, 4, &dims[0], &wid));
00107
00108   /* Set attributes... */
00109   add_text_attribute(ncid, "time", "long_name", "time");
00110   add_text_attribute(ncid, "time", "units", "day as %Y%m%d.%f");
00111   add_text_attribute(ncid, "lon", "long_name", "longitude");
00112   add_text_attribute(ncid, "lon", "units", "degrees_east");
00113   add_text_attribute(ncid, "lat", "long_name", "latitude");
00114   add_text_attribute(ncid, "lat", "units", "degrees_north");
00115   add_text_attribute(ncid, "lev", "long_name", "air_pressure");
00116   add_text_attribute(ncid, "lev", "units", "Pa");
00117   add_text_attribute(ncid, "T", "long_name", "Temperature");
00118   add_text_attribute(ncid, "T", "units", "K");
00119   add_text_attribute(ncid, "U", "long_name", "U velocity");
00120   add_text_attribute(ncid, "U", "units", "m s**-1");
00121   add_text_attribute(ncid, "V", "long_name", "V velocity");
00122   add_text_attribute(ncid, "V", "units", "m s**-1");
```

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

Here is the call graph for this function:




## 5.34 wind.c

```
00001 /*
```

```
00002   This file is part of MPTRAC.
00003
00004   MPTRAC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   MPTRAC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
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00014   You should have received a copy of the GNU General Public License
00015   along with MPTRAC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copright (C) 2013-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "libtrac.h"
00026
00027 /* ------------------------------------------------------------
00028    Functions...
00029    ------------------------------------------------------------ */
00030
00031 void add_text_attribute(
00032   int ncid,
00033   char *varname,
00034   char *attrname,
00035   char *text);
00036
00037 /* ------------------------------------------------------------
00038    Main...
00039    ------------------------------------------------------------ */
00040
00041 int main(
00042   int argc,
00043   char *argv[]) {
00044
00045   ctl_t ctl;
00046
00047   static char filename[LEN];
00048
00049   static double r, t0, z0, z1, dataLon[EX], dataLat[EY], dataZ[EP],
00050     u0, u1, alpha;
00051
00052   static float dataT[EP * EY * EX], dataU[EP * EY * EX], dataV[EP * EY * EX],
00053     dataW[EP * EY * EX];
00054
00055   static int ncid, dims[4], timid, levid, latid, lonid, tid, uid, vid, wid,
00056     idx, ix, iy, iz, nx, ny, nz, year, mon, day, hour, min, sec;
00057
00058   /* Check arguments... */
00059   if (argc < 3)
00060     ERRMSG("Give parameters: <ctl> <metbase>");
00061
00062   /* Read control parameters... */
00063   read_ctl(argv[1], argc, argv, &ctl);
00064   t0 = scan_ctl(argv[1], argc, argv, "WIND_T0", -1, "0", NULL);
00065   nx = (int) scan_ctl(argv[1], argc, argv, "WIND_NX", -1, "360", NULL);
00066   ny = (int) scan_ctl(argv[1], argc, argv, "WIND_NY", -1, "181", NULL);
00067   nz = (int) scan_ctl(argv[1], argc, argv, "WIND_NZ", -1, "61", NULL);
00068   z0 = scan_ctl(argv[1], argc, argv, "WIND_Z0", -1, "0", NULL);
00069   z1 = scan_ctl(argv[1], argc, argv, "WIND_Z1", -1, "60", NULL);
00070   u0 = scan_ctl(argv[1], argc, argv, "WIND_U0", -1, "38.587660177302", NULL);
00071   u1 = scan_ctl(argv[1], argc, argv, "WIND_U1", -1, "38.587660177302", NULL);
00072   alpha = scan_ctl(argv[1], argc, argv, "WIND_ALPHA", -1, "0.0", NULL);
00073
00074   /* Check dimensions... */
00075   if (nx < 1 || nx > EX)
00076     ERRMSG("Set 1 <= NX <= MAX!");
00077   if (ny < 1 || ny > EY)
00078     ERRMSG("Set 1 <= NY <= MAX!");
00079   if (nz < 1 || nz > EP)
00080     ERRMSG("Set 1 <= NZ <= MAX!");
00081
00082   /* Get time... */
00083   jsec2time(t0, &year, &mon, &day, &hour, &min, &sec, &r);
00084   t0 = year * 10000. + mon * 100. + day + hour / 24.;
00085
00086   /* Set filename... */
00087   sprintf(filename, "%s_%d_%02d_%02d_%02d.nc", argv[2], year, mon, day, hour);
00088
00089   /* Create netCDF file... */
00090   NC(nc_create(filename, NC_CLOBBER, &ncid));
00091
00092   /* Create dimensions... */
00093   NC(nc_def_dim(ncid, "time", 1, &dims[0]));
```

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

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

# Index