

# User guide - Online-Trajectory Module (1.0)

---

*Supplementary material to Miltenberger et al. (2013), GMD*

Annette K. Miltenberger, Stephan Pfahl, Heini Wernli

IAC ETH Zurich September 2013

*contact: annette.miltenberger@env.ethz.ch*

The new COSMO Online-Trajectory Module consists of three different source files, namely `data_traj.f90`, `organize_traj.f90` and `src_traj.f90`, which contain the declaration and allocation of the required variables, the forward integration of the trajectories, the communication between different processors and the IO. Only very few modifications in the original COSMO-model source code are required, which basically are the calls to the new routines named above. In the following the technical details are described. The model source code is for scientific purposes available from the authors.

## 1.1 Namelist variables, default settings

The COSMO Online-Trajectory Module can be switched on and off by an additional switch in the namelist group `RUNCTRL` named `ltraj`, which is by default set to `false`.

### 1.1.1 Namelist variables

The relevant, user-defined parameters for the trajectory calculation can be specified in a separate, new namelists called `TRAJCTL` and `TRACEVAR`. Via these namelists the following parameters can be specified, which are except for `trace_var` in `TRAJCTL`:

- `numit` : number of iterations in the Pettersen scheme
- `dt_traj` : output interval of position and additional trace variables along the trajectory in seconds (any multiple of the main COSMO-model time step specified by `dt` in the name list group `RUNCTL`)
- `ntrace` : number of trace variables
- `trace_var` : names of the variables, which should be traced along the trajectory. The naming should be consistent with the table in the COSMO-model source code file `src_setup_vartab.f90`, which is also used for the COSMO-model output. This parameter is the only one in the namelist `TRACEVAR`.
- `end_t` : time, at which the trajectory calculation stops (minutes after model start). It only has to be specified, if the trajectory calculation should stop before the model integration.
- `outdir` : directory to which output should be written
- `ljump` : specifies if the terrain intersecting trajectories should be re-initialized (jump flag)
- `ltraj_init` : specification of the mode for selecting trajectory starting points in time:

- `ltraj_init = 1` : User-specified list of starting times given as array in `traj_inittime`. The array contains the starting time in minutes after model start. Trajectories are always started at the same locations.
- `ltraj_init = 2` : Trajectories are started repeatedly at a fixed temporal interval from the same location, i.e. at  $t_{\text{start}} = t_0 + n \cdot \Delta t$ .  $t_0$  and  $\Delta t$  can be specified by the first and second entry in `traj_inittime` in the namelist. The trajectories are repeatedly started till the model integration finishes or `end_t` is reached.
- `ltraj_init = 3` : Trajectories are started at user-specified times at user-specified locations. The times and locations are given in a start-file (s. section 1.2).
- `lstartf` : specification of the mode for selecting trajectory starting points in space:
  - `lstartf = .false.` : Trajectories are started at every gridpoint within a rectangular box specified by `start_reg`. The six entries in `start_reg` specify the minimum and maximum longitude, latitude and height. Longitude and latitude should be given in the rotated latitude-longitude coordinate system of the COSMO-model. The first and second entry are the minimum and maximum longitude, the third and fourth the minimum and maximum latitude and the fifth and sixth the minimum and maximum altitude.
  - `lstartf = .true.` : The trajectory starting points are given in a startfile. In this case the path, where the start file is stored has to be given in `startf_path` as well as the number of trajectories which should be started out of this file (starts at top) in `ntra_startf`. For more details on the startfile see section 1.2.

An example of the namelist TRAJCTL is given below:

```
cat > INPUT_TRAJ << end_input_traj
&TRAJCTL
  start_reg = -1.0, -0.9, -0.50, 0.5, 10, 3000,
  numit = 3,
  dt_traj = 10,
  ntrace = 6,
  ltraj_init = 1,
  traj_inittime = 120,
  end_t = 480,
  outdir = '~/traj',
  lstartf = .false.,
  startf_path = '~/startfile',
  ntra_startf = 2000,
  ljump = .true.,
/
&TRACEVAR
  trace_var = 'T', 'P', 'QR', 'QC', 'QV', 'RELHUM',
/
end_input_traj
```

In this example trajectories are started at all grid points between  $-1^\circ\text{E}$  and  $-0.9^\circ\text{E}$ ,  $-0.5^\circ\text{N}$  and  $0.5^\circ\text{N}$  and between  $z = 10\text{ m}$  and  $z = 3000\text{ m}$ . The trajectories are started once two hours after the model start and end eight hours after the model start. Along the trajectories 6 variables are traced, which are temperature, pressure, rain and cloud water content, water vapor content and relative humidity.

## 1.1.2 Default settings of namelist variables

The default settings of the variables in the namelist are:

```

!-----
!- Section 1: Initialize the default variables
!-----

! Set the default values of start_reg to the left domain boundary and
! heights between 10 and 1000 m elevation above the surface.
! (1, 3: lower left corner; 2, 4: upper right corner;
! 5, 6: elevation)
start_reg_d(1)      = startlon_tot+nboundlines*dlon
start_reg_d(2)      = startlon_tot + dlon*(ie_tot-nboundlines)
start_reg_d(3)      = startlat_tot+nboundlines*dlat
start_reg_d(4)      = startlat_tot + dlat*(je_tot-nboundlines)
start_reg_d(5)      = 10
start_reg_d(6)      = 1000

! Set default for starting time to start of model integration
ltraj_init_d        = 1
traj_inittime_d     = 0
end_t_d             = nstop*dt/60

! Set the default number of iterations
numit_d             = 3

! Set default for start region specification
lstartf_d           = .FALSE.

! Set default for output timestep (long model timestep)
dt_traj_d           = (hstop-hstart)*3600/(nstop-nstart)  ! seconds

! Set default trajectory pathes
out_dir             = '□'
ntra_startf_d       = 0
startf_path_d       = '□'

! Set default number of traced variables
ntrace_d = 0

! Set default for jump flag
ljump = .TRUE.
    
```

## 1.2 The startfile

The format of the startfile should look similar to the following example:

```
Reference Date 19870725_0000
time          lon          lat          z
-----
0.00         -8.625         8.250         10.000
1.00         -6.625        10.750        400.000
1.00        -12.500       -10.000       400.000
```

The longitude and latitude of the positions are in degrees in the rotated coordinate system, the height is in meters above ground. The first column specifying at which time a trajectory should be started at a certain location has to be only contained in the startfile if `ltra_init = 3`. If nevertheless present and another option of `ltra_init` is used, it is disregarded. It gives the time in hours since the start of the model integration.

## 1.3 Output

Output is written at a time spacing of `dt_traj` to one or several netcdf-files in the directory specified in `outdir`. The output is splitted automatically to let files not become much larger than about 2GB. All timesteps of a certain trajectory are contained in one file. In case that trajectories are started at several times, for each set of trajectories a new output file is generated, which is named after the starting time in minutes (e.g. `traj120` if `traj_inittime = 120`). The different files containing data of a certain starting time are named `traj120p1`, `traj120p2` etc., where the first file contains the first `n` trajectories in the list of starting points.

Each output file has a header (`global attributes`), which contains the start date of the COSMO-model simulation (`ref_year`, `ref_month` etc.), the length of the trajectories contained in the file in seconds (`duration`), the output time step in seconds (`timestep`) and the location of the pole of the rotated coordinate system (`pollon` and `poll at`). The output file also contains a variable `time` indicating the time after model start in seconds, at which output was written. The start longitude, latitude and elevation are written with the time flag -1. Further the output files contain three variables named `longitude`, `latitude` and `z`, which contain the position information of the trajectories at each timestep. The first dimension of the respective variable contains the data of one timestep and the second dimension corresponds to the different trajectories. Additional variables contain the data for the trace variables specified in the namelist. The naming of this variables is consistent with the standard naming in the COSMO-model (specified in `src_setup_vartab.f90`).

An example header of the output file:

```
netcdf traj {
dimensions:
    id = 2000 ;
    time = 2161 ;
variables:
    float time(time) ;
    float longitude(time, id) ;
    float latitude(time, id) ;
    float z(time, id) ;
```

```
float T(time, id) ;
float P(time, id) ;
float QR(time, id) ;
float QC(time, id) ;
float QV(time, id) ;
float RELHUM(time, id) ;
// global attributes:
: ref_year = 1987 ;
: ref_month = 7 ;
: ref_day = 25 ;
: ref_hour = 0 ;
: ref_min = 0 ;
: duration = 21600 ;
: pollon = -171.5 ;
: pollat = 47.5 ;
: timestep = 10 ;
data:
  time = -1,7200, 7220, 7240, 7260, 7280, ...
  ...
}
```