

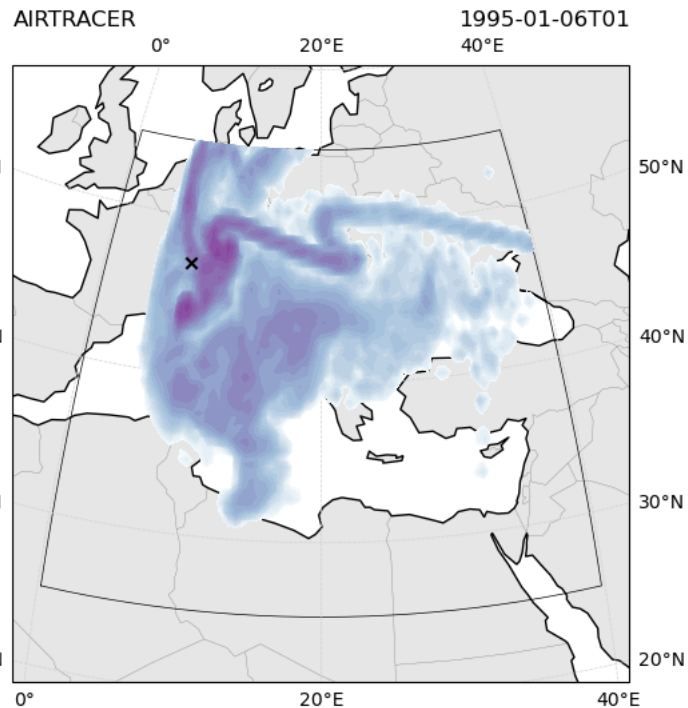
Exercise 1: Airtracer

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The goal of this exercise is to understand how Flexpart works and how to interpret the output it produces.

Flexpart output

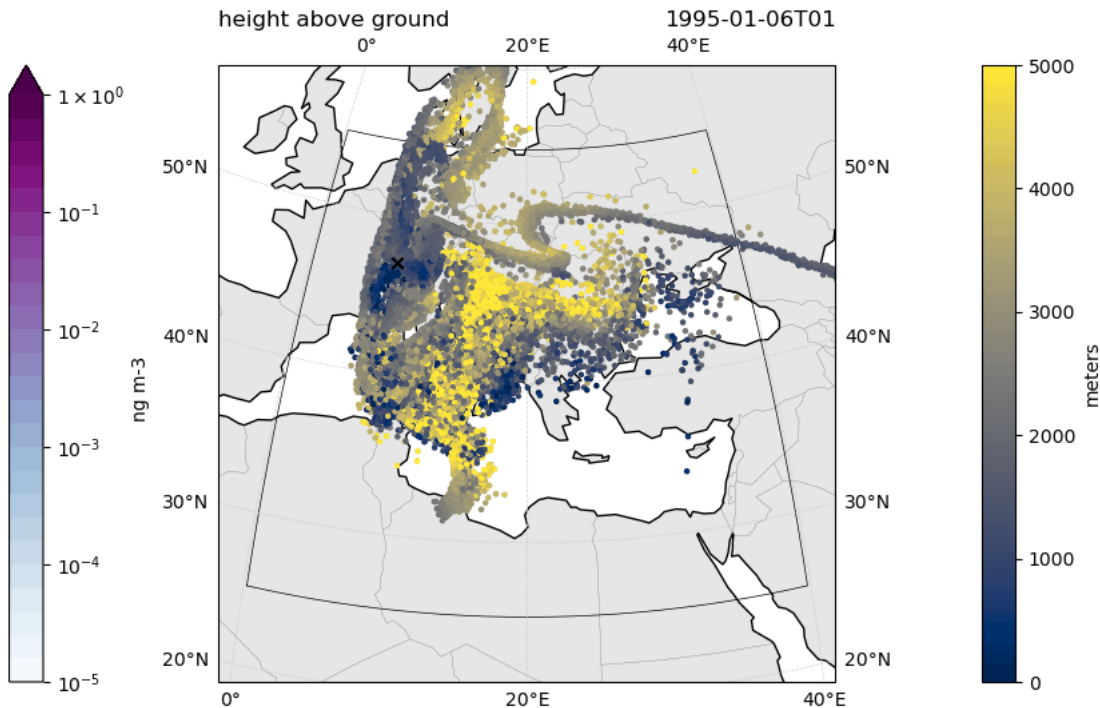
Gridded output (IOUT)



Dimensions:

nageclass, pointspec, time, latitude, longitude

Particle output (IPOUT)



Dimensions:

particle, time

Flexpart setup

Flexpart needs to know:

- 1. How it should run (options)
- 2. Where it should save the output
- 3. Where it finds the input data
- 4. Which input files are available
and how they are called

This information has to be provided in a file called pathnames:

```
./options/  
/jetfs/scratch/mduetsch/flexpart_output/  
/jetfs/shared-data/ECMWF/ERA5_glob_0.5deg_1h/  
./AVAILABLE
```

Example AVAILABLE file

XXXXXX EMPTY LINES XXXXXXXXX			
XXXXXX EMPTY LINES XXXXXXXXX			
YYYYMMDD	HMMSS	name of the file(up to 80 characters)	
19950101	000000	1995/01/EA1995010100	ON DISK
19950101	010000	1995/01/EA1995010101	ON DISK
19950101	020000	1995/01/EA1995010102	ON DISK
19950101	030000	1995/01/EA1995010103	ON DISK
19950101	040000	1995/01/EA1995010104	ON DISK
19950101	050000	1995/01/EA1995010105	ON DISK
19950101	060000	1995/01/EA1995010106	ON DISK
19950101	070000	1995/01/EA1995010107	ON DISK
19950101	080000	1995/01/EA1995010108	ON DISK
19950101	090000	1995/01/EA1995010109	ON DISK
19950101	100000	1995/01/EA1995010110	ON DISK
19950101	110000	1995/01/EA1995010111	ON DISK
19950101	120000	1995/01/EA1995010112	ON DISK
19950101	130000	1995/01/EA1995010113	ON DISK
19950101	140000	1995/01/EA1995010114	ON DISK
19950101	150000	1995/01/EA1995010115	ON DISK
19950101	160000	1995/01/EA1995010116	ON DISK
19950101	170000	1995/01/EA1995010117	ON DISK
19950101	180000	1995/01/EA1995010118	ON DISK
19950101	190000	1995/01/EA1995010119	ON DISK
19950101	200000	1995/01/EA1995010120	ON DISK

Flexpart options

The configuration of the Flexpart simulation is defined in the options directory.

- COMMAND: Length of simulation, output type, parameterizations
 - RELEASES: Time and location of the releases
 - OUTGRID: Domain of the gridded output
 - PARTOPTIONS: Variables to be saved in particle output
 - AGECLASSES: Maximum age(s) of particles
 - RECEPTORS: Locations of receptors
- 

COMMAND file

```
&COMMAND
LDIRECT=          1, ! Simulation direction in time      ; 1 (forward) or -1 (backward)
IBDATE=          19950101, ! Start date of the simulation ; YYYYMMDD: YYYY=year, MM=month, DD=day
IBTIME=           000000, ! Start time of the simulation ; HHMISS: HH=hours, MI=min, SS=sec; UTC
IEDATE=          19950107, ! End date of the simulation   ; same format as IBDATE
IETIME=           000000, ! End time of the simulation   ; same format as IBTIME
LOUTSTEP=         3600, ! Interval of model output; average concentrations calculated every LOUTSTEP (s)
LOUTAVER=         3600, ! Interval of output averaging (s)
LOUTSAMPLE=       600, ! Interval of output sampling (s), higher stat. accuracy with shorter intervals
LOUTRESTART=     864000, ! Interval of writing restart files (s)
LSYNCTIME=        600, ! All processes are synchronized to this time interval (s)
CTL=             -5.0000000, ! CTL>1, ABL time step = (Lagrangian timescale (TL))/CTL, uses LSYNCTIME if CTL<0
IFINE=           10, ! Reduction for time step in vertical transport, used only if CTL>1
IOUT=             9, ! Output type: [1]mass 2]pptv 3]1&2 4]plume 5]1&4, +8 for NetCDF output
IPOUT=            1, ! Particle position output: 0]no 1]every output 2]only at end 3]time averaged
LSUBGRID=         0, ! Increase of ABL heights due to sub-grid scale orographic variations;[0]off 1]on
LCONVECTION=      1, ! Switch for convection parameterization;0]off [1]on
LTURBULENCE=      1, ! Switch for turbulence parameterisation;0]off [1]on
LAGESPECTRA=      0, ! Switch for calculation of age spectra (needs AGECLASSES);[0]off 1]on
IPIN=             0, ! Warm start from particle dump (needs previous partposit_end file); [0]no 1]yes
IOUTPUTFOREACHRELEASE= 1, ! Separate output fields for each location in the RELEASE file; [0]no 1]yes
MDOMAINFILL=      0, ! Switch for domain-filling, if limited-area particles generated at boundary
IND_SOURCE=       1, ! Unit to be used at the source; [1]mass 2]mass mixing ratio
IND_RECEPTOR=   1, ! Unit to be used at the receptor; [1]mass 2]mass mixing ratio 3]wet depo. 4]dry depo.
NESTED_OUTPUT=    0, ! Output also for a nested domain
LINIT_COND=       0, ! Output sensitivity to initial conditions (bkw mode only) [0]off 1]conc 2]mmr
NXSHIFT=          0, ! Shift of the global meteorological data. Default 359 for ECMWF and 0 for GFS if not give
LNETCDFOUT=       1, ! Gridded netcdf output: [0]no [1]yes
/
```

RELEASES file

```
&RELEASES_CTRL
  NSPEC      =      1, ! Total number of species
  SPECNUM_REL=      24, ! Species numbers in directory SPECIES
/
&RELEASE      ! For each release
  IDATE1 =      19950101, ! Release start date, YYYYMMDD: YYYY=year, MM=month, DD=day
  ITIME1 =      000000, ! Release start time in UTC HHMISS: HH hours, MI=minutes, SS=seconds
  IDATE2 =      19950101, ! Release end date, same as IDATE1
  ITIME2 =      000000, ! Release end time, same as ITIME1
  LON1    =      8.000, ! Left longitude of release box -180 < LON1 < 180
  LON2    =      8.000, ! Right longitude of release box, same as LON1
  LAT1    =      47.000, ! Lower latitude of release box, -90 < LAT1 < 90
  LAT2    =      47.000, ! Upper latitude of release box same format as LAT1
  Z1      =      0.000, ! Lower height of release box meters/hPa above reference level
  Z2      =     1000.000, ! Upper height of release box meters/hPa above reference level
  ZKIND   =      1, ! Reference level 1=above ground, 2=above sea level, 3 for pressure in hPa
  MASS    =     1000, ! Total mass emitted, only relevant for fwd simulations
  PARTS   =     100000, ! Total number of particles to be released
  COMMENT = "RELEASE 1", ! Comment, written in the outputfile
/
```

has to point to an existing SPECIES file

```
$ ls options/SPECIES/
Radionuclides SPECIES_BC SPECIES_DUST-FINE SPECIES_HN03 SPECIES_N03-aero SPECIES_S04-aero
SPECIES_README SPECIES_C2H6 SPECIES_G-HCH SPECIES_N20 SPECIES_O3 specoverview.f90
SPECIES_024 SPECIES_CH4 SPECIES_H202 SPECIES_NH3 SPECIES_PAN
SPECIES_AEROSOL SPECIES_CO SPECIES_HCHO SPECIES_NO SPECIES_PCB28
SPECIES_AIRTRACER SPECIES_DUST-COARSE SPECIES_HN02 SPECIES_N02 SPECIES_S02
```

OUTGRID file (only for IOUT>0)

```
!*****
!  
!      Input file for the Lagrangian particle dispersion model FLEXPART      *  
!      Please specify your output grid                                     *  
!                                                                           *  
! OUTLON0   = GEOGRAPHICAL LONGITUDE OF LOWER LEFT CORNER OF OUTPUT GRID *  
! OUTLAT0   = GEOGRAPHICAL LATITUDE OF LOWER LEFT CORNER OF OUTPUT GRID *  
! NUMXGRID  = NUMBER OF GRID POINTS IN X DIRECTION (= No. of cells + 1) *  
! NUMYGRID  = NUMBER OF GRID POINTS IN Y DIRECTION (= No. of cells + 1) *  
! DXOUT     = GRID DISTANCE IN X DIRECTION                               *  
! DYOUN     = GRID DISTANCE IN Y DIRECTION                               *  
! OUTHEIGHTS = HEIGHT OF LEVELS (UPPER BOUNDARY)                         *  
!*****
```

```
&OUTGRID  
  OUTLON0=    0.00,  
  OUTLAT0=   25.00,  
  NUMXGRID=    80,  
  NUMYGRID=    60,  
  DXOUT=     0.50,  
  DYOUT=     0.50,  
  OUTHEIGHTS= 100.0, 500.0, 1000.0, 50000.0,  
  /
```

AGECLASSES file (only for LAGESPECTRA=1)

```
&NAGE  
  NAGECLASS=1,  
  /
```

```
&AGECLASS  
  LAGE=432000,  
  /
```

PARTOPTIONS file (only for IPOUT>0)

```
&PARTOPTIONS  
  LONGITUDE=                .true., !  
  LONGITUDE_AVERAGE=       .false., !  
  LATITUDE=                 .true., !  
  LATITUDE_AVERAGE=        .false., !  
  HEIGHT=                   .true., !  
  HEIGHT_AVERAGE=          .false., !  
  PV=                       .false., !  
  PV_AVERAGE=              .false., !  
  QV=                       .true., !  
  QV_AVERAGE=              .false., !  
  ...
```

<VAR>:

instantaneous values

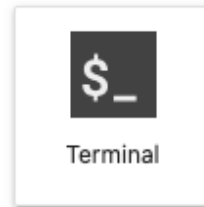
<VAR>_AVERAGE:

values averaged over LOUTSTEP

Exercise 1

In this exercise, we are going to study where the air over a region of your choice comes from. For this purpose, we are going to run a *backward* simulation with FLEXPART.

- Go to https://mybinder.org/v2/gh/duetschm/flexpart11_training/HEAD
- Open a terminal via the launcher.



Binder throws you out after 10 minutes of inactivity. Make sure to keep doing something to avoid this, or download files regularly to save them.

Step 1: Compile Flexpart

- Change to the flexpart directory. This directory contains the source code.
- Compile Flexpart by typing make. You should then see an executable called FLEXPART_ETA.

```
$ make
Using GNU Fortran compiler: gfortran-14
-----
Detected Fortran compiler: gfortran-14 (default: FC=gfortran)
Using architecture flags: native (default: arch=native)
Using debugging flags: false (default: debug=no)
NetCDF output enabled: true (default: ncf=yes)
Eta coordinates enabled: true (default: eta=yes)
Serial (OpenMP): false (default: serial=no)
Shared libraries: false (default: shared=no)
FFLAGS: -O2 -m64 -cpp -mcmodel=large -fconvert=little-endian -frecord-marker=4 -DUSE_NCF -DETA
-march=native -mtune=native -fopenmp
LDFLAGS: -leccodes -leccodes_f90 -lm -lnetcdff -Wl,-rpath=/srv/conda/envs/notebook/lib
To see include and library paths, run make with the V=1 flag
-----
Building: FLEXPART_ETA
```

Step 2: Setup the simulation

- Change to the directory `airtracer/run/`. It already contains the pathnames and `AVAILABLE` file, but you have to modify the options.
- You can open text files with `vim` or by clicking on them in the filebrowser on the left.

In the [COMMAND](#) file:

- Set the direction of the simulation to backward.
- Select a simulation length of 5 days. The start and end times should be between 2017-09-25 and 2017-10-03.
- Set the output time step to 1 hour.
- Enable both gridded output (`IOUT=9`) and particle output (`IPOUT=1`).

Step 2: Setup the simulation

In the [RELEASES](#) file:

- Define two instantaneous releases toward the end date of the simulation (e.g. one day before the end and at the end).
- Set the species to "air tracer". You need a SPECIES file in the SPECIES subdirectory that has the same number as SPECNUM_REL (e.g. SPECIES_024).
- Choose a reasonable number of particles to release. More particles give a more representative picture but increase the simulation time and memory use. 10000 is a good number for our purpose.
- Choose a release point or box in a region and height you are interested in. It should be within 0°E-90°E and 0°N-90°N, because this is the domain of the input data.
- The release mass is irrelevant for backward simulations.

Step 2: Setup the simulation

In the [OUTGRID](#) file:

- Select two output heights (e.g. 100 m and 10000 m above ground).
- Define the output grid centered on the release point/box. It should cover at least the area where you expect the air to come from, but should not be too big to save memory and plotting time.

In the [PARTOPTIONS](#) file:

- Set variables to true that you would like to have in the particle output (e.g. HEIGHT, TEMPERATURE). We will need at least LONGITUDE and LATITUDE.

In the [AGECLASSES](#) file:

- Define two ageclasses of 2 days (= 172800 seconds) and 4 days (= 345600 seconds).

Step 3: Run the simulation

- In the run directory (where the pathnames file is located) create a link to the Flexpart executable:

```
ln -s ../../flexpart/FLEXPART_ETA .
```

- Run Flexpart by typing: `./FLEXPART_ETA`
- It will take a few minutes to finish. You can track the current simulation time in the runtime log.
- When Flexpart is done, you should see the message:
CONGRATULATIONS: YOU HAVE SUCCESSFULLY COMPLETED A FLEXPART
MODEL RUN!

Step 4: Analyze the output

- Open the file `exercise1.ipynb`. It will guide you through the different steps.
- The first part uses the gridded output. The data are contained in the variable `"spec001_mr"`. Can you find out what the different dimensions mean?
- The second part uses the particle output. There is an entry for each variable set to `.true.` in the `PARTOPTIONS` file.
- What are the main differences between the gridded and the particle output?
- What do you think are the advantages and disadvantages of one vs. the other?