Technical note: The Lagrangian particle dispersion model FLEXPART version 6.2 – electronic supplement

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Appendix A FLEXPART sample input files

A1 The pathnames file

A file `pathnames` must exist in the directory where FLEXPART is started. It states the pathnames (absolute or relative) of input and output files:

```
/home/as/FLEXPART50/options/
/volc/as/contrace/modelresults/forward/
/volc/windcontrace/
/volc/windcontrace/AVAILABLE
/volc/nested/
/volc/nested/AVAILABLE
=============================================

Line 1: path where control files "COMMAND" and "RELEASES" are available
Line 2: name of directory where output files are generated
Line 3: path where meteorological fields are available (mother grid)
Line 4: full filename of "AVAILABLE"-file (mother grid)

Subsequent lines:
Line 2n+3: path where meteorological fields are available (nested grid n)
Line 2n+4: full filename of "AVAILABLE"-file (nested grid n)

Line below last pathname must be:
=============================================

The grids must be arranged such as that the coarse-scale nests
come before the fine-scale nests. Multiple nests of the same
nesting level are allowed. In that case, the order is arbitrary.
```

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A2 Files in directory windfields

The directory where the meteorological input data are stored, here called `windfields` (`/volc/windcontrace/` in the above example `pathnames` file), contains grib-code files containing the ECMWF data. All meteorological fields must have the same structure, i.e. the same computational domain and the same resolution. An example listing of this directory is given below.

```
AVAILABLE       EN01102806      EN01102815
EN01102800      EN01102809      EN01102818
EN01102803      EN01102812      EN01102821
```

The file names of the grib-code files and their validation dates and times (in UTC) must be listed in the file `AVAILABLE`. While it is practical to have this file reside in the same directory as the wind fields, this is no necessity and it can also be located elsewhere, as its file name is also given in the `pathnames` file.

```
DATE     TIME         FILENAME     SPECIFICATIONS
YYYYMMDD HHMISS
________ ______      ___________     ___________
20011028 000000      EN01102800      ON DISC
20011028 030000      EN01102803      ON DISC
20011028 060000      EN01102806      ON DISC
20011028 090000      EN01102809      ON DISC
20011028 120000      EN01102812      ON DISC
20011028 150000      EN01102815      ON DISC
20011028 180000      EN01102818      ON DISC
20011028 210000      EN01102821      ON DISC
```

Nested wind fields must be stored in one or more different directory/ies, as specified in the `pathnames` file.

A3 Files in directory options

The files in directory `options` are used to specify the model run. An example listing of `options` is given below.

```
AGECLASSES                  EMISSION_VARIATION_023.dat  landuse.asc   RELEASES.alternative
COMMAND                     EMISSION_VARIATION_025.dat  OUTGRID       RELEASES.reference
COMMAND.alternative         EMISSION_VARIATION_026.dat  OUTGRID_NEST  SPECIES
COMMAND.reference           EMISSION_VARIATION_027.dat  RECEPTORS     surfdata.t
EMISSION_VARIATION_008.dat  EMISSION_VARIATION_028.dat  RELEASES      surfdepo.t
```

A3.1 File COMMAND

The most important file is the `COMMAND` file which specifies (1) the simulation direction (either forward or backward), (2) the start and (3) the end time of the simulation, (4) the frequency T_c of the model output, (5) the averaging time ΔT_c of model output, and (6) the intervals ΔT_s at which concentrations are sampled, (7) the time constant for particle splitting Δt_s, (8) the synchronisation interval of FLEXPART, (9) the factor c_{tl} by which the time steps must be smaller than the Lagrangian time scale, and (10) the refinement factor for the time step used for solving the Langevin equation of the vertical component of the turbulent wind. If (9) (c_{tl}) is negative, the Langevin equations are solved with constant time steps according to the synchronisation interval. In that case, the value of (10) is arbitrary. The synchronisation interval is the minimum time interval used by the model for all activities (such as concentration calculations, wet deposition calculations, interpolation of data, mesoscale wind fluctuations or output of data) other than the simulation of turbulent transport and dry deposition (if ($c_{tl} > 0$). Further switches determine (11) whether concentrations, mixing ratios, residence times or plume trajectories (or combinations thereof) are to be calculated, (12) the option of particle position dump either at the end of or continuously during the simulation, (13) on/off of subgrid terrain effect parameterization, (14) on/off of deep convection parameterization, (15) on/off calculation of age spectra, (16) continuation of simulation from previous particle dump, (17) on/off for mass flux calculations and output, (18) on/off for the domain-filling option of FLEXPART, (19) an indicator that determines whether mass or mass mixing ratio units are to be used at the source, (20) an indicator that determines whether mass or mass mixing ratio units are to be used at the receptor, (21) on/off of additional compact dump of the positions of numbered particles, (22) on/off for the use of nested output fields.

Two versions of COMMAND may be used, which both can be read in by FLEXPART: the first contains formatted input (i.e., a mask to be filled for the various input options that must be filled in), the second contains largely unformatted input and is recommended for the more experienced FLEXPART user. The following example is for formatted input.

```
*******************************************************************************
*                                                                             *
*      Input file for the Lagrangian particle dispersion model FLEXPART       *
*                           Please select your options                        *
*                                                                             *
*******************************************************************************

1. __                3X, I2
    1
   LDIRECT           1 FOR FORWARD SIMULATION, -1 FOR BACKWARD SIMULATION

2. ________ ______   3X, I8, 1X, I6
   20040626 000000
   YYYYMMDD HHMISS   BEGINNING DATE OF SIMULATION

3. ________ ______   3X, I8, 1X, I6
   20040816 120000
   YYYYMMDD HHMISS   ENDING DATE OF SIMULATION

4. _____             3X, I5
    7200
   SSSSS             OUTPUT EVERY SSSSS SECONDS

5. _____             3X, I5
    7200
   SSSSS             TIME AVERAGE OF OUTPUT (IN SSSSS SECONDS)

6. _____             3X, I5
     900
   SSSSS             SAMPLING RATE OF OUTPUT (IN SSSSS SECONDS)

7. _________         3X, I9
   999999999
   SSSSSSSSS         TIME CONSTANT FOR PARTICLE SPLITTING (IN SECONDS)

8. _____             3X, I5
     900
   SSSSS             SYNCHRONISATION INTERVAL OF FLEXPART (IN SECONDS)

9.  ---.--           4X, F6.4
     -5.0
```

```
    CTL             FACTOR, BY WHICH TIME STEP MUST BE SMALLER THAN TL

10. ---             4X, I3
      4
    IFINE           DECREASE OF TIME STEP FOR VERTICAL MOTION BY FACTOR IFINE

11. -               4X, I1
    3
    IOUT            1 CONCENTRATION (RESIDENCE TIME FOR BACKWARD RUNS) OUTPUT, 2 MIXING RATIO OUTPUT, 3 BOTH,4 P

12. -               4X, I1
    2
    IPOUT           PARTICLE DUMP: 0 NO, 1 EVERY OUTPUT INTERVAL, 2 ONLY AT END

13. _               4X, I1
    1
    LSUBGRID        SUBGRID TERRAIN EFFECT PARAMETERIZATION: 1 YES, 0 NO

14. _               4X, I1
    1
    LCONVECTION     CONVECTION: 1 YES, 0 NO

15. _               4X, I1
    0
    LAGESPECTRA     AGE SPECTRA: 1 YES, 0 NO

16. _               4X, I1
    0
    IPIN            CONTINUE SIMULATION WITH DUMPED PARTICLE DATA: 1 YES, 0 NO

17. _               4X, I1
    0
    IFLUX           CALCULATE FLUXES: 1 YES, 0 NO

18. _               4X, I1
    2
    MDOMAINFILL     DOMAIN-FILLING TRAJECTORY OPTION: 1 YES, 0 NO, 2 STRAT. O3 TRACER

19. _               4X, I1
    1
    IND_SOURCE      1=MASS UNIT , 2=MASS MIXING RATIO UNIT

20. _               4X, I1
    1
    IND_RECEPTOR    1=MASS UNIT , 2=MASS MIXING RATIO UNIT

21. _               4X, I1
```

```
    0
    MQUASILAG        QUASILAGRANGIAN MODE TO TRACK INDIVIDUAL PARTICLES: 1 YES, 0 NO

22. _                4X, I1
    0
    NESTED_OUTPUT    SHALL NESTED OUTPUT BE USED? 1 YES, 0 NO
```

1. Simulation direction, 1 for forward, -1 for backward in time

2. Beginning date and time of simulation. Must be given in format
   YYYYMMDD HHMISS, where YYYY is YEAR, MM is MONTH, DD is DAY, HH is HOUR,
   MI is MINUTE and SS is SECOND. Current version utilizes UTC.

3. Ending date and time of simulation. Same format as 3.

4. Average concentrations are calculated every SSSSS seconds.

5. The average concentrations are time averages of SSSSS seconds
   duration. If SSSSS is 0, instantaneous concentrations are outputted.

6. The concentrations are sampled every SSSSS seconds to calculate the time
   average concentration. This period must be shorter than the averaging time.

7. Time constant for particle splitting. Particles are split into two
   after SSSSS seconds, 2xSSSSS seconds, 4xSSSSS seconds, and so on.

8. All processes are synchronized with this time interval (lsynctime).
   Therefore, all other time constants must be multiples of this value.
   Output interval and time average of output must be at least twice lsynctime.

9. CTL must be >1 for time steps shorter than the Lagrangian time scale
   If CTL<0, a purely random walk simulation is done

10. IFINE=Reduction factor for time step used for vertical wind

11. IOUT determines how the output shall be made: concentration
    (ng/m3, Bq/m3), mixing ratio (pptv), or both, or plume trajectory mode,
    or concentration + plume trajectory mode.
    In plume trajectory mode, output is in the form of average trajectories.

12. IPOUT determines whether particle positions are outputted (in addition
    to the gridded concentrations or mixing ratios) or not.
    0=no output, 1 output every output interval, 2 only at end of the
    simulation

13. Switch on/off subgridscale terrain parameterization (increase of mixing heights due to subgridscale orographic variations)

14. Switch on/off the convection parameterization

15. Switch on/off the calculation of age spectra: if yes, the file AGECLASSES must be available

16. If IPIN=1, a file "partposit_end" from a previous run must be available in the output directory. Particle positions are read in and previous simulation is continued. If IPIN=0, no particles from a previous run are used

17. If IFLUX is set to 1, fluxes of each species through each of the output boxes are calculated. Six fluxes, corresponding to northward, southward, eastward, westward, upward and downward are calculated for each grid cell of the output grid. The control surfaces are placed in the middle of each output grid cell. If IFLUX is set to 0, no fluxes are determined.

18. If MDOMAINFILL is set to 1, the first box specified in file RELEASES is used as the domain where domain-filling trajectory calculations are to be done. Particles are initialized uniformly distributed (according to the air mass distribution) in that domain at the beginning of the simulation, and are created at the boundaries throughout the simulation period.

19. IND_SOURCE switches between different units for concentrations at the source
    NOTE that in backward simulations the release of computational particles takes place at the "receptor" and the sampling of particles at the "source".
    1=mass units (for bwd-runs = concentration)
    2=mass mixing ratio units
20. IND_RECEPTOR switches between different units for concentrations at the receptor
    1=mass units (concentrations)
    2=mass mixing ratio units

21. MQUASILAG indicates whether particles shall be numbered consecutively (1) or with their release location number (0). The first option allows tracking of individual particles using the partposit output files

22. NESTED_OUTPUT decides whether model output shall be made also for a nested output field (normally with higher resolution)

A3.2 File OUTGRID

The file `OUTGRID` specifies the output grid. The maximum allowed number of output levels is set by parameter `maxzgrid` in file `includepar`. The maximum dimensions in x and y by parameters `maxxgrid` and `maxygrid`.

```
*******************************************************************************
*                                                                             *
*      Input file for the Lagrangian particle dispersion model FLEXPART       *
*                        Please specify your output grid                      *
*                                                                             *
*******************************************************************************

1.  ------.----       4X,F11.4
       -10.0000       GEOGRAFICAL LONGITUDE OF LOWER LEFT CORNER OF OUTPUT GRID
    OUTLONLEFT        (left boundary of the first grid cell - not its centre)


2.  ------.----       4X,F11.4
        40.0000       GEOGRAFICAL LATITUDE OF LOWER LEFT CORNER OF OUTPUT GRID
    OUTLATLOWER       (lower boundary of the first grid cell - not its centre)

3.  -----             4X,I5
      101             NUMBER OF GRID POINTS IN X DIRECTION (= No. of cells + 1)
    NUMXGRID

4.  -----             4X,I5
       47             NUMBER OF GRID POINTS IN Y DIRECTION (= No. of cells + 1)
    NUMYGRID

5.  ------.---        4X,F10.3
         0.500        GRID DISTANCE IN X DIRECTION
    DXOUTLON

6.  ------.---        4X,F10.3
         0.500        GRID DISTANCE IN Y DIRECTION
    DYOUTLAT

7.  -----.-           4X, F7.1
      100.0
    LEVEL 1           HEIGHT OF LEVEL (UPPER BOUNDARY)

8.  -----.-           4X, F7.1
      300.0
    LEVEL 2           HEIGHT OF LEVEL (UPPER BOUNDARY)

9.  -----.-           4X, F7.1
      600.0
```

```
    LEVEL 3           HEIGHT OF LEVEL (UPPER BOUNDARY)

10. -----.-           4X, F7.1
     1000.0
    LEVEL 4           HEIGHT OF LEVEL (UPPER BOUNDARY)

11. -----.-           4X, F7.1
     2000.0
    LEVEL 5           HEIGHT OF LEVEL (UPPER BOUNDARY)

12. -----.-           4X, F7.1
     3000.0
    LEVEL 6           HEIGHT OF LEVEL (UPPER BOUNDARY)
```

In order to define the grid for a nested output field, the file OUTGRID_NEST must exist. It has the same format as file OUTGRID, but does not contain the vertical level information:

```
*******************************************************************************
*                                                                             *
*      Input file for the Lagrangian particle dispersion model FLEXPART       *
*                       Please specify your output grid                       *
*                                                                             *
*******************************************************************************

1.  ------.----       4X,F11.4
      -125.0000       GEOGRAFICAL LONGITUDE OF LOWER LEFT CORNER OF OUTPUT GRID
    OUTLONLEFT        (left boundary of the first grid cell - not its centre)

2.  ------.----       4X,F11.4
        25.0000       GEOGRAFICAL LATITUDE OF LOWER LEFT CORNER OF OUTPUT GRID
    OUTLATLOWER       (lower boundary of the first grid cell - not its centre)

3.  -----             4X,I5
        1             NUMBER OF GRID POINTS IN X DIRECTION (= No. of cells + 1)
    NUMXGRID

4.  -----             4X,I5
        1             NUMBER OF GRID POINTS IN Y DIRECTION (= No. of cells + 1)
    NUMYGRID

5.  ------.-----      4X,F12.5
         0.33333      GRID DISTANCE IN X DIRECTION
    DXOUTLON

6.  ------.-----      4X,F12.5
         0.25000      GRID DISTANCE IN Y DIRECTION
    DYOUTLAT
```

A3.3 File RECEPTORS

`RECEPTORS` specifies the receptor locations for which the parabolic kernel method shall be applied to calculate air concentrations. The maximum number of receptor sites is set by parameter `maxreceptor` in file `includepar`.

```
*******************************************************************************
*                                                                             *
*      Input file for the Lagrangian particle dispersion model FLEXPART       *
*                       Please specify your receptor points                   *
*     For the receptor points, ground level concentrations are calculated     *
*                                                                             *
*******************************************************************************
1.  ----------------  4X,A16
    F15               NAME OF RECEPTOR POINT
    RECEPTORNAME

2.  ------.----       4X,F11.4
         6.1333       GEOGRAFICAL LONGITUDE
    XRECEPTOR

3.  ------.----       4X,F11.4
        49.0833       GEOGRAFICAL LATITUDE
    YRECEPTOR
===============================================================================
1.  ----------------  4X,A16
    NL01              NAME OF RECEPTOR POINT
    RECEPTORNAME

2.  ------.----       4X,F11.4
         5.7833       GEOGRAFICAL LONGITUDE
    XRECEPTOR

3.  ------.----       4X,F11.4
        50.9167       GEOGRAFICAL LATITUDE
    YRECEPTOR
===============================================================================
```

A3.4 File RELEASES

`RELEASES` defines the release specifications. In the first input line, the number N of emitted species is defined (1 in the example below). At all locations, the same species must be released. The next N input lines give a cross-reference to file `SPECIES`, where the physical and chemical properties of the released species are given (also the temporal variations of emissions is defined for each species). Then follows a list of release sites (maximum specified by parameter `maxpoint` in file `includepar`), for each of which the release characteristics must be entered: the beginning and the ending time of the release, geographical coordinates of the lower left and upper right corners of the release location, type of vertical coordinate (above ground level, or above sea level), lower level and upper level of source box, the number of particles to be used, and the total mass emitted. Note that the mass entry must be repeated N times, one mass per species released. Finally, a name is assigned to each release point.

The particles are released from random locations within a four-dimensional box extending from the lower to the upper level above a rectangle (on a lat/lon grid) defined by the geographical coordinates, and between the release's start and end. With some identical coordinates, line or point sources can be specified, too.

As for `COMMAND`, the `RELEASES` file can be provided formatted or unformatted. The example below shows the formatted version.

```
*****************************************************************************
*                                                                           *
*                                                                           *
*                                                                           *
*   Input file for the Lagrangian particle dispersion model FLEXPART        *
*                        Please select your options                         *
*                                                                           *
*                                                                           *
*                                                                           *
*****************************************************************************
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
  1
___                         i3    Total number of species emitted

 24
___                         i3    Index of species in file SPECIES

=============================================================================
20011028  150007
```

```
________ ______            i8,1x,i6 Beginning date and time of release

20011028  150046
________ ______            i8,1x,i6 Ending date and time of release

   9.4048
____.____                  f9.4  Longitude [DEG] of lower left corner

  48.5060
____.____                  f9.4  Latitude [DEG] of lower left corner

   9.5067
____.____                  f9.4  Longitude [DEG] of upper right corner

  48.5158
____.____                  f9.4  Latitude [DEG] of upper right corner

        2
_________                  i9    1 for m above ground, 2 for m above sea level, 3 for pressure in hPa

 6933.60
_____.___                  f10.3 Lower z-level (in m agl or m asl)

 6950.40
_____.___                  f10.3 Upper z-level (in m agl or m asl)

    20000
_________                  i9    Total number of particles to be released

1.0000E00
_.____E__                  e9.4  Total mass emitted

FLIGHT_11242
_________________________________   character*40 comment
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
20011028  150047
________ ______            i8,1x,i6 Beginning date and time of release

20011028  150107
________ ______            i8,1x,i6 Ending date and time of release

   9.3038
____.____                  f9.4  Longitude [DEG] of lower left corner

  48.5158
____.____                  f9.4  Latitude [DEG] of lower left corner
```

```
   9.4048
____.____                 f9.4  Longitude [DEG] of upper right corner

  48.5906
____.____                 f9.4  Latitude [DEG] of upper right corner

        2
_________                 i9    1 for m above ground, 2 for m above sea level, 3 for pressure in hPa

 6833.50
_____.___                 f10.3 Lower z-level (in m agl or m asl)

 6950.40
_____.___                 f10.3 Upper z-level (in m agl or m asl)

    20000
_________                 i9    Total number of particles to be released

1.0000E00
_.____E__                 e9.4  Total mass emitted

FLIGHT_11185
_____________________________________   character*40 comment
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
```

A3.5 EMISSION_VARIATION files

Since FLEXPART version 6.0, emission factors can be defined that change the temporal variation of particle releases. This is useful, for instance, to simulate the typical daily and weekly cycle of anthropogenic emissions. The emission factors are given in files `EMISSION_VARIATION_nnn.dat`, where `nnn` is the species number defined in file `RELEASES`. If file `EMISSION_VARIATION_nnn.dat` does not exist, emission rates for species `nnn` are taken as constant. Release rates can vary with the hour of the day and with the day of the week, according to the local time at the release location. Emission factors must be 1 on average. 24 hourly as well as 7 daily values must be specified. Furthermore, different disaggregation factors must be given for area sources and for point sources. FLEXPART distinguishes between the two using the lower altitude of the release box: area sources are assumed to start below 0.5 m above the ground, whereas point sources are assumed to be higher. Please note that when this option is used, it is not so easy to determine the maximum number of particles present at a particular time of the model run. It might then be necessary to increase the parameter `maxpart` to a higher value than what would otherwise be needed. The following is an example for an `EMISSION_VARIATION_nnn.dat` file.

```
hr_start nox_area  nox_point
 0       0.578       0.845      0-1 local time
 1       0.491       0.806      1-2 local time
 2       0.428       0.786
 3       0.329       0.779
 4       0.384       0.793
 5       0.485       0.832
 6       0.763       0.895
 7       1.103       0.977
 8       1.084       1.031
 9       1.047       1.071
10       1.096       1.105
11       1.196       1.118
12       1.298       1.131
13       1.357       1.136
14       1.447       1.143
15       1.565       1.141
16       1.636       1.133
17       1.662       1.118
18       1.401       1.097
19       1.168       1.091
20       1.031       1.079
```

21	0.926	1.036	
22	0.816	0.966	
23	0.709	0.892	23-24 local time
week_day	nox_area	nox_point	
1	1.060	1.000	Monday
2	1.060	1.000	Tuesday
3	1.060	1.000	Wednesday
4	1.060	1.000	Thursday
5	1.060	1.000	Friday
6	0.900	1.000	Saturday
7	0.800	1.000	Sunday

A3.6 File AGECLASSES

AGECLASSES provides the times for the age class calculation. In the first data line, the number n of age classes is set, and ages are listed in the following n lines. The entries specify the end times (in seconds) of the respective intervals to be used, the first one starting at zero seconds. Particles are dropped from the simulation once they exceed the maximum age. Even if no age classes are needed, this option (with the number of age classes set to 1) can be useful to determine the age at which particles are removed from the simulation.

```
*********************************************
*                                           *
*Lagrangian particle dispersion model FLEXPART *
*         Please select your options        *
*                                           *
*This file determines the ageclasses to be used*
*                                           *
*Ages are given in seconds. The first class    *
*starts at age zero and goes up to the first   *
*age specified. The last age gives the maximum *
*time a particle is carried in the simulation. *
*                                           *
*********************************************
 6          Integer        Number of age classes
43200       Integer        Age class 1
86400       Integer        Age class 2
129600
172800
259200
345600
```

A3.7 Files SPECIES and surfdata.t

`SPECIES` is a list of species and their physico-chemical properties from which the user can select some for the simulation. Entries are the half life (due to radioactive or chemical decay), wet deposition information (A and B are the factors defined by equation 39 of the main manuscript, dry deposition information for gases ($D = D_{H_2O}/D_i$, D_{H_2O} is the diffusivity of water vapor and D_i is the diffusivity of the species, H is the effective Henry's constant, and $f0$ varies between 0 and 1 and gives the reactivity of a species relative to that of ozone. For nonreactive species $f0$ is 0, for slightly reactive it is 0.1 and for highly reactive it is 1.), dry depsosition information for particulates (rho specifies the density of the substance, $dquer$ its mean diameter $\overline{d_p}$, and $dsig$ the measure of variation σ_p). Radioactive decay is switched off by specifying a negative half life, wet deposition is switched off by specifying negative A, dry deposition of gases is switched off by negative D, dry deposition of particles is switched off by negative rho. If no detailed information for deposition velocity calculation is available, a constant deposition velocity vd (cm s^{-1}) can be used. Finally, $molweight$ gives the molecular weight of the species, which is needed for mixing ratio output.

```
*****************************************************************************
*                                                                           *
*     Input file for the Lagrangian particle dispersion model FLEXPART      *
*               Definition file of chemical species/radionuclides           *
*                                                                           *
*****************************************************************************
           Radioactivity    Wet depo         Dry depo (gases)      Dry depo (particles)  Dry depo
     SPECIES HALF LIFE [s]     A      B       D      H     f0      rho    dquer    dsig      vd   molweight
  1 TRACER        -999.9   -9.9E-09         -9.9                -9.9E09                    -9.99  350.00
  2 O3            -999.9   -9.9E-09          1.5  1.0e-02  1.0   -9.9E09                    -9.99   48.00
  3 NO            -999.9    8.0E-06  0.62    1.2  2.0e-03  0.0   -9.9E09                    -9.99   30.00
  4 NO2           -999.9    1.0E-05  0.62    1.6  1.0e-02  0.1   -9.9E09                    -9.99   46.00
  5 HNO3          -999.9    8.0E-04  0.62    1.9  1.0e+14  0.0   -9.9E09                    -9.99   63.00
  6 HNO2          -999.9   -9.9E-09          1.6  1.0e+05  0.1   -9.9E09                    -9.99   47.00
  7 H2O2          -999.9    1.0E-04  0.62    1.4  1.0e+05  1.0   -9.9E09                    -9.99   34.00
  8 SO2           -999.9   -9.9E-09  0.62    2.0  1.0e+05  0.0   -9.9E09                    -9.99   64.00
  9 HCHO          -999.9   -9.9E-09          1.3  6.0e+03  0.0   -9.9E09                    -9.99   30.00
 10 PAN           -999.9   -9.9E-09          2.6  3.6e+00  0.1   -9.9E09                    -9.99  121.00
 11 NH3           -999.9   -9.9E-09          1.1  2.0e+14  0.0   -9.9E09                    -9.99   17.00
 12 SO4-aero      -999.9    1.0E-04  0.80   -9.9                 2.0E03  4.0E-7  3.0E-1   -9.99   -9.99
 13 NO3-aero      -999.9    1.0E-04  0.80   -9.9                 2.0E03  4.0E-7  3.0E-1   -9.99   -9.99
 14 I2-131      691200.0    8.0E-05  0.62    2.7  1.0e+05  0.1   -9.9E09                    -9.99   -9.99
 15 I-131       691200.0    1.0E-04  0.80   -9.9                 2.5E03  6.0E-7  3.0E-1   -9.99   -9.99
```

```
 16 Cs-137        -999.9    1.0E-04  0.80   -9.9                2.5E03  6.0E-7  3.0E-1   -9.99   -9.99
 17 Y-91         5037120.0  1.0E-04  0.80   -9.9                2.5E03  6.0E-7  3.0E-1   -9.99   -9.99
 18 Ru-106      31536000.0  1.0E-04  0.80   -9.9                2.5E03  6.0E-7  3.0E-1   -9.99   -9.99
 19 Kr-85         -999.9   -9.9E-09         -9.9               -9.9E09                  -9.99   -9.99
 20 Sr-90         -999.9    1.0E-04  0.80   -9.9                2.5E03  6.0E-7  3.0E-1   -9.99   -9.99
 21 Xe-133       198720.0  -9.9E-09         -9.9               -9.9E09                  -9.99   -9.99
 22 CO            -999.9   -9.9E-09         -9.9               -9.9E09                  -9.99   28.00
 23 NO2TRACER     -999.9   -9.9E-09         -9.9               -9.9E09                  -9.99   46.00
 24 AIRTRACER     -999.9   -9.9E-09         -9.9               -9.9E09                  -9.99   29.00
```

`landuse.asc` contains the landuse inventory, and `surfdata.t`, shown below, gives the roughness lengths for each landuse class:

```
8 landuse categories are related with Leaf Area Index and roughness length
-----------------------------------------------------------
landuse    LAI         z0(m)       Albedo     comment
-----------------------------------------------------------
 1         0.50       0.10          0.18      Grassland for agricultural use
 2         2.00       0.15          0.10      Arable land
 3         3.00       0.30          0.18      Permanent crops
 4         7.00       0.60          0.15      Forest
 5         0.00       0.10          0.12      Inland water
 6         0.20       0.70          0.20      Urban areas
 7         1.00       0.10          0.15      Other
 8         0.00       0.10          0.12      Ocean
```

A3.8 File surfdepo.t

`surfdepo.t` gives the resistances needed for the parameterization of dry deposition of gases for the eight landuse classes and five seasonal categories. This file must not be changed by the user.

```
================================================================================
INPUT RESISTANCES (s/m) FOR THE COMPUTATION OF SURFACE RESISTANCES TO
DRY DEPOSITION
================================================================================
AFTER WESELY, 1989
================================================================================
1 to 8: Landuse types
================================================================================
Values are tabulated for 5 seasonal categories:
1     Midsummer with lush vegetation
2     Autumn with unharvested cropland
3     Late autumn after frost, no snow
4     Winter, snow on ground and subfreezing
5     Transitional spring with partially green short annuals
================================================================================
              1       2       3       4       5       6       7       8
--------------------------------------------------------------------------------
ri          120.     60.     65.     90.   9999.   9999.    150.   9999.     1
rlu        2000.   2000.   2000.   2000.   9999.   9999.   4000.   9999.
rac         100.    200.    365.   2000.      0.    100.    200.      0.
rgss        350.    150.    230.    500.      0.    400.    400.      0.
rgso        200.    150.    170.    200.   2000.    300.    200.   2000.
rcls       2000.   2000.   2000.   2000.   9999.   9999.   4000.   9999.
rclo       1000.   1000.   1000.   1000.   9999.   9999.   1000.   9999.
--------------------------------------------------------------------------------
ri         9999.   9999.   9999.    500.   9999.   9999.   9999.   9999.     2
rlu        9000.   9000.   9000.   5500.   9999.   9999.   9000.   9999.
rac         100.    150.    270.   1710.      0.    100.    140.      0.
rgss        350.    200.    285.    500.      0.    400.    400.      0.
rgso        200.    150.    170.    200.   2000.    300.    200.   2000.
rcls       9000.   9000.   9000.   3270.   9999.   9999.   9000.   9999.
rclo        400.    400.    400.    570.   9999.   9999.    400.   9999.
--------------------------------------------------------------------------------
ri         9999.   9999.   9999.    500.   9999.   9999.   9999.   9999.     3
rlu        9000.   9999.   9470.   5500.   9999.   9999.   9000.   9999.
rac         100.     10.     20.   1330.      0.    100.    120.      0.
rgss        350.    150.    230.    500.      0.    400.    400.      0.
rgso        200.    150.    170.    200.   2000.    300.    200.   2000.
rcls       9000.   9999.   9470.   4500.   9999.   9999.   9000.   9999.
rclo        400.   1000.    570.    570.   9999.   9999.    600.   9999.
```

ri	9999.	9999.	9999.	800.	9999.	9999.	9999.	9999.	4
rlu	9999.	9999.	9999.	1200.	9999.	9999.	9000.	9999.	
rac	10.	10.	20.	1330.	0.	100.	50.	0.	
rgss	100.	100.	100.	100.	0.	100.	50.	0.	
rgso	3500.	3500.	3500.	3500.	2000.	600.	3500.	2000.	
rcls	9999.	9999.	9470.	390.	9999.	9999.	9000.	9999.	
rclo	1000.	1000.	570.	632.	9999.	9999.	800.	9999.	
ri	240.	120.	130.	180.	9999.	9999.	300.	9999.	5
rlu	4000.	4000.	4000.	2670.	9999.	9999.	8000.	9999.	
rac	80.	50.	100.	1500.	0.	100.	120.	0.	
rgss	350.	150.	230.	500.	0.	500.	400.	0.	
rgso	200.	150.	170.	200.	2000.	300.	200.	2000.	
rcls	4000.	4000.	4000.	2670.	9999.	9999.	8000.	9999.	
rclo	500.	1000.	670.	750.	9999.	9999.	800.	9999.	