Development of a Lagrangian Particle Dispersion Model Compatible with the Weather Research and Forecasting (WRF) Model – Phase 3

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1. Summary

During phases 1 and 2 of this project, the FLEXPART particle dispersion model [*Stohl et al.*, 2005] was modified so that transport and diffusion of atmospheric contaminants and source-receptor relationships were based on the meteorological predictions from the Weather Research and Forecasting (WRF) [*Fast and Easter*, 2006]. Over the past year, the FLEXPART-WRF model was modified to 1) provide alternative treatments of the turbulent wind components based on the predicted turbulent kinetic energy in WRF and 2) account for vertical convective mixing that is consistent with the parameterizations in WRF. The next section describes the specific changes that were made to the code.

2. Specific Modifications

2.1 New Options

The *TURB_OPTION* parameter in the main input file is used to specify how the turbulent wind components are treated. The existing options included:

- *TURB_OPTION* = 0: turns off all turbulent wind components for particle trajectory calculations
- *TURB_OPTION* = 1: turbulent wind components are computed based on surface-layer scaling and local stability

The following two options have been added:

- *TURB_OPTION* = 2: turbulent wind components are computed based on predicted turbulent kinetic energy (TKE) where TKE is partitioned based on surface-layer scaling and local stability as used in TURB_OPTION = 1
- *TURB_OPTION* = 3: same as TURB_OPTION = 2 except that TKE is partitioned by assuming a balance production of turbulent energy and dissipation.

For the new options, TKE must be written in the WRF output files.

The LCONVECTION parameter in the main input file is used to specify how convective mixing affects particle dispersion. The existing options included:

- *LCONVECTION* = 0: there is no convection treatment.
- *LCONVECTION* = 1: subgrid–scale convection is treated based on Emanuel scheme [*Emanuel*, 1991: *Emanuel and Zivkovic-Rothman*, 1999]

The following two options have been added:

- *LCONVECTION* = 2: convective fluxes are calculated based on KFeta scheme [*Kain and Fritsch*, 1990; *Kain*, 2004] and particle are repositioned based on the assumption that particles in the updraft plume are well mixed

- *LCONVECTION* = 3: same as *LCONVECTION* = 2 except that particles are repositioned based on probability of being entrained into and detrained out the cloud region

The new convection treatments in FLEXPART-WRF are applied on mesoscale sub-grid scales. Note that the code turns off convection when the horizontal grid size is equal to or smaller than 10 km, where WRF itself can resolve convection to some extent.

The new convective treatments are computationally expensive. Users have the option to compute convective mixing at selected time intervals (similar to the frequency that convective mixing is computed in WRF) using the parameter *DT_CONV* in the main input file.

In addition, wet removal has been modified to included to use rain (both explicit and sub-grid scale) predicted by WRF. The user must ensure the variables RAINC, RAINNC, and CLDFRA are written to the WRF output files. If they are not present, wet removal will be zero.

A more detailed description of the methodology associated with the new treatments of turbulence and convective mixing are described in the Appendices A and B.

2.2 New and Modified Code

The code now contains the following new routines:

- *tke_partition_hanna.f*: partition of TKE based on relationship given by Hanna's empirical formula
- *tke_partition_MY.f*: partition of TKE based on Mellor-Yamada
- *convmix_kfeta.f*: routine for preparing meteorological data for KFeta convection scheme
- *convection_kfeta.f90* : subroutines for determining convection calculating convective fluxes using KFeta scheme that are extracted from WRF.
- *pre_redist_kf.f*: routine for preprocessing data for redist_kf.f
- *redist_kf.f*: subroutine for redistributing particle positions that are involved in updrafts
- *include_kftable*: definition of variables used in KF convection scheme

Modifications were also made to the existing code to read new variables needed for incorporating TKE and convection into FLEXPART, including the following routines

includecom
includeinterpol
includepar
advance.f
gridcheck.f
gridcheck_nests.f
initialize.f
interpol_all
interpol_all_nests
interpol_misslev
interpol_misslev_nests
interpol_rain
interpol_rain_nests
read_ncwrfout.f
readinput.f
readwind.f

readwind_nests.f
timemanage.f
verttransform.f
verttransform_nests.f

3. Users

An older version of FLEXPART-WRF (prior to the consolidation of the input files) has been made publicly available through Andreas Stohl's web site:

http://zardoz.nilu.no/~andreas/flextra+flexpart.html.

The code is now being widely used, as indicated by e-mail correspondence to Jerome Fast. Most of the correspondence pertains to minor questions associated with how to set up and run the code. There have been no major bugs reported by the users. Known users include:

- Danny McKenna, NCAR
- Adam Hirsch, Jerome Brioude, NOAA
- Bret Anderson, EPA
- Matthew Simpson, LNLL
- Stephanie Seely, ENSCO
- Stephan de Wekker, University of Virginia
- Ben de Foy, University of St. Louis
- Henry Fuelburg, Florida State University
- several international scientists

Appendix A: Treatment of Turbulence

TKE can be partitioned two ways.

1) *Based on surface scaling and local stability*

$$\sigma_u^2 = f_u \times TKE, \tag{A.1}$$

$$\sigma_v^2 = f_v \times TKE, \tag{A.2}$$

$$\sigma_w^2 = f_w \times TKE, \tag{A.3}$$

where σ_u , σ_v , and σ_w are standard deviations of velocity components in the *x*, *y*, and *z* directions, respectively; f_u, f_v, and f_w are fractions of TKE $(=(\sigma_u^2 + \sigma_v^2 + \sigma_w^2)/2)$, and estimated from the ratios of turbulence velocity components given by surface scaling and local stability. Detailed formulation can be found in *Stohl et al.* [2005].

2) *Based on a simplified 2nd-order closure technique*

Given TKE, wind, and potential temperature fields produced by WRF, standard variance of wind components can be estimated based on a simplified 2nd-closure technique [*Mellor and Yamada*, 1974, 1982; *Helfand and Labraga*, 1988]. The turbulence length scale, *l*, is calculated as,

$$l = \frac{\kappa(z+z_0)}{1+\kappa(z+z_0)/l_\infty}, \tag{A.4}$$

$$l_\infty = 0.1\frac{\int_0^H z\sqrt{e}dz}{\int_0^H \sqrt{e}dz}. \tag{A.5}$$

An upper limit for *l* under stable conditions is

$$l \le 0.75\left[\frac{2e}{(g/\theta)\partial\theta/\partial z}\right]^{1/2} \tag{A.6}$$

The nondimensional vertical gradients of wind and temperature are,

$$G_u = \frac{l}{\sqrt{2e}}\frac{\partial u}{\partial z}, \tag{A.7}$$

$$G_u = \frac{l}{\sqrt{2e}}\frac{\partial v}{\partial z}, \tag{A.8}$$

$$G_m = G_u^2 + G_v^2, \tag{A.9}$$

$$G_h = -\frac{g}{\theta}\frac{l^2}{2e}\frac{\partial\theta}{\partial z}, \tag{A.10}$$

$$\sigma_u^2 = 2e(1/3 - 2A_1(S_m G_m + S_h G_h) + 6A_1 S_m G_u^2, \tag{A.11}$$

$$\sigma_v^2 = 2e(1/3 - 2A_1(S_m G_m + S_h G_h) + 6A_1 S_m G_v^2, \tag{A.12}$$

$$\sigma_w^2 = 2e(1/3 - 2A_1(S_mG_m + S_hG_h) + 6A_1S_mG_h^2, \tag{A.13}$$

Lagrangian time scales are expressed as,

$$T_u = c_t \frac{l}{\sigma_u}, \tag{A.14}$$

$$T_v = c_t \frac{l}{\sigma_v}, \tag{A.15}$$

$$T_w = c_t \frac{l}{\sigma_w}, \tag{A.16}$$

$$S_m = \frac{A_1\{1 - 3C_1 - 3A_2[B_2(1-3C_1) - 12A_1C_1 - 3A_2]G_h\}}{1 - 3A_2(7A_1 + B_2)G_h + 27A_1A_2^2(4A_1 + B_2)G_h^2 + 6A_1^2[1 - 3A_2(B_2 - 3A_2)G_h]G_m}, \tag{A.17}$$

$$S_h = A_2 \frac{1 - 6A_1S_mG_m}{1 - 3A_2(4A_1 + B_2)G_h}, \tag{A.18}$$

Empirical constants follows *Mellor and Yamada* [1982], so that (A_1, A_2, B_1, B_2, C_1) = (0.92, 0.74, 16.1, 10.1, 0.08). The above relations are applied to decaying turbulence when TKE is greater than the equilibrium TKE that is calculated as,

$$e_r = \frac{B_1}{2} l^2 \left[S_{mr} \left(\frac{\partial u}{\partial z} \right)^2 \left(\frac{\partial v}{\partial z} \right)^2 - S_{hr} \frac{g}{\theta} \frac{\partial \theta}{\partial z} \right] \tag{A.19}$$

$$S_{hr} = C_h \frac{R_{fc} - R_f}{1 - R_f}, \tag{A.20}$$

$$S_{mr} = C_m \frac{R_{f1} - R_f}{R_{f2} - R_f} S_{hr}, \tag{A.21}$$

The flux Richardson number

$$R_f = -\frac{S_hG_h}{S_mG_m}, \tag{A.22}$$

Here the critical flux Richardson number R_{fc}, R_{f1}, R_{f2}, C_h, C_m are determined from empirical constants,

$$R_{fc} = \frac{E_1}{E_2}, \tag{A.23}$$

$$R_{f1} = \frac{E_3}{E_4}, \tag{A.24}$$

$$R_{f2} = \frac{E_1}{E_5}, \tag{A.25}$$

$$C_h = \frac{A_2}{B_1} E_2, \tag{A.26}$$

$$C_m = \frac{A_1}{A_2}\frac{E_4}{E_5}, \quad (A.27)$$

where

$E_1 = B_1 - 6A_1$ (A.28)
$E_2 = 12A_1 + B_1 + 3B_2$ (A.29)
$E_3 = B_1(1\text{-}3C_1) - 6A_1$ (A.30)
$E_4 = B_1(1\text{-}3C_1)+12A_1+9A_2$ (A.31)
$E_5 = B_1 + 3A_1 + 3B_2$ (A.32)

For growing turbulence when $e < e_r$, modification proposed by *Helfand and Labraga* [1988] is used, i.e.,

$$S_m = \sqrt{e/e_r}\,S_{mr}, \quad (A.33)$$

$$S_h = \sqrt{e/e_r}\,S_{hr}, \quad (A.34)$$

And e is replaced by e_r when standard variances of turbulent wind components are calculated.

Figures A.1 – A.3 depict the differences in predicted concentrations resulting from the various treatments of the turbulent wind components. Figure A.1 employs *TURB_OPTION* = 1, the default setting that does not employ the TKE from WRF. Figures A.2 and A.3 employ *TURB_OPTION* = 2 and 3, respectively. While the spatial extent of particle dispersion is qualitatively similar among the three methods, there are differences in the concentrations. The results from *TURB_OPTION* = 2 and 3 are more similar to each other than to the default value given by *TURB_OPTION* = 1.

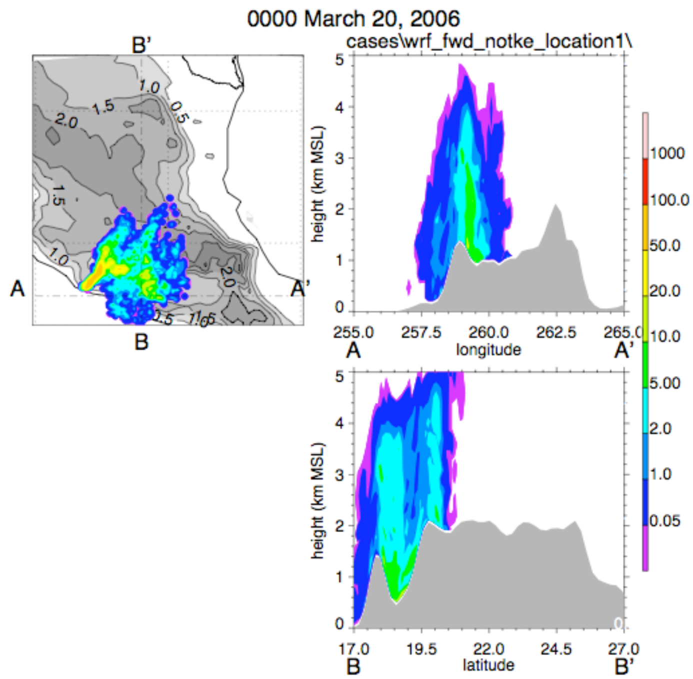

Figure A.1. Predicted particulate concentrations using *TURB_OPTION* = 1.

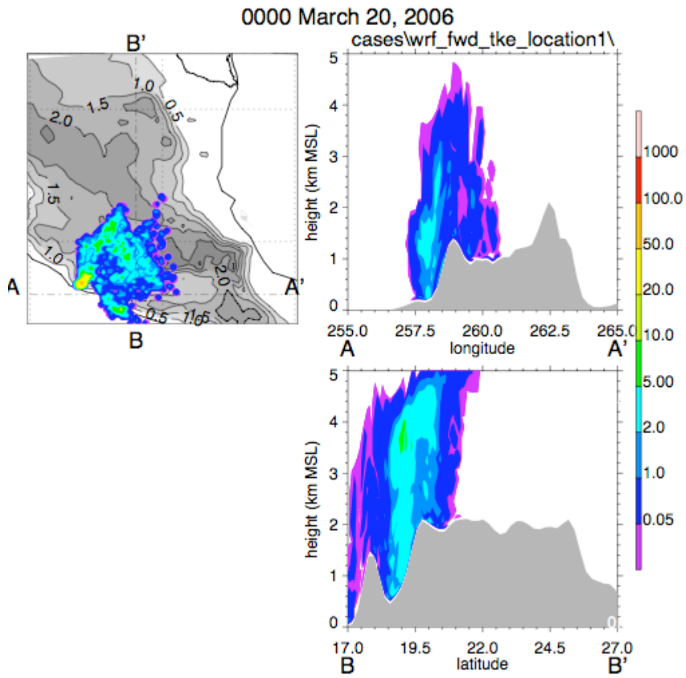

Figure A.2. Predicted particulate concentrations using *TURB_OPTION* = 2.

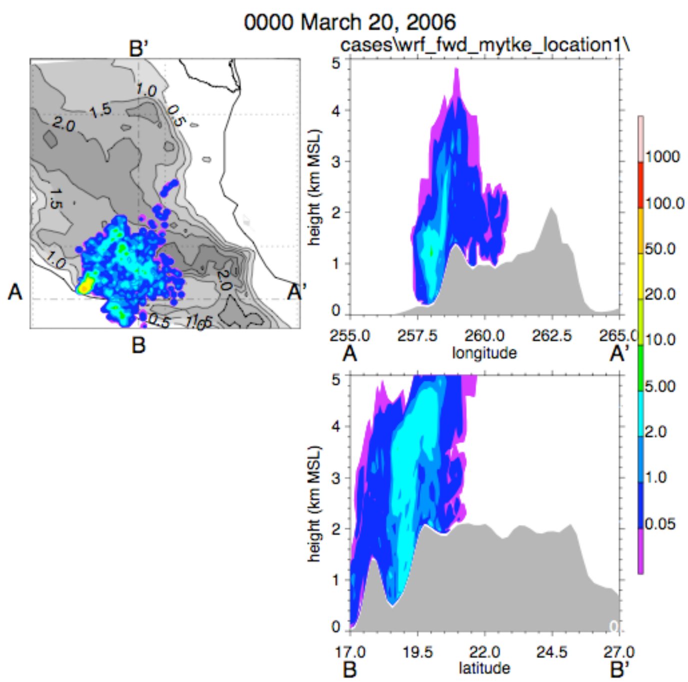

Figure A.3. Predicted particulate concentrations using *TURB_OPTION* = 3.

Appendix B: Treatment of Subgrid-Scale Convection

Particles within convective plumes are redistributed in a probabilistic manner. Probabilities are determined based on convective mass fluxes provided by the KFeta convective parameterization scheme [*Kain*, 2004] used by WRF. Formulations are similar to one proposed by *Collins et al.* [2002].

In the KFeta scheme, the change in updraft and downdraft mass fluxes with height can be expressed as,

$$\frac{\partial F_u}{\partial z} = e_u - d_u \,, \qquad \text{(B.1)}$$

$$\frac{\partial F_d}{\partial z} = e_d - d_d \,, \qquad \text{(B.2)}$$

where F_u is the updraft mass flux (kg/s/m^2) and F_d is the downdraft mass flux (kg/s/m^2), e_u and d_u are the entrainment and detrainment rates for the updraft plume, respectively, and e_d and d_d for the downdraft plume. In the KFeta scheme, mass fluxes at a level k are

$$F_u(k) = F_u(k\text{-}1) + E_u(k) - D_u(k), \qquad \text{(B.3)}$$

$$F_d(k) = F_d(k+1) + E_d(k) - D_d(k), \qquad \text{(B.4)}$$

where E_u and D_u are the entrainment and detrainment fluxes (kg/s/m^2) for the updraft plume, respectively, and D_u and D_d are for the downdraft, respectively. They are calculated based on the KFeta convective parameterization scheme.

For a particle located at a height between $z(k\text{-}1)$ and $z(k)$, the probability to be entrained into the updraft plume during a time interval Δt , p_{eu}, is calculated as the ratio of the entrained air mass into updraft to the total mass between $z(k\text{-}1)$ and $z(k)$,

$$p_{eu}(k) = \frac{E_u(k)\Delta t\Delta x\Delta y}{\rho\Delta z(k)\Delta x\Delta y} = \frac{E_u(k)\Delta t}{\rho\Delta z(k)}, \qquad \text{(B.5)}$$

Where Δx and Δy are the horizontal grid sizes in meters, Δz is equal to $z(k)$-$z(k$-1), ρ is air density (kg/m^3). Similarly, the updraft detrainment probability, p_{du}, is,

$$p_{du}(k) = \frac{D_u(k)}{F_u(k-1)} \qquad \text{(B.6)}$$

We assume that the particle entrained into the updraft can reach any levels till it is detrained out the updraft during the time interval Δt. If the particle is detrained at a level, then it will stay there and no longer be repositioned during Δt. The probability that the particle can reach level z(m) above z(k) (inside updraft) is,

$$p_u(m) = (1 - p_{du}(k+1)) \times (1 - p_{du}(k+2)) .... \times (1 - p_{du}(m-1)) = \prod_{i=k+1}^{m-1} [1 - p_{du}(i)]. \qquad \text{(B.7)}$$

Then the probability that the particle is detrained and stays at level m is,

$$P_u(m) = p_u(m) \times p_{du}(m)$$

Based on mass consistent, all particles at level k move downward by a distance $F_u(k)\Delta t/(\rho\Delta x\Delta y)$. Similarly, the probability of a particle being entrained into the downdraft during Δt, $p_{ed}(k)$, is,

$$p_{ed}(k) = \frac{E_d(k)\Delta t\Delta x\Delta y}{\rho\Delta z(k)\Delta x\Delta y} = \frac{E_d(k)\Delta t}{\rho\Delta z(k)} \tag{B.8}$$

The downdraft detrainment probability, $p_{dd}(k)$, is,

$$p_{dd}(k) = \frac{D_d(k)}{F_d(k+1)} \tag{B.9}$$

The probability that the particle reaches level z(m) below z(k) is,

$$p_d(m) = (1-p_{dd}(k-1))\times(1-p_{dd}(k-2))....\times(1-p_{dd}(m-1)) = \prod_{i=k-1}^{m-1}[1-p_{dd}(i)] \tag{B.10}$$

Then the probability that the particle is detrained out the downdraft and stays at level m is,

$$P_d(m) = p_d(m)\times p_{dd}(m) \tag{B.11}$$

All particles at level k move upward by a distance $F_d(k)\Delta t/(\rho\Delta x\Delta y)$.

Since the downdraft's mass flux is usually significantly smaller than updraft's, particles are repositioned mainly by updraft. The above particle redistribution scheme is implemented in the FLEXPART-WRF by selecting *LCONVECTION* = 3.

FLEXPART-WRF also provides a simple redistribution scheme (*LCONVECTION* = 2) that assumes particles involved in cloud will be redistributed randomly between cloud bottom and top.

The probability of a particle below cloud top being mixed inside the cloud updraft flow, p_u, is assumed to be equal to the ratio of air mass pumped by cloud at the cloud base during Δt to the total air mass below the cloud base, i.e.,

$$p_u = \frac{F_u(k_B)\Delta t\Delta x\Delta y}{\rho z_B\Delta x\Delta y} = \frac{F_u(k_B)\Delta t}{\rho z_B} \ . \tag{B.12}$$

Then the probability of the particle being repositioned to interval between $z(m\text{-}1)$ and $z(m)$ is,

$$P_u(m) = \frac{\Delta z(m)}{\sum_{i=kb}^{kt}\Delta z(i)}, \tag{B.13}$$

where z_B is the cloud base height above the ground, kt and kb are indexes of height for convective cloud top and bottom. The downdraft flux, which is usually much smaller than the updraft flux, is not considered.

This scheme is implemented by selecting *LCONVECTION* = 2.

Figures B.1 – B.3 depict the differences in predicted concentrations resulting from the various treatments of the convective mixing. Figure B.1 employs *LCONVECTION* = 0, the default setting that does not include any convective mixing. Figures B.2 and B.3 employ *LCONVECTION* = 2 and 3, respectively. The differences in the predicted spatial extent of particle dispersion and magnitude of the concentrations are usually small. However, *LCONVECTION* = 3 produces a deeper layer of vertical mixing within 2 km of the surface in some locations. The minor differences in this case may be the result of the amount of convective mixing that is produced in the simulation. For this case, convection was occurring in portions of the domain. Additional tests would be required to more rigorously test the new treatments under a broader range of meteorological conditions.

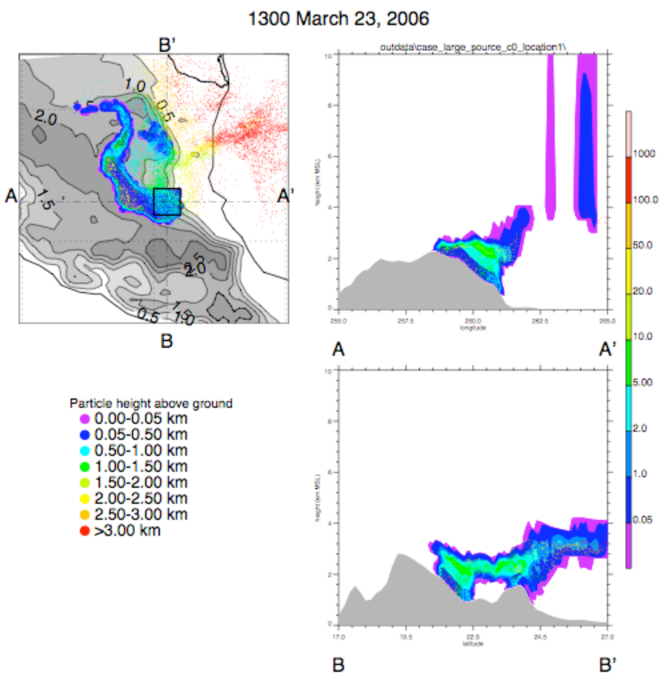

Figure B.1. Predicted particulate concentrations using *LCONVECTION* = 0.

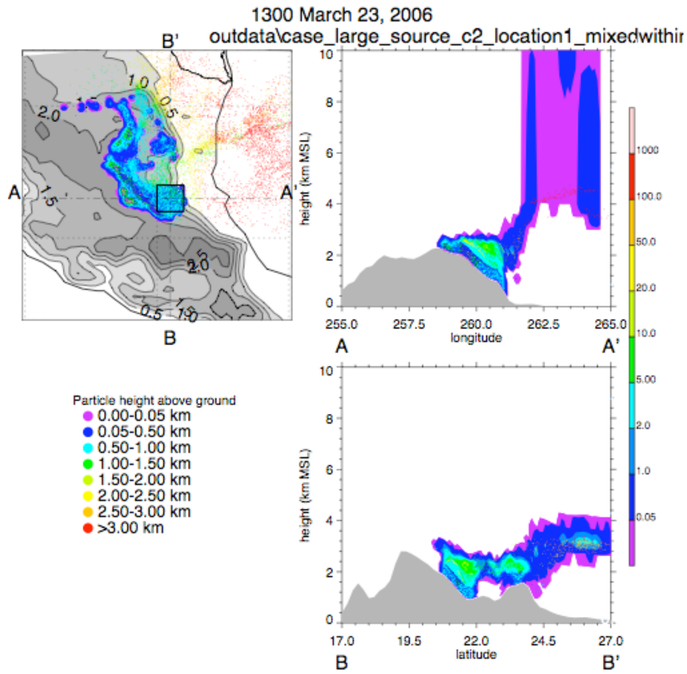

Figure B.2. Predicted particulate concentrations using *LCONVECTION* = 2.

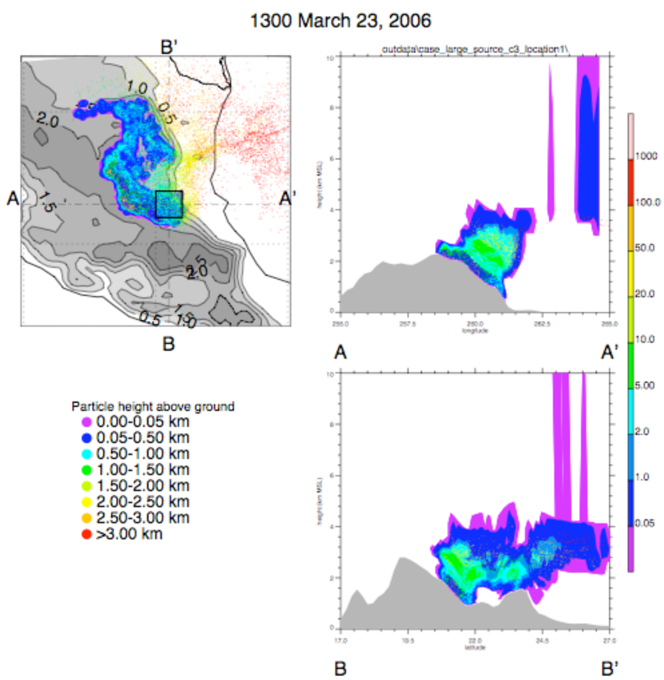

Figure B.3. Predicted particulate concentrations using *LCONVECTION* = 3.

Appendix C: Main Input File

Parameters that have been added or modified are highlighted in red:

```
=====================FORMER PATHNAMES FILE===================
/files1/d3p207/aftac/mytest/pilt/testrun_long/out_6days_location4_test/
/files1/d3p207/aftac/mytest/pilt/testrun_long/netcdf/
/files1/d3p207/aftac/mytest/pilt/testrun_long/netcdf/AVAILABLE
=============================================================
=====================FORMER COMMAND FILE=====================
    1                LDIRECT:          1 for forward simulation, -1 for backward simulation
    20060322 120000  YYYYMMDD HHMISS   beginning date of simulation
    20060328 120000  YYYYMMDD HHMISS   ending date of simulation
    3600             SSSSS             output every SSSSS seconds
    3600             SSSSS             time average of output (in SSSSS seconds)
    900              SSSSS             sampling rate of output (in SSSSS seconds)
    999999999        SSSSS             time constant for particle splitting (in seconds)
    900              SSSSS             synchronisation interval of flexpart (in seconds)
    -5.0             CTL               factor by which time step must be smaller than tl
    4                IFINE             decrease of time step for vertical motion by factor ifine
    1                IOUT              1 concentration, 2 mixing ratio, 3 both, 4 plume traject, 5=1+4
    1                IPOUT             particle dump: 0 no, 1 every output interval, 2 only at end
    1                LSUBGRID          subgrid terrain effect parameterization: 1 yes, 0 no
    0                LCONVECTION       convection: 1 yes, 0 no
    3600.            DT_CONV           time interval to call convection, seconds
    0                LAGESPECTRA       age spectra: 1 yes, 0 no
    0                IPIN              continue simulation with dumped particle data: 1 yes, 0 no
    0                IFLUX             calculate fluxes: 1 yes, 0 no
    0                MDOMAINFILL       domain-filling trajectory option: 1 yes, 0 no, 2 strat. o3 tracer
    1                IND_SOURCE        1=mass unit , 2=mass mixing ratio unit
    1                IND_RECEPTOR      1=mass unit , 2=mass mixing ratio unit
    0                MQUASILAG         quasilagrangian mode to track individual particles: 1 yes, 0 no
    0                NESTED_OUTPUT     shall nested output be used? 1 yes, 0 no
    3                TURB_OPTION       0=no turbulence; 1=diagnosed as in flexpart_ecmwf; 2=from tke.
    1                ADD_SFC_LEVEL     add a level near sfc using u10,v10,t2,qv2? 1 yes, 0 no
    0                SFC_OPTION        0=default computation of u*, hflux, pblh, 1=from wrf
    1                IOUTTYPE          0=default binary, 1=ascii
=====================FORMER AGECLASESS FILE==================
    1                NAGECLASS        number of age classes
    1728000          SSSSSS           age class in SSSSS seconds
=====================FORMER OUTGRID FILE=====================
    -102.000         OUTLONLEFT      geograhical longitude of lower left corner of output grid
    13.500           OUTLATLOWER     geographical latitude of lower left corner of output grid
    101              NUMXGRID        number of grid points in x direction (= # of cells + 1)
    101              NUMYGRID        number of grid points in y direction (= # of cells + 1)
    -92.000          DXOUTLON        grid distance in x direction
    23.500           DYOUTLON        grid distance in y direction
    17               NUMZGRID        number of vertical levels
    50.0             LEVEL           height of level (upper boundary)
    100.0            LEVEL           height of level (upper boundary)
    200.0            LEVEL           height of level (upper boundary)
    400.0            LEVEL           height of level (upper boundary)
    600.0            LEVEL           height of level (upper boundary)
    800.0            LEVEL           height of level (upper boundary)
    1000.0           LEVEL           height of level (upper boundary)
    1200.0           LEVEL           height of level (upper boundary)
    1400.0           LEVEL           height of level (upper boundary)
    1600.0           LEVEL           height of level (upper boundary)
    1800.0           LEVEL           height of level (upper boundary)
    2000.0           LEVEL           height of level (upper boundary)
    2500.0           LEVEL           height of level (upper boundary)
    3000.0           LEVEL           height of level (upper boundary)
    3500.0           LEVEL           height of level (upper boundary)
    4000.0           LEVEL           height of level (upper boundary)
    10000.0          LEVEL           height of level (upper boundary)
=====================FORMER RECEPTOR FILE====================
    7                NUMRECEPTOR     number of receptors
    F01              RECEPTORNAME    name of receptor point
    -99.125          XRECEPTOR       geographicl longitude
     19.375          YRECEPTOR       geographical latitude
    F02              RECEPTORNAME    name of receptor point
    -99.750          XRECEPTOR       geographicl longitude
     19.375          YRECEPTOR       geographical latitude
    F03              RECEPTORNAME    name of receptor point
   -100.750          XRECEPTOR       geographicl longitude
     19.375          YRECEPTOR       geographical latitude
    F04              RECEPTORNAME    name of receptor point
   -101.750          XRECEPTOR       geographicl longitude
     19.375          YRECEPTOR       geographical latitude
    F05              RECEPTORNAME    name of receptor point
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   -102.750          XRECEPTOR       geographicl longitude
     19.375          YRECEPTOR       geographical latitude
    F06              RECEPTORNAME    name of receptor point
   -103.750          XRECEPTOR       geographicl longitude
     19.375          YRECEPTOR       geographical latitude
    F07              RECEPTORNAME    name of receptor point
   -104.750          XRECEPTOR       geographicl longitude
     19.375          YRECEPTOR       geographical latitude
=====================FORMER SPECIES FILE=====================
     1               NUMTABLE        number of variable properties
  1 AIRTRACER     -999.9   -9.9E-09         -9.9                 -9.9E09                    -9.99   29.00
=====================FORMER RELEEASES FILE===================
    1                NSPEC           total number of species emitted
    1                EMITVAR         1 for emission variation
    1                LINK            index of species in file SPECIES
    0  1.000  1.000    IHOUR         include if EMITVAR=1 for each species
    1  1.000  1.000    AREA_HOUR
    2  1.000  1.000    POINT_HOUR
    3  1.000  1.000
    4  1.000  1.000
    5  1.000  1.000
    6  1.000  1.000
    7  1.000  1.000
    8  1.000  1.000
    9  1.000  1.000
   10  1.000  1.000
   11  1.000  1.000
   12  1.000  1.000
   13  1.000  1.000
   14  1.000  1.000
   15  1.000  1.000
   16  1.000  1.000
   17  1.000  1.000
   18  1.000  1.000
   19  1.000  1.000
   20  1.000  1.000
   21  1.000  1.000
   22  1.000  1.000
   23  1.000  1.000
    1  1.000  1.000    IDOW          include if EMITVAR=1 for each species
    2  1.000  1.000    AREA_DOW
    3  1.000  1.000    POINT_DOW
    4  1.000  1.000
    5  1.000  1.000
    6  1.000  1.000
    7  1.000  1.000
    1                NUMPOINT        number of releases
    20060322 120000  ID1, IT1        beginning date and time of release
    20060328 120000  ID2, IT2        ending date and time of release
    -101.0          XPOINT1         longitude [deg] of lower left corner
    16.           YPOINT1         latitude [deg] of lower left corner
    -92.000          XPOINT2         longitude [deg] of upper right corner
    20.00           YPOINT2         latitude [DEG] of upper right corner
    1                KINDZ           1 for m above ground, 2 for m above sea level
    0000.00          ZPOINT1         lower z-level (in m agl or m asl)
    1000.00          ZPOINT2         upper z-level (in m agl or m asl)
    90000            NPART           total number of particles to be released
    1.0000E00        XMASS           total mass emitted
    RELEASE_TEST1    COMPOINT        character*20 comment
=============================================================
```

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