A Lagrangian Particle Dispersion Model Compatible with WRF

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Why Particle Dispersion?

The emission, transport, diffusion, and deposition of tracers can be computed in WRF-chem by turning off chemistry. Lagrangian particle models that compute trajectories of a large number of particles (infinitesimally small air parcels) is another way to describe the transport and diffusion of tracers in the atmosphere. The main advantage of Lagrangian models is that, unlike Eulerian models such as WRF-chem, there is no numerical diffusion. In Eulerian models a tracer released from a point source is instantaneously mixed within a grid cell, whereas the Lagrangian framework is independent of computational grid and can resolve diffusion near point sources. Lagrangian models can also be used to determine source-receptor relationships and air mass trajectories.

Example

- released particles continuously from Mexico City
- particles tagged by release time
- WRF run with 22.5, 7.5, and 2.5 km grids
- multi-day period of southwesterly synoptic flow during 1997 IMADA-AVER field campaign

FLEXPART

FLEXPART is a Lagrangian particle model that has evolved into a comprehensive tool for atmospheric transport modeling and analysis. Mean conditions are obtained from global model output turbulent wind fluctuations are based on parameterized boundary layer parameters and a Markov process that uses a Langevin equation. For example, the turbulent vertical wind component can be written as:

$$dw = -w\frac{dt}{\tau_{L_w}} + \frac{\partial \sigma_w^2}{\partial z}dt + \frac{\sigma_w^2}{\rho}\frac{\partial \rho}{\partial z}dt + \left(\frac{2}{\tau_{L_w}}\right)^{1/2}\sigma_w dW \quad \text{(long time steps)}$$

$$d\left(\frac{w}{\sigma_w}\right) = -\frac{w}{\sigma_w}\frac{dt}{\tau_{L_w}} + \frac{\partial \sigma_w}{\partial z}dt + \frac{\sigma_w}{\rho}\frac{\partial \rho}{\partial z}dt + \left(\frac{2}{\tau_{L_w}}\right)^{1/2}dW \quad \text{(short time steps)}$$

drift correction; density correction; where τ_L is the Lagrangian time scale

Future Work

FLEXPART -WRF should be considered a beta code. We are working on additional modifications including:

- routine graphics for output
- consistent turbulence (i.e. use WRF TKE)
- consistent near-surface meteorological quantities
- computational efficiency

Changes in FLEXPART-WRF

- lat/lon coordinate system to those in WRF
- use u*, PBL height, and heat flux from WRF
- options more applicable for mesoscale use
- one or multiple WRF nested domains simulation can be used, but not all domains have to be used (e.g. innermost nested domain only)
- read WRF netcdf files

ECMWF → grib files → FLEXPART → binary

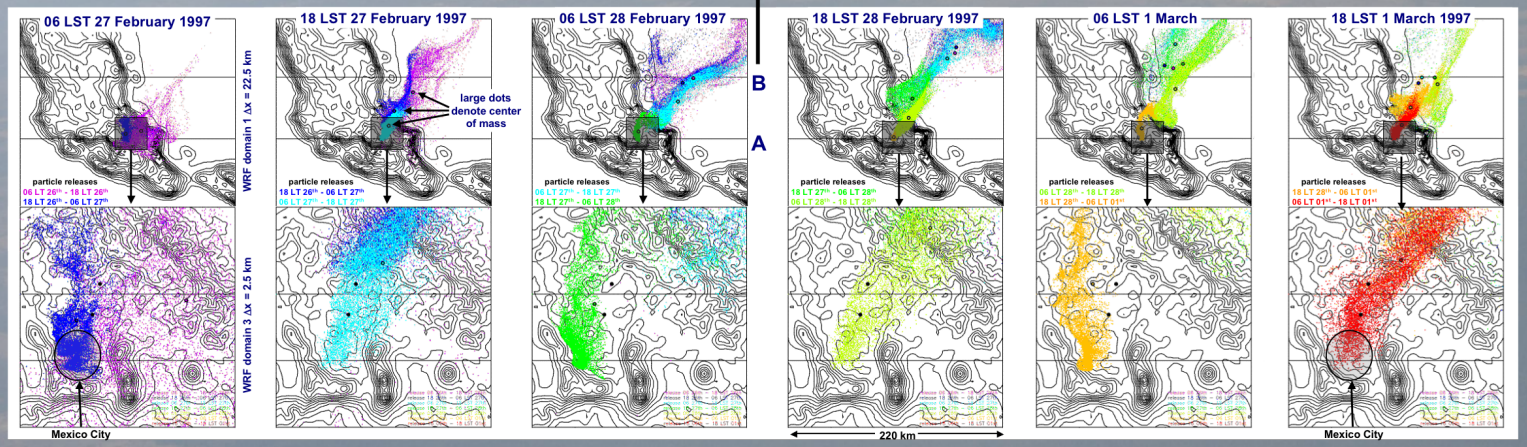
WRF → netcdf files → FLEXPART-WRF → binary/ascii

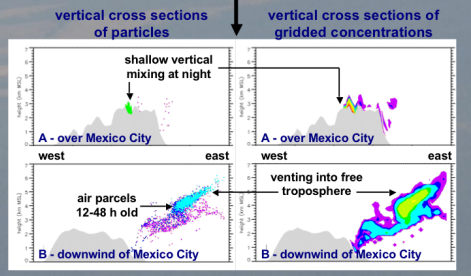
New code retains many capabilities of FLEXPART:

- forward/backward dispersion
- removal by radioactive decay, wet/dry deposition
- mimic atmospheric trace gases
- concentration, uncertainties, age spectra, and mass flux calculations

Note: All of these features have yet to be tested in the FLEXPART-WRF framework.

FLEXPART-WRF can also calculate forward/backward trajectories by turning off turbulent diffusion





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FLEXPART-WRF code available at http://zardoz.nilu.no/~andreas/flextra+flexpart.html