Regional ATDM Simulations using MLDP0 and CMC's GEM Global Analyses Data

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Model Configuration

- Meteorological model: GEM Global NWP model
  - Type of data: Analyses
  - Horizontal resolution: 33 km (~0.30°) grid mesh
  - Vertical resolution: 80 terrain-following hybrid levels interpolated over 58 eta levels
  - Temporal resolution: 6-h time intervals (valid at 00, 06, 12 and 18 UTC)

- ATDM: MLDP0 (*Modèle Lagrangien de Dispersion de Particules d'ordre 0*)

- Number of input met data vertical levels: 30 eta levels selected from the 58 eta levels.
- Input grid: polar stereographic grid (size: 742×550, horiz. res.: 5 km grid mesh)
- Output grid: Results (concentrations and depositions) are outputted on the same input grid. However, they are interpolated after (in post-processing) over a cylindrical-equidistant (Lat-Lon) grid (size: 601×401, horiz. res.: 5 km grid mesh) to meet requirements as stated in Annex VII of TT-MA-FDNPP-Accident report (see Figure 1).

- Release duration: 3 h
- Release rate: 1 unit/h (uniform)
- Simulation (integration) duration: 72 h
- Number of Lagrangian particles : 100k/h (i.e. a total of 300k during release duration)
- Internal model time step: 5 min
- Output time step: 3 h
  - Average time period for air concentration
  - Integration time period for total deposition
- Release height: 0-100 m AGL
- Vertical distribution of the mass: uniform
- Number of species (surrogates): 3, i.e. Ngas, Lpar, Dgas (see Table 1).

- Period of interest: 11-31 March 2011
- Number of simulations: 168 (8 simulations/day for 21 days)
  - 1st simulation:
    - Release date-time: 11 March 2011 at 0000 UTC
    - End of simulation: 14 March 2011 at 0000 UTC
  - 2nd simulation:
    - Release date-time: 11 March 2011 at 0300 UTC
    - End of simulation: 14 March 2011 at 0300 UTC
  - 3rd simulation:
    - Release date-time: 11 March 2011 at 0600 UTC
    - End of simulation: 14 March 2011 at 0600 UTC

    …
  - 168th simulation:
    - Release date-time: 31 March 2011 at 2100 UTC
    - End of simulation: 3 April 2011 at 2100 UTC

- **Physical removal processes:**
  - Dry deposition and wet scavenging applied only for Lpar and Dgas species.
  - Radioactive decay is not applied for all species
  - Gravitational settling is neglected for all species

- **Output Fields:**
  - Air Concentrations:
    - 3-h time averaged near-surface concentrations (0-100 m AGL)
  - Depositions:
    - 3-h time integrated total ground deposition (including dry and wet deposition)

Results are available in ARL-HYSPLIT binary format files at the following address:

http://eer.cmc.ec.gc.ca/people/Alain/eer/case_studies/h75Fgp3Cu9jFwA1jBmZ8V4g7s4Fx/WMO-TT-MA-FDNPP-Accident/regsim/CMC_Global_Analysis/unit-source_conc/

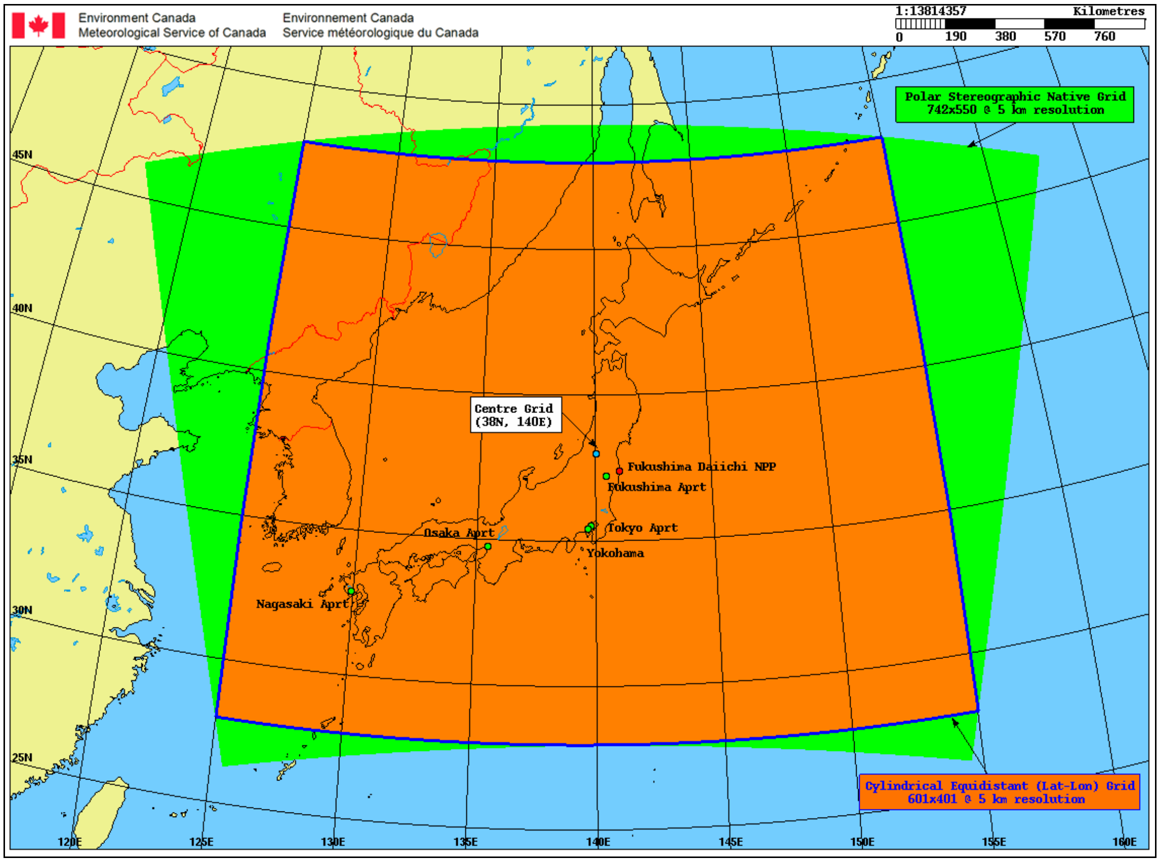

Figure 1. The Polar stereographic computational (input and output) grid used by ATM MLDP0 is shown in green (size: 742x550 at 5 km horizontal grid mesh), while the cylindrical-equidistant (lat-lon, size: 601x401 at 0.05° horizontal grid mesh) grid in orange represents the final output grid on which MLDP0 results were interpolated.

Type	Species Name	v_d [cm/s]	s_w [s^{-1}]	Dry Deposition	Wet Scavenging	Radioactive Decay	Gravitational Settling	Surrogate for
Gas	Ngas	0	0	No	No	No	No	Noble gases (Kr, Xe, Rn)
Particle, light	Lpar	0.1	3×10^{-5}	Yes	Yes	No	No	^{137}Cs, ^{131}I
Gas, depositing	Dgas	1	3×10^{-4}	Yes	Yes	No	No	^{131}I

Table 1. Different physical removal processes accounted in MLDP0 simulations. Here, v_d is the dry deposition velocity [cm/s] and s_w is the wet scavenging rate [s^{-1}].

Short overview and description of MLDP0 and physical removal processes

MLDP0 (*Modèle Lagrangien de Dispersion de Particules d'ordre 0*) is a Lagrangian particle dispersion model of zeroth order designed for long-range dispersion problems occurring at regional and global scales and is described in details in D'Amours and Malo (2004) and D'Amours *et al.* (2010). Dispersion is estimated by calculating the trajectories of a very large number of air particles (also called parcels or fluid elements). Large scale transport is handled by calculating the displacement due to the synoptic component of the wind field and diffusion through discretized stochastic differential equations to account for the unresolved turbulent motions. Vertical mixing caused by turbulence is handled through a random displacement equation based on a diffusion coefficient. This coefficient is calculated in terms of a mixing length, stability function, and vertical wind shear. Lateral mixing (horizontal diffusion) is modeled according to a first order Langevin Stochastic Equation for the unresolved components of the horizontal wind (mesoscale fluctuations).

In MLDP0 a particle (or parcel) is assumed to represent the ensemble average of a large number of "real" particles, also called sometimes aerosols. At the emission, it is assigned a mass which depends on the total quantity of material emitted and the total number of particles. The effect of radioactive decay, wet scavenging, dry deposition and gravitational settling can be simulated by calculating the amount of material removed from the carrier particle, when it travels in regions of the atmosphere where such processes are active.

Dry deposition occurs when a particle is subjected to a reflection to the ground surface. It is modeled in terms of a deposition velocity and an absorption probability. The absorption probability is calculated according to Wilson *et al.* (1989). The deposition rate is calculated by assuming that a particle contributes to the total surface deposition flux in proportion to the tracer material it carries when it is found in a layer adjacent to the ground surface. Wet deposition is treated with a simple scheme and will occur when a particle is presumed to be in a cloud (*in-cloud scavenging*) and is modeled in term of a wet scavenging rate. Below-cloud scavenging is not considered yet in the operational version of MLDP0. The tracer removal rate is proportional to the local cloud fraction, which is a function of relative humidity, and the particle mass. Local cloud fraction can be estimated in hindcast mode using analyzed meteorological fields (specific or relative humidity).

Gravitational settling in the trajectory calculations is computed according to Stokes' law for fine particles. By default, MLDP0 is run neglecting gravitational settling effects. However, this optional removal process can be included accounting together for a particle size distribution and density of a particle. This process can represent, in some cases, a critical parameter in estimating total ground deposition at short scale and airborne concentrations at long range, and can be included in volcanic ash transport simulations.

References

D'Amours, R., and Malo, A., 2004, "A Zeroth Order Lagrangian Particle Dispersion Model: MLDP0", Internal report, Canadian Meteorological Centre, Environmental Emergency Response Section, Dorval, Québec, Canada, 19 pp.

D'Amours, R., Malo, A., Servranckx, R., Bensimon, D., Trudel, S., and Gauthier, J.-P., 2010, "Application of the atmospheric Lagrangian particle dispersion model MLDP0 to the 2008 eruptions of Okmok and Kasatochi volcanoes", *Journal of Geophysical Research*, **115** (D00L11), 1–11, doi:10.1029/2009JD013602.

Wilson, J. D., Ferrandino, F. J., and Thurtell, G. W., 1989, "A relationship between deposition velocity and trajectory reflection probability for use in stochastic lagrangian dispersion models", *Agricultural and Forest Meteorology*, **47** (2-4), 139–154, doi:10.1016/0168-1923(89)90092-0.