RSMC Montréal Report of Activities for 2012

Executive Summary

Primary activities for 2012 consisted of the Regional Specialized Meteorological Centre (RSMC) monthly tests - conducted for scenarios over Canada, the United States, Guam, France and Iran - and incremental updates and improvements to the response procedures, software, and to the joint RSMC secure web pages, which are used for communicating transport model products between some of the RSMCs. The Provisional Technical Secretariat (PTS) of the Comprehensive Test Ban Treaty Organization (CTBTO) made both operational and planned requests for inverse modelling support by RSMC Montréal in April, May, June, July, August, October and December.

1. Introduction

The Canadian Meteorological Centre (Meteorological Service of Canada, Environment Canada) is designated by the World Meteorological Organisation (WMO) as the RSMC Montréal for the provision of atmospheric transport modelling (ATM) in case of an environmental emergency response. The primary regions of responsibility are WMO Regional Associations (RA) III & IV, which encompasses Canada, United-States, Mexico, Central and South America. In addition to emergency response, RSMC Montréal contributes global inverse modelling support to the CTBTO verification system.

2. Operational Contact Information

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3. Responses and information on dissemination of products

i. Accident at the Fukushima Daiichi Nuclear Power Plant: Modelling for Health Canada

At the request of Health Canada, relatively long simulations of the accident at the Fukushima Daiichi NPP were run. These span a period of roughly 6 weeks and the aim is to see what deposition patterns were like over Canada.

ii. Production of CTBTO meteorological bulletins

Work continued in 2012 to transfer the production of bulletins containing meteorological data from CTBTO atmospheric monitoring stations from the Canadian Meteorological Centre (CMC) to Zentralanstalt für Meteorologie und Geodynamik (ZAMG) in Austria. These bulletins are issued by

CMC under header SNCN19 CWAO. This work was still ongoing at the end of 2012.

As part of the work to make these stations officially recognized internationally, the WMO requested that each member-state that has CTBTO stations on its territory assign synoptic codes to identify the stations. This request was received by Canada, but because of a shortage of available synoptic codes, none had been assigned at the end of 2012. Work is ongoing to free up synoptic codes, and it is hoped that in 2013, the 4 CTBTO stations operating in Canada will be assigned identifiers.

iv. Dissemination of products

Transport model graphical products and joint statements are posted to secure joint web pages, and faxed to relevant RSMCs and National Meteorological and Hydrological Services (NMHS), when requested by the International Atomic Energy Agency (IAEA). For examples of the graphical products, see Annex 4 of **WMO, 2011**. In 2012, efforts were made to ensure that all the RSMC mirror web pages were indeed identical. Work continues to ensure this is the case.

RSMC Montréal now has the operational capability to transmit blank charts to all RSMC mirror websites at the start of each response, as well as being able to transmit its response charts once the response is underway, of course.

In addition to the other RSMCs, the following countries' NMHSs are in our email and / or fax lists: Antigua and Barbuda, Argentina, Bahamas, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Guatemala, Guyana, Mexico, Netherlands Antilles and Aruba, Panama, Peru, Suriname, Trinidad and Tobago, Uruguay and Venezuela. Constant efforts are made to keep our contact list up-to-date.

v. Response to requests from CTBTO-PTS

There were a total of 23 requests from the PTS of the CTBTO in 2012. Many of these were related to detections in Japan, likely the result of continued emanations from the Fukushima Daiichi Nuclear Power Plant. The yearly CBTO-WMO Exercise was held in May 2012, with only one request for backtracking calculation made.

vi. Other responses

RSMC Montréal participated in an internal IAEA exercise on 28 March 2012 whose aim was to help train staff at IAEA.

4. Routine operations

Monthly Test:
RSMCs Montréal, Washington and Melbourne hold a joint test on the second Thursday of every month. Following interest demonstrated by other RSMCs, the request to start the exercise is now emailed to all RSMCs. In addition, RSMC Montréal participated in the quarterly test initiated by the IAEA. The following table lists tests in 2012.

Month	Source location	Initiated by	RSMC providing joint statement
January	Port Adelaide, Australia	Melbourne	Melbourne
February	Pickering, ON, Canada	IAEA	RA III and IV RSMCs
March	Laguna Verde, Mexico	Washington	Montréal

Month	Source location	Initiated by	RSMC providing joint statement
April	Point Lepreau, NB, Canada	Montréal	Washington
May	Apra Harbour, Guam	IAEA	RA V RSMC
June	Lucas Heights, Australia	Melbourne	Melbourne
July	Donald Cook NPP, MI, USA	Washington	Montréal
August	Penly, France	IAEA	RA I & VI RSMCs
September	Donald Cook NPP, MI, USA	Washington	Montréal
October	Pickering, ON, Canada	Montréal	Melbourne
November	Bushehr NPP, Iran	IAEA	RA II RSMCs
December	Fort Calhoun NPP, NE, USA	Washington	Montréal

5. Lessons learned and significant operational or technical changes:

- Two upgrades to the software used to run the operational Lagrangian dispersion model called MLDP0 (see section 4 of http://www.wmo.int/pages/prog/www/DPS/WMOTDNO778/Annex4.html) were implemented during the course of 2012. This model is continually being worked on and more adjustments and improvements are expected again in the coming year.
- A major upgrade to the Numerical Weather Prediction (NWP) Regional Deterministic Prediction System centered over North America (see figure 2 of the following document) and used to drive the ATM was implemented on Wednesday October 3 2012, starting with the 1200 UTC run. The grid spacing of this new model is about 10 km. A 4D-Var data assimilation system replaces the previous 3D-Var and important changes to the GEM model physics were also implemented.

6. Operational issues and challenges:

- Faxing of products to NMHSs has stopped for monthly tests, as email has become the preferred method of communications and faxes exhibit a high failure rate. Faxes are only sent to RA III and IV NMHS upon request from the IAEA.
- Multiplication of messages related to a nuclear emergency (transmitted under header WNXX01 IAEA) during tests was reduced after technical experts at RTH Offenbach discovered that there was an unexpected feedback from a recipient of the WNXX IAEA message.

7. Other activities:

- René Servranckx (member of RSMC Montréal and Chairperson of the WMO nuclear ERA Coordination Group) and Alain Malo (member of RSMC Montréal) participated in the WMO Technical Task Team on Meteorological Analyses for Fukushima-Daiichi Nuclear Power Plant Accident. The reports of the 3 meetings are available here: http://www.wmo.int/pages/prog/www/CBS-Reports/DPFSERA-index.html

8. Summary and status of the operational atmospheric transport and dispersion models:

Current global weather conditions and forecasts are available at CMC at all times, to provide, in real time, the necessary input to the ATM, and for their evaluation and interpretation.

For forecasts, the GEM is used by CMC operations. Two configurations are available: regional and global. The latter, which has a uniform horizontal resolution (33 km) over the globe, is used to provide quality analyses, through the assimilation cycle, and medium term forecast guidance. As mentioned above, the grid spacing of the former is now at about 15 km.

i. The Modèle Lagrangien de Dispersion de Particules d'ordre zéro (MLDP0)

This 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. Dispersion is estimated by calculating the trajectories of a very large number of air particles (or parcels). 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).

MLDP0 is an off-line model and uses the full 3-D meteorological fields provided by a NWP system. Therefore fields of wind, moisture, temperature and geopotential heights must be provided to the model, which are obtained either from the GEM model forecasts and objective analysis systems in Global, Regional or high resolution configuration.

Dry deposition is modeled in term of a deposition velocity. 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 will occur when a particle is presumed to be in a cloud. The tracer removal rate is proportional to the local cloud fraction.

The source term is controlled through a sophisticated emission scenario module which takes into account the different release rates of several radionuclides over time. For volcanic eruptions, a particle size distribution can be used to model the gravitational settling effects in the trajectory calculations according to Stoke's law. The total released mass can be estimated from an empirical formula derived by Sparks *et al.*, 1997, which is a function of particle density, plume height and effective emission duration (Malo, 2007). MLDP0 can be run for a large number of isotopes (Cs-137 by default) as well as for volcanic ash (D'Amours et al, 2010) or an inert gas tracer.

In MLDP0, tracer concentrations at a given time and location are obtained by assuming that particles carry a certain amount of tracer material. The concentrations are then obtained by calculating the average residence time of the particles, during a given time period, within a given sampling volume, and weighting it according to the material amount carried by the particle. Concentrations are expected to be estimated more accurately near the source with a Lagrangian model than with an Eulerian model.

MLDP0 operates on a polar stereographic grid and can run on both hemispheres. The grid size and resolution define the geographical domain. Fourteen horizontal grid resolutions are now available:

- 50 km (687× 687), (477×477), (400×400) and (334×334)
- 33 km (722×722), (606×606), (505×505), (400×400) and (229×229)
- 15 km (503×503) and (251×251)
- 10 km (229×229)
- 5 km (457×457)
- 2 km (300×300)

A global configuration also exists at horizontal resolution of 1° (360×181). MLDP0 can be executed in inverse (adjoint) mode. The model has been used extensively in this configuration in the context of the WMO-CTBTO cooperation. The vertical discretization is made for 25 levels in the SIGMA, ETA or HYBRID terrain following coordinates depending on the version of the GEM NWP model used.

ii. Trajectory model

This model uses winds directly as given by the analyses and/or GEM model. The wind fields are available every hour in forecast mode and every 3 hours in diagnostic mode. Initial positions of one or more air parcels in a column are specified, and the parcels are then incrementally displaced, using time and spatial discriminations of the local three-dimensional wind field. It is assumed that air parcels preserve their identity as they are transported in the wind.

The model has been validated using back-trajectories from stations that measured concentrations of tracers from a single source (D'Amours 1998). The back-trajectories converge remarkably well towards the tracer source location. On the other hand, the lack of a boundary layer treatment and the assumption air parcel identity preservation are reflected in the results, which indicate vertical motions that are not in line with the observations.

8. Plans for 2013:

- The schedule of routine monthly tests for all of 2013 has been set up in collaboration with RSMCs Washington and Melbourne. Each RSMC will select the simulated accident location and write the joint statement on a rotating basis. Quarterly tests are also scheduled with the IAEA.
- Implement the capability to vary the source term release with time for simulations using the Lagrangian transport and dispersion model.
- Incorporate the script to produce backtracking calculations for CTBTO into the software used for environmental emergency response and RSMC modelling.
- The Global Deterministic Prediction System NWP model will be upgraded in 2013, with a grid spacing of about 25 km.
- Work on operational challenges and issues identified in section 6.

References

D'Amours, R.., 1998: Modelling the ETEX plume dispersion with the Canadian Emergency Response Model, *Atmospheric Environment*, **32**, 4335-4331

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, 18 pp.

D'Amours, R., A. Malo, R. Servranckx, D. Bensimon, S. Trudel, and J.P. Gauthier-Bilodeau (2010), Application of the atmospheric Lagrangian particle dispersion model MLDP0 to the 2008 eruptions of Okmok and Kasatochi volcanoes, J. Geophys. Res., 115, D00L11, doi:10.1029/2009JD013602.

Malo, A., 16 November 2007, "*Total Released Mass Calculation for Volcanic Eruption in CMC's Long-Range Transport and Dispersion Model MLDP0*", Internal Publication, Canadian Meteorological Centre, Environmental Emergency Response Section, Dorval, Québec, Canada, 2 pp.

WMO, 2011: Documentation on RSMC Support for Environmental Emergency Response. *WMO-TD/No.778*. Available online at http://www.wmo.int/pages/prog/www/DPFSERA/td778.html