RSMC Montréal Report of Activities for 2011

Executive Summary

Primary activities for 2011 consisted of the RSMC responses to the accident at the Fukushima Daiichi Nuclear Power Plant (NPP). A total of 22 responses were performed in support of the IAEA activities. Thirteen (13) so-called private requests were also made of RSMC Montreal, in addition to the standard RSMC responses. The accident at Fukushima generated a total of 37 requests for inverse modelling from CTBTO between the date of the accident and 9 September 2011.

Two of the four quarterly RSMC-IAEA tests were cancelled due to the workload generated by the Fukushima Daiichi NPP accident. The monthly RSMC test between RSMCs Montreal and Washington was cancelled in April for the same reason.

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 every month of 2011 after the accident at Fukushima (including in March).

1. Introduction

The Canadian Meteorological Centre (Meteorological Service of Canada, Environment Canada) is designated by the WMO as the Montréal Regional Specialized Meteorological Centre (RSMC) for the provision of atmospheric transport modelling 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 the IAEA

Following the accident at the Fukushima Daiichi NPP caused by the tsunami generated by the Tohoku earthquake on March 11, 2011, a total of 22 responses were performed by RSMC Montreal in support of the IAEA. The IAEA also made 13 "private" requests to RSMC Montreal for more specialized modelling, at both higher resolution and with more complex release scenarios than in the standard requests. Further details on RSMC Montreal's support are given in the following document presented at the WMO CBS Coordination Group for Nuclear Emergency Response Activities meeting held in Vienna, Austria 31 October – 4 November 2011: "*Fukushima Daiichi NPP Accident: Meteorological Service of Canada's Response, Challenges and Lessons Learned*". It is available here: http://www.wmo.int/pages/prog/www/DPFSERA/Meetings/CG-NERA_Vienna2011/documents/Doc-5-3-Canada.doc

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

In order to help determine whether the atmospheric flow transporting radioactivity from Fukushima would affect Canadians in Japan (largely based in Tokyo), modelling support was provided to Health Canada, the lead department responsible for coordinating Canada's Federal Nuclear Emergency Response Plan. A total of 20 simulations were executed for Health Canada.

In addition to the forward simulations just mentioned, 5 inverse simulations were also run for Health Canada. This could allow observations of radioactivity at CTBTO stations to be traced back in time to their source, which was presumably Fukushima for most of the radioactive isotopes detected.

iii. Production of CTBTO meteorological bulletins

Work continued in 2011 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 2011.

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 2011. Work is ongoing to free up synoptic codes, and it is hoped that in 2012, 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 NMHSs. For examples of the graphical products, see Annex 4 of **WMO, 2011**. In 2011, RSMCs Beijing, Obninsk, Toulouse and Tokyo launched new common web pages.

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, such as several exchanges this year regarding the contact information for Costa Rica and Panama.

v. Response to requests from CTBTO-PTS

There were a total of 49 requests from the Provisional Technical Secretariat of the Comprehensive Test Ban Treaty Organization in 2011. Most of these were related to the accident at the Fukushima Daiichi Nuclear Power Plant. Unlike previous years, no CBTO-WMO Exercise was held in 2011. In all cases, the products were supplied to CTBTO within a few hours of receiving the request, though for one request (on 18 April 2011), CTBTO exceptionally extended the allowable response time from 24 to 72 hours given the increased workload in the response to Fukushima.

vi. Other responses

RSMC Montreal also did ‘’what if’’ modelling runs (no request from IAEA) for the North Anna NPP in Virginia following an earthquake (23 August 2011) and for an explosion at a nuclear waste disposal site near Marcoule NPP, France (12 September 2011).

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 Montreal participated in the quarterly test initiated by the IAEA. The following table listd of tests in 2011.

Month	Source location	Initiated by	RSMC providing joint statement
January	Gentilly, Canada	RSMC Washington	Montréal
February	Rockingham, Australia	IAEA	Melbourne
March	Manyberries, Canada	RSMC Montréal	Washington
April	Test cancelled due to Fukushima Daiichi accident	RSMC Washington	Montréal
May	Test cancelled due to Fukushima Daiichi accident	IAEA	RA I and VI RSMCs
June	Lucas Heights, Australia	RSMC Melbourne	Melbourne
July	Bruce, Canada	RSMC Montréal	Washington
August	Test cancelled due to Fukushima Daiichi accident	IAEA	RA II RSMCs
September	Pickering, Canada	RSMC Montréal	Washington
October	Lucas Heights, Australia	RSMC Melbourne	Melbourne
November	Atucha, Argentina	IAEA	RA III and IV RSMCs
December	Clinton, USA	RSMC	Montréal

Month	Source location	Initiated by	RSMC providing joint statement
		Washington	

5. **Lessons learned and significant operational or technical changes:**

- Several improvements and corrections were made to the operational Lagrangian model called MLDP0 used at CMC (see section 4 of http://www.wmo.int/pages/prog/www/DPS/WMOTDNO778/Annex4.html). Several new output products from this model were developed in response to the accident at Fukushima and will be further explored with the IAEA. This model is continually being worked on and several adjustments and improvements are expected again in the coming year.

6. **Operational issues and challenges:**

- Faxing of products to NMHSs continues to exhibit a high failure rate. Delivery of information by email / web displays a much higher success rate. This is being followed-up as per the recommendations of CBS-XIV.
- See Section 3 of http://www.wmo.int/pages/prog/www/DPFSERA/Meetings/CG-NERA_Vienna2011/documents/Doc-5-3-Canada.doc

7. **Other activities:**

René Servranckx (member of RSMC Montreal and Chairperson of the WMO nuclear ERA Coordination Group) is part of the WMO Task Team on meteorological analyses for Fukushima.

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 atmospheric transport and dispersion models, and for their evaluation and interpretation.

For forecasts, the Global Environmental Multiscale model (GEM) 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. The former configuration was changed on 20 October 2010. The grid spacing of the regional GEM remains at 15 km, but the grid its forecasts are produced on is now slightly larger than the previous one.

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 Numerical Weather Prediction (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 2012:

- The schedule of routine monthly tests for all of 2012 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 (GUI) toolkit used for environmental emergency response and RSMC modelling.
- Work on operational challenges and issues identified in section 6.

References

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