RSMC Washington report of activities for 2015

Executive Summary

RSMC Washington did not receive any requests for support for real events. Other RSMC-related activities for 2015 consisted of Regions III, IV, and V monthly tests, conducted for scenarios over Canada, the United States, and Australia, and four IAEA exercises during the year with RSMC Washington and Montreal as Lead RSMCs in November. A special exercise was conducted in October in conjunction with the National Meteorological Service of Argentina. Response procedures, software, and joint RSMC secure common web pages and numerical models were improved. The joint web pages are used for communicating transport model products to National Meteorological and Hydrological Services (NMHS) and between RSMCs and IAEA.

1. Introduction

The National Oceanic and Atmospheric Administration's (NOAA) Air Resources Laboratory (ARL) together with NOAA's National Weather Service's (NWS) National Centers for Environmental Prediction (NCEP) are designated by the WMO as the Washington Regional Specialized Meteorological Centre (RSMC) for the provision of atmospheric transport model products in case of an environmental emergency response. The primary regions of responsibility are WMO Regional Associations (RA) III & IV, which encompass Canada, United States, Mexico, Central and South America.

2. Operational Contact Information

RSMC Washington
National Oceanic and Atmospheric Administration (NOAA)
National Weather Service
NCEP Center for Weather and Climate Prediction
Suite 4600, W/NP
College Park, MD 20740
United States of America

Business contact: Mr Jeffery McQueen
Tel : 1 301 683 3736
Fax : 1 301 683 3703
Email : jeff.mcqueen@noaa.gov

Operational contact (24 hours): Senior Duty Meteorologist
Tel : 1 301 683 1500
Fax : 1 301 683 1501
Email : SDM@noaa.gov

3. Emergency operations

RSMC Washington did not respond to an emergency in 2015.

4. Routine operations

Monthly Tests:

RSMCs Montréal, Washington, and Melbourne generally hold a joint exercise on the second Thursday of every month and invite other RSMCs to participate. In addition, RSMC Washington participated in four IAEA-initiated exercises during the year, one of which RSMC Montréal and RSMC Washington were designated as Lead RSMCs. Table 1 shows the breakdown of the details for the exercises in 2015.

Table 1: RSMC Washington monthly tests for 2015

Month	Source location
Jan 8	Lucas Heights, Australia
Feb 19	Wolsong, Korea (IAEA request)
Mar 12	Susquehanna, PA, USA
Apr 9	Bruce, ON, CA
May 21	Lucas Heights, Australia (IAEA request)
Jun 11	Dresden, IL, USA
Jul 9	Lucas Heights, Australia
Aug 20	Borssele, Netherlands (IAEA request)
Sep 10	Point Lepreau, MB, CA
Oct 7	Atucha, Argentina (special request)
Oct 8	Lucas Heights, Australia
Nov 19	Nine Mile Point, NY, USA (IAEA request)
Dec 9	Monticello, MN, USA

Once the model products are posted to all the common web pages, an email is sent in both Spanish and English to those NMHS contact points with valid email addresses in WMO RA III and IV, the IAEA and WMO. The email contains login information to retrieve the RSMC products from the common web pages.

Also held during June and October were time of arrival product tests to help with determining the type of graphic that could be recommended as a new product for RSMCs. Unfortunately, the time between when the proposed product defaults were announced to all the RSMCs and the dates of the test was too short for RSMC Washington to provide anything but the current time of arrival product already in operations. The RSMCs directly involved with the time of arrival development were able to produce plots, but those not directly involved could not generate such a

product without sufficient time for development to operations processing. In the future, it is proposed that product development should be conducted with just a few RSMCs and then results should be presented to the other RSMCs at the next Expert Team meeting for consideration as a new product in the future.

Common web pages:

RSMC Washington (ARL) continues to maintain and update, as needed, the common web page code. RSMC Washington is responsible for maintaining and distributing the web page code to all RSMCs and to make changes to the code based on lessons learned and RSMC technical meeting suggestions from other RSMCs. In 2015, RSMC Washington was able to post its results to the common web sites at all other RSMCs. In addition, most RSMCs regularly post their results to the RSMC Washington common web page for IAEA and Region III/IV exercises. The goal is for all RSMCs to post their products on all common web pages whenever possible.

Currently ARL operates the RSMC Washington web site, but not on a 24x7 operational basis. Products are automatically sent and posted to this ARL site from the NCEP supercomputer which runs HYSPLIT and generates the graphics/product files. ARL manually runs scripts to send the products to the other RSMCs' web sites. Other RSMCs' products are automatically posted to this ARL site. The RSMC Washington joint web page is being ported to an operational NCEP web server, with tentative plans for implementation in March, 2016. NCEP has developed the new web page, but testing the transfer of files from the NCEP supercomputer to this web page and the other RSMC web pages, and receipt/posting of other RSMC products on the NCEP site is scheduled to be tested in early 2016.

Provision of atmospheric backtracking Modelling for CTBTO Support:

The Department of State and NOAA entered into a Memorandum of Agreement for projects to make in-kind contributions to the CTBTO Preparatory Commission (PrepCom) on September 20, 2012 in accordance with the NOAA Backtracking Support to CTBTO Statement of Work of July 11, 2012. Therefore, NOAA, specifically, NCEP, agreed to become an operational center for CTBTO backtracking capabilities by utilizing the HYSPLIT dispersion model. The designation of RSMC Washington for the provision of atmospheric backtracking products was approved by CBS- Ext (2014) in Asunción, Paraguay, 8 to 12 September 2014 and the RSMC Washington CTBTO capability was successfully implemented into NWS operations (NCEP) on September 30, 2014.

HYSPLIT dispersion for atmospheric transport model backtracking response is primarily driven by the NWS/NCEP Global Forecast System (GFS) Global Data Assimilation System (GDAS). Outputs are at 1 degree horizontal resolution and 6 hour time intervals back 30 days from the present time. At least one month of GDAS model output at one-degree resolution is available for the CTBTO application.

RSMC Washington participated in several CTBTO initiated requests to provide backtracking information for radionuclide monitors in 2015. Table 2 shows the breakdown for the non-exercise requests during 2015 and Table 3 shows the exercise requests in 2015. A special exercise was also configured by the CTBTO to test multiple day continual response by the centers.

Table 2. List of CTBTO source-receptor matrix requests in 2015 (non-exercise)

Request Date/time (UTC)	Backward run ending time (UTC)	Latest measurement time (UTC)	Number of Receptors
20150106 1350	20141216 00	20141227 06	7
20150127 0920	20150115 00	20150126 06	7
20150316 0655	20150223 00	20150306 06	7
20150324 1130	20150310 00	20150321 06	7
20150422 0830	20150407 00	20150418 06	7
20150527 0750	20150512 00	20150523 06	7

Note: Number of receptors. A single station can have multiple receptors as each 24-hr-average measurement counts as a separate receptor.

Table 3. List of CTBTO exercise requests in 2015(EXERCISE SCENARIO, including 12-day National Data Centre Preparedness Exercise 10/27 -- 11/7)

Request date/time (UTC)	Backward run ending time (UTC)	Latest measurement time (UTC)	Number of stations
20150219 1200	20150205 00	20150216 06	7 (JPP38 x3)
20150303 0930	20150217 00	20150228 06	7 (JPP38 x3)
20151027 1430	20151005 00	20151020 06	13X, 7P
20151028 1500	20151006 00	20151021 06	11X, 5P
20151029 1350	20151007 00	20151022 06	16X, 10P
20151030 1100	20151008 00	20151023 12	14X, 8P
20151031 1035	20151009 00	20151024 12	16X, 11P
20151101 1045	20151010 00	20151025 12	15X ,10P
20151102 1240	20151011 00	20151026 12	24X ,14P
20151103 1130	20151012 00	20151027 12	20X ,12P
20151104 1100	20151013 00	20151028 18	14X, 9P
20151106 1100	20151014 00	20151029 12	15X
20151107 1100	20151015 00	20151030 12	25X, 19P

P: Receptors for particulate measurements only.
X: Receptors for both noble gas and particulate measurements.

5. Lessons learned from recent experiences and significant operational or technical changes:

RSMC Washington continues to experience some intermittent problems during exercises due to the fact that the common web page is hosted by ARL on a non-operational web server. It is planned that the web site will be moved to NCEP operations in 2016 and work on creating the web applications and scripts is currently being done. We hope to allow testing to the new server in the first few months of 2016.

6. Additional operational issues and challenges:

RSMC Washington continues to have difficulty with invalid email addresses for NMS contacts who receive email notices of updated model products. Guidance from WMO on the proper procedure to remove bad email addresses from our system would be helpful.

7. Summary and status of the operational atmospheric transport and dispersion models

HYSPLIT Model

RSMC Washington's operational atmospheric transport and dispersion model is the HYSPLIT (formerly called the HYbrid Single-Particle Lagrangian Integrated Trajectories) model (Draxler and Hess, 1998; Stein et al, 2015), developed at the ARL. HYSPLIT is driven by meteorological forecast data from the operational Global Forecast System (GFS) model (T1534, approximately 13 km, converted to 1 degree and half-degree latitude-longitude grids) and the North American Meso (NAM) Non-hydrostatic Multi-scale Model on a 12 km parent and 4 km CONUS, Alaska and Hawaii nested grids (NMMB). Note that a half- and quarter-degree GFS model output is also available and on the native hybrid-sigma levels compared to the 1 degree pressure levels. The system is available for running on demand and can produce forecast trajectories, concentrations (or exposures) and depositions for nuclear accidents, volcanic eruptions, smoke episodes and other related atmospheric pollutant releases.

HYSPLIT can be used for modeling atmospheric transport and dispersion of pollutants over a broad range of distances; from local to global scales. The equations used in the calculation of pollutant transport and dispersion are a hybrid between Eulerian and Lagrangian approaches. Advection and diffusion calculations are made in a Lagrangian framework using the gridded meteorological analysis and forecast fields. Air concentrations are calculated on a fixed three dimensional grid by integrating all particle masses over a pre-set averaging period. Routine calculations may consist of simple trajectories from a single source to complex emissions from several sources. Dry deposition is treated with a deposition velocity. Wet deposition can be divided into two processes: a scavenging ratio for pollutants located within a cloud layer and a scavenging coefficient for pollutant removal in rain below a cloud layer. Alternatively, a scavenging coefficient can be used for both in- and below-cloud removal, which gave the best results when used for the Fukushima simulations. The alternative wet deposition calculation will be implemented into RSMC operations in March 2016. Radiological decay can also be included, when necessary.

9. Research and Development activities:

The HYSPLIT model is a complete system for computing simple air parcel trajectories as well as complex transport, dispersion, chemical transformation, and deposition simulations. As of 2015, HYSPLIT continues to be one of the most extensively used atmospheric transport and dispersion models in the atmospheric sciences community (e.g., more than 800 citations to Draxler and Hess, 1998, Web of Science, http://thomsonreuters.com/thomson-reuters-web-of-science/).

In a recently published paper, Stein et al. (2015) present the model's historical evolution over the last 30 years from simple hand drawn back trajectories to very sophisticated computations of transport, mixing, chemical transformation, and deposition of pollutants and hazardous materials. They highlight recent applications of the HYSPLIT modelling system, including the simulation of atmospheric tracer release experiments, radionuclides, smoke originated from wild fires, volcanic ash, mercury, toxic chemicals and wind-blown dust. Among the model updates it is worth mentioning the inclusion of backward-in-time advection with dispersion to estimate footprints, time varying emissions, an embedded Global Eulerian Model (GEM), and the built-in capability to produce three different simulation ensembles.

In addition, HYSPLIT has very recently been coupled inline to WRF (Ngan et al, 2015) taking advantage of the higher temporal frequency available from the meteorological data. The model runs within the WRF architecture using the same spatial and temporal resolution and it has been tested against tracer experiments. This is a very promising approach for applications influenced by rapidly changing conditions and/or complex terrain. Further evaluation of this approach is underway.

Plans for 2016 and beyond:

There will be a HYSPLIT upgrade at NCEP, tentatively planned for March, 2016. The main features relevant to RSMC are (1) transfer of the RSMC Washington web page from NOAA ARL to NCEP (see Section 4), (2) upgrade of the wet deposition parameterization to one that relies on a scavenging coefficient, replacing a scavenging ratio, (3) posting of the HYSPLIT output in GRIB2 format to the "All Products" section of the RSMC Washington web page, and (4) minor updates to the time-of-arrival products, though not meeting all the proposed standards currently being tested.

- The schedule of routine monthly tests for all of 2016 has been set up in collaboration with RSMCs Montréal and Melbourne.
- Four exercises in 2016 will be initiated by IAEA with the August exercise being designated "Lead" for RSMCs Washington and Montréal.
- The joint web page will be installed on an operational server run by NCEP.
- Continue to make small modifications to the common web page code as needed based on problems encountered during exercises/events and provide the changes to all RSMCs.
- RSMC/CTBTO applications continue using GFS/GDAS model output at half or one-degree though the GFS/GDAS modeling system will be upgraded (see NWP section below)
- Upgrade the HYSPLIT system at NCEP to a more recent version, including improved wet deposition in March 2016.
- In 2017, implement the Transfer Coefficient Matrix (TCM) approach in a development computer user account following NCEP operational scripting protocols for planned transfer to operations. Also allow HYSPLIT to be driven by NOAA's High Resolution Rapid Refresh (HRRR) 3 km model predictions.
- Direct GRIB2 Input and Output

10. Summary and status of the operational Numerical Weather Prediction (NWP) models

The HYSPLIT dispersion for RSMC response is primarily driven by the NWS/NCEP Global Forecast System (GFS) or the North American Model (NAM). The NAM 12 km Non-hydrostatic Multiscale Meteorological Model on the B grid (NMMB; Janjic and Gall, 2012) has been NCEP's operational North American Mesoscale model since October 2011. Four fixed domain nests (4 km CONUS, 6 km Alaska, 3 km Hawaii and 3 km Puerto Rico) are embedded within the NAM 12 km parent model. No upgrades to NAM-NMMB were made in 2015.

In 2015, all NCEP models continued to run on the Weather and Climate Operational Supercomputer system (WCOSS). WCOSS is based on the IBM iDataPlex/Intel Sandy Bridge/Linux hardware and software operation system. Phase II WCOSS was installed in 2015 with an additional 1080 compute nodes with an additional 2 Petabytes of storage. Early in 2016, a CRAY based supercomputer will be made operational increasing the total capacity of both IBM and CRAY systems to 2.8 PFlops, 3748 Nodes, 84,512 processors and 8.124 PB of storage.

WCOSS provides the operational and developmental platform to run HYSPLIT, GFS, NAM as well as the 16 km Short Range Ensemble Forecast (SREF), T190 Global Ensemble Forecast, hourly 13 km Rapid Refresh (RAP), 3 km High Resolution Rapid Refresh (HRRR) models and 2.5 km Real-Time Mesoscale Analysis (RTMA) and other customized weather and ocean modeling systems. The HRRR hourly analysis and forecast system (15 forecast hours) over the Continental U.S is based on the Weather Research and Forecasting (WRF) Advanced Research WRF (ARW) model with explicit microphysics, 2nd order closure boundary layer scheme and a multiple layer land surface model.

A major upgrade to the Global Forecast System (GFS) was implemented in January, 2015:

- Increased horizontal resolution to 13 km
- Moved to a semi-Lagrangian dynamical core to allow longer time steps
- Improvements to boundary layer and radiation physics
- Output high resolution grid files for public access (1/4 and ½ degree)
- In October 2015, the Global Ensemble Forecast System (GEFS) resolution was increased to T574 (around 25 km) and also used for data assimilation

Plans for 2016:

Development of the TCM on the NCEP supercomputer will continue, with the intent to replace the current operational RSMC run with the TCM approach in 2017, however the current graphics will still be produced from the forecast portion of the TCM calculation.

- Update all NAM nests to 3 km horizontal resolution with forecasts to 60 hours four times per day.
- Implement a high resolution ensemble prediction system (~3 km) targeted for improving short-term severe storm prediction.
- In 2016, the Global Forecast System (GFS) system will be updated to the NOAA Environmental Modeling System architecture to improve coupling between various physical process components (eg: Ocean-atmosphere, aerosol-atmosphere). Global data assimilation will also be upgraded to use a time variational approach within the current ensemble Kalman filter system.

References

Draxler R.R, and Hess G.D., 1998. An overview of the HYSPLIT_4 modeling system for trajectories, dispersion, and deposition. Australian Meteorological Magazine 47, 295-308.

Janjic, Z. I., Gerrity Jr, J. P., & Nickovic, S. 2001. An alternative approach to nonhydrostatic modeling. *Monthly Weather Review*. 129(5), 1164-1178.

Janjic, Z., Gall, R.L. 2012. Scientific documentation of the NCEP nonhydrostatic multiscale model on the B grid (NMMB). Part 1 Dynamics. http://nldr.library.ucar.edu/repository/collections/TECH-NOTE-000-000-000-857 (full text at http://nldr.library.ucar.edu/repository/assets/technotes/TECH-NOTE-000-000-000-857.pdf)

Ngan F., Stein A.F., and Draxler R.R., 2015. Inline coupling of WRF-HYSPLIT: model development and evaluation using tracer experiments. Journal of Applied Meteorology and Climatology. doi: http://dx.doi.org/10.1175/JAMC-D-14-0247.1

Stein, A.F., R.R. Draxler, G.D. Rolph, B.J.B. Stunder, M.D. Cohen, and F. Ngan. 20015. NOAA's HYSPLIT atmospheric transport and dispersion modeling system. Bulletin of the American Meteorological Society, doi: http://dx.doi.org/10.1175/BAMS-D-14-00110.1

WMO, 2012: Documentation on RSMC Support for Environmental Emergency Response. *WMO-TD/No.778*. Available online at http://www.wmo.int/pages/prog/www/DPS/WMOTDNO778/Annex4.html