

**RSMC WASHINGTON**  
**USER'S INTERPRETATION GUIDELINES**  
**ATMOSPHERIC TRANSPORT MODEL OUTPUTS**

-Version 2.0-

*(January 2007)*

**1. Introduction**

In the context of current agreements between the National Oceanic and Atmospheric Administration (NOAA) and WMO, NOAA is prepared to provide diagnostic and forecast transport, dispersion, and deposition estimates for atmospheric releases of hazardous pollutants that may cross international political boundaries. The primary regions (RA-III & IV) of coverage include the United States, Canada, Mexico, Central and South America. This document provides a description of NOAA's RSMC products.

**2. Meteorological Forecast Models**

The NOAA's National Weather Service's (NWS) National Centers for Environmental Prediction (NCEP) runs a series of computer analyses and forecasts<sup>1</sup>. Some of the primary operational products are produced by the Global Data Assimilation System<sup>2</sup>, which uses the Global Forecast System (GFS) model for the forecast<sup>3,4</sup>. Another system, over North America, is the North American Mesoscale (NAM), which uses the Weather Research and Forecasting version of the Nonhydrostatic Mesoscale Model (WRF-NMM)<sup>5</sup> for its forecast.

The customized transport and dispersion products are developed at NOAA's Air Resources Laboratory (ARL) and run operationally at NCEP. The NCEP analysis and forecast products are used as input to a variety of transport and dispersion models and air quality simulations, which all share a common set of meteorological input files produced operationally. Forecast and analysis fields going back several days are maintained at NCEP for historical calculations. The graphics produced by the dispersion model, in addition to being distributed via facsimile, are automatically downloaded to ARL's web server for access via a username and password.

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<sup>1</sup> <http://www.nco.ncep.noaa.gov/pmb/nwprod/analysis/>.

<sup>2</sup> Kanamitsu, M., J.C. Alpert, K.A. Campana, P.M. Caplan, D.G. Deaven, M. Iredell, B. Katz, H.-L. Pan, J. Sela, and G.H. White, 1991: Recent changes implemented into the global forecast system at NMC. *Wea. and Forecasting*, 6, 425-435.

<sup>3</sup> Global Climate & Weather Modeling Branch, EMC, 2003: NCEP Office Note 442: The GFS Atmospheric Model. <http://www.emc.ncep.noaa.gov/officenotes/newernotes/on442.pdf>.

<sup>4</sup> Kalnay, M. Kanamitsu, and W.E. Baker, 1990: Global numerical weather prediction at the National Meteorological Center, *Bull. Amer. Meteor. Soc.*, 71, 1410-1428.

<sup>5</sup> Dimego, G, 2006: Briefing on WRF in NAM, <http://www.emc.ncep.noaa.gov/WRFinNAM/>

The emergency response system is usually initiated by a telephone call and facsimile message to the Senior Duty Meteorologist (SDM) at the operations center of the NCEP. An "on-call" meteorologist who specializes in transport and dispersion is available to assist the SDM in the event of a major environmental emergency.

### **3. Emergency Response Model (HYSPLIT)**

The Hybrid Single-Particle Lagrangian Integrated Trajectories (HY-SPLIT)<sup>6</sup> model is routinely used for many of the long-range dispersion modeling studies conducted by ARL<sup>7</sup>. The equations used in the calculation of pollutant transport and dispersion are a hybrid between Eulerian and Lagrangian approaches. A single pollutant particle represents the initial source. Advection and diffusion calculations are made in a Lagrangian framework using the meteorological gridded analysis and forecast fields. As the dispersion of the initial particle spreads it into regions of different wind direction or speed, the single particle, represented by a "puff", is divided into multiple particles. The rate of horizontal dispersion is linearly proportional to time and the rate of vertical dispersion is proportional to the square root of the vertical mixing coefficient. Vertical mixing coefficients are computed from a bulk Richardson number. 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 consideration of complex emissions from several sources.

Dry deposition is treated with the deposition velocity concept. Additional gravitational settling is included for particles. Wet deposition is divided into two processes: a scavenging ratio (concentration in air to concentration in water) for pollutants located within a cloud layer and a scavenging coefficient (removal rate) for pollutant removal in rain below a cloud layer. Radiological decay is also included when necessary.

### **4. Description of the HYSPLIT output maps for the default scenario**

As defined by WMO<sup>8</sup>, an initial response of an RSMC will be to provide a set of forecast products based on a "default scenario" unless details about the emergency are known at the time of the model run. The default products consist of a cover sheet with details on the scenario, a 3-level trajectory forecast, three 24-h average exposure maps, and a total surface deposition map. Figures 1-6 present a typical product suite from HYSPLIT using the default scenario. For these maps the following items are identical:

- (1): The source location is MANYBERRIES, ALBERTA, CANADA;
- (2): It is located at latitude 49.39 degrees North and at longitude 110.68 degrees West;

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<sup>6</sup> Draxler, R., and G.D. Hess, 1997: Description of the HYSPLIT\_4 modeling system. NOAA Technical Memo ERL ARL-224, National Technical Information Service, Springfield VA, 24 pp.

<sup>7</sup> Draxler, R., 2006: The use of global and mesoscale meteorological model data to predict the transport and dispersion of tracer plumes over Washington, D.C. Wea. Forecasting, 21, 383-394.

<sup>8</sup> WMO, 2006: World Weather Watch, Environmental Emergency Response Activities. <http://www.wmo.int/web/www/DPFSERA/EmergencyResp.html>.

(3): and the hypothetical release started at 0900 UTC on 12 October 2006.

Figure 1 shows the cover sheet that accompanies each facsimile which provides details about the model scenario. Included is the RSMC center providing the results and the time the products were produced.

Figure 2 shows forecast air parcel trajectories starting at 500 (red triangles), 1500 (blue squares), and 3000 meters (green circles) above model ground level on a map. Trajectories are labeled every 6 hours by a filled symbol. The vertical projection of the trajectories with time is shown in the panel below the map.

Figures 3-5 show 24-hour average surface to 500 meter time integrated concentration (exposure) from the start of the release to the nearest even 12 hour synoptic period, which results in a time integration of greater than 12 hours. Figure 3 has been marked with red coded letters in this document only to explain the meaning of each section. Here is a description of what it contains:

- 1: Identification of the NOAA HYSPLIT transport model used in the calculation.
- 2: Indicates that the air concentration or exposure output units are averaged from the ground to 500 meters above the model ground level and the units are Becquerel-seconds per cubic meter (default units). Unless the source release rate is known at the time of the model run, the default emission rate is one Bq over six hours. Output units can easily be scaled to any multiple of the default emission rate. Ground-level deposition maps are identified on this line with units of Becquerel per square meter.
- 3: The integration period over which the time-integrated air concentrations are computed. All times are in UTC (Universal Time Coordinate) and are indicated by the start and end of the integration period.
- 4: The 4-letter ID used to denote the pollutant and the UTC time that the release started. The default scenario would be a release of six hours starting at this time.
- 5: The latitude and longitude of the release location in degrees and hundredths of a degree, and the height of the release in meters above model ground level. Single letter abbreviations are used for East, West, North and South.
- 6: The time at which the forecast model was initialized and an abbreviated name for the meteorological model: NAM (WRF-NMM model), GFSG (Global Forecast System model).
- 7: Colors used for plotting the four concentration contour intervals and their corresponding values. If the range of values on the map is less than eight orders of magnitude then the contour intervals are at factors of 10. If the range is greater, then the contour intervals are at factors of 100.
- 8: The maximum exposure (or deposition) value is indicated by a solid red square (the size of the grid cell) on the map and its value is indicated on this line along with the minimum concentration value on the map (not plotted).

- 9: The contents of this section will vary with the product being displayed; concentration, deposition, or trajectories. The following is a list of possible contents.

Identifies time the product was issued and the RSMC sending this product.

The name, latitude and longitude, and the release height of the location of the release site are repeated on this line.

Describes the emission scenario used for the concentration (exposure) simulations, including the species type, the rate of release and its duration, and the number of particles release per emission cycle. The indication of species type is used only in the definition of specific internal model parameters for decay and deposition.

The distribution of the concentration (exposure) output maps is indicated to be a layer average between the surface and 500 meters above the model ground level.

The deposition computations include both wet and dry deposition using a deposition velocity for the dry component of the removal process and in-cloud and below-cloud removal rates for the wet deposition.

The meteorological model that is used for the forecast is repeated here.

Additional notes indicate that the contour intervals may change from map to map as the interval depends upon the concentration range on each map.

The results for this simulation are based upon the default scenario, since no additional information was available at the time of the model run.

The nature of the event is indicated here as either an exercise, an unconfirmed event, or an IAEA confirmed event. In the case of unconfirmed events, the existence or the actual amount of release may be unknown.

Figure 6 shows the total deposition for the entire simulation period from release at 0900 UTC 12 October to 0000 UTC on 15 October. Note that output units are Bq per square meter.

## **5. Other products available from RSMC Washington and contact for additional information**

Additional products can be produced by RSMC Washington if the situation requires it. These products go beyond the scope of the document and will not be described here. For additional information contact the RSMC directly.

U.S. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

RSMC Washington (NOAA ARL, NOAA NCEP)

Room 410 - W/NMC33  
World Weather Building  
5200 Auth Road  
Camp Springs, Maryland USA

Tel (24 hrs - NCEP): 301-763-8298  
Tel (Backup - ARL): 301-713-2614

Fax (24 hrs - NCEP): 301-763-8592  
Fax (Backup - ARL): 301-713-4592

RSMC products issued Thu Oct 12 13:10 UTC 2006

The following charts will follow:

- 2 or 3 time-integrated concentration maps
- total (dry + wet) deposition map

Please contact us if any problems arise with these products.

Source term and dispersion model details

RSMC Washington - NOAA ARL / NCEP

Response: EXERCISE EXERCISE EXERCISE

Location: MANYBERRIES\_AB\_CANADA lat:49.39 lon:-110.68

Release Start (YYYY MM DD HH MM): 2006 10 12 09 00

Meteorology: GFS

Trajectories: 500.0, 1500.0, 3000.0 m AGL

Release ID: C137 Rate: 0.1667/hr Duration: 6.0 hr Particles: 500

Distribution: Uniform between 10 and 500 m AGL

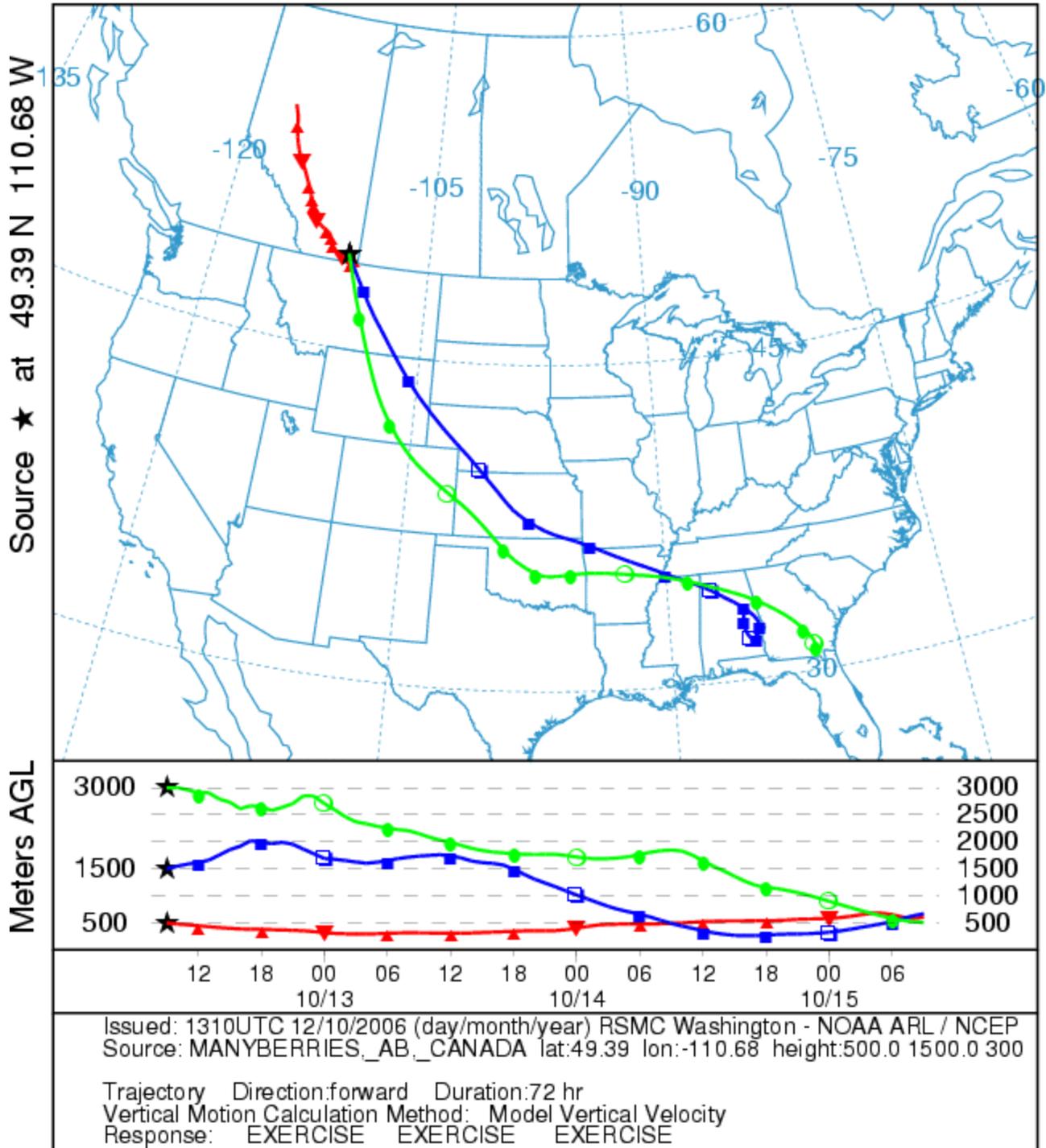
Dry Deposition Rate: .001 m/s Wet Removal (below/in-cloud):  $5.0E-5/3.2E+5$

Note: Contour values may change from chart to chart

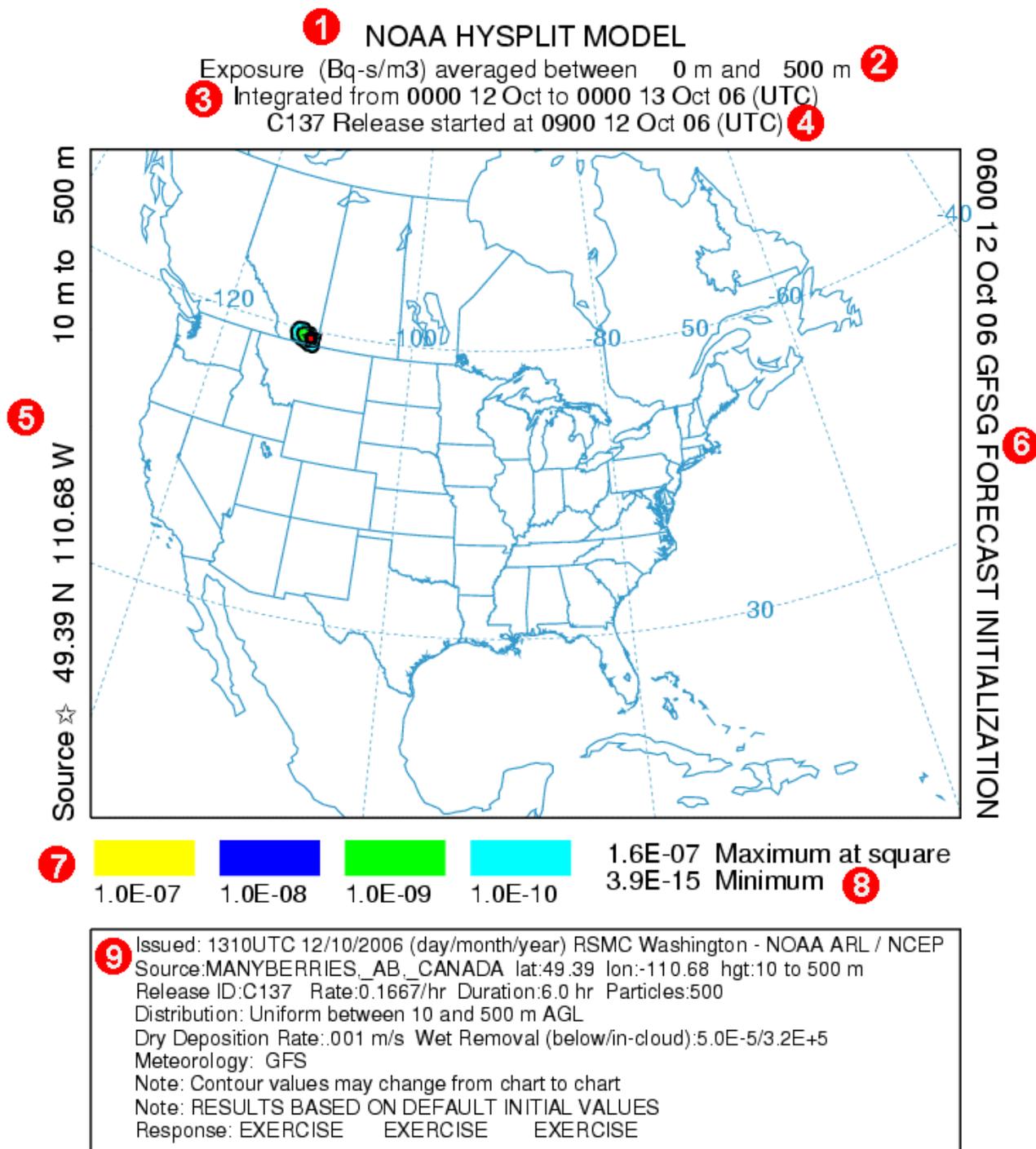
Note: RESULTS BASED ON DEFAULT INITIAL VALUES

Figure 1. Cover sheet with details on the model scenario.

NOAA HYSPLIT MODEL  
 Forward trajectories starting at 09 UTC 12 Oct 06  
 06 UTC 12 Oct GFSG Forecast Initialization



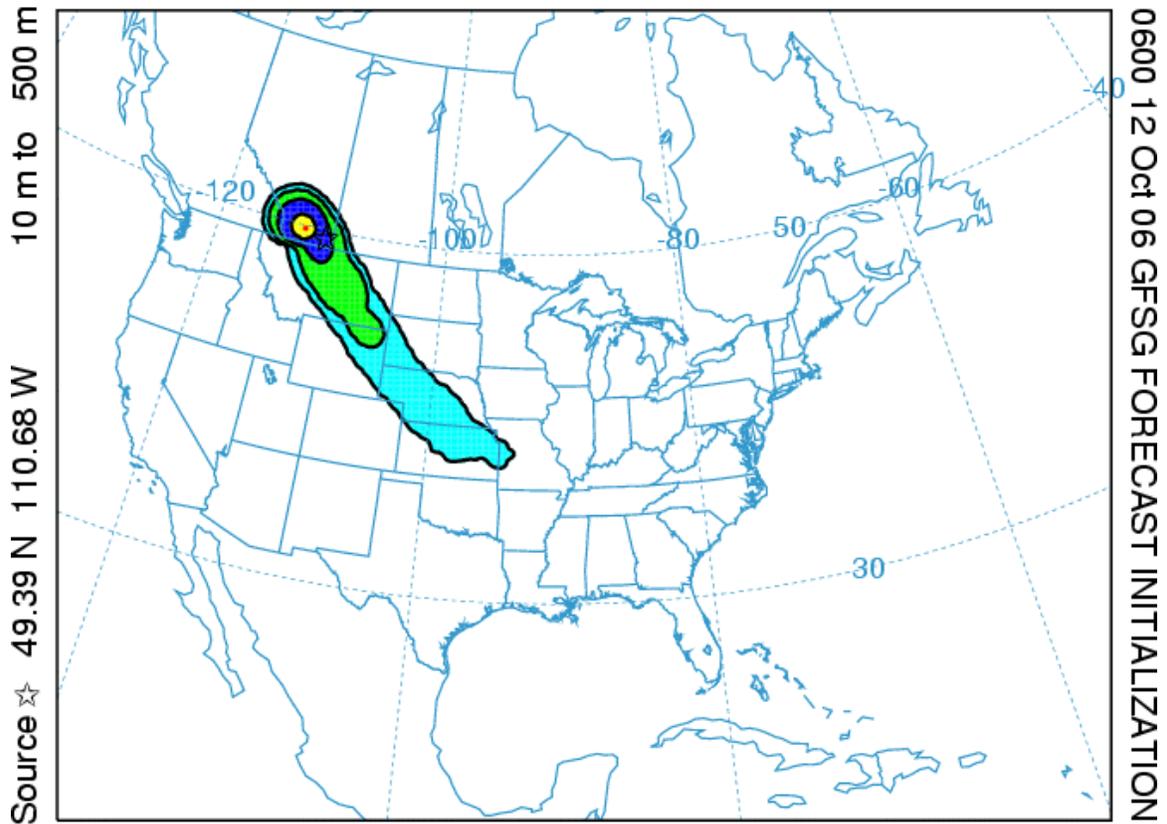
**Figure 2. Horizontal and vertical projection of the 500, 1500, and 3000 meter above ground level forecast air parcel trajectories.**



**Figure 3. First 24-hour average exposure forecast for a hypothetical accident in Alberta, Canada. The red circled numbers are for reference in this document only and do not appear on the forecast products.**

### NOAA HYSPLIT MODEL

Exposure (Bq-s/m<sup>3</sup>) averaged between 0 m and 500 m  
 Integrated from 0000 13 Oct to 0000 14 Oct 06 (UTC)  
 C137 Release started at 0900 12 Oct 06 (UTC)

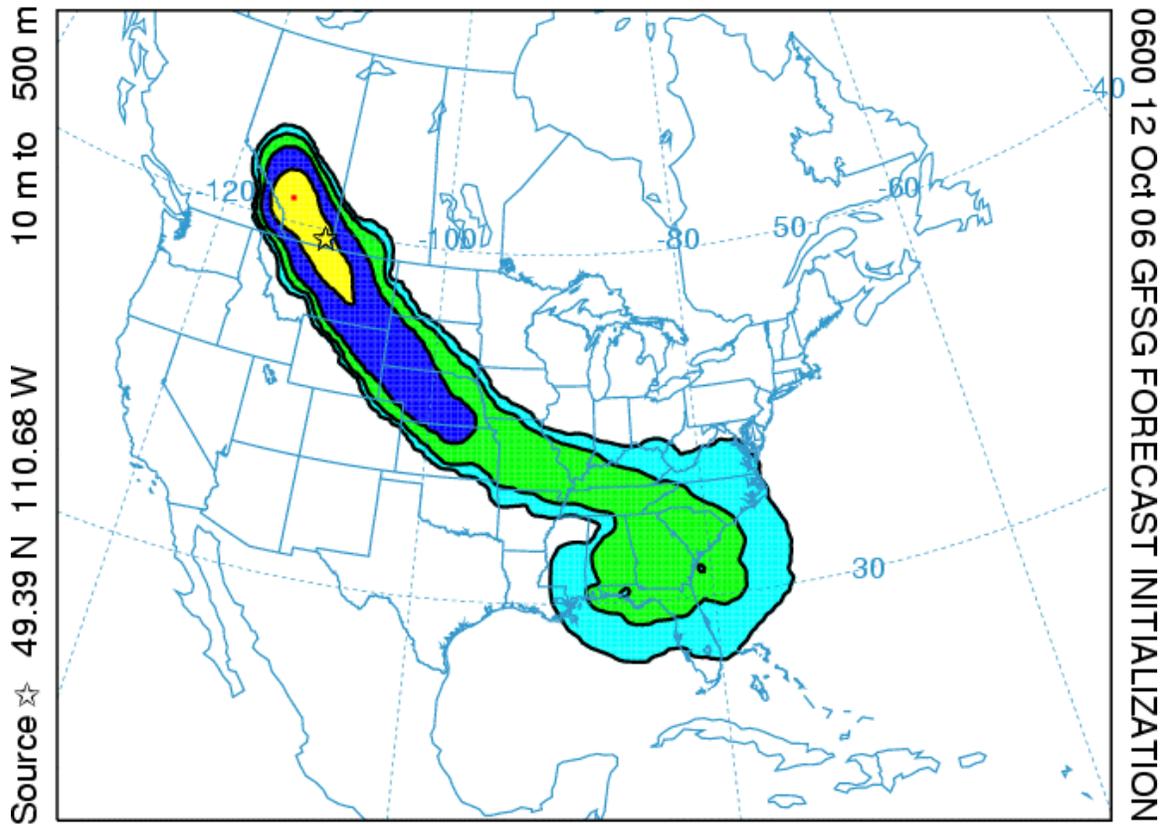


Issued: 1310UTC 12/10/2006 (day/month/year) RSMC Washington - NOAA ARL / NCEP  
 Source:MANYBERRIES\_AB\_CANADA lat:49.39 lon:-110.68 hgt:10 to 500 m  
 Release ID:C137 Rate:0.1667/hr Duration:6.0 hr Particles:500  
 Distribution: Uniform between 10 and 500 m AGL  
 Dry Deposition Rate:.001 m/s Wet Removal (below/in-cloud):5.0E-5/3.2E+5  
 Meteorology: GFS  
 Note: Contour values may change from chart to chart  
 Note: RESULTS BASED ON DEFAULT INITIAL VALUES  
 Response: EXERCISE EXERCISE EXERCISE

**Figure 4. Second 24-hour average exposure forecast for a hypothetical accident in Alberta, Canada.**

### NOAA HYSPLIT MODEL

Exposure (Bq-s/m<sup>3</sup>) averaged between 0 m and 500 m  
 Integrated from 0000 14 Oct to 0000 15 Oct 06 (UTC)  
 C137 Release started at 0900 12 Oct 06 (UTC)

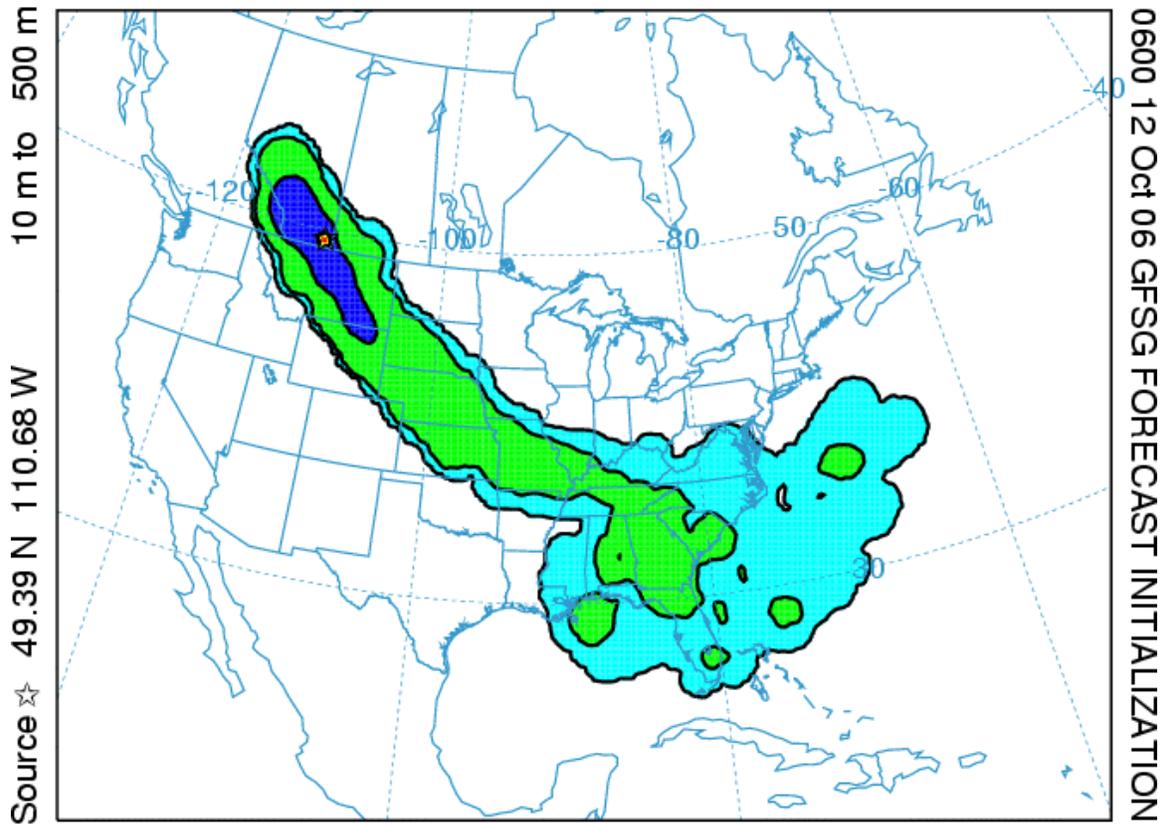


Issued: 1310UTC 12/10/2006 (day/month/year) RSMC Washington - NOAA ARL / NCEP  
 Source:MANYBERRIES\_AB\_CANADA lat:49.39 lon:-110.68 hgt:10 to 500 m  
 Release ID:C137 Rate:0.1667/hr Duration:6.0 hr Particles:500  
 Distribution: Uniform between 10 and 500 m AGL  
 Dry Deposition Rate:.001 m/s Wet Removal (below/in-cloud):5.0E-5/3.2E+5  
 Meteorology: GFS  
 Note: Contour values may change from chart to chart  
 Note: RESULTS BASED ON DEFAULT INITIAL VALUES  
 Response: EXERCISE EXERCISE EXERCISE

**Figure 5. Third 24-hour average exposure forecast for a hypothetical accident in Alberta, Canada.**

# NOAA HYSPLIT MODEL

Deposition (Bq/m<sup>2</sup>) at ground-level  
Integrated from 0000 12 Oct to 0000 15 Oct 06 (UTC)  
C137 Release started at 0900 12 Oct 06 (UTC)



Issued: 1310UTC 12/10/2006 (day/month/year) RSMC Washington - NOAA ARL / NCEP  
Source:MANYBERRIES\_AB\_CANADA lat:49.39 lon:-110.68 hgt:10 to 500 m  
Release ID:C137 Rate:0.1667/hr Duration:6.0 hr Particles:500  
Distribution: Uniform between 10 and 500 m AGL  
Dry Deposition Rate:.001 m/s Wet Removal (below/in-cloud):5.0E-5/3.2E+5  
Meteorology: GFS  
Note: Contour values may change from chart to chart  
Note: RESULTS BASED ON DEFAULT INITIAL VALUES  
Response: EXERCISE EXERCISE EXERCISE

Figure 6. Total surface deposition forecast for a hypothetical accident in Alberta, Canada.