

RSMC WASHINGTON USER'S INTERPRETATION GUIDELINES ATMOSPHERIC TRANSPORT MODEL OUTPUTS

(July 2010)

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 forecasts¹. Some of the primary operational products are produced by the Global Data Assimilation System^{2,3}, which uses the Global Forecast System (GFS) model for the forecast^{4,5,6}. 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)⁷ 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

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

² Kleist, D.T., D.F. Parrish, J.C. Derber, R. Treadon, W.-S. Wu, and S. Lord, 2008: Implementation of a new 3DVAR analysis as part of the NCEP global data assimilation system. *Wea. Forecasting.*, 24, 1691-1705

³ 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.

⁴ 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>.

⁵ Kalnay, M. Kanamitsu, and W.E. Baker, 1990: Global numerical weather prediction at the National Meteorological Center, *Bull. Amer. Meteor. Soc.*, 71, 1410-1428.

⁶ Han, J., and H.-L. Pan, 2010: Revision of convection and vertical diffusion schemes in the NCEP global forecast system. Submitted to *Mon. Wea. Rev.*

⁷ Dimego, G, 2006: Briefing on WRF in NAM, <http://www.emc.ncep.noaa.gov/WRFinNAM/>

model, in addition to being distributed via facsimile, are automatically downloaded to ARL's web server for access via a username and password.

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)⁸ model is routinely used for many of the long-range dispersion modeling studies conducted by ARL⁹. 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 WMO¹⁰, 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 SOUTH TEXAS, TEXAS, UNITED STATES;

⁸ 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.

⁹ 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.

¹⁰ WMO, 2006: World Weather Watch, Environmental Emergency Response Activities. <http://www.wmo.int/web/www/DPFSERA/EmergencyResp.html>.

- (2): It is located at latitude 28.80 degrees North and at longitude 96.05 degrees West;
- (3): and the hypothetical release started at 1200 UTC on 10 June 2010.

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. 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 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 1200 UTC 10 June to 1200 UTC on 13 June. 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

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RSMC products created Thu Jun 10 12:34 UTC 2010

The following charts will follow:

- trajectory map
- several 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: SOUTH_TEXAS-1 lat 28.80 lon -96.05

Release Start (YYYY MM DD HH MM): 2010 06 10 12 00

Meteorology: 0600 UTC 10 Jun 2010 GFS

Trajectories: 500.0, 1500.0, 3000.0 m AGL

Release ID: 1131 Rate: 5.0E16 Bq/hr Duration: 6.0 hr Particles: 500

Distribution: Uniform between 10 and 500 m AGL

Dry Deposition Rate: 0.02 m/s Wet Removal (below/in-cloud): 1.00E-04/3.20

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 12 UTC 10 Jun 10
 06 UTC 10 Jun GFSG Forecast Initialization

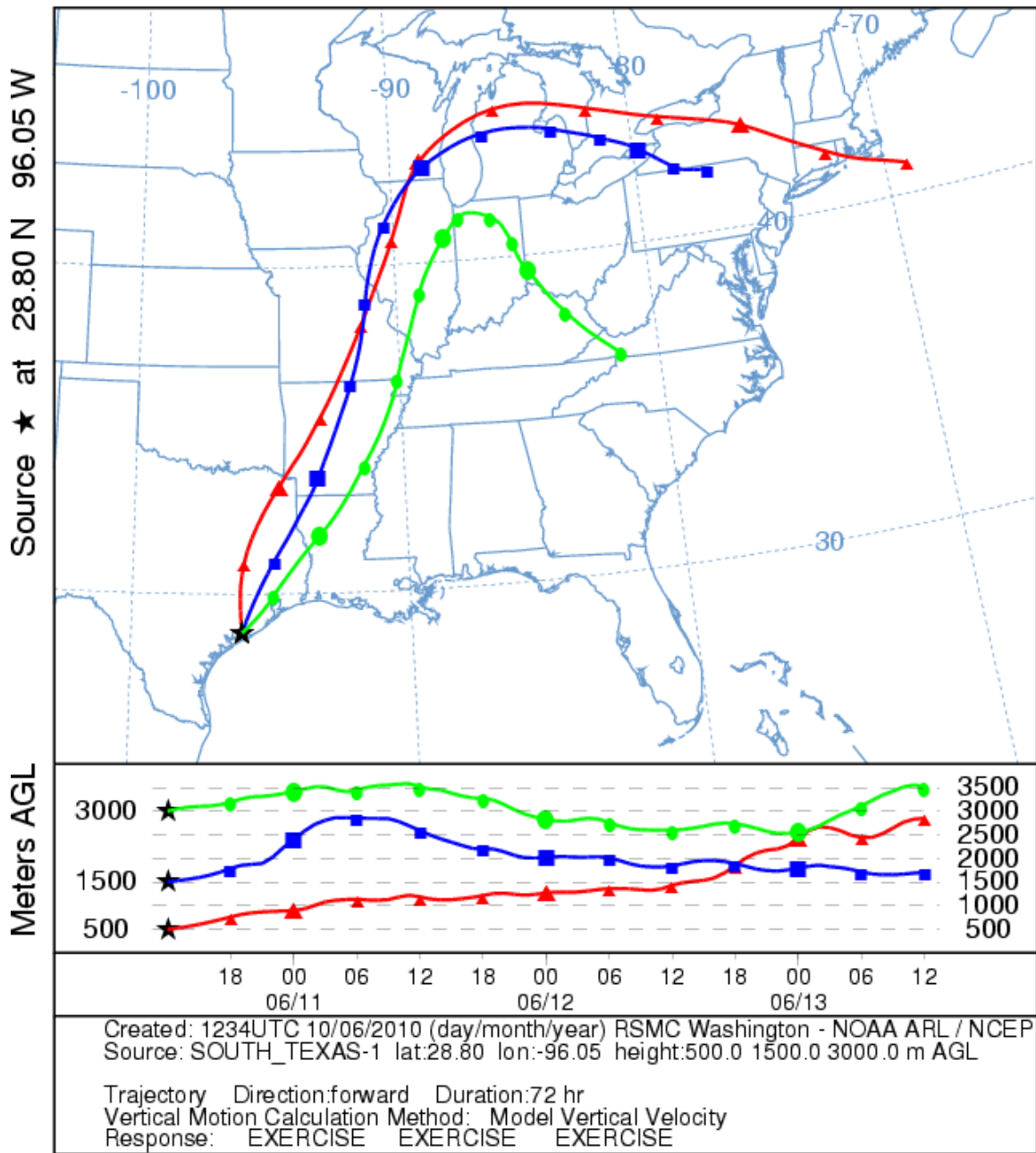


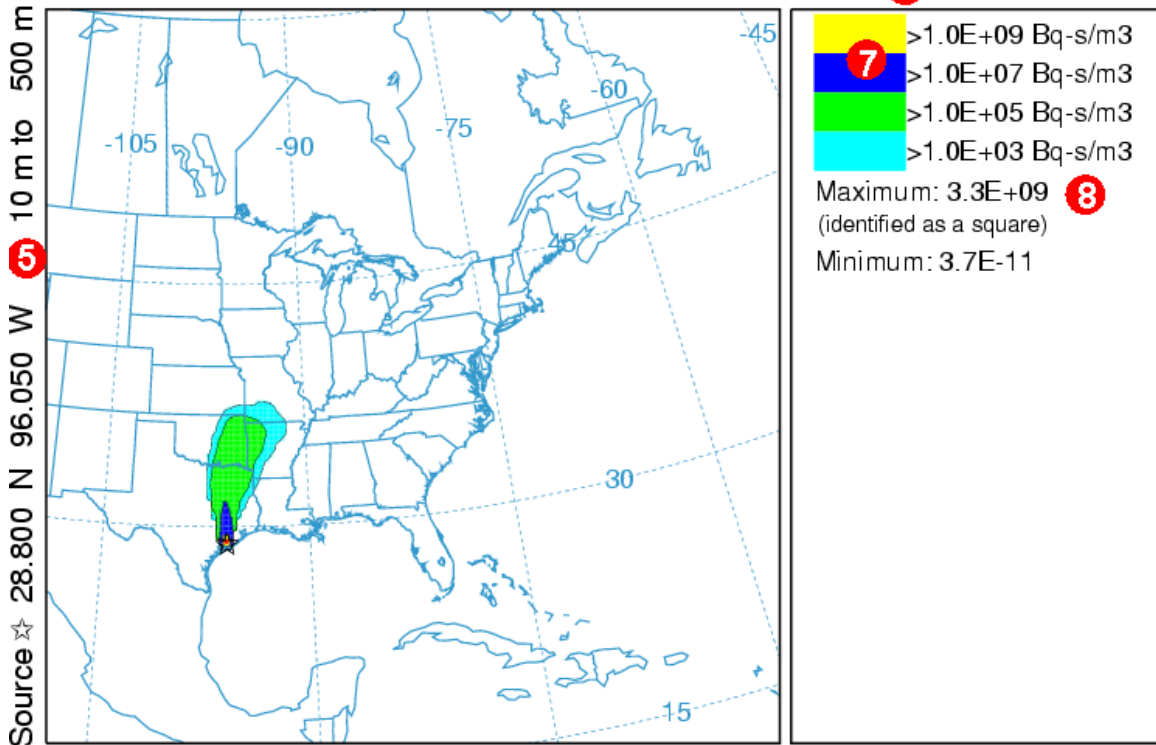
Figure 2. Horizontal and vertical projection of the 500, 1500, and 3000 meter above ground level forecast air parcel trajectories.

1 NOAA HYSPLIT MODEL

Exposure (Bq-s/m³) averaged between 0 m and 500 m **2**

Integrated from 1200 10 Jun to 1200 11 Jun 10 (UTC)

3 I131 Release started at 1200 10 Jun 10 (UTC) **4**

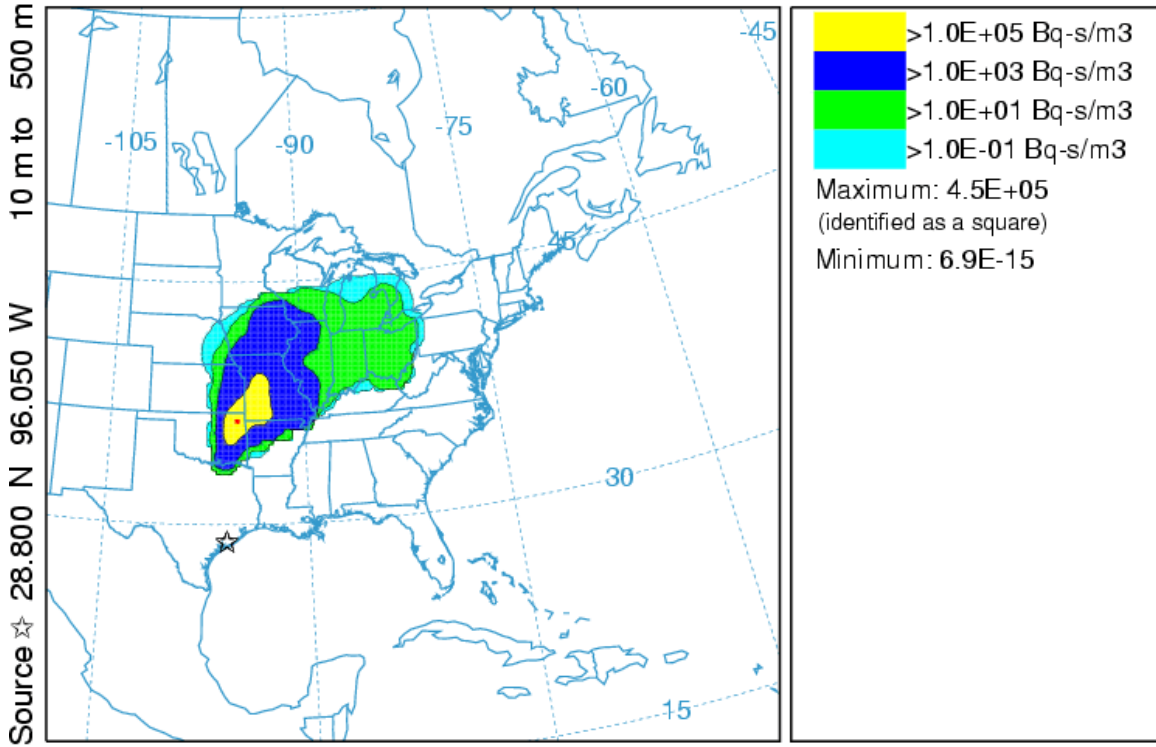


Created: 1234UTC 10/06/2010 (day/month/year) RSMC Washington - NOAA ARL / NCEP
Source: SOUTH_TEXAS-1 lat:28.80 lon:-96.05 hgt:10 to 500 m
Release ID:I131 Rate: 5.0E16 Bq/hr Duration: 6.0 hr Particles: 500
Distribution: Uniform between 10 and 500 m AGL
Dry Deposition Rate:0.02 m/s Wet Removal (below/in-cloud):1.00E-04/3.20E+05 **9**
Meteorology: 0600 UTC 10 Jun 2010 GFS
Note: Contour values may change from chart to chart
Note: RESULTS BASED ON DEFAULT INITIAL VALUES
Response: EXERCISE EXERCISE EXERCISE

Figure 3. First 24-hour average exposure forecast for a hypothetical accident in South Texas, USA. 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/m³) averaged between 0 m and 500 m
Integrated from 1200 11 Jun to 1200 12 Jun 10 (UTC)
I131 Release started at 1200 10 Jun 10 (UTC)



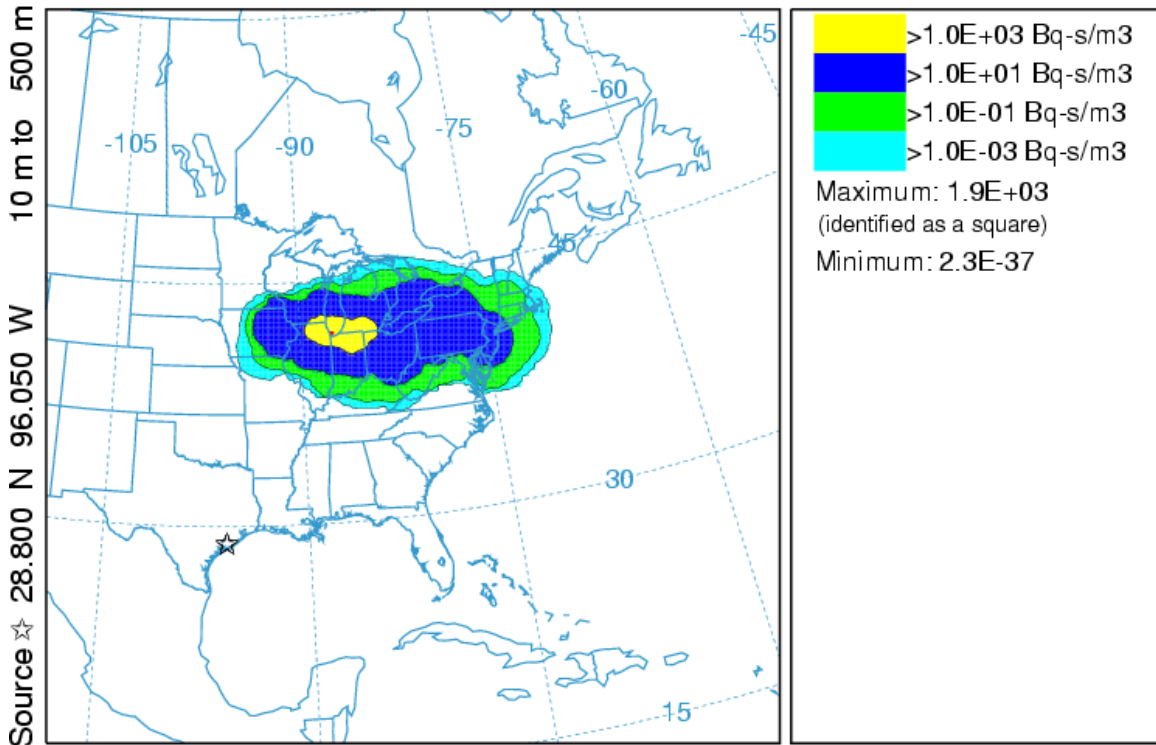
0600 10 Jun 10 GFSG FORECAST INITIALIZATION

Created: 1234UTC 10/06/2010 (day/month/year) RSMC Washington - NOAA ARL / NCEP
Source: SOUTH_TEXAS-1 lat:28.80 lon:-96.05 hgt:10 to 500 m
Release ID:I131 Rate: 5.0E16 Bq/hr Duration: 6.0 hr Particles: 500
Distribution: Uniform between 10 and 500 m AGL
Dry Deposition Rate:0.02 m/s Wet Removal (below/in-cloud):1.00E-04/3.20E+05
Meteorology: 0600 UTC 10 Jun 2010 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 South Texas, USA.

NOAA HYSPLIT MODEL

Exposure (Bq-s/m³) averaged between 0 m and 500 m
Integrated from 1200 12 Jun to 1200 13 Jun 10 (UTC)
I131 Release started at 1200 10 Jun 10 (UTC)



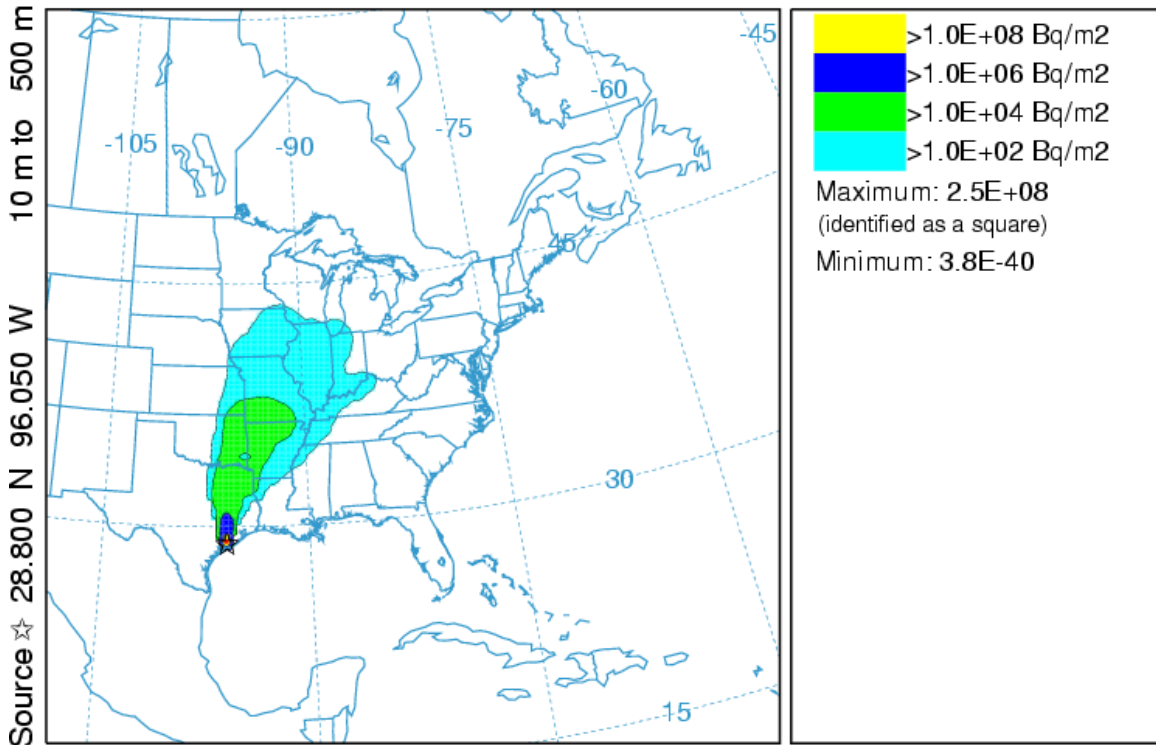
0600 10 Jun 10 GFSG FORECAST INITIALIZATION

Created: 1234UTC 10/06/2010 (day/month/year) RSMC Washington - NOAA ARL / NCEP
Source: SOUTH_TEXAS-1 lat:28.80 lon:-96.05 hgt:10 to 500 m
Release ID:I131 Rate: 5.0E16 Bq/hr Duration: 6.0 hr Particles: 500
Distribution: Uniform between 10 and 500 m AGL
Dry Deposition Rate:0.02 m/s Wet Removal (below/in-cloud):1.00E-04/3.20E+05
Meteorology: 0600 UTC 10 Jun 2010 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 South Texas, USA.

NOAA HYSPLIT MODEL

Deposition (Bq/m²) at ground-level
Integrated from 1200 10 Jun to 1200 13 Jun 10 (UTC)
I131 Release started at 1200 10 Jun 10 (UTC)



0600 10 Jun 10 GFSG FORECAST INITIALIZATION

Created: 1234UTC 10/06/2010 (day/month/year) RSMC Washington - NOAA ARL / NCEP
Source: SOUTH_TEXAS-1 lat:28.80 lon:-96.05 hgt:10 to 500 m
Release ID:I131 Rate: 5.0E16 Bq/hr Duration: 6.0 hr Particles: 500
Distribution: Uniform between 10 and 500 m AGL
Dry Deposition Rate:0.02 m/s Wet Removal (below/in-cloud):1.00E-04/3.20E+05
Meteorology: 0600 UTC 10 Jun 2010 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 South Texas, USA.