RSMC WASHINGTON
USER'S INTERPRETATION GUIDELINES
ATMOSPHERIC TRANSPORT MODEL OUTPUTS

(January 2015)

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[1]. 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[4,5,6,12]. Another system, over North America, is the North American Mesoscale (NAM)[7,8], which uses the Weather Research and Forecasting version of the Non-hydrostatic Mesoscale Model (WRF-NMM) for its forecast.

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 higher resolution nested grids (NMMB). Prior to the September 30, 2014 NWS implementation, the default meteorology was the 1 degree GFS, since then it is the half-degree GFS. Note the half-degree model outputs are 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.

The NAM 12 km Non-hydrostatic Multiscale Meteorological Model on the Arakawa B staggering grid (NMMB[8]) became NCEP’s operational North American Mesoscale model in October 2011, replacing the previous operational model, Weather Research and Forecasting (WRF) NMM[7]. 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. Unlike its predecessor, the NMMB model is formulated on the Arakawa B grid using a generalized hybrid vertical coordinate, and it can be applied at global scales. Among all the upgrades in NMMB, the most important change for dispersion predictions is the use of a more recent Land Use Land Cover (LULC) database with more expansive urban areas, based on the Moderate Resolution Imaging Spectro-radiometer (MODIS) measurements for the years 2001-2005, which replaced the USGS (U.S. Geological Survey) LULC data based on the Advanced Very High Resolution Radiometer (AVHRR) measurement for the years 1992-1993. Changes in LULC can impact dispersion predictions through a variety of mechanisms, including modulation dry deposition velocities, or by modifying planetary boundary layer (PBL) height and eddy diffusivity coefficients.

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 7 days are maintained at NCEP for historical calculations. The graphics produced by the dispersion model, in addition to being distributed via email and facsimile, are automatically downloaded to a 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)[9] model is routinely used for many of the long-range dispersion modeling studies conducted by ARL[10]. 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[11], 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 through 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 PALO VERDE, ARIZONA, UNITED STATES;

(2): It is located at latitude 33.387 degrees North and at longitude 112.865 degrees West;

(3): and the hypothetical release started at 1200 UTC on 09 October 2014.

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

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. In this case, the release rate was 4.5E+16 Bq per hour over one hour. 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, however this release was over only one hour.

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. This release was between the surface and 10 meters above the ground.

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 09 October to 1200 UTC on 14 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.

6. References

[1] http://www.nco.ncep.noaa.gov/pmb/products/.

[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] Zheng, W., H. Wei, Z. Wang, X. Zeng, J. Meng, M. Ek, K. Mitchell, and J. Derber, 2012: Improvement of daytime land surface skin temperature over arid regions in the NCEP GFS model and its impact on satellite data assimilation. J. Geophys. Res., 117, D06117, doi:10.1029/2011JD015901.

[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] Yang F., H-L Pan, S. Krueger, S. Moorthi, S.J. Lord, 2006: Evaluation of the NCEP Global Forecast System at the ARM SGP Site. Monthly Weather Review. 134, No. 12, 3668-3690.

[6] Han, J., and H.-L. Pan, 2011: Revision of Convection and Vertical Diffusion Schemes in the NCEP Global Forecast System. Weather and Forecasting, 26, 520-533.

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

[8] Janjic, Z. and 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)

[9] 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.

[10] 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.

[11] WMO, 2006: World Weather Watch, Environmental Emergency Response Activities. http://www.wmo.int/pages/prog/www/DPFSERA/EmergencyResp.html.

[12] http://www.emc.ncep.noaa.gov/GFS/ref.php

U.S. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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RSMC products created Thu Oct 09 12:50 UTC 2014

The following charts will follow:

- trajectory map
- several time-itegrated concentration maps
- several deposition (dry + wet) maps

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:PALO_VERDE lat:33.386855 lon:-112.865115
Release Start (YYYY MM DD HH MM):2014 10 09 12 00
Meteorology: 0600 UTC 09 Oct 2014 GFS
Trajectories: 500.0 1500.0 3000.0 m AGL
Release ID:C137 Rate: 4.5E+16 Bq/hr Duration: 1.0 hr Particles: 500
Distribution: Uniform between 10 and 10 m AGL
Dry Deposition:Yes Wet Removal:Yes
Note: Contour values may change from chart to chart

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

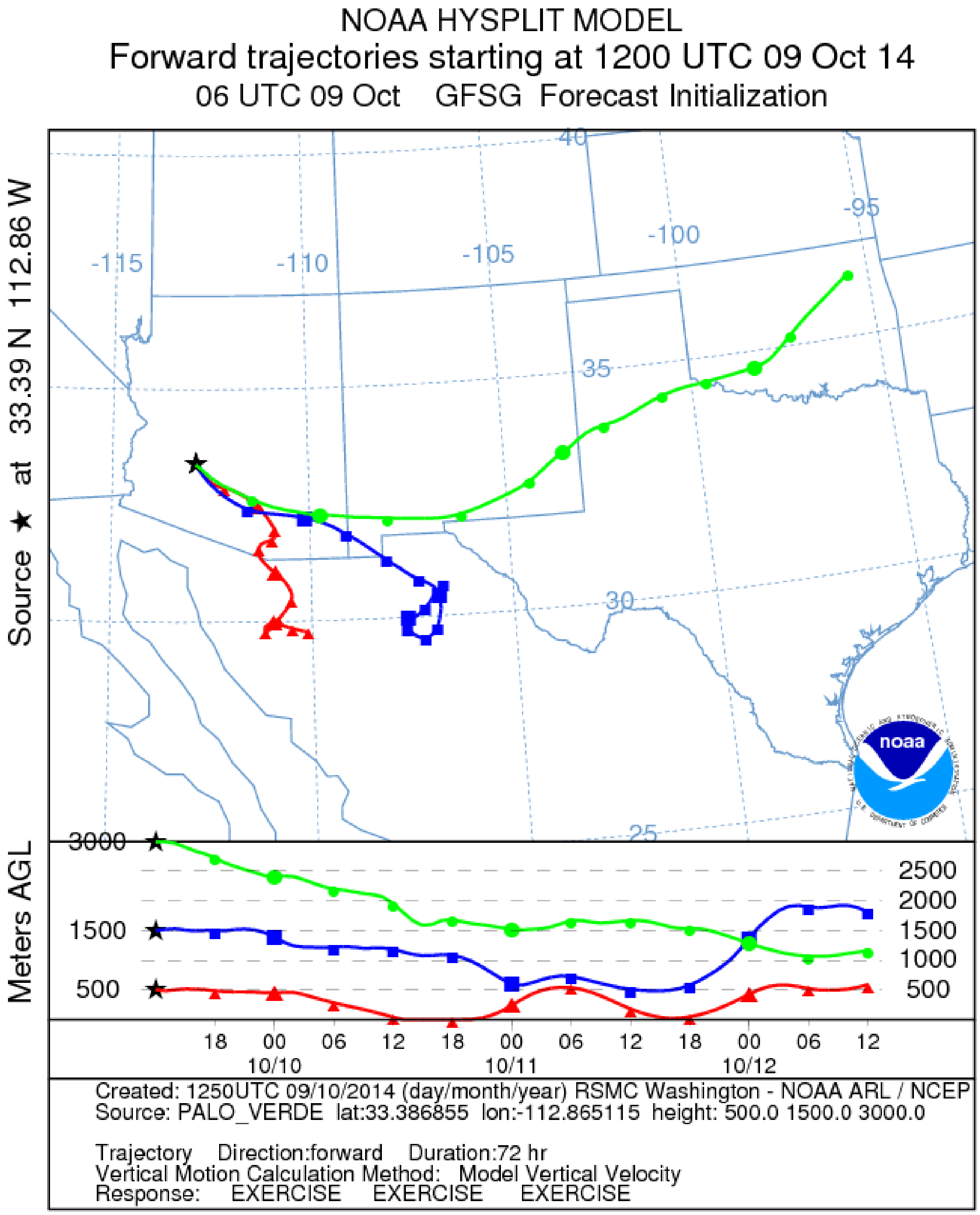

Figure 2. Horizontal and vertical projection of the 500, 1500, and 3000 meter above ground level forecast air parcel trajectories.

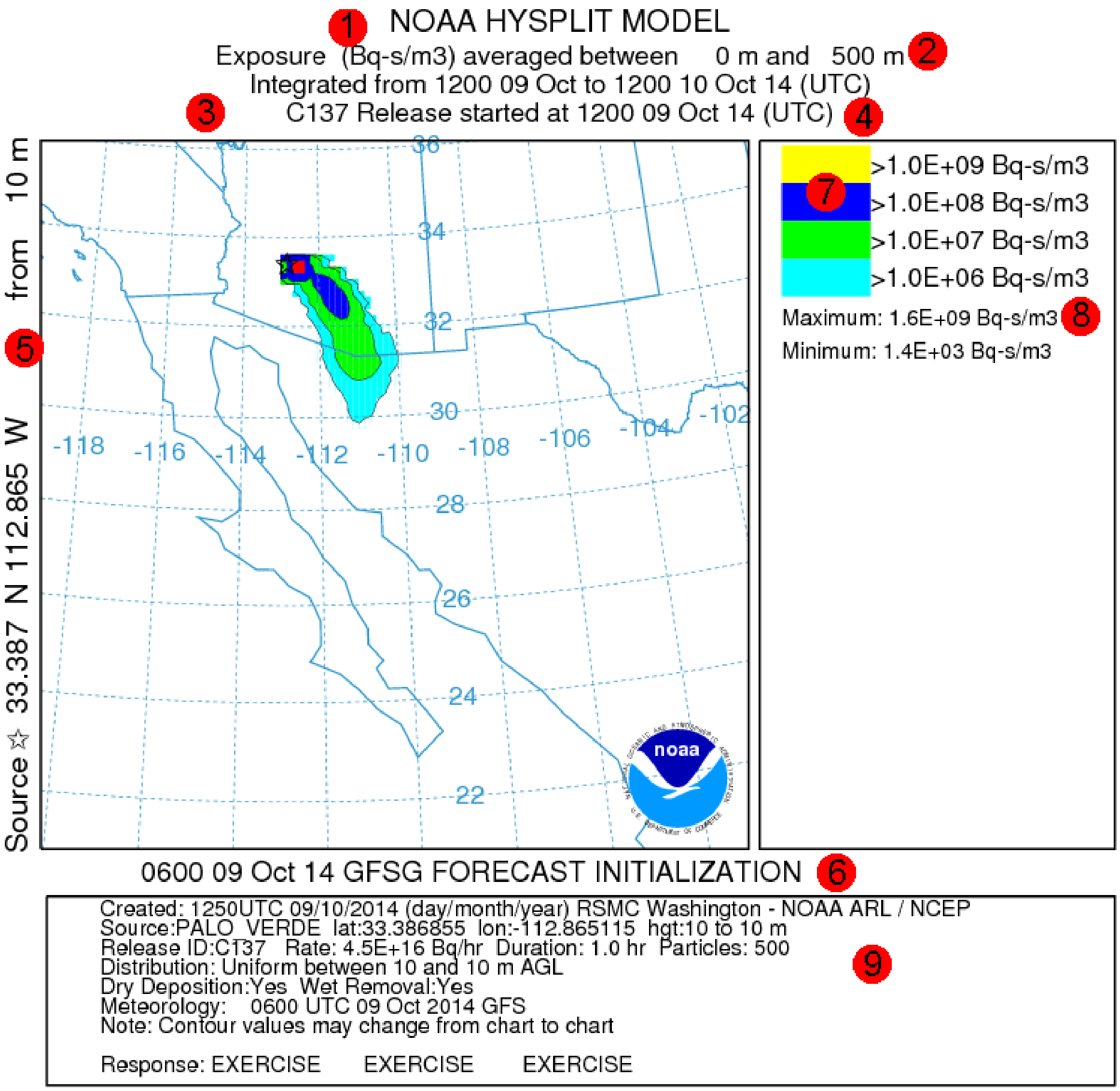

Figure 3. First 24-hour average exposure forecast for a hypothetical accident at Palo Verde, Arizona, USA. The red circled numbers are for reference in this document only and do not appear on the forecast products.

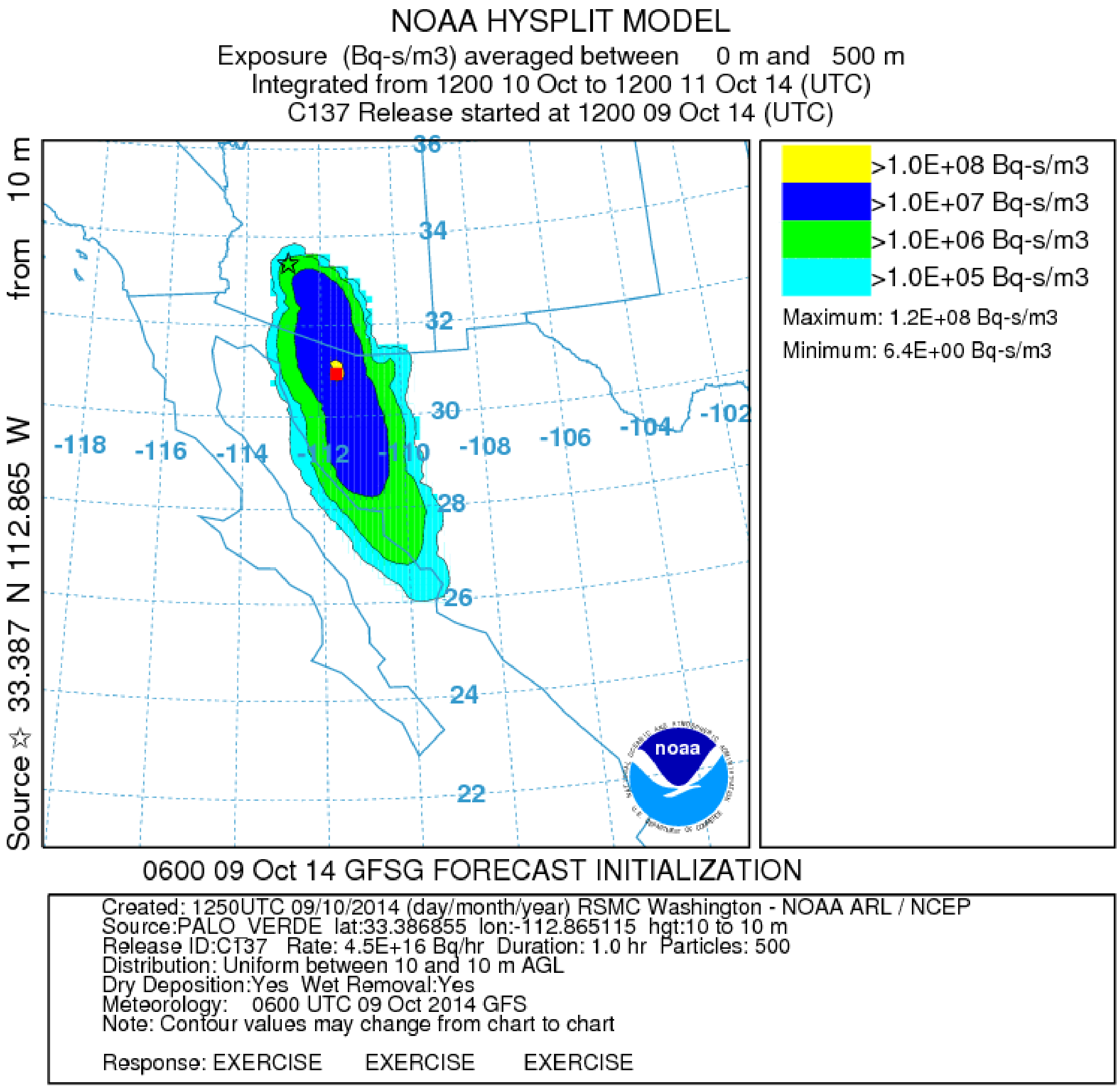

Figure 4. Second 24-hour average exposure forecast for a hypothetical accident at Palo Verde, Arizona, USA.

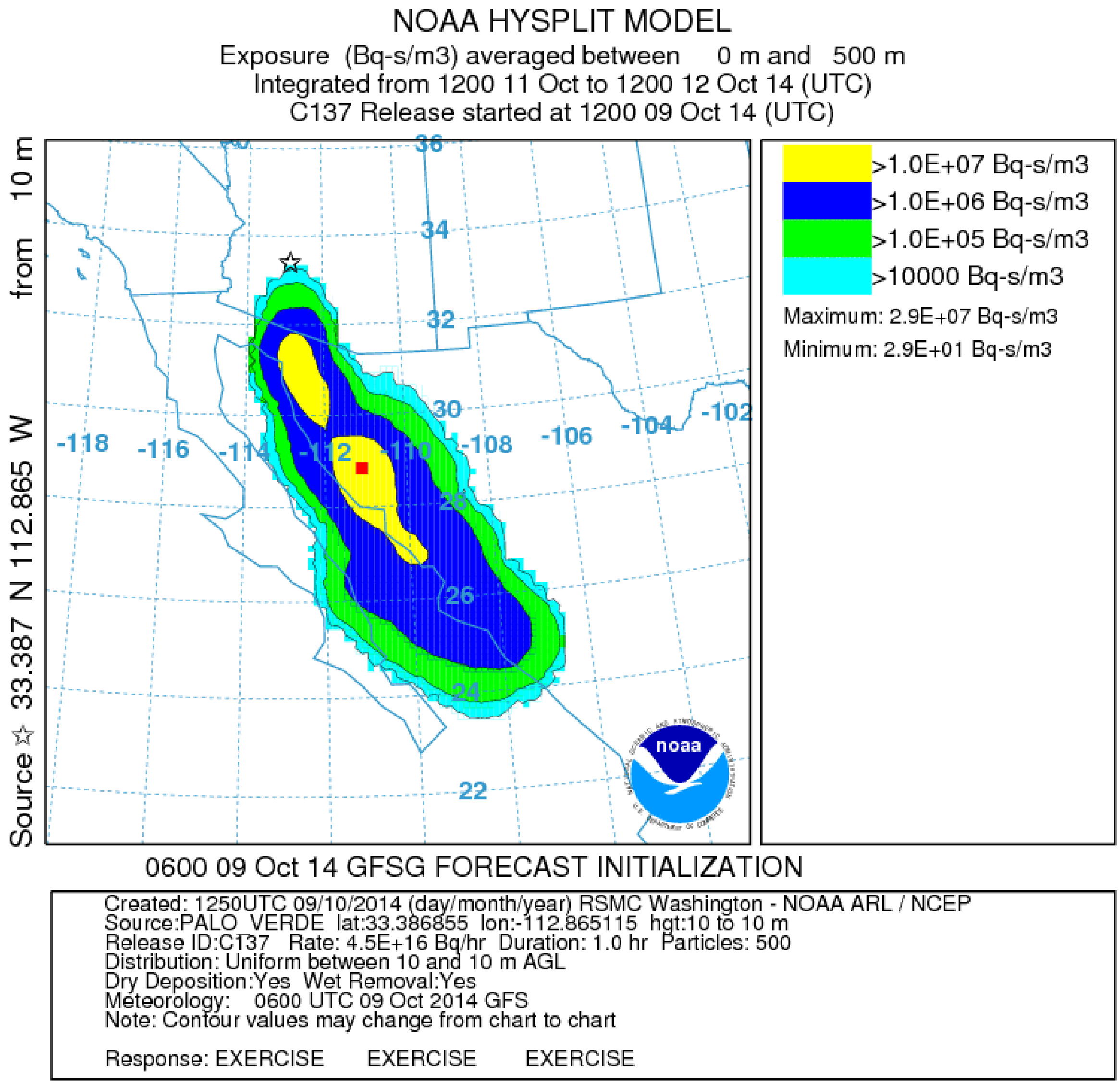

Figure 5. Third 24-hour average exposure forecast for a hypothetical accident at Palo Verde, Arizona, USA.

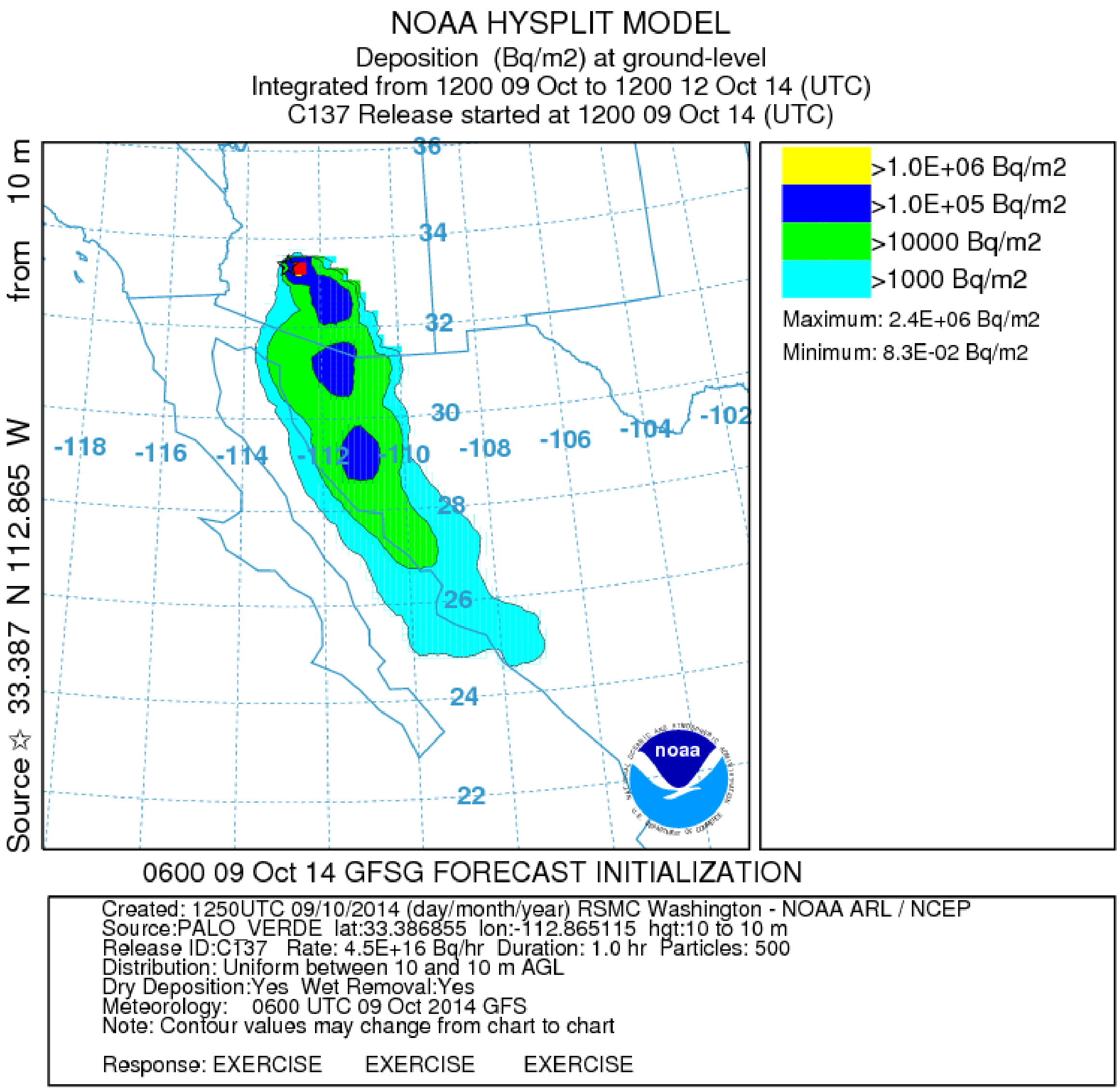

Figure 6. Total surface deposition forecast for a hypothetical accident at Palo Verde, Arizona, USA.