Office of the Federal Coordinator for Meteorological Services and Supporting Research

Special Session, 17th Annual George Mason University (GMU) Atmospheric Transport and Dispersion Modeling Conference

Progress in Governmental Atmospheric Transport and Dispersion Modeling and Response

This document provides a summary of the OFCM-sponsored special session within the 17th Annual GMU Atmospheric Transport and Dispersion Modeling Conference. The session was chaired and moderated by Mr. Mark W. Miller, Development Group Supervisor, Department of Commerce (DOC)/National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS)/Office of Response & Restoration (OR&R), Seattle, WA. The conference was held on the GMU campus in Fairfax, VA, and the session was conducted on June 25, 2013. The summary report has three sections, which are outlined as follows:

- **Section I - Overview**
  - Purpose and Theme
  - Objectives
  - Key Takeaways
- **Section II - Session Synopsis**
  - Opening Remarks and Presentations
  - Question-and-Answer (Q&A) Period
- **Section III - Outcomes**
  - Next Steps
  - Tentative Location for Next Year's GMU Modeling Conference

I. OVERVIEW

Purpose and Theme:

The OFCM participates in the annual GMU modeling conference and routinely sponsors a session to inform attendees on the status and future plans of the Federal government's atmospheric transport and dispersion (ATD) modeling efforts. Accordingly, this year's session provided a forum for the responsible Federal agencies, together with representatives of the user communities, to review the Nation's ATD modeling efforts and to make recommendations on future ATD model improvements, as well as improvements to services and products derived from ATD model output.

This year's session reviewed the Federal meteorological community's ongoing work and progress in governmental response and requirements in the area of ATD modeling and response. The theme of the session was *Progress in Governmental Atmospheric Transport and Dispersion Modeling and Response.* Reflecting the strong partnerships built over many years, the session had 44 attendees, including representatives from the following Federal agencies: DOC/NOAA, the Department of Defense ((DoD) the U.S. Army, the Defense Threat Reduction Agency (DTRA), the Department of Energy (DOE), and the Department of Homeland Security (DHS). Attendees also included representatives from academia, industry, State and local governments, and the emergency management community.

All presentations can be found at in a section of the OFCM web site dedicated to the conference.

Objectives: The session was structured to address the following objectives:

1. Current status: Discussion of roles in Federal ATD modeling, responsibilities, and governance; status of existing modeling capabilities; and how model output is provided to decision makers.
2. Advances: Discussion of improvements made in the past year to models or processes.
3. Gaps: Discussion of known areas of basic research, model development, and tool development that are the highest priorities to address.
4. Where we need to go: Discussion of topics and areas of concern the community should pursue or continue to pursue.

Key Takeaways:

1. **Objective #1.** Session presenters reviewed their recent experiences in applying dispersion models to operational scenarios. Federal dispersion models have been used to provide information relative to both routine and highly publicized environmental events, including the following examples:
   - Several organizations (e.g., NOAA and DoD) applied in-house ATD models to support World Meteorological Organization (WMO) and DoD requirements to ascertain the likely atmospheric dispersion of radioactive particles following the 2011 Fukushima Dai-ichi nuclear power plant incident in Japan.
   - The IMAAC provided chemical release incident support during the 2012 West Point, Kentucky, train derailment.
   - Results from NOAA dispersion models supported Federal resource deployment decisions following the 2010 Deepwater Horizon oil well blowout in the Gulf of Mexico.
   - NOAA dispersion models support the Comprehensive Test Ban Treaty Organization.

2. **Objective #2.** Key takeaways, concerning improvements made in the past year to models or processes, from the session presentations and the Q&A period:
   - The integration of ALOHA's source estimation models with HYSPLIT's dispersion routines significantly expands the scale of chemical releases that can be modeled for emergency response.
   - Funding through the [Hurricane] Sandy Supplemental has enabled the enhancement of the Weather and Climate Operational Supercomputing System (WCCOSS) Phase 2 capability, which focuses on mesoscale, regional, and shorter-range meteorological ensemble models and which should provide movable 1-km grid nests out to 18 hours by 2018.

- Enhanced boundary layer parameterization is both a technical challenge and an opportunity for model improvements.
- No model can be evaluated independent of the context in which it will be used.
- First responders view dispersion model output as a critical factor in initially estimating the size and scope of a potentially hazardous environmental event and in the attendant decision to deploy, and how to deploy, appropriate resources.
- Evaluating, characterizing, and communicating uncertainty associated with ATD model output is critical. Evaluating, characterizing, and communicating uncertainty associated with other areas, such as predictions of health effects and economic value (e.g., performance over different cost/lost ratios), should also be considered.
- NOAA updated the Areal Locations of Hazardous Atmospheres (ALOHA) model to better estimate the hazards associated with fires and explosions.
- To improve support for military operations in Middle East urban areas, DTRA has developed a second urban model, called the Microswift/Spray (MSS) model. The MSS model is a microscale model that yields improved spatial and temporal scale interactions between DoD meteorological and ATD models (e.g., it bridges the scale gap). As a result, the MSS model is used by DoD to calculate detailed flow and dispersion around individual buildings.
- To address an issue with over-prediction of hazardous chlorine gas in Middle East urban areas, DTRA collaborated with the Air Force Research Laboratory and ENSCO, Inc. to develop the Degrade model, which detects a limited set of toxic industrial chemicals (TIC). Degrade model results have already been incorporated into the Hazard Prediction and Assessment Capability (HPAC) model run. Plans to incorporate Degrade output into the Joint Effects Model (JEM) run are pending.
- The NOAA/National Weather Service National Centers for Environmental Prediction (NCEP) introduced the National Environmental Modeling System in 2011as part of the National Unified Operational Predication Capability (NUOPC) with the Navy and the Air Force. This system has a 4-km grid over the contiguous United States (CONUS), a 3-km grid over Hawaii and Puerto Rico, and a 6-km grid over Alaska. Further system development is ongoing.

3. **Objective #3.** The following key takeaways were derived from the presenters, reviewing known areas of basic research, model development, and tool development that are the highest priorities to address:
   - ATD, ocean deposition, and ocean dispersion were clearly manifested in environmental events following such occurrences as the 2011 Fukushima Dai-ichi nuclear power plant incident and the 2010 Deepwater Horizon oil well blowout. These interrelated and interactive environmental dynamics underscore the need for a concerted effort to advance coupled ocean-atmospheric modeling.
   - In consideration of particle transport and diffusion as it relates to health, NOAA is investigating the feasibility of modifying existing, or developing new, ATD models with the goal of deriving improved insight into small particle (e.g., atmospheric dust particle) transport and diffusion.

4. **Objective #4.** Key takeaways regarding directions in which the community needs to move:

- Some attention should be focused on information-sharing challenges that need to be overcome. The Interagency Modeling and Atmospheric Assessment Center (IMAAC) helps address this for the most significant events, but routine information sharing between distinct research and operational communities could be improved.
- There are education and training concerns for developing the next generation of skilled personnel who can work in a complex interagency and interdisciplinary field.
- Partnerships between Federal and State governments, academia, and industry should be supported and further developed.
- Further investments may achieve great returns for public safety, public health, and environmental stewardship. However, priority-setting by the Federal partners among these investments during a period of fiscal uncertainty will be difficult at best.

II. SESSION SYNOPSIS

The session consisted of opening remarks by the session chair and presentations from six invited speakers. A Q&A period followed each presentation. Slides from session presentations are available on the OFCM Web site.

Opening Remarks and Session Presentations

1. **Session Opening Remarks:** Mr. Mark W. Miller, Development Group Supervisor, DOC/NOAA/NOS/OR&R, Seattle, WA, opened the session, stating that prior OFCM-sponsored interdepartmental efforts helped shape the session and its overall purpose. Accordingly, he reminded the attendees that:
   - The session was a follow-on activity based on interdepartmental ATD modeling requirements captured in the OFCM publications *Atmospheric Modeling of Releases from Weapons of Mass Destruction: Response by Federal Agencies in Support of Homeland Security* and *Federal Research and Development Needs and Priorities for Atmospheric Transport and Diffusion Modeling*, published in 2002 and 2004, respectively.
   - The requirements articulated in those documents resulted in interagency goals and supported coordinated agency objectives.[1]
   - Consequently, the purpose of the session was to examine the progress and challenges that agencies have faced toward achieving the aforementioned goals and objectives.

2. **Invited Presentations:**

   - **Dr. Ivanka Stajner**, Physical Scientist, DOC/NOAA/NWS/Office of Science & Technology (OS&T), Silver Spring, MD. Dr. Stajner supported Mr. Miller’s statements and further noted that support is provided as needed for volcanic ash

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1 The two interagency goals are: (1) interpret ATD model uncertainty and (2) routinely quantify ATD model uncertainty. The six coordinated agency objectives are: (1) capture and use existing data sets, (2) develop standards for evaluating modeling system performance, (3) improve the spatial and temporal scale interactions between meteorological and ATD models (i.e., bridge the scale gap), (4) improve measurement capabilities, (5) implement ATD test beds, and (6) site local/regional instrumentation that will reasonably represent wind and turbulence fields needed for ATD concentration fields.

dispersion and, in specific cases, for radiologic releases. Dr. Stajner's presentation highlighted recent experience in applying dispersion models in operational and as-needed scenarios, model improvements, model verification efforts, and model improvement requirements. Her presentation also:

- Provided examples of how the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model was used to (a) predict smoke concentrations associated with the May 2011 Arizona Wallow wildfire, (b) monitor and predict volcanic ash dispersion from the 2010 Eyjafjallajokull volcano eruption, and (c) run transport simulations (including ocean deposition) in response to the Fukushima Dai-ichi nuclear power plant incident;

- Enumerated new products resulting from new modeling capabilities, such as dust concentration predictions;

- Noted that the availability and use of new and existing products and data sets (e.g., Geostationary Operational Environmental Satellite aerosol/smoke products and NOAA experimental tracer data) have advanced ATD model verification efforts (with respect to simulated dust dispersion) from non-routine verification to daily verification over the CONUS; and

- Emphasized that accurate wind observations, inclusion of surface moisture variation, and better observational representation of smaller dust emission sources are essential to improving ATD model predictions.

Question-and-Answer Period:

Q: How is plume top height determined?
A: Plume height from satellite observations still has large uncertainty; it is determined from the model (HYSPLIT). There is no routine observation, but NEXRAD can be used, as was the case in 9/11 and the Puerto Rico fuel storage fire.

- **Mr. Mark Miller**, Development Group Supervisor, DOC/NOAA/NOS/OR&R, Seattle, WA. Mr. Miller presented an emergency management perspective on the Computer-Aided Management of Emergency Operations (CAMEO) system. He provided background on CAMEO, enumerated the latest upgrades to the system, reviewed model evaluation procedures and measures, and discussed completed and ongoing dispersion model integration efforts. His presentation included the following key points:

  - CAMEO is a system of four components, which are used to plan for and respond to chemical emergencies. The four components are (1) a database and information management tool, (2) a chemical reactivity prediction tool with attendant chemical response datasheets, (3) mapping applications for emergency response and for planning and executing local operational tasks, and (4) the ALOHA model.

- NOS uses the ALOHA model to evaluate releases of hazardous chemical vapors by estimating the downwind dispersion of a chemical cloud, based on the toxicological/physical characteristics of the released chemical, atmospheric conditions, and specific circumstances of the release.

- As a result of requirements listed in the aforementioned 2004 OFCM report, the ALOHA model has been successfully modified to simulate atmospheric dispersion resulting from fires and explosions.

- Work is underway to integrate the ALOHA model with the HYSPLIT model. The end result of this effort will be an integrated system that will use the ALOHA model to derive chemical characteristics and source strength estimates and will use the HYSPLIT model to forecast the atmospheric dispersion of those sources. The first phase of this integration (i.e., integrating web-based versions of the ALOHA model with the HYSPLIT model) is complete. Full integration—for small-scale releases and inclusion of the newly developed fire and explosion simulation capability—is expected to take approximately 18-24 months.

Question-and-Answer Period:

Q: Has the model been evaluated with short-duration event data (e.g., from the Prairie Grass experiment)?
A: No, but it has been verified with other tests.
Q: Is the model publicly available?
A: ALOHA can be exported publicly.

- **Dr. Geoff DiMego,** Supervisory Meteorologist, DOC/NOAA/NWS/NCEP, Camp Springs, MD. Dr. DiMego provided an overview of NCEP preliminary dispersion modeling plans, centered on the utilization of WCOSS. Specifically, he focused on model improvements and challenges, including the following highlights:

  - An increase from 80 teraFLOPS (TF, 10^{12} floating point operations per second [FLOPS]) to 200 TF is expected by the end of Phase 1 of WCOSS, planned for 2015. Phase 1 includes operational runs of the High Resolution Rapid Refresh (HRRR) model.

  - WCOSS Phase 2 ramps up the capacity of WCOSS to 2 petaLOPS (PF, 10^{15} floating point operations per second [FLOPS]) by 2018, allowing for convective data assimilation in the Weather Research and Forecast (WRF), and Non-hydrostatic Mesoscale Model on B grid (NMMB) numerical weather prediction models, in addition to storm-scale ensemble members for both CONUS and OCONUS. This represents more than a ten-fold increase over current computing capacity.

- The ATD-related focus of NCEP's modeling suite is weather support to particulate models for events such as the 2011 Fukushima Dai-ichi nuclear power plant incident and the 2010 Deepwater Horizon oil well blowout. Specifically, NCEP and the Air Resources Lab (ARL) in NOAA's Office of Oceanic and Atmospheric Research applied HYSPLIT to forecast long-range transport plumes emanating from the Fukushima Dai-ichi nuclear power plant. HYSPLIT model output from NCEP is publicly available on the Web.

- Funds from the Sandy Supplemental have enabled improvements to WCOSS, increasing node capacity ten-fold and allowing the WRF-NMM to run outside CONUS with 3 km horizontal resolution and irregular convection–allowing physics twice a day. The ensemble based on the HRRR, the HRRRE model will run a 13km/3km nested grid hourly.

- A simulation was presented of the June 2012 derecho event in the northeast United States at 1.33 km nested resolution and 10 min. temporal resolution.

- The NGAC aerosol model, which is under development, is based on NCAR's global aerosol model.

- Ensemble guidance needs to be developed by 2018 to address the need for sufficient member diversity.

Question-and-Answer Period:

Q: What is the temporal resolution of the HRRRE model?
A: Initially, HRRRE output will be hourly, but we would want to go to every 15 minutes eventually. Temporal resolution is constrained by compute time, disk storage, and bandwidth.
Q: What is the vertical extent of the global model?
A: The GFS extends to 0.1 mb. Work is underway to extend this to 800 km, where it will connect with space weather model.

- **Dr. Gayle Sugiyama,** Program Leader, DOE/National Atmospheric Release Advisory Center (NARAC), Lawrence Livermore National Laboratory (LLNL), Livermore, CA. Dr. Sugiyama discussed the following continuing developments at NARAC:

  - NARAC responds to hazardous atmospheric releases (chemical, biological, or radiological, C/B/R) at any time ("24/7/365") and runs different models for different application in support of DOE's National Nuclear Security Administration (NNSA), international partners, the U.S. Navy, and the National Aeronautical and Space Administration (NASA), with the goal of providing actionable information, including casualty and fatality estimation.

- Priorities include modeling for urban sheltering, user product communication, and supplementary analyses (e.g., plume impact chronology).

- NARAC can leverage other agency capabilities and has its own safety analysis and hazard assessment codes such as Hot Spot and Episode.

- Drivers include mission area requirements, interagency needs, lessons learned, science and technology developments (internal and external), customer feedback, and partnership concerns.

- NARAC has the following model development priorities:
  - Data-model fusion of numerical weather predictions, field data, data–model comparisons, and improved source estimation.
  - Improved model fidelity. Recent improvements include treatment of ballistic early ejecta (which acts to decrease some of the release “footprint”), nuclear cloud characterization, radionuclide inventories, and fallout fractionation.
  - Urban modeling. Need to resolve building-scale flow and dispersion, applying an efficient computational fluid dynamics code (e.g., AEOLUS), rapid grid generation algorithms, coupling to regional scale, infiltration, and leakiness model and data to provide estimates of building protection factors for gamma radiation.
  - Estimation and communication to users of uncertainty regarding source and physics used in modeling, using a variety of briefing products that exploit geographical information system (GIS) frameworks and various output formats.

- NARAC provided support to the Fukushima nuclear reactor incident, in which numerical weather prediction was key to accurate modeling of impacts.

- NARAC is collaborating with the Nuclear Regulatory Commission on improved nuclear power plant source estimation and data exchange.

- Model validation is an ongoing activity, relying on real-world events and analytic comparisons against known results, laboratory experiments, field studies, and operational testing.

- Transferability to operations uses DOE/LLNL software quality assurance (SQA) standards, extensive in-house and external testing, and accreditation.

- Ongoing challenges include improving CBRNE [chemical, biological, radiological, nuclear, and explosives] source terms and environmental interaction processes, development of multidisciplinary staff, and cost-effective user support, along with better weather, buoyant source, and fallout validation data; communicating with planners, decision makers, and responders; and development of realistic exercises.

Question-and-Answer Period:

Q: Does DOE do field surveys?
A: DOE does not field teams; it gathers information.

- **Ms. Betsie Chacko,** Deputy Director, DHS/IMAAC, and **Dr. Andy Grose**, DTRA, Ft. Belvoir, VA.

  – The mission of the IMAAC is to provide a single point for coordinating and disseminating Federal atmospheric modeling and hazard prediction products during actual or potential incidents among the various partner and member agencies.

  – The IMAAC is run by DTRA and staffed 24/7/365, can be activated by any public agency, and is the primary resource to respond to requests for information on CBRNE incidents.

  – The IMAAC can generate contingency scenarios, though these require many assumptions.

  – To inform the audience about how the IMAAC functions, Ms. Chacko gave an example of a real-world activation following the 30-car derailment in Jefferson County, KY, in Oct 2012. The IMAAC was activated and issued products, updating transport and dispersion of known released chemicals to local responders and participating emergency management officials.

Question-and-Answer Period:

Q: How do you deal with model uncertainty?
A: There are prescribed contours of uncertainty levels, and there is discussion of model uncertainty.
Q: How do you know what gases were released in the train derailment situation you described?
A: Chlorine and ammonia are very common in railcars, so these were assumed initially, though release species were later revised based on new data.
Q: Do you know how exposure time is determined in support of AEGL levels and mean?
A: AEGL versus time data are included in an output table produced by the model run.
Q: How are assumptions and ensemble output refined?
A: Model output is not directly given to decision makers; staff always interprets model and other data.
Q: What are the default non-railroad scenarios?
A: That is handled on a case-by-case basis.

III. OUTCOMES

Next Steps (how OFCM moves forward)

Based on discussion from the session participants, additional interagency partnerships are desired and continued participation by OFCM in the annual GMU ATD Modeling Conference is desired. Additional next steps include:

- OFCM will conduct a follow-up meeting in the early fall of 2013 to review the key takeaways detailed above and any results of the coordination visit with DTRA (see bullet below). Based on that review, participants will consider opportunities to address gaps in capabilities or otherwise collaborate to improve Federal ATD modeling. Their agencies will take actions as appropriate to coordinate a response to the issues that are identified.
- Representatives from DTRA expressed interest in deepening or expanding ties between OFCM and DTRA in this area. An OFCM representative will coordinate an information-gathering meeting with the DTRA Technical Reachback Center and the IMAAC to explore options and ascertain how OFCM might assist DTRA in facilitating interagency awareness and participation in the IMAAC.

Tentative Location for Next Year's GMU Modeling Conference: The tentative location for the 18th annual GMU ATD Modeling Conference is on the GMU campus in Fairfax, VA.

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