Office of the Federal Coordinator for Meteorological Services and Supporting Research

2016 Special Session, 20th Annual George Mason University (GMU) Atmospheric Transport and Dispersion (ATD) Conference

Field experiments and observational networks to support challenges with high resolution dispersion models and potential developments for an ATD test-bed

This document provides a summary of the OFCM-sponsored special session within the 20th Annual Atmospheric Transport and Dispersion Conference at George Mason University (GMU). The session was chaired and moderated by Mr. Jeff McQueen of National Weather Service (NWS)/Environment Modeling Center, College Park, Maryland, and Dr. Daniel Melendez, NWS/Office of Science and Technology Integration, Silver Spring, Maryland. The conference was held on the GMU campus in Fairfax, VA, and the session was conducted on Tuesday June 14, 2016. The session had 10 presentations and discussion.

OVERVIEW

Purpose and Theme:

The OFCM participates in the annual GMU ATD conference and has sponsored a special session since 2003 to inform attendees on the status and plans of the Federal government's atmospheric transport and dispersion (ATD) experimental, observational and modeling efforts.

Reflecting the strong partnerships built over many years, the session had over 60 attendees, including representatives from the following Federal agencies: the Department of Commerce/National Oceanic and Atmospheric Administration (NOAA); the Department of Defense, including the U.S. Army, the Defense Threat Reduction Agency (DTRA), the U.S. Air Force, and the US Navy; the Nuclear Regulatory Commission (NRC); and the Department of Homeland Security (DHS). Attendees also came from academia, industry, state and local governments, and the emergency management community. The session highlighted the implications of agency ATD observational campaigns in support of improved modeling and operational effectiveness.

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

1. Current status: Discuss federally-managed ATD observing and modeling programs, results of recent research activities, and the availability of datasets for researchers and modelers.
2. *Advances:* Discuss impacts of observational campaigns to the ATD agencies.
3. *Gaps:* Discuss scientific ATD priorities of relevance to agency operations.
4. *Where we need to go:* Discuss areas the community should focus on.

SESSION SYNOPSIS

The session consisted of ten presentations which followed opening remarks by the Federal Coordinator for Meteorology and the session chair. Questions were taken after some of the presentations. Slides from session presentations are available on the OFCM Web site.

Opening Remarks and Session Presentations:

1. **Opening Remarks:** Dr. Bill Schulz, Federal Coordinator for Meteorology, OFCM, followed by Mr. Jeff McQueen, Research Meteorologist, DOC/NOAA/NWS/NCEP, College Park, MD, opened the session reviewing goals and issues.

2. **Presentations:**

- **Dr. Ron Meris,** DTRA Reachback Division, discussed modeling efforts at DTRA for smoke, dust and volcanic ash. The presentation can be found at http://www.ofcm.gov/homeland/gmu2016/pdf/1%20Meris.pdf.

    - The US Geological Survey defines approximate volcano eruption characteristics while NOAA's Volcanic Ash Advisory Center (VACC) is responsible for defining the extent and boundaries of "no-fly" zones associated with particle levels exceeding $2x10^6$ kg m^{-3}. The largest uncertainty in this process is in the vertical profiles particulate matter.
    - DTRA modeling does not override VAAC's authority.
    - The Chilean volcanic event of April 2015 was discussed. In this case, the mesoscale dispersion modeling capability seemed to work well.
    - "What if" notional Bakken crude oil fire simulation (90-car train) exercise in La Crosse, WI, was discussed. Human impacts were drawn from US EPA guidelines.
    - Looking to the future, a nowcasting capability is being developed based on the WRF model.

- Dr. Casper Sun, NRC, discussed nuclear power plant control room habitability (radiation protection) code HABIT v2.0, covering both radiological and non-radiological threats. The presentation can be found at http://www.ofcm.gov/homeland/gmu2016/pdf/2%20Sun.pdf.

    - Update from version 1.2 from 2015
    - Gaussian plume modeling is being replaced with more accurate physical approaches.
    - Code includes dense-gas model, which solves for gravity-driven gas concentrations over flat terrain, and a momentum-driven gas concentration code SLAB. Both can calculate release from various scenarios including explosions.
    - Enhancements include SI units, new chemicals, revised dose coefficients, and integration into the Radiation Analysis and Maintenance Program (RAMP).
    - A Request for Additional Information process has been started to help improve NRC modeling.

Question-and-Answer Period:

    - Q: Are the models open source code?
    - A: No, NRC does not want source codes altered, but suggestions are welcome.

- **Dr. John Pace,** US Army Research Laboratory, briefed on the Mock Urban Setting Test (MUST) and Granite Mountain Atmospheric Science Testbed (GMAST) at Dugway Proving

Ground (DPG). He discussed the history and goals of these projects. The presentation can be found at http://www.ofcm.gov/homeland/gmu2016/pdf/3%20Pace.pdf.

- The MUST experiment focused on the "intermediate scale" for use in urban dispersion model development and validation. It used conex shipping containers to represent houses and other buildings. Propylene tracer gas was released 63 times under five trials with multiple puff releases while meteorological sensing arrays gathered data in and around the container array. The project allowed for subsequent accurate computational fluid dynamical modeling and wind tunnel studies.
- GMAST is a customer-funded testbed facility with extensive instrumentation and flexibility with scheduling and user-provided equipment.
- Since 2007 DPG has maintained a modeling program on high performance computers running the Four-Dimensional Weather (4DWX) system developed by the National Center for Atmospheric Research (NCAR). The modeling capability includes an ensemble version that provides estimates of uncertainty. NCAR is using GMAST data from the MATERHORN project to improve 4DWX.
- The Jack Rabbit field test program was conducted in 2010 at DPG to study 90-ton tanker releases and vapor/aerosol properties. Jack Rabbit II (2015-16) involves large chlorine releases.

Question-and-Answer Period:

- Q: How many sonic anemometers are available in GMAST?
- A: Over 60, used for turbulence and other studies. In addition, the array includes over 200 towers plus five profilers, three sonars, and LIDARs.

- **Dr. Fantine Ngan,** NOAA Air Resources Laboratory and Cooperative Institute for Climate and Satellites at the University of Maryland, College Park, MD, discussed the NOAA Air Resources Laboratory (ARL) HYSPLIT aerosol modeling of Sagebrush tracer experiment. The presentation can be found at http://www.ofcm.gov/homeland/gmu2016/pdf/4%20Ngan.pdf.

  - HYSPLIT code inline (embedded) with WRF allows calculation of dispersion simultaneously with WRF integration and in native WRF resolution. All post-processing codes can be used with inline HYSPLIT approach.
  - Comparison between in-line and offline HYSPLIT methodology shows modeling advantage of inline approach.
  - The multi-domain WRF nesting down to 333m horizontally and 33 layers vertically, and running every 5 minutes is being tested with ARL Field Research Division Sagebrush SF_6 tracer experiment data.
  - Statistical performance of WRF dispersion results was evaluated with rank and other metrics, showing the advantage of inline HYSPLIT simulating Sagebrush field data.
  - Elimination of temporal and spatial interpolation of the WRF data is deemed the main enabler of the inline HYSPLIT improved performance.
  - WRF testing will continue with other tracers and in other terrain environments.

Question-and-Answer Period:

- Q: Is it time consuming to do the WRF evaluation?

- A: Computational cost depends on the details of the simulation (tracer types/concentrations, etc.) with more CPU time needed for larger concentrations.

- **Dr. Chat Williamson,** Army Research Laboratory (USARL) discussed the lab's meteorological sensor array at White Sands Missile Range along with new paradigms for laboratory collaboration in basic and applied research. The presentation can be found at http://www.ofcm.gov/homeland/gmu2016/pdf/5%20Williamson.pdf.

    - The Atmospheric Sciences Center at White Sands is working on an "Open Campus" business model featuring improved collaboration between defense laboratories, academia, and industry.
    - A boundary layer knowledge exploitation approach is aimed at producing actionable environmental intelligence, with the primary focus of advancing applications through better understanding of boundary layer processes in complex and urban terrain. There are few high resolution datasets for validating high resolution (meso-γ to micro-scale) models.
    - USARL meteorological sensor arrays are deployed at various ranges encompassing different terrain types at White Sands to address various needs of the Army and the larger ATD community. Persistent sensors, including unmanned aerial sensors, are maintained year round at the various ranges. Towers are powered by solar panels whereas additional equipment uses power lines or generators and transmit data via wireless links. There is excess power and wireless capacity. Flexibility in configuring existing instrumentation allows users to validate sensors.
    - USARL is working to implement NCAR host datasets.
    - USARL participation in upcoming experiments away from White Sands includes Perdigão in Portugal, a site with two parallel ridge lines perpendicular to the mean flow, an ideal setting for model validation in semi-complex terrain.

Question-and-Answer Period:

- Q: Are many customers using the facility?
- A: It is still under development. Industrial and academic users are invited as facilities are built.
- Q: What is the timeline for completion?
- A: Ecological clearance is anticipated within next month or so, and sensors are to be deployed by end of this summer.
- Q: Can you do fine scale analyses and forecasts with your data?
- A: Yes.

- **Dr. Harindra Fernando,** University of Notre Dame, briefed the Mountain Terrain Atmospheric Modeling and Observations (MATERHORN) project (2011-2016 with one-year extension), supported via a Multi-disciplinary Research Initiative (MURI) from the Office of Naval Research. The presentation can be found at http://www.ofcm.gov/homeland/gmu2016/pdf/6%20Fernando.pdf.

    - Typically, near-surface bulk properties are poorly predicted in complex terrain. Soil moisture is an important example of a poorly measured quantity impacting model performance. There is need for holistic multi-scale observations of synoptic to Kolmogorov (1 mm) scale. The nocturnal boundary layer is another poorly predicted regime. As a result simulations at 50 m resolution have been nearly impossible over

complex terrain. Other long-standing issues with numerical simulations include turbulence equations closure and the proper representation of complex terrain.

- Dr. Fernando is the principal investigator for MATERHORN. Emphasis is on complex terrain. The collaborators list has grown as project moved forward from its inception at the GMU 2010 ATD meeting.
- MATERHORN has four components: experiments, modeling, technology development, and parameterizations.
- The modeling component seeks to improve mesoscale predictability. Poorly simulated nighttime boundary layers lead to errors in predicting near-surface dynamical and component fields. The many PBL parameterizations did not successfully reproduce dynamical profiles
- MATERHORN-II was a spring experiment featuring over 100 instrumented towers. Nighttime slope flows were observed to be significantly more complicated than expected, with colliding flows, Kelvin-Helmoltz waves and sloshing.
- For information go to http://www3.nd.edu/~dynamics/materhorn/ and see the cover article in the November 2015 Bulletin of the American Meteorological Society.

Question-and-Answer Period:

- Q: To what extent are you not adding another parameterization? There must be a more unified approach.
- A: The WRF physics are being looked at using the MATERHORN WRF version.

- **Dr. Shannon Fox,** DHS/Aberdeen Proving Ground, MD, gave and overview of the Jack Rabbit II Chlorine release field trials held in 2015, including fascinating video. The presentation can be found at http://www.ofcm.gov/homeland/gmu2016/pdf/7%20Fox.pdf

  - Chlorine is shipped through populated areas as pressurized liquefied gas by all modes of surface transportation but release predictions have not been tested at operationally relevant scales to understand the behavior of the resulting cloud. Hazard prediction models are not consistent with data from previous fatal Cl2 disasters.
  - Chlorine is second to anhydrous ammonia in terms of surface shipping, but is more toxic. Any release can generate a lethal vapor cloud.
  - Jack Rabbit II trials consisted of five night releases of 5-9 tons of Cl_2. Gas clouds reached 100 meters upwind and 7 miles downwind. The Urban Test Grid included over 80 conex containers and emergency for infiltration studies, samples of various construction material, and arcs of instrumentation both upwind and downwind.
  - A 20 ton Cl_2 release trial are planned for August, 2016, to better quantify release parameters and effects on buildings and emergency response equipment and materials.
  - Future studies will focus on other widely transported chemicals of concern.

Question-and-Answer Period:

- Q: Are datasets going to be made available?
- A: Data and videos will be made public through the DHS information network.

- **Dr. Everette Joseph,** University of Albany, NY, gave and overview of NY State boundary layer mesonet. The presentation can be found at http://www.ofcm.gov/homeland/gmu2016/pdf/8%20Joseph.pdf

- The New York state economy is especially sensitive to weather as quantified by Lazo et al. (BAMS, 2011). To address this sensitivity, planning for a mesonet began following hurricane Irene and tropical storm Lee; a contract award announced in January, 2014.
- The mesonet award called for 125 stations about 19 miles apart with a common array of sensors collecting data every 5 minutes. Enhancements at some stations include soil moisture, still imagery, snow sites, and enhanced profilers (LIDARS) and flux sites. Over 50 sites are now operational, and all sites will be operational by December, 2016. Siting considerations cover various terrain types as well as WMO and FEMA standards applied with NWS/stakeholder input.
- University of Albany-NCEP collaboration led to unified development of PBL real-time operational analysis system leveraging a NOAA-NASA-Howard ROSES 2007 project.
- A pilot study is underway to assess the impact of the mesonet on numerical weather prediction.
- URL for project, which also has a Facebook and Twitter presence, is http://nysmesonet.org.

Question-and-Answer Period:

- Q: Are modelers asking for this data?
- A: Yes, the especially private sector.

- **Dr. Harindra Fernando,** University of Notre Dame, briefed on observations and modeling as part of the NOAA- Department of Energy-funded second phase of Weather Forecast Improvement Program (WFIP2). The presentation can be found at http://www.ofcm.gov/homeland/gmu2016/pdf/9%20Fernando.pdf

  - Goal of WFIP2, which focuses on wind energy, is to improve understanding of atmospheric flows and processes that impact wind forecasts at wind turbine hub height (~ 100 m) complex terrain. The program involves a year-long campaign in the Columbia River basin
  - WFIP2 seeks to develop better physical parameterizations in WRF-ARW so as to increase the accuracy of 0-15 hour wind forecasts (the time-scale of power load balancing) and develop decision support tools (probabilities, uncertainty estimates, reliability) for system operations. Results are to be provided to both the operational weather community and private industry.
  - Modeling and operational challenges in this context include the formation and erosion of stable PBL layers/cold pools, frontal passage, and orographic dynamics.
  - Model developments are expected to include scale-aware parameterization that can transition between one- and three-dimensional separate vertical and horizontal sub-grid processes.
  - Evaluations of models can be found at http://wfip.esrl.noaa.gov/psd/programs/wfip2/

Question-and-Answer Period:

- Q: How accurate can hub-height wind forecasts can be?
- A: Relative accuracy of 10% is anticipated but European microscale modeling effort has a 3% goal.

- **Dr. Joseph Chang,** Homeland Security Studies and Analysis Institute, VA, briefed on the Modelers Data Archive (MDA) initiative to collect atmospheric transport and dispersion datasets. The presentation can be found at http://www.ofcm.gov/homeland/gmu2016/pdf/10%20Chang.pdf

    - Extensive field and laboratory experiments have been conducted since the 1950s; however, little has been done in terms of systematic archiving of results. There is no systematic database management, just "as is" repositories. Data is perishable, and it will disappear if not properly preserved (which requires funding). Often, recently-collected datasets managed by sponsors, who limit free distribution.
    - MDA is a grass-roots unfunded effort to address locating and archiving research data, building on previous experience with 50+ datasets.
    - Future experiments should consider carefully dataset longevity, including documentation and data ease of use. Suggestions are welcome on how to sustain this nascent effort.

DISCUSSION

Discussion at the end of the session took the form of real-time online informal polling of attendees. Conference participants responded to survey questions by logging into a web site using their smart phones, and the results of the survey were projected in real time as the as the responses were entered. The questions and responses can be viewed at http://www.ofcm.gov/homeland/gmu2016/pdf/11%20Community%20Survey.pdf. Based on the responses, there is community support (at least as represented by conference participants) for continued leveraging of existing test beds and for further field/network experiments addressing gaps related to complex terrain, stable layers, and model validation/verification.