NOAA Air Resources Laboratory

Quarterly Activity Report

FY2016 Quarter 4 (July-August-September, 2016)

Contents:

DISPERSION AND BOUNDARY LAYER

1. Preparation for new READY web server

Preparations and testing are being done to bring a new READY web server online in late October. READY is a web site (http://www.ready.noaa.gov) that allows users to access and run the HYSPLIT transport and dispersion model as well as meteorological display programs. Some new features include: a HYSPLIT trajectory frequency program, improved web design, and the addition of 4 km NAM and 3 KM HRRR meteorological data. In addition, the NWS text products are being transitioned from a socket communication system to reception via the Local Data Management system, which will greatly reduce the intermediary programs necessary to process the data from the National Weather Service. (glenn.rolph@noaa.gov, Albion Taylor)

2. HYSPLIT Updates

As a major annual or biennial event, the NOAA National Centers for Environmental Prediction's (NCEP) version of HYSPLIT.v7.4.4 (ARL version 723) was implemented on the NCEP "Phase 2" supercomputer in July 2016. The purpose was to bring the NCEP HYSPLIT suite up to a more current version, improve dispersion forecasting particularly when wet deposition occurs, transfer the ARL password-protected Regional Specialized Meteorological Center web page from ARL to an NCEP operational server, extend the duration of the HYSPLIT-formatted NAM 4 km CONUS nest forecast for strategic planning, and provide additional support for Alaska volcano strategic planning. The primary science change is in the wet deposition algorithm, based on extensive Fukushima modeling. The complete transfer of the password-protected Regional Specialized Meteorological Center web page from ARL to NCEP was not yet achieved; however products will be sent to both ARL and NCEP servers as the final configuration changes are made at NCEP related to product exchange with other RSMCs. Additional products include the extension of the NAM 4 km CONUS nest from 24 to 48-hours, and automated trajectories for numerous Alaska volcanoes.

NCEP HYSPLIT.v7.4.7 was delivered to NCEP Central Operations in September 2016, following testing and development by ARL and the NCEP Environmental Modeling Center. This implementation is as a downstream application to NCEP's North America Model (NAM). NCEP changed the NAM output from grib-format edition 1 to 2, changed the raw model output format and increased the NAM CONUS nest resolution from 4 to 3 km. The processing of the NAM output needed to be changed for NCEP operations to continue their HYSPLIT smoke/dust forecasting, to have a HYSPLIT-formatted NAM file available for NCEP volcanic ash or radiological dispersion forecasting, and to make the HYSPLIT-formatted NAM files available to Weather Forecasting Office dispersion forecasters on a password-protected web page, as well as the public on READY. (barbara.stunder@noaa.gov)

3. Unmanned Aircraft Systems

A Coyote aircraft, S/N 050, was delivered to ARL's Atmospheric Turbulence and Diffusion Division (ATDD) for testing. However, several items needed to be addressed before an

evaluation of the existing instrumentation on the Coyote could begin, such as powering the aircraft with an external power supply, activating the radio transmitter, and collecting and properly decoding data from the aircraft. A wiring harness is being procured from Raytheon to facilitate these operations but the process is slowed due to Raytheon's commitment to support Coyote operations during the current hurricane season.

The MD4-1000 small Unmanned Aircraft System (sUAS) and the DJI S-1000 sUAS were each flown at the Knox County Radio Control (KCRC) model flying field on August 29, 2016, to compare the performance of two identical, calibrated iMet-XQ temperature/relative humidity/pressure (T/RH/P) sensors on these different platforms under nearly identical conditions.

Averaged data from the flight tests were grouped for the ascending and descending portion of each profile. It was found that descending profiles have less overall variation than the ascending profiles. Additional tests will be performed once the MD4-1000 platform becomes available to ATDD again.

ATDD is in the process of obtaining permission to fly the S-1000 and other sUASs at the House Mountain Radio Control (HMRC) model flying field in Corryton, TN (Figure 4). This flying site offers a relatively large, flat homogeneous grass field that will be ideal for testing sUASs. Particularly, ATDD hopes to test recent developments in the measurement of the variability of surface heat fluxes around a tower from the S-1000 and the MD4-1000. ATDD is working with the landowners and the NOAA Aircraft Operations Center to allow sUAS flights to be made under the NOAA-FAA Memorandum of Understanding (MOU) in Class G airspace. The maximum flight altitude is expected to be 1200 feet above ground level.

HMRC offers several advantages over the KCRC field in that it is larger and has more homogeneous terrain and a longer runway that will accommodate larger fixed-wing sUASs more easily. The HMRC is in closer proximity to ATDD than the other large flat grassland flying sites in Belle Mina and Cullman, AL, which will save costs for the flight tests. (ed.dumas@noaa.gov, Lee, Buban, Baker)

4. Project Sagebrush

The ARL Field Research Division (FRD) conducted four summer daytime tracer experiments of Phase 2 of Project Sagebrush (PSB2) between July 26 and August 5. These releases targeted light winds on sunny afternoons. Tracer was released for 2.5 hours and collected in bags at 10-minute averaging intervals. The sampling was done for a two hour period (12 bags per sampler) at four arcs located between 100 and 800 m from the source. The three closest arcs spanned an angle of 210^{o} at 6^{o} sampler spacing, whereas the 800 m arc was narrower. A mobile tower provided vertical tracer samples up to 25 m AGL. One fast response tracer analyzer was also deployed on each arc.

A preliminary summary of the meteorology during each of the four tests has been prepared. The analysis of the bag samples has been completed, including the primary quality assurance and control procedures. Overall, predicting the average wind direction under daytime light wind

conditions proved challenging even with the wide 210^{o} sampling arcs. Even high-resolution numerical forecasts have difficulty forecasting wind directions under these conditions. Still, three of the four daytime experiments ended up providing useful tracer data, and even the fourth experiment may have limited periods of useful data.

Four nighttime releases are planned for October. The requisite number of bag sampling cartridges have been cleaned and prepared for these releases. These night experiments will use 210^{o} sampling arcs at 100, 200, and 400 m from the source. Samplers that were on the 800 m arc during the summer experiments will instead be installed on four towers located on the 100 and 200 m arcs. On these towers they will provide additional vertical tracer measurements up to 12 m AGL in addition to the continued use of the mobile tower providing measurements up to 25 m AGL. Fast response tracer analyzers will again be deployed on each arc during the night tests.

The same extensive suite of meteorological instrumentation and measurements in place for the summer daytime experiments will also be used for the October nighttime experiments. This will be augmented with an additional five sonic anemometers and a ceilometer provided by Washington State University. The anemometers will be arrayed at the surface at 3 m AGL across the tracer sampling array to evaluate spatial and temporal variability in the horizontal of the turbulence field in stable nighttime conditions. Two of the anemometers will be collocated with an IRGA for measurement of water vapor and carbon dioxide fluxes. (kirk.clawson@noaa.gov, all FRD staff)

5. Birch Creek Valley Wind Flow Study

The manuscript “Evidence for gap flows in the Birch Creek Valley, Idaho” by FRD’s Dennis Finn and co-authors, Brad Reese, Bret Butler, Natalie Wagenbrenner, Kirk Clawson, Jason Rich, Eric Russell, Zhongming Gao, and Heping Liu was accepted for publication in the Journal of the Atmospheric Sciences. The paper examines the origins and dynamics of gap flows in a mountain valley. In mountain valley settings, gap flows are set up by the development of a pressure gradient across a constriction in the valley. This results in the generation of high velocity winds downwind of the constriction at night. Gap flows, or their absence, affect the timing of the shifts in wind patterns related to morning and evening transitions. (dennis.finn@noaa.gov)

6. Wind Forecast Improvement Project (WFIP2)

The WFIP2 site at Prineville, Oregon continued to present a challenge for FRD due to rodents chewing the underground cables. In an attempt to reduce the problem a conduit will be added to the most easily damaged cables. Although, protecting all the cables in this manner may not be feasible.

FRD is now starting to look at monthly biases between the observations at the two WFIP2 flux stations operated by FRD and forecasts provided by the High Resolution Rapid Refresh (HRRR) model. During the 2016 summer months, significant model biases have been observed with several variables, including outgoing shortwave and longwave radiation, daytime sensible

heat flux, latent heat flux, and soil heat flux. Some of the biases are mainly at one station, and in some cases the biases in the standard HRRR 3 km model domain differ from what is seen with a special 750 m nested grid being run specifically for WFIP2. FRD is collaborating with the Earth System Research Laboratory to better understand the causes of these model biases. (matt.brewer@noaa.gov, Rick Eckman, Kirk Clawson, Brad Reese, Shane Beard)

7. London Fog

The FRD provided wind forecast support for a classified dispersion project, called London Fog. The project began in September at the Idaho National Laboratory. It is being spearheaded by the Johns Hopkins University. The project is expected to continue into October. (richard.eckman@noaa.gov, Jason Rich)

8. Assistance with Mars Methane Study

The FRD assisted with logistical preparations for a Mars methane study that will take place at the NOAA INL Tracer Test Facility in October. The research study group, led by Cornell University, will make measurements of methane on the INL Grid 3 sampling array. This is part of an effort to develop algorithms for search patterns to identify and potentially locate naturally occurring methane emissions on Mars. (dennis.finn@noaa.gov and Kirk Clawson)

9. Historical Tracer Studies

The FRD has been a principal participant in many tracer studies going back several decades. Unfortunately, results for many of these studies could not be readily utilized for analysis. Older studies frequently did not have electronic digital records but were in hard copy in various formats. FRD was able to digitize many of these older studies. The experimental datasets from 12 field studies preceding Project Sagebrush have been consolidated into a database. These are in a form that would provide a basis for effective utilization and analysis. Reports are included for an additional three older field studies but the tracer data itself is not available in a convenient form. The database has been provided to the ARL HYSPLIT group for future model validation studies. (dennis.finn@noaa.gov, FRD staff)

10. Consequence Assessment for the Nevada National Security Site

ARL's Special Operations and Research Division (SORD) staff, James Wood, Rick Lantrip, and Walt Schalk, participated in an emergency response Functional Exercise as the Consequence Assessment Team (CAT) for the NNSA Nevada Field Office. The exercise was conducted on the Nevada National Security Site (NNSS). In the exercise, location weather data and weather forecasts were provided and dispersion products were generated based on the worst case event information provided for the scenario. The event was a chemical spill at a facility. This event was conducted with the DOE/NNSA/ NFO Emergency Response Organization. Routine training and practice continue to maintain qualifications and expertise. (rick.lantrip@noaa.gov, James Wood, Walt Schalk)

11. SORD Mesonet Upgrade

There are power issues in the building at the radio location point on the NNSS. Generators are in place as back-up and have been running routinely. This creates occasional outages, but SORD's equipment continues to collect data. Research is being conducted to determine if a reasonable back-up power/communications solution is feasible.

James Wood and Rick Lantrip have begun the Fall calibration cycle of the mesonet. (walter.w.schalk@noaa.gov, James Wood, Rick Lantrip)

12. Support to DOE/NNSA NNSS Projects and Experiments

SORD staff, Walt Schalk, James Wood, and Rick Lantrip, are preparing for the field support at the Nevada National Security Site (NNSS) for the non-proliferation Source Physics Experiment #6 (SPE-6) to be conducted in mid-October. Daily weather forecasts and weather surveillance activities focusing on wind and lightning were provided in preparation for the experiment. Several experiment practice runs were supported by providing experiment location specific forecasting as well as wind speed measurements.

Walt Schalk is working to develop a portable micro-net of weather stations to support experiments on the NNSS such as the SPE. A proof of concept with one station will be deployed in support of SPE-6. A test system has been operating at the Desert Rock Weather Observatory at the NNSS for a couple of weeks. Walt also has been researching a tethered balloon platform for non-weather sensors in support of the SPE. A suitable "balloon" has been found that actually uses the wind to create additional lift and stability. Unfortunately, SORD was not able to procure the "balloon" in time to test and field it for SPE-6. This will be done over the next 6 months. (walter.w.schalk@noaa.gov, James Wood, Rick Lantrip)

ATMOSPHERIC CHEMISTRY AND DEPOSITION

13. Atmospheric Mercury Modeling

Several advancements were made in ARL's atmospheric mercury modeling:

- Chris Loughner and Mark Cohen made additional progress on parallelizing the HYSPLIT-Hg model, to further improve consistency between the serial and parallel simulations.
- Mark continued work on assembling and synthesizing anthropogenic mercury emissions inventory data for the period 1990-2014. New emissions-based analyses were carried out in support of two manuscripts in preparation, regarding trends in atmospheric mercury concentrations and trends in mercury concentrations in Great Lakes fish.
- Mark worked with the State of Maryland to define watershed and waterbody receptors for a collaborative project to estimate mercury deposition for a Total Maximum Daily Load (TMDL) analysis for impacted waterbodies in Maryland. Model-ready representations of these new receptors were created and the process of incorporating these receptors into the HYSPLIT-Hg model is underway. (mark.cohen@noaa.gov, Christopher Loughner)

14. NSF Aircraft Project to Measure Methane Emissions

In July and August 2016, Xinrong Ren worked with a research team at the University of Maryland's Department of Atmospheric and Oceanic Science on an aircraft project sponsored by National Science Foundation. The project was designed to characterize methane emissions from oil and natural gas operations in the Marcellus Shale in southwestern Pennsylvania and northern West Virginia. Research flights were conducted over the oil and natural gas operation area to collect measurements of methane, as well as other air pollutants. A mass balance approach was used to estimate methane emissions. The researchers estimated that the average methane leakage rate from the oil and natural gas operations in the surveyed area is 4.3±0.7%. This is higher than expected and may affect natural gas production in this area. (xinrong.ren@noaa.gov)

15. ACCESS Model

Two NOAA Hollings Scholars, Sheridan Green from the University of North Carolina-Chapel Hill and Kathryn Wheeler from the University of Delaware, completed their summer internships at ARL's Atmospheric Turbulence and Diffusion Division (ATDD) in late July. They worked with Rick Saylor and performed research with the Atmospheric Chemistry and Canopy Exchange Simulation System (ACCESS) model exploring biogenic hydrocarbon chemistry in different forest types and environmental conditions. Results from the research are intended to help advance the representation of surface-atmosphere exchange processes in three-dimensional air quality models, including NOAA's National Air Quality Forecasting Capability. Each student made a final presentation at the 2016 NOAA Office of Education Student Science and Education Symposium in Silver Spring, MD. (rick.saylor@noaa.gov)

CLIMATE OBSERVATIONS AND ANALYSES

16. U.S. Climate Reference Network

The ATDD installed a U.S. CRN site at Yakutat, Alaska and conducted ten annual maintenance visits in Alaska. In addition, seventeen annual maintenance visits and one unscheduled maintenance visit were made throughout the rest of the U.S. (mark.e.hall@noaa.gov)

17. Flux Observations of Carbon from an Airborne Laboratory (FOCAL)

The collaborative project Flux Observations of Carbon from an Airborne Laboratory (FOCAL) conducted with Harvard University's Anderson Group and the Aurora Flight Sciences Corporation explored the strength and spatial distribution of greenhouse-gas (especially methane) emissions over the Alaskan Tundra. The results have now appeared for discussion in Atmospheric Chemistry and Physics Discussions at http://www.atmos-chem-phys-discuss.net/acp-2016-862/. Companion work upgrading the uncertainty analysis for fluxes from the flux-fragment method (FFM) has been submitted to the *Journal of Atmospheric and Oceanic Technology*. The FFM is a conditional-sampling technique effective for computing fluxes from flights over surfaces having repeated small features otherwise obliterated in the necessary

averages. This upgrade addresses a number of statistically questionable assumptions of the earlier version providing a more defensible estimate. (ron.dobosy@noaa.gov)

18. NOAA/INL Mesonet

Semiannual calibrations of all instruments in the NOAA/INL Mesonet began in late September. Completion of this process is expected sometime in November.

The no-cost lease agreement for the Dubois mesonet station at the U.S. Sheep Experiment Station (USSES) operated by the USDA expired at the end of September. At the request of the USSES, a cooperative agreement is being fashioned to accommodate the needs of the USDA. It is anticipated that the agreement will be signed sometime in the first quarter of FY17. (kirk.clawson@noaa.gov)

ARL 4th Quarter Publications

Cohen, M. D., R. R. Draxler, **R. S. Artz**, P. Blanchard, M. S. Gustin, Y. Han, T. A. Holsen, D. A. Jaffe, P. Kelley, H. Lei, C. P. Loughner, **W. T. Luke**, S. L. Lyman, D. Niemi, J. M. Pacyna, M. Pilote, L. Poissant, D. Ratte, X. Ren, F. Steenhuisen, A. Steffen, R. Tordon and S. Wilson (2016). Modeling the global atmospheric transport and deposition of mercury to the Great Lakes. Elementa Science of the Anthropocene 4: 000118. doi:10.12952/journal.elementa.000118

Dong, X., J.S. Fu, K. Huang, D. Tong, and G. Zhuang (2016). Model development of dust emission and heterogeneous chemistry within the Community Multiscale Air Quality modeling system and its application over East Asia. Atmospheric Chemistry and Physics, 16, 8157–8180. doi:10.5194/acp-16-8157-2016

Battye, W. H., Casey D. Bray, Viney P. Aneja, Daniel Tong, Pius Lee, and Youhua Tang (2016). Evaluating ammonia (NH3) predictions in the NOAA National Air Quality Forecast Capability (NAQFC) using in situ aircraft, ground-level, and satellite measurements from the DISCOVER-AQ Colorado campaign. Atmospheric Environment 140: 342-351. http://dx.doi.org/10.1016/j.atmosenv.2016.06.021

Tong, D., L. Pan, W. Chen, L. Lamsal, P. Lee, Y. Tang, H. Kim, S. Kondragunta, and I. Stajner (2016). Impact of the 2008 Global Recession on air quality over the United States: Implications for surface ozone levels from changes in NO_x emissions. Early Geophysical Research Letters 43 (17); 9280-9288, doi:10.1002/2016GL069885.

Crawford, A. M., **B. J. B. Stunder**, F. Ngan, and M. J. Pavolonis (**2016**). Initializing HYSPLIT with satellite observations of volcanic ash: A case study of the 2008 Kasatochi eruption, Journal of Geophysical Research – Atmosphere. 121, 10,786-10,803. doi:10.1002/2016JD024779.

Outreach & Engagement

The Summer Science Academy of the Appalachian Regional Commission and Oak Ridge Associated Universities ORAU sponsored a science academy in Oak Ridge for middle-school science students. A primary activity was wind generation of electric power. The students visited the Tennessee Valley Authority's wind-turbine site above Oak Ridge and also built their own model wind turbines on a commercial model generator hub. They designed their own blades and constructed them of dowels, balsa, and corrugated plastic sheet. At the end of the camp, they came to ATDD to use the wind tunnel to test the effectiveness of their designs. There was a competition for bragging rights over whose design can produce the most power over a standard 10 settings of wind speed in the outflow region of the wind tunnel. The activity was exciting for everyone and gave a practical demonstration that some designs are better for low wind, others for strong wind. There was a large range of power produced, depending on the blade design, which provided an opportunity to explain why some designs are better than others. The four images show: (1) assembly of the model turbines, (2) testing of a turbine, (3) and (4) recording of data during the turbine tests.

Assembling the turbine

Testing the wind turbine.

(ron.dobosy@noaa.gov, Randy White, David Senn)

Students recording their data

Walt Schalk and Rick Lantrip hosted two tours of about 15 scientists each from the DOE National Laboratories. The tour was part of the Federal Expertise Training program hosted by the NNSA. The tour took place at the Desert Rock Weather Observatory at the Nevada National Security Site. A verbal history of the SORD program and support of the testing program was given. SORD's current activities were also presented. The numerous instrumented sites that SORD maintains for NNSS Programs (SODAR, mesonet and lightning detection network) and hosts for a variety of NOAA Programs (Climate Reference Network, SURFRAD, GPS Water Vapor soundings – ESRL) located in the immediate Desert Rock area were discussed. As a finale, a Pilot Balloon (PIBAL) release was demonstrated.

Walt Schalk visited with Dr. Darrell Pepper at the University of Nevada, Las Vegas Department of Engineering and several of his students. Walt provided an overview of SORD and its work with the DOE/NNSA. The UNLV students talked about their areas of research and application development. The primary topic was the concept of developing an inexpensive small sodar with limited range located at valley fire stations as input to a wind field model for use by emergency responders on handheld devices.