NOAA Air Resources Laboratory

Quarterly Activity Report

FY2017 Quarter 3 (April, May, June 2017)

Contents:

DISPERSION AND BOUNDARY LAYER

1. 2017 HYSPLIT Workshop

A 4-day HYSPLIT workshop was given June 13-16, 2017, at NOAA's Center for Weather and Climate Prediction in College Park, Maryland. The workshop focused on the use of the January 2017 release of the PC model and its Graphical User Interface with a focus on the HYSPLIT model verification of the CAPTEX 2 atmospheric tracer release conducted in 1983. Twenty-three participants from U.S. and state government agencies, including NOAA, National Institutes of Health, Georgia, Utah, the U.S. Army, and the Air Force, as well as academia and foreign participants from South Korea, Mexico, Chile and Canada attended the workshop in person and at least 80 people viewed the workshop through video conferencing from as far away as Mali, Chile, Egypt, Croatia, and India. Recordings of the workshop were also made available to all participants during the workshop. Roland Draxler, former ARL modeler and the original developer of HYSPLIT, presented most of the material. glenn.rolph@noaa.gov

2. HYSPLIT Runs for Annual Site Environmental Report

The Field Research Division continued their transition from the puff model to using the HYSPLIT model to provide estimates of annual radiological exposures from activities at the Idaho National Laboratory (INL). First, a year of Mesonet data was converted to the gridded format used by HYSPLIT. Then, the model was configured so that an annual run for each facility could be completed in a reasonable amount of time on FRD's computing cluster. Some INL releases are from stacks, but the existing plume-rise algorithms in HYSPLIT were not well suited to stack releases (instead being developed for wildfires). Therefore, FRD has added a new plume-rise algorithm to the model for stack emissions. All the annual runs for 2016 were eventually completed in June and are now being used to develop the population exposures that will go into the INL annual report. richard.eckman@noaa.gov, Dennis Finn, Roger Carter

3. Unmanned Aircraft Systems and VORTEX-SE

ATDD performed functional testing of the Coyote small Unmanned Aircraft System (sUAS) iMet-XF instrumentation in late May 2017. Five iMet-XF systems were tested in a Coyote airframe that was mounted into a test fixture on the back of a pickup truck. The test fixture, shown below, included a Vaisala T and RH sensor that was used as a reference, as well as an experimental F-TUTN high-frequency sensor that was installed for independent purposes.

During each test, the truck was driven at approximate flight speeds (50 knots, 57 MPH) while data from the iMet-XF was collected through the aircraft transmitter and ground station. This simulated the environment which the instruments will experience/be subject to in flight.

Four channels were tested for each sensor: Air temperature, Humidity, Air pressure, and Infrared (sea) temperature. Ground speed was also measured and recorded.

A complete report was written and provided to the NOAA Project Lead, Joe Cione, with NOAA's AOML Hurricane Research Division. ed.dumas@noaa.gov, M. Heuer, R. Dobosy, C.B. Baker

The Penguin BE fixed-wing sUAS arrived at ATDD on June 21, 2017. It was evaluated and then shipped to BlackSwift Technologies in Boulder, CO for autopilot installation and test flights. Steve Brooks with the University of Tennessee Space Institute, along with a graduate student made measurements of the payload bay of the aircraft in preparation for instrument installation. Below is a picture of the aircraft just after it was assembled at ATDD.

ATDD participated in the VORTEX-SE 2017 experiment in the vicinity of Huntsville, AL, to study severe storm and tornado genesis in the southeastern US. The DJI S-1000 sUAS was used to measure temperature and humidity profiles in the lower 213 meters of the atmosphere and to map the Earth's skin temperature during four intensive observation periods (25 March, 27 March, 05 April, and 28 April). ATDD and personnel from the NOAA Office of Marine and Aviation Operations' Aircraft Operations Center (AOC) also flew the Microdrone MD4-1000 sUAS during the 28 April intensive. During this intensive, four MD4-1000 flights were flown simultaneously with the DJI S-1000. Mark Rogers from the AOC was pilot-in-command of the MD4-1000 during the simultaneous flights.

Nineteen flights were made with the DJI S-1000 sUAS. The sUAS flights at Cullman, AL were made primarily to measure atmospheric temperature profiles and surface temperature. Flights were not made this year for tornado storm damage assessment. A NOAA Technical Memorandum OAR-ARL-274 was written to document the flights made by the DJI S-1000 and MD4-1000 in VOREX-SE 2017. ed.dumas@noaa.gov, T. Lee, M. Buban, C.B Baker

4. Project Sagebrush

Drafts for all chapters of the NOAA technical memorandum summarizing the data and results for Phase 2 of Project Sagebrush (PSB2) have been completed. The database itself is very nearly complete pending some final contributions by the Washington State University collaborators. A draft manuscript on Project Sagebrush Phase 2: Plume Dispersion and Measurement Uncertainty in the Very Stable Boundary Layer was also worked on and will be submitted to a journal pending publication of the technical memorandum. The emphasis of the paper is on the large uncertainties in tracer measurements in the very stable boundary layer and the significance of that with respect to plume modeling. This is the case for both the mean and higher frequency measurements that can be used for estimating concentration variance. The potential causes of the measurement uncertainty are linked to characteristic features of turbulence and meandering in the very stable boundary layer. The investigation to date has established that many of the features observed during prominent stable boundary layer studies, such as CASES-99, were also present during PSB2.

PSB2 provides a dataset with a special combination of higher resolution time-averaged bag sampling, fast response tracer sampling, and extensive meteorological measurements of wind and turbulence that offers revealing insights into plume dispersion in light wind conditions during continuous releases in open terrain. dennis.finn@nnoaa.gov, Roger Carter, Jason Rich

5. Wind Forecast Improvement Project (WFIP2)

The 18-month field deployment for the WFIP2 ended in early April. Field Research Division staff traveled to Oregon and retrieved all the equipment. All data collected during WFIP2 have now been quality controlled and uploaded to the project's online archive. Comparisons were made between the observed surface energy balance at two flux stations and forecasts from the High Resolution Rapid Refresh (HRRR) model. FRD's Matthew Brewer—who was leading the WFIP2 analysis—unfortunately decided to accept another job. Due to funding uncertainties for fiscal year 2018, it was not possible to immediately hire a replacement to continue the WFIP2 research. The data analysis for the project is therefore on hold until more is known about the 2018 budget. richard.eckman@noaa.gov, Matt Brewer, Dennis Finn, Jason Rich, Devin Clinger

6. Consequence Assessment for the Nevada National Security Site

James Wood, Rick Lantrip, and Walt Schalk participated in three emergency response training events as the Consequence Assessment Team (CAT) for the National Nuclear Security Administration's Nevada Field Office. The training was conducted on the Nevada National Security Site (NNSS). The events consisted of a training drill, a hands-on drill, and a full field exercise that occurred at several different locations on the NNSS. In these events, the activities to be conducted were discussed and local weather data and weather forecasts were provided and dispersion products were generated based on the worst case event information provided for the scenarios. In addition, the CAT worked with field measurement teams to help identify/locate the atmospheric plume. The events included both radiological and chemical scenarios at different facilities. These events were conducted with the DOE/NNSA/NFO Emergency Response Organization. rick.lantrip@noaa.gov, James Wood, Walter Schalk

7. SORD Mesonet

SORD continues to look at ways to improve the SORD/ Nevada National Security Site (NNSS) mesonet. As SORD has moved well into the second year with this new system, they have identified several areas of improvement. Ice riming of the 3D sonic anemometers and the need for heated precipitation gauges are at the top of the list of improvements. Other improvements to be considered include new weighing precipitation gauges. Also, extra grounding to help prevent scrambling of the wind sonic programming is being considered. James Wood finished the installation, update, and refurbishment of the alter shields for the precipitation gauges in the network. James Wood and Rick Lantrip have completed the current instrumentation calibration cycle. Rick Lantrip is updating the weather station site surveys with new pictures. In addition, Rick is removing the large battery from the main Logger Box on the towers to a separate box on the ground. This will make the towers weigh less when tilting them down. Walt Schalk has provided several processed data sets from the NNSS weather

towers for use by NNSS environmental and experimental groups. walter.w.schalk@noaa.gov, James Wood, Rick Lantrip

8. Support to DOE/NNSA NNSS Projects and Experiments

James Wood, and Rick Lantrip participated in the support of an experiment conducted on the Nevada National Security Site (NNSS). Lantrip and Wood participated in the Plan of the Day activities providing daily weather forecasts and weather surveillance focusing on winds and lightning. The experiment concluded in April.

Walt Schalk participated in several planning meetings in preparation for Phase II of non-proliferation experiments (Source Physics Experiments (SPE) – Phase I, Dry Alluvium Geology – Phase II). Discussions with DOE's Los Alamos National Laboratory scientists have been conducted to determine collaborative and support areas especially in the use of balloon elevated instrument platforms. These activities will continue to evolve over the fiscal year.

Walt Schalk continues 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 was deployed in support of SPE-6. A test system had been operating at the Desert Rock Weather Observatory at the NNSS for a couple of weeks. The proof of concept station during the SPE-6 experiment was a success and greatly appreciated by the National Laboratory scientists. walter.w.schalk@noaa.gov, James Wood, Rick Lantrip

ATMOSPHERIC CHEMISTRY AND DEPOSITION

9. Long Island Sound Air Quality Study

Xinrong Ren participated in the Long Island Sound Air Quality Study in collaboration with a research group at University of Maryland (UMD). The UMD's Cessna 402B research aircraft was used to collect air quality data over the Long Island Sound and its surrounding areas. This was done to investigate the transport of air pollution from the New York City metropolitan area to the northeast, resulting in high ground-level ozone concentrations in areas along the Connecticut coastline. The primary goal of the project was to understand the relative importance of the ozone precursors (i.e., nitrogen oxides and volatile organic compounds) on ozone formation within the marine layer. The results from this study have strengthened understanding of ozone production and the ability to develop control strategies for ozone in the New York City metropolitan and Connecticut coast areas. The project was sponsored by the Northeast States for Coordinated Air Use Management and the Maryland Department of Environment. xinrong.ren@noaa.gov

10. Methane Emissions in Marcellus Shale Region

Xinrong Ren joined a research team at University of Maryland's Department of Atmospheric and Oceanic Science to continue research flights over the Marcellus Shale area in southwestern Pennsylvania and northern West Virginia to characterize methane emissions from oil and natural gas operations. Measurements of methane, as well as other air pollutants, were made during these flights. A mass balance approach was used to estimate methane emission rates and natural gas loss from oil and natural gas operations in this area. The project was sponsored by the National Science Foundation. xinrong.ren@noaa.gov

11. Atmospheric Mercury and Toxics Modeling

Several advancements were made in atmospheric mercury and toxics modeling during this quarter. *(1) Great Lakes Restoration Initiative (GLRI):* A modeling analysis was completed to estimate the transport and deposition of mercury from regional, national, and global sources to the Great Lakes. A final technical report is being prepared to document the methodology and findings. As part of this work, a comparison of plume-based and grid-based modeling approaches was carried out. *(2) Publication:* The following paper was published: Zhou C, Cohen MD, Crimmin BA, Zhou H, Johnson TA, Hopke PK, Holsen TM. Mercury Temporal Trends in Top Predator Fish of the Laurentian Great Lakes from 2004 to 2015: Are Concentrations Still Decreasing? *Environmental Science & Technology* 51: 7386-7394. *(3) Nested Grid:* Chris Loughner completed work on implementing a nested-grid capability within the HYSPLIT-Hg model. This capability allows the use of a relatively coarse grid for simulating mercury over most of the globe, along with a finer grid over the region of interest (e.g., the Great Lakes). This type of approach is desired, as it would be impractical to attempt to model the entire globe with a comparably fine grid, given current computational resources. This capability will be used to examine the influence of grid size on modeling results. *(4) HYSPLIT-SV:* The plume-based version of the HYSPLIT-SV model was updated to contain all comparable features of the latest HYSPLIT-Hg version. This new HYSPLIT-SV is being used by a visiting scientist from Mexico, Miguel Angel Cahiuch Lopez, who is investigating the fate and transport of dioxins in the Yucatan peninsula region of Mexico. *(5) Mercury Plume Visualization:* Zhuoran (Gray) Li, a summer intern from Smith College, used 3-dimensional Geographical Information System (GIS) software (ESRI ArcScene) to visualize plumes from mercury emissions sources that may have been measured at ARL's Beltsville Maryland long-term mercury monitoring site. *(6) Texas Power Plant Plumes:* The HYSPLIT model was used to simulate the fate and transport of emissions of SO2 and other pollutants emitted from power plants in Texas. The modeling results

were found to be very consistent with aircraft-based measurements. mark.cohen@noaa.gov; christopher.loughner@noaa.gov

12. Major Upgrade of the NAQFC

The ARL Atmospheric Chemistry Team provided the NWS with a major model upgrade of the National Air Quality Forecasting Capability in June 2017, setting the stage for a multiple pollutant approach to assess human health exposure for the nation. The upgrade consisted of improvements in applying the meteorological model, utilizing an analysis procedure to improve wildland fire emissions, and employing an advanced gas- and particle-phase chemistry module to simulate the formation and fate of the various air pollutants relevant to acute and chronic responses by the human body. The NAQFC upgrade allows for improved accuracy in capturing the prescription of pollutant distribution in space and time, which improves forecasts and allows warnings two days in advance of the forecasted pollution event. Many states and local air quality managers approve of and have praised this upgrade. pius.lee@noaa.gov

CLIMATE OBSERVATIONS AND ANALYSES

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

Two papers, related to the FOCAL aircraft (Flux Observations of Carbon from an Airborne Laboratory) and its 2013 field campaign in Alaska, were prepared for publication. One has appeared in an early online release by the *Journal of Atmospheric and Oceanic Technology.* The other is expected to appear in *Atmospheric Chemistry and Physics* soon. The FOCAL was a collaboration led by Harvard University and including ARL/ATDD and Aurora Flight Sciences, Inc. In the 2013 campaign, the FOCAL successfully measured the emission of methane and water vapor over a wide range of tundra on Alaska's North Slope between Prudhoe Bay and Barrow. FOCAL's innovation is to carry a gas analyzer which can sample at a high enough rate for eddy covariance from a small minimally intrusive aircraft, but also measure the mix of isotopologues in the gases being sampled. These two papers demonstrate the ability of the system to measure ordinary fluxes of total gas (all isotopologues) over an area on the order of (100 km)^2. The fluxes match in general with those measured from fixed sites and in particular with those from a surface site established for intercomparison. They also provide an improved estimate of the random uncertainty in flux analyzed using the flux-fragment method (FFM), as well as a theoretical comparison of the assets and liabilities of the FFM with those of the more widely accepted method of wavelet analysis. These are two approaches to the challenging and important analysis of the spatial patterns of fluxes measured from the air over heterogeneous landscape. The type of instrument suite and data analysis demonstrated in these papers, combined with

fixed and remote sensors, is well suited to quantifying the emissions of methane and other greenhouse gases and their change with time over large, difficult to reach areas in the remote and demonstrably warming arctic. ron.dobosy@noaa.gov

14. NOAA/INL Mesonet

A low level of radio interference started affecting the Idaho National Laboratory (INL) Mesonet communications. This has normally been a problem in the cold season and therefore is somewhat unusual this time of year. Interference of this nature has nearly always been related to the failure of lightning arresters located near the entrance to the ARL Field Research Division (FRD). As parts fail, the arresters start arcing, resulting in broadband radio interference. Two of the three arresters near FRD have been replaced, so suspicion falls on the third. So far, Idaho Falls Power has not been able to isolate the problem to the third arrester. This arrester may be just starting to fail, so their electrical arc detection equipment may not be sensitive enough to see it.

The 61 m Mesonet tower at Grid 3 has flights of stairs that are used to climb up the side of this tower. However, recent changes in OSHA regulations regarding the required railings for stairs has led to this tower—built in the 1960s—no longer meeting the requirements that would allow staff to walk up the steps without some kind of fall protection. FRD is therefore investigating options that would provide staff with fall protection while on the tower. The simplest option is to have each person attach to a rope running down the center of the tower. Roger.Carter@noaa.gov

On 24 April, FRD staff along with partners from the Department of Energy, INL contractors, and the State of Idaho conducted a safety tour of several Mesonet towers. This was a follow-up to a previous tour to identify safety issues related to the equipment installed at the tower sites. Some issues were identified with NOAA equipment and some were associated with the equipment installed by others. One issue was related to keeping the lead-acid batteries at each tower in weather housing. The standard battery housings bought at stores have not worked well, tending to accumulate water and draw rodents. FRD is testing a home-build housing that hopefully will mitigate these problems. Richard.Eckman@noaa.gov, Donna Davis, Roger Carter, Devin Clinger

ARL 3rd Quarter Publications

Balasubramanian, S., A. Nelson, S. Koloutsou-Vakakis, J. Lin, M.J. Rood, **L. Myles**, and C. Bernacchi (2017). Evaluation of DeNitrification DeComposition Model for Estimating Ammonia Fluxes from Chemical Fertilizer Application. Agricultural and Forest Meteorology 237, 123-134, https://doi.org/10.1016/j.agrformet.2017.02.006.

Biederman, J. A., R. L. Scott, T. W. Bell, D. R. Bowling, S. Dore, J. Garatuza-Payan, T. Kolb, P. Krishnan, D. J. Krofcheck, M. E. Litvak, G. E. Maurer, **T. P. Meyers**, W. C. Oechel, S. A. Papuga, G. E. Ponce-Campos, J. C. Rodriguez, W. K. Smith, R.

Vargas, C. J. Watts, E. A. Yepez, and M. L. Goulden (2017). CO2 exchange and evapotranspiration across dryland ecosystems of southwestern North America. Early On-Line in Global Change Biology 1– 8. https://doi.org/10.1111/gcb.13686

Bieser, J., F. Slemr, J. Ambrose, C. Brenninkmeijer, S. Brooks, A. Dastoor, F. DeSimone, R. Ebinghaus, C. N. Gencarelli, B. Geyer, L. E. Gratz, I. M. Hedgecock, D. Jaffe, P. Kelley, C.–J. Lin, L. Jaegle, V. Matthias, A. Ryjkov, N. E. Selin, S. Song, O. Travnikov, A. Weigelt, **W. Luke**, X. Ren, A. Zahn, X. Yang, Y. Zhu, and N. Pirrone (2017). Multi-model study of mercury dispersion in the atmosphere: vertical and interhemispheric distribution of mercury species, *Atmospheric Chemistry and Physics*.,17, 6925-6955. https://doi.org/10.5194/acp-17-6925-2017

Chai T., H.C. Kim, Li Pan, **P. Lee**, and D. Tong (2017). Impact of Moderate Resolution Imaging Spectroradiometer (MODIS) aerosol optical depth (AOD) and AirNow $PM_{2.5}$ assimilation on Community Multi-scale Air Quality (CMAQ) aerosol predictions over the contiguous United States, *Journal of Geophysical Research Letters*, 122; 5399–5415. doi:10.1002/2016JD026295

Kochendorfer, J., R. Rasmussen, M. Wolff, **B. Baker**, M.E. Hall, **T. Meyers**, S. Landolt, A. Jachcik, K. Isaksen, R. Brækkan, and R. Leeper (2017). The quantification and correction of wind-induced precipitation measurement errors, Hydrology and Earth System Sciences, 21, 1973-1989, doi:10.5194/hess-21-1973-2017

Nelson, A.J., S. Koloutsou-Vakakis, M.J. Rood, L. Myles, C. Lehmann, C. Bernacchi, S. Balasubramanian, E. Joo, M. Heuer, M. Vieira-Filho, and J. Lin (2017). Season Long Ammonia Flux Above Fertilized Corn in Central Illinois, USA, Using Relaxed Eddy Accumulation. Agricultural and Forest Meteorology 239, 202-212, https://doi.org/10.1016/j.agrformet.2017.03.010.

Ren, X., …**Mark Cohen**…et al. (2017), Methane emissions from the Marcellus Shale in southwestern Pennsylvania and northern West Virginia based on airborne measurements, *Journal of Geophysical Research- Atmospheres*, 122, 4639–4653, doi:10.1002/2016JD026070.

Tong, D. Q., **J.X. Wang**, T.E. Gill, H. Lei, and B. Wang (2017). Intensified dust storm activity and Valley fever infection in the southwestern United States. Geophysical Research Letters, 44(9), 4304-4312. doi:10.1002/2017GL073524

Conferences, Presentations, & Invited Talks

LaToya Myles served as co-chair of the OAR Forums on Atmospheric Chemistry and Ecological Modeling held on June 15-16 in Silver Spring, MD. The goals of the Forums were to encourage robust and meaningful peer-to-peer communication across the OAR science community and improve awareness and understanding of the broad spectrum of OAR's scientific activities. Rick Saylor presented an Ignite talk entitled "Beyond Emissions and Deposition: The New Paradigm of Biosphere-Atmosphere Exchange" at the OAR Forum on Atmospheric Chemistry and Composition and Ecological Modeling. The talk highlighted the need for atmospheric chemistry and air quality models to begin adopting a new approach to modeling emissions and deposition by incorporating chemically, physically and biologically integrated modules of biosphere-atmosphere exchange processes, rather than continuing to treat emissions and deposition as separate and largely independent processes.

Rick Saylor and Michael Buban attended the 2017 Modeling Research in the Cloud Workshop at the University Corporation for Atmospheric Research (UCAR) Foothills Laboratory in Boulder, Colorado, from May 31 through June 2. The workshop was organized by UCAR with funding from the National Science Foundation to raise awareness in the atmospheric science community about the potential for using cloud computing resources in atmospheric modeling research.

Outreach & Engagement

A NOAA "Postcard from the Field" was created and published to highlight work done by the sUAS during VORTEX-SE 2017. ed.dumas@noaa.gov, T. Lee, M. Buban, C.B. Baker

Walt Schalk and James Wood hosted a tour of SORD for about 15-20 DOE National Laboratory scientists and DoD representatives in early May. The tour was part of the Federal Expertise Training program hosted by 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.