NOAA Air Resources Laboratory

Quarterly Activity Report

FY2018 Quarter 2 (January-February-March 2018)

Contents:

DISPERSION AND BOUNDARY LAYER

1. HYSPLIT Model Sets New Usage Record in 2017

In 2017, a new record was achieved for the most HYSPLIT simulations ever produced on the READY web server (http://www.ready.noaa.gov), with over 1.2 million (1,217,438) simulations performed; exceeding the previous record of one million set in 2016 (1,094,305). HYSPLIT simulations have seen a steady increase since tabulation of usage results first began in 2009. READY users can create air parcel trajectories or air concentration maps with HYSPLIT using archived or forecast meteorological data, providing important results for both weather forecasters and the research community. (glenn.rolph@noaa.gov)

2. Project Sagebrush

The draft manuscript "Plume dispersion in low-wind-speed conditions during Project Sagebrush Phase 2, with emphasis on measurement uncertainties" was accepted by *Boundary Layer Meteorology* with minor editorial changes. The revised draft, including those changes, will be submitted early next quarter. This paper emphasizes the large uncertainties associated with tracer measurements in the very stable boundary layer and the significance of those uncertainties on plume modeling.

Two manuscripts that investigate stable boundary layers using data collected during Project Sagebrush were submitted to the *Journal of the Atmospheric Sciences* in the first quarter. Bruce Hicks, former Director of ARL, is the lead author on both manuscripts. The manuscripts have since been rejected in their current form, but revisions are underway on the second manuscript so it can be resubmitted. The revised manuscript will deal principally with the limitations of Monin-Obukhov similarity theory in the stable boundary layer. Dennis Finn has begun a new line of analysis with regard to an alternate development of the topics included in the first manuscript. This will focus on how mechanisms aloft may contribute to turbulence events at the surface.

The draft manuscript "Mechanisms for wind direction changes in the very stable boundary layer" was submitted to the *Journal of Applied Meteorology and Climatology* late in the quarter. In light winds at night, the wind direction during Project Sagebrush was often relatively steady for minutes, or tens of minutes, but then abruptly shifted to a new direction. These abrupt shifts have a significant effect on dispersion under such conditions and are not handled well using standard dispersion modeling techniques. The manuscript explores mechanisms that could be responsible for the shifts.

The draft manuscript "Distinct turbulence structures in stably stratified boundary layers with weak and strong surface shear" was submitted to the *Journal of Geophysical Research – Atmospheres*. Researchers at Washington State University are leading this effort, with coauthors from ARL's Field Research Division (FRD). This work also draws upon measurements made during Project Sagebrush, particularly from the turbulence instruments deployed by Washington State. (dennis.finn@noaa.gov)

FRD is collaborating with researchers and students from the University of Texas at San Antonio's Department of Mechanical Engineering to perform high-resolution simulations of atmospheric conditions during Project Sagebrush releases. The department runs a Laboratory of Turbulence Sensing and Intelligence Systems focused on high-resolution modeling of turbulent flows using direct numerical simulation and large eddy simulation (LES). A Ph.D. student at the university has obtained the Project Sagebrush data and is working on LES runs, starting with the daytime cases. Combining the field observations with three-dimensional atmospheric simulations will provide a better picture of the boundary-layer structure during the releases. (richard.eckman@noaa.gov)

3. HYSPLIT Interface at the NOAA Web Operations Center (WOC)

FRD is collaborating with ARL Headquarters to update the web browser interface used at the NOAA WOC to run HYSPLIT simulations. These updates are being driven by rapid shifts in web programming practices. The original WOC interface was based on the Adobe Flash plug-in and Google Maps software because those options were common practice several years ago for web programming and provided the best performance. Now, the Flash plug-in is rapidly disappearing and the companies offering mapping software have repeatedly changed their licensing terms to the detriment of users. The updated interface is based on standard JavaScript and HTML5 programming supported natively in browsers and uses the open-source Leaflet mapping software. A working prototype of the new interface was nearly complete in the second quarter and should be ready in the third quarter. (brad.reese@noaa.gov, dennis.finn@noaa.gov)

4. FRD Tracer Program

The staff members principally responsible for maintaining the tracer program and its measurement capabilities will likely be retiring within the next one to two years. To retain as much of the programmatic knowledge as possible, FRD is cross-training other staff on the use of the tracer equipment. This includes becoming familiar with the program documentation and extensive hands-on training with the equipment. A practice tracer study involving 20 air samplers and 80 sampler cartridges has been developed to provide a more realistic environment for the training. The first release in this practice study is scheduled for early April. Cartridges have been cleaned and are undergoing cleaning checks, and many of the preliminary setup and equipment check-out steps have been completed. (roger.carter@noaa.gov, dennis.finn@noaa.gov)

5. Wind Forecast Improvement Project (WFIP)

FRD's field deployments related to the WFIP ended last year, but the division is still wrapping up data processing and working on publications related to the project. Data from the two surface-flux systems deployed in Oregon during the second phase of WFIP were processed during the quarter to flag observation gaps and other problems. These reviewed data have now been uploaded to the WFIP archive.

A manuscript based on the first phase of WFIP was completed during the quarter, with Richard Eckman as a coauthor, and submitted to *Wind Energy.* This manuscript investigates how adding more observations to the initialization of the Rapid Refresh model affects forecast skill for wind-

energy applications. A second manuscript, describing the observations collected during the second phase of WFIP, is under preparation for submission to the *Bulletin of the American Meteorological Society* as part of a special issue on WFIP. A conference paper with FRD coauthors has also been prepared for a remote sensing symposium in Germany. (richard.eckman@noaa.gov)

6. NOAA/Idaho National Laboratory (INL) Mesonet

FRD staff are ready to begin spring semi-annual maintenance and calibrations on the NOAA/INL Mesonet stations. A new, automated maintenance form has been developed to guide the technicians and record the results of the calibrations. Running on a tablet computer, the form automatically performs calculations, makes pass/fail determinations, and dynamically adjusts the instructions for the technicians based on inputs. Initial tests indicate that significant time savings are possible with the new form and we anticipate a reduction in errors.

During the spring semi-annuals, electronic circuitry is being added to the stations to monitor the temperature/humidity sensor aspirator fans. Currently, the most time consuming part of the meteorologist quality control review of the Mesonet data is checking for aspirator fans that are not functioning. This new circuitry will allow automatic detection of inoperable fans, significantly reducing the manual workload. (roger.carter@noaa.gov, devin.clinger@noaa.gov, adam.haggerty@noaa.gov, Jason.rich@noaa.gov)

7. NOAA/Atmospheric Turbulence & Diffusion Division (ATDD) – Coyote Small Unmanned Aircraft System (sUAS)

A new iMet-XF system was tested in the Thunder Scientific temperature/relative humidity (T/RH) chamber. This instrument will go on the last remaining Coyote sUAS airframe that will be deployed in the 2018 hurricane season to measure air temperature, relative humidity, ocean surface temperature, and atmospheric pressure during the Coyote's flight.

Preparations were made to test three Vaisala RSS421 dropsonde T/RH sensors in the Thunder Scientific T/RH chamber. These instruments are potential replacements for the iMet-XF instruments currently on the Coyote aircraft. A transistor-transistor-logic level shifter was tested to enable serial communication between the RSS421 devices and the Linux data acquisition computer. Custom software was also written to collect data from the Vaisala devices, operate the T/RH chamber, and collect data from the reference devices used during the test. The devices will be tested next quarter. (Ed.Dumas@noaa.gov, B. Baker)

8. NOAA/ATDD – sUAS Instrument Testing

Four ManoNano Technologies eMotes were tested this quarter. These sensors were designed to be dropped from altitude and transmit data as they fall through the air. The devices have antennae that are configured like wings to allow the devices to auto-rotate as they descend, similar to a maple seed. Data is transmitted in real-time from each eMote to a ground-based computer where it is recorded.

Each eMote has two temperature sensors, a relative humidity (RH) sensor, an atmospheric pressure sensor, GPS, and several accelerometers. These sensors are used to measure the thermodynamic quantities of the atmosphere, as well as the position, altitude, and inertial state of the device as it falls through the atmosphere. Testing this quarter was performed on the two temperature sensors and the RH sensor using the Thunder Scientific T/RH chamber.

The next phase of testing will involve dropping the devices from the DJI S-1000 sUAS to test them in real-world conditions next quarter. (Ed.Dumas@noaa.gov, T. Lee, M. Buban, B. Baker)

9. NOAA/ATDD – UAS Program Office Work

Work continues toward the goal of performing daily boundary layer profiles of temperature and relative humidity using the sUAS for the National Weather Service (NWS) office in Morristown, Tennessee. In order to reach the target altitude of 1 km (3300 feet) above ground level, the DJI S-1000 sUAS must be flown beyond the pilot's visual line-of-sight (BVLOS).

Two systems will be used for airborne collision avoidance while flying the sUAS at these altitudes. The PrecisionHawk LATAS system (http://www.flylatas.com/) can provide real-time Federal Aviation Administration air traffic data for a local region, as well as tracking data for the sUAS being flown. Echodyne (http://www.echodyne.com/) has a small portable solid-state radar system that can detect full-scale aircraft targets up to 3 km away, while also tracking smaller targets at < 3 km.

Discussions were initiated this quarter between PrecisionHawk and Echodyne to provide a system that will merge these technologies. ATDD plans to use this merged system to monitor air traffic in the area where the sUAS will be operating to ensure air traffic separation and safe BVLOS operations. (Ed.Dumas@noaa.gov, T. Lee, M. Buban, B. Baker)

ATMOSPHERIC CHEMISTRY AND DEPOSITION

10. Fluxes of Greenhouse Gases in Maryland (FLAGG-MD) Project

Xinrong Ren participated in the FLAGG-MD project to continue characterizing greenhouse gas (GHG) emissions from the Baltimore-Washington area. The University of Maryland's (UMD) Cessna 402B research aircraft flew over this area to measure GHGs, meteorological variables, and other trace gases and aerosol optical properties. GHGs emissions were estimated based on the aircraft measurements and then compared to the emissions in state and national emission inventories. The FLAGG-MD project has produced policy-relevant science that aided in improved quantification of anthropogenic GHG emissions to the scientific community and regulatory agencies, such as the Maryland Department of the Environment, through direct analysis of ambient measurements and model simulations. (xinrong.ren@noaa.gov)

11. Coordinated Measurement Campaigns Targeting Volatile Organic Compounds (VOCs)

Xinrong Ren and several UMD colleagues conducted two research flights over New York City on March 26 in collaboration with a research group from the Chemical Sciences Division of NOAA's Earth System Research Laboratory (ESRL), who were measuring VOCs in the city and its surrounding areas using an instrumented mobile van. Whole air samples were collected during the flights, both upwind and downwind of the area where the mobile lab was making measurements. The air samples were analyzed and the results are being compared to the measurements by the mobile lab. Planning is underway to conduct similar coordinated measurements on the ground and in the air this coming summer during the Long Island Sound Tropospheric Ozone Study. (xinrong.ren@noaa.gov)

12. Special Issue Editors for *Atmosphere*

Dr. Pius Lee and Dr. Rick Saylor served as invited Guest Editors for a recently-published special issue of *Atmosphere* titled, "Air Quality Monitoring and Forecasting," along with Jeff McQueen of the NWS Environmental Modeling Center.

The issue begins with an editorial by the three Guest Editors highlighting the synergies and co-benefits of lock-step improvements in atmospheric modeling; citing the frequent culmination of accurate forecasting and optimal design and deployment of monitoring instrumentation. The 12 papers that follow represent a dual focus on monitoring and forecasting measurements. These papers were chosen from a pool of applicants by a small panel of anonymous reviewers, themselves selected by the journal's editor. One of the selected papers is "Overview of the Model and Observation Evaluation Toolkit (MONET) Version 1.0 for Evaluating Atmospheric Transport Models," by ARL's Barry Baker and Li Pan. In all, the papers represent efforts by nine universities, seven U.S. agencies, and five different countries.

Drs. Lee and Saylor, who support ARL headquarters and ATDD, respectively, worked on developing the issue for over a year. The topic was provided to them, then they refined the title and wrote a solicitation on the website which, in turn, was promoted by various well-known scientists and managers at various industry-wide meetings and events. Approximately nine months lapsed between the manuscript submission deadline and the ultimate publication date, a faster-than- normal turnaround for this type of publication.

Atmosphere is a well-known international, open access journal providing monthly access to scientific studies related to the atmosphere. Air quality is one of five sections within this journal. The remaining sections include atmospheric chemistry, atmospheric physics, air quality – climate interactions, and meteorology. (pius.lee@noaa.gov)

CLIMATE OBSERVATIONS AND ANALYSES

13. Climate Reference Network (CRN)

Climate Reference Network personnel made 31 annual maintenance visits and one unscheduled maintenance visit this quarter. (Mark.E.Hall@noaa.gov)

An automated testing program for the CRN Vaisala T/RH sensors was created that will automatically collect data from the Thunder Scientific T/RH thermal chamber, the EdgeTech dew point sensor, and one of the reference platinum resistance thermometer sensors while automatically stepping through pre-determined T/RH setpoints. (Ed.Dumas@noaa.gov, M. Black)

In January, February, and March the National Centers for Environmental Information (NCEI) retrieved 27 data files from USCRN sites through the server ftp.atdd.noaa.gov. Data are passed to NCEI by this path when retrieved episodically by ATDD from individual site visits to fill data gaps. Instruments' characteristics for each site are maintained in the Integrated Station Information System (ISIS) database on NCEI's server, along with a record of events which affect data quality. New ISIS events are identified from ATDD's field crews and archived data. (Lynne.Satterfield@noaa.gov)

14. Local Meteorological Support

Data reduction for January, February, and March was completed without problems. The monthly data for these three months was entered into WxCoder and submitted. (Lynne.Satterfield@noaa.gov)

ARL 2nd Quarter Publications

Christian, K. E., Brune, W. H., Mao, J., and Ren, X. (2018). Global sensitivity analysis of GEOS-Chem modeled ozone and hydrogen oxides during the INTEX campaigns, *Atmos. Chem. Phys.*, 18, 2443-2460, https://doi.org/10.5194/acp-18-2443-2018.

Kochendorfer, J., Nitu, R., Wolff, M., Mekis, E., Rasmussen, R., **Baker, B.**, Earle, M. E., Reverdin, A., Wong, K., Smith, C. D., Yang, D., Roulet, Y.-A., **Meyers, T.**, Buisan, S., Isaksen, K., Brækkan, R., Landolt, S., and Jachcik, A. (2018). Testing and development of transfer functions for weighing precipitation gauges in WMO-SPICE. *Hydrol. Earth Syst. Sci.*, 22, 1437-1452, https://doi.org/10.5194/hess-22-1437-2018.

Conference Presentations & Invited Talks

Bruce Baker, Ed Dumas, Temple Lee, Michael Buban, Rick Saylor, and John Kochendorfer attended the American Meteorological Society's (AMS) Annual Meeting in Austin, Texas, where ATDD participants authored or co-authored 10 oral presentations. Bruce Baker chaired the 19th Symposium on Meteorological Instrumentation and Observations and John Kochendorfer presented *"Errors and Adjustments for WMO-SPICE Tipping-Bucket Precipitation Gauges"* and was a co-author on *"A New Low Cost Sensor for Determining Heat and Moisture Fluxes"* with lead author and presenter, Dr. Temple Lee. Dr. Lee, who co-authored four additional papers, also chaired the session on Use of UAVs for Atmospheric Research That Includes Discussions on Platforms, Instrumentation, Regulations, and Science II, during which Edward Dumas

presented, *"Use of Small Unmanned Aircraft Systems in VORTEX-SE 2017 and LAFE 2017."* Dr. Michael Buban presented, *"The Role of Surface Heterogeneities on Low-Level Vorticity Production and Boundary Layer Characteristics during VORTEX-SE."* Dr. Rick Saylor presented, *"The Atmospheric Chemistry and Canopy Exchange Simulation System for Ammonia (ACCESS-NH3): Formulation and Application to Measurements from a Deciduous Forest Canopy"* during the 20th Conference on Atmospheric Chemistry. (Bruce.Baker@noaa.gov)

Scientists from ARL and ESRL met in Boulder, Colorado, January 17-18, 2018, for a collaborative strategy session. There were three primary goals for this meeting: to exchange information on current air chemistry research at ARL/ESRL; to discuss short-term and long-term plans to utilize air chemistry research to support NOAA core missions and educate Office of Oceanic and Atmospheric Research (OAR) management about the importance of air chemistry research to NOAA's missions; and to explore potential opportunities for collaboration (i.e. joint projects, proposals, interactions with OAR programs). Following the presentation of laboratory overviews to the entire group, participants divided into three subgroups to participate in concurrent sessions related to their respective areas of specialty - air chemistry, dispersion, and CRN/boundary layer processes. Each of the three topic areas had its own full agenda, complete with a lengthy slate of five-minute "lightning talks" on projects, personal interests, and suggested collaborations, followed by more in-depth, focused discussions. The entire group then reconvened Thursday afternoon to hear a summary of each working group's interactions, and to discuss strategies and next steps. (Rick.Saylor@noaa.gov)

Dr. Ariel Stein, Dr. Mark Cohen, and Dr. Alice Crawford participated in the 9th Biennial Education and Science Forum of the NOAA Educational Partnership Program with Minority Serving Institutions at Howard University, Washington D.C., March 20, 2018. Dr. Stein gave an invited, keynote presentation about HYSPLIT research in a conference session devoted to NOAA's Weather Ready Nation. Drs. Cohen and Crawford developed and presented an instructional HYSPLIT Workshop that incorporated a live demonstration of the HYSPLIT modeling system, including extensive instruction on the use of scripts to automate HYSPLIT analysis. An accompanying presentation was used to reinforce important points, and a HYSPLIT cheat sheet was provided to all workshop participants. The event was hosted by Howard University and the NOAA Cooperative Science Center in Atmospheric Sciences and Meteorology. (alice.crawford@noaa.gov)

Outreach & Engagement

Technology Transfer and Engagement: (a) Dr. Mark Cohen helped students and faculty of Florida State University use the HYSPLIT model to analyze aerosol and rain samples collected during three recent ocean cruises via a multi-session webinar, provision of scripts, and extensive online troubleshooting and instruction. (b) Dr. Cohen and Dr. Alice Crawford helped students and faculty at UMD to use HYSPLIT in a project investigating the impact of different injection height estimation methods on the dispersion of wildfire smoke and volcanic ash. This project highlighted the importance of accurate plume rise estimates in wildfire simulations and has led to a new collaborative project to develop an improved wildfire-plume-rise algorithm for the HYSPLIT model. (c) Dr. Cohen presented a webinar to ESRL's Lagrangian Particle Dispersion Model meeting in

February 2018 entitled: *Using spatial and chemical interpolation for source-attribution and calculation efficiency: Some examples for mercury and dioxin*. The presentation outlined a powerful interpolation-based approach that can provide detailed source-receptor information and flexibility to examine alternative emissions assumptions. (d) As a result of the above interactions, and in addressing HYSPLIT Forum and other questions posed to ARL, Dr. Cohen made several improvements to the HYSPLIT model.

Training

HYSPLIT Short Course Taught in Conjunction with 98th AMS Annual Meeting

A one day HYSPLIT short course was delivered to 13 participants on Sunday, January 7, 2018, as part of the 98th AMS Annual Meeting in Austin, Texas. Titled, "*Using PC/Mac-based HYSPLIT for Basic Trajectory and Dispersion Applications*" and requiring each participant to use their own computer, this course was designed for novice HYSPLIT users and focused on basic trajectory and particle dispersion calculations. Topics included meteorological data sources required for the computations, the trajectory calculation, sources of trajectory error, and the use of multiple trajectories including cluster analysis. The generation of multiple particle trajectories to compute dispersion patterns and air concentrations were also reviewed, including the uncertainty introduced by the limitations of the meteorological data. Instructors for the short course were Roland Draxler, Ariel Stein, and Glenn Rolph. (glenn.rolph@noaa.gov)

Other

Richard Eckman, Jason Rich, and Donna Davis attended the Pocatello NWS Weather Forecast Office's annual weather briefing and chili cook-off in February.