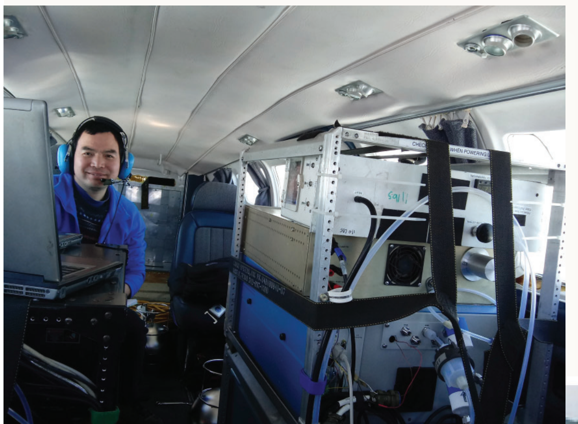
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Air Resources Laboratory

Quarterly Report Q1 - 2021



Contents

Photos, cover, upper left: Xinrong Ren on ainstrumented small planes to sample air in the MidAtlantic states; Small UAS the ATDD operators in Oak Ridge, TN take vertical profiles of the atmosphere; ISS astronaut’s photo of the Raikoke volcano erupting on June 22, 2019. (Image credit: NASA). Back cover: Astronauts aboard the ISS captured the Earth’s atmospheric layers on July 31, 2011, revealing the troposphere, or boundary layer (in orange-red), stratosphere and above (Image credit: NASA).

Dispersion and Boundary Layer

Locust Migration Web Application

Work has continued on the locust migration web application, in collaboration with Keith Cressman, Senior Locust Forecasting Officer of the United Nations Food and Agriculture Organization (FAO). A new "matrix" functionality was added that allows the user to specify a grid of locust-swarm starting locations and then forecast the migration from each grid point. The resulting trajectories can be displayed discretely (see figure below) or summarized as gridded frequencies. The system was modified to allow simulations in parallel to support the more computationally intensive matrix-mode runs. The allowable forecast duration was increased to 15 days. A number of important improvements were also made to graphical outputs, as well as with web-application security. A talk was prepared for presentation at the 101st Annual Meeting of the American Meteorological Society, including a summary slide for a Lightning Talk, a slide presentation, and a video-taped presentation of the slides.
Sonny Zinn (sonny.zinn@noaa.gov) and Mark Cohen (mark.cohen@noaa.gov)

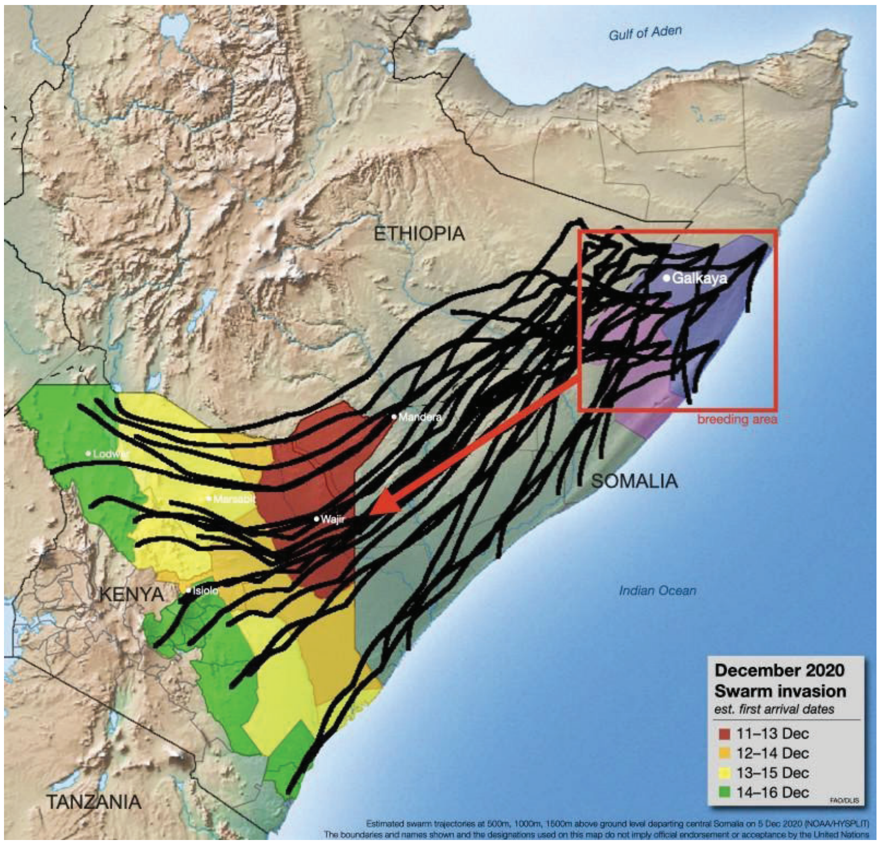


Figure 1. Locust migration estimated via the NOAA ARL web application by the United Nations Food and Agriculture Organization, using a prototype of the new matrix-based gridded source region approach. Image credit: UNFAO, http://www.fao.org/ag/locusts/common/ecg/75/en/201205som2ken.jpg

HYSPLIT Dispersion Modeling Enhanced by Unmanned Aircraft System (UAS) Measurements

NOAA National Weather Service (NWS) Weather Forecasting Offices (WFO's) carry out a number of critical emergency response activities in collaboration with governmental emergency management authorities. One such activity is the forecasting of downwind concentrations of air pollutants emitted during an industrial accident, transportation accident, or other unexpected or unusual atmospheric release. The purpose of the downwind forecast is to provide information to emergency management authorities that can help guide evacuation and other orders in efforts to protect public health.

The WFO's use the HYSPLIT model developed by the NOAA Air Resources Laboratory (ARL) – coupled with NOAA NWS weather forecast data – to carry out these downwind pollutant forecasts. To operate, the HYSPLIT model requires meteorological data such as wind speed, wind direction, temperature, and humidity, at different levels in the atmosphere. As with any modeling system, there are inherent uncertainties, and efforts to understand and reduce these uncertainties are an important priority. In the case of downwind pollutant dispersion modeling, the accuracy of the local wind speed and wind direction data, as well as other meteorological parameters, will directly affect the accuracy of the downwind concentration results.

ARL has been pioneering the collection of meteorological data using Uncrewed Aircraft Systems (UAS) and a new effort is underway to use these data to improve the accuracy of WFO HYSPLIT-based emergency-response air pollutant dispersion forecasts. During this quarter, the initial effort to integrate UAS primary HYSPLIT-integration work has been to convert UAS-based meteorological data to HYSPLIT format and carry out tests of HYSPLIT dispersion using these data. We expect to finish this first task in the next quarter.
christopher.loughner@noaa.gov, mark.cohen@noaa.gov

NWS Hysplit Improvements

In response to a request from the Weather Forecast Office, several enhancements were made to the Hysplit web application. The changes include 1) the additional capability of specifying a source location by its address, 2) entering a location by selecting a point on satellite image, which proves useful when the location for a storage tank, a building, etc. is necessary, 3) displaying local date and time instead of coordinated universal time, and 4) others. These changes are deployed to ARL servers and they are in the process of being deployed to NOAA Web Operation Center.
Sonny Zinn, sonny.zinn@noaa.gov

Development of HYSPLIT-based Emissions Inverse Modeling System (HEIMS)

Accurate estimations of hazardous event emissions, both from natural and anthropogenic sources, are crucial in atmospheric numerical models to predict future impacts to the public. ARL scientists have developed emission inverse modeling systems for multiple incidents, based on the transport and dispersion of pollutants constrained by space-born and surface monitoring measurements. The system is designed to minimize the cost function which quantifies the differences between model predictions and observed measurements, weighted by their uncertainties. The HEIMS is designed to be adopted in multiple incident types, including wildfire (HEIMS-f), nuclear incident (HEIMS-n), and volcanic eruption emissions (HEIMS-v).

Fire emissions (HEIMS-f):

Smoke forecasts have been challenged by high uncertainty in fire emission estimates. The HEIMS-f is designed to assimilate wildfire emissions based on the GOES Aerosol/Smoke Product (GASP) and HYSPLIT dispersion simulations, Figure 2, below.

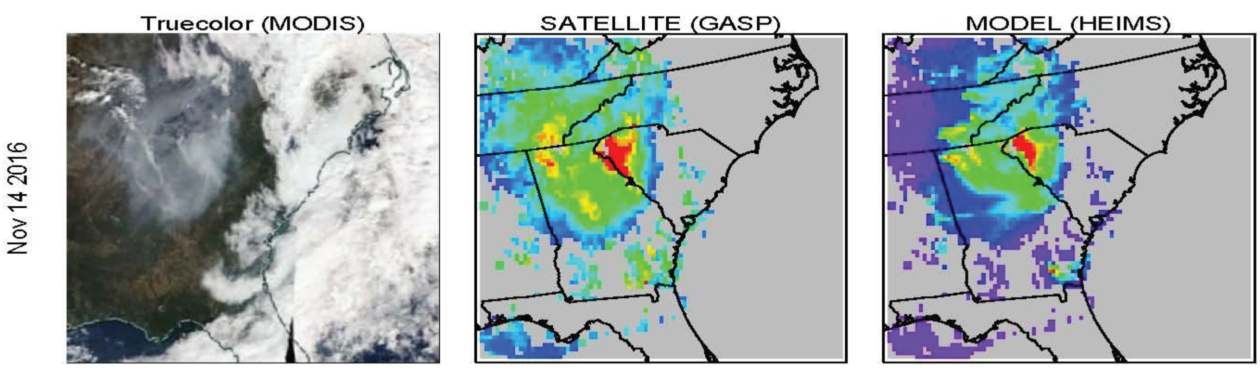


*Figure 2.	Case study of HEIMS-f system. Wildfire emissions in Southeastern US during November 2016 was estimated. MODIS truecolor image (left), GASP AODs, and HYSPLIT using assimilated emission are shown.*

Nuclear emissions (HEIMS-n):

An emission inverse modeling system for nuclear incident has been developed under the collaboration with the Korean Institute of Nuclear Safety (KINS, South Korea) to alert potential release of nuclear materials in South Korea. The HEIMS-n for South Korea system utilizes the Integrated Environmental Radiation Monitoring Network (IERNet), which includes the sodium iodide scintillation detectors (NaI-Tl) and the high pressure ion chamber (HPIC) detectors.

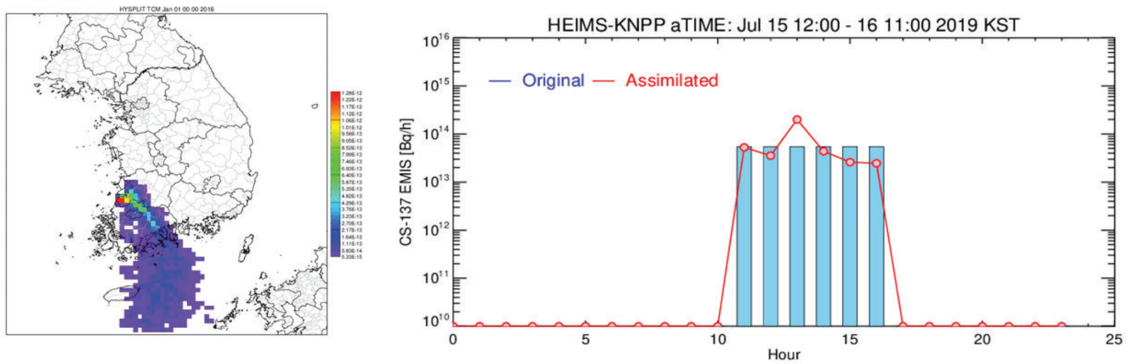


Figure 3. Example of nuclear incident emissions estimation using HEIMS-n system. A pseudo incident from Hanbit nuclear power plant in South Korea (left) was tested. Hourly variations of estimated Cs-137 emissions are compared to the pseudo incident emissions (right).

Volcanic emissions (HEIMS-v):

The effects of eruption of large volcanoes to regional environment include short-term damages, such as the flow of crushed stone to adjacent areas, long-range damages, such as aviation difficulty by deteriorated visibility and volcanic ash deposition, and long-term effect such as climate changes in a global scale. The HEIMS-v has been developed to estimate volcanic emissions based on aerosol (e.g. MODIS AODs) and/or gaseous properties (e.g. TROPOMI SO2). A case study has been conducted using the Nishinoshima (Japan) volcano eruptions that happened in August 2020 (Figure 4, below).

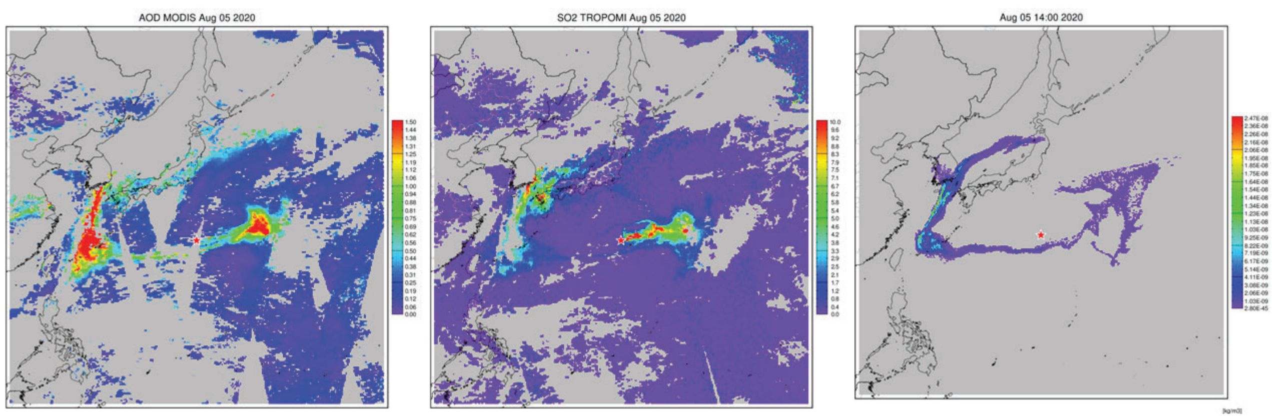


Figure 4. Case study of Nishinoshima volcano eruption in August 2020. Spatial distributions of MODIS AODs (left), TROPOMI SO2 column densities (middle), and HYSPLIT dispersion simulation on August 5, 2020, are shown.

HyunCheol Kim (Hyun.Kim@NOAA.gov) and Tianfeng Chai (tianfeng.chai@noaa.gov)

Volcanic ash

The International Civil Aviation Authority, ICAO, is in the process of drafting new requirements for volcanic ash forecasts. The new requirements will contain provisions for probabilistic and quantitative gridded products. Several ARL efforts are working to support the prospective change in requirements and develop the new products which will be needed. The Joint Technology Transfer Initiative, JTTI, in collaboration with environmental modeling center, EMC, will provide for HYSPLIT ensemble dispersion runs driven with the global ensemble forecast system, GEFS. A joint polar satellite system, JPSS, project in collaboration with the National Environmental Satellite, Data, and Information Service, NESDIS, is developing a modeling system that will assimilate satellite products to improve forecasts of the atmospheric transport and dispersion of volcanic emissions. A Forecasting a Continuum of Environmental Threats, FACETs, project in collaboration with Global Systems Lab, GSL, is developing ways to visualize and ingest ensemble dispersion products into Advanced Weather Interactive Processing System, AWIPS2, and hazard services. Results from all of these projects were presented at the American Geophysical Union, AGU, fall meeting this year. Additionally Alice Crawford and Barbara Stunder have been providing support and feedback to the volcanic ash advisory center, VAAC, managers and the FAA involved in drafting the volcanic ash forecast requirements and communicating with the NWS Volcanic Ash program manager. Barbara Stunder has been attending international civil aviation organization, ICAO, meteorological information and service development, MISD, meetings as part of the working group. Alice Crawford, Sonny Zinn, and Allison Ring have been developing web applications on the HYSPLIT READY system in support of volcanic ash forecasting. One page provides results from automated HYSPLIT runs triggered by satellite alerts. Another page allows VAACs to create probabilistic products using the GEFS to drive HYSPLIT and provide a testbed for new volcanic ash products.
(Alice Crawford – alice.crawford@noaa.gov)

Tracers of Opportunity

In actual hazmat incidents with atmospheric releases, estimates of the amount of chemical released are frequently uncertain, and downwind concentration measurements are usually not available, making model evaluation challenging. Tracer experiments are carried out to test models, and ARL has been a leader in carrying out such model-evaluation exercises (e.g., see ARL's DATEM program). However, these experiments are resource-intensive and there are therefore very few of them. As an alternative, ARL uses "Tracers of Opportunity" taking advantage of emissions data from well-quantified sources and downwind concentration measurements. One area of this work uses SO2 from power plants as a boundary-layer tracer of opportunity for dispersion model evaluation. The time-varying emissions of SO2 from electric generating facilities are known and available from the EPA and air quality sampling networks throughout the U.S. (EPA Air Quality System (AQS)) contain SO2 measurements. This tracer of opportunity has been used to evaluate the use of the High Resolution Ensemble Forecast, HREF, to drive HYSPLIT and produce dispersion model ensemble results for chemical release applications. This evaluation is an important part of a joint technology transfer initiative, JTTI project and shows that use of the dispersion model ensemble is clearly preferable to using one deterministic run. (Alice Crawford – alice.crawford@noaa.gov)

Dispersion Model Evaluation using the 1996 Model Validation Program Tracer Study

The 1996 Model Validation Study (MVP) consisted of over two hundred tracer releases covering three seasons for the Cape Canaveral Air Force Station (CCAFS) and provided tracer measurements taken by a moving van, as well as comprehensive meteorological measurements including 46 instrumented towers and a wind profiler (Figure 5). The coastal characteristics of these experiments add complexities to the meteorological and dispersion modeling.

To demonstrate the feasibility of using the 1996 MVP to develop a database to support the evaluation of the performance of both the numerical weather prediction models, Fantine Ngan and Will Pendergrass used the Weather Research Forecast (WRF) model to develop the meteorological fields for Trail 308 (May 1st, 1996) from the tracer study to drive HYSPLIT for the dispersion simulation.

The model wind were nudged toward the observations collected during the experiment that corrected the model wind direction bias. Optimizing the nudging coefficient increased the influence of wind observations and further improved the wind speed prediction. The differences between modeled and observed concentrations decrease when transitioning from using the WRF data with no observational nudging to nudging with both surface and upper-air measurements (Figure 6). While we only utilized a small set of tracer releases, we conclude that given the appropriate n00umerical weather simulation, the 1996 MVP Study could provide a rich database for evaluation, verification, and validation of numerical modeling of the potential release of hazardous materials within the environment of the CCAFS. This study was published in NOAA Tech memo ARL-281 (https://doi.org/10.25923/x74e-3k77).

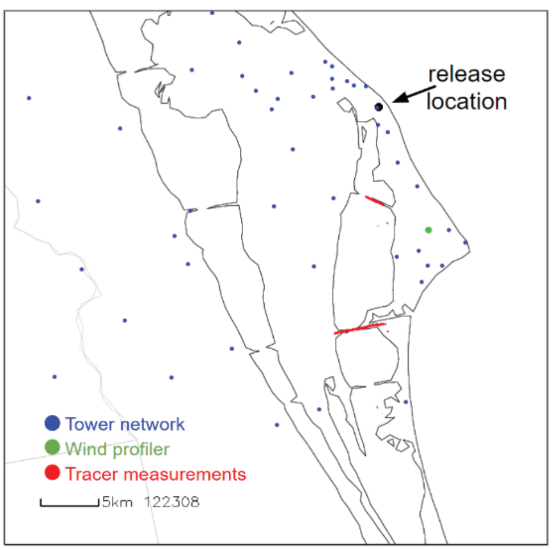


Figure 5. The regional map of the study area showing the release location (black dot), tower network (blue dots), wind profiler location (green dot), and tracer measurements (red dots).

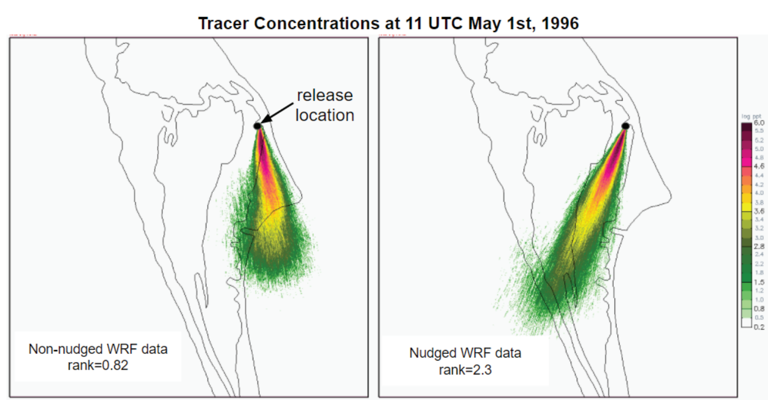


Figure 6. Tracer concentrations from the HYSPLIT results driven by non-nudged WRF (left panel) and nudged WRF data (right panel) at 11 UTC on May 1st , 1996. Unit: log ppt. The Rank is the statistical score computed used modeled and observed concentrations.

Data Archive of Tracer Experiments and Meteorology (DATEM)

The atmospheric tracer verification archive, DATEM (https://www.arl.noaa.gov/research/dispersion/datem), was developed to provide access to experimental data, relevant reports, meteorological data, statistical analysis, and display software for controlled tracer experiments. Since launching the archive to the public in early 2000s, it has been expanded to cover a wide range of durations and distances, ranging from 10's to 1000's of km. More recently we added the Project Sagebrush Phase 1, which consisted five tracer releases and aimed for the sub-kilometer scale transport with near neutral or unstable stability conditions, to the archive (Figure 7). Fantine Ngan conducted series of HYSPLIT simulations for nine controlled experiments available in DATEM. Using two sets of meteorological data on ARL data server and the corresponding mixing configurations for HYSPLIT modeling, the study is to evaluate the dispersion results using the tracer measurements obtained from the tracer experiments. (Fantine Ngan – fantine.ngan@noaa.gov)

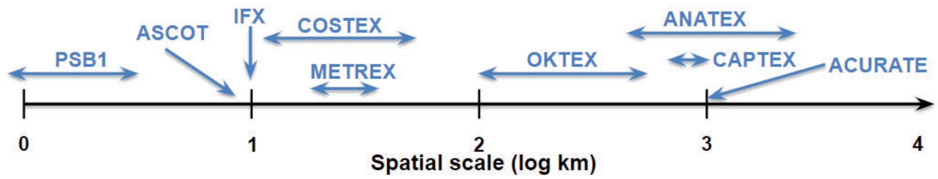


Figure 7. The schematic of the spatial scale (log km) of nine controlled tracer experiments in DATEM: Atlantic Coast Unique Regional Atmospheric Tracer Experiment (ACURATE), Across North America Tracer EXperiment (ANATEX), Cross APpalachian Tracer EXperiment (CAPTEX), OKlahoma Tracer EXperiment (OKTEX), MEtropolitan Tracer EXperiment (METREX), Colorado Springs Tracer Experiment (COSTEX), Idaho Field Experiment (IFX), Atmospheric Studies in Complex Terrain (ASCOT), and Project Sagebrush Phase 1 (PSB1).

Consequence Assessment for the Idaho National Laboratory

Routine training and practice to maintain qualifications and expertise were conducted. The INL Emergency Operations Center (EOC) had no activations or exercises this quarter.
(Jason.Rich@noaa.gov, Bai.Yang@noaa.gov)

FRD Mesonet

Fall semi-annual calibrations on the NOAA INL Mesonet were completed. Calibrations were started a little earlier than normal this Fall since the Spring cycle was put on hold due to Covid-19 and that extra time may be needed to include additional technician training. Good weather and the quick learning electronic technicians allowed the semi-annuals to be completed in October.
(Jason.Rich@noaa.gov, Bai Yang, Jonathan Forman, and Logan Honeycutt)

The NOAA INL Weather Center issued seven warnings during the last quarter. All of the alerts issued were for high winds.
(Jason.Rich@noaa.gov and bai.yang@noaa.gov.)

The INL DMZ was taken down during the first week of August and as a result, the FRD Home Page and NOAA INL Weather Center Website have been out of service. Limited access to the website has been restored within the BEA firewall. This issue continues to cause a problem for FRD, INL employees outside of the BEA firewall, and others in the public who rely on the weather data from the NOAA INL Mesonet for their safety and daily operations. FRD has been fielding a large increase in the number of requests for current weather, forecasts, daily summaries, and archived data due to this outage.
(brad.reese@noaa.gov, Jason.Rich@noaa.gov)

Washington State University Project

The Field Project collaboration between FRD and a research group from the Washington State University, "The Role of Coherent Structures in Scalar Transport over Heterogeneous Landscapes", continued this quarter. On-going field activities and measurements around the GRID 3 tall tower that were set up in September 2020 were evaluated. Potential problems and issues were discussed through on-line meetings. Planning and logistical preparations for phase two of this experiment occurred. Phase 2 is planned to begin in Spring 2021.
(bai.yang@noaa.gov)

FRD – Additional Research Activities

To broaden FRD research and explore collaborative opportunities, Bai Yang reached out to Tilden Meyers and John Kochendorfer from ATDD (Atmospheric Turbulence Diffusion Division). Discussions were held to find common interests that would potentially advance the research missions of both Divisions. After several discussions, it was decided to begin a data-model study by utilizing the eddy covariance data collected at the flux station on the INL and the SEBN (Surface Energy Budget Network managed by ATDD) to validate and test a land surface model (LSM) developed by the NOAA Geophysical Fluid Dynamics Laboratory (GFDL). The team contacted scientists from the GFDL to discuss this specific LSM model and to plan for tutorial sessions.
(bai.yang@noaa.gov)

Meteomatics Meteodrone SSE Flights

Daily profiles were flown again this quarter with the Meteomatics Meteodrone Sever Storms Edition aircraft (S/N SSE-80). This work is funded by the NOAA UAS Program Office, and is being performed in conjunction with the Morristown WFO. Ed Dumas and Travis Schuyler acted as both pilots-in-command and visual observers for a series of flights from October 7-December 6, 2020. All flights were made at

Oliver Springs Airport in Oliver Springs, TN. Measurements of temperature, relative humidity, wind speed and wind direction were made as the aircraft ascended and descended along a vertical axis.

Ed Dumas and Travis Schuyler received training to fly the latest Meteomatics SSE aircraft at Oliver Springs airport on October 15-16, 2020. The new aircraft is a significant upgrade of the existing Meteomatics SSE aircraft. It is capable of flying to 1 km above ground level at a rate of 10 m/s. The aircraft is larger and has more powerful lights to enable it to be seen at 1 km altitude. Several profiles were completed by both Ed and TJ to validate the operation of the aircraft.

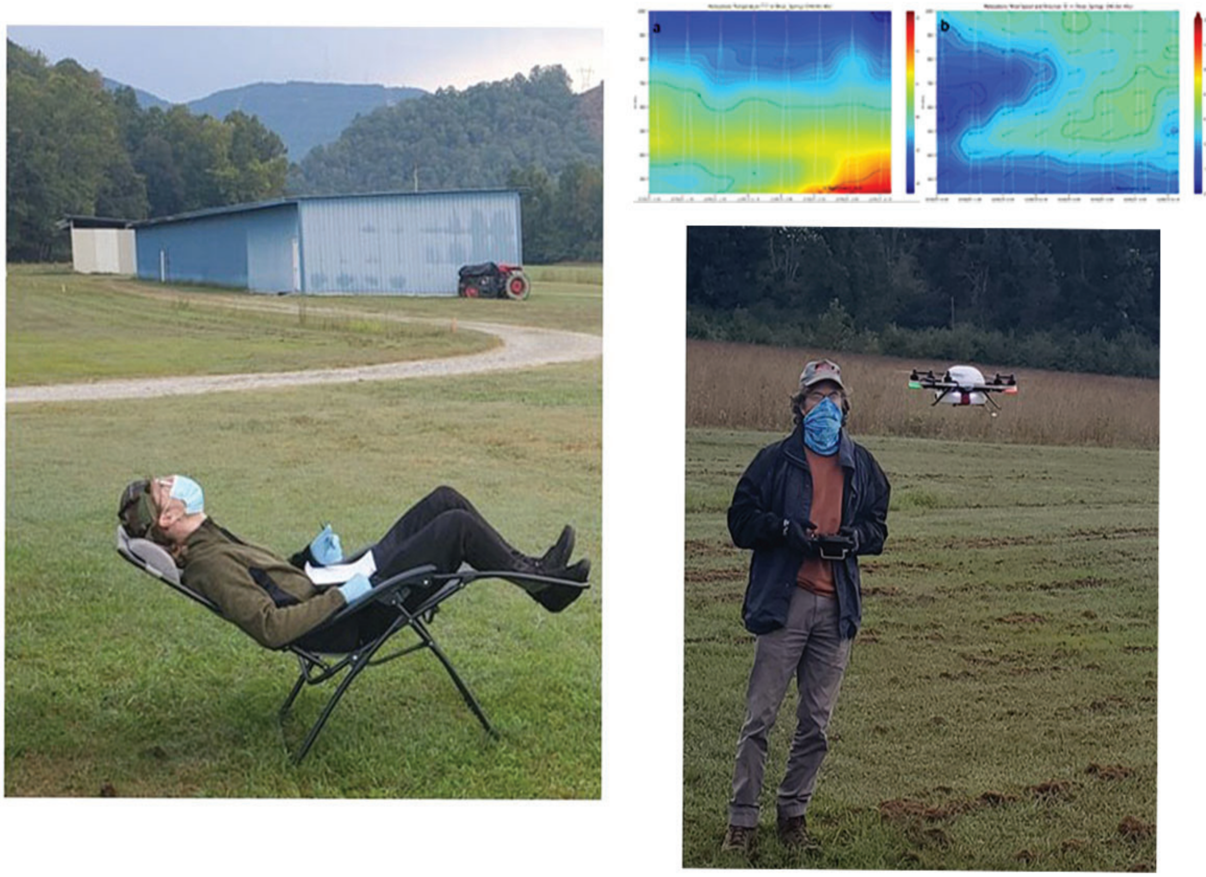


Figure 8. Observer Travis Schuyler, left and Ed Dumas, right, operating the Meteomatics SSE aircraft during flights at Oliver Springs, TN.

APH-28 Addition to Fleet

Progress was made integrating the Aerial Imaging Solutions APH-28 sUAS into the ATDD fleet. It was transferred to ATDD from NOAA/OMAO/AOC in September and arrived in October 2020. After receiving the aircraft, two iMet T/RH sensors and a TeAx ThermalFusion visible and infrared camera system were added to it by the manufacturer. However, training to fly the aircraft has been postponed indefinitely due to COVID-19.

F-TUTN Temperature / Relative Humidity Sensor Testing

Testing continued this quarter on the UPSI F-TUTN fast-response temperature and humidity sensor. A new version of this sensor was received at ATDD in September 2020 and was tested in the Thunder Scientific T/RH chamber in November 2020 to validate its factory calibration. The new version was modified to include a faster response temperature sensor from previous versions, as well as tighter full-scale range for the new temperature sensor (-20° to +50° C as opposed to ±50° C). An example of the temperature calibration from the Thunder Scientific chamber is shown on the next page.

Figure 9 shows the ratio of F-TUTNA.44 temperature data to the reference temperature used in the chamber. In the top figure, the ideal surface would all values of 1.0 across the entire range of T and RH values. The bottom figure shows the difference between the F-TUTNA.44 temperature data and the reference temperature used in the chamber.

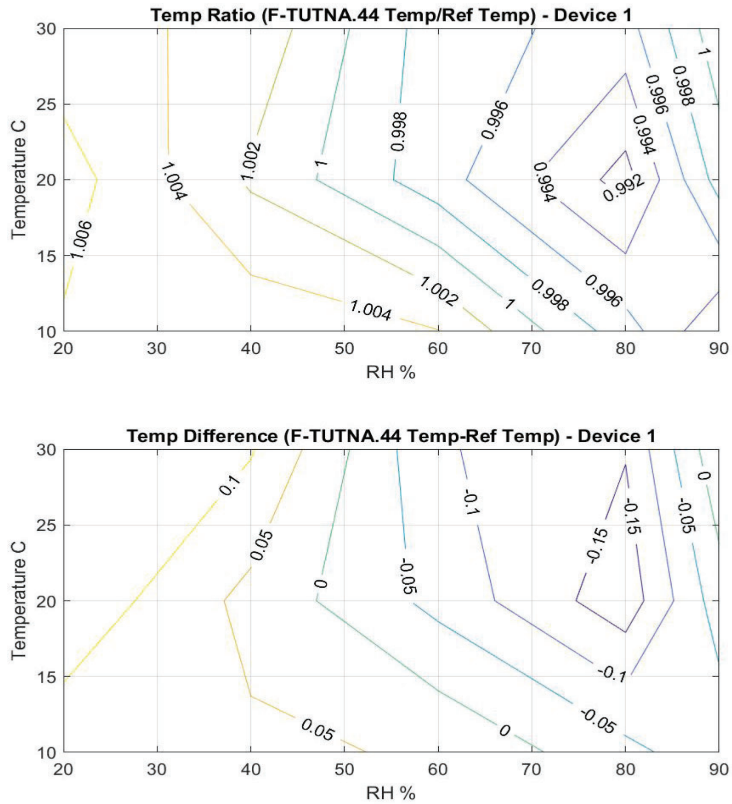


Figure 9. Ratio of F-TUTNA.44 temperature data to the reference temperature

Community outreach and engagement.

Alice Crawford and Mark Cohen are supporting a student project in the space hardware club at University of Alabama Huntsville. The students will launch a total of five high altitude balloons with gps tracking devices tethered to them. The students plan to compare the balloon paths to HYSPLIT generated trajectories. They plan to drive HYSPLIT with several meteorological datasets including the GEFS.

Dispersion and Boundary Layer – Publications for Q1

Angevine, W. M., Peischl, J., **Crawford, A., Loughner, C. P.,** Pollack, I. B., and Thompson, C. R.: Errors in top-down estimates of emissions using a known source, Atmos. Chem. Phys., 20, 11855–11868, https://doi.org/10.5194/acp-20-11855-2020

Crawford, A.: The Use of Gaussian Mixture Models with Atmospheric Lagrangian Particle Dispersion Models for Density Estimation and Feature Identification. Atmosphere 2020, 11, 1369. https://doi.org/10.3390/atmos11121369

Hicks, B.B., **Pendergrass, W.R.,** Oetting, J.N. et al. The North American Solar Eclipse of 2017: Observations on the Surface Biosphere, Time Responses and Persistence. Boundary-Layer Meteorol (2020). https://doi.org/10.1007/s10546-020-00582-1

Pendergrass, W.R., Ngan, F., Hicks, B. B., Hosker, R.P., Mazzola, C.A.: Demonstrating the Feasibility of Using the 1996 MVP Tracer Study for Transport and Diffusion Model Validation, 2020, NOAA Technical Memorandum OAR ARL-281; https://doi.org/10.25923/x74e-3k77

Dispersion and Boundary Layer – Presentations for Q1; AGU Fall meeting 2020.

Off the Grid: The use of Gaussian mixture models with Lagrangian transport and dispersion models for density estimation and feature identification.
Alice Crawford, NOAA Air Resources Laboratory, College Park, MD, United States

A Comparison of Meteorological Deterministic and Ensemble Inputs to HYSPLIT For Volcanic Ash Transport in Small to Moderate Sized Eruptions
Eric Roy[1], **Alice Crawford**[2], **Barbara Stunder**[2] and Binyu Wang[3], (1)University of Massachusetts Lowell, Lowell, MA, United States, (2)NOAA Air Resources Laboratory, College Park, MD, United States, (3)IMSG, Rockville, MD, United States

Development and Evaluation of a Volcanic Ash Ensemble Forecasting System Using the NOAA HYSPLIT Model
Binyu Wang[1], **Barbara Stunder**[2], Jeffrey McQueen[3], **Alice Crawford**[4], Allison Ring[4,5], Binbin Zhou[6], Edward Strobach[7], Michael Pavolonis Sr.[8], Jian-Ping Huang[9], Ho-Chun Huang[10] and Li Pan[11], (1)IMSG at NOAA/NWS/NCEP/EMC, College Park, MD, United States, (2) NOAA, College Park, United States, (3)NOAA College Park, National Weather Service, College Park, MD, United States, (4)NOAA Air Resources Laboratory, College Park, MD, United States, (5)Cooperative Institute for Satellite Earth System Studies, Atmospheric and Oceanic Science, College Park, United States, (6)NOAA, Springfield, United States, (7)Environmental Modeling Center, Washington, DC, United States, (8)NOAA/NESDIS, Madison, United States, (9)IMSG, College Park, MD, United States, (10)UMD/ESSIC at NOAA/NESDIS/STAR, College Park, MD, United States, (11)NOAA NWS NCEP/EMC and IMSG, College Park, MD, United States

Exploring Volcanic Ash Forecasting Techniques Using HYSPLIT and VOLCAT Observations
Allison Ring[1,2], **Alice Crawford**[1], Tianfeng Chai[3], Justin Sieglaff[4] and Michael Pavolonis Sr.[5], (1)NOAA Air Resources Laboratory, College Park, MD, United States, (2)Cooperative Institute for Satellite Earth System Studies, Atmospheric and Oceanic Science, College Park, United States, (3)NOAA, Silver Spring, MD, United States, (4)Cooperative Institute for Meteorological Satellite Studies, Madison, WI, United States, (5)NOAA/NESDIS, Madison, United States

Application of a novel ensemble mean technique to probabilistic forecasting of volcanic ash transport using HYSPLIT
Jorge Eduardo Guerra, NOAA/NSSL/OU-CIMMS, Boulder, CO, United States and **Alice Crawford**, NOAA Air Resources Laboratory, College Park, MD, United States

A176-0007 Estimating biomass burning emissions with HYSPLIT-based emission inverse modeling system and GOES Advanced Baseline Imager (ABI) observations
Tianfeng Chai[1,2], Hyun C Kim[2,3], **Ariel F Stein**[2], **Mark Cohen**[2], Daniel Tong[2,4], Yunyao Li[5] and Shobha Kondragunta[6], (1)University of Maryland College Park, College Park, MD, United States, (2)NOAA Air Resources Laboratory, College Park, MD, United States, (3)Cooperative Institute for Satellite Earth-System Studies, University of Maryland, College Park, MD, United States, (4)George Mason University, Fairfax, VA, United States, (5)George Mason University Fairfax, Fairfax, VA, United States, (6)NOAA College Park, College Park, MD, United States

A065-0003 Dispersion Model Evaluation using the 1996 Model Validation Program Tracer Study
Fong Ngan[1], **Will Pendergrass[2], Mark Cohen[3]** and **Ariel F. Stein[3],** (1)University of Maryland College Park, College Park, MD, United States, (2)NOAA, Boulder, CO, United States, (3)NOAA Air Resources Laboratory, College Park, MD, United States

A066-0005 Quantitative assessment of surface particulate matter concentrations change over China during the COVID-19 pandemic and its implication to Chinese economic activities

Hyun C Kim[1,2], Soontae Kim[3], **Mark Cohen**[2], Changhan Bae[4], Dasom Lee[5], **Rick D Saylor**[6], Minah Bae[7], Eunhye Kim[4], Byeong-Uk Kim[8], JinHo Yoon[5] and **Ariel F Stein**[2], (1)Cooperative Institute for Satellite Earth-System Studies, University of Maryland, College Park, MD, United States, (2)NOAA Air Resources Laboratory, College Park, MD, United States, (3)Ajou University, Environmental and Safety Engineering, Suwon, South Korea, (4)Ajou University, Environmental and Safety Engineering, Suwon, Korea, Republic of (South), (5)GIST Gwangju Institute of Science and Technology, Gwangju, Korea, Republic of (South), (6)NOAA Air Resources Laboratory, Oak Ridge, TN, United States, (7)Ajou University, Environmental and Safety Engineering, Suwon, South Korea, (8)Georgia Environmental Protection Division, Atlanta, GA, United States

Atmospheric Chemistry and Deposition

National Air Quality Forecasting Capability (NAQFC) Administrator's Award

Pius Lee (ASMD) and Rick Saylor (ATDD) received a NOAA Administrator's Award in October 2020 as part of an OAR and National Weather Service (NWS) team "for implementing and upgrading NOAA's air quality forecasting capability for improving the lives of Americans and saving billions of dollars per year." The award recognizes an effort spanning more than ten years to continuously improve the forecast accuracy of ground-level ozone and fine particle concentrations across the entire U. S., thereby providing the nation with reliable warnings of impending air pollution so that appropriate actions could be taken by health-sensitive members of the general public.
Rick Saylor (Rick.Saylor@noaa.gov)

Impacts of the COVID-19 Economic Slowdown on Ozone Pollution in the U.S.

Dr. Campbell (with collaboration with Dr. Daniel Tong) continued his research and finalization of the initial submission of their manuscript, "Impacts of the COVID-19 Economic Slowdown on Ozone Pollution in the U.S." to the journal Atmospheric Environment. This collaborative effort between George Mason University, NOAA-ARL, NASA, and Harvard University comprehensively quantifies the COVID-19 related mobility and traffic changes on anthropogenic emissions and consequential ozone changes over the entire contiguous U.S. We use a scientifically sound method to adjust the anthropogenic emissions based on long-term trends in ground-based and satellite-based observations. We ingest the adjusted emissions in an experimental version of the NAQFC, and quantify the ozone changes. We also use the observed and modeled ozone trends in previous years compared to 2020 to approximate the role of natural variability on the observed ozone changes. The major results show that during the peak of the lockdown and reduced mobility and traffic in the U.S. during March – April of last year, there are widespread emissions decreases that lead to widespread ozone decreases in rural regions, but some local increases in urban regions (Figure 10).

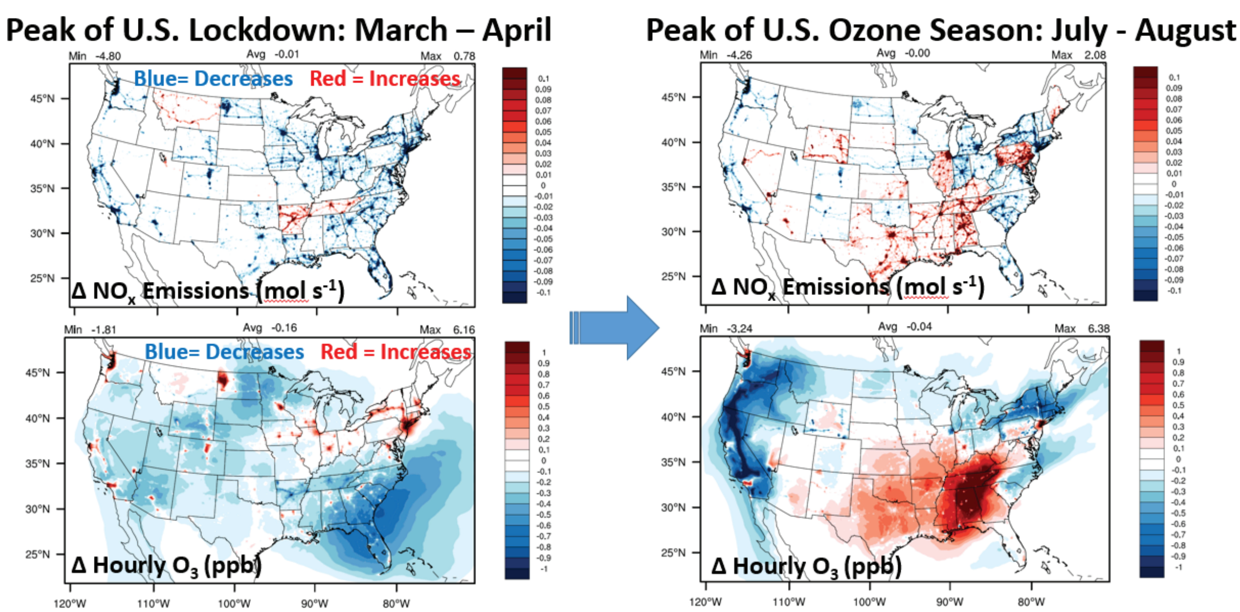


Figure 10. Spatial difference plots representative of emissions changes (top: NOx) and hourly ozone changes (O3: bottom) due to the COVID-19 lockdown during its 2020 peak (left) and later in the warmer ozone season (right).

Later during the peak of the warmer, ozone season in the U.S. during July – August last year, the model results suggest widespread increases in emissions in south-southeast, but decreases near some major cities, which leads to some areas of widespread ozone increase in the the U.S. Overall, the maximum daily ozone changes for the entire study period (March – September) show decreases ranging from 5-10% and increases ranging from 5 – 15%. The reason for increased ozone in some regions of reduced precursor emissions is due to the complex, non-linear nature of ozone formation in different regions of the U.S. While the ozone changes due to the COVID-19 lockdown appear only moderate, these results are impactful, especially for those regions near cities where people live and may already be exposed to high ozone pollution. *POC: Dr. Patrick C. Campbell*

Advanced Developments and Evaluation of the NOAA-EPA Atmosphere-Chemistry Coupler (NACC), version 1.3.1.

Dr. Campbell (with collaboration from Dr. Youhua Tang and Dr. Barry Baker) has worked on advanced developments and evaluation of the novel NOAA-EPA Atmosphere-Chemistry Coupler (NACC), which is based on the Meteorology-Chemistry Interface Processor, version 5 (MCIPv5), and directly couples the latest Global Forecast System (GFS) version 16 to the recently released Community Multiscale Air Quality (CMAQ) model version 5.3.1. The updated developments of NACC-CMAQv5.3.1 include near-real-time (i.e., rapid-refresh) land cover characteristics including satellite-based Visible Infrared Imaging Radiometer Suite (VIIRS) Leaf Area Index (LAI) and Greenness Vegetation Fraction (GVF), and a temperature dependent vegetation frost switch parameter that is used to determine if summer or winter normalized emissions are used in CMAQ. NOAA-ARL's developments of NACC-CMAQ for the advanced National Air Quality Forecasting Capability (NAQFC) are shown in the schematic in Figure 11, and are available to the greater scientific community at the NOAA ARL's GitHub page.

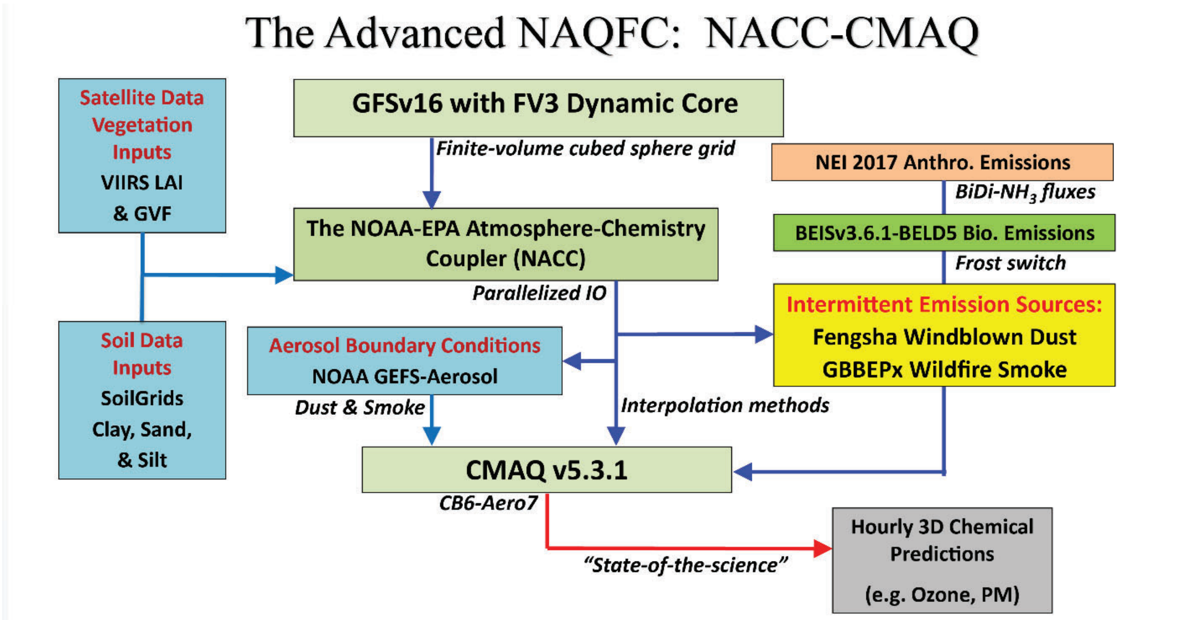


Figure 11. Overview of the advanced NAQFC, which is based on GFSv16/NACC-CMAQv5.3.1.

Initial tests of the advanced NACC-CMAQ system for a retrospective fall case (October 01-31, 2020) shows high spatiotemporal variability in the dynamic VIIRS LAI in the U.S. compared to a monthly average value from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument (Figure 2), as well as defined impacts of a dynamically varying LAI and GVF (in space and time) on biogenic emissions, dry deposition, and ozone and fine particulate (PM2.5) concentrations when compared to a static LAI = 4 across the U.S. (Figure 12). We note that the current operational NAQFC uses a static LAI=4 for the entire domain in its air quality predictions.

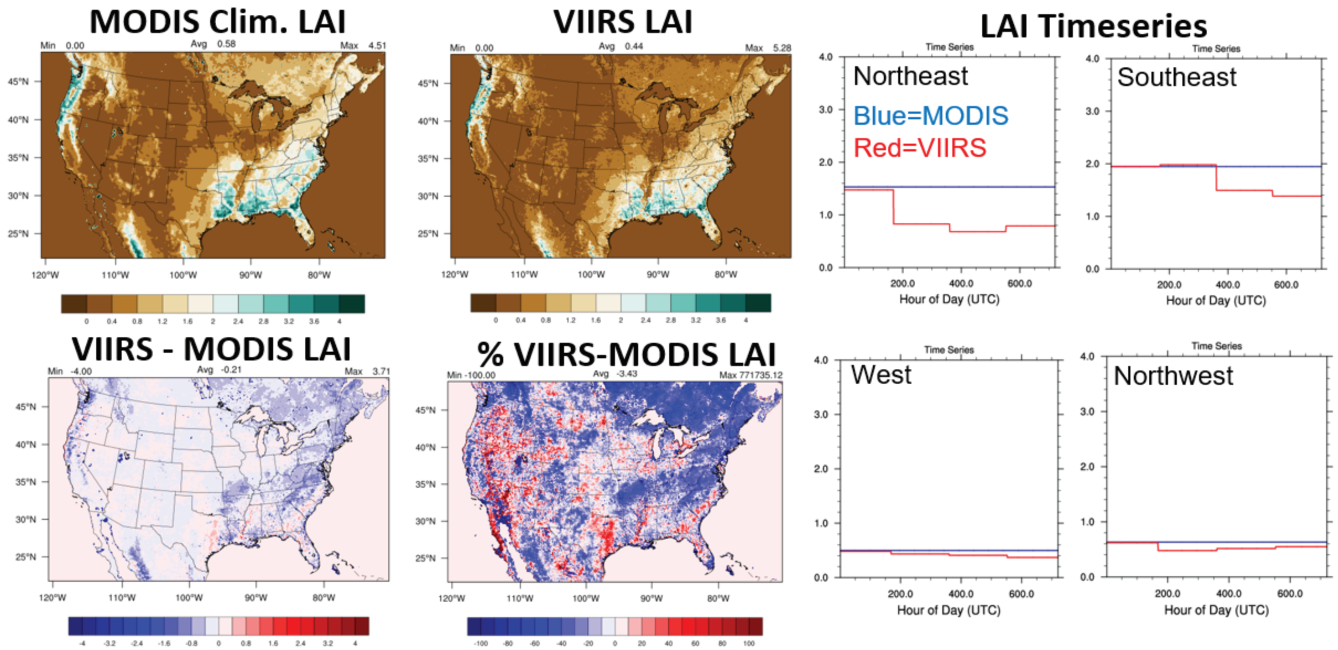


Figure 12. Left panels: October 2020 monthly average MODIS and rapid-refresh (8-day product) VIIRS LAI (top), and their absolute and relative differences (bottom). Right panels: Associated time series for MODIS climatological (blue) and VIIRS rapid-refresh (red) averaged over states included in four regions of the U.S. (i.e., northeast, southeast, west, and northwest) according to the U.S. EPA Regional and Geographic Offices

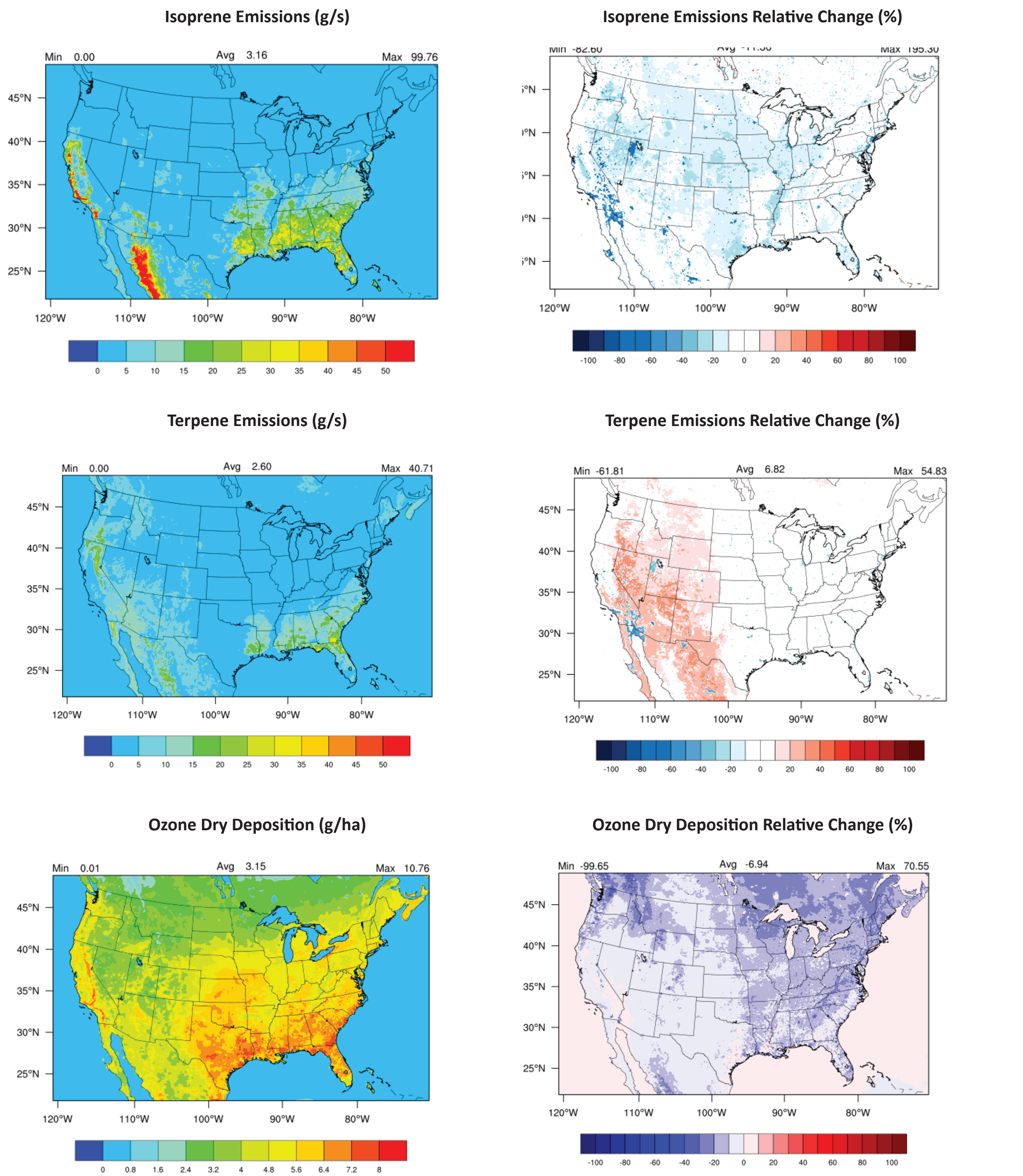


Figure 13. October 2020 monthly average absolute values when LAI = 4 (left column) and relative percent change due to implementation of VIIRS GVF and LAI rapid refresh (right column) in biogenic emissions (rows 1 & 2; for isoprene and terpene), ozone and PM2.5 ammonium dry deposition (rows 3 & 4), and ozone and total PM2.5 concentrations (rows 5 and 6).

The model performance for ozone and fine particulate matter (compared against the AirNow observation network) averaged over the winter month of December 2020 is also generally improved in all regions when the vegetation frost switch is included. Figure 14 shows example results for the Northeast and Southeast U.S. regions.

Figure 14. December 2020 average statistics for ozone and PM2.5 (in parenthesis) for the advanced NACC-CMAQ model base (no frost switch) and sensitivity runs (with frost switch) across the northeast and upper Midwest U.S. regions according to the [U.S. EPA Regional and Geographic Offices]().

Run	NMB	NME	Corr	IOA
Northeast U.S. Ozone (PM2.5)				
Base No Frost Switch	+11.3 (+30.0)	25.6 (67.9)	0.65 (0.61)	0.78 (0.72)
Sensitivity Frost Switch	+10.7 (+27.4)	+25.1 (66.6)	0.66 (0.61)	0.78 (0.73)
Upper Midwest U.S. Ozone (PM2.5)				
Base No Frost Switch	+23.5 (+21.1)	32.8 (53.1)	0.66 (0.62)	0.75 (0.75)
Sensitivity Frost Switch	+22.2 (+19.1)	+31.9 (52.1)	0.66 (0.63)	0.76 (0.76)

NMB: Normalized Mean Bias. NME: Normalized Mean Error. Corr: Pearson's Correlation Coefficient. IOA: Index of Agreement
POC: Dr. Patrick C. Campbell   Email: Patrick.C.Campbell@noaa.gov

Atmospheric Chemistry and Deposition – Q1 Conferences

National Atmospheric Deposition Program

Dr. Winston Luke serves as the Vice Chair of the Network Operations Subcommittee (NOS) of the National Atmospheric Deposition Program. During the recent Fall 2020 NADP meeting, Dr. Luke was responsible for the documentation and promulgation of meeting proceedings, agendas, and minutes. Dr. Luke serves as the incoming Chair of the NOS for 2021, and will be responsible for all aspects of meeting planning and execution in the Spring and Fall 2021 meetings.

NADP is a cooperative program comprised of five monitoring networks and over 500 independent sites that provide long-term, high-quality air and precipitation measurements to evaluate atmospheric deposition over space and time. NADP's Executive Committee instructs program direction based on recommendations from its five subcommittees (two technical and three science). The Network Operations Subcommittee is one of two technical subcommittees responsible for providing guidance regarding initiatives, projects, and recommended program changes. NOS oversees field-siting criteria and laboratory and sample collection protocols, and evaluates equipment and record keeping methods.

Dr. Luke is known for his leadership in developing and optimizing operating protocols used in national and international monitoring networks, as well as for convening global workshops to improve sampling methodologies in existing networks. During his decades-long career at NOAA, Dr. Luke developed and tested methodologies to quantify and successfully reduce measurement uncertainties and led pioneering efforts to measure mercury using aircraft; leading to expanded measurements of mercury in the air and precipitation worldwide. He is also a recipient of the coveted Department of Commerce Silver Medal Award for exceptional achievement.

19th Annual CMAS Conference (Virtual), October 26-30, 2020.

Dr. Campbell presented on "An Improved National Air Quality Forecasting Capability Using the NOAA Global Forecast System. Part I: Model Development and Community Application. This presentation highlighted the work on NACC-CMAQv5.3.1", much of which was discussed in Page 12. POC: Dr. Patrick C. Campbell; [Patrick.C.Campbell@noaa.gov]()

Atmospheric Chemistry and Deposition Q1 – AGU Presentations

A066-0005 Quantitative assessment of surface particulate matter concentrations change over China during the COVID-19 pandemic and its implication to Chinese economic activities

Hyun C Kim[1,2], Soontae Kim[3], **Mark Cohen**[2], Changhan Bae[4], Dasom Lee[5], **Rick D Saylor**[6], Minah Bae[7], Eunhye Kim[4], Byeong-Uk Kim[8], JinHo Yoon[5] and Ariel F. Stein[2]: (1)Cooperative Institute for Satellite Earth-System Studies, University of Maryland, College Park, MD, United States, (2)NOAA Air Resources Laboratory, College Park, MD, United States, (3)Ajou University, Environmental and Safety Engineering, Suwon, South Korea, (4)Ajou University, Environmental and Safety Engineering, Suwon, Korea, Republic of (South), (5)GIST Gwangju Institute of Science and Technology, Gwangju, Korea, Republic of (South), (6)NOAA Air Resources Laboratory, Oak Ridge, TN, United States, (7)Ajou University, Environmental and Safety Engineering, Suwon, South Korea, (8)Georgia Environmental Protection Division, Atlanta, GA, United States.

[A048-01 Measurements and models of COVID-19 impacts on short-lived pollutants and greenhouse gases over the eastern US.]()

Russell R Dickerson[1], **Xinrong Ren**[2], Ross J Salawitch[1], Timothy Canty[3], Hao He[4], Doyeon Ahn[5], Philip Stratton[3], Dolly L Hall[3], Ning Zeng[6], Joel Dreessen[7], Israel Lopez-Coto[8], Anna Karion[8], James R Whetstone[8], Colm Sweeney[9], Ariel F Stein[10], **Winston T Luke**[11], Eric A Kort[12], Paul Shepson[13] and Brian C McDonald[14]: (1)University of Maryland, AOSC and Chemistry, College Park, MD, United States, (2)NOAA Science Center, College Park, MD, United States, (3)University of Maryland, College Park, MD, United States, (4)University of Maryland College Park, Department of Atmospheric and Oceanic Science, College Park, MD, United States, (5)University of Maryland College Park, College

Park, MD, United States, (6)University of Maryland, Department of Atmospheric and Oceanic Science, College Park, United States, (7) Maryland Department of the Environment, Air Monitoring Program, Baltimore, MD, United States, (8)National Institute of Standards and Technology Gaithersburg, Gaithersburg, MD, United States, (9)NOAA Global Monitoring Laboratory, Boulder, CO, United States, (10)NOAA Air Resources Laboratory, College Park, MD, United States, (11)NOAA-Air Resources Lab, Silver Spring, MD, United States, (12)University of Michigan Ann Arbor, Climate and Space Sciences and Engineering, Ann Arbor, MI, United States, (13)Stony Brook University, School of Marine and Atmospheric Sciences, Stony Brook, NY, United States, (14)Chemical Sciences Division, NOAA Earth System Research Laboratory, Boulder, CO, United States

A048-02 Ozone Photochemistry in New York City – Long Island Sound: Results from Summer 2020 Aircraft Observations

Xinrong Ren[1], Philip Stratton[2], Hannah Daley[2], Russell R Dickerson[3], Brian C McDonald[4], Jessica Gilman[5], Aaron Lamplugh[6], **Ariel F Stein**[1], Joel Dreessen[7] and George Allen[8], (1)NOAA Air Resources Laboratory, College Park, MD, United States, (2)University of Maryland, College Park, MD, United States, (3)University of Maryland, AOSC and Chemistry, College Park, MD, United States, (4)Chemical Sciences Division, NOAA Earth System Research Laboratory, Boulder, CO, United States, (5)NOAA Earth System Research Laboratory, Chemical Sciences Laboratory, Boulder, CO, United States, (6)CIRES and NOAA ESRL, Chemical Sciences Laboratory, Boulder, CO, United States, (7)Maryland Department of the Environment, Air Monitoring Program, Baltimore, MD, United States, (8)NESCAUM, Boston, United States

A048-03 Aircraft-Based Measurements of Black Carbon and Inferred Emissions over the Baltimore-Washington Area Pre- and Post-COVID-19 Lockdowns.

Hannah Daley[1], Russell R. Dickerson[2], **Xinrong Ren**[3], Ross J Salawitch[2], Timothy Canty[1], Brian C McDonald[4], Dolly L Hall[1], Courtney Grimes[1] and Philip Stratton[1], (1)University of Maryland, College Park, MD, United States, (2)University of Maryland, AOSC and Chemistry, College Park, MD, United States, (3)NOAA Science Center, College Park, MD, United States, (4)Chemical Sciences Division, NOAA Earth System Research Laboratory, Boulder, CO, United States

B097-0004 - On surface fluxes at night – Application of the virtual chamber approach to ammonia flux measurements above a corn canopy in central Illinois

Nebila Lichiheb[1,2], Bruce Hicks[3], Mark Heuer[4], Deb O'Dell[5], Joel Oetting[6], Neal Eash[5] and LaToya Myles[2], (1)NOAA Oak Ridge, Oak Ridge, TN, United States, (2)NOAA ATDD, Oak Ridge, TN, United States, (3)Metcorps, Norris, TN, United States, (4)NOAA/ARL/ATDD, Oak Ridge, TN, United States, (5)Institute of Agriculture, University of Tennessee, Knoxville, United States, (6)University of Tennessee, Knoxville, TN.

Atmospheric Chemistry and Deposition – Q1 Publications

Gaubert, B., Emmons, L. K., Raeder, K., Tilmes, S., Miyazaki, K., Arellano Jr., A. F., Elguindi, N., Granier, C., Tang, W., Barré, J., Worden, H. M., Buchholz, R. R., Edwards, D. P., Franke, P., Anderson, J. L., Saunois, M., Schroeder, J., Woo, J.-H., Simpson, I. J., Blake, D. R., Meinardi, S., Wennberg, P. O., Crounse, J., Teng, A., Kim, M., Dickerson, R. R., He, H., **Ren, X.,** Pusede, S. E., and Diskin, G. S.: Correcting model biases of CO in East Asia: impact on oxidant distributions during KORUS-AQ, Atmos. Chem. Phys., 20, 14617–14647, https://doi.org/10.5194/acp-20-14617-2020, 2020

Shi, X., Ge, Y., Zheng, J., Ma, Y., **Ren, X.**, Zhang, Y.,: Budget of nitrous acid and its impacts on atmospheric oxidative capacity at an urban site in the central Yangtze River Delta region of China, Atmospheric Environment, Volume 238, 2020,v117725, ISSN 1352-2310, https://doi.org/10.1016/j.atmosenv.2020.117725.

Wang, L., Yu, S., Li, P., Chen, X., Li, Z., Zhang, Y., Li, M., Mehmood, K., Liu, W., Chai, T., Zhu, Y., Rosenfeld, D., and Seinfeld, J. H.: Significant wintertime PM2.5 mitigation in the Yangtze River Delta, China, from 2016 to 2019: observational constraints on anthropogenic emission controls , Atmos. Chem. Phys., 20, 14787–14800, https://doi.org/10.5194/acp-20-14787-2020, 2020

Kang, Y.-H., S. You, M. Bae, E. Kim, C. Bae, K. Son, Y. Kim, B.-U. Kim, H.C. Kim, and S. Kim: Impact of anthropogenic pollution reductions due to COVID-19 on PM2.5 concentration, isolated impacts of meteorological change and emission reduction policies in Northeast Asia, *Scientific Reports,* 10, 22112, doi:10.1038/s41598-020-79088-2, 2020

Kim, E., B.-U. Kim, H.C. Kim, and S. Kim: Sensitivity of Fine Particulate Matter Concentrations in South Korea to Regional Ammonia Emissions in Northeast Asia, *Environmental Pollution,* 273 (2021) 116428, doi:10.1016/j.envpol.2021.116428

Kang, Y.-H., S. You, M. Bae, E. Kim, C. Bae, K. Son, Y. Kim, B.-U. Kim, H.C. Kim, and S. Kim: Impact of anthropogenic pollution reductions due to COVID-19 on PM2.5 concentration, isolated impacts of meteorological change and emission reduction policies in Northeast Asia, *Scientific Reports,* 10, 22112, doi:10.1038/s41598-020-79088-2, 2020

Kim, E., B.-U. Kim, H.C. Kim, and S. Kim: Sensitivity of Fine Particulate Matter Concentrations in South Korea to Regional Ammonia Emissions in Northeast Asia, *Environmental Pollution,* 273 (2021) 116428, doi:10.1016/j.envpol.2021.116428

Climate Observations and Analyses

Climate Observations and Analyses – Q1 Publications

Buban, M. S., Lee, T. R., & Baker, C. B.: A Comparison of the U.S. Climate Reference Network Precipitation Data to the Parameter-Elevation Regressions on Independent Slopes Model (PRISM), Journal of Hydrometeorology, 21(10), 2391-2400. Retrieved Dec 15, 2020, from https://journals.ametsoc.org/view/journals/hydr/21/10/jhmD190232.xml https://doi.org/10.1175/JHM-D-19-0232.1

Salinger, M.J., Diamond, H.J., Renwick, J.A.: Surface temperature trends and variability in New Zealand and surrounding oceans: 1871-2018: Climate and Weather (Weather and Climate is the official journal of the Meteorological Society of New Zealand).https://www.metsoc.org.nz/weather-and-climate/

Climate Observations and Analyses – Q1 Presentations

AGU Fall Meeting 2020: GC127-02 An intercomparison of ground-based land surface temperature measurements
Praveena Krishnan[1], Tilden P Meyers[1], Simon J Hook[2], Mark Heuer[1], David Senn[1] and Edward J Dumas[1], (1)NOAA/ARL/ATDD, Oak Ridge, TN, United States, (2)Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, United States

Training

Routine NOAA training completed. Due to COVID and holidays, training was restricted to completion of the Safety Manual review and safety videos. Videos watched:

- Fire Extinguisher Training Video – OSHA
- How to Rescue a Fallen Worker (Tower Safety), provided by OSHA.

All ARL Pubs from October 1, 2020 – December 31, 2020.

1. Angevine, W. M., Peischl, J., Crawford, A., Loughner, C. P., Pollack, I. B., and Thompson, C. R.: Errors in top-down estimates of emissions using a known source, Atmos. Chem. Phys., 20, 11855–11868, https://doi.org/10.5194/acp-20-11855-2020

2. Benish, S. E., He, H., Ren, X., Roberts, S. J., Salawitch, R. J., Li, Z., Wang, F., Wang, Y., Zhang, F., Shao, M., Lu, S., and Dickerson, R. R.: Measurement report: Aircraft observations of ozone, nitrogen oxides, and volatile organic compounds over Hebei Province, China, Atmos. Chem. Phys., 20, 14523–14545, https://doi.org/10.5194/acp-20-14523-2020, 2020.

3. Buban, M. S., Lee, T. R., & Baker, C. B.: A Comparison of the U.S. Climate Reference Network Precipitation Data to the Parameter-Elevation Regressions on Independent Slopes Model (PRISM), Journal of Hydrometeorology, 21(10), 2391-2400. Retrieved Dec 15, 2020, from https://journals.ametsoc.org/view/journals/hydr/21/10/jhmD190232.xml https://doi.org/10.1175/JHM-D-19-0232.1

4. Crawford, A.: The Use of Gaussian Mixture Models with Atmospheric Lagrangian Particle Dispersion Models for Density Estimation and Feature Identification. Atmosphere 2020, 11, 1369. https://doi.org/10.3390/atmos11121369

5. Gaubert, B., Emmons, L. K., Raeder, K., Tilmes, S., Miyazaki, K., Arellano Jr., A. F., Elguindi, N., Granier, C., Tang, W., Barré, J., Worden, H. M., Buchholz, R. R., Edwards, D. P., Franke, P., Anderson, J. L., Saunois, M., Schroeder, J., Woo, J.-H., Simpson, I. J., Blake, D. R., Meinardi, S., Wennberg, P. O., Crounse, J., Teng, A., Kim, M., Dickerson, R. R., He, H., Ren, X., Pusede, S. E., and Diskin, G. S.: Correcting model biases of CO in East Asia: impact on oxidant distributions during KORUS-AQ, Atmos. Chem. Phys., 20, 14617–14647, https://doi.org/10.5194/acp-20-14617-2020, 2020

6. Hicks, B.B., Pendergrass, W.R., Oetting, J.N. et al. The North American Solar Eclipse of 2017: Observations on the Surface Biosphere, Time Responses and Persistence. Boundary-Layer Meteorol (2020). https://doi.org/10.1007/s10546-020-00582-1

7. Kang, Y.-H., S. You, M. Bae, E. Kim, C. Bae, K. Son, Y. Kim, B.-U. Kim, H.C. Kim, and S. Kim: Impact of anthropogenic pollution reductions due to COVID-19 on PM2.5 concentration, isolated impacts of meteorological change and emission reduction policies in Northeast Asia, Scientific Reports, 10, 22112, doi:10.1038/s41598-020-79088-2, 2020

8. Kim, E., B.-U. Kim, H.C. Kim, and S. Kim: Sensitivity of Fine Particulate Matter Concentrations in South Korea to Regional Ammonia Emissions in Northeast Asia, Environmental Pollution, 273 (2021) 116428, doi:10.1016/j.envpol.2021.116428

9. Pendergrass, W.R., Ngan, F., Hicks, B. B., Hosker, R.P., Mazzola, C.A.: Demonstrating the Feasibility of Using the 1996 MVP Tracer Study for Transport and Diffusion Model Validation, 2020, NOAA Technical Memorandum OAR ARL-281; https://doi.org/10.25923/x74e-3k77

10. Salinger, M.J., Diamond, H.J., Renwick, J.A.: Surface temperature trends and variability in New Zealand and surrounding oceans: 1871-2018: Climate and Weather (Weather and Climate is the official journal of the Meteorological Society of New Zealand).https://www.metsoc.org.nz/weather-and-climate/

11. Shi, X., Ge, Y., Zheng, J., Ma, Y., Ren, X., Zhang, Y.,: Budget of nitrous acid and its impacts on atmospheric oxidative capacity at an urban site in the central Yangtze River Delta region of China, Atmospheric Environment, Volume 238, 2020,v117725, ISSN 1352-2310, https://doi.org/10.1016/j.atmosenv.2020.117725.

12. Wang, L., Yu, S., Li, P., Chen, X., Li, Z., Zhang, Y., Li, M., Mehmood, K., Liu, W., Chai, T., Zhu, Y., Rosenfeld, D., and Seinfeld, J. H.: Significant wintertime PM2.5 mitigation in the Yangtze River Delta, China, from 2016 to 2019: observational constraints on anthropogenic emission controls , Atmos. Chem. Phys., 20, 14787–14800, https://doi.org/10.5194/acp-20-14787-2020, 2020

About ARL

NOAA’s Air Resources Laboratory (ARL) conducts research on the lowest part of the atmosphere, the boundary layer, the area where we live and breathe. World-class research on the chemistry and physics of the boundary layer contributes to accurate regional and global predictions of weather and air quality, as well as climate variability. ARL also works to generate actionable information and highly localized forecasts to respond to a variety of emergencies efficiently. Scenarios may include chemical or nuclear-related industrial accidents, wildfires, volcanoes, and high-impact air pollution episodes; data from ARL informs local managers whether evacuations or stay- at- home orders may be necessary. ARL’s scientists, engineers and technicians conduct research at four geographically distributed divisions:

- Atmospheric Sciences and Modeling Division (ASMD) in College Park, Maryland
- Atmospheric Turbulence and Diffusion Division (ATDD) in Oak Ridge, Tennessee
- Field Research Division (FRD) in Idaho Falls, Idaho
- Special Operations and Research Division (SORD) in Las Vegas, Nevada

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