Field Projects

The Air Resources Laboratory (ARL) is an applied science lab with a long history with dispersion, atmospheric chemistry, and climate field projects. These studies explore important interactions between the atmosphere and the biosphere that address serious societal issues, such as air pollution, airborne release and dispersion of harmful materials from accidents or through malicious intent, deposition of harmful materials onto our terrestrial and aquatic ecosystems, and changes in our climate. Below are field projects ARL has been involved with over the period 2010-2016.

Vortex-SE: Verification of the Origins of Rotation in Tornadoes EXperiment-Southeast 2016

VORTEX-SE is a research program led by the NOAA National Severe Storms Laboratory to understand how environmental factors characteristic of the southeastern United States affect the formation, intensity, structure, and path of tornadoes in this region. During the VORTEX-SE intensive observation periods in spring 2016, ARL launched weather balloons and performed seven flights with a DJI S-1000 small Unmanned Aircraft System (sUAS) as lines of thunderstorms approached northern Alabama. The sUAS was used to make vertical profile measurements of temperature and relative humidity, which provide key atmospheric data that can be used to understand how the land surface may play a role in tornadogenesis. The sUAS was also used to conduct several storm damage assessments during the study.

ARL's small Unmanned Aircraft System (sUAS)

Regional Air Quality Impact of Natural Gas Production Operations 2014-2015

The goals of this project, funded by the Maryland Department of Environment, were to determine natural gas production contributions to regional air quality, to improve the state of the science for describing vertical transport of emissions from ground-level sources, and to develop tools that can be used for determining the most effective emission reduction strategies for local and regional air quality improvement. ARL was involved in the aircraft measurements to investigate emissions of methane and associated air pollutants from natural gas operations (primarily hydraulic fracturing or fracking) in Southwestern Pennsylvania. The in-situ observations collected by ARL were combined with meteorological data to improve understanding of the emissions of methane and other air pollutants from the fracking operations in the region and will help to evaluate their impact on Maryland.

FLAGG-MD: Fluxes of Greenhouse Gases in Maryland 2014-2015

The goal of FLAGG-MD was to produce the best estimates of sources, sinks, and fluxes of carbon dioxide, methane, and carbon monoxide (i.e., C-gases) for the Baltimore/Washington area. The study, which was funded by the National Institute of Standards and Technology (NIST), consisted of three components: observations, carbon cycle and meteorological modeling, and climatology. ARL was responsible for surface and airborne measurements of trace gases and meteorological variables and for harmonizing all extant and planned observations with NIST standards and methods.

Leveraging Observations and Models to Improve Predictions of Convective Initiation 2014

NOAA OAR funded an ARL-led study of convective initiation (CI) through its Hurricane Sandy Supplemental Program. The study, which was conducted in collaboration with the University of Alabama in Huntsville, focused on developing a probabilistic 0-6 hour product using machine-learning approaches with real-time observations to improve boundary-layer parameterizations in forecast models. A series of field studies were conducted in northern Alabama from July through September 2014 using four 10 m micrometeorological towers to obtain high temporal resolution meteorological data. ARL's studies found that days on which CI occurred were characterized by morning dew point temperatures >21°C, wind speeds <2 m s^{-1}, and median convective available potential energy values, obtained from the nearest sounding station, of 548 J kg^{-1}. ARL also noted that increases in boundary layer moisture coupled with

large gradients in sensible heat flux during morning hours may be responsible for triggering CI under synoptically quiescent conditions.

Ammonia Emission from Fertilizer Application: Understanding an Uncertain Input to Air Quality Models 2014

The goals of this NSF-funded study were to measure ammonia emissions from fertilizer application at the local scale in an intensively managed agro-ecosystem in Illinois and develop a method to facilitate connection of local emissions with the regional scale. ARL deployed a suite of micrometeorological instruments, both above-canopy and in-canopy, to quantify ammonia emissions from fertilizer applications to a corn field at the University of Illinois Energy Farm. Results from the study were used to determine spatial and temporal variability of ammonia and to investigate the dependence of ammonia emissions on environmental and field management parameters.

Project Sagebrush 2013-ongoing

Project Sagebrush is a multi-year study focused on re-evaluation of data from classical tracer field experiments from the 1950s and 1960s addressing short-range plume dispersion. Results from the earlier experiments are still widely accepted and frequently used. Newer technologies available for measuring both turbulence levels and tracer concentrations were applied in Project Sagebrush. ARL was responsible for deploying modern meteorological instrumentation and tracer technology, which were not available during the older dispersion studies. ARL conducted the study at its tracer release facility, located on the Department of Energy's Idaho National Laboratory (INL). Results include a modern set of tracer data, along with high-quality measurements collected from an extensive set of sensors in the boundary layer. The results will be highly useful to the dispersion research community both for understanding short-range dispersion in open terrain and for developing, improving, and testing dispersion models.

Aircraft Observations and Model Simulations in Support of GOES-R/VIIRS 2013-2014

The goals of this study were to use observations to evaluate Geostationary Operational Environmental Satellite System Advanced Baseline Imager (GOES-R ABI) retrievals and characterize ABI aerosol optical depth (AOD)/suspended matter accuracy and precision; explore the use of observations to develop techniques for relating remotely sensed AOD and its link to surface fine fraction particulate matter; and gain a better understanding of the fundamental meteorology and chemistry of aerosols to provide policy-relevant science as guidance to air pollution control agencies. ARL was involved in the aircraft measurement of aerosols and provided Weather Research and Forecasting (WRF)-Community Multi-scale Air Quality (CMAQ) model simulations over the study area.

FOCAL: Flux Observations of Carbon from an Airborne Laboratory 2013-2014

FOCAL was an NSF-funded study conducted in collaboration with Aurora Flight Sciences Corporation and Harvard University to measure fluxes of carbon dioxide and methane, two important greenhouse gases. The goal of this project was to quantify the fluxes of carbon-based greenhouse gases from the permafrost region of the Alaskan North Slope using aircraft and tower-based eddy covariance measurements. ARL's Best Aircraft Turbulence (BAT) probe was a key part of the FOCAL campaign. The probe is a custom-designed wind sensor that was mounted to the front of an aircraft to make high frequency measurements of atmospheric pressure, air temperature, and turbulence—chaotic, three dimensional flow of winds that drive upward and downward transport of mass, momentum, and energy between the surface of the Earth and the lower part of the atmosphere. In addition, isotopologue concentrations of carbon dioxide and methane were recorded to

ARL measurement site and the Aurora Flight Sciences plane in Alaska

determine if greenhouse gas emissions were thermogenic or biogenic.

SENEX: Studying the Interactions Between Natural and Anthropogenic Emissions at the Nexus of Climate Change and Air Quality 2013

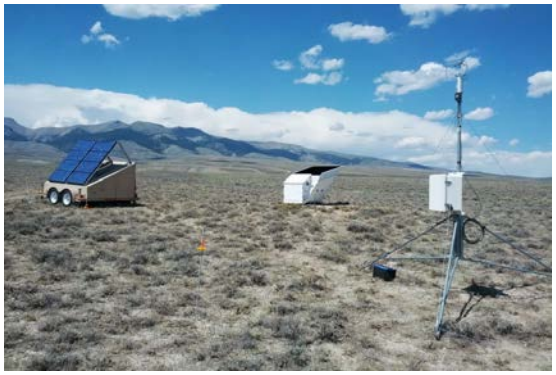
SENEX 2013 was a NOAA-led study to quantify emissions of greenhouse gases and aerosols in the Southeast U.S. and to investigate the roles played by anthropogenic and natural emissions in the formation of ozone and aerosol in the atmosphere. ARL provided forecasting support for SENEX and evaluated the CMAQ prediction of carbon monoxide (CO) vertical profiles in the upper and lower troposphere in comparison to CO measurements from flights during the study. ARL's work on SENEX illustrated that National Air Quality Forecast Capability (NAQFC) real-time wildfire emission modeling can reconstruct the distribution of CO and related pollutants during wildfires.

SOAS: Southern Oxidant and Aerosol Study 2013

SOAS was a comprehensive campaign led by Rutgers University and the U.S. EPA to advance understanding of emissions, atmosphere-biosphere exchange, chemistry, aerosol processes, and climate change in the southeastern U.S. ARL measured ambient concentrations of ozone, sulfur dioxide, and reactive nitrogen species and compared these measurements with aircraft profiling and satellite column observations. Data from the study were used to characterize differences in the diurnal variations for these trace gases. ARL also provided forecasting and post-analysis support during the field study.

Birch Creek Valley 2013

The goal of this project was to study wind flows in highly complex terrain and generate a database for the improvement of models for predicting high resolution wind fields in complex terrain. ARL partnered with Idaho National Laboratory (INL) to conduct a series of measurements to investigate large-scale wind flows in Birch Creek Valley, a large intermontane valley with relief of several thousand feet. ARL deployed a radar profiler, three sodars, and two sonic anemometers during the study. ARL's efforts produced high-resolution wind and planetary boundary layer observations in complex terrain, and these observations were used to test wind models used for wildfire spread predictions.



ARL's Birch Creek Valley station in Idaho

SPICE: World Meteorological Organization Solid Precipitation Intercomparison Experiment 2012-ongoing

SPICE is an international study supported by the WMO to investigate the measurement of precipitation amount, intensity, and type (liquid, solid, mixed), over various time periods (minutes, hours, days, season). SPICE also includes intercomparisons of snow depth measurements (on the ground) and snowfall measurements. ARL has a leading role with SPICE that focused on quantification of errors and uncertainty in solid precipitation measurements and creation of adjustments to correct measurements made with different precipitation gauges.

Nnet: Nitrogen Human Environment Network, Nitrogen Cycling in Latin America: Drivers, Impacts and Vulnerabilities 2012-ongoing

Nnet is a study funded by NSF and Inter-American Institute for Global Change to determine the main nitrogen sources and sinks in South America. ARL supports a wet deposition collection site, Mar Chiquita, located in Argentina. This site follows the National Atmospheric Deposition Program (NADP) protocol for measuring the ion composition in rain.

DISCOVER-AQ: Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality 2012-2014

DISCOVER-AQ was a multi-year campaign led by NASA to improve the use of satellites to monitor air quality for public health and environmental benefit. ARL provided forecasting support for all four DISCOVER-AQ studies: over the Washington, DC, metropolitan area in 2011; Central Valley of California

and Houston, TX, in 2013; and over the Front Range of Colorado in 2014. In addition, ARL installed and operated a suite of trace gas measurement instrumentation to measure nitrogen oxides, carbon monoxide, sulfur dioxide, and ozone in Texas in 2013. ARL was one of the few research organizations capable of fielding the ultra-sensitive detectors needed to measure this suite of compounds at low atmospheric concentrations. ARL's participation in DISCOVER-AQ produced comparisons of land surface temperatures from NOAA and NASA satellites (e.g., Geostationary Operational Environmental Satellite system (GOES) and Suomi National Polar-orbiting Partnership (S-NPP)) and from the North American Mesoscale Forecast System (NAM) and Weather Research and Forecasting (WRF) Model with surface and aircraft observations. ARL also characterized differences in diurnal variations of surface and column observations for key trace gases and aerosols and examined horizontal scales of variability affecting satellites and model calculations.

ARL and collaborators preparing for mercury flight

Aircraft Measurement of Atmospheric Mercury and Trace Gases 2012-2014

The goal of this NOAA-funded study was to examine potential transport of mercury from the upper troposphere to the lower troposphere and potential correlations of mercury concentrations aloft to those at the surface. ARL was involved in aircraft measurements of mercury species and trace gases during the study. Data from ARL's measurements were used to evaluate and improve models, and to identify potential oxidation pathways and assess the relative contributions of natural and anthropogenic processes to local, regional, and global mercury burdens.

Air Temperature Biases Near Roadways and Buildings 2012-2014

The goal of this project was to quantify biases in air temperature measurements and investigate the typical statistical treatment used to address inhomogeneities in air temperature. ARL's work focused on biases caused by siting of instrumentation near artificial heating sources and also biases caused by different measurement systems.

DC3: Deep Convective Clouds and Chemistry 2012-2013

DC3 was a study funded by NSF and NASA to investigate the impact of deep, mid-latitude continental convective clouds, including their dynamical, physical, and lightning processes, on upper tropospheric composition and chemistry in northeastern Colorado, central Oklahoma, and northern Alabama. ARL was engaged in the measurement of a few key chemical species using a laser instrument onboard the NASA DC-8 aircraft.

Airborne Mercury Sampling aboard the University of Tennessee Space Institute (UTSI) Piper Navajo Aircraft 2012-2013

The goal of this study was to investigate the vertical profiles of atmospheric mercury species from the surface to 20,000 feet above sea level through monthly sampling flights over central Tennessee. The data were used to investigate the distribution and transport of mercury in the regional scale and to assess the importance of vertical transport of atmospheric mercury species in the mid-to-upper troposphere. ARL made measurements of mercury, ozone, and sulfur dioxide from the aircraft and at a nearby surface site.

Ammonia Emissions at the University of Tennessee Farm 2012

The goal of this study was to improve the understanding of the complex relationships between ambient ammonia and meteorological parameters, such as temperature and relative humidity, which influence volatilization rates and ultimately, ambient concentrations near emission sources. ARL's role was to determine how environmental conditions affected ambient concentrations, and therefore, the amount of ammonia available in the atmosphere to form particulate matter or participate in deposition processes.

Assumption of Mercury Monitoring Research Activities at the Mauna Loa Observatory 2011-ongoing

ARL was tasked by U.S. EPA's Clean Air Markets Division to assume operational oversight of mercury monitoring studies at NOAA's Mauna Loa Observatory baseline monitoring station. The goal of the project is to better understand the emissions, transport, transformations, and dynamics of atmospheric mercury from a site in the remote free troposphere, and to provide atmospheric mercury data for public access through the National Atmospheric Deposition Program's Atmospheric Mercury Network. ARL operates chemical detectors for atmospheric mercury species and ancillary trace gases (ozone, sulfur dioxide, carbon monoxide) at this important site. Thus far, examination of mercury data from the Observatory revealed an important artifact in the measurement of particulate mercury, with substantial impact to our understanding of the atmospheric mercury cycle. Volcanic emissions from the Kilauea vent are occasionally transported toward the Observatory, and it was theorized that mineral aerosols in the volcanic plume were responsible for this artifact. ARL deployed a duplicate mercury measurement system atop Mauna Kea, some 40 km distant, for measurement comparison purposes; unlike Mauna Loa, Mauna Kea is an inactive volcano, and the summit is typically free from volcanic influences. ARL staff designed and conducted the entire measurement comparison and deployed duplicate instrumentation for the measurement of mercury, ozone, and sulfur dioxide atop Mauna Kea for the short-term study.

WFIP1 and WFIP2: Wind Forecast Improvement Program 2011-ongoing

The WFIP studies were conducted in two phases. The goal of the WFIP1 (2011-2012) was to improve the ability to model and forecast winds to optimize the generation of wind power, primarily in flat terrain of the Great Plains. The goal of WFIP2 (2013-present) is to improve the ability to model and forecast winds to optimize the generation of wind power with an emphasis on the more complex terrain of the Pacific Northwest. As part of these studies, ARL operated a radar wind profiler, three sodars, and two full component surface flux suites at three Oregon sites: Boardman, Wasco, and Prineville. ARL also collaborated with NOAA ESRL on installation of a RASS system with the radar wind profiler.

Launch of ARL radiosondes in Texas

Texas Radiosonde Study 2011

The goal of this study was to investigate the day and nighttime planetary boundary layer heights and the formation and persistence of the low-level nocturnal jet. ARL conducted high-resolution radiosonde profiles at the Ocotillo Field Research site near Big Spring, TX. ARL's analyses revealed a persistent (in time) nocturnal jet with the maximum velocity at the base of the nighttime surface-based inversion. Evidence of the persistence of the nocturnal jet is apparent in the radiosonde profiles acquired three hours after sunrise.

Dust Transport/Tracer Dispersion Project 2011

ARL partnered with the Pacific Northwest National Laboratory and the Desert Research Institute to design a dust transport study for the Hanford Reservation in central Washington. The design of the experiment paired collocated dust and tracer measurements, with the source for both species being dust generated by a vehicle driven on a dirt road while simultaneously releasing an inert non-depositing tracer. Simultaneous tracer measurements were made using ARL's fast response tracer gas analyzers to identify the optimum tracer release rates.

NOAA/Federal Aviation Administration/National Center for Atmospheric Research Precipitation Testbed 2010-ongoing

The goal of this study is to assess the methods of measurement and the observation of solid precipitation, snowfall, and snow depth at automatic, unattended stations used in cold climates (e.g., polar and alpine). Results from the study's intercomparisons and evaluations of the different precipitation measurement techniques will be used by national precipitation measurement networks. The precipitation testbed in Marshall, CO, is the focus of the U.S. effort for evaluating a new standard for measuring solid precipitation. While solid precipitation measurements have been the subject of many studies, there have

been only a limited number of coordinated assessments on the accuracy, reliability, and repeatability of automatic precipitation measurements. Through this study, ARL will provide the scientific community with 1) a better understanding of the accuracy and precision of gauges and the ability of those gauges to report solid precipitation; 2) an evaluation of new and emerging technology for the measurement of solid precipitation (e.g., non-catchment); and 3) an assessment of the gauges' potential use in operational applications.

NOAA and Duke Energy Generation Wind Energy Study 2010-2013

As part of a three-year Cooperative Research and Development Agreement (CRADA) with Duke Energy Generation Services, Inc., ARL conducted a field study at Duke Energy's Ocotillo Wind Farm, located in western Texas, to collect surface-based, energy-balance observations. ARL installed two meteorological monitoring systems, a 30-meter high tower instrumented to measure winds and temperature at five different heights and a 10-meter high tower to measure energy balance, such as the exchange of heat, momentum, and water vapor at the surface. The data collected were used to explore the potential for improvements in forecast model performance.

Comparison of In-situ, Aircraft, and Satellite Land Surface Temperature Measurements over a NOAA U.S. Climate Reference Network site 2010-2012

The goal of this study was to better quantify the spatial variability and overall representativeness of the single-point land surface temperature being recorded at NOAA's U.S. Climate Reference Network (USCRN) sites and to improve the accuracy of satellite-based land surface temperature measurements. ARL was involved in collection of data from airborne flights over USCRN sites in Crossville, TN, and Bondville, IL, and from intensive experiments in Oak Ridge, TN. Results from the study showed good agreement between in-situ, aircraft and satellite land surface temperature measurements.

Sonic Anemometer Intercomparison and Calibration in Turbulent Conditions 2010-2011

The goal of this project was to quantify non-orthogonal sonic anemometer measurement errors in turbulent atmospheric conditions. Sonic anemometers are used to measure eddy covariance fluxes of mass and energy between the Earth's surface and the atmosphere. ARL investigated angle of attack errors that are caused by wakes formed downwind of sonic anemometer transducers and offered solutions to reduce underestimation of the measured vertical wind speed from non-orthogonal sonic anemometers.

Mercury Intensive Field Research at the Grand Bay National Estuarine Research Reserve (NERR) 2010-2011

ARL conducted an intensive study of mercury at the Grand Bay NERR in partnership with Florida State University, the University of Miami, and the Georgia Institute of Technology. The goals of the study were to assess the relative contributions of natural and anthropogenic processes to local, regional, and global burdens of mercury; the role of atmospheric transport from the upper troposphere in influencing mercury concentrations at the surface; and the role of halogen compounds in mercury transformations. ARL played the leading role in designing the experimental approach; facilitating and coordinating all logistics of several research groups at the NERR; providing ground- and aircraft-based measurements of mercury and ancillary trace gases and aerosols; and studying upper air composition and structure using balloon-borne ozonesondes and raiwinsondes.

Big Southern Butte 2010

ARL collaborated with the Fire Sciences Laboratory of the U.S. Forest Service, Washington State University, and the National Institute of Standards and Technology during a field experiment at Big Southern Butte in eastern Idaho that included an array of 50 wind sensors deployed on transects across the butte. ARL provided meteorological measurements using sonic anemometers, sodars, and a radar profiler and contributed data from its mesonet of 34 stations in Idaho. ARL also provided Weather Research and Forecasting (WRF) modeling data for the eastern Idaho area for the duration of the experiment.

CalNex: California Nexus, Research at the Nexus of Air Quality and Climate Change 2010

CalNex 2010 was a joint field study involving NOAA (primarily ESRL), the California Air Resources Board, and numerous academic scientists, that focused on atmospheric processes over California and the eastern Pacific coastal region, with a particular emphasis on the interactions between air quality and climate change issues. ARL conducted field experiments at the urban supersite near Pasadena, CA, and at an agricultural site near Modesto, CA. ARL deployed a suite of fast-response wind, temperature and solar radiation instrumentation at the urban supersite to measure various components of the energy balance system. At the agricultural site, ARL partnered with the University of California at Davis (UC Davis) and Lawrence Berkeley National Laboratory to quantify ammonia exchange processes over an agricultural ecosystem adjacent to a dairy farm.

ARL engineer installing equipment for study in California

ARL GEWEX: Observations of the surface energy budget to characterize land surface feedbacks to extreme climatic events 1996-ongoing

ARL has a long-term engagement with the Global Energy and Water Cycle Exchanges Project (GEWEX), which is an integrated program of research, observations, and science activities that focuses on the atmospheric, terrestrial, radiative, hydrological, coupled processes, and interactions that determine the global and regional hydrological cycle, radiation and energy transitions, and their involvement in climate change. The goal of ARL's GEWEX monitoring is to provide a predictive understanding of the response of various land surface types to changing climate regimes and the quantifying potential feedbacks.