Collaborations

ARL is fortunate to have established productive research collaborations with a number of government, university, tribal, private industry, and non-governmental organizations, both nationally and internationally. These strategic partnerships support ARL's mission and are instrumental to day-to-day operations, ongoing multi-decadal programs, and emerging projects. The following is a list of organizations that collaborated with ARL during the period of 2010-2015, with a brief description of the partnership.

Cooperative Institute Partnerships

ARL conducts research and development activities in close collaboration with the Cooperative Institute for Climate and Satellites (CICS), a national consortium of academic, non-profit, and community organizations, with leadership from the University of Maryland College Park and North Carolina State University. ARL's partnership with CICS-Maryland involves evaluating and improving forecast models run operationally by the National Weather Service (NWS) to provide consistently high-quality forecast products and support air quality planners and managers, air quality forecasters, and the research community. The collaboration between ARL and CICS-North Carolina focuses on sustaining and improving the quality of in-situ climate observations and observing networks, particularly NOAA's U.S. Climate Reference Network, to provide a 50-year picture of climate change across the U.S.

Cooperative Research and Development Agreements

ARL established three Cooperative Research and Development Agreements (CRADAs) with private industry partners. The duration of each CRADA was three years.

- In 2010, ARL established a CRADA with Duke Energy Generation Services, Inc. to improve wind energy forecasts. Regional meteorological measurements were used to address deficiencies in low-level wind predictions and improve model sub-grid parameterizations. ARL provided data to support Duke Energy's analyses of turbine performance and energy grid balance. ARL's work showed that forecasts of wind turbine hub-height wind speeds could be improved through inclusion of site-specific flux-gradient wind modeling techniques.
- ARL established a CRADA with Catch the Wind, Inc. in 2010 to evaluate the capabilities and assist in the development of laser anemometer measurement systems. These laser systems provided better information for plume dispersion forecasts related to renewable energy, dispersion within complex terrain, and urban emergency management. ARL instrumented a testbed for the laser system and conducted an intercomparison study.
- In 2012, ARL established a CRADA with Belfort Instruments Co. to develop innovative technologies for climate observing systems. The objective was to collaborate on research, design, performance, and engineering of new sensors and techniques for measuring air temperature, precipitation, and other meteorological parameters. ARL helped test and develop a new weighing precipitation gauge, vibrating wires for the measurement of precipitation, low-porosity double Alter wind shield for precipitation gauges, and aspirated radiation shield for air temperature measurements. In addition to being made in the U.S., these sensors meet the criteria necessary for inclusion in the U.S. Climate Reference Network, providing a needed and viable alternative to the currently used sensors and shields in the network. They also offer advantages in cost and performance over other comparable sensors being used in U.S. climate and meteorology networks.

International

International Workshop on Air Quality Forecasting and Research (IWAQFR)

- ARL hosted the 3rd IWAQFR in 2011 at the Bolger Conference Center in Potomac, MD. The goal of the workshop was to provide a venue for the discussion of science issues and advancements related to air quality forecasting, including improvement of operational air quality forecasts and promotion of collaborations among air quality forecasting researchers and practitioners. Over 100 scientists from 17 countries participated in the workshop, which was sponsored by Environment Canada, NOAA, and the World Meteorological Organization (WMO). A steering committee led by ARL scientists, along with partners NOAA Earth Systems Research Laboratory (ESRL) and

NWS, published proceedings in *Eos*, the American Geophysical Union's international newspaper. The article summarized the latest developments and areas of active research associated with several national air quality forecasting programs in Europe, Asia, and Americas.

- In 2015, ARL hosted the 7th IWAQFR in College Park, MD, which focused on the need to acquire temporally and spatially relevant satellite data, develop high resolution models and ensemble modeling systems, and address current limitations in atmospheric aerosol science. Over 100 scientists, including 20 international participants from South America, Australia, Canada, Asia, and Europe, engaged in scientific discussions and attended a town hall, which announced the official release of a prototype marine isoprene emissions product developed by ARL and NESDIS/STAR from Joint Polar Satellite Systems products. A special journal issue is planned for the Journal of the Air and Waste Management Association for late 2016.

World Meteorological Organization (WMO)

- In partnership with Environment Canada and the Australian Bureau of Meteorology, ARL develops atmospheric dispersion model products that are used by the WMO Regional Specialized Meteorological Centers (RSMC) in response to major nuclear accidents around the world.
- ARL's research with the Global Observing System for Climate (GCOS) Reference Upper-Air Network (GRUAN) includes direct collaborations with Bodeker Scientific in New Zealand and Deutscher Wetterdienst in Germany.

Argentina

- ARL collaborates with the University of Cordoba to model dust and salt storms.

Asia Pacific Mercury Monitoring Network

- In collaboration with environmental program officers from a consortium of Asian nations (Taiwan, Vietnam, Philippines, Indonesia, Thailand, etc.), ARL works in conjunction with U.S. EPA and the National Atmospheric Deposition Program to provide technical guidance and expertise for the design and implementation of an Asian mercury monitoring network.

Canada

- ARL partners with Environment Canada researchers from Saskatoon, Saskatchewan; Dartmouth, Nova Scotia; and Toronto, Ontario, to analyze and develop corrections for precipitation measurements and ensure that U.S. national network precipitation measurements and Canadian national network precipitation measurements are comparable, a significant advancement for continental scale analyses of wet deposition.
- ARL has a Memorandum of Understanding with Environment Canada that calls for the establishment of a visibility and particle speciation monitoring site in remote Western Canada. The site is operated as part of the U.S. Interagency Monitoring of Protected Visual Environments (IMPROVE) network.
- In collaboration with the University of British Columbia-Vancouver, ARL develops methods for observed water and carbon flux measurements.
- ARL participates in the Lake Superior Work Group, a binational group of State, Federal, Provincial, and Tribal governments, who work together to protect, restore, and maintain Lake Superior. In this role, ARL conducted an analysis and prepared a detailed report describing source attribution for atmospheric mercury deposition to Lake Superior.

China

- ARL collaborates closely with Peking University in Beijing and the Najing University of Information Science and Technology on air pollutant measurements and atmospheric oxidation chemistry.
- ARL conducts assessments and analyses of extreme climate anomalies and its impacts on China.

France
- ARL performs back trajectories to determine the origin of metals from pre-columbine civilizations in partnership with Chargé de Recherche CNRS, EcoLab Campus Ensat.
- In collaboration with AgroParisTech, ARL studies air-surface exchange of ammonia and incorporates data into bi-directional exchange models.
- ARL works with the European Space Agency to analyze satellite remote-sensed soil moisture data.

Italy
- Through the Global Mercury Observation System, ARL, along with the U.S. EPA Clean Air Markets Division and NOAA Earth Systems Research Laboratory, participates in the collection and dissemination of atmospheric mercury data at NOAA's Mauna Loa Observatory.

Korea
- ARL signed a Memorandum of Understanding with the National Institute for Environmental Research of Republic of Korea Universities in support of air quality modeling research activities.
- ARL collaborates with the National Institute of Environmental Research and Ajou University in Suwon, Korea, to develop an air quality forecast system in East Asia.

Mexico
- ARL conducted a back-trajectory analysis to aid in the interpretation of atmospheric pesticide samples and taught the investigators how to conduct the analysis.

New Zealand
- With the National Institute of Water and Atmospheric Research (NIWA), ARL analyzes and presents eddy covariance measurements of water and carbon dioxide fluxes from different agricultural systems in New Zealand.

Norway
- ARL collaborates closely with the Norwegian Meteorological Institute in Oslo to develop transfer functions for precipitation measurements.

Spain
- In close collaboration with the regional Spanish Meteorological Agency (AEMET) office in Zaragoza, ARL analyzes and presents climate data from measurement sites within the Spanish Pyrenees.
- ARL partners with the University of Huelva on various atmospheric modeling topics, such as local arsenic transport and Saharan dust transport.
- ARL collaborates with the Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas (CIEMAT), Government of Spain, to study formation of secondary organic aerosols (SOA).

Sweden
- ARL conducted a back-trajectory analysis to aid in the interpretation of atmospheric pesticide samples and taught the investigators how to conduct the analysis.

United Kingdom
- ARL works with the European Centre for Medium-Range Weather Forecasts (ECMWF) on boundary layer research and model development.
- ARL partners with the University of Reading on stratospheric temperature research.
- ARL collaborates on studies of upper-air climate change and stratospheric sudden warming events with the UK Meteorological Office.
- As part of its work with various Volcanic Ash Advisory Centers (UK, U.S., Australia, Canada, Japan, and France), ARL created a proto-type web page to be used by the centers for comparing model outputs.

National

National Oceanic and Atmospheric Administration

- ARL collaborates with the OAR ESRL on the development of plans for a complete Surface Energy Budget Network.
- ARL worked closely with the OAR ESRL on field observations and forecast model improvements for the Wind Forecast Improvement Project 1 and 2.
- ARL hosts instrumentation and provides basic maintenance and repair of the research stations for the OAR ESRL's Surface Radiation (SURFRAD) network and the Ground-Based GPS Meteorology Network at the Nevada National Security Site.
- ARL and the NOS Office of Response and Restoration partner to develop a joint dispersion modeling system which combines results of chemical spills from the Computer-Aided Management of Emergency Operations (CAMEO) software with dispersion calculations from the Hybrid Single Particle Lagrangian Integrated Trajectory Model (HYSPLIT), and displays the resulting plume simulation.
- ARL and the NESDIS Center for Satellite Applications and Research collaborate on emergency response volcanic ash HYSPLIT modeling using satellite analyses and on radiosonde temperature corrections.
- ARL collaborates with the NWS National Centers for Environmental Prediction, Alaska Region, Alaska Aviation Weather Unit, Aviation Services Branch, in addition to the NESDIS Satellite Analysis Branch, for the NOAA volcanic ash program.
- For the National Air Quality Forecast Capability, ARL partners with the NWS Office of Science and Technology Integration and the National Centers for Environmental Prediction Environmental Modeling Center.
- For the NOAA Smoke Forecasting System, ARL partners with the NESDIS Satellite Products and Services Division.
- ARL collaborates with the NESDIS Center for Satellite Applications and Research on satellite calibration and validation.
- ARL partners with the OAR Earth System Research Laboratory for research in renewable energy, nitrogen chemistry, mercury measurement, carbon dioxide footprints at a continental scale, dispersion modeling, stratospheric sudden warmings, climate engineering, and extreme weather events.
- ARL collaborates with the Cooperative Program for Operational Meteorology, Education, and Training (COMET) program to update HYSPLIT training materials and examples designed to support the forecasters at the NWS Weather Forecast Offices.
- In partnership with the OAR Geophysical Fluid Dynamics Laboratory, ARL conducts boundary layer research and studies to improve the representation of reactive nitrogen exchange between the land and atmosphere.
- ARL partners with the NESDIS National Center for Environmental Data on the U.S. Climate Reference Network (US-CRN) and research focused on the soil moisture, air temperature, and precipitation measurements recorded by the US-CRN.
- ARL works with NWS to implement model updates into operational HYSPLIT products.
- ARL has an ongoing collaboration with the Pocatello, ID Weather Forecast Office on sharing local modeling products and observations. The WFO also makes extensive use of observations from ARL's 34-tower meteorological network when issuing forecasts, watches, and warnings.
- In partnership with NOS, ARL investigated methods to improve understanding of the biological, chemical, and physical processes that drive the exchange of greenhouse gases and nutrients between the atmosphere, land, and water in coastal ecosystems.
- ARL collaborates with the National Estuarine Research Reserves (NERRs) in the continued operation of the Grand Bay NERR atmospheric mercury monitoring site in Moss Point, MS.
- ARL partners with the NESDIS National Center for Environmental Prediction on improving land-surface-model parameterizations.
- ARL collaborates with the NWS Las Vegas Weather Forecast Office on boundary layer meteorology. The various ARL mesonets, including a 10 m tower network and a lightning detection network, provide much needed information in a vastly data sparse region. These data

describe boundary layer characteristics of the region that are critical to providing information to protect people and property from high winds, flooding, extreme heat, and lightning.

Other Federal Government

- ARL collaborates closely with the Idaho National Laboratory emergency response personnel in the development of HYRAD (HYSPLIT Radiological), an application combining the use of the HYSPLIT model for calculating radiological dispersion, and a new user interface.
- ARL works with the Pacific Northwest Laboratory to expand implementation of HYRad across all DOE facilities.
- ARL conducts volcanic ash R&D work in partnership with the Federal Aviation Administration.
- ARL collaborates with the U.S. Environmental Protection Agency in using the EPA RadNet radiation measurement network to improve dispersion modeling results by using inverse modeling techniques to estimate the nuclear source term during accidents. A Memorandum of Agreement is in development.
- ARL works with the U.S. Nuclear Regulatory Commission through a Memorandum of Understanding on research related to atmospheric transport and dispersion of pollutants in severe nuclear accidents.
- ARL collaborates on climate engineering detection with the NASA Langley Research Center.
- ARL collaborates with the NASA Goddard Space Center and the NASA Jet Propulsion Laboratory to compare satellite land surface temperature measurements to tower- and aircraft-based measurements of land surface temperature.
- ARL partners with the NASA Goddard Space Center for dust data analysis.
- With the U.S. Forest Service Rocky Mountain Research Station in Fort Collins, CO, ARL quantifies errors in sonic anemometer measurements.
- With the National Park Service in Fairbanks, AK, ARL conducts research to provide more accurate temperature calibration equations for the NPS climate network.
- ARL conducts scientific studies and monitoring programs with the EPA Clean Air Markets Division to address atmospheric mercury measurements and regional and global modeling.
- As part of the National Atmospheric Deposition Program, ARL collaborates with the U.S. Department of Agriculture, National Park Service, U.S. EPA, U.S. Forest Service, and U.S. Geological Survey to monitor the concentration and deposition of major ions and mercury in precipitation, as well as speciated mercury in air.
- ARL works with National Institute of Standards and Technology to determine carbon dioxide footprints in urban areas.
- ARL collaborates with the U.S. Department of Defense on development of an inline HYSPLIT-WRF model.
- ARL partners with the DOE Richland Operations Office and the Office of River Protection to estimate ash concentrations originating from the resuspension of volcanic ash.
- In partnership with the DOE Pacific Northwest National Laboratory, ARL develops calculations of nuclide transport and dispersion.
- ARL collaborates with the U.S. Forest Service Fire Sciences Laboratory on field studies in complex terrain to improve wind-field modeling for wildfires and other applications.
- ARL works with the DOE Subcommittee on Consequence Assessment and Protective Actions (SCAPA) on the development of Software Quality Assurance (SQA) documentation for HYSPLIT and HYRad that has enabled their acceptance as modeling tools for radiological releases and assessments.
- ARL partners with the DoD, DHS, DOE, and EPA to conduct atmospheric tracer studies and improve dispersion modeling.
- ARL collaborates with DOE through a Memorandum of Understanding to provide emergency response support associated with accidental releases of hazardous substances and wildfires, and operates a meteorological network in collaboration with the DOE Idaho National Laboratory.
- ARL worked with NASA on the implementation and operation of ground-based chemical detection equipment in the 2013 DISCOVER-AQ field program.
- ARL partners with the EPA for the Great Lakes Restoration Initiative and provides modeling analysis to estimate the atmospheric transport and deposition of mercury to the Great Lakes.

- ARL was invited by the EPA to conduct modeling analysis of atmospheric fate and transport of dioxin in response to Deepwater Horizon Oil Spill and to investigate potential impacts of emissions from in-situ sea-surface oil burning.
- ARL collaborates with the USGS to investigate climate issues and carry out trajectory-based analysis.
- ARL provided data and assistance to the USGS for mapping mercury emissions sources in North America.
- ARL leads a team of researchers from NOAA, NASA, USDA, and University of Texas to develop a dust climate indicator for the National Climate Assessment.
- ARL works with the DOE National Nuclear Security Administration on mutually relevant applied meteorological topics, including dispersion/plume modeling, mesonet and upper air data collection, and analysis for national security and non-proliferation projects, operations, and experiments (Nevada National Security Site, Shock Physics Experiments, Wind in the Willows).

Non-Government Organizations

- ARL collaborates with the University Corporation for Atmospheric Research for chemical data assimilation and analog-based uncertainty quantification to improve decision-making in public health and air quality.
- ARL partners with the Cristal Baltimore Research Center on a photocatalysis project to study the conversion of NO_x to nitrate on a photocatalytic surface.
- ARL collaborates with Remote Sensing Systems (RSS) on stratospheric temperature research. RSS is a scientific research company specializing in satellite microwave remote sensing of the earth.
- ARL partners with the Belfort Instrument Company to develop and test new sensors and shields for air temperature, wind speed, and precipitation measurements.
- ARL collaborates closely with the National Center for Atmospheric Research at the NCAR/NOAA/FAA precipitation testbed for the World Meteorological Organization Solid Precipitation InterComparison Experiment.
- At the Exploratorium Science Museum in San Francisco, CA, ARL designed and implemented environmental program studies and exhibits.
- ARL worked with the Biodiversity Research Institute, EPA, and others on a national mercury monitoring plan.
- ARL collaborated with the Keys Marine Laboratory to install Extreme Turbulence probes on navigation structures in the Florida Keys.
- ARL partners with Vaisala to make field observations and perform numerical modeling associated with the Wind Forecast Improvement Project 2.

State and Local Government

- ARL partners with the Gulf of Mexico Alliance (GOMA), a group of Federal, State, NGO, and other entities, for atmospheric chemistry and boundary layer research.
- ARL works with the Texas Commission on Environmental Quality to investigate surface layer parameterization of the WRF model and its impact on the observed nocturnal wind speed bias.
- In association with the State of Texas, ARL studies ozone production in Houston, TX.
- ARL collaborates with the State of Maryland Department of Environment on air quality monitoring and modeling and atmospheric deposition.
- ARL collaborates with the State of Idaho Idaho National Laboratory Oversight Program to provide NOAA/INL mesonet data for the State's dispersion modeling effort and to collocate observation systems in Southeast Idaho for dispersion modeling activities.
- ARL partners with the Mississippi Department of Natural Resources in the operation of the Grand Bay NERR atmospheric mercury monitoring site.
- ARL collaborates with the State of Maryland to provide information and modeling analysis to support Total Maximum Daily Load (TMDL) studies involving mercury.
- ARL provides the Clark County, Nevada, Department of Air Quality with assistance on using HYSPLIT and other tools to understand air quality issues.

- ARL collaborates with the State of Texas on development of an IDL-based Geospatial Data Processor.

Tribes

- ARL collaborates with the Red Cliff Band of Lake Superior Chippewa to provide information about atmospheric mercury, including an extensive hands-on tutorial regarding trajectory-based analysis of monitoring data.
- ARL provides a meteorological tower and real-time data display as part of a community monitoring effort to Shoshone-Bannock Tribes at the Fort Hall Indian Reservation (Idaho).

Colleges and Universities

- ARL collaborates with the NOAA High-Performance Computing and Communications program and Boise State University on the potential for implementing GPU computing with HYSPLIT.
- ARL collaborates with the University of Alabama at Huntsville on the development of methods for improving the predictions of convective storms.
- ARL partners with Harvard University for the Fluxes of Carbon from an Airborne Laboratory (FOCAL) project in Alaska which studied greenhouse gas emissions from arctic permafrost using eddy covariance from aircraft.
- ARL works with the University of Maryland College Park on various projects including air quality monitoring, greenhouse gas emissions, and atmospheric oxidation chemistry.
- ARL collaborate with Pennsylvania State University on atmospheric photochemical modeling.
- ARL partners with University of Iowa, Georgia Institute of Technology, University of Alabama at Huntsville, and Emory University for NASA Air Quality Applied Sciences Team (AQAST) chemical analysis.
- With Colorado State University, ARL studies tropical width research and stratospheric temperature research.
- With the University of Colorado Boulder, ARL studies stratospheric sudden warmings.
- ARL collaborates with the University of California, Davis on development of new surface layer turbulence parameterizations.
- In partnership with the University of Montana, ARL investigates upscaling permafrost flux measurements using remote sensing and models.
- ARL collaborates with the University of Tennessee Space Institute on measuring land surface temperatures from aircraft and airborne tracer studies.
- ARL partners with the University of Tennessee on application of numerical techniques from the simulation of supernova explosions to air quality modeling.
- ARL participates in the Cooperative Institute for Climate and Satellites, operated by NOAA NESDIS in collaboration with the University of Maryland Earth System Science Interdisciplinary Center and the Atmospheric and Oceanic Science department.
- ARL collaborates with the University of Delaware on precipitation chemistry and nutrient deposition studies in coastal areas.
- ARL partners with the University of Illinois on ammonia emission from fertilizer application and its representation in air quality models; precipitation chemistry and nutrient deposition; and regional climate studies.
- With the University of Virginia, ARL investigates nitrogen cycling in the environment.
- ARL and Cornell University study precipitation chemistry, nutrient deposition, and coastal eutrophication.
- ARL collaborates with the Laboratory for Atmospheric Research at Washington State University for measurements of winds, turbulence, and fluxes during field experiments.
- ARL partners with the NOAA Environmental Cooperative Science Center at Florida A&M University to study nitrogen cycling in the environment.
- With the University of Texas at El Paso, ARL conducts dust data analysis and applications.
- ARL collaborates with Florida State University, the University of Miami, the Georgia Institute of Technology, and the University of Tennessee Space Institute in atmospheric mercury measurement initiatives.

- ARL collaborates with the University of Houston, Valparaiso University, and the University of Maryland in air quality field research activities.
- ARL partners with the University of Tennessee on measurements of carbon, water, and energy fluxes in different plant-climate environments.
- ARL and Washington State University participated in two field studies involving winds in complex terrain and tracer releases.
- ARL collaborates with the University of Wyoming on possible cloud-seeding studies.
- With the University of Maryland Baltimore County, ARL conducts LiDAR and photchemical modeling studies.
- ARL collaborates with Cornell University on the modeling of a multilayer particle deposition model.
- ARL and Southern Methodist University have a Memorandum of Understanding for data collection experiments in infrasound.

Reimbursable Support

During this time period, ARL received (or currently receives) reimbursable support from the following federal agencies:

- Department of Energy: Collaborative dispersion research and technical services associated with the DOE Idaho National Laboratory.
- Department of Energy: Meteorology and dispersion expertise for the Nevada National Security Site operations, national security experiment support, and emergency response activities.
- Department of Energy: Ash resuspension assessment for the Hanford Site as a contribution to a program designed to process radioactive waste.
- Department of Defense: Development of HYSPLIT in-line modeling to assess fate and transport of nuclear materials in the atmosphere.
- National Park Service and U.S. Environmental Protection Agency: Funding to provide expert air quality monitoring and management assistance for the oversight of the Interagency Monitoring of Protected Visual Environments (IMPROVE) Program. IMPROVE involves particulate matter and visibility monitoring at about 170 locations nationwide.
- Federal Aviation Administration: Quantification of volcanic ash source terms to protect aircraft from ash plumes.
- U.S. Environmental Protection Agency: Great Lakes Restoration Initiative funding to estimate mercury deposition to the Great Lakes.
- U.S. Environmental Protection Agency: Support for monitoring speciated mercury at the Mauna Loa Observatory in Hawaii.
- Department of State: Support for moving HYSPLIT products into operations at the National Weather Service in support of the Comprehensive Nuclear Test Ban Treaty.
- Department of Homeland Security: Dispersion research in urban environments such as Midtown Manhattan.
- Department of Homeland Security: Support to put HYSPLIT products into a Geo-Targeted Alerting System (GTAS) Reverse 911 notification system.
- National Aeronautics and Space Administration: Funding for a detailed examination of the relevant meteorological and atmospheric transport and diffusion components of the Mars Science Laboratory Program.
- Battelle Pacific Northwest National Laboratory: Funding for dispersion modeling studies for surface and elevated emissions sources at the Idaho National Laboratory Advanced Test Reactor.
- Southern Methodist University: Funding for forecasts and meteorological data in remote southern Nevada to support infrasound non-proliferation research.
- Government of Canada: Funding to expand the IMPROVE Program into Canada and to advance the long-term cooperation on the sharing of air quality visibility data.

During this time period, ARL received (or currently receives) reimbursable support from the following state agencies and institutions:

- University of Houston: Funding for photochemical modeling in Texas.
- Texas Commission for Environmental Quality: Funding was received to develop laminar layer parameterization for the WRF model and to study its impact on nocturnal winds, for geospatial data processing, and for development of a fine resolution air quality forecasting capability in support of NASA field campaigns as a part of the NASA Air Quality Applied Science Team.