Air Resources Laboratory

Atmospheric Boundary Layer and Surface Exchange Research and Development

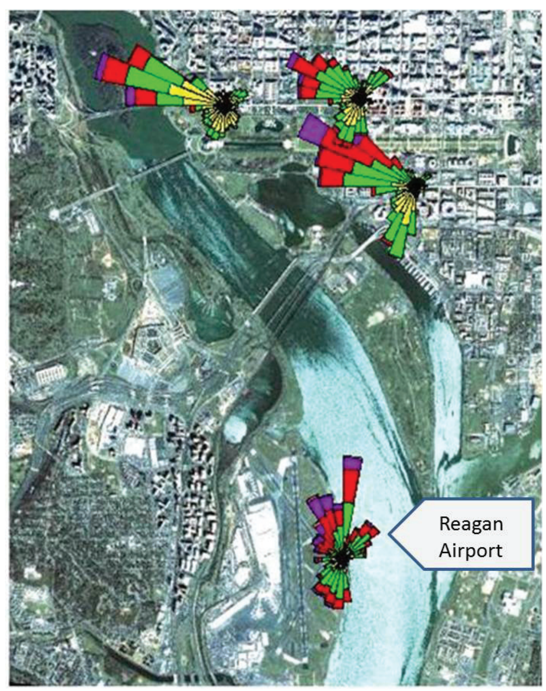
Improving the Prediction of Surface and Near-Surface Weather and Climate Conditions

The atmospheric boundary layer is the mixed layer of the atmosphere that extends from the Earth's surface to heights which can range from tens of meters to several kilometers, depending on conditions. On a daily cycle the boundary layer undergoes noticeable changes in response to exchanges of energy, mass, and momentum between the underlying surface and the atmosphere (termed air-surface exchange). Basically, it is the area that is most in contact with people, and its behavior is directly influenced by what exists and occurs on the Earth's surface. As such, it has a significant influence on a number of important atmospheric and environmental issues. These include how and where harmful airborne materials and air pollution are transported and dispersed; the transfer of chemical compounds between the atmosphere and the underlying land and water surfaces; how winds and turbulence affect transportation and wind energy production; hurricane evolution and impacts; climate variability and change; and the behavior of wildland and agricultural fires and the smoke they produce.

What We Do

The Air Resources Laboratory (ARL) uses state-of-the-art methods and techniques, and develops new ones as necessary, to better understand and model the atmospheric boundary layer and air-surface exchange processes. This research directly supports NOAA and ARL's other research in dispersion, air quality, and climate by improving the prediction of surface and near-surface weather and climate conditions. Three examples of ARL's Atmospheric Boundary Layer and Surface Exchange Research and Development are provided below.

<u>DCNet</u>
Since 2003, ARL has been operating an intensive urban research meteorological network within the National Capital Region, called DCNet. The network collects standard meteorological data and also measures characteristics of atmospheric turbulence at several locations. DCNet provides critical data and insights that improve the predictions of where airborne hazardous materials will go; thus improving an emergency manager's ability to protect first responders and the public. The image to the right, for example, shows the variability in wind speed and direction within a small geographic area. Data from three DCNet stations (top of image) show wind speed and direction are different than at Reagan Airport.



High quality wind data from several DCNet meteorological towers. The colors represent wind speed scales. Data are used to drive computer models to better predict movement of airborne hazardous materials and to track severe weather. Image: NOAA.

With a strong focus on data quality, DCNet is designed to support development of urban monitoring methodologies and observation standards within urban environments. It also provides an intensive dataset for model evaluation and initialization, process studies, and decision support. The data have allowed researchers to determine the spatial and temporal fluctuations of horizontal winds throughout the District, as well as to characterize the atmospheric layer immediately above the urban canopy where winds are poorly predicted by meteorological models. While DCNet is a research network, its observations are used by numerous government security and emergency management personnel for various activities within the National Capital Region.

Extreme Turbulence Probe

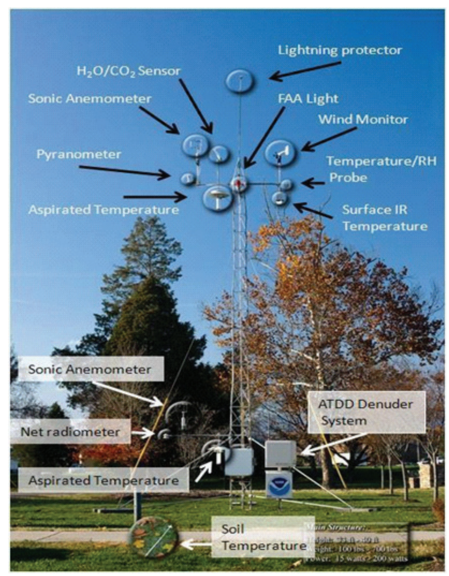
The Extreme Turbulence (ET) probe is an innovative wind sensor specifically developed by ARL to work in hurricane conditions. The ET probe is designed to measure winds, turbulence, and air-sea exchanges in conditions with heavy rain and high winds, such as those encountered in hurricanes. The ET probe is basically an aircraft gust probe that has been adapted for use at a fixed surface location in high winds. It has special modifications to mitigate the effects of rain and spray on the wind data. The ET probe has been successfully deployed on land in advance of hurricanes to measure details of wind gusts and turbulence.

ARL scientist deploying an ET Probe on a tower at the end of a 560 meter long pier in Duck, NC Image: NOAA.

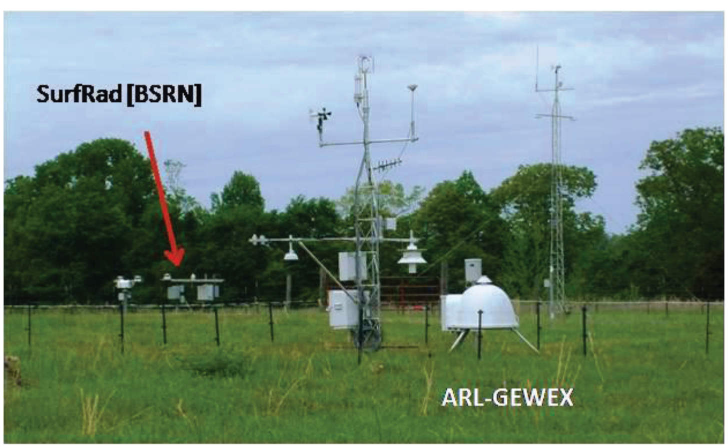
ARL is currently developing a version of the probe that could be placed on buoys in the open water for several months in areas likely to encounter a hurricane. This would enable the collection of information on the exchange of energy between the ocean and the atmosphere in a hurricane, which is a poorly understood but an important factor in hurricane intensification. The probe also may be useful for other applications beyond hurricane measurements. Because turbulent gusts are a significant factor in the damage patterns observed from hurricanes and other large storms, the probes could provide useful information related to wind loading on structures. For example, since large wind turbines are now being deployed offshore, probes may be useful for measuring extreme wind loads that could damage the turbines.

Surface Energy Budget Network (SEBN)

ARL collaborates with NOAA's Earth System Research Laboratory to measure energy fluxes at the air-land interface to improve understanding of the Earth's surface energy balance. It is this balance that drives weather, climate, and ocean circulation, and therefore must be accurately reproduced in climate models in order for decision-makers to make sound choices regarding environmental and economic policy. Accurate simulation of this balance is also important for weather prediction, including short-term and seasonal predictions of water resources.



ARL's Surface Exchange System at the Atmospheric Turbulence and Diffusion Division in Oak Ridge, TN. Image: NOAA.



A SEBN Station at Goodwin Creek, MS showing the Surface Radiation (Baseline Surface Radiation Network) equipment (left) and the ARL-Global Energy and Water Exchanges (GEWEX) project equipment (right). Image: NOAA.

For More Information:

DCNet: www.atdd.noaa.gov
ET Probe: www.noaa.inel.gov/capabilities/etprobe.htm
SEBN: www.atdd.noaa.gov

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