Knowing How and Where Harmful Materials Move through the Air Can Save Lives

Whether it’s an accidental or intentional release of harmful materials into the air, local emergency managers need to know how best to respond in order to protect people. However, the atmospheric flow of material can be complex and hard to predict. This is especially true of areas with complex terrain, such as in a city.

Currently, there are models used to forecast the atmospheric transport of materials at large regional scales. There are also models used to focus at the very local scale (within a kilometer of the source). But in between, at a neighborhood-level scale (1-10 kilometers), models tend to be less reliable in forecasting the dispersion of material. Yet, this is where many people live and where exposure to a harmful release potentially has very serious consequences.

Since September 11, 2001, there has been a heightened awareness of the importance to understand how and where a chemical, biological, or radiological release would move through the air in populated areas. To meet the needs of emergency managers, as well as the atmospheric dispersion modeling community, scientists with NOAA’s Air Resources Laboratory (ARL) collect dispersion observations at the local scale using multiple techniques, including high resolution observing networks and short-term, intensive field studies.

The focus of ARL’s research is to improve the understanding of the transport of materials in the lower part of the atmosphere, called the planetary boundary layer (PBL).
A schematic of the Troposphere, showing the area of the Planetary Boundary Layer (PBL).

Photo Credit: Source: www.skybrary.aero/index.php/Tropopause

A DCNet station on the roof of a building at Howard University.

ARL engineer installing new sensors on the tower at the DCNet station.

The station is located on the roof of a NOAA building in Silver Spring, MD.

Meteorological instruments on top of the tower include a sonic anemometer (top left); temperature and humidity probe (bottom left); and a Propeller and Vane anemometer (top right) used by ARL for dispersion studies.

Photo Credit: NOAA

This is the mixed layer of the atmosphere closest to the ground, basically where people live, work, and play. Local topographical features (e.g., buildings, mountains, trees, water bodies) and other factors play a critical role in determining the behavior of this layer. Due to a multitude of interactions between the surface and the atmosphere, the boundary layer is also the region of the atmosphere most difficult to simulate with computer models. Thus, ARL’s dispersion observations are crucial in the development of new models that will be able to forecast the local dispersion of harmful material.

High Resolution Observing Networks

Unlike weather stations located tens of kilometers or more apart, high resolution meteorological observing stations are placed roughly a few kilometers or less apart. This higher resolution captures smaller-scale air flows that influence how and where chemicals and materials are transported. The stations usually involve 10 meter high towers with various sensors to measure standard meteorological parameters, such as temperature, precipitation, humidity, wind speed and direction.

ARL has a long history in establishing observing networks. One which has been in operation since 2003 is in the District of Columbia—called DCNet. Due in part to obvious security concerns, as well as a fairly uniform low building height, the National Capital Region was chosen as a testbed to acquire air flow data and determine flow characteristics above the urban canopy. Data are used to improve local dispersion modeling in support of emergency planning and response.

There currently are 15 DCNet stations, most of them on building rooftops, which collect not only the standard meteorological parameters but also measure characteristics of atmospheric turbulence. Data are analyzed by computers on each tower and are transmitted to a central analysis location every 15 minutes.

According to Chris Vogel with ARL’s Atmospheric Turbulence and Diffusion Division, while wind steers the airborne plume of material into a direction, atmospheric
turbulence acts to spread and dilute the plume. Think of turbulence as the gusty motion of the air embedded in the average wind. Although turbulence often exists throughout the boundary layer, greater (more intense) turbulence exists close to the rough urban surface. In order to understand how and where material moves through the air, both wind and turbulence measurements are needed.

Yet, most dispersion forecast models do not adequately treat atmospheric turbulence in an urban environment, but instead draw upon studies performed over flat, homogeneous areas, such as cropland. Height restrictions in U.S. cities, including D.C., pose a challenge to collecting data. So, to acquire turbulence data near the ground at select DCNet locations, ARL uses a Sodar (SOnic Detection And Ranging), an instrument that measures the scattering of sound waves by atmospheric turbulence. The Sodar is pointed skyward and can reach several kilometers into the PBL. This provides a three-dimensional perspective on air flow. Unfortunately, due to a somewhat intruding sound it makes while in operation, the Sodar is only used in intense field studies for short periods of time to avoid disrupting people nearby.

DCNet was developed as a prototype for the Washington region, designed to contribute to model development in an urban environment and to provide data to emergency response partners. While the long-term future of the network is uncertain, information of this type is required for model development at locations around the country, and ARL will continue to seek opportunities to assemble additional datasets in support of its programs. In the meantime, the dispersion observations network now in place offers the region an unparalleled capability for effective emergency response.

The ARL plume model, called HYSPLIT, is being updated to simulate neighborhood-scale incidents. Use and application are being coordinated with the National Weather Service and other first responders. The goal is to provide online access to high quality products in a minimum amount of time to local emergency managers. This picture is an example of the type of product that can be displayed with Google Earth. Future models will be improved using high density observations such as DCNet.

The Air Resources Laboratory (ARL) provides research and development for air quality, atmospheric dispersion, climate, and other atmospheric issues. ARL’s goal is to improve the Nation’s ability to protect human and ecosystem health while also maintaining a vibrant economy. Key activities include developing, evaluating, and applying models of ozone and particulate matter; improving approaches for predicting atmospheric dispersion of hazardous materials; generating new insights into air-surface exchange and climate variability and trends; and advancing the understanding of and ability to predict the behavior of the planetary boundary layer. For More Information: www.arl.noaa.gov

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