TRACKING AND PREDICTING THE ATMOSPHERIC DISPERSION OF HAZARDOUS MATERIAL RELEASES: IMPLICATIONS FOR HOMELAND SECURITY

Statement of

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Good afternoon, Mr. Chairman and members of the Subcommittee. Thank you for this opportunity to testify. I am Eric Barron, Dean of the College of Earth and Mineral Sciences and a Professor of Geosciences at Pennsylvania State University. I am the current Chair of the National Research Council's Board on Atmospheric Sciences and Climate (BASC). As you know, the National Research Council is the operating arm of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, and was chartered by Congress in 1863 to advice the government on matters of science and technology.

The BASC recently produced the report "Tracking and Predicting the Atmospheric Dispersion of Hazardous Material Releases: Implications for Homeland Security". This report was produced as part of a major initiative launched by the National Research Council after September 11, 2001, to provide guidance to the federal government on scientific and technical matters related to counter-terrorism and homeland security. I am here today to discuss the findings and recommendations from this report.

Atmospheric scientists and emergency managers have long been concerned with tracking and predicting the atmospheric dispersal of hazardous agents that are accidentally released from industrial sites, energy facilities, and transport vehicles. Today, the terrorist threat carries with it the possible use of weapons of mass destruction, including the deliberate release of chemical / biological / nuclear (C/B/N) agents. Our ability to track the dispersal of these agents has become a critical element of terrorism planning and response. Because it is impossible to anticipate all possible scenarios for airborne release of a C/B/N agent, and in many cases, the exact source location or nature may not be known initially, dispersion modeling systems must be capable of providing useful information even in the absence of some basic input information. This presents a tremendous technical challenge.

Our capacity to meet this challenge rests upon three interconnected elements: 1) atmospheric dispersion models that predict the path and spread of the hazardous agents, 2) observations of the plume and of local meteorological conditions, and 3) effective communication and coordination among the relevant atmospheric science and emergency response communities. The following is an overview of the committee's key findings and recommendations related to each of these three elements.

Dispersion Modeling: Capabilities and Needs

Dispersion modeling systems range from the relatively simple to the highly complex, and they can potentially be used to assist emergency management personnel in the following stages of an event:

- *preparedness stage*: for predicting the outcome of possible C/B/N release scenarios.
- *response stage*: for evaluating the hazard zone in the minutes to hours after an event occurs.
- *recovery and analysis stage*: for assessing human health and environmental impacts in the days to months after the event occurs.

For each of these stages, different dispersion modeling capabilities are required. For preparedness activities (e.g., training for response to threats against specific events such as the Olympics, or specific targets such as a nuclear power plant), existing dispersion models appear to satisfy many of the needs of the emergency response community. Likewise, for post-event recovery and analysis (e.g., reconstructing the dispersal paths of radioactive material released from the Chernobyl reactor accident; or assessing what communities were exposed to smoke plumes from the World Trade Center fires), existing models also seem to provide useful support. However, in the case of immediate response to unanticipated emergency events, where fast-response models are required, the needs of emergency management do not seem to be well satisfied by existing capabilities. There is clearly room for improvement in the dispersion models currently in operational use.

The committee's primary concern is that emergency managers need a realistic understanding of uncertainties associated with a dispersion model prediction; and at present, the uncertainties in most atmospheric dispersion forecasts are not well bounded. Most atmospheric dispersion models predict only the ensemble-average dispersion pattern (that is, the average over a large number of realizations of a given dispersion situation) and not the event-to-event variability about that average. As a result, a forecast from even a very sophisticated dispersion model may have large single-event errors. This represents substantial human health risks when emergency managers must use this information to determine appropriate response actions. **Thus, new approaches are needed for modeling individual hazardous releases, to quantify not only the average downwind concentration distribution of the hazardous plume, but that also to provide some measure of the expected event-to-event variability in that situation.**

Other recommendations for improving modeling capabilities include the following:

- **It is necessary to learn how to more effectively assimilate into models data from meteorological observations and C/B/N sensors, especially as the quality and availability of these data increase.**

- **Urban field programs and wind-tunnel urban simulations should be continued, to improve our understanding of dispersion in different weather regimes and release scenarios, and to allow for the testing, evaluation, and development of modeling systems.**

- **Many currently used models are not well designed for complex natural topographies or built urban environments; and likewise, the effects of urban surfaces are not well accounted for in most meteorological models. Development work in this area should be enhanced.**

- **There is a need for independent, quantitative review and intercomparison of the various models used for operational response to C/B/N events. Most evaluations carried out to date have been largely qualitative in nature.**

Observations: Capabilities and Needs

The basic observations required for tracking and predicting the dispersion of a hazardous agent include:
- identification of the hazardous agent source and plume
- characterization of low-level winds (to follow the plume trajectory)
- characterization of the depth and intensity of atmospheric turbulence (to estimate plume spread)
- identification of areas of potential degradation and dry/wet deposition of the hazardous agents

The committee found that existing observational systems need to be used more effectively, and enhanced in a number of specific ways to become more useful in the context of tracking and predicting dispersion of hazardous agents. Recommendations include the following:

- **A comprehensive survey of the capabilities and limitations of currently existing observational networks should be conducted, followed by action to improve these networks and access to them, especially near areas deemed most vulnerable to terrorist attacks.**

- **There should be an evaluation of the potential for supplementing the national Doppler radar network with sub-networks of short-range, short-wavelength radars, which can be useful for estimating boundary layer winds, monitoring precipitation, and possibly tracking some C/B/N plumes.**

- **Wind and temperature profilers (which measure variations of wind and temperature with height) provide important information for response to C/B/N attacks and should become an integral part of fixed-observational networks.**

- **Mobile observational platforms such as Unmanned Aerial Vehicles, and portable scanning lidars and radars can be used to characterize wind, temperature, turbulence in areas where other platforms cannot easily reach. There should be continued development of these technologies, and plans developed to make such instruments rapidly available for timely use in vulnerable areas.**

- **Local topography and the built environment lead to wind patterns that can carry contaminants in unexpected directions. Efforts should be made to systematically characterize local-scale windflow patterns in areas deemed to be potential terrorist targets, with the goals of optimizing the design of observational systems and educating forecasters about local flows.**

Management and Coordination: Capabilities and Needs

There are numerous federal agencies that operate dispersion modeling systems, including DOE, DoD, NOAA, EPA, FEMA, and the Nuclear Regulatory Commission. In addition, it seems likely that the new Department of Homeland Security could eventually augment or subsume some of the activities currently residing in other federal agencies. The committee did not make specific recommendations about agency leadership responsibilities. However, we do feel that a more carefully crafted management strategy, with a strong center of coordination and clear lines of responsibility, is essential to ensure further progress in the development and effective operation of dispersion modeling systems. **Thus we recommend that a nationally coordinated effort be established for the support and systematic evaluation of existing models, and research and development of new modeling approaches.**

Emergency responders need to better understand the strengths and weaknesses of existing observational and dispersion modeling tools; and in turn, atmospheric scientists need to better understand how dispersion forecasts are used in emergency response situations. **Thus we recommend that joint training exercises (perhaps most usefully, in the form of tabletop event simulation exercises) should be convened regularly to bring together emergency responders and atmospheric scientists, to establish and exercise protocols for information exchange and decision support.**

Currently, emergency responders face a confusing array of seemingly competitive atmospheric transport model systems supported by various agencies, and in many cases, they do not have a clear understanding of where to turn for immediate assistance. Emergency responders do not enjoy the luxury of in depth analysis and comparison of differences among competing atmospheric models; they need immediate, definitive support without excessive complexity or confusion. **Thus we recommend that a single federal point of contact should be established (e.g., a central clearing house with a 1-800 phone number) that could be used to connect emergency responders to appropriate dispersion modeling centers for immediate assistance.**

In closing, we emphasize that much can be done with better use of existing observational networks and modeling systems, but additional resources likely will be required to strengthen the capabilities of many communities. It should be noted, however, that robust atmospheric observing systems and high-resolution atmospheric models could be used for other important purposes: for instance, to support severe weather warnings and air quality forecasting. Using these observational and modeling resources for multiple purposes would help justify costs and ensure that the systems are regularly maintained and evaluated.