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# ENSEMBLE ATMOSPHERIC MODELING FOR EMERGENCY RESPONSE IN SUPPORT OF FEDERAL CONSEQUENCE ASSESSMENTS

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**Abstract** – Emergencies of catastrophic scale, whether they are the result of a natural disaster, a major industrial accident, or from malicious acts of terrorism, may overwhelm a single governmental agency's ability to respond, requiring cooperation and collaboration across many agencies. Events such as our nation experienced on 9/11, and more recently from Hurricanes Rita and Katrina, or the disastrous Tsunami south-east Asia experienced, are examples of such events. U.S. Federal Agencies are tasked under the National Response Plan to develop, coordinate, and disseminate timely and accurate consequence assessment information to appropriate decision makers at all levels of government for use in responding to an emergency. Many Federal agencies have developed effective hazardous material atmospheric transport and dispersion models to support their respective statutory missions. Utilizing an ensemble approach to consequence assessments, a system could be developed to analyze, compare, and integrate "approved" Federal model plume projections and other relevant data to support timely decision-making at all levels of government. This paper addresses the need for establishing an ensemble based Federal consequence assessment system supported by regional emergency response centers to provide a "defense in depth" and utilize the advantage of regional resources and knowledge to more effectively assist state and local decision-makers. By using existing Federal atmospheric transport and dispersion expertise and technology/infrastructure capabilities with regional organizational structures, support of Federal consequence assessment functions at the national level could be accomplished in a cost effective manner.

## I. INTRODUCTION

In response to 9/11, President George W. Bush issued Homeland Security Presidential Directive (HSPD)-5 on February 28, 2003 which directed the U. S. Department of Homeland Security (DHS), in coordination with other Federal Agencies, to develop a new "all hazards" National Response Plan (NRP). The NRP was issued in December 2004[1]. Federal Agencies were tasked to develop and maintain systems/capabilities to respond to potential natural or man-made hazards, including capabilities for responding to the NRP design basis threat of simultaneous international/domestic terrorist threats or acts involving the use of Weapons of Mass Destruction (WMD).

The NRP utilizes the National Incident Management System (NIMS) to provide a common basis for planning, response, communications, and coordination between Federal, State, local, and Tribal Governmental authorities/organizations, consistent with the scope of an emergency event. In accordance with NRP and NIMS, the Federal Government has initiated an approach of establishing national, regional, state, and local capabilities (i.e., planning, preparedness, and response) for

responding to "Incidents of National Significance." Under the NRP/NIMS, the incident management system can expand or contract consistent with the magnitude of the emergency and also be effective for responding to limited scope events at the local and/or state level.

The tasks of various Federal Agencies, under the NRP, include the development, coordination, and dissemination of timely and accurate consequence assessment information associated with the potential/actual release of radiological/non-radiological hazardous materials to appropriate Federal, State, local, and Tribal Governmental authorities/decision makers for use in responding to an emergency. Use of additional Federal Agency resources to support the regionalization of Federal consequence assessment functions would constitute an expansion of Federal Agency mission responsibilities under the NRP and require an obligation of additional funding.

## II. ENSEMBLE METHODOLOGIES AND FEDERAL CONSEQUENCE ASSESSMENT

Federal Agencies, such as those identified below; have developed many effective hazardous material

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atmospheric transport and dispersion models, expertise, and related infrastructure and technological assets, at varying levels of capability, to support their respective statutory responsibilities and missions.

- § Department of Energy (DOE)/National Nuclear Security Administration (NNSA)
- § Department of Homeland Security (DHS)
- § National Oceanic and Atmospheric Administration (NOAA)
- § Environmental Protection Agency (EPA)
- § Nuclear Regulatory Administration (NRC)
- National Aeronautics and Space Administration (NASA)

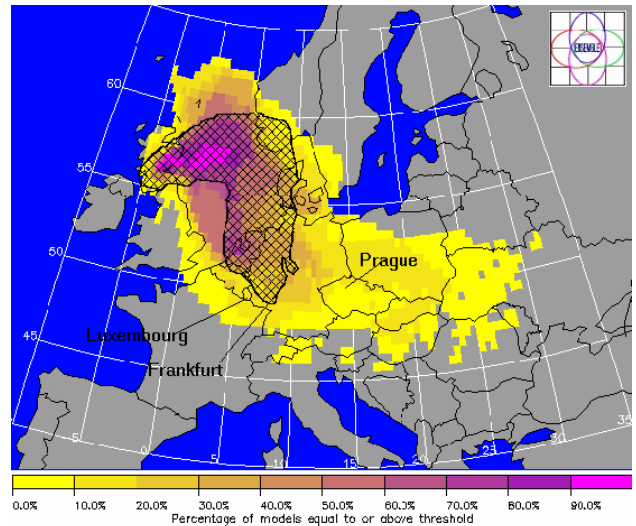
In order to make effective use of the many existing Federal atmospheric transport and dispersion models, a system is needed to analyze, compare, and integrate plume projections and other relevant data. Such a system would facilitate providing accurate, timely, and mutually supporting Federal consequence assessment information to assist governmental authorities, in implementing protective action and other essential decisions to protect the public health and safety.

The European ENSEMBLE program (Fig. 1) has demonstrated a methodology that facilitates comparing results from over 25 different atmospheric consequence assessments from modeling systems from over 20 different countries, including the U. S., in real-time. Differences between the various consequence assessments may be due to differences in the basic meteorological analyses and forecasts from the respective national weather services, or due to basic differences between each transport and diffusion model, or they may represent different, but equally mathematically valid, solutions to a complex physical system described by many nonlinear differential equations. In the ENSEMBLE project, composites of model plume ensembles have been compared with tracer studies from the European Tracer Experiment (ETEX). It was found that ensemble plumes are more accurate than individual model plumes [2].

### III. BENEFITS OF REGIONAL CONSEQUENCE ASSESSMENT CENTERS

There are clear advantages in having a network of complementary Federal assets, equipment/infrastructure and experienced personnel, located in different regions across the United States (U. S.), rather than a single centralized asset/center. This approach would ensure continuous Federal coverage during a disaster and provide necessary support as may be available to all levels of government. The recent response to natural disasters our nation has faced, Hurricanes Rita and Katrina, demonstrate how vulnerable an entire region of the U. S.

is to an “Incident of National Significance.” The concept of “defense in depth” for “Incidents of National Significance” supports a geographically distributed system.



**Fig. 1:** A composite or ensemble plume from 16 atmospheric numerical models from 13 nations’ modeling centers for a fictitious release from a nuclear plant at Glasgow Scotland. The pinks and purple contours indicate 70-100% of the models predict the location of a surface concentration; the yellows indicate only up to 30% of the models predict that threshold surface concentration.

Federal agencies as described above, maintain, at varying levels of capability, atmospheric transport and dispersion modeling technology/infrastructure and experienced personnel that could support the establishment of Regional Consequence Assessment Centers (Regional Center). Specific locations would be based on the adequacy of existing capabilities and geographic location. Regional centers would utilize lines of communications established by other Federal agencies with regional homeland security responsibilities to facilitate planning and preparedness coordination with appropriate Federal, State, local, and Tribal Government authorities. Appropriate Federal agencies would coordinate with the Department of Homeland Security (DHS) in the development policy, plans, and procedures to support regional center operations.

Regional Centers would enhance the effectiveness of the Federal consequence assessment function to include the following:

- § Promote more thorough routine planning; preparedness; emergency response communications and coordination between regional centers and responsible Federal, State, local, and Tribal Government authorities throughout the designated

region. This would include contingency planning for designated “National Special Security Event” (NSSE).

- § Continue the development and improvement of mutual cooperation and respect between Federal, regional, State, local and Tribal Governmental authorities in meeting government’s responsibilities for protecting the public health and safety, especially through more interpersonal interactions which are possible at the regional level;
- § Provide defense in depth through redundancy to respond to “Incidents of National Significance” impacting multiple regions of the U. S. ;
- § Provide an additional resource base and reach-back capability for responding to a NRP design basis WMD threat that could exceed the capacity of a single center;
- § Ensure the availability, and provide more timely and customized, consequence assessment information to appropriate regional, State, local, and/or Tribal governmental authorities/decision makers; and
- § Facilitate the development of region specific consequence assessment capabilities/applications by identifying regional, state, and local data resources (e.g., meteorological data collection systems, locally maintained geographic information system (GIS) data, HAZMAT inventories, etc.) for optimum use in regional center consequence assessment systems.
- Providing ENSEMBLE based consequence assessment information through a Regional Center would significantly increase the timeliness and technical/political credibility of the data.

Capabilities to support Regional Consequence Assessment Center operations would include:

- § Ability to observe, collect, forecast, and archive meteorological conditions/data to support Federal consequence assessment functions on a local, regional, and national basis;
- § A 24/7 operations center to:
  - Receive requests for consequence assessment support;
  - Notify “On-Call” regional center staff;
  - Support notification and communications with national center; and,
  - Provide other assistance as requested.
- § An established suite of atmospheric transport and dispersion consequence assessment models with attendant technology, infrastructure, and communication capabilities; and,
- On call experience personnel (24/7) with computer stations at residences to ensure timely initial response;

#### **IV. “NOTIONAL” CONCEPT OF OPERATIONS FEDERAL CONSEQUENCE ASSESSMENT RESPONSE**

A regional consequence assessment response to limited scope events, as well as an initial response to events designated as “Incidents of National Significance”, would essentially be the same. A “Notional” Concept of Operations for a Regional Consequence Assessment Center (Regional Center) emergency response is presented in Figure 2 and described below.

Local authorities would request consequence assessment support through an authorized State/Tribal organization (e.g., Emergency Management Agency). The request would be forward with available event data (e.g., event location, description, release information, meteorological data, etc.) to the appropriate Regional Center. The On-call staff would acknowledge the request, initiate a response utilizing the Regional Center’s “approved” (locally developed) primary model, and notify the National Consequence Assessment Center (National Center). The National Center would initiate notification of other Regional Centers, consistent with the scope/severity of the event, to support consequence assessments utilizing their respective “approved” primary models.

Each Regional Center’s model output would be entered into an Ensemble program, with which the Regional Center would develop a composite analysis for communication and interpretation to the requesting State/Tribal/local decisions makers. Results would be updated as incident data changes, or as additional Regional Center models come on line, and/or, specialized analysis/modeling is requested.

The responsible Regional Center would continue to provide consequence assessment data and maintain direct communications through technical consultations with State/Local/Tribal decision makers. When the National Center comes on line, with support of other Regional Centers as appropriate, it will assume the responsibility for the coordination of Federal assets, and the dissemination of timely and accurate Federal consequence assessment information. Depending on the anticipated duration of the emergency and/or upon request of proper governmental authority, the responsible Regional Center would deploy a field liaison team(s) to facilitate communications, coordination, and interpretation of consequence assessment data with Federal regional and State/Local/Tribal governmental authorities, as appropriate.



Relationships that were developed through this ongoing collaboration enabled effective communication with local authorities/decision makers and confidence in the consequence assessments they were given during the course of the response. In addition to providing model data that confirmed the adequacy of protective measures during the early response phase, ongoing discussions fostered a prompt evaluation of alternatives for the recovery of an additional chlorine tanker at the scene that had been damaged. Consequence modeling results showed that a rupture of this damaged tanker would have posed a significant hazard to populations well beyond the existing evacuation zone. As a result, local incident commanders wisely deferred disturbing the scene and implemented a plan to passively siphon the chlorine inventory from the tanker. Providing standard atmospheric plume plots from a remote location, without close interactive communications and guidance is ineffective. Regional centers would be better equipped to work closely with local and state responders and decision makers, as was shown in this example.

### VIII. CONCLUSIONS

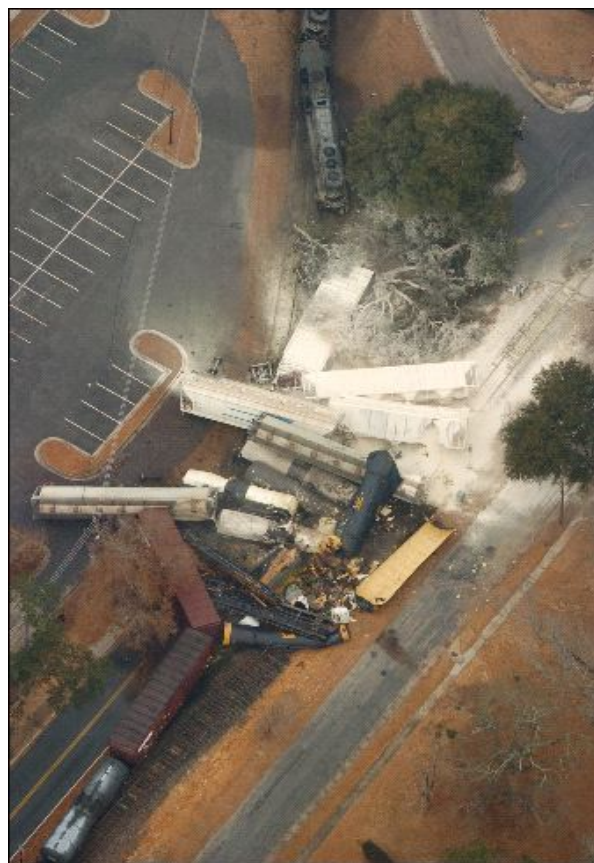
Federal agency implementation of the regional center concept as described above could provide a defense in depth redundancy of “state of the art” consequence assessment capabilities. These capabilities based on an ensemble of “approved” Federal Agency atmospheric transport and dispersion models and geographically distributed in the U.S., would provide for the communication of timely, accurate, and coordinated Federal consequence assessment information to appropriate Federal, State, local, and Tribal Government authorities/decision-makers to protect the public health and safety. The regional concept could also provide additional resources for responding to a NRP design basis WMD threat. By building on the existing expertise, capabilities, and infrastructure of Federal agencies, development of Federal consequence assessment resources could be accomplished in a more cost effective manner.

### ACKNOWLEDGMENTS

- § National Nuclear Security Administration, Office of Emergency Operations
- National Nuclear Security Administration, Savannah River Site Office

### REFERENCES

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- § S. GALMARINI ET. AL. “Ensemble dispersion forecasting – Part II: application and evaluation” Atmospheric Environment, 2004, 38, PP. 4619-4632.



**Fig. 3:** Aerial photograph of the Graniteville train accident on January 6, 2005. Three chlorine cars were derailed: one was ruptured, spilling 90 tons of chlorine, tone other was damaged, but did not release any chlorine. Photograph courtesy of the Augusta Chronicle Newspaper