Proposed Regional Centers for Emergency Response in Support of Federal Consequence Assessment

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Agenda

- Introduction
- National Response Plan (NRP)
- Federal Consequence Assessment/Interagency Modeling and Atmospheric Assessment Center (IMAAC)
- Vulnerabilities of Centralization
- Regional Consequence Assessment Centers
- "Notional" Concept of Operations
- Federal Atmospheric Dispersion Modeling Assets
- DOE/NNSA Atmospheric Technology Integration
- "Notional" Regional Center Baseline Requirements
- Modeling Uncertainties and Ensemble Methodology
- Case Study: Graniteville Train Derailment 1/6/2005
- Conclusions

Introduction

This presentation represents views of the authors and does not reflect current policy or positions of the U. S. Department of Energy (DOE), National Nuclear Security Administration (NNSA), or other Federal Agencies.

- **The purpose of this discussion is to:**
  - **Offer a concept to establish regional consequence assessment centers to support the IMAAC mission under the National Response Plan (NRP); and.**
  - **Gain visibility to support possible considered of the regional concept as option by the inter-agency group responsible for establishing Federal emergency consequence assessment requirements.**
  - **Promote the establishment of the DOE/NNSA complex as a prototype to demonstrate the benefits of integrating multiple atmospheric technologies/models to support consequence assessment response during an emergency.**

Introduction

- **The proposed concept is based on the authors' 50+ years of experience in atmospheric transport and dispersion modeling and Federal/State emergency management; and,**

- **Implementing the concept of integrating multiple atmospheric technologies/models to support emergency consequence assessment functions under the NRP and establishing the DOE/NNSA complex as a prototype to demonstrate the benefits of this approach will require additional funding.**

National Response Plan

- **National Response Plan (NRP)**
  - **Tasks Federal agencies to develop capabilities for responding to "Incidents of National Significance," to include the "NRP Design Basis Threat" (NRP DBT) of multiple WMD events (Authors' Terminology).**

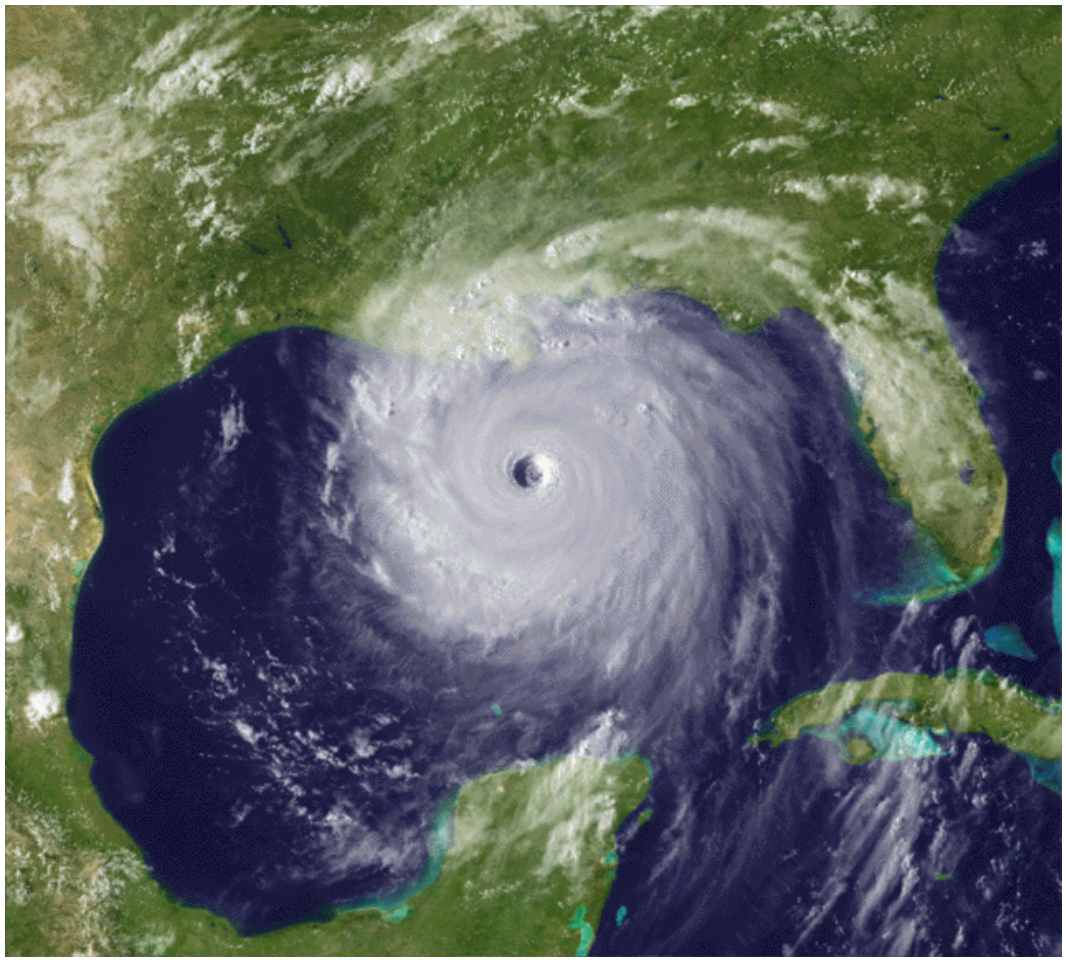
National Response Plan
(Continued)

- **National Incident Management System (NIMS) Established under the NRP;**
  - **Provides a common basis for planning, coordination, and response between Federal, State, local, and Tribal Governmental authorities;**
  - **Promotes the establishment of national, regional, state, and local capabilities for responding to "Incidents of National Significance" as defined in the NRP; and,**
  - **Expands or contracts consistent with the magnitude of the situation and is also effective for managing limited scope events at the local and/or state level.**

Federal Consequence Assessment

- **The Interagency Modeling and Atmospheric Assessment Center (IMAAC) was established under the NRP to develop and disseminate timely and accurate consequence assessment information for use by decision-makers when responding to potential or actual release of hazardous materials (radiological or non-radiological) including the NRP-DBT. The IMAAC concept provides:**
  - **Centralized design and location;**
  - **Sophisticated atmospheric modeling systems; and,**
  - **Necessary computer/communication infrastructure.**

Vulnerabilities of Centralization



Hurricane Katrina approaching New Orleans

Regional Consequence Assessment Centers

The strength of distributed systems:

- **Distributed systems are more resilient than centralized systems:**
  - **Multiple modeling centers avoid dependence on a single center/system of atmospheric models (single point failure);**
  - **Use of ensemble methodologies would strengthen the technical and political credibility of Federal agency plume projections;**
  - **Multiple centers enables work load sharing and provides additional technical resources (personnel, computer, communications, ect) for responding to the "Incidents of National Significance;" and,**
  - **Expand reach-back capability.**

Regional Consequence Assessment Centers

- **Regional centers would benefit from:**
  - **Development of region specific consequence assessment capabilities/applications by:**
    - **Utilizing regional, state, and local knowledge; and,**
    - **Identifying/sharing regional, state, and local data resources (e.g., meteorological data collection systems, locally maintained GIS, HAZMAT inventories, etc.); and,**
    - **Strengthening relationships/mutual respect between Federal, state, and local authorities through routine joint planning, training, and exercises activities.**
- **Regional centers would be in a better position to identify and meet State/local needs by providing more timely and customized consequence assessments.**

“Notional” Regional Center Baseline Requirements

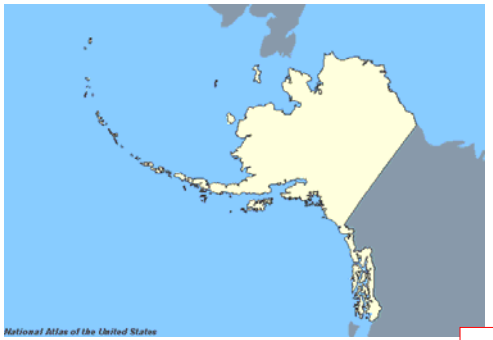
- 24/7 meteorological observation and forecast capabilities;
- Existing atmospheric consequence assessment systems and infrastructure;
- Experienced technical personnel on call 24x7 with computer stations at residences to ensure timely initial response; and,
- 24x7 operations center to:
  - Receive requests for regional support and notify “On-Call” technical staff;
  - Support notification of IMAAC and other Federal agencies, as appropriate; and,
  - Provide other assistance as requested.

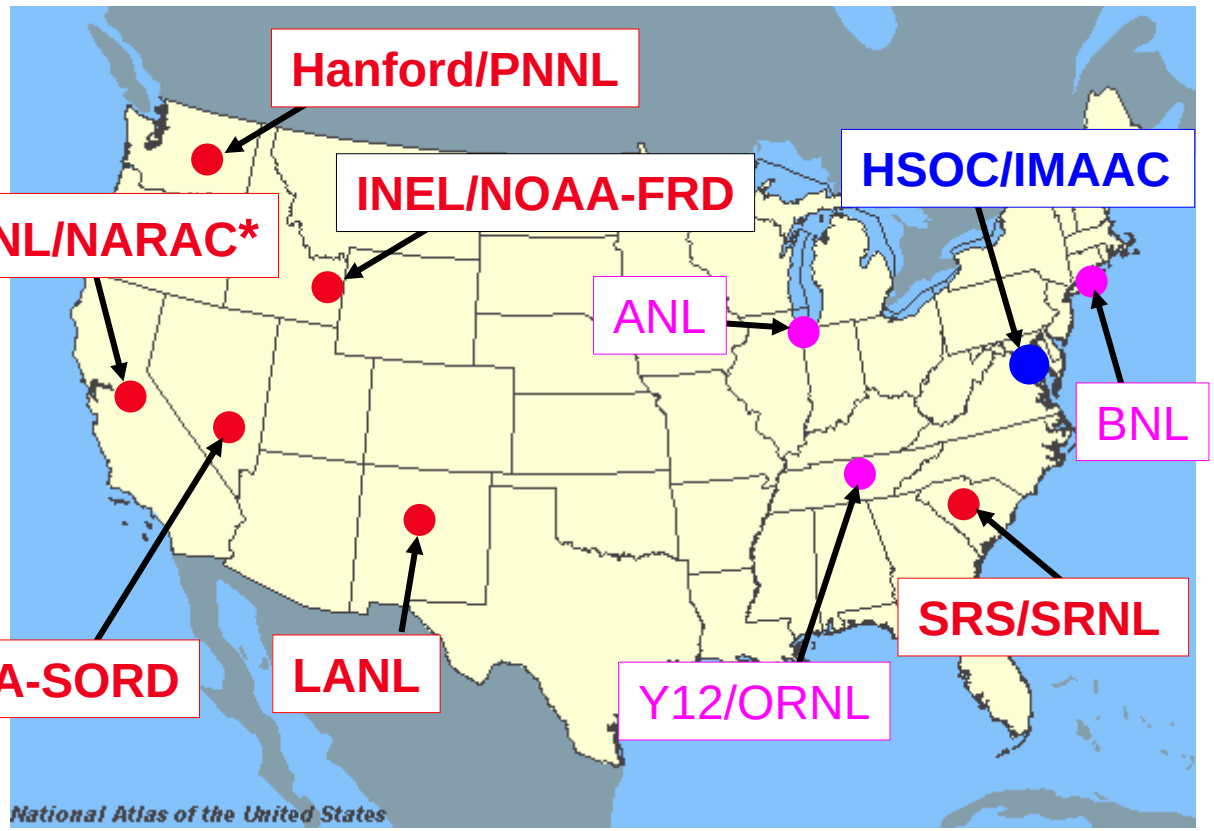
Federal Atmospheric Technology Assets

- **In support of assigned missions, Federal agencies have developed and maintained valuable capabilities and infrastructure over the past decades. Agencies include those listed below.**
  - **Department of Energy (DOE)/National Nuclear Security Administration (NNSA);**
  - **National Oceanic and Atmospheric Administration (NOAA);**
  - **Environmental Protection Agency (EPA);**
  - **National Aeronautics and Space Administration (NASA);**
  - **Department of Defense (DOD);**
  - **Nuclear Regulatory Administration (NRC); and,**
  - **Department of Homeland Security (DHS).**
- **Regional Center selection should based on existing capabilities, infrastructure and geographic location to promote a more efficient use of limited Federal resources.**

Regional Consequence Assessment Centers
DOE/NNSA Candidate Sites

- Sites (6) with baseline capabilities
- Other potential locations (3)
- Homeland Security Operations Center (HSOC)/IMAAC



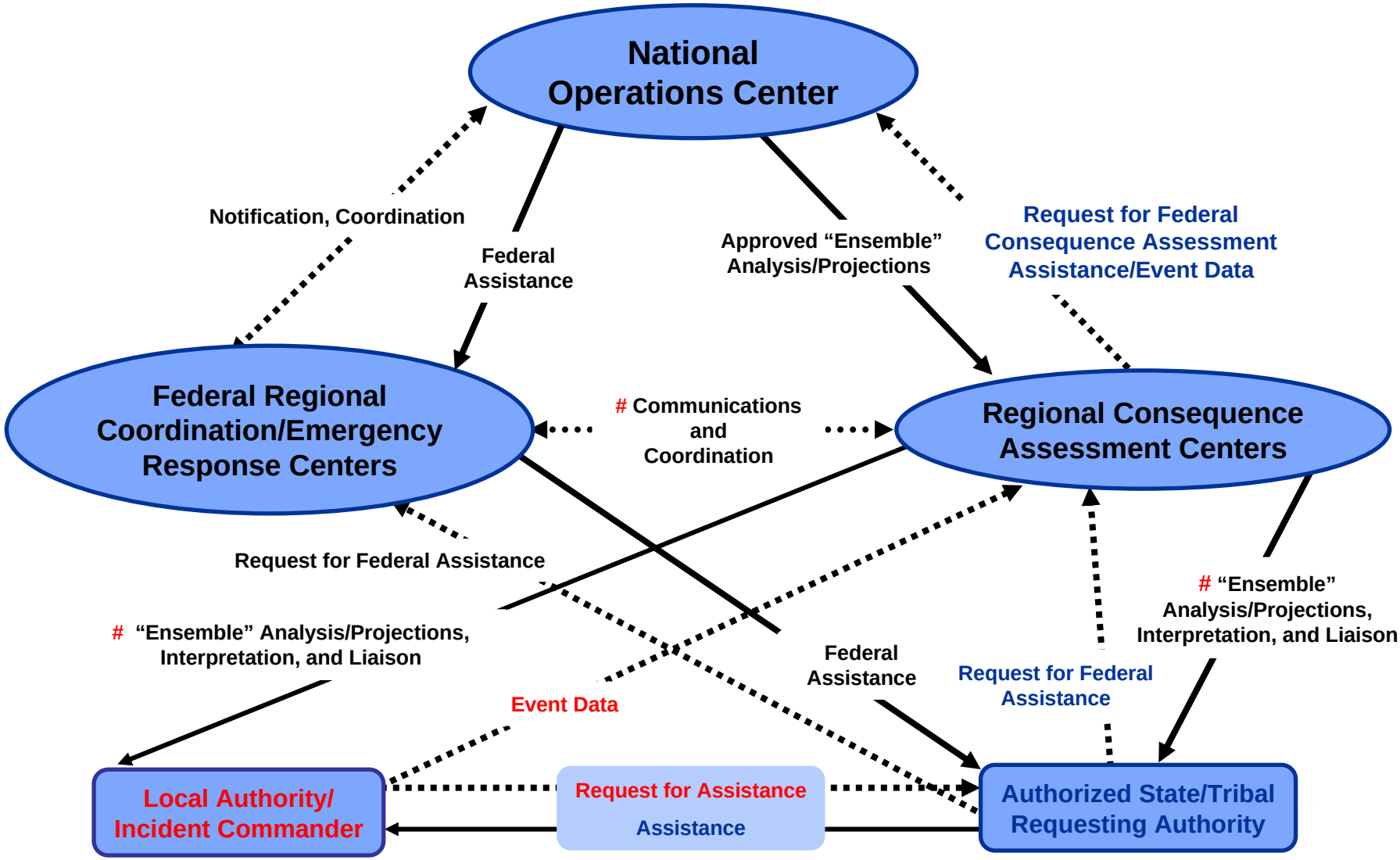


Legend: * Interim IMAAC

DOE/NNSA Atmospheric Technology Integration

- **Increased emergency planning and response coordination between DOE/NNSA Sites and LLNL/NARAC; and,**
- **Integrate DOE/NNSA complex atmospheric technology capabilities/models through an ensemble approach.**
- **Provide demonstration of use of integrated models in responding to a DOE/NNSA site emergency event.**

"NOTIONAL" CONCEPT OF OPERATIONS

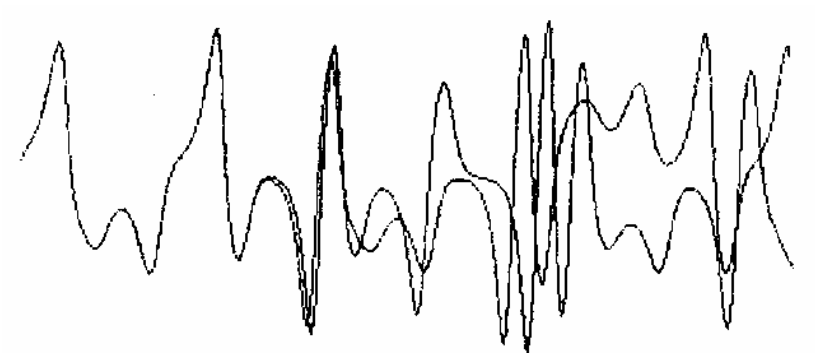


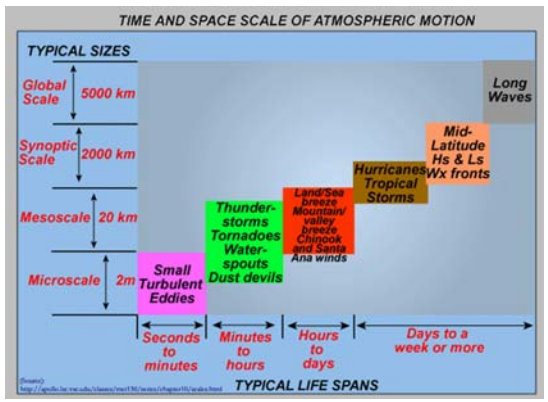
Legend: # Liaison Dispatched as Necessary and/or Requested

Modeling Uncertainties and Ensemble Methodologies

The problem with atmospheric models…..

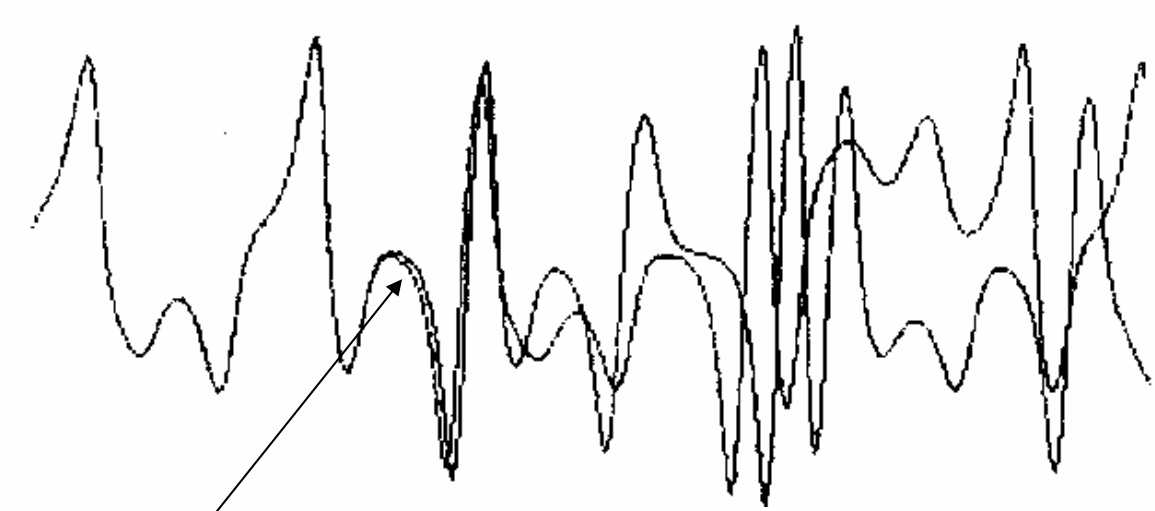
$$\frac{\partial \vec{\mathbf{u}}}{\partial t} = -\vec{\mathbf{u}}\nabla \bullet \vec{\mathbf{u}} - \frac{1}{\rho}\nabla p - 2(\Omega \times \vec{\mathbf{u}}) - g\hat{\mathbf{k}}$$





- **Atmosphere is governed by non-linear partial differential equations**
  - The solutions are not unique
- **In models, uncertainties in initial a and boundary conditions create uncertainties in the analyzed and forecast fields (Chaos Theory)**
- **Incomplete knowledge of physical processes, how to parameterize them and how to describe scale interactions also leads to uncertainties in model results.**

The problem with atmospheric models…..



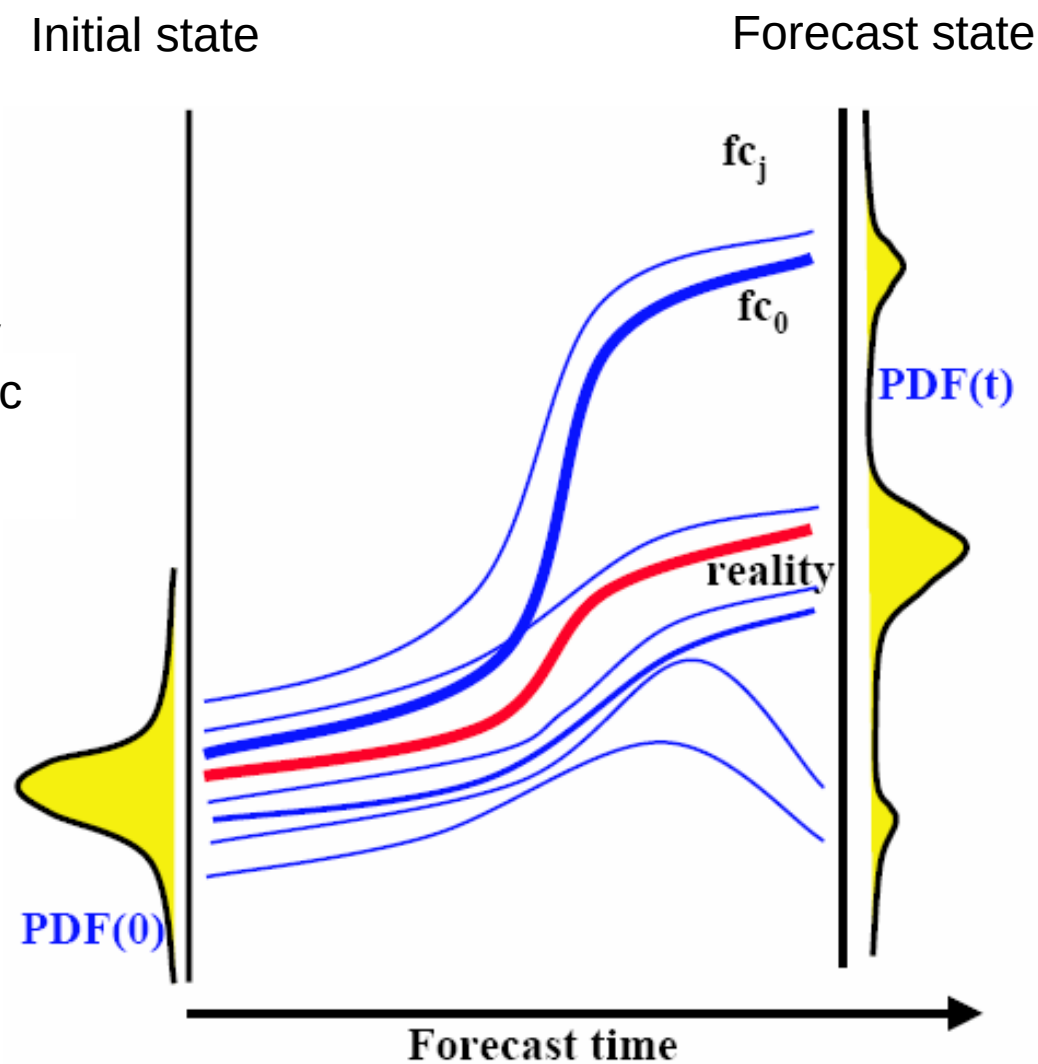
Initial difference:
0.000127
or
0.025%

- **Edward Lorenz was running a model of convective atmospheric rolls. He wanted to rerun it from the middle**
- **He jotted down the intermediate parametric value to 3 significant figures: 0.506, and reran it.**
  <u>The solution diverged.</u>
- **The computer stored the intermediate parameter on the first run to 6 significant figures: 0.506127**

Importance of initial conditions……

Initial uncertainty of an atmospheric variable:
T, P, u, etc.

Described by a probability density function

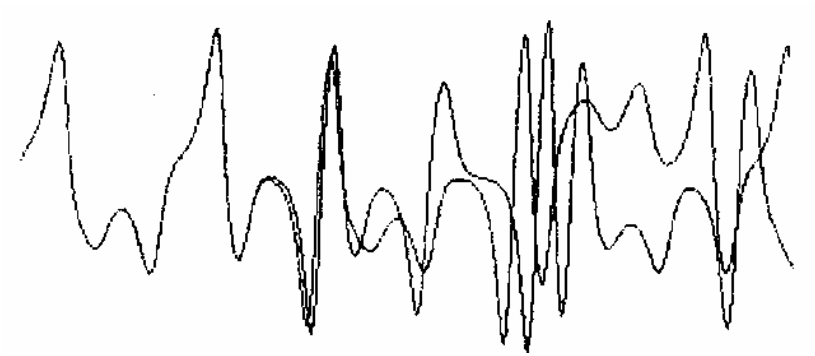


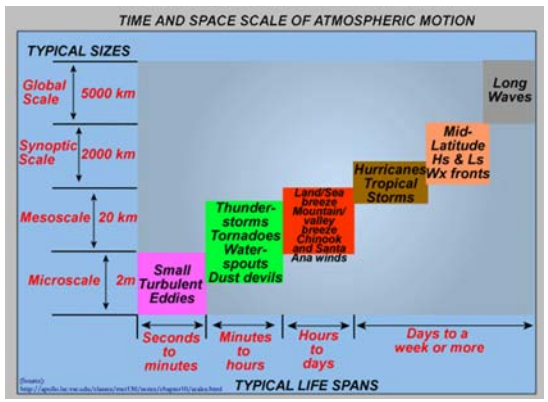
Produces an ensemble of predicted states

Reference:
Roberto Buizza
ECMWF

The problem with atmospheric models…..

$$\frac{\partial \vec{\mathbf{u}}}{\partial t} = -\vec{\mathbf{u}}\nabla \bullet \vec{\mathbf{u}} - \frac{1}{\rho}\nabla p - 2(\Omega \times \vec{\mathbf{u}}) - g\hat{\mathbf{k}}$$





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  - The solutions are not unique
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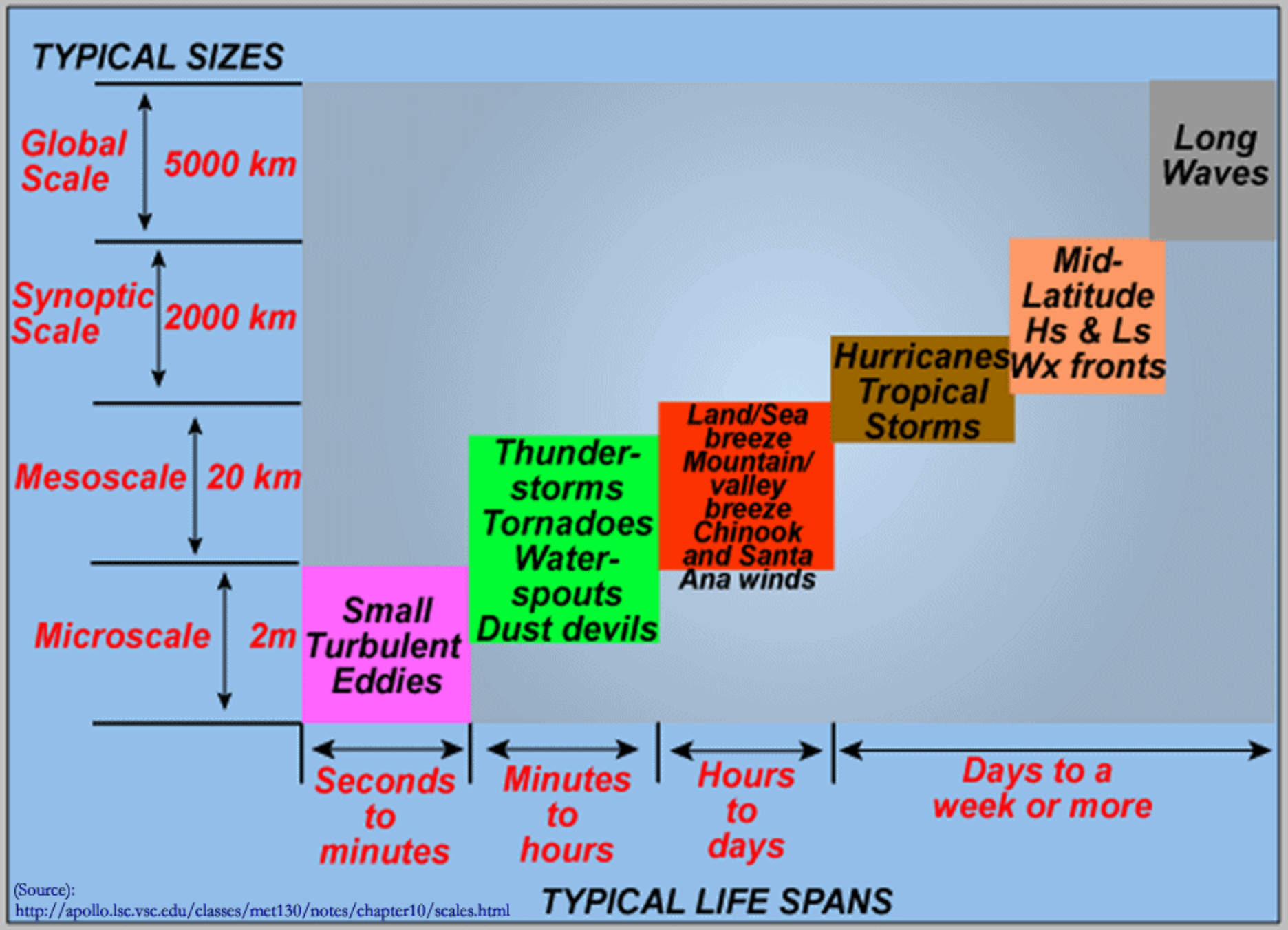
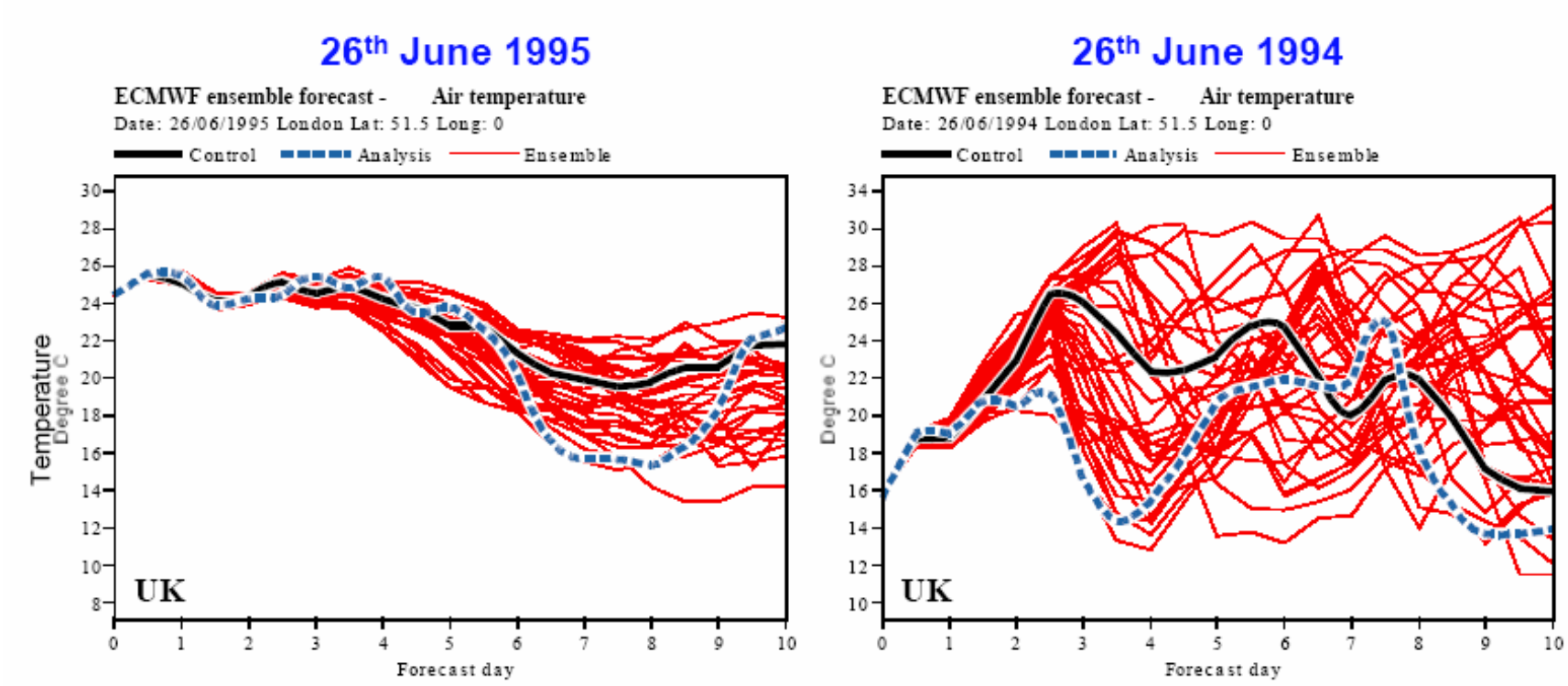
- **Incomplete knowledge of physical processes, how to parameterize them and how to describe scale interactions also leads to uncertainties in model results.**

TIME AND SPACE SCALE OF ATMOSPHERIC MOTION



(Source):
http://apollo.lsc.vsc.edu/classes/met130/notes/chapter10/scales.html

Ensembles – part of the solution



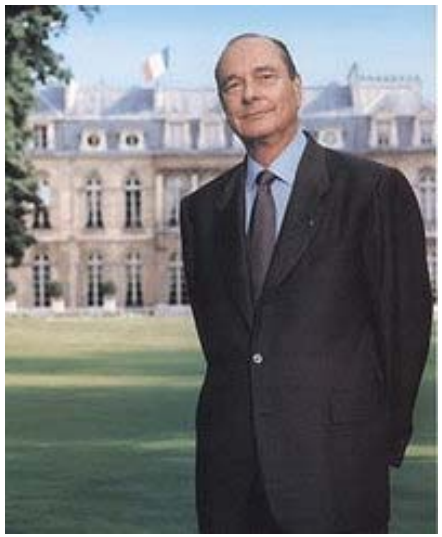
Ensembles – help us understand uncertainties

Reference:
Roberto Buizza
ECMWF

Ensemble Exercise 10

- Release from London
- June 11, 2003 noon
- Duration 15 minutes
- Rate 1E13 Bq/hr
- Cs-137
- 350 m above ground

Decisions?



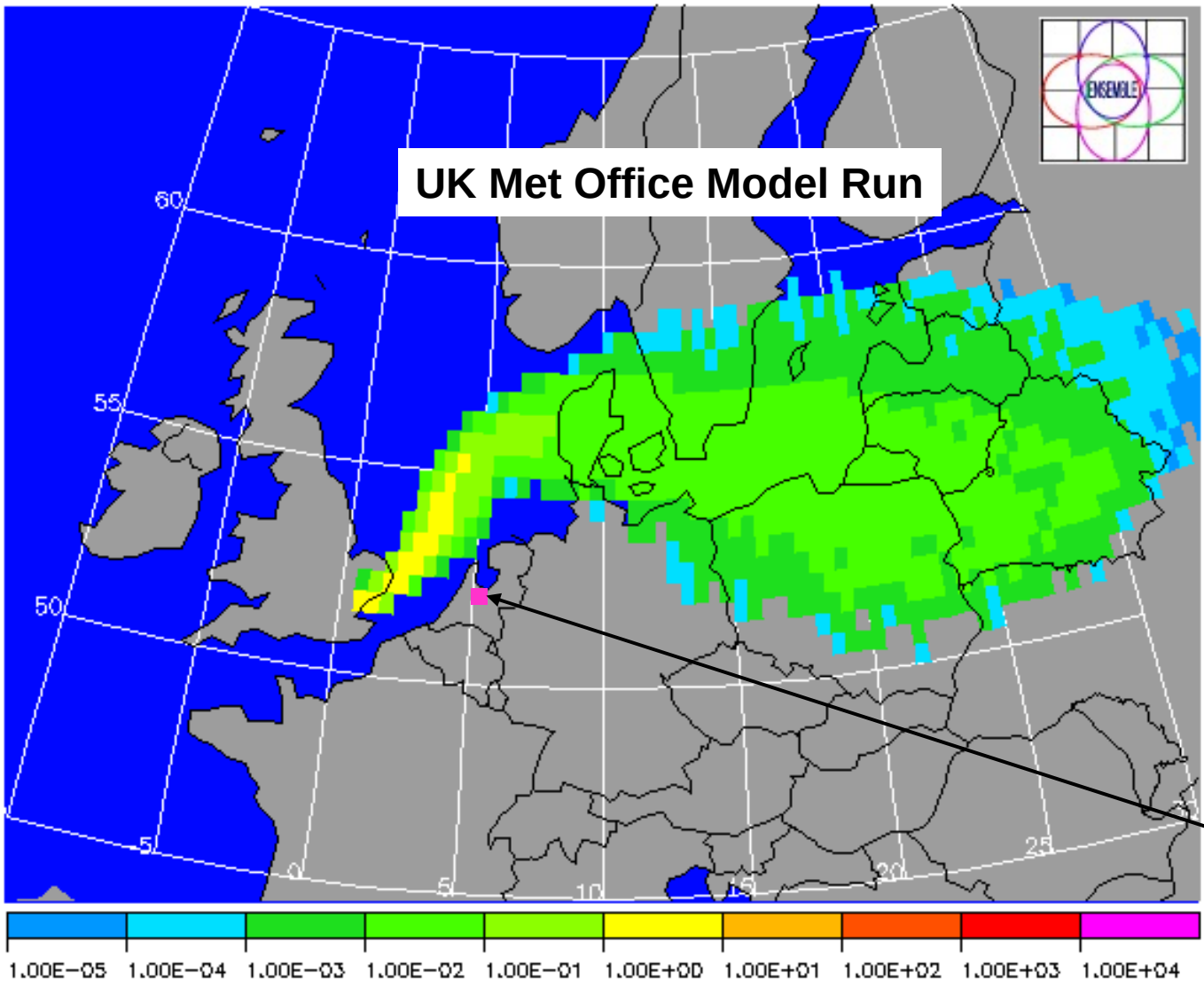
- **You:**
  - **are the Prime Minister of the UK**
  - **the Prime Minister of the Netherlands calls you**
  - **What do you tell him?**
- **What did the President of France tell him?**
- **What did his own experts tell him?**

Exercise 10 – Grid plot for time-integrated concentration of Cs137 in Bqh/m³
Date and time: 2003-06-14 00:00 UTC (+60h0m after release start)
Data range: [3.19E-07, 4.33E+00]

Release from London (UK)
Location: 00:00 E 51:33 N
Start: 2003-06-11 12:00 UTC
Duration: 900 s hours

Ensemble type: none

Model(s) [delta meteo/delta upload]
UK1 [+60h0m/+117h45m]



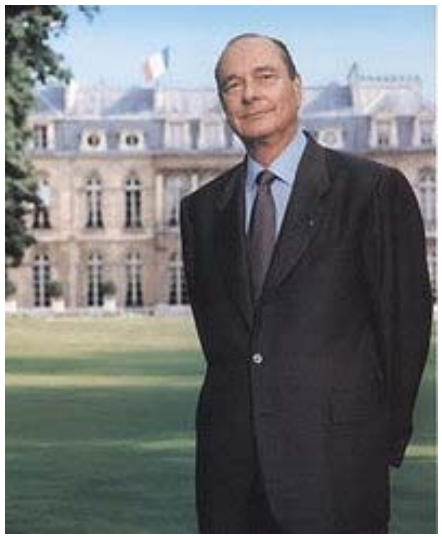
The UK Met Office uses this information to advise PM Blair.

Mr. Blair tells PM Balkenende: “The plume is well clear of the Netherlands. You have nothing to worry about.”

Amsterdam

Projection: LambertAzimuthal
Created by user raddis on 2005-11-03 22:03:49 UTC

Decisions?



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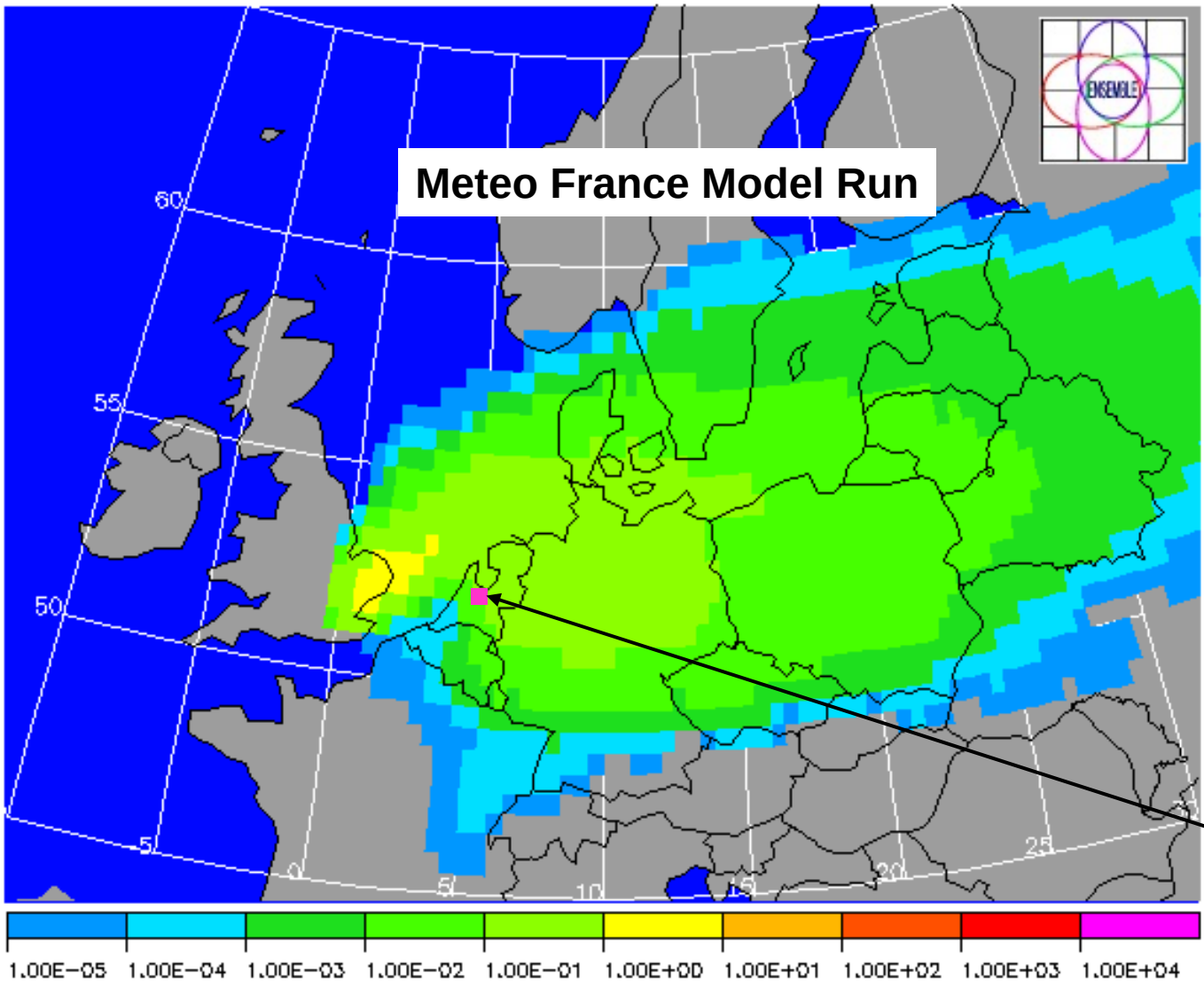
Exercise 10 – Grid plot for time-integrated concentration of Cs137 in Bqh/m³
Date and time: 2003-06-14 00:00 UTC (+60h0m after release start)
Data range: [2.20E-13, 1.90E+00]

Release from London (UK)
Location: 00:00 E 51:33 N
Start: 2003-06-11 12:00 UTC
Duration: 900 s hours

Ensemble type: none

Model(s) [delta meteo/delta upload]
FR2 [+60h0m/+11710h4m]



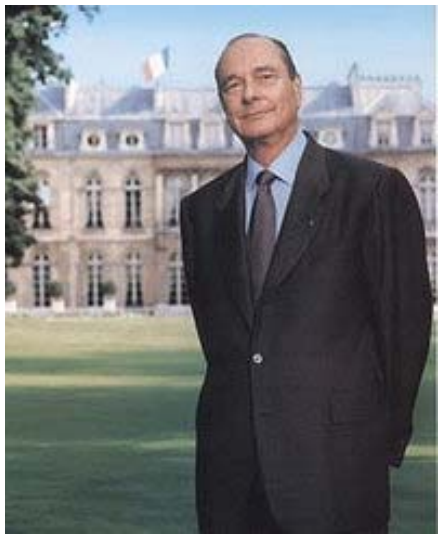
Meteo France uses this information to advise President Chirac.

President Chirac tells PM Balkenende: “The plume is definitely inundating the Netherlands. You must take protective actions.”

Amsterdam

Projection: LambertAzimuthal
Created by user raddis on 2005-11-03 22:07:51 UTC

Decisions?



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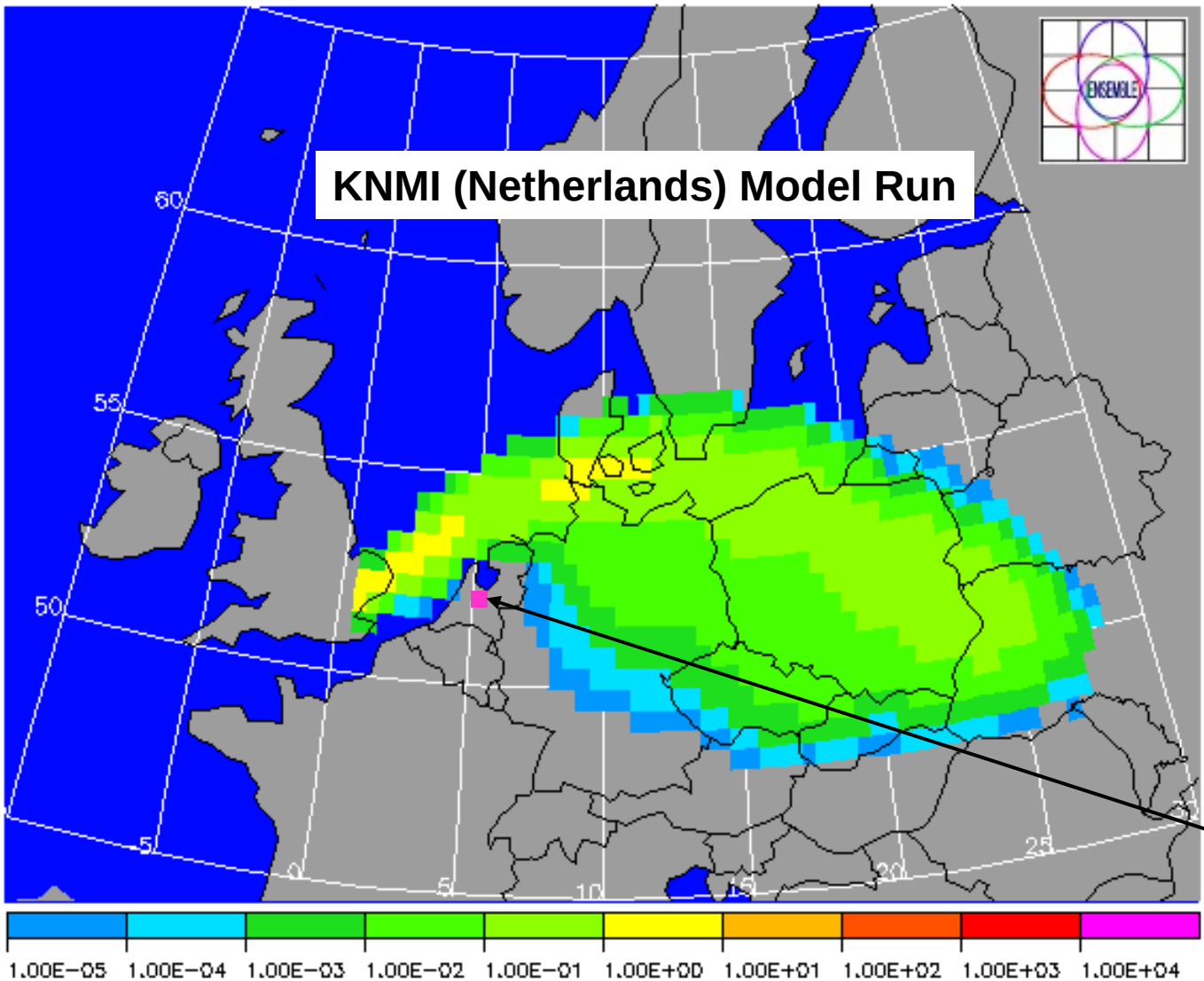
  - **the Prime Minister of the Netherlands calls you**
  - **What do you tell him?**
- **What did the President of France tell him?**
- **What did his own experts tell him?**

Exercise 10 – Grid plot for time-integrated concentration of Cs137 in Bqh/m³
Date and time: 2003-06-14 00:00 UTC (+60h0m after release start)
Data range: [1.28E-09, 6.14E+00]

Release from London (UK)
Location: 00:00 E 51:33 N
Start: 2003-06-11 12:00 UTC
Duration: 900 s hours
Ensemble type: none
Model(s) [delta meteo/delta upload]
NL1 [+60h0m/+144h43m]



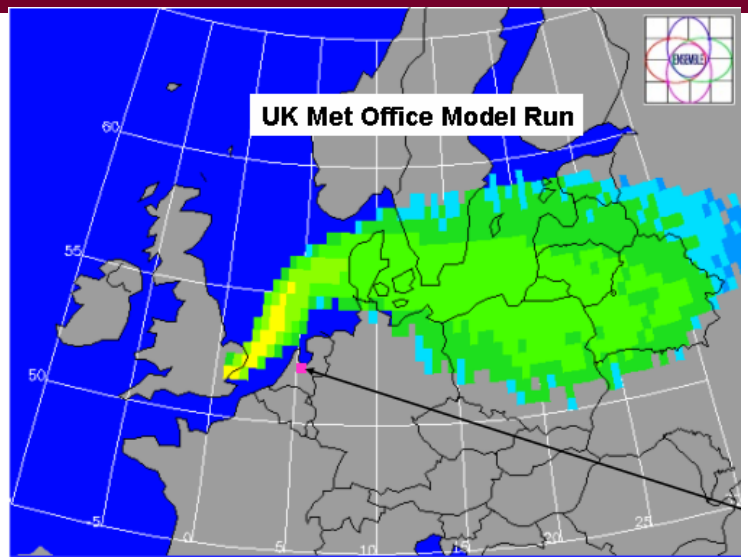
The Netherlands Met Office (KNMI) uses this information to advise PM Balkenende.

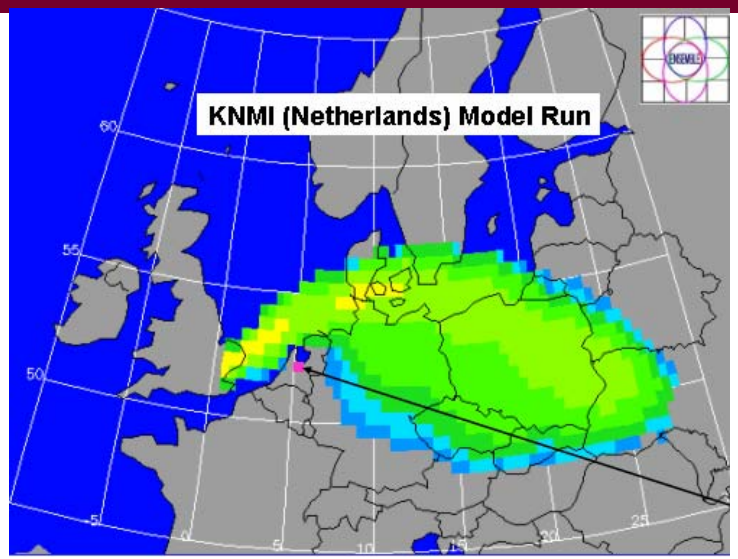
What does Mr. Balkenende think about the advice of Mr. Blair or Mr. Chirac?

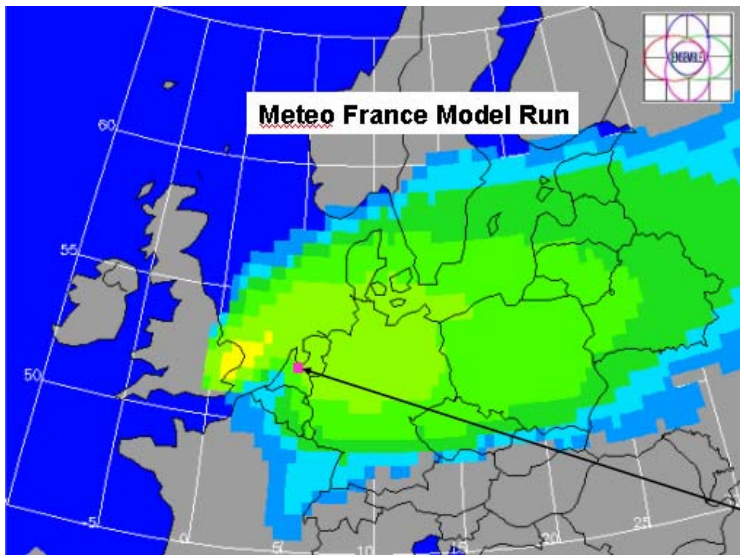
Amsterdam

Projection: LambertAzimuthal
Created by user raddis on 2005-11-03 22:05:58 UTC

Three reputable assessments…..

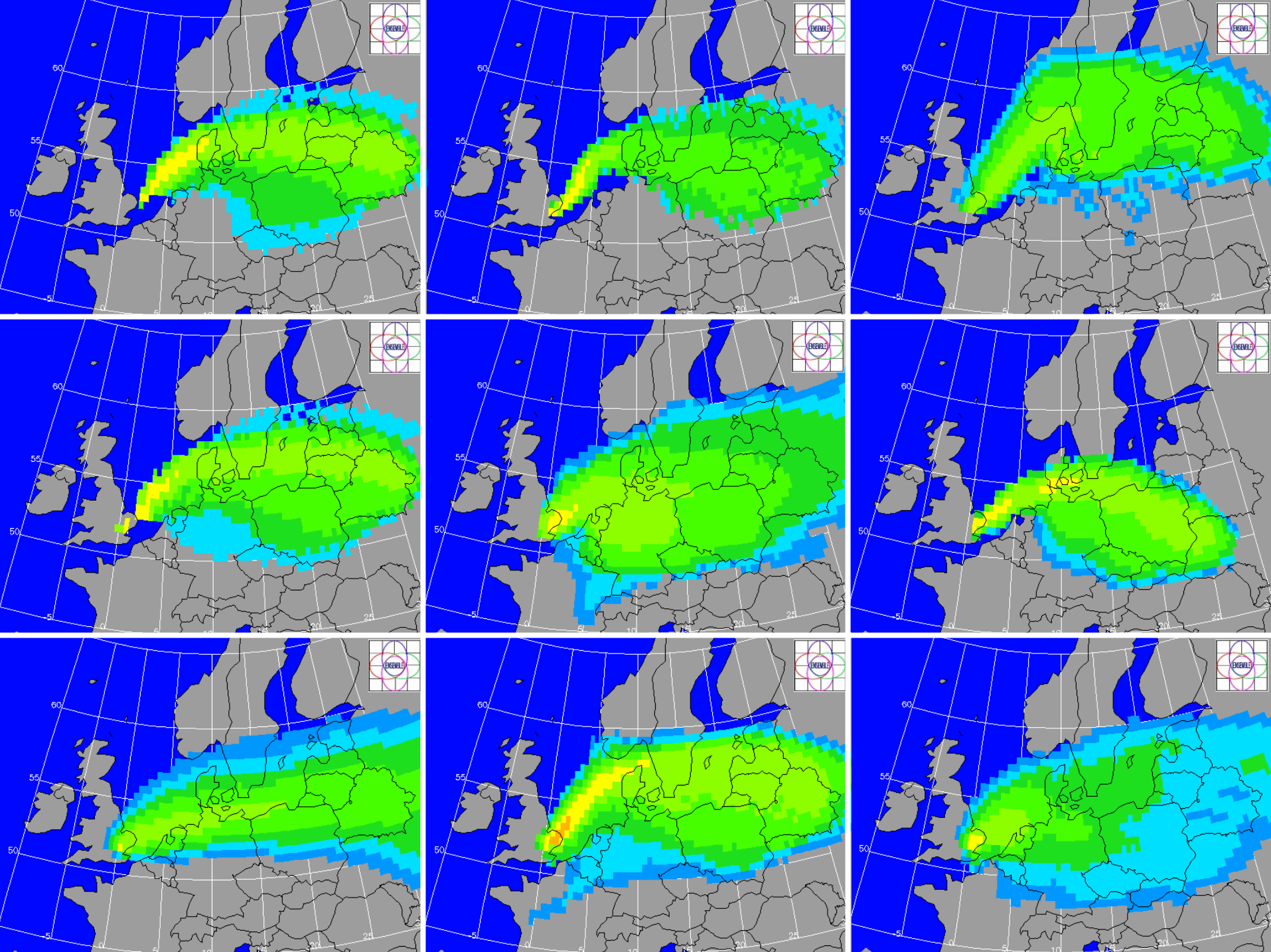






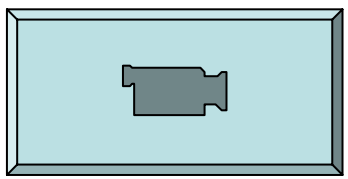
- UK Met Office
- Meteo France
- KNMI (Royal Netherlands Met Inst)

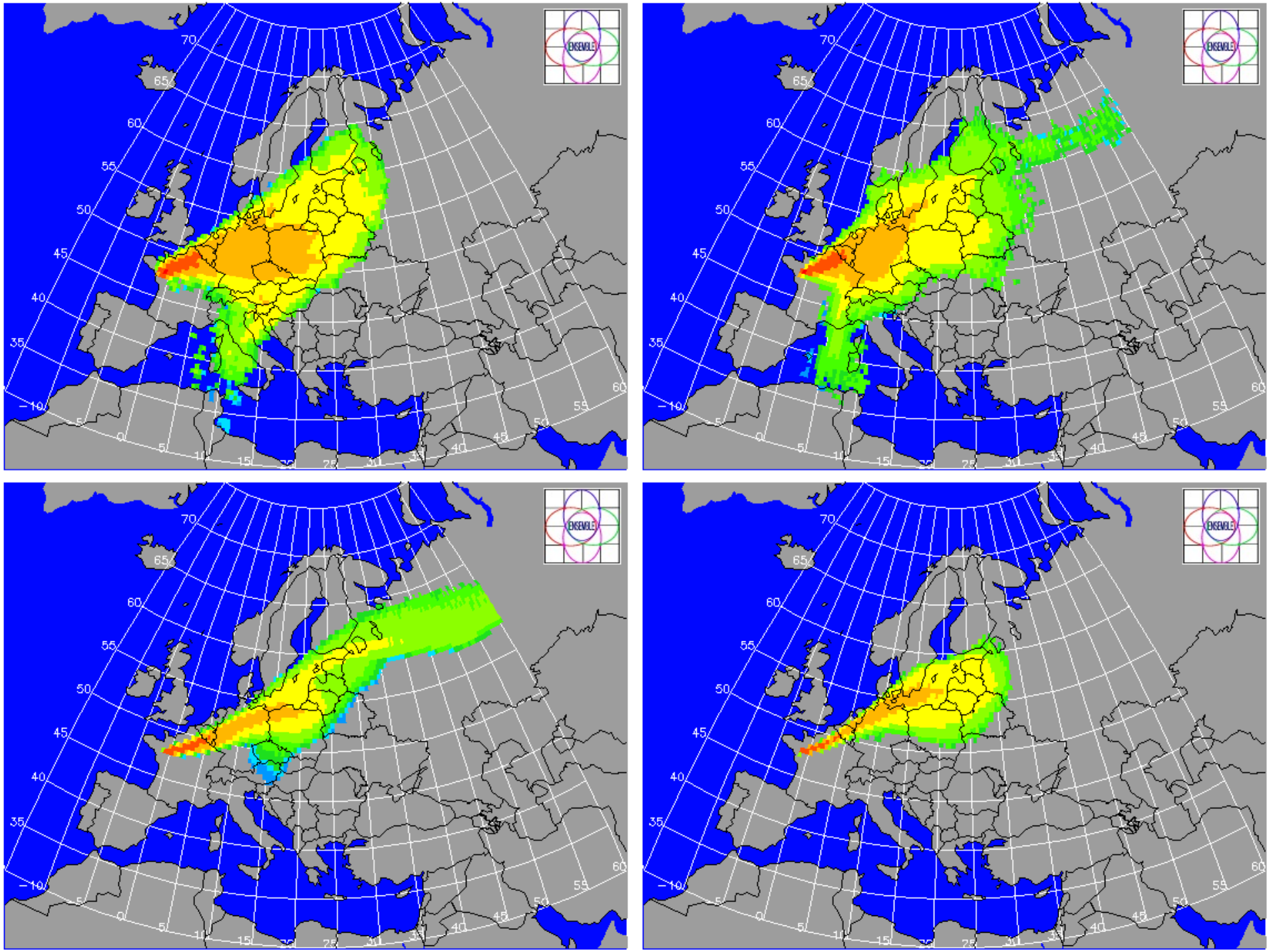
Three of the most respected national weather centers in the world. Their modeling is excellent.


EXEMPLE
60
55
50
-5
0
5
10
15
20
25

Let's look at another example:

- **Discrepancies between models is more the norm, than the exception.**
- **Consider this example and ask what the Italian Prime Minister Berlusconi would do depending on which model output he was given.**
- **Would he respond differently if his advisers were aware of all 4 outputs?**




ENSEMBLE
70
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60

Exercise 04 – Agreement on threshold level for time-integrated concentration of Cs137

Date and time: 2002-02-07 21:00 UTC (+57h15m after release start)

Threshold level = 1 Bqh/m³

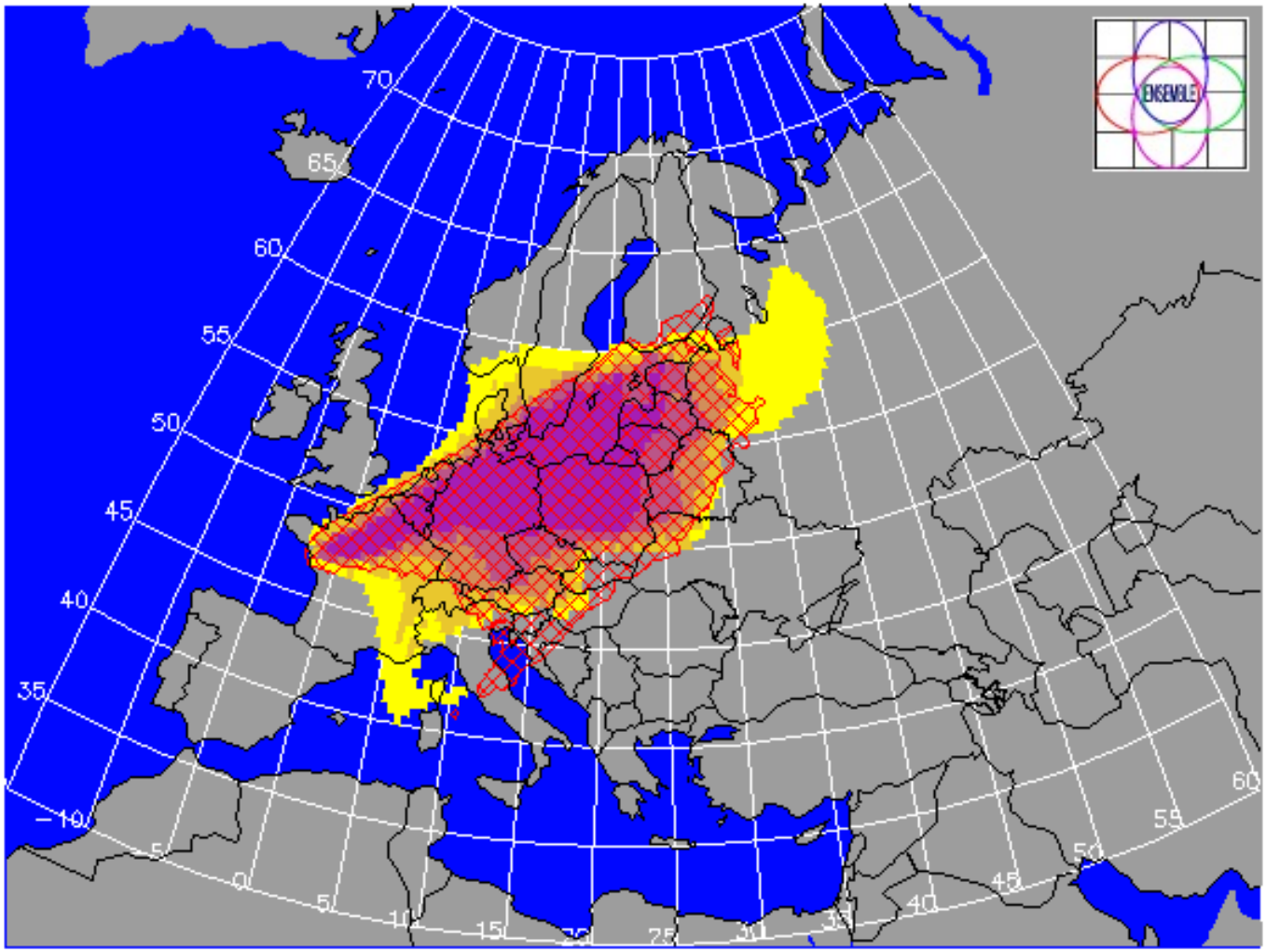
Warning: No data available for one or more models (*).

Release from Nantes (F)

Location: 01:33 W 47:13 N

Start: 2002-02-05 11:45 UTC

Duration: 6 hours



Model(s) [delta meteo/delta upload]

ATL members:

UK1 [+60h15m/+4062h36m]

SE1 [+60h15m/+145h43m]

DE1 [+60h15m/+69h1m]

FR1 [+60h15m/+142h11m]

AT1 [+60h15m/+71h5m]

* NL1 [+60h15m/+167h13m]

CA1 [+60h15m/+146h45m]

DE2 [+60h15m/+69h2m]

FR2 [+60h15m/+143h3m]

BG1 [+60h15m/+3840h9m]

Ensemble (crosshatch): none

US1 [+60h15m/+72h20m]

0.0% 20.0% 40.0% 60.0% 80.0% 100.0%

Percentage of models equal to or above threshold

Projection: LambertAzimuthal

Created by user raddis on 2002-11-15 15:00:22 UTC

Graniteville, SC Accident Background

- **Time of accident: 2:39 am Thursday January 6, 2005**
- **Situation: Norfolk Southern Railroad freight train collides with stationary train on a rail spur**
- **Accident involved rail cars of chlorine, cresol, and sodium hydroxide**
- **Chlorine greatest airborne concern due to high volatility**

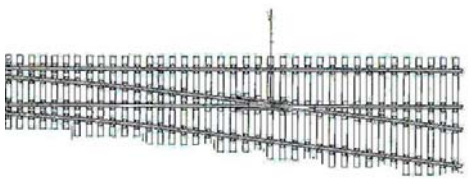
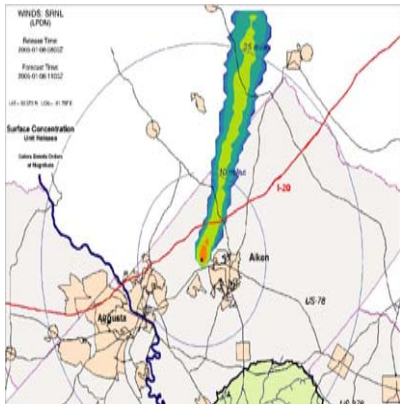
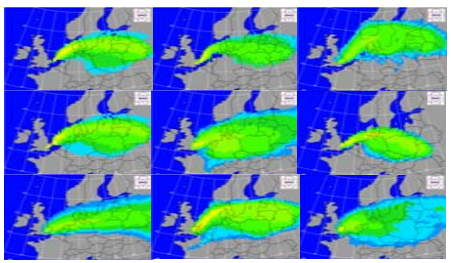


Photo Courtesy of Augusta Chronicle

Conclusions

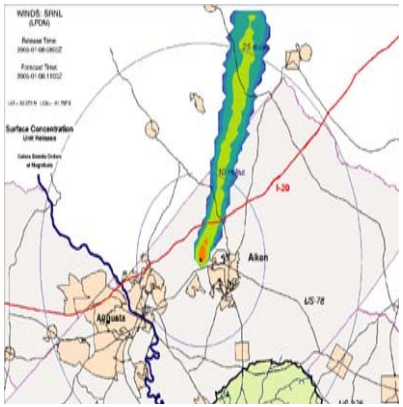
- **The NRP consequence assessment concept needs to be expanded to regional centers for robustness and redundancy**
- **Regional Centers would:**
  - **Strengthen relationships and mutual respect between Federal, state, and local authorities; and,**
  - **Be better situated to meet the needs of local and state decision makers.**
- **Atmospheric models require a locally based Geospatial Framework to assist decision-makers in visualizing the scope and severity of the event.**

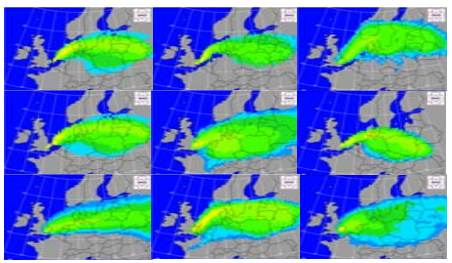




Conclusions
(Continued)

- **Atmospheric models require an ensemble approach to better understand modeling uncertainties.**
- **Ensembles also provide increased technical and political credibility of model results.**
- **The European Joint Research Institute in Italy has expressed interest in hosting an ENSEMBLE demonstration utilizing DOE/NNSA atmospheric modeling capabilities.**





This presentation represents the views of the authors and <u>does not</u> reflect current Federal agency policy or positions.