Tom Warner Symposium: Tom and coupled applications

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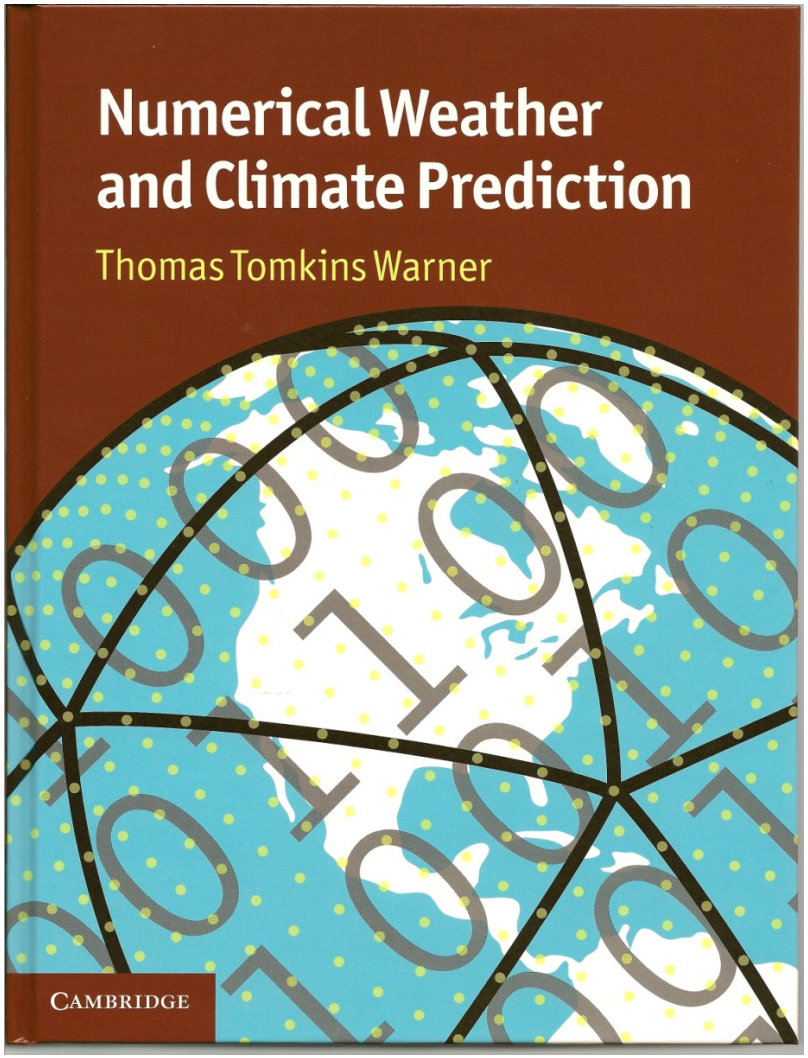
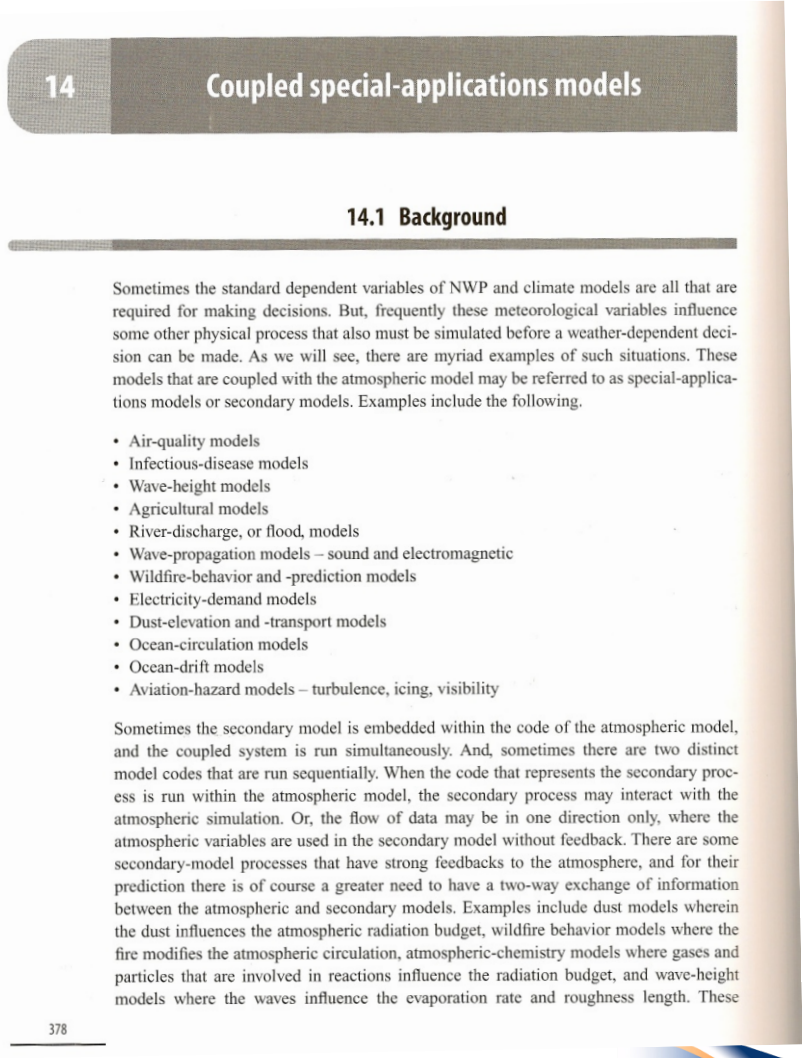
Coupled Applications





14 Coupled special-applications models

14.1 Background

Sometimes the standard dependent variables of NWP and climate models are all that are required for making decisions. But, frequently these meteorological variables influence some other physical process that also must be simulated before a weather-dependent decision can be made. As we will see, there are myriad examples of such situations. These models that are coupled with the atmospheric model may be referred to as special-applications models or secondary models. Examples include the following.

- Air-quality models
- Infectious-disease models
- Wave-height models
- Agricultural models
- River-discharge, or flood, models
- Wave-propagation models – sound and electromagnetic
- Wildfire-behavior and -prediction models
- Electricity-demand models
- Dust-elevation and -transport models
- Ocean-circulation models
- Ocean-drift models
- Aviation-hazard models – turbulence, icing, visibility

Sometimes the secondary model is embedded within the code of the atmospheric model, and the coupled system is run simultaneously. And, sometimes there are two distinct model codes that are run sequentially. When the code that represents the secondary process is run within the atmospheric model, the secondary process may interact with the atmospheric simulation. Or, the flow of data may be in one direction only, where the atmospheric variables are used in the secondary model without feedback. There are some secondary-model processes that have strong feedbacks to the atmosphere, and for their prediction there is of course a greater need to have a two-way exchange of information between the atmospheric and secondary models. Examples include dust models wherein the dust influences the atmospheric radiation budget, wildfire behavior models where the fire modifies the atmospheric circulation, atmospheric-chemistry models where gases and particles that are involved in reactions influence the radiation budget, and wave-height models where the waves influence the evaporation rate and roughness length. These

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From Warner, Numerical Weather and Climate Prediction, Cambridge 2011

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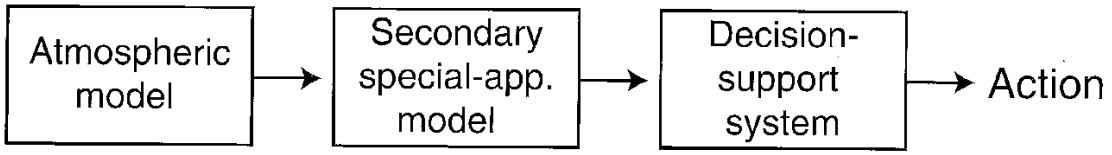
Coupled applications (cont.)



Sequence of software components that are involved in providing the basis for a decision (action) that is weather dependent.

- NWP forecast model output drives secondary application
- This provides a **forecast** of the event
- Can use a single sounding from single NWP model to provide a **deterministic** forecast
- Or use ensembles to provide a measure of uncertainty in the results, i.e. a **probabilistic** forecast
  - Ensembles of NWP forecasts
  - Spatial ensembles of a single NWP forecasts
  - Ensembles of ensembles
- Output can be tailored for a DSS

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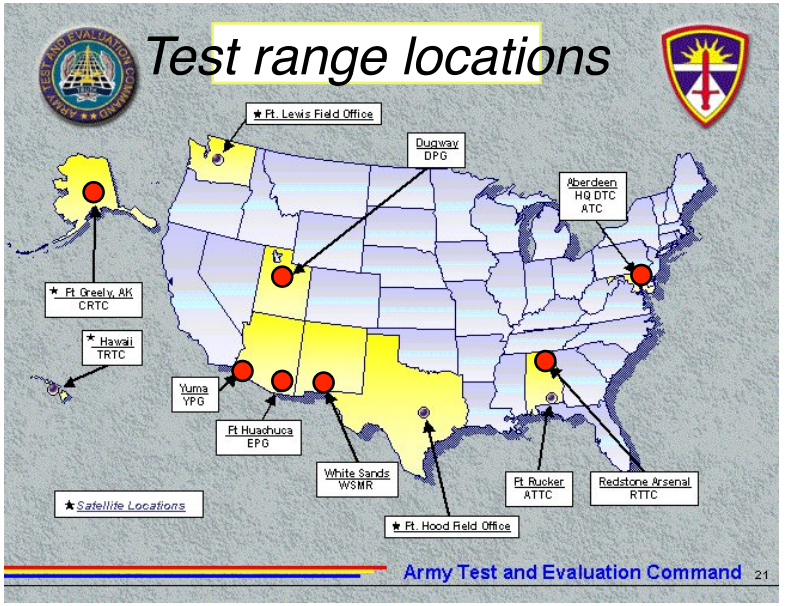
Coupled applications at the U. S. Army Test and Evaluation Command (ATEC) ranges

- Test centers for Army equipment and software
- Since 1995, NCAR has developed “4D Weather” (4DWX) advanced weather analysis and forecasting systems to support tests
- Each ATEC test range is provided with “24X7” nested NWP 36 hr forecasts
  - Routine meteorological forecasts
  - Originally MM5 now AR WRF
  - Coupled to special applications for test planning
- Tom initiated and coordinated a 4pt paper in JAM describing the project



The Operational Mesogamma-Scale Analysis and Forecast System of the U.S. Army Test and Evaluation Command. Part III: Forecasting with Secondary-Applications Models

ROBERT D. SHARMAN,* YUBAO LIU,* RONG-SHYANG SHEU,* THOMAS T. WARNER,*,+ DARAN L. RIFE,* JAMES F. BOWERS,# CHARLES A. CLOUGH,@ AND EDWARD E. ELLISON&

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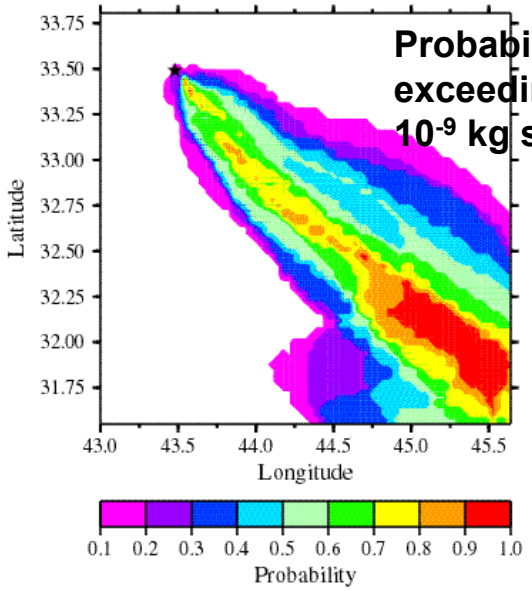
Example 1: T&D model (SCIPUFF) driven by NWP ensemble

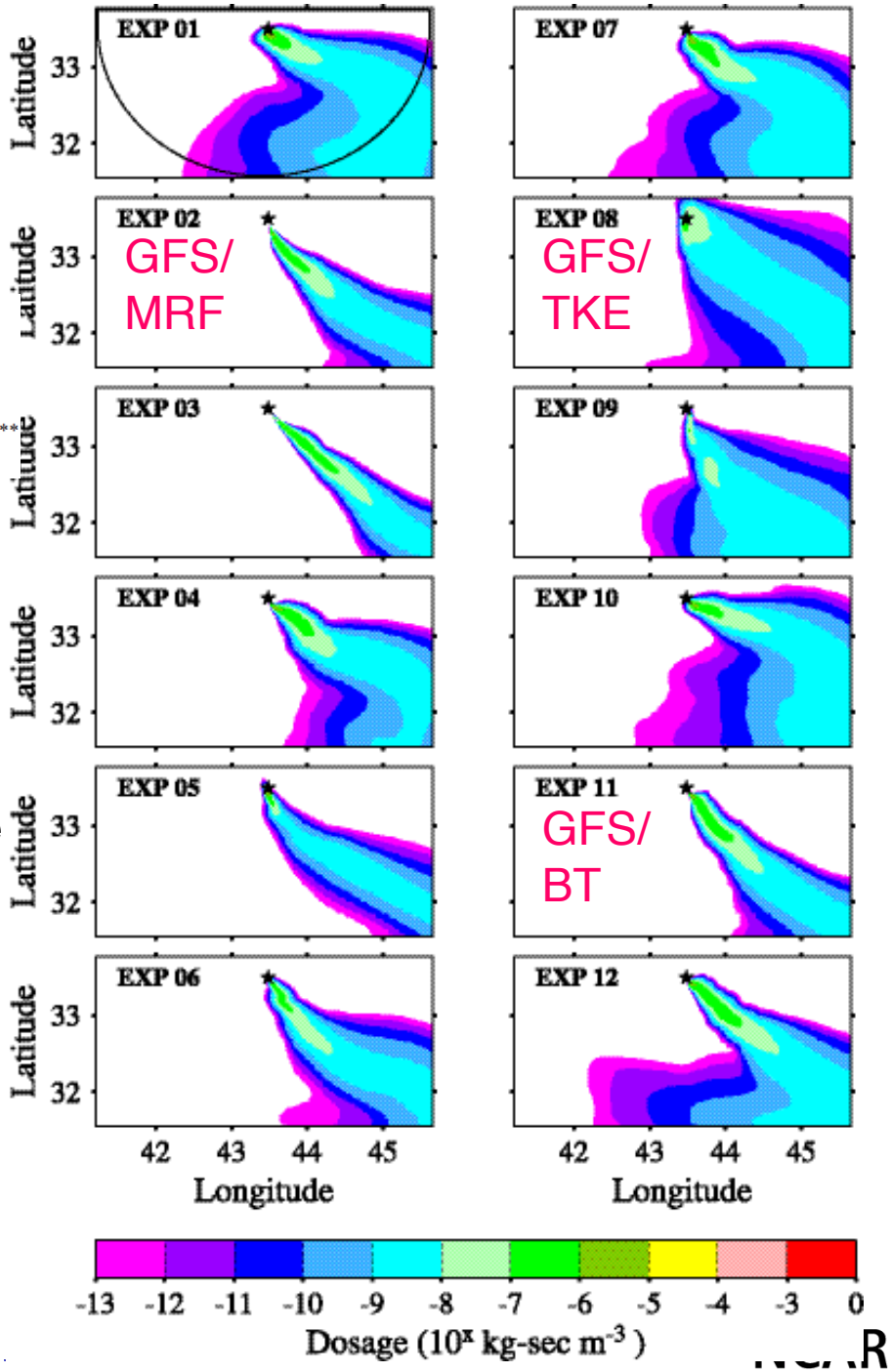
Ensemble Simulations with Coupled Atmospheric Dynamic and Dispersion Models: Illustrating Uncertainties in Dosage Simulations

THOMAS T. WARNER,*# RONG-SHYANG SHEU,* JAMES F. BOWERS,@ R. IAN SYKES,& GREGORY C. DODD,** AND DOUGLAS S. HENN&

- Dugway Proving Ground (DPG)
- 3 driving models (GFS, NOGAPS, ECMWF) + 3 boundary layer parameterizations + 2 land-surface models

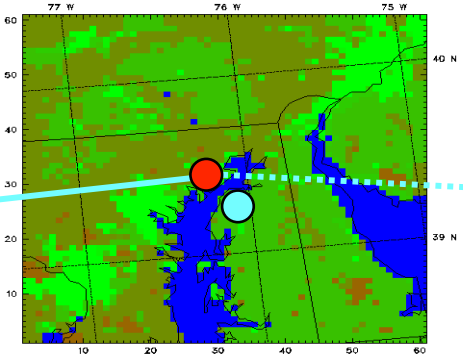


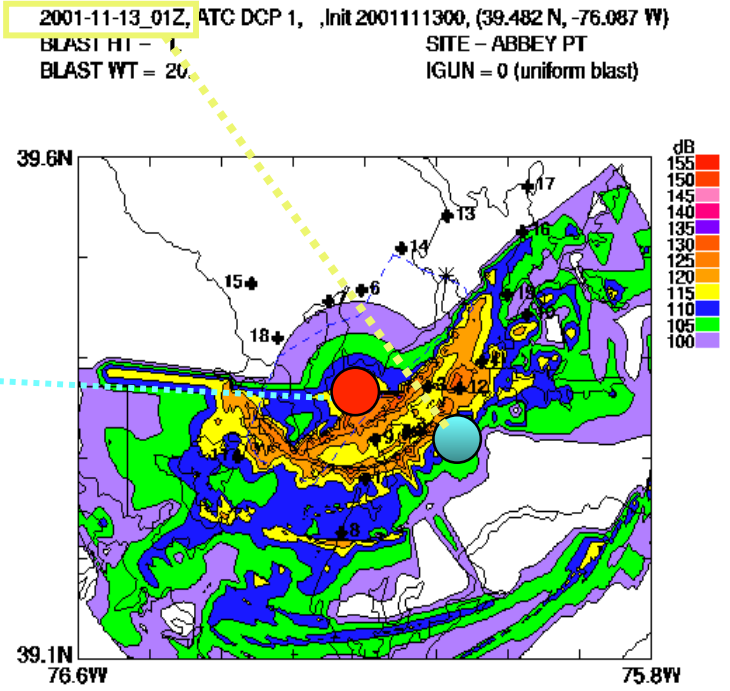
Probability of dosage exceeding 10^{-9} kg s/m^3



Example 2: Blast noise forecasting at the U.S. Army Aberdeen Proving Ground (APG)*

- APG is responsible for Army explosive/ordnance testing
- Residences adjoin test area and are susceptible to damaging noise levels
- Need to predict sound levels in residential areas for test planning and go/no-go decisions
- Use NWP model forecast (RTFDDA) to drive sound propagation model





***From 4-pt paper in JAMC 2008:**
The Operational Mesogamma-Scale Analysis and Forecast System of the U. S. Army Test and Evaluation Command

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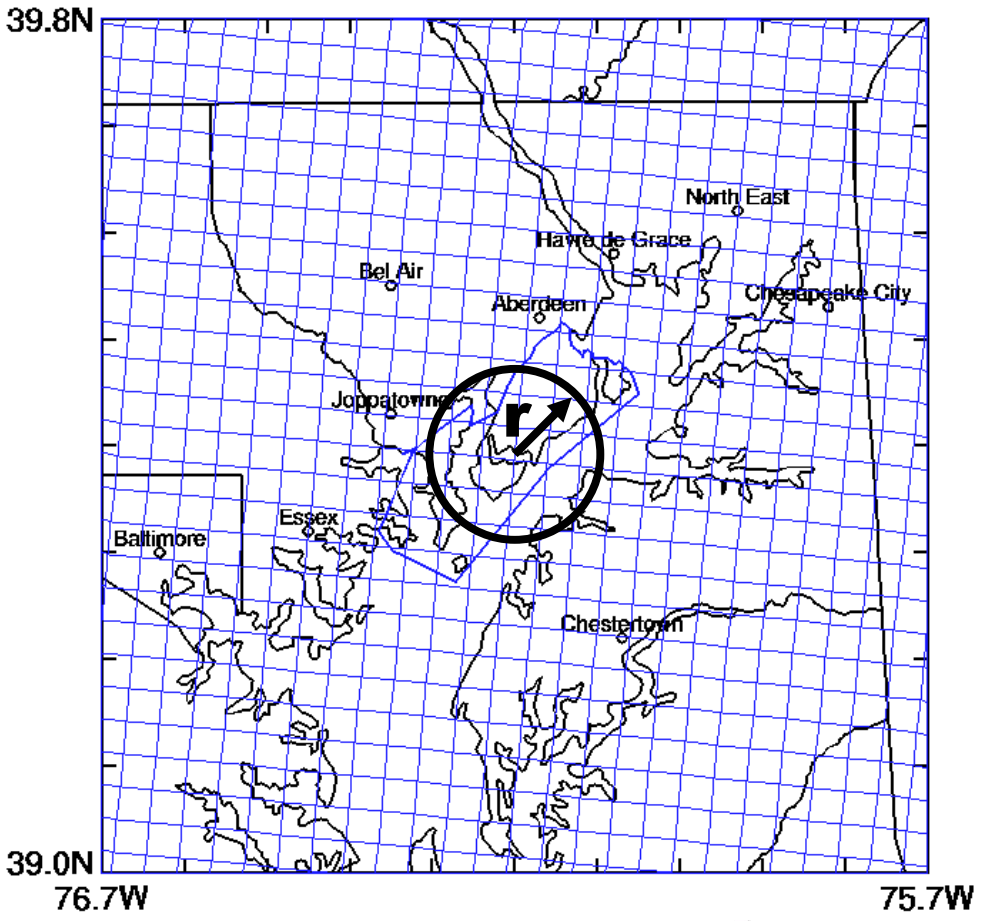
Spatial ensembles

- Uncertainties in timing/ location of mesoscale phenomena (e.g., sea breeze front) can lead to substantial gridpt-gridpt differences in NWP derived soundings
- Use spatial ensembles to account for these uncertainties
- NWP output provides spatial ensemble of soundings within radius *r* of blast
- Execute sound propagation model on each sounding
- Develop ensemble statistics



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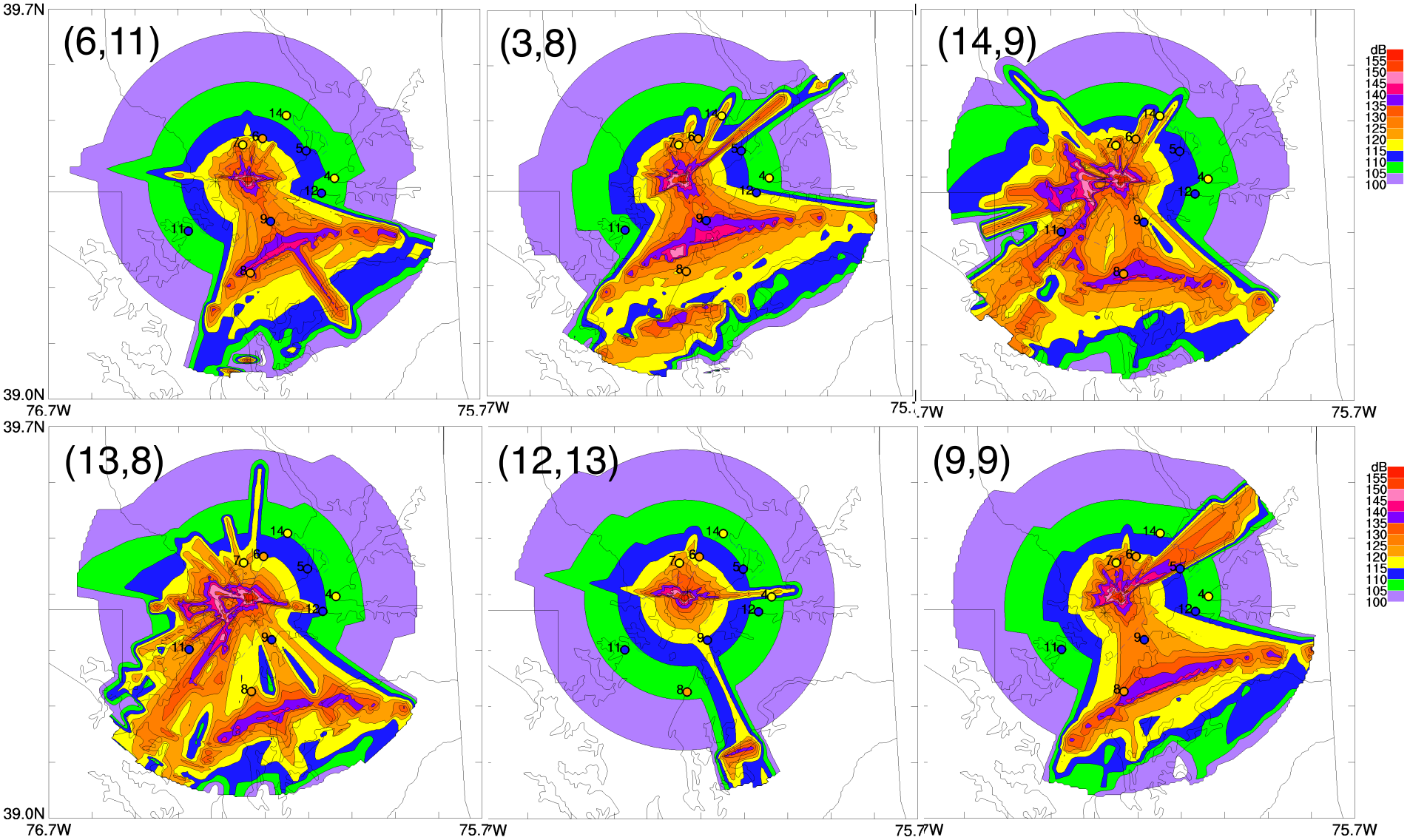
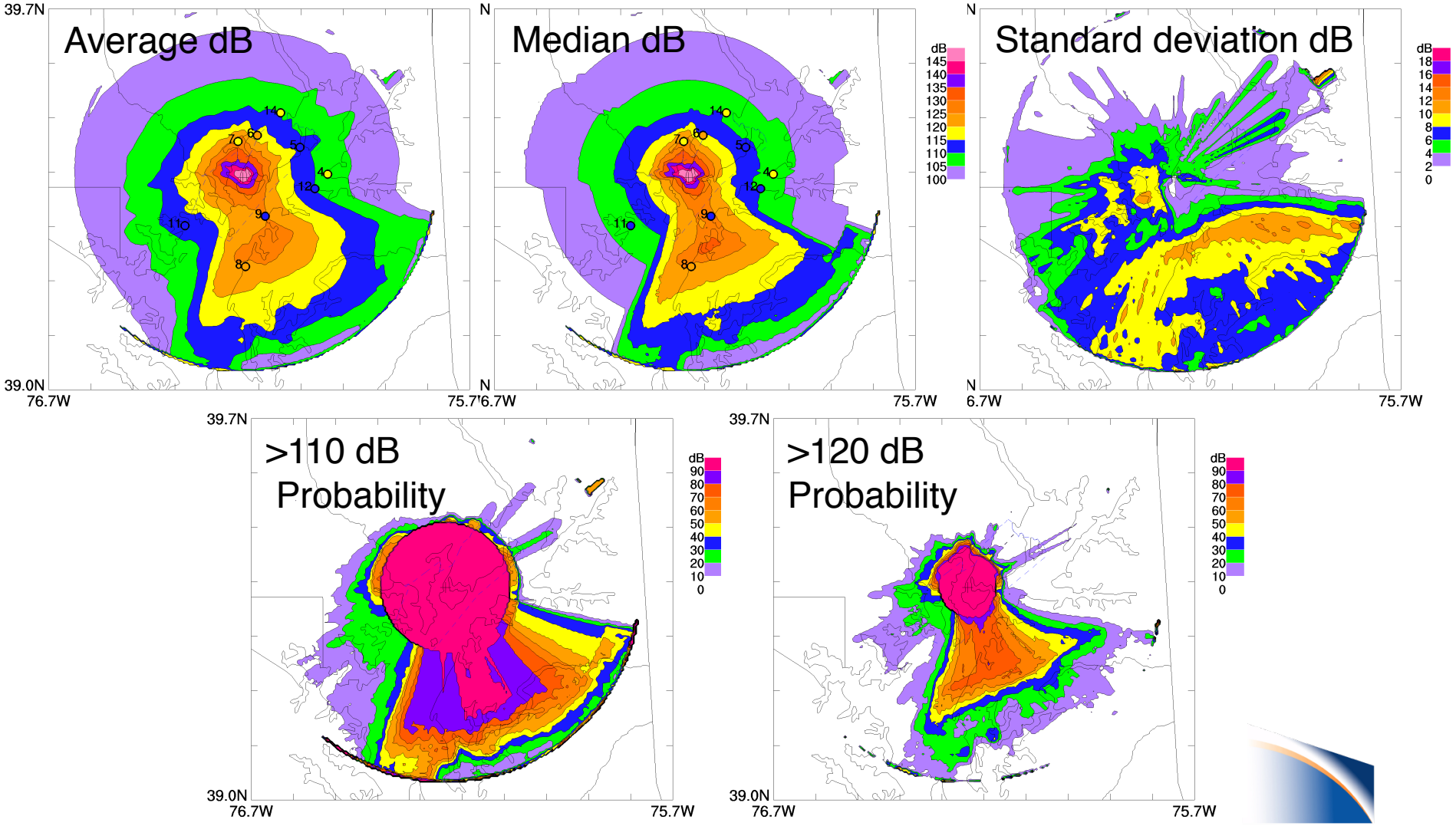
Examples of spatial ensemble members



Spatial ensemble statistics



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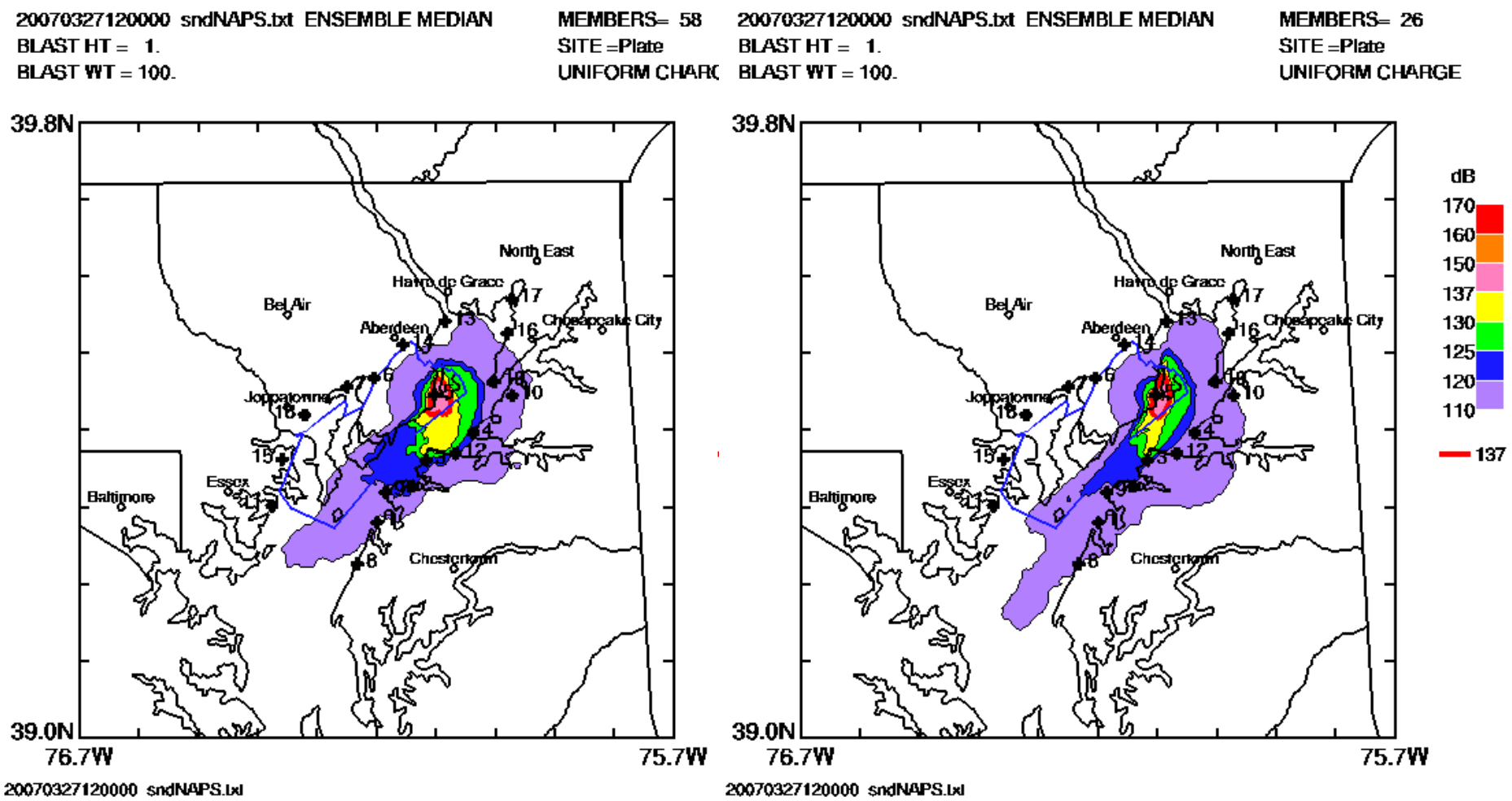
Comparison of meteorological ensembles with spatial ensembles



MET ENSEMBLE

SPATIAL

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Example 3: Missile trajectory models at White Sands Missile Range, N. M.*

- Need to ensure missile trajectories stay within range boundaries
- Launch scrubbed if winds or wind tendencies out-of-limits
- Trajectory depends on
  - Surface and upper-level winds
  - Atmospheric density
- Several missile trajectory models in use at WSMR

***From 4-pt paper in JAMC 2008:**
The Operational Mesogamma-Scale Analysis and Forecast System of the U. S. Army Test and Evaluation Command

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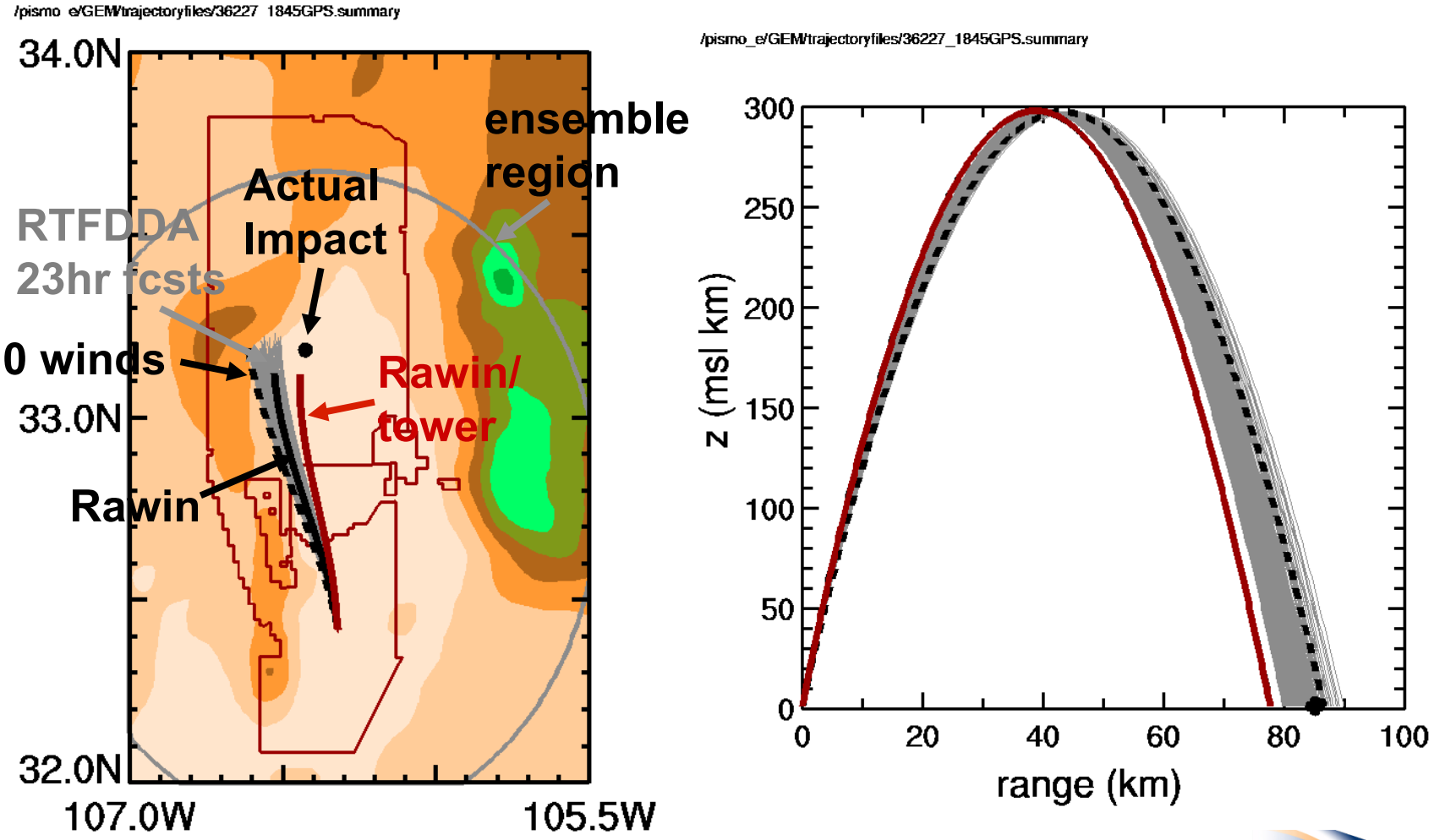
Example 3 output



362.27 launch 3Aug2005 1845 UTC

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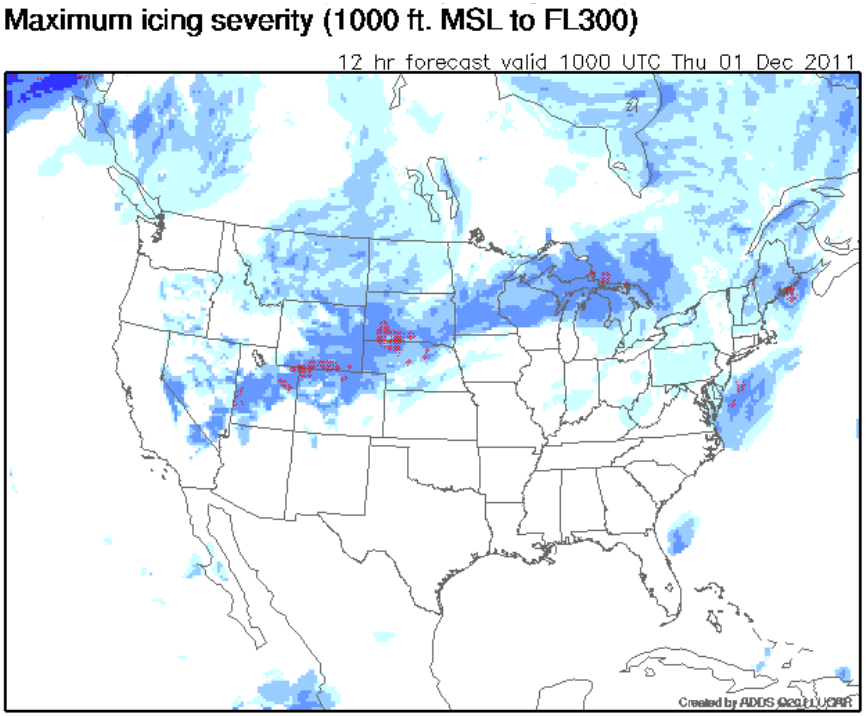
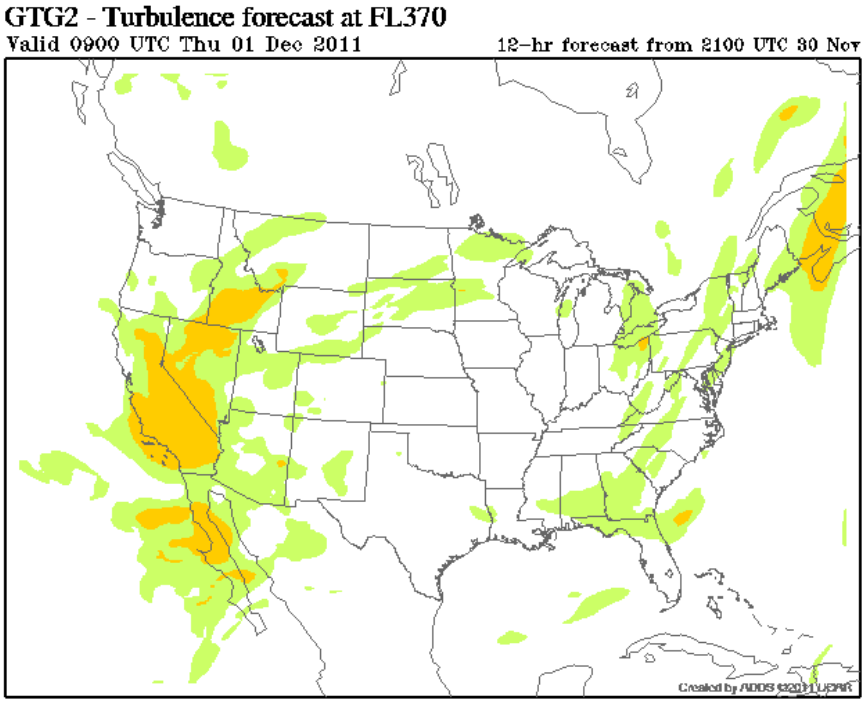
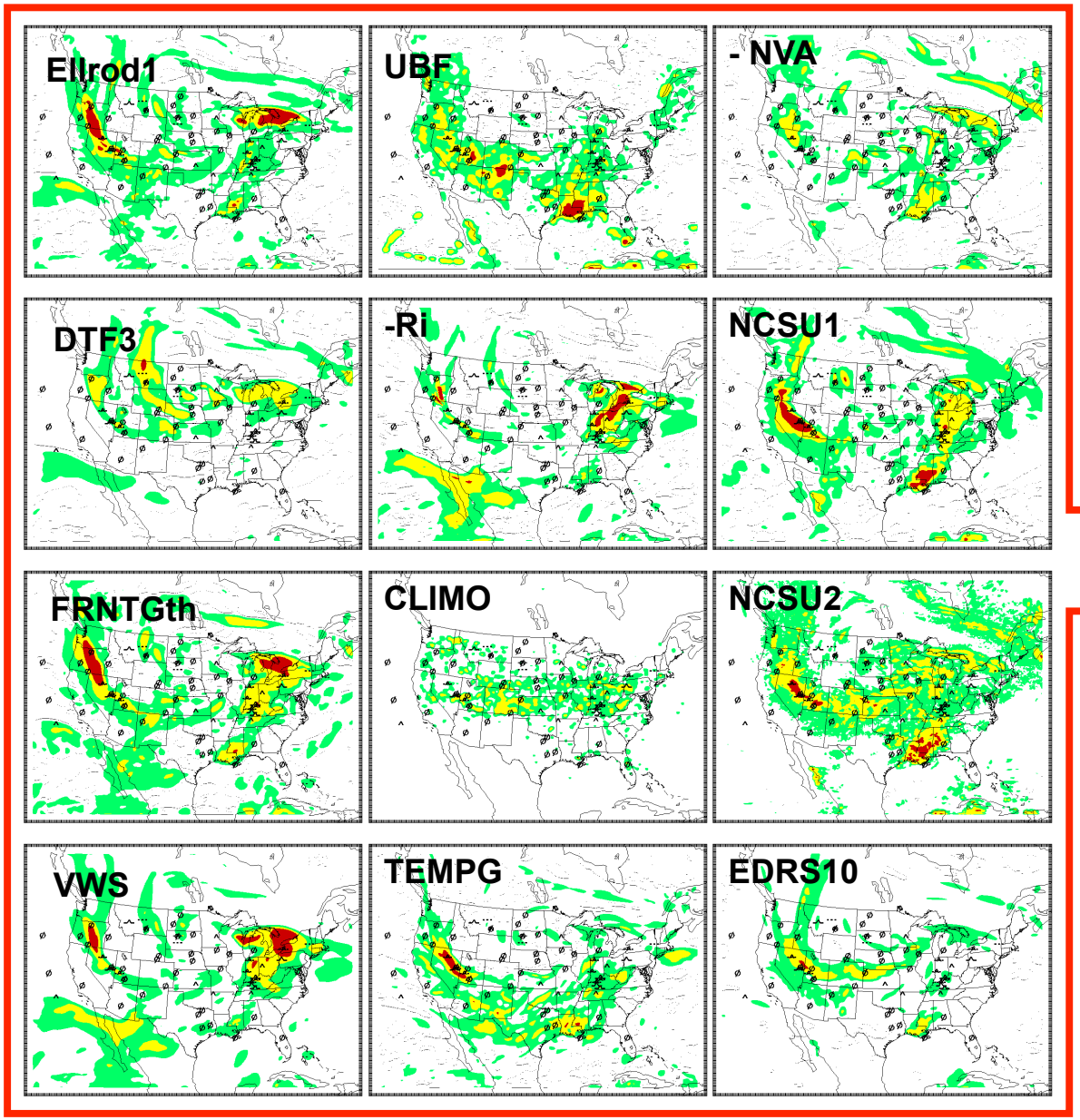
Example 4: Aviation-related coupled applications*

- NWP models are used to drive secondary applications for
  - Turbulence
  - In-flight icing
  - Ceiling & visibility
- Available on Operational ADDS (http://aviationweather.gov/adds) at AWC as a “supplementary” product to NWS issued advisories
- Typically compute and combine many different diagnostics derived from the NWP model output

*see Warner, Numerical Weather and Climate Prediction, Section 14.6.1

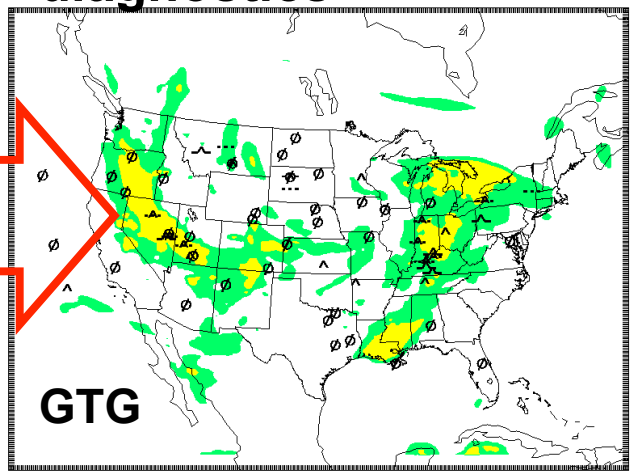






GTG (Graphical Turbulence Guidance) for Turbulence

=Weighted ensemble mean of turbulence diagnostics



0 h forecast valid at 22 Sep 2006 15Z

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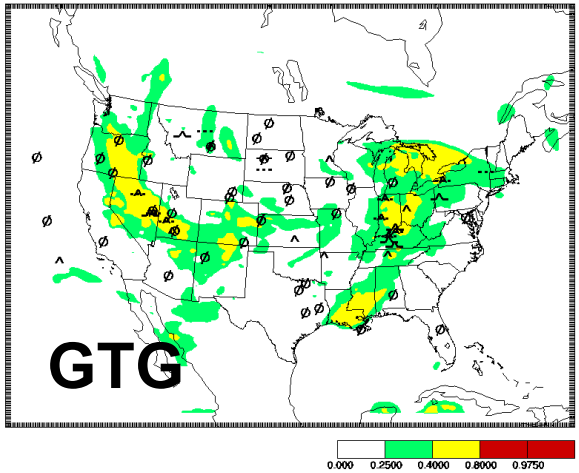
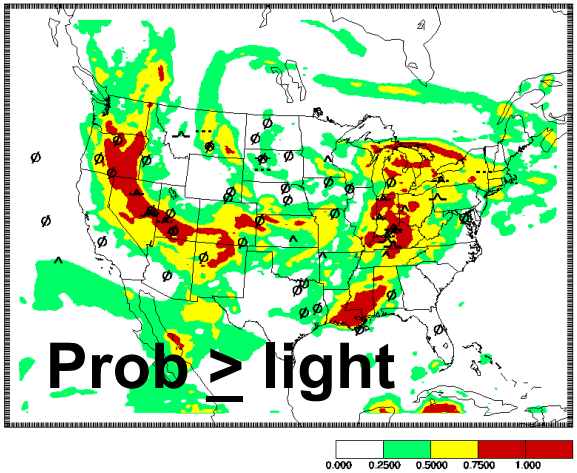
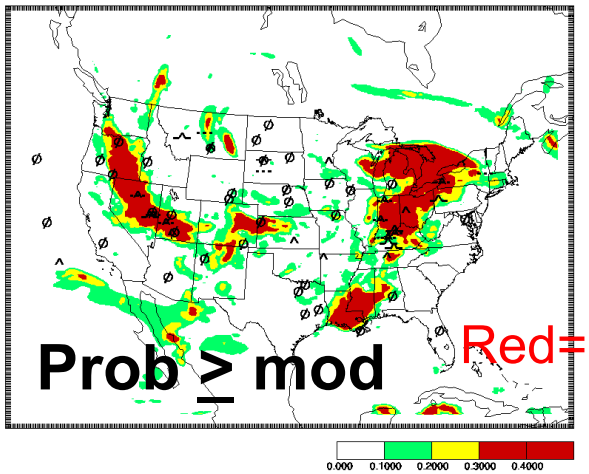
Use of indices as ensembles provides confidence values (or uncalibrated probabilities)





Red=.75



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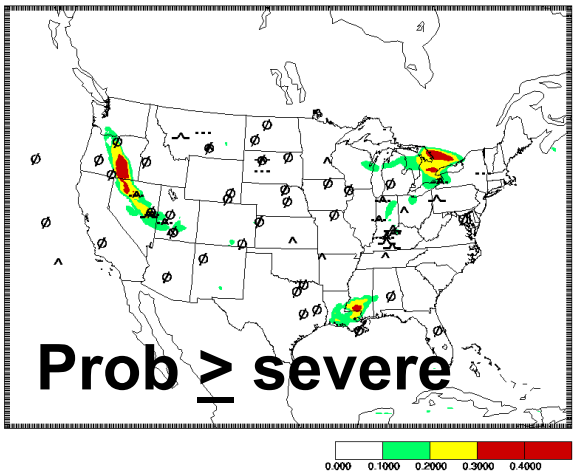

Red=.30

0 h forecast valid at 22 Sep 2006 15Z

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Summary

- “Coupled” (actually one-way, Warner type 3) NWP-secondary applications forecasts fill a special operational need for information not routinely available from NWP models
- This needs helps justify special purpose NWP configurations
- Ensemble approach is useful for decision making
- Tom appreciated this*

*see Warner, Numerical Weather and Climate Prediction, Chapter 14

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