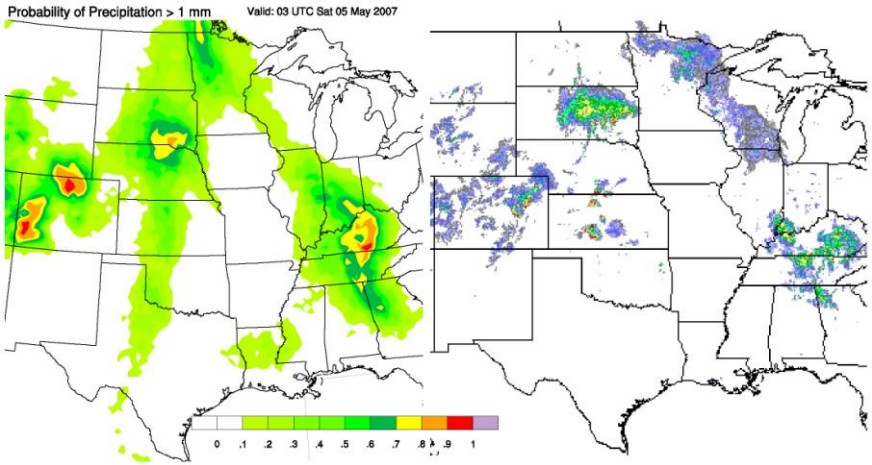
Experiences in short-range ensemble forecasting

David J. Stensrud

NOAA/National Severe Storms Laboratory



[Reprinted from BULLETIN OF THE AMERICAN METEOROLOGICAL SOCIETY, Vol. 76, No. 9, September 1995]
Printed in U. S. A.

Short-Range Ensemble Forecasting:* Report from a Workshop, 25–27 July 1994

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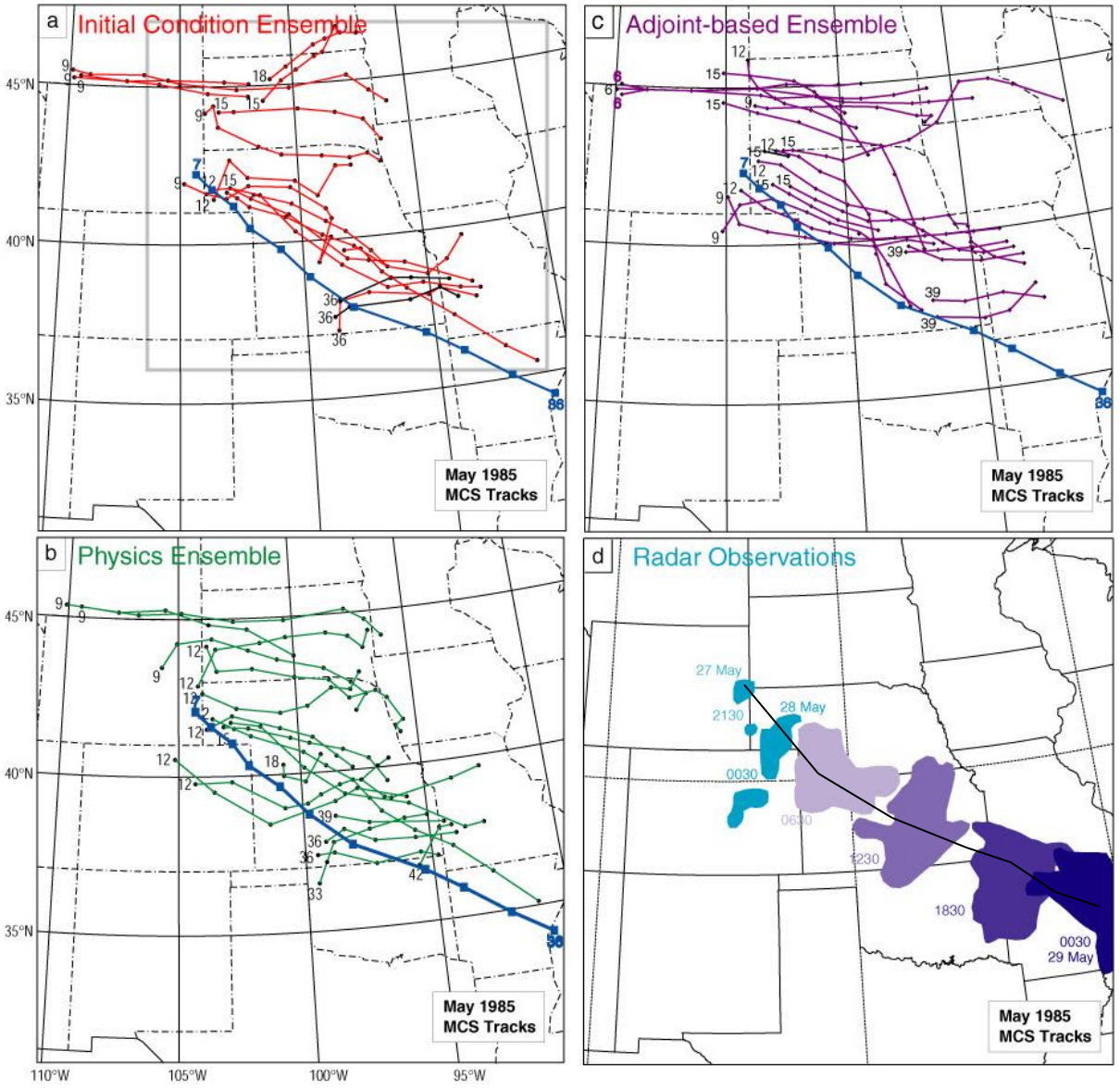
*SREF is still a teenager

Research Themes

- Multi-physics and multi-model ensembles in comparison with fixed model configuration ensembles
- Ensemble postprocessing
- Convection-resolving ensembles
- Ensemble data assimilation (EnKF)

Mesoscale Short-range Ensemble Forecasting

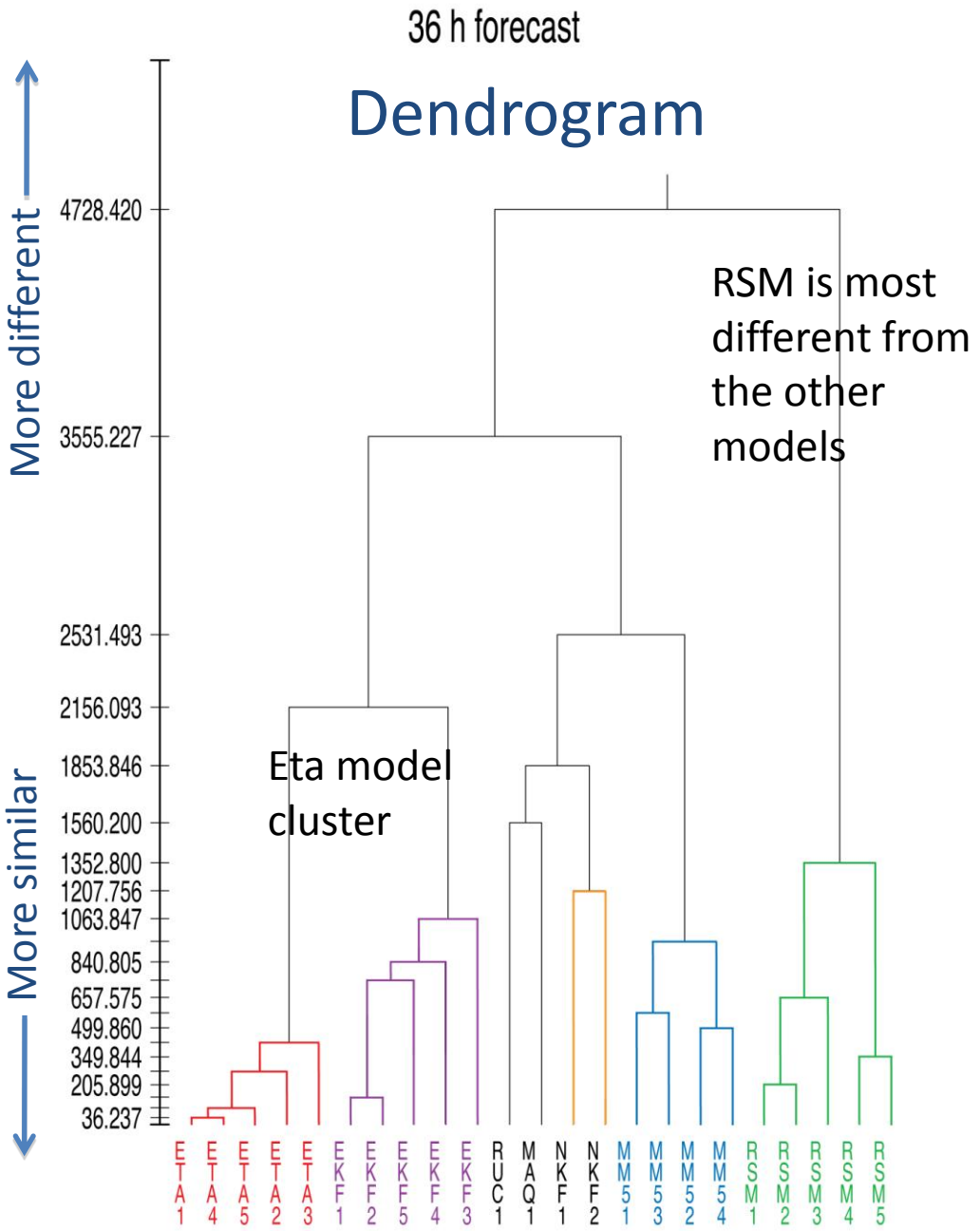


Longest lived MCC during PRE-STORM (blue line). Note how PH ensemble more diverse and tracks often cross the observed track.

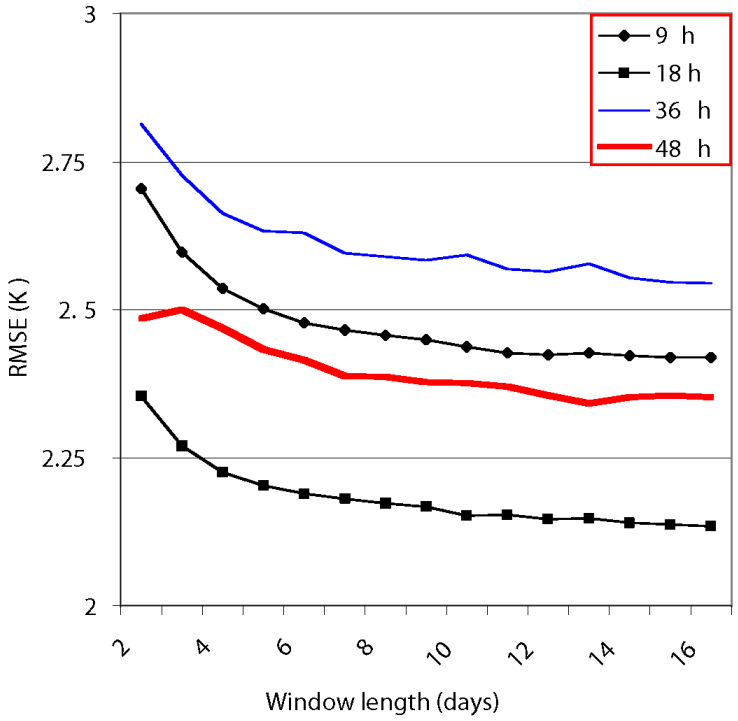
Physics diversity important for short-range ensemble forecasting.

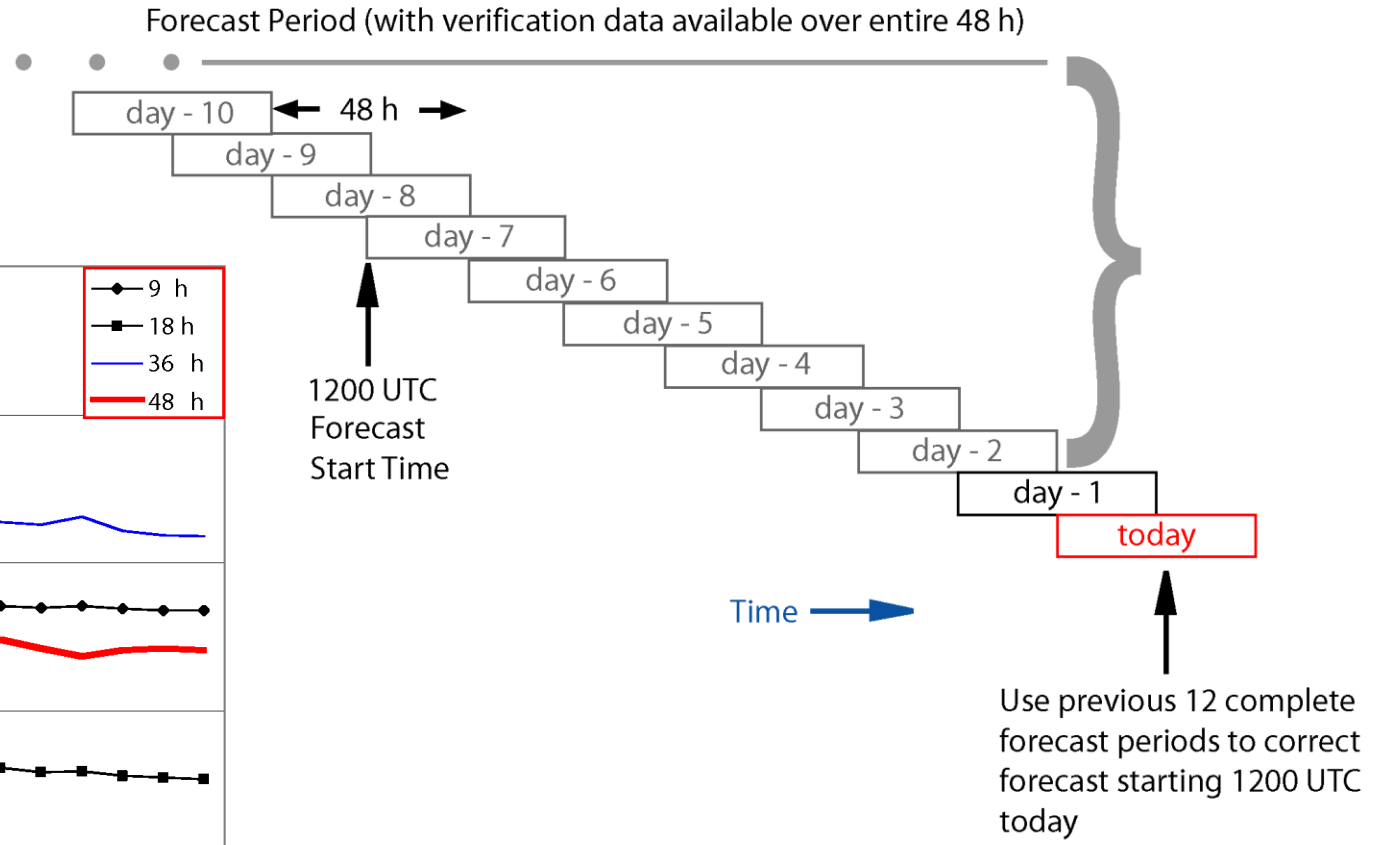
Forecasts from multi-model ensembles tend to cluster in model subgroups as shown by the dendrogram → for 2-m temperature.

One can view this behavior as sampling different parts of the attractor.



Postprocessing:
Bias-corrected ensemble (BCE)





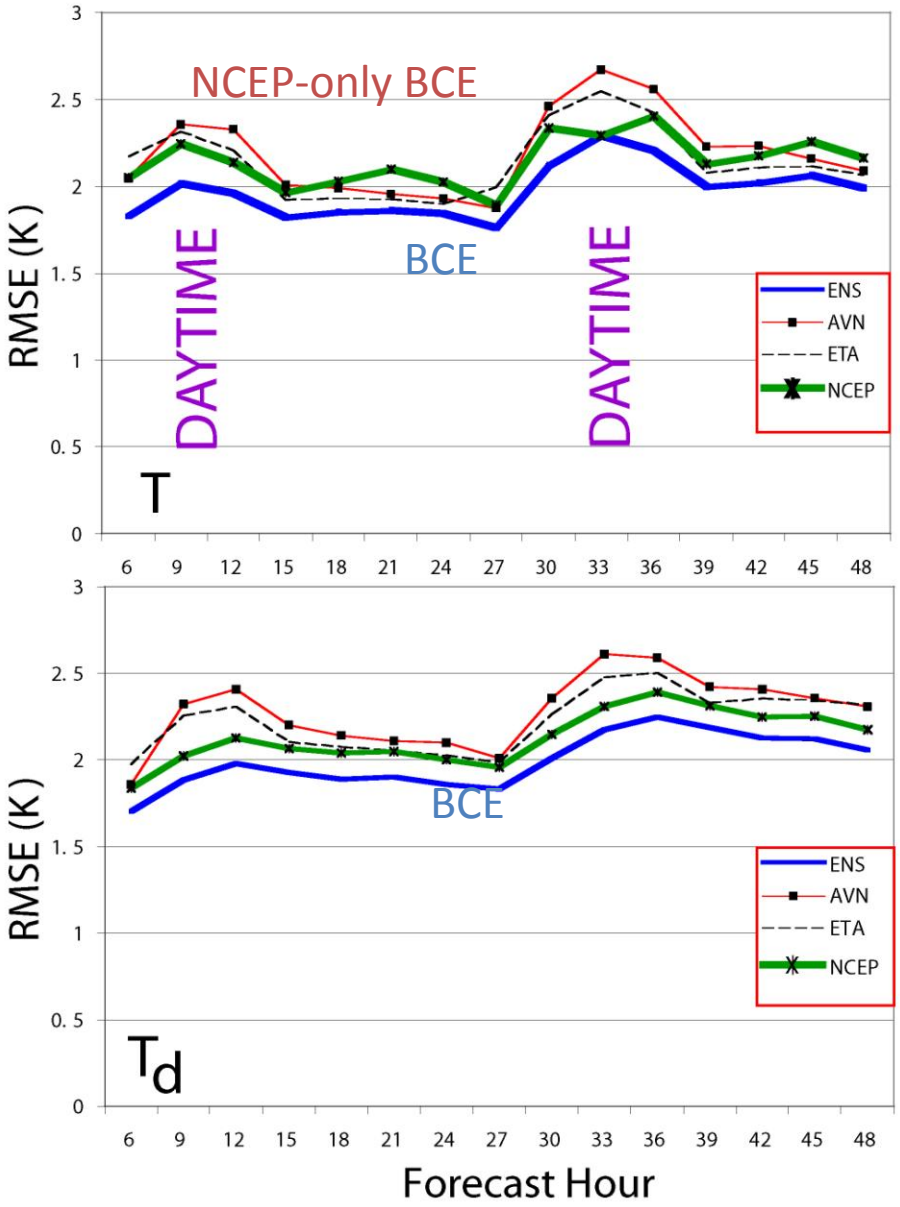
BCE Results

BCE mean is more accurate than either MOS products (AVN, ETA) for both temperature and dewpoint temperature.

Differences significant at 95% level.

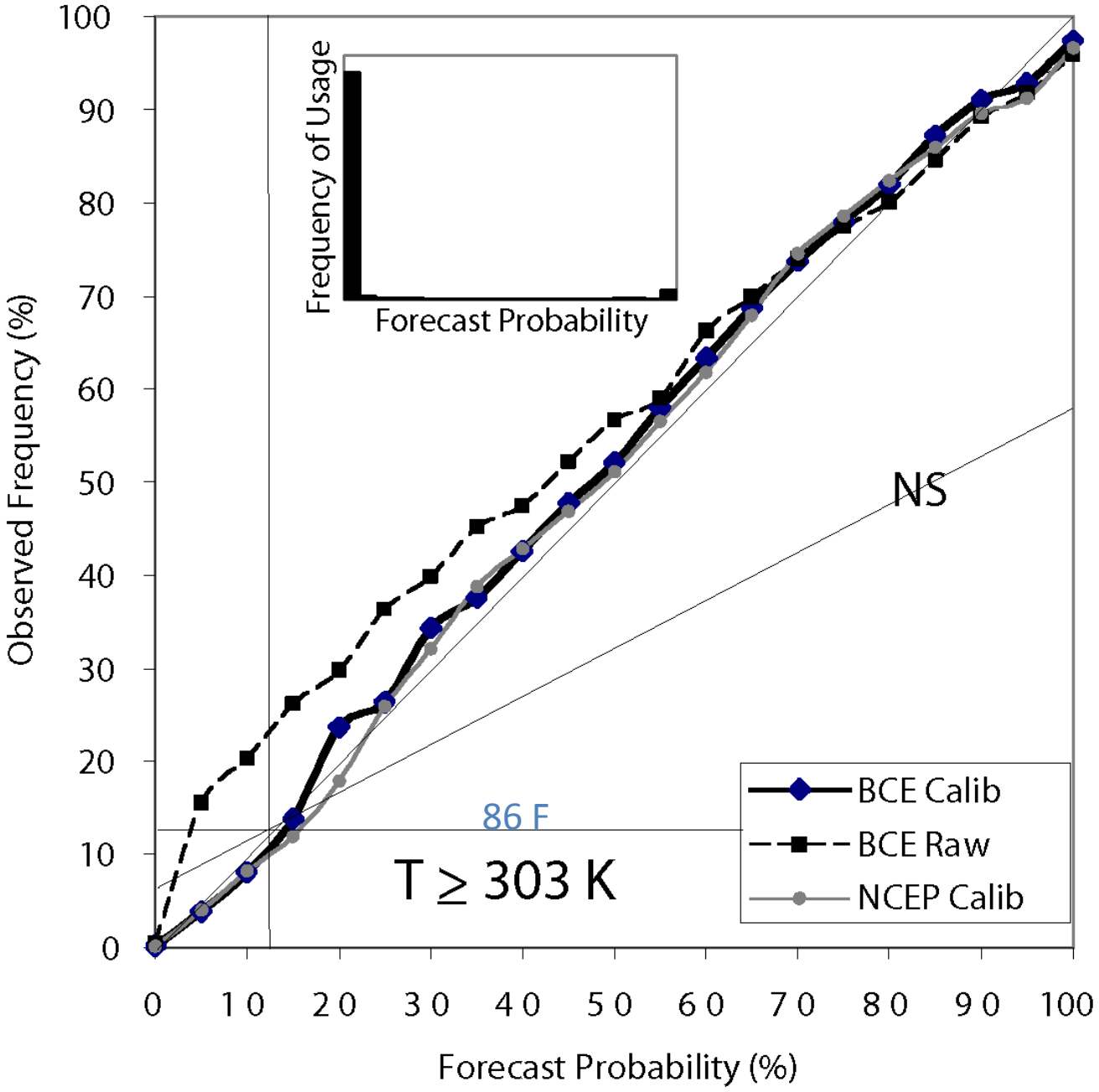
Advantage is that the BCE approach is easy and fast to implement once you have an ensemble.

Use of non-NCEP models improves forecasts

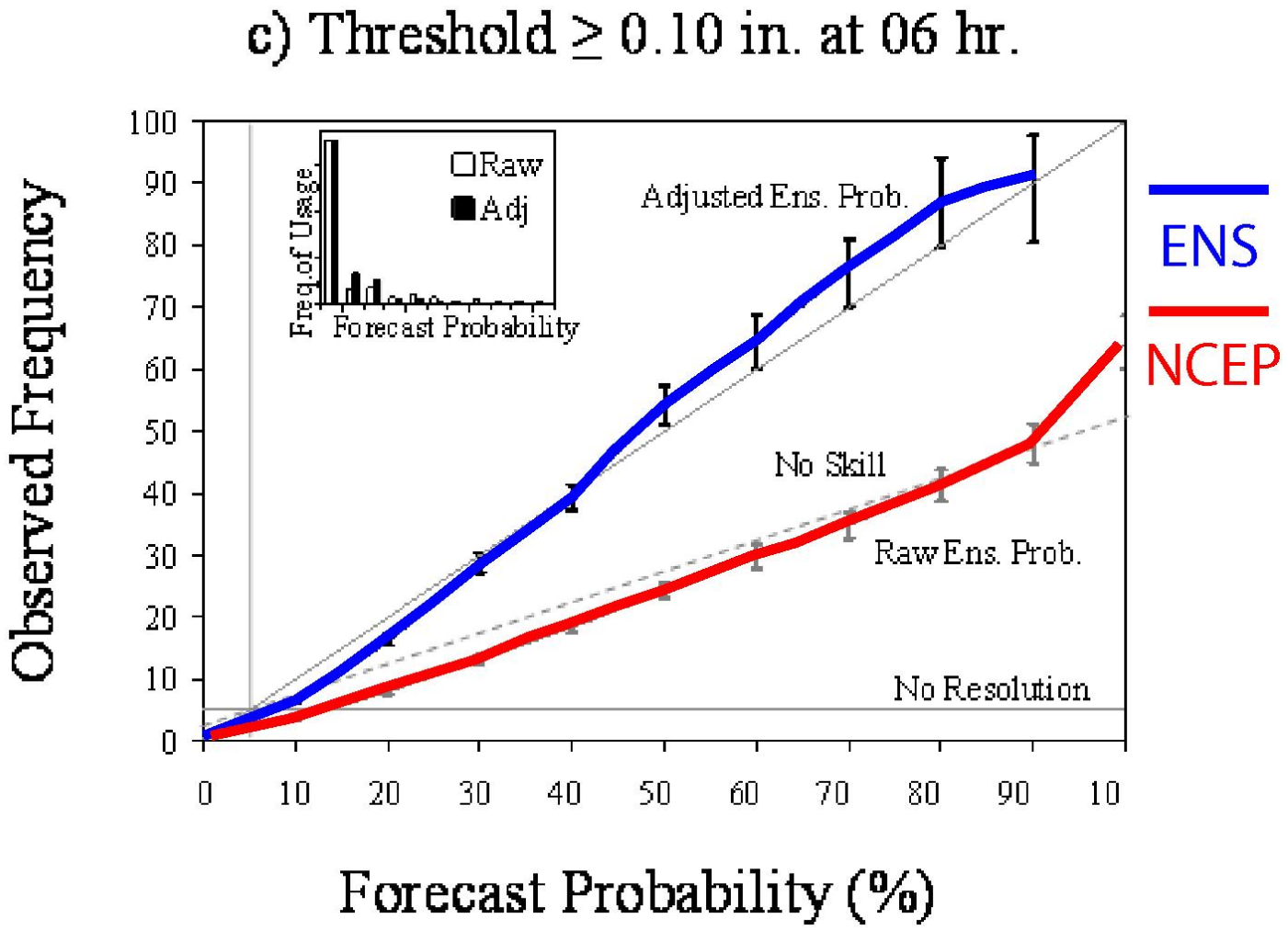


Ensemble output can be easily calibrated to provide reliable probabilities.

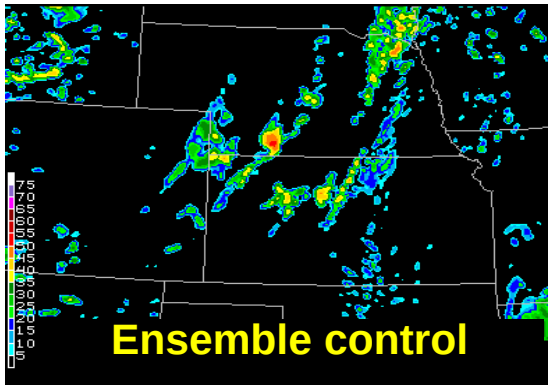
Ensembles typically are more valuable for unlikely events.

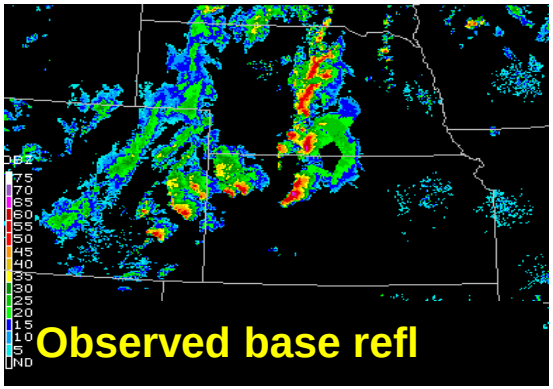


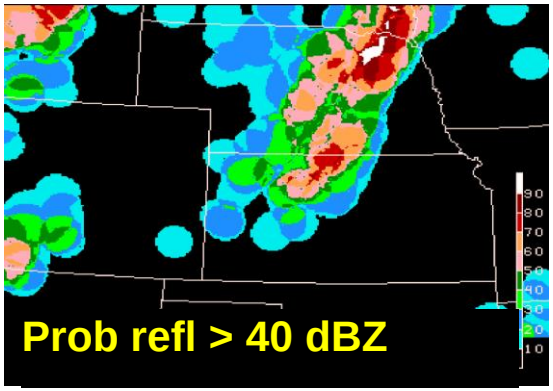
Postprocessing can also produce reliable PQPF

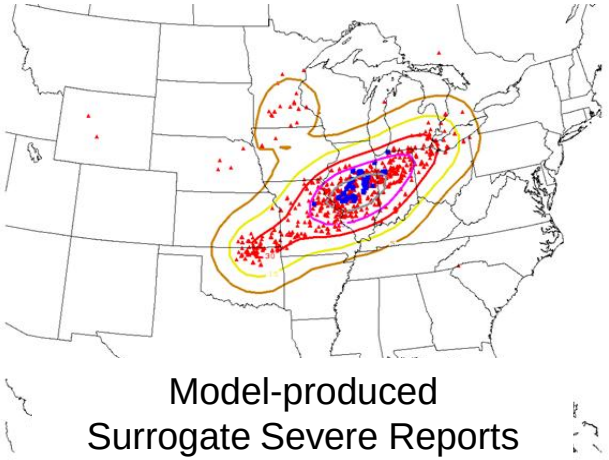


SE2007 - 09: *Convection-allowing ensembles*









Model-produced
Surrogate Severe Reports

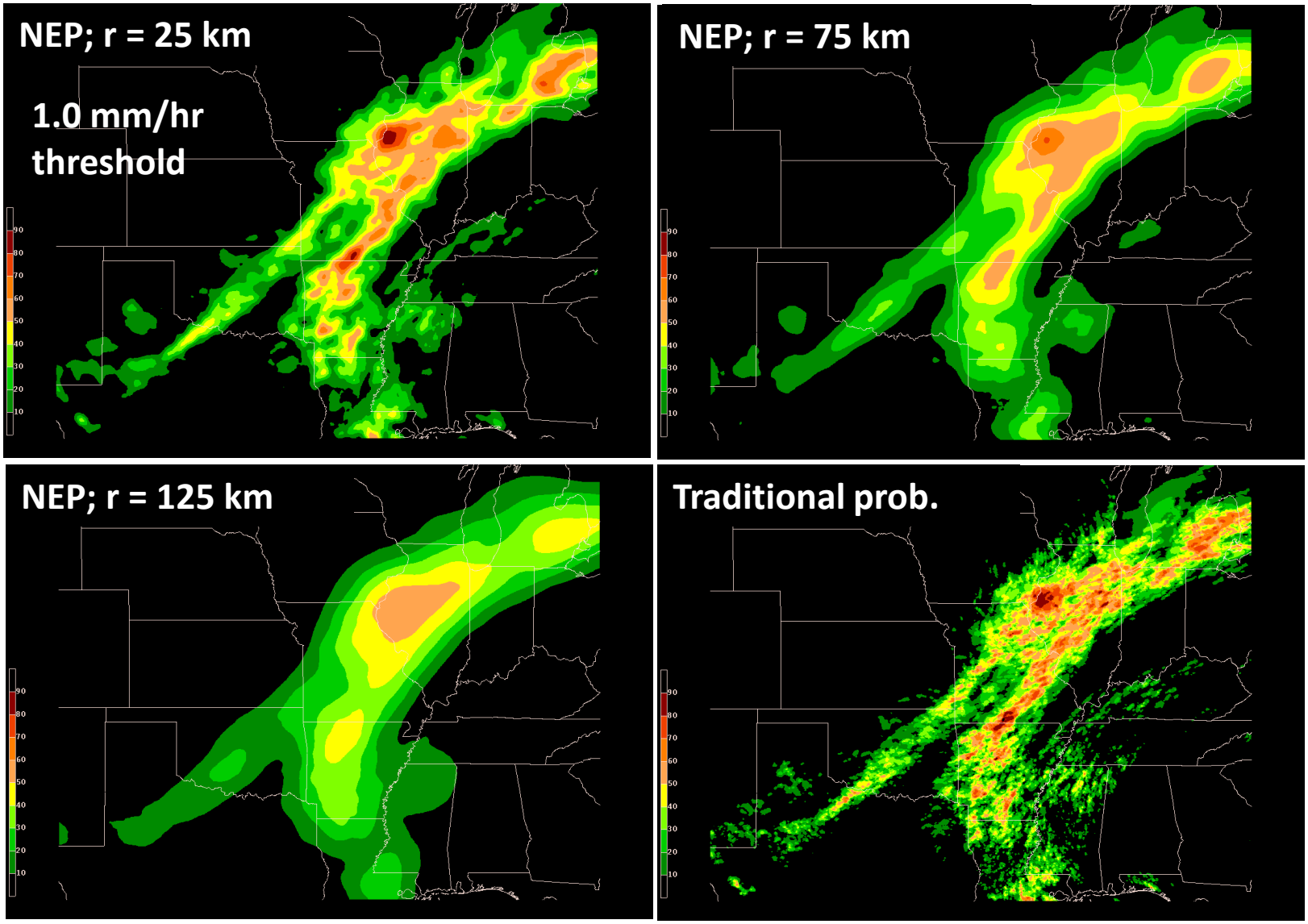
Observed Severe Reports

Center for Analysis and Prediction of Storms
University of Oklahoma

CAPS

Courtesy Jack Kain

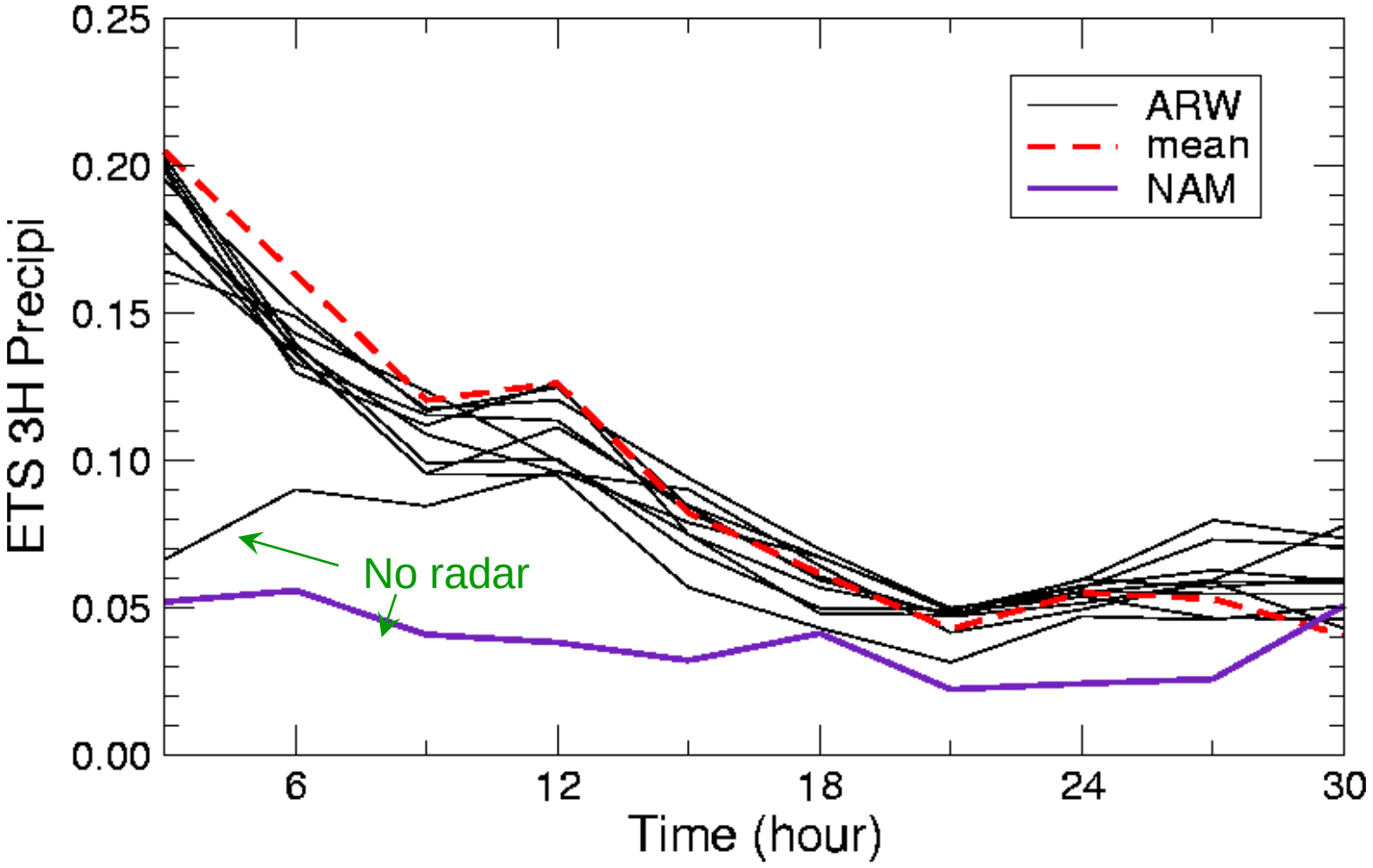
Neighborhood Ensemble Probability (NEP)



Courtesy Craig Schwartz, Jack Kain

4-km Ensemble vs 12-km NAM

3-h accum. precip. ≥0.5 in



Courtesy Fanyou Kong and Ming Xue


DANGER
Data
Overload
Ahead!

Ensemble data assimilation

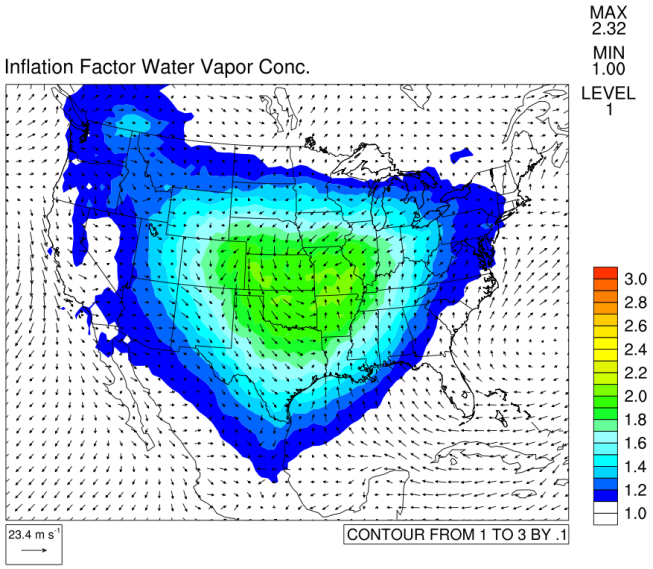
- Do multi-physics ensembles provide any benefit to ensemble data assimilation?
  - Inflation – artificially increasing ensemble spread to account for model and IC/BC errors
  - Case studies

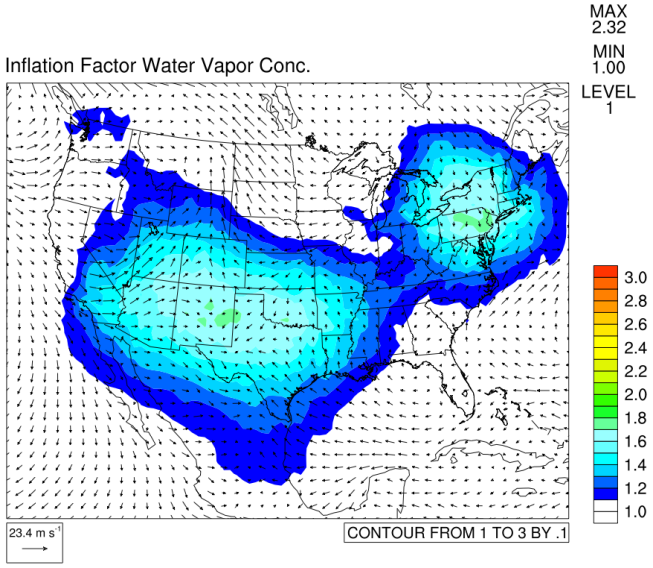
Adaptive Inflation Factor (QVAPOR near surface)

Day 3

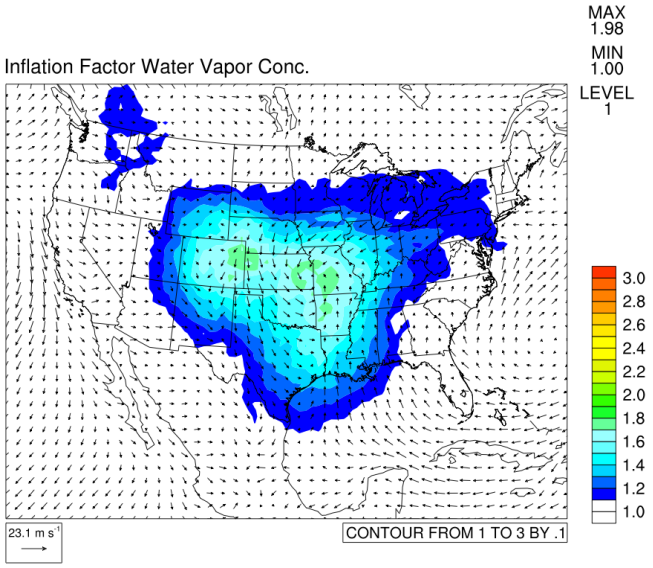
Day 10

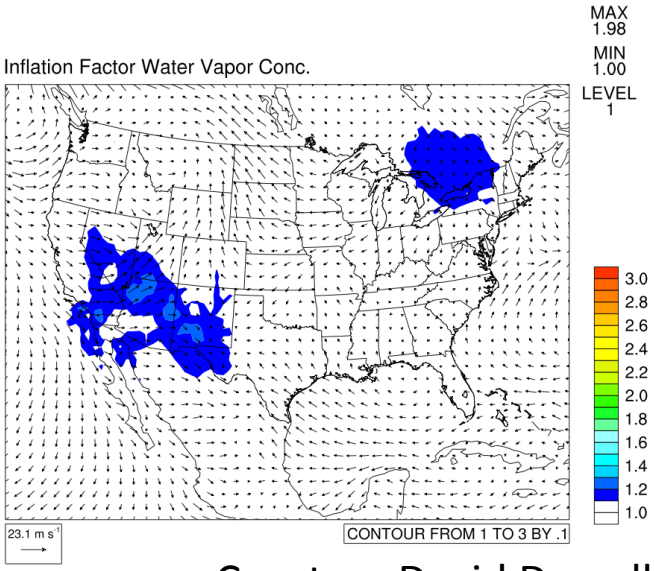
Fixed Model Configuration Ensemble





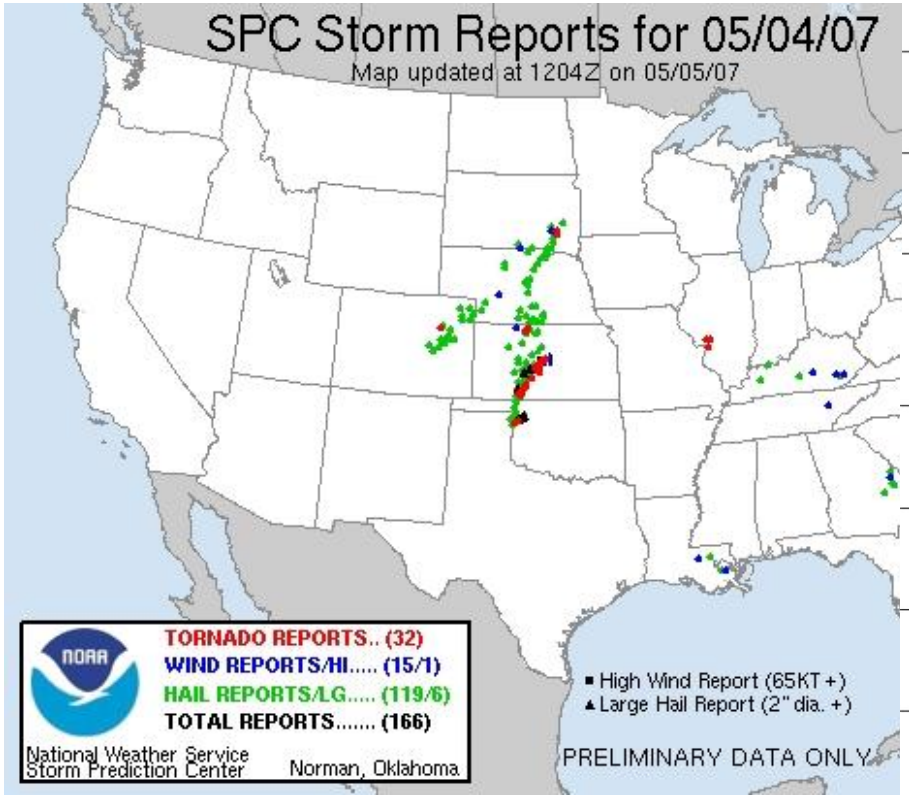
Multiphysics Ensemble

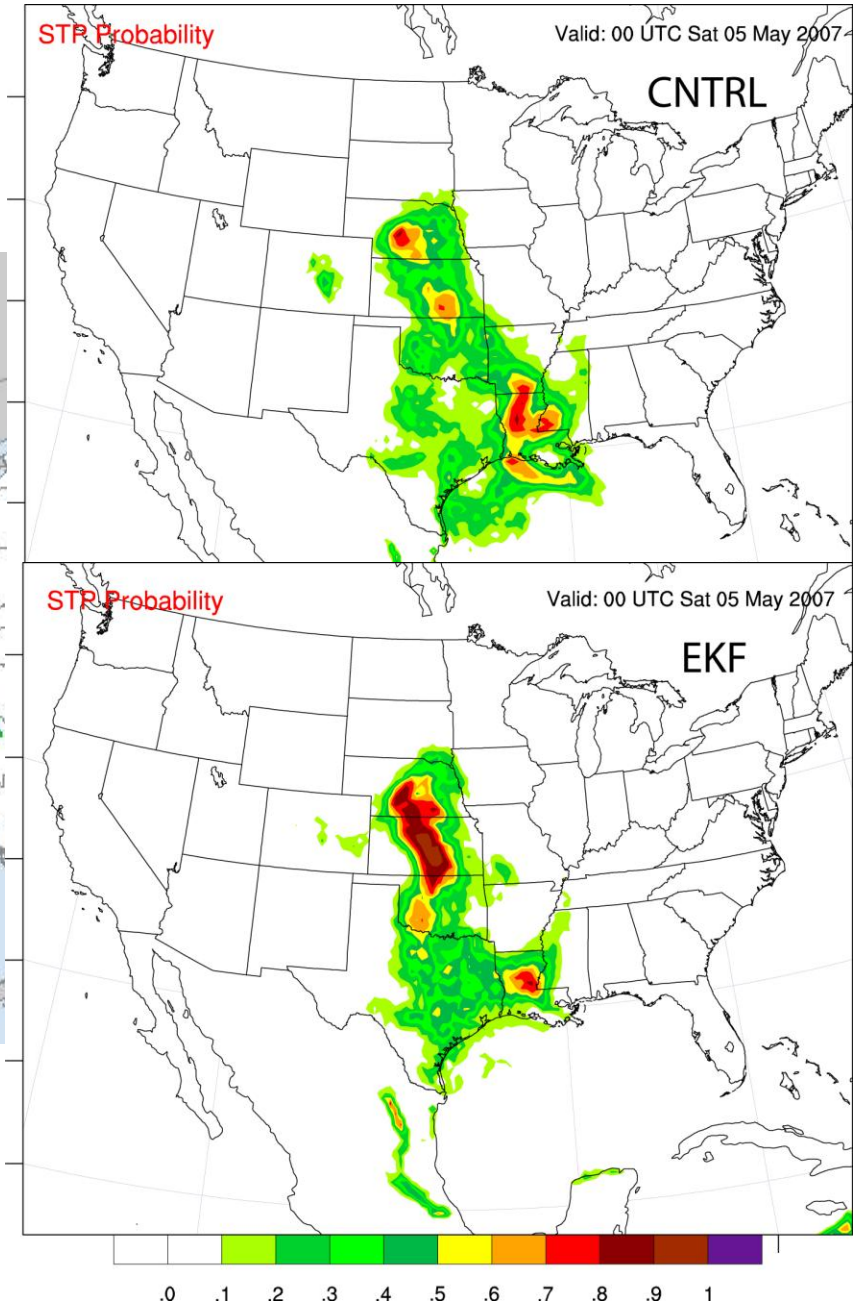




Courtesy David Dowell

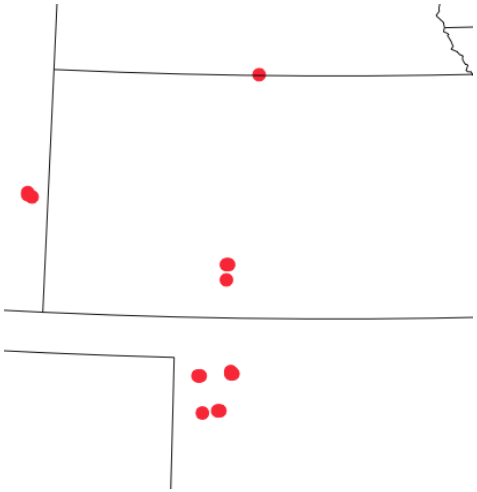
6-h Ensemble Forecasts from 4 May 2007



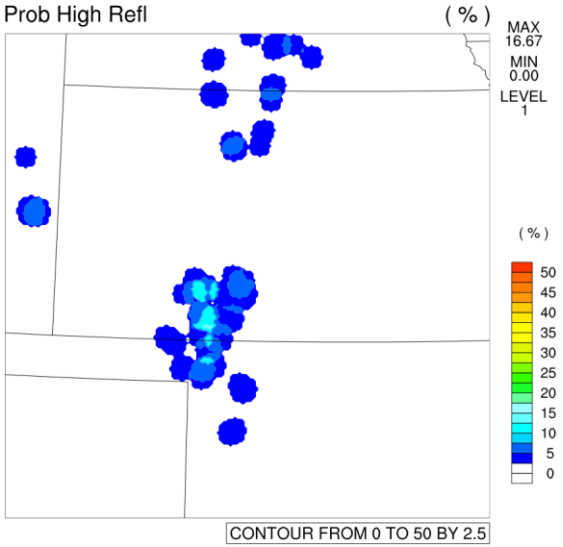


3-km Ensemble Forecast: 4-5 May 2007 (Greensburg)

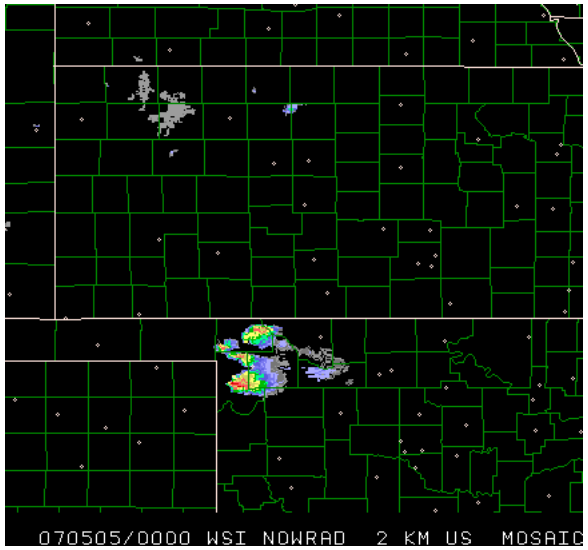
Supercell locations
in ensemble
12 hr fcst



$P(Z_{dB}>50$ dBZ within 15 km)
uncalibrated
12 hr fcst



observed reflectivity
0000 UTC 5 May 2007



Courtesy David Dowell

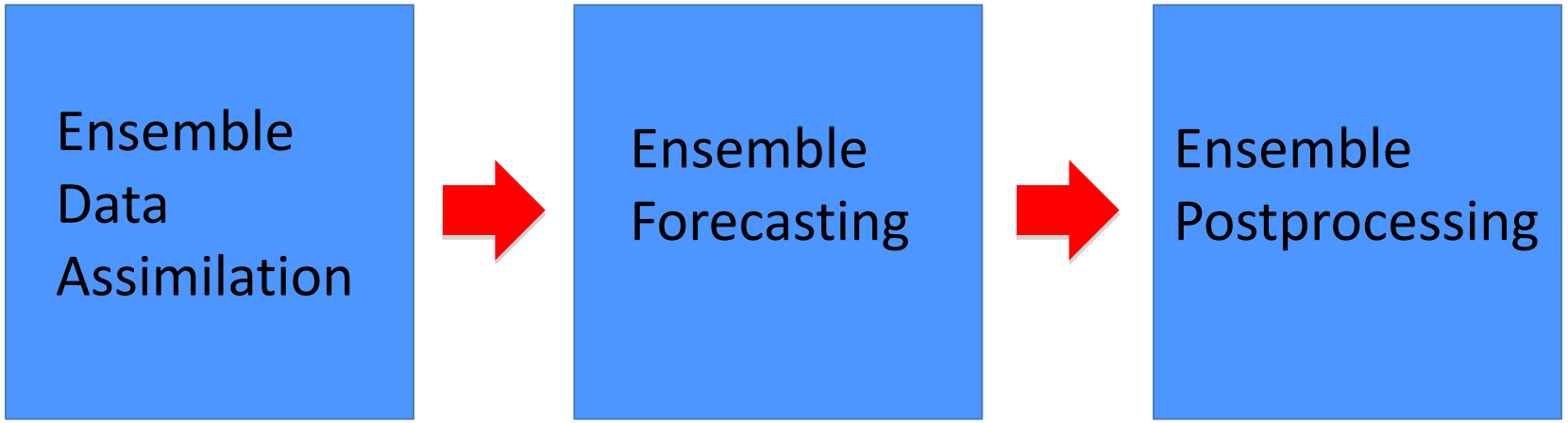
Conclusions

- Multi-physics and multi-model ensembles are beneficial. Analyses and forecasts are improved in comparison with a fixed model configuration ensemble.
- Ensemble postprocessing adds tremendous value – perhaps a decade worth of model improvements.
- Ensemble data assimilation (EnKF) is viable and provides forecast improvements in cases examined. Multi-physics ensembles lead to even greater improvements.
- Convection-resolving ensembles add information, particularly on convective mode and rainfall amounts. Data overload is a concern.

Discussion

- Mesoscale SREF is very useful and has changed how NWS produces forecasts. Questions remain regarding
  - creation of ensemble members (IC/BC + physics) and this problem persists even when using convection-resolving ensembles
  - how we postprocess ensemble data and provide it to forecasters in a useful way
- Strong links exist between ensembles and data assimilation that could be very beneficial

Future?


Ensemble
Data
Assimilation
Ensemble
Forecasting
Ensemble
Postprocessing