Ensembles at the Weather Prediction Center: Uses and Needs

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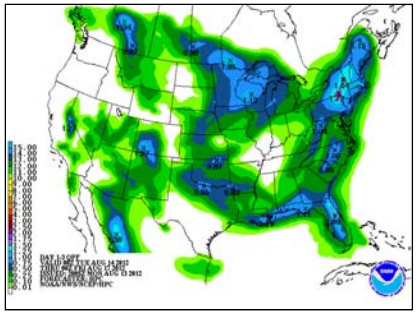
Science and Operations Officer
Weather Prediction Center

with numerous contributions from WPC staff

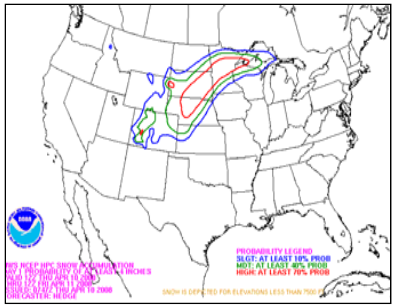
Outline

- Weather Prediction Center (WPC) operations
- WPC's ensemble-derived forecast products
  - Quantitative Precipitation Forecasts (QPFs)
  - Winter Weather
  - Medium Range
- Summary and ensemble needs

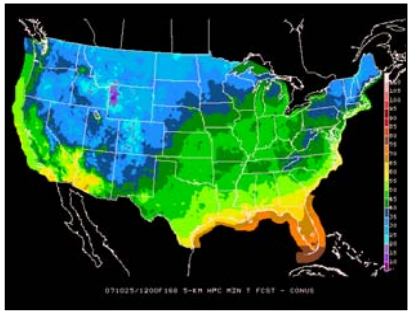
WPC Operational Desks



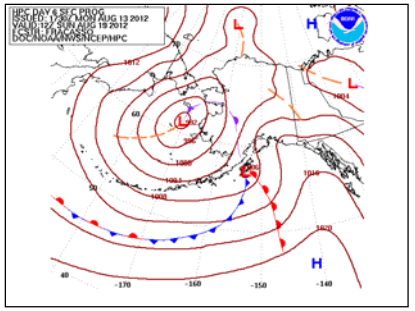
QPF



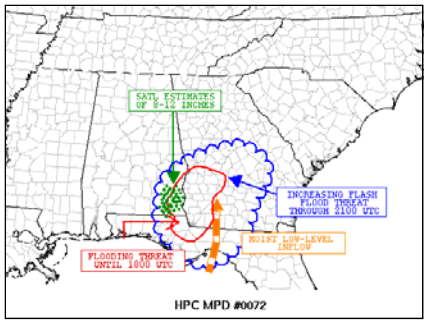
Winter Weather



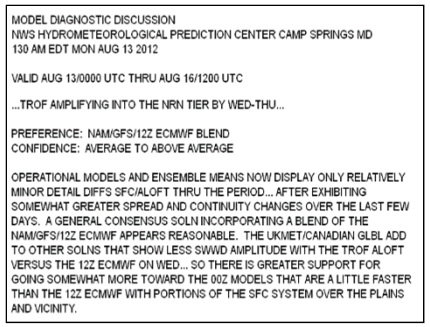
Medium Range



Alaska Med. Range



Met Watch


MODEL DIAGNOSTIC DISCUSSION
NWS HYDROMETEOROLOGICAL PREDICTION CENTER CAMP SPRINGS MD
130 AM EDT MON AUG 13 2012

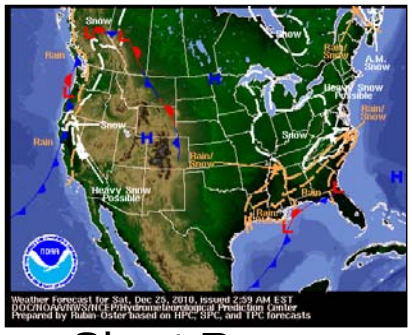
VALID AUG 13/0000 UTC THRU AUG 16/1200 UTC

...TROF AMPLIFYING INTO THE NRN TIER BY WED-THU...

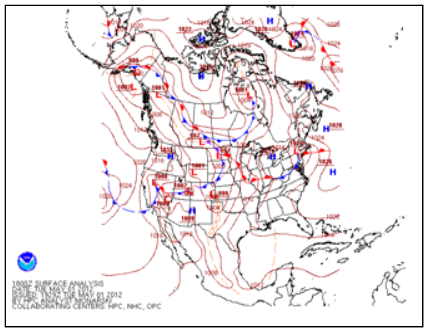
PREFERENCE: NAM/GFS/12Z ECMWF BLEND
CONFIDENCE: AVERAGE TO ABOVE AVERAGE

OPERATIONAL MODELS AND ENSEMBLE MEANS NOW DISPLAY ONLY RELATIVELY MINOR DETAIL DIFFS SFC/ALOFT THRU THE PERIOD... AFTER EXHIBITING SOMEWHAT GREATER SPREAD AND CONTINUITY CHANGES OVER THE LAST FEW DAYS. A GENERAL CONSENSUS SOLN INCORPORATING A BLEND OF THE NAM/GFS/12Z ECMWF APPEARS REASONABLE. THE UKMET/CANADIAN GLBL ADD TO OTHER SOLNS THAT SHOW LESS SWVD AMPLITUDE WITH THE TROF ALOFT VERSUS THE 12Z ECMWF ON WED... SO THERE IS GREATER SUPPORT FOR GOING SOMEWHAT MORE TOWARD THE 00Z MODELS THAT ARE A LITTLE FASTER THAN THE 12Z ECMWF WITH PORTIONS OF THE SFC SYSTEM OVER THE PLAINS AND VICINITY.

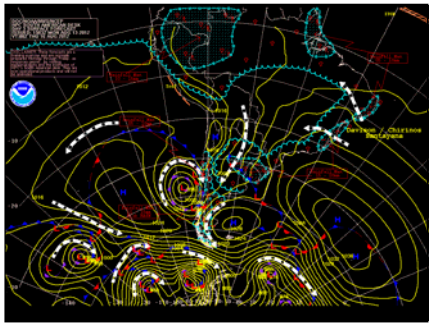
Model Diagnostics



Short Range



Surface Analysis

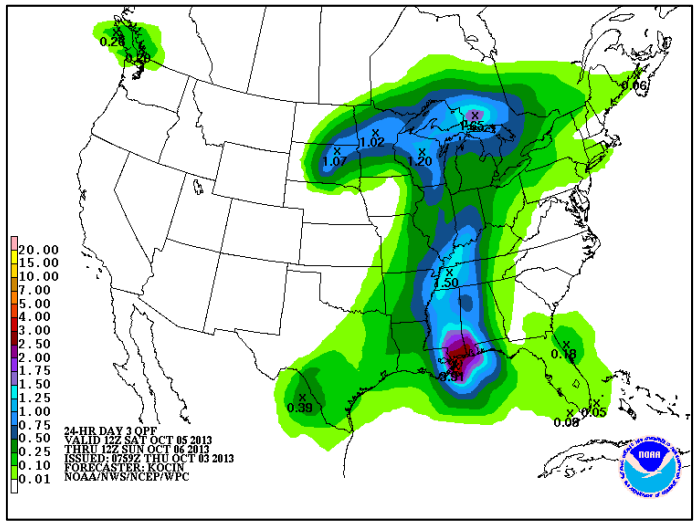


International

Tropical

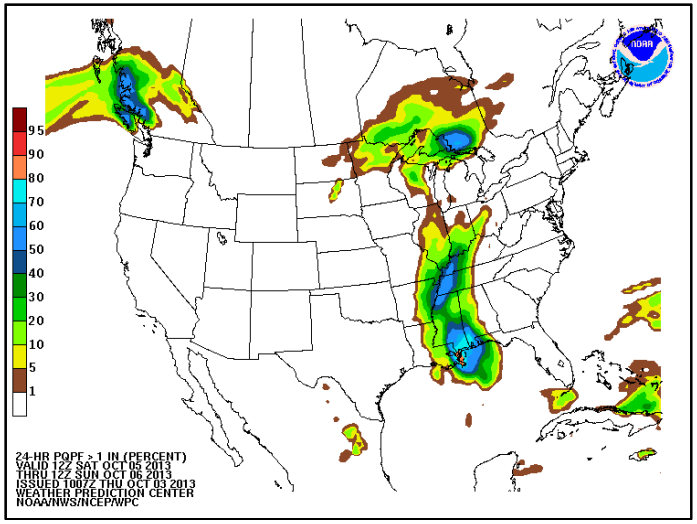
WPC QPF Products

Deterministic QPF



Forecaster assimilates all available guidance to determine the most likely deterministic solution

Probabilistic QPF (PQPF)

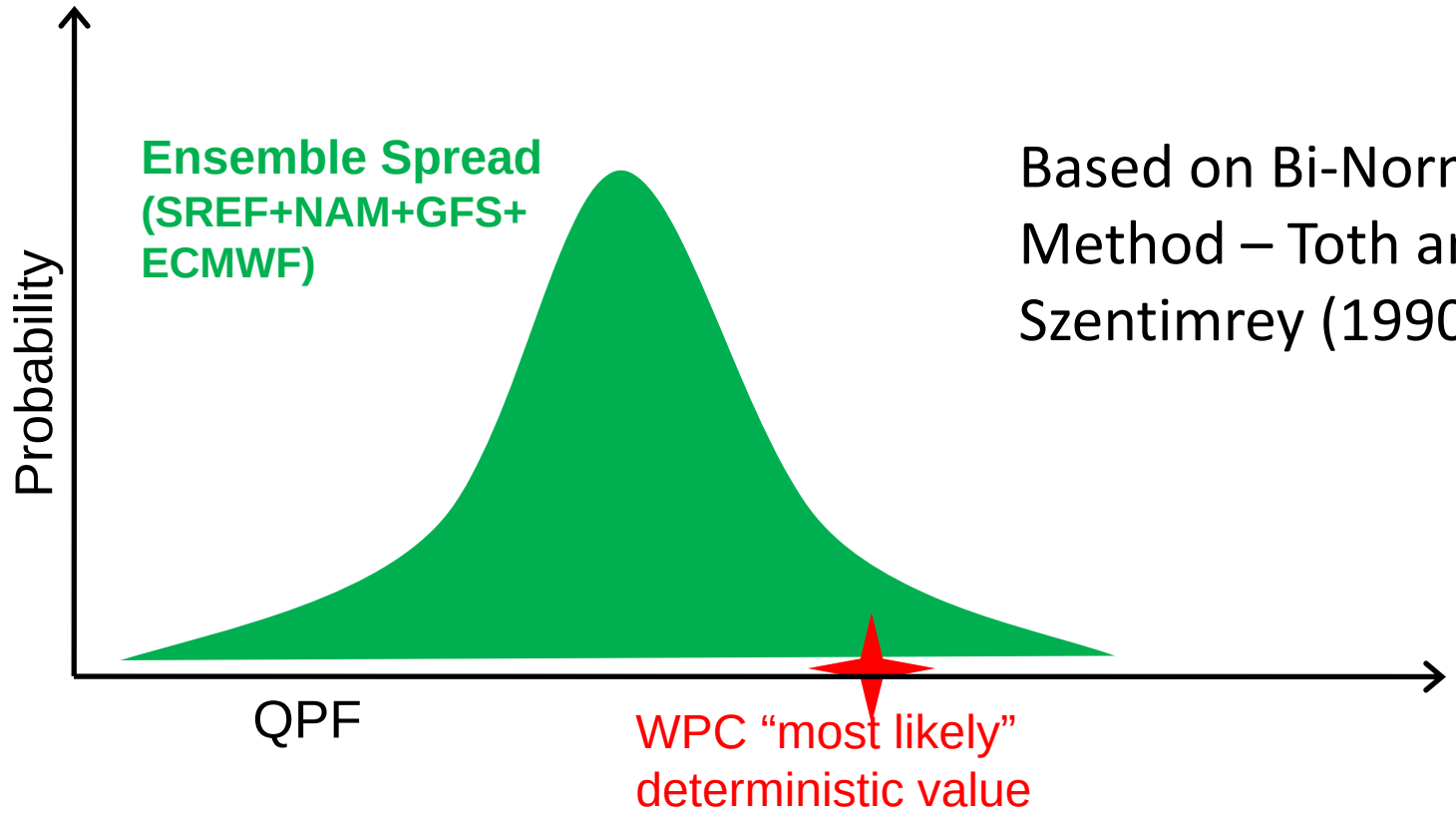


Automated process creates a PDF from a multi-model ensemble. WPC forecast is the mode.

http://www.wpc.ncep.noaa.gov/pqpf/conus_hpc_pqpf.php

WPC PQPF Method

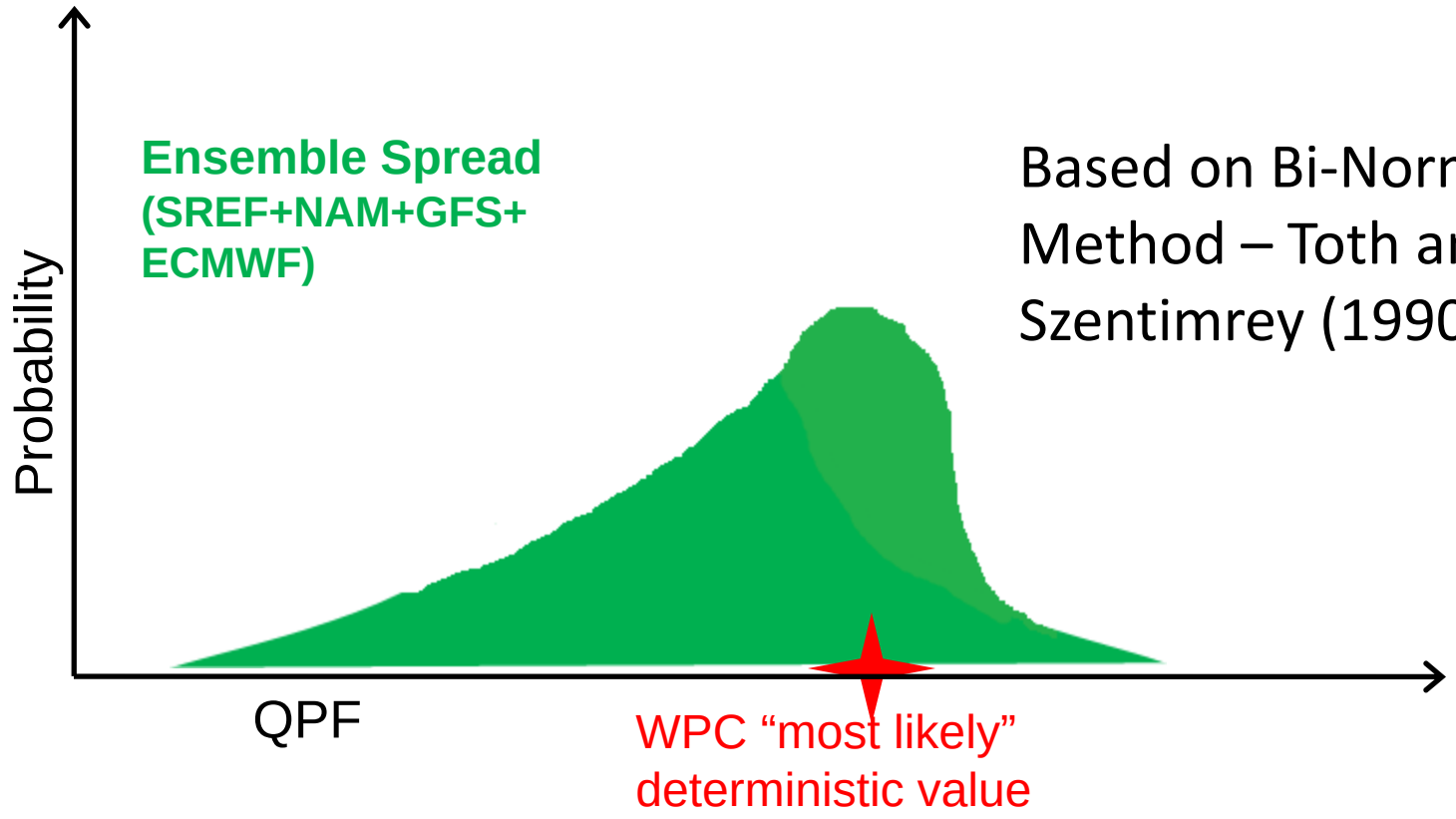
Modifies ensemble distribution such that WPC deterministic QPF is the mode, while allowing skew



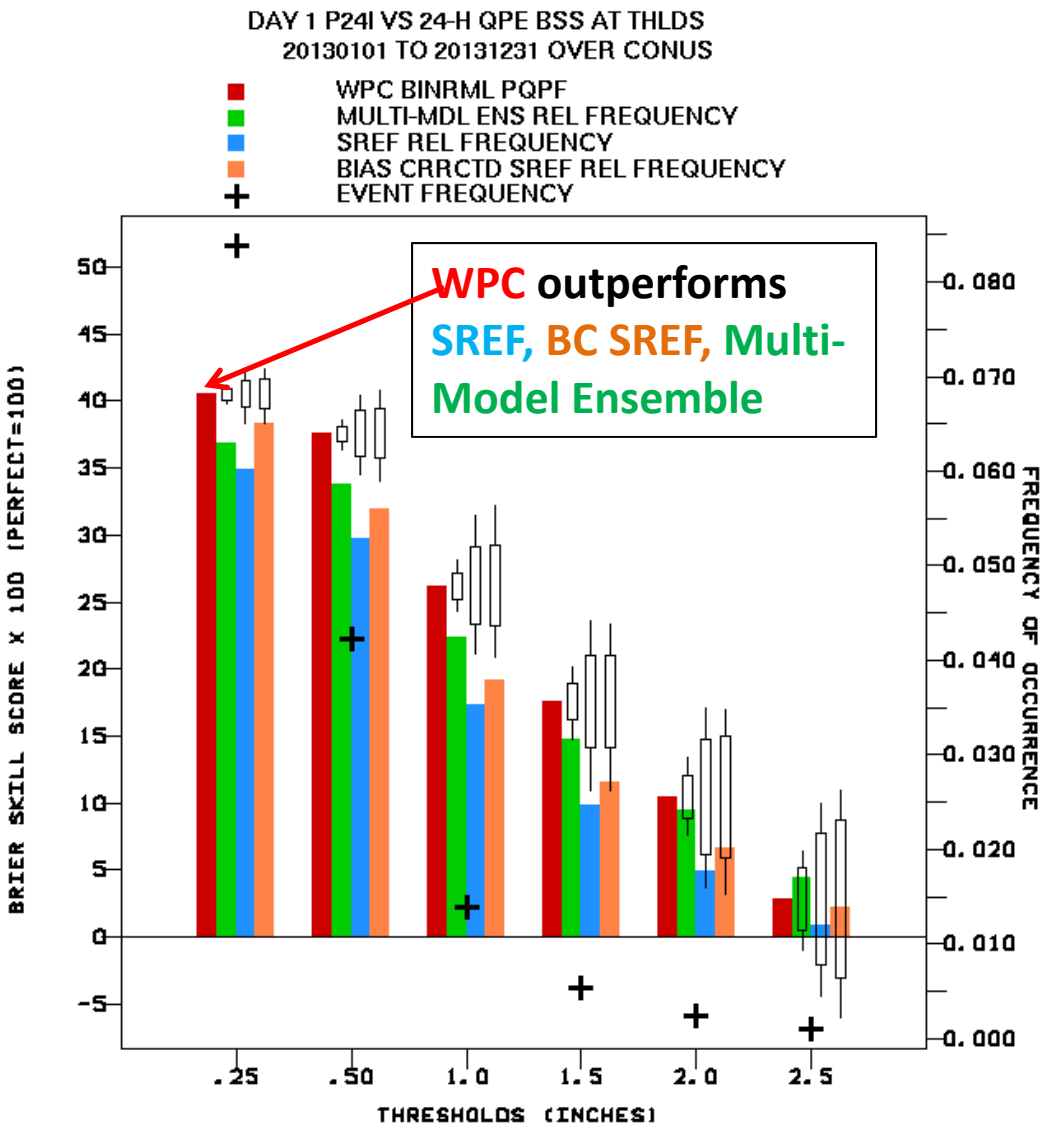
Based on Bi-Normal Method – Toth and Szentimrey (1990)

WPC PQPF Method

Modifies ensemble distribution such that WPC deterministic QPF is the mode, while allowing skew



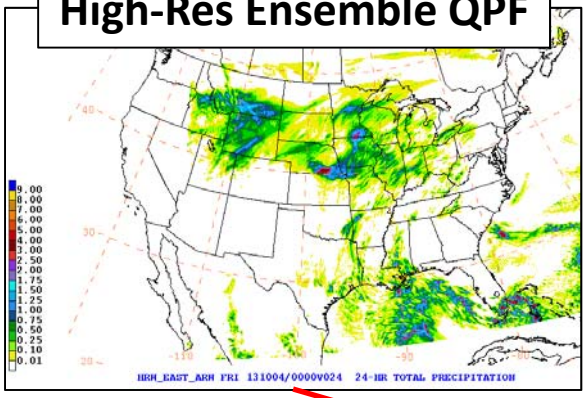
WPC PQPF – 2013 Verification



- WPC technique outperformed both SREF and multi-model ensemble in 2013
- Statistically significant improvement up to 2” threshold
- **Verification supports involvement of the forecaster**

Ensemble QPF Application: Flash Flood Forecasts

High-Res Ensemble QPF



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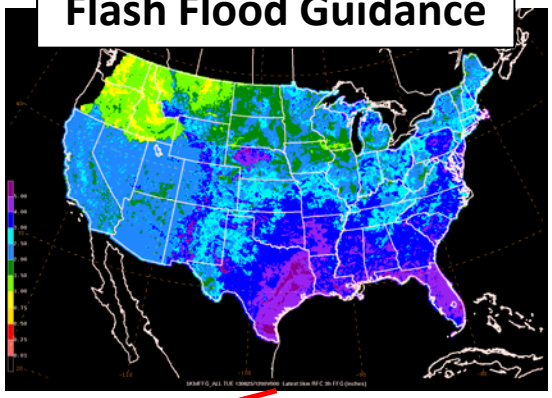
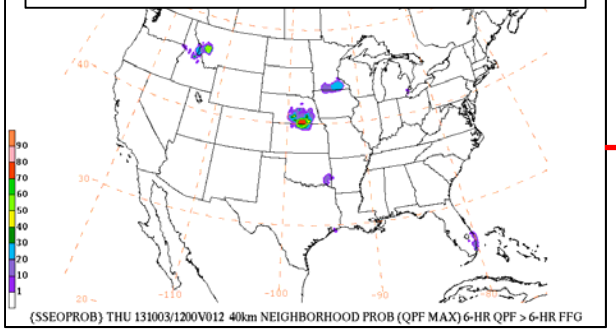
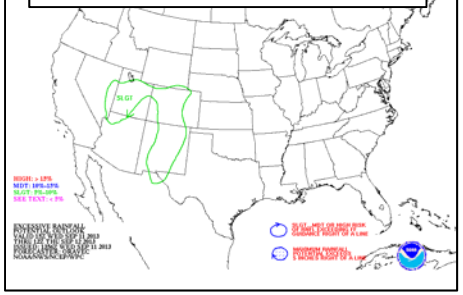
Flash Flood Guidance



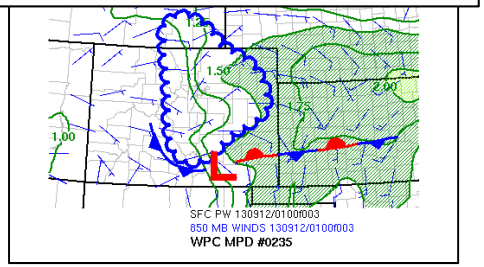
Probability of Flash Flood



Excessive Rainfall



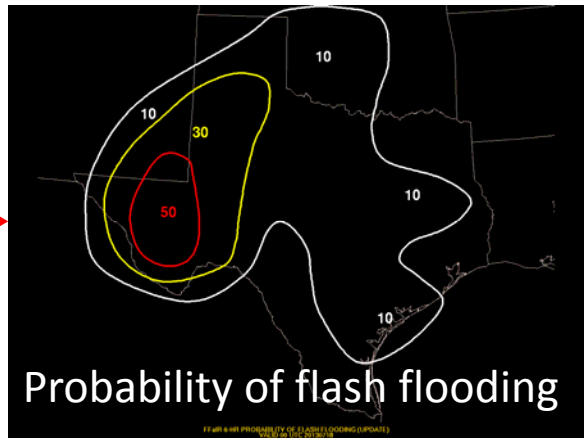
Mesoscale Discussions



- High-res ensembles are the foundation
- Need: reliable, unbiased, and sufficiently diverse ensemble QPF

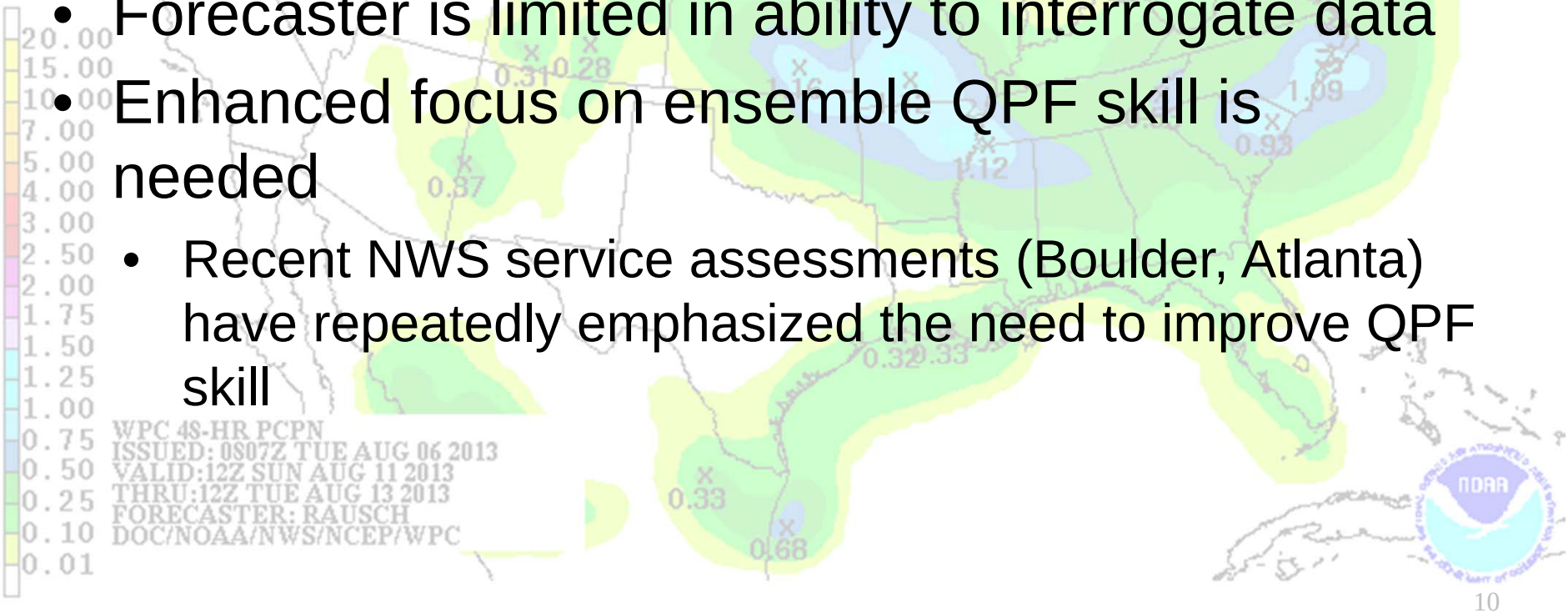
Flash Flood and Intense Rainfall (FFaIR) Experiment

- In 2013, WPC hosted a real-time forecasting experiment focusing on short-term flash flood forecasts
  - Produced probabilistic flash flood forecasts
  - Developed tools using operational and experimental ensemble QPF (EMC, ESRL)
- Planning ongoing for July 2014 experiment



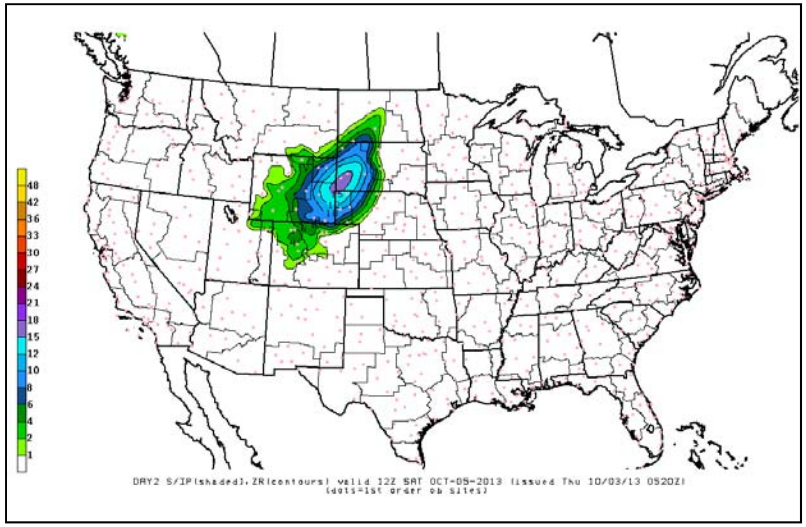
QPF: Next Steps and Needs

- WPC will continue to work with EMC and research community to test new ensemble systems
- Forecaster is limited in ability to interrogate data
- Enhanced focus on ensemble QPF skill is needed
  - Recent NWS service assessments (Boulder, Atlanta) have repeatedly emphasized the need to improve QPF skill



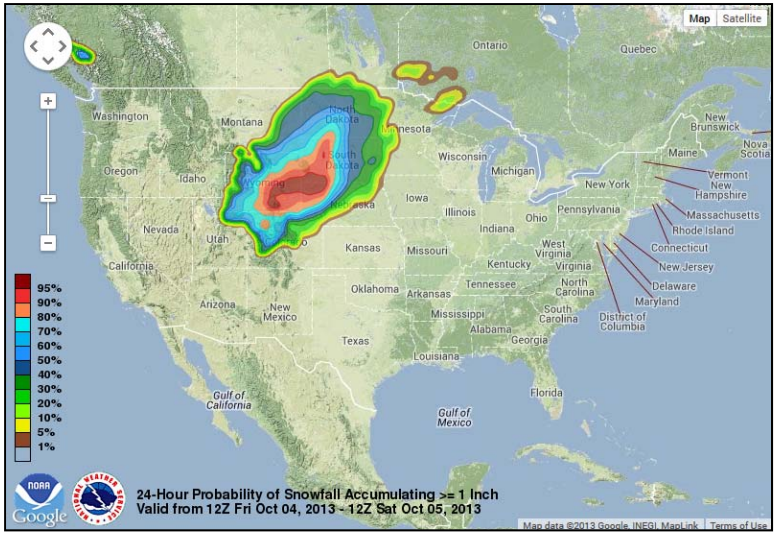
WPC Winter Weather

Deterministic Snow & Ice



- Forecaster assimilates all available guidance to determine the most likely deterministic solution
- Accounts for model shortcomings (bias, SLRs, etc.)

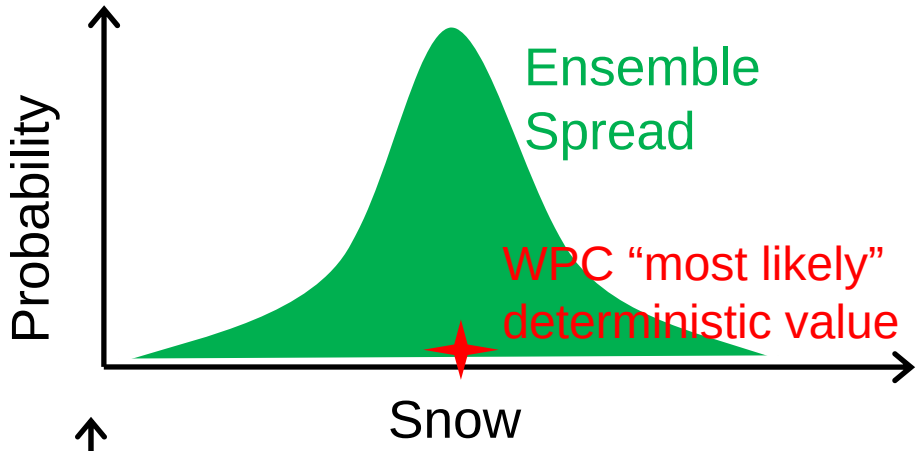
Probabilistic Snow & Ice

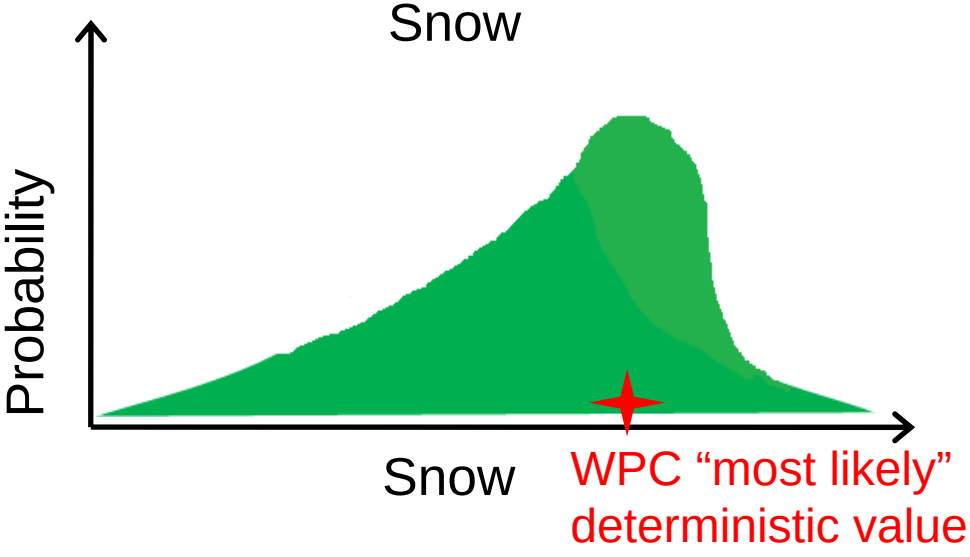


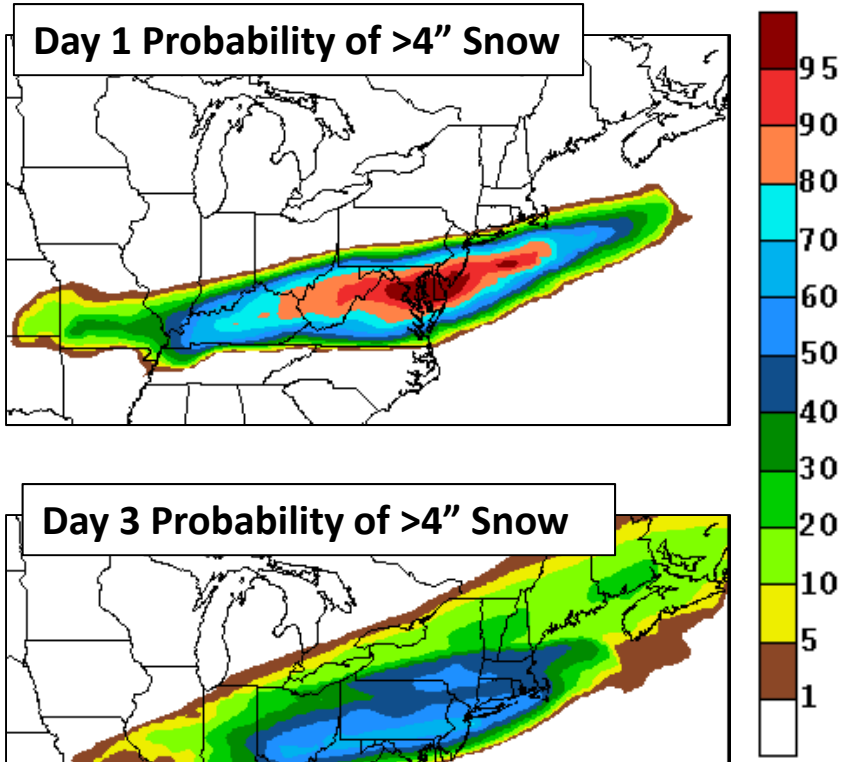
- Automated process creates a PDF from a multi-model ensemble.
- WPC forecast is the mode.
- 32 Ensemble Members

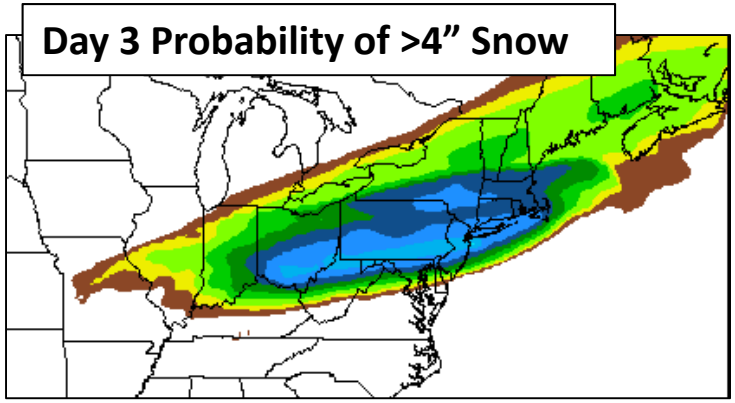
Winter Weather Forecasts: http://www.wpc.ncep.noaa.gov/wwd/winter_wx.shtml

March 4, 2014 Example



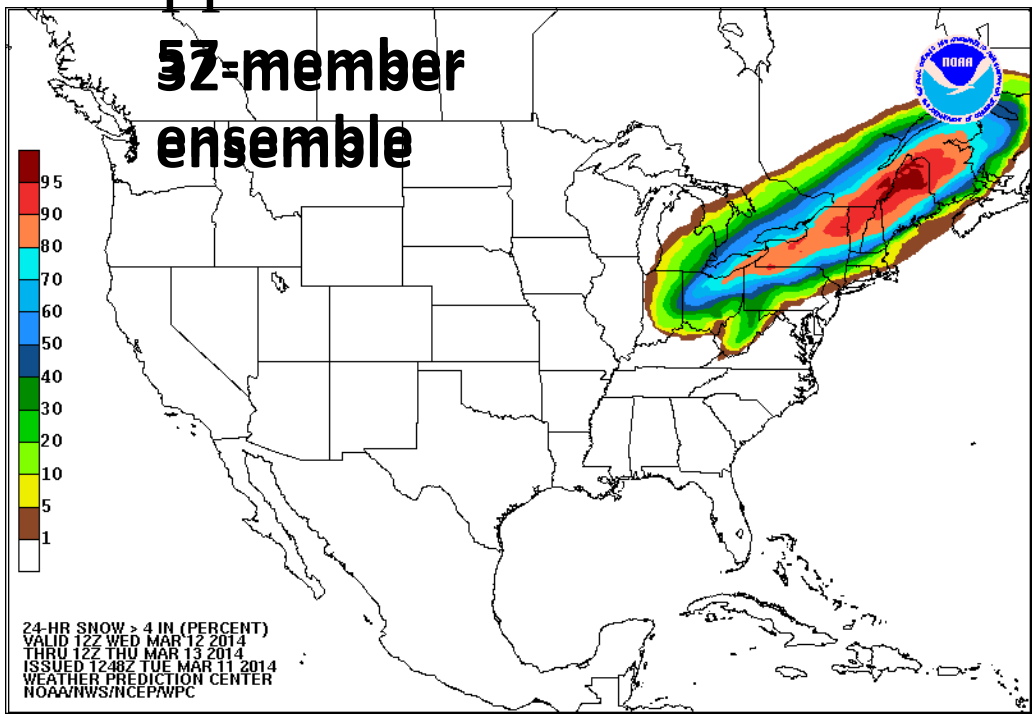






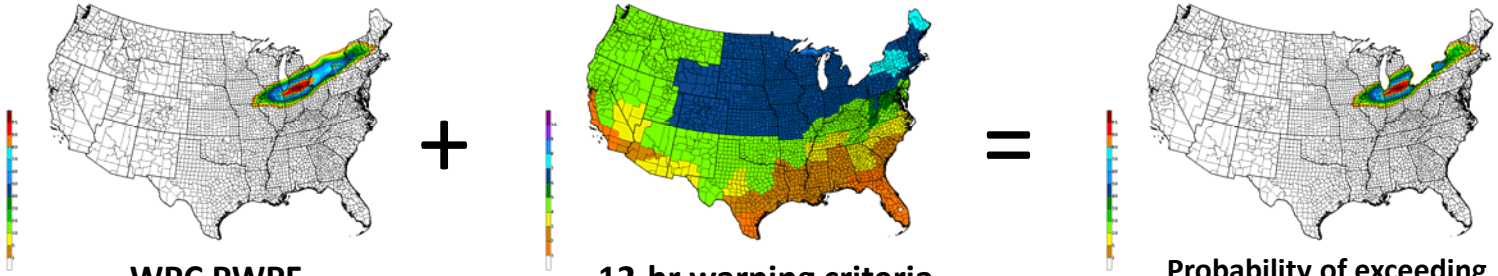
Ensemble-Derived Products

- WPC is working to further diversify the multi-model ensemble for probabilistic winter weather forecast (PWPF) product suite
- With skillful ensemble datasets, many products can be derived to support downstream users



Winter Storm Watch Recommender

Step #1 – Combine ensemble data and local warning criteria to determine the probability of exceeding warning criteria



WPC PWPF | **12-hr warning criteria** | **Probability of exceeding warning criteria**

Step #2 – If probability of exceeding warning criteria ≥ 50%, recommend watch issuance

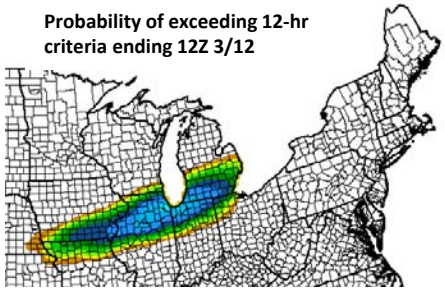
Probability of exceeding warning criteria

Watch issuance recommendation

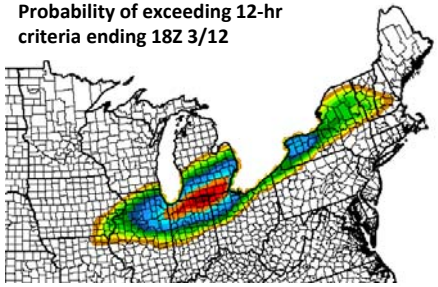
Step #3 – Aggregate watch recommendations over the entire 72 hr period to produce the final product

Example – 12 March 2014

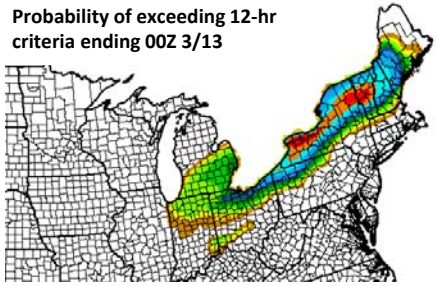
Probability of exceeding 12-hr criteria ending 12Z 3/12



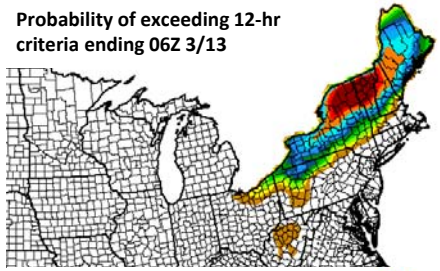
Probability of exceeding 12-hr criteria ending 18Z 3/12



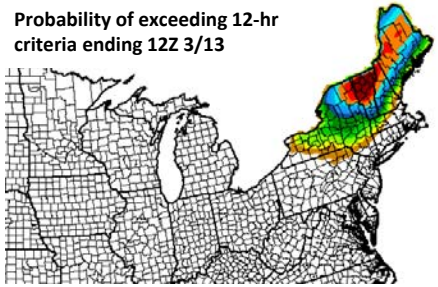
Probability of exceeding 12-hr criteria ending 00Z 3/13



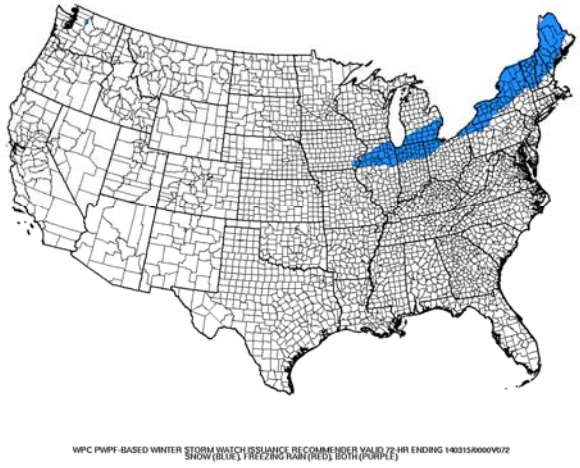
Probability of exceeding 12-hr criteria ending 06Z 3/13

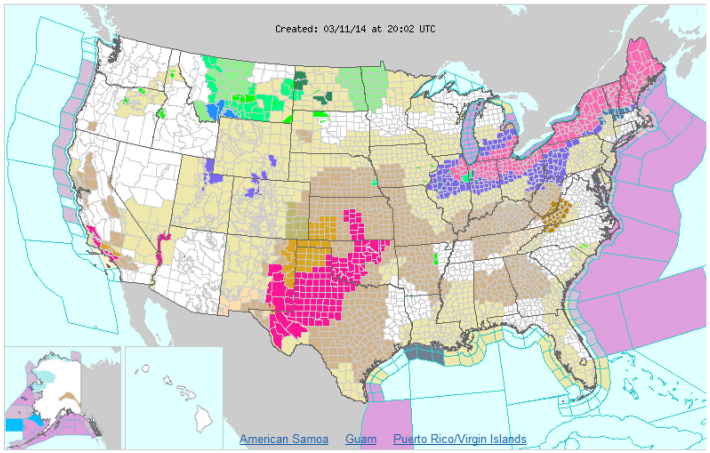


Probability of exceeding 12-hr criteria ending 12Z 3/13



watch recommendations for the 72 hr period ending 00 UTC 3/15 (12-hr criteria)

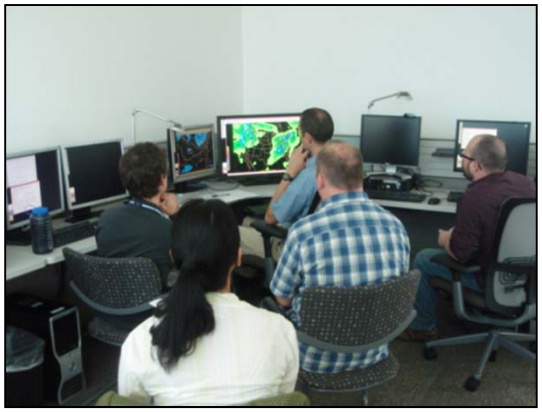




Watch Recommender is a tool for collaboration to achieve national watch/warning consistency

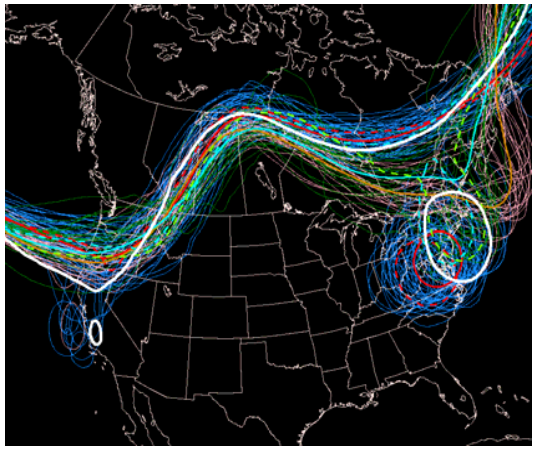
Winter Weather: Needs and Next Steps

- Enhanced focus on ensemble skill and reliability
  - Utility of probabilistic products critically dependent on underlying ensemble
  - Ensemble design (members, resolution, etc.) decisions based on skill/reliability
- WPC will continue to work with EMC and research community on new ensemble systems and new accumulation techniques
  - HMT-WPC Winter Weather Experiment

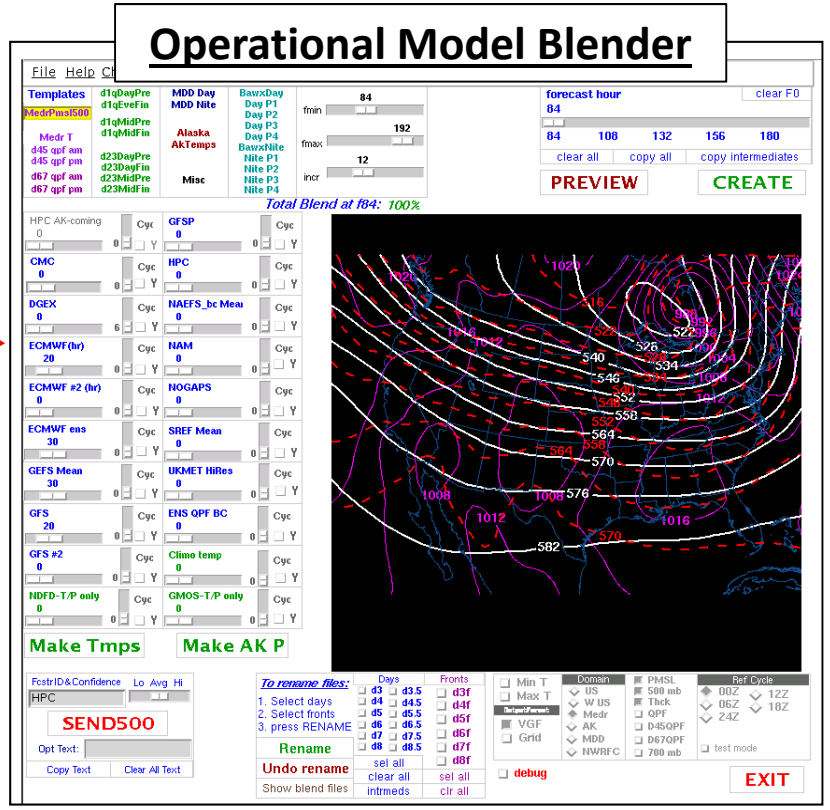


WPC Medium Range - Present

All International Ensemble Prediction Systems

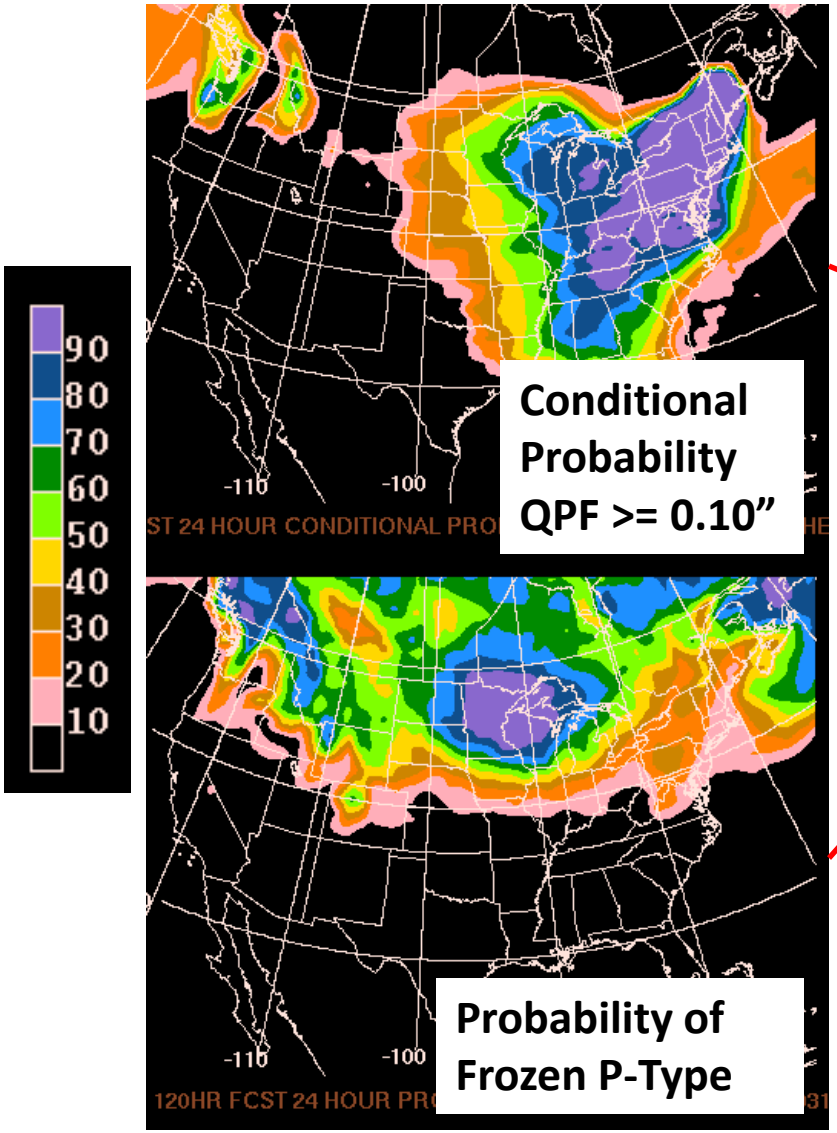


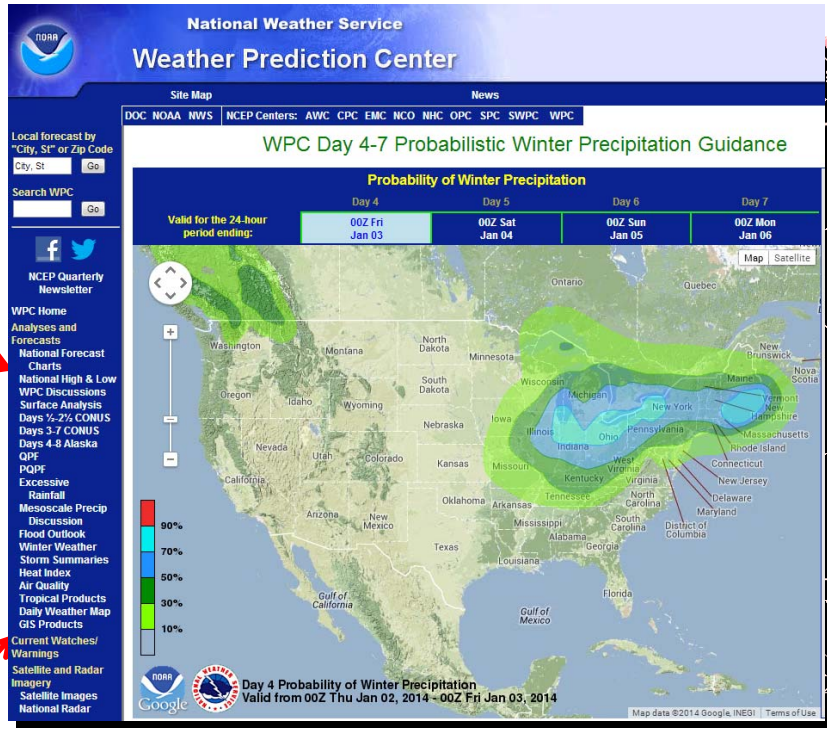
Operational Model Blender



- WPC operational products are almost exclusively deterministic
- Forecaster subjectively determines the “most likely” multi-model ensemble blended solution

Medium Range Hazards: Day 4-7 Winter Wx Outlook

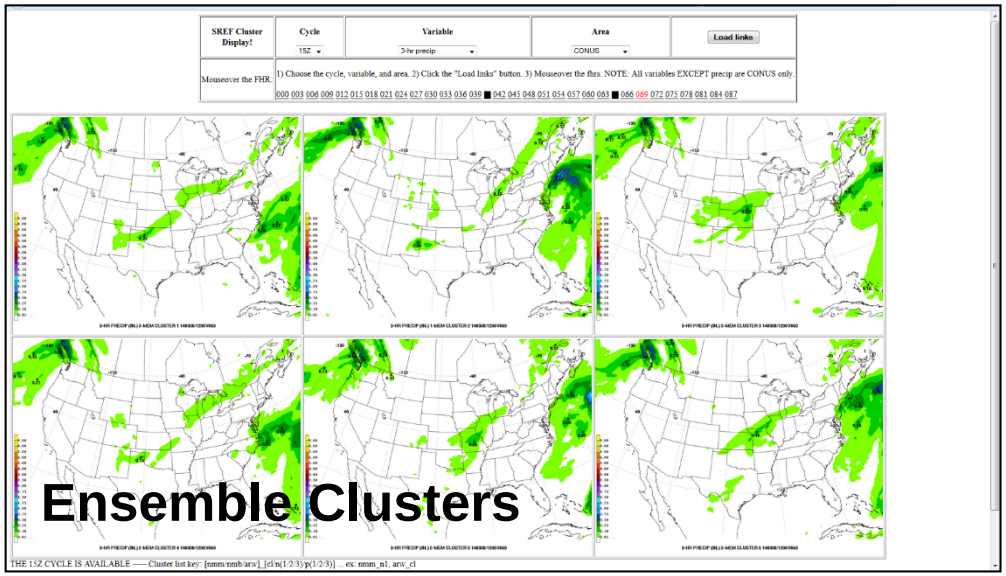


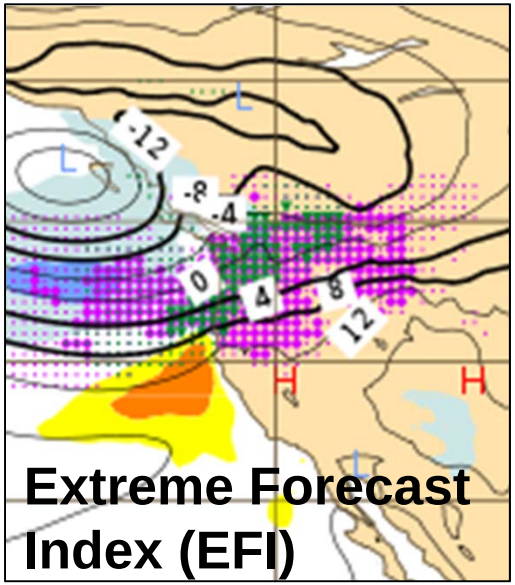


Uses all ensemble data (CMC, NCEP, ECMWF) to provide probability of “winter weather”

WPC Medium Range - Future

- In 2014, WPC plans to begin producing percentiles for max/min T, as well as extend probabilistic QPF to Day 7.
- Sandy Supplemental efforts will contribute new blended datasets to improve skill of consensus forecasts.
- Enhanced visualization and data processing techniques are necessary to bridge the gap between data and forecast services





Medium Range Forecasting: Next Steps and Needs

- WPC is beginning to develop probabilistic products for the medium range forecast suite
- Hazard-focused, ensemble-based products (EFI) – ongoing work with ESRL/GSD
- Sandy Supplemental datasets will be transitioned to operations
- Need well-calibrated global ensemble – Reforecasts and use of multiple ensemble systems will help

Summary: Ensemble Needs

- WPC operations are critically dependent on ensemble data
  - Decreasing emphasis on standalone deterministic models
  - Increasing focus on probabilistic products
- Ensemble needs:
  - Skillful and reliable ensemble QPF
    - Renewed focus on model physics?
  - Full suite of calibrated forecast variables
  - Advanced forecast tools integrated into AWIPS2

Extras

Summary: Ensemble Needs