Model Ensemble Tools for Winter Weather Forecasting

Winter Weather Seminar

WFO FWD

November 14, 2007

Topics

- Review the concept of model ensemble forecasting
- Discuss Ensemble visualization tools in Winter Weather Forecasting
- Examples and websites

Ensemble Prediction Systems Rationale

- Atmosphere is chaotic
  - Forecast sensitive to Initial Conditions (ICs)
  - Perturb ICs (e.g. breeding) to get most accurate range of forecast solutions possible
- NWP model formulations (esp physics) are imperfect approximations of behavior
  - Use different model configurations to cover possible forecast outcomes
- Use either IC perturbations, NWP model perturbations, or combination of both

NCEP EPS

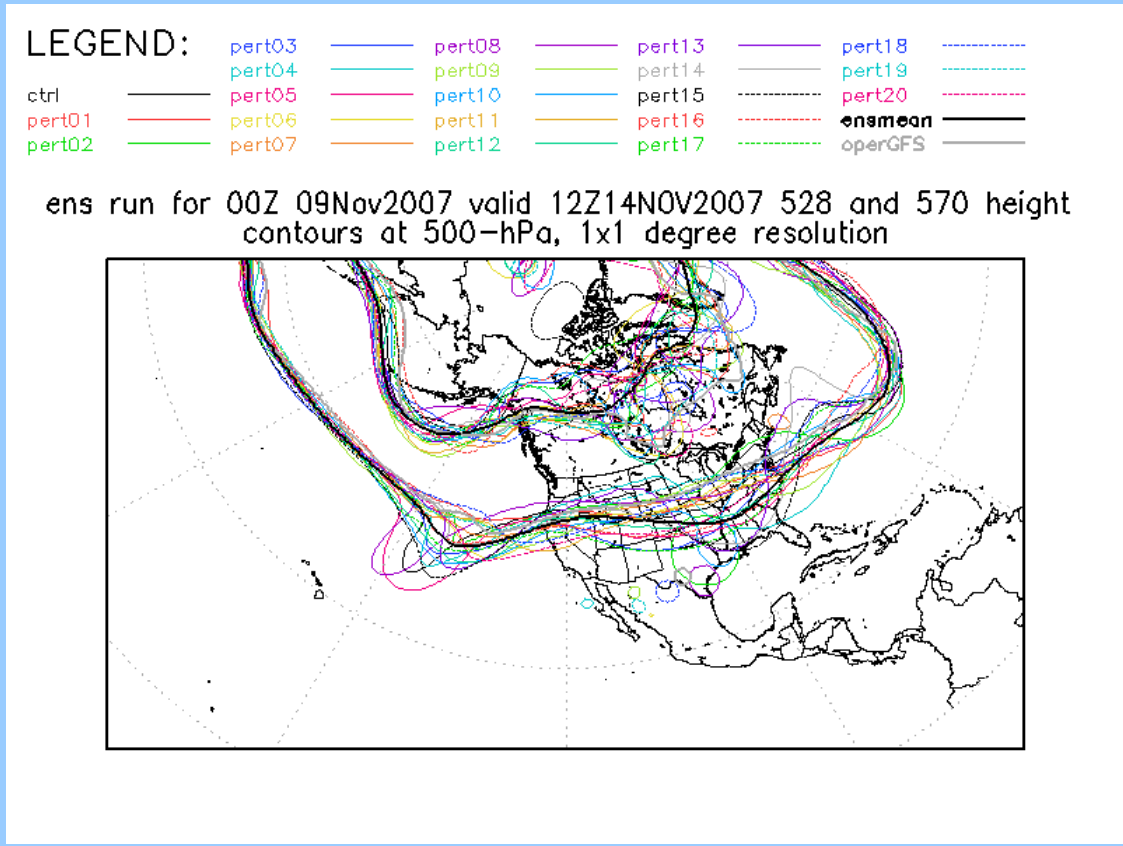
- Ensemble Prediction Systems at NCEP

1. NAEFS (formerly GEFS or MREF) is the North American Ensemble Forecasting System
   Major upgrade planned Dec 4, 2007

2. SREF – Short Range Ensemble Forecasting

Global Ensemble at NCEP

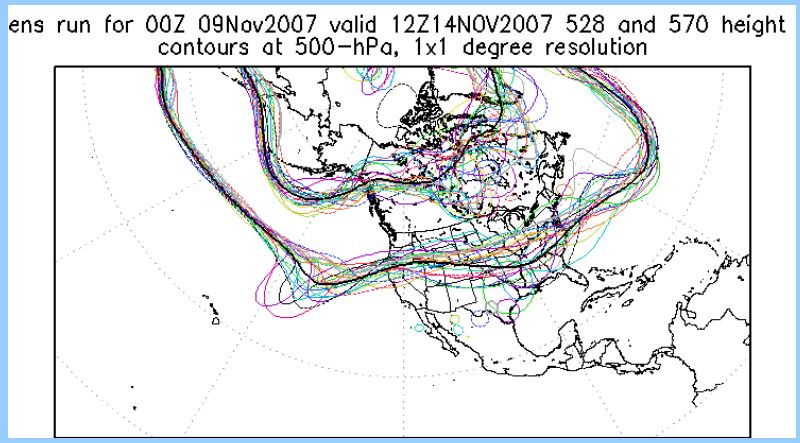
- Currently 21 members
- Operational control + 20 IC perturbations
- Members run at T126L28 (28 lyr, ~ 100 km)

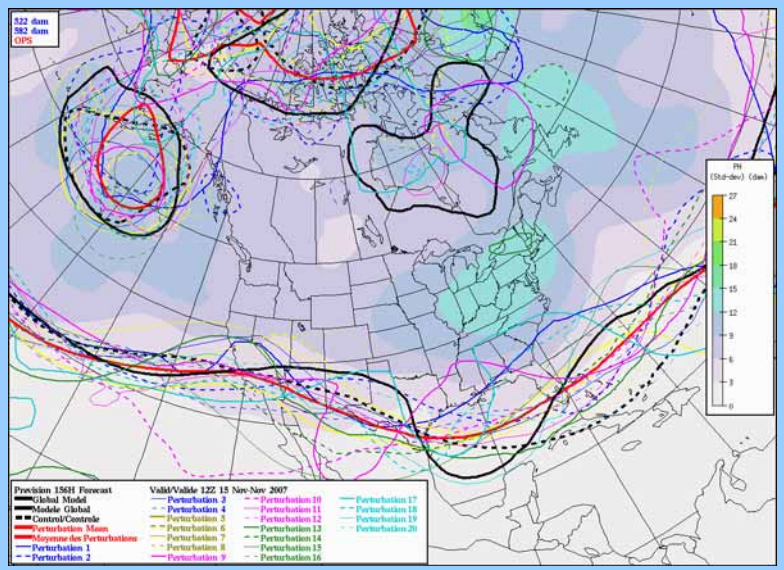


http://www.emc.ncep.noaa.gov/gmb/ens/

Major Upgrade – Dec 4 2007

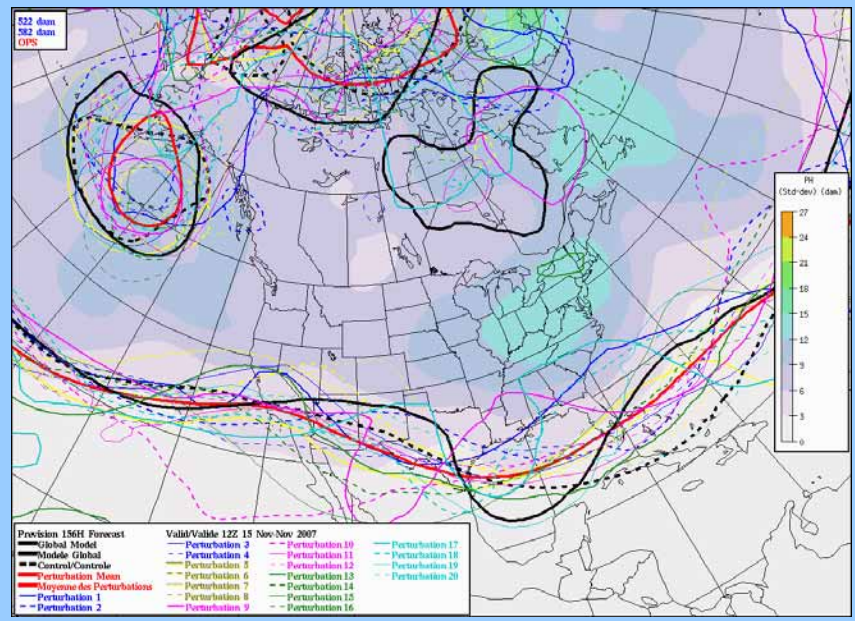
- Called NAEFS
- Add Canadian Model Ensemble!
- Total of 40 members
- Output through 384 h
- Bias correction, downscaling implemented



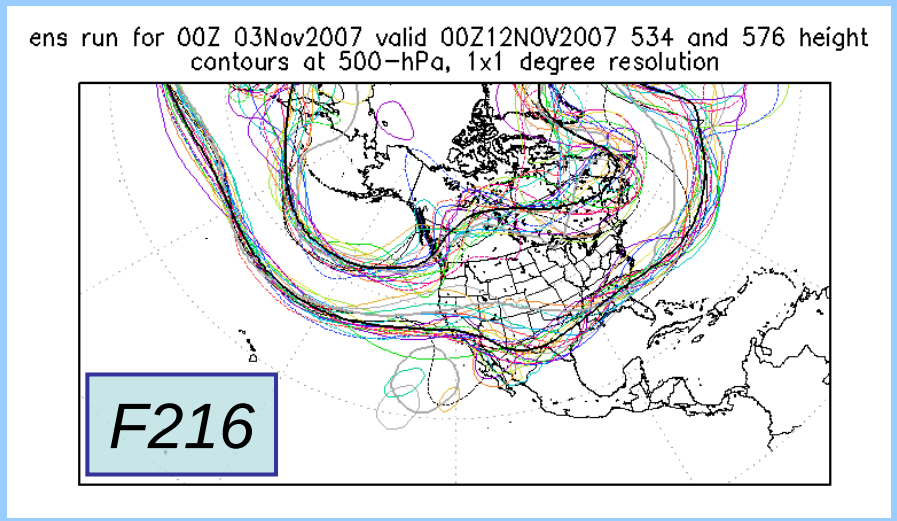


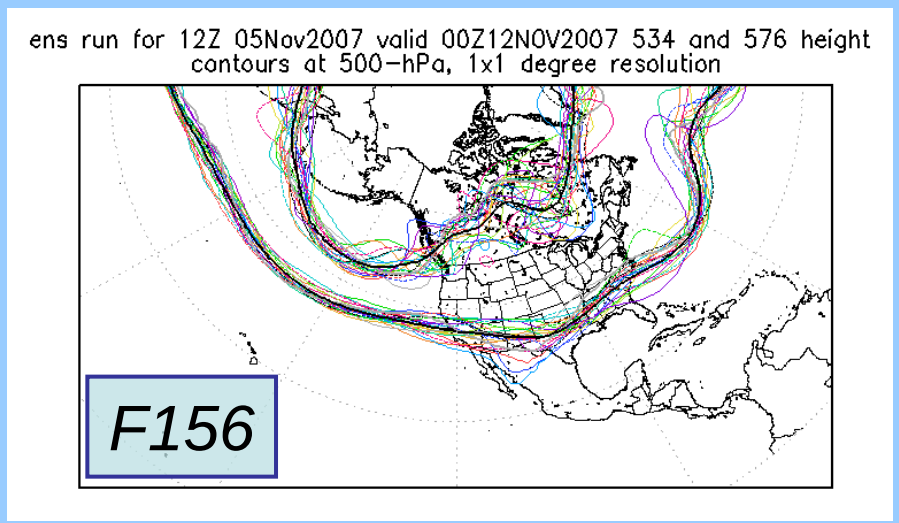
Using Global Ensembles in Medium Range Forecasting

- Relatively coarse resolution
- Look for large scale patterns in ensemble mean and spread, and spaghetti diagrams of individual ensemble members
  - Winter Weather Events – southern Rockies cutoff lows or patterns outlined by Ryan
  - Patterns favorable for Arctic outbreaks

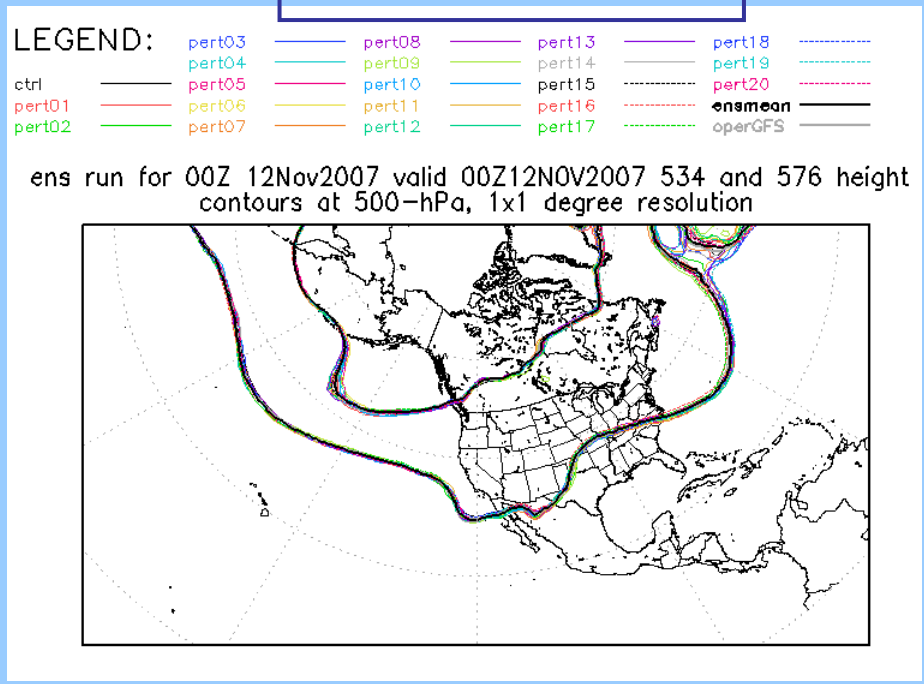


Global Ensembles – Example 00Z Nov 12, 2007





Verification



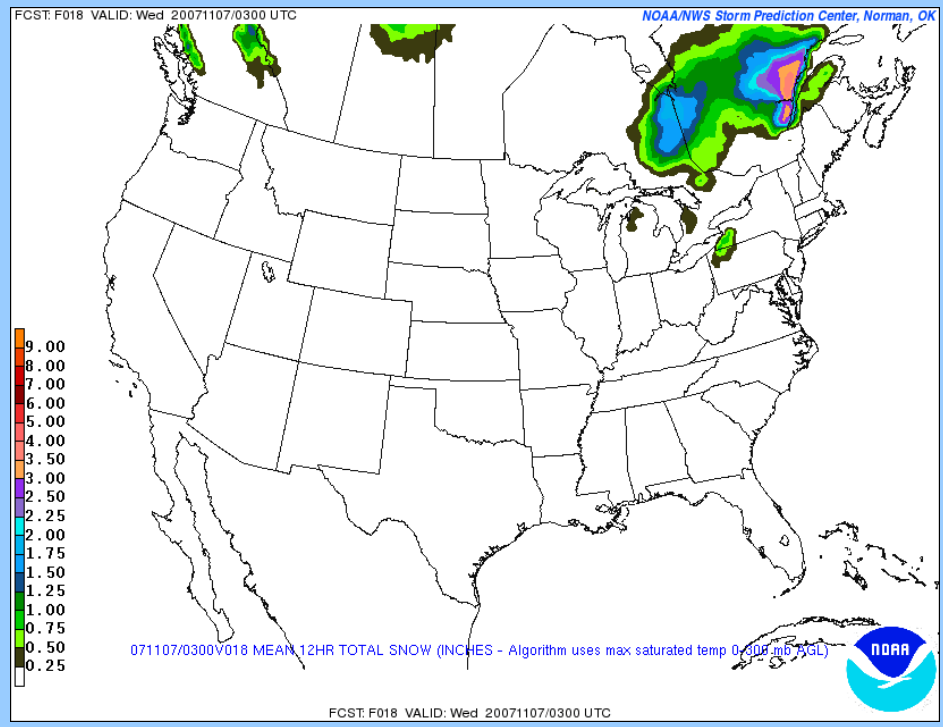
Ensembles - SREF

- 21 Members (22 for SPC graphics)
- Runs 4 times/day at 09Z, 15Z, 21Z, 03Z
- 3 hourly output to 87 hours
- SPC site has Winter Specialty graphics

http://www.spc.noaa.gov/exper/sref
http://www.spc.noaa.gov/exper/sref/frames.php?run=latest
Click on Winter Weather Tab in left frame

SREF Members

3 WRF-NMM (40 km)
3 WRF-ARW (45 km)
5 RSM (GFS) (45 km)
5 Eta – BMJ (32 km)
5 Eta – KF (32 km)
21 Total Members
+
1 latest WRF-NMM
22 Members (SPC)



Ensemble Visualization Tools

- Spaghetti Plots - select contours for most or all members
  - Display Ensemble Mean value
  - Display operational run(s)
- Mean and Spread
- Probabilities - % of members with a value exceeding some threshold
- Other tools – box and whiskers plots, plume diagrams

Mean and Spread: Advantages

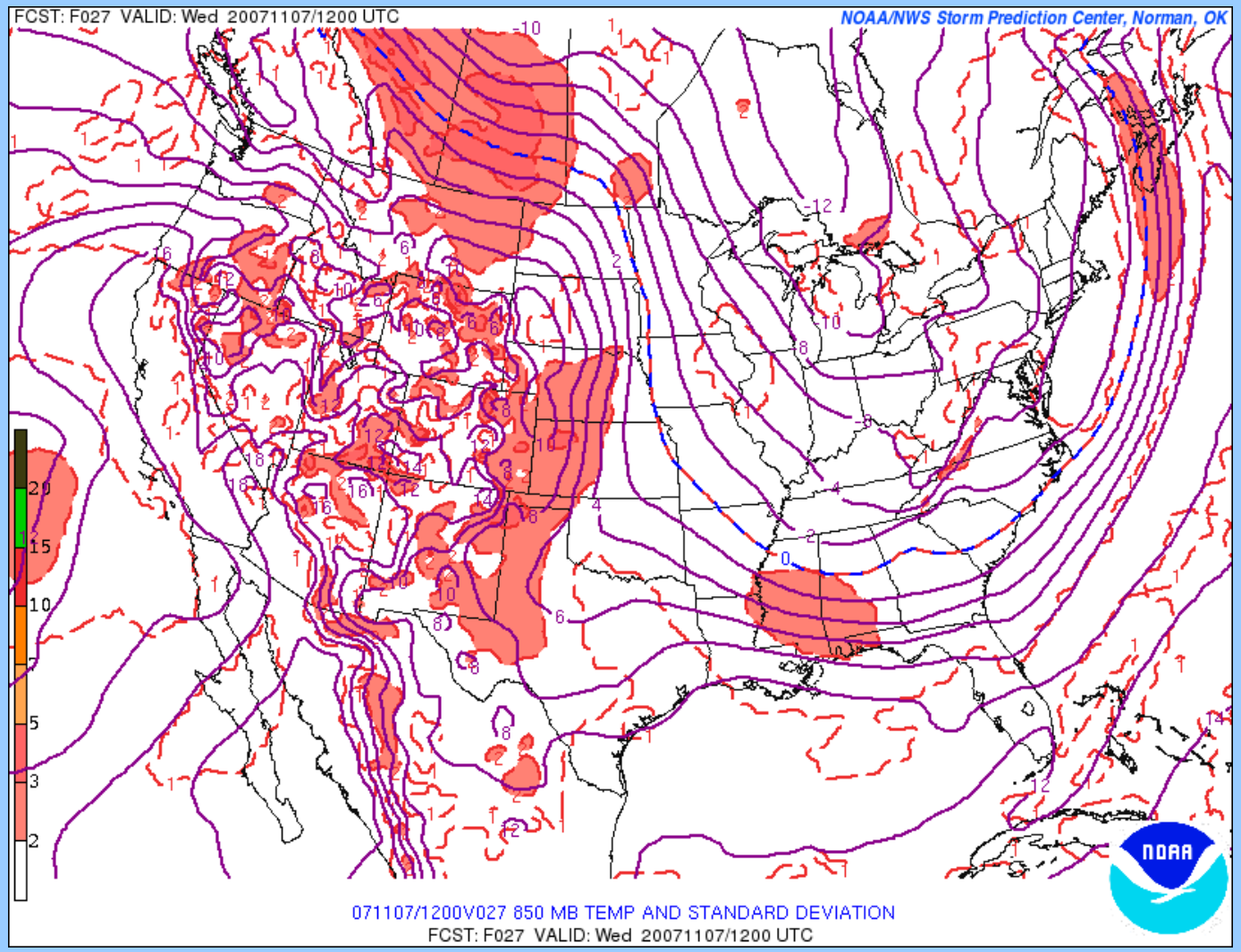
- Compact communication
- Can see field over entire domain
- Ensemble mean *on average* has greater skill than any individual member
- Spread (sample standard deviation) quantifies the degree of uncertainty

Mean and Spread: Limitations

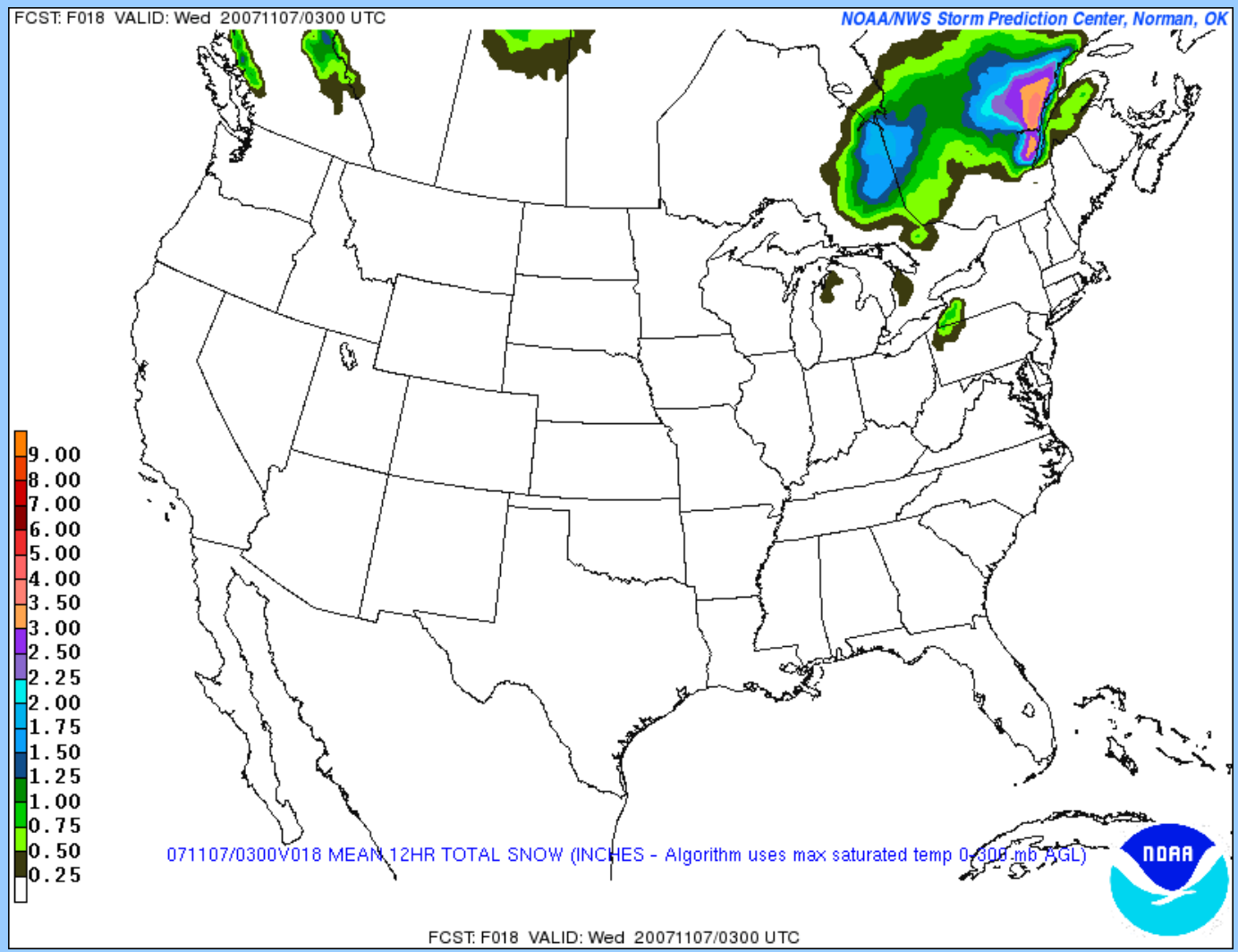
- **Mean may hide important details**
  - **Bi- or multi-modal solutions**
  - **Timing problems in prediction of features**

  COMMON PROBLEM: cyclone/shortwave timing mismatches – all members have wave/cyclone but shows up much weaker in ensemble mean (phase cancellation)
  - **Precipitation forecasts (particularly where convective precipitation is expected to be important)**
- **Can use spread as guide to where mean may not be communicating the correct information, and use additional tools to make further assessments**

Mean and Spread – 850 mb T



Mean – 12 hr Snowfall Amount



Probability charts: Advantages

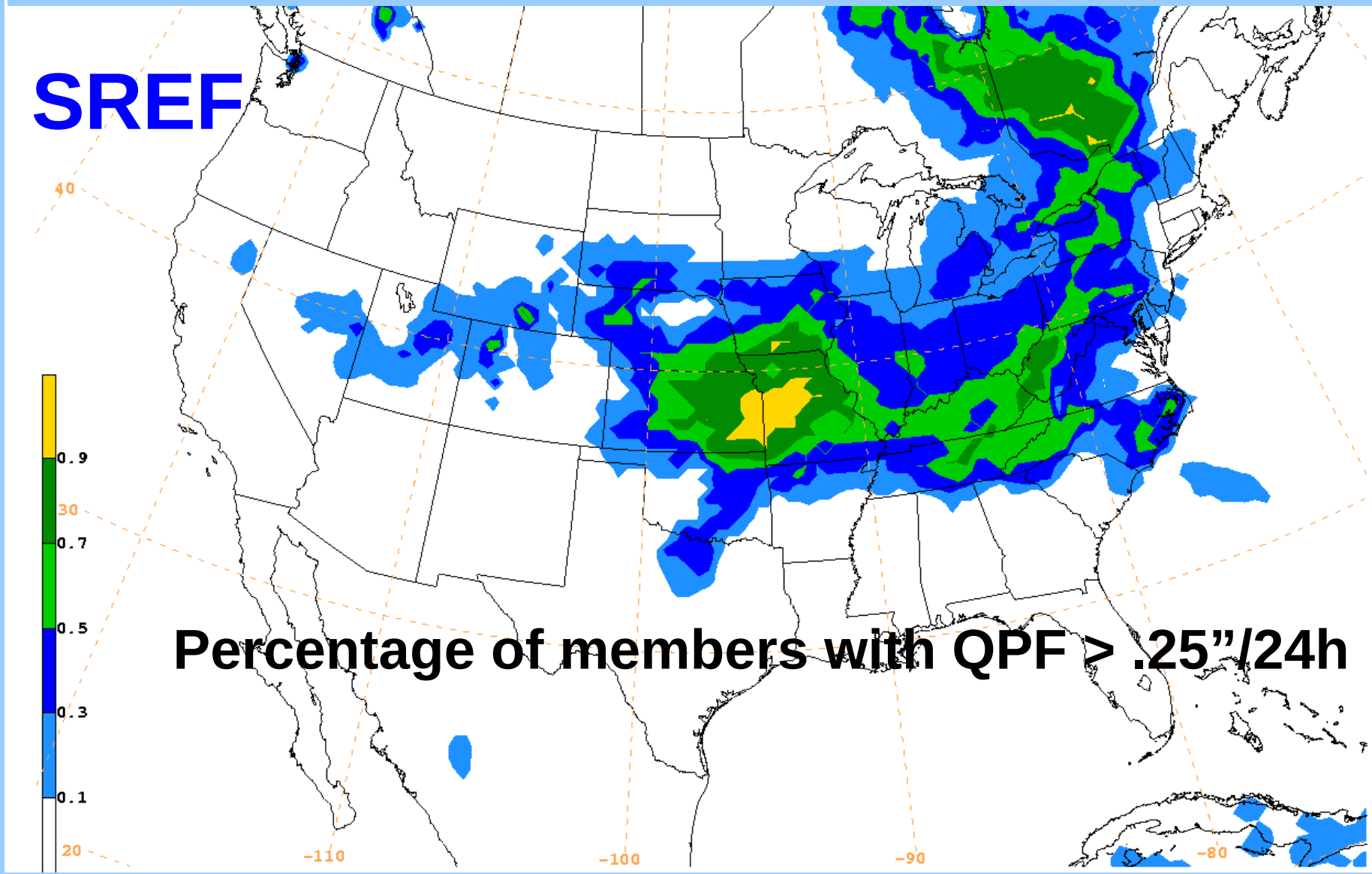
- Depicts probabilities for exceeding critical value in a compact manner
- Variable of interest is seen over the full domain
- Uses actual distribution of data from ensemble members to determine probabilities. Ex: 11 of 22 members have $T_{850} = 0$ at a grid pt, then Prob = 50%

Probability charts: Limitations

- Only know percentage of ensemble members that exceed some threshold value (sampling problem of limited ensemble size)
- Need to use several threshold values for complete picture
- Does not depict maximum value

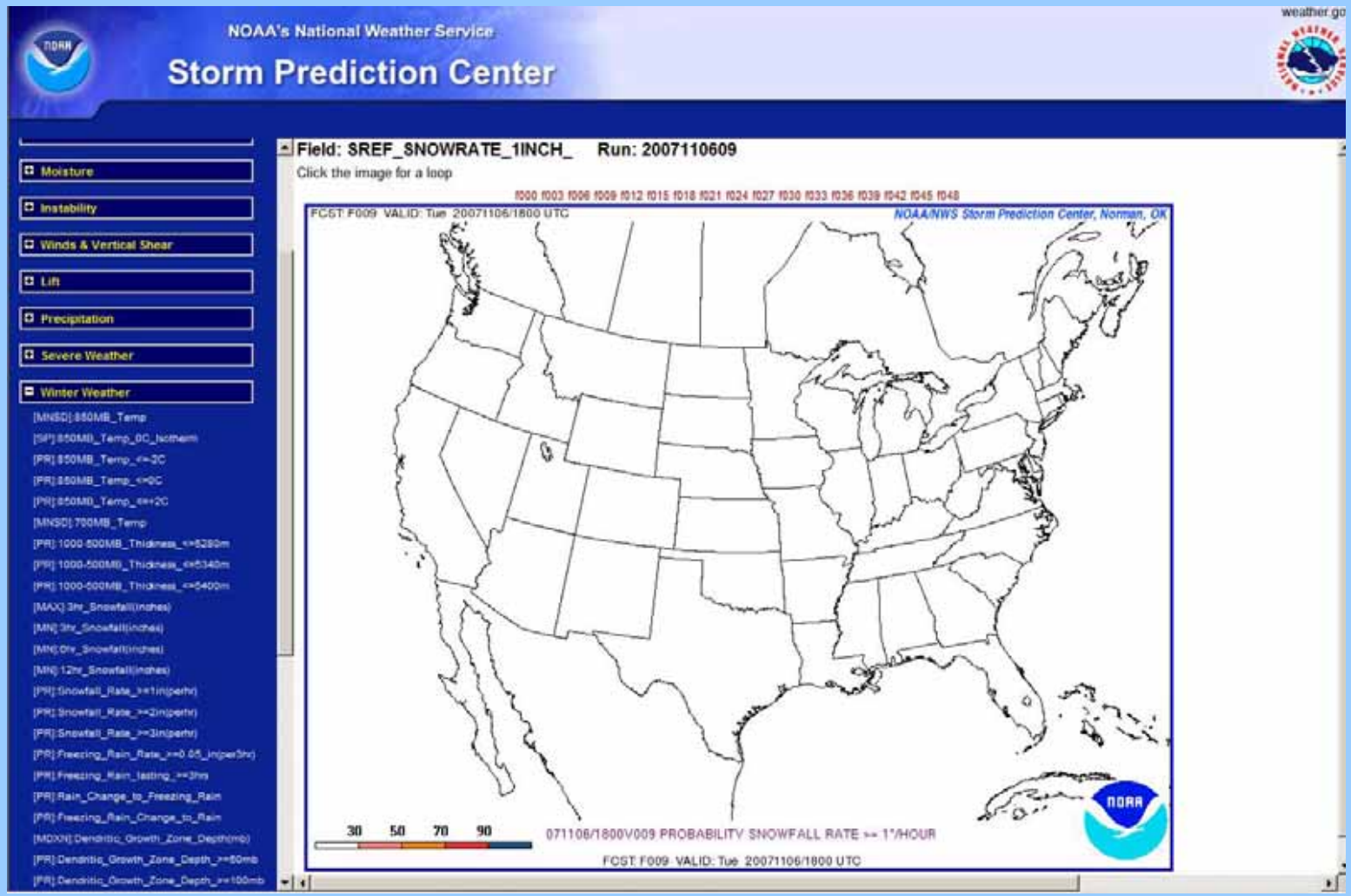
PROBABILITY CHARTS

percentage of ensemble members with value exceeding threshold

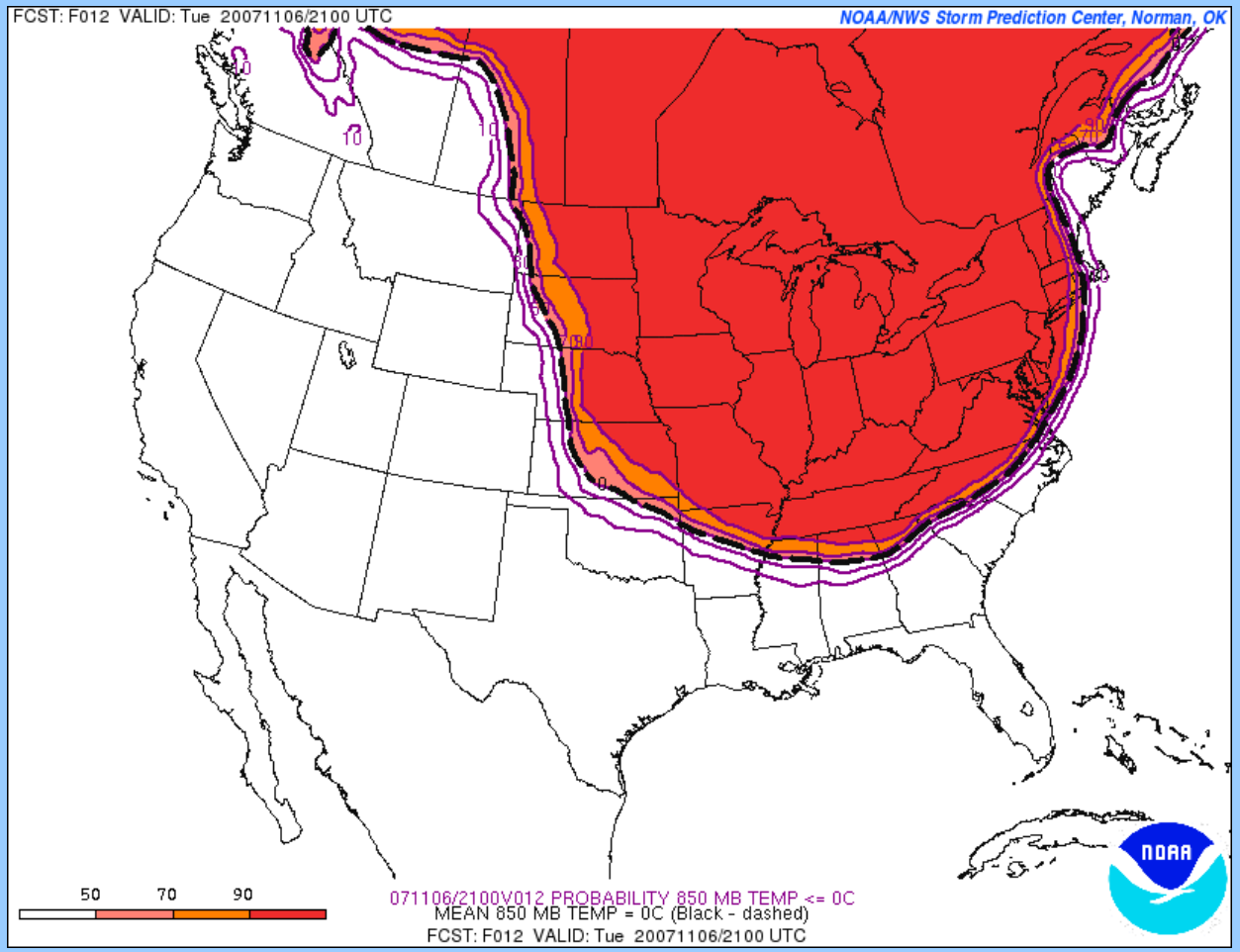


010519/0000V63 SREFX-CMB; 24HR PQPF OF .25”

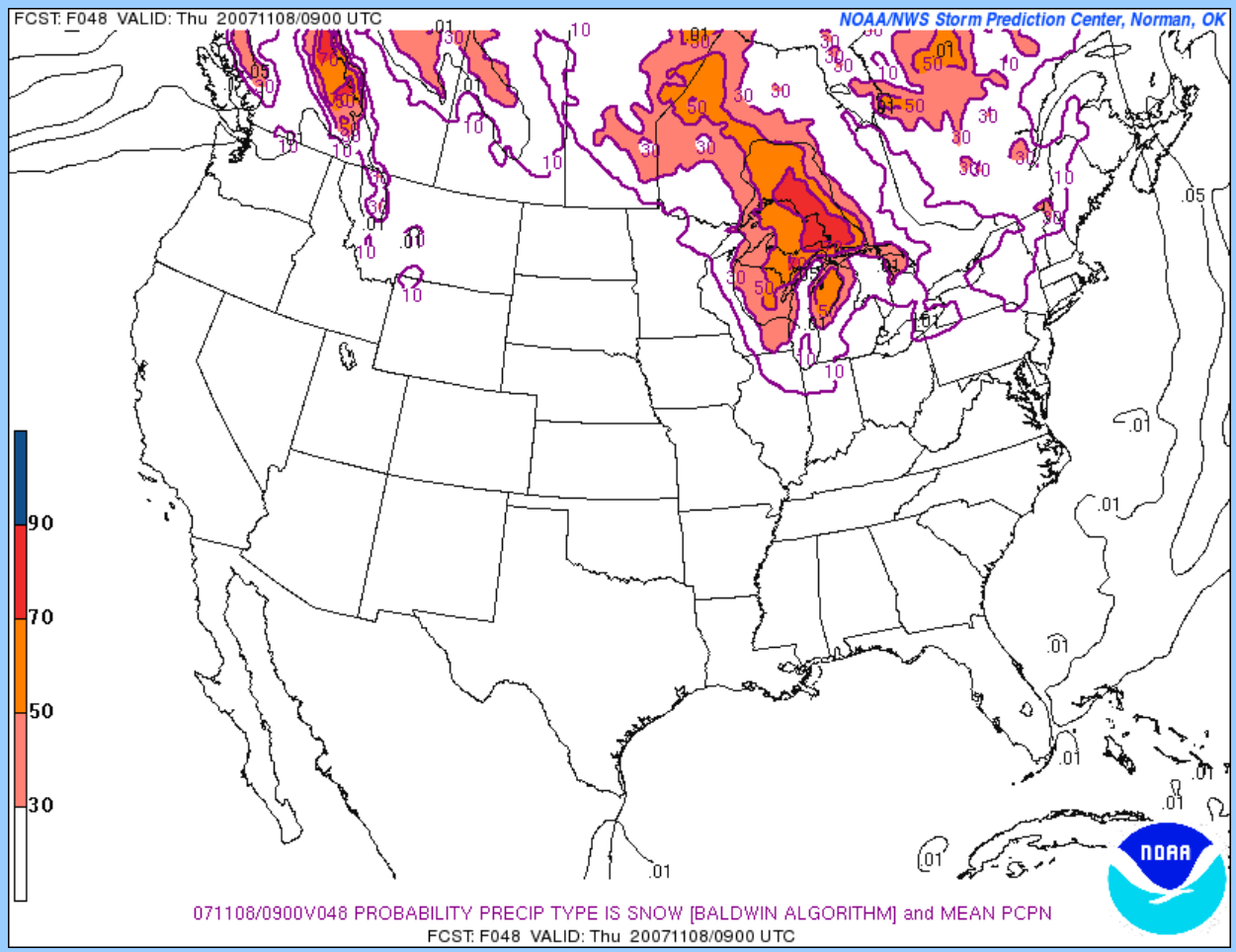
http://www.spc.noaa.gov/exper/sref/frames.php?run=latest



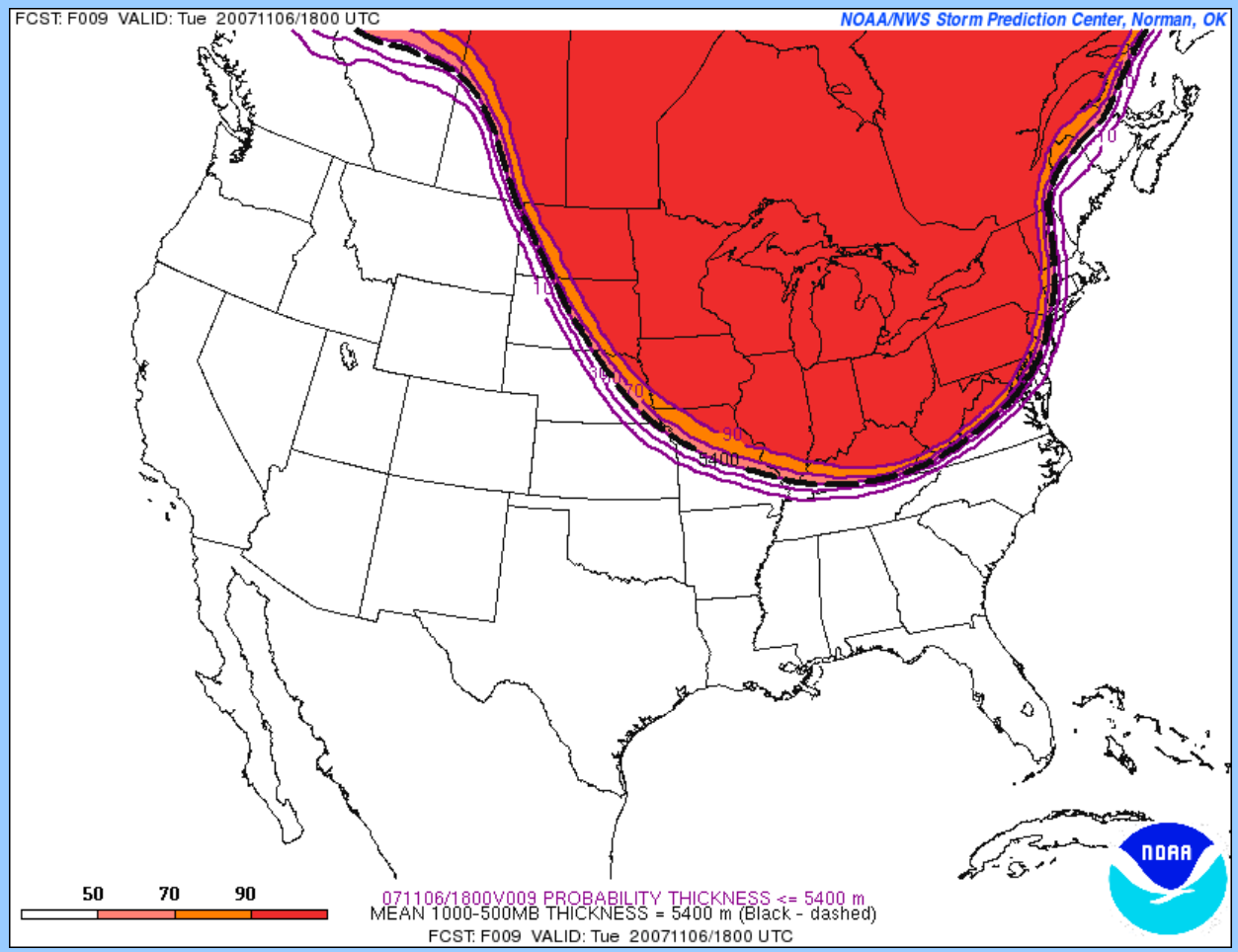
Probability of 850 Temp <= 0 C



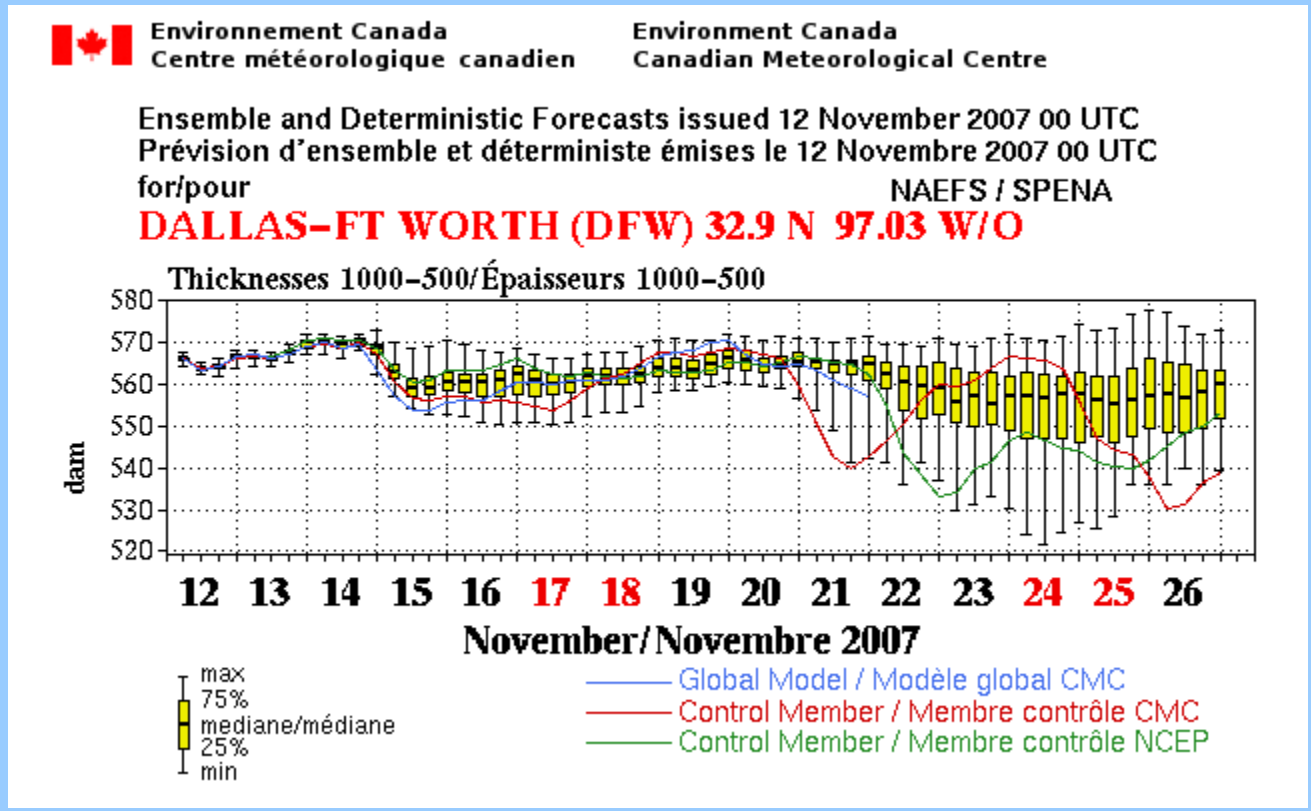
Probability – Precip Type is Snow



Prob of Thickness < 5400 m



CMC Ensemble Page – Example 12Z Nov 12, 2007



http://www.weatheroffice.gc.ca/ensemble/EPSgrams_e.html

Ensemble Web Pages

http://www.spc.noaa.gov/exper/sref - SPC SREF page

http://www.hpc.ncep.noaa.gov/ensembletraining/ - training page

http://www.emc.ncep.noaa.gov/gmb/ens/index.html - global ensemble home

http://www.emc.ncep.noaa.gov/mmb/SREF/SREF.html - SREF home

http://www.cdc.noaa.gov/map/images/ens/ens.html - PSD page

http://www.weatheroffice.gc.ca/ensemble/index_naefs_e.html - Environment Canada

http://www.weatheroffice.gc.ca/ensemble/EPSgrams_e.html - CMC EPSgrams

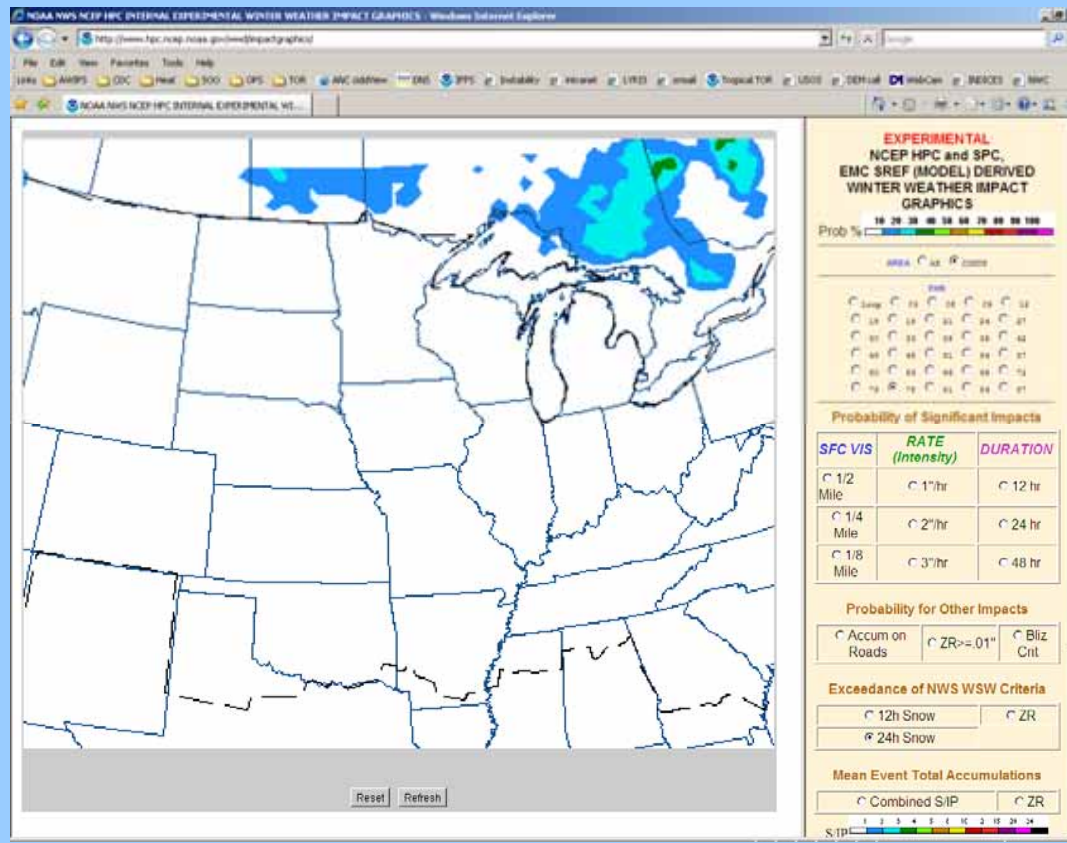
END


Bizarro
By Dan Piraro
LETS STICK ONE OF THESE UP THERE AND SEE HOW MANY CALLS WE GET.
PIRARO

Experimental WW Impact Graphics

http://www.hpc.ncep.noaa.gov/wwd/impactgraphics/

- **Image content automatically derived strictly from SREF output**
- Societal Impact of Winter Events defined by more than just accumulation
  - Duration, Timing, Intensity
- “Heads Up” of impact can be provided via SREF derived probability graphics highlighting these attributes



Partial Thicknesses

Layer	*Best for Snow or Frozen*
1000-500mb	<= 5400 m
1000-850mb	<= 1300 m
850-700mb	<= 1540 m
1000-700mb	<= 2840 m