Post-processing Activities in WPC, Probabilistic Techniques, and Data Requirements

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NOAA Statistical Post-processing Workshop

January 19, 2016

Topics

- Current WPC post-processing activities
- Future considerations (1-5+ years)

WPC PQPF and Probabilistic Winter Precipitation Forecast (PWPF) methodology

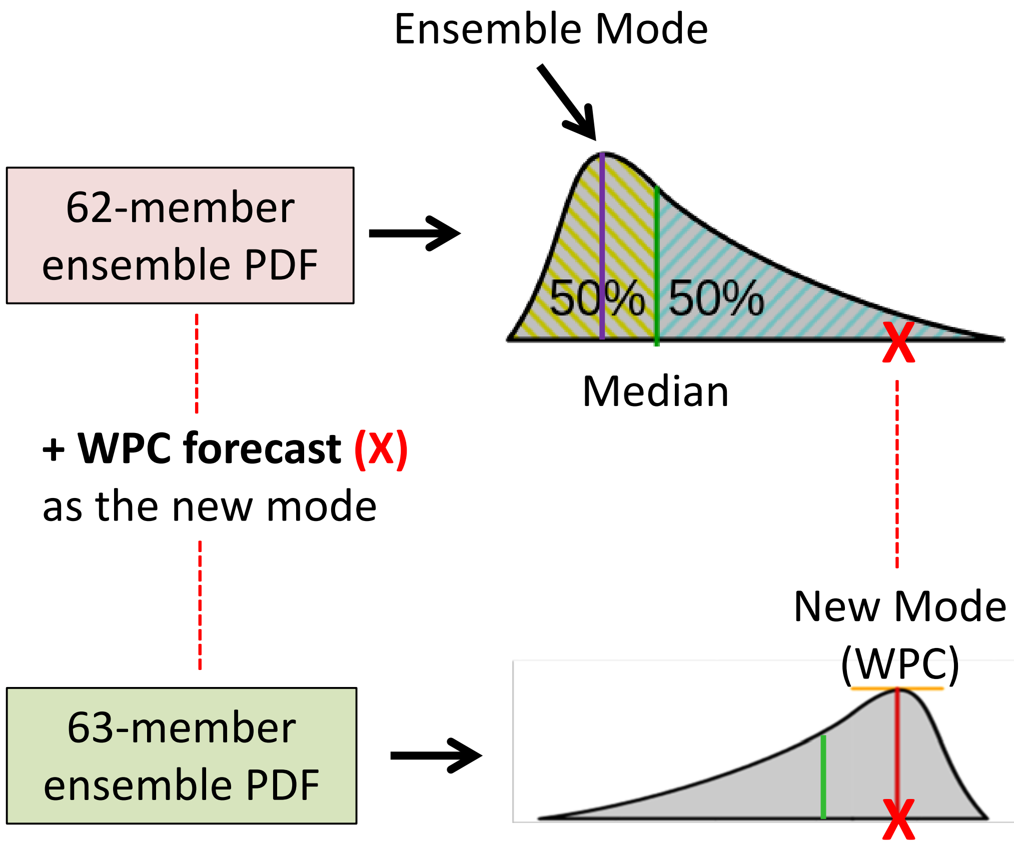
- A binormal probability density function (from Toth and Szentimrey, 1990) is used to construct the PQPFs and PWPFs
  - QPF cannot be represented by a simple normal distribution
  - PDF consists of two normal curves that meet at the mode, with differing variances to the left and right of the mode

- Leverages the strengths of the human forecaster and ensembles
  - WPC deterministic forecasts of snow, freezing rain, and rain accumulations are considered the "most probable" solution and assigned as the mode of the distribution
  - The multi-model ensemble supplies the variance of the distribution
  - Placement of WPC forecast (mode) determines the skewness

- Computed at each grid point (20km CONUS grid), then PRISM-downscaled to 2.5km (PWPFs) or 5km (PQPF)

- Probabilities of exceedance and percentile accumulations calculated from the resulting PDFs

Creating the PQPF/PWFP Probability Density Function



Post-processed set bounds:

PWPF: 12^{th} %ile < WPC < 88^{th} %ile

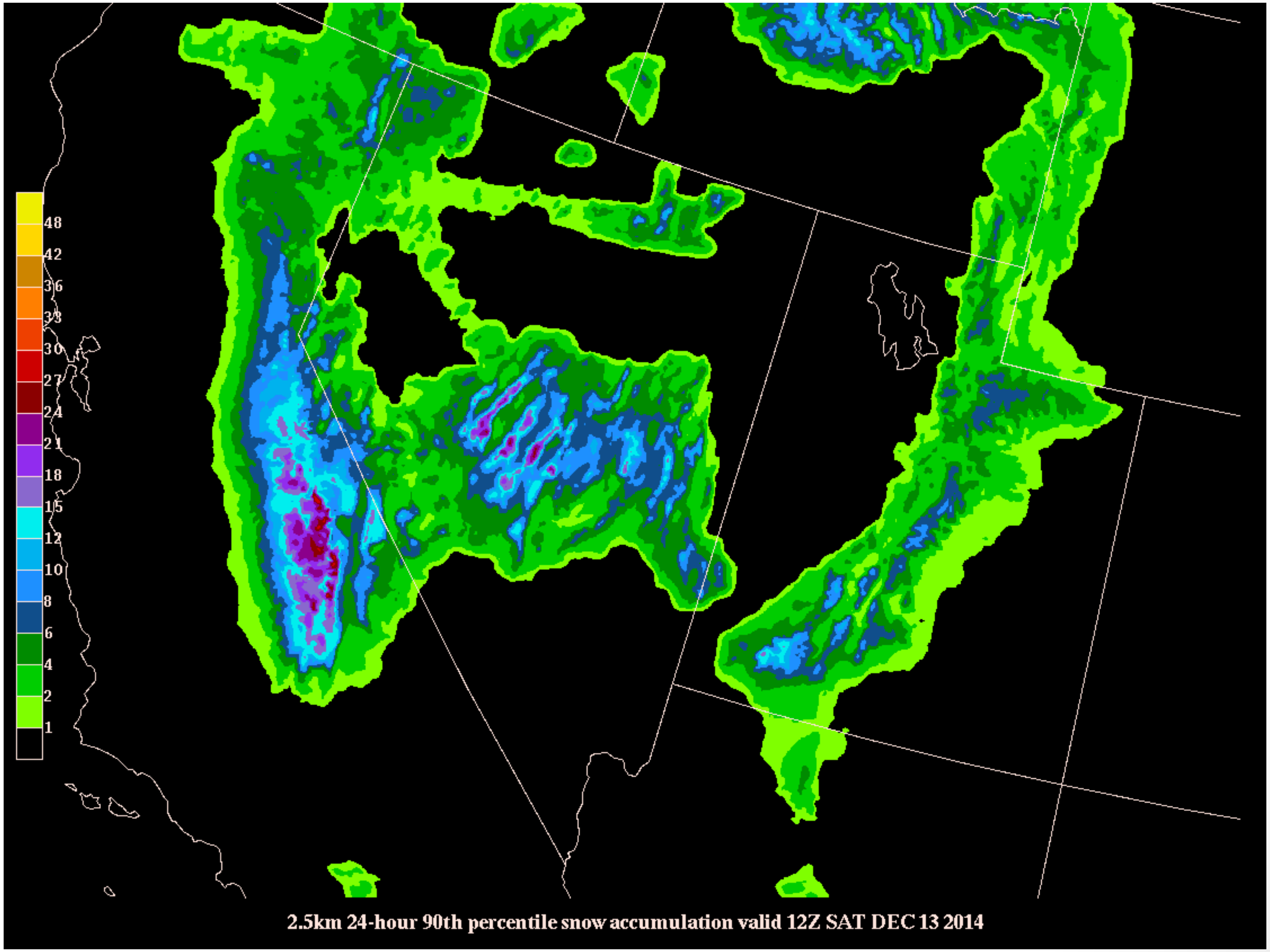
PQPF: 7^{th} %ile < WPC < 93^{rd} %ile

Downscaling Techniques

- Using 2.5km resolution 1971-2010 daily PRISM climatology
  - More realistic representation of QPF in mountainous regions, especially cold season
  - Disadvantages
    - Provides little added value for lake effect situations
    - Will perform more poorly in non-climatological situations
- Utilizing high-resolution NWP
  - Advantages
    - More realistic representation of QPF in mountainous regions, especially cold season
    - Depicts banded lake effect precipitation
    - Better handle non-climatological patterns in terrain
  - Disadvantages
    - Only an “ensemble” of 3 deterministic models
    - Limited forecast projections

20km resolution vs 2.5km PRISM-downscaled

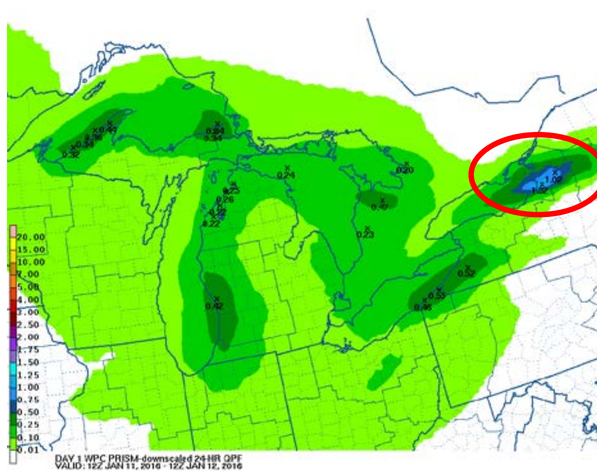
90th percentile of 24-hour snowfall



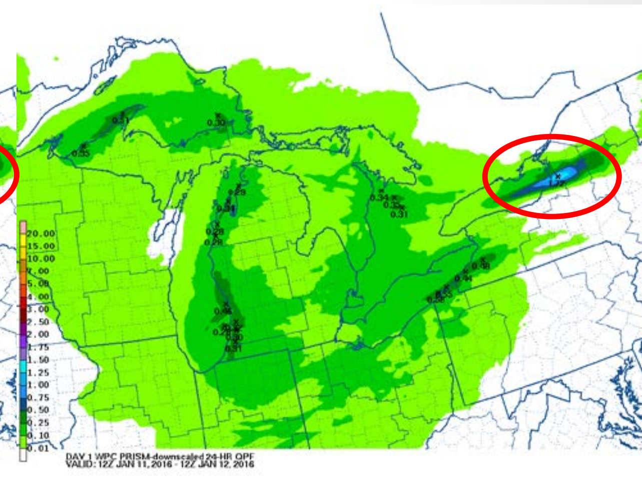
Consensus Downscaling Technique

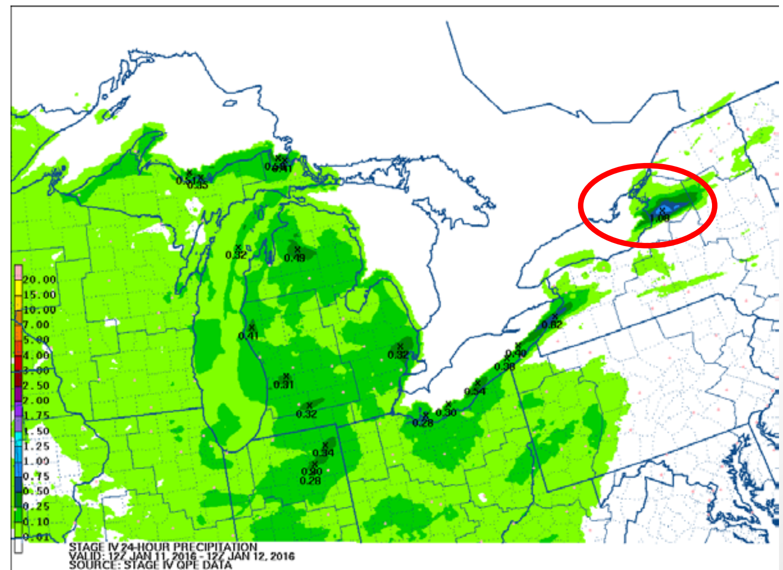
- Based on combination of PRISM downscaling (up to 50% weight over Western 1/3 of CONUS) and consensus downscaling (up to 50% weight) of convection allowing models (NAMnest, High Res Window ARW, High Res Window NMB)
- Initial objective verification shows improvement over PRISM downscaling alone

CURRENT Operations



Dynamical Downscaling



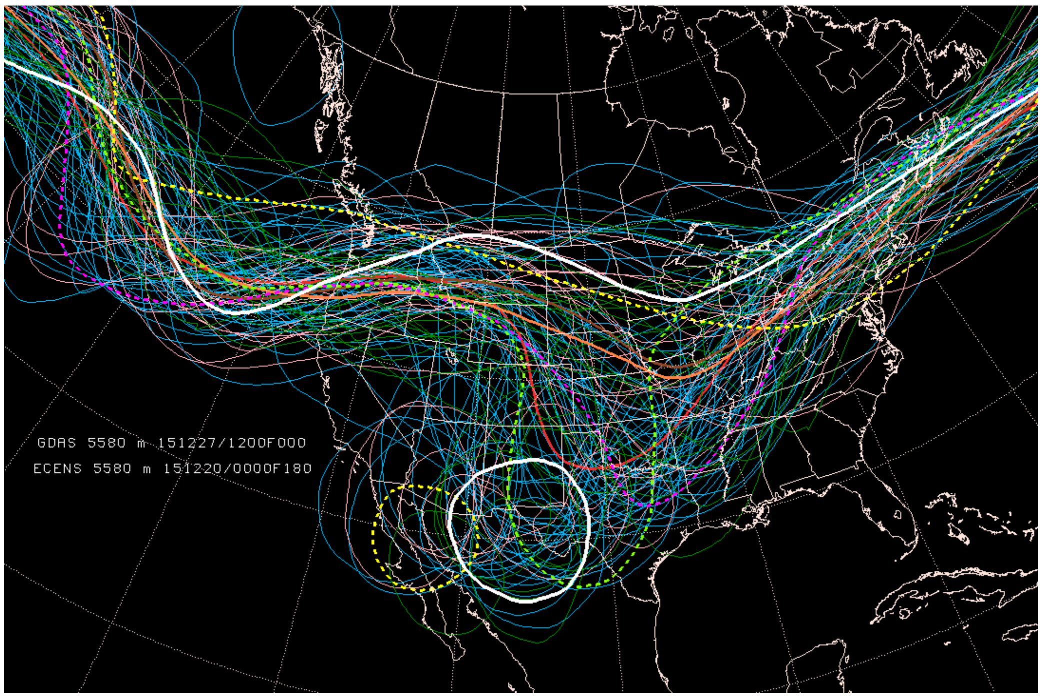


Verifying RFC QPE

Synthesizing Model Guidance

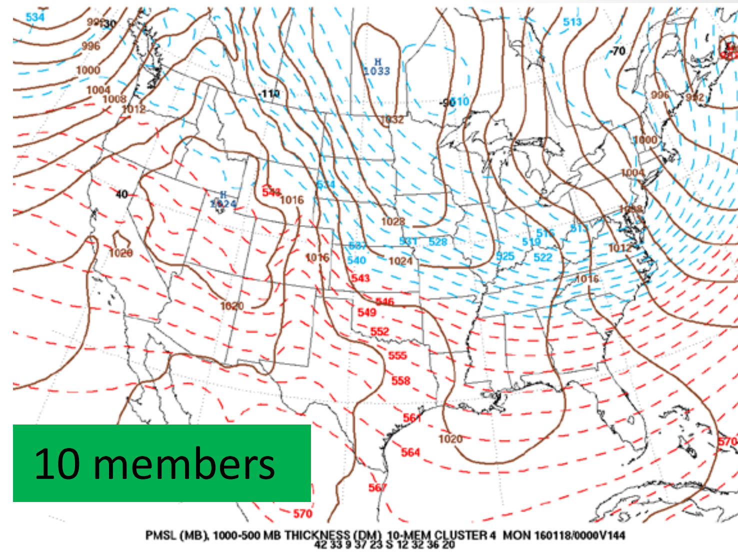
Spaghetti plots

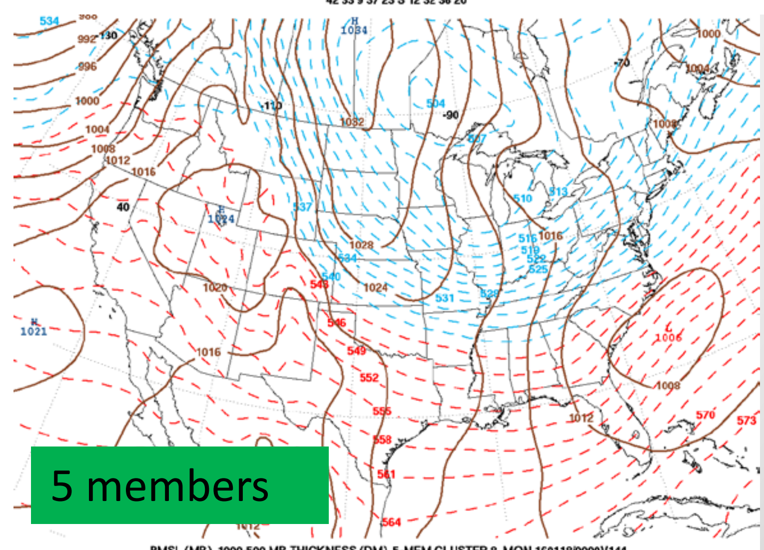
Day 7 500mb 558 dam contour from ECMWF/GFS/CMC deterministic and ensembles, including verification (white)



GEFS/ECENS Ensemble clusters

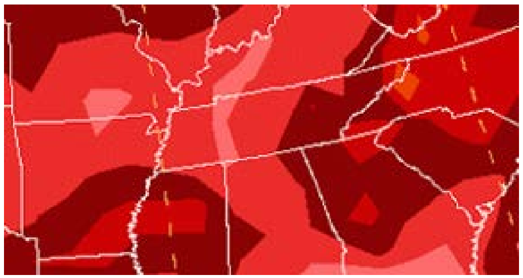
Day 5 PMSL/1000-500mb thickness



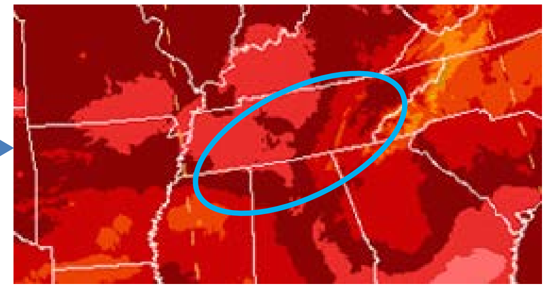


Medium Range Forecasting

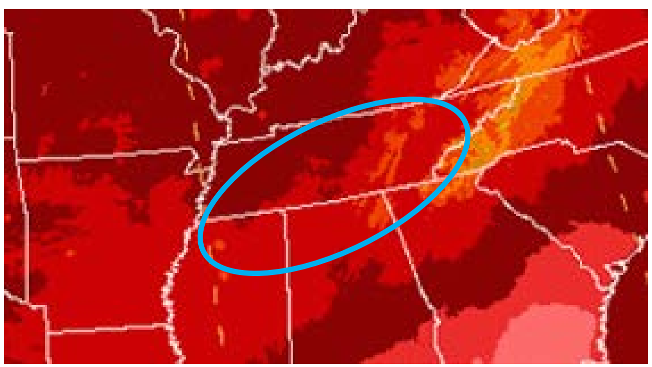
- Coarse resolution models are bias-corrected and downscaled to 2.5km using the URMA in a “decaying average” scheme



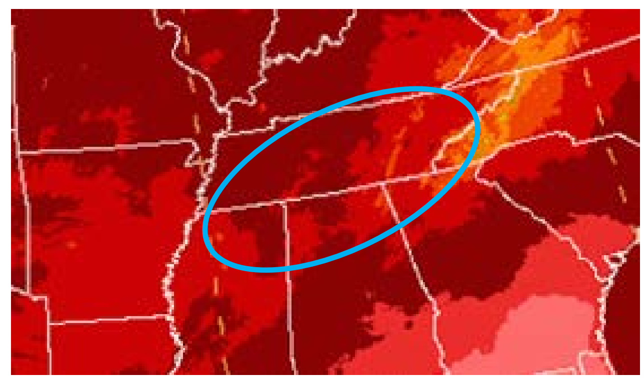
1º GFS Max Temp



Downscaled/bias corrected GFS Max



Downscaled/bias corrected forecaster-preferred model blend



Forecaster-modified Blend Max

Ensemble Situational Awareness Table (ESAT)

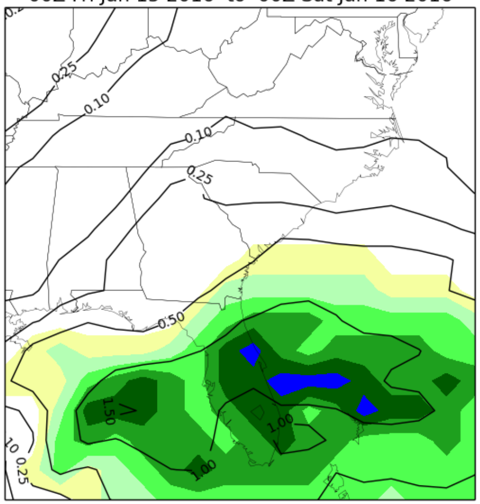
- Ensemble guidance contains very useful information, but how can forecasters extract the important information?
- The ESAT fills this role, enabling forecasters to identify the potential for high impact weather from NAEFS and/or GEFS ensemble products
- Compares NAEFS (GEFS) forecasts to reanalysis (model) climatology to assess both likelihood and significance of an event
- Output forecast products include:
  - Standardized anomalies
  - Percentile forecasts
  - Return Intervals
  - Probability of extreme events (outside reanalysis climatology)

Model Run: Jan 11, 2016 00Z **Table Region:** Southeast U.S. **Plot Region:** Southeast U.S. **Output:** GEFS QPF M-Climate View Table **Fcst Hr:**

WFO Southeast U.S. Table Jan 11, 2016 00Z Run

			6-h	12-h	24-h	48-h	72-h
6	Mon 11th	06Z	96.0				
12		12Z	<90	93.8			
18		18Z	92.6	95.0			
24	Tue 12th	00Z	92.1	94.7	92.3		
30		06Z	<90	<90	91.9		
36		12Z	93.5	92.5	93.7		
42		18Z	96.8	97.0	96.0		
48	Wed 13th	00Z	95.2	97.7	97.0	95.8	
54		06Z	93.6	95.7	97.8	97.4	
60		12Z	92.8	92.9	97.0	97.0	
66		18Z	92.9	94.1	94.8	96.2	
72	Thu 14th	00Z	95.2	94.9	93.8	95.3	95.1
78		06Z	99.3	98.8	97.9	95.3	95.6
84		12Z	99.9	99.8	99.7	99.1	98.3
90		18Z	MAX	99.9	99.9	99.6	99.3
96	Fri 15th	00Z	MAX	MAX	MAX	MAX	99.7
102		06Z	MAX	MAX	MAX	99.9	99.8
108		12Z	MAX	MAX	99.9	MAX	99.8
114		18Z	MAX	MAX	99.8	MAX	99.8
120	Sat 16th	00Z	MAX	99.9	99.9	99.9	99.8
126		06Z	99.8	MAX	99.9	99.9	99.8
132		12Z	96.5	98.6	99.9	99.7	99.9
138		18Z	96.1	96.7	99.6	99.7	99.9
144	Sun 17th	00Z	99.2	99.0	98.9	99.5	99.9
150		06Z	94.6	97.7	98.9	99.1	99.9
156		12Z	95.7	97.1	97.6	99.1	99.8
162		18Z	97.7	97.7	97.1	98.8	99.7
168	Mon 18th	00Z	95.8	97.3	97.0	98.7	99.5
174		06Z	96.1	96.5	96.9	98.6	99.2

GEFS Mean QPF (in) and M-Climate percentile
96-120-h forecast valid
00Z Fri Jan 15 2016 to 00Z Sat Jan 16 2016

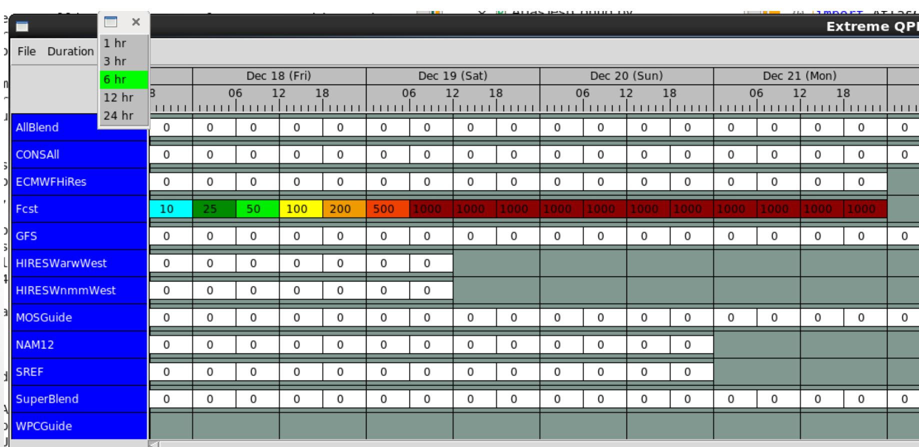


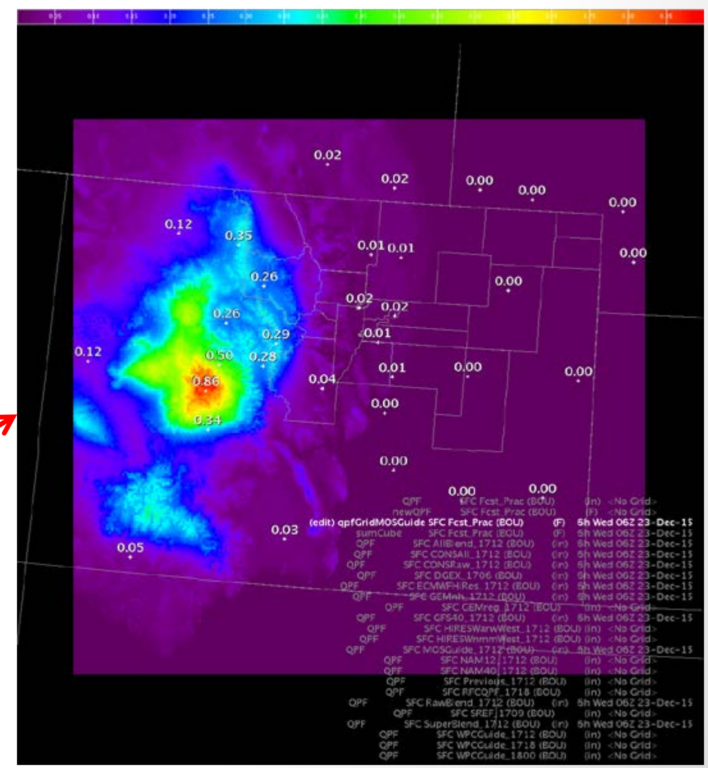
relative to GEFS reforecasts initialized
27-Nov to 25-Feb (1985-2012)

GFE Extreme QPF Awareness Tool

- STI Extreme QPF Project
  - Multi-SOO/ESRL/CIRES team chartered to develop a tool to improve situational awareness of forecasting extreme precipitation (top 1%) events
- Compares NWP and WPC QPFs to NOAA Atlas 14 Annual Return Interval (ARI) rainfall data
- Fully integrated into AWIPS 2 GFE

Prototype (below) displays return interval associated with highest QPF in the grid area





Product and Data Requirements (1-2 years)

- *Operational* products from GEFS reforecast data set
- PWPF/PQPF
  - Incorporation of high-resolution ensemble guidance
  - User-specified ensemble membership
  - Regional blending techniques (e.g. use higher resolution models for LES situations)

- Additional post-processing, including:
  - Improved methods for utilizing ensemble products for QPF
    - Coalesced mean?
    - Probability-matched mean QPF
  - IVT (atmospheric river prediction)
  - Neighborhood probabilistic fields
  - Tools displaying joint probabilistic fields to better conceptualize potential impacts, e.g. probability of snowfall rates >1”/hour during rush hour.

Product and Data Requirements (2-5 years)

- Drive toward more probabilistic output and products
  - Extreme Forecast Index (EFI) products
  - Day 8-10 temperature and precipitation outlooks
  - Incorporation of hydrologic parameters to augment prediction of flash floods
- Increased focus on IDSS
  - Tools to measure uncertainty/predictability and provide forecast confidence information to users
  - Additional tools to synthesize the output of model data
- Toth concept – Interactive Forecast Editing tool
  - Make targeted changes to a single parameter; using ensemble covariance data, tool propagates change across multiple variables
  - Similar to UKMO's Metmorph tool

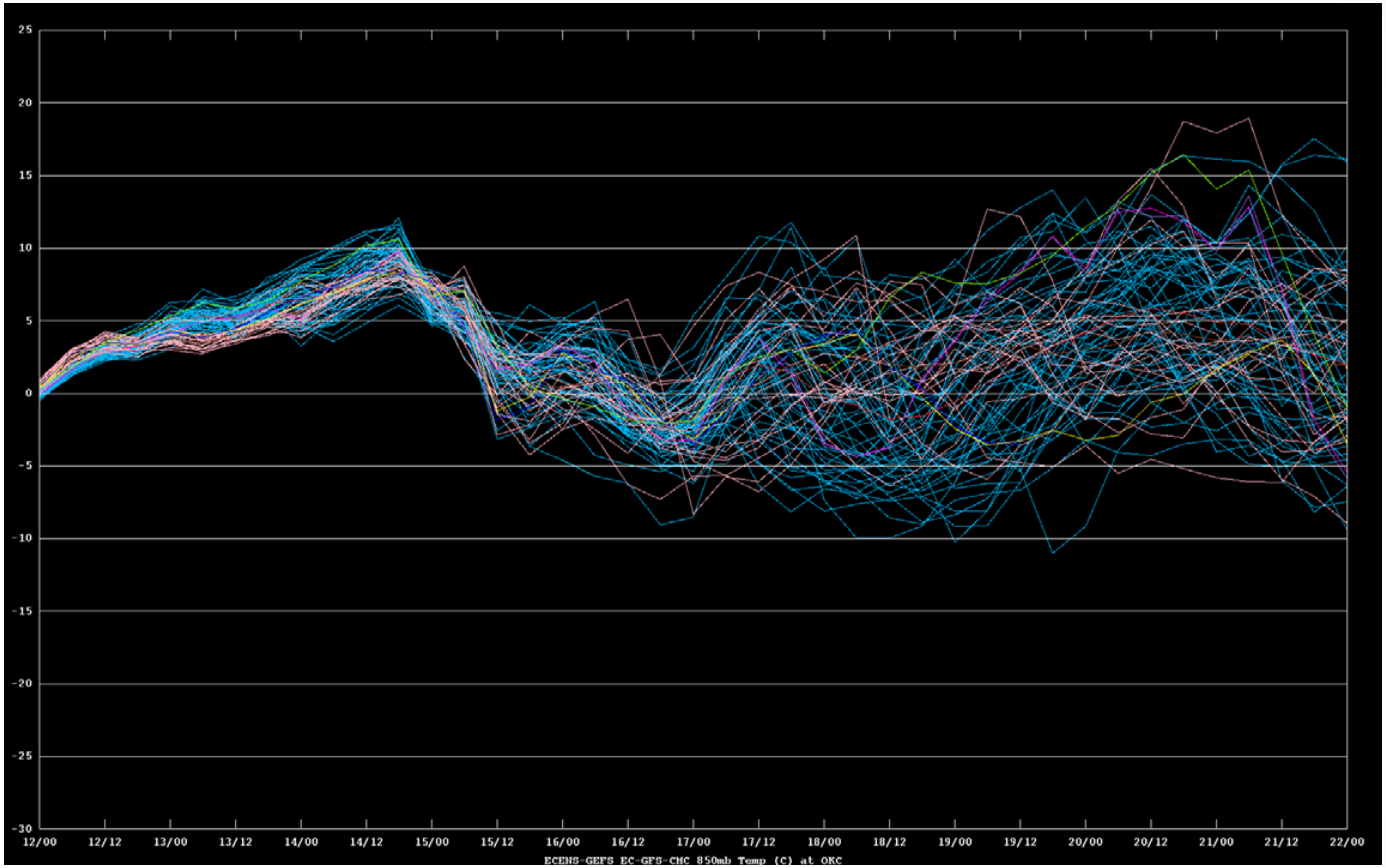
Summary

- Majority of WPC's operational product suite incorporates a unique blend of forecaster input and objective computing
  - PWPF/PQPF
    - Forecaster → Mode of the ensemble distribution
    - Post-processing → Binormal method to create suite of products
  - Medium Range
    - Pre-processing → Downscale/bias correction of coarse resolution models
    - Forecaster → Determine preferred blend and target regional changes
    - Post-processing →Day 3-7 Max/min temperatures, dew point, sky and weather at 2.5km
- Multiple ongoing efforts to mine critical data (ESAT and GFE Extreme QPF tools)
- Future post-processing will be tailored for IDSS, more impact-based guidance, for example:
  - Probability of 1" snow at rush hour in a populated region
  - Probability of minimum temperatures below freezing at Day 9

Extra Slides

Synthesizing Model Guidance

Plume Diagrams



GFS/ECMWF/CMC ensemble 850mb temperature forecasts from 00Z 12 Jan 2016

Downscaling Techniques

- PRISM
  - Uses 2.5km resolution 1971-2010 daily PRISM climatology
  - Process for QPF
    1. Smooth PRISM grid to 40km (WPC forecaster draws QPF contours at effectively ~40km)
    2. Compute ratio of unsmoothed to smoothed PRISM values
    3. Multiply this ratio by the WPC QPF → downscaled QPF
  - Constraints
    - Minimum correction factor determined by monthly-varying lower bound (.3 in winter to .9 in summer). Allow more terrain influence in the cold season
    - Maximum factor is 80% of the maximum value on the grid (to limit overcorrections to the original QPF)
  - Provides realistic representation of QPF in mountainous regions, especially cold season
  - Disadvantages
    - Provides little added value for lake effect situations
    - Will perform more poorly in non-climatological situations

Day 3-7 Post-processing

- Coarse resolution models are bias-corrected and downscaled to 2.5km for temperature, winds (only speed bias-corrected) and dew point
- Bias correction and downscale vector for each parameter use a “decaying average” scheme incorporating the URMA as the analysis

  DV|Bias = (1-*w*)*Dvprior|Biasprior + *w**(*MODEL* – URMA)

  - *MODEL:* GDAS for DV
  - *w* = decaying weight:
    - DV → Winds – 10%, Dew point – 1%, Temperature – 2%
    - Bias correction → 4% for all variables

PWPF Ensemble Composition

<u>63 members total (equally weighted)</u>

- 26 SREF members
- 25 ECMWF ensemble members, randomly selected
- 1 NAM operational run
- 1 GFS operational run
- 1 ECMWF operational run
- 1 Canadian Global Model (CMC) operational run
- 1 ECMWF ensemble mean
- 1 GFS ensemble mean
- 5 GFS ensemble members, randomly selected
- WPC deterministic forecast