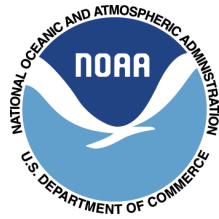




NGGPS Post-processing



Overall Objective

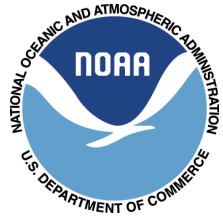
- Improve post-processing methods, data sets and products, resulting in products that are dramatically more useful to the weather enterprise

Strategy

- Query experts and stakeholders on what's needed
- Evolve supporting infrastructure to better support research to operations (R2O)
- Identify and generate supporting data sets
- Identify and develop advanced post-processing techniques



NGGPS Post-processing



Focus Areas

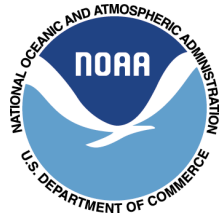
- Evolution to a community, open-source post-processing infrastructure in response to stakeholders.
- Generation of global reanalyses and a durable infrastructure that enables regeneration when needed.
- Global reforecasts based on reanalyses.
- Development of advanced post-processing techniques that support the National Blend of Models (NBM)
- Development of post-processing techniques for weeks 2-4



Input: UMAC, August 2015



- UCAR Community Advisory Committee for NCEP (UCACN) established in March 2011 as a permanent external advisory committee to provide guidance to NCEP.
- UCACN Modeling Advisory Committee (UMAC) provides a comprehensive, technical review of the NCEP Production Suite (NPS) strategy for development
- UMAC recommendations addressed post-processing

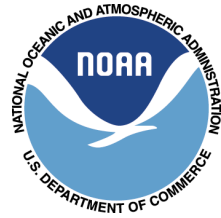


UMAC recommendations

- General: evidence-based decision making, reduced complexity of production suite, understand requirements, collaboration beyond NWS, actionable strategic and implementation plans.
- Reanalysis, reforecast (R/R), post-processing specific recommendations.
 - Regular production of R/R recognized as integral to production suite, so plan HPC/disk resources for doing this regularly in the future. Use non-operational HPC for their generation (cheaper).
 - However, extent of R/R and when to do a new R/R should be based on evidence, not political pressures.
 - Migrate post-processing resources to National Blend.
 - Also: develop techniques that require less training data; engage international partners to expand MME; hire ~5 Ph.D.-level statisticians to bring statistical rigor. Consider co-locating MDL and NCEP. Invest in development of hi-res. analyses for training and verification.



Input: Workshop, January 2016



You are here: NCAR • RAL • Events • The Future of Statistical Post-processing in NOAA and the Weather Enterprise

The Future Of Statistical Post-processing In NOAA And The Weather Enterprise



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THE FUTURE OF STATISTICAL POST-PROCESSING IN NOAA AND THE WEATHER ENTERPRISE

January 19 - 22, 2016

NOAA Center for Weather and Climate Prediction Building
5830 University Research Ct, College Park, MD 20740

The NOAA / National Weather Service's (NWS) Strategic Plan, "[Weather-Ready Nation](#)" envisions NOAA providing dramatically improved weather decision support to its customers through the generation of much more skillful and reliable forecast guidance. Statistical post-processing of weather forecast guidance (its adjustment using discrepancies between past forecasts and observations/analyses) will be a key component of helping the NWS meet this goal.

Statistical post-processing is aided tremendously when the relevant data is in place, including recent or retrospective forecasts (reforecasts) and associated recent or retrospective observations and analyses. NOAA intends to generate these data sets more regularly and make them of higher quality and consistency in the future.

This workshop will help NOAA set its future requirements for providing internal and external customers with the high-quality data they need to achieve expected benefits from statistical post-processing. The workshop will discuss several topics, including: (1) a conversation with internal and external customers about their desires and requirements for data. For example, what length of retrospective forecast and analysis data is needed? What storage formats are most convenient? What regions of the world are needed, and what weather elements are most important to save? What platforms should host the data, internal NOAA, and/or commercial cloud vendors' platforms? (2) Conversations about how the post-processing community can make more rapid progress through sharing of software, including potentially establishing a community repository of post-processing algorithms, test data sets, I/O routines, verification routines, and so forth. (3) New developments in statistical post-processing, especially ones that may have implications with regards to what data NOAA should store and make available.

The Future of Statistical Post-processing in NOAA and the Weather Enterprise

Held:

January 19 - 22, 2016
NOAA Center for Weather and Climate Prediction Building
5830 University Research Ct
College Park, MD 20740

Workshop Sponsors

For more information, please contact Tom Hamill (tom.hamill@noaa.gov) or Dave Rudack (David.Rudack@noaa.gov).

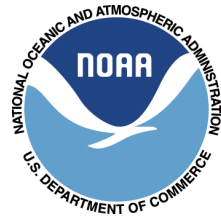
Workshop on statistical post-processing, held in College Park MD, Jan 2016.

Included > 90 participants from NOAA, labs, universities, other met services, and corporations.

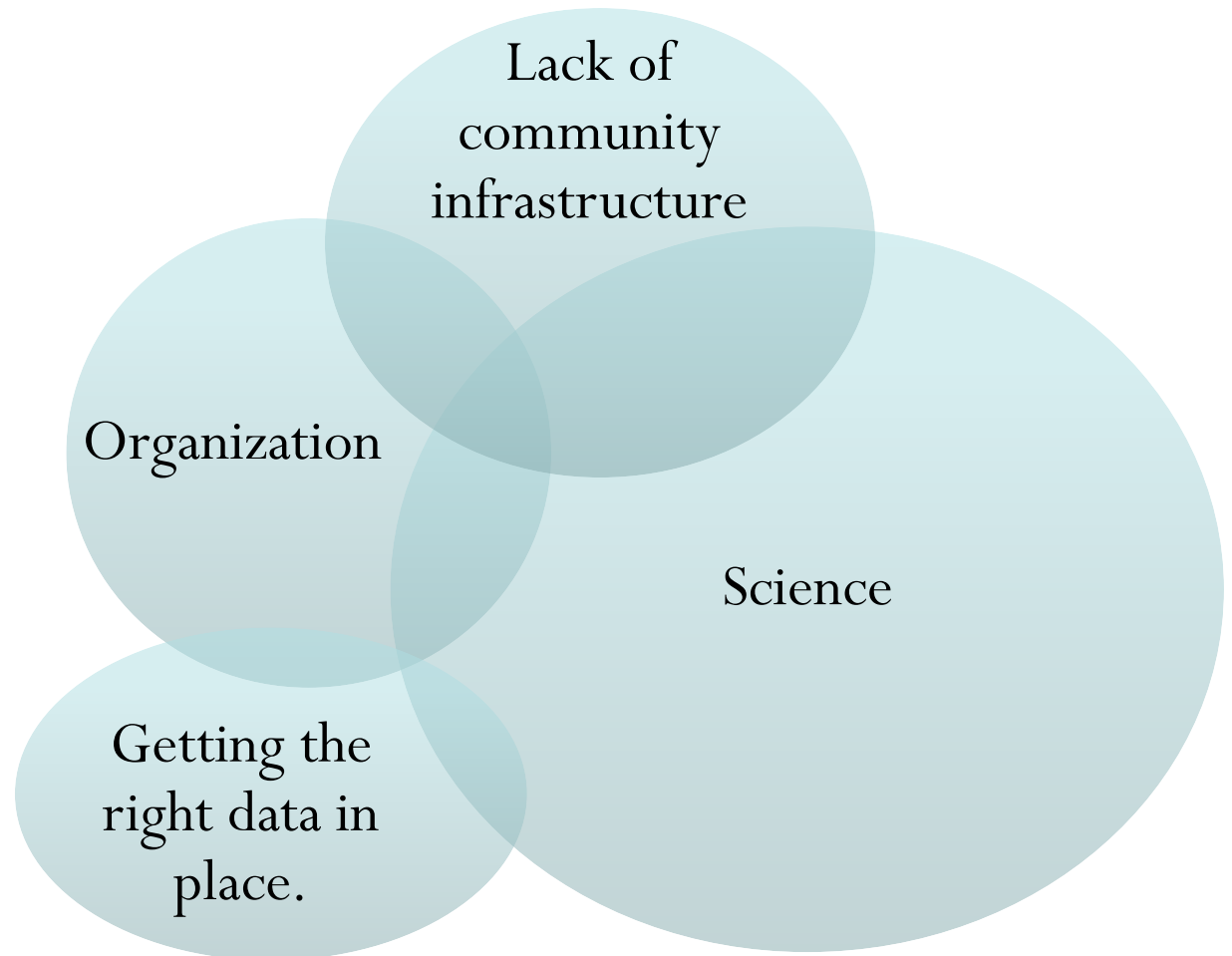
Participants expressed strong support for community-based efforts for StatPP across NOAA, and the wider weather-climate enterprise.



Post-processing Challenges



Note the substantial overlap.





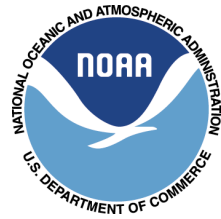
Post-processing workshop recommendations (1)



- Full recommendations [here](#).
- **Science:**
 - >4 professional statisticians.
 - Determine best algorithms for “foundational” guidance (e.g. T2m, POP, etc.) and use them.
 - Generate R/R’s regularly.
 - Generate high-quality, hi-res analyses for training/verification.
 - Determine how to efficiently use the least amount of training data.
- **Organization:**
 - Define requirements, per UMAC.
 - Develop and use strat/implementation plan.
 - Develop a new, open-source, community PP infrastructure.
 - Train staff in software, modern languages.
 - Organizational streamlining.



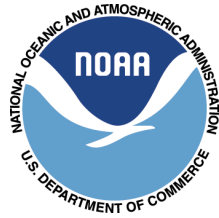
Post-processing workshop recommendations (2)



- **Community infrastructure:** Establish modern, widely-utilized distributed version control system to facilitate R2O and O2R.
 - Use industry-standard version control software, e.g., git.
 - Develop a code repository with tiers (outer: all can contribute; inner: tightly controlled by NOAA).
 - Governance process for community participation, migration of code from outer to inner.
 - Metadata, test data, and standards established.
 - More (see full recommendations)
- **Data and infrastructure:**
 - R/R incorporated into HPC planning.
 - Make foundational PP guidance readily available to wider community.
 - Global R/R data sets, analyses, etc. also made readily available.



NGGPS Post-processing Summary



- **Major Accomplishment in FY16:**

- Held successful post-processing workshop in January 2016. Briefed outcomes to NWS leadership and wrote Functional Requirements Document for Statistical Post-processing (StatPP)
- Developed a "Functional Requirements Document for Post-processing" and delivered to STI management.
- Next-gen R/R project for GEFS underway.
- Rollout of basic algorithms for National Blend.

- **Priority Focus for FY17**

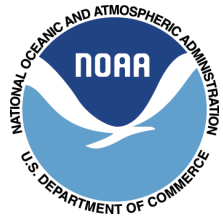
- Generate global reanalysis/reforecast and set up durable infrastructure to regenerate future reanalyses.
- Develop Weather Information Statistical Post-processing System (WISPS), the community-based infrastructure.

- **Key Issues**

- Management attention to the UMAC and PP workshop recommendations.
- Develop software solutions that facilitate R2O and O2R



NGGPS Projects





Toward the Operational Production of Next-Generation Global Reanalyses



Tom Hamill (ESRL/PSD), with contributions from NCEP/EMC and NCEP/CPC

- This project will generate a multi-decadal reanalysis and reforecast for the GEFS system. Funding also via OAR/CPO.
 - Year 1 (current) of the project is setting up the infrastructure and testing it at lower resolution during periods of changes in the observing system, and testing methods for breaking production into streams.
 - Year 2 will largely be dedicated to the production of reanalyses and then reforecasts.
 - Main challenge has been getting our staff access to the WCOSS system; > 6-month delay for security clearances.
- Reforecasts are needed for high-quality post-processing of rare events (e.g., heavy precip) and longer-lead forecasts (e.g, weeks 2-4 T, P). Reanalyses are needed for their initialization.
 - R/R generation is an important part of the NGGPS post-processing implementation plan.

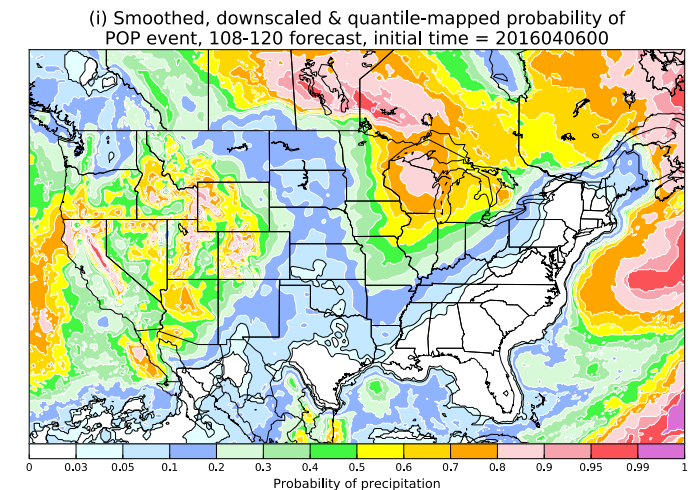
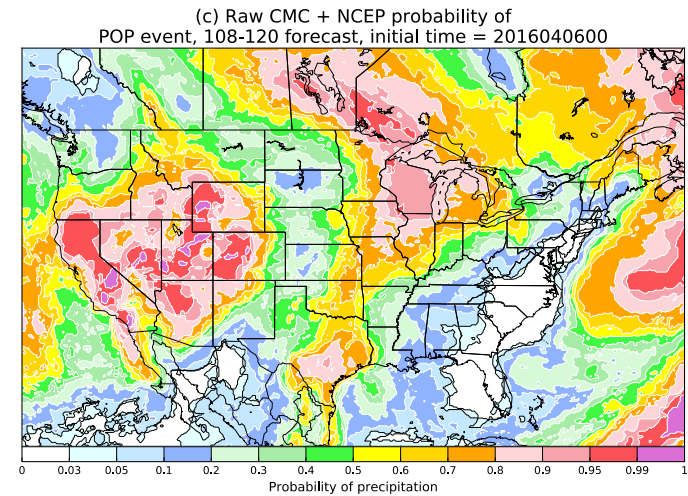


National Blend of Models Probability of Precipitation and Precipitation Amount



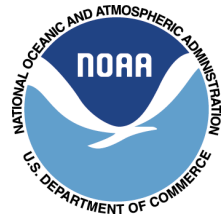
Tom Hamill PI, ESRL/PSD

- Via funding from many sources, NGGPS included, ESRL/PSD is delivering an advanced 12-hourly POP and 6-hourly QPF algorithm to MDL for use in the National Blend of Models.
 - Implementation expected for v. 2.1 in Dec 2016
 - The POP's are quite reliable and sharp, the QPFs are designed to provide useful guidance on precipitation maxima.
- The NGGPS post-processing implementation plan has as one of its major objectives the development of advanced post-processing methodologies, especially for high-impact variables, and their implementation in the National Blend of Models program.





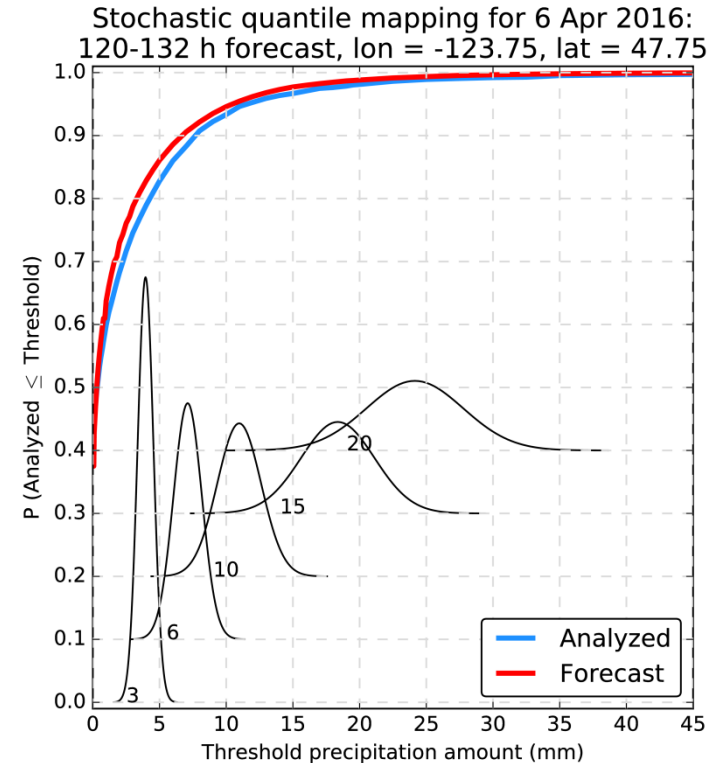
National Blend of Models Probability of Precipitation and Precipitation Amount



Tom Hamill, ESRL/PSD

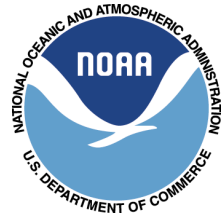
- At the heart of POP12 is “*stochastic quantile mapping*.” This both corrects for conditional bias (the bias for a given forecast precipitation amount) and adds noise from a normal distribution whose standard deviation depends on the mapped precipitation amount. This procedure is applied to each ensemble member. POPs are calculated from the ensemble and smoothed.

- Pending funding, ESRL/PSD will continue to evaluate alternative POP12 methodologies, including Michael Scheuerer’s CSGD (censored, shifted Gamma distributions), and work with MDL to transfer the best possible algorithms for operational use.





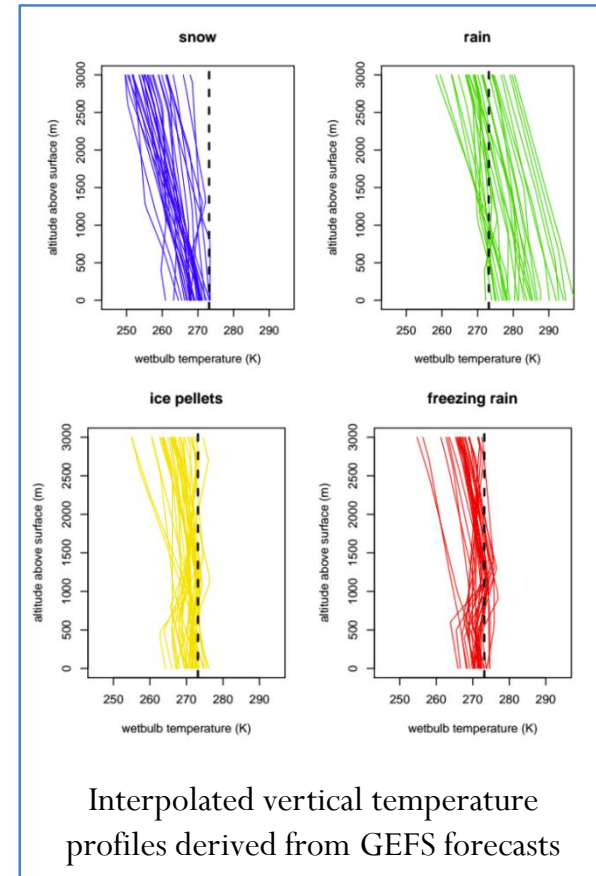
Probabilistic Forecasts of Precipitation Type and Snowfall Amounts based on Global Ensemble Forecasts



Thomas M. Hamill, ESRL/PSD

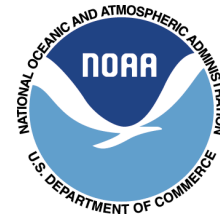
- Predictors: GEFS model predictions of surface and pressure level temperatures
- Objective: reliable probabilistic predictions of precipitation type and snowfall amounts
- Collaboration with MDL staff permits comparison against existing methods and may inform future operational use

- The NGGPS implementation plan promotes the development of improved post-processing algorithms for high-impact events
- Freezing rain and heavy snowfall can have a high impact, but have not been studied as much as other variables
- This project explores new statistical techniques, focusing especially on improving forecasts of freezing categories





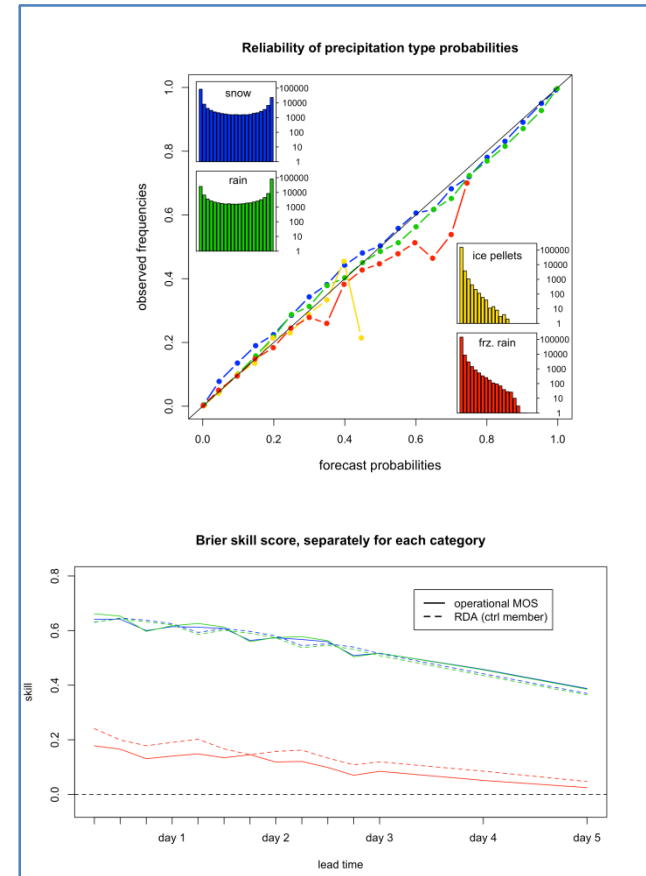
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Thomas M. Hamill, ESRL/PSD

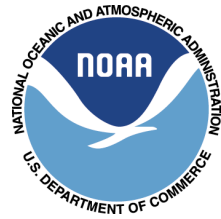
- The new precipitation type algorithm yields reliable probability forecasts for all types
- Its performs similar to MOS for snow/rain, for freezing types it performs better
- The work on the algorithm for snowfall amount is ongoing

- A recent decision of the NBMWxG Team requires forecasts to be based on a number of specific input variables that can be edited by WFO forecasters
- Since the method studied here uses the full vertical profile, it does not meet these requirements
- Our developments could, however, inform future operational implementations, if the requirement of forecaster editable grids becomes obsolete one day





Calibration and Evaluation of GEFS Ensemble Forecasts at Weeks 2-4

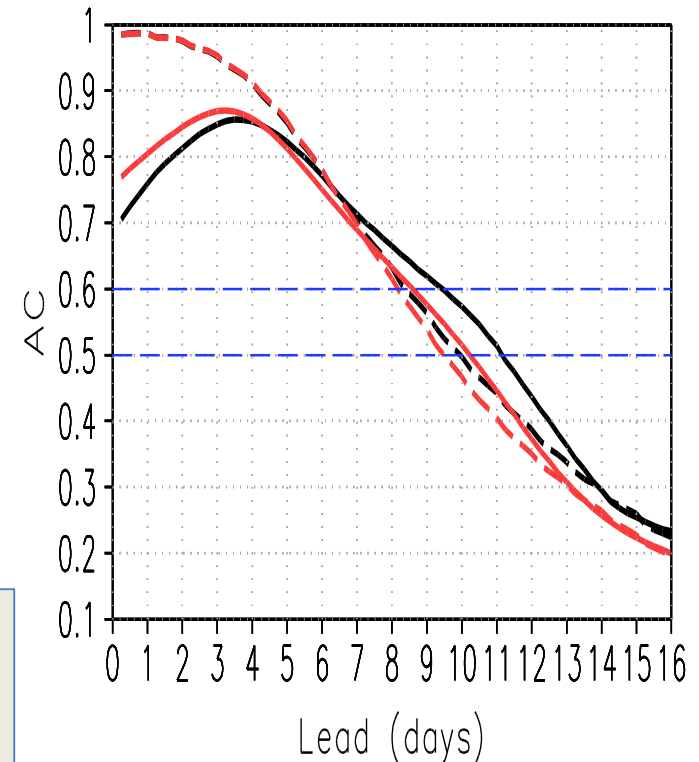


Ping Liu, Stony Brook University

- Separating lasting signals from chaotic noises with an EOF approach proves effective to improve the week-2-4 forecasts. Persistent ridges and blockings (PMZs) and MJOs are the two signals investigated in this project.
- A new tracking algorithm is for monitoring PMZs; a revised RMM index is for MJOs.

- Connection to NGGPS

The tracking algorithm of PMZ, the revised RMM index of MJO, and the EOF approach being investigated on the GEFS ensemble forecasts will be applied to the NGGPS to improve the predictions at weeks 2-4.



Useful skill of Z500 associated with the PMZs can be extended by 1.2 days (solid vs. dashed in black) in the Northern Hemisphere after the EOF approach.



Calibration and Evaluation of GEFS Ensemble Forecasts at Weeks 2-4, cont.



Ping Liu, Stony Brook University

- Summary research project results

A Revised RMM index (*Mon. Wea. Rev.*, 2016) is developed to observe the MJO in real time and in GEFS ensemble predictions.

A new tracking algorithm of PMZs (submitted to *Mon. Wea. Rev.*) is observing persistent ridges and blockings in real time and in GEFS ensemble predictions. The algorithm has identified substantially more persistent ridges to impact the T_{2m} and precipitation over the US during all seasons.

- Potential transition to operations/future implementation

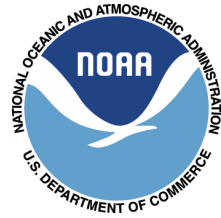
The Revised RMM index can compensate or replace the existing RMM index in evaluating the ensemble predictions of the GEFS and NGGPS.

The new tracking algorithm of PMZs can compensate or replace the existing indices for identifying the blocking episodes in the predictions of the GEFS and NGGPS.

These two indices are updated daily on a web server constructed in collaboration with the EMC and CPC. The web pages are nearly ready in transition to both EMC and CPC.



Improved Statistical Post-processing with the Bayesian Processor of Ensemble (BPE)



Zoltan Toth (GSD/ESRL), Mark Antolik (MDL/NWS), Roman Krzysztofowicz (Univ. Va), Melissa Petty (CIRA at GSD), Geary Layne (CIRES at GSD), and Malaquias Pena (IMSG at EMC)

- Fuse climatology & multiple forecast guidance
 - Prototype for probabilistic National Blend of Models
- Bayesian & distributional approach
 - Extremes handled well with smaller set of hind-casts
 - All continuous variables calibrated with unified method
- Multiple & versatile output formats
 - Probabilistic NDFD w only factor of 2 storage increase
- Algorithms & codes to be developed & tested
 - Comparison with operational EKDMOS

Contributions to accomplishing major NNGPS goals

- “Reliable weather, water... information”
- “Improv[e] the probabilistic guidance of high impact weather elements by
 - Decreasing... uncertainty and improving product calibration”
- “Cutting edge techniques” made available to NWS to
 - “develop them for operations”

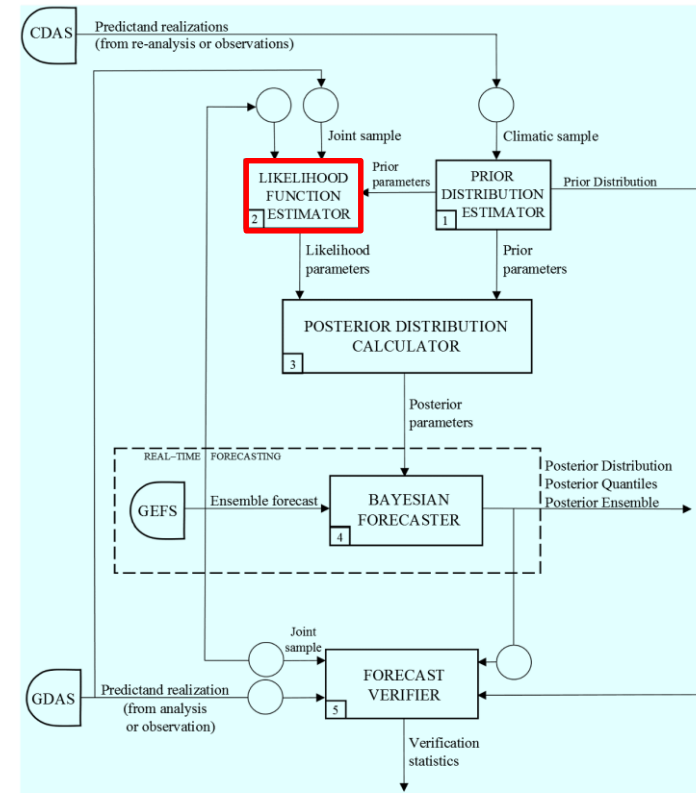


Figure 1. Structure of the BPE — its five components and its couplings with systems supplying data, illustrated for NCEP: Global Ensemble Forecast System (GEFS), Global Data Analysis System (GDAS), and Climate Data Analysis



Improved Statistical Post-processing with the Bayesian Processor of Ensemble (BPE), cont.



Toth et al, GSD/ESRL

Status

- Algorithms developed & documented (U. Va, see right)
 - Multiple predictors from multiple controls & one ensemble
- Codes developed (GSD) & tested (GSD & U. Va)
- Transition to MDL (GSD & MDL, by Oct16)
- Enhancement added (U. Va & GSD, by Nov16)
 - Capability to merge ensembles from multiple centers
- Compare with EKDMOS in operational environment
 - Assessment of quality and comp. speed at observation sites
 - Final report by May 2017

Potential use in operational probabilistic NBM

- BPE ready to serve EKDMOS functionality (yr-2, 2017)
- Gridpoint application of BPE on model variables
 - Serve NAEFS functionality (yr-3, 2018 – not yet funded)
- Develop perfect prog application
 - Relate fine scale user variables to calibrated model vars
 - Serve probabilistic NBM functionality (yr-4, 2019)
- Include NAM, HRRR, SREF etc fine scale guidance (yr-5 2020)
 - Expand NBM to short ranges, serve LAPM functionality

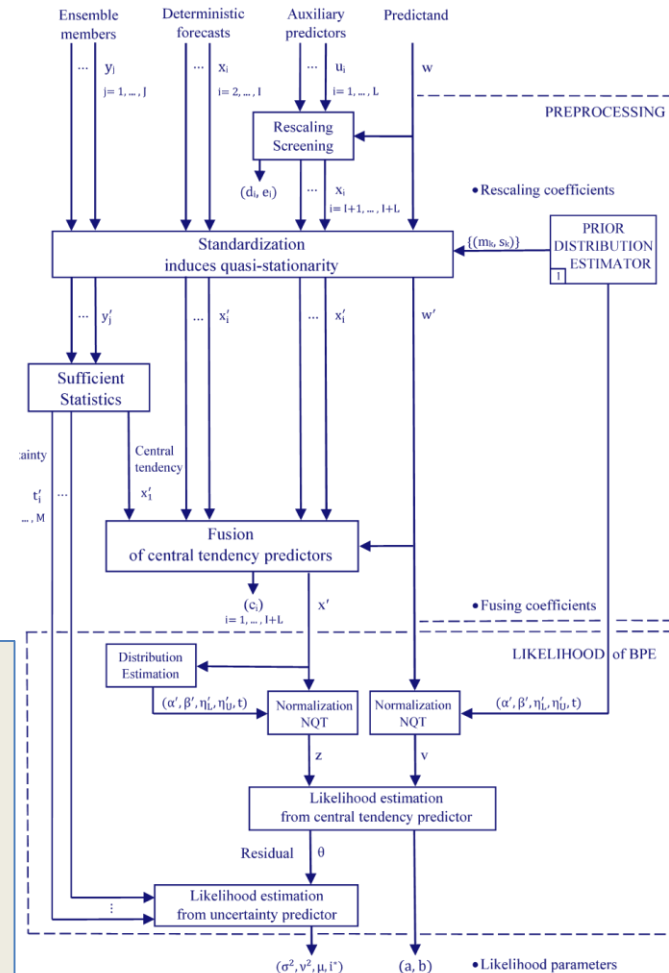


Figure 2. Structure of the likelihood function estimator of the BPE, version SMM, which processes and fuses Single ensemble forecast, Multiple deterministic forecasts, and Multiple auxiliary predictors.



Weather Information Statistical Post-processing System



Matt Peroutka, NOAA/NWS/STI

- Community-based software system, designed to statistically post-process NWP output throughout the weather enterprise
- Modern software techniques and self-describing data formats
- Widely-accepted standards
- Facilitate transition from research to operations

- No NGGPS funding (NWS base to date)
- Clear connection