Summary and Recommendations from the 5th Ensemble User Workshop

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5th NCEP Ensemble User Workshop

- Logistics
  - Workshop organized by EMC/NCEP and DTC/NCAR (co-organizer)
  - May 10-12 2011, Laurel, MD, 90+ participants
    - NWS Regions (6), Headquarters (17), NCEP (44)
    - OAR (5), other government agencies (4), private (2), academic (5) & international (11)
  - For further info, see: http://www.dtcenter.org/events/workshops11/det_11/
- Main Theme
  - How to support NWS in its transition from single value to probabilistic forecasting
    - Goal is to convey forecast uncertainty in user relevant form
- 46 presentations
  - Covering all ensemble forecast systems
    - SREF, GEFS/NAEFS, Wave ensemble, CFS and NMME
  - Reports from NCEP Service Centres and Regions (WFOs)
    - E.g., first numerical ensemble-based 2-day tornado, week 3-4, monthly MJO outlook
- Working groups
  - Ensemble configurations
  - Statistic post processing
  - Probabilistic product generation
  - Ensemble data depository / access
  - Ensemble forecasting
  - Reforecast/hindcast generation
  - Forecaster's role and training
  - Database interrogation / forecaster tools
- Outcome / Recommendations
  - Prepared report for NWS roadmap reference
    - Plan for immediate steps (interim solution to be implemented in 2-3 years)
    - Outline for long term solution and resource requirements (5-10 years)
  - All activities to be coordinated under NWS Forecast Uncertainty Program (NFUSE)

Main Theme

- Continue to support NWS in its transition from single value to probabilistic forecasting
- Continue to convey forecast uncertainty in user relevant form
- Review NCEP ensemble forecast systems
- Review probabilistic forecast products

Draft Plan

- Goal
  - Capability to answer any question related to future weather, climate, & water conditions, including ***forecast uncertainty***
    - Example
      - *What is joint probability of heavy precipitation, strong wind or severe weather?*
- Resource limitations
  - Computing power & storage, telecommunication, workforce training, etc, etc
- Two-stage approach
  - Interim stage
    - Increase probabilistic forecast information across all time scales related to weather, water and climate products and services.
    - Improve the communication of uncertainty prediction products.
    - Limited capability with approximations (short term)
    - Major enhancement of forecast system, leading toward long term solution
  - Final stage
    - Full capability
    - Built on Interim stage achievements
    - Requires long term budget planning and commitments

Recommendation – Ensemble Configurations

- Analysis and initial perturbation
  - Improving analysis – reducing analysis error
  - Try hybrid EnKF and ETR to generate initial perturbations
- Multi-model ensembles
  - Multi-model is the way to improve forecast uncertainty
    - Regional – SREF – already m-model, expect for NAEFS-LAM which combining Canadian regional ensemble
    - Global – NAEFS – already m-model, expect to include FNMOC ensemble in the future
    - Wave – jointly NCEP/GEFS with FNMOC ensemble
    - Beyond week-2 – working on NMME and IMME
  - Stochastic physics – another way to help
- Coupling system
  - With ocean/land - could be very important for interseasonal forecast
  - Coupling GEFS with ocean, and extending to 30 days, will be of more value than extending GFS to 30 days
  - Perturbed soil moisture could benefit for short/median range near surface (variables/parameters) forecast
- Resolution .vs ensemble size (membership)
  - Both are important (trade-off)
    - Resolution is good for short range, ensemble size is important for extended range and higher moments
    - Computation resources are always limited
  - Possible to have the same model resolution for all global model???

Recommendation – Ensemble Forecasting

- Ensemble as backbone of probabilistic forecast system
  - Needs more resources for operation and research
  - Plan to request more computation resources
- Develop local ensemble forecast system for operation
  - For high impact weather system
- Improve ensemble methods for coupled system – further study
  - Ocean-atmosphere-land coupling system
- Optimal configuration for operational system
  - Study the possibility for tuned out deterministic forecast
    - If there is no any better than climatology
  - At least, there is no need for deterministic forecast beyond day-8
- Temporal frequency and spatial resolution
  - 3 hourly outputs are required for driving many downstream models
  - Users may request different spatial/temporal resolutions which depends on
    - Global or regional model
    - Different users

Recommendation – Statistical Post Processing

- Introduction
  - Value added by statistical post-processing – mainly reliability
  - Users need covariance, reliable probabilities and etc.
  - Need for collaborative effort
- Existing methods
  - MDL: GFS/NAM MOS / NAEFS EKDMOS (stations and grids)
  - EMC: NAEFS bias correction & downscaling (Cui et al)
  - CPC: Ensemble regression
  - Precipitation
    - Frequency matching (EMC); piecewise linear correction (CPC); weighted members (HPC)
  - Bayesian processor of ensembles (Krzysztofowicz et al)
  - Analogy method (Hamill et al)
- Distinct problems to solve
  - Lead time dependent systematic error
  - Relating model variables to sensible weather
    - Raw forecasts are still needs if we can not offer full calibration
  - Combine all predictive info into single consensus guidance
  - Choice of proxy for truth
- Statistical calibrated ensemble guidance
  - Derive user specific information from full pdf/ensemble to user specific information (single value – user dependent)

Recommendation – Reforecast/Hindcast Generation

- Generation
  - Resource (both CPUs & disk spaces) allocation for real-time forecast .vs hind-casts
  - Sample size is still study topic
- Sample size???
  - Good for extreme weather events (high impact event, too?)
  - Bulk of improvements from downscaling, not from bias correction?
    - If a Perfect Prog technique is used for downscaling, no need for hind-casts, only reanalysis is needed
  - If fast-converging methods (Bayesian) can be realized for all weather elements, need 3 times smaller sample
  - Size .vs representativeness of sample
    - If representative, sample could be as small as 3 and not larger than 30?
  - Adjustment for extremes?
    - If overall distribution is sampled, extremes would also get adjusted
  - Downstream users – can they use reanalysis to test their models?
  - Use GEFS re-forecasts to study various questions
    - Operational system improves and added value in oper is lost in 2-3 yrs?

Recommendation – Probabilistic Product Generation

- General guideline: three tiers of ensemble product
  - Tier 1: Individual members for sophisticated users, downstream models, post-processing, and research etc.
  - Tier 2: Pre-processed ensemble products of basic meteorological fields for wider range of general users
  - Tier 3: Pre-processed ensemble products of special fields for key users such as aviation, convection, fire weather, and hurricane.
- General guideline: three types of ensemble output to meet various needs
  - Type 1: full probability density function (pdf) containing full uncertainty information such as fitting curves
  - Type 2: representative points on a pdf containing partial uncertainty information such as clusters, min, max, mean, mode, 10, (25), 50 (median), (75), 90%
  - Type 3: improved deterministic forecasts such as ensemble mean, median and best member
- Uncertainty proving ground – How to test?
  - DET, HMT, HWT, AWT, JHT
  - So…uncertainty proving ground helps organize testbed efforts to make progress, including how users interpret and use uncertainty information

Recommendation – Forecaster Role and Training

- Forecaster Modification
  - Weight ensemble systems to create multi-model ensemble distributions - Reforecasts may offer these skills
  - Subjective weights - Past verification performance; Known biases; Pattern recognition
  - Weaknesses to this process - Shift-to-shift continuity; Too much focus on deterministic
  - Strengths to this process - Flow-dependent downscaling ensembles don't have
  - Flow-dependent weights (based on verification) (weight recommender)
  - Human shows skill for making probabilistic forecasts for specific thresholds
    - SPC Severe, Winter Weather, NHC TC genesis
    - Should humans edit points?
  - How to put human information back into ensemble information? Curve fitting? New tools (AWIPS II)
- Joint probability
  - Who's responsible? – Centers? Users? Based on need?
  - AWIPS II requirement to do joint probabilities on-fly
- Training
  - Basics are out there (COMET) – Focusing on forecast process
  - Local training catered toward local audience – Ad Hoc
  - ACUF Report (includes community consensus on approach including K-12, media, public, partners)
    - University education is slowly adapting
    - Where is the public/private line?
    - Interactive – Facebook
    - Any chance for forecaster to keep involved in process, need constant retraining
- Verification
  - Difficult to compare with deterministic
  - Difficult concepts to relate – Need training – Need examples
  - How to evaluate a single case? – Over climo? – 0 versus 100% – Coverage definition?
  - How to show value? – Cost/loss
  - Explore new object-oriented approaches

Recommendation- Ensemble Data Depository /Access

- Data types – NDFD / NDGD format
  - Grib 2 is standard, can be converted easily to other formats
- Product access (e.g., NOMADS)
  - Need smart “pull” capability – access to parts of files, for example; output format becomes less important
  - Methods to get specific info from files
    - Some tools are there to do this (e.g., perl modules)
  - Need SREF data in NOMADS archive
- Graphical display – AWIPS II (merge with NAWIPS)
  - Tools are needed for probability/ensemble interrogation
  - Need full ensemble on-line
- Considering future ensemble info – 6D
- Data archive (short-term and long term)
  - Need a data archive plan
  - Users require to access to CFSv2
  - New reforecasts – need to append the new forecasts to these

Recommendation - Database Interrogation

- Access is needed to international ensemble datasets (e.g., UKMO, ECMWF) by internal NWS users
  - Example: OHD and RFC needs
- Ensure RFCs etc. know where to access real-time NWS products
- Links to useful tools for tailored data access in NOMADS, with documentation
  - Develop software for data access, mining, and cataloging
- Good user documentation on datasets
  - Also trouble shooting guidance
- Guidance on other locations with data
- AWIPS II will need efficient “pull” capability
  - Well, designed and implemented to meet multiple needs is necessary

Background !!!

Background (cont…)

- Scientific and technical preparedness
  - High due to major advance in past 50+ years
- Past initiatives
  - MDL PoP and other probabilistic products since 1971
  - NCEP ensemble forecasting since 1992
    - Regional, global, wave and climate (seamless)
  - Numerous other guidance and products by NCEP centers and WFO/RFC
- Corporate policy
  - Version 2005 – NWS strategic plan
    - Deliver better products and service
      - Provide weather, water and climate forecasts in probabilistic terms (2005)
  - 2009-2014 – NCEP strategic plan
    - From the Sun to the Sea… Where America's Climate, Weather, Ocean and Space Weather Services Begin
      - Products in probabilistic terms conveying levels of uncertainty