Hydrologic Applications of NCEP Products

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Outline

- Hydrologic Products and Services
- Hydrologic Ensemble Prediction System
- Ensemble Preprocessor
- Leveraging and Collaboration
- Requirements
Hydrologic Products & Services

• Objectives:
  – Provide seamless and consistent probabilistic forecasts for all lead times
  – Reduce and quantify input and hydrologic uncertainties

• The methodology is currently tied to the lead times of available meteorological forecasts:
  – 1 to 5 days: short term
  – 6 to 14 days: medium range
  – two weeks and beyond: long range

• The spatial scale ranges from a few km² to the continental
Hydrologic Products & Services

- Seamless probabilistic forecasts for all lead times
Hydrologic Products & Services

- Uncertainties in Hydrologic Forecast

- Reduced uncertainty due to pre-processing
- Reduced uncertainty due to calibration
- Reduced uncertainty due to data assimilation
- Reduced uncertainty through modeling, DA...

Uncertainty in initial conditions

Meteorological/Input uncertainty

Parametric uncertainty

Uncertainty due to regulations

Ensemble Preprocessor

Ensemble Postprocessor, Parametric Uncertainty Processor

Ensemble Postprocessor, Data Assimilator

A big challenge
Hydrologic Products & Services

- Hydrologic Ensemble Prediction System under development
Hydrologic Products & Services

- Ensembles and associated meta data for each River Forecast Center (RFC) basin and for all lead times (1 hr to 2 yrs)
  - Ensemble inputs: precipitation, temperature, potential evaporation, freezing level
  - Ensemble outputs: streamflow, river stage, soil moisture, channel storage...
  - Meta data: how product information was generated; full disclosure of assumptions, inputs, impact of regulations, disclaimers

- Verification information for all ensemble forecasts
  - How reliable and skillful are the forecasts?
  - Requires retrospective forecasts - hindcasts
Ensemble Streamflow Prediction (ESP)

- Long-term ESP for all RFC basins
- Short- to medium-term ESP for test basins

Variational Data Assimilation
Distributed Hydrologic Modeling
ESP Under Improvement

- Design of Experimental Ensemble Forecast System (XEFS)

**XEFS Graphical User Interface**

- EPP User Interface
- Ens. Pre-Processor
- Hydro-meteorol. ensembles
- Atmospheric forcing data
- Ens. Streamflow Prediction Subsystem
- HMOS Ensemble Processor
- Hydrologic Ensemble Hindcaster
- Ens. Post-Proc.
- Raw flow ens.
- Ens. Post-Proc.
- Pp’ed flow ens.
- Ens. Product Generation Subsystem
- Ensemble verification products
- Ensemble /prob. products
- Ensemble Verification System
- Web Interface
ESP Under Improvement

- Products from Experimental Ensemble Forecast System (XEFS)

**Reliable and skillful ensembles**
(streamflow and inputs) and associated meta data for 1 hour to 2 years

**Specific data, forecasts, ensembles, and analysis**
for use in *value added* processes (e.g. flood inundation mapping)

**User selectable attributes**
- period
- duration
- time aggregation
- probability levels
- thresholds
- probability type
- analogs based on meta data

**User selectable context**
- mean, median, max, min
- analogs based on meta data
- specific years
- specific forecast w/outcome

Archive of hindcasts, forecasts, simulations, observations, and meta data

Verification information in user friendly form

Instructional (annotated examples)
Ensemble Preprocessor: Goals

• Current ensemble forecasts from NWP have significant biases in the mean and in the spread
• Single-value forecasts (HPC/RFC deterministic, atmospheric model ensemble mean) have additional skill
• Goals of Ensemble Preprocessor:
  – Retain/Improve on skill contained in single-value forecasts
  – Correct systematic biases (in the mean) in single-value forecasts
  – Generate ensembles that are unbiased in the mean and in the spread
  – Preserve space-time properties of hydrometeorological variables (Schaake Shuffle method)
  – Account for temporal scale-dependency of meteorological variables
  – Simple, efficient and robust; can be extended to longer range
Current Ensemble Preprocessor

- Current Ensemble Preprocessor produces:
  - **Short-range ensembles** conditioned on HPC/RFC deterministic forecasts
  - **Medium-range ensembles** conditioned on ensemble means from frozen version of NCEP Global Forecast System (GFS)
  - **Long-range ensembles** using:
    - climate adjustment of historical ensembles based on CPC outlooks
    - climatology distribution re-sampling to better estimate true climatological distribution

![Diagram showing the flow of data through RFC, GFS, and Statistical Adjustment subsystems to create ensembles out to 1 year.](image)
Envisioned Ensemble Preprocessor

- Envisioned Ensemble Pre-Processor will integrate:
  - other short-term ensemble forecasts: SREF, etc.
  - other medium-term ensemble forecasts from NCEP GFS and NAEFS
  - additional climate forecasts: CFS forecasts
Envisioned Multi-Model Ensemble Forecasts

Performance measures for individual and multi-model ensemble forecasts

- Mean of multi-model ensemble
- ROC (Receiver Operating Characteristic)
Leveraging NCPO/Climate Prediction Program for the Americas (CPPA)

Climate Testbed

CPPA Research Projects
CPPA Ensemble Project
CPPA Core Project
Advanced Hydrologic Prediction Service (AHPS)
Water Customers

Hydro-Testbed / Hydroclimatic Component
Collaboration with NCPO PIs

- NCEP (Mitchell, Toth et al.)
- Clark (verification, ensemble prediction, data assimilation, pre-processor)
- East-Wide and West-Wide forecast system and multi-model applications (Wood and Lettenmeier)
- K & A Georgakakos (INFORM, California)
- Alternative algorithms: Clark/Hay, Werner, Princeton, NCEP, others
- Conditional uncertainty confidence: NCEP, Princeton, Washington
- Verification statistics: Bradley, UCI, Arizona, Weber
- Future unified NWS Ensemble Pre-Processor: Community Ensemble Pre-Processor (CEPP)
Requirements

• Reliable and skillful hydrometeorological ensemble forecasts for Hydrologic Ensemble Prediction System
  – For all RFC basins
  – For all lead times from 1 hr to 2 yrs

• Weather and Climate ensemble re-forecasts/hindcasts with “recent” models for EPP calibration and hydrologic forecast verification

• Integrated verification of hydrometeorological and hydrologic ensembles across NCEP, OHD, and RFCs

• Community effort is needed toward multi-model ensemble prediction
Thank you!

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