Hydrologic Applications: CPPA’s potential contributions to NOAA’s Climate Services vision

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The Climate Prediction Program for the Americas (CPPA) 2008 PI Meeting

Silver Spring, MD
Sept 29 – Oct 1, 2008
GOAL

Understand climate variability and change
to enhance society’s ability to plan and respond

VISION

Seamless climate services enabling

• Information for better management of energy, agriculture, water, living marine resources, and other sectors, through observations, analyses and predictions, and sustained user interaction.
• Assessment of environmental impacts of climate change and variability, including related decision support information.

OUTCOMES

• A predictive understanding of the global climate system with quantified uncertainties sufficient for making informed and reasoned decisions on timescales of weeks to decades.
• Climate-sensitive sectors and the climate-literate public effectively incorporating NOAA’s climate products into their decisions and plans.
NOAA Climate Program

Seamless climate services enabling:
• Information for better management of energy, agriculture, water, living marine resources, and other sectors, through observations, analyses and predictions, including renewable energy resources.
• Assessment of environmental impacts of climate change and variability, including regional and local effects.
• A predictive understanding of the global climate system with quantified uncertainties for regional and sectoral timescales.
• Climate-sensitive sectors and the climate-literate public effectively incorporating NOAA’s climate products into their decisions and plans.

Strategic Plan for a National Climate Service

NOAA’s Climate Service Development Team
June 10, 2008

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June 10, 2008
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The atmospheric sciences view of climate service elements

Fig. 6. Conceptual links between atmospheric observations, weather and climate models, and risk and financial models, and decisions and actions.

(from Dutton, BAMS, September 2002)
The critical role of CPPA/hydrology in providing climate service products

CPPA’s research interests.
CPPA contributions to the goals of a National climate service

GOAL
Improve intraseasonal and interannual hydrologic climate predictions to enable regional and national managers to better plan for the impacts of climate variability and change.

VISION
Seamless set of hydro-climate forecast products that provide information for better management of water, energy, agriculture, and other sectors, through observations, analyses and predictions, and sustained user interaction.

OUTCOMES
Integrated suite of hydro-climate ensemble forecast products (biased corrected, downscaled, and processed via land hydrology models.)
Space/Time Analysis of hydro-climate ensemble forecast products.
Hydro-climate diagnostic studies that include hindcast analysis of forecast skill, analysis of recent and projected climate events, etc.
The role of CPPA in developing hydro-climate service products

Observations

Weather and Climate Prediction

Hydrology and Water Resources Modeling, Prediction and Data Assimilation

Water Information

Decision making

The Hydrologic Ensemble Prediction System
Elements of a Hydrologic Ensemble Prediction System

- **Weather and Climate Forecasts**
  - Single-value and ensemble forecasts

- **Atmospheric Ensemble Pre-Processor**
  - Reliable hydrologic inputs

- **Land Data Assimilator**
  - Ensemble initial conditions

- **Hydrologic Ensemble Processor**
  - Ensemble forecasts

- **Product Generator**
  - Reliable hydrologic products

- **Hydrological Models (& Regulation)**

- **Products and Services**
  - Single-value and ensemble forecasts

- **Observe (Obs)**
CPPA Science Issues in developing a HEPS

- **Downscaling**
- **Ensemble QPE**
- **Initial Conditions**
- **Product Generation**

**Weather and Climate Forecasts**
- Single-value and ensemble forecasts

**Atmospheric Ensemble Pre-Processor**
- Reliable hydrologic inputs
- Ensemble initial conditions
- Ensemble forecasts

**Hydrologic Ensemble Processor**

**Product Generator**
- Reliable hydrologic products

**Parameter Estimation**

**Hydrological Models (Regulation)**

**Hydrologic Uncertainty**

**Post-Processing**

**Products and Services**
CPPA Science Issues in developing a HEPS

- Atmospheric Pre-Processing and Downscaling
- Ensemble QPE, Precipitation Analysis and Remote Sensing
- Other Observed/Analyzed Forcing
- Ensemble Estimation of Initial Conditions
- Parameter Estimation and Parameter Uncertainty
- Hydrologic Uncertainty: Causes, Diagnostics, Analysis and Representation
- Post-Processing: Fixing Bias and Spread in Products and Hydrographs
- Product Generation for User Applications
CPPA Science Infusion Process (SIP) to develop hydro-climate forecast products.

CPPA Science activities

- Hydro-climate product generation (down scaling, ensemble generation, land data assimilation)
- Space-time analysis of the forecast products
- Diagnostic studies (hindcast analyses, orographic studies)

CPPA Testbed Projects
Prototype operational products

Seasonal climate predictions

Users
NCEP Ensemble Forecasts: Why is Ensemble Post-processing needed?

- Atmospheric forecasts are biased
- NCEP ensemble forecasts do not account for all of the uncertainty
  - Spread is typically under-estimated
  - Events that might occur not well represented
  - Space-time structure of members not fully representative: i.e. space-time structure of future events is essentially unknown

- Ensemble spread is not properly related to differences between ensemble mean and observed values
- Atmospheric ensemble members are not equally likely
  - they are more like sensitivity analyses to estimated uncertainty in initial conditions

- Major research is needed to adjust raw atmospheric ensemble members for hydrologic application
NCEP Global Ensemble Forecasts are Biased
Hydrology Ensemble Forcing Requirements

• Need skillful and reliable precipitation and temperature ensemble forcing time-series for each sub-basin/segment (1-day to ~ 1-year)

• Ensemble forcing must “preserve” space-time variability of precipitation and temperature forcing.

• Uncertainty in future forcing is time and space scale dependent and this must be represented in ensemble input to ESP

• Ensemble members must be “consistent” in space and time (over entire forecast space-time domain).
  – Required to assure streamflow members can properly be routed downstream

• Need to make “best possible” use of all weather and climate forecast information

• Ensemble members input to ESP must be “equally likely”
Atmospheric Pre-Processing Requirements

- Mesh ensemble forcing from short, medium, and long range techniques.

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<thead>
<tr>
<th>mesoscale wx models</th>
<th>medium range wx models</th>
<th>long range global circulation models</th>
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<tbody>
<tr>
<td>downscaling</td>
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<td>variable</td>
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<td>climate forecasts and indexes</td>
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- Maintain spatial and temporal relationships across very large areas.

Irrational outcomes
This needs to be extended to apply to ensemble traces so that post-processed traces can be routed downstream,
Streamflow Forecast: 198805

03075070: OHIO RIVER AT CANNELTON DAM AT CANNELTON, IN (97000.00 sq mile)

03277200

03303280

03611500

0303280: OHIO RIVER AT METROPOLIS, IL (203000 sq mile)
Soil Moisture: 198805 Forecast

Observations

Climatological Forecast

CFS-based Forecast

Multi-model Forecast

Lead time
Thank You