Experimental Medium-range Ensemble Streamflow Forecasts Based on Coupled GFS-Noah Ensemble Runoff Forecast

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Introduction

Background:

- Land Surface component of NCEP coupled weather/climate prediction models (Mitchell et al, 2005) facilitates streamflow forecast in these coupled systems.
- River routing experiment in analysis mode of the North American Land Data Assimilation System (NLDAS) project (Lohmann et al, 2004) revealed potential extension to stream flow forecast in coupled prediction models.
- Existence of uncertainty in initial conditions, model structure and land surface forcing needs to be considered with an ensemble approach.

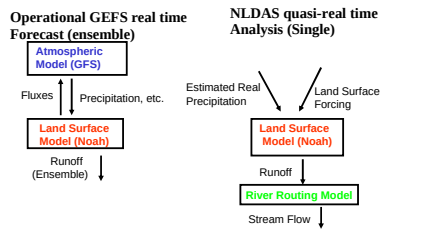
Purpose:

- Demonstrate feasibility of medium-range river flow forecast in operational NCEP Global Ensemble Forecast System (GEFS).
- Develop suitable strategy to account for uncertainties.
- Validate model output of stream flow.
- Extent the concept to the seasonal range by utilizing ensemble coupled CFS/Noah predictions of runoff when such forecasts are available.

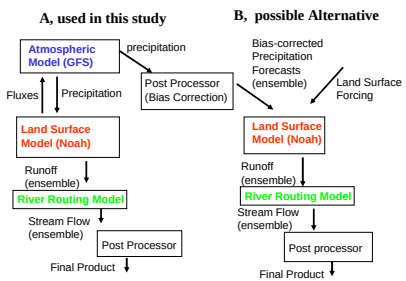
General Strategy:

- NLDAS stream flow analysis is used as initial condition and verification;
- Water management issues are postponed and natural flow forecast is emphasized;
- Extension to global domain is in mind with domestic and international users;
- River flow forecast capability is considered a component of the Earth System Modeling Framework;
- Hind cast data set to be generated for post pressing.

Current NCEP Routines



Ensemble Stream Flow Forecast Two possible Approaches



Configuration (Design of Experiment, Approach A)

River Routing Model: linear program, distributed approach, same as used in NLDAS (Lohmann et al., 2004).

Model domain: For this preliminary test, both the GFS/Noah runoff predictions and streamflow routing network are represented on the 1/8- degree latitude/logitude CONUS of the NLDAS (Mitchell et al., 2004).

River Flow Direction Mask: A D8 model, river stream in each grid point is discharged to one of the eight main directions (Lohmann et al, 2004). Data provided by OHD/NWS and merged at NCEP/EMC.

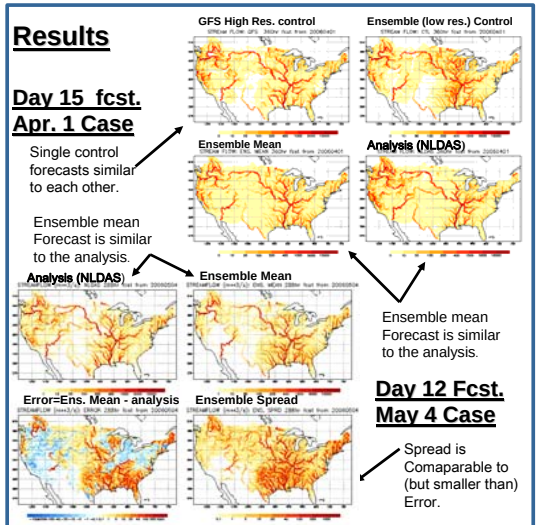
Forcing: Runoff fields from the coupled land-atmosphere GFS/Noah model, as executed in ensemble mode in the operational GEFS system, and the high resolution single forecast (GFS), interpolated to NLDAS grid.

Initial Condition is generated by running the streamflow routing model in analysis mode, driven by the analysis of runoff fields. The later is produced by NLDAS system forced by observed precipitation and other land surface forcing from NCEP's mesoscale N. American Data Assimilation System (NDAS).

Uncertainty considered in river routing: only the uncertainty associated with the forcing is partially represented. No initial uncertainty is included. Hydrological model error is ignored but the systematic errors can be corrected via post processing.

Evaluation: Streamflow forecasts are evaluated against the NLDAS streamflow analysis (the same as that used as the initial condition).

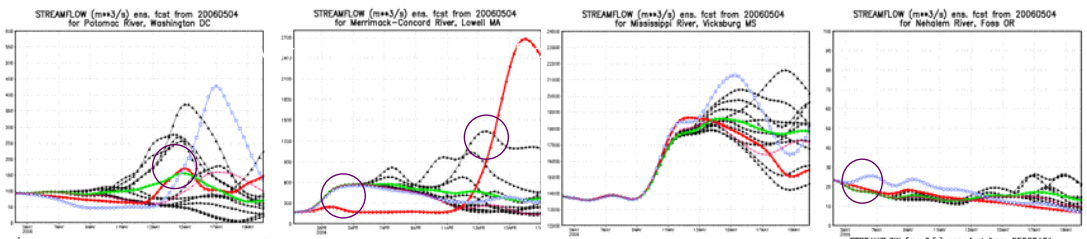
Results



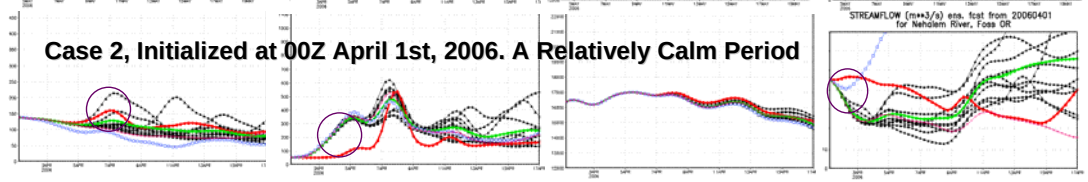
Results (Forecast Time Series, lead time day 0 to day 16)

----- GEFS members
----- GEFS ensemble mean
----- GEFS control
----- GFS high resolution
----- NLDAS Analysis

Case 1, Initialized at 00Z May 4th, 2006. New England Floods



Case 2, Initialized at 00Z April 1st, 2006. A Relatively Calm Period



Potomac River, Washington, DC
A Medium-sized basin

Single Forecasts are insufficient;

Non-linear evolution of ensemble members help to improve forecast and capture major and minor flood events.

Merrimack-Concord River, Lowell, MA
A Medium-size basin

The ensemble forecast shows some skills with a number of members stretching to capture the flood events.

Major problem: under-dispersive ensemble.

Mississippi River Vicksburg, MS
A Large Basin

Trend and the flood event are well captured.
Short lead time is dominated by initial condition, showing little spread. Spread Increases with time in the flood case.

Nehalem River, Foss, OR
A small-sized Basin

Problem in short range forecast.

Possible causes: Bias, lack of spread, insufficient spatial/temporal resolution in precipitation/runoff fields.

Summary of Results

- Distributed river routing ensemble system (coupled GEFS, Noah and the river routing model used) works well with the variability in the ensemble streamflow forecasts being of the same order of magnitude as the error in the mean of the ensemble.
- For large basins, the ensemble streamflow forecasts appear to capture well the variations in the NLDAS analysis of streamflow.
- For medium- and small-sized basins, a serious under-dispersion is present in the spread of the ensemble streamflow forecasts. This is likely due to a lack of sufficient variability in the precipitation forcing on the scale of the chosen river basin.

References:

Mitchell, K. et al., 2005: NCEP implements major upgrade to its medium-range global forecast system, including land-surface component. GEWEX newsletter, May 2005.

Lohmann, D. et al.,2004: Streamflow and water balance intercomparisons of four land surface models in the North American Land Data Assimilation Systems project. J. Geophy. Res., 109, D07S91.

Mitchell, K. et al., 2004: The multi-institution North American Land Data Assimilation Sysytem (NLDAS): Utilizing multiple GCIP products and partners in a continental distributed hydrological modelling system. J. Geophy. Res., 109, D07S90.

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