Western U.S.

Test Bed Leaders

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Test Bed Description

The test bed targets hydrologic ensemble forecasting challenges that are particular to the orographically complex, snowmelt-driven basins of the Western US and British Columbia. Although this region presents water management difficulties ranging from flood prevention to multi-year reservoir operations, and streamflow forecasts are operationally produced for lead times from hours out to 2 years, the primary focus of this test-bed is on prediction at monthly to seasonal lead times (i.e., 2 weeks t0 12 months).
Several basins within this region are proposed for study:

- The Mica Basin (BC): Located at the headwaters of the Columbia River. As BC Hydro's second largest basin, it is significant not only for power production, but also for flood control as part of the Columbia River Treaty between Canada and the United States.
- Feather River (CA): Inflow to the primary water storage of the (CA) State Water Project, Lake Oroville, which supports a large variety of water uses.
- Columbia River sub-basins:
    - a) Yakima River (WA): Inflow to a number of reservoirs that support irrigation and fisheries; this east-slope Cascades mountain range basin is relatively vulnerable to warm winters.
    - b) Salmon River (ID): One of the larger relatively unimpaired basins in the western US, with snow playing a large role in summer runoff.
    - c) Upper Klamath River, OR: Inflow to Klamath Lake, the central project supporting Klamath River basin irrigation, fisheries, water quality and other demands.
- Gunnison River (CO): Inflow to the Aspinall Unit, collectively the largest surface storage project in Colorado and an important component in management of springtime flows for fish.

Key Scientific Questions

The science questions for this test-bed focus on both the reduction and accurate estimation of hydrologic forecast uncertainties related to initial hydrologic state, hydrologic model error and climate forecasts. What strategies are appropriate for reducing uncertainty from each of the following sources:

- <u>Hydrologic model calibration</u>
  Does ensemble forecasting require different parameter estimation approaches than deterministic forecasting, such as multiple parameter sets or tailored objective functions?
  How can automatic calibration aid in characterizing uncertainty?
  Are improvements possible through multi-model combination or bias-correction techniques?

- Initial conditions
  What are effective techniques for data assimilation of snow?
- Climate forecasts
  How best to merge forecasts with different lead times, and to combine different types of forecast information (e.g., climate indices, climate model outputs)?

Also of interest, but of secondary priority, are questions concerning approaches for assimilation of soil moisture and streamflow (for initial condition estimation), and downscaling of climate model forecasts. Lastly, a related general question is: for different forecasting objectives (e.g., seasonal streamflow volume), how does the attribution of total forecast uncertainty in these three areas (model, initial state, climate forecast) vary in space and time?

Key Objectives of the Research Project

This test-bed is intended to facilitate the comparison and evaluation of practical ensemble forecast related methods *that are viable in an operational setting*, and address current operational forecast difficulties. Because snow is such an important predictor in the western U.S. and British Columbia, insight into strategies for snow assimilation and the implications of snow assimilation for estimating forecast uncertainty and bias, is a high priority. Likewise, hydrologic model error reduction and estimation via calibration approaches are critical to the widespread operational deployment of hydrologic models in forecast operations, hence collaborative research in this area is strongly encouraged. Where initial conditions play less of a role (e.g., in the Klamath River basin), climate forecast related research is emphasized.

In each of the proposed basins, one or more of the questions are currently being addressed (incompletely) via various existing methods. The test-bed leaders will make available datasets and models related to those methods, and request that others in the community contribute alternative approaches (data, models, methods) for a parallel evaluation (retrospective, and if possible, in real-time).

Data Resources

In general, the resources available for the six basins in the test-bed region are models, retrospective and in some cases real-time model inputs and outputs, verification datasets, and methods (programs and guidance in using them)

Existing resources for the Mica Basin

- Calibrated conceptual hydrologic model (UBC watershed model).
- Model input: hydrometeorologic data available since 1965 (climate data: Golden, Blue River, Roger's Pass; flow data: Kinbasket Lake inflows; app. 20 snow courses and pillows).
- Model output: ESP forecasts are available since 1978.
- Archive of reference statistical forecasts.
- Methods for (a) merging short-lead and seasonal forecasts; and (b) snow assimilation – and data input/output for a retrospective application of these methods.

Existing or pending resources for the Salmon, Klamath, Yakima and Feather Rivers (and Mica and Gunnison R. basins)

- 1/8 degree model forcings (daily precip, tmin, tmax, wind speed) from 1915-present (by various methods).
- VIC model implementations in various stages of calibration and development.

- 1/8 degree VIC model outputs from 1915-present (by various methods), including runoff, evaporation, snow water equivalent and soil moisture.
- Naturalized monthly flow data for a number of locations; naturalized daily flow data for fewer.
- Real-time forecasts, once monthly (increasing to bi-monthly), since autumn 2003, from a variety of sources (NCEP and NSIPP1 climate models, ESP, CPC outlook), not all months present for all forecasts.
- Statistical downscaling methods for climate model ensemble output and CPC probability of exceedence format seasonal outlooks.
- A real-time/retrospective index station meteorology dataset (daily Prec, Tmax, Tmin, Wind speed).
- A VIC-specific SWE observation assimilation routine, and associated inputs/outputs in real-time (once a month) and retrospectively to winter 2002 or 2003 (depending on location).
- Calibrated PRMS models for the Klamath, Yakima and Gunnison river basins, with associated simulated and retrospective runs.
- Archive of historical official water supply outlooks.

Data are available to the HEPEX community from the following site:
http://www.hydro.washington.edu/forecast/hepex/

Recent Activities

Link to the web-site http://www.hydro.washington.edu/forecast/hepex/