The HEPEX Seasonal Streamflow Forecast Intercomparison Project

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Overview

- Recent years have seen the proliferation of new operational and experimental streamflow forecasting systems.
- These systems are developed by scientific and operational groups working independently, which makes comparison of different methods difficult.
- The ***HEPEX Seasonal streamflow Forecasting Intercomparison Project (SSFIP)*** aims to compare a range of different streamflow forecasting approaches over a common set of catchments using a common set of validation methods.
- SSFIP is conducted under the auspices of the Hydrological Ensemble Prediction Experiment (HEPEX; http://www.hepex.org), and was formulated at a HEPEX Workshop on SS Forecasting at SMHI (Sep, 2015)

Experimental protocols

A set of experimental protocols have been established through regular meetings (~fortnightly) of the initial SSFIP participants (from NCAR & CSIRO).

Predictands

SSFIP will test the ability of prediction systems to forecast streamflows for the coming:

- 1-month and 3-month periods
- Specific future runoff periods (for instance, in some basins the snowmelt period runoff is a key predictand)

Forecasts will be generated at the end of each month (i.e., each year 12 forecasts will be generated for each predictand). Data are formatted in netCDF according to a common standard to facilitate consistent analysis.

Predictors

A common set of predictors is compiled for each catchment experiment, e.g.:

- Antecedent watershed moisture measures (streamflow, modeled soil moisture, snow water equivalent)
- Relevant climate system states (eg, climate teleconnection indexes; climate reanalyses)
- Observed daily or monthly meteorology (precipitation, temperature, potential evaporation)
- Climate forecasts (dynamical or statistical, eg from POAMA, CFSv2, NMME

Cross-validation and verification

Because streamflow can have long memory – for example, soil moisture stores can drain over years – we have adopted a stringent leave-3-years-out cross-validation scheme for SSFIP experiments (Figure 1).

A set of **metrics** has been agreed upon to verify forecast accuracy, reliability and sharpness. These include probabilistic performance measures such as the continuous ranked probability score and the probability integral transform, as well as deterministic measures such as the root mean square error.

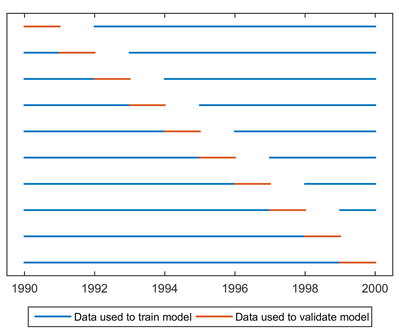

Figure 1: Leave-3-years-out cross-validation scheme

Initial Forecast Basins

The project begin in 2016 with two pilot basins, the Murray River at Biggara (Australia) and the South Fork Flathead River, MT, which forms the inflow to the Hungry Horse Reservoir, which is operated by the US Bureau of Reclamation.

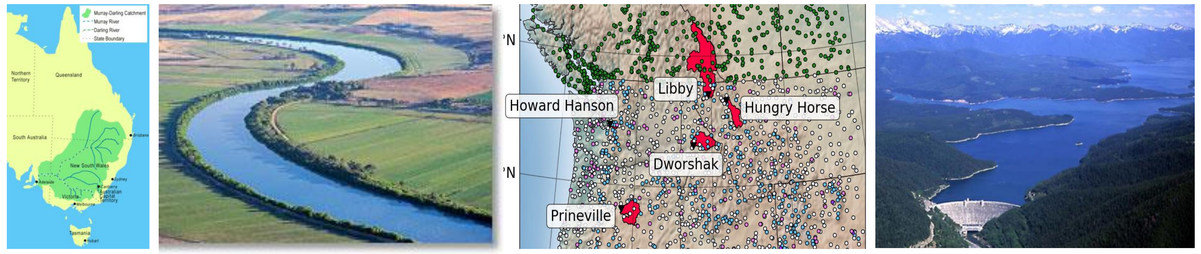

Figure 2: Map and photo: (left) Murray Darling Basin (MDB) and (right) Hungry Horse Reservoir (HHWM8) drainage basin

Preliminary experiments and findings

- NCAR and CSIRO have each performed hindcasts for two watersheds, each using their preferred approach while making use of the same predictors and predictands. The experiment thus assessed the efficacy of elemnts of the approach for harnessing predictability.
  - CSIRO: Bayesian joint probability modelling approach (BJP, Wang et al. 2009)
  - NCAR: Heirarchical Expert Streamflow Prediction approach (HESP, Mendoza et al. 2016)
- The approaches differed in several aspects, including the methods to relate predictands and predictor and the normalizations of variables. Preliminary results (e.g., Figure 3) suggest that CSIRO's normalization and BJP offer a slight improvement over the heirarchical linear regression applied by NCAR. NCAR's development of custom climate predictors from reanalysis also was found in some cases to offer advantages over standard climate indices. Both sets of results had a high degree of reliability (additional verification displays not shown)
- Work is now being carried out to diagnose results further and to add additional catchments and forecasting methods

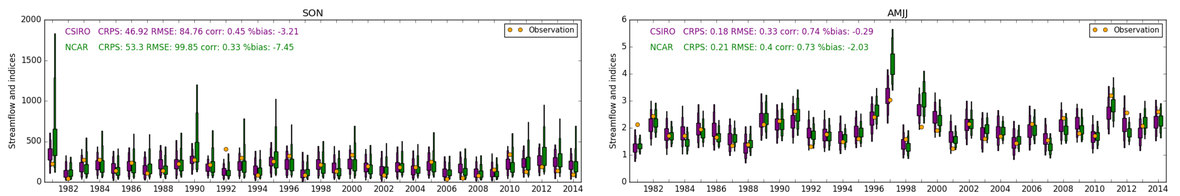

Figure 3: Left panel: example hindcasts generated for September-October-November for the upper Murray River in SE Australia. Right panel: hindcasts April-June-July-August for the Hungry Horse Reservoir catchment in NW United states.

Knowledge Sharing / Collaboration

- A website has been established to share forecast data and verification (Figure 4): http://www.ral.ucar.edu/staff/wood/ssfip/#

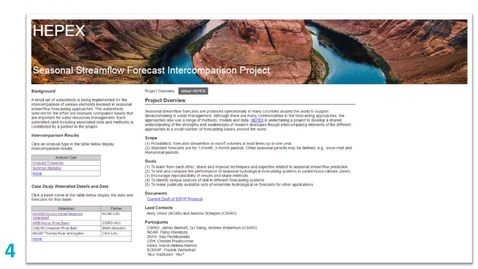

Figure 4

FOR FURTHER INFORMATION
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REFERENCES

Wang QJ, Robertson DE, Chiew FHS. 2009. A Bayesian joint probability modeling approach for seasonal forecasting of streamflows at multiple sites. *Water Resources Research* 45: W05407. DOI: 10.1029/2008WR007355.

Mendoza, PA, AW Wood, E Rothwell, EA Clark, MP Clark, B Nijssen, LD Brekke, and JR Arnold, 2016, An intercomparison of approaches for harnessing sources of predictability in operational seasonal streamflow forecasting, *HESS* (submit Dec 2016)

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HEPEX a community of research and practice to advance hydrologic ensemble prediction

CSIRO NCAR UCAR RAL