Long-Lead Streamflow Forecast for the Columbia River Basin for 2003-2004

JISAO Climate Impacts Group and the Department of Civil Engineering
University of Washington
September, 2003

Alan F. Hamlet
Andy Wood
Seethu Babu
Marketa McGuire
Dennis P. Lettenmaier
What’s New:

• Expansion to West-Wide forecasting domain
  • Andy Wood
  • Seethu Babu
  • Marketa McGuire

• Quasi-operational forecasts updated monthly from October-April. New methods for estimating the initial soil moisture and snow state. Climate model and ESP forecasts.

• 50-year retrospective forecast simulations for two forecast systems

• New hydrologic model driving data sets for a longer period from 1915-2000

• Bias corrected linkages from streamflow forecasts to reservoir models
A Brief Overview of the Hydroclimatology of the Columbia River
Hydrological Characteristics of the Columbia Basin

Avg Naturalized Flow

- Snowmelt Dominant
- Winter Climate Determines Summer Peak Flows

The Dalles
Effects of the PDO and ENSO on Columbia River Summer Streamflows
In 5 out of 7 test years, accurate categorical ENSO forecasts (warm, neutral, cool) have been available in June preceding the water year. By October simple persistence provides a good forecast.
Variable Infiltration Capacity (VIC) Model

Variable Infiltration Capacity (VIC) Macroscale Hydrologic Model

Cell Energy and Moisture Fluxes

Variable Infiltration Curve

\[ \text{Variable Infiltration Curve} \]

\[ i = \frac{i_t}{1 - (1 - A)^{10}} \]

Baseflow Curve

\[ D_0, D_m, W_0, W_2 \]

Fraction of Area

Routing Flow Network

Columbia River 1/8° degree resolution
Ensemble Streamflow Prediction

1) Observed Meteorological Time Series
2) Climate Model Forecasts

Standardized Initial Conditions

Hydrologic Model

Streamflow Ensemble
Time Line for 12-month Lead Time Retrospective Forecasts

- Climate Forecast
- Estimated Initial Conditions
- Forecast Ensemble

Lead time = 12 months
How did we do last year?
Recap of 2003 Forecast at The Dalles

Climatology

Blue = ensemble mean
Red = observed flow
Baseline Forecast at The Dalles using Older Resampling Methods (Oct 1, 1993 initial conditions)

Blue = ensemble mean
Red = long-term mean

Climatology

2004
Domain of New West-Wide Experimental Forecasting System
Expanded Pacific Northwest Routing Locations
Overview of Simulations

1-2 years back

VIC model spin-up

NCDC meteorol. station obs. up to 2-4 months from current

LDAS/other meteorol. forcings for remaining spin-up

Forecast Products
- streamflow
- soil moisture
- runoff, snowpack

start of month 0

VIC forecast ensemble

VIC climatology ensemble

Adjustment of snow state using Snotel or remote sensing products

data sources

end of water year
Soil moisture state from Sept 1, 1994 used for forecast initialization
Selected 2004 Forecasts for the Columbia Main Stem and Snake River Basin

http://www.ce.washington.edu/pub/HYDRO/aww/w_fcst/w_fcst.htm
Natural Flow at The Dalles (ENSO neutral)
(Sept 1, 1994 initial conditions)
CRB Streamflow Forecast vs. Climatology (1960-99)
FORECAST DATE: September 1, 2003

Columbia River at the Dalles, OR

avg flow (kcfs)

Sep  Oct  Nov  Dec  Jan  Feb  Mar  Apr  May  Jun  Jul  Aug

climatology  forecast  enso=Neut  enso=N, pdo=+
CRB Streamflow Forecast vs. Climatology (1960-99)
FORECAST DATE: September 1, 2003

Jackson Lake

avg flow (kcfs)

climatology  forecast  enso=Neut  enso=N, pdo=+
CRB Streamflow Forecast vs. Climatology (1960-99)
FORECAST DATE: September 1, 2003

Milner

avg flow (kcsf)

Sep  Oct  Nov  Dec  Jan  Feb  Mar  Apr  May  Jun  Jul  Aug

- climatology
- forecast
- enso=Neut
- enso=N, pdo=+
CRB Streamflow Forecast vs. Climatology (1960-99)

FORECAST DATE: September 1, 2003

Snake River at Ice Harbor, WA
Linkage to Reservoir Models

Streamflow Forecast → Bias Correction → Reservoir Model → Storage Ensemble

Observed Reservoir Contents → Reservoir Model

Demand Scenarios
Portion of Domain in Storage Forecast
System Storage Forecast from SnakeSim:

Jackson Lake
Palisades
Island Park
Ririe
American Falls
Lake Walcott

11 ENSO neutral years (reshuffled 3 times)

Random historic demand scenarios
Probability of Exceedence Plot for System Storage Simulation
Summary and Conclusions

Natural streamflows for April-September in the Columbia basin have shown relatively consistent associations winter ENSO and PDO state for the past 100 years.

The long range forecast for WY 2004 is based upon estimates of initial hydrologic conditions, the historic climate record from 1960-2000, and a forecast of ENSO neutral state for the coming winter.

An ENSO neutral event for the winter of 2003-2004 is associated with a higher likelihood of natural streamflows for the Columbia basin in the middle third of the climatological distribution (moderately above average to moderately below average). One very high flow event occurred in 1997. Dry initial conditions generally result in lower flow values, although the highest ensemble member produces higher peak flows in June at The Dalles.

System storage in the upper Snake is likely to refill substantially in 2004, and carryover storage in September, 2004 has about an 80% chance of exceeding 1500 kaf, a 60% chance of exceeding 1700 kaf, and a 40% chance of exceeding 2000 kaf according to the forecast.