Seasonal Hydrologic and Streamflow Forecasting: A Western U.S. Experiment

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UW Center for Water and Watershed Studies

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Presentation Outline

1. Introduction
   • hydrologic forecasting in the western U.S.
   • seasonal climate prediction
   • experimental hydrologic forecasting system

2. Results: Last Water Year and Current Water Year

3. Future Directions
The Big Picture: Importance of Hydrologic Forecasts

**Water Management**
- Hydropower
- Irrigation
- Flood control
- Water supply

**Fisheries**
- Recreation
- Navigation
- Water quality

**Introduction: Hydrologic prediction and NRCS**

SNOTEL Network

McLean, D.A., 1948
Western Snow Conf.

Snow water content on April 1

April to August runoff
Introduction: Hydrologic prediction and NWS


Ensemble Streamflow Prediction (ESP)
- used for shorter lead predictions;
- ~ used for longer lead predictions

Currently, some western RFCs and NRCS coordinate their seasonal forecasts, using mostly statistical methods.

Introduction: Potential Advances since regression / ESP

- 1920s 1930s 1940s 1950s 1960s 1970s 1980s 1990s 2000s
- snow survey / graphical forecasts / index methods / i.e., regression
- hydrologic computer model
- Internet / real-time data
- computing in water resources
- satellite imagery
- SNOTEL network
- ENSO / seasonal climate forecasts
- aerial snow surveys
- desktop computing
- ESP method
Introduction: Seasonal climate prediction

Climate prediction has markedly advanced in the last several decades

- better monitoring of oceans and atmosphere
- deeper understanding of ocean-atmosphere teleconnections
- Monthly / seasonal climate forecasting has become operational at a number of research centers

**Sea Surface Temps**

**Circulation Features**

*e.g.* El Nino / La Nina

**Typical climate model spatial resolution**

**Introduction: Seasonal Climate Prediction**

**National Weather Service Climate Prediction Center**

**Seasonal Outlooks**

OFFICIAL Forecasts

(PROPOSED 1 & 3 MONTH SERVICE CHANGE)

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<th>6-Month</th>
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<td>Jan-Mar</td>
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**e.g., precipitation**
Introduction: Seasonal climate prediction

N. American Precip forecasts made: 1Jul2003

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Introduction: Experimental Hydrologic Forecasting

This website presents current monthly-to-seasonal hydrologic, streamflow and reservoir system forecasts for the western U.S. The experimental effort is funded by primarily by NOAA/OIfF, the RMACS Regional Applications Project, and the NASA Seasonal-to-Intrannual Prediction Project (NSIPP). Currently, two forecast approaches are used, both centering on the use of macroscale hydrologic simulation with the VIC model:

- the Ensemble Streamflow Prediction (ESP, formerly Extended Streamflow Prediction) method, and the ESP method conditioned on BSSO and FDCO states
- ensemble forecasts downscaled from several climate models (CCE, CEM, and NASA NSIPP-1)

Forecast outputs include monthly streamflow ensembles, spatial distributions of snow water equivalent (SWE), soil moisture and runoff, and (outlet active) reservoir system storage and flow forecasts. In addition, the analysis of the initial hydrologic state at the forecast date constitute a forecast of SWE and soil moisture conditions throughout the domain, based on observed meteorology.
Introduction: Experimental Hydrologic Forecasting

VIC model runoff is routed to streamflow gages, and verified against observations.
Introduction: Experimental Hydrologic Forecasting

Spatial and temporal disaggregation of seasonal climate forecasts is essential

Bias-correction of forecasts is also needed

A variety of reliable methods exist

* experimental, not yet in real-time product
Introduction: Experimental Hydrologic Forecasting

*streamflow forecast locations*

*monthly hydrographs*

**targeted statistics** e.g., runoff volumes

Forecast flow percent of average for 2004 APR-SEP average at low, median and high percentiles

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Mar-05

Apr-05

May-05

**UW Experimental Hydrologic Forecasting**

**Precip**

**Temp**

**SWE**

**Runoff**

**Soil Moisture**
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Results: WY2004, late February hydrologic conditions
Results: WY2004’s, March climate

CPC estimates of seasonal precipitation and temperature

March

very dry

hot

Results: WY2004, late March hydrologic conditions
Results: **WY2004, Columbia R. volume forecast**

Apr-Sep Volume Flow Forecasts, UW compared to NWRFC
Columbia River at the Dalles, OR

- UW ESP: median, 0.10 and 0.90 bounds
- UW CPC: median, 0.10 and 0.90 bounds
- NWRFC: "most probable", probable min and max bounds

Results: **WY2005, Feb. 1 hydrologic conditions**

Soil Moisture Percentiles (wet/1060-1999)
February 1, 2005

Snow Water Equivalent Percentiles (after obs. precipitation)
February 1, 2005  threshold = 100 mm
Results: WY2005, Feb. 1 SWE observations

The observed SWE values, which are merged with the forecast initial conditions, were in good agreement with the VIC simulated snow state.

The PNW currently has very low snowpack, while the Southwest and California have record high snowpacks.

Are we headed for some kind of a record low year in the Columbia River basin?

Detour: Headlines from February, 1977
Detour: Headlines from February, 1977

Governors seek federal funds for drought aid

Vance ends Mideast tour

O'Neill defends Congress’ pay raise

Dry weather causes aluminum layoffs

Engineers hold back river flow

Results: WY2005 vs. WY1977 SWE

How does the PNW current year compare to the worst in the last 50 years?

Columbia R. basin upstream of The Dalles, OR
**Results: WY2005 vs. WY1977 Soil Moisture**

How does the PNW current year compare to the worst in the last 50 years?

Columbia R. basin upstream of The Dalles, OR

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**Results: WY2005, Feb. 1 streamflow forecasts**

- **98%**
- **85%**
- **1977: 55%**
- **80%**
**Future Directions**

- Move from monthly to weekly forecast updates
- Incorporate other hydrologic models
- Add more flow forecast points, particularly west of the Cascades
- Work with NRCS on their current exploration of model-based forecasting
- Improve use of satellite imagery, particularly for snow covered area

**Questions?**

website:

www.hydro.washington.edu / Lettenmaier / Projects / fcst /
Results: WY2004, a typical PNW streamflow forecast

By Fall, slightly low flows were anticipated.

By mid-winter, moderate deficits were forecasted.

Results: WY2005 vs. WY1977 Precip

How does the PNW current year compare to the worst in the last 50 years?

Columbia R. basin upstream of The Dalles, OR