A RiverSMART Testbed to Analyze Colorado River Streamflow Forecasts and Operational Projections

Sarah Baker^{1,2}, Jim Prairie², Carly Jerla², Alan Butler², Edie Zagona^{1,3}, Balaji Rajagopalan¹, Andy Wood⁴,

RiverWare User Group Meeting February 2, 2018



U.S. Department of the Interior Bureau of Reclamation

University of Colorado Boulder¹, Bureau of Reclamation², CADSWES³, NCAR⁴

Overview

- Motivation & Research Objectives
- Testbed Framework
- Results & Analysis



Motivation

- Streamflow forecasts provide information regarding the quantity and timing of flow through a river system
 - Important for water users: agriculture, municipal, industrial, and recreation
 - Input to operations and planning models that project reservoir operations
- Skillful second year forecast would be valuable to stakeholders



Research Objectives

- 1. Create a testbed framework and establish a protocol for testing the performance of streamflow forecasts and modelled operational projections in the Colorado River Basin (CRB).
- Assess the current uncertainty and error of streamflow forecasts and operational projections made by the Mid-term Probabilistic Operations Model (MTOM).
- 3. Evaluate experimental streamflow forecasting methods, and subsequently modelled operations in the testbed.

Mid-term Probabilistic Operations Model

- Risk-based operational planning and analysis
- Models operations of 12 reservoirs in the basin
- Monthly rule-driven operations of the 2007 Interim Guidelines
- Forecast Upper Basin
 - Ensemble Streamflow Prediction (ESP) produced by the CBRFC for 12 locations
 - 30 traces of monthly streamflow from hydrology model forced with T&P data from the period of record



CRB Testbed Framework



Design of Testbed Simulations



Testbed Structure – RiverSMART



Hydrology Metrics –

Annual Lake Powell Unreg. Inflow – CRPSS Streamflow Forecast: ESP (1981-2016)



Operational Projection Metrics – RMSE of Lake Powell EOCY Pool Elevation Streamflow Forecast: ESP vs. Observed (1981-2016)



Study Month / Outlook Length (Months)

Operational Projection Metrics – RMSE of Lake Mead EOCY Pool Elevation Streamflow Forecast: ESP vs. Observed (1981-2016)



Operational Projection Metrics –

Pool Elevation Evolution – Observed Streamflow (2008-2016)



Conclusions

Streamflow Forecast:

 ESP exhibits 2nd year skill starting in the Fall (~15 month lead), and further increased skill by April (9 month lead)

Operational Projections:

- ESP produces large range of possible pool elevations in Powell and Mead at longer lead times
 - Error decreases significantly by June (7 month lead)
- A RiverSMART testbed run with hindcasts is a useful strategy for evaluating streamflow forecasts and operational projections

QUESTIONS?

Colorado River Basin Forecast Testbed

EXTRA SLIDES IF NEEDED

Operating Tiers

	Lake Powell		Lake Mead		
Elevation (ft)	Operational Tier	Active Storage (maf)	Elevation (ft)	Operational Tier	Active Storage (maf)
3,700	Equalization Tier equalize, avoid spills or release 8.23 maf	24.3	1,220	Flood Control Surplus or Quantified Surplus Condition Deliver > 7.5 maf	25.9
3,636 – 3,666	Upper Elevation Balancing Tier release 8.23 maf; if Lake Meed < 1.075 feet	15.5 – 19.3	~1,200	Domestic Surplus or ICS Surplus Condition Deliver > 7.5 maf	~22.9
	balance contents, release 7.0 - 9.0 maf		1,145	Normal or ICS Surplus Condition Deliver ≥ 7.5 maf	15.9
3,575	Mid-Elevation Release Tier	9.5	1,075	Shortage Condition Deliver 7.167 maf	9.4
	release 7.48 maf; if Lake Mead < 1,025 feet, release 8.23 maf		1,050	Shortage Condition Deliver 7.083 maf	7.5
3,525	Lower Elevation Balancing Tier balance contents, release	5.4	1,025	Shortage Condition Deliver 7.0 maf Further actions may be taken by Secretary of the	5.8
3,370	7.0 - 9.5 maf	0	895	Interior	0

Coordinated operations for Lake Powell and Lake Mead (U.S. Bureau of Reclamation, 2007).

Review of Past Hydrologies

Year	Wet/Normal/Dry (2.8-7.3 / 7.3-12.4 / 12.4-21.1 MAF)
2001	Dry – 6.7 MAF
2002	Dry – 2.8 MAF
2003	Dry – 6.2 MAF
2004	Dry – 6.4 MAF
2005	Wet – 12.8 MAF
2006	Normal – 9.6 MAF
2007	Normal – 7.6 MAF
2008	Normal – 11.9 MAF
2009	Normal – 10.1 MAF
2010	Normal – 8.8 MAF
2011	Wet – 16.2 MAF
2012	Dry – 4.2 MAF
2013	Dry – 5.8 MAF
2014	Normal – 10.6 MAF
2015	Normal – 9.8 MAF