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Enhancing the resilience of energy and water resources through integrated management and the use of probabilistic forecasts

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California Energy Commission Workshop: Climate Adaptation in California's Energy Sector

The INFORM Project – Integrated Forecast and Reservoir Management

Major Resevoirs in Nothern California



Reservoir Management Components:

A system of reservoirs modulates the climatic and weather variability to support a range of socio-economic and env. services

- flood damage reduction
- hydroelectric power generation
- water supply/conservation for agriculture and other sectors
- ecosystem management
- others

Reservoir effectiveness is substantially influenced by

- climatic variability and trends
- sectoral demands variability and trends
- interactions of resources and uses

Challenge:

Total Northern Cal System Water Deliveries: 5,810 TAF – 2006 3,368 TAF – 2008

Vision:

Improve multi-objective reservoir-system management in Northern California using climate, hydrologic, and decision science to support inclusive stakeholder decision processes.

From Research to Demonstration to Operations

Joint Effort Hydrologic Research Center and Georgia Water Resources Institute at Georgia Tech

1990	2000	2010	2020

Research:

Coupled climate-weather-hydrology forecasts with reliable uncertainty measures and lead times from 6 hours to 9 months Decision models for reservoir system management with explicit account of forecast uncertainty and multiple decision horizons

Demonstration:

Implement a virtual integrated forecast-management system for the Northern California reservoirs **in collaboration with forecast and management agencies using near operational models**. Perform tests with actual data and **with management input** to demonstrate utility over several-years.

Operations:

Install INFORM software at the CA DWR Sacramento Operational Facility and facilitate access of INFORM weather and hydrology forecasts, risk-based performance trade-offs, and associated decision policies by Agency Forecasters and Managers. 8 Aug 2019 INFORM

Funding and Collaborating Agencies

FUNDING:

Research: U.S. National Science Foundation, U.S. National Oceanic and Atmospheric Administration, U.S. Geological Survey, California Energy Commission

Demonstration: U.S. National Oceanic and Atmospheric Administration, CALFED, California Energy Commission

Operations (up to present): California Department of Water Resources

COLLABORATING AGENCIES:

California Department of Water Resources; California-Nevada River Forecast Center; Sacramento Area Flood Control Agency U.S. Army Corps of Engineers; U.S. Bureau of Reclamation; National Centers of Environmental Prediction (NCEP)



INFORM System Components



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A Typical INFORM Run [March 1, 2012]

Mean Streamflow Forecasts vs. Historical Averages:



PROJECTIONS DEPART SUBSTANTIALLY FROM HISTORICAL INFLOWS

DEPARTURE PATTERN IS DIFFERENT FOR DIFFERENT RESERVOIRS

A Typical INFORM Run [March 1, 2012]

Associated Mean Tradeoffs: Water Deliveries vs. Carryover Storage vs. Energy Gen.





CONSTRUCT TRADE-OFF CURVES USING A FIXED SYSTEM DELIVERY MEAN FORECASTS AND MAXIMIZING BENEFITS TO ALL RESERVOIR SYSTEM OBJECTIVES

COMPARE TO CLIMATOLOGICAL MEAN TRADE-OFF CURVES

A Typical INFORM Run [March 1, 2012] cont'd

Risk-based Tradeoffs: System Storage on March 1 and Nov 1 for alternative mgt. policies



PROJECTING FROM MARCH 1 TO THE FINAL CARRY-OVER STORAGE (WATER AVAILABLE TO START THE NEW WET SEASON) OF THE SYSTEM OF RESERVOIRS IN NOVEMBER

UNCERTAINTY IN INFLOWS TRANSLATED INTO TRADE-OFF LIKELIHOOD PROBABILITY FOR CARRY-OVER STORAGE

Initial storage [3/1] above historical average (~18%). Policies 1, 2, 3 maintain carryover storage [11/1] above 50%; Policies 4, 5 deplete storage below 50%.

A Typical INFORM Run [March 1, 2012] cont'd

Tradeoff Pt 3: Bay Salinity Interface [Env. Requirement < 80 Km from Golden Gate]



FOR EACH TRADEOFF POINT THE LIKELIHHOD OF MEETING VARIOUS TARGETS/CONSTRAINTS IS EXAMINED USING THE PROBABILISTIC FORECAST INFORMATION



DEMONSTRATION OF INFORM vs. ACTUAL BENEFITS



Adaptive Management Policies Foster Resilience to a Changing Climate



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Summary of INFORM Demonstration Experience

- INFORM consistently reconciles long-, mid-, and short-range management objectives and decisions.
- The use of reliable climate and hydrologic forecasts mitigates climate variability risks, tunes decisions to climate conditions, and reduces user vulnerabilities.
- Integrated, forecast-decision support tools can effectively inform participatory, interactive, and consensus-based stakeholder processes for sustainable resource management.
- Adaptive, risk based reservoir regulation strategies are self tuning to the changing climate, deliver more robust performance than current management practices.

Promising Future Steps

- Integrate INFORM with energy system management tools for more efficient utilization of water and energy resources in both sectors (efficient use of hydropower ancillary services and renewable resources and make for a more resilient energy system operation)
- Complete operational implementation of INFORM at DWR for the short and medium range decision horizons (relevant to operational management of the hydroelectric power generation)
- Implement INFORM for other river basins to improve utilization and resilience of California's water and energy resources statewide.