BUREAU OF RECLAMATION

Updates to Forecast-Informed Reservoir Operations (FIRO) at Folsom and Klamath Dams

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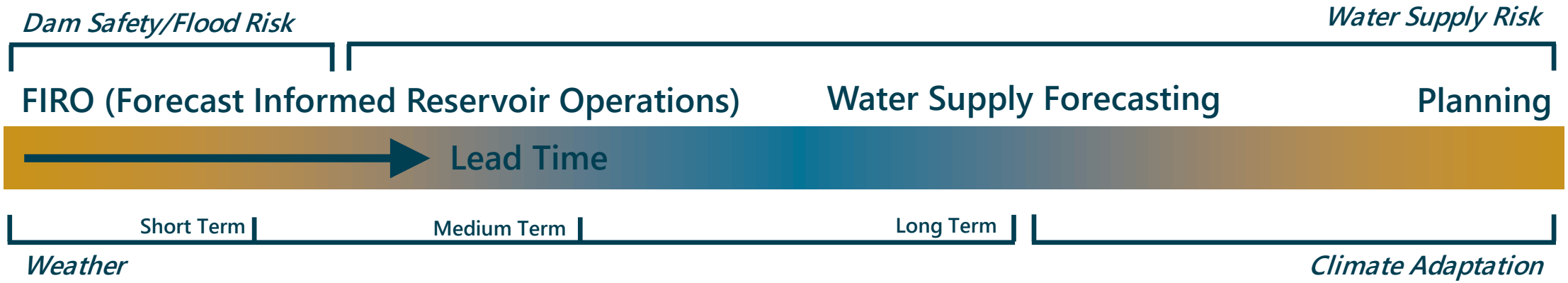
Overview

- What is FIRO
- Forecast metrics
- Updates
  - Folsom
  - Klamath
- Next steps

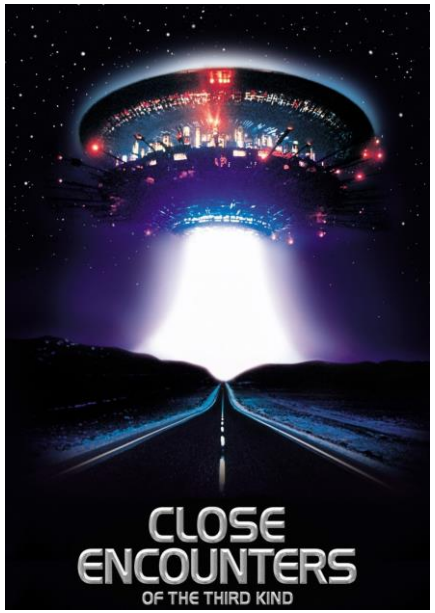
Jim Jefferies Show

Timescales are Important



- Operations affect dam safety at short timescales
- FIRO is defined at the short-term to tradeoff dam safety and water supply risk
- Physical processes are relevant for different timescales
  - Weather – Short term operations
  - Seasonal – Water supply
  - Climate – Long term operations and climate adaptation

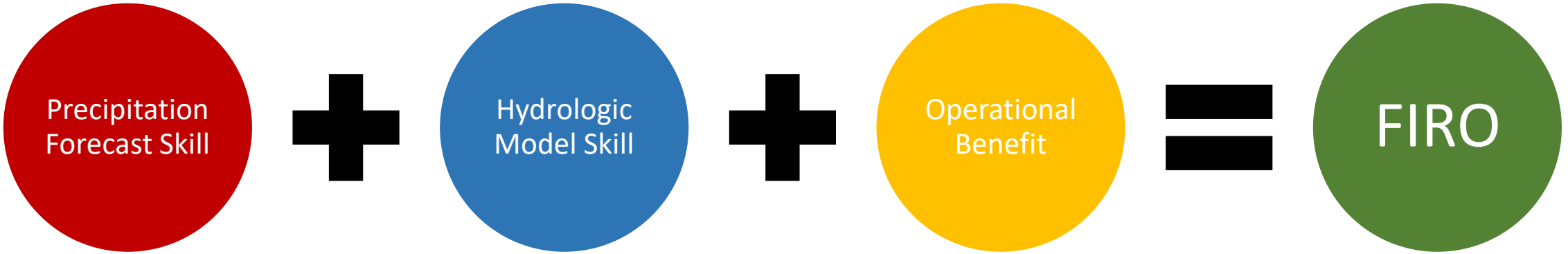
Types of FIRO



- First Kind – Informal
  - Forecasts are used to inform operator expert judgement
- Second Kind – Reanalysis
  - Hindcasts are used to evaluate operation guidelines for changes
- Third Kind – Real-time Operations
  - Forecasts are coupled with hydrologic/hydraulic/decision models to calculate real time optimal solutions

- Extension – Climate Adaption
  - Climate projections are used to evaluate operations guidelines

Stages of FIRO



Statistical Forecast Evaluation

Correlation	Pearson Correlation
	Spearman Correlation
	p Value
Distance	MAE
	ME
	MSE
	RMSE
Probabilistic	Brier Score
	CRPS
	CRPSS
	Discrimination
	Rank Histogram
Contingent	Hit Rate
	Miss Rate
	False Alarm Rate
	Success Ratio
	Relative Operation Characteristic

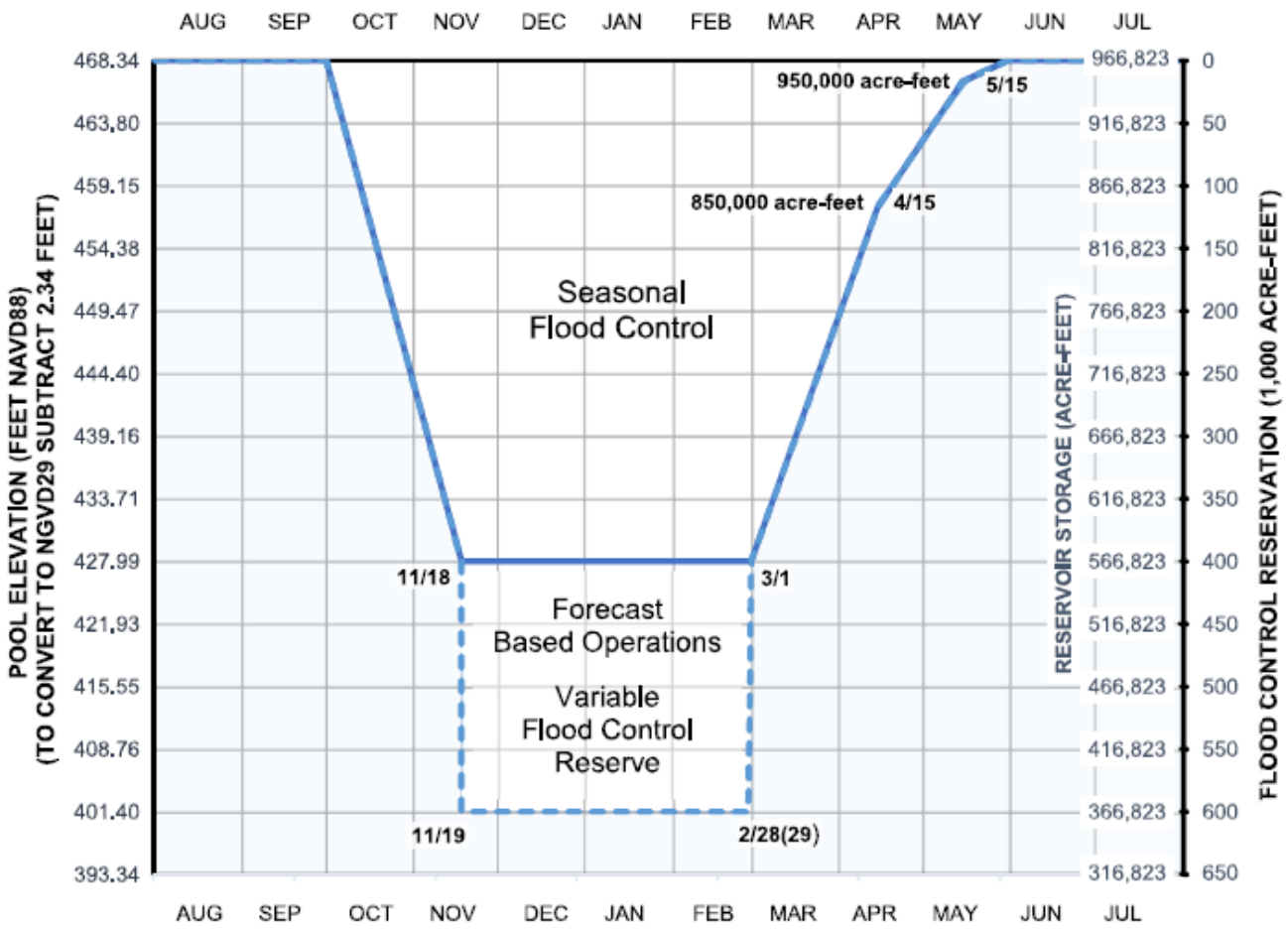
- Converts forecasts to water management skill
- Must capture the variability/uncertainty of the ensemble
- No single metric is sufficient to describe all forecast features

Need to critique forecast skill across metrics and use in formulating risk-based rule curve

Since last year…

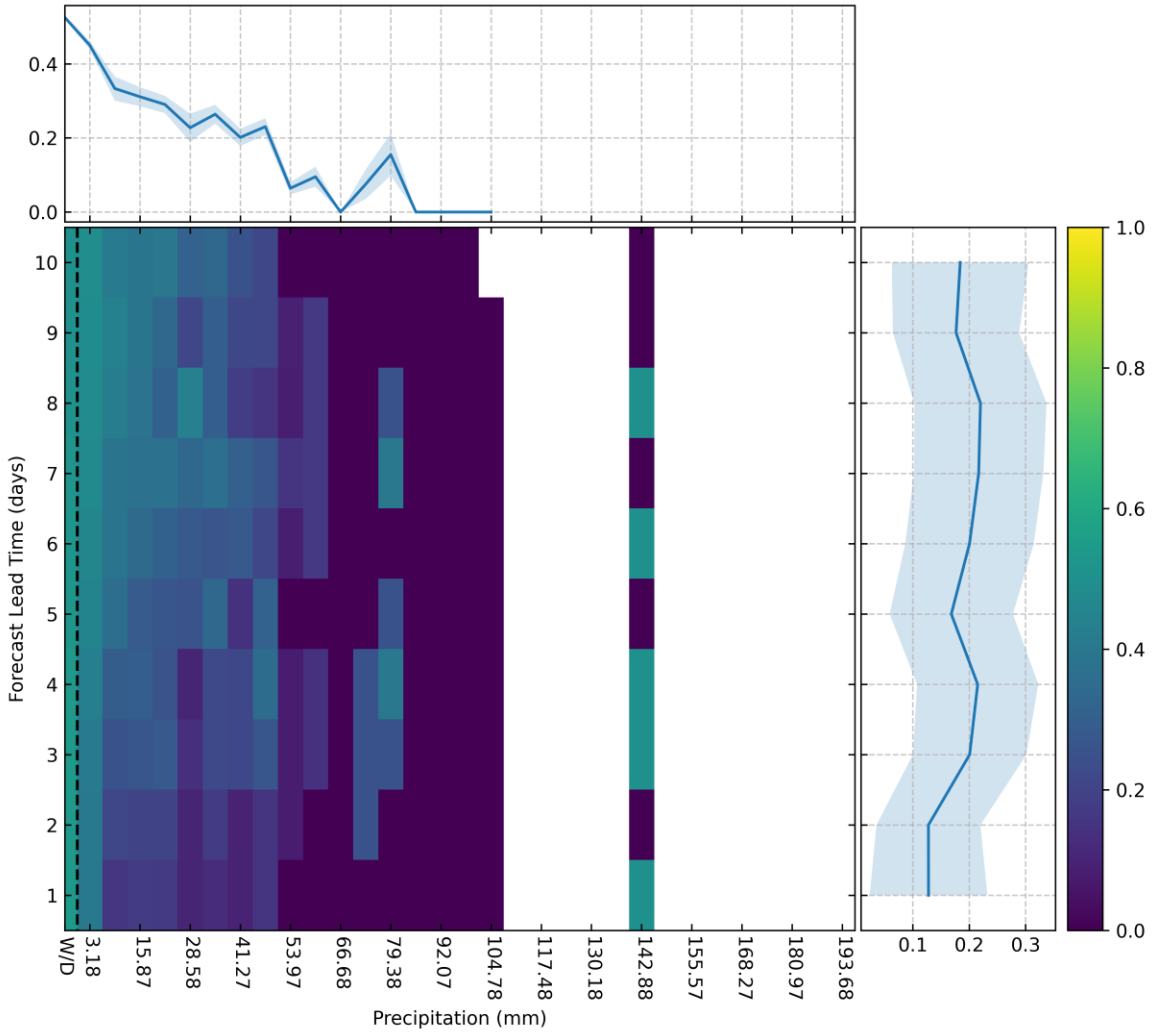
- Local GEFS forecast archive at Reclamation
- Reworked the Reclamation Applied Hydrology FIRO Toolkit
  - Out of memory computing approaches
  - Accelerated computing timelines
  - Includes precipitation and streamflow analyses
- Operations optimization model
  - Optimize operations for a streamflow ensemble under tolerable risk
  - Building forecast statistical skill
- Applied at other Reclamation facilities to support Dam Safety
  - Willow Creek and Heart Butte

Folsom Basin



- Flood control drawdown
- Climate change
- Decision confidence as a function of forecast skill
- Repeatability and staff experience offsets
- Competing management objectives
- 2022 example

Folsom Precipitation Forecast Skill

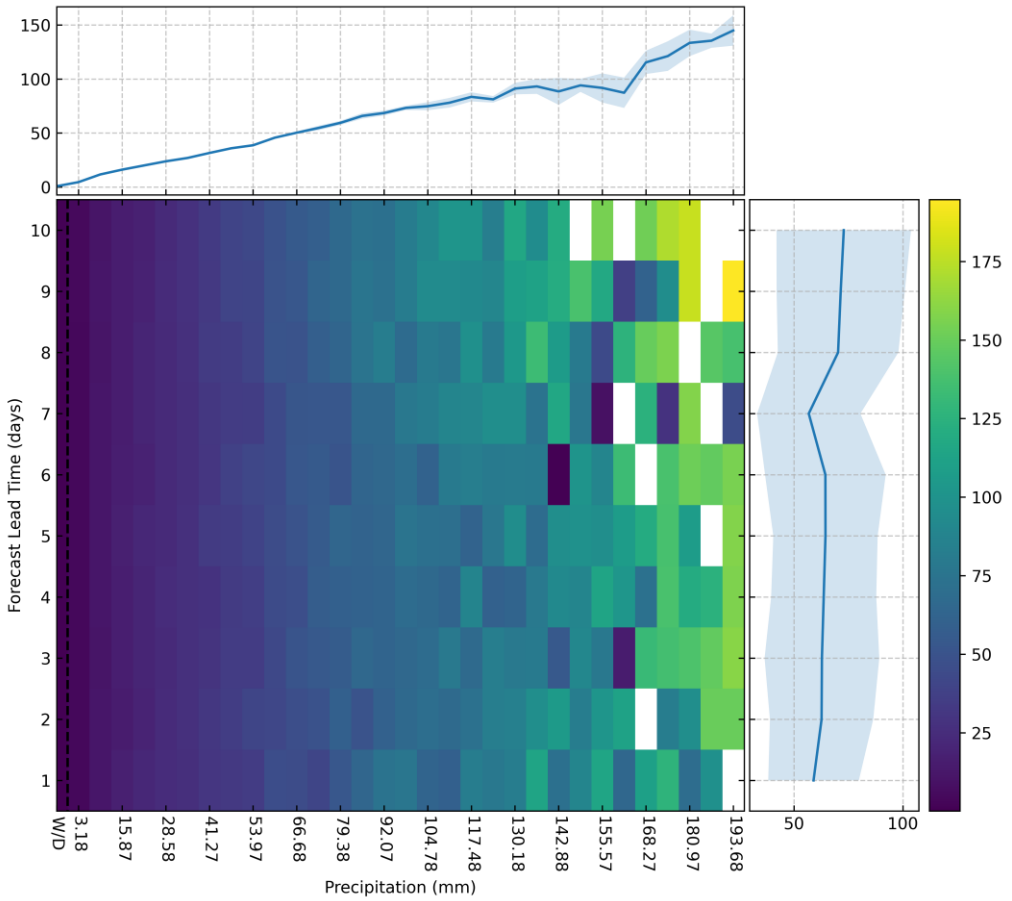


Hit Rate

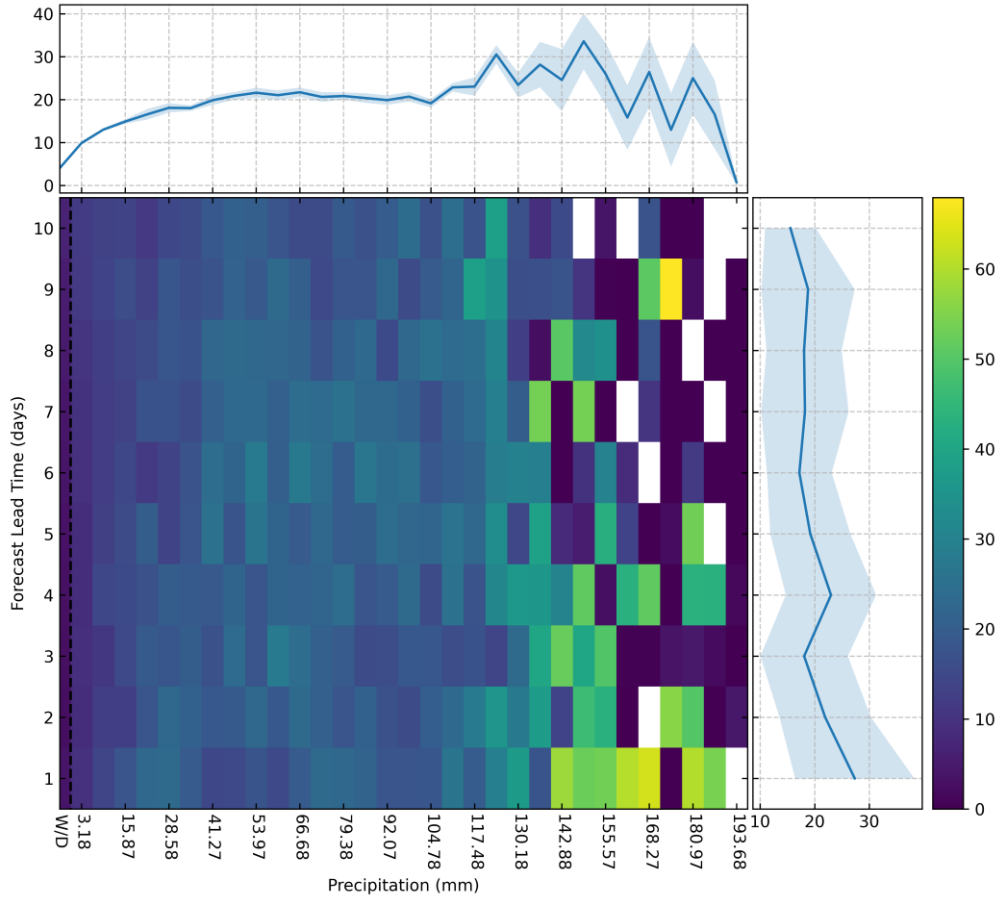
- Not normalized by the total number of forecasts
- Averages on the marginal diagrams are on a per bin basis

Given a forecast prediction of a magnitude and lead time, what are the properties of that forecast?

Folsom Precipitation Forecast Skill



Mean Absolute Error



Standard Deviation of Absolute Error

Klamath Basin

- Leading the operations optimization modeling development
  - Limited storage capacity without Section 7 storage
  - Greater importance given dam removals
- Continued refinements
  - Better edge case handling
  - Reduced solution time

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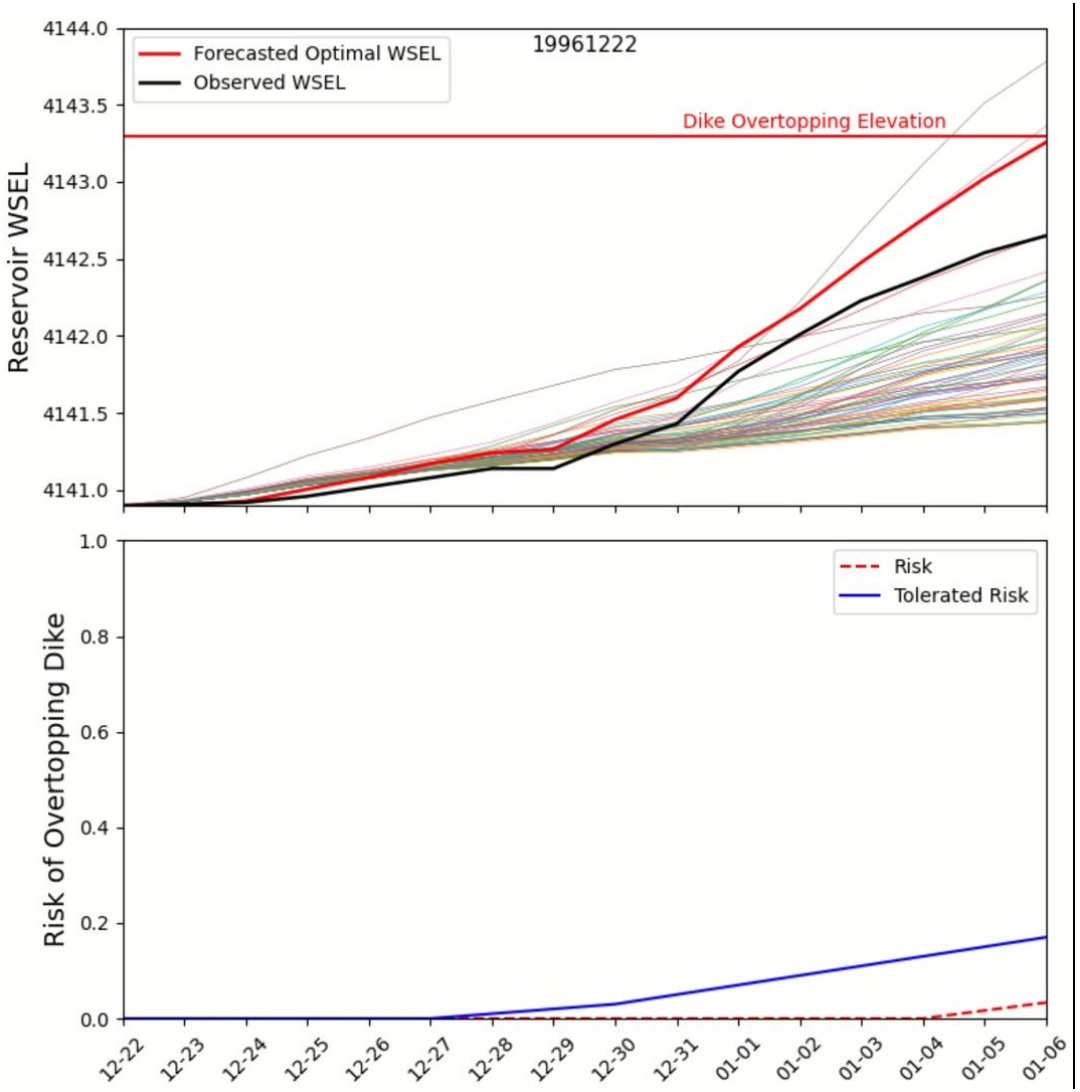
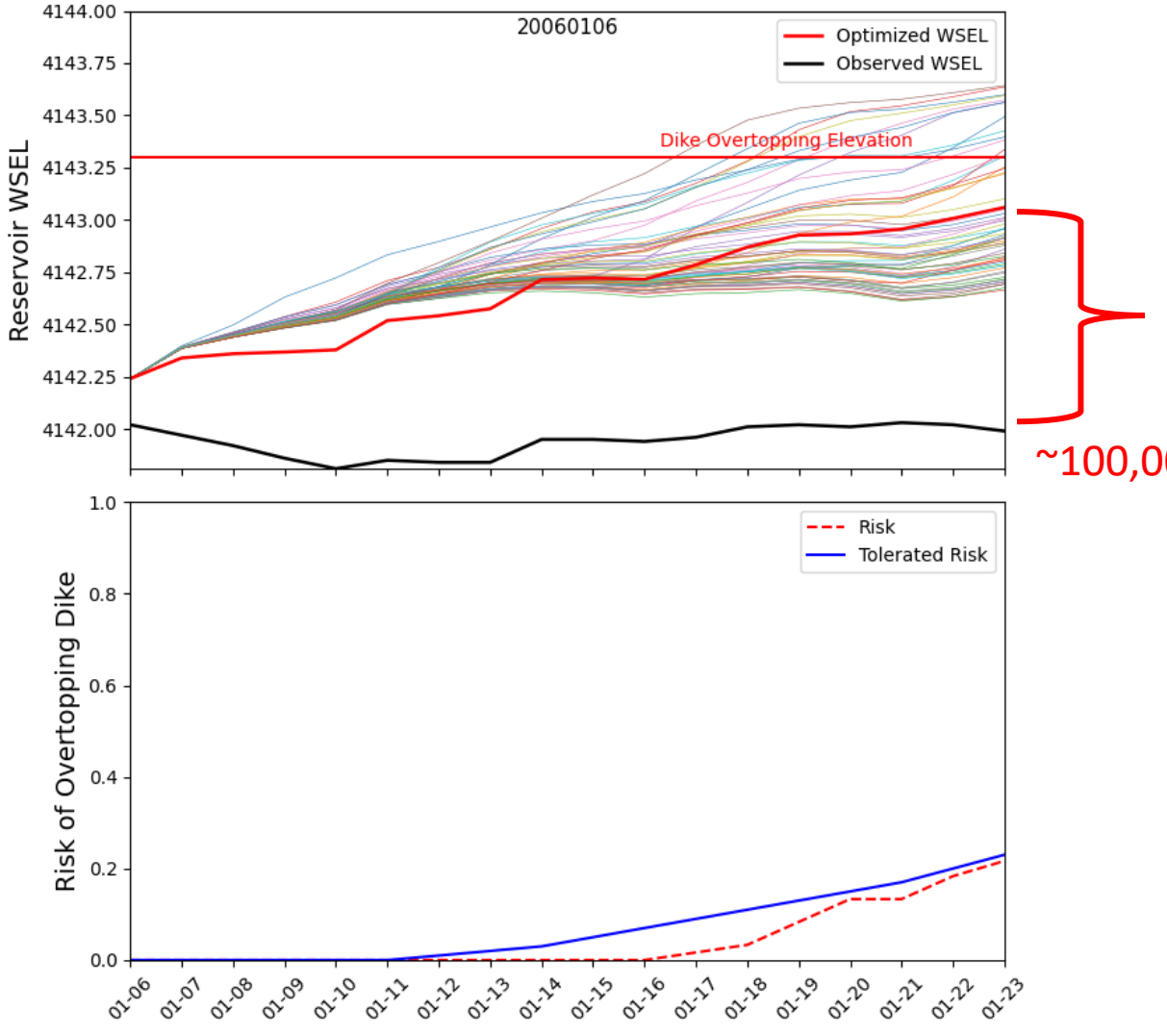
Klamath Basin





Statistical Forecast/Operations Connection

- Flood Control Space becomes Uncertainty Space
  - Tied to the expected value of the forecast error
  - Can be weighted by the probability of miss
  - Fixed and dynamic Uncertainty Space possible
- Operations optimization
  - Ensemble traces are informed by forecast skill
  - Gives basis for treating ensemble members as imperfect
  - Potentially gives basis for tolerable risk curve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