



Center for Water Resources

FIRO: Flood Resilience & Emerging Themes

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RTI International

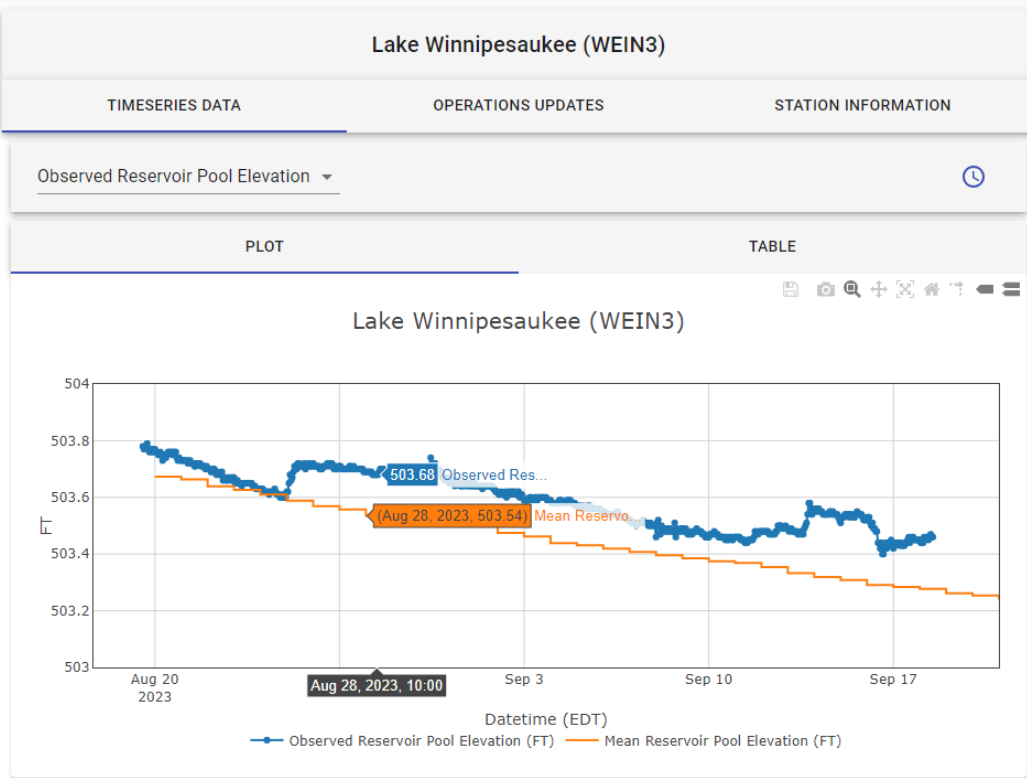
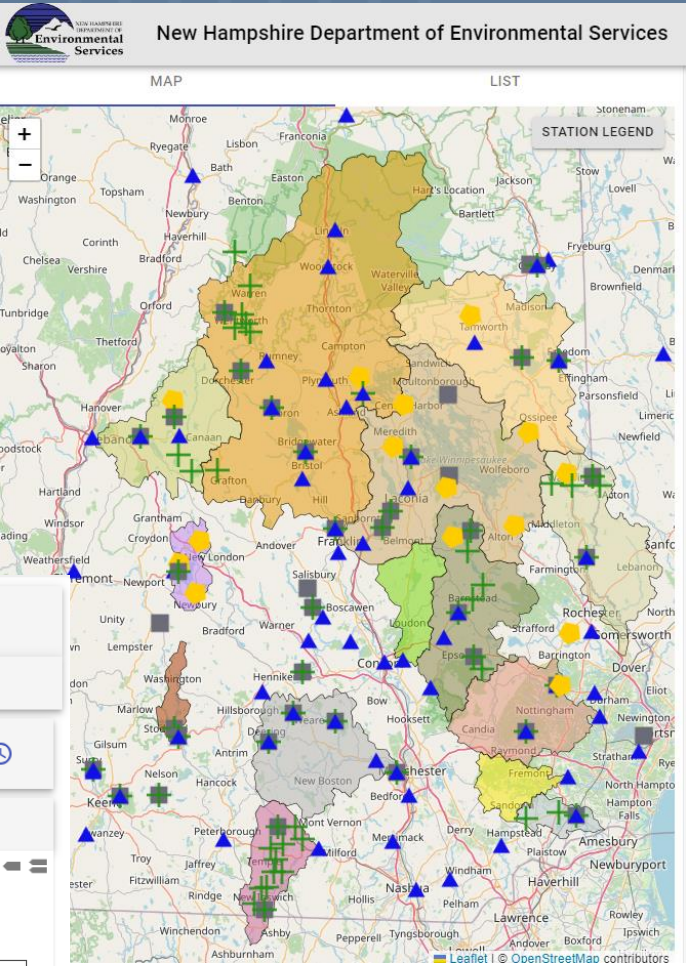
September 22, 2023



NHDES Winnepesaukee Forecast & Optimization System

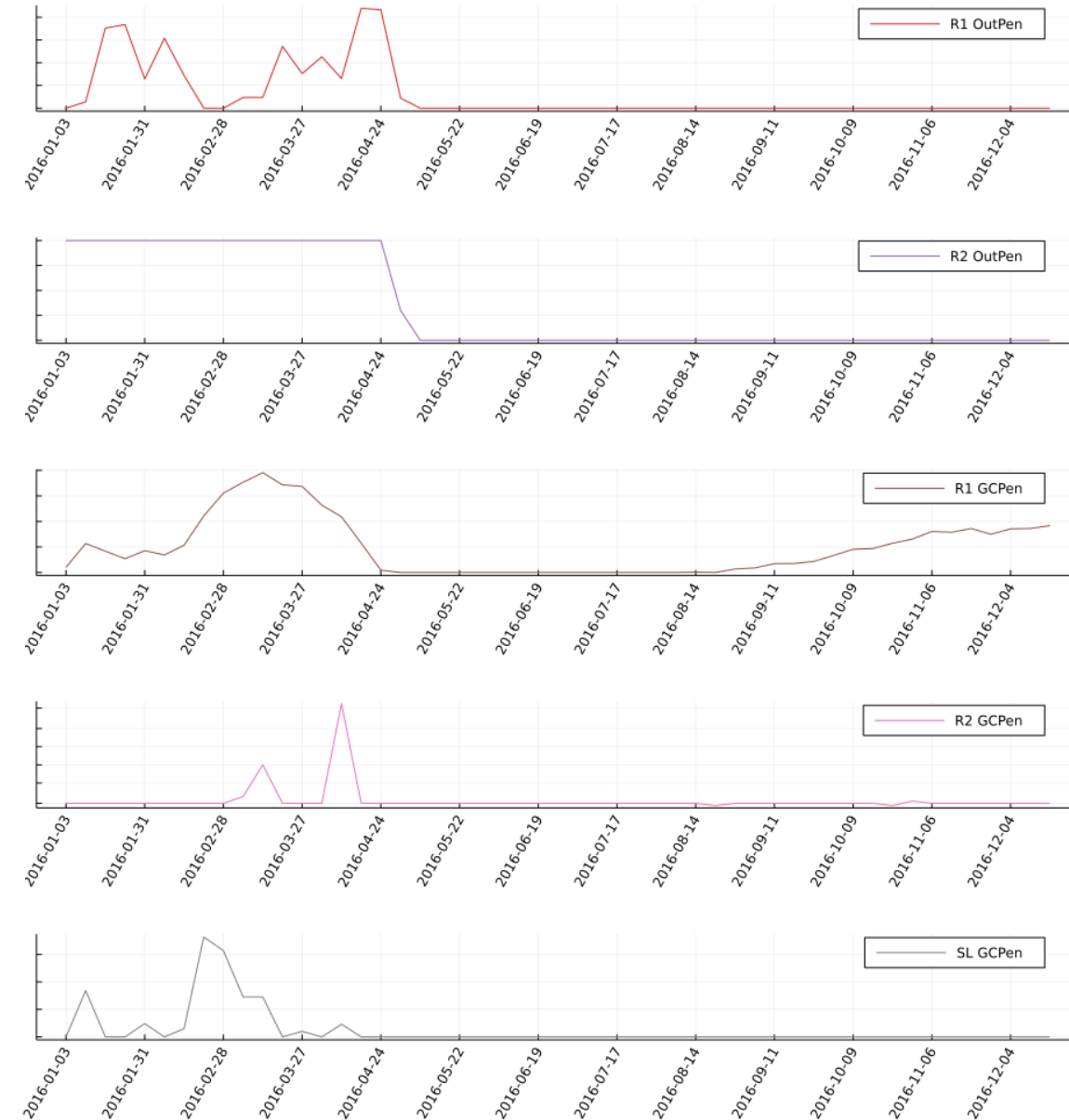
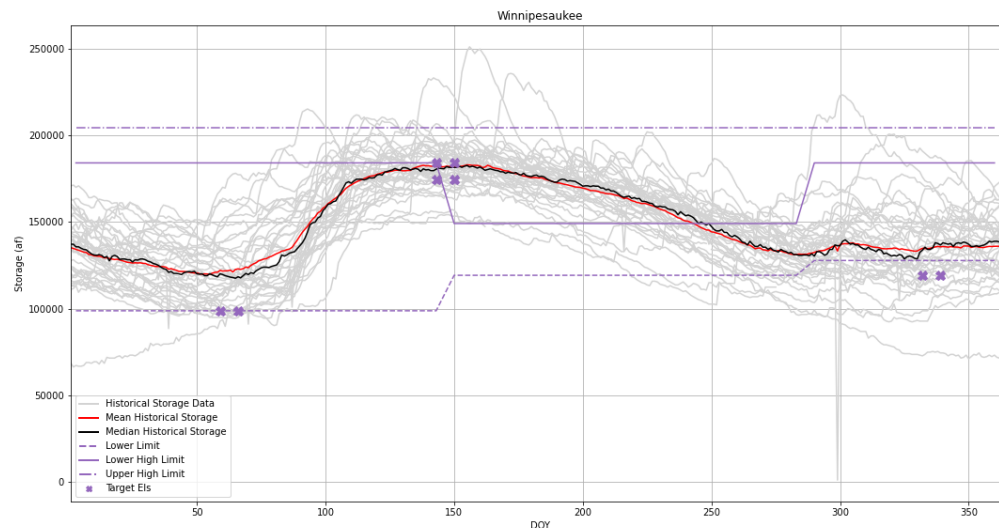
NHDES: Operational Forecast System

- Updated 20-year old Rivertrak forecast system
- Winnepesaukee Lake key storage management
- Public dashboard / Private operational & optimization dashboard



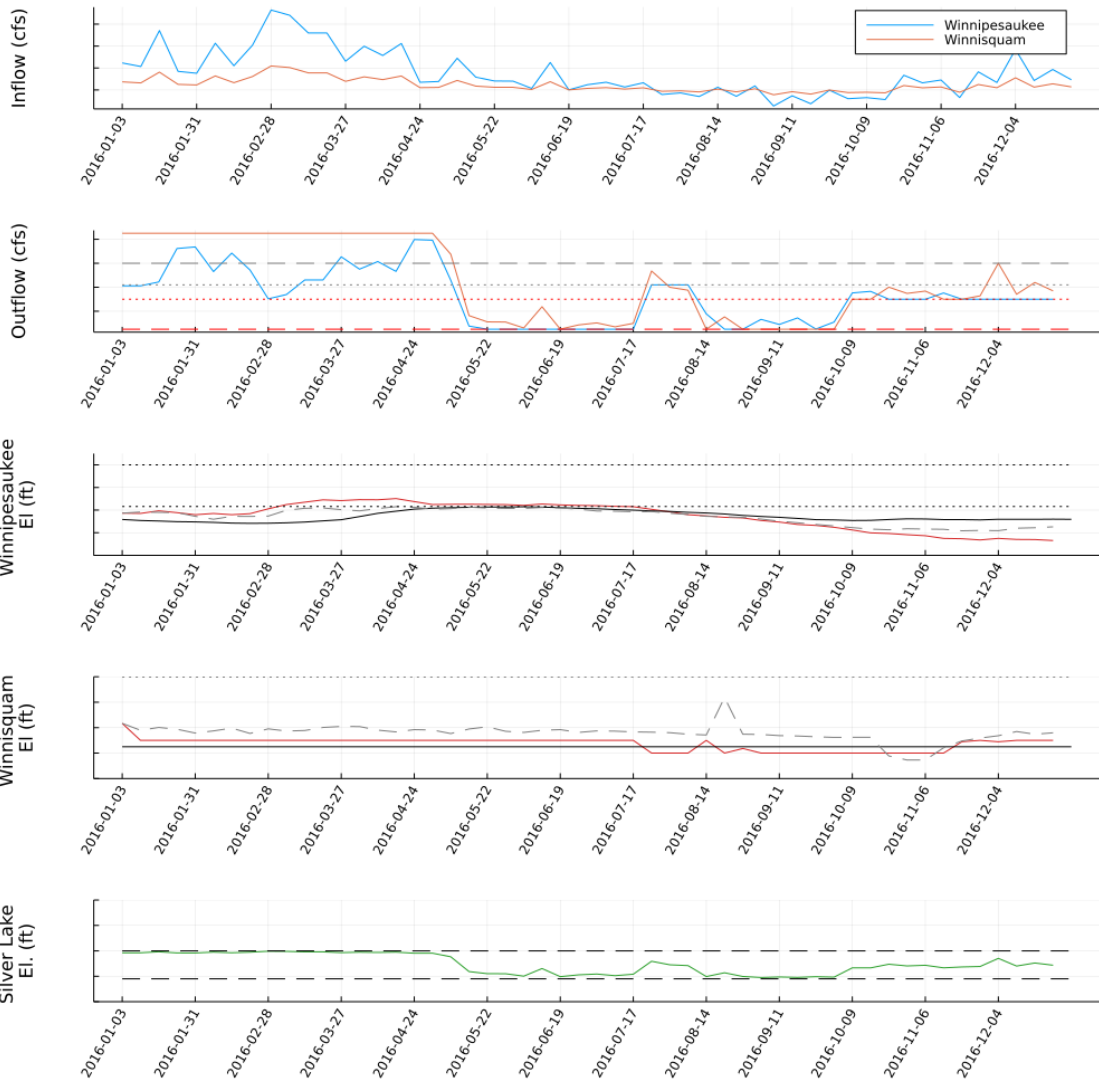
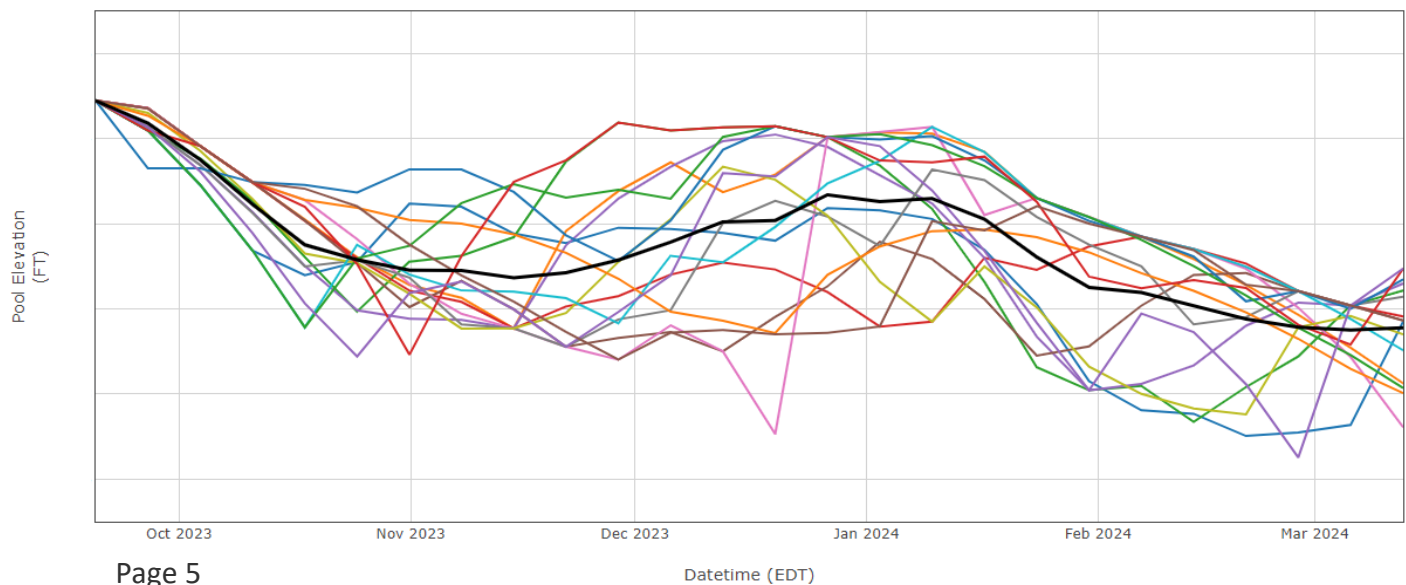
NHDES: Operational Optimization Model

- Reservoir positioning for **seasonal storage** management / CFSv2 forecasts
- Objectives: Power, flood mitigation (d/s and u/s), water supply, recreation
- Implicit stochastic optimization w/ Dual Dynamic Programming (SDDP.jl)



NHDES: Results?

- Improved fitness over historical operations
- Validates well with perfect foresight
- CFSv2 meteorology is reasonable
- Short-term state initialization producing
- Importance quality inflow forecasts





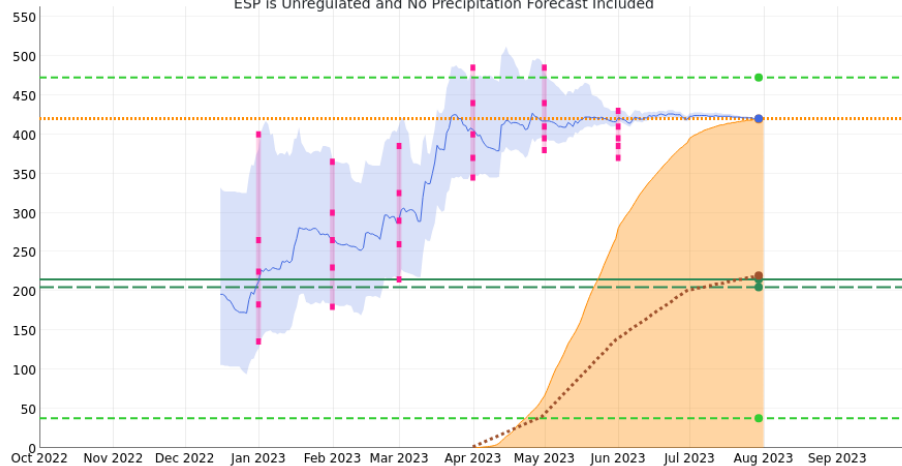
NASA-ROSES Forecast Quality & Ensemble Optimization

FIRO: FLOOD RESILIENCE & EMERGING THEMES

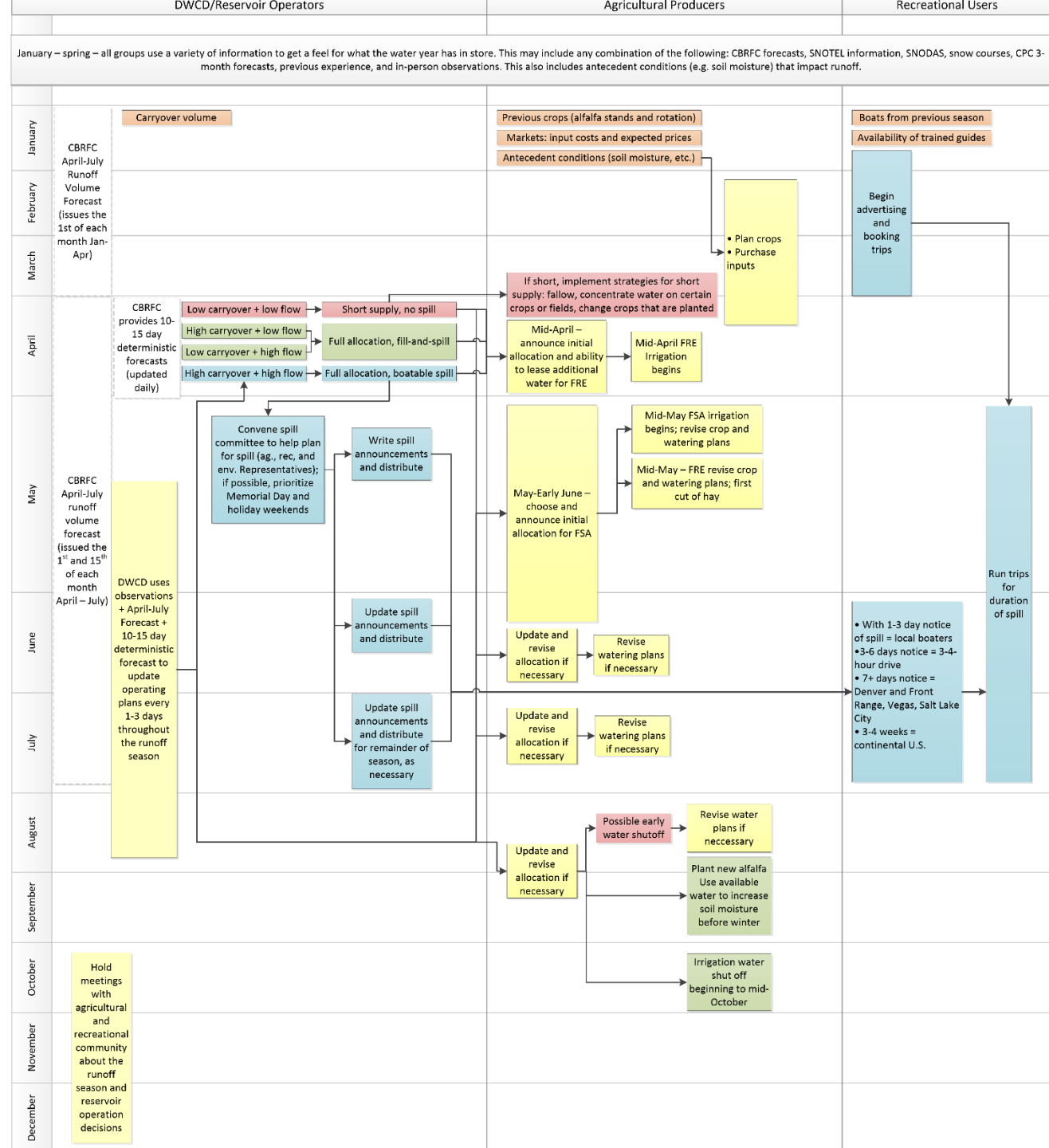
NASA-ROSES: McPhee Reservoir (Dolores River, CO River Basin)

- “Impacts and Benefits Assessment from Improved Streamflow Forecasts”
- Economic impacts of better decisions | increased skill?
- Sub-study: modify forecast skill

Dolores - Dolores (DOLC2)
Period: Apr-Jul, Observed Volume: 420 kaf (195% Average, 205% Median)
ESP is Unregulated and No Precipitation Forecast Included

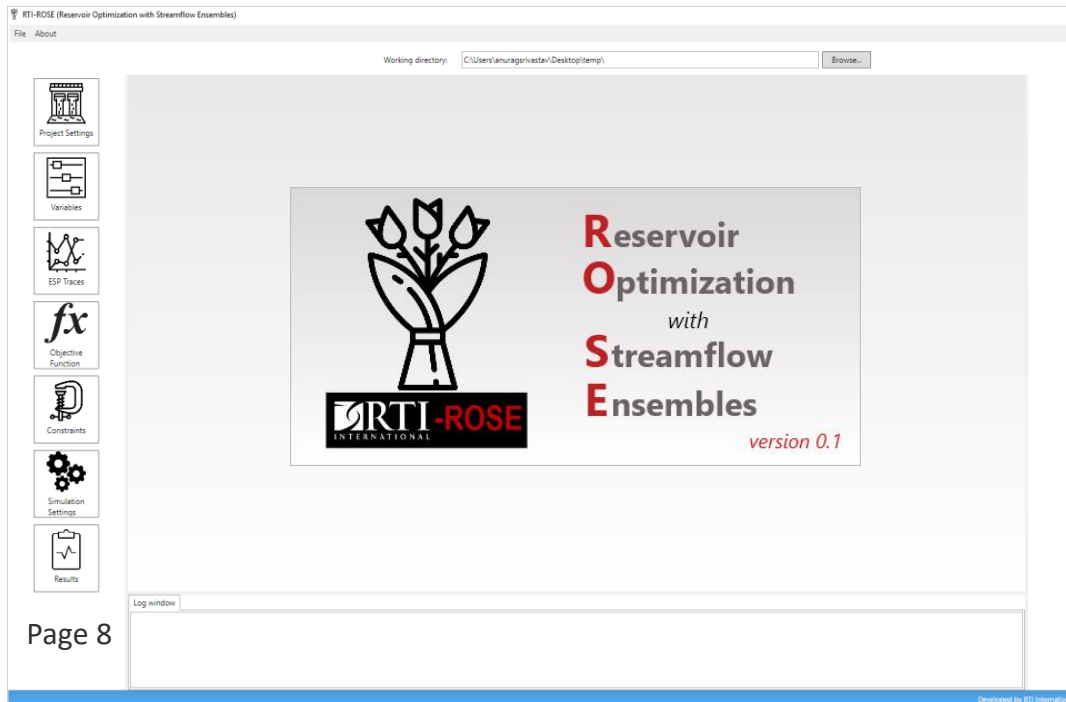
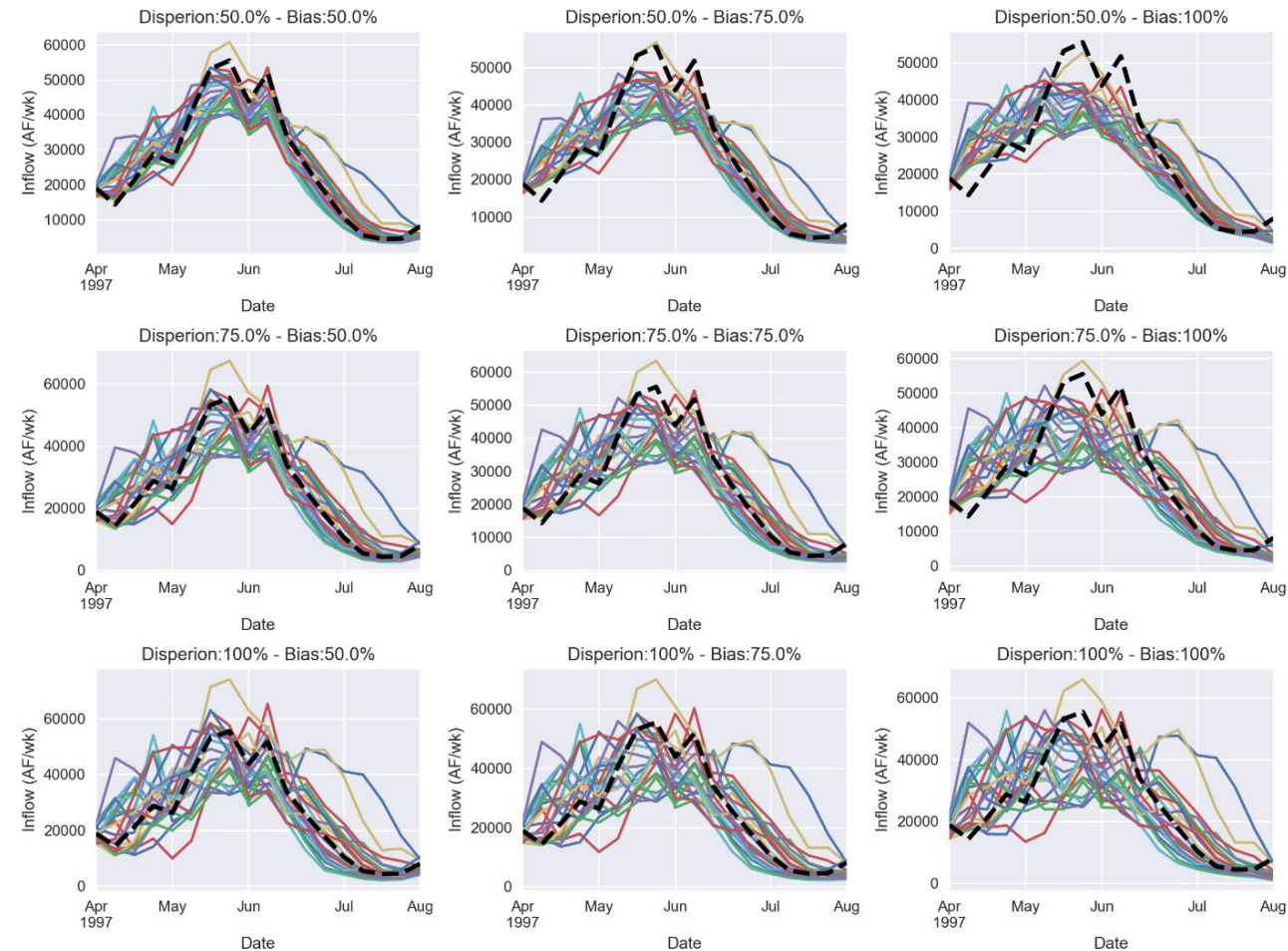


2023/07/30:
Max 1926: 472.45
Min 1977: 37.97
Average: 215
Median: 205
Observed Accumulation: 4
Observed Total: 420
Normal Accumulation: 220
ESP: 420

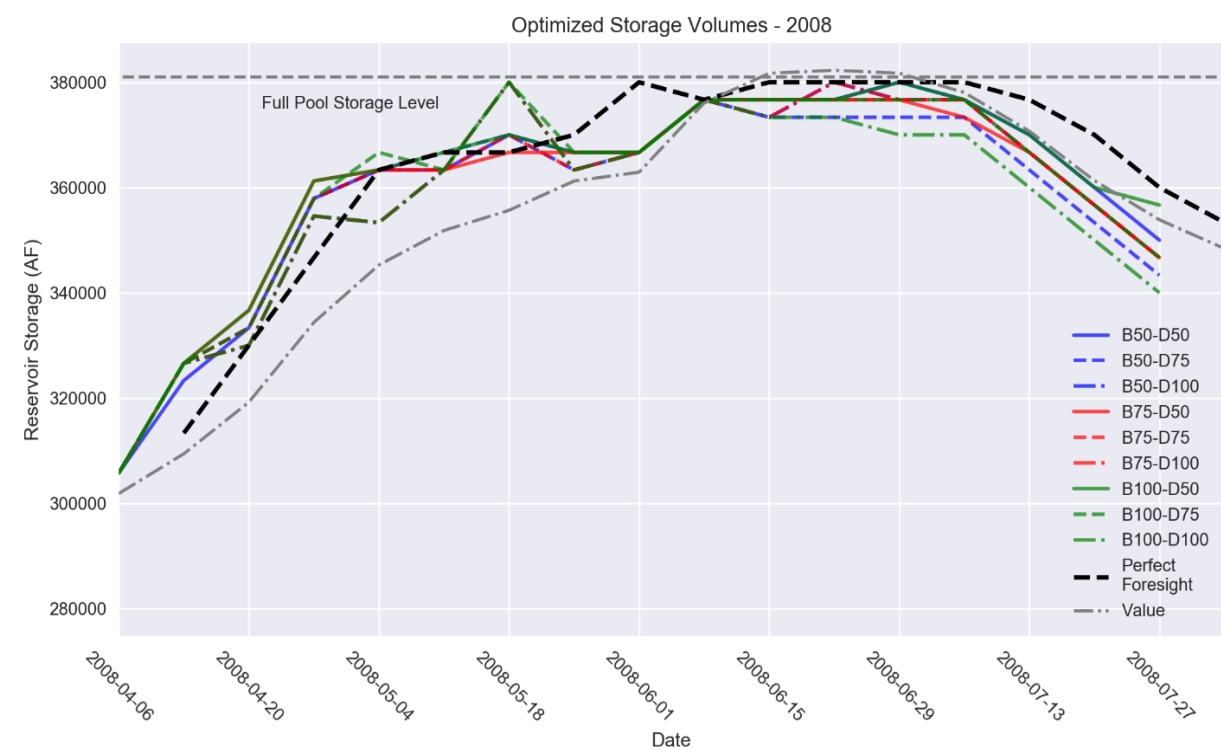
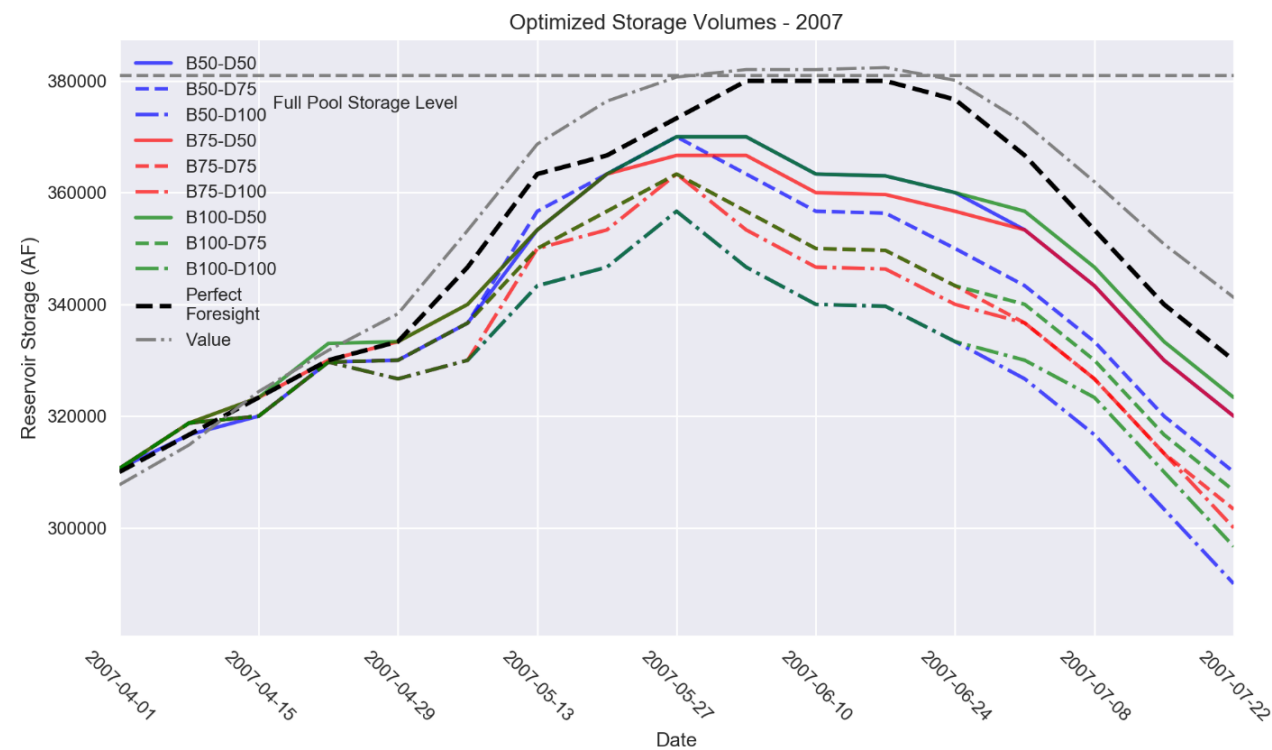


NASA-ROSES: Optimization with Forecast Ensemble

- Modify Bias and Ensemble Dispersion
- Sampling Stochastic Dynamic Programming (SSDP)
- Goals: storage, deliveries, hydro, recreational spill
- 1-step no-recourse decisions & realization loop



NASA-ROSES: Forecast Skill Response





NASA-ROSES: Forecast Skill Response

Bias

Dispersion

Year	Disp	50	75	100
1991	50	333333.3	323092	299882.7
	75	339758.7	323092	306758.7
	100	339758.7	326425.4	306758.7
1997	50	380000	380000	380000
	75	380000	380000	380000
	100	380000	380000	380000
1999	50	380000	376666.7	380000
	75	380000	380000	376666.7
	100	380000	380000	376666.7
2003	50	271000	266500	257500
	75	266500	266500	257500
	100	283333.3	275500	257500
2006	50	323333.3	316666.7	310000
	75	330000	320000	313333.3
	100	323333.3	313333.3	306666.7
2007	50	370000	370000	356666.7
	75	366666.7	363333.3	363333.3
	100	370000	363333.3	356666.7
2008	50	380000	376666.7	380000
	75	376666.7	376666.7	380000
	100	380000	380000	380000

Year	Disp	50	75	100
1991	50	325234.3	314519.4	290245.1
	75	331852.7	314886.9	296953.6
	100	332886.9	318220.3	296953.6
1997	50	378666.7	374666.7	373333.3
	75	378666.7	376000	373333.3
	100	378666.7	374000	374000
1999	50	370669	368169	368169
	75	370669	369002.4	364835.7
	100	370669	369002.4	364835.7
2003	50	261717.5	257217.5	246048.7
	75	257217.5	257217.5	250548.7
	100	274750.9	266217.5	248217.5
2006	50	312620.3	302620.3	291064.9
	75	319287	305953.7	294377.4
	100	312620.3	299287	287752.4
2007	50	364082.6	356582.6	339916
	75	360749.3	349916	346582.6
	100	364082.6	349916	339916
2008	50	375333.3	372666.7	374666.7
	75	374666.7	374666.7	374666.7
	100	375333.3	374666.7	372000

Year	Disp	50	75	100
1991	50	6589.2	6048.1	6372
	75	6541	5680.5	6413.9
	100	5013.9	5680.5	6413.9
1997	50	23651.2	19651.2	20317.9
	75	23651.2	20317.9	20317.9
	100	23651.2	22317.9	20984.5
1999	50	10347.1	11180.5	12847.1
	75	10347.1	10347.1	12013.8
	100	10347.1	10347.1	12013.8
2003	50	4807.6	4807.6	3007.6
	75	4807.6	4807.6	3007.6
	100	4574.3	4807.6	3907.6
2006	50	2091.3	2091.3	2841.3
	75	2091.3	2091.3	2862.1
	100	2091.3	2070.4	2820.4
2007	50	5852.1	6685.5	6685.5
	75	5018.8	6685.5	5852.1
	100	5018.8	5852.1	5852.1
2008	50	13035.9	13702.5	13035.9
	75	13702.5	13035.9	13035.9
	100	13035.9	13035.9	14369.2

Annual Max Storage

June Mean Storage

June Deliveries



CIROH FIRO NWM/NexGen

CIROH: Forecast-Informed Reservoir Operation for Flooding Risk Reduction and Post-Flooding Season Water Conservation

Cooperative Institute for Research to Operations in Hydrology (CIROH)

Partners: UIUC, U. South Carolina, U. Cal. San Diego, RTI International

Core Components:

- Integrate Decision Policy-Tree system into OWP's NexGen
- Optimize policies using Genetic Algorithms
- Build objectives using market and non-market based water valuation

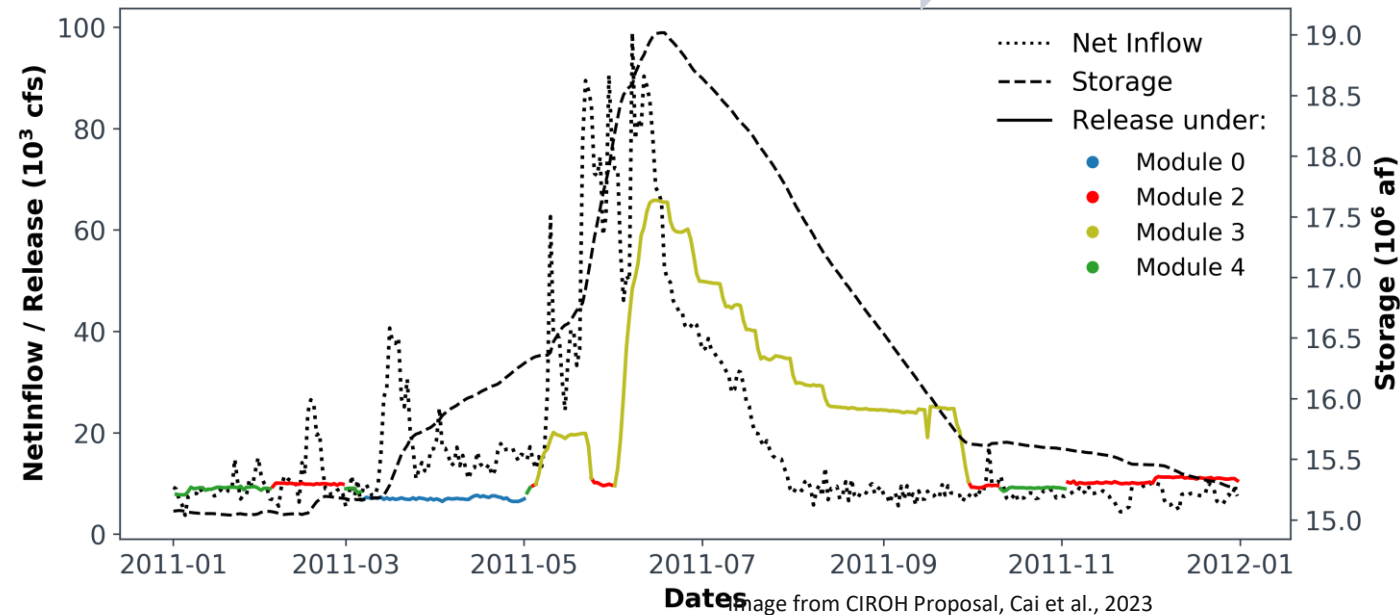
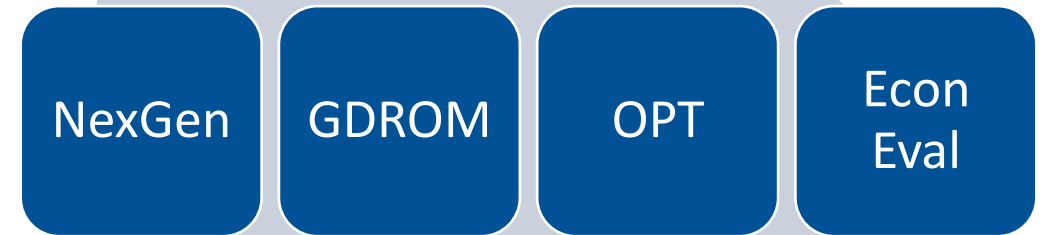


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CIROH: NexGen integrated reservoir models for forecasting

- NexGen framework for forecasts (8-13 days)
- Generic Data-Driven Reservoir Operation Model (GDROM)
- Trained on 450+ reservoirs in US, but not 'optimal'
- Optimized Policy Tree (OPT)
- Target: reduce flood damage but retain storage for beneficial use.
- Feedbacks for hedging policies





WHERE DOES THAT LEAVE US?

- Optimization great – not ‘optimal’
- Recognized challenge in scaling & generalization
- FIRO is not a ‘one-way street’ (ROIF?!)
- Best investment: forecast vs. ops?
- Incorporation of feedbacks:
 - Economic
 - Risk definition



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Thank you

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