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Using Idealized FIRO to Understand the Upper-Limit of Future Projected Storage at Lake Shasta

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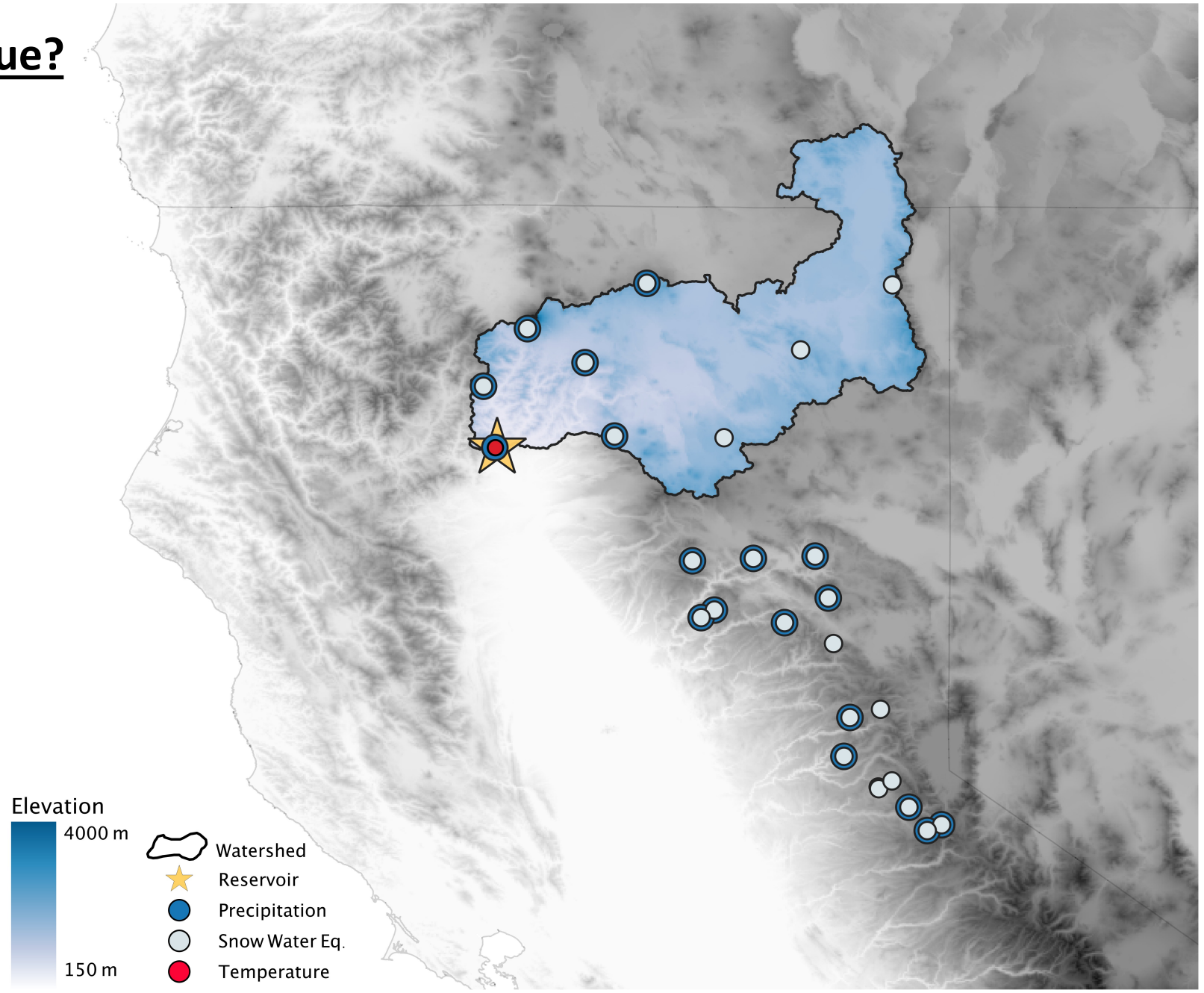
What Makes Lake Shasta Unique?

Largest Reservoir in California

10% of total built storage

67% of basin is below snowline



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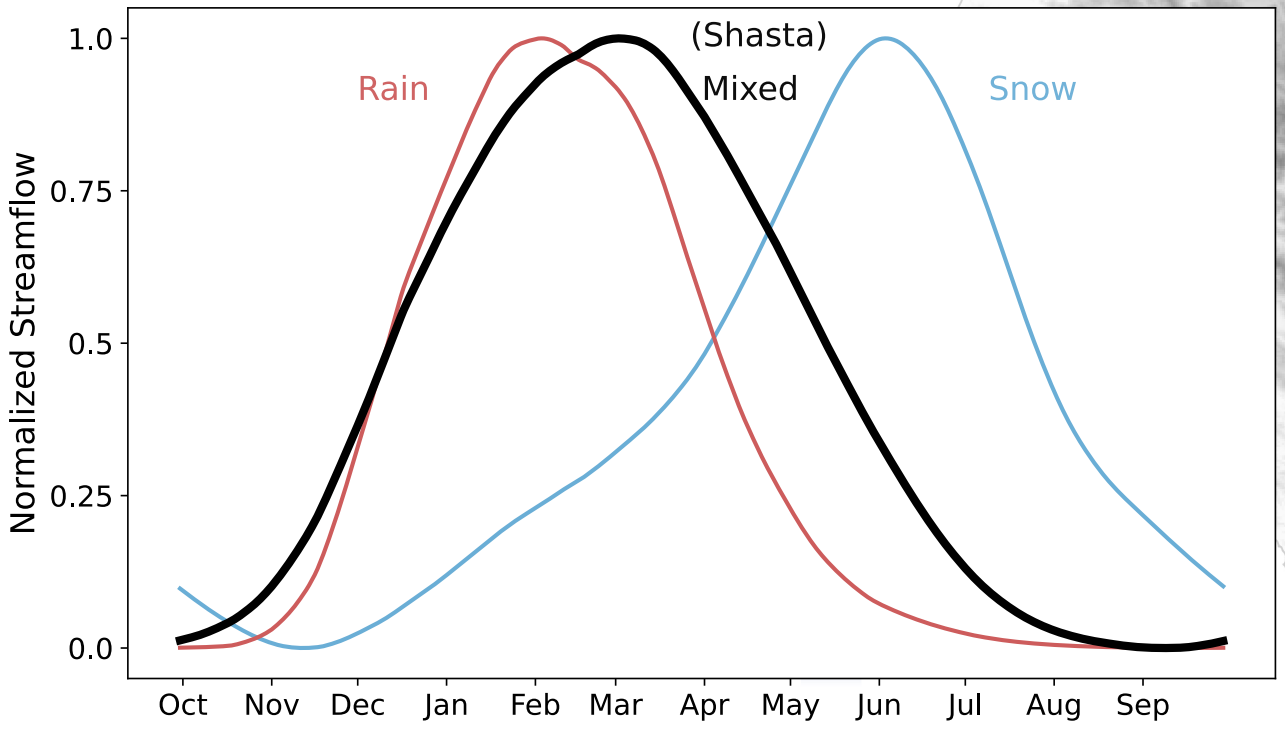
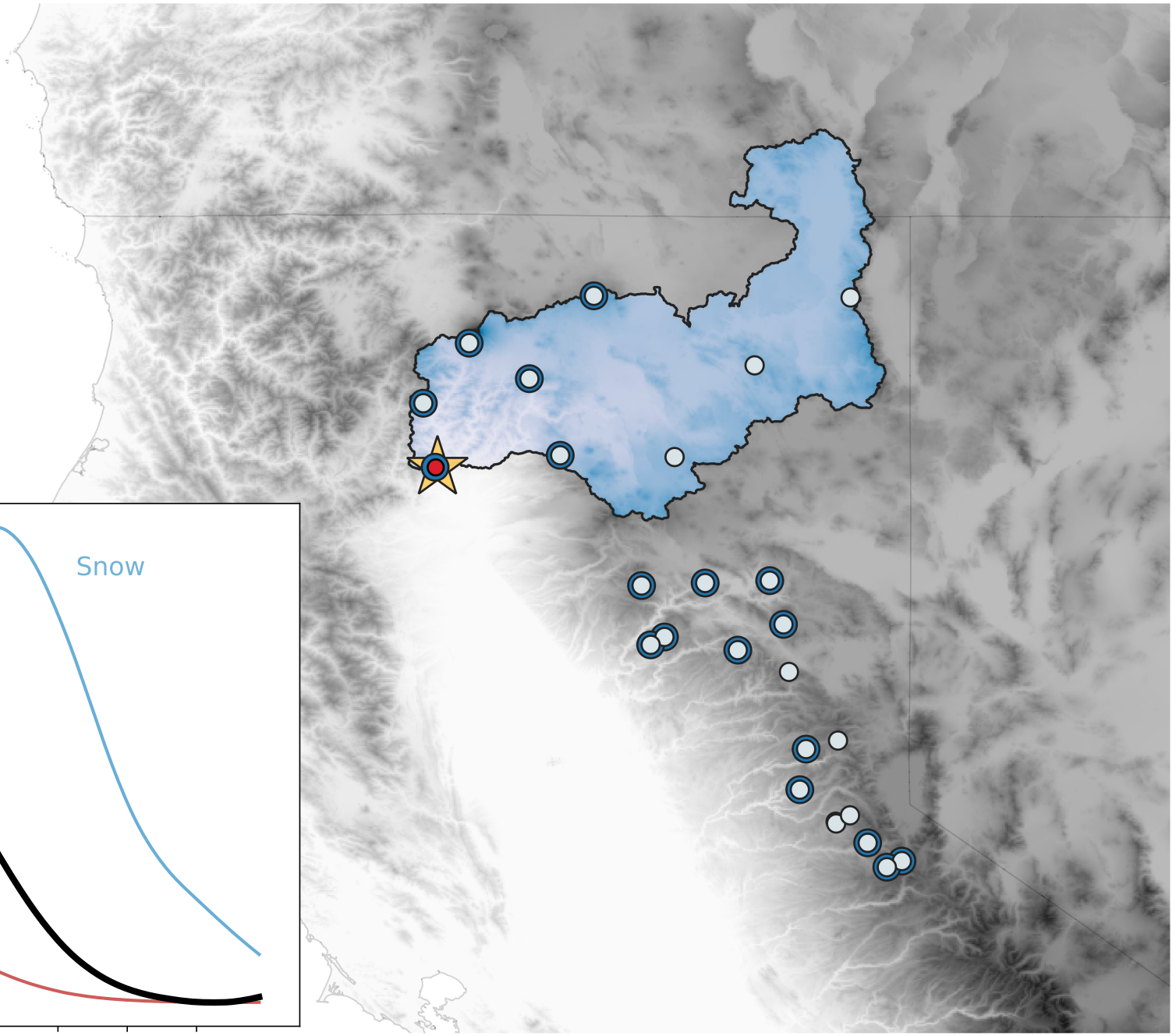
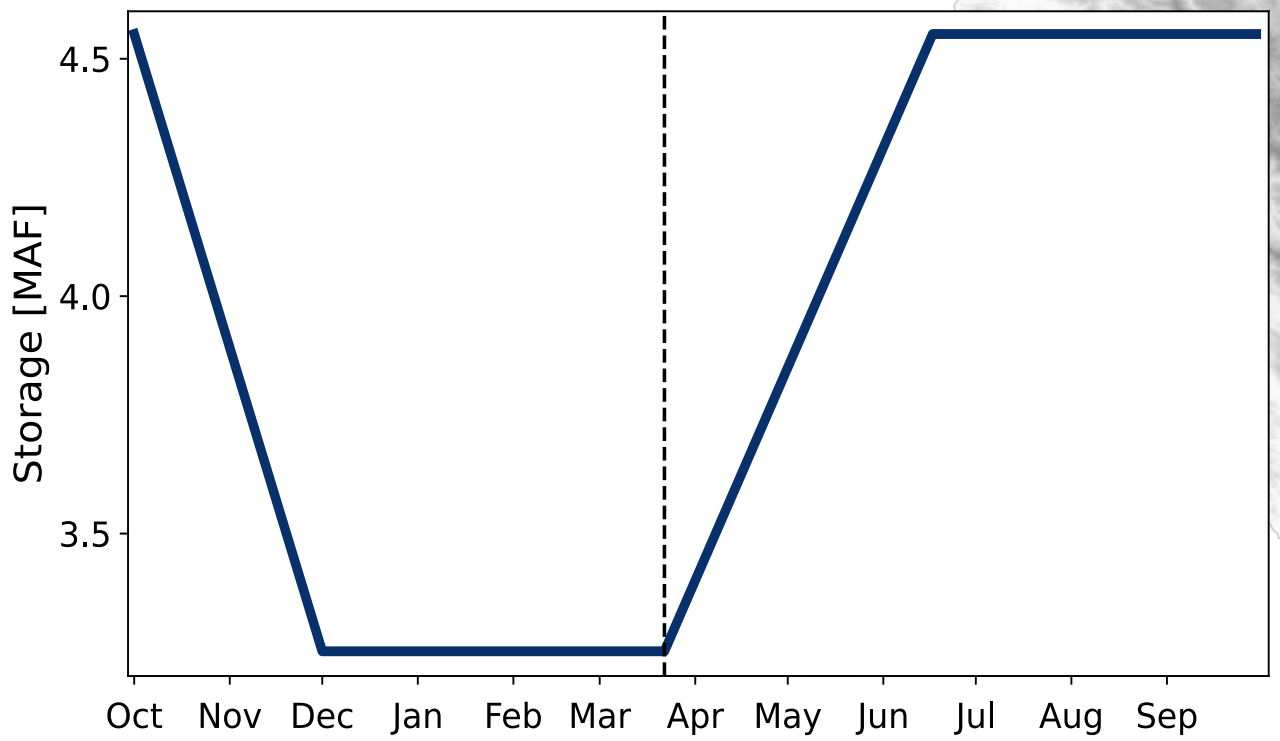


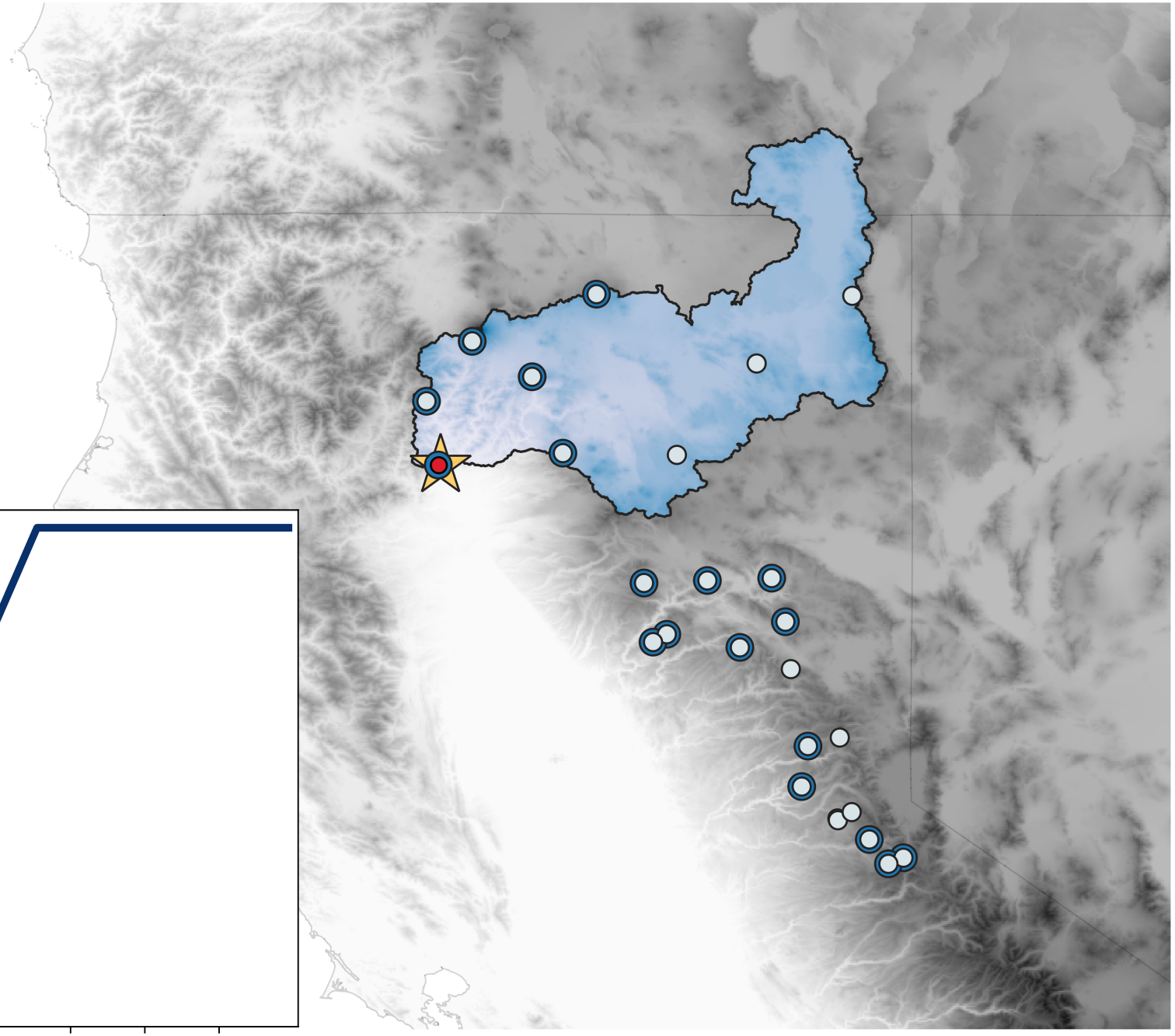


What Makes the Model Unique?

Build a highly flexible model

Experiment with various operation adaptation measures





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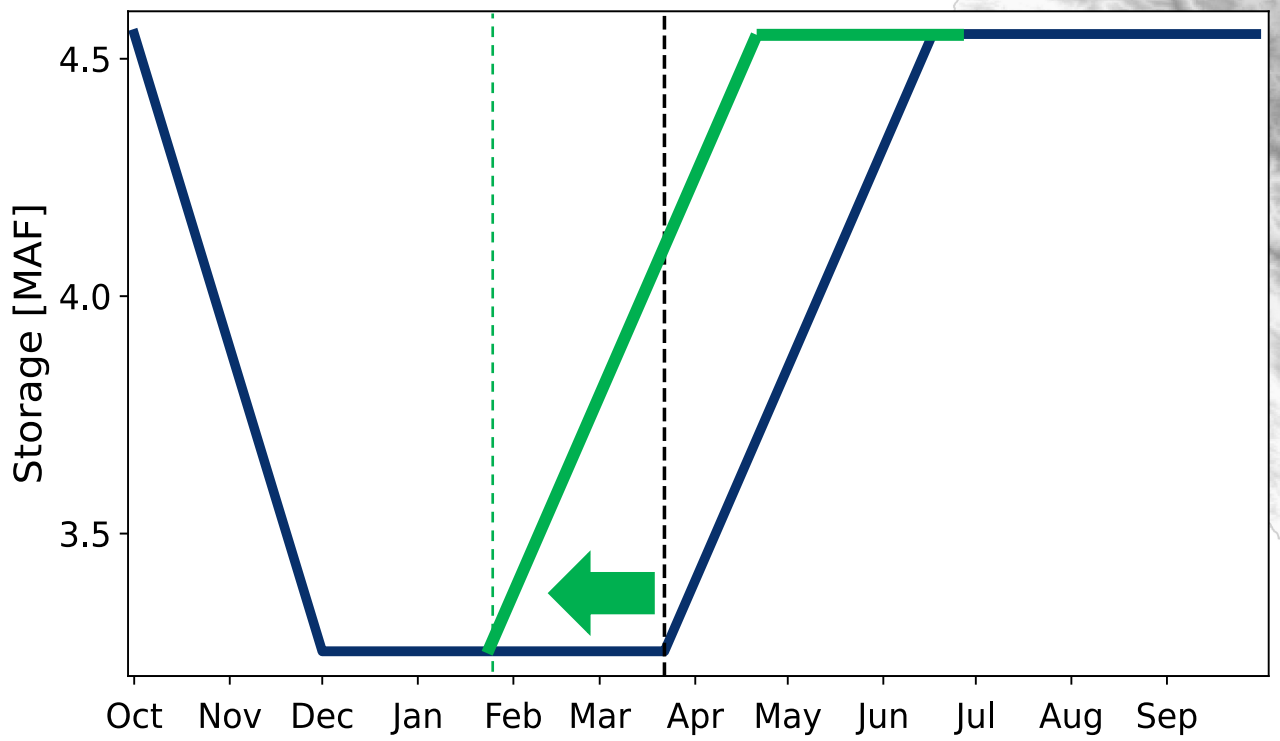

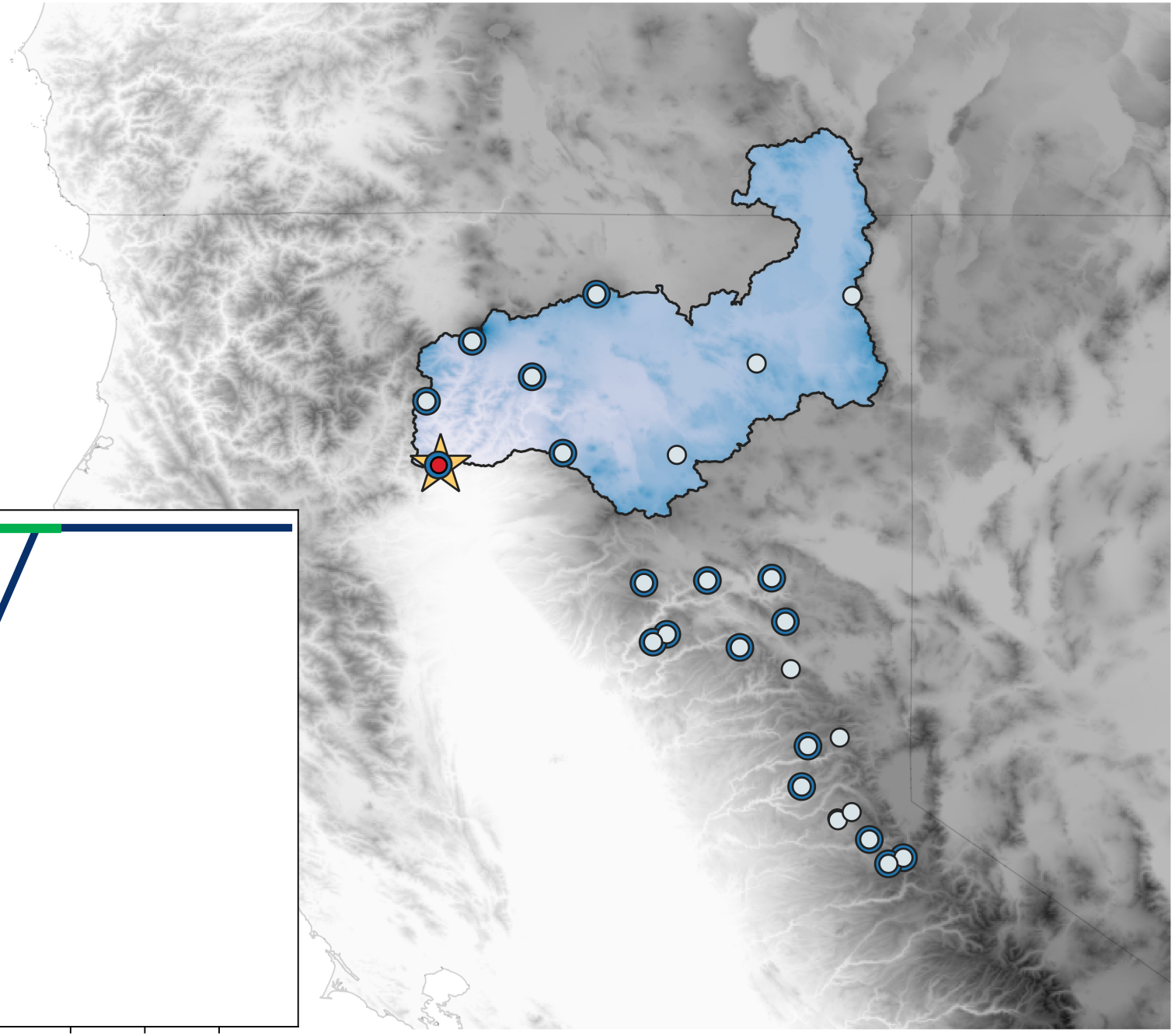

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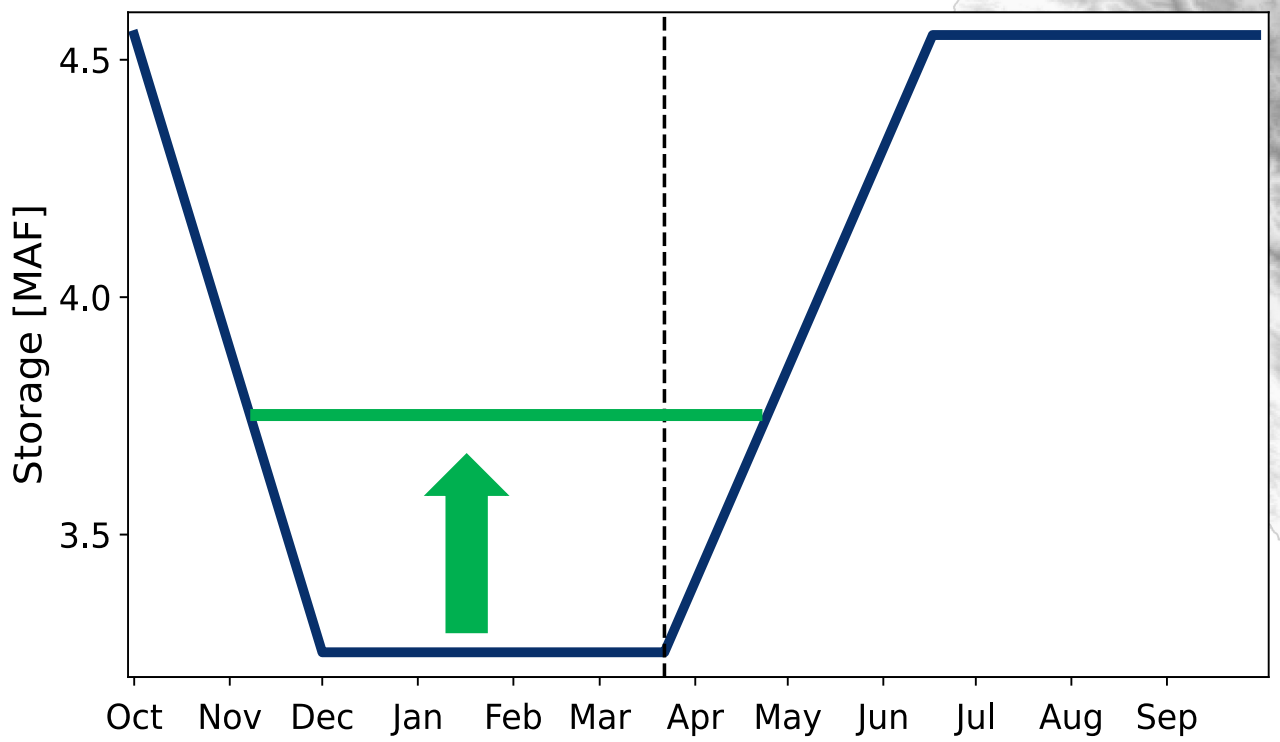

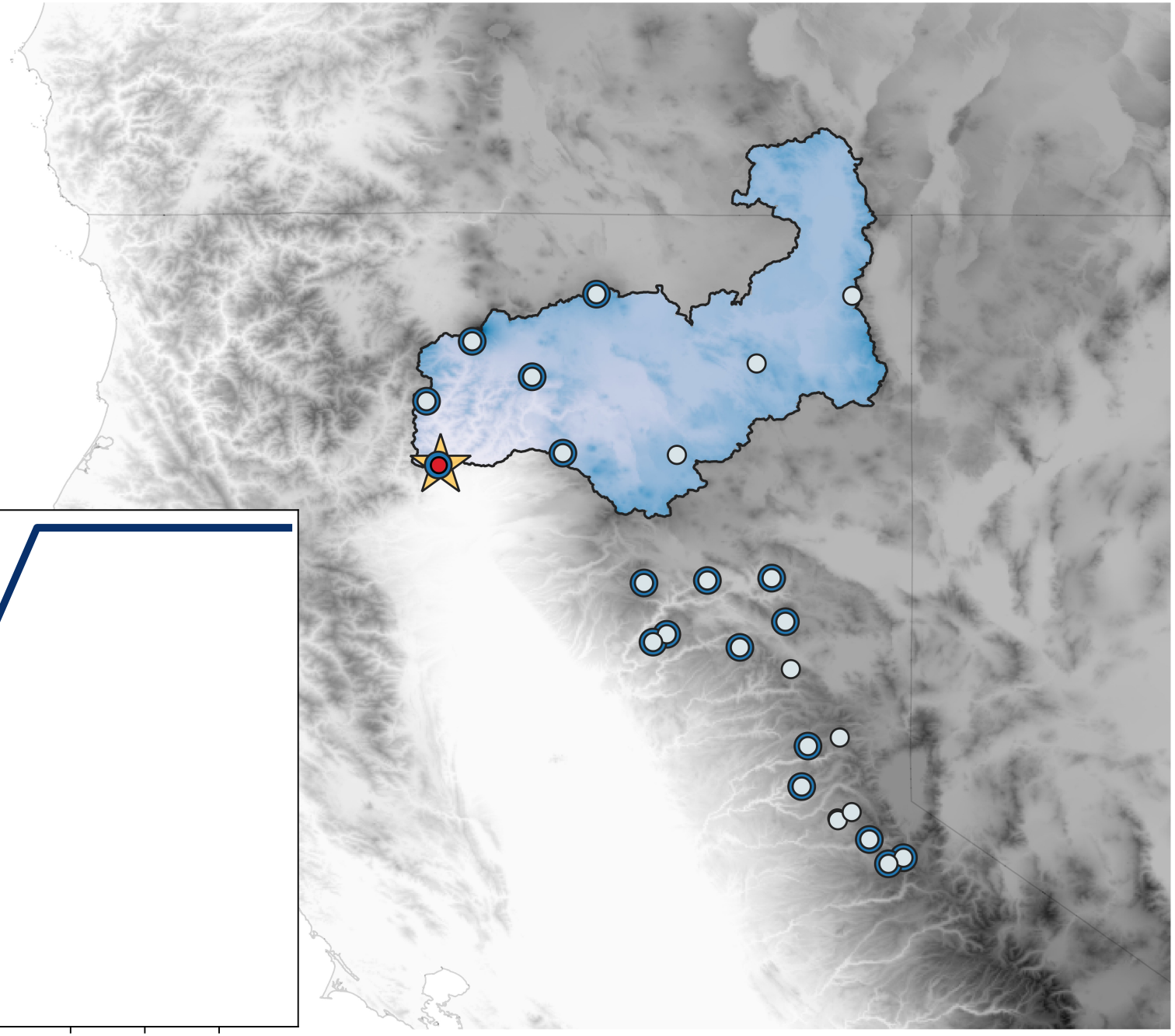

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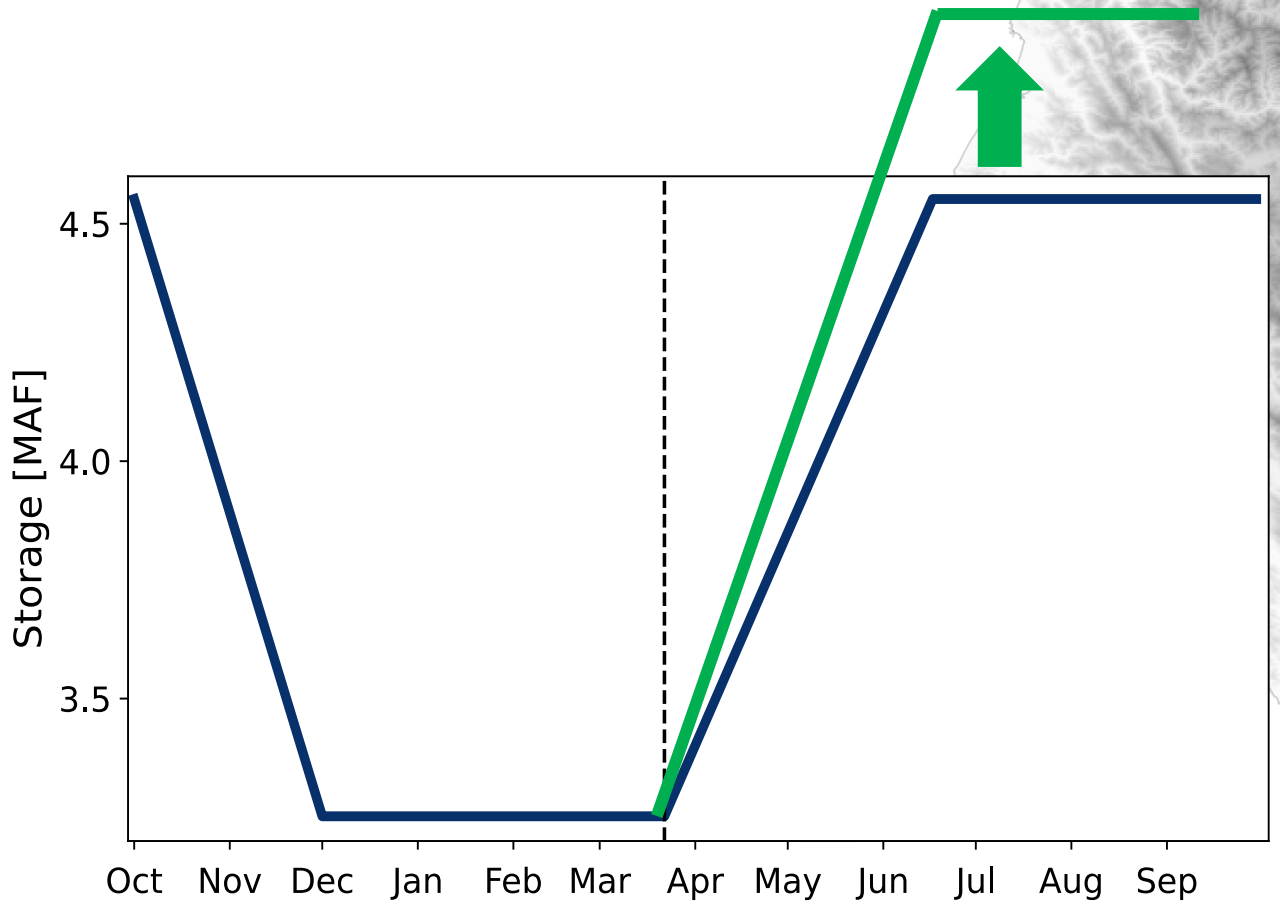
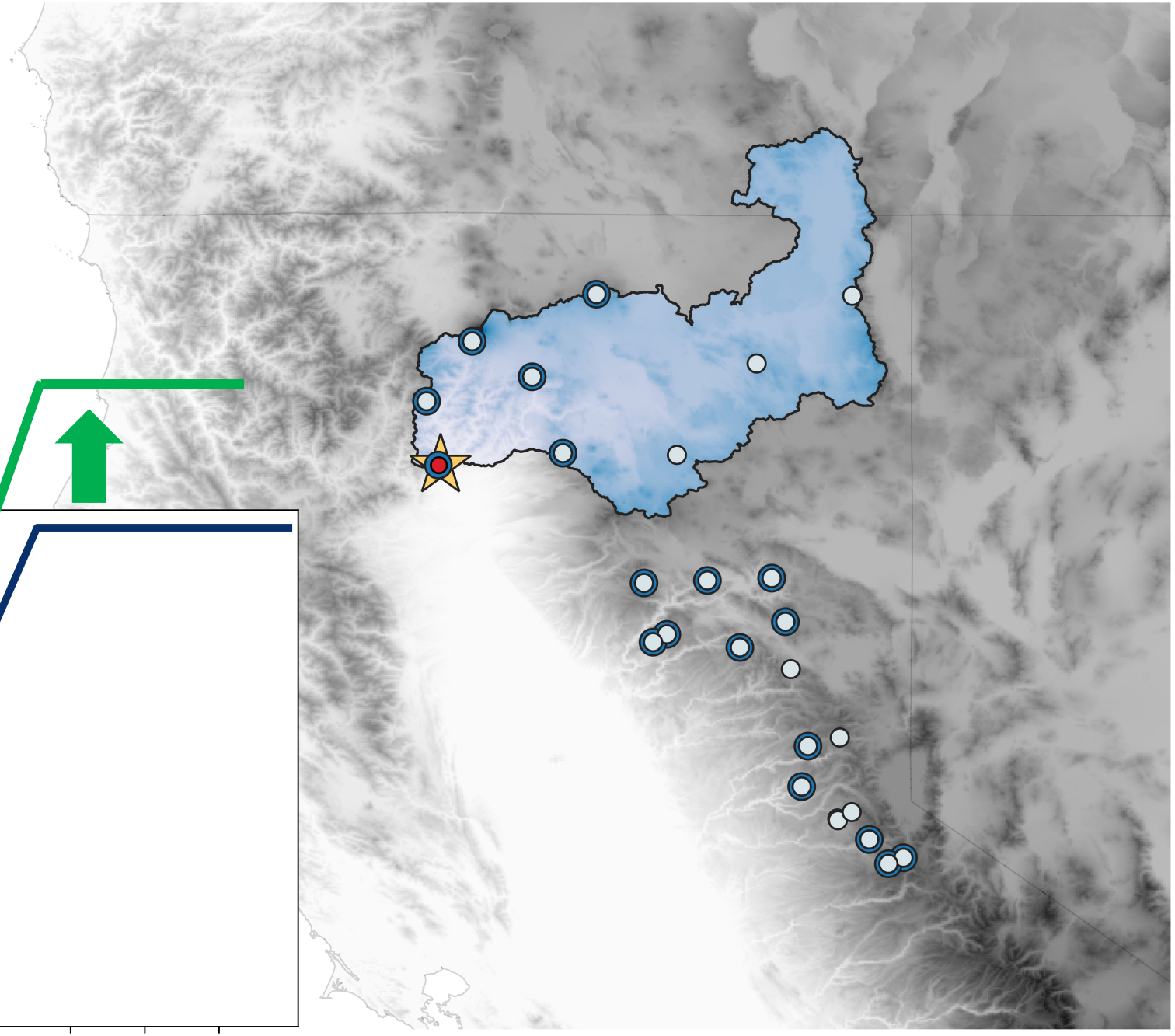




Demo: Perfect FIRO

Flood-pool on during wet season

No flood-pool during wet season

RC is dependent on recent inflow (that is why the red line is 'jumpy')

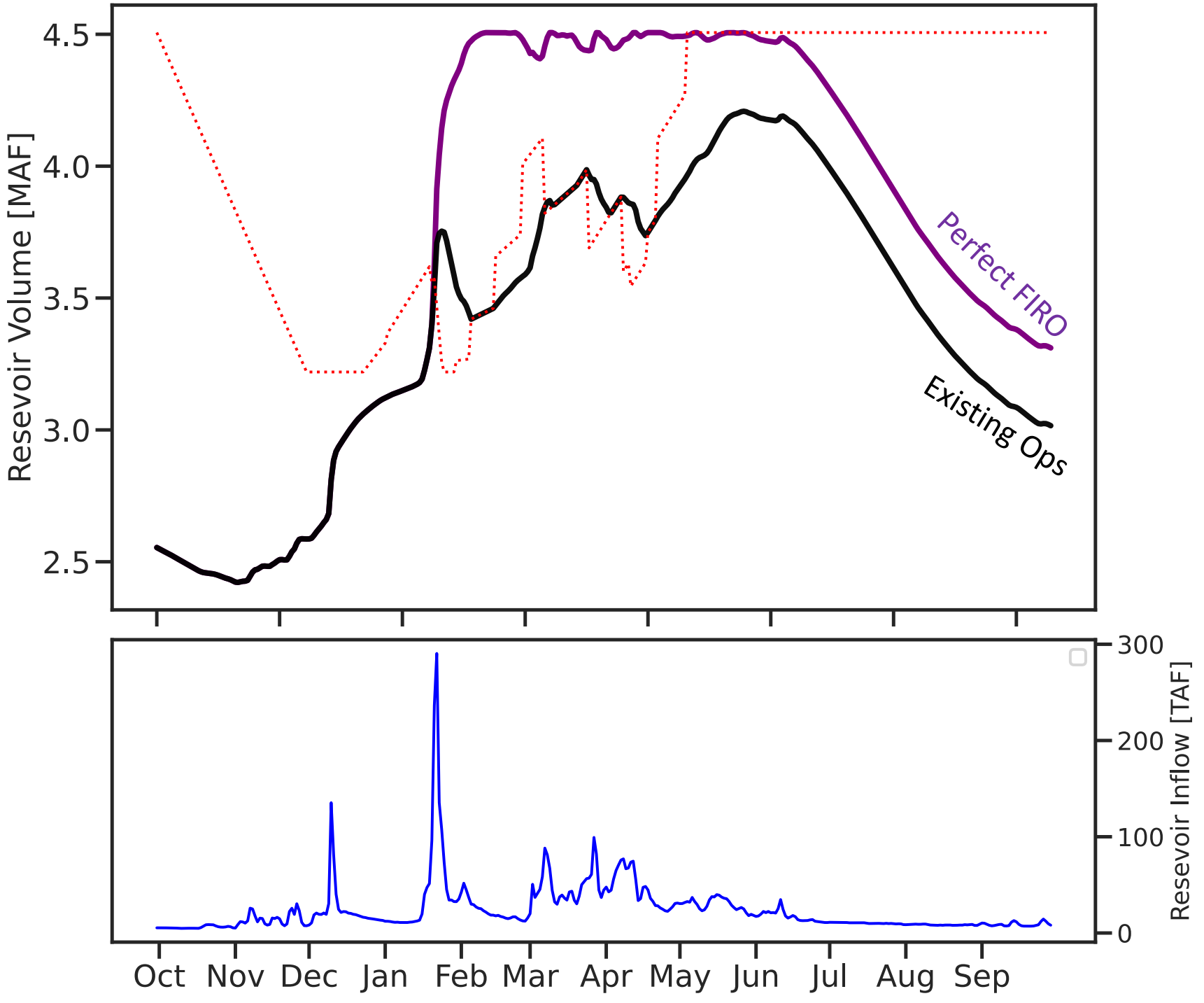
Reservoir allowed to fill ASAP

Flood risk operations respond to 'water on the ground'

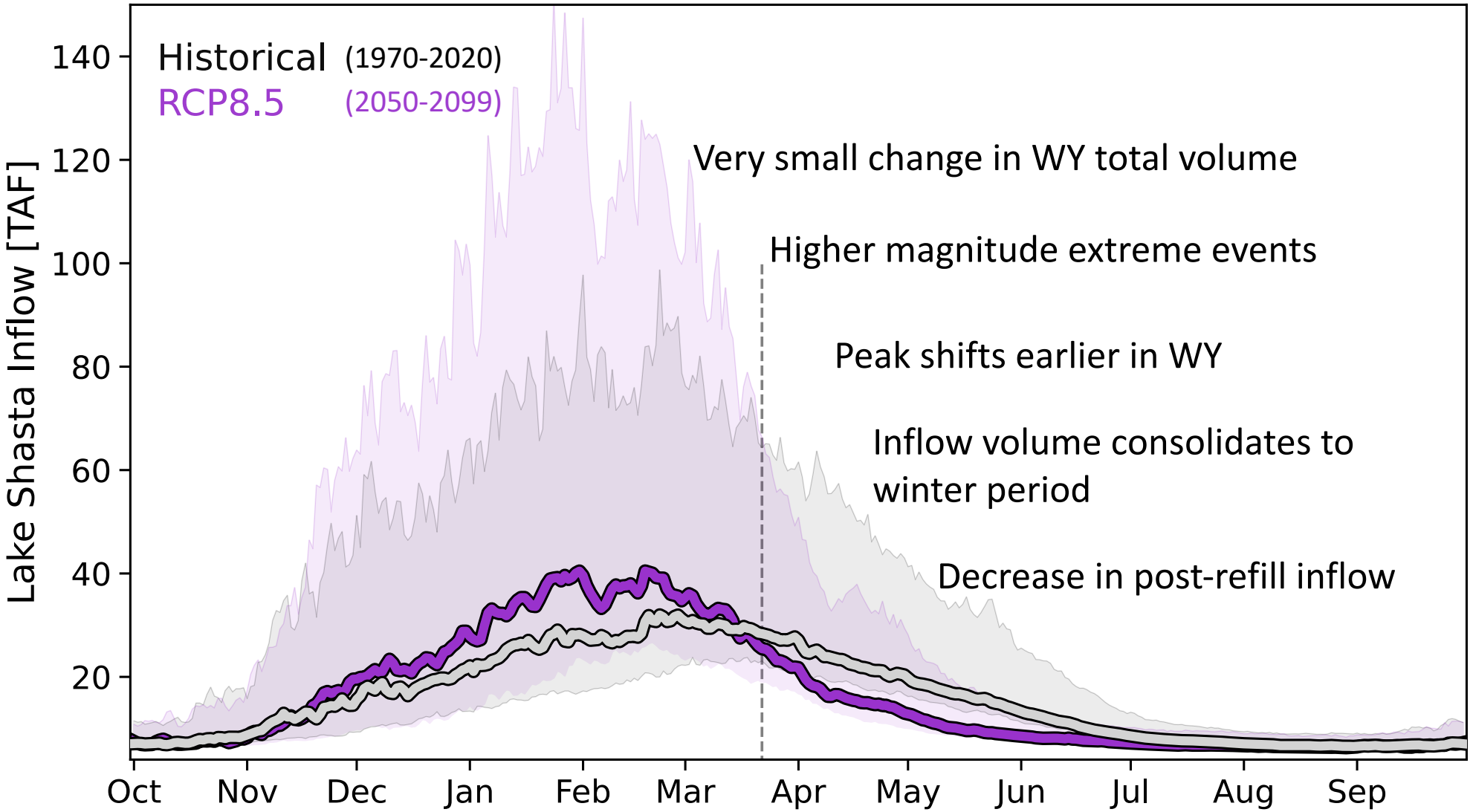
Pre-event releases are made to avoid storage exceeding RC

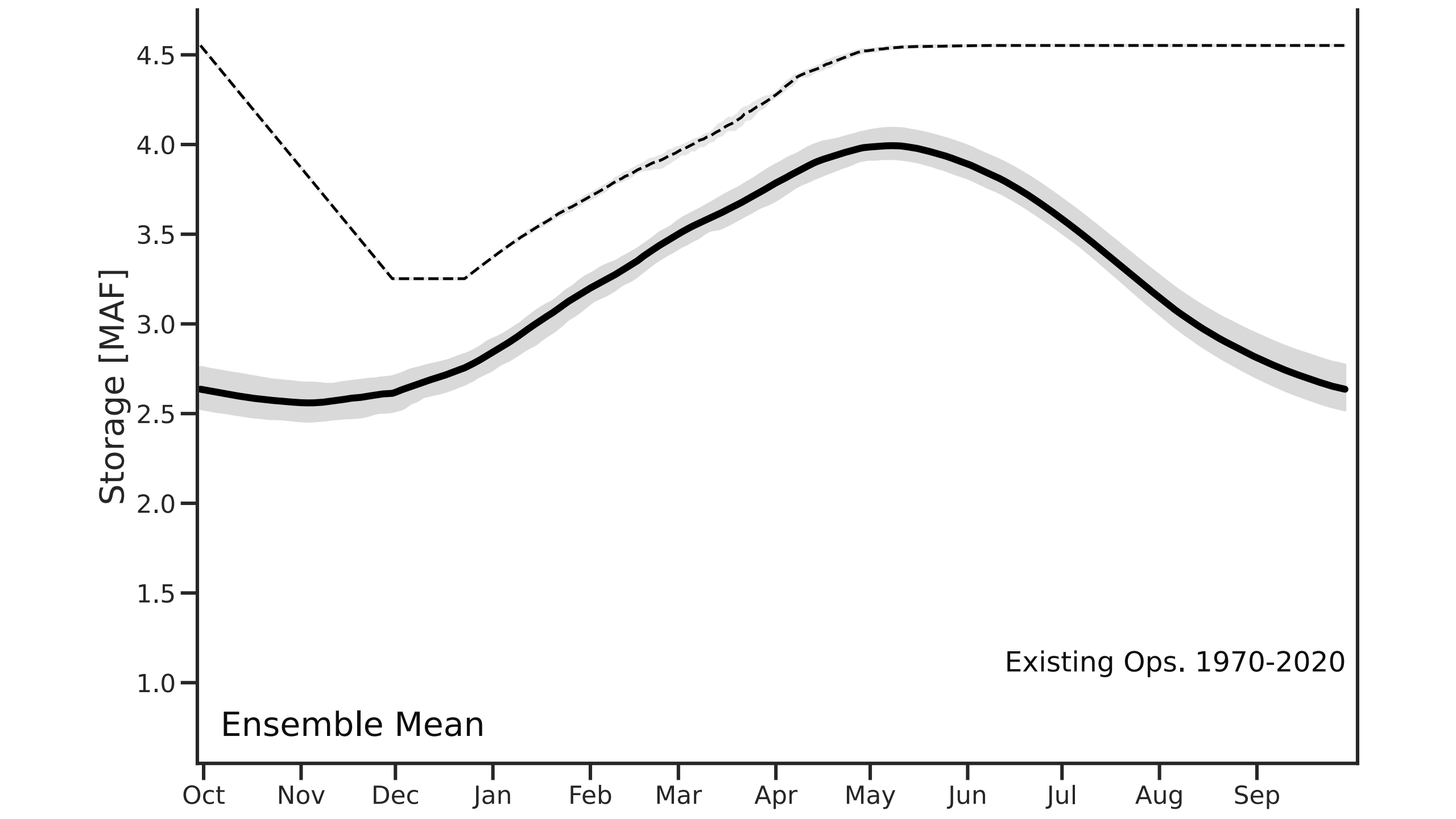
Demand-season May-September

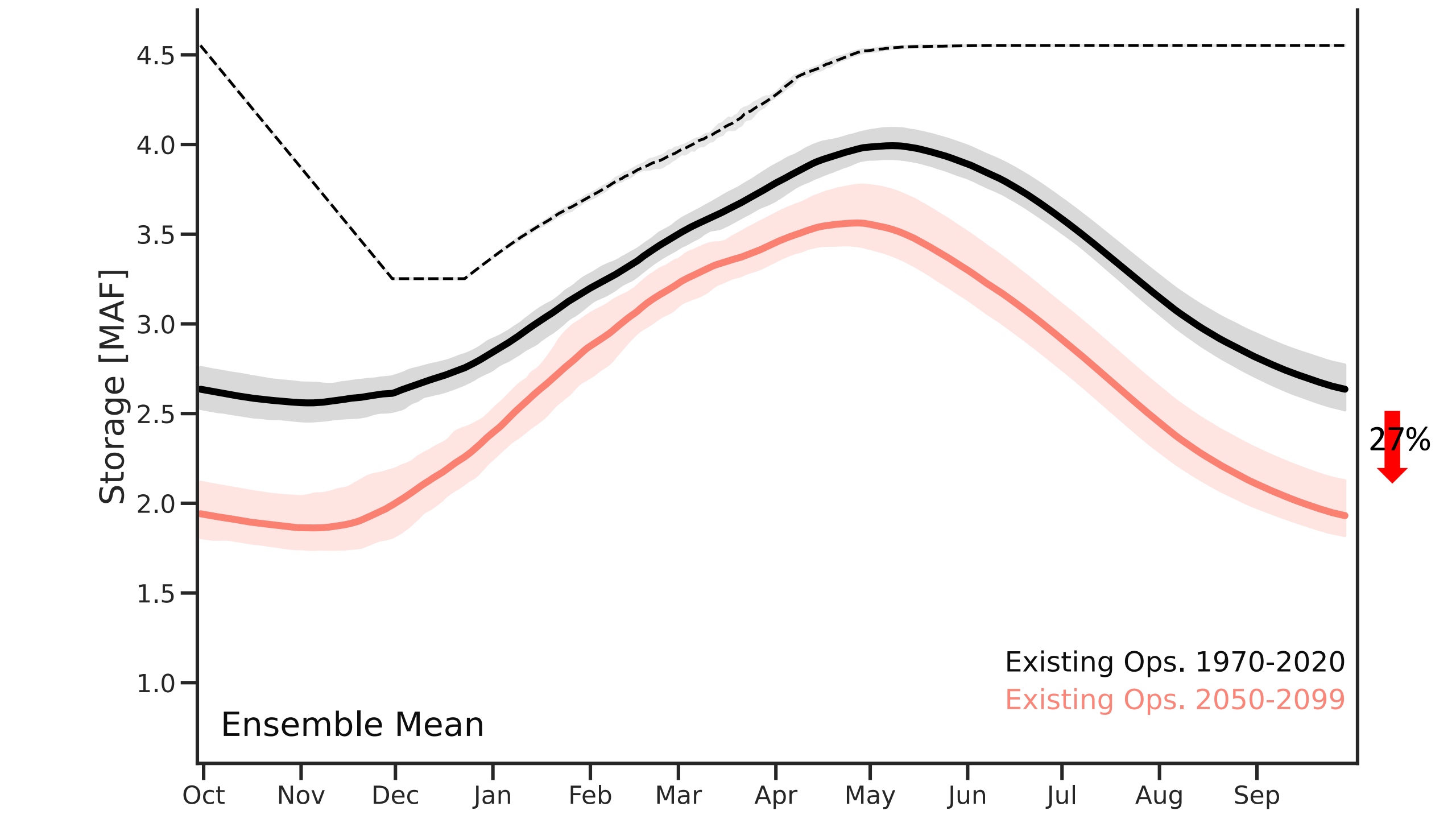
Demand-season May-September

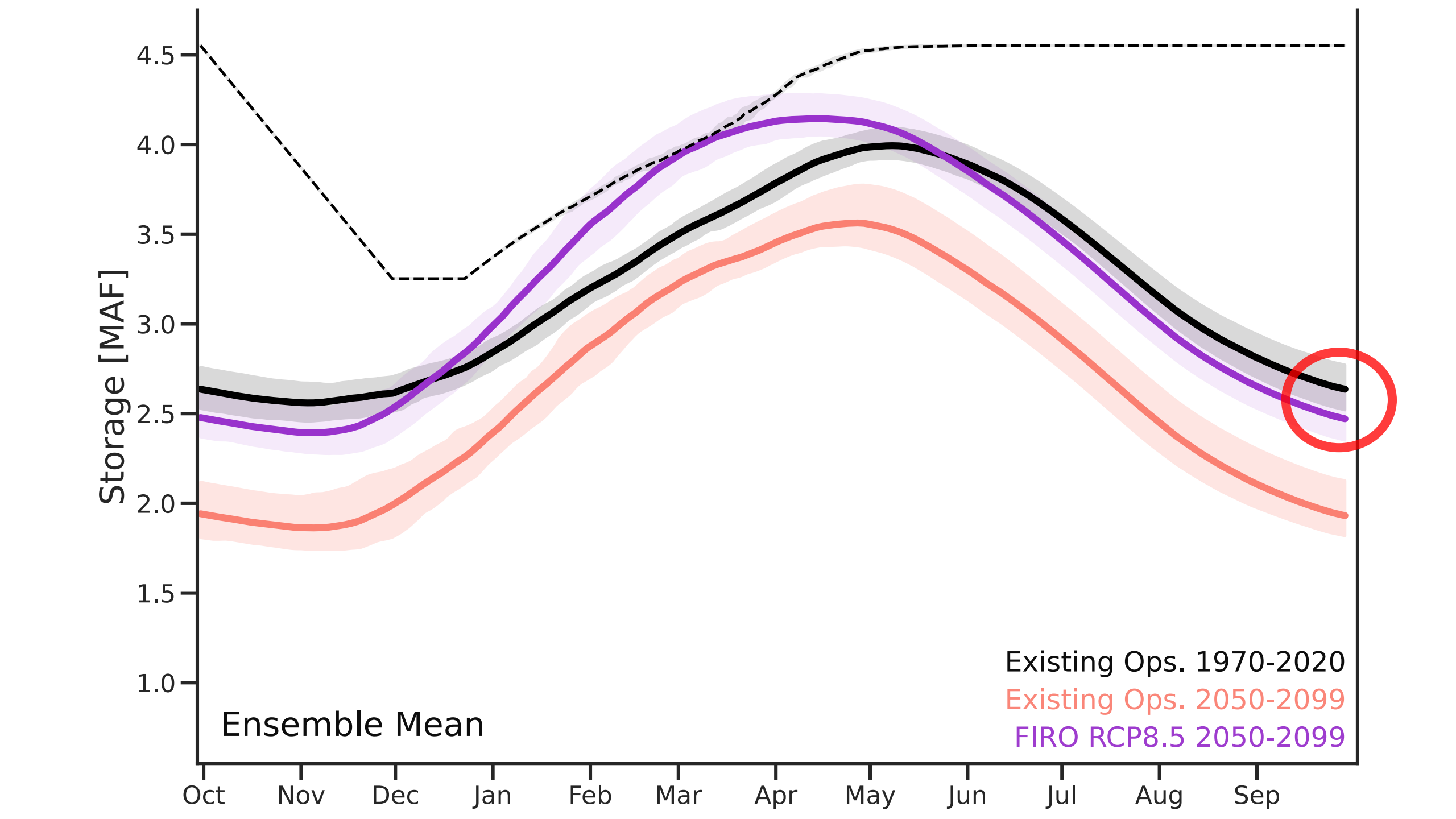


Climate Change Projections




Storage [MAF]
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Ensemble Mean
Existing Ops. 1970-2020


Storage [MAF]
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
27%
Existing Ops. 1970-2020
Existing Ops. 2050-2099
Ensemble Mean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Nov
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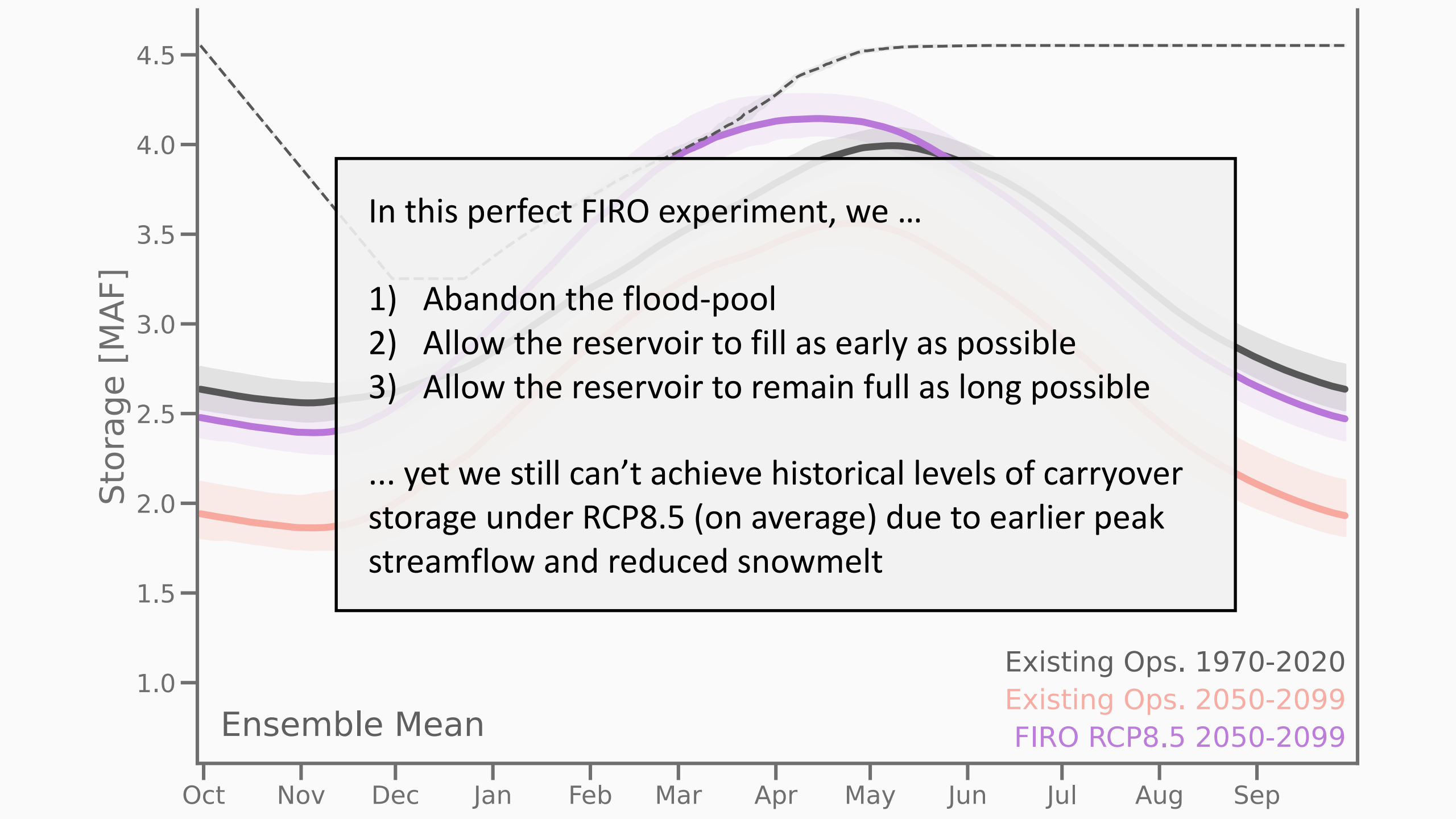
Existing Ops. 2050-2099
FIRO RCP8.5 2050-2099


In this perfect FIRO experiment, we …
1) Abandon the flood-pool
2) Allow the reservoir to fill as early as possible
3) Allow the reservoir to remain full as long possible
… yet we still can't achieve historical levels of carryover storage under RCP8.5 (on average) due to earlier peak streamflow and reduced snowmelt
Storage [MAF]
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Ensemble Mean
Existing Ops. 1970-2020
Existing Ops. 2050-2099
FIRO RCP8.5 2050-2099

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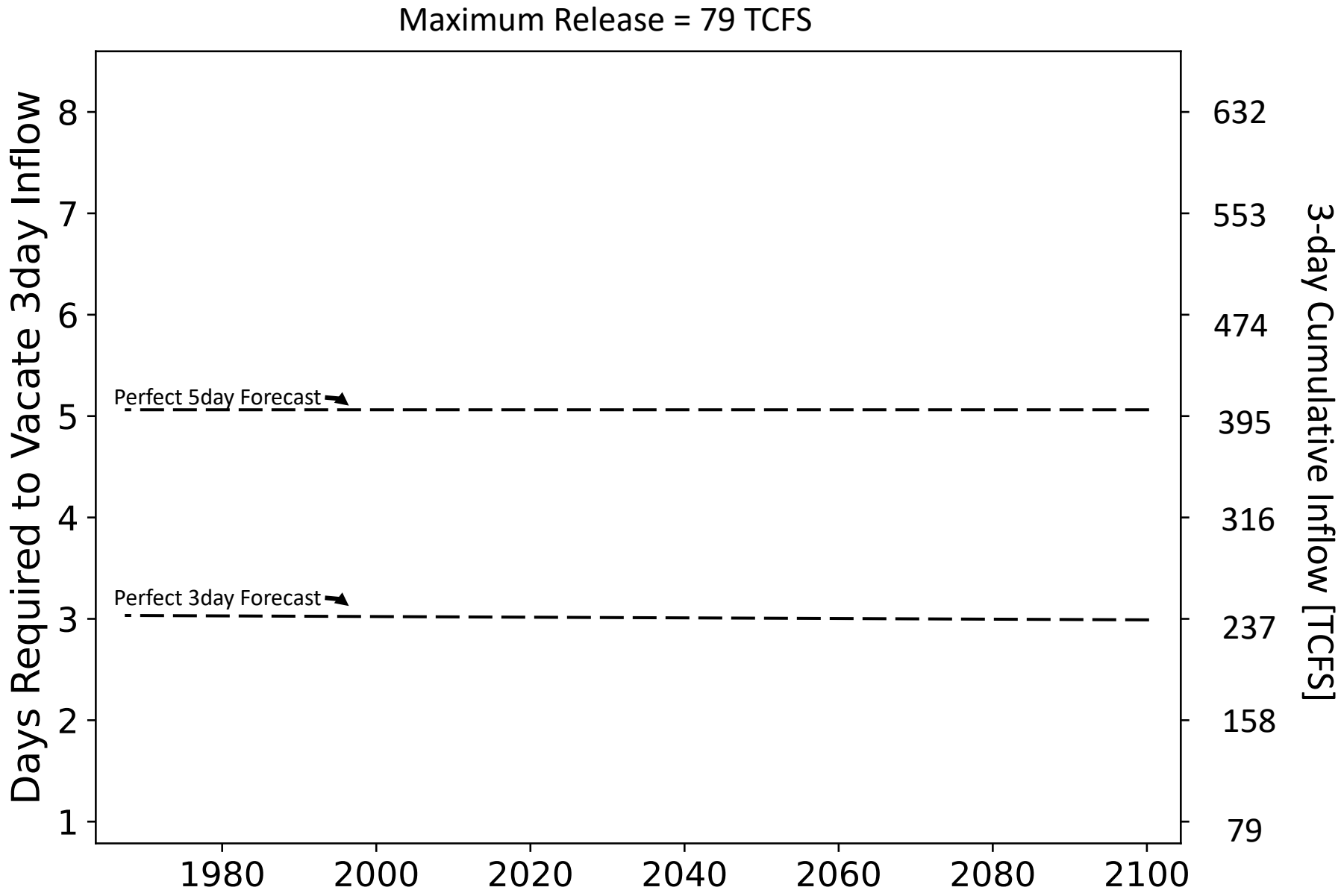
Perfect Forecast Limits



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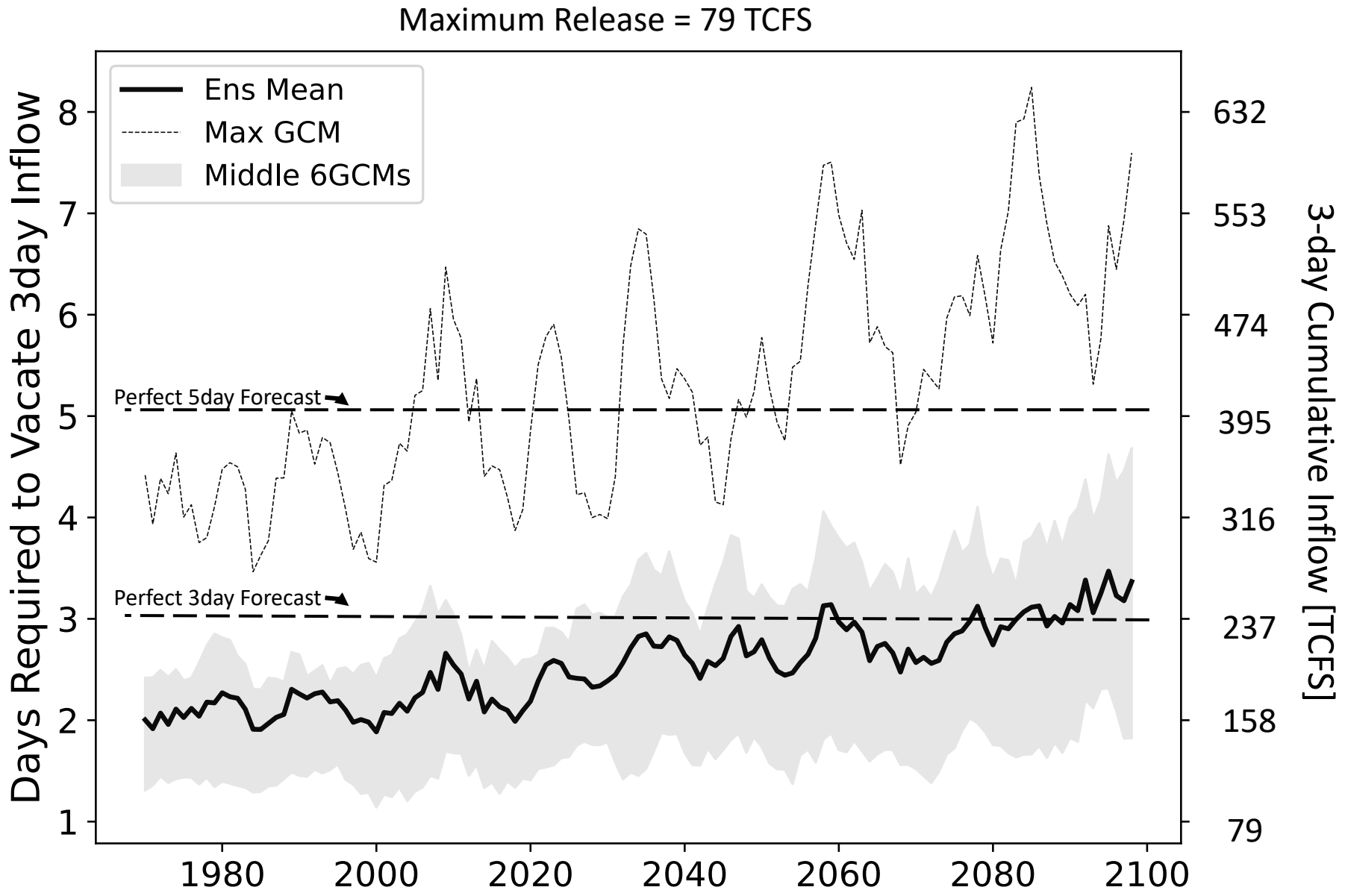

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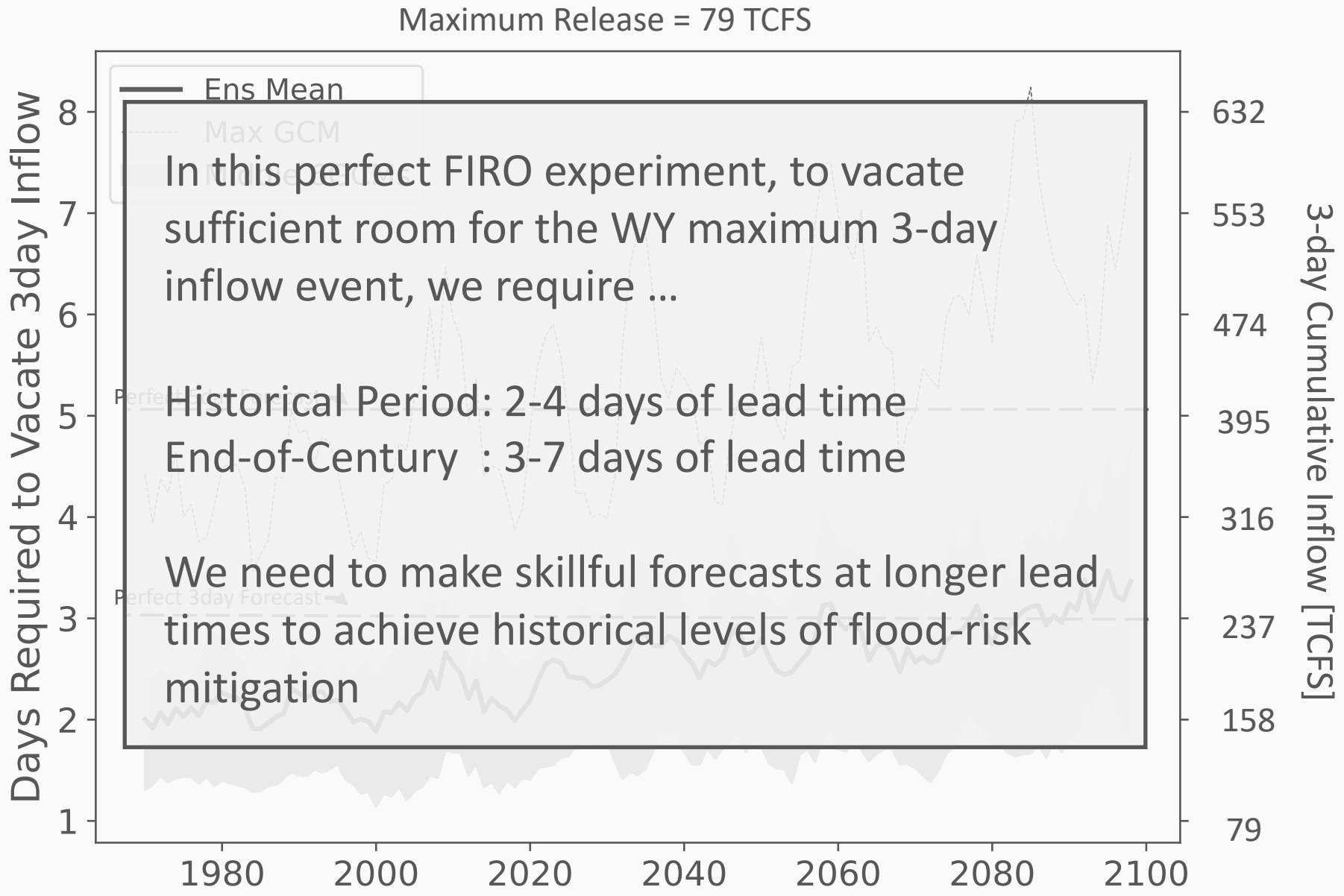

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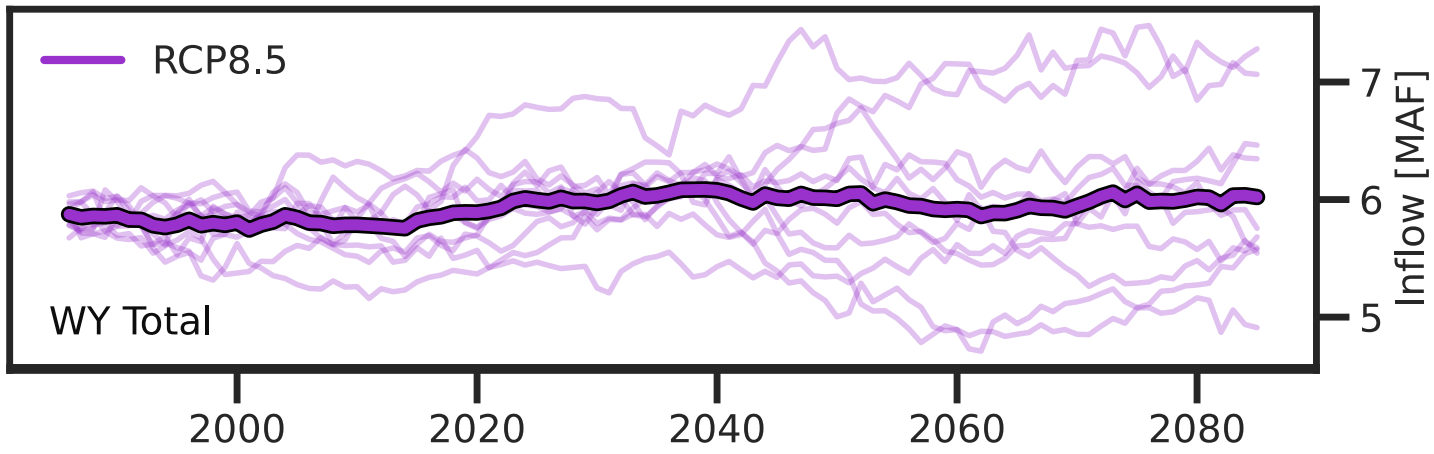
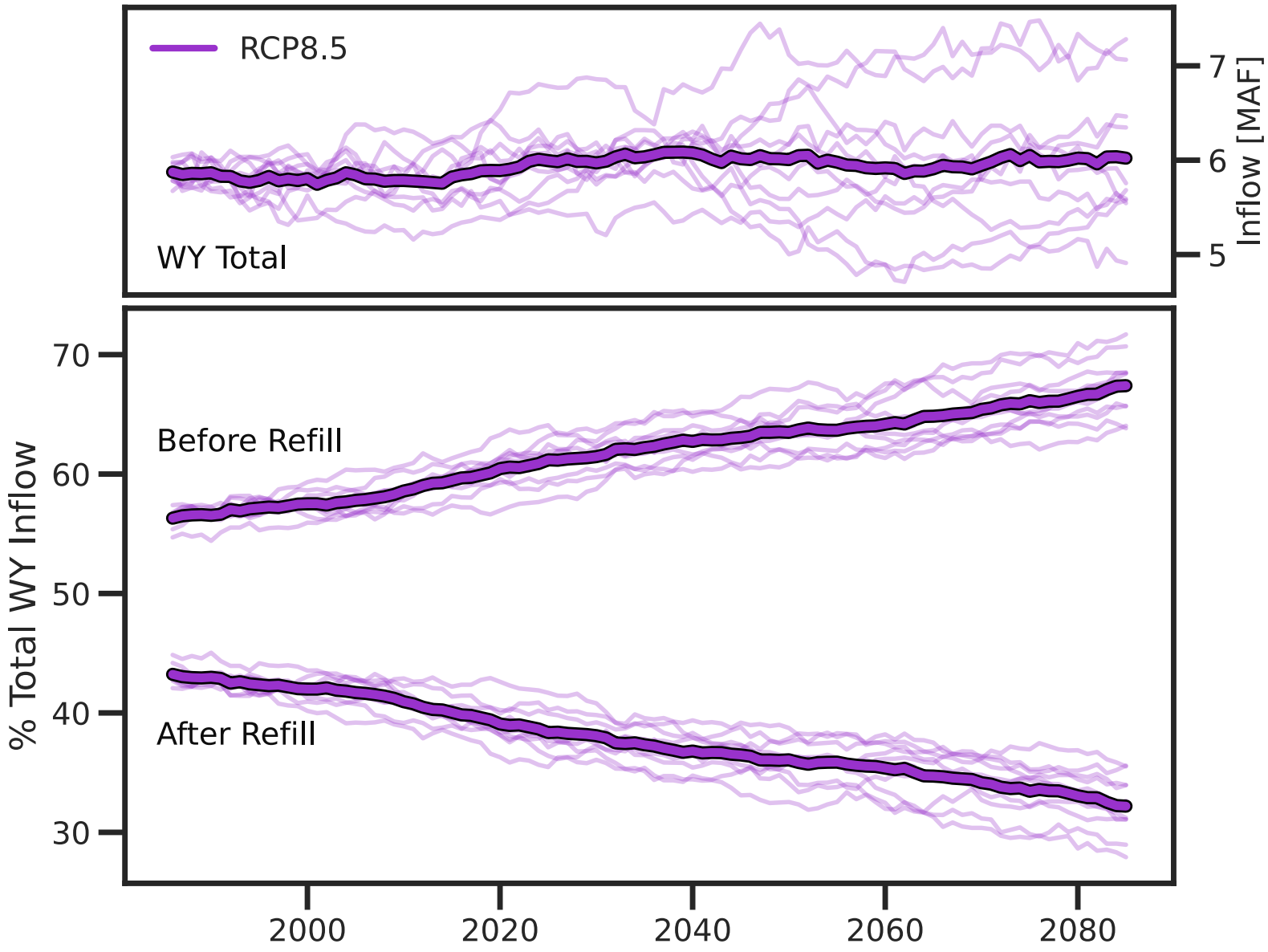


Little change in WY Total Inflow

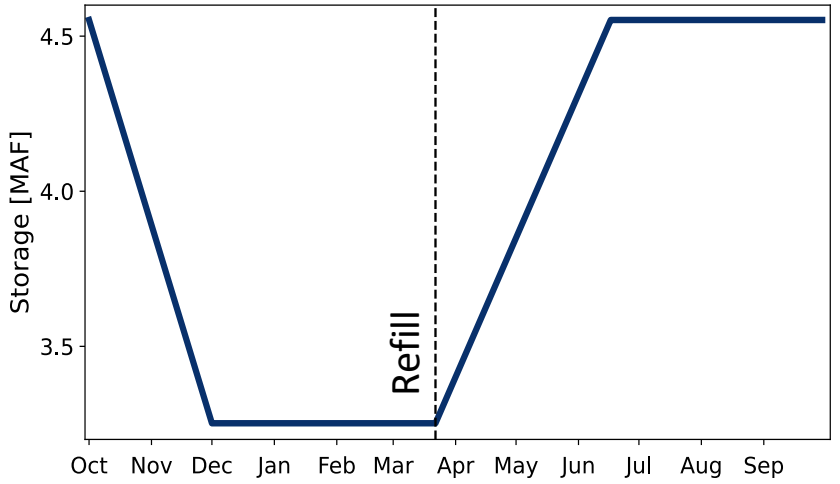
Climate Change Projections



Little change in WY Total Inflow

Inflow volume consolidates to winter period

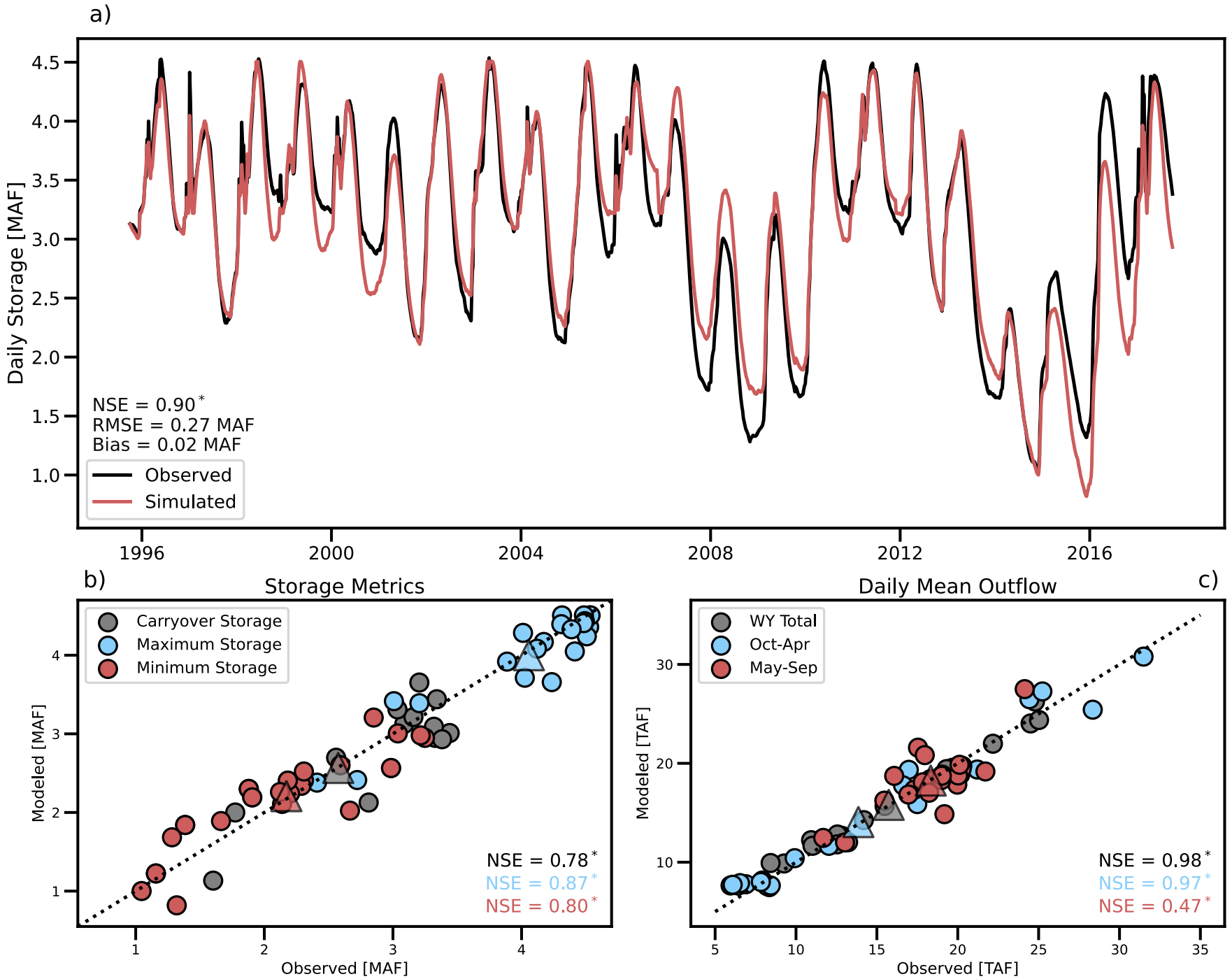
Decrease in post-refill inflow

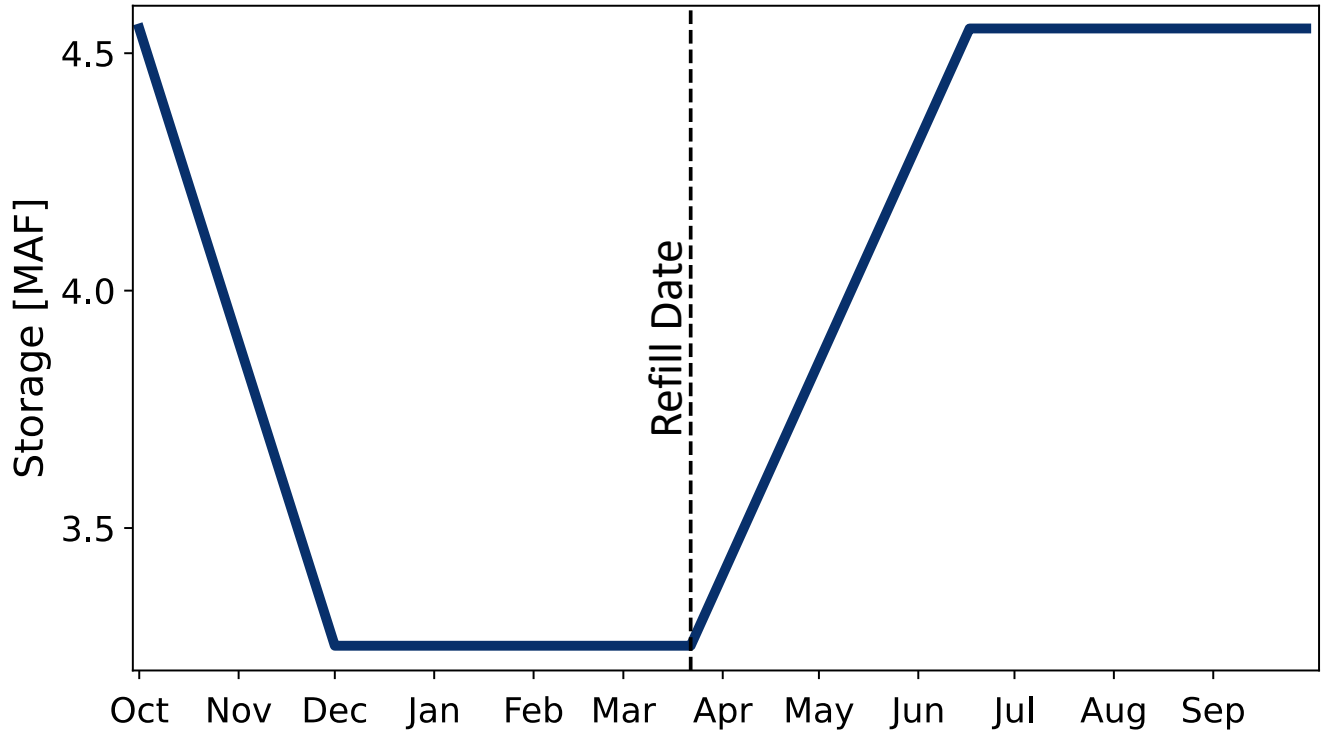


We build a model using station data from around Sacramento River Basin (precip, SWE, streamflow)

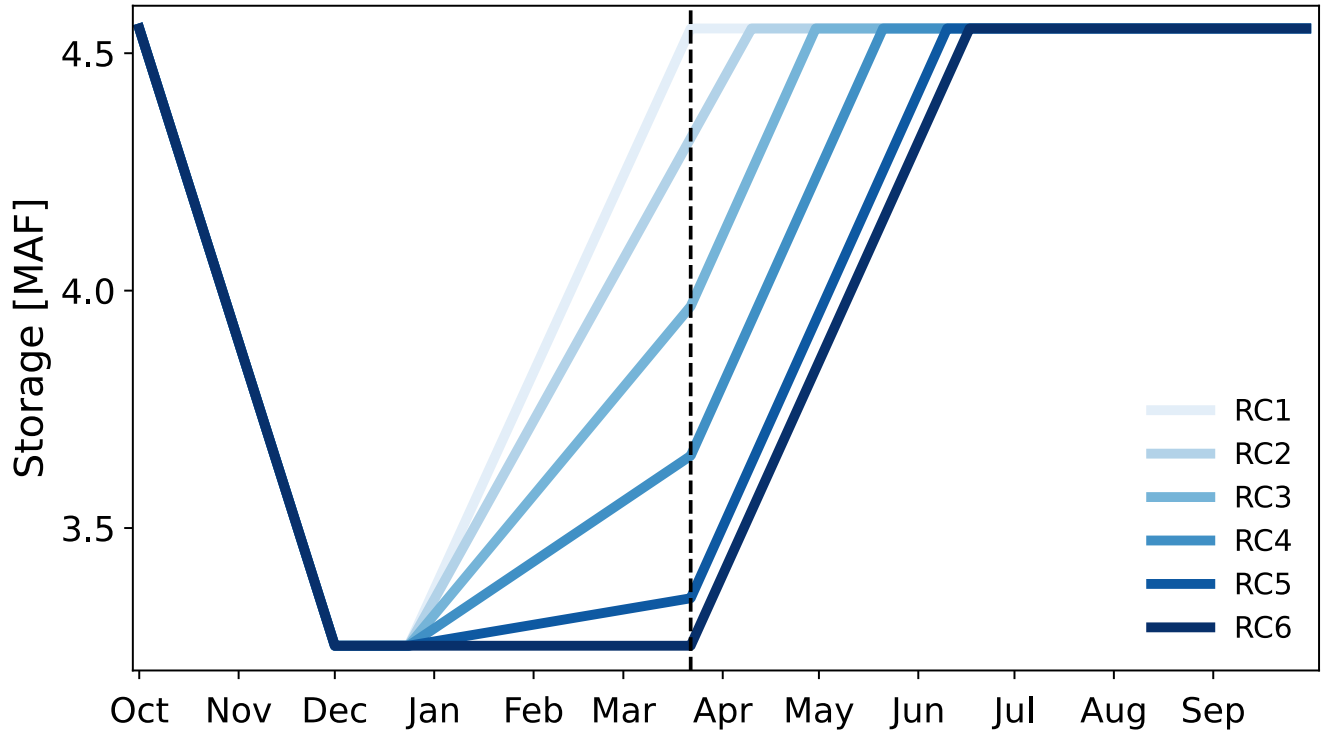
Calibrate and Validate over a historical period (WYs 1996-2017)

It does pretty well! (you'll have to take my word for it…)

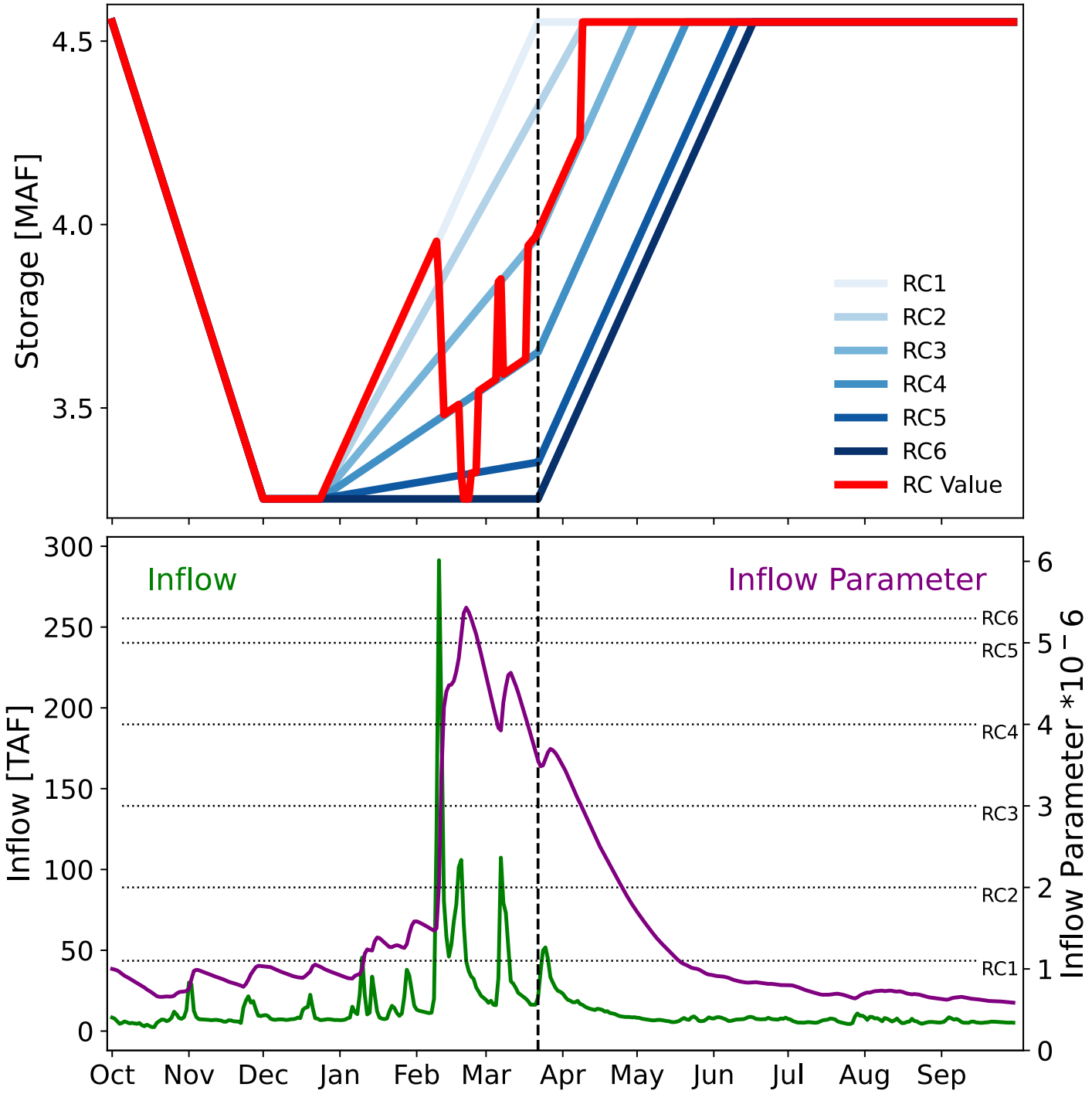




Many reservoirs have a rule curve (RC)



Shasta has 6 ”sub-RCs” (blues)



The ‘operative’ value of the RC is set by the volume of recent inflows (red)

Inflow

“Recent Inflow”