

Seasonal Effects of River Flow on Water Temperatures in the Scott River

Eli Asarian
Riverbend Sciences

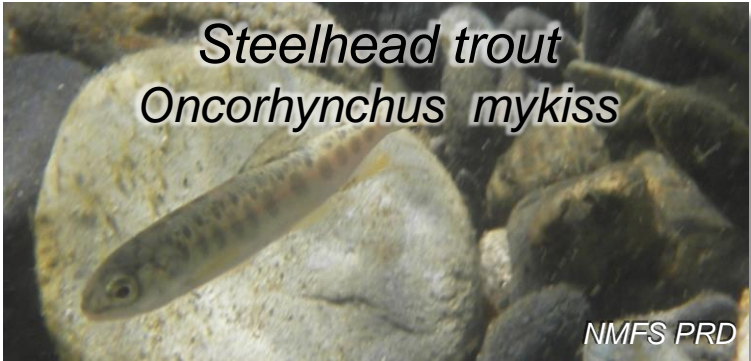
Crystal Robinson
Quartz Valley Indian Reservation

ALL RESULTS PROVISIONAL

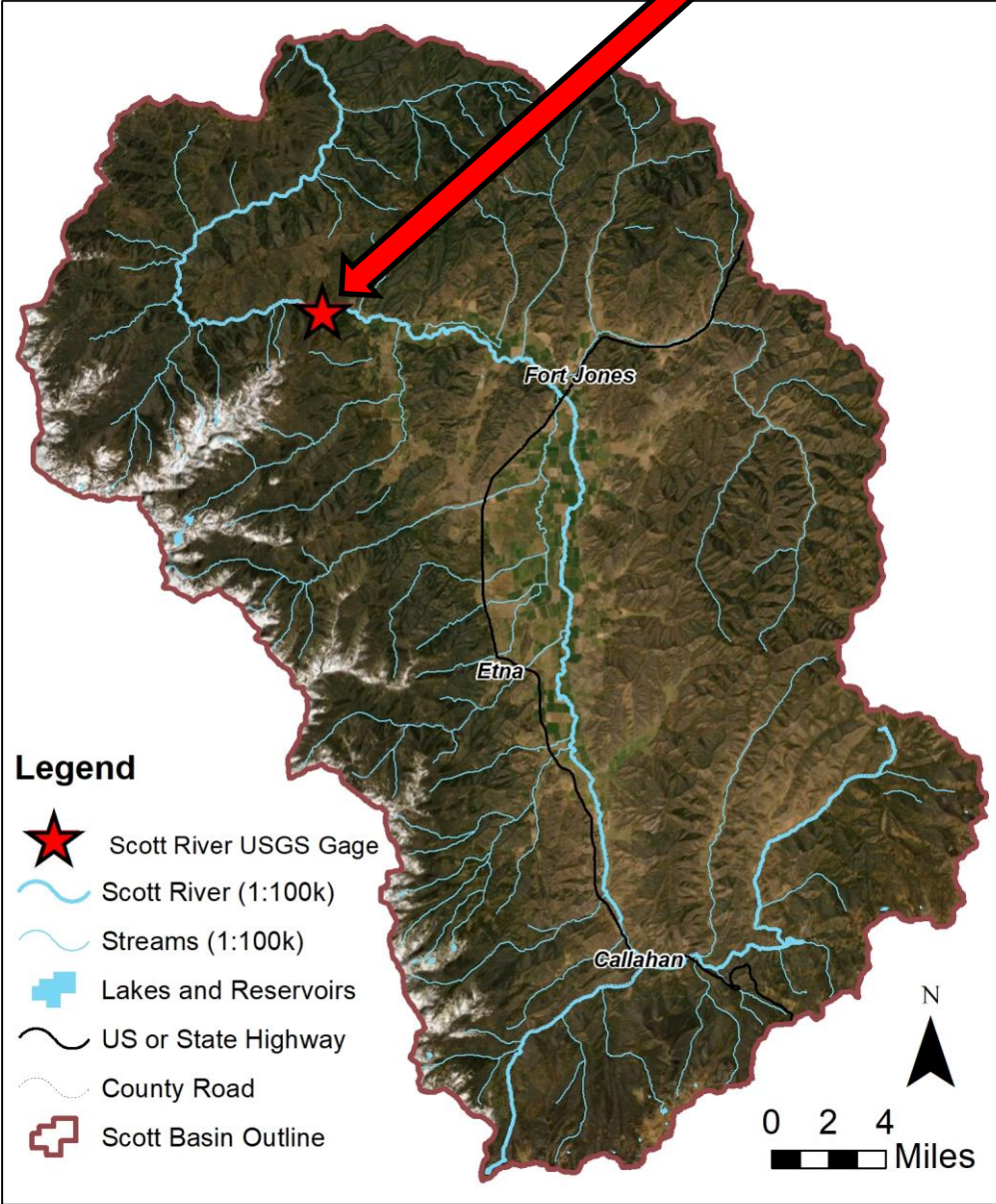
2/17/2022

Scott Watershed Information Forum

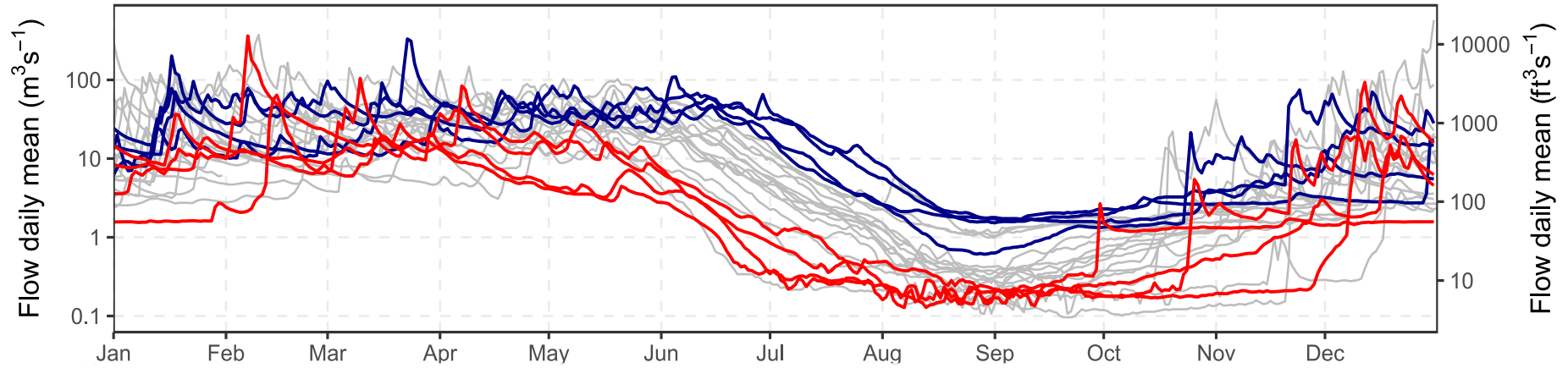
Funding provided by:
Klamath Tribal Water Quality Consortium



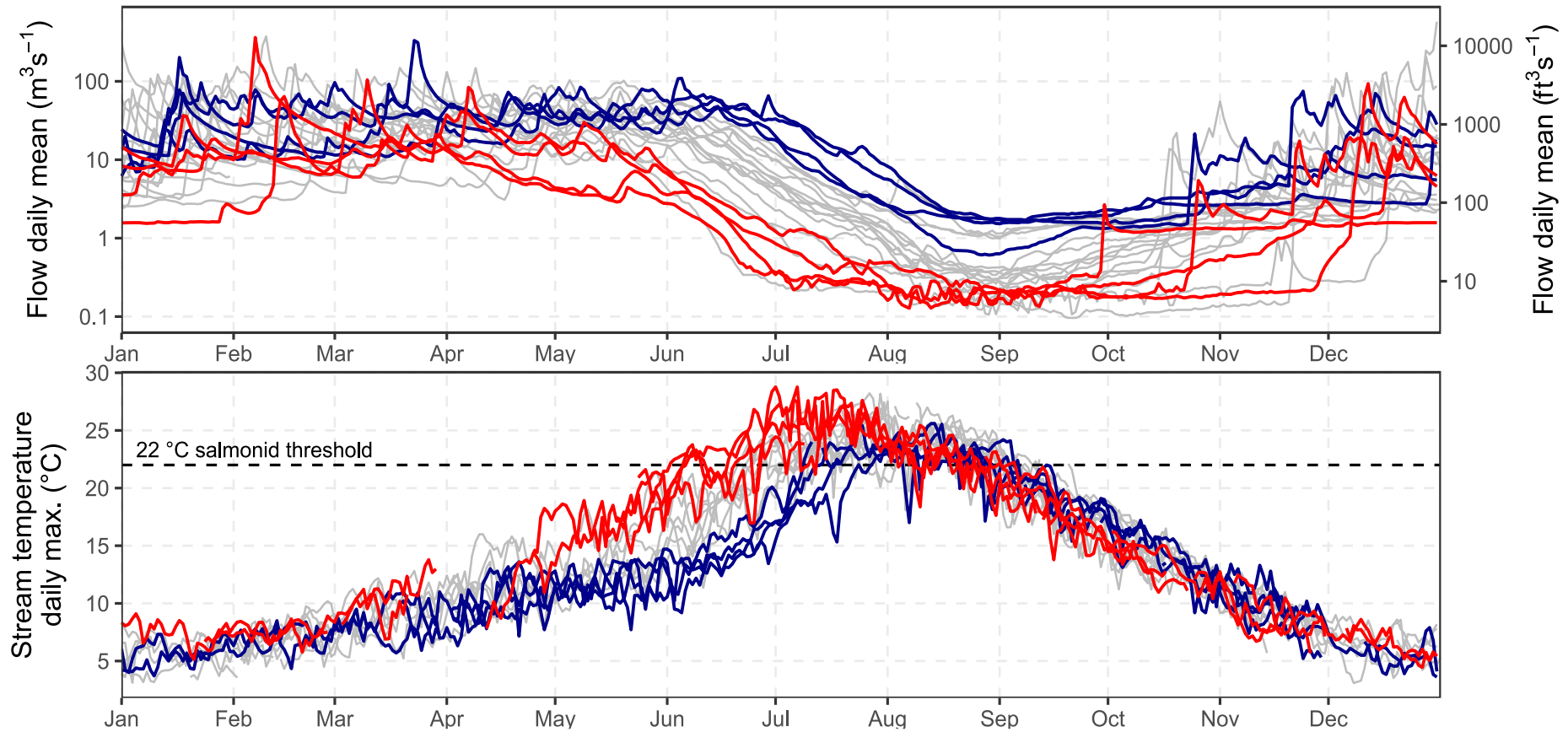
Scott River Gage

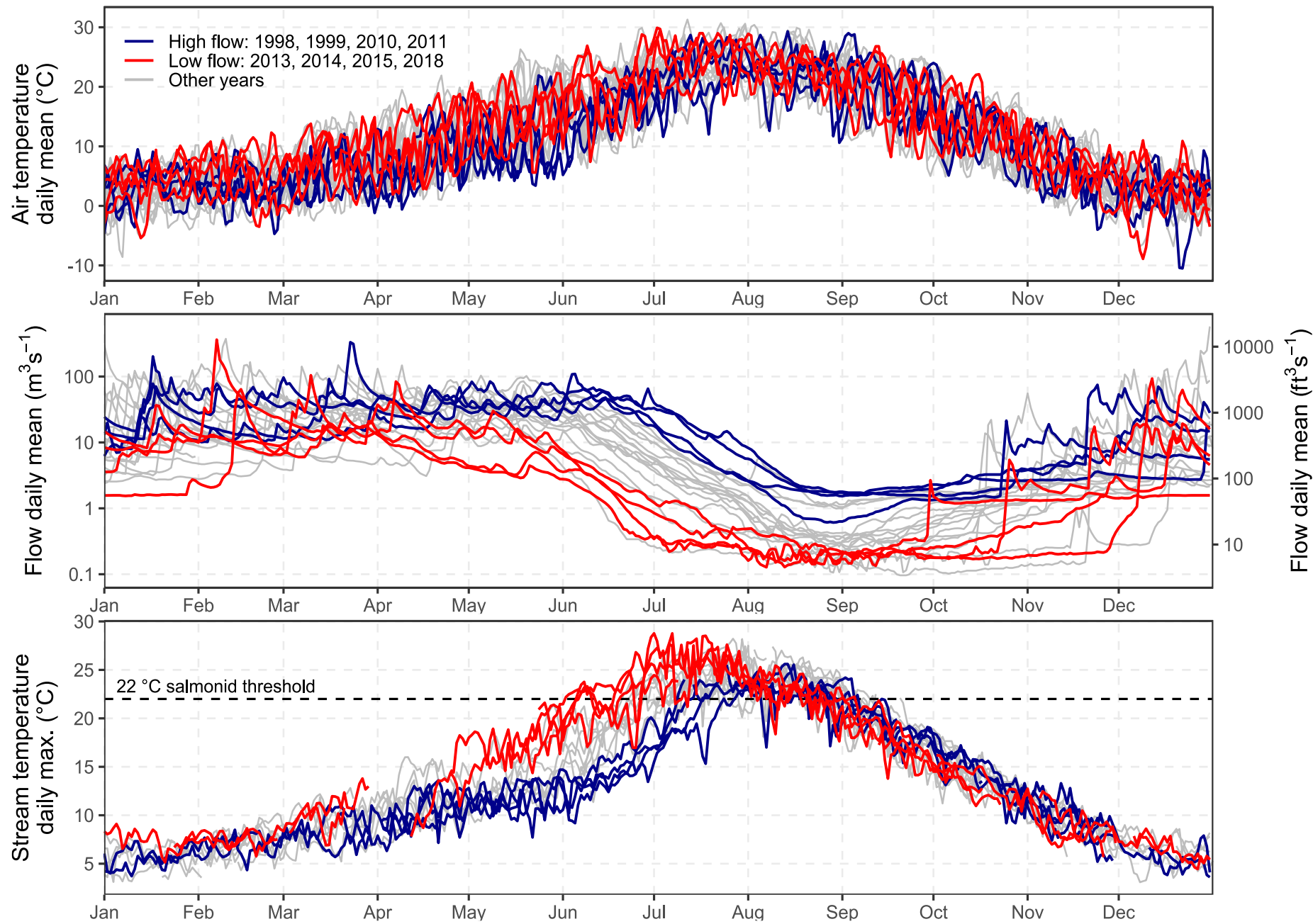


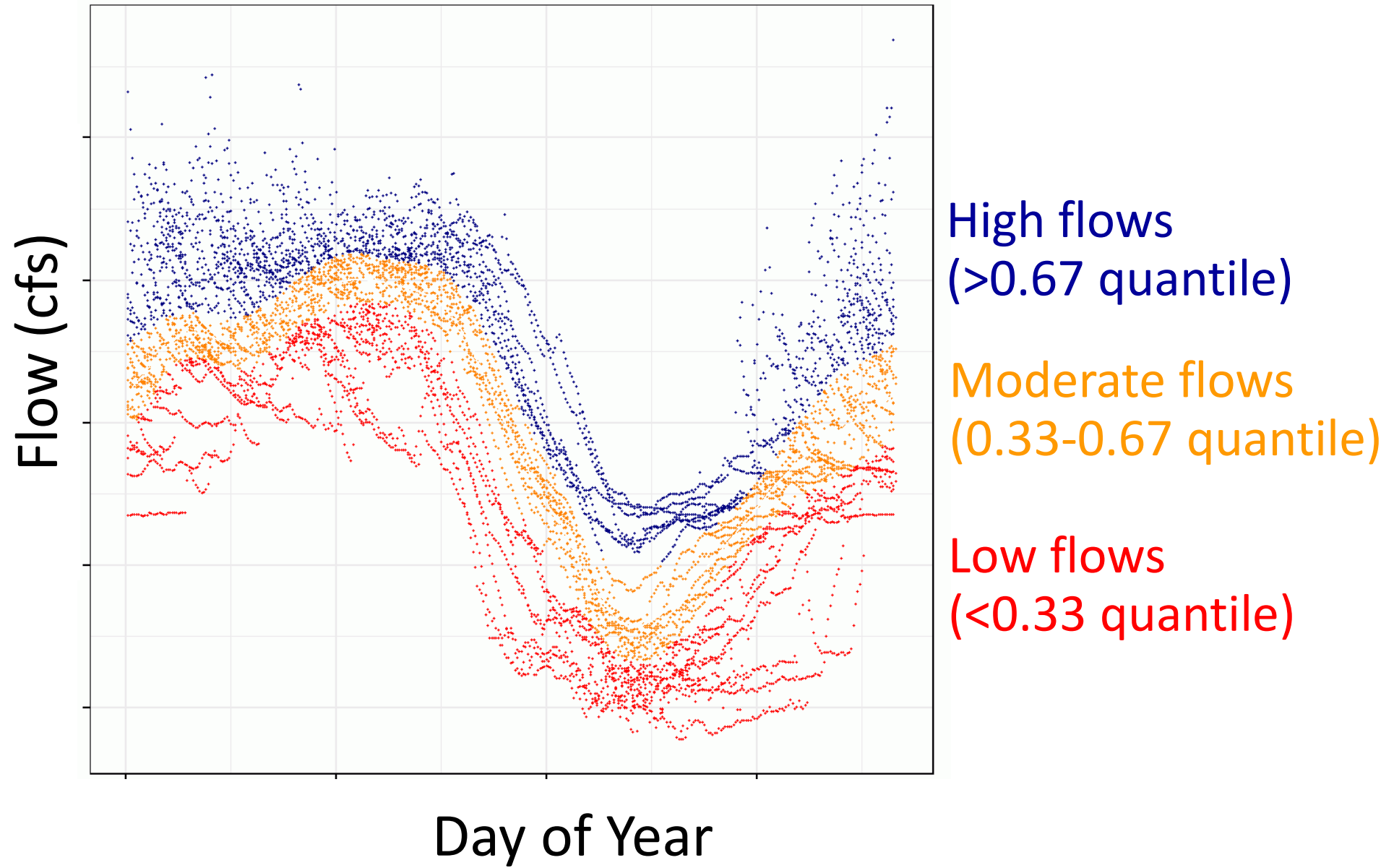
- High flow: 1998, 1999, 2010, 2011
- Low flow: 2013, 2014, 2015, 2018
- Other years

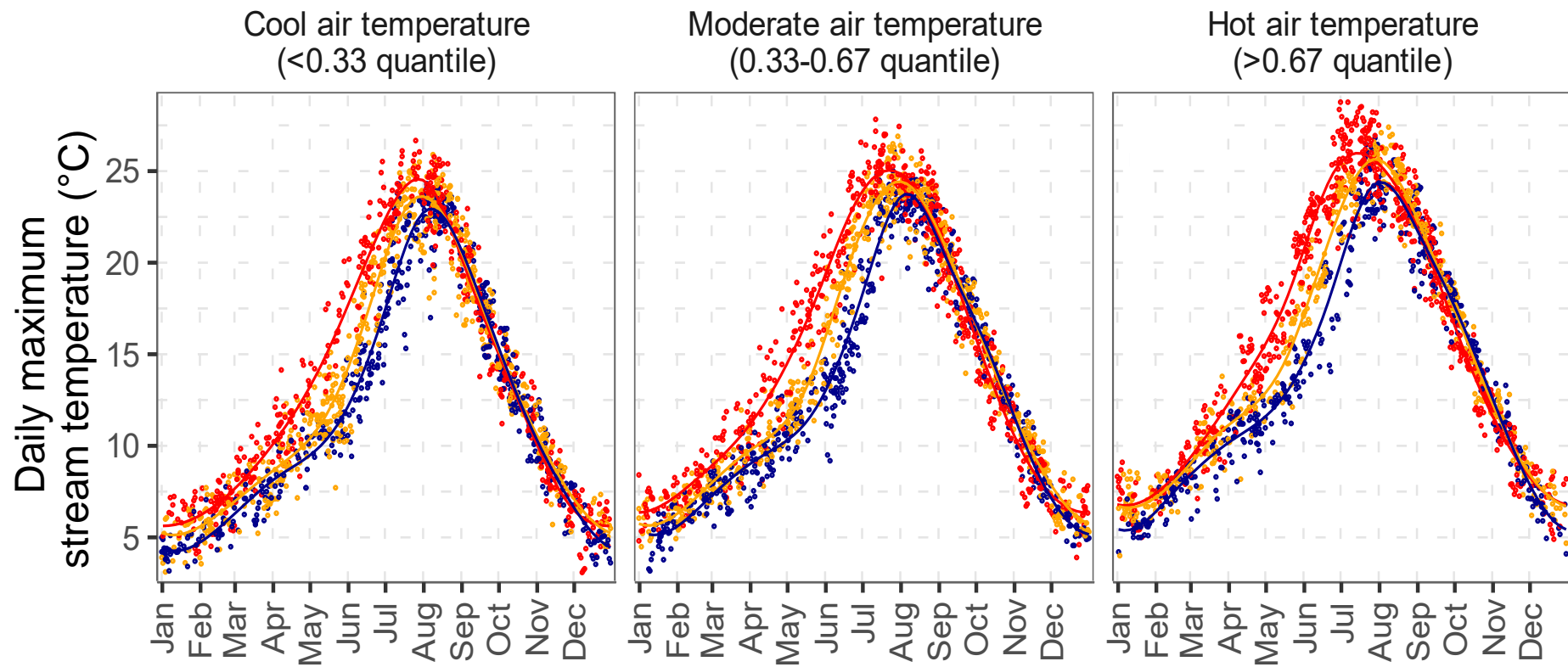


- High flow: 1998, 1999, 2010, 2011
- Low flow: 2013, 2014, 2015, 2018
- Other years









- Low flows (<0.33 quantile)
- Moderate flows (0.33-0.67 quantile)
- High flows (>0.67 quantile)



Water temperature

Instream probes 1998-2020

Reclamation Forest Service Quartz Valley




BUREAU OF
RECLAMATION



Summarize
daily mean,
daily maximum

 **Water temperature**
Instream probes 1998-2020
Reclamation Forest Service Quartz Valley


  


— BUREAU OF —
RECLAMATION


FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE




Summarize
daily mean,
daily maximum

Climate data

 **Air Temperature**
PRISM


 **Flow**
USGS


 **Water temperature**
Instream probes 1998-2020
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FOREST SERVICE
DEPARTMENT OF AGRICULTURE


Climate data


 **Air Temperature**
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Summarize
daily mean,
daily maximum

Generalized additive model (GAM) with autocorrelation

 $T_{\text{water}} = \text{Flow} + \text{Air Temperature} + \text{Day}$

Effects vary smoothly
by day of year 

Water temperature
Instream probes 1998-2020
Reclamation Forest Service Quartz Valley



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FOREST SERVICE
DEPARTMENT OF AGRICULTURE

Climate data


Air Temperature
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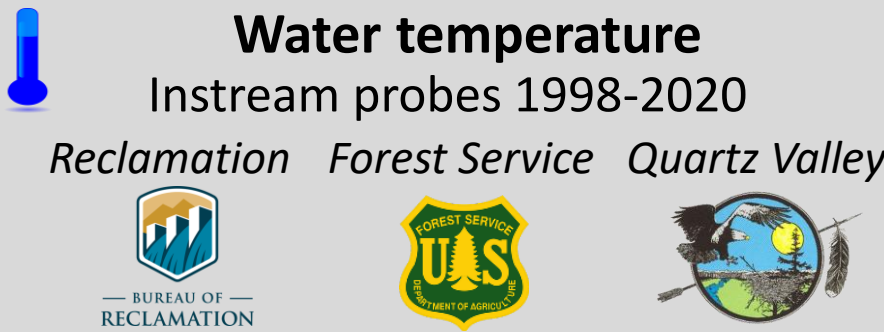
Generalized additive model (GAM) with autocorrelation

$$T_{\text{water}} = \text{Flow} + T_{\text{air}} + \text{Day}$$

Effects vary smoothly
by day of year 

Calibration
with measured
water
temperatures

Water temperature
Instream probes 1998-2020
Reclamation Forest Service Quartz Valley



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Air Temperature
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Validation
Leave one year out
Non-random cross
validation

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 with measured water temperatures

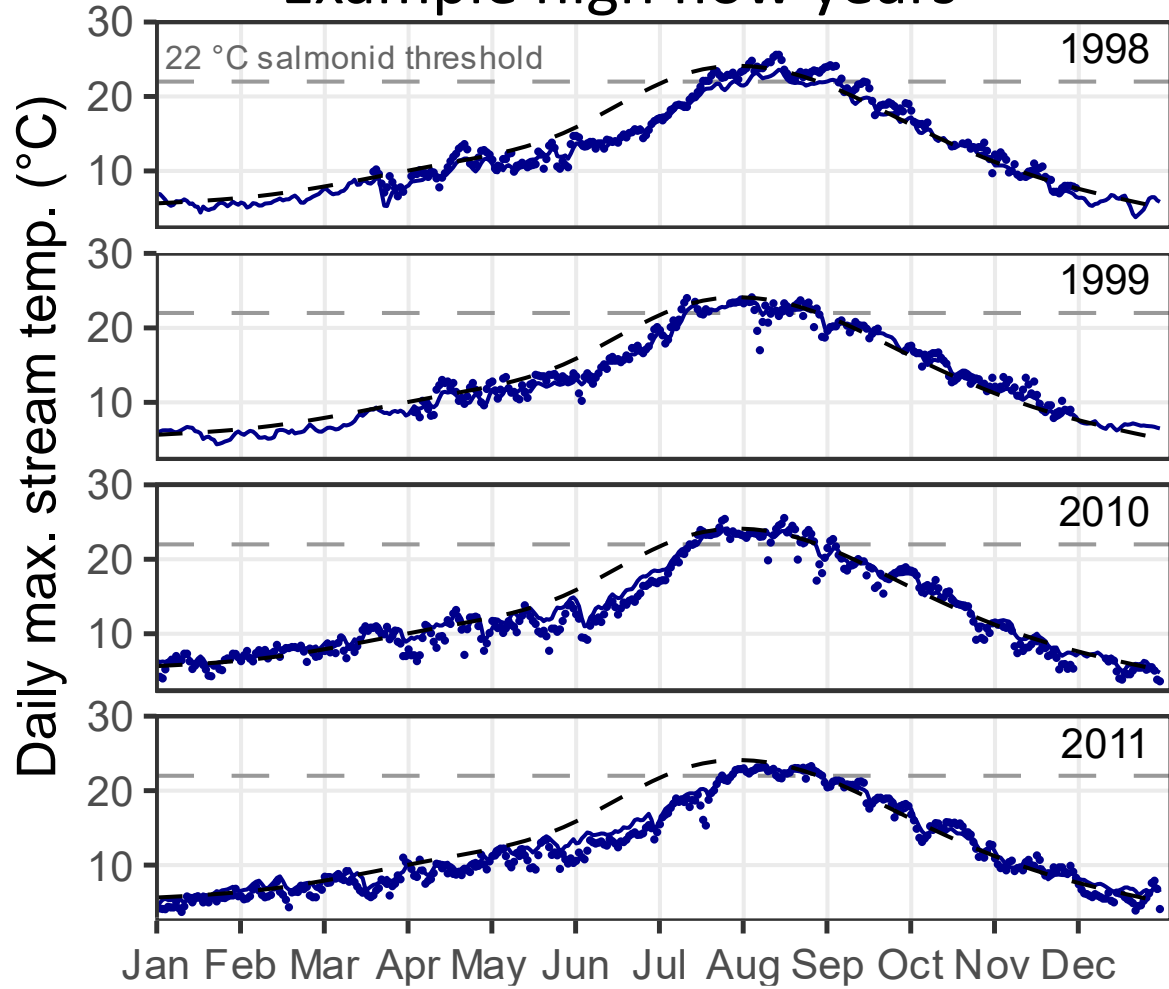
Scenarios

Combos of high/typical/low:

USFS water right & 2017 CDFW criteria

Validation

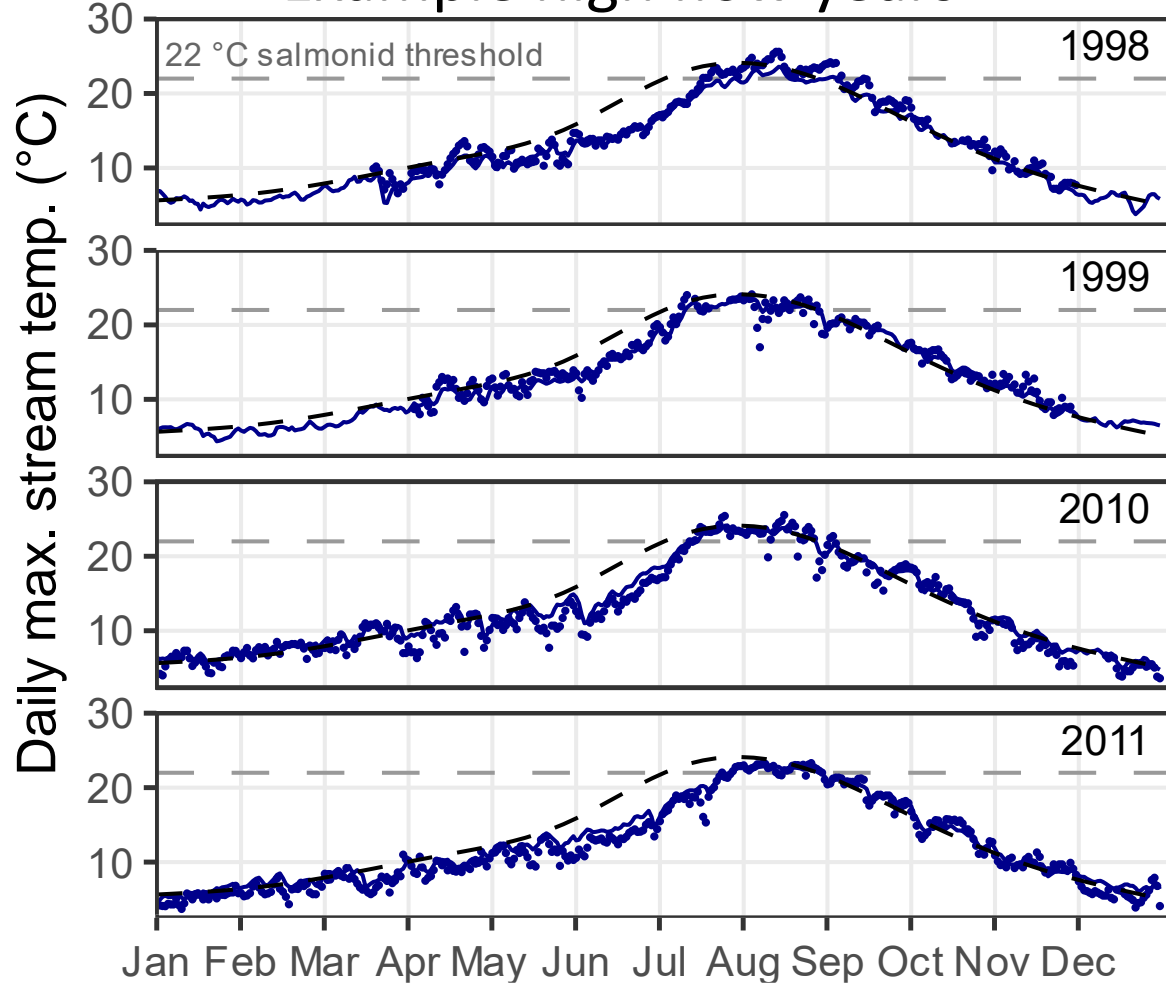
Example high flow years



- Modeled
- Measured
- Smoother of all years

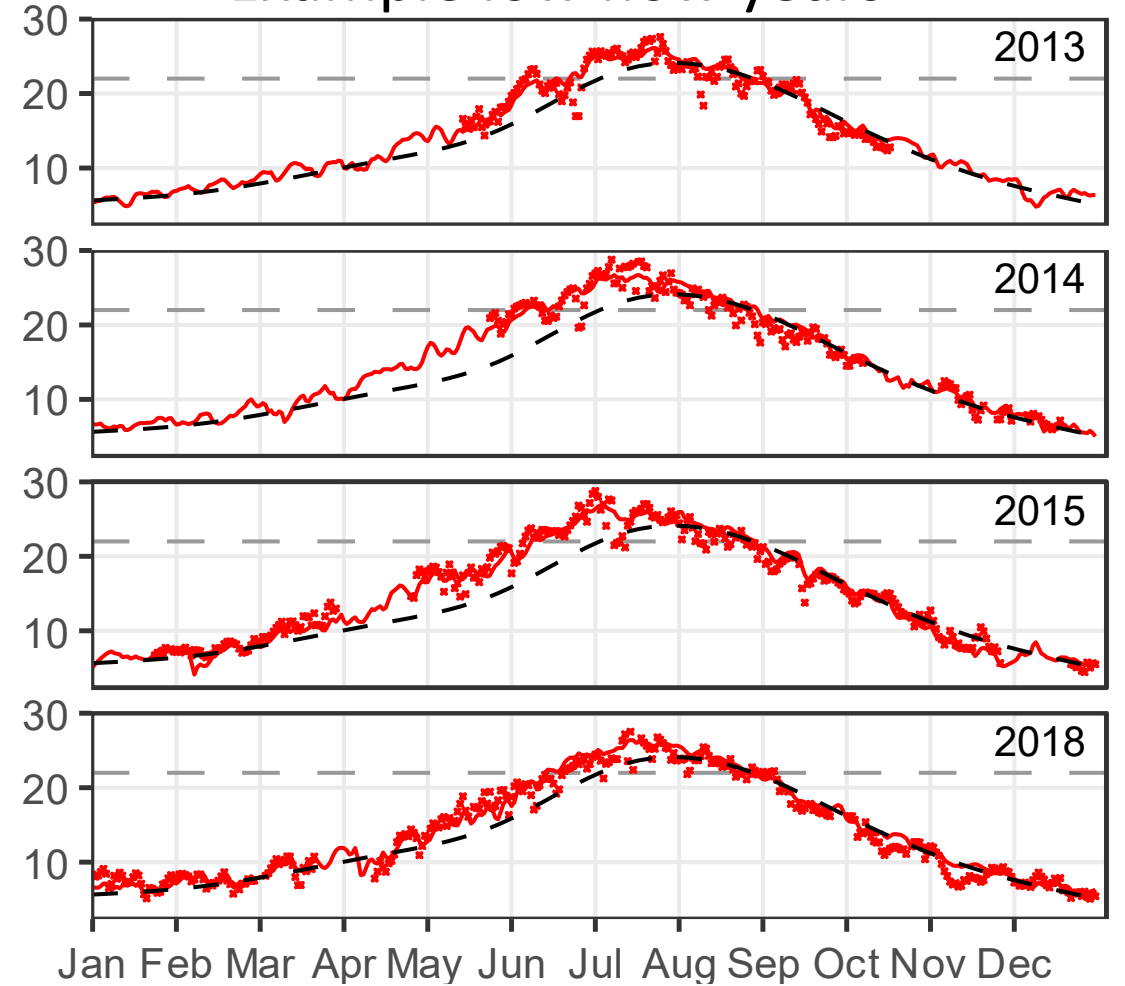
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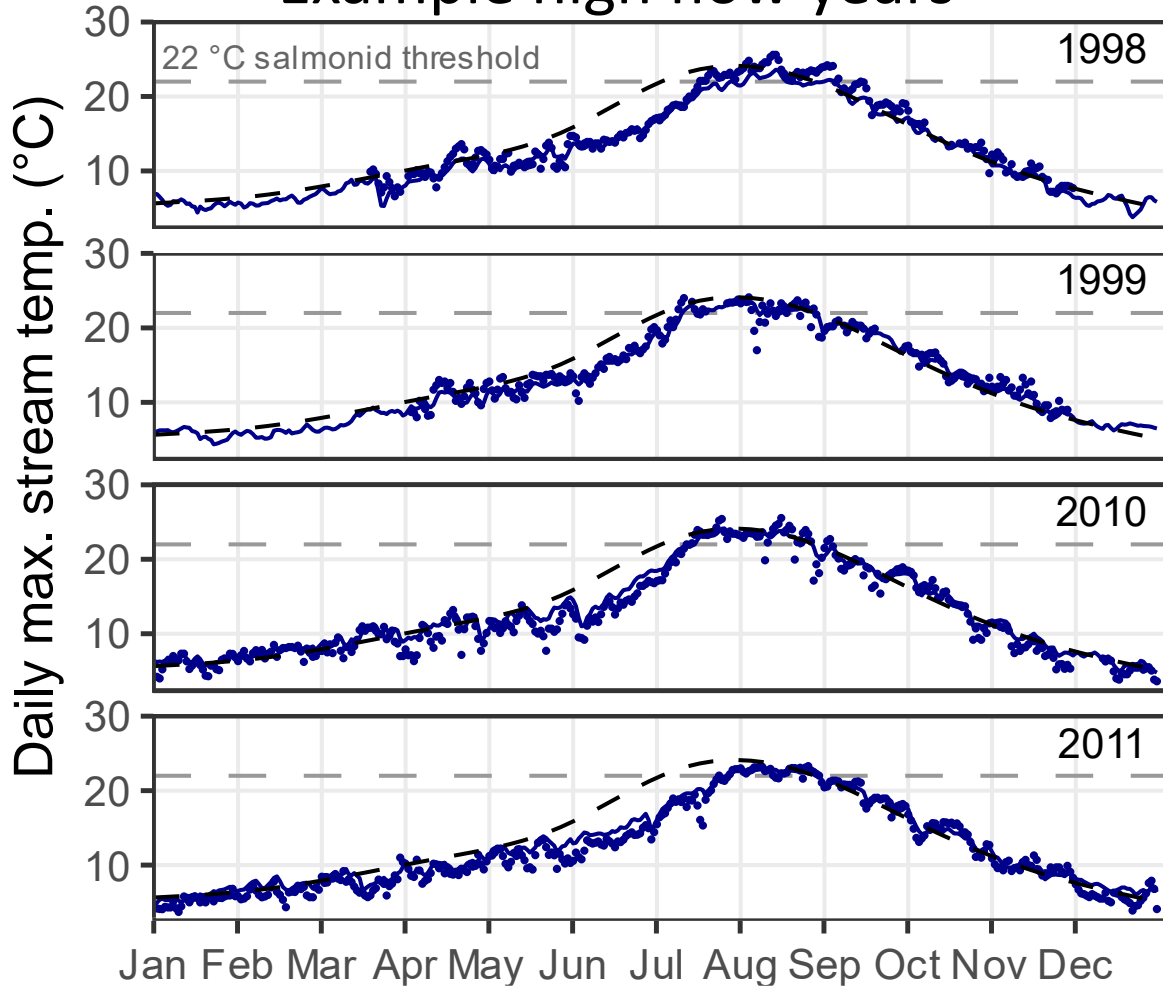
Example low flow years



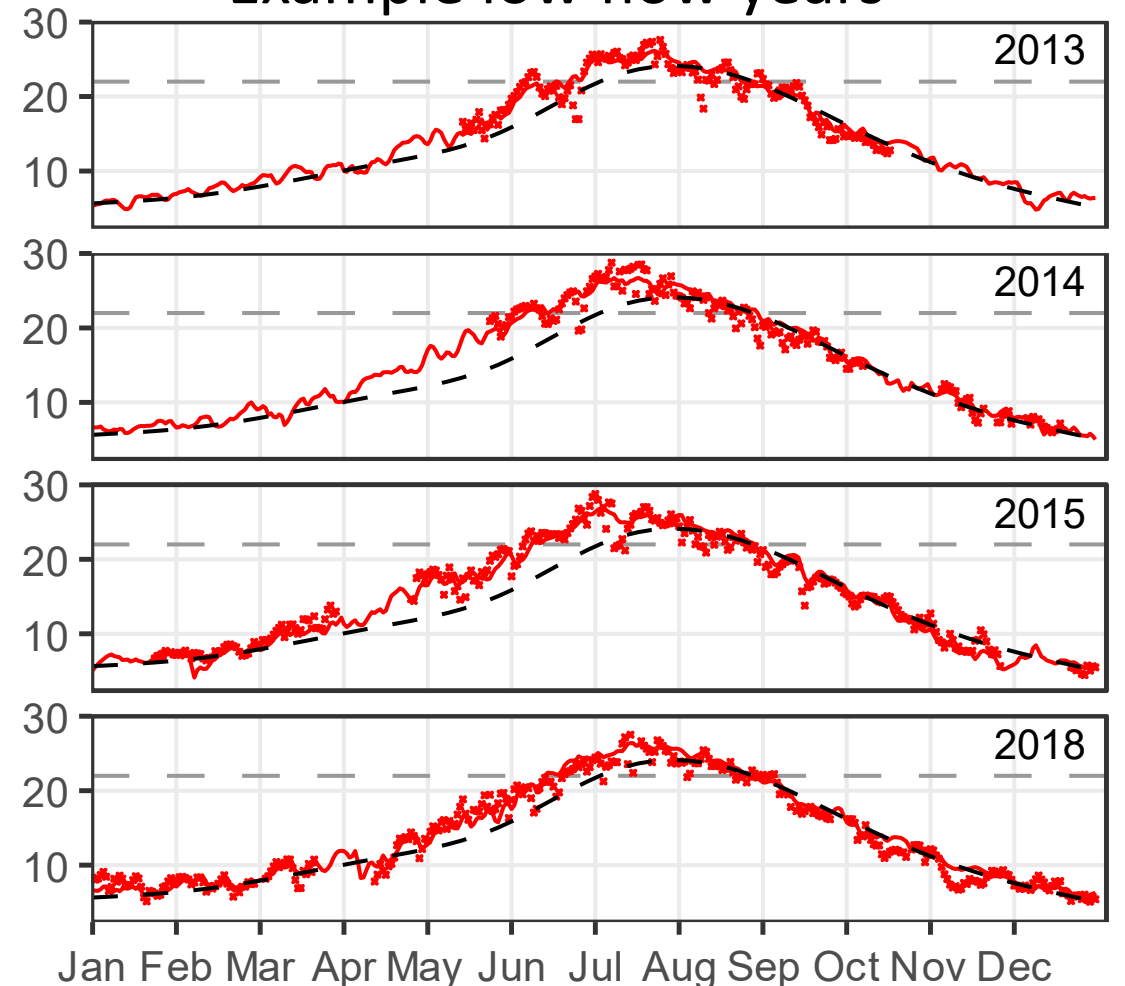
- Modeled
- Measured
- Smoother of all years

Validation

Example high flow years



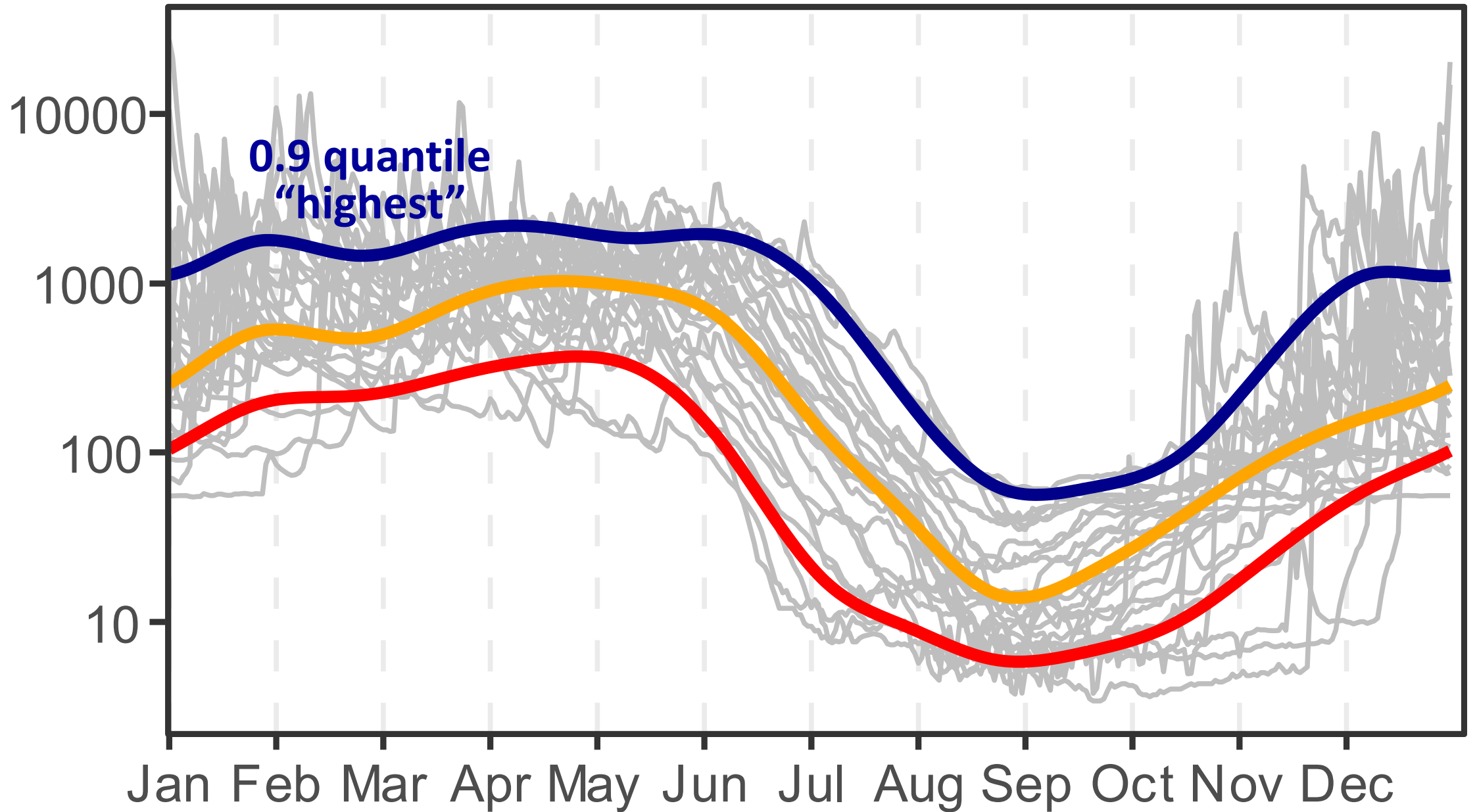
Example low flow years



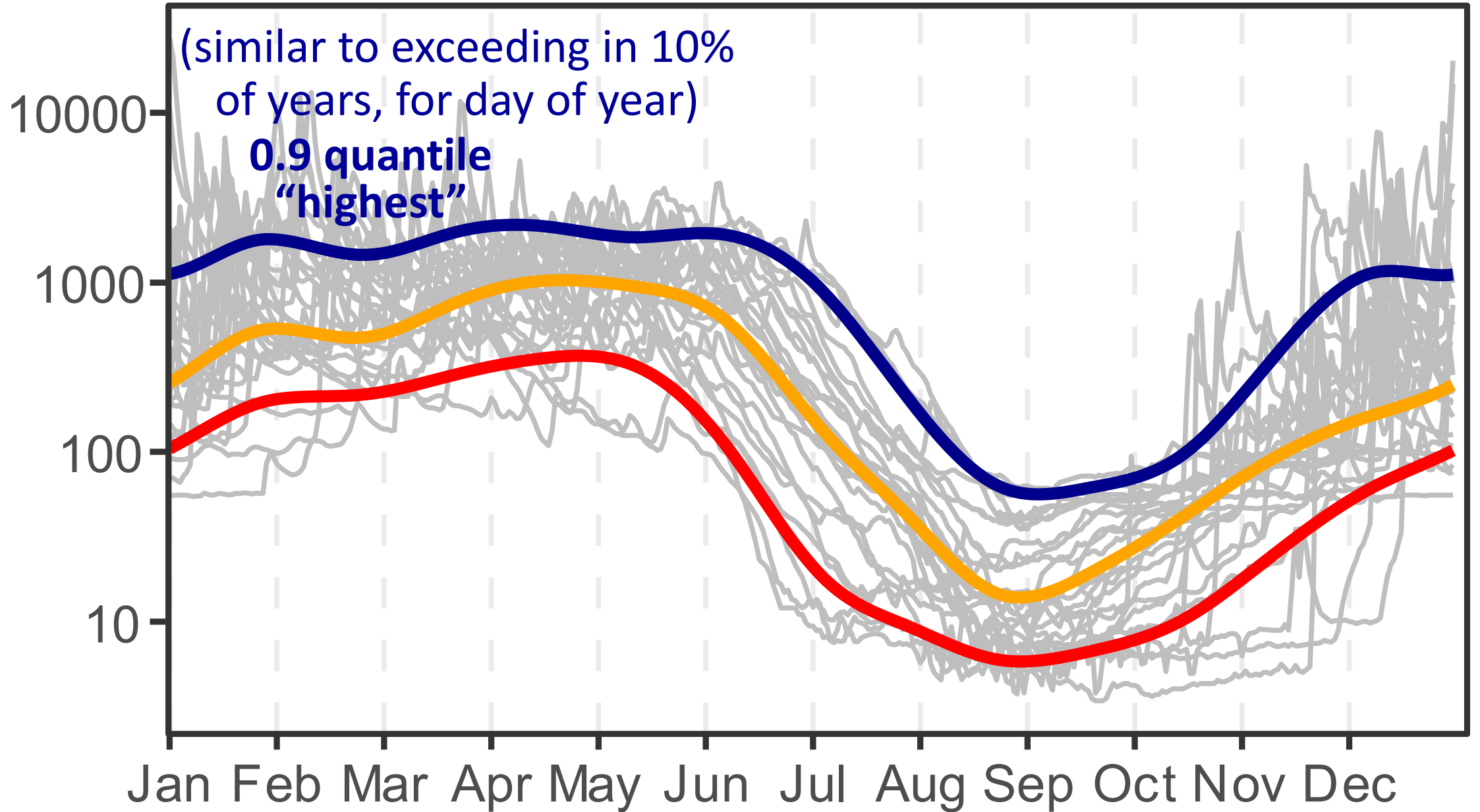
Leave one year out (LOYO) cross-validation all years:

- Root mean squared error (RMSE) = 1.18 °C
- $R^2 = 0.97$

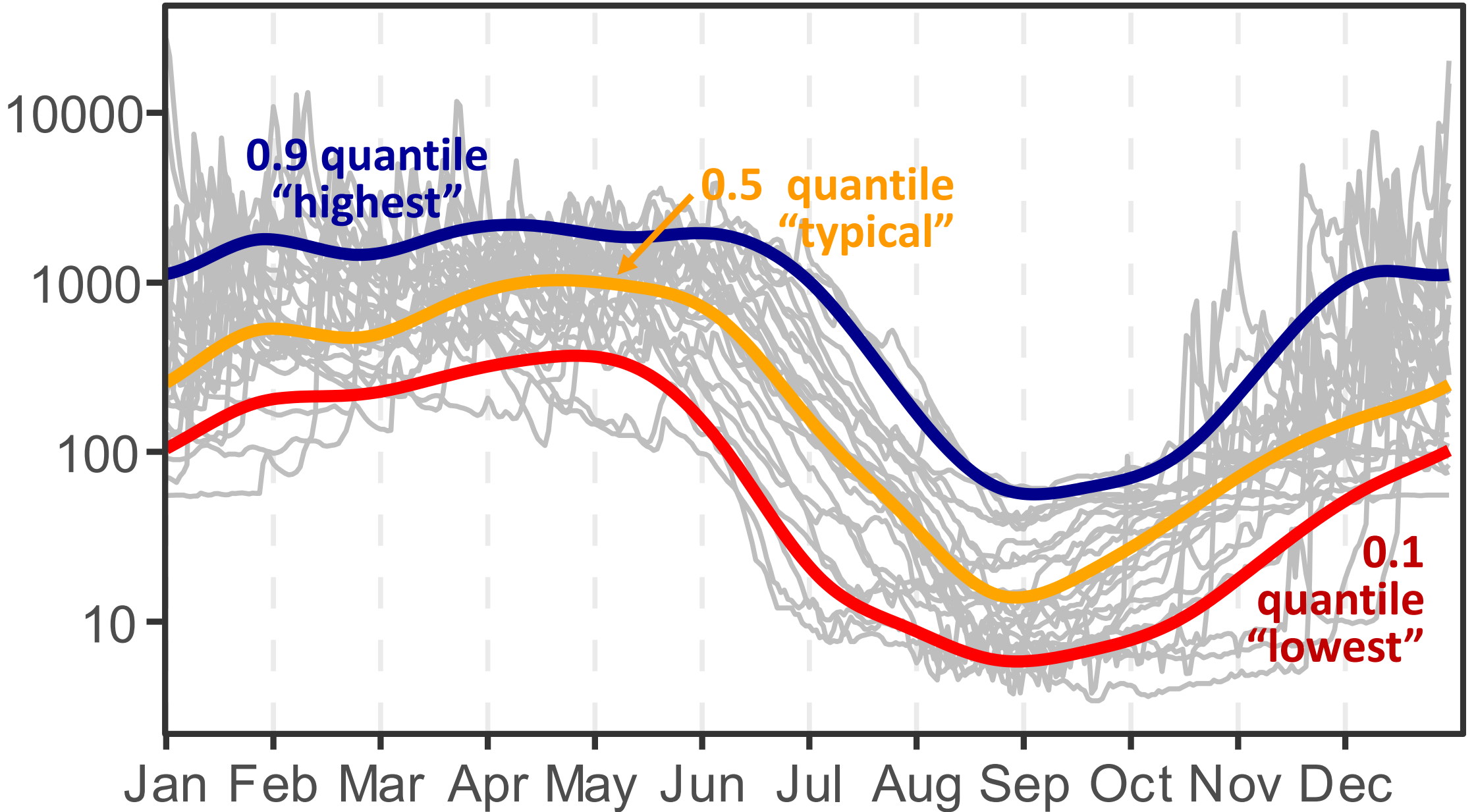
 Flow (cfs)



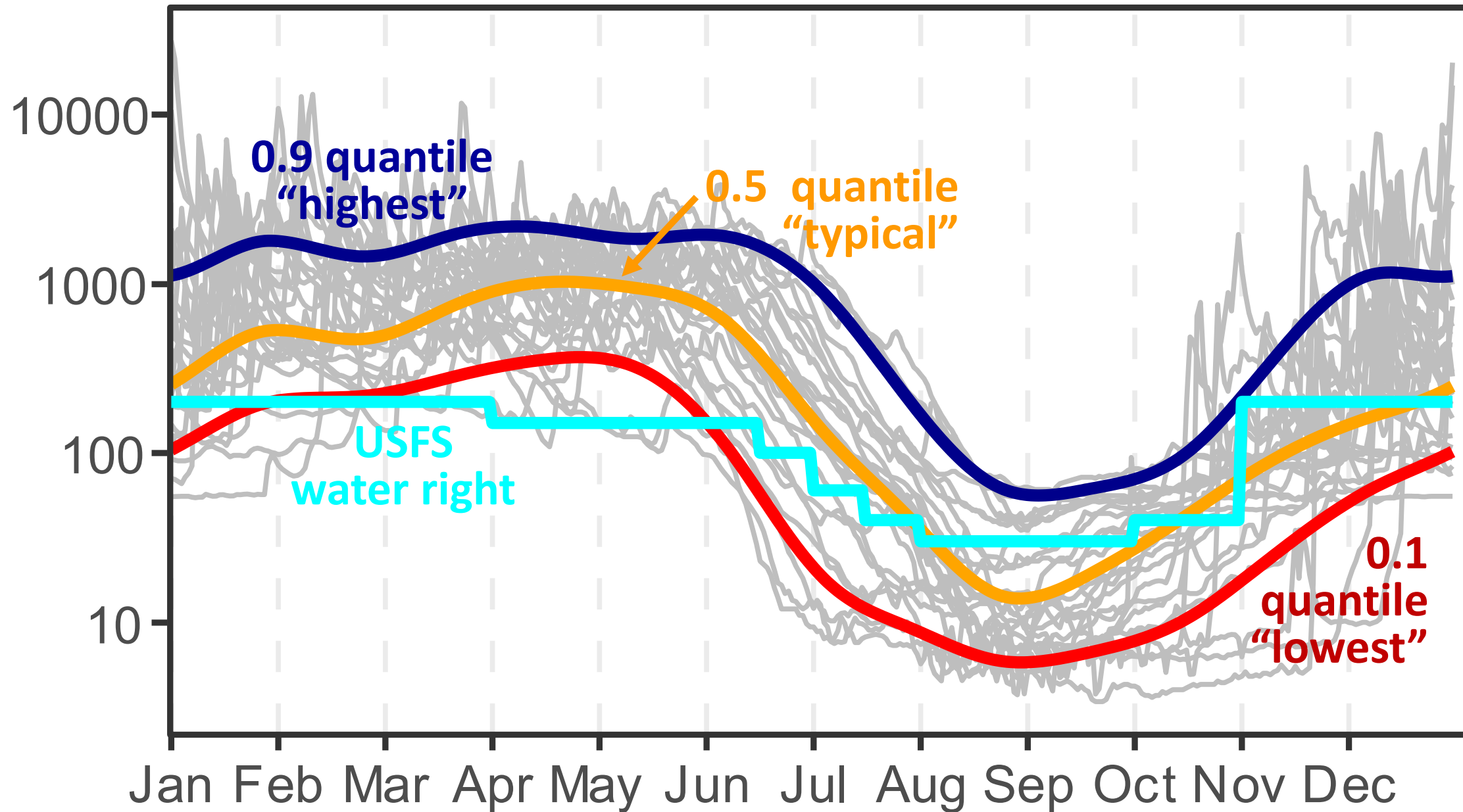
 Flow (cfs)



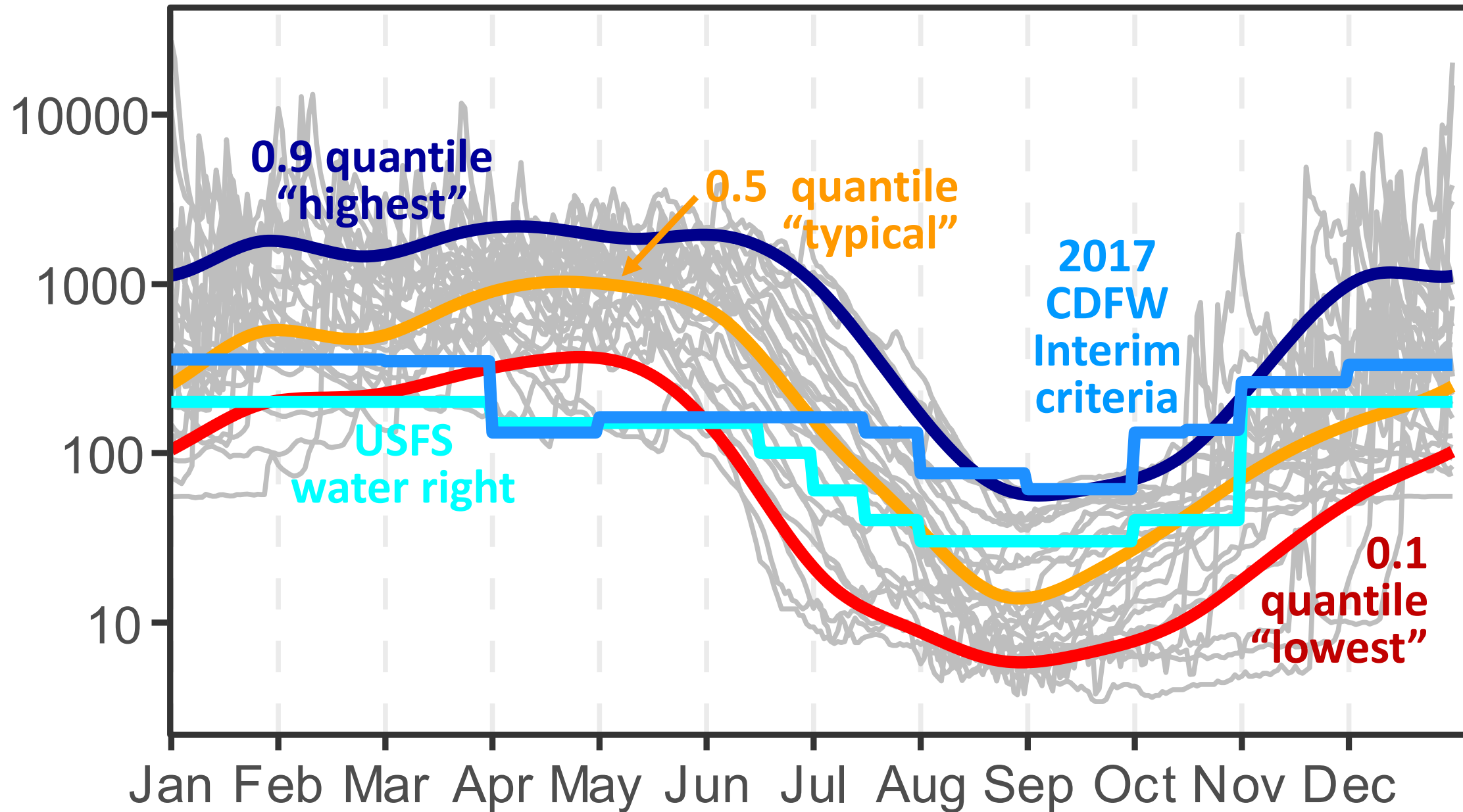
 Flow (cfs)



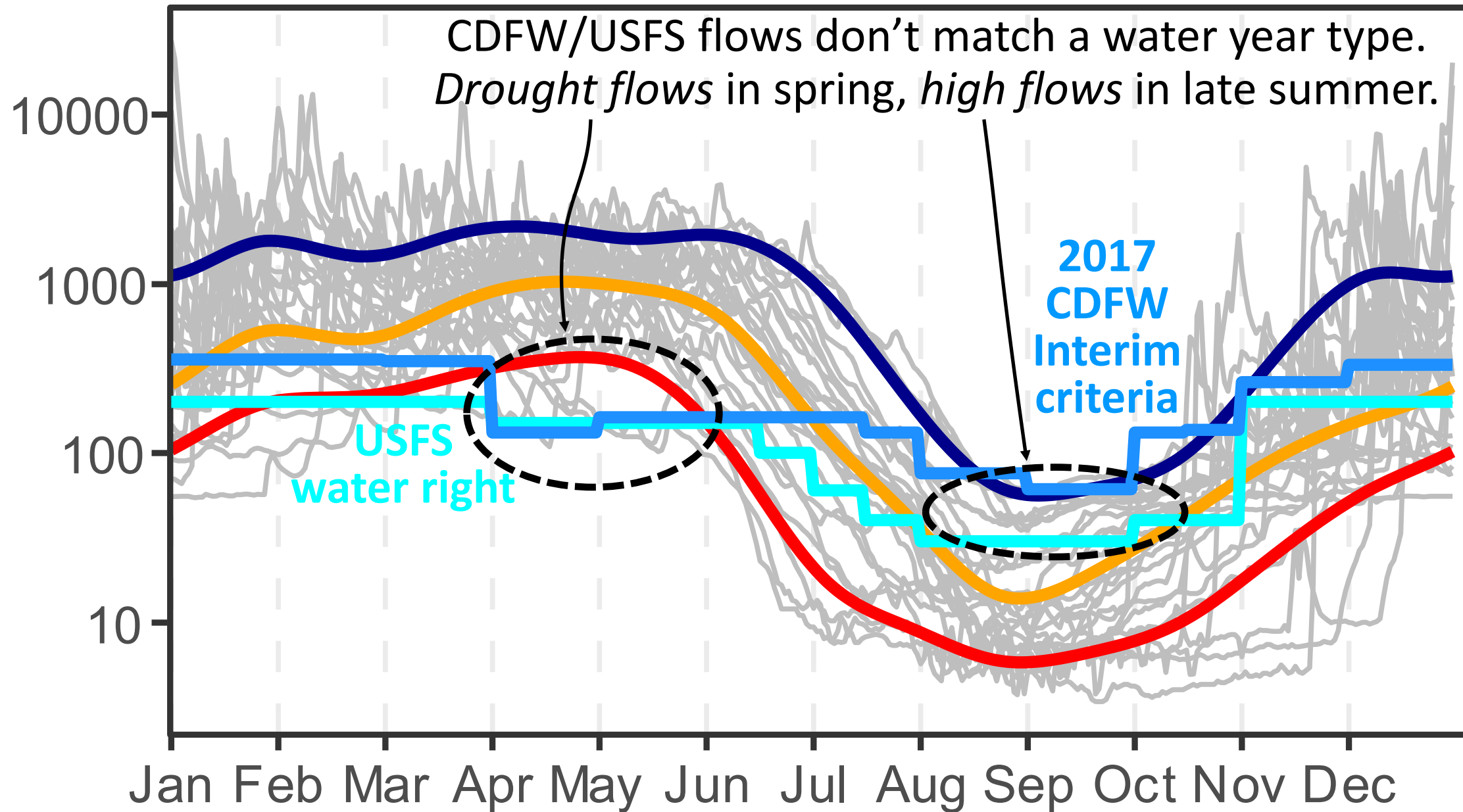
 Flow (cfs)



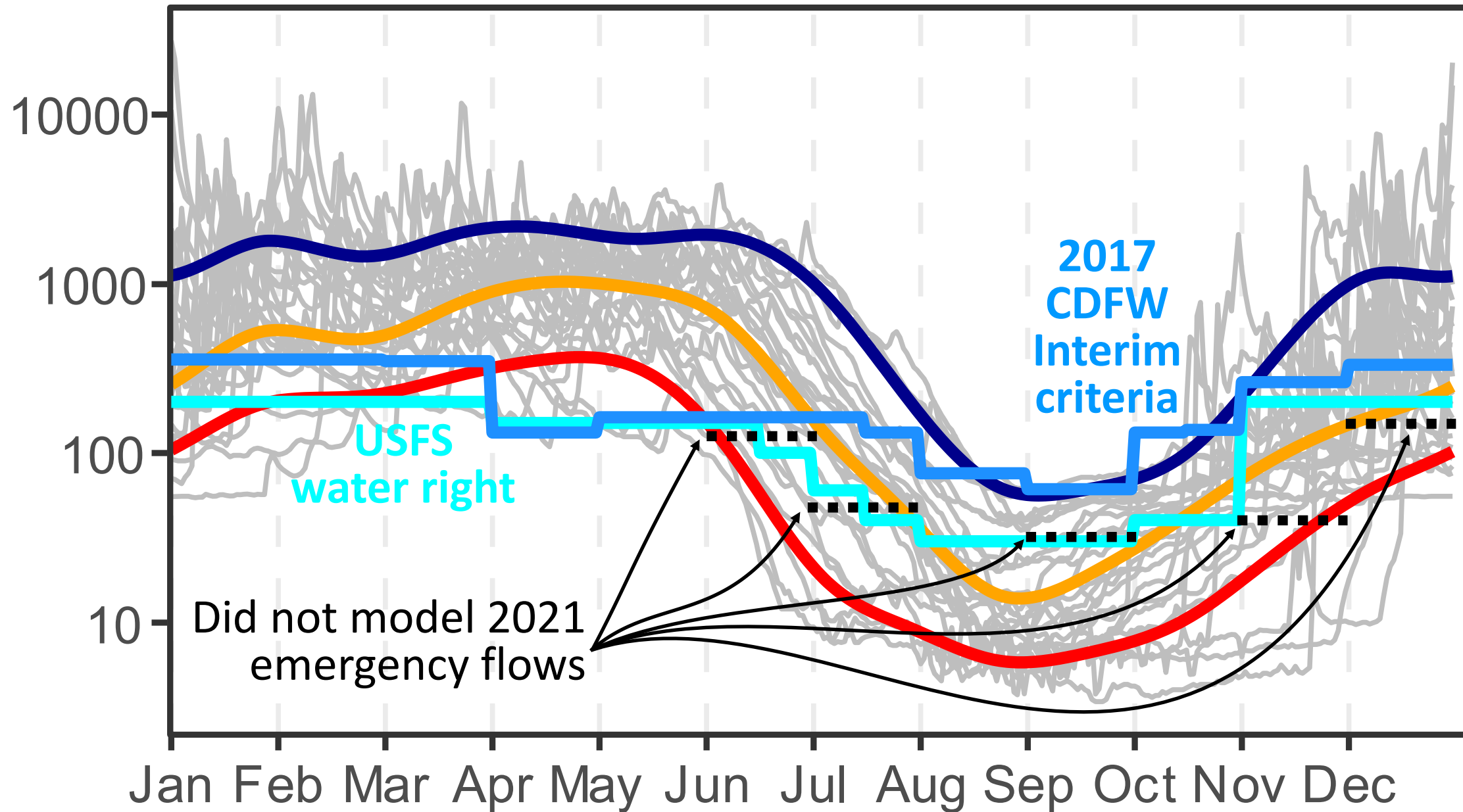
 Flow (cfs)



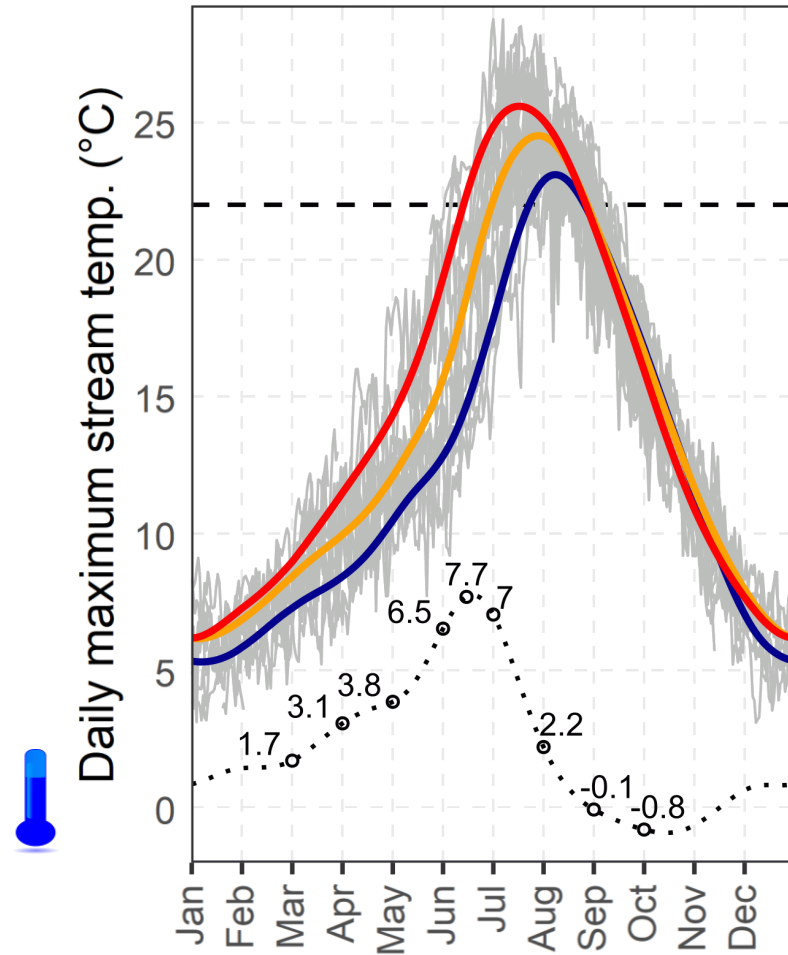
 Flow (cfs)



 Flow (cfs)

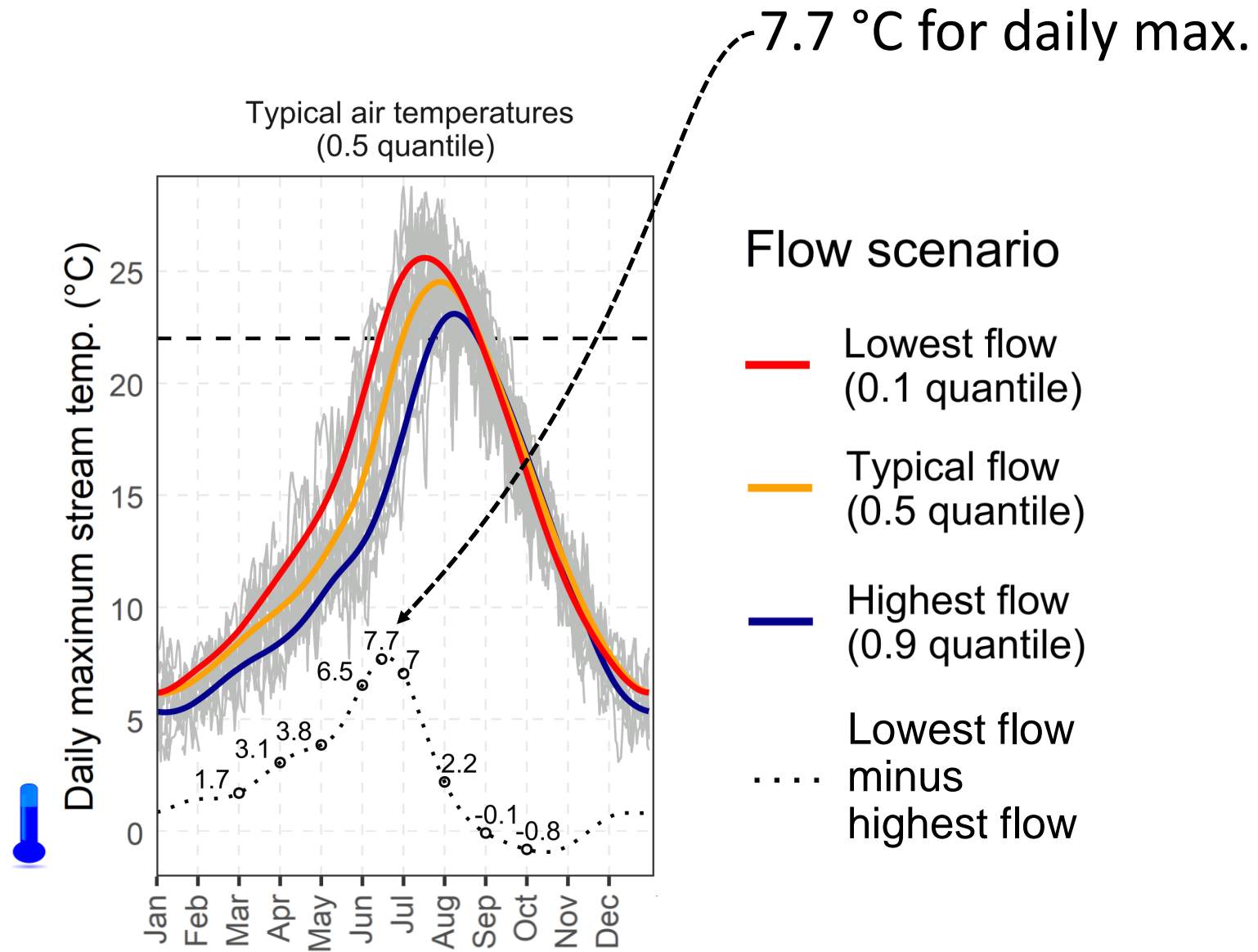


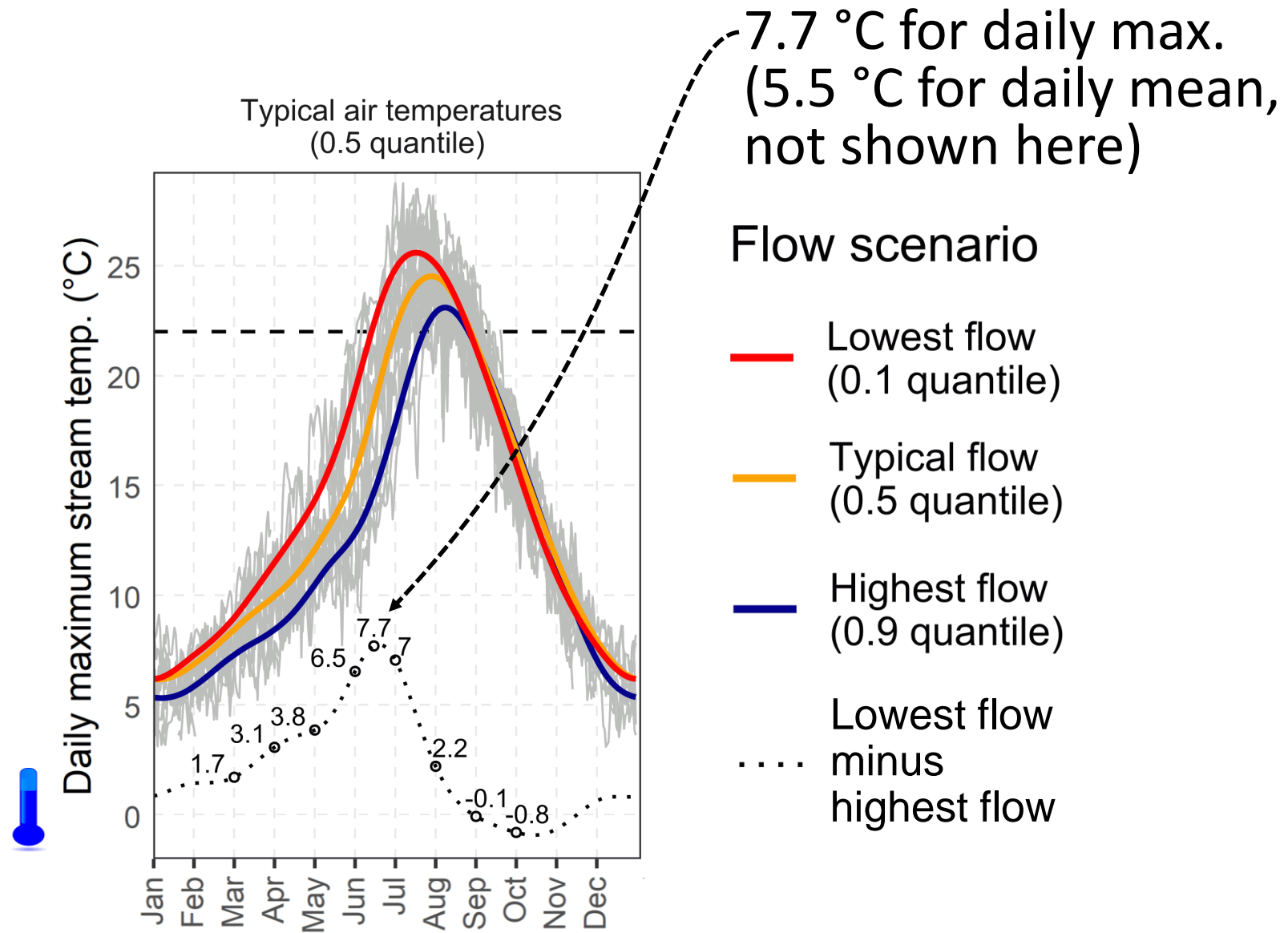
Typical air temperatures
(0.5 quantile)



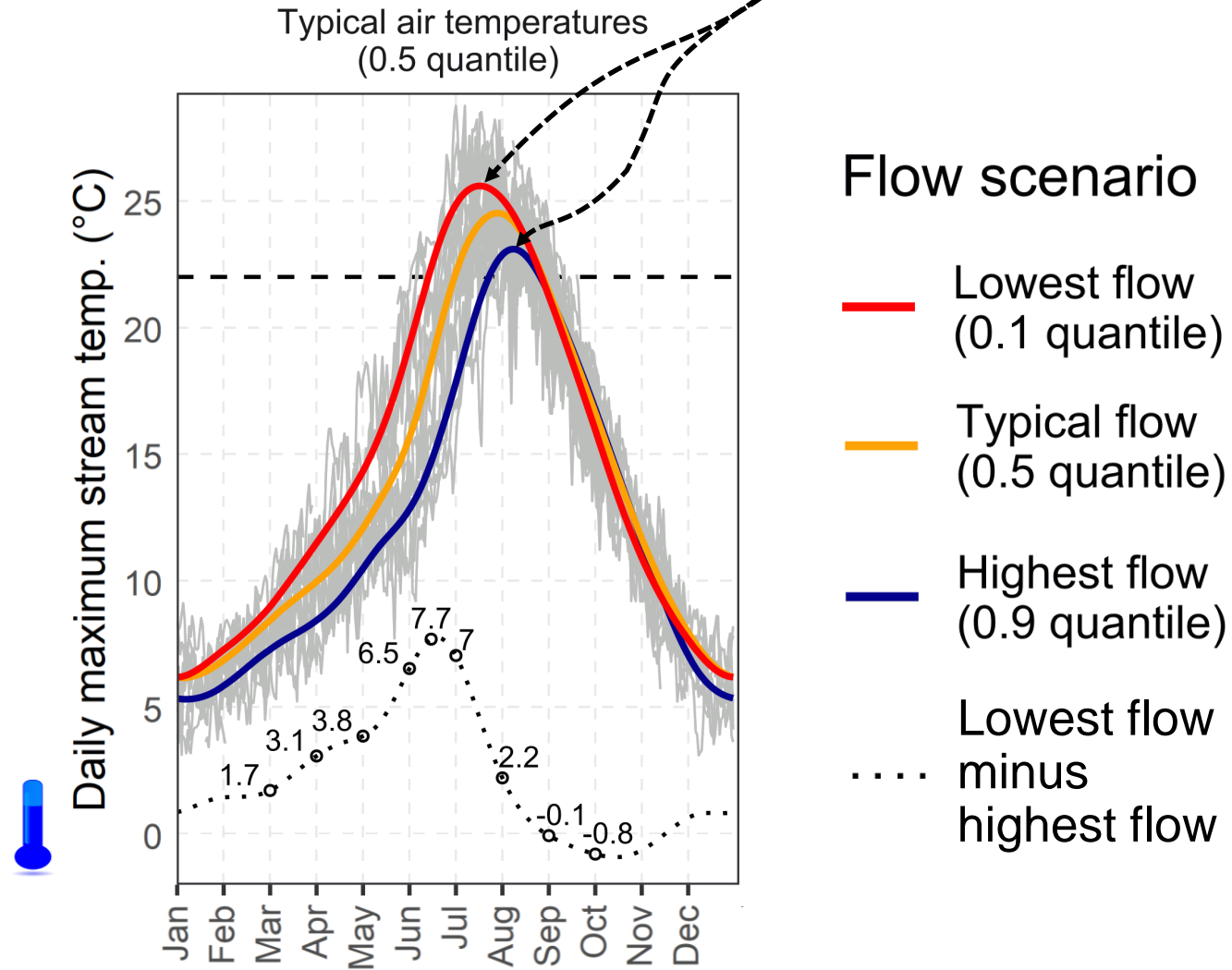
Flow scenario

- Lowest flow (0.1 quantile)
- Typical flow (0.5 quantile)
- Highest flow (0.9 quantile)
- Lowest flow minus highest flow

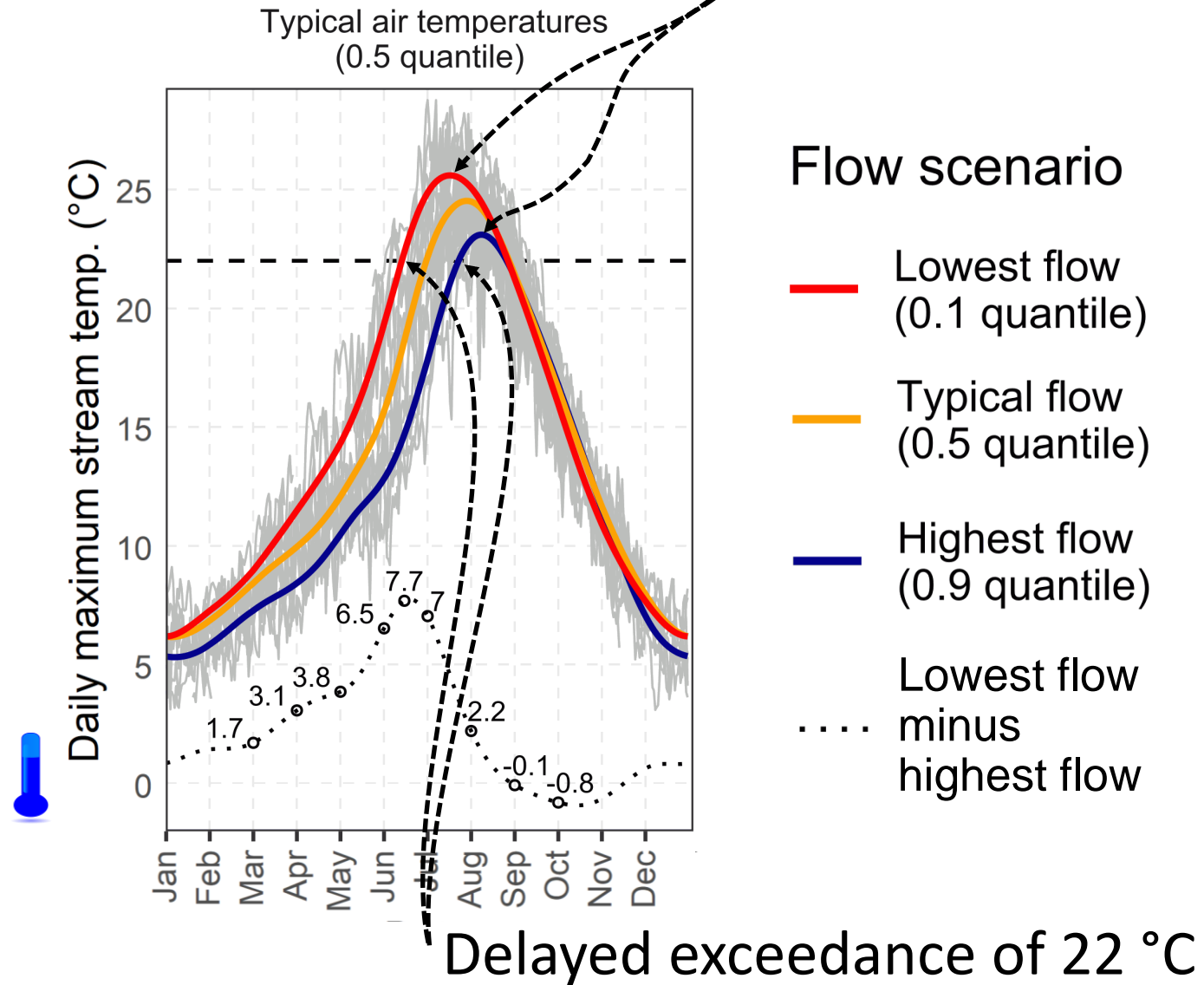




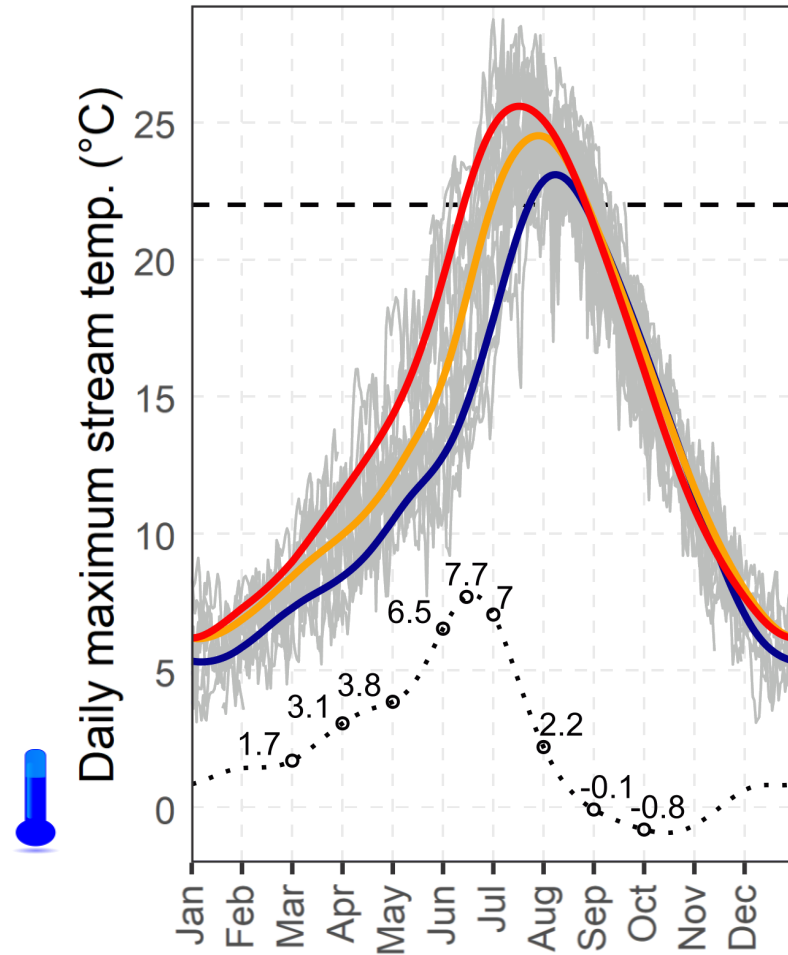
Annual maximum temperature: delayed and reduced



Annual maximum temperature: delayed and reduced



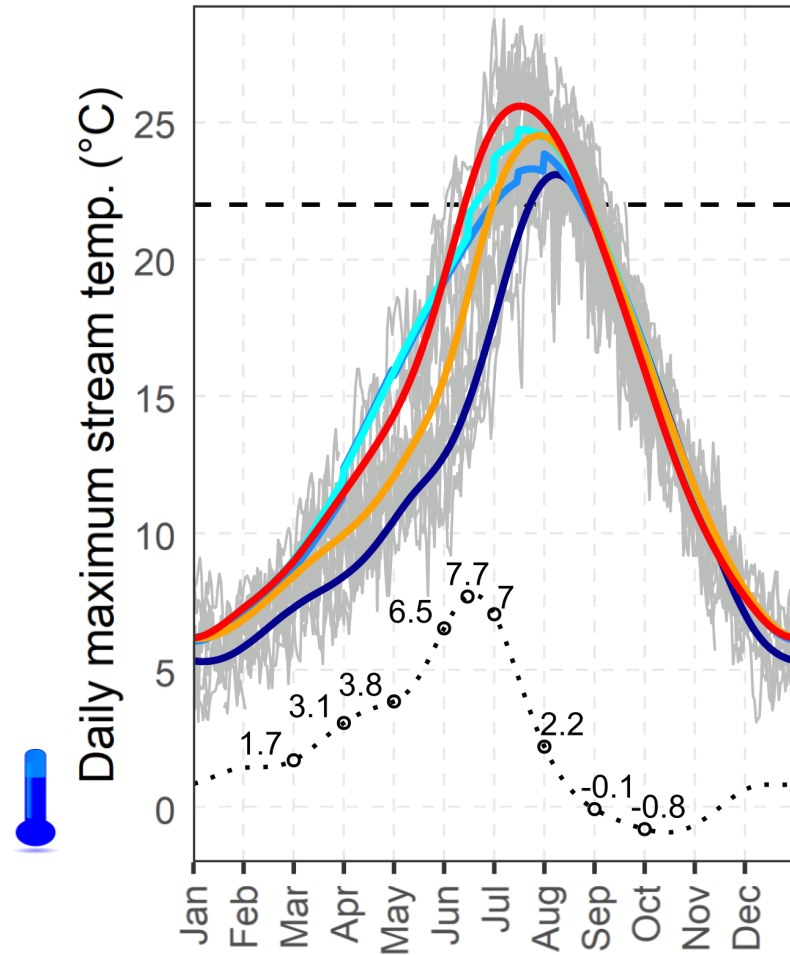
Typical air temperatures
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Flow scenario

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- Typical flow (0.5 quantile)
- Highest flow (0.9 quantile)
- ... Lowest flow minus highest flow

Typical air temperatures
(0.5 quantile)



Flow scenario

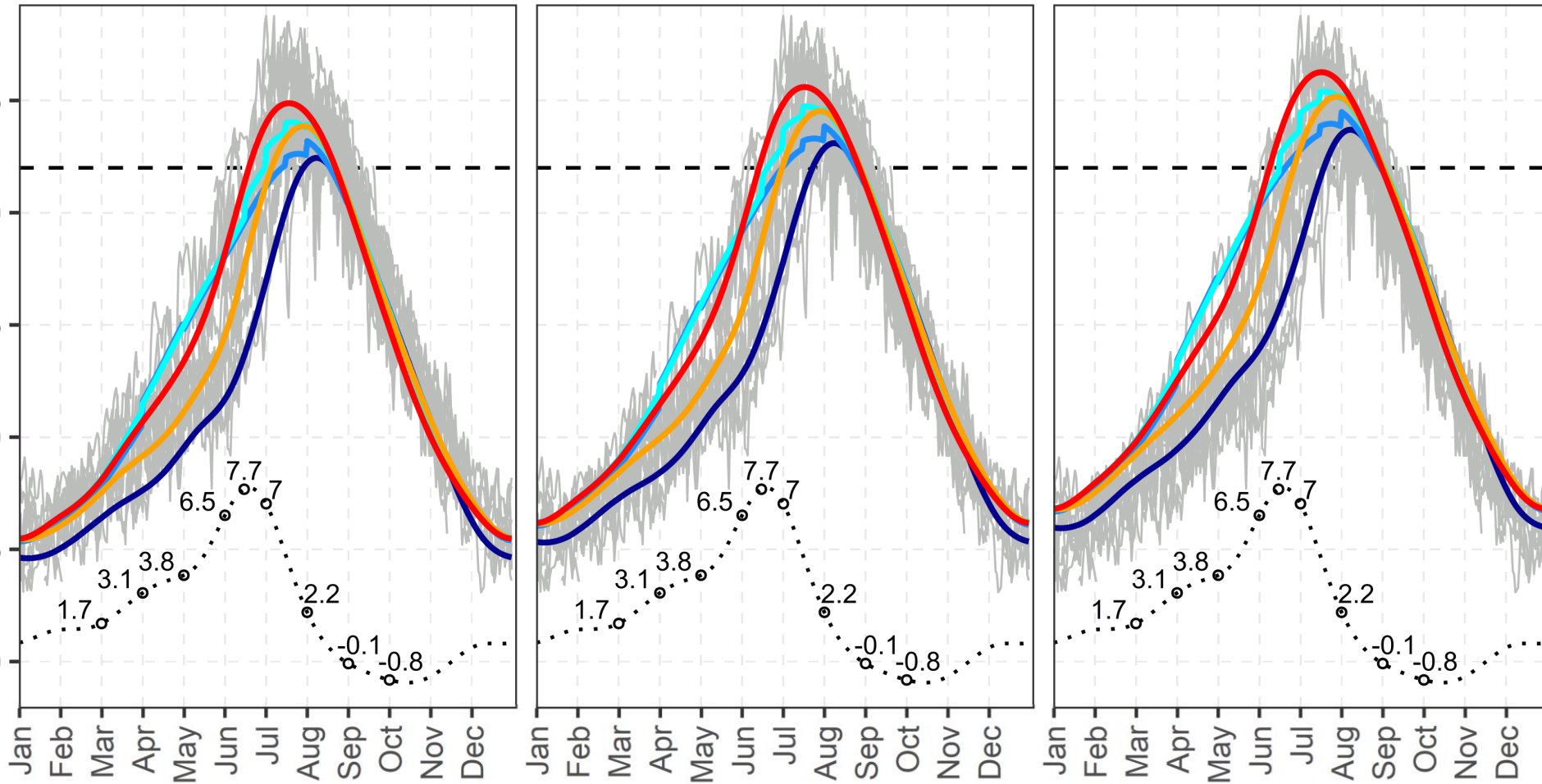
- Lowest flow (0.1 quantile)
- 2017 CDFW interim flow criteria
- USFS water right
- Typical flow (0.5 quantile)
- Highest flow (0.9 quantile)
- Lowest flow minus highest flow

Coolest air temperatures
(0.1 quantile)

Typical air temperatures
(0.5 quantile)

Hottest air temperatures
(0.9 quantile)

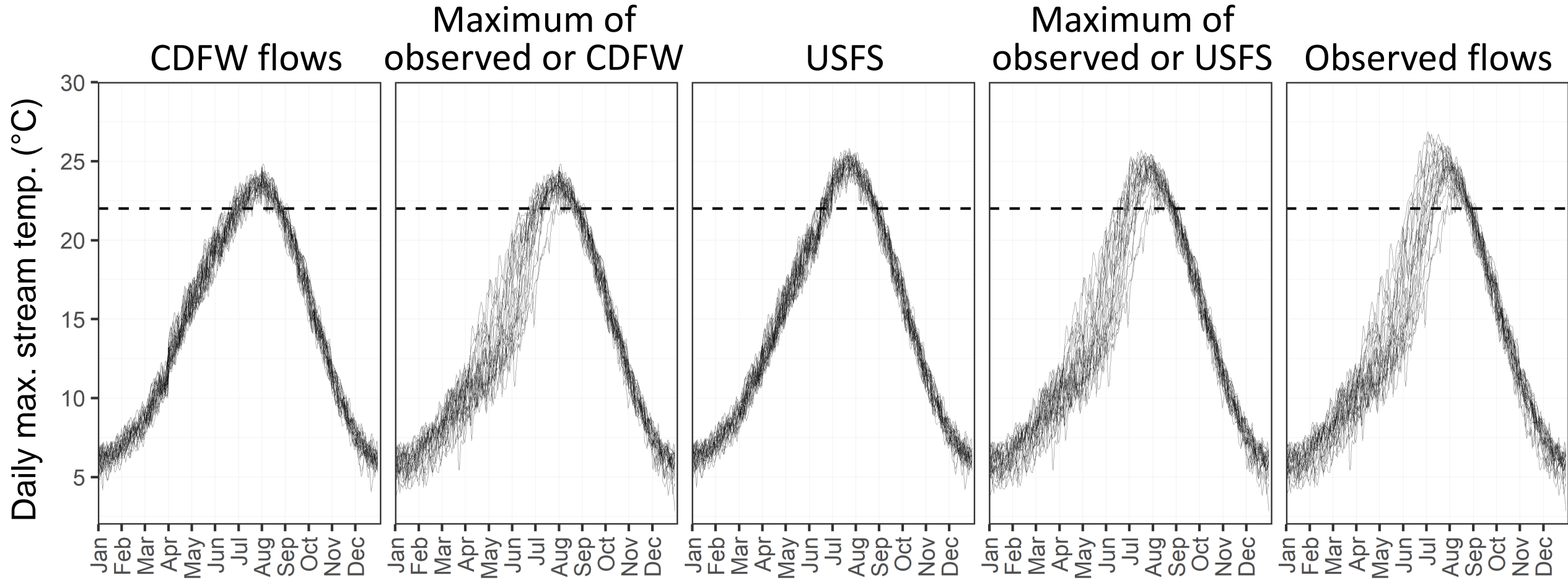
Daily maximum stream temp. (°C)



Flow scenario

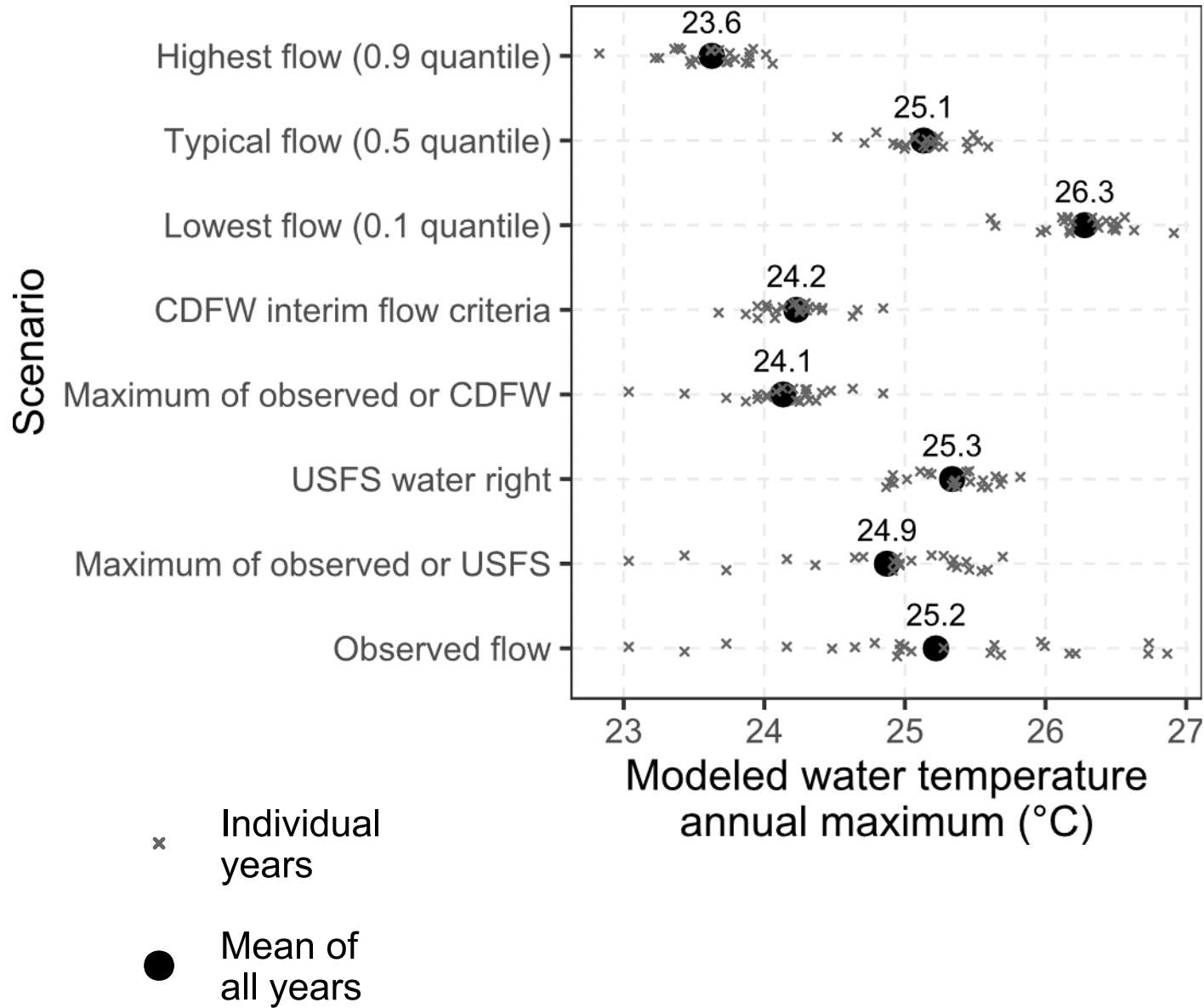
- Lowest flow (0.1 quantile)
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- Highest flow (0.9 quantile)
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Modeled water temps with historical air temps 1998–2020

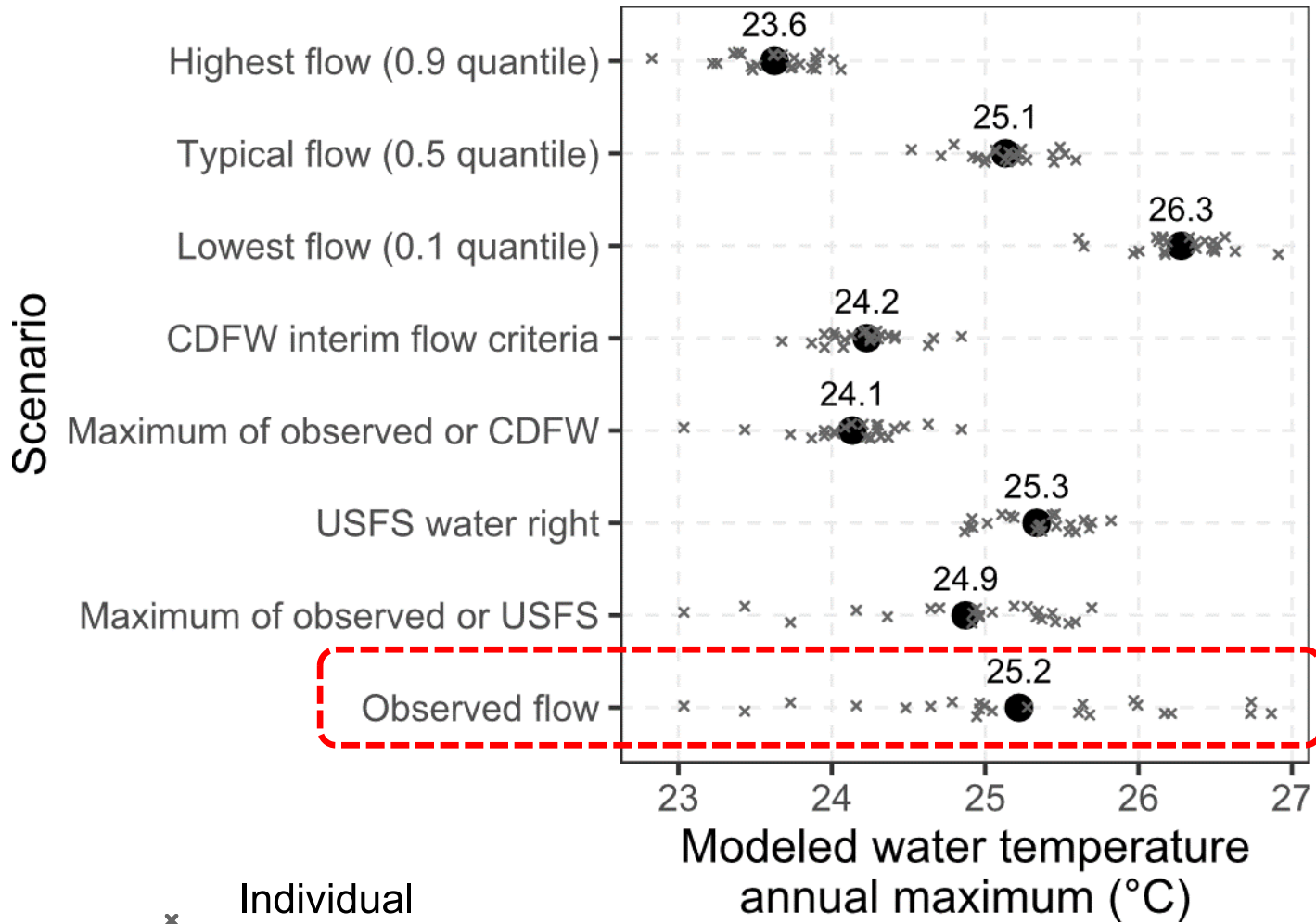


Meeting USFS water right or 2017 CDFW instream flow criteria would reduce water temps in June–August

Modeled water temps with historical air temps 1998–2020



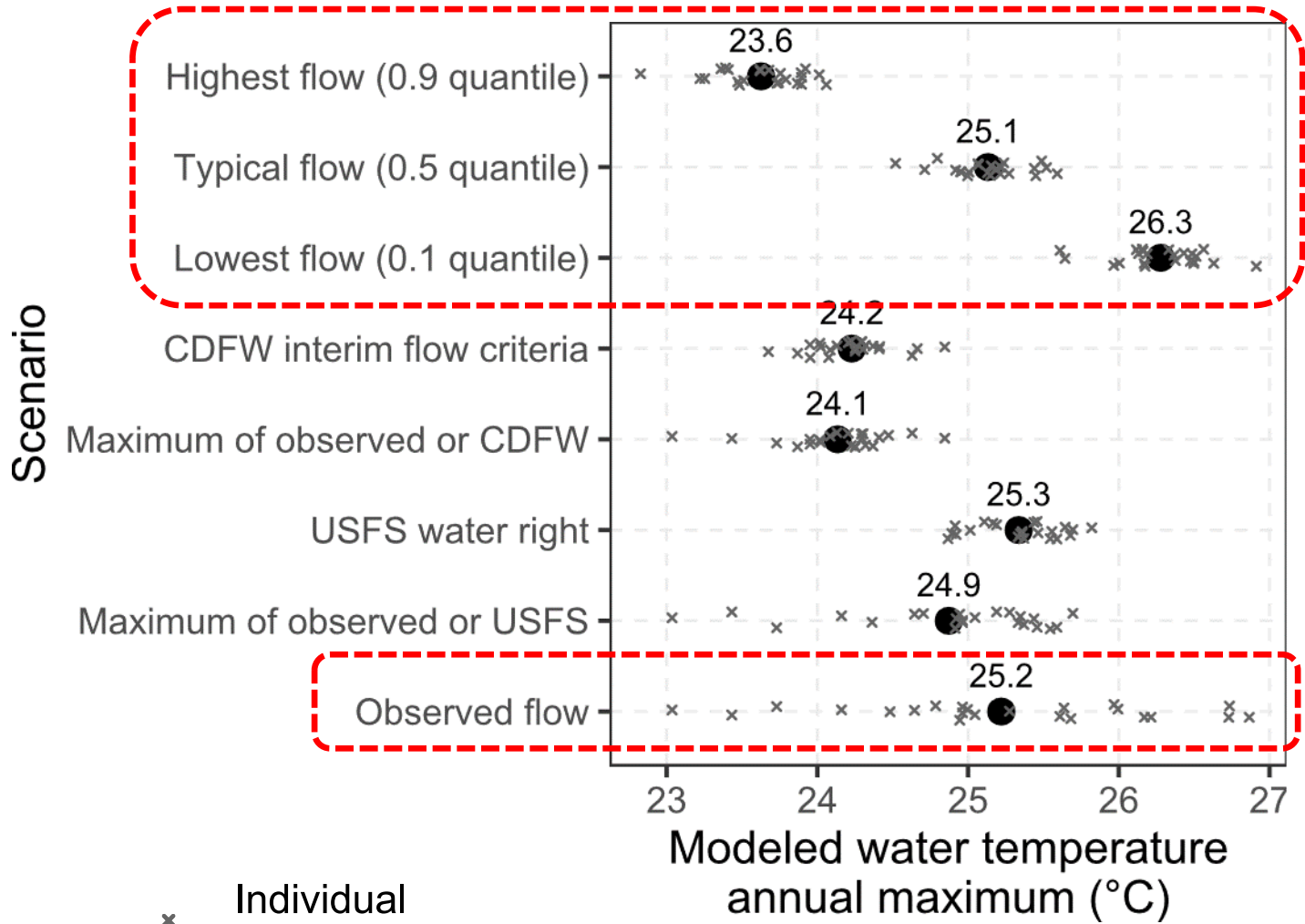
Modeled water temps with historical air temps 1998–2020



x Individual years

● Mean of all years

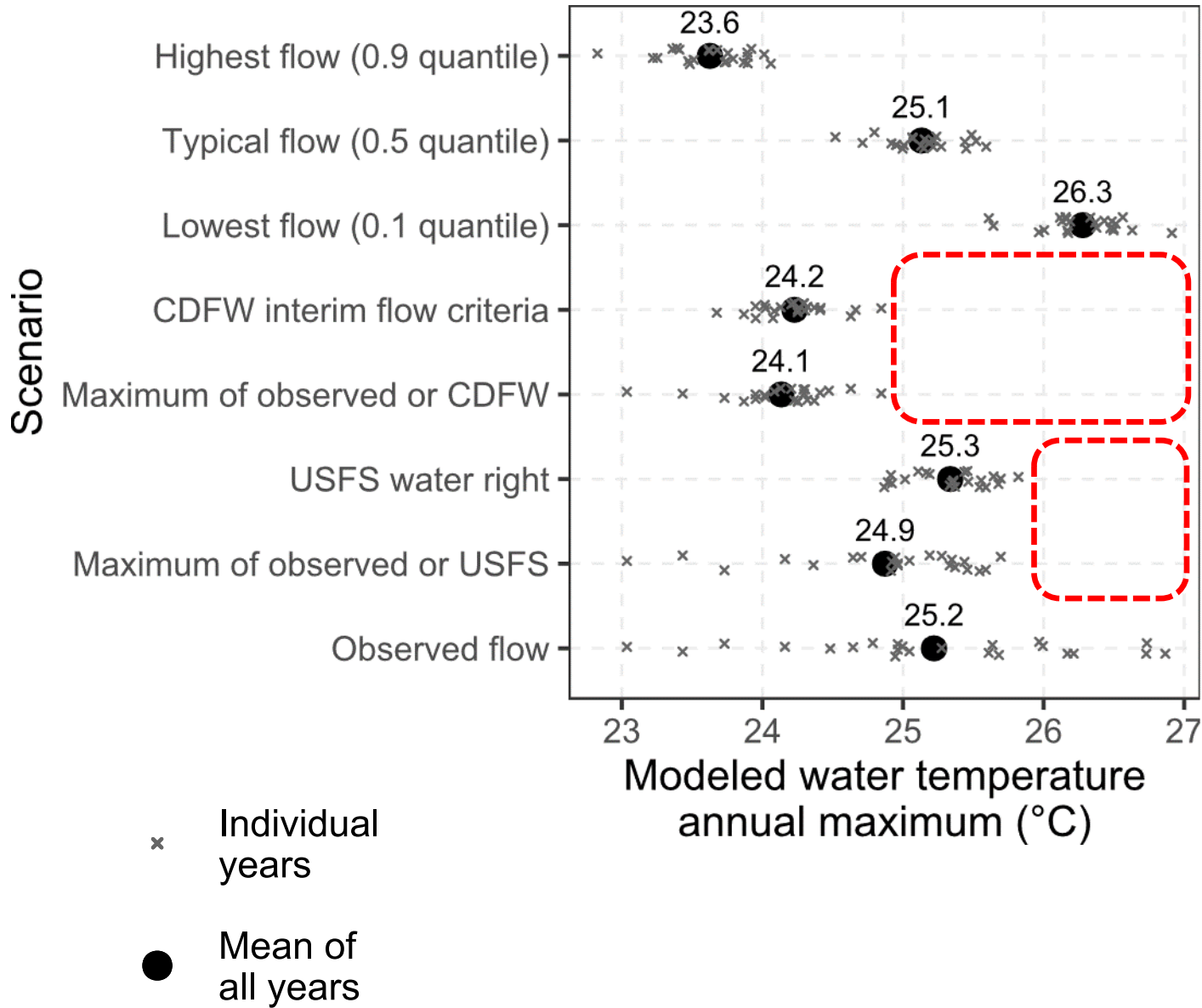
Modeled water temps with historical air temps 1998–2020



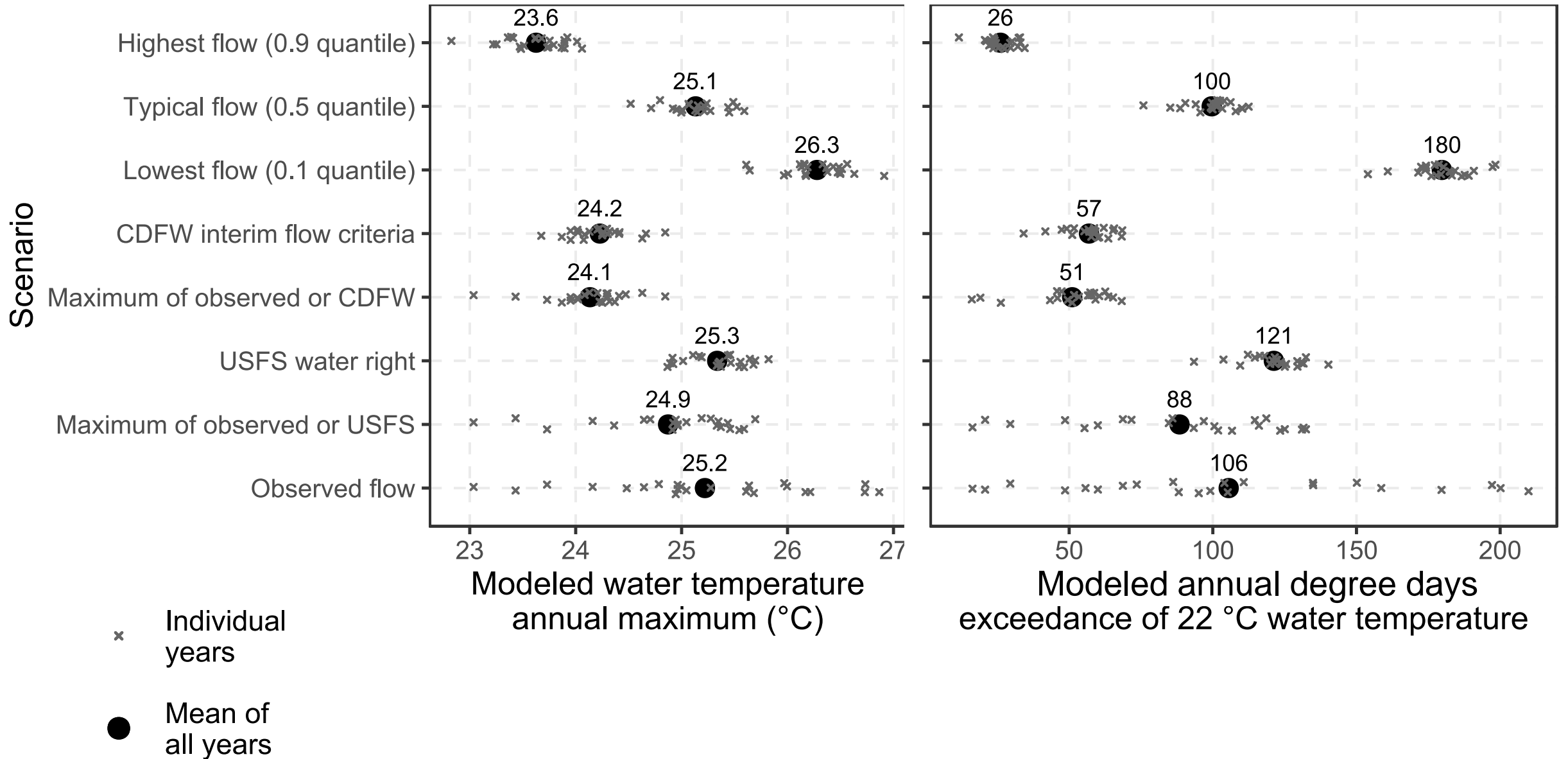
x Individual years

● Mean of all years

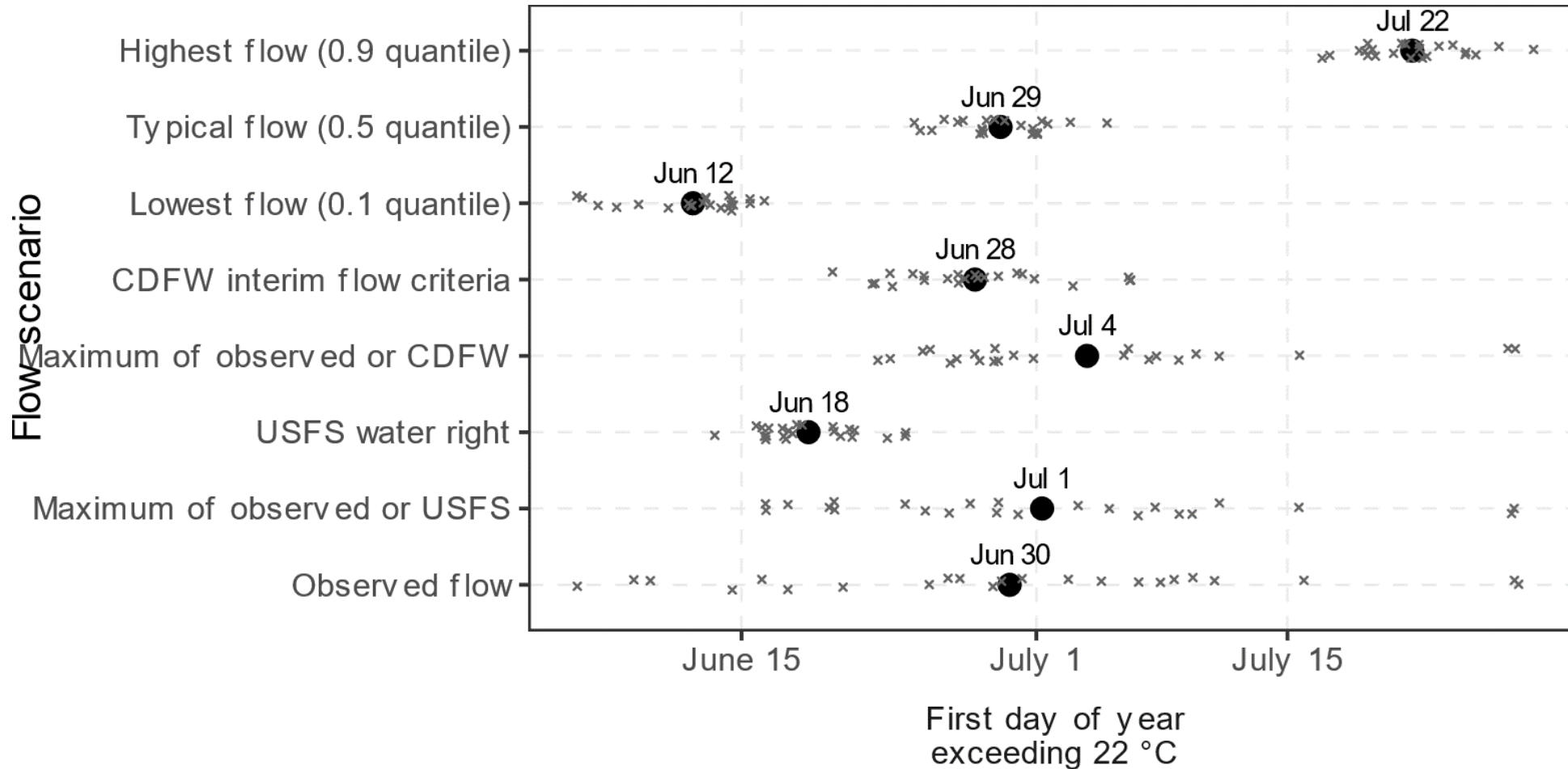
Modeled water temps with historical air temps 1998–2020



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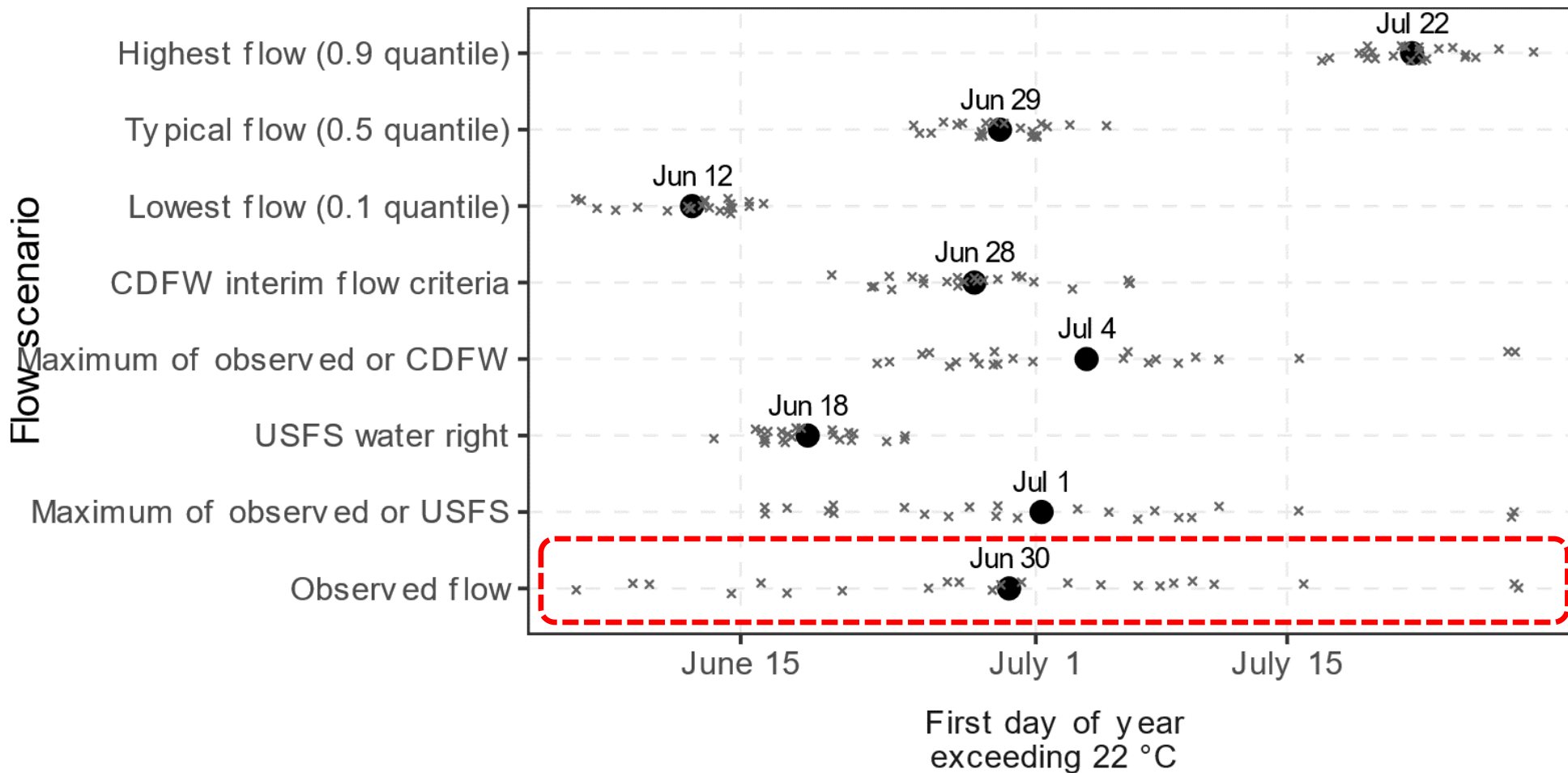
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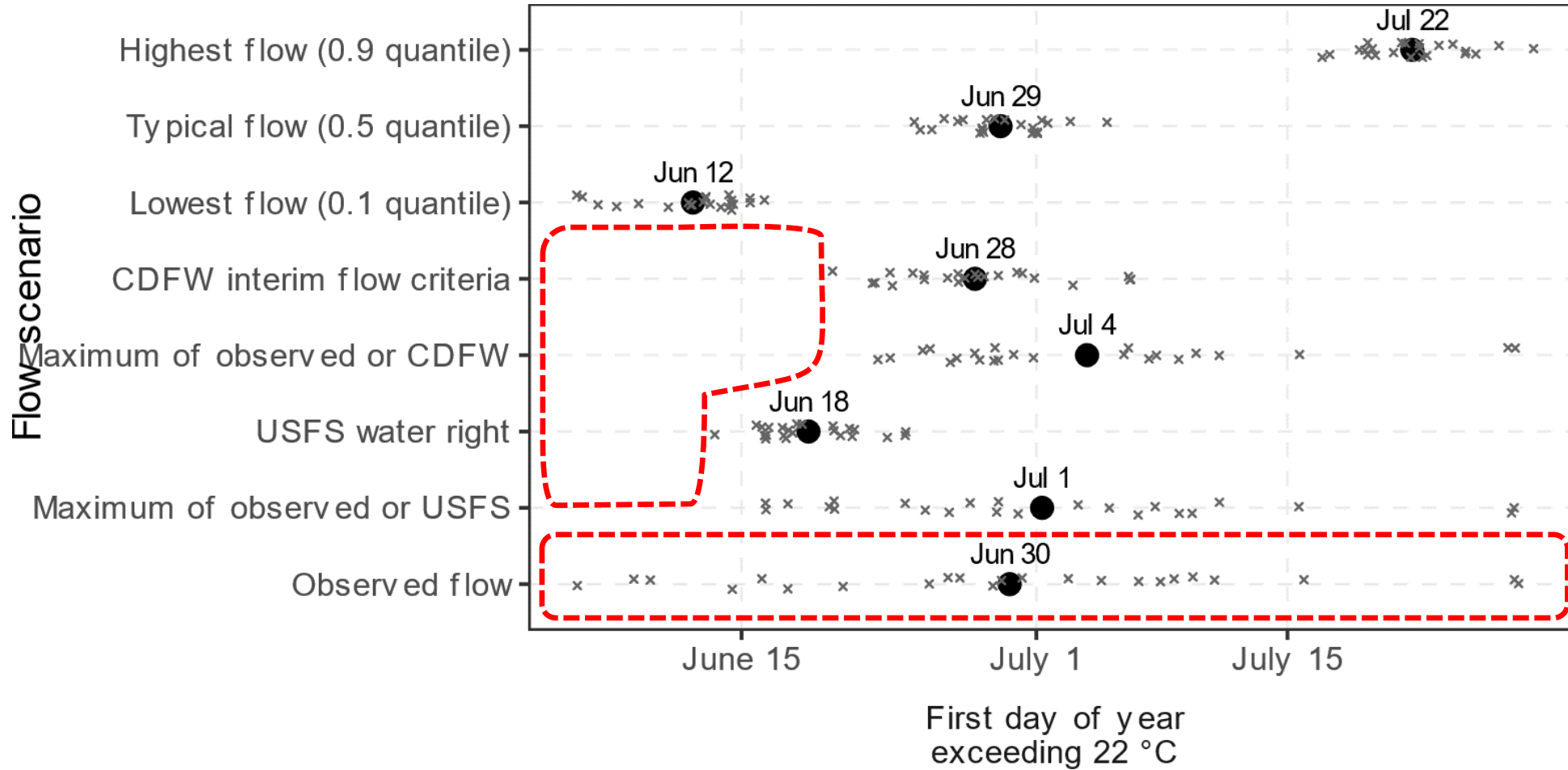
Modeled water temps with historical air temps 1998–2020



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● Mean of all years

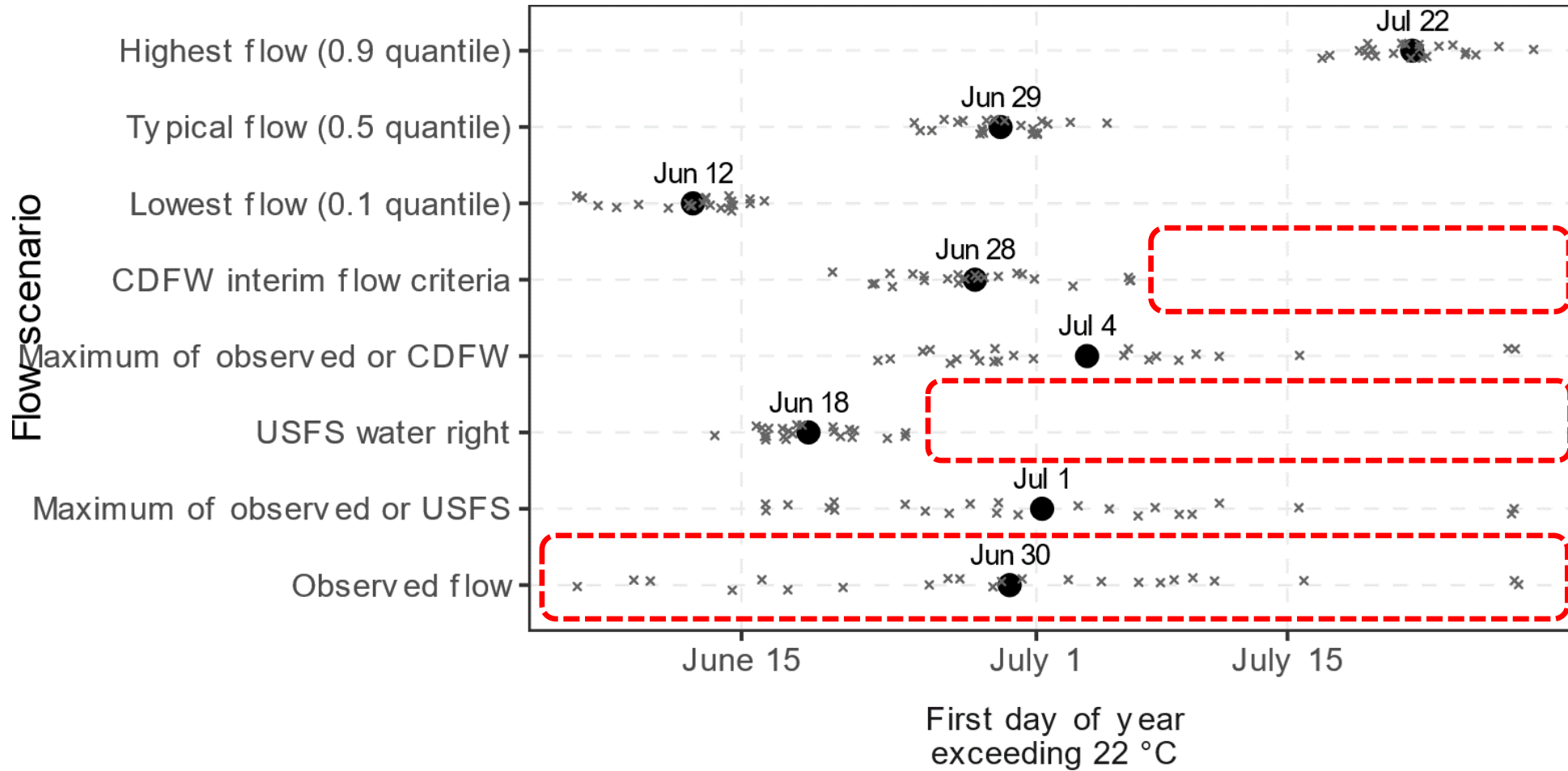
Modeled water temps with historical air temps 1998–2020



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● Mean of all years

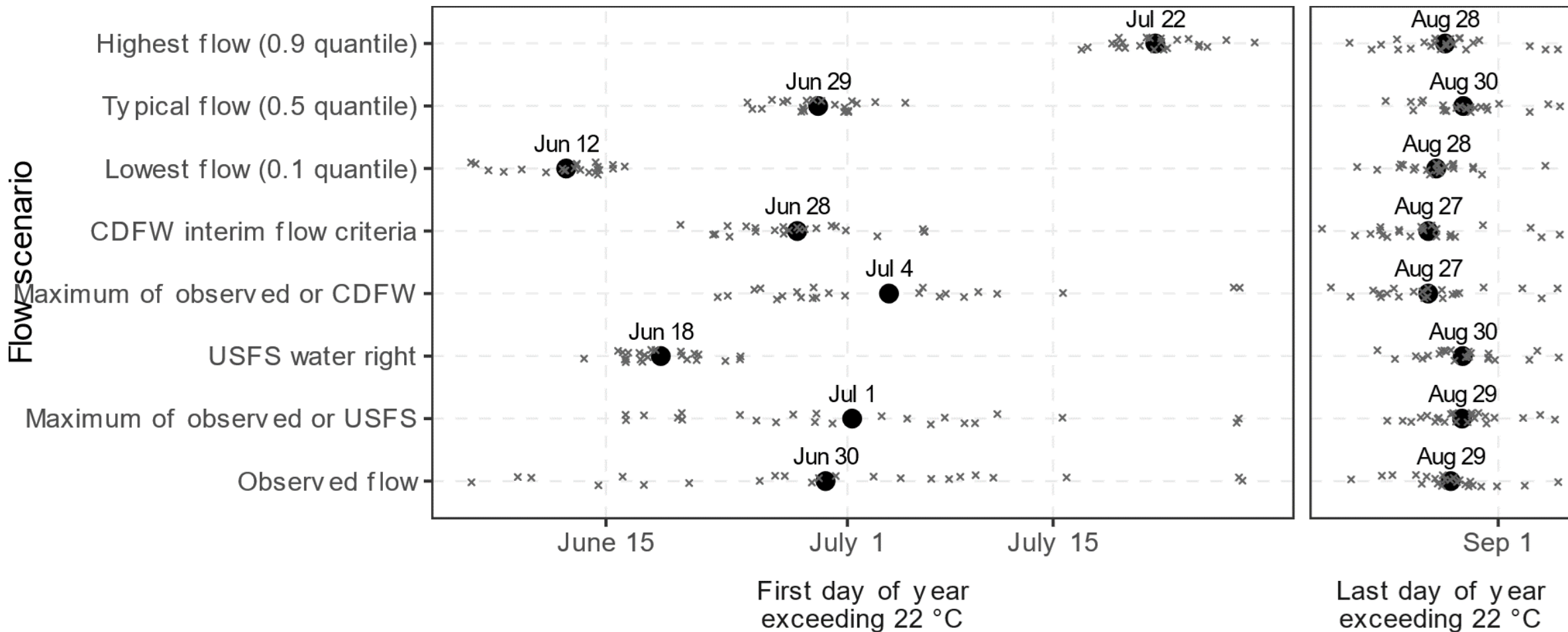
Modeled water temps with historical air temps 1998–2020



x Individual years

● Mean of all years

Modeled water temps with historical air temps 1998–2020



x Individual years

● Mean of all years

Status

Report with preliminary analysis: 2020

Publication in peer review

Code/data (draft): <https://www.hydroshare.org>

Pre-print version 1 (resubmitting soon!):

Asarian, J.E., C. Robinson. 2021. Modeling Seasonal Effects of River Flow on Water Temperatures in an Agriculturally Dominated California River [Preprint]. Earth and Space Science Open Archive. <https://doi.org/10.1002/essoar.10506606.1>

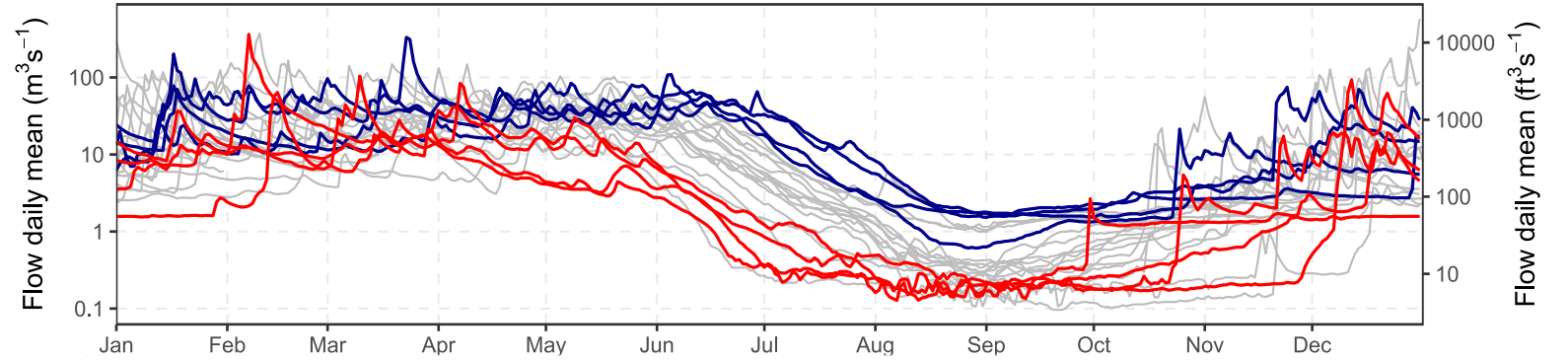
Potential applications

Caveats

Potential applications

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Extrapolation



Potential applications

Caveats

Extrapolation

Groundwater vs surface water

Potential applications

Caveats

Extrapolation

Groundwater vs surface water

New flow scenarios

Adapt to other sites with long-term data

Quartz Valley

Conclusions

- Flow effects vary seasonally
 - Greatest cooling in Apr-July
 - Very little effect in Sept-Oct
 - Water temps cool from air temps and short days

High flows

- Delay seasonal onset of high temps
 - extends period for juvenile salmon rearing/outmigration
- Reduce annual max water temps
 - Still exceeds 22 °C when air temps high

Meeting USFS water right or CDFW instream flow criteria would reduce water temps in June–August

Extra slides

