# Revisiting bias correction of earth system models for climate-informed ecosystem based management

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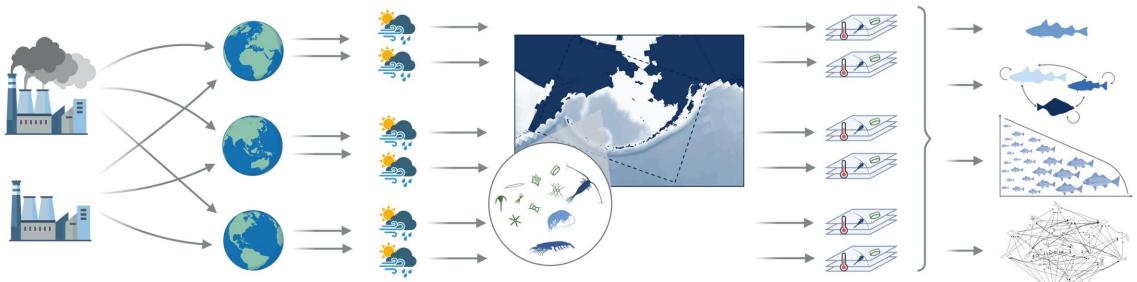


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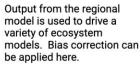
# Bias correction in regional modeling: why, when, and how?



Alaska Climate Integrated Modeling Project Hollowed et al., 2020



Scenario uncertainty: The ensemble of shared socioeconomic pathways (SSPs) encompasses uncertainty across low and high emissions. Model uncertainty: Multiple parent ESMs represent our best understanding of the climate system. Output from these models may be biased. Bulk flux output variables (temperature, wind, heat fluxes, precipitation, etc.) from each ESM simulation are used as input to the regional model. Bias correction can be applied here (but is not in this study). The regional model downscales the ESM model simulations using its own ocean, ice, and biogeochemical models. This may correct for some biases but introduce others.



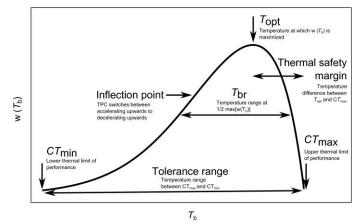
# Bias correction in regional modeling: why, when, and how?

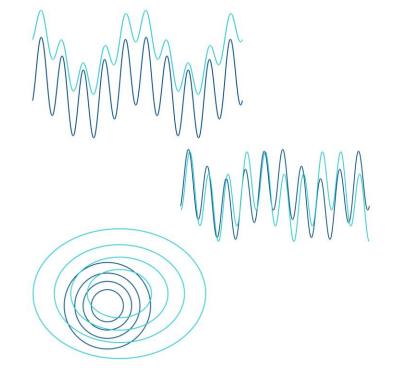
#### Small biases matter

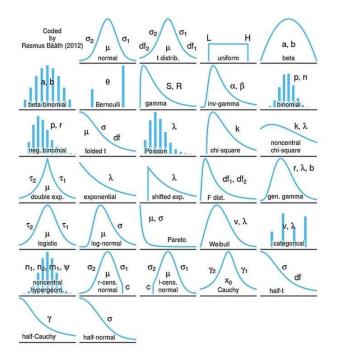
#### Value? Space? Time?

#### All the indices!

Sinclair et al., 2016



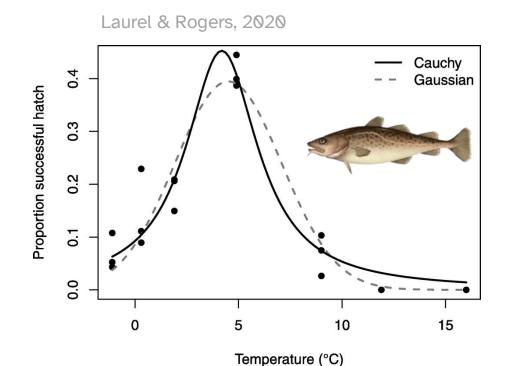


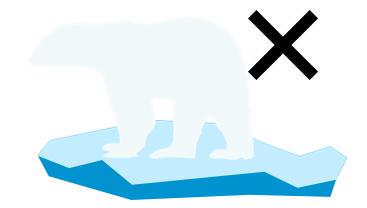


# **Bias in a tipping-point context**

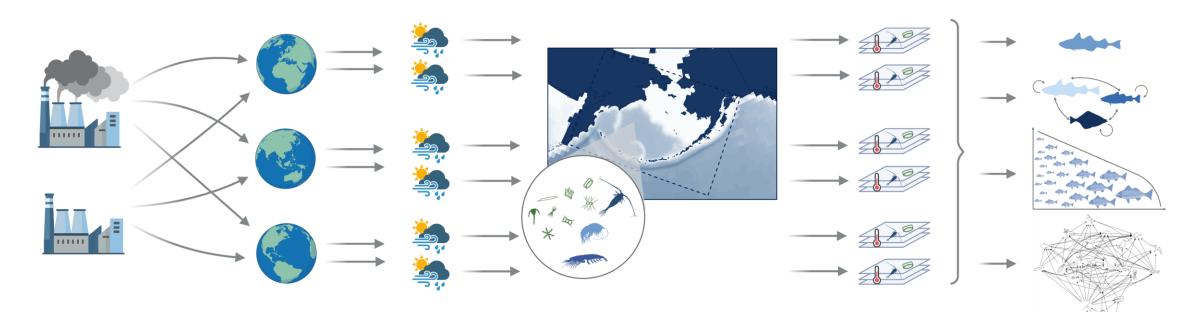
**1.** How will spawning suitability change for P.cod across the eastern Bering Sea shelf?

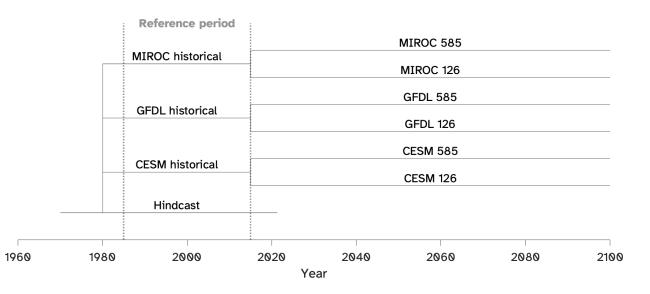
**2.** Will the southeastern Bering Sea shelf become ice-free in the winter?



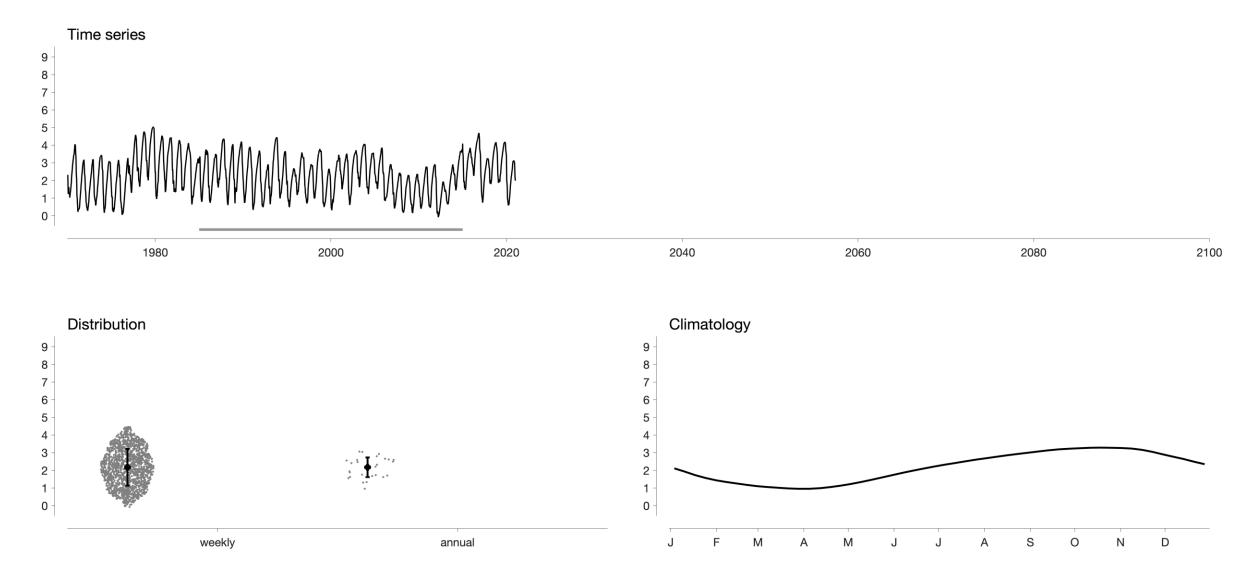


### **Regional model simulations**

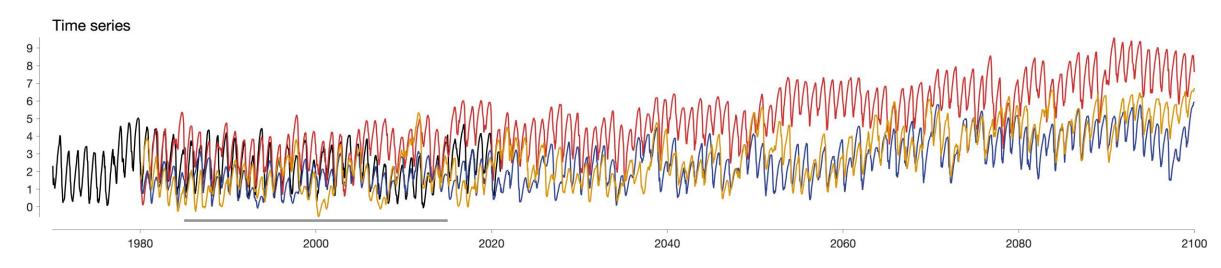


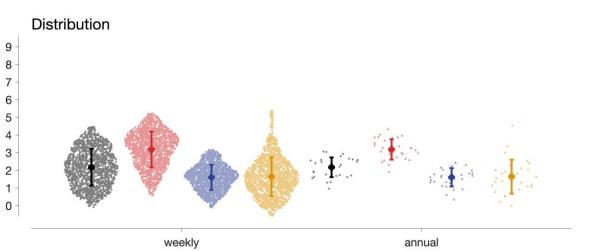


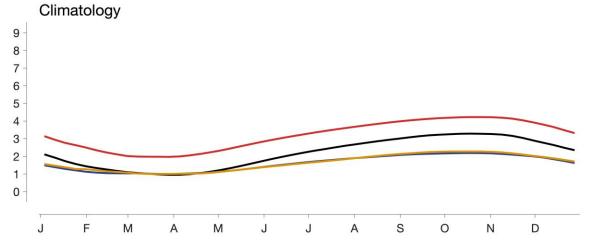
# **Bottom temperature (°C)**



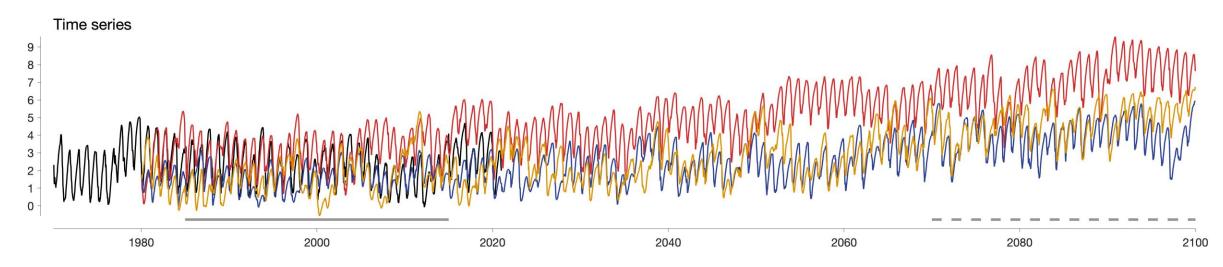
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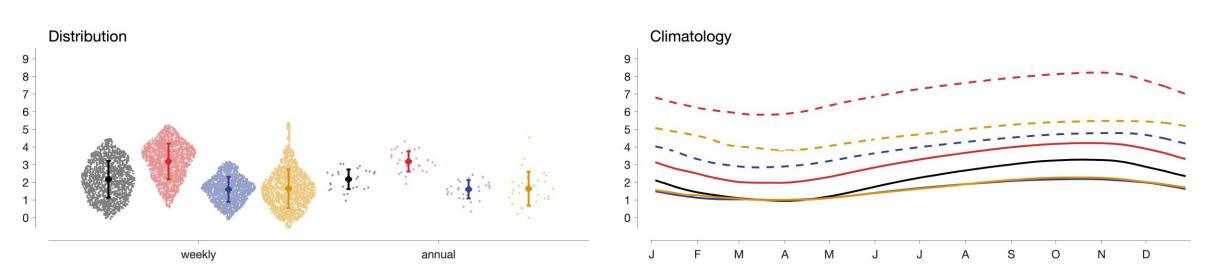






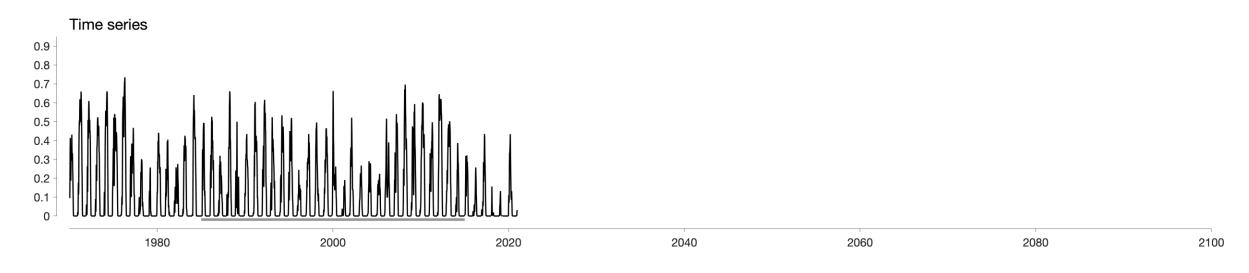
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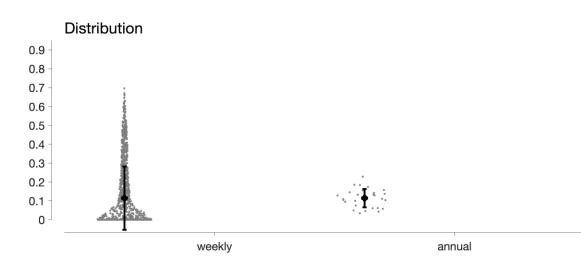


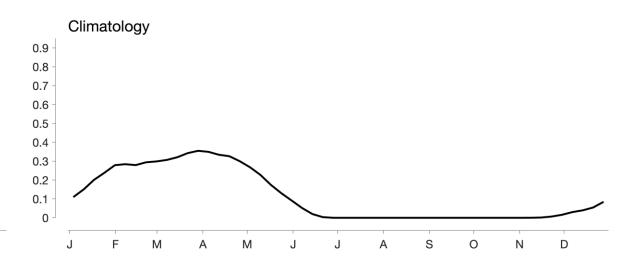


### **Sea Ice Fractional Coverage**

#### CESM GFDL MIROC

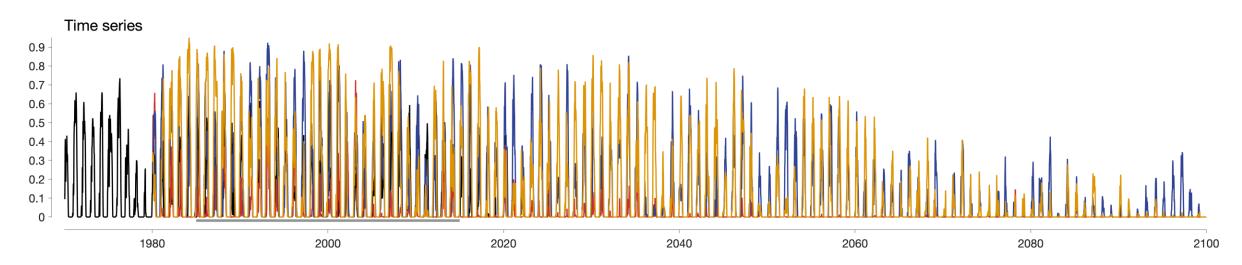


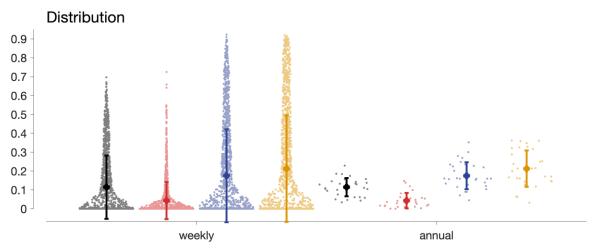


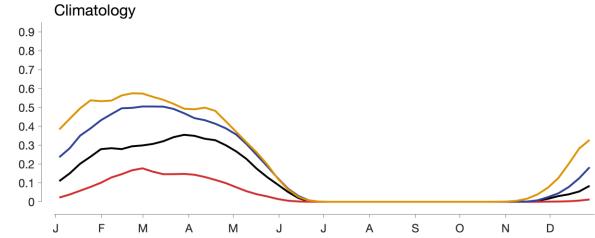


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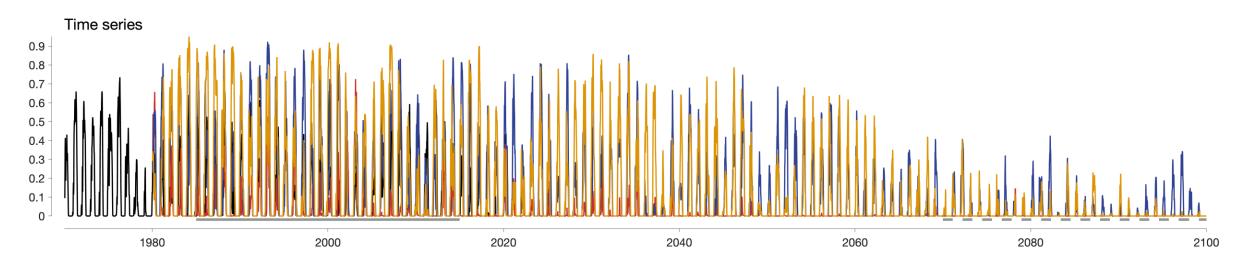
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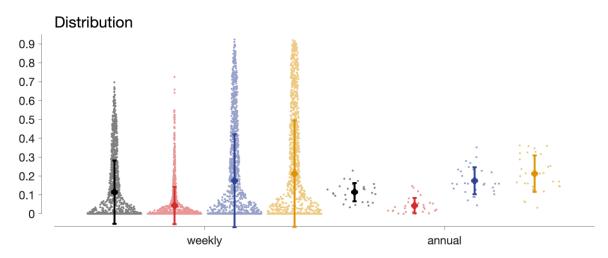


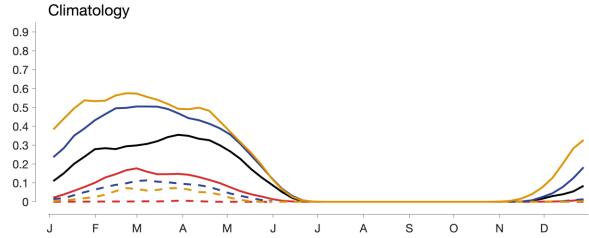




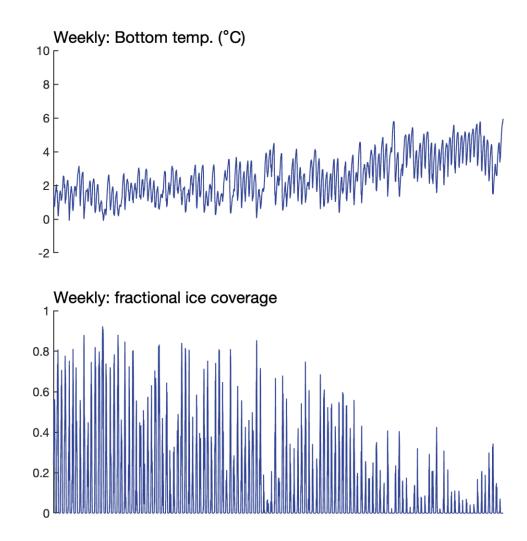
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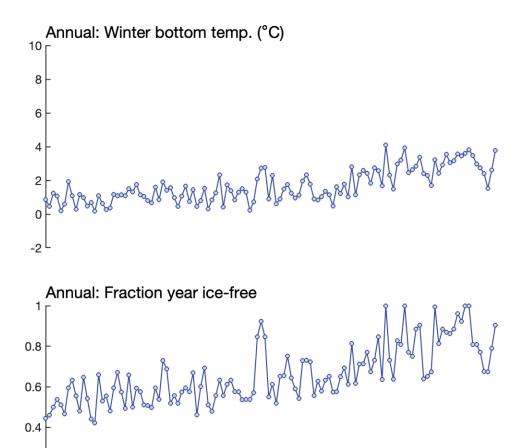






## How to bias correct?

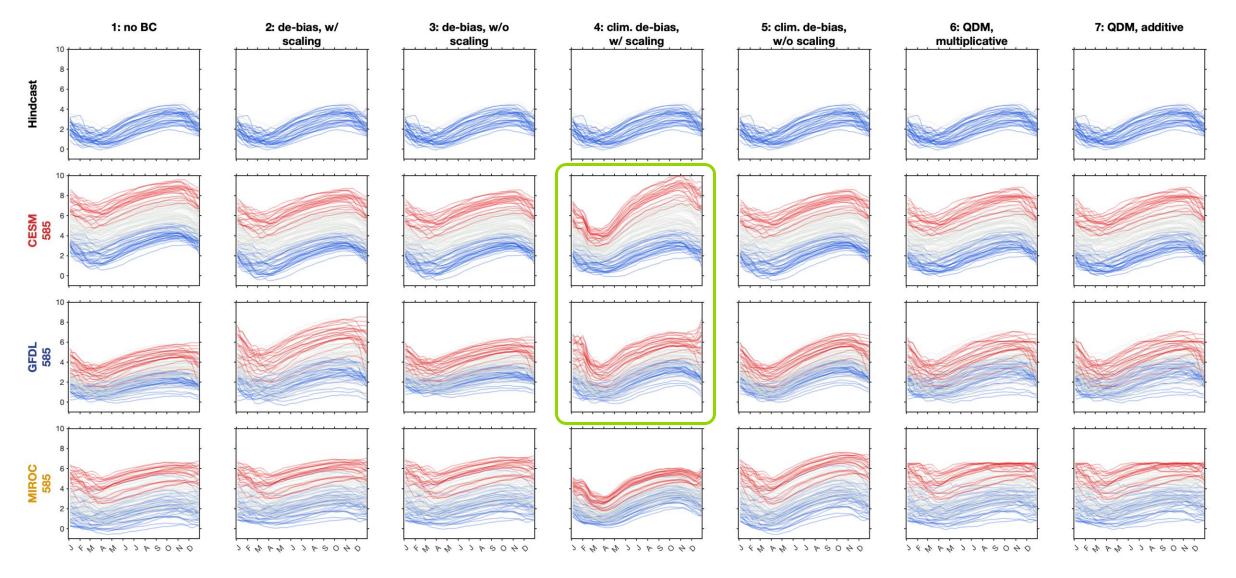




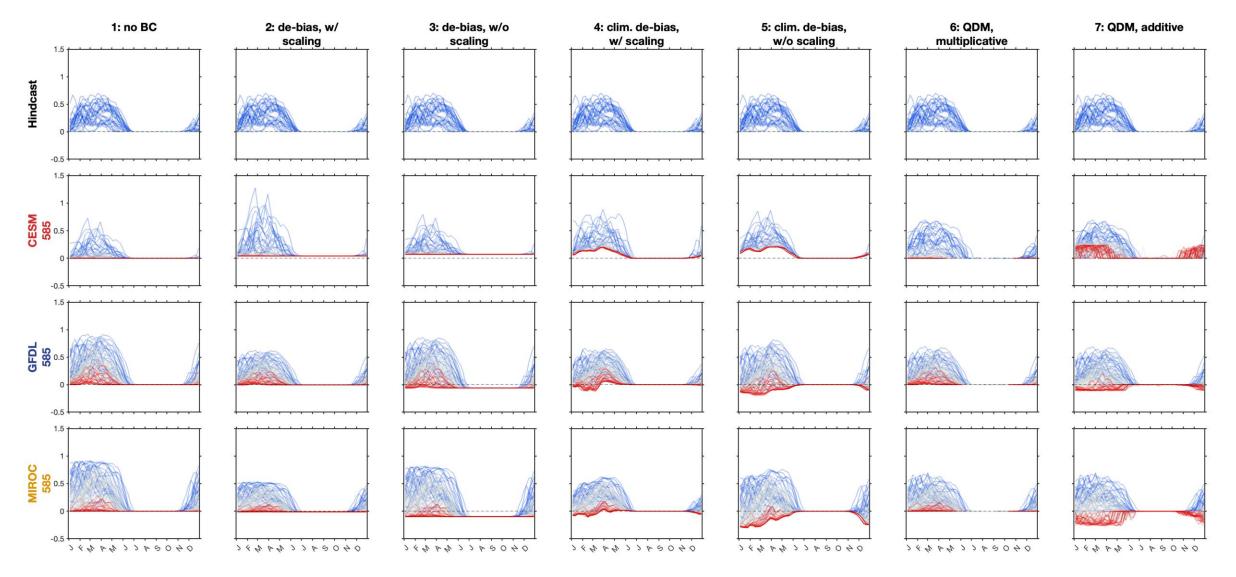
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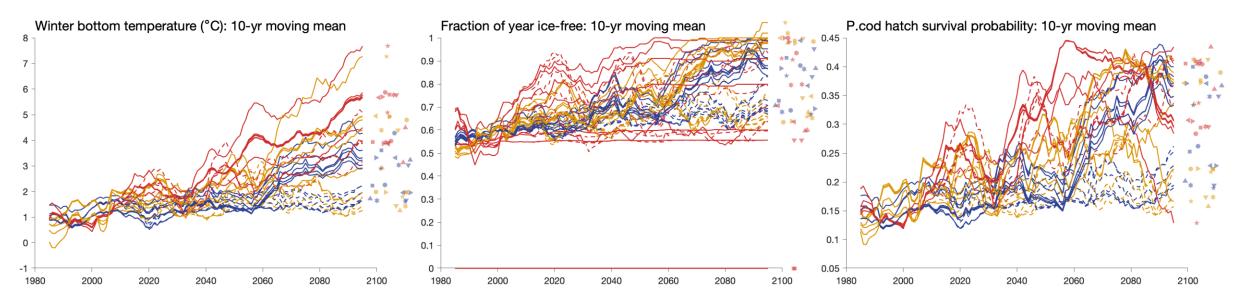
### Impact of bias correction on weekly timeseries



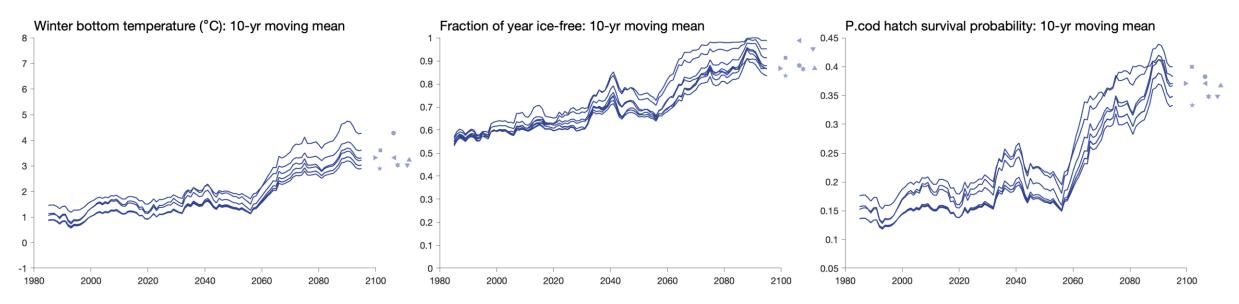
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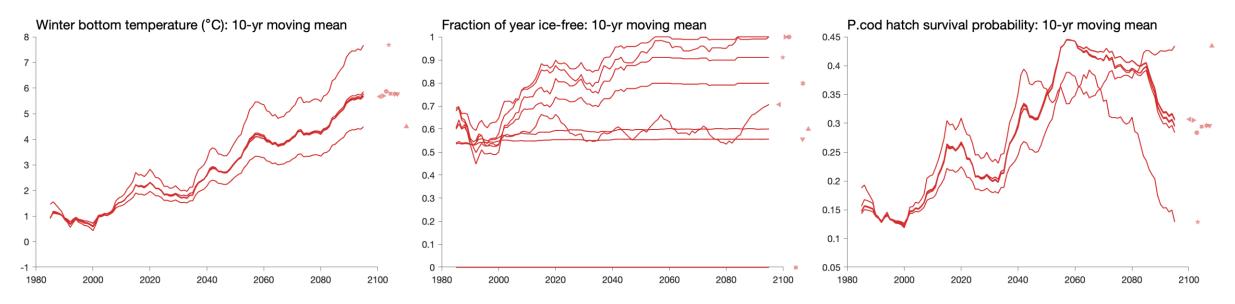
#### CESM GFDL MIROC -- SSP1-2.5 -- SSP5-8.5



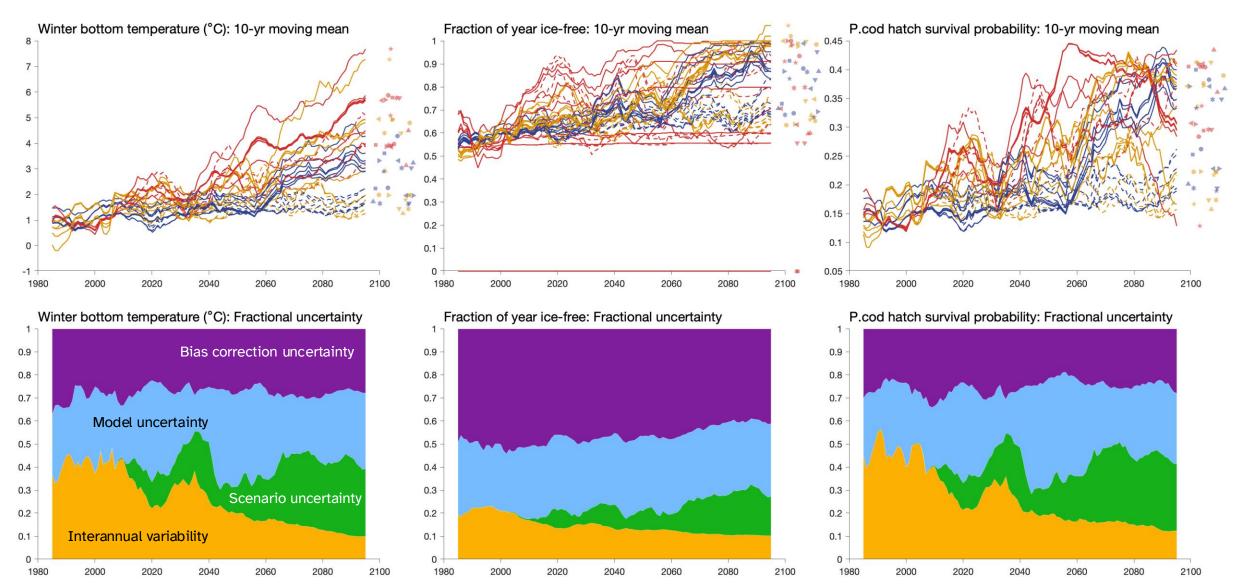
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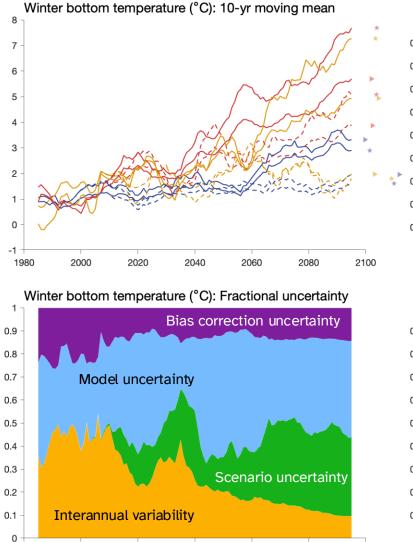


#### CESM GFDL MIROC -- SSP1-2.5 - SSP5-8.5



Uncertainty calculations after Frölicher et al., 2016

#### CESM GFDL MIROC - SSP1-2.5 — SSP5-8.5



2020

1980

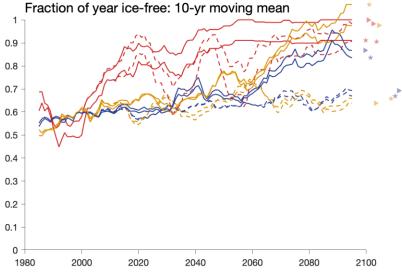
2000

2040

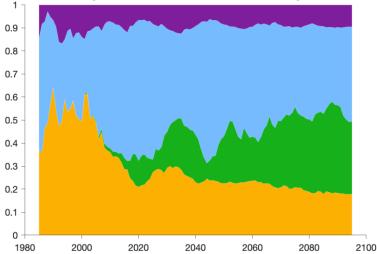
2060

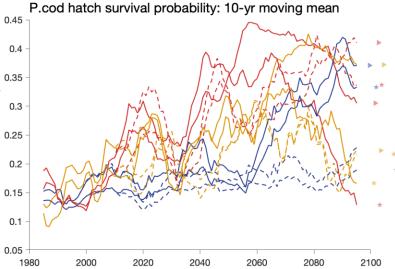
2080

2100

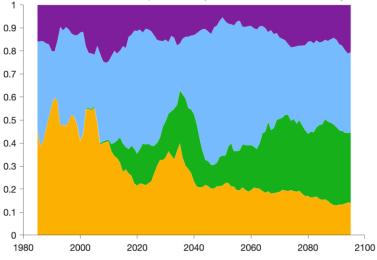


Fraction of year ice-free: Fractional uncertainty





P.cod hatch survival probability: Fractional uncertainty



#### Conclusions

**Bias correction matters!** 

When, how, across which temporal and spatial scales...

2 Common techniques can create un-physical artifacts if not applied carefully Results should be carefully examined at different scales

**Constant of the size fits all**" approaches may not exist Different techniques suit certain ranges, distributions, scales of variability, etc.



**Bias correction cannot fix all — or even most — tricky biases** Search out and correct for biases upstream where possible. Otherwise, it may make sense to rephrase the question.