

# A Hector application: Sea-level constraints tighten climate sensitivity and temperature projections



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Climate impacts/damages closely linked to extreme (low-probability) events



Minnesota Dept. of Agriculture

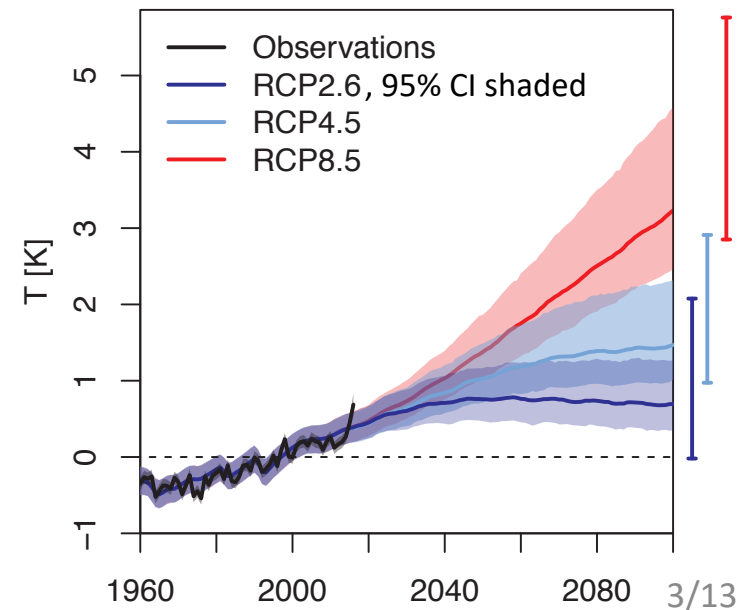
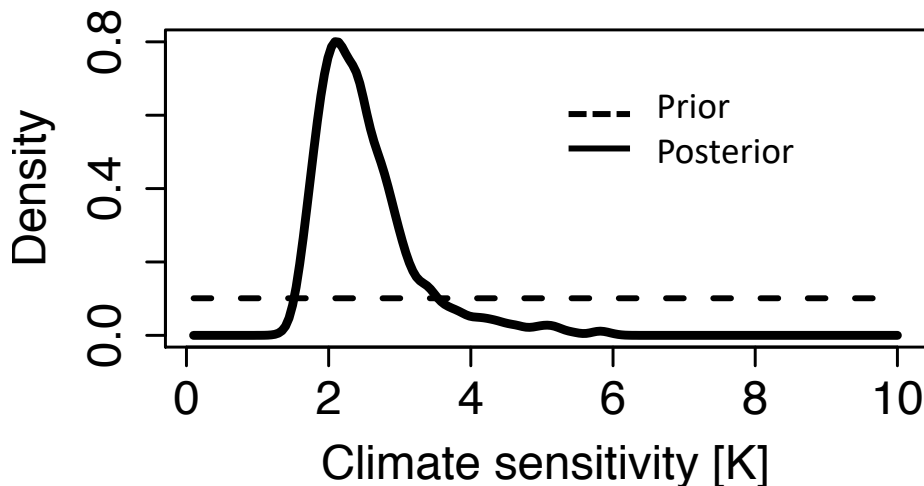


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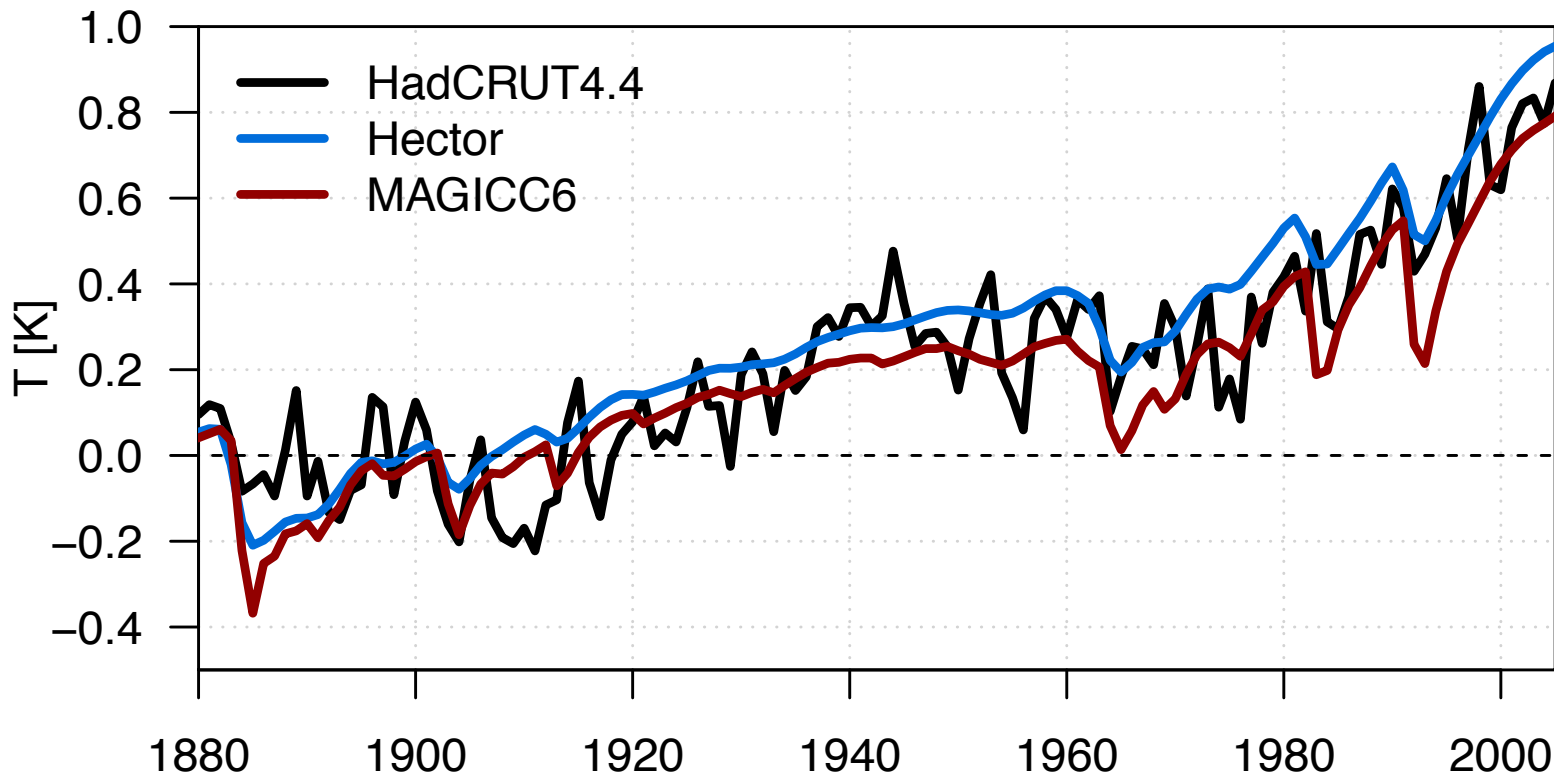
**Uncertainty quantification, including the tails, is critical for climate projections**

# Pinning the tails on Hector

- Updated Hector energy balance (DOECLIM, part of Hector v2.0)
- Enhanced sea-level module available (BRICK, [https://github.com/bvegawe/hector/tree/dev\\_slr](https://github.com/bvegawe/hector/tree/dev_slr))
- Bayesian (MCMC) calibration tools available ([https://github.com/bvegawe/hector\\_probabilistic](https://github.com/bvegawe/hector_probabilistic))
- Default: calibrate 39 parameters



# Sanity check #1: Do calibrated results fit the observations?

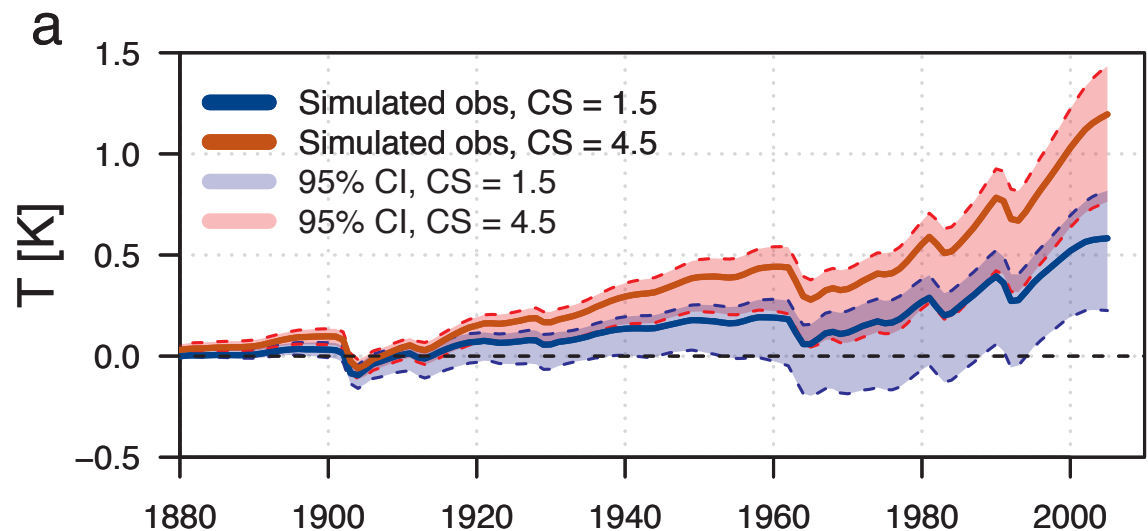
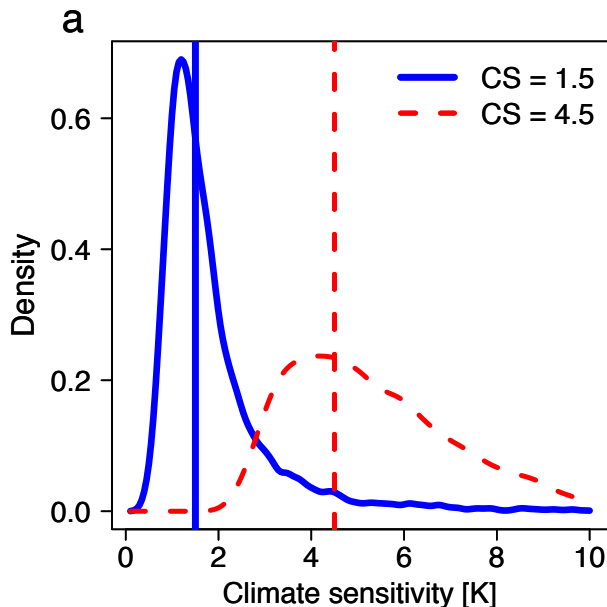


- Simple model -> can't capture short-term variability (but accounted for in our probabilistic assessment)
- Similar RMSE to MAGICC6 (0.118K for Hector, 0.119 for MAGICC)
- GISTEMP instead of HadCRUT -> same result

# Sanity check #2: A perfect model experiment

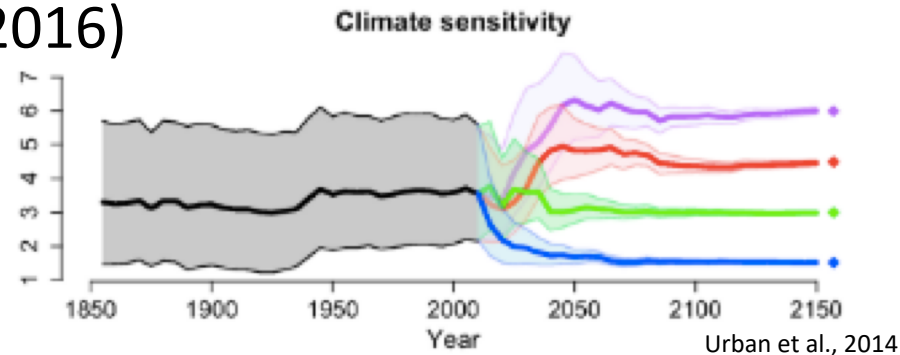
- Create 2 sets of simulated observations with different climate sensitivities:
  - 1.5 deg C
  - 4.5 deg C
- Can the calibration tool distinguish between the two?

(equilibrium  $\Delta T$  due to a doubling of CO<sub>2</sub>)

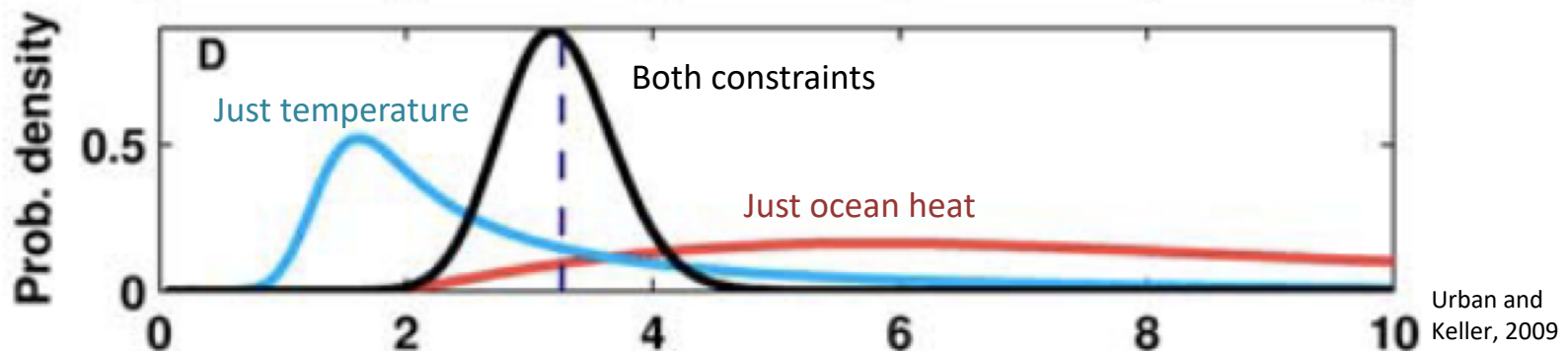


# Scientific application of the Hector calibration tool

- Past studies investigated:
  - How does longer temperature data affect climate sensitivity estimates and temperature projections (Urban et al., 2014; Shiogoma et al., 2016)



- What about adding in ocean heat observations (Urban and Keller, 2009)?



# Scientific application of the Hector calibration tool

Our question:

How do sea-level constraints affect climate sensitivity estimates and key climate projections?

Our approach:

Two Hector calibrations

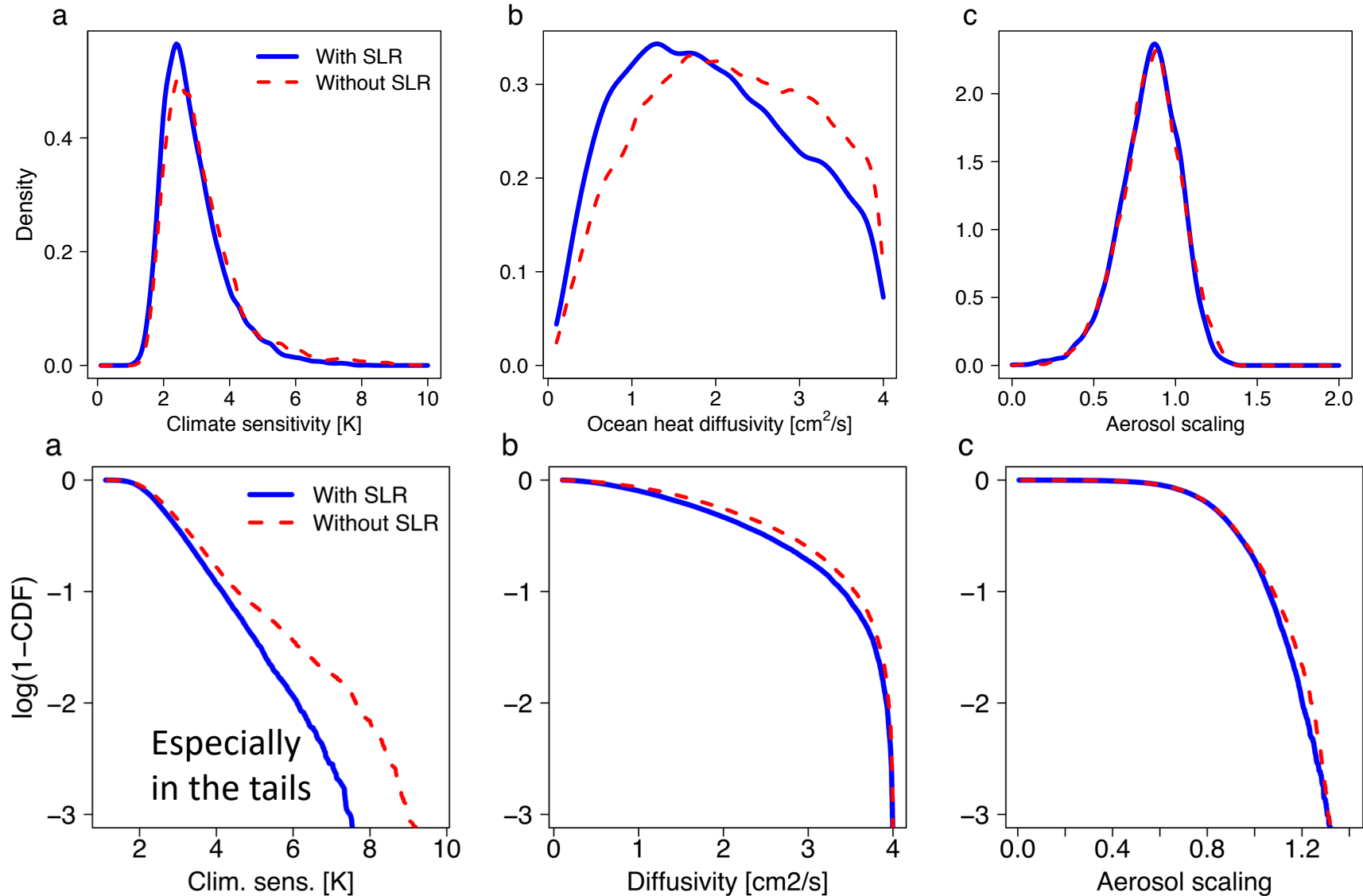
## Calibration #1: “Without SLR”

- Only calibrate energy balance parameters (3 physical and 6 statistical)
- Ignore sea level

## Calibration #2: “With SLR”

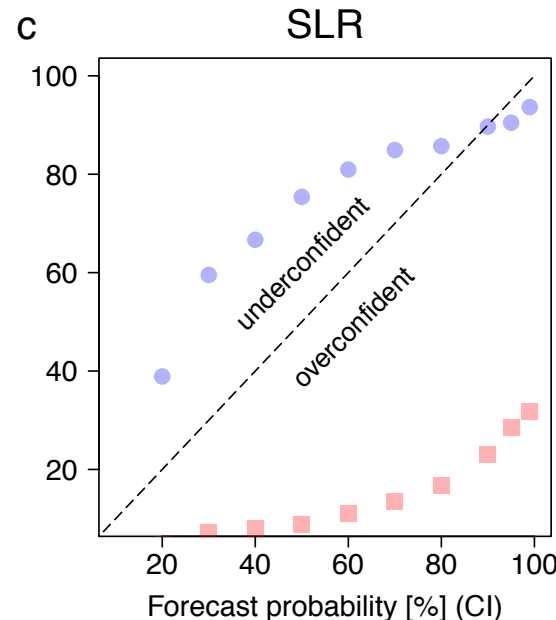
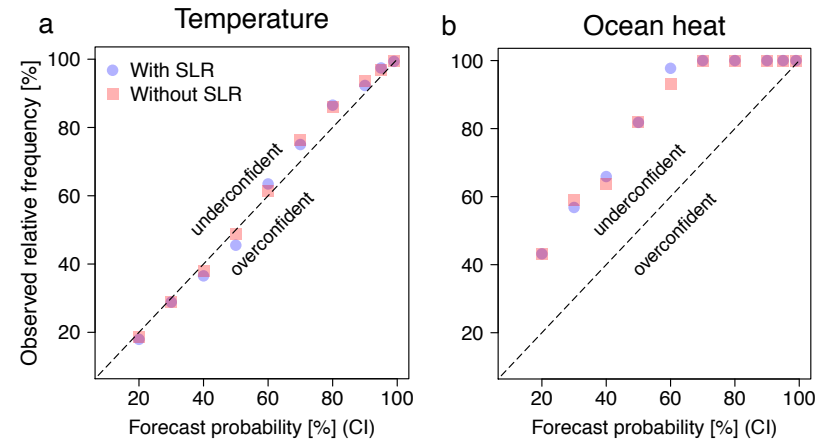
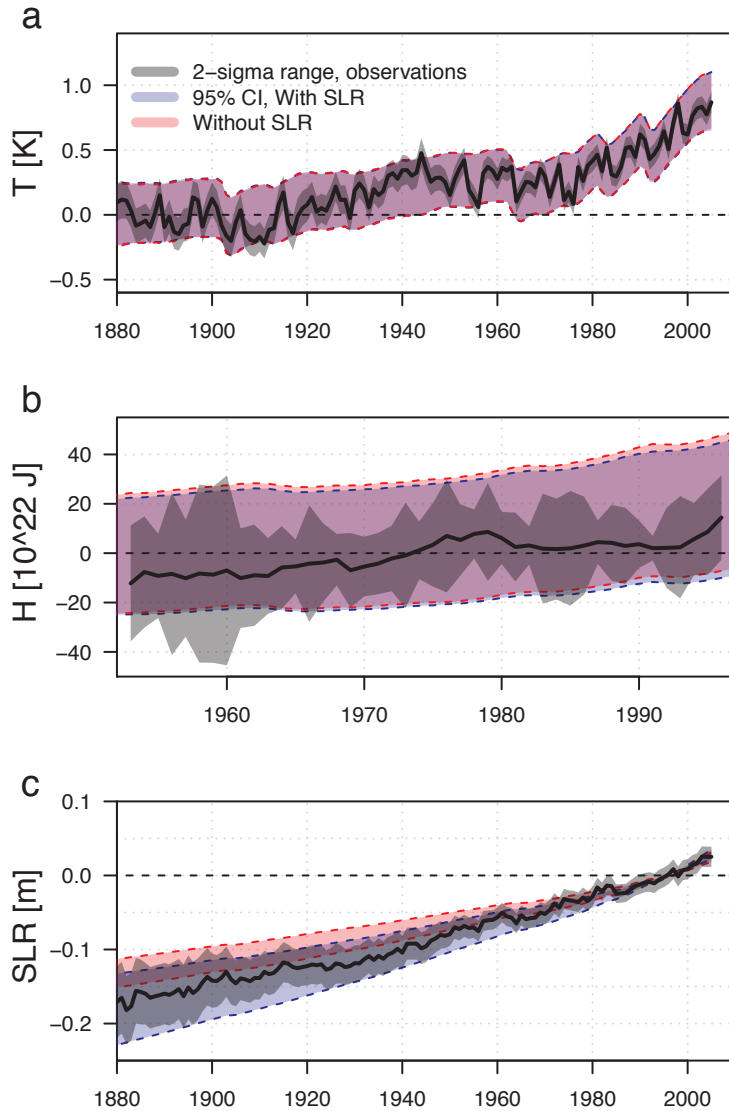
- Calibrate energy balance and BRICK sea-level parameters (39 total)
- Include sea-level contributor constraints

# Sea-level constraints sharpen the climate sensitivity estimate



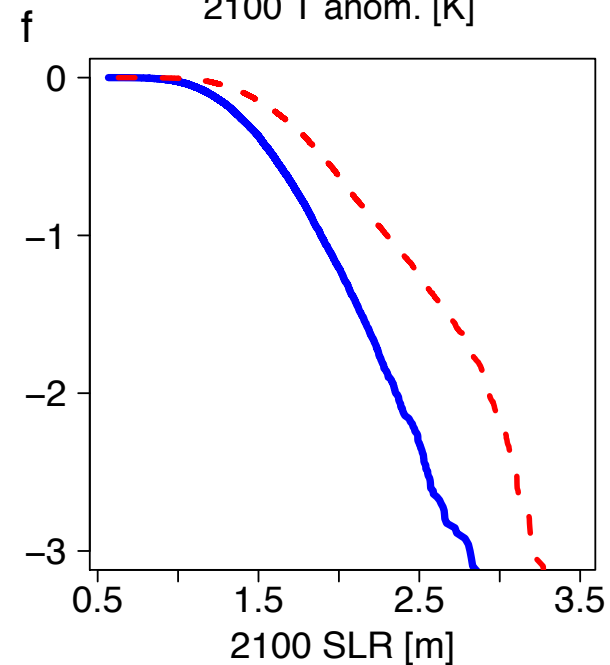
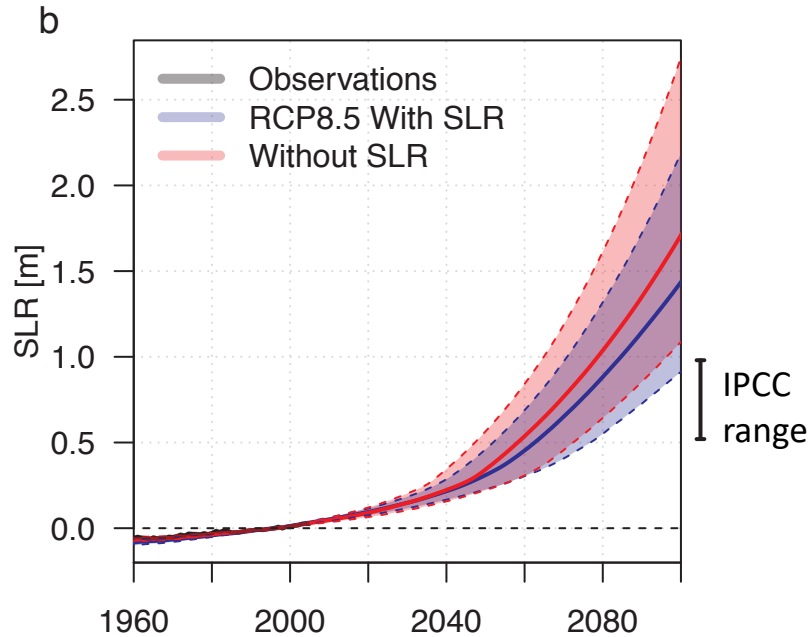
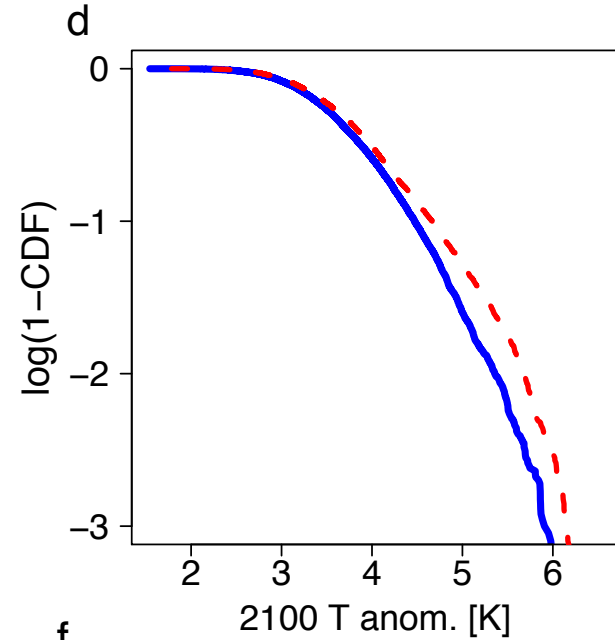
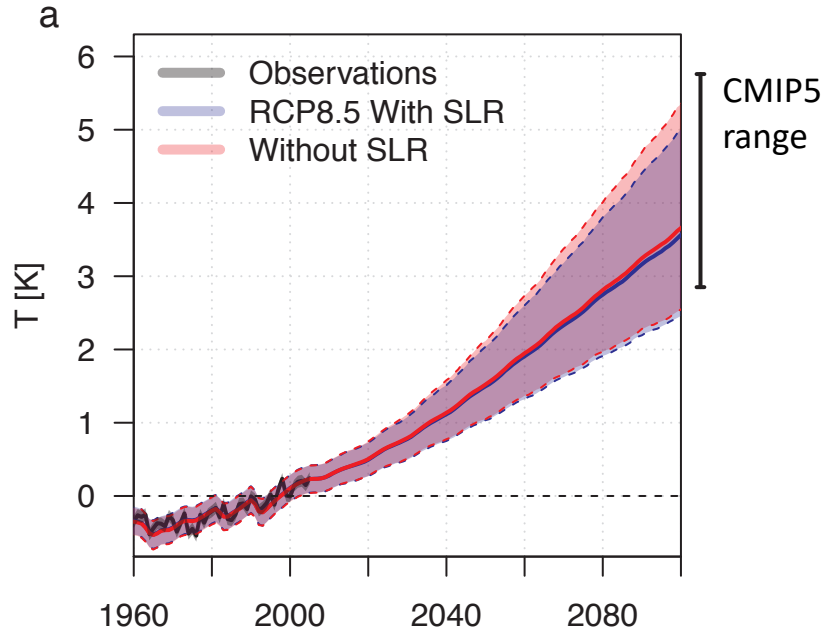


# Sea-level constraints have little effect on hindcasts (besides sea-level)



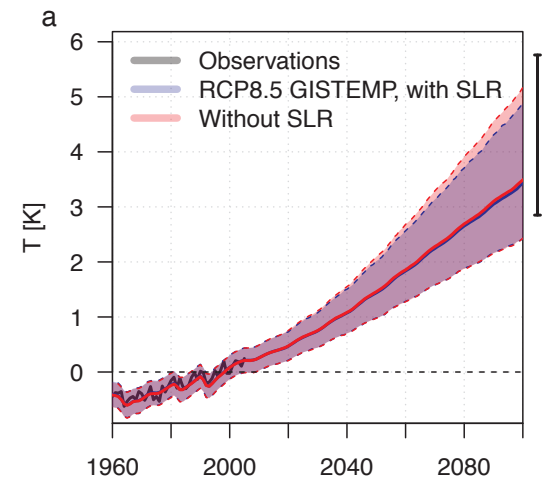
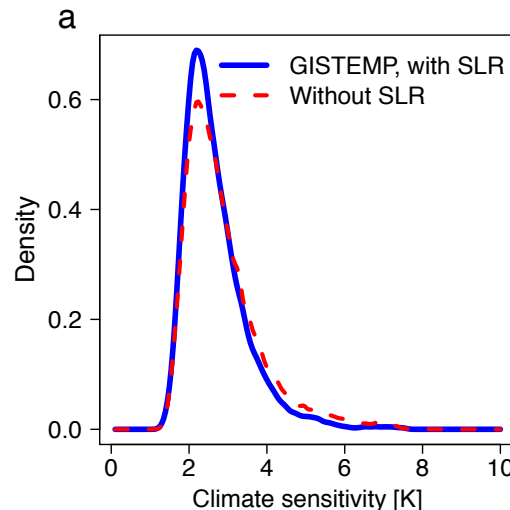
Overconfidence in sea level is bad!  
(e.g. underestimate flood risks, Srivier et al., 2018)

# Sea-level constraints sharpen projections



# A Hector application: Sea-level constraints tighten climate sensitivity and temperature projections

- Results robust to observational temperature data set and observational time range
- Just submitted (Sunday) to Environmental Research Letters



# Future work

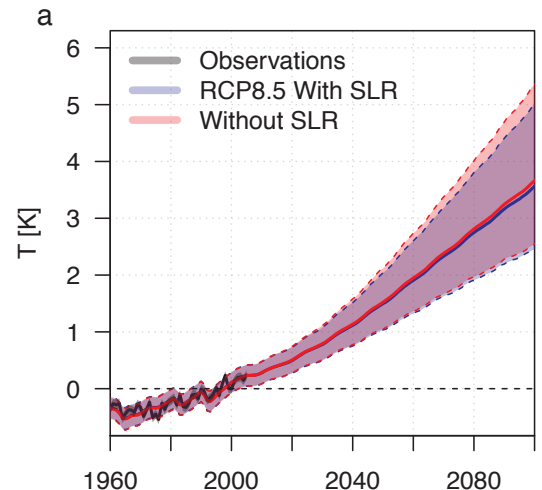
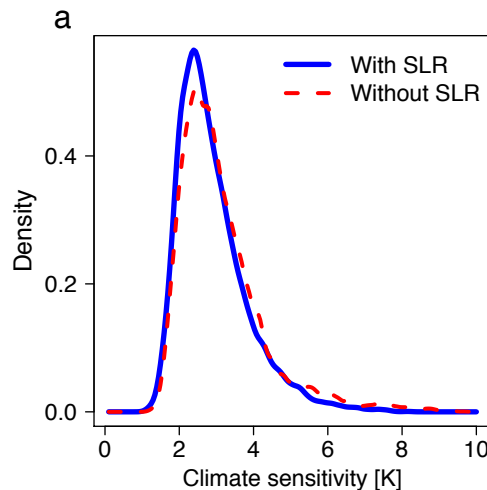
- Expand calibration to carbon cycle parameters
- Investigate calibration sensitivity to length of observations (what is the role of the hiatus)
- Apply probabilistic projections to downscaling applications (e.g. future tropical cyclone properties)

# Acknowledgements

- Elmar Kriegler - DOECLIM model
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# Summary

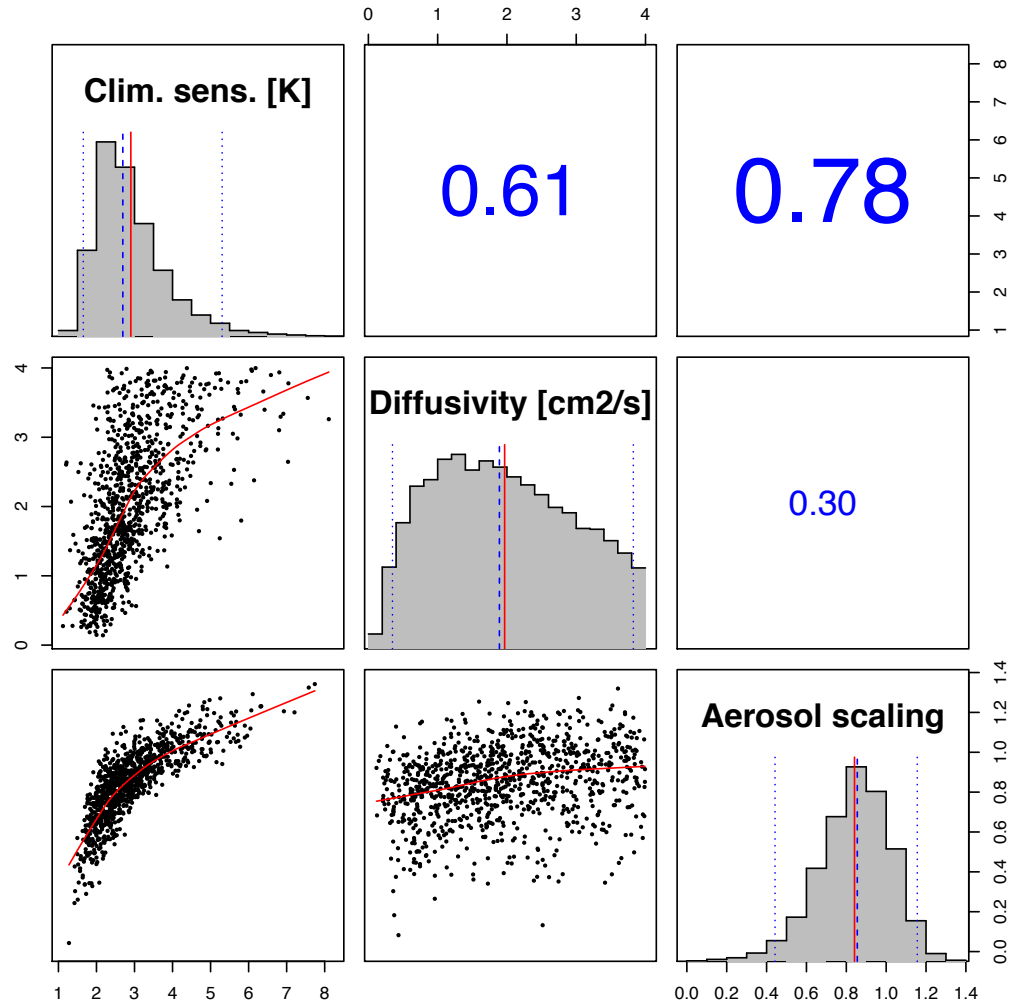
- Bayesian (MCMC) calibration tools available for Hector ([https://github.com/bvegawe/hector\\_probabilistic](https://github.com/bvegawe/hector_probabilistic))
- Sanity checks performed, including perfect model experiments
- A first application: Sea-level constraints tighten climate sensitivity and temperature projections



# References

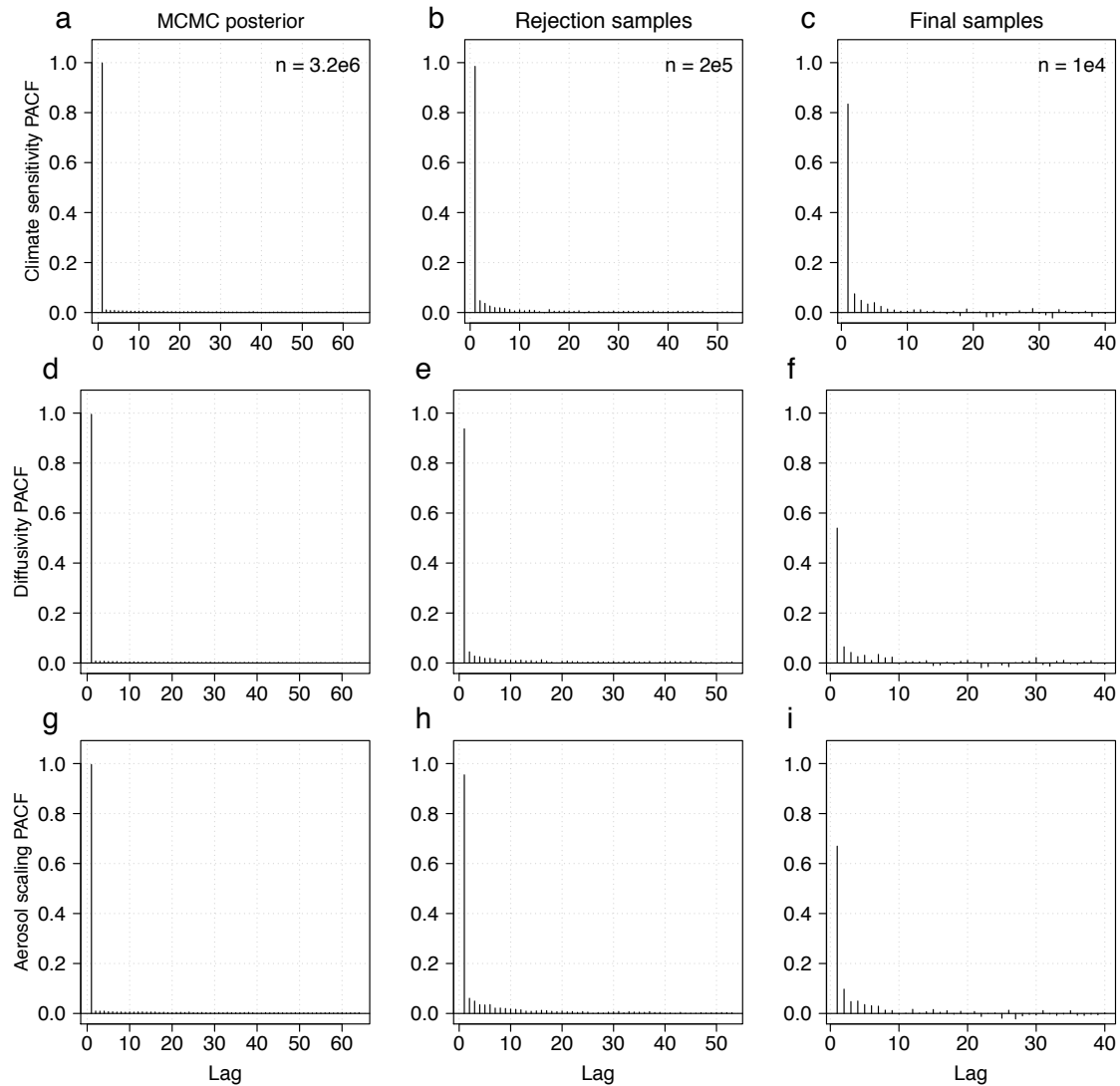
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# Supplemental: climate parameter correlations





# Supplemental: partial autocorrelations



# Supplemental: Calibrations to 2009

