

Global scale change: temperature and sea level

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If you had to pick only two numbers to represent the most important features of climate change...

What would they be?

If you had to pick only two numbers to represent the most important features of climate change...

1. How much will climate warm in response to a doubling atmospheric CO₂ concentrations.
(Also called equilibrium climate sensitivity.)
2. How much will sea level rise by 2100?

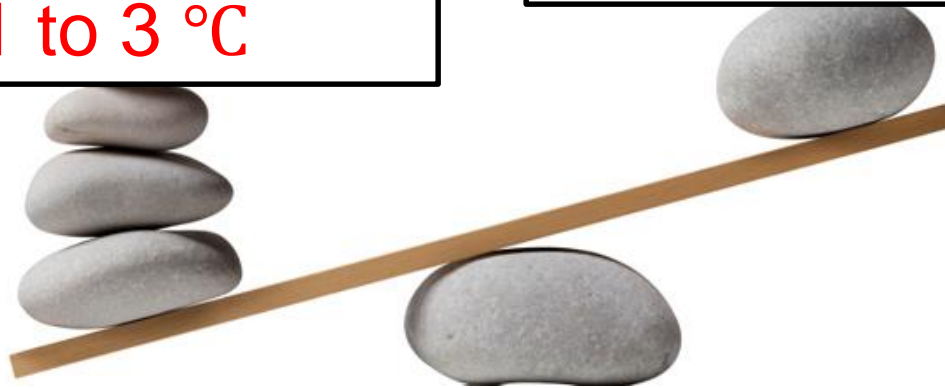
Estimates of equilibrium climate sensitivity are discrepant.

Estimates from historical
instrumental observations

1 to 3 °C

Estimates from paleoclimate
studies and model simulations

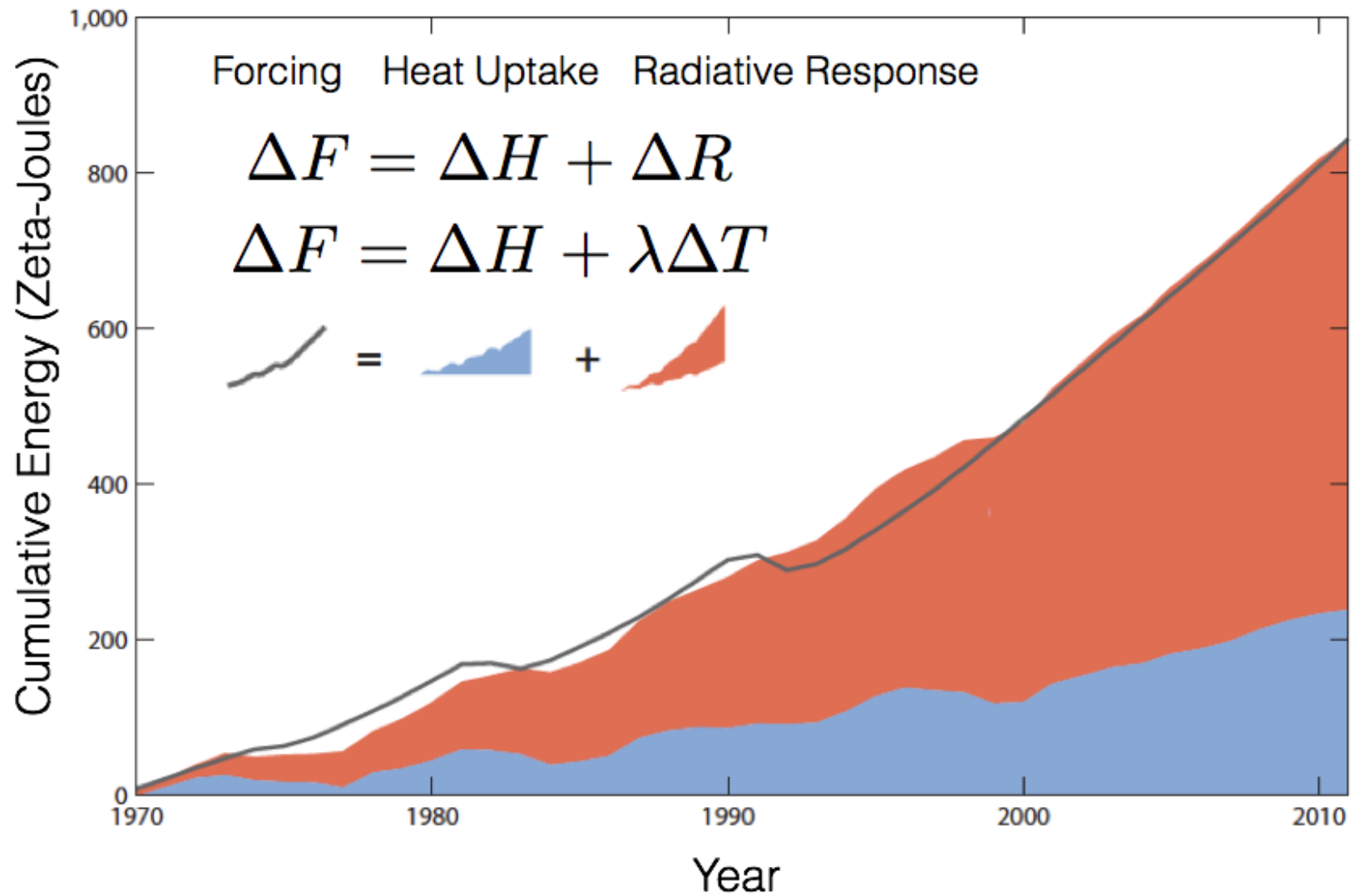
2 to 5 °C



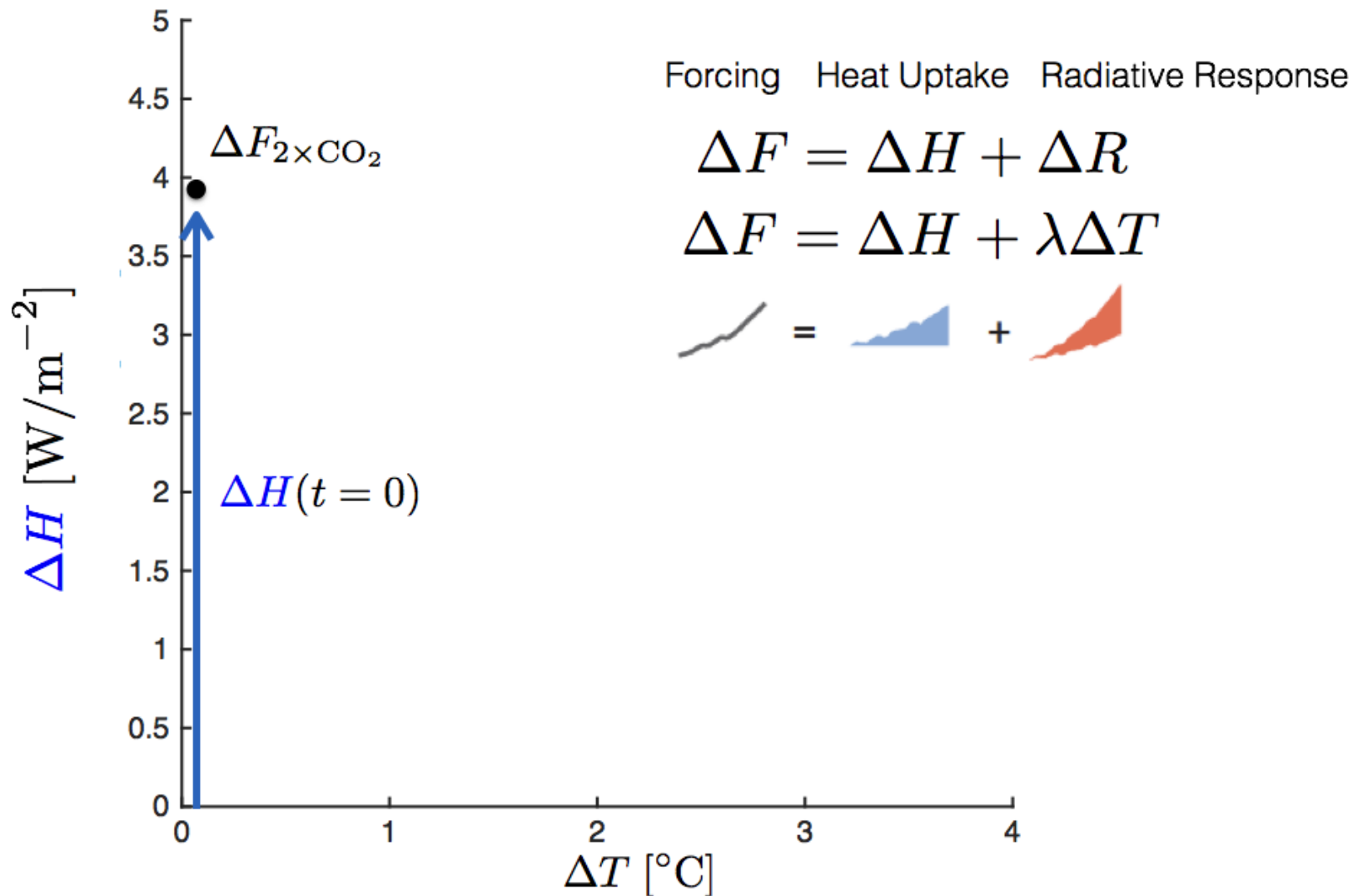
“No best estimate for equilibrium climate sensitivity can now be given because of a lack of agreement on values across assessed lines of evidence and studies.”

-Footnote 16, IPCC AR5 Summary for Policymakers.

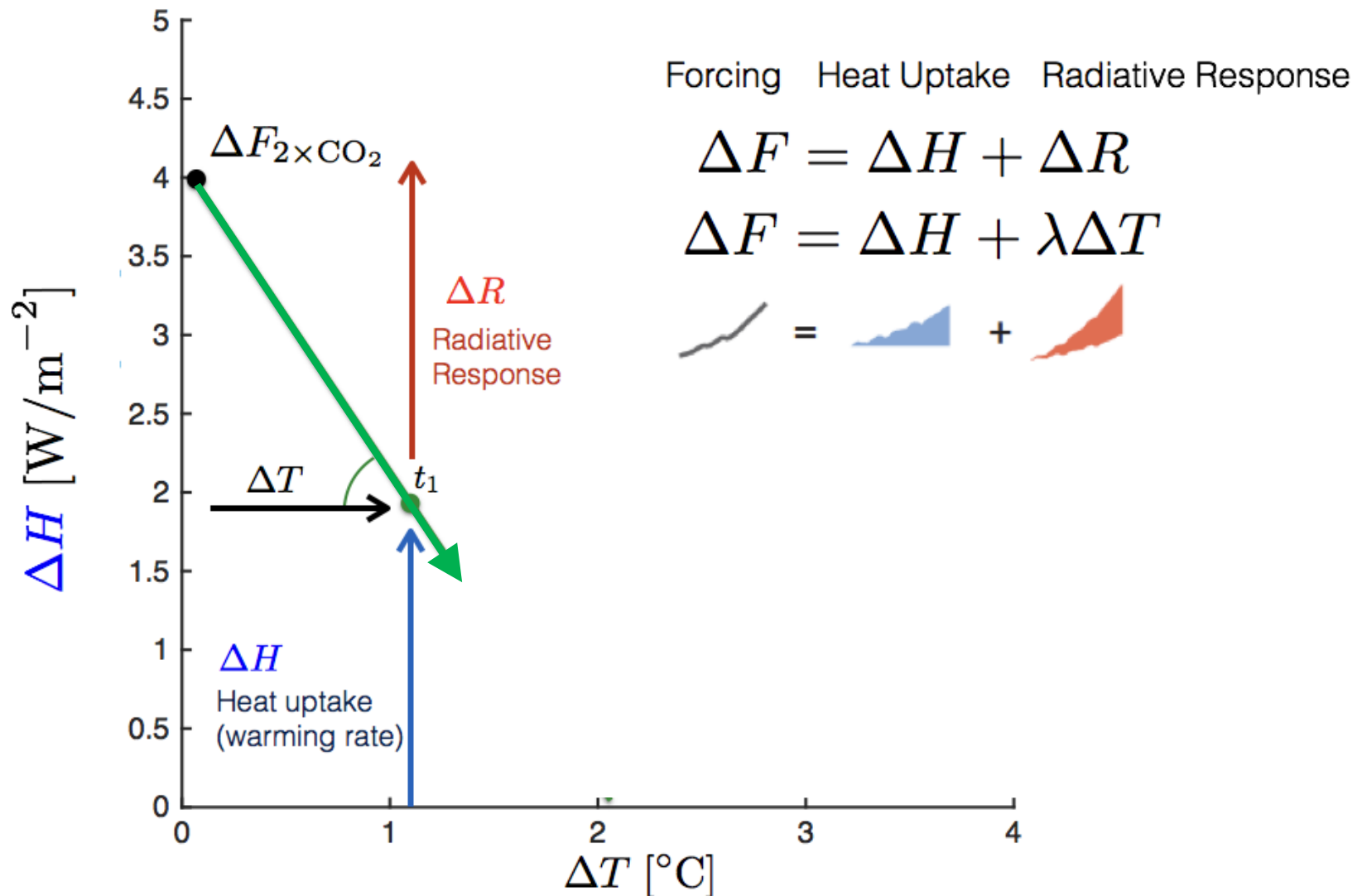
Climate 101: A framework for estimating equilibrium climate sensitivity



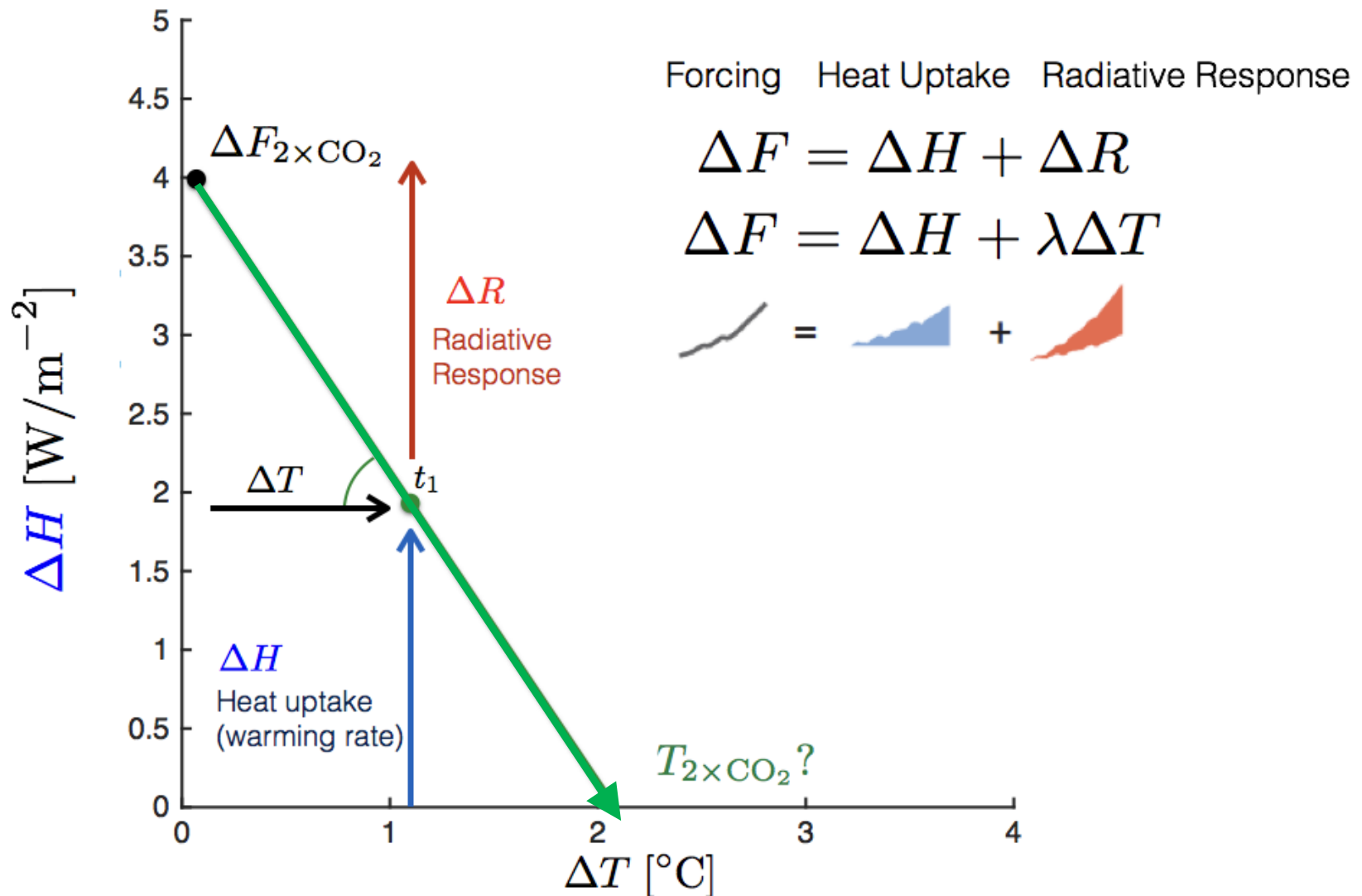
Imagine atmospheric CO₂ doubles instantly: heat uptake increases, but no warming yet



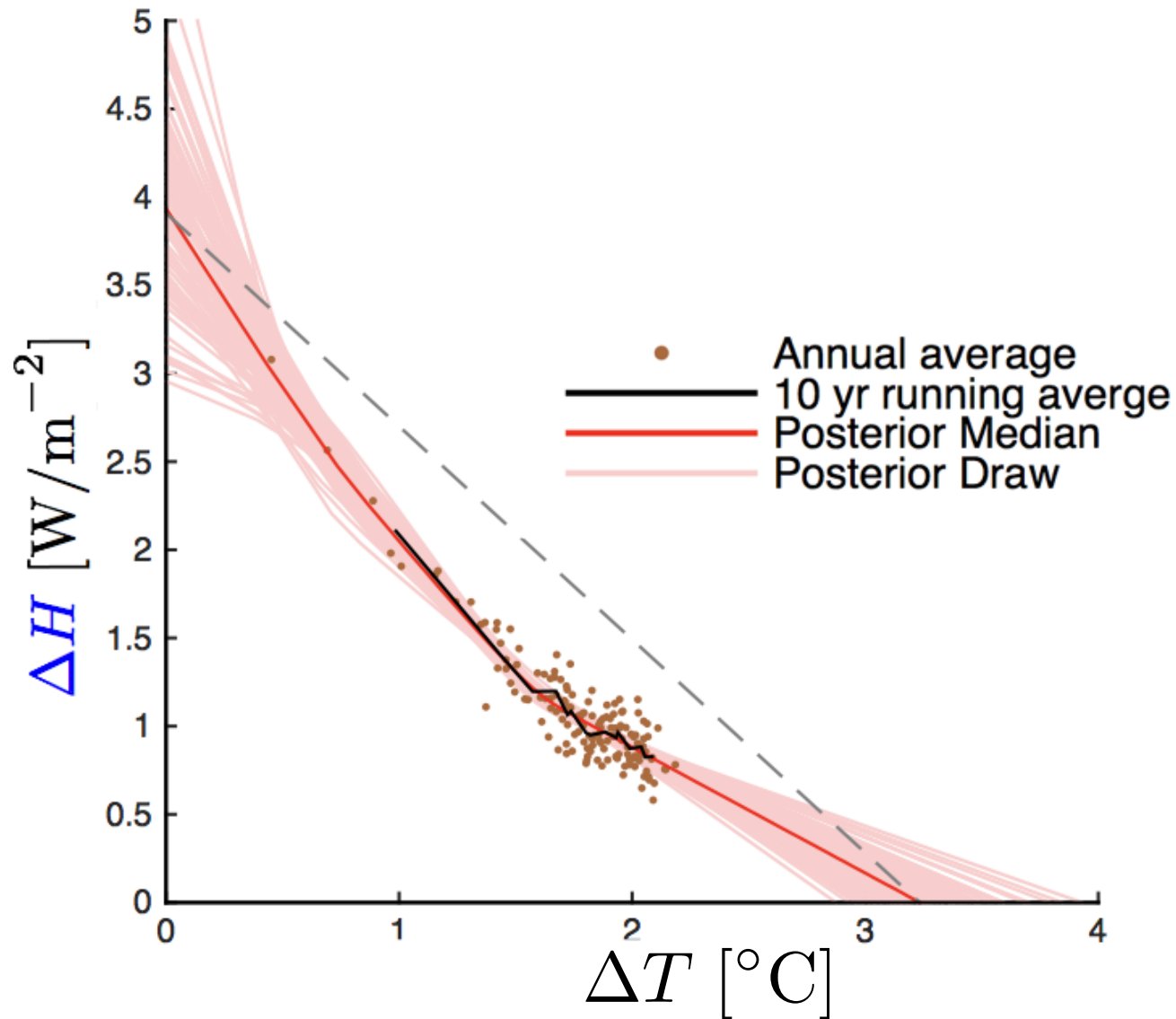
After some years, warming leads to less heat uptake and more radiation sent out to space



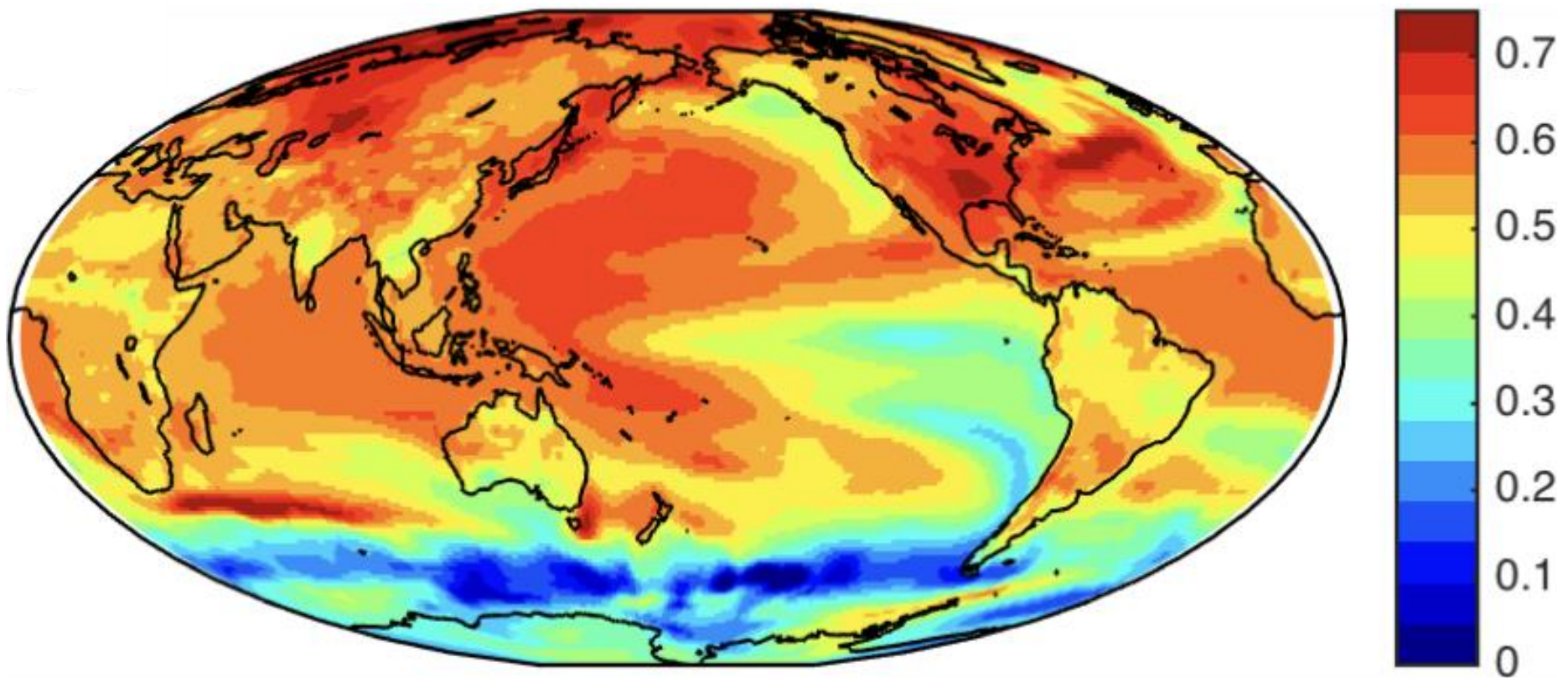
Historically-based estimates linearly extrapolate the heat- radiation relationship to equilibrium



But model simulations show a heat-radiation relationship that is curved



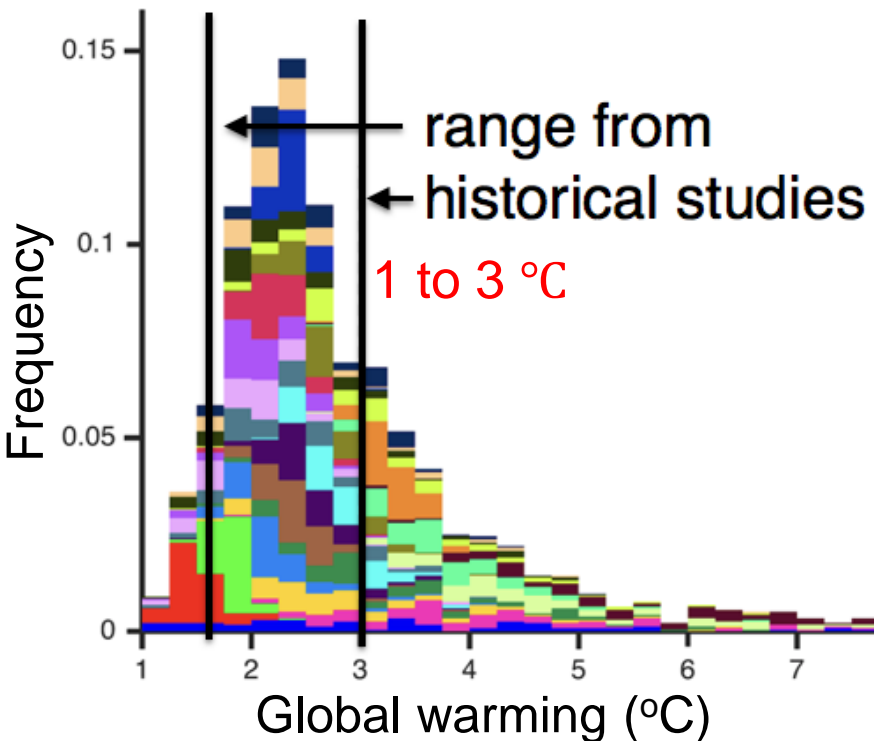
Curvature arises from slow adjustment of oceanic regions with strong upwelling



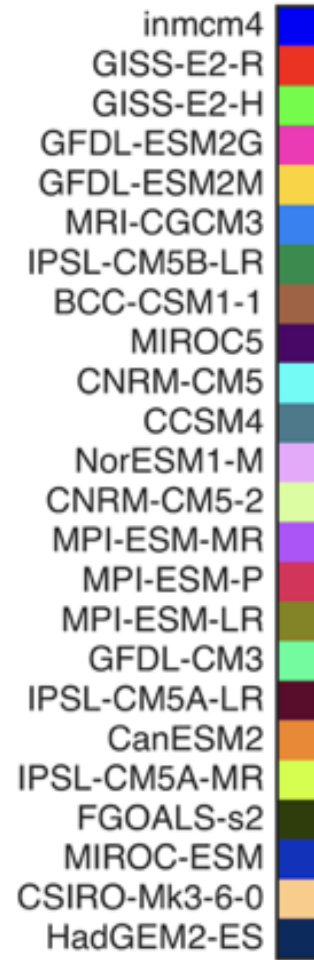
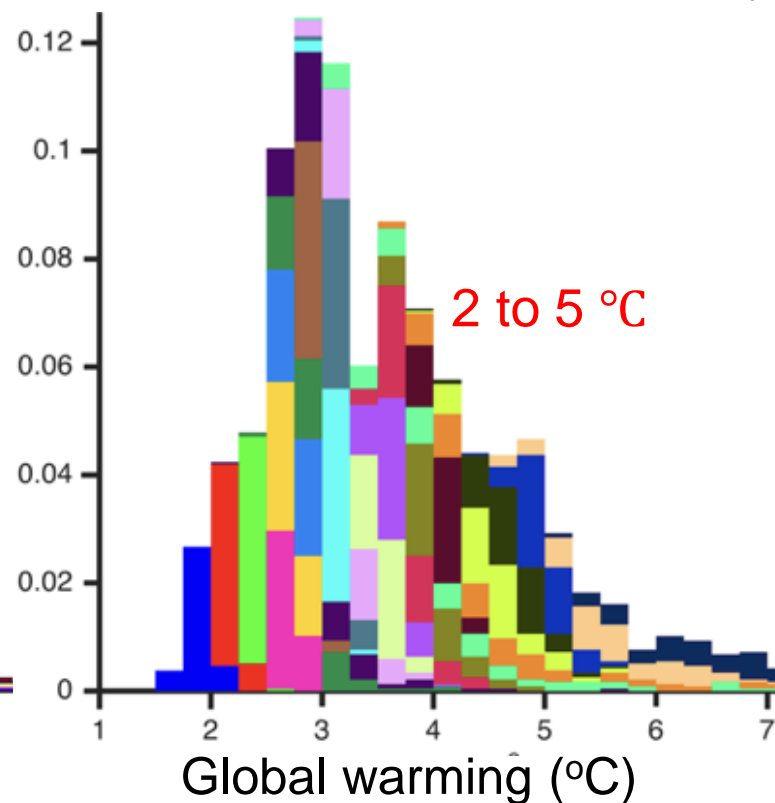
Fraction of warming realized between
modern and equilibrium temperature

Applying linear versus curved heat-radiation relationships accounts for discrepant estimates

Emulation of historical instrumental estimates



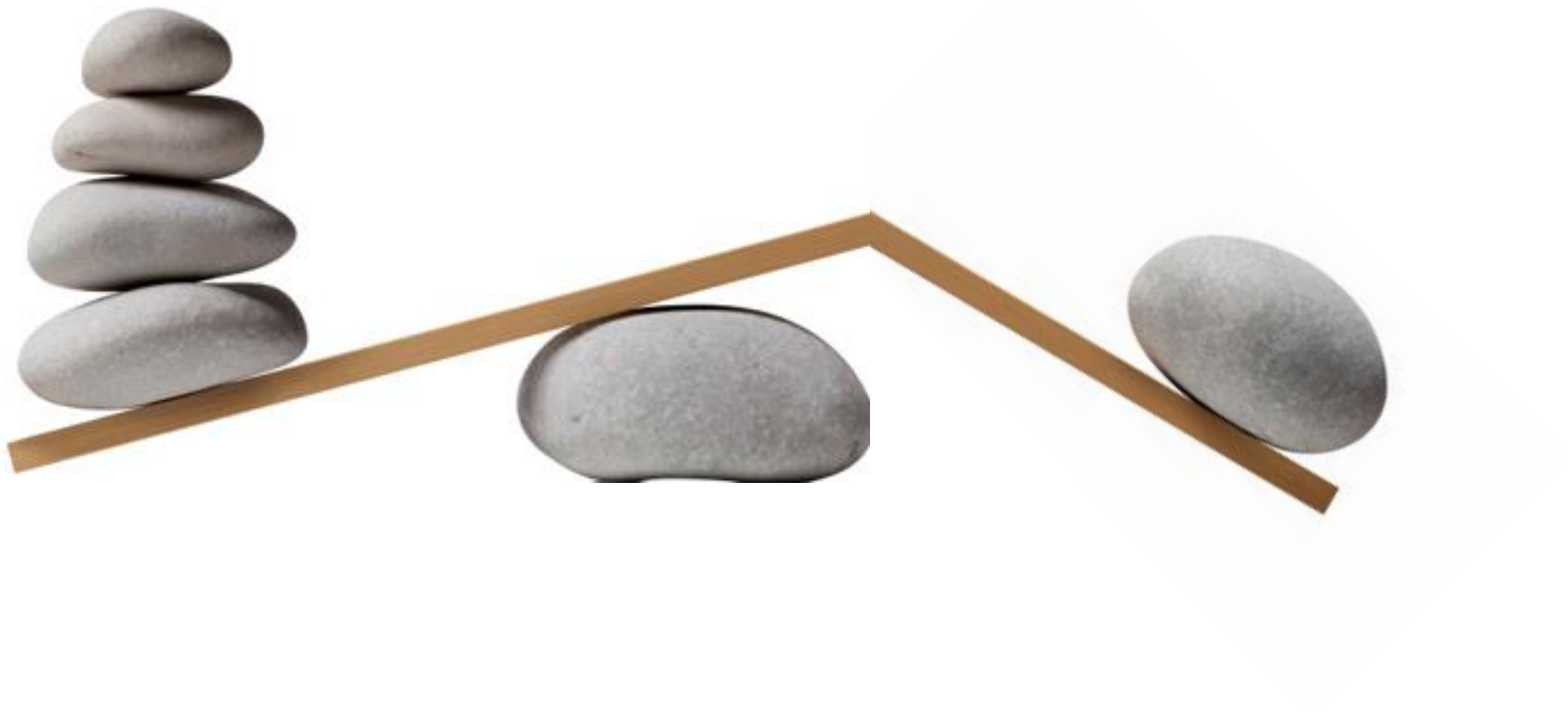
Best estimate of model equilibrium climate sensitivity



Applying linear versus curved heat-radiation relationships accounts for discrepant estimates

Emulation of historical
instrumental estimates

Best estimate of model
equilibrium climate sensitivity



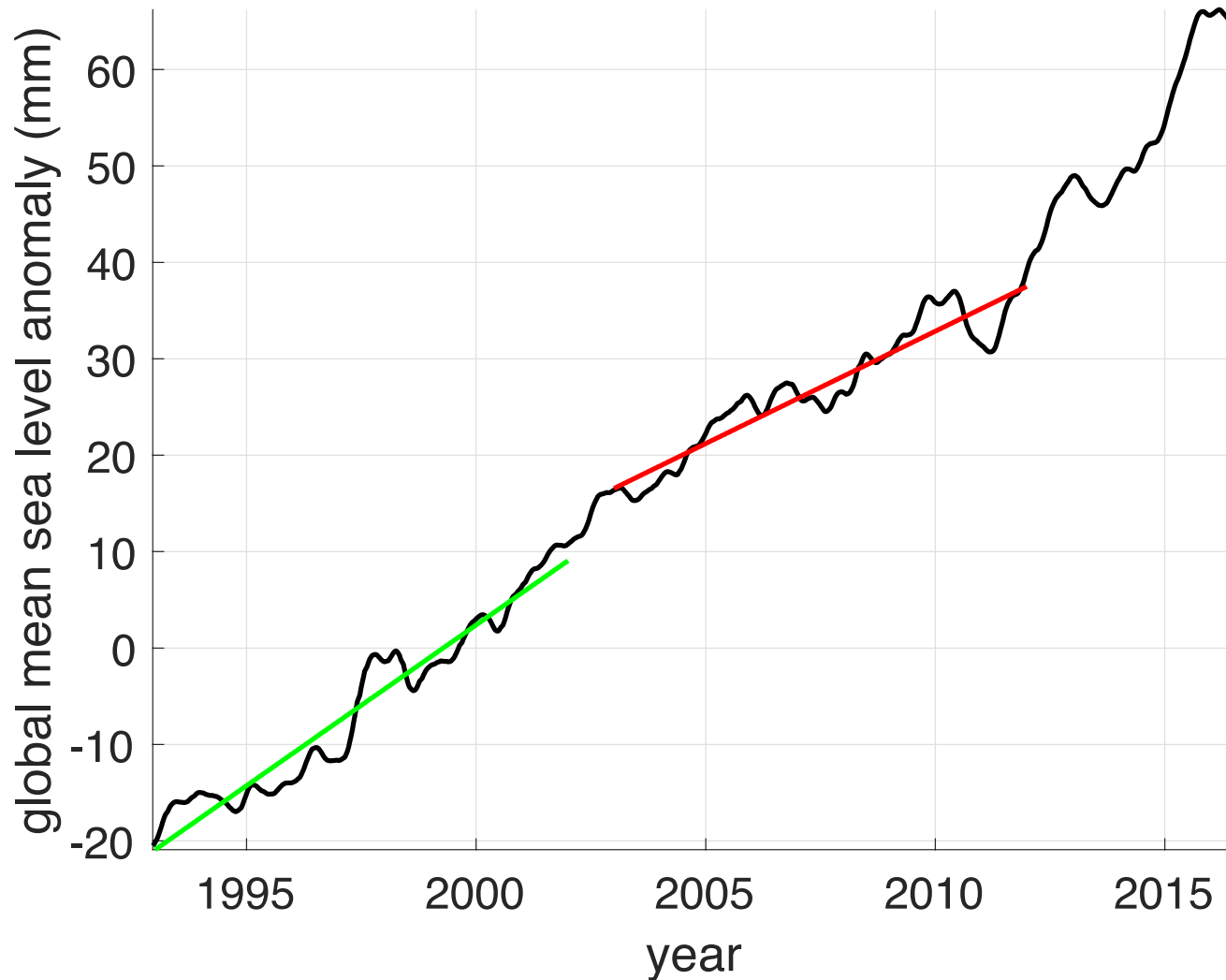
Global sea level rise

1. **Equilibrium climate sensitivity:** How much will climate warm in response to a doubling atmospheric CO₂ concentrations?
2. **Global mean sea level:** How much will sea level rise by 2100?

“The public is largely unaware of the intense debates within climate science. At a recent national laboratory meeting, I observed more than 100 active government and university researchers challenge one another as they strove to separate human impacts from the climate's natural variability. **At issue were not nuances but fundamental aspects of our understanding, such as the apparent--and unexpected--slowing of global sea-level rise over the past two decades.**”

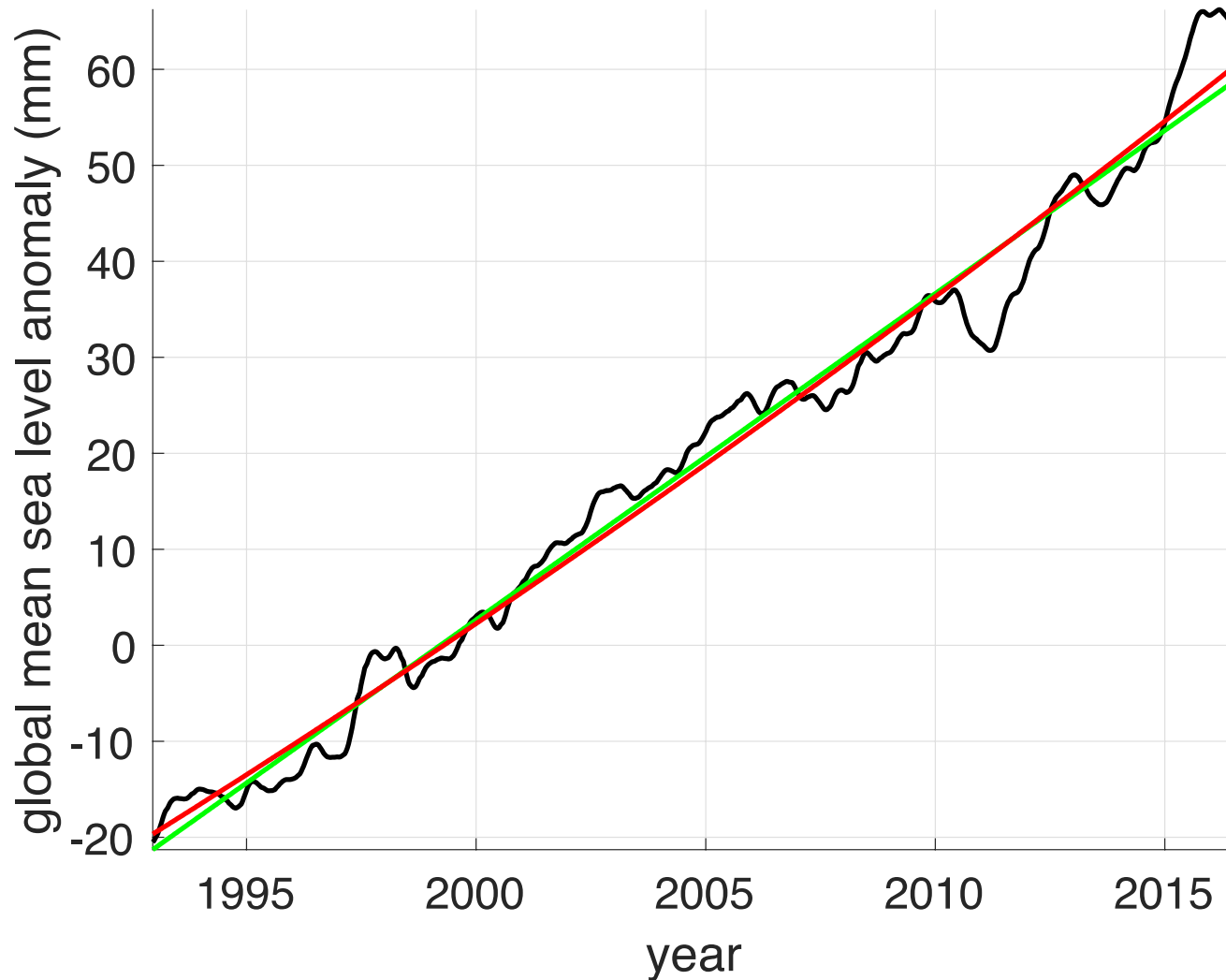
-Steven Koonin, *Wall Street Journal*, April 21st 2017

Is global sea level decelerating?

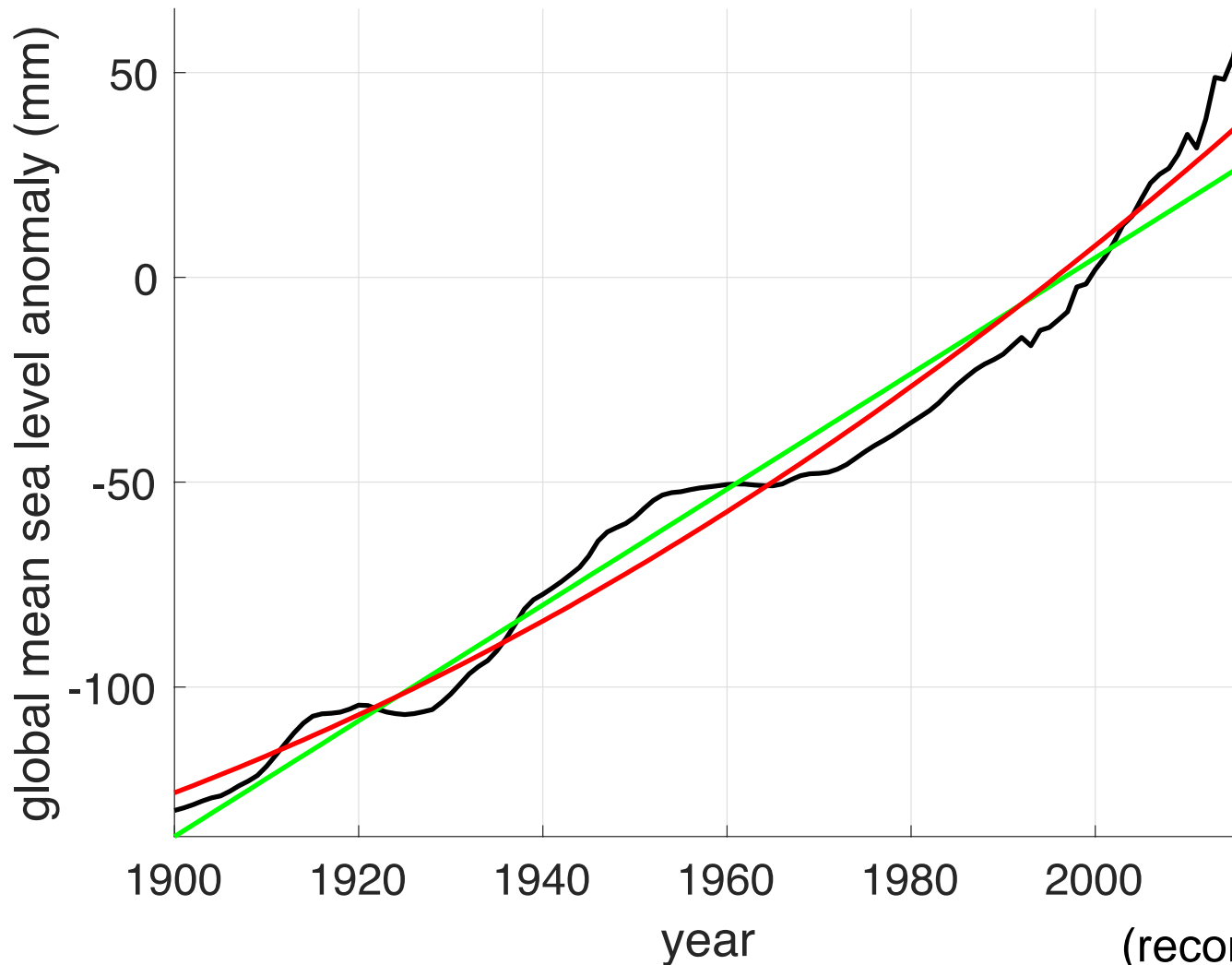


(after Fasullo et al., 2016)

Is global sea level accelerating?



Is global sea level accelerating?



(reconstruction from
Hay et al., 2015)

Conclusions

1. Estimates of equilibrium climate sensitivity based on historical instrumental records are consistent with those derived from paleoclimate records and simulations, once they are properly compared.
2. Rates of sea level rise have accelerated over the last century, suggesting more rapid rise going forward.
3. The climate system is complex, but much of the confusion about its fundamental behavior can be resolved through careful examination of the data.