Ocean Model Uncertainty in Transient Climate Change

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Sources of Uncertainty in Forecasts

- Initial Condition Uncertainty
- Forcing Uncertainty
- Model Uncertainty
  - Structural - which parameterisation?
  - Parameter - what numbers to use in schemes?

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Sampling Ocean Model Uncertainty

- Need ensemble with perturbed parameters
- Expert elicitation to find parameter ranges
- Spin up models (for 500 years)
- Check each model has a “realistic climate”
- Perform increasing CO_2 experiment

7 Ensemble Members

	Isopycnal Diffusivity (m^2s^{-1})	Background Vertical Diffusivity profile ($x10^{-5}$ m^2s^{-1})	Mixed Layer Parameters, fraction, depth (m)	
Standard	1000	1-15	0.7	100
Low ISO	200	1-15	0.7	100
High ISO	2000	1-15	0.7	100
Low VDiff	1000	0.5-4	0.7	100
High VDiff	1000	2-50	0.7	100
Low LAM	1000	1-15	0.3	100
Med LAM	1000	1-15	0.5	50

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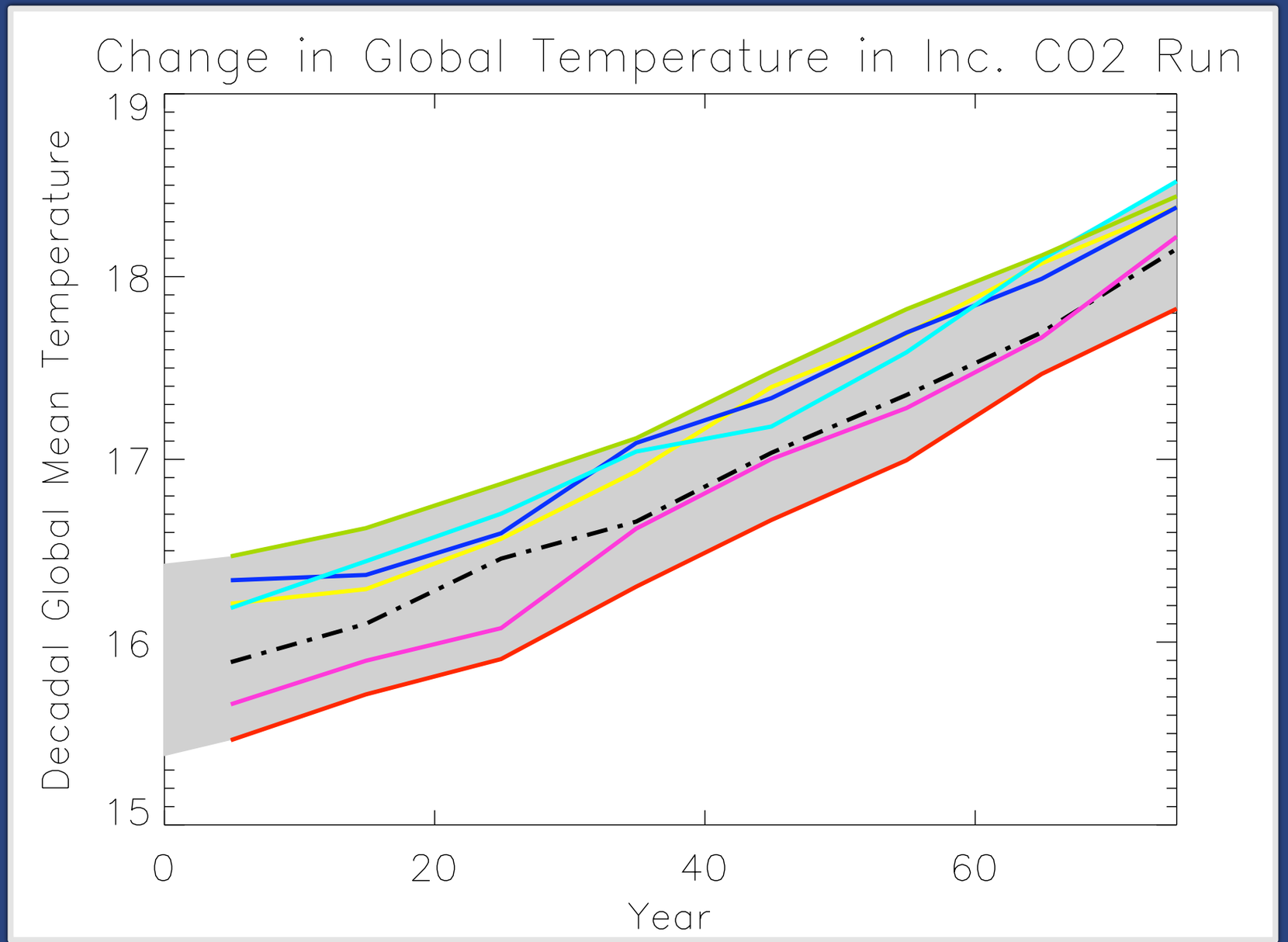
Global Mean Air Temperature



Not all temperature responses are the same

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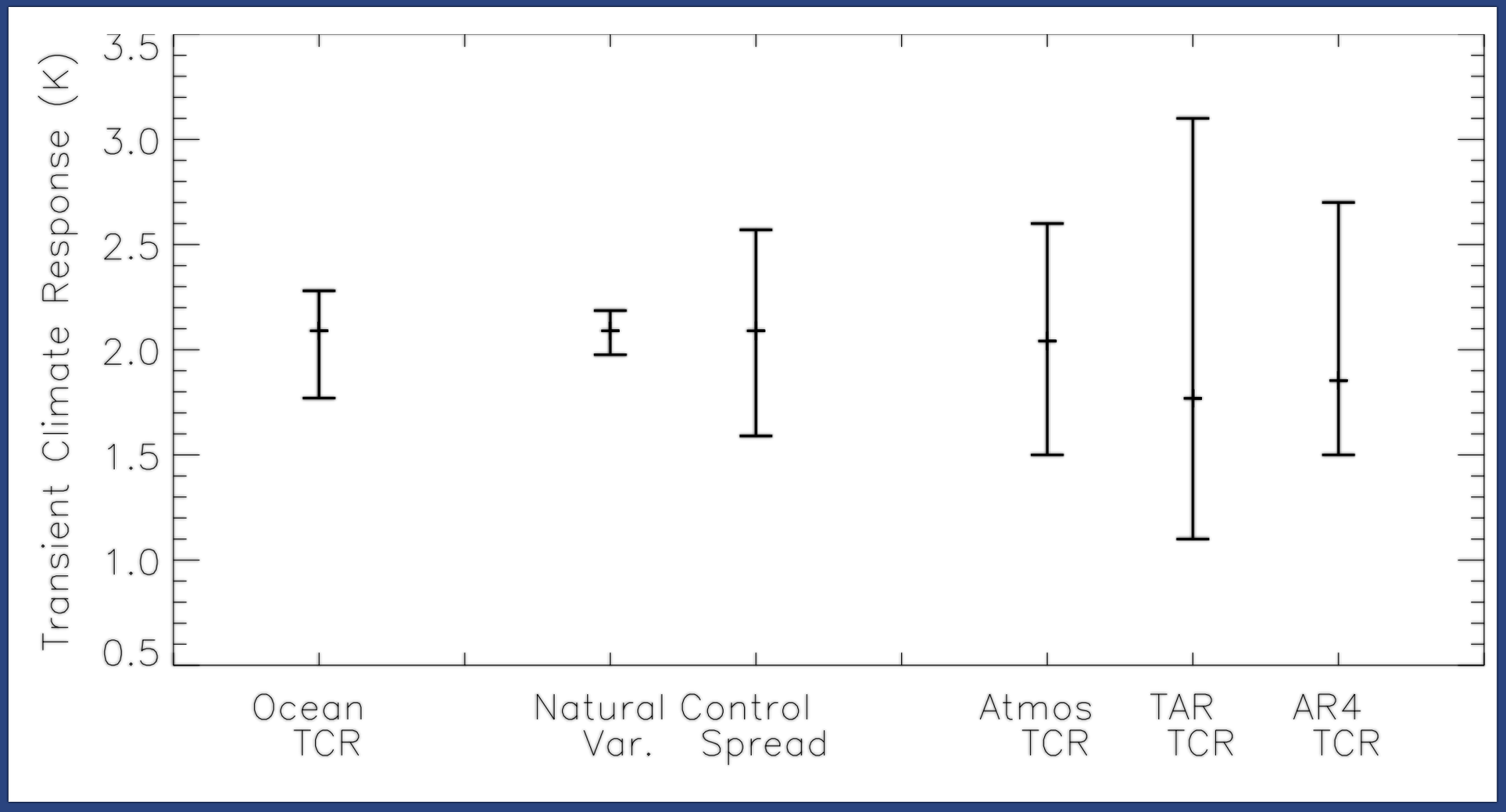
Transient Climate Response

- Difference in 20 yr average g.m. temperature centred on time of doubling of CO_2.



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Conceptual Model

$$Q = (\kappa + \Lambda)\Delta T$$

- Q is the imposed radiative forcing
- ΔT is the global mean temperature change
- Λ is the climate feedback parameter
  - related to the climate sensitivity
  - measure of equilibrium warming
- κ is the ocean heat uptake efficiency.
  - fraction of warming realised

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Hypothetical TCR

- Diagnose κ and Λ for ensemble members
- Calculate temperature changes by considering the spread in each property in isolation

	All Variations of Λ and κ	*With standard model's Λ*	*With standard model's κ*
Ocean	*1.8-2.3*	*2.0-2.2*	*1.9-2.3*
Atmosphere	*1.7-2.8*	*2.0-2.2*	*1.6-2.6*

- Find that changes in Λ (climate sensitivity) are more important than uncertainty in the rate of ocean heat uptake.

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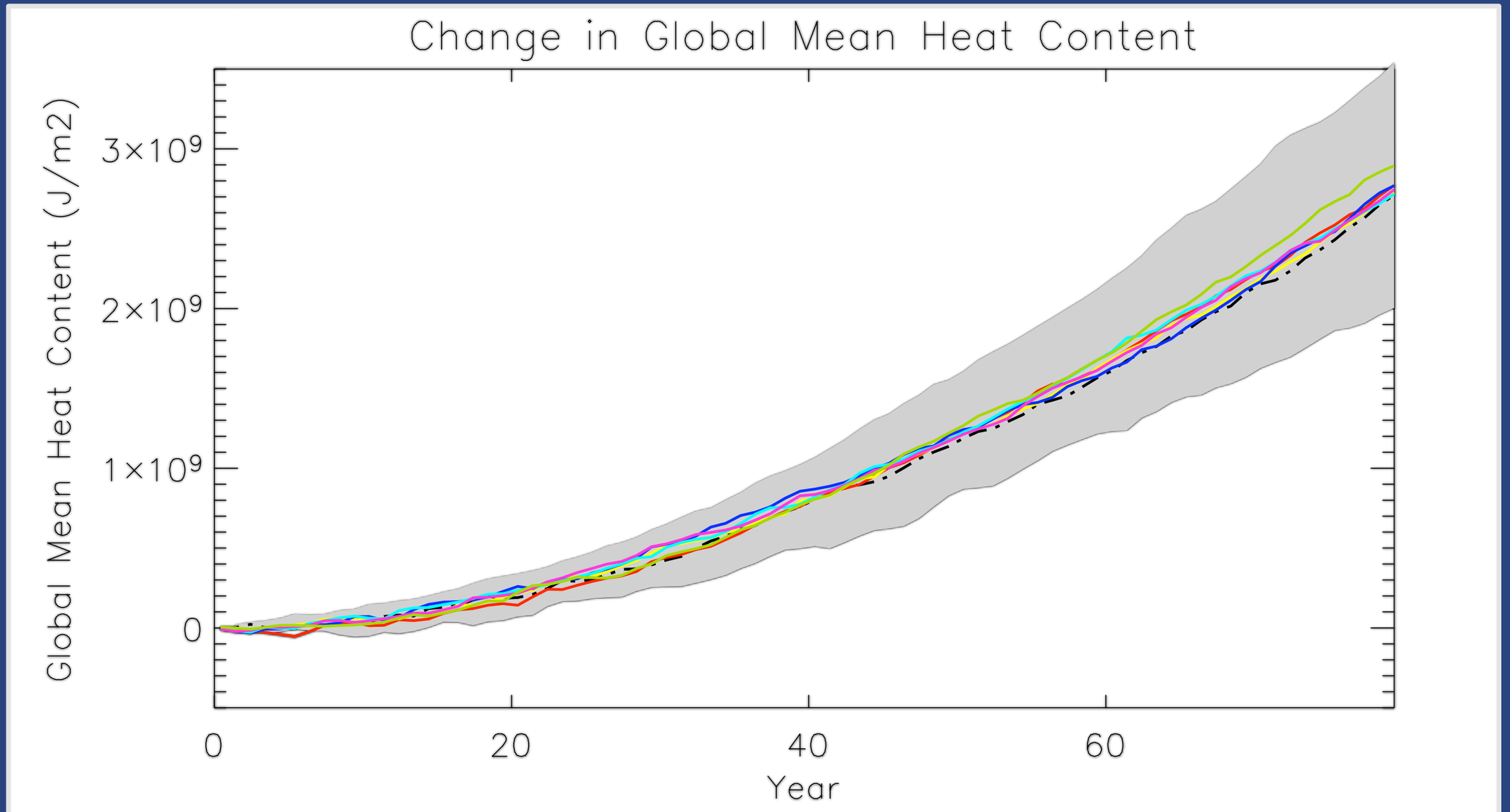
Ocean Heat Uptake



Shaded area is spread from atmospheric model uncertainty

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Caveats

- *It could be that the ensemble does not represent uncertainty:*
  - *Ranges are too conservative*
  - *Wrong parameters chosen*
  - *Single perturbations hide non-linearities*
- *Looking only at the global mean is masking some important regional differences.*

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Conclusion

- The ocean parameter uncertainty has been investigated.
- Its effects on the global mean temperature response of transient climate are small.
- The spread that does exist seems to come from changes in the equilibrium response not the rate of ocean heat uptake.
- Further work is needed to understand why the ocean physics has only a small impact on global mean ocean heat uptake.

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