The relative roles of feedbacks, forcing, and effective heat capacity for higher transient warming in CMIP6 compared to CMIP5

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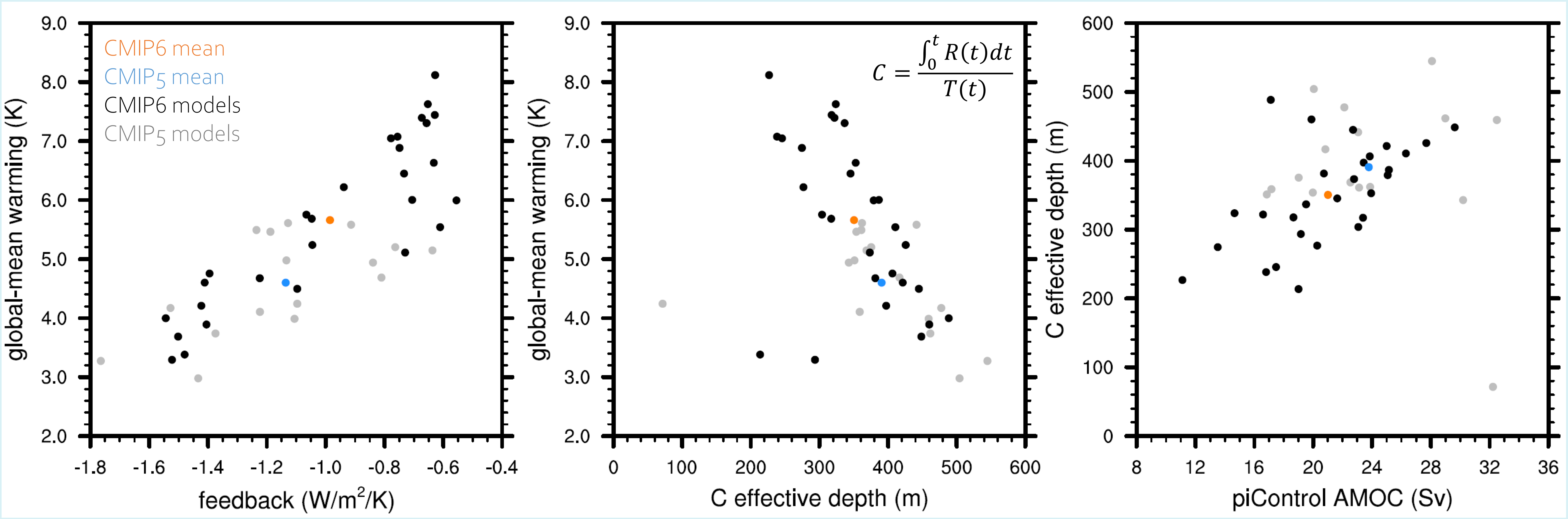
Motivation

- The mean equilibrium climate sensitivity (ECS) is larger in CMIP6 than CMIP5 primarily due to less-negative **climate feedbacks** (Zelinka et al., 2020)
- Larger **radiative forcing** in models with less-negative feedbacks supports a higher range of ECS values for CMIP6 models than CMIP5 models
- Forcing and feedbacks contribute most to uncertainty in transient warming in GCMs; **ocean thermal inertia** contributes less uncertainty (Geoffroy et al., 2012; Lutsko and Popp, 2019)
- *Key question: What are the relative roles of feedbacks, forcing, and effective heat capacity for larger transient warming in CMIP6 vs. CMIP5?*

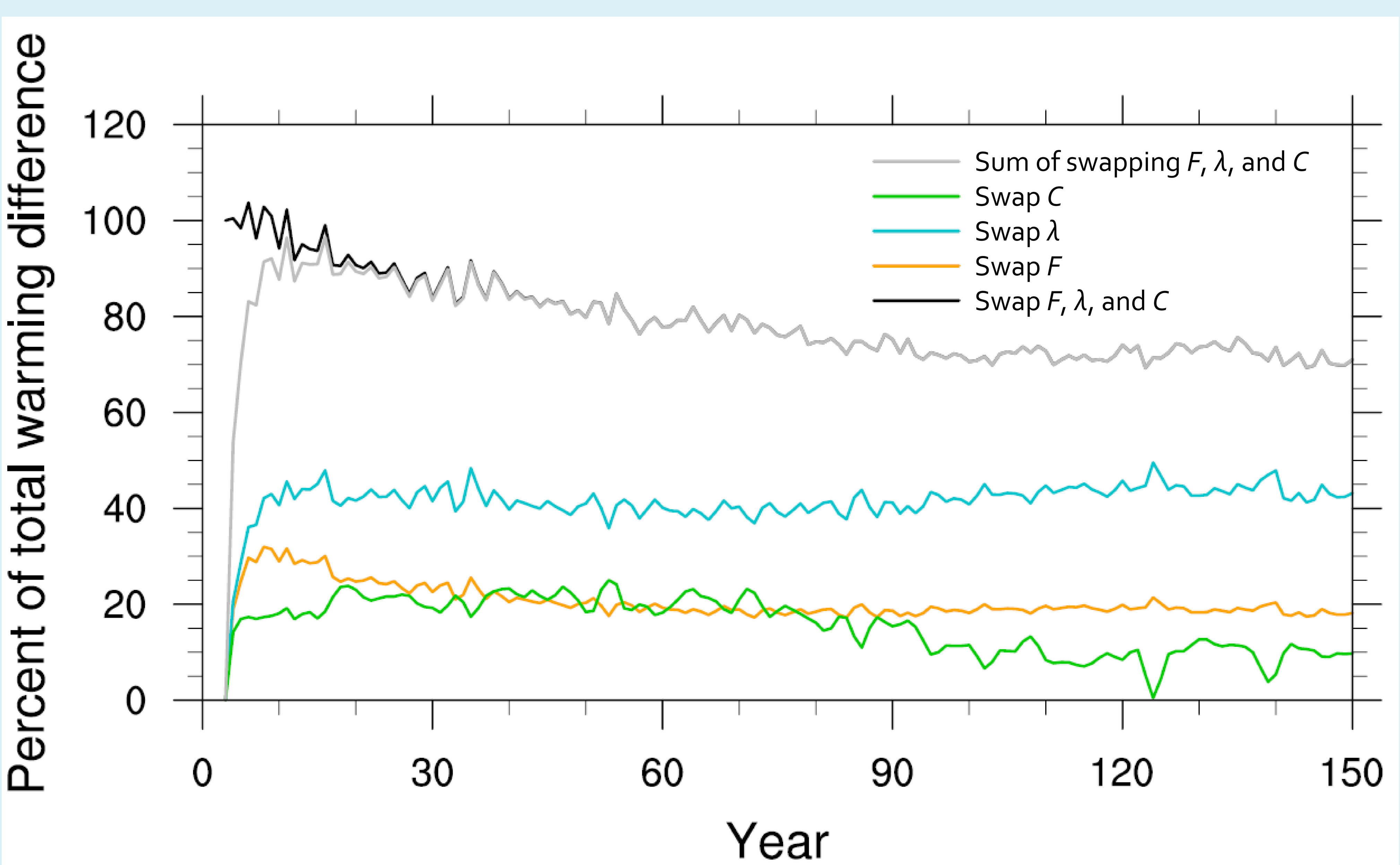
- Global-mean warming and effective depth are shown for 30-year averages surrounding year-100 in *abrupt-4xCO2* vs. *piControl* experiments; *piControl* AMOC index is also centered on year 100; global feedback is calculated by regression over the full 150-year time series.



- Larger global-mean warming in CMIP6 than CMIP5 is correlated both with less-negative feedbacks and reduced ocean effective heat capacity
- The direction of causality between ocean effective depth and global-mean warming is unclear

- Possible that a weaker preindustrial AMOC in CMIP6 supports a reduced effective depth and larger warming

Warming Reconstructions



- Use Gregory regression to calculate effective radiative forcing (F) and feedback (λ) for 150-year *abrupt-4xCO2* vs. *piControl* experiments
- Individually swap ensemble-mean effective radiative forcing (*F*), feedback (*λ*), and effective ocean heat capacity (*C(t)*) for CMIP5 and CMIP6 to reconstruct T(t)

$$\frac{dT(t)}{dt} = \frac{-T(t)\frac{dC(t)}{dt} + F - \lambda T}{C(t)}$$

- ***F* and *C(t)* combined contribute as much as *λ* to increased warming in CMIP6 over the first half of these 150-year abrupt-4xCO2 experiments**

Future Work

- What is the role of covariances between *F*, *λ*, and *C* for transient warming differences between CMIP5 and CMIP6?
- What is the effect of individually swapping CMIP5 and 6 parameters in a 2-layer energy balance model?
- Why is C generally smaller in CMIP6 models, and what is the role of the mean-state AMOC?

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