Analyzing the Unforced Pattern Effect Using a Modified Energy Balance Framework

Motivation

Evaluating the model performance is essential to understand the reliability of model-estimated climate feedbacks and climate sensitivity.

Climate Feedback: 
\[ \lambda = \frac{\Delta R - \Delta F}{\Delta T_a} \]

However, there are several issues in the traditional energy balance framework, including the pattern effect.

Dessler et al. (2018): 
\[ \theta = \frac{\Delta R - \Delta F}{\Delta T_a} \]

\( \Delta T_a \) is the 500hPa tropical temperature.

The goal of this poster is to analyze the short-term climate feedbacks in models using two frameworks, especially focus on the impacts of unforced pattern effect.

Data

Observation:
- CERES EBAF Ed4.1 and ERA5 reanalysis
- March 2000 to October 2017

Model:
- 26 models in CMIP6 pre-industrial control run
- Divided into several 18-year segments to be consistent with the observations
- For each model, there are ~27 estimates of feedback from individual 18-year segments.
- Abrupt4xCO2 runs are also analyzed

Climate feedback decomposition:
- Radiative kernels from Huang et al. (2017)
- Feedback is estimated by regressing TOA flux anomaly against global average surface temperature anomaly

Sources of uncertainty in model

- Structure difference: The differences in model parameterizations (±1.645*standard deviation)
- Unforced pattern effect: The pattern effect due to unforced variability (avg of model spread, excluding max and min values)
- Combined uncertainty: (5% – 95% range of all 18-year feedbacks from all models)

Model evaluation

Quantify the model performance by the differences between observed and modelled feedbacks:
\[ TE = \frac{1}{N} \sum (\lambda_{i, \text{obs}} - \lambda_{i, \text{model}})^2 \]

- CMIP6 ensemble average TE is 28% smaller in \( \theta \) framework
- 70% of the models (18 of 26) have smaller TE value in \( \theta \) framework

Concluding remarks

- Unforced pattern effect is not negligible. Both uncertainties are important when comparing to observed short-term climate feedbacks
- The modified framework provides a more robust way of comparing short-term climate feedbacks, with both smaller structural differences and smaller unforced pattern effect.

Check more information at:

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