Interpreting Differences in Radiative Feedbacks from Aerosols Versus Greenhouse Gases

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Abstract

Aerosols and greenhouse gases (GHGs) exhibit different forcing patterns, with GHGs causing more uniform forcing that only drops off gently from the tropics whilst aerosol forcing is focused in the northern hemisphere (NH) extratropics.

Data

- CMIP6 data from ESGF
- AGCM experiments: piClim-[histaer,histghg,histall]
- AOGCM experiments: hist-aer, hist-GHG, historical
- 7 models: CanESM5, CNRM-CM6-1, GISS-E2-1-G, HadGEM3-GC31-LL, IPSL-CM6A-LR, MIROC6, NorESM2-LM
- Monthly data over years 1850–2014
- Extra: HadAM3 (and HadSM3) simulations of tropical and hemispheric extra-tropical forcing

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3. Differences in feedbacks

- Response calculated as difference of AOGCM vs AGCM output, to remove adjustments from results
- Convention: less -ve feedback parameter α means more amplified temperature change
- Stability, measured as estimated inversion strength over 50S–50N oceans, used as measure
- Model-by-model variation in agent-dependent feedbacks
- More consistent picture in stability: aerosol causes less positive stability change per unit surface warming
- MMM shows more amplifying feedbacks for aerosol than GHG, consistent with MMM MMM MMM MMM MMM MMM MMM MMM

4. Relating differences in feedbacks to stability changes

- Radiative feedbacks related to dS/dT differences in CMIP6 MMM, explaining differences across hist-aer, hist-GHG, and historical experiments
- Model spread large, but model differences are well-correlated in feedbacks and dS/dT
- HadSM3/HadAM3 experiments also follow trend

5. Explaining differences in stability change

- Aerosol and NH extratropical forcing both cause shallow temperature change in NH compared to GHGs (with the opposite effect in the historical)
- By contrast, tropical forcing reproduces the air temperature change patterns of GHGs, even more pronounced
- This is related to deep convective regions being present in tropical regions, whilst these are absent in extra-tropics
- Thus, NH skew of aerosol forcing provides negative dS/dT contribution that explains the overall less positive dS/dT of aerosol vs GHGs

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