

Climate models disagree on the sign of total radiative feedback in the Arctic

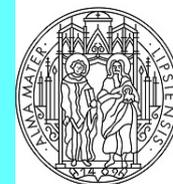
PAMIP workshop, Dartington Hall, 27.6.2019

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Marc Salzmann & Johannes Quaas

University Leipzig
*Arizona State University



Arctic Amplification:
Climate Relevant Atmospheric and Surface Processes
and Feedback Mechanisms (AC)³



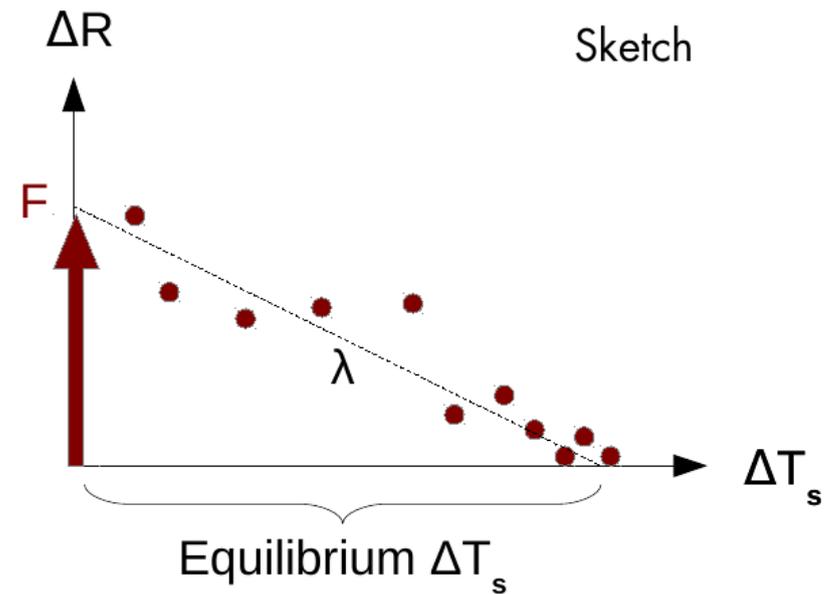
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Feedback computation

- for 13 CMIP5 models
- using Partial Radiative Perturbation (PRP) method
- with model inputs from preindustrial (pictrl) and forced (abrupt 4xCO2) simulations
- using standalone radiative transfer model (RRTMG/ECHAM6)

$$\Delta R = F_{\text{CO}_2} + \lambda \Delta T_s$$

$$\lambda = \lambda_A + \lambda_T + \lambda_C + \lambda_{\text{WV}}$$



Feedback computation

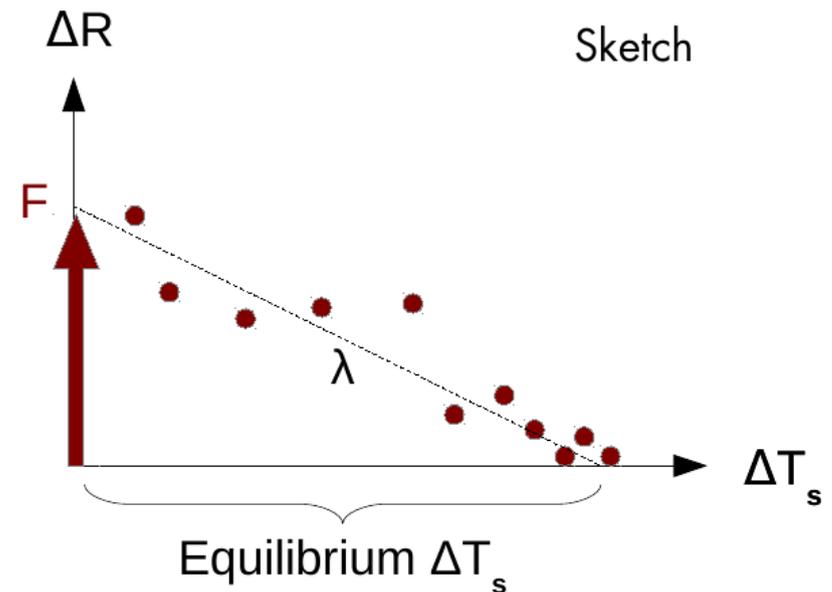
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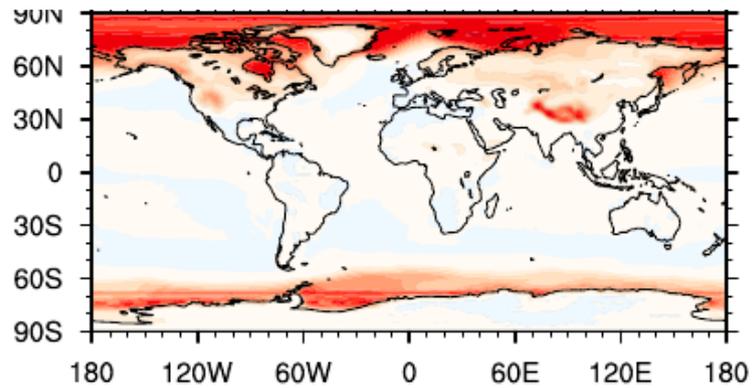
$$\lambda = \lambda_A + \lambda_T + \lambda_C + \lambda_{\text{WV}}$$

$$\lambda_x = \left[\frac{\partial R}{\partial x} \right]_y \frac{dx}{dT_s}$$

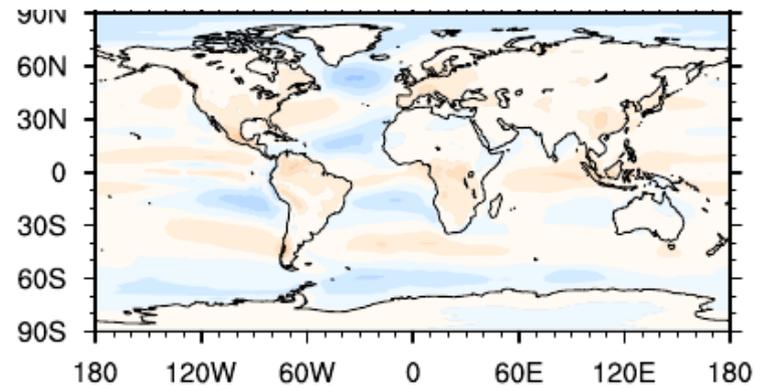
$$\lambda_x = \frac{\Delta_x R}{\Delta x} \frac{\Delta x}{\Delta T_s} = \frac{R(x_{\text{ptrb}}, y_{\text{ctrl}}) - R(x_{\text{ctrl}}, y_{\text{ctrl}})}{T_{s,\text{ptrb}} - T_{s,\text{ctrl}}}$$



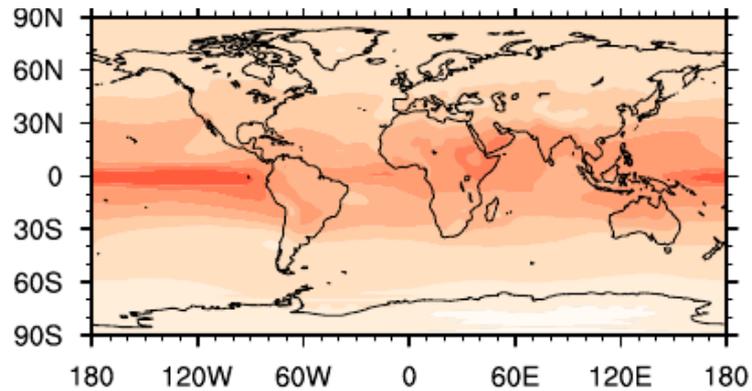
Surface albedo feedback



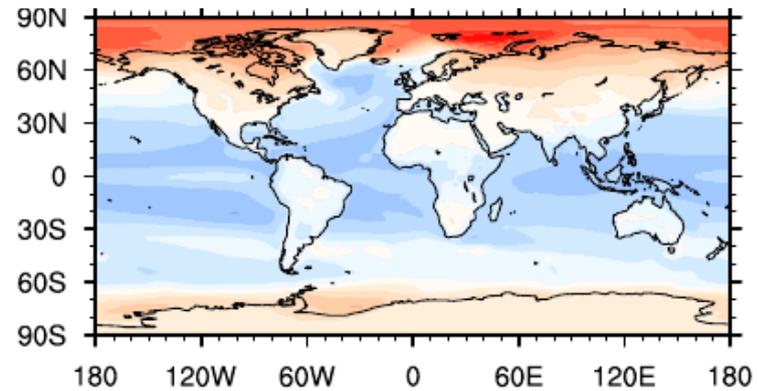
Net cloud feedback



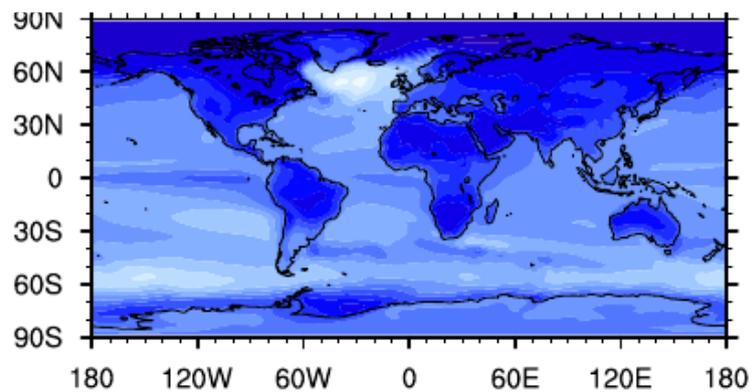
Water vapour feedback



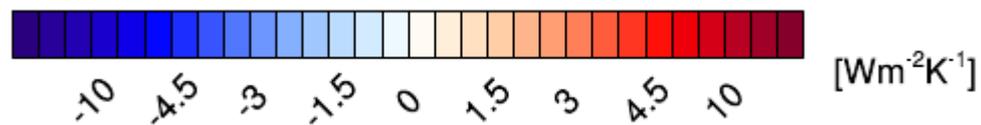
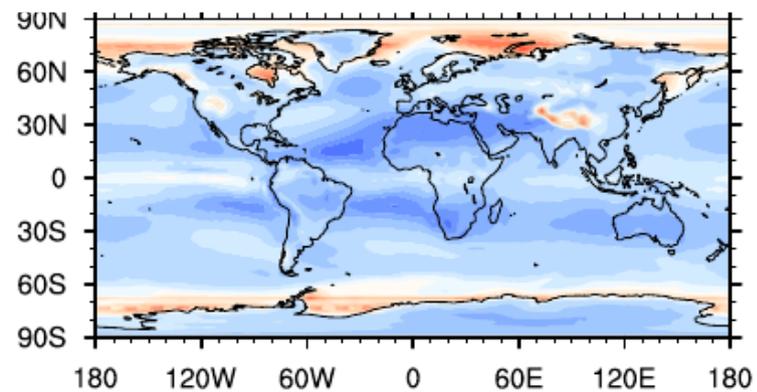
Lapse rate feedback



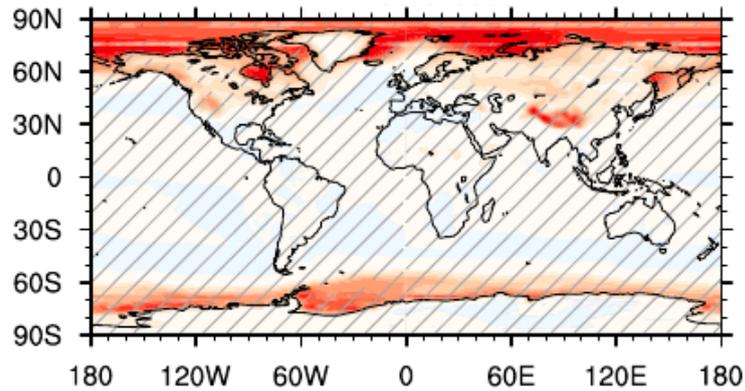
Planck feedback



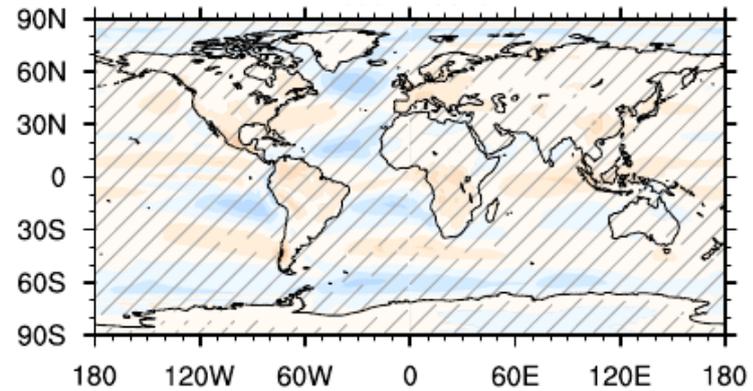
Total feedback



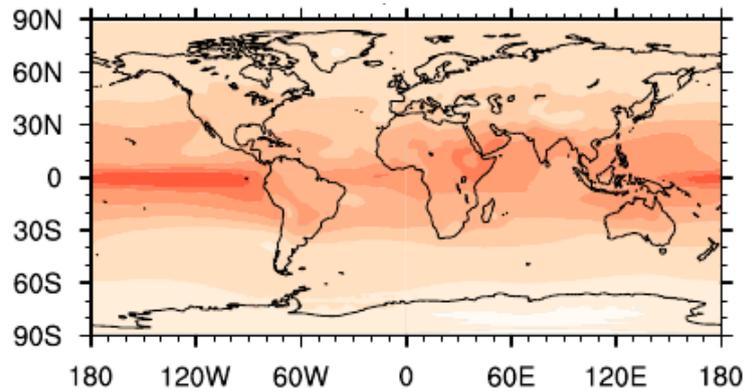
Surface albedo feedback



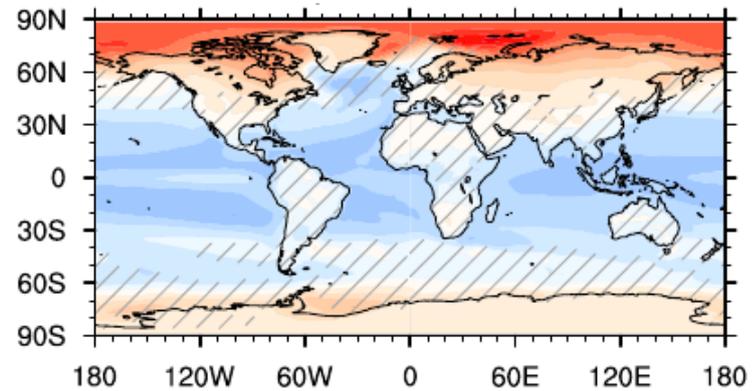
Net cloud feedback



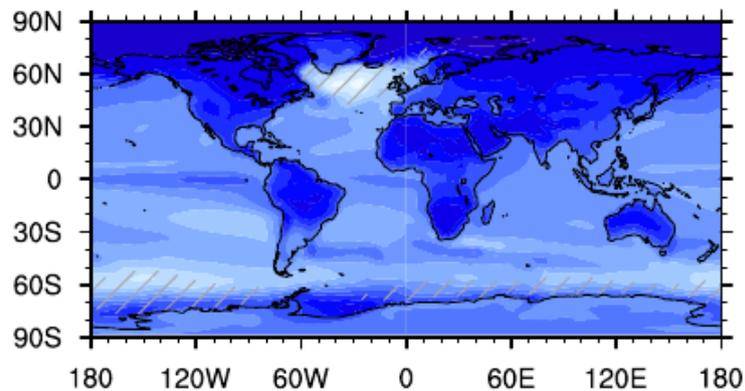
Water vapour feedback



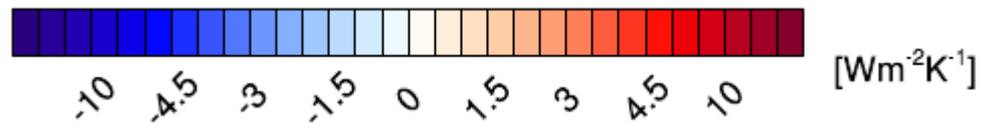
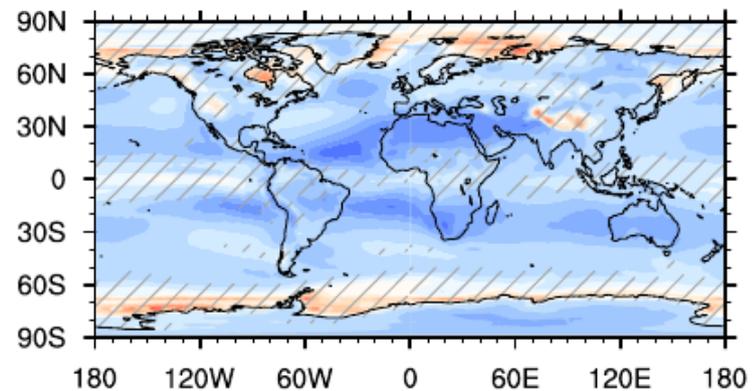
Lapse rate feedback



Planck feedback

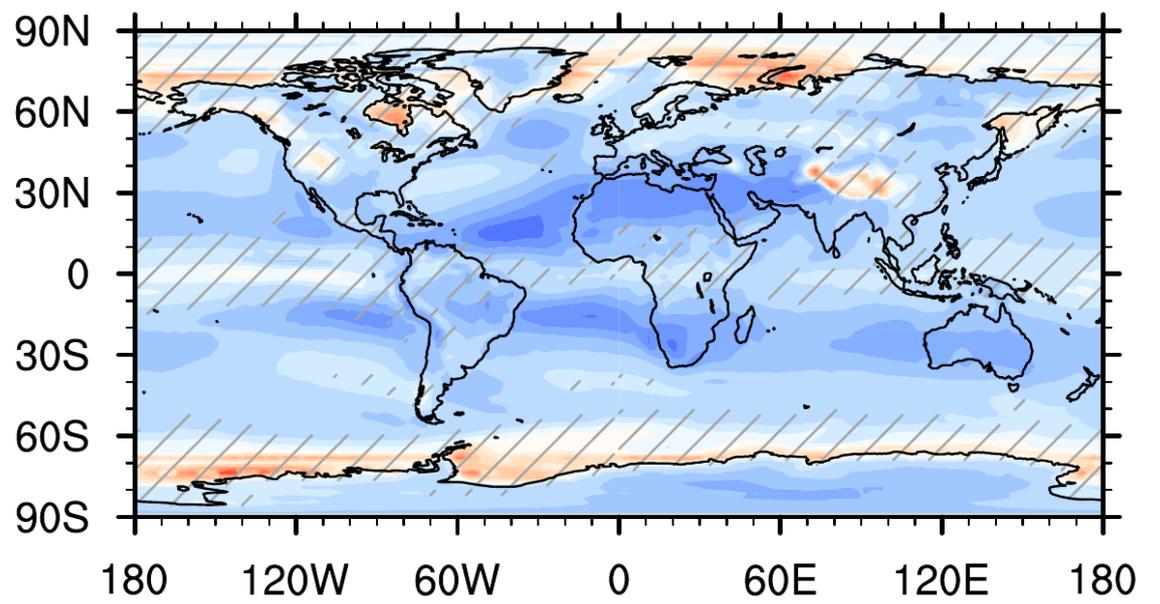


Total feedback



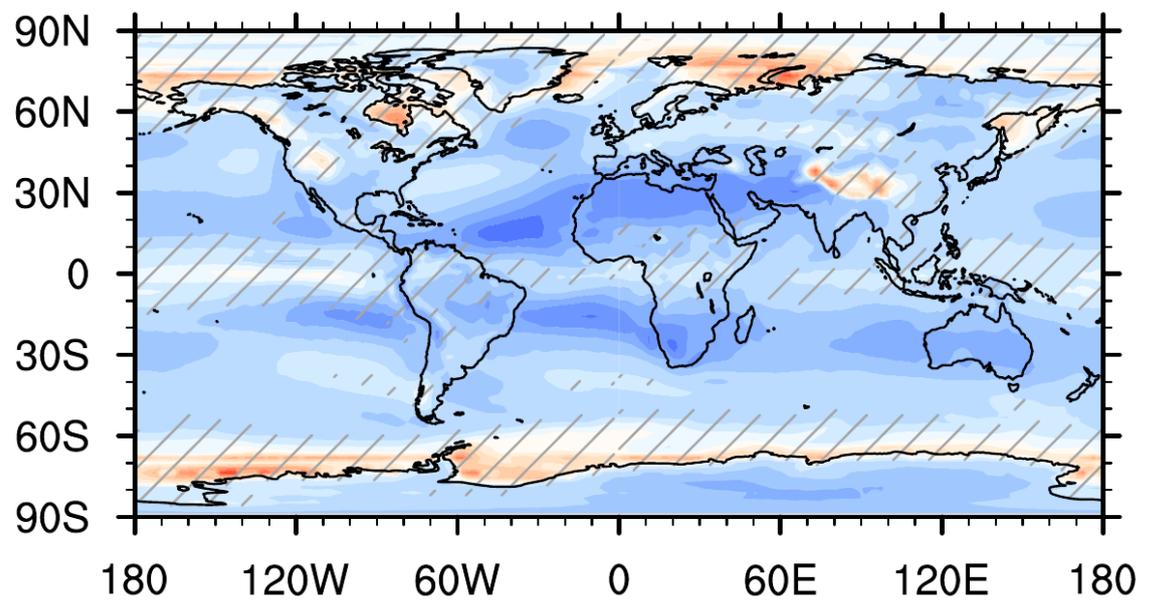
Is the Arctic a local runaway system?

Hatched: Local net feedbacks are insignificant (< 90% show the same sign as multimodel mean)

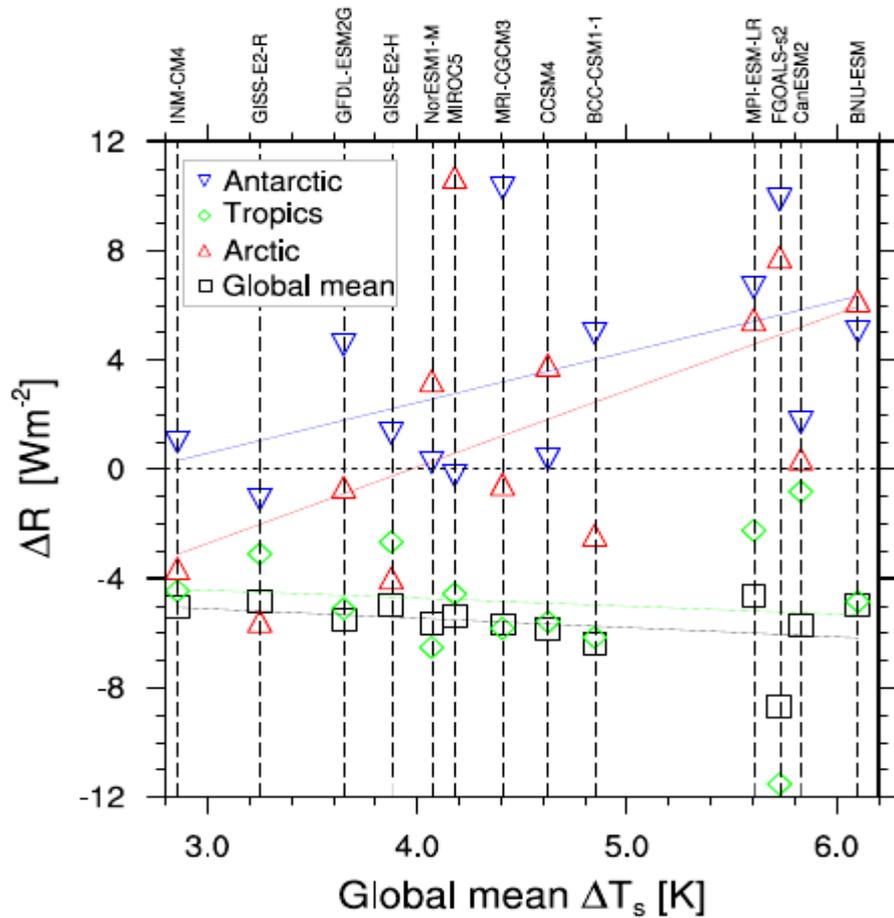


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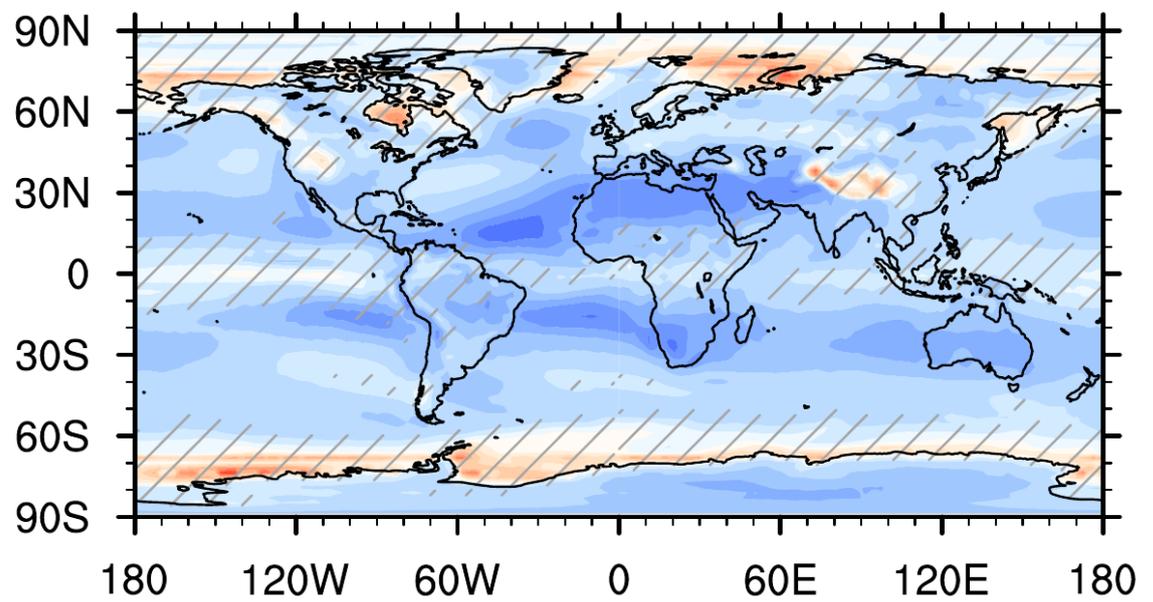


Regional area-weighted means:

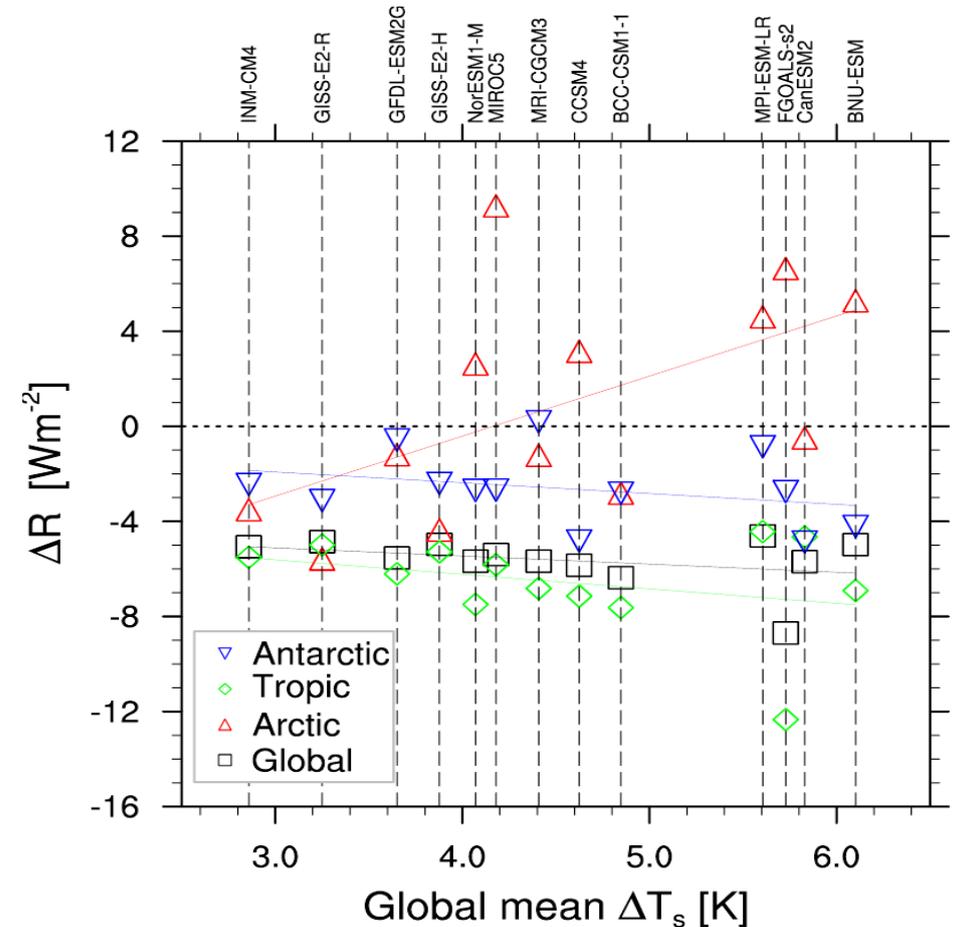
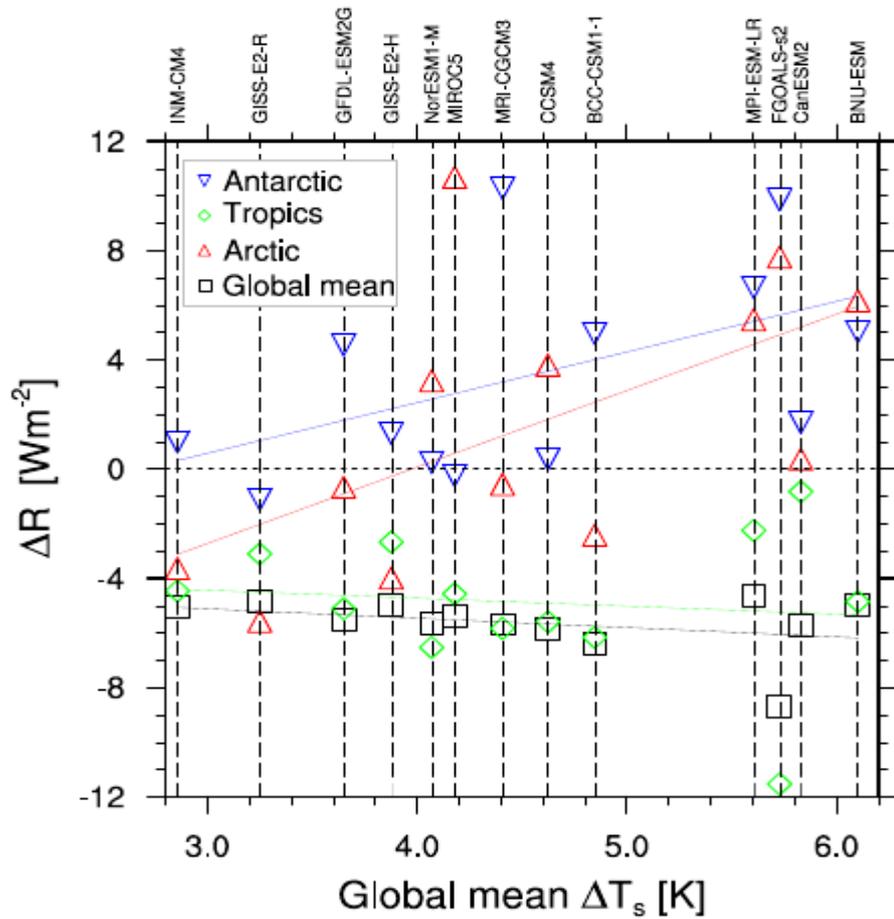


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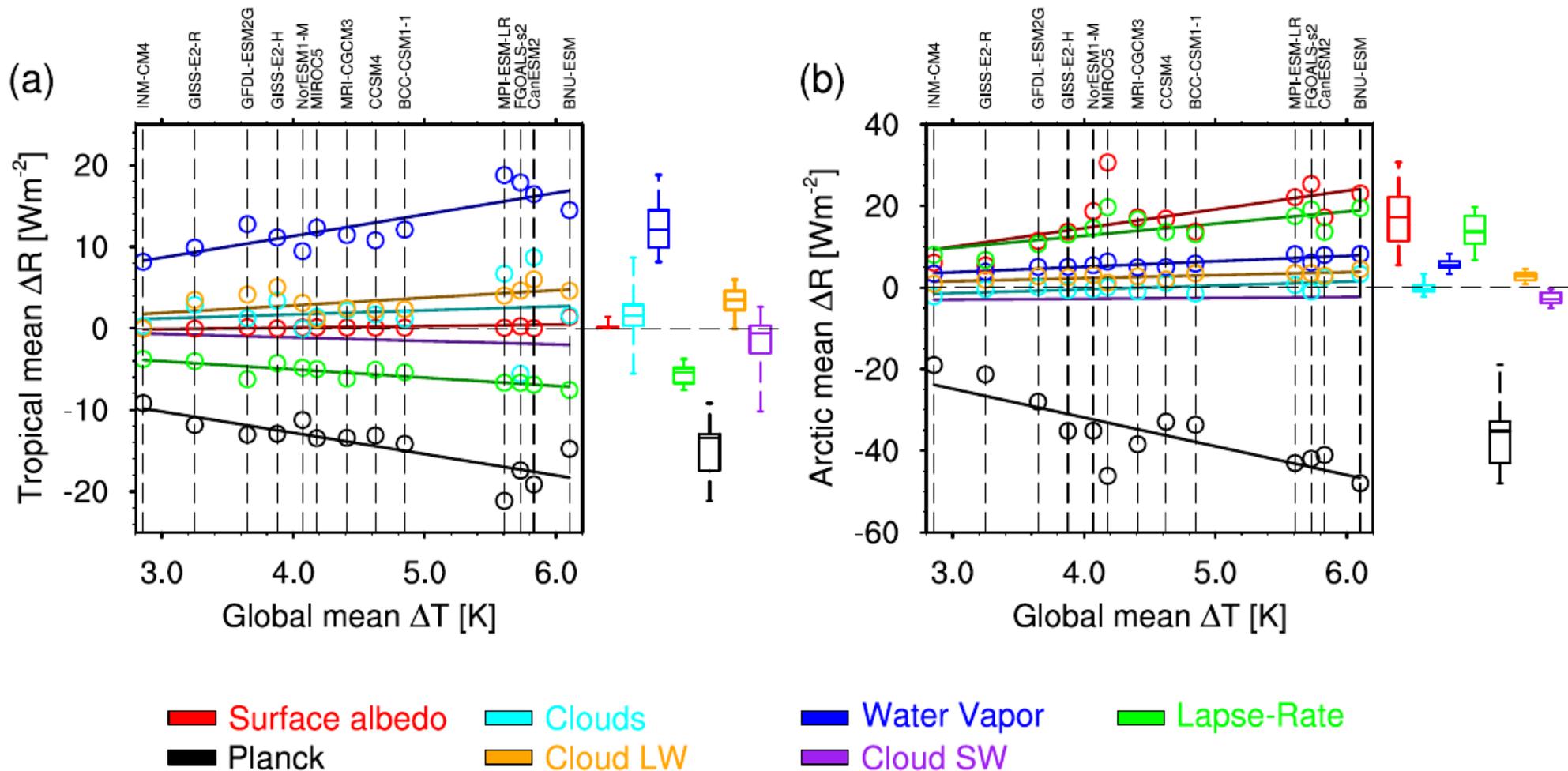
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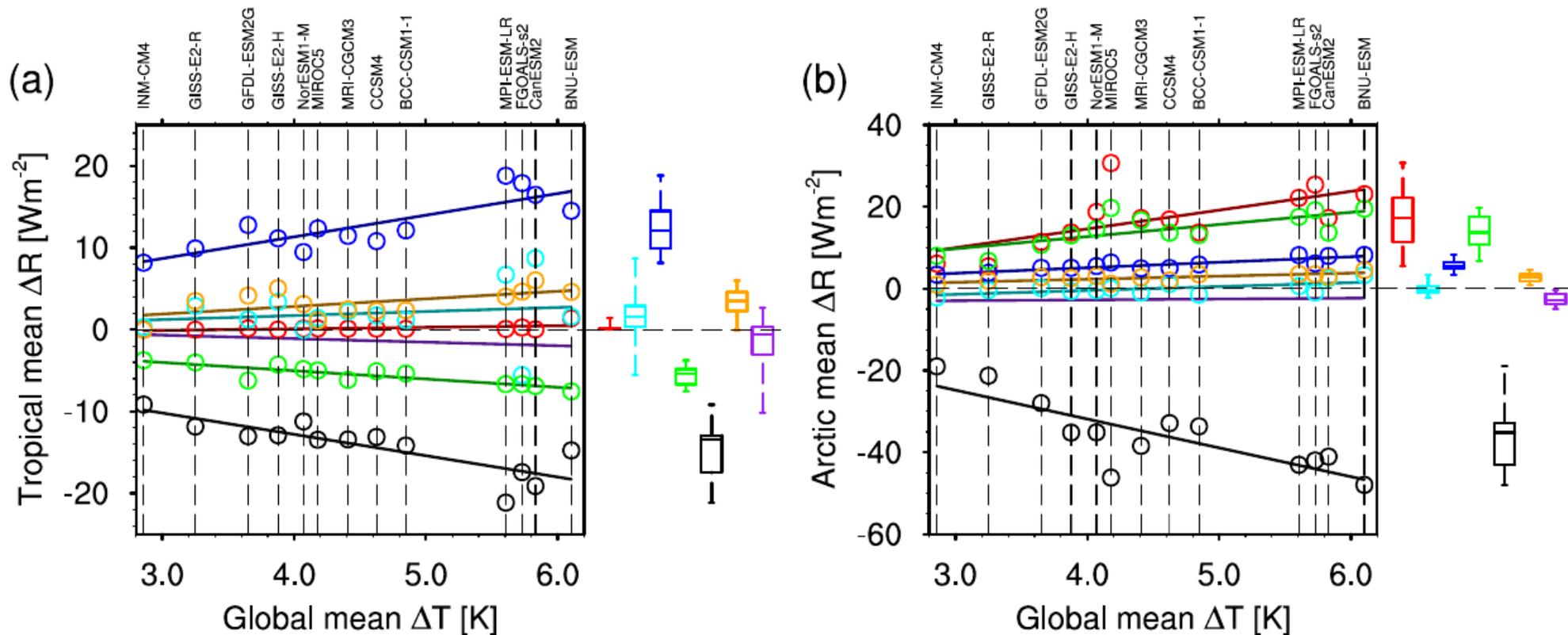
Regional area-weighted means:



Intercomparison of regional feedback uncertainties



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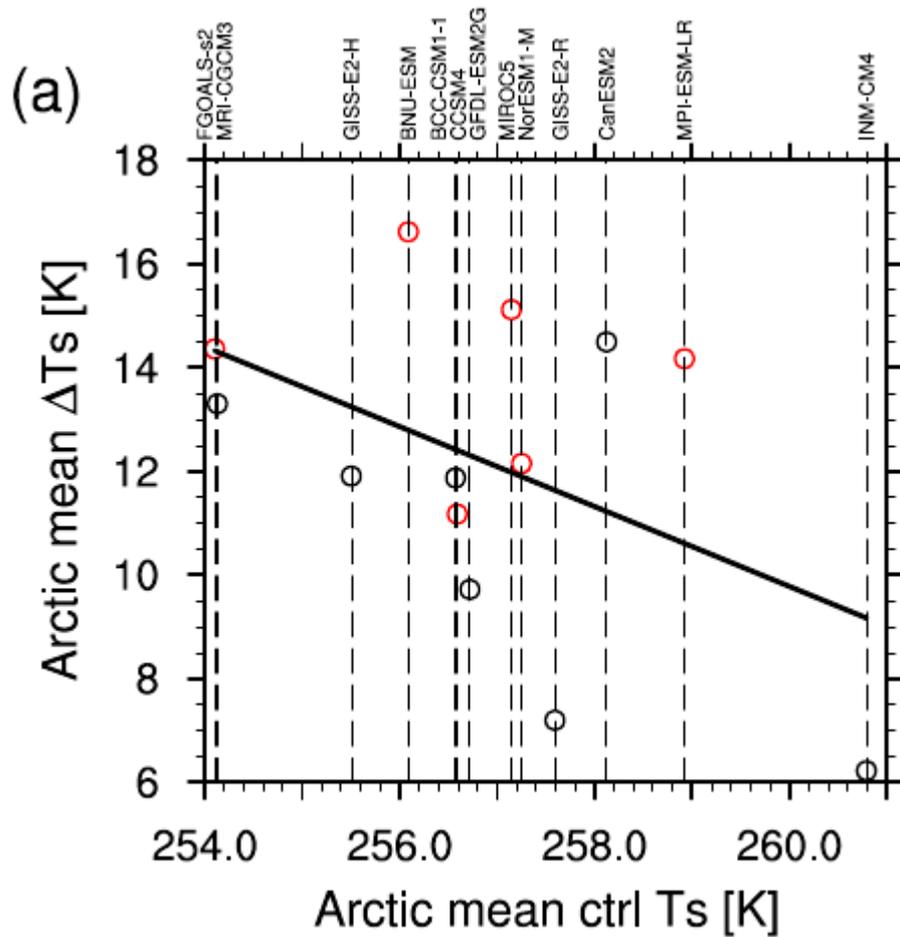


- Surface albedo
- Clouds
- Water Vapor
- Lapse-Rate
- Planck
- Cloud LW
- Cloud SW

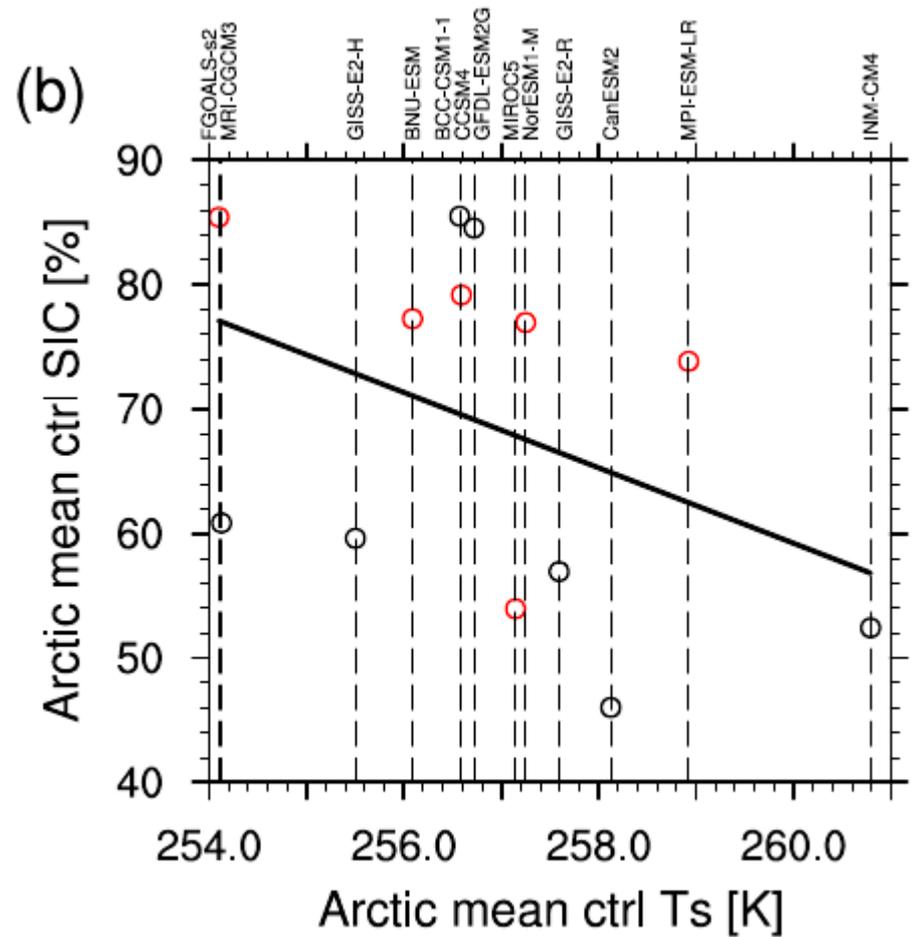
$$\lambda_{\text{PL,polar}} = \frac{\Delta R_{\text{PL,polar}}}{\Delta T_{\text{global}}} = -\frac{\Delta T_{\text{polar}}}{\Delta T_{\text{global}}} 4\epsilon\sigma T_{\text{ctrl,polar}}^3$$

Dependance on base state?

Possible impact from model divergence in preindustrial climate



Red: positive Arctic feedbacks



Black: negative Arctic feedbacks

Take home notes

1. Climate models disagree on sign of Arctic total feedback:
 - 7 out of 13 models show local runaway effect
 - radiation balance must be achieved from decreased heat transports
 - in 6 models local feedbacks are negative
 - suffice to locally bring back system to new balance without much change of meridional transports
2. Model uncertainty not random/noise, but temperature dependent:
 - runaway effects for strong warming
 - main contributions from albedo and Planck feedbacks
3. Impact of preindustrial model uncertainty? How to constrain SST and SIC fields?

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