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

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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)

\[ \Delta R = F_{CO_2} + \lambda \Delta T_s \]

\[ \lambda = \lambda_A + \lambda_T + \lambda_C + \lambda_{WV} \]
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\[ \lambda_x = \left[ \frac{\partial R}{\partial x} \right]_y \frac{dx}{dT_s} \]

\[ \lambda_x = \frac{\Delta x R}{\Delta x} \frac{\Delta x}{\Delta T_s} = \frac{R(x_{ptrb}, y_{ctrl}) - R(x_{ctrl}, y_{ctrl})}{T_{s,ptrb} - T_{s,ctrl}} \]
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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Regional area-weighted means:
Intercomparison of regional feedback uncertainties

(a) Tropical mean ΔR [Wm⁻²]

(b) Arctic mean ΔR [Wm⁻²]
Intercomparison of regional feedback uncertainties

Dependance on base state?

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