CERES Joint Science Team Meeting –

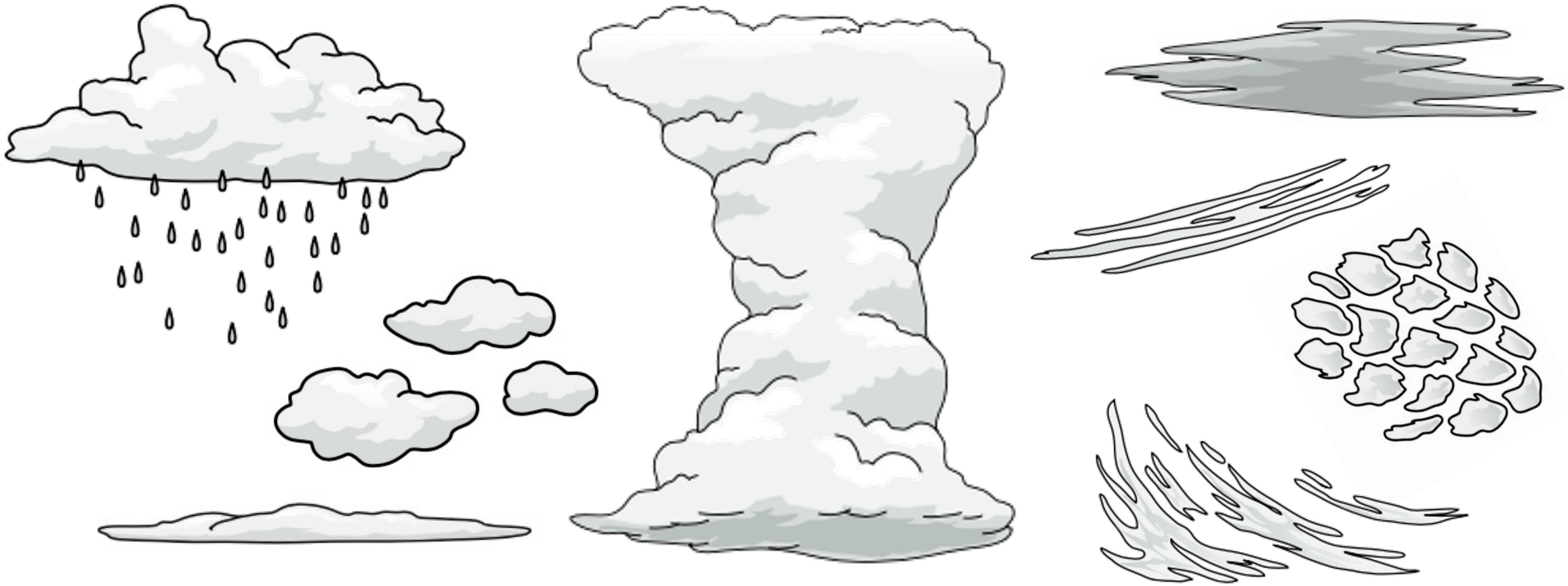
The Pattern Effect on Cloud feedback in CERES

Li-Wei Chao, Jacob Muller, Andrew Dessler

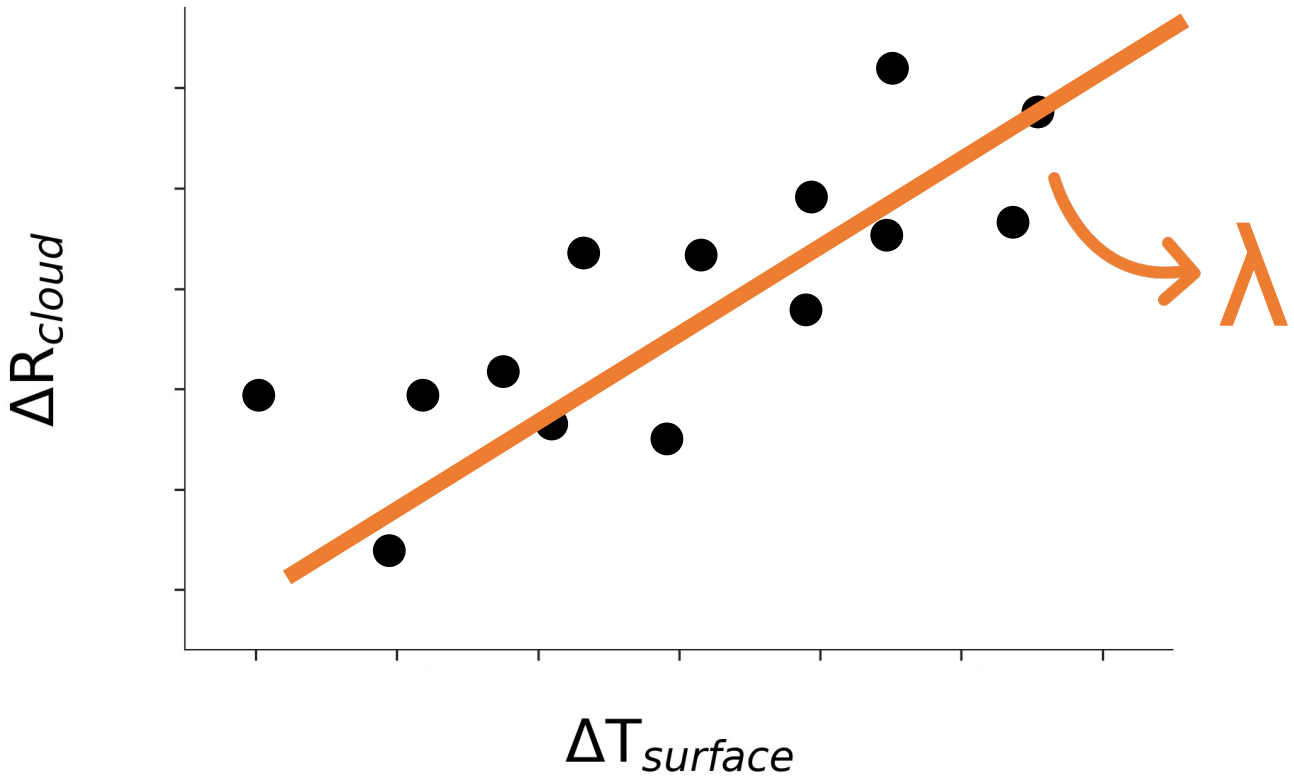
Department of Atmospheric Sciences, Texas A&M University

Cloud:

Changes in clouds can amplify or dampen the global warming



Cloud Feedback



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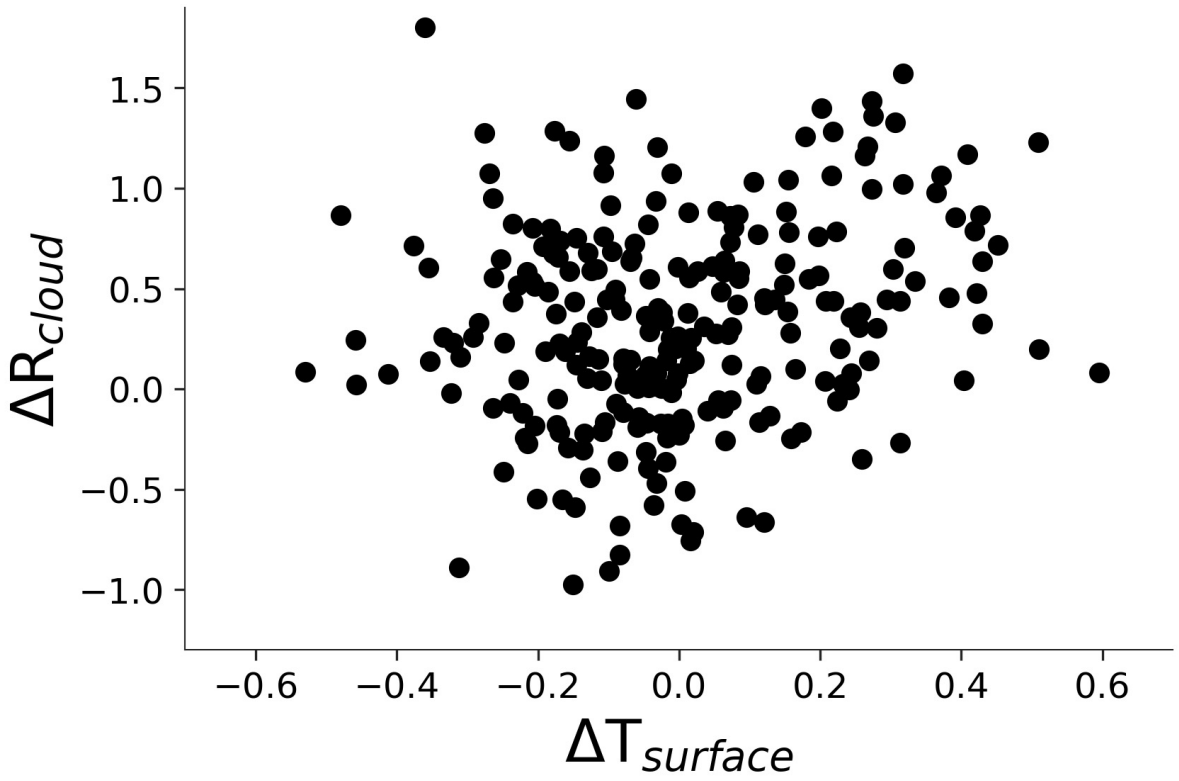


ΔR_{cloud}:

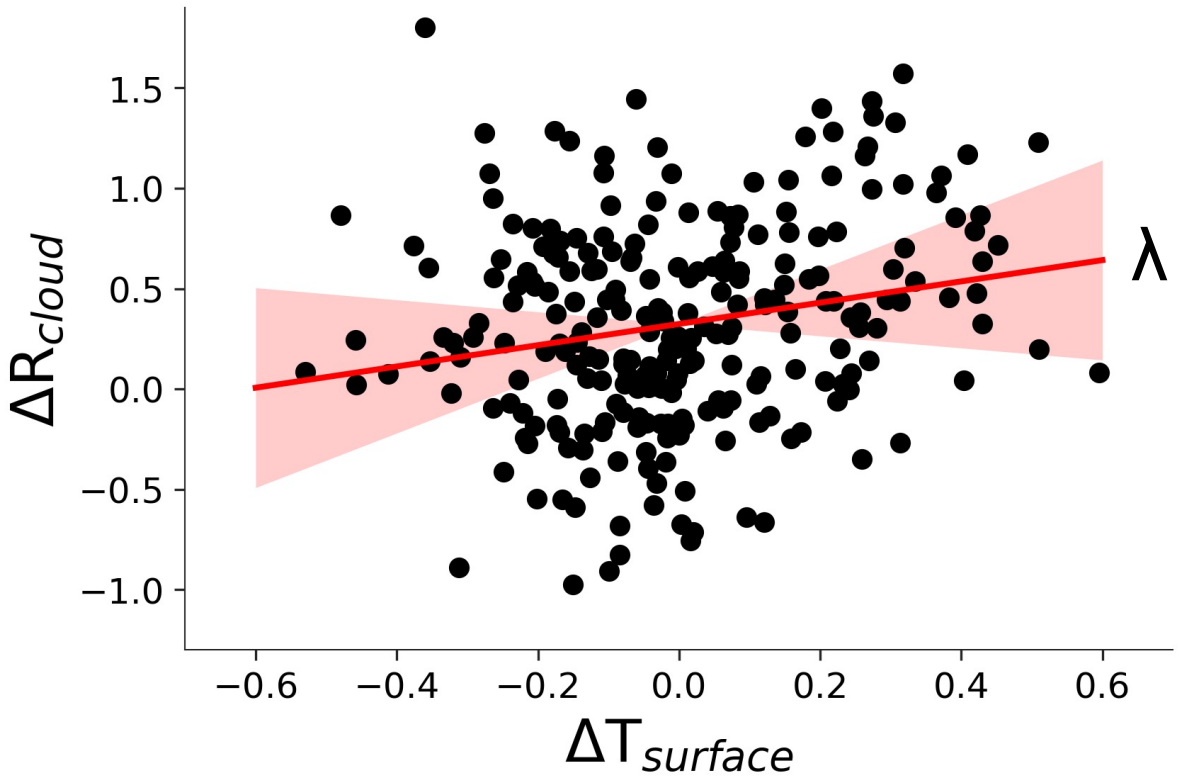
- CERES EBAF Ed 4.1
- CRE = All-sky flux minus clear-sky flux
- adjusted for cloud masking on non-cloud feedbacks using radiative kernels

$\Delta T_{surface}$:

- ERA5 reanalysis

Time:
2000/03-2020/12

Cloud Feedback

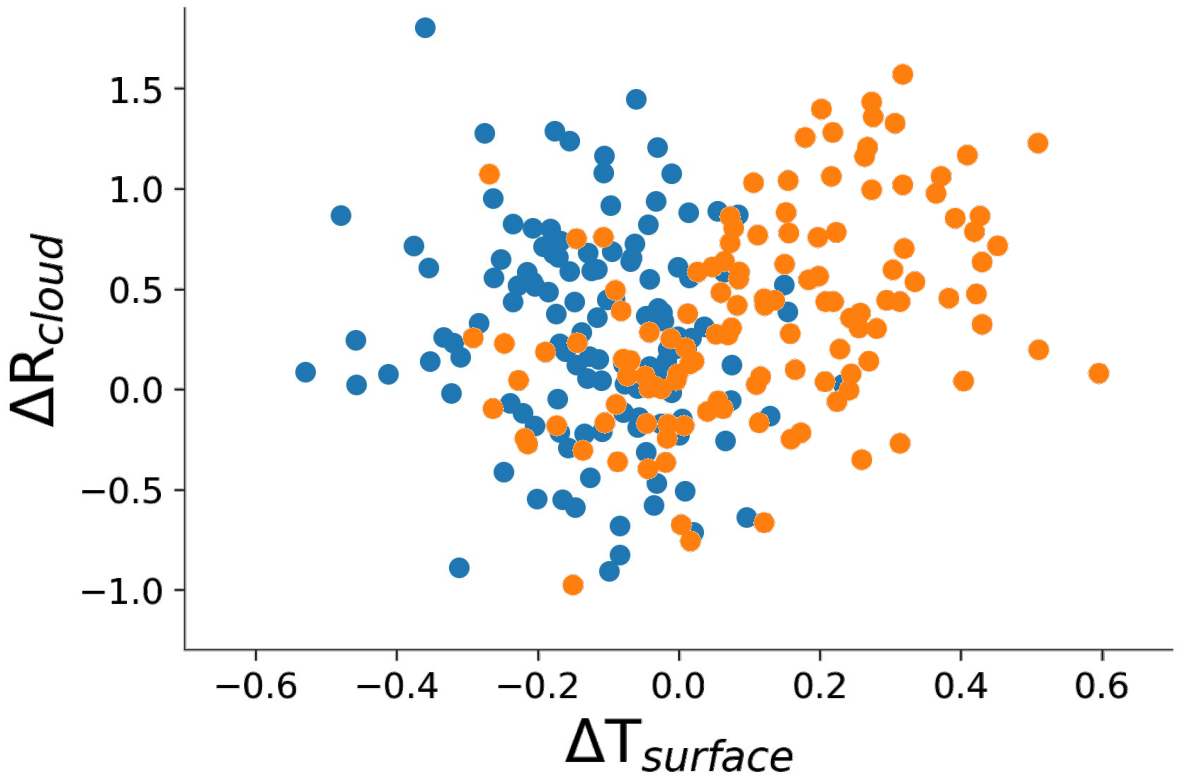


$\lambda = 0.53 \pm 0.83$ W/m^2/K
(90%CI)

Cloud Feedback

Period 1: 2000/03 – 2010/07

Period 2: 2010/08 – 2020/12

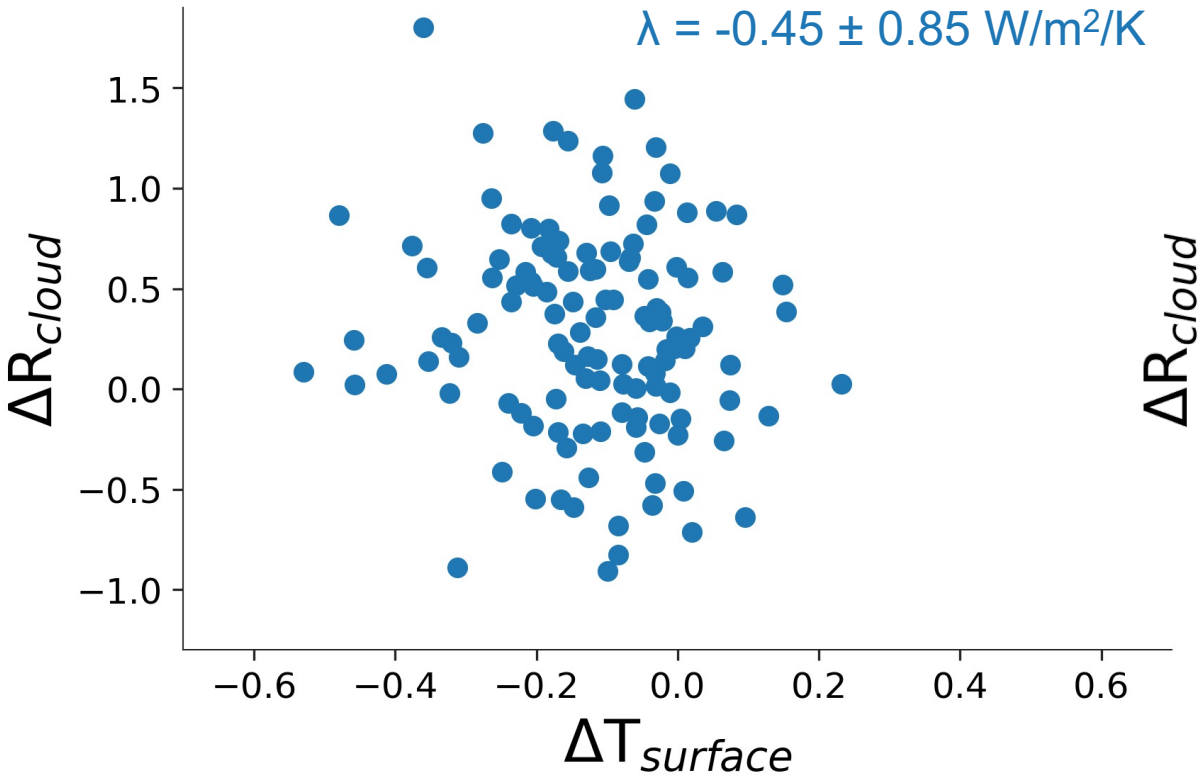


Cloud Feedback

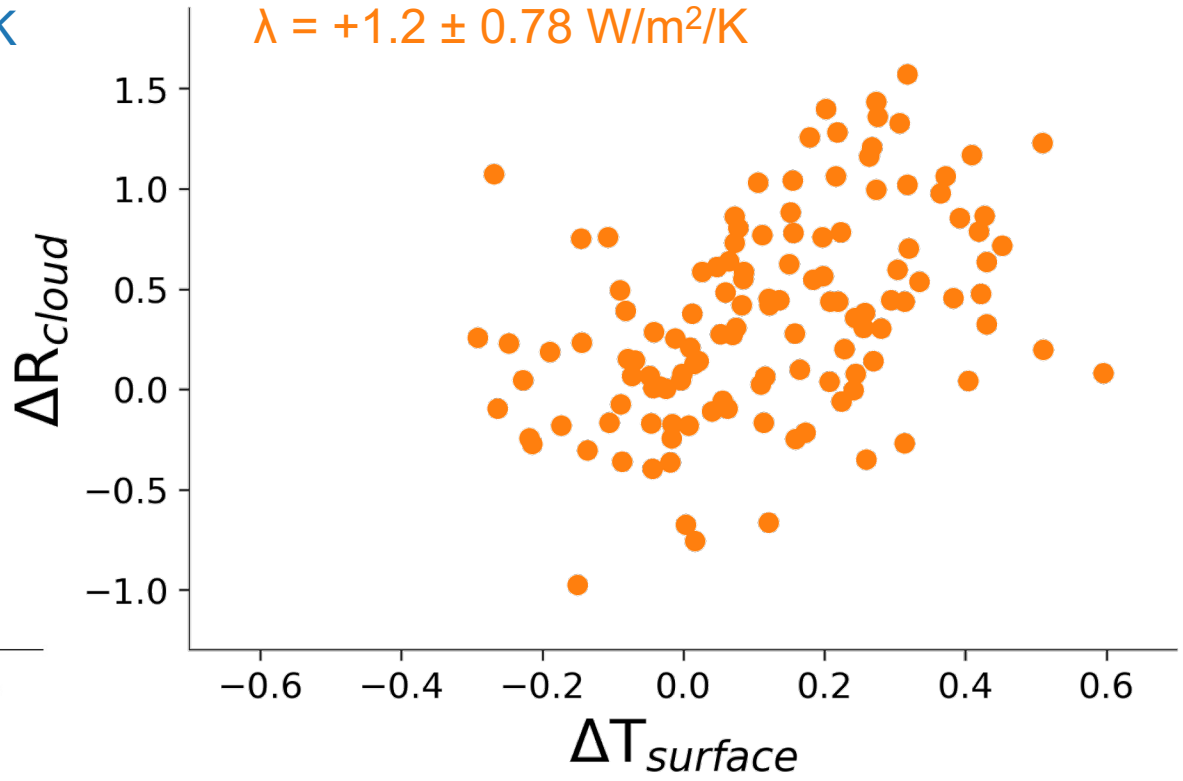
$\Delta\lambda = 1.6 \pm 1.1$ W/m^2/K (90%CI)

Pattern Effect

Period 1: 2000/03 – 2010/07



Period 2: 2010/08 – 2020/12



Cloud Feedback

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Pattern Effect

Period 1: 2000/03 – 2010/07

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Geophysical Research Letters

Research Letter | Full Access

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Geophysical Research Letters

- Net climate feedback
- 2000-2014 vs. 2000-2017

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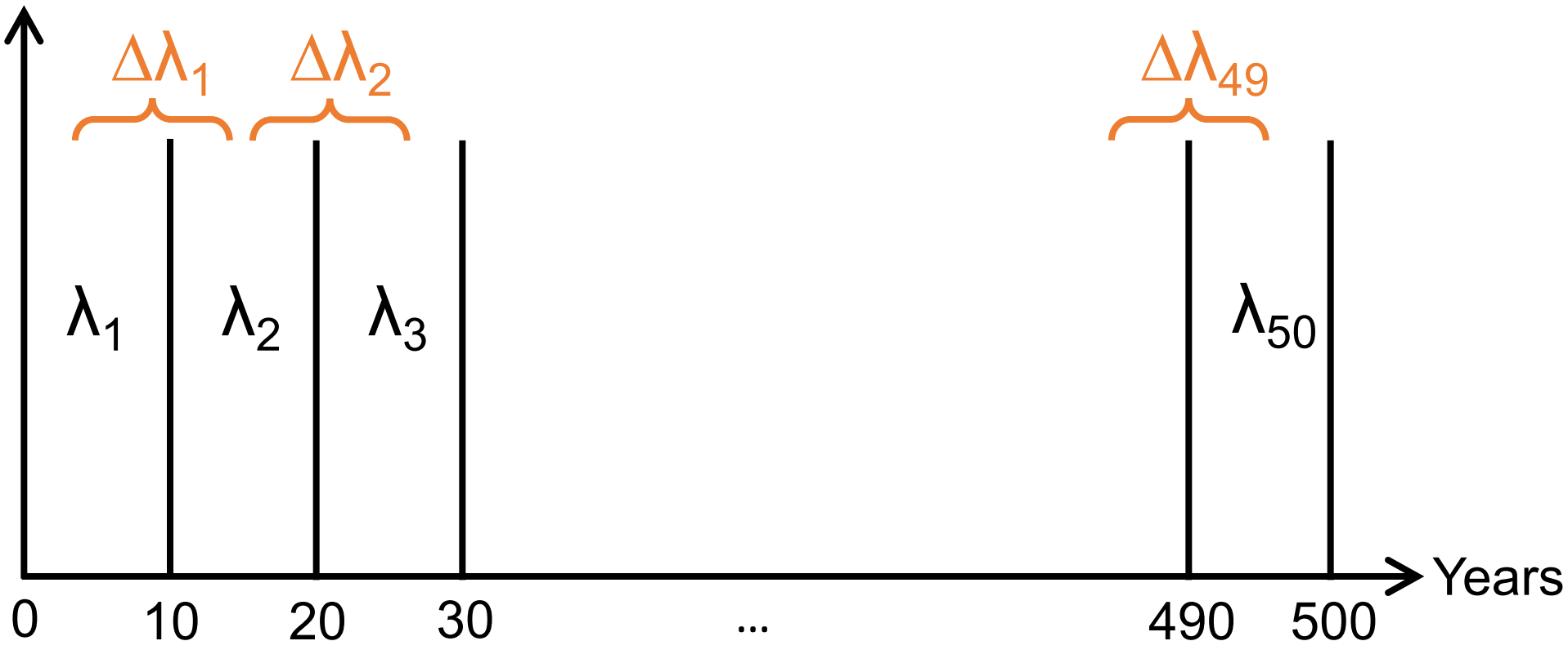
0.6

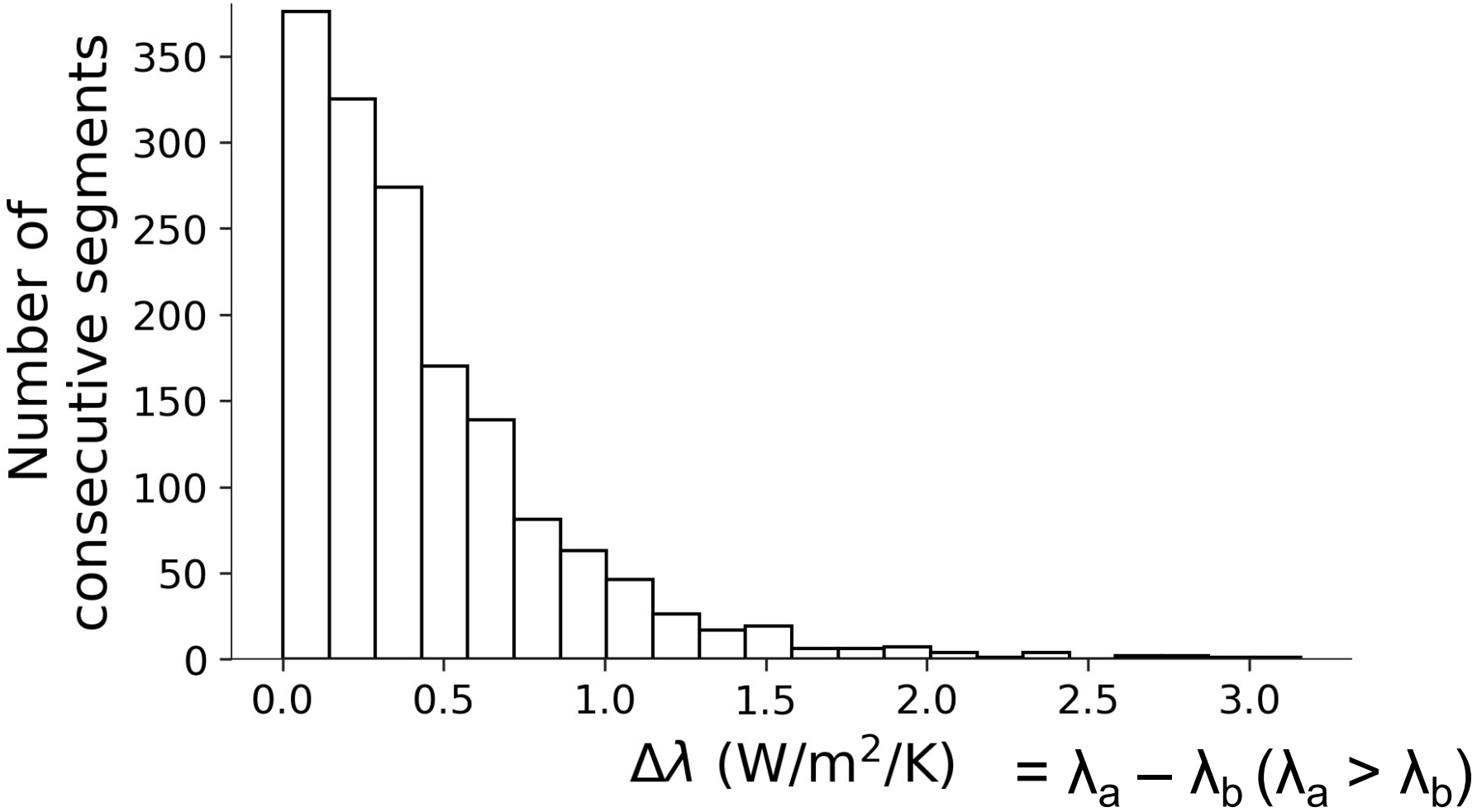
Pattern effect in CMIP6 models

26 CMIP6 pre-industrial control runs

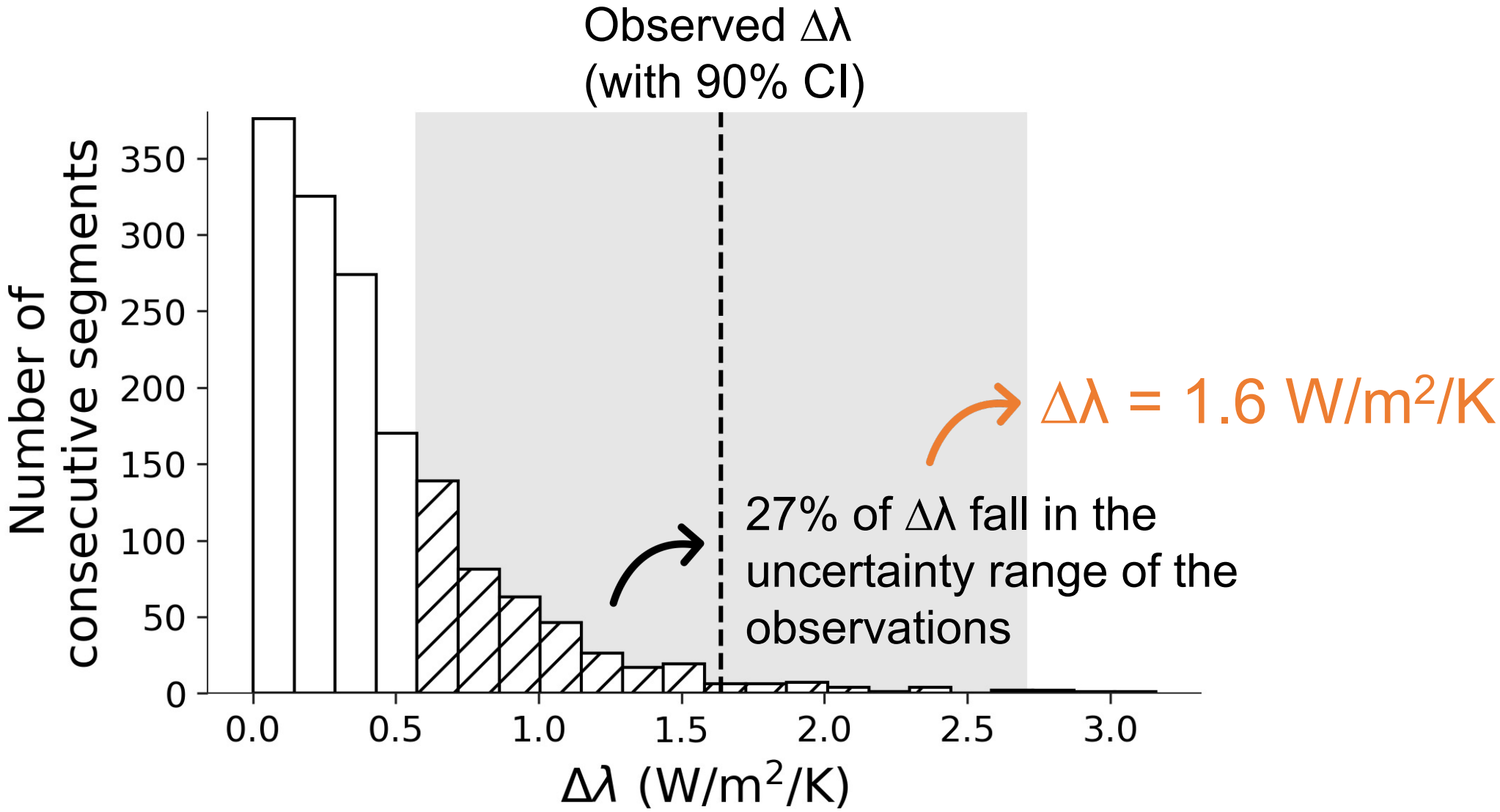
For each model (~500 years):



Pattern effect in CMIP6 models

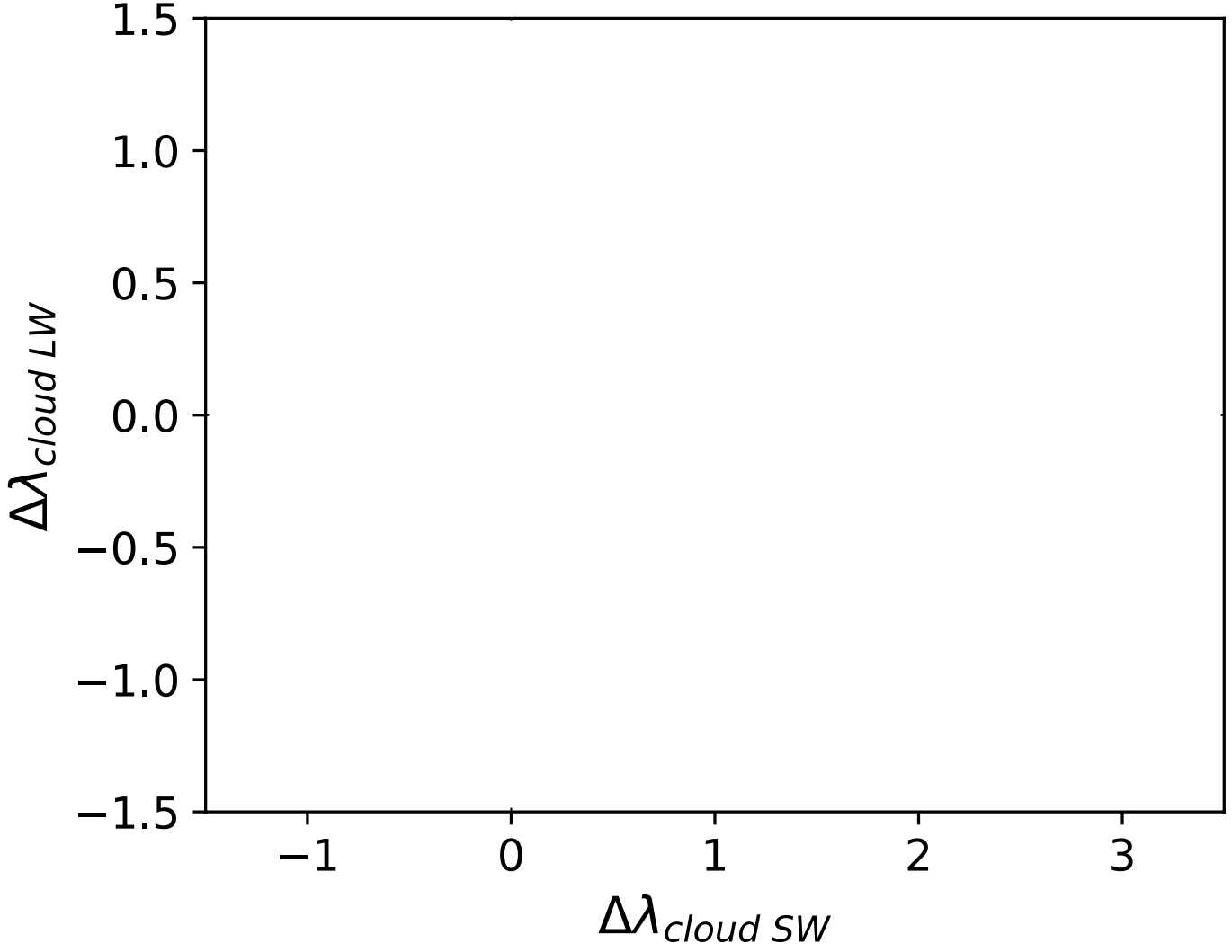


Pattern effect in CMIP6 models



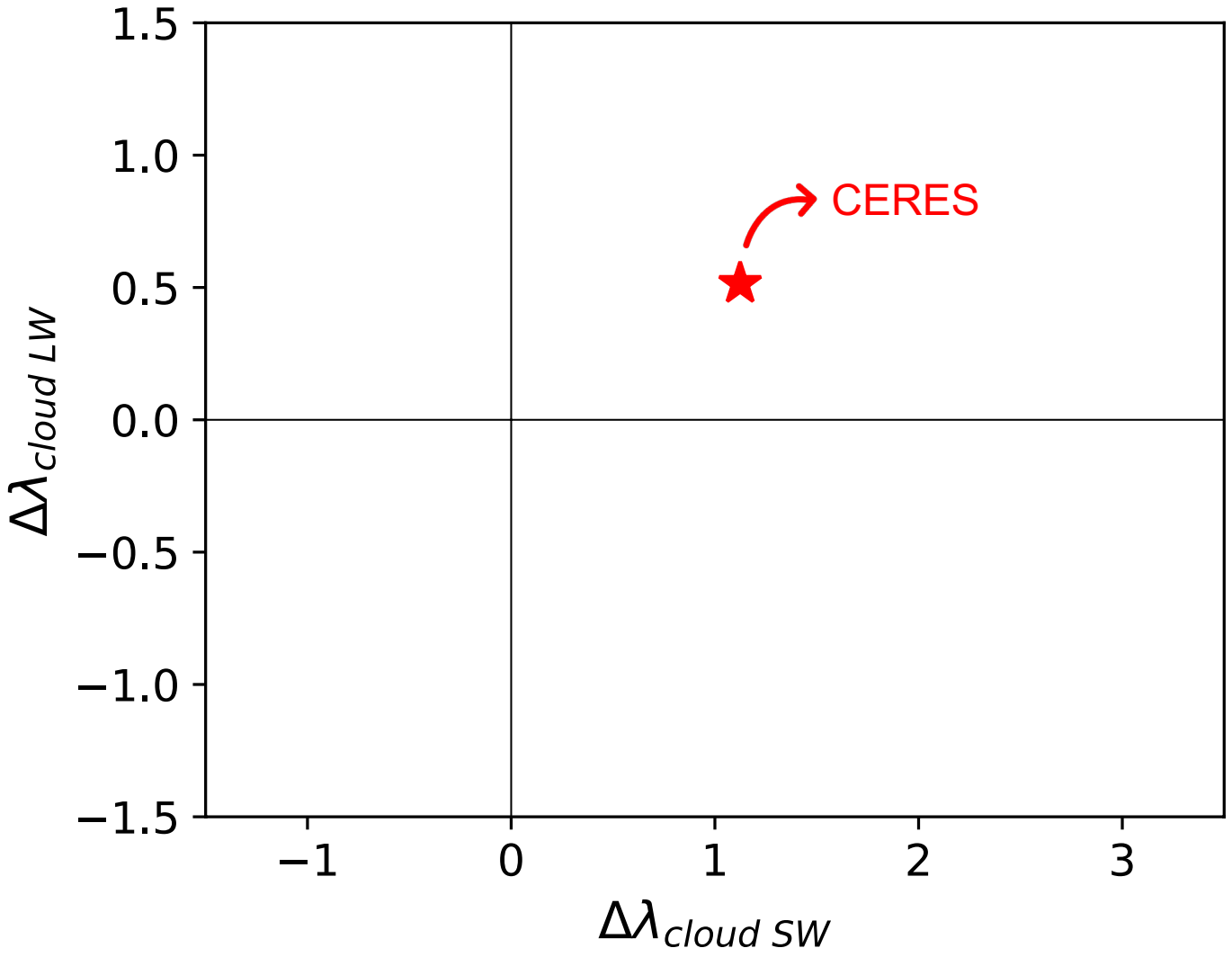
Pattern effect in CMIP6 models

$\Delta\lambda_{\text{cloud}} = \Delta\lambda_{\text{cloud SW}} + \Delta\lambda_{\text{cloud LW}}$



Pattern effect in CMIP6 models

$\Delta\lambda_{cloud} = \Delta\lambda_{cloud\ SW} + \Delta\lambda_{cloud\ LW}$



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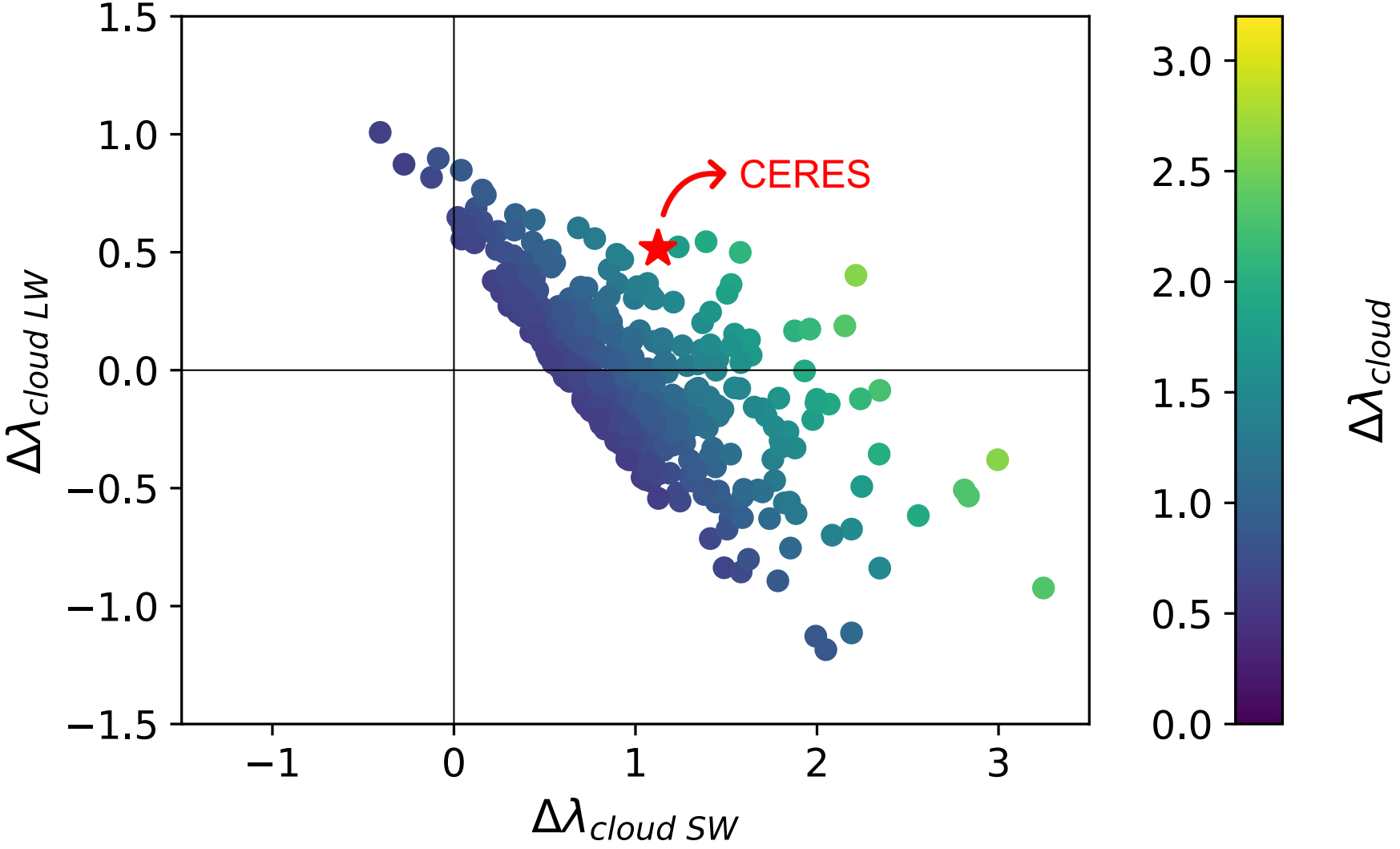
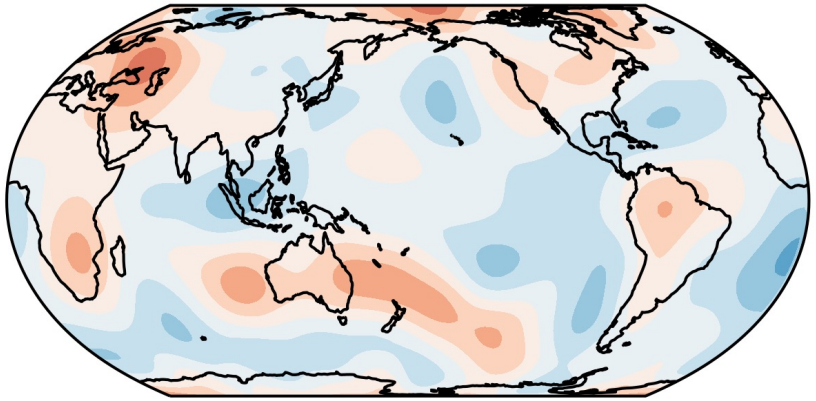


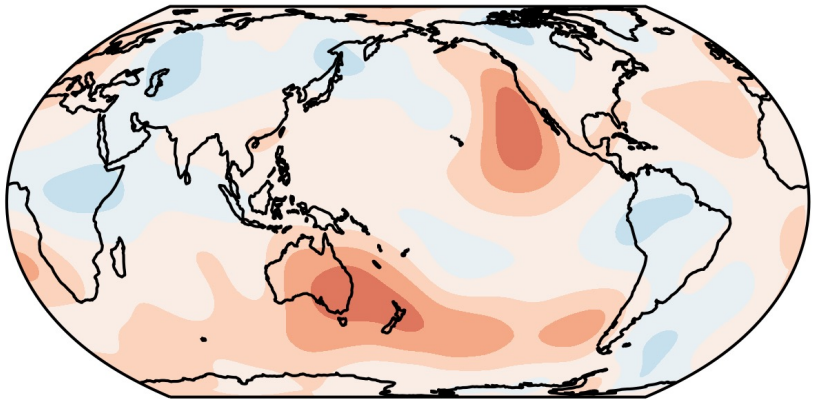
Spatial structure of pattern effect:

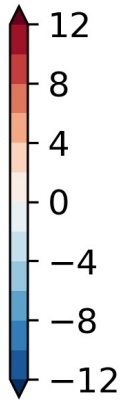
CERES (Period 1: 2000/03-2010/07)
$\lambda = -0.45 \pm 0.85$ W/m^2/K

CERES (Period 2: 2010/08-2020/12)
$\lambda = +1.2 \pm 0.78$ W/m^2/K

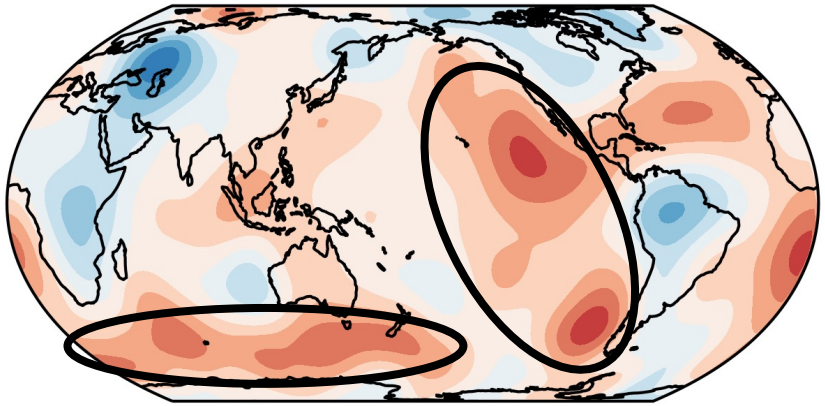
λ

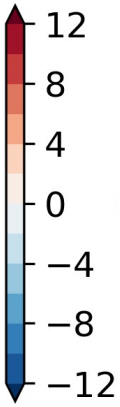






$\Delta\lambda$





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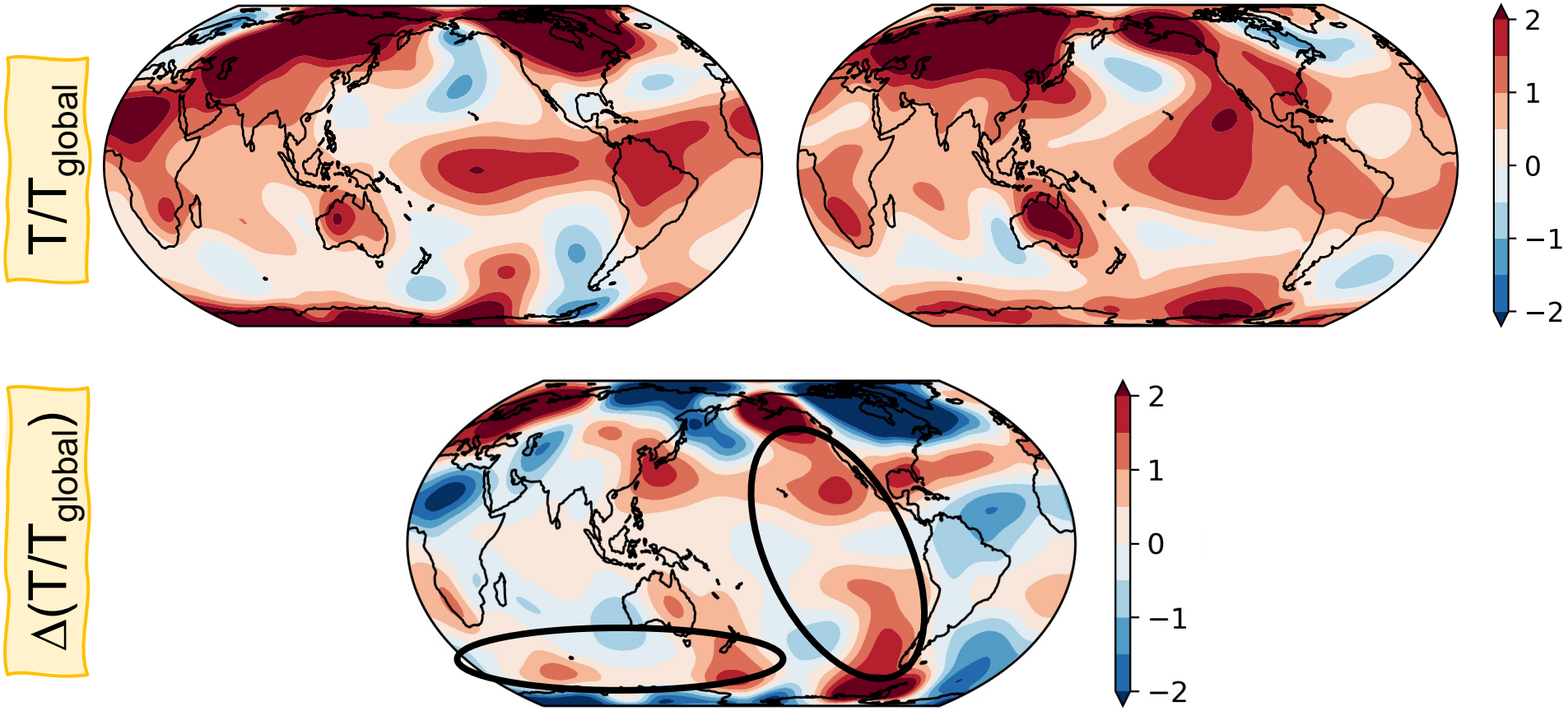

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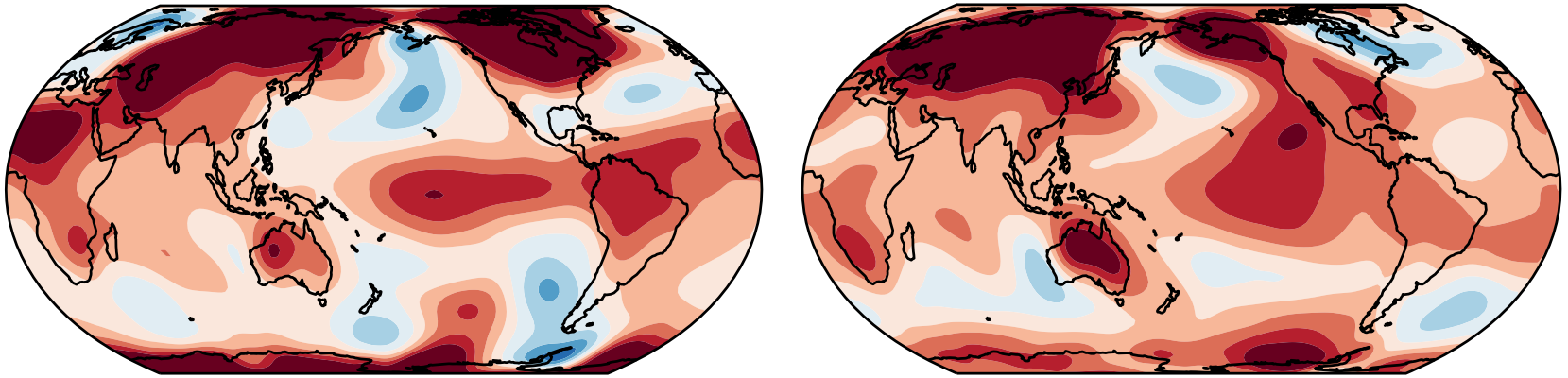
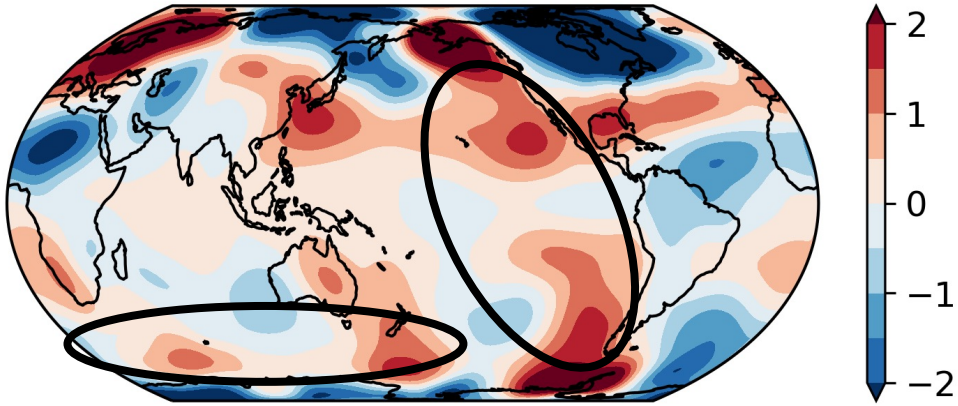
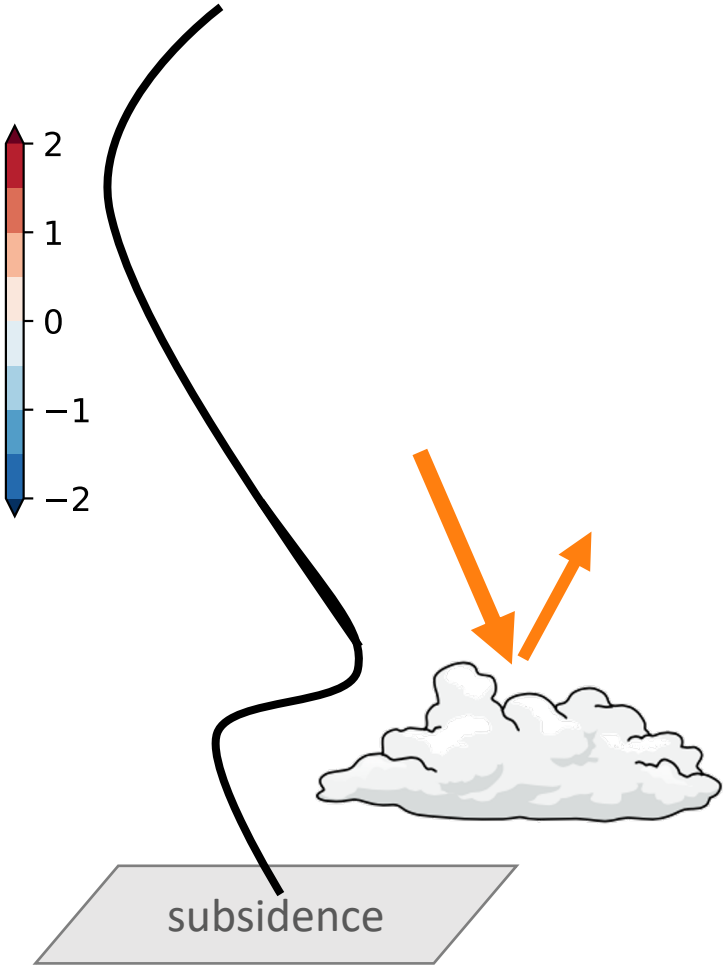
T/T_{global}



$\Delta(T/T_{global})$





Mauritsen (2016), Zhou et al. (2017)

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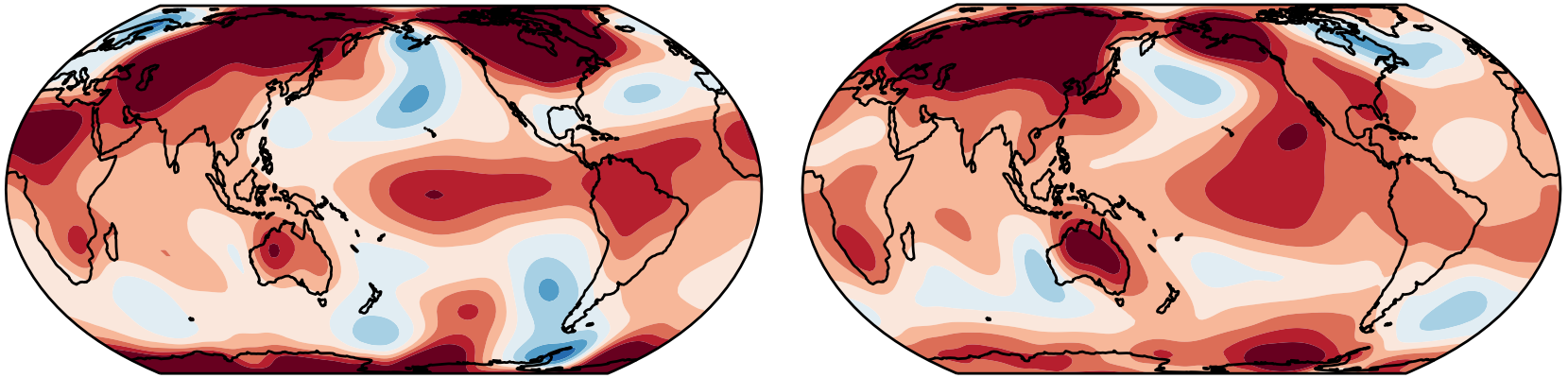

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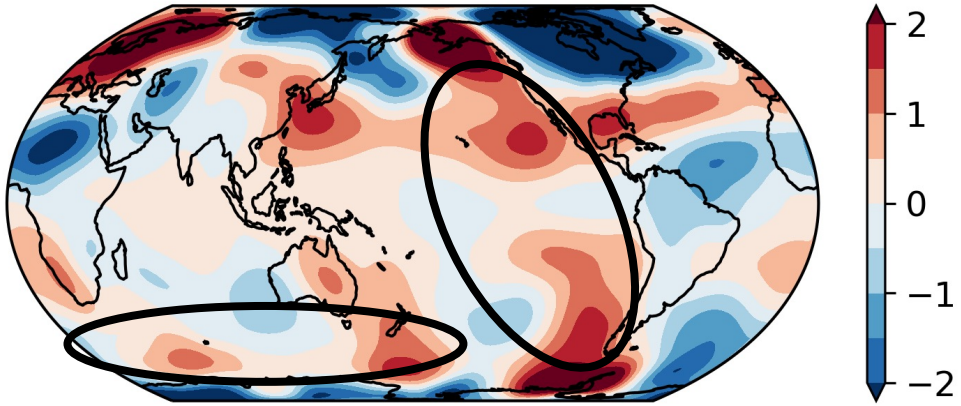

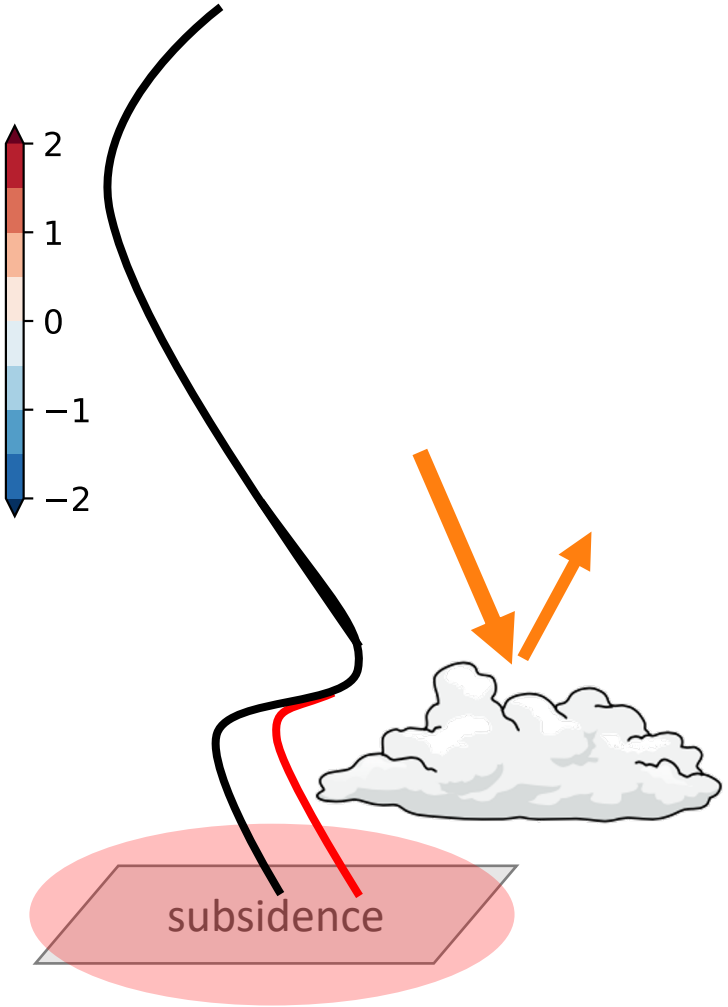

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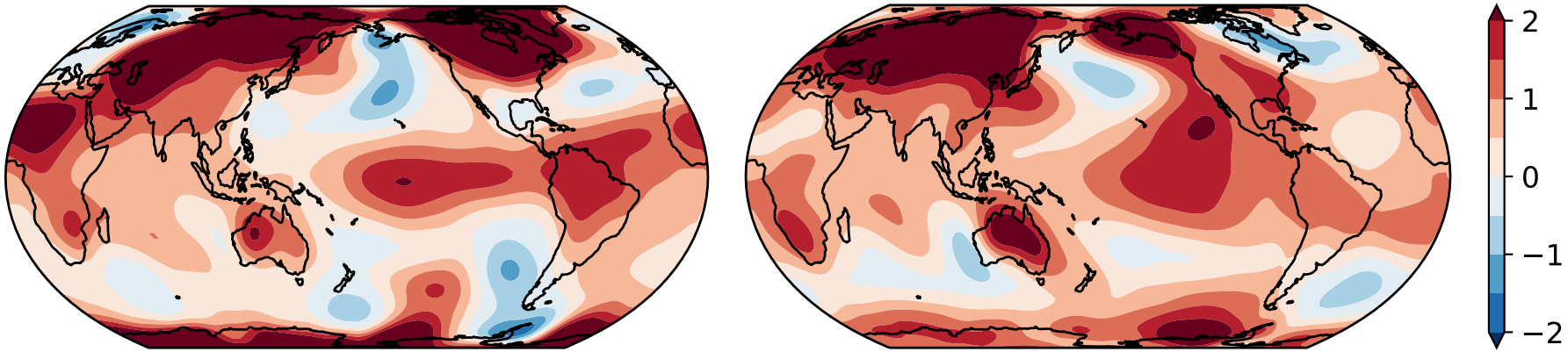

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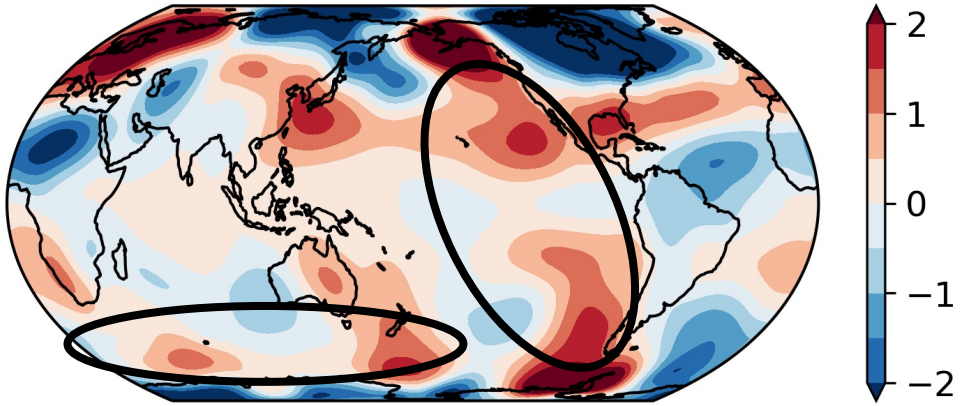
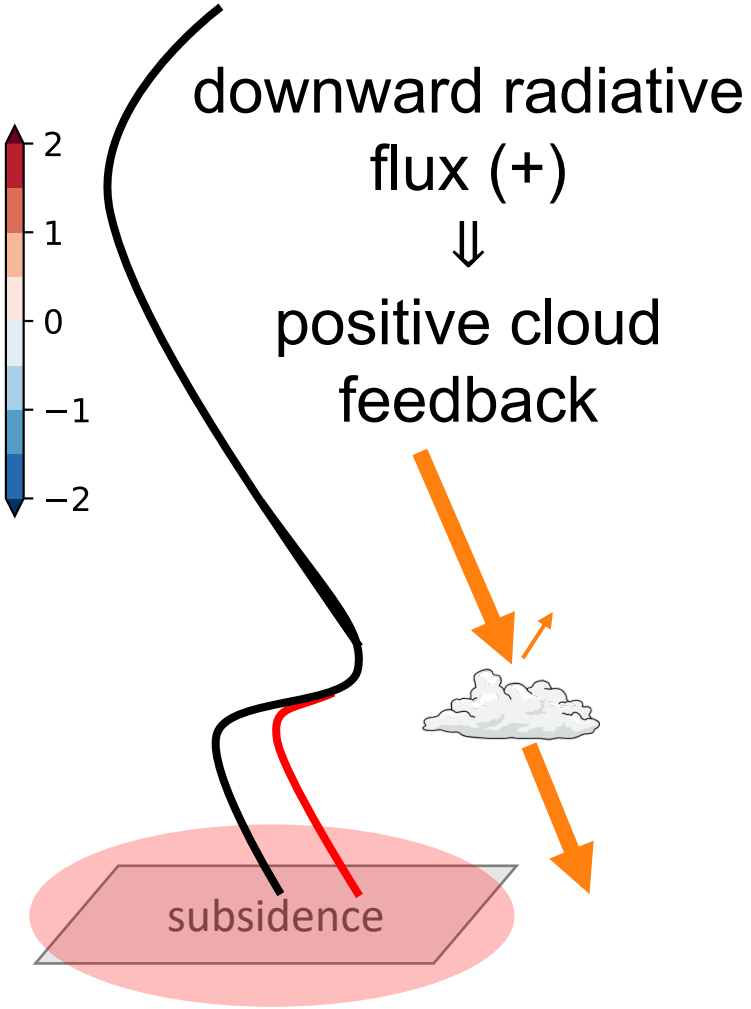


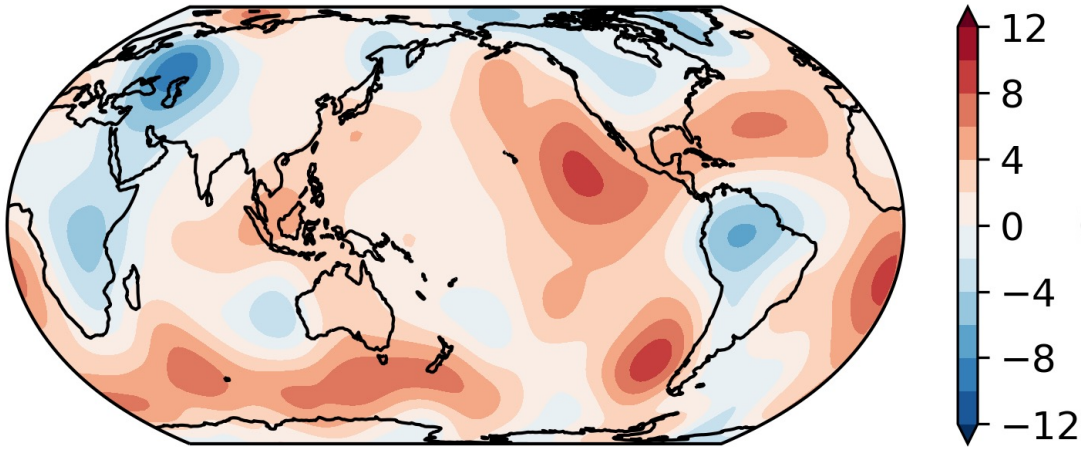


Mauritsen (2016), Zhou et al. (2017)

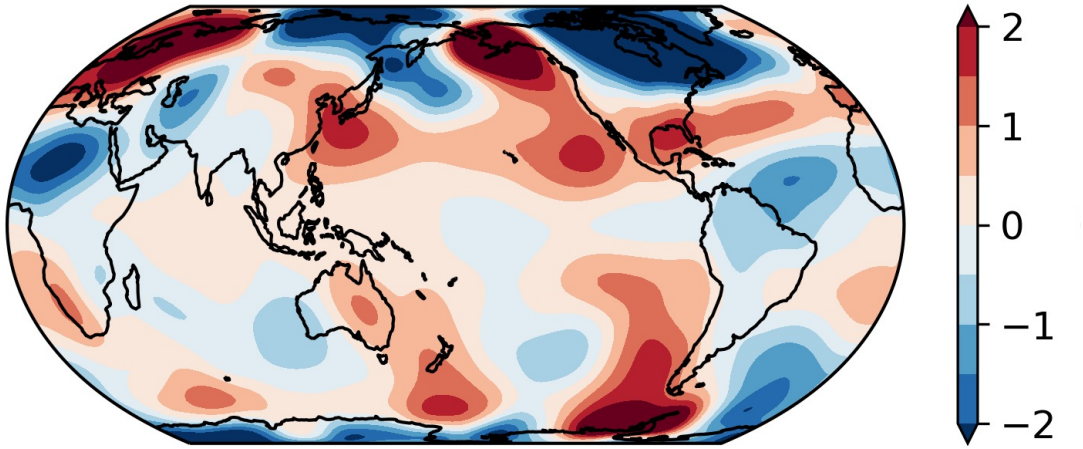
Spatial structure of pattern effect:

CERES observations vs. CMIP6 models

$\Delta\lambda$



$\Delta(T/T_{global})$



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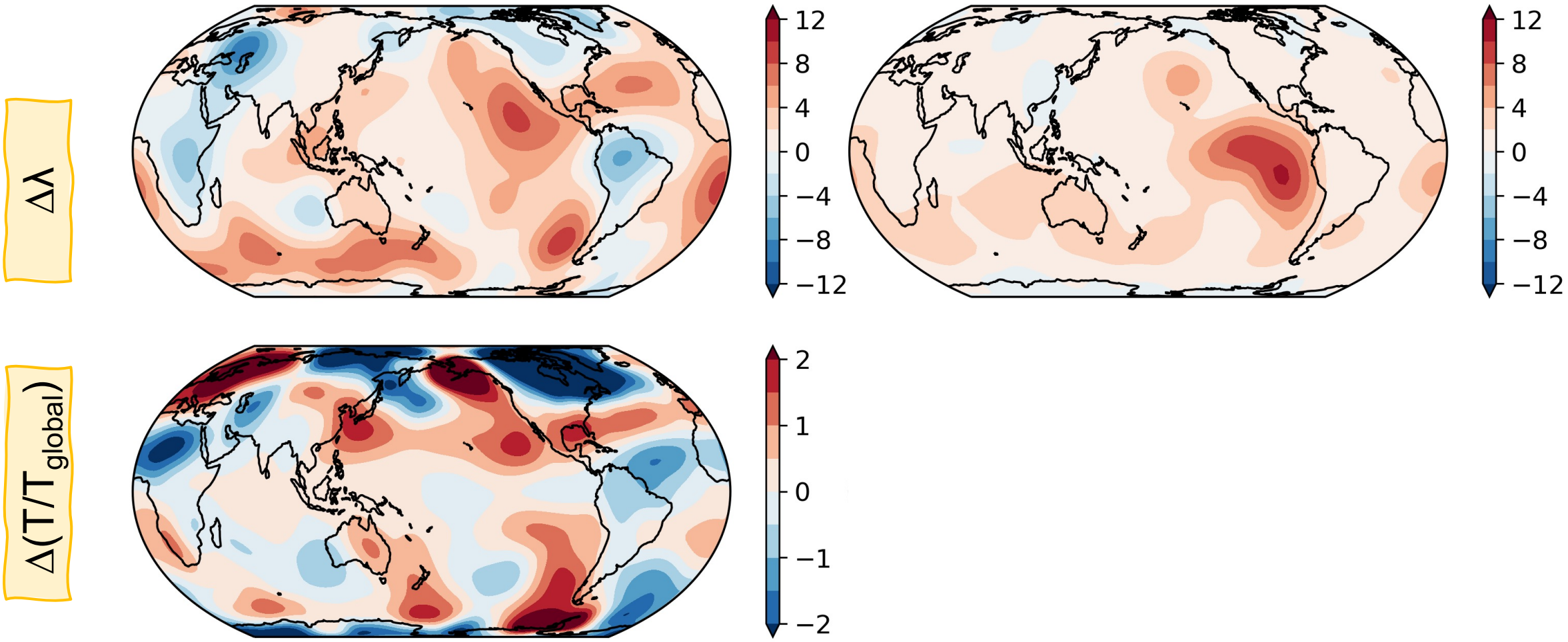

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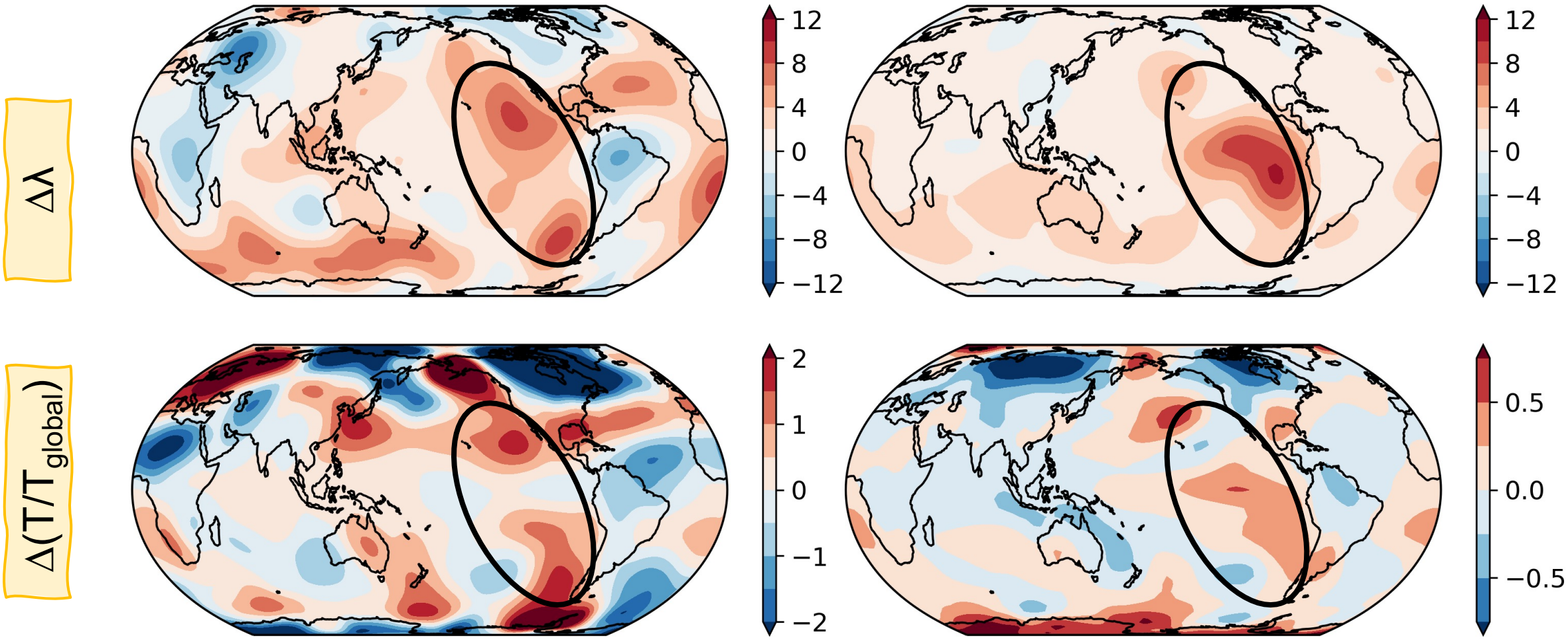

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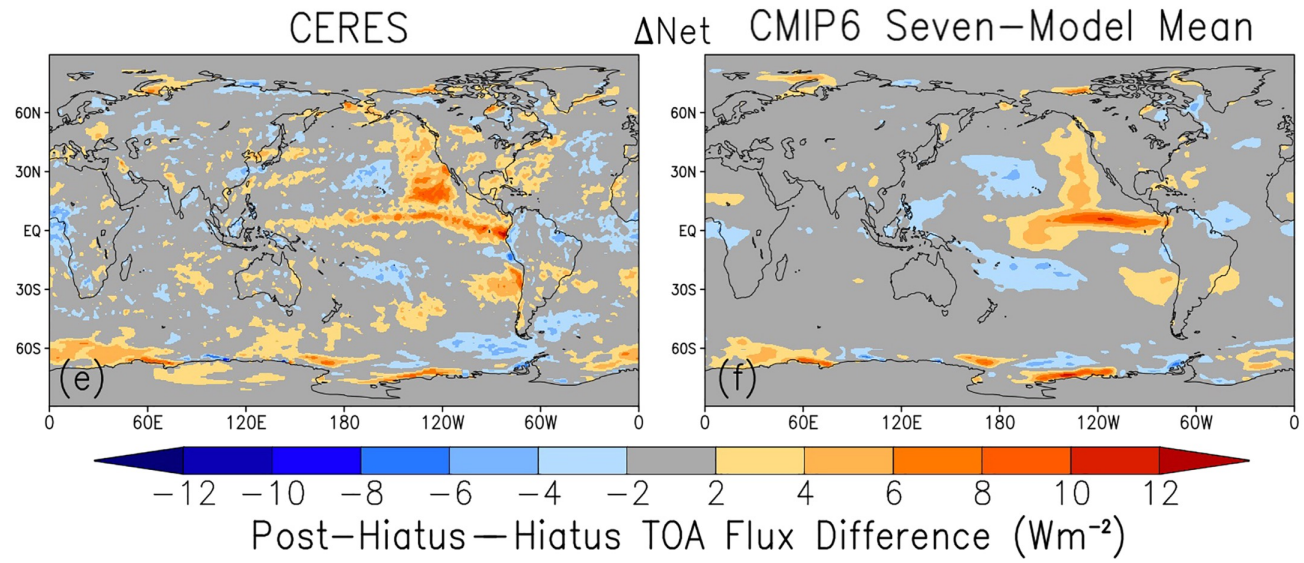
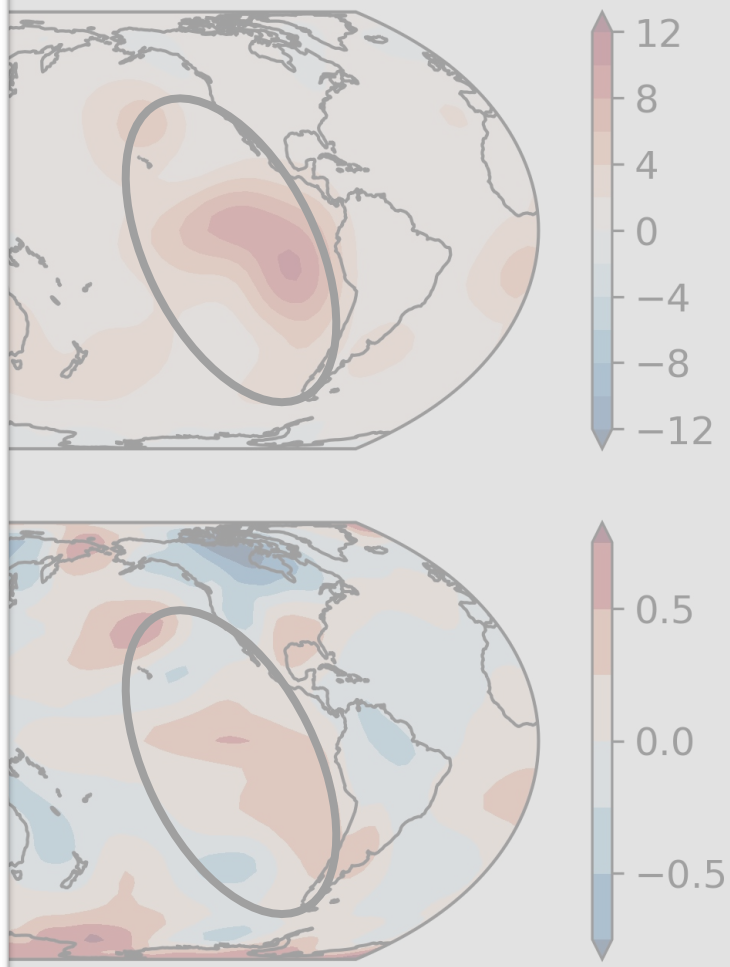


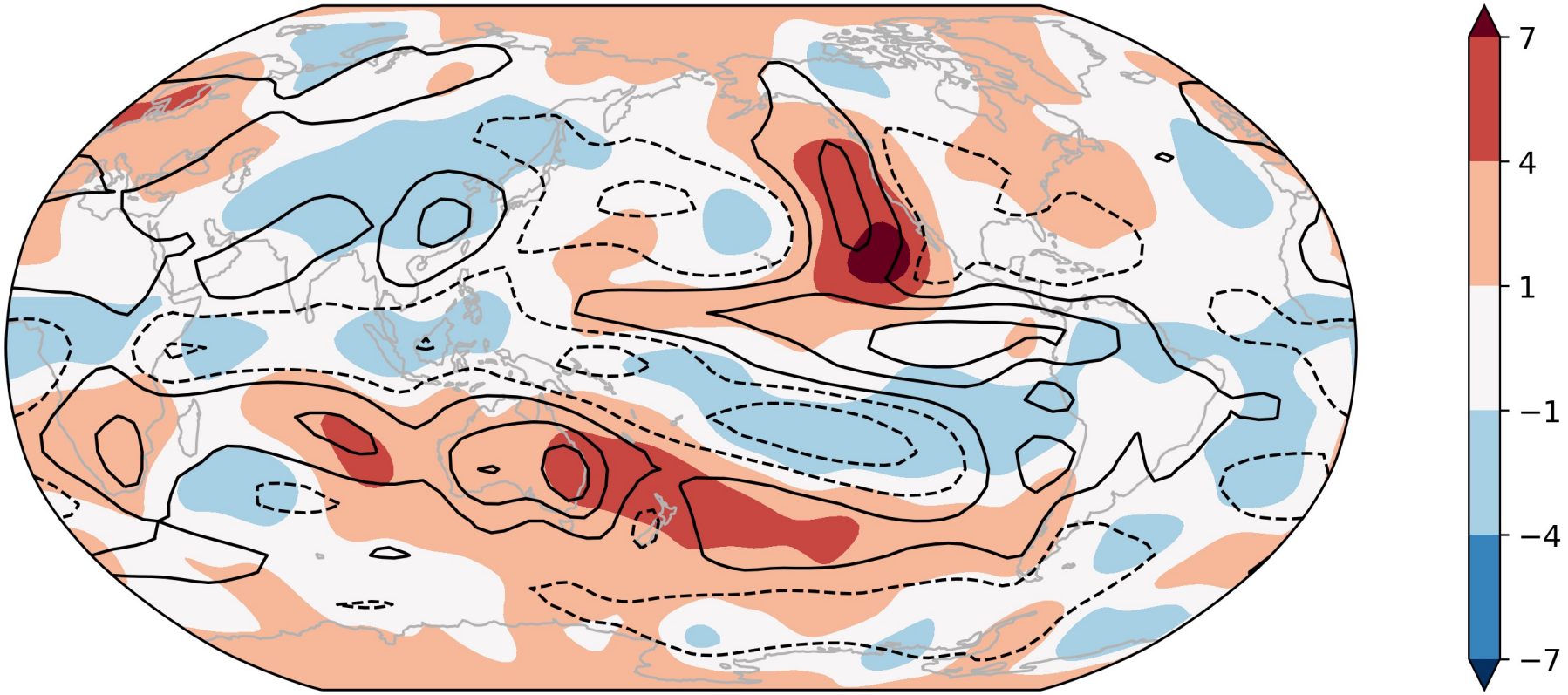


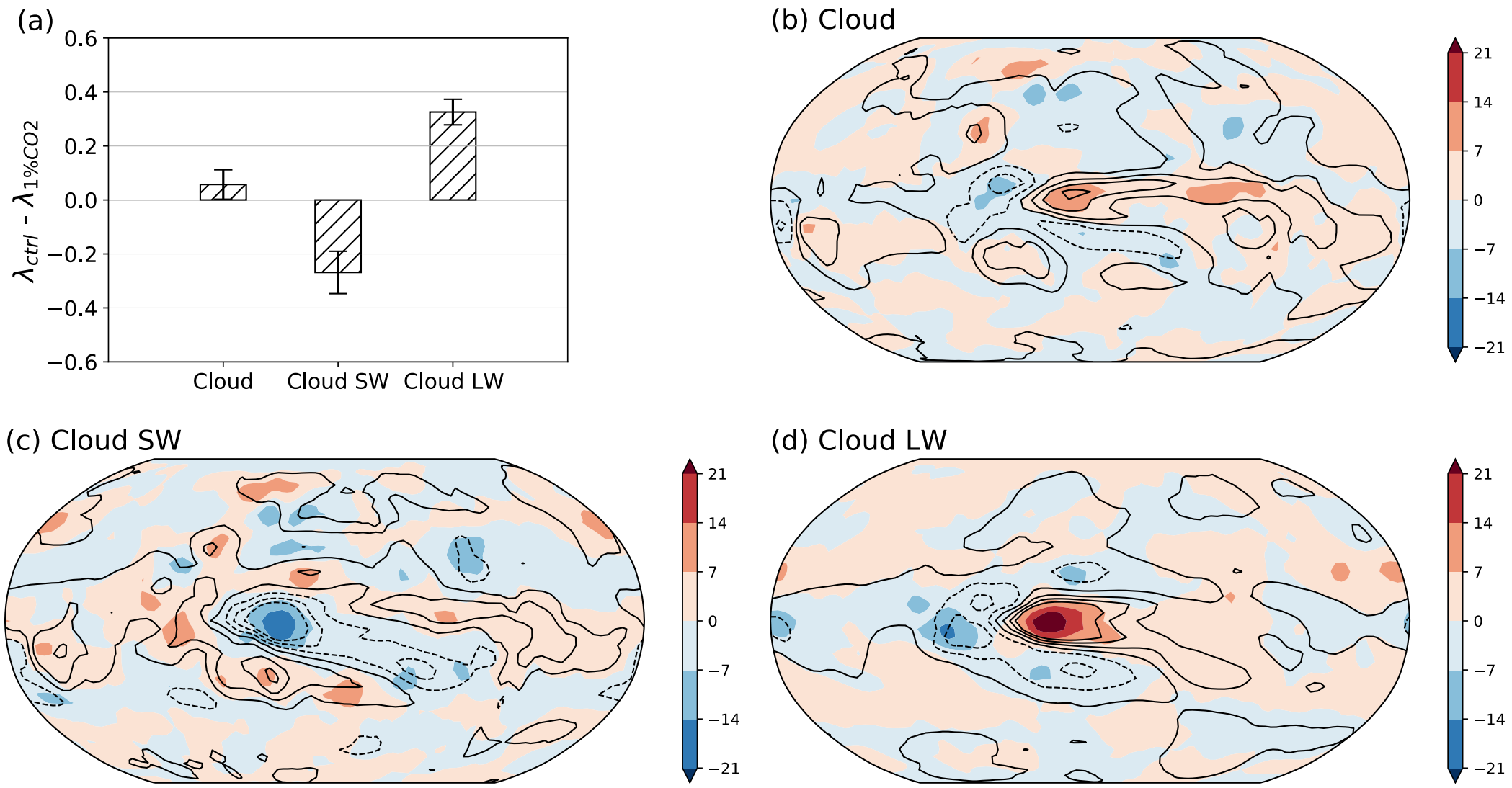
Conclusions

- ✓ Cloud feedbacks are dependent on the surface temperature warming pattern, which is known as pattern effect.
- ✓ We found a large pattern effect on cloud feedback in CERES data
  - related to the temperature pattern over East Pacific
- ✓ The CMIP6 models can reproduce the pattern effect with similar magnitude and main features of spatial structure

Supplement

CERES EBAF Ed 4.1: 2000/03-2020/12 (color shading)
CMIP6: ensemble mean of 20-yr feedbacks (black lines)





(a) The ensemble-average feedback differences between 2000-year control run and 68 members of 1%CO_2 ensemble. For the control run, the values are averaged cloud feedbacks derived from non-overlapping 20-year segments. For the 1%CO_2 ensemble, the 20-year period that has ensemble averaged warming of 0.8 K is first identified. The values are the ensemble average of 20-year cloud feedbacks from each member. The uncertainty is 90% confidence intervals. (b-d) The spatial pattern of cloud, cloud SW, cloud LW feedback differences between control run and 1%CO_2 ensemble (color) and the feedbacks from control run (black lines).

Spatial structure of pattern effect:

CERES observations vs. CMIP6 models