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Observational quantification of high cloud radiative effect and feedback: an analysis of differences across the tropical Pacific

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High clouds from observations

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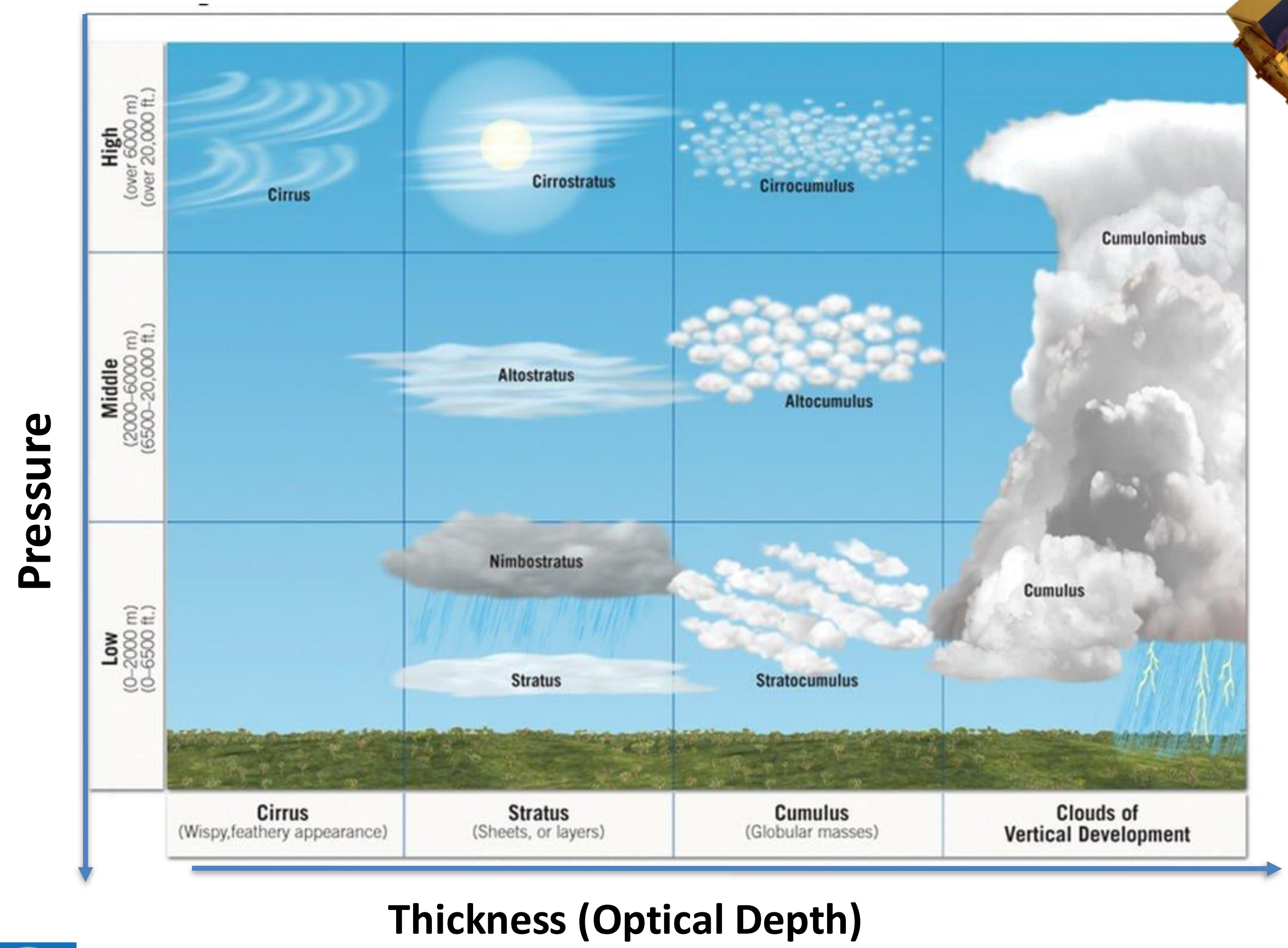

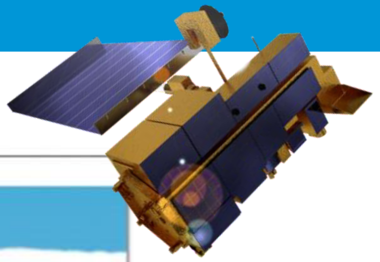

MODIS

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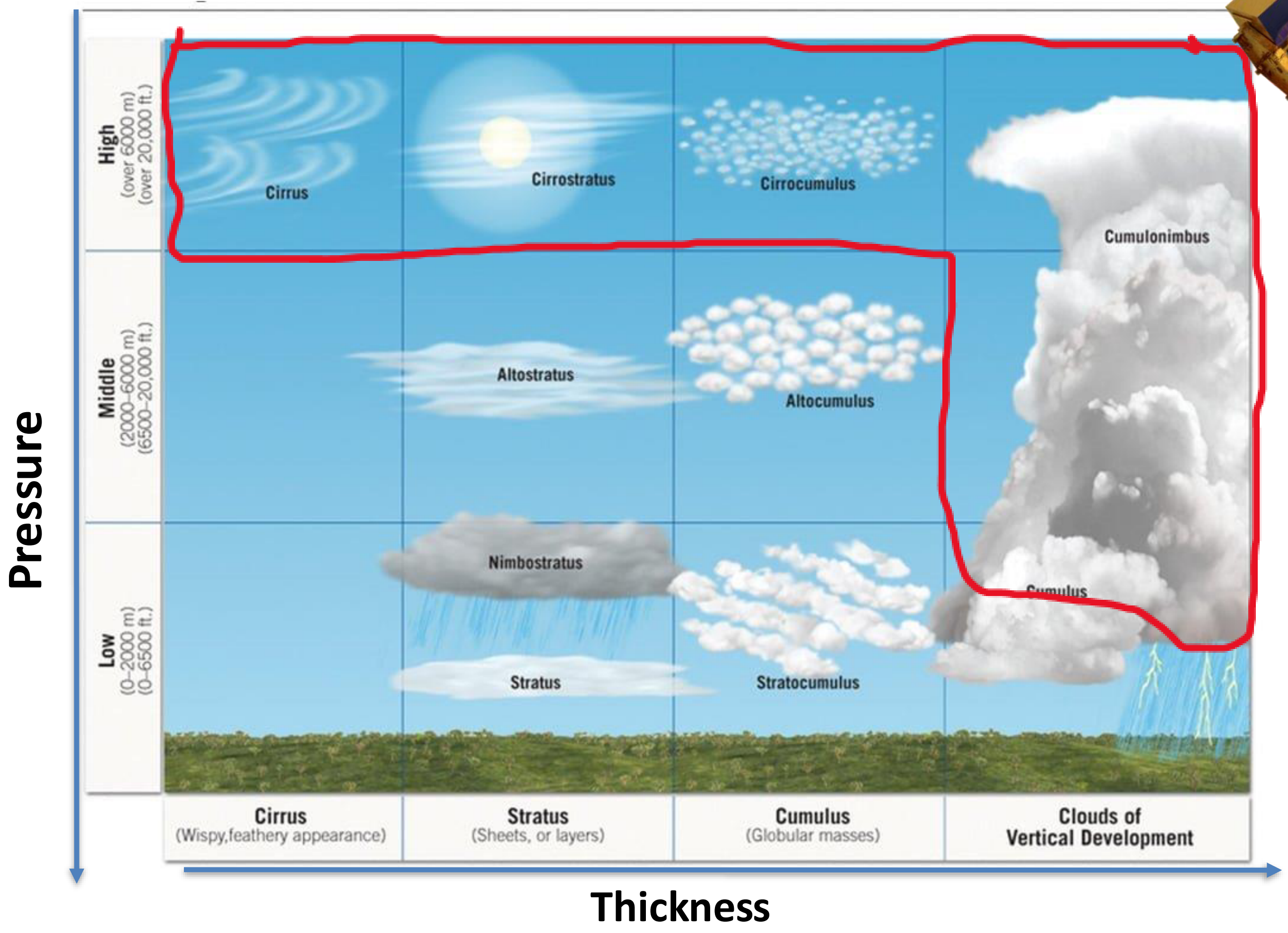
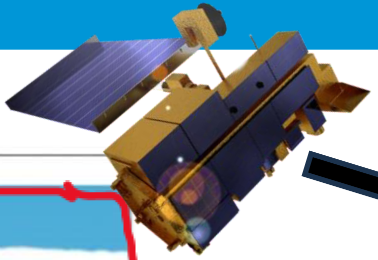
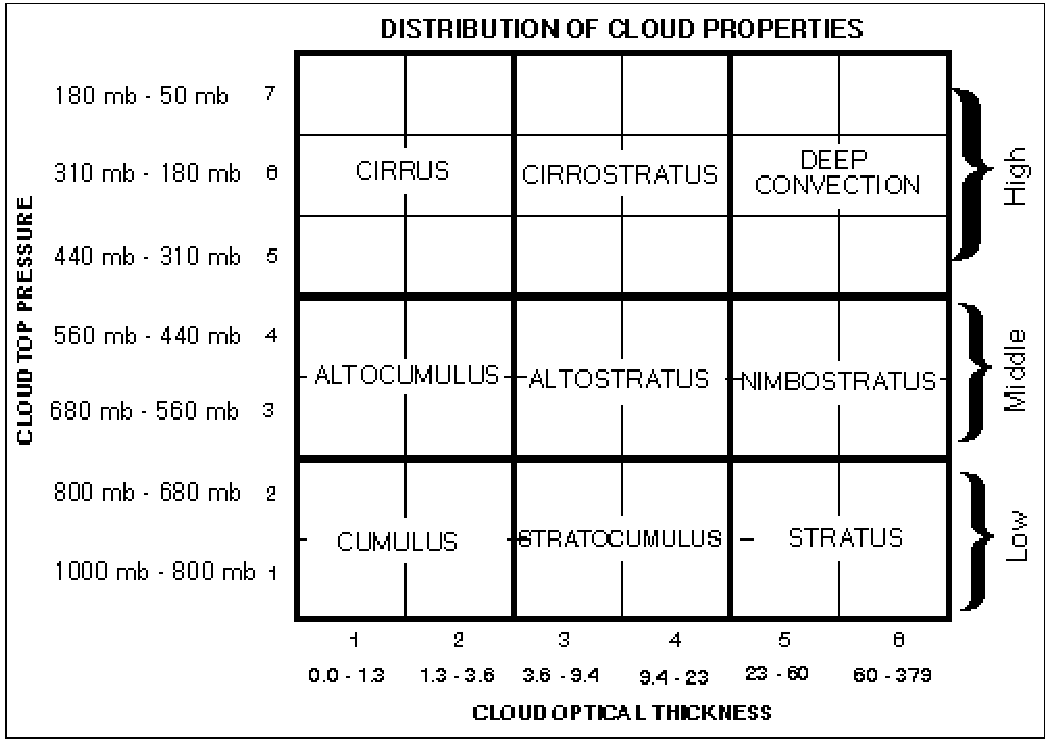
High clouds from observations





CERES Flux by cloud type Dataset



ISCCP cloud classification chart

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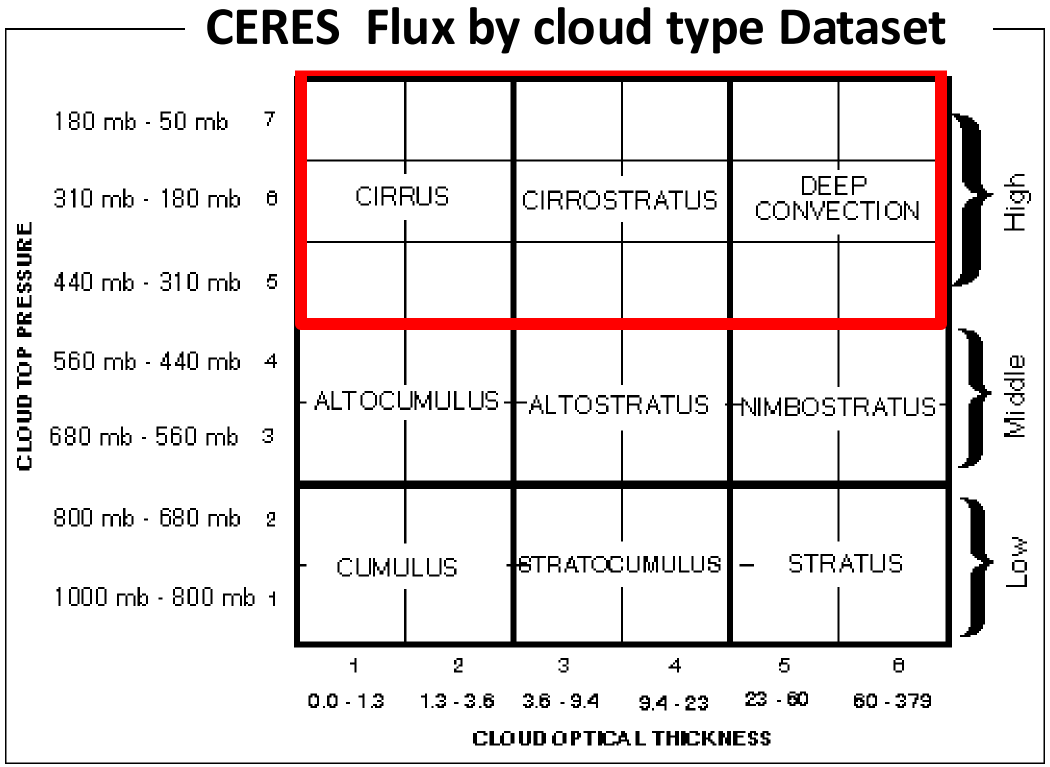
High clouds from observations



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High clouds climatology 2002-2020

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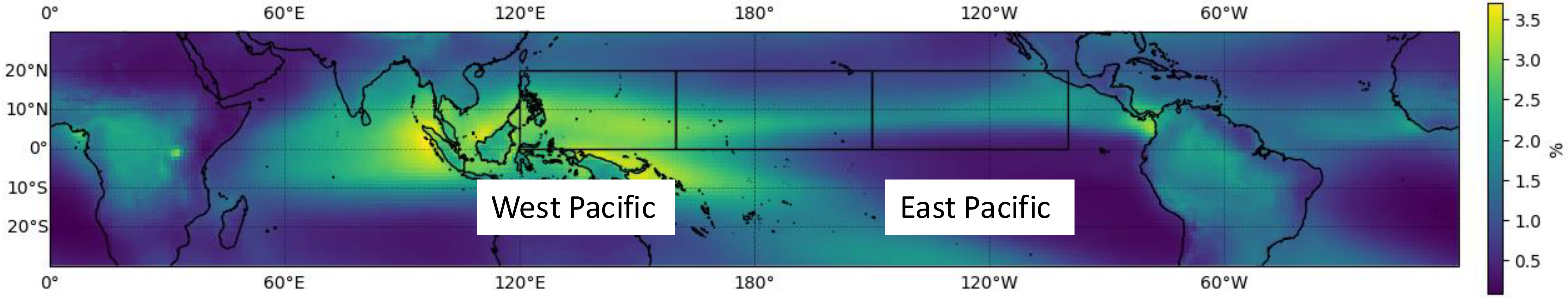
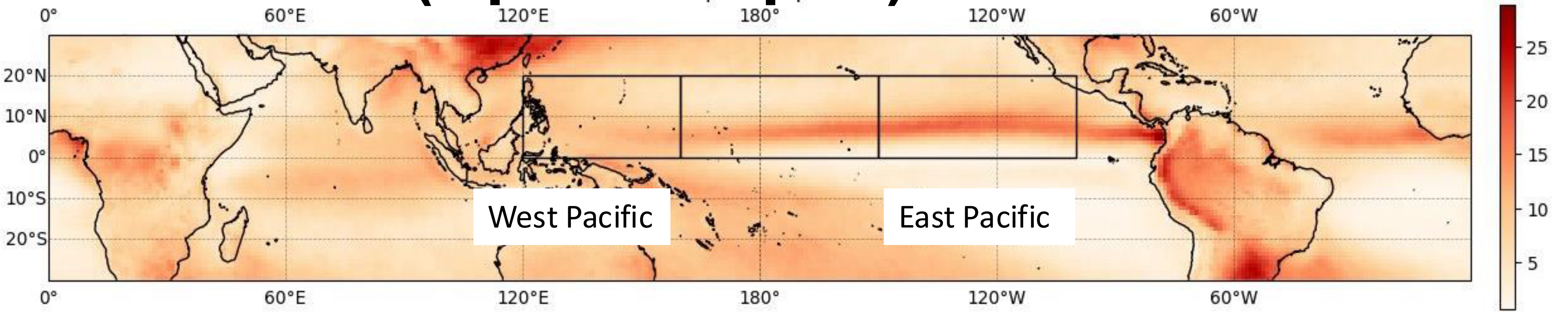
Cloud cover (%)



Thickness (Optical depth)



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High clouds climatology 2002-2020

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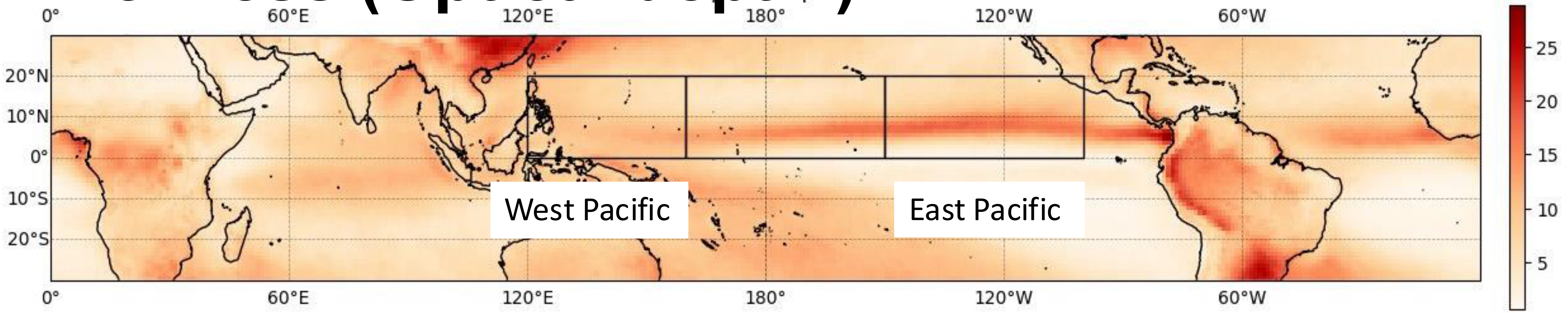
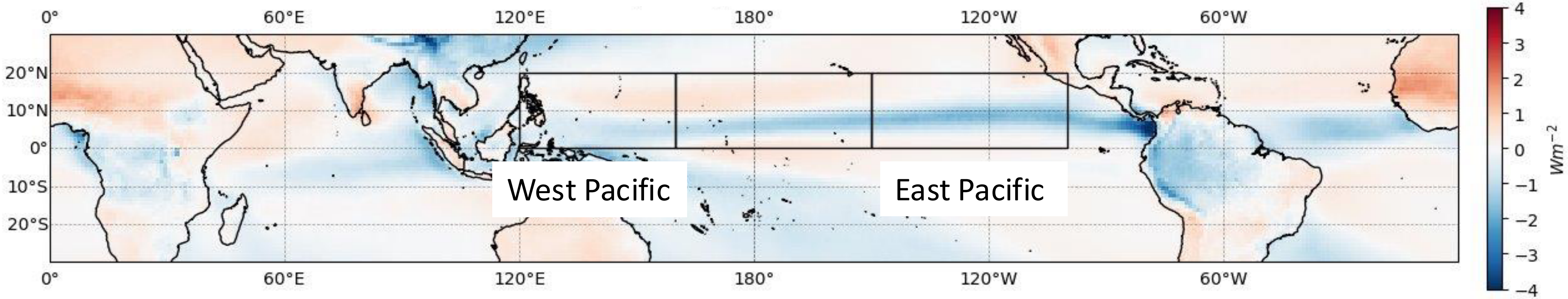
Thickness (Optical depth)



Net cloud radiative effects (Wm^{-2})



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Cloud cover sensitivity to Global Surface Temperature

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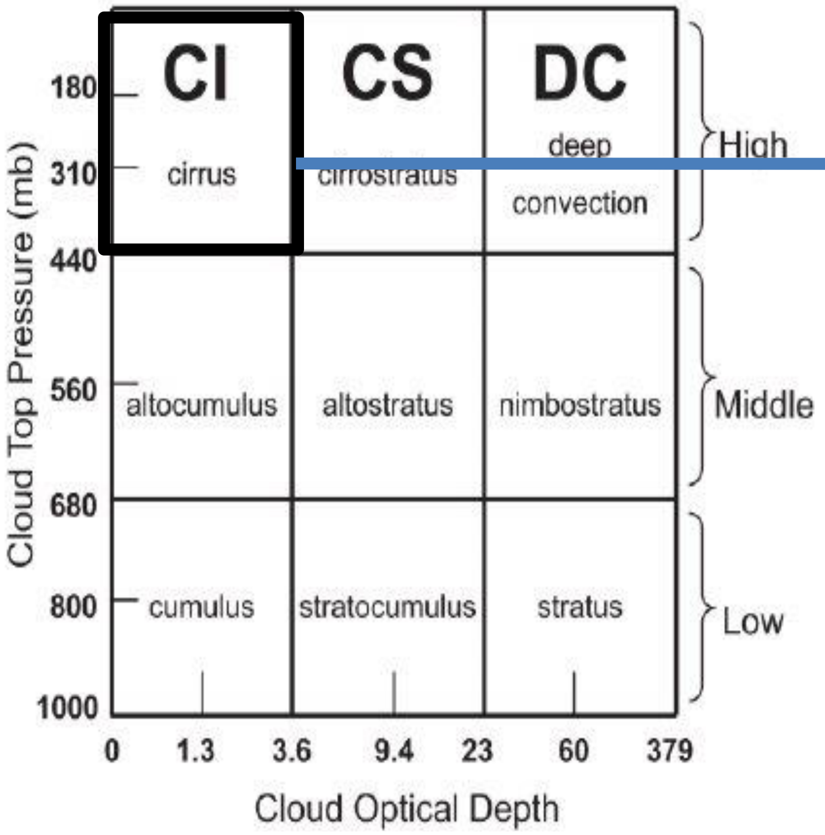
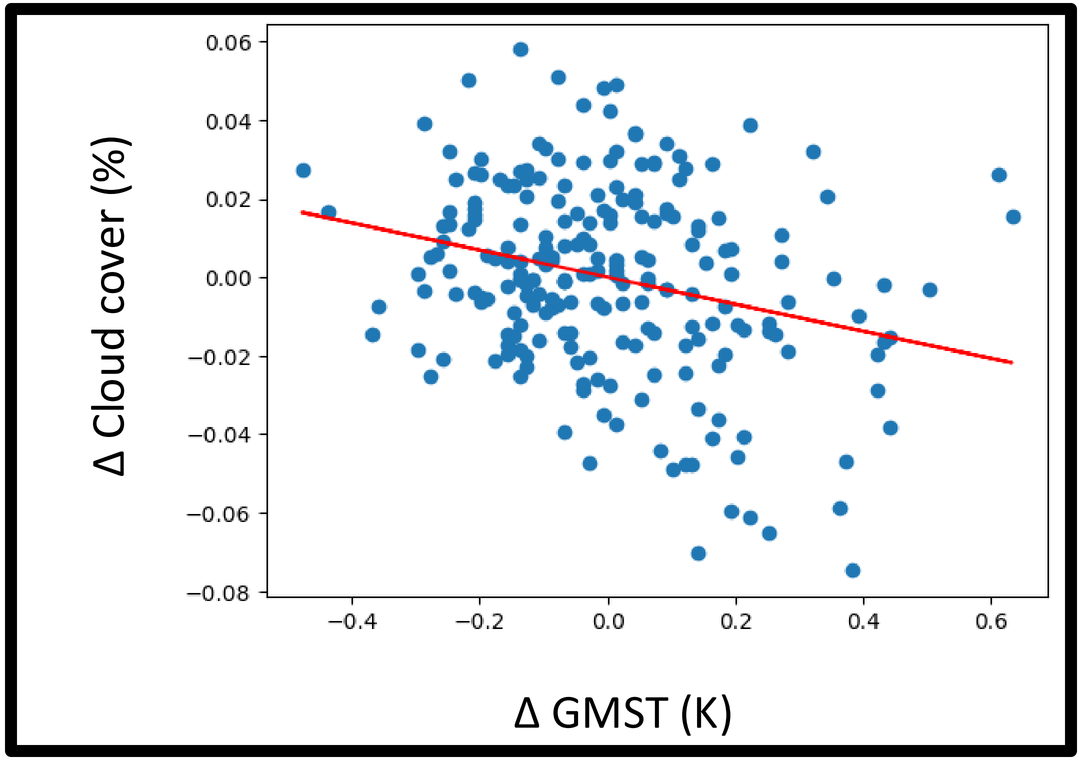
$$\text{Sensitivity} = \frac{\text{Changes in cloud cover}}{\text{changes in global mean surface temperature}}$$





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Cloud cover sensitivity to Global Surface Temperature

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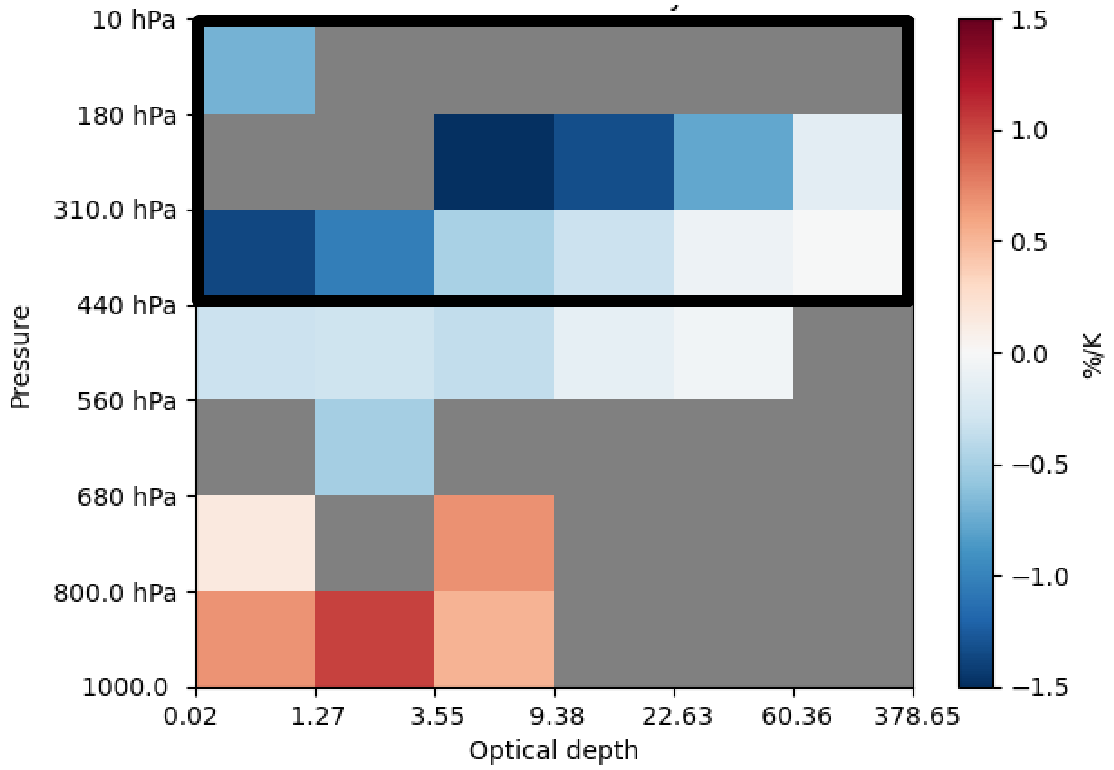
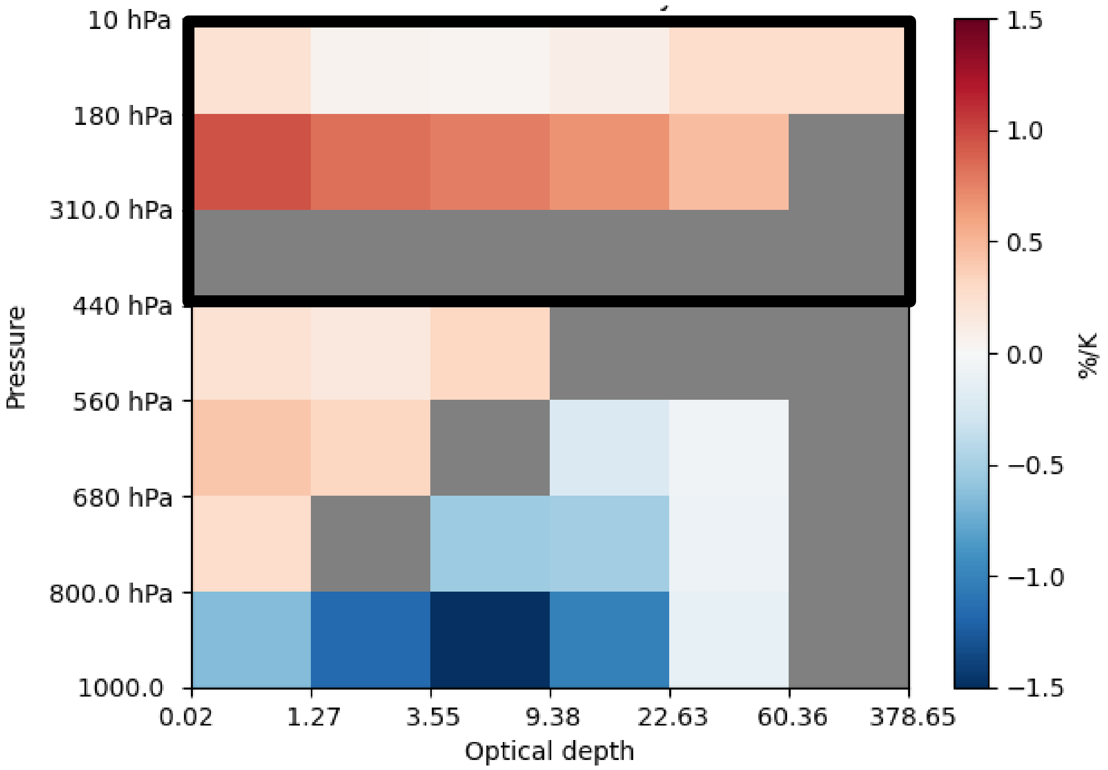
$$\text{Sensitivity} = \frac{\text{Changes in cloud cover}}{\text{changes in global mean surface temperature}}$$

West Pacific



East Pacific



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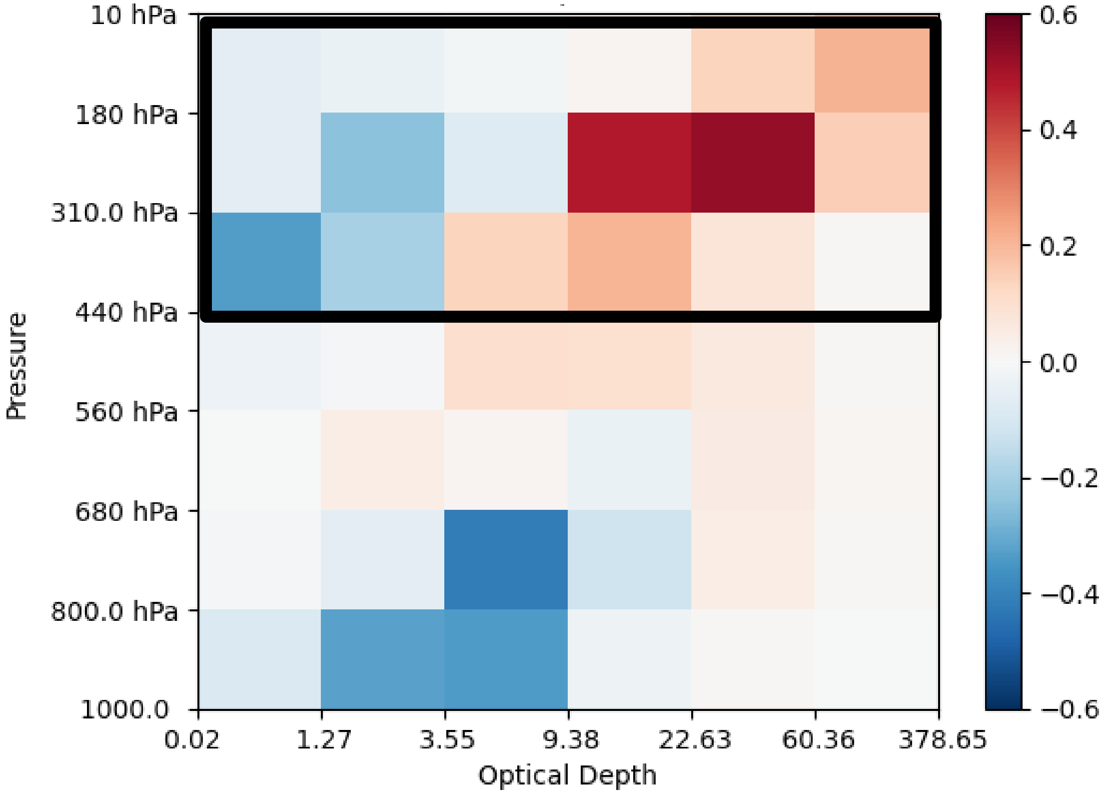
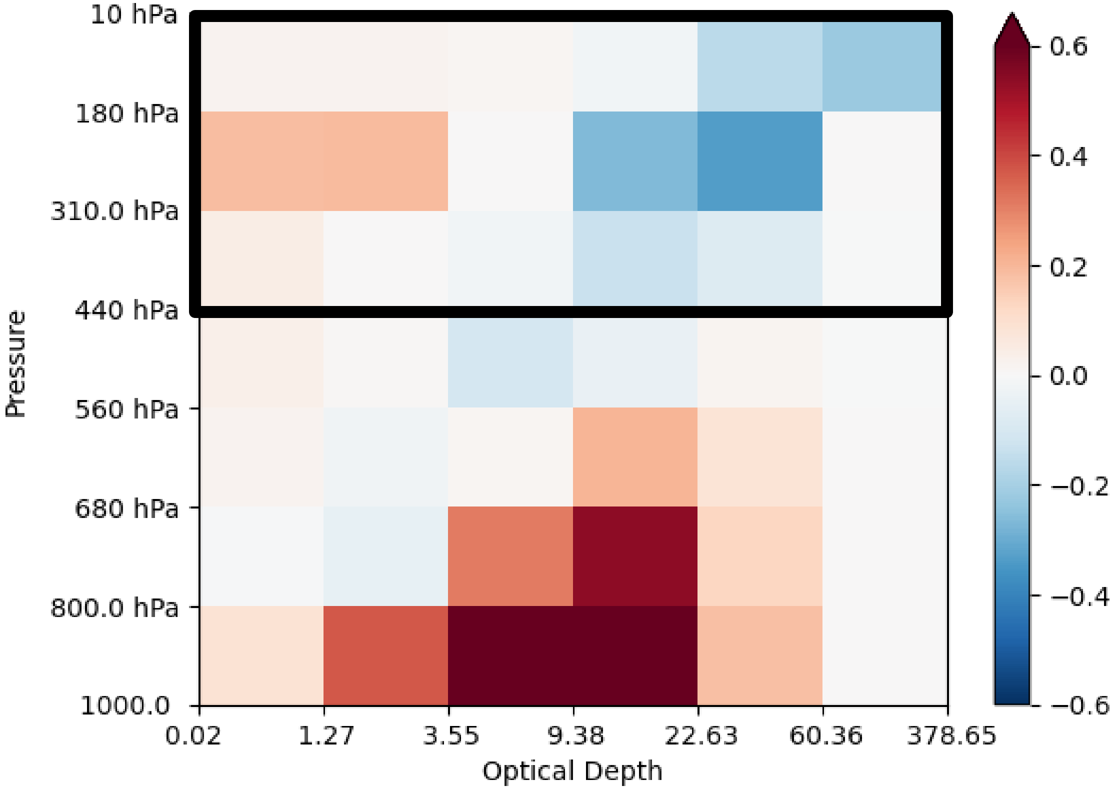
Observed short term net radiative feedback

$$\text{Cloud radiative feedbacks} = \frac{\text{Changes in cloud radiative effects}}{\text{Changes in Global mean surface temperature}}$$

West Pacific



East Pacific



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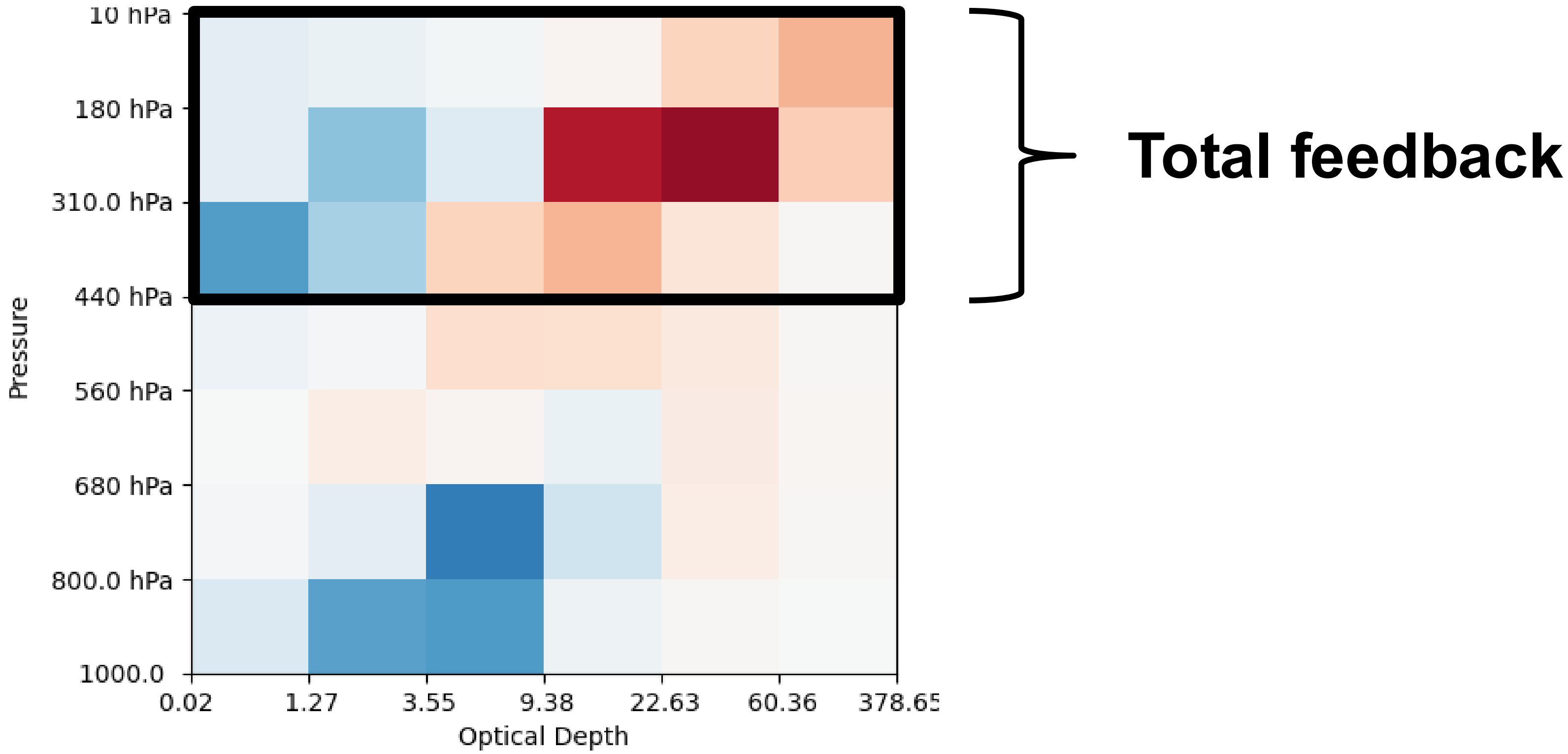
Total feedbacks



Total feedback

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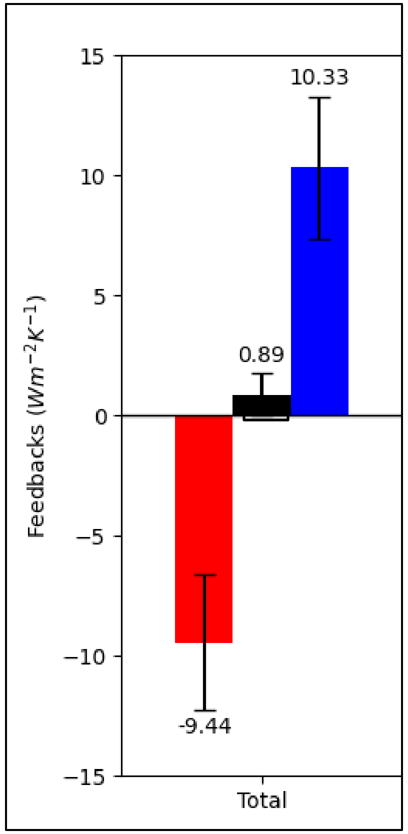
West Pacific feedback

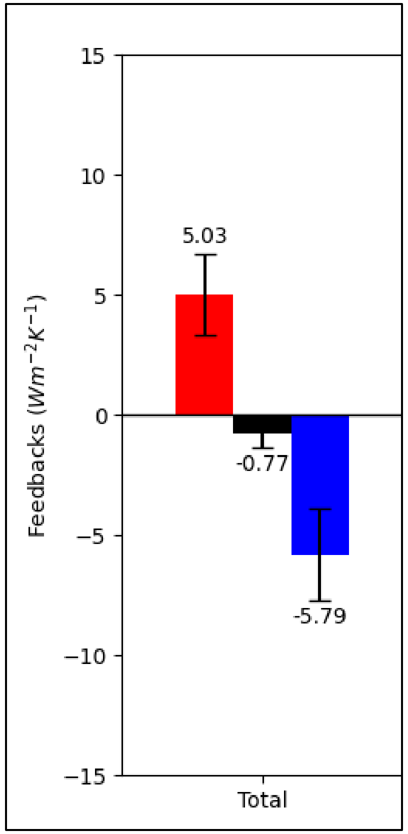


Long-Wave

Short -Wave

Net = LW + SW

East Pacific feedback



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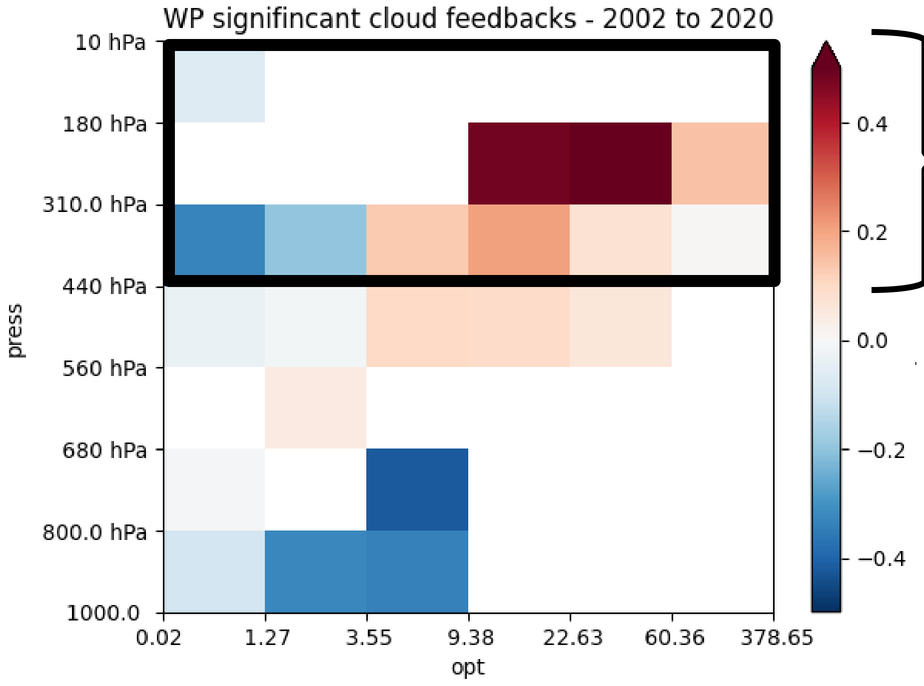
Feedback decomposition



Total feedback =

Amount feedback +

Height feedback +

Optical depth feedback

Zelinka et al. 2012, Raghuraman et al. (2024)

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Net Feedback decomposition

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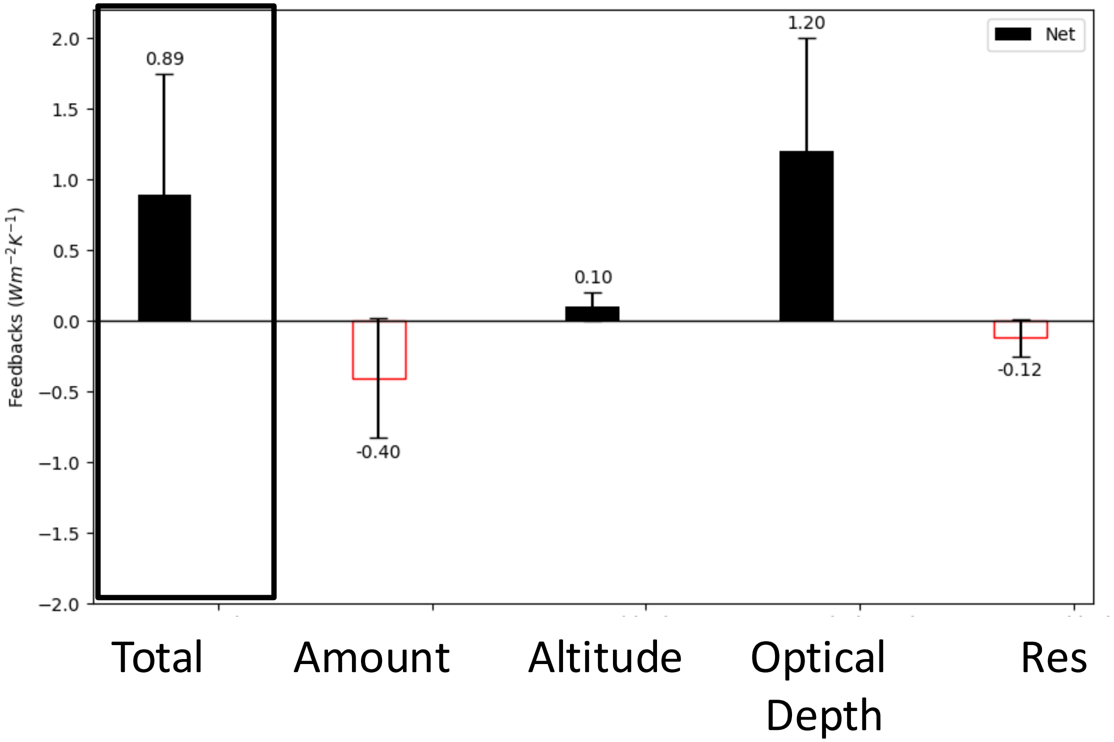
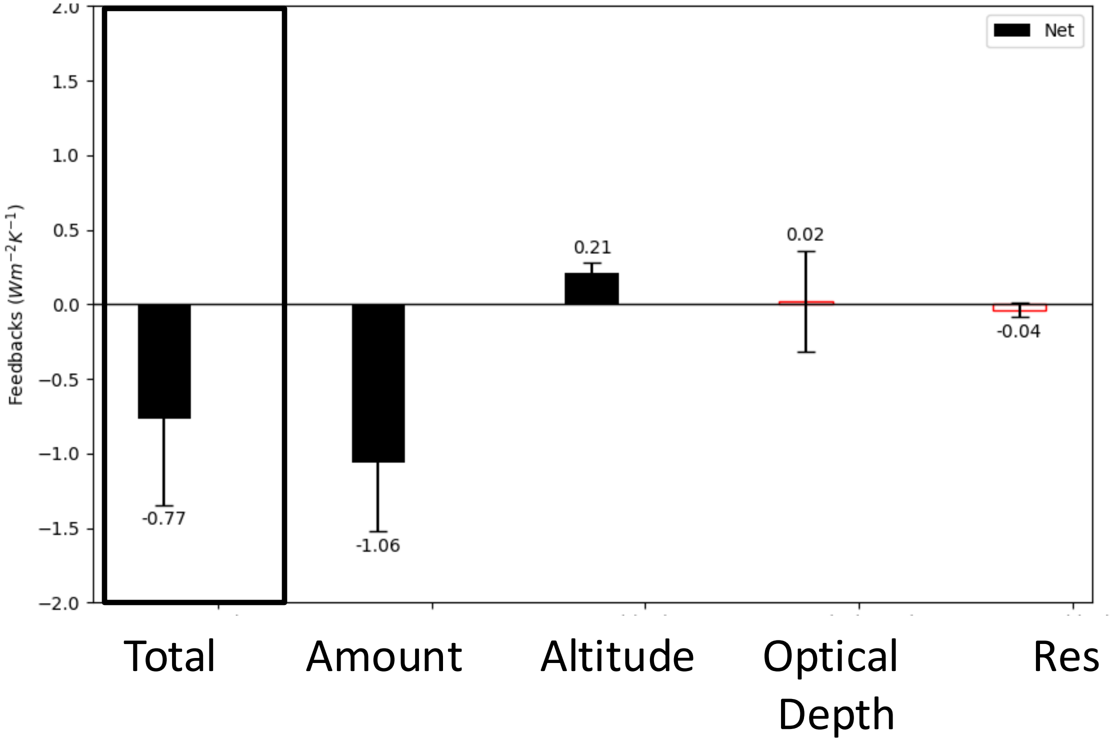
West Pacific feedback



East Pacific feedback



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Net Feedback decomposition: Altitude

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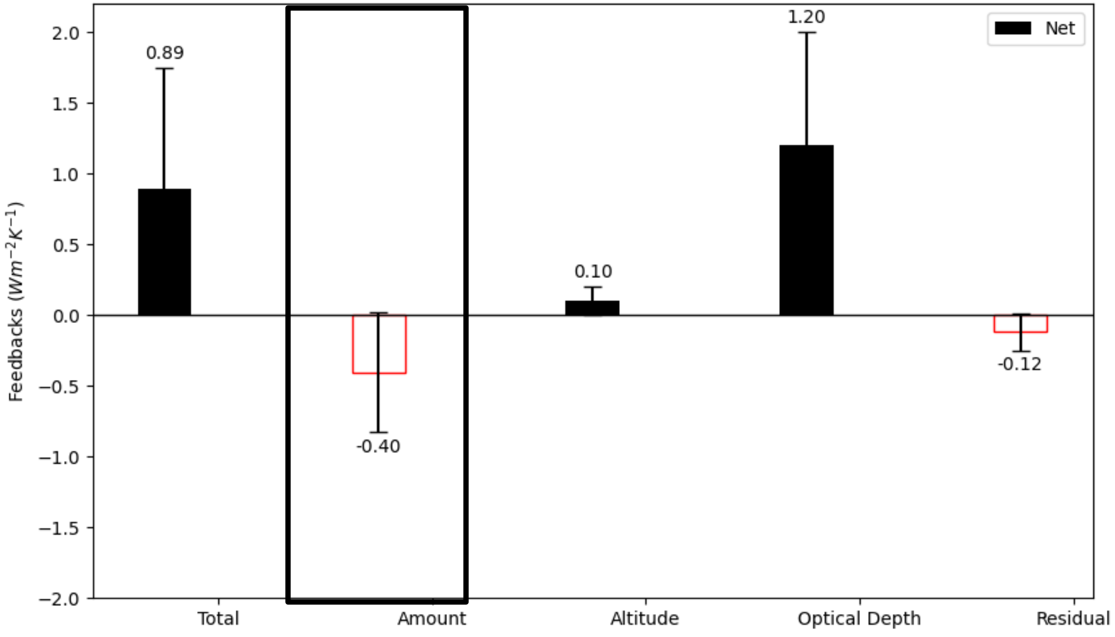
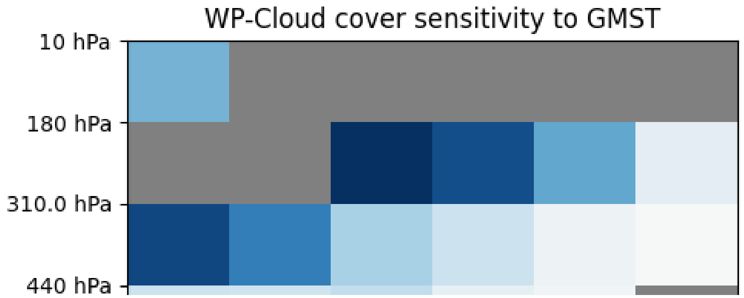
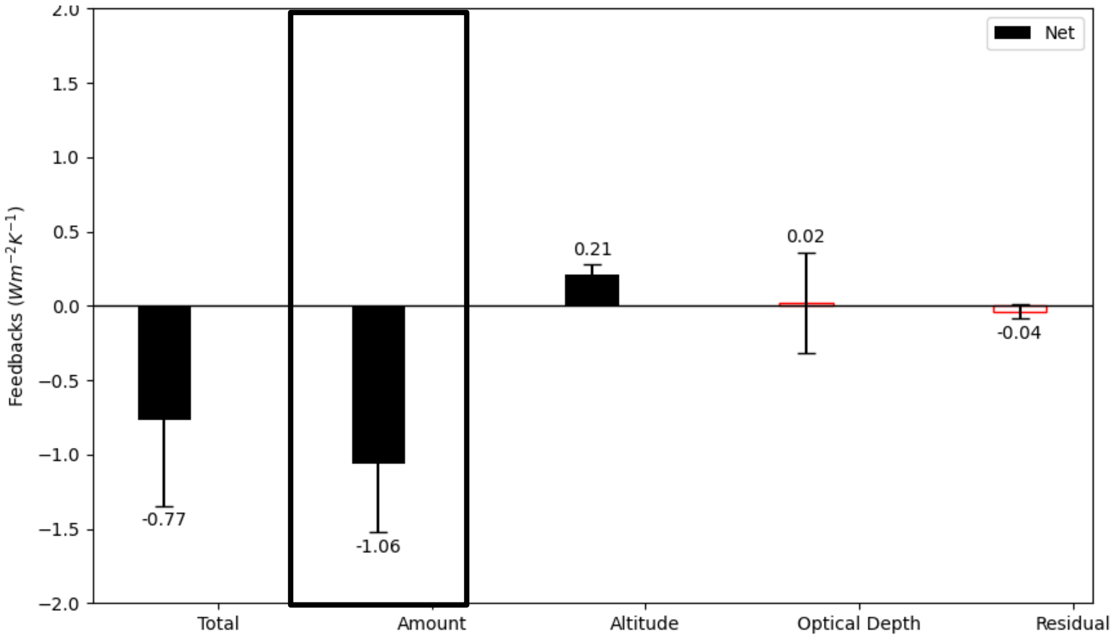
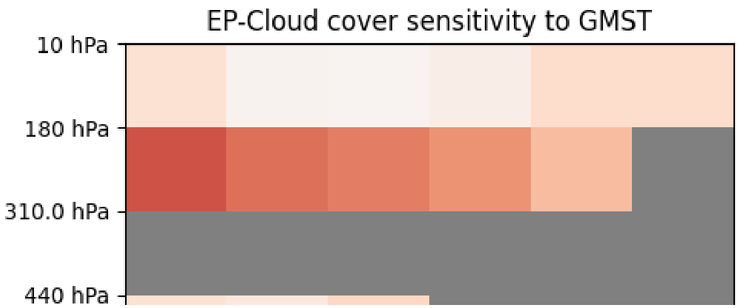
West Pacific feedback





East Pacific feedback





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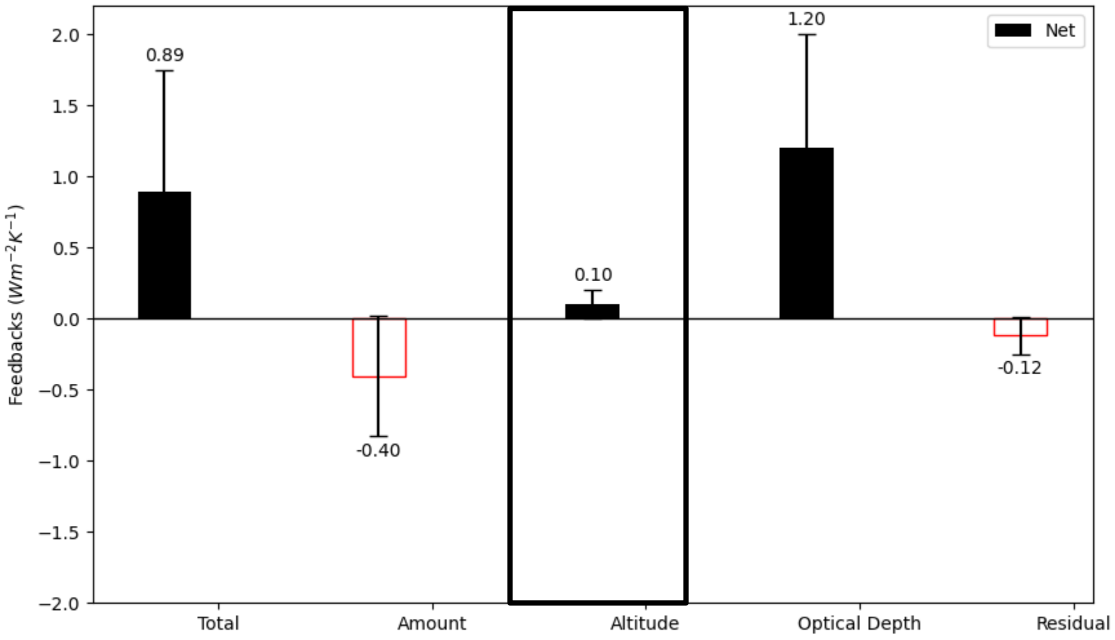
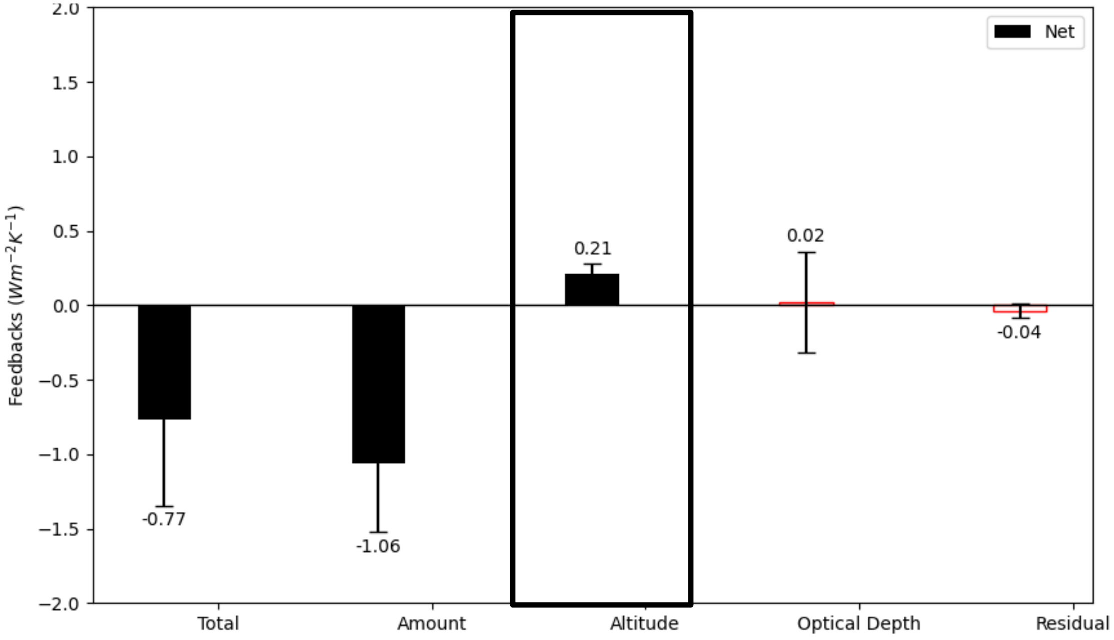
Net Feedback decomposition: Optical Depth

West Pacific feedback



East Pacific feedback



Net Feedback decomposition: Optical Depth

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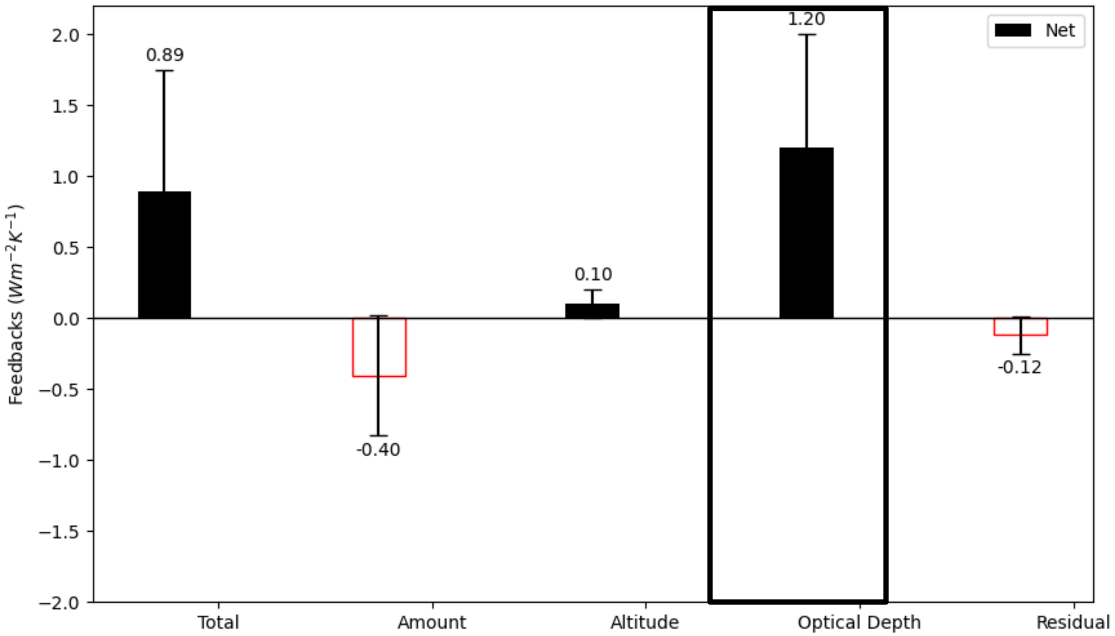
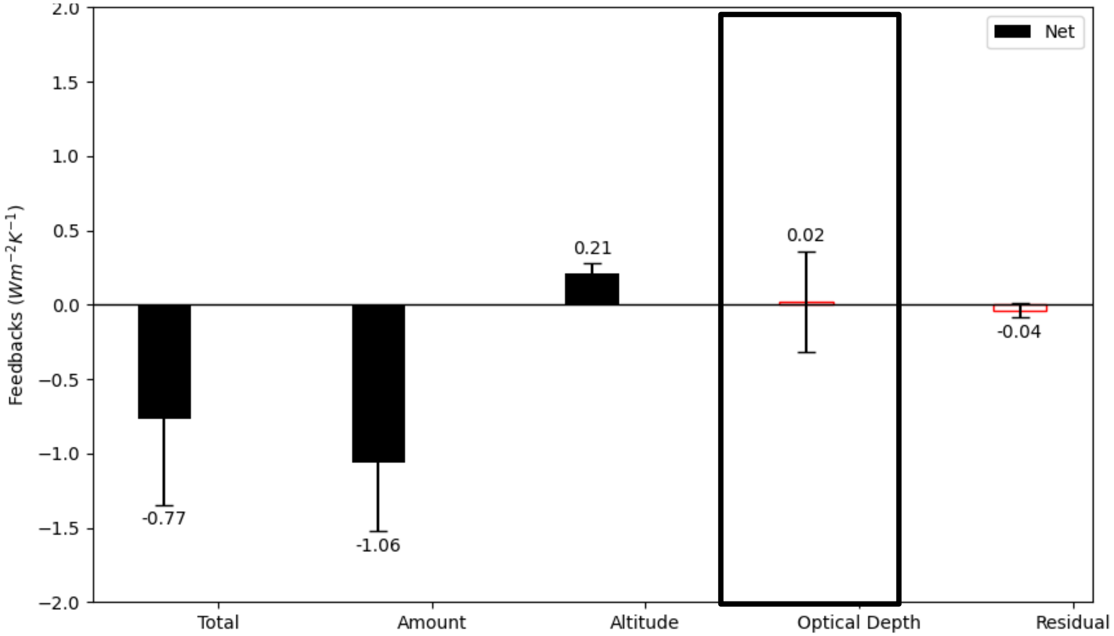
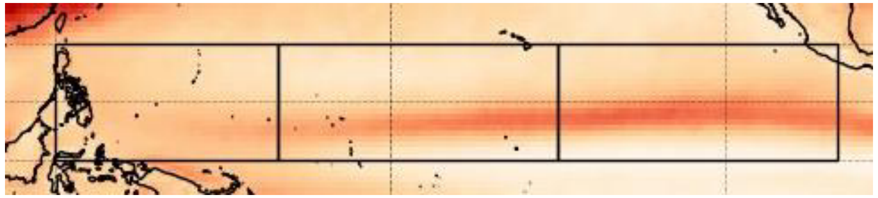
West Pacific feedback



East Pacific feedback





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Effect of removing El Nino months

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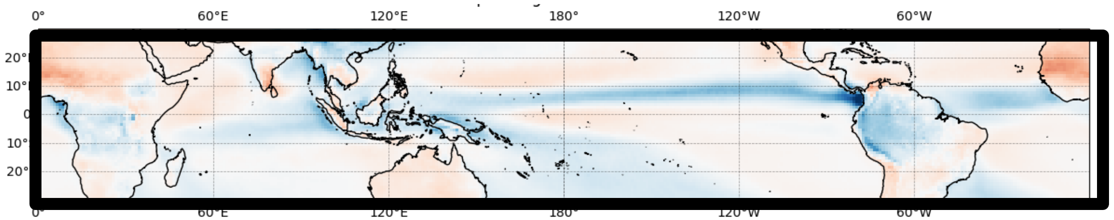
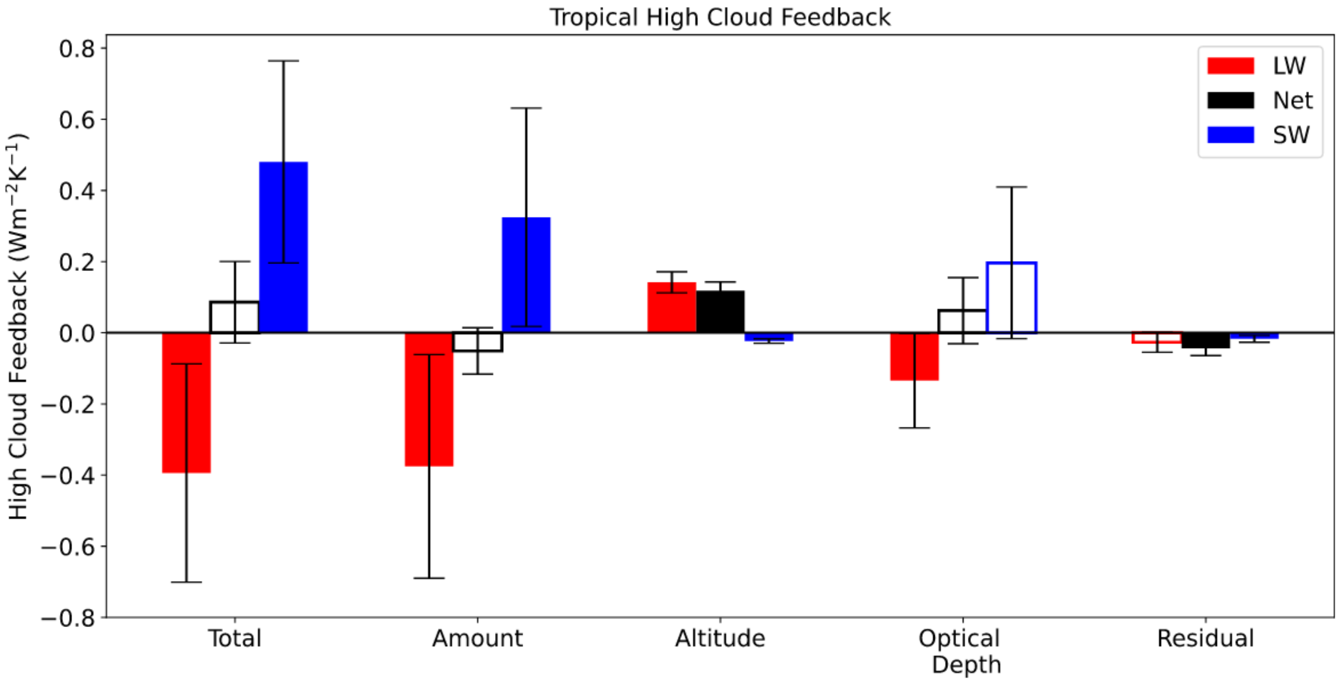


Tropic-wise high cloud net feedbacks



Courtesy of Raghuraman et al. (2024)

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Effect of removing strong ENSO months

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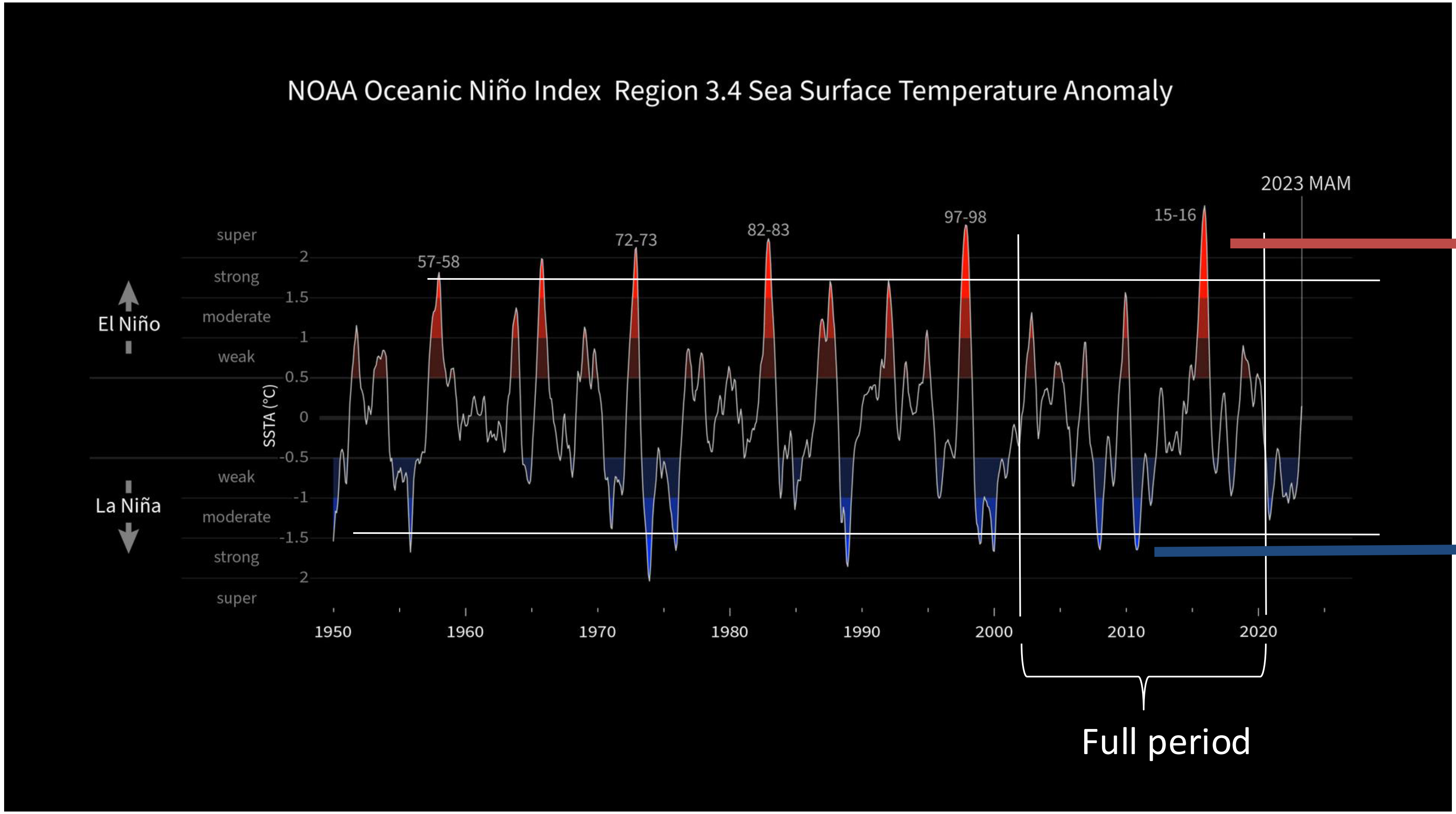

Jun 2025 to Feb 2016

7 % of full period data

Nov 2007 to Jan 2008
Sep 2010 to Feb 2011

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Effect of removing strong ENSO months

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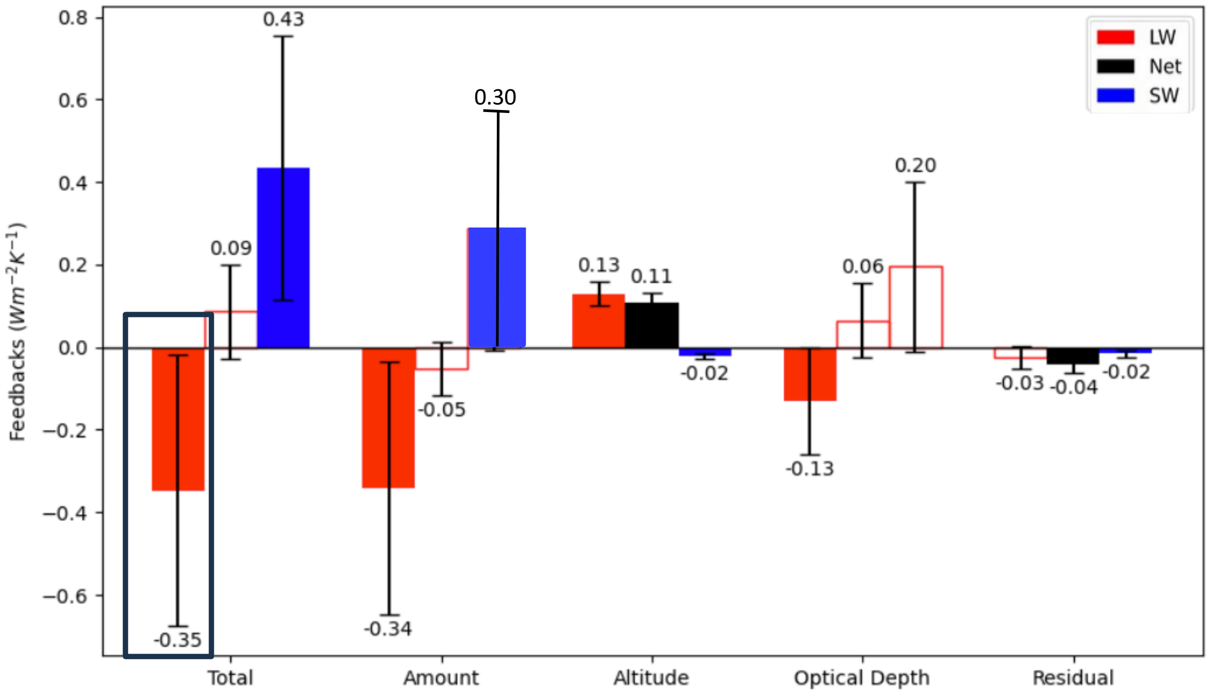
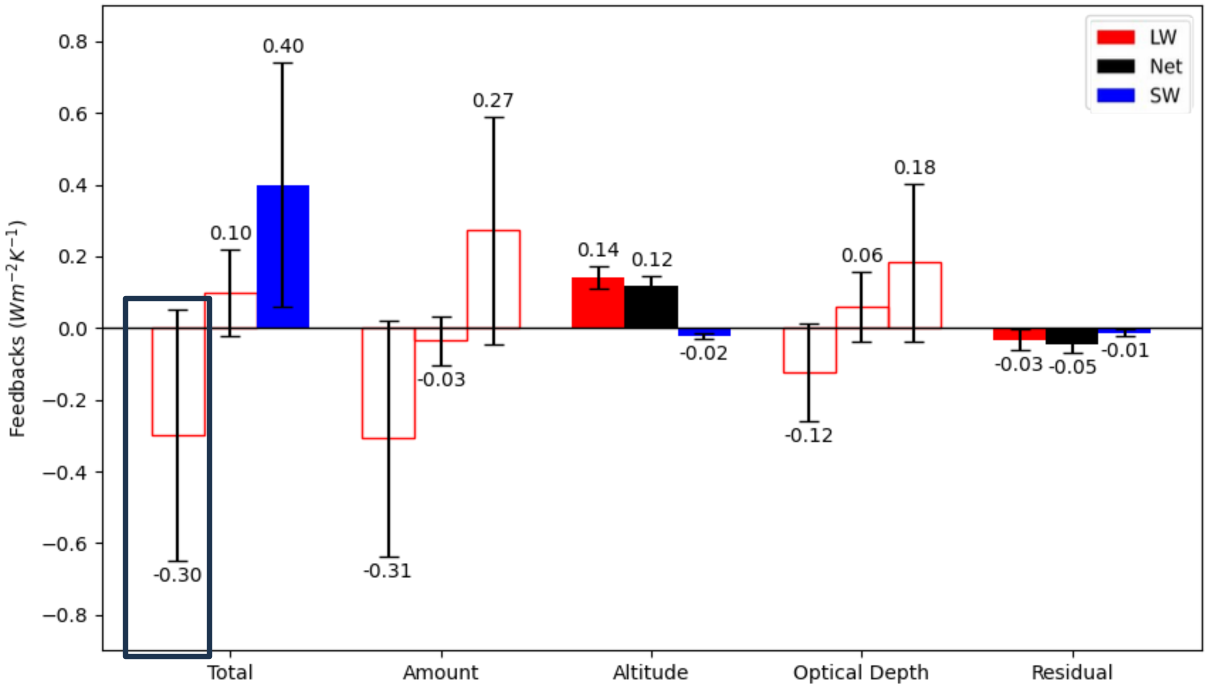
Tropic-wise high cloud feedbacks

Full period



Without strong ENSO events



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Effect of removing strong ENSO months

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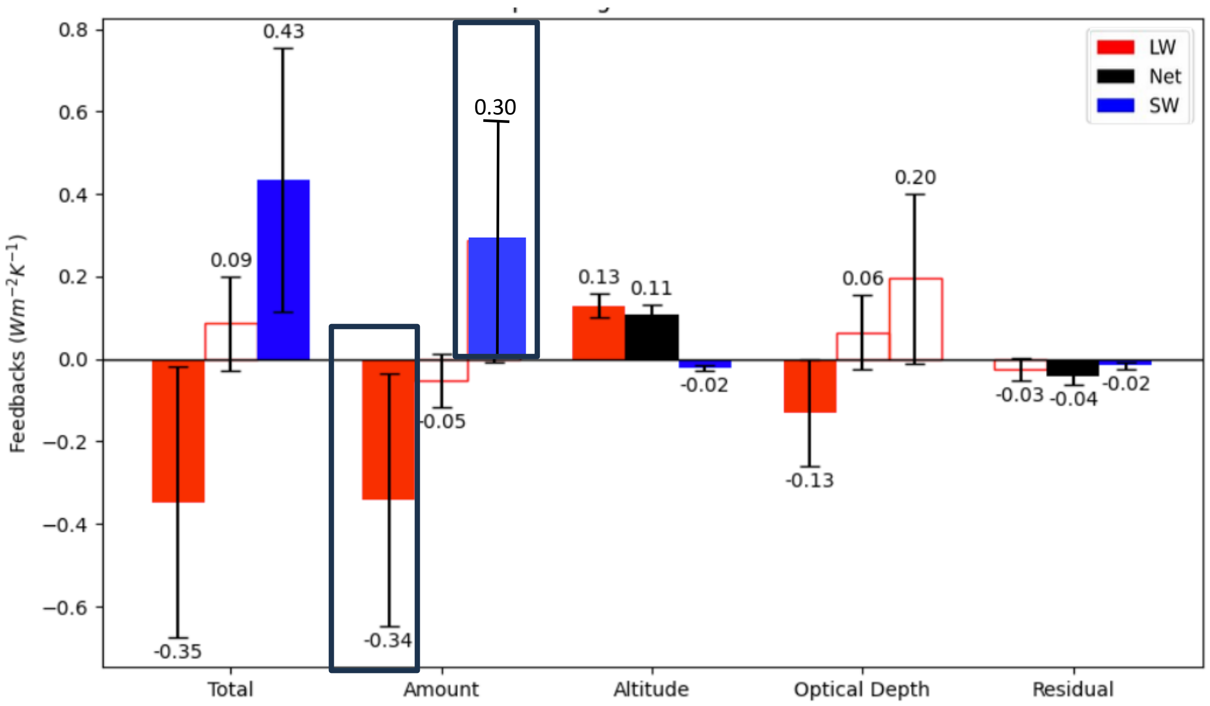
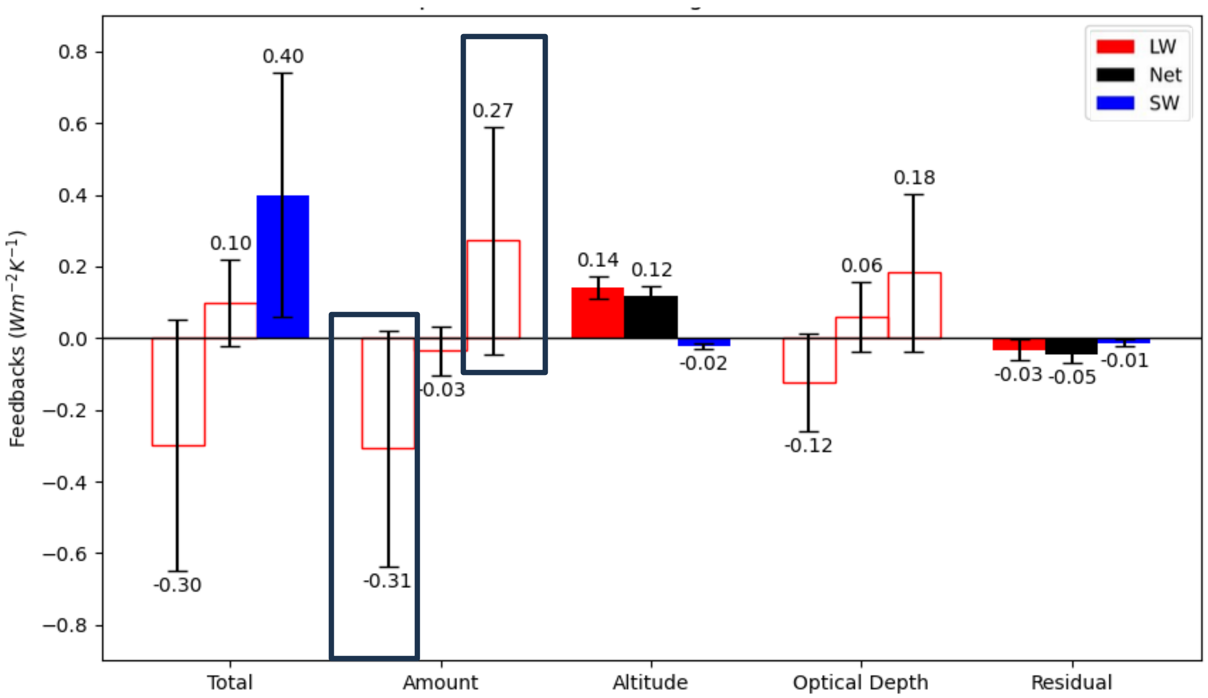
Tropic-wise high cloud feedbacks

Full period



Without strong ENSO events



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Effect of removing strong ENSO months

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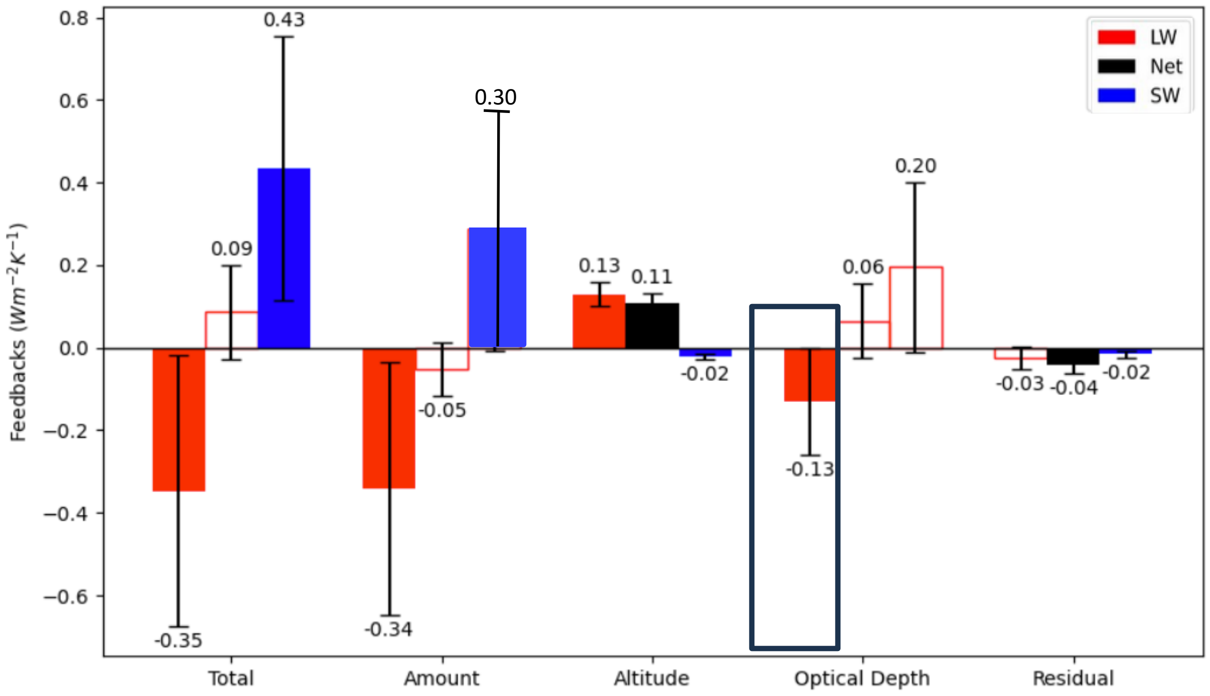
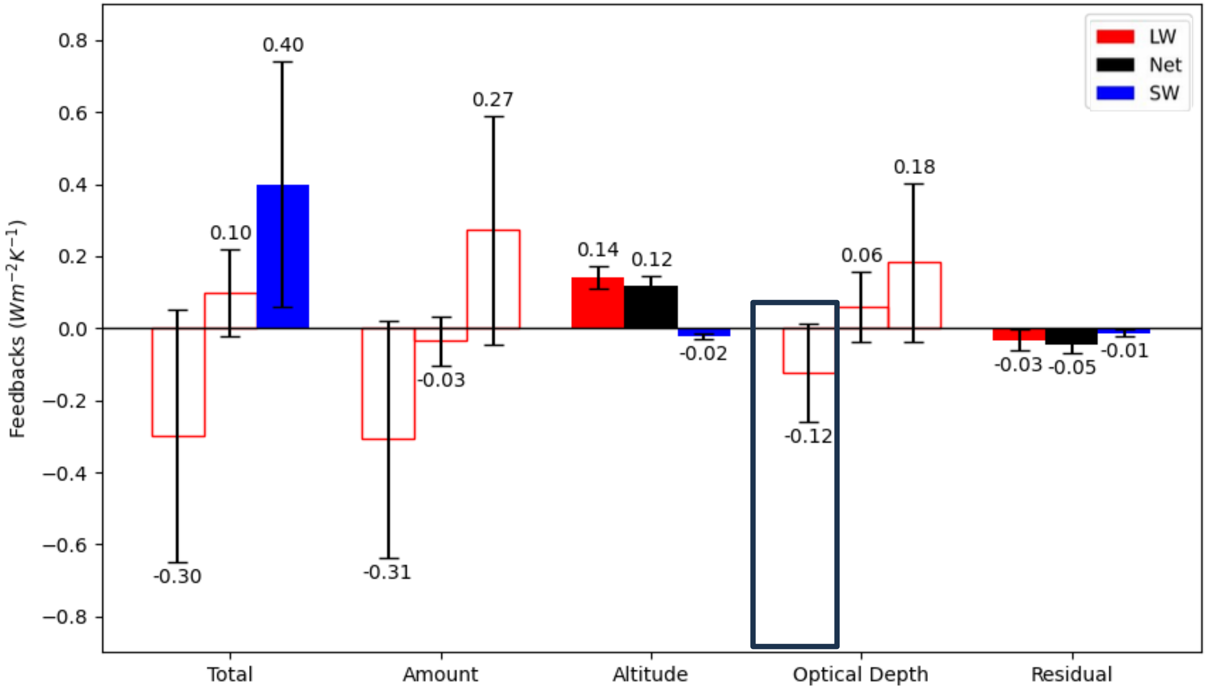
Tropic-wise high cloud feedbacks

Full period



Without strong ENSO events



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Effect of removing strong ENSO events

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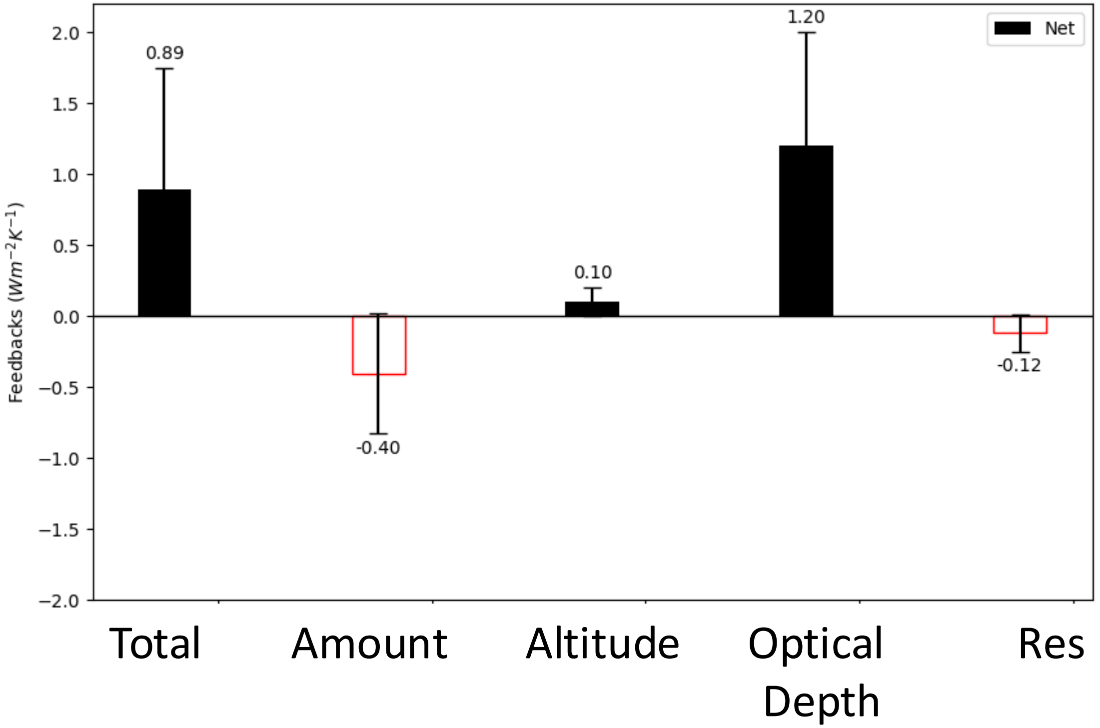
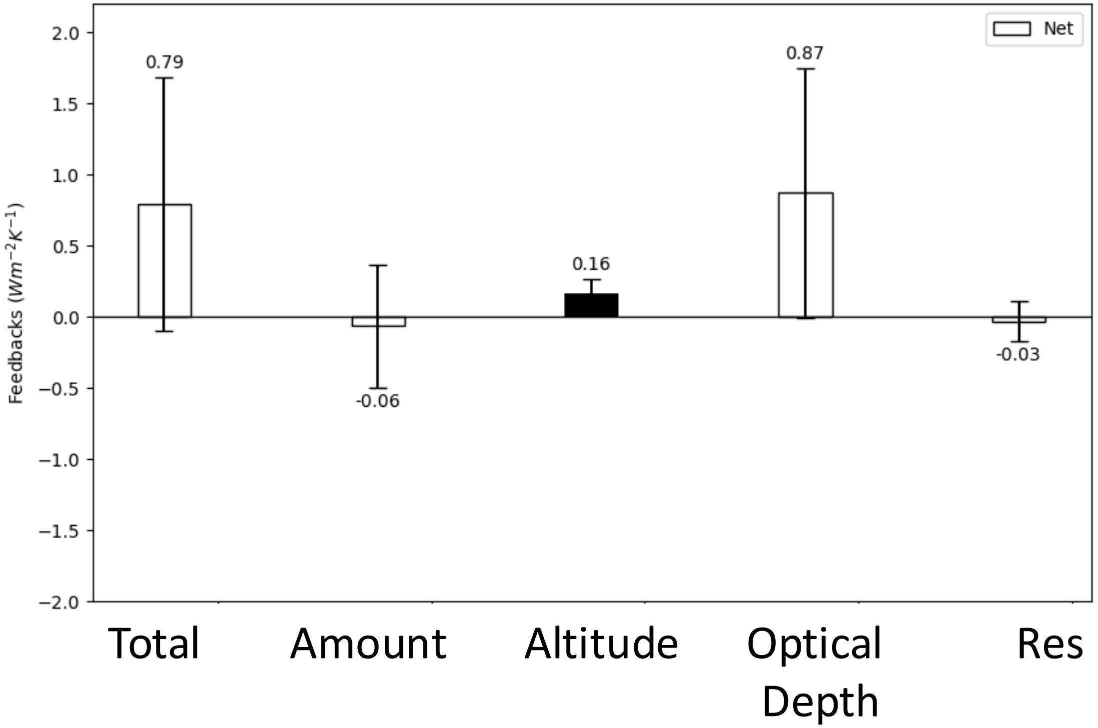
West Pacific high cloud feedbacks

Full period



Without El Nino 2015-2016 event



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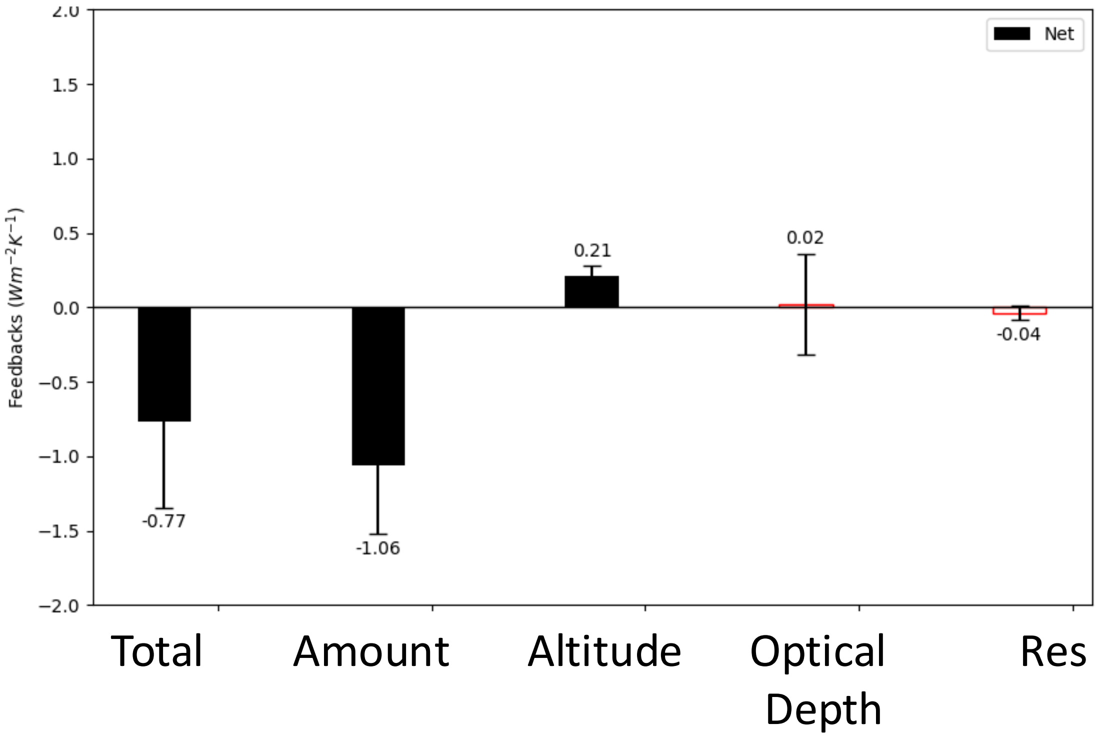
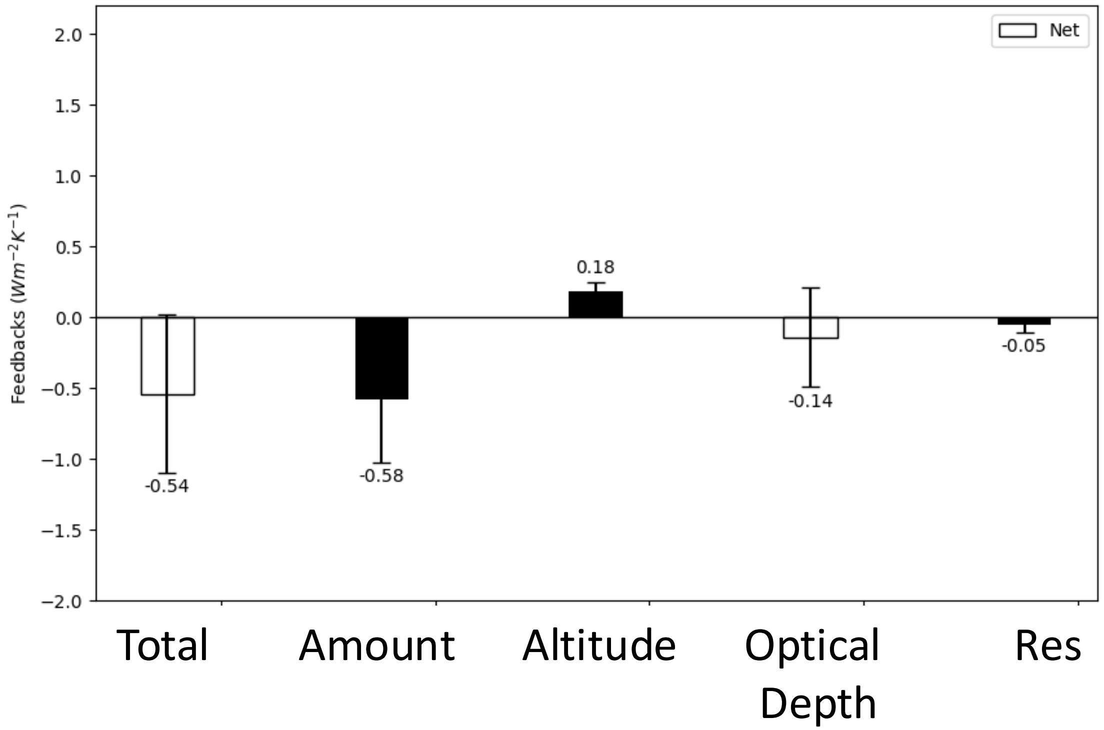
Effect of removing strong ENSO events

East Pacific high cloud feedbacks

Full period



Without El Nino 2015-2016 event



Summary

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- High clouds in East Pacific:
  - Greater optical depths
  - Most negative net CRE
- High clouds total **net** feedback opposite and significant in East and West Pacific.
  - Optical depth (thickness): significant only in West Pacific, positive
- El Nino Southern oscillation is a key effect in the Tropics.
  - Feedback estimations depends on the inclusion of ENSO data.
- Future work: What is the role of aerosols in the local radiative effects?

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References

- ISCCP Cloud Types (2001): Hahn, Carole J., William B. Rossow, and Stephen G. Warren. "ISCCP Cloud Properties Associated with Standard Cloud Types Identified in Individual Surface Observations", Journal of Climate 14, 1 (2001): 11-28, doi: https://doi.org/10.1175/1520-0442(2001)014<0011:ICPAWS>2.0.CO;2
- ISCCP cloud classification chart courtesy of Goddard Space Flight Center https://www.giss.nasa.gov/edu/icp/research/ppa/1996/abeyie/
- Zelinka, Mark D., Stephen A. Klein, and Dennis L. Hartmann. 'Computing and Partitioning Cloud Feedbacks Using Cloud Property Histograms. Part I: Cloud Radiative Kernels'. *Journal of Climate* 25, no. 11 (1 June 2012): 3715–35. https://doi.org/10.1175/JCLI-D-11-00248.1.
- Raghuraman, Shiv Priyam, Brian Medeiros, and Andrew Gettelman. 'Observational Quantification of Tropical High Cloud Changes and Feedbacks'. *Journal of Geophysical Research: Atmospheres* 129, no. 7 (2024): e2023JD039364. https://doi.org/10.1029/2023JD039364.
- CERES Flux by Cloud Type: https://ceres.larc.nasa.gov/data/#fluxbycldtyp-level-3
- NOAA ONI: https://www.climate.gov/news-features/understanding-climate/climate-variability-oceanic-nino-index