Latent heating and large scale transport cause arctic amplification in a model without sea ice

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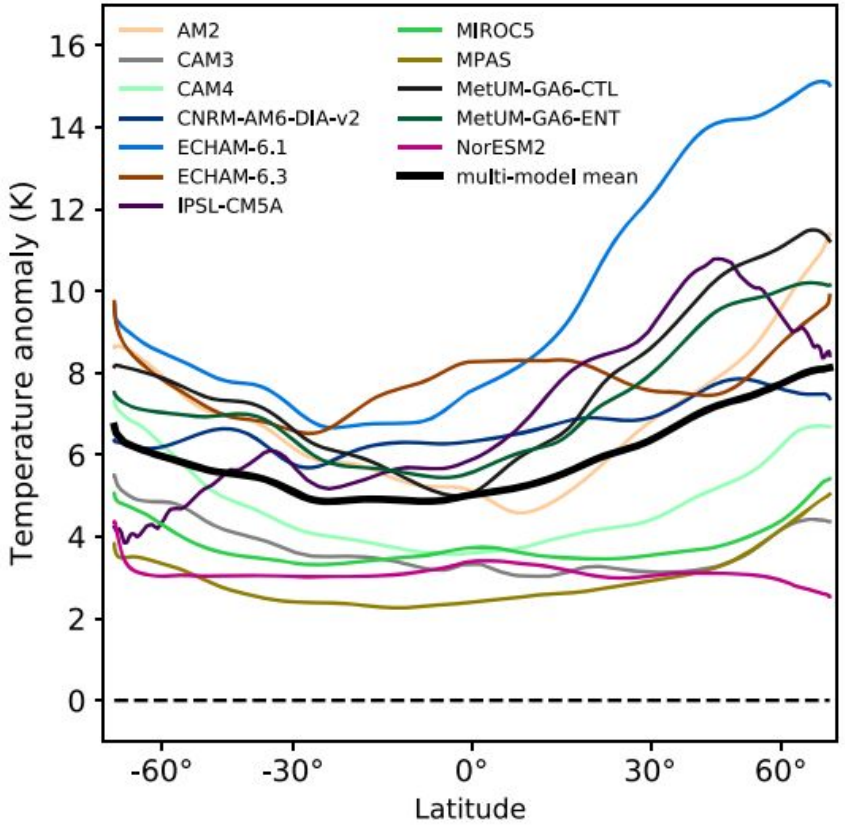
- Models without land or sea ice show polar amplification

- We will show that in an idealized model this comes from latent heating and transport

Aquaplanet Δ(Surface Temperature)
For CO2 Doubling

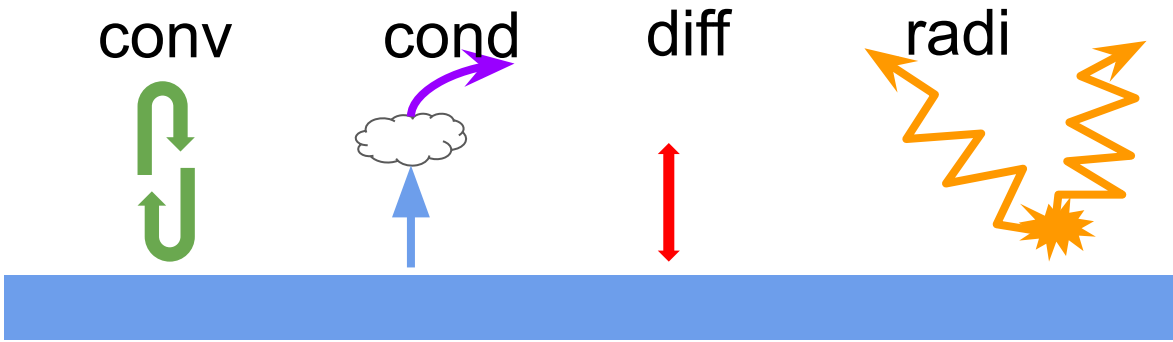


Russotto and Biasutti (2020)

Methods

We use an idealized aquaplanet with minimalistic parametrized physics

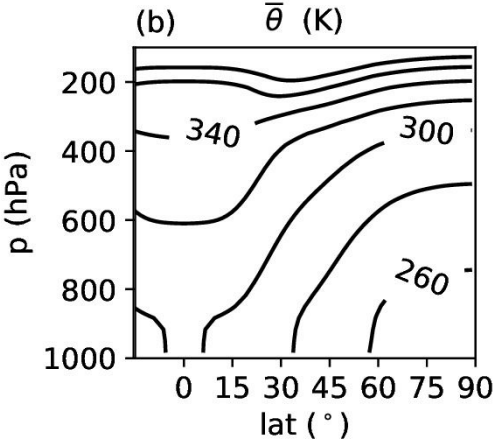
(Isca Model, see Vallis et. al. 2018, https://github.com/ExeClim/Isca)



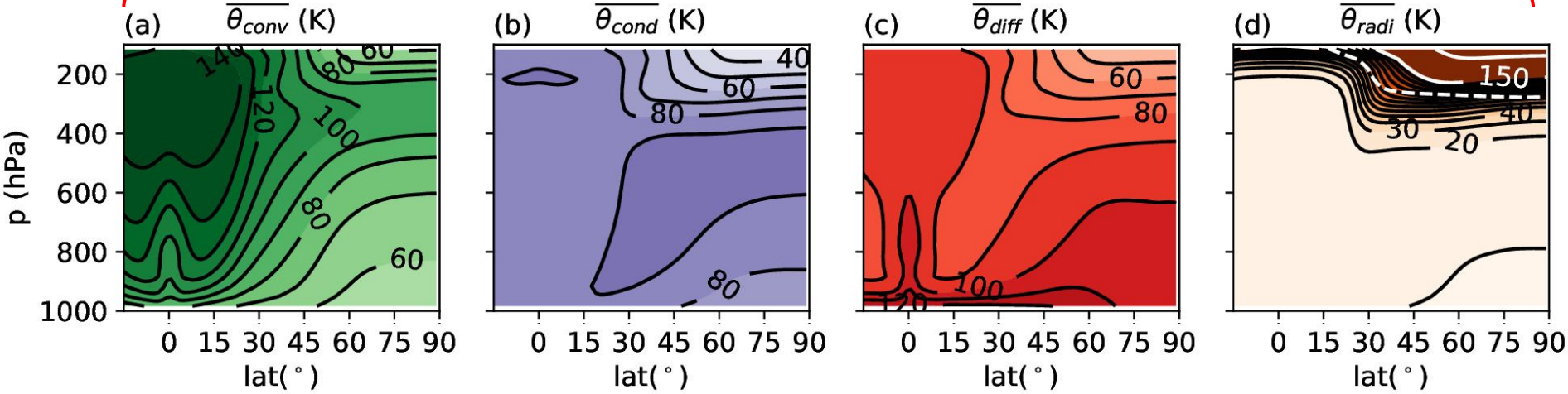
We add passive tracers to the model - called heat tags - which allow us to decompose the potential temperature field by physical process.

$$\theta = \theta_{conv} + \theta_{cond} + \theta_{diff} + \theta_{radi}$$

Decomposition of the zonal mean θ

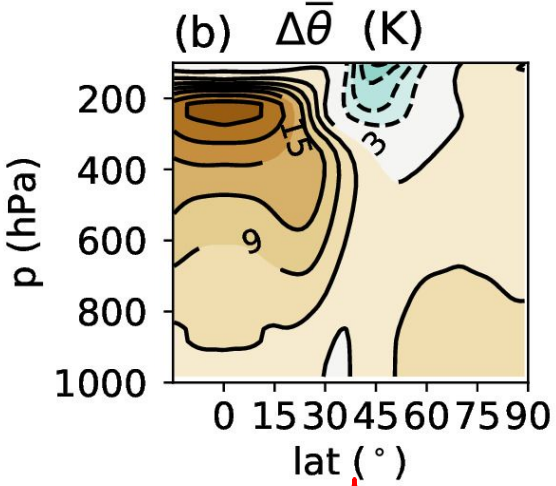


- The heat tags have localized sources:
  - Conv <-> Tropics, Cond<-> Midlatitudes, Radi<-> Stratosphere, Diff <-> surface
- Heat tags extend far beyond the regions where they were produced
- Heat tags related to latent heating make up 2/3 of polar θ

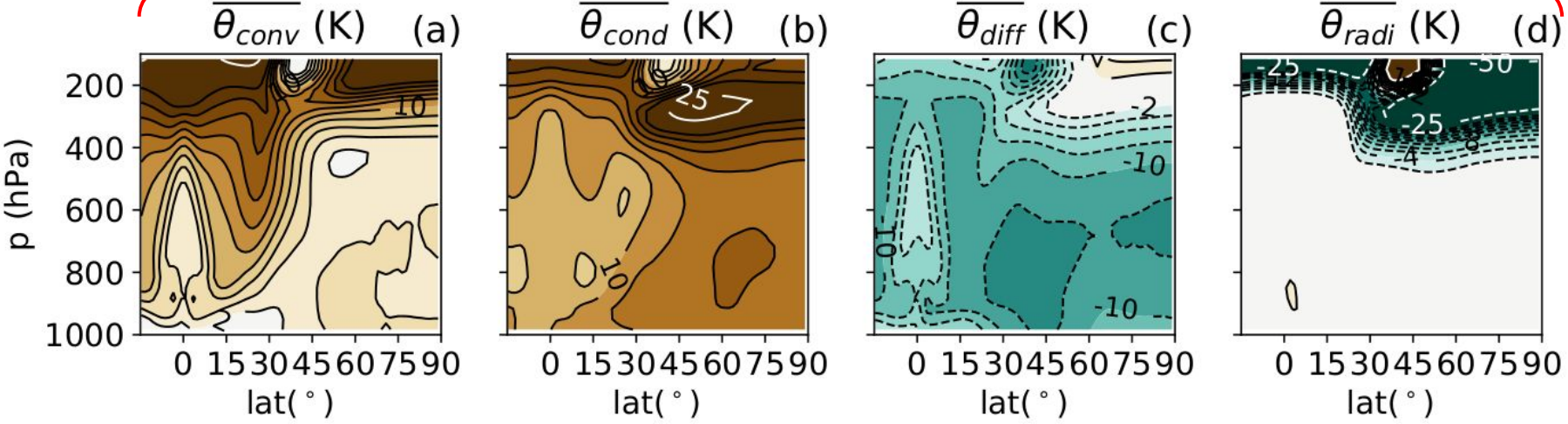


Tropical Source | Midlatitude Source | Surface Source | Stratospheric Source

Decomposition of the zonal mean Δθ For a CO_2 Doubling

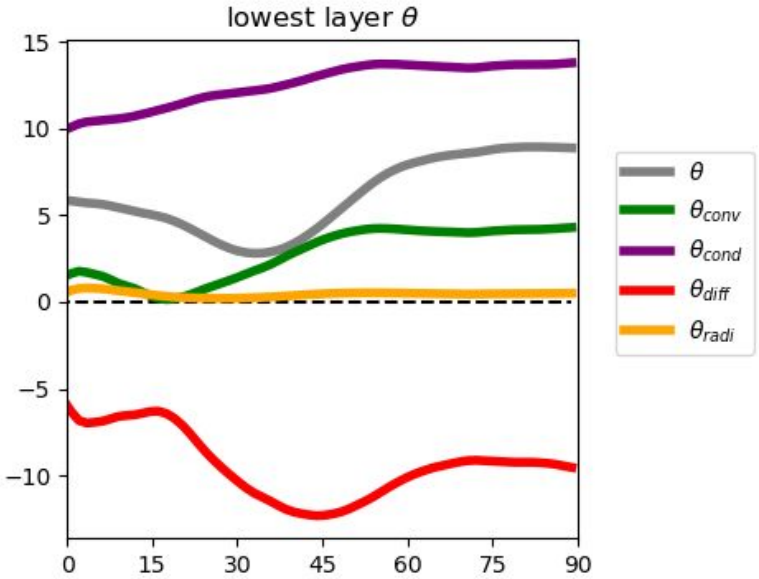


- Δθ largest in upper tropics, some response in the polar surface
- Heat tags from latent heating increase, Heat Tags related to sensible heating decrease
- Still no latent heating in the polar atmosphere
  - ⇒ increase in polar heat content coming from other latitudes



Tropical Source | Midlatitude Source | Surface Source | Stratospheric Source

Decomposition of θ in the lowest model layer



Conclusions

- Remote Latent Heating accounts for 2/3 of polar heat content
- Under a CO2 doubling, evaporation and latent heating increase in the tropics and midlatitudes
- The warm air is transported to the poles to cool, and this causes polar amplification

Future Work

- How do other controls on the hydrological cycle affect polar amplification?
- Can we use this technique in a less idealized model?

References

Russotto, Rick D., and Michela Biasutti. "Polar amplification as an inherent response of a circulating atmosphere: results from the TRACMIP aquaplanets." *Geophysical Research Letters* 47.6 (2020)

Vallis, Geoffrey K., et al. "Isca, v1. 0: A framework for the global modelling of the atmospheres of Earth and other planets at varying levels of complexity." *Geoscientific Model Development* 11 (2018).

Submitted manuscript, coming soon in JAS

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