Climate Response of an Earth-like Planet to Ocean Heat Transport Changes

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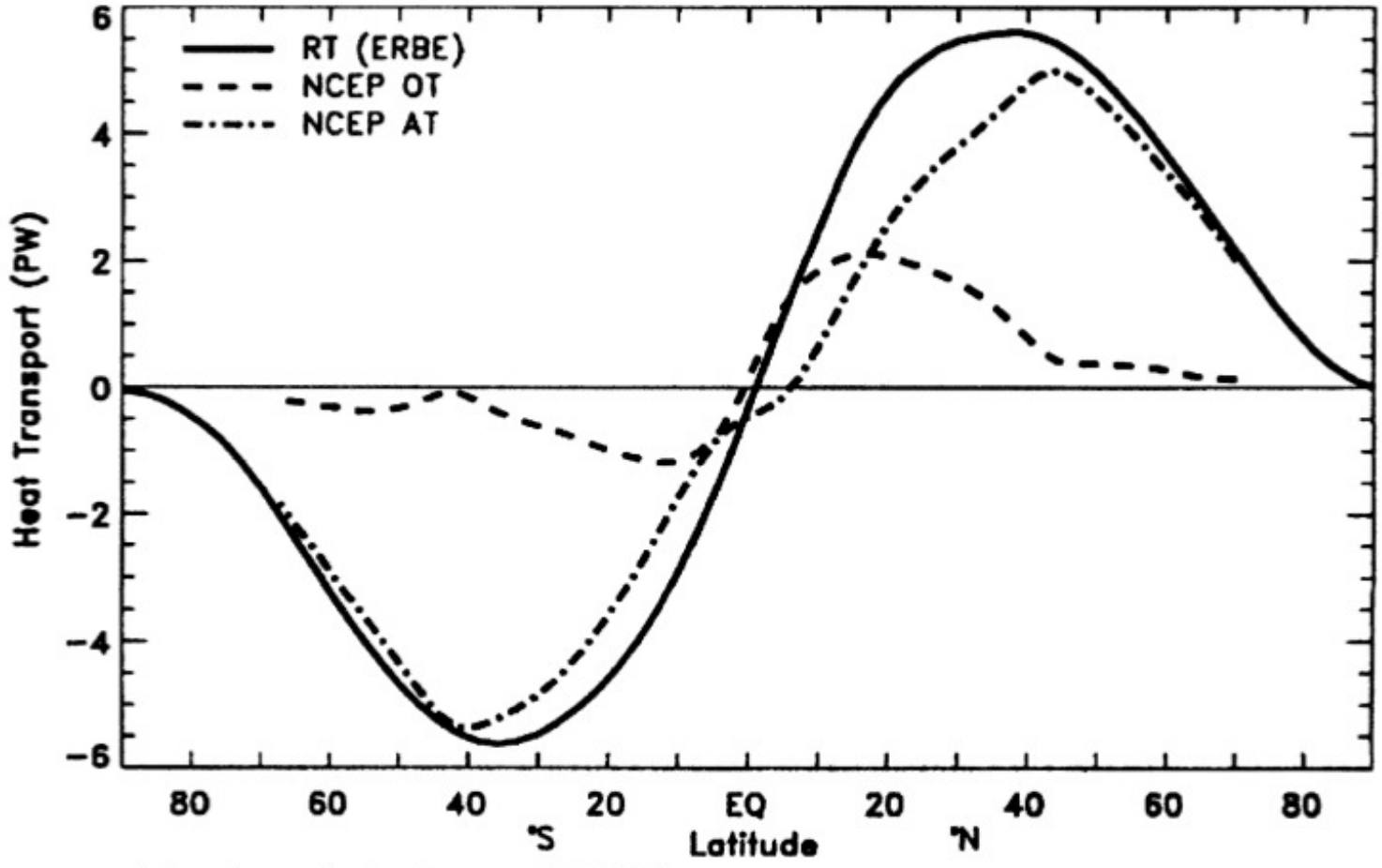
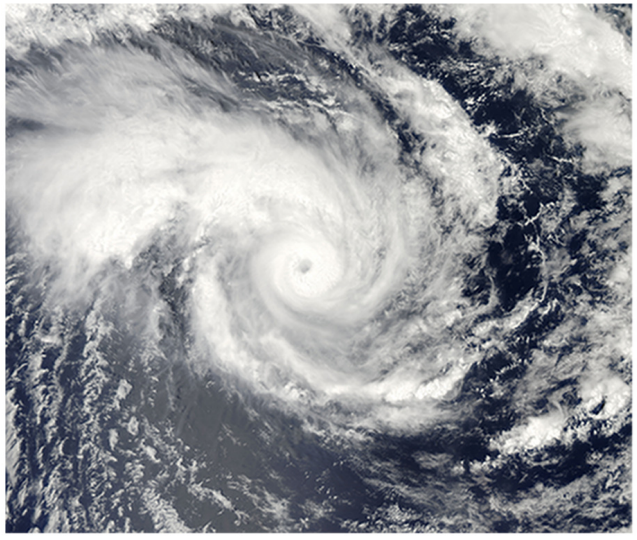
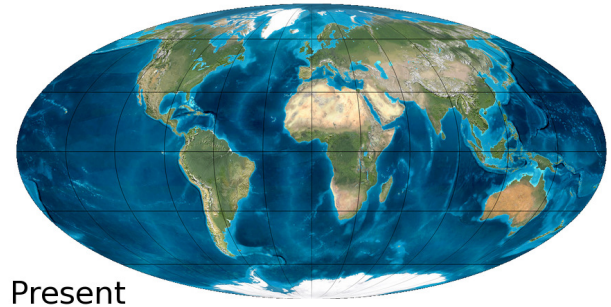
This is the energy transported on Earth by the ocean & atmosphere.



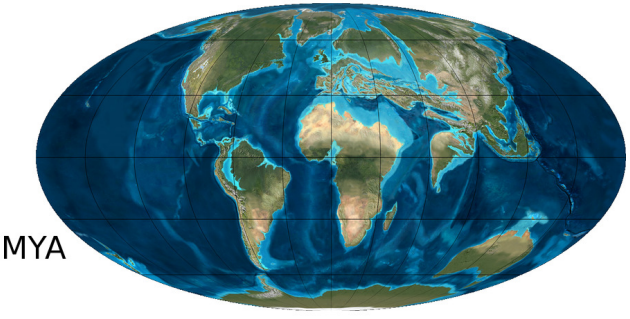
Trenberth & Caron (2010)

Past climates on Earth and exoclimates could have very different Ocean Heat Transports.

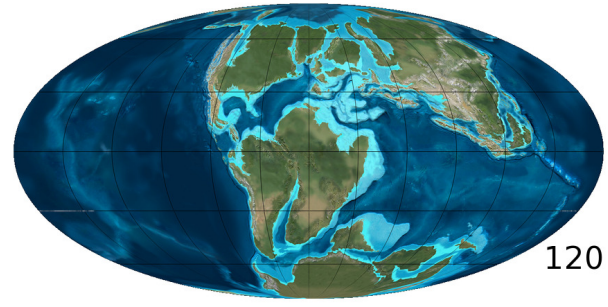




Present



50 MYA



120 MYA

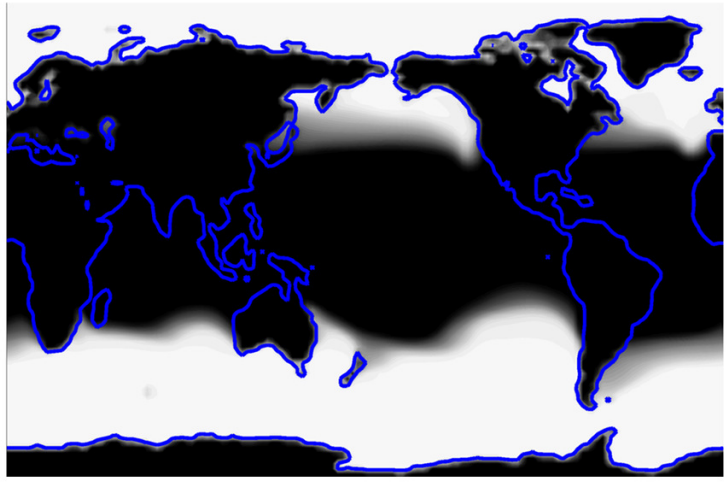
Ocean Heat Transport and "Habitability"

Changes in OHT can have a big impact on the "habitability" of a planet.

Sea Ice Fraction

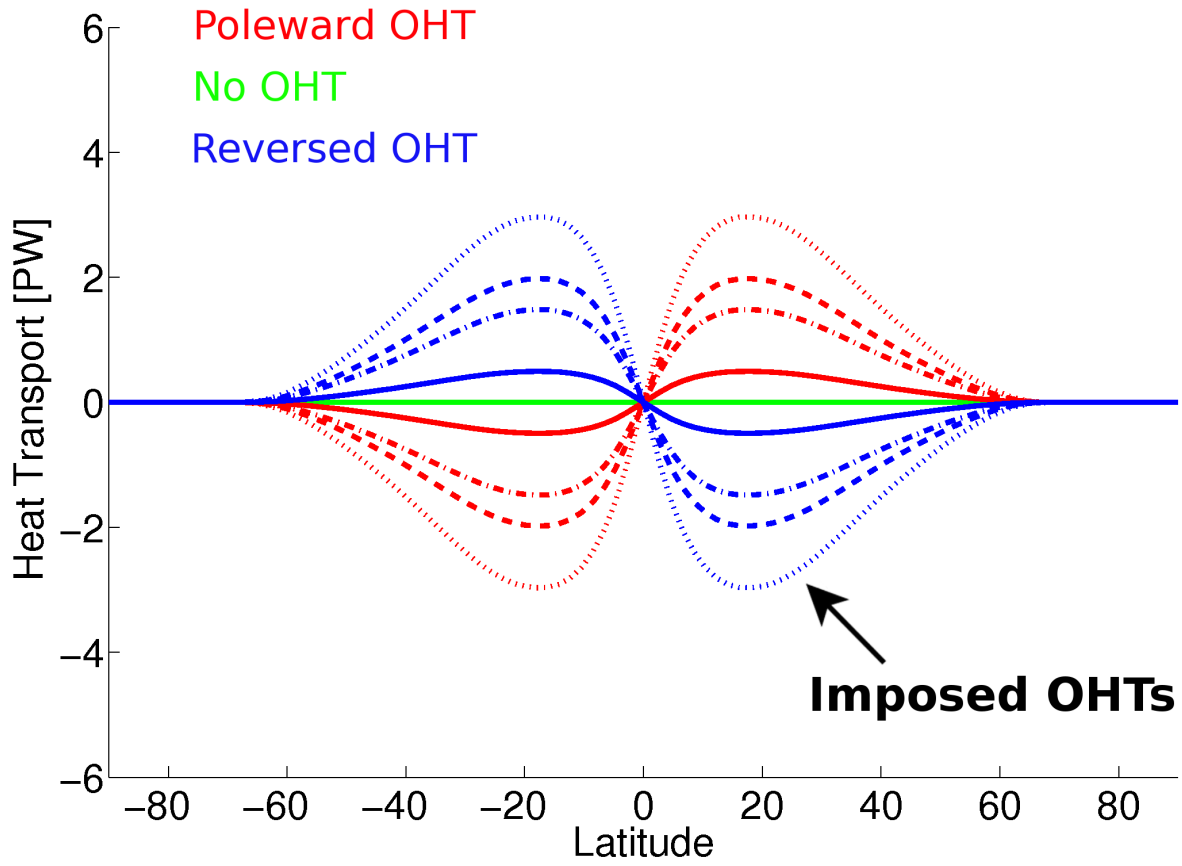
Dynamic Ocean (on)

Swamp Ocean (off)



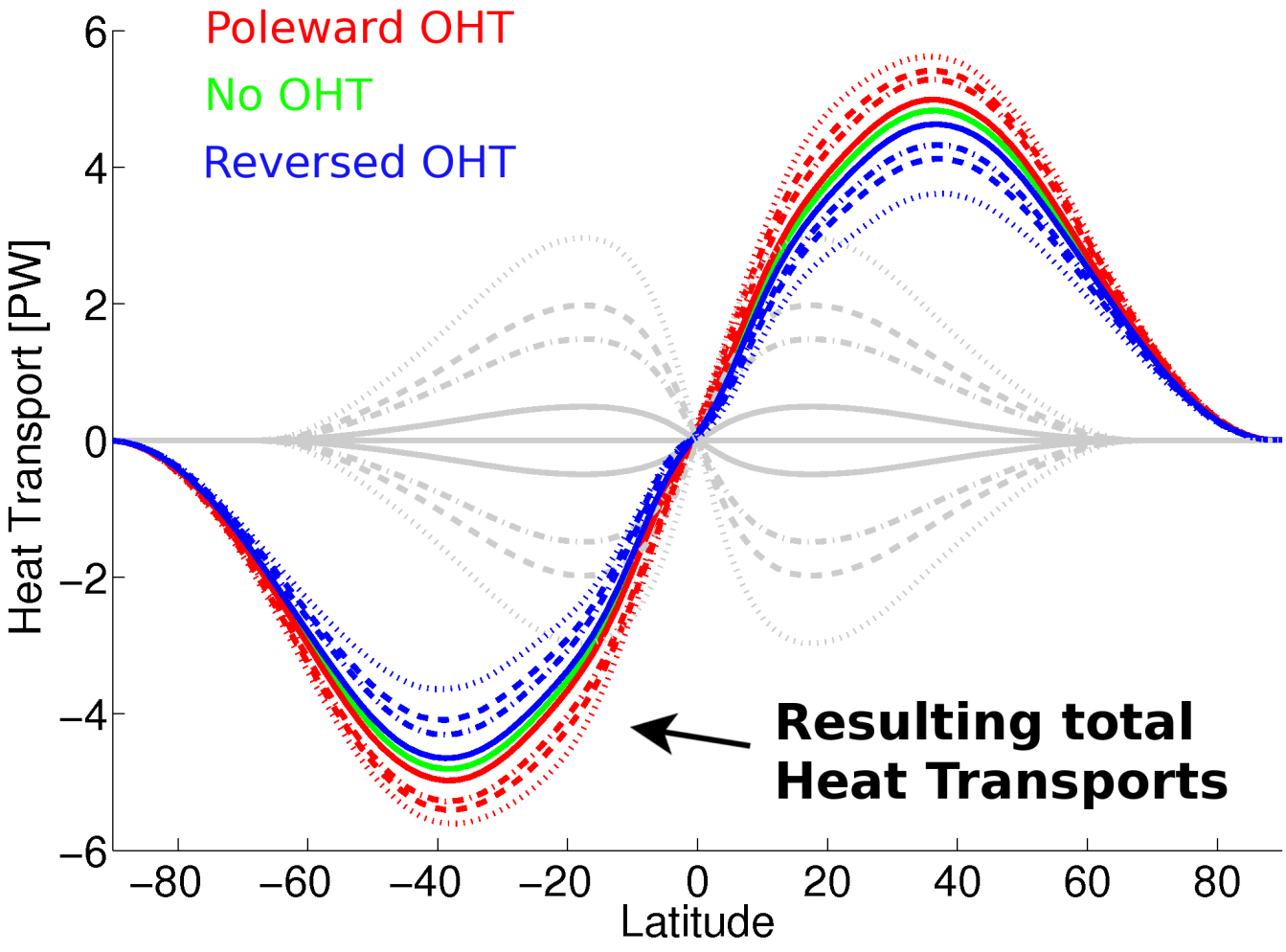
We test how OHT influences climate in a comprehensive Global Climate Model.

- CAM4 and CAM5 atmosphere model.
- No land or ice, slab ocean with prescribed OHT.
- Also see Herweijer et al (2005) and Rose et al (2011).

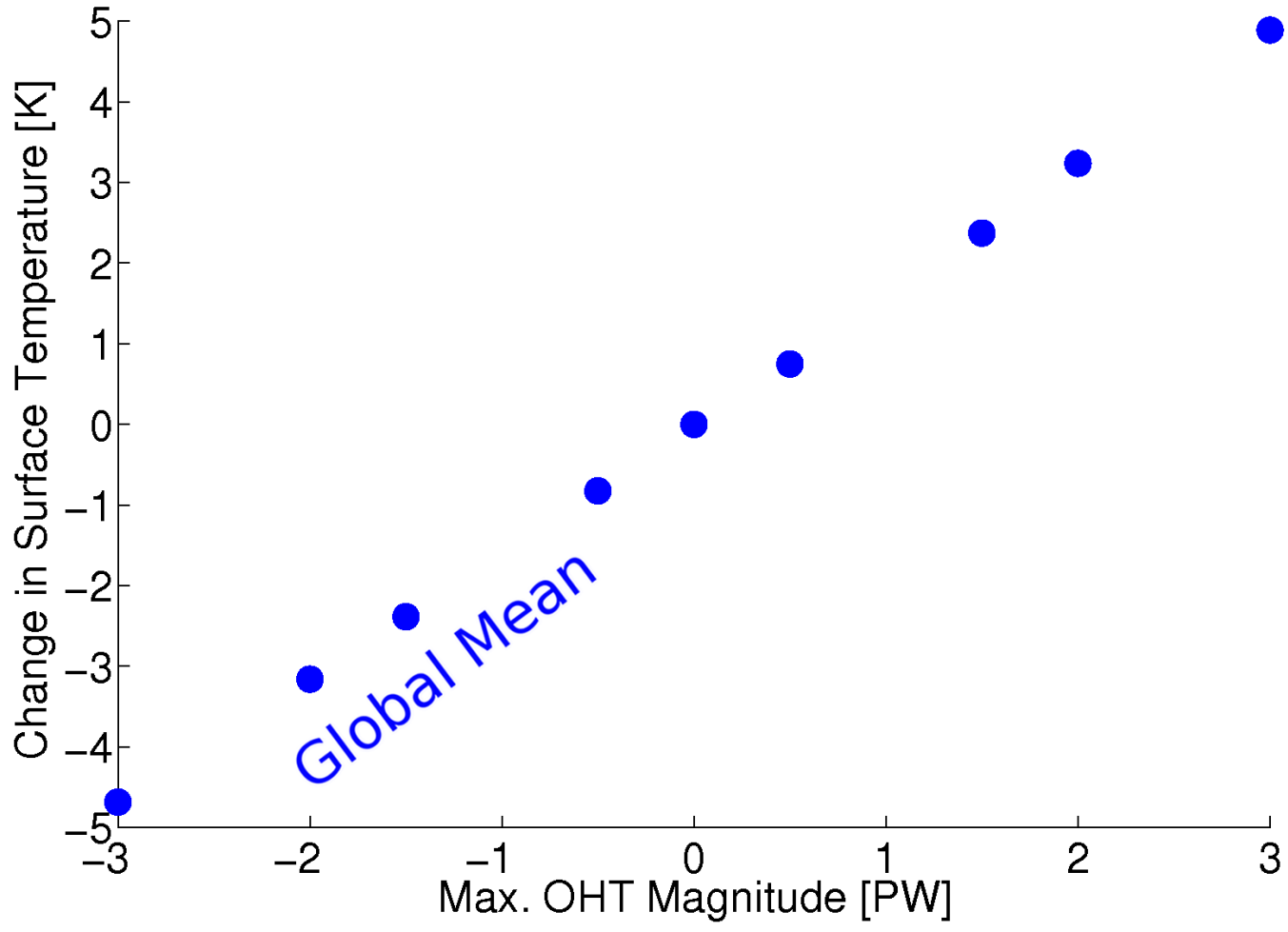


Results

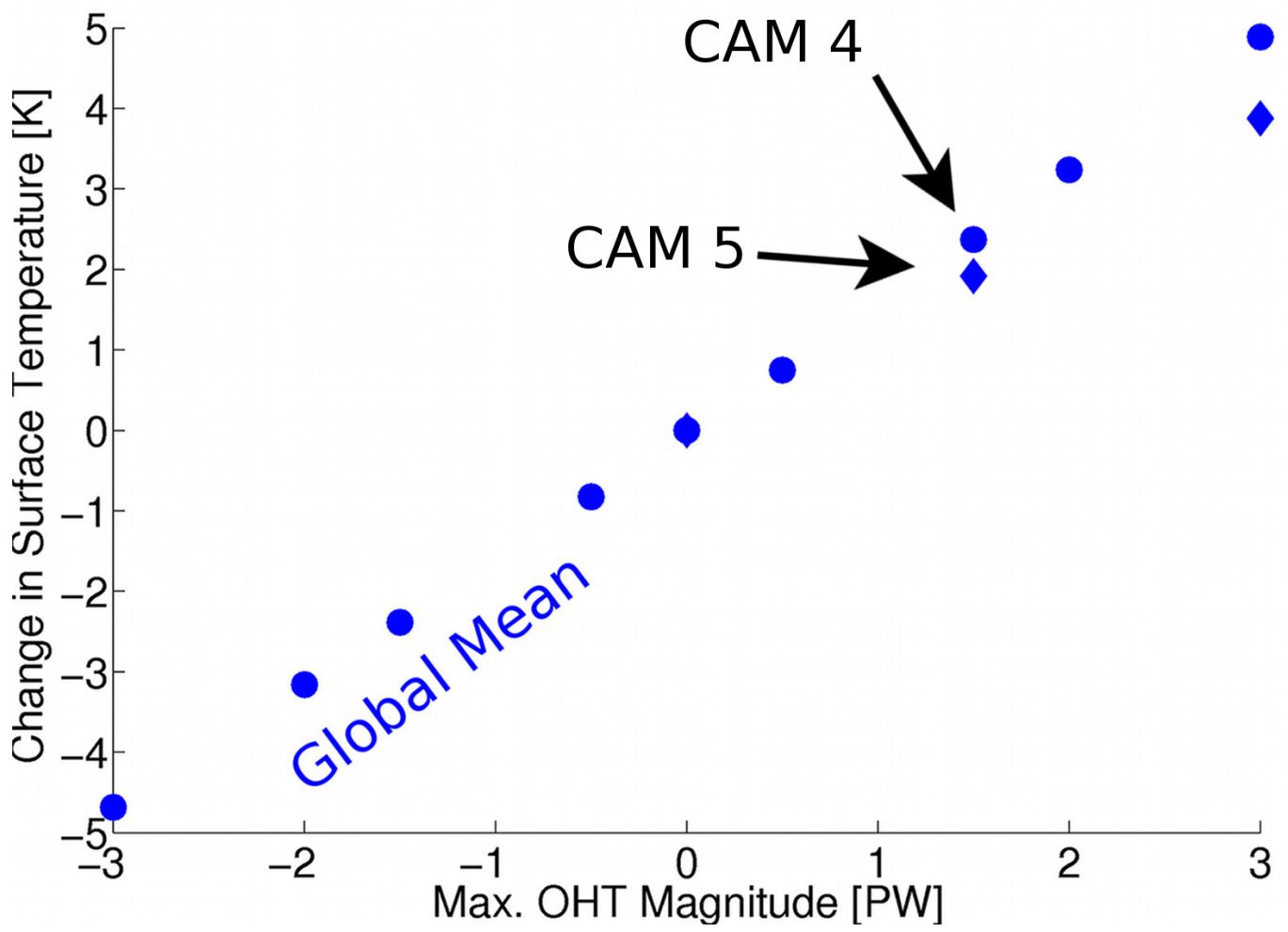
The atmospheric heat transport largely compensates for changes in OHT.



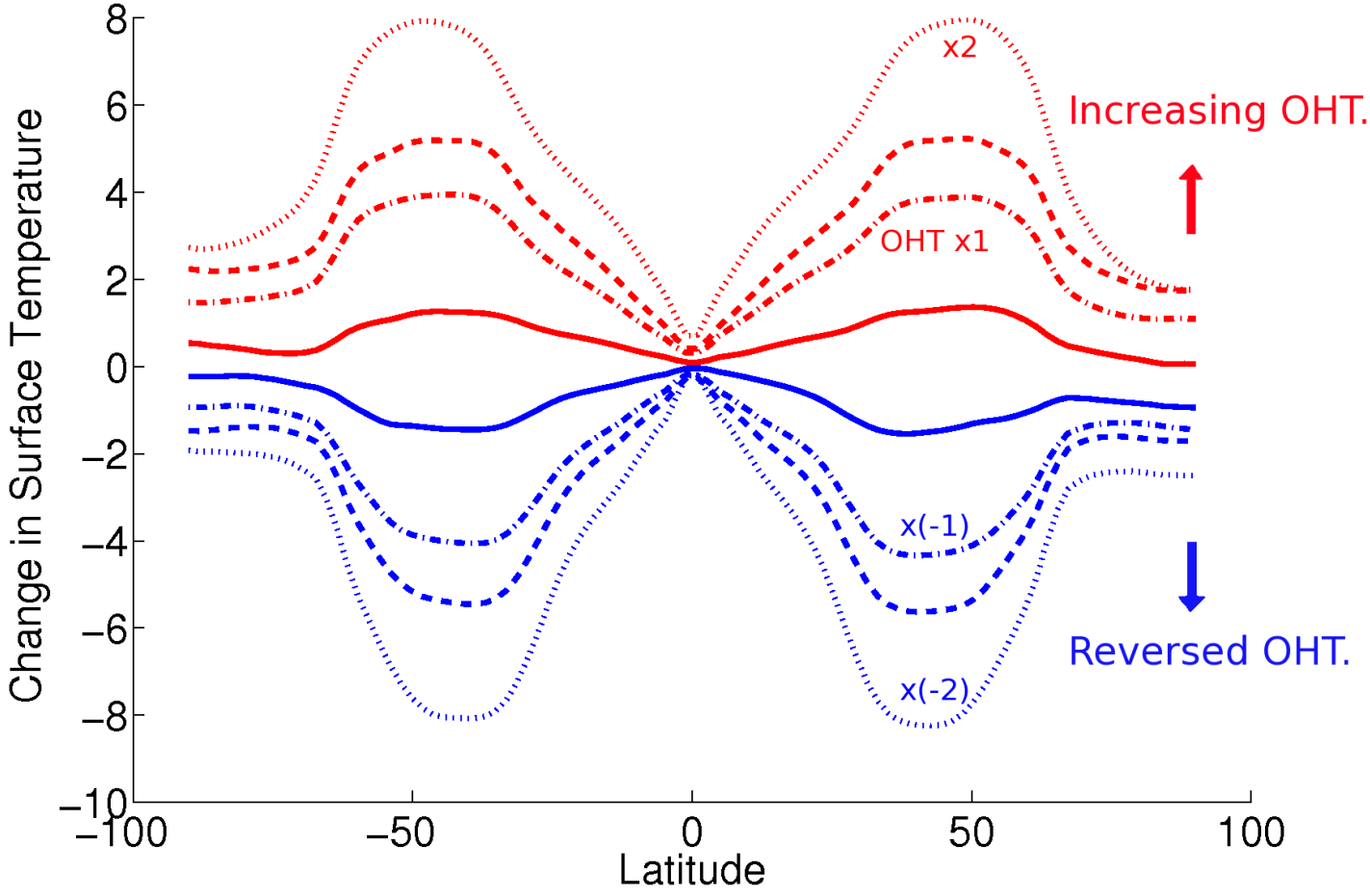
An increase in OHT raises global mean temperature (and vice versa).



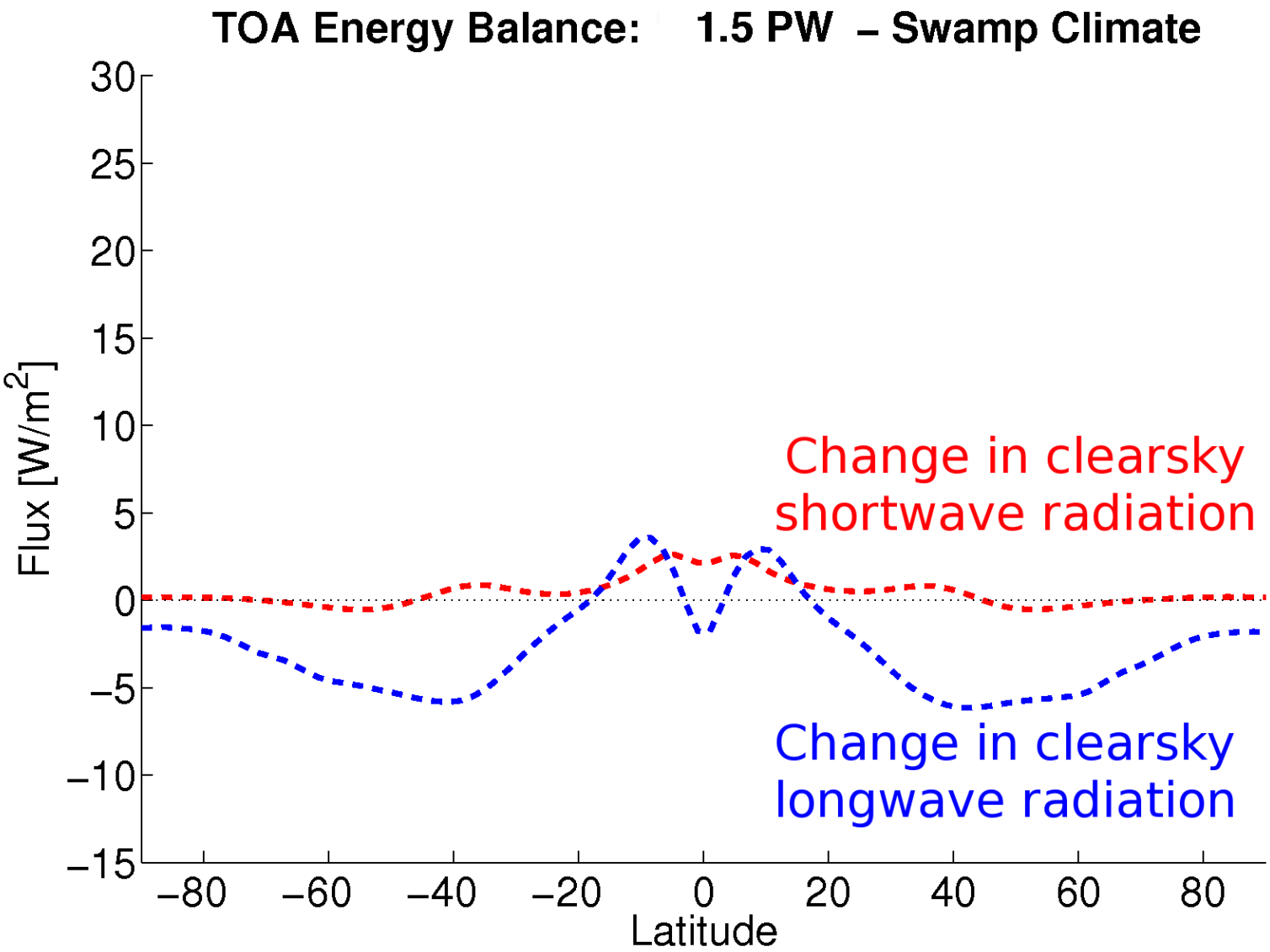
We find similar linear behavior in both models.



The temperature changes are different at high and at low latitudes.



The latitudinal differences are caused by different water vapor and cloud responses.



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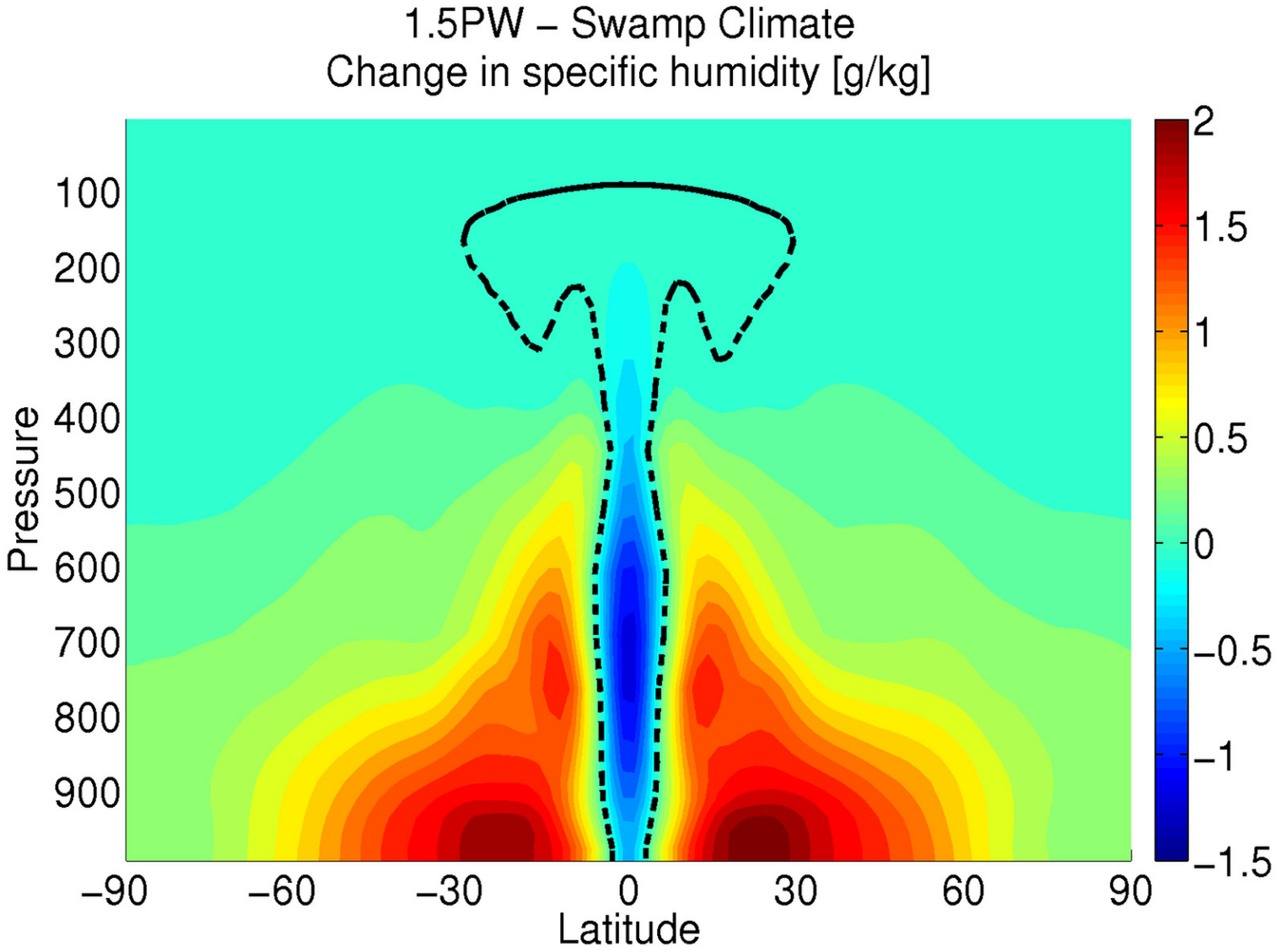

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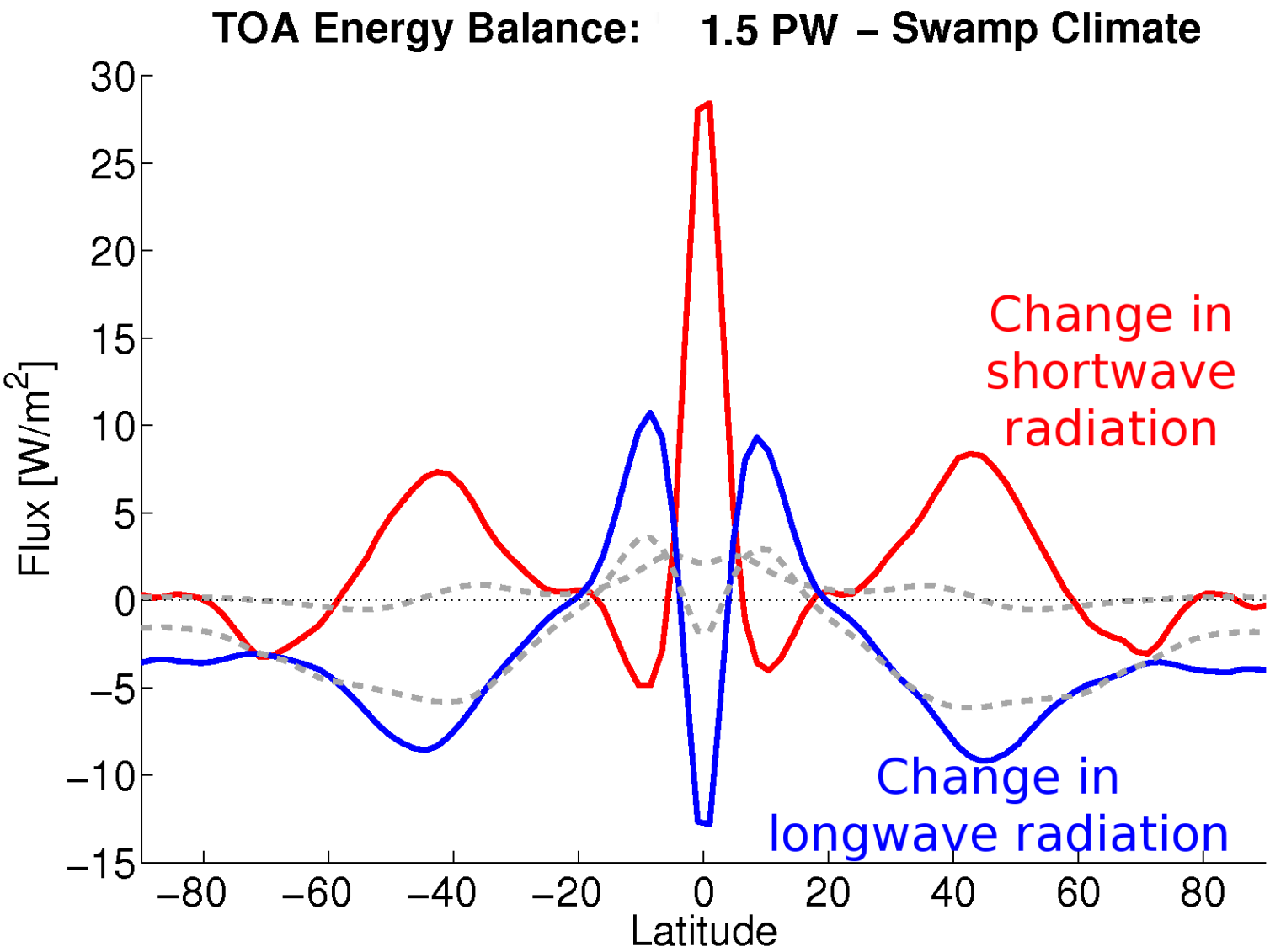
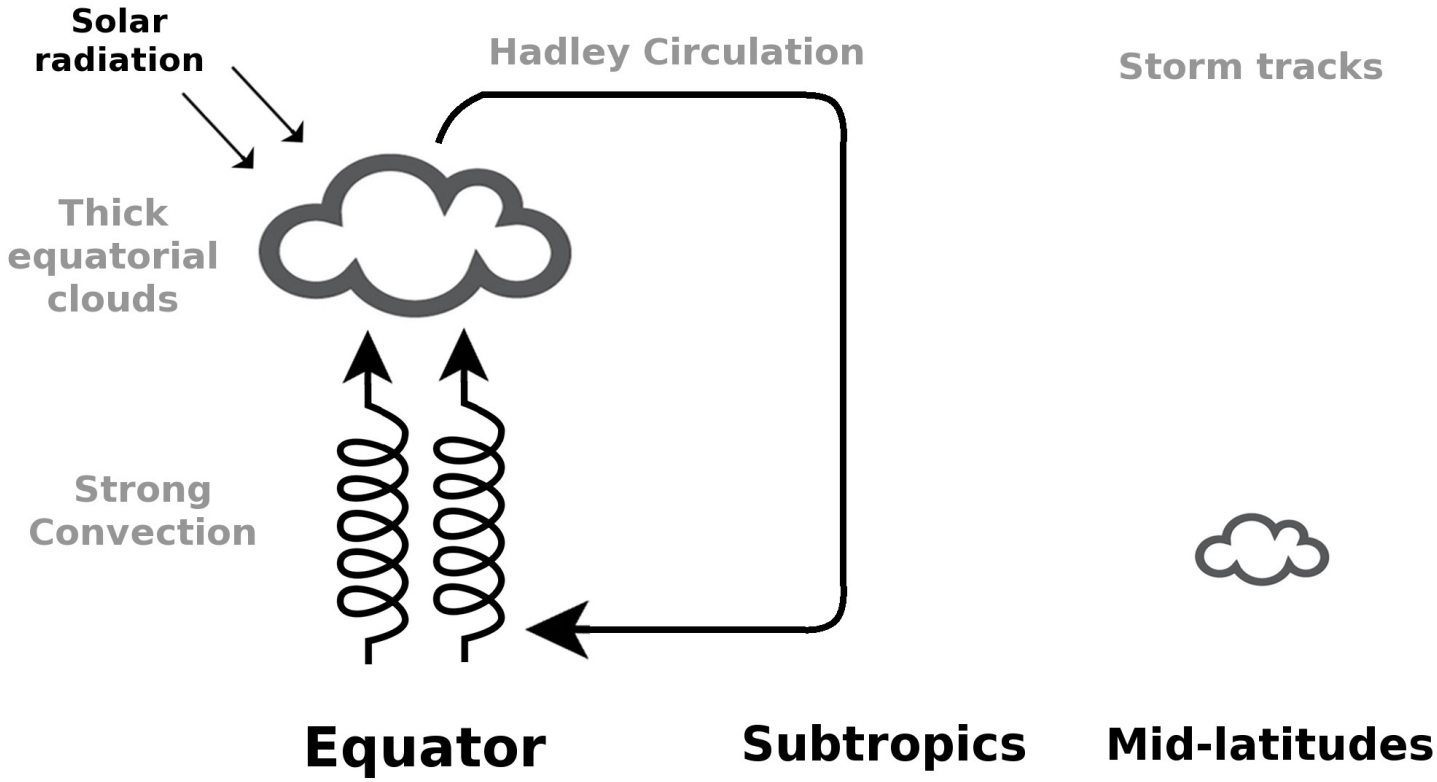
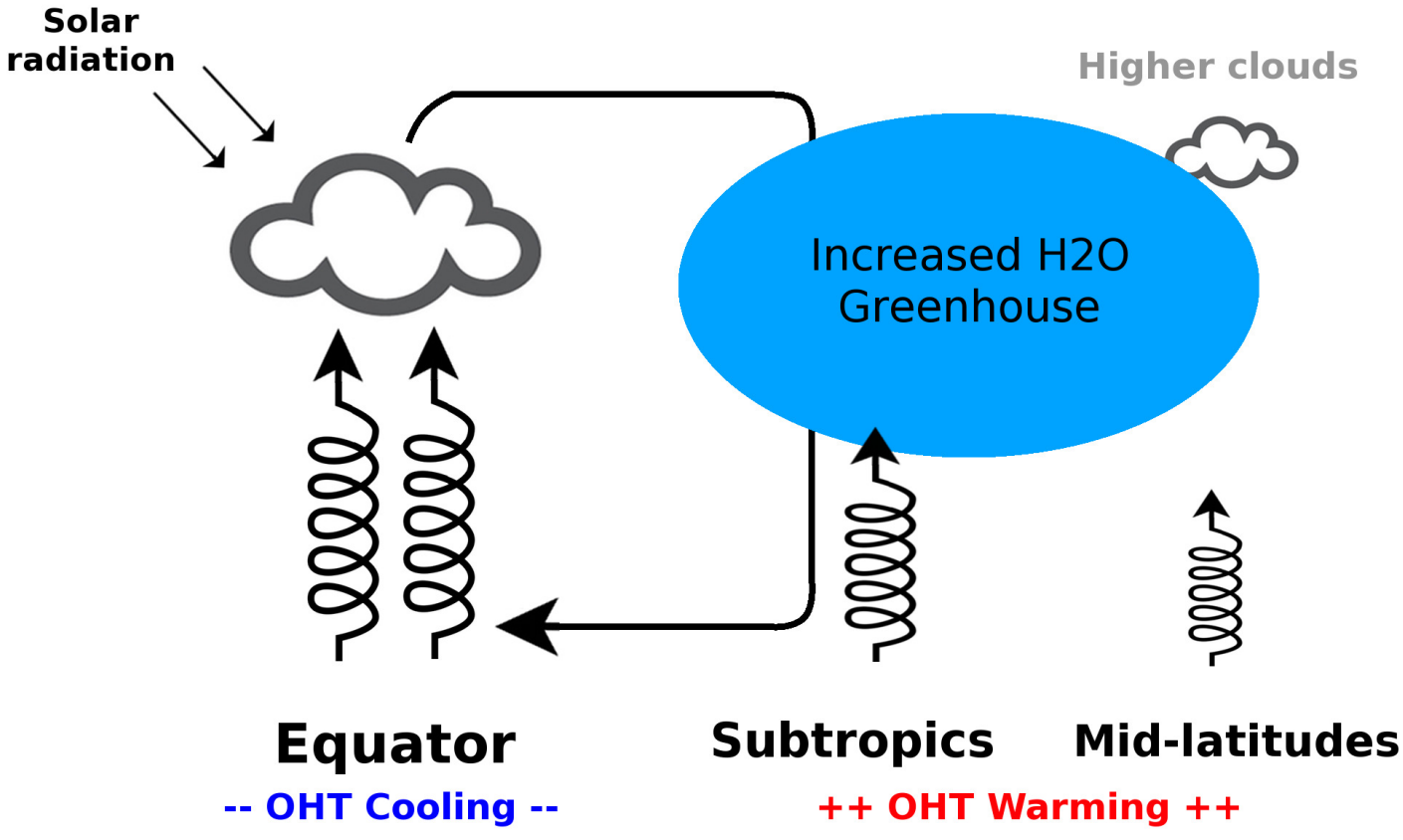


Tropical vs. Extra-Tropical Response to OHT Changes

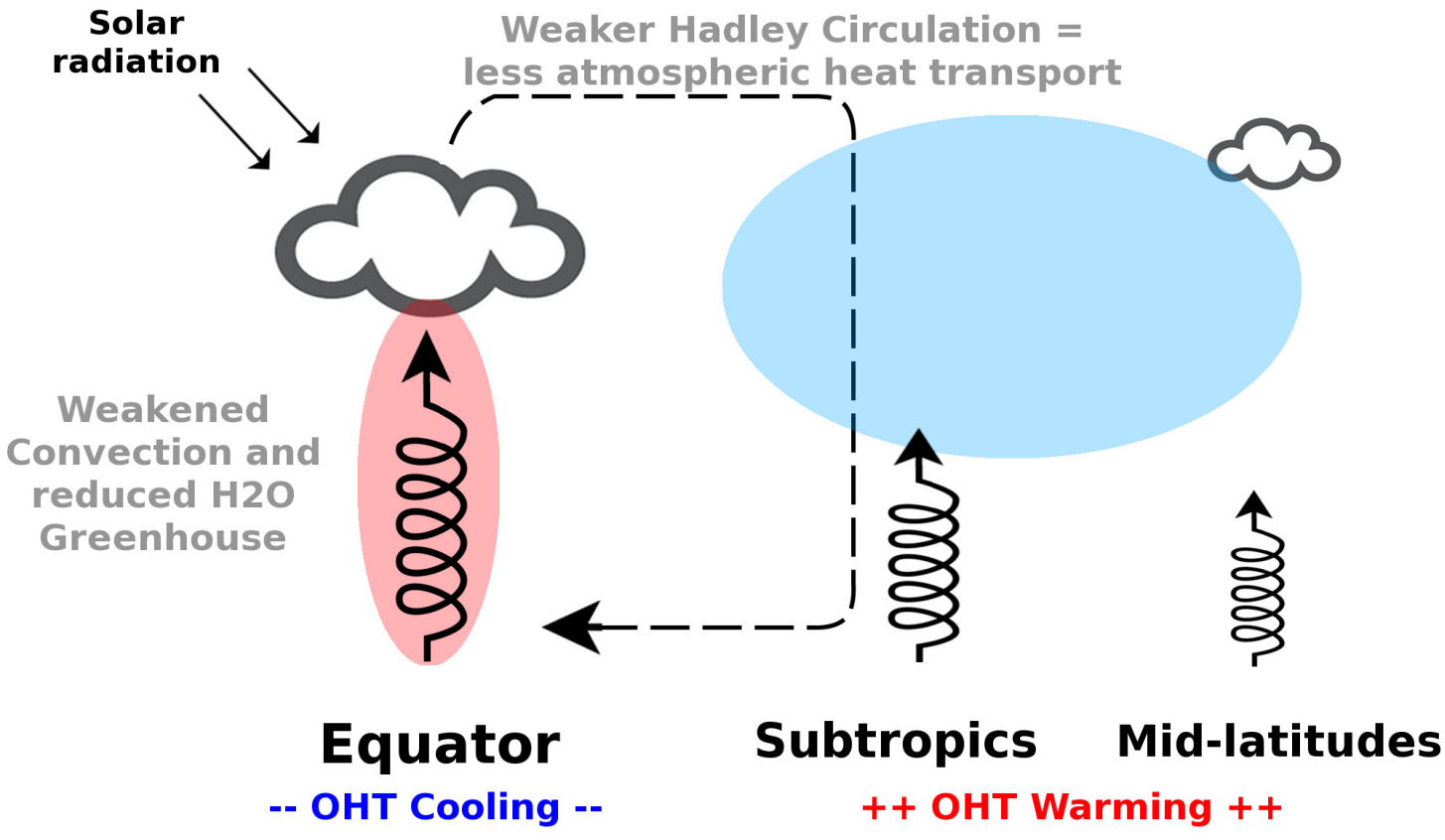
Radiative Changes at high latitudes driven by water vapor (& clouds), at low latitudes by clouds.



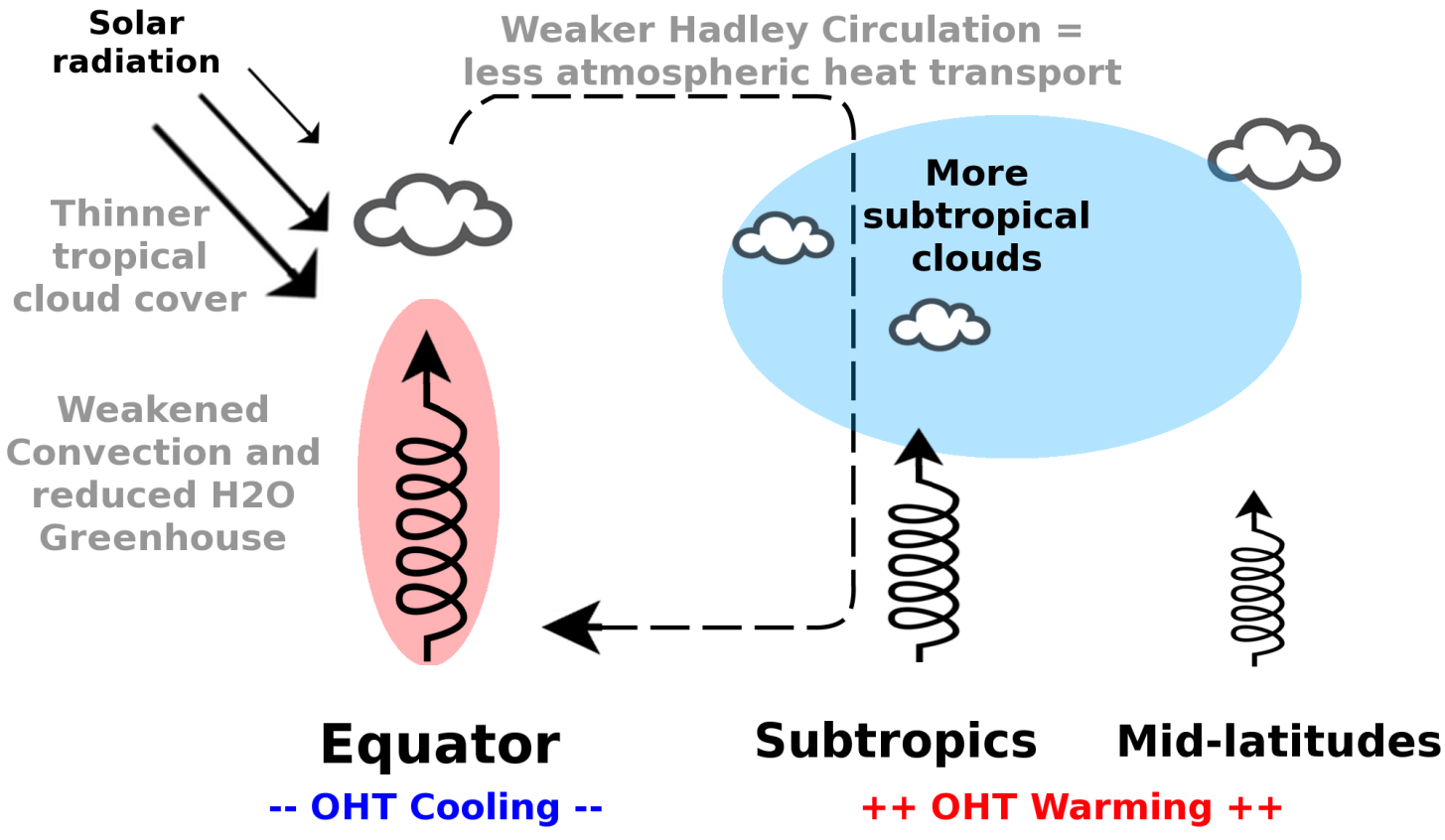
Radiative Changes at high latitudes driven by water vapor (& clouds), at low latitudes by clouds.



Radiative Changes at high latitudes driven by water vapor (& clouds), at low latitudes by clouds.



Radiative Changes at high latitudes driven by water vapor (& clouds), at low latitudes by clouds.



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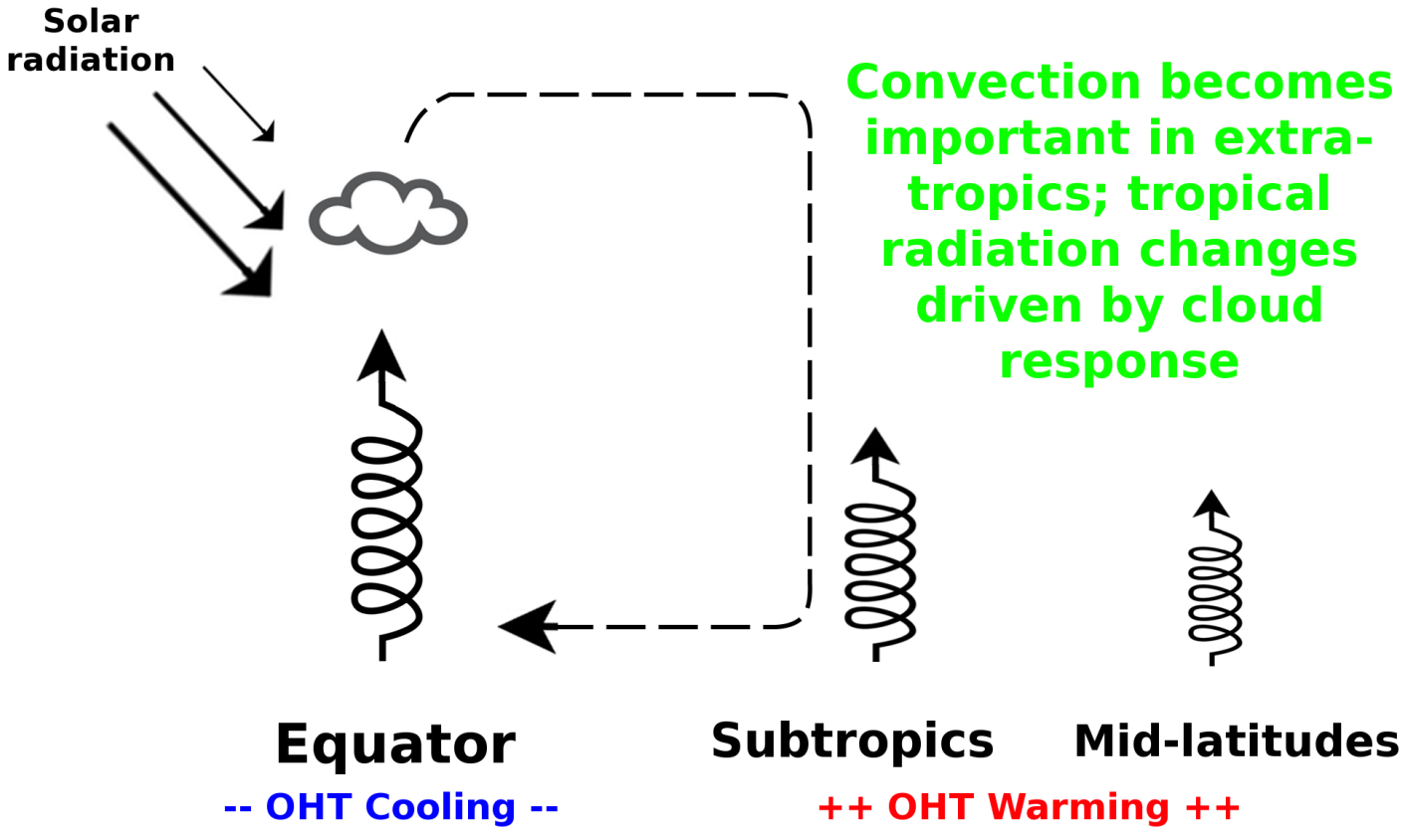

Conclusions.

- Present-Earth GCMs, if used in the right way, can be useful tools to study exoclimates.
- In our experiment, the atmosphere largely compensates for changes in OHT. However, same total heat transport does not mean same climate.
- Exoclouds can have big radiative impacts (observable?!). Cloud feedbacks will be difficult to quantify, studying them on Earth will be a first step.

Images: Stephen Hudson, Joost Bakker, Ron Blakey (NAU Geology), NASA Goddard Center, Midnightcomm, The Noun Project collection.