Basic physics predicts stronger high cloud radiative heating with warming

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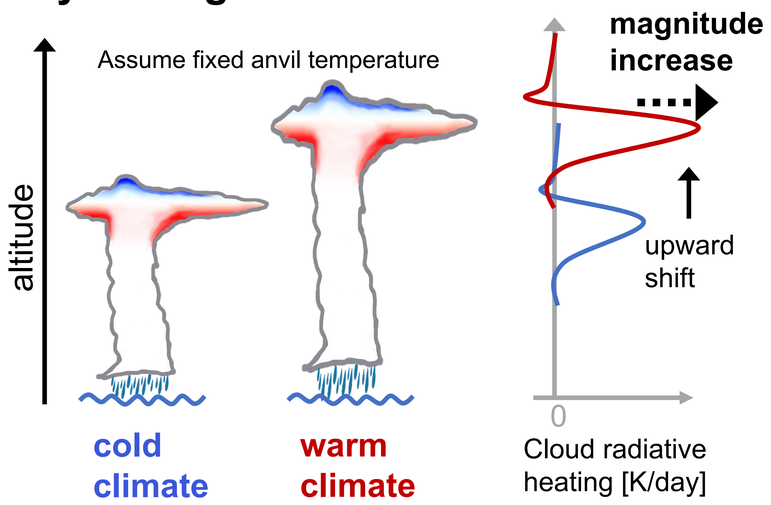
Key finding



Cloud radiative heating (CRH) equation:

$$\frac{dT}{dt} = g\frac{1}{\rho c_p}\frac{dF_{cloud}}{dz}$$

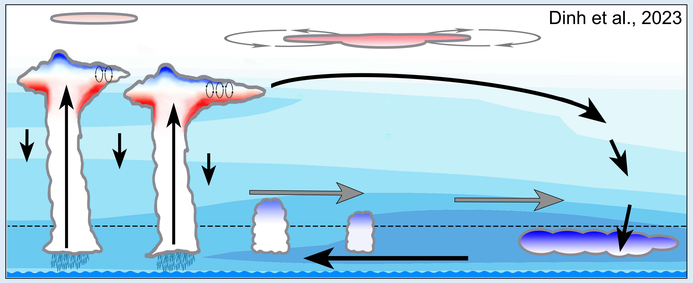
More at:

CRH is determined by two terms:

1. the $1/c_p\rho$ term, determined by air density and
2. the dF/dz term, controlled by cloud properties

As a cloud moves to higher altitudes, air density decreases, increasing the magnitude of the first term and thus, assuming no change in cloud properties, **increasing the magnitude of CRH due to its inverse proportionality with density**.

So what?

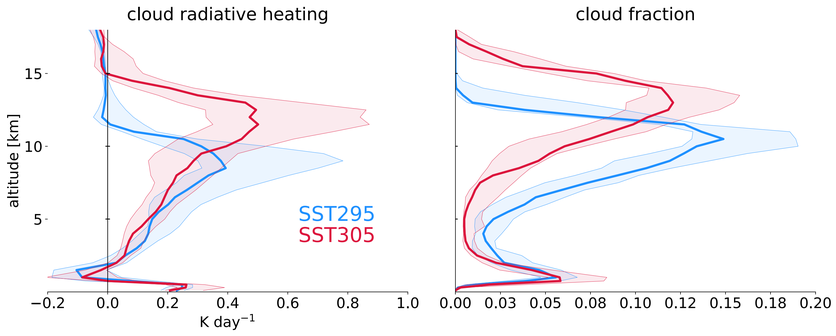


CRH drives large-scale dynamics and its response to global warming (Voigt et al., 2021) and strongly influences cloud evolution and climate (e.g. Gasparini et al., 2019, Wall et al., 2020, Sullivan and Voigt, 2021).

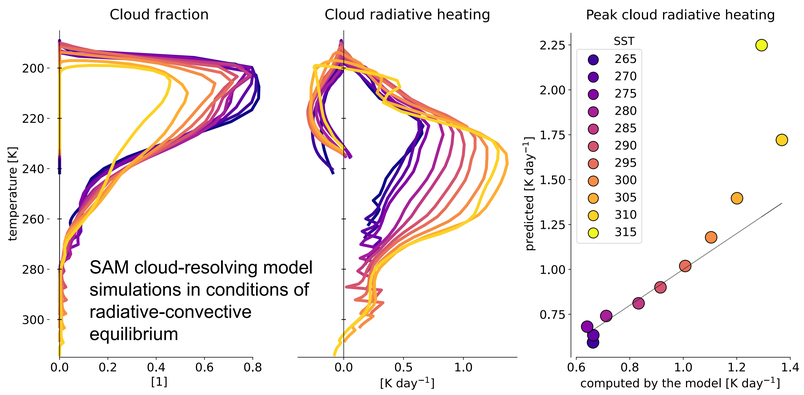
Stronger upper tropospheric CRH can therefore lead to changes in circulation and cloud optical depth.

The mechanism is robust across RCEMIP models

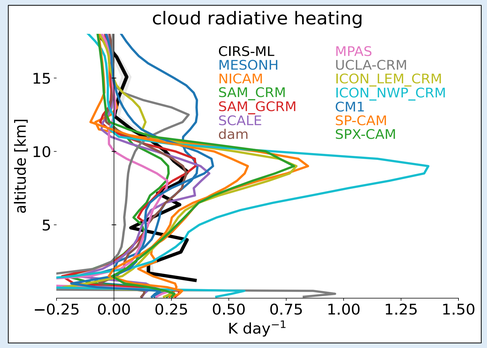
Upper tropospheric **cloud radiative heating intensifies** despite a **decrease in cloud fraction**.



CRH intensifies across a large range of climates; its magnitude can be predicted



Implication: If we know the present day CRH we can predict its response to surface warming

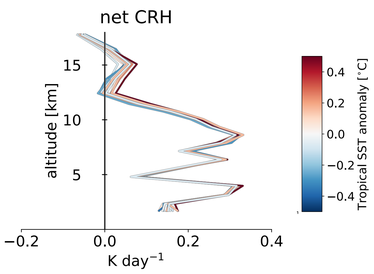


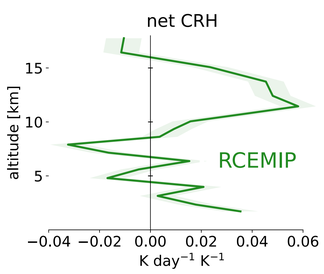
Large intermodel spread in simulated CRH for RCEMIP models

➔ tuning CRH to the plausible range of observations should be a priority for models

Satellite data also show an increase in CRH in warmer years

15-year satellite dataset based on infrared sounder data trained on 2B-FLXHR (Stubenrauch et al., 2021)





Intriguing to see that the response of satellite retrieval to surface warming is comparable to CRH changes in models

Interested in CRH in CMIP6?

Voigt et al. (2024): Atmospheric cloud-radiative heating in CMIP6 and observations and its response to surface warming, ACP