Cloud Feedbacks on Greenhouse Warming in an MMF with a Higher-order Turbulence Closure

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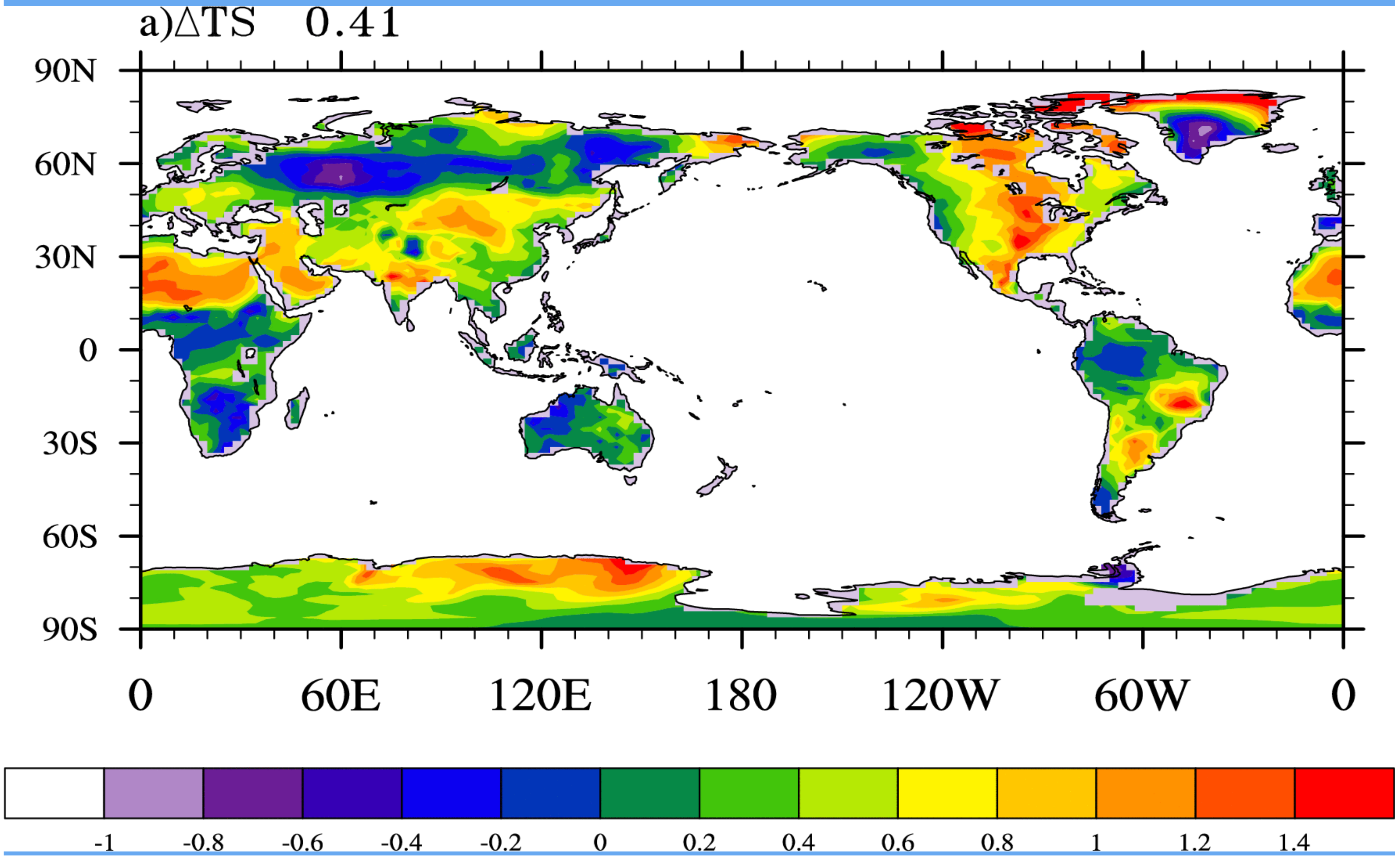
Motivation

- Intermediately-prognostic higher-order turbulence closure (IPHOC) substantially improves the representation of boundary-layer clouds and turbulence in multiscale modeling framework (MMF).
- How do cloud fraction, liquid and ice water path, cloud radiation forcing, and precipitation response to green house warming in MMF with the representation of low-level clouds and turbulence improved?
- What is the difference between this work and $4\times CO_2$ experiment performed by MMF?

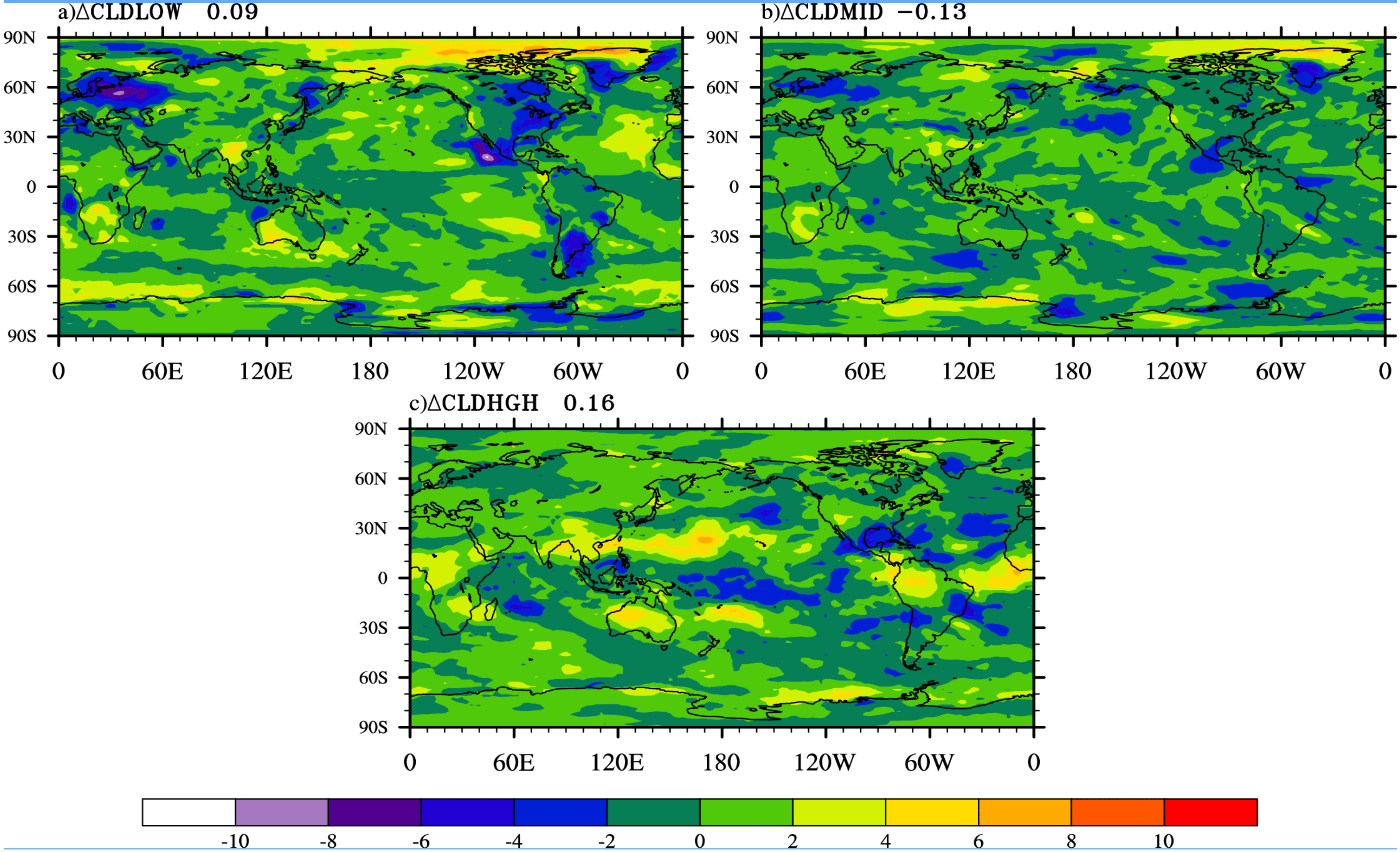
Experiment Design

- The MMF model is based on CAM3.5 with finite-volume dynamic core as the host GCM. The CRM is the 2-D version of System for Atmospheric Modeling (SAM) with IPHOC, the grid spacing is 4 km, with 32 columns within a GCM grid box.
- The GCM grid spacing is 1.9°x2.5° with total 32 vertical layers (12 levels below 700 hPa).
- The simulations are forced with climatological SST and sea ice distributions (not an AMIP simulation).
- A control experiment with the current CO_2 concentration and a sensitivity one doubled the concentration. The simulation duration is 5 years and 3 months, with last 5 years analyzed.

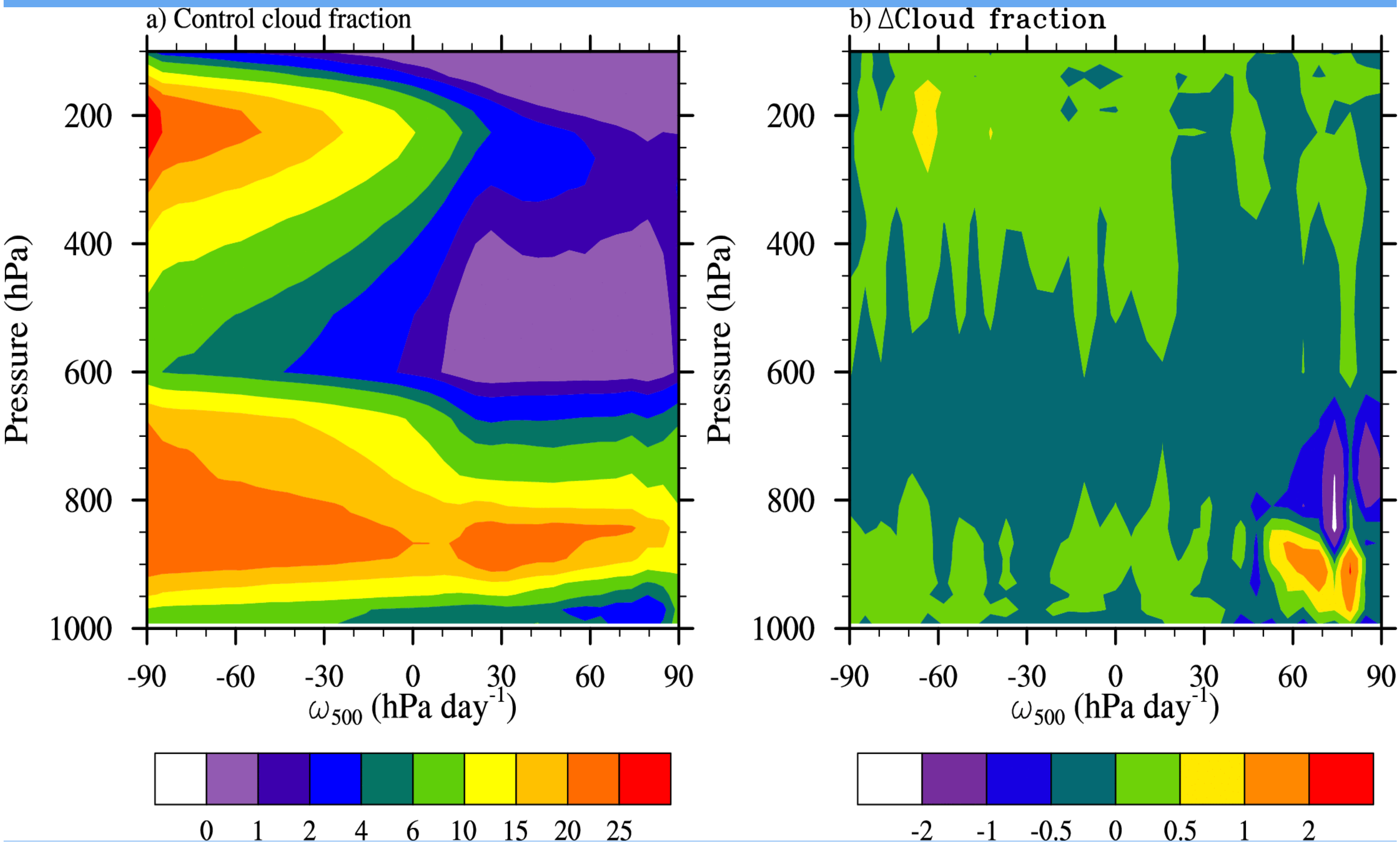
Land Surface Temperature



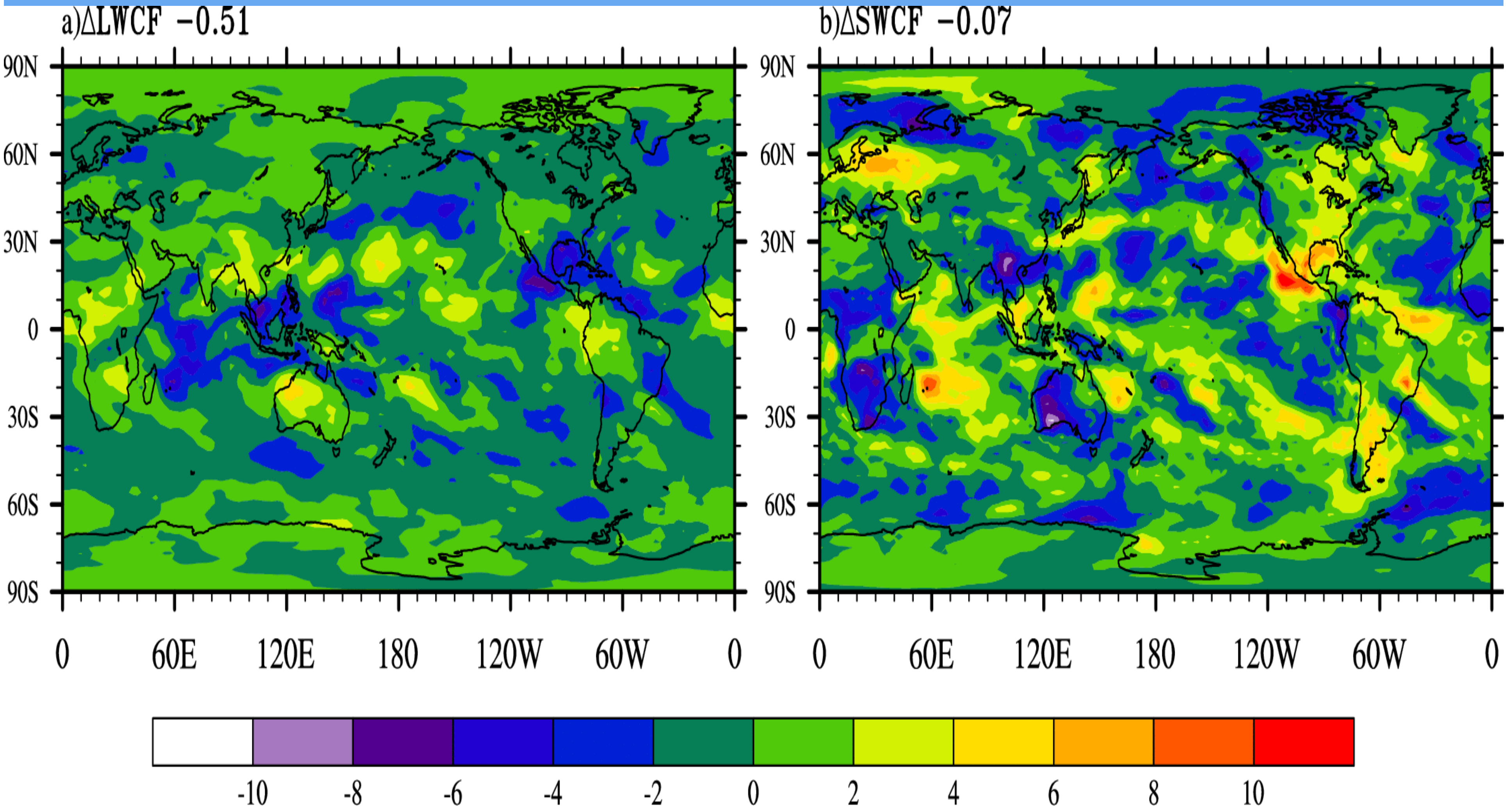
Cloud Fractions



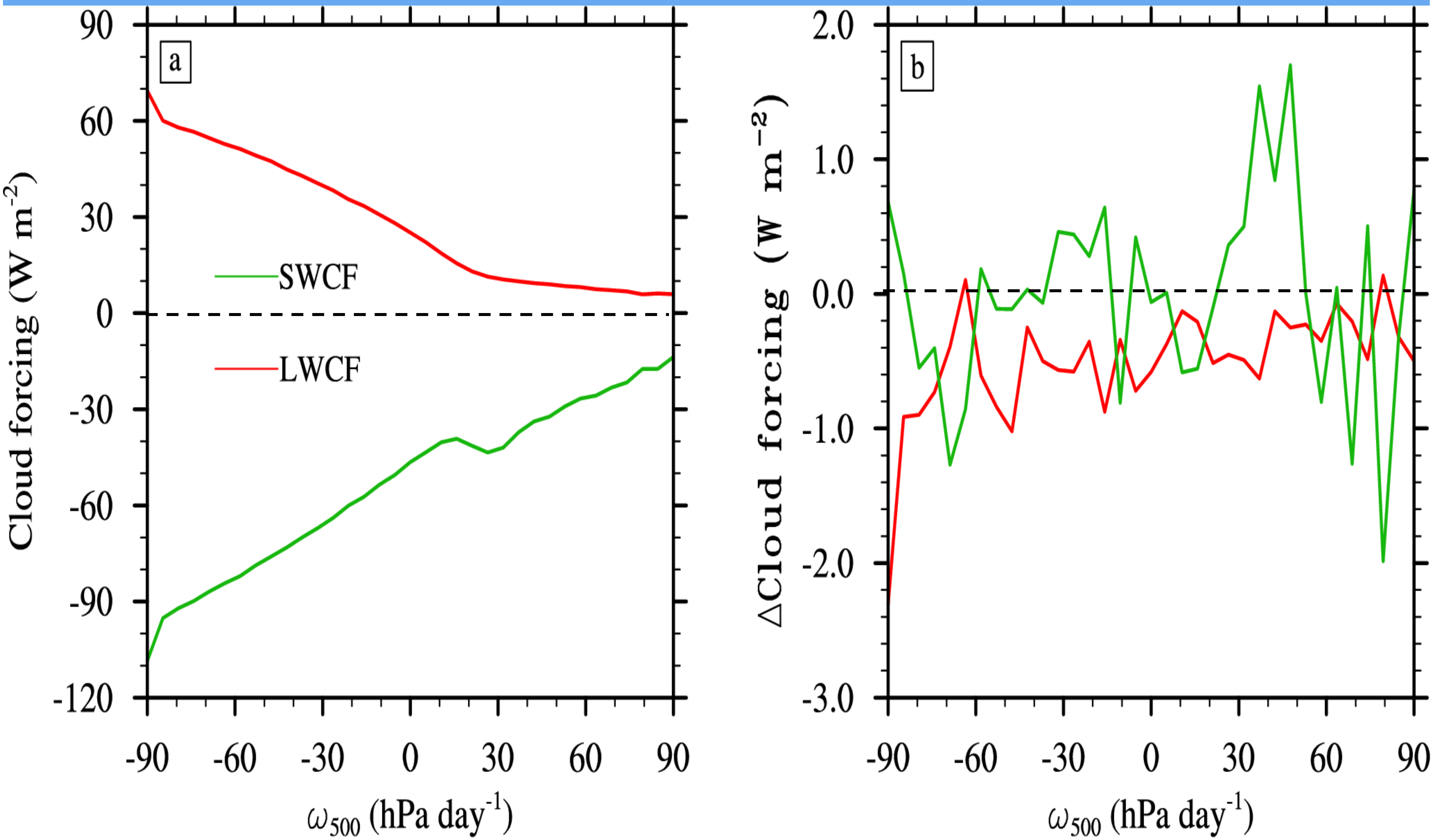
Tropical ω_{500} Sorted Cloud fraction



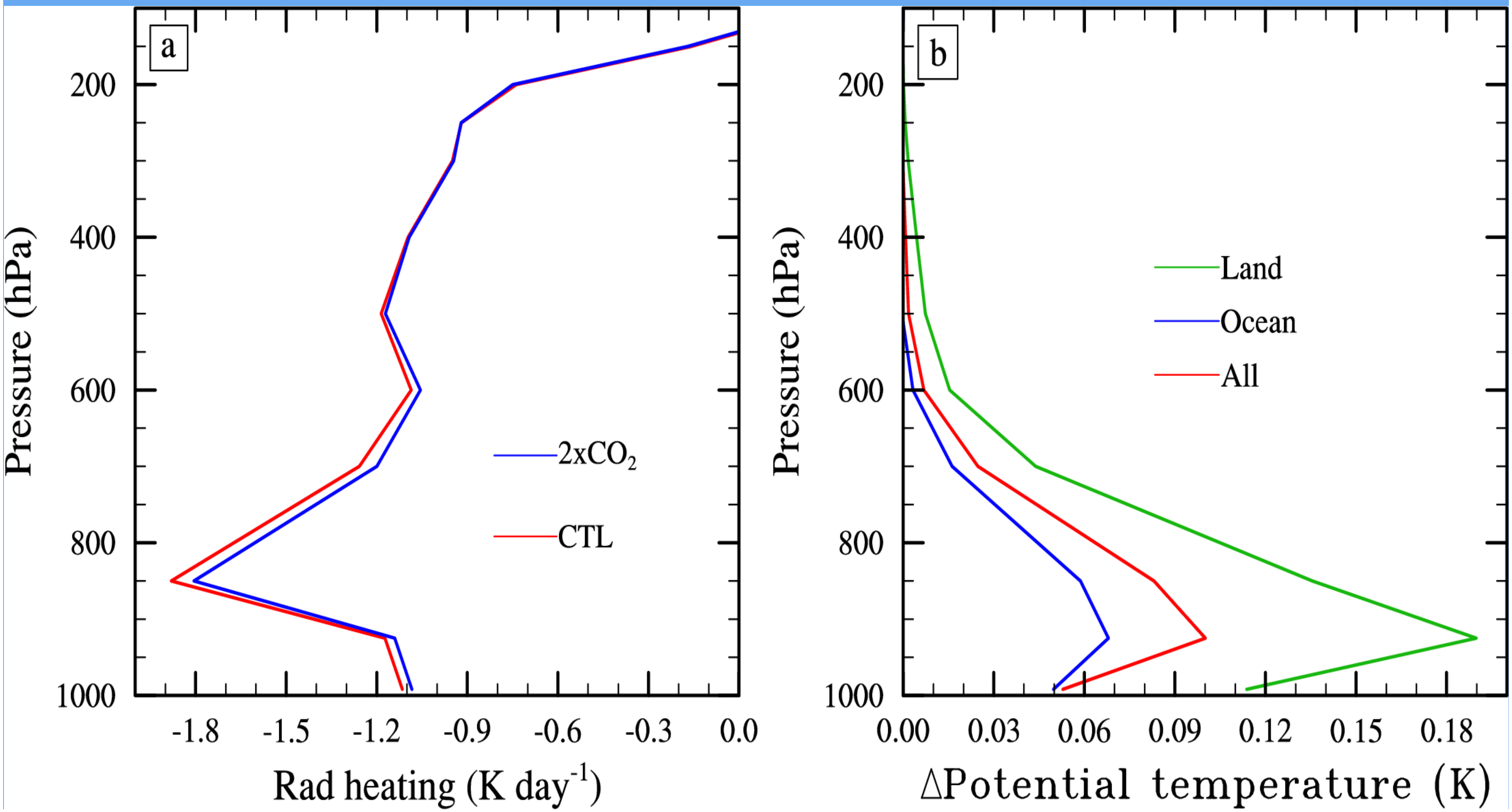
Cloud Radiative forcing



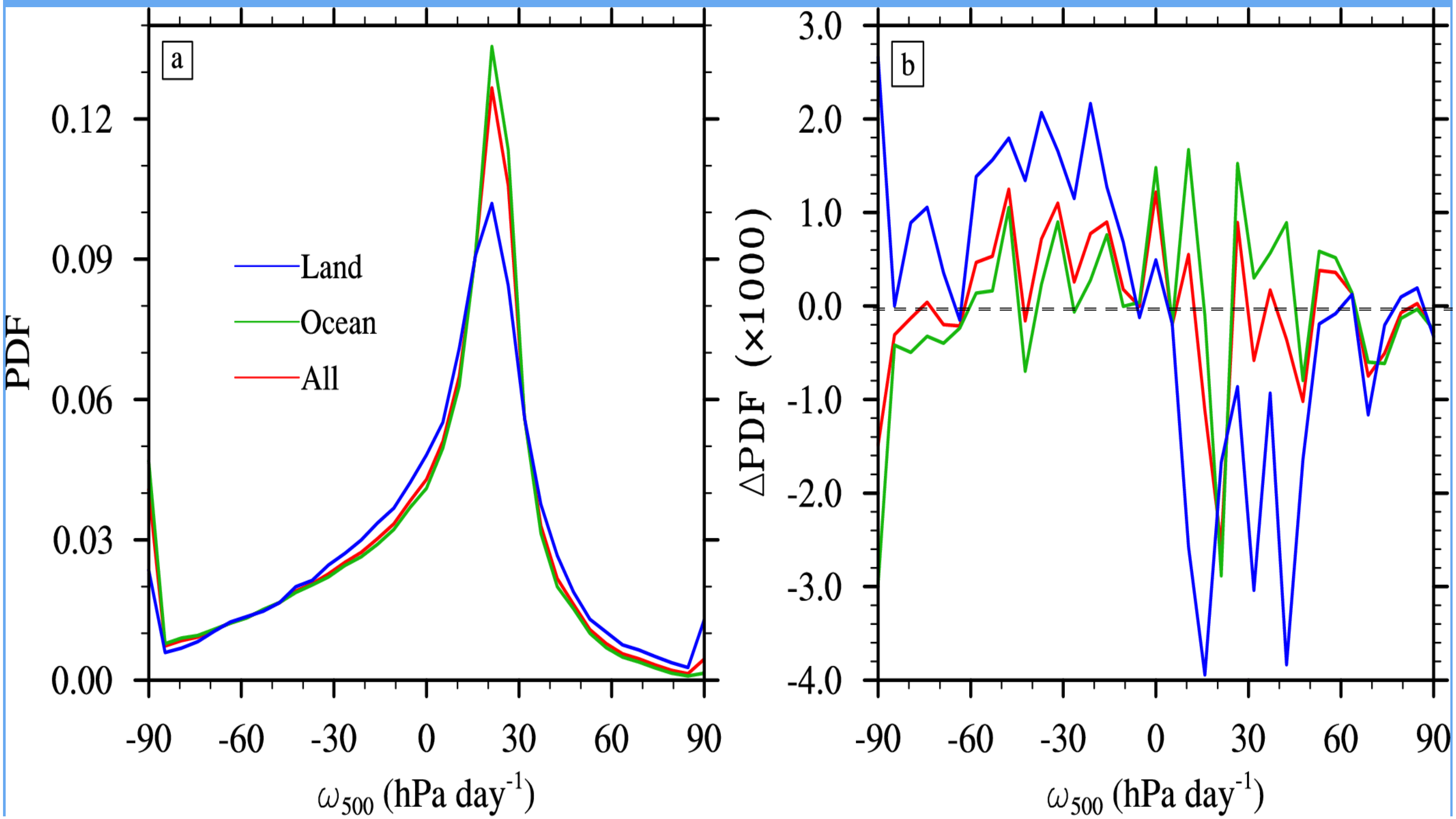
Tropical ω_{500} Sorted Cloud Radiative forcing



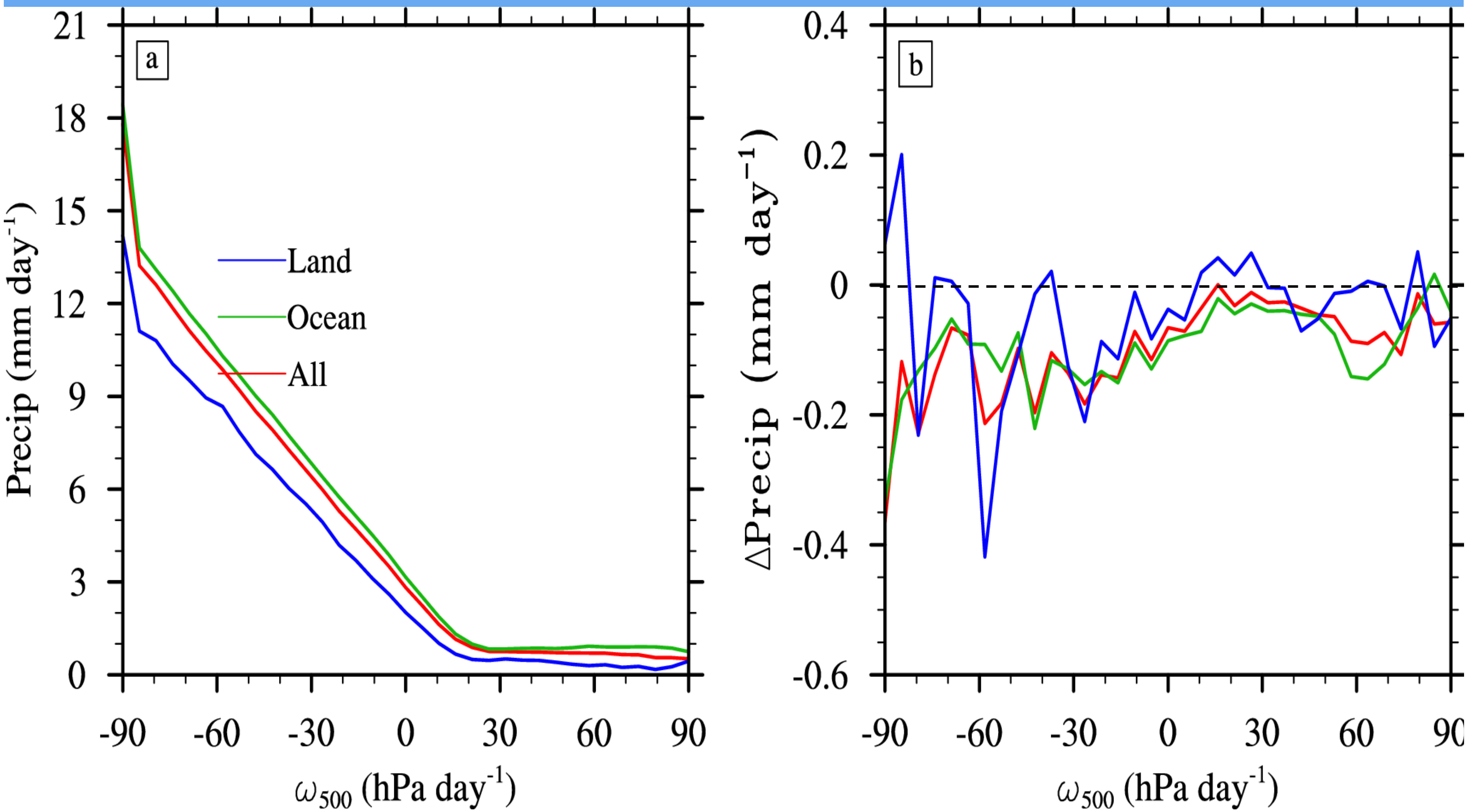
Tropical Radiative Heating and Mean Potential Temperature Profiles



Tropical ω_{500}



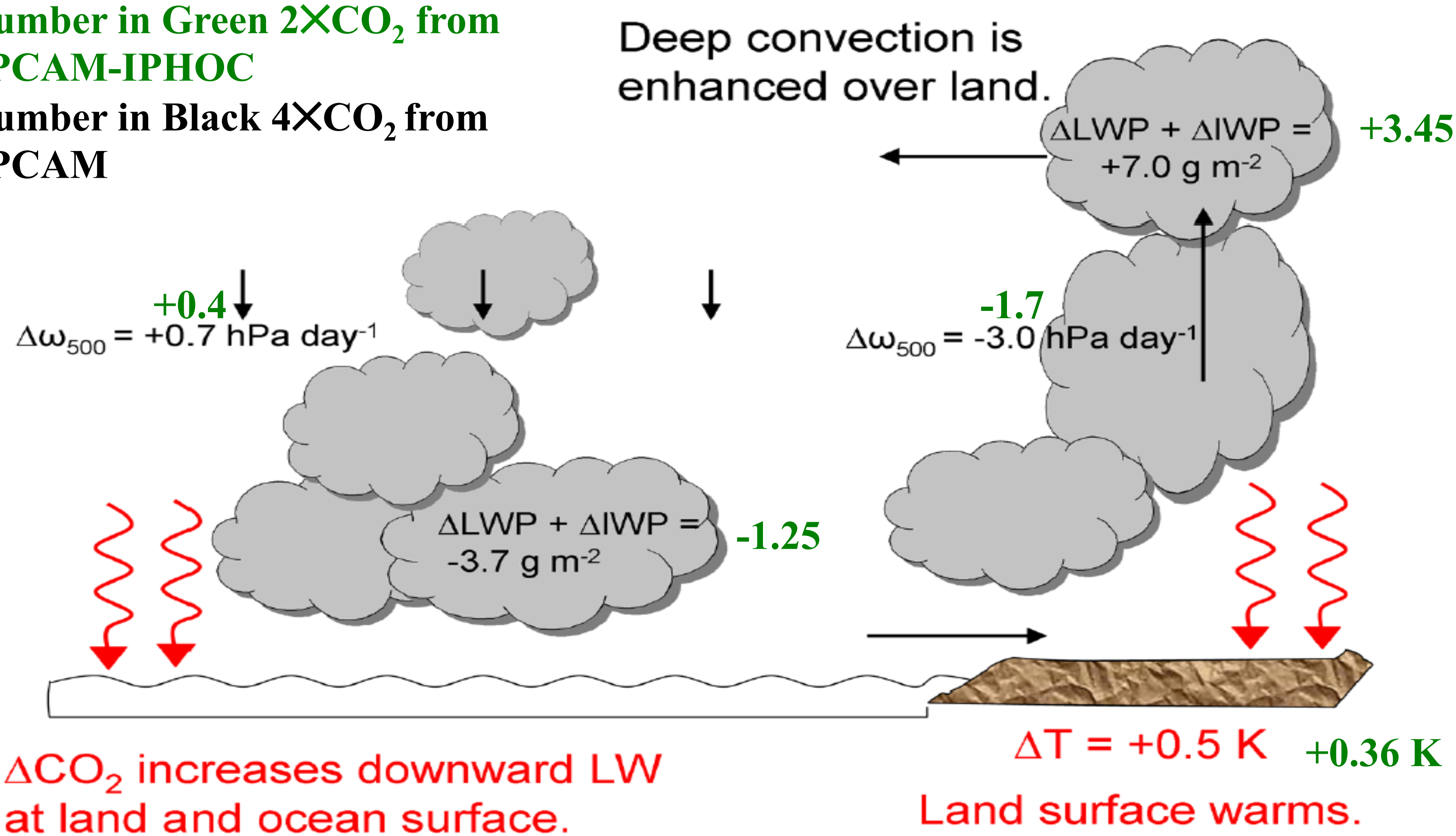
Tropical ω_{500} Sorted Precipitation



Conceptual Picture

Number in Green 2×CO_2 from SPCAM-IPHOC

Number in Black 4×CO_2 from SPCAM



Summary and Discussions

- Cloud feedbacks on greenhouse warming are investigated with SPCAM-IPHOC.
- The tropical land surface is warmed by 0.35 K.
- The rising motion, surface precipitation and cloud cover shift from ocean to land in tropics.
- There is a 2% increase of low level cloud in the subsidence regime. The trade-wind inversion capping the boundary-layer slightly decreases.
- The high-level clouds in tropics increase 0.7%, while middle-level clouds decrease 0.5%.