Response of convectively coupled Kelvin waves under warming scenarios in a global storm-resolving model

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Why is the +4K response stronger?

MOTIVATION

CCKWs are a key mode of tropical intraseasonal rainfall variability.

- **How do convectively coupled Kelvin waves respond to warming?**
- **Is the response driven mainly by SST warming or by direct CO_2 radiative forcing?**
- **What physical processes support the response?**

EXPERIMENT DESIGN

CNTL	P4K	4CO$_2$
SST hist	SST +4K	$CO_2 \times 4$
CO_2 base	CO_2 base	SST Fixed

- ICON global storm-resolving atmosphere ~10 km, without cumulus parameterization, are used to isolate the effects of SST warming and CO_2.

CCKW RESPONSE

- Kelvin-band spectral power increases markedly in +4K, while negligible changes occur in 4×CO_2.

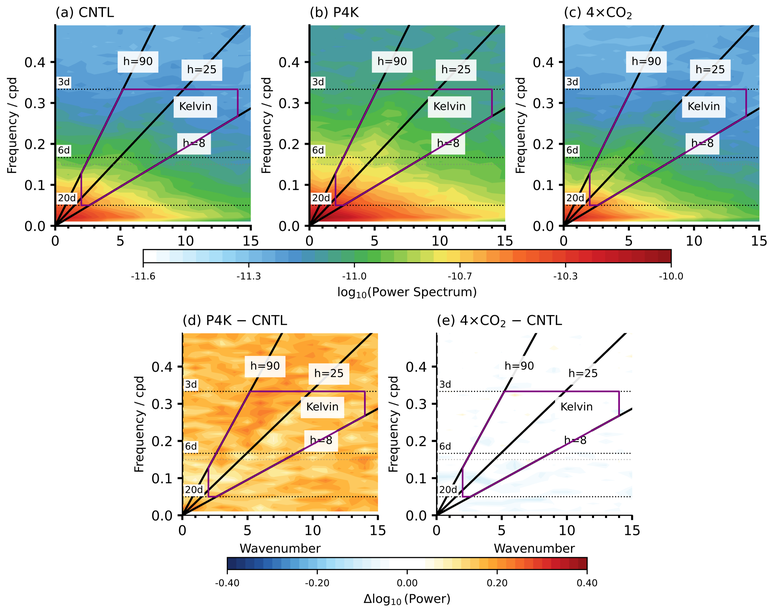

Fig 1. Power spectra of symmetric precipitation anomalies for Kelvin waves.

Experiment	Kelvin power	Phase speed	Response
CNTL	baseline	baseline	–
+4K	increase	slightly faster	strong
4×CO_2	weak change	little change	weak

BACKGROUND STATE CHANGES

- P4K exhibits increased tropospheric height and atmospheric stability increase, implying an increase in the equivalent depth (fast).

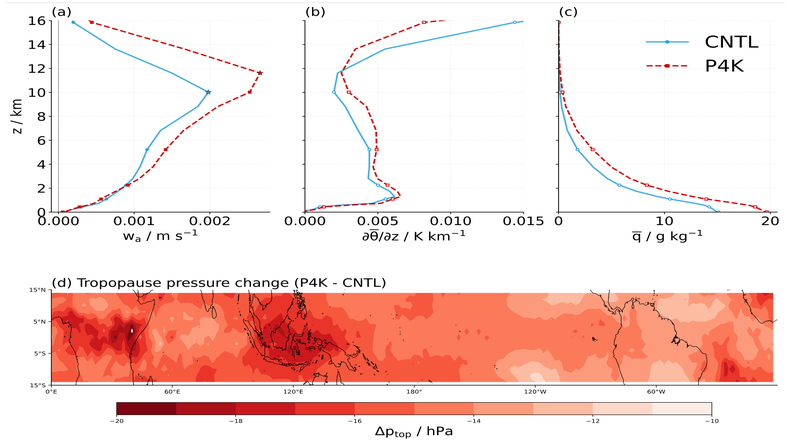

Fig. 2. Background state between +4K and CNTL.

ENERGY BUDGET

- Enhanced latent heat flux under the RCE framework.

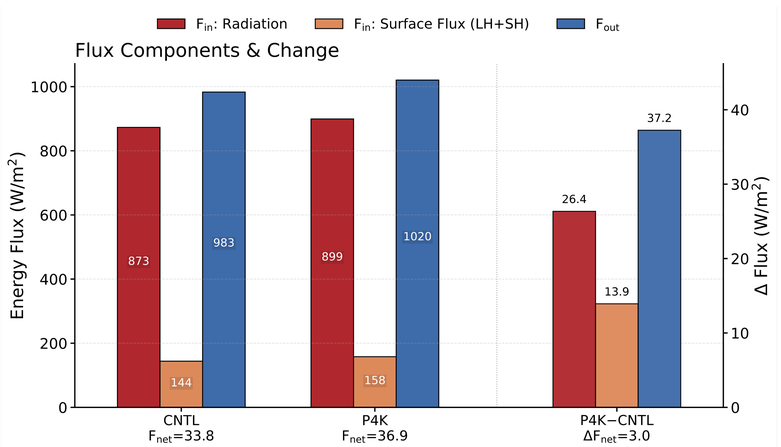

Fig. 3. Atmospheric energy budget comparison between CNTL and +4K.

CONVECTIVE COUPLING

Surface-flux and energy input enhancement before CCKW Passage.

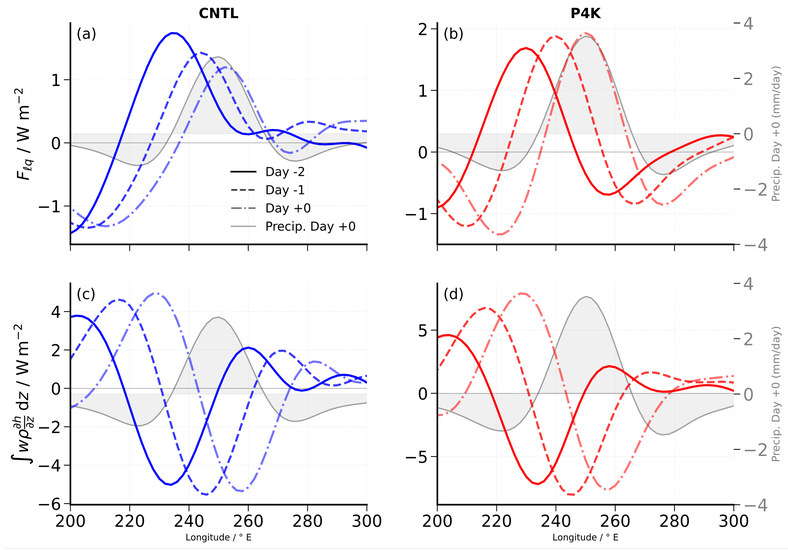

Fig. 4. Longitude profiles of wave-related anomalies in CNTL and +4K.

- **Stronger coherence** between the first and second modes of convection in the Kelvin band under P4K.

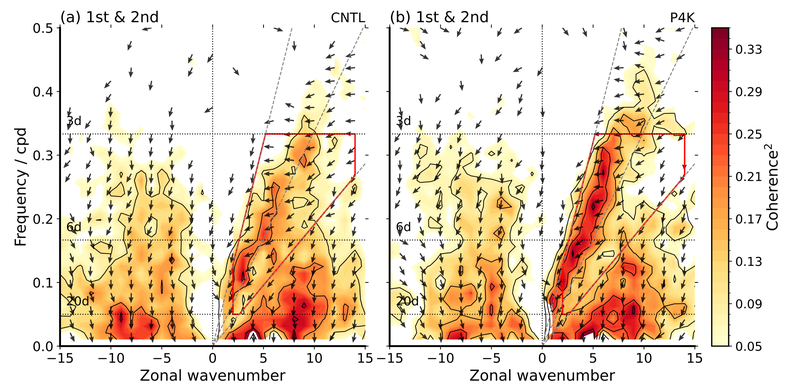

Fig. 5. Cross-spectral diagnostics of precipitation and circulation-related variability.

KEY FINDINGS

CCKWs are intensified primarily in response to SST warming rather than directly to CO_2 forcing.

The intensification and faster propagation of CCKWs are addressed in P4K with two aspects:

- 1) indicators of a deepening of the equivalent depth,
- 2) changes in the circulation-convection coupling related to CCKW, and its coupling with surface heat fluxes.

Sharing is encouraged

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