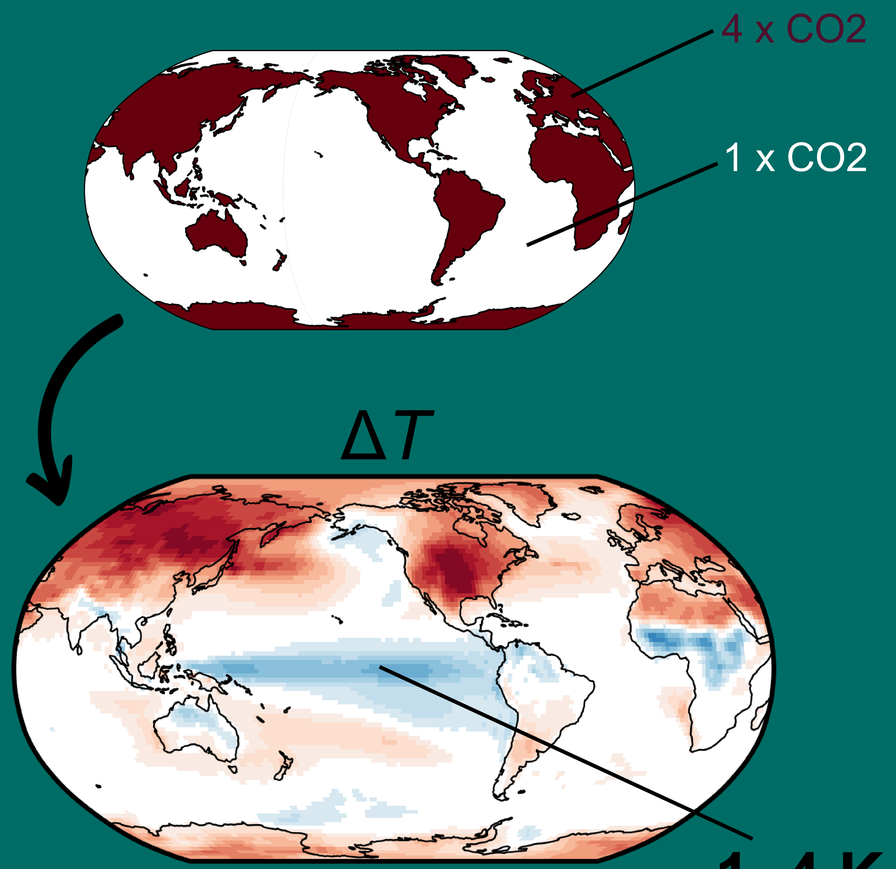
CO_2 forcing over land cools the Equatorial and Eastern Pacific

This poster tells you how, and what we learn from this about SST pattern formation in the eastern Pacific.



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Land-sea contrasts of atmospheric heating drive the transient equatorial and eastern Pacific cooling response to CO2 forcing

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BACKGROUND & MOTIVATION

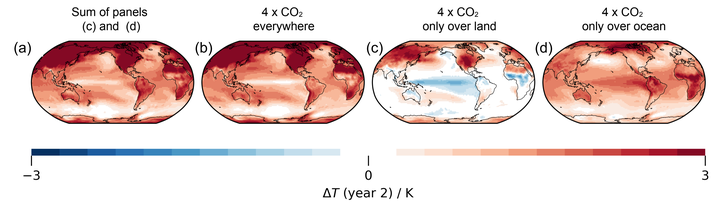
The fast response to CO_2 forcing in many models includes transient Equatorial and Eastern Pacific cooling (or suppressed warming). As an explanation, the ocean dynamical thermostat mechanism is commonly invoked: climatological upwelling through enhanced stratification cools the surface. We question the relevance of this mechanism, and highlight the role of land-sea contrasts.

METHODS

MPI-ESM simulations with *locally* increased CO2 concentrations (constant in time, 24 ens. members):

- Everywhere
- Only over land
- Only over ocean

RESULTS

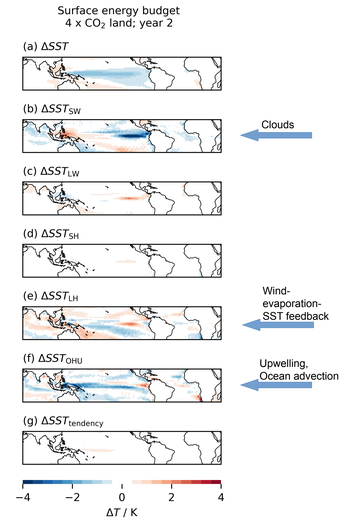


Responses to forcing only over land and forcing only over ocean add up linearly to the response to forcing everywhere.

Land-forcing cools the eastern and equatorial Pacific, driven by upwelling, wind-driven evaporation, and cloud feedbacks.

In a 1%CO_2/yr over land simulation cooling persists for ~20 years.

We identify three mechanisms that drive the cooling. All of them act via the winds they induce, initiating further feedback processes.



MECHANISMS to explain the cooling

Forcing only NH land / only trop. land / only South America yields a similar cooling patch as forcing all land (Fig. 1 (c)), but weaker. Each land region has its own mechanism of cooling the Pacific.

ITCZ shifts northward

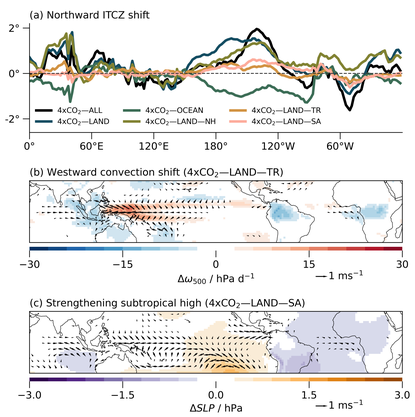
→ stronger southerly trades
→ WES feedback

Convection shifts westward

→ stronger equat. Easterlies
→ upwelling, Bjerknes feedback

Subtropical highs strengthen

→ WES feedback (+ cloud feebdack, coastal upwelling)



KEY TAKEAWAYS

Land-sea contrasts drive the fast equatorial and eastern Pacific cooling response to CO_2 forcing.

The three mechanisms that cause this are a northward ITCZ shift, a westward shift of convection, and a strengthening of the subtropical anticyclone. This is in contrast to the commonly invoked ocean dynamical thermostat mechanism, which should also emerge in response to forcing over ocean if it were important - but it doesn't. All mechanisms we identify have their origin in atmospheric dynamics, but are enhanced by coupled air-sea feedbacks.