Intertropical Convergence Zone (ITCZ) and the Nontraditional Coriolis Terms (NCTs)

Hing Ong[1], Owen Hughes[2], Adam R Herrington[3], Christiane Jablonowski[2], Peter Hjort Lauritzen[3], Da Yang[4]

[1]Independent Scholar; [2]University of Michigan; [3]NSF National Center for Atmospheric Research; [4]Stanford University

Introduction

The double intertropical convergence zone (ITCZ) bias has been studied for decades in generations of general circulation models, most of which share a common approximation: the traditional shallow-atmosphere approximation, which neglects the nontraditional Coriolis terms (NCTs).

Hypothesis

When diabatic heating is present in the tropics but off the equator, the NCT-forced easterly winds induce equatorward moisture flux due to Ekman transport in the planetary boundary layer, and the equatorward moisture flux further concentrates the precipitation toward the equator.

Methods

This study conducts atmospheric simulation pairs with and without NCTs and focuses on differences in large-scale long-term tropical circulation and precipitation. The simulations use the NSF NCAR **Community Earth System Model version 3 (CESM3)** framework with the **Model for Prediction Across Scales (MPAS)** dynamical core, where the equation solver supports an experimental switch between deep atmosphere with NCTs and shallow atmosphere without NCTs. We have tested a hierarchy of model configurations.

Table 1. Hierarchical Model Configurations from More Idealized to More Realistic.

Name	Realistic radiation and convection	Symmetric forcing w.r.t. the equator	Realistic lands and oceans	Ocean dynamics
FHS94	No[a]	Yes	No	No[b]
QPC7	Yes	Yes	No	No[b]
FHISTC_LTso	Yes	No	Yes	No[b]
B1850C_LTso	Yes	No	Yes	Yes

[a]Temperature relaxation

[b]Prescribed sea surface temperature

The NCTs concentrate tropical precipitation toward the equator

in CESM3 driven by deep-atmosphere MPAS.

Scan for a digital version of this poster

Correspondence to Hing Ong (hing5ong5@gmail.com)

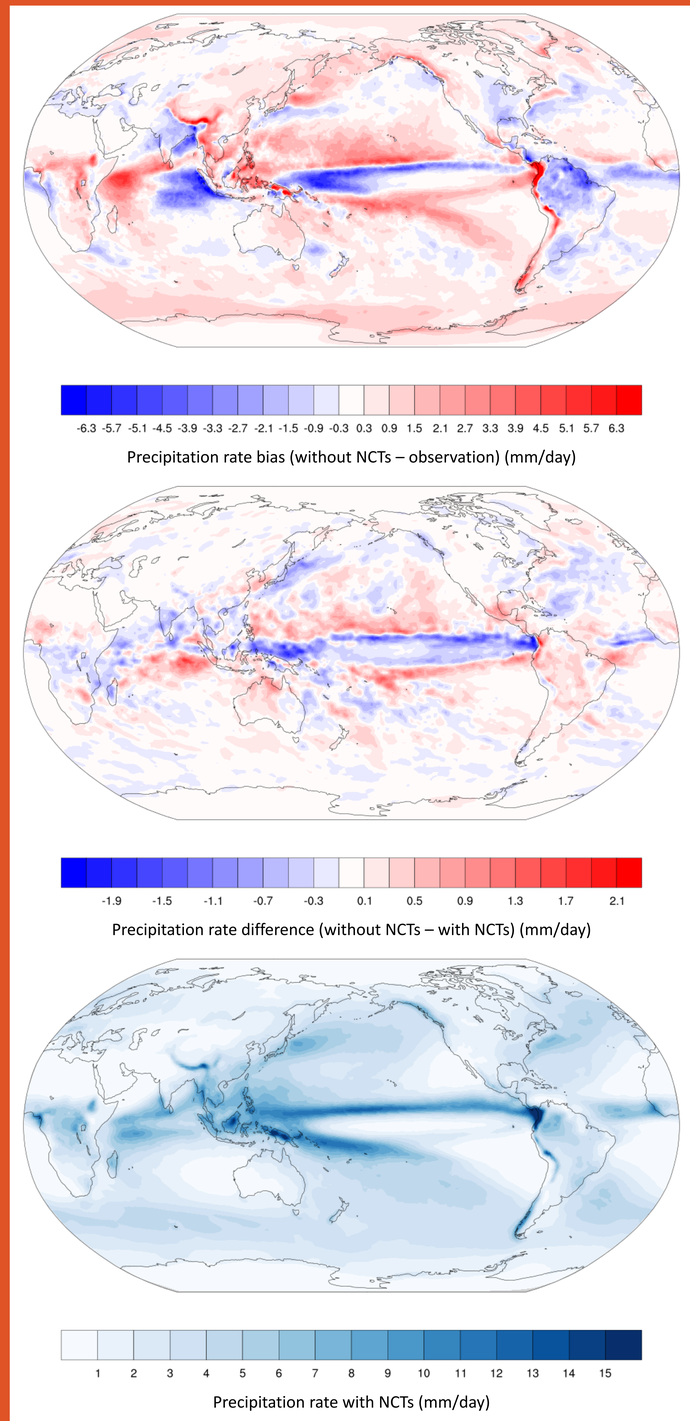

Figure 1. Precipitation rate climatology in the second decade of the B1850C_LTso simulations and the differences. The observation is based on the NASA IMERG product.

Results

Comparing the deep-atmosphere simulation (with NCTs) to the shallow-atmosphere simulation (without NCTs), the results suggest that the shallow-atmosphere approximation (without NCTs) tends to produce a westerly wind anomaly in regions with diabatic heating and weaken the Hadley circulation throughout the hierarchy of model configurations. In more-realistic simulations, switching off the NCTs tends to distribute tropical precipitation away from the equator and promote the double-ITCZ bias.

Table 2. Checklist of differences due to omitting NCTs.

Name	Produce westerly winds	Weaken the Hadley circulation	Distribute precipitation away from the equator	Promote the double-ITCZ bias
FHS94	Yes	Yes	N/A	N/A
QPC7	Yes	Yes	Yes	N/A
FHISTC_LTso	Yes	Yes	Yes	Yes
B1850C_LTso	Yes	Yes	Yes	Yes

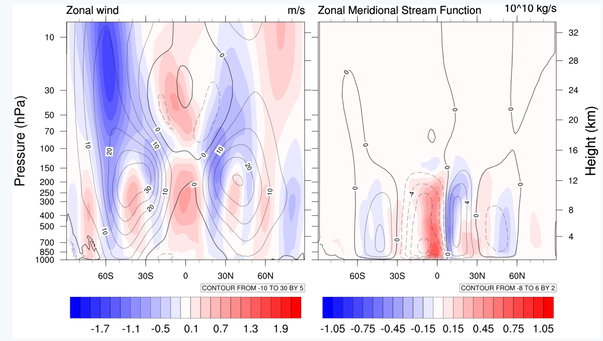

Figure 2. Circulation climatology with NCTs (contoured) and the difference due to omitting NCTs (shaded) in the second decade of the preliminary B1850C_LTso simulation (coupled).

Caveats

1. The B1850C_LTso results are preliminary. We are still tuning the top-of atmosphere radiation budget.
2. The model behavior depends on the dynamical core. The present poster focuses on the MPAS core. Please visit Owen Hughes' poster for the distinct behavior with the Spectral Element core at A41J-VR8812 on Thursday.
3. We have implemented the NCTs in the dynamical core. Ongoing work is introducing the NCTs to the turbulence and shallow convection parameterization.

Scan for Owen's poster