Investigation of the tropical atmosphere with a radiative-convective version of a comprehensive GCM

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Motivation

Does the control state of the RCE model resemble the tropical atmosphere?

Is the RCE model a useful framework in climate change experiments?
Radiative-convective equilibrium model

TOA: 340 W m\(^{-2}\)

Ω = 0

340 W m\(^{-2}\)

SST (K)

Ω = 0

230 250 270 290

296 298 300 302
Space-time variability of convection

Cloud cover & surface winds

Tiedtke: integrated vertical velocity at equator
Profiles of mean state resemble tropical atmosphere

Graphs showing temperature, relative humidity, cloud fraction, cloud liquid water, and cloud ice concentration as functions of height.
RCE model captures main characteristics of vertical velocity PDF
Cloud radiative effect of RCE model similar to GCM tropics

\[ \text{LW CRE (W m}^{-2}\text{)} \]

\[ \text{SW CRE (W m}^{-2}\text{)} \]

- piControl, Tropics (Nordeng)
- Nordeng
- Tiedtke

\[ \omega \text{ (925 to 200 hPa) (hPa/day)} \]
Climate sensitivity comparable to GCM tropics
RCE model exhibits fixed anvil temperatures

5 K range as in Hartmann & Larson (2002)

*data sampled from 25 % strongest upsidence regions
Summary

Does the control state of the RCE model resemble the tropical atmosphere?
→ yes, the RCE model resembles the tropical atmosphere in
  • vertical profiles of the mean state
  • PDF of the vertical velocity
  • CRE effect in LW and SW

Is the RCE model a useful framework in climate change experiments?
→ RCE model is a promising framework in climate change experiments
  • Climate sensitivity of RCE model in the range of values given by last IPCC
  • Fixed anvil temperature hypothesis is a robust feature in RCE model