Observed Changes in Tropical Precipitation and Convection Under Global Warming

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The hydrological cycle and global warming



Held and Soden (2006)

The hydrological cycle and global warming



The tropical overturning circulation slows down with warming

Held and Soden (2006)

Model projections of extreme precipitation



• Hampered by parameterizations: convective, microphysics, turbulence,...

O'Gorman (2015)

Questions

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- How do <u>extremes</u> of precipitation and convective intensity change in observations from 1987 to 2024?
- How do coupled climate models compare to the observed record?

Methods — SSM/I and SSMIS

- Passive microwave radiometers on board DMSP satellites
- Coverage over tropical oceans
- Collect simultaneous measurements of rain rate and column water vapor



Data from Remote Sensing Systems

Effect of orbital degradation



Effect of orbital degradation



Methods — CMIP6 historical experiment

• 19 atmosphere-ocean general circulation models

- Run from 1850 to 2014, extended to 2024 using a hypothetical future scenario (SSP5-8.5)
- Capture in broad strokes the climate of the 20th and 21st centuries

Proxy for convective intensity: M* = P/q



Mean rainfall and water vapor







Rainfall

Water vapor

Convective intensity M* = P/q









Precipitation extremes — models



Moderate rainfall is decreasing in frequency while heavy rainfall is increasing

Convective intensity — observations



Convective intensity — models



Missing water vapor at high rain rates



Convective events are shifting from higher to lower intensities, except possibly at the highest intensities

Summary



Summary

- Heavy rainfall is increasing in frequency at the expense of moderate rainfall
- Models do a reasonable job of simulating the trends in mean and extreme rainfall
- Future work will investigate the discrepancy between observed and simulated trends in the intensity of convective events

Thank you!

Contact me at eric.mischell@earth.miami.edu

Extra Slides









Intensity of convection by rainfall bin



Intensity of convection by rainfall bin



Summary



Deficiencies of Mischell and Soden (2025)

- Rain rate observations are limited
 - < 25 mm/h, ocean only, 2-dimensional, etc.
- Used M* = P/q to "estimate" convective vertical velocity
- Water vapor cannot be retrieved at high rain rates