Vertical Structure of Water Vapor Change

\[ \frac{\delta e_s}{e_s} \sim \frac{\delta T}{T^2} \]

\[ \sim 6\%/K \quad @ \quad T=300 \quad K \]

\[ \sim 14\%/K \quad @ \quad T=200 \quad K \]
Vertical Distribution of Water Vapor Feedback

Uniform Warming and Constant RH

Most feedback from tropical upper trop

Clouds mask lower trop contribution

Total Sky

Clear Sky
Total Column Water Vapor Anomalies (1987-2004)
HIRS 6.7 micron radiances

- Sensitive to RH over deep layer of upper trop
- Clear-sky only
- Long record: 1979-2005 (NOAA 6,7,9,10,11,12,14)
- Orbital drift corrected, intercalibrated (Li and Bates, 2010)
- Compare to simulated 6.7 µm radiances from 20 coupled ocean-atmosphere models from CMIP5.
• Observed and CMIP5 GCM simulated T12 show little trend
• HIRS/2 → HIRS/3-4 discontinuity at 2006 due to channel shift
• GCM T12 with constant RH shows no trend
• GCM T12 with fixed mixing ratio increases by ~0.4 K
• Tropospheric temperature increases in both GCM and MSU
Emission Levels of T2 and T12

- As UT mixing ratio increases, T12 emission level must increase
- T2 emission level remains fixed (O2 is not changing)
- So T2-T12 must diverge
• Emission levels of T2-T12 diverge over past decade by ~0.4 K
CMIP5 GCM Simulations: Control (Pre-Industrial) Scenario

Red: Observed Trend (1979-2005)
CMIP5 GCM Simulations: Historical Scenario

PDFs of trend from 20 GCM simulations for 1979-2005
(Ensemble mean trend ----)

- Observed trends lie within spread of GCM simulations with historical forcing
- Observed moistening trend (T2-T12) is about 30% smaller than ensemble mean due to smaller tropospheric warming trend (T2)
CMIP5 GCM Simulations: Historical Scenario
Conclusions

- Models predict the moisture of the upper troposphere should double over the next century due to anthropogenic forcing.

- HIRS provides a method for looking at changes in upper level moisture over the 1979-2005. Continuity of observations after 2005 remains problematic.

- HIRS/MSU show a distinct increase in global UT water vapor over this period.

- The observed trend is consistent with constant RH hypothesis and NOT consistent with a fixed mixing ratio hypothesis.

- The observed moistening is consistent with model simulations under historical forcing scenarios.

- This moistening is primarily due to anthropogenic forcing and cannot be explained from natural causes alone.
Extra Slides