MLS-Related Scientific Publication

Scientific Theme: Climate Research

Water Vapor Feedback in the Tropical Upper Tropopause: Model Results and Observations, Ken Minschwaner and Andrew E. Dessler *J. Climate*, **17**, 1272–1282, (2004).

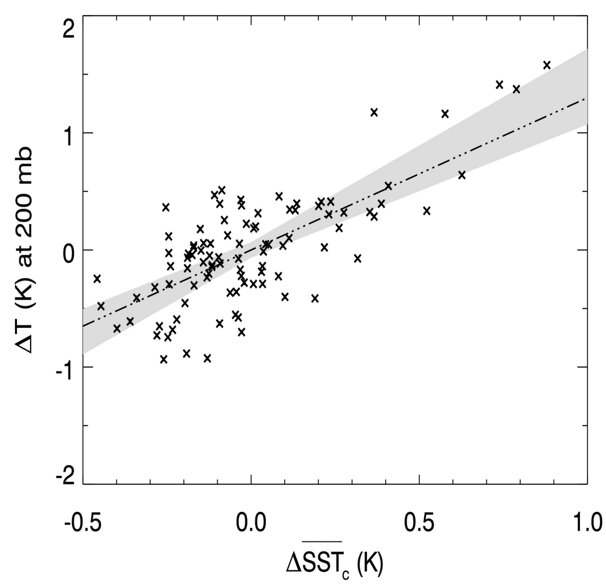
First Author: Ken Minschwaner, krm@kestrel.nmt.edu
MLS contact: W. G. Read, bill@mls.jpl.nasa.gov, 818-354-6773.

Summary

An outstanding question is accurately forecasting climate changes caused by increasing CO_2 and other anthropogenic gases. The 2001 Intergovernmental Panel on Climate Change report shows model predictions of surface warmings as high as 5.8°C over the next 100 years. A major contributor to the increase in surface temperature is the warming caused by H_2O in response to warming from increased CO_2 (H_2O feedback). Most climate models predict that relative humidity stays the same regardless of temperature. Since specific humidity increases exponentially with temperature, maintaining relative humidity requires more evaporation and moistening of the atmosphere. The resulting increase in water vapor, an effective greenhouse gas, promotes further warming. For example, doubling CO_2 without any change in specific humidity, causes a surface warming of 0.8°C, but when specific humidity increases without changing relative humidity, a 1.6°C surface warming occurs. An opposing view raised by Prof. Lindzen at M.I.T. argues that H_2O acts as a negative feedback mechanism in climate. According to this view surface warming is expected to intensify tropical deep convection and dry the upper troposphere.

Using a radiative-convective model, Drs. Minschwaner and Dessler in this paper show that the climate has a positive H_2O feedback, but weakened because warming from increased specific humidity is partially reduced by drying from more intense deep convection as suggested by Lindzen. The model predicts a warming of 1.2°C per doubled CO_2 and a sensitivity of relative humidity to surface temperature of (ΔRHi/Δ T) of -3– -5%$C^{\circ -1}$. Results from this model were compared to upper tropospheric measurements of relative humidity (UTRH), from the Microwave Limb Sounder (MLS) and specific humidity (UTH), from the HALogen Occultation Experiment (HALOE). Scattering tropical MLS 215 hPa UTRH monthly averages against sea surface temperatures that are coincident with deep convection (SSTc) from the previous month show a linear correlation of -4.8±3.4 %$C^{\circ -1}$ (2-σ uncertainty). The one month lag accounts for the time it takes UTH to come into equilibrium with a change in SSTc. Likewise, tropical HALOE 215 hPa UTH versus SSTc has a linear correlation of 3.0±1.2 ppmv $C^{\circ -1}$ (2-σ uncertainty). The H_2O sensitivity to surface temperature change calculated by the model agrees within the 2-σ uncertainty of the MLS measurement. The HALOE measurement implies a smaller positive feedback than that measured by MLS or predicted by the model.

The Clausius-Clapeyron equation links relative humidity and specific humidity to temperature. The humidity correlations with SSTc measured by MLS and HALOE were used to calculate the linear correlation of 215 hPa temperature with respect to SSTc. The figure shows a scatter plot of the National Centers for Environmental Prediction (NCEP) 215 hPa temperatures versus SSTc lagged by one month. The x's are monthly NCEP temperatures between 20°S –20°N and SSTc, the shaded region is the linear correlation ± 2-σ uncertainty of the NCEP data, and the dashed-dot-dot-dot is the SSTc-215 hPa temperature correlation implied by the MLS and HALOE observations. The good quantitative agreement between MLS, HALOE and NCEP suggests that the feedback is better understood than indicated by the uncertainty in the individual MLS and HALOE fits and that the H_2O feedback is positive but less so than predicted in most climate models.



This work benefits society by improving our ability to predict the magnitude of global warming.