Studies of the tropical upper troposphere using MODIS data

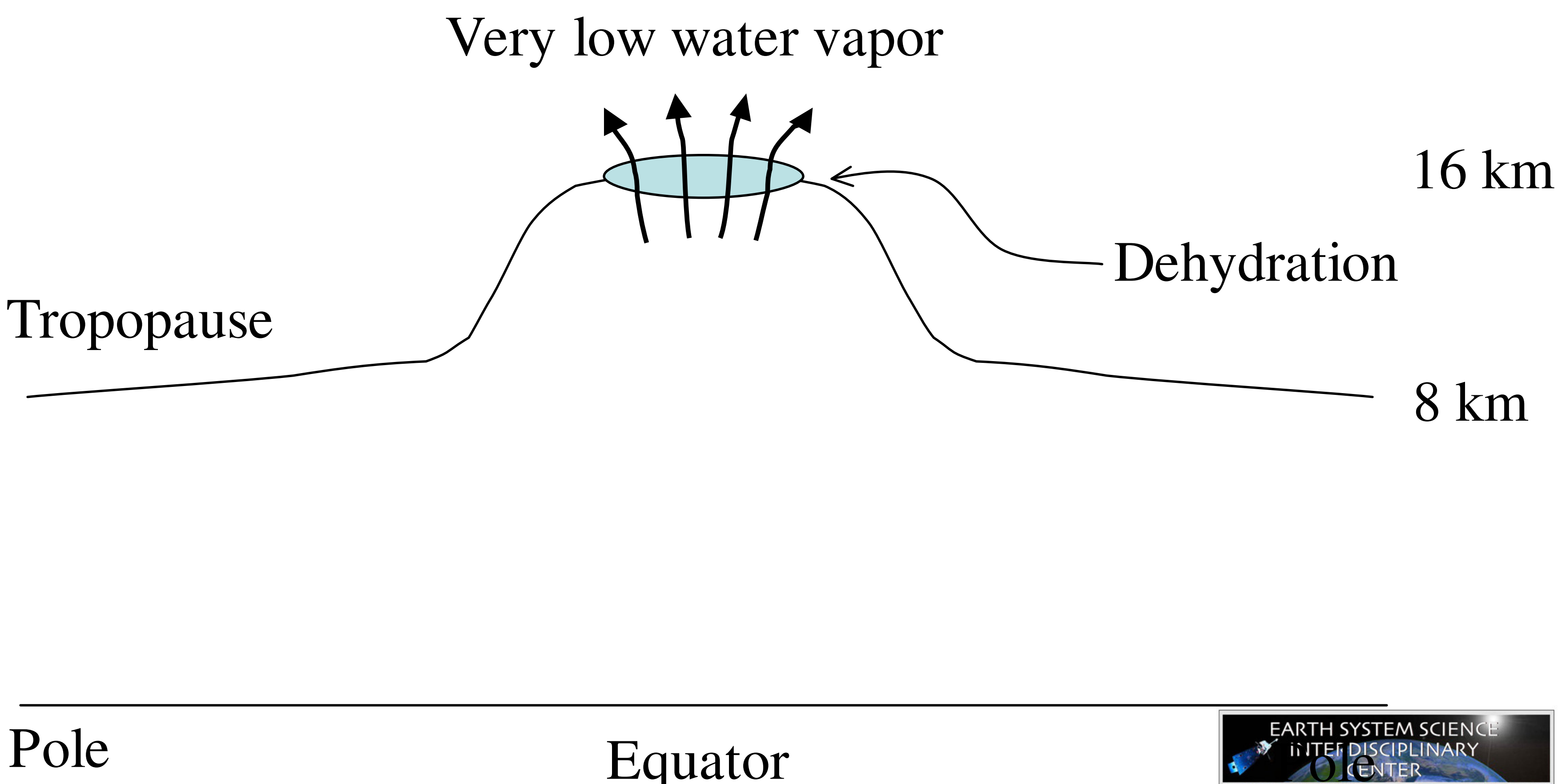
A. E. Dessler

Earth System Science Interdisciplinary Center

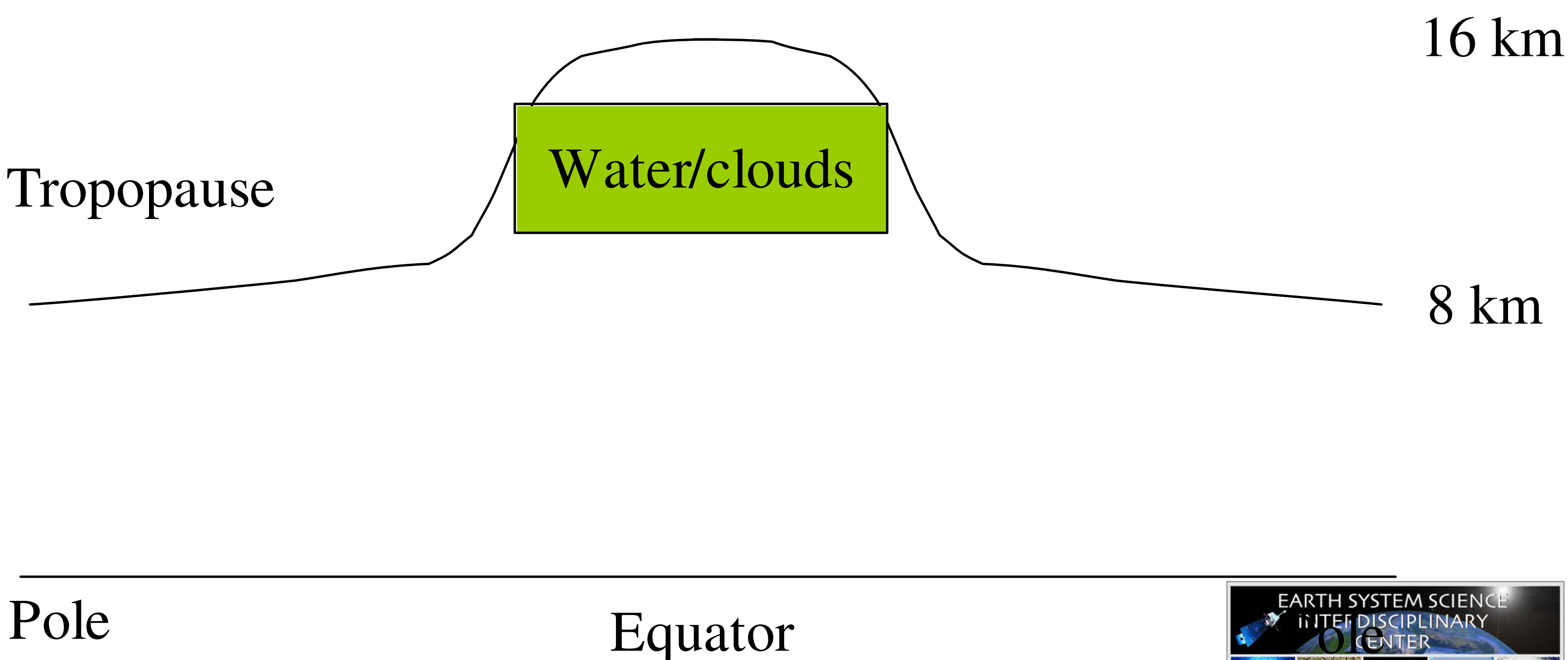
University of Maryland

S. Sherwood, K. Minschwaner, P. Yang, G. North

Brewer, A.W., Evidence for a world circulation provided by the measurements of helium and water vapour distribution in the stratosphere, *Q. J. R. Meteorol. Soc.*, 1949.



Another issue …



Summarized in
Held, I.M., and B.J. Soden, Water vapor feedback and global warming, *Ann. Rev. Energy Environ.*, *25*, 441-475, 2000.

1990: **"The best understood feedback mechanism is water vapor feedback, and this is intuitively easy to understand."**

1992: **"There is no compelling evidence that water vapor feedback is anything other than positive — although there may be difficulties with upper tropospheric water vapor."**

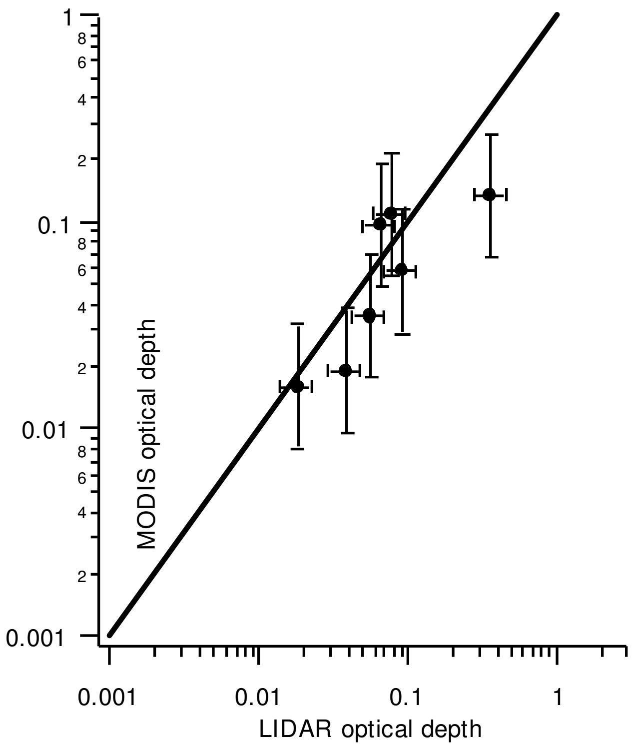
1995: **"Feedback from the redistribution of water vapor remains a substantial source of uncertainty in climate models—much of the current debate has been addressing feedback from the tropical upper troposphere."**

EARTH SYSTEM SCIENCE INTERDISCIPLINARY CENTER
ESSIC
UNIVERSITY OF MARYLAND

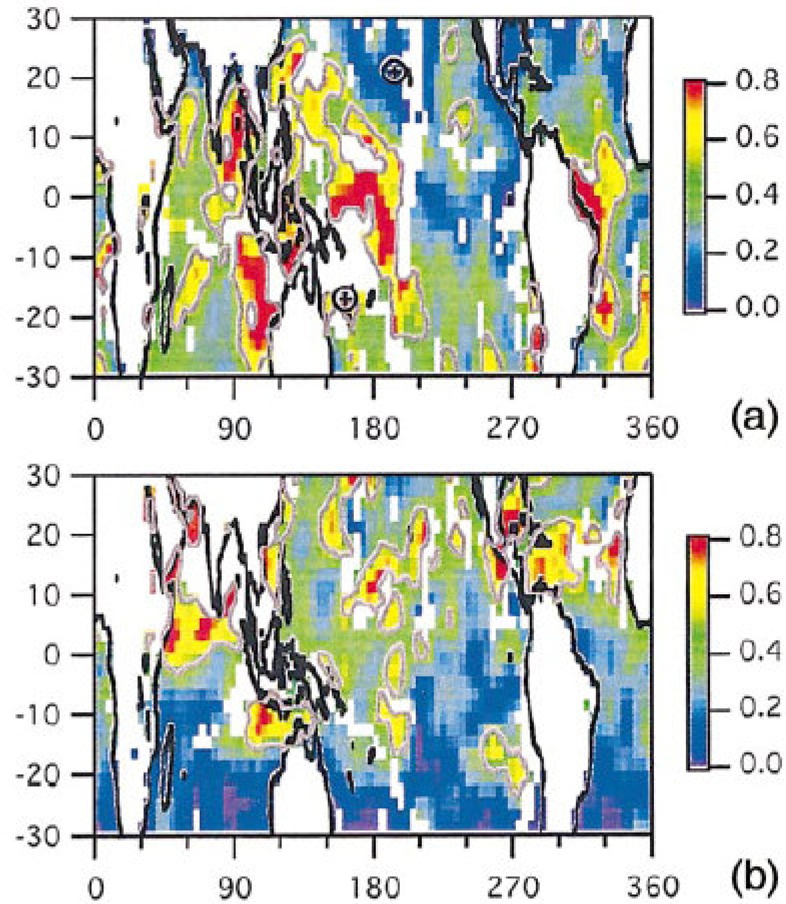
2001:

The decade since the First IPCC Assessment Report (IPCC, 1990) has seen progressive evolution in sophistication of thinking about water vapour feedback. Concern about the role of upper-tropospheric humidity has stimulated much theoretical, model diagnostic and observational study. The period since the SAR has seen continued improvement in the analysis of observations of water vapour from sondes and satellite instrumentation. Theoretical understanding of the atmospheric hydrological cycle has also increased. As a result, observational tests of how well models represent the processes governing water vapour content have become more sophisticated and more meaningful. Since the SAR, appraisal of the confidence in simulated water vapour feedback has shifted from a diffuse concern about upper-tropospheric humidity to a more focused concern about the role of microphysical processes in the convection parametrizations, and particularly those affecting tropical deep convection. Further progress will almost certainly require abandoning the artificial diagnostic separation between water vapour and cloud feedbacks.

Thin cirrus observations



Adapted from Fig. 1



Dec.

June

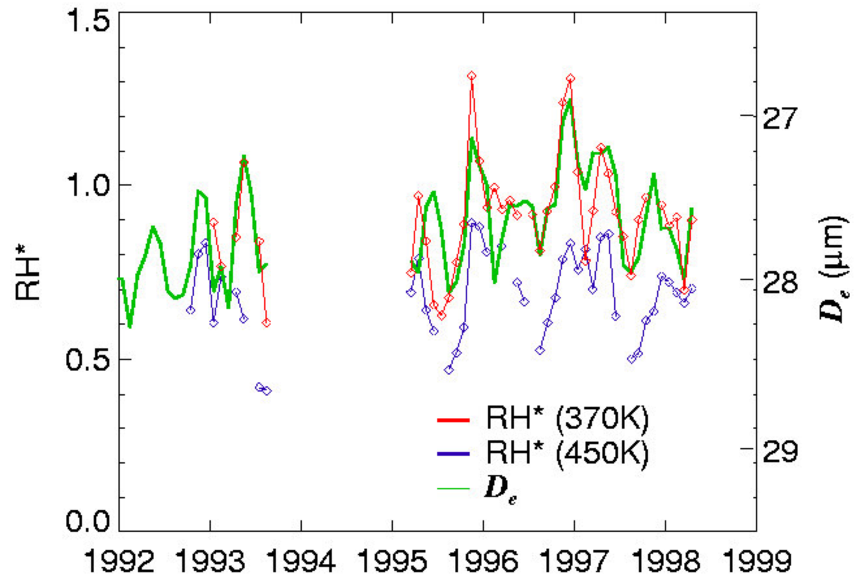
FIG. 2. Fraction of observations (color scale) between latitudes 30°N and 30°S and longitudes 0° to 360° during the (a) 6–8 Dec 2000 and (b) 6–8 Jun 2001 time periods whose optical depth τ exceeded 0.02. White indicates less than 1000 measurements in the box. The + symbols in (a) are the locations from which the histograms in Figs. 3b and 3c are derived. The fields have been smoothed to emphasize the large-scale structure. Gray contours indicate the 30% frequency contour for $\tau > 0.03$.

Dessler, A. E. and P. Yang, 2003: The distribution of tropical thin cirrus clouds inferred from Terra MODIS data. *J. Climate*, **16,** 1241-1248.

Next steps:

- More detailed climatologies
  - Comparisons with IceSAT, other correlative
- Correlations with CERES to determine longwave forcing

Regulation of stratospheric humidity

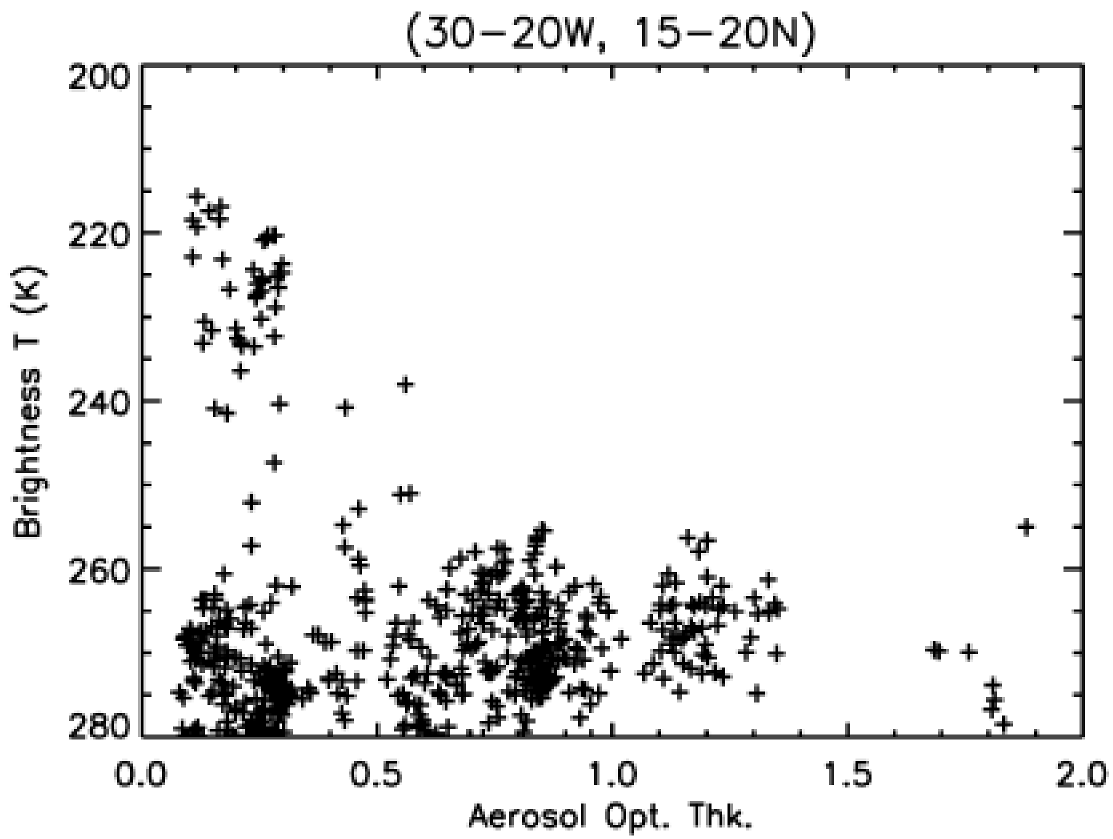


After Sherwood, A microphysical connection among biomass burning, cumulus clouds, and stratospheric moisture. *Science*, 295, 1272-1275, 2002.

Variations in RH* (relative humidity corrected for advection delay and warming) at two levels below and above the tropical tropopause, vs. effective ice diameter.

Next steps: Verify correlation, identify spatial patterns, determine why particle size is varying

Aerosol and convection



QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

Scatter plots of relationship between thermal cloud top (x-axes), cloud top estimated from MOD06 pressure retrieval (top panel), and MISR stereoscopic cloud top (bottom). MODIS altitudes are determined using nearby radiosondes. Data comprise three Terra image segments from the Tropical Western Pacific region.

Next steps: incorporate IceSAT and aircraft data

Summary

- Studies of the UT/tropical tropopause region
- What controls water vapor/clouds in these regions?
  - Emphasis on climate feedback processes
- Use combination of measurements, with MODIS playing an important role
- This has not been an exhaustive list

EARTH SYSTEM SCIENCE INTERDISCIPLINARY CENTER
ESSIC
UNIVERSITY OF MARYLAND