NASA EOS TES - Tropospheric Pollution Transport Observed from Space

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TES

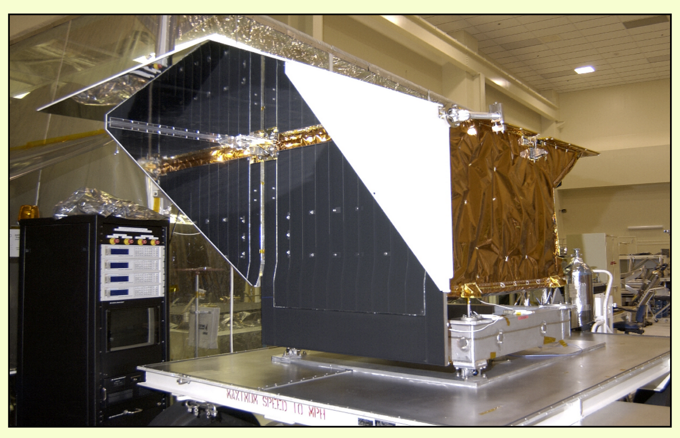
•TES stands for Tropospheric Emission Spectrometer. TES is focused on these science area:

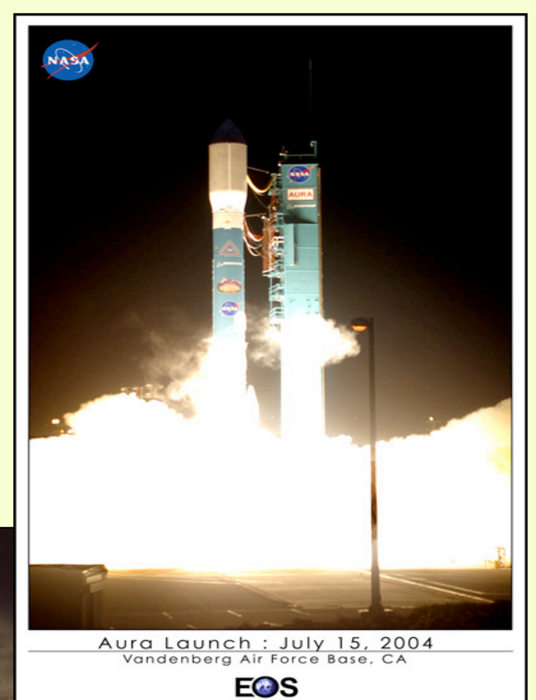
- Global and regional tropospheric atmospheric chemistry budgets and quantification of long range transport impacts
- The role of tropospheric ozone in radiative forcing
- The impact of satellite measurements on air quality science

TES on EOS Aura is providing the first vertically resolved measurements of tropospheric ozone from space. Along with the ozone measurements, we retrieve profiles of water vapor, temperature, and CO. Effective cloud top pressure and cloud optical depth are determined in this retrieval.

TES on EOS Aura

TES is a Fourier Transform Spectrometer that measures infrared radiation with very high spectral resolution (0l.06 cm-1), to profile trace gases in the atmosphere (including the troposphere).

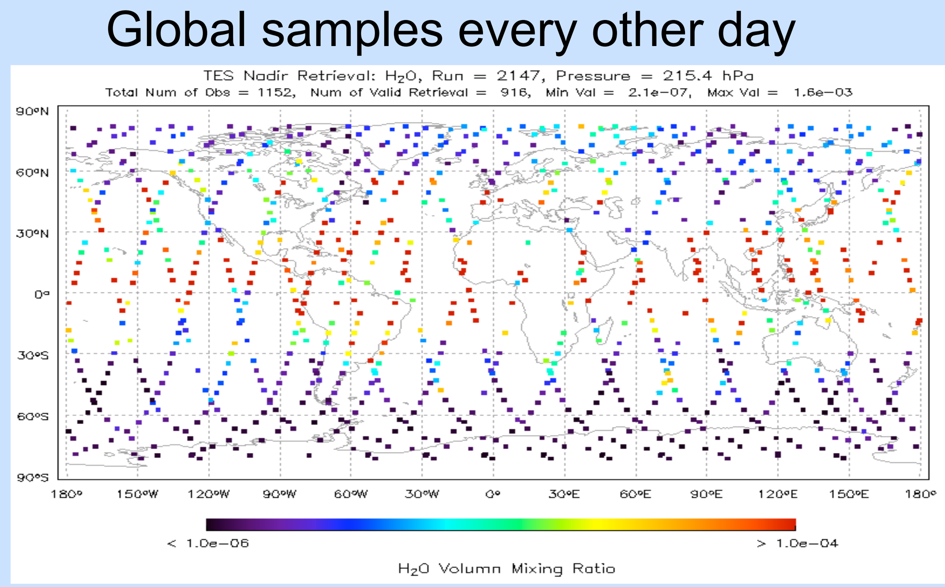




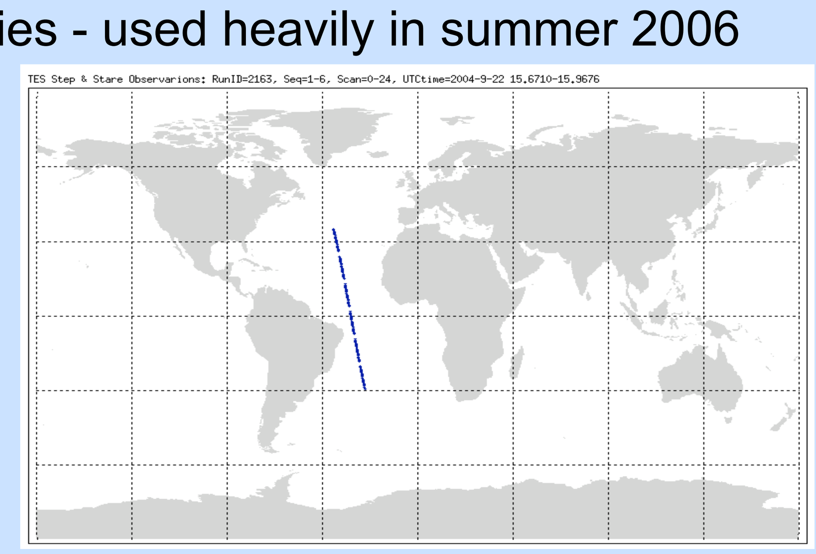
Locations of IONS sonde launches in 2004 campaign

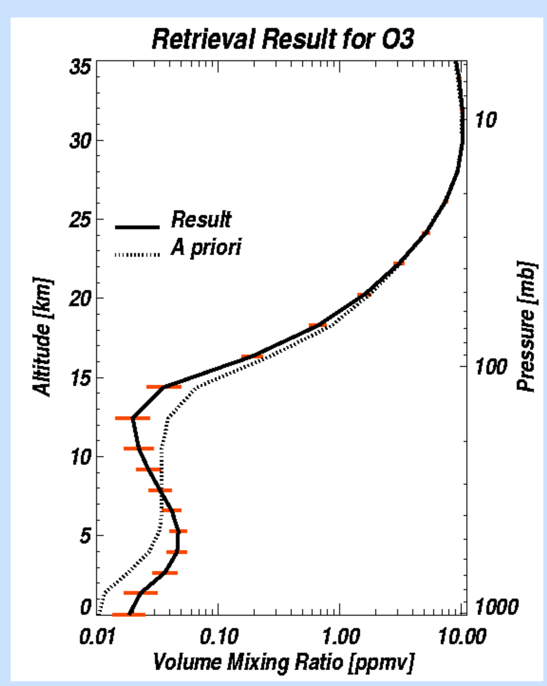
TES Observations and Retrievals

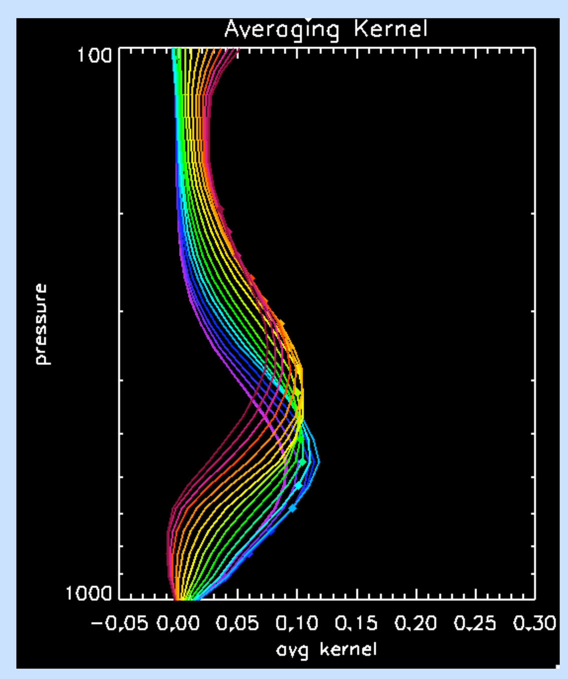
Global samples every other day

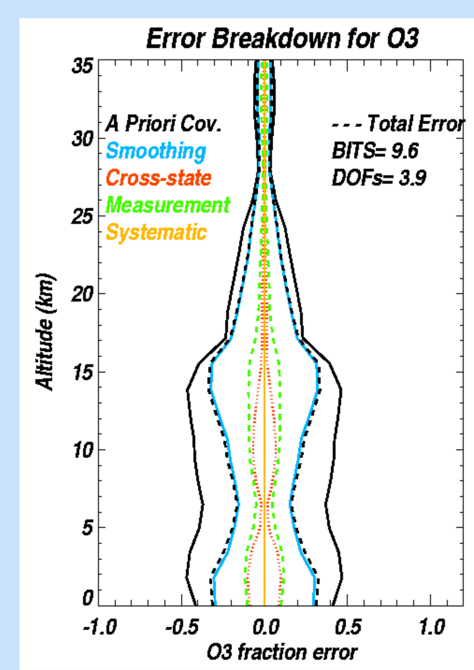


'Step and Stare' - densely sampled for special studies - used heavily in summer 2006



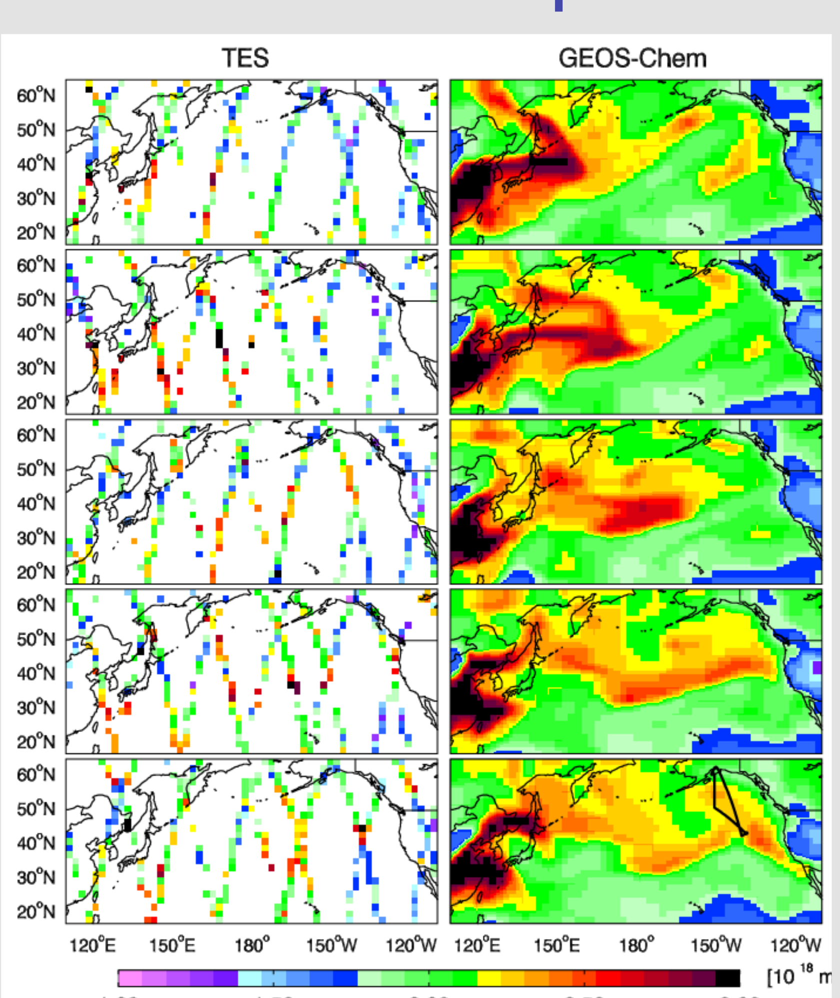






Optimal estimation is used, and provides retrieval profile, averaging kernel (indicating sensitivity), and error characterization. Clouds are treated in this same framework, and an effective cloud top pressure and effective optical depth at a set of about 25 frequencies are retrieved.

Pollution transport across the Pacific



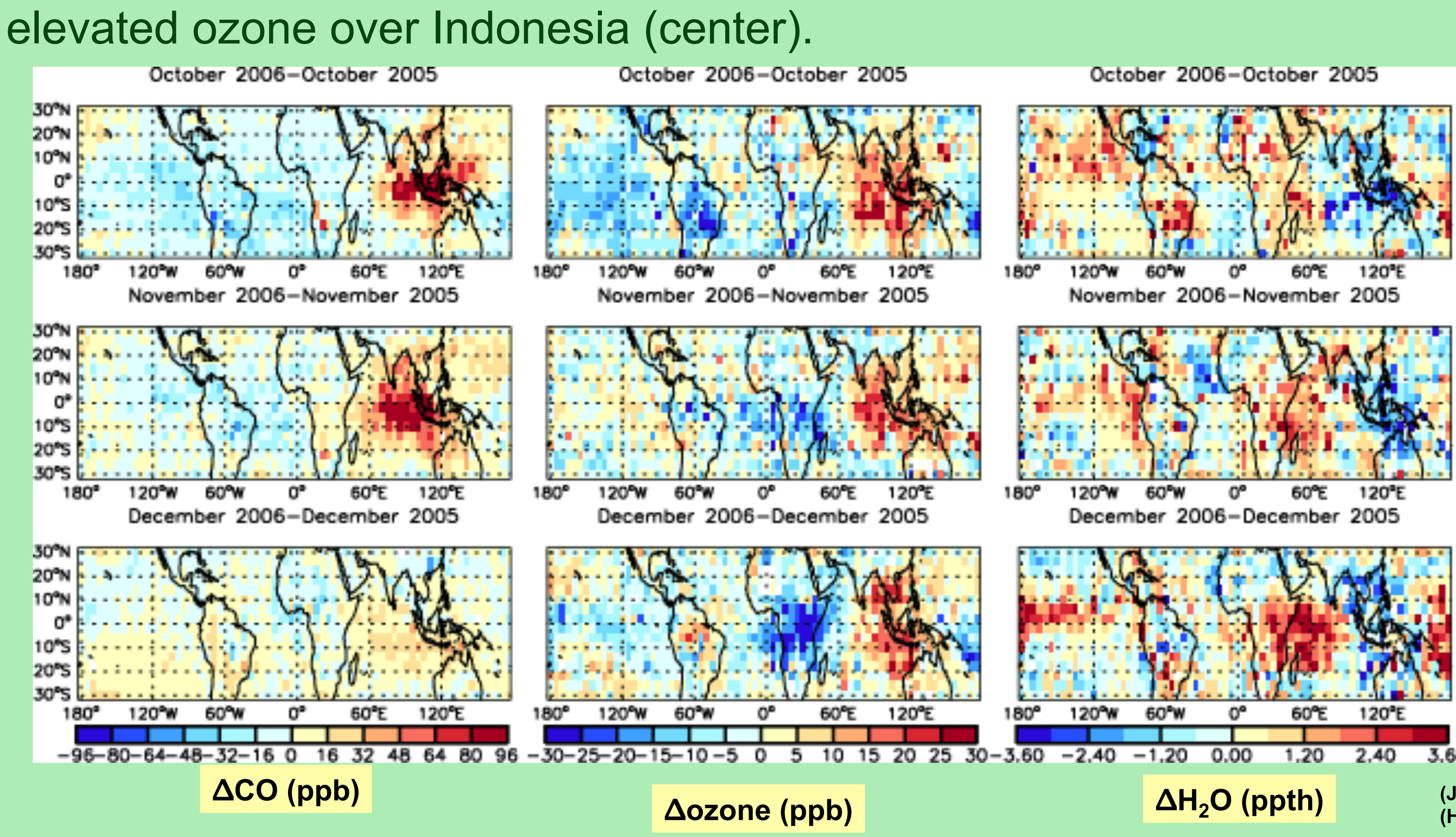
Zhang (Harvard) et al, in preparation

•Asian NOx emissions have increased by a factor of 2 from 2000-2006.
•Asian anthropogenic emissions contribute 5-7 ppb to the U.S. surface ozone levels in the west.
•The 2000-2006 rise in Asian anthropogenic emissions has lead to an increased surface ozone of 1-2 ppbv relative to 2000.
•Transpacific pollution plumes split over the Northeast Pacific

•OMI NO_2 observations used to scale GEOS-Chem emissions
•TES and AIRS CO used to track episodic pollution events
•TES ozone/CO correlations were used to test GEOS-Chem pollution export
•DC-8 and C-130 aircraft observations of PAN, NOx, CO, and ozone used to examine chemical mechanisms

El Nino Impacts on O_3, CO, and H_2O

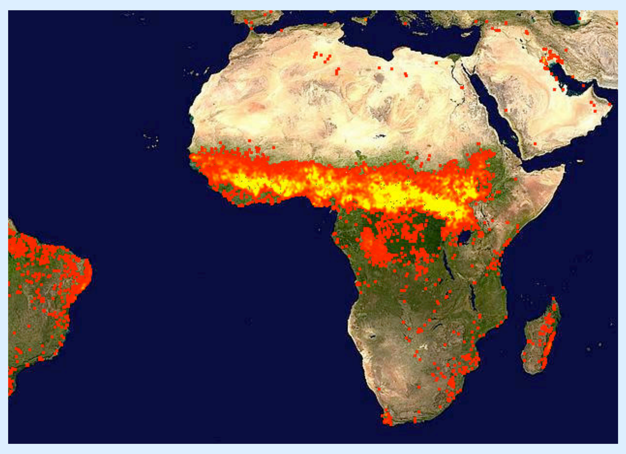
- Drought in Indonesia from the 2006 El Niño caused major fires.
- Decreased water vapor over Indonesia (right) results from convection shifting to the Pacific during El Niño.
- CO from the fires (left) and shifts in convection both contribute to elevated ozone over Indonesia (center).

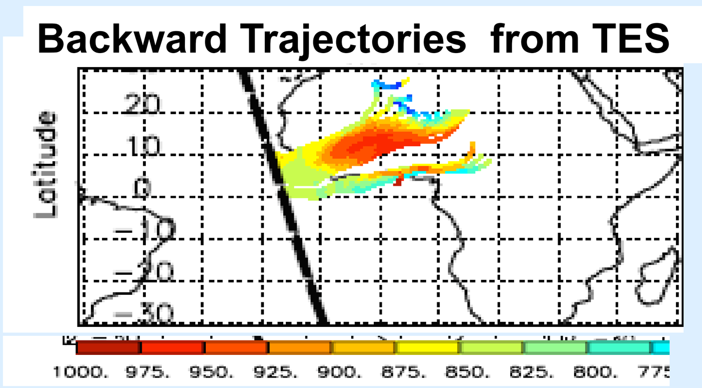


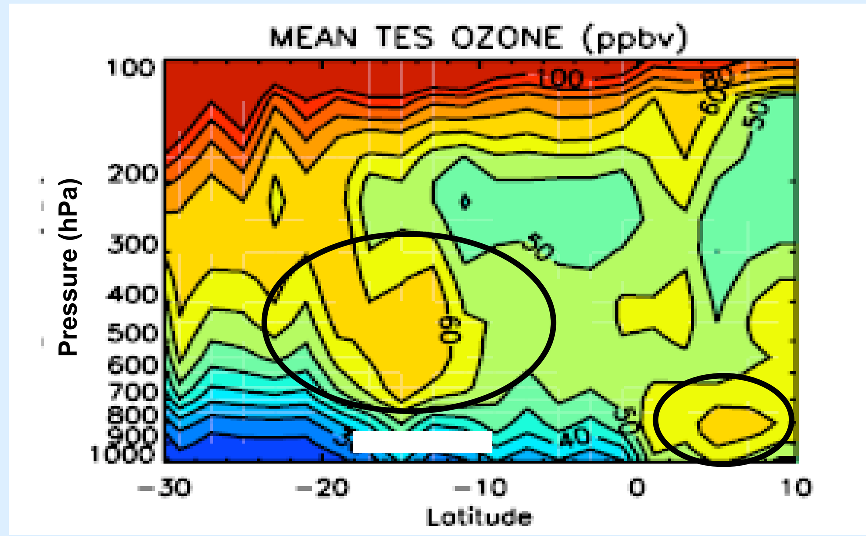
(J. Logan et al. (Harvard), 2008)

Tropical Atlantic ozone ‘paradox’

The tropical Atlantic “paradox” came from TOMS observations of high ozone column South of the ITCZ but low ozone columns North of the ITCZ over Africa during peak biomass burning season (Thompson *et al*, 2000).





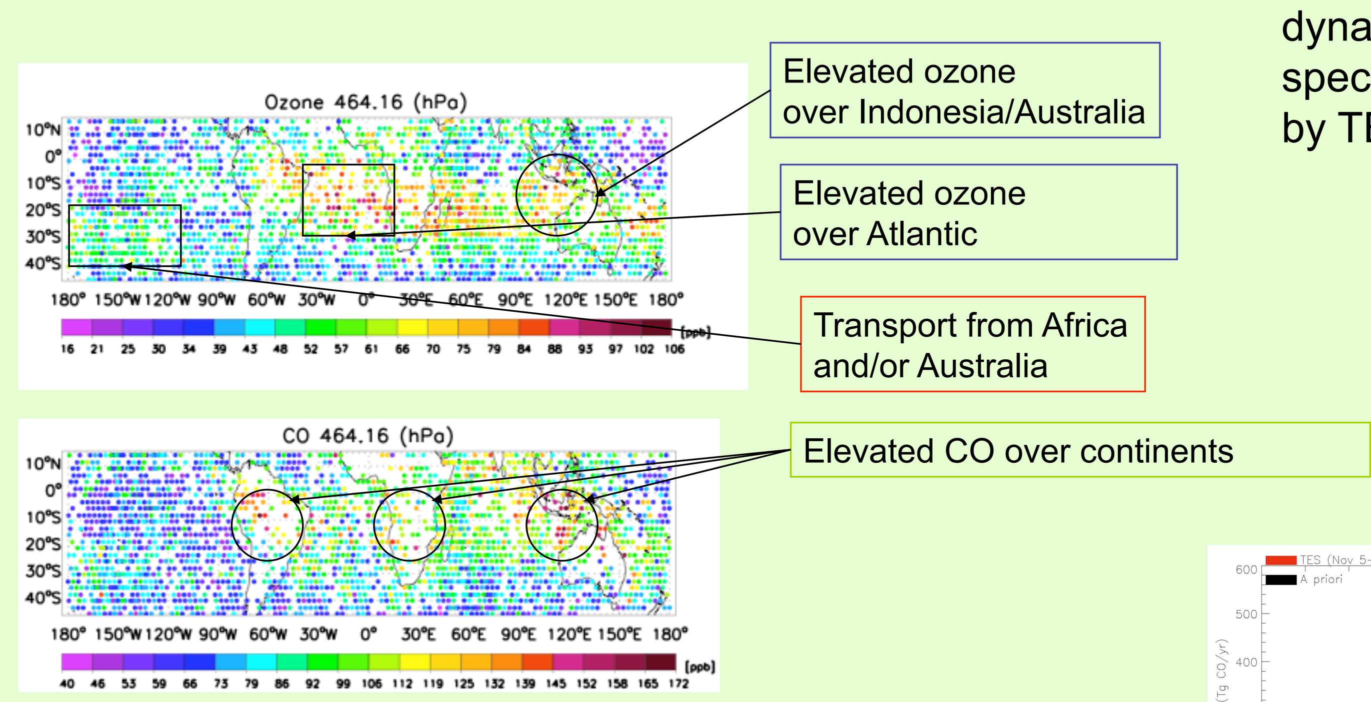


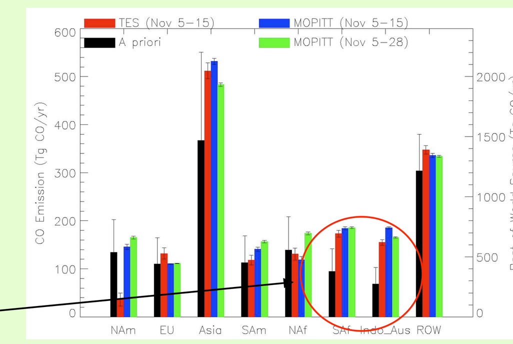
With greater sensitivity to the lower troposphere,TES observations show elevated concentrations in the lower troposphere over Africa and in the free troposphere over the tropical Atlantic consistent with in-situ data and model predictions

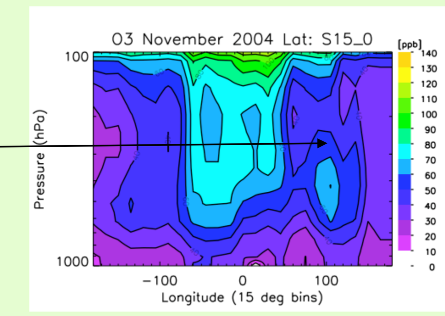
Jourdain (JPL) *et al*, 2007

Chemical and Dynamical relationship of CO and O_3:

Beyond El Nino effects, we see the global interplay of chemistry and dynamics for the species measured by TES.



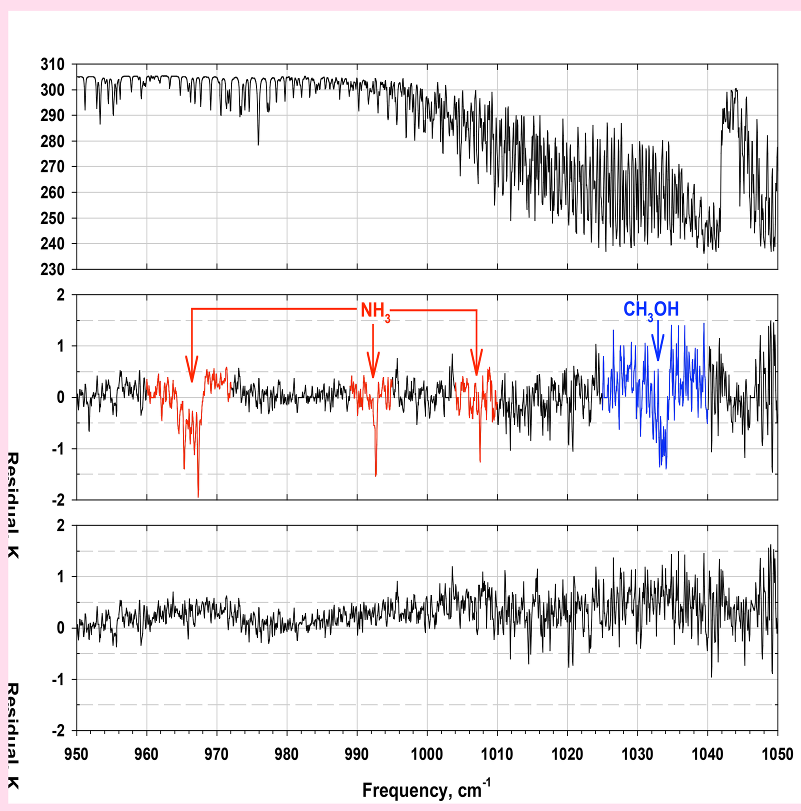


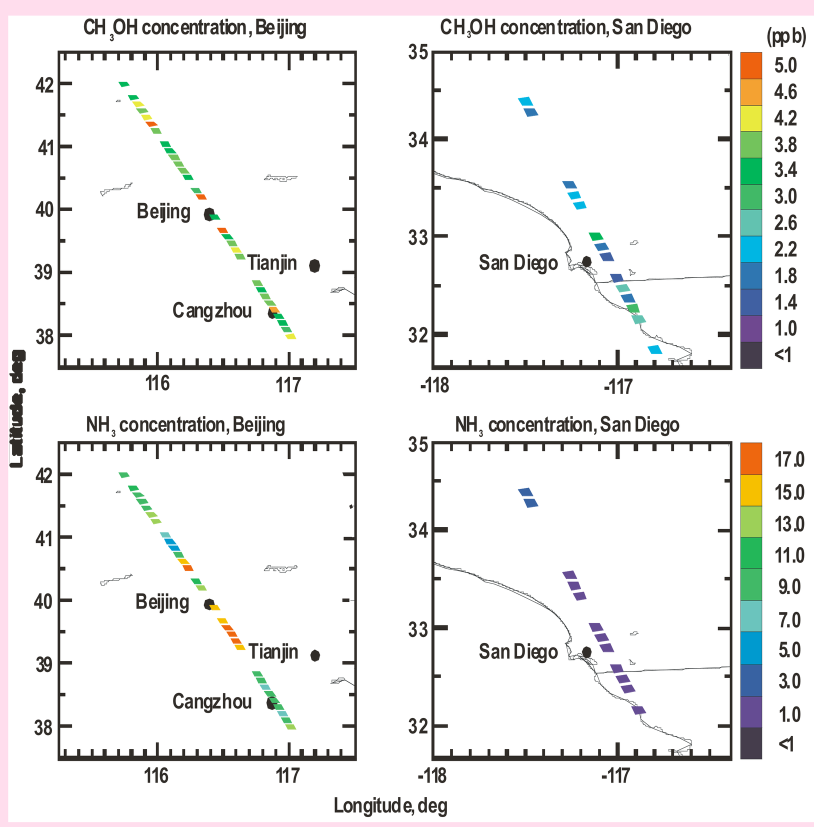


Emission estimates derived from TES CO and inverse modeling showed a factor of 2 increase relative to climatological inventories

Free tropospheric ozone over Indonesia/Australia is sensitive to changes in regional surface emissions and these emissions make a significant contribution to the regional ozone budget.

Methanol & Ammonia Retrievals from TES:

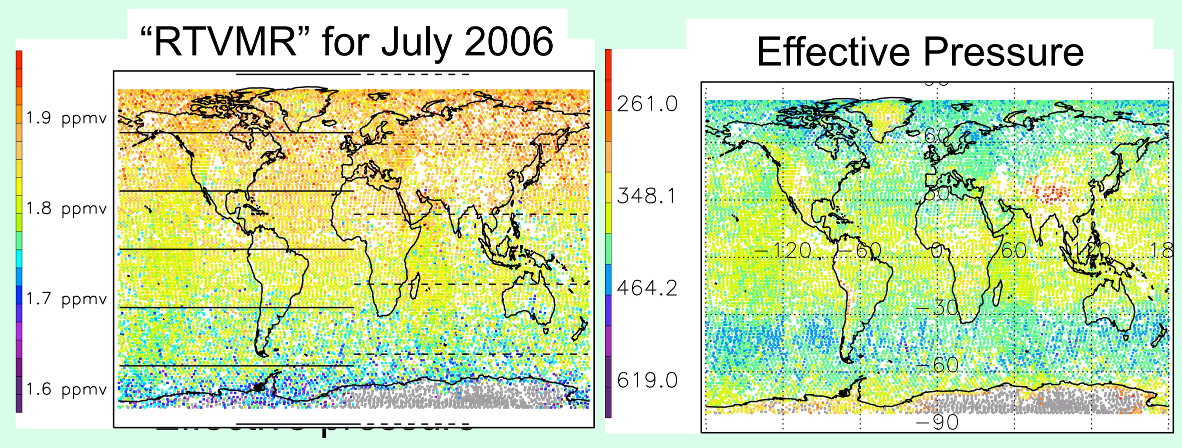




The figure above shows the spectral signatures of ammonia and methanol in the TES measurement spectra.

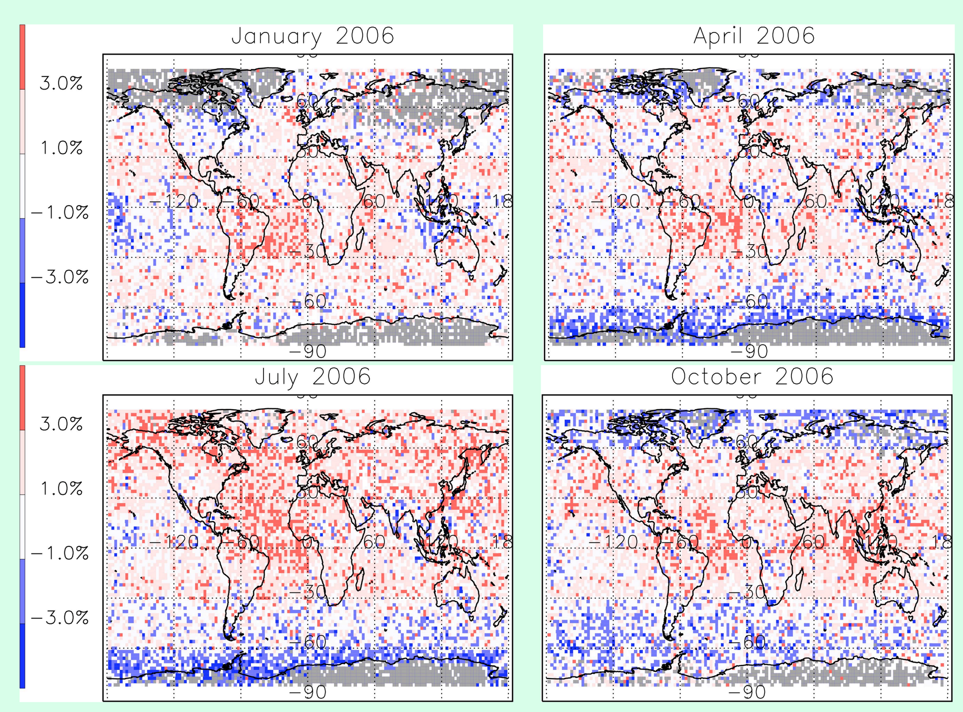
Average tropospheric concentrations were retrieved over the Beiing region and Southern California, consistent with previous measurements, but elevated over China relative to S. California.

Methane Retrievals:



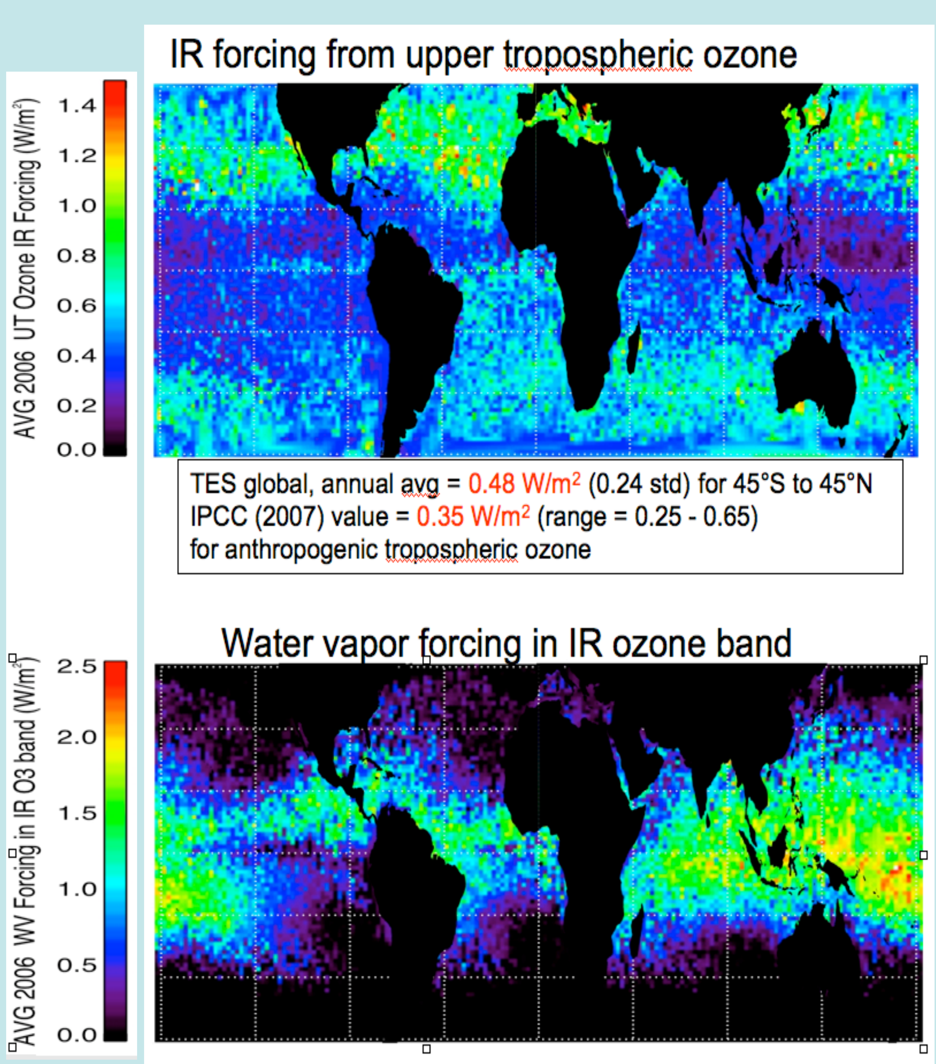
TES retrieves methane with sensitivity closer to a column rather than a profile. The plots to the left show the effective VMR and the altitude of most sensitivity.

TES appears tp capture the latitudinal gradients, and features such as tropical forest emissions (noted by Frankenberg), and elevated emissions from the Indonesian biomass burning in 2006. TES is biased high relative to GEOS-Chem.



Monthly percent differences from GEOS-CHEM, after accounting for 3.5% bias

Radiative Forcing of Tropospheric Ozone



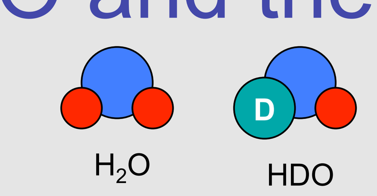
Problem: Radiative forcing of tropospheric ozone is modeled, but not measured. Tropospheric ozone is important in total radiative budget and uncertain in the future.

Result: **TES** observations used to quantify the observed IR forcing of tropospheric ozone and water vapor in the ozone band.

Significance: First space-borne measurement of tropospheric ozone forcing. TES observations are in the range of model forecasts, but show more sensitivity of IR forcing in the Northern Hemisphere than models.

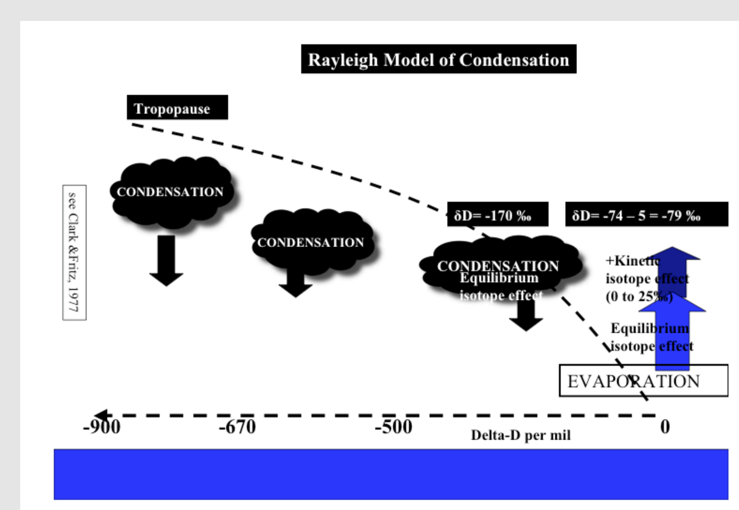
(H. Worden et al., Nature Geosciences, 2008)

HDO and the water cycle

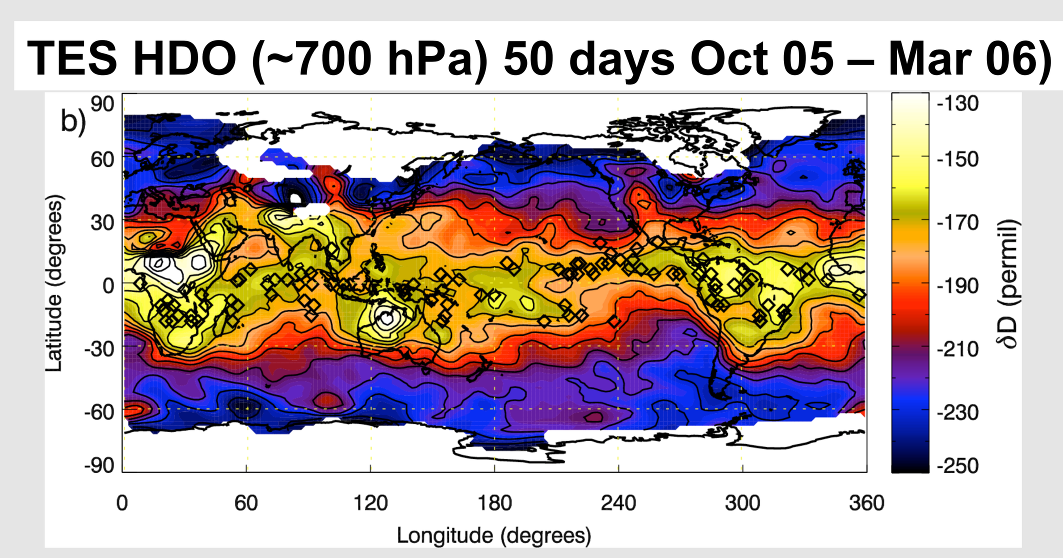


Water vapor isotopes evaporate and condense at slightly different rates than water.

We can use HDO to infer internal terms in the water cycle (evaporation and condensation rates)



TES HDO (~700 hPa) 50 days Oct 05 – Mar 06)



TES water vapor isotopes suggest that rainfall evaporation an important rehydration mechanism in tropics.

TES measurements indicate that 20-50% of rainfall re-evaporates near convective clouds.

J. Worden, D. Noone, K. Bowman, *et al*., *Nature* 445, 528 - 532 (01 Feb 2007)

IMPORTANT WEBSITES:

http://tes.jpl.nasa.gov - a great starting point about the data, the instrument, and the team

http://eosweb.larc.nasa.gov/ - data access - v003 data is now being delivered

The ASDC Data pool will have the data processed in the last 12 months (http://eosweb.larc.nasa.gov/HPDOCS/datapool/)

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