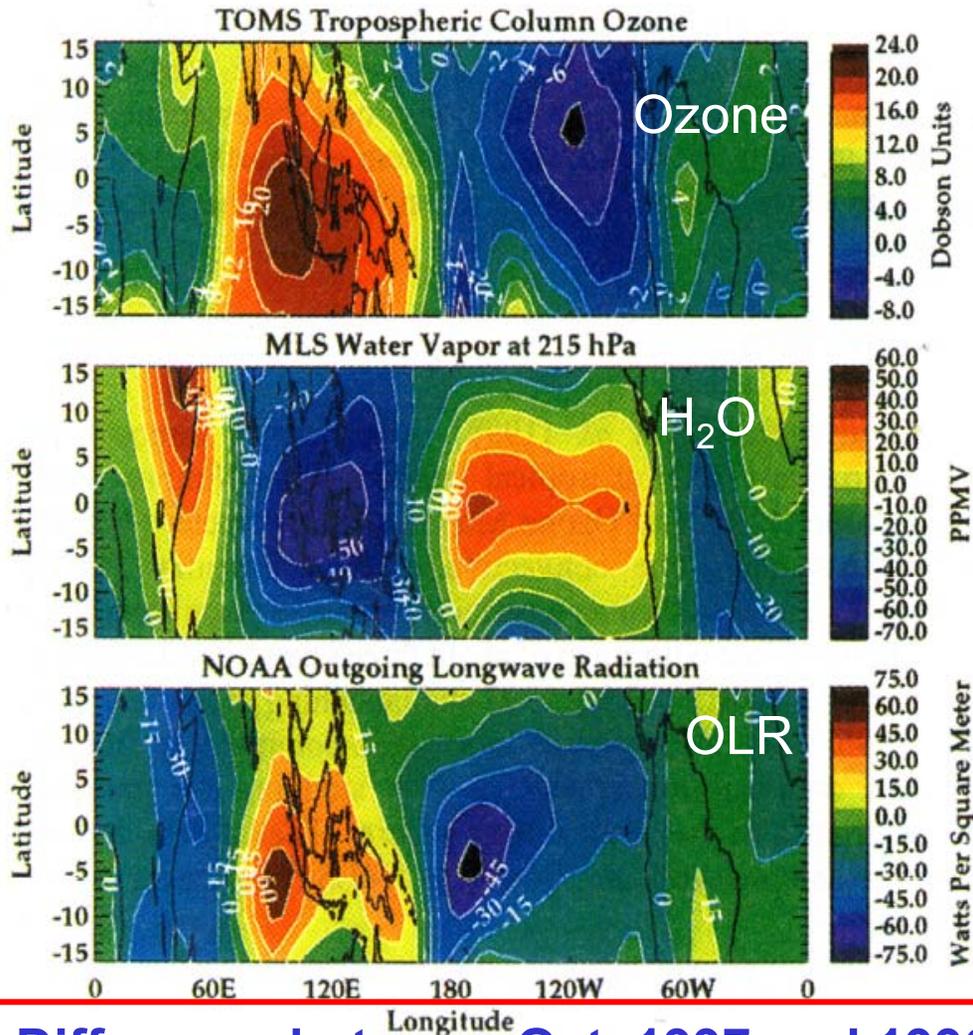


**The effects of the 2006 El Niño on tropospheric
composition as revealed by data from the
Tropospheric Emission Spectrometer (TES)**

**J. A. Logan, I. A. Megretskaya, R. Nassar, L. T. Murray,
L. Zhang, K. W. Bowman, H. M. Worden, and M. Luo**

(Submitted to GRL)

Effects of the 1997 El Nino (Chandra et al., GRL, 1998)

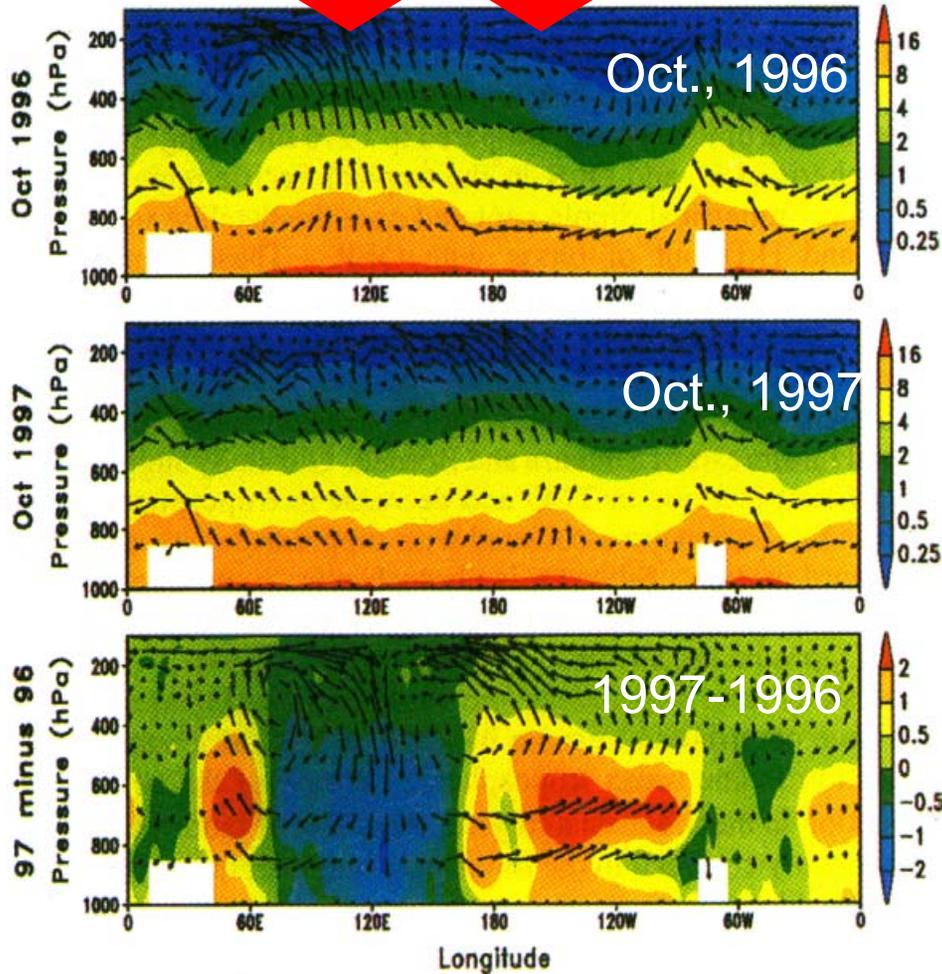


Model calculations show half the ozone change is caused by BB emissions in Indonesia, half by changes in dynamics (Sudo and Takahashi, 2001; Chandra et al., 2002)

Difference between Oct. 1997 and 1996

Note the dipole pattern, with more ozone over Indonesia and less over the Pacific

Indonesia Pacific



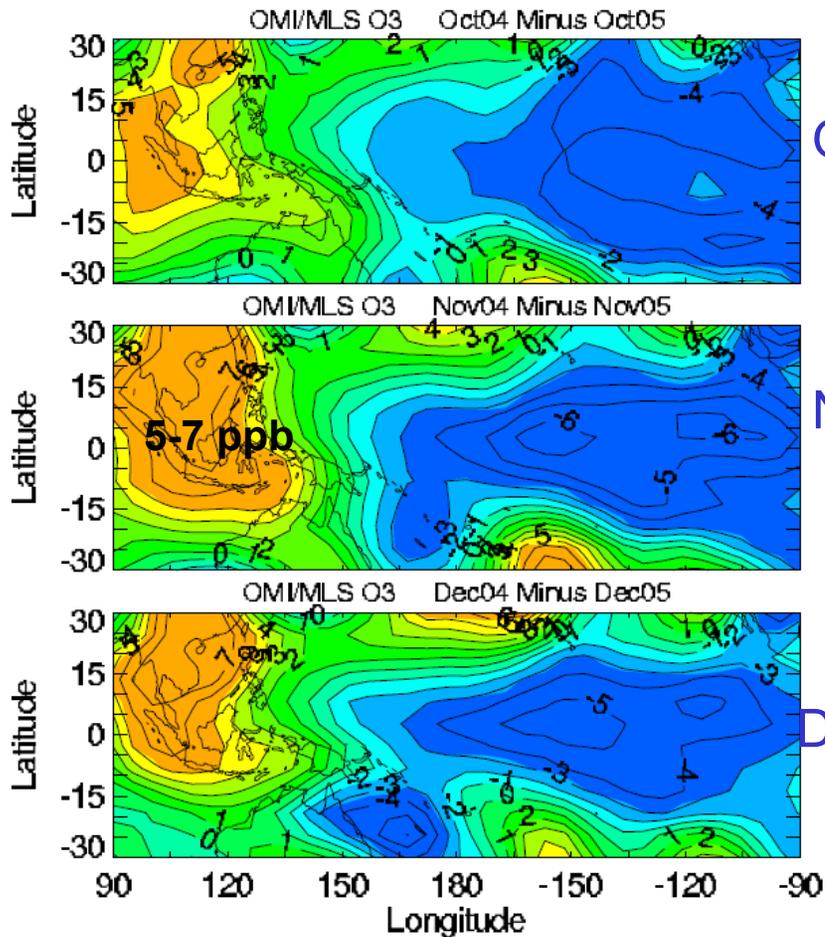
In an El Nino, convection moves to the central Pacific instead of being located over Indonesia.

More convection over the Pacific => more vertical mixing and more H₂O, both => more photochemical removal of O₃ in the lower trop.

Specific humidity (color)
Zonal+vertical velocity (arrows)

Effects of the 2004 El Nino on tropospheric ozone and water vapor. (Chandra et al., GRL, 2007)

2004 was a mild El Nino; figures show 2004-2005, Oct-Dec.

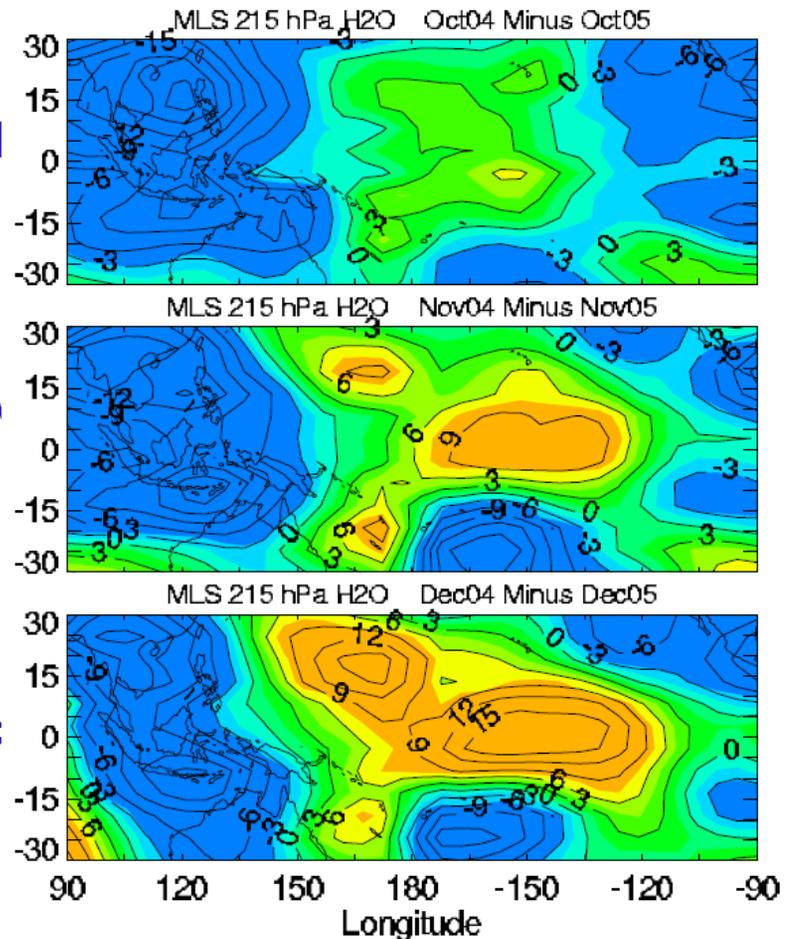


Oct

Nov

Dec

Difference in O₃ in ppb, from
OMI/MLS trop. column.

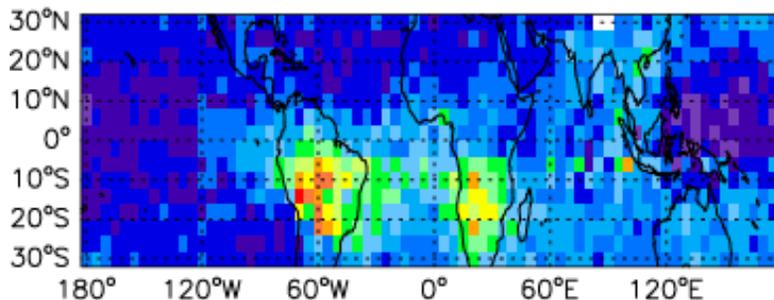


MLS H₂O at 215 hPa

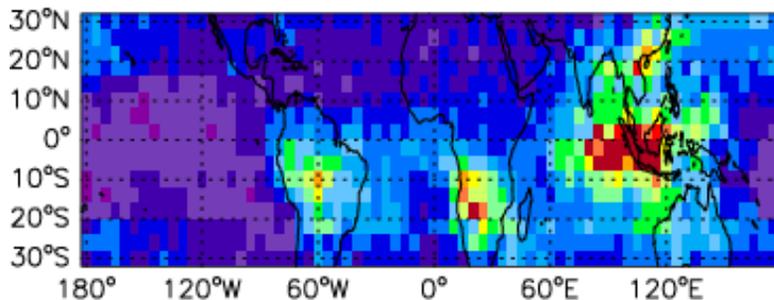
TES observations of CO and ozone in the mid-troposphere (511 hPa) in October 2005 and 2006

CO

October 2005

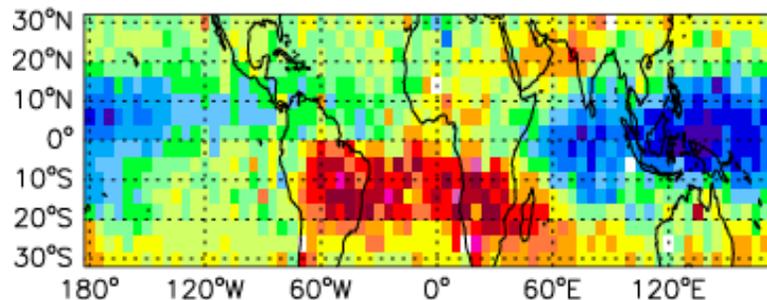


October 2006

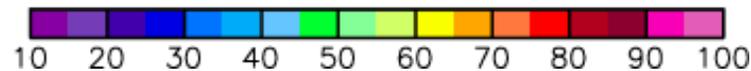
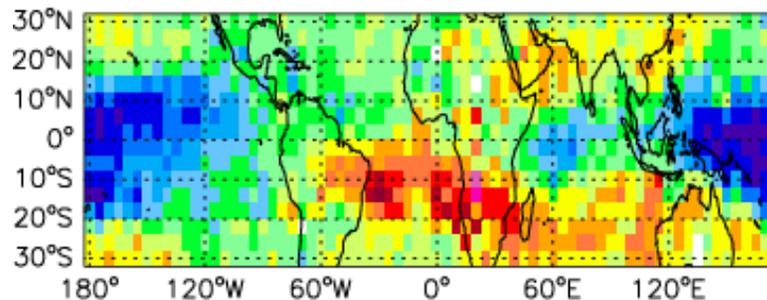


Ozone

October 2005



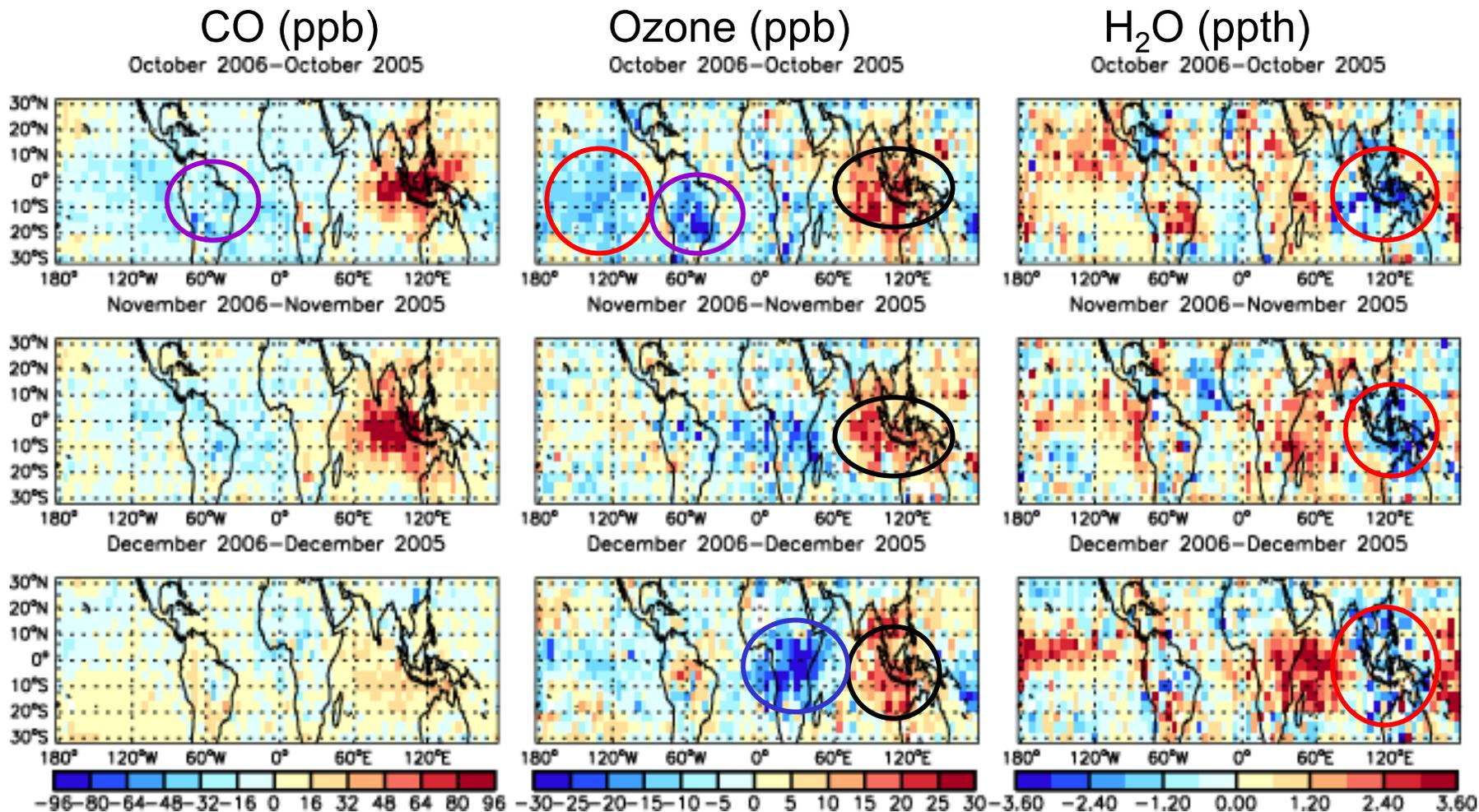
October 2006



High CO in 2006 related to drought induced fires in Indonesia – lowest rainfall since 1997, except for 2002. A moderate El Nino occurred in late 2006.

Analysis used uniform prior for 30°N-30°S

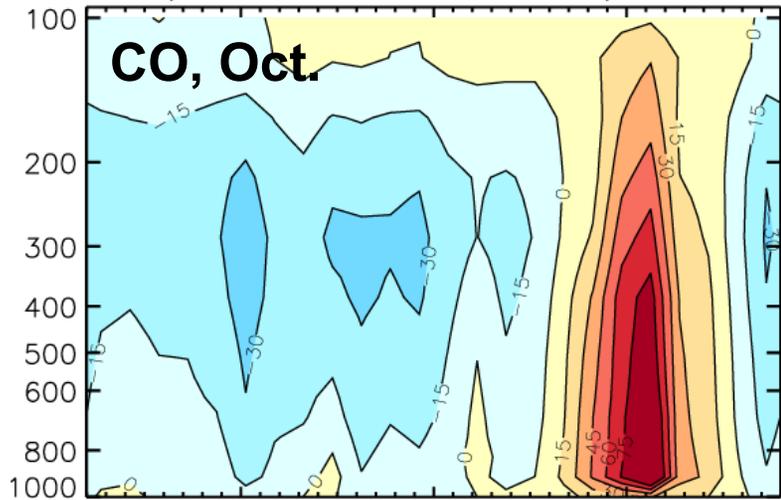
TES data, mid-trop: 2006 minus 2005 for Oct-Dec. First simultaneous observations of CO, O₃ and H₂O



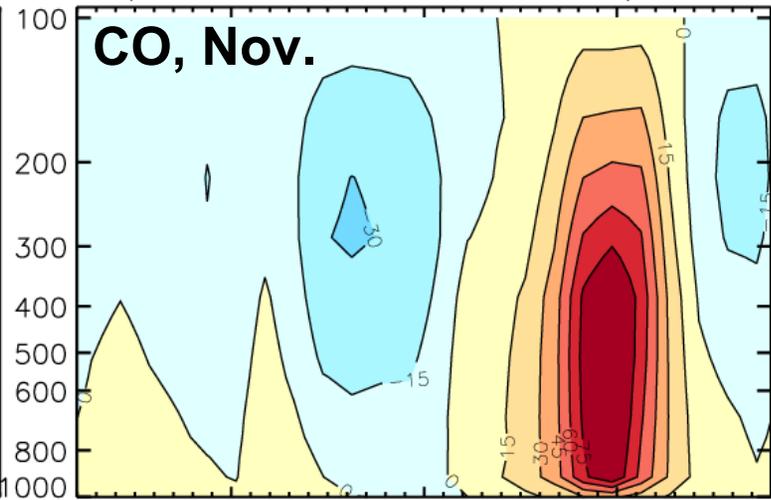
CO anomaly over Indonesia persists for 2 months, O₃ for 3 months. Fires ended in early November. Note also the low CO and O₃ over S. America in Oct. and low O₃ over Central Africa in Dec.

Vertical distribution of CO, O₃ differences, 0-12°S

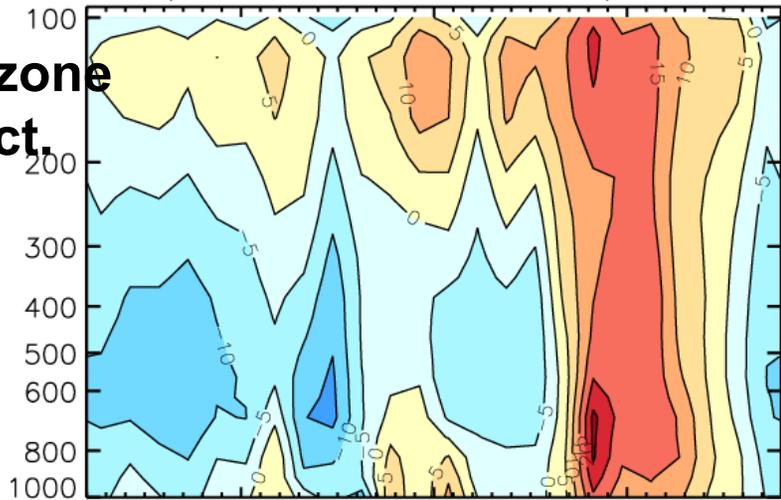
CO, October 2006–October 2005, 0–12S



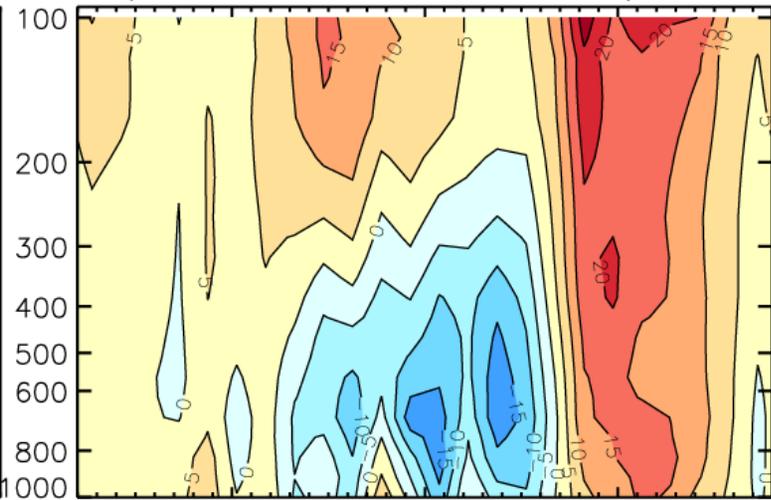
CO, November 2006–November 2005, 0–12S



O₃, October 2006–October 2005, 0–12S



O₃, November 2006–November 2005, 0–12S

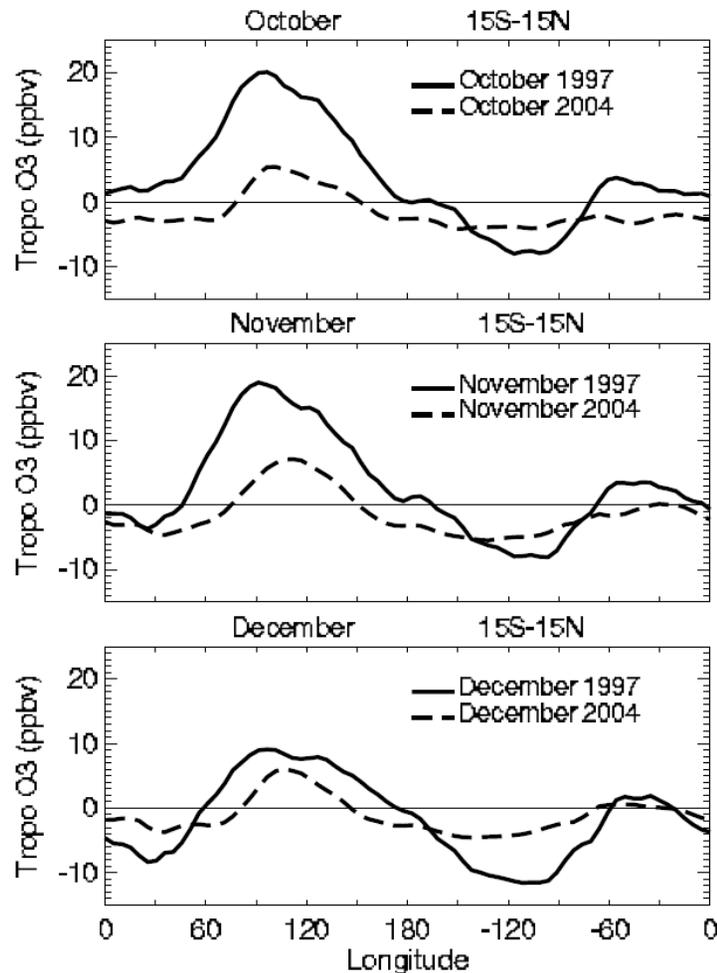


**Ozone
Nov.**

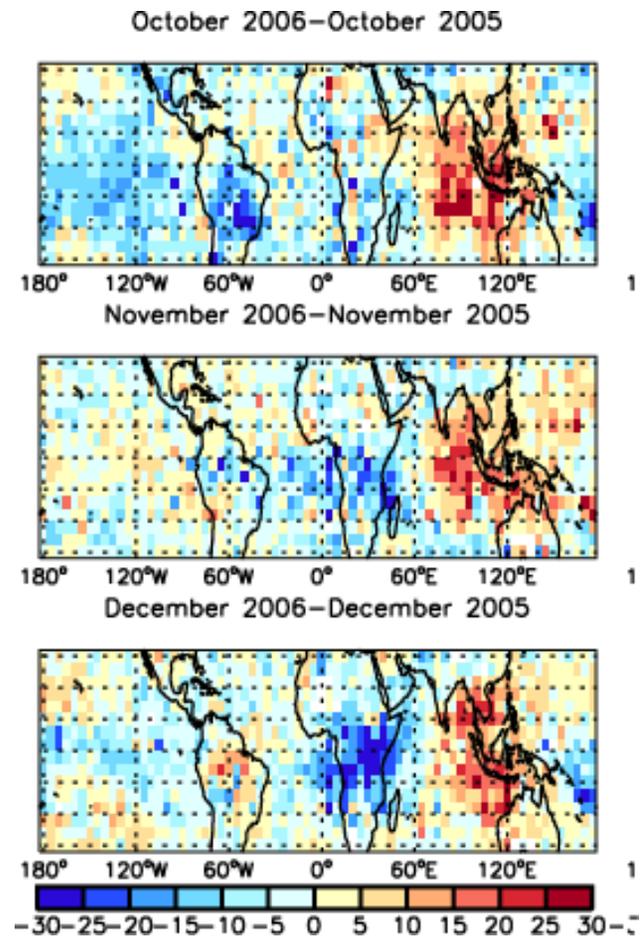
↑ ↑ ↑
 -100 0 100
S. America Africa Indonesia

O₃ difference is slightly larger in the LT in October, in the UT in Nov.

Comparison of O₃ “anomaly” for the 1997 El Nino/fires and the 2004 event (Chandra et al., 2007)



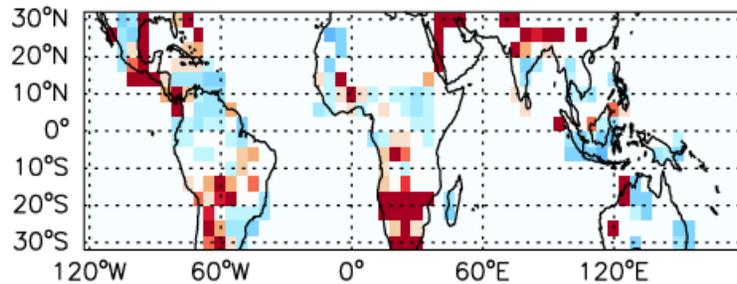
TES O₃ “anomaly” in 2006



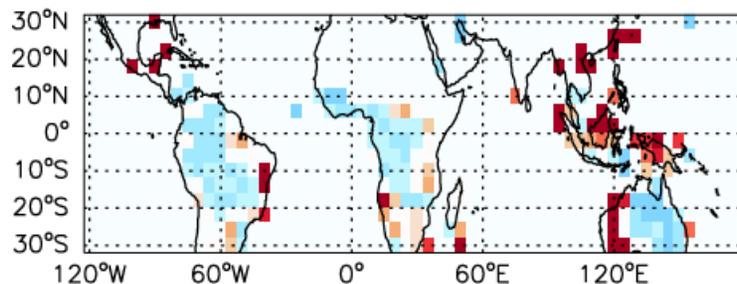
The anomaly in 1997 was much smaller in Dec. than in Oct. and Nov., but this does not appear to be so in 2006.

Difference in lightning (%) 2006-2005, from LIS data

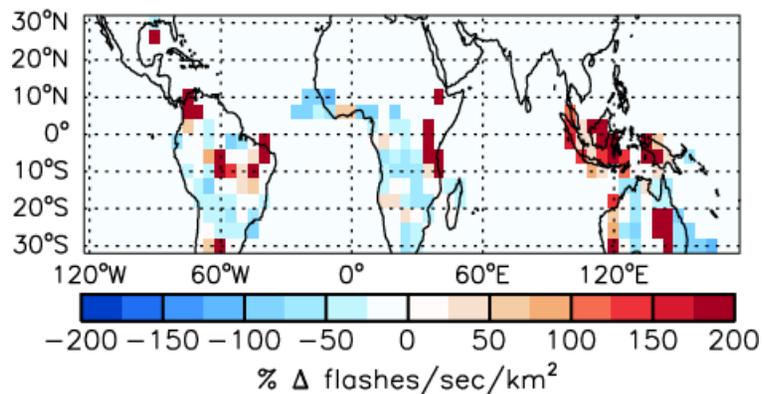
Oct 2006-2005



Nov 2006-2005



Dec 2006-2005



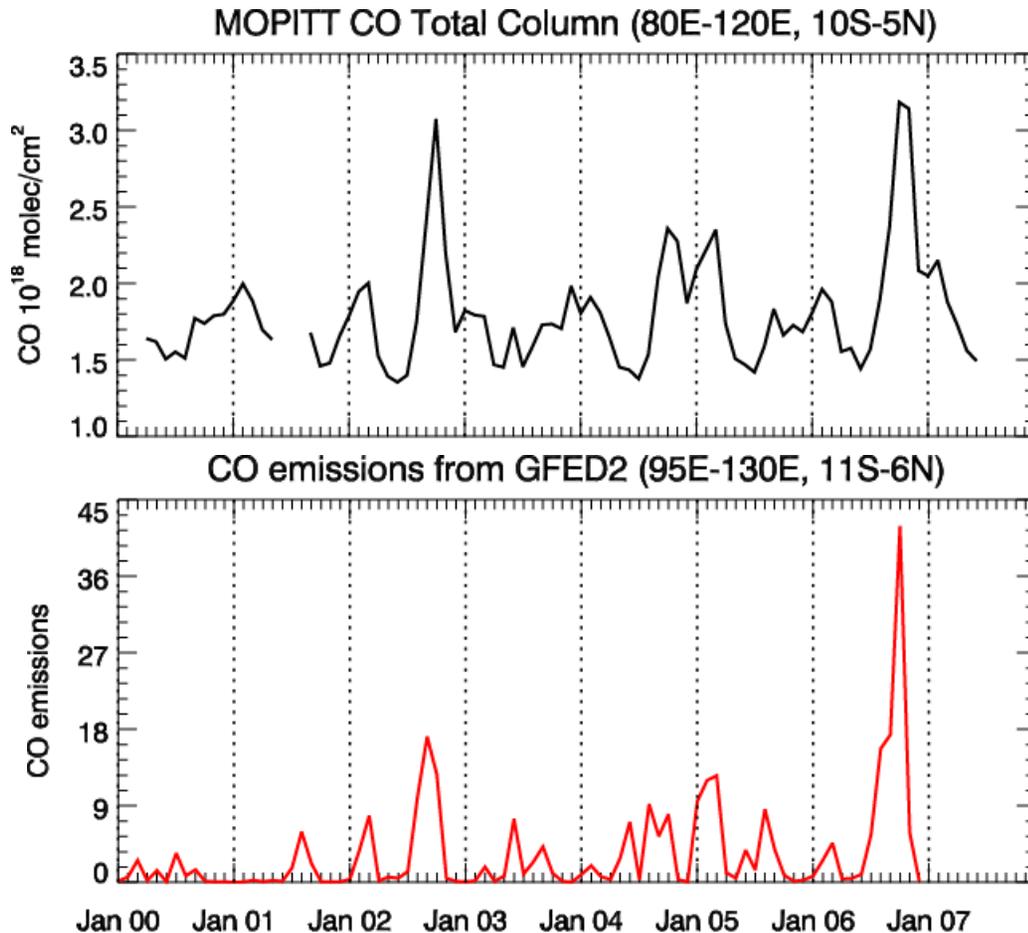
Why did the ozone anomaly persist in 2006? Effect of lightning NO_x? LIS data indicate more lightning in Nov. and Dec 2006 than in 2005.

(LIS data not available in late 1997)

This will be explored in model simulations - see talk by R. Nassar.

The 2006 event in a longer-term context: CO

CO over Indonesia and the eastern Indian Ocean



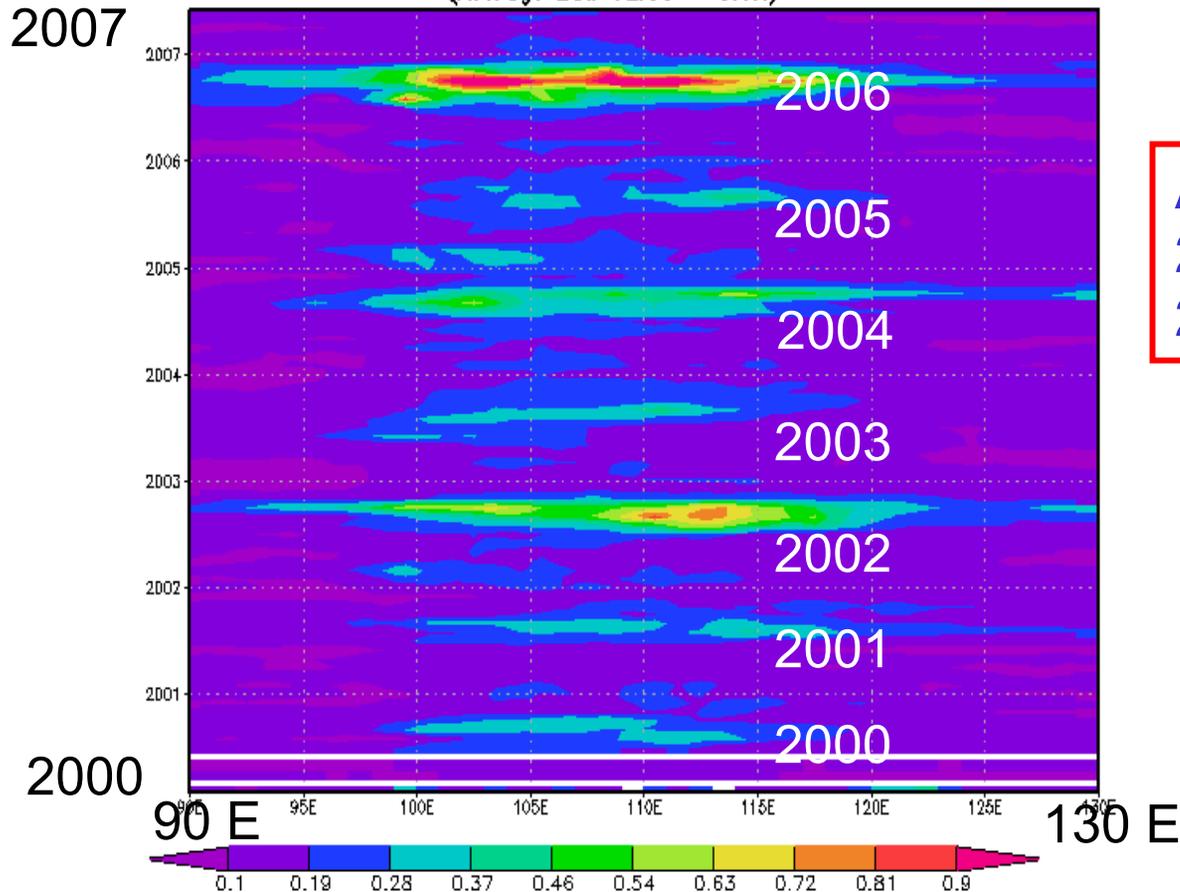
**CO highest in 2006,
then 2002, then
2004.
(MOPITT may have
saturated in 2006).**

**GFED2 inventory
Van der Werf et al. (2006)**

The 2006 event in a longer-term context: aerosol optical depth from MODIS

AOD average for 5°N-12°S

Monthly MOD08_M3.005 Aerosol Optical Depth at 0.55 micron [unitless]
(Average Lat: 12.0S - 5.0N)



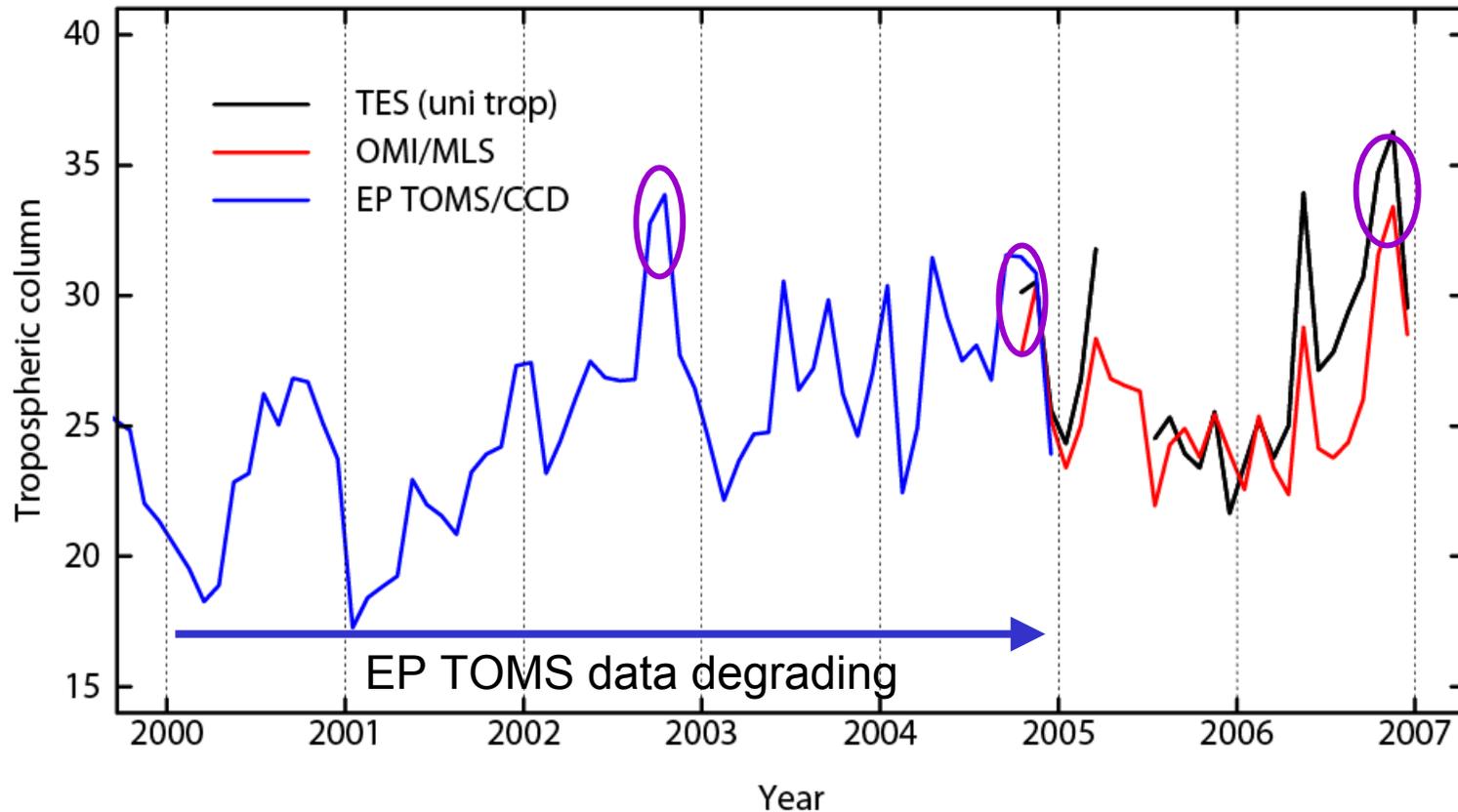
**Aerosols highest in
2006, then 2002, then
2004.**

Produced from the GIOVANNI website

Trop. ozone columns from TES, OMI/MLS, and EP-TOMS (CCD method)

Highest ozone in Sept.-Nov. in 2006, 2002, 2004.

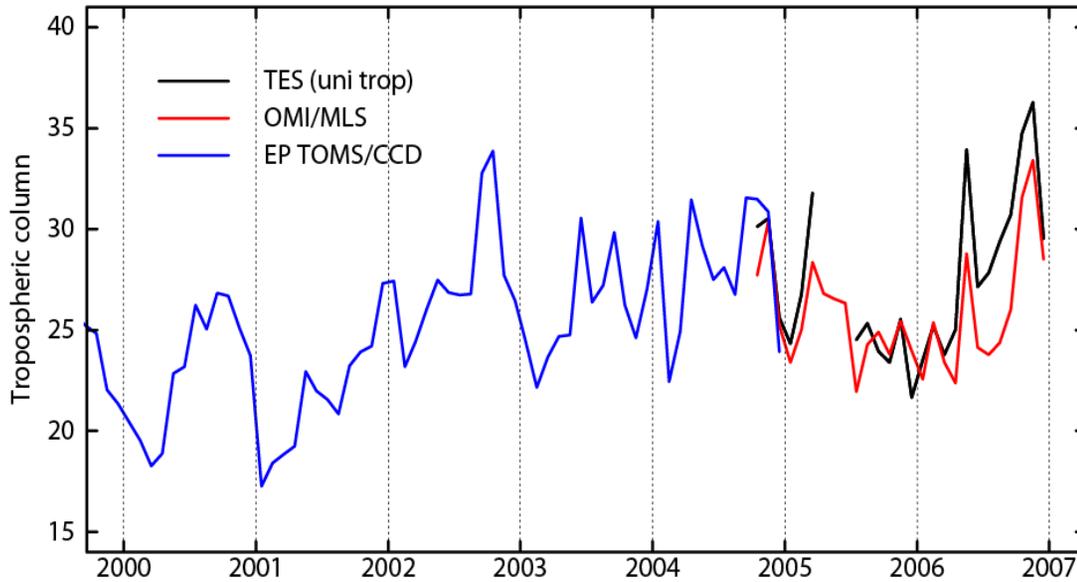
Indonesia (5N-10S, 70-120E)



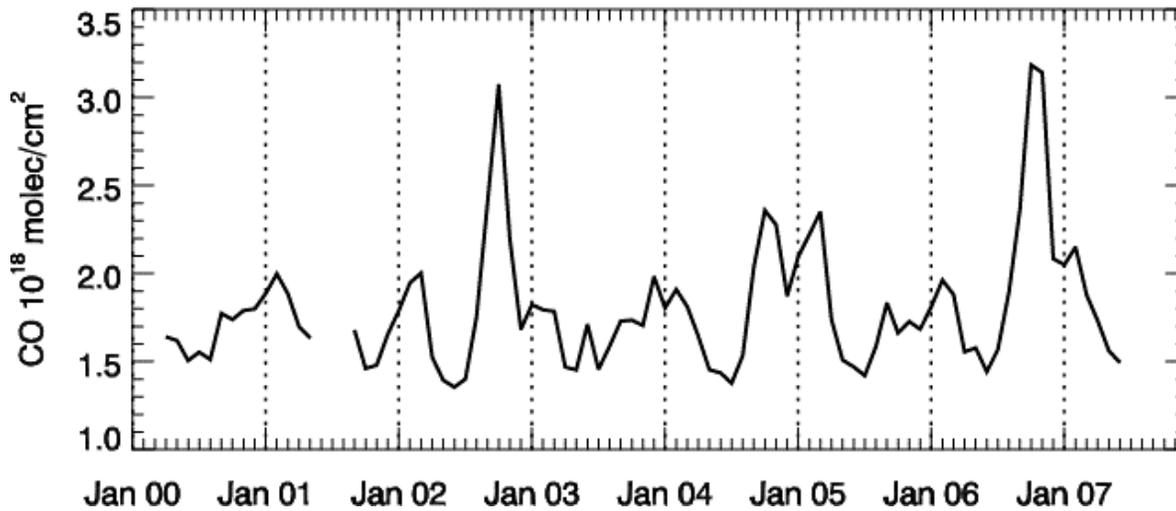
EP-TOMS and OMI/MLS results from Chandra and Ziemke

CO and ozone, 2000-2006

Indonesia (5N-10S, 70-120E)

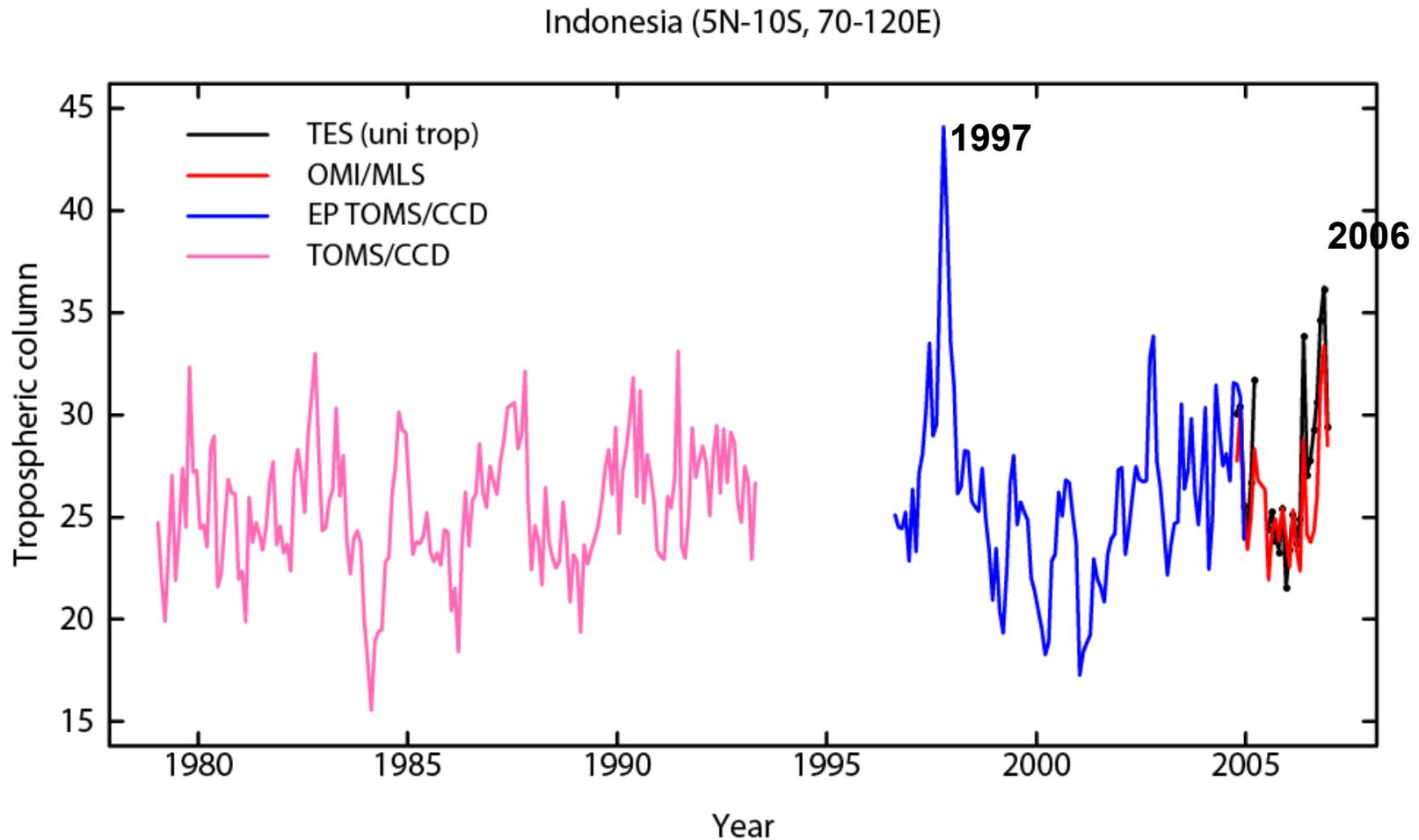


MOPITT CO Total Column (80E-120E, 10S-5N)



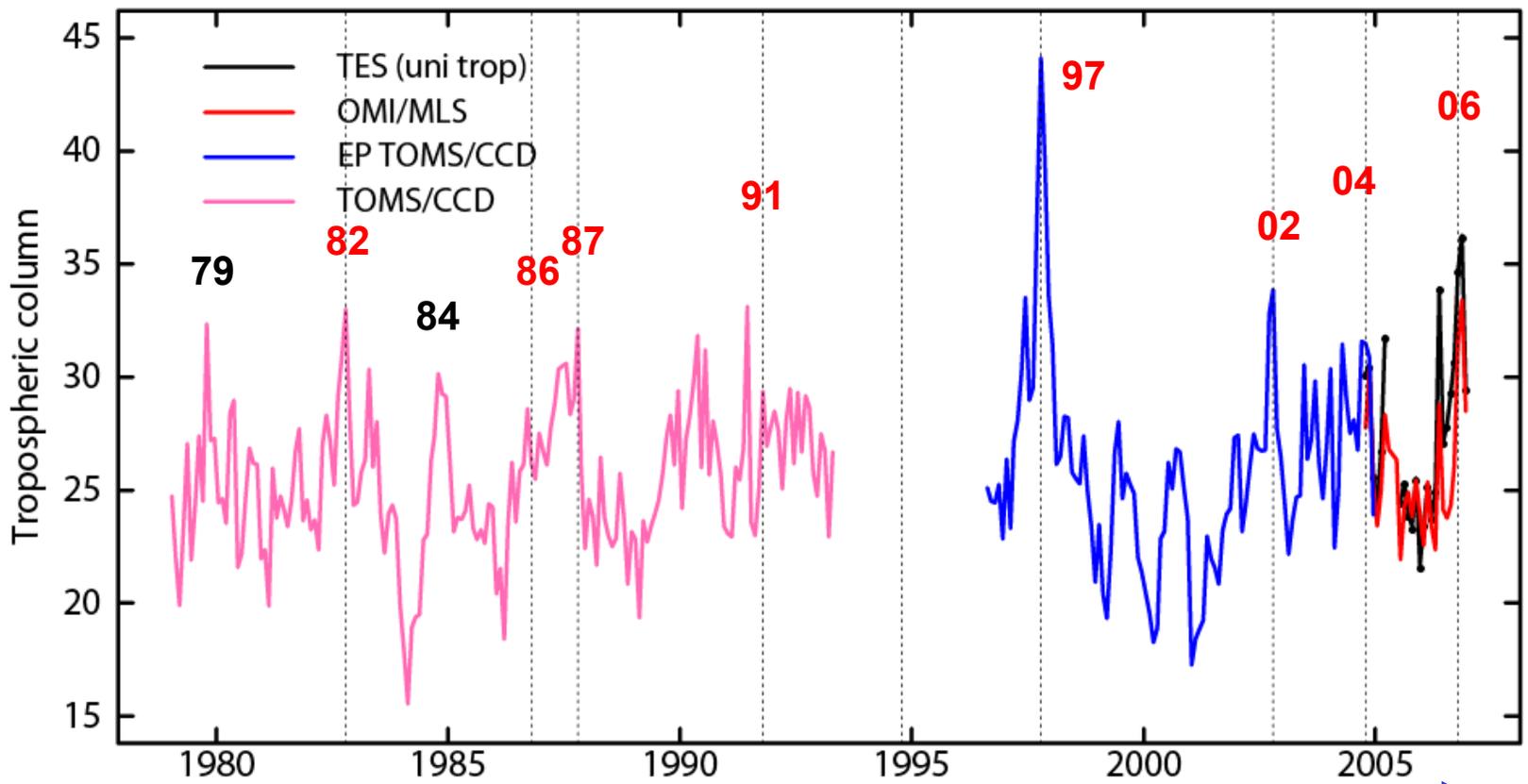
Trop. ozone columns: 1979-2006

2006 El Nino has highest trop. ozone columns after 1997



Dashed lines: October of El Nino events – most, but not all, have high ozone. 1986 and 1991 do not. Burning usually in Aug.-Oct.

Indonesia (5N-10S, 70-120E)



Labels on maxima are all for October:
Red = El Nino year

Burning of peat lands in Borneo after land drained for rice cultivation

Summary.

- Large El Nino related signals seen in CO, O₃ and H₂O over Indonesia in 2006
- These differences caused by high fire emissions in 2006 associated with lowest rainfall since 1997, and by dynamical differences
- The persistence of the ozone anomaly may be caused by enhanced lightning in the El Nino year
- The 2006 event had the highest CO, O₃, and AOD since 2000, and the second highest O₃ since 1979
- These time series provide an excellent test of model hindcasts