

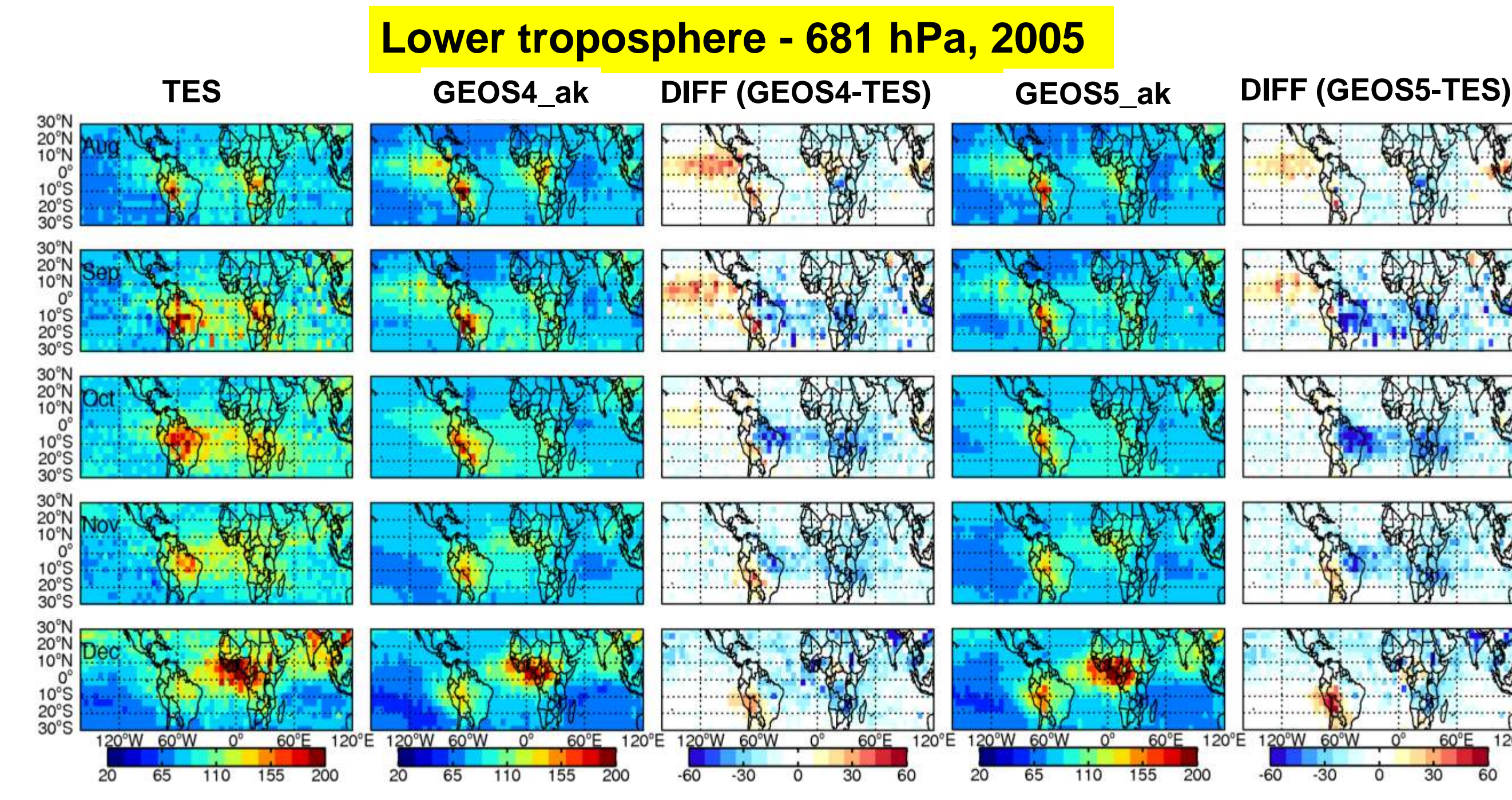
# The effect of tropical convection on the carbon monoxide distribution in the upper troposphere inferred from Aura Satellite data and GEOS-Chem model

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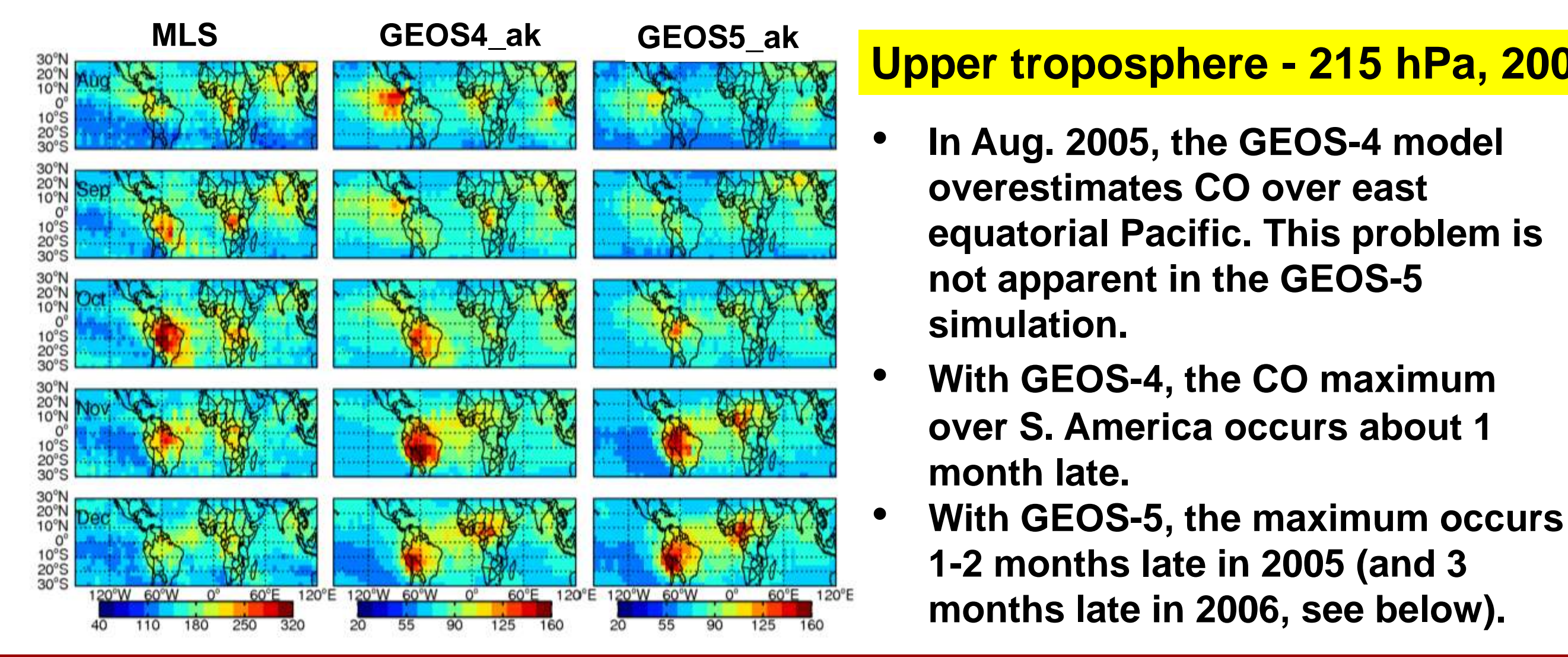
## Abstract

We use CO mixing ratios observed by the Tropospheric Emission Spectrometer (TES) and the Microwave Limb Sounder (MLS) to evaluate transport in the tropics in the GEOS-Chem model and to investigate causes of discrepancies with the observations. The model is driven by two different versions of assimilated meteorology from the Goddard Earth Observing System, GEOS-4 and GEOS-5. We focus on transport during the southern biomass burning season, and in particular on vertical mixing at the end of the dry season when convection moves over the source region. The model reproduces the timing of the observed CO maximum over South America and South Africa during the biomass burning season in 2005 and 2006 in the lower troposphere. However, in the upper troposphere (UT), the model CO maximum with GEOS-4 over South America occurs ~1 month later than observed, while with GEOS-5 it occurs 1-2 months later. Most convective outflow over South America in both meteorological fields ends below 200 hPa. Therefore the CO around 215 hPa is mainly accumulated by slow vertical ascent, causing the lag of the CO maximum in the model compared to observations. The lag in GEOS-5 is greater in part because the convection decays at a lower altitude, and in part because the convection moves southward later than in GEOS-4. Compared to the GEOS-5 model, the GEOS-4 model has a larger CO overestimate in the east equatorial Pacific, resulting from stronger local convection, and stronger easterly winds in GEOS-4 in the lower altitudes. Both GEOS-4 and GEOS-5 match the timing of the CO maximum over Indonesia in the UT.

## 2. TES, MLS and Model Comparisons

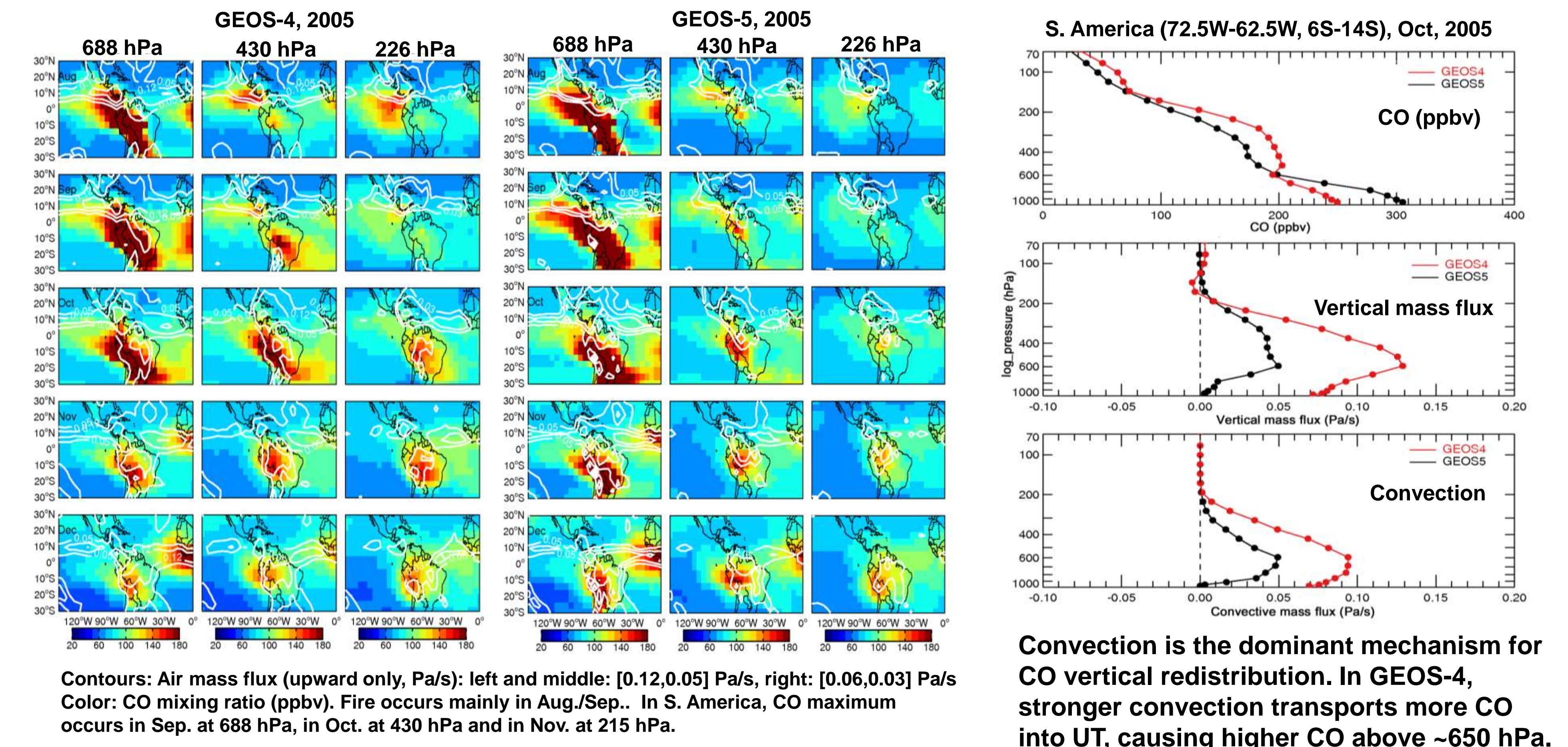


- In S. America, CO is highest in Sep. and Oct. in 2005. The models underestimate CO over Brazil, overestimate CO over the Andes, south of 10°S.
- In S. Africa, CO maximum persists from Aug. to Oct., but a large underestimate occurs in the models.
- In Aug. and Sep., overestimate of CO in the eastern tropical Pacific within the ITCZ. This discrepancy is larger in GEOS-4 than in GEOS-5.
- N. Africa BB causes the maximum in Dec. over N. Africa, equatorial Atlantic.



- In Aug. 2005, the GEOS-4 model overestimates CO over east equatorial Pacific. This problem is not apparent in the GEOS-5 simulation.
- With GEOS-4, the CO maximum over S. America occurs about 1 month late.
- With GEOS-5, the maximum occurs 1-2 months late in 2005 (and 3 months late in 2006, see below).

## 4. South America: vertical mixing and CO profiles

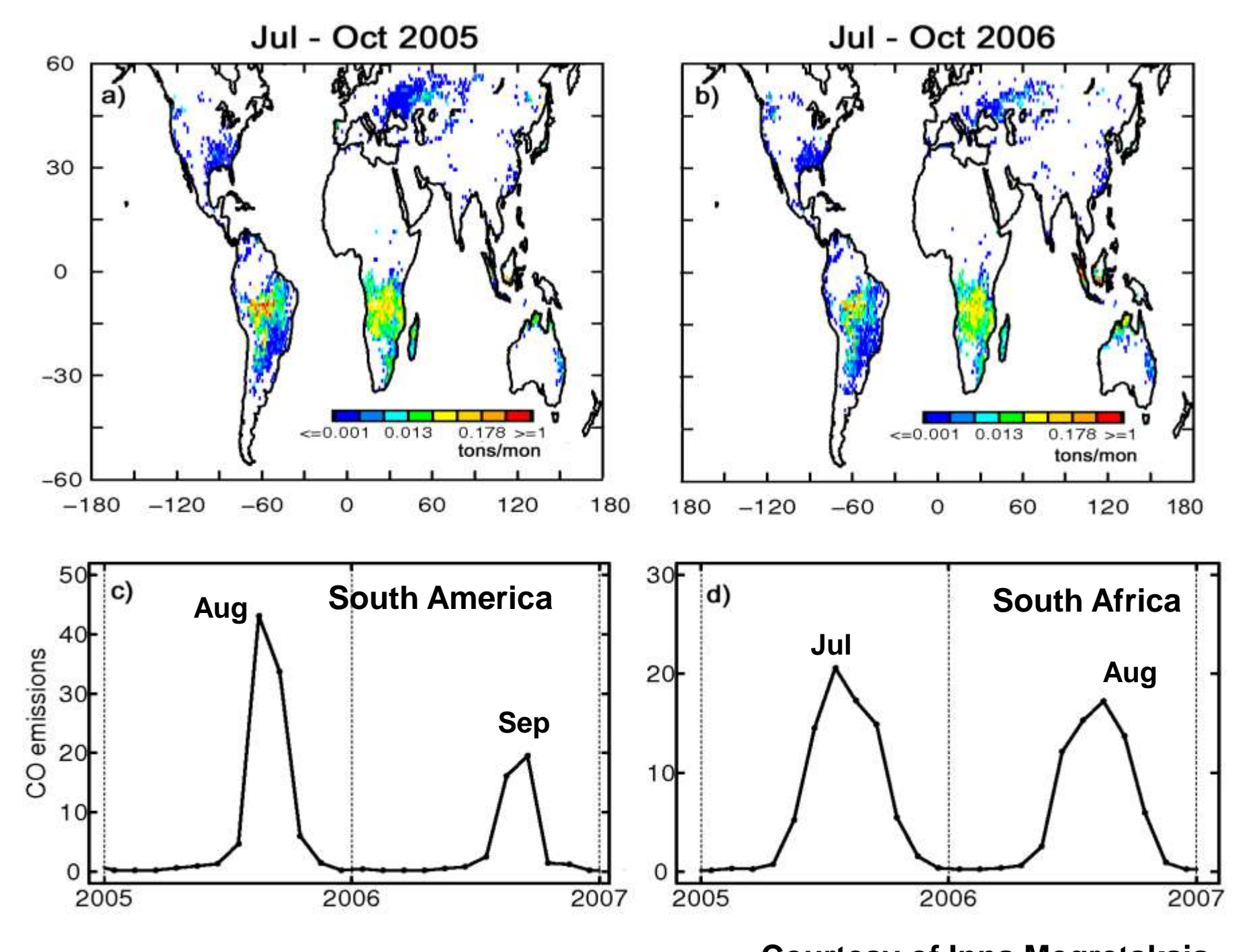


Contours: Air mass flux (upward only, Pa/s): left and middle: [0.12,0.05] Pa/s, right: [0.06,0.03] Pa/s  
 Color: CO mixing ratio (ppbv). Fire occurs mainly in Aug./Sep.. In S. America, CO maximum occurs in Sep. at 688 hPa, in Oct. at 430 hPa and in Nov. at 215 hPa.

Convection is the dominant mechanism for CO vertical redistribution. In GEOS-4, stronger convection transports more CO into UT, causing higher CO above ~650 hPa.

The lag in GEOS-5 is greater in part because the vertical mixing decays at a lower altitude, and in part because the location of extensive vertical mixing moves southward later than in GEOS-4.

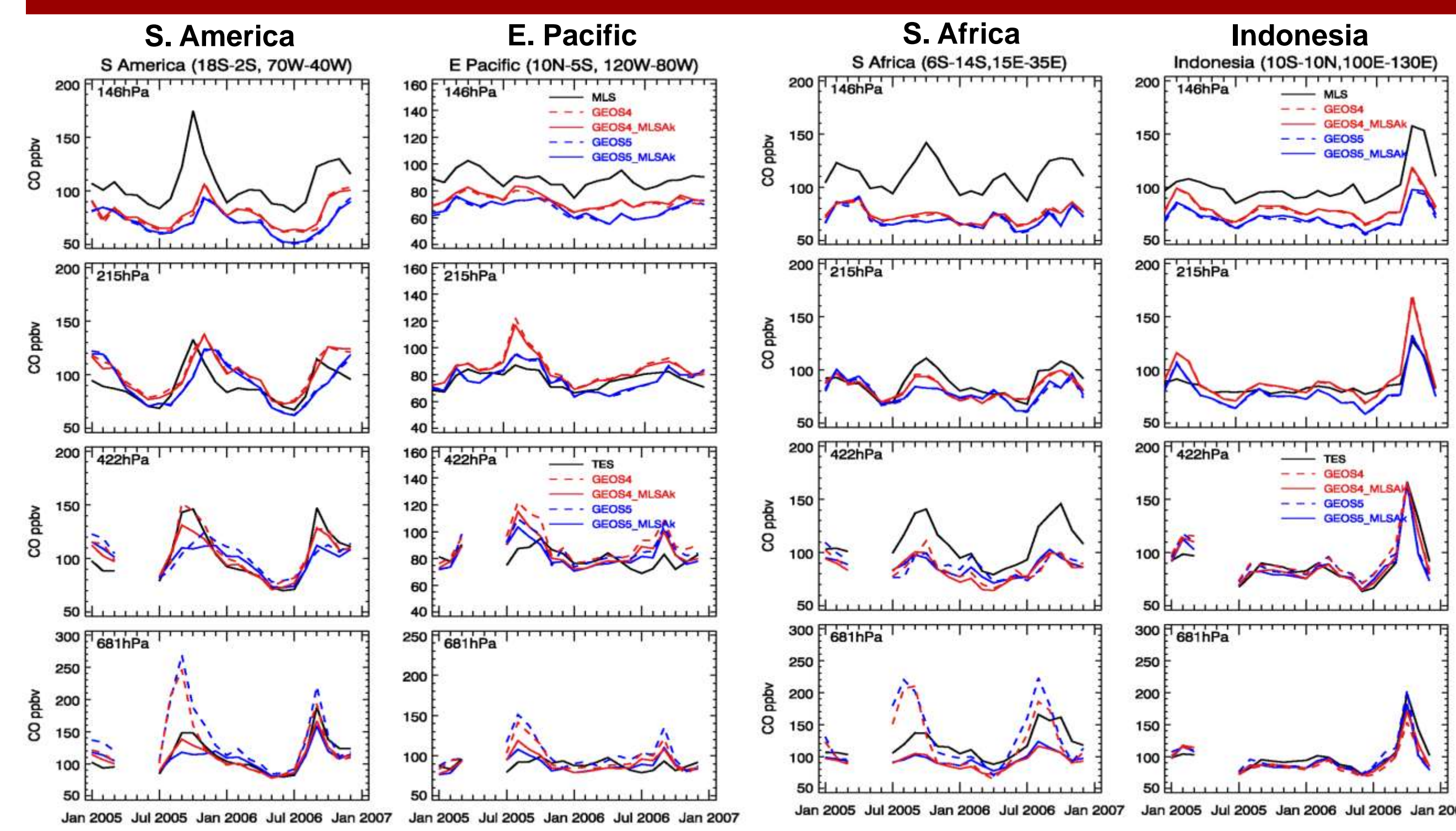
## 1. Biomass burning emissions (GFED2)



Courtesy of Inna Megretskaja

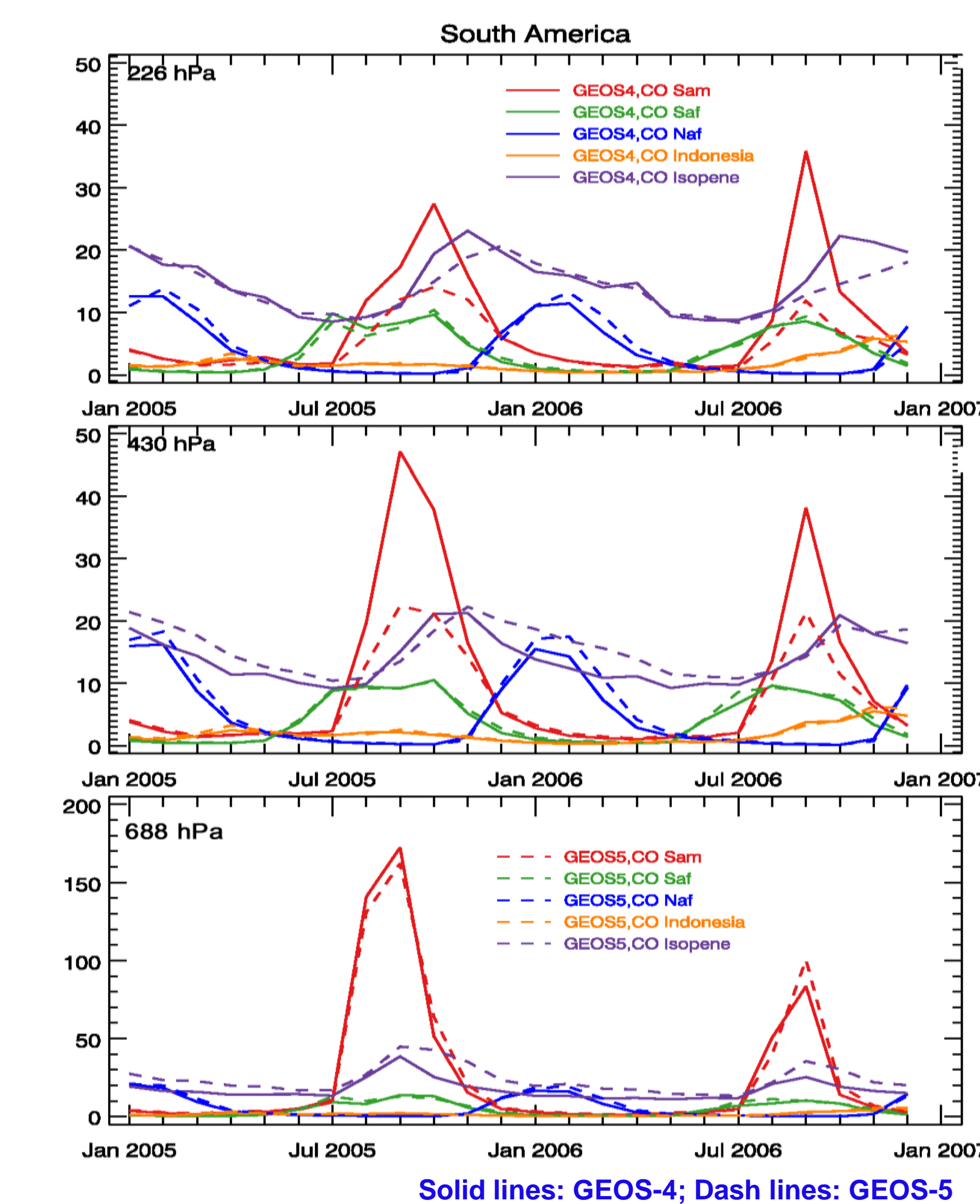
- South America:
- Biomass burning peaks in August/September.
  - Drier in 2005 (La Nina), CO emissions are twice those in 2006.
- South Africa:
- Biomass burning peaks in June-September.
  - Relatively stable seasonal variation with smaller interannual variation

## 3. Seasonal and interannual variation



- In S. America, in 2005, 420 hPa, GEOS-5 CO increases at a lower rate than GEOS-4 and TES data, and has the maximum underestimate. In 2006, the timing of peak CO matches the data at ~420 hPa, but the GEOS-5 peak is much too late at 215 hPa.
- In S. Africa, the model simulations are lower than observations, affected by the known low emission in the model. The two model simulations are consistent: they match the phase but underestimate the amplitude of the maximum.
- Both models match the timing of the CO maximum over Indonesia. And the maximum of CO in 2006 stands out ~ caused by the occurrence of the El Nino event in Oct..

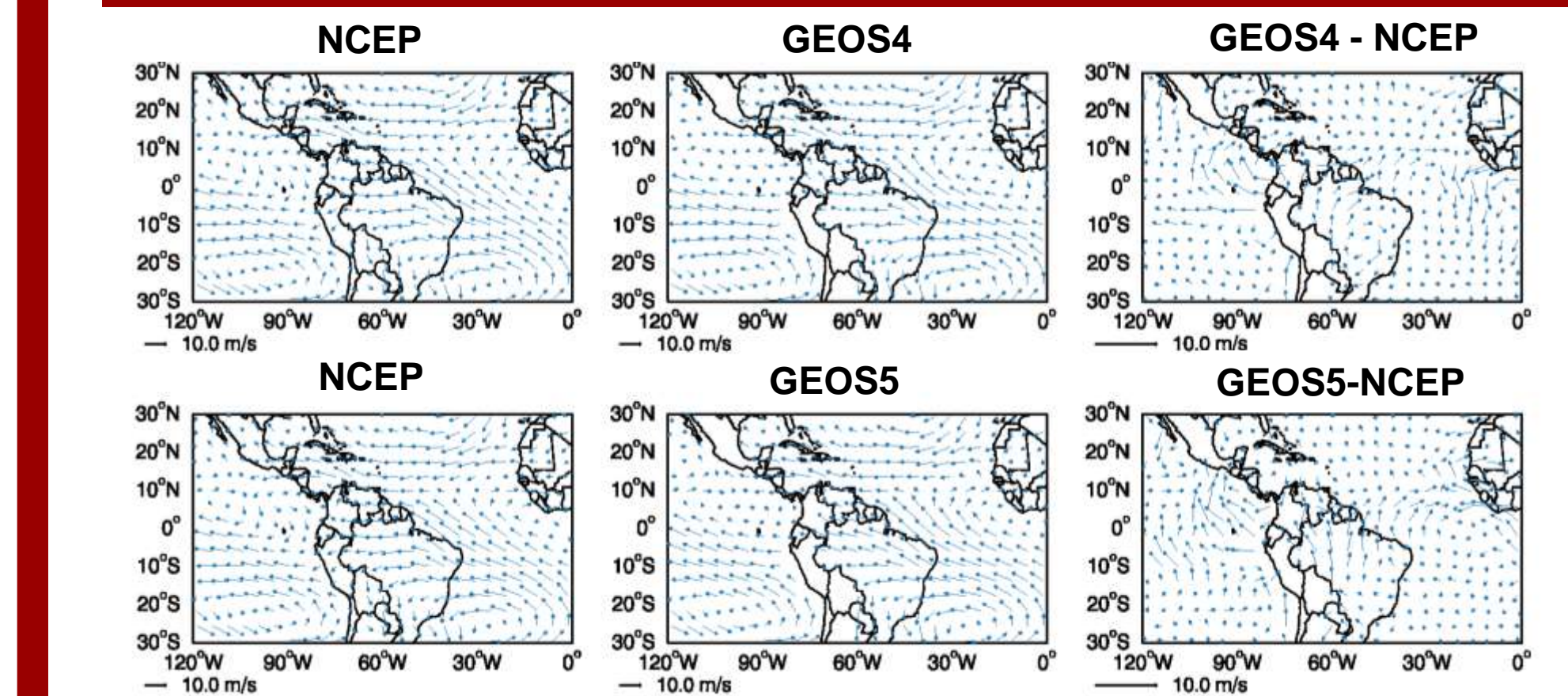
## 5. Isoprene contribution



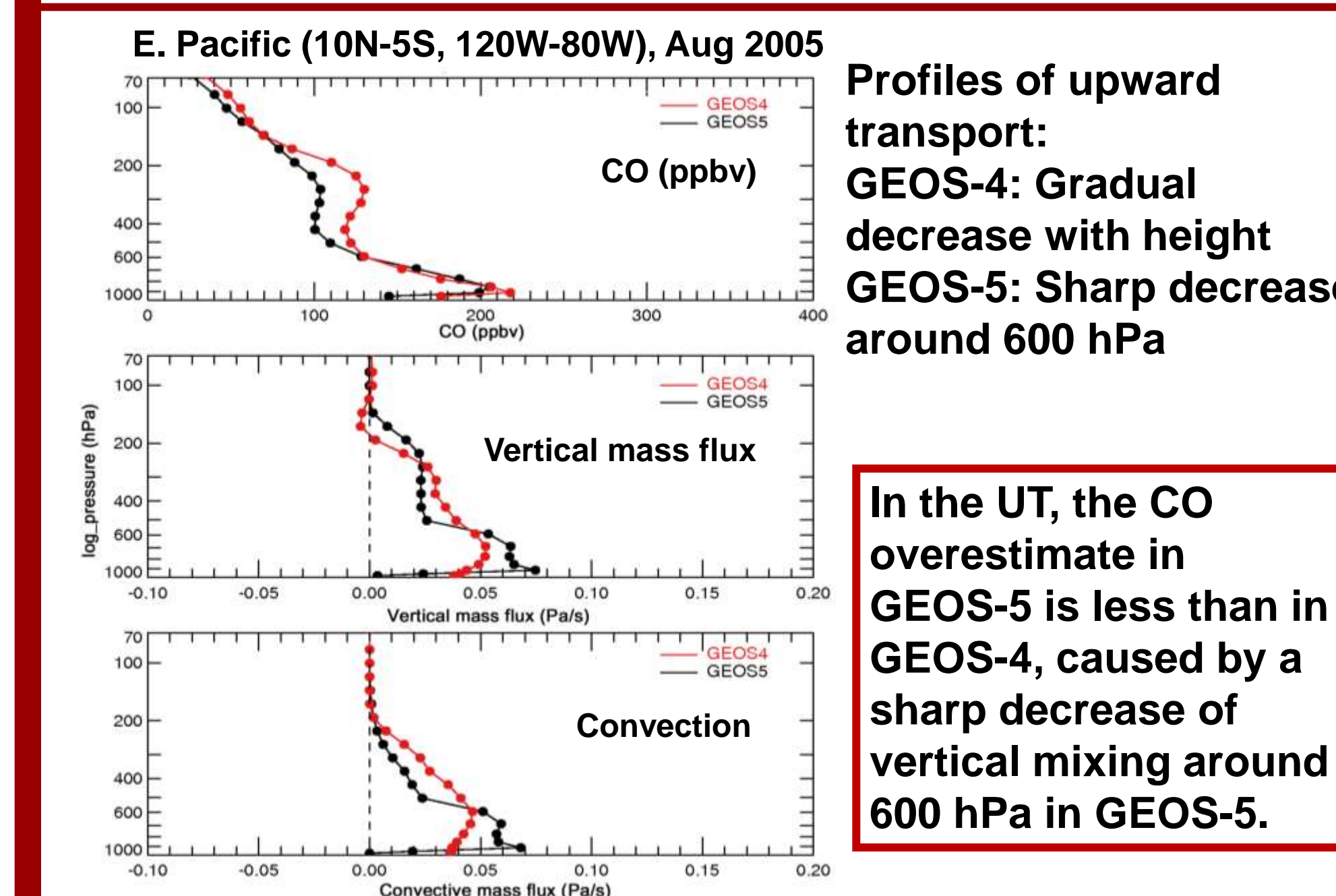
LT: CO from local biomass burning dominates over S. America from Jul to Oct. In N. winter, CO influenced by N. Africa biomass burning.

UT: More CO coming from isoprene – causing the CO peak to stay high at the end of dry season.

## 6. East Pacific



Horizontal winds for GEOS4/GEOS5 and NCEP at surface level in Aug. 2005. GEOS fields have stronger south-easterly winds blowing off the burning region of S. America, transporting more CO to the E. Pacific: causing overestimates in E. Pacific and underestimates over S. America.



Profiles of upward transport:  
 GEOS-4: Gradual decrease with height  
 GEOS-5: Sharp decrease around 600 hPa

In the UT, the CO overestimate in GEOS-5 is less than in GEOS-4, caused by a sharp decrease of vertical mixing around 600 hPa in GEOS-5.

## ACKNOWLEDGEMENTS

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