

# Understanding enhancements in tropospheric CO from biogenic VOC emissions over North America using TES and MOPITT data

Yunsoo Choi<sup>1</sup>, Annmarie Eldering<sup>1</sup>, Greg Osterman<sup>1</sup>, Yuhang Wang<sup>2</sup>, Eric Edgerton<sup>3</sup>, and TES team<sup>1</sup>

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Result: CO from SEARCH and Model

Result: CO column from MOPITT and Model

Result: 800 hPa CO from TES and Model

Result: CO vertical profiles from TES and Model

Conclusions

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- ▶ CO is from anthropogenic CO (fossil-fuel combustion + oxidation of anthropogenic VOC), biogenic CO (oxidation of biogenic VOC emission), oxidation of CH<sub>4</sub>, and biomass burning CO emission.
- ▶ 2006 summer is the 3rd warmest on record [NOAA].
- ▶ High temperatures enhance biogenic VOC (e.g., isoprene, monoterpene, and alkene) emissions and VOC oxidation processes.
- ▶ Oxidated CO from biogenic VOC emissions over the eastern US. are larger than anthropogenic CO (60% reduction in NEI99 fossil fuel CO emission + anthropogenic VOC emission) in summer 2004 [Hudman et al., 2008].
- ▶ In this work, we investigate (1) whether this trend is apparent in summer 2006, (2) if observed large enhancements in column CO and lower tropospheric CO in MOPITT and TES over North America and the western Atlantic are also simulated in Regional chEmical trAnsport Model (REAM), and (3) if enhanced CO regions from the measurements are primarily driven by biogenic VOC emissions.

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# REAM(Regional chEmical trAnsport Model)

- ▶ Time period: July 2006
- ▶ Resolution: Horizontal resolution of 70 km with 23 vertical layers reaching to 10 hPa
- ▶ Boundary and initial chemical conditions from GEOS-CHEM (version 7.2)
- ▶ Archive meteorological variables every 30 minutes and every 2.5 minutes for cloud convection and lightning from MM5
- ▶ GEIA inventory [Guenther et al., 1995] for isoprene and monoterpene emissions
- ▶ 50% reduced fossil fuel CO emission from 1999 EPA NEI over the U.S. [Parrish et al., 2006]
- ▶ Detailed in REAM setup and evaluations by Choi et al. [2005,2007,2008]

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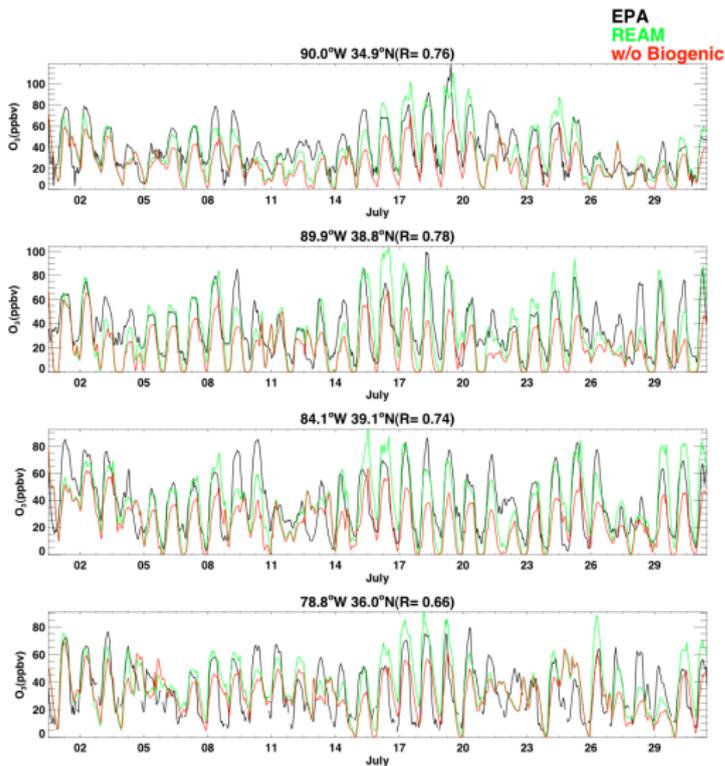
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# Model evaluation: O<sub>3</sub> from EPA and REAM



- ▶ Model captures multi-day O<sub>3</sub> variations.
- ▶ In certain times and locations, biogenic VOC emissions contribute to >50% O<sub>3</sub> peaks.

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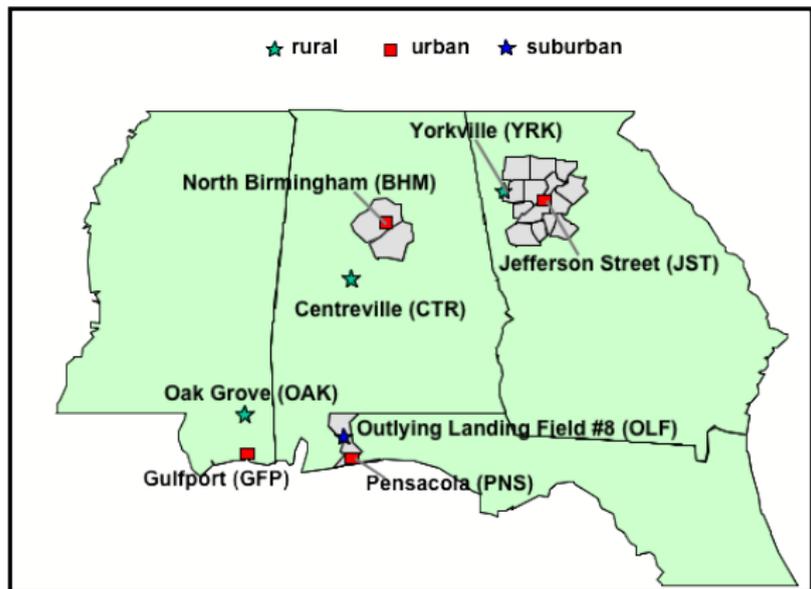
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# Sotheastern Aerosol Research and Characterization Study (SEARCH) network



- ▶ Stations are located in the southeastern US.
- ▶ Temperature and CO data from 3 stations (Oak Grove in Mississippi, Outlying Landing Field in Florida, and Yorkville in Georgia) are from Eric Edgerton at ARA.

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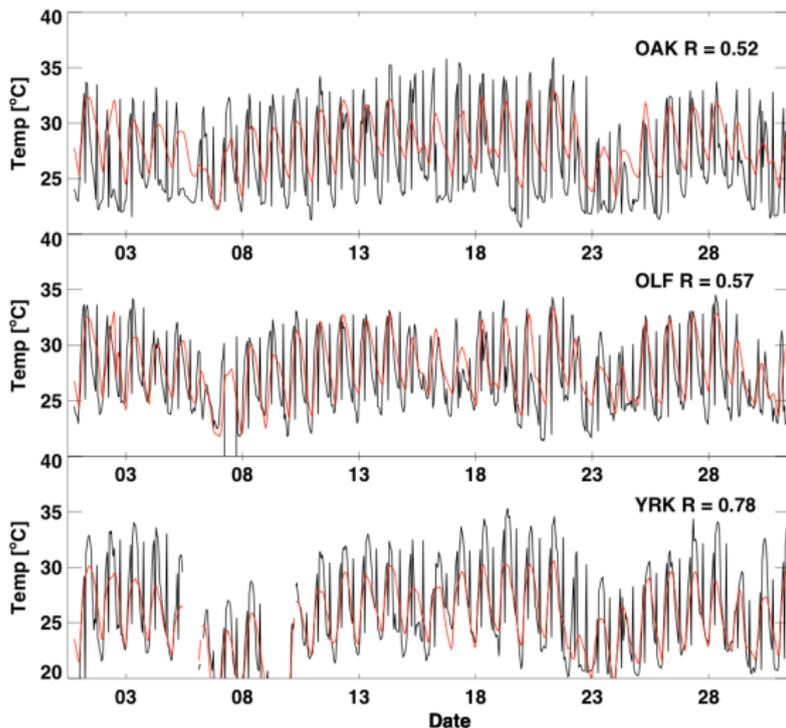
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# Temperature from SEARCH network and Model



- ▶ Black: observed, Red: simulated
- ▶ Capturing surface temperature is a key in simulating reasonable biogenic VOC emissions.

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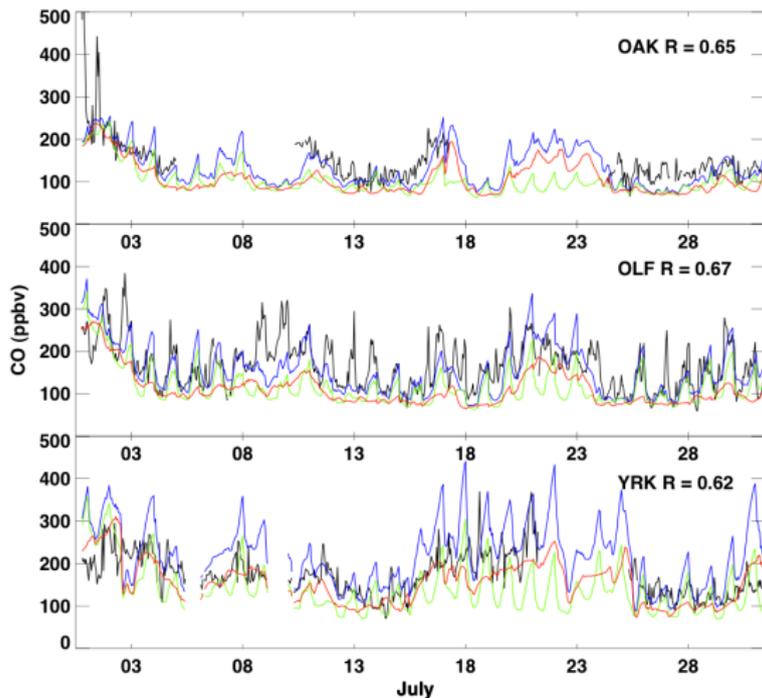
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# CO from SEARCH network and Model



- ▶ Black: observed, Blue: simulated, Green: w/o Biogenic, Red: w/o Anthropogenic
- ▶ Biogenic source impacts are larger than anthropogenic at OAK and YRK, but the opposite is true at OLF.

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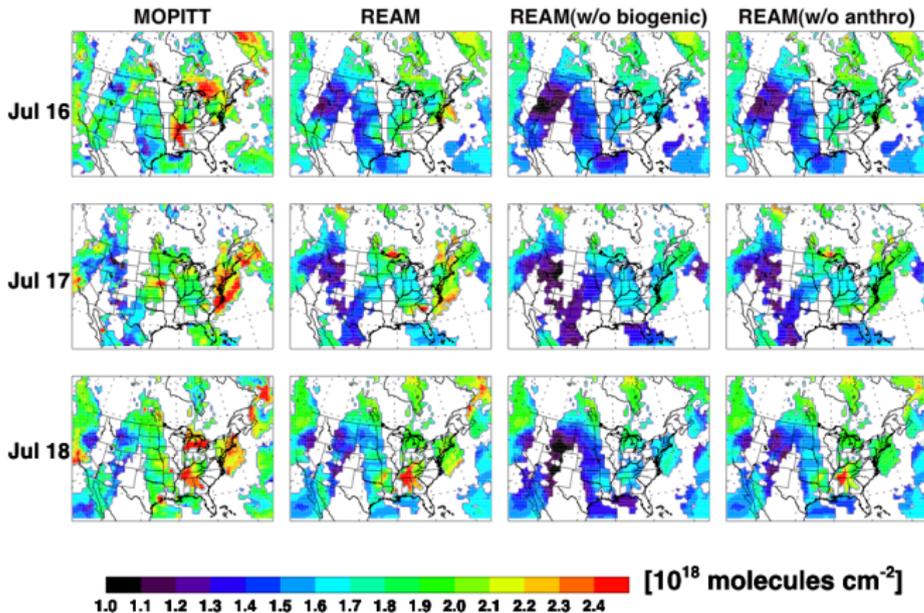
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# CO column from Terra MOPITT and Model



- ▶ MOPITT averaging kernels are processed and data having a priori fraction  $<60\%$  are used.
- ▶ REAM underestimates column CO due to the underestimated wild fire and BRAVO CO emissions.

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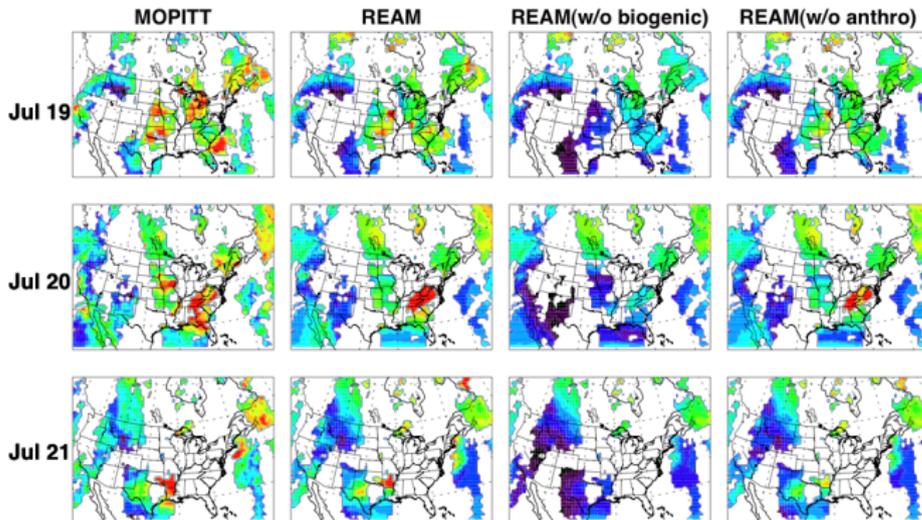
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# CO column from Terra MOPITT and Model



- ▶ MOPITT averaging kernels are processed and data having a priori fraction  $<60\%$  are used.
- ▶ Biogenic source impacts are larger than anthropogenic, which is seen by color contrasts.

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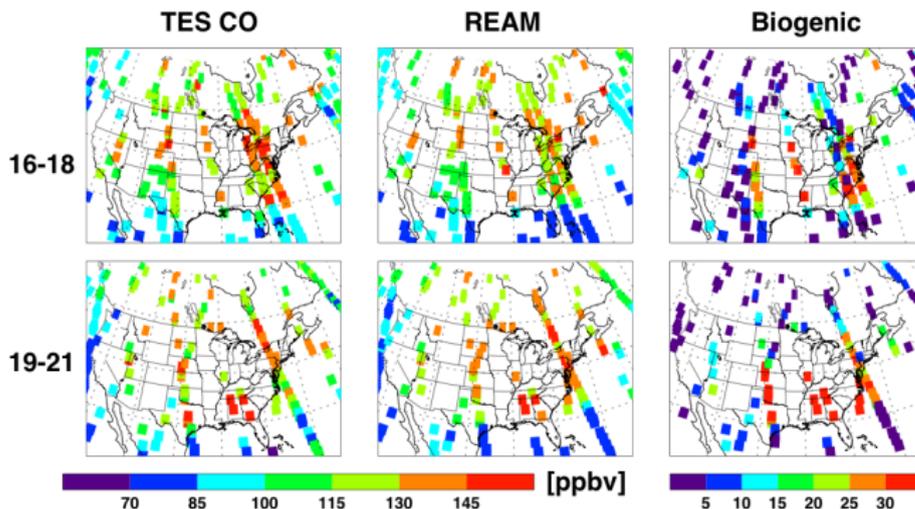
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# 800 hPa CO from Aura TES and Model



- ▶ TES averaging kernels are processed and data having  $>30$  ppbv at 500 hPa are used.
- ▶ Model generally underestimates 800 hPa CO due to the underestimated wild fire for 16-18 July and BRAVO CO emissions for 16-21 July.

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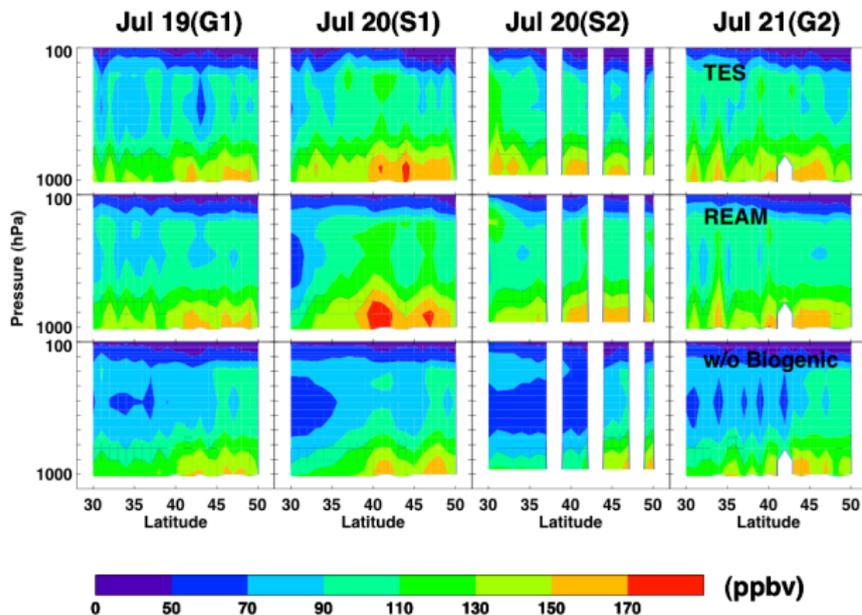
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# CO vertical profiles from Aura TES and Model



- ▶ Zonally averaged global survey results on July 19 and 21, and two special observations on July 20
- ▶ Simulated lower tropospheric CO enhancements due to biogenic sources and free tropospheric CO enhancements due to elevated and convective activities (<70 ppbv)

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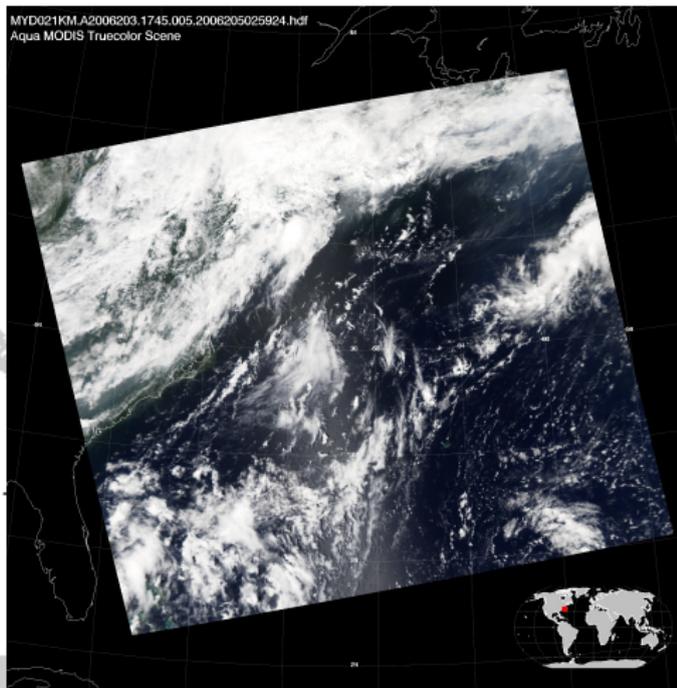
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# Clouds on July 22 from Aqua MODIS



- ▶ Blanket-like lower tropospheric CO peaks caused by biogenic sources on July 20 meet with dense clouds in the process of continental outflow.

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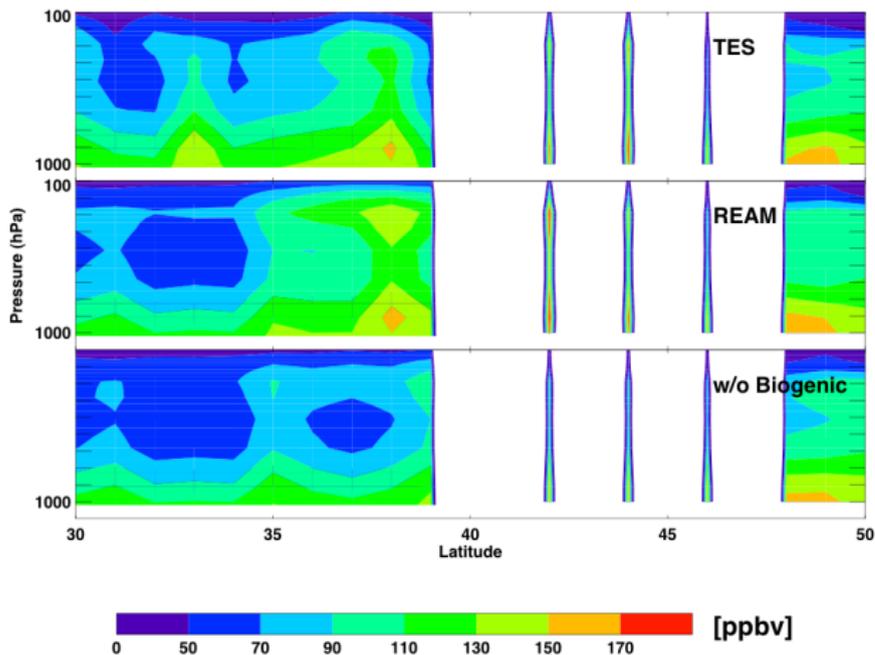
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# TES CO evidence for cloud convection



- ▶ Many TES data are missed due to dense clouds, where Aqua MODIS captures deep clouds.
- ▶ A stereotypical cloud convection evidence is shown both in TES observed and model simulated CO.

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- ▶ In certain times and locations, surface O<sub>3</sub> and CO mixing ratios are enhanced >60% due to biogenic VOC emissions.
- ▶ Observed large enhancements in MOPITT column CO and TES lower and free tropospheric CO (<70 ppbv) over North America and the western North Atlantic are also simulated in REAM.
- ▶ Enhanced CO regions from remote sensing measurements are primarily driven by biogenic VOC emissions in the hot summer of 2006.
- ▶ Satellite CO measurements could provide more quantitative constraints on the continental convective outflow of air pollutants.

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