Analysis of CO in the tropical troposphere using Aura satellite data and the GEOS-Chem model: insights into transport characteristics of the GEOS meteorological products

Junhua Liu¹, Jennifer A. Logan¹, D. B. A. Jones², N. J. Livesey³, I. Megretskaia¹, C. Carouge¹, P. Nedelec⁴

1. School of Engineering and Applied Sciences, Harvard University, Cambridge, Massachusetts, USA
2. Department of Physics, University of Toronto, Toronto, Ontario, Canada
3. Jet Propulsion Laboratory, Pasadena, CA, USA
4. CNRS-Laboratoire d'Aerologie, France

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Outlook

Objective:

- To understand processes affecting tropical tropospheric CO
- To evaluate the effect of different vertical mixing in GEOS-4 and GEOS-5 on model performance
- To identify possible causes for the discrepancies between model simulations and observations.

Tools:

- Chemistry-transport Model
  - GEOS-Chem full chemistry model driven by GEOS-4 and GEOS-5
  - Tagged CO simulation
- Satellite data
  - LT: TES
  - UT: MLS
South America:
- Drier in 2005 (La Nina), CO emissions are twice those in 2006.
- Fires start about one month later than southern Africa.

Southern Africa and northern Africa
- Relatively smaller interannual variation, with slightly higher emissions in 2005.
Similar CO spatial pattern for model results with GEOS-5.
MLS and GEOS-Chem CO at 215 hPa, 2005

Max. in E. Pacific in models especially in GEOS4, but not in MLS.

MLS has highest CO in October.

GEOS-4 max. in Nov

GEOS-5 max. in Nov-Dec
South America - Seasonality and interannual variation

**MLS correction:**
- 146 hPa: x 0.7 & 215 hPa: x 0.5

**215 hPa & 146 hPa:**
- 2005: GEOS-4 ~1 month delay
- GEOS-5 1-2 month delay
- 2006: both model peaks are too broad and too late

**681 hPa & 422 hPa:**
- GEOS-4: matches data
- GEOS-5: peak too broad, lower than GEOS4
South America - Dynamic influence

The lag in GEOS-5 is greater because 1) the convection moves southward later than in GEOS-4, and 2) the convection decays at a lower altitude.

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 (ppbv).
South America – Source contributions

215 hPa & 139 hPa:

- More CO from isoprene – causing the CO peak to stay high in Nov.
- CO from local fires peaks in Oct at 215 hPa, in Nov at 139 hPa.

430 hPa

- In N. winter, CO influenced by N. Africa fires.

688 hPa

- More CO from local fires in 2005
South America

The UT CO maximum is too late in the models compared with MLS, because:

- Deep convection decays at too low an altitude, especially in Oct, when the wet season starts. The lag in GEOS-5 is greater because the convection moves southward later than in GEOS-4, and the convection decays at a lower altitude.

- The source of CO from isoprene in the model is too large during the wet season.
Southern Africa - Seasonality and interannual variation

Model and observations:
- Phase matches from 681 to 146 hPa well – reflecting reasonable meteorological patterns and less influence from isoprene.
- Modeled CO lower than the observations – too low surface emissions in the model.

CO temporal patterns:
- Small IAV in the UT.
- 2nd maximum in the winter – North Africa fire.
- A time lag of the peak in fire counts (Jul, Aug) and CO loading (Sep, Oct) – seasonal change of meteorological pattern.

Isoprene is a smaller source of CO over Africa.
Increased the CO emissions by ~70% in S. America and by ~100% in S. Africa from Jun. to Oct. in the model (Kopacz et al. 2010).

- Better agreement with the magnitude of observed CO in July to October in LT, MT.
- CO is too high in UT.
- Difficult to match CO in the LT and UT in GEOS-4 – possible overly vigorous vertical transport.
Northern Africa - Seasonality and interannual variation

Too much CO is lofted to the UT as indicated by MLS data – verified by Mozaic data
Too much CO is lofted to the UT
Too strong Harmattan Winds? or too strong convection?

CO is lofted in the ITCZ
Anticyclone over the source region – preventing vertical mixing

Harmattan winds transport CO from fires to Gulf of Guinea
Conclusion

- South America:
  - equatorial easterlies may be too strong in Aug/Sept
  - convection in October detrains at too low an altitude, particularly in GEOS-5
  - isoprene is too large a source of CO, causing CO max. to occur too late in model
- South Africa:
  - GEOS-4: Possible overly vigorous vertical transport early in the wet season.
  - GEOS-5: Vertical transport may be more realistic than that in GEOS-4
- North Africa
  - Harmattan winds too strong?
  - Possible excessive lofting in ITCZ

These transport problems will impact inversion studies, which cannot account for biases in transport.