Indirect Validation of GOME-2/MetOp-A and B and New OMI formaldehyde (HCHO) retrievals using SEAC⁴RS data: Preliminary results

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1. Motivation

Satellite observations of HCHO have been used successfully as proxies for biogenic isoprene and anthropogenic highly reactive VOC emissions. However, the data quality HCHO columns becomes an issue after 2008 due to aging instruments and row anomalies. Recently, two updated HCHO retrievals from Ozone Monitoring Instrument (OMI) and Global Ozone Monitoring Experiment-2 (GOME-2/MetOp-A and B) have been released with the aim of providing data continuity. But those products have not been validated yet over North America in term of tropospheric vertical columns, temporal variations or spatial distributions.

The SEAC⁴RS data provide a unique opportunity for validation of the updated retrievals. We will indirectly validate the two new HCHO products with SEAC⁴RS data using GEOS-Chem as a common intercomparison platform with emphasis on Southeast US, Ozark isoprene volcano areas, as well as regions with high anthropogenic VOCs emissions.

2. Data and approach

- GOME-2 A and B HCHO tropospheric data are from Belgian Institute for Space Aeronomy (BIRA-IASB)
- New OMI HCHO retrievals are under development by G. Abad and K. Chance at Harvard CFA.
- Surface albedo (345nm) are from OMI Surface Reflectance Climatology Data Product-OMLER.
- Air Mass Factor (**AMF**) is calculated based on a nested GEOS-Chem (0.25×0.3125°) model and a radiative transfer model, LIDORT.
- HCHO mixing ratio are measured at DC-8 using CAMS and LIF approaches.
- Calculation of AMF
  - Fitted Slant Column Density (**SCD**) is a function of satellite observation angles, scattering, surface albedo and absorption.
  - Vertical Column Density (**VCD**)
  - VCD=SCD/AMF

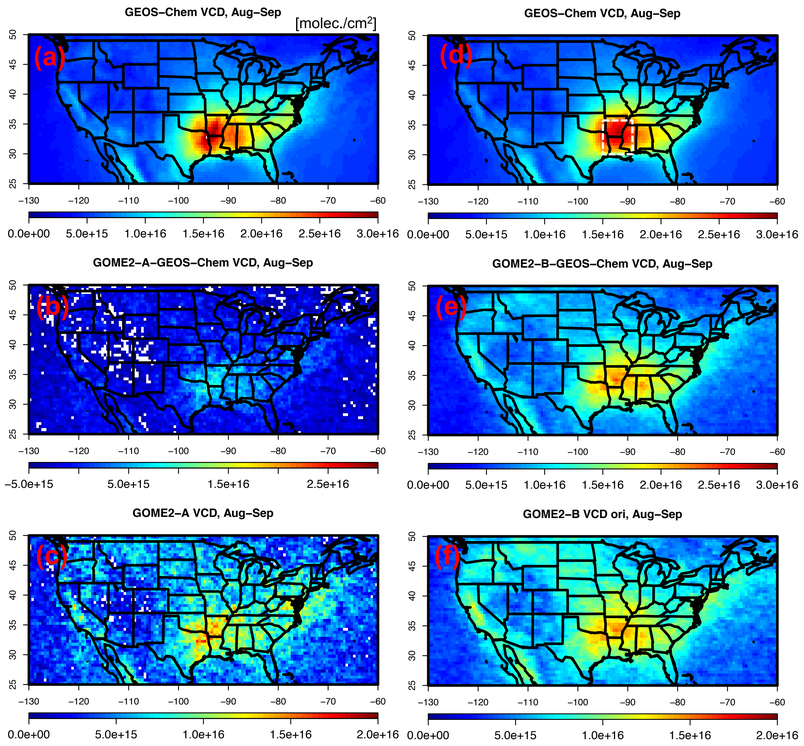
$$AMF = AMF_G \int_0^{\infty} W(z)S(z)dz$$ [Palmer, *et al.*, 2001]

  - W(z): Scattering weights, from satellite and LIDORT
  - S(z): Shape factor, from GEOS-Chem

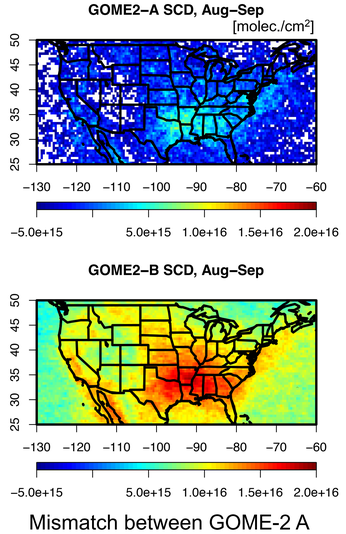
References

- Millet, D. B., et al. (2006), Formaldehyde distribution over North America: Implications for satellite retrievals of formaldehyde columns and isoprene emission, J. Geophys. Res., 111, D24S02, doi:10.1029/2005JD006853.
- Palmer, P. I., et al., Air mass factor formulation for spectroscopic measurements from satellites: Application to formaldehyde retrievals from the Global Ozone Monitoring Experiment, J. Geophys. Res., 106, 14,539–14,550, 2001.

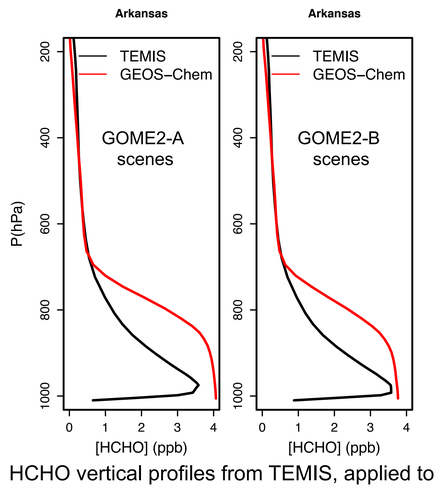
3. HCHO columns from space and GEOS-Chem



Mean 2013 Aug.-Sep. **(a)** GEOS-Chem VCD calculated for GOME2-A scenes, **(b)** GEOS-Chem-GOME-2A VCD, **(c)** GOME-2 A original VCD from the retrieval, **(d)** GEOS-Chem VCD calculated for GOME2-B scenes, **(e)** GEOS-Chem-GOME-2B VCD, **(f)** GOME-2 B original VCD. Air mass factors (AMF) are calculated at the time and location of GOME-2 A and B overpass, respectively. All the data are at 0.5°×0.5° resolution.



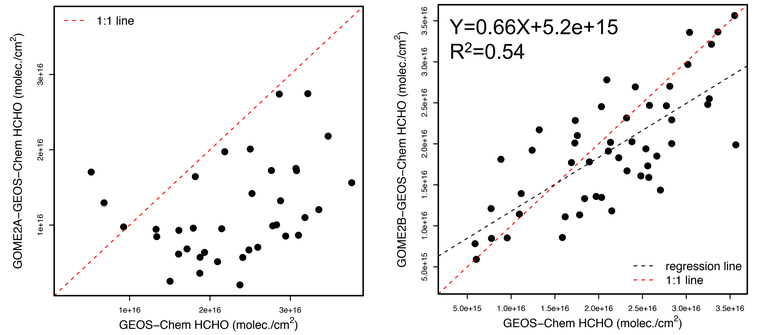
Mismatch between GOME-2 A and B VCD (panels **b** and **e** above) shows the differences in original fitted SCD.



HCHO vertical profiles from TEMIS, applied to GOME2 VCD (panel **c** and **f**), and from GEOS-Chem, used in the AMF calculation (panel **b** and **e**) over Arkansas. Discrepancies between GOES-Chem based VCD and GOME2 VCD are possibly related to the different shape files.

4. Mismatch of HCHO columns over SE US

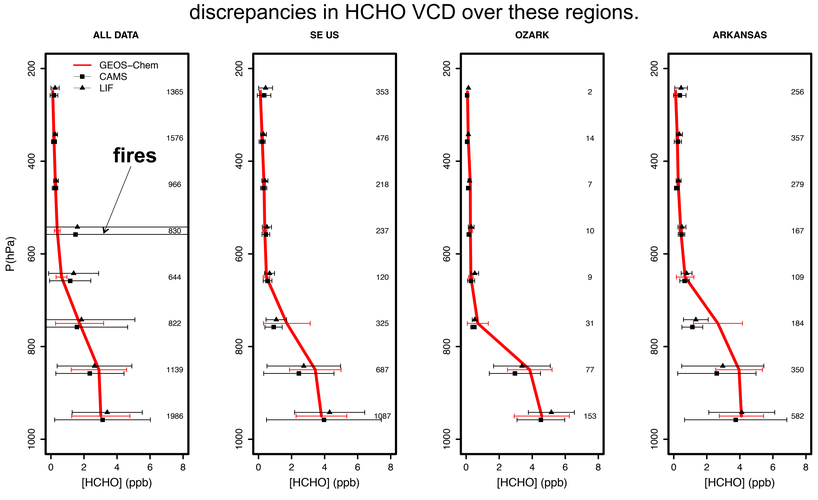
GEOS-Chem HCHO VCD is ~1.5 times higher than GOME2-B-GEOS-Chem VCD over Arkansas area (30-36N,95-88W, white dashed rectangle of panel **d**). However, GOME2-B captures over 54% of the daily variability in GEOS-Chem.



Comparison between daily GOME-2 A (left) and B (right) with GEOS-Chem AMF and GOES-Chem VCD over Arkansas during SEAC⁴RS period. No significant regression is found between GOME-2 A-GEOS-Chem VCD and GOES-Chem VCD.

5. The ability of GEOS-Chem in simulating observed HCHO vertical profiles and their variability

GEOS-Chem overestimates HCHO in the lower troposphere, especially over SE US and Arkansas area. This overestimate could be the reason of the large discrepancies in HCHO VCD over these regions.



Mean simulated (lines) and observed (symbols) HCHO vertical distributions during SEAC⁴RS, calculated for 100 hPa bins. Error bars represent standard deviations (the numbers of points are indicated on the right). The vertical coordinates for CAMS and LIF observations are offset slightly for visibility. The model is sampled along the flight tracks at the time of the measurements.

6. Next

- Examine the errors of AMF from HCHO profiles using SEAC⁴RS observations and GOES-Chem model results following [Millet et al., 2006]
- Examine the potential impacts from fires on HCHO columns
- Compare new OMI (Kelly Chance, PI) and GOME-2 B HCHO VCD with GEOS-Chem modeled VCD to look for the consistency in the model bias
- Evaluate HCHO-isoprene relationships simulated by GEOS-Chem
- Try to explain why satellites fail to observe high HCHO over Ozark isoprene volcano area

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