Validation of satellite HCHO retrievals with aircraft (SEAC⁴RS) observations

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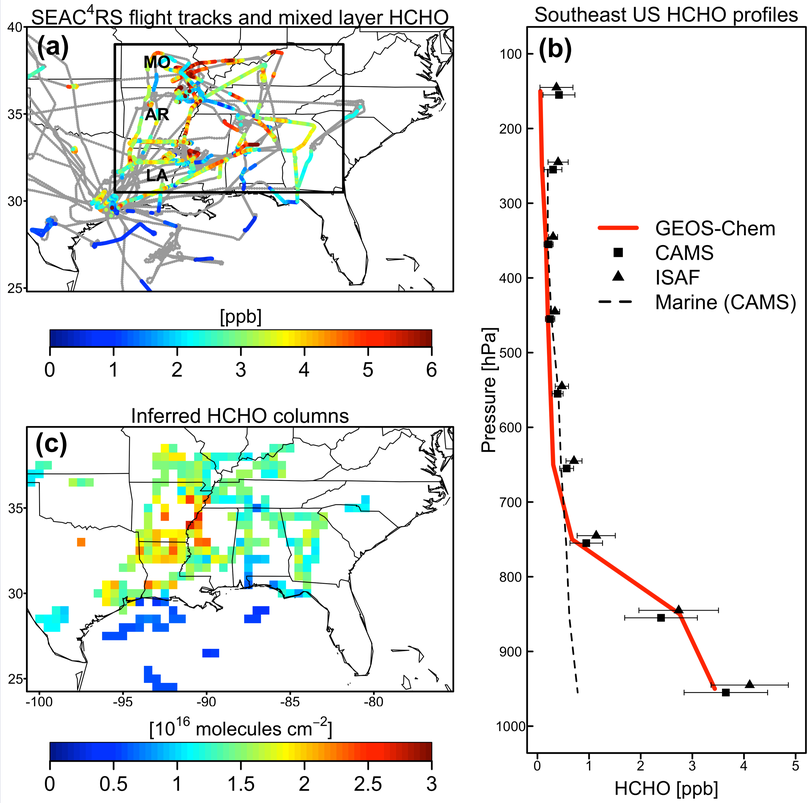
1. Introduction

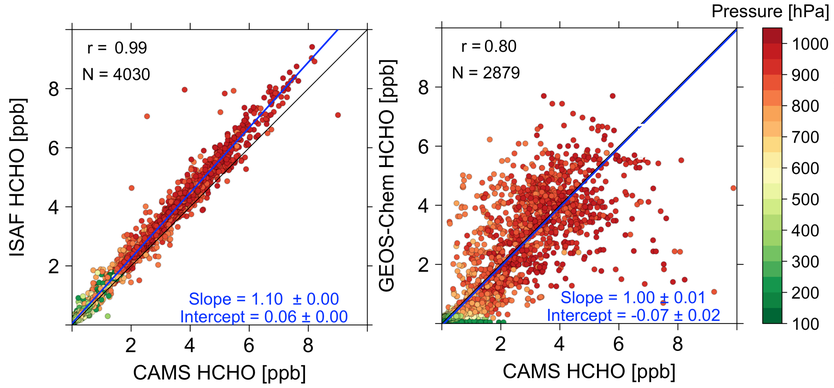
- Formaldehyde (HCHO) column data from satellites are widely used as a proxy for emissions of VOCs, but validation of the data has been extremely limited.
- Here we use accurate HCHO aircraft observations from the NASA SEAC⁴RS campaign over the Southeast US in August–September 2013 to validate and intercompare six operational and research retrievals of HCHO columns.
- The SEAC⁴RS aircraft did not conduct direct satellite validation profiles, nor would these be helpful because of the large noise in individual satellite retrievals.
- Instead, we use an indirect validation method involving joint comparisons of satellite and in situ HCHO observations with the GEOS-Chem chemical transport model.
- Under such a validation framework, satellite and in situ observations do not need to be concurrent, thus increasing considerably the range of data and conditions that can be used for validation.

2. SEAC⁴RS HCHO aircraft observations



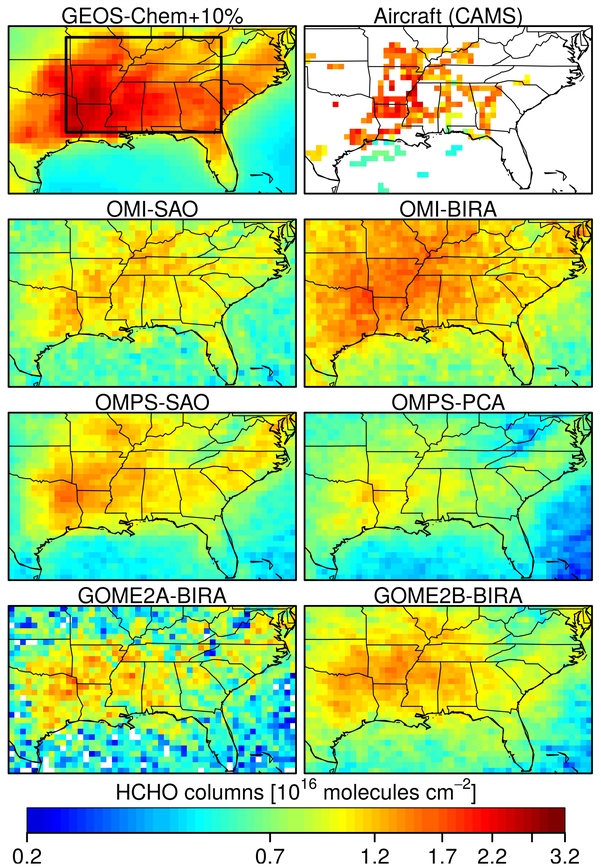
(a) SEAC⁴RS DC-8 flight tracks (in grey) and the CAMS measurements aboard the aircraft in the mixed layer. **(b)** Mean vertical profiles observed by the CAMS and ISAF instruments, and simulated by GEOS-Chem, for the Southeast US domain (box in panel a). **(c)** Mean HCHO columns derived from the CAMS.

3. GEOS-Chem model simulation

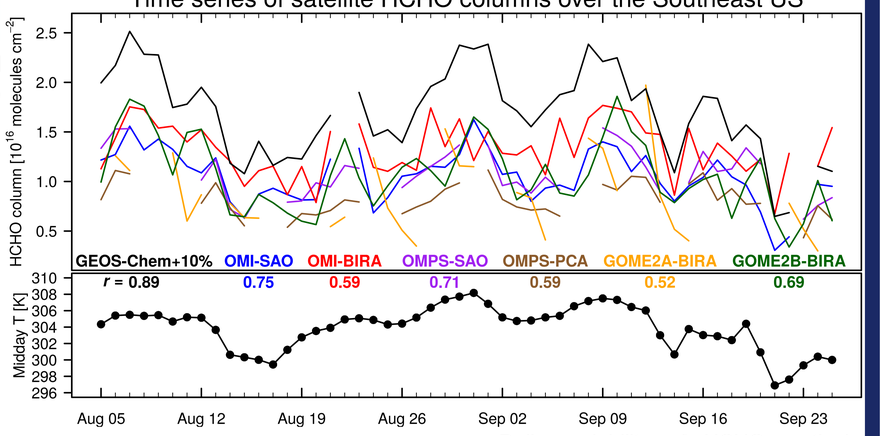


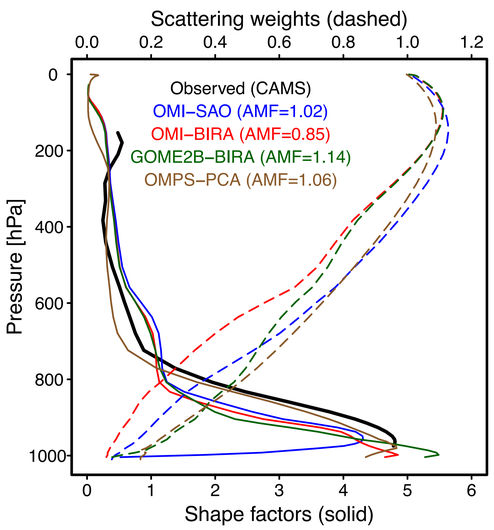
Comparisons between HCHO from CAMS and ISAF (left) aboard the SEAC⁴RS aircraft, and simulated by GEOS-Chem (right), for the Southeast US flight tracks.

4. Intercomparison and validation of satellite data sets



HCHO vertical column densities over the Southeast US averaged over the SEAC⁴RS period. The bottom panels show six retrievals from four satellites (OMI, GOME-2A, GOME-2B and OMPS) and three different groups. The top panels show (1) GEOS-Chem model results sampled on the OMI schedule and increased by 10% to correct for the bias relative to CAMS aircraft measurements; and (2) columns derived from the CAMS aircraft measurements. Color bar is a logarithmic scale.





Daily variability of HCHO vertical column densities over the Southeast US during SEAC⁴RS. (Top) Daily HCHO columns averaged over the Southeast US for the different satellite retrievals. (Bottom) Local midday (1200–1300 local time) surface air temperature over the Southeast US domain from the GEOS-5 data. Also shown for each data set is the temporal correlation coefficient (*r*) with temperature.

Mean scattering weights and shape factors for HCHO retrievals over the Southeast US during the SEAC⁴RS period, and resulting air mass factor (*AMF*). Also shown are the observed HCHO shape factors (black) from the mean CAMS profile.

5. Conclusions

- ✓ All retrievals capture the HCHO maximum over Arkansas and Louisiana, reflecting high emissions of biogenic isoprene, and are consistent in their spatial variability over the Southeast US (r=0.4–0.8 on a 0.5°×0.5° grid) as well as their day-to-day variability (r=0.5–0.8).
- ✓ This success demonstrates that HCHO columns observed from space can provide a reliable proxy for isoprene emission.
- ✓ Satellite retrievals are biased low in the mean, by 20% to 51% depending on the retrieval.
- ✓ The bias is smallest for OMI-BIRA and could be further reduced (-12%) by correcting the assumed HCHO vertical profiles assumed in the AMF calculation. Aside from OMI-BIRA, the shape factors used in the retrievals are not a significant source of error.
- ✓ Other retrievals have larger biases that appear to reflect a reflect a combination of (1) spectral fitting affecting the corrected slant columns, and (2) scattering weights in the radiative transfer model.
- ✓ Improvement in HCHO retrievals should focus on slant column fitting, on corrected slant columns, and on calculation of scattering weights.

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