Validation of satellite HCHO retrievals with aircraft (SEAC\textsuperscript{4}RS) observations

Lei Zhu\textsuperscript{1}, D. J. Jacob\textsuperscript{1}, P. S. Kim\textsuperscript{1}, J. A. Fisher\textsuperscript{2}, K. Yu\textsuperscript{3}, K. R. Travis\textsuperscript{2}, L. J. Mickley\textsuperscript{1}, R. M. Yantosca\textsuperscript{1}, M. P. Sulprizio\textsuperscript{1}, I. De Smedt\textsuperscript{3}, G. Gonzalez-Abad\textsuperscript{3}, K. Chance\textsuperscript{1}, C. L.\textsuperscript{1,4}, R. Ferrare\textsuperscript{1}, A. Fried\textsuperscript{1}, J. W. Hair\textsuperscript{2}, T. F. Hanisco\textsuperscript{2}, D. Richter\textsuperscript{4}, A. J. Scarno\textsuperscript{6}, J. Walega\textsuperscript{7}, P. Weibring\textsuperscript{8}, G. M. Wolfe\textsuperscript{3,9}

\textsuperscript{1}Harvard University, \textsuperscript{2}University of Wollongong, \textsuperscript{3}Belgian Institute for Space Aeronomy, \textsuperscript{4}Harvard-Smithsonian Center for Astrophysics, \textsuperscript{5}University of Maryland, College Park, \textsuperscript{6}NASA Goddard, \textsuperscript{7}NASA Langley, \textsuperscript{8}University of Colorado, Boulder, \textsuperscript{9}Science Systems and Applications, Inc., \textsuperscript{10}University of Maryland, Baltimore County

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 SEAC\textsuperscript{4}RS campaign over the Southeast US in August–September 2013 to validate and intercompare six operational and research retrievals of HCHO columns.
- The SEAC\textsuperscript{4}RS 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. SEAC\textsuperscript{4}RS HCHO aircraft observations

(a) SEAC\textsuperscript{4}RS 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 SEAC\textsuperscript{4}RS 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 SEAC\textsuperscript{4}RS 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.

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\degree x 0.5\degree 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 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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