Global Formaldehyde Products from the OMPS Nadir Mappers on Suomi NPP and NOAA-20

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1. Atmospheric Formaldehyde

- Formaldehyde (HCHO) is one of the most abundant non-methane volatile organic compounds (NMVOCs) in the troposphere.
- Enhanced levels result from oxidation of VOCs from biogenic, anthropogenic and pyrogenic activities, and direct emissions from fires and industry.
- Background HCHO exists in the global atmosphere due to the oxidation of methane.
- ***HCHO measured by satellites can be used as a proxy for other NMVOCs and as a top-down constraint on isoprene emissions.***

2. The OMPS Nadir Mapper Instruments

- The OMPS (Ozone Mapping and Profiler Suite) instruments include a nadir mapper which uses a 2D CCD array detector to measure backscattered solar light in a ~2800 km wide swath.
- The equatorial local overpass time is ~1:30 PM.
- OMPS currently flies on the Suomi NPP and NOAA-20 satellites.

Table 1: Characteristics of OMPS nadir mappers currently on orbit.

	OMPS Suomi NPP	OMPS NOAA-20
Launch	October 2011	November 2017
Spectral Coverage	300 – 380 nm	300 – 420 nm
Spectral Resolution	1 nm	1 nm
Spatial Resolution at Nadir*	50 × 50 km²	17 × 17 km² (launch – 02/2019) 12 × 17 km² (02/2019 – present)

* The OMPS nadir mapper on JPSS-2 (launch 2022) has a planned resolution of 10 × 10 km².

3. OMPS Formaldehyde Retrievals

- The Smithsonian Astrophysical Observatory (SAO) OMPS retrieval is based on our operational OMI HCHO retrieval, which is also the basis for future TEMPO retrievals.
- The SAO HCHO product uses a 3-step approach:
  1. Fit a slant column of HCHO for each spectrum using a cross-track dependent reference spectrum from a clean area over the Pacific.
  2. Determine an air mass factor and convert to vertical column.
  3. Adjust the background using a modeled column over the Pacific.

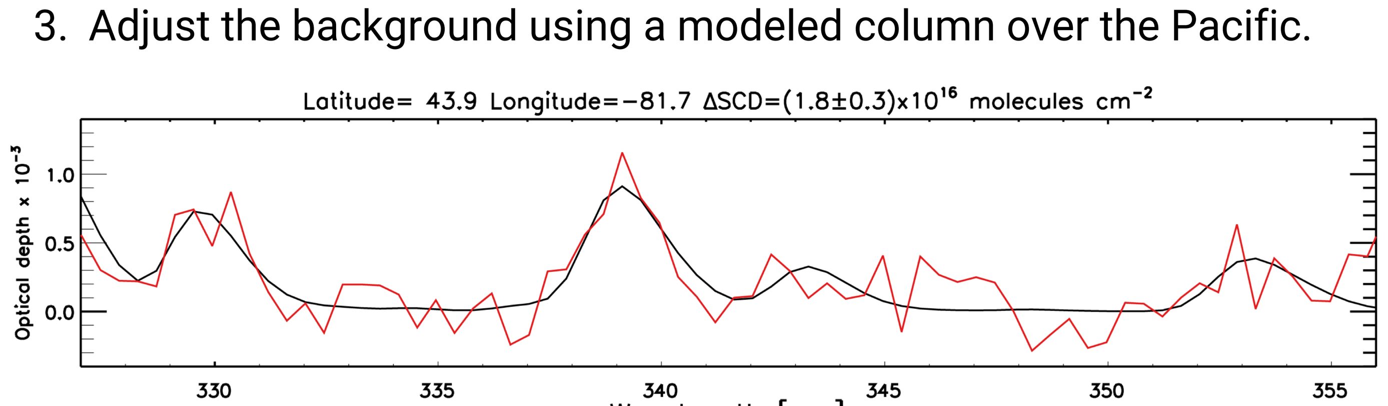

Figure 1: Simulated (black) and observed (red) optical depth of HCHO from a single OMPS Suomi NPP spectrum (González Abad et al., 2016).

4. OMPS HCHO from Suomi NPP and NOAA-20

We are producing a multi-year HCHO dataset from OMPS on Suomi NPP and NOAA-20.

- A multi-year Version 1 product should become available mid-2020. Users can download from a dedicated publicly-accessible SAO website.
- The OMPS Suomi NPP algorithm will be integrated into the NASA Science Investigator-led Processing Systems, with the HCHO product eventually provided by NASA.

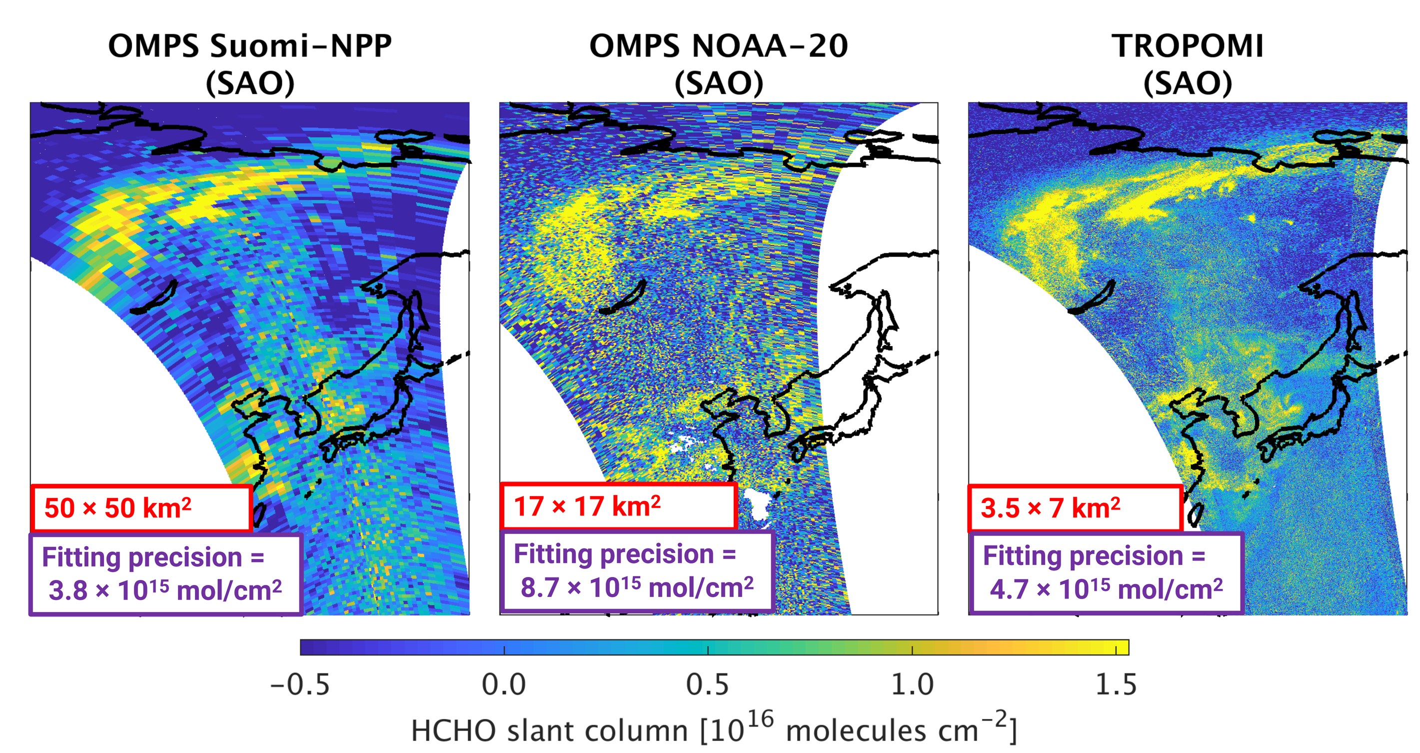

Figure 2: Fitted HCHO slant columns from OMPS/Suomi-NPP, OMPS/NOAA-20 and TROPOMI (using SAO algorithm) for orbit passing over East Asia and a Siberian fire on 4 July 2018. All observations (clear and cloudy) are shown. Because OMPS Suomi NPP spectra are spatially averaged on-board, observations are at a coarser spatial resolution than those from OMPS NOAA-20, and fitting uncertainties are lower. NOAA-20 operates 50 minutes ahead of Suomi NPP. The ESA/KNMI TROPOMI instrument was launched in October 2017 into an orbit 5 minutes behind Suomi NPP. Its observations are of high spatial resolution and have low fitting uncertainties due to high instrument signal-to-noise.

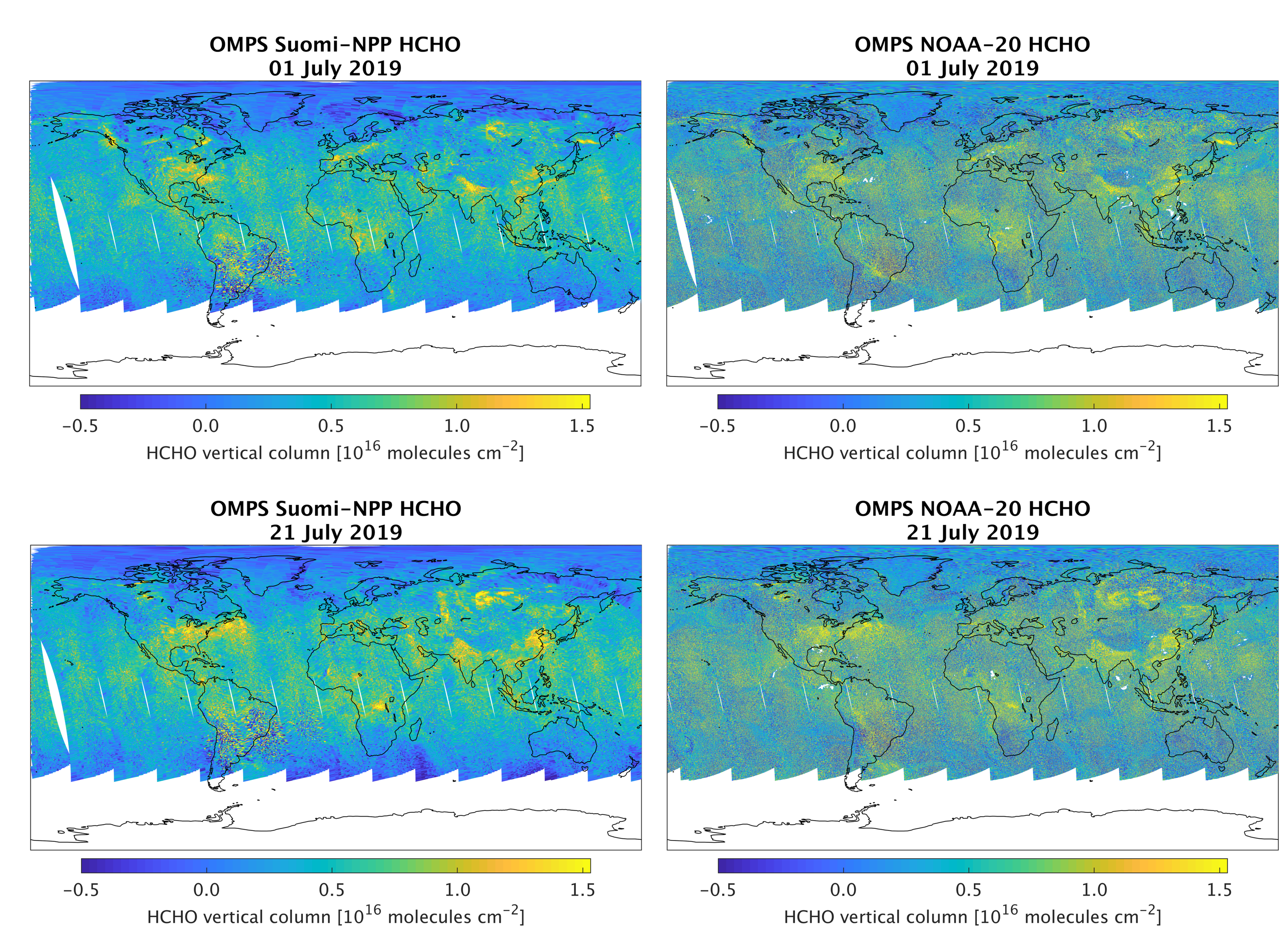

Figure 3: Global HCHO vertical columns observed from OMPS/Suomi-NPP and OMPS/NOAA-20 for all orbits on 1 and 21 July 2019. Cloudy and clear observations are included. Several areas of enhanced HCHO are clearly visible, including over fires in Spain, Russia, Canada, the US, South America and Africa, and from anthropogenic emissions in China.

5. Validation

- We are validating the retrieval using airborne data from multiple field campaigns through indirect validation with a model as an intercomparison platform (Zhu et al., 2016).
- Zhu et al. (2020) have prepared the validation framework using 12 campaigns, initially applied to OMI HCHO retrievals.
- Figures 4 – 6 show an example for OMPS/Suomi-NPP from the May-June 2016 KORUS-AQ campaign over South Korea.

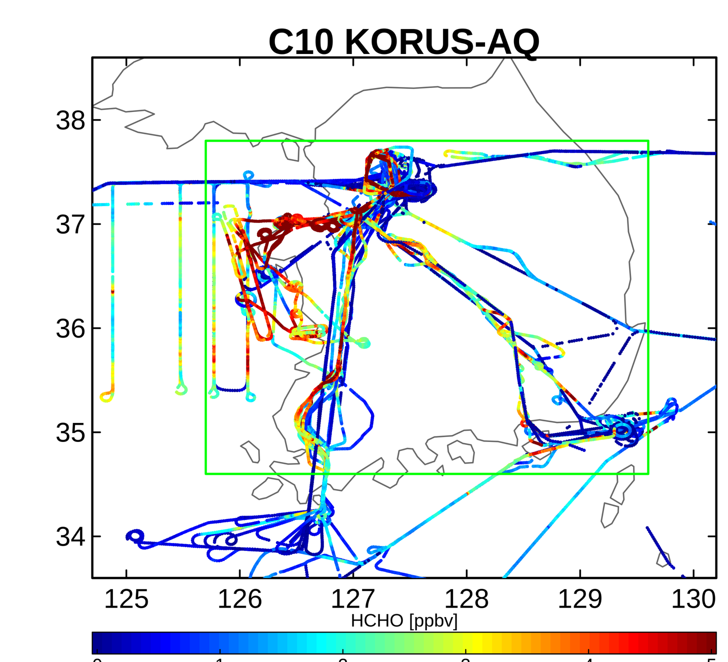

Figure 4: HCHO mixing ratio measured in situ by the CAMS instrument on the DC-8 aircraft over South Korea during the KORUS-AQ campaign in May-June 2016. All altitudes are shown (0-7.5 km). The green rectangle indicates the validation region.

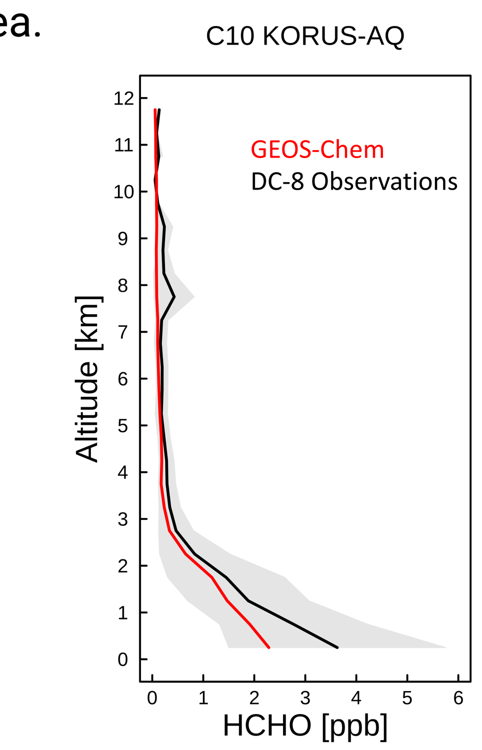

Figure 5: Mean mixing ratio profiles from observations (CAMS) and a coincidentally-sampled model (GEOS-Chem) for the entire KORUS-AQ campaign. Here, GEOS-Chem underestimates the column by 31%. The model is later scaled using the ratio of the observed to modeled column so that it can be compared with OMPS and OMI.

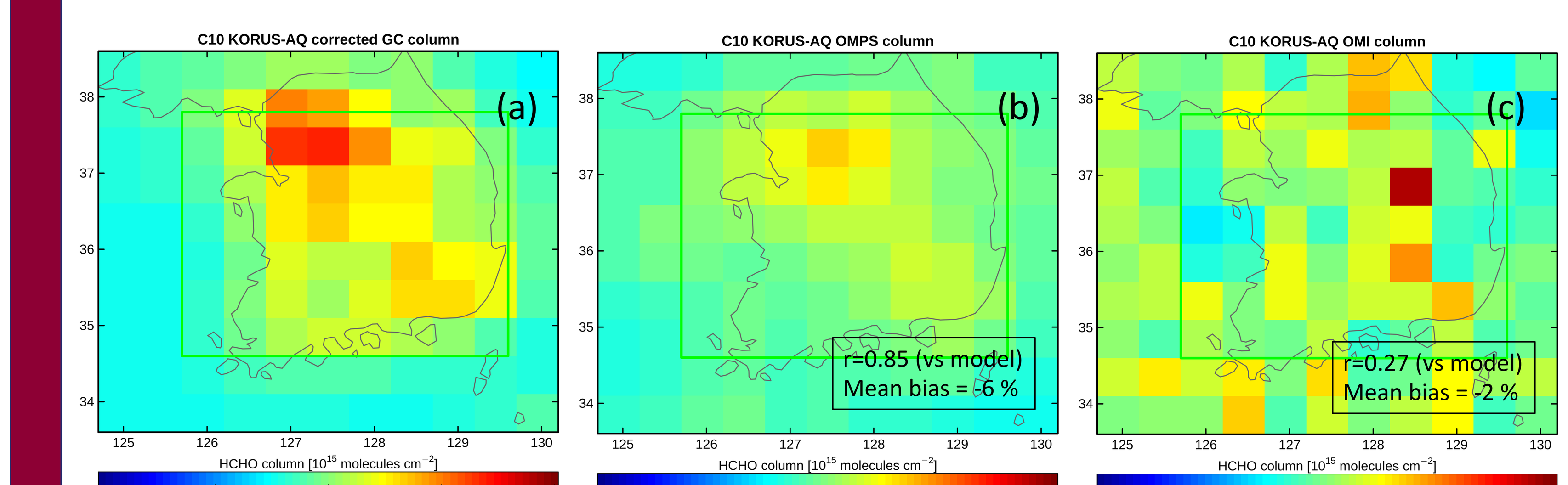

Figure 6: Mean vertical column HCHO during KORUS-AQ at satellite overpass time on a 0.5°x0.5° grid from a) GEOS-Chem scaled to match mean in situ observations (above); b) OMPS/Suomi-NPP; and c) OMI. OMPS shows a much better spatial correlation than OMI with the model, due partly to the OMI row anomaly and missing data from an OMI instrument outage during the campaign.

References

González Abad et al., Smithsonian Astrophysical Observatory Ozone Mapping and Profiler Suite (SAO OMPS) formaldehyde retrieval, Atmos. Meas. Tech., 9, 2797-2812, 2016.

Zhu et al., Observing atmospheric formaldehyde (HCHO) from space: validation and intercomparison of six retrievals from four satellites (OMI, GOME2A, GOME2B, OMPS) with SEAC⁴RS aircraft observations over the southeast US, Atmos. Chem. Phys., 16, 13477–13490, 2016.

Zhu et al., Validation of satellite formaldehyde (HCHO) retrievals using observations from 12 aircraft campaigns, Atmos. Chem. Phys. Discuss., 2020, under review.

Acknowledgements

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