# ⊛AGU PUBLICATIONS

*Earth and Space Science*

Supporting Information for

**Global Formaldehyde Products from the Ozone Mapping and Profiler Suite (OMPS) Nadir Mappers on Suomi NPP and NOAA-20**

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## Introduction

This document contains supporting information for the article ``Global Formaldehyde Products from the Ozone Mapping and Profiler Suite (OMPS) Instruments on Suomi NPP and NOAA-20", which describes the formaldehyde retrieval algorithm and publicly-available data products for the OMPS nadir mapper instruments on the Suomi-NPP and NOAA-20 satellites.

The Level 2 OMPS HCHO (OMPS_NPP_NMHCHO_L2 and OMPS_N20_NMHCHO_L2) files consist of orbital swath total vertical column densities of formaldehyde from the OMPS nadir mappers. The vertical columns are accompanied by support data consisting of uncertainty estimates, geolocation, quality flags and statistics, vertically resolved scattering weights, a priori formaldehyde profiles and ancillary data. Each file contains Level 2 swath data for a single orbit. There are typically 14 to 15 orbits per day.

The OMPS_NPP_NMHCHO_L2 and OMPS_N20_NMHCHO_L2 files are in netCDF (version 4) format. The file information is divided into five main groups:

1. **key_science_data**: the HCHO column, uncertainty and main data quality flag
2. **geolocation**: information on observation time, latitude, longitude, viewing and solar angles, and terrain height at observation surface location
3. **qa_statistics**: fit convergence statistics and flags, RMS fitting residuals
4. **support_data**: support data used in the VCD calculation, including fitted slant column, air mass factor, cloud and surface information. This group also contains the vertically-resolved scattering weights.
5. **uncertainty_budget**: uncertainty estimates in key parameters

Orbital metadata are included as global keyword:value pairs.

Table S1 summarizes the main possible dimensions of data fields. Tables S2 – S6 list the data fields included in the OMPS Level 2 HCHO files by group. Each variables also includes attributes such as units and flag meanings. The data field `support_data/surface_pressure` includes the Eta coordinates for calculating vertical pressure grids. See the OMPS HCHO README document (Nowlan and González Abad, 2022) for further details on the file format.

**Table S1.** Main data field dimensions. Not all data fields have all dimensions.

| Name | Description | Nominal Dimensions |
|---|---|---|
| `along_track` | Number of ground pixels along the satellite track | 400 (SNPP) 1201 (NOAA-20) |
| `cross_track` | Number of ground pixels across the satellite track | 36 (SNPP) 104 (NOAA-20, Orbits 1 – 6418) 140 (NOAA-20, Orbits 6419 – present) |
| `corner` | Number of corners in latitude and longitude bounds | 4 |
| `vertical_layer` | Number of layers in data fields with vertical information | 47 |

**Table S2.** Data fields in `key_science_data` group.

| Data Field Name | Description | Type | Dimensions | Units |
|---|---|---|---|---|
| `column_amount` | HCHO column amount | 64-bit floating-point | `along_track, cross_track` | molecules/cm$^2$ |
| `column_uncertainty` | HCHO column amount uncertainty. This is derived from the random uncertainty in the slant column spectral fit. | 64-bit floating-point | `along_track, cross_track` | molecules/cm$^2$ |
| `main_data_quality_flag` | main data quality flag | 16-bit integer | `along_track, cross_track` | none |

**Table S3.** Data fields in `geolocation` group.

| Data Field Name | Description | Type | Dimensions | Units |
|---|---|---|---|---|
| `latitude` | Latitude at pixel center | 32-bit floating-point | `along_track`, `cross_track` | degrees north |
| `latitude_bounds` | Latitude at pixel corners | 32-bit floating-point | `along_track`, `cross_track`, `corner` | degrees north |
| `longitude` | Longitude at pixel center | 32-bit floating-point | `along_track`, `cross_track` | degrees east |
| `longitude_bounds` | Longitude at pixel corners | 32-bit floating-point | `along_track`, `cross_track`, `corner` | degrees east |
| `solar_zenith_angle` | Solar zenith angle at pixel center | 32-bit floating-point | `along_track`, `cross_track` | degrees |
| `solar_azimuth_angle` | Solar azimuth angle at pixel center | 32-bit floating-point | `along_track`, `cross_track` | degrees |
| `relative_azimuth_angle` | Relative azimuth angle at pixel center | 32-bit floating-point | `along_track`, `cross_track` | degrees |
| `terrain_height` | Terrain height | 16-bit integer | `along_track`, `cross_track` | m |
| `time` | Exposure start time in seconds since 1993-01-01T00:00:00Z | 64-bit floating-point | `along_track` | seconds |
| `viewing_zenith_angle` | Viewing zenith angle at pixel center | 32-bit floating-point | `along_track`, `cross_track` | degrees |
| `viewing_azimuth_angle` | Viewing azimuth angle at pixel center | 32-bit floating-point | `along_track`, `cross_track` | degrees |

**Table S4.** Data fields in `qa_statistics` group.

| Data Field Name | Description | Type | Dimensions | Units |
|---|---|---|---|---|
| `fit_convergence_flag` | Slant column fit convergence flag | 16-bit integer | `along_track`, `cross_track` | none |
| `fit_rms_residual` | Normalized radiance fit RMS residual | 64-bit floating-point | `along_track`, `cross_track` | none |
| `num_good_input` | Number of pixels for which slant column fitting is attempted | 32-bit integer | `1` | none |
| `percent_bad_output` | Percent of `num_good_input` flagged as "bad" in main quality flag | 32-bit floating-point | `1` | % |
| `percent_good_output` | Percent of `num_good_input` flagged as "good" in main quality flag | 32-bit floating-point | `1` | % |
| `percent_suspect_output` | Percent of `num_good_input` flagged as "suspect" in main quality flag | 32-bit floating-point | `1` | % |

**Table S5.** Data fields in `support_data` group.

| Data Field Name | Description | Type | Dimensions | Units |
|---|---|---|---|---|
| albedo | Geometry-dependent surface Lambertian-Equivalent Reflectivity. This is not used in the AMF calculation but is given to help user estimate effective surface reflectivity. | 32-bit floating-point | along_track, cross_track | none |
| amf | Calculated air mass factor | 32-bit floating-point | along_track, cross_track | none |
| bias_correction | Bias correction | 32-bit floating-point | along_track, cross_track | molecules/cm² |
| brdf_geo | Amplitude of Li-Sparse BRDF kernel | 32-bit floating-point | along_track, cross_track | none |
| brdf_iso | Amplitude of isotropic BRDF kernel | 32-bit floating-point | along_track, cross_track | none |
| brdf_vol | Amplitude of Ross-Thick BRDF kernel | 32-bit floating-point | along_track, cross_track | none |
| cloud_fraction | Effective cloud fraction used in AMF computation | 32-bit floating-point | along_track, cross_track | none |
| cloud_pressure | Cloud pressure used in AMF computation | 32-bit floating-point | along_track, cross_track | hPa |
| fitted_slant_column_amount | Fitted slant column density | 64-bit floating-point | along_track, cross_track | molecules/cm² |
| fitted_slant_column_uncertainty | Fitted slant column density uncertainty | 64-bit floating-point | along_track, cross_track | molecules/cm² |
| gas_profile | A priori gas mixing ratio profile used in AMF calculation | 32-bit floating-point | vertical_layer, along_track, cross_track | none |
| glint_flag | Flag for possible glint | byte | along_track, cross_track | none |
| ice_fraction | Sea ice fraction | 32-bit floating-point | along_track, cross_track | none |
| land_fraction | Land fraction | 32-bit floating-point | along_track, cross_track | none |
| meridional_wind | Meridional wind | 32-bit floating-point | along_track, cross_track | m/s |
| ocean_salinity | Ocean salinity in Practical Salinity Units (PSU) | 32-bit floating-point | along_track, cross_track | g/kg (1e-3) |
| ref_sector_correction | Reference sector background correction | 32-bit floating-point | along_track, cross_track | molecules/cm² |
| scattering_weights | Scattering weights | 32-bit floating-point | vertical_layer, along_track, cross_track | none |
| snow_fraction | Snow fraction | 32-bit floating-point | along_track, cross_track | none |
| surface_pressure | Surface pressure | 32-bit floating-point | along_track, cross_track | hPa |
| temperature_profile | Temperature profile | 32-bit floating-point | vertical_layer, along_track, cross_track | K |
| zonal_wind | Zonal wind | 32-bit floating-point | along_track, cross_track | m/s |

**Table S6.** Data fields in `uncertainty_budget` group.

| Data Field Name | Description | Type | Dimensions | Units |
|---|---|---|---|---|
| `amf_total_uncert` | Total AMF uncertainty | 32-bit floating-point | `along_track, cross_track` | % |
| `bias_uncertainty` | Estimated uncertainty in bias correction | 32-bit floating-point | `along_track, cross_track` | molecules/cm$^2$ |
| `ref_sector_uncertainty` | Estimated uncertainty in reference background correction | 32-bit floating-point | `along_track, cross_track` | molecules/cm$^2$ |