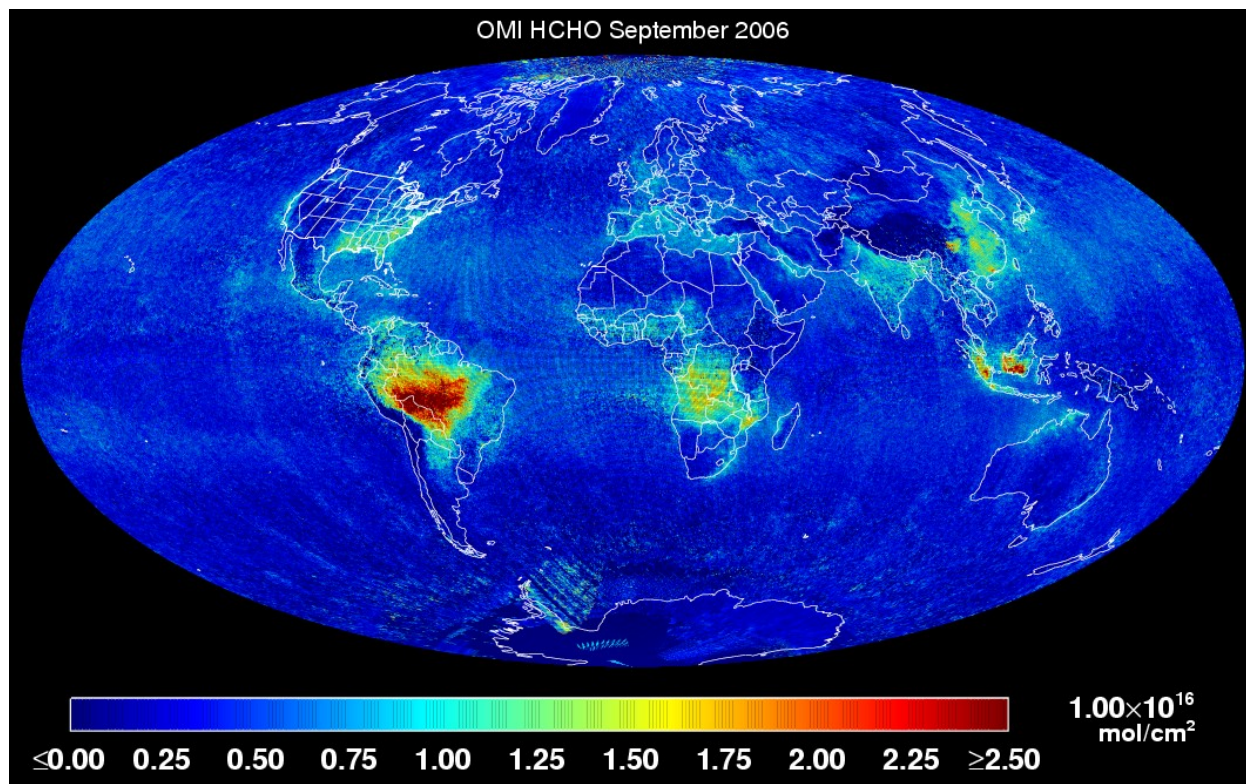


OMHCHO README FILE
Date of this Document: 1 May 2008



Overview

This document provides a brief description of the OMHCHO data product. OMHCHO contains total column HCHO and ancillary information retrieved from OMI global and spatial zoom mode measurements using a retrieval algorithm that is based on non-linear least-squares fitting originally developed for GOME, and adapted for the OMI instrument. In global mode, *i.e.*, global coverage in one day, each file contains a single orbit of data covering a swath of approximately 2,600 km wide from pole to pole (sunlit portions only).

Fitting uncertainties for the HCHO slant columns (single measurement) typically range between 40-100%, with the lower end of this range over HCHO hotspots. This is roughly comparable to what has been achieved from GOME. Uncertainties in the air mass factor (AMF), used to convert slant to vertical columns, are estimated to be 30%. Hence the total uncertainties of the HCHO vertical columns typically range within 50-105%.

The image above shows monthly average HCHO for September 2006, including only pixels with cloud fraction up to 20%.

Release History and Release-Specific Information

OMHCHO Algorithm Version ¹	2.0
Collection/Product Version ¹	003
This Public Release	1 May 2008
First Public Release	1 February 2007
Validation Release	25 December 2005
Known Issue List	Across-track striping in the data product

¹ *Algorithm Version* (level-2 related) and *Collection/Product Version* (level-1 related) must not be confused: While the *Collection/Product Version* number is part of any OMHCHO data file name, *e.g.*,
OMI-Aura-L2-OMHCHO_<acquisition date>-o<orbit number>_v003-<processing date>.he5
the *Algorithm Version* is stored within the data product file, in the Metadata field PGEVERSION.

Algorithm Description

The algorithm is based on the direct fitting of radiances and irradiances. In particular, and differing from what is commonly referred to as Differential Optical Absorption Spectroscopy (DOAS) fitting, radiances are not divided by irradiances, no logarithms are taken of the spectra, and no high-pass filtering is applied. In the current version, an OMI radiance measurement over the remote Pacific is used in lieu of an irradiance measurement.

The four main stages of the algorithm are (1) Solar wavelength calibration, in which the optimum wavelength registration of the composite solar irradiance, derived from a principal component analysis of three years of individual OMI irradiance measurements, is determined; (2) Radiance wavelength calibration, which finds the optimum wavelength registration for a representative swath of radiance measurements (usually in the middle of the orbit) and determines a common wavelength grid for auxiliary data bases (molecular reference cross sections, etc.); (3) On-line computation of a residual “common mode” spectrum; and (4) Non-linear, least-squares fitting of all swath lines in the OMI granule. In each stage, the calibration/fitting is performed individually for the 60 cross-track pixels² of an OMI swath line. For improved numerical stability, radiances and irradiances are divided by their respective averages over the fitting window; in other words, they are “normalized” to values ~1.

HCHO fitting is performed in the spectral window 327.5–356.5 nm, within the UV-2 channel of the OMI instrument. The model that is fitted to the measurements consists of the radiance reference (from the remote Pacific), attenuated by contributions from HCHO (the target gas), inelastic (rotational Raman, or *Ring*) scattering, and interferences from other atmospheric gases, including ozone, NO₂, and BrO; it also contains additive and multiplicative closure polynomials and parameters for spectral shift and, potentially, squeeze, as well as a sampling correction [[Chance et al., 2005](#)] and a common mode spectrum, both of which are computed on-line. The common mode spectra (one per cross-track position) are the average of several hundred fitting residuals and include any instrument effects that are unrelated to molecular scattering and absorption cross sections. The least-squares fit is mostly unconstrained, with the exception of selected parameters, including the spectral shift, which are constrained in order to prevent problems arising from out-of-bounds values.

The results from the spectral fitting are HCHO slant columns. These are converted to vertical columns using a look-up table of air mass factors (AMFs). AMF tables have been pre-computed with a radiative transfer model using climatological HCHO profiles. They include the effect of clouds (non-scattering, reflecting cloud top). The AMFs used for the conversion from slant to vertical columns are provided in the data product for all ground pixels. For global mode granules, the HCHO retrieval uses cloud fraction and cloud top pressure from the OMI O₂-O₂ cloud product, [OMCLDO2](#).

The algorithm employs several methods to reduce cross-track striping of the HCHO columns. These include “soft calibration” (*i.e.*, the use of a radiance reference), outlier screening in the fitting residuals, the use of a composite solar spectrum (all employed during the fitting process), as well as a post-processing cross-track smoothing of the fitted columns. These smoothed columns are provided in a separate data field, [ColumnAmountDestriped](#). In the current version the smoothed columns are included more for historic reasons, since advances in level-1 radiance calibration, particularly the time-dependent OPF, and the HCHO retrievals themselves have brought the regular columns to a level where further destriping is of little benefit. It must also be pointed out that the across-track smoothing almost certainly introduces an as yet unquantified bias to the fitted columns. For the present version, the use of [ColumnAmountDestriped](#) is discouraged.

More details on algorithm specifics can be found in the [OMI Algorithm Theoretical Basis Document](#) Vol. 4, and in [Kurosu et al. \[2004\]](#). A summary table of algorithm specifics and molecular cross-section data bases used in the fitting is provided at the end of this document.

Data Quality Assessment

Across-track striping (systematically elevated or reduced column values at the same cross track position along the whole track) of the HCHO columns is still an issue, despite the improvements achieved in OMHCHO v2.0 (Collection/Product Version 003). This is not unique to HCHO but affects all OMI data products to a greater or lesser extent. Small absorbers like BrO, HCHO and OClO however, are more strongly affected by striping since the column values are of a similar order of magnitude as the stripes, so that the effect is relatively stronger. Users of the HCHO columns provided here must be aware of this issue.

2 Alternatively: 30 cross-track pixels in rebinned spatial zoom mode, occurring every 32 days.

The HCHO data product provides RMS (data field [FittingRMS](#)) and one standard deviation (1σ) fitting uncertainties ([ColumnUncertainty](#)), as derived from the fitting covariance matrix. The uncertainties do not include contributions from uncertainties in the measurements or the reference cross sections. The main guidance to data quality provided with the HCHO columns is the [MainDataQualityFlag](#), which is set to any of four values (0, 1, 2, and -1) based on the outcome of the fitting process (see description below, under “Which Data Should Be Used?”). This flag should be used for data screening prior to use of each individual OMI pixel column. Additional information on the convergence of the fit is provided in a fitting diagnostic flag ([FitConvergenceFlag](#)); this flag should be consulted if more detailed information on the fitting process is desired. For details see the product specification document [OMHCHO.fs](#) or consult the [File Specification README](#).

Cloud Information

The OMHCHO product file contains two data fields with cloud information, taken from the OMCLDO2 data product and provided in slightly modified form: (1) [AMFCloudFraction](#) contains the cloud fractional cover (between 0 and 1) in the OMI pixel, as it has been used in the AMF calculation; it has been adjusted from the original OMCLDO2 data field, first by forcing all non-missing values into the interval [0,1], and second by replacing any missing values of pixels for which HCHO retrievals were successful by values from the ISCCP D2 cloud fraction climatology. (2) [AMFCloudPressure](#) contains the cloud top pressure (in hPa), with any missing values for pixels of successful HCHO retrievals replaced by ISCCP D2 cloud pressure climatological values. As the names of the data fields suggest, they have been used in the calculation of the HCHO air mass factor. It must be emphasized that the information on cloud parameters included with the OMHCHO product is not identical to the original OMCLDO2 product, and that it may not be used for independent cloud studies. The data fields are mainly provided to facilitate cloud screening of the HCHO columns.

Preliminary Validation

Several validation activities for the OMI HCHO product are ongoing. These include comparisons with other satellite instruments (GOME and SCIAMACHY) and ground-based measurements, as well as comparisons with chemical transport models (GEOS-Chem). At present, preliminary results from satellite comparisons are available.

Direct comparisons with GOME data products are difficult since HCHO retrievals from GOME are no longer reliable due to the advanced degradation of the GOME instrument. SCIAMACHY data on the other hand are strongly influenced by instrument artifacts that render the retrieval of HCHO challenging. However, vertical columns of $\sim 2\text{-}3 \cdot 10^{16}$ mol/cm² retrieved from OMI over regions of enhanced formaldehyde (for example, the Ozarks in the U.S.) are in reasonable agreement with what has been observed from GOME in the past and is currently retrieved by SCIAMACHY. The comparisons have shown OMI columns over such hot-spots to be about 30% lower than GOME and SCIAMACHY. All three sensors retrieve similar background values of $\sim 2\text{-}4 \cdot 10^{15}$ mol/cm².

Which Data Should Be Used?

Each SAO standard data product (BrO, HCHO, OClO) contains the data field [MainDataQualityFlag](#) to aid the user in the selection of which data to use and which to avoid. Each ground pixel is assigned a value, the range and classification of which are as follows:

Value	Classification	Rationale
0	Good	Column value present and passes all quality checks; data may be used with confidence.
1	Suspect	Caution advised because one or more of the following conditions are present: <ul style="list-style-type: none"> FitConvergenceFlag is < 300 (but > 0): convergence at noise level Column+2σ uncertainty < 0 (but Column+3σ uncertainty \geq 0) Absolute column value > MaximumColumnAmount ($1 \cdot 10^{19}$ mol/cm²)
2	Bad	Avoid using data because one or more of the following conditions are present: <ul style="list-style-type: none"> FitConvergenceFlag is < 0: abnormal termination, no convergence Column+3σ uncertainty < 0
≤ -1	Missing	No column values have been computed; entries are missing

Product Description

A 2600 km wide OMI swath contains 60 cross-track pixels, ranging in size from 14x24 km² (along x across track) in the center of the swath to about 28x150 km² at the edges of the swath (median: 15x33 km²). The pixels on the swath are not symmetrically aligned on the line perpendicular to the orbital plane. However, the latitude and longitude provided with each pixel represents the location of each pixel on the ground to a fraction of a pixel.

The OMHCHO product is written as [HDF-EOS5](#) swath file. A single OMHCHO file contains information retrieved from each OMI pixel over the sun-lit portion of the orbit (a.k.a. an *OMI granule*). The information provided in these files include: Geodetic longitude and latitude, solar and line-of-sight zenith and azimuth angles, total column HCHO with RMS and 1 σ fitting uncertainties, longitude and latitude corner coordinates for each OMI pixel, and a range of ancillary parameters that provide information to assess data quality. Average values over an OMI granule for the HCHO total column, uncertainties, and RMS, as well as the percent values of “good” (converged and columns positive within 2 σ fitting uncertainties) and “bad” (failed convergence or truly negative columns) provide general, granule-based information on data quality. For a complete list of data fields and their description, please read the file specifications [OMHCHO.fs](#) or see the [File Specification README](#).

OMHCHO data are publicly available from NASA's [OMI/Aura Data Products Web Page](#) (GES-DISC). Also, subsets of these data over many ground stations and along Aura validation aircraft flight paths are available through the [Aura Validation Data Center](#) (AVDC) website to those investigators who are associated with the various Aura science teams.

For questions and comments related to the OMHCHO dataset please contact [Thomas P. Kurosu](#). Please send a copy of your e-mail to [Kelly Chance](#), who has the overall responsibility for this product.

Summary of Algorithm Fitting Specifics

Fitting window	327.5 – 356.5 nm
Baseline polynomial	3 rd order
Scaling polynomial	3 rd order
Instrument slit function	Hyper-parameterization of pre-flight measurements
Wavelength calibration	Spectral shift (no squeeze)
Solar reference spectrum	Kurucz, 1995
HCHO cross sections	Cantrell <i>et al.</i> , 1990; 300K
O ₃ cross sections	Malicet <i>et al.</i> , 1995; 228K
NO ₂ cross sections	Vandaele <i>et al.</i> , 1998; 220K
BrO cross section	Wilmouth <i>et al.</i> , 1999; 228K
Molecular Ring cross sections	Chance and Spurr, 1997
Sampling correction	Computed on-line
Residual common mode spectrum	Computed on-line

Selected List of Elements in an OMHCHO Output File

The tables below show a selected list of data elements in an OMHCHO HDF-EOS5 output file. The tables are divided into (a) *Swath Dimensions*, (b) *Geolocation Fields*, and (c) *Data Fields*. The selection of the listed *Geolocation* and *Data Fields* is entirely arbitrary and made solely to facilitate the identification of what is assumed will be the most-used parameters from the OMHCHO data product. No such distinction is made in the HDF-EOS5 product file itself. Naturally, whether or not any part of the product is of interest ultimately depends on the application. For a complete list of fields please refer to [OMSAO_FileSpecifications_README.pdf](#).

(a) Swath Dimensions

Field Name	Field Type	Description
nTimes	HEST_NATIVE_INT	Number of swath lines in an OMI granule (usually about 1650)
nXtrack	HEST_NATIVE_INT	Number of cross-track positions in a swath line (usually 30 or 60)
nUTCdim	HEST_NATIVE_INT	Number of elements in a single <i>TimeUTC</i> field entry (6)

(b) Geolocation Fields of prime interest

Field Name	Field Type	Dimensions	Description
Latitude	HEST_NATIVE_FLOAT	nXtrack,nTimes	Geodetic latitude [deg] at the center of the ground pixel
Longitude	HEST_NATIVE_FLOAT	nXtrack,nTimes	Geodetic longitude [deg] at the center of the ground pixel
SolarZenithAngle		nXtrack,nTimes	The solar zenith angle [deg] at the center of the ground pixel
TimeUTC	HEST_NATIVE_INT16	nUTCdim,nTimes	UTC value of the TAI93 time. The 6 different elements of the UTC string YYYY-MM-DD hh:mm are stored in the 6 arrays positions.
ViewingZenithAngle	HEST_NATIVE_FLOAT	nXtrack,nTimes	The viewing zenith angle [deg] at the center of the ground pixel

(c) Data Fields of prime interest

Field Name	Field Type	Dimensions	Description
AirMassFactor	HEST_NATIVE_DOUBLE	nXtrack,nTimes	Molecule specific air mass factor for each ground pixel, including scattering weights, clouds, and vertical distribution of HCHO
AMFCloudFraction	HEST_NATIVE_FLOAT	nXtrack,nTimes	Cloud fraction from external cloud ESDT, adjusted such that it falls within the range of [0, 1]
AMFCloudPressure	HEST_NATIVE_FLOAT	nXtrack,nTimes	Cloud pressure from external cloud ESDT, internally adjusted such that it falls within the range AMF table cloud pressure variable range of [0, 900]
ColumnAmount	HEST_NATIVE_DOUBLE	nXtrack,nTimes	Total column amount [mol/cm ²] for each ground pixel
ColumnUncertainty	HEST_NATIVE_DOUBLE	nXtrack,nTimes	Total column amount uncertainty [mol/cm ²] for each ground pixel
MainDataQualityFlag	HEST_NATIVE_INT16	nXtrack,nTimes	Main flag to indicate data quality (see above)
PixelCornerLatitudes	HEST_NATIVE_FLOAT	nXtrack+1,nTimes+1	The geodetic latitudes [deg] of the corner coordinates of the OMI ground pixels.
PixelCornerLongitudes	HEST_NATIVE_FLOAT	nXtrack+1,nTimes+1	The geodetic longitudes [deg] of the corner coordinates of the OMI ground pixels.

References

[OMI Algorithm Theoretical Basis Document, Volume IV, OMI Trace Gas Algorithms, OMI-ATBD-VOL4, ATBD-OMI-04, Version 2.0, August 2002.](#)

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