MOPITT V6 Level 2 Data Quality Summary

The following information applies to MOPITT Level 2 (L2) data, Version 6 (V6; L2V16.2.x)
August, 2013

Further details on MOPITT Data Quality and recommended analysis methods may be found in the updated V6 User's Guide, which is available at the MOPITT Publications page. Users may also need to consult the V5 and/or V4 User's Guide.

Several significant retrieval algorithm and product format changes have been introduced in the V6 product. Details can be found in the V6 User's Guide. A bias in the geolocation data (latitude and longitude values) contained in previous MOPITT products has been corrected in V6. Meteorological data required for Level 2 processing (specifically, water vapor and temperature profiles, and surface skin temperature) is now based on the MERRA reanalysis product instead of NCEP. A priori profiles for CO for V6 are based on a new climatology based on the CAM-Chem chemical transport model for the years 2000-2009. The a priori CO total column has been added to the V6 Level 2 files; otherwise the content of the V6 files is the same as V5. **However, the format of the V6 Level 2 files is now HDF-EOS5, which is fundamentally different than the format of previous MOPITT products. This format change will require users of previous MOPITT products to adapt the code they use for reading the contents of MOPITT Level 2 data files. An example IDL script demonstrating the required commands to read the contents of the new V6 files is available on the Data Products page and is included as an appendix in the V6 User's Guide.**

CO Retrieval Products

Three different types of Level 2 products are available based on different subsets of the MOPITT calibrated radiances. The format and variables contained in these files are identical.

The V6 Level 2 products include:

- A **TIR-only** product, similar to the MOPITT V4 product and V5 TIR-only product. *Example filename: MOP02T-20010101-L2V16.2.1.he5.*
- A **NIR-only** product, similar to the MOPITT V5 NIR-only product and qualitatively similar to the ENVISAT SCIAMACHY CO product. This dataset is produced only for daytime observations over land. This product exhibits relatively large random errors and may require significant spatial and/or temporal averaging. *Example filename: MOP02N-20010101-L2V16.2.2.he5*.
- A **TIR/NIR** product, featuring the maximum sensitivity to near-surface CO. In this product, information from the NIR channels is exploited only in daytime observations over land. This product exhibits relatively large random errors and may require significant spatial and/or temporal averaging. *Example filename: MOP02J-20010101-L2V16.2.3.he5*.

Carbon monoxide (CO) mixing ratio profiles are retrieved on the 9 standard MOPITT pressure levels: 900, 800, 700, 600, 500, 400, 300, 200, and 100 hPa, and at the surface, for clear sky measurements. Retrieved CO total columns are calculated by integrating the retrieved mixing ratio profile and are not retrieved independently. The horizontal footprint of each MOPITT retrieval is 22 km by 22 km at nadir. The contents of the Level 2 (MOP02) files are provided in the V6 User's Guide.

For V6 products, as well as for V5 products, each retrieval 'level' corresponds to a uniformly-weighted layer immediately above that level. For example, the V6 surface-level retrieval product corresponds to the mean volume mixing ratio over the layer between the surface and 900 hPa. This association is different than it was for V4 products.

Estimated errors

For CO vertical profiles, estimated errors are available in the error field (2nd element) of the "Retrieved CO Mixing Ratio Profile" and "Retrieved CO Surface Mixing Ratio" variables of the MOP02 files. These values represent the cumulative error from smoothing error, model parameter error, forward model error, geophysical noise, and instrumental noise.

Missing data when surface pressure < 900 mb

For the 'standard' case (p_sfc > 900 mb), there are 10 valid levels in the retrieved profile (including the surface-level retrieval), and the Retrieval Averaging Kernel Matrix A (provided in the Level 2 product) is a 10 by 10 matrix.

For the case where 800 mb < p_sfc < 900 mb, the surface level moves to the second row and column of A. In this case, the first row and column of A is populated by the value 0. For cases where there are even more missing levels (e.g., p_sfc < 800 mb), the surface level always skips down to replace the missing level closest to p_sfc.

For the vertical profile mixing ratios, the values at the standard retrieval levels that are greater than the surface pressure will be reported as "nodata" (-9999).

Cloud detection

MOPITT retrievals are only performed for clear-sky observations. The presence or absence of clouds in a particular MOPITT observation is determined using a combination of information from MOPITT's thermal-channel radiances and the MODIS Cloud Mask. A "Cloud Description" flag is provided in the MOPITT Level 2 product describing the basis of clear/cloudy determination for each retrieval.

Cloud Description Value -> Basis of Clear-sky Determination

1 -> MOPITT clear / MODIS unused

2 -> MOPITT clear / MODIS clear

3 -> MOPITT cloudy / MODIS clear

4 -> MOPITT clear / MODIS 'low clouds'

5 -> High latitude, MOPITT unused / MODIS clear

More detailed information regarding the MODIS cloud mask values corresponding to each MOPITT pixel are contained in the “MODIS Cloud Diagnostics” vector in the L2 product files (see below).

Data Interpretation

Averaging Kernels: Averaging kernels indicate the sensitivity of the retrievals to different levels of the atmosphere, and must be examined in order to properly interpret the retrieved data. For V6 (and both V4 and V5), the "Retrieval Averaging Kernel Matrix" is provided for each retrieval. Details on properly applying the retrieval averaging kernels are included in the V4 and V5 User's Guides.

High latitude data: Retrievals south of 65S and north of 65N should be used with caution, because of potential problems with cloud detection and due to difficulties in performing retrievals over very cold surfaces. Moreover, TIR-only and TIR/NIR retrievals in these regions tend to have low information content as quantified by the "Degrees of Freedom for Signal" diagnostic because of poor thermal contrast conditions.

Day-Night and Land-Ocean differences: Due to the sensitivity of the MOPITT radiances to surface temperature, differences between day and night may appear in retrievals over land. This effect can be identified through analysis of the retrieval averaging kernels. At land-ocean boundaries, similar differences may be seen. These differences are the result of radiative transfer effects (e.g., thermal contrast variability) and should not be interpreted as changes in the atmospheric concentration of CO.

Validation

Currently, the V6 product is considered unvalidated, since validation results have not yet been published. Validation studies are underway in which MOPITT CO mixing ratios will be validated with numerous aircraft profiles measured by NOAA/ESRL, as well as with datasets from field campaigns including HIPPO. A manuscript documenting the validation results for the V6 product will be prepared and submitted for publication.

CO Retrieval Diagnostics

V6 diagnostics (introduced in earlier MOPITT products) include

- 'RetrievalErrorCovarianceMatrix': For each retrieval, a floating point array (10 x 10) containing the a posteriori covariance matrix in base-10 log(VMR).
- 'SurfaceIndex': For each retrieval, an integer equal to 0 for open water (oceans, seas and large lakes), 1 for land, and 2 for mixed (e.g., coastline).
- 'CloudDescription': For each retrieval, an integer describing the results of the MOPITT cloud detection algorithm, as described above.
- 'RetrievalAveragingKernelMatrix': For each retrieval, a floating point array (10 x 10) containing the matrix describing the sensitivity of the retrieved CO profile to the true CO profile.
- 'DegreesofFreedomforSignal': For each retrieval, a floating point value describing the number of pieces of independent information in the retrieval, equal to the trace of the averaging kernel matrix.
- 'Level1RadiancesandErrors': For each retrieval, a floating point array (2 x 12) containing the L1 radiances and corresponding radiance uncertainties. Radiance sequence is 7A, 3A, 1A, 5A, 7D,

3D, 1D, 5D, 2A, 6A, 2D, 6D. Radiances and uncertainties are in units of W/(m^2Sr).

- 'DEMAltitude': Altitude of retrieval in m.
- 'SwathIndex': For each retrieval, a three-element integer vector containing the unique 'pixel' (varies from 1 to 4), 'stare' (varies from 1 to 29), and 'track' indices.
- 'MODISCloudDiagnostics': For each retrieval, a ten-element floating point vector containing a variety of MODIS cloud mask statistics, as follows.

element -> diagnostic
(1) Number of "determined" MODIS pixels
(2) Fraction of cloudy MODIS pixels
(3) Fraction of clear MODIS pixels
(4) Average value of "sun glint" MODIS flag
(5) Average value of "snow/ice background" MODIS flag
(6) Average value of "non-cloud obstruction" MODIS flag
(7) Average value of "IR threshold test" MODIS flag
(8) Average value of "IR temperature difference tests" MODIS flag
(9) Average value of "visible reflectance test" MODIS flag
(10) Fraction of "determined" MODIS pixels .

Methane Retrieval Products

Methane (CH_4) retrievals are not available in this data version.