
The following information applies to MOPITT level 2 (L2) data, Version 5 (V5; L2V10.0 or higher)
March, 2011

Further details on MOPITT Data Quality (and recommended analysis methods) may be found in the updated [V5 User's Guide](#) (PDF), which is available at the [MOPITT Publications page](#). Users may also need to consult the [V4 User's Guide](#) (PDF).

CO Retrieval Products

In contrast to previous MOPITT retrieval products, which were exclusively based on thermal-infrared (TIR) observations, three different V5 products based on different subsets of the MOPITT observations are available. The contents of the MOP02 HDF files for the three different products share a common format.

The Level 2 V5 products include:

- A **TIR-only** product, similar to the MOPITT V4 product. This product will initially be released as 'provisionally validated.' Compared to V4, this product offers improved long-term stability and more accurately accounts for random errors due to geophysical noise. (Example filename: MOP02T-20091230-L2V10.0.1.prov.hdf .)
- A new near-infrared **NIR-only** product, qualitatively similar to the ENVISAT SCIAMACHY CO product. This 'beta' product will be available only for daytime observations over land. **Users should be very cautious in using this product, and are encouraged to collaborate with MOPITT science team members to exploit it properly. Compared to earlier TIR-based MOPITT products, this product exhibits larger random errors and may require significant spatial and/or temporal averaging.** (Example filename: MOP02N-20091230-L2V10.0.2.beta.hdf).
- A new joint (multispectral) **TIR/NIR** product, featuring the maximum sensitivity to near-surface CO. In this 'beta' product, information from the NIR channels is limited to daytime observations over land. **Users should be very cautious in using this product, and are encouraged to collaborate with MOPITT science team members to exploit it properly. Compared to earlier TIR-based MOPITT products, this product exhibits larger random errors and may require significant spatial and/or temporal averaging.** (Example filename: MOP02J-20091230-L2V10.0.3.beta.hdf).

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 V5 User's Guide available from the MOPITT website.

The new V5 products will employ the same 10-level retrieval grid used for V4, but the association between retrieval levels and atmospheric layers has been modified. Specifically, for V5 products, each retrieval 'level' corresponds to a uniformly-weighted layer immediately above that level. For example, the V5 surface-level retrieval product corresponds to the mean volume mixing ratio over the layer between the surface and 900 hPa. Quantitatively, this change may be important when comparing MOPITT products to model output or *in-situ* data exhibiting strong vertical gradients in the CO profile.

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 instrument noise.

Missing data when surface pressure < 900 mb

For the 'standard' case ($p_{\text{sfc}} > 900$ 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 $800 \text{ mb} < p_{\text{sfc}} < 900$ 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., $p_{\text{sfc}} < 800$ 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 radiances and the MODIS Cloud Mask. A "Cloud Description" flag is provided in MOPITT level-2 products for each pixel. When both MOPITT radiances and MODIS cloud mask are used and agree the Cloud Description is 2. When MODIS cloud mask states clear for a pixel and MOPITT radiances indicate cloudy the pixel is treated as clear and the Cloud Description is 3. In the case that MODIS cloud mask is not available, only MOPITT radiances are used. Cloud Description is 0 if both MOPITT thermal and solar channels are used for cloud detection, and 1 if only thermal radiances are used. Poleward of 65N/S only MODIS cloud mask is used and the Cloud Description is 5. More detailed information regarding the MODIS cloud mask values corresponding to each MOPITT pixel are contained in the new "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 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 icy 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 should not be interpreted as changes in the atmospheric concentration of CO₂, but are due solely to the change in sensitivity of the measurement over different surfaces.

Validation

MOPITT CO mixing ratios have been validated with numerous aircraft profiles measured by NOAA/ESRL, as well as with datasets from many field campaigns.

CO Retrieval Diagnostics

For V5 products, additional diagnostics have been included to permit more detailed analyses of the data. New V5 diagnostics include:

- 'Retrieval Error Covariance Matrix': For each retrieval, a floating point array (10 x 10) containing the a posteriori covariance matrix in base-10 log(VMR).
- 'Level 1 Radiances and Errors': 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/(m²Sr).
- 'DEM Altitude': Altitude of retrieval in m.
- 'MODIS Cloud Diagnostics': 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 .

- 'Swath Index': 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.

Existing diagnostics (introduced in earlier MOPITT products) include:

- 'Surface Index': 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).
- 'Cloud Description': For each retrieval, an integer describing the results of the MOPITT cloud detection algorithm, as described above.
- 'Retrieval Averaging Kernel Matrix': 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.

- 'Degrees of Freedom for Signal': 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.

Methane Products

Methane (CH₄) retrievals are not available in this data version.

