Clear-Sky Performance of MOPITT Retrievals Using MODIS Collection 6 Cloud Mask Products

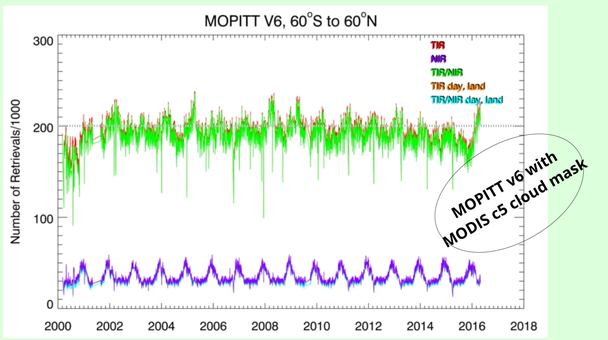
Sara Martínez-Alonso, Merritt N. Deeter, Helen M. Worden, Debbie Mao, and The MOPITT Team
National Center for Atmospheric Research, Boulder, CO, USA

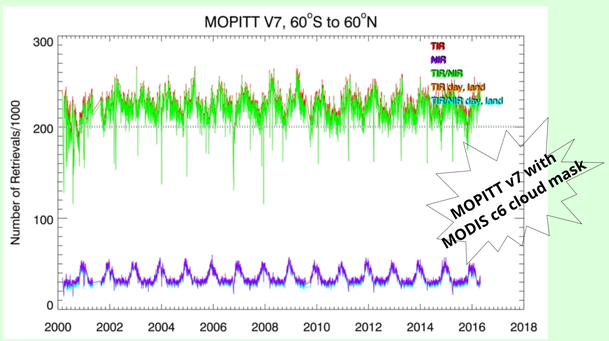
ABSTRACT

We describe improvements in the latest version of MOPITT carbon monoxide (CO) products (v7) to be released in Summer 2016. This will be the first full MOPITT release to utilize MODIS Cloud Mask products from Collection 6 (c6).

There has been a sizable increase (~15%) in the number of MOPITT v7 CO retrievals respect to v6.

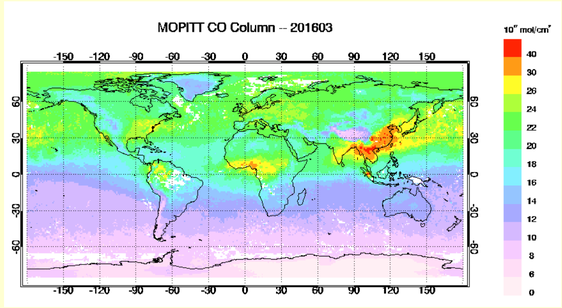
A decreasing trend in the number of MOPITT v6 retrievals since ~2010 (traceable to an issue with MODIS Band 29 resulting in false cloud detections) has been corrected in v7.



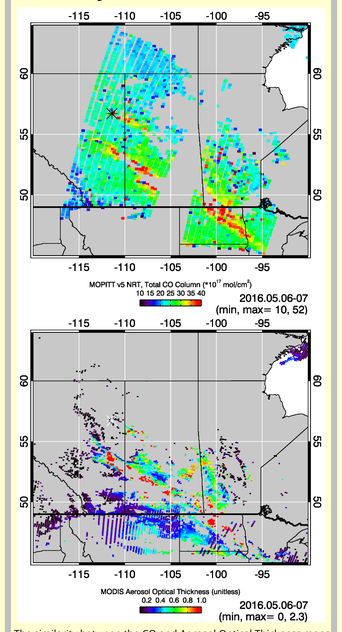


MOPITT MEASUREMENTS

- Measurements Of Pollution In The Troposphere
- on board NASA's EOS-Terra satellite
- 2000-present; longest global CO record to date
- global coverage every ~3 days
- each MOPITT retrieval represents a surface area of ~22x22km^2
- CO retrievals are only performed for cloud-free measurements
- three retrieval configurations: thermal infrared-only (TIR), near infrared-only (NIR), and a unique multispectral product (TIR/NIR) that has enhanced sensitivity to CO near the surface [1]
- products: total CO column, vertical CO profiles, surface CO



The Fort McMurray fire as seen by MOPITT and MODIS



The similarity between the CO and Aerosol Optical Thickness maps is quite obvious. The fire plume originates near Fort McMurray, Canada (shown with an asterisk) and extends mostly southeast for more than 1600 km, crossing state and country boundaries.

MOPITT v7 UPDATES

Updates to the V7 retrieval products [2] include:

- Improved **cloud detection**
  - MODIS c6 cloud mask files are used for processing the entire MOPITT mission
  - a new clear class ("6") is assigned to ocean observations identified as clear by MOPITT and cloudy (but not due to low clouds) by MODIS; such MOPITT observations were previously considered cloudy and thus discarded
- Improved **radiative transfer modeling**
  - the model now accounts for the steady growth of atmospheric N_2O concentrations over the MOPITT mission
  - the operational radiative transfer model has also been updated with the HITRAN 2012 spectral database
- Improved **meteorological fields** used in Level 2 processing
  - temperature and water vapor profiles as well as a priori surface temperature values from the recently released MERRA-2 product (versus MERRA, NCEP used in previous MOPITT versions)
- Globally **optimized retrieval biases** determined by minimizing observed retrieval biases at 400 and 800 hPa as determined using in-situ CO profiles from:
  - the 'HIPPO' (HIAPER Pole to Pole Observations) field campaign for NIR radiances
  - the NOAA aircraft profile set for TIR radiances

MOPITT CLOUD MASK

STEP #1
For each MOPITT track: Find the MODIS pixel closest to the center of the track ("MODIS central")

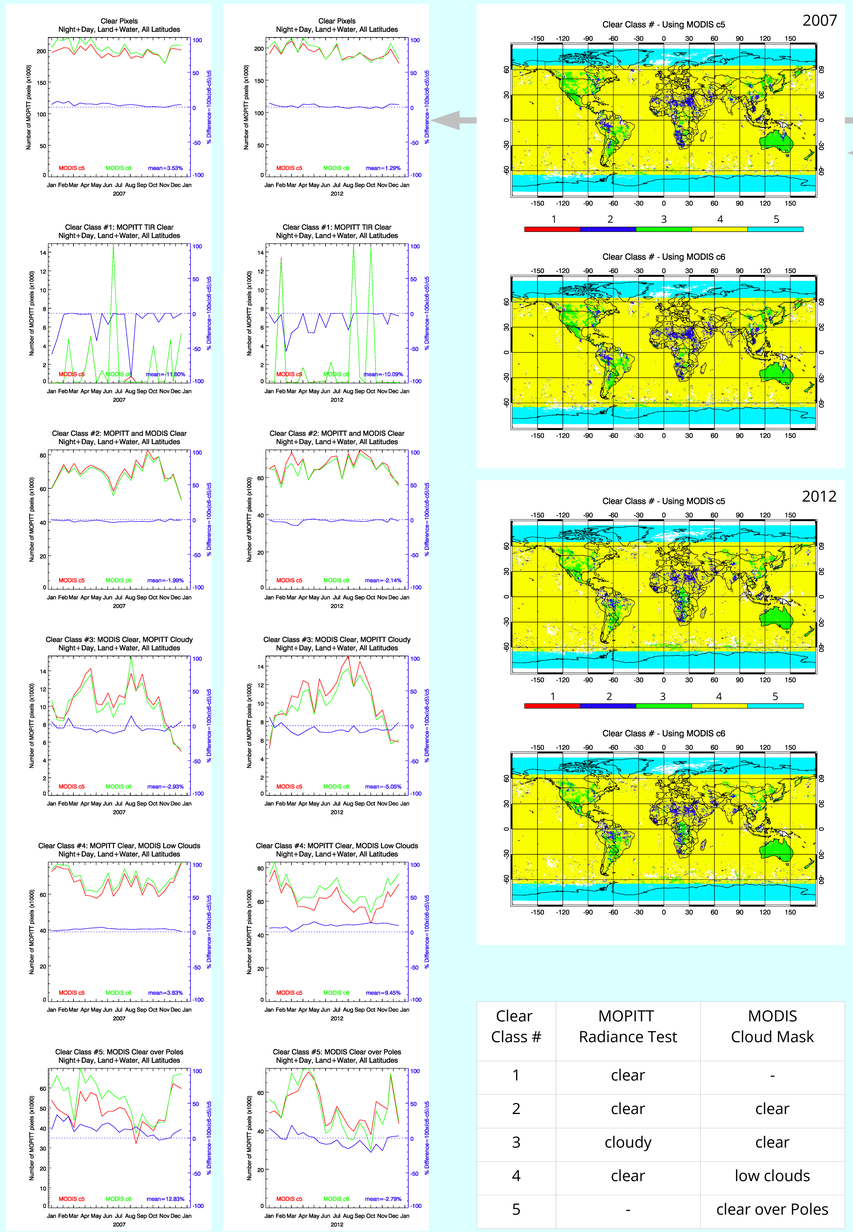
STEP #2
MODIS pixels are assigned to each MOPITT pixel using a fix set of indices relative to "MODIS central"

STEP #3
The statistics of relevant MODIS cloud parameters are derived for each MOPITT pixel. Resulting MODIS Cloud Diagnostics are included in the archived MOPITT files

MOPITT pixel has ≤5% areal cloud coverage?

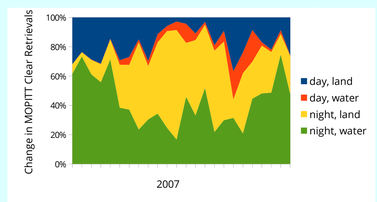
- no → Reject MOPITT pixel
- yes → Accept MOPITT pixel → L2 PROCESSOR ⇒ CO retrieval

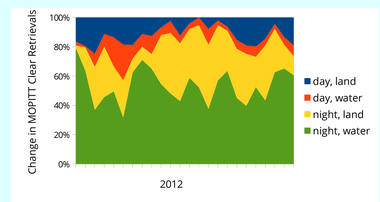
IMPACT OF MODIS CLOUD PRODUCT (c5 vs c6) IN MOPITT RETRIEVALS



The **number of MOPITT clear retrievals** resulting from using either c5 or c6 MODIS cloud mask products are compared here. This test utilizes TIR (Thermal InfraRed) products from the last released MOPITT version (v6) for selected dates in 2007 and 2012:

- the number of retrievals has increased globally by <4% (<3% between -60°N and 60°N)
- clear class type assignments have remained, overall, unchanged
- most changes occur for night observations over water or land; this is consistent with enhanced detection of low-level water-phase clouds and transmissive cirrus due to improvements to the MODIS c6 nighttime Brightness Temperature Difference Test [3]

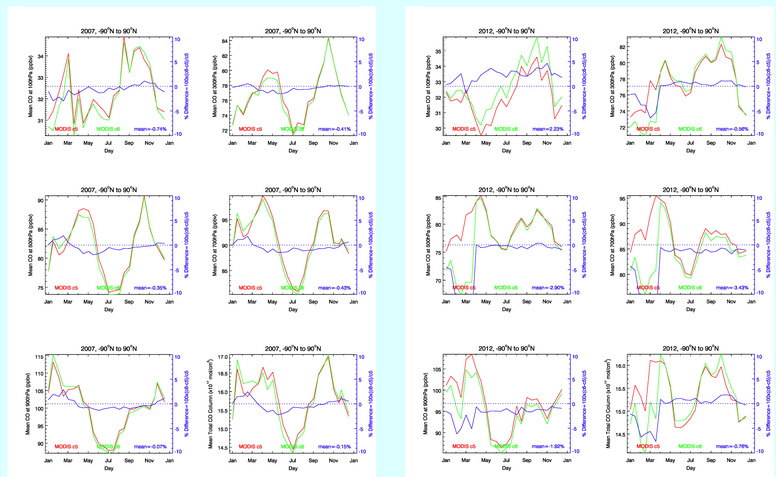




- the large increase (~15%) in number of MOPITT v7 clear retrievals respect to v6 cannot be explained by the use of MODIS cloud mask c6 alone. The new clear class "6" may explain this as well as the removal of a decreasing trend in the number of MOPITT v6 retrievals since ~2010

Clear Class #	MOPITT Radiance Test	MODIS Cloud Mask
1	clear	-
2	clear	clear
3	cloudy	clear
4	clear	low clouds
5	-	clear over Poles

MOPITT v6 TIR CO values were analyzed to investigate possible effects of using either c5 or c6 MODIS cloud mask products in the retrieval process. The resulting CO retrievals differ in average between -3% and +2%, well below the instrument's 10% detection limit.



REFERENCES

[1] Worden, H. M. et al. (2010), Observations of near-surface CO from space using MOPITT multispectral retrievals, JGR Atmospheres, 115(d14), 18314, doi:10.1029/2010JD014242.

[2] Deeter, M.N (2016), MOPITT V7 Product User's Guide.

[3] Baum et al. (2012), MODIS Cloud-Top Property Refinements for Collection 6, JAMC, 51, 1145-1163, doi:10.1175/JAMC-D-11-0203.1.