A NASA cloud pressure algorithm based on the O2-O2 absorption band at 477 nm

Eun-Su Yang1, Alexander Vasilkov1, Joanna Joiner2, Sergey Marchenko1, Nickolay Krotkov2, David Haffner1, Pawan K. Bhartia2

2. NASA Goddard Space Flight Center, Greenbelt, MD

Abstract

There are two operational OMI cloud algorithms: OMCLDRR (developed by the NASA GSFC) based on rotational-Raman scattering (RRS) that uses the OMI UV-2 channel and OMCLDO2 (developed by KNMI) based on O2-O2 absorption in the OMI Vis channel. We discuss a NASA algorithm that retrieves effective cloud pressure (a.k.a. cloud optical centroid pressure) from O2-O2 absorption at 477 nm, intended for use in NASA algorithms including the upcoming TEMPO geostationary mission. This algorithm uses temperature-dependent O2-O2 cross-sections and incorporates a new spectral fitting technique. The fitting procedure derives O2-O2 slant column densities (SCD) using retrieved O3, NO2 and H2O slant column estimates from independent algorithms (OMDOAO3 and OMNO2SCD). The algorithm utilizes the common Mixed Lambert-Equivalent Reflectivity (MLER) concept. Effective cloud fraction (ECF) is calculated at 466 nm with the minimum interference from RRS and ozone absorption. The optical centroid pressure (OCP) is derived from a match of the measured SCD to that calculated with the MLER method. Temperature profiles needed for computation of vertical column densities are retrieved from the OMI model. We investigate interpolation errors due to the selection of interpolation nodes and effects of temperature profiles on the retrieved cloud pressure. The NASA ECFs and OCPs are compared with the operational OMCLDO2 data for different cloud fraction bins. We compare OCP retrievals derived for low CRF (over aerosol polluted and non-polluted areas) and analyze the cross-track dependence of ECF and OCP.

Approach

- Latest temperature-dependent absorption cross-sections of O2-O2 collision pairs (Thalman & Volkamer, 2013)
- New spectral fitting technique (Marchenko et al., 2015). The fitting procedure derives O2-O2 slant column densities (SCD) using retrieved O3, NO2 and H2O slant column estimates from independent algorithms.
- The Mixed Lambert-Equivalent Reflectivity (MLER) method with cloud reflectivity of 0.8. Effective cloud fraction (ECF) is calculated at 466 nm with the minimum interference from RRS and ozone absorption.
- The optical centroid pressure (OCP) is derived from a match of the measured SCD to that calculated with MLER:

\[
\text{OCP}_{\text{MLER}} = \text{AMF}_{\text{cloud}}(1 - f_c) + \text{AMF}_{\text{cloud}}f_c
\]

where VCD is the vertical column density, \(f_c\) is the cloud radiance fraction, AMFs are calculated at 477 nm, \(\text{AMF}_{\text{cloud}}\) depends on OCP and therefore allows deriving OCP.
- Temperature profiles for computation of VCD and surface pressures are taken from the GMI model.
- Lookup tables of TOA radiances and AMFs are generated with VLIDORT.

Reduction of interpolation errors

Increased number of LUT nodes

Comparison of ECF with OMCLDO2

Comparison of OCPs derived with NASA SCD and KNMI SCD

Comparison of NASA SCD with KNMI SCD

Comparison of OCPs with OMCLDO2

Using SCDs from OMCLDO2

Sensitivity of VCD to T profiles

Sensitivity of AMF to O2-O2 X-sections and T profiles

Conclusions

- There is a good agreement between NASA ECFs (466 nm) and those from OMCLDO2 (477 nm).
- NASA ECFs agree with OMCLDO2 at large ECFs.
- NASA OCPs are noticeably higher than those from OMCLDO2 at low ECFs. OCPs from the NASA algorithm get closer to the surface pressure.
- To account for the OCP dependence on temperature profile, a GMI climatology of ToA radiances and AMFs is calculated at 477 nm, AMF_{cloud} depends on OCP and therefore allows deriving OCP.

References.

- S. Marchenko et al. Revising the slant column density retrieval of nitrogen dioxide observed by the Ozone Monitoring Instrument, IGR, 120, 5670-5692, 2015.

Acknowledgments. The authors acknowledge support through NASA.