Validation of Sentinel-5p retrieved cloud height data using ground-based radar/lidar measurements from the CLOUDNET network

Steven Compernolle1, Athina Argyrouli2, Ronny Lutz2, Maarten Sneep3, José Granville1, Daan Hubert1, Arno Keppens1, Tijl Verhoelst1, Ann Mari Fjaeraa4, Diego Loyola2, Ewan O’Connor5, and Jean-Christopher Lambert1

1Royal Belgian Institute for Space Aeronomy, synergistic exploitation of atmospheric data, Brussels, Belgium (steven.compernolle@aeronomie.be)
2German Aerospace Center (DLR), Oberpfaffenhofen, Germany
3Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands
4Norwegian Institute for Air Research (NILU), Kjeller, Norway
5University of Reading, Department of Meteorology, Reading, United Kingdom

Satellite measurements of tropospheric or total column trace gas species, including those from Sentinel-5p TROPOMI, are affected by the presence of clouds. Therefore, cloud data products retrieved with the same sensor play an essential role, as they allow the data provider to take an estimated cloud impact on the trace gas retrieval into account. Examples are the modification of the radiative transfer and associated quantities such as the air mass factor, and the partial masking of the measurement scene. Evidently, the accuracy of these corrections relies on the accuracy of the retrieved cloud properties, like radiometric cloud fraction (CF), cloud top height (CTH) or cloud height (CH), and cloud optical thickness (COT) or cloud albedo (CA).

We consider here three S5p TROPOMI-based cloud products: (i) L2_CLOUD OCRA/ROCINN CAL (Optical Cloud Recognition Algorithm/Retrieval of Cloud Information using Neural Networks; Clouds-As-Layers), (ii) L2_CLOUD OCRA/ROCINN CRB (Clouds-as Reflecting Boundaries), and (iii) the S5p support product FRESCO-S (Fast Retrieval Scheme for Clouds from Oxygen absorption bands). These are input to the S5p operational processors for several trace gas products, including ozone columns and profile, total and tropospheric NO2, formaldehyde, sulfur dioxide. The quality assessment of these cloud products is carried out within the framework of ESA’s Sentinel-5p Mission Performance Centre (MPC) with support from AO validation projects focusing on the respective trace gases.

In this work, cloud height (from S5p CLOUD CRB and S5p FRESCO algorithms) and cloud top height (from S5p CLOUD CAL) S5p data is validated with radar/lidar-based cloud profile information from the ground-based networks CLOUDNET and ARM at 17 sites. For some sites the comparison is difficult due to e.g., orography or snow/ice cover. S5p and CLOUDNET report similar cloud height variations at several sites, and the correlation between the S5p cloud products and CLOUDNET can be high (Pearson R up to 0.9). However, there is a site-dependent negative bias of the S5p cloud (top) height with respect to the CLOUDNET data: up to -2.5 km for S5p CLOUD CAL cloud top
height and -1.5 km for S5p CLOUD CRB and S5p FRESCO cloud height. The dependence on other parameters measured by S5p and CLOUDNET (e.g., radiometric cloud fraction, cloud phase,...) is investigated.