Seminar on Physics and Chemistry of the Atmosphere 06.12.2024, WiSe 2024/2025, IUP Bremen

Extension of the S5P-TROPOMI CCD tropospheric ozone retrieval to middle latitudes

Swathi Maratt Satheesan, Kai-Uwe Eichmann, Mark Weber, and John P. Burrows

Institute for Environmental Physics, University of Bremen

Tropospheric ozone, a key atmospheric pollutant and greenhouse gas, shows significant spatio-temporal variability on seasonal, inter-annual, and decadal scales, posing challenges for satellite observation systems. Traditional methods like the Convective Cloud Differential (CCD) and Cloud Slicing Algorithms (CSA) are effective for Tropospheric Column Ozone (TCO) retrieval but are typically restricted to the tropical region (20°S-20°N). The CCD approach has been successful with satellite sensors like Aura OMI, MetOp GOME-2, and Sentinel-5 Precursor TROPOMI.

In this study, we present the first application of the CCD retrieval method outside the tropical region, introducing CHORA-CCD (Cloud Height Ozone Reference Algorithm-CCD) to retrieve TCO from TROPOMI in the mid-latitudes. The approach uses a local cloud reference sector (CLCD, CHORA-CCD Local Cloud Decision) to estimate the stratospheric (above-cloud) column ozone (ACCO), which is then subtracted from the total column under clear-sky scenes to determine TCO. This method minimises the impact of stratospheric ozone variations.

An iterative process automatically selects an optimal local cloud reference sector around each retrieval grid point, varying the radius from 60 to 600 km, to estimate the mean TCO. Due to the prevalence of low-level clouds in middle latitudes, the estimation of TCO is constrained to the column up to a reference altitude of 450 hPa. In cases where cloud-top heights in the local cloud sector are highly variable, an alternative approach is introduced to directly estimate the ACCO down to 450 hPa using Theil-Sen regression. This method allows for the combination of the CCD approach with the CSA. The algorithm dynamically selects between CCD and the Theil-Sen method for ACCO estimation based on an analysis of cloud characteristics. Additionally, the CLCD algorithm is optimised by incorporating a homogeneity criterion for total ozone, addressing potential inhomogeneities in stratospheric ozone.

Monthly averaged CLCD-TCOs for the time period from 2018 to 2022 were calculated from TROPOMI for the middle latitudes (60°S–60°N). Validation results, based on comparisons with collocated HEGIFTOM SHADOZ/WOUDC/NDACC ozonesondes from 32 stations, show good agreement with TCO retrievals at 450 hPa using the CLCD algorithm.

This study demonstrates the advantages of using a local cloud reference sector in mid-latitudes, providing valuable insights for the future systematic application of the method in geostationary satellite missions.