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Simulation study of synergetic retrieval for tropospheric ozone with UV, TIR, and MW measurements

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Tropospheric ozone, one of short-lived climate pollutants (SLCPs), plays an important role on climate change, atmospheric chemistry, and air quality. First, ozone acts a greenhouse gas, especially in the upper troposphere (UT) and its effect is the strongest near the tropopause where the climate system is more sensitive. Second, ozone in the planetary boundary layer (PBL) is known to be a major component of photochemical smog and causes severe damages the health of both plants and animals. Finally, ozone has an oxidizing capability to remove many pollutants (e.g., methane and carbon monoxide) from the atmosphere. In order to understand these processes of tropospheric ozone with the aid of numerical model calculations, it is essential to monitor the global distribution of tropospheric ozone with a fine vertical resolution. However, current available remote sensing instruments, which measure backscattered solar UV radiance (e.g., Aura/OMI) and thermal infrared emission (e.g., Aura/TES), cannot resolve tropospheric ozone alone.

For the purpose of improving the current capability of tropospheric ozone retrieval, we have proposed a new atmospheric remote sensing equipment named Air Pollution Observation (APOLLO) to be carried aboard the Japanese Experiment Module (JEM) on the International Space Station (ISS). APOLLO is planned to carry two nadir-viewing passive instruments (UV+VIS and TIR) and one limb-viewing microwave passive instrument (MW), which are dedicated to measure tropospheric ozone and its precursors relating to air quality with high spatial resolution (~2 km) and high vertical resolution (the requirement is to divide troposphere into three layers: UT, LT (lower troposphere), and PBL).

In this study, we investigate synergetic effect of combination of UV, TIR, and MW measurements on retrieval sensitivity of tropospheric ozone. We evaluate the retrieval sensitivity to tropospheric ozone profile with Optimal Estimation Method (OEM) [Rodgers, 2000]. Twenty atmospheric scenarios generated from a global-regional chemical transport model system are used as true profiles for this aim. The combination of UV and TIR measurements improves values of the degree of freedom for signal (DOFS) in PBL. MW limb measurements provide significant information on UT and the stratosphere. We find that adding MW limb measurements to UV+TIR measurements significantly improve values of DOFS in PBL, although MW limb measurements alone are not sensitive to PBL. We conclude that this is because UV+TIR measurements become more sensitive to PBL by adding MW limb measurements which can reduce the uncertainty of ozone concentration in UT compared with that from UV+TIR measurements.

Keywords: International Space Station, Tropospheric ozone, Multispectral observations