RECENT RESEARCH ACTIVITIES

Diurnal ozone variations in the stratosphere as revealed by SMILES measurements

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Since the discovery of the ozone hole, stratospheric ozone has been extensively investigated over the last 30 years; however, the global structure of diurnal variations in stratospheric ozone remains unclear, particularly for the lower to middle stratospheric ozone that mainly contributes to total column ozone.

Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) were launched in September 11, 2009 and attached to the Japanese Experiment Module (JEM) onboard the International Space Station (ISS). The SMILES achieved an exceptionally precise observation of atmospheric minor constituents (e.g., ozone) between October 2009 and April 2010. The resulting precision is one-order of magnitude better than that from many other satellite measurements. Also, SMILES can measure the atmosphere at different local times because of the non-Sun-synchronous ISS orbit.

By using the SMILES data, we, for the first time, observationally revealed the global pattern of diurnal ozone variations throughout the stratosphere (Figure 1) [1]. We found that the peak-to-peak difference in stratospheric ozone profiles (total column ozone) is up to 8% (1%) over the course of a day. In addition, these results were quantitatively reproduced by nudged chemistry-climate models. An analysis of the model output showed that the diurnal variations are due to dynamical processes (vertical transport by atmospheric tidal winds) as well as photochemical processes.

Our findings could lead to correct bias in satellite measurements that are caused by the difference in local time of measurements. In fact, we showed that the diurnal variations could explain the 'sunset-sunrise differences in ozone amount' reported in several solar occultation measurements (N.B. Solar occultation instruments make measurements only at sunrise and sunset) [2].

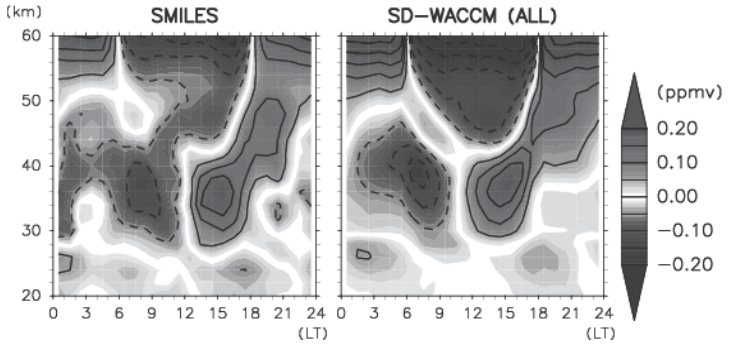

Figure 1. Local-time versus altitude distribution of diurnal ozone variations (ppmv) averaged between 10°S and 10°N, as derived from data by (left) SMILES observations and (right) chemical transport model simulations (SD-WACCM).

References

[1] Sakazaki, T., M. Fujiwara, C. Mitsuda, K. Imai, N. Manago, Y. Naito, T. Nakamura, H. Akiyoshi, D. Kinnison, T. Sano, M. Suzuki, and M. Shiotani, "Diurnal ozone variations in the stratosphere revealed in observations from the Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) on board the International Space Station (ISS)." *Journal of Geophysical Research*, 118, 2991-3006, doi:10.1002/jgrd.50220, 2013.

[2] Sakazaki, T., M. Shiotani, M. Suzuki, D. Kinnision, J. M. Zawodny, M. McHugh, and K. Walker, "Sunset-sunrise difference in solar occultation measurements (SAGE II, HALOE, and ACE-FTS) and its relationship to tidal vertical winds", *Atmos. Chem. Phys. Discuss.,* 14, pp. 16043-16083, 2014.