Evaluation of ozone column amount from the solar backscattering spectra measured with the Airborne-OPUS and error analysis

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Satellite observation is one of the best methods to monitor the increase of atmospheric pollutants, including tropospheric ozone, especially due to industrial activities in Asia. It is significant to investigate the satellite sensor and data processing algorithm for developing next generation monitoring system. The Airborne Ozone and Pollution measuring Ultraviolet Spectrometer (Airborne-OPUS) sensor was developed by JAXA/EORC to study the solar ultraviolet backscattering measurement of ozone, nitrogen dioxide, sulfur dioxide, and some other species from a satellite. In this study, we deduced slant column amounts of ozone from the Airborne-OPUS data during an aircraft observation, and estimated analytical errors.

The Airborne-OPUS, which consists of a compact spectrometer (Jobin-Yvon CP-200), thermoelectric-cooled CCD (SpectraVideo SV11C) and optics, measures backward-scattered ultraviolet spectra between 300 and 455 nm with a spectral resolution of 0.9 nm (FWHM) from an aircraft. In this study, the spectra between 315 and 325 nm, obtained during Pacific Exploration and Asia and Continental Emission phase-A campaign (Parrish et al., 2004) in January 2002, were analyzed to evaluate the ozone column amount. In this analysis, the absorption by ozone, the scattering by atmospheric molecules and the Ring effect were estimated from the ratios between the target spectra derived when the solar zenith angle (SZA) exceeded about 60ž and the reference spectra when SZA was minimum at the same day. The scattering by aerosols, surface albedo, and artificial continuous components were also included in this analysis as one continuum component. The absorption of SO2 and HCHO was estimated and found to be negligible. The slant column amounts of ozone were evaluated by the least-square fitting of calculated spectrum ratios to measured ones. The fitting calculation was optimized on the basis of Bayesian statistics.

The instrumental and analytical errors were also estimated for this data analysis. The shift of the measured spectra (between the target and reference spectra), probably caused by airplane vibration, and the error in the instrument function (spectral resolution of the spectrograph) are significant instrumental errors. The instrumental function was estimated from the Hg-lamp spectra measured just before the aircraft observation, considering the asymmetry of the instrumental function for the wavelength. In the spectral fitting, errors in the ozone absorption cross-section and the assumed profiles of the ozone density and atmospheric temperature can cause significant errors. As a validation of our observation, the evaluated slant column amounts of ozone are compared with those measured with the TOMS satellite sensor at the same day. Differences of the two measurements were significantly correlated from the shift of the measured spectra, and were about 5 % when the shift was small. We present the result of our analyses including the error analyses to discuss the sensor spec and other factors required for satellite monitoring of ozone.