SMILESが捉えた中層大気HO2ラジカルの増大とスプライト発生の相関性について

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Global distribution of HO2 enhancements derived from SMILES observation and correlation with sprite events

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Active radicals and ions are a trigger of chemical reaction chain in upper atmosphere. It has been pointed out that sprite discharge produces radicals and ions and modulates abundances of atmospheric compositions in upper atmosphere [e.g., Hikraki et al., 2008]. Hiraki et al. [2008] estimated that a significant enhancement of HO_2 amount (about one to four orders of magnitude) can be induced by a single sprite event in the upper atmosphere. The number of sprite events is obtained about 720 in a day in the global scale from the Imager of Sprite and Upper Atmosphere Lightning (ISUAL) experiment [Chen et al., 2008]. Our motivation is to verify how sprite events modulate the distribution of atmospheric compositions. In this study, we performed a survey of enhancements of HO_2 amount using global observations by the Superconducting Submillimeter-Wave Limb Emission Sounder (SMILES), and investigated their correlations with the distribution of sprite events.

SMILES observed HO_2 in the upper atmosphere during 12 October 2009 and 21 April 2010. The observation local time covers a full local time (0 - 24 h) with 1 - 2 months observations. The sensitivity of SMILES HO_2 observation at 649.701 GHz is one order magnitude better than past similar satellite observations; actually, the signal-to-noise (S/N) ratio of an average of three observed HO_2 spectra (0.47 s data integration per single spectrum), at tangent height of 72 +/- 2 km, is about three at midnight when HO_2 has a minimum abundance in its diurnal variation. The high sensitivity makes SMILES as the only one satellite observation which is able to detect 'single local event of HO_2 enhancement'.

Two strategies are considered for the detection of enhancement of HO_2 abundances caused by sprite events.

1. Statistical approach: Comparison of global distribution between enhanced HO_2 abundances and sprite events. Key issue is how to define the 'enhanced HO_2', because HO_2 has a strong diurnal variation (e.g., 0 - 6 ppbv at tangent height of 75 km) and it is difficult to estimate the background level. We used the specific time zone (local time between 0:00 and 5:00) that has less variation of HO_2 abundances than other time zone for taking probability distribution of the spectrum S/N ratios. We defined 'enhanced' HO_2 conditions when the spectrum S/N ratio is larger than three times of the standard deviation of the dataset at each region. we extracted the global distribution of the HO_2 enhancement. This global distribution of enhanced HO_2 was compared with the global distribution of occurrence rate of transient luminous events given by Chen et al. [2008]. We confirmed less HO_2 enhancement over the Sahara region, where is known as less lightning activity. However, distribution of HO_2 enhancement was not thoroughly coincident with areas that have high occurrence rates of lightning. We plan to get further precise criteria to define the 'enhancement of HO_2' from the fitting of the probability distribution function and use the time zone at which more lightning occurs.

2. Direct approach: Searching an air-mass, where sprite event happened and SMILES observed HO_2. We used ISUAL/FORMOSAT-2 satellite observation for the sprite detections. ISUAL CCD imager has been taking snap shots of lightning events in a limb-viewing geometry with a field-of-view of 20^o (horizontal) X 5^o (vertical). 127 most clear sprite events were detected during SMILES observation period/coverage. Coincidence between SMILES HO_2 observation (18000 points) and ISUAL sprite observation were taken, and two cases were obtained for the common air-mass, that both HO_2 observation and sprite observation were performed. One is the sprite observation at 04:28AM UTC 18 Nov 2009 at 6.7^oN/78.9^oE, another at 09:41AM UTC 14 Nov 2009 at 20.8^oN/159.7^oE. The intensity of HO_2 spectra at both of these two cases were significantly enhanced than that of background.