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Analysis of Arctic stratospheric minor gases related to ozone depletion observed with JEM/SMILES in 2009/2010

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The Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) is a sensor equipped in the Japanese Experiment Module "KIBO" on board the International Space Station (ISS), which has unprecedented high sensitivity with superconducting technology. SMILES had observed atmospheric minor constituents in the stratosphere and mesosphere from November 2009 to April 2010 with more than ten times the precision of other existing sensors. We analyzed SMILES L2 research products provided by the National Institute of Information and Communications Technology ("L2r") to discuss the relationship between temperature and stratospheric minor gases related to ozone depletion in the Arctic winter of 2009/2010.

Analysis of the SMILES L2r temperature data from 60 to 65^{o}N showed that the lowest temperatures occurred in a region centered at 30^{o}E at 24 km in January. The lowest temperature region shifted downward to 20 km in February. Here, we compared the SMILES L2r temperature data with the Goddard Earth Observing System Model Version 5 (GEOS-5) temperature data to assess the data quality of the L2r temperature product. Temperature data derived from Band B of SMILES had no distinct bias to the GEOS-5 temperature data, and those from Band A of SMILES were 5-10 times higher than the corresponding GEOS-5 temperature data.

Nitric acid concentrations were low in the lowest temperature region at 24 km in early and mid-January; in the same region, HCl concentrations decreased, ClO concentrations increased, and ozone concentrations slightly decreased. Similar feature was also seen at 20 km in late January and early February. These results suggest that Polar Stratospheric Clouds (PSCs) that were mainly composed of nitric acid were formed under cold conditions, and heterogeneous reactions on the surface of the PSCs particles occurred in these regions.

We calculated Nitric Acid Trihydrate (NAT) saturation temperature ("T_{NAT}") at each measurement location by using SMILES L2r nitric acid data. In the region where temperatures were lower than the calculated T_{NAT}, the amount of nitric acid was low, and the concentrations of HCl and ClO dramatically decreased and increased, respectively. However, changes in concentrations of nitric acic, HCl, and ClO were also seen in relatively warm region with temperatures higher than T_{NAT}; for more detailed analysis, we have to evaluate the quality of the L2r nitric acid data through comparisons with other independent data.

Keywords: stratospheirc minor gases, ozone depletion, remote sensing