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Composition and meteorological changes associated with a strong stratospheric intrusion event in the Canadian High Arctic

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Stratosphere-troposphere exchange (STE) provides a mechanism for trace gas transport between the lower stratosphere and the troposphere. Intense downward stratospheric intrusions may significantly affect the oxidizing capacity of the troposphere. Most STE events occur in tropical and mid-latitude regions, with less known about STE in the polar regions. In this work, we present an observation and modelling study of a strong stratospheric intrusion in the high Arctic (Eureka, 80°N) in March 2013, which led to an increase of total ozone and BrO columns observed by both ground-based and satellite instruments.

The meteorological conditions for this event were similar to those observed for STEs associated with cold fronts. Before the cold front arrived at Eureka, the surface temperature first increased from -25.3°C (25 March 13:00 UTC) to -14.5°C (27 March 20:00 UTC) and then dropped to -36.4°C (29 March 6:00 UTC) after the front passed by. Meanwhile, the ground-level pressure decreased from 103.8 kPa to 101.8 kPa, then rose back to 102.6 kPa. Ozonesonde data (27 March 23:15 UTC) showed unusually high ozone (>100 ppbv) above ∼3 km altitude, while the relative humidity profile indicated that the airmass was of stratospheric origin (very low relative humidity). The thermal tropopause height was ∼9 km, based on a uniform lapse rate of 3.9 K/km from surface to 9 km. From ECMWF Interim data, the airmass with high relative potential vorticity (4 pvu) extended down to 3 km. In addition, HYSPLIT model ensemble back-trajectories show a clear Rossby wave signature in the upper troposphere during this event, which could explain the intrusion. However, there are no strong downwelling layers along the trajectories, which indicates that the intrusion may have occurred close to Eureka.

Trace gas composition data from three ground-based spectrometers and the GOME-2 satellite instrument are presented in this work. Ozone vertical column densities (VCDs) measured by two Zenith-Scattered Light Differential Optical Absorption Spectroscopy (ZSL-DOAS) instruments and a Fourier Transform Infrared (FTIR) spectrometer, increased by 12-15% during this intrusion event. BrO tropospheric profiles retrieved using a Multi-Axis -DOAS (MAX-DOAS) instrument indicate no enhancement within the boundary layer. GOME-2 data shows increased BrO total VCDs over this region with a similar pattern to that of the temperature at the tropopause. After applying the partitioning method to correct for the tropopause height, the satellite retrieved tropospheric BrO column is still larger than that measured by ground-based MAX-DOAS. This work suggests that partitioning of stratospheric and tropospheric BrO signals remains a challenge for satellite measurements during strong stratospheric intrusion events.