



Stratospheric column NO₂ anomalies over Russia related to the 2011 Arctic ozone hole

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We analyze data of spectrometric measurements of stratospheric column NO₂ contents at mid- and high-latitude stations of Zvenigorod (55.7°N, Moscow region), Tomsk (56.5°N, West Siberia), and Zhigansk (66.8°N, East Siberia). Measurements are done in visual spectral range with zenith-viewing spectrometers during morning and evening twilights. Alongside column NO₂ contents, vertical profiles of NO₂ are retrieved at the Zvenigorod station. Zvenigorod and Zhigansk are the measurement stations within the Network for the Detection of Atmospheric Composition Change (NDACC). For interpretation of results of analysis of NO₂ data, data of Ozone Monitoring Instrument measurements of total column ozone and rawinsonde data are also analyzed and back trajectories calculated with the help of HYSPLIT trajectory model are used. Significant negative anomalies in stratospheric NO₂ columns accompanied by episodes of significant cooling of the stratosphere and decrease in total ozone were observed at the three stations in the winter-spring period of 2011. Trajectory analysis shows that the anomalies were caused by the transport of stratospheric air from the region of the ozone hole observed that season in the Arctic. Although negative NO₂ anomalies due to the transport from the Arctic were also observed in some other years, the anomalies in 2011 have had record magnitudes. Analysis of NO₂ vertical profiles at Zvenigorod shows that the NO₂ anomaly in 2011 compared to other years anomalies was additionally contributed by the denitrification of the Arctic lower stratosphere. NO₂ profiles show that a certain degree of the denitrification probably survived even after the ozone hole.