QOS2016-218, 2016
Quadrennial Ozone Symposium of the International Ozone Commission

Trends in stratospheric column NO_2 in mid-latitudes of the European part of Russia

A.N. Gruzdev, A.Ya. Arabov, A.N. Borovsky, N.F. Elansky, A.S. Elokhov, G.S. Golitsyn, and I.I. Mokhov
A.M. Obukhov Institute of Atmospheric Physics, Moscow, Russian Federation (a.n.gruzdev@mail.ru)

Long term column NO_2 measurements were done at two mid-latitude stations, Zvenigorod and Kislovodsk, in the European part of Russia. Zvenigorod Scientific Station (55.7˚N, 36.8˚E) is located in a rural area 50 km west to Moscow, while Kislovods Mountain Scientific Station (43.7˚N, 42.7˚E) is located in the North Caucasus at a height 2070 m above sea level. Measurements at Kislovodsk Station were carried out in 1981–2008 by direct-sun visible radiation at large solar zenith angles in morning and evening. The nearest town, Kislovodsk, is located in a valley 20 km north to the station, and the polluted air from the town does not reach the station. Rare pollution episodes at the station are related to long range transport, in particular from West Europe. Due to a small background tropospheric NO_2 abundance the column NO_2 content may be attributed to the stratospheric column. Results of direct-sun measurements were compared with results of simultaneous zenith-sky NO_2 measurements in 1993–1998 and 2000–2008. Measurements at Zvenigorod Station are carried out since 1990 by zenith-scattered solar radiation within 435–450 nm spectral range during morning and evening twilight at solar zenith angles 84˚–96˚. The station is a part of the Network for the Detection of Atmospheric Composition Change (NDACC). Vertical NO_2 profiles are retrieved at Zvenigorod, and stratospheric column NO_2 contents are calculated by integrating profiles in 10–50 km layer.

For the trend analysis, a multiple linear regression technique is used. The regression model takes into account a linear trend, effects of solar activity, quasi-biennial-oscillation, El Nino-Southern Oscillation as well as the influence of products of El Chichon (only for Kislovodsk data) and Pinatubo volcano eruptions. The inter-annual evolution of column NO_2 at Kislovodsk is characterized by a general increase in the 1980-th followed by a general decrease during the 1990-th and 2000-th. Large, statistically significant, trends were observed for the two time intervals. The linear trends are about 1.6% and 1.9% per year for the 1981–1989 period and –1.4% and –0.8% per year for the 1990–2008 period, for morning and evening data respectively. The trends for the whole observational period are about –1.1% and –0.7% per year. The morning trend estimates are assumed to be more reliable due to generally better conditions of direct-sun observations in morning than in evening. The linear trends in stratospheric NO_2 columns at Zvenigorod Station derived from morning and evening data are close to each other. The NO_2 trends at Zvenigorod are negative and equal to –0.38% per year for the whole observational period from 1990 through March 2016. The trend becomes stronger ($\sim$ –0.8%) if the time interval is narrowed to the period of the negative NO_2 trend at Kislovodsk. Taking into account the negative trend in column NO_2 at the mid-latitude European station of Jungfraujoch reported by Gruzdev (Int. J. Remote Sens. 2009, v. 30, p. 4227) we conclude that column stratospheric NO_2 in the mid-latitude European sector had a negative trend during the past 2.5 decades.

The regression analysis also shows that stratospheric column NO_2 at Zvenigorod experiences variations opposite to the 11-year solar cycle, with magnitude of about 6%.