Geophysical Research Abstracts
Vol. 15, EGU2013-991, 2013
EGU General Assembly 2013

Long-term total NO_2 variations at North Caucasus from 1979 to 2008

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Nitrogen dioxide observations were carried out at Kislovodsk High Mountain Station (HMS) of A.M. Obukhov Institute of Atmospheric Physics of Russian Academy of Sciences from 1979 to 2008. The station is located at an unpolluted region of North Caucasus Mountains (43.7N, 42.7E, 2070 m.a.s.l.). The total and stratospheric NO_2 contents were obtained. These quantities were retrieved from the direct and scattered spectral solar radiation measured for low solar elevation.

Thirty-years dataset of the total NO_2 content is unique by its duration. The characteristics of diurnal, seasonal and 11-year solar activity cycles, volcano eruptions, QBO and El-Nino are analyzed. These features are noticeable different from ones detected at some other NDACC stations.

The average morning and evening total NO_2 contents are $(4.83\pm1.31)10^{15}$ and $(3.22\pm0.96)10^{15}$ mol/cm^2 respectively. Evening data have greater variability. The average seasonal variations basically are the same as seasonal variability of stratospheric NO_2 at middle-latitudes of the Northern hemisphere. The maximal NO_2 content are observed in July, minimal – in January (4.610^{15} and 1.910^{15} mol/cm^2 for morning and 6.5 10^{15} and 3.010^{15}mol/cm^2 - for evening).

Minimal seasonal variability of the difference between evening and morning NO_2 content in percentage with respect to daily values for corresponding month takes place in July-September (36%), maximal – in March (47%).

Decrease of the NO_2 content after powerful volcano eruptions is pronounced feature of these data. The Pinatubo eruption was most powerful (explosivity index K=6). The NO_2 content decrease began at the end of 1991. Maximal decrease for the morning values was in the first half of 1992 (22%).

The increase of total NO_2 content from minimum to maximum of 11-year solar cycle is 11% for morning and 7% for evening.

The observations at Kislovodsk HMS were carried out for about 30 years. These unique data allow to estimate the NO_2 trend more correctly. The linear approximation of the NO_2 trend from 1979 to 2008 is -7.4$\pm$2.4% for 10 years for morning values (-6.6$\pm$2.8% for evening).

Removing of above features from the dataset allows to estimate the QBO and El-Nino effects on the NO_2 content. The analysis confirms the dependence of the total NO_2 content on the QBO and El-Nino. For example, the linear trends for the total NO_2, corresponding to the Eastern and Western QBO phases, are different (13.2$\pm$3.8% and 7.5$\pm$4.2% for 10 year with 95% confidence interval).

Opportunities of the retrieval of the tropospheric NO_2 basing on the simultaneous observations of the total and stratospheric contents NO_2 are analyzed.

The research was partially supported by RFBR grants 10-05-00272, 10-05-01014 and 12-05-31471.