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Longitudinal dependence of annual cycle of total ozone in the Northern mid-latitudes

Gennadi Milinevsky, Oleksandr Evtushevsky, and Asen Grytsai

Taras Shevchenko National University of Kyiv, Space Physics Laboratory, Physics Department, Kyiv, Ukraine (genmilinevsky@gmail.com)

In the Northern mid-latitudes, annual change of the total ozone content (TOC) in terms of zonal means is mainly determined by stratospheric ozone accumulation in winter and spring due to the Brewer–Dobson circulation (BDC) and following photochemical relaxation continuing to autumn. It is known from previous studies that annual TOC cycle in some regions could be close to or differ from the zonal mean one. For example, annual TOC minimum over Eastern Asia is observed two months earlier (August) than over Europe (October).

In this work, a consecutive analysis of the TOC seasonality along the latitudinal belt 50–55°N in 36 segments (10°-step in longitude) is analyzed. The latitude range includes northern Ukraine and Kyiv–Goloseyev Dobson station. Analysis is based on the Merged Ozone Data Set (MOD) reanalysis 1979–2011 (http://acd-ext.gsfc.nasa.gov/Data_services/merged/). We use also the NCEP–NCAR reanalysis data (http://www.esrl.noaa.gov/psd/cgi-bin/data/composites/printpage.pl) to estimate seasonal changes in geopotential heights and tropopause heights.

It is shown that the seasonal TOC cycle over the cyclonic anomalies (high mean TOC level) is shifted to the beginning of year in comparison with that over the anticyclonic anomalies (low mean TOC level). The largest TOC values over the Aleutian low (around 150°E) are characterized by the earliest seasonal maximum (February–March) and minimum (August). Here, the tropospheric dynamics (winter/summer extremes in the planetary wave activity and stationary pressure anomaly formation/disappearance) and related tropopause effects seem to have dominant influence on the earliest development of the annual TOC cycle. Zonal asymmetry in stratospheric ozone accumulation influences rather the maximum TOC levels in this region than timing of the TOC extremes.

In the opposite longitude range (zonal TOC minimum in region of the Azores high influence, 20–30°W), the annual TOC cycle lags by 2–3 months reaching a TOC maximum in May and a TOC minimum in November. Seasonal changes in this subtropical anomaly (pressure and tropopause height) are weak. Hence, troposphere influence on the TOC seasonality here is small in comparison with Aleutian low region. Slow accumulation of the stratospheric ozone during winter and spring leads to the latest occurrence of seasonal TOC maximum. Photochemical ozone relaxation lasts also longer up to beginning of the next BDC intensification since December.

The results of this analysis could be useful for explanation of the interannual variations in the local annual TOC cycles considering the climatological ones in neighboring segments of the northern midlatitudes. Possible effects of the TOC seasonality in regional climate changes could also be analyzed in future studies.

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