Influence of the Arctic ozone depletion on the total ozone over Bulgaria

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Introduction

Although ozone appears in the Earth’s atmosphere in a small abundance, it plays a key role in the energy balance of the planet through its involvement in radiative processes [1]. On the other hand it has also biological relevance due to a strong absorption in the short-wave UV solar radiation , which damages the living beings at the Earth’s surface. These circumstances have driven the scientific community to focus its attention on the content and behaviour of the ozone in the terrestrial atmosphere.

Chemical ozone destruction occurs over both polar regions in local winter-spring. In the Antarctic, essentially complete removal of lower-stratospheric ozone currently results in an ozone hole every year, whereas in the Arctic, ozone loss is highly variable and has until now been much more limited.

An Arctic "low ozone event" could easily be blown south by high-altitude winds, and appear over populated areas of North America, Europe and Asia. In this way hundreds of millions of people as well as animals and plants will be exposed to dangerous levels of UV solar rays.

Such destruction of ozone over the Arctic in early 2011 was, for the first time in the observational record, comparable to that in the Antarctic ozone hole. Unusually long-lasting cold conditions in the Arctic lower stratosphere led to persistent enhancement on ozone-destroying forms of chlorine and to unprecedented ozone loss, which exceeds 80 per cent over 18-20 km altitude [2].

The particularly cold Arctic vortices taken place in the 2000, 2005 and 2011 winter-spring caused deeper than usual ozone depletion in the north polar region, which disturbed the ozone amount behaviour at mid-latitudes [3].

Instrument and methods

The impact of the Arctic ozone loss in winter-spring 2005 and 2011 on the total ozone content (TOC) over Bulgaria is investigated. For this purpose data from Ozone Monitoring Instrument (OMI) onboard the EOS-Aura satellite are used.

The OMI instrument is a nadir viewing imaging spectrograph that measures the solar radiation backscattered by the Earth's atmosphere and surface over the entire wavelength range from 270 to 500 nm with a spectral resolution of about 0.5 nm. The 114° viewing angle of the telescope corresponds to a 2600 km wide swath on the surface, which enables measurements with a daily global coverage. The light entering the telescope is depolarised using a scrambler and then split into two channels: the UV channel (wavelength range 270 - 380 nm) and the VIS channel (wavelength range 350 - 500 nm). Two algorithms, OMI-TOMS and OMI-DOAS (Differential Optical Absorbtion Spectroscopy) are used to produce OMI daily total ozone datasets [4].

Data analysis and results

A strong ozone depletion event occurred in the Arctic region during the spring 2011 was found to cause appreciable reduction effects on the ozone column at lower latitudes in West Europe. The data from many ground-based stations evidence that the ozone column at about 40°N latitude is significantly influenced by the Arctic ozone loss with a delay of nearly two weeks. The decreasing phase of ozone column started on 20 - 25 March over the sector 10º W – 20º E и 40º N – 60º N , moving from North to South. The entire sector was subsequently involved by such an ozone depletion event, presenting values of ozone column lower by 15-20% than those observed in the previous years. This occurrence was observed to continue in the following two weeks, after which the low ozone column area moved to South-East Europe.

The total ozone content over Stara Zagora (42°25’ N, 25° 37’ E), Bulgaria in March and April 2011, using OMI satellite data, is presented in Fig.1. It is compared to the average TOC for those months in the 2006-2010 period. The results show that on 8 April a sharp ozone decrease of 55-69 DU (Dobson Unit), which is 15-18% with respect to its mean value determined over the previous five-year period, began. On 9 April 2011 a TOC minimum is registered: 303 DU. During the rest of April the ozone values are in the range from 326 to 356 DU, whereas in the previous years they vary between 344 DU and 386 DU. The decrease in ozone in April 2011 is 7–18 % compared to the average TOC for 2006-2010,

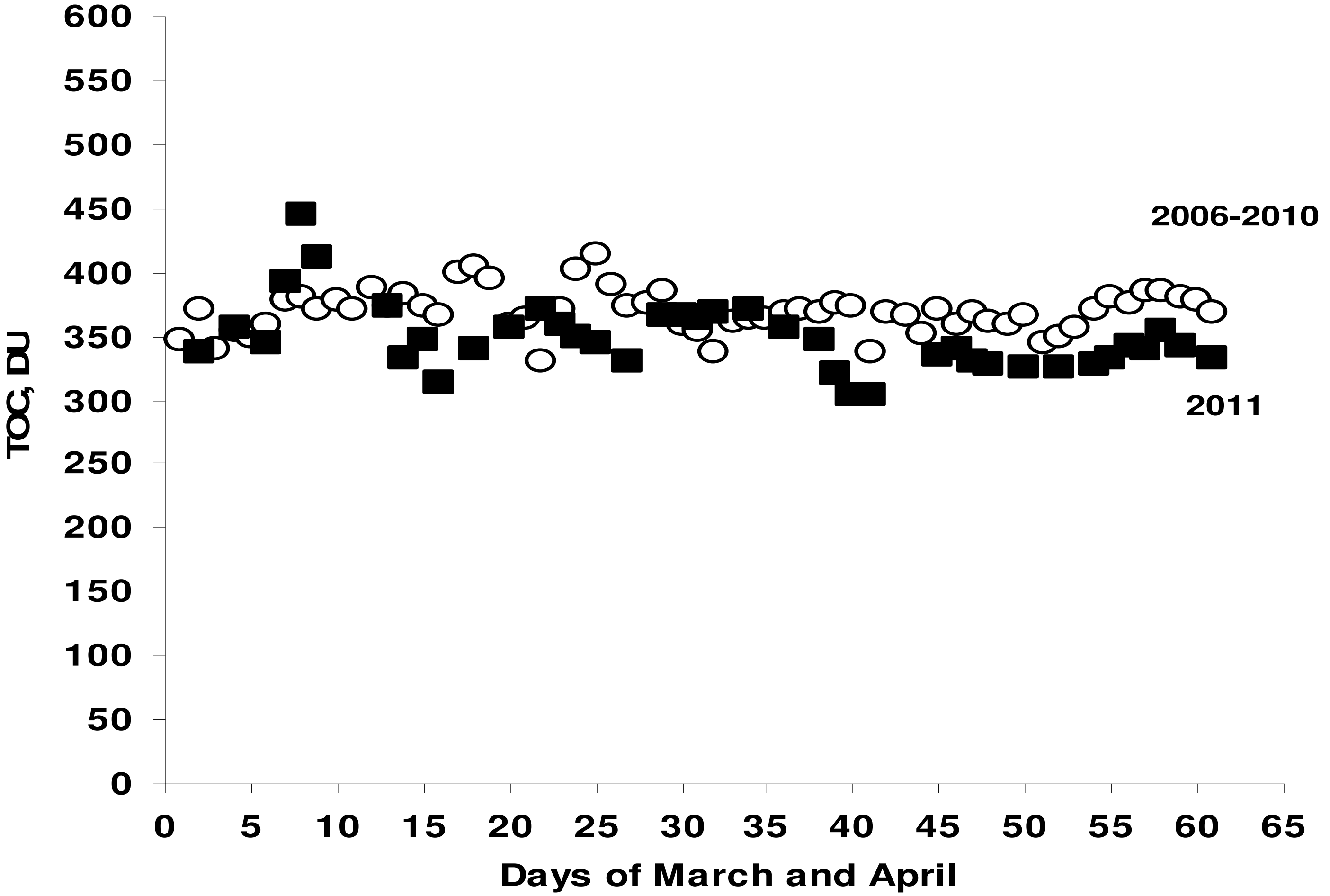

Fig.1. The total ozone content over Stara Zagora in March-April 2006-2010 (○) and 2011 (■).

A significant Arctic ozone loss was recorded during the winter-spring 2005. It also influenced the TOC at mid-latitudes. Fig.2 presents TOC behaviour in February-March 2005 over Stara Zagora, compared to the average TOC for those months in the 2006-2010 period. On 17 March a sharp ozone decrease of 54 DU , which is 14% with respect to its mean value determined over the five-year period, began. On 20 March 2005 a TOC minimum is registered: 277 DU, which is 23% decrease. During the rest of Marchl the ozone values are in the range from 293 to 362 DU, whereas in the control period they vary between 350 DU and 414 DU. The decrease in ozone in March 2005 is 6 – 26 % compared to the average TOC for 2006-2010.

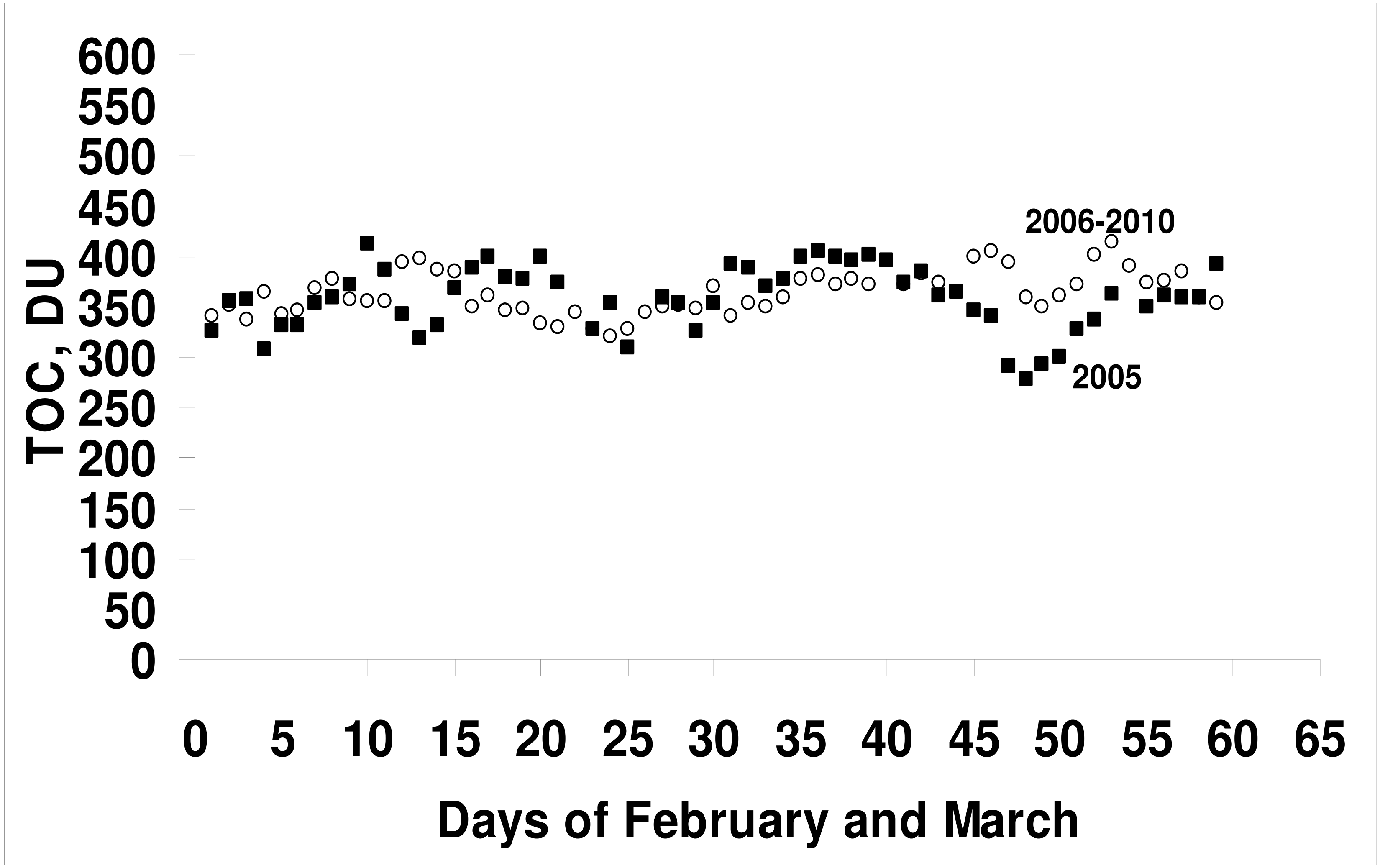

Fig.2. The total ozone content over Stara Zagora in February-March 2006-2010 (○) and 2005 (■).

These results indicate that the impact of the Arctic ozone loss on the total ozone content reached in the spring of 2005 and 2011 the territory of Bulgaria.

The main feature differing the 2011 reaction of the mid-latitude ozone column to the Arctic ozone depletion is the period when such a reaction is manifested. While in the 2005 event mid-latitude ozone was disturbed during the existence of the polar vortex and after its destruction the usual behaviour was followed, in the spring 2011 the ozone column at mid-latitude European regions was affected after the destruction of the polar vortex and it can be likely accounted for by transition of the polar air masses toward the mid latitudes.

References

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