Total Ozone Dynamics over Bulgaria

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The aim of this paper is to present the investigation of the total ozone content (TOC) over Bulgaria in the time period 1997-2008. Data from the satellite experiments TOMS-EP (1997-2002) and SCIAMACHY (2003-2008) are used. The course of the monthly mean ozone values is presented. The seasonal TOC variations are clearly marked. Quasi-biennial periodicity in the amplitude of the ozone maxima can be seen. The experimental data show that there is no any trend in this course during the period 1997-2008.

Introduction

The ozone is one of the components of the Earth's atmosphere, which strongly absorbs the short-wave solar ultraviolet (UV) radiance, which damages the biosphere. At the same time, the ozone is a gas, major for the thermal conditions of the stratosphere. The significant changes of the total ozone amount in the atmosphere over the South pole regions, observed during the last decades, have attracted the attention of the scientific community. Together with the ozone decrease in the polar atmosphere, similar behavioral features have also been observed at mid-latitudes [1,2]. The measurements show unambiguously that the total ozone over northern mid-latitudes decreased from 1980 to the mid-1990s. Since then TOC depletion hasn't been registered [3,4,5,6]. Therefore, the monitoring of the ozone amount in global scale is considered nowadays a task of primary significance for the life of our planet.

For this purpose the Global Atmosphere Watch (GAW) network has been created to monitor the total ozone by a set of ground-based instruments. Simultaneously, several projects such as the Total Ozone Mapping Spectrometer (TOMS), the Global Ozone Monitoring Experiment (GOME), the SCanning Imaging Absorption SpectroMeter for Atmospheric CHartographY (SCIAMACHY), Ozone Monitoring Instrument (OMI) etc. investigate the ozone from space.

Experiments and data

The aim of this paper is to present the investigation of the total ozone content (TOC) over Bulgaria in the time period 1997-2008. The ozone dynamics is examined using data from the Total Ozone Mapping Spectrometer on the Earth Probe satellite (TOMS-EP) and the SCanning Imaging Absorption SpectroMeter for Atmospheric CHartographY (SCIAMACHY) on board ENVISAT (ESA).

TOMS-EP continues the NASA Program for mapping and research of the global ozone distribution in the Earth's atmosphere in the period from 1996 to 2005. The TOMS measurements cover the near ultraviolet region of the electromagnetic spectrum where the solar radiation is partially absorbed by the ozone. The intensity is registered in 6 wavelengths. TOMS measures the total ozone content in an atmospheric column from the Earth's surface to the upper atmospheric boundary under different geophysical conditions.

SCIAMACHY is an imaging spectrometer, which carries out global measurement of various trace gases in the troposphere and stratosphere. They are retrieved from the instrument by observation of transmitted, back scattered and reflected radiation from the atmosphere in the wavelength range between 240 nm and 2400 nm. In Nadir Mode, the global distribution (total column values) of the atmospheric trace gases, including ozone, is observed.

Results and discussion

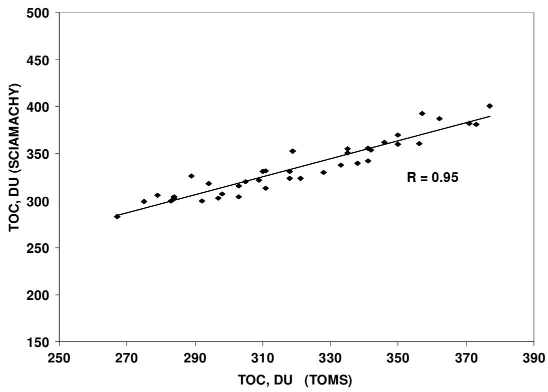

Fig.1. Correlation straight line between TOC monthly mean values (2002-2005), measured by TOMS-EP and SCIAMACHY

An analysis of the total ozone over Sofia (42o 39' N, 23o 23' E), Bulgaria is presented. For tracking out the TOC course for a longer period we use TOMS and SCIAMACHY data. The results from the two instruments, simultaneously operating in the period 2002 – 2005 are compared. There is a good agreement between them : R = 0.95 (Fig.1). This allows to use the consecutive TOMS data (1997–2002) and the SCIAMACHY data (2003-2008) for investigation of the ozone behaviour in the period 1997-2008 (Fig.2).

In this figure seasonal TOC variations are clearly marked, showing an abrupt maximum in the spring and a decrease to the minimum in the autumn. This seasonal course doesn't correspond to the solar radiation energy distribution throughout the year. It is also different from the course of other parameters, such as temperature, humidity, air pressure, which follow the solar radiation course with a certain delay at all latitudes. Fig.2 shows also a quasi-biennial periodicity in the amplitudes of the ozone maxima. For example, in 1999, 2001, 2003 etc. these amplitudes are bigger than in 2000, 2002, 2004 etc., as the biggest TOC maximum (400 DU) is registered in March 2003 and the smallest one (357 DU) – in March 2000.

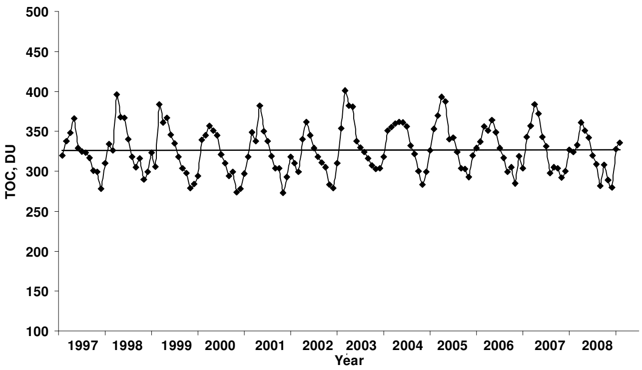

Fig.2. Behaviour of the monthly mean ozone data from TOMS-EP (1997-2002) and SCIAMACHY (2003-2008) over Sofia

The existence of long-term ozone data enables the study of the ozone trends. In the last years many scientists in various projects have focused their attention on this problem. The EU CANDIDOZ project (Chemical And Dynamical Influences on Decadal Ozone Change) investigated the chemical and dynamical influences on decadal ozone trends focusing on the Northern Hemisphere [6]. The overall synthesis of the individual analysis in this project shows clearly one common feature in the northern mid-latitudes and in the Arctic: an almost monotonous negative trend from the late 1970s to the mid 1990s followed by an increase.

To investigate of the total ozone behaviour over Sofia, Bulgaria we have used monthly mean ozone satellite data in the period 1997-2008. Our analysis shows that there isn't any trend in this course. Despite the absence of a trend in the whole period, the calculations give different trend values in the various seasons (Fig.3). Thus, in winter (December) and in spring (March) the linear trend is positive: 2.2% and 0.2%, respectively, and in summer (July) and in autumn (September) it is negative : -3.5% and – 1.6%. Zanis et al. found also a positive ozone trend over Arosa during the winter to spring period [7]. These results show a probable seasonal dependence of the TOC trend

Figure 4 presents a comparison between the variation of the annual mean total ozone content and the variation of the amplitude of the annual wave in the total ozone. There exists an agreement between the two curves, demonstrating that the trend in total ozone over Sofia is driven by the same mechanisms that influence the annual wave. A similar result is obtained by Chandra and Varotsos for the Mediterranean region [8].

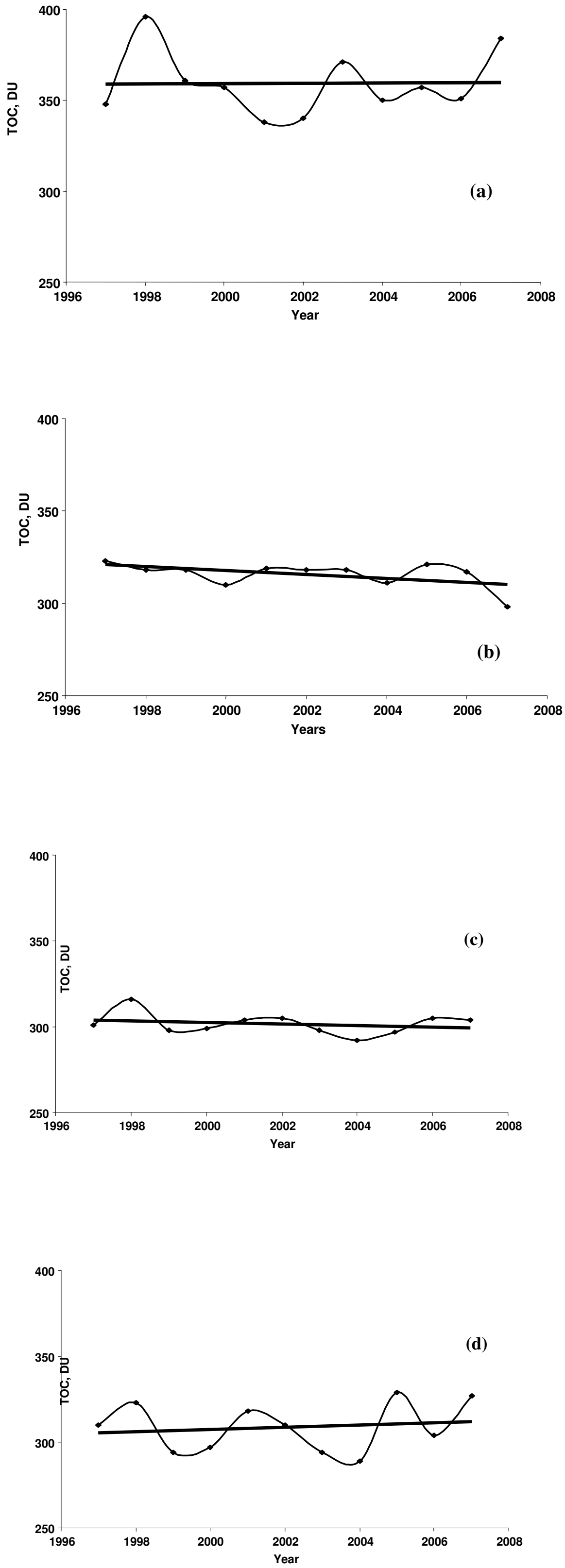

Fig.3. TOC monthly mean values from TOMS and SCIAMACHY (1997-2007) : a) March; b) July; c) September; d) December.

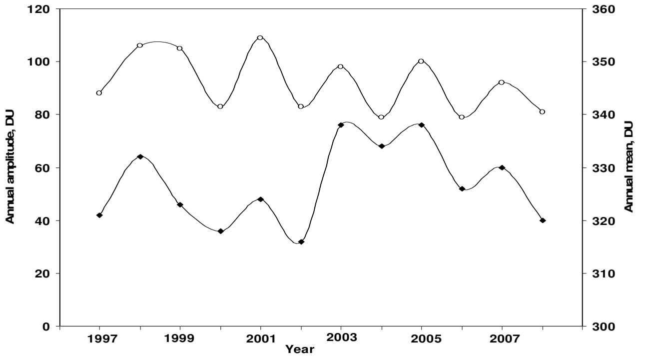

Fig.4. Comparison of the interannual TOC variability (♦) with the variability of the amplitude of annual wave (○) in total ozone over Sofia during the period 1997-2008.

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