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Ozone destruction by solar electrons in relation to solar variability and the terrestrial latitude

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Abstract

Precipitating electrons from the radiation belts with energies greater than from 150 keV to 5 MeV have been correlated with ozone data of a large number of stations located within 40–70° N. Energetic electrons have been collected by the low altitude polar Russian satellite METEOR while ozone data have been compiled from almost ninety (90) stations located all over the world within the latitude zone 40–70° N.

In more than 60% of the stations examined, we detect a clear decrease of the ozone variation during and after the occurrence of an electron flux excess, which recovers within 3–5 days. The more northern is a station located, the deeper is the ozone decrease. Moreover, clear evidence that the solar cycle affects ozone destruction through energetic electron events is presented. The preliminary results of the present work stimulate a future attempt for a simple ozone destruction mechanism formulation, which could describe atomic nitrogen ionization by energetic electrons, which in the following merge to atomic oxygen and produce nitrogen oxides. Finally, nitrogen oxides destruct ozone creating characteristic decreases on the normal ozone variation.

Keywords: Stratospheric ozone destruction; Solar variability; Solar electrons

1. Introduction

One of the most crucial points in the stratospheric physics, especially ozone depletion and climate change, is the balance of the odd oxygen which is highly affected by odd nitrogen. The incidence of the electromagnetic radiation on the atmospheric constituents has been extensively studied in contrast to the energetic particles influence which has been studied much less.

Some very important studies on the particles reaction with the middle atmosphere elements, especially their contribution to the ozone depletion, have been reported since 1990. Magnetospheric electrons coupling with stratospheric odd nitrogen and ozone has been explicitly studied by Solomon et al. (1982), Callis et al. (1991) Callis and Lambeth (1998), Randall et al. (1998), while Thorne (1980) and Jackman (1991, 1993) have reviewed the consequences of the particles incidence on the chemical composition of the middle atmosphere.

Reactions involving NO_x, play a dominant role in the stratospheric odd oxygen loss in the ozone layer, mainly through the cycle:

$$NO + O_3 \rightarrow NO_2 + O_2$$
$$NO_2 + O \rightarrow NO + O_2$$

$$\text{Net}: \quad O_3 + O \rightarrow 2O_2$$

The aim of the present study is to illustrate the relation between strong fluxes of precipitating electrons and ozone depletion detected by ground-based observations. We expect

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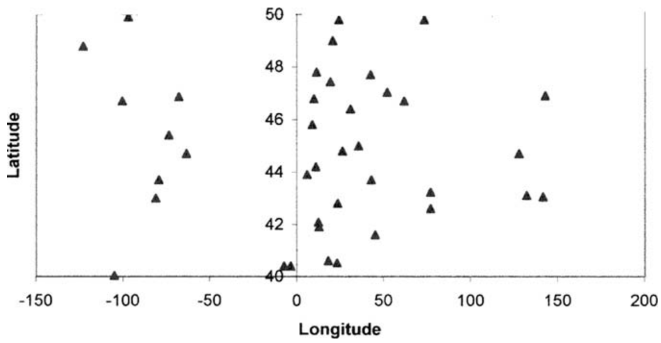

Fig. 1. Longitudinal distribution of the stations under consideration.

in the near future to proceed to a detailed description of the whole procedure by a numerical model which finally could predict place, time and magnitude of ozone depletion on the globe after a strong incidence of precipitating electrons.

2. Data description

Daily total ozone measurements covering the time span 1992–1997 of almost 90 ground-based stations located between 40° N and 70° N and distributed mainly within

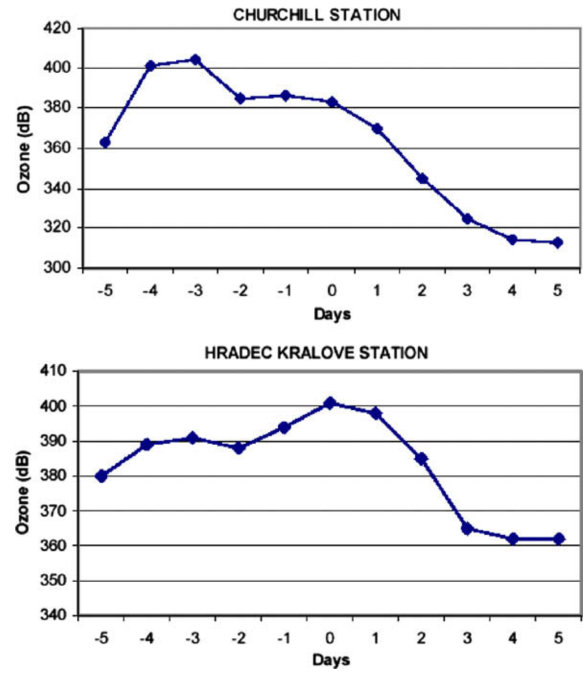

Fig. 2. Ozone data from Churchill and Hradec Kralove stations five days before and after the zero day where an electron event (>2σ) occurs.

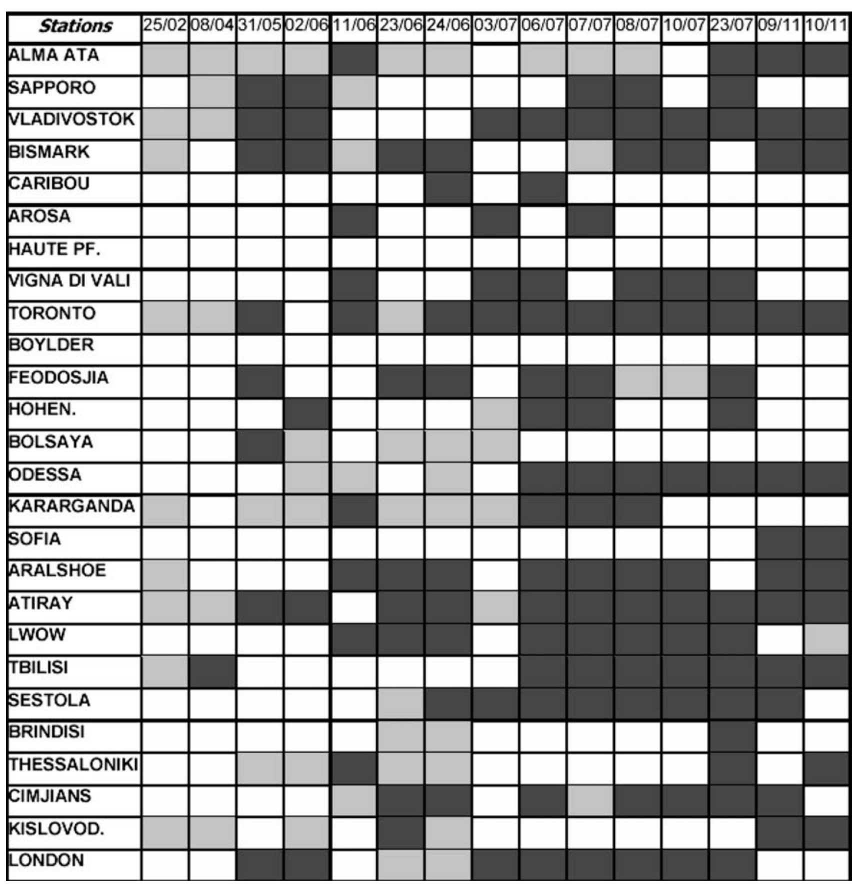

Fig. 3. Ground-based stations within the 40–50° N latitude zone during the year 1991 and the dates when electron events (>2σ) detected. Dark gray cells represent ozone destruction while gray cells express no response. White cells mean lack of data.