

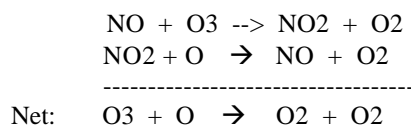
NUMERICAL SIMULATION OF THE RESPONSE OF OZONOSPHERE TO SOLAR PROTON EVENTS

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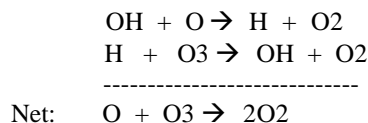
Abstract. Photochemical modeling and satellite data have been used to investigate the response of ozonosphere to the solar proton event occurred in July 2000 - one of the strongest SPE of the current (23d) solar maximum. Model runs showed strong ozone depletion in the mesosphere and stratosphere after this event due to additional production of NO and OH amounts caused by ionization by solar protons. Data analysis of ozone variations (HALOE instrument placed on board UARS) gave a picture of ozone response similar to the results of photochemical simulations.

Introduction

Energetic particle fluxes produce a certain NO (Crutzen et al., 1975) and OH (Solomon et al., 1981) amount in the mesosphere and stratosphere. Then, the mentioned precipitating particle-produced minor constituents can deplete ozone through the catalytic reaction cycles



and



Additional nitrogen and oxygen produced by solar protons could be transported downwards and affect the chemical balance in the middle atmosphere including long-term effects (Jackman et al., 1995, 1999, 2000). Model simulation of ozone response after the first SPE of the current 32d solar maximum in November 1997 showed rather a small effect (Krivolutsky et al., 2000). Now we present the results of calculations for a stronger SPE in July 2000 supported by data analysis based on UARS data.

Photochemical model

1-D time-dependent photochemical model (Krivolutsky et al., 2000) was used for calculations. This model includes 100 gas-phase chemical reactions and 45 reaction of photodissociation and describes the vertical eddy diffusion transport in the range of 0-100 km. The SPE ionization rates have been calculated in accordance with the method used by Vitt and Jackman (1996). Solar proton fluxes in different energetic canals, measured from the board of *GOES-10*, have been used for ionization rates calculation in the middle atmosphere. Odd nitrogen from SPE was assumed to be produced at the rate of 1.25 per ion pair, and we also assume that two molecules of OH were produced by one ion pair (Porter et al., 1976).

Results of photochemical calculations

Figure 1 shows the ionization rates of the atmosphere caused by solar protons of SPE in July 2000 at 70 deg. of latitude for both hemispheres. There is some difference between the ionization over southern and northern polar regions due to the corresponding differences in the atmospheric parameters. Figure 2 shows corresponding calculated response of ozone caused by additional NO and OH production. Ozone in the mesosphere is practically destroyed in accordance to photochemical calculations. It should be mentioned that ozone response stays longer than the corresponding ionization after SPE. This effect is the manifestation of the "nitrogen family" life time in this range of atmospheric altitudes.

Discussion and conclusions

Therefore, the presented results demonstrate a clear negative response of ozone after a strong SPE in July 2000. In accordance to photochemical model calculation, as it is seen in Figure 2, ozone was practically destroyed in the mesosphere. The results of data analysis (HALOE instrument placed on board UARS) also showed ozone depletion after 14th July 2000, which was very similar to model calculations.

Thus, energetic particles can strongly influence chemical composition of the middle atmosphere. Such, particle-induced chemical disturbances may change the radiation budget and temperature in this region. These possible effects should be studied in the future.

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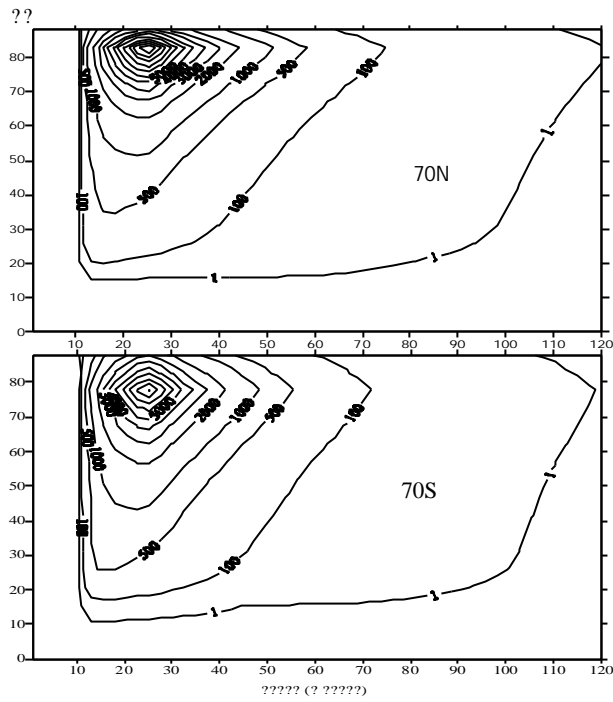


Fig. 1. Ionization rates (ion pairs/sec*cm**3) caused by SPE in July 2000 near North and South Poles (calculations based on GOES-10 data).

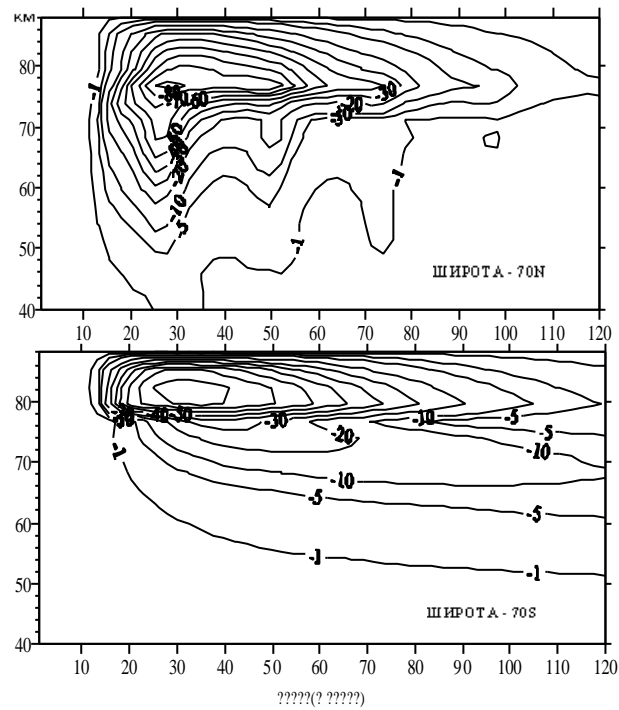


Fig. 2. Ozone response (%) after SPE in July 2000 near polar regions (1-D photochemical calculations)