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OZONE MEASUREMENTS IN THE MESOSPHERE DURING A SOLAR PROTON EVENT

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INTRODUCTION

Charged particle precipitation in the Earth's atmosphere produces odd nitrogen and odd hydrogen. These species take part in catalytic reactions which destroy atmospheric ozone in the stratosphere and mesosphere. Modeling efforts regarding the impact of these ionization events on the neutral atmosphere (e.g. SOLOMON and CRUTZEN, 1981; THORNE, 1980) describe ozone depletions in good agreement with observations in the stratosphere and mesosphere.

CRUTZEN and SOLOMON (1980), discussing the photochemical effects of the solar proton event (SPE) of August 1972, presented calculations for higher altitudes (70-90 km) indicating that after a brief reduction during and immediately following intense particle precipitation, ozone will later reach higher concentrations than those present before the event.

MESOSPHERIC PHOTOCHEMISTRY

In order to study mesospheric photochemistry with regard to ozone we follow the discussions of CRUTZEN and SOLOMON (1980). Water vapour photolysis is the major source of odd hydrogen (H, OH, HO_2) under normal conditions. The odd hydrogen may then be converted to H_2 by the reaction $H + HO_2 \cdot H_2 + O_2$. This process is responsible for the decrease in the H_2O mixing ratio.

Charged particle precipitation events are calculated to cause the same effect of producing odd hydrogen. The odd hydrogen has a lifetime on the order of hours for altitudes of 70 - 80 km. For the first few hours following a particle precipitation event, odd hydrogen concentrations will remain high. Odd hydrogen is by far the most important factor in the destruction of ozone or more generally of odd oxygen via reactions such as

$$H + O_3 \rightarrow OH + O_2$$

$$O + OH \rightarrow H + O_2$$

The increased odd hydrogen concentrations are therefore expected to yield a reduction in ozone during and within a few hours after the event.

The normal supply of water vapour by eddy diffusion from lower altitudes is too slow to make up for the rapid depletion of water vapour taking place during the SPE. A decrease of odd hydrogen concentration and eventually an increase of ozone a few hours after the event will be the result.

EXPERIMENTAL RESULTS

It is the aim of this paper to examine our experimental ozone densities as to a possible influence by solar proton events according to the mechanism proposed by CRUTZEN and SOLOMON (1980). We derived vertical density profiles of ozone between 55 and 82 km from INTERKOSMOS - 11 occultation measurements during local sunset.

The period between early September and early October 1974 has been chosen. Three solar proton events occur during this time as given by Solar Geophysical Data. Out data base comprises 37 ozone density profiles between 10 September and 3 October 1974 (see Fig. 1). The geomagnetic position of the profiles varies from lower northern latitudes to medium and high southern latitudes.

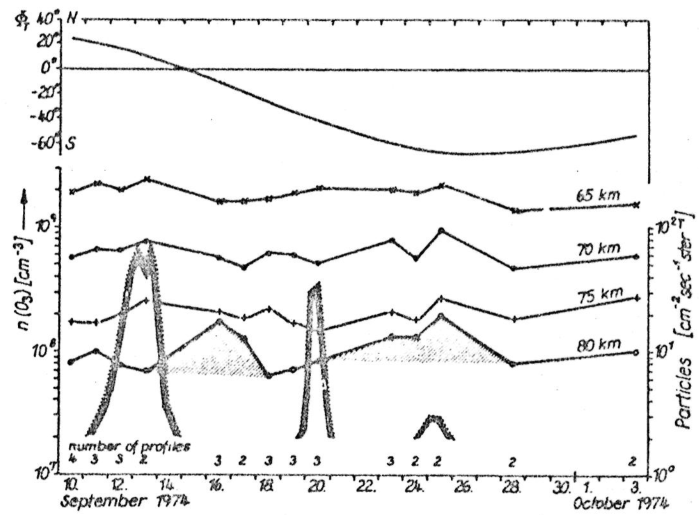

Figure 1.

Our ozone densities seem in general to reflect at least some of the predicted features. The proton event with its peak on 13 September as well as the one on 20 September seem to be followed by pronounced enhancements of densities at 80 km height a few days after the event. Even the third event around 25 September seems to contribute to the ozone enhancement. The densities at lower altitudes possibly indicate that during the first event the response to the particle influx penetrates down to altitudes of only 70 km and with increasing time delay while during the second and third events altitudes as low as 65 km have obviously been reached. This could be explained by different energy spectra of the precipitating protons (KARSZENBAUM and GAGLIARDINI 1981).

Figure 2 illustrates the difference in ozone density for normal conditions and those influenced by the particle precipitation event. The 10 September comprising 4 profiles has been chosen as a reference. The curve for 16 September comprising 3 individual profiles represents the maximum of enhanced ozone density of the first event. The ratio $\rho\,(O_3)$ between both profiles is shown in Fig. 3. No enhancement has been found below 70 km. A maximum seems to occur around 80 km with enhanced ozone densities of up to a factor of 2.4, considerably higher than value of 1.4 predicted by CRUTZEN and SOLOMON (1980). The particulars of the measurements do not provide sufficient temporal resolution in order to study the relatively short phase of the predicted ozone decrease during and a few hours after the event. The behavior of ozone density during the first event seems nevertheless to indicate that such a process is indeed taking place.

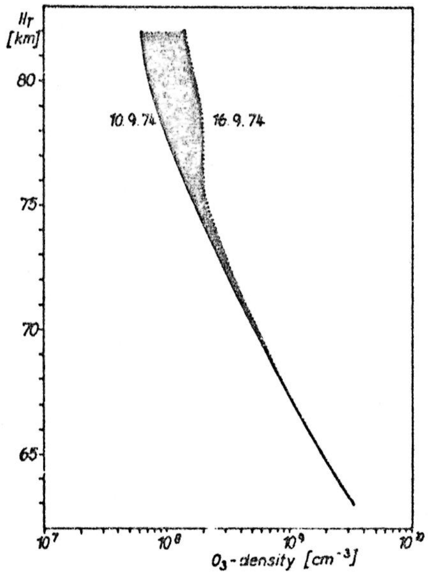

Figure 2.

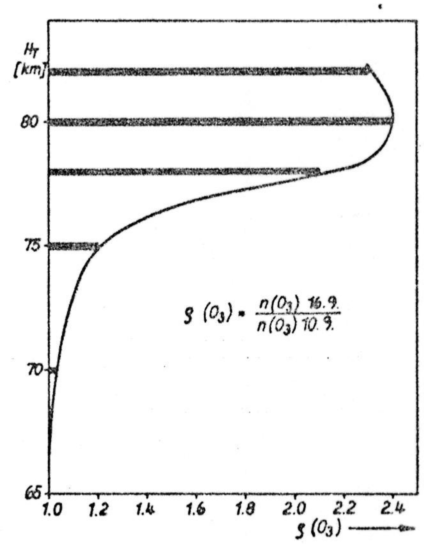

Figure 3.

CONCLUSIONS

Ozone densities at altitudes of 55 - 82 km have been examined as to their reaction to solar proton events. It seems that at least some of the features predicted by CRUTZEN and SOLOMON (1980) are reflected in the data. While the shorttime decrease is not amenable to the experimental method used the ozone density increase, lasting for several days, seems to be well pronounced around 80 km. More data are however necessary in order to provide information on dynamic processes and on the role of odd hydrogen in controlling the ozone balance in the mesospheric region.

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