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Variability of Solar EUV Fluxes and Exospheric Temperatures

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Abstract. The response of exospheric temperature to variations in solar EUV radiation was measured by the AEROS-EUV spectrometer. Correlation of these parameters is strongly impeded by the competing influence of the solar wind and by the changes in EUV heating efficiency. While the comparison of exospheric temperatures with those from the MSIS model gives rather good agreement for geomagnetically quiet conditions, the experimental data are significantly higher than the model data for disturbed conditions.

Key words: Aeronomy – Upper atmosphere – Energy budget

Introduction

Extreme ultra-violet (EUV) flux variations have been measured aboard many rockets and satellites (Hall and Hinteregger 1970; Timothy and Timothy 1970; Schmidtke 1976; Hinteregger 1977; Hinteregger 1979a). Observation of the atmospheric response to these variations, changes in the exospheric temperature for example, is rather difficult. One way to achieve this goal is the application of atmospheric EUV extinction analysis to occultation measurements (Hinteregger and Hall 1969; Schmidtke et al. 1974a; Hinteregger and Chaikin 1977). The purpose of this note is to present results from the AEROS-EUV spectrometer (Schmidtke et al. 1974b), which monitored variations of the solar EUV flux and provided data from which exospheric temperatures could be derived.

Measurements

During the periods December 1972–August 1973 and July 1974–September 1975 aboard the satellites AEROS-A and -B, respectively, solar EUV fluxes in the spectral range 16–106 nm were measured. In addition height profiles of atomic oxygen within the

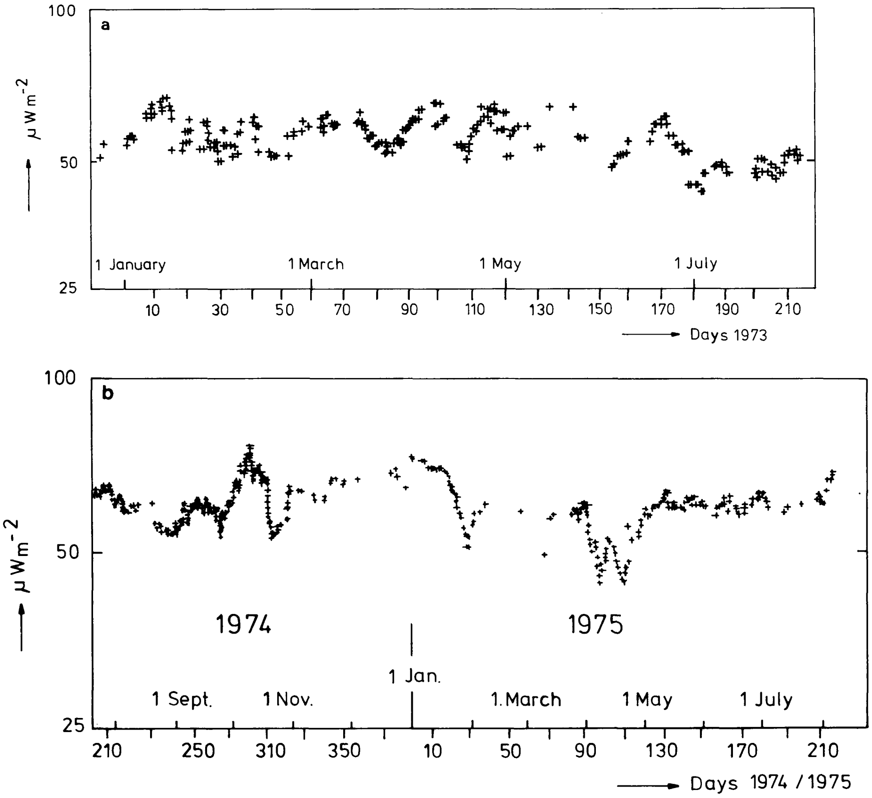

Fig. 1a, b. Temporal variation of the reference emission He 58.4 nm. **a** for AEROS-A, **b** for AEROS-B

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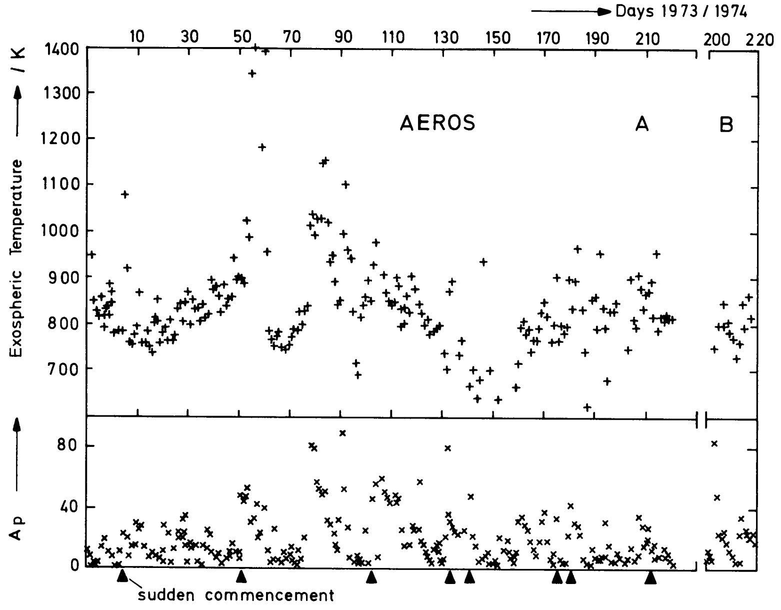

Fig. 2. Exospheric temperatures derived from EUV extinction measurements and A_P Index

height range 200–450 km approximately were derived from occultation measurements at selected solar emissions (Schmidtke et al. 1974a).

For the period of AEROS-A a decrease of the solar EUV flux of about 30% has been reported with the declining Solar Cycle 20 (Schmidtke 1976, Schmidtke 1978). To demonstrate the variability of the solar EUV radiation in more detail, daily averages of the solar emission of helium 58.4 nm radiation are shown in Fig. 1a. Since this line is representative of the chromospheric emissions comprising most of the EUV energy, it is proposed as a 'chromospheric reference' line (Hinteregger, in press 1981). Although the variability of the coronal emissions is much stronger, their contribution to the total EUV flux is relatively small. During the AEROS-B mission no significant long-term flux variation was measured as can be seen in Fig. 1b. A small difference in the flux levels of AEROS-A and B is caused by calibration uncertainties in the absolute values (about ±20% in this case).

The solar 'EUV minimum' first reported by Hinteregger (1977) is seen clearly (Fig. 1b). The agreement of the absolute solar flux numbers from Atmospheric Explorer-C and AEROS-B is also satisfactory for the overlapping periods of both satellite missions, in view of the experimental difficulties.

In Fig. 2 daily average exospheric temperatures are shown in the upper part. The temperatures are derived from scale heights (Schmidtke et al. 1974b) and extrapolated by the Bates formula. This method is also applicable to geomagnetically disturbed conditions, since the optical depth measurement includes the product of the number density times the scale height. For these grazing incidence conditions of the solar radiation in the upper atmosphere the rays traverse a horizontal distance of, for example, about 800 km sensing a height interval of 50 km, which is reasonable for the scale height of atomic oxygen.

The measurements were made at low southern latitudes at the end of 1972 and beginning of 1973, at high latitudes for days 80–220 in 1973, and at mid-latitudes for days 200–220 in 1974.

Comparing Fig. 2 with Fig. 1, it can be seen that the exospheric temperatures reflect neither the solar rotations as seen clearly in the EUV fluxes nor the long-term EUV flux decrease. Geomagnetic activity has a stronger impact on exospheric temperatures than solar EUV activity. The temperature peaks are well correlated with geomagnetic activity such as sudden commencements and increases in A_P index (most pronounced for the events on 3 January, 21 February and 1 March 1973). However, because of operational constraints on the satellite, not all of the geomagnetic events could be traced by this experiment. Intercomparison with similar data from Atmospheric Explorer-C (Hinteregger 1979b) shows this to be consistent.

In addition Hinteregger (1978) reported rather constant temperatures while the EUV radiation increased significantly at the beginning Solar Cycle 21.

In Fig. 3 the AEROS data are compared to the MSIS model, orbit by orbit. Good agreement is found for low A_P values (bearing in mind the uncertainty in the EUV absorption cross section of about 10%–20%), whereas the MSIS model represents too low temperatures for higher A_P's.

Conclusions

The comparison of the relative and absolute solar EUV fluxes, as measured aboard AEROS-B, and of the derived exospheric temperatures, with data from the Atmospheric Explorer-C, show a comfortable agreement. The derived exospheric temperatures are in rather good agreement with the MSIS model for geomagnetic quiet conditions. However, the temperatures of the MSIS model seem to be too low for higher A_P's. More importantly, the decrease in the solar EUV radiation by about 30% from the end of 1972 to August of 1973 seems to be compensated. The decrease of $\Delta Q_{EUV} \approx 0.7\ \mathrm{mWm^{-2}}$ implies, for the whole earth, a decrease of about 10^{11} W (or 10^{18} erg $\mathrm{s^{-1}}$), which is a good order of magnitude for the energy involved in a geomagnetic storm (Akasofu 1979). Joule heating has long been recognized as a major contributor to the energy budget of the upper atmosphere (Cole 1962). Particle dissipation is another energy source. In general, the conversion of the solar wind is probably more important for the upper atmosphere than so far recognized, especially under solar minimum conditions. Changes in the heating efficiency of the solar EUV radiation (Torr et al., in press 1981) might also explain, at least

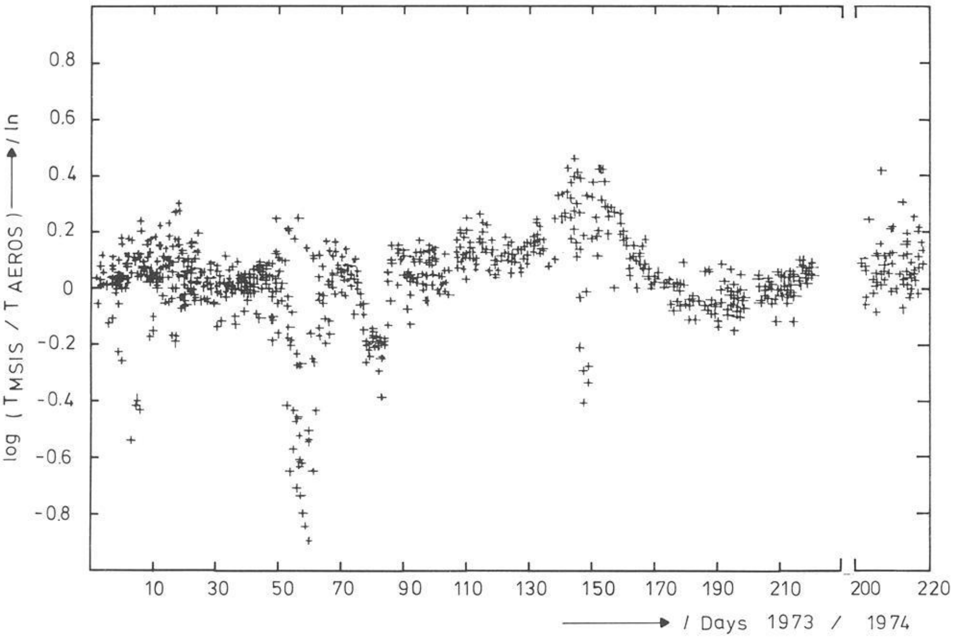

Fig. 3. Comparison of temperatures MSIS/AEROS

in part, the poor correlation of EUV flux and exospheric temperature variations.

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