SOLAR INFLUENCE ON THE EARTH'S RADIATION BELTS

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The more than two years operation of two Radiation Environment Monitors have allowed to study the influence of solar activity variations on the particles trapped in the earth's radiation belts. Decreasing solar activity causes low electron fluxes in the outer belt but results in an enhanced radiation in the South Atlantic Anomaly.

1 INTRODUCTION

The earth's environment is strongly influenced by the solar irradiation, which comprises electromagnetic emission and also particles in the solar wind. This emission undergoes variations, cyclic ones due to the 11-year solar activity cycle and 27-day solar rotation period, but also non-cyclic ones like solar flares and energetic proton events. These variations are also reflected in the state of the earth's environment, i.e. the particles trapped in the earth's magnetic field forming the radiation belts. The earth is surrounded by two radiation belts, the outer, of which the high-energy part (E = 1 MeV) consists mainly of electrons and the inner, which is dominated by high energy protons.

Since summer 1994 two Radiation Environment Monitors, REM [1] from PSI are orbiting the earth on different orbits and monitor the energetic charged particle fluxes in the earth's radiation belts. The period of time covered with REM measurements is in the declining phase of the solar 11-year activity cycle (the minimum of the actual cycle is expected to be reached towards the end of 1997). The declining phase is characterized by decreasing solar magnetic activity that results in a decrease of the Radio, EUV and X-ray emission. In the uppermost panel of Figure 1 we plot as a measure for solar activity the three-month running average of the solar radio flux, F10.7A. The flux of $80 \cdot 10^4$ Janskys (1 Jansky = 10^{-26} W/m^2/Hz) reached in summer 1994 is a factor two smaller than the typical fluxes at solar maximum. Between April 1995 and April 1996 the radio flux decreased by an other 15%.

A drop of the number of sporadic solar events also characterizes the declining phase. In the two years since August 1994 GOES satellites have detected only two proton events. During solar maximum this number would be typically 20. Due to the lack of eruptive events, the solar wind arriving at the edge of the earth's magnetosphere, the magnetopause, is characterized by recurrent fast wind streams which are escaping the sun from coronal holes and reappear after each solar rotation as long as a specific coronal hole exists.

2 SOLAR WIND VERSUS OUTER BELT

It is the impact of these fast wind streams on the magnetosphere which cause strong variations of the high-energy electron population trapped in the outer radiation belt. The arrival of a fast solar wind stream at the earth causes first a depletion of the outer belt within typically one day. This is followed by a rapid (few days) increase where the level reached depends on the wind peak velocity and season [2]. In the middle panel of Figure 1 the three-month running average of the electron flux measured in the outer belt with the REM aboard the UK satellite STRV-1B is plotted versus time. Due to the averaging the fast variations are smoothed out, whereas the seasonal variation is clearly seen.

The low fluxes during winter and summer are not due to the absence of fast solar wind streams during that time. But although solar wind streams of similar velocity and density impinge upon the magnetosphere their effect on the trapped electrons is different than during spring and fall. The effectiveness of the solar wind-magnetosphere interaction is controlled by the orientation of the earth's magnetic dipole axis with respect to the solar wind flow. On the other hand, together with the solar activity also the mean solar wind speed has decreased after summer 1995, which is the reason for the smaller flux maxima observed in fall 1995 and spring 1996 compared to those in fall 1994 and spring 1995.

3 SOLAR FLUENCE VERSUS INNER BELT

Particles trapped in the earth's magnetic field bounce between mirror points located in the north and south hemispheres. At the mirror points the particles dip deepest into the atmosphere, where they can interact with the ambient atoms and molecules and become lost from stable trapping. The altitude above earth of the mirror points of particles trapped in the inner radiation belt depends on geographic position, as the dipole axis of the earth's magnetic field is tilted and shifted relative to the earth's rotation axis. The magnetic field configuration is such that the mirror points are lowest in a region centered on the east cost

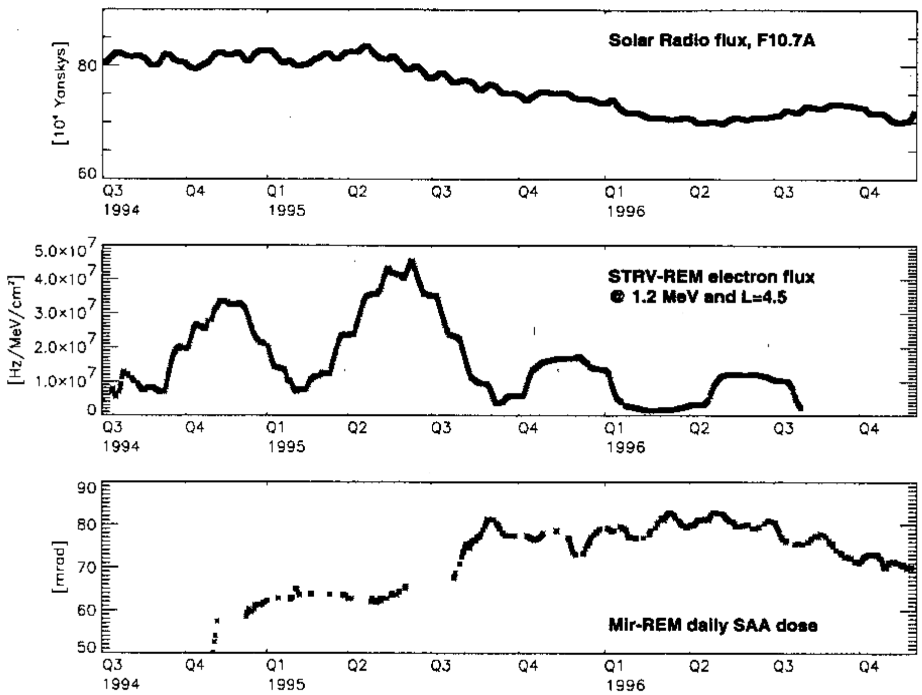

Fig. 1: Three month running averages of (t.t.b.) Solar radio fluence (F10.7A), REM electron flux in outer belt, and REM daily SAA dose. The lowering of solar activity after summer 1995 caused a overall decrease of the flux of electrons trapped in the outer radiation belt and an increase of the daily dose measured in the South Atlantic Anomaly.

of Brazil, in the so-called South Atlantic Anomaly, SAA. This is thus the area where the particles can reach low altitudes (and are experienced by satellites on Low Earth Orbits), but also where their fluxes are most strongly influenced by atmospheric conditions. Variations of the atmospheric density are expected to modulate the loss rate of trapped particles and thus the trapped particles fluxes in the SAA.

In the lowest panel of Figure 1 the daily average dose measured in the SAA by the REM flying aboard the Russian spacestation Mir is plotted versus time [3]. Around the middle of 1995 the SAA dose increased by 25%, nicely coinciding with the observed decrease of the solar radio flux. Calculations using a standard atmospheric density model show that the decrease of heating power from the sun causes a lowering of the atmospheric density in the SAA region by typically 20% which can account for the enhanced SAA doses.

RFERENCES

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