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Extreme solar events: Proxy for the active young Sun and consequence for planetary atmosphere evolution

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Abstract

In this study a high-precision accelerometer onboard the CHAMP satellite, which is a low Earth orbiting (LEO) mission, is used to investigate the temporal and spatial variation of the atmospheric density. This density is caused by the so-called Halloween event, which count to extreme solar activity events, at an altitude of about 400 km. Our focus concentrates on the variation of the neutral atmospheric density and related temperature in the upper thermosphere during such extreme solar events. Afterwards, we compare the absolute density values with state of the art density models such as NRLMISE-00 and Jacchia-Bowman 2008. These atmospheric disturbances are generated from CMEs, which are associated with a solar flare of magnitude X17.2 and caused increasing densities up to about 300 - 400% which may lead to significant local rise in temperatures of the exobase compared to quiet solar conditions. An analysis of these events is used for the investigation of the connection between such extreme solar events and the activity of solar proxies with different age.

Solar data of the Halloween event in Oct./Nov. 2003 are used as proxy for the active young sun, especially the data of the 28th October 2003. Therefor, the data sets are retrieved from the Coronal Diagnostic Spectrometer (CDS), which is developed to detect solar extreme ultraviolet radiation onboard SOHO. The detected flare is measured in the EUV at about 300-380 Angstroms and 510-630 Angstroms, respectively, which is an important range for studying the solar influence on upper atmospheres. After applying correction and calibration procedures to the CDS data they are compared to the quiet sun and afterwards to spectra of young solar-like stars of different age. If solar flare spectra match spectra of young solar analogues they can simulate the situation of the young sun.

We show that this approach is important for studies that relate to the evolution of the early nitrogen-rich atmospere of the Earth and for Earth-like nitrogen atmospheres of exoplanets which orbit around active host stars.

1. Introduction

The Coronal Diagnostic Spectrometer [2] is designed to determine information about characteristics of a plasma such as density, temperature, velocity, flux etc... on spatial, temporal and spectral scales. Therefor, the emission lines are studied in the extreme ultraviolet (EUV). CDS consists of a Wolter-Schwarzschild II grazing incidence telescope, a set of slits, a scan mirror and two spectrometers, called grazing incidence spectrometer (GIS) and normal incidence spectrometer (NIS). In our study we use rasterd images of the NIS in two spectral ranges.

2. Observations

To determine solar EUV irradiances it is necessary to apply cleaning, correction and calibration procedures which are provided from CDS. The incoming light is focused on a CCD detector producing two spectrally disperesed stigmatic images which have units of Analog to Digital Conversion units ("'ADC"'). To convert into physical units three steps are necessary, starting with removing the CCD readout bias due to cosmic rays, followed by a routine that converts the data to photon-events/pixel/sec. Here the term photon-events refers to the count of pixel which have been detected by the instrument. The final step is to convert this units into absolute units which includes factors such as quantum efficiency, wavelength calibration and effective area of the CDS telescope.

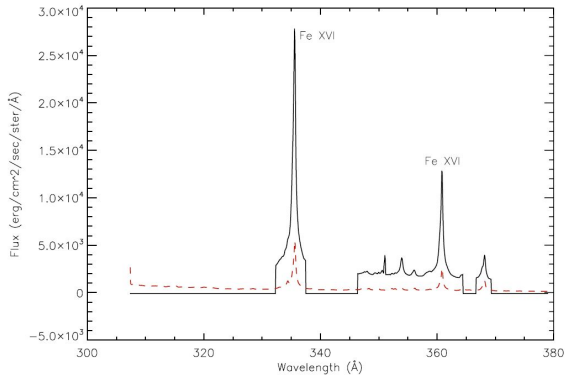

Figure 1: Spectrum of the 28th October 2003 compared with the quiet sun and identified lines.

3. Figures

Fig.1 shows the spectrum of the 28th October at 11:02:53 UT. The gaps found in this plot due to the different slits the NIS uses. The flare spectrum and the spectrum of the quiet sun vary by a factor of about 2.4, the ratio of both Fe XVI lines active/quiet is 5.

4. Summary and Conclusions

Our Aim is to compare this CDS spectrum with those of Ribas et al. (2005) [3], who analysed the EUV irradiances of different stages of the evolution of solar-type stars. With more of such extreme events it is possible to simulate the sun of different ages. An erupting flare on the Sun should affect the Earth's atmosphere. Using data from the CHAMP [1] (CHAllenging Minisatellite Payload) satellite this influence can be investigated and results can be then used as a proxy for the influence of the young Sun on the early Earth.

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