PAMELA's measurement of geomagnetic cutoff variations during solar energetic particle events

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on behalf of the PAMELA collaboration

PAMELA

a Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics

Introduction

Large Solar Energetic Particle (SEP) events can strongly perturb the Earth's magnetic field, inducing geomagnetic storms and modifying the cosmic-ray access to the inner magnetosphere. Estimates of geomagnetic cutoffs have been provided by satellite observations and theoretical calculations mainly based on tracing particles through models of the Earth's magnetosphere. Here we present PAMELA's measurements of the variability of the geomagnetic cutoff during the SEP events on 2006 December 13-14.

Data analysis

PAMELA is a space-based experiment designed for a precise measurement of the charged cosmic-rays in the kinetic energy range from some tens of MeV up to several hundreds of GeV [1]. The analysis described in this work is based on the **IGRF-11** [2] and the **TS05** [3] models for the description of the internal and external geomagnetic field sources, respectively. For comparison, the T96 model [4] was used as well. Solar Wind (SW), Interplanetary Magnetic Field (IMF) and geomagnetic parameters were obtained from the high resolution (5-min) Omniweb database. Data were analyzed in terms of **AACGM** coordinates [5].

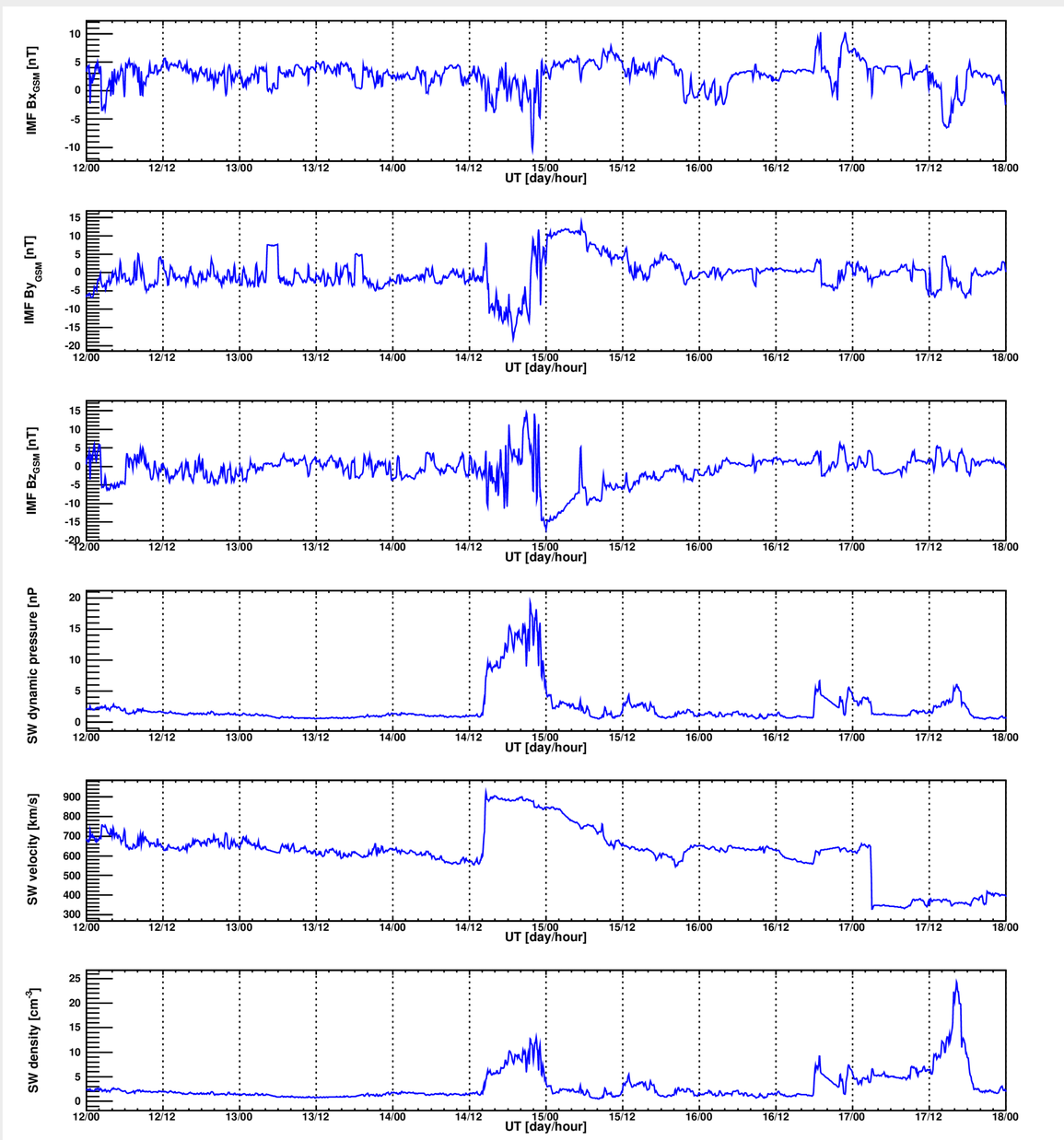
Cutoff evaluation

The numerical algorithm developed to extract cutoff latitudes from the PAMELA data is similar to one used by [6] and [7].

- For each rigidity bin, a mean flux was obtained by averaging fluxes above 65 degrees latitude and the cutoff latitude was evaluated as the latitude where the flux intensity is equal to the half of the average value.
- Alternatively, cutoff latitudes were calculated with back-tracing techniques [8]: at a given rigidity, the cutoff latitude was estimated as the latitude where an equal percentage of interplanetary and albedo protons was identified.

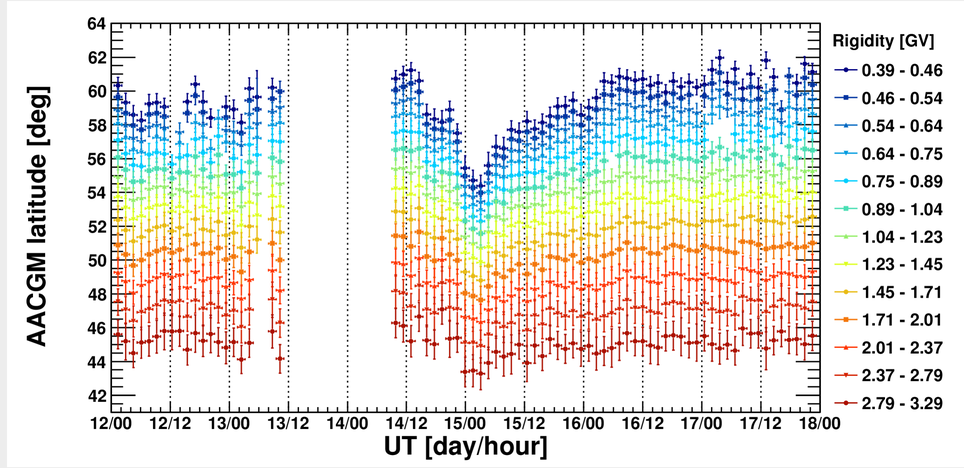
Cutoff observations were averaged over orbital periods (~94 min).

The 2006 December 13 and 14 events

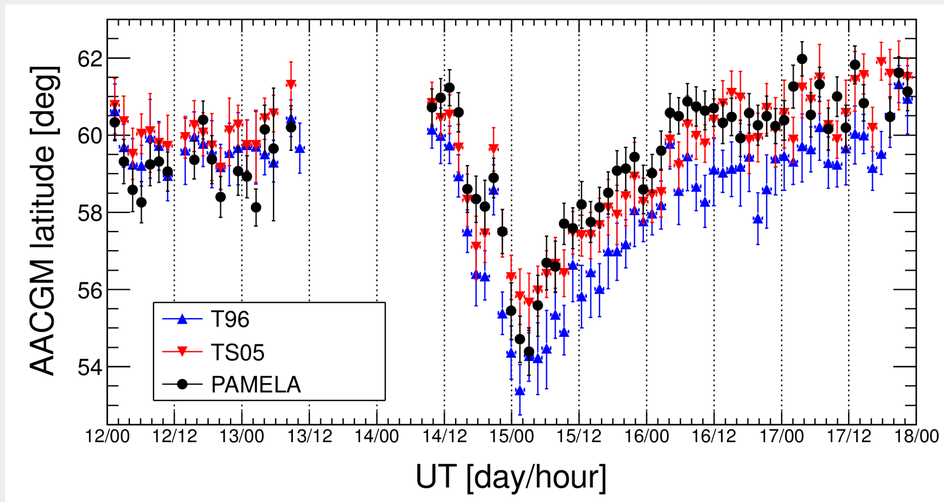


Variations of IMF and SW variables between Dec 12-18. The large increase in the SW velocity associated with the leading edge of the CME caused a sudden commencement of a geomagnetic storm. The initial phase was characterized by intense fluctuations in the SW density and in all IMF components. Then B_z became negative, the SW density decreased, and the main phase started, reaching a maximum between 02:00-08:00 UT on Dec 15.

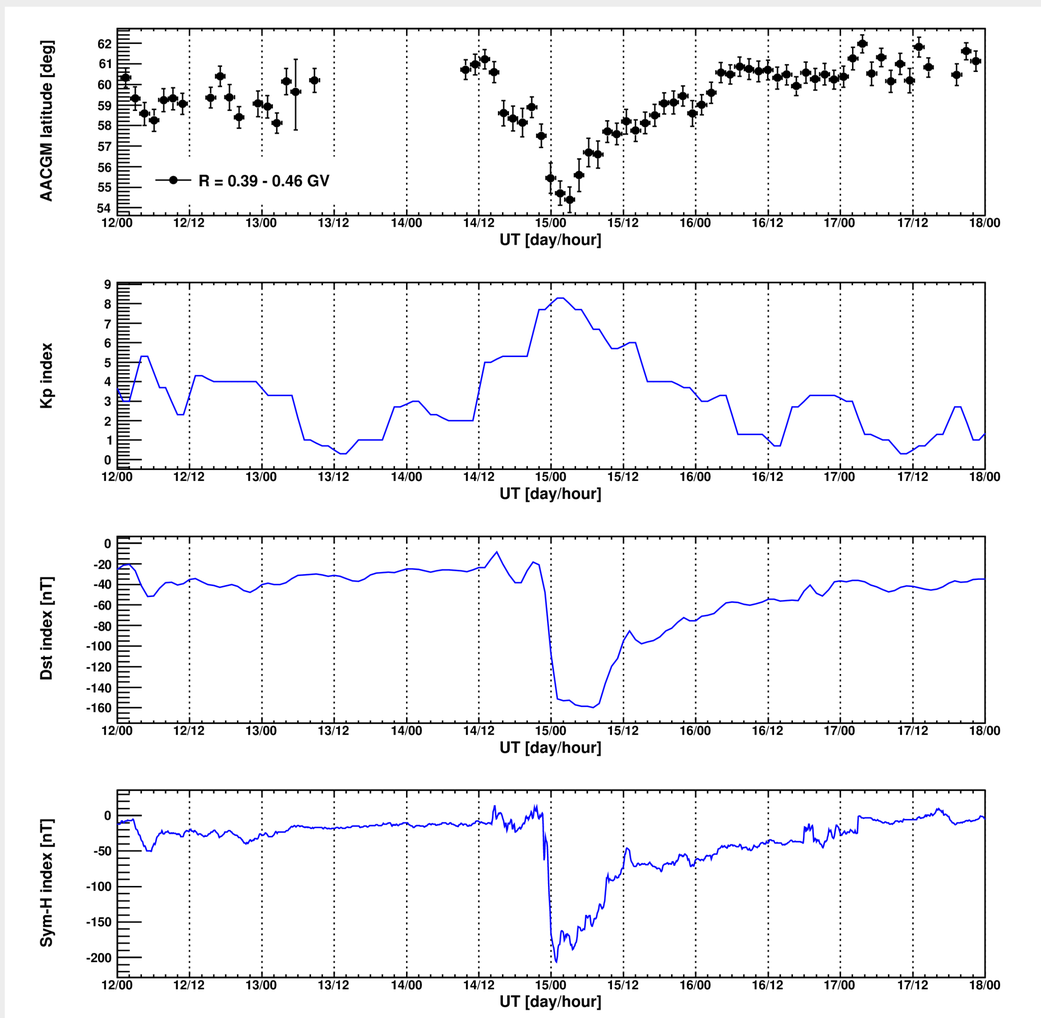
Results



Cutoff latitudes measured by PAMELA for different rigidities. Data were missed from Dec 13, 10:00 UT to Dec 14, 09:14 UT due to an onboard system reset of the satellite. The evolution of the Dec 14-15 storm followed the typical scenario with cutoff latitudes moving equatorward as a consequence of a CME impact on the magnetosphere with an associated transition to southward B_z



Comparison between measured and modeled cutoff latitudes, for the lowest rigidity bin. While the T96 model underestimates (up to 4%) the observations, a much better agreement can be noted for the TS05 model. However, the TS05 cutoff latitudes overestimate (up to 2%) the PAMELA ones during the storm main phase.



Comparison of measured cutoff latitudes with Kp, Dst and Sym-H indexes. In general, the shapes of the time variations in the cutoff measurements are well correlated with corresponding indexes changes (corresponding correlation coefficients are 0.8, 0.78 and 0.78, respectively). However, a better agreement is found for Kp during the initial phase, while the Dst and the Sym-H indexes show an improved correlation during main and recovery phases.

References

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