Project Details

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Program Element: Focused Science Topic

Topic: Understanding and Predicting Radiation Belt Loss in the Coupled Magnetosphere

Project Title:
Analyzing the first all-sky images of DREP events measured with COSI

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Summary:
Science goals and objectives:
Electron precipitation into the atmosphere can significantly drain the radiation belts during geomagnetic storms. Loss to the magnetopause may also be significant, but the relative importance of magnetopause versus atmospheric loss is so far not well quantified. Quantifying the electron loss rate is crucial for incorporating accurate loss estimates into radiation belt models. Wave-particle interactions are thought to be responsible for pitch-angle scattering of electrons into the atmospheric loss cone. Based on observations, atmospheric precipitation has been classified into at least two main types, believed to be caused by different wave-particle interactions: duskside relativistic electron precipitation (DREP) and microburst precipitation.
Both event types have been observed with the Compton spectrometer and imager. COSI is a balloon-borne Compton telescope operating in the energy range from 150 keV up to 5 MeV. In spring 2016, COSI was launched from Wanaka, New Zealand, for a 46-day flight at ~110,000 feet altitude. Its observation of DREP and microburst events marks the first time these events have been observed with an all-sky imaging gamma-ray detector combining an angular resolution of a few degrees with millisecond time resolution, a few keV energy resolution, and the capability to measure gamma-ray polarization.
As a consequence, COSI provides the first direct images of these events and thus enables the determination of the spatial scale and structure of the precipitation along with any potential drifts of the emission region with time. This will enable a much more accurate determination of the loss rate of the electrons and ultimately help to verify or refine the radiation belt models. In addition, the knowledge of the spatial scale of the emission will give us a better understanding of the electron scattering mechanism (e.g. the efficiency of the interaction with EMIC waves). An exploratory analysis of the data of the strongest observed event (160530A) shows clear indications for spatial variability between the individual sub-peaks of the event. Finally, the COSI data will for the first time constrain the polarization levels of the gamma-ray emission. The emitted Bremsstrahlung is expected to be polarized, and therefore the observed level and angle of polarization (after taking into account polarization loss due to electron scattering in the atmosphere) can help inferring the pitch angle distribution of the precipitating electrons and distinguish between strong diffusion, weak diffusion, and non-linear scattering mechanisms.

Methodology:
The first goal of this proposal is to generate all-sky maps of the incoming gamma-ray flux (including uncertainties) as a function of energy and time at the balloon altitude, and to constrain the polarization level and angle. For the analysis we can rely on existing simulation models, responses, and analysis tools developed for the analysis of COSI s astrophysical targets. However, the tools need to be adapted to determine polarization from extended sources and then evaluated with realistic simulations.
The second goal is to evaluate existing models of how the electron precipitation is generated with the COSI results and constrain the spatial scale and the pitch angle distribution of the precipitating electrons. This will be achieved via Monte-Carlo simulations of the expected precipitation emission and the atmosphere, followed by a comparison of the simulation results and COSI observations.

Connection to the Science Objectives of the Focus Science Team efforts:
This proposal is relevant for FST #2: Understanding and predicting radiation belt loss in the coupled magnetosphere (B.5-6). By determining the spatial and temporal emission variations during electron precipitation events, it will further our understanding and the predictability of radiation belt losses in the inner atmosphere due to precipitation.

Publication References:

no references