The Impacts of Substorms on the Ring Current

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Substorms are a highly dynamic process that results in the global redistribution of energy within the magnetosphere. The occurrence of a substorm can provide the inner magnetosphere with hot ions and consequently intensify the ring current population. However, substorms are a highly variable phenomenon that can occur as an isolated event or as part of a sequence. In this study we investigate how substorms shape the energy content, anisotropy, and storm time behaviour of the ring current population.

Using ion observations (H+, O+, and He+) from the RBSPICE and HOPE instruments onboard the Van Allen Probes, we quantify how the total ring current energy content and ring current anisotropy changes during the substorm process. A statistical analysis demonstrates the impact of a typical substorm energises the ring current by 12% on average. The features of the energy enhancement correlate well with the expected properties of particle injections into the inner magnetosphere, and large enhancements in the O+ contribution to the energy content suggest important compositional variations.

Analysis also shows that the ring current ions experience significant isotropisation following substorm onset. Although previously attributed to enhanced EMIC wave activity, a consideration of different drivers of the isotropisation identifies that although EMIC wave activity plays a role, the properties of the injected and convected population is the dominant driver.

Finally, we explore the storm time variations of the ring current, revealing important information on the role of substorms in storm dynamics. A superposed epoch analysis of ring current energy content shows large enhancements particularly in the premidnight sector during the main phase, and a reduction in both local time asymmetry and intensity during the recovery phase. A comparison with estimated energy content using the Sym-H index was conducted. In agreement
with previous results, the Sym-H index significantly overestimates energy content. A new finding is an observed temporal discrepancy, where estimates maximise ~ 12 hours earlier than the in-situ observations. We assert that an observed enhancement in substorm activity coincident with the Sym-H recovery is responsible. The results highlight the drawbacks of ring current indices and emphasise the impacts of substorms on the ring current population.