Electron precipitation from the outer radiation belt during the St Patrick's Day storm 2015: observations, modelling, and validation

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Recently, a model for medium energy (30–1000 keV) radiation belt-driven electron precipitation (ApEEP) has been put forward for use in decadal to century-long climate model runs as part of the Climate Modelling Intercomparison Project, phase 6 (CMIP6) [1]. The model describes the loss of radiation belt electrons into the lower ionosphere. The ApEEP model is based on directly observed precipitation data spanning 2002-2012 from the constellation of low Earth orbiting Polar Operational Environmental Satellites (POES). Here we test the ApEEP model's ability using its magnetic local time variant, ApEEP_MLT, to accurately represent electron precipitation fluxes from the radiation belts during a large geomagnetic storm that occurred outside of the span of the development dataset. Our goal is to validate the electron precipitation values provided by the ApEEP_MLT model, using independent radio propagation observations. This work has recently been published [2].

In a study of narrow band sub-ionospheric VLF transmitter data collected during March 2015, continuous phase observations have been analyzed throughout the entire St. Patrick's Day geomagnetic storm period. High quality phase observations lasting almost a month are interpreted in terms of non-disturbed background ionospheric electron density profiles, and storm-induced energetic electron precipitation fluxes. Using phase data from the UK transmitter, call-sign GVT (22.1 kHz), received in Reykjavik, Iceland, electron precipitation fluxes from L=2.8-5.4 are calculated around magnetic local noon (12 MLT), and magnetic midnight (00 MLT).

We find that the VLF-inferred >30 keV electron fluxes are similar to the equivalent directly-observed POES electron fluxes. The ApEEP_MLT >30 keV electron fluxes for L<5.5 describe the overall St Patrick's Day geomagnetic storm-driven flux enhancement well, although they are a factor of 1.7 (1.3) lower than POES (VLF-inferred) electron fluxes during the recovery phase. Such close agreement in >30 keV flux levels during a large geomagnetic storm, using three different techniques, indicates this electron flux forcing is appropriate for decadal climate simulations for which the ApEEP model was created.

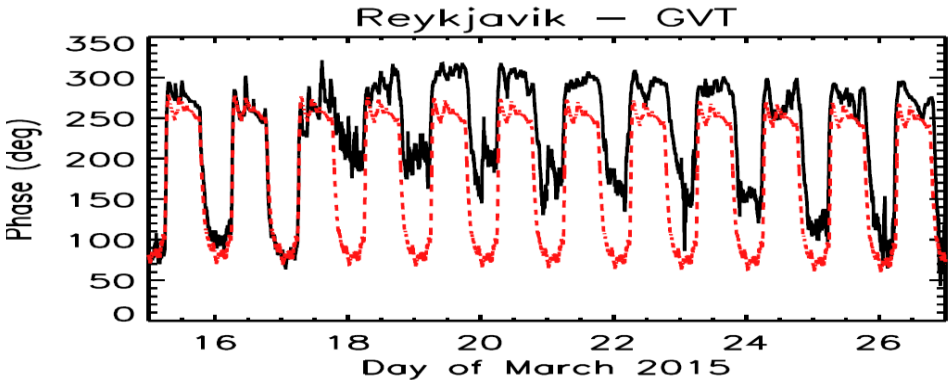

Figure 1. Subionospheric VLF phase during the St Patrick's Day geomagnetic storm in March 2015, from the UK transmitter, GVT (22.1 kHz), received at Reykjavik, Iceland (black line), with a superposed quiet day curve (QDC, red dashed line) including a 1°/day phase drift caused by the transmitter.

References

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[2] M. A. Clilverd, C. J. Rodger, M. van de Kamp, and P. T. Verronen, Electron precipitation from the outer radiation belt during the St Patrick's Day storm 2015: observations, modelling, and validation, *J. Geophys. Res.*, **125**, e2019JA027725, doi:10.1029/2019JA027725, 2020.