Diagnosing the Causes of Extremely Fast Loss from the Radiation Belts: High Cadence Swarm and GPS Satellite Monitoring

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Swarm vs. Van Allen Probes – polar LEO, 90 minute orbit period

Van Allen Probe ~9 hours orbit, Swarm ~90 mins
Two storms – additional loss mechanism needed

- modelling work by Louis Ozeke shows good correspondence with Van Allen probe measurements..

- but additional loss is required to explain rapid (hour-timescale) dropouts

- Swarm observes enhanced wave power in the Pc1 band at the time of the dropouts
GPS flux plot

Dropout happens roughly here (6-9 UT)
Olifer et al. 2018 (JGR in review)
Two storms – additional loss mechanism needed

- a zoom-in on the 17 March 2015 time period

- Pc1 wave power increasing at Low L-shells in the heart of the outer radiation belt around the time of the dropout period
AMPERE hourly plot for 17 March 2015: extremely powerful FACs
Field aligned currents and waves on Swarm

Waves!

Field-aligned currents
Coherent wave region – but different multi-spacecraft phase

$L \sim 2.6-2.8$
Alfvén waves and field aligned currents – observations + modelling

- Pakhotin et al. (2018) JGR – Swarm observations of Alfvén waves within high-latitude FAC system

- Song and Lysak (2018 Chapman poster) – in the presence of a continuous power source, Alfvén wave Poynting flux propagating to ground and reflecting from the ionosphere will set up quasi-static structures

- the energy to support these structures is wave driven

- red curves demonstrate an example Lysak (1991) model run initialised with reasonable parameters
Alfvén waves and field aligned currents - observations
Pc1 waves at southern conjugate hemisphere – L~2.8-3
Conclusions

- Swarm can be used as a high-cadence Pc1 wave monitor, potentially observing waves that may be missed by e.g. Van Allen probes.
- Spatio-temporal ambiguity is a problem, but can be resolved by using multiple spacecraft and looking for coherency.
- Large amplitude Pc1 waves have been observed around the time of the main dropout of the St Patrick’s Day 2015 storm.
- Future work – use E and B together to ascertain Alfven wave nature of disturbances, use Swarm B, e-POP to scan extra MLT sectors.
- Swarm can be used to potentially observe Pc1 waves which may be responsible for rapid relativistic electron flux dropouts in the outer belt.