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

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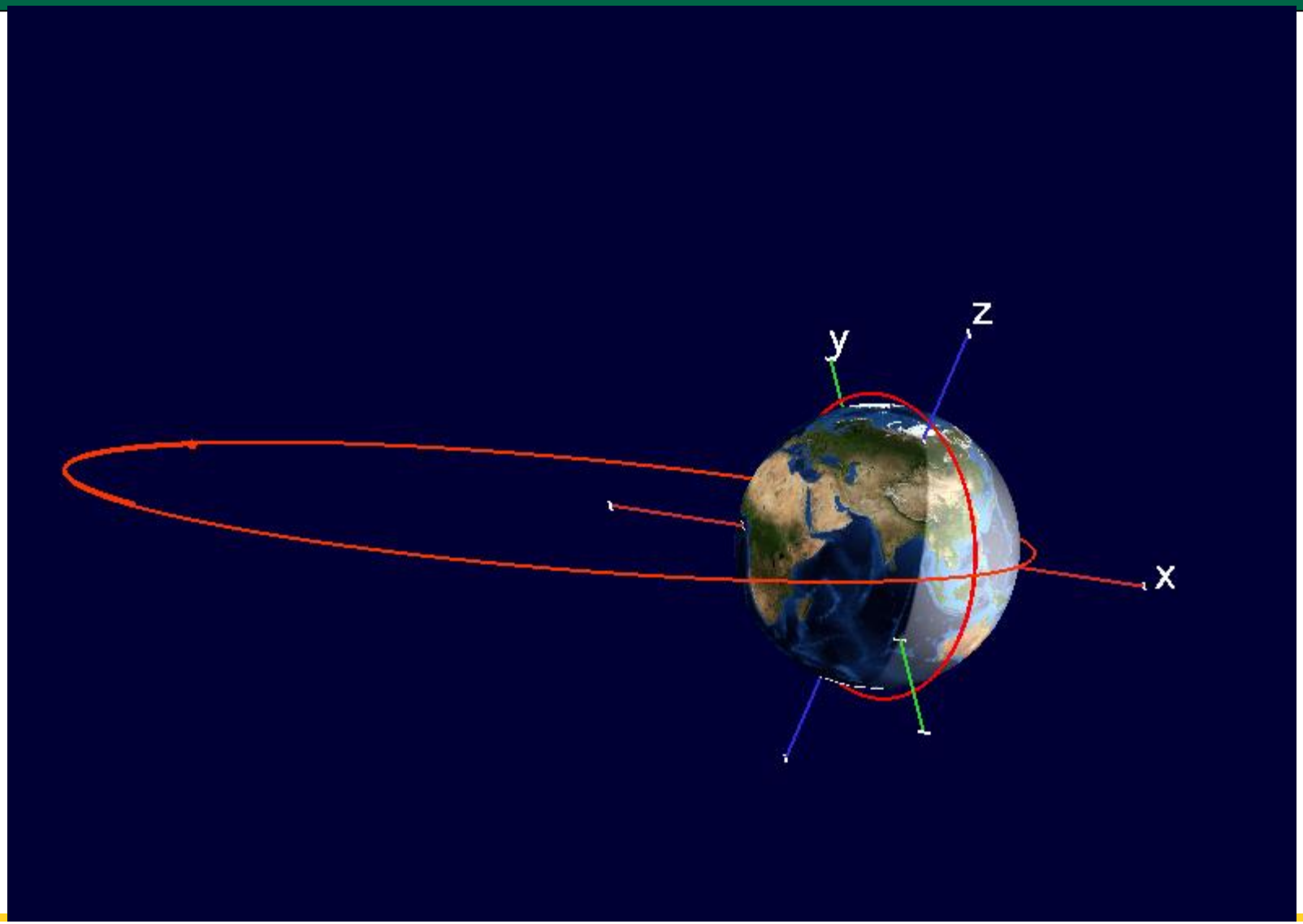
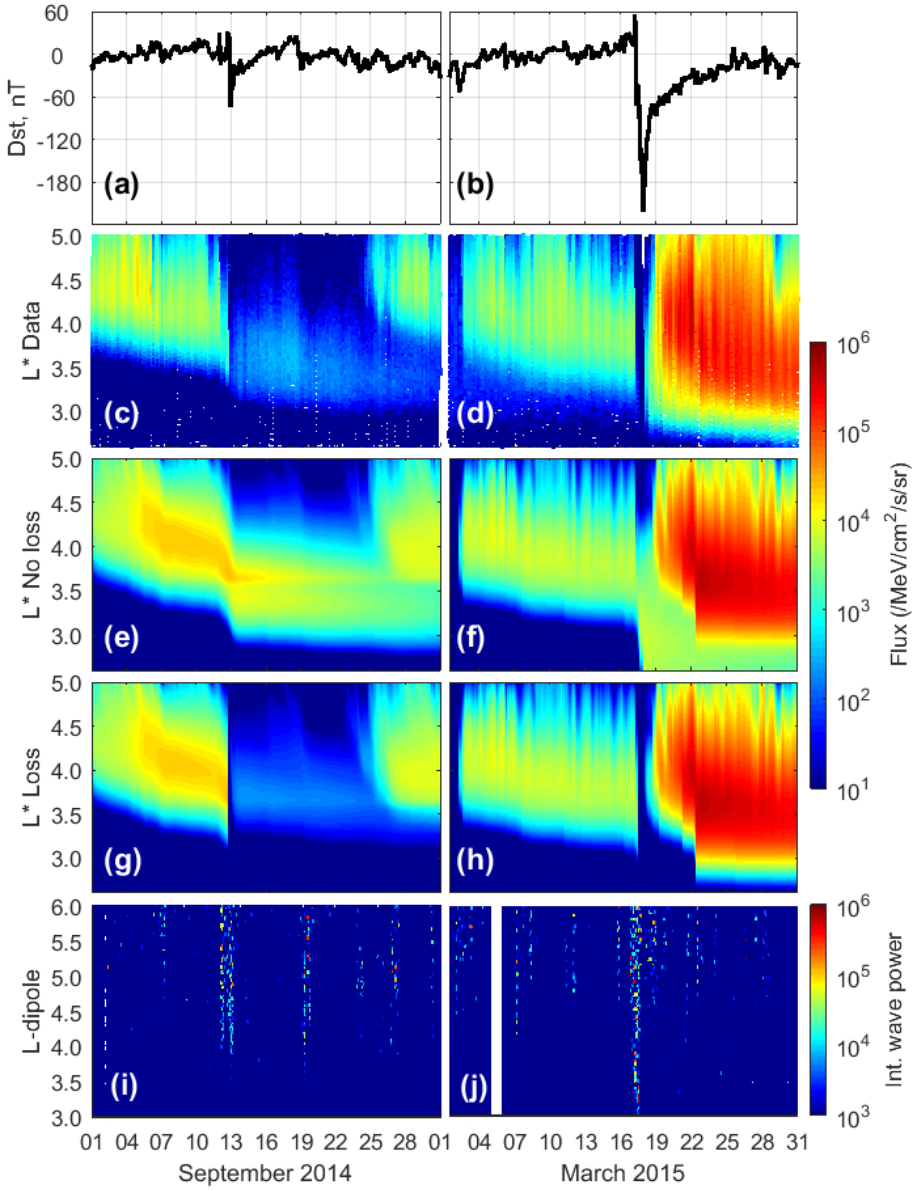
Swarm vs. Van Allen Probes – polar LEO, 90 minute orbit period



Van Allen Probe ~9 hours orbit, Swarm ~90 mins

Two storms – additional loss mechanism needed

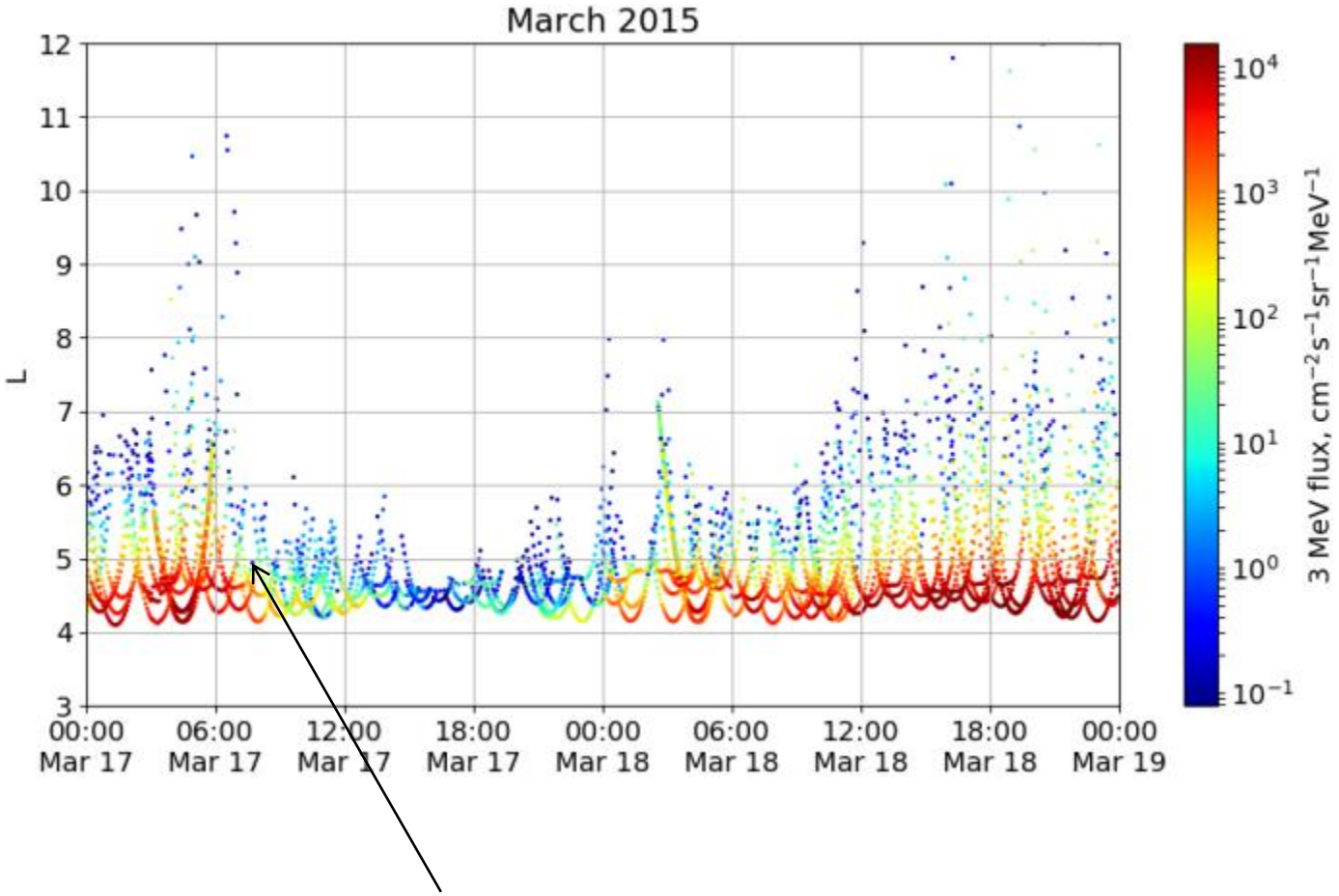


- modelling work by Louis Ozeke shows good correspondence with Van Allen probe measurements..

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

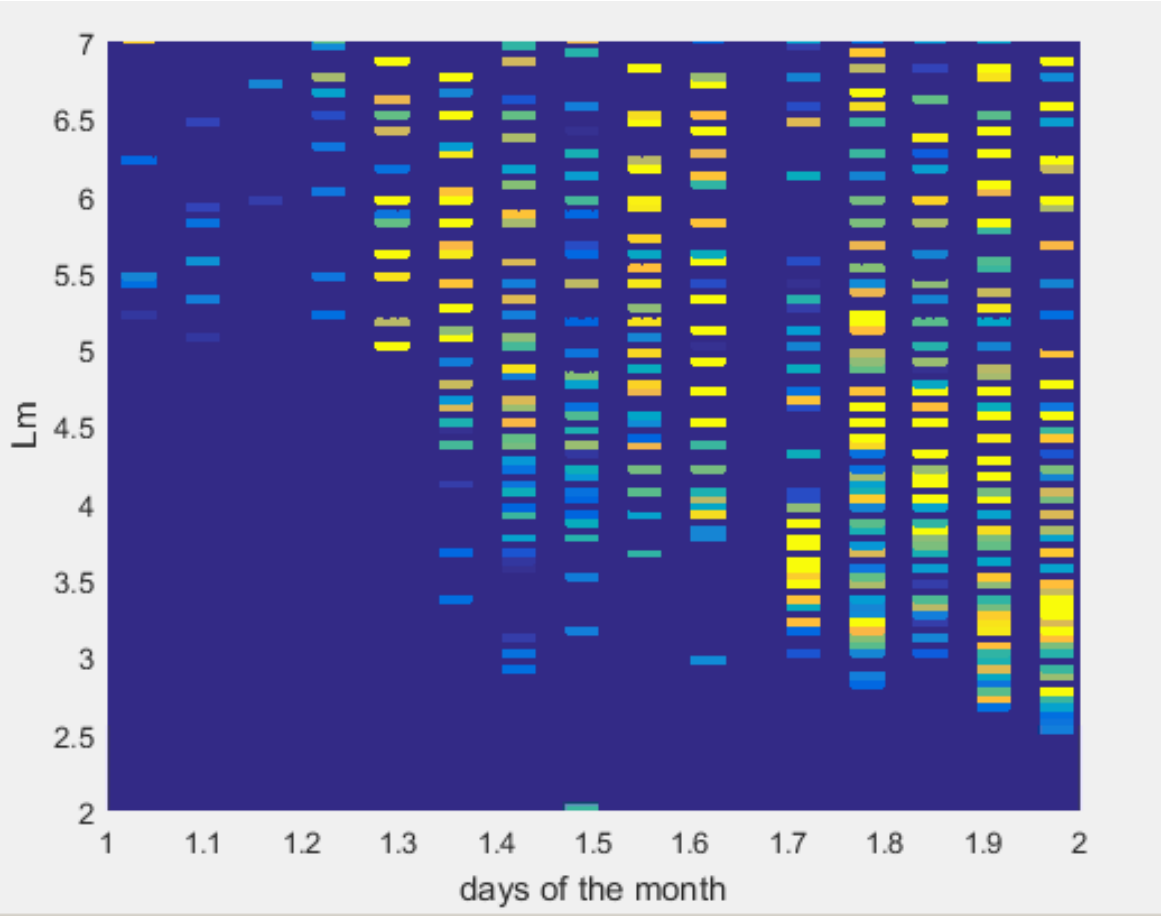
- Swarm observes enhanced wave power in the Pc1 band at the time of the dropouts

GPS flux plot



Dropout happens roughly here (6-9 UT)
Olifer et al. 2018 (JGR in review)

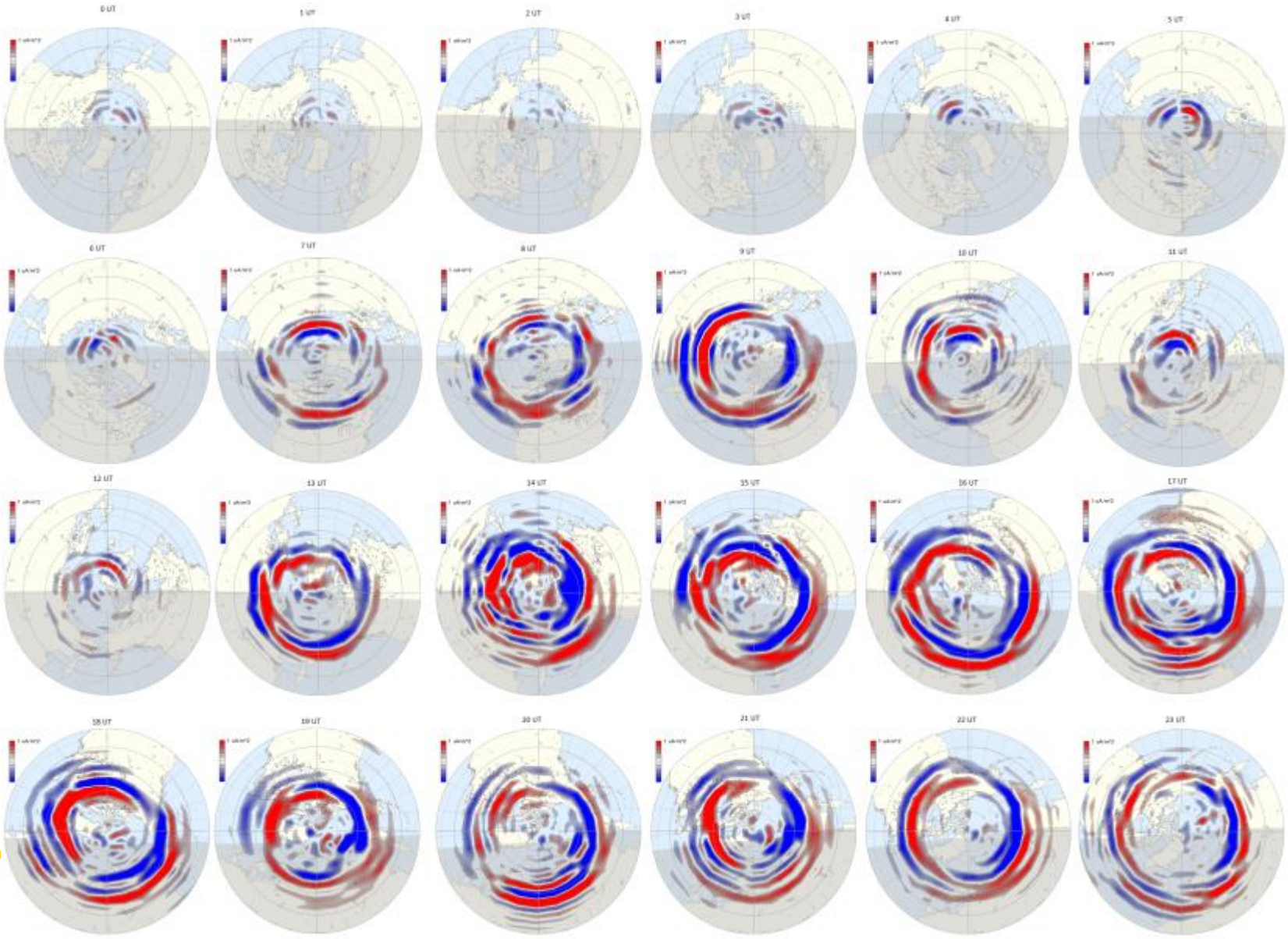
Two storms – additional loss mechanism needed



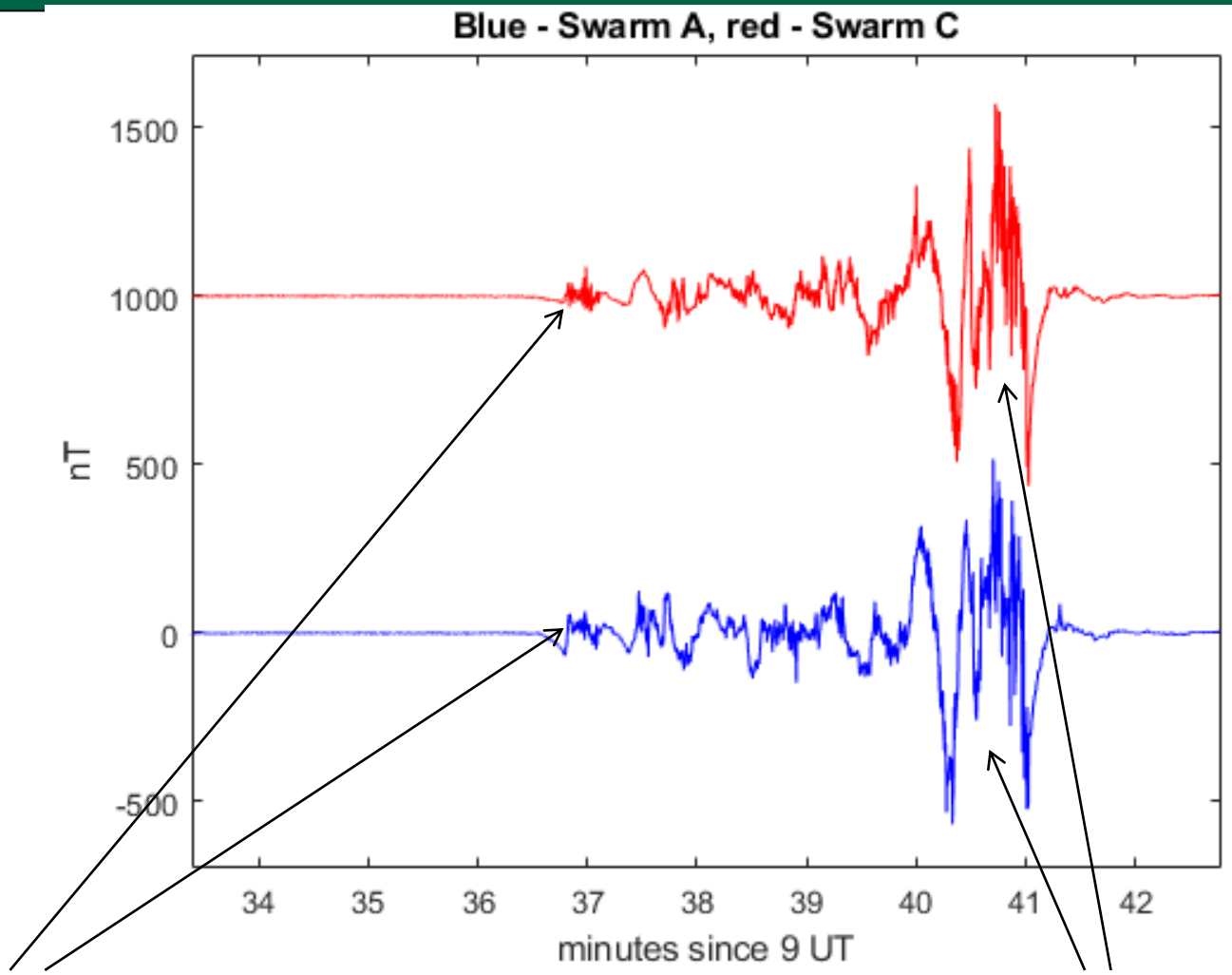
- a zoom-in on the 17 March 2015 time period

- 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



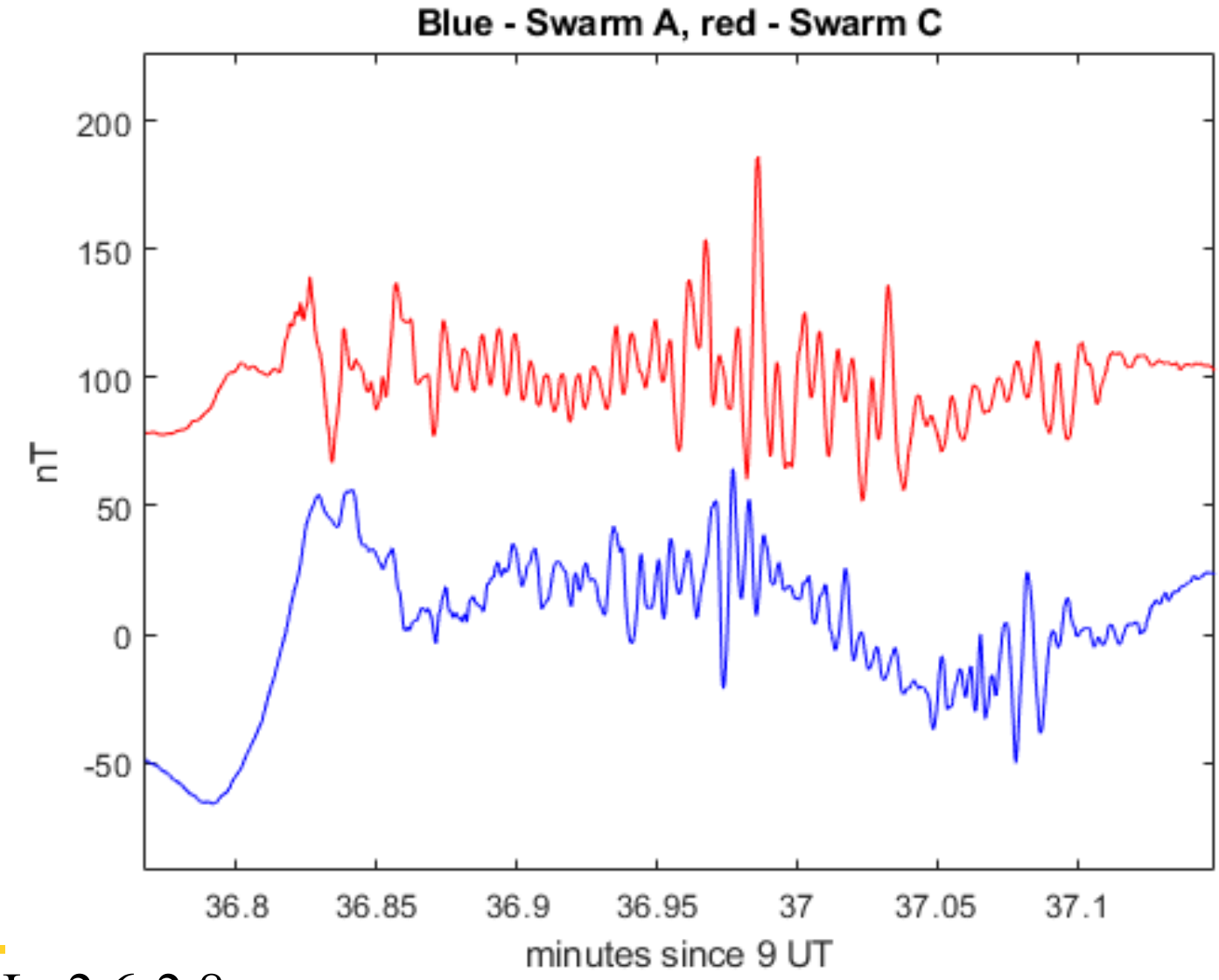
Field aligned currents and waves on Swarm



Waves!

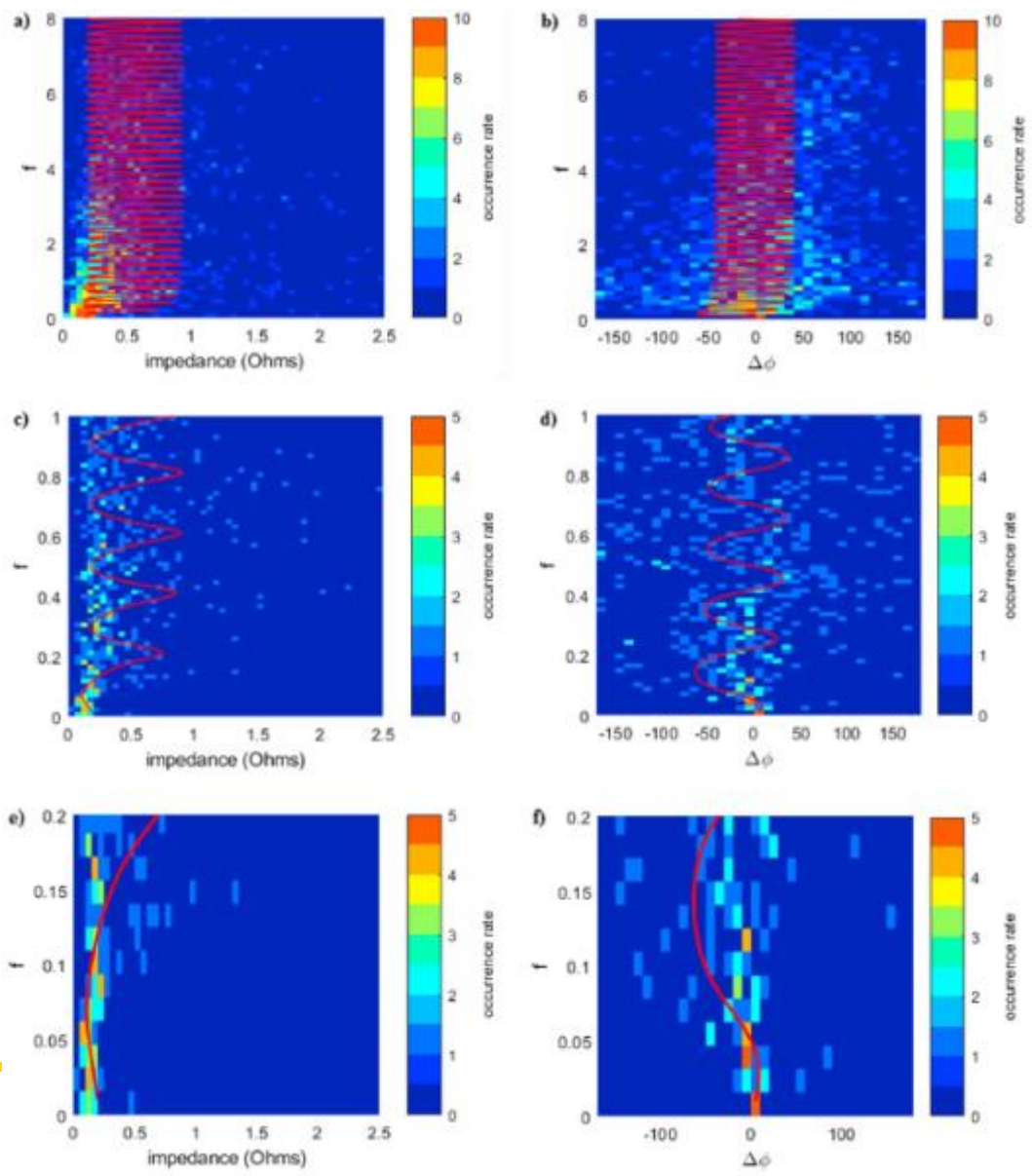
Field-aligned currents

Coherent wave region – but different multi-spacecraft phase



L~2.6-2.8

Alfven waves and field aligned currents – observations + modelling



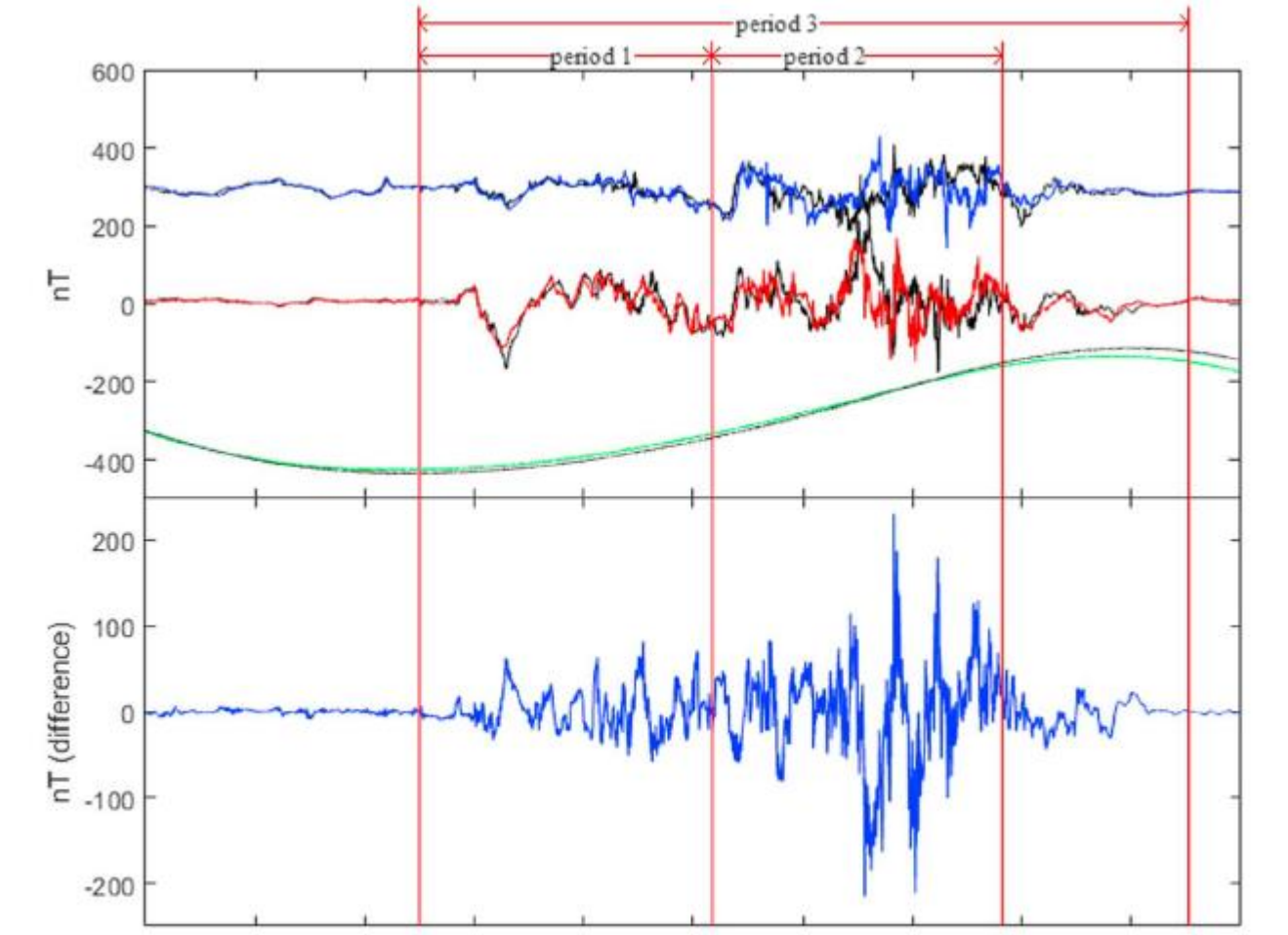
- Pakhotin et al. (2018) JGR – Swarm observations of Alfven waves within high-latitude FAC system

- Song and Lysak (2018 Chapman poster) – in the presence of a continuous power source, Alfven 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

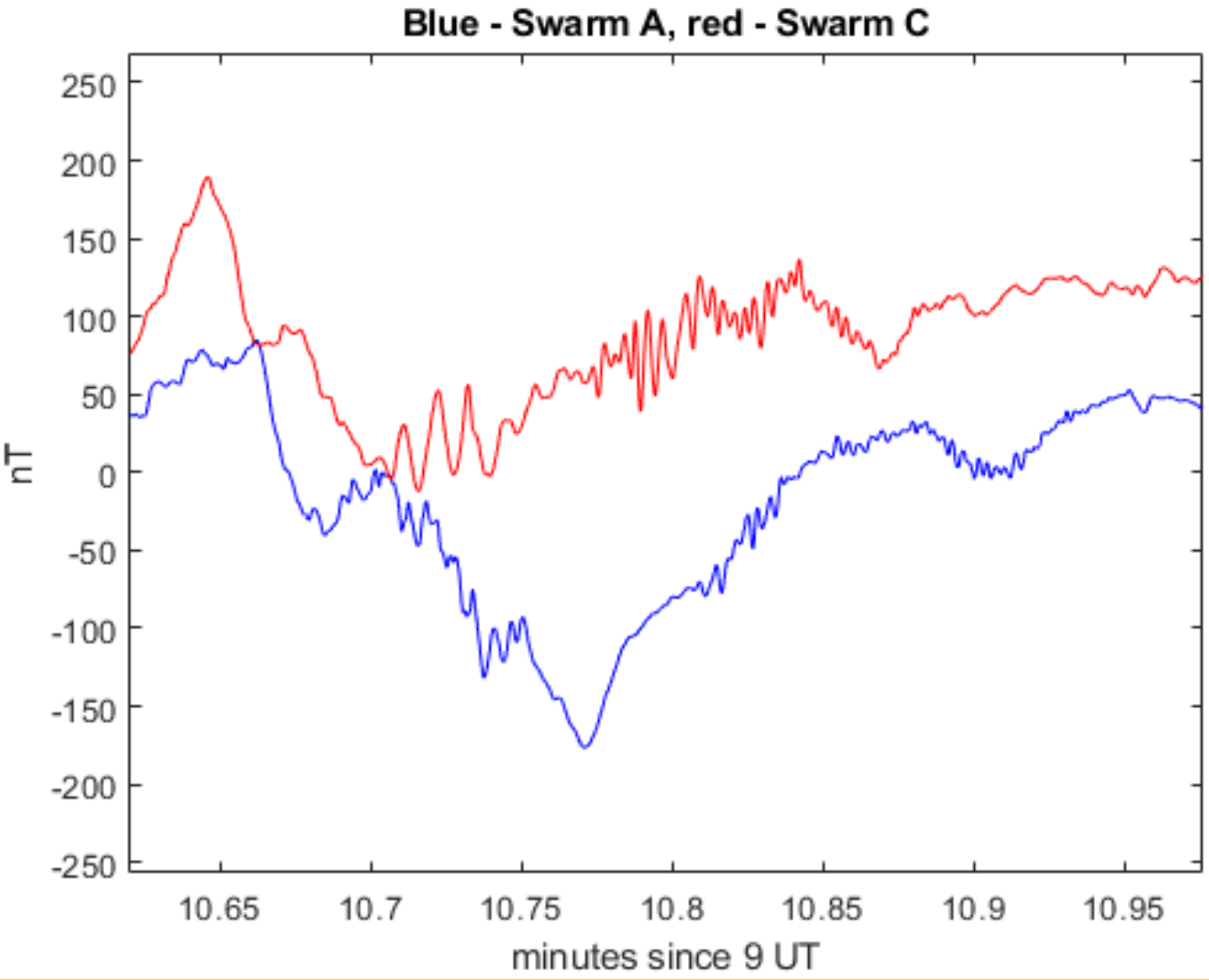
- red curves demonstrate an example Lysak (1991) model run initialised with reasonable parameters

Alfven waves and field aligned currents - observations



UT	17:15:00	17:15:40	17:16:20	17:17:00	17:17:40	17:18:20	17:19:00	17:19:40	17:20:20	17:21:00	17:21:40
MLAT	79.64	81.32	82.61	83.28	83.14	82.22	80.76	78.95	76.93	74.78	72.51
MLON	173.89	184.03	198.29	216.85	236.97	254.38	267.25	276.31	282.72	287.37	290.79
MLT	23.88	0.46	1.32	2.54	4.02	5.40	6.41	7.09	7.56	7.89	8.13

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