# Evolution of ionospheric convection and ULFs during the 27 March 2017 storm: ERG-SuperDARN campaign

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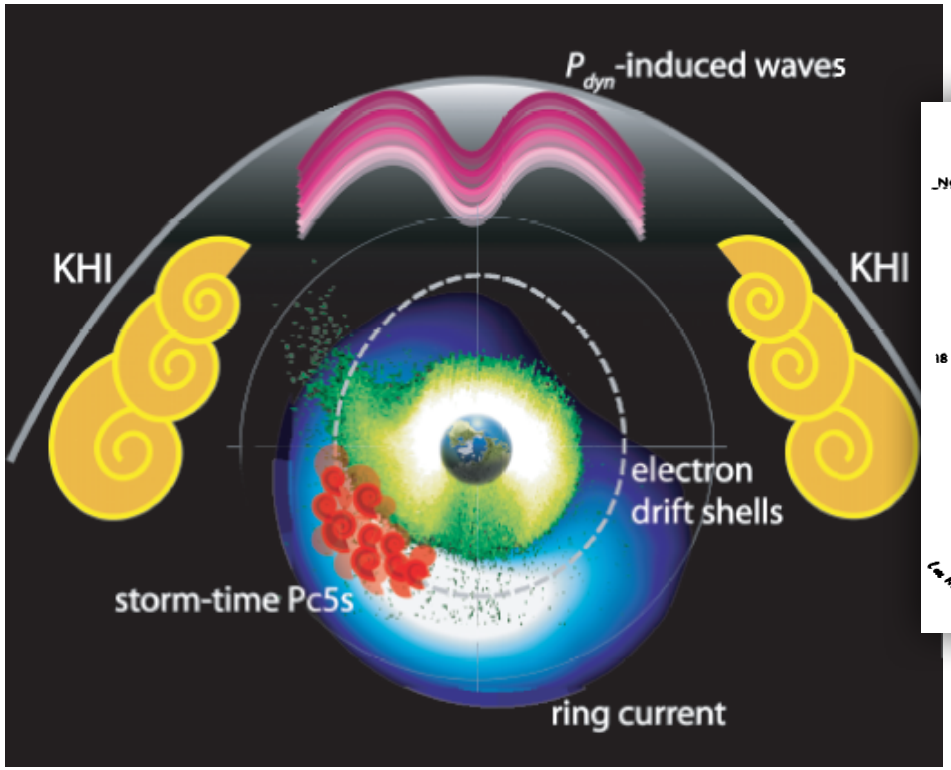
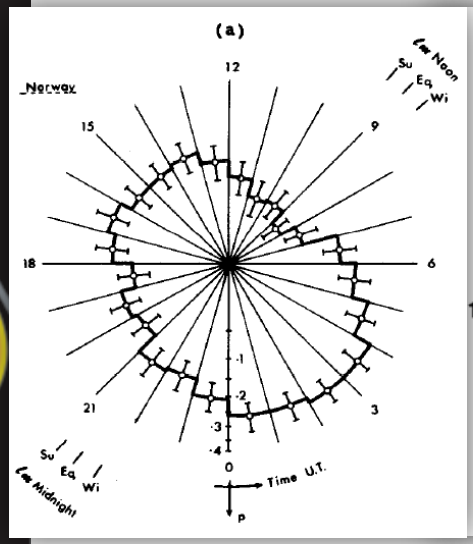
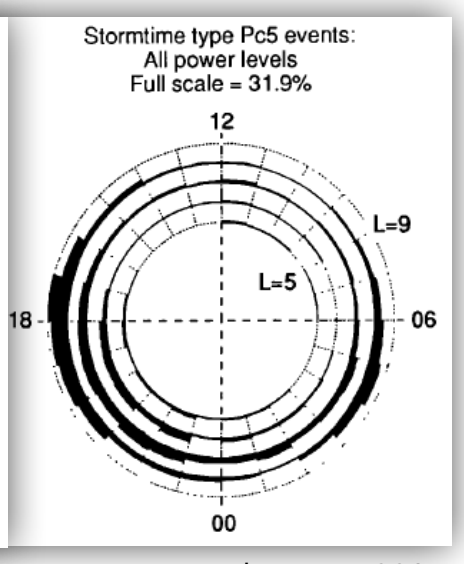
# Introduction:
# Storm-time Pc5, a category of Pc5 ULF waves




[Ukhorskiy+2009]




[Walker+1981]

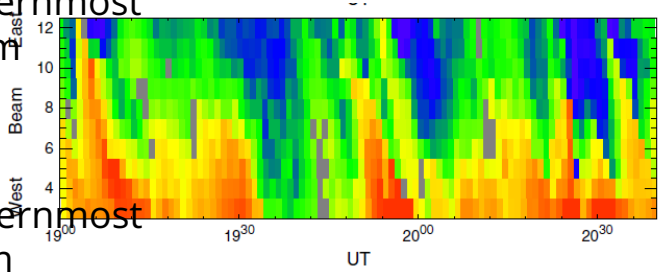



[Anderson+1990]

- Pc5 ULF waves can roughly be classified by their energy source into two categories:
  - Solar wind driven Pc5 ULFs →transverse, typically low-m, pumped externally
  - Storm-time Pc5 ULFs → compressional, often high-m, driven internally

# Drivers of substorm-injection-driven ULFs

easternmost beam

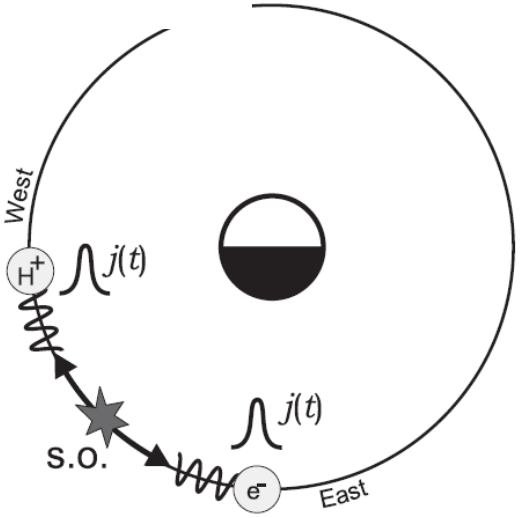



[James+2013; 2016]

westernmost beam

Period ~ several to 10 min

Both westward- and eastward-propagating with m ~ 0–30



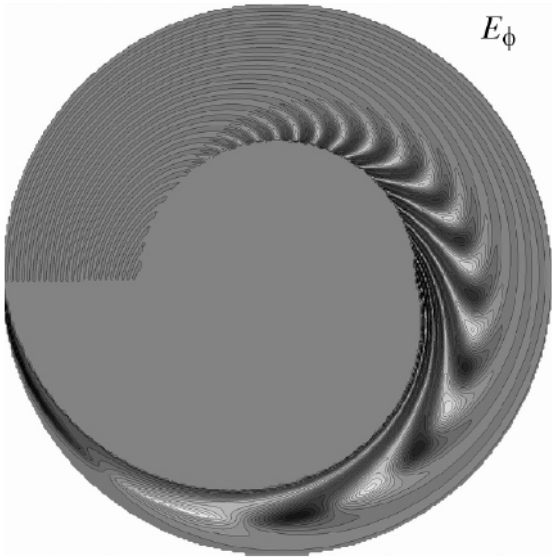
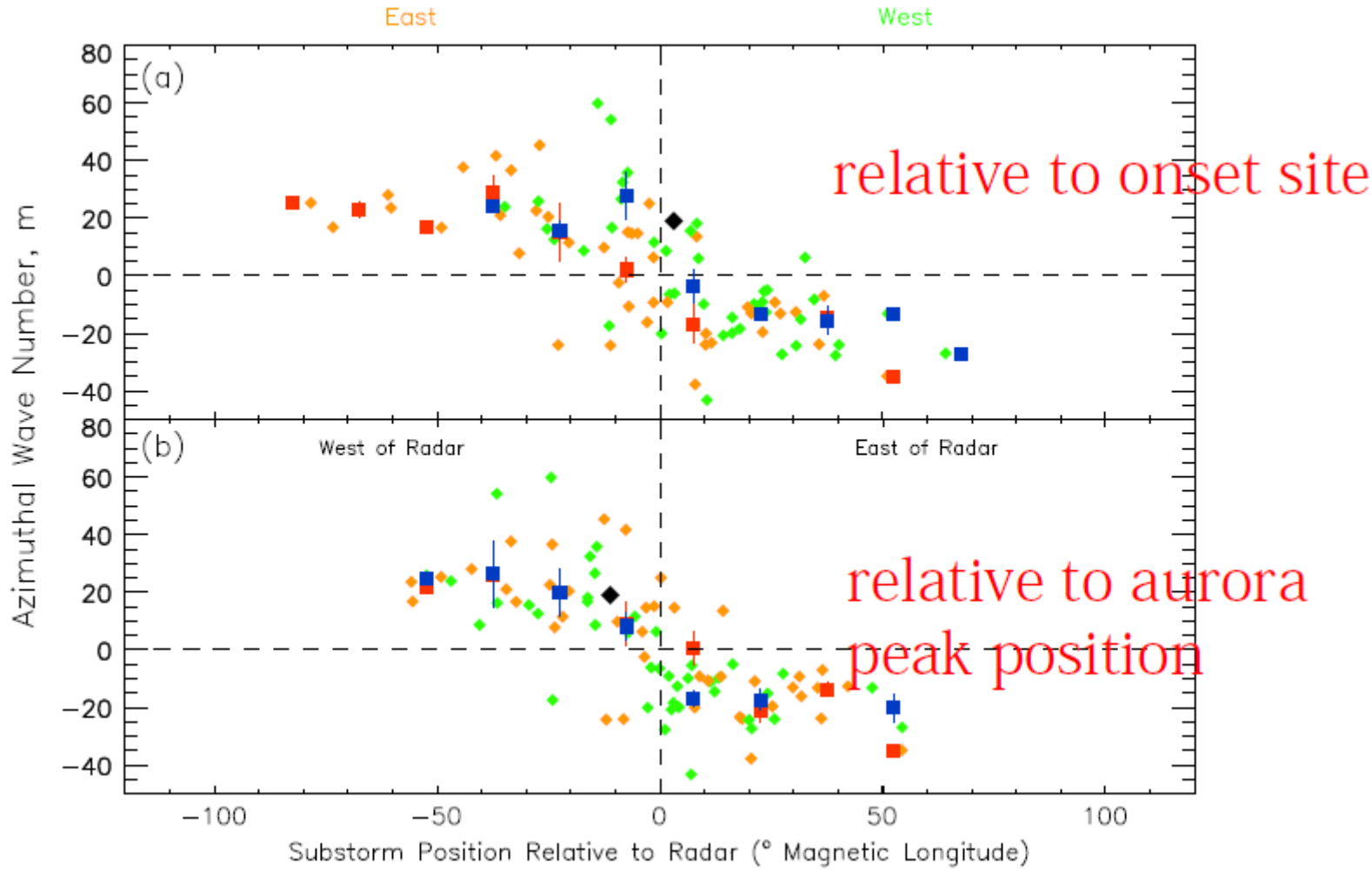




**Fig. 6.** The azimuthal component of the electric field.

[Mager+2008]

- High-m, poloidal, more or less irregular fluctuations of Pc5 freq. range
- Injected ions/electrons generate westward-/eastward-propagating waves.

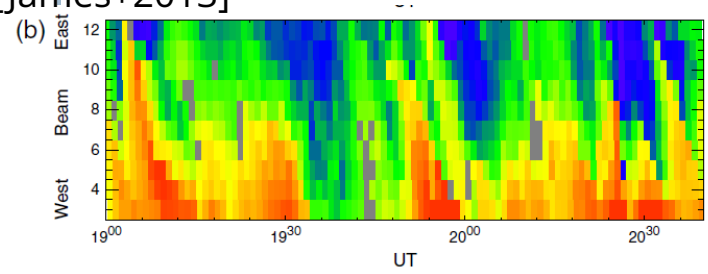
# James+2013

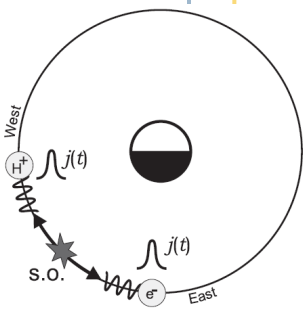

East
West
(a)
(b)
West of Radar
East of Radar
Azimuthal Wave Number, m
Substorm Position Relative to Radar (° Magnetic Longitude)
relative to onset site
relative to aurora peak position

# Prev. studies & Present event

- Prev. studies
  - Isolated substorms in auroral latitutdes
  - Eastward-/westward-prop. waves are studied separately
  - 1-2 radars give a limited f-o-v in longitude

[James+2013]



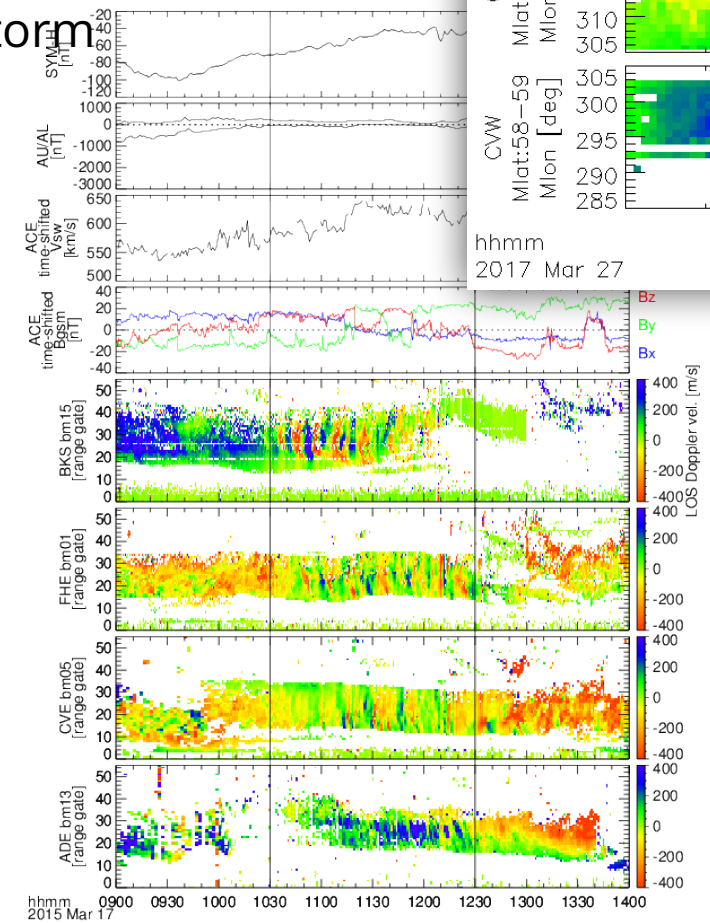



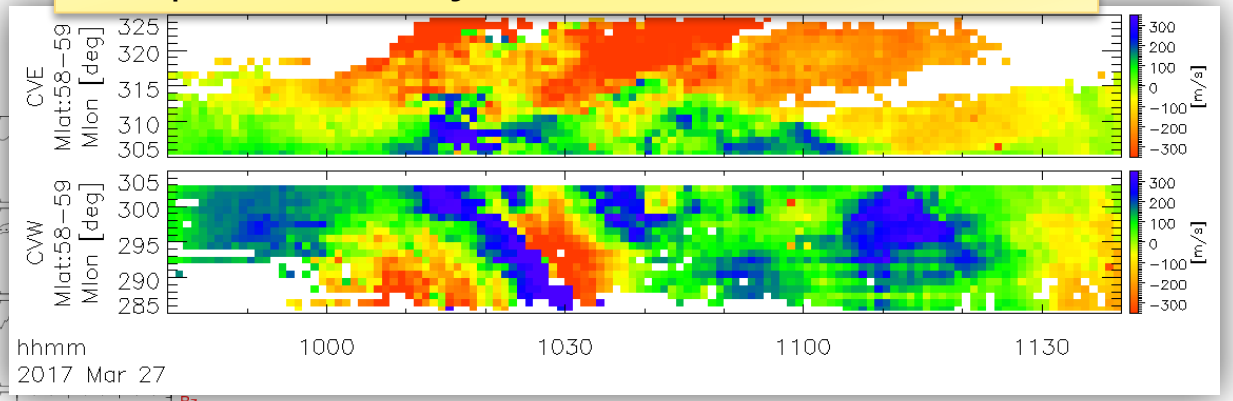

- Present event
  - A storm-time substorm in mid-latitudes
  - Eastward-/westward-prop. waves are seen simultaneously
  - 4 radars provide an extensive longitudinal coverage.

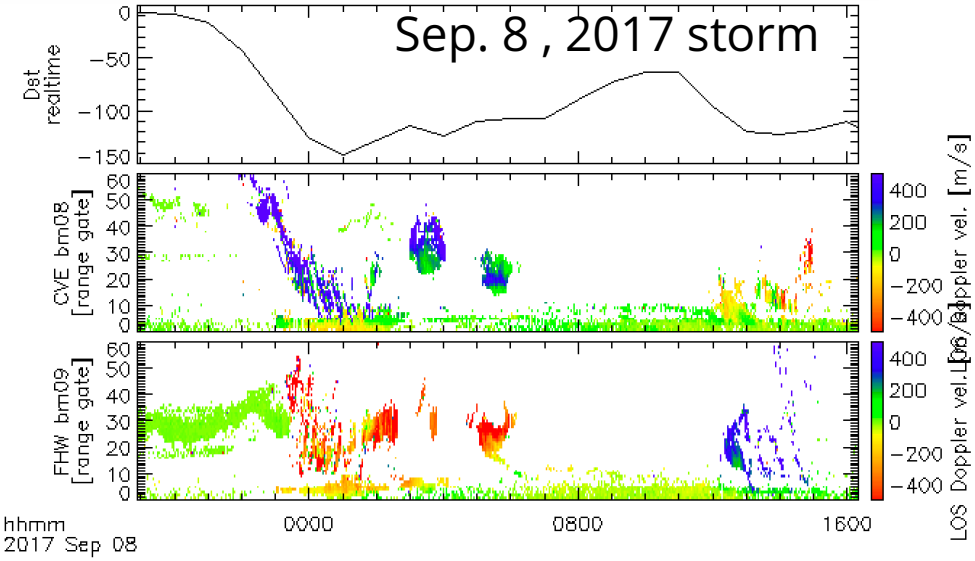
# ULF-like fluctuations of ionospheric flow during storms

The present study (March 27, 2017 storm)

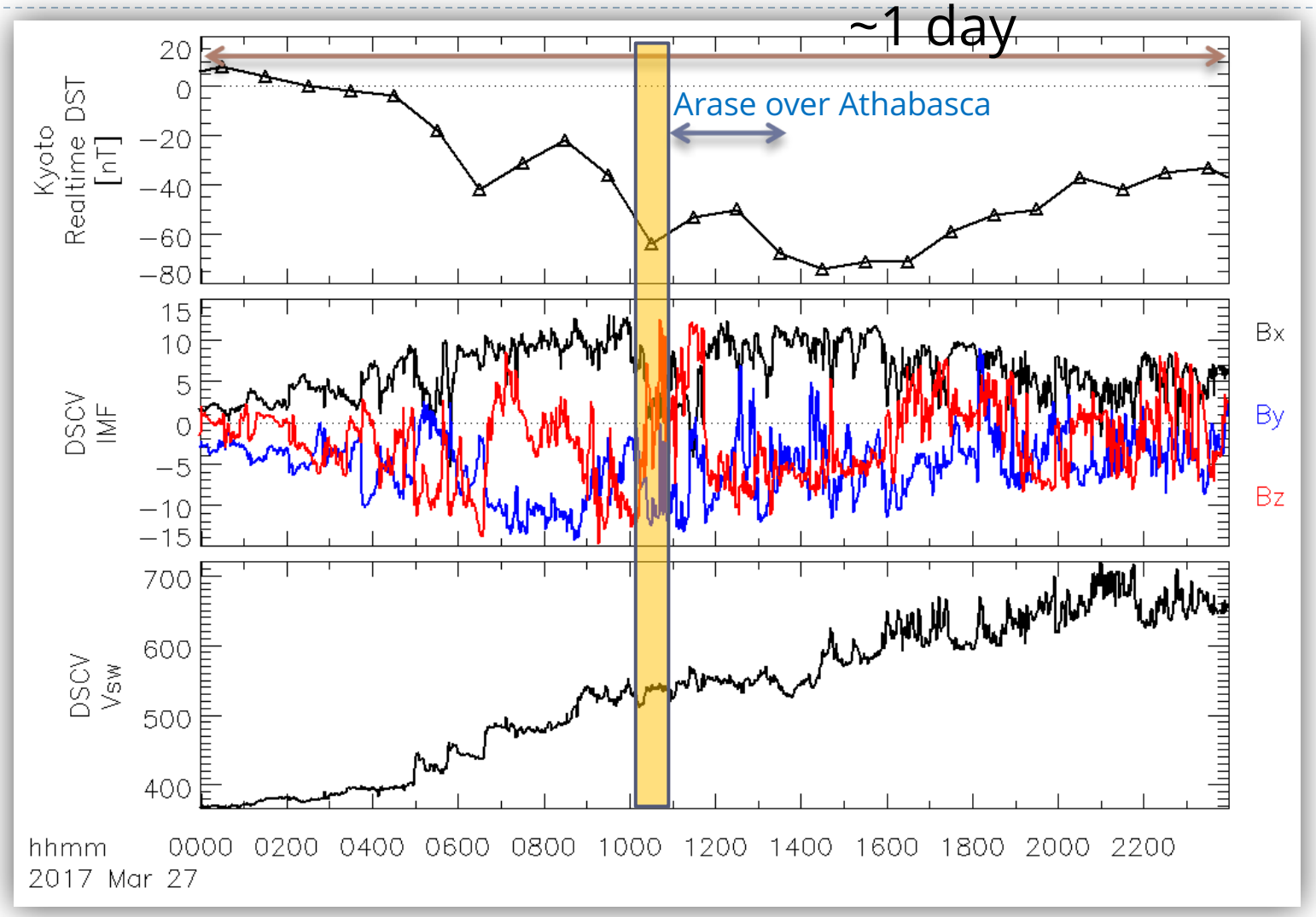
March 17 , 2015 storm



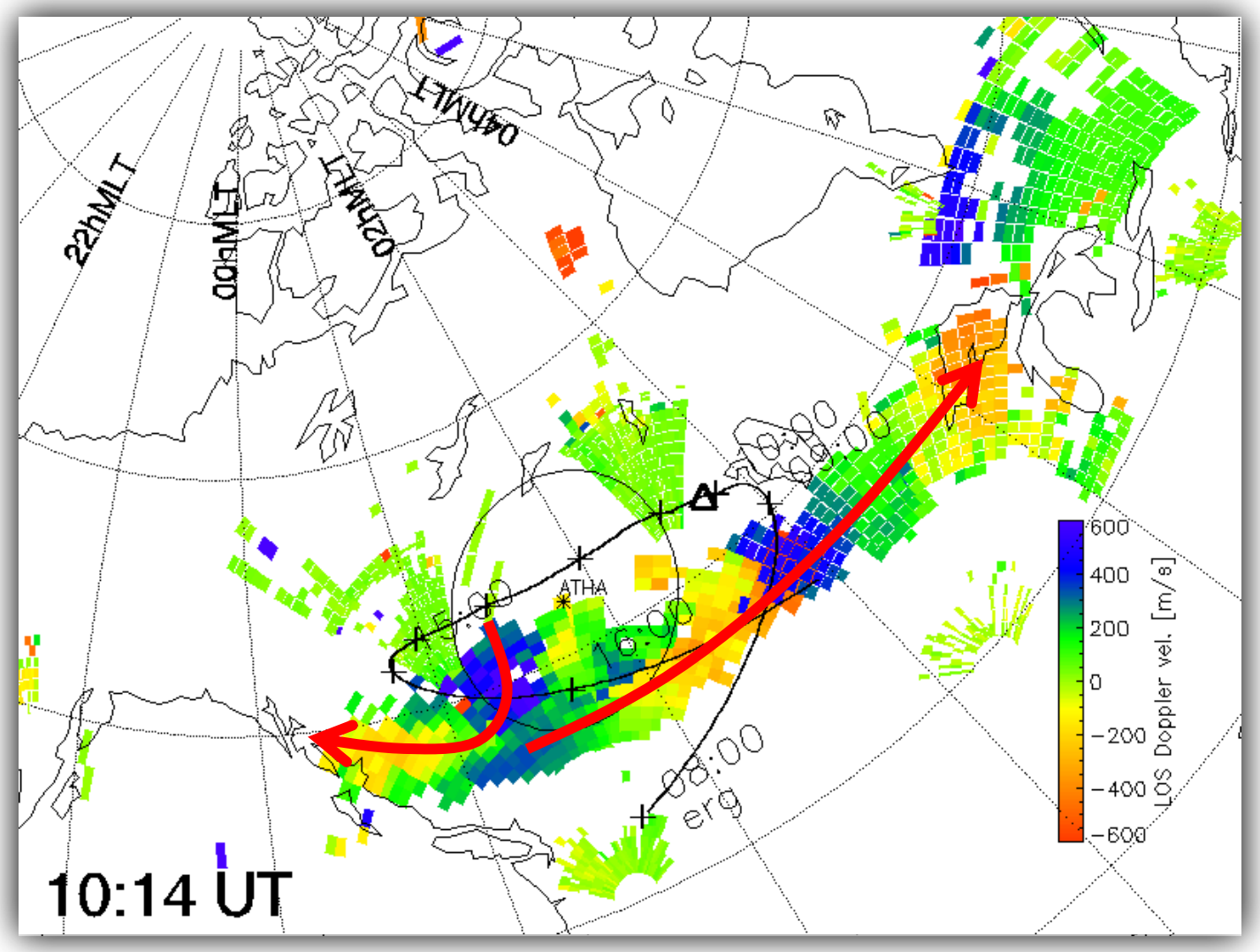



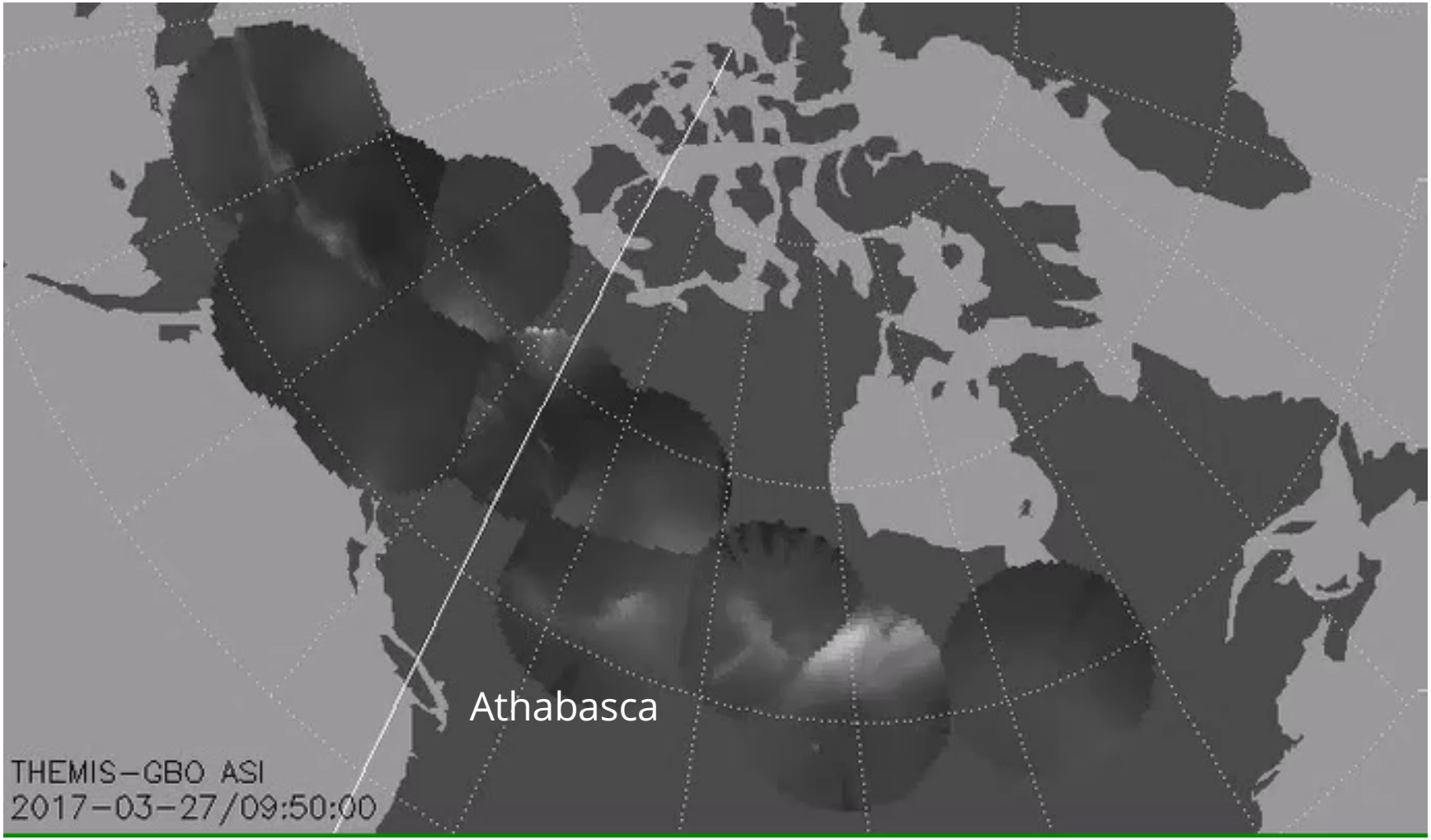
# March 27-28 magnetic storm



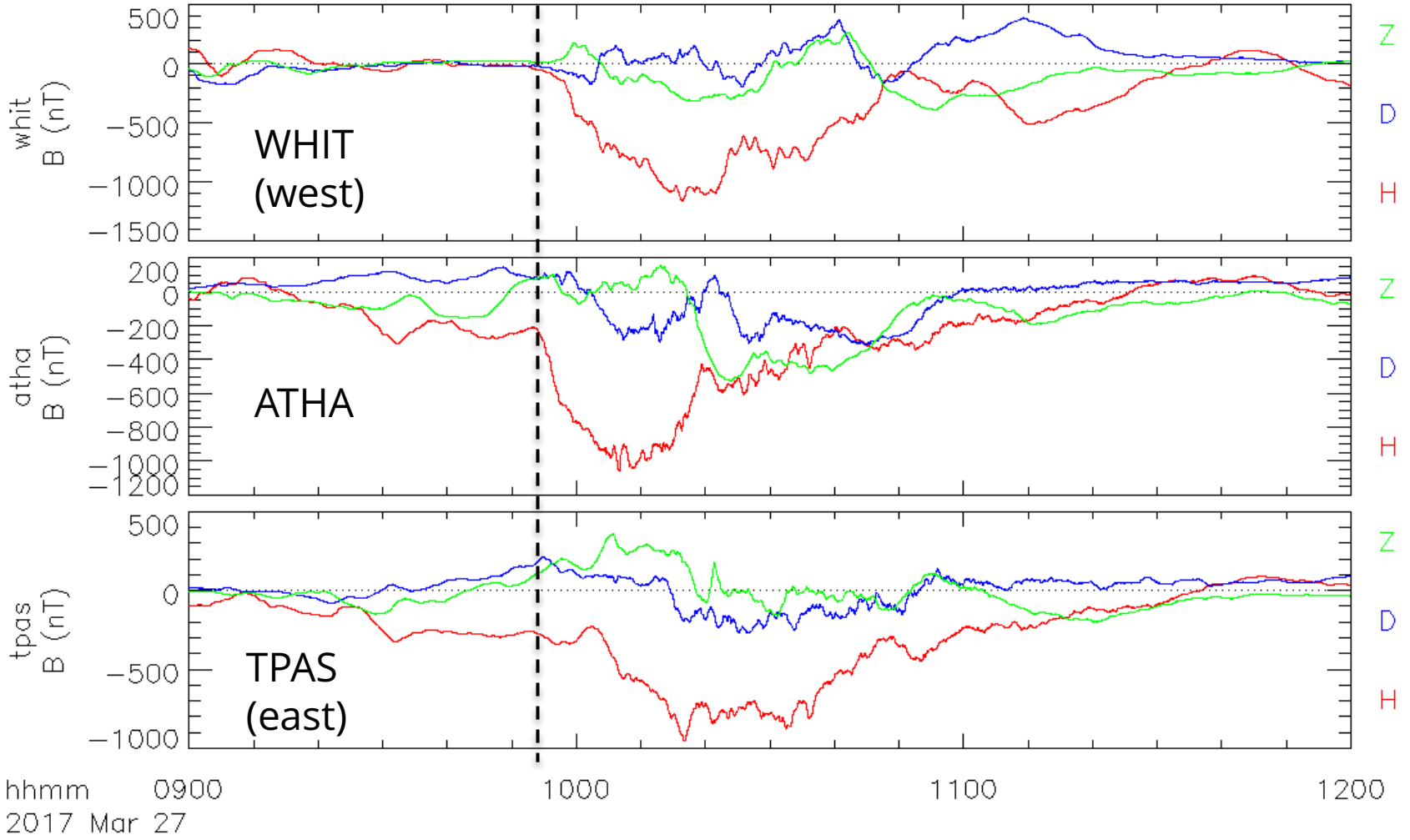
# Arase ionospheric footprint for 8-16 UT on March 27, 2017



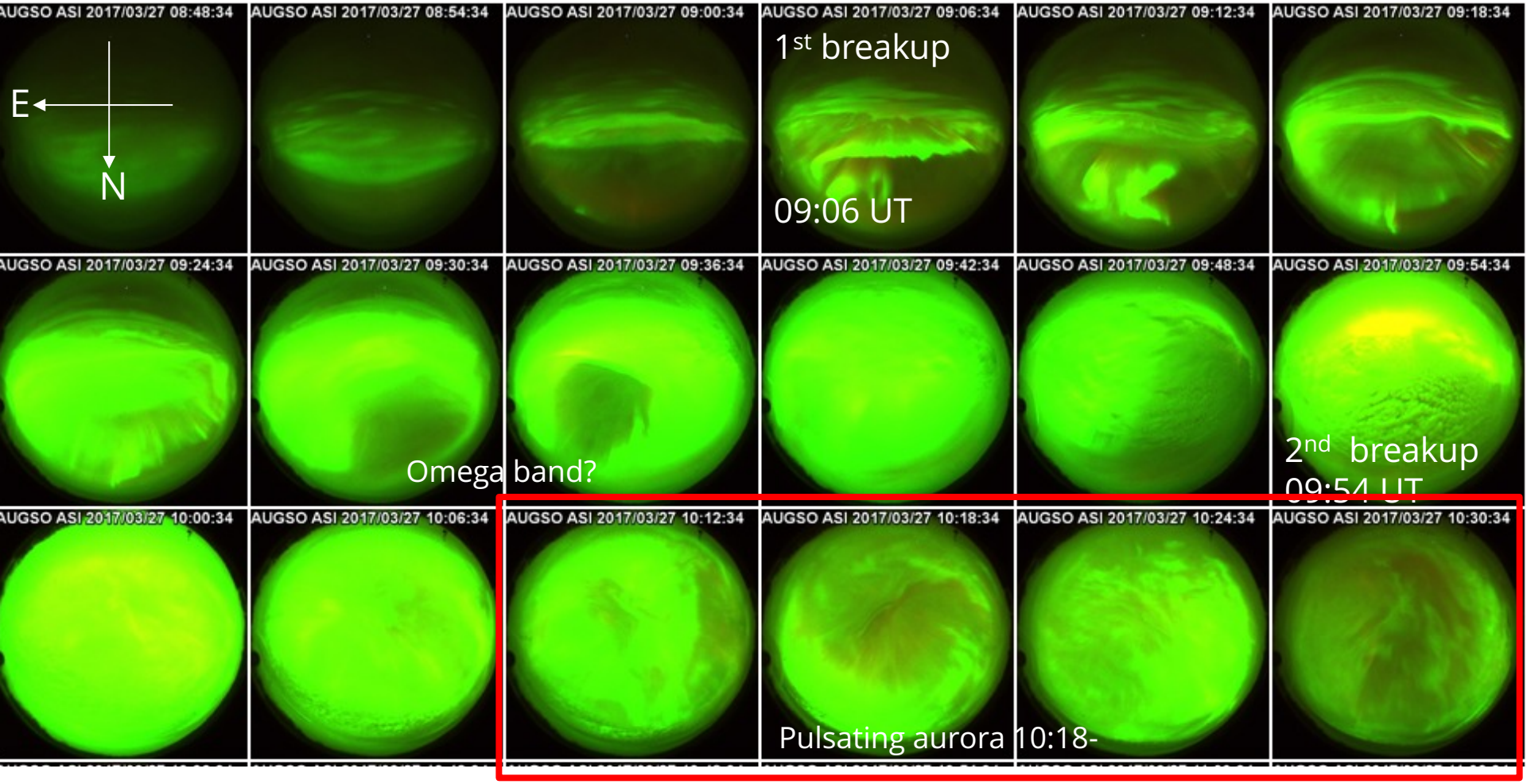
# An intense auroral breakup at ~09:54 UT



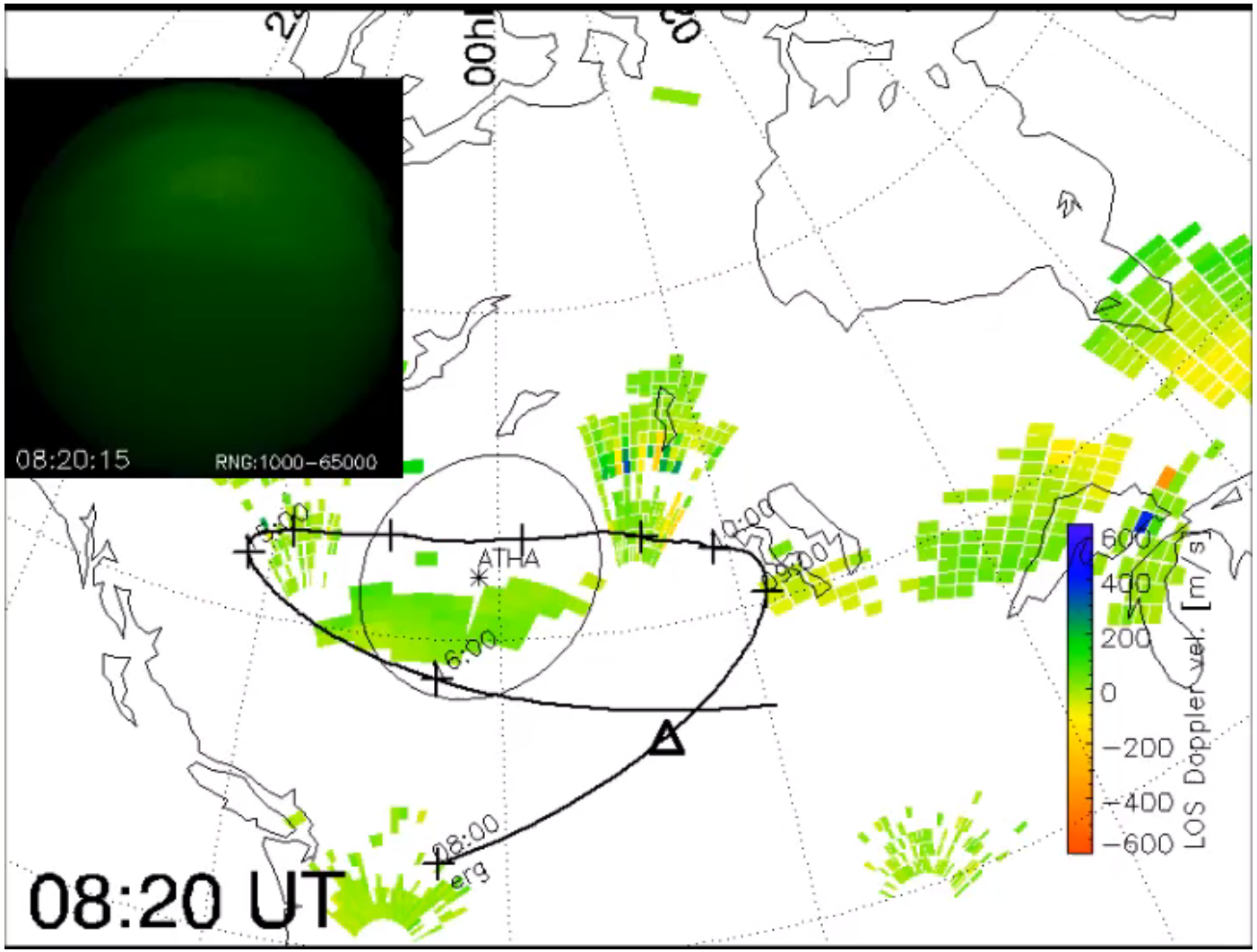
# Geomag @ATHA, TPAS, WHIT



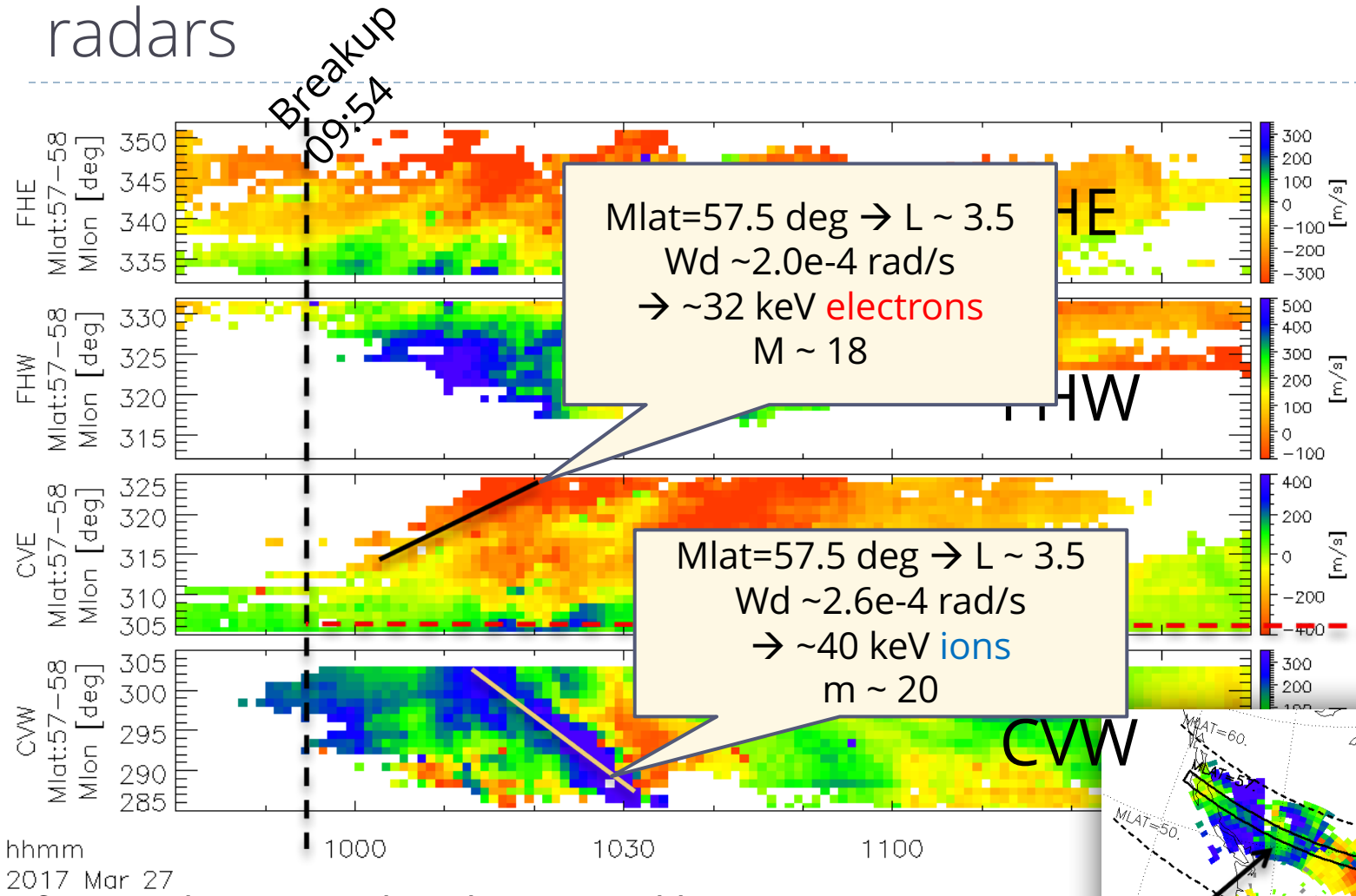
# EMCCD all-sky images @Athabasca for 08:48—10:30 UT

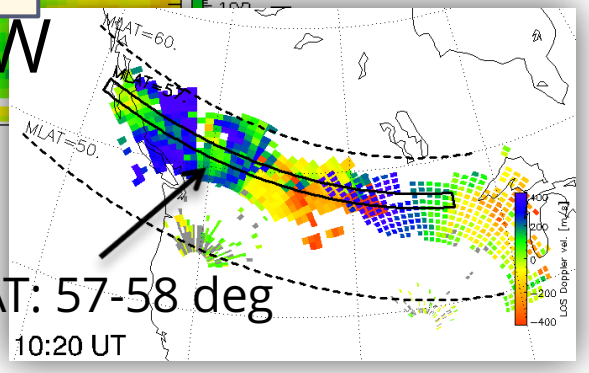


# SD observation as a movie



# Ewograms of LOSV seen by CVW, CVE, and FHW radars




MLAT: 57-58 deg

Bifurcated westward and eastward between CVE/E, indicating a local injection there.

Apparent frequency ~ 1.7 mHz (T ~ 10 min)

# Drivers of substorm-injection-driven ULFs

- Prev. studies
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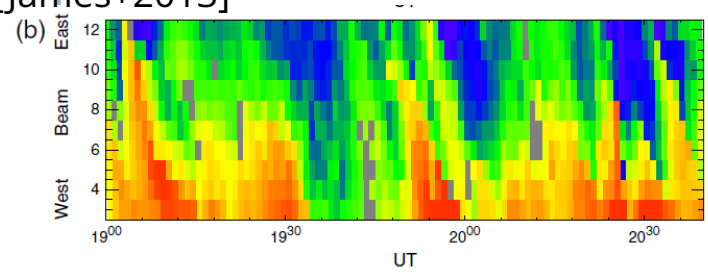
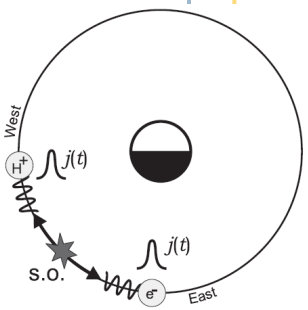
[James+2013]

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# Summary and conclusion

- We have investigated ULF-like ionospheric flow fluctuations observed during 27 March 2017 storm under a SD-Arase conjunction campaign.
- The fluctuations propagate both westward and eastward with roughly the same speed.

- From Arase:
  - Injected electrons with a few to several tens of keV
    - Consistent with the observed propagation speed
  - Timing between multiple injections and LOSV fluctuations.
    - roughly correspond to arrival of drifting electrons
  - Pressure of injected electron clouds
    - Sufficient to drive ULFs in terms of energetics?