Solar flare effect on the ionospheric current: a newly-found phenomenon at 70°-75° latitude (cf. well-studied effect at < 65° latitude)

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Outline

Case study on X9.3 flare on 2017-9-06

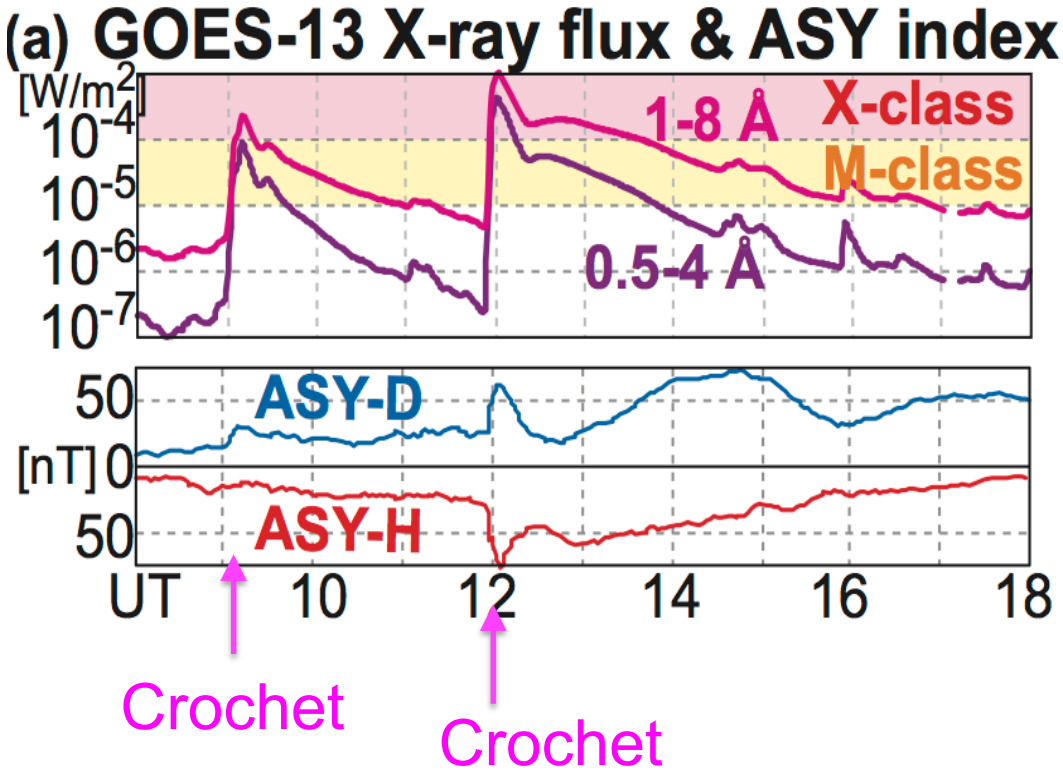
- What is the "well-studied" solar flare effect (sfe) Crochet?
- What is new at high-latitude? ⇒ **Much stronger and longer!**
  ⇒ But, past observations interpreted as "evening Crochet"
- What are similarity and difference between them?
- What caused such large $\Delta I_{ionosphere}$? ⇒ enhancement of Sq

Survey of > X2 flare since 1994

- Crochet is almost always seen in ASY index.
- New high-latitude ΔB is sometimes detected with AE, but not as often as ASY

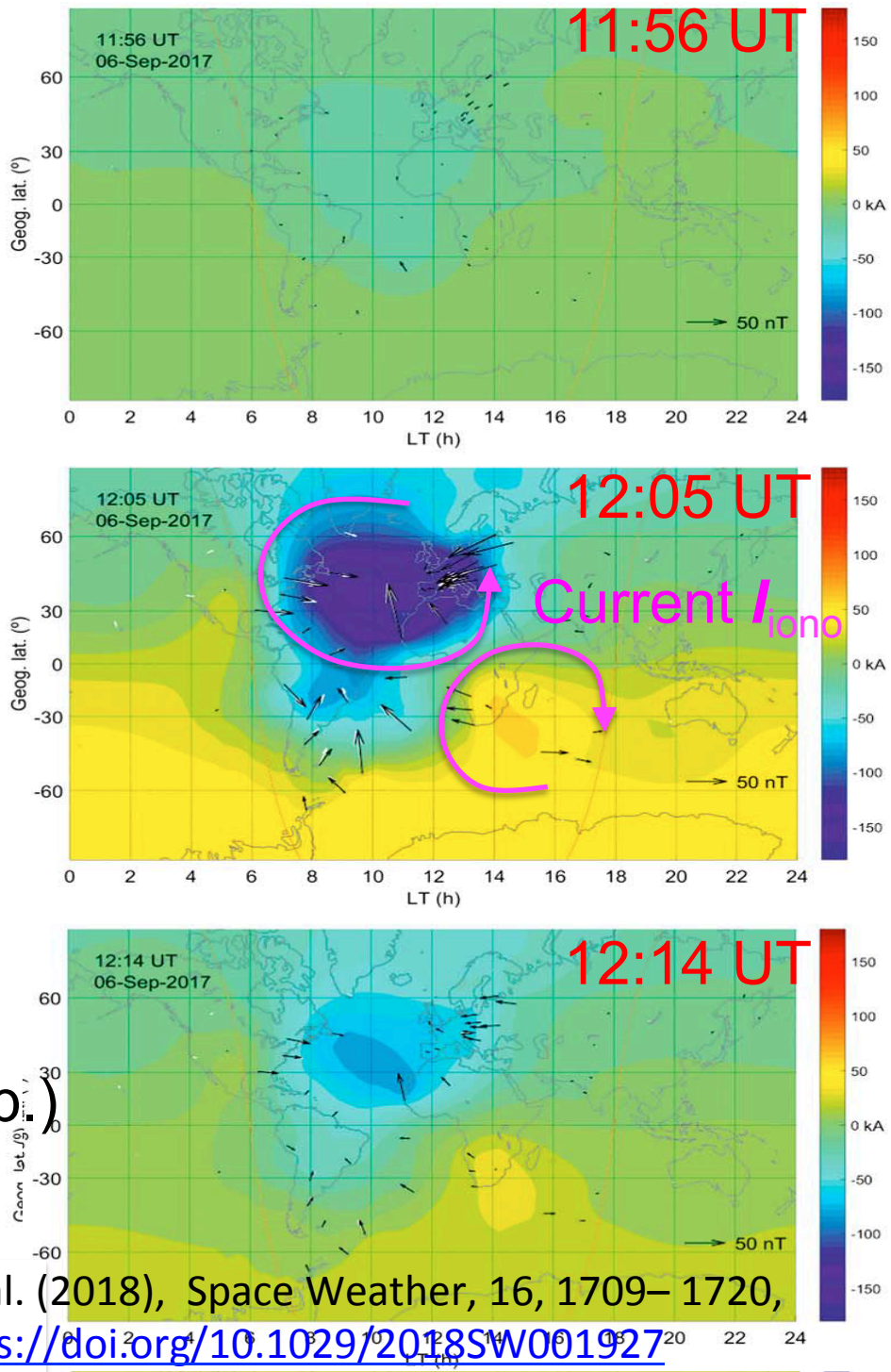
What is "traditional" Crochet (or SFE)

Example: 2017-9-06



(i) westward ΔB near noon (N-hemisp.)
(ii) Short (< 20 min) for all flare length
(iii) peak < 70 nT
(iv) seen in ASY index

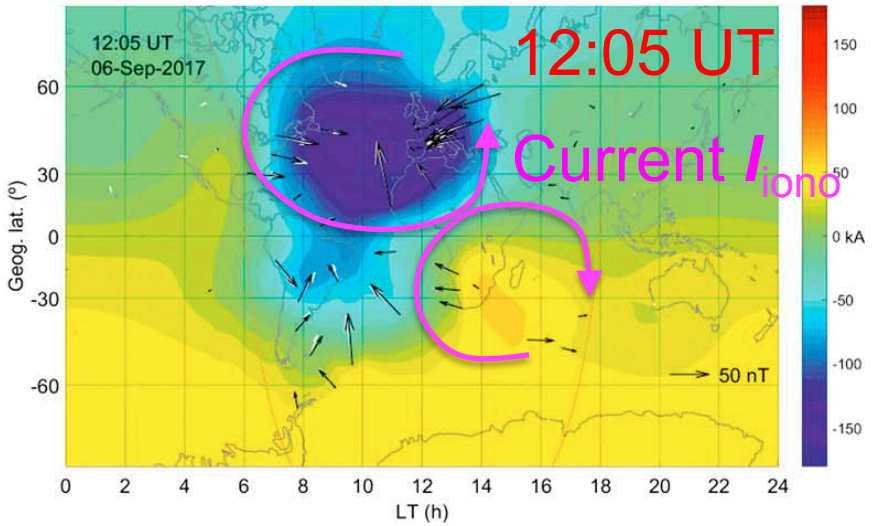
I_{iono} (kA) & ΔB (Curto et al, 2018)

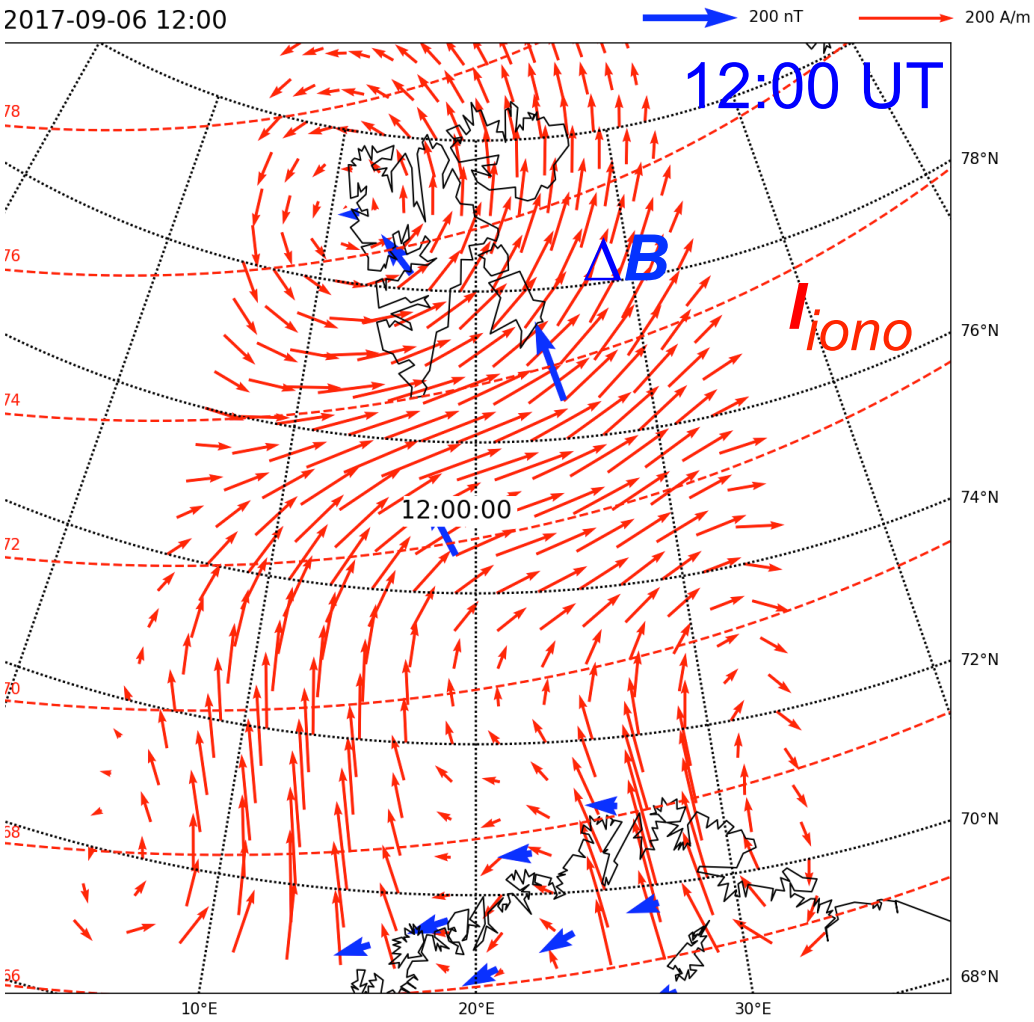


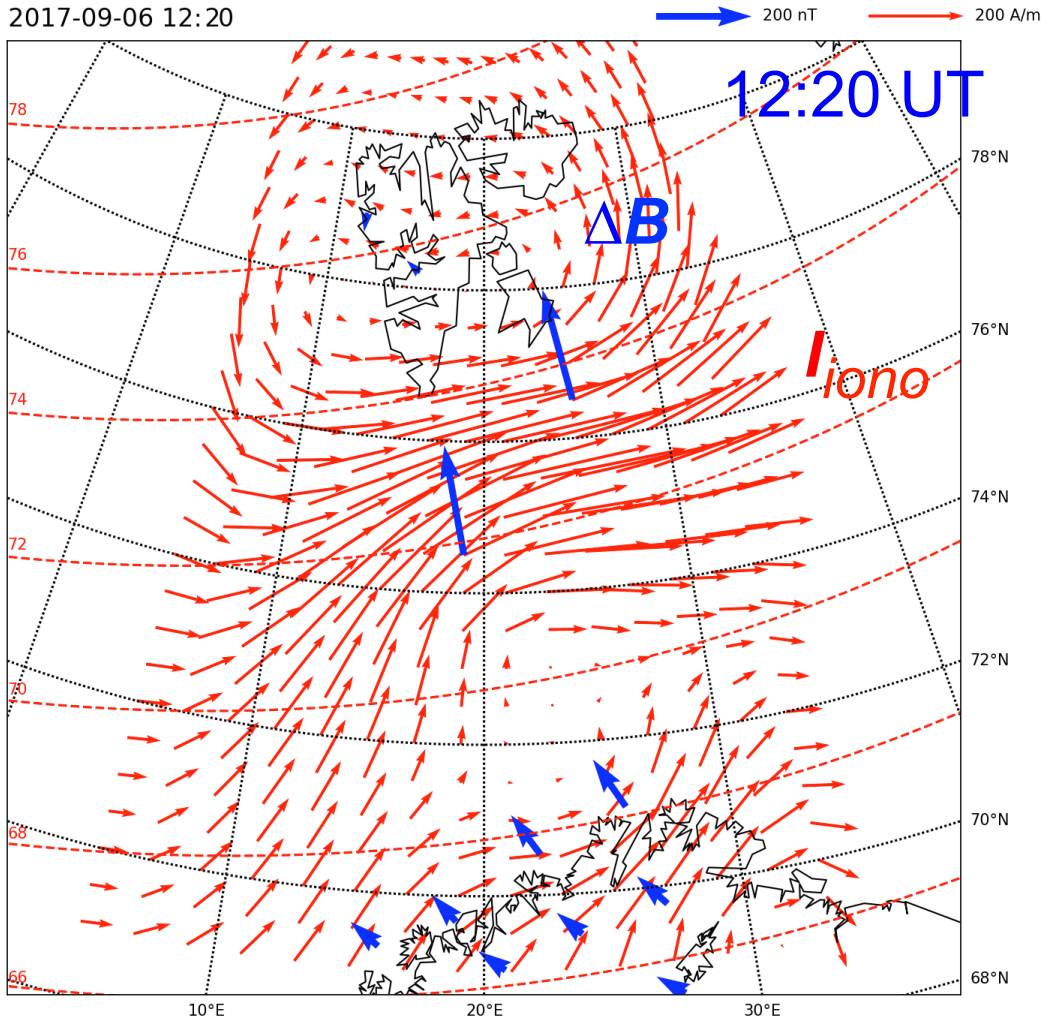
Curto, J.J., et al. (2018), Space Weather, 16, 1709– 1720, figure 9. https://doi.org/10.1029/2018SW001927

Different response at high latitudes

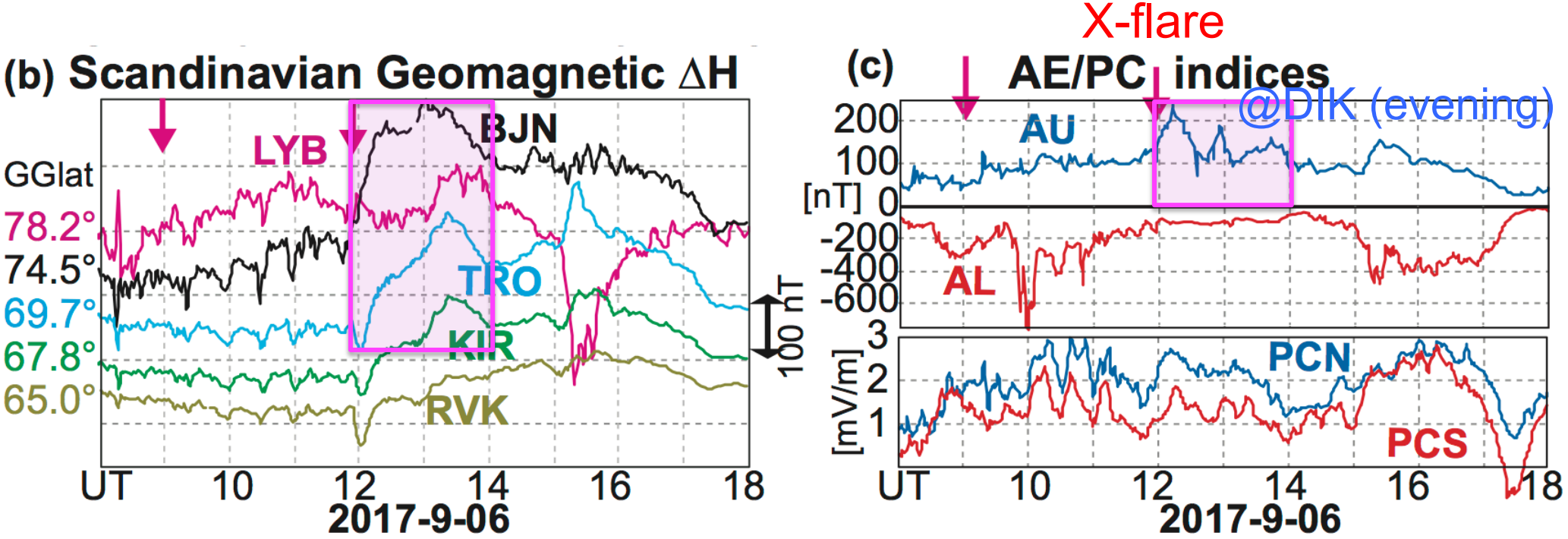
northward ΔB = eastward ΔI near noon (much stronger than Crochet's return current at 60° latitude)





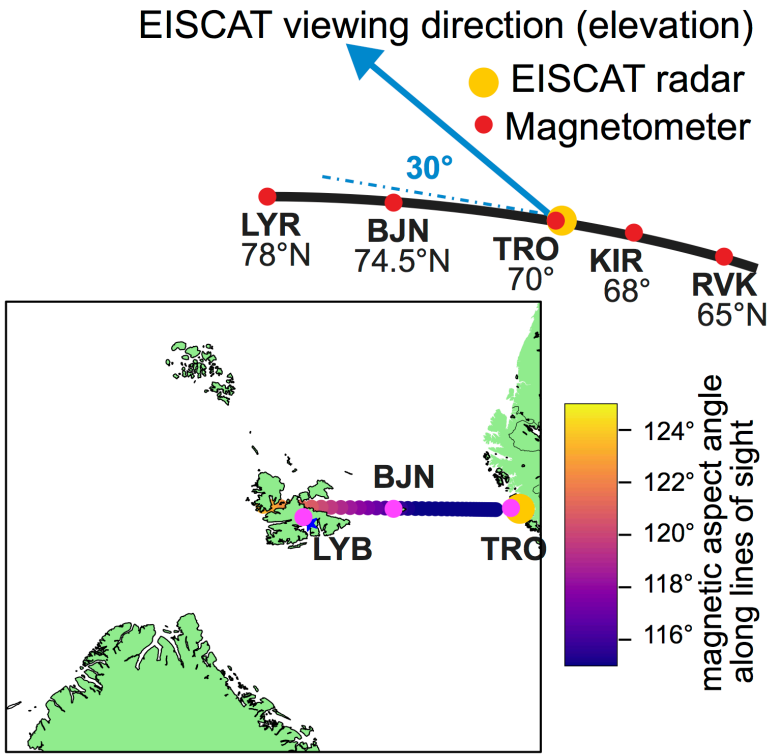


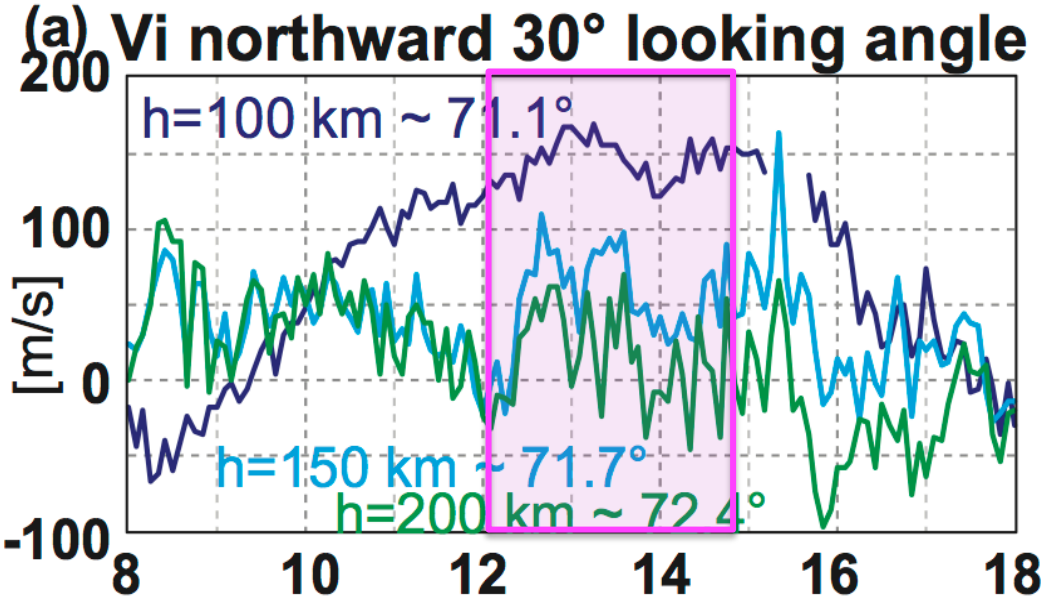
Many differences between Crochet & new ΔB

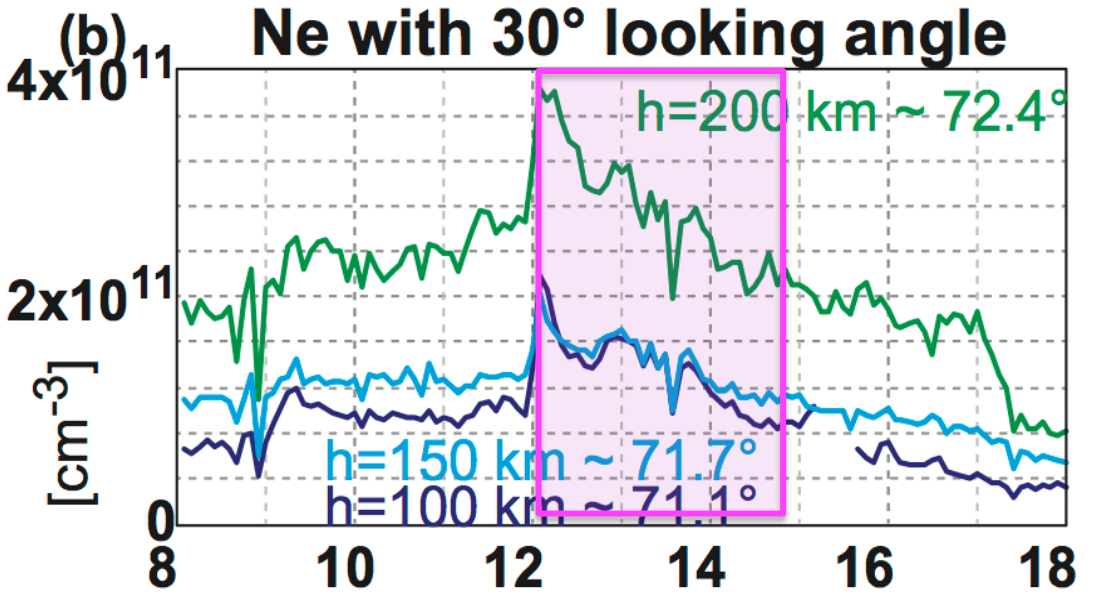


Crochet ΔB (dayside N-hemisph)	vs	high-latitude ΔB (new)
(i) ΔB points south-westward		ΔB points northward
(ii) Short (< 20 min)		Long (X-ray flux > M3 class)
(iii) ΔB < 70 nT		ΔB > 200 nT
(iv) @ < 70° GGglat		@ 67°-77° GGglat
(v) ASY-D & ASY-H		AU

Use EISCAT data (Ne and Vi) to find out the cause of ΔI

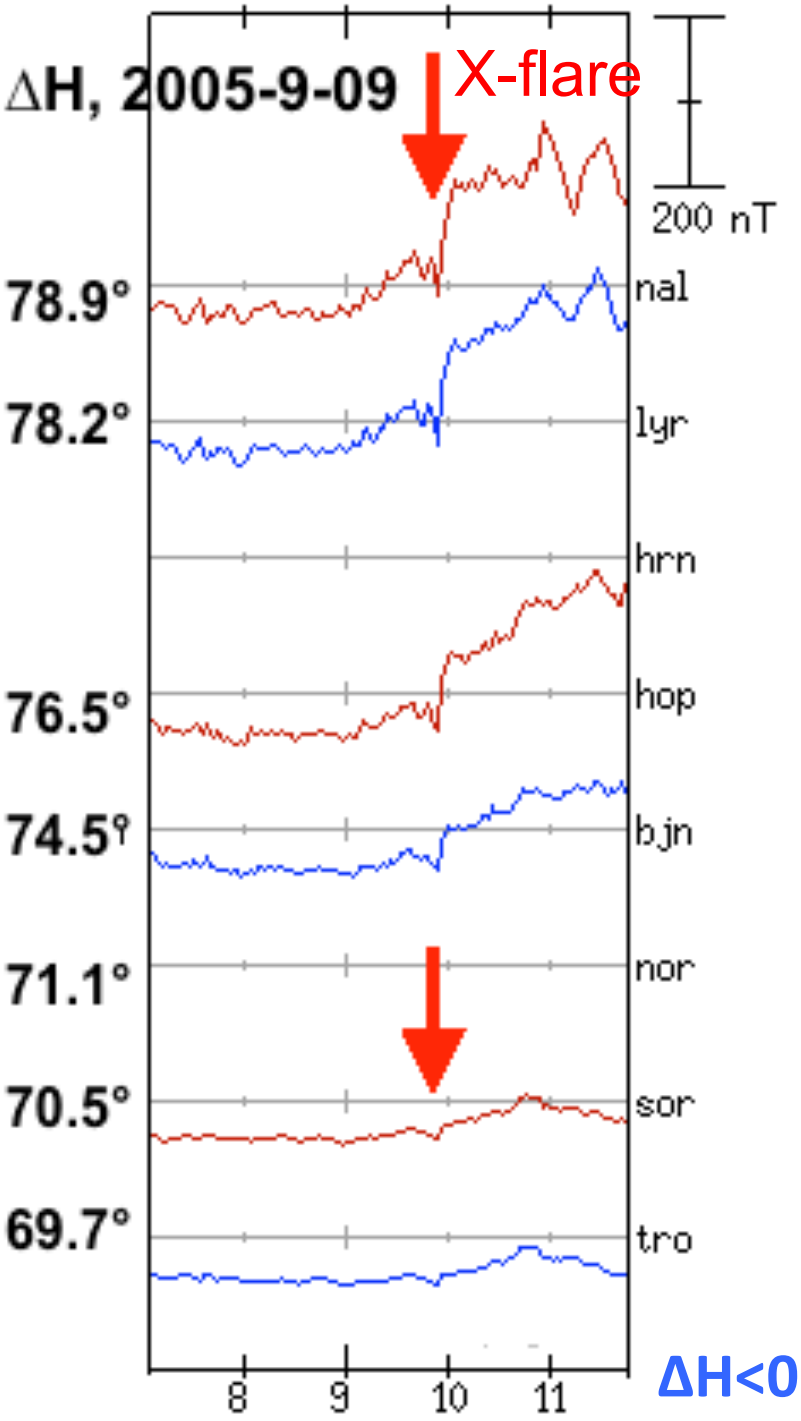






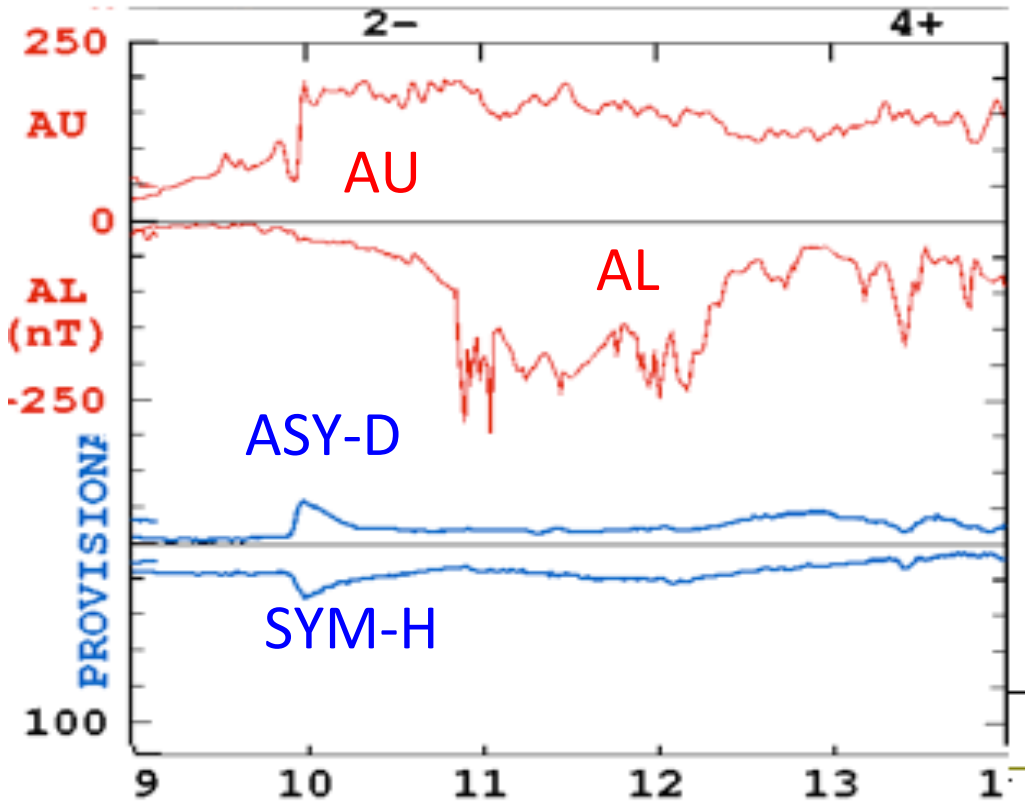
Sq at this latitude = strong northward V_{ion} (> 100 m/s) @ h=100 km

Enhanced n_e ⇒ enhanced Sq ⇒ explains same profile as X-ray flux!

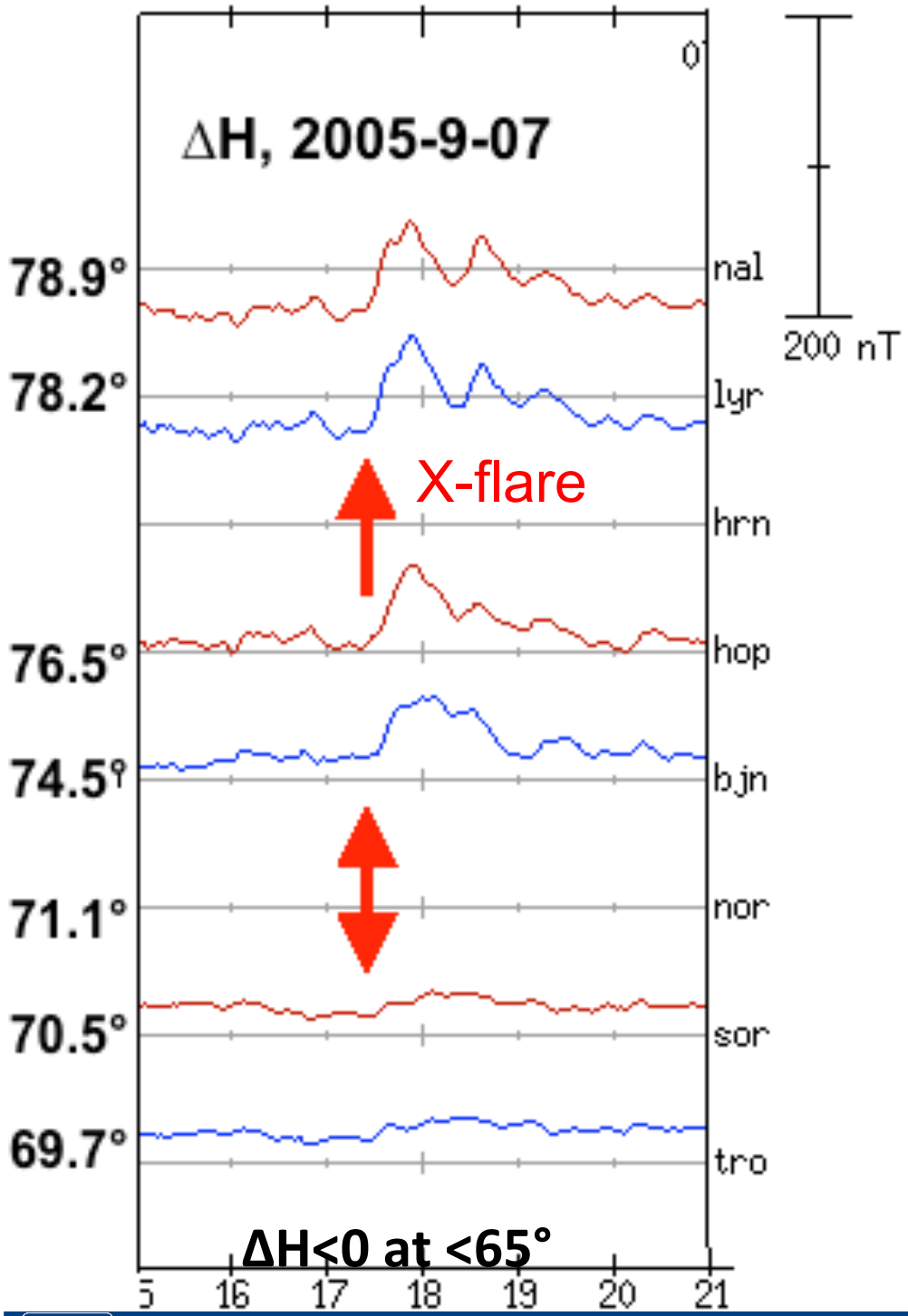


Next, we surveyed ~70 solar flares (> X2-flare)

AU signature in ~ 30 cases (40%)

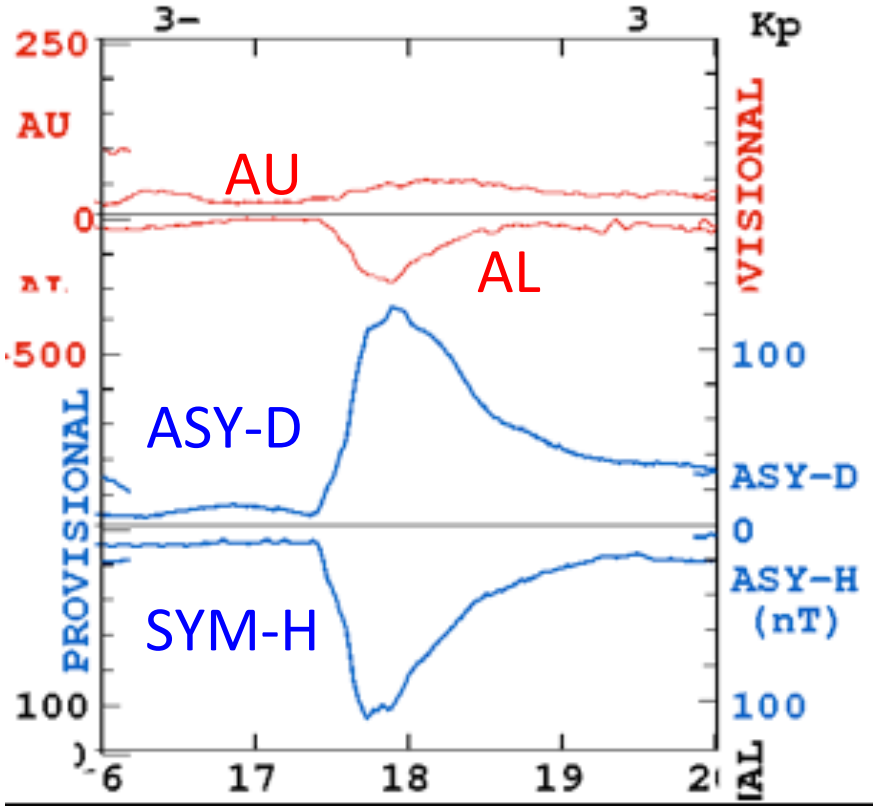


ΔH<0 at <60°



Seen even in AL ~ 10 cases

Most cases are in the evening sector



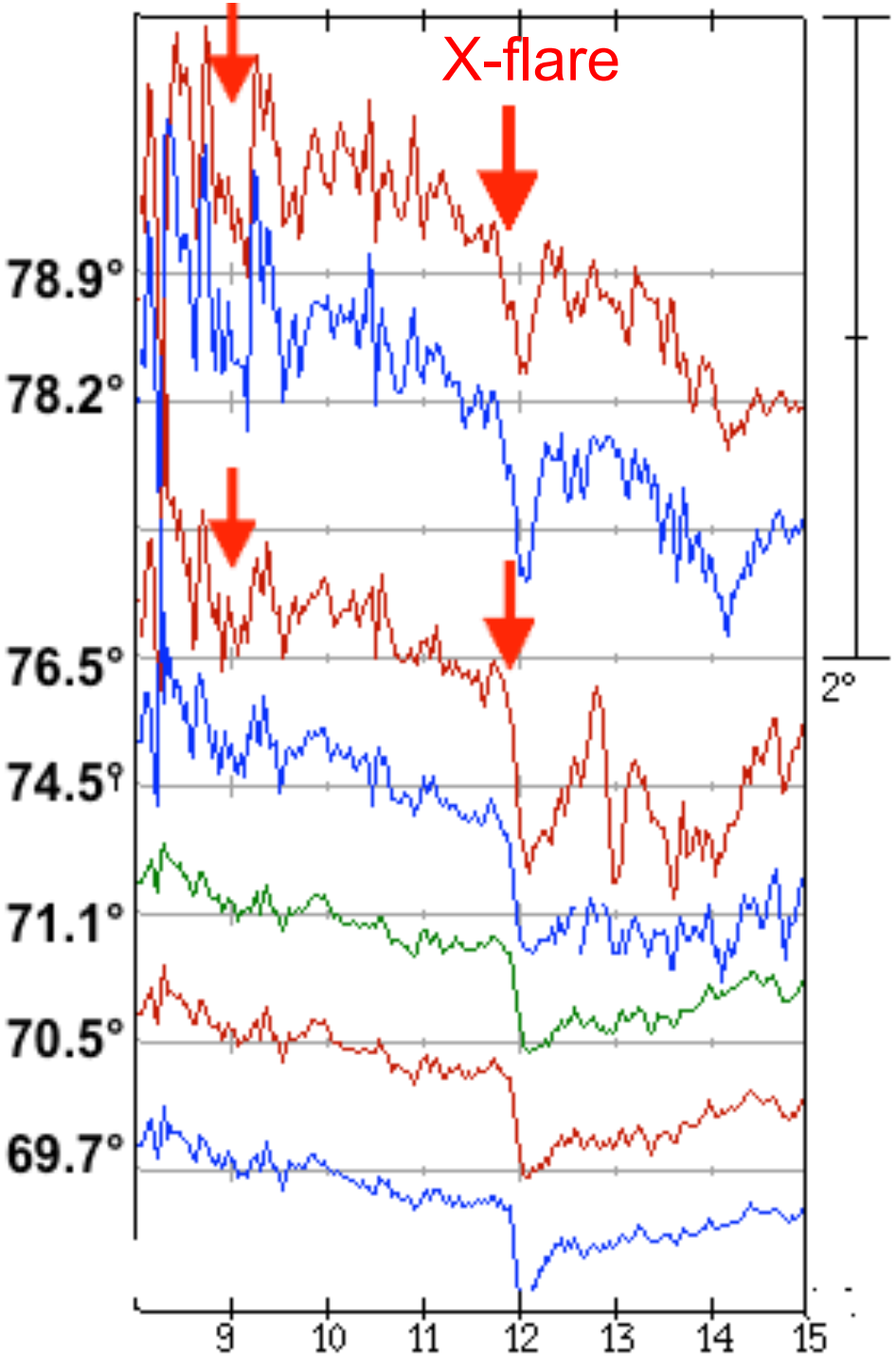
Summary: high-latitude crochet (sfe)

(1) X9.3 flare at ~ 12 UT (Scandinavia was near local noon)

Crochet ΔB (dayside N-hemisph)	vs	high-latitude ΔB (new)
(i) ΔB points south-westward		ΔB points northward
(ii) Short (< 20 min)		Long (X-ray flux > M3 class)
(iii) ΔB < 70 nT		ΔB > 200 nT
(iv) @ < 70° GGglat		@ 67°-77° GGglat
(v) ASY-D & ASY-H		AU
(vi) n_e re-arrangement		n_{ion} enhancement over V_{Sq}

(2) Survey for >X2-flare

(vii) ASY		sometimes AU (and even AL)



small ΔD compared to the traditional Crochet