Evidence for vertical wind upwelling caused by ion frictional heating at Svalbard

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Carlson mechanism for producing strong vertical wind upwelling

• ion shear flow caused by magnetic reconnection events

• soft particle precipitation, 100-300 ev, to increase plasma density 150-300 km region, i.e., “indirect pathway”

•ion frictional heating caused by (Vi-Vn) difference

Idea is essentially high altitude Joule heating that takes place above 150 km so that there is not so much air to move upward as there would be for Joule heating occurring at 110 km.

Description of CME event – 22 Jan 2012

Svalbard instrumentation

- narrow field FPI devoted to zenith
  to measure vertical winds

- SCANDI FPI to measure horizontal winds

- IMAGE magnetometer array

- EISCAT Svalbard radar constrained
  to look up B only
  -measured $n_e(h)$ and $T_i(h)$

- SuperDARN measurement of plasma drifts

CME encounters Earth at 0617UT

a) IMAGE Magnetometer Network + SCANDI sectors mapped at altitude 240km

b) IMAGE magnetometer network 2012-01-22

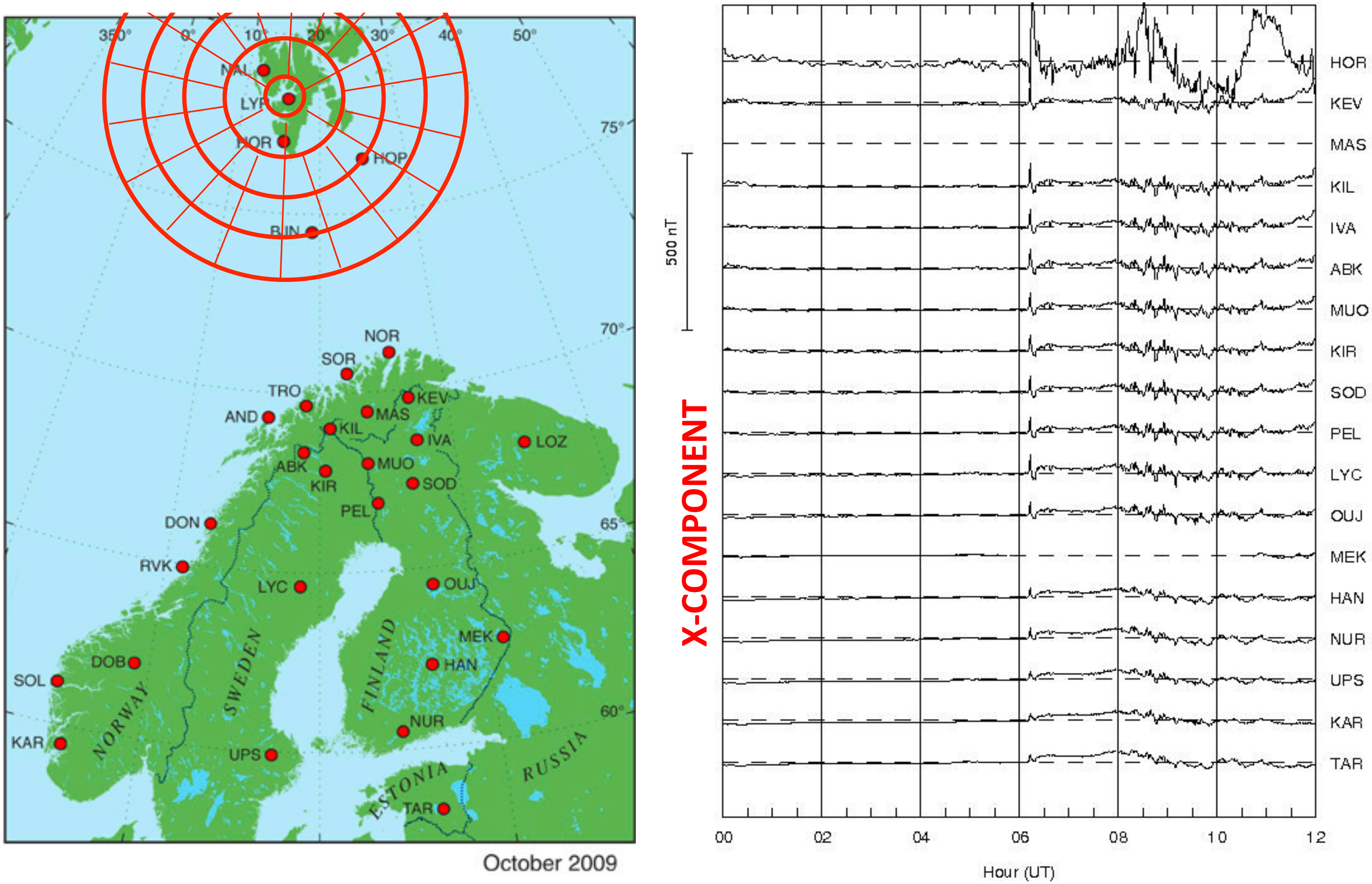


Figure 1 a,b a) SCANDI sectors mapped onto a map of the IMAGE magnetometers; b) IMAGE magnetometers stack plot of x-component.

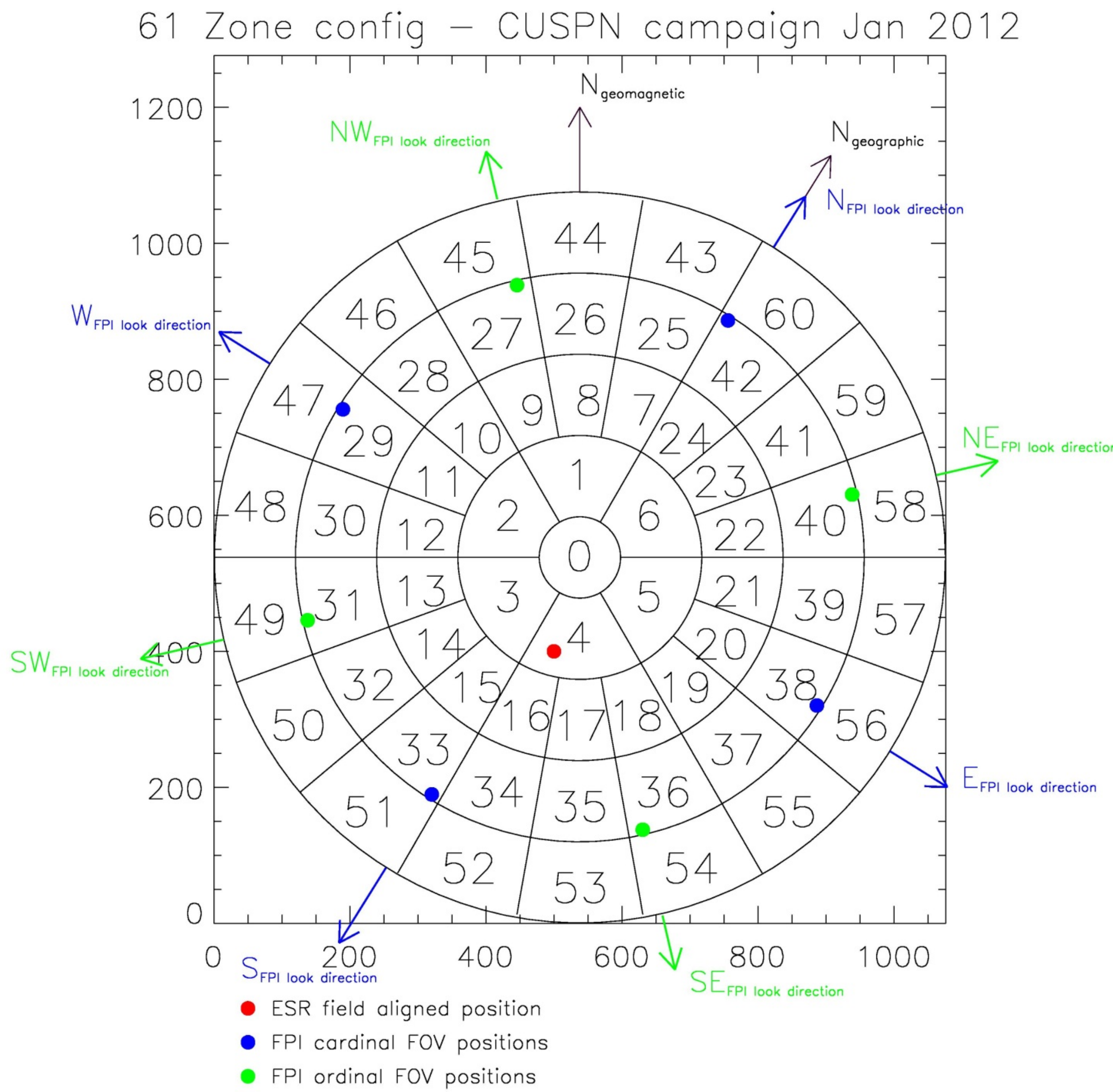
Figure 1c

Spatial map of SCANDI field-of-view divided into 61 zones.

The top of the figure is geomagnetic north, and the major geographic directions are indicated.

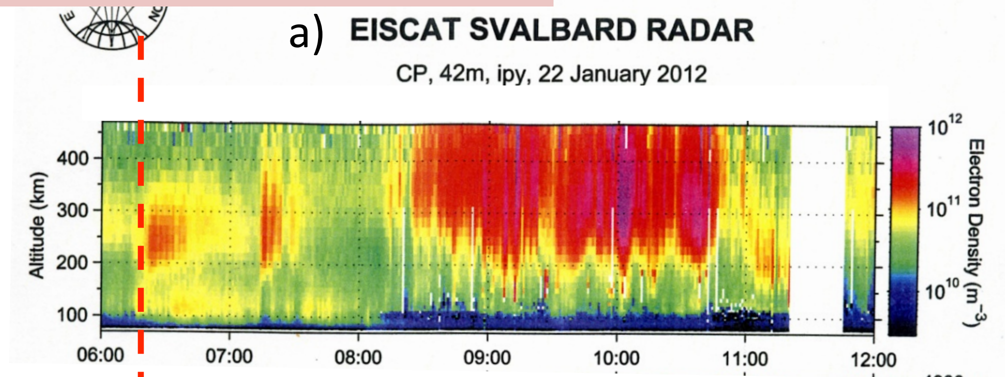
The look directions of the narrow field FPI are indicated by blue dots

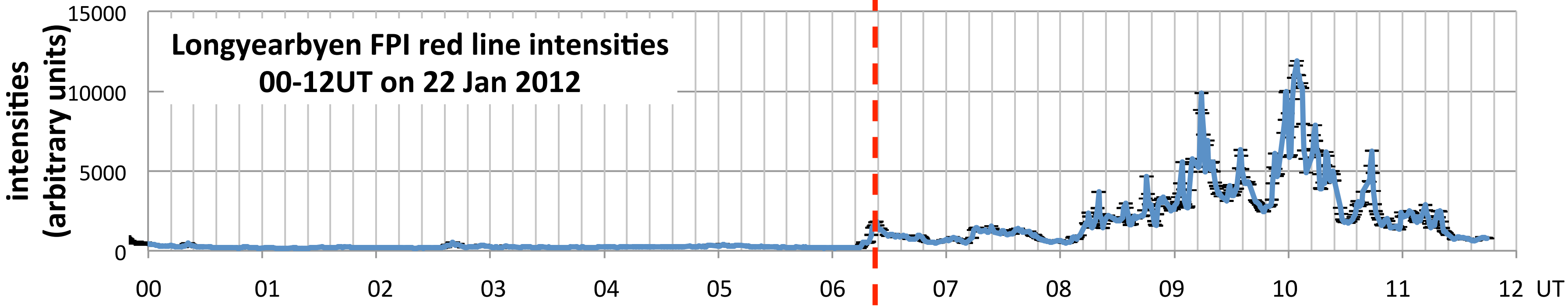
The ESR field-aligned direction is indicated by a red dot.

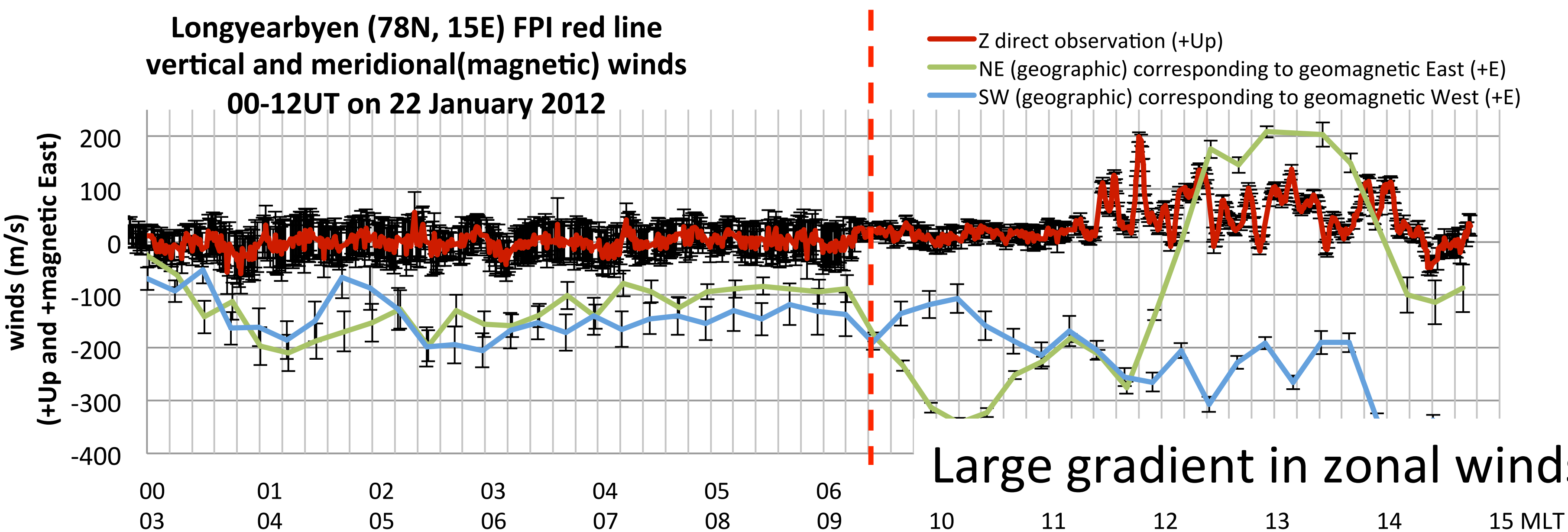


CME encounters Earth at 0617UT

electron densities along the geomagnetic field line;

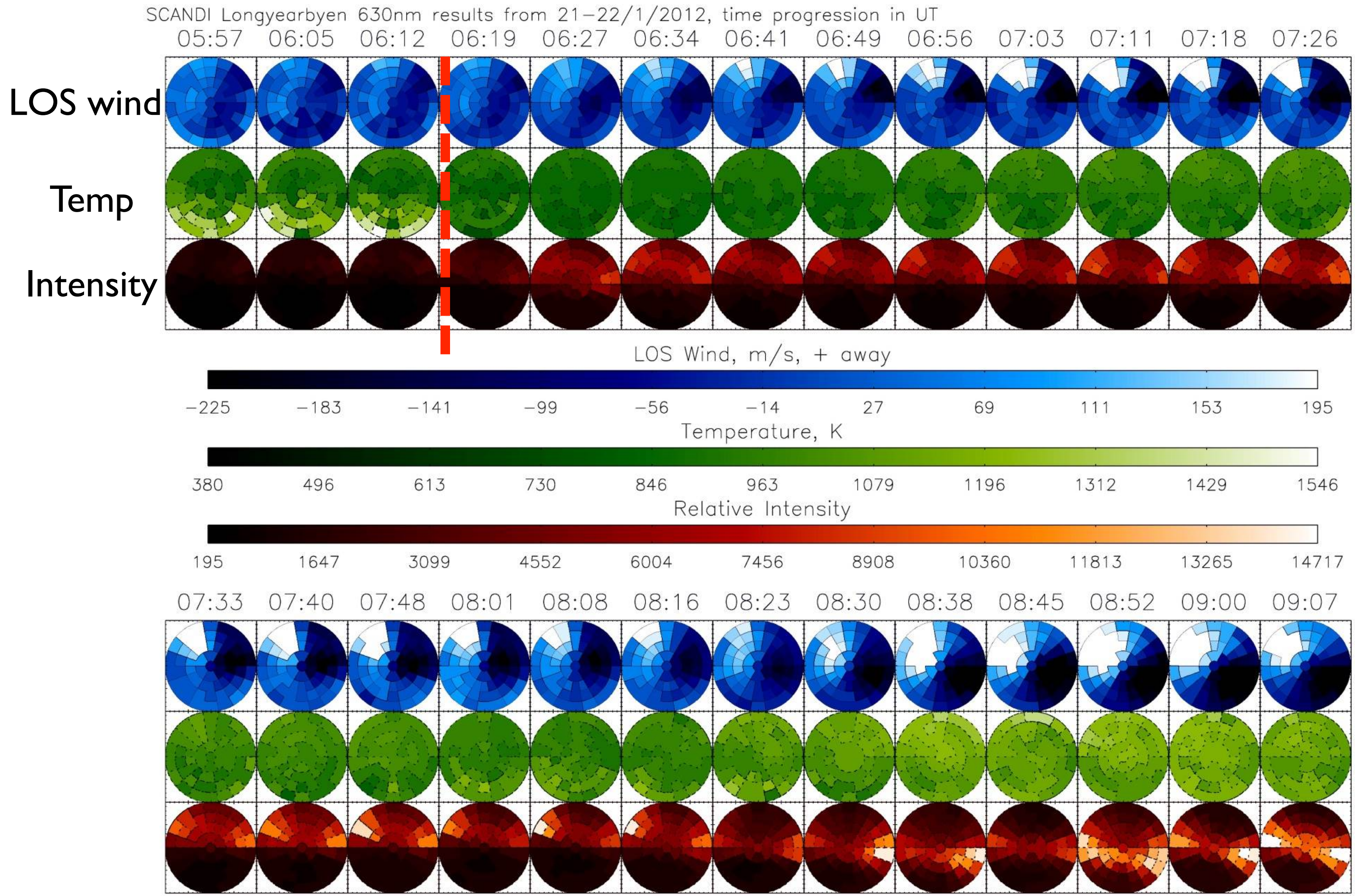






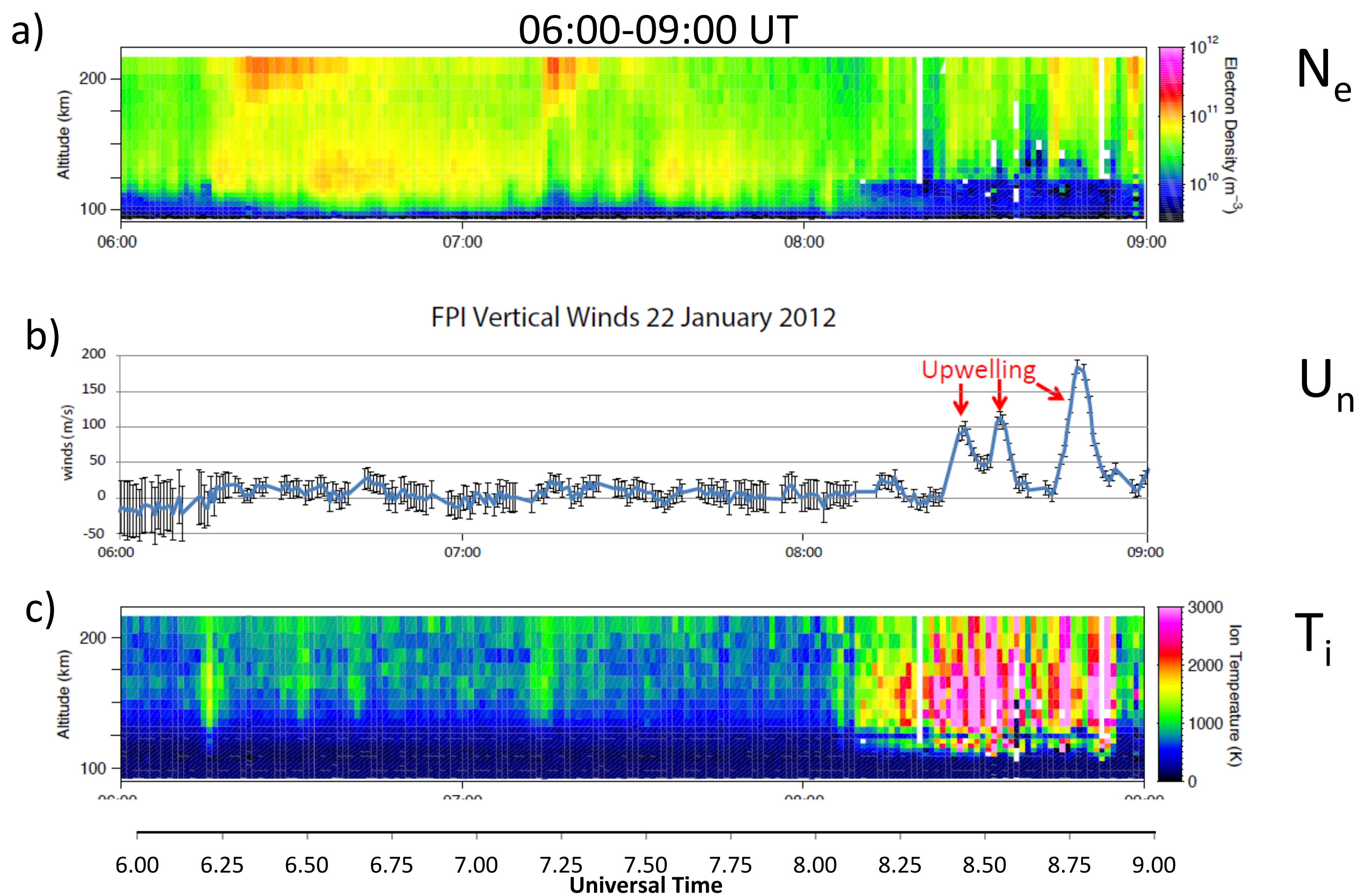
Large gradient in zonal winds

CME encounters Earth at 06:17 UT



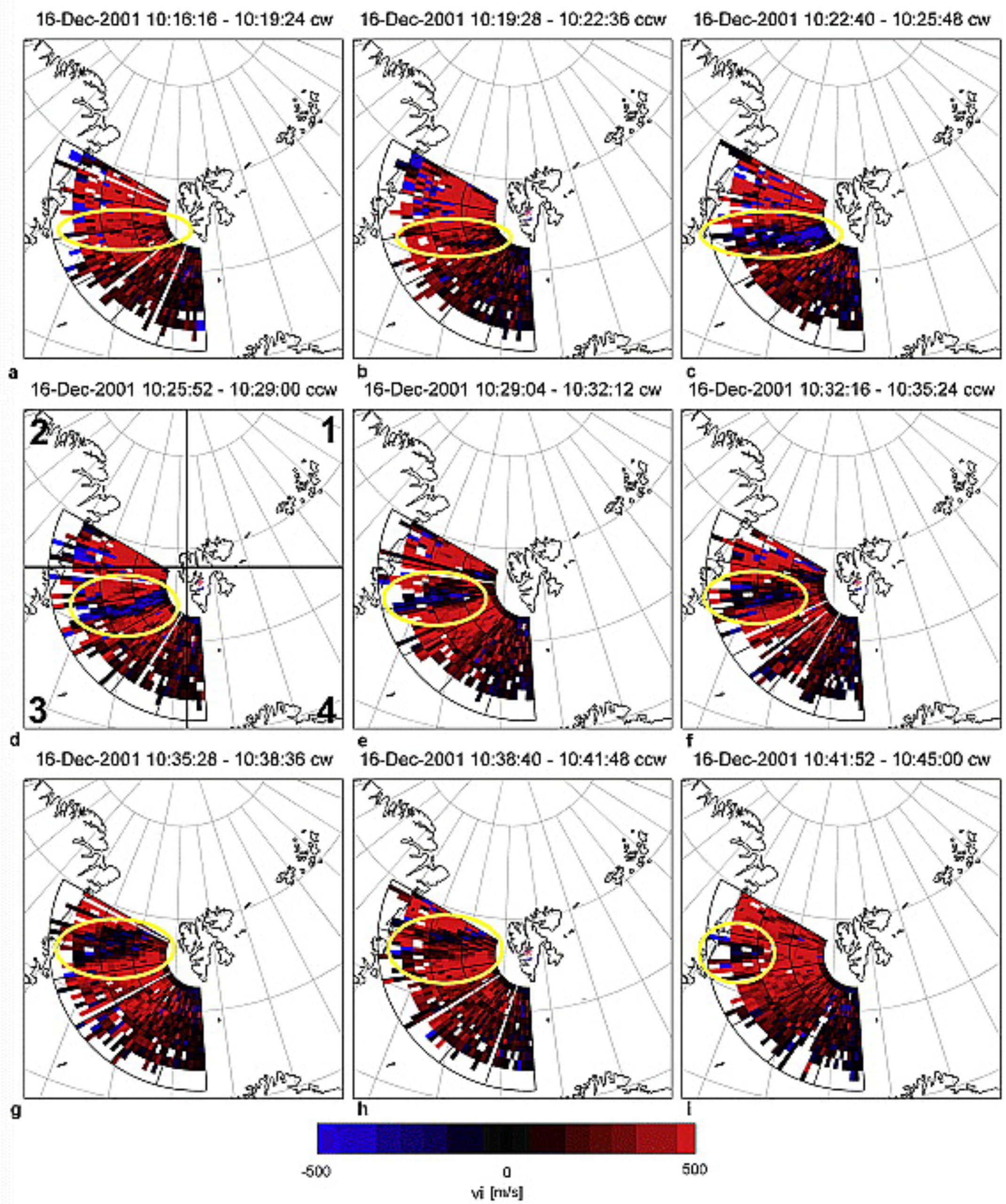
The SCANDI data for the period 05:57-11:57 UT. The top (blue) row - line-of-sight wind components; the second (green) row - the neutral temperatures, and the third (red) row - the 630 nm intensities at the peak emission altitude (~240km).

22 Jan 2012 ESR Radar



Upwelling events seen upon the first ion frictional-drag ion-heating event (evidenced in *Ti*) near 200 km.

These heating events recur in the data as long as the active cusp was overhead.



An example of shear plasma jets seen at Svalbard

"Wiper" mode for EISCAT Radar – sequential az scans

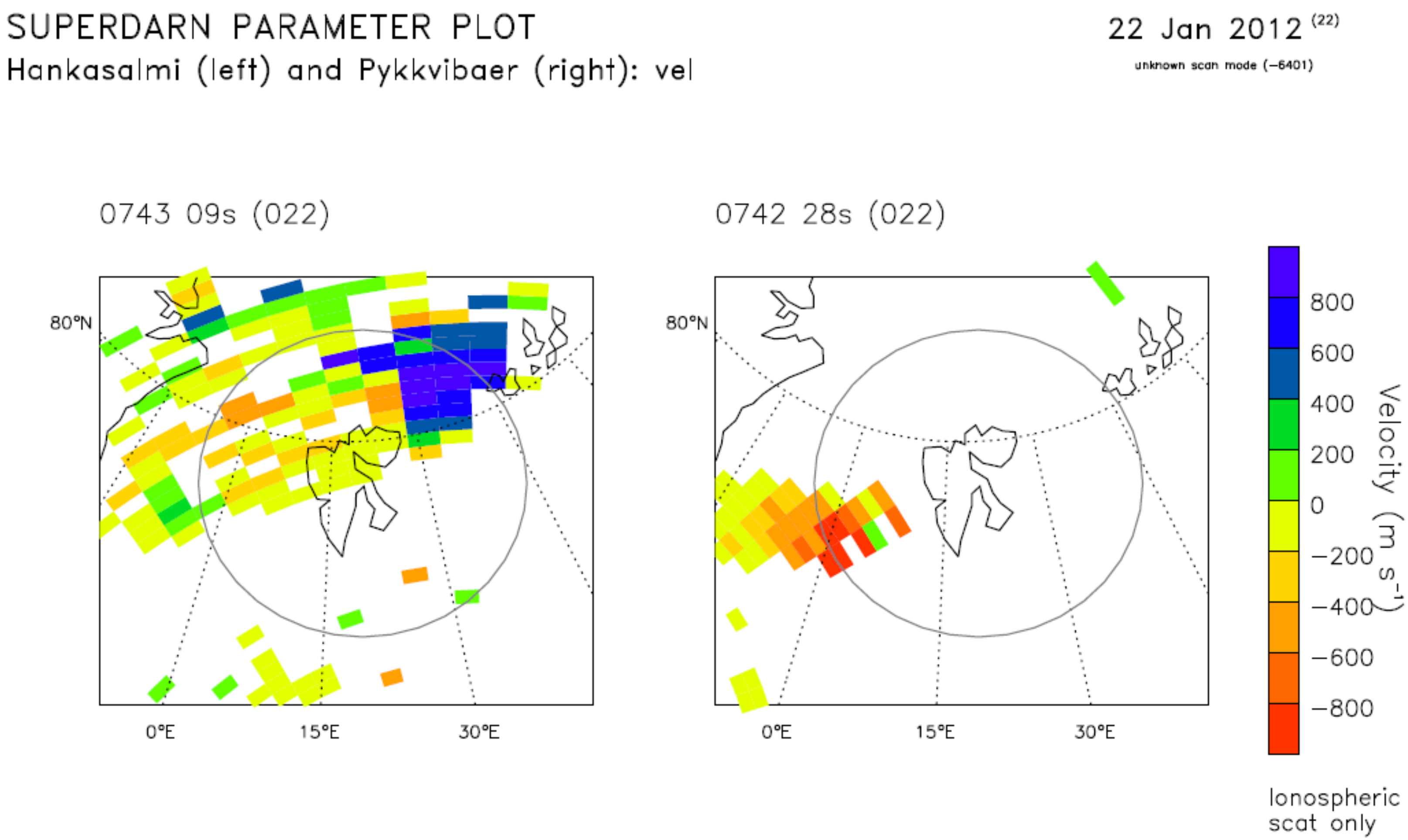
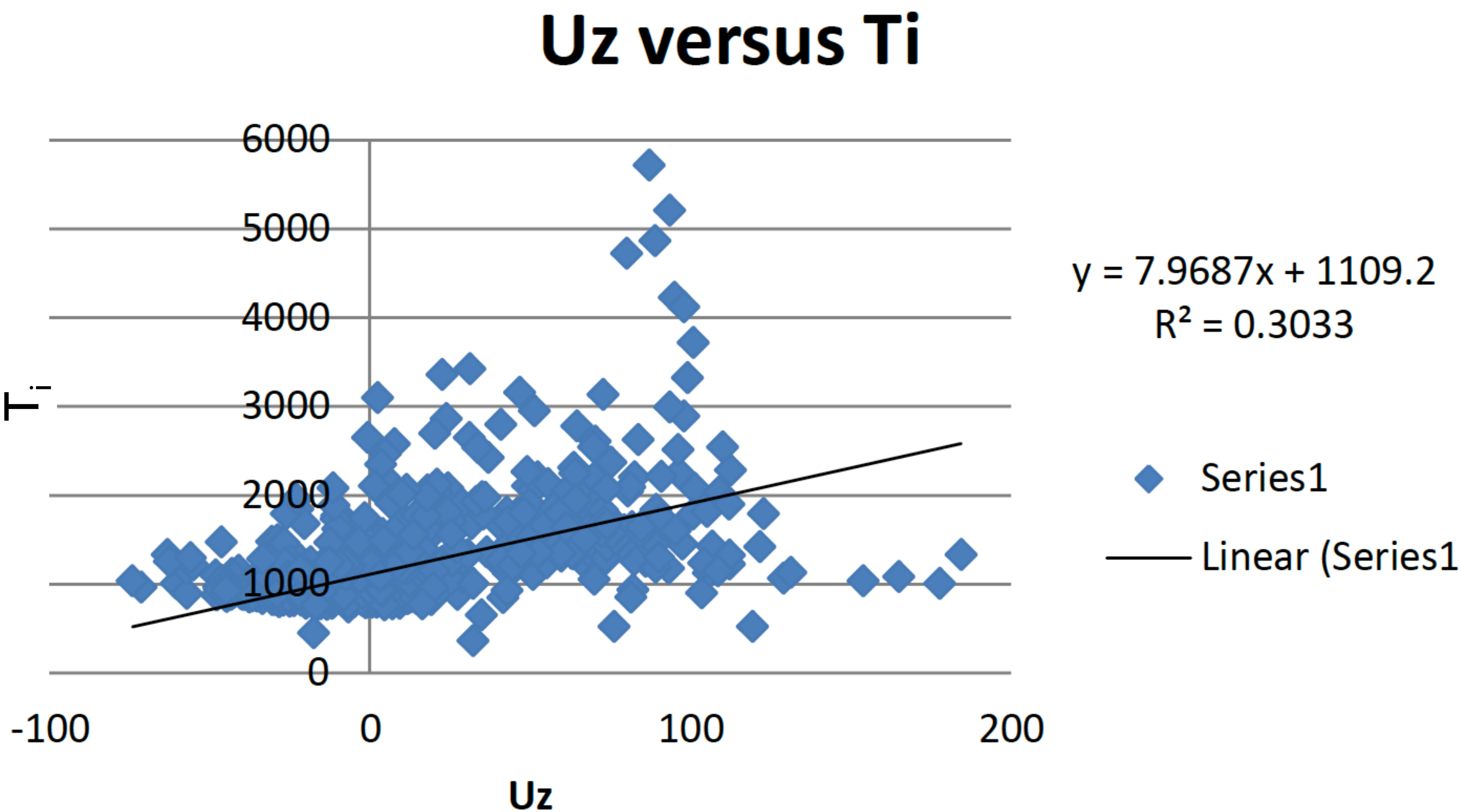
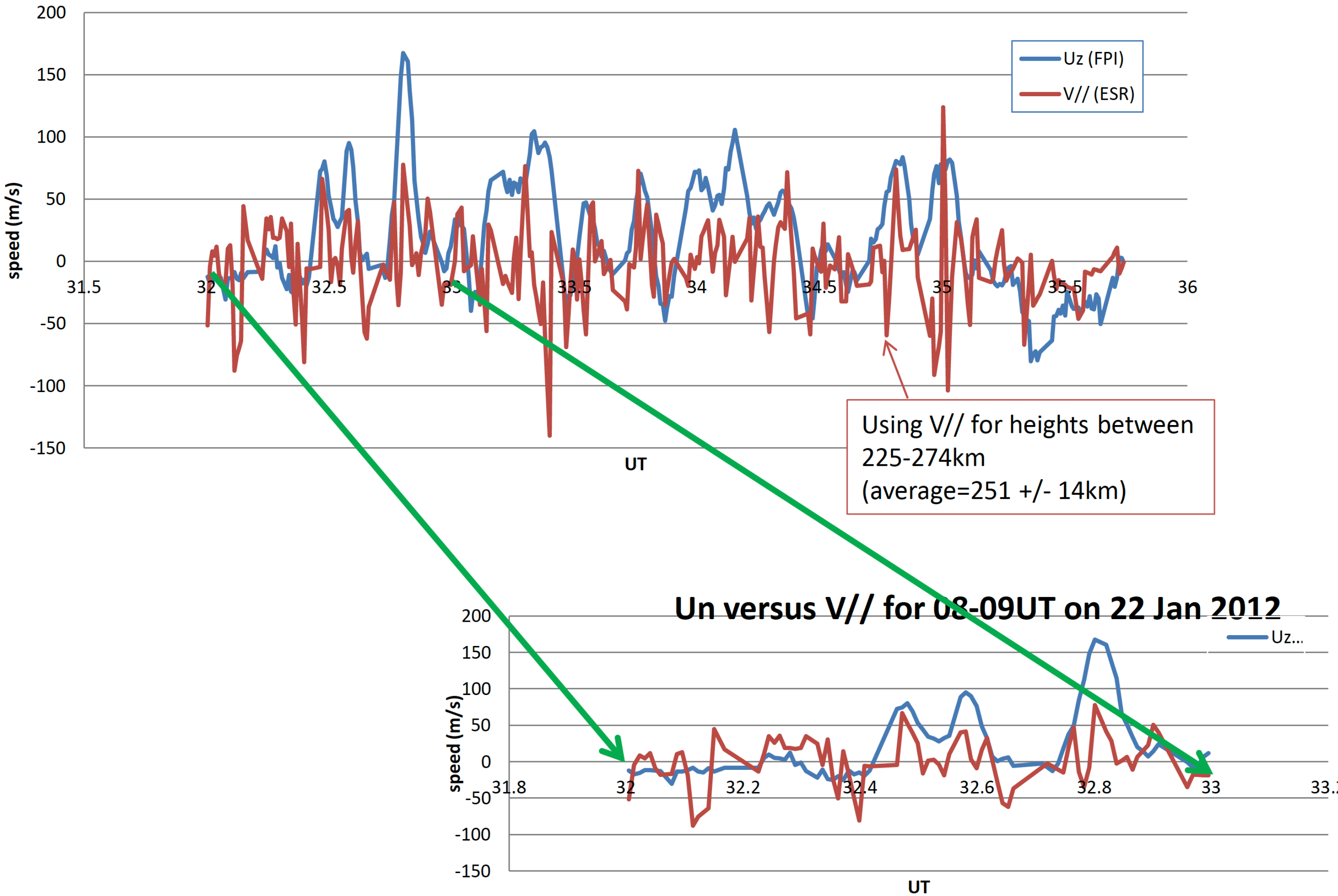


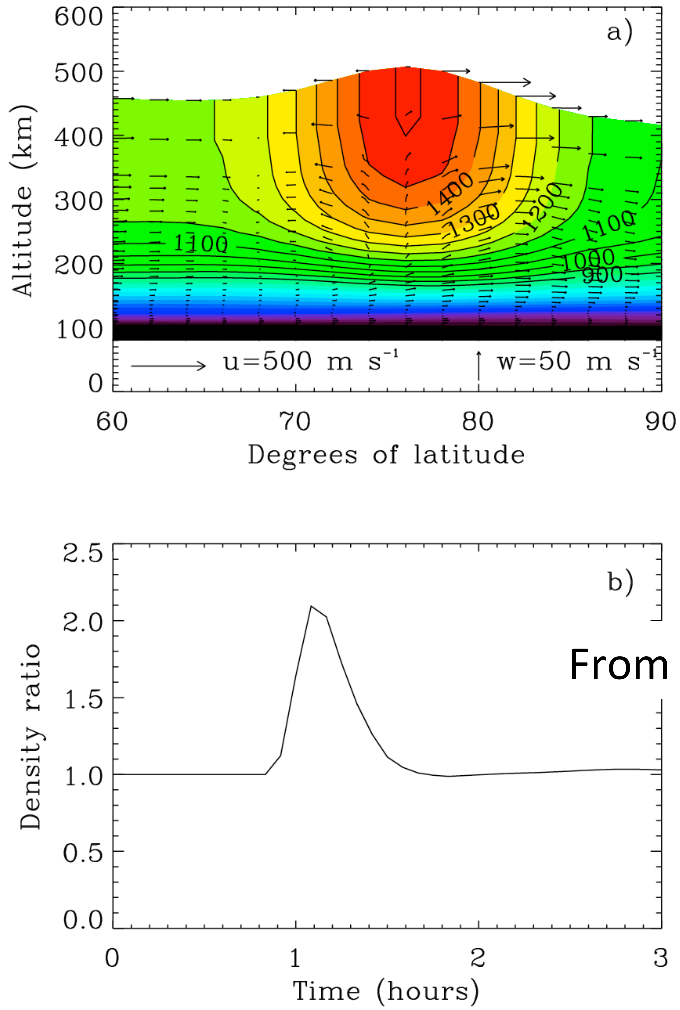
Figure 8 Example of a transient burst of large plasma flow shown by the CUTLASS Hankasalmi and Pykkvibær radars (part of the SuperDARN radar network) within 1 minute of 0743 UT on 22 Jan 2012 superimposed on a map centred on Svalbard. A grey circle centred on Svalbard with radius 500km defines the field-of-view of the narrow field FPI. Despite the large line-of-sight plasma flows > 800 ms^{-1} seen to the north-east of Svalbard by Hankasalmi and to the south-west by Pykkvibær, there was no upwelling of the thermosphere.


Uz versus Ti
6000
5000
4000
3000
2000
1000
0
Ti
-100
0
100
200
Uz
y = 7.9687x + 1109.2
R² = 0.3033
Series1
Linear (Series1

Svalbard Un (FPI) versus V// (32m ESR) for 08-12UT on 22 Jan 2012



201200122_lyr_32m_v3.xlsx



From Carlson et al., 2012

Figure 2. (a) Model output of thermospheric temperature and wind vectors (overlaid to show upwelling and circulation) vs. altitude/latitude at the time and longitude of the density ratio peak in Figure 2b. (b) Model output of corresponding thermospheric density enhancement, by a factor of 2.1 for input typical of magnetic reconnection events at high end (3 km/s) of spectrum of typical plasma flow jet events. The doubling is attributed not to any difference in the model, but only to use of realistic $n_e(h)$ and flow shears typical of large-shear reconnection events common in the cusp.

Summary

• Combination of results from Svalbard instrumentation provide evidence suggesting that strong vertical winds are produced by "high altitude" Joule heating in region of 150-250 km, i.e., ion frictional heating.

• modeling demonstrates increase of density at 400 km by factor 2 which is consistent with CHAMP results.