SuperDARN北海道-陸別HFレーダーで観測されたSAID/SAPS構造の準周期的西向き伝搬現象

2009/10/27-28, 総長陸別訪問

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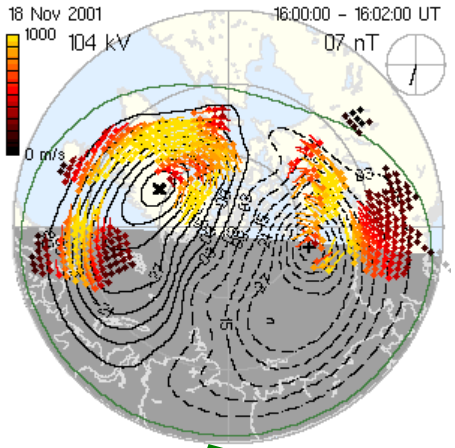
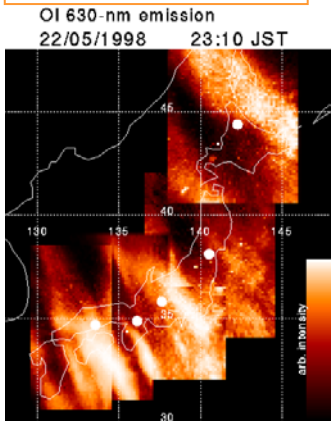
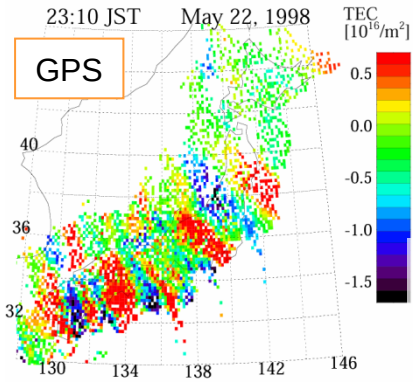
(photo: 2009/09/03 1419 JST)

北海道-陸別HFレーダー(SuperDARN) 2006. 11~

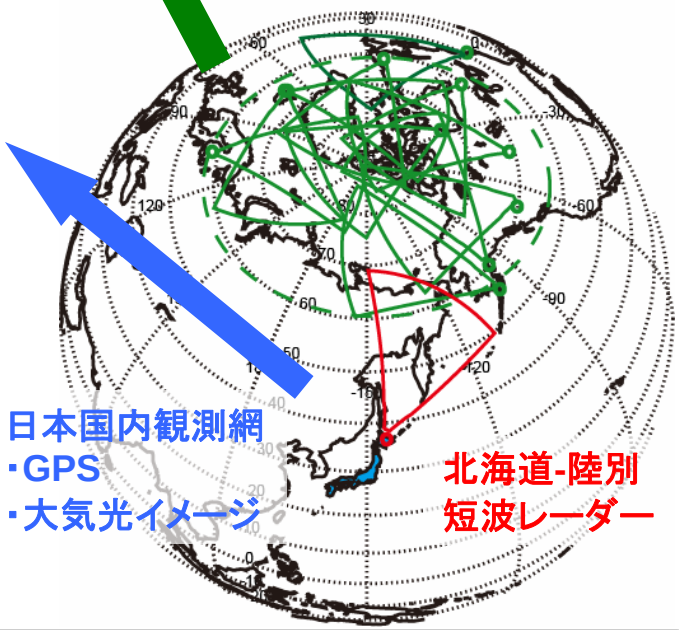


大気光イメージング



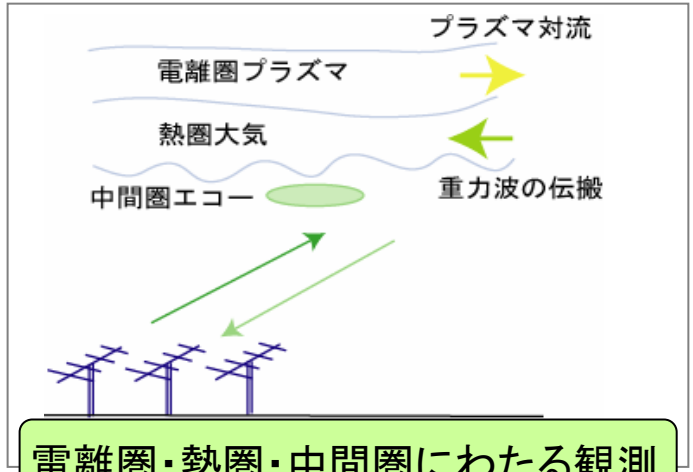


極域短波レーダーネットワーク



日本国内観測網
・GPS
・大気光イメージ

北海道-陸別
短波レーダー



電離圏・熱圏・中間圏にわたる観測

従来の観測空白域をカバー
高緯度と中緯度を結ぶ領域のダイナミクスの統一的な解明

地磁気擾乱時のSub-auroral帯における電場･プラズマ密度分布

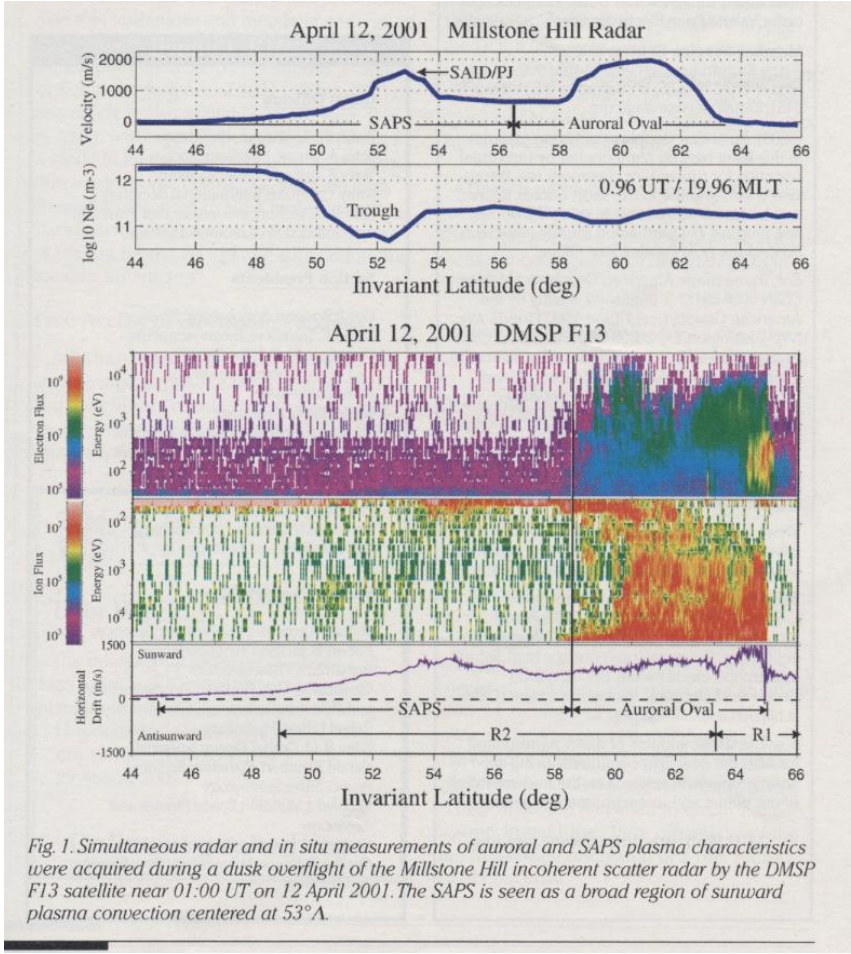


Fig. 1. Simultaneous radar and in situ measurements of auroral and SAPS plasma characteristics were acquired during a dusk overflight of the Millstone Hill incoherent scatter radar by the DMSP F13 satellite near 01:00 UT on 12 April 2001. The SAPS is seen as a broad region of sunward plasma convection centered at 53°A.

(Foster and Burke, EOS, 2002)

- SAPS: オーロラオーバルより低緯度側の、広範囲で電場が増加した領域
- SAID:局所的に極向き電場が強まった領域
- trough: プラズマ密度現象領域

SAPSの周期的振動(Foster et al., 2004)

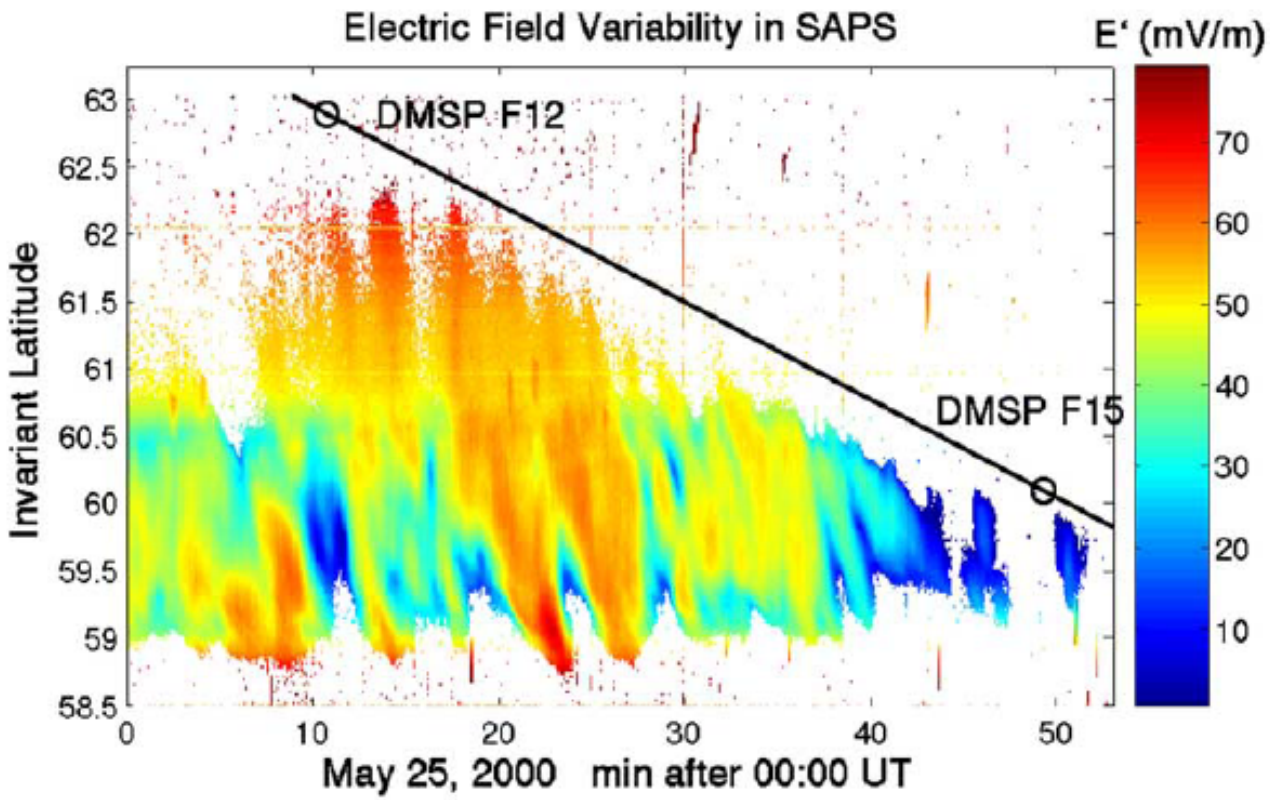
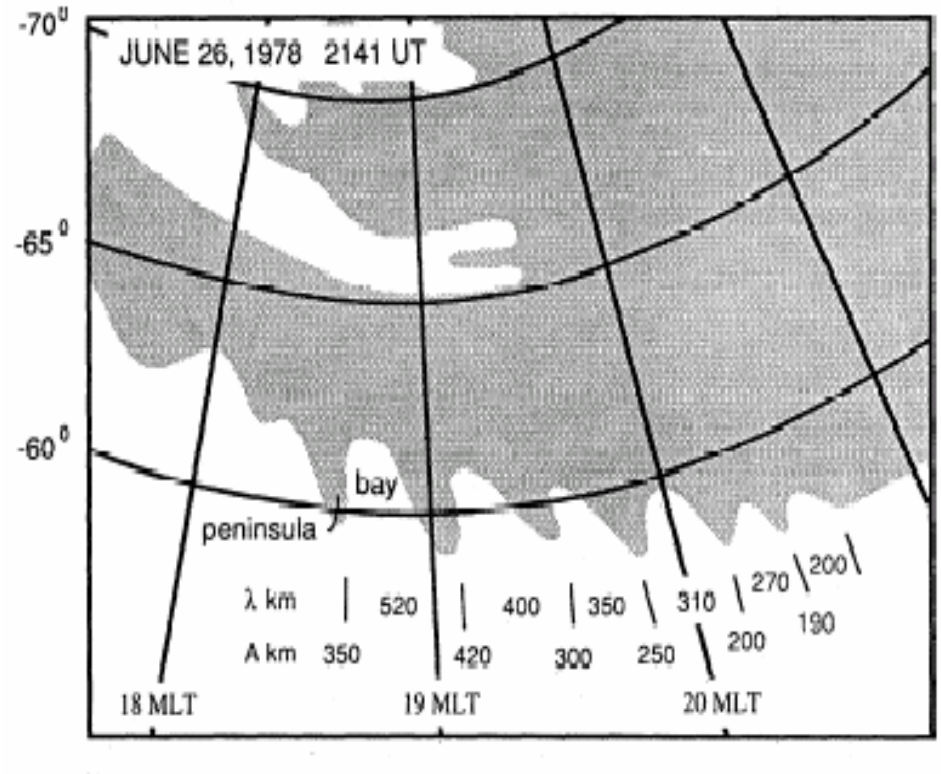


Figure 1. High resolution coherent scatter observations of electric field variability with the Millstone Hill UHF radar reveal periodic wavelike structures within the SAPS channel. The line indicates DMSP observations of the equatorward extent of auroral electron precipitation.

どのような2次元構造に関連しているのかは不明

Giant undulation (Lui et al., 1982)



Yamamoto et al., 1994

DMSP image

- 低緯度側diffuse auroral boundary付近に発生
- 地磁気擾乱時に発生
- 比較的まれ

  ->Viking,Freja等ではもっと頻繁に観測されている?
- 場合により

  A(amplitude) > λ

Ground-based all-sky TV observation of giant undulation

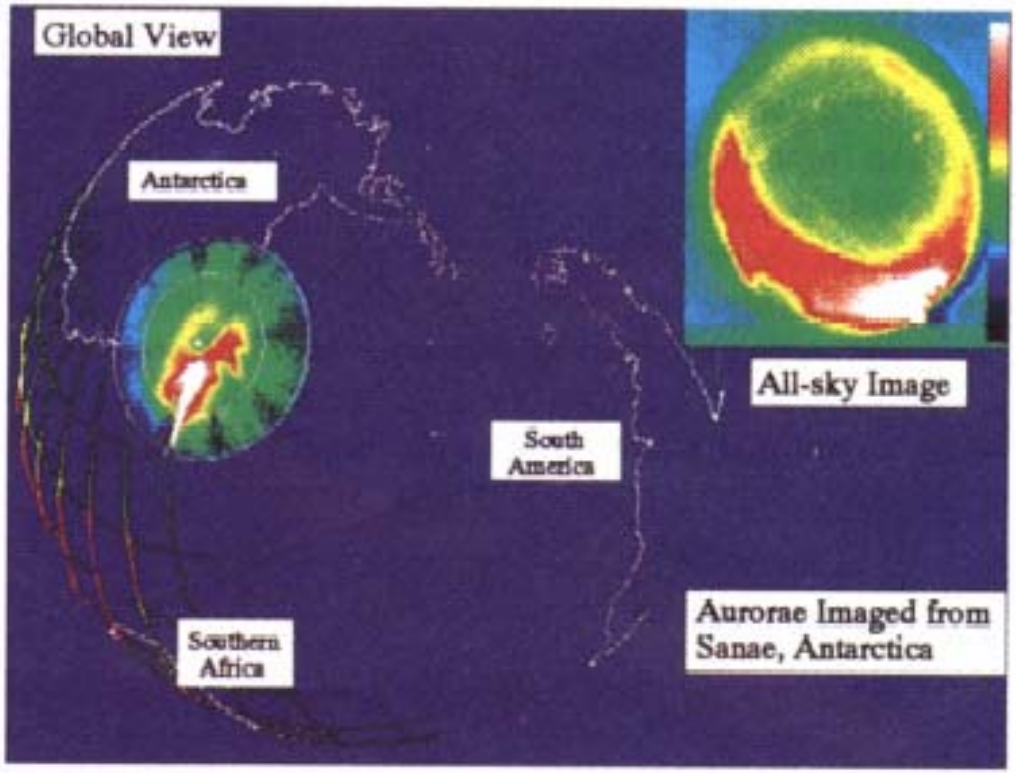


Figure 2. All-sky and projected images of giant undulation at 2358 UT.

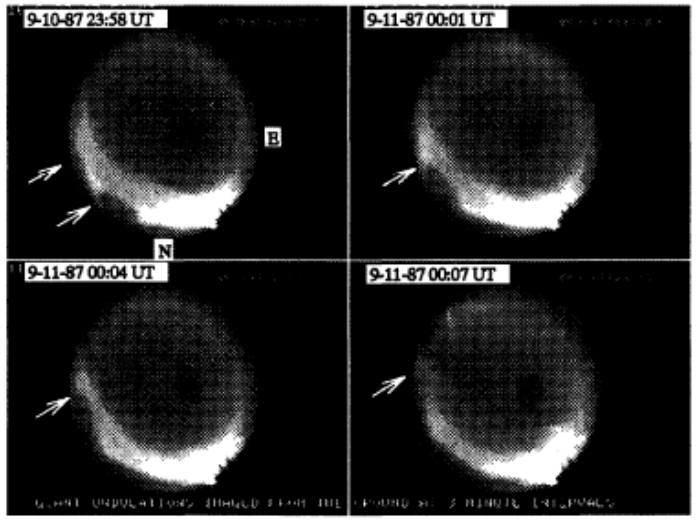


Figure 1. Sequential pictures, at 3 minute intervals, of all-sky TV images obtained at SANAE between 2358 UT and 0007 UT.

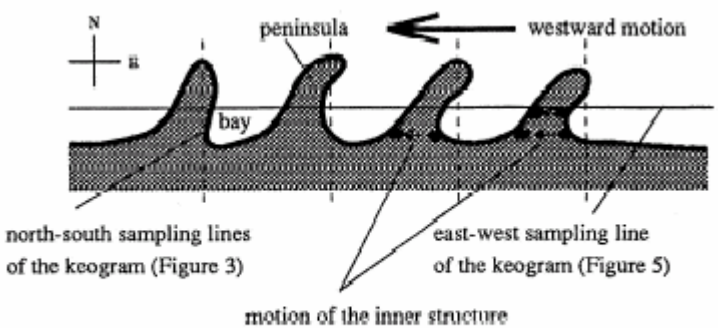


Figure 4. Schematic view of the observed giant undulation.

Nishitani et al., GRL, 1994.

Temporal and Spatial characteristics of giant undulation (Nishitani et al., 1994, GRL)

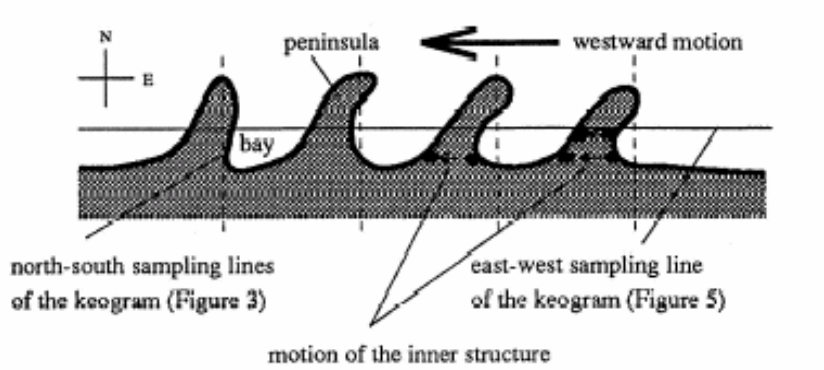


Figure 4. Schematic view of the observed giant undulation.

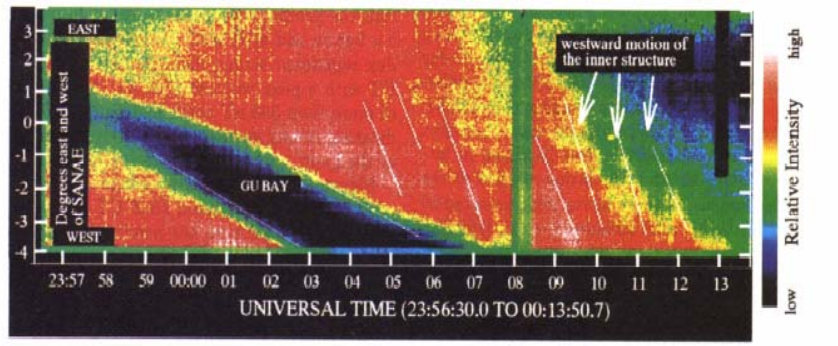
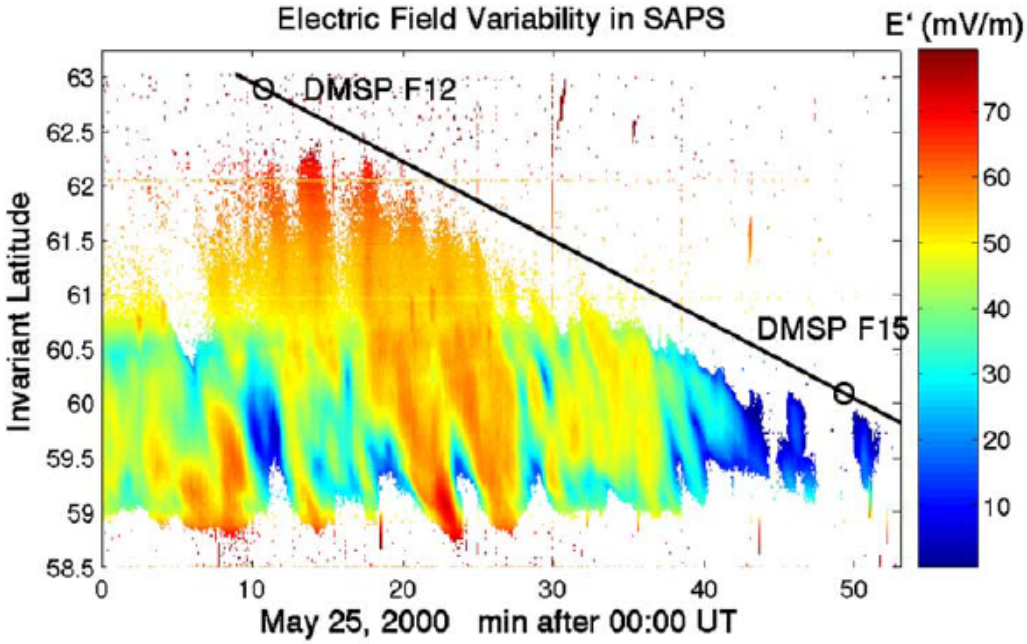


Figure 5. Auroral keogram sampled along two lines along the wave forms, as illustrated in Figure 4. The westward motion of inter structure is clearly seen as indicated by white lines and white arrows, together with that of bay structure. The speed of these inner structure is measured to be 2.5 to 4.0 km/s.

- Wave: westward motion
- Wave amplitude grows with time (70 -> 140 km)
- Pediod: ~ 5 min
- Small-scale inner structure moving westward (2.5 to 4 km/s) much faster than the wave motion (~500 m/s)
- Observed growth rate is slightly slower than the linear theory of shear instability

空間・時間的に急激に変動するsub-auroral電場構造:SAPS/SAIDの観測 (Foster et al., GRL, 2004)



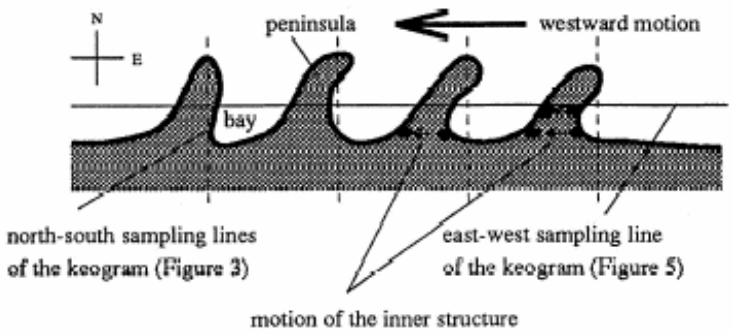


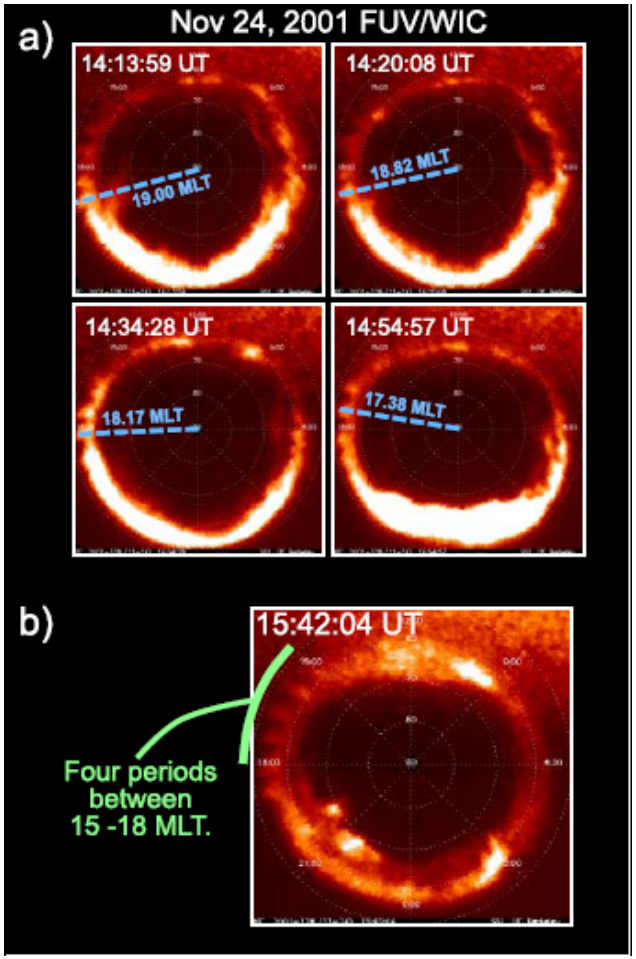
Figure 4. Schematic view of the observed giant undulation.

- 約5分周期で周期的に変化する電場構造
- 緯度幅: 100-200 km

↓

- これらはundulationに対応する電場構造??
- 2次元観測ではないので詳細は不明
- SuperDARNのような2次元snapshotの観測が不可欠

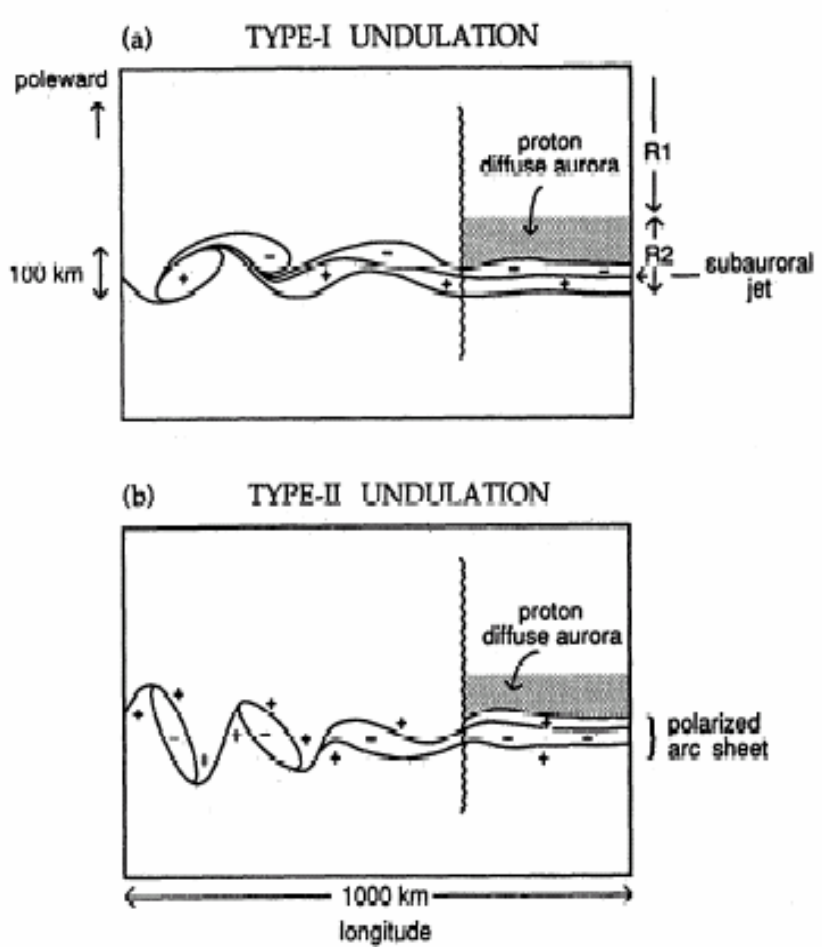
Henderson et al. (JGR, in press)
IMAGE FUV imageによるgiant undulationの観測



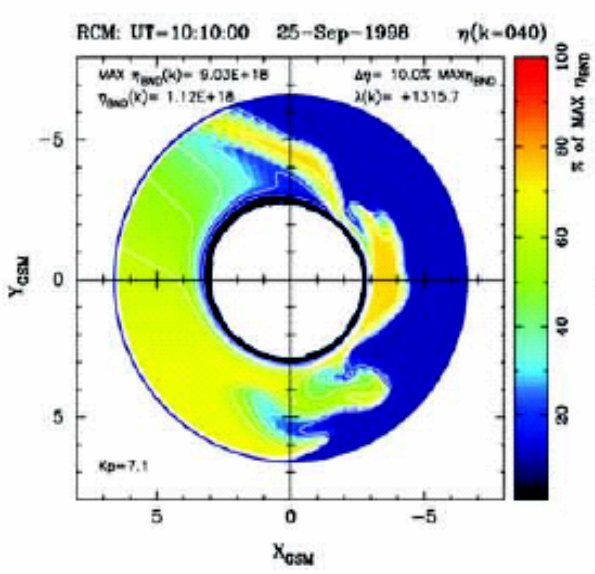
- Start-to end observation of giant undulation
- Westward propagation, which is consistent with Nishitani et al. (1994)
- Speed: 0.6 km/s, period: ~1100 s.
- Correlated with SAPS structure observed by DMSP driftmeter
- Consistent with the growth of a shear flow or ballooning type instability

2-D electrostatic particle simulation by Yamamoto et al. (1993, 1994)

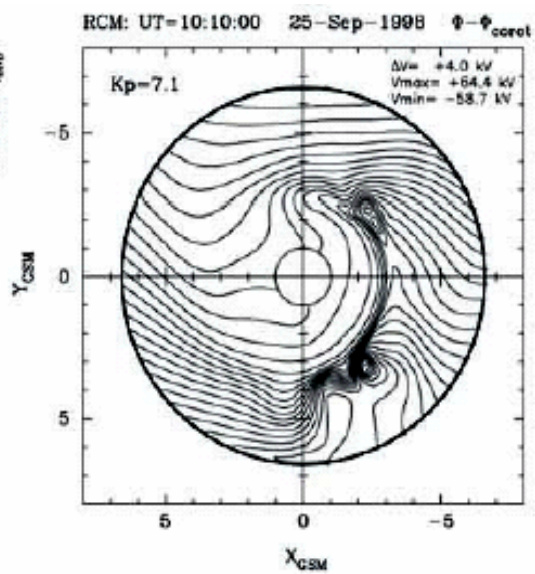
- TYPE-I: 2 charged sheetを仮定->
  波状構造が発達するがA>λまで至らず
- TYPE-II: 3 charged sheetを仮定->
  A>λまで発達するが、このようなsheet構造に関連した電場分布の観測例なし



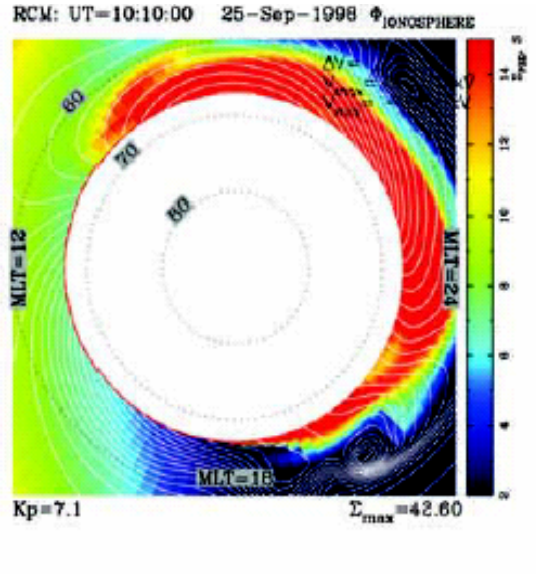
RCM simulation of the interchange instability in the inner magnetosphere (Sazykin et al., 2002)



Plasma density



Electric potential



Conductivity (ionosphere)

- The spatial grid scale is much larger than the spatial scale of giant undulations

Event study:

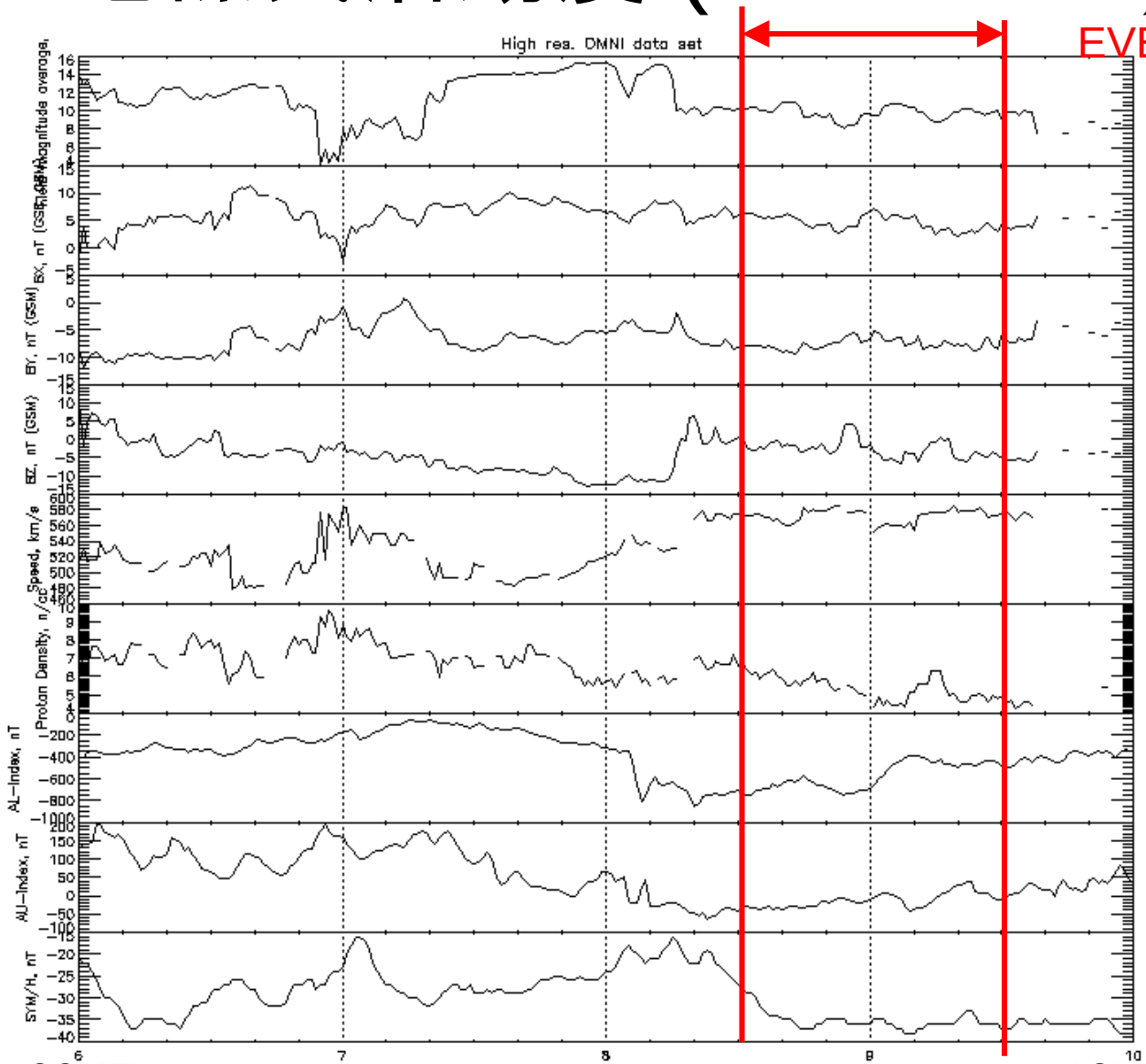
2008/04/23 0830-1000 UT

During a main phase of a storm (Minimum Dst=-43 nT)

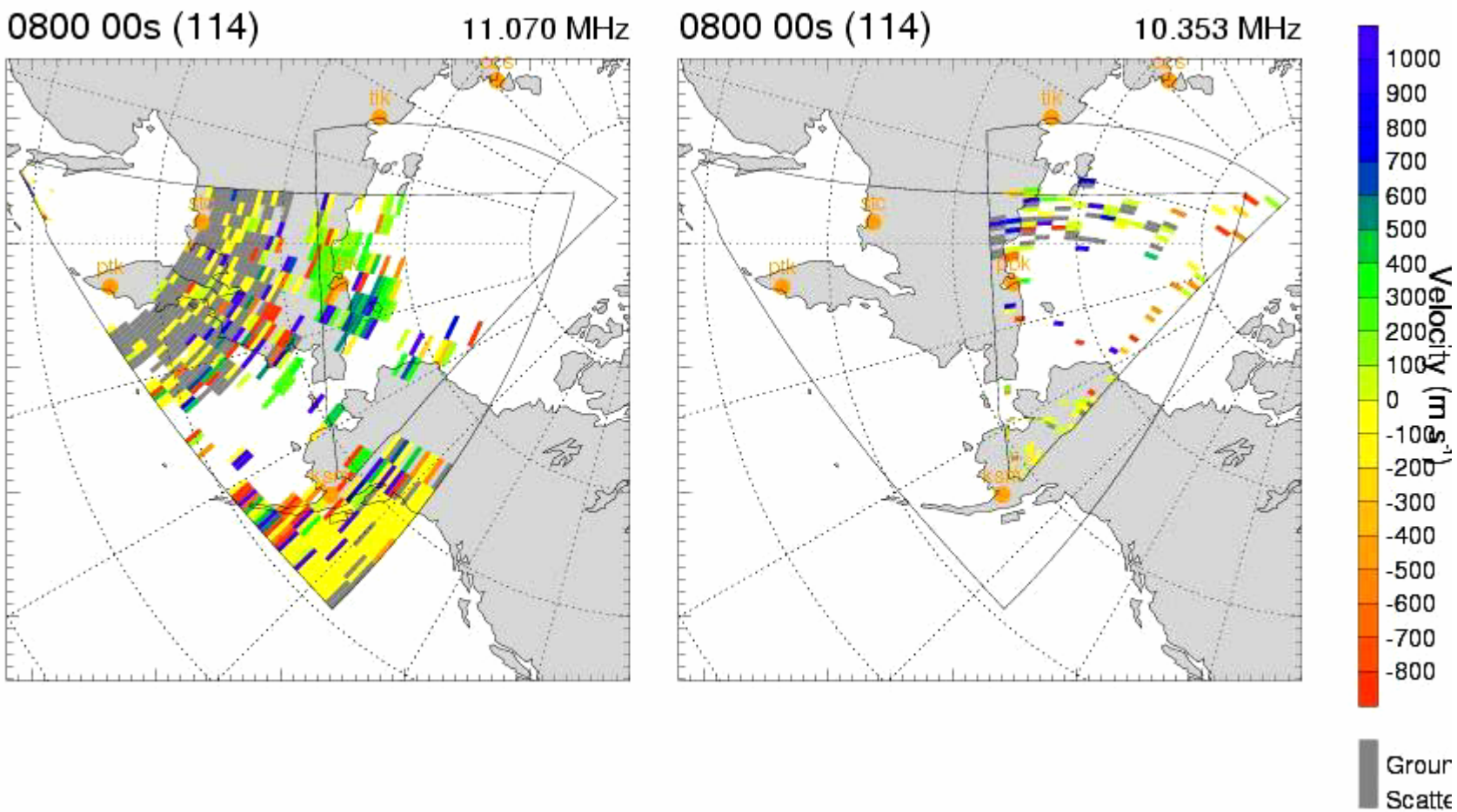
Hokkaido radar: duskside

IMF および太陽風パラメータ、地磁気活動度 (OMNIweb)

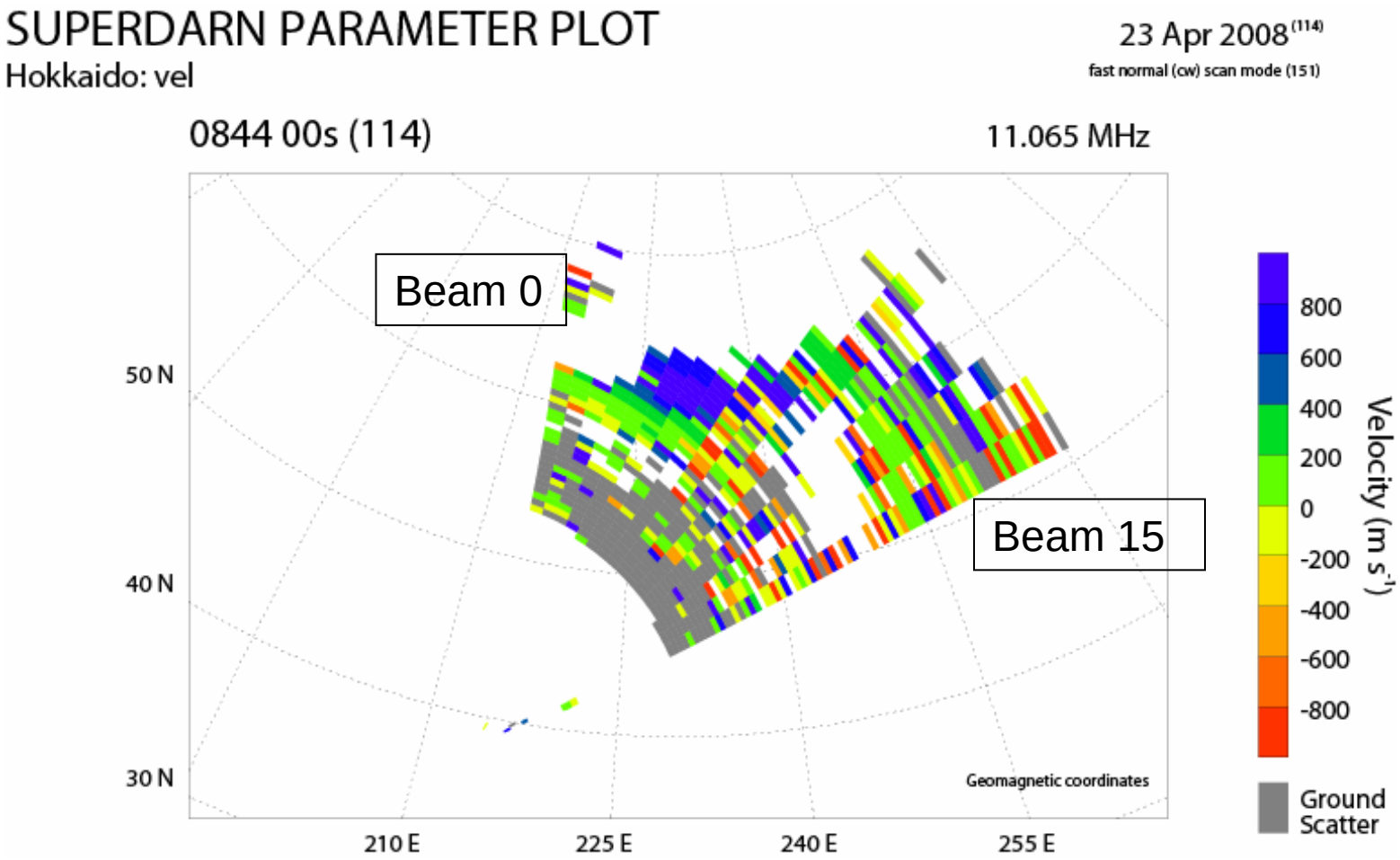
2008/04/23



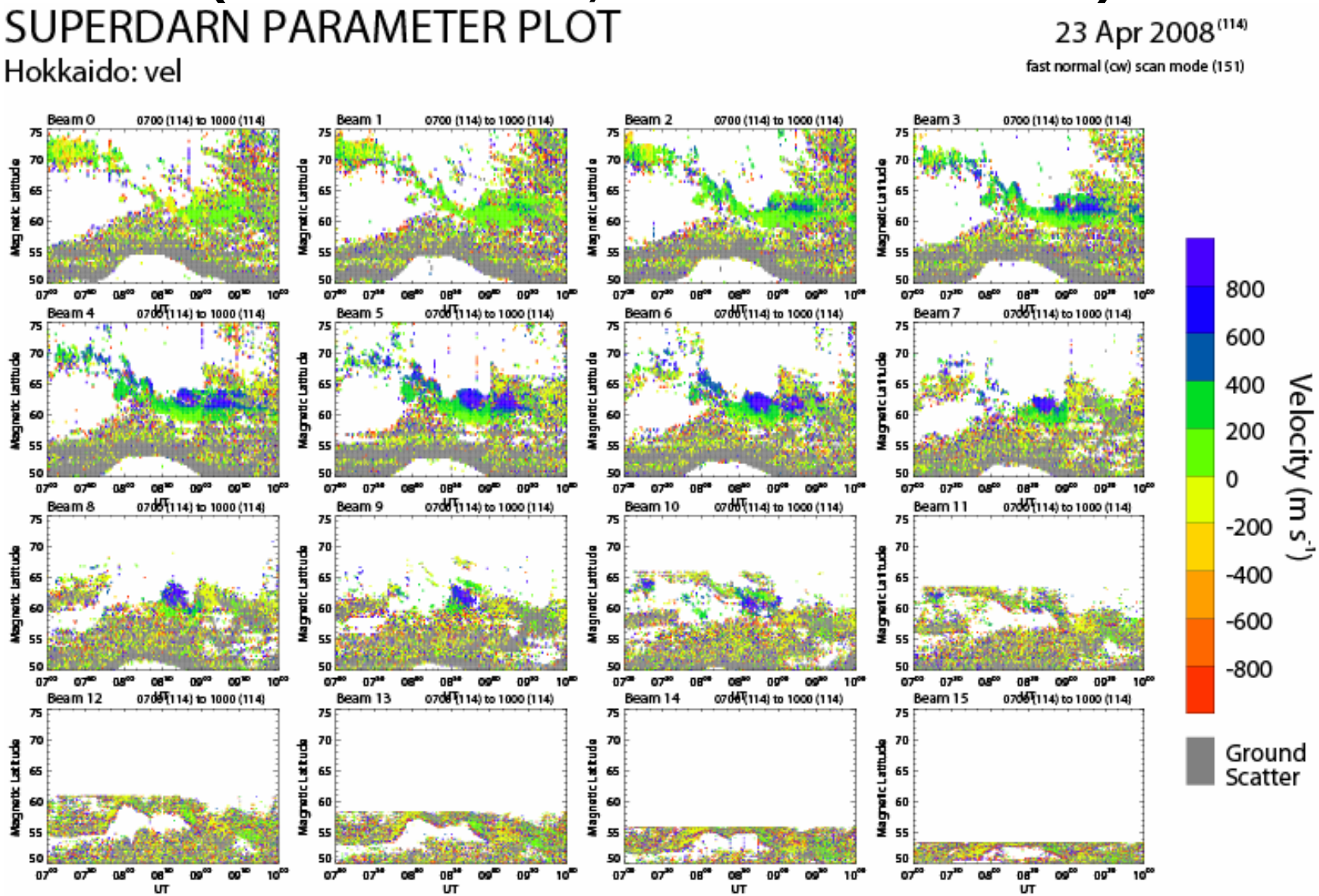
Movie: 2008/04/23 0830-1000 UT

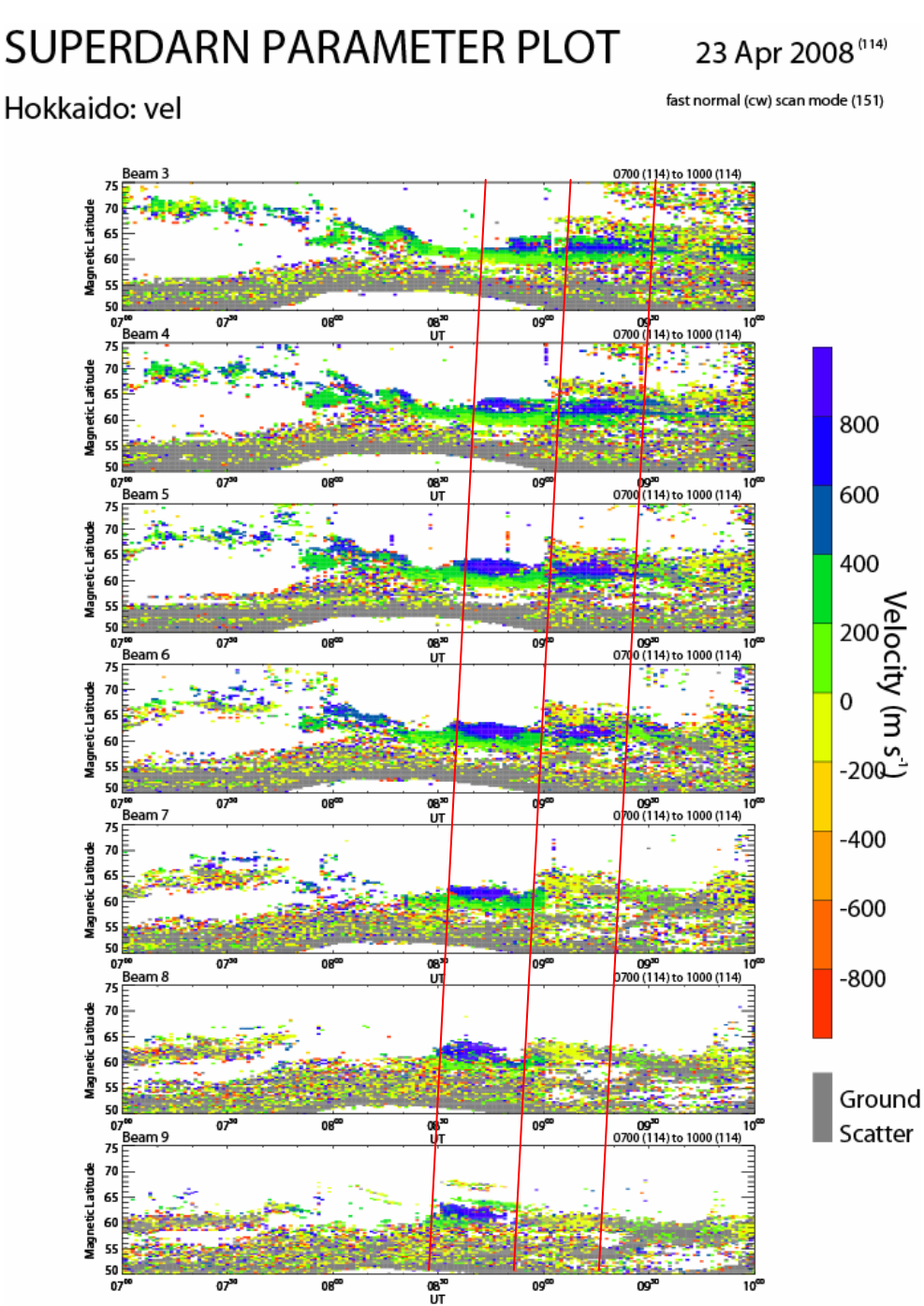


2-D LOS plot (地磁気座標系)



RTI plots for all beams (07-10 UT, 30-75 MLAT)





RTI plots for beams 3-9

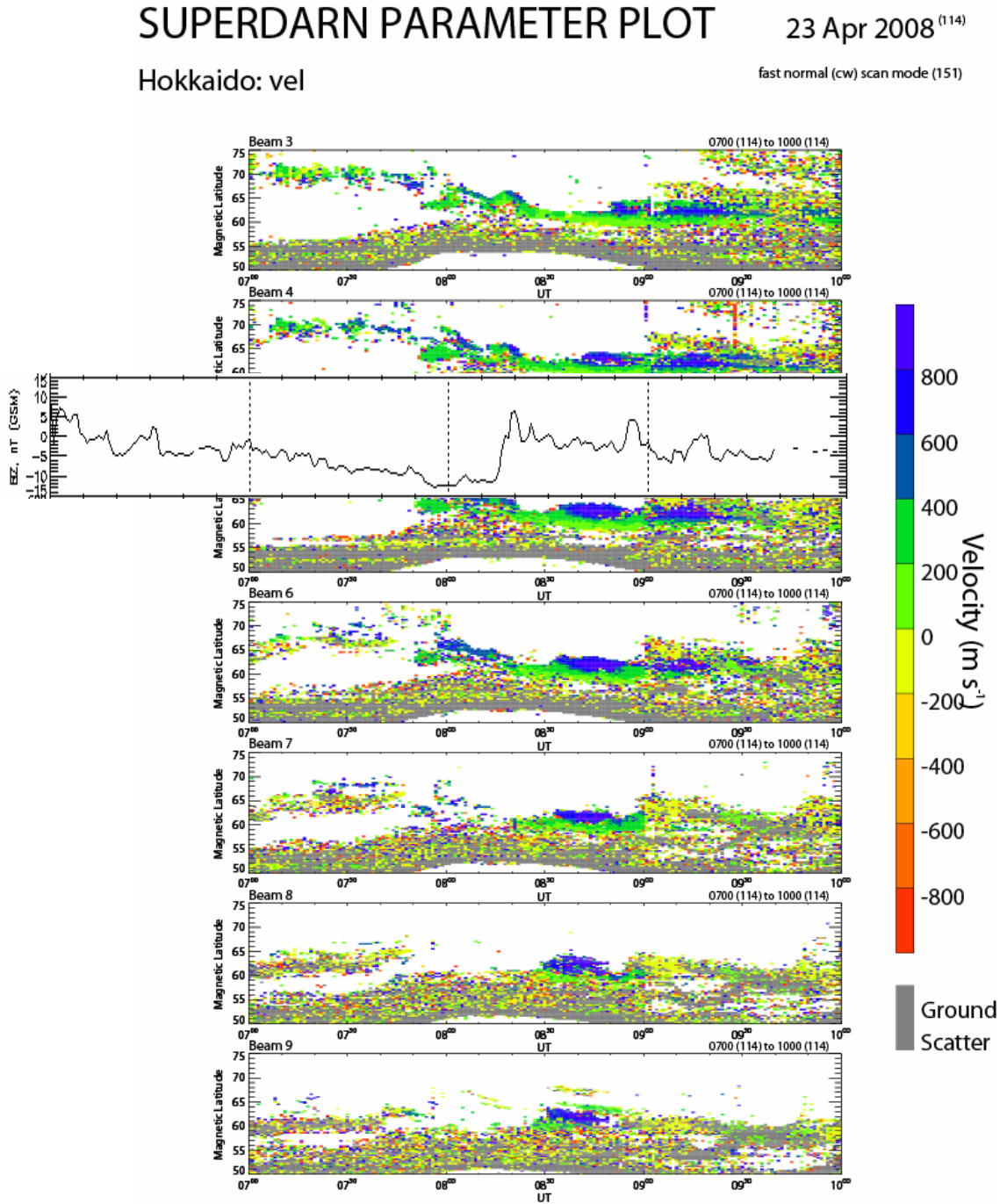
period:
~30 min

velocity:
~700m/s in geog. coords.
(~460m/s in the ML-MLT coords.)

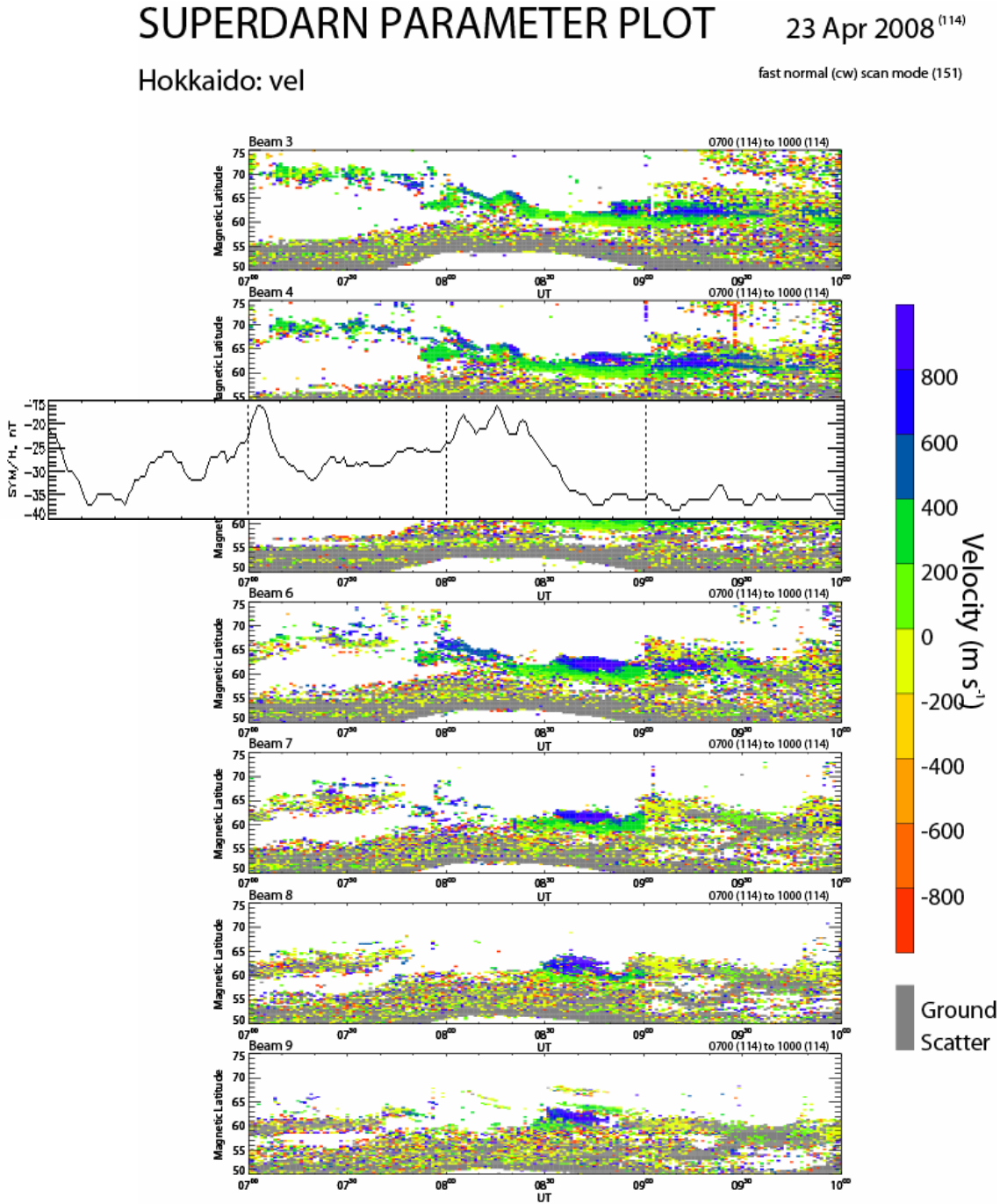
wavelength:
~1200 km (1.5h MLT)

latitudinal span:
~ 200 km

IMF Bzとの比較


SUPERDARN PARAMETER PLOT
23 Apr 2008 (114)
Hokkaido: vel
fast normal (cw) scan mode (151)
Beam 3
Beam 4
Beam 6
Beam 7
Beam 8
Beam 9
0700 (114) to 1000 (114)
Magnetic Latitude
UT
EBZ, nT (GSM)
800
600
400
200
0
-200
-400
-600
-800
Velocity (m s-1)
Ground Scatter

SYM/Hとの比較


SUPERDARN PARAMETER PLOT
23 Apr 2008 (114)
Hokkaido: vel
fast normal (cw) scan mode (151)
Beam 3
Beam 4
Beam 6
Beam 7
Beam 8
Beam 9
0700 (114) to 1000 (114)
Magnetic Latitude
UT
SYM/H, nT
Velocity (m s-1)
800
600
400
200
0
-200
-400
-600
-800
Ground Scatter

Conclusions

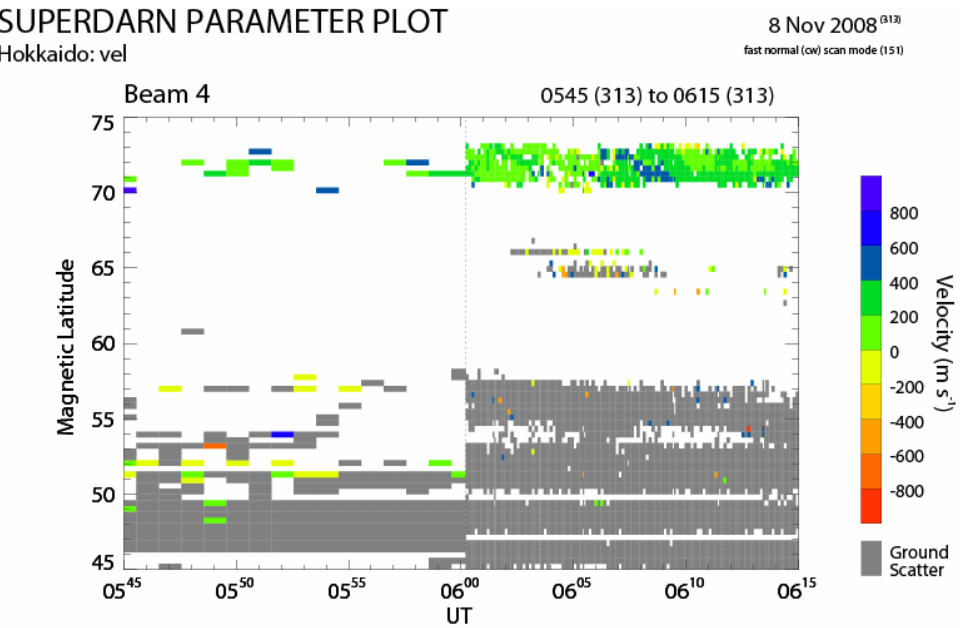
- One event is studied for the periodic oscillations of SAID/SAPS structure.
- Its period, propagation velocity and wavelength are 30 min, 700 m/s and 1200 km respectively.
- Relation between SAPS/SAID and IMF Bz is not clear.
- The structure appears during the main phase of a geomagnetic storm, which is consistent with the result by Kataoka et al. (2009).
- It has similar characteristics to traditional ‘giant undulation’ auroral structures. The present period is different from the results by Foster et al. (2004) and Nishitani et al. (1994), but it is comparable with the result by Henderson et al. (2010) (~ 1100 seconds). In any case some kind of instability must be working for the generation of the present structure.
- Operation of special modes such as ‘themisscan’ programs is promising for monitoring detailed characteristics of SAID/SAPS oscillations.

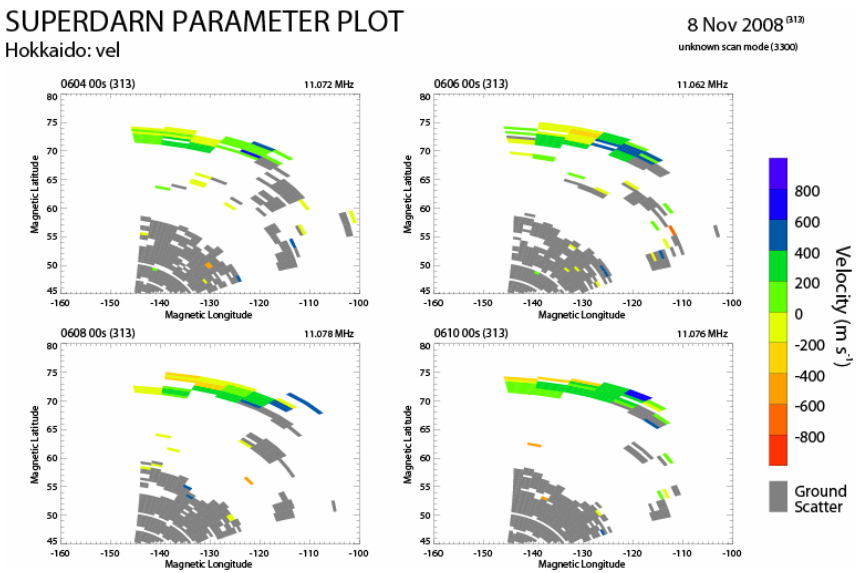
Nov. 08, 2008 periodic (~ 5 min) oscillation of duskside sunward flow in the auroral zone, observed during THEMIS mode

normal mode: beam 15,14, …,1,0,15,14,…

THEMIS mode: beam 15,4,14,4,…,1,4,15,4,..

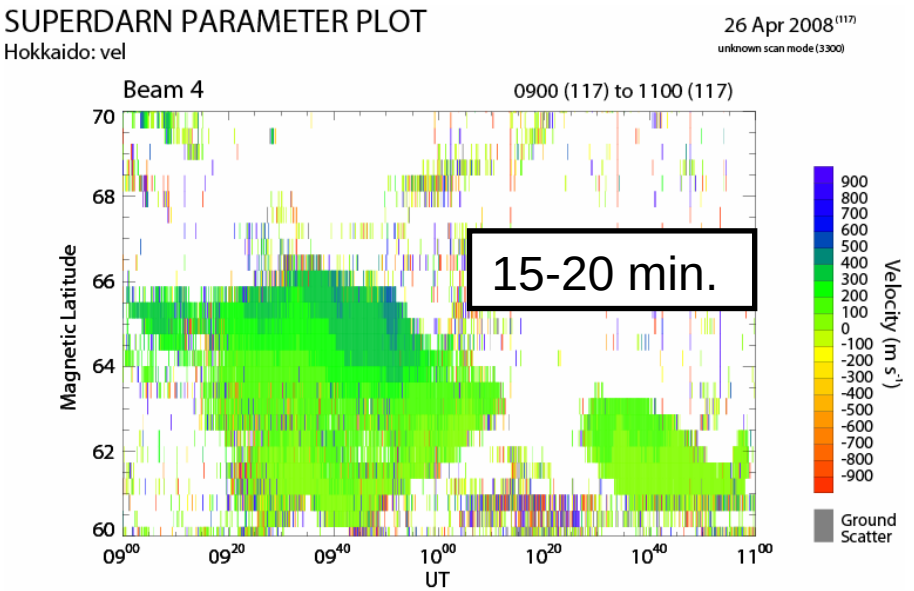
Beam 4(北北東方向)については数秒間隔の観測が可能.

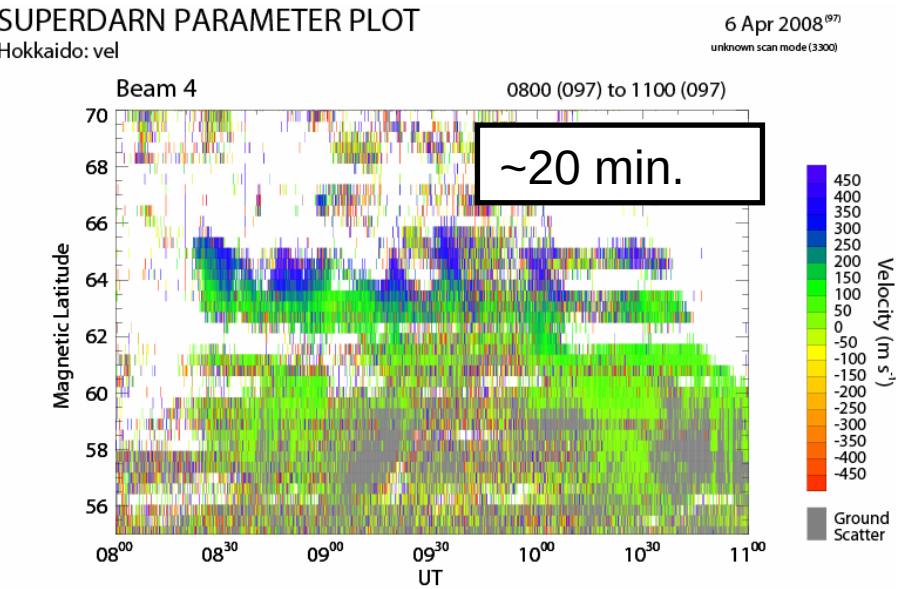


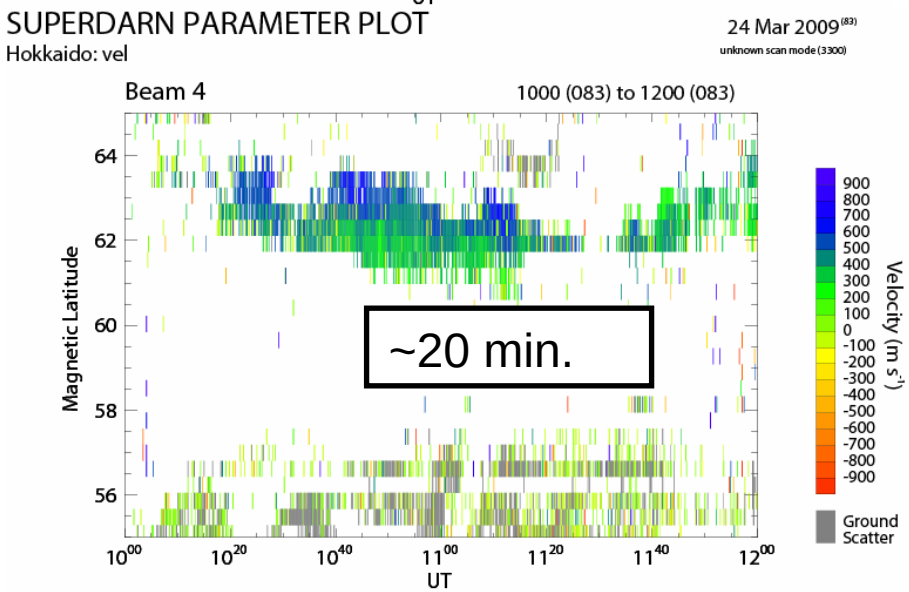


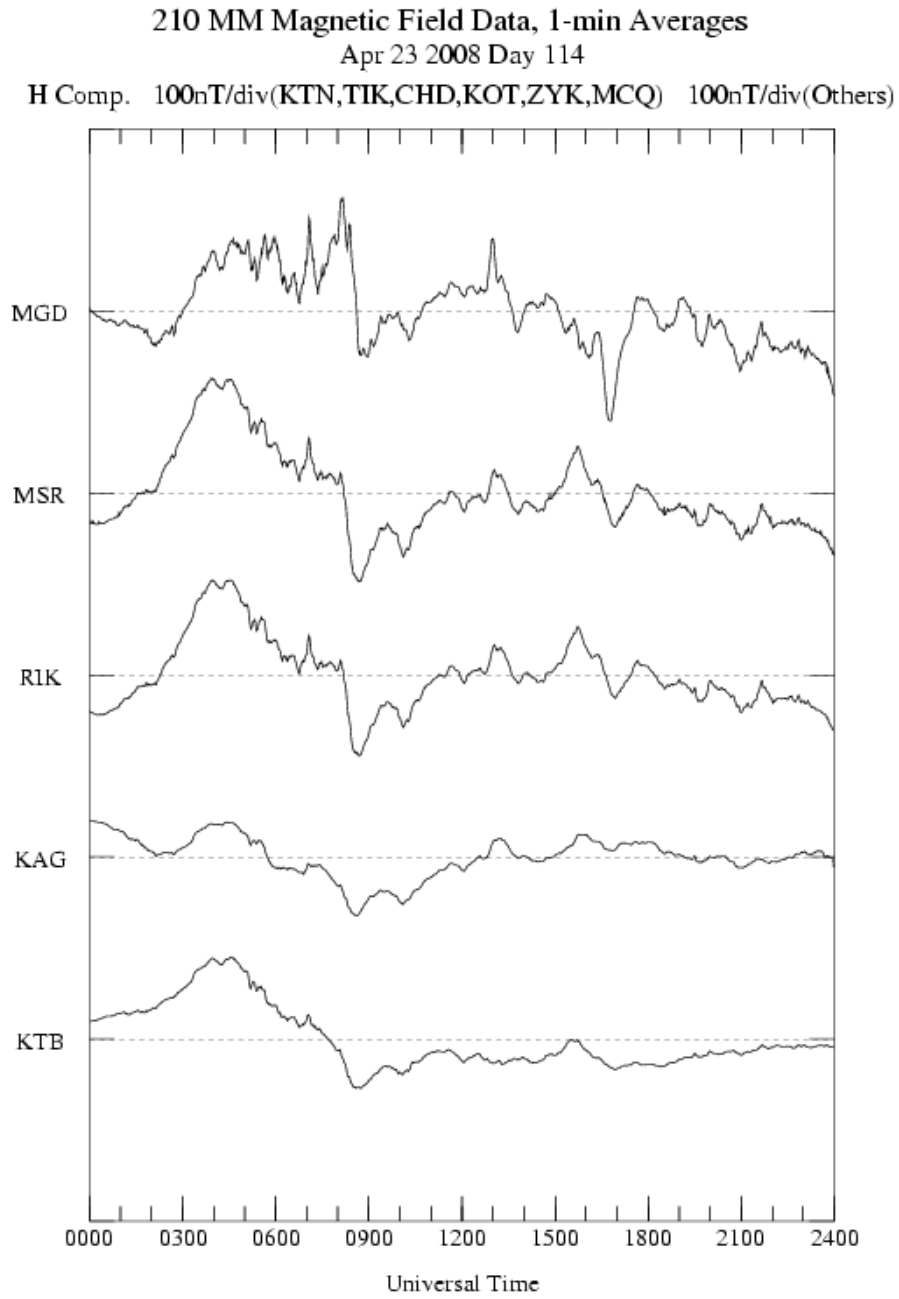
Examples of recurring SAPS during THEMIS mode

2008/04/06 0800-1100 UT
2008/04/26 0900-1100 UT
2009/03/24 1000-1200 UT
Westward flow > 500 m/s
for < 66 geomag. Lat.









H component magneic field variations at 210 MM chain stations

(obtained from: http://stdb2.stelab.nagoya-u.ac.jp)