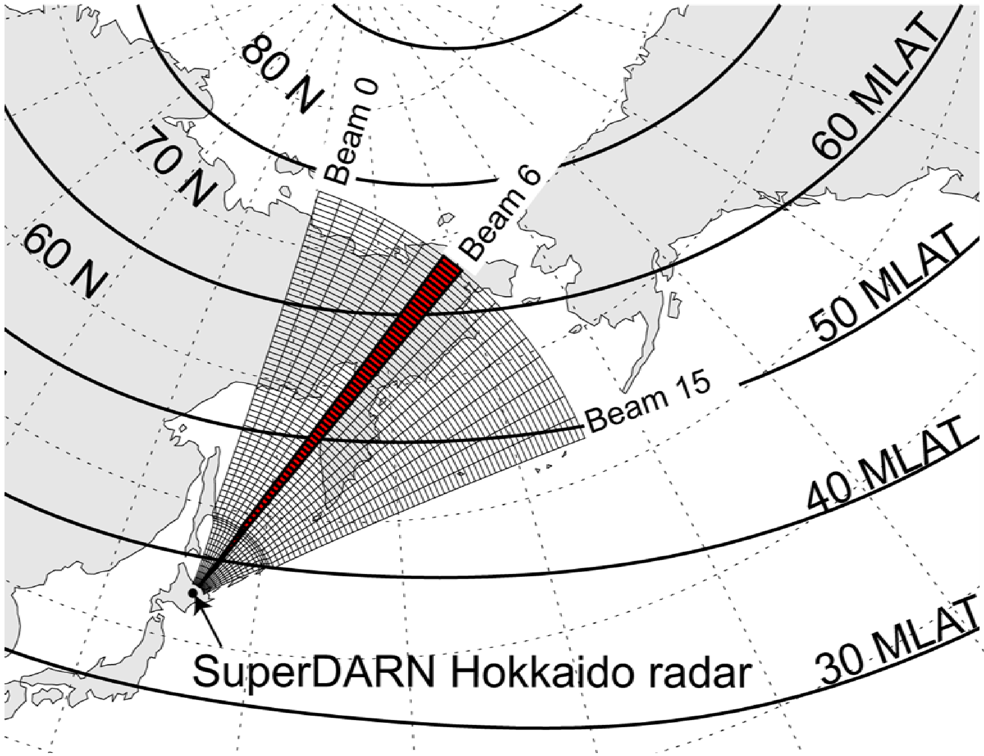
Geospace
Environment
Modeling
System
for
Integrated
Studies

Subauroral plasma flows: Intercomparison between Hokkaido SuperDARN radar and simulation

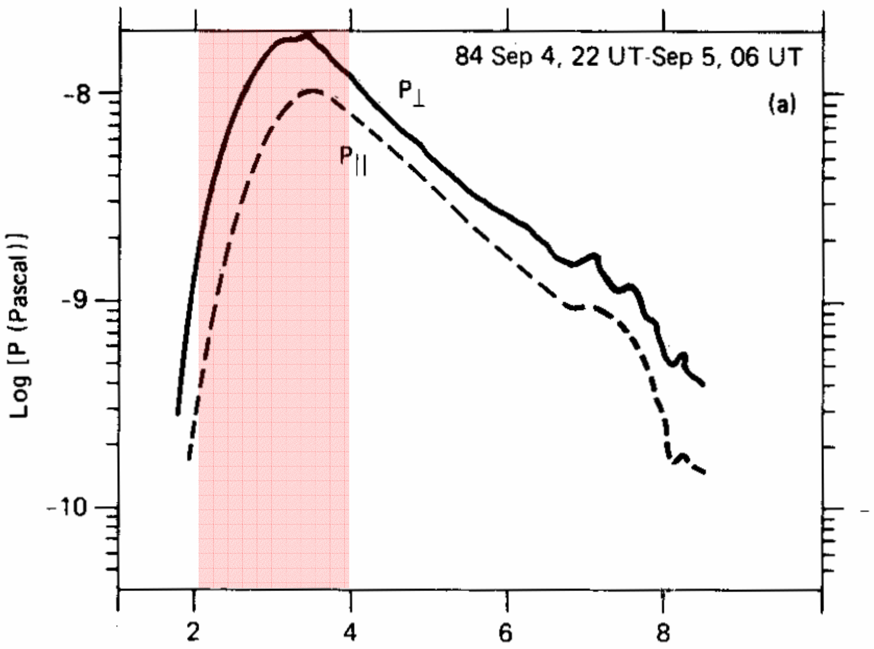
海老原祐輔(名古屋大高等研究院)
西谷望・菊池崇・小川忠彦(名古屋大STE研)
細川敬祐(電通大)
Mei-Ching　Fok　(NASA GSFC)

Field of view of Hokkaido radar

Field of view



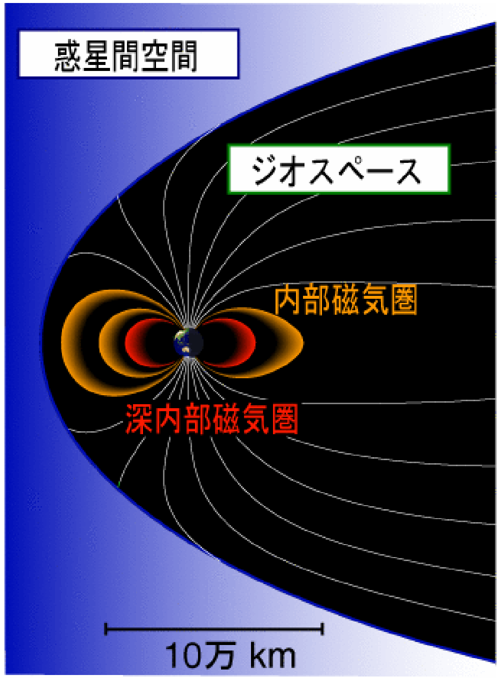
Plasma pressure (ring current)

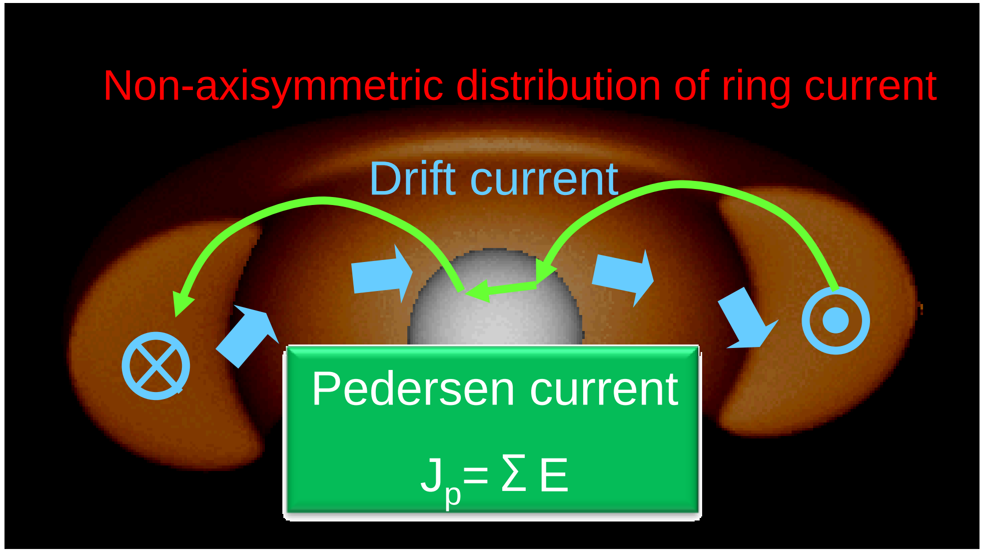


Lui et al. (1987)

Peak of plasma pressure takes places at L=2-4.

M-I couping in subauroral region





$$\mathbf{J}_\perp = \mathbf{J}_M + \mathbf{J}_B + \mathbf{J}_c$$

$$= \frac{\mathbf{B}}{B^2} \times \left[\nabla P_\perp + \left(P_\parallel - P_\perp \right) \frac{(\mathbf{B} \cdot \nabla)\mathbf{B}}{B^2} \right]$$

$$J_\parallel = -B \int \nabla \cdot \mathbf{J}_\perp dl / B$$

Field-aligned current

$$\nabla \cdot \left(-\underline{\underline{\Sigma}} \cdot \nabla \Phi \right) = J_\parallel \sin I$$

Conductivity Electric potential

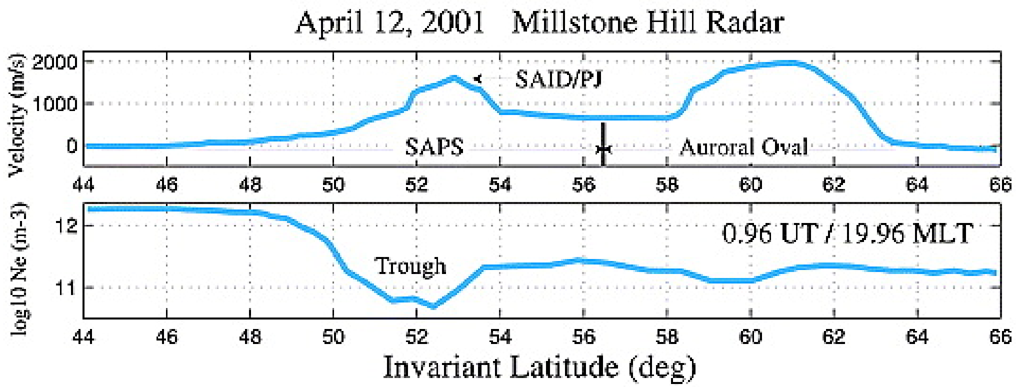
- Divergence of the magnetospheric current is converted to FACs flowing into/away from the ionosphere.
- To conduct away from the space charge deposited by FACs, Pedersen currents must flow in the ionosphere, resulting in the additional electric field in the ionosphere.

Subauroral plasma flows

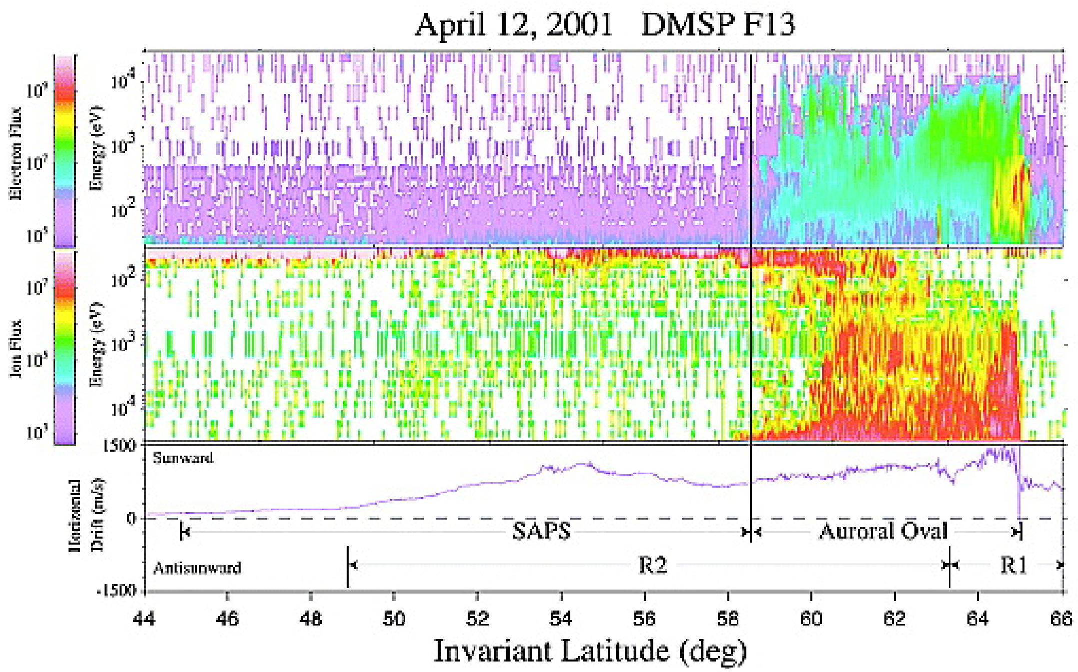
- Fast westward flow on nightside
  - Polarization Jet (PJ) [Galperin et al., 1973]
  - Subauroral Ion Drift (SAID) [Spiro et al., 1979]
  - Subauroral Electric Fields (SAEF) [Karlsson et al., 1998]
  - Subauroral Polarization Stream (SAPS) [Foster and Vo, 2002]
    - King Salmon radar [Kustov et al., 2006]
    - Wallops radar [Oksavik et al., 2006]
    - Hokkaido radar [Kataoka et al., 2007]
  - Auroral Westward Flow Channel (AWFC) [Parkinson et al., 2003]
- Shielding
- Overshielding

Subauroral Polarization Stream

Millstone Hill IS radar (54 MLAT)



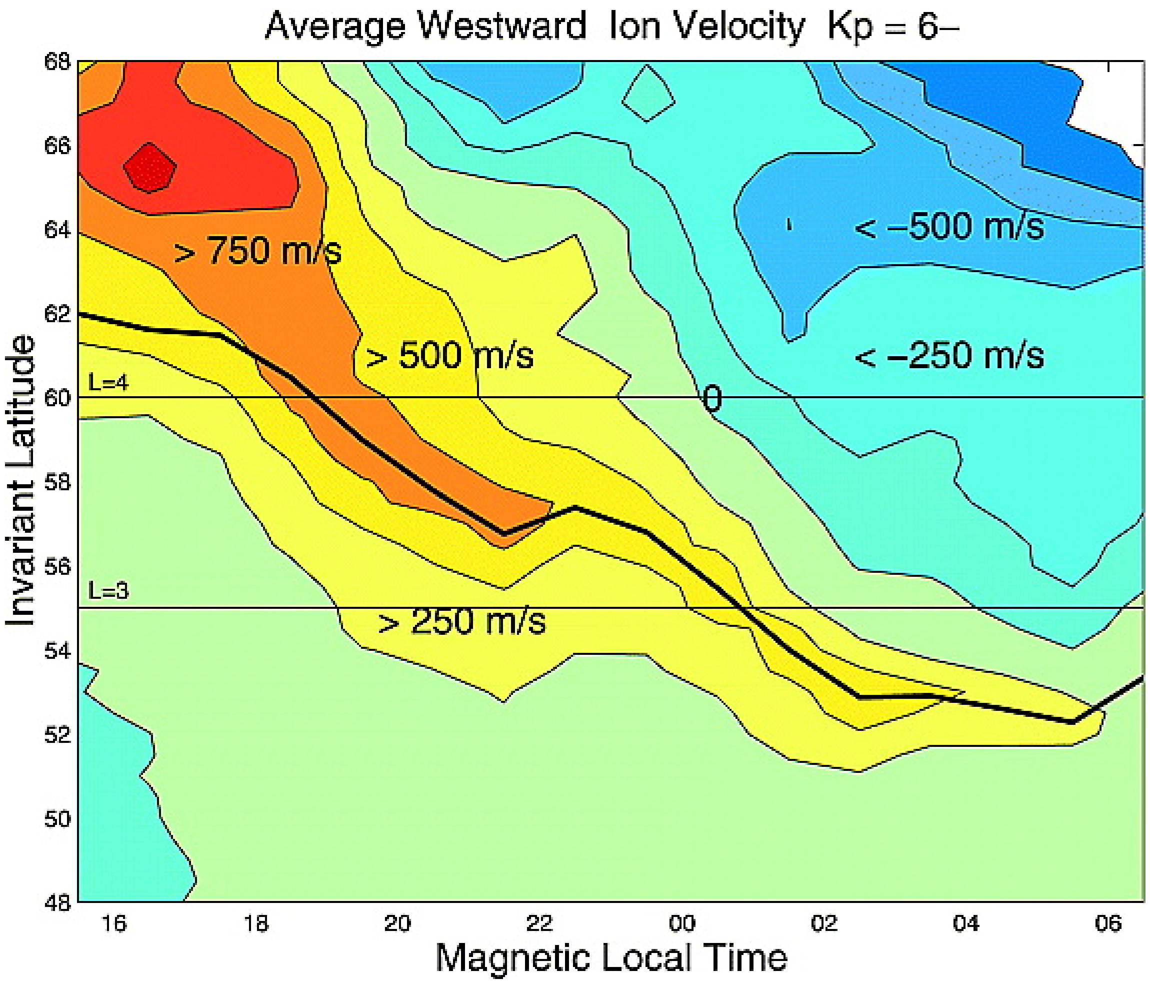
Haystack Observatory/MIT



Foster and Vo (2002)

Subauroral Polarization Stream

Millstone Hill IS radar (54 MLAT)



Haystack Observatory/MIT

Foster and Vo (2002)

Storm on 14-15 December 2006

Solar wind density

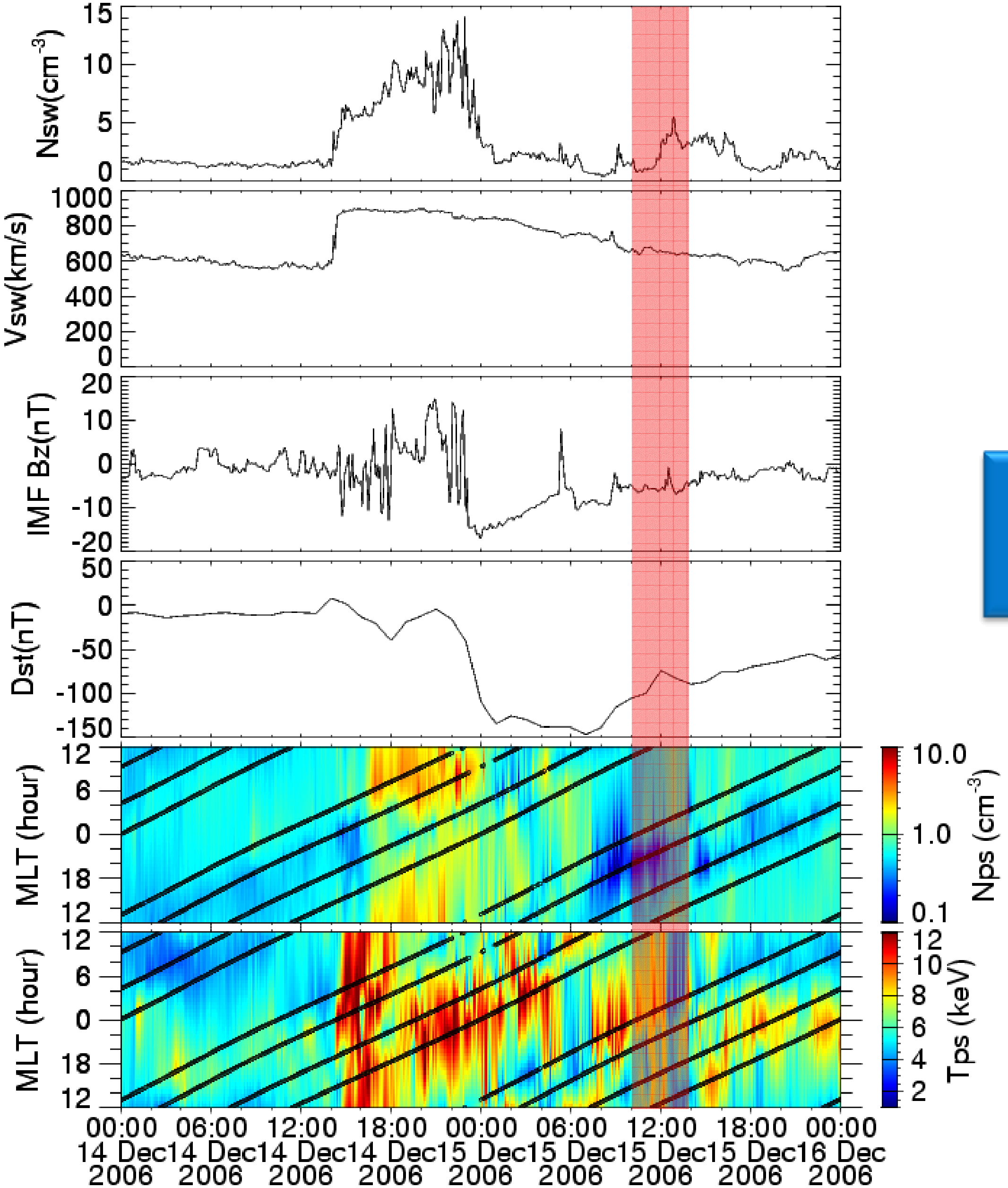
Solar wind velocity

IMF Bz

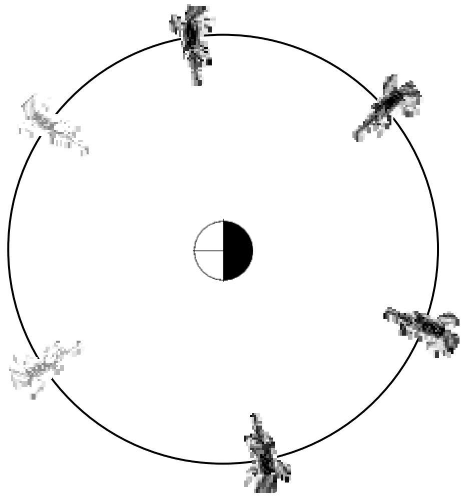
Dst

Plasma sheet density

Plasma sheet temperature



LANL/MPA measured “seed” ions of the ring current at 6.6 Re



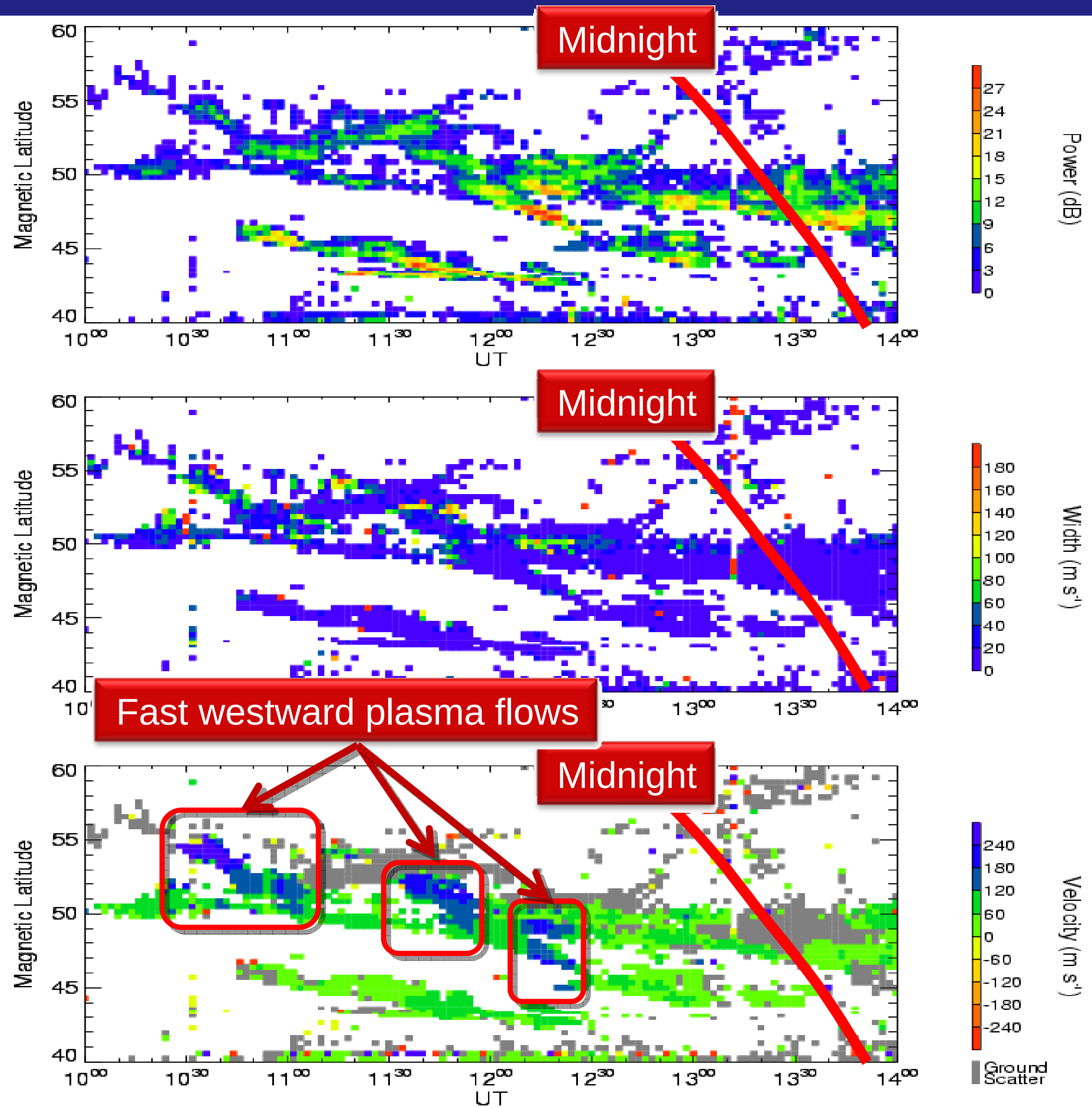
SuperDARN Hokkaido radar

Beam 7

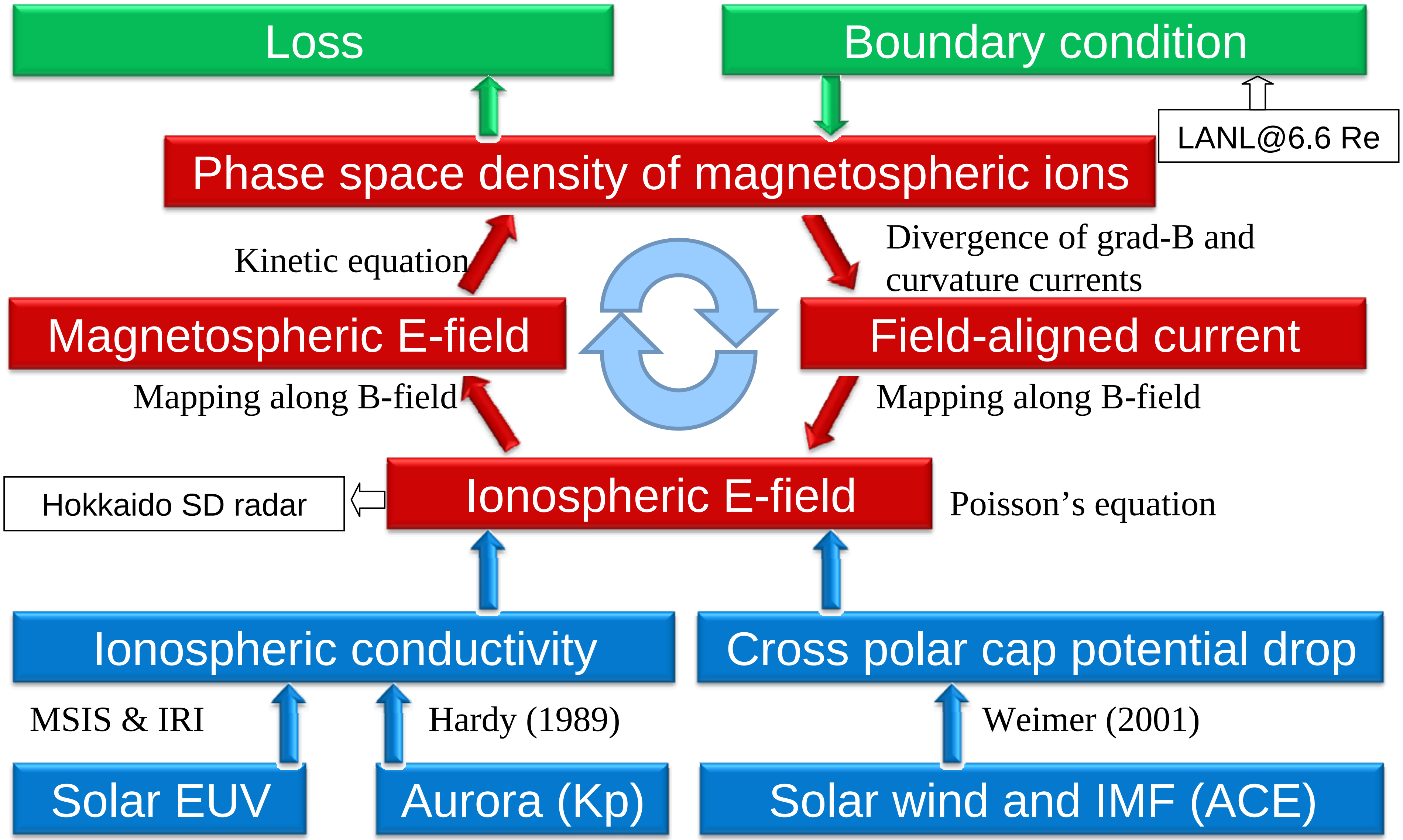
Power

Width

Velocity

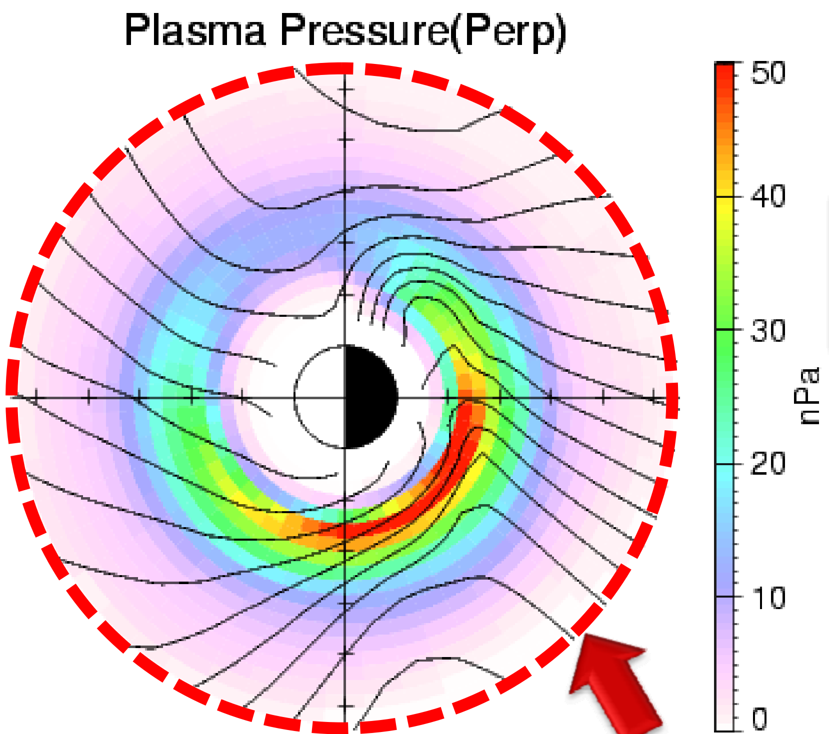


Inner magnetosphere simulation



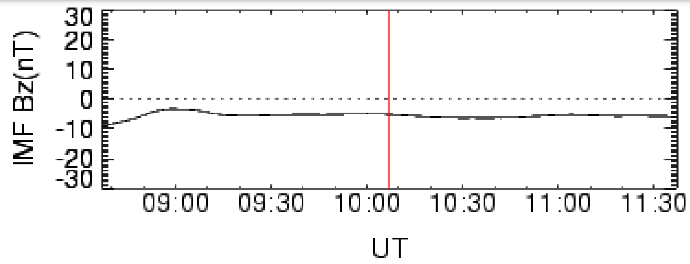
Simulation result

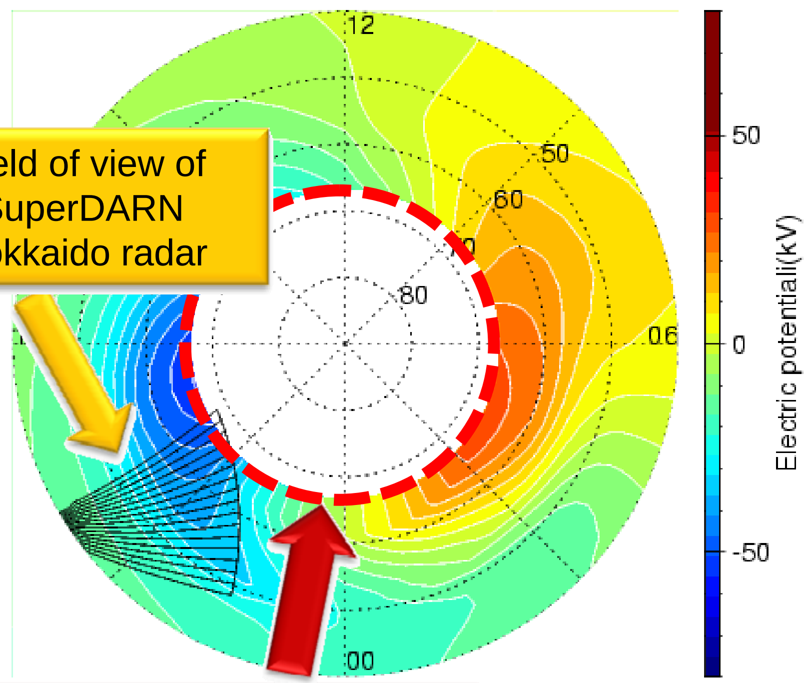
Perpendicular plasma pressure



Plasma sheet density and temperature were given by LANL satellites at 6.6 Re

Electric potential



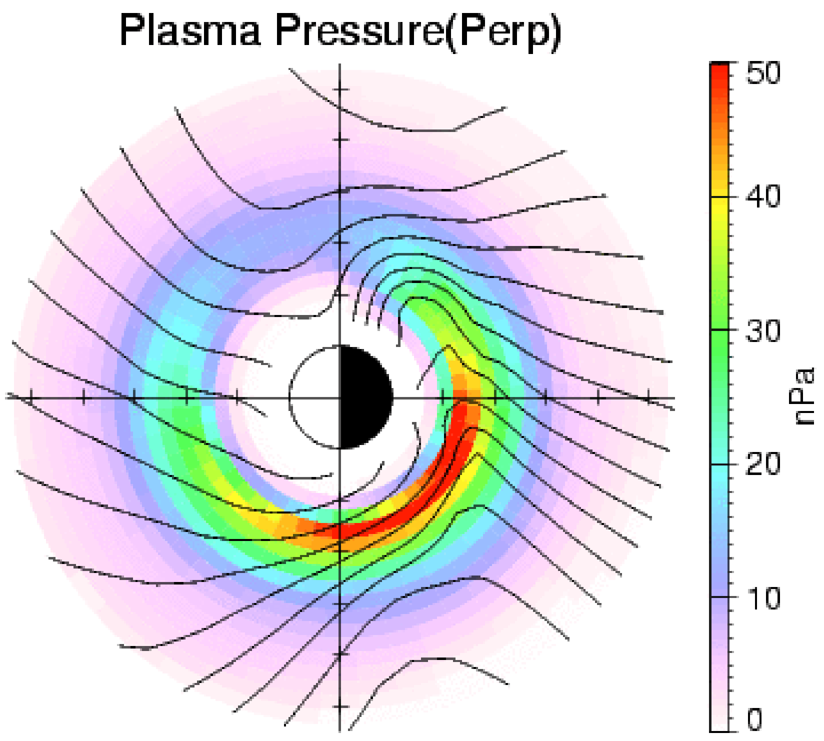


Field of view of SuperDARN Hokkaido radar

Electric potential at poleward boundary was given by the Weimer 2001 empirical convection model.

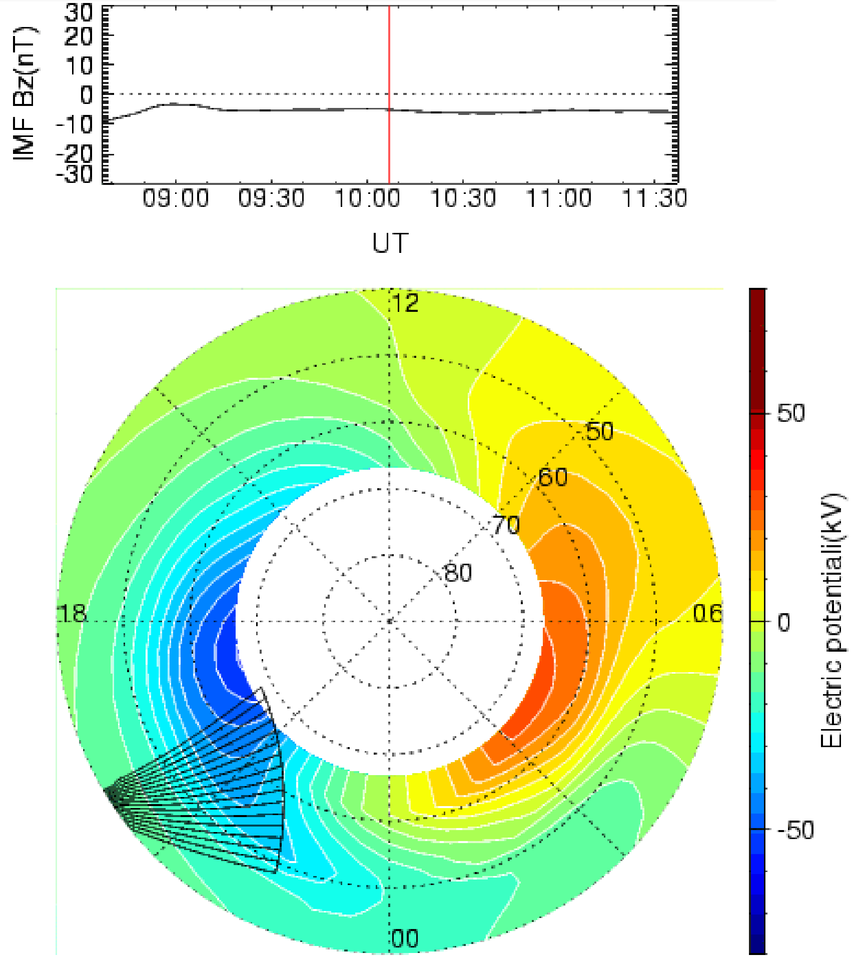
Simulation result

Perpendicular plasma pressure



DEC 15,2006(349) 10:07:00 UT

Electric potential



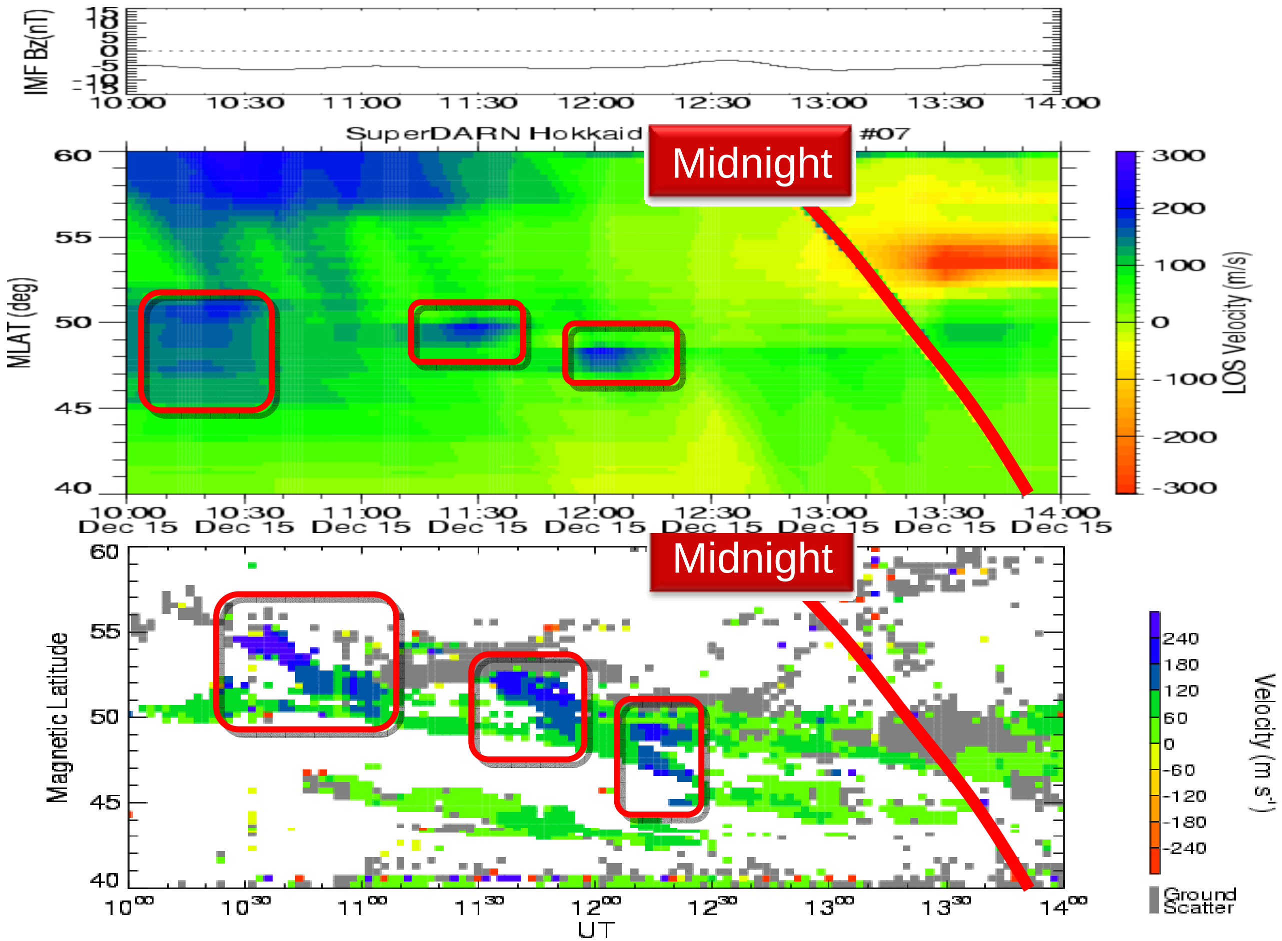
DEC 15, 2006 10:07:00 UT

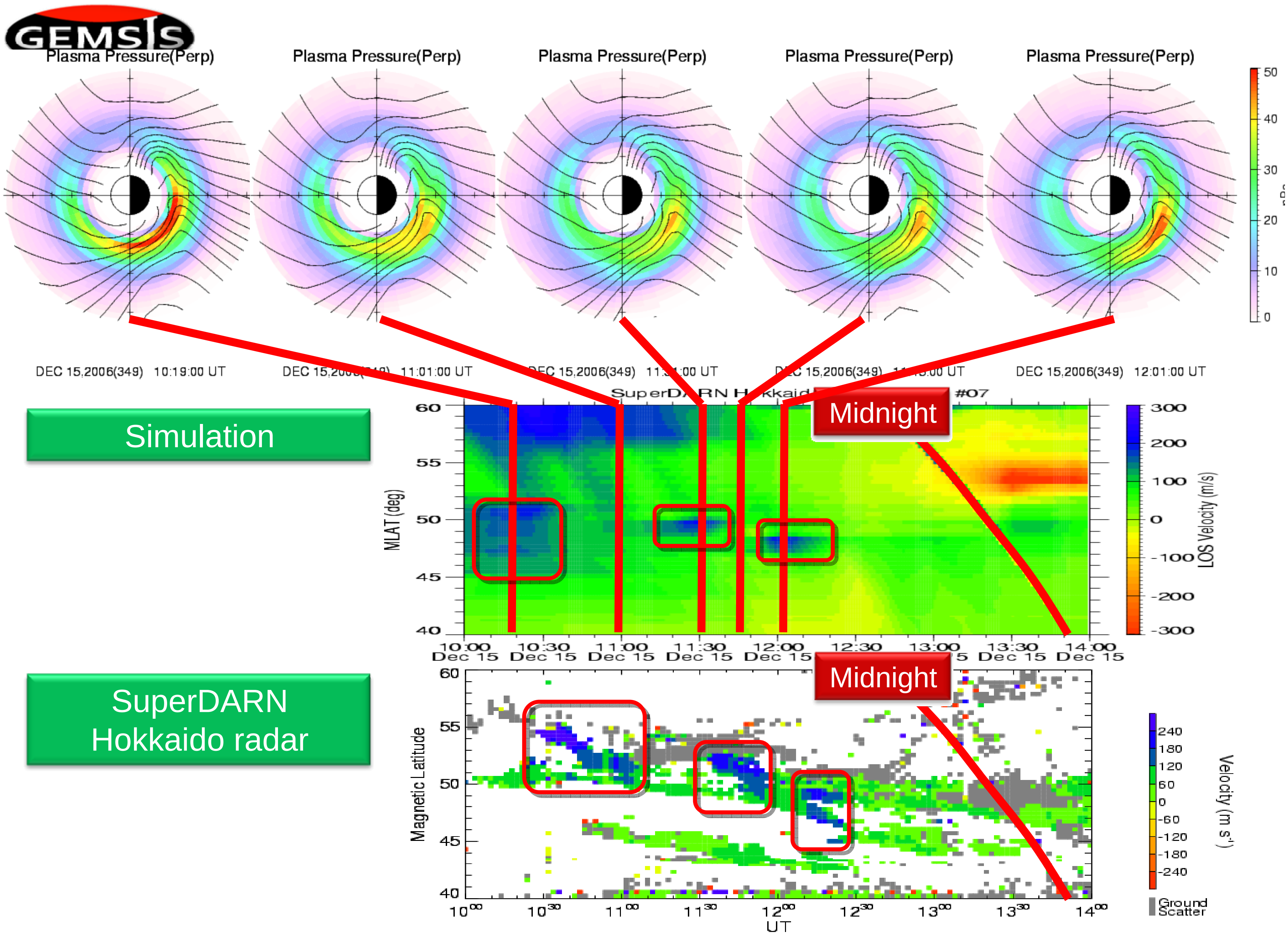
Line-of-sight velocity

Beam 7

Simulation

SuperDARN Hokkaido radar

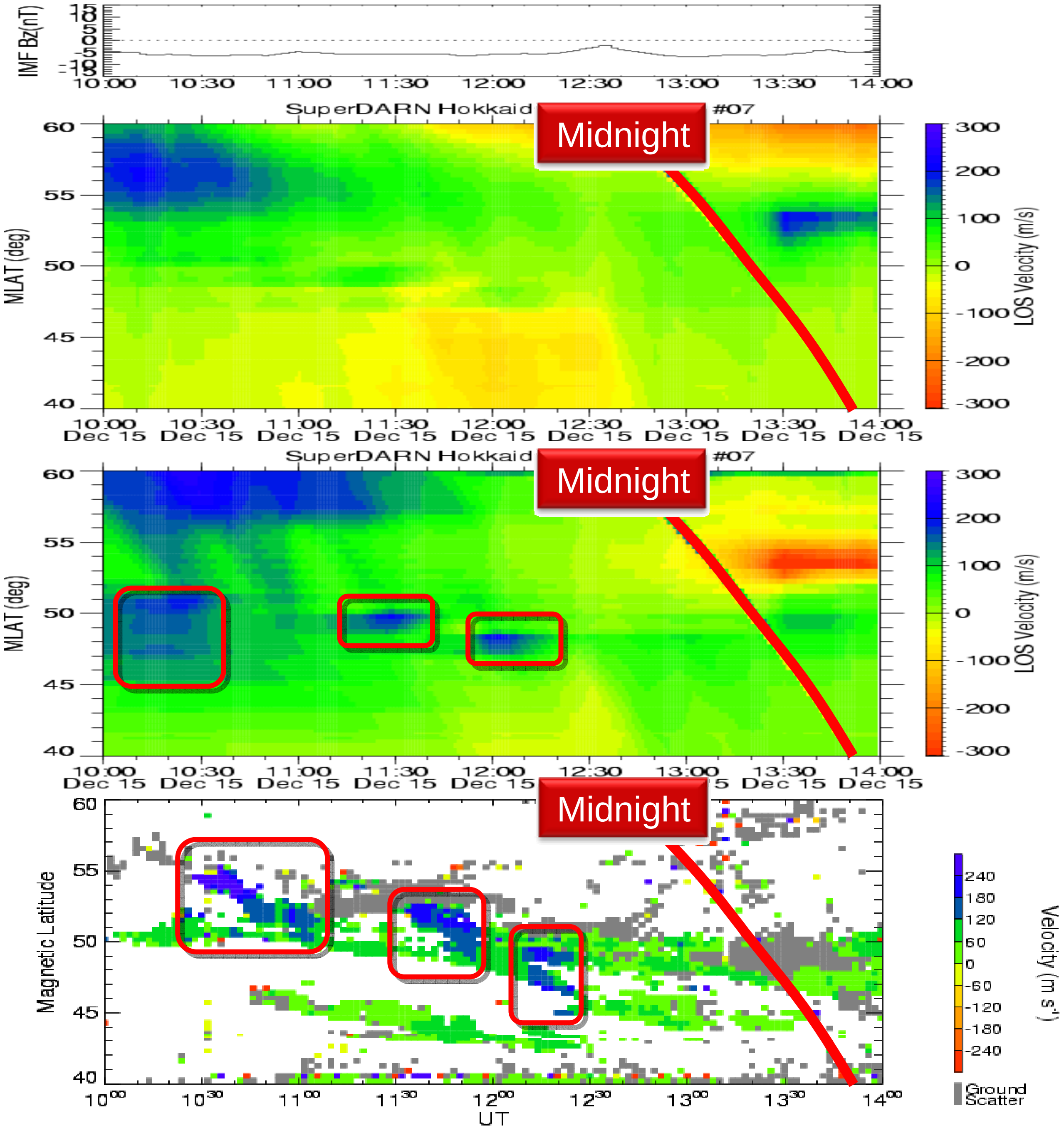



GEMSIS
Plasma Pressure(Perp)
Plasma Pressure(Perp)
Plasma Pressure(Perp)
Plasma Pressure(Perp)
Plasma Pressure(Perp)
DEC 15,2006(349) 10:19:00 UT
DEC 15,2006(349) 12:01:00 UT
50
40
30
20
10
0
Simulation
SuperDARN
Hokkaido radar
Midnight
Midnight
60
55
50
45
40
MLAT (deg)
10:00 Dec 15
10:30 Dec 15
11:00 Dec 15
11:30 Dec 15
12:00 Dec 15
12:30
13:00
13:30 Dec 15
14:00 Dec 15
300
200
100
0
-100
-200
-300
LOS Velocity (m/s)
Magnetic Latitude
UT
240
180
120
60
0
-60
-120
-180
-240
Velocity (m s⁻¹)
Ground Scatter

Simulation
(Constant plasma sheet density and temperature at 6.6Re)

Simulation

SuperDARN Hokkaido radar



Conclusion

- SuerDARN Hokkaido radar observed short-lived SAPS-like flows in the premidnight sector during the magnetic storm of December 2006.
- Results of the ring current simulation taking into account the M-I coupling agree well with the observation.
  - The boundary condition for ring current particles is determined using data from 4 LANL satellites at 6.6 Re.
- The short-lived SAPS-like flows are most likely attributed to short- and meso-scale structure of the ring current.
  - Meso-scale structure of the ring current can be “monitored” by mid-latitude SuperDARN radars.