中緯度短波レーダー研究会（名古屋、2008.12.8）

準周期地磁気変動時の対流電場と過遮蔽電場

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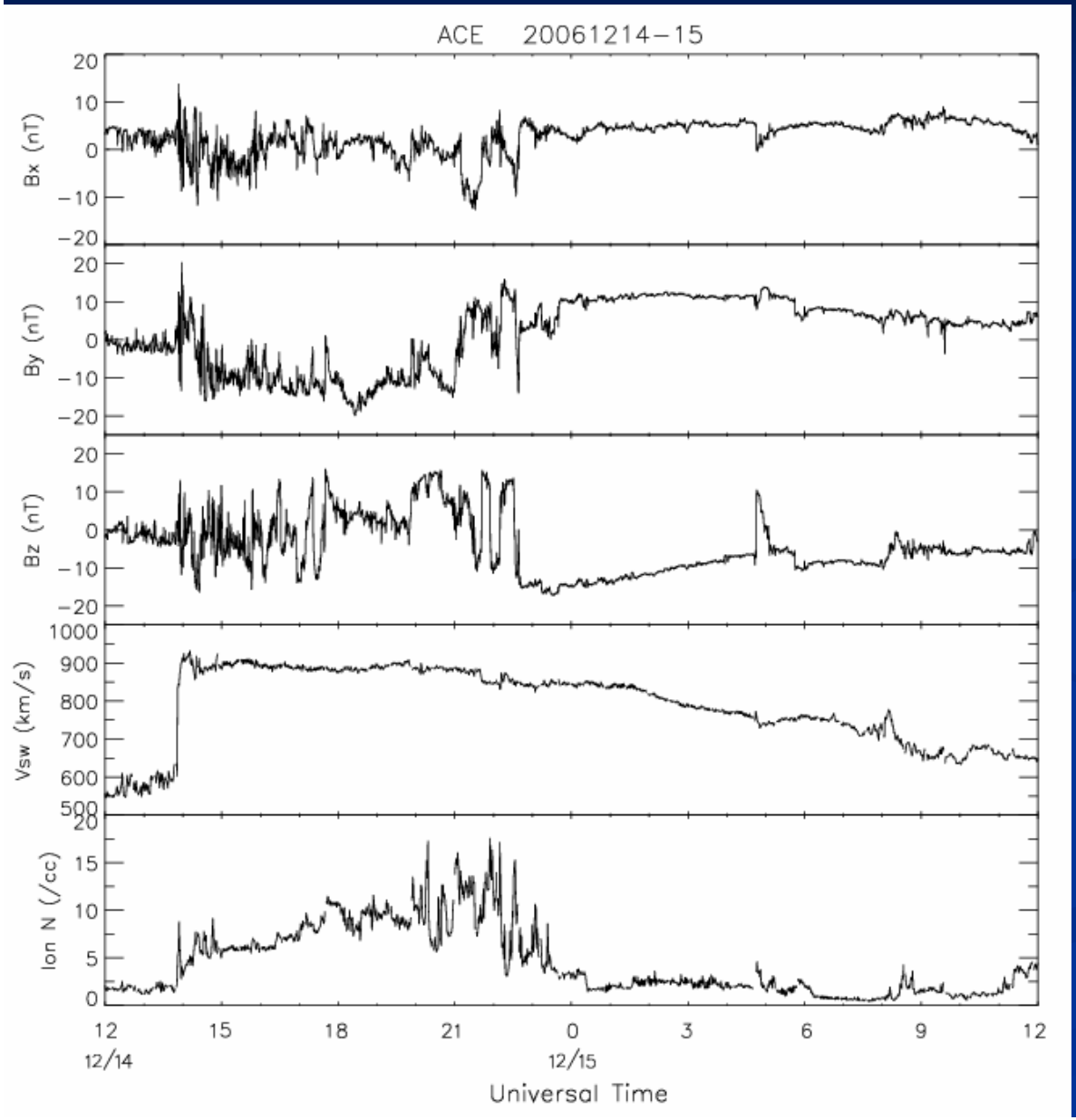
Motivation

- The quasi-periodic DP2 geomagnetic fluctuations with periods of 30 - 60 min occurred coherently at high latitudes and dayside geomagnetic equator (Nishida et al., 1966), being caused by fluctuations in the southward IMF (Nishida, 1968).
- High coherency of the DP2 fluctuation at these two latitudes suggested that the convection electric field penetrated instantaneously to the equator with no significant shielding (Kikuchi et al., 1996).
- No significant shielding has also been observed over several hours during storm main phase (Huang et al., 2005, 2007)
- On the other hand, the shielding electric field became significant in 17-20 min during substorm growth phase (Somayajulu et al., 1987; Kikuchi et al., 2000) and 1 hour during storm main phase (Kikuchi et al., 2008).
- Furthermore, the overshielding due to dominant shielding electric field occurred when the convection electric field reduced its intensity during substorms (Kikuchi et al., 2000, 2003; Kobea et al., 2000) and during storm recovery phase (Kikuchi et al., 2008).
- A question may arise on a contribution of the shielding/overshielding electric field in the quasi-periodic DP2 fluctuation.

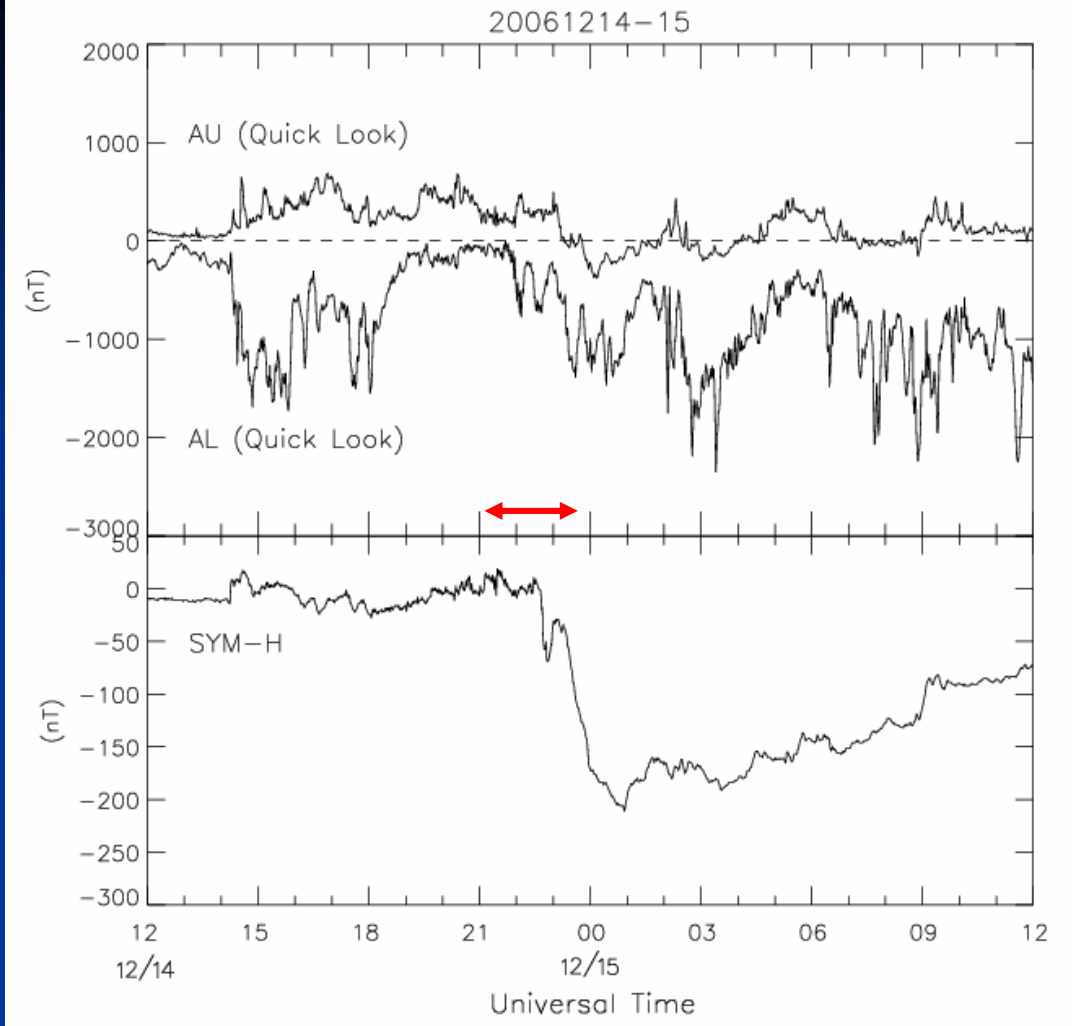
In this paper

- We selected a DP2 fluctuation event with period of 30 min that was recorded at the dayside geomagnetic equator before substantial development of the ring current of the geomagnetic storm on December 14-15, 2006.
- It is found that the equatorial DP2 fluctuations were caused by alternating eastward and westward electrojets (e-EJ, w-EJ) caused by the southward and northward IMF, respectively.
- The e-EJ was associated with a large-scale two-cell convection pattern as observed with SuperDARN, while the w-EJ was associated with distorted two-cell or multi-cell pattern accompanied by reversed convection vortices equatorward of the large-scale vortices.
- Hokkaido radar detected plasma flow associated with the reversed convection at mid-latitude.
- Using the CRCM (Fok et al., 2001), we revealed that the reversed flow was caused by the R2 FACs that became dominant during northward IMF.

Solar wind data for the storm on December 14-15, 2001

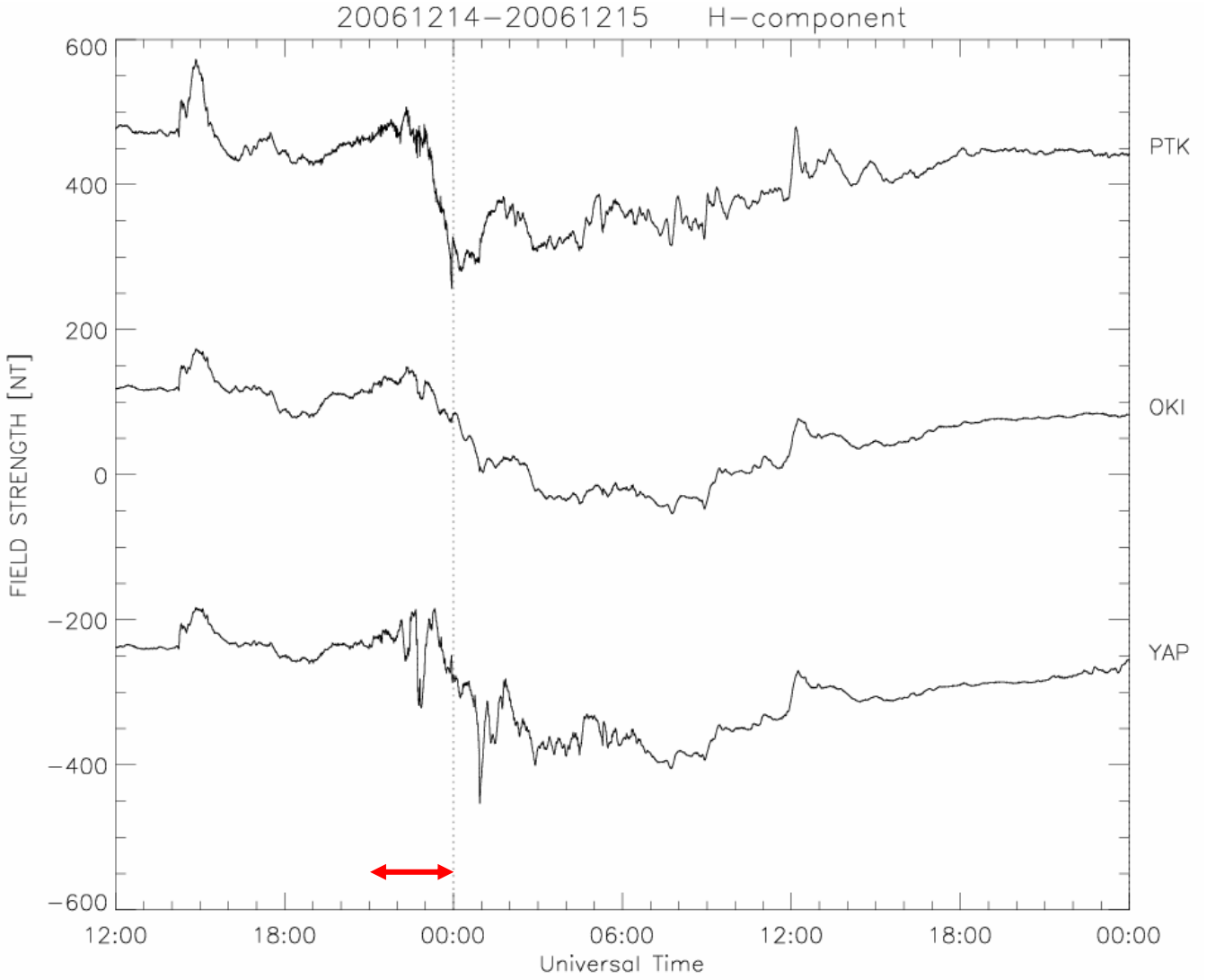


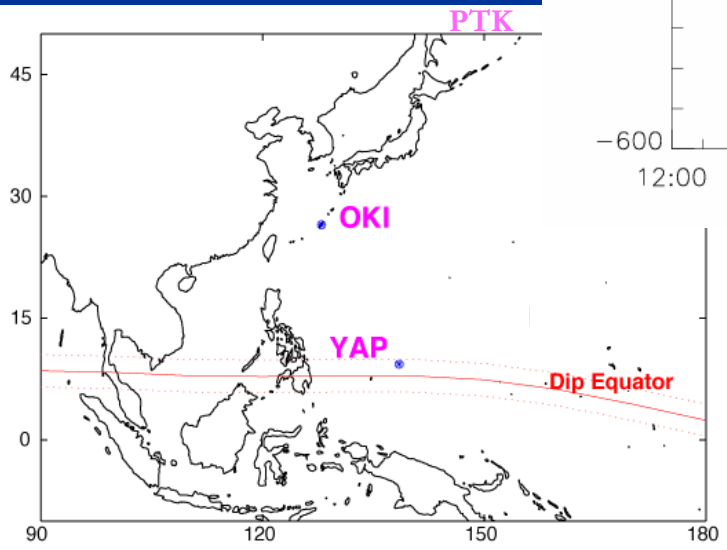
Geomagnetic indices



The DP2 fluctuation event occurred at the beginning of ring current develoment. The 4-hour substorm activities may not have caused disturbances in the thermosphere responsible for the disturbance dynamo.

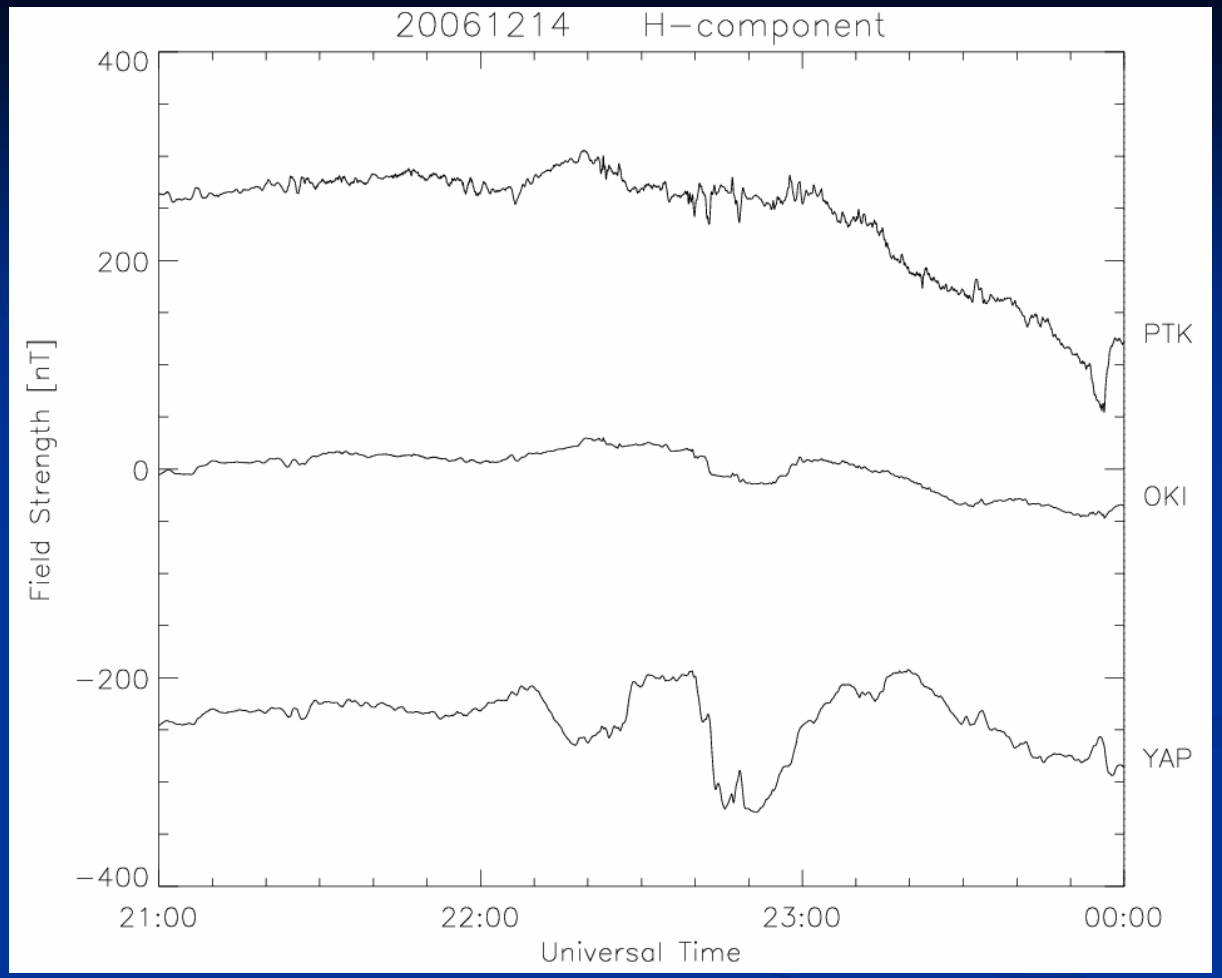
Geomagnetic H-component at Paratunka, Okinawa, and Yap

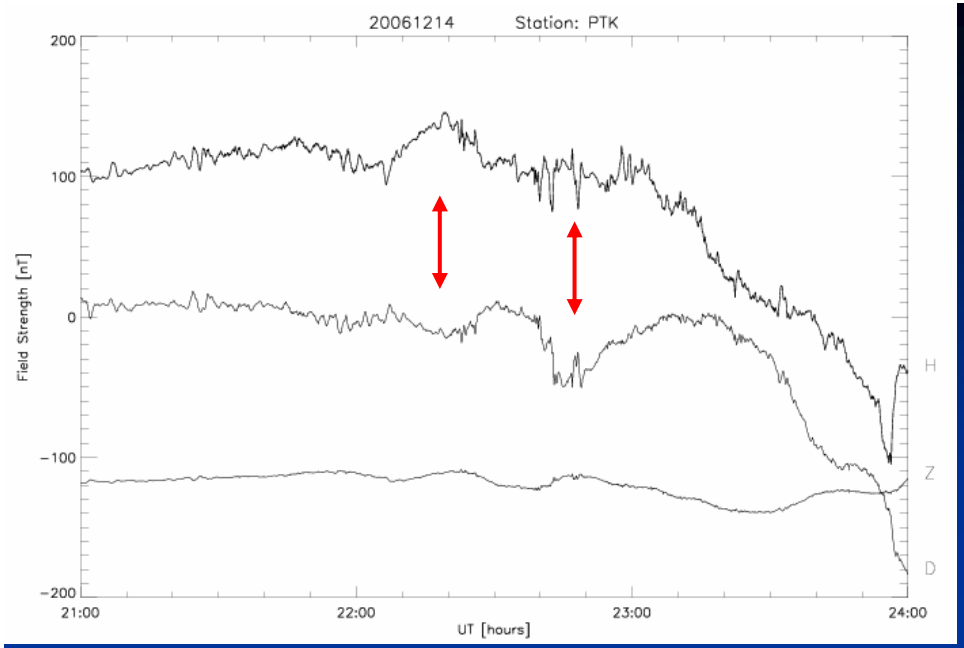




(NICT space weather monitoring magnetometers)

Geomagnetic H-component at Paratunka, Okinawa, and Yap




20061214 Station: PTK
Field Strength [nT]
200
100
0
−100
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H
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D
21:00
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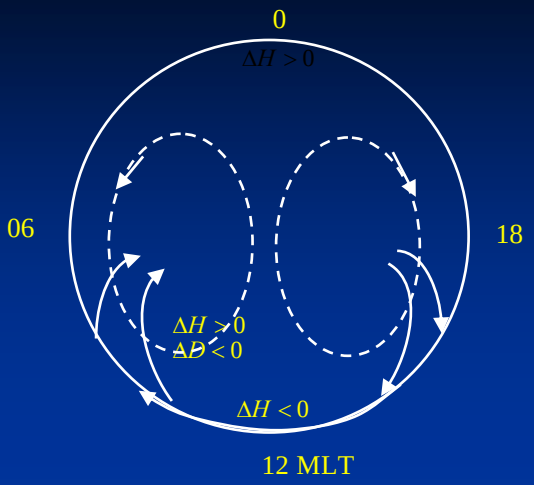
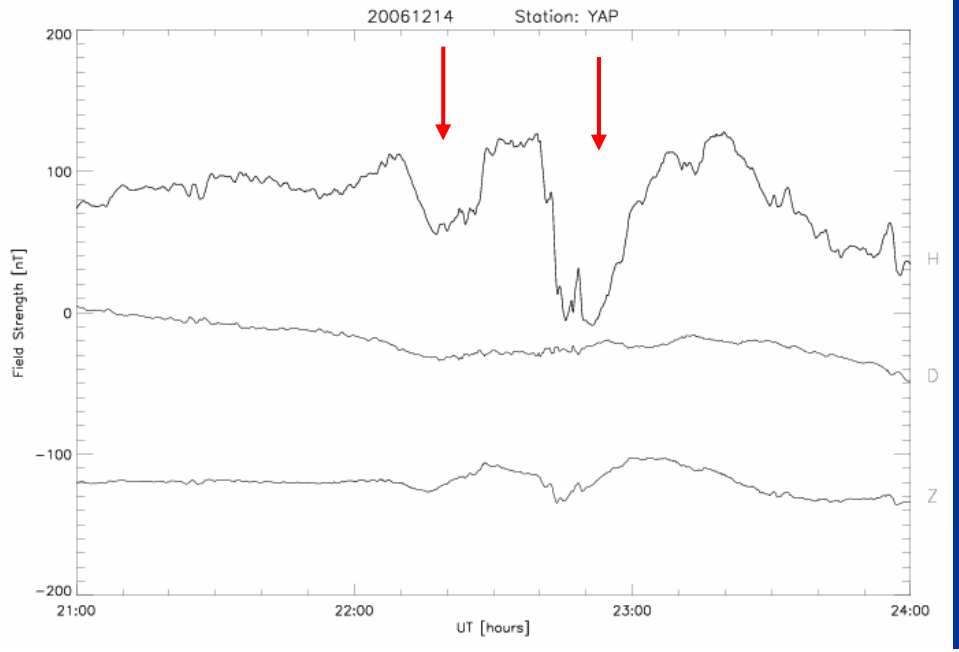
UT [hours]

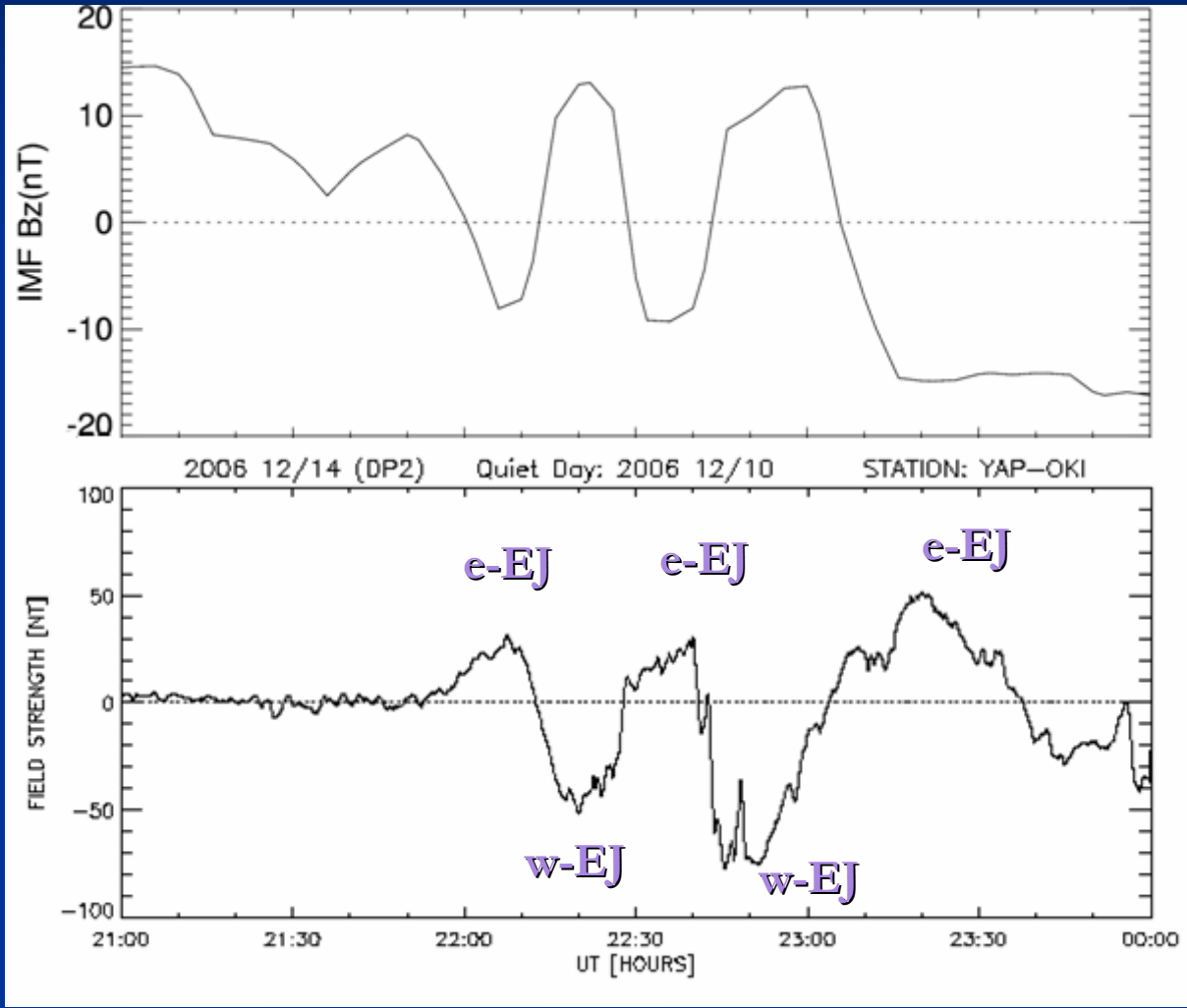

0
ΔH > 0
06
18
ΔH > 0
ΔD < 0
ΔH < 0
12 MLT


20061214 Station: YAP
Field Strength [nT]
200
100
0
−100
−200
H
D
Z
21:00
22:00
23:00
24:00
UT [hours]

Correlation between the IMF Bz and the QP magnetic fluctuations

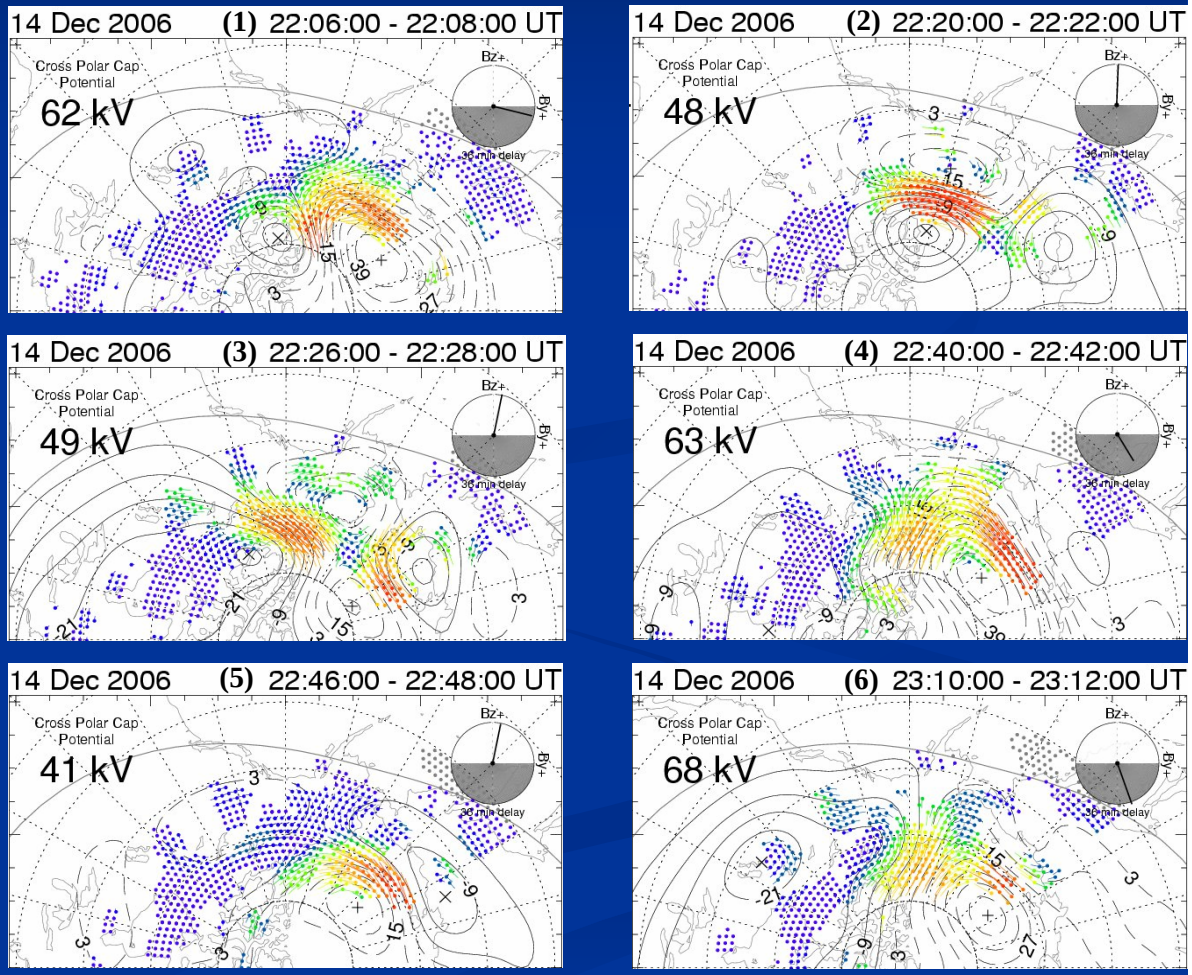
To obtain magnetic disturbances caused by the ionospheric currents, we subtracted OKI from YAP.

We shifted the time axis of ACE by 36 min behind, we see clear correspondence between the QP magnetic fluctuations and the IMF Bz. The southward IMF caused the eastward electric field, while the northward IMF caused the westward electric field at the dayside equator.

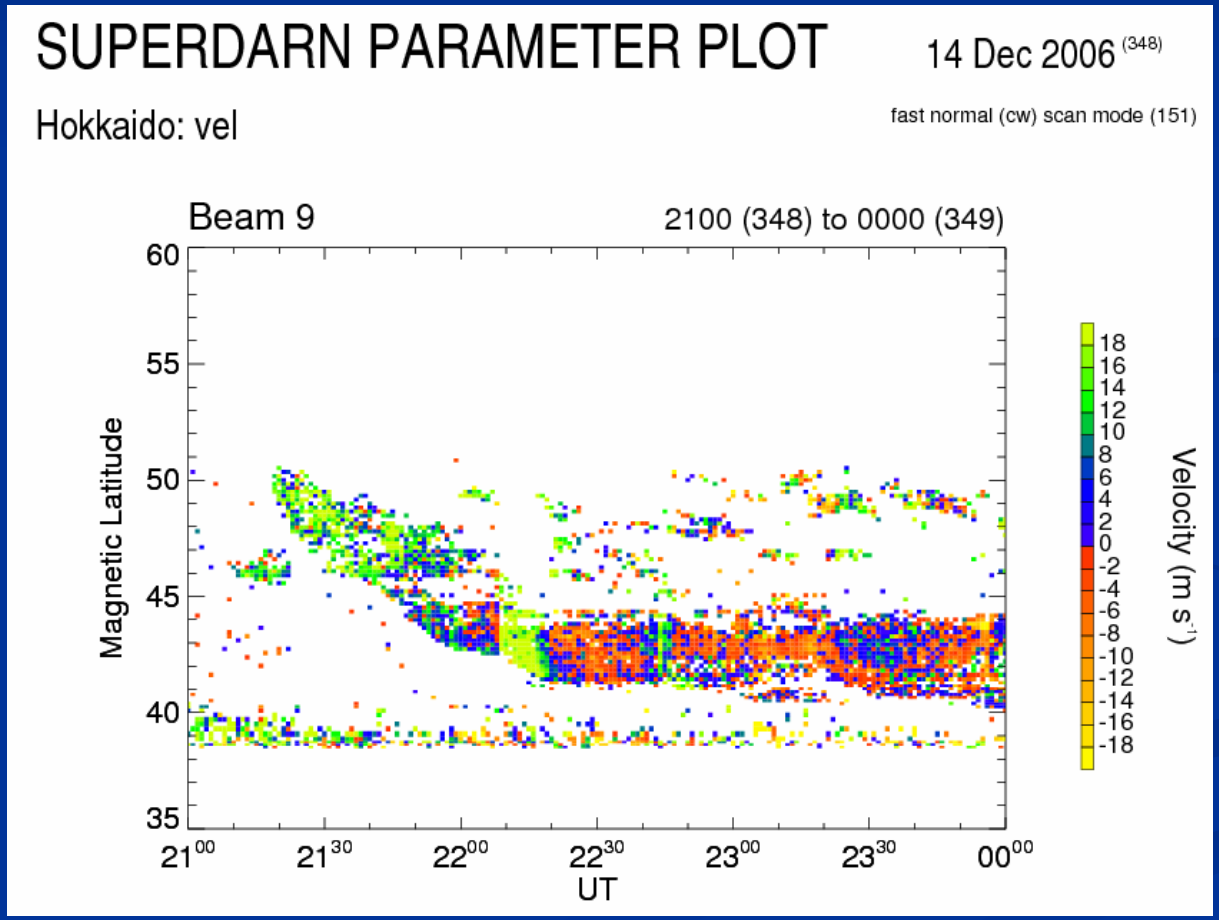


Comparison between the QP magnetic fluctuations and the convection map

The convection pattern was distorted significantly, but was not reversed during the northward IMF. A clockwise vortex appeared in the morning sector.

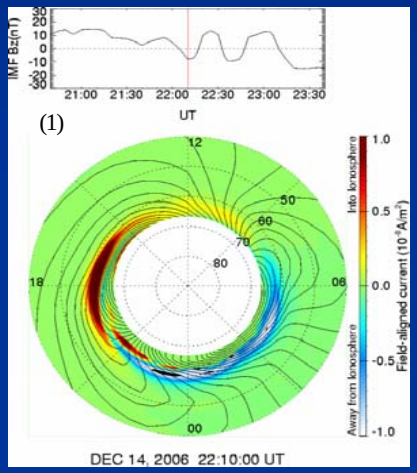


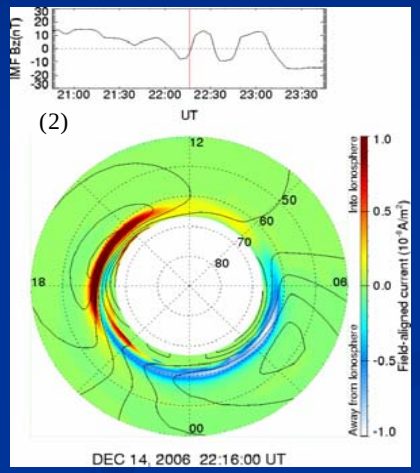
Hokkaido radar detected an equatorward flow of the clockwise vortex

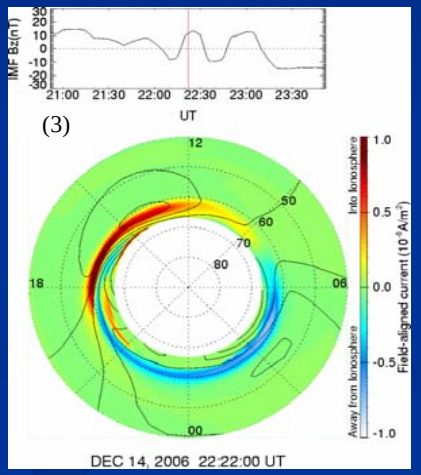


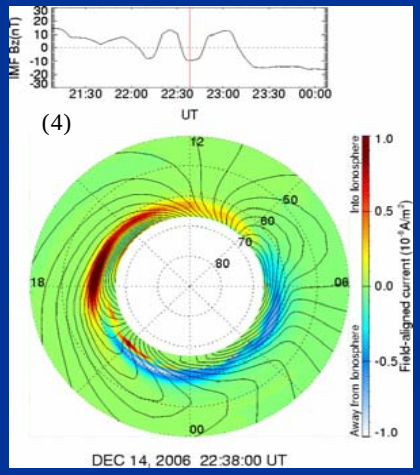
Comparison between the QP magnetic fluctuations and the ring current simulation

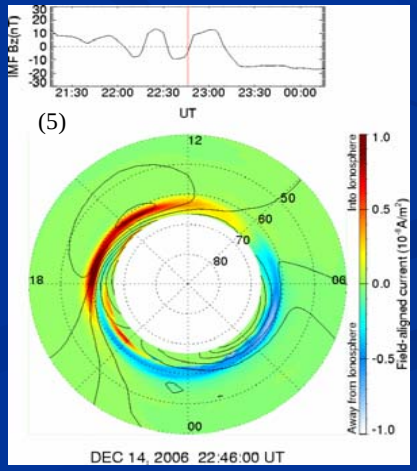
(ACE data is shifted 36 min behind in time axis)

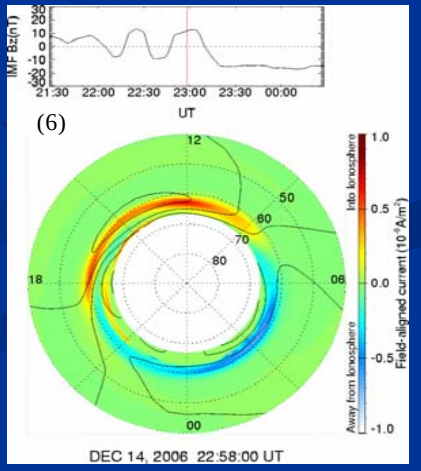








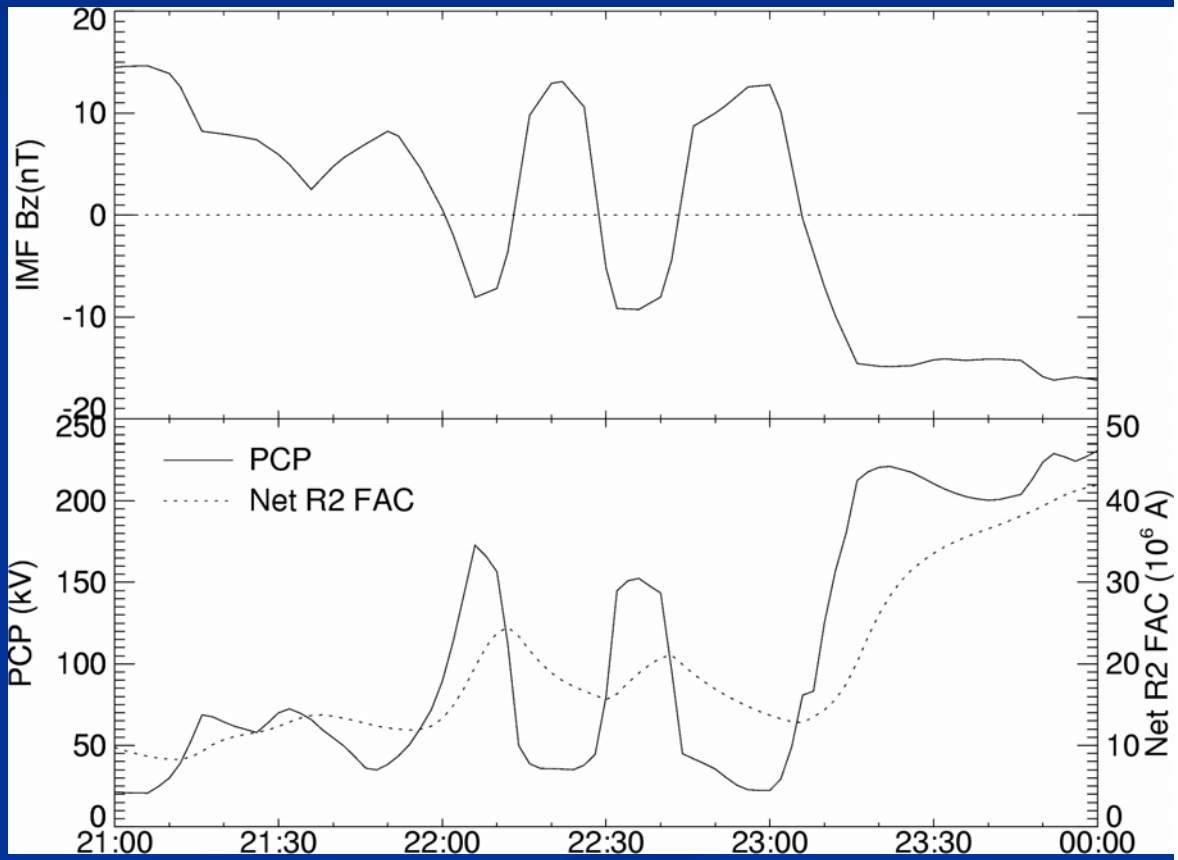




Temporal variation of the net R2 FACs (dotted curve)

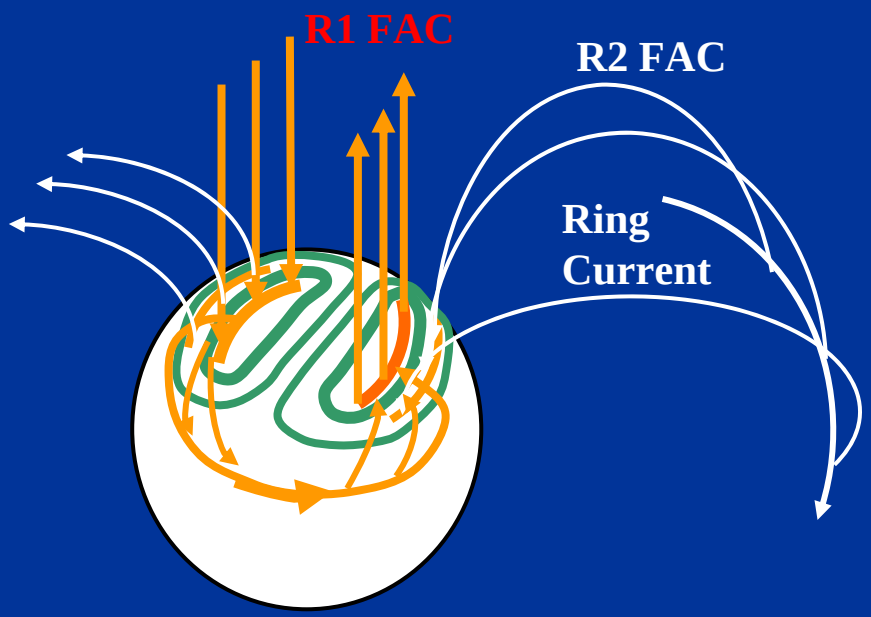
The R2 FACs grow and decay slowly, even when the polar cap potential (PCP) changes rapidly as shown with the dotted curve in the bottom panel.

As a result, an electric field associated with the R2 FACs becomes dominant, when the PCP decreased substantially due to the northward IMF.

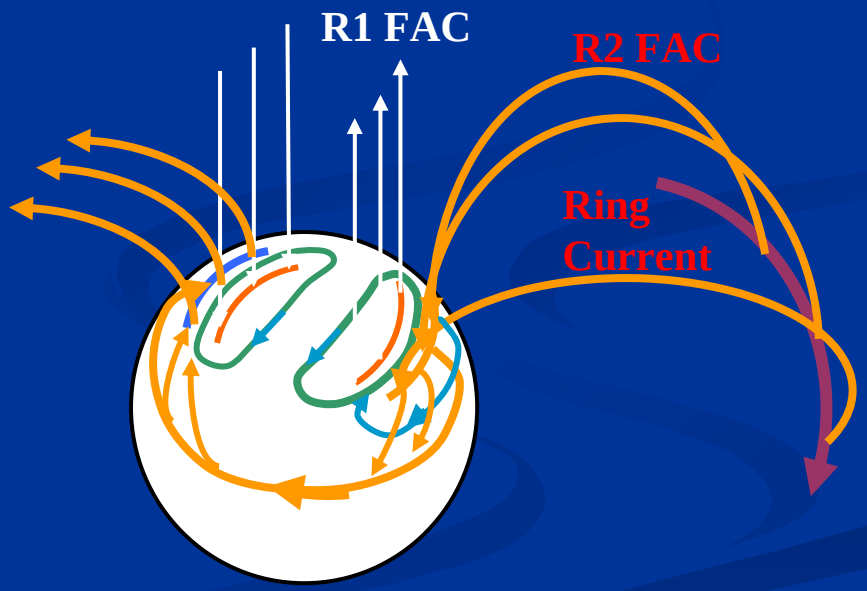


Current system of the quasi-periodic DP2 fluctuation

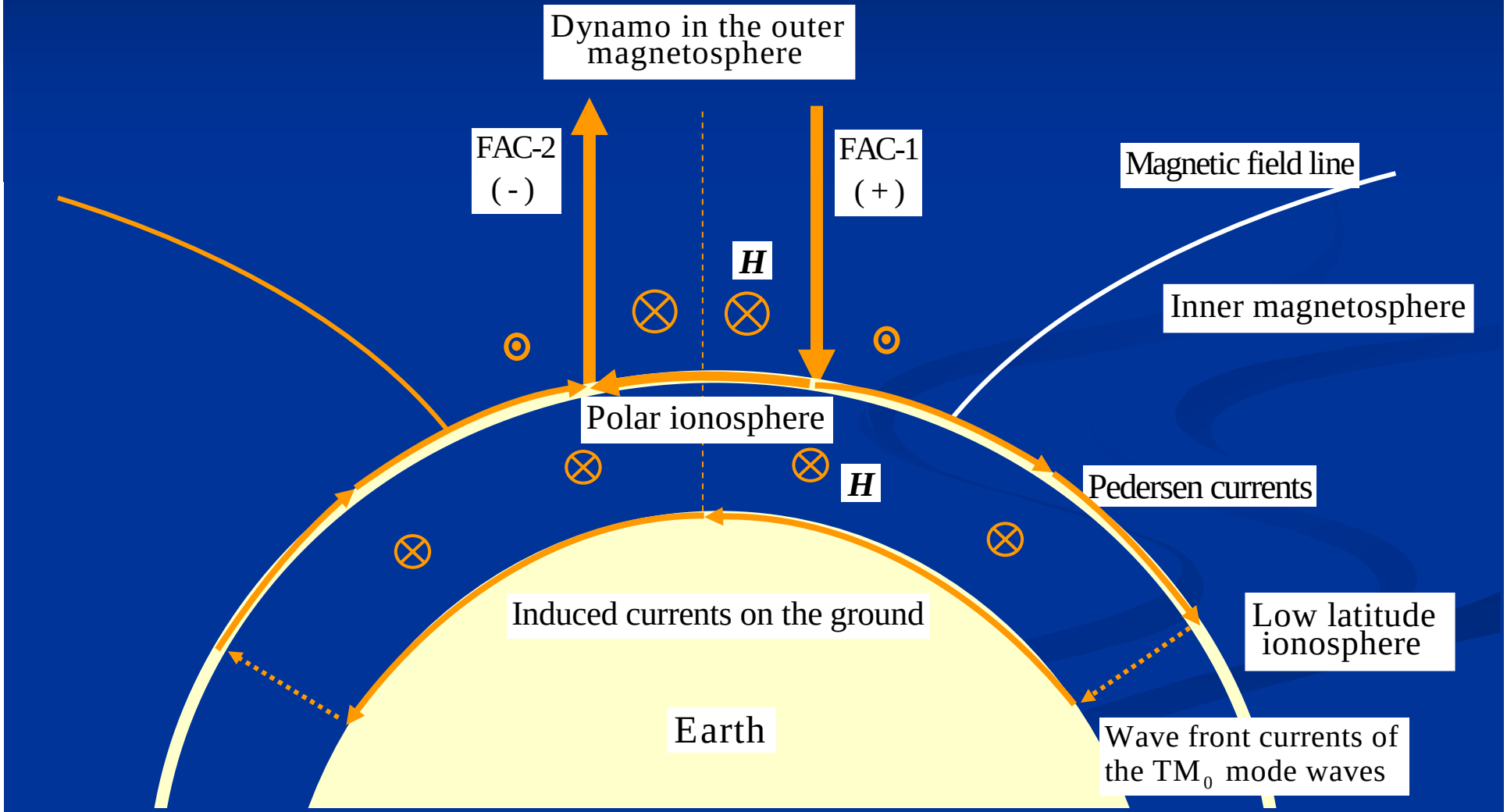
R1 FAC - e-EJ current circuit



R2 FAC - w-EJ current circuit



Magnetosphere-ionosphere-ground current circuit is completed by the wave front currents of the TM0 mode waves



How can the electric field be transmitted to the F-region ionosphere?

Upward Poynting flux in the fully ionized ionosphere

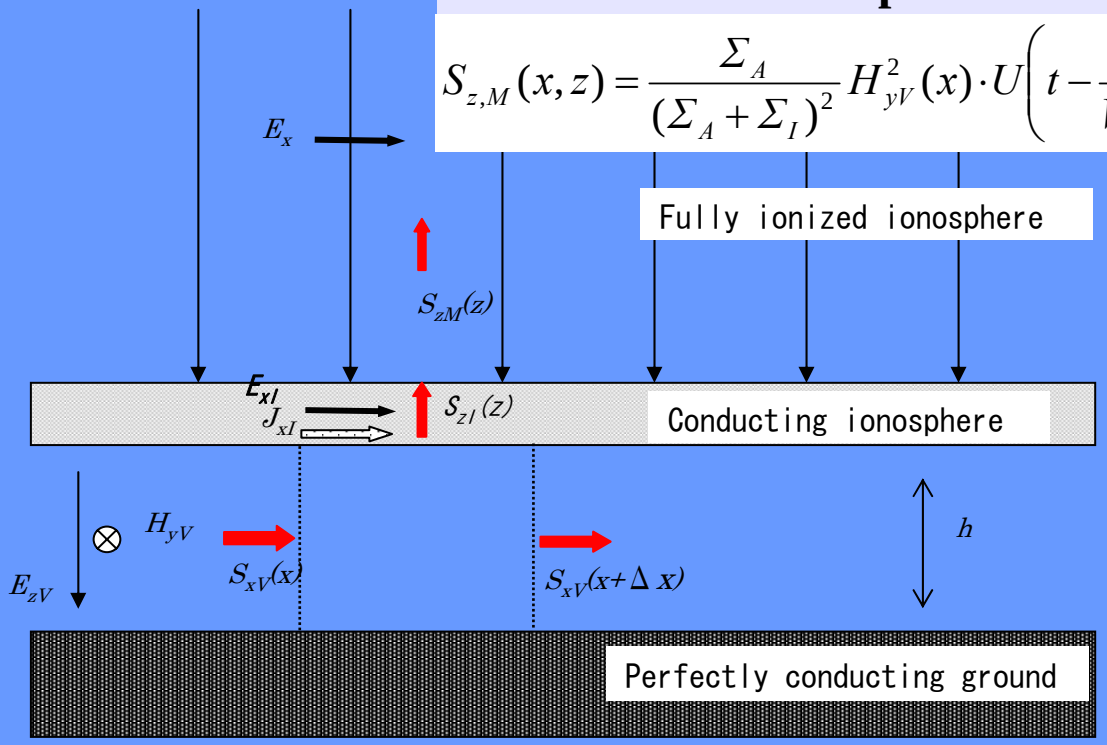
$$S_{z,M}(x,z) = \frac{\Sigma_A}{(\Sigma_A + \Sigma_I)^2} H_{yV}^2(x) \cdot U\left(t - \frac{z}{V_a}\right)$$

Upward Poynting flux in the conducting ionosphere

$$S_{zI}(x,z) = \frac{\Sigma_A + \Sigma_I - \sigma z}{(\Sigma_A + \Sigma_I)^2} H_{yV}^2(x)$$

Horizontal Poynting flux in the waveguide

$$S_{xV}(x) = Z_0 H_{yV}{}^2(x) = E_{zV}{}^2(x) / Z_0$$



Conclusion

- The quasi-periodic magnetic fluctuations (period = 30 min) at the equator were composed of alternating eastward and westward electric currents, which must be driven by the R1 and R2 FACs.
- The King Salmon and Hokkaido radars detected the clockwise convection vortex at subauroral and mid latitudes in the morning sector, in correspondence to the westward equatorial electrojet. This agrees with the R2 FACs.
- The shielding electric field develops following the growth of the PCP, but is not dominant during a period of southward IMF. However, the shielding electric field becomes dominant when the PCP decreases rapidly, resulting in the overshielding at mid to equatorial latitudes.