中緯度短波レーダー研究会（名古屋、2008.1.28)

Penetration of the convection and overshielding electric fields to low latitude during the quasi-periodic DP2 geomagnetic fluctuations

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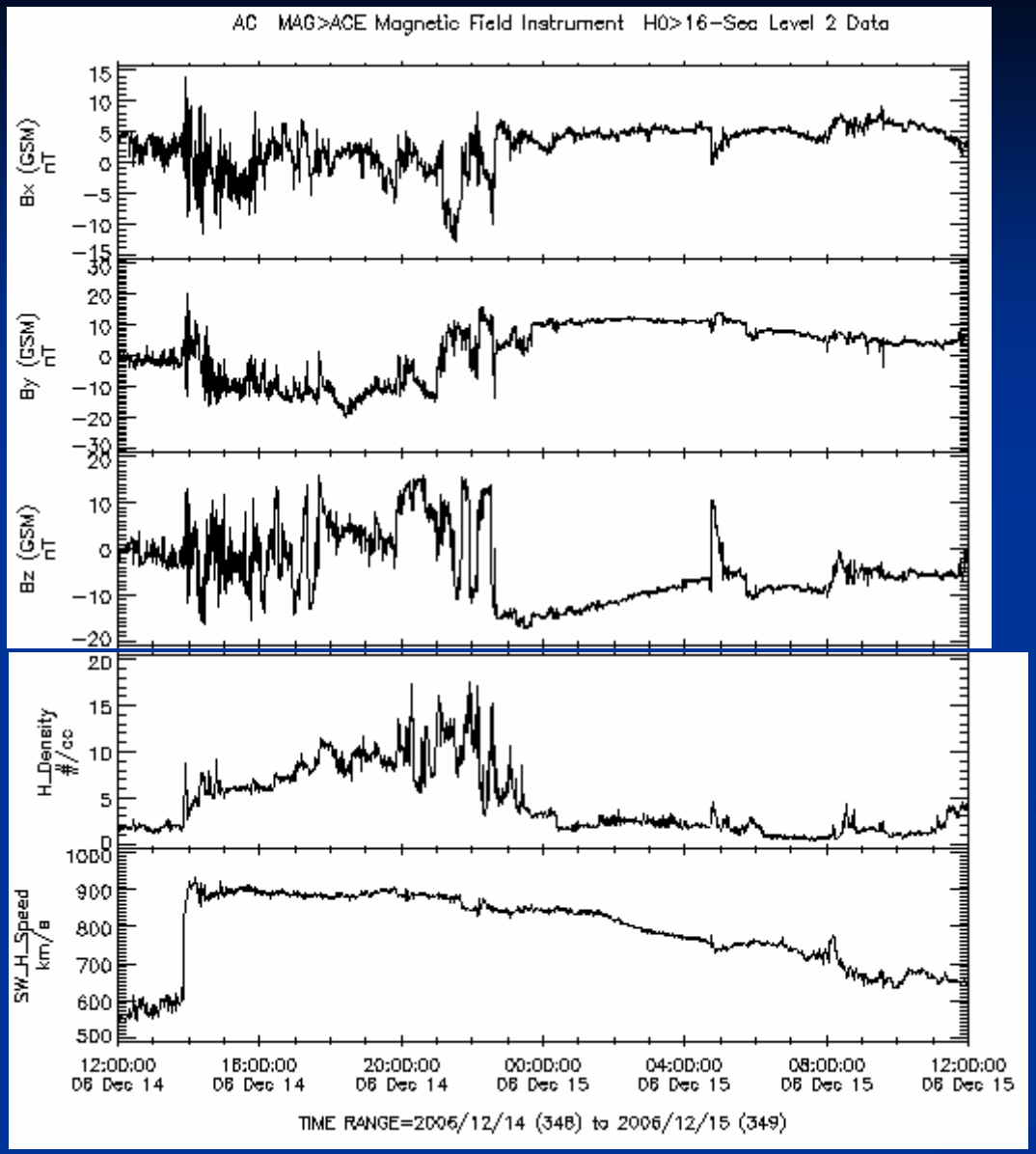
Motivation

- The quasi-periodic DP2 magnetic fluctuations with periods of 30 - 60 min appear coherently at high latitude and the dayside geomagnetic equator (Nishida et al., 1966). Nishida (1968) found that the DP2 fluctuations were coherent with those in the southward IMF.
- Nishida's results and subsequent analyses based on high time resolution magnetometer data (Kikuchi et al., 1996; Kobea et al., 1998) showed no significant shielding effects during the DP2 fluctuation events.
- Huang et al. (2005) suggested that the shielding did not work over several hours during the storm main phase.
- On the other hand, there have been lots of evidence and their theoretical explanation of the shielding/overshielding electric field at the equator (Kelley, Gonzales, Fejer, Kobea, Kikuchi, Vasyliunas, Harrell and Wolf, Southwood, Senior and Blanc, Peymirat). The shielding time constant was deduced from the magnetometer observations as 17-20 min (Somajajulu et al., 1987; Kikuchi et al., 2000) and from model calculation as 20-30 min for typical ionospheric and magnetospheric parameters (Senior and Blanc, 1987).
- We need to clarify the role of the shielding/overshielding electric field for short period (30 min) events.

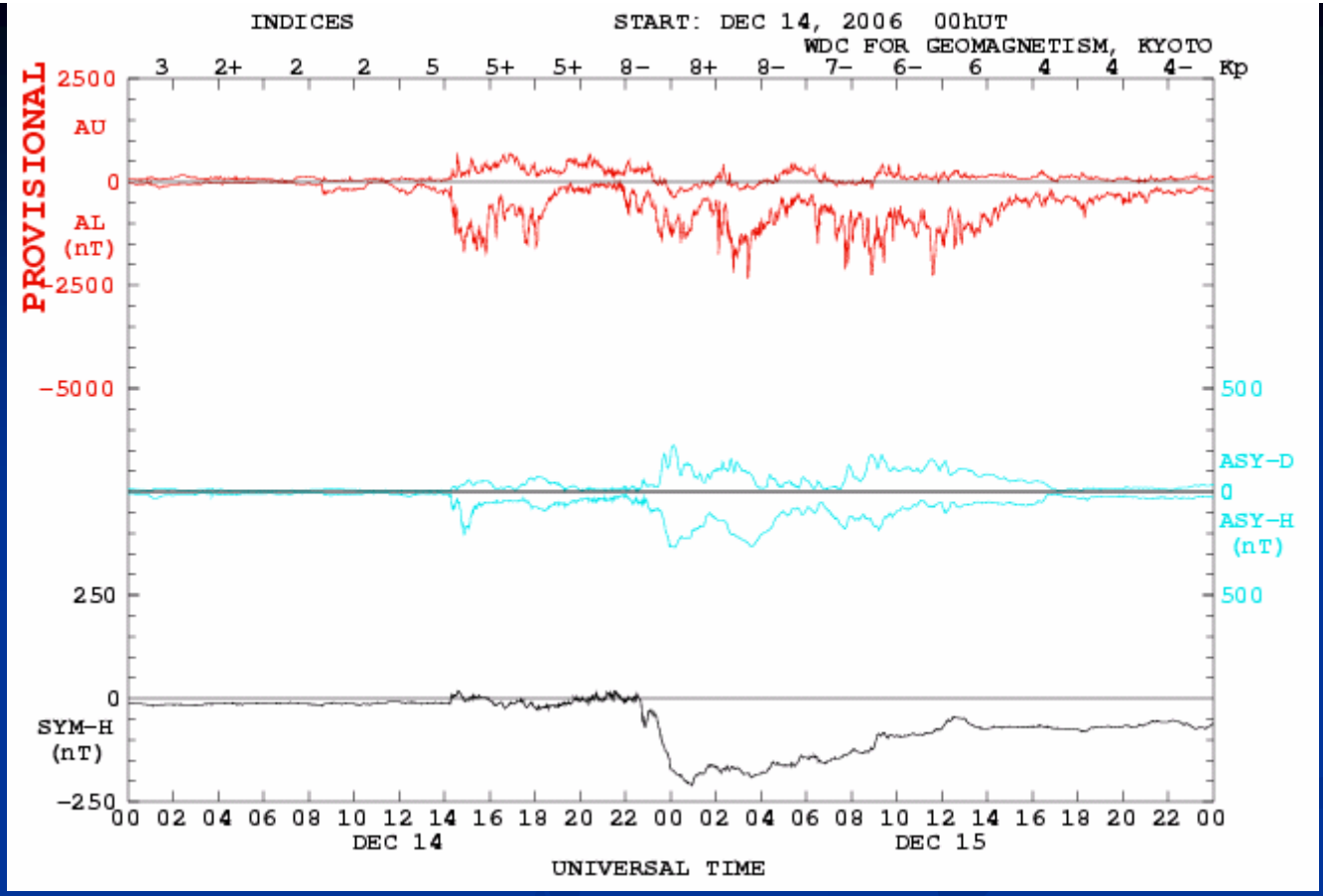
In this paper

- 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 ionospheric currents responsible for the DP2 fluctuations were composed of eastward and westward electrojets caused by the southward and northward IMF, respectively.
- The eastward electrojet was associated with a large-scale two-cell convection pattern as expected, however, the westward electrojet was associated with distorted two-cell or multi-cell pattern accompanied by a reversed convection vortex equatorward of the large-scale convection.
- 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.



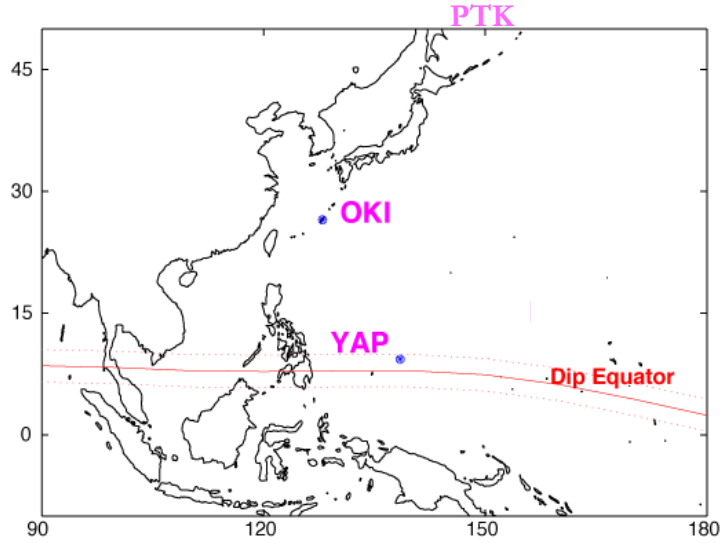
Solar wind data for the storm on December 14-15, 2001

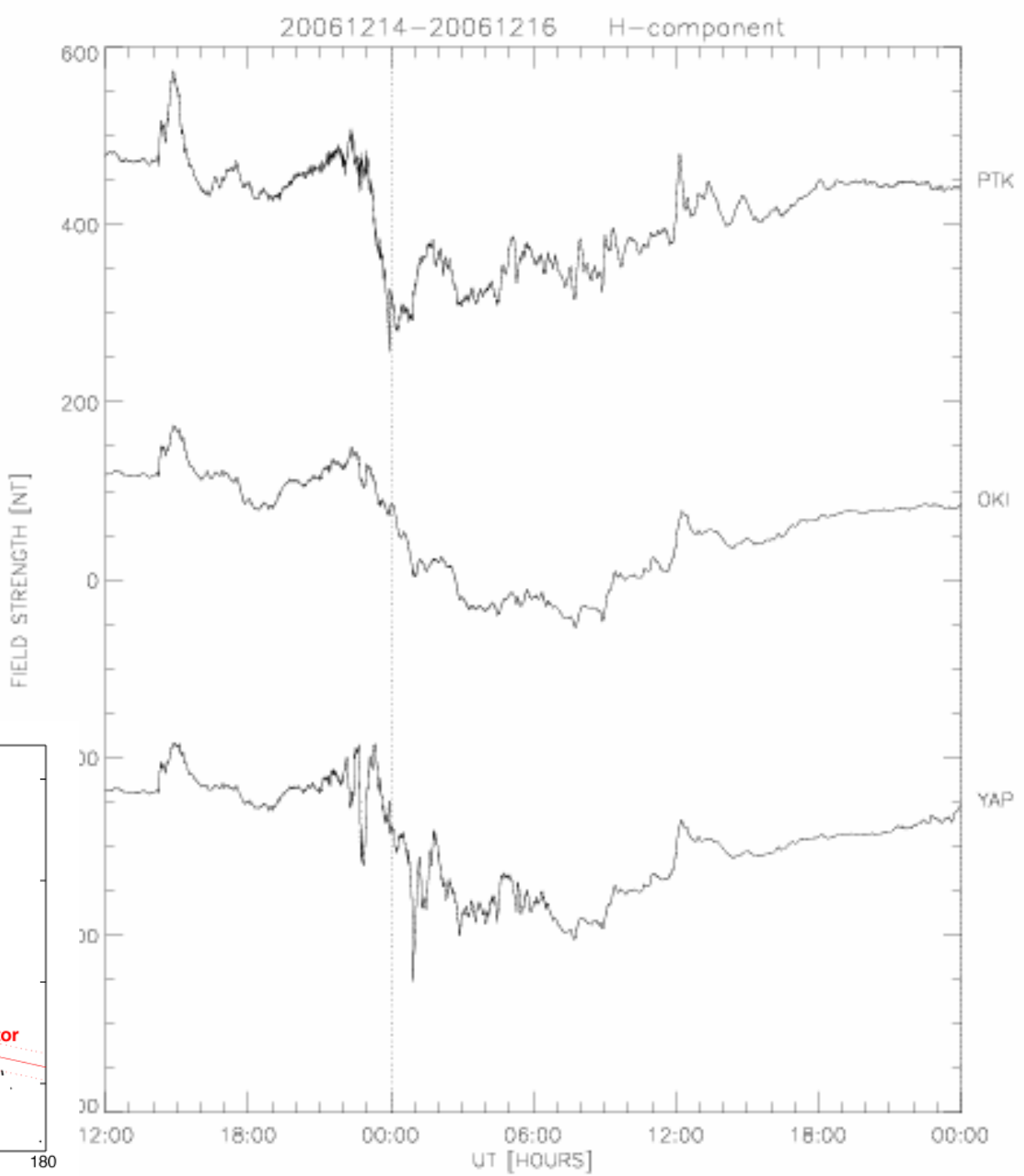
Geomagnetic indices



Significant auroral magnetic disturbances occurred after the SC and continued for 4 hours, and then remained quiet for 3 hours and then the DP2 fluctuation event occurred in the beginning of the development of the storm ring current. 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





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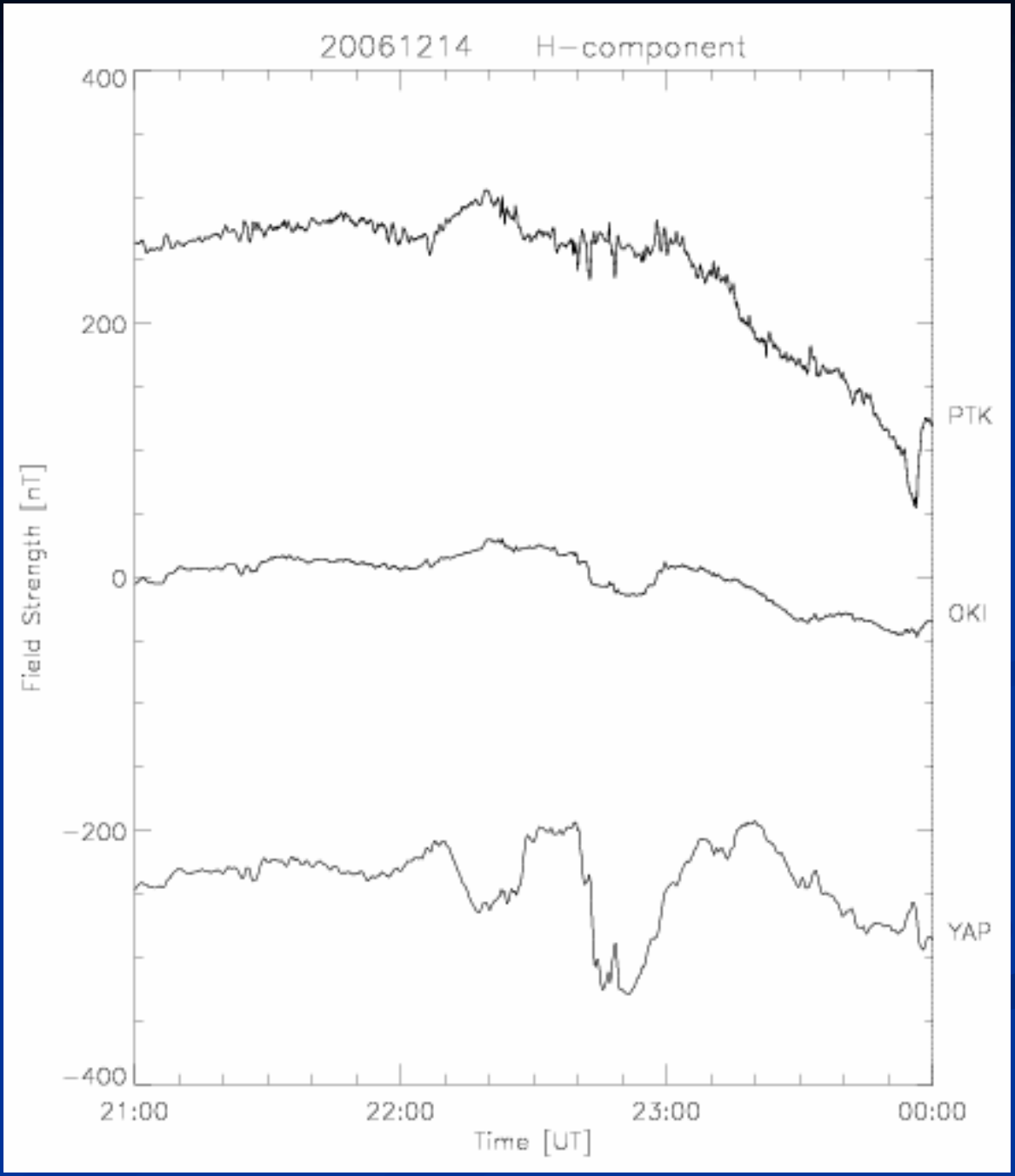
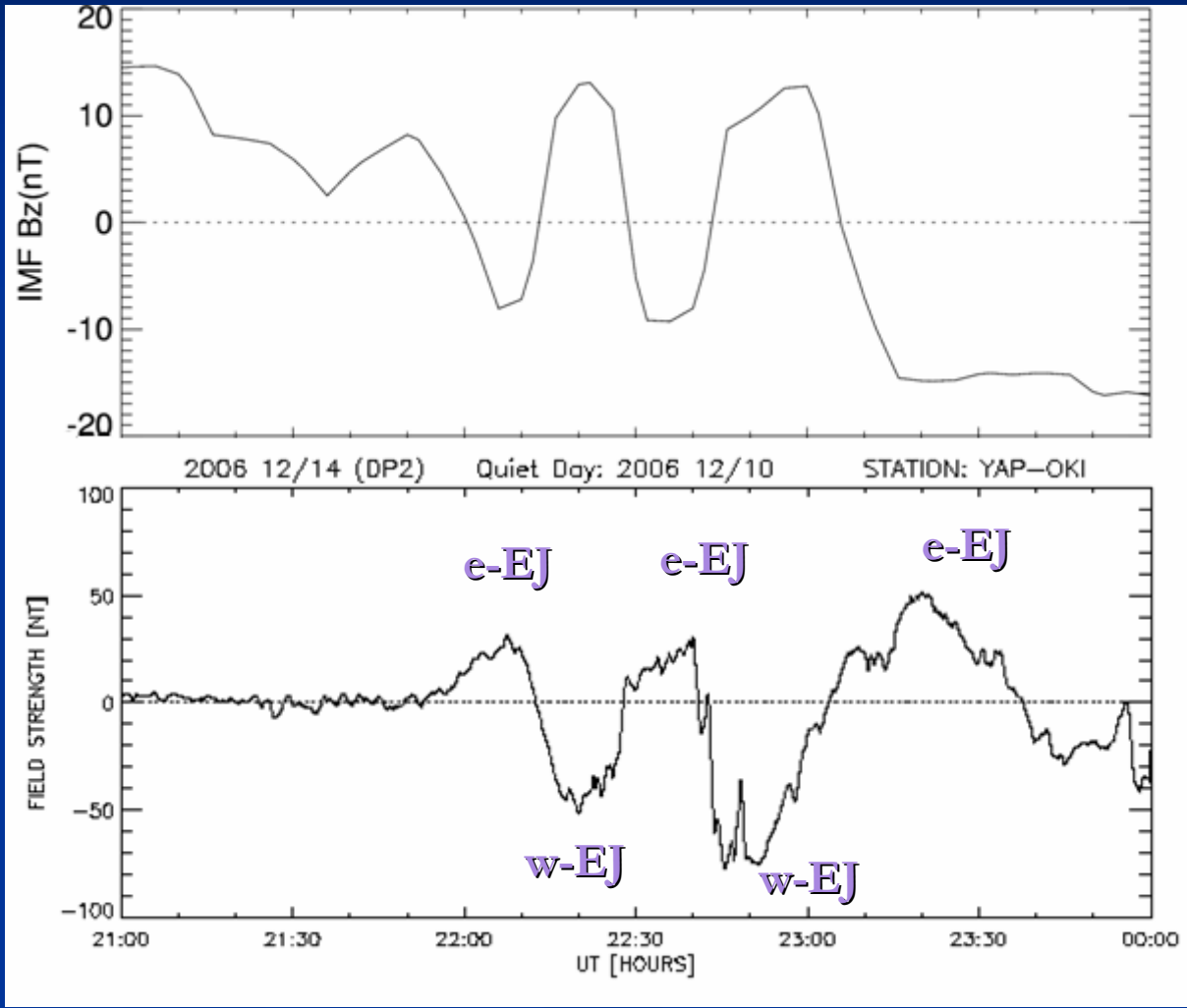


Correlation between the IMF Bz and the QP magnetic fluctuations

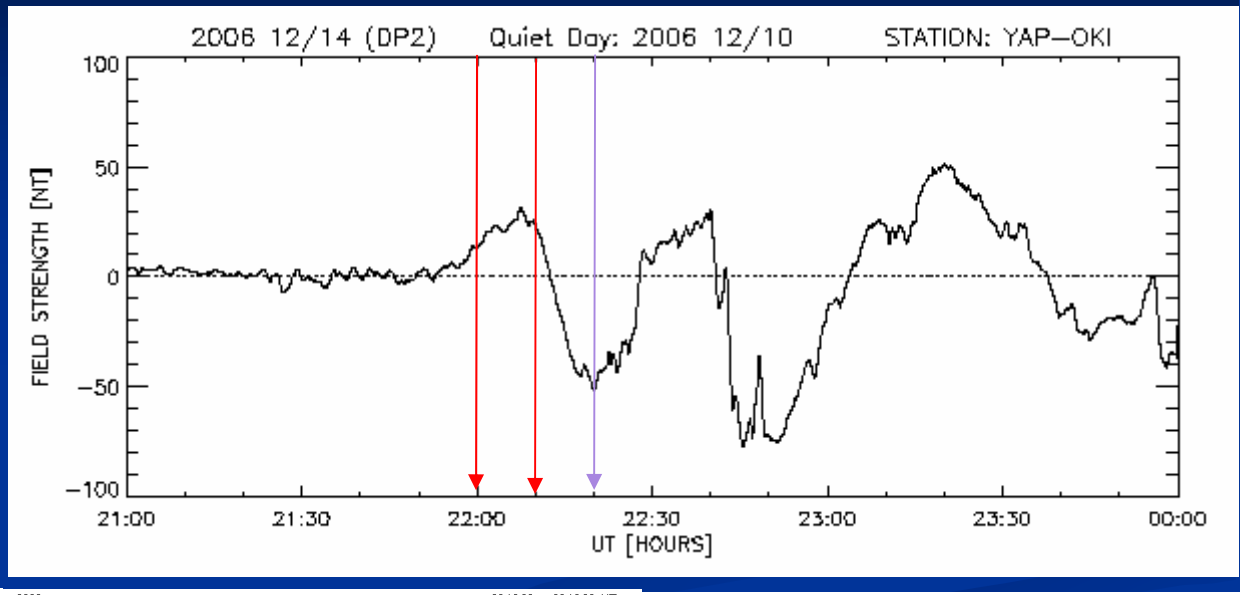
To obtain magnetic disturbances caused by the ionospheric currents, we subtracted OKI from YAP.

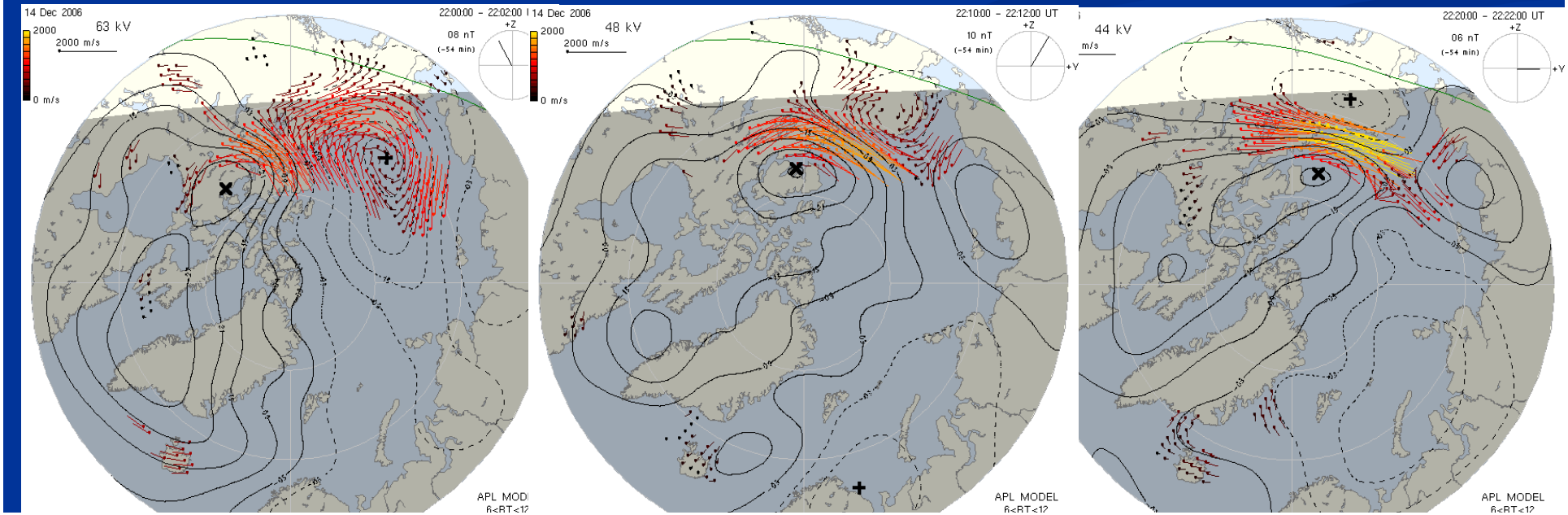
We shifted the time axis of ACE by 36 min behind, we see clear correspondence between the QP magnetic fluctuations and the IMF Bz. The southward IMF caused the eastward electric field, while the northward IMF caused the westward electric field at the dayside equator.



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.





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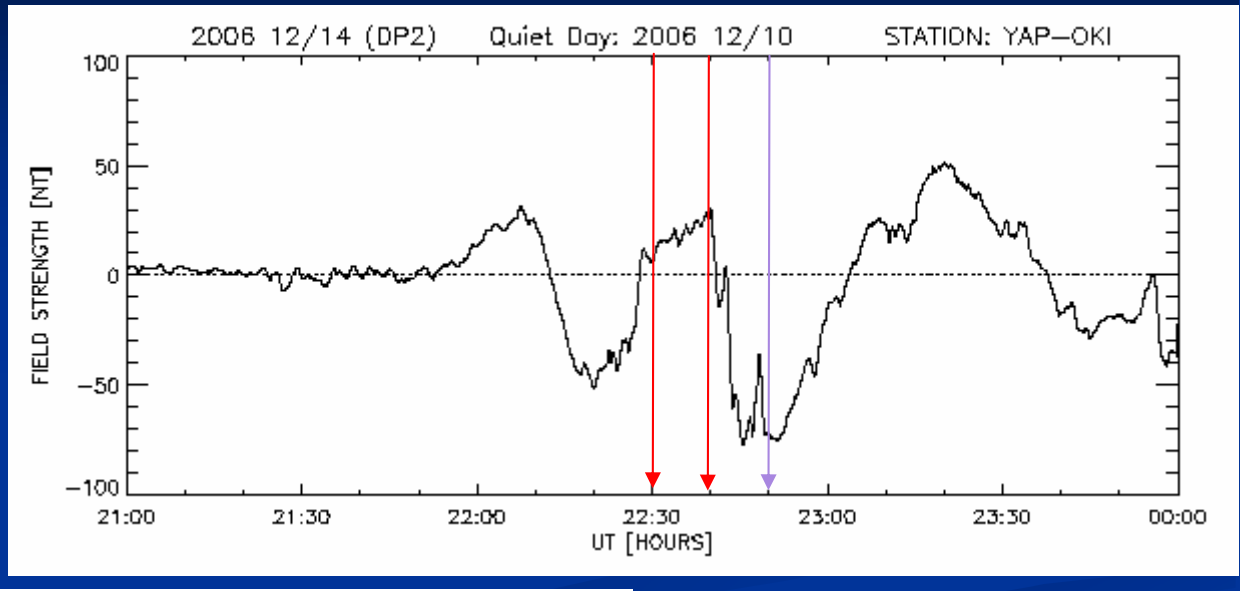

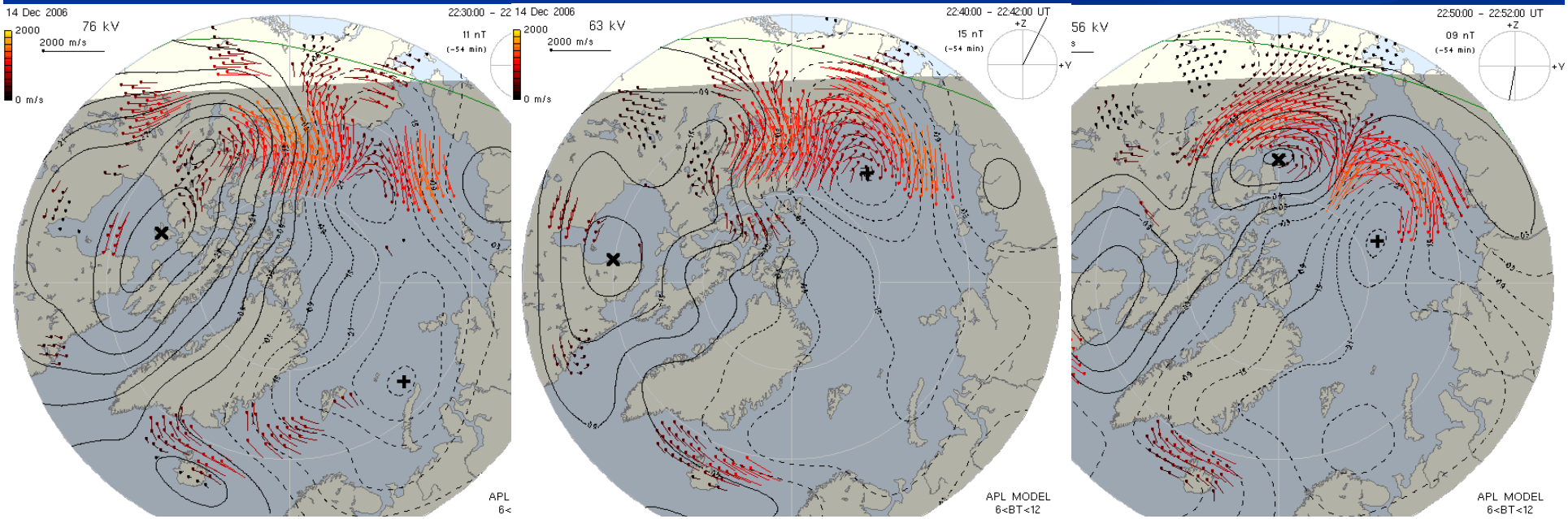

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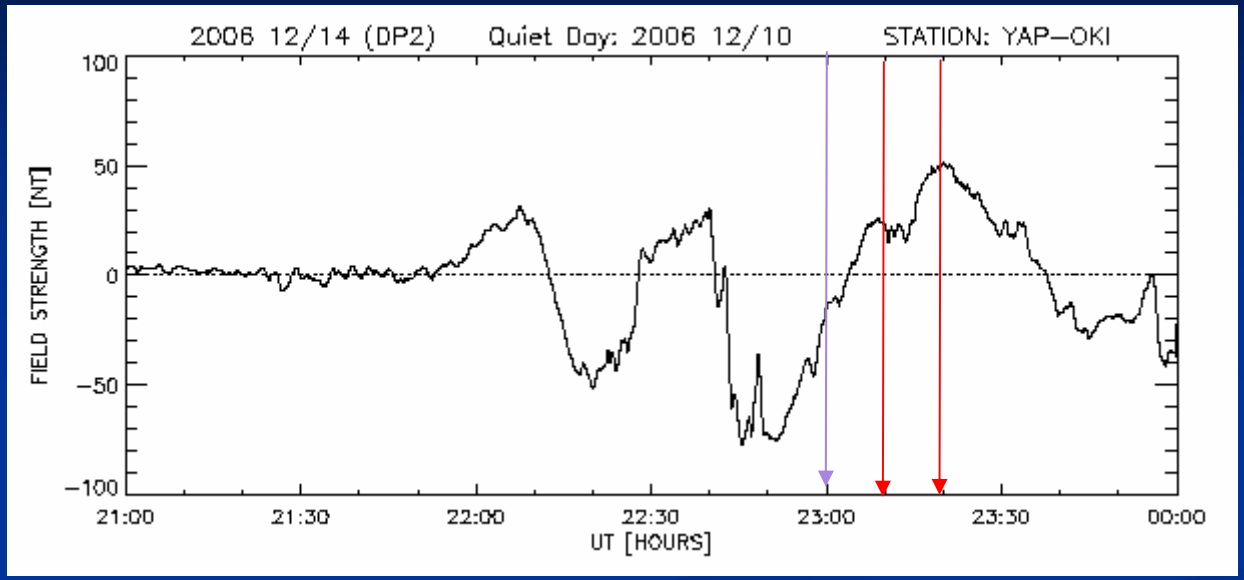
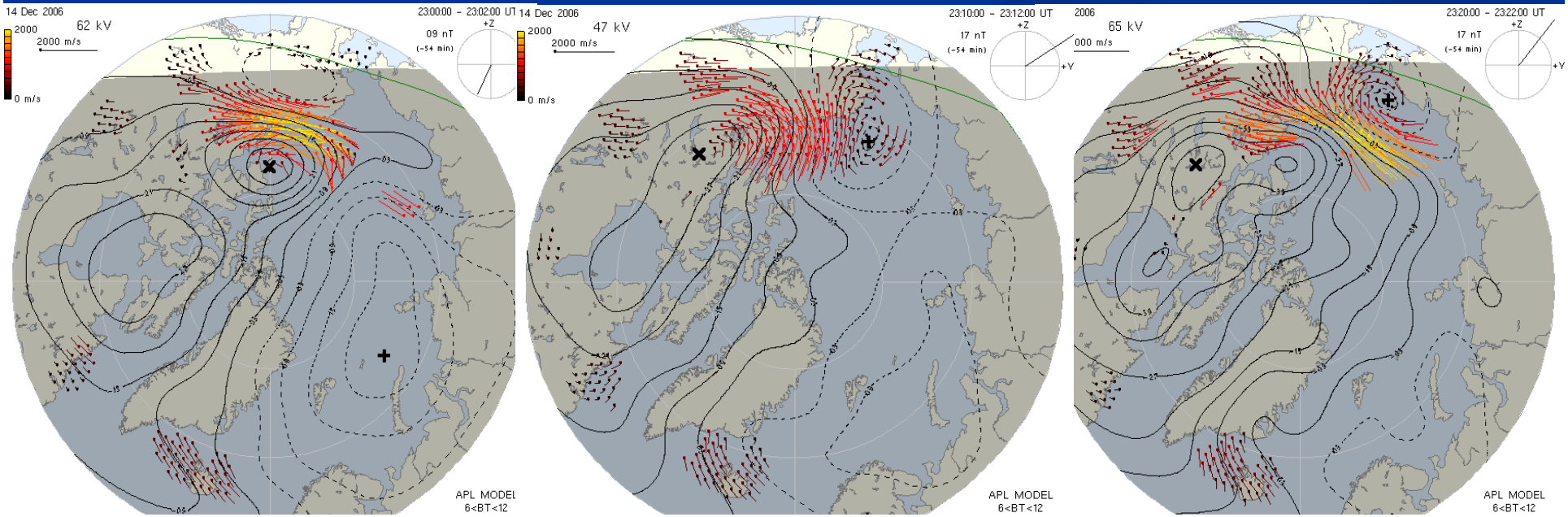
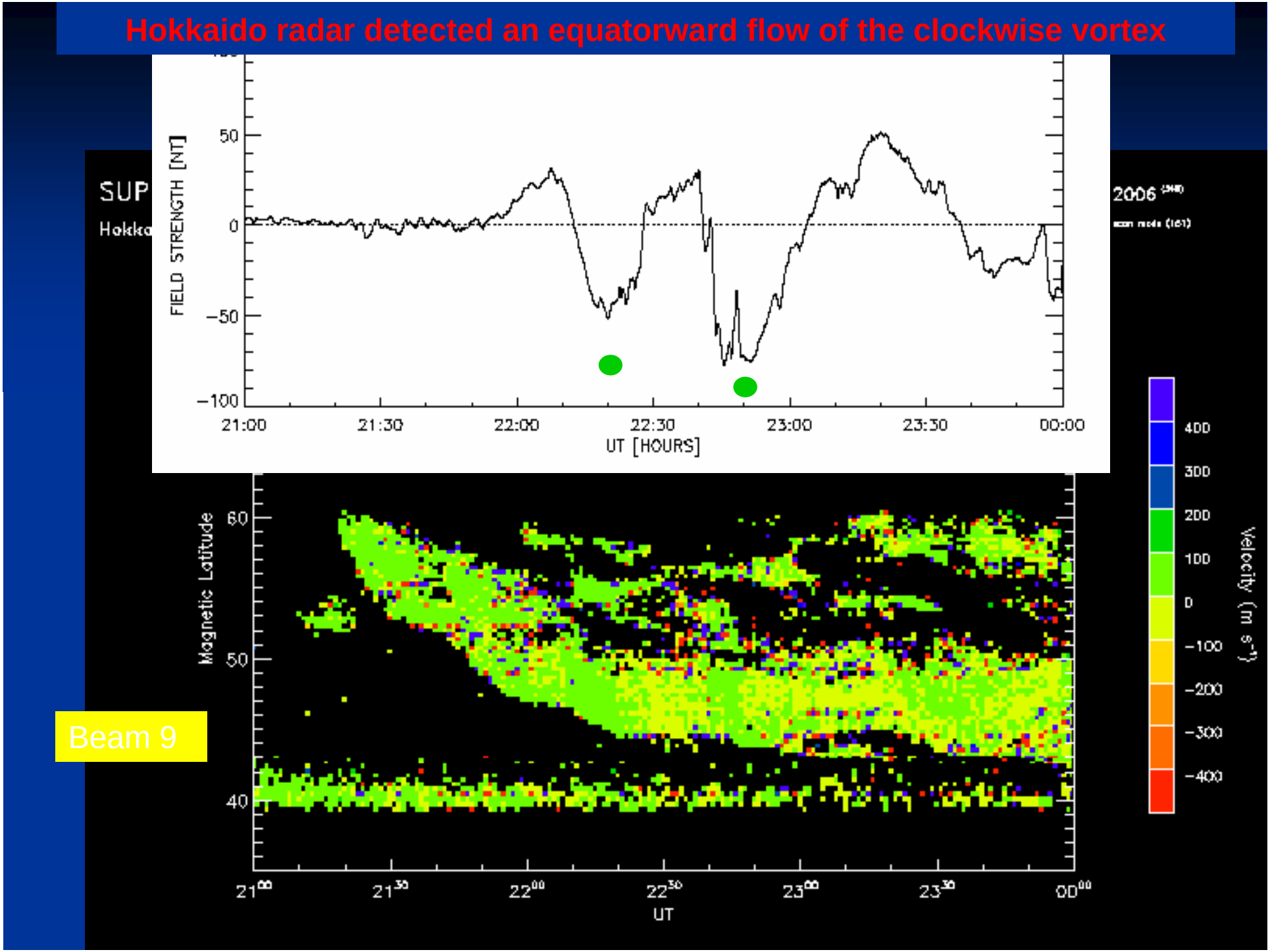


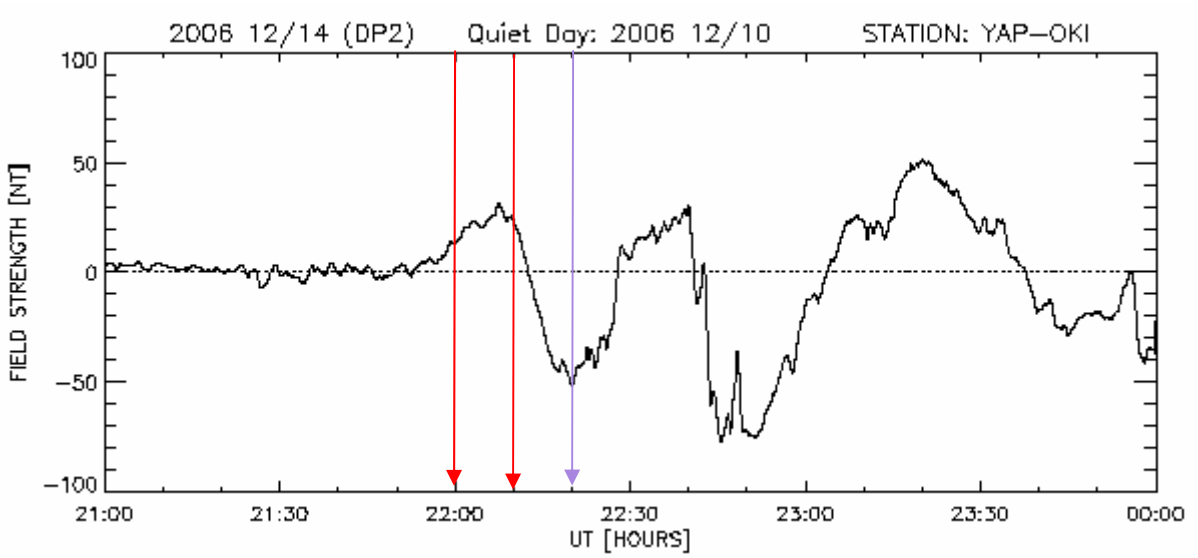


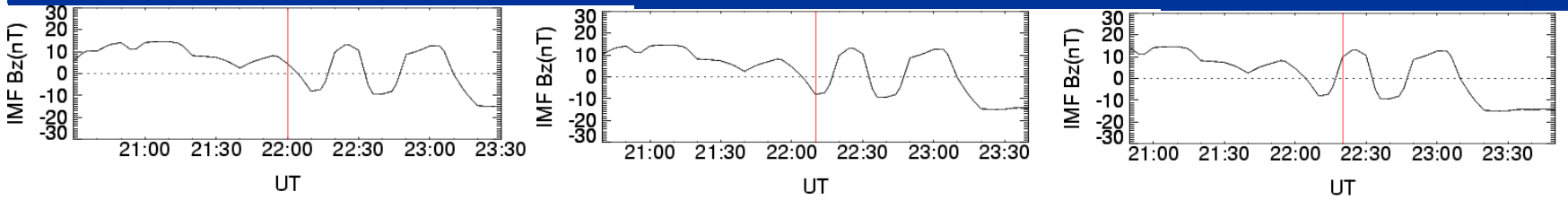
Hokkaido radar detected an equatorward flow of the clockwise vortex

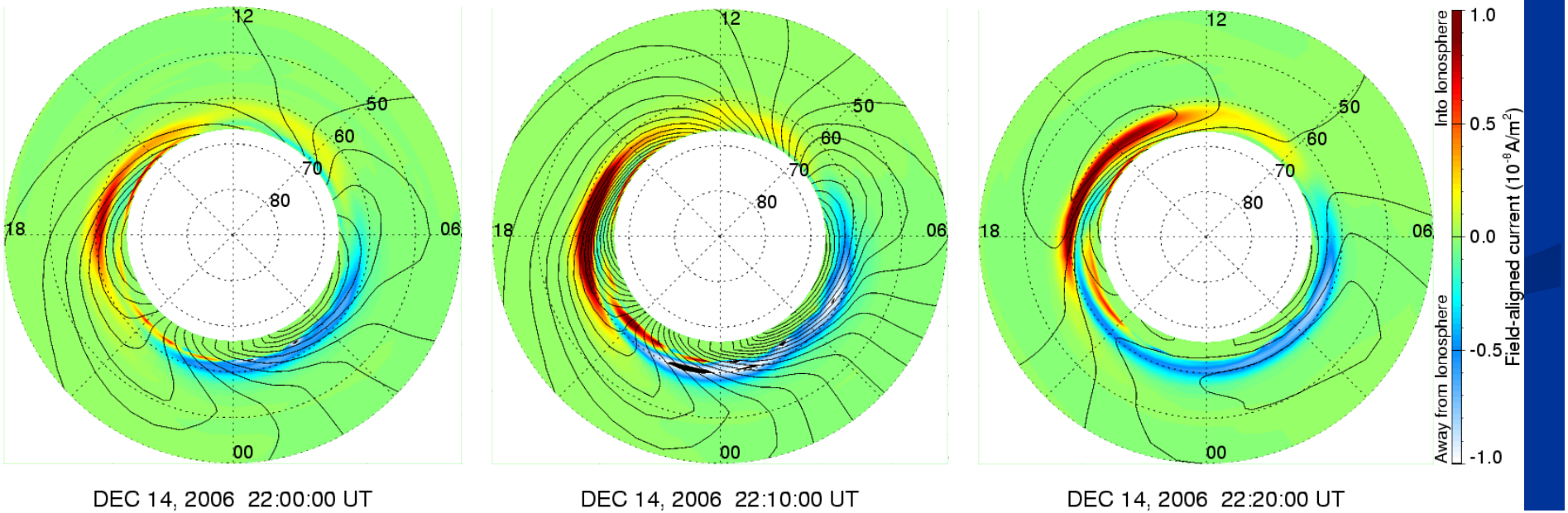


Comparison between the QP magnetic fluctuations and the ring current simulation

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







DEC 14, 2006 22:00:00 UT

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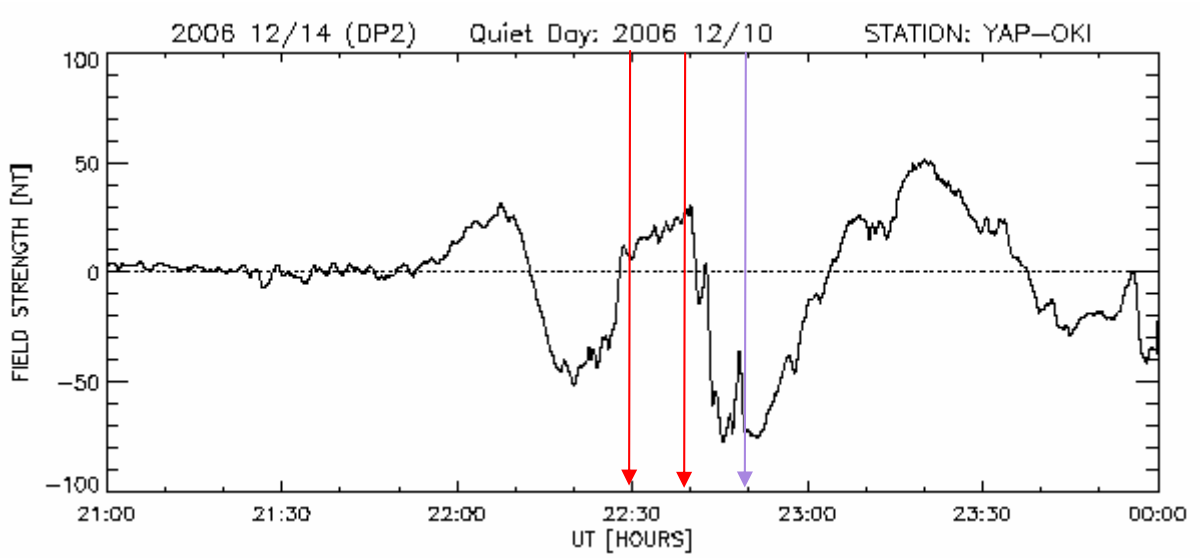

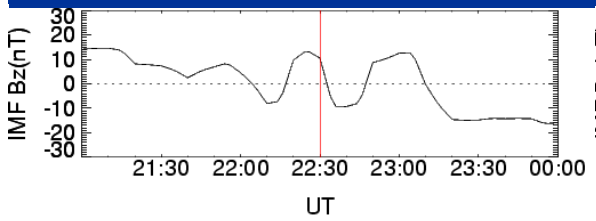

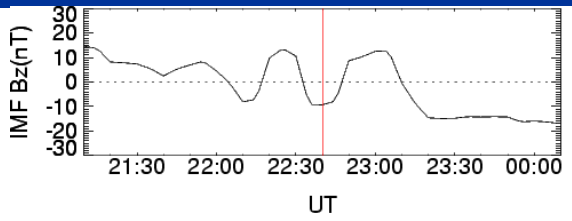

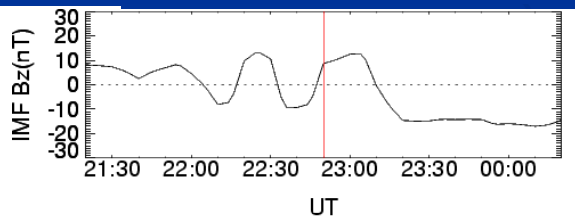

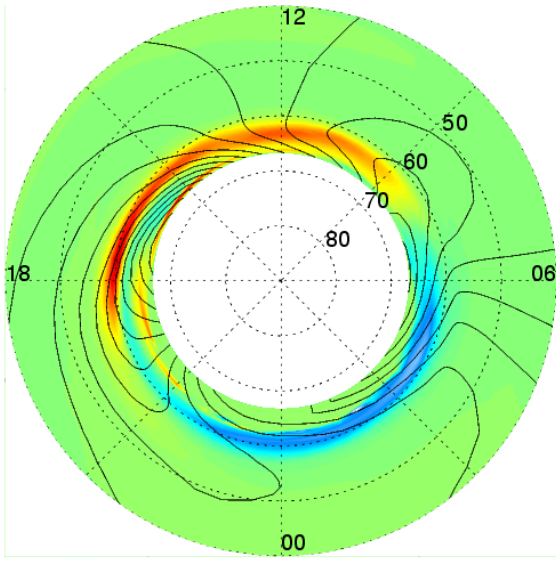

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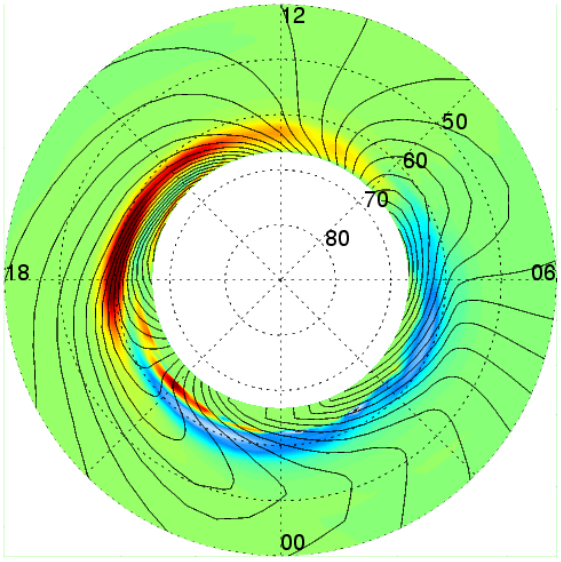

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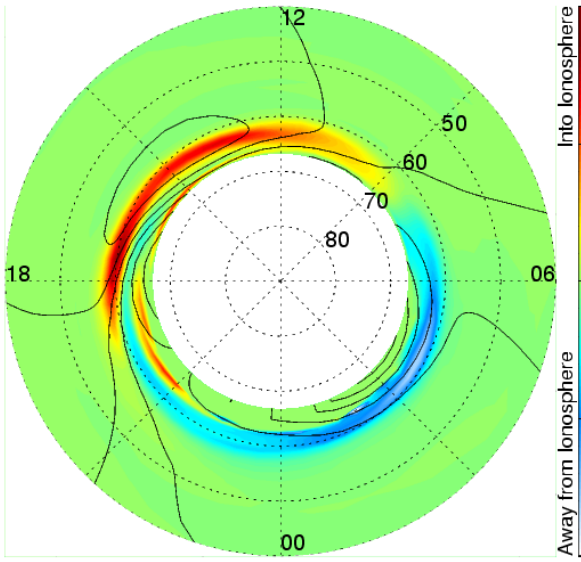

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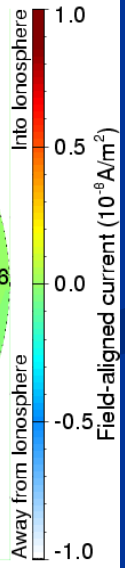

Comparison between the QP magnetic fluctuations and the ring current simulation

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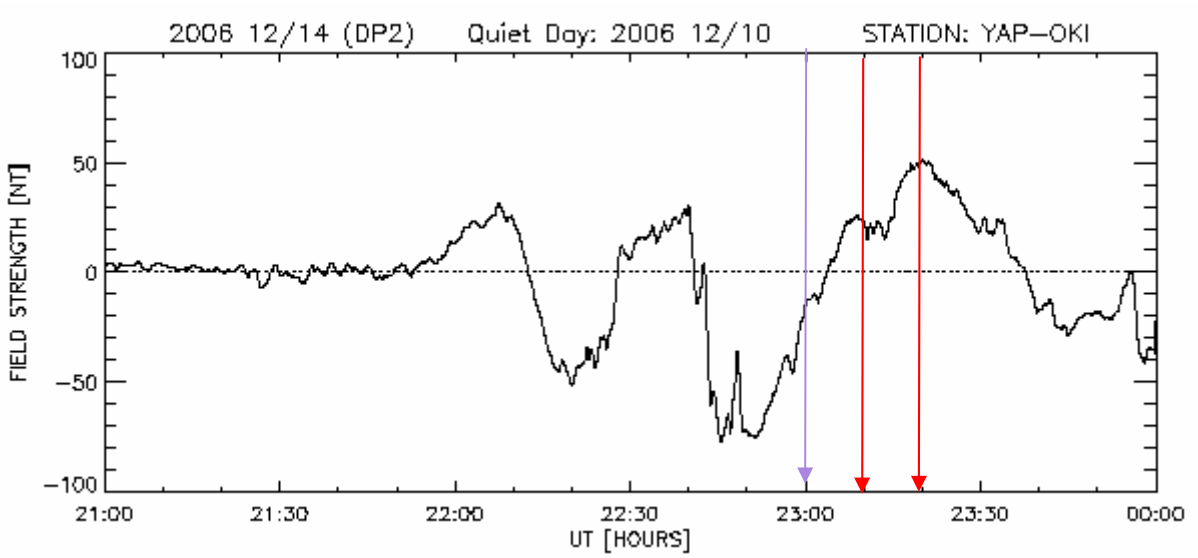

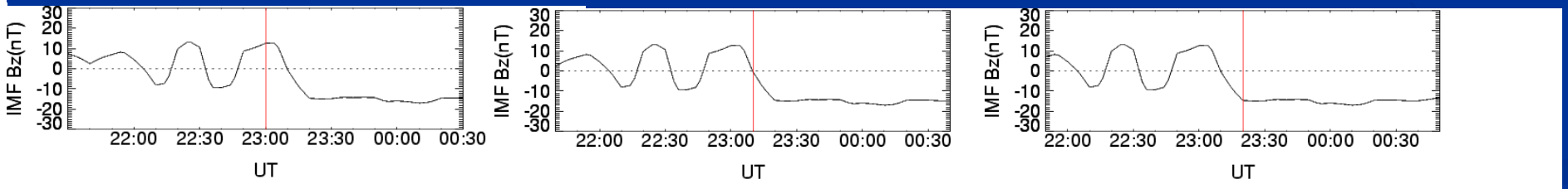

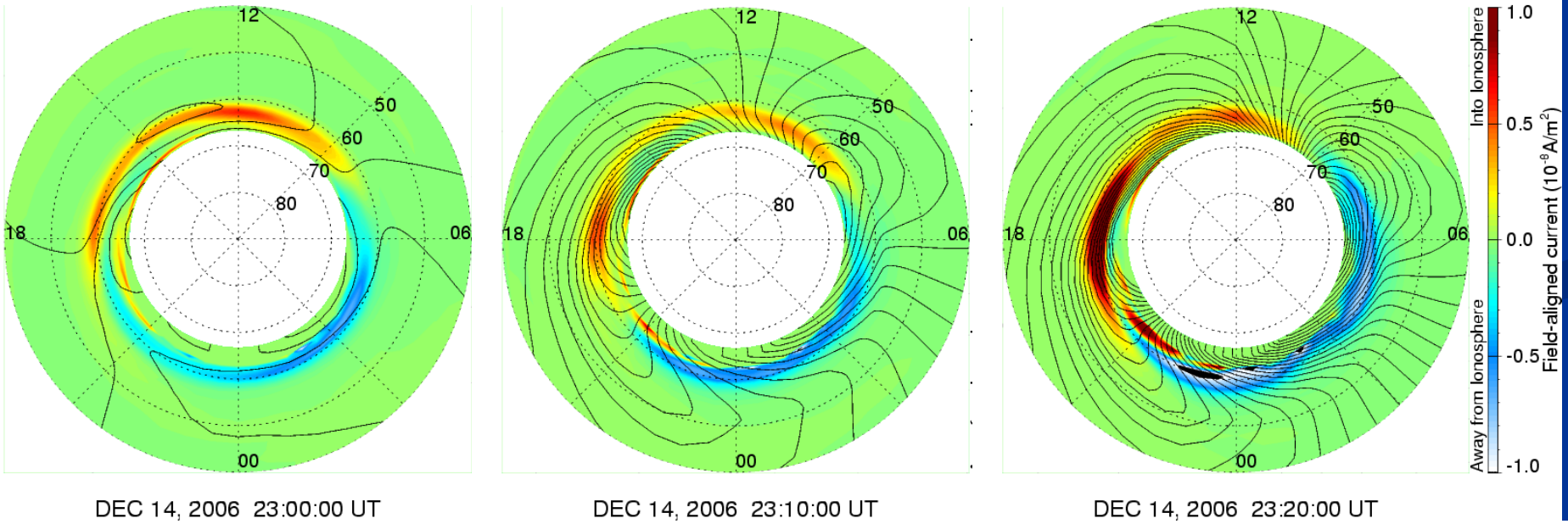

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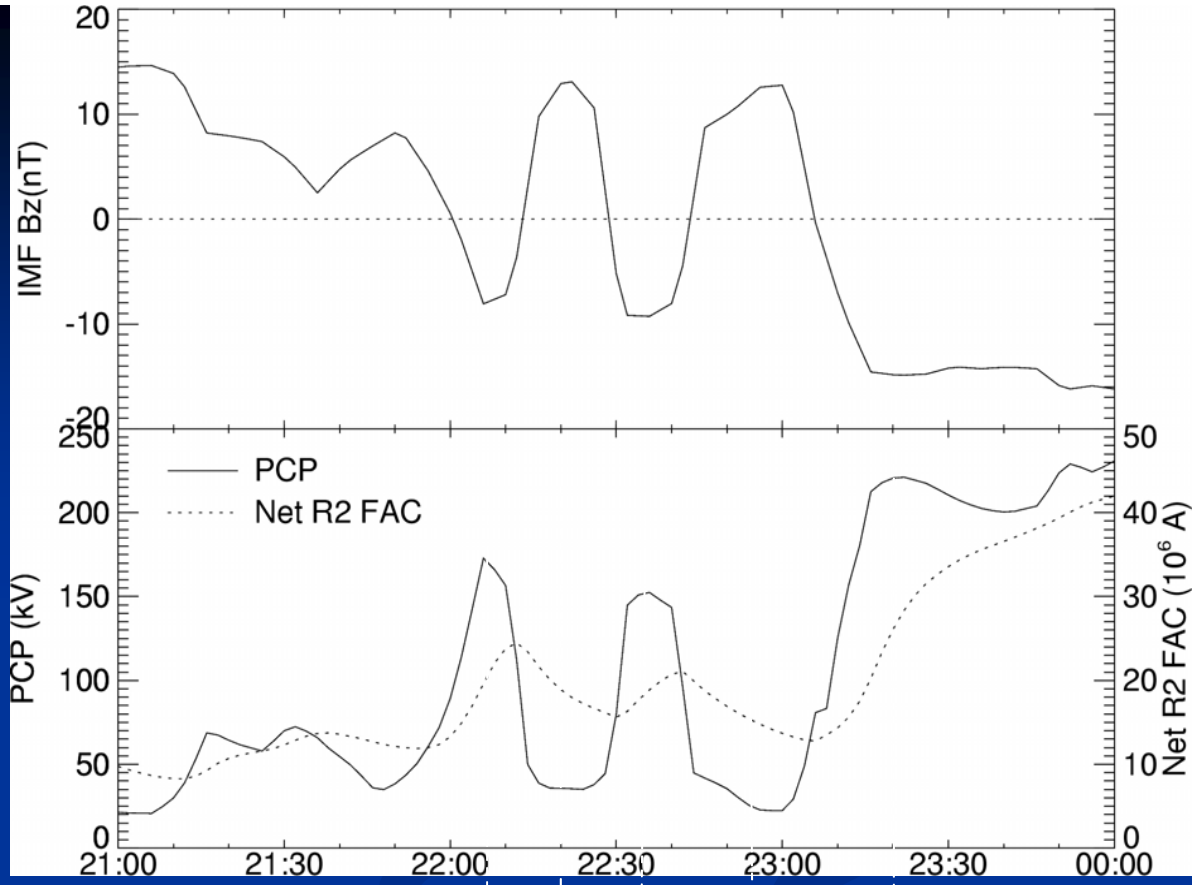
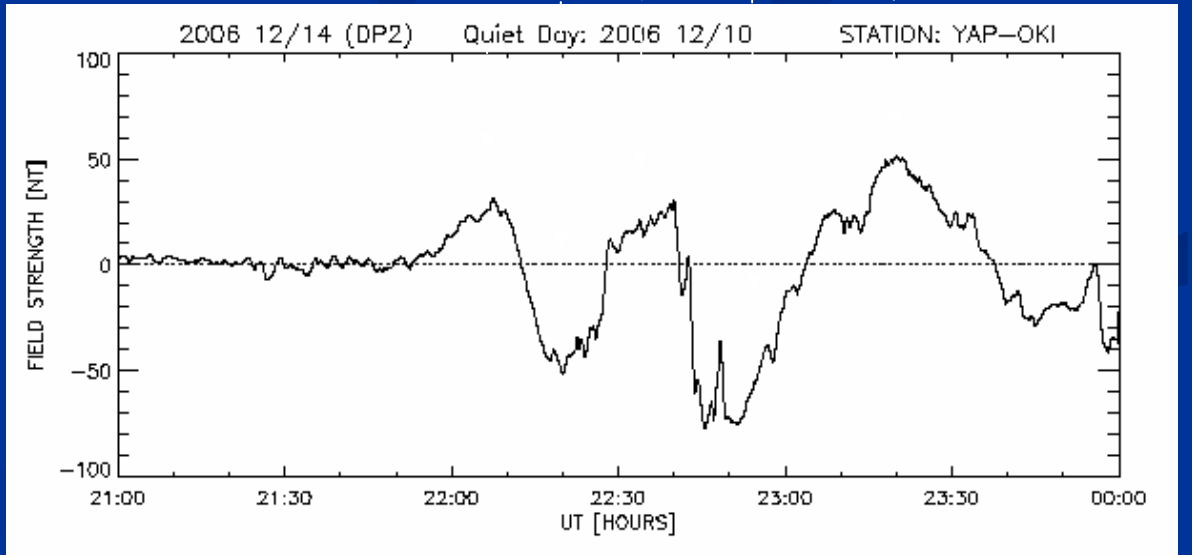
Temporal variation of the net R2 FACs (dotted curve)

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

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





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 PCP, but is not effective 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.