Terminator effects and dayside ionospheric current system on Pi2 pulsations

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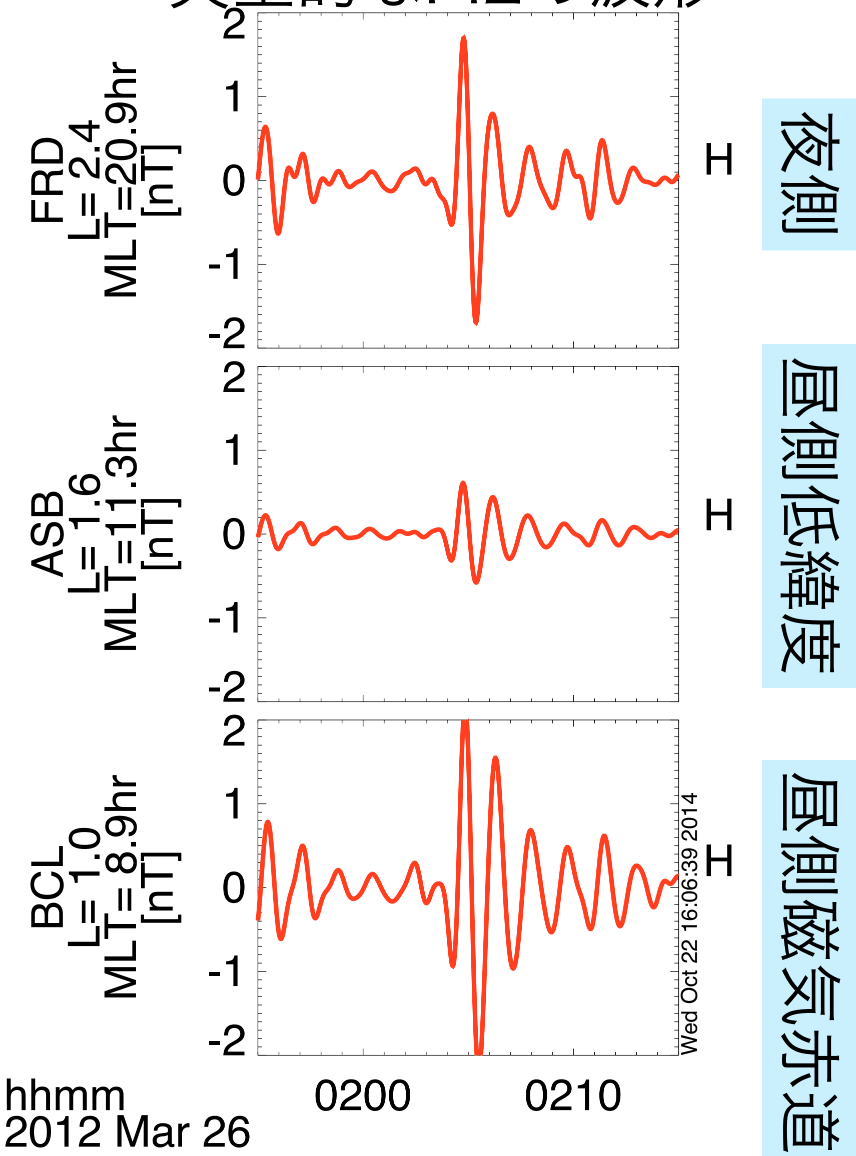
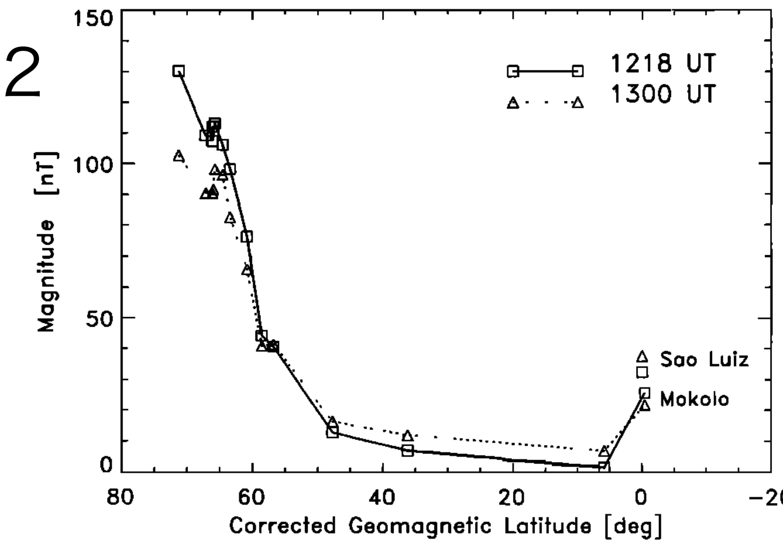
磁気圏起源擾乱の赤道強化現象

Pi2地磁気脈動を含む多くの磁気圏起源の擾乱
(DP2, Pc5, SCなど)は昼間側磁気赤道で振幅が増す

典型的なPi2の波形

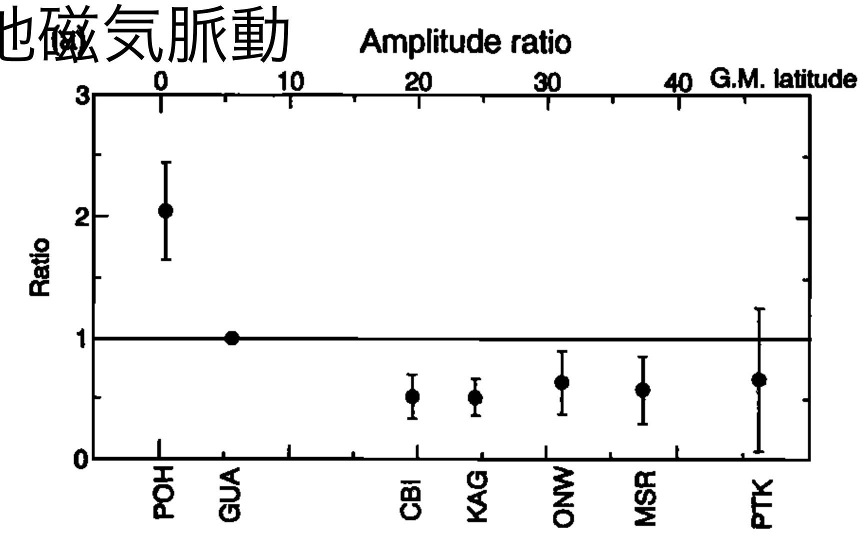


DP2



Kikuchi et al. [JGR,1996]

Pi2地磁気脈動



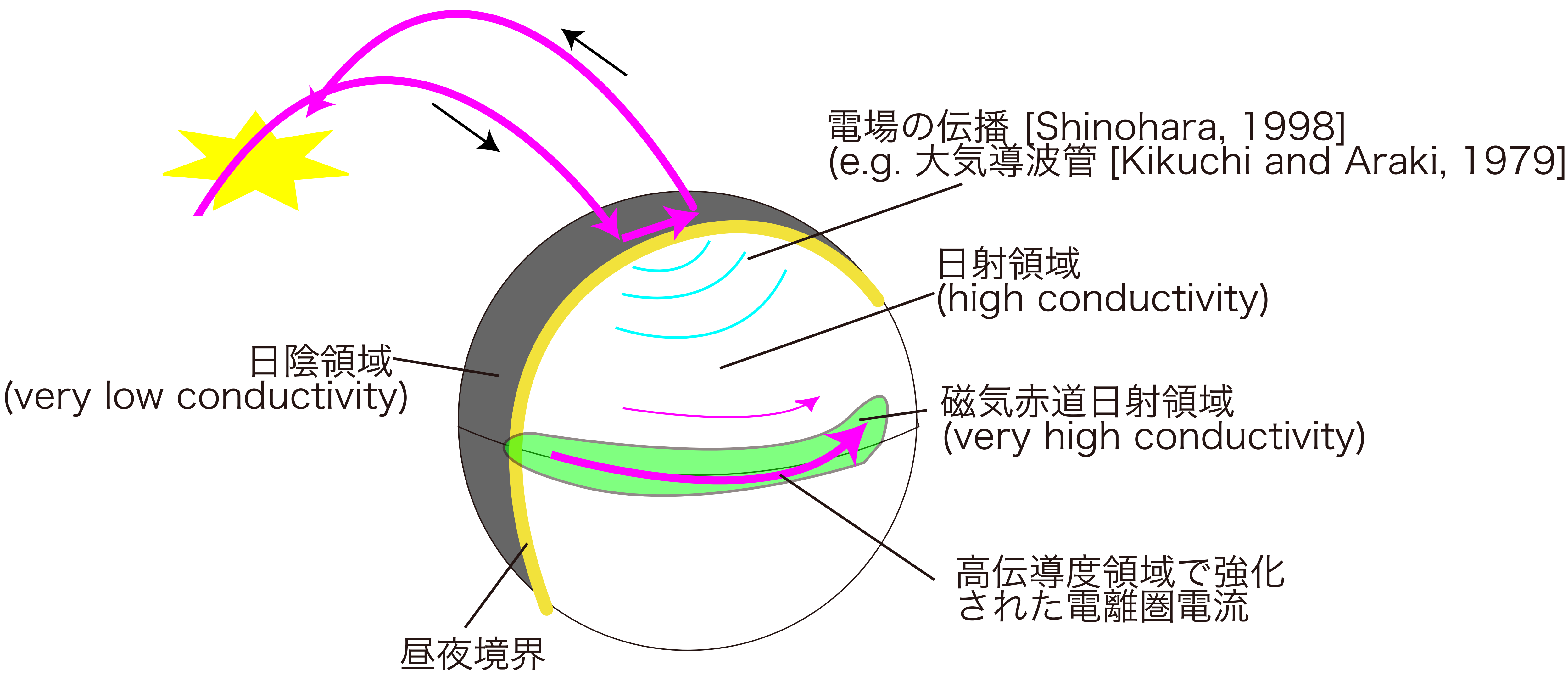
Shinohara et al. [GRL,1997]

夜側起源のPi2がどのようにして伝わり昼間側赤道に
大きな振幅をもたらすか?

昼間側Pi2と電離圏電流

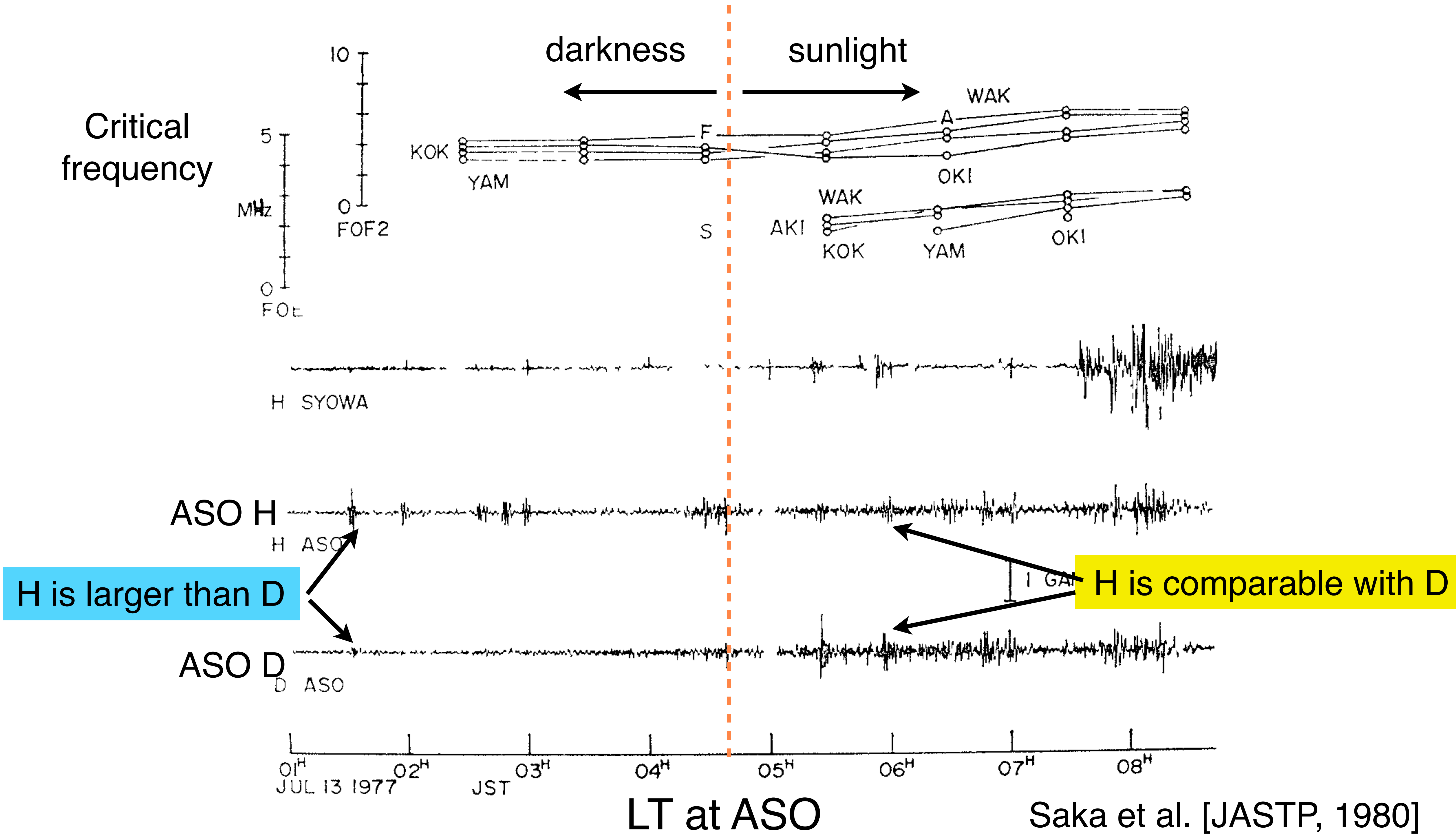
過去の研究では、昼間側地上低緯度のH成分磁場は極域電場の侵入による東西の電離層電流振動が原因であると解釈される。
[Kikuchi and Araki,1979, JASTP; Shinohara et al.,1998, JGR]

昼夜境界=電気伝導道が急激に変化するところ



日射領域のPi2が電離圏電流が関与していれば朝夕昼夜境界付近でなんらかの変化が見られるはず

Sunrise effect on Pi2 and Pc4 range wave

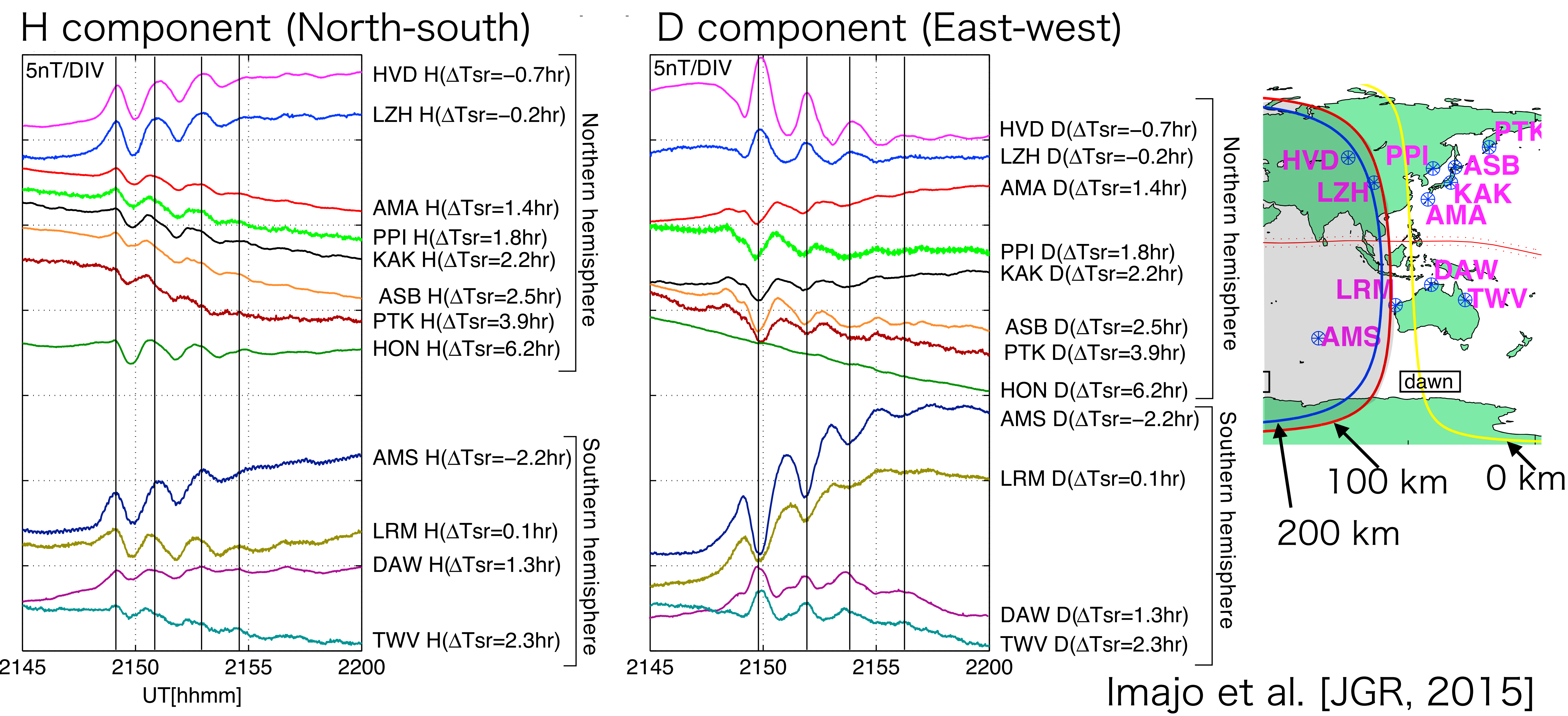


Saka et al. [JASTP, 1980]

複数観測点での同時観測はでは未だ検証されていない。

Imajo, S., A. Yoshikawa, T. Uozumi, S. Ohtani, A. Nakamizo, R. Marshall, B. M. Shevtsov, V. A. Akulichev, U. Sukhbaatar, A. Liedloff, and K. Yumoto (2015), **Pi2 pulsations observed around the dawn terminator**. *J. Geophys. Res.* Space Physics, 120, 2088–2098. doi: 10.1002/2013JA019691.

朝側昼夜境界でのPi2 (21:50 UT on 16 September 2011)

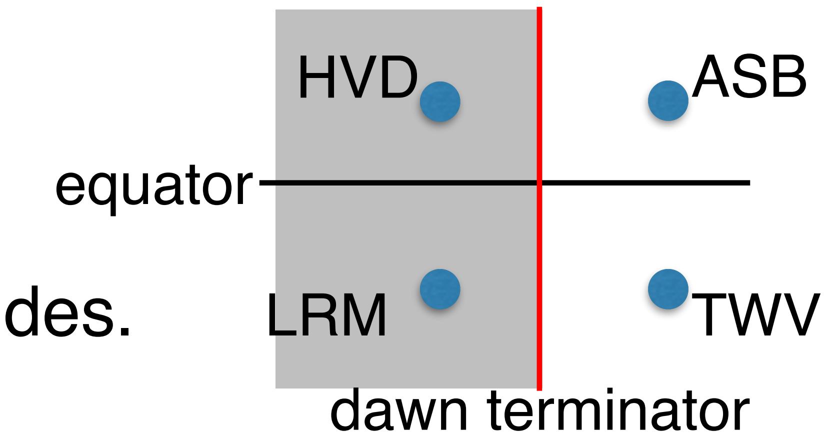


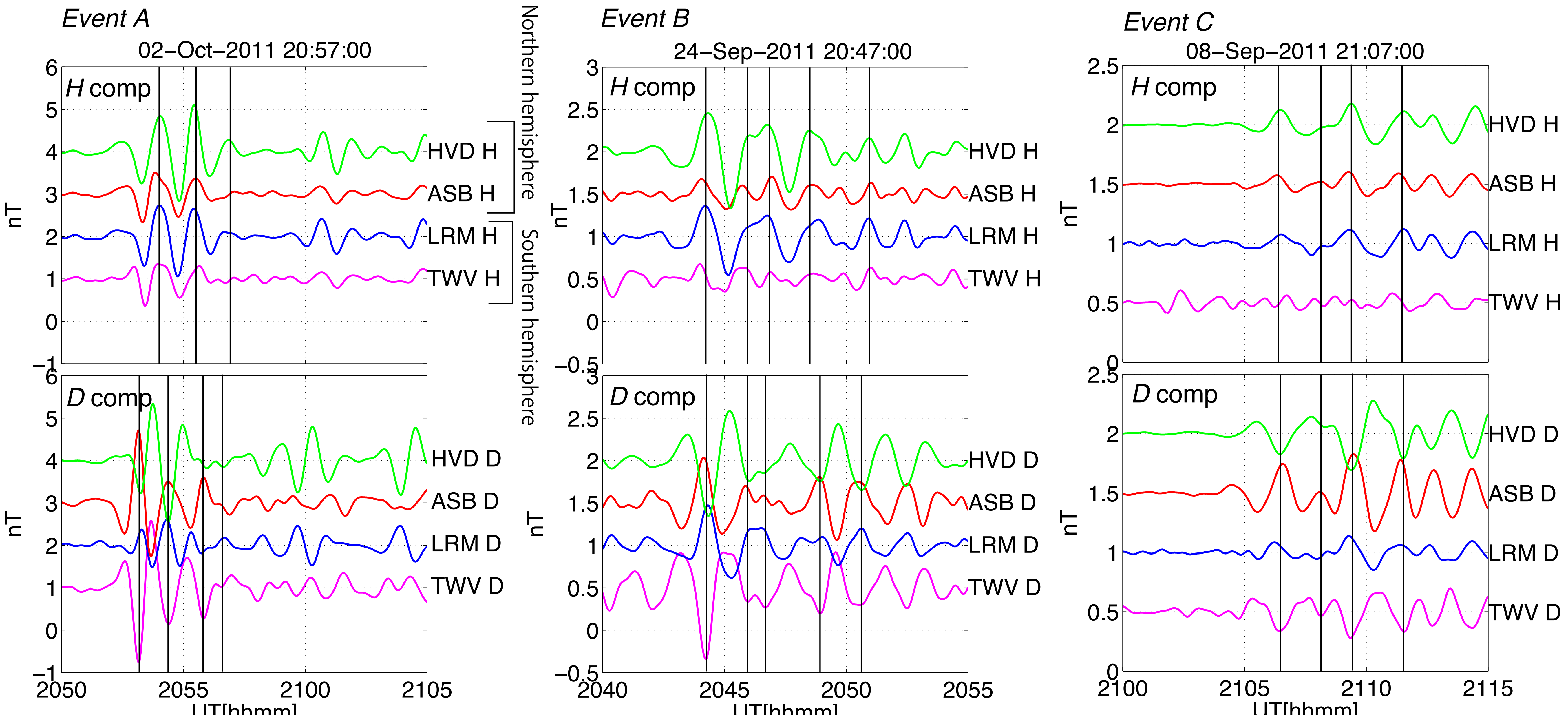
Imajo et al. [JGR, 2015]

- H成分はほぼ同位相。
- 昼夜境界付近を境にD成分の位相が反転する。
- 日陰、日射領域共に、南北半球でD成分の位相が反転する。

朝側昼夜境界でのPi2 (その他の例)

- D-component oscillations in the dark and sunlit hemispheres were in antiphase, whereas the H component oscillated in phase.
- At the sunlit stations (ASB, TWV), D-component amplitudes were larger than the H-component amplitudes.



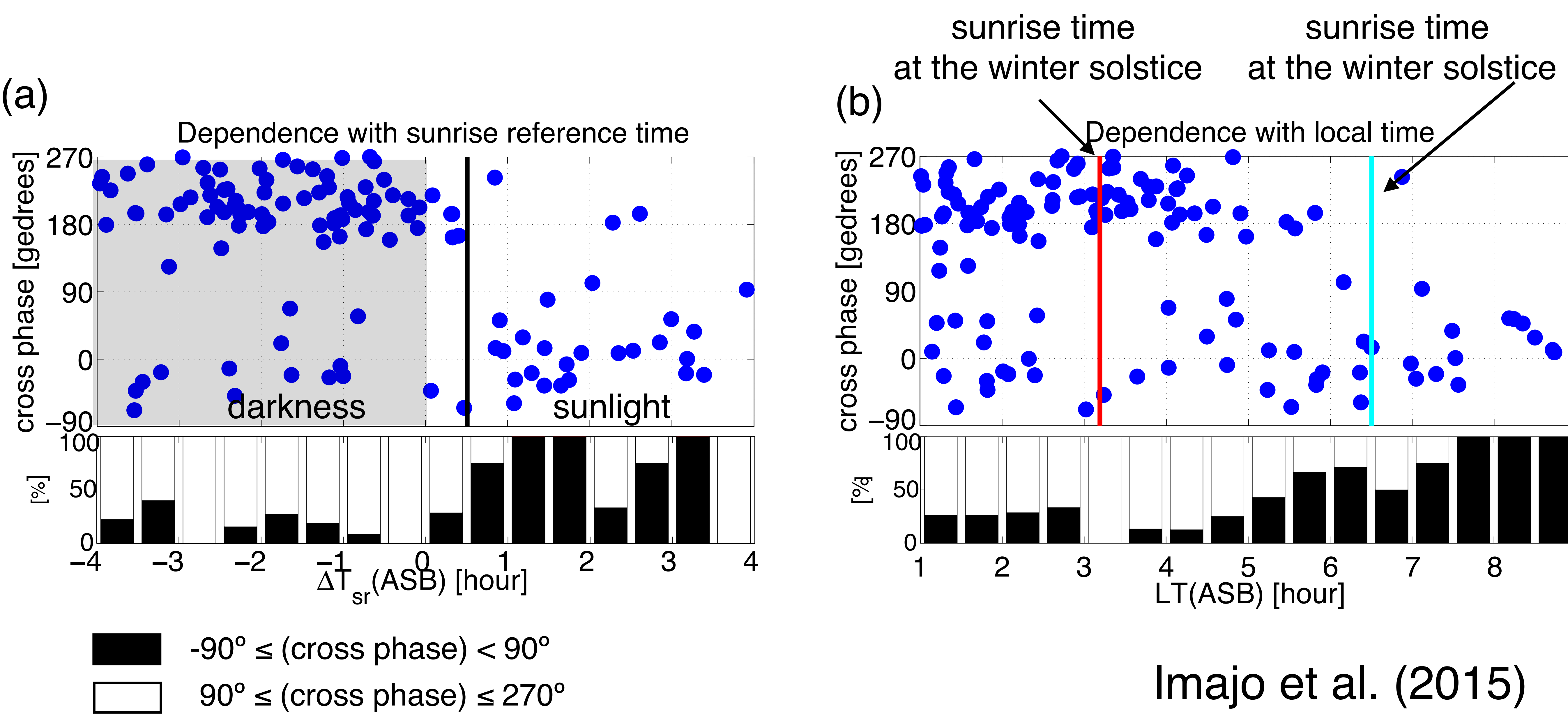


Imajo et al. (2015, JGR)

統計解析 (位相反転のタイミング)

朝側ASBのD成分とそのとき夜側にあるTAMのH成分の位相差を計算した

- D成分の位相反転のタイミングはは地方時(b)よりむしろ日の出からの時刻(b)に従う。
- D成分の位相反転は100km高度の昼夜境界の約0.5時間昼間側で起こる。

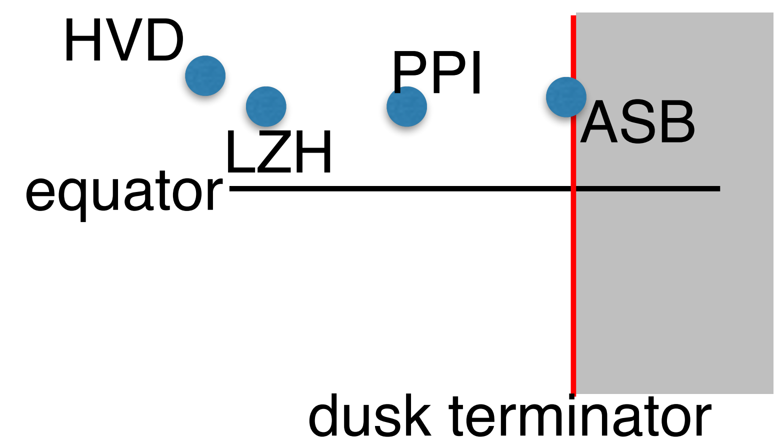


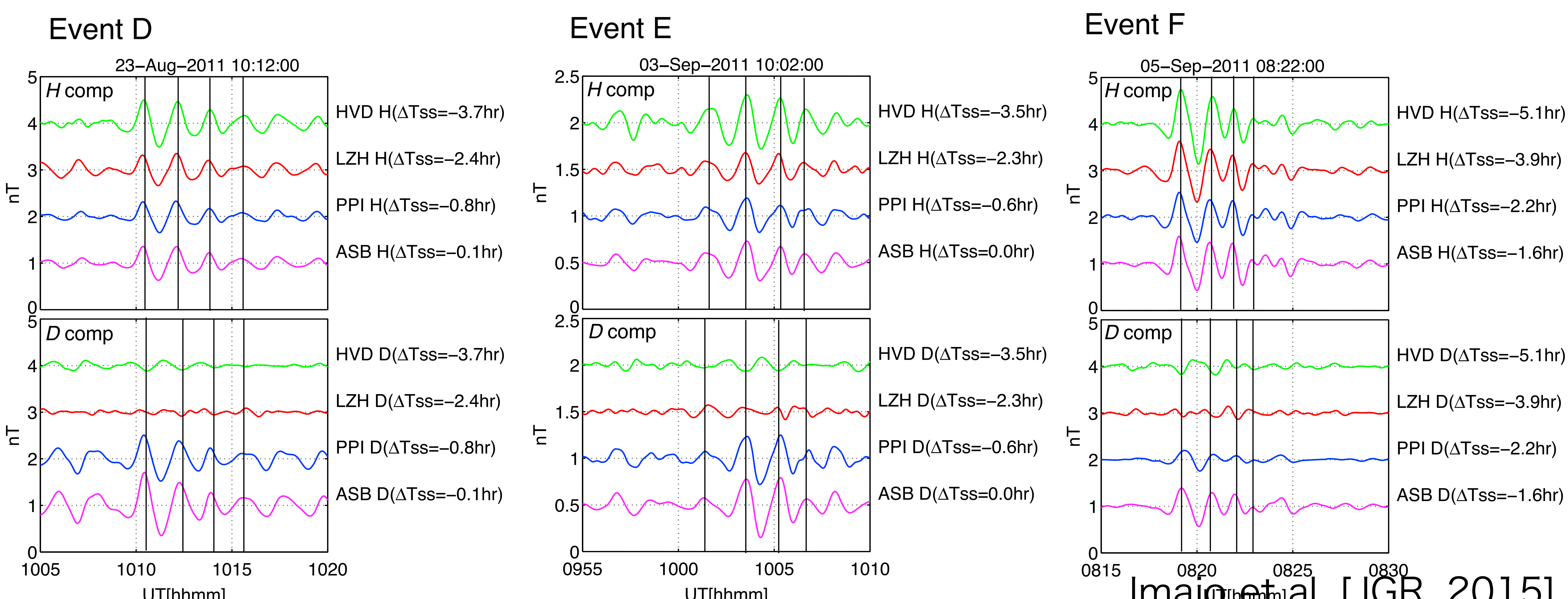
Imajo et al. (2015)

夕方側昼夜境界付近のPi2

- 日の入境界から約2-3時間昼間側でD成分の位相の反転が見られる
- 位相の反転する経度から昼間側のD成分の振幅は非常に小さい

relative location of stations



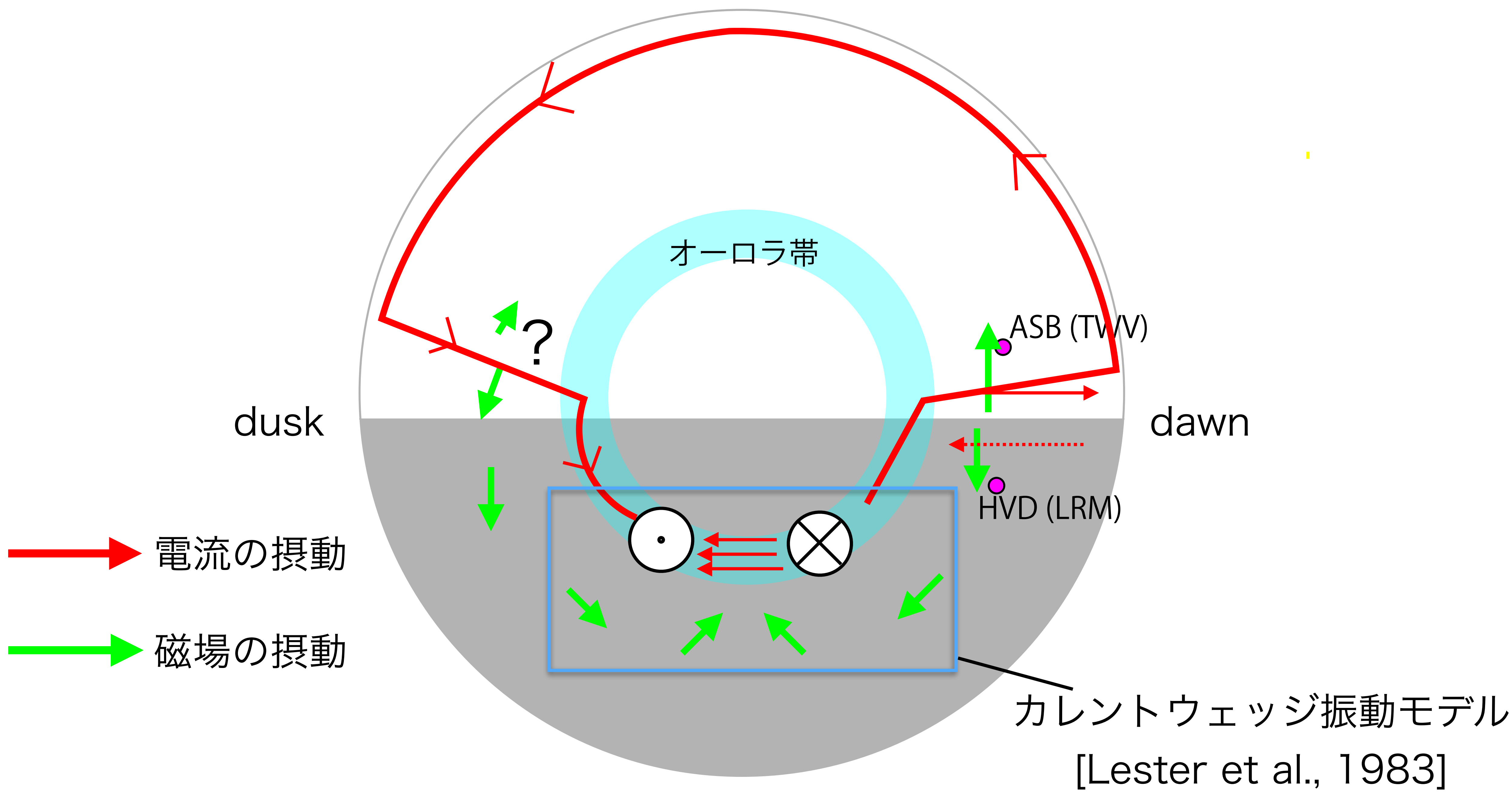


Imajo et al. [JGR, 2015]

昼夜境界付近のPi2の解釈

多点磁場観測を用いた等価電流分布から検証

大体こういうcurrent closureになっているはず

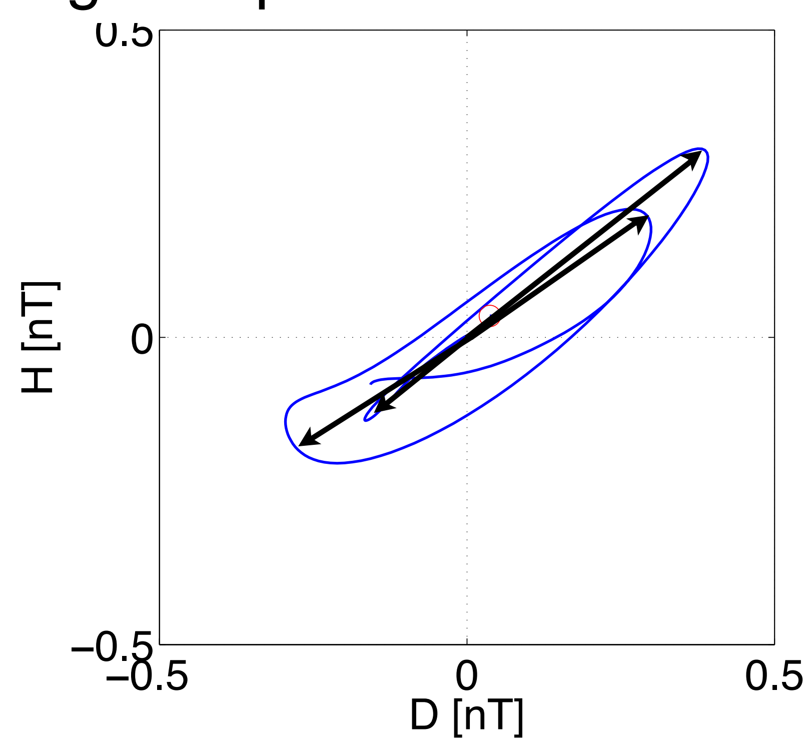


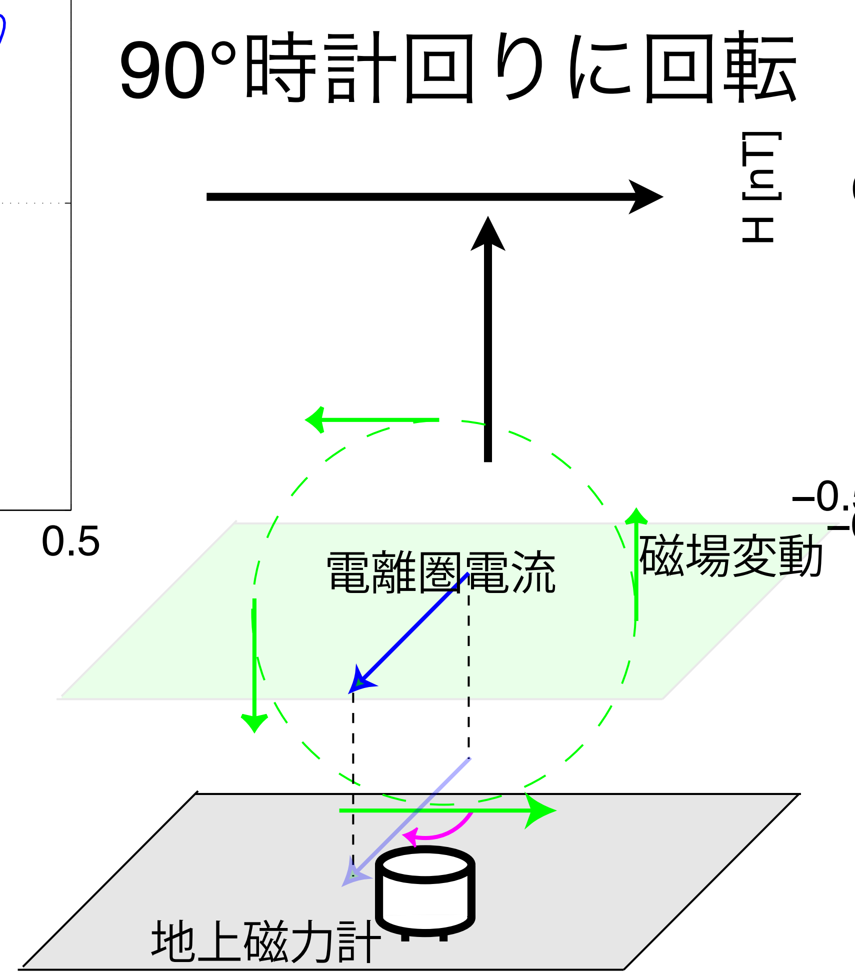
Pi2の等価電流の定義

水平成分に関して主軸に沿った変動のみに注目する

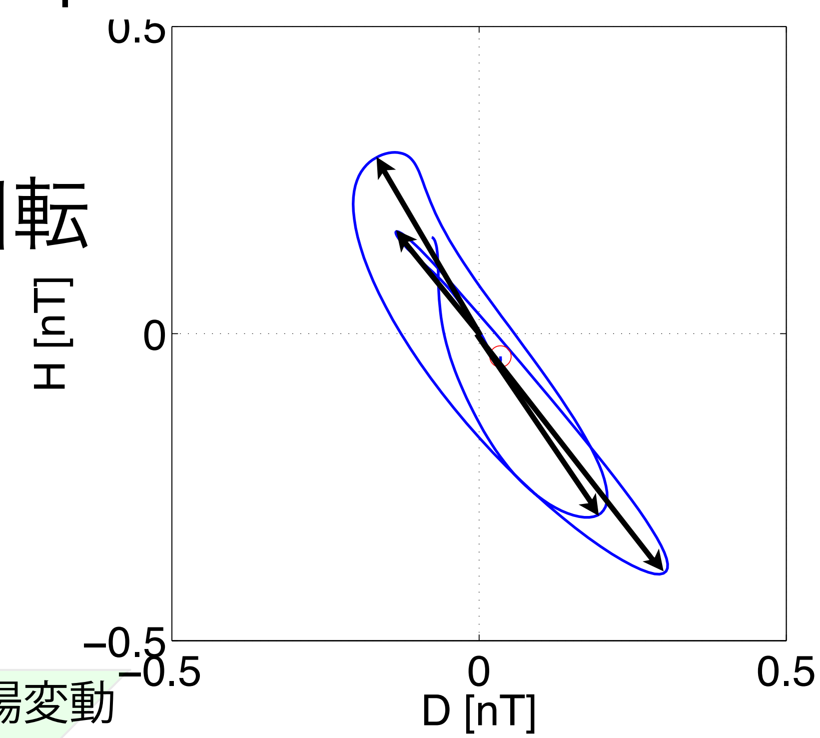
水平成分の磁場変動($\sqrt{\Delta H^2 + \Delta D^2}$)の極大時に関して等価電流の方向をマッピングする

magnetic perturbation of Pi 2 range

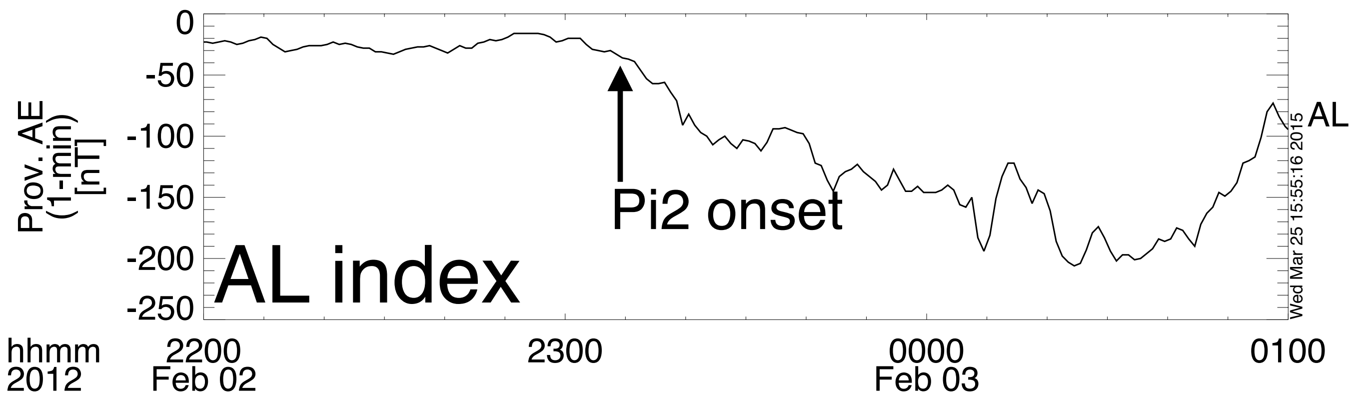


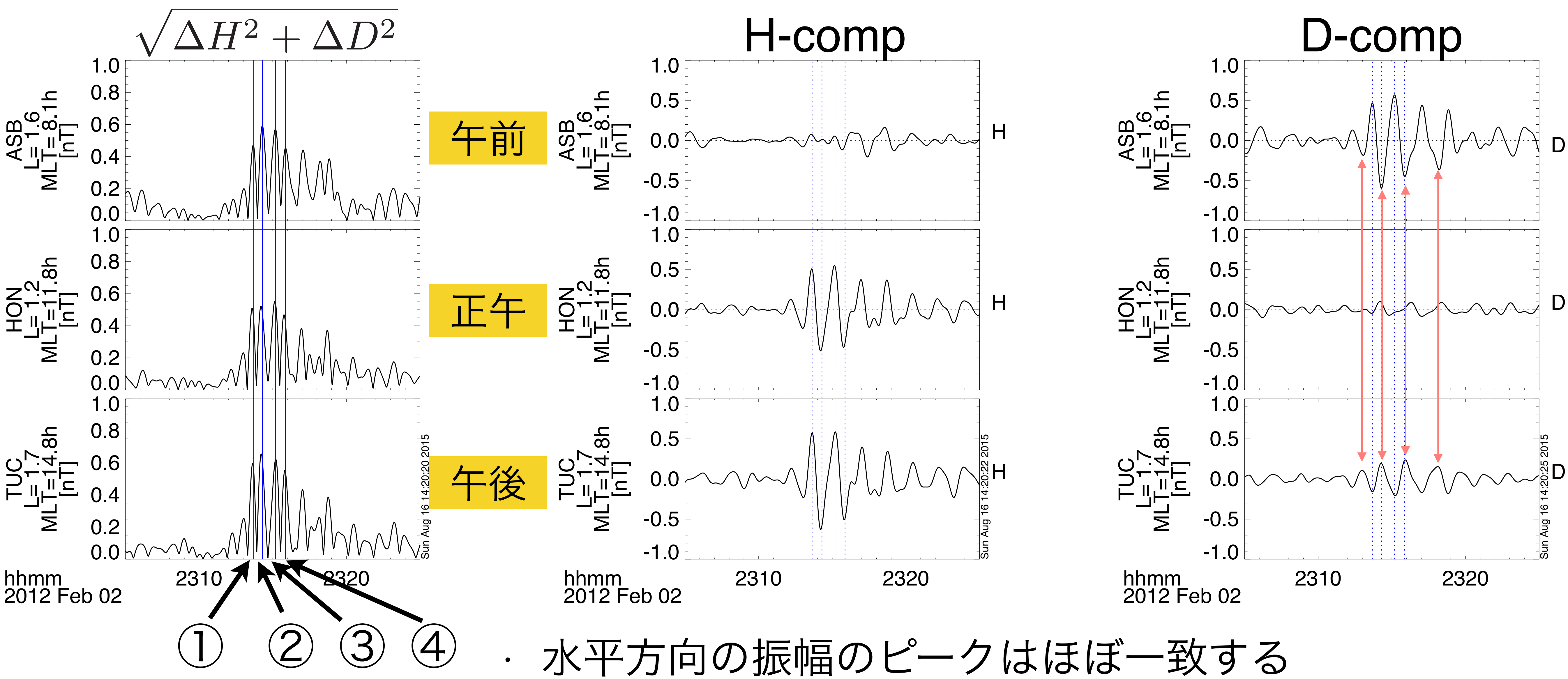


Equivalent current of Pi 2 range



AL index, 昼間側Pi2の波形 (23:10 UT on 2 February 2012)

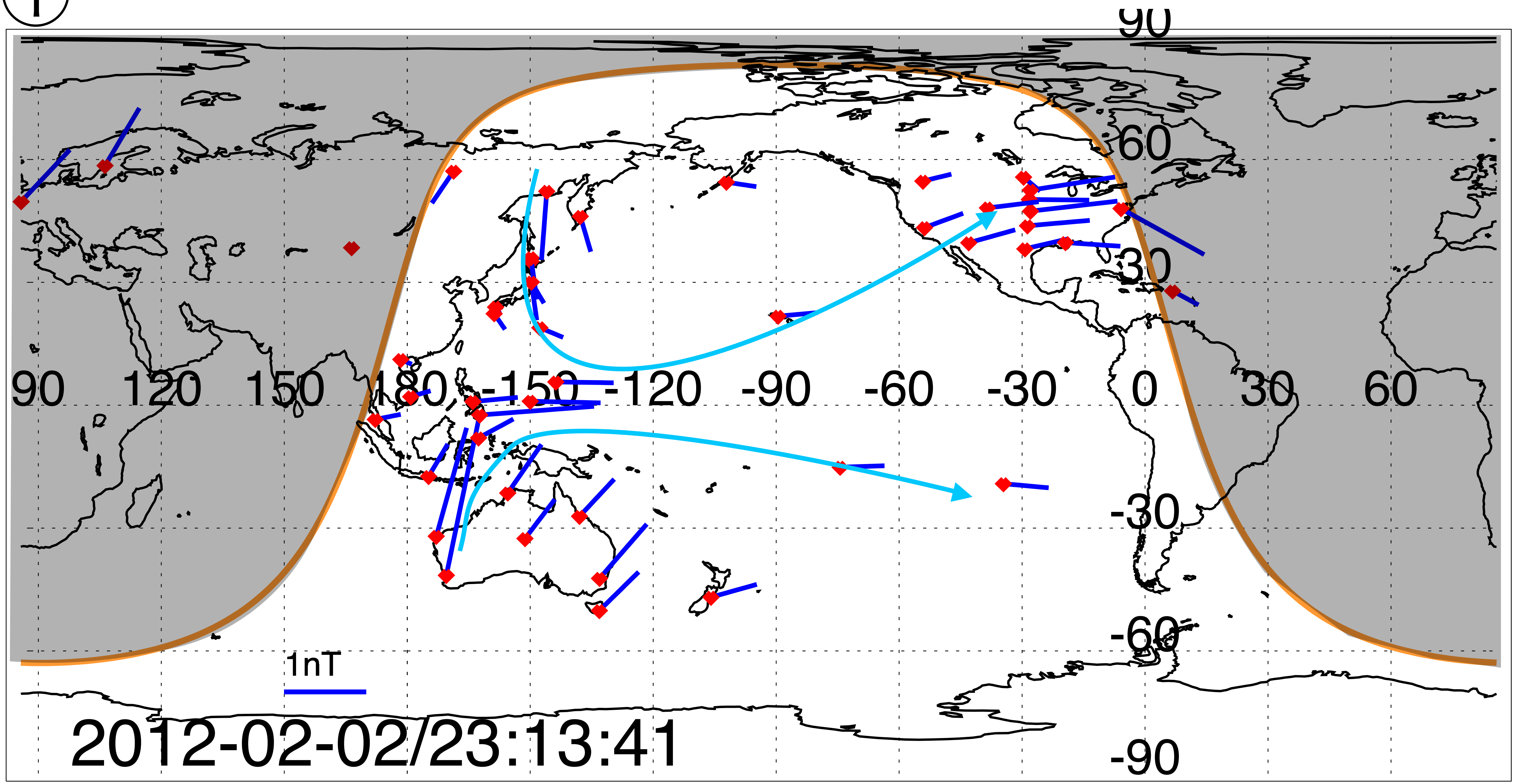




- 水平方向の振幅のピークはほぼ一致する
- 午前-午後でD成分の位相が反転
- D/H振幅比は午前側が大きい

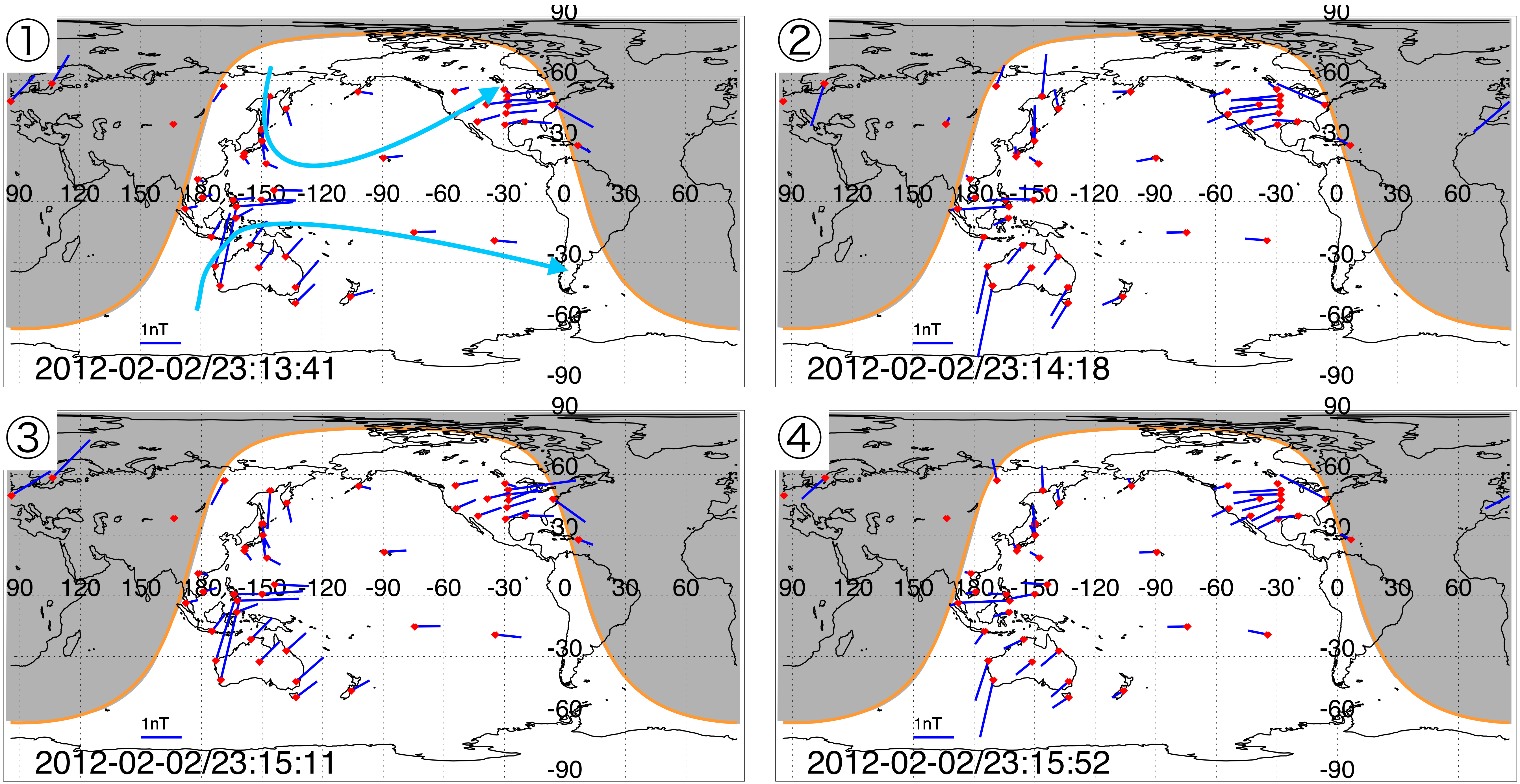
Equivalent currents at the first local maximum

①



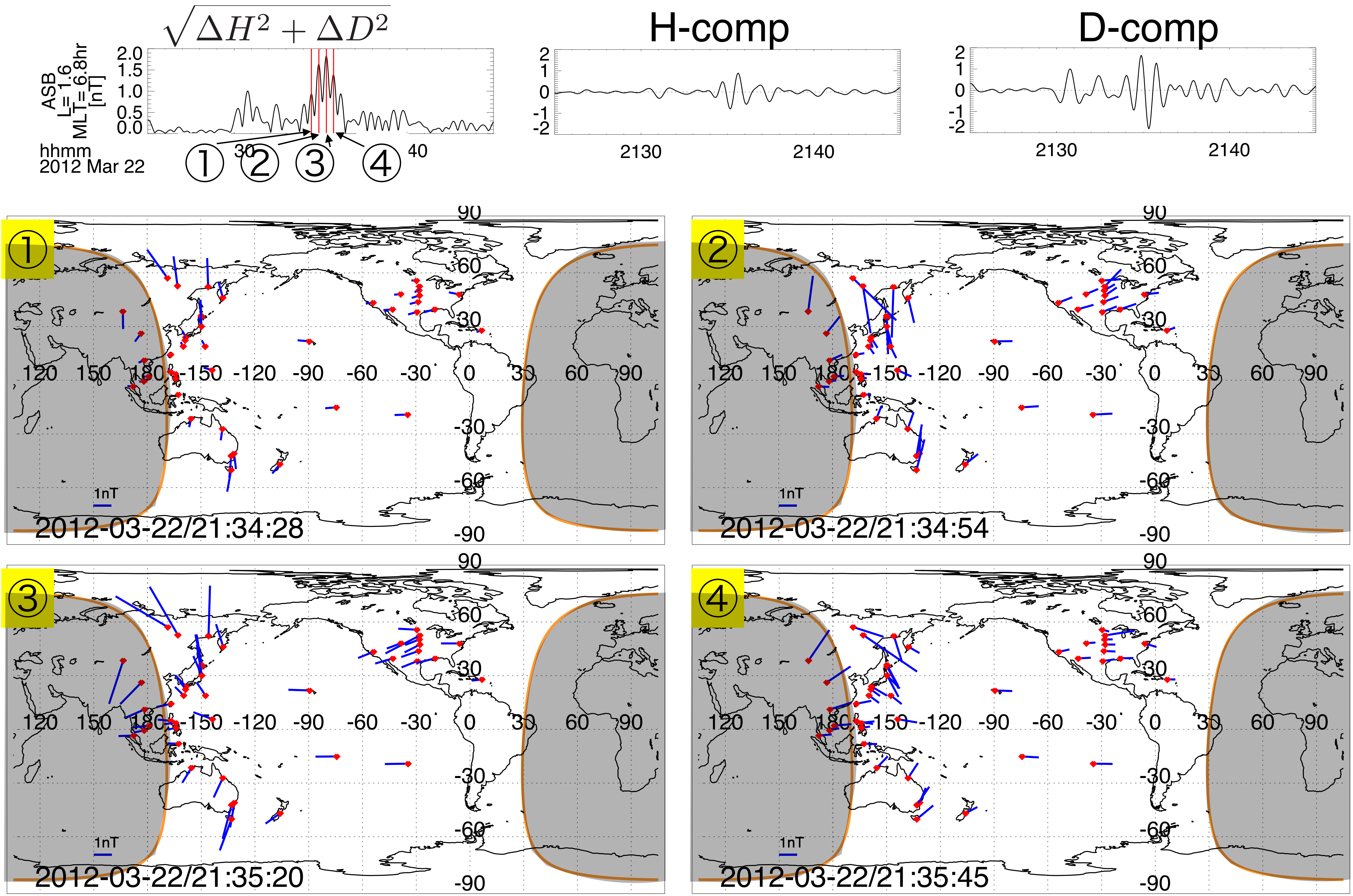
- The meridional component of equivalent current vectors are directed equatorward in the prenoon sector and poleward in the postnoon sector.
- The meridional component in the postnoon sector is smaller than in the prenoon sector.

Time variation of equivalent current

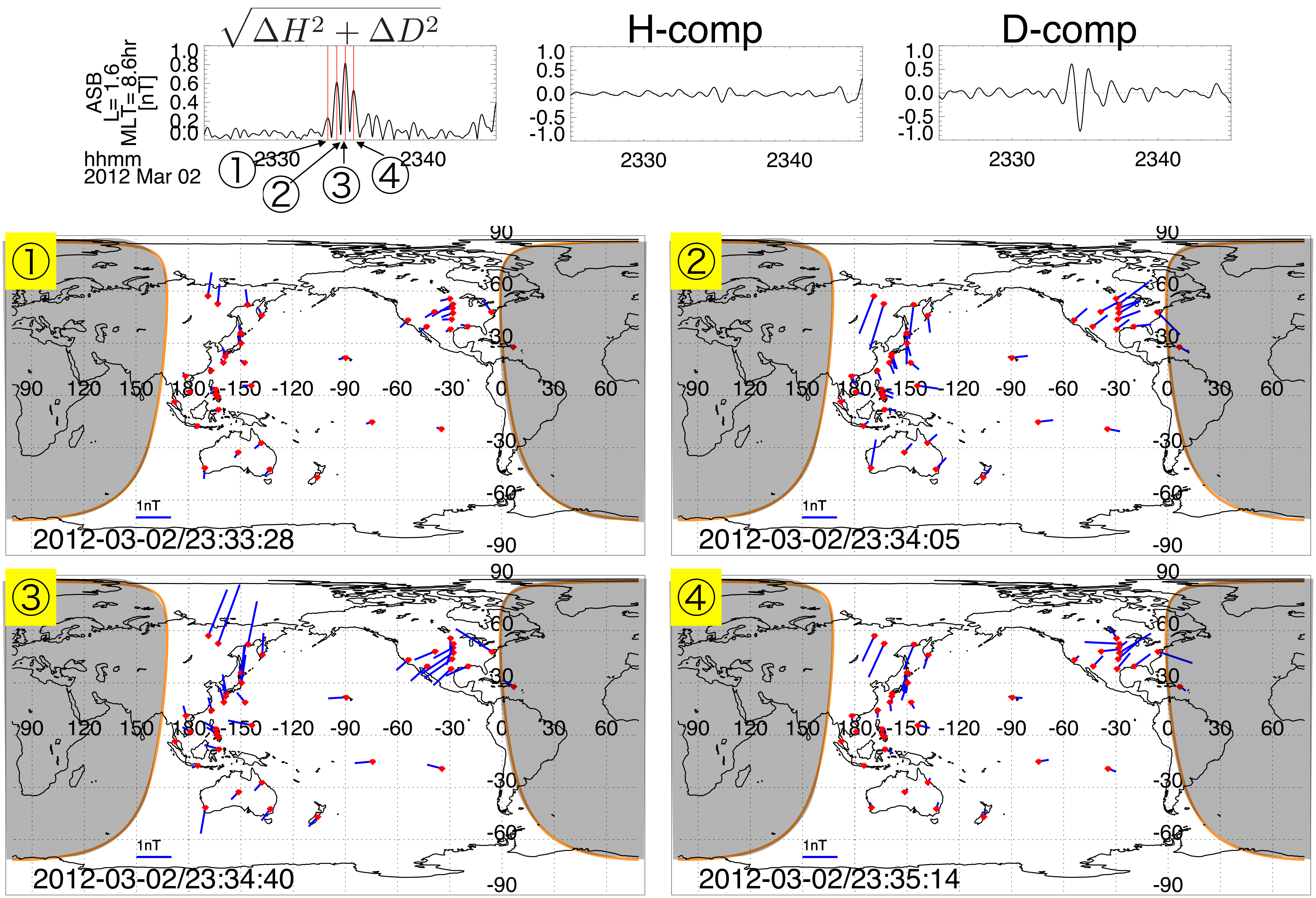


- 午前午後で赤道方向に出入りするような逆成分の南北成分電流が見られる
- 午前側でより南北電流の卓越した非対称性が見られる
- 電流系形状を維持したままPi2周期で振動している

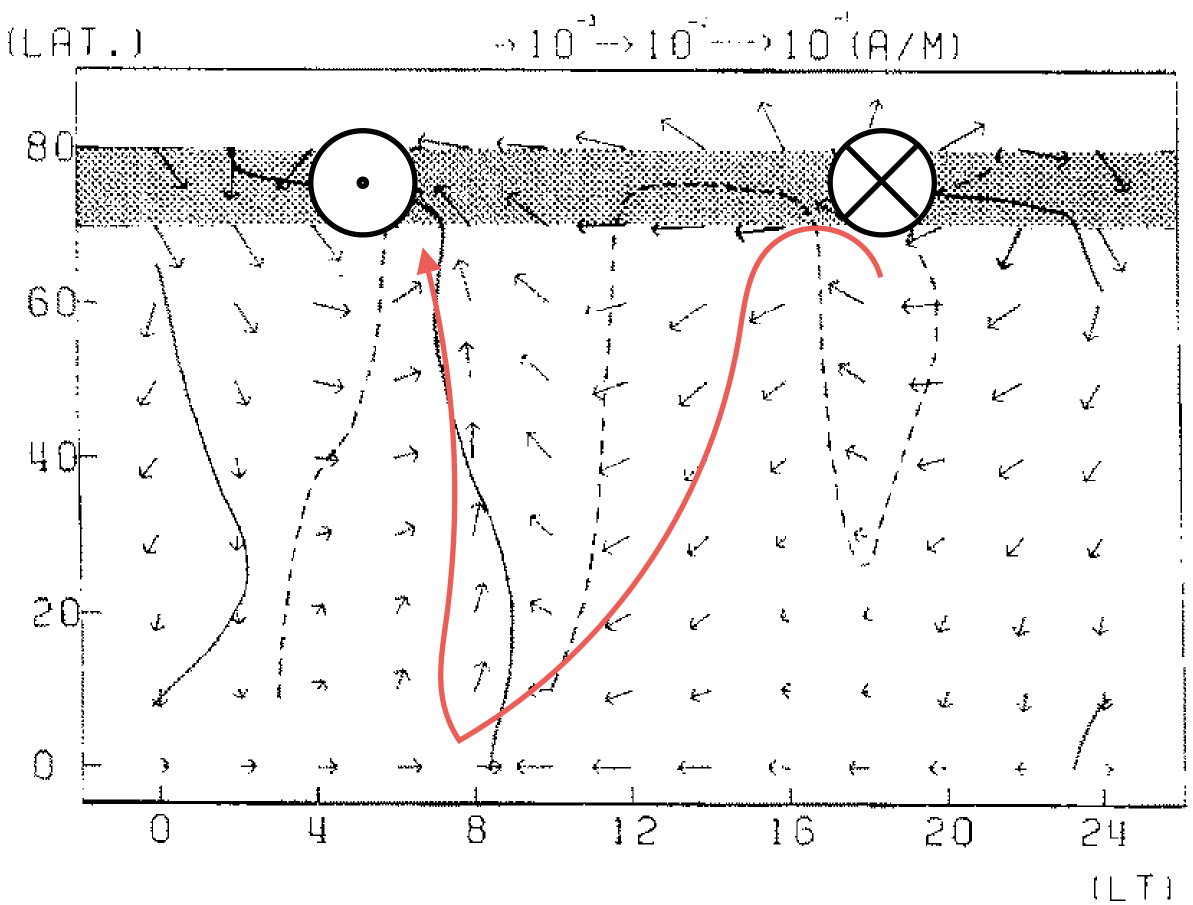
Event 2 (2012-03-22/21:35:00)



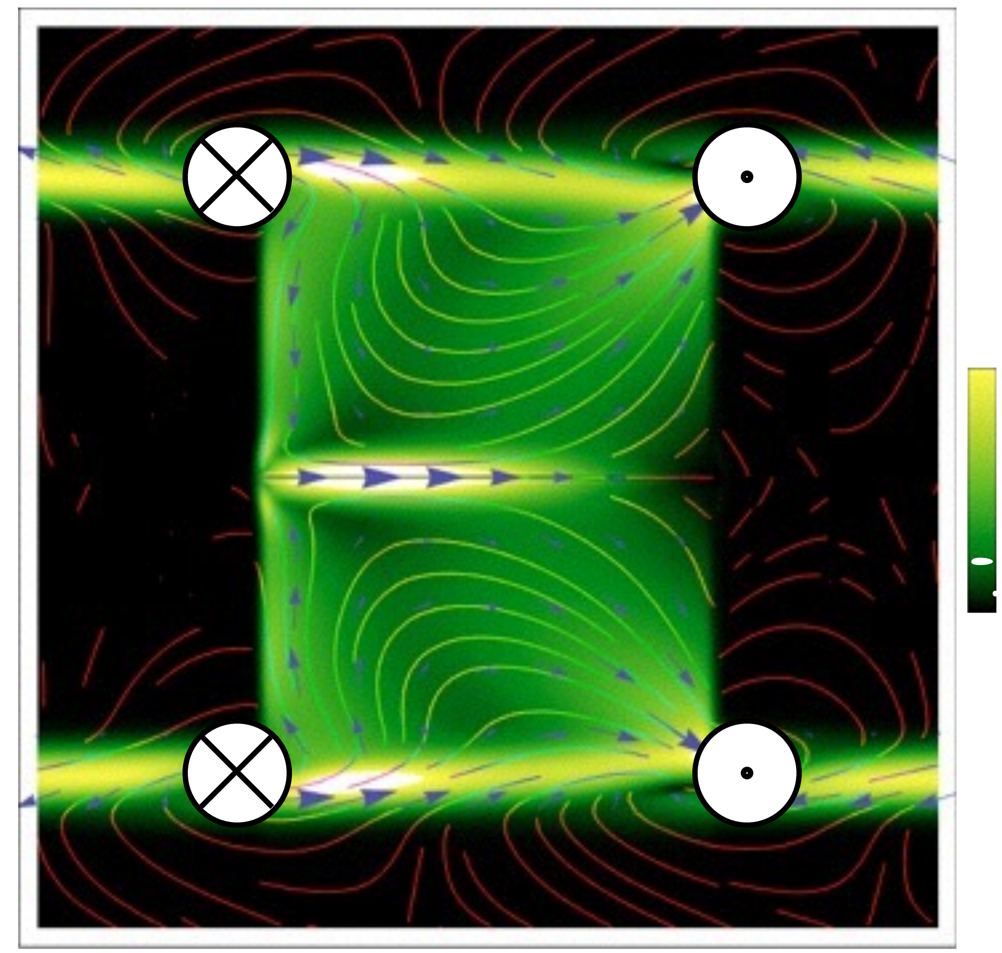
Event 3 (2012-03-02/23:35:00)



電離層電流系の数値計算



Tsunomura and Araki [PSS, 1984]



Yoshikawa et al. [AGU fall meeting, 2012]

昼間側Pi2の等価電流はdawnとduskにFACを置いた
時の昼間側電離圏電流系とゆがみ方がよく似ている

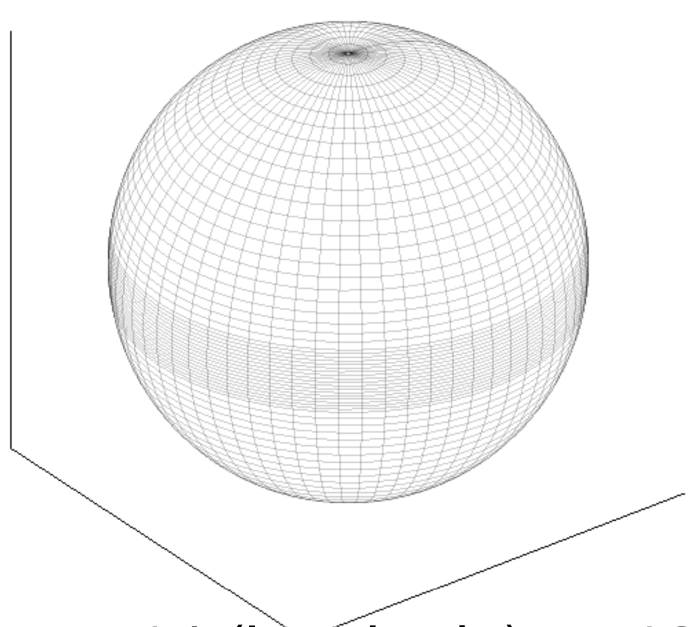
夜側に局在したFACでも同様の昼間側電離圏電流系が出来るのか?

Ionospheric current derived by global potential solver

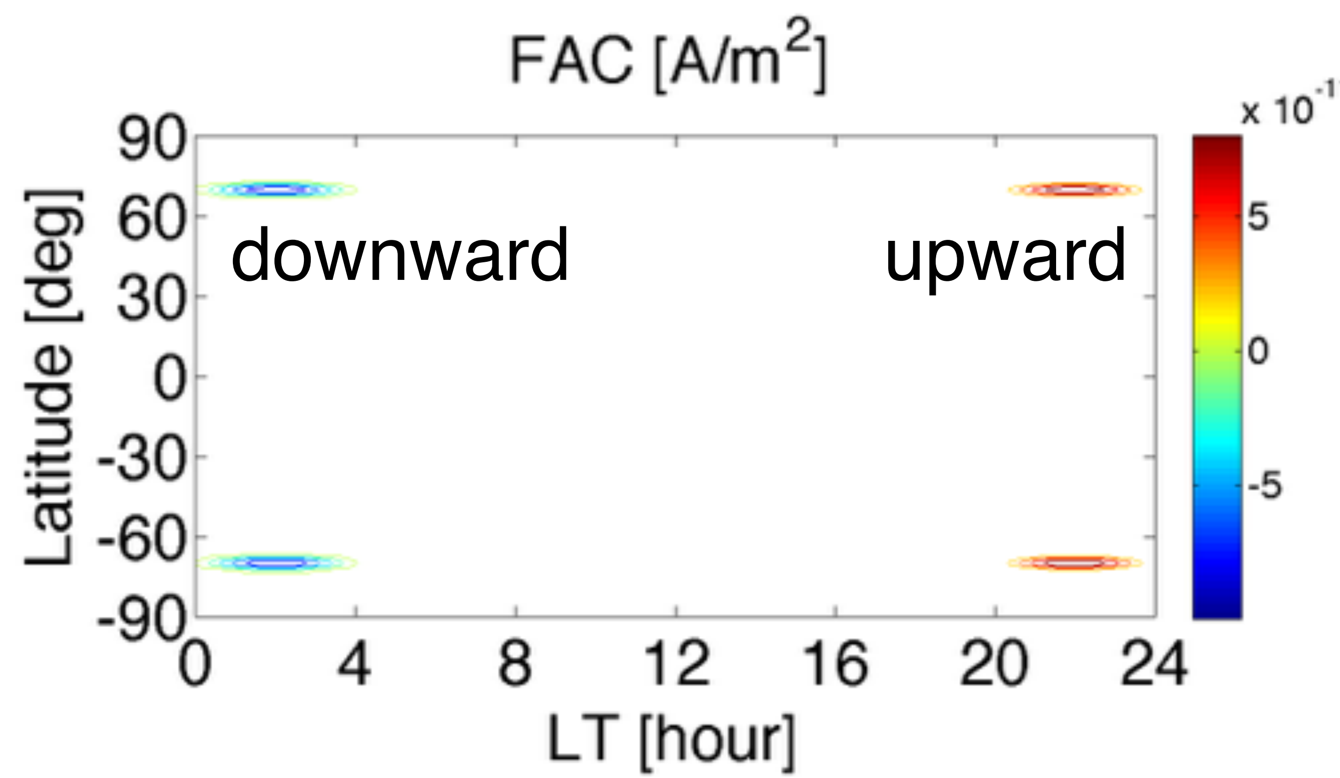
We solve ionospheric potential Φ produced by fixed FACs in a similar frame work of Nakamizo et al. [2012]

We derive ionospheric current J from $E = -\nabla \cdot \Phi$ and $J = \Sigma \cdot E$

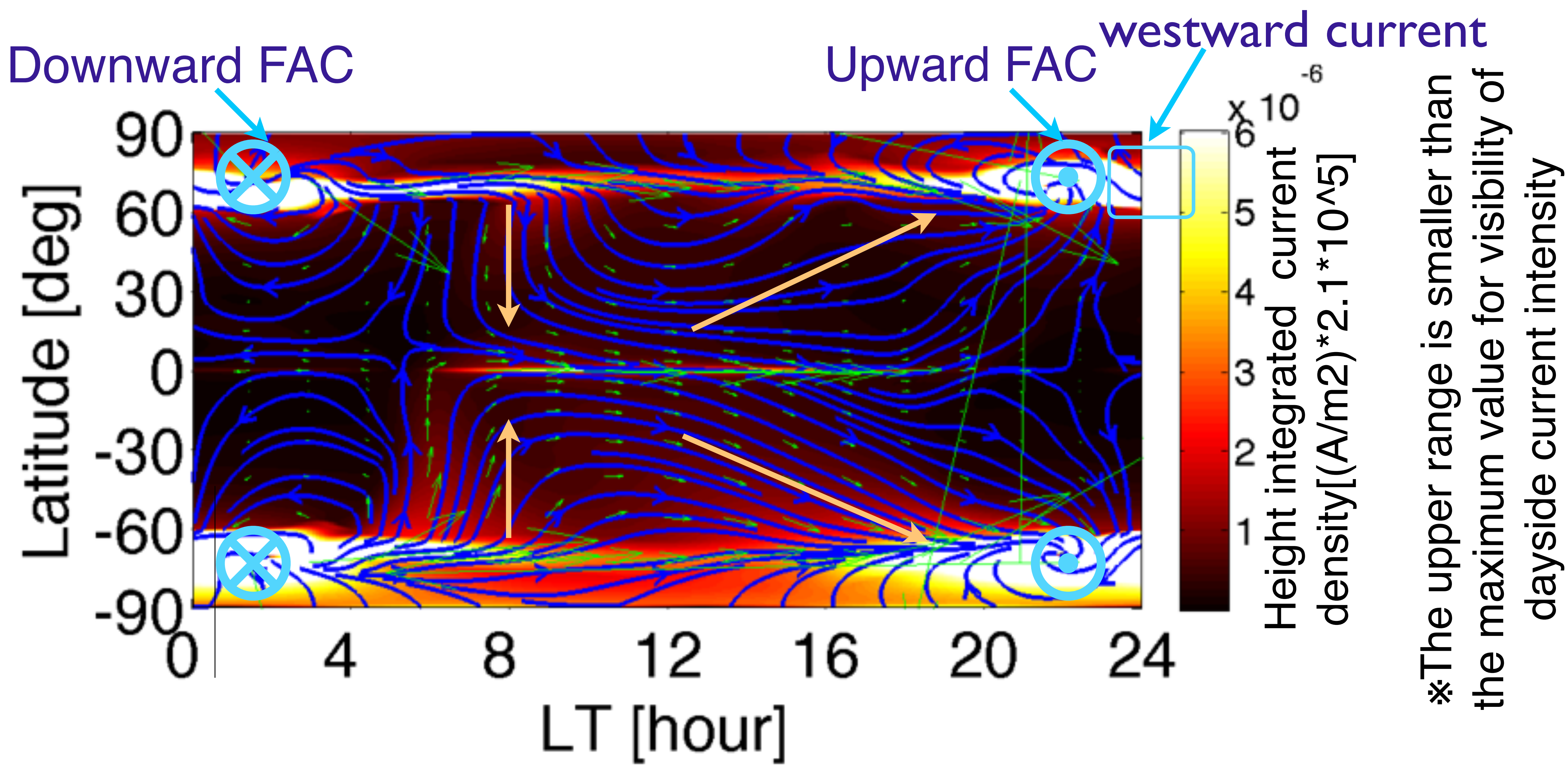
- Time-variable effects are negligible.
- Relative value of outputs does not depend on the magnitude of FACs.
- Conductivity tensor are calculated by the same method as Nakamizo et al. with input parameters at the case study event. This method includes the modifications by auroral precipitation [Hardy et al., 1987] and equatorial Cowling conductivity [Tsunomura, 1999].



grid size : 514 (longitude) x 513 (latitude)
(The grid size of the figure is reduced by 1/8)



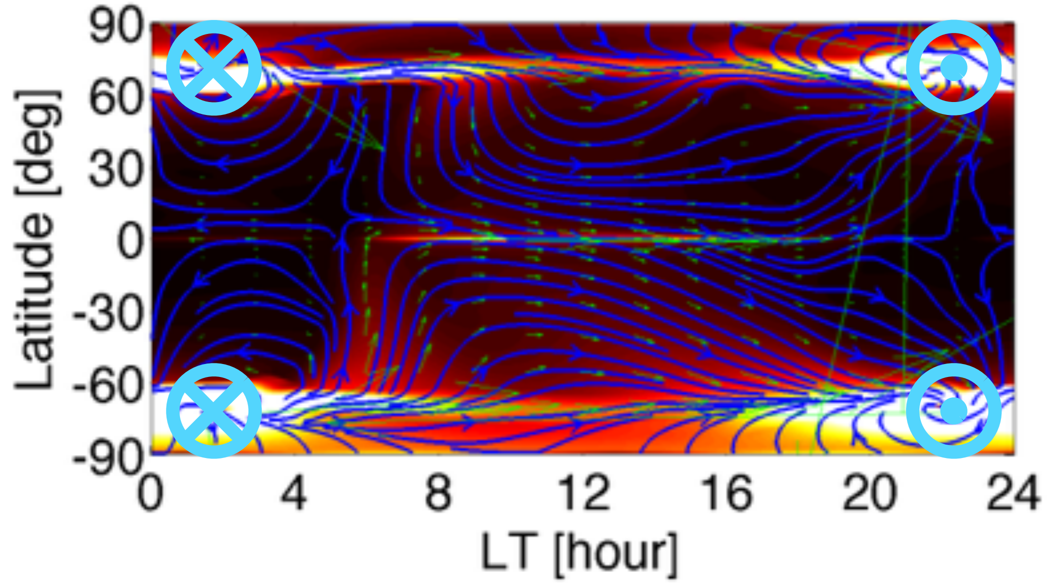
Calculated ionospheric current distribution



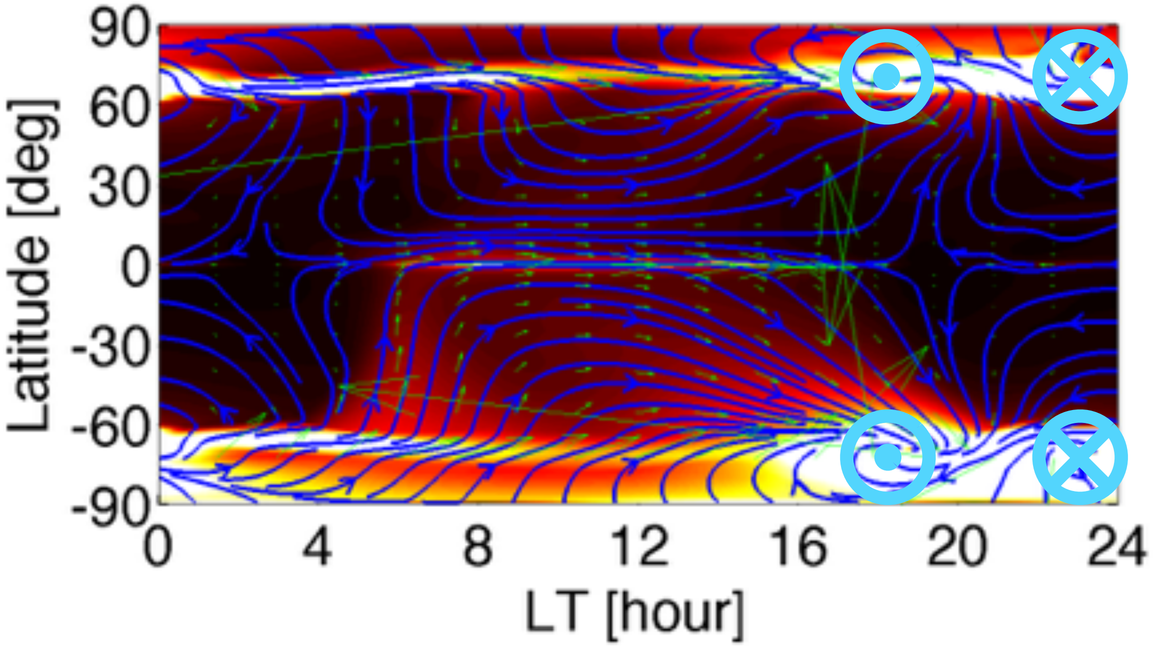
- The zonal current reaches a peak at the equator because of higher conductivities modified by the Cowling effect.
- The simulated dayside current system shows the prenoon-postnoon asymmetry similar to equivalent current distributions of dayside Pi2.
- The order of the current density in the dayside low-latitude region is approximately 1/100 of the current density in the nightside auroral region.

偏ったFAC配置の場合

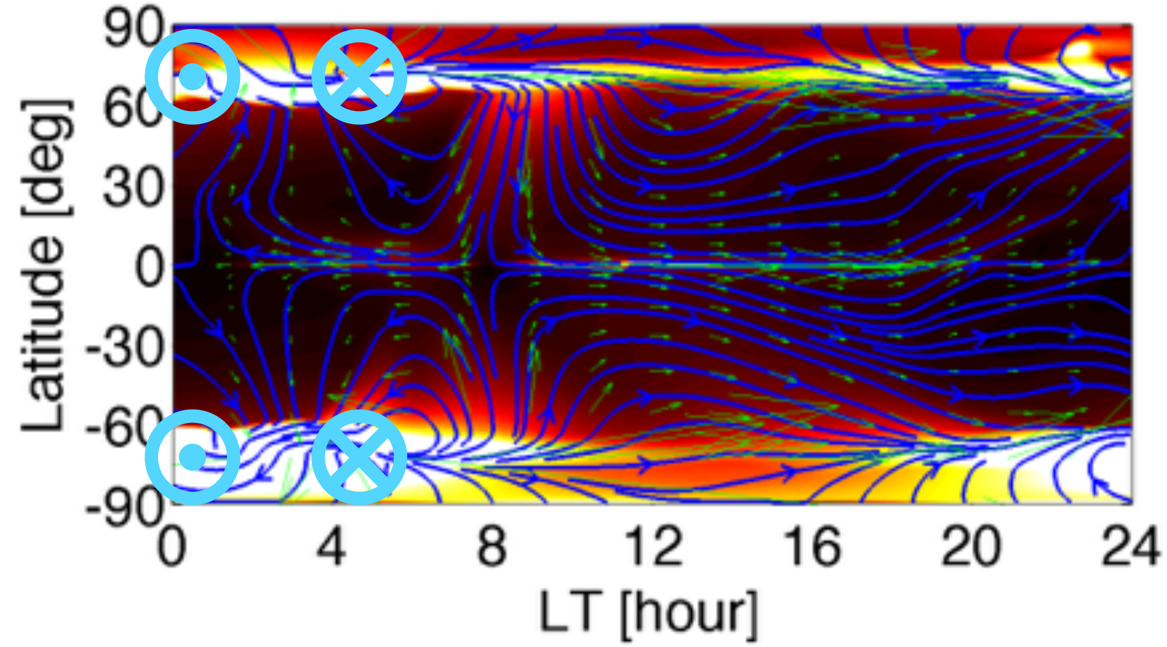
対称な場合　Current



夕方側寄り　Current

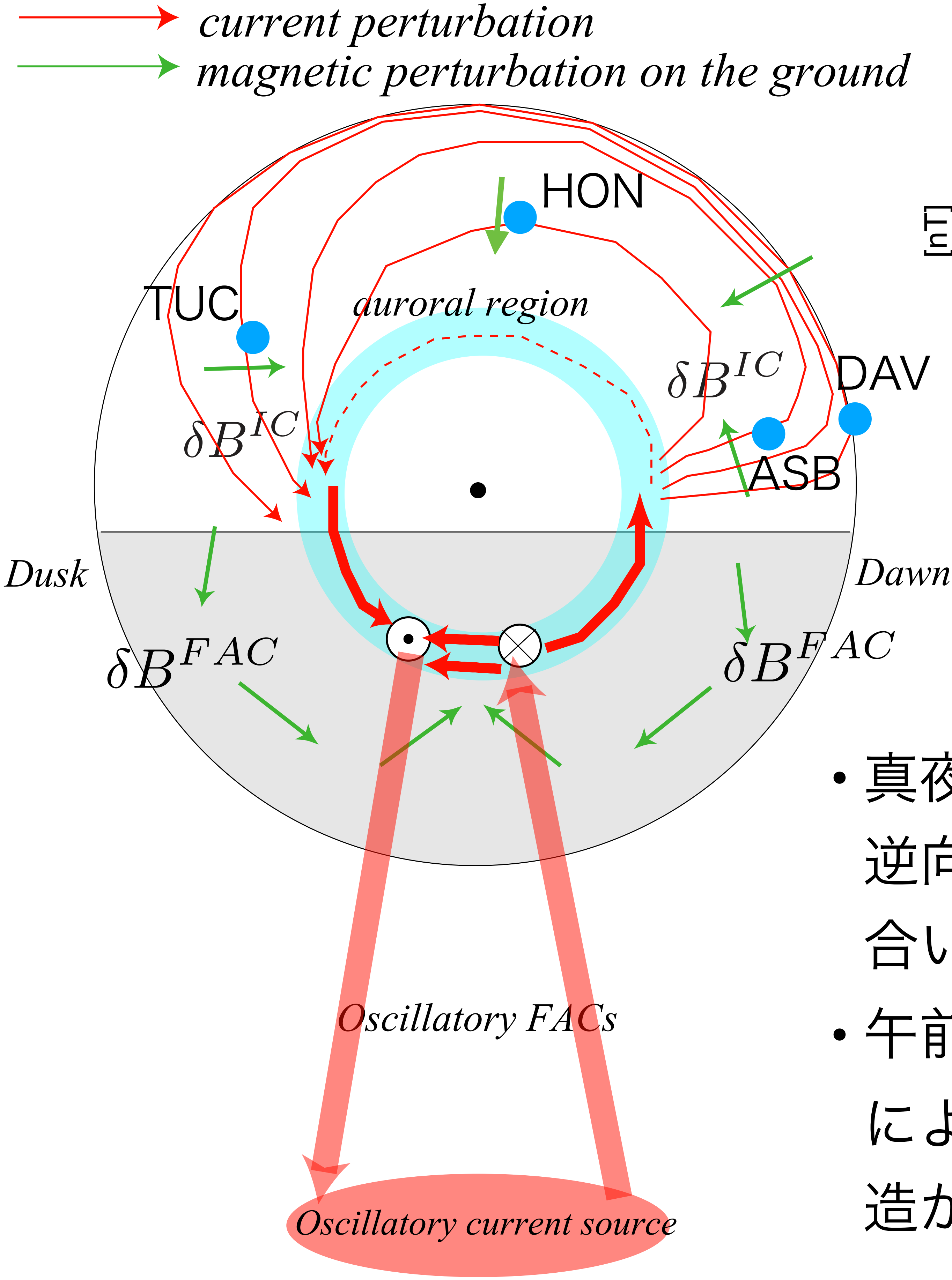


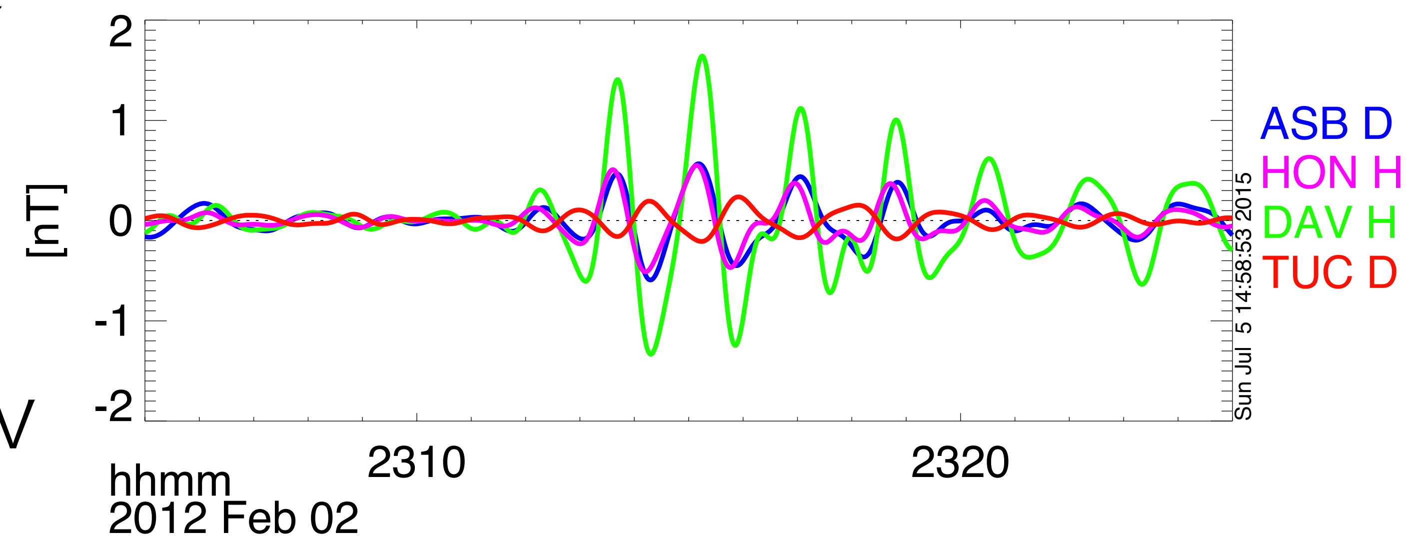
朝方側寄り　Current



- 昼間側で閉じる電流系の非対称性に対するFACの非対称性の依存は小さい
- イベントごとのFACの構造は昼間側電流系にあまり影響しないと考えられる

Pi2のグローバル電流系による解釈





- 真夜中、真昼、朝夕昼夜境界付近では逆向きに東西成分磁場変動が打ち消し合い位相が反転する。
- 午前-午後のD/Hの振幅比の違いはFACによって作られる電離圏電流の歪んだ構造から説明出来る。

END

Thank you for your attention

Acknowledgement:
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