

# Storm time Penetration electric fields observed by SWARM and Ground based magnetometers

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# Overview

What is Prompt Penetration Electric Field (PPE)?

PPE during southward and northward IMF turnings

PPE during geomagnetic storms

- Data reduction of geomagnetic observatories

- Data reduction of SWARM

- Observations

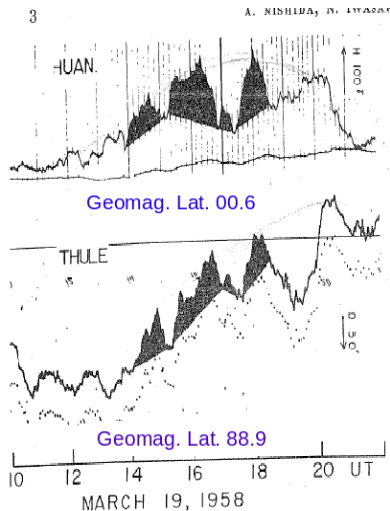
  - Ground based

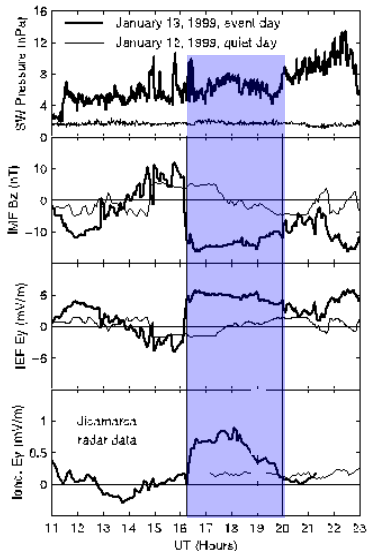
  - Satellite based

Summery

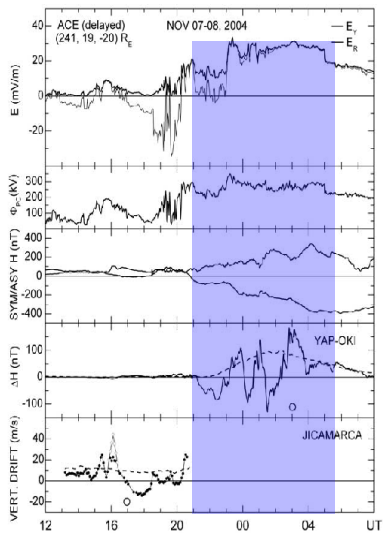
# What is Prompt Penetration Electric Field (PPE)?

- ▶ The geomagnetic fluctuations at the equatorial stations correlated with high latitudes geomagnetic fluctuations [Nishida et al.,1966, Nishida,1968, Kikuchi et al.,1996]
- ▶ Indicates the instantaneous transmission of high latitude electric fields to equatorial region which is termed as a prompt penetration of electric field (**PPE**).





Huang et al., 2005



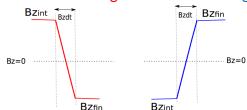
Fejer et al., 2007

## Characteristics of prompt penetration electric fields during southward and northward IMF turnings

*Bhaskar and Vichare, JGR 2013.*

- Total 250 events were identified and analyzed using EEJ index and interplanetary electric fields.
- EEJ index in all events is normalized to noon values.

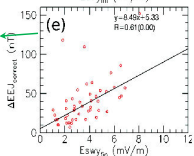
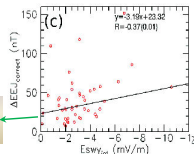
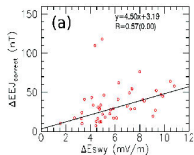
Southward turning Northward turning



North to zero  
Scatter

Zero to South  
Good dependence  
Prompt Penetration effect

Southward



Northward

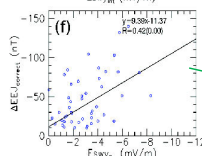
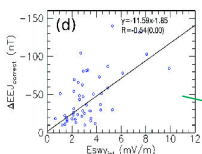
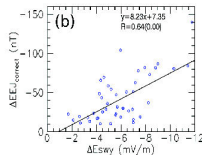


Fig (a) & (b) show higher efficiency during northward turnings.

South to zero  
Good dependence  
Reduction in convection

Zero to North  
Overshielding effect

Thus, the study signifies the role of inner magnetospheric shielding electric field in addition to ceasing of convection during northward turnings.

## PPE during geomagnetic storms

- ▶ Geomagnetic storms are built up due to large southward IMF  $B_z$ .
- ▶ Interplanetary electric field associate with IMF  $B_z$  transmits to the ionosphere.
- ▶ The signatures can be observed in ground magnetometers and low altitude satellites

### Database

- ▶ Geomagnetic field measurements from *INTERMAGNET*, (about 120 observatories)
- ▶ Vector magnetic field data from *SWARM*
- ▶ Interplanetary data at 1 AU, *OMNI*.

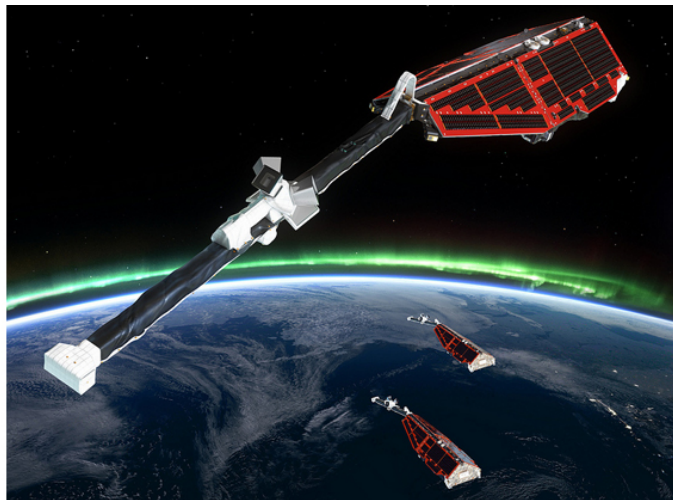
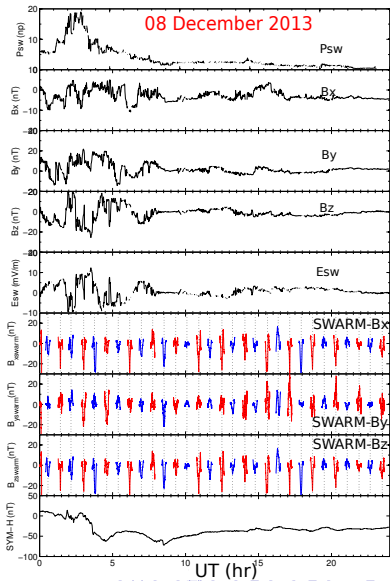
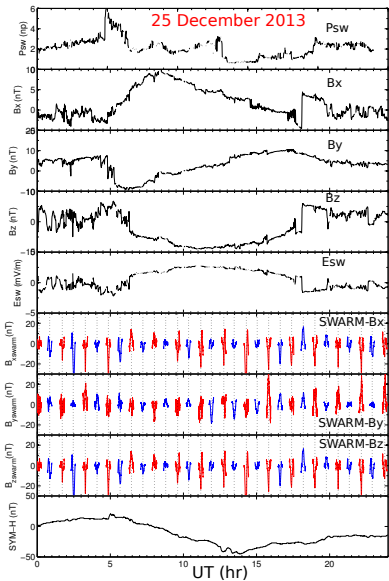


Figure: Artistic impression of SWARM satellites

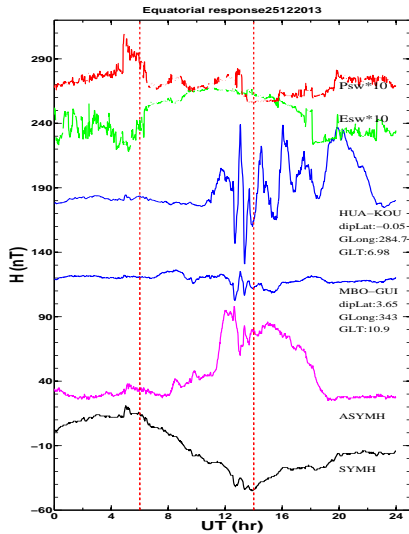
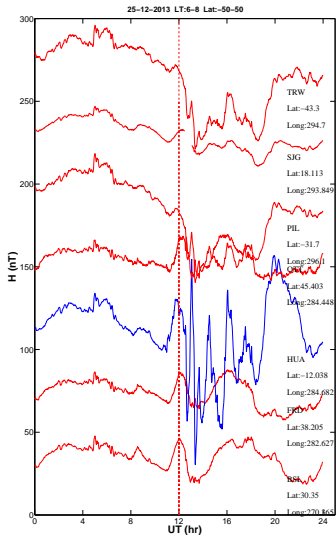
## Data reduction

- ▶ To estimate magnetospheric effect quite time diurnal variation is subtracted.
- ▶ For equatorial stations, low latitude off-equatorial magnetic variations were also removed.
- ▶ To extract small magnetic field variations due to ionospheric phenomenon POMME 6.1 model used to subtract internal geomagnetic field.
- ▶ To overcome on longitudinal variation in Estimated ionospheric magnetic signature of each pass previous quite day pass corresponding to similar longitude were subtracted.

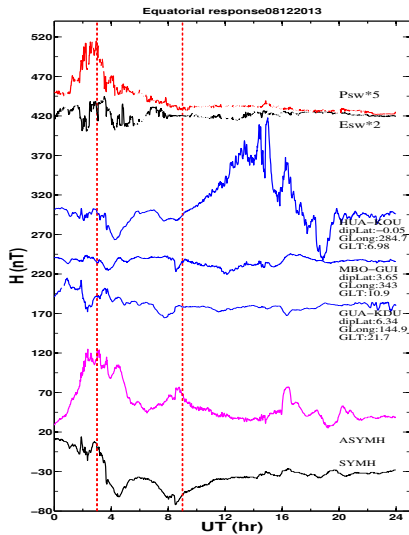
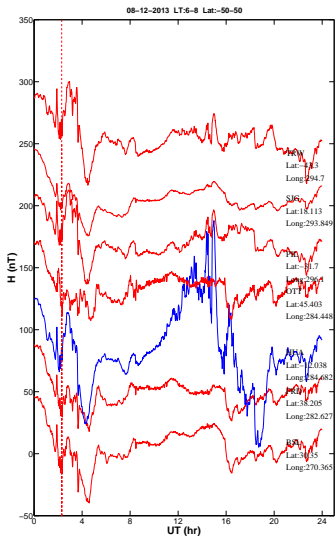




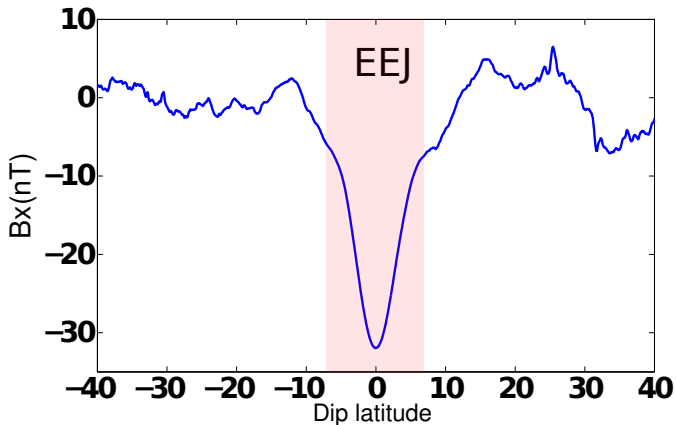
# Equatorial geomagnetic response for Dec 25, 2013



## Equatorial geomagnetic response for Dec 08, 2013 storm

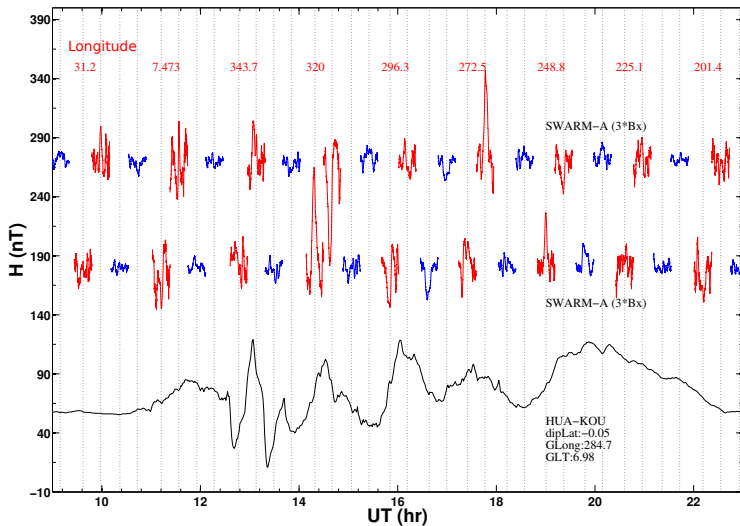


## Typical day time EEJ profile observed by SWARM



$$B_x = B_{x\text{SWARM}} - (B_{x\text{internal}} + B_{x\text{sq}})$$

## Quite time subtracted SWARM and ground based variations



## Summery

- ▶ During almost steady IMF  $B_z$  large fluctuations (100nT) in EEJ observed for December 25, 2013 storm.
- ▶ The rapid positive and negative excursion of EEJ indicate under-shielding and over-shielding state of the inner magnetosphere.
- ▶ These rapid excursions appear to be due to small fluctuations in solar wind dynamic pressure.
- ▶ Overall strength of the EEJ on storm days remained high compare to the previous quite days.
- ▶ The EEJ latitudinal profiles are constructed which are similar to that of CHAMP.
- ▶ However, day to day variability and spatial dependence of EEJ put constraints on the interpretations.
- ▶ The derived equatorial ionospheric electric field will be used to investigate PPE signatures in detail.

Thank you