Relation between variations of the solar wind and noon-time equatorial ionospheric electric fields

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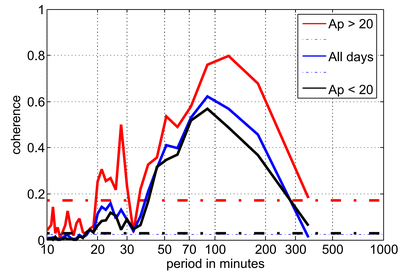
1. Introduction

Penetration of the interplanetary electric field (IEF) to the mid and low latitude ionosphere is well documented (Nishida 1968, Kikuchi et al. 1996). This effect was believed to last only upto ~30 minutes due to a shielding effect by the ring current system. However, recent studies (Huang et al., 2005, Kelley at al., 2007) report that the Prompt Penetrating Field can be present for longer durations (up to 10 hours) in the low-latitude ionsophere. Due to the sporadic nature of radar-based ionospheric electric field and/or magnetic field measurements, most of these studies were event based. Hence the frequency dependance of electric field penetration to low latitudes is not clearly understood. Using six years of ionospheric drift measurements at the low latitude JULIA radar, and the interplanetary solar wind and magnetic field measured by the ACE satellite, we estimate a coherence spectrum between IEF and the equatorial drift velocities. We also investigate the coherence of IEF with polar-cap-potential index (PC), sub-auroral geomagnetic data from LER & ESK and the equatorial electrojet index.

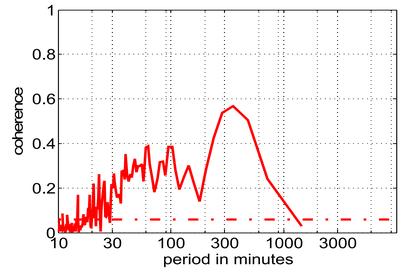
2. Data and analysis

Station	GG Lat	GG Long	Type of data	Period
ACE	Satellite		Solar wind, IMF	2000-2006
JULIA	-11.95	283.13	Vertical drift ,Vz	2000-2006
HUA	-12.05	284.67	H nT	2000-2006
PIU	-5.01	278.93	H nT	2000-2006
LER	55.32	356.8	H nT	2000-2006
ESK	60.13	358.82	H nT	2000-2006
THU	76.55	291.17	PC index	2000-2005

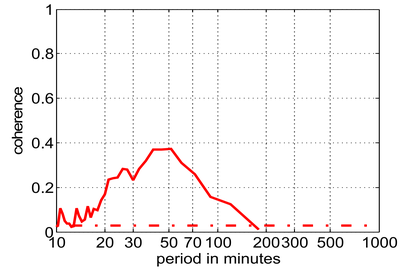
We restrict our study to geomagnetically active days with Ap > 20 and local time 9-15. The ACE data were first propagated to the magnetopause and then delayed by 20 minutes to account for the signal propagation from the magnetopause to the ionosphere. The JULIA and magnetometer data were high-pass filtered to remove the regular daily variations. Finally, the coherence spectrum was estimated using Welch's average periodogram method and its confidence level was estimated following Thompson(1979).



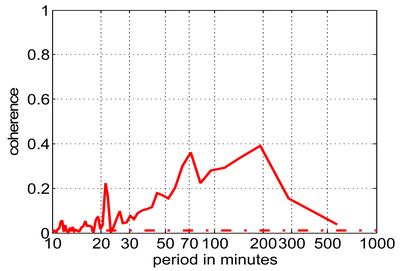
Coherence between ACE Ey and JULIA Vz. The coherence is highest for days with high geomagnetic activity levels. The broken line indicates a 95% confidence level of the null hypothesis.



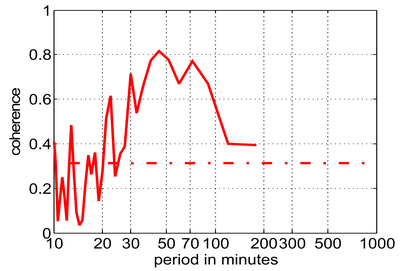
Coherence between ACE Ey and PC index.



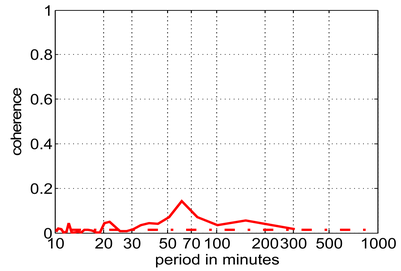
Coherence between JULIA Vz and LER-ESK magnetic data.



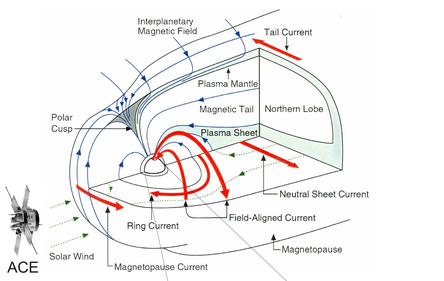
Coherence between ACE Ey and EEJ index (HUA -PIU).

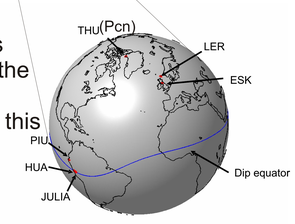


Coherence between JULIA Vz and PC index.

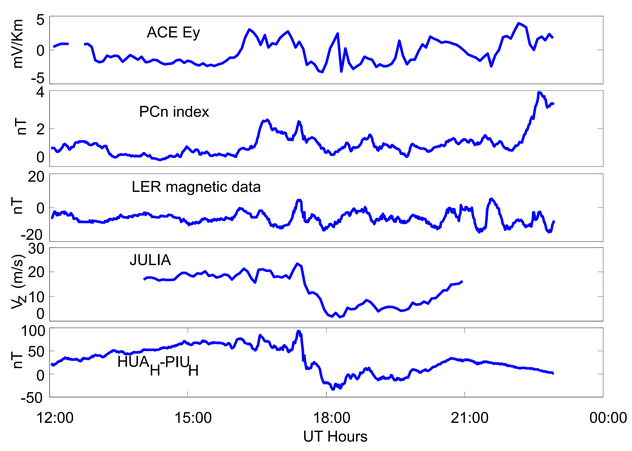


Coherence between ACE Ey and LER-ESK magnetic data.





Cartoon of the Earth's magnetosphere and the locations of the observatories used in this study



Sample time series from all stations for the day 2002-12-06. The are highly correlated across all the data sets.

3. Results and conclusions:

The coherence spectrum between ACE Ey and JULIA Vz show two statistically significant peaks at 20-30 minutes and 70-200 minutes. The coherence reaches up to 0.8 for high-Ap days.
The coherence spectra between ACE Ey and EEJ index show similar pattern, but with lower values.
PC index shows moderate coherence with ACE Ey with a peak around 300 minutes. Interestingly, we find that the PC index is highly correlated with JULIA Vz in the period range 30-100 minutes. Sub-auroral magnetic variations observed at LER and ESK have smallest coherence with ACE Ey data. The coherence between LER-ESK and JULIA Vz is moderate, peaking at 50 minutes period.
The penetration of IEF to equatorial ionosphere is found to be an efficient process. The ionospheric current systems in the sub-auroral region seems to be less responsive to IEF variations.

4. Outlook:

The high coherence between IEF and equatorial electric field can be used to introduce daily variability in climatological models of equatorial electric field (cf. Alken, 2007)

References

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