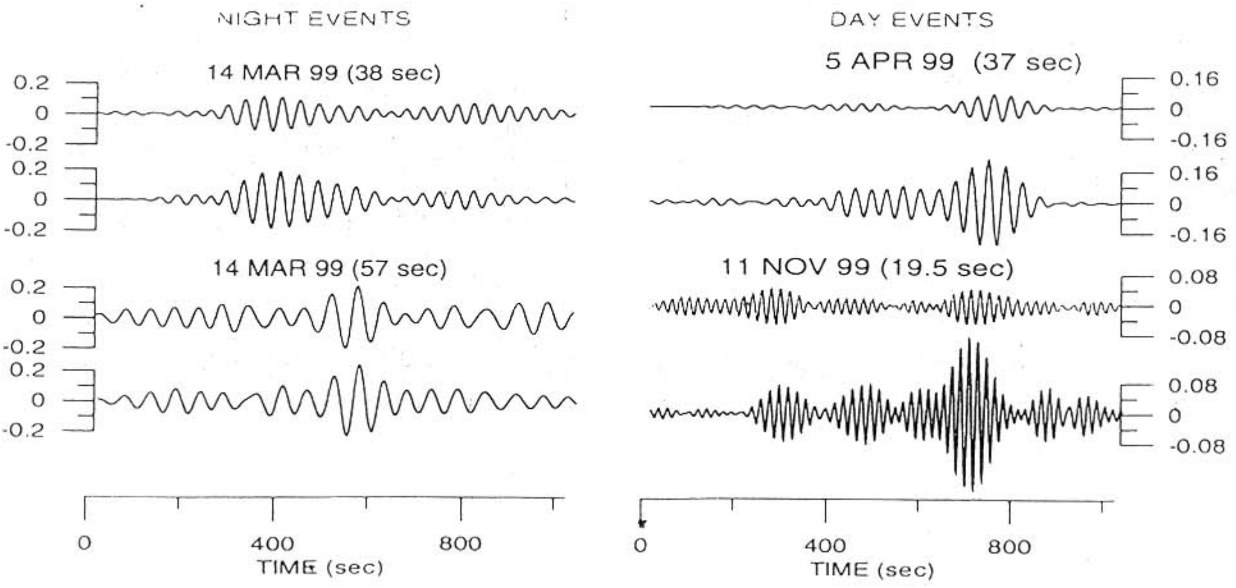
090707 ✓

IDENTIFICATION OF EXTERNAL CURRENT VARIATIONS IN OERSTED DATA.

Geeta Jadhav, Mita Rajaram and R. Rajaram.
Indian Institute of Geomagnetism, Mumbai-400 005. INDIA.

Geomagnetic pulsations (0.5s<T<1000s) are generally either transverse Alfven waves or compressional magneto-acoustic waves originating in the magnetosphere. There has been an increased interest in the study of compressional waves in the 10 to 150 seconds period range making up the Pc3-4 and Pi2 pulsation [eg. Kim and Takahashi, 1999]. These investigations have utilized satellite and ground data to identify cavity wave oscillations from the amplitude and phase relations between the satellite and surface measurements. An uncertainty in estimating the extent of modifications introduced by the ionosphere has come in the way of an unambiguous identification. **One of the less understood aspects of the propagation of the hydromagnetic waves to the surface of the earth is the role played by the low latitude ionosphere.** We study the amplitude and phase changes introduced by the ionosphere on compressional hydromagnetic waves passing through it. Oersted completes one rotation around the earth in ~90 minutes. Therefore in one minute, it covers around 4° in latitude. Temporal variation of period well in excess of a minute cannot be unambiguously identified as the spatial variations due to the quiet day ionospheric currents, including equatorial electrojet, can masquerade as temporal variations in the satellite data. Therefore, the study is restricted to less than 60 sec period. Ground based data taken from Japanese stations having 1 sec sampling rate of geomagnetic data with following geomagnetic latitude, geographic longitude coordinates: Kanoya (21.12°N, 130.88°E), Kakioka (26.62°N, 140.18°E) and Memambetsu (34.61°N, 144.20°E). **Satellite passes** were restricted to the geographic **longitude** zone between **125° E and 155° E** (scalar data). IGRF(10c/99) (Olsen and Sabaka, 2000) including Dst corrections of first order were removed from satellite observations. We examined 60 days of satellite scalar data, ~25% of passes exhibited oscillations in selected longitude zone. Pulsations could be unambiguously identified on days that included two night time and six day time events.

Satellite and ground time series data were band pass filtered to pass10-100 seconds oscillations. Power spectra of the three surface stations show similar structures on almost all events and almost all peaks in the surface station spectra appear as broad peaks in the satellite spectrum. Two closely spaced frequency peaks on the ground data tend to merge into a single peak in the satellite data. This could be due to the smearing out of the peak produced by the satellite motion. It is also observed that the relative power (ratio of the powers at the two frequencies) need not be same at the satellite and the ground stations.



Frequency peaks which are seen in the satellite and all three ground stations are selected. The data are then subjected to standard band pass filter centered at the corresponding common spectral line. The band passed data have been subjected to a cross correlation analysis. It is found that all the ground stations are by and large similar in structure, amplitude and phase. The above figure shows the filtered data sets for two night and two day events for the satellite and ground (corresponding to the highest correlation with the satellite). In the figure blue represents Kanoya, red Membabetsu and black Satellite. Here, both the satellite and ground data sets show same time structure. The table below shows nighttime and daytime events and periods of analysis, corresponding maximum correlation coefficients (ρ_{max}), corresponding time lag in seconds and phase shift in degrees related to maximum positive correlation coefficient.

NIGHT TIME EVENTS:

DATE 1999	PERIOD (SEC)	ρ_{max}	TIME LAG FOR ρ_{max} (SEC)
14 March	38	+0.92	0
	57	+0.84	0
5 April	34.5	+0.90	1
	41	+0.83	0

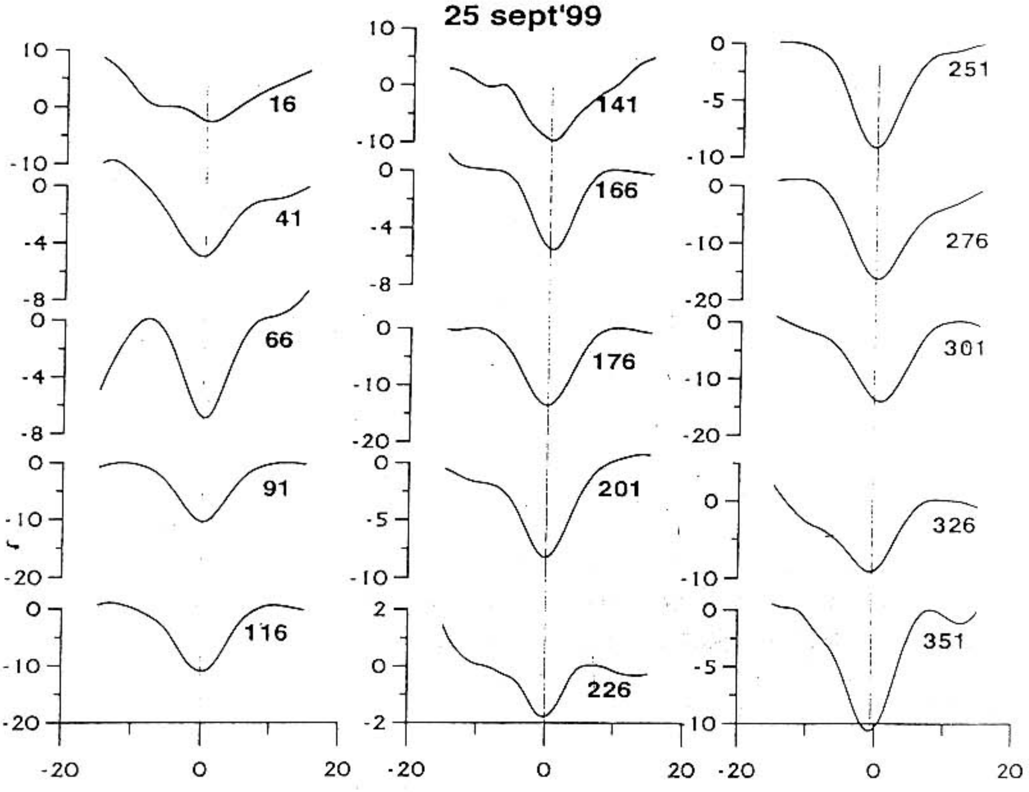
DAY TIME EVENTS:

NO.	DATE 1999	PERIOD (SEC)	ρ_{max}	TIME LAG FOR ρ_{max} (SEC)	PHASE (DEG.)
1	3 April	20.5	-0.85	2	215
2	5 April	37	-0.88	7	250
3	1 May	23	-0.73	2	210
4		27	-0.93	4	235
5		31	-0.87	5	240
6		40	-0.84	14	305
7	2 Nov	25	-0.79	8	295
8	11 Nov (a)	15	-0.82	4	275
9		19	-0.87	5	275
10		22.5	-0.86	7	290
11		30.5	-0.90	10	300
12		35	-0.92	12	300
13		43	-0.88	19	340
14	11 Nov (b)	19.5	-0.65	3	235
15		38	-0.81	9	265

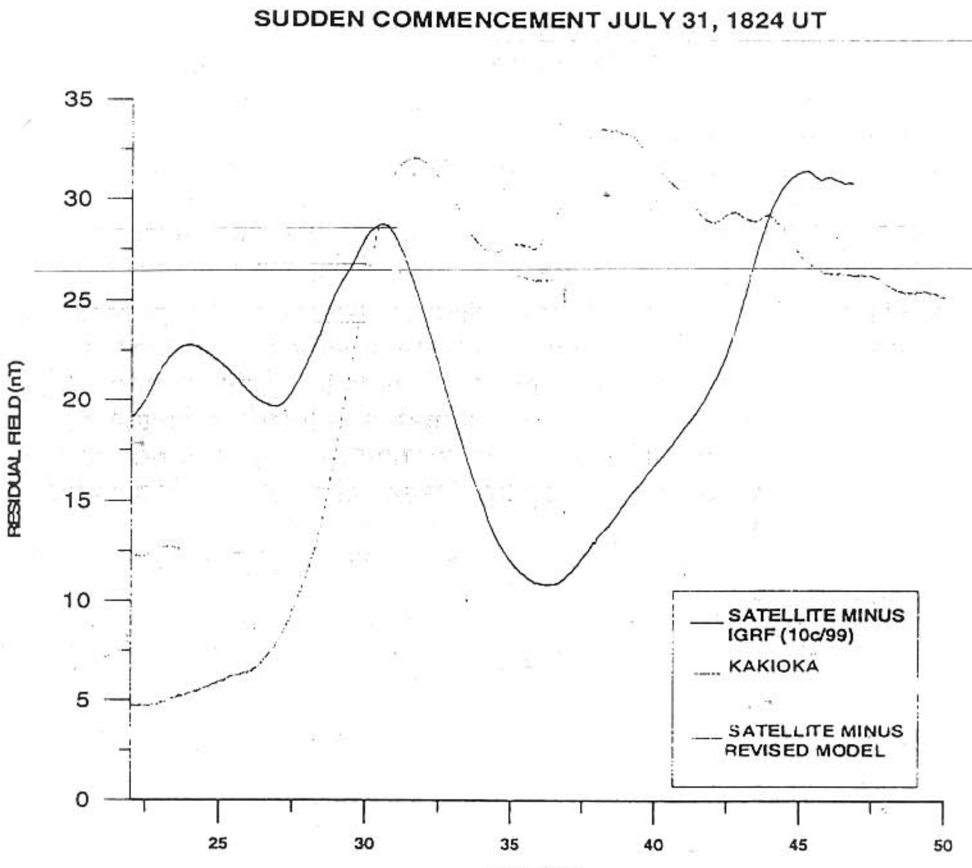
At night time, for all considered periods, ρ_{max} is very highly significant (~99.9%); satellite and ground data are in phase. The night time events show no significant enhancement at the satellite height. For day time events also the correlation between satellite and ground is remarkably good. **The ionosphere introduces considerable phase shift.** The phase shift is period dependent. It is also dependent on the condition of the ionosphere. The amplitude of the signal is greater at the satellite height than on the ground, indicating a clear effect of ionospheric screening. **The amplitude enhancement appears to be latitude dependent.** We find that **the daytime time amplitude enhancement are most significant in ± 20° latitude range.**

For identification of compressible cavity modes from simultaneous ground and satellite data, modification introduced by the ionosphere has to be incorporated.

The **Equatorial Electrojet** is controlled by the geomagnetic field as well as the atmospheric tidal forces. This combination of geomagnetic and geographically controlled dynamic forces can be expected to lead to longitudinal variations in the equatorial electrojet variations. More than 70% of the area covered by the dip equator lies in the oceanic region; thus Global coverage of the equatorial electrojet is possible only by Satellite data. For proper identification of the equatorial electrojet variations, after removal of IGRF (Olsen and Sabaka, personal communication) upto degree and order 19 and second order Dst variations, it is necessary to remove the background trend from the Oersted data. Plots of the electrojet signatures as a function of dip latitude, on a quiet day (25 September, 1999) spanning the entire globe for different longitude sectors (marked in the figure below) is shown. Equatorial Electrojet can be clearly identified on almost all the passes. There is a clear indication of zonal variation in the electrojet strength; largest amplitude is found in the American sector. The main driving force of the electrojet comes from the Cowling conductivity which varies as ($1/B^2$) and it also shows a maximum in the same region. Variations at other longitude are more sporadic in nature and are not related to the conductivity parameters. They could perhaps be linked with longitude dependent forces associated with non migrating tides.



Sudden Storm Commencement (SSC): The motion of the satellite in a spatially inhomogeneous background geomagnetic field, can appear as a time variation. For study of magnetic variations with periods greater than a few minutes, such distortions can result in significant misinterpretation of the time structure of the signal, unless the background field is very accurately removed. This is demonstrated by the study of a **SSC** event of July 31, 1999. Alibag and Kakioaka Observatories though separated by more than 15° in geomagnetic latitude show similar time structure for the SSC event (see figure given below). **The satellite data after removal of the IGRF(10c/99)** (Olsen and Sabaka, 2000) including Dst corrections of first order, **apparently does not show any signature of the SSC event.** However, by some modifications of the first few coefficients the time structure of the SSC event is retrieved to a considerable extent.



Conclusions:

Using the Oersted data we find that:

The night time ionosphere has no significant influence on the propagation of magneto acoustic waves; magneto-acoustic oscillations are modified both in amplitude and phase as they pass through the daytime ionosphere; Oersted data can be effectively used to identify modes of magnetospheric oscillations provided ionospheric effects are understood.

Equatorial Electrojet can be clearly identified on most longitude passes; there is a clear indication of zonal variation in the electrojet strength; largest amplitude is found in the 270° to 300° longitude region as expected from conductivity considerations; Variations in some of the other regions suggest longitude dependent tidal forcing.

Correct removal of the background geomagnetic field is able to reconstruct the actual time structure of transient SSC variations.

Acknowledgement: We are grateful for the support of the Orsted Project Office and the Orsted Science Data Centre at the Danish Meteorological Institute. The Orsted Project is funded by the Danish Ministry of Transport, Ministry of Research and Information Technology, and Ministry of Trade and Industry. Additional support was provided by National Aeronautics and Space Administration (NASA), European Space Agency (ESA), Centre Nationale d'Etudes Spatiales (CNES), and Deutsche Agentur fur Raumfahrtangelegenheiten (DARA). We are very thankful to the Worls Data Center –C2 for providing the ground magnetic data for the Japanese stations.

References

Kim and Takahashi, 1999. Ground-satellite coherence analysis of Pc3 pulsations, J. Geophysical Res., 104, 4539-4558.

Olsen, N. and Sabaka, T. J., 2000, Estimation of the IGRF 2000 model, Earth and Planetary Sciences, (communicated).

Olsen, N. and Sabaka, T. J., Oersted Initial Field Model (personal communication).