On the Geo-Electric Fields, Low-latitude Ionospheric Dynamics and GPS Positioning errors

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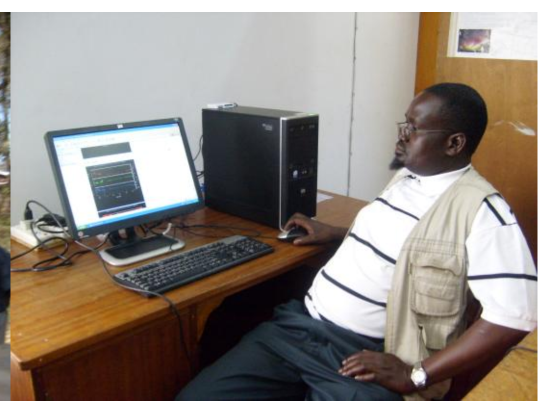
Outline

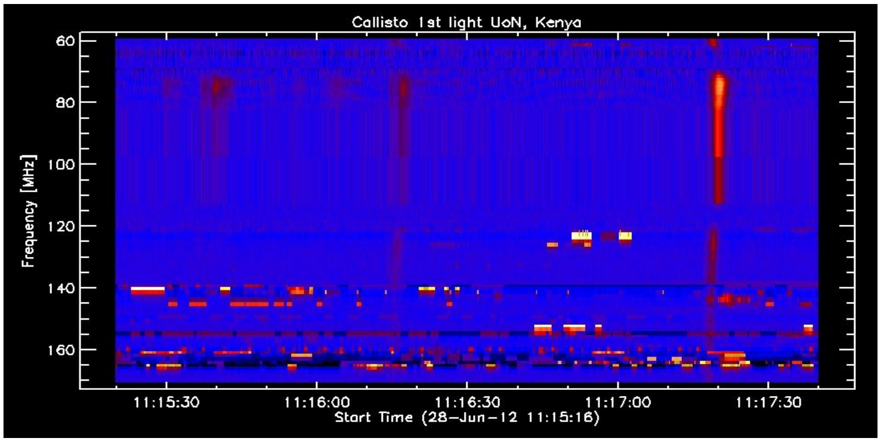
- Space Weather Observing Infrastructure
- Science & Results
- Future Plans

1. Space Weather Observing Facilities in Kenya

(a) MAGDAS - University of Nairobi/SERC(Kyushu University)



(b) CALLISTO -University of Nairobi/ Institute of Astronomy ETH (Zurich)



(c)VHF Receiver – Installed in 2010

(d) SCINDA-GPS - 3 Receivers

University of Nairobi/Maseno Univeresity/Jomo Kenyatta University of Agriculture and Technology- US Air Force Research Laboratory/Boston College (2008/2010/2011)

(e) Satellite Beacon Receiver- Technical University of Kenya/Kyoto University (2011)

(f) VPIR Ionosonde- Maseno University/Boston college

(a) Boston College Team with Vice Chancellor (b) Transmitter & Receiver Antennas

2. Science with some of the Instruments

(a) MAGDAS & SCINDA-GPS: Geo-Electric Fields & Scintillations

Data and Methods of Analysis

Nairobi (Lat: 1.3^0 S; Lon: 36.8^0 E), MAGDAS data for July 2009 together with data from SCINDA-GPS co-located with it. Considered geo-magnetically disturbed day 22nd July, 2009 when the Kp-index was 5 and a day before and after.

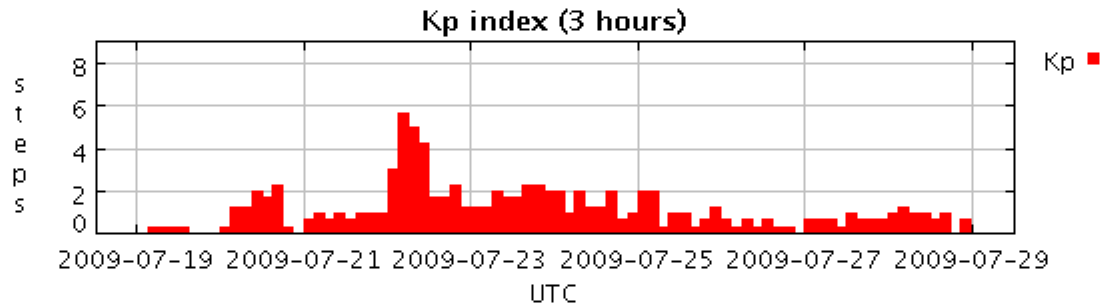


Fig. 1. Kp indices between 19 July,2009 to 28 July, 2009

(i) Computation of the Geo-electric field

The geo-electric field was computed using the plane wave model [Viljanen et al. 2004] and ground resistivity data.

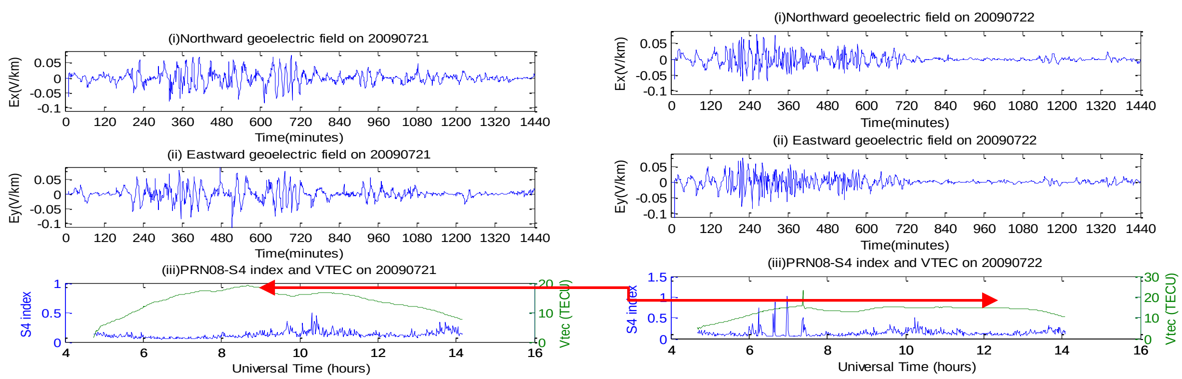
Graphs of northward and eastward components of the geo-electric field against time for day were plotted. The motivation was to study geo-magnetically induced currents in power grid in Nairobi (Kenya)- a low latitude site.

(ii) Scintillation index (S_4) and Total Electron Content

The processing of the S4 index and relative TEC obtained from Nairobi SCINDA station was performed using GPS TEC analysis software developed by Seemala and Valladres (2008) of the Institute of Scientific Research, Boston College, USA. The elevation angle was set at 20^o to eliminate multipath effects. The scintillation index, S_4, and TEC data used in this study was that for PRN08 satellite.

Results

Fig2: Geo-electric fields, S_4 and TEC



(a) Geo-magnetically Quiet Day (July 21) (b) Geo-magnetically Disturbed Day (July 22)

- NB: Reduction in TEC with increasing magnetic activity ; Daytime scintillations observed.
- Reduction in occurrence of scintillations with increasing magnetic activity.
- Geo-electric field enhancements and transformer failures during geo-magnetically disturbed days observed.

Date of geomagnetic event	**Geomagnetic event**	**Maximum GIC(A)**	**Date of power system event**	**Power system event**	**Start time**	**Dura-tion**
20090204	**Kp-index=5**	**1.3114**	**20090209**	**Broken**	1734h	1h

				jumper beyond Y563 andY436 at Kileleshwa and Cianda.		6min
20090303	Geomagnetic sudden impulse	7.3153	20090307	Broken jumpers at a point of cable take off in Riverside.	1722 h	3h 3 min
20090411	Kp-index =4	1.4141	20090411	Faulty 315 KVA transformer s/s 14691 at Nairobi West Cables shorting to earth at Hill 2.	0615h	9h 45min

20090722	Kp-index=5	6.2327	20090726	Burnt transformer link s/s 3117 at Hurlingam	1319h	10 mins
20090830	Kp-index	7.6439	20090904	Unestablished fault in Eastleigh	0006h	37 hrs

(b) Dilution of Precision & Positioning Errors During Geo-magnetically Quiet and Disturbed days.

Quiet day (February 3, 2009)

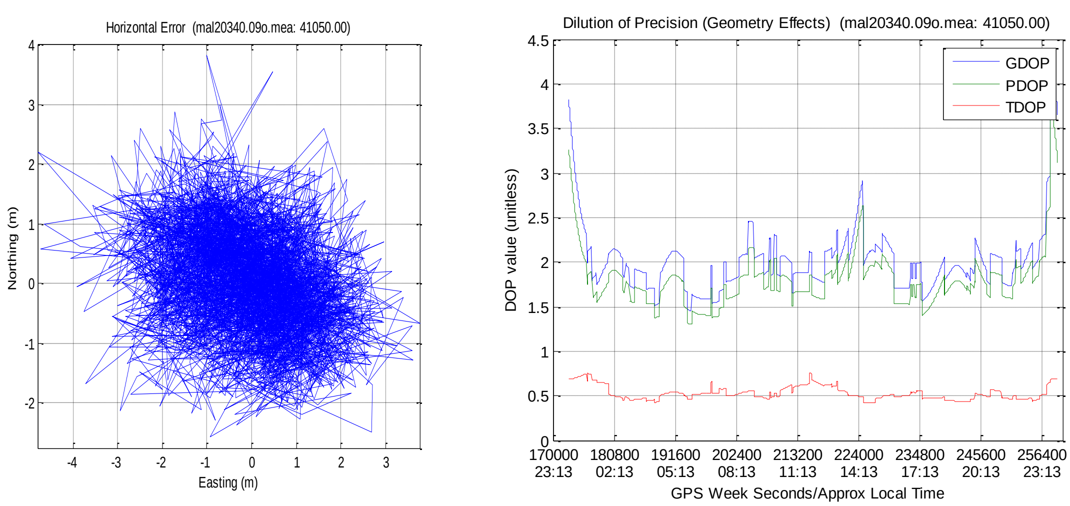
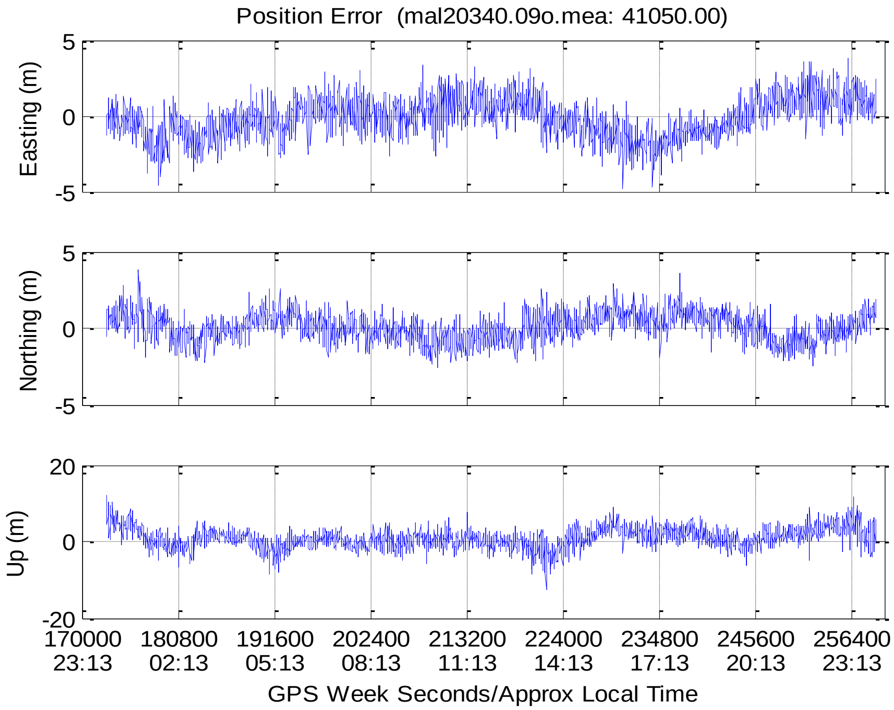


Fig 4 (a)Horizontal error: 2m Northing; 3m Easting (b) Dilution of Precession



Disturbed day (February 4, 2009)

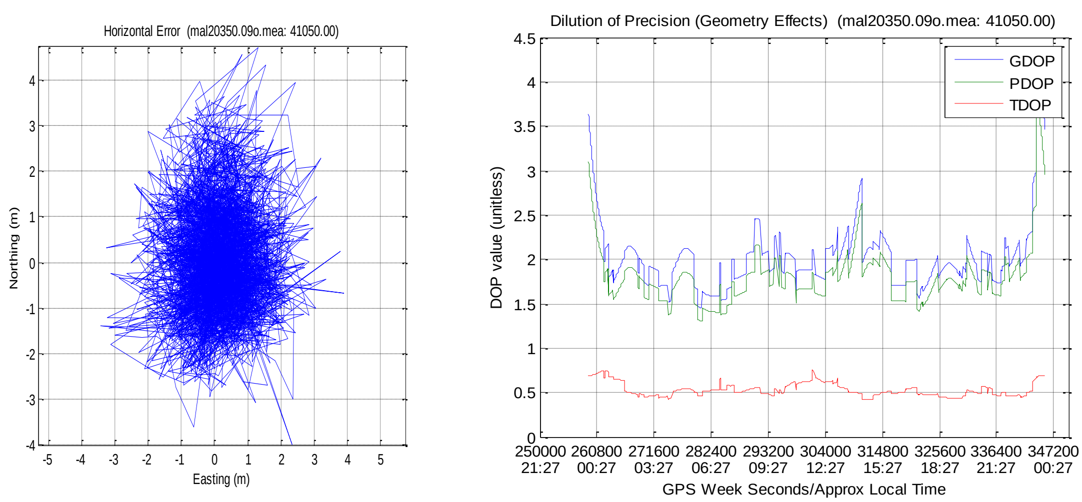
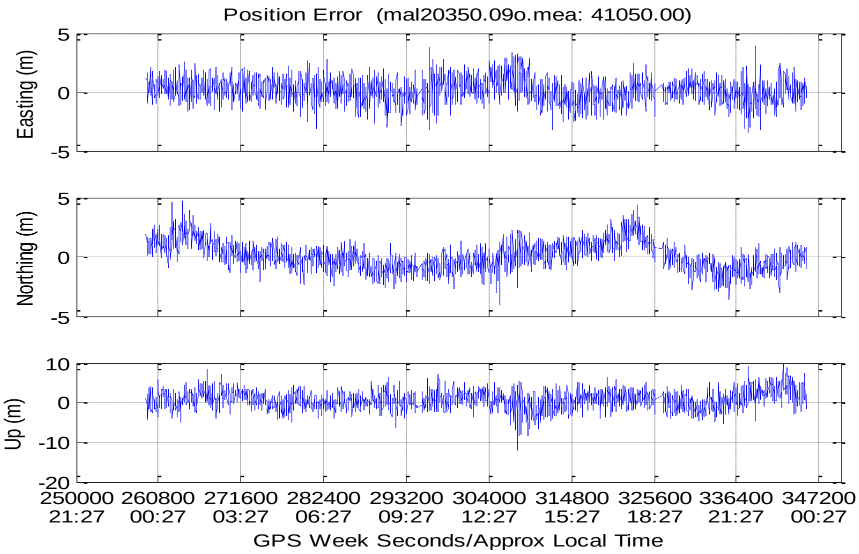


Fig 4 (c)Horizontal error: 3m- Northing; 2m-easting (d) Dilution of precession



Observed

- Significant positioning errors of about 2-3m observed in horizontal and vertical components during both quiet and disturbed days.
- During storm-time, larger errors observed in the North-South direction (perhaps due to B_z)- could impact landing of aircrafts.

(c) VIPIR Ionosonde and Preliminary Results

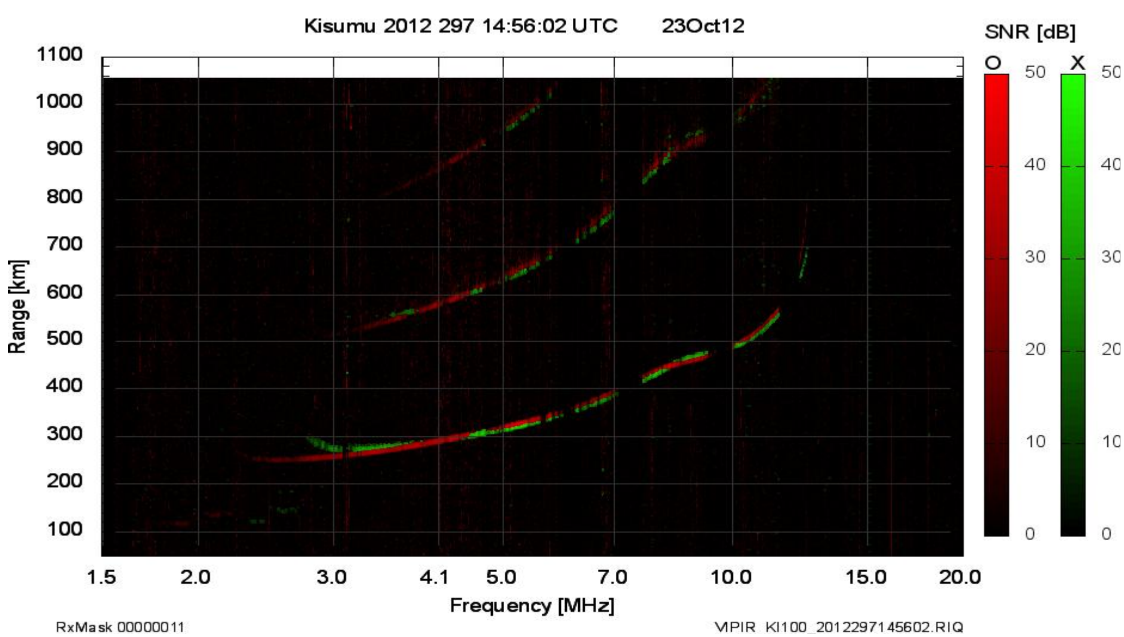


Figure 4: One of the first ionograms recorded with Maseno VIPIR ionosonde. The plot shows signal strengths in dB for ordinary (red) and extraordinary (green) waves

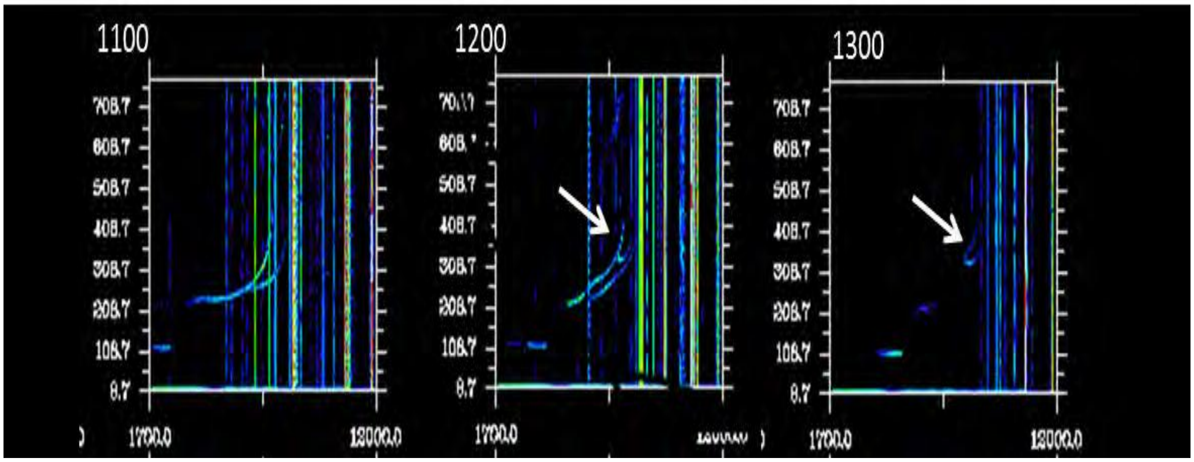


Fig 5: Sequence of ionograms recorded on January 9, 2013 11-13 UT showing an interesting structure in the F2 layer which was present for at least one hour.

Observed:

- In the ionograms shown in Figure 5 there is a very interesting feature present near the middle of the F2 layer developed at around 12 UT and still visible at 13 UT.

- This ionospheric structure could be associated with sporadic processes like TID or F3 layer or could be a result of steep density gradient present in the ionosphere during the observation.
- More investigations needed.

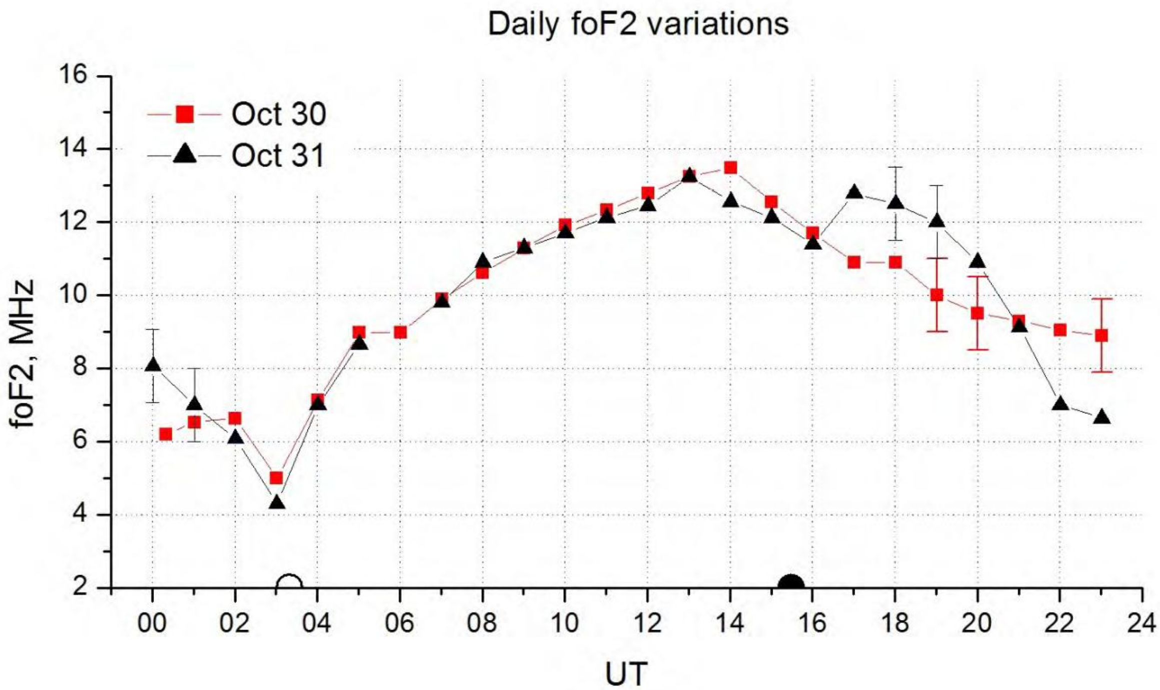


Figure 6: Daily foF2 variations recorded with Maseno VIPIR ionosonde on October 30, 31 2013. Sunrise and sunset times are indicted with open and closed circles correspondingly. The periods of spread-F are indicated with vertical error bars, foF2 values for those times are estimated.

Observed:

- NB: During the night of October 30/October 31 spread-F was observed twice: shortly after the sunset (18-20 UT) and much later at night (23-01UT).
- The intensities of all observed spread-F conditions were approximately similar.
- The presence of the late night spread-F is similar to the observations of late-night ionospheric scintillations have also been made with SCINDA- GPS in Nairobi.
- It will be very interesting to investigate this phenomenon in further details and try to determine what geophysical conditions in this region are responsible for the formation of the equatorial spread-F several hours after the sunset.

Future Plans

- Investigate African Low-latitude Ionospheric dynamics using MAGDAS, SCINDA-GPS and VIPIR Ionosonde
- More Magnetometers needed- collaborations necessary.
- Space Weather Service

Acknowledgements

- UNOOSA & ICSWSE for invitation & support.

References

Viljanen A., Pulkkinen A., Amm O., Pirjola R., Korja T. and Bear W.G.:2004, *Fast computation of geoelectric field using the method of elementary current systems and planar Earth models,* Annales Geophysicae 22:101-113 (2004)