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Identification of Night-time F region currents from CHAMP satellite observations over Equatorial Africa

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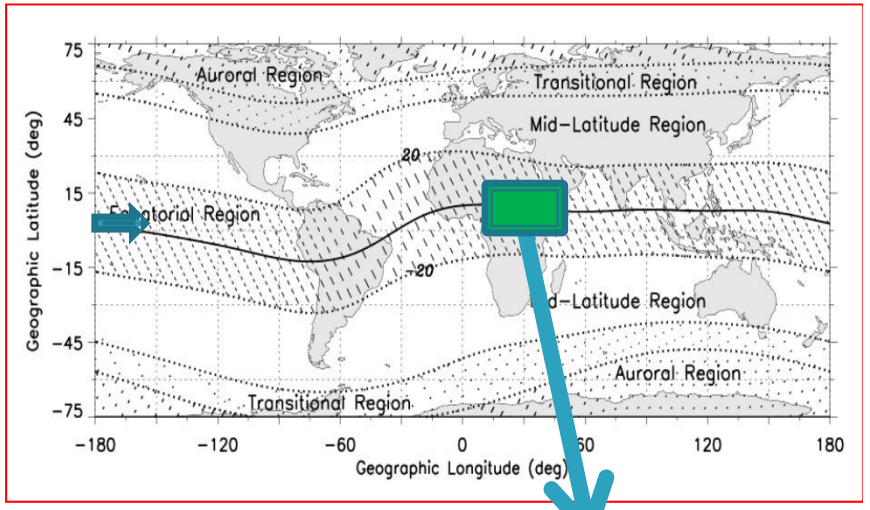
Outline of presentation

- Equatorial Ionosphere
- Observations
- Results
- Discussions
- Conclusions and Way forward

The Equatorial Ionosphrere

Magnetic dip equator is defined as the path of zero dip along the surface of the earth.

- In its neighborhood, the magnetic filed line are nearly horizontal,
- Charged particles move generally along magnetic field lines.



Area of study, Magnetic Equatorial Africa

Ionospheric conductivity and F-region current drivers

$$\sigma_0 = \frac{Ne^2}{m_e \nu_e} + \frac{Ne^2}{m_i \nu_i}$$

Parallel conductivity

$$\sigma_P = Ne^2 \left[\frac{\nu_e}{m_e(\nu_e^2 + \Omega_e^2)} + \frac{\nu_i}{m_i(\nu_i^2 + \Omega_i^2)}\right]$$

Pedersen conductivity

$$\sigma_H = Ne^2 \left[\frac{\Omega_e}{m_e(\nu_e^2 + \Omega_e^2)} - \frac{\Omega_i}{m_i(\nu_i^2 + \Omega_i^2)}\right]$$

Hall conductivity

$$\Omega_e = \frac{eB}{m_e}$$

Gyrofrequency of electrons

$$\Omega_i = \frac{eB}{m_i}$$

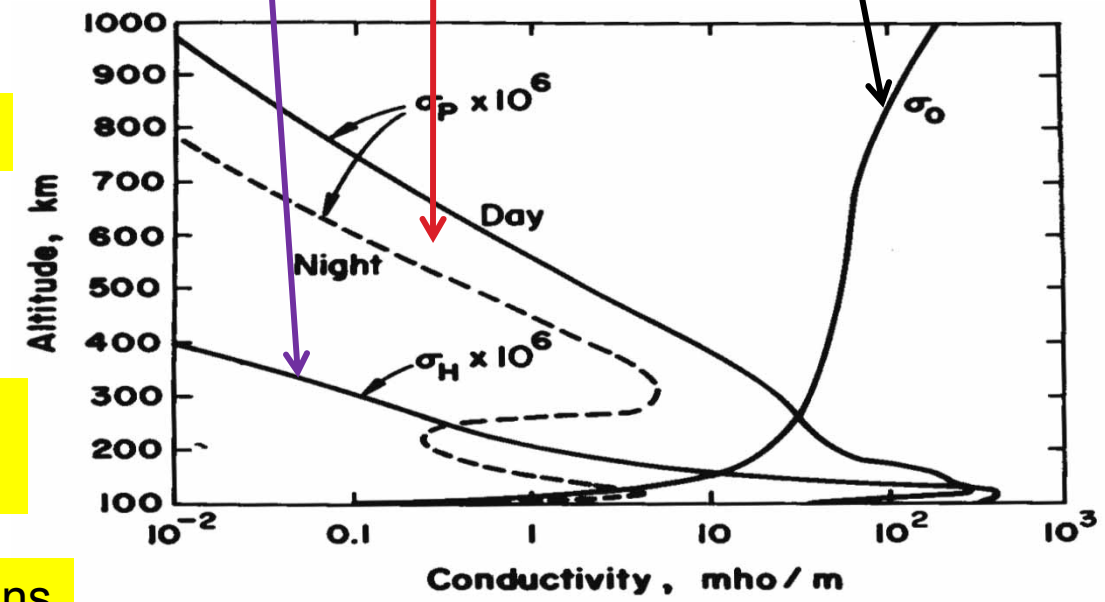
Gyrofrequency of ions

$$\nu_e = \nu_{en} + \nu_{ei}$$

Collision frequency of electrons

$$\nu_i = \nu_{in} + \nu_{ie}$$

Collision frequency of ions



Ionospheric F-region Currents

$$\boldsymbol{j} = \sigma(\boldsymbol{E} + \boldsymbol{u} \times \boldsymbol{B}) + \{N_e m_i \boldsymbol{g} \times \boldsymbol{B} - k\nabla[(T_i + T_e)N_e] \times \boldsymbol{B}\}\frac{1}{B^2}$$

F-region dynamo

Gravity dynamo

Plasma pressure gradient

Currents on the y-component;
Assume an infinite current sheet
THUS;

$$\Delta B = \frac{\mu_o}{2} J_z$$

Gravity currents

$$b = \frac{N_e m_i \mathbf{g}}{B}$$

Plasma pressure gradient currents

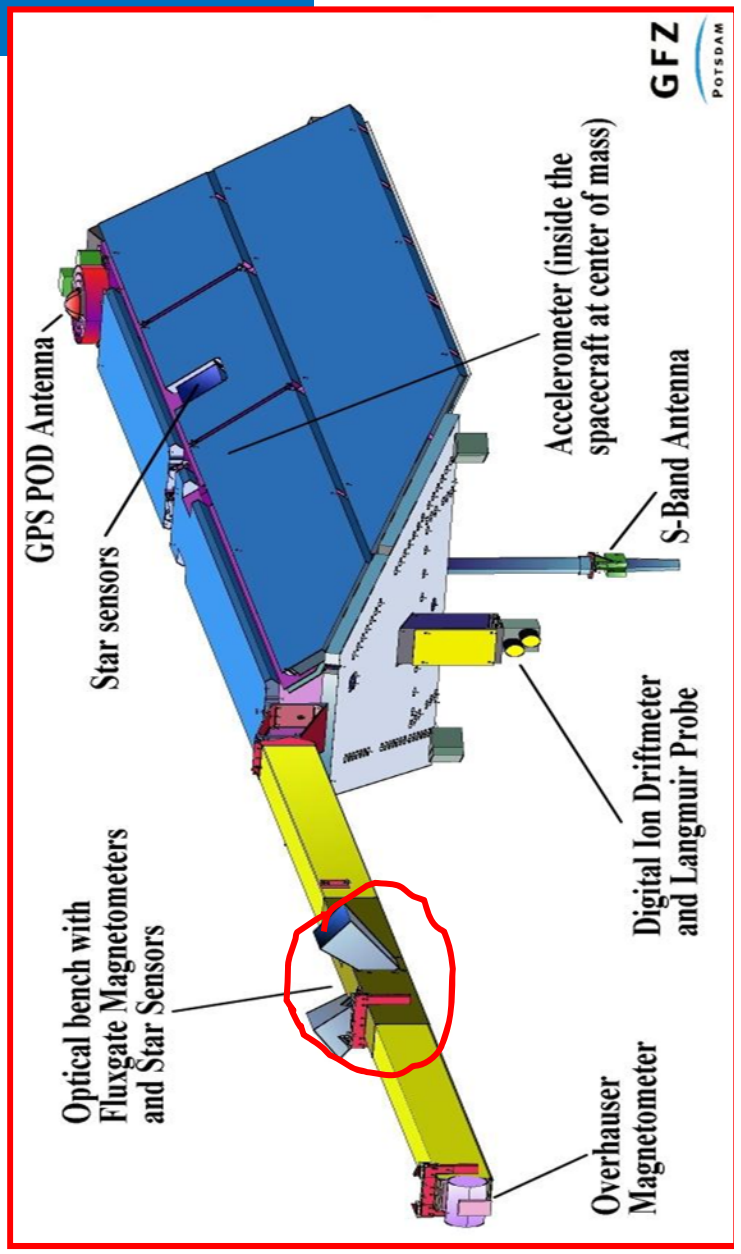
$$b = \frac{nk\mu_o}{B}(T_i + T_e)$$

Observations

➢The CHAMP Satellite (Challenging Minisatellite Payload) was launched on 15th July, 2000 with an initial altitude of 450km into an almost circular, near-polar orbit with an inclination of 87.3^{0}.

➢**The primary objectives;** the gravity field, atmosphere and the magnetic field.

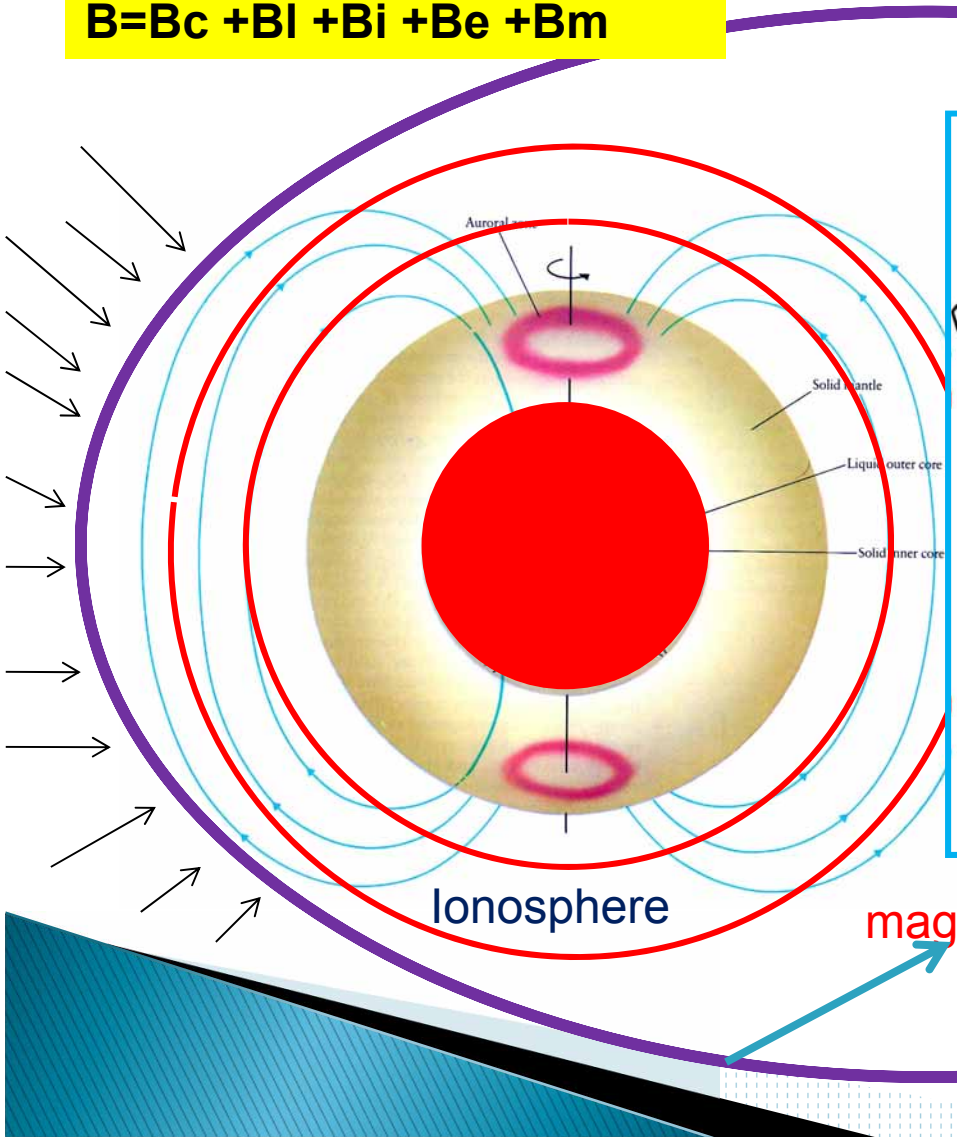
➢ Magnetic field measurements taken from **Fluxgate magnetometer** are used in this study covering the year 2001.

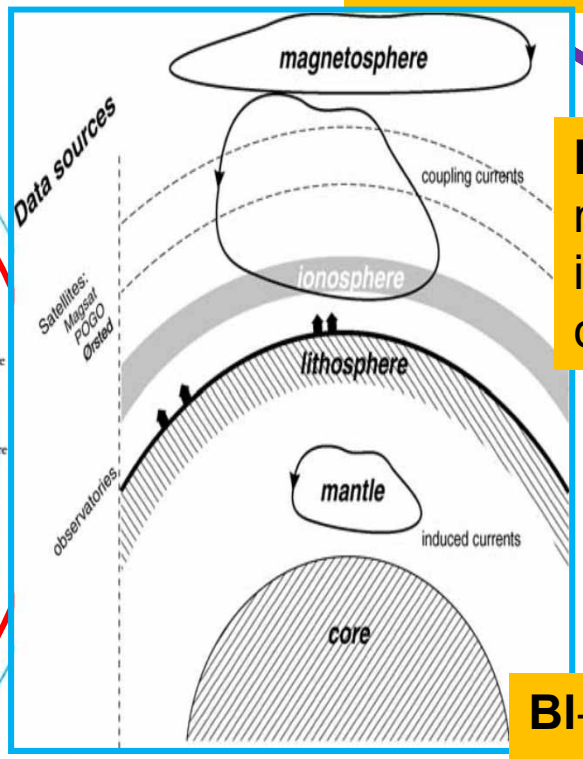


Data Analysis

The satellite magnetic data result from the contribution of fields from different sources.

B=Bc +Bl +Bi +Be +Bm





Bm- Magnetospheric sources

Be-magnetosphere-ionospheric coupling

Bi-ionospheric sources

Bl-lithospheric sources

Bc-Liquid core of the earth

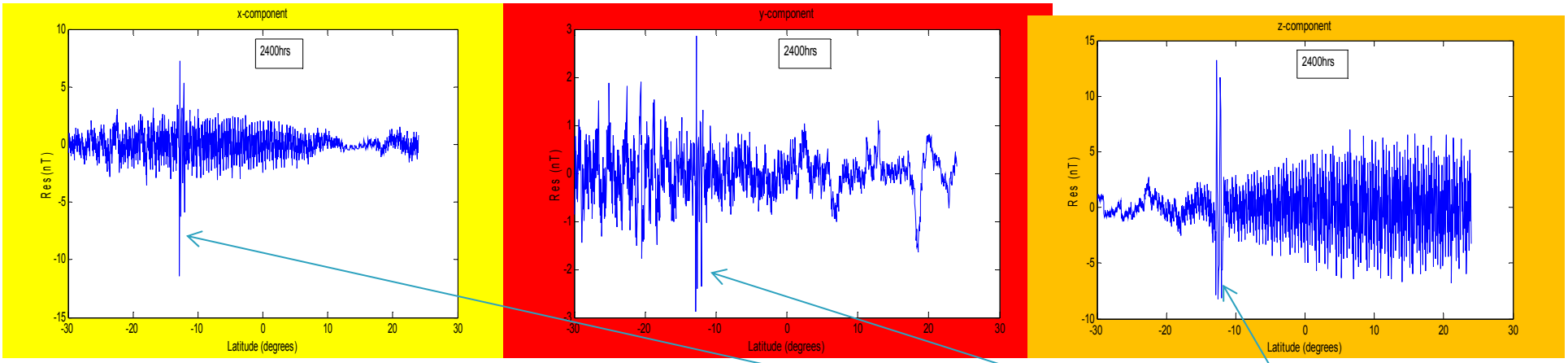
•The processing of the data was done on the fortrun programme upon which all field models; main field, crustal field, epoch and spline fitting models are embedded.

•To remove earth's main field contribution, the data is run in the IGRF 10 model (harmonics of degrees 1–13)

• lithospheric field or crustal field contribution are eliminated by running the data on the crustal field model (degrees 14-90).

•Finally to remove the ring currents, a spline fit to the X, Y and Z residuals, and subtracted is done leaving us with only external field contributions resulting from F region currents.

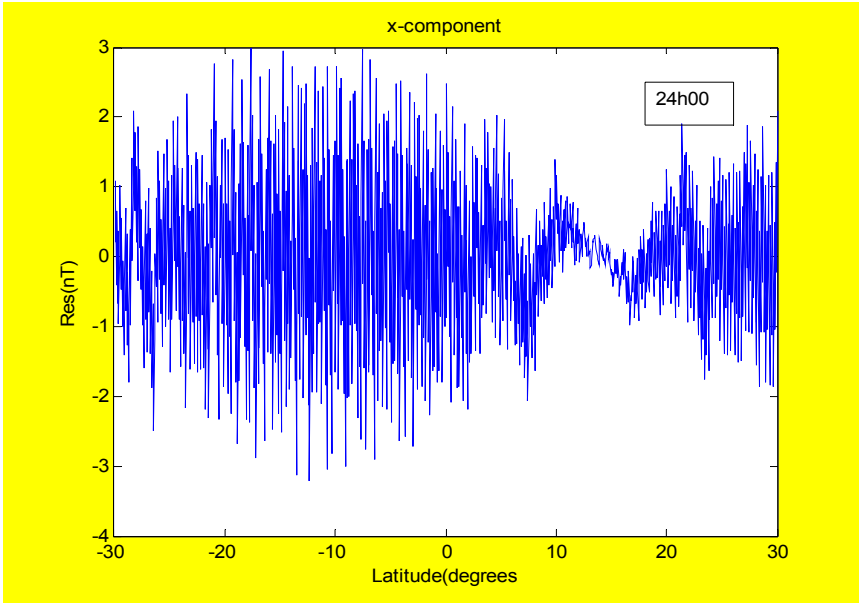
Results and Discussions

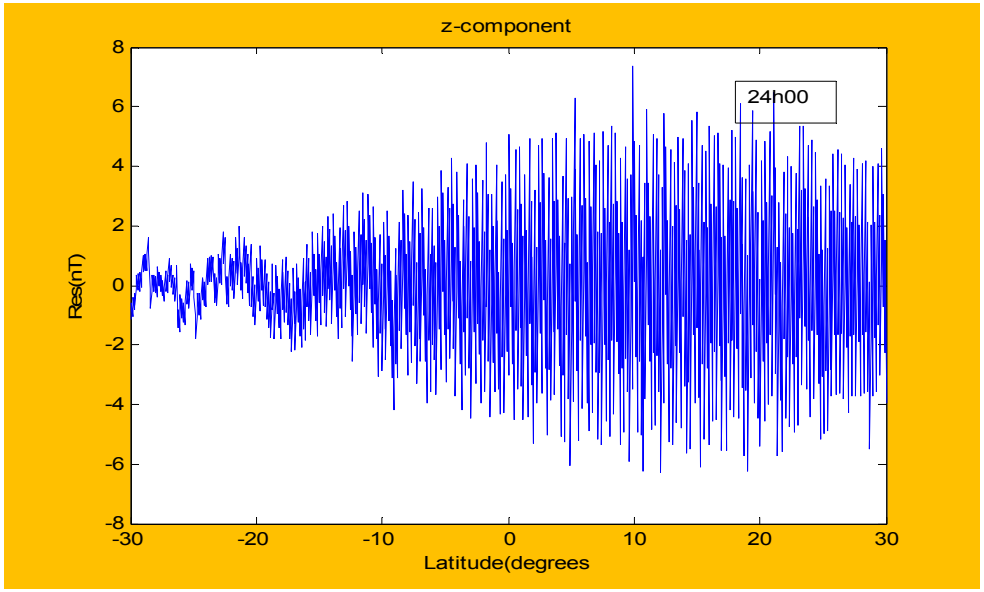


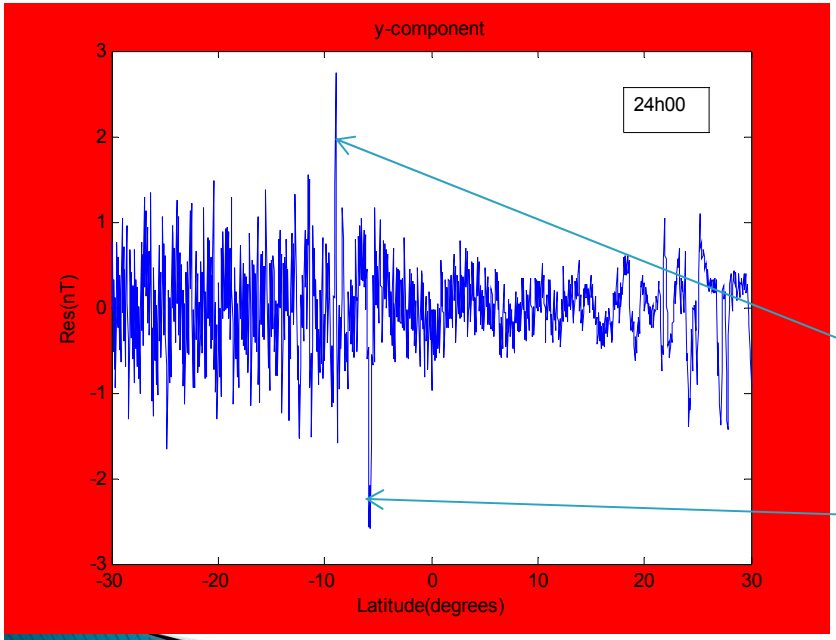
Magnetic residuals,2001/08/05

The peaks are prominent in all the x, y, z components;

X-component----±8nT
Y-component-----±2nT
Z-component-----±9nT

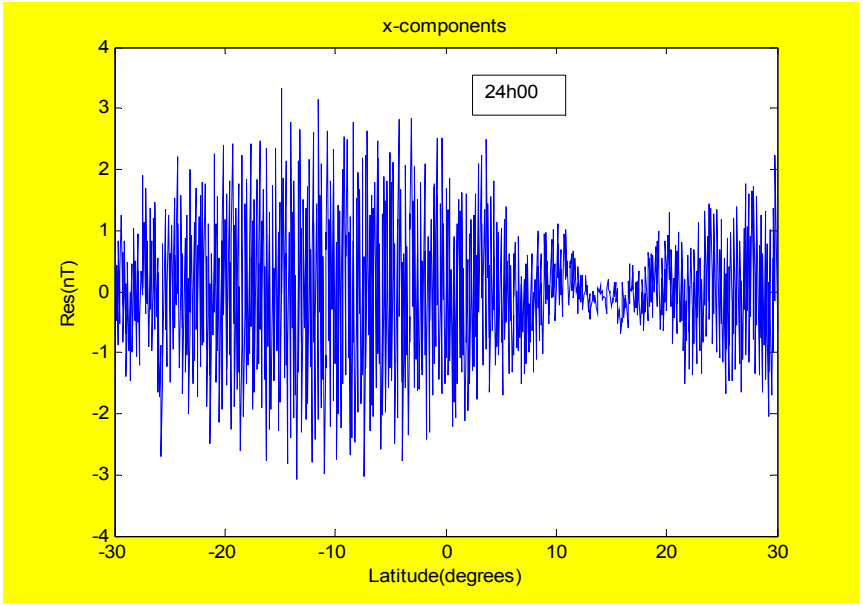


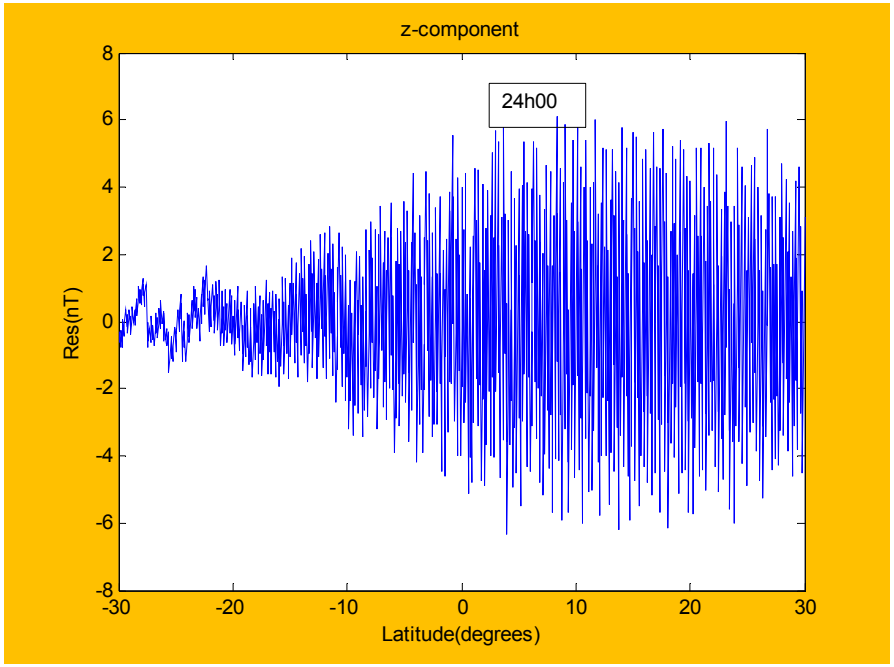


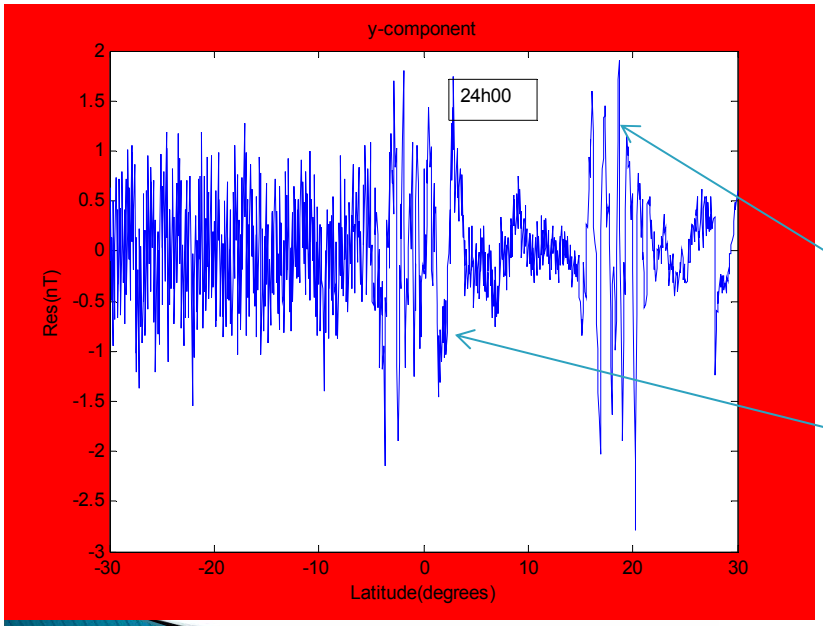


Magnetic residual on 2001/08/08

Prominent on Y-component

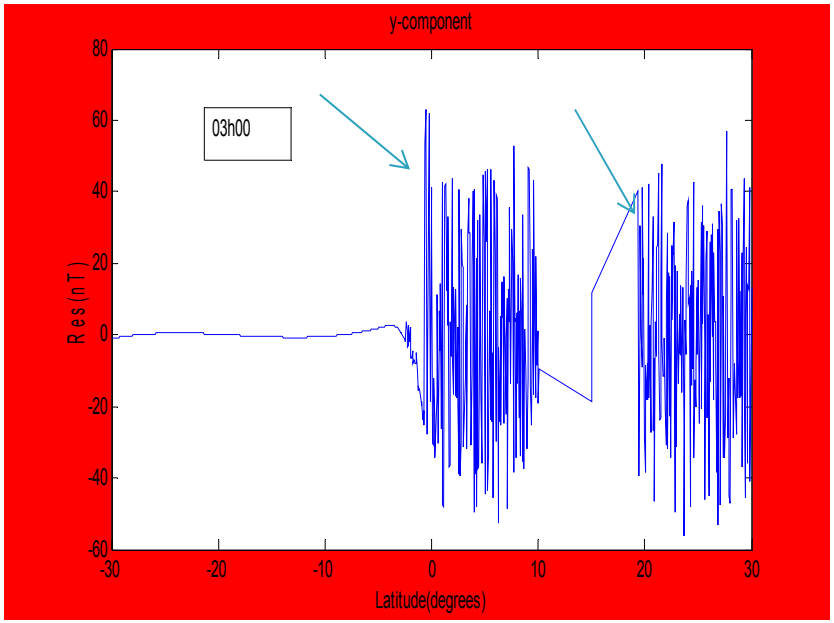


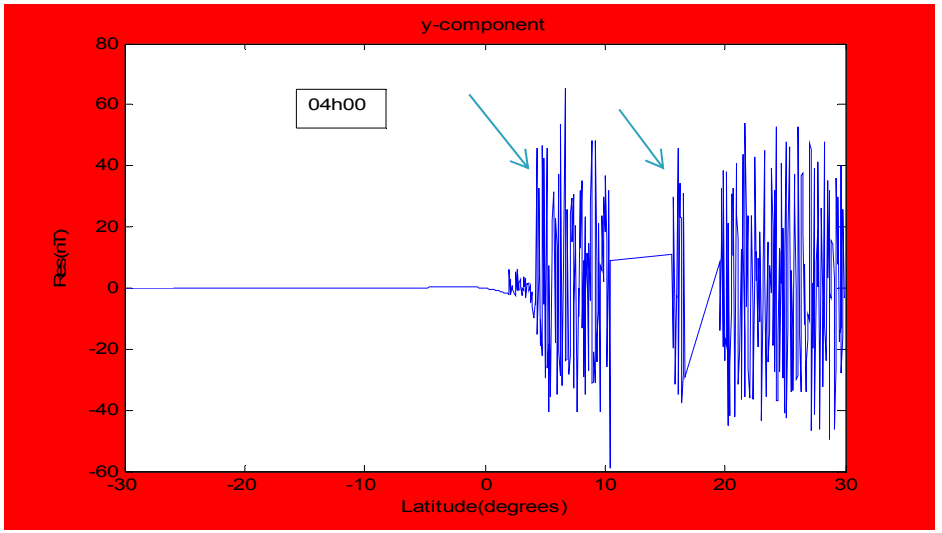


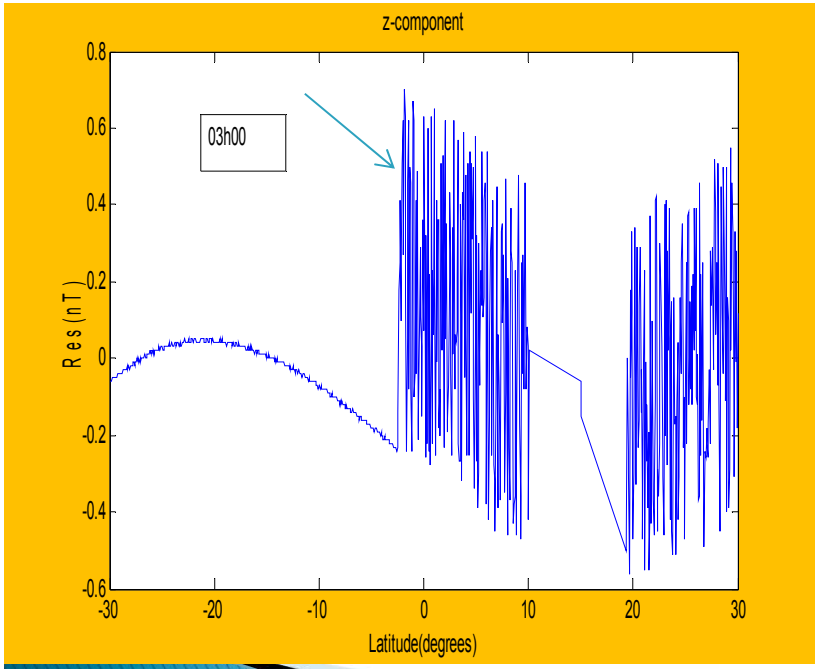


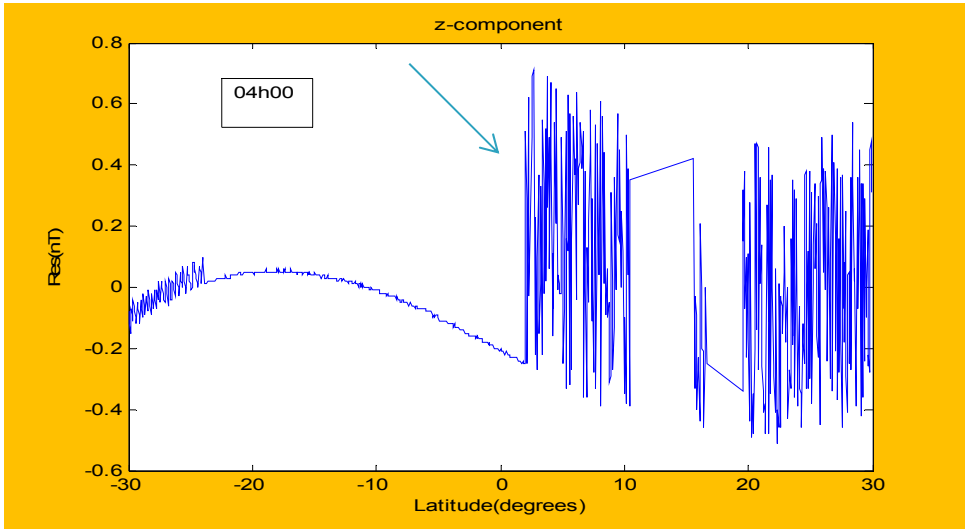
Magnetic residual 0n 2001/08/22

A near symmetry is seen on y-component

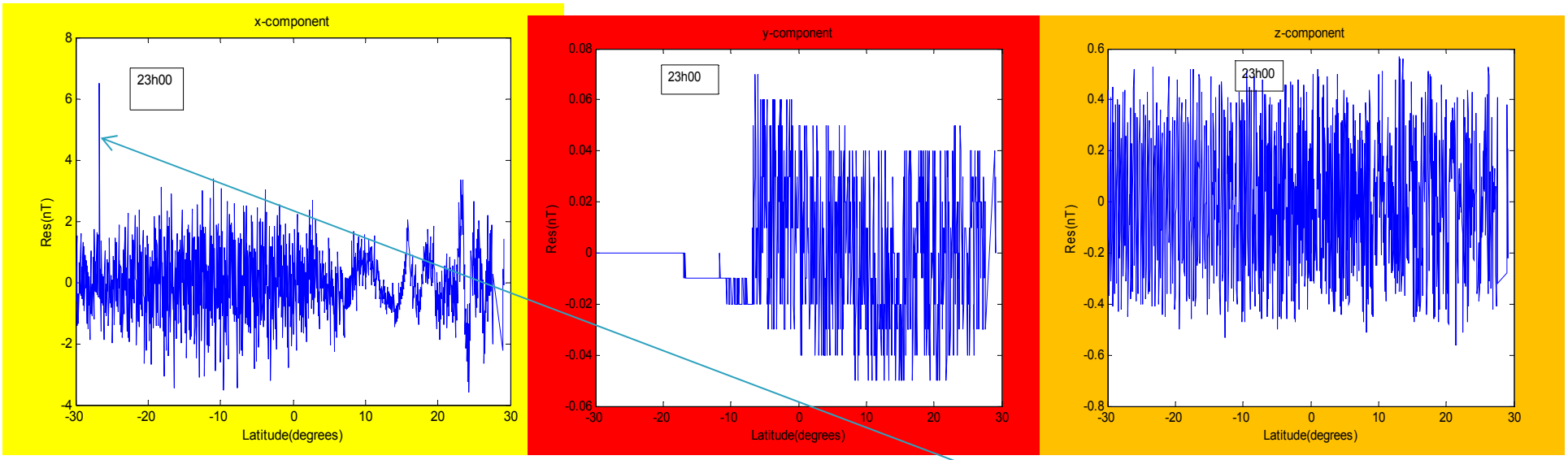








Two passes of the satellite on 2001/11/14, Y and Z give peaks



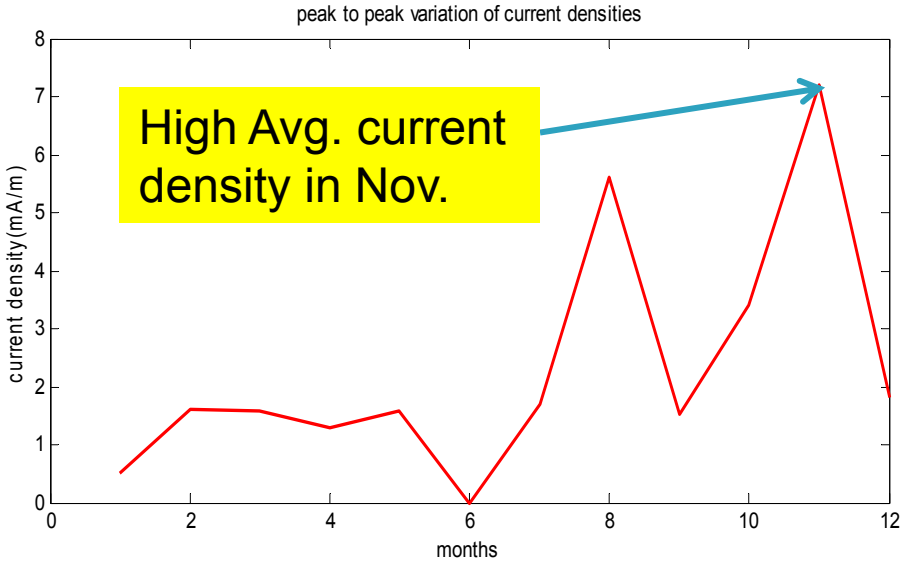
Magnetic residuals, 2001/12/27

Residual most prominent in x-component,

+6.5nT at -29^0 and ±4nT at 25^0

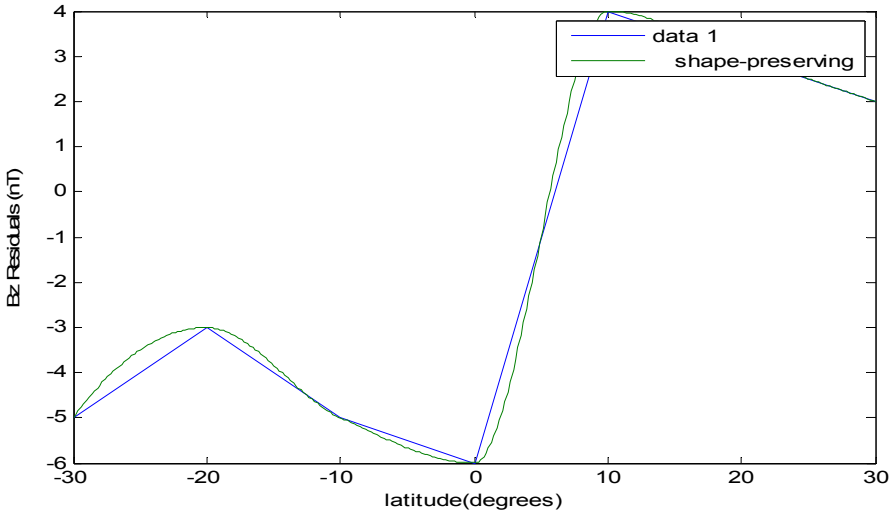
The y and z-components are masked with noise but still a considerable effect can be noticed

Peak-to-peak variation of the current density along y-axis;



Monthly average of current density

Bz component



CHAMP vertical magnetic field residuals between 20-24 LT. Much current density at around +12 degrees

Conclusion

- The results compare favorably with that of the first in-situ observation of night-time F-region currents with the CHAMP satellite [Luhr et al]. That is, it confirms the spatial confinement of the currents to the near-equatorial region bounded by the Appleton anomaly in both pre-midnight and post-midnight sectors

- The average current density along the y-component is generally less than 6.5mA/m while the current density believed to be due to Earth's gravity is about 10mA/m.

- The comparison of our results with ground based observations (MAGDAS, SCINDA) along the equatorial region and IRI model is still pending and we are convinced that such comparison will shed more light on our current results

Thanks for your Attention