Ionospheric Response to Space Weather During Satellite Anomalies

[1]Rabiu A.B, [1,2]**Abdulrahim R.B,** [3] Erinfolami F.

[1]National Space Research & Development Agency, NASRDA, Abuja, Nigeria

[2]Centre for Satellite Technology Development, NASRDA, Abuja, Nigeria

3 African Regional Centre for Space Science And Technology Education – English ,Ile –Ife, Nigeria

Email: bourlarnley@gmail.com

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Introduction

Satellites and Space Environment

- Space environment refers to the space that envelopes the earth and other planets.
- Failures occur as a result of anomalies in the space environment.
  - »Satellite parts/components malfunction
  - »Space Weather Effects

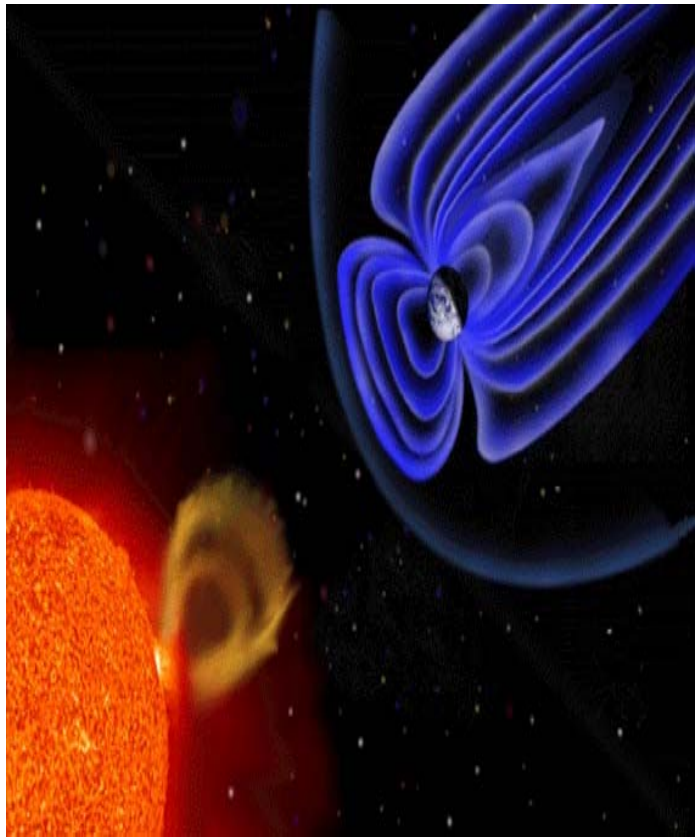
Space Weather

- Space Weather is referred as the nature of activities in the sun.
- These changes most times affects the performance of space based technologies such as satellites
- Basically, the sun is the source of the Space Weather

The Sun and the Space Weather Effects

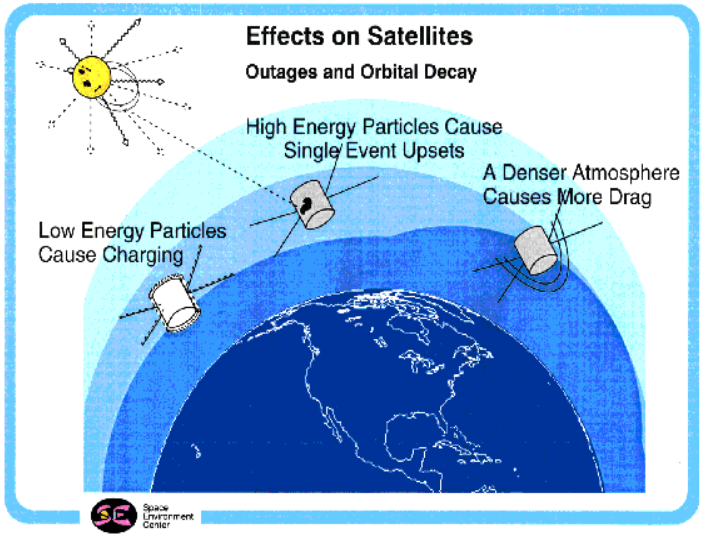
The Sun

- 150 million km from Earth
- sends its light to the Earth in 8 minutes
- 11-year cycle of solar activity
- Emits CMEs
- Strong CMEs have the capability to push the Earth's bow region from the centre of the earth-usually in geosynchronous Orbit



Space Weather Effects on Satellites

- The severity of the space weather effects on satellites depends on the orbit and the position of the Satellite.



Space Weather Effects on Satellites

Space Weather Effects Phenomenon

- Satellite Electrical Charging- objects motion through an electrically charged medium, direct particle bombardment and Solar illumination
  - Surface Charging
  - Dip Dieletric Charging
  - Spacecraft Drag
  - Disorientation of Magnetic Field.e.t.c

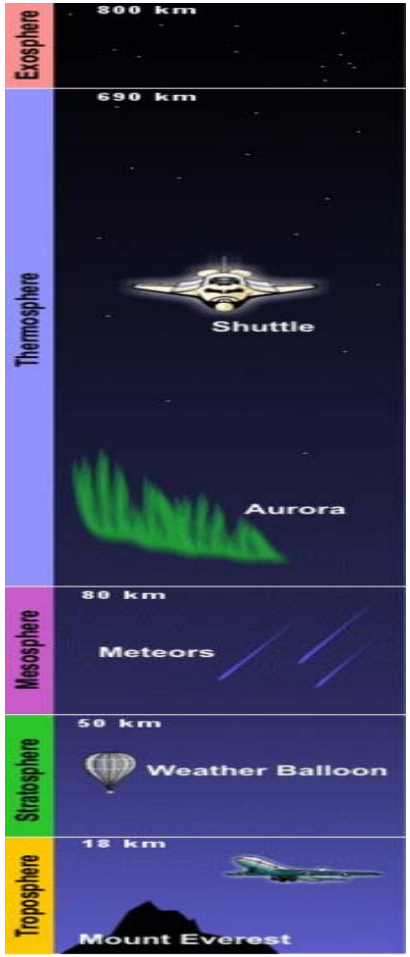
Space Weather Parameters

- Ap, Kp Index
- Electron & Proton Flux
- Interplanetary Magnetic Field (IMF)
- Solar wind Plasma
- Sunspot Number

The Ionosphere

- Upper part of the earth's atmosphere where electrons exist in sufficient proportion as to affect the propagation of radio waves

- Above 50 km

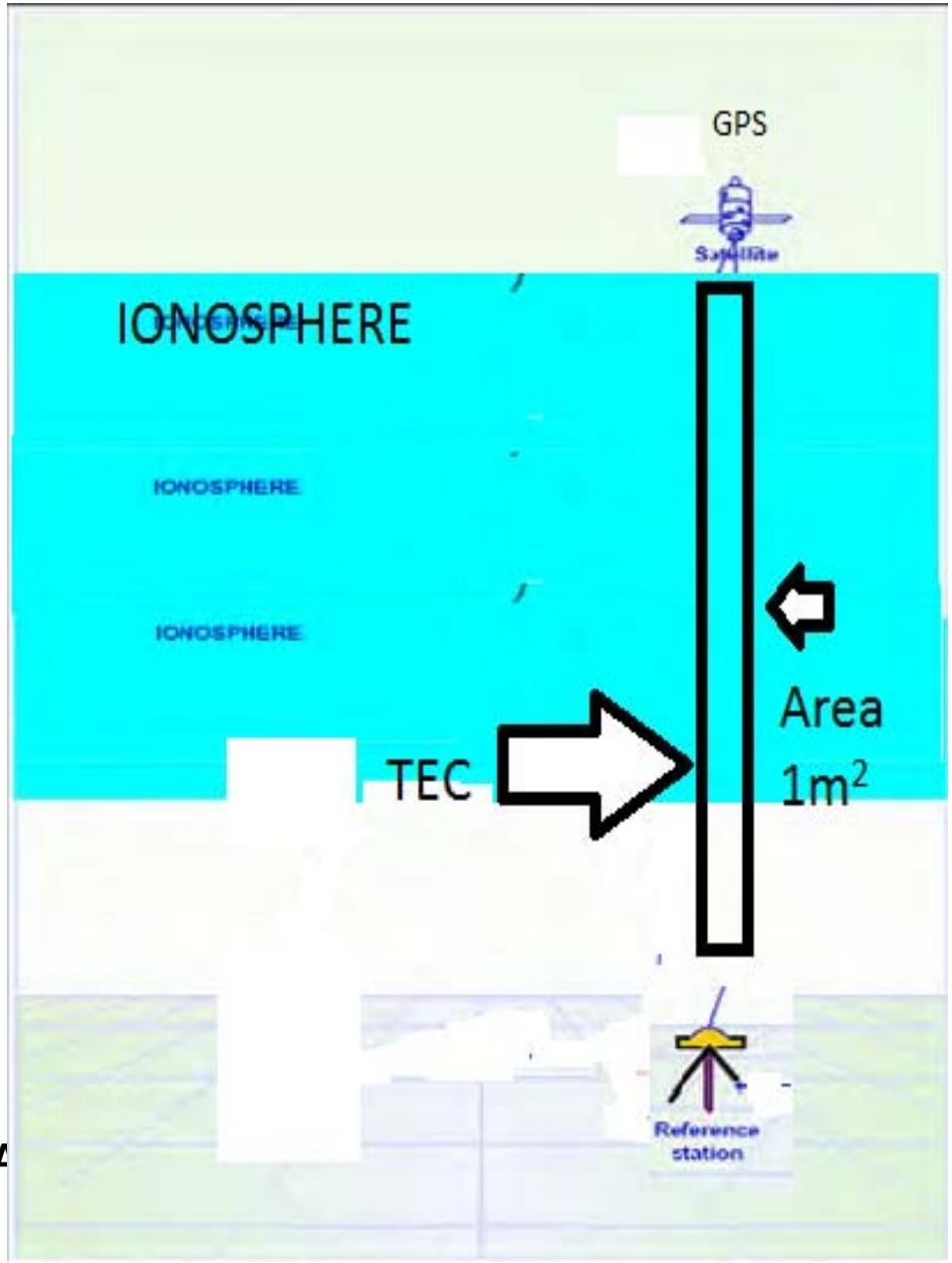


Total Electron Content (TEC)

- TEC is the number of electrons in a tube of $1m^2$ cross section extending from the receiver to the satellite
- TEC along the signal path is given by

$$TEC = \int_{path} N_e ds$$

- Where N_e is the electron density along the signal path



objective

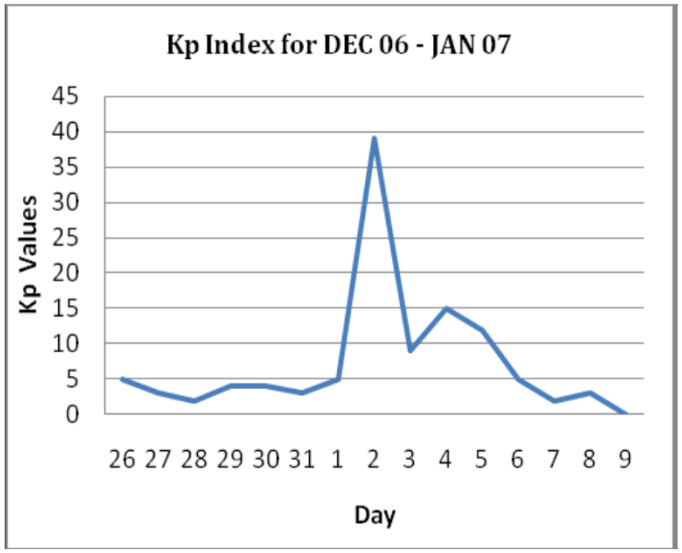
- To investigate the Response of the Total Electron Content of the Ionosphere during Satellite Anomalies

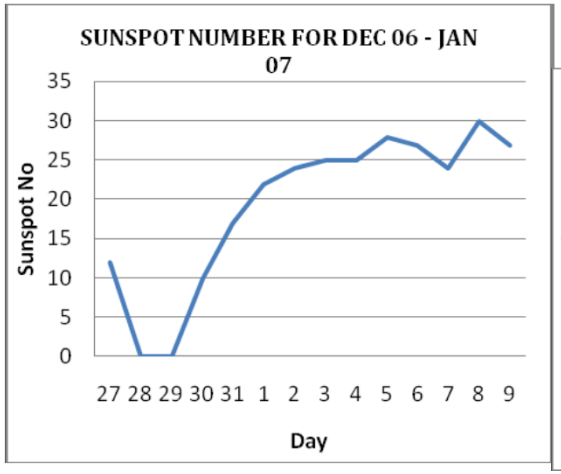
Methodology

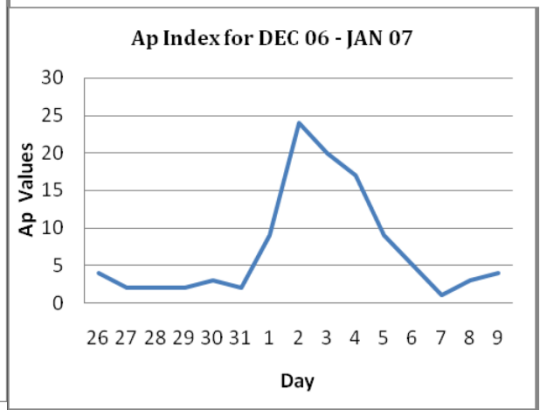
- A Few anomalies were studied using space weather parameters available for those periods
- The anomalies on focus were INSAT-4A and ASCA(ASTRO-D)
- The Variability of the Ionosphere during the period of the event was studied using Rinex TEC data obtained from Sopac Website.

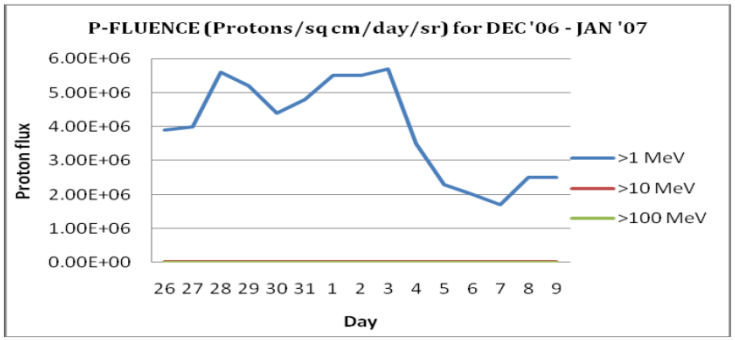
Discussions

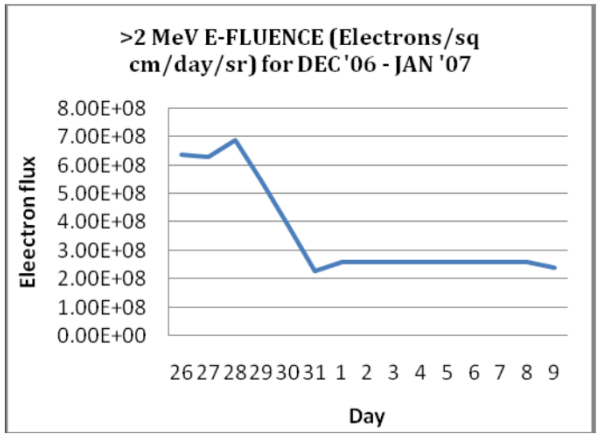
Daily variation of mean SW indices associated with the **INSAT-4A** 2nd of Jan. 200







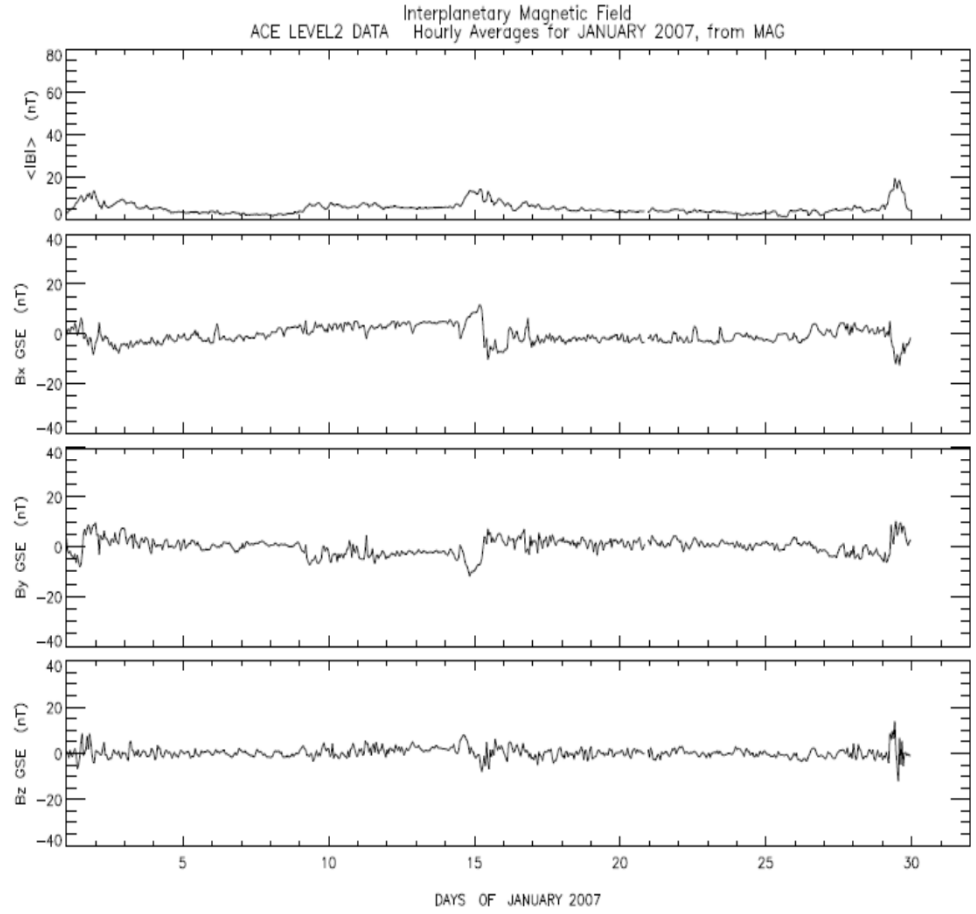




INSAT -4A

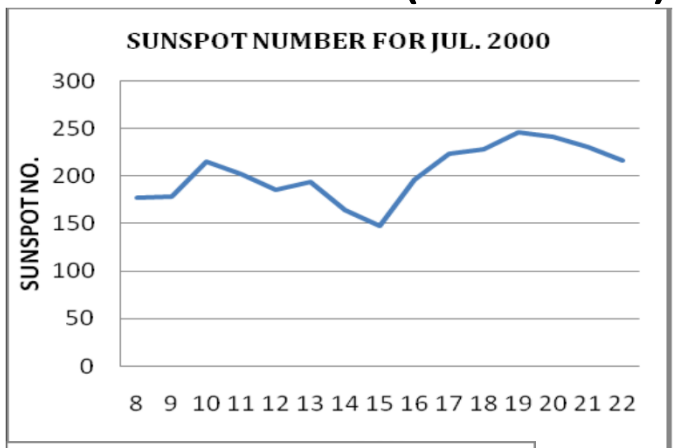
- There continous increase in sunspot number from Dec'06 till Jan'07which by Jan 2nd '07, it was already 25
- Ap Value which has been low in December suddenly increased to 25
- Electron Flux dropped from 6.00+ 08 to 2.00+08

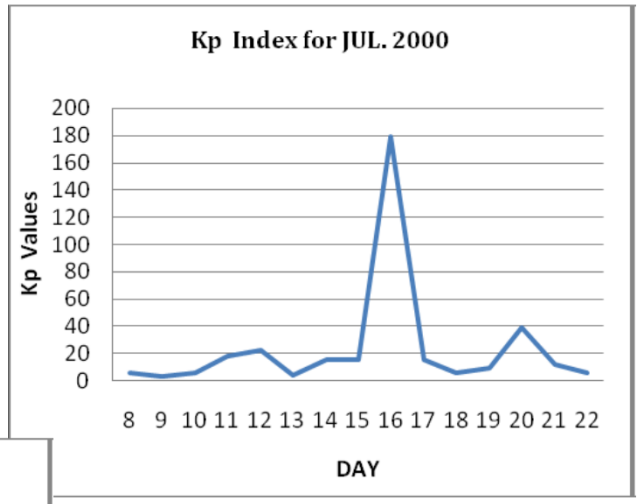
Daily variations of solar wind plasma for **INSAT-4A** 2nd of Jan. 2007

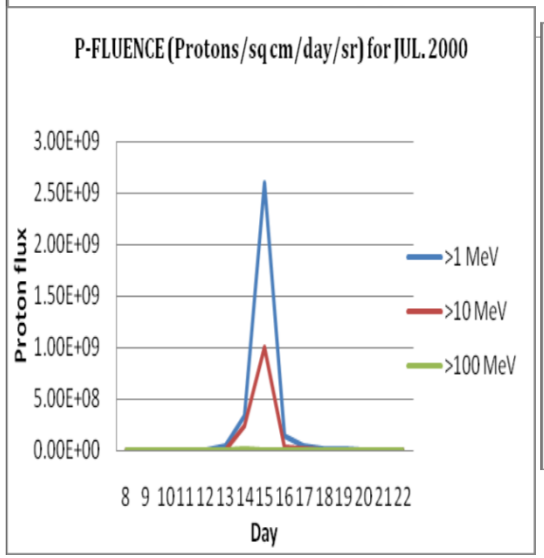


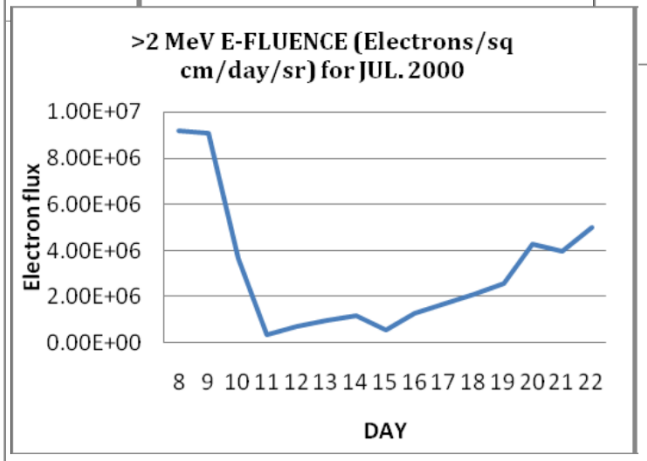
the IMF for the month of Dec. 2006 and January 2007, it can be seen that the magnitude is at an all-time 5nT

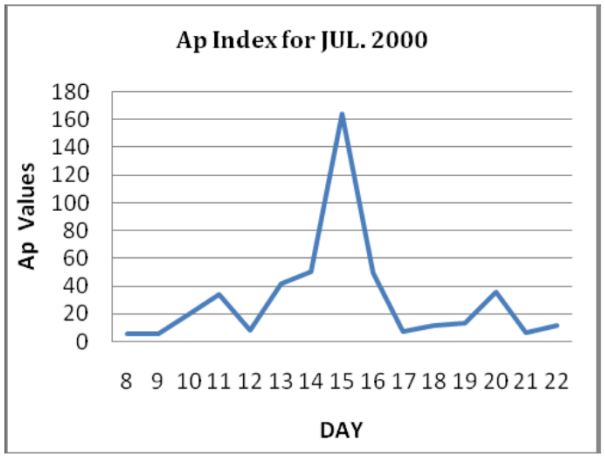
Daily variation of mean SW indices associated with the ASCA (Astro-D) 15th of July 2000 anomaly







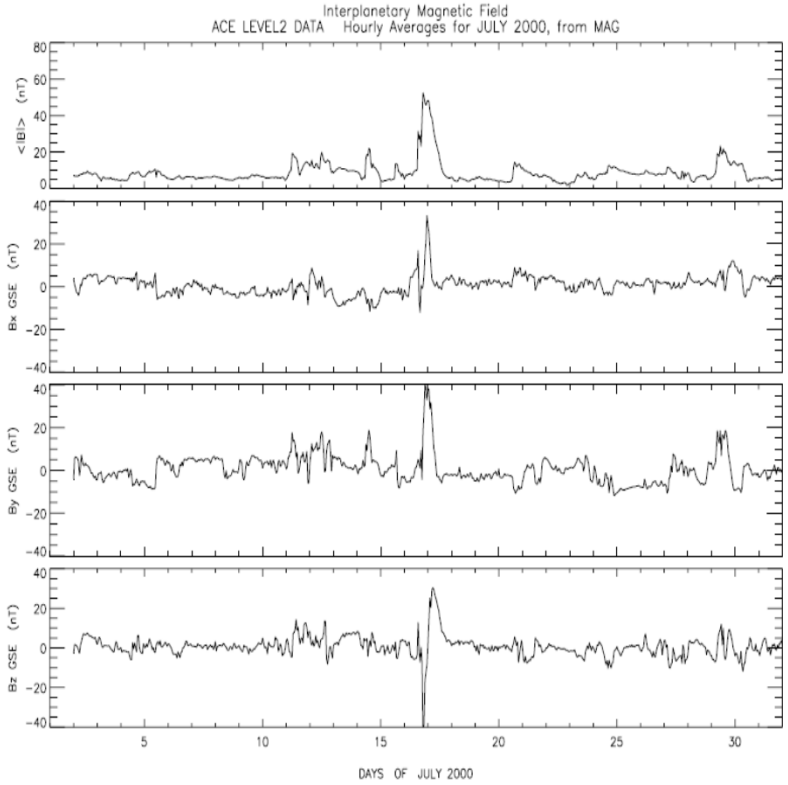


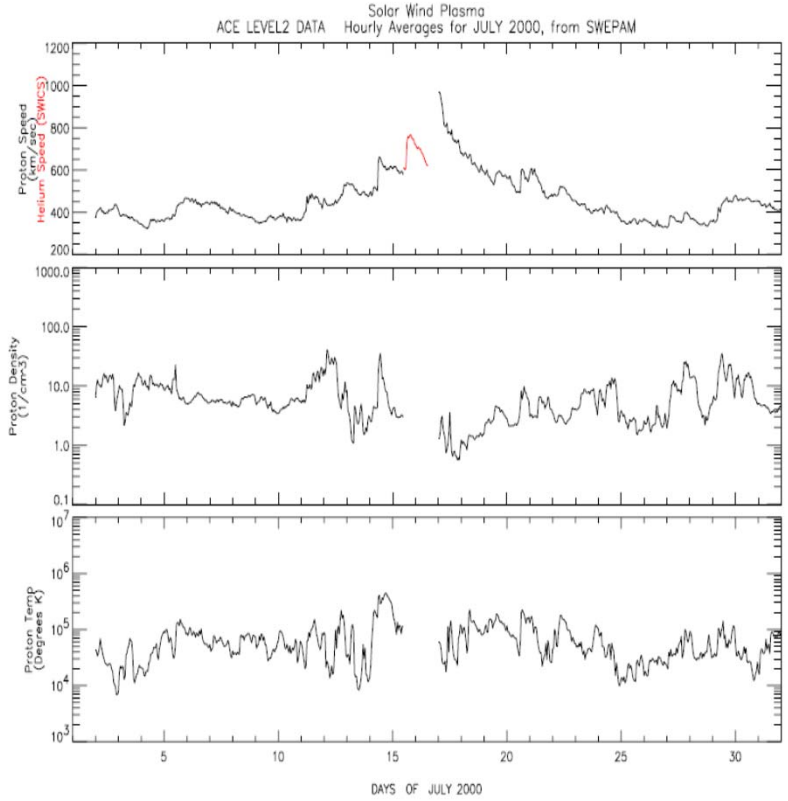


Daily variation of mean SW indices associated with the ASCA (Astro-D) 15th of July 2000 anomaly

- There was increase in sunspot number few days to the event between 180-210
- Ap index was at peak of 162 on the 11th of Jul ’07
- Electron flux decreases after reaching peak on the 8th Jul’07
- Proton flux >1mev and >10mev

Daily variations of IMF and solar wind plasma for ASCA (Astro-D) 15th of July 2000 anomaly

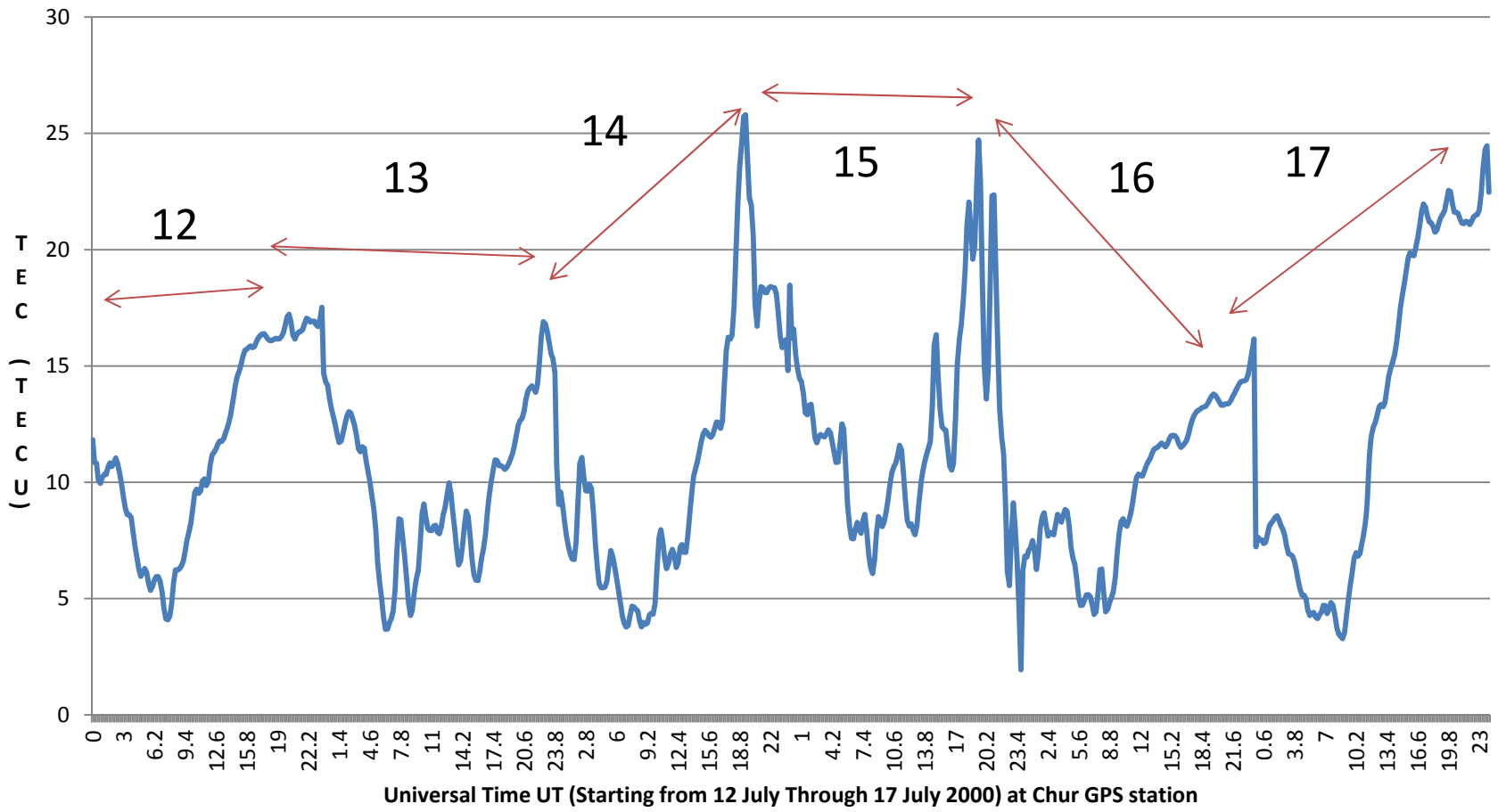




Daily variations of IMF and solar wind plasma for ASCA (Astro-D) 15th of July 2000 anomaly

- Magnetic field was about 10nT during this period
- Solar wind plasma Temp was almost 10^6 degrees Kelvin
- Plasma Density was about about 60 per cm3
- Steady increase in solar wind speed from 300km/s to 800km/s

Variability of Total Electron Content



Daily TEC Variation

- There was positive increase in daily amplitude of TEC from about 16 TEC units (TECU) on 14th July, the day preceding the anomaly, to as high as 25 TECU at about 19 UT on 15th July when the satellite anomaly was recorded.
- After that day the daily amplitude of TEC reduced to about 15.5 TEC at about 23 UT on 16th July.

Conclusion

- It can be deduced from the SW indices studied that there was a rapid ejection of solar particles during July 15th 2000 event, hence a justification of the damage to the spacecraft.
- It can be said that this very satellite anomaly is associated with an increase in TEC
- Even if no significant activity is taking place on the day of a particular event, the impact of the solar activity of past days may be the cause of damage.

Recommendations

- More efforts should be channeled to the study of TEC behaviour at different latitudes during satellite anomalies
- This will improve alerts/warning system to satellite operators and this alerts should be made readily available.

Acknowledgement

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THANK YOU FOR YOUR ATTENTION!