Analysis of ionospheric storm effects based on GPS and ionosonde data during geomagnetic storms: Preliminary results

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Ionosphere

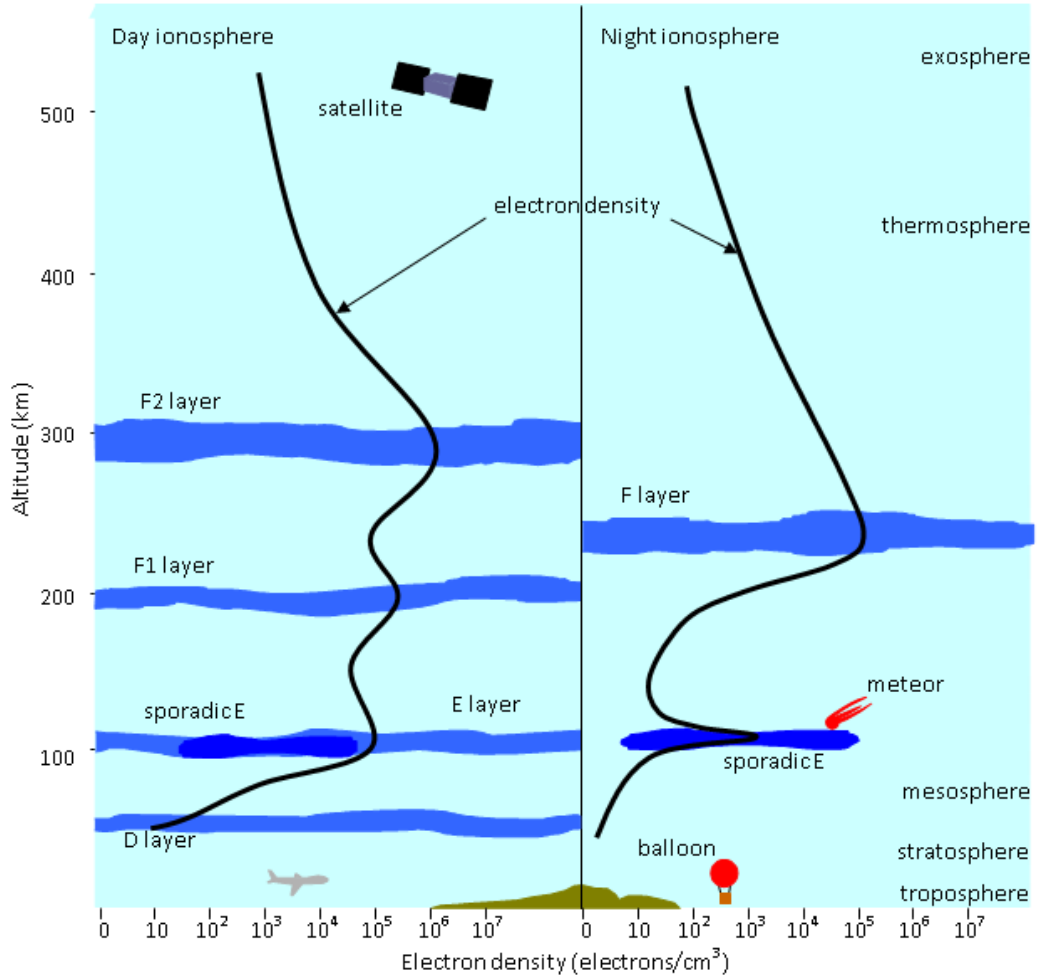
- Ionosphere: The partially ionised region of the Earth's upper atmosphere that where there is a number of free electrons and ions are present (Schunk & Nagy, 2009).It extends approximately from 50 km up to 1000 km.
- Variations of the ionosphere (McNamara, 1991)

- Diurnal.
- Seasonal.
- Location.
- Solar activity.

- Day time- photoionization process occurs and electron density increases.

- Night-time- recombination occurs and electron density decreases.

- Ionospheric storm effects: An enhancement (positive) or depletion (negative) in the electron density.



Measuring the ionosphere: Ionosonde

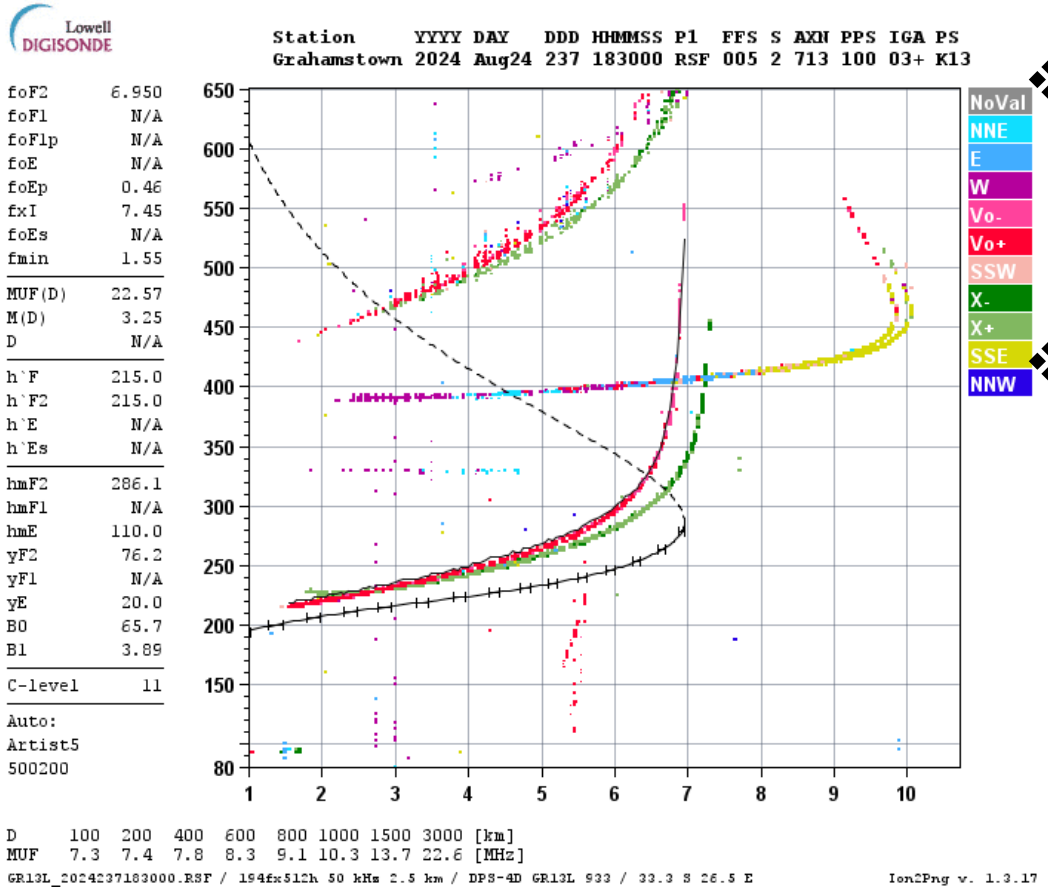


Figure : Ionogram illustrates vertical profile for Makhanda formerly known as Grahamstown.

- A pulse is emitted into the ionosphere.
- Ionosonde records the time delay between the transmission and receivers of the pulse over a range of different frequencies.
- Limitations: Measures up to the peak of the F2 layer.

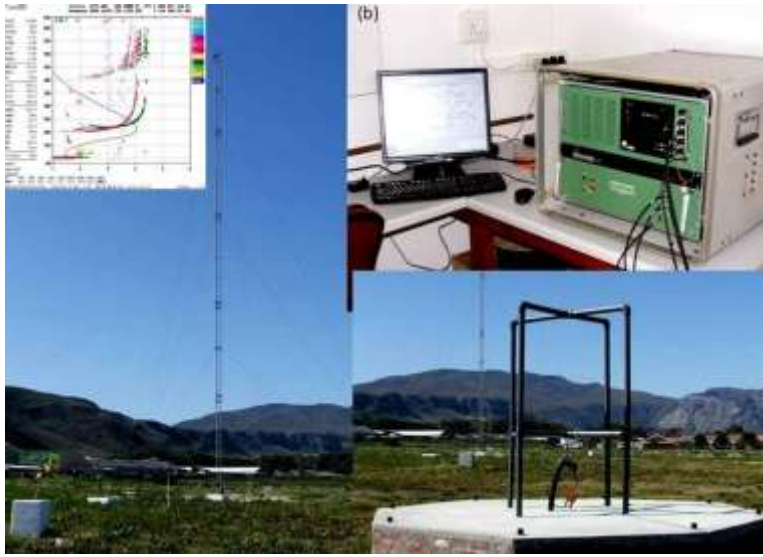
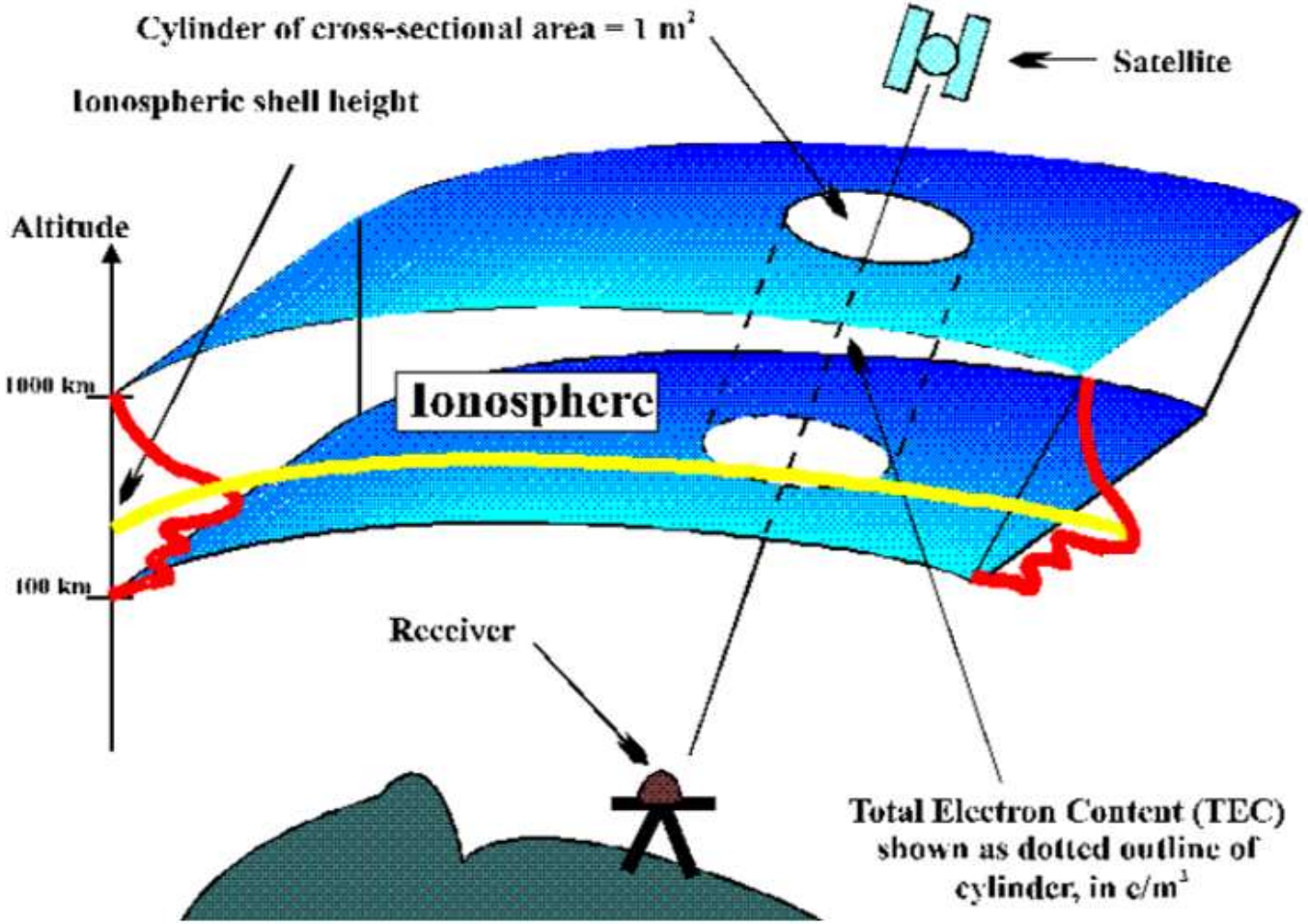


Figure : SANSA ionosonde located in Hermanus with temporal resolution of 5 minutes.

Total Electron Content



(Chen et al., 2021)

- Total Electron Content (TEC): is the number of free electrons in a column of unit cross sectional area along the ray of path from transmitter to the receiver (McNamara, 1991).

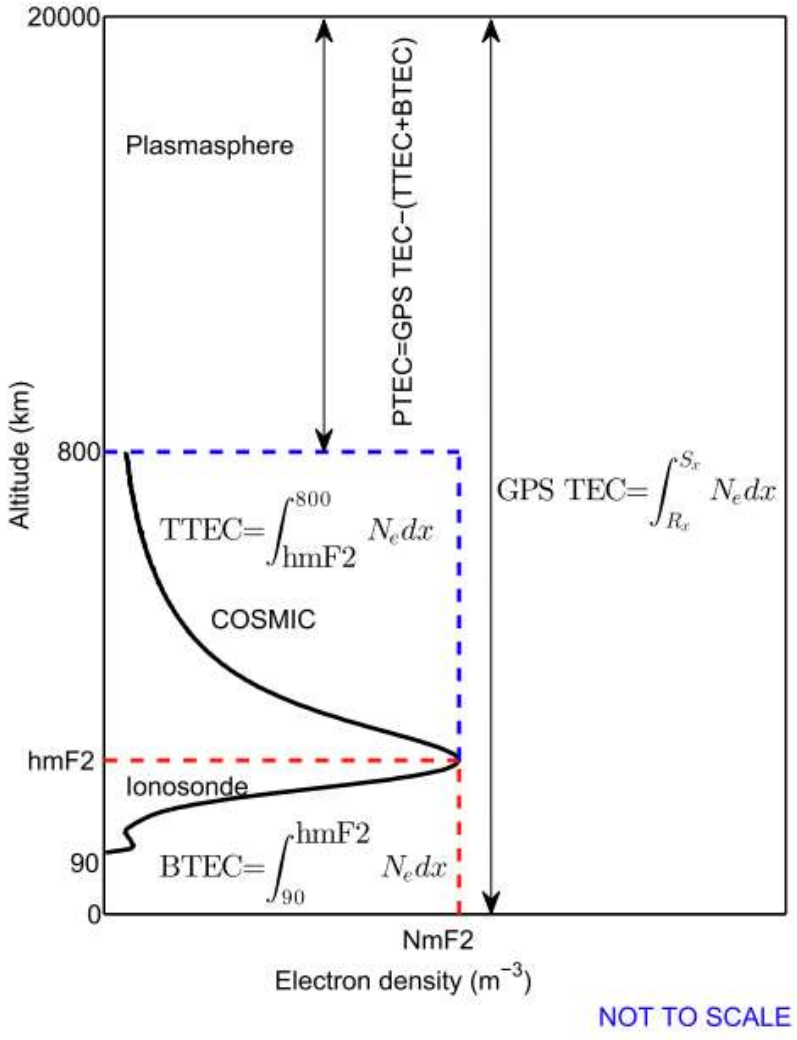
- TEC can be estimated by comparing the difference in the time delay between the two (L1= 1575.42 MHz and L2=1227.60 MHz) frequencies experience by the radio waves (Cander,2019 ; Yasyukevich et al.,2015; Singh et al., 2023).

Project

- Analyse the ionospheric storm effects using total electron content derived from ionosonde and GPS observations during geomagnetically disturbed conditions.
- Determine the ionospheric storm effects where the ionospheric response will be separately studied as established from GPS TEC, Ionospheric TEC and plasmaspheric TEC.
- Purpose: Establish quiet time threshold for Ionospheric TEC and plasmasphere TEC
- Study area : Makhanda formerly known as Grahamstown.

Value of Dst (nT)	Storm category
$-30 \geq Dst > -50$	Small
$-50 \geq Dst > -100$	Moderate
$-100 \geq Dst > -200$	Intense
$-200 \geq Dst \geq -350$	Strong
$Dst < -350$	Great

- Table: Geomagnetic storm periods are identified: based on well-established storm-time criteria of Dst<-30nT (Loewe & Prölss , 1997).
- $\Delta TEC \frac{TEC - TEC_{monthlymedian}}{TECmonthlymedian} \times 100\%$



(Habarulema et al.,2021)

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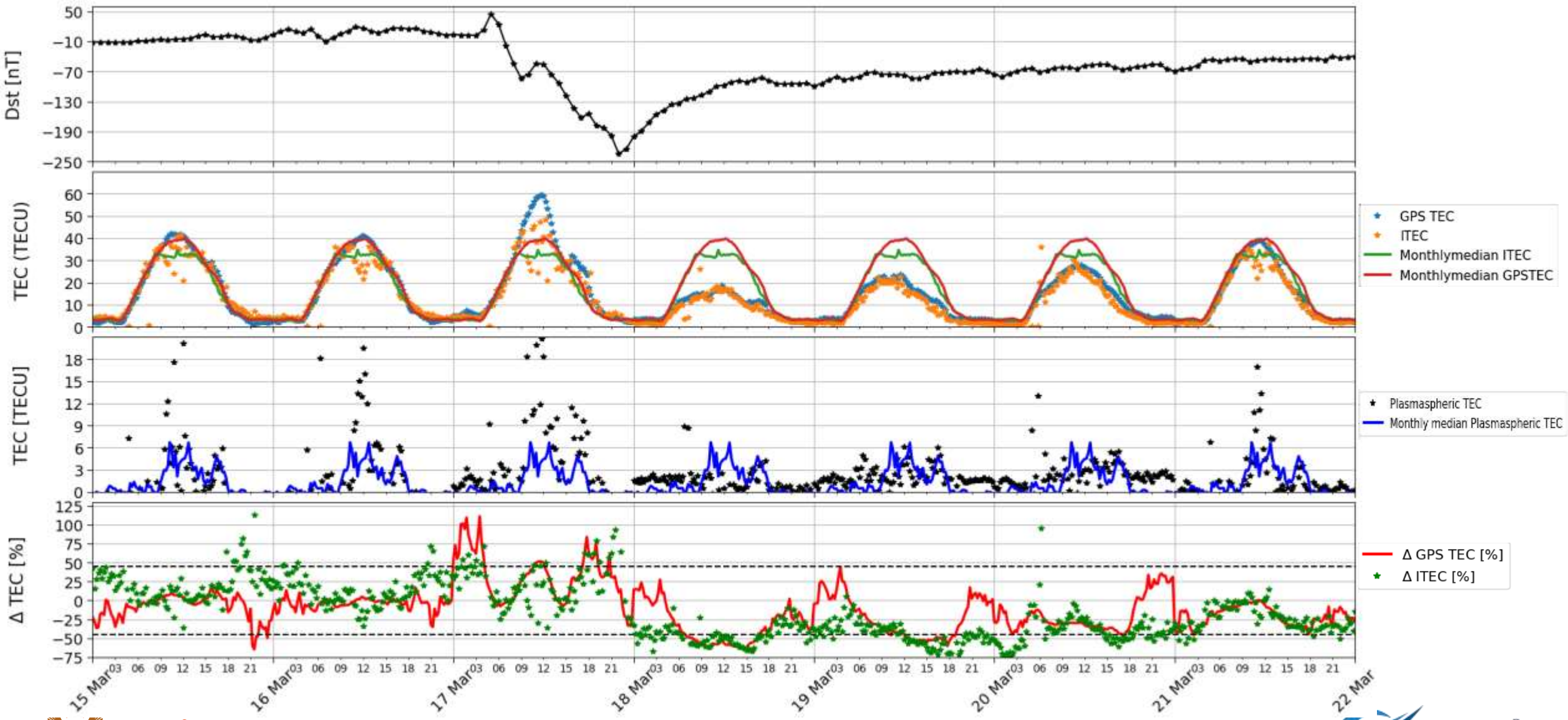
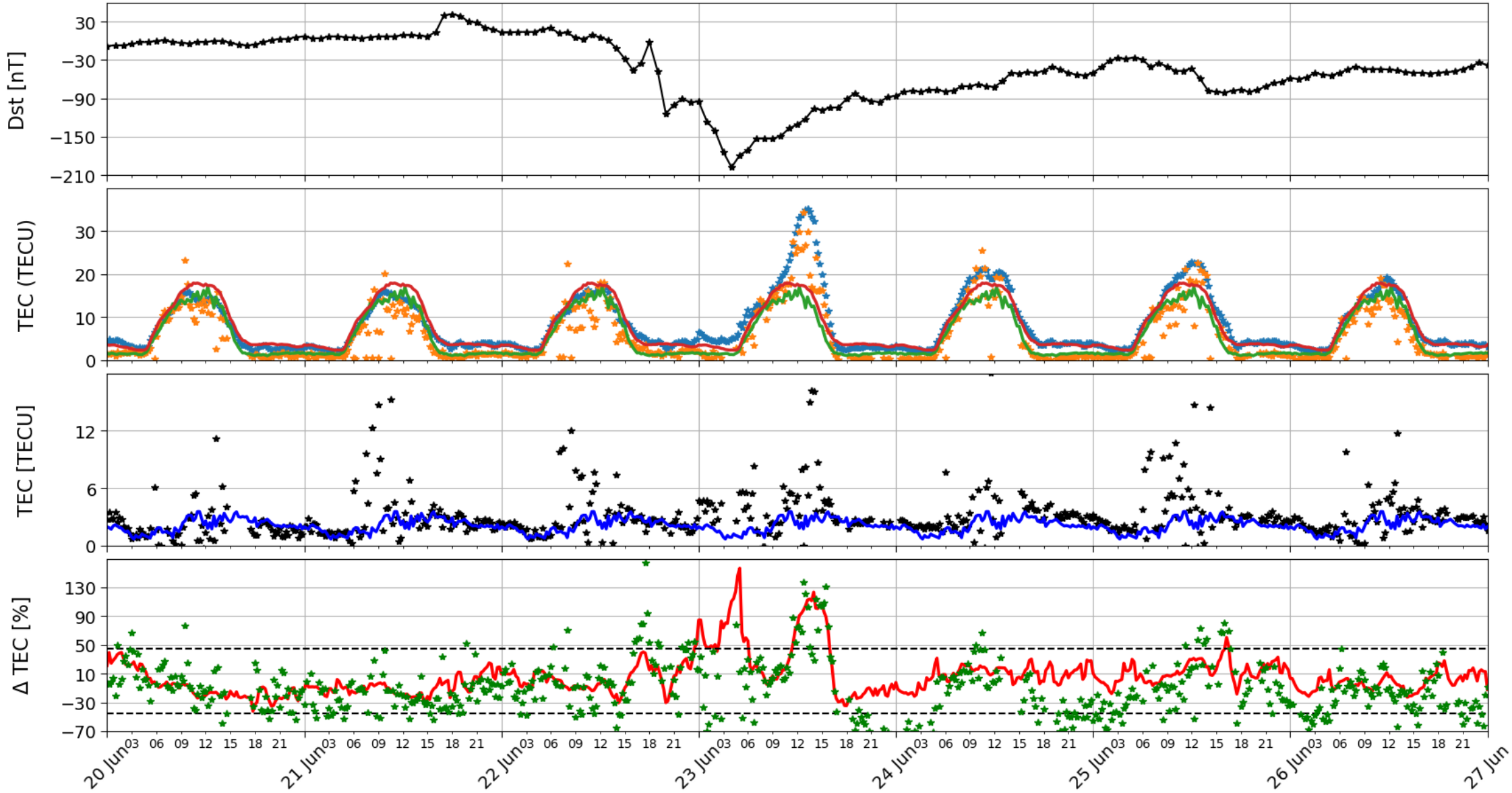
Preliminary Results: 15-22 March 2015



- $\Delta TEC \frac{TEC - TEC_{monthlymedian}}{TECmonthlymedian} \times 100\%$

Preliminary Results: 20-27 June 2015



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$$\Delta TEC \frac{TEC - TEC_{monthlymedian}}{TECmonthlymedian} \times 100\%$$

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Summary and Future work

- Threshold are needed to quantify the duration of ionospheric storm.
- By comparing the TEC deviations from the expected (quiet time) values, you can identify the negative and positive storm effects.

- Identify which mechanism drives the storm .

- Analyse separately what is the contribution from ionospheric TEC , plasmaspheric and GPS TEC during a geomagnetic storm.

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