# A South African analysis of GPS TEC and ionospheric variability during magnetic storms

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## Abstract

The solar wind effects on the Earth's environment are studied for their basic scientific values and crucial practical impacts on human technological systems. In this paper, total electron content (TEC) changes during two severe ionospheric storms (5-8 April 2000 and 7-12 November 2004) are analysed using GPS data derived from dual frequency receivers located at Sutherland (32.38°S, 20.81°E) and Springbok (29.67°S, 17.88°E), South Africa. The analysis of the storm time ionospheric variability over South Africa was undertaken by comparing the ionospheric slab thickness ($\tau$), foF2, scale height around the F2 peak (Hm) and the hmF2 values obtained from Grahamstown (33.30°S, 26.53°E) and Madimbo (22.4°S, 30.9°E) ionosonde measurements. Results show that GPS TEC for the analysed periods was depleted significantly during the storm period with a corresponding depletion in foF2. Ionospheric F2 layer peak parameters foF2, hmF2 and observational TEC values were compared with those generated by the IRI model.

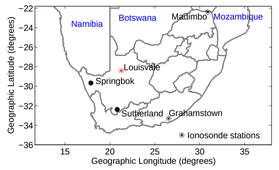
## Introduction

Increased dissipation of solar wind energy in the near-Earth environment is a significant source of consequent perturbations in the upper atmosphere and ionosphere. Despite the enormous work that has been done to understand ionospheric dynamics during magnetic storms, little knowledge is known over the African region due to a lack of instruments and continuous databases. This work deals with the analysis of GPS TEC variability (derived from South African receiver network) during storm conditions. To understand the level of the ionospheric disturbance, South African ionosonde data was also used.

## Data, results and discussion

### Data sources

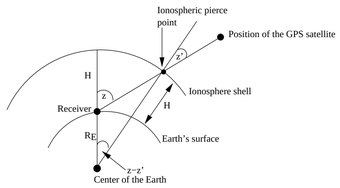
- GPS TEC: Dual frequency receiver stations (Sutherland (32.38°S, 20.81°E) and Springbok (29.67°S, 17.88°E))
- Dst&Kp indices and IMF Bz parameter: ACE satellite and downloaded from http://cdaweb.gsfc.nasa.gov/cdaweb/sp_phys/
- Ionosonde data: Grahamstown (33.30°S, 26.53°E) and Madimbo (22.4°S, 30.9°E).



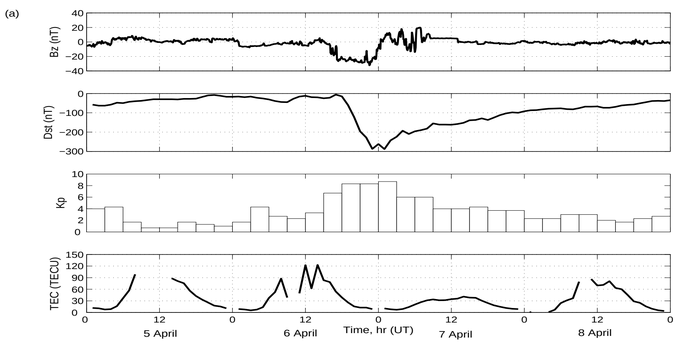

South African Map showing GPS and ionosonde stations

### Results and discussion

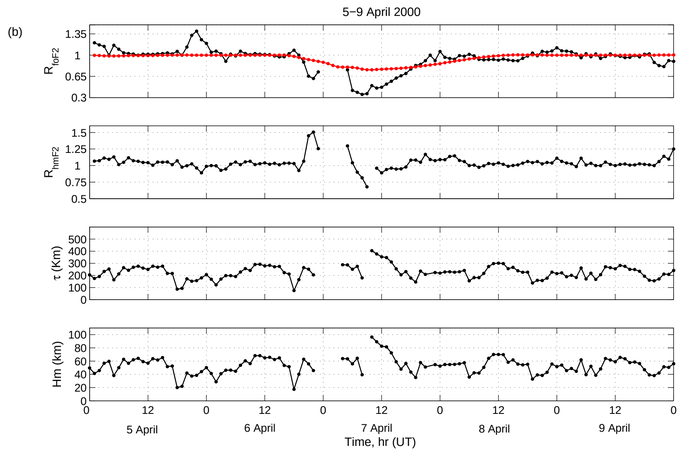
- For April 2000 storm, the day time variation of TEC and foF2 was quite different during the storm's main phase on 6 April.
- Significant irregular day time variations in TEC are observed before the main phase of the storm .
- No substantial variation in foF2 and hmF2 in the morning and at about midday has been observed as it was recorded in the case of TEC.




Conversion of slant TEC to vertical TEC

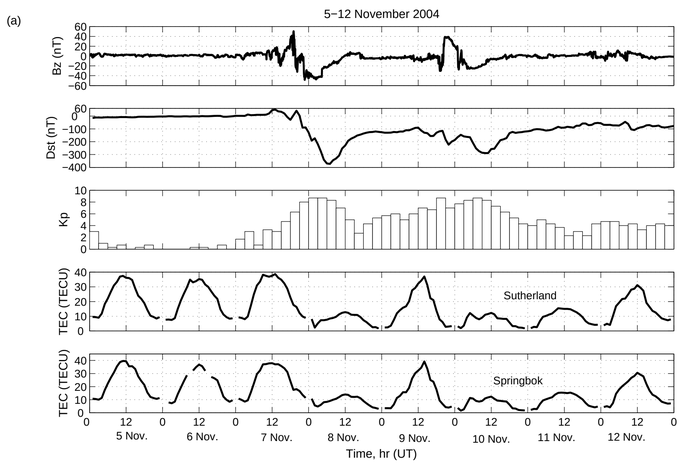



## Ionospheric variations during the storm of April 2000



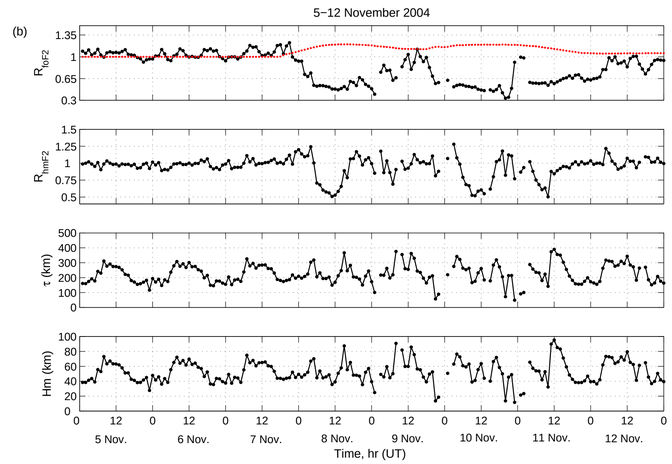

- At about 19:00 UT the maximum F2 region electron density decreased significantly and at the same time the hmF2 showed an opposite behaviour.
- A probable explanation of the increased altitude of hmF2 could be the travelling ionospheric disturbances (TADs) carrying along equatorward-directed winds of moderate magnitude (Prolss, 2004).

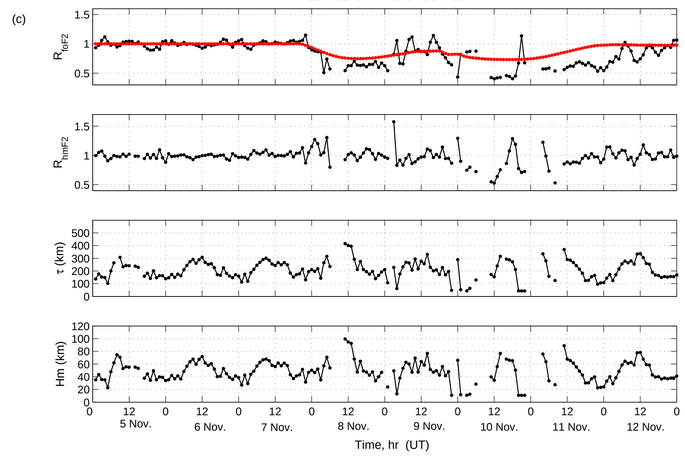
## The storms of November 2004




- During the 8 Nov. 2004, a significant TEC depletion is observed which could be due to changes in thermospheric composition caused by the heating of the low thermosphere in the auroral region.
- On 9 Nov., the electron density recovered to its near-to-quiet condition state and maximum TEC values were observed at $\sim$ 14 : 00 UT for both GPS stations. We have observed a substantial long-lasting decrease of the F2 region peak altitude during the daytime above Grahamstown, whereas Madimbo, which is closer to low latitude, indicated a drop of hmF2 about 3 hrs before noon of 8 Nov.
- Dabas et al. (2006) reported results for the same event for the low latitude station Delhi (28.3°N; 77.1°E) which exhibited a substantial decrease of foF2 during the storm main phase on 7 Nov while practically no changes in foF2 were observed for the equatorial station Trivandrum (8.2°N; 76.9°E).

## Ionospheric variations during the storms of November 2004




- During the storm main phase, the variation of hmF2 was insignificant for Delhi, and Trivandrum showed a drop in hmF2 (about 150 km) during the local evening of 7 Nov. (LT= UT+5:30h)
- On 8 Nov., Delhi showed a substantial rise in hmF2 and a well-developed positive phase before local noon, while for Trivandrum a moderate decrease in the hmF2 values before local noon followed by an electron density enhancement during the afternoon has been observed.
- Compared to Grahamstown and Madimbo, the changes in foF2 observed over Delhi and Trivandrum were quite different during 7-11 Nov. The variation in hmF2 observed for both Southern and Northern Hemisphere stations was more similar during the second storm.

## Conclusion

The STORM option gave relatively effective results for Madimbo but provided negative results from what is observed for Grahamstown during the storm conditions.

## References

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