International Civil Aviation Organization

THE FOURTH MEETING OF IONOSPHERIC STUDIES TASK FORCE (ISTF/4)

New Delhi, India, 05 – 07 February, 2014

Agenda item 3: Review of status of States' activities

UPDATE ON RELEVANT ACTIVITIES IN AUSTRALIA

(Presented by Australia)

SUMMARY

This paper presents an update on the current status of ionospheric and space weather research and development in Australia

1. INTRODUCTION

1.1 The Space Weather Services section of the Bureau of Meteorology maintain a suite of real time space weather products and services relevant to satellite communication and navigation in the Australian region, and conduct research relevant to the mitigation of ionospheric and space weather effects on a wide range of technological systems including GNSS.

1.2 The SPACE Research Centre at RMIT University has progressed a research program aimed at modelling Equatorial Plasma Bubbles (EPB) / ionospheric scintillation in the southern equatorial anomaly region with a view to developing a short-range forecast capability for EPB.

1.3 The GNSS Research Centre at Curtin University and Geoscience Australia have commenced a research program aimed at improved monitoring and modelling of ionospheric scintillation in the southern equatorial anomaly region, including the installation of 9 additional ISMs throughout the region.

2. DISCUSSION

2.1 A new scintillation product has been added to the suite of BoM/IPS space weather products for satellite communication and navigation.

The new product is a real time map of a proxy index for ionospheric scintillation derived from high rate GNSS data. This map complements the existing S4 scintillation map derived from Ionospheric Scintillation Monitors (ISM) but provides a denser spatial sampling by using all available high rate CORS GNSS data streams from the region of interest. The real time map available at: http://www.ips.gov.au/Satellite/1/2/2.

The underlying quantity computed for the scintillation proxy is the variance of the time derivative of the total electron content (TEC) over 1 minute intervals. This is commonly known as ROTI (Rate of change of TEC). This serves as a measure of ionospheric scintillation since the disturbed ionospheric conditions that cause scintillation lead to short timescale fluctuations in the TEC. Comparison of the two products show close correlation between the spatial distribution of ionospheric scintillation observed by the two methods.

The ROTI-based map scale has four discrete levels of scintillation. The mild and moderate scintillation levels were defined initially through calibration with a co-located Ionospheric Scintillation Monitor (ISM) at Darwin. The severe level of scintillation used on the map is reported when ROTI levels over a 1 minute period are high and the GPS receiver reports a loss of lock on the corresponding satellite during the same period. This indicates the presence of scintillation sufficiently severe to cause the receiver to no longer track the satellite, with a corresponding reduction in positioning accuracy. The colours show the highest level of scintillation observed over 15 minute intervals and the size of the plot marker indicates the age of the data, with the most recent data shown with larger dots. See Appendix (Figs 1 & 2) for examples.

2.2 A recent paper submitted to JGR Space (Carter et al., 2014 [JGR submitted]) by researchers from RMIT University, Boston College and IPS presents a detailed analysis of the occurrence of post-sunset Equatorial Plasma Bubbles (EPBs) at Vanimo (PNG), detected using GNSS and ionosonde. Modelling using a time-dependent 3D physics-based numerical model of the Earth's thermosphere and ionosphere (TIEGCM) shows that the day to day variability of the Rayleigh-Taylor instability growth rate closely matches observed scintillation (S4) variability, and that this is primarily driven by Kp. Ie EPB variability during the scintillation season resides in the variations caused by geomagnetic activity (as parameterized by Kp) rather than solar EUV flux (as parameterized by F10.7). The authors were able to use the TIEGCM modelled R-T growth rate with fitted thresholds to reproduce the EPB occurrence observations to an accuracy of better than 85%. Refer Figure 3 in Appendix.

This research is of significance to the activities of the ISTF and its representative States. In particular those wishing to forecast the occurrence of EBP. While further work needs to be done, it suggests that reasonable accuracy can be achieved in prediction of the quiet time occurrence of EPB with the use of a physics-based coupled ionosphere-thermosphere model, for which the most important driver of daily variability is the geomagnetic activity level (eg Kp) which can in turn be modeled with good accuracy from in-situ solar wind observations.

2.3 The GNSS Research Centre at Curtin University and Geoscience Australia, under the umbrella of the Cooperative Research Centre for Spatial Information (CRCSI) have commenced a research program aimed at improved monitoring and modelling of ionospheric scintillation in the southern equatorial anomaly region, including the installation of 9 additional ISMs throughout the region. The ISMs are Septentrio PolaRxS. The following sites are planned:

Groote Eylandt, NT.
Christmas Island, WA.
Kununurra, WA
Mareeba, QLD
Horn Island, QLD
Townsville, QLD (installed)
Nauru, South Pacific (installed)
Manus Island, PNG
Casey, Antarctica (installed)

These sites complement the existing BoM/IPS sites in northern Australia.

3. ACTION REQUIRED BY THE MEETING

3.1 The meeting is invited to note the information in this paper.

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APPENDIX

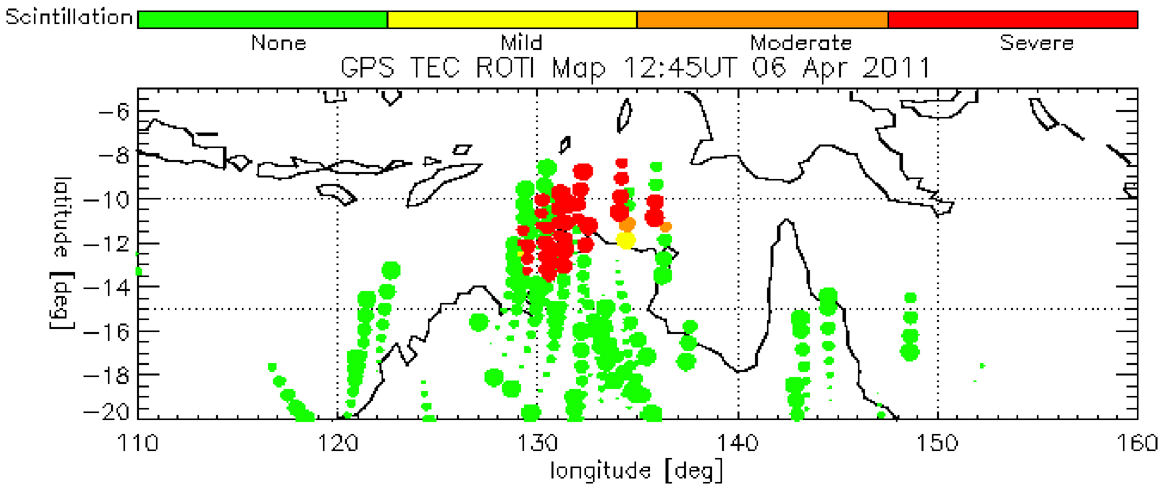

Figure 1. New product: Real time map of ROTI-based ionospheric scintillation proxy (derived from high rate CORS GNSS data)

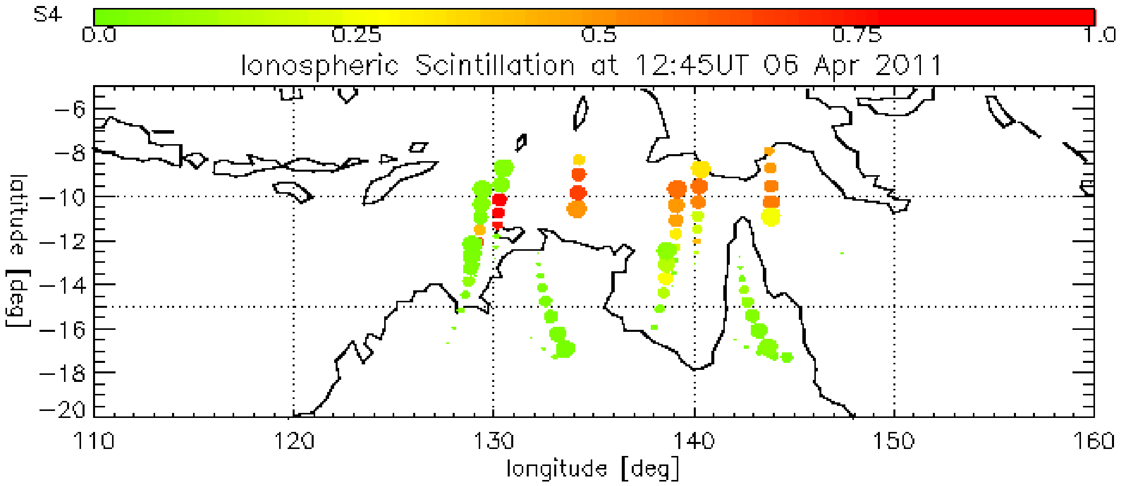

Figure 2. Real time map of ionospheric scintillation index S4 (derived from Ionospheric Scintillation Monitors) covering the same period as Figure 1.

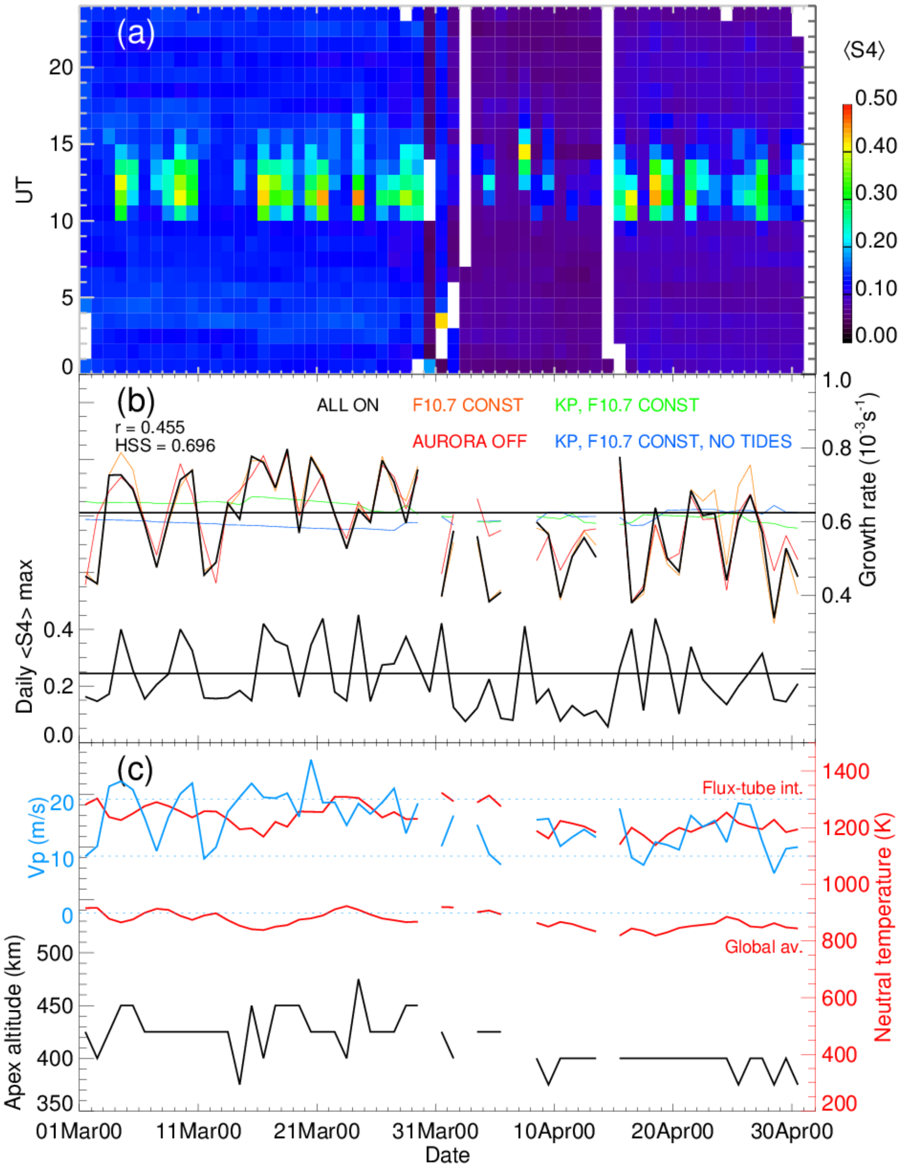

Figure 3. Summary of observations and modeling results from Carter et al 2014 [JGR submitted] showing high correlation between modeled Rayleigh-Taylor growth rate variability and scintillation (S4) variability.