International Civil Aviation Organization

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

New Delhi, India, 05 – 07 February, 2014

Agenda Item 4: Review of progress of tasks and related action items
(f) Space Weather effects

SPACE WEATHER EFFECTS ON GAGAN

(Presented by AAI, India)

SUMMARY

This paper presents assesses the space weather effects on Indian SBAS, GAGAN. The recent solar storms- geomagnetic and radiation storms were selected to analyze the impact on availability of GAGAN service APV1/1.5 and RNP 0.1.

1. INTRODUCTION

1.1 The solar storms produces geomagnetic storms, radiations storms and other geophysical disturbances which have varied effects on earth and earth orbiting satellites. The number and intensity increases with increasing solar activity.

1.2 The solar activity have remained moderate in the year 2013 which witnessed around 8-9 geomagnetic storms.

1.3 The intensity of geomagnetic storms is primarily defined by two indices- *Kp* index and *Dst* index. *Kp* index describe the geomagnetic activity at mid-latitudes whereas *Dst* is the indicator for equatorial region.

1.4 Intense geomagnetic storms can cause electrical power outages, failure of communication/navigation satellites, loss of HF communication link, ionospheric disturbances etc.

1.5 The geomagnetic storms typically last for few days with four different phases- Sudden storm commencement, initial phase, main phase, and recovery phase. Figure 1 shows the variation of Dst and Kp index during geomagnetic storm of 17 March, 2013.

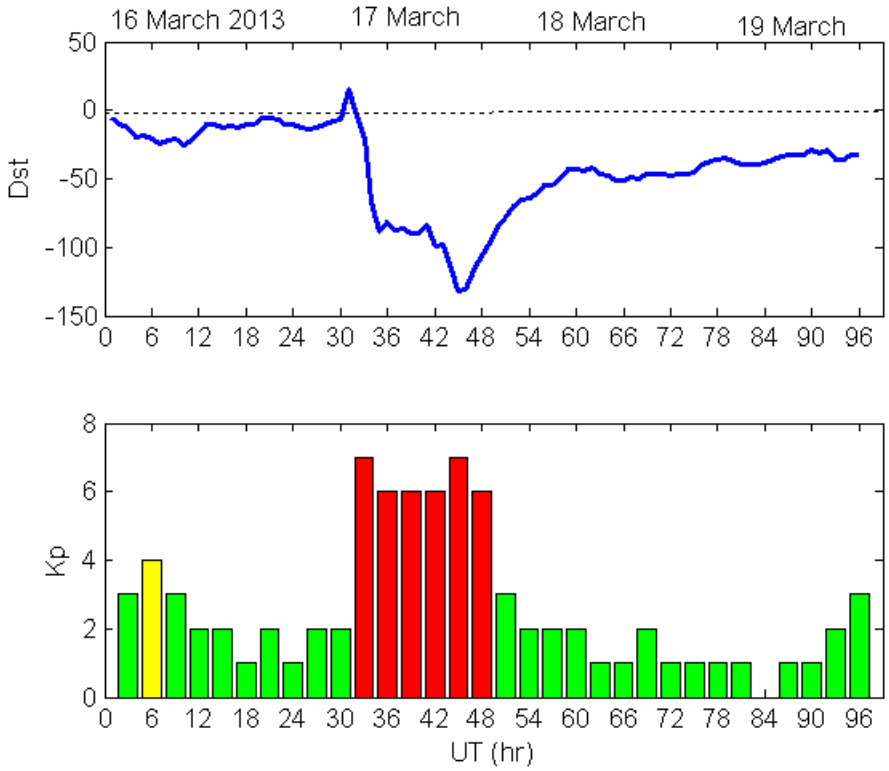

Figure 1: The Dst and Kp index during geomagnetic storm of 17 March, 2013

2. DISCUSSION

2.1 The performance of GAGAN system during recent solar storms in 2012-13 has been evaluated. The iono model used in GAGAN is Multi-layer data fusion-Kriging which broadcast the grid based iono delay corrections along with its error bound.

2.2 The error bound would increase in presence of large temporal and spatial gradients in the electron density. The high variance would reduce the availability of the service.

2.3 To maintain the integrity of the system, the model also employs the storm detector following 'Chi-Square Test' which would trip in case of any extreme irregularity. The threshold value of storm detector to get tripped is 5. However, if the ESD >3 is considered as stormy day for performance evaluation of GAGAN. Figure 2 shows the Extreme Storm Detector (ESD) metric plot for 17th March, 2013. Figure 3 shows the availability contours of GAGAN service APV1/1.5 (left) and RNP 0.1 (right) on 17th March, 2013.

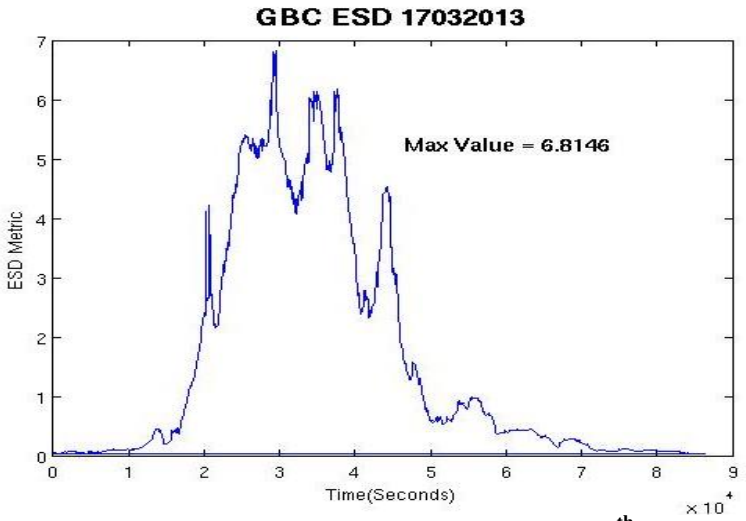

Figure 2: Extreme Storm Detector Metric plot for 17th March, 2013

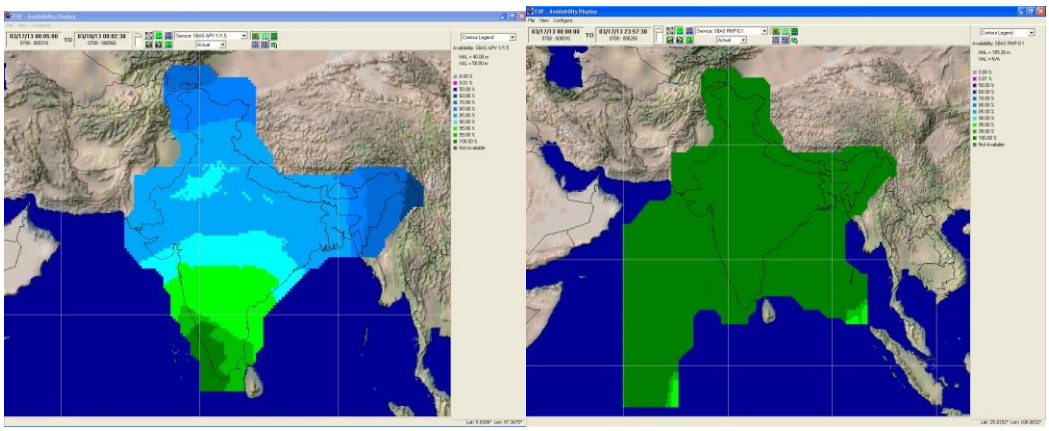

Figure 3: (left) GAGAN Service APV 1/1.5 Availability Coverage is 17.53% at 95% Contour (right) GAGAN Service RNP 0.1 Availability Coverage is 100% at 95% Contour on 17th March 2013.

2.4 Figure 4 shows the ionospheric response to the geomagnetic storm of 16-18 March, 2013. It indicates that equatorial ionization anomaly was enhanced on 16 March, with its crest extending above ~25° N (geographic latitude).

2.5 The strength of anomaly on 18 March is weaker than previous days. However, the availability of GAGAN APV 1 service reduces to Zero on this day. The large spatial and temporal gradients could be one of the reasons for degraded performance of GAGAN. More detailed analysis is required for this verification.

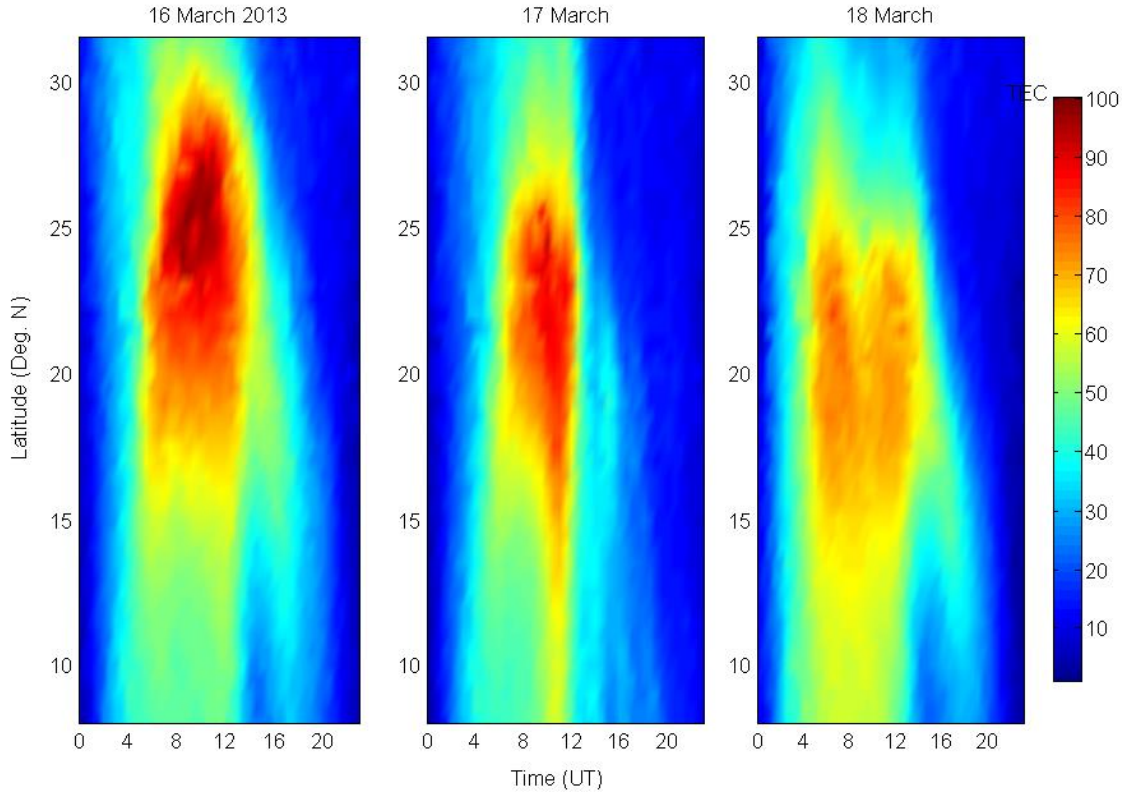

Figure 4: The development of equatorial ionization anomaly at ~77° E longitude during the geomagnetic storm of 16-18 March, 2013

2.6 The GAGAN performance during recent storms has been tabulated. The table below lists the percentage availability of GAGAN service – APV1/1.5 and RNP 0.1 at 95% contour and the number of times Chi-Square failed during the geomagnetic storms.

2.7 In general, it is noticed that availability of GAGAN APV1 service gets affected more on the next day of main phase of storm i.e. during recovery phase of storm. And storms during summer months were found to have negligible impact on GAGAN system, implying seasonal dependency of geomagnetic storms on low latitude ionosphere.

2.8 The space weather effects on GAGAN RNP 0.1 service were noticed to be negligible as GAGAN maintained its required availability and continuity.

Date	Max Kp	Min. Dst	Availability % at 95% contour for RNP0.1 service	Availability % at 95% contour for APV1 service	No. of times Chi-Square Failed
15-Jul-12	7	-133	100	100	0
16- Jul-12	6	-105	100	100	0
08-Oct-12	6	-106	100	64.97	44
09-Oct-12	7	-111	100	0	162
14-Nov-12	6	-109	100	32.43	690
15-Nov-12	1	-41	100	0	1201
17-Mar-13	7	-132	100	26.6	1096
18-Mar-13	3	-97	100	0	219
29 June- 13	6	-98	100	100	0
30 June- 13	3	-48	100	75.36	0
2 Oct- 13	8	-67	100	93.34	0
3 Oct- 13	3	-50	100	0	289
8 Oct- 13	6	-30	100	0	159
9 Oct- 13	5	-65	100	10.87	28
Radiation storm					
22 May- 13	3	-17	100	96.32	-
23 May- 13	3	-13	100	98.79	-

3. ACTION REQUIRED BY THE MEETING

3.1 The meeting is invited to:

a) note the results presented in the paper; and

b) discuss any relevant matters as appropriate.

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