AOGS - AGU (WPGM) Joint Assembly
13 to 17 August 2012
Singapore

Ionospheric scintillation observation using GPS data at UKM, Malaysia

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Outline

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Introduction

- **Ionospheric scintillation**: Rapid variations of amplitude and phase in radio signals caused by small scale irregularities of electron density known as scintillation.

- Two main parameters of scintillation are :
    1. Amplitude scintillation(S4 index)
    2. Phase scintillation (sigmaphi)

Introduction

- Scintillations are intense in the equatorial region; they are strong at high latitudes and weak at mid latitudes (Basu et al, 1988). The worst source of ionosphere scintillation is at the equatorial region.

- Scintillation activity in equatorial region highly depend on the geomagnetic condition, local time (LT), seasonal variations and the 11-year solar cycle (Basu et al, 1988).

- Scintillation phenomena has an influence on both reliability and accuracy of the communication systems like GPS. Therefore, it is desirable to obtain further understanding of ionosphere scintillation and effects on GPS.

Methodology

- Data recorded by GISTM with a dual frequency receiver at UKM was used to examine ionospheric scintillation activities between January and December 2010.

1. GISTM , type GSV4004B EuroPak-3M
2 .GPS Antenna
3,4,5,6 .Connection cable < 30 m
7. PC processing data,
8. UPS

- A network of GPS Ionospheric Scintillation and TEC Monitor (GISTM) systems installed in Malaysia.

- Four GSV4004 receivers have been deployed at UKM (2.55° N, 101.46° E), UTHM (1.55° N, 103.6° E), LANGKAWI (06.19° N, 99.51° E) and UNIMAS (1.28° N, 110.25° E), in Malaysia.

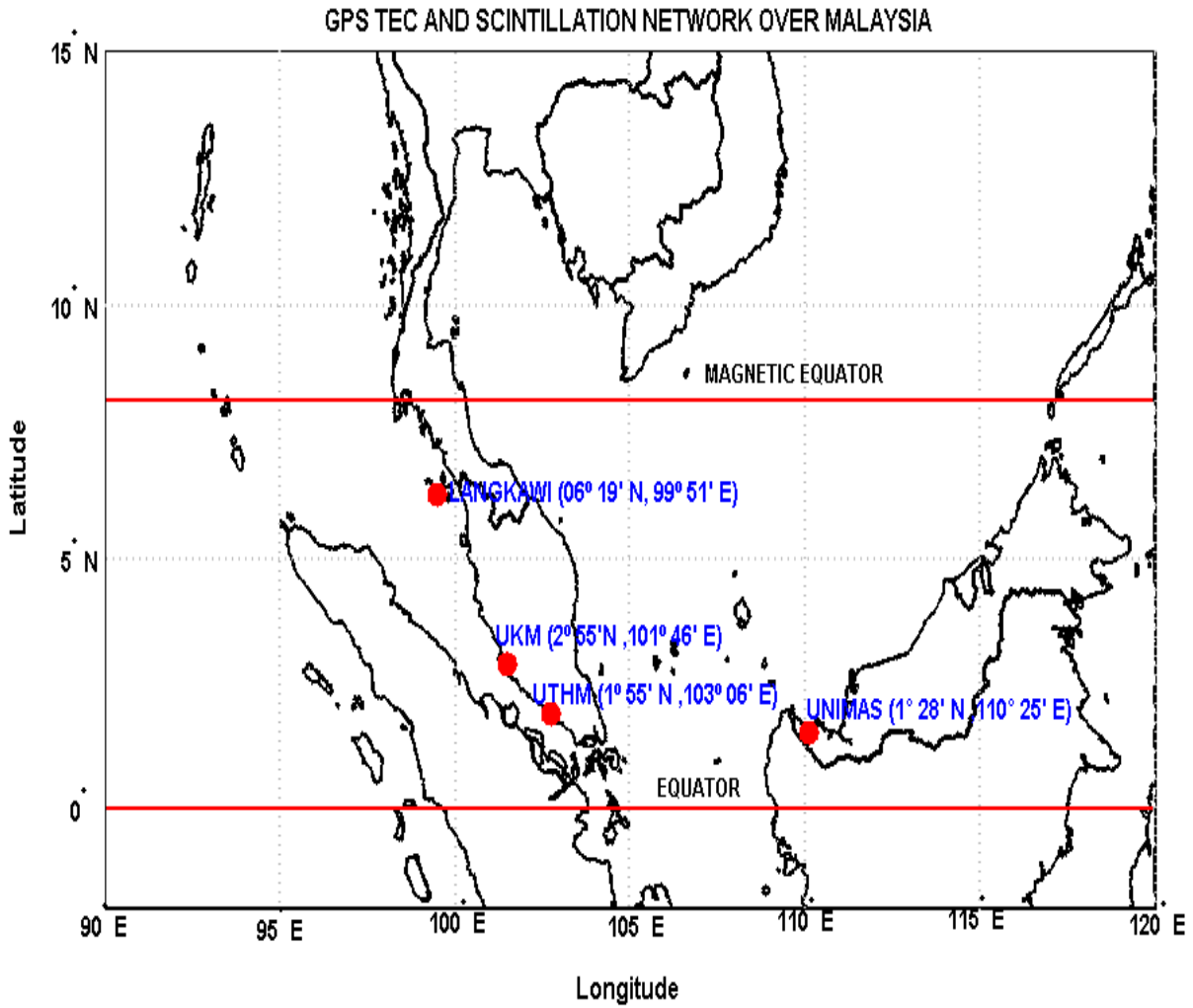

Fig.1. GPS TEC and Scintillation network over Malaysia.

GSV4004B dual frequency receiver

- The GSV4004B receiver is capable of tracking up to11GPS signals at both the L1 and L2 frequencies of 1575.42MHz and 1227.6MHz, respectively.

- The sampling rate of the amplitude scintillation (S4 index) and phase scintillation used in this work is 50Hz for each satellite on L1 frequency.

Amplitude scintillation

- Amplitude scintillation calculated over 60-s intervals as the standard deviation of the detrended signal intensity (SI) and is referred to as total S4, in (S4t) column.

- The correction to the total S4(S4cor) due to ambient noise. Then the corrected S4 with the effects of ambient noise removed is computed by this formula:

$$S4 = \sqrt{(S_{4t}^2 - S_{4cor}^2)}$$

- In order to detect the occurrence of amplitude scintillation activity, the analysis took into consideration that the S4 measurements from the GPS satellites must exceed values of 0.2 with elevation angel greater than 30°.

Result

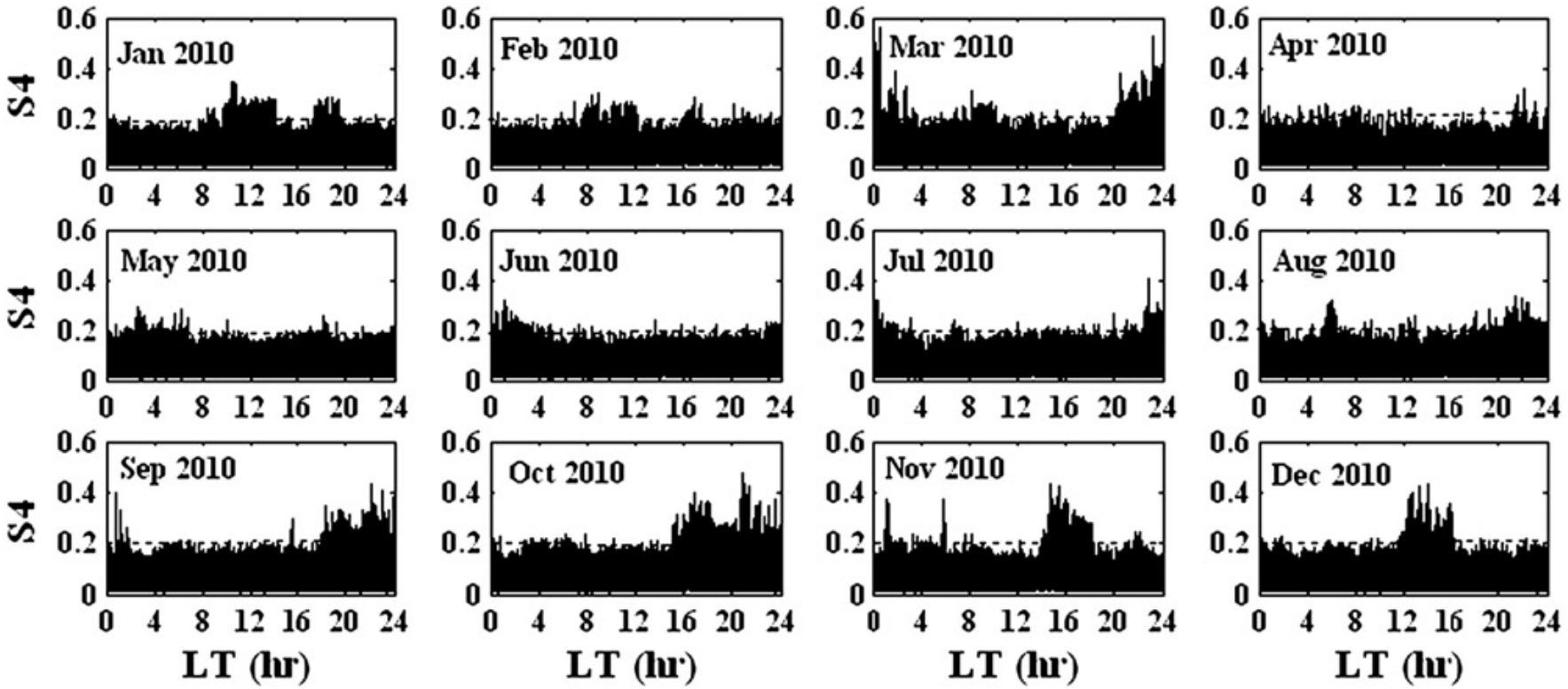

Fig. 2. Month-to-month variations of the S4 index scintillation activities observed at UKM station from January to December2010.(published by j.actaastro.2012 (A. Seif et al.))

It is noted that in the equatorial region nighttime amplitude scintillations activity is associated with electron density irregularities occurring in F region while daytime amplitude scintillation is often attributed to E region.

Table1. Percentage of the amplitude scintillation events detected at UKM station from January to December 2010.

Month	**Daytime Scintillation (%)**	**Nighttime Scintillation (%)**
January 2010	77.4	12.9
February 2010	-	-
March 2010	22.58	45.16
April 2010	-	-
May 2010	-	-
June 2010	-	-
July 2010	-	-
August 2010	25.8	35.4
September 2010	-	90
October 2010	16.12	93.5
November 2010	90	-
December 2010	93.5	-
Total	**35.61%**	**79.63%**

Seasonal variations of amplitude scintillation

Summer : (May, June, July and August)

Equinox: (September, October, March and April)

Winter : (November, December, January and February)

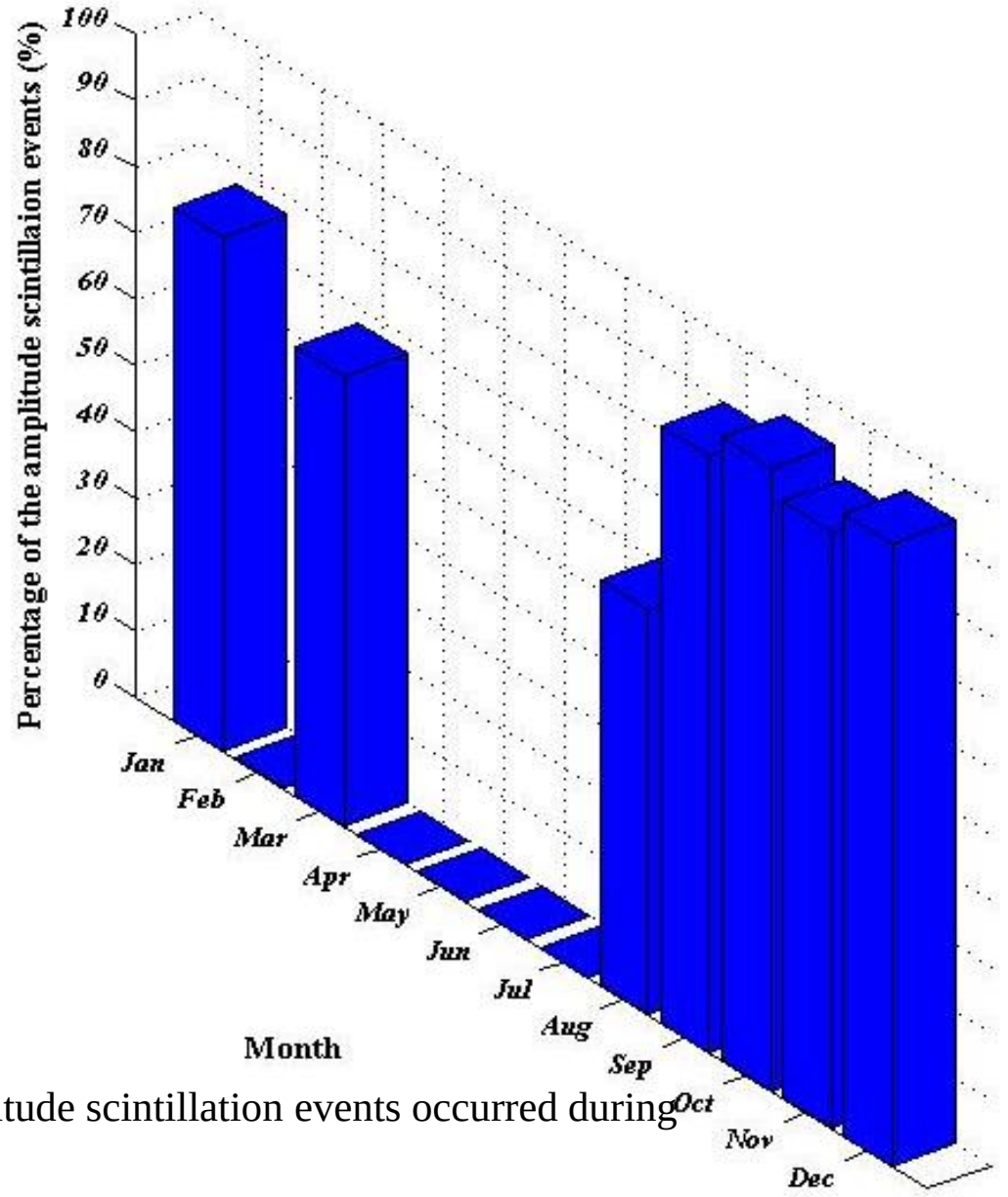

Fig. 3. The monthly percentage of the amplitude scintillation events occurred during the year of 2010 at UKM station.

Seasonal variations of amplitude scintillation

- As can be seen from Figure 4 **highest** percentage occurrence of scintillations is observed for the **equinox** months and **lowest** is observed for **summer.**

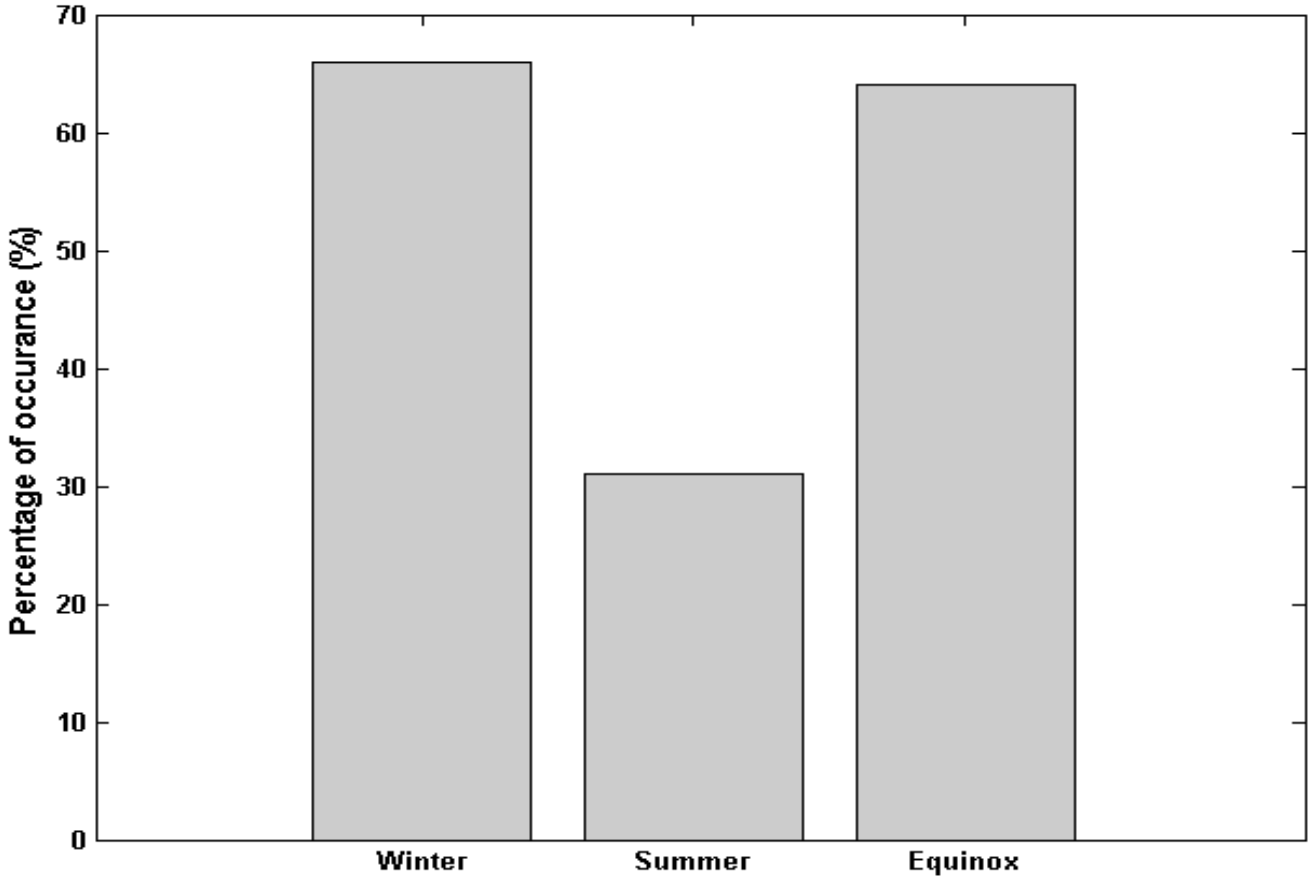

Figure 4: Percentage occurrence of GPS amplitude scintillations (S4>0.2) for different seasons (winter, summer and equinox) during the year of 2010.

Discussion

Equinox :

Ionospheric scintillation were found maximum due to the close alignment of solar terminator with magnetic meridian. This result in simultaneous decreasing conductivity of E region. However severe scintillations may be due to the intense irregularities generated by quite large electric field events.

Summer:

High conductivity of E region the growth rate of instability becomes slow. Electron density is small in equatorial region during summer.

Summary

- Ionospheric scintillation at UKM station was investigated using GISTM recorded between January 2010 and December 2010.

- The results of this investigation show that amplitude scintillation with S4 $\geq$ 0.2 occurred mainly in January, March, August, September-December 2010.

- The month-to-month occurrence rate of ionospheric scintillation shows that amplitude scintillation activities are maximum during the equinox months and minimum during the summer months.

- Further statistical results of the amplitude scintillation events revealed more occurrence of nighttime amplitude scintillation (79.63%) than daytime amplitude scintillation (35.61%).

Thank you!