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IONOSPHERIC TEC MAPS

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Abstract **:** This project deals with the ionospheric error correction in Differential Global Positioning System (DGPS) applications over the Indian region by using GAGAN TEC station data. In DGPS, it is assumed that the ionosphere over the reference station and rover is same, reference station computes ionospheric corrections of its own and transmits to the rover. Since the ionosphere over low latitude is active /dynamic spatially, corrections computed by the reference station are not sufficient. Hence, we are proposing instantaneous TEC maps generated by reference station for correcting rover ionospheric errors. In this paper, the local ionosphere variability is predicted using a polynomial model with first order and TEC maps were generated within the latitude and longitude region of 2^0 x 2^0. The results show that the first order polynomial is capable of approximating TEC within a DGPS service region.

INTRODUCTION

A.Overview

The Global Positioning System (GPS)provides the position and location of the object on the earth and it is a satellite based navigation and this technology uses a stand alone receivers and it even includes a constellation of 24 satellites and extra backup purpose.It uses a timely signals generated by satellites revolving around the earth.

A **Differential Global Positioning System** (**DGPS**) is an enhancement to the Global Positioning System (GPS) which provides improved location accuracy, in the range of operations of each system, from the 15-meter nominal GPS accuracy to about 1-3 cm[1] in case of the best implementations.

Each DGPS uses a network of fixed ground-based reference stations to broadcast the difference between the positions indicated by the GPS satellite system and known fixed positions. These stations broadcast the difference between the measured satellite pseudoranges and actual (internally computed) pseudoranges, and receiver stations may correct their pseudoranges by the same amount. The digital correction signal is typically broadcast locally over ground-based transmitters of shorter range.

A similar system which transmits corrections from orbiting satellites instead of ground-based transmitters is called a Wide-Area DGPS (WADGPS).

B.Objectives

Our main objectives are to know the exact location of the object and this can be detected by using first order of the polynomial model with the generation of TEC maps of latitude and longitude region and to rectify the errors to get the more accuracy of the object.

C.Errors

GPS is a satellite based navigation system.It provides PNT services to the users all over global. But its accuracy is limited by various errors.The various errors are broadly classified into 3 type

1. Satellite based error
2. Medium based errors (propagation errors)
3. Receiver based errors

In medium based errors the dominant error is ionospheric error (or) ionospheric time delay (or) TEC (Total Electron Content).TEC is defined as a total number of electrons that are integrated between two points.TEC is measured in a unit called "TECu"(1TECu=1*10^6 electrons/m^2

D.Explanation of GPS

A space based navigation system that provides location and time information in all weather conditions.Maintained by the United States of government and is freely accessible anyone with a GPS receiver.It consists of two main components.

1. Receiver 2 Location

I. Concept of DGPS

Differential Global Positioning System (DGPS) is a standard method to improve the positioning accuracy of GPS receiver. In DGPS operation, the reference station (Dual frequency receiver) computes differential corrections and transmit to the rover (single frequency GPS receivers) to eliminate satellite clock error and to reduce the other correlated errors due to orbit, ionosphere and troposphere (Fig 1). Spatial and temporal decorrelation of ionospheric corrections can degrade the performance of DGPS users. Because the separation between the receiver and the reference station increases significantly. Park et al., (2006) found that the ionospheric error has the largest effect due to the decoration of differential corrections between reference stations and user

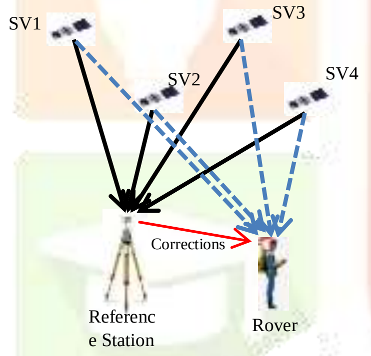

Fig. 1 DGPS concept

In DGPS scenario, the decorrelation of ionospheric correction was less understood in equatorial and low latitude regions Hence, it is necessary to understand and provide better solution for improving the accuracy of the DGPS user receiver. Wan Aris et.al., (2015) studied Spatial and Seasonal Ionospheric corrections variation for DGPS users over the Malaysian region[3]. In this paper a new method is proposed to minimize ionospheric corrections decorrelation impact for DGPS users over the Indian region.

Total Electron Content (TEC), which gives the total number of electrons integrated along a trans-ionospheric signal path, is frequently used to quantify the behavior of the Earth ionosphere [4]-[6]. TEC along the signal path using pseudoranges can be computed as,

$$TEC = \frac{1}{40.3}\frac{f_1^2 f_2^2}{\left(f_1^2 - f_2^2\right)}(P_1 - P_2)$$

Where, P_1 and P_2 are the pseudoranges measured on two L-band frequencies *i.e* f_1 (1575.42 MHz) and f_2 (1227.60 MHz) are different for the same propagation path at any instant of time.

The dynamic behavior of TEC is still a major problem for GPS/GNSS based positioning applications over low latitudes like India . Over the past few years, researchers from the India and other low latitude nations have been studied and developed mathematical models for TEC prediction and estimation.This paper investigates the ionosphere TEC variability over the Hyderabad station by producing instantaneous TEC maps in the context of DGPS. The instantaneous TEC maps were produced with first order polynomial model. Before that an analytical work was done to validate the model performance.

II. Experimental Data and Methodology

The pseudorange/carrier phase observations from GPS satellites measured by a dual frequency receiver located at Hyderabad station (17.44^0N, 78.47^0E) are used to compute STEC. Then, STEC is converted into VTEC by multiplying a slant factor.This measured VTEC data is interpolated by the lower order polynomial interpolation method as given in the following equation.

$$TEC(\phi,\lambda)=\sum_{i=0}^{p}\sum_{j=0}^{q}C_{ij}(\phi-\phi_0)^i(s-s_0)^j$$

$$s-s_0=(\lambda-\lambda_0)+(t-t_0)$$

Where (ϕ_0,λ_0) are the IPP coordinate of the center of the map.

ϕ,λ are the IPP latitude and longitude

C_{ij} = Coefficients of the polynomial

t = Observation epoch

t_0 = epoch at which the s_0 is measured

III. EXPERIMENTAL RESULTS

The instantaneous local TEC maps over a small region (2^0x2^0) were produced with the first order polynomial co-efficient generated by using GPS TEC data. Before producing the maps, the co-efficients are evaluated by predicting TEC at different IPPs (Ionospheric Pierce Point) of various satellites. In the proposed method it is assumed that the ionosphere is constantly located at the height of 350 Kms. We also examined the TEC maps accuracy at various elevation mask angles, the results are good for elevation mask angle of 30^0. Infact, the higher order polynomial model results are not up to mark because the systems gets distorted (non-linear).

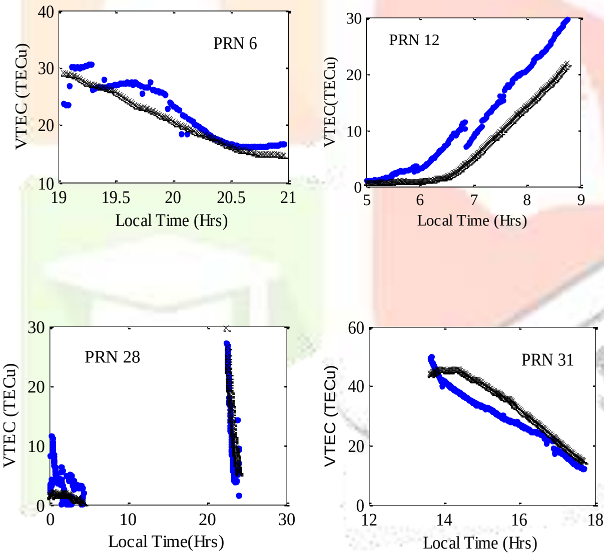

Fig. 2 VTEC predicted for different PRNs

Fig 2 shows, ionospheric VTEC for PRN6, PRN12, PRN28, PRN31 on January 18, 2014. In this figure, a blue color line indicates the model predicted VTEC and black color line indicates measured TEC due to satellite signal. The maximum error between predicted and satellite observed VTEC is 9.24 TECu at 0.3 Hrs for PRN 28. It is also noticed that the polynomial model predicted TEC is able to follow the trend of practical data. Therefore, this model can be used to produce TEC maps with spatial prediction.

Fig 3 shows the instantaneous TEC maps which provides spatial variation at 10 Hrs, 14 Hrs and 20 Hrs on January 18, 2014. In this process STEC is obtained from the receiver installed at the location (17.44^0N, 78.47^0E), then VTEC is computed using satellite and receiver position geometry. VTEC of the signals received with elevation angle greater than 30^0 are used to interpolate VTEC spatially so as to produce the maps.

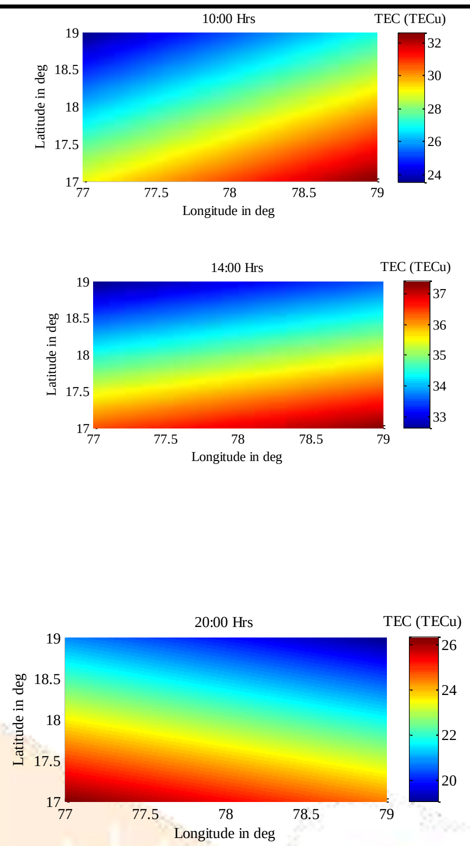

Fig.3 Local ionosphere (2^0 x2^0) TEC maps generated for January 18, 2014 over HYDE GAGAN TEC station

For these maps, the origin is chosen as the co-ordinates of station (i.e. 17.44^0N, 78.47^0E), obviously the results show TEC decreases as the latitude increases, TEC variation over the specified region (2^0x2^0) is 8TECu, 4TECu and 6TECu at 10:00 Hrs, 14:00 Hrs and 20:00 Hrs respectively. However, the maximum TEC is occurring at different longitudes for different instants of time. Further, the spatial resolution of TEC maps can be improved with more number of data points over the specified region.

IV. CONCLUSION

This paper presents the idea of local TEC maps generation for DGPS applications over the Indian region. In this, polynomial model is used to predict the TEC so as to produce maps. Indeed the polynomial model performance is tested with the TEC measured by different satellites. The maximum TEC observed is 32 TECu, 37 TECu and 26 TECu at 10:00 Hrs, 14:00 Hrs and 20:00 Hrs respectively. It is found that the model is able to follow and predict the real data with good accuracy. DGPS is a very useful during adventures, water navigation, air navigation.

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