PROPOSAL ON TROPOSPHERE MODELING ONE OF THE PARAMETERS THAT AFFECTS THE SATELLITE BASED COMMUNICATION, NAVIGATION AND SURVEILLANCE SYSTEMS IN INDIAN SUB-CONTINENT

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Abstract: An attempt is made to review tropospheric models used to estimate the effect of various tropospheric parameters such as atmospheric temperature, partial water vapour pressure, and pressure signal propagation delay for different elevation angles of the signal. It has found that Goad and Goodman model and Saastamoinen models are highly relevant to estimate the signal propagation delay for Indian subcontinent. The results based on simulation are found to be encouraging.

Key words: Troposphere, atmospheric temperature, vapourpressure, Indian sub-continent.

1. Introduction

It is highlighted[1]that the accuracy of tracking of space bound objects is limited by selective availability followed by atmospheric time delay. If one depends on such services in the area of some strategic applications like defence, accuracy is challenging. Its established that the civilians accuracy of GPS is 100m. The other important accuracy limitations are by atmosphere as outlined below. In this paper, an attempt of using all the troposhperic models is made through development of algorithm in Matlab. Thorough fundamental ground is given at elsewhere(dolukanov,1995)[2], the three important agents that are essential to focus are outlined as shown below.

A. Troposphere Refraction

The troposphere is up to about 17 Km from the surface of the earth in the equatorial region. The effect of the neutral atmosphere (i.e the normalized part) is denoted as the tropospheric refraction, tropospheric path delay or simply tropospheric delay.

The neutral atmospheric is a non dispersive medium with respect to radio waves up to frequencies of 15GHz and thus the propagation is frequency independent. The propagation delay of the troposphere reaches about 1.9 to 2.5m in the zenith direction and increases approximately with the cosecant o the elevation angle,yielding about a 20 to 28m delayaat5 degree elevation angle. The atmosphere can be thought of as a mixture of two ideal gases, dry and water vapor. The ‘dry’ part contributes about 90 percent troposphere refraction. It can be accurately modeled to about 2 to 5 percent using surface measurements such as pressure and temperature. The dry air component is assumed to obey the ideal gas law. The problem wit the “wet” contribution is that the distribution of water vapor cannot be accurately predicted. Even under normal conditions there are localized sources of water vapor, often in the form of liquid water. These water vapor sources along with the turbulence in the low atmosphere cause variations in the concentration of water vapor that cannot be correlated over the time or space. These variations cannot be accurately predicted from surface measurements. Fortunately, the wet contribution is only about 10percent of total tropospheric refraction. Tropospheric Refraction effect can be reduced by various Tropospheric models. The different models available on this are discussed else where[3] .

B. Ionospheric Delay

The ionosphere, extending in various layers from about50Km to 2000Km above earth ,is a dispersive medium with respect to the GPS radio signals. The propagation delay of Ionosphere is about 5 to 30m.When a radio signal penetrates the ionosphere, it is modified by the medium due to the presence of electrons and earth's magnetic field. The effects include scintillation, absorption, and variation in the directive of arrival, propagation delay, dispersion, and frequency change and polarization rotation. Out of all these effects the ionospheric time delay has the most determental effect on the ranging accuracy of GPS. The important parameter responsible for ionospheric time delay is the Total number of electrons encountered by the radio waves on its path from the satellite to the user .

C. Multipath Effect

The effect is well described by its name; a transmitter emitted signal arrives at the receiver via more than one path. Multipath is namely caused by reflecting surface near by the ground based transmitter and secondary effects are reflections of space bound object. As a consequence, the received signal have relatives phase offsets between direct and indirect signals and the phase differences are proportional to the difference of the path lengths. There is no general model of multipath effect because o the arbitrarily different geometric situations. Sometimes the reflected signal may be as strong as the direct signal. The magnitude of the multipath signal depends on the strength of the reflected signal and the ability of user's antenna to resist the reflected signal. The strength of the reflection-coefficient of the reflecting surface that varies not only with a difference in the ground coarseness, but also with a difference in the ground coarseness and also with a difference in ground plant quills.

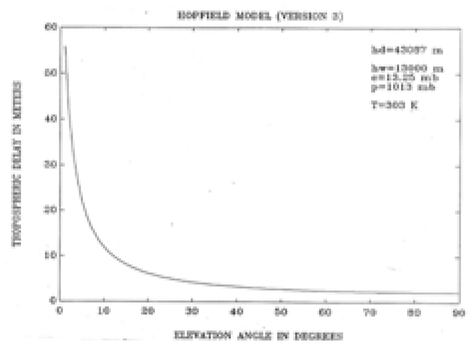

Figure.1: Latest Hop Field Model

2. Results and Discussion

The basic theory on six models (3 versions of Hopfield, Goad and Goodman and 2 versions of Saastamoinen) is given . The parameters that are used in obtaining the delay are, total atmospheric pressure, P = 1013 mb, absolute temperature T = 303 K, partial water vapour pressure e = 13.25 mb, dry component height h_d = 43087 m (from eqn. 11), and we component height h_w = 13000 m. In Hofmann (1992) it is given h_w as 12000 m. However, here we have taken as 13000m because; the location under consideration is near to the equator, where troposphere can extend up to 16 km. The $h_d$and hw are calculated in using meteorological parameter in Goad and Goodman model. Using the equations available in literature, an algorithm is developed in matlab and estimation of tropospheric time delay is carried out..

A. Hopfield Model

Hopfield model[4,10] version 1 is independent of elevation angle. That is, the delay is calculated in the zenith direction only. However, for the present work more accurate and which is sensitive to elevation angle is needed. Hopfield Model (version 2).Shows that the model can not be applied below 10^o .At 10^oelevation angle, a spike is appearing which is completely unacceptable. As expected with high elevation angles the delay decreases. At 90^o the delay is about 2.8738 m. Hopfield Model (version 3)uses Simpson's rule is used in evaluating the integrals involved in the relevant equations [7]. Fig1 shows the delay for different elevation angles. Here there is a sharp rise in delay around 2^o to 5^o. At zenith the delay is 2.1529 m.

B. Goad and Goodman Model

This model is also known as modified version of Hopfield. The main difference is in the integration. Here series expansion of the integrand is taken into consideration for the integral estimation. This graph in Fig.2.is similar to that of previous case. This model is widely used in GPS receivers. At 15^o , the delay is about 8.7m. Saastamoinen model (version 1)l is entirely different from the previous models. Here, the dry and wet components are

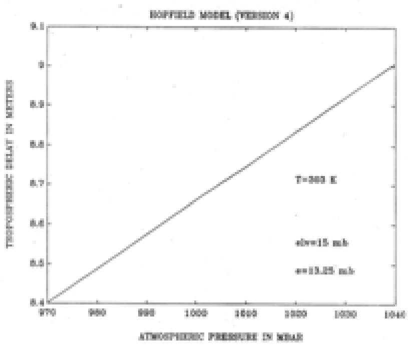

Figure.2: Goad and Goodman model

calculated in a single formula which is not the samein the case of Hopfield (Fig.3,Fig.4). This program does not ask the h_d and h_w as inputs. The correction factor required for different altitudes.This has been further refined the previous model by adding two correction terms, one being dependent on the height of the observing site and the other on the height and on the zenith angle. This model is used for the regions of high altitudes where the delay is calculated more accurately when compared to the other models. Fig. 6 shows the graph for this model. For an elevation angle of 15^o the delay is about 9.2 m which is approximately equal to the previous model.

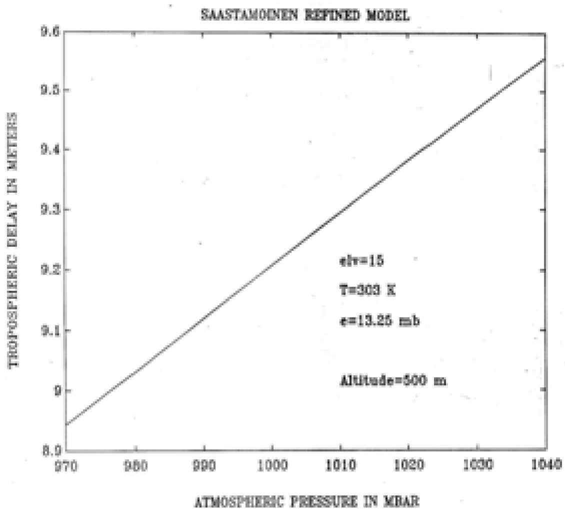

Figure.3:Saastamoinen Model with respect to Atmospheric Pressure.

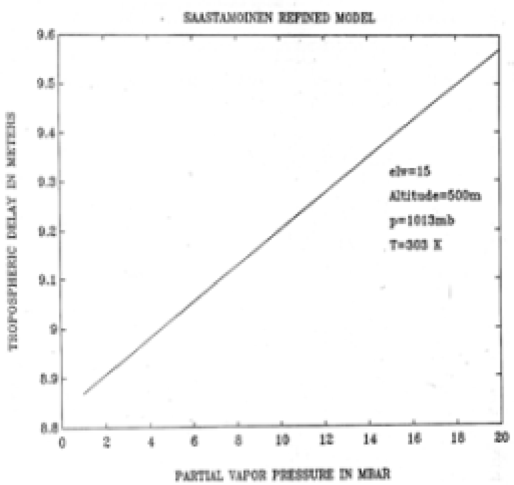

Figure. 4 :Saastamoinen Model with respect to Partial vapour pressure

3. Conclusions

In this paper, the various models of troposphere are highlighted. To calculate the tropospheric delay initially zenith delay is required. Afterwards, mapping function is required to calculate the delay along the propagation path. This zenith delay is calculated from meteorological data. However, it is convenient to use standard atmospheric models for a particular altitude station, which gives better results.This paper mainly presented models proposed by Hopfield and Saastamoinen through simulated results.. For typical atmospheric parameters, time delays are estimated using various time delay models. It is found that, the effect of individual atmospheric parameters cannot be neglected while estimating the delay. Saastamoinen and Refined Saastamoinen models give almost same results.It is found that Goad and Goodman and Saastamoinen models are suitable for specified tasks. One of those models will be selected after further investigations with practical results.

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