Forecasting of ionospheric delay using the Holt-Winters method

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Abstract

Radio waves such as Global Positioning System (GPS) signals propagate through the ionosphere and experience several effects, one of which is an additional group delay that is approximately proportional to the total number of free electrons encountered by the wave. Accurate correction, prediction and assessment for ionospheric error are needed for accurate measurement. In forecasting ionospheric delay, the statistical method is still considered a new approach. One of the statistical methods is known as the Holt-Winters method, which is based on time series with repeated trends and seasonal patterns. Based on the characteristics of the ionospheric delay that has repeated trends and seasonal patterns, the Holt-Winters method is suited to forecast ionospheric delay. In this research, a forecasting of ionospheric delay was carried out over three chosen stations, namely Parit Raja (1° N, 103° E) in Malaysia, Seattle (47° N, 122° E) and New York (40° N, 73° E) which are both in the United States of America (USA). GPS observation data from August to October in 2005 from the Parit Raja station and from May to July in 2008 from the Seattle and New York stations were used. Results over Parit Raja show that the error between the forecast and the real ionospheric delay value is about 6% for the three months of analysis. In contrast, the results obtained over Seattle and New York show that the percentage of the average error is in the range of 2 % to 6 %. The Holt-Winters method is believed to show a different value of accuracy based on the variation of TEC which is dependent on diurnal and seasonal changes, solar cycle, geographical location, and geomagnetic field. The two stations in the USA were facing seasonal transition at that time; in May and June, it was spring time, while in the middle of July, it was the beginning of summer. Therefore, high variations of TEC value occurred because of the transition of season. The Seattle and New York stations are located at the mid-latitude zone. On the other hand, the Parit Raja station is located in the low latitude zone. The results gave a small error for all three stations; therefore, it can be concluded that the Holt-Winters method is effective and can be used in forecasting ionospheric delay for different regions.