A study of the positioning error estimated from numerical model results

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1. Introduction

The positions of the GPS receivers are determined from the path lengths between GPS satellites and receivers. Since the path lengths contain the delay due to the atmosphere, the delay is estimated by being fitted to the modeled distribution and is removed from the observed lengths. If the estimated delay distribution is different from the observed one, the difference between these distributions causes the error of the receiver's position. Because the kinematic positioning is commonly used and the delay distribution observed by the kinematic positioning is quite complicated, the evaluation of the positioning error from the delay distribution becomes more important. However, the actual observed data contains the error of the receiver position and makes the estimation of the atmospheric delays difficult. The delay distribution simulated by the weather forecast model, which contains only the influence of the atmosphere, is used to discuss the atmospheric error.

2. Weather forecast model and analysis program

The non-hydrostatic model of Meteorological Research Institute (Saito and Kato, 1996) was used to simulate the refractivity distribution. The position of the slant path was obtained by using the ray tracing method. The delays along the slant path are obtained by integrating the refractivity multiplied by the divided length of the slant path.

3. Non-uniform distribution caused by the mountain lee waves

The mountain lee wave occurred on the lee side of the Izu peninsula on 7 March 1998 (Shimada, 1999). The delay distribution was calculated using the actual position of GPS receivers and satellites. When the simulated delays are fitted to the constant distribution, the position of GPS receivers shifted by 1-2cm toward the small zenith delay region. The positioning error is greatly improved by using the linearly varying distribution, however, the positioning error of 3mm remained on the Izu peninsula. Since the lee wave that affects the one GPS receiver is half of the wavelength at most, the quadratic distribution was used as the modeled one. The positioning error was further improved because the quadratic distribution fits to observed one. The vertical error was also reduced to half by using the quadratic distribution.

4. Time varying distribution caused by the cold front

The cold front passed the Kyushu on 29 June 1999. The delay distribution affected by the cold front was complicated. The position error estimated by using the constant distribution was as large as -2.2cm. The positioning errors were estimated using following three modeled distribution; 1) a linearly varying distribution, 2) a temporally varying distribution, 3) a linearly and temporally varying distribution. The positioning error estimated using the third modeled distribution was smallest. When the delays were fitted to the linearly varying distribution every 20minutes, the positioning error estimated from the differences during whole analysis period was 0.4mm, which was comparable to one estimated by using the linearly and temporally varying distribution.

5. Summary

The results of the numerical models are useful in the evaluation of the positioning error. Although the linearly varying distribution improves the positioning error, the quadratic distribution reduces further the positioning error when the small-scale variation of the delay existed. If the delays change with time, the temporal change and spatial gradient should be considered simultaneously or the fitting to the modeled distribution should be performed with short temporal interval.

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