Zenith tropospheric delay of GPS microwave in mountain area

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GPS campaigns were performed near the top of Mt. Sobatsubu in the Southern Alps of Japan for 20 days. The data obtained were analyzed with other GPS data obtained in the valley near Mt. Sobatsubu in order to investigate the zenith tropospheric delay of the GPS wave.

There were not much difference in the variation phases of the zenith delays near the top of the mountain and in the surrounding valleys. The absolute values of the zenith delay near the top were 85 - 90% of those at the surrounding valleys, the wet terms near the top were 40 - 85% of those at the valleys, and the variation amplitudes were 40 - 100% of those of the valleys.

The amplitudes of the variation of the wet terms near the mountain top were small in a fine day.

GPS observation is usually performed in a plain or a valley among mountains. The zenith tropospheric delays obtained from GPS data are those at valleys and they may be different from those at mountain top areas.

In order to investigate the difference between zenith delays at valleys and those at mountain top areas, we performed five GPS campaigns (Sept. 22 - 25, 1997; Nov. 8 - 11, 1997; July 30 - Aug. 2, 1998; Oct. 28 - 31, 1998 and Dec. 2 - 5, 1998) at Yamainudan (about 1400 m) near the top of Mt. Sobatsubu in the Southern Alps of Japan. Their data were analyzed with the data at five stations of surrounding valleys (300 - 400 m) to obtain the zenith delays. The software used is Gamit ver. 9.66 and Gamit ver. 9.74.

First we analyzed the six stations' data of the first day at each campaign with the data at five IGS stations; Fairbanks, Kokee Park, Shang-hai, Tsukuba and Usuda; and obtained the coordinates of the six stations based on ITRF96. Next we calculated the zenith delays of the six stations by referring to five IGS stations. In the analysis we constrained the coordinates of the six stations to be within 5 mm for horizontal components and within 10 mm for vertical component.

We studied the existence of the phase difference between the zenith delays at mountain top area and those at valley areas. The relation ratios between the zenith delays at Yamainudan and those at valley areas were calculated by changing the time difference of the two delays between + 3 hours to - 3 hours. The ratios calculated were largest when the time difference was zero. This result shows that there is no phase difference between the zenith delays at the mountain top area and those at valley areas.

The absolute values of the zenith delay at Yamainudan was 85 - 90 % of those of the surrounding valley areas. The dry term of the zenith delay was estimated from the barometric data at Shizuoka Meteorological Observatory by considering the height of the stations. By subtracting the dry term from the zenith delay, we estimated the wet term of the zenith delay. The wet terms at Yamainudan were 40 - 85 % of those the valley areas and they scattered more widely than the absolute values. The wet term variations were defined here as the difference of the maximum wet term of the day and the minimum one. The variations at Yamainudan were 40 - 100 % of those of the valley areas. They scattered very much.

The 20 days of the campaign were divided into two groups; fine days and cloudy days, by referring to weather maps. Absolute values of the zenith delay at Yamainudan were about 87 % of those at valley areas both in fine and cloudy days. Wet terms of the zenith delay at Yamainudan were about 64 % of those at valley areas in fine days and about 68 % in cloudy days. Their variations were more different by the weather. The variations at Yamainudan were about 76 % of those at valley areas in fine days and about 91 % in cloudy days.

This fact shows that there is smaller water vapor in the upper atmosphere than in the valley gas in a fine day compared with in a cloudy day, and its time variation is still smaller than the amount of the vapor in a fine day than in a cloudy day in the upper atmosphere. This can be understood that the upper atmosphere is more stable than the lower atmosphere in a fine day, because of downward current.

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