Seasonal Change of Precipitable Water Vapor Estimated from GPS Data in Thailand

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1. Introduction

GPS observation has usually been carried out to monitor the crustal deformations, but the excess path delay of the GPS microwave gives us useful information on the atmosphere conditions, especially on the water vapor change of the troposphere. GPS observation started to monitor the atmospheric change of Asian Monsoon region in March 1998 as one of the GAME-T projects in Thailand. We analyzed their GPS data in order to obtain precipitable water vapor (PWV) change, and to investigate its characteristics.

2. Observation

GPS observations have been carried out at 6 stations in Thailand for the GAME-T project. Their stations are Bangkok, Chiang Mai, Nong Khai, Sri Samrong, Ubon Ratchatani and Phuket. The observation at the Phuket station continued only 2 months and the data at Phuket is not included in the present analyses.

Trimble 4000SSE or 4000SSi receivers are used in the observation and the antennas are fixed at the roofs of the buildings. The data are logged at 30 seconds interval for 24 hours per day. The logged data are automatically downloaded to the hard disk of a personal computer at the observation site. The location of the GPS stations whose data were analyzed is shown in Fig.1.

3. Analyses

The data at Bangkok, Chiang Mai, Nong Khai and Ubon Rachatani were analyzed from April 1998 to December 1999 because we got the meteorological data in the period concerned. The GAMIT ver 9.95 software was used in the data processing and the Zenith Tropospheric Delay (ZTD) was obtained at every 1 hour referring to seven IGS stations at shao (Shanghai, China), yar1 (Yaragadee, Australia), tskb (Tsukuba, Japan),

guam (Guam Island, USA), lhas (Lhasa, Tibet), coco (Cocos Island, Australia), and ntus (Nanyang Technological Univ., Singapole).

In order to calculate the Zenith Hydrostatic Delay (ZHD), we need the data of air pressure at the observation site, but only the data of air pressure at mean sea level were available. We estimated the altitudes at the stations from mean sea level by using ellipsoidal height obtained from GPS data and geoidal height of EGM96 geoid model. The Zenith Wet Delay (ZWD) was obtained by subtracting ZHD from ZTD, and the PWV can be calculated from ZHD.

4. Results

PWV change at Bangkok station in 1999 thus obtained was shown in Fig. 2. PWV is almost constant to be 60 mm from April to September when it is thought to be the wet season from rainfall data. On the other hand, PWV changes widely ranging from 10 mm to 60 mm in 1 or 2 weeks cycle in the periods from January to March and from October to December when it is the dry season.

The results of other stations are almost similar to that of Bangkok. There are always high PWV values in the wet season and PWV seldom changes except small diurnal change, but it changes with a large amplitude in 1 or 2 weeks cycle in the dry season. It is almost equal to that of the wet season when it is high in the dry season, but its average value is lower than that of the wet season.

5. Comparison with PWV obtained from MWR

The amount of water vapor in the troposphere has been observed by a microwave radiometer (MWR) at Sri Samrong station since March 2000. We estimated PWV from MWR and also from GPS at Sri Samrong station. We compared the two kinds of PWV, and the results are shown in Fig. 3. Fig. 3 shows that the PWV estimated from GPS is usually larger than that by MWR. The root-means-square in the two PWV difference was 7.78 mm, and the bias was 6.70 mm.

6. Summary

1. PWV change was obtained from GPS data at 4 stations in Thailand in 1998 – 1999.
2. PWV is almost constant in high value in the wet season and it changes with a large amplitude in 1 or 2 weeks cycle in the dry season.
3. When PWV is high in the dry season, it is almost equal to that in the wet season, but its average value is clearly lower than that of the wet season

4. PVW obtained from GPS is larger than that from MWR (bias 6.7 mm)

Fig. 1. Location of the GPS stations whose data were analyzed in this investigation.

Fig. 2. (Upper) Obtained PWD and rainfall at Bangkok station in 1999.
(Lower) Air pressure and air temperature at Bangkok station in 1999.

Fig. 3. Comparison between PWV estimated from MWR and that from GPS at Sri Samrog station.