Pecipitable Water Vapor Change Obtained From GPS Data

Sununtha Kingpaiboon Mikio Satomura2
Associate Professor Professor
Khon kaen University, Khon Kaen, Thailand Shizuoka University, Shizuoka, Japan
sununtha@kku.ac.th semsato@ipc.shizuoka.ac.jp

Mayumi Horikawa Tosiyuki Nakaegawa
Shizuoka University, Shizuoka, Japan Meteorological Research Institute, Tsukuba, Japan

Seiichi Shimada
National Research Institute for Earth Science and Disaster Prevention, Tsukuba, Japan

Abstract: GPS observation has been performed at Khon Kaen in northeast Thailand to investigate the Precipitable Water Vapor (PWV) change since August 2001 by using a Trimble 4000SSi receiver. The data obtained in the period from March to June in 2002 were processed by using CAMIT software to obtain the Zenith Tropospheric Delay (ZTD) at every one hour referring to some IGS stations around Thailand. We estimated the Zenith Hydrostatic Delay (ZHD) at every three hours with barometer data at Khon Kaen of Thai Meteorological Department, The Zenith Wet Delay (ZWD) was obtained by subtracting ZHD from ZTD and PWV can be calculated from ZTD. The results obtained shows that PWV changes with a large amplitude in March and April before the monsoon onset, and also we can see steep PWV increases before rain and decreases after rain. In May and June after the onset, the PWV is almost constant to be 60 to 70 mm, but there is a semi-diurnal change which has high PWV values at about 8 and 20 o'clock in local time.
Keywords: Pecipitable Water Vapor (PWV), Global Positioning System (GPS)

1. Introduction

The study on the water vapor change in the troposphere is important for the meteorology and hydrology, but it is difficult to measure the vapor change in the upper atmosphere. On the other hands, GPS observation is usually performed to obtain precise positions for the geodetic survey or civil engineering. The microwave of GPS delays when it passes through the ionosphere and the troposphere. The delay makes errors in the positioning but they are good signals to get information on atmosphere conditions for the meteorologists and hydrologists. The excess path delay caused by the ionosphere is depend on the wavelength and it can be estimated by using the data of two wavelengths from the satellites. After removing the effects of the ionosphere, we can get the delay due to the troposphere. The delay due to the troposphere consists of the hydrostatic delay by the dry gas and another delay by the water vapor. The former is called the dry term and the latter is the wet term. The dry term can be estimated precisely from the barometer data and we can get the wet term. The amount of the water vapor can be obtained by transforming the wet term to precipitable water vapor (PWV). The GPS observation to investigate the PWV had been carried out at Bangkok, Chiang Mai, Phuket, Sri Samrong, Ubon Ratchatani and Nong Khai in Thailand as observations of GAME-T Project [3]. We have started another GPS observation at Khon Kaen in August 2001.

2. Observation and Data Processing

A Trimble 4000SSi receiver is used in the present observation. The antenna was set on a tripod on a roof of a building of the Department of Agriculture Engineering, Khon Kaen University. The data were recorded at every 30 seconds and they were downloaded to a PC once a day. The data obtained in the period from March to June in 2002 were processed by using GAMIT software by referring to seven IGS stations at Shanghai, Yaragadee, Tsukuba, Guam, Lhasa, Cocos and Singapore. The coordinates of the Khon Kaen site were obtained first with GLOBK software, and the Zenith Tropospheric Delay (ZTD) were obtained at every one hour by constraining its coordinates within 3 mm in horizontal components and 5 mm in the vertical component. The 3 hourly air pressure data by Khon Kaen TMD station were used to obtain the dry terms. They are the value at mean sea level and we calculated the pressure at the antenna site whose elevation is 198.21 m, which is obtained from the ellipsoidal height by GPS and geoid height of NIWA EGM geoid[1]. The elevation on the benchmark in front of the Department of Civil Engineering of the Khon Kaen University is 195.505 m and this value is proper considering the height of the building.

3. Results

The PWV change from March to June 2002 obtained from the present processing is shown in Fig. 1. The PWV values change widely between 20 to 60 mm in March and April before the monsoon onset. On the other hand, they are almost constant to be 60 or 70 mm in May and June after the onset. These features are almost same as other GPS stations in Thailand [2], but the PWV values are somewhat larger than other stations. The PWV value at Bangkok is about 60 mm in the wet season. The elevation at Khon Kaen is almost 200 m and that at Bankok is less than 10 m and we had expected that the PWV value at Khon Kaen is smaller than Bankok, but the result is contrary. We checked the processed data and also thought its reason, but the cause is not yet clarified.

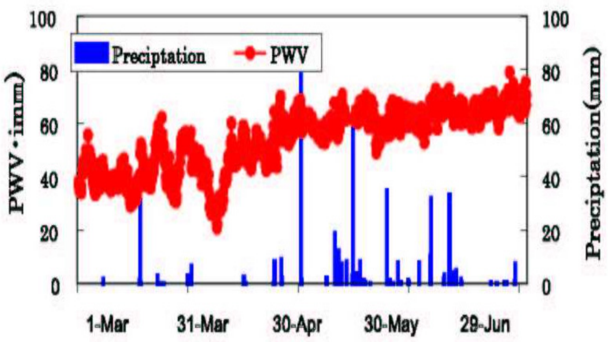

Fig. 1. PWV change obtained at Khon Kaen in 2002. Precipitation (three hourly) is alsoshown in this figure.

In order to investigate the relationship between the PWV and precipitation, the results only in March is shown in Fig. 2. This is in the dry season but it rained from the 17th night to 18th early morning. Total precipitation is more than 50mm. The PWV increase from about 35 mm to 50 mm preceded the rainfall, and PWV decreased to be about 40 mm after the rainfall. We have small rainfall of 3 mm on 22nd and the PWV change is similar to the 17th and 18th one. However, there is no clear relationship between the PWV and precipitation after May. This may be one of the differences between the dry season and wet season.

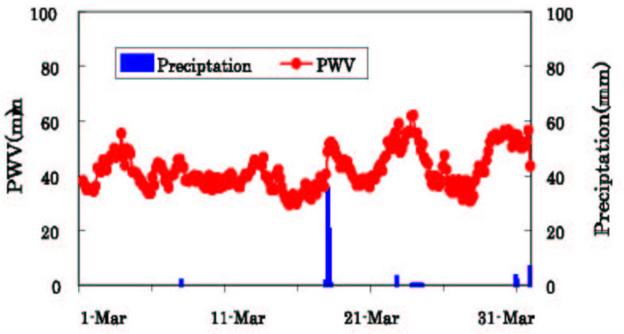

Fig. 2. PWV change obtained at Khon Kaen in March 2002. Precipitation (three hourly) is also shown in this figure

We also investigated the PWV diurnal change. In order to the diurnal change, we took the running mean of 27 hours (9 of 3 hourly data) PWV data, and subtract it from the original PWV. The results are shown in Fig. 3. We can see no clear phase of diurnal change in March and April, but PWV is large at about 7 and 20 O'clock in May and June. There may exist the semi-diurnal change that PWV is high in the morning and evening and it is low in the afternoon and midnight in the wet season.

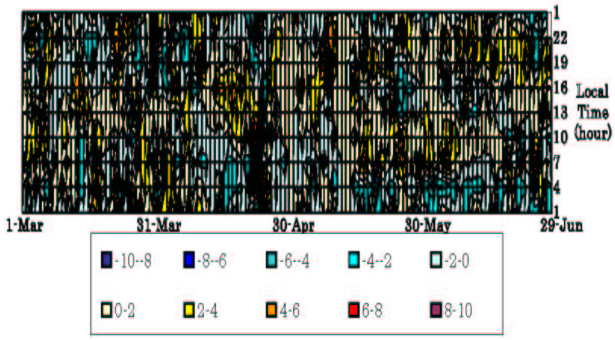

Fig. 3. Diurnal change of the PWV. Running mean of 27 hours (9 data) is subtracted fromthe original PWV.

4. Conclusion

We have performed GPS observation at Khon Kaen to investigate the water vapor change in the troposphere. The data obtained from March to June 2002 are processed preliminarily and obtained the following results.

1. The PWV changes widely in March and April (dry season) and almost constant at high value in May and June.
2. PWV value obtained at Khon Kaen is larger than that at Bangkok. We cannot get its cause yet.
3. PWV increased before rainfall and decreased after

rainfall in March, but such change is not clear in the wet season.

4. There is no dominant diurnal change in PWV in the dry season, but there may exist semi-diurnal change that PWV is high in the morning and the evening and it is low in the afternoon and midnight in the wet season This is a preliminary results of the GPS data and we must process more data and discuss the details of the results to clarify the characteristics of the PWV in this area.

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