Study On Precipitable Water Vapor Change (obtained from GPS) and Humidity

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Abstract

GPS observation was set up in the campus of Khon Kaen University, Northeastern Thailand (under the GAME-T Project) to investigate the Precipitable Water Vapor (PWV) change and to understand the characteristics of its seasonal and diurnal changes. The GPS observation has been performed since August 2001. The data obtained from January 2001 to December 2002 were processed and presented in this study. A Trimble 4000 SSi receiver and a Trimble microcentered L1/L2 antenna are used for the observation. The antenna is fixed on the roof of a building and the data is recorded by every 30 minutes for 24 hours a day. The data obtained were processed by using GAMIT software referring the 7 IGS stations data to obtain the Zenith Tropospheric Delay (ZTD) at every one hour. The three hourly PWV was calculated from the ZTD using air pressure and temperature data which were measured by the Thai Meteorological Department. The results obtained showed that PWV change with a large amptitude from 20 mm. to 60 mm. before the monsoon onset (dry season), it was noted that the PWV increased before rain and decreased after rain. In the wet season, the PWV was almost constant at about 60 mm. or 70 mm. The PWV was related with the humidity. Daily relative humidity measurements were obtained from Rawinsonde data, observed at standard pressure levels : 1000 mbs 850 mbs 700 mbs 600 mbs 500 mbs 400 mbs 400 mbs 300 mbs, or from ground level to 32,000 ft. above ground level. Statistical analysis indicated that PWV and relative humidity at 300 mbs or at 32,000 ft above ground level were relative with the minimum variance and standard deviation of 125.33 and 11.19.

Keyword: Global Positioning System (GPS), Precipitable Water Vapor (PWV), Relative Humidity (RH), Rawinsonde-Observation

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 Khon Kaen University since August 2001.

2. Observation and Data Processing

A Trimble 4000SSi receiver and a trimble microcentered L1/L2 antenna are 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 January to December 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 station of the Thai Meteorological Department (TMD) were used to obtain the dry terms. They are the values 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. 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.

The relation between PWV and Relative Humidity (RH) were studied. Daily relative humidity (January-December, 2002) were obtained from Rawinsonde data, at Ubonratchathani Meteorological station where is the nearby area representative. Rawinsonde data were observed at standard pressure levels of 1,000 mbs 850 mbs 700 mbs 600 mbs 500 mbs 400 mbs and 300 mbs. On the other hand, the Rawinsonde observation were made at the height of from ground level to 32,000 ft above ground level. Variance and standard deviation between PWV and RH of every standard pressure levels were analized.

3. Results

The PWV change from January to December 2002 obtained from the processing is shown in Fig.1. The precipitation (three hourly) is also shown in this figure. The PWV periodically change widely between 20 to 60 mm, with 1 or 2 weeks duration in the dry season (November-April). It is noted that PWV increases before rainfall and decreases after rainfall. On the other hand, they are almost constant to be 60 or 70 mm from May to September (wet season). These features are almost same as other GPS stations in Thailand.

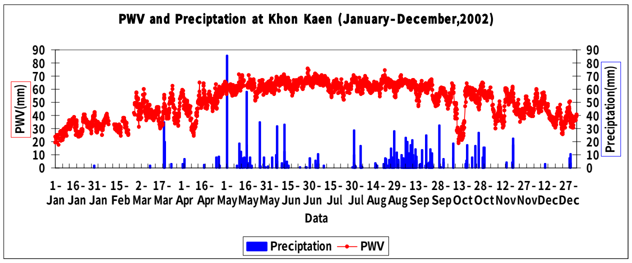

Fig. 1: PWV change obtained at Khon Kaen in the year of 2002.

In orders to investigate the relationship between the PWV and the Relative Humidity (RH). Daily RH by Rawinsonde observation at every standard pressure levels (have been maintioned above) were statistically analized, the results have shown in Table 1. It was found that PWV and RH at 300 mbs (32,000 ft height above ground level) were relative with the minimum variance and standard deviation (Fig.2.).

Table 1. Statistical analysis of PWV and RH.

Statistical Analysis	Standard Pressure Level At (mbs)						
	1000	850	700	600	500	400	300
Average*	24.75	24.67	22.63	18.60	18.01	16.50	15.24
Variance	262	173	219	147	149	131	125
Standard Deviation	16.20	13.16	14.80	12.16	12.22	11.47	11.20

* Average of the difference between PWV and RH.

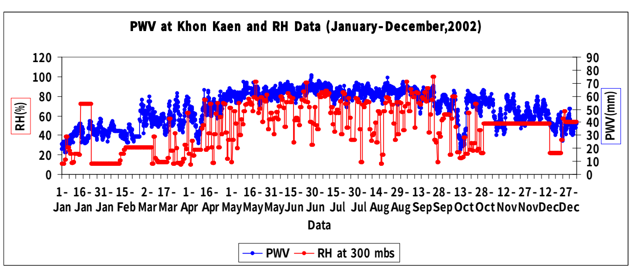

Fig. 2: Change of PWV and RH at 300 mbs.

4. Conclusion

We have performed GPS observation at Khon Kaen University to investigate the precipitable water vapor changed. The data observed from January to December 2002 are processed and obtained the following results:

The PWV changes widely in dry season (November-April) and almost constant at high value in wet season (May-September). It is remarked that PWV increased before rainfall and decreased after rainfall. PWV and RH at 300 mbs (32,000 ft height above ground level) were relative with the minimum variance and standard deviation.

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