Precipitable Water Measurements in Southern Areas over Thailand and Philippines Using AERONET Data from 2007 to 2017

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Abstract

This study investigated of precipitable water for Songkhla in Thailand, Manila and Marbel University of Philippines in the case of daily and monthly average precipitable water. The investigation was based on the solar spectrum from sunphotometers measured at three locations: Songkhla Meteorological Station (7.18°N, 100.61°E) Manila (14.64°N 121.08°E) and Marbel University (6.50°N 124.84°E). The measured spectral data of precipitable water (W) obtained from the range of 2007 to 2017 revealed that the seasonal variation of precipitable water for the three sites have similar patterns.

As the number of precipitable water monitoring station in Thailand and Philippines are still very limited, it is suggested that a number of the stations be increased in order to obtain more spatial coverage of information on precipitable water.

Keywords**:** *precipitable water*, *AERONET*, *precipitable water in atmosphere*

1. Introduction

The precipitable water (W) is one of the most active components in the atmosphere. Although its proportion in the atmosphere is very small, that is about 0.1–3% (Liu & Liu, 2009). Water vapor shows a large spatial and temporal variability (Zhang, Wang, Zhai, Gu, & He, 2013). It is a necessary condition to produce clouds and precipitation and also plays a very important role in the evolution of the weather and climate (Wang, Zhang, Dai, Hove, & Baelen, 2007). Water vapor is also a main greenhouse gas, with atmospheric advection, vertical transport, evaporation and condensation, it impacts atmospheric and solar radiation, and thereby affects the water cycle and energy balance between the land and the atmosphere (Chou & Arking, 1981; Lin, Moore, Messin De Visser, & Wu, 2012). Accurate knowledge of the distribution of atmospheric water vapor and its change over time provides helpful data that has been used to investigate and evaluate variations in weather systems. In addition, water vapor observations may help researchers to understand weather processes and forecast precipitation (Gaffen et al., 1992; Elliott, Ross, & Gaffen, 1995). The changes in water vapor in the upper troposphere are especially important for climate change. Some changes in water vapor in the upper troposphere from human influences contribute to radioactive forcing on the order of 0.1 Wm^{-2} (Trenberth, Fasullo, & Smith, 2005). Therefore, water vapor is a very essential factor for the predictions of weather and climate change.

The precipitable water can be measured directly using ground-based measurements. An estimation of aerosol optical properties from ground-based observations often involves measurements of direct and diffuse solar radiation in distinct narrow spectral bands (Iqbaz, 1983). The purpose of this paper is to compare W data retrieved in southern Thailand and Philippines by used ground-based data.

Due to the importance of precipitable water, a number of studies have been carried out for many parts of the world. However, limited works were focused on Southeast Asia. In the case of Thailand and Philippines, the information on precipitable water in this tropical country is still very limited, and not sufficient for atmospheric research and environmental studies. In response to the demand for this information, we have established three sun photometer stations in three main regions.

2. Objectives

In this work, precipitable water in Songkhla province in Thailand, Manila and Marbel University over Philippines

3. Materials and Methods

The data

Ground-based measurements

For this paper we procured sun photometers and then installed them at our existing solar radiation monitoring stations in three main regions of Thailand and Philippines. These stations are situated in Songkhla (7.2 ºN, 100.60 ºE) in the southern region of Thailand and Manila (14.64^{o}N 121.08^{o}E) and Marbel University (6.50^{o}N 124.84^{o}E) in the Philippines. The sun photometers at Songkhla and Philippines were fabricated by Cimel (model CE-318).

The Cimel 318N-VBS7 is a motor-tracked sun photometer which points automatically to the Sun (Cimel, 2001). This instrument is the standard Sun/sky photometer from the AErosol RObotic NETwork (AERONET) (Holben, Eck, Slutsker, Tanre, Buis, & Setzer, 1998). It has an optical header with two collimators (a glassless one to observe the Sun and another with glasses to observe the sky). The whole FOV is 1.2°. This header points to the Sun using two microprocessors that calculate the zenithal and azimuthal angle from the geographical coordinates and the date and time. The orientation is finally sharpened with a four-quadrant detector with a precision of 0.1°. The instrument has 7 channels 340, 380, 440, 675, 870, 936 and 1020 nm with a FWHM of 10 nm (except for the channels of 340 and 380 nm which have a FWHM of 2 nm). Cimel instrument measures the direct irradiance, the almucantar irradiance (i.e., observed along a circle parallel to the horizon at a given elevation angle) and the principal plane irradiance (over an arc of varying elevation angle given a fix azimuth) at the Earth's surface. For each measurement the instrument covers all 7 filters in 8 s and after a break of 20 s, it repeats the series two times more; therefore for either channel there are 3 non-simultaneous measurements available. The direct sun triplets are used to perform cloud discrimination and stability controls following the AERONET standard algorithm (Smirnov, Holben, Eck, Dubovik, & Slusker, 2000).

All Cimel sun photometers were incorporated into the Aerosol Robotic Network (AERONET) of NASA. These sun photometers were calibrated by AERONET every 1-1.5 years, resulting in precipitable water accuracy of ~0.01-0.02, with the higher error in the UV (Eck et al., 1999) AERONET precipitable water data screened for clouds by the algorithm of Smirnov et al (Smirnov et al., 2000) that relies on the greater temporal variance of cloud versus precipitable water. It should also be mentioned that only Version 3, level 1.5 W data were utilized in this study.

4. Results and Discussion

This work focuses on W, which is commonly used to show the effect of precipitable water on solar radiation.

Figures 1-3 illustrate the daily average W values for Songkhla Manila and Marbel University, respectively. W values at the two inland stations: Songkhla over Thailand, Manila and Marbel University for the Philippines. There was variation of precipitable water throughout the year at the three stations (see Figure 4).

Figures 5-7 shows the trends of precipitable water over Songkhla during 2007-2017, and Manila and Marbel University from 2009-2017. This is due to the climate of Thailand and Philippines being influenced strongly by the northeast monsoon (November-February) and the south- west monsoon (May-October)

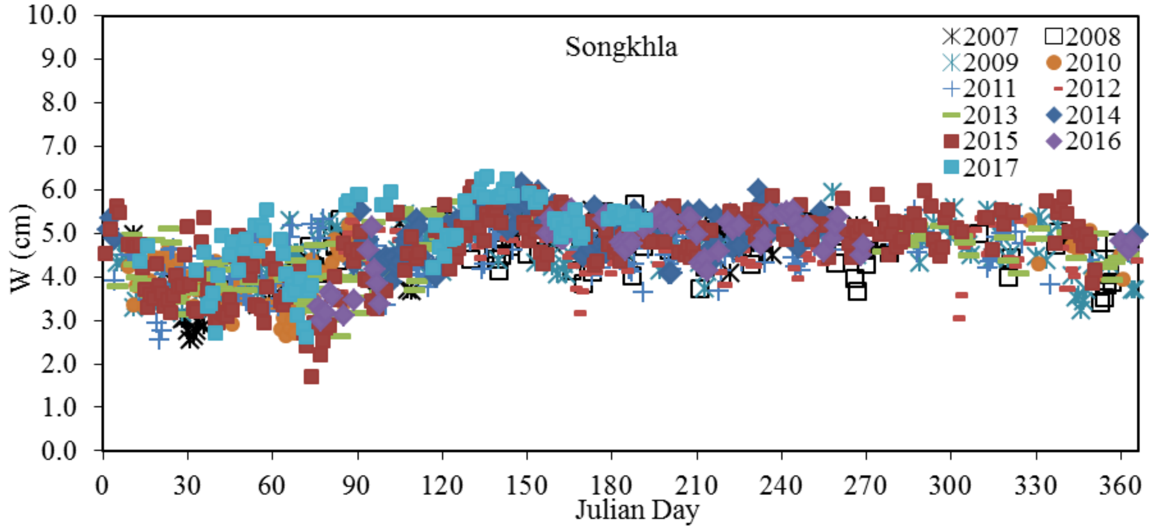

Figure 1 Mean daily values of precipitable water (2007-2017)

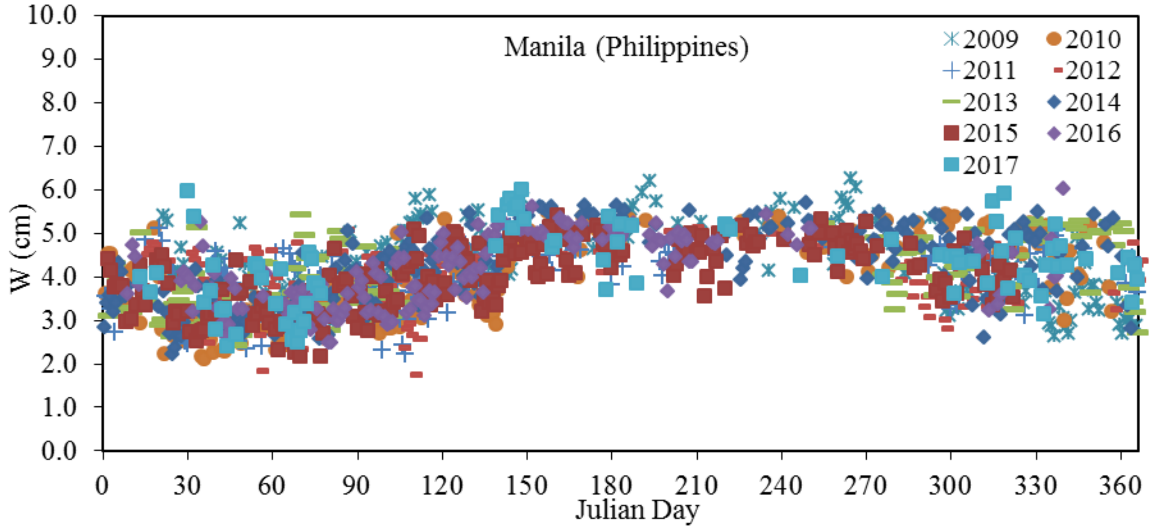

Figure 2 Mean daily values of precipitable water (2009-2017)

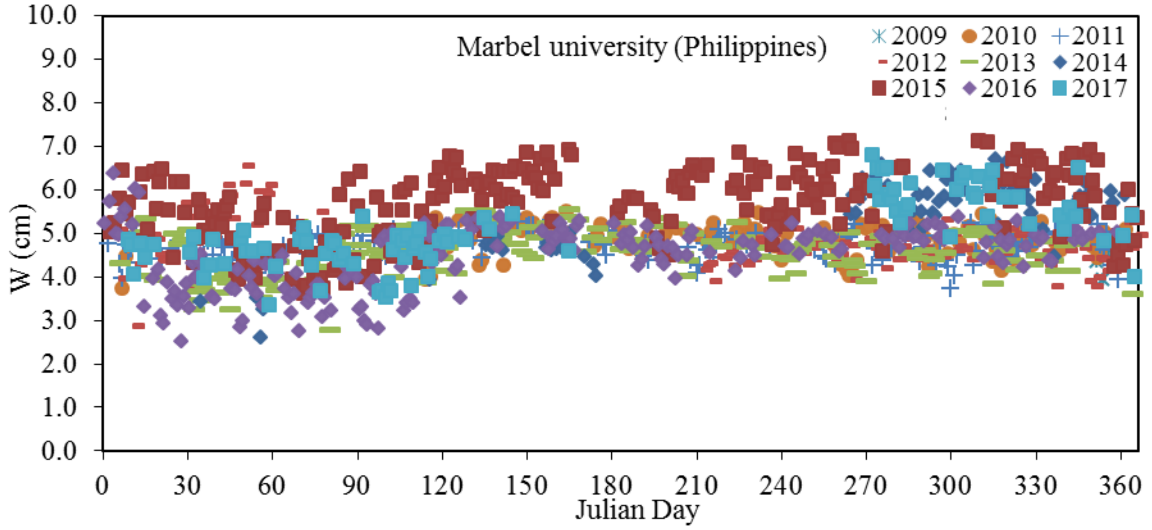

Figure 3 Mean daily values of precipitable water (2009-2017)

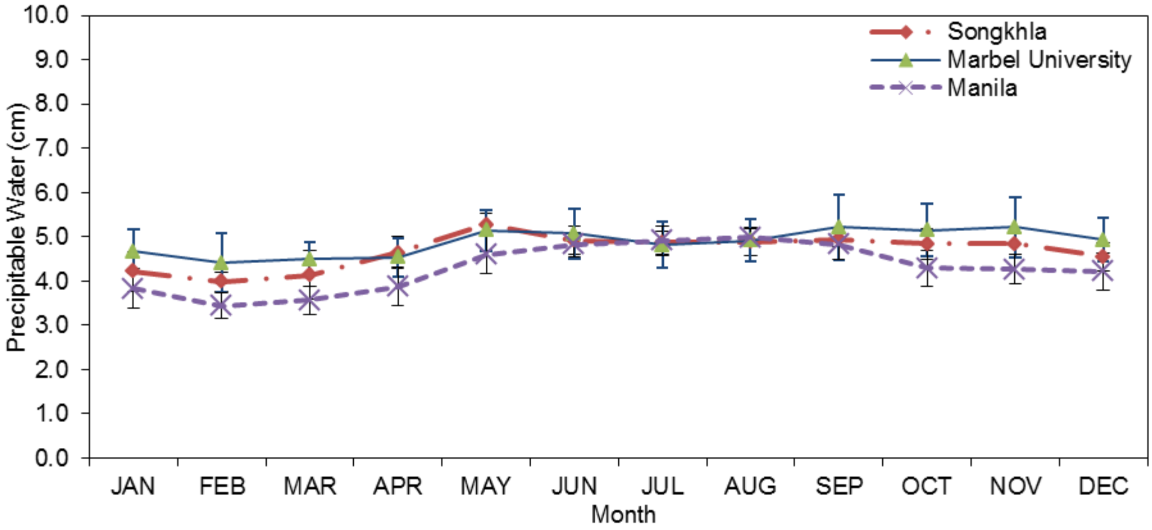

Figure 4 Monthly average of precipitable water for the three sites

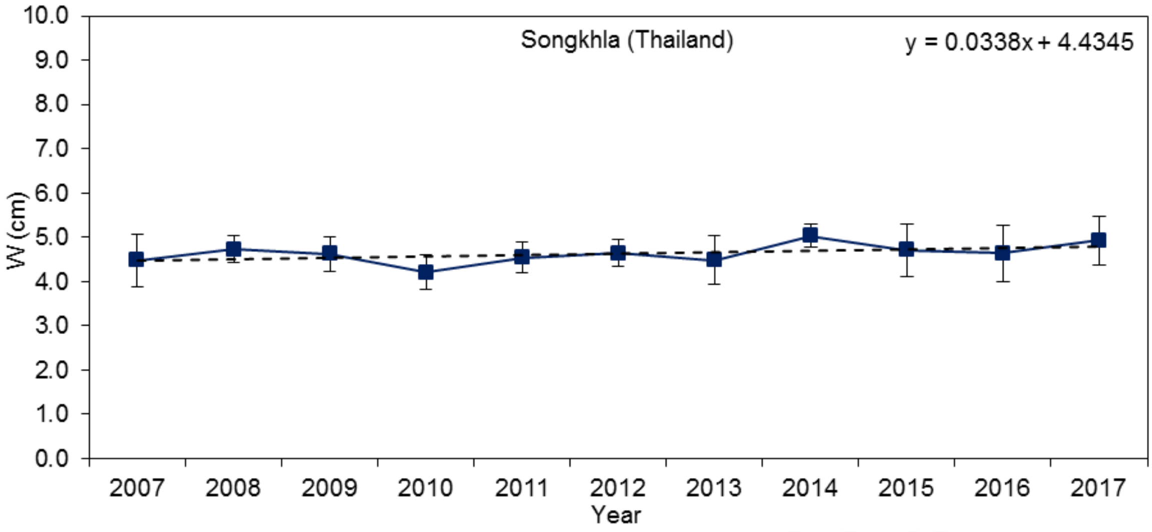

Figure 5 The yearly average of precipitable water in Songkhla from 2007 to 2017

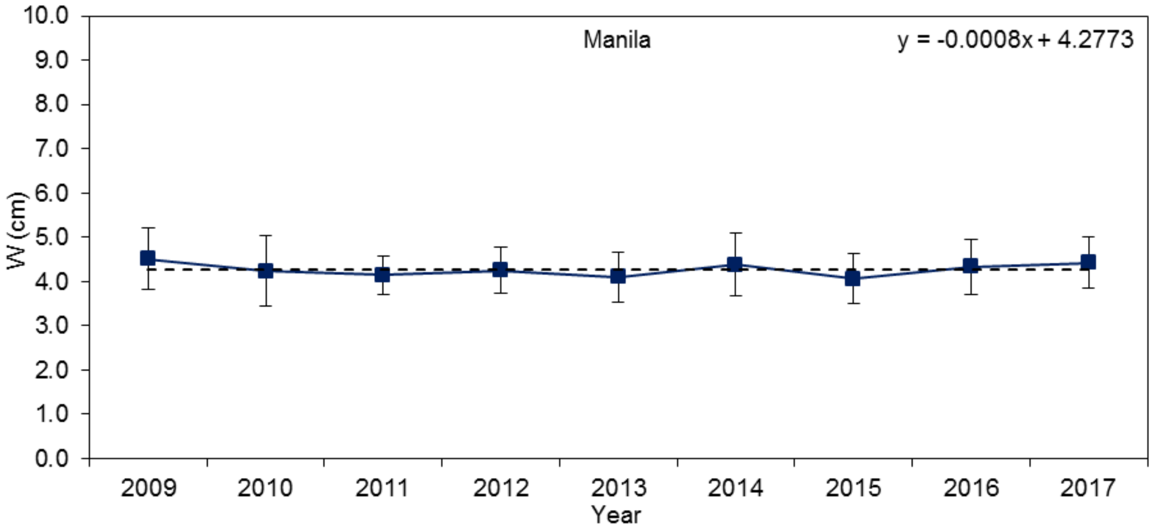

Figure 6 The yearly average of precipitable water over Manila from 2009 to 2017

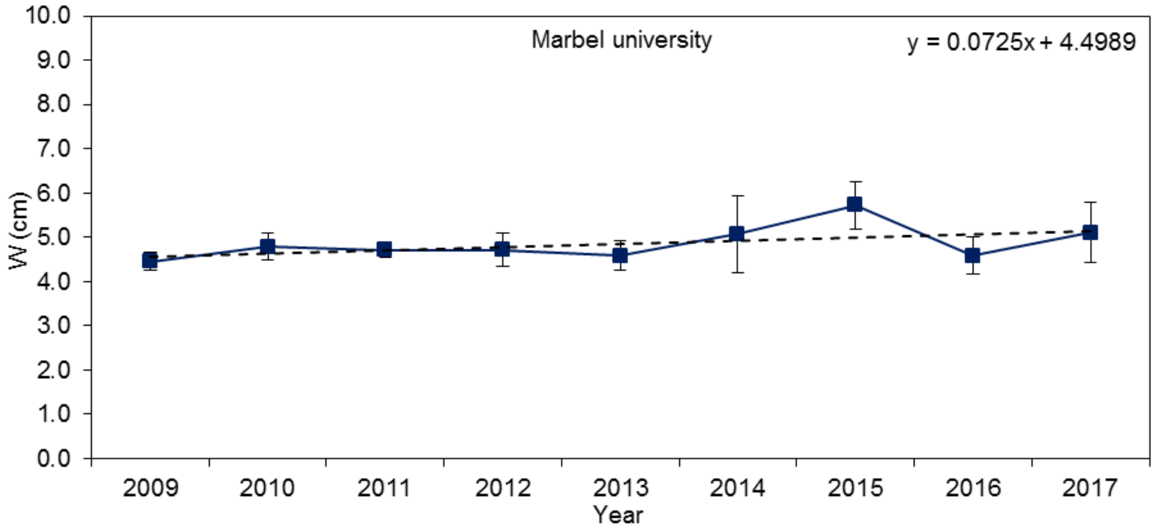

Figure 7 Linear trend of precipitable water for Marbel university from 2009 to 2017

Result showed that the precipitable water with the maximum monthly average W of 5.27 cm, 4.99 cm and 5.22 cm for Songkhla, Manila and Marbel University, respectively. These maximums occur in the dry season (May-October). The minimum monthly average W of 3.99 cm for Songkhla, 3.44cm for Manila and 4.40cm for Marbel university. It was found that the seasonal variation of W from the three sites have a similar pattern.

It was found that in studying precipitable water of Songkhla and Marbel University tended to be increased except for Manila which tended to be decreased.

As the number of precipitable water monitoring station in Thailand and Philippines are still very limited, it is suggested that the number of the stations be increased in order to obtain more spatial coverage of information on precipitable water.

5. Conclusion

The measured spectral data of precipitable water (W) obtained from the range of 2007 to 2017 revealed that the seasonal variation of precipitable water for the three sites have similar patterns. However, the tendency of precipitable water for Songkhla and Marbel University tended to increase while Manila decreased.

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