Presented at the DLSU Research Congress 2016
De La Salle University, Manila, Philippines
March 7-9, 2016

A Preliminary Study on the Precipitable Water Vapor (PWV) from the Davao Radiosonde Station for 2014

Kristine Mae R. Carnicer*, Edgar A. Vallar, and Maria Cecilia D. Galvez
Environment and RemoTe sensing ResearcH (EARTH) Laboratory, Physics Department, De La Salle University, Manila
**kristine_carnicer @dlsu.edu.ph*

Abstract: Water vapor is the most important greenhouse gas and plays a fundamental role in the climate system and for the chemistry of the earth's atmosphere. Hence it is important that a long-term change in the amount of water vapor in the atmosphere is monitored to help detect and predict changes in the earth's climate as well as improve weather forecasting. This study presents the preliminary results of the precipitable water vapor (PWV) calculated from the radiosonde data of the Davao Airport Station (ID#97853) for the whole year of 2014. Data observations include altitude, pressure, temperature, dew point depression, wind speed and wind direction. These data are used to estimate humidity-related variables that are needed to calculate precipitable water vapor (PWV), which is the amount of water in a column of the atmosphere with a unitary basal area. The average annual PWV for the year 2014 is calculated as 53.19 mm. The highest amount of PWV was for the month of June (59.11 mm) while the lowest was for the month of February (46.77 mm). For or all months, the 00 launching (around 8:00 AM) was less than PWV calculated during the 12 launching (around 8:00 PM). The month of February still posted the lowest PWV and June gave the highest value. In terms of the seasonal variations of the calculated PWV, the months of June-July-August (JJA) posted the highest average at 56.15 mm while the months of December-January-February had the least average value at 50.77 mm. The study showed that the PWV calculated from the local radiosonde profiles is in good agreement when considered for the wet and dry season as well as the seasonal variation of precipitation.

Key Words: precipitable water vapor; radiosonde data; seasonal variation

1. INTRODUCTION

Water vapor is the most important greenhouse gas and plays a fundamental role in the climate system and for the chemistry of the earth's atmosphere. It is important that a long-term change in the amount of water vapor in the atmosphere is monitored to help detect and predict changes in the earth's climate. (Coster et. al., 1996)

It can also be used to improve weather forecasting. Atmospheric water vapor is a critical component in the formation of clouds, precipitation and severe weather. However, despite its importance to atmospheric processes over a wide range of spatial and temporal scales, water vapor is one of the least understood and poorly described components of the earth's atmosphere. Many scientific reports in recent years have highlighted and validated the role of water vapor as a critical component of the greenhouse gases driving global weather and climate changes. Water vapor content makes up only 5% of the air and is highly variable in its distribution; that is, it fluctuates seasonally and regionally. (Choy et. al., 2015) This makes water vapor difficult to measure and observe. In fact, water vapor content is one of the poorest observed atmospheric parameters, both spatially and temporally. From a climatic perspective, accurate and consistent observations of the atmospheric water vapor content over extended periods of time are fundamental to provide the initial conditions required for climate models.

The radiosonde network has already become the cornerstone upper atmosphere observing system for many countries and it has long been the primary in situ observing system for monitoring atmospheric water vapor. This technology is useful to estimate humidity-related variables such as mixing ratio or specific humidity. These variables are needed to calculate precipitable water vapor (PWV), which is the amount of water in a column of the atmosphere with a unitary basal area. In Davao City, radiosonde measurement has been conducted since 1984 at Davao Airport Station. However, to our knowledge no one had utilized yet the radiosonde measurement in Davao City to obtain PWV. Hence, in this study we present some preliminary results of the PWV calculated from the radiosonde data of the Davao Airport Station (ID#97853) for the whole year of 2014 to have an initial understanding of how PWV can be used to examine climate trends and variability especially with the current concern in climate change.

2. EXPERIEMNTAL SITE, DATA SOURCES AND METHODOLOGY

The study was conducted in Davao City (7^{o}4'N, 125^{o}36'E), which is located in south-eastern Mindanao, on the north-western shore of Davao Gulf. Davao has a tropical rainforest climate (Köppen climate classification), with little seasonal variation in temperature. This gives the city a tropical climate, without a true dry season; while there is significant rainfall from June to August, most precipitation occurs during the summer months. The radiosonde data used in this study is from the compiled data sets of the Integrated Global Radiosonde Archive (IGRA) produced by the NOAA's National Climatic Data Center (NCDC). The Davao Airport Station (Station ID# 98753) is being maintained by the Department of Science and Technology-Philippine Atmospheric, Geophysical and Astronomical Services Administration (DOST- PAGASA). Data observations include altitude, pressure, temperature, dew point depression, wind speed and wind direction.

The total atmospheric water vapor contained in a vertical column of unit cross-sectional area extending between any two specified levels is commonly expressed in terms of the height to which that water substance would stand if completely condensed and collected in a vessel of the same unit cross section. In the troposphere, water vapor pressure and temperature vary continuously with height, z, above ground level. However, in practice we only know these values at a set of discreet height levels {zj}. Within such limitations, precipitable water (PW) may be defined as the height, in meters, of a column of condensed water of area A from ground level to the top of the troposphere, PW_Z, or

$$PW_z = \frac{1}{\rho}\left(\frac{M}{R}\right)\sum\left(\frac{P_j}{T_j}\right)\Delta z_j \qquad \text{(Eq. 1)}$$

where:

ρ	=	Density of water
M	=	Mass of vapor
P_i	=	Pressure at height level Δz_i
T_i	=	Temperature at height level Δzi
Δz_i	=	Discrete height level
R	=	8.314 J/mol-K, ideal gas constant

ISSN 2449-3309

3. RESULTS AND DISCUSSION

Upper air radio sounding data for the year 2014 conducted twice daily (00 and 12 UTC) was utilized in this study. PWV are calculated for the two radiosonde launches each day, one at 8:00AM (00 UTC) and another at 8:00PM (12UTC). The average for each month is then calculated. The monthly average of the morning and evening launch was also determined and compared.

The annual average PWV for 2014 was calculated as 53.19 mm. Table 1 shows the average PWV for each month as well as the mean for both the morning and evening radiosonde launch of each month. The month of June yields the highest monthly average PWV at 59.11 mm while the month of February has the lowest monthly average at 46.77 mm. Comparison of the mean PWV for the 00 and 12 UTC sounding yield greater value in the 12 UTC for all months. But a closer inspection of the daily mean values show that there were instances when there was an observed decreased in the mean PWV value later in the day. It can be verified that precipitation later in the day caused the said decrease in the PWV value. Several studies have reported the decrease of PWV after a rain event (Cruz and Villarin, 20013; Castilla et. al., 2013).

DOST PAG-ASA has classified the Davao climate as Type IV which is characterized by more or less evenly distributed rainfall throughout the year with no pronounced dry season. Seasonal variations of the PWV has the highest value for the months of June-July-August (JJA) with 56.15 mm, followed by the months of September-October-November (SON) with 54.37 mm and the months of March-April-May (MAM) with 51.45 mm.

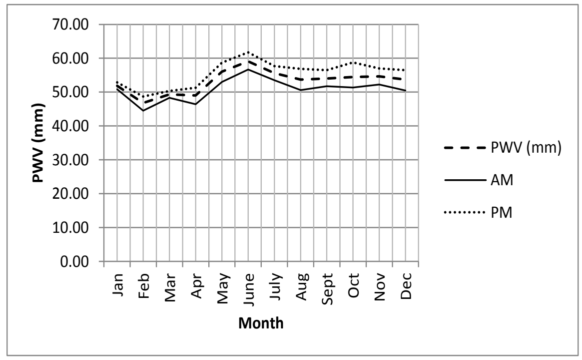

Fig. 1. AM, PM, and Average Monthly PWV for the months of 2014

The least mean PWV was calculated during the months of December-January-February at 50.77 mm. The months of December to May had been generally classified as the dry season while the months of June to November are classified as the wet season by the DOST PAG-ASA in terms of rainfall amount. The calculated seasonal variation of the PWV seems to agree well with the aforesaid classification.

Table 1. Summary of average monthly PWV

Month	PWV (mm)	PWV, 00 (mm)	PWV, 12 (mm)
Jan	51.86	50.83	52.89
Feb	46.77	44.54	48.69
Mar	49.33	48.34	50.32
Apr	49.02	46.42	51.29
May	56.01	52.98	58.67
June	59.11	56.67	61.71
July	55.62	53.53	57.70
Aug	53.73	50.58	56.87
Sept	54.04	51.76	56.48
Oct	54.44	51.35	58.75
Nov	54.63	52.25	56.99
Dec	53.70	50.48	56.51

4. CONCLUSION

The results of this study showed that the calculated PWV from the local radiosonde station is in good agreement with the seasonal variation of precipitation according to the DOST PAG-ASA climatic classification of the region. It is also observed that the PWV gave reasonable values when considered for the wet and dry seasons. The results of the study can therefore confirm that water vapor profiles from radiosonde can be used to examine climatology, trends and variability of the atmospheric water vapor content in the area. The Davao radiosonde station's database dates back to 1984. It can therefore be utilized to provide the baseline data for PWV measurements and its correlation to other meteorological parameters for Davao City. Further, it can also be integrated to the current weather monitoring, flood warning and disaster-vulnerability mapping systems to improve the city's adaptive and preventive capacity against climate-related disasters.

5. ACKNOWLEDGMENTS

The authors are grateful to the DOST Pag-asa Davao for generously sharing their data and to Fr. Francisco Glover, SJ for his valuable contribution in the data processing. This research work is also made possible through the corresponding author's DOST-SEI ASTHRDP-NSC scholarship grant.

6. REFERENCES

Castilla, Red M., Floyd Rey P. Plando, Edgar A. Vallar, Maria Cecila D. Galvez and Vernon R. Morris, 2014, "Characterization of columnar water vapor measurements and its comparsion with model estimates and surface meteorological parameters over Manila, Philippines (14.567^{o}N, 120.980^{o}E), 35th Asian Conference on Remote Sensing 2014, ACRS 2014: Sensing for Reintegration of Societies

Choy, Suelynn, Chuan-Sheng Wang, Ta-Kang Yeh. John Dawson, Minghai Jia and Yuriy Kuleshov, 2015, "Precipitable water vapor estimates in the Australian region from ground-based GPS observations," Advances in meteorology, 1-14

Coster, A.J., A.E. Niell, F.S. Solheim, V.B. Mendes, P.C. Toor, K.P. Buchmann and C.A. Upham, "Measurements of precipitable water vapor by GPS, radiosondes and a microwave water vapor radiometer," Presented at ION-GPS, Kansas City, Kansas, September 17-20, 1996

Cruz, F.T. and J.T. Villarin, 2003, "An analysis of the precipitable water vapor over the PIMO GPS station," Science Diliman 15:1, 84-87