

การประมาณค่าปริมาณน้ำฝนจากปริมาณไอน้ำในอากาศของประเทศไทย

Estimation of rainfall from the amount of water vapor in the air of Thailand

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บทคัดย่อ

การวิจัยนี้มีวัตถุประสงค์เพื่อประมาณค่าปริมาณน้ำฝนในอากาศในแต่ละภูมิภาคของประเทศไทย โดยใช้ข้อมูลอุณหภูมิและความชื้นสัมพัทธ์ที่ได้จากการตรวจวัดของสถานีอุตุนิยมวิทยาในแต่ละภูมิภาคของประเทศไทย ระหว่างปี พ.ศ. 2557 ถึง พ.ศ.2567 นำข้อมูลมาคำนวณหาปริมาณไอน้ำในอากาศ จากนั้นนำค่าปริมาณไอน้ำที่คำนวณได้มาหาความสัมพันธ์กับปริมาณน้ำฝนที่วัดได้ของสถานีเดียวกัน ผลการวิจัยแสดงให้เห็นว่าความสัมพันธ์ระหว่างปริมาณน้ำฝนกับปริมาณไอน้ำในอากาศมีความน่าเชื่อถือค่อนข้างสูงสามารถแสดงได้ในรูปแบบจำลองทางคณิตศาสตร์ซึ่งจะมีรูปแบบแตกต่างกันไปในแต่ละภูมิภาค เมื่อทดสอบกับชุดข้อมูลอิสระของปี พ.ศ. 2568 พบว่าค่าเฉลี่ยรายเดือนของปริมาณน้ำฝนจากแบบจำลองมีความสอดคล้องที่ดีทั้งในด้านการกระจายตัวและแนวโน้มกับค่าที่ได้จากการวัดโดยไม่มี ความแตกต่างอย่างมีนัยสำคัญที่ระดับ 0.05 ค่าความคลาดเคลื่อนรากที่สองกำลังสองเฉลี่ย (RMSE) เท่ากับ 38.693 มิลลิเมตร

คำสำคัญ: ปริมาณไอน้ำ, ปริมาณน้ำฝน, ข้อมูลอากาศชั้นบน, ข้อมูลพื้นผิว, แบบจำลองทางคณิตศาสตร์

Abstract

This research aims to estimate rainfall amounts in different regions of Thailand using temperature and relative humidity data obtained from meteorological stations in each region of the country between 2014 to 2024. The data was then used to calculate the amount of water vapor in the air. The calculated water vapor content was then correlated with the rainfall measured at the same station. The results showed that the relationship between rainfall and water vapor in the air was relatively reliable and could be represented in a mathematical model, which would vary depending on the region. When tested with an independent dataset from the year 2025, the monthly average rainfall from the model a good agreement in distributions and trends with the measured values, showing no significant difference at the 0.05 level. The root mean square error (RMSE) was 38.693 mm.

Keywords: amount of water vapor, rainfall, upper air data, surface data, mathematical model

1. Introduction

Water vapor is the atmosphere's composition indicates the change of weather, cloud formation, rain, fog, snow and hail etc. In addition, the amount of water vapor in the atmosphere has a significant influence on the reduction of solar radiation through the atmosphere to the Earth's surface [1]. The amount of water vapor is part of the hydrologic cycle. The water vapor is a carrier and distributes heat to the atmosphere and the surface. It has heat retention properties, making the temperature of the earth warm for living [2]. The amount of water vapor in the air is expressed in terms of the precipitable water vapor in centimeters. Which can be said in terms of the height of the water in the column of the atmosphere, if the water vapor inserted in the column of the atmosphere condenses into water [3-4]. The precipitable water vapor in the air is rare and there is no measurement of water vapor in Thailand. The amount of water vapor is related to the relative humidity and air temperature obtained from the upper air data. It changes according to latitude and season [4-5]. The heat from the sun causes water to evaporate into a vapor floats up in the air. When the air temperature decreases, the water vapor in the atmosphere condenses into small droplets floating in the air, they will gather into clouds. Water vapor in the clouds gathered in a large drop of water to fall to the ground, called rain. Temperature and relative humidity are important factors that affect the amount of water vapor and rainfall, higher water vapor levels increase the chances of rain [2, 5].

Rainfall is a vital and essential resource for all living things. Rainfall refers to the height of accumulated rainfall on a flat surface over a given period of time, assuming the water does not seep into the ground. It is measured in millimeters. Climate change makes rainfall patterns difficult to predict. It is highly variable and varies greatly across different regions [2, 5]. Accurate and precise forecasting can effectively reduce risks to life, the economy, and the environment [1, 6]

Rainfall is also a significant global issue because it affects every aspect of human life. Accurately predicting rainfall is a challenging task today. Thailand is an agricultural country, so rainfall is a major factor affecting agricultural yields, food production, the spread of diseases and pests, the occurrence of natural disasters, and biodiversity. This research presents a method for estimating rainfall from the amount of water vapor in the air, using readily available surface data (temperature and relative humidity), which can be applied in areas where measurements are not available.

2. Materials and Methods

This research, the relative humidity and air temperature data from the upper air data during 2014-2024 were used. There are only 4 stations in Thailand namely, Chiang Mai, Ubon Ratchathani, Songkhla and the Bangkok Meteorological Department. This is used to calculate the amount of water vapor using theoretical equation [2-5].

$$w = -\frac{1}{\rho g} \int_{p_0}^0 M_p dp \quad (1)$$

where w is the amount of water vapor in centimeters, M_p is the mixing ratio at any pressure level p (decimal), g is the acceleration due to gravity (986.665 cm/s^2), p_0 is the atmospheric pressure at the Earth's surface (mbar), ρ is the air density (g/cm^3). The minus sign indicates pressure decreases as the height increases.

The amount of water vapor from upper data at the four monitoring stations between 2014 to 2024 was correlated with the surface data (temperature, relative humidity, and saturated vapor pressure) at the same station and simultaneously in the mathematical model to calculate the water vapor of the stations that does not have the upper air data. After that, the mathematical model was tested using surface data and upper air data of the same station using data in 2025 which is independent data to test and find the efficiency in the form of root mean square error (RMSE). Finally, rainfall data from 29 regularly monitored stations nationwide were used, including 7 stations in the North, 8 stations in the Central region, 7 stations in the Northeast, and 7 stations in the South. The monthly average for each region is calculated. The relationship between rainfall and water vapor data at the same station and time period is used to create a mathematical model to estimate rainfall using surface data for different regions.

3. Results and Discussion

The amount of water vapor from the upper air data of four stations were correlated with temperature and relative humidity, which is the surface data at the same station and the same time, as shown in

Figure 1. The results showed that data were correlated in mathematical models. The correlation coefficient (R^2) was 0.891. Relationships was fitted as the following equation.

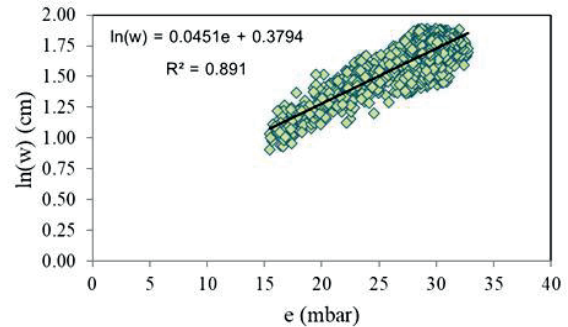


Figure 1 The relationship between water vapor and vapor pressure.

$$w = 1.461407 \exp(0.0451e) \quad (2)$$

where e is the vapor pressure (mbar). It is obtained by the product of the saturated vapor pressure (e_s) and the relative humidity (RH) at that pressure level [2, 5].

$$e = \frac{RH \times e_s}{100} \quad (3)$$

The saturated vapor pressure value depends only on the air temperature (T) in degree Celsius. The saturated vapor pressure (in mbar) is calculated according to [2, 5].

$$e_s = 6.112 \exp\left(\frac{17.67 \times T}{T + 243.5}\right) \quad (4)$$

The model was retested with independent data that had never been used to build the model, using data from the four stations mentioned above in 2025 to verify the accuracy of the model. It was found that, the amount of water vapor from the upper air data was close to the value obtained from the model, where the RMSE was 0.528 cm and the R^2 was 0.851. This model was

used to calculate water vapor for stations without upper air data.

The data from 29 stations across four regions of Thailand during the years 2014 to 2024 were analyzed to identify the relationship between rainfall and water vapor, as shown in Figure 2. The mathematical relationship between rainfall and amount of water vapor in each region can be analyzed and shown in Table 1, which varies according to the climate of each region.

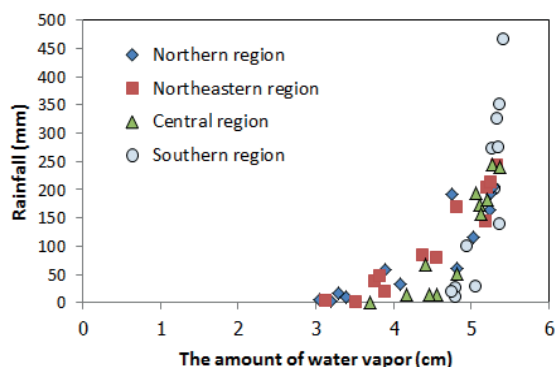


Figure 2 Average monthly rainfall and amount of water vapor from 4 regions of Thailand during the years 2014 to 2024.

Table 1 The Equation of relationship between rainfall and amount of water vapor

Region	The equation of the relationship
North	$RF = 0.0026 w^{6.7737}$; $R^2 = 0.871$
Northeast	$RF = 2.9074 w^3 + 0.4992 w^2 - 62.601 w + 100.56$; $R^2 = 0.931$
Central	$RF = 0.0002 \exp(2.658 w)$; $R^2 = 0.808$
South	$RF = 7 \times 10^{-10} w^{24.154}$; $R^2 = 0.843$

The model was tested with independent data, which had never been used in the modeling by using the same data from 29 stations across four regions of Thailand in

2025 of the same stations to verify the accuracy of the model (show as Figure 3). It was found that, the monthly average rainfall from the model agreement in distributions and trends with the measured values, the data are not significantly different at the confidence level 0.05. The RMSE was 38.693 mm and the R^2 was 0.879 with the relationship as shown in the equation.

$$RF = 0.8667(RF_M) + 9.9098 \quad (5)$$

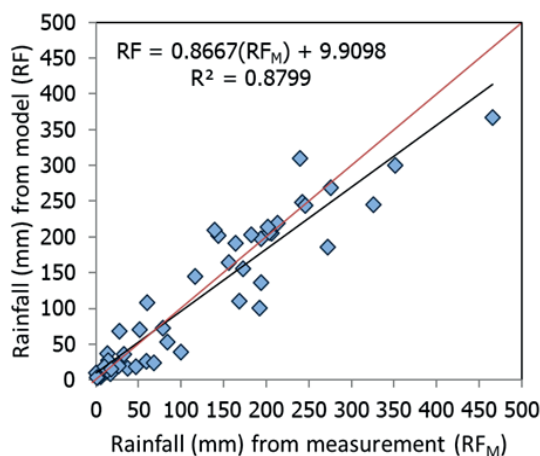


Figure 3 The average monthly rainfall from the model is compared to the measured rainfall in each region in 2025.

4. Conclusions

In this paper, the rainfall is estimated from the amount of water vapor in the atmosphere using mathematical models. It was found that the rainfall is related to the amount of water vapor in the atmosphere, which can estimate the rainfall from water vapor data. The mathematical model for estimating rainfall in Thailand is divided into 4 regions. Each region has a relationship between rainfall and the amount of water vapor in the atmosphere. The results of the study were as follows:

- 1) Northern region has a power relationship, the correlation coefficient equal to 0.871.
- 2) Northeastern region had a polynomial relationship, the correlation coefficient equal to 0.931.
- 3) Central region has an exponential relationship, the correlation coefficient equal to 0.808.
- 4) Southern region has a power relationship, the correlation coefficient equal to 0.843.

The rainfall model was compared with the measured rainfall. It was found that the rainfall were consistent and very similar, with a root mean square error of 38.693 mm. There were not significantly different at the confidence level of 0.05, and the R^2 was 0.879.

5. Acknowledgement

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6. References

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