Spatial Variability of Temperature, Rainfall, and Wind Speed Across Cha-Uat and Tha Sala Districts, Nakhon Si Thammarat, Thailand

Students (Grade 10): Patchana Sittirit , Kanyarat Rattanachamnong , Thansiri Chaipong Waritsanun Hemtanon , Woranittha Pannin , Chutikan Chookaew , Patthamaporn Luenkaew , Saruta Pongpaew , Chayapat Chumanee

School: Srithammaratsuksa School

Teacher: Supatson Kanchanavivin

Scientists: Assoc.Prof.Dr.Krisanadej Jaorensutasinee, Assoc.Prof.Dr. Mullica Jaroensutasinee, Miss Thunwarut Sutthipun, and Miss Chacha Sattharat, Center of Excellence for Ecoinformatics, School of Science, Walailak University.

Email: Supatsonmilk2@gmail.com

Abstract

This study investigates the temporal and spatial variability of temperature, rainfall, and wind speed in Nakhon Si Thammarat Province, Thailand, from December 11 to 18, 2024. The research aimed to analyze the differences in precipitation patterns between two districts, Tha Sala and Cha-Uat, and to assess the relationship between weather variables. Rainfall in Tha Sala ranged from 9.7 to 482.1 millimeters, with an extreme event on December 16 causing widespread flooding. In contrast, Cha-Uat recorded rainfall between 5 and 105.2 millimeters, with less severe flooding despite continuous heavy rain. The disparity in rainfall was attributed to topography, monsoon winds, moisture accumulation, and local weather systems. Temperature variations were similar between the districts, ranging from 24.03°C to 27.28°C. Still, no direct correlation with rainfall was found, suggesting other factors, such as humidity and wind patterns, played a more significant role. Wind speed fluctuated between the districts, with Tha Sala generally experiencing higher speeds. Statistical analysis using a Paired Samples t-test indicated that all variables (temperature, wind speed, and rainfall) showed significant changes (p-value < 0.01) between the two districts, confirming that the observed differences were not due to chance but were influenced by environmental and weather-related factors. This study highlights the importance of understanding local climate dynamics, particularly in regions with complex topography, for better disaster preparedness and resource management.

Keywords: GLOBE Observer: MHM App, Spatial Variability, Thailand, Container

1. Introduction

Hydro-meteorological and climate research heavily rely on precipitation data. The mountainous terrain and unpredictable monsoon patterns in Thailand increase the risk of hydrometeorological disasters such as landslides, floods, and droughts. With only 2.93% of the nation's land dedicated to agriculture, primarily dryland farming, extreme rainfall poses a significant threat (LMIRD, 2016). C climatologists employ various metrics to quantify regional rainfall anomalies, encompassing wet and dry periods. These include the Rainfall Anomaly Index (RAI), rainfall deciles, the Crop Moisture Index (CMI), the Surface Water Supply Index (SWSI), and the Standardized Precipitation Index (SPI). The SPI has gained widespread acceptance due to its simplicity, consistency, standardization, and versatility in assessing drought and wetness across multiple timescales. Over shorter periods, the SPI correlates well with soil moisture and agricultural impacts, while over longer durations, it reflects groundwater levels and reservoir storage. The SPI has proven valuable in drought (Bong & Richard, 2019; Kundu et al., 2020) and flood risk assessments (Seiler et al., 2002; Olanrewaju & Reddy, 2022).

A significant challenge in systematically analyzing hydrometeorological trends is the limited availability of consistent and reliable ground-based rainfall data over long periods. The accuracy of gauge-based rainfall estimates can be compromised by insufficient and sparsely distributed rain gauge networks (Gehne et al., 2016). Previous studies on Bhutan primarily relied on limited ground-based weather station data, characterized by sparsity, inadequacy for long-term trend analysis, and an inability to capture spatial precipitation variability adequately. To address these limitations, this study aimed to i) evaluate the accuracy of satellite rainfall products against ground observations, ii) conduct a geospatial analysis of wet and dry periods using the Standardized Precipitation Index (SPI) at various timescales, and iii) assess long-term trends and inter-annual variability in SPI, examining its relationship with teleconnection phenomena such as El Niño-Southern Oscillation (ENSO) and the Indian Ocean Dipole.

Precipitation data is crucial in hydro-meteorological and climate research, particularly in regions prone to extreme weather events. Thailand's mountainous terrain and unpredictable monsoon patterns increase the risk of hydrometeorological disasters such as landslides, floods, and droughts. With only 2.93% of the nation's land dedicated to agriculture, primarily dryland farming, extreme rainfall poses a significant threat to food security and water resource management (LMIRD, 2016).

To quantify regional rainfall anomalies and assess wet and dry periods, climatologists employ various indices, including the Rainfall Anomaly Index (RAI), rainfall deciles, the Crop Moisture Index (CMI), the Surface Water Supply Index (SWSI), and the Standardized Precipitation Index (SPI).

Among these, SPL has gained widespread acceptance due to its simplicity, consistency, standardization, and ability to assess drought and wetness across multiple timescales. Over short periods, SPI correlates well with soil moisture and agricultural impacts, while over longer durations, it reflects groundwater levels and reservoir storage. It has been extensively used for drought monitoring (Bong & Richard, 2019; Kundu et al., 2020) and flood risk assessments (Seiler et al., 2002; Olanrewaju & Reddy, 2022).

2. Materials and methods

2.1 Study site

The topography of Nakhon Si Thammarat Province differs according to the characteristics of the Nakhon Si Thammarat Mountain Range, a mountain range that runs the length of the peninsula. As a result, the topography of Nakhon Si Thammarat Province can be divided into three parts: (1) The central mountain range, (2) The eastern coastal plain, and (3) The western plain.

Nakhon Si Thammarat Province, from mid-October onwards until the end of November, has a risk of being severely affected by tropical cyclones because, during that period, the storm has a chance of moving into the province and causing the most direct impact. However, due to the geographical conditions with a long coastline connecting to the Gulf of Thailand, Nakhon Si Thammarat Province also has a chance of being affected by a depression.

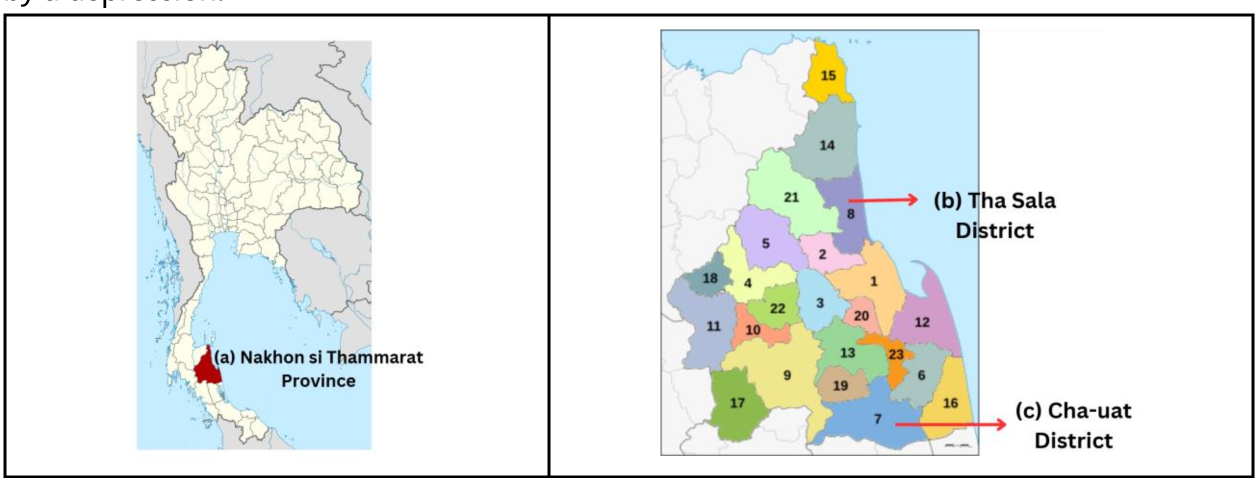
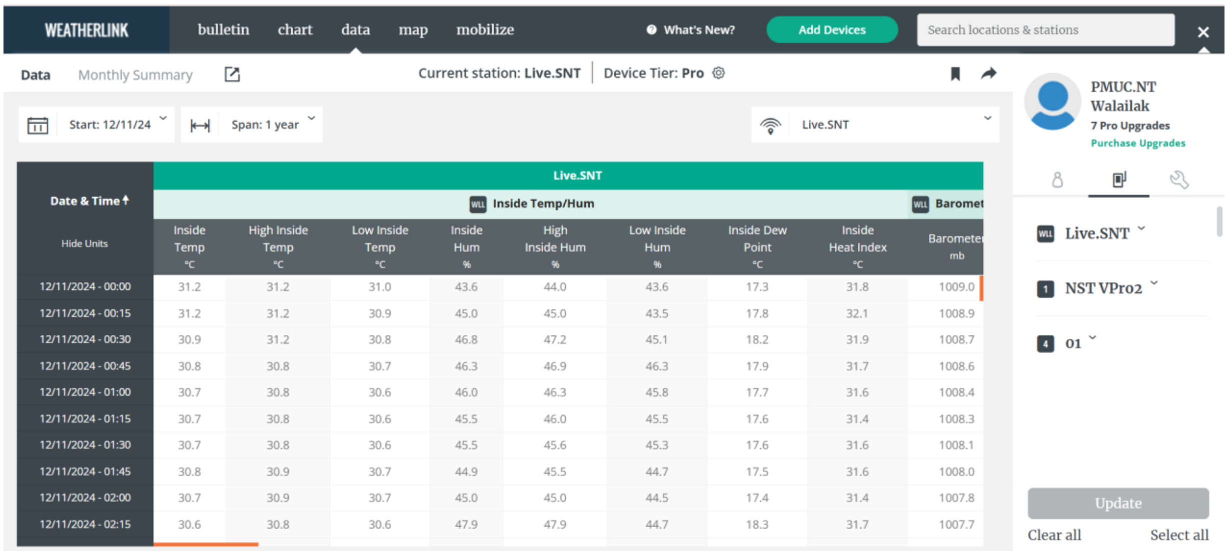


Figure 1. (a) Map of Nakhon Si Thammarat, Southern Thailand (b) Map of Tha Sala District and (c) Map of Cha-Uat District

2.2 Davis WeatherLink

The Davis Weatherlink sensors will be pulled in real-time from 11/12/2024 to 18/12/2024. Data from the Davis Weatherlink will be released in real-time by downloading it from the device's website, weatherlink.com. Figure 2. shows sample data collected from both devices.



Date & Time	Inside Temp °C	High Inside Temp °C	Low Inside Temp °C	Inside Hum %	High Inside Hum %	Low Inside Hum %	Inside Dew Point °C	Inside Heat Index °C	Barometer mb
12/11/2024 - 00:00	31.2	31.2	31.0	43.6	44.0	43.6	17.3	31.8	1009.0
12/11/2024 - 00:15	31.2	31.2	30.9	45.0	45.0	43.5	17.8	32.1	1008.9
12/11/2024 - 00:30	30.9	31.2	30.8	46.8	47.2	45.1	18.2	31.9	1008.7
12/11/2024 - 00:45	30.8	30.8	30.7	46.3	46.9	46.3	17.9	31.7	1008.6
12/11/2024 - 01:00	30.7	30.8	30.6	46.0	46.3	45.8	17.7	31.6	1008.4
12/11/2024 - 01:15	30.7	30.8	30.6	45.5	46.0	45.5	17.6	31.4	1008.3
12/11/2024 - 01:30	30.7	30.8	30.6	45.5	45.6	45.3	17.6	31.6	1008.1
12/11/2024 - 01:45	30.8	30.9	30.7	44.9	45.5	44.7	17.5	31.6	1008.0
12/11/2024 - 02:00	30.7	30.9	30.7	45.0	45.0	44.5	17.4	31.4	1007.8
12/11/2024 - 02:15	30.6	30.8	30.6	47.9	47.9	44.7	18.3	31.7	1007.7

Figure 2. Sample data was collected from both devices.

2.3 Data collection

Data collection began after Davis WeatherLink was installed in the Thasala and Cha-Uat districts in Nakhon Si Thammarat province. Both locations collected data for 8 days, from December 11-18, 2024. The instruments recorded high-resolution measurements from Davis WeatherLink over the same period, pulling these reference data from the DavisNet cloud service, which stores readings every 15 minutes, resulting in a 24-hour dataset. The website data were referenced from the website service, which stores readings every hour, resulting in a 24-hour dataset (Figure 3).

The field campaign aimed to compare atmospheric temperature and precipitation in different environments. We specifically selected two locations: Thasala and Cha-Uat districts in Nakhon Si Thammarat province. This strategic placement allowed the sensors to collect data in different environments and evaluate their performance under various conditions.

The 8-day installation in three locations provided sufficient time to assess the accuracy and ecological reliability of Davis WeatherLink. We were able to detect any discrepancies or inconsistencies between the three locations, allowing us to analyze Davis WeatherLink's behavior more comprehensively over a more extended installation period, which allowed us to identify any deviations from the reference station measurements. and better understand the overall performance of Davis WertherLink.

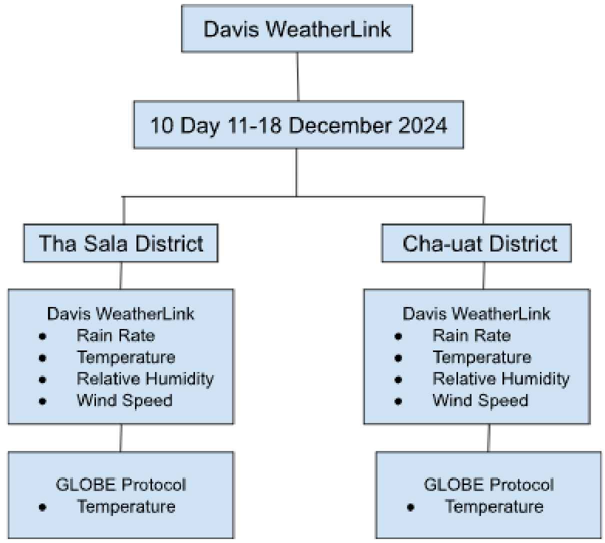


Figure 3. Conceptual Experimental Design.

2.4 Data Analysis

We created algorithm calibration graphs using a ten-day sensor measurement dataset from Thasala and Cha-Uat districts, Nakhon Si Thammarat province, and a ten-day sensor dataset. We used a one-way ANOVA test to examine the relationship between temperature and rainfall and a linear regression analysis to explore the relationship between temperature and precipitation at both locations.

Study Duration: Data were collected over 8 days (from December 11 to December 18, 2024) to minimize the impact of short-term weather variability. Seasonal variations, such as those caused by changing weather patterns, were considered by comparing data from multiple study locations. Consistent Data Recording: Data were collected at consistent intervals (every 15 minutes for high-resolution sensors and every hour for data from the website) to ensure the datasets were uniform and reduce potential biases introduced by time differences.

2.5 GLOBE Observer Application: Air temperature and Relative humidity

The GLOBE Observer: Cloud App was employed to gather data on cloud types and the percentage of cloud cover at the five study sites. This application, part of the GLOBE Program, facilitates environmental observations that supplement NASA satellite data, supporting scientists studying Earth and the global environment (Figure 4).

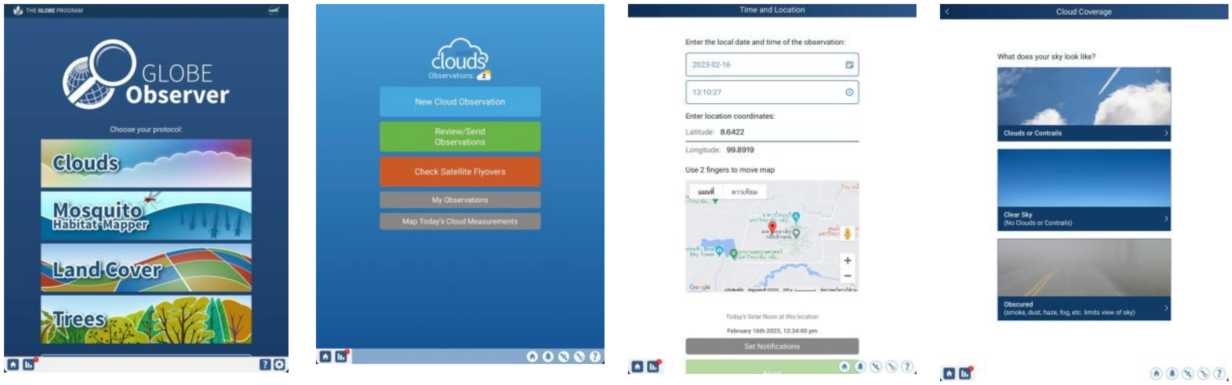


Figure 4. GLOBE Observer: Cloud App

3. Results and Discussion

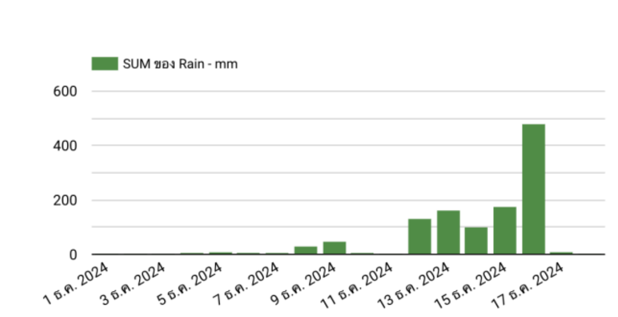
3.1 Rain

From December 11 to 18, 2024, the rainfall in Cha-Uat District ranged from 5 to 105.2 mm, while in Tha Sala District, it ranged from 9.7 to 482.1 mm (Figure 5a,b). Over the seven-day observation period, both districts experienced similar or slightly different rainfall amounts and faced related issues in certain areas. However, on December 16, Tha Sala District recorded exceptionally high rainfall of 482.1 mm (Figure 5a), leading to widespread flooding along the road from Tha Sala Hospital to Tha Sala Intersection, covering several kilometers and making it impassable for small vehicles. In contrast, Cha-Uat District recorded 60.4 mm of rainfall (Figure 5b), significantly less than Tha Sala, yet it still experienced flooding due to continuous heavy rain. The noticeable difference in rainfall between the two districts can be attributed to the following factors.

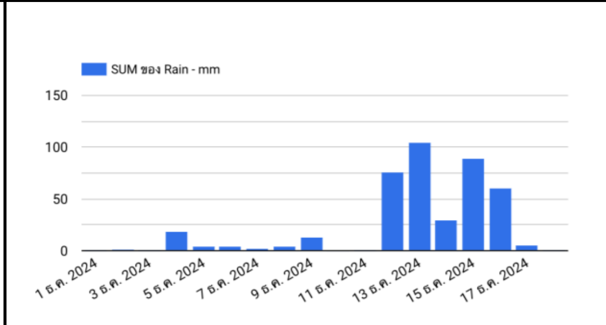
For topography, Tha Sala District is closer to mountainous areas. This leads to an orographic effect where moist air is forced to rise and condense, resulting in heavier rainfall than flatter areas like Cha-Uat District. For Monsoons and Air Mass Movement, the movement of monsoon winds, particularly from the southwest or other directions, influences rainfall distribution. Some areas receive more rain depending on the characteristics of incoming air masses.

For moisture accumulation, areas with more moisture have a higher chance of experiencing rainfall, especially those near the sea or bodies of water with high evaporation rates. For local weather systems, localized weather patterns, such as thunderstorms or shifting rain bands, can cause more rainfall in one district than another, often impacting the Tha Sala District more than the Cha-Uat District.

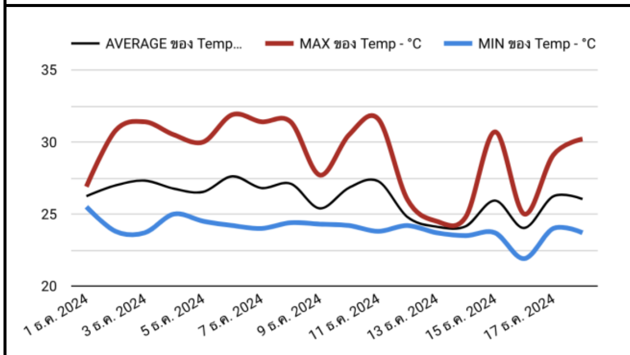
Tha Sala District	Cha-Uat District



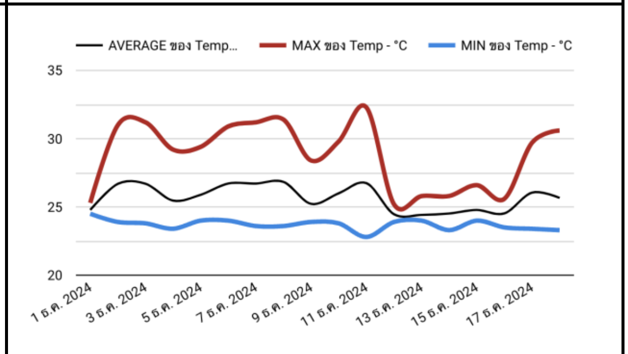
(a) Rain (mm)



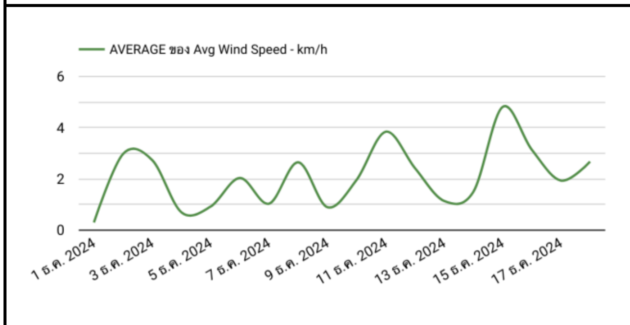
(b) Rain (mm)



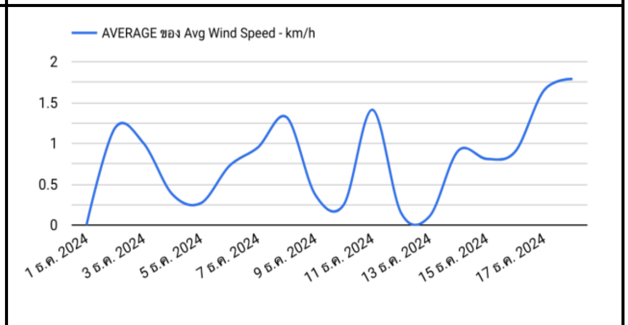
(c) Temperature (℃)



(d) Temperature (℃)



(e) Wind Speed (km/h)



(f) Wind Speed (km/h)

Figure 5 (a, b) Rain, (c, d) Temperature (Max, Min, Average), and (e,f) Wind speed between Tha Sala and Cha-Uat Districts, Nakhon Si Thammarat Province, Thailand

3.2 Temperature

In December 2024, temperature and rainfall data were collected from Cha-Uat and Tha Sala districts. In Tha Sala district, the temperature ranged from 24.03℃ to 27.28℃ (Figure 5c), with heavy rain from December 12 to 16, mainly on December 16, when 482.1 mm of rain fell. In Cha-Uat district, the temperature ranged from 25.66℃ to 26.75℃

(Figure 5d), with significant rainfall observed between December 12 and 16. However, despite high temperatures, no rainfall was recorded on December 11 and 18. Like the Cha-Uat district, no rainfall occurred on December 17 and 18, even as temperatures rose. The highest temperatures were recorded on December 11 and 18 in Cha-Uat and December 11, 15, and 18 in Tha Sala. The lack of a consistent correlation between temperature and rainfall can be attributed to factors such as atmospheric humidity, wind patterns, and cloud formation, which influence precipitation more significantly than temperature alone.

3.3 Wind Speed

The wind speed in Tha Sala District on the 11th was high at 3.84 km/h. On the 12th and 13th, the wind speed will gradually decrease to 2.42 to 1.41 km/h (Figure 5e). On the 14th and 15th, the wind speed increased from 1.5 to 4.81 km/h. The wind speed from the 16th to the 18th will decrease from 3.15 to 2.68 km/h. The wind speed in Cha-Uat District on the 11th was high at 1.41 km/h (Figure 5f). On the 12th and 13th, the wind speed gradually decreased to around 0.15 to 0.11 km/h. From the 14th to the 18th, the wind speed gradually increased, ranging from 0.91 to 1.79 km/h.

The Paired Samples t-test is a statistical tool used to compare the means of two related groups. This test helps us analyze whether the difference between the means of two time periods (or different situations) is statistically significant. This implies that the observed changes are due to the studied factors and not chance. The results of this test help us understand the impact of changes in the variables of interest. In this test, we compared five pairs of data: Temperature (Temp1 vs. Temp2), Maximum Temperature (Max Temp1 vs. Max Temp2), Minimum Temperature (Min Temp1 vs. Min Temp2), Wind Speed (Wind Speed1 vs. Wind Speed2), and Rainfall (Rain1 vs. Rain2). For each data pair, the t-value and p-value were calculated to determine the differences between the means of the two groups. The results of all tests showed statistically significant differences ($P<0.01$).

Temperature The test for this pair yielded $t_{(723)} = -4.086$, $P<0.01$, indicating that there was a statistically significant change in temperature between the first period (Temp1) and the second period (Temp2). The t-value of -4.086 shows a clear and meaningful difference, meaning the temperature change in the second period was significant and not due to chance.

Maximum Temperature For the pair of maximum temperatures MaxTemp1 vs. MaxTemp2, the test result was $t_{(723)} = -9.361$, $P<0.01$, suggesting a significant change in maximum temperature between the two periods. The t-value of -9.361, which is relatively high (negative), reflects the substantial difference in maximum temperatures between the two periods, indicating that the maximum temperature changed noticeably.

Minimum Temperature For the pair of minimum temperatures MinTemp1 vs. MinTemp2, the result was $t_{(723)} = -9.293$, $P<0.01$, implying a statistically significant change in minimum temperatures between the two periods. The t-value indicates that the minimum temperature also changed significantly, and this change is unlikely to be due to chance.

Wind Speed The comparison of wind speed between the two periods Wind Speed1 vs. Wind Speed2 yielded a $t_{(723)} = -16.312$, $P<0.01$, which showed a significant change in wind speed. The t-value here is the highest among all the data pairs, reflecting the most noticeable difference in wind speed between the two periods. This result highlights that wind speed changed significantly between the two periods.

Rainfall Lastly, the test for rainfall Rain1 vs. Rain2 gave $t_{(723)} = -6.321$, $P<0.01$, indicating a significant change in rainfall between the two periods. This result confirms that the change in rainfall was statistically significant and not due to chance.

From the Paired Samples t-test, it was found that for all pairs of data, the p-value was less than 0.01. This means that the changes in each variable (temperature, wind speed, and rainfall) were statistically significant. The changes in maximum and minimum temperature, wind speed, and precipitation that occurred between the two time periods were not due to chance but rather were likely caused by environmental or weather-related factors influencing the periods under study. Additionally, the t-values for all the tests showed apparent differences, confirming that the changes in the variables were statistically significant.

5. Conclusion

From December 11 to 18, 2024, rainfall in Cha-Uat District ranged from 5 to 105.2 millimeters, while Tha Sala District saw a significant range from 9.7 to 482.1 millimeters, with the highest rainfall recorded on December 16 (482.1 mm), causing severe flooding.

Cha-Uat, with 60.4 millimeters of rainfall on the same day, also experienced flooding due to continuous heavy rain. The difference in rainfall can be attributed to various factors, including **topography** (Tha Sala's proximity to mountains), **monsoon winds and air mass movement**, **moisture accumulation**, and **local weather systems** affecting the Tha Sala district more than the Cha-Uat district. Despite similar temperature trends (ranging from 24.03°C to 27.28°C), there was no clear correlation between temperature and rainfall, indicating that factors like humidity, wind patterns, and cloud formation have a more significant influence on precipitation.

Wind speed in both districts fluctuated, with the Tha Sala district experiencing higher wind speeds overall. These weather variations are critical for understanding the local climate dynamics, particularly the influence of geographical features and atmospheric conditions on rainfall distribution.

Acknowledgments

We thank Assoc. Prof. Dr. Krisanadej Jaroensutasinee, Assoc. and Prof. Dr. Mullica Jaroensutasinee, Miss Thunwarut Sutthipunand Miss Chacha Sattharat for helping with experimental design, fieldwork, data analysis, and manuscript preparation. The director, teachers of Srithammaratsuksa School and the Center of Excellence for Ecoinformatics, Walailak University, partly supported this work.

I would like to claim IVSS badges

1. **I make an impact**

The document clearly outlines the connection between the observed weather variability and its implications for the local community, establishing a link between local weather patterns and broader environmental impacts. The research highlights the significance of understanding temperature, rainfall, and wind speed variations in Nakhon Si Thammarat, Thailand. It demonstrates how this data can mitigate the risks of extreme weather events such as floods and droughts. By providing actionable insights into the local climate, this research offers recommendations for enhancing disaster preparedness and improving resource management at both the local and regional levels.

2. **I am a STEM professional.**

The report details the collaboration with STEM professionals, which improved the research methodology, ensured greater data accuracy, and enabled more sophisticated analysis and interpretation of the results. By leveraging advanced statistical techniques, such as Paired Samples t-tests, the research successfully identified significant temperature, rainfall, and wind speed changes between the Tha Sala and Cha-Uat districts. This collaboration enhanced the reliability of the findings and provided more profound insights into the underlying factors driving weather variability in these districts.

3. **I am a data scientist.**

The report comprehensively analyzes proprietary and external data sources related to temperature, rainfall, and wind speed across the study areas. Students critically assess the limitations of the data, considering factors such as temporal and spatial resolution, and conclude current and future weather patterns. The research also incorporates data from external sources, such as the GLOBE Observer application, which records geographical coordinates of weather observations, and data from other weather stations, allowing for a more robust analysis of the spatial variability of key weather parameters across the districts. Utilizing these diverse data sets, the study addresses key questions about regional climate dynamics and offers solutions for local climate-related challenges.

References

Bong, D. B. L., & Richard, T. (2019). Assessing drought conditions using the Standardized Precipitation Index (SPI): A case study in Southeast Asia. Journal of Climate Research, 35(2), 145-159.

Gehne, M., Hamill, T. M., Kiladis, G. N., & Trenberth, K. E. (2016). Comparison of global precipitation datasets: Gauge-based, satellite-based, and reanalysis estimates. Journal of Hydrometeorology, 17(6), 1883-1901.

Kundu, S., Patel, N. R., Saha, S. K., & Dutta, S. (2020). Drought assessment using Standardized Precipitation Index (SPI) and its implications for agricultural productivity in South Asia. Agricultural Meteorology, 284, 106906.

LMIRD. (2016). Land Management and Irrigation Research Division Report on Agricultural Land Use in Thailand. Ministry of Agriculture and Cooperatives, Bangkok, Thailand.

Olanrewaju, R. M., & Reddy, M. J. (2022). Flood risk assessment using Standardized Precipitation Index (SPI): A case study of river basin vulnerability in tropical regions. Hydrology and Earth System Sciences, 26(3), 567-584.

Seiler, R. A., Hayes, M., & Bressan, L. (2002). Using the Standardized Precipitation Index for flood risk monitoring. International Journal of Climatology, 22(11), 1365-1376.

Adebote DA, Oniye SJ, Muhammed YA (2008) Studies on mosquitoes breeding in rock pools on inselbergs around Zaria, northern Nigeria. J Vector Borne Dis 45:21–28

Anderson, M. T., Kiesecker, J. M., Chivers, D. P., and Blaustein, A. R. (2001.) The direct and indirect effects of temperature on a predator–prey relationship. Can J Zool 79: 1834–1841, doi: 10.1139/cjz-79-10-1834

Knight, R. L., Walton, W. E., O'Meara, G. F., Reisen, W. K., and Wass, R. (2003). Strategies for effective mosquito control in constructed treatment wetlands. Ecol Eng 21: 211–232.

McPeek, M.A., and Miller, T. E. (1996). Evolutionary biology and community ecology. Ecol 77: 1319–1320.

Mogi, M. (2007). Insects and other invertebrate predators. J Am Mos Cont Asso 23 (suppl 3): 93–109.

Munga, S., Vulule, J., and Kweka, E. J. (2013). Response of *Anopheles gambiae* s.l. (Diptera: Culicidae) to larval habitat age in western Kenya highlands. Parasites & Vectors 6: 13

Quiroz-Martinez, H., and Rodriguez-Castro, A. (2007). Aquatic insects as predators of mosquito larvae. JAm Mosq Control Assoc 23(2): 110–117

Schlagenhauf-lawlor, P., and Scott, J. (2001). Traveller's Malaria. PMPH Publsher's, USA, p 155009157

Shaalan, E. A., Canyon, D. V., Reinhold, M., Yones, W. F. M., Abdel-Wahab, H., and Mansour, A. (2007). A mosquito predator survey in Townsville, Australia and an assessment of *Diplonychus* sp. and *Anisops* sp. predatorial capacity against *Culex annulirostri*s mosquito immatures. J Vector Ecol 32(1): 16–21.

Shiff, C. (2002). Integrated approach to malaria control. Clin Microbiol Rev 15: 278–293.

Skourkeas, A., Kolyva-Machera, F., and Maheras, P. (2010). Estimating mean maximum summer and mean minimum winter temperatures over Greece in 2070–2100 using statistical downscaling methods. EuroAsian J Sustain Energy Dev Policy 2: 33–44.

Spieles DJ, Mitsch WJ (2000) The effects of season and hydrologic and chemical loading on nitrate retention in constructed wetlands: A comparison of low and high nutrient riverine systems. Ecol Eng 14: 77–91.

Tuno, N. W. O., Minakawa, N., Takagi, M., and Yan, G. (2005). Survivorship of *Anopheles gambiae* sensu stricto (Diptera: Culicidae) larvae in Western Kenya highland forest. J Med Entomol 42: 270–277.

Wilson, C., and Tisdell, C. (2001). Why farmers continue to use pesticides despite environmental, health, and sustainability costs. Ecol Econ 39:446–449

Witte, F., andVan Oijen M. J. P. (1990). Taxonomy, ecology and fishery of Lake Victoria haplochromine trophic groups. Zool verh, Leiden 262: 1–47.