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COMPARISON OF WEATHER ELEMENT VALUES FROM POWER PROJECT AND OBSERVATION DATA, A CASE STUDY OF SOUTHERN EAST COAST REGION OF THAILAND

Abstract: Weather elements monitoring is important for all activities planning, which were: Air Pressure (Press.), Maximum (TMax) and Minimum (TMin) Temperature, Relative Humidity (%RH), Rainfall (Pr.), Wind Speed (WS) and Wind Direction (WD) leading to the objectives which are 1) to compare the observation data from 15 stations over the Southern East coast region of Thailand and POWER Project data in the same locations using MAE methods to confirm the suitability of using as alternative data and 2) to study each element characteristics in the study area using kriging technique and its trend by Man-Kandal trend test and Sen's slope method. The results indicated that TMax, TMin, Pr., %RH, Press, and WS data from the POWER Project could be used instead of observation data after these values were adapted following MAE values. However, WD data from the POWER Project were not appropriate to use instead of observation data. The big increasing trends were found at high latitude for TMin and %RH while these were found at low latitude for TMax and Pr.

Keywords: weather element values, POWER project, Southern-East coast region, Thailand

Introduction

Weather conditions were observed and monitored for many years because all organisms on the earth were under an influent by the weather. Weather-related natural disaster warnings and predictions were used for human operations planning and activities such as Transportation, Construction work, Agricultural activities, Flight operations, Industry, and Health (Spiridonov & Ćurić, 2021) Weather monitoring is the measurement of various

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characteristics of the weather using Weather Elements such as Air Pressure, Temperature, Humidity, Precipitation, Cloud, Wind Speed and Direction, Visibility, Sun duration, Sun radiation, Weather Variability, etc. (Ahrens, 2001). Weather elements must be measured carefully to get as much accurate information as possible to make reliability for research and utilization in the next step (Biavetti et al., 2014).

Most Weather Elements in Thailand are gathered from meteorological stations over Thailand, operated by the Thai Meteorological Department with only 122 meteorological stations which measure all data hourly, daily, monthly, and yearly from historical to the current period following all rules from the World Meteorological Organization: WMO. (Ahrens, 2001; Thai Meteorological Department, 2023) Moreover, The Prediction of Worldwide Energy Resource Project (POWER Project) also serves many important weather elements for 30 years past to the present in hourly, daily, monthly, and yearly periods. The data are accurate and accepted to use for many activities by many sectors and can be extracted at the latitude and longitude of any interested location. The weather data from POWER Project were ever used to determine the climate zone for sustainable building design in the United States of America, and the correlation of average, maximum, and minimum surface temperature from POWER Project data and observation data of 1,116 surface sites was about 0.94, reported by the coefficient of determination (R^2) (Chandler et al., 2013). Furthermore, Surface meteorology and Solar Energy from the POWER Project were also used in representing global surface solar insolation with R^2 between the POWER Project data and observation data at 0.92 (Zhang et al., 2007). For another thing was the estimation of the potential evaporation over 10 years from free water surface and ground surface and the possibility of reducing evaporation due to the installation of photovoltaic panels on water bodies in the Doosti Reservoir Dam which is located in Iran and Turkmenistan borders was extracted by POWER Project also and this could be useful in water resources management in the area (Asmani et al., 2021).

The Southern East Coast Region of Thailand has a large floodplain and coastal plain, that connects to the Gulf of Thailand which has so many populations living there. There were about 8,222,914 people living in this area with 77.90% and 12.47% for the Southern region and overall, of Thailand, respectively (The Bureau of Registration Administration, 2024). There were several attractive places for both Thai and foreigners to visit such as Koh Samui Island, Koh Tao Island, Hat Yai District, Rajjaprabha Dam, Mu Ko Ang Thong, Kiriwong Village, etc. (Tourism Authority of Thailand, n.d.), however; this region was affected by the southwest alternating with northeast monsoon throughout the year, leading to much humidity in the area then, flooding situations usually happened in the area especially in October to December from the effect of strong northeast monsoon such as the biggest flood over 37 years in Yala provinces and many provinces in the Southern East Coast Region in the end of November 2024 (BCC Thai, 2024). Furthermore, the area usually faces tropical storms from October to December such as Tropical Storm Pabuk which came to the Southern East Coast Region at the beginning of January 2019 leading to floods and strong wind effects that caused big damage there (BCC, 2019). Incidentally, Phumkokrux (2021) reported that the koppen climate classification in the area drifted from Tropical Monsoon (Am) to Tropical Savanna, dry winter (Aw) in many locations of the region (Phumkokrux, 2021). Therefore, monitoring of the weather characteristics and the changes must be checked frequently in the area.

However, the observation data were sometimes lost or could not be measured due to human error or equipment error, the data from POWER Project can be used instead with easy access. Furthermore, this research aims 1) to compare the observation data and POWER Project data to confirm the suitability of using as alternative data and 2) to study each element's characteristics and its trend in the Southern East Coast region of Thailand for hazard warning, energy production, agricultural planning and all activities preparation in the future (Chandler et al., 2013; NASA (a), 2023).

Study Area and Data

The Southern East Coast Region of Thailand was focused on covering latitude approximately 5° 36' N to 13° 20' N and longitude around 98° 26' E to 102° 05' E, connecting to the Gulf of Thailand at the east side along the coast with large floodplain and coastal plain, however; the west side connects to Nakhon Si Thammarat and Phuket Mountain ranges which separated the area from Southern-West Coast region. The area is about 73,300 km² covering 10 provinces with 15 meteorological stations as illustrated in Figure 1 and Tab. 1. (Morley et al., 2011).

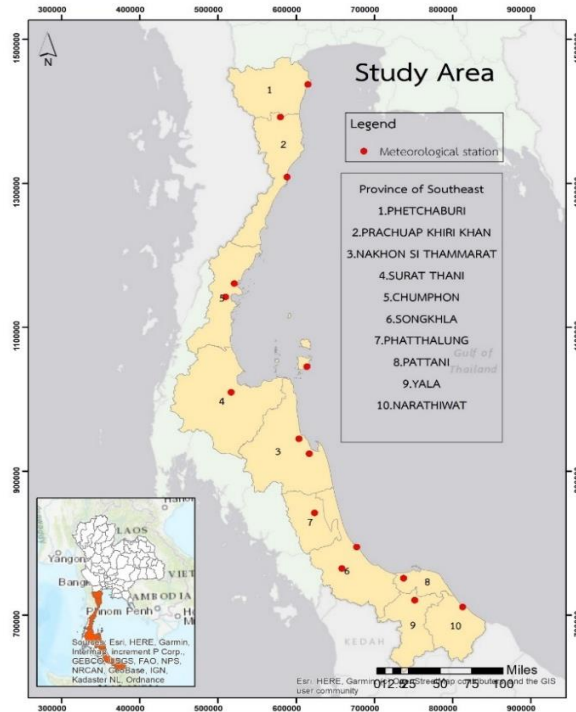


Fig. 1. The Southern East Coast Region of Thailand which is located in Southeast Asia, near Malaysia and Myanmar (Source: Developed from National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp., 2021)

Weather Element Values used in this research were Air Pressure (Press.), Maximum (TMax) and Minimum (TMin) Temperature, Relative Humidity (%RH), Precipitation (Pr.), Wind Speed (WS), and Wind Direction (WD). The observation data of these Weather Element Values were gathered from 15 stations from 2006 to 2022 (16 years)

by the Thai Meteorological Department. Moreover, these Weather Element Values of the same periods and locations were also prepared by The Prediction of Worldwide Energy Resource Project (POWER Project) which was operated by NASA (<https://power.larc.nasa.gov/data-access-viewer/>).

Table 1. Description of Meteorological Stations in the Southern East Coast Region of Thailand

No.	Station No.	Province	Latitude	Longitude	Altitude (msl)	Period	Year
1	48465	Phetchaburi	12.99944	100.0606	2	2006-2022	16
2	48474	Prachuap Khiri Khan	12.58897	99.73447	No data	2006-2022	16
3	48500	Prachuap Khiri Khan	11.83511	99.81036	4	2006-2022	16
4	48517	Chumphon	10.49875	99.18847	4	2006-2022	16
5	48520	Chumphon	10.33015	99.08827	No data	2006-2022	16
6	48550	Surat Thani	9.451265	100.0333	4	2006-2022	16
7	48551	Surat Thani	9.134278	99.15206	5	2006-2022	16
8	48552	Nakhon Si Thammarat	8.546306	99.93961	3	2006-2022	16
9	48554	Nakhon Si Thammarat	8.359306	100.0594	No data	2006-2022	16
10	48560	Phatthalung	7.613889	100.1178	No data	2006-2022	16
11	48568	Songkhla	7.184694	100.6046	5	2006-2022	16
12	48569	Songkhla	6.93985	100.3923	27	2006-2022	16
13	48580	Pattani	6.79000	101.1471	4	2006-2022	16
14	48581	Yala	6.515528	101.2736	No data	2006-2022	16
15	48583	Narathiwat	6.426889	101.8252	4	2006-2022	16

Source: Thai Meteorological Department (n.d.)

Methodology

Weather element values from the Observation data from 15 meteorological stations in the area and the POWER Project data of the same locations were gathered and then compared by Mean Absolute Error (MAE) as eq. (1) or it could be computed by the function from Agricultural and Meteorological Software (<https://agrimetsoft.com/calculators/Mean%20Absolute%20Error#>) (AgriMetSoft., 2019; Chicco et al., 2021; Bobbitt, 2021; Hodson, 2022).

$$MAE = \frac{1}{n} \times \sum_{i=1}^n |O_i - P_i| \quad (1)$$

where O_i is observation data and P_i is POWER Project data of each Weather Element. The MAE value reports the different values of both data. The lowest MAE value indicates that both of the data are consistent.

Moreover, the Mann-Kendall Trend Test Statistic is eq. (2)-(4) (Mann, 1948; Kendall, 1948; Frimpong et al., 2022) and Sen's slope as eq. (5) – (6) (Sen, 1968; Agbo and Ekpo, 2021; Saimi et al., 2020; Frimpong et al., 2022) of each weather element in the time series was examined by XLSTAT Premium of Student Version (Lumivero, 2023).

$$s = \sum_{i=1}^{n-1} \sum_{j=i+1}^n \text{sgn}(X_j - X_i) \quad (2)$$

$$\text{sgn}(x_j - x_i) = \begin{cases} +1, & \text{if } X_j - X_i > 0 \\ 0, & \text{if } X_j - X_i = 0 \\ -1, & \text{if } X_j - X_i < 0 \end{cases}$$

where: n is the total number of data points, x_i and x_j means data values in time series i and j ($j > i$), respectively. The variance was calculated in eq. (3).

$$\text{VAR}(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^m t_i(t_i-1)(2t_i+5)}{18} \quad (3)$$

Where: m is the number of tied groups and t_i means the number of ties to the extent i . A tied group is a set of sample data having the same value. If the sample size is more than 10 ($n > 10$), the standard normal test statistic (Z) would be calculated as eq. (4). The positive of Z indicates that the trend is increasing while the negative of Z means the trend is decreasing.

$$Z = \begin{cases} \frac{S-1}{\sqrt{\text{Var}(S)}}; & S > 0 \\ 0; & S = 0 \\ \frac{S+1}{\sqrt{\text{Var}(S)}}; & S < 0 \end{cases} \quad (4)$$

The non-parametric method named Sen's slope is used to estimate the slope of the trend as eq. (5)

$$Q_i = \frac{(X_j - X_k)}{j - k} \text{ for } i = 1, 2, 3, \dots, N \quad (5)$$

where X_j and X_k are the data values at times j and k ($j > k$), respectively. The values of Q_i would be ranked from the lowest to highest while the medium value of Q_i (Q_{med}) is calculated by the eq. (7). The positive and negative of Q_{med} denote an increasing and decreasing trend, respectively.

$$Q_{\text{med}} = \begin{cases} Q_{\lfloor \frac{N+1}{2} \rfloor}; & \text{if } N \text{ is odd} \\ \frac{Q_{\lfloor \frac{N}{2} \rfloor} + Q_{\lfloor \frac{N+2}{2} \rfloor}}{2}; & \text{if } N \text{ is even} \end{cases} \quad (6)$$

Spatial distribution maps of each weather element and each trend were drawn by Raster interpolation technique (Kriging), cooperated with Geographic Information System Software for understanding the spatial distribution of each element characteristic and its trend in the study area to be necessary data for city and activities planning in the next chapter.

Results and Discussion

The Weather Element Values such as Maximum (TMax) and Minimum (TMin) Temperature, Air Pressure (Press.), Relative Humidity (%RH), Rainfall (Pr.), Wind Speed (WS), and Wind Direction (WD) from 15 meteorological stations over the region and POWER Project were used to compared by Mean Absolute Error (MAE). Moreover, trends of each Weather Element from observation data were calculated by Mann Kendall and Sen's slope test.

Comparison of Maximum Temperature (TMax) and its trends

TMax of 2006-2022 was about 31.3 – 33.2 °C and 29.9 – 33.0 °C for observation and POWER project data respectively. Moreover, high TMax was found at the left side of the area then gradually fading at the right side as illustrated in Figure 2 (1st row with 1st and 2nd column). From the table 2 and Figure 2 (1st row with 3rd column), All TMax values from observation were greater than the POWER project with high MAE values found in low latitudes then decreasing in higher latitudes, approximately at ± 1.14 to ± 2.68 °C. TMax trends by Man Kendall and Sen's slope test by monitoring both data, indicated that the total area got increasing trends at about +0.01 to +0.03 °C/year with an average at +0.02 °C/year for both as illustrated in Figure 2 (1st row with 4th column) and Table 3 and Table 4. These changing rates were also similar to a work of Ren et al. (2023) at about 0.015 °C/year due to tropical monsoon led the area had the lowest rate of warming. (Phumkokrux, 2023; Ren et al., 2023).

Comparison of Minimum Temperature (TMin) and its trends

TMin of 2006-2022 were about 22.6-25.2 °C and 21.7-26.4 °C for observation and POWER project data respectively with the pattern same as TMax. All TMin values from observation were lower than the POWER project as in the Figure 2 (2nd row with 1st and 2nd column) with the highest MAE values found in the bottom area at ± 0.6 to ± 2.7 °C as in the table 2 and Figure 2 (2nd row with 3rd column). TMin trends illustrated that high increasing values appeared in the top of the area while these decreased to the bottom of the area with the rate at -0.02 to +0.04 °C/year with an average at +0.017 and +0.022 °C/year for observation and POWER project data, respectively as presented in Figure 2 (2nd row with 4th column) and Table 3 and Table 4 due to Tropical monsoon and humidity leading to low changing there (Phumkokrux, 2023; Ren et al., 2023).

Comparison of Rainfall (Pr.) and its trends

Pr. of 2006-2022 was about 1,014 to 2,913 mm and 1,191 to 2,478 mm for observation and POWER project data respectively. Pr. of observation values were higher than POWER data at the top of the area while observation values were lower than POWER data at the bottom of the area. The pattern of Pr. was bigger at the bottom area, especially in the Andaman Sea side then gradually dropped down to the Gulf of Thailand side due to an influence of the Southwest monsoon from May to October bringing more rain in the area almost every day especially in September and October for afternoon as in the Figure 2 (3rd row with 1st and 2nd column). These values were similar to the work of Üрге-Vorsatz et al. (2015) [6, 21, 23]. MAE and trend values were greater at the low latitude while these gradually dropped in higher latitude with the MAE at about ± 47.5 to ± 75.6 mm as in the table 2 and Figure 2 (3rd row with 3rd column) and the average increasing trend were similar pattern for both data, however; the rising values were big different at +8.7 and +29.2 mm/year for observation and POWER project data, respectively as presented in Figure 2 (3rd row with 4th column) and Table 3 and Table 4. The increasing rates were consistent with a work of Ren et al. (2023) but these rates were not insignificant levels. Due to the observation data were collected from each ground-based equipment point in each station, rainfall may fall more-or less-intensely at the location of the ground-based equipment making the difference from reality (NASA(b), 2023). However, the data from POWER Project were gathered from

satellite images and simulated from climate model (The Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2)), the rainfall values represented the rainfall in atmosphere not ground area. From both reasons, the data of rainfall from both sources might gave the different values (NASA(a), 2023).

*Table 2. Description of Mean Absolute Error Test (MAE)
from observation and POWER data in the Southern East Coast Region of Thailand*

Sta. No.	Press. (±mb)	Tmax (± °C)	Tmin (± °C)	RH (±%)	Pr. (± mm)	WS. (± knot)	WD.
48465	5.59	1.19	1.72	3.37	32.79	2.04	inconsistent
48474	4.11	1.46	1.23	2.64	47.90	5.29	inconsistent
48500	6.94	2.15	0.65	4.24	71.13	5.28	inconsistent
48517	2.54	1.22	1.41	3.02	59.09	5.28	inconsistent
48520	1.66	1.32	1.97	3.03	71.43	7.37	inconsistent
48550	1.59	1.45	1.40	3.29	54.02	5.53	consistent
48551	7.10	1.14	0.92	2.52	74.32	3.10	inconsistent
48552	12.04	1.92	0.54	2.48	67.32	4.35	inconsistent
48554	12.36	1.74	0.66	2.73	61.98	4.04	inconsistent
48560	9.09	1.25	1.38	3.17	101.95	2.54	inconsistent
48568	5.57	1.31	1.49	6.59	101.95	3.03	consistent
48569	2.54	1.97	0.70	4.67	49.50	2.73	inconsistent
48580	0.19	2.68	1.67	2.16	54.60	5.85	inconsistent
48581	11.13	2.38	1.78	7.21	73.85	0.81	inconsistent
48583	1.58	1.28	2.82	2.15	80.84	2.54	inconsistent

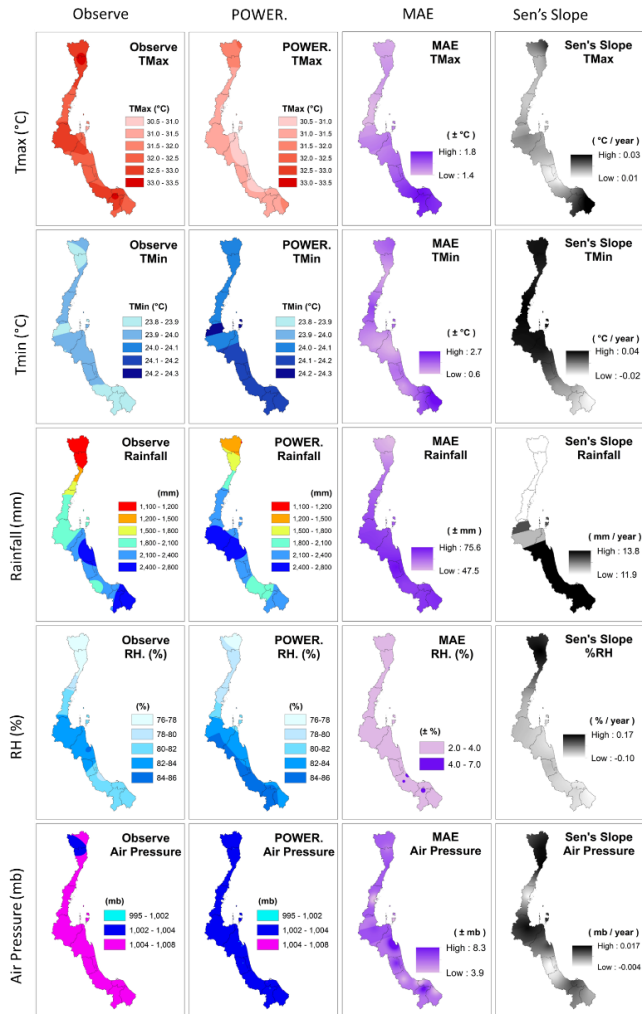


Fig. 2. Comparison of TMax, TMin, Pr., RH(%), and Air Pressure from observation data and POWER Project data, and its trends

Comparison of Relative Humidity (%RH) and its trends

The %RH values of the POWER project (75.9 – 88.5) were higher than the observation data (76.5 – 84.9) for all with the pattern that %RH was bigger at the low latitude, especially on the Andaman Sea side then fading to the Gulf of Thailand side due to an influence of Southwest monsoon in May to October bringing warm humid air to the area as in the Figure 2 (4th row with 1st and 2nd column) (Met Office, n.d.; Urge-Vorsatz et al, 2012; Üрге-Vorsatz et al, 2015). The most MAE values were about ± 2 to $\pm 4\%$ as in the table 2 and Figure 2 (4th row with 3rd column), these indicated that the data from both sources quite similar and could be used instead together. Moreover, there was an increasing %RH trend with the similar pattern for both data, appearing in high latitudes then gradually dropping in lower latitudes with the rate at -0.09 to $+0.35\%/year$ for observation data and -0.10 to $+0.17\%/year$ for POWER project data as illustrated in Figure 2 (4th row with 4th column) and Table 3 and Table 4. The reason of a change of %RH might be difficult to indicate due

to various weather parameters such as Temperature, Rainfall, Wind speed, etc., were quite complex in the relationship (Mawonike & Mandonga, 2017).

Comparison of Air Pressure (Press.) and its trends

All Press. values of observation data (1,005 – 1,008 mb) were higher than POWER Project data (1,002 – 1,004 mb) as in the Figure 2 (5th row with 1st and 2nd column). The pattern of MAE values could not define with the rate at ± 3.9 to ± 8.3 mb as in the table 2 and Figure 2 (5th row with 3rd column). Moreover, there were high Press. changing rates at the top, middle, and bottom alternating with low rates changing between -0.01 to 0.02 for both data as illustrated in Figure 2 (5th row with 4th column) and Table 3 and 4. A change of Air Pressure caused by heat intensity from the sun (National Oceanic and Atmospheric Administration, 2023), however; this would not change much in short terms.

Comparison of Wind Speed and Direction (WS and WD) and its trends

WS of POWER Project (2.3-8.6 knots) were higher than observation data (1.1 – 4.8 knots) for all as in the Figure 3 (1st row with 1st and 2nd column). MAE values were about ± 0.81 to ± 7.37 knots with the most values at about ± 3 to ± 4 knots as in the table 2 and Figure 3 (1st row with 3rd column). For WD, only 2 stations had the direction same together as illustrated in Figure 3 (1st row with 1st and 2nd column) thus in the author's opinion, WD data from the POWER Project might not be used in the Southern East Coast region of Thailand. However, WS and WD were not be checked of the trend changing. Due to unstable of air pressure from unstable heat which leads the WS and WD changing (National Oceanic and Atmospheric Administration, 2023), this reason might make unpredictable for WS and WD.

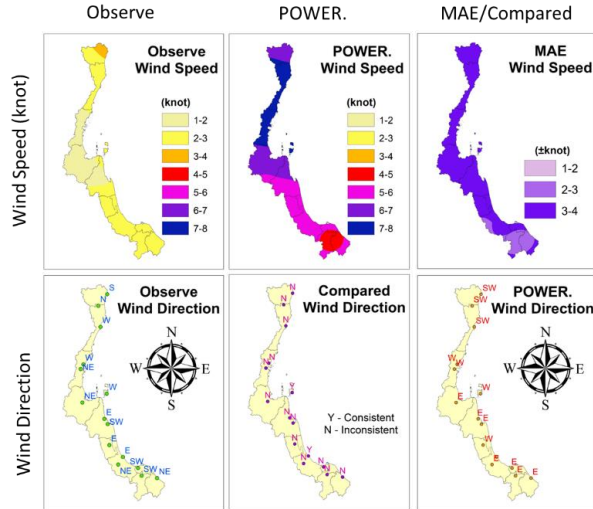


Fig. 3. Comparison of Wind Speed and Direction from observation data and POWER Project data, and its trends.

Overall summarization

The observation data were gathered from each ground-based equipment point from each station which the area was smaller than 1 grid cell of POWER project area (NASA (b), 2023) thus the observation data also could not represent the real data for other area that not have an equipment collection, however; The POWER project were gathered the weather data

from satellite images and simulated from MERRA-2, gave the data in a global $1/2^\circ \times 5/8^\circ$ latitude/longitude grid (approximately $55 \times 70 \text{ km}^2$) (NASA (a), 2023) thus each value was covered the large area. These might lead the data from POWER project being quite different from observation data. Therefore, the results from this work indicated that POWER Project data could be alternative sources for the area that did not have meteorological station or ground-based equipment collection. Moreover, everyone could access the weather data from POWER Project from everywhere and every time by improving the error value based on MAE values.

There were 7 parameters which were evaluated in the Southern East Coast Region of Thailand area for this study, however; only Maximum temperature, Minimum temperature, Rainfall, Relative Humidity, and Air pressure values from POWER Project could be used as alternative sources instead of observation data after improving the error value based on MAE values.

Conclusions

TMax, RH(%), and WS data from POWER Project were quite higher than observation data while TMin and Press. from observation data were higher than other. However, Pr. values from observation data were quite lower than other at the top area, were quite higher at the bottom area. The high MAE were also found in low latitude for TMax, TMin, Pr., and RH(%) while these found in high latitude for WS. However, the high MAE values were appeared alternating with low MAE values. If the POWER Project data would adapt by MAE values, these weather elements from POWER Project could be used instead of observation data in the author's opinion with MAE values evidences. However, WD from POWER Project might cannot use due to large of different data. The high increasing rate were found at the high latitude for TMin and RH(%) while these high increasing were appeared in low latitude for TMax and Pr. Moreover, TMin increased at a greater rate than the TMax same as a work of Ren et al. (2023). However, big increased changing of Press. were illustrated in top, middle, and bottom area alternating with low increasing rate.

Table 3. Description of Mann Kendall and Sen's Slope Test at Each Weather Element Value

Station	Tmax			Tmin			Pr.		
	Kendall's tau	p-value	Sen's slope	Kendall's tau	p-value	Sen's slope	Kendall's tau	p-value	Sen's slope
48465	0.273	0.138	0.068	0.191	0.303	0.040	0.015	0.967	1.717
48474	-0.074	0.711	-0.016	0.353	0.053	0.036	0.294	0.108	22.221
48500	0.162	0.387	0.021	0.222	0.231	0.010	0.162	0.387	10.283
48517	0.044	0.837	0.010	0.471	0.009**	0.032	0.191	0.303	14.264
48520	0.185	0.322	0.019	0.618	0.001**	0.050	0.176	0.343	13.754
48550	0.229	0.216	0.019	0.250	0.174	0.022	0.088	0.650	13.855
48551	0.303	0.099	0.037	0.338	0.064	0.030	0.118	0.537	8.987
48552	0.103	0.592	0.017	0.382	0.036*	0.067	0.044	0.837	8.513
48554	0.265	0.149	0.034	0.244	0.187	0.012	0.235	0.202	36.383
48560	0.015	0.967	0.002	0.435	0.017*	0.033	0.029	0.902	4.000
48568	-0.118	0.537	-0.023	0.412	0.023*	0.025	0.118	0.537	18.696
48569	0.347	0.058	0.037	-0.303	0.099	-0.038	-0.074	0.711	-9.437
48580	0.162	0.387	0.022	0.317	0.083	0.017	0.088	0.650	16.847
48581	0.125	0.509	0.019	0.126	0.509	0.007	0.029	0.902	12.838
48583	0.471	0.009**	0.062	-0.214	0.248	-0.067	0.147	0.434	26.336
Overall	0.162	0.387	0.021	0.338	0.064	0.017	0.132	0.484	8.663
Station	%RH			Press.			Note: *, ** refers to significant level at 95% and 99% respective		
	Kendall's tau	p-value	Sen's slope	Kendall's tau	p-value	Sen's slope			
48465	0.258	0.161	0.083	0.206	0.266	0.017			
48474	-0.089	0.650	-0.045	0.103	0.592	0.018			
48500	0.421	0.021*	0.148	0.147	0.434	0.021			
48517	0.567	0.002**	0.130	-0.132	0.484	-0.012			
48520	0.305	0.099	0.083	0.044	0.837	0.005			
48550	0.444	0.015*	0.131	0.074	0.711	0.015			
48551	0.141	0.457	0.031	0.074	0.711	0.020			
48552	0.448	0.015*	0.145	0.044	0.837	0.004			
48554	0.528	0.004**	0.167	0.074	0.711	0.020			
48560	0.271	0.147	0.139	-0.029	0.902	-0.009			
48568	0.119	0.536	0.042	-0.015	0.967	-0.002			
48569	0.509	0.005**	0.350	-0.015	0.967	-0.002			
48580	0.022	0.934	0.015	0.088	0.650	0.017			
48581	-0.067	0.741	-0.019	0.074	0.711	0.010			
8583	-0.148	0.433	-0.089	0.000	1.000	0.000			
Overall	0.376	0.039*	0.064	0.029	0.902	0.006			

Table 4. Description of Mann Kendall and Sen's Slope Test at Each Weather Element Value from POWER Data

Station	Tmax			Tmin			Pr.		
	Kendall's tau	p-value	Sen's slope	Kendall's tau	p-value	Sen's slope	Kendall's tau	p-value	Sen's slope
48465	-0.103	0.592	-0.031	0.074	0.711	0.006	0.426	0.019*	32.505
48474	-0.235	0.202	-0.067	0.096	0.621	0.012	0.412	0.023*	50.231
48500	-0.191	0.303	-0.031	0.279	0.127	0.017	0.397	0.029*	55.898
48517	0.206	0.266	0.030	0.500	0.006**	0.035	0.324	0.077	22.412
48520	0.206	0.266	0.030	0.500	0.006**	0.035	0.324	0.077	22.412
48550	0.382	0.036*	0.031	0.529	0.003**	0.026	0.250	0.174	39.063
48551	0.324	0.077	0.052	0.412	0.023*	0.030	0.382	0.036*	47.656
48552	0.353	0.053	0.053	0.529	0.003**	0.035	0.235	0.202	32.266
48554	0.353	0.053	0.053	0.529	0.003**	0.035	0.235	0.202	32.266
48560	0.221	0.232	0.047	0.426	0.019*	0.023	0.250	0.174	34.979
48568	0.368	0.044*	0.046	0.324	0.077	0.016	0.206	0.266	25.979
48569	0.368	0.044*	0.046	0.324	0.077	0.016	0.206	0.266	25.979
48580	0.382	0.036*	0.043	0.412	0.023*	0.021	-0.162	0.387	-21.444
48581	0.338	0.064	0.049	0.235	0.202	0.014	0.206	0.266	14.987
48583	0.324	0.077	0.050	0.250	0.174	0.014	0.279	0.127	29.335
Overall	0.191	0.303	0.029	0.397	0.029*	0.022	0.279	0.127	29.184
Station	%RH			Press.			Note: * , ** refers to significant level at 95% and 99% respectively		
	Kendall's tau	p-value	Sen's slope	Kendall's tau	p-value	Sen's slope			
48465	0.103	0.592	0.111	0.170	0.364	0.017			
48474	0.353	0.053	0.173	0.191	0.303	0.017			
48500	0.250	0.174	0.114	0.206	0.266	0.016			
48517	-0.147	0.434	-0.026	0.118	0.537	0.017			
48520	-0.147	0.434	-0.026	0.118	0.537	0.017			
48550	-0.294	0.108	-0.065	0.118	0.537	0.017			
48551	-0.088	0.650	-0.039	0.118	0.537	0.018			
48552	-0.279	0.127	-0.072	0.118	0.537	0.022			
48554	-0.279	0.127	-0.072	0.118	0.537	0.022			
48560	-0.074	0.711	-0.032	0.176	0.343	0.023			
48568	-0.294	0.108	-0.062	0.176	0.343	0.024			
48569	-0.294	0.108	-0.062	0.176	0.343	0.024			
48580	-0.426	0.019*	-0.083	0.185	0.322	0.025			
48581	-0.088	0.650	-0.058	0.185	0.322	0.024			
48583	-0.309	0.091	-0.102	0.191	0.303	0.025			
Overall	0.029	0.902	0.008	0.147	0.434	0.020			

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