KEMENTERIAN SUMBER ASLI DAN
KELESTARIAN ALAM
Ministry of Natural Resources and Environmental
Sustainability

MALAYSIAN METEOROLOGICAL DEPARTMENT MINISTRY OF NATURAL RESOURCES AND ENVIRONMENTAL SUSTAINABILITY

Research Publication No. 3/2024

Changes of Diurnal Rainfall Distribution Over West Coast Peninsular Malaysia during Tropical Cyclone (TC) and non-Tropical Cyclone (TC) days

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Perpustakaan Negara Malaysia Data Pengkatalogan-dalam-Penerbitan

Cataloguing-in-Publication Data

Perpustakaan Negara Malaysia

A catalogue record for this book is available from the National Library of Malaysia

ISBN 978-967-2327-21-9

Published and printed by:
Jabatan Meteorologi Malaysia
Jalan Sultan
46667 Petaling Jaya
Selangor Darul Ehsan
Malaysia

Contents

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Abstract

Tropical Cyclones (TCs) are significant weather events that rarely make landfall directly in Malaysia, but they influence local atmospheric circulation, resulting in heavy rainfall, storm surges, and strong winds. Rainfall and TC data for 31 years are used to examine the impact of TCs on the diurnal rainfall patterns and intensity in the west coast of Peninsular Malaysia. The results indicate that TCs significantly increase rainfall intensity and probability of occurrence along the west coast of Peninsular Malaysia, particularly during 00 UTC when the TCs are located off the Vietnam coast. In contrast, while there is a higher chance of rainfall occurring at 06 UTC, the rainfall intensity is relatively lower. The lag rainfall at 00 UTC and 12 UTC shows increased rainfall intensity, particularly when TCs are in the WNP and SCS regions. The observed trends should be closely monitored to mitigate potential flooding issues along the west coast of Peninsular Malaysia.

1.0 Introduction

The most intense weather systems worldwide are tropical cyclones (TCs). They are also known as typhoons or hurricanes depending on the ocean basin where they are spawned. Tropical cyclones are one of the biggest threats to life and property even in the formative stages of their development. Countries exposed to tropical cyclones have to deal with severe floods, storm surges and extreme high winds. The most active areas for TCs in the world are at the Western North Pacific (WNP) and South China Sea (SCS) with approximately 30 TCs generated annually, of which approximately 10 TCs are active in the SCS (Chan 2005; Matsuura et al., 2003 and Goh et al., 2010). The TCs developed in the WNP and SCS are parts of the tropical system and main weather system causing significant rainfall along the coast of South China in the pre-and post-flood periods. Tropical cyclones (TCs) are observed to form routinely throughout the year in two basins, the Western North Pacific and the South China Sea. These periods are often referred to as the basin's tropical cyclone seasons.

The density plot of tropical cyclones (TC) occurring from 1991 to 2021 (31 years) shows that the Western North Pacific (WNP) is the most active basin in the world in terms of tropical cyclone activity (**Figure 1**). The most frequent tropical cyclone (TC) with a significant colour contour is proven to occur in the western North Pacific region. The Japan Meteorological Agency (JMA) has been monitoring the TC activities and maintained related records since 1951. According to the climatology of the tropical cyclone (TCs), the annual normal for the numbers of TCs generated in the western North Pacific is 25.1. **Figure 2 to 5** show the density plot of the TC locations at 00, 06, 12 and 18 UTC respectively. TCs are more frequently found in the WNP and SCS region at 00 UTC. For the rest of the time, the TCs are more or less evenly distributed in the basin (**Figure 3 to Figure 5**).

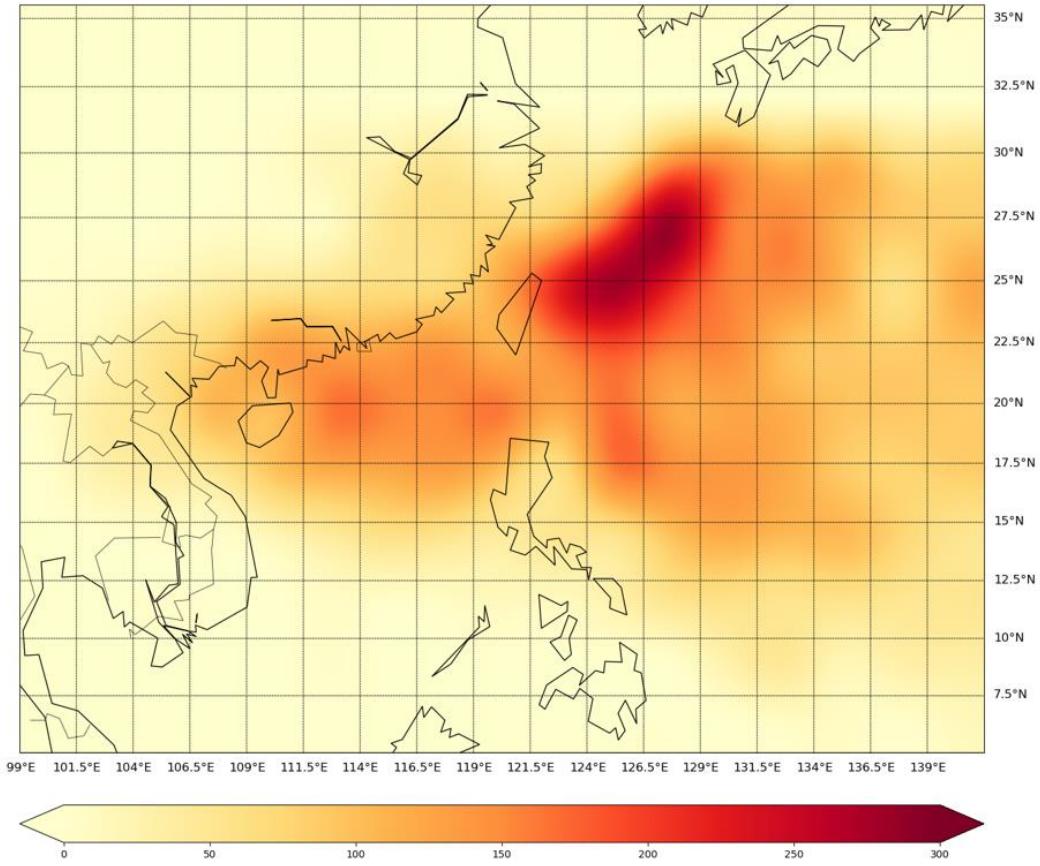

Figure 1: Density plot of TC, 1991 – 2021

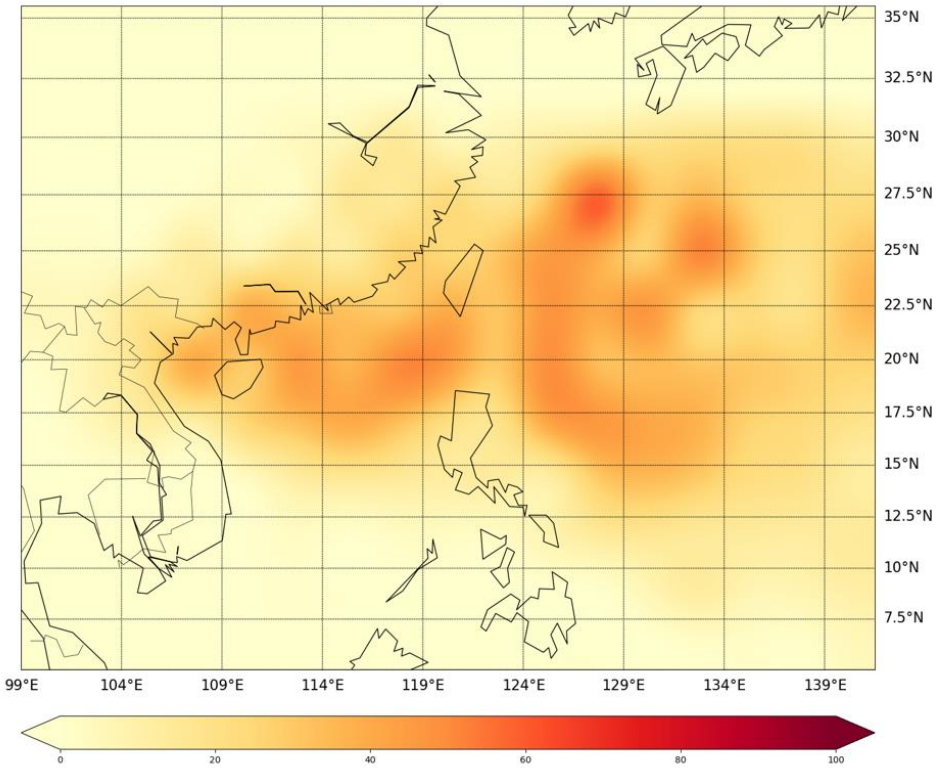

Figure 2: Density plot of TC, 1991 – 2021 (00 UTC)

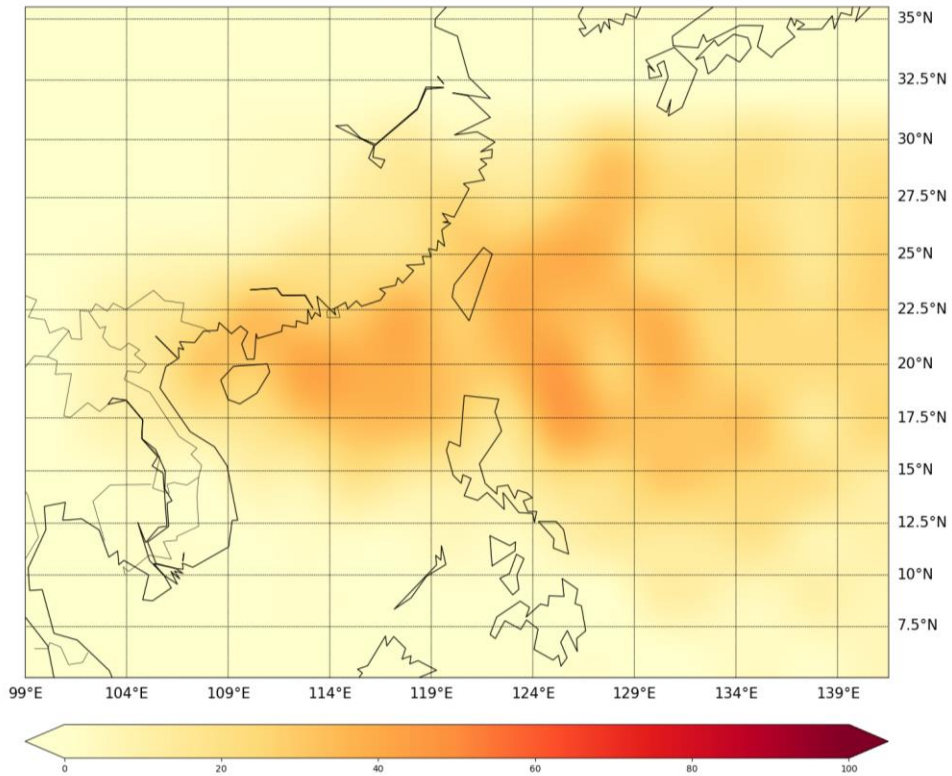

Figure 3: Density plot of TC, 1991 – 2021 (06 UTC)

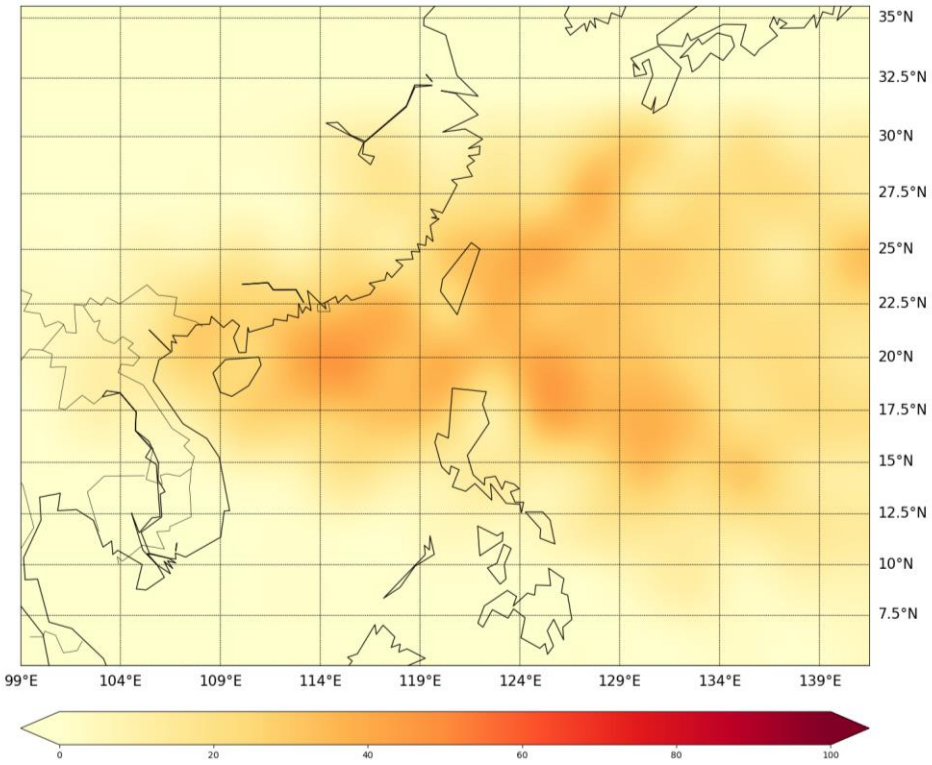

Figure 4: Density plot of TC, 1991 – 2021 (12 UTC)

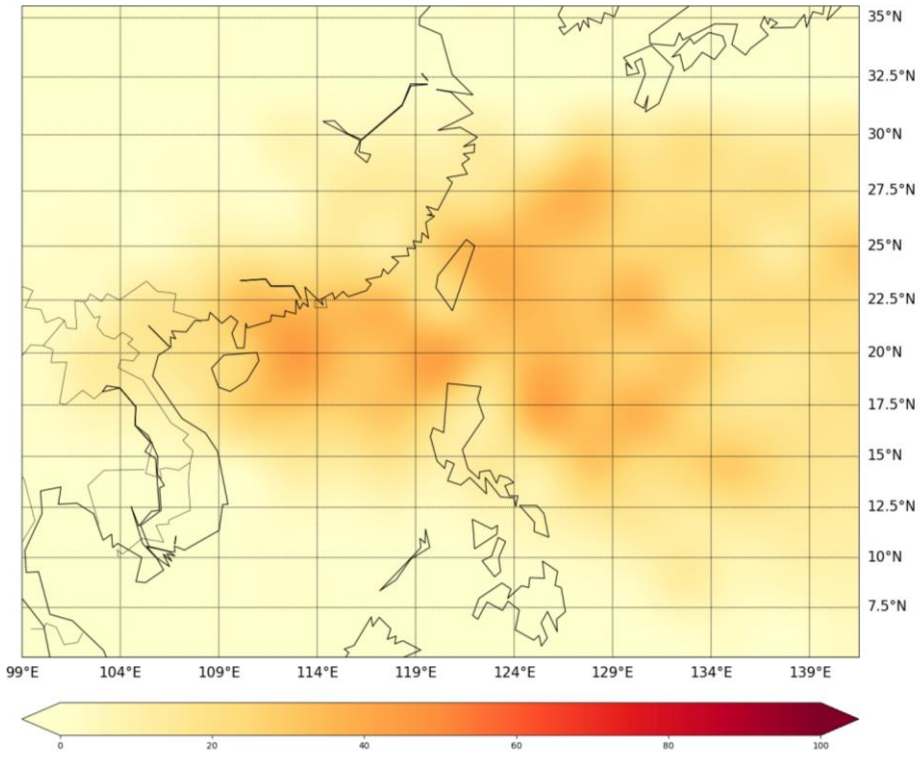

Figure 5: Density plot of TC, 1991 – 2021 (18 UTC)

Malaysia is located close to the equator in Southeast Asia, situated between 1°N and 7°N and 100°E and 119°E. TCs are rarely found in the equatorial belt within 10°N and 10°S due to the weak Coriolis force in this region and hence, are unable to sustain the development of TCs. Even though the direct threat of TCs is practically nonexistent in the Malaysian region, a powerful typhoon can significantly impact the atmospheric circulation and weather of the nearby areas (Lim, 1981).

Munirah and Subramaniam (2009) observed the impact of the TCs based on their location and intensity on the rainfall in the East Malaysia (Sabah and Sarawak) and northwest Peninsular Malaysia. Using the 57 years of annual TC records, they found Sabah has a higher chance of rain when the TCs are located in the open sea than when the TCs make landfall. In Sarawak, the likelihood of rain is high when TCs are located in the central SCS, but it reduces to about 50% when the TCs make landfall. In northwestern Peninsular Malaysia, the chance of rain is high when TCs are off the coast of Vietnam or making landfall.

The climate of the tropics is fundamentally characterized by the diurnal cycle of rainfall and convective activity (Wallace, 1975; Murakami, 1983; Nitta and Sekine, 1994; Yang and Slingo, 2001; Nesbitt and Zisper, 2003). The climatology of the diurnal rainfall cycle and its relationship with the monsoon in Peninsular Malaysia has been studied by Lim (1979), Nieuwolt (1968), Oki and Musiake (1994) and Ramage (1964).

Although Malaysia is not directly in the path of the world's most active cyclone region, a powerful tropical cyclone, such as a typhoon, can significantly impacts the atmospheric circulation and change the weather pattern in the region. As the rainfall in Malaysia is largely dominated by the diurnal regime, we intend to study the impact of TCs on the diurnal rainfall distribution in particular the west coast of Peninsular Malaysia. The main objectives of this study are to analyse the changes in the rainfall occurrences and their intensity on the TC days.

2.0 Data and Methodology

Rainfall data and the best track tropical cyclone data from May to September 1991 – 2021 are used in this study. The best track data are obtained from the Regional Specialized Meteorological Centre (RSMC) – Tokyo. They contain six-hourly tropical cyclone information including the latitude and longitude of the storms and the intensity of TC. All the best track data are processed using a Python program. In this study, storms with intensity greater than tropical depression (33 knots) are considered and they are grouped in boxes of 2.5°x 2.5° bounded by 5°N and 30°N and 100°E and 140°E (**Figure 6**). Each box contains the number of TCs calculated on the specified latitudes and longitudes. Boxes with fewer than seven (7) TCs are considered insignificant.

Hourly rainfall data from nineteen (19) main meteorological stations operated by the Malaysian Meteorological Department are obtained for this study. The stations are located on the west coast of Peninsular Malaysia (**Figure 7**). To match the time with the best track data, hourly rainfall data are first converted to UTC and then resampled to obtain 6 hourly accumulated rainfalls. Finally, the data are summed for all 19 stations to represent rainfall on the west coast Peninsular Malaysia. In this study, rainy day is defined as a day with rainfall of 1 mm and above. The impact of the TCs in Peninsular Malaysia are measured based on the probability changes in the occurrence of diurnal rainfall. The significant p-value was calculated using the chi square method. The analysis is computed for each box when the total numbers of TCs exceeds seven.

Analyzing the probability of rainfall during TCs is crucial for showing the impact of TCs on rainfall in Malaysia and contributing to better preparedness of significant weather. In the study of rainfall patterns, it has been observed that the diurnal rainfall cycle is dominant over Peninsular Malaysia (PM). Two calculations were conducted to determine the probability of rainfall during TC and the seasonal probability of rainfall.

The seasonal probability of rainfall and the probability rainfall during TC is calculated as follows.

a) Seasonal probability rainfall (PR) for 31 years

$$\frac{Total\ rainfall\ day\ (mm)\ x\ 100\%}{Total\ seasonal\ day\ (4743)}$$

b) Probability rainfall during TC

$$\frac{Total\ number\ of\ rain\ day\ on\ TC\ day x\ 100\%}{Total\ TC\ day}$$

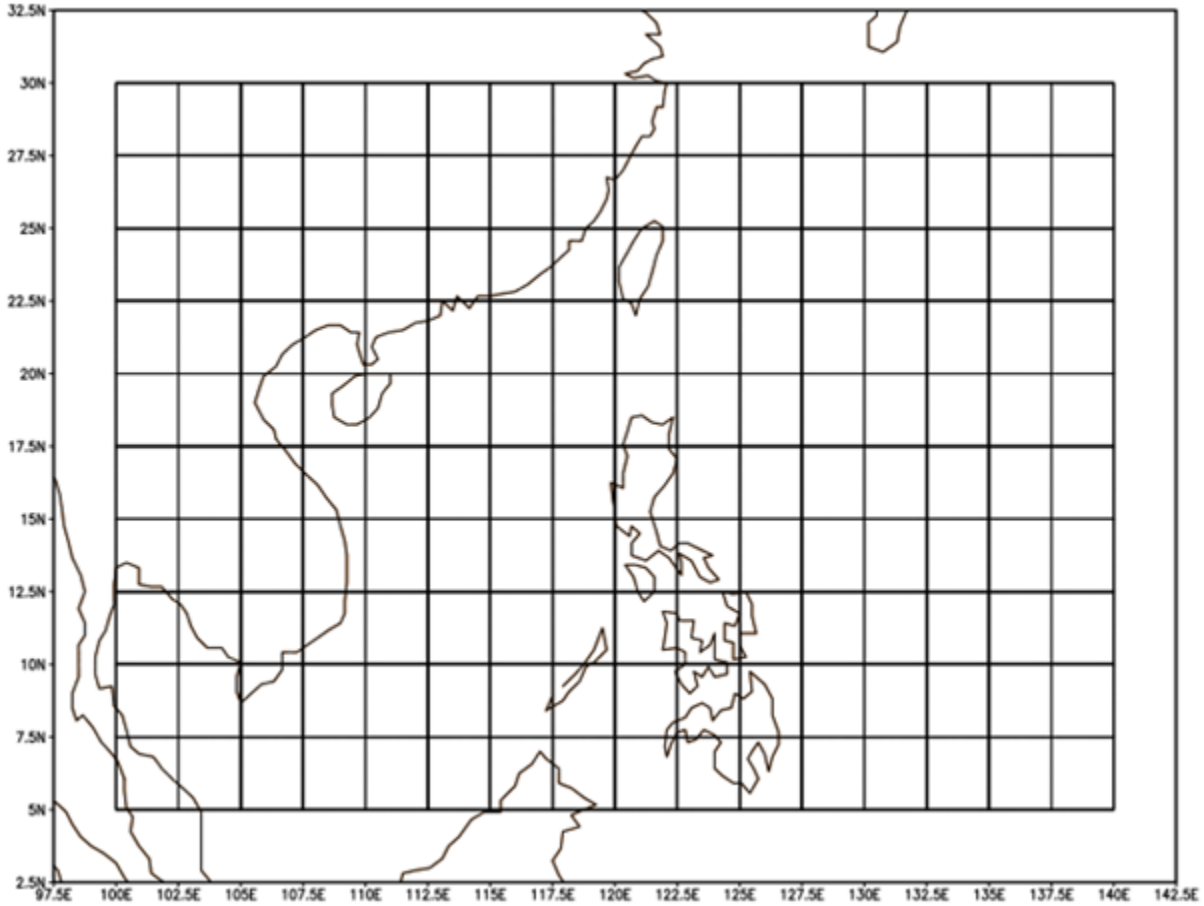

Figure 6: The 2.5° X 2.5° grid boxes of the TC formation region within 5°N - 40°N and 100°E - 140°E

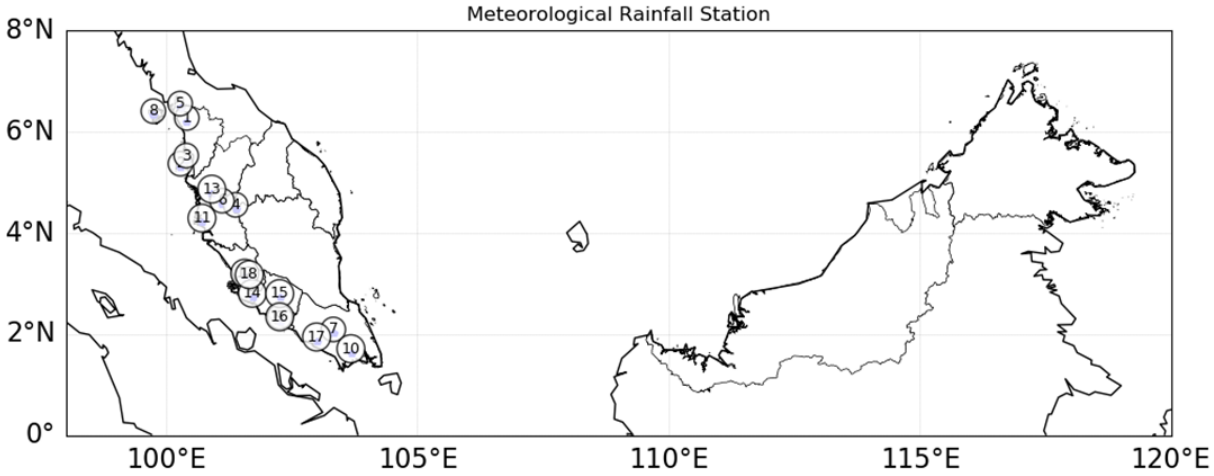

Figure 7: Location of the rainfall stations used in this study.

3.0 Results and Discussion

3.1 Probability Rainfall during TC

During the MJJAS season, climatologically, our analysis shows that there are 80% chances of rainfall occurring during the local afternoon (14 - 19 LT) or at 06 UTC. This result is expected as the local sea breeze regime strengthens in the afternoon and the local heating can contribute to the local convective activities. This is followed by a 66% probability at 00 UTC (08 - 13 LT), a 62% probability at 18 UTC (02 - 07 LT), and a 56% probability at 12 UTC (20 - 01 LT). In short, the results indicate the highest rainfall probability aligns with the late afternoon, a time of peak convective activity, while the lowest probability occurs in the evening to early nighttime when the atmosphere is typically more stable.

Figure 8 shows that when the TCs are located in the East China Sea, Vietnam and the Philippines Sea region at 00 UTC, the probability of rainfall occurring on the west coast of Peninsular Malaysia exceeded 70%. In contrast, when TCs are located in the Philippines region and part of the SCS, the probability of rainfall during TC reduced to less than 70%. This is in agreement with the findings of Munirah and Subramaniam

(2009), who demonstrated that Northwestern Peninsular Malaysia has a greater than 80% chance of rain when TCs are off the Vietnam coast. However, when the TCs are located farther east over, the central South China Sea, the chance of rain decreases to 50%.

When TCs are located in the Western North Pacific and the South China Sea at 06 UTC, the probability of rainfall on the west coast of Peninsular Malaysia exceeds 70%, as illustrated in **Figure 9**. Meanwhile, the majority of the boxes indicate the probability of rainfall at 12 UTC (20 - 01 LT) is less than 70% over the west coast of Peninsular Malaysia (**Figure 10**). Similarly, **Figure 11** also indicates that the probability of rainfall during TC is less than 70% when the TCs are located in most of the WNP and SCS except when the TCs are located in Taiwan, eastern China and the coast of Indochina.

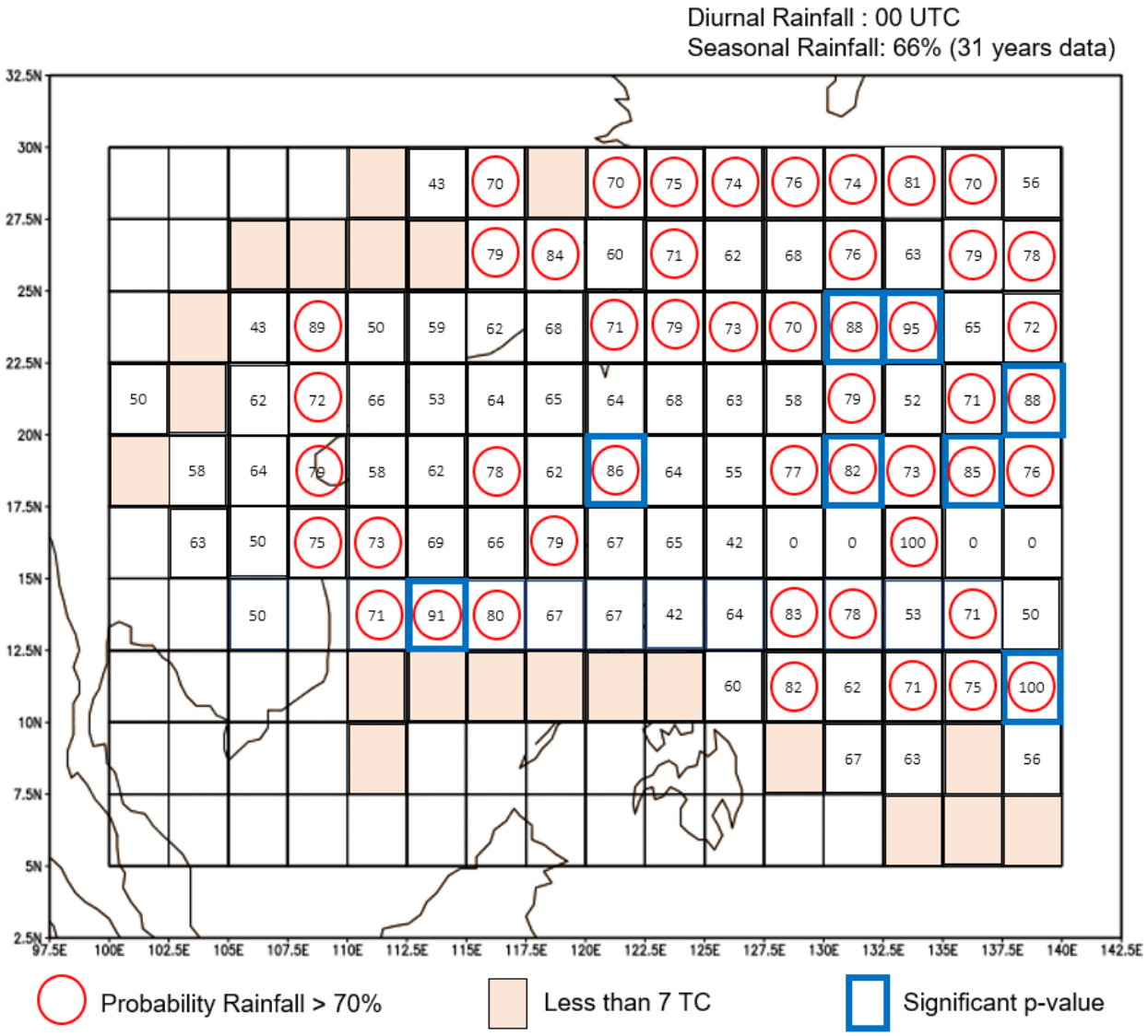

Figure 8: Probability of rainfall occurring during the tropical cyclones (TCs) at 00 UTC

Notes: Boxes with a red circle represent a probability of rainfall during TCs greater than 70%. The blue-bordered boxes indicate that these boxes have a significant p-value, corresponding to the 90th percentile for the probability of rainfall.

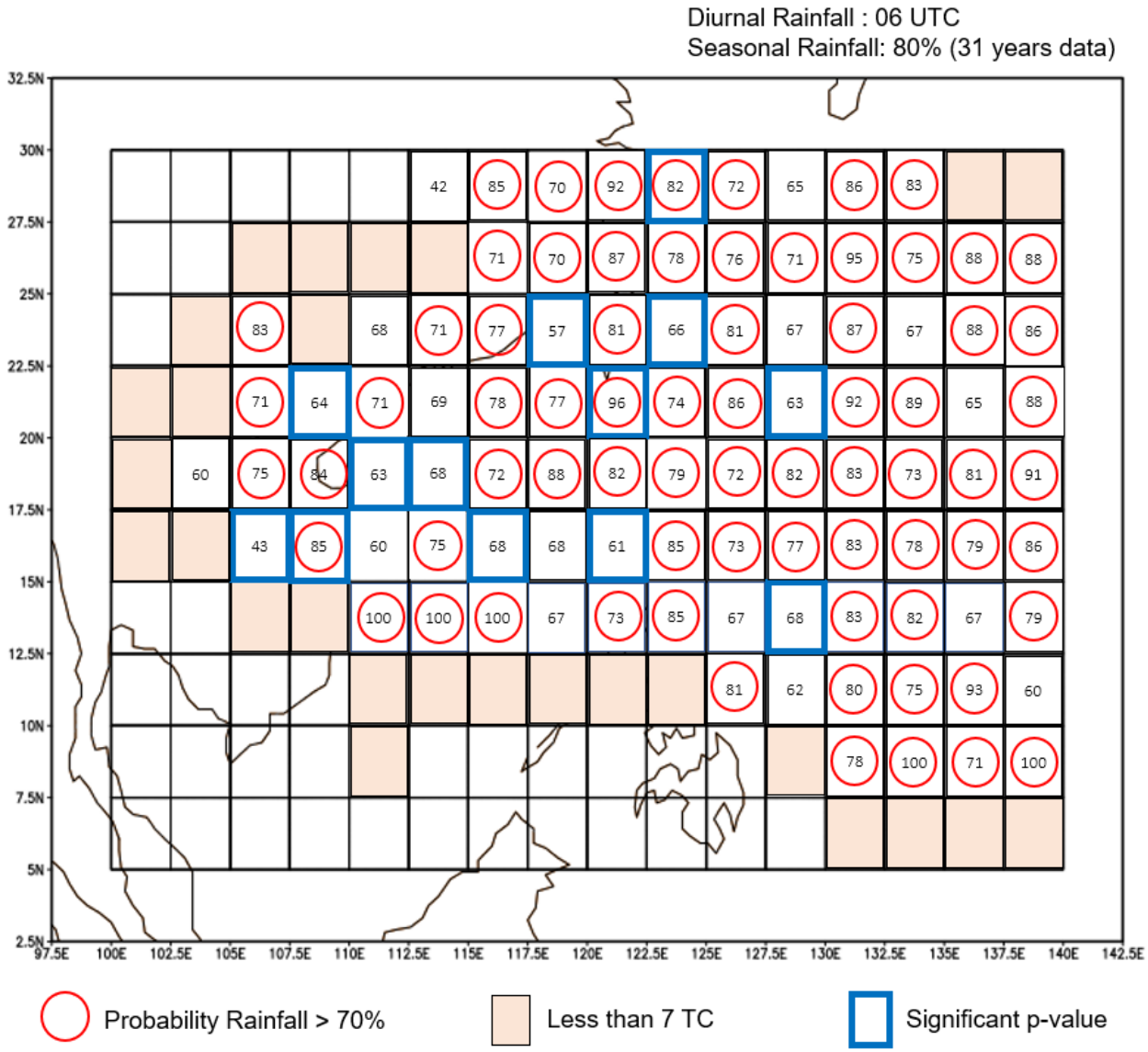

Figure 9: Probability of rainfall occurring during the tropical cyclones (TCs) at 06 UTC

Notes: Boxes with a red circle represent a probability of rainfall during TCs greater than 70%. The blue-bordered boxes indicate that these boxes have a significant p-value, corresponding to the 90th percentile for the probability of rainfall.

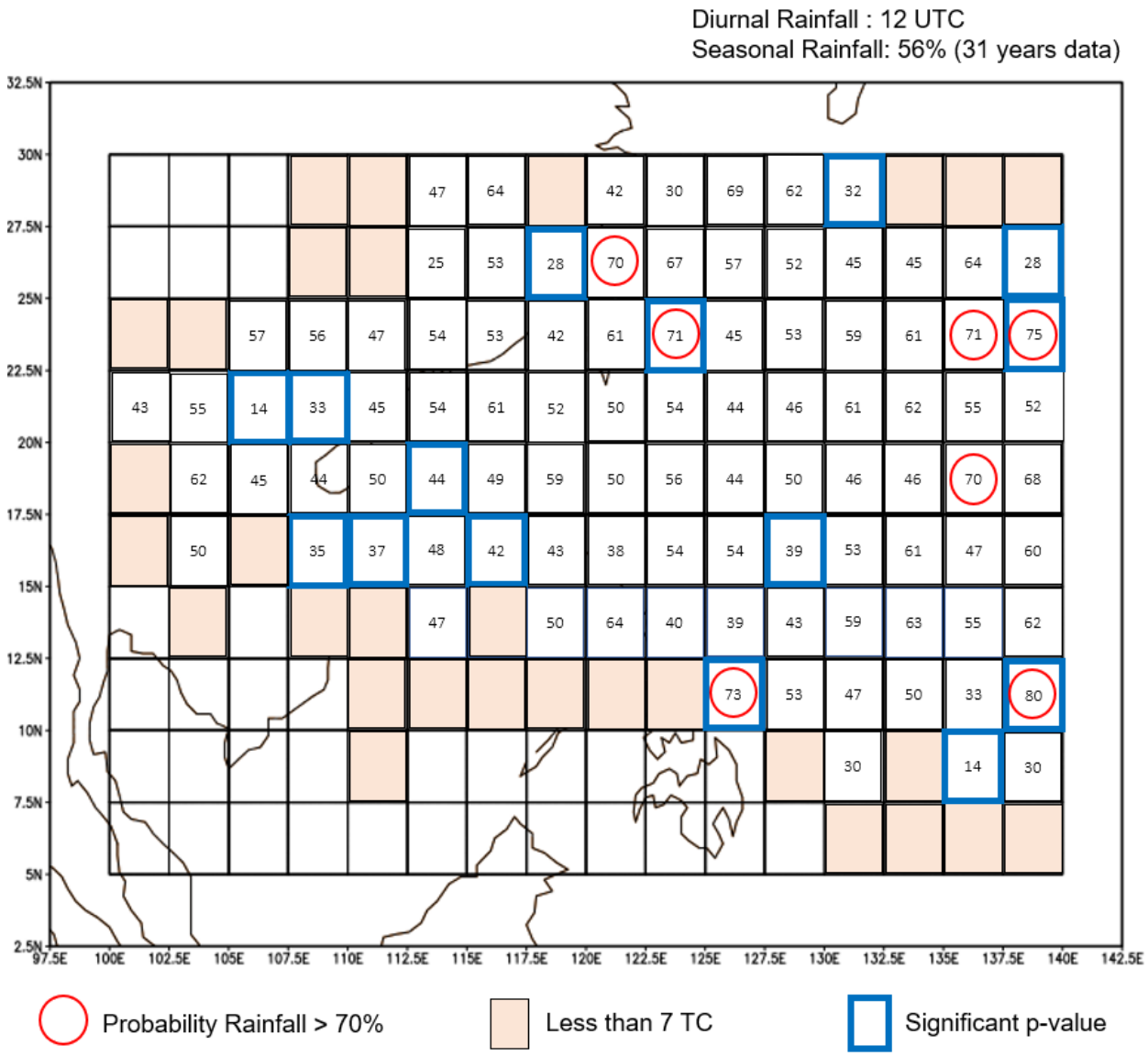

Figure 10: Probability of rainfall occurring during the tropical cyclones (TCs) at 12 UTC

Notes: Boxes with a red circle represent a probability of rainfall during TCs greater than 70%. The blue-bordered boxes indicate that these boxes have a significant p-value, corresponding to the 90th percentile for the probability of rainfall.

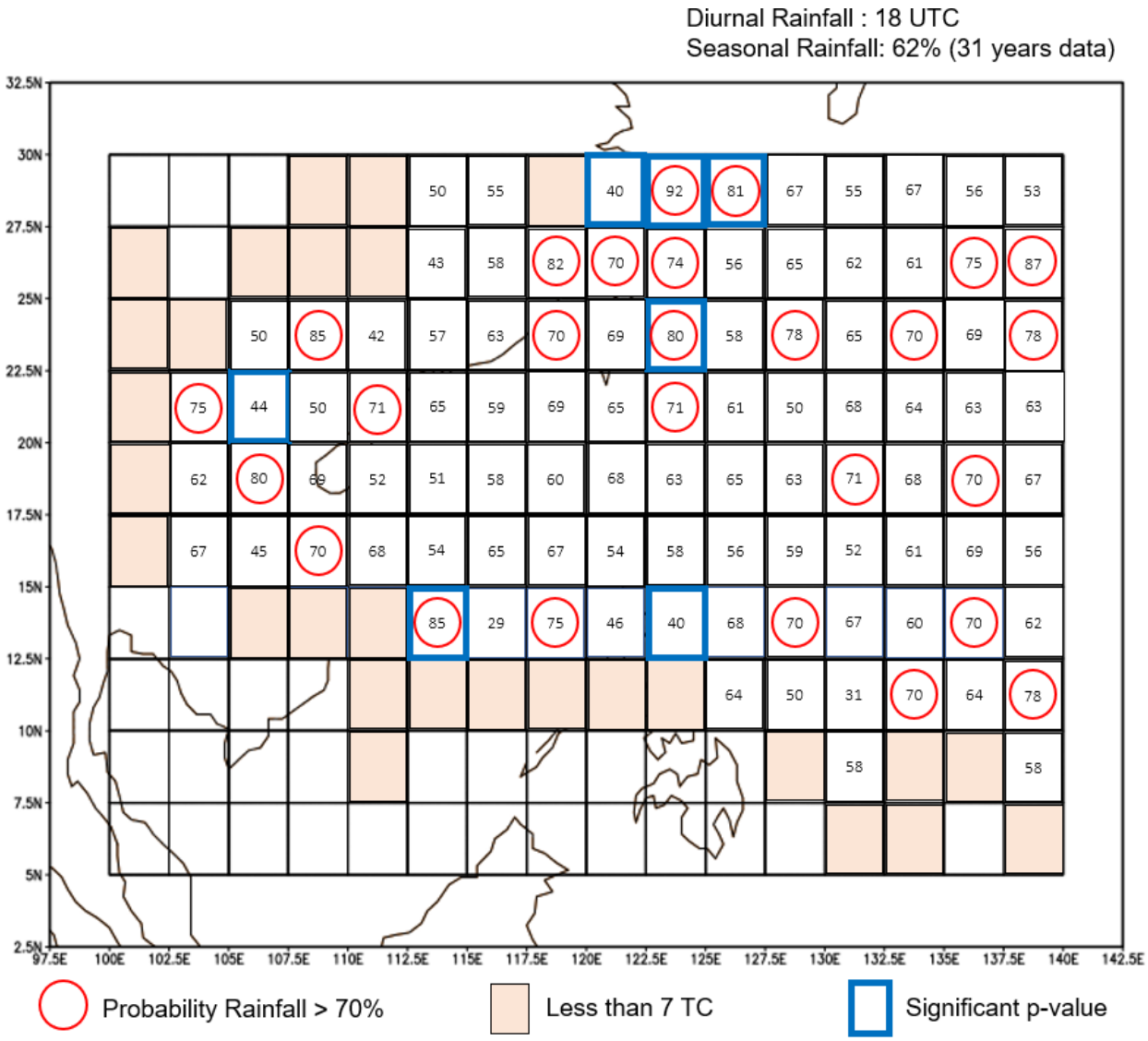

Figure 11: Probability of rainfall occurring during the tropical cyclones (TCs) at 18 UTC

Notes: Boxes with a red circle represent a probability of rainfall during TCs greater than 70%. The blue-bordered boxes indicate that these boxes have a significant p-value, corresponding to the 90th percentile for the probability of rainfall.

3.2 Changes in the Rain Day Probability (CRDP) during TC

To examine the changes in the rain day probability, the calculation is given below:

Changes of Rain Day Probability = Probability rainfall during TC - Seasonal rainfall

The CRDP shows two results with negative (-) values indicated by red circles and positive (+) values indicated by blue boxes. The changes in the probability of rainy days are most noticeable during 00 UTC as shown in **Figure 12**. At 00 UTC, the west coast of Peninsular Malaysia has a higher probability of rain occurring, particularly when the TCs are located off the coast of Vietnam and in central SCS. The chances of rain occurring are reduced when the TCs make landfall further inland.

Similar results are also observed in the 06 UTC as shown in **Figure 13**. However, further analysis shows that during this time, the chances of rain occurring on the west coast of Peninsular Malaysia are also reduced even if TCs are located off the coast of Vietnam. A negative change in rain day probability at 12 UTC is observed overall in the SCS and WNP regions, as illustrated in **Figure 14**. A significant reduction in occurrences of rain is observed over the west coast of Peninsular Malaysia when tropical cyclones are located in the South China Sea and Western North Pacific regions.

In contrast, the probability changes mostly show positive values when tropical cyclones are located in the South China Sea and Western North Pacific, except in the central South China Sea, off the Vietnam coast, and the northern Philippines region. This indicates an increase in the probability of rain occurring over the west coast of Peninsular Malaysia (**Figure 15**) during this time.

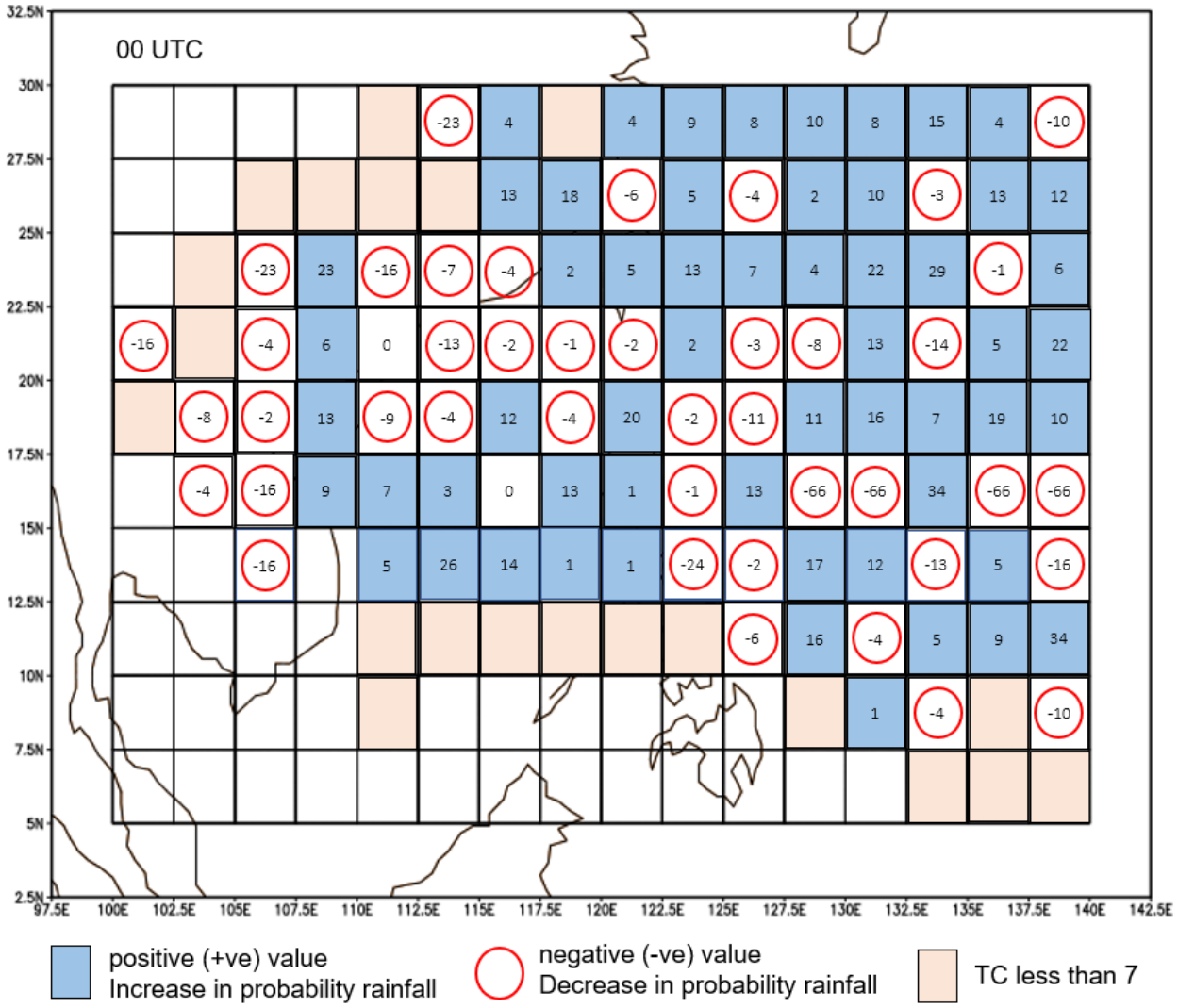

Figure 12: Changes in the probability of rain occurring during the tropical cyclones (TCs) at 00 UTC

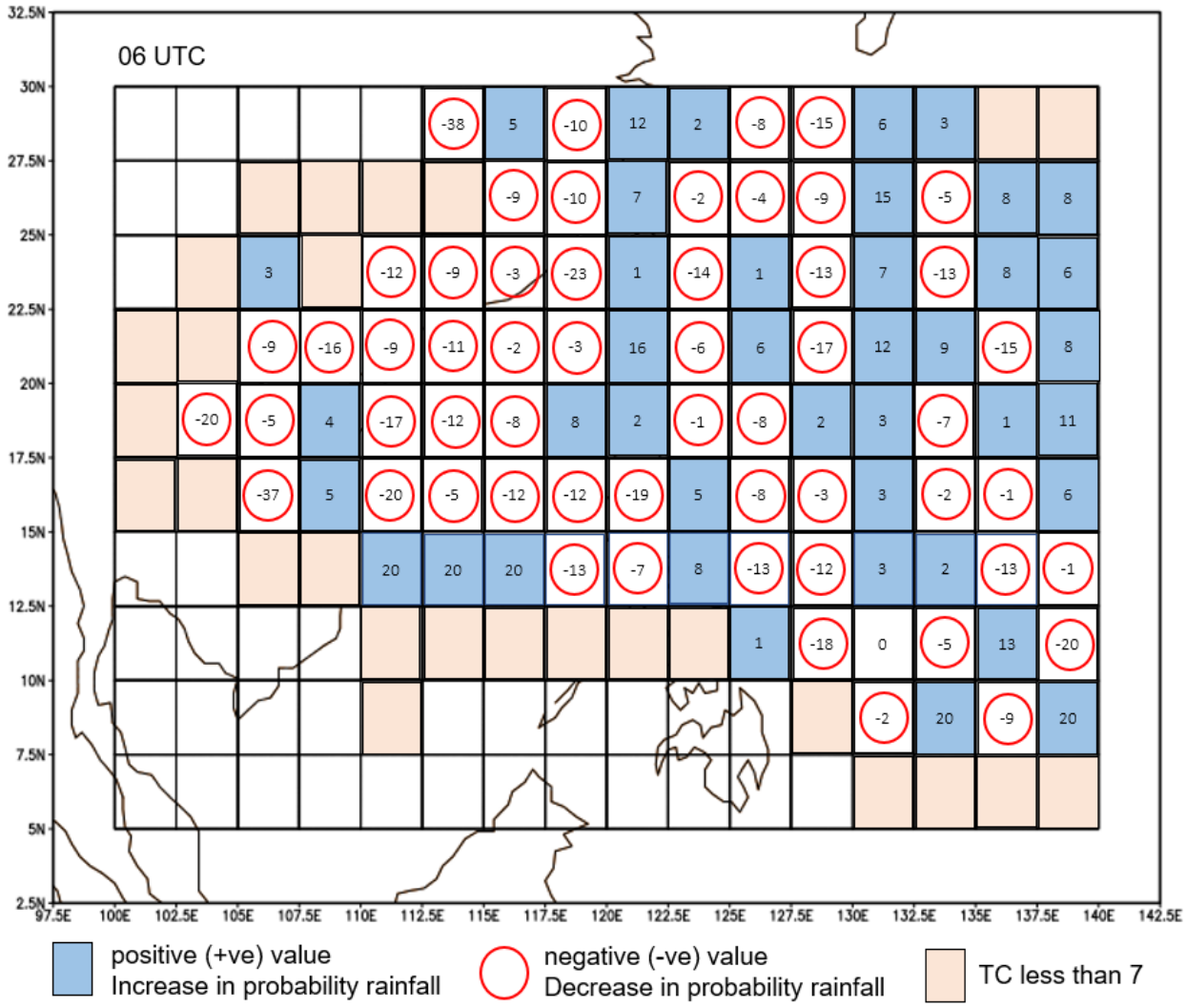

Figure 13: Changes in the probability of rain occurring during the tropical cyclones (TCs) at 06 UTC

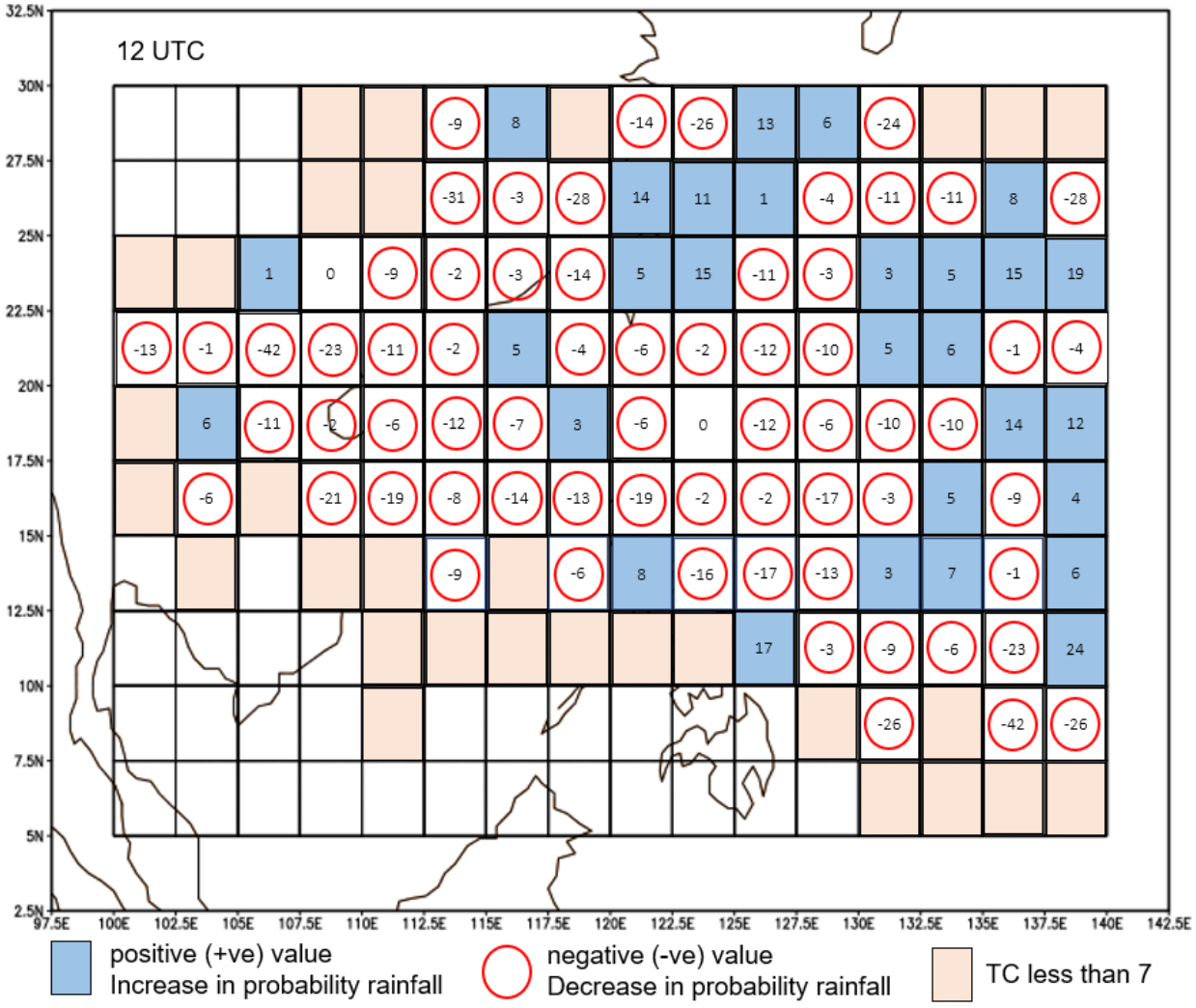

Figure 14: Changes in the probability of rain occurring during the tropical cyclones (TCs) at 12 UTC

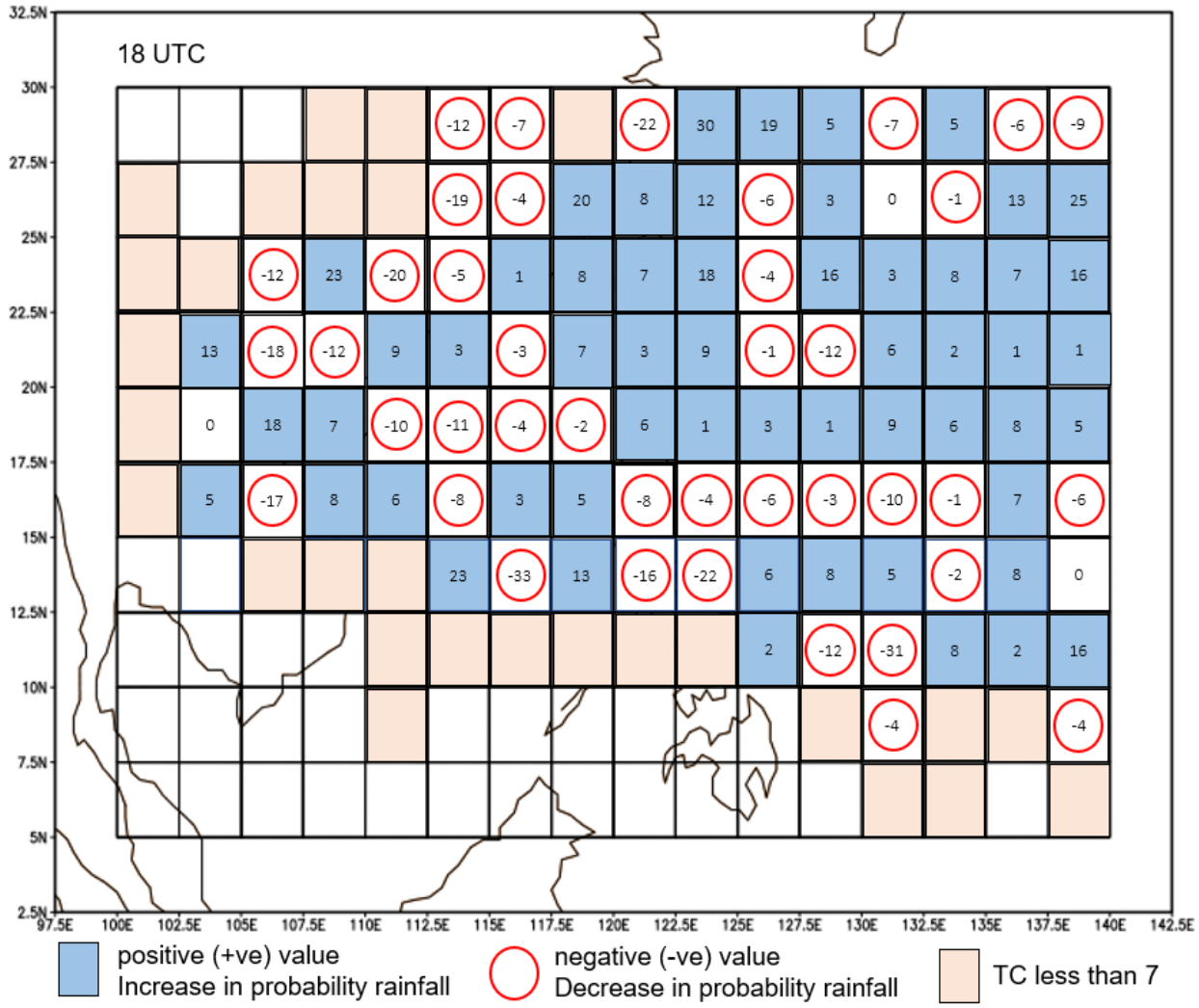

Figure 15: Changes in the probability of rain occurring during the tropical cyclones (TCs) at 18 UTC

3.3 Average Rainfall Intensity during TC

The seasonal rainfall intensity and average rainfall intensity during TC are calculated using the formula given below.

a) Seasonal Rainfall Intensity

$$\frac{Total\ rainfall\ amount\ (1 > mm)}{Total\ num.\ of\ rain\ day\ x\ 6hr}$$

b) Rainfall Intensity during TC

$$\frac{Total\ rainfall\ amount\ (1 > mm)}{Total\ num.\ of\ rain\ day\ x\ 6hr}$$

The blue boxes represent the rainfall intensity values that are higher than the seasonal rainfall intensity for 00 UTC, 06 UTC, 12 UTC, or 18 UTC. The highest average intensity of rainfall during the season occurs at 06 UTC (14 - 19 LT) with 7.8 mm/day, as shown in **Figure 17**. This is followed by 7.1 mm/day at 18 UTC (02 - 07 LT) as shown in **Figure 19**, 5.6 mm/day at 00 UTC (08 - 13 LT) as shown in **Figure 16** and 5.2 mm/day at 12 UTC (20 - 01 LT) as shown in **Figure 18**.

Average rainfall intensity during TC at 00 UTC shows an increase in rainfall intensity over the west coast of Peninsular Malaysia with the presence of TC in most areas of the WNP and SCS region, as shown in **Figure 16**. This indicates that tropical cyclones (TCs) in this region not only increase the probability of rainfall over the west coast of Peninsular Malaysia but also its intensity. At 06 UTC, an increase in rainfall intensity over the west coast of Peninsular Malaysia is observed only when the TCs are located in certain areas, such as the southern part of China, the Philippine Sea, and a few locations in the SCS region, as shown in **Figure 17**.

Although the probability of rain occurring during TC at 06 UTC is high, only a few locations with tropical cyclones show an increase in rainfall intensity over the west coast of Peninsular Malaysia. At 12 UTC, an increase in rainfall intensity over the west coast of Peninsular Malaysia is observed when TCs are located in a few areas, such as the Philippine Sea, the SCS, parts of the Vietnamese coast, central Thailand, and the eastern part of China, as shown in **Figure 18**. A similar increase in the rainfall intensity is also observed at 18 UTC (**Figure 19)**.

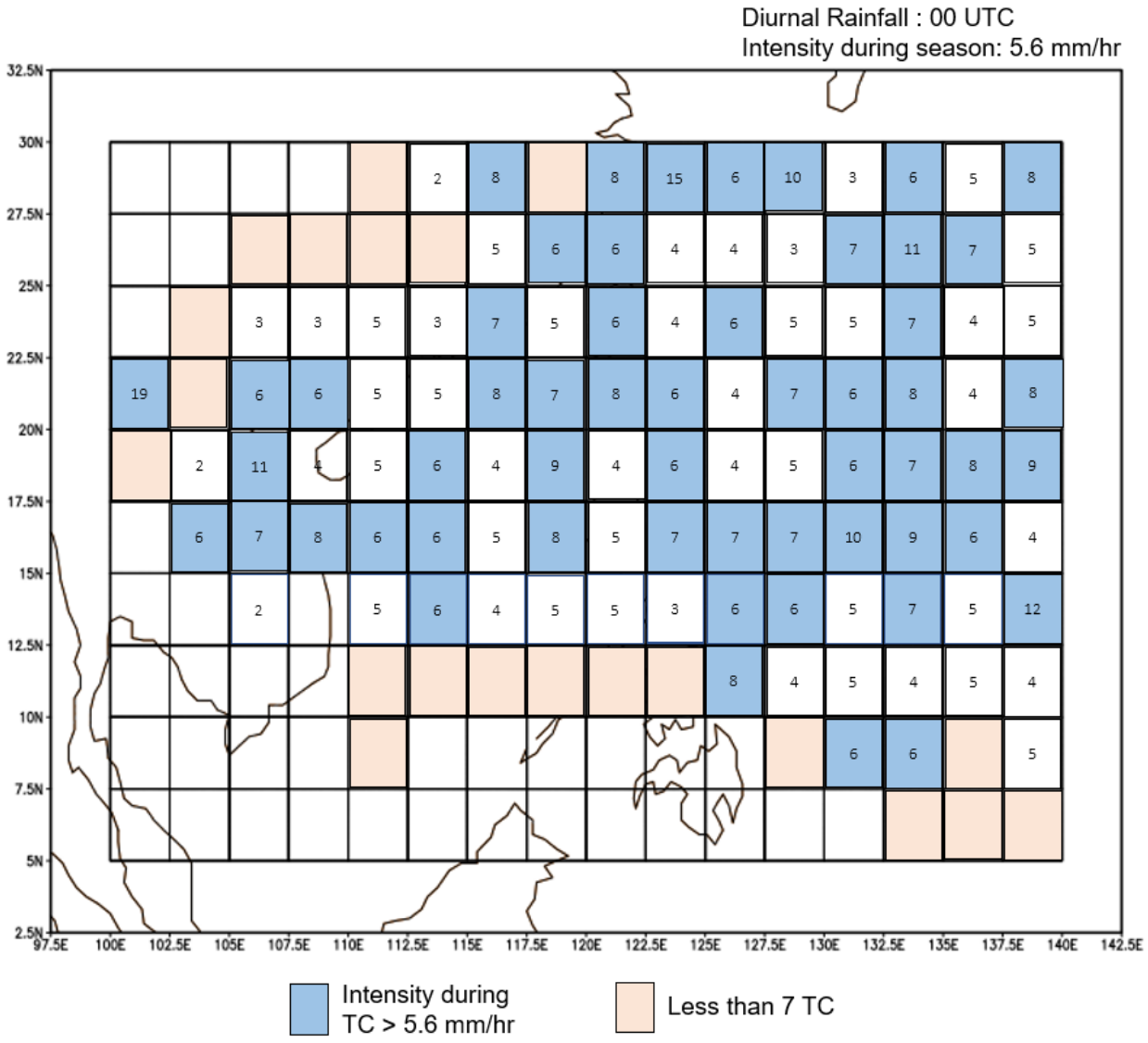

Figure 16: Average Rainfall Intensity during the tropical cyclones TC at 00 UTC

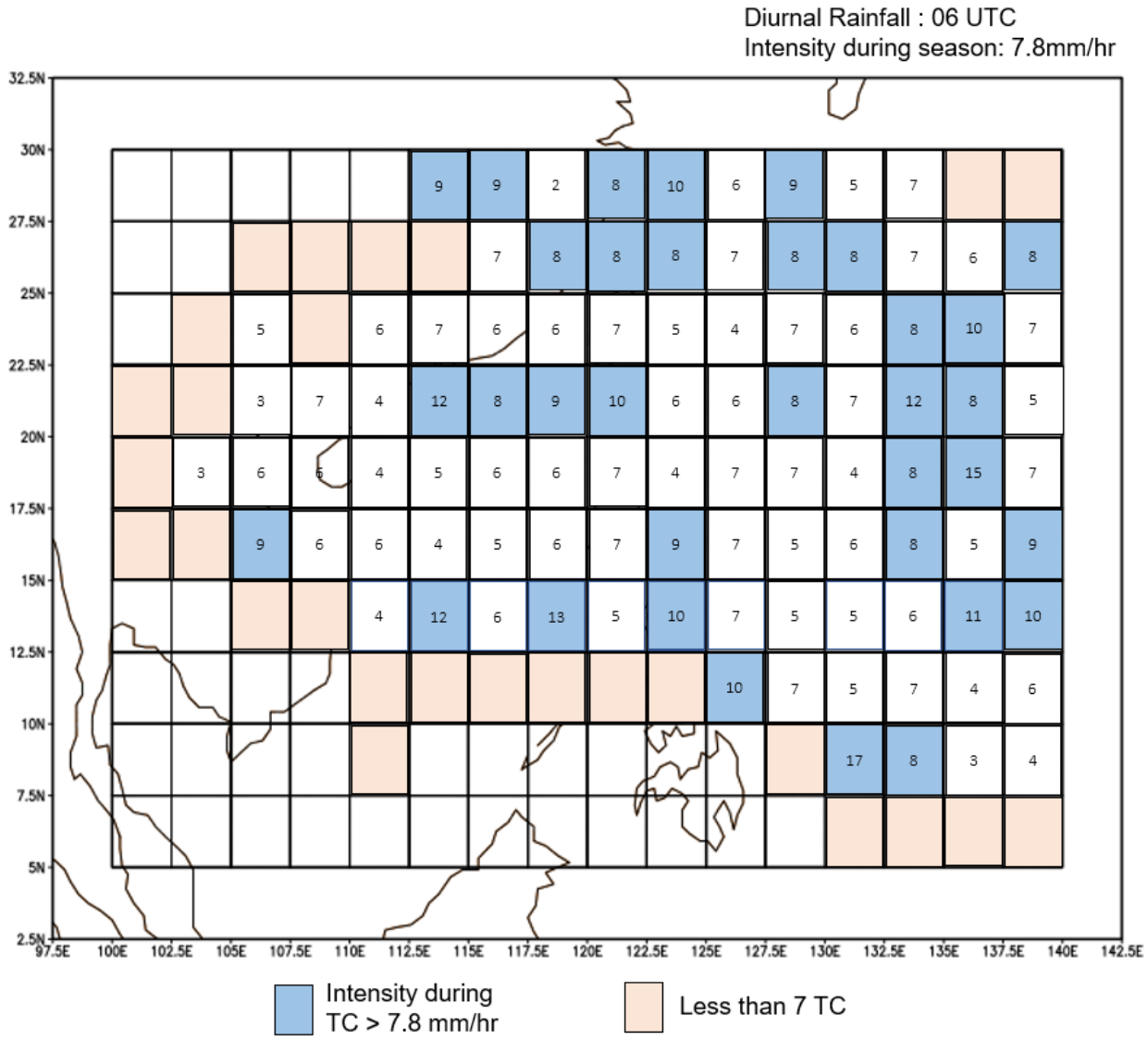

Figure 17: Average Rainfall Intensity during the tropical cyclones TC at 06 UTC

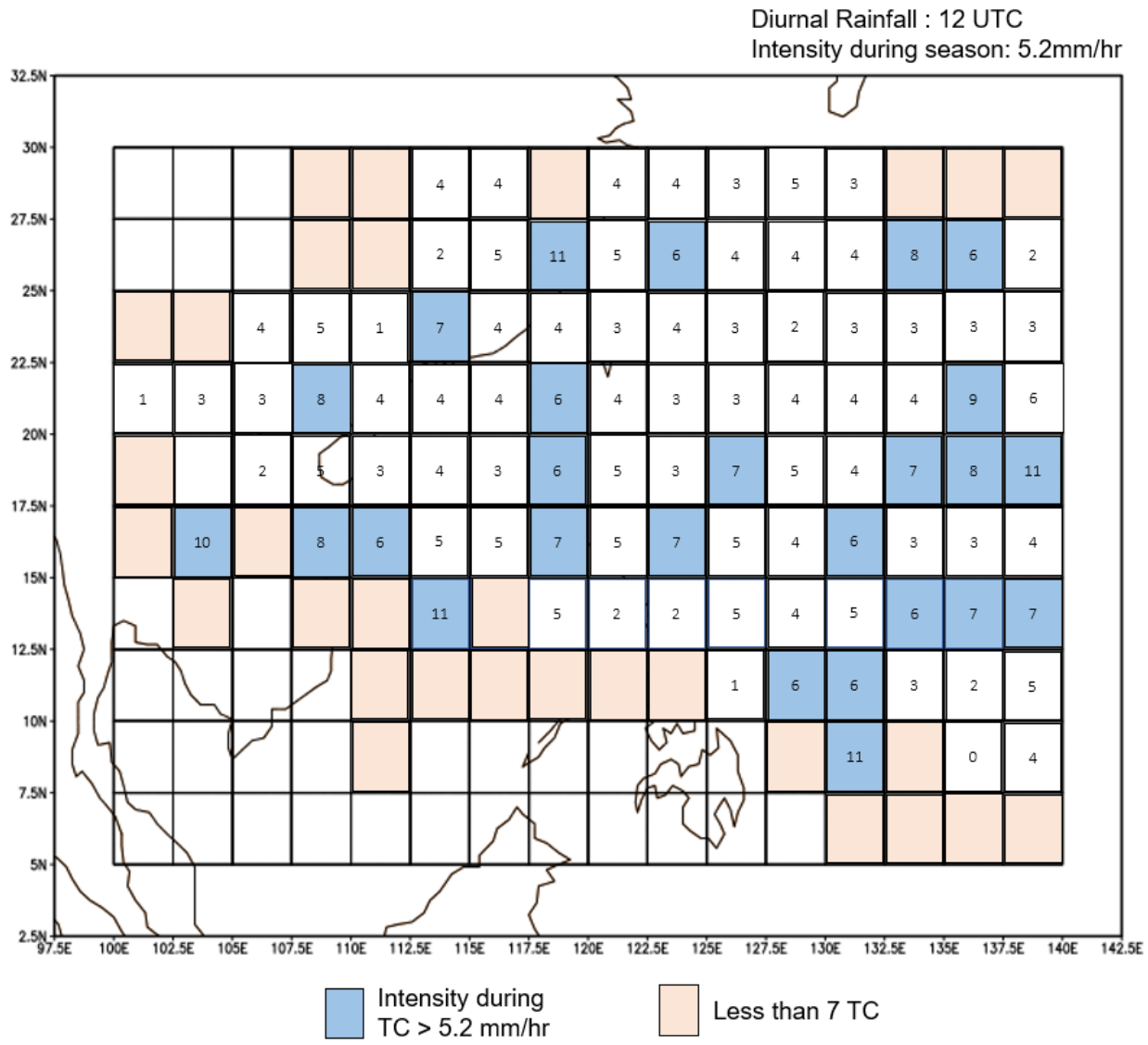

Figure 18: Average Rainfall Intensity during the tropical cyclones TC at 12 UTC

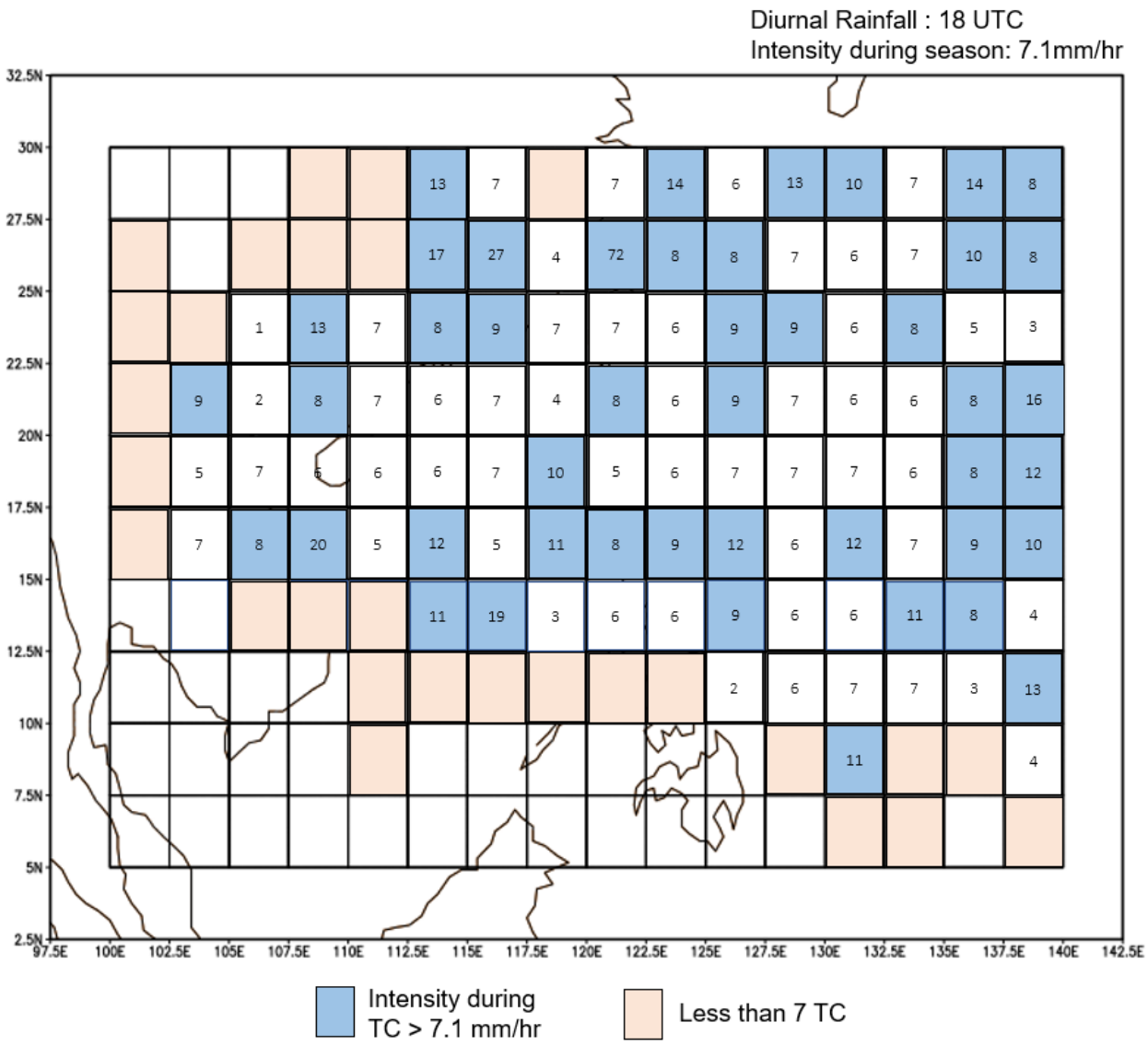

Figure 19: Average Rainfall Intensity during the tropical cyclones TC at 18 UTC

3.4 Changes in the Average Rainfall Intensity during TC

To further illustrate the effect of TCs on rainfall intensity, we calculate the changes in the average rainfall intensity during TC as below:

Changes of Rainfall Intensity = Average Rainfall intensity during TC - Seasonal Rainfall Intensity

Figure 20 shows the change in rainfall intensity for TCs at 00 UTC. An increase in rainfall intensity (positive values) is observed along the west coast of Peninsular Malaysia when most tropical cyclones are located in the SCS and the Western North Pacific. Overall, this indicates that when the TCs are located in these regions, the likelihood of rain occurring rises and so does the magnitude of the rain events. However, the increment in the rainfall intensity is not observed when TCs are located in certain areas, such as off the coast of Vietnam, the Indochina region, the northern Philippines, and a few locations in the SCS.

In general, the change in average rainfall intensity at 06 UTC shows negative values (a decrease) over the west coast of Peninsular Malaysia when TCs are located in most areas of the SCS and Western WNP, as shown in **Figure 21**. This suggested that although the probability of rainfall occurring increases as discussed in Section 3.2, these events tend to produce less rainfall compared to the seasonal rainfall intensity. The probability change in average rainfall intensity at 12 UTC also shows negative values (a decrease) over the west coast of Peninsular Malaysia (**Figure 22**). During this time, the probability of rain occurring also decreases. This combination generally signals a drier, more stable period with fewer rainfall events, which could reduce the risk of flooding.

The change in average rainfall intensity at 18 UTC is shown in **Figure 23**. During this time, the average rainfall intensity increases over the west coast of Peninsular Malaysia when TCs are located in certain parts of the SCS and WNP region. However,

the probability of rain decreases at 18 UTC. This combination of higher intensity and lower probability suggests a trend toward more extreme and sporadic rainfall events rather than steady, moderate rainfall.

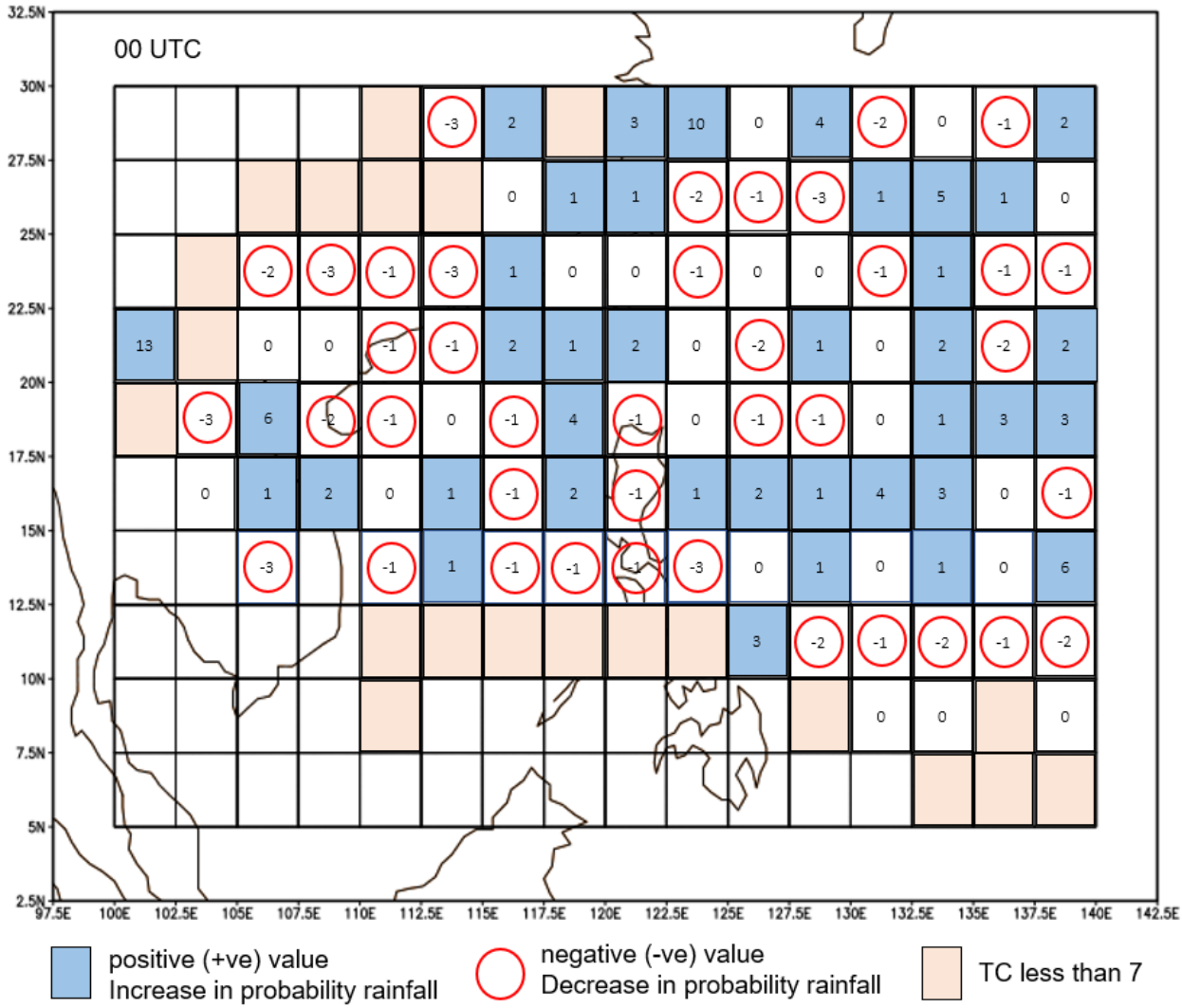

Figure 20: Changes in the Average Rainfall Intensity during the tropical cyclones (TCs) at 00 UTC

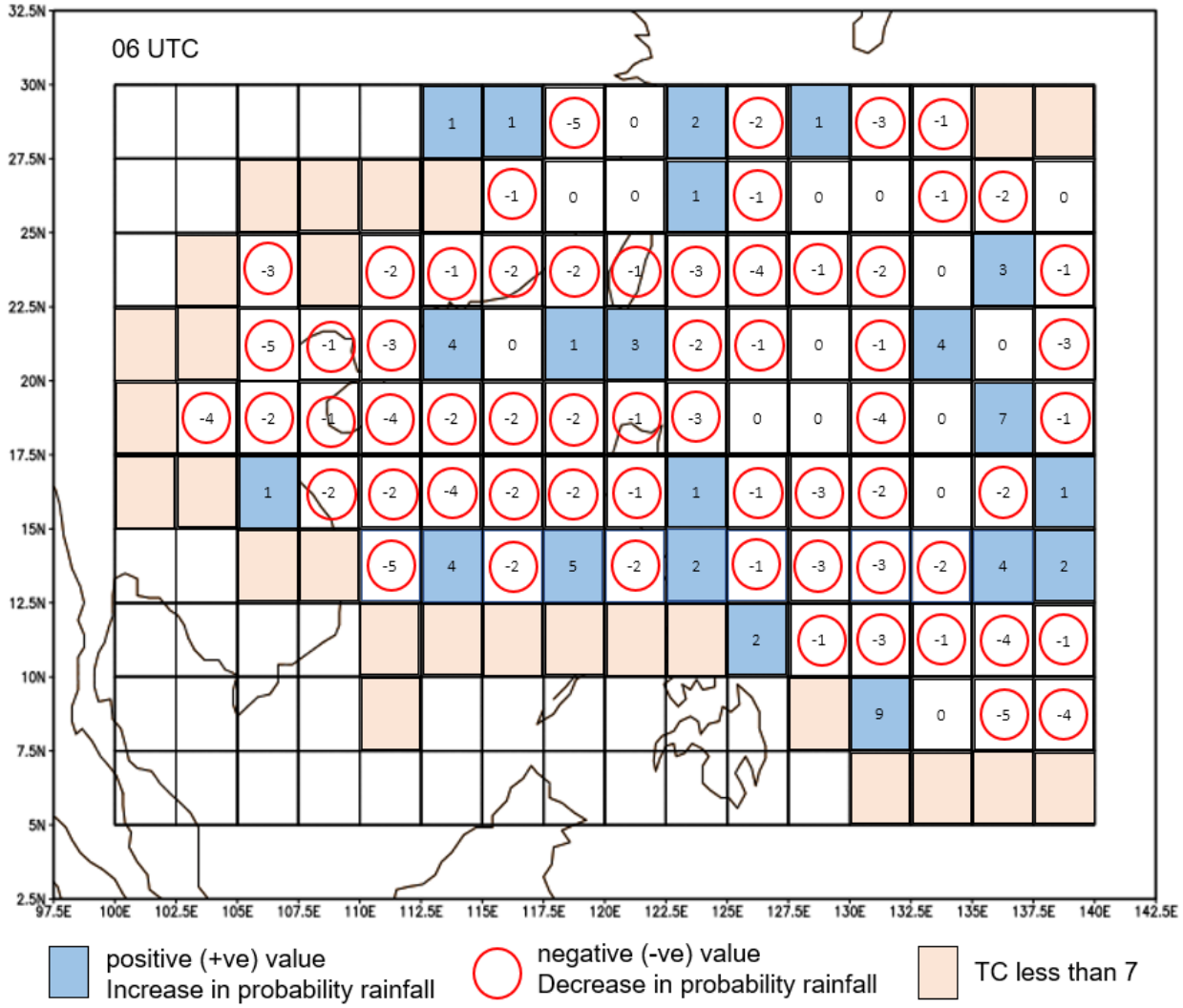

Figure 21: Changes in the Average Rainfall Intensity during the tropical cyclones (TCs) at 06 UTC

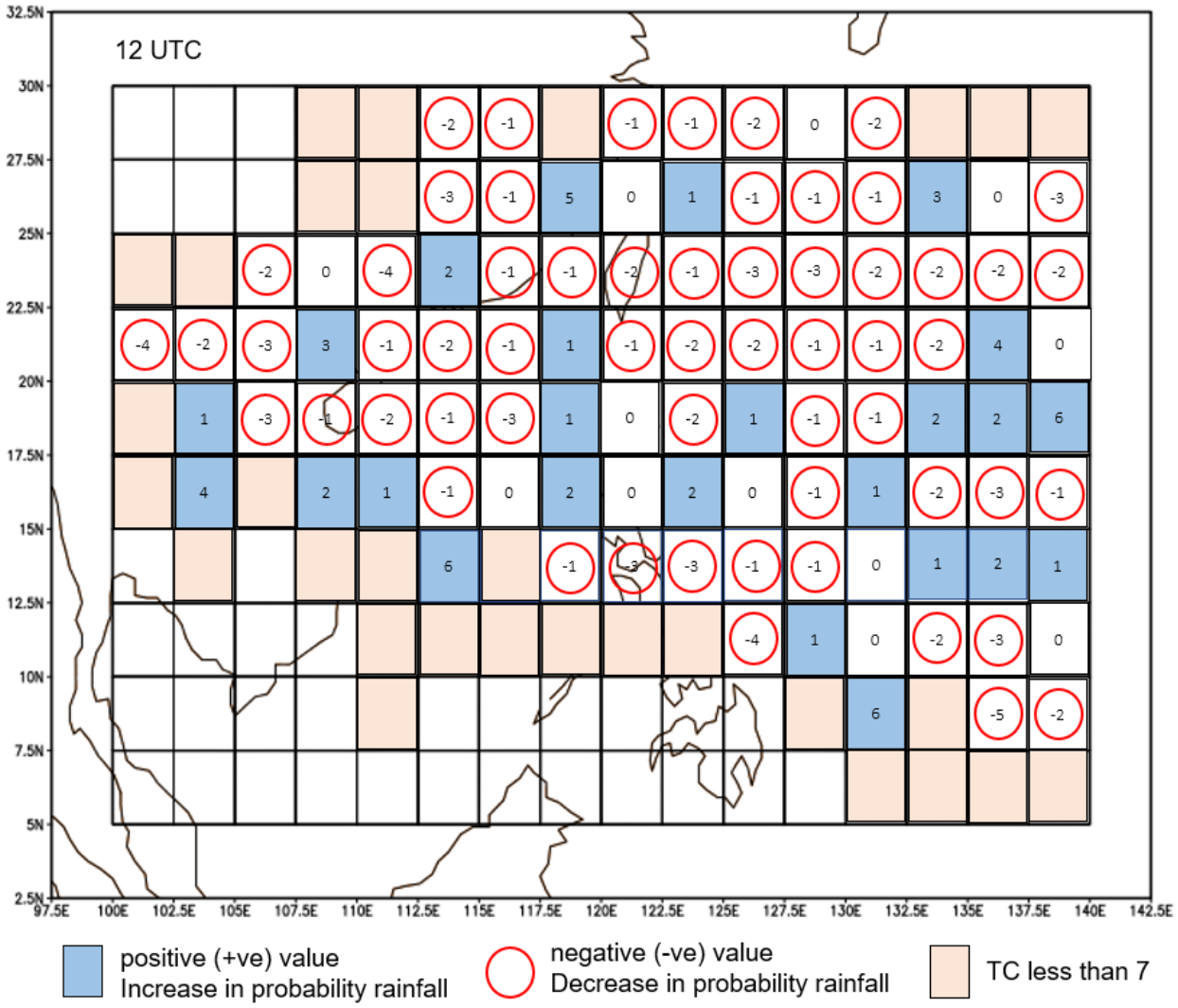

Figure 22: Changes in the Average Rainfall Intensity during the tropical cyclones (TCs) at 12 UTC

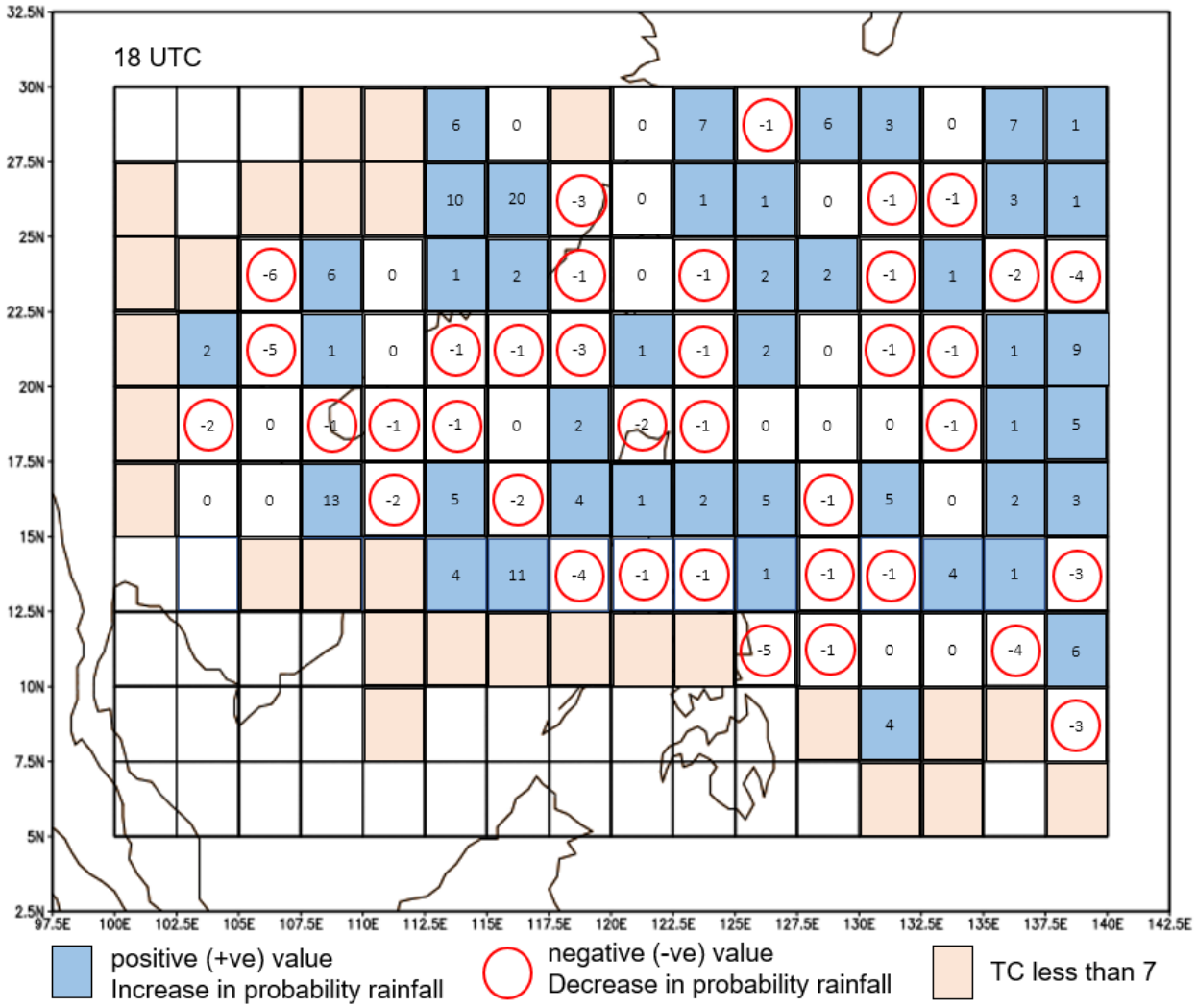

Figure 23: Changes in the Average Rainfall Intensity during the tropical cyclones (TCs) at 18 UTC

3.5 Lag Effect of TCs on Rainfall

In this part, we investigate the lag effect of the tropical cyclones (TCs) on the subsequent 6 hours rainfall. For example, for TC events 00 UTC, the rainfall amount accumulated from 06 to 11 UTC is investigated. Similarly, for TCs at 06 UTC, we will analyze the rainfall amount accumulated from 12 to 17 UTC. The purpose of this is to study the lag effect of TCs on the rainfall and thus will enable us to forecast rainfall for the next 6 hours based on the current TCs location. **Figure 24** shows the lag effects of TCs at 00 UTC on rainfall on the west coast of Peninsular Malaysia at 06 - 11 UTC. Overall, when TCs are located in certain regions of the WNP and SCS, the intensity of the rainfall on the west coast of Peninsular Malaysia is expected to increase. Specifically, these regions are found in the southern Philippines, northern Indochina, Taiwan, and parts of the China region.

When TCs are located in most areas of the WNP and SCS (**Figure 25**) at 06 UTC, they tend to increase the rainfall intensity (accumulated from 12 - 17 UTC) over west coast of Peninsular Malaysia. **Figure 26** indicates no coherent spatial patterns of the TC location at 12 UTC that can increase the rainfall intensity over the west coast of Peninsular Malaysia. In contrast, when the TCs are located in the WNP and SCS region at 18 UTC, the rainfall intensity increases (at 00 - 07 UTC the next day) as shown in **Figure 27**.

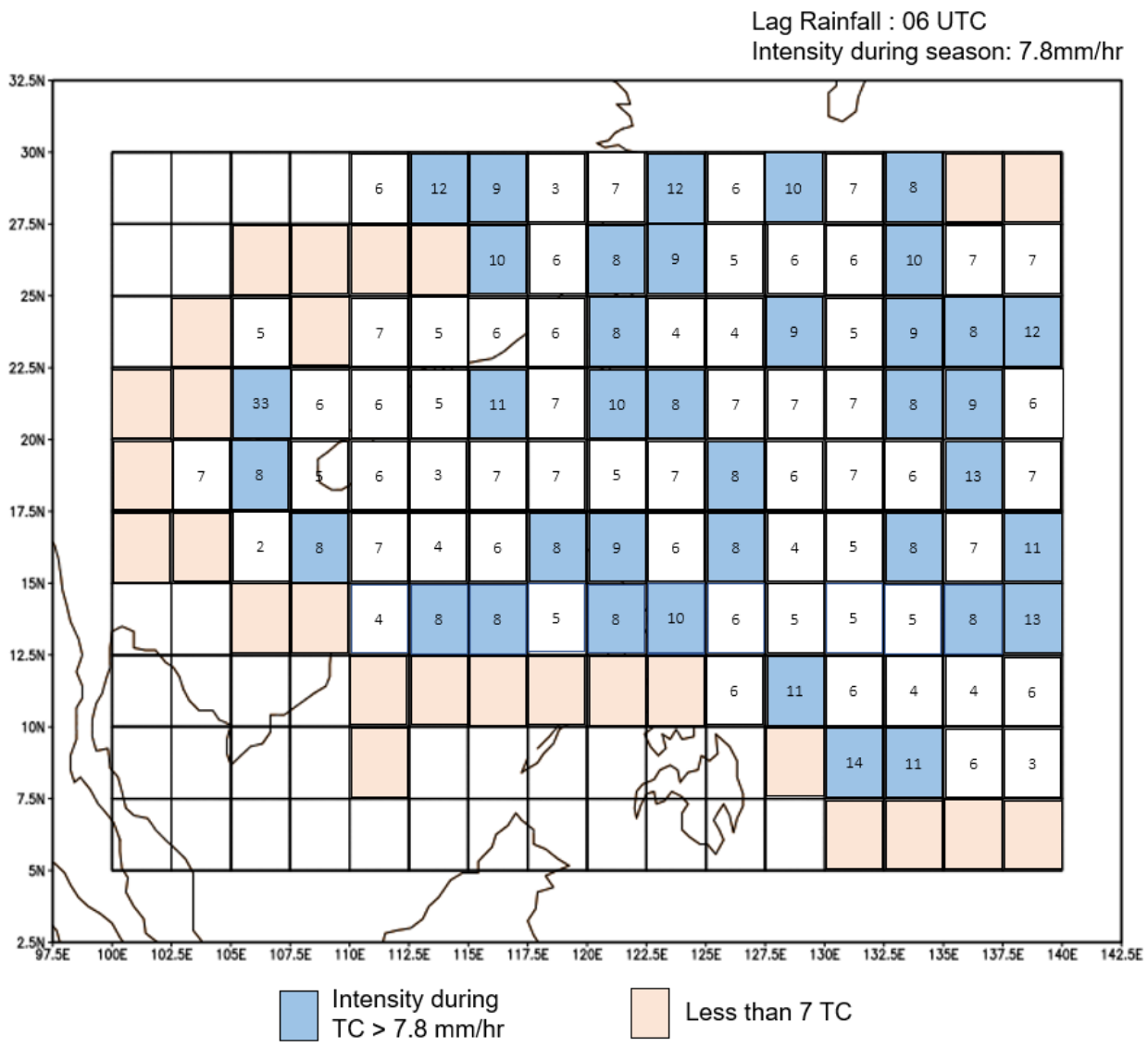

Figure 24: Leading rainfall at 06 UTC

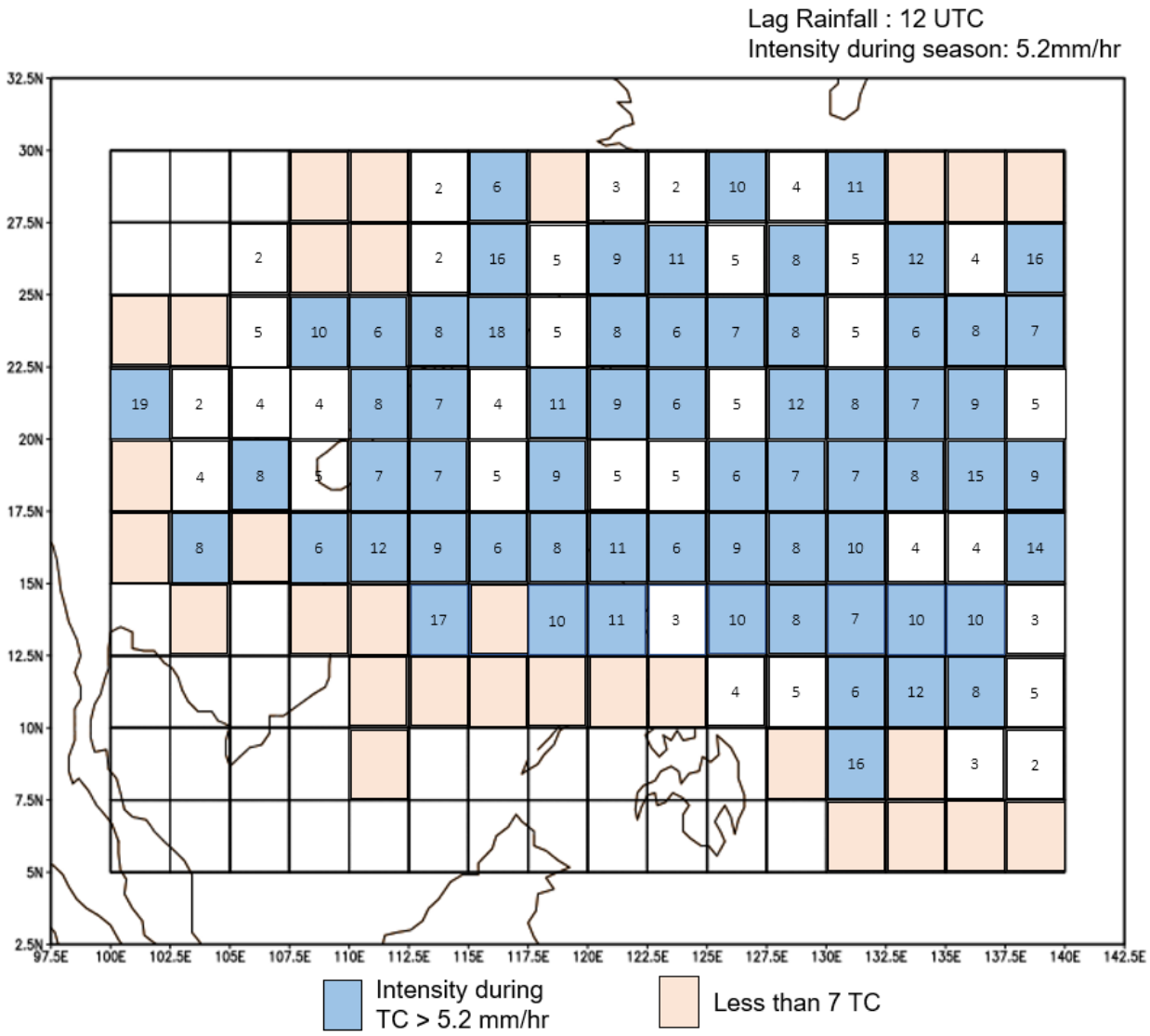

Figure 25: Leading rainfall at 12 UTC

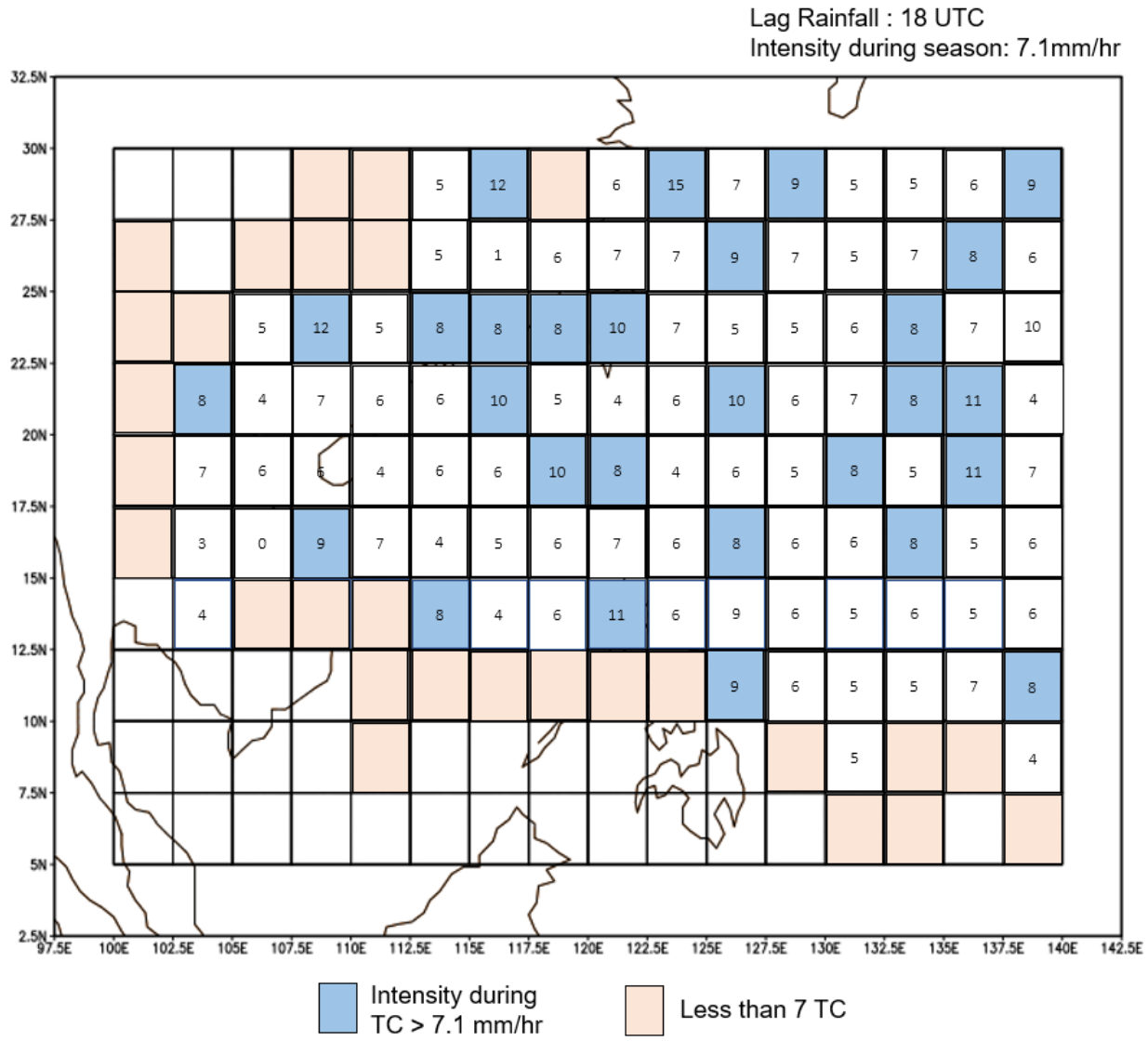

Figure 26: Leading rainfall at 18 UTC

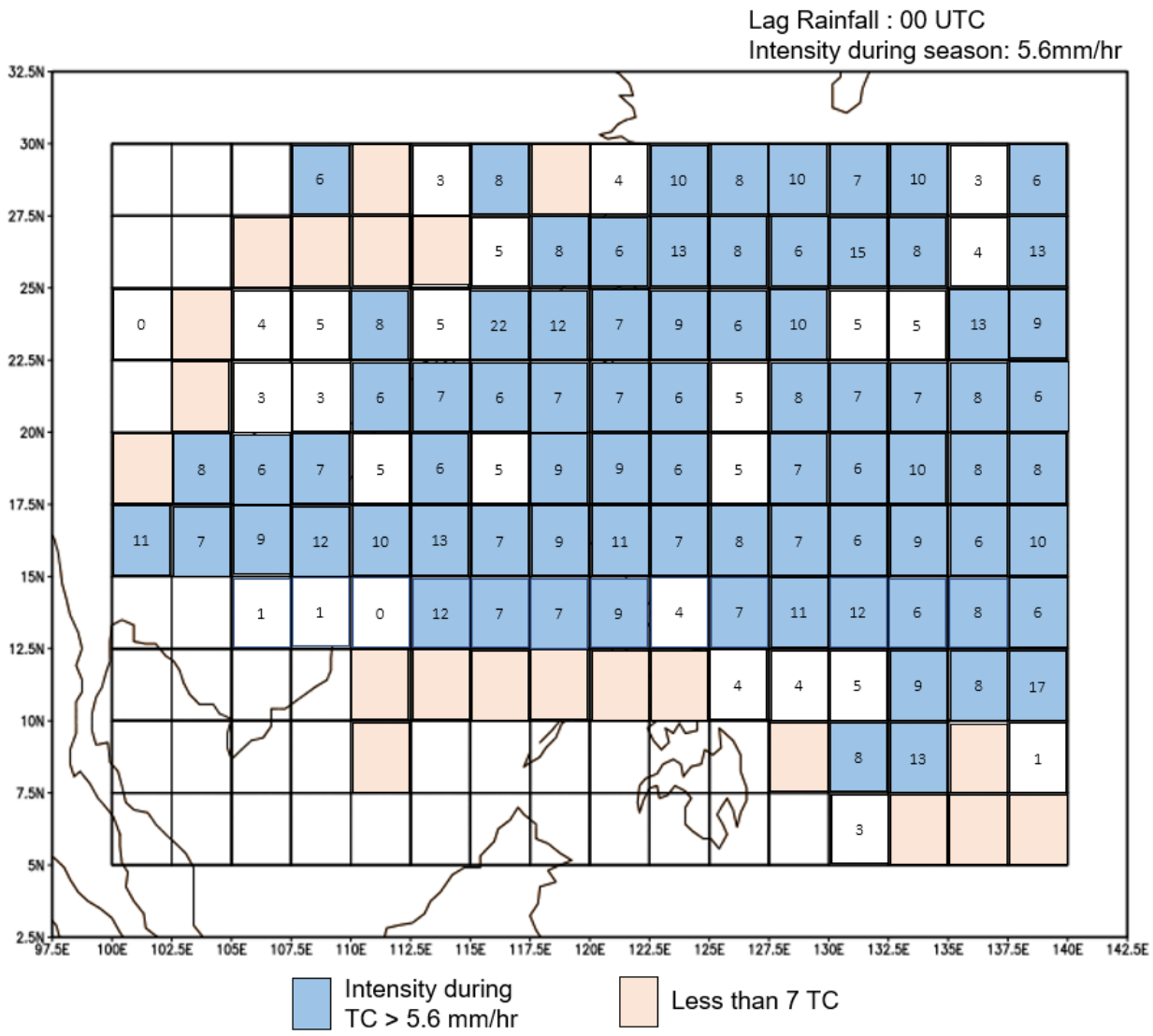

Figure 27: Leading rainfall at 00 UTC

3.6 The Changes in the Probability of Lead Rainfall Intensity during TCs

The changes in rain intensity are calculated using the formula given below.

Changes in Rain Intensity = Average rainfall intensity during TC - Seasonal rainfall

The changes in leading rainfall at 06 UTC show a reduction in rainfall intensity over the west coast of Peninsular Malaysia when the TCs are located in the Western North Pacific (WNP) and South China Sea (SCS) region (**Figure 28**). The reduction in rainfall intensity is observed to occur more significantly during the changes in leading rainfall at 06 UTC compared to the changes in rainfall intensity during the TC at 00 UTC.

The changes of rainfall intensity during lag rainfall at 12 UTC over the west coast of Peninsular Malaysia increase compared to the changes of rainfall intensity during TC at 06 UTC, which shows a reduction in rainfall intensity when the TCs are located in the WNP and SCS regions (**Figure 29**). The only TC areas that show a decrease in rainfall intensity are Northern Indochina, the east coast of China, and the eastern Visayas.

Meanwhile, the changes in rainfall intensity during lag rainfall at 18 UTC show a decrease in rainfall intensity over the west coast of Peninsular Malaysia, aligning with the changes of average rainfall intensity during TC at 12 UTC (**Figure 30**). For the changes in lag rainfall at 00 UTC, the average rainfall intensity shows an increase over the west coast of Peninsular Malaysia when most TCs are located in the WNP and SCS region, except in the areas of northern and southern Indochina and the eastern Visayas (**Figure 31**). An increase in rainfall intensity is observed during the changes in lag rainfall at 00 UTC, compared to the changes in rainfall intensity during TC at 18 UTC.

Compared to all other changes in lag rainfall, the changes at 12 UTC and 00 UTC shows a significant increase in rainfall intensity. This increase requires precautionary measures, as it may lead to flooding during these times.

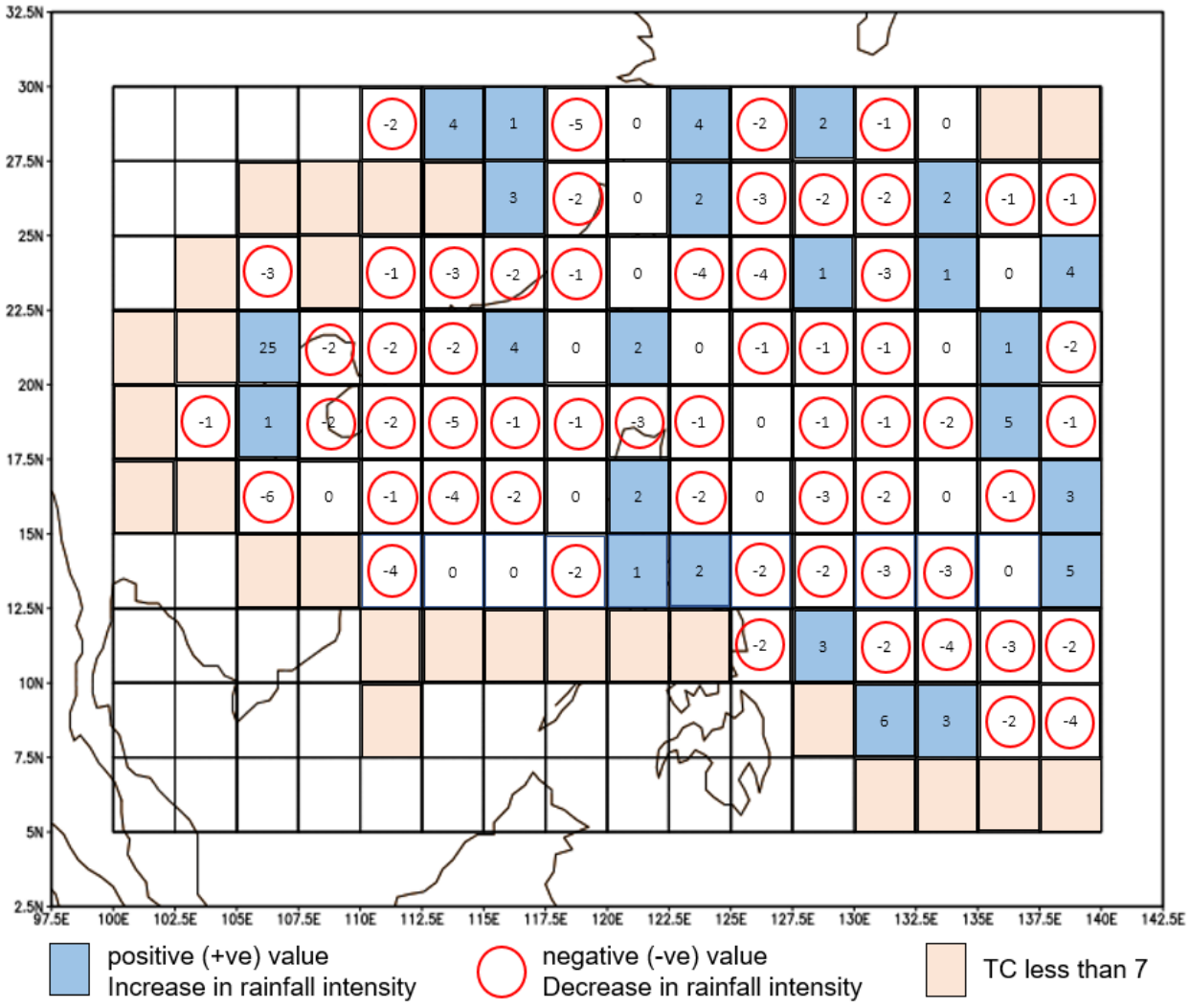

Figure 28: The Changes in the Probability of Lead Rainfall Intensity at 06 UTC

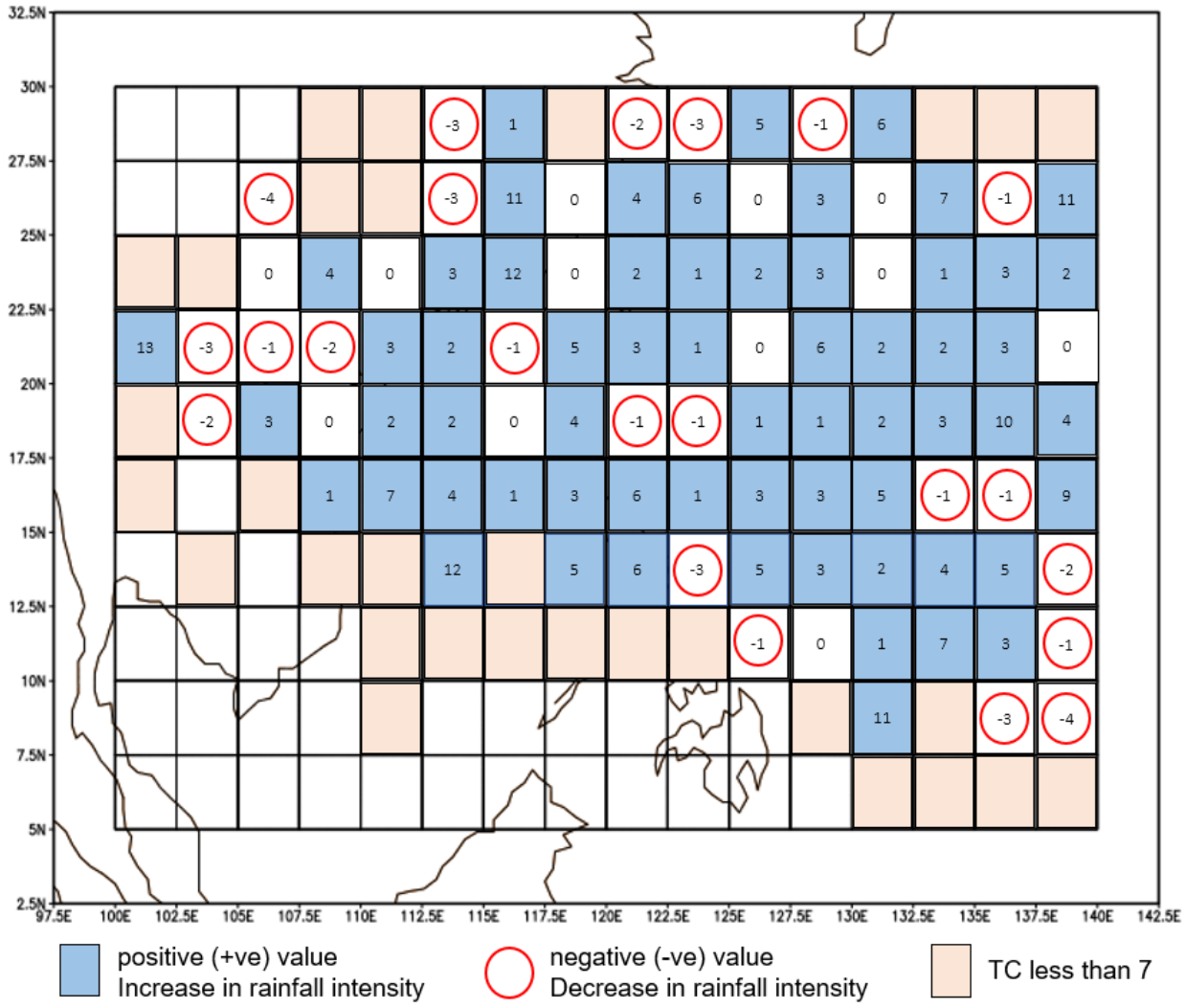

Figure 29: The Changes in the Probability of Lead Rainfall Intensity at 12 UTC

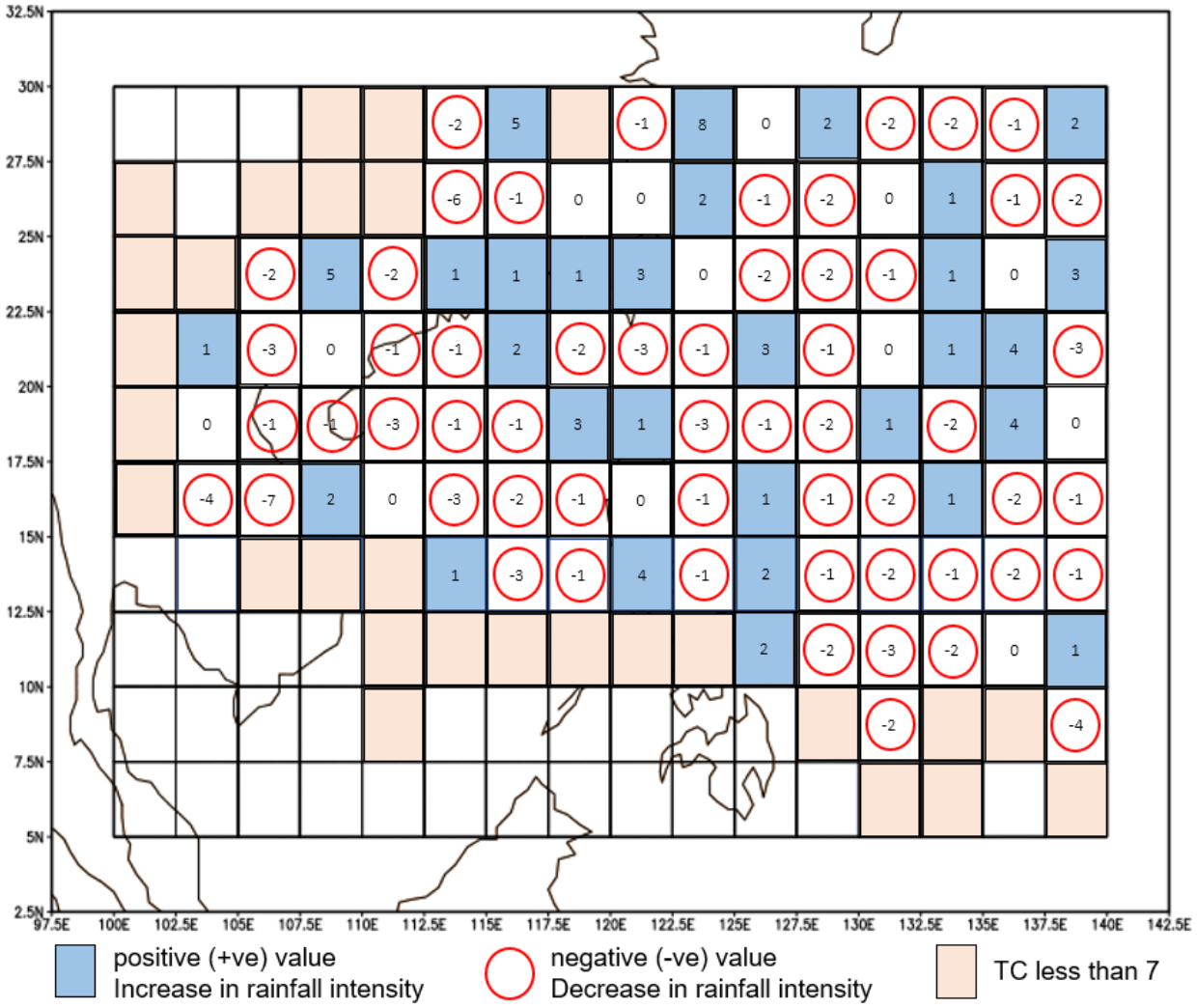

Figure 30: The Changes in the Probability of Lead Rainfall Intensity at 18 UTC

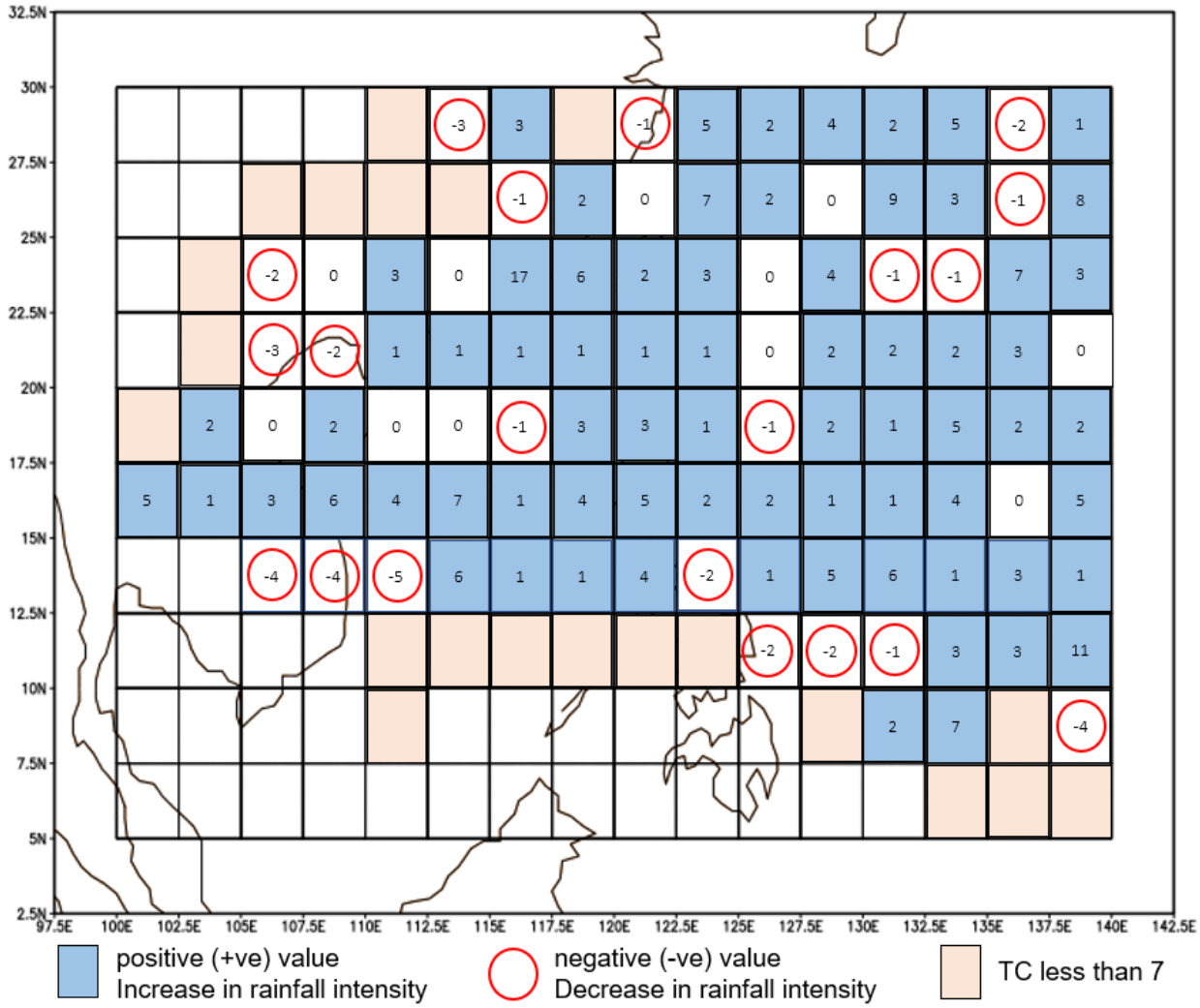

Figure 31: The Changes in the Probability of Lead Rainfall Intensity at 00 UTC

4.0 Conclusion

This study examines the probability of rainfall on TC days and the changes in rainfall intensity during TC days along the west coast of Peninsular Malaysia when TCs are located in the Western North Pacific (WNP) and South China Sea (SCS) regions from 1991 to 2021 (31 years). The significant positions of tropical cyclones were also observed at 00 UTC, 06 UTC, 12 UTC, and 18 UTC. Furthermore, lag rainfall and its changes were analyzed in this research. Overall, TCs are predominantly located in the Western North Pacific (WNP) and South China Sea (SCS) regions. However, based on the density plot, TCs are shown to be more active in the WNP region compared to the SCS region over the 31-year dataset. The position of TCs at 00 UTC shows the highest number of TC occurrences in the WNP and SCS regions.

The results for the probability of rainfall and the changes in the probability of rainfall on TC days vary at 00 UTC, 06 UTC, 12 UTC, and 18 UTC. The highest seasonal probability of rainfall, 80%, occurs at 06 UTC. The probability of rainfall during TC exceeds 70% at 06 UTC (14 – 19 LT) along the west coast of Peninsular Malaysia when the TC is located in the WNP and SCS regions. The probability of rainfall on TC days exceeding 70% is also observed along the west coast of Peninsular Malaysia at 00 UTC, even though the seasonal probability of rainfall is 66%.

An increase in the probability of rainfall during TCs over the west coast of Peninsular Malaysia was observed at 00 UTC and 06 UTC. Furthermore, although fewer TCs are present at 06 UTC (based on TC positions) in the WNP and SCS regions, the probability of rainfall on TC days is high during this time, which has a more significant impact on Malaysia. Additionally, the changes in rainfall probability on TC days increased over the west coast of Peninsular Malaysia at 00 UTC (08 – 13 LT) and 18 UTC (02 – 07 LT) when TCs are located in the WNP and SCS regions. Meanwhile, a decrease in the probability of rainfall is observed at 06 UTC (14 – 19 LT) and 12 UTC (20 – 01 LT) over the west coast of Peninsular Malaysia.

The results show that the average rainfall intensity during TCs at 00 UTC increases significantly over the west coast of Peninsular Malaysia, particularly when the TC is located off the Vietnam coast. This indicates that the high probability of rainfall during TCs at 00 UTC is closely linked to an increase in rainfall intensity in the region. These findings suggest that TCs, especially those situated near the Vietnam coast at 00 UTC, contribute to higher rainfall intensity along the west coast of Peninsular Malaysia. The association between TC position and rainfall intensity underscores the importance of monitoring TC tracks and their impact on regional weather patterns. Accurate forecasting of these events is crucial for mitigating the risk of flooding and other adverse weather impacts on the affected areas.

However, despite the observed increase in rainfall intensity, the overall impact on the west coast of Peninsular Malaysia was minimal, as the rainfall probability at 12 UTC remained below 70%. Similarly, at 18 UTC, the observed rainfall intensity showed minimal impact due to a rainfall probability of less than 70%. These findings suggest that while TC position at these times can influence rainfall intensity, the relatively low probability of rainfall at 12 UTC and 18 UTC limits the overall impact on the west coast of Peninsular Malaysia.

The lag rainfall at 00 UTC and 12 UTC also shows an overall increase in rainfall intensity, with a concentrated pattern of high intensity observed when most TCs are situated in the WNP and SCS regions. These findings highlight that TC location and timing, particularly at 12 UTC and 00 UTC, significantly influence rainfall intensity along the west coast of Peninsular Malaysia. The observed patterns emphasize the importance of monitoring TC positions and their associated lag rainfall to predict the potential impacts of tropical cyclones on regional weather.

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ISBN 978-967-2327-21-9