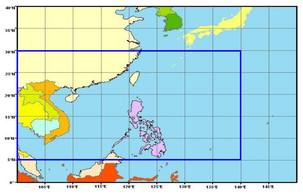
Impact of Tropical Cyclones in the West North Pacific and South China Sea on the Asian Monsoon Rainfall during the Pre-monsoon, Monsoon and Post-Monsoon Seasons

Subramaniam Moten, Munirah Ariffin, Siva Shangari Govindan and Diong Jeong Yik
Research Section, Malaysian Meteorological Department, MALAYSIA
Email: subra@met.gov.my

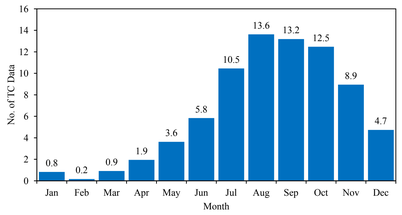
Introduction

The Western North Pacific (WNP) and South China Sea (SCS) region is the most active basin in the world accounting for nearly one third of all global tropical cyclone (TC) activity. An average of 26 TCs form in this basin annually with an average of 77 days the TCs attaining tropical storm category and higher. For the period 1979 – 2007, the lowest and highest number of TC days were recorded in 1998 (43 days) and 1986 (111 days) respectively. The month of August has the most number of TC days with an average of 13.6 days. There is large seasonal and interannual variability of TC genesis in this basin. The strong diabatic heating of the upper troposphere from the TC convective activity that drives the divergent circulation causes major shifts and changes in the intensity of the east-west circulation, which could be responsible for the vagaries of the Asian monsoon precipitation. In this study the impact of TC activity on the precipitation over the Asian Monsoon region during the pre-monsoon, monsoon and post monsoon periods are examined together with their associated synoptic circulation pattern anomalies of atmospheric parameters.

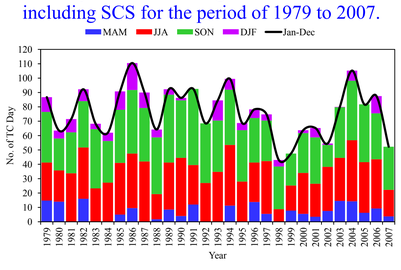
Region of TC activity is enclosed by blue rectangular line.



Monthly average number of TC day with TCs reaching tropical storm intensity or higher from 1979 to 2007.



Average seasonal number of TC day with intensity of TS or higher over the WNP including SCS for the period of 1979 to 2007.



Season	Category		
	Active	Average	Least Active
Pre-Monsoon (MAM)	11–16 days (8 years)	6–10 days (8 years)	0–5 days (13 years)
Monsoon (JJA)	32–43 days (13 years)	20–31 days (12 years)	9–19 days (4 years)
Post-Monsoon (SON)	41–53 days (6 years)	29–40 days (19 years)	15–28 days (4 years)

Duration of TC lifetime (day) for TC reaching TS intensity or higher during MAM, JJA and SON 1979 to 2007.

Data

The TC data (1979 – 2007) is from RSMC-Tokyo Typhoon Center for the region indicated. The atmospheric data is the gridded reanalysis JRA-25 from JMA Climate Data Assimilation System. The APHRODITE high resolution (0.25 degrees) gridded rainfall data from MRI-RIHN, Japan over the land mass for the same period is used for obtaining rainfall anomalies.

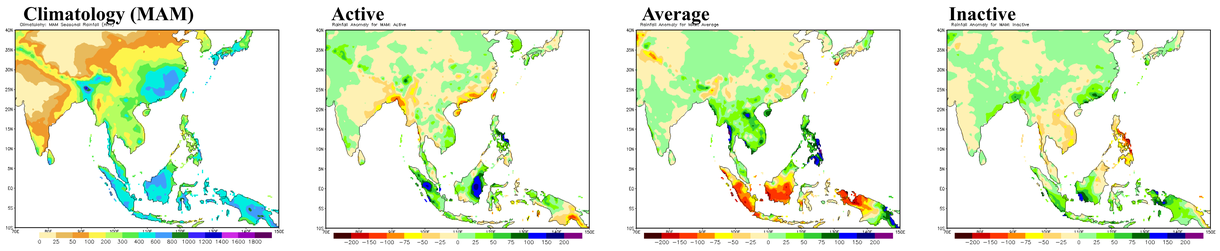
Methodology

TC activities are categorized into 3 groups based on TC lifetime (Active, Average and Inactive) for 3 seasons: Pre-Monsoon (March-May), Monsoon (June-August) and Post-Monsoon (September-November). The number of TC days for each category by season and the number of seasons that belong to each group are shown in the table.

The anomaly in the regional precipitation and large-scale atmospheric circulation patterns are obtained to understand the impact of TC activity in the WNP and SCS on the regional distribution pattern for the 3 different seasons.

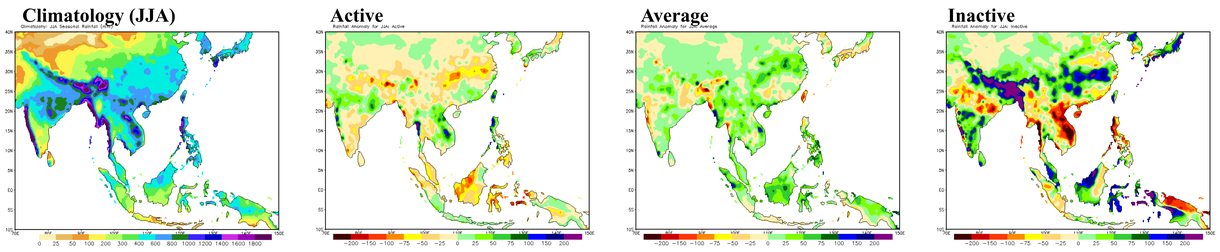
Results

❑ Rainfall Anomaly



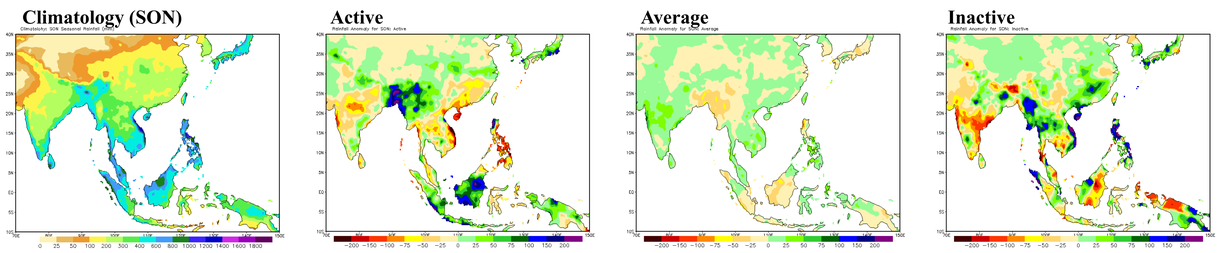
Pre-Monsoon Season (MAM)

Between the active and inactive phase opposite rainfall patterns are observed over the Asian Monsoon region. South of the equator the rainfall is below normal during normal TC activity season and above normal during active and inactive phase, with significant difference being observed over the Indonesian region.



Monsoon Season (JJA)

The Indian Subcontinent, Southeast Asia and East Asia all exhibit contrasting rainfall pattern between the active and inactive TC activity seasons with the largest intra-regional difference in the quantum of rainfall during seasons with fewer tropical cyclone days.

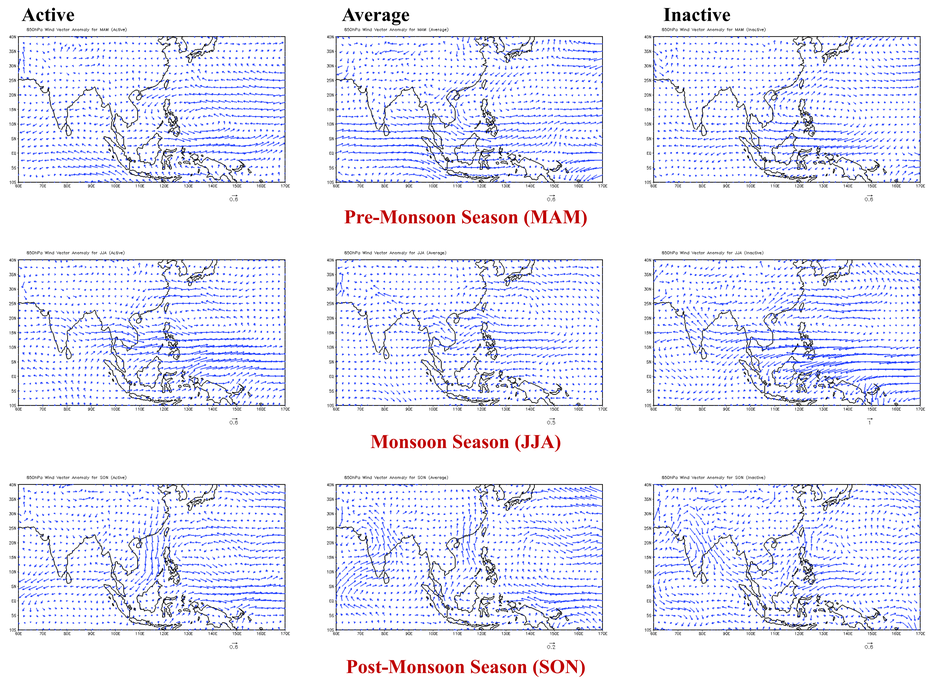


Post-Monsoon Season (SON)

Southeast Asia including the Indonesian Archipelago is strongly impacted by TC activities during this season with opposite rainfall anomaly patterns being observed between the active and inactive TC activity seasons. Similar, opposite anomaly rainfall patterns are also observed over the Indian sub-continent and East Asia. During normal TC activity season there is little departure in the seasonal rainfall amounts.

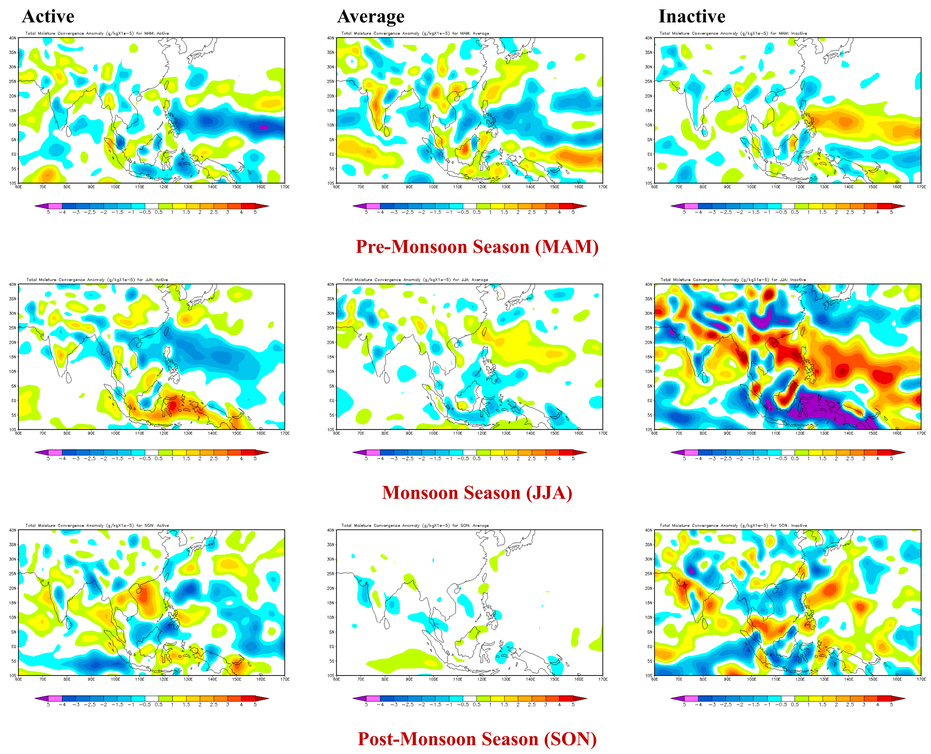
Results

❑ 850-hPa Wind Vector Anomaly



In all the three seasons the anomalous stream flows pattern in the lower troposphere during the three phases of TC activity clearly shows the impact of TC activity on the regional synoptic flow pattern. Between the active and inactive seasons in particular contrasting anomalous flow pattern are observed and region of enhanced (reduced) rainfall are typically associated with cyclonic (anticyclonic) circulations or over trough (ridge) region.

❑ Moisture Convergence Anomaly



The nature of TC activity dictates lower troposphere moisture convergence and it is most prominent during the monsoon and post monsoon seasons. Large scale moisture convergence towards active TC region results in enhanced divergence of moisture mainly to the south and north, and to some extend the west of the TC belt, resulting in the observed rainfall anomalies.

Conclusions

The duration of TC activity in the WNP and SCS basin has strong seasonal and interannual variability. This study has shown that tropical cyclone activity in this basin has a strong influence on the regional synoptic circulation over the entire Asian Monsoon region which has a significant impact on the rainfall distribution. The impacts are different for the three different seasons; pre-monsoon, monsoon and post monsoon seasons. Most notable is during the monsoon season from June to August where the rainfall anomaly is almost the opposite between active TC season and least active TC season. During the pre-monsoon season when TCs occurs at much lower latitudes the rainfall over the maritime regions of Southeast Asia are greatly impacted by TC activities. Prominent among the synoptic and planetary scale features that dynamically drive the regional circulation patterns that causes the observed anomalies during the three phases are the strengthened relative vorticity over the TC region in the lower troposphere brought about by the enhanced cyclonic circulation as evidenced from the streamfunction analysis. Forced moisture convergence that contributes to the variations in diabatic heating over the WNP and SCS during different TC activity phases and seasons causing major shifts in the upper level divergent circulations. Lower tropospheric moisture convergence/divergence over the Asian Monsoon region associated with enhanced or reduced TC activity over the tropical cyclone belt of the WNP and SCS basin, influences the rainfall distribution over the Asian Monsoon region.