Summary of the 2019 Asian Summer Monsoon

1. Precipitation and temperature

CLIMAT report data detailing four-month total precipitation amounts for the monsoon season (June – September) show more than 140% of the normal from the southern part of Central Asia to the central part of South Asia and in/around northern and northeastern China, while values less than 60% of the normal were seen in and around Indonesia, southern Pakistan and northwestern China, and from eastern China to the Korean Peninsula (Figure 5-1). In and around South Asia, heavy rain caused more than 1,900 fatalities from July to August (sources: governments of India/Pakistan, European Commission) and more than 360 in September (sources: government of India, European Commission). In Singapore, monthly precipitation in September was at its lowest for the month since 1869 according to the Meteorological Service Singapore.

Four-month mean temperatures for the same period were above normal in many parts of Asia. Anomalies of more than 1°C above normal were seen from northern China to the southern part of Central Siberia, from eastern China to northern Japan, and in and around southern China and southern Pakistan (Figure 5-2).

2. Tropical cyclones

A total of 18 tropical cyclones (TCs[1]) had formed over the western North Pacific and the South China Sea by September 2019, as compared to the normal of 18.4 (Table 5-1). From June to September, a total of 16 TCs (climatological normal: 16.0) formed, with 14 approaching or making landfall on East Asia and 11 (climatological normal: 9.2) on Japan.

Among these, Typhoon Lekima passed by Japan's Sakishima Islands with a maximum wind speed of 105 knots and made landfall on eastern China, resulting in more than 40 fatalities in the eastern part of the country (source: government of China).

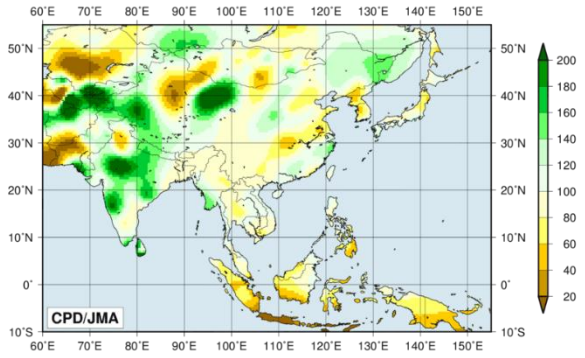


Figure 5-1 Four-month precipitation ratios (%) from June to September 2019

The base period for normal is 1981 – 2010. Note that the data in Afghanistan, Bhutan, Cambodia, Kazakhstan, Laos, Nepal, Papua New Guinea and Viet Nam are interpolated due to the lack of CLIMAT report or climatological normal.

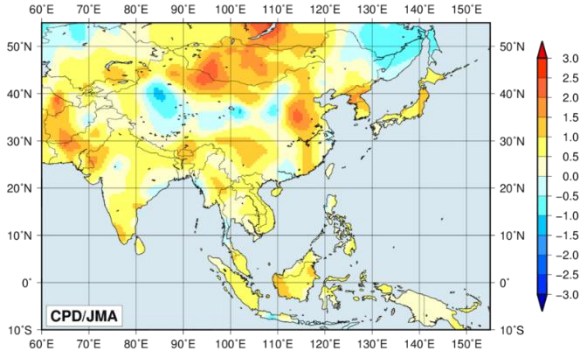


Figure 5-2 Four-month mean temperature anomalies (°C) from June to September 2019

The base period for normal is 1981 – 2010. Note that the data in Afghanistan, Bhutan, Cambodia, Kazakhstan, Laos, Nepal, Papua New Guinea and Viet Nam are interpolated due to the lack of CLIMAT report or climatological normal.

Table 5-1 Tropical cyclones forming over the western North Pacific up to September 2019

Number ID	Name	Date (UTC)	Category[1)]	Maximum wind[2)] (knots)
T1901	PABUK	1/1-1/4	TS	45
T1902	WUTIP	2/19-2/28	TY	105
T1903	SEPAT	6/27-6/28	TS	40
T1904	MUN	7/2-7/4	TS	35
T1905	DANAS	7/16-7/20	TS	45
T1906	NARI	7/25-7/27	TS	35
T1907	WIPHA	7/30-8/3	TS	45
T1908	FRANCISCO	8/2-8/6	TY	70
T1909	LEKIMA	8/4-8/12	TY	105
T1910	KROSA	8/6-8/16	TY	75
T1911	BAILU	8/21-8/25	STS	50
T1912	PODUL	8/28-8/29	TS	40
T1913	LINGLING	9/2-9/7	TY	95
T1914	KAJIKI	9/2-9/3	TS	35
T1915	FAXAI	9/4-9/9	TY	85
T1916	PEIPAH	9/15-9/16	TS	35
T1917[3)]	TAPAH	9/19-9/22	TY	65
T1918[3)]	MITAG	9/28-10/3	TY	75

Note: Based on information from the RSMC Tokyo-Typhoon Center.

1) Intensity classification for tropical cyclones.
TS: tropical storm,
STS: severe tropical storm,
TY: typhoon

2) Estimated maximum 10-minute mean wind.

3) Based on early analysis data, but not best track.

[1] Here, a TC is defined as a tropical cyclone with a maximum sustained wind speed of 34 knots or more.

3. Monsoon activity and atmospheric circulation

Convective activity (inferred from OLR) averaged for June – September 2019 was enhanced in and around the western Indian Ocean and over the sea northeast of the Philippines, while values were suppressed from the southeastern tropical Indian Ocean to the Maritime Continent and in/around the northwestern part of Southeast Asia (Figure 5-3). OLR index data (Table 5-2) indicate that the overall activity of the Asian summer monsoon (represented by the SAMOI (A) index) was below normal except in August. The active convection area was shifted northward of its normal position other than in June and October (SAMOI (N) index) and eastward other than in August and October (SAMOI (W) index). Convective activity over India and the Bay of Bengal (Figure 5-4 (a)) was suppressed from May to July and enhanced from August to September. Convective activity over the Philippines (Figure 5-4 (b)) was suppressed from mid-May to June and from late September to October, and was enhanced from August to mid-September.

In the upper troposphere (Figure 5-5 (a)), the northwestward extension of the Tibetan High was stronger than normal and anti-cyclonic circulation anomalies straddling the equator were seen from Africa to the western Indian Ocean. Such anomalies were also seen over the western tropical North Pacific. In the lower troposphere (Figure 5-5 (b)), cyclonic circulation anomalies were seen over and around the Arabian Sea and over the southern part of the East China Sea, while anti-cyclonic circulation anomalies straddling the equator were seen over the eastern Indian Ocean. The monsoon trough over Southeast Asia was shifted northeastward of its normal position, and surface westerly winds were weaker than normal over the Bay of Bengal (Figure 5-6). Zonal wind shear between the upper and lower troposphere over the northern Indian Ocean and southern Asia (Figure 5-7) was weaker than normal from May to early June and from late September to mid-October.

(Hitoshi Sato, Tokyo Climate Center)

References

Wang, B. and Z. Fan, 1999: Choice of South Asian summer monsoon indices. *Bull. Amer. Meteor. Soc.*, **80**, 629–638.

Webster, P. J. and S. Yang, 1992: Monsoon and ENSO: Selectively interactive systems. *Quart. J. Roy. Meteor. Soc.*, **118**, 877 – 926.

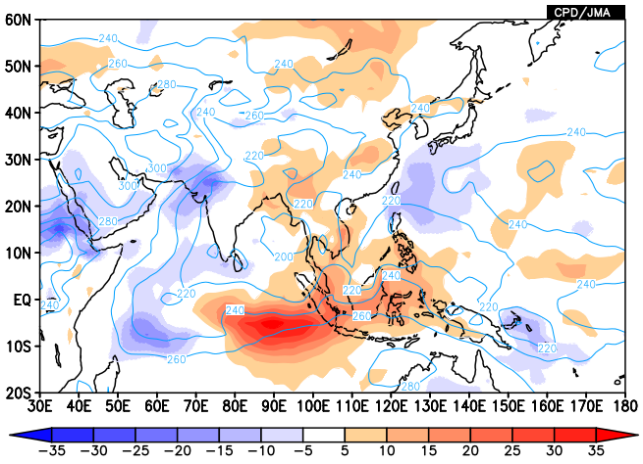
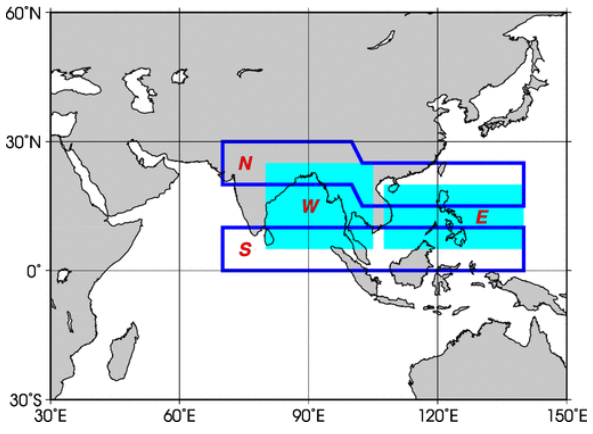


Figure 5-3 Four-month mean OLR and its anomaly (W/m^2) for June–September 2019
The contours indicate OLR at intervals of 20 W/m^2, and the color shading denotes OLR anomalies from the normal (i.e., the 1981–2010 average). Negative (cold color) and positive (warm color) OLR anomalies show enhanced and suppressed convection compared to the normal, respectively. Original data are provided by NOAA.

Table 5-2 Summer Asian Monsoon OLR Index (SAMOI) values observed from May to October 2019
Asian summer monsoon OLR indices (SAMOI) are derived from OLR anomalies from May to October. SAMOI (A), (N) and (W) indicate the overall activity of the Asian summer monsoon, its northward shift and its westward shift, respectively. SAMOI definitions are as follows: SAMOI (A) = (-1) × (W + E); SAMOI (N) = S – N; SAMOI (W) = E – W. W, E, N and S indicate area-averaged OLR anomalies for the respective regions shown in the figure on the right normalized by their standard deviations.

	Summer Asian Monsoon OLR Index (SAMOI)		
	SAMOI (A): Activity	SAMOI (N): Northward-shift	SAMOI (W): Westward-shift
May 2019	-1.8	+1.8	-1.1
Jun. 2019	-0.8	-1.5	-0.1
Jul. 2019	-1.1	+1.4	-1.3
Aug. 2019	+0.4	+0.8	0.0
Sep. 2019	-0.9	+2.8	-0.2
Oct. 2019	-1.7	-0.8	+0.8



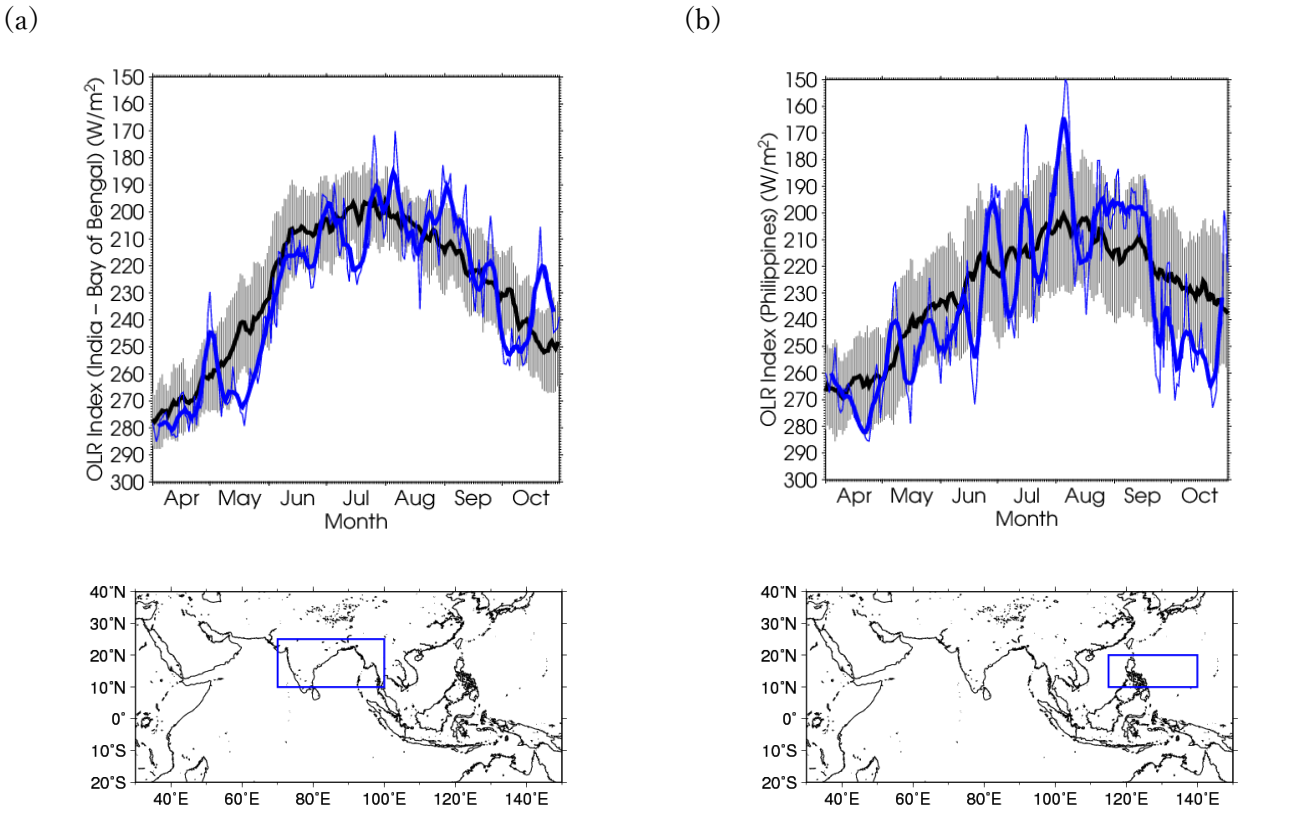


Figure 5-4 Time-series representation of OLR (W/m^2) averaged over (a) India and the Bay of Bengal (shown by the rectangle on the bottom: 10°N - 25°N, 70°E - 100°E) and (b) the Philippines (shown by the rectangle on the bottom: 10°N - 20°N, 115°E - 140°E)

The OLR indices are calculated after Wang and Fan (1999). The thick and thin blue lines indicate seven-day running mean and daily mean values, respectively. The black line denotes the normal (i.e., the 1981 - 2010 average), and the gray shading shows the range of the standard deviation calculated for the time period of the normal.

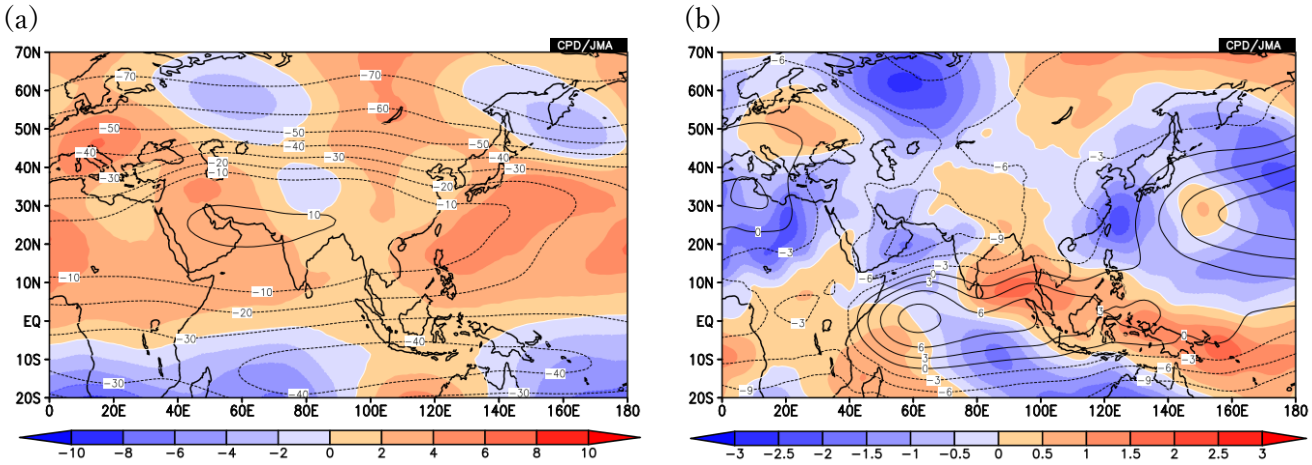


Figure 5-5 Four-month mean (a) 200-hPa and (b) 850-hPa stream function (contour) and its anomaly (color shading) (10^6 m^2/s) for June–September 2019

Contour intervals are (a) 10 × 10^6 m^2/s and (b) 3 × 10^6 m^2/s. Warm (cold) shading denotes anti-cyclonic (cyclonic) circulation anomalies in the Northern Hemisphere, and vice-versa in the Southern Hemisphere. The base period for the normal is 1981 – 2010.

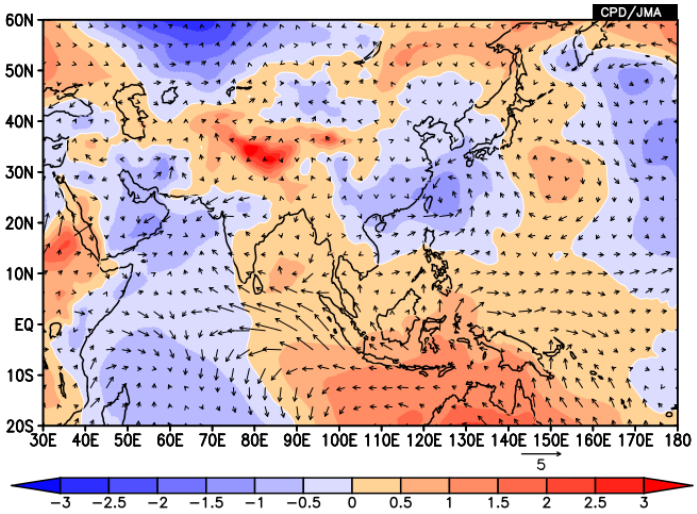
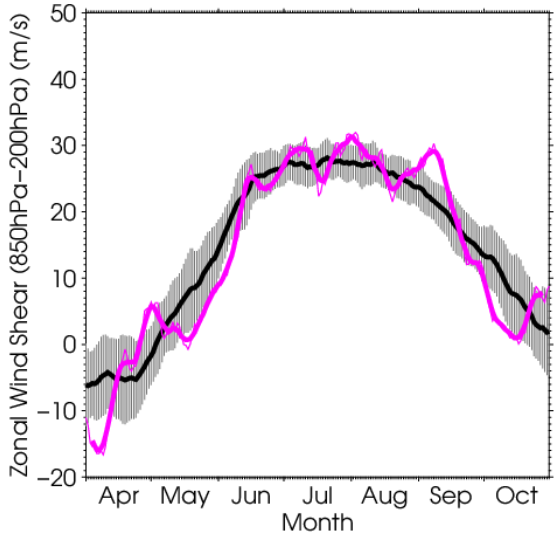


Figure 5-6 Sea level pressure anomaly (color shading) (hPa) and surface wind vector anomaly (vectors) (m/s) for June–September 2019.
The shading shows sea level pressure anomalies at intervals of 0.5 hPa. The base period for the normal is 1981 – 2010.



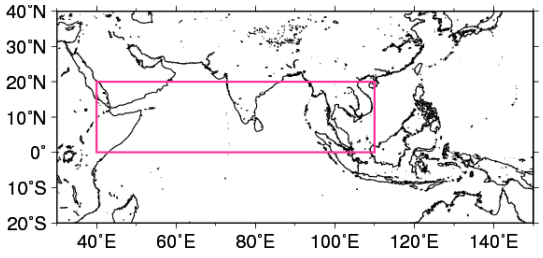


Figure 5-7 Time-series representation of the zonal wind shear index between 200-hPa and 850-hPa averaged over the northern Indian Ocean and southern Asia (the region enclosed by the pink rectangle in the right figure: equator – 20°N, 40°E – 110°E)
The zonal wind shear index is calculated after Webster and Yang (1992). The thick and thin pink lines indicate seven-day running mean and daily mean values, respectively. The black line denotes the normal (i.e., the 1981 – 2010 average), and the gray shading shows the range of the standard deviation calculated for the time period of the normal.

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