Predictive factor affecting summer monsoon onset in the Bay of Bengal and its possible mechanism

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1. Introduction

Monsoon systems show considerable temporal variability on a wide range of scales. The most important sub-seasonal phenomenon is the monsoon onset. The summer monsoon onset characterizes the start of rain season and large-scale convection, accompanied by a abrupt change of circulation. So forecasting the timing of onset is critical for agrarian ploughing and planting in the monsoon region.

Asian monsoon is the typical and important monsoon system in the world. Recent studies have also proposed that the earliest onset of the Asian summer monsoon occurs in the Bay of Bengal (BOB). BOB summer monsoon (BOBSM) affects a large range of weather and climate by teleconnection and circulation transitions.

Regional sea surface temperature (SST) in the tropic has a strong influence on monsoon onset. Jiang and Li (2011) found that an abrupt northward jump of WSSTA results in a marked change in regional meridional SST gradient and consequent onset of wind. This study provides a new idea to study monsoon onset.

We further studies on the relationship between WSSTA and BOBSM in the BOB, as well as its possible mechanism.

One of the key goals of the present study is to find a predictive factor to forecast BOBSM onset and to serve agriculture in Asia.

2. Data and methodology

✓ Datasets

NCEP/NCAR reanalysis (1982~2010)
NOAA OISST, OLR (1982~2010)

✓ Methodology

- Calculation of Warmest SST Axis (WSSTA)

First criterion: $\partial T/\partial y = 0$. Second criterion: $\partial^2 T/\partial y^2 < 0$.
Third criterion: the meridional SST maximum among all the positions which meet the two criteria in tropical Ocean.
Boundary condition: if $T_b > T_{max}$, then $T_{max} = T_b$.

- Calculation of Warmest SST Second Axis (WSSTSA)

positions which meet the first two criteria

- Three indexes that define BOBSM onset dates

u-component (U), meridional middle-upper (200-500 hPa) temperature gradient (MTG) and OLR.

3. Determination of predictive factor

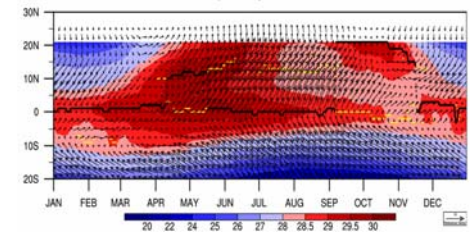


Fig. 1 Latitude-time diagram of climatological longitudinally averaged SST (° C; shading) and wind at 925 hPa over BOB, and the black solid line represents the position of the meridional SST peak, the yellow dots represent the positions of the entire meridional SST maximum.

	U	MTG	OLR	WSSTA	WSSTSA
U	1				
MTG	0.71***	1			
OLR	0.65***	0.53**	1		
WSSTA	0.66***	0.5*	0.51**	1	
WSSTSA	0.56**	0.52**	0.39	0.74***	1
Average	118	118	118	104	88
Standard deviation	11	14	12	10	12

Table 1 Correlations between time series of U, MTG, OLR, WSSTA and WSSTSA occurrence dates.
The significant correlation at the 0.05, 0.01, 0.005 and 0.001 level are marked in no star, one stars, two stars and three stars.

4. Causes of the occurrence of WSSTSA during BOBSM onset

✓ Climatological mean

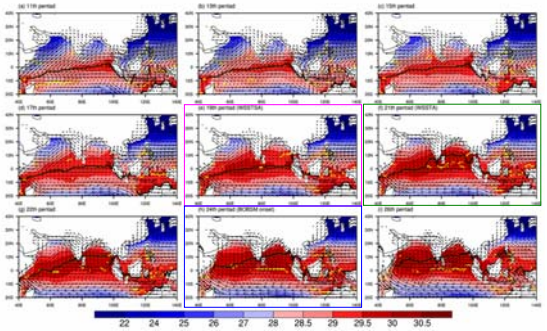


Fig. 2 Climatological pentad-mean SST (° C; shading) and wind at 925 hPa, and the black (yellow) solid lines (dots) represent WSSTA (WSSTSA).

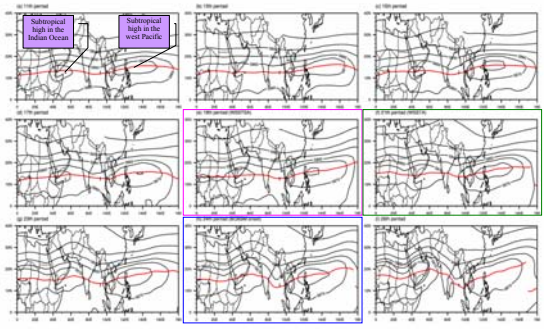


Fig. 3 Climatological pentad-mean 500 hPa geopotential height during the Bay of Bengal summer monsoon onset, and the red lines represent subtropical high ridge.

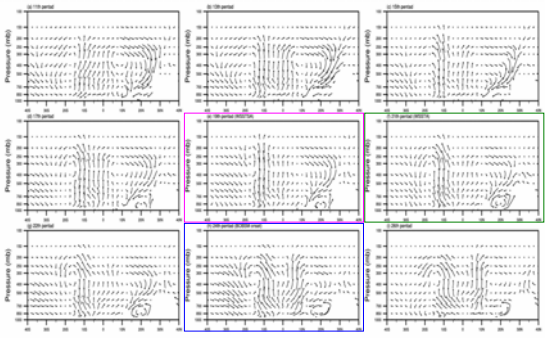


Fig. 4 Latitude-height vectorgraph of climatological pentad-mean meridional and vertical velocity during the Bay of Bengal summer monsoon onset.

5. Characteristics of the early and late occurrence of WSSTSA

✓ Composite analysis

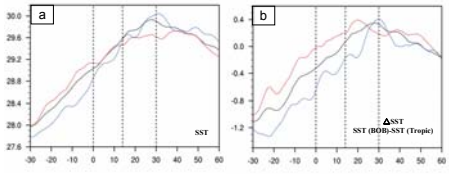


Fig. 5 Time evolution of SST over the BOB (a) and difference value of SST between the BOB and the tropical BOB (b) during the Bay of Bengal summer monsoon onset.
The first vertical dashed line represents the occurrence date of WSSTSA, the second vertical dashed line represents the occurrence date of WSSTA, and the third vertical dashed line represents the onset date of BOBSM.
The black solid line represents climatological mean, the red line represents earlier occurrence years of WSSTSA, and the blue line represents later occurrence years of WSSTSA.

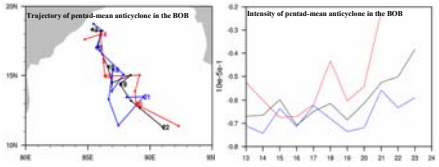
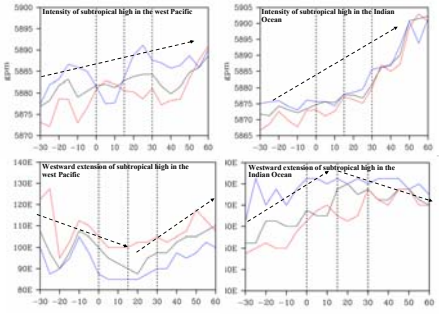
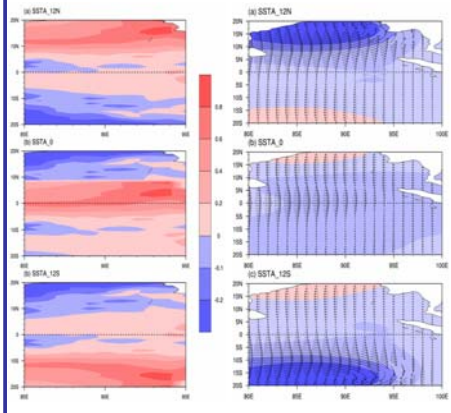


Fig. 6 Time evolution of Trajectory and intensity of pentad-mean anticyclone in the BOB.



As for Fig. 5, but for intensity and westward extension of subtropical high in the west Pacific and in the Indian Ocean.

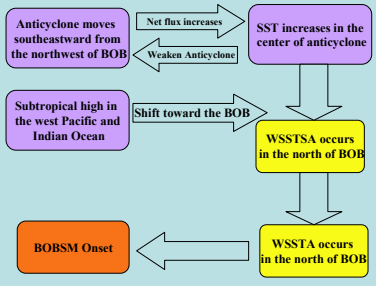
6. Numerical experiments to verify priming action of the jump of WSSTA



Left: Heating anomalies, SSTA (shading). Right: Gill model results, wind and sea level pressure (shading).

7. Conclusion Remarks

1. The occurrence dates of WSSTSA have significant positive correlations with the dates of BOBSM onset.
2. A possible mechanism between WSSTSA and BOBSM onset



3. Intensity of circulation systems in early years of BOBSM onset are relatively weak.