



## Southwest monsoon onset dates over Malaysia and associated climatological characteristics

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### ABSTRACT

In Malaysia precipitation prevails throughout the year. However, the southwest monsoon (late May to September) is characterised with low precipitation, less cloud, high outgoing long-wave radiation (OLR) and often featured by dry epochs. Therefore, onset of the monsoon here is best determined by considering multiple onset parameters such as wind, OLR, rainfall and relative humidity. We used modified Malaysian Meteorological Department wind shear index based on major convection centres during the monsoon onset. The 850 hPa winds were chosen to investigate the onsets of the monsoon in view of the marked orographic and mesoscale processes. The next criterion was the presence of sustained westerlies averaged between 850 hPa and 600 hPa from all the available radiosonde stations data over Malaysia for at least 5 days. As the strongest convective activity in the tropics is represented by OLR of less than  $220 \text{ W m}^{-2}$ , the third criterion was to check whether the value of OLR was greater than  $220 \text{ W m}^{-2}$  over the region. The mean date of the summer monsoon onset over Malaysia is found to be 19 May, with a standard deviation of 8 days. Further, climatological composites show that there is a gradual change from easterlies to westerlies from the surface up to 500 hPa in Malaysian stations both in Peninsular Malaysia and East Malaysia during May. OLR and rainfall analysis reveal that, the southwest monsoon daily rainfall over Malaysia is less than 10 mm and OLR is greater than  $220 \text{ W m}^{-2}$ . Additionally, monsoon onset tends to be late during the El Niño years and earlier during the La Niña years.

### 1. Introduction

Malaysia, being surrounded by the Andaman Sea to the west, the South China Sea (Fig. 1), the Sulu Sea and Celebes Sea to the east, is subjected to the seasonal rhythm of the Asian winter and summer monsoons in consonance with the temporal influence and variation of large-scale differential land-sea heating in the Asia continent. However, Malaysia, being in the Maritime Continent, experiences a wet monsoon during boreal winter and a relatively dry season during boreal summer (Chang et al., 2005). Even though the onset of the southwest monsoon over the South China Sea and Malaysia is not as spectacular as that over the Indian subcontinent and in the East Asian region, its uniqueness lies in its simultaneous onset commencement across a large latitudinal belt from  $3^\circ \text{ N}$  to  $20^\circ \text{ N}$  (Wang et al., 2004). Therefore, Ta Tao and Chen (1987) and Lau and Yang (1997) suggest that onset of the southwest monsoon in this region can be considered as the pre-cursor to the

southwest monsoon onset in the East Asian region.

Determination of the southwest monsoon onset dates and a generally accepted definition of the onset criteria are necessary to assess the extent, impact and the interannual variabilities of the monsoon due to its substantial socioeconomic consequences in the country. For example, during a significant warm phase of the El Niño-Southern Oscillation, forest fires in the neighbouring country are known to cause severe transboundary haze towards Malaysia (Lim and Ooi, 1998, Nichol, 1997, 1998), threatening health and water supply as well as disrupting transport activities. Also, onset criteria based on indices would help to facilitate studies on the monsoon variability and to assess the capability of mesoscale and climate models in simulating and predicting the monsoon variability (Wang and Fan, 1999). Cook and Buckley (2009) and Lin and Luo (2017) employed an easy, objective and applicable approach to determine the timing of the summer monsoon onset and withdrawal in the South China Sea. However, to date,

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