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Climate extremes in Malaysia and the equatorial South China Sea

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ABSTRACT

The southern extent of the South China Sea (SCS) is an important natural resource epicenter for Malaysia which experiences climate extremes. This paper documents the variability of extremes in the equatorial SCS through selected ground-based observations of precipitation in Malaysia and ship-based observations of wind data in the Maritime Continent region, to elucidate the interrelationship between precipitation variability over Malaysia and wind variability over the ocean. The data have been carefully inspected and analyzed, and related to the real-time multivariate Madden–Julian Oscillation (MJO) time series. The analysis suggests that the northeast or boreal winter monsoon dominates extreme rainfall in eastern Malaysian cities. Further, the west coast of Peninsular Malaysia and Borneo Malaysia are affected by the MJO differently than the east coast of Peninsular Malaysia. From the wind analysis we found that average zonal wind is westerly from May to September and easterly from November to April. When the active (convective) phase of the MJO is centered over the Maritime Continent, the strong westerly wind bursts are more frequent in the South China Sea. While more investigation is needed, these results suggest that the status of the Madden–Julian Oscillation can be used to help forecast climate extremes in areas of Malaysia.

1. Introduction

The southern extent of the South China Sea (SCS) is an important natural resource for Malaysia in regards to fisheries, recreation and tourism, commerce, and oil production. The SCS also communicates tropical climate variability to Malaysia through extreme weather. This region is influenced by the intraseasonal mode of climate variability, often expressed as the Madden–Julian Oscillation (MJO), which has a time scale of 30–90 days. A better understanding of the MJO is important as it can affect extreme weather over the Indian Ocean and the Maritime Continent region (Kajikawa et al., 2003).

Recent studies have examined the climatology and low frequency variability of precipitation over Malaysia (Tangang, 2001; Tangang and Juneng, 2004) as determined by 12 monthly gauge stations. Tangang and Juneng (2004) found wet conditions in Malaysia during December–January–February are accompanied by a large cyclonic circulation to the northeast, which is related to westerly winds and anomalously low temperatures at the surface of the equatorial South China Sea. A recent study demonstrated that extreme precipitation events, including the worst floods in southern Peninsular Malaysia, are associated with strong northeasterly winds over the South China Sea (Tangang et al., 2008). Daily precipitation from 10 gages over Peninsular Malaysia were fit to distribution models for characterizing wet and dry spells (Deni et al., 2008). While this work is important for hydrologic modeling applications, the study did not attribute the wet and dry spells to climate. Cyclones are most prevalent in the South China Sea in November–December and often originate near Malaysia (Zuki and Lupo, 2008). Further, most cyclonic disturbances are found near the coastal area of Borneo (Chang et al., 2005). Finally, individual cases of extreme rainfall have been studied, for example the 9–11 December 2004 synoptic event (Juneng et al., 2007). Juneng et al. (2007) state "Forecasting these extreme events is difficult and often inaccurate leading to end-users not taking the forecasts seriously. Thus, investigations of these weather systems are not only of scientific but also practical importance."

There are several large-scale disturbances that usher in extreme weather to the South China Sea, namely the Borneo vortex, northeast cold surge, and Madden–Julian Oscillation (Chang et al., 2005). The Madden–Julian Oscillation (MJO) is characterized by eastward moving centers of enhanced and suppressed convection with a periodicity of 30–60 days (Madden and Julian, 1972). The MJO is especially strong through the equatorial South China Sea and Maritime Continent region (Chang et al., 2005), as compared with the Arabian Sea and the Bay of Bengal (Kajikawa and Yasunari, 2005). The presence of the MJO acts to inhibit cold surges and vortex days, resulting in abundant precipitation over Malaysia followed by westerly winds in the equatorial South China Sea (Chang et al.,

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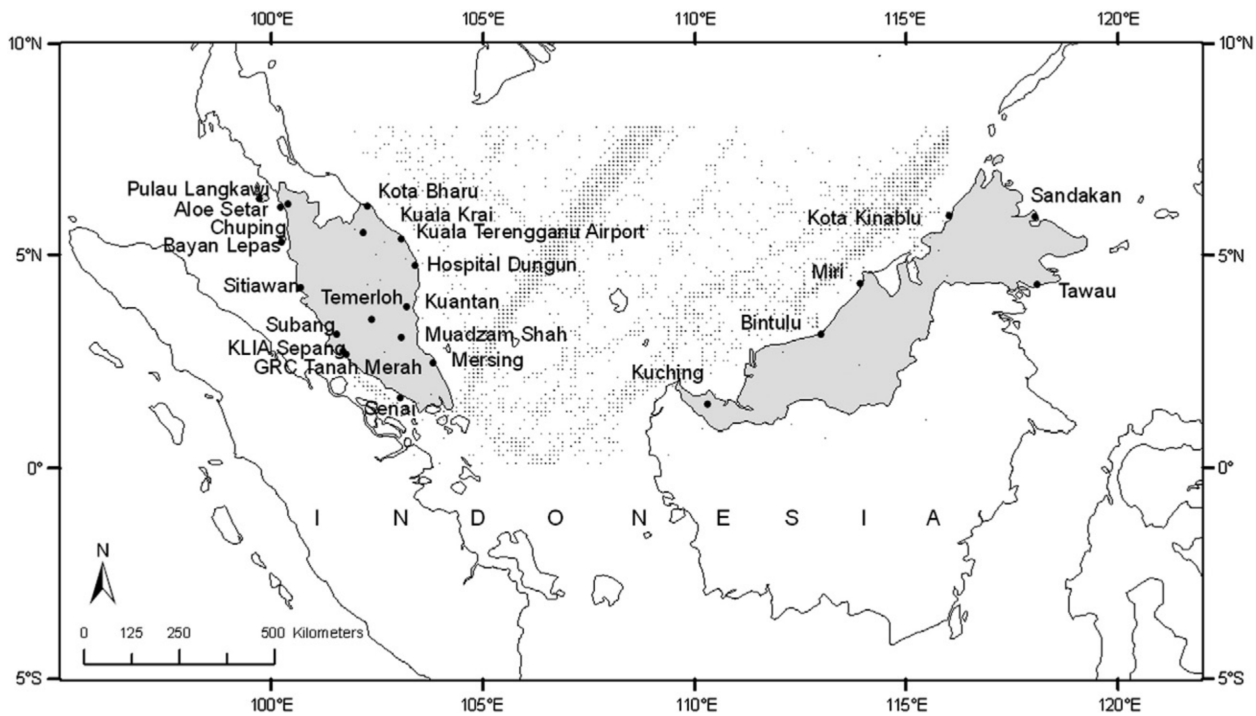

Fig. 1. Malaysian rainfall stations and a sample year (1998) of ship observations.

2005; Straub et al., 2006). The westerly wind anomalies are often short-lived, but extreme and known as "westerly wind bursts" (WWB). Previous WWB climatologies have been developed for the western Pacific (Harrison and Vecchi, 1997) and Indian Ocean (Curtis et al., 2004), but not the southern South China Sea.

The purpose of this study is to further characterize the inter-relationships between precipitation variability over Malaysia and wind variability over the ocean using comparatively high resolution surface data sets. In particular, means, standard deviations, and upper-percentiles are computed and mapped, precipitation and wind are related to the MJO, and westerly wind bursts are quantified.

2. Materials and methods

In this study we analyze ground-based observations of precipitation and ship-based observations of wind data in the Maritime Continent, to elucidate the linkage between extremes in these variables and the MJO. We chose to focus on the MJO because it is an equatorial feature (and our data is all equatorward of 8° N) and has been studied less than other synoptic features in the region (e.g. northeast cold surges, Borneo vortex, and tropical cyclones). Previous studies have used reanalysis winds to understand the wind disturbances associated with El Nino events from the eastern Indian Ocean to the Pacific Ocean, however there are some serious deficiencies in the reanalysis data in this part of the world (Goswami and Sengupta, 2003). In this study we used observed wind data derived from the marine surface observations recorded by ships that participated in the World Meteorological Organization Voluntary Observing Ships Scheme, oilrigs/oil platforms and light houses that are located in the Malaysian waters. The wind data are not adjusted to the 10 m standard height. The Malaysia Meteorological Department provided 32 years (1976 to 2007) of hourly wind observations in the domain 0–8° N and 102–116° E. The primary trade routes are evident from a year's worth of observations in Fig. 1. An index of the zonal component (u) of wind was computed by multiplying the wind speed by the negative of the sine of the wind direction. A daily zonal wind index was created by averaging all hourly observations in the SCS domain for each day. Averaging over these time and space scales is consistent with other studies of WWBs (Harrison and Vecchi, 1997; Curtis et al., 2004). The overall mean of u ($\bar{u}$) was −0.77 knots. The

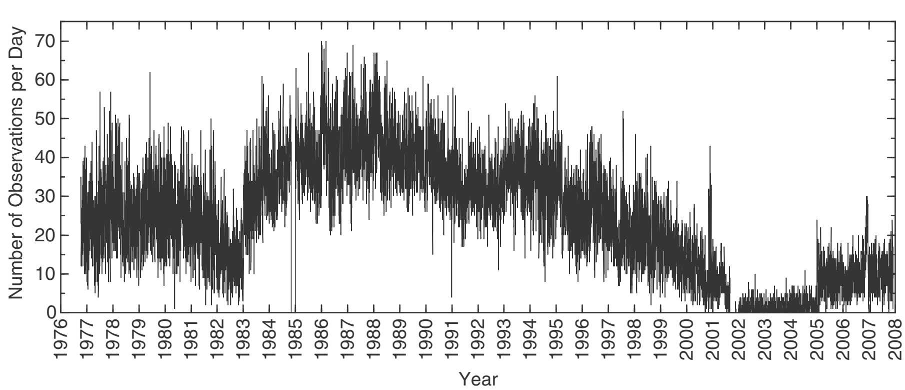

Fig. 2. Counts of hourly ship observations per day in the South China Sea (0–8° N and 102–116° E).