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Thermodynamic and dynamic structure of atmosphere over the east coast of Peninsular Malaysia during the passage of a cold surge

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ABSTRACT

An intense field observation was carried out for a better understanding of cold surge features over Peninsular Malaysia during the winter monsoon season. The study utilizes vertical profiles of temperature, humidity and wind at high vertical and temporal resolution over Kota Bharu, situated in the east coast of Peninsular Malaysia. LCL were elevated during the passage of the cold surge as the relative humidity values decreased during the passage of cold surge. Level of Free Convection were below 800 hPa and equilibrium levels were close to the LFC in most of the cases. Convective available potential energy and convection inhibition energy values were small during most of the observations. Absence of local heating and instability mechanism are responsible for the peculiar thermodynamic structure during the passage of the cold surge. The wind in the lower atmosphere became northeasterly and was strong during the entire cold surge period. A slight increase in temperature near the surface and a drop in temperature just above the surface were marked by the passage of the cold surge. A remarkable increase in specific humidity was observed between 970 and 900 hPa during the cold surge period. Further, synoptic scale features were analyzed to identify the mechanism responsible for heavy rainfall. Low level convergence, upper level divergence and cyclonic vorticity prevailed over the region during the heavy rainfall event. Dynamic structure of the atmosphere as part of the organized convection associated with the winter monsoon was responsible for the vertical lifting and subsequent rainfall.

1. Introduction

The Asian winter monsoon plays a vital role in all activities in the Maritime Continent. The winter monsoon over the Maritime Continent has a peculiar behavior associated with the formation of intermittent cold surges. Usually cold surges are formed during November to February with maximum intensity in January (Cheang, 1980). Chang et al. (2006) brought out an elaborate review on the role played by the cold surges on the East Asia winter monsoon. They described the formation of cold surges as a result of strengthening and southeastward movement of the Siberian–Mongolian High (SMH), which leads to an increase of northeasterly wind and a decrease of surface temperature to the east and south of the SMH. Outbreaks occur with an extension of the SMH to the southeast or a split of the high pressure area that moves to the southeast coast of China (Lim and Chang, 1981; Chan and Li, 2004; Chan, 2005). In early September, the Siberian–Mongolian High (SMH) builds up and becomes intense by November. Cold air emanating from the SMH affects the South China and Indo-China in early October and the central South China Sea by late October. When the event progresses rapidly southward and affects the tropics, particularly in the vicinity of the South China Sea, the weather system is referred as a cold surge.

The development of a cold surge starts with the building up and subsequent southeastward extension or split of the SMH pressure area. The center of the SMH either moves southeastward (Ding and Krishnamurti, 1987; Zhang et al., 1997) or remains nearly stationary but with packets of cold air propagates eastward in conjunction with small high pressure or anticyclonic centers (Wu and Chan, 1995; Chan and Li, 2004). Jeong et al. (2006) found a precursory signal in the stratospheric circulation prior to the formation of the cold surge in East Asia. They found strong stratospheric negative potential vorticity anomalies and rising of geopotential height over northern Eurasia about one week before the cold surge occurrence. Changes in upper tropospheric circulations over Siberia are favorable for the formation of cold surges. When northwesterly forms in the vicinity of Lake Baikal that is associated with an upper level wave, the situation causes the formation of a surge over southern coast of China by 1 to 2 days

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