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Intraseasonal and interannual variability of the winter monsoon cold surges over the South China Sea (SCS) and its relationship to convection over southern SCS

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The southern South China Sea (SCS) and the east coastal areas of Peninsular Malaysia and the state of Sarawak in Borneo Island receives substantial amounts of precipitation during the winter monsoon season. Much of this rainfall comes in episodes, which are associated with monsoon wind surges over central SCS that are driven by cold air outbreaks from the Siberian High (SH). In this study the intraseasonal and interannual variability in the pressure surges, wind surges, intensity of the meridional overturning and convection is examined using 32 years of daily gridded reanalysis data (JRA25) of the Japan Meteorological Agency for the period 1 November to 28 February. The strongest wind surges close to the surface are observed over central SCS and the wind speed averaged over this region is used as the cold surge index (CSI), with CSI exceeding 10m/s being recorded as a surge having occurred. It is found that the first surge normally occurs around the middle of November and the number of surges varies from 3 to 12 with an annual average of 7. During El Niño years the number of surges are fewer with an average of 5 to 6 and more during La Niña years with an average of 8 to 9 per year respectively. Precursor to the strengthening in wind speed is the strong pressure gradient buildup between the SH and southern China and the lag is about 2 to 3 days. Spectral analysis of the daily CSI and MSLP shows significant variation in the intensity and frequency of the intraseasonal oscillation (ISO) from year to year. For the SH the strongest signal is noted during El Niño years at periods between 10 to 35 days and a weaker weekly oscillation. Whereas during La Niña years the significant signals are observed in the time period of 15 to 30 days and another at 6 to 8 days. The oscillation in the CSI follows closely the SH MSLP during the La Niña years but during El Niño years a single peak at the submonthly periods (13 to 20 days) is observed. During the neutral ENSO years the oscillation is spread out over 10 to 30 day periods in both the CSI and SH MSLP. Relative vorticity over southern SCS gets strengthened during cold surges and it is observed that they are closely in phase with the CSI. In direct response the convective activity as depicted by OLR anomalies shows similar intraseasonal fluctuations with the La Niña years showing strong signals in the 20 to 40 day and 6 to 10 day periods, whereas during El Niño years the signals are weaker with significant signal in the period of 12 to 20 days. In examining the contribution of the SH, cold surge and the strong convection near the equator the intensity of the local Hadley circulation computed using the divergent wind at 200 hPa level shows a strong signal centered around 25 days with the variance being higher during El Niño years and weakest during La Niña years. On the interannual time scale the MSLP over Siberia has a strong signal in the 2 to 3 year period and the pressure over southern China has a 3 to 4 year period, which is almost in phase with the cold surge and the relative vorticity in the SCS on this time scale. However the convective activity over this region has a strong signal in the 8 to 15 year period and a quasi-biennial oscillation, which is not in tandem with the other indices. On the other hand the intensity of the local Hadley circulation has prominent signals centered at 2.5 years and 5 years and is not in phase with surface indices.