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Tropical ISO and Extratropical Extreme Weather during the 2009-2011 ENSO Cycle

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The tropical intraseasonal oscillation (ISO) shows distinct variability centers and propagation patterns between boreal winter and summer. To accurately describe and monitoring the state of the ISO at any particular time of a year, a *bimodal ISO index* is used. It consists of Madden-Julian Oscillation (MJO) mode with predominant equatorial eastward propagation and Boreal Summer ISO (BSISO) mode with prominent northward propagation and large variability in off-equatorial monsoon trough regions. The spatial-temporal patterns for the MJO and BSISO modes are identified with the extended empirical orthogonal function analysis of 31 years (1979-2009) OLR data for the December-January-February and June-July-August period, respectively. The details are referred to Kikuchi *et al.* (2010). The dominant mode of the ISO at any given time can be judged by the proportions of the OLR anomalies projected onto the two modes. The proposed bimodal ISO index provides objective and quantitative measures on the annual and interannual variations of the predominant ISO modes. From December through April the MJO mode dominates while from June through October the BSISO mode dominates. May and November are transitional months when the predominant mode changes from one to the other (Fig. 1). The fractional variance reconstructed based on the bimodal index is significantly higher than the counterpart reconstructed based on the Wheeler and Hendon's index (Wheeler and Hendon 2004). The bimodal ISO index provides a reliable real time monitoring skill. The method and results provide critical information in assessing models' performance to reproduce the ISO and developing further research on predictability of the ISO and are also useful for a variety of scientific and practical purposes.

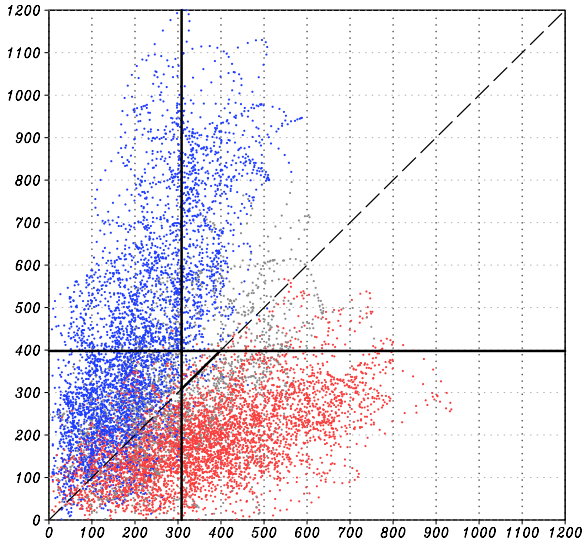

Fig. 1 Scatter plot of ISO amplitude in terms of the BSISO mode (x-axis) and the MJO mode (y- axis) for the period 1979–2009. Solid lines parallel to the x and y axes represent one standard deviation of each ISO mode during the period each EEOF analysis was performed. Dashed line represents the situation when both the MJO mode and the BSISO mode have the same variance. Three seasons are marked by different colors (June–October in red, December–April in blue, otherwise in gray).

The tropical ISO during the past ENSO cycle (December 2009 to August 2011) is analyzed using the bimodal index. The DJF 2009/2010 is a mature phase of El Niño while the DJF 2010/2011 is a mature phase of La Niña. The JJA 2010 is a developing phase of La Niña while the JJA2011 is a decaying phase of La Niña. Due to strong regulation of the ENSO, the MJO is amplified during DJF 09/10 at the El Niño mature phase, while

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suppressed during DJF 10/11 when the La Niña matures (Fig. 2).

The pulsation of the strong MJO during the winter of 2009/10 had strongly modulated the winter storms in the United States through an atmospheric teleconnection, resulting in a number of record-breaking snowfall events registered in the eastern United States (Moon *et al.* 2011). The intraseasonal variation of OLR had reached maximum strength over the eastern subtropical Pacific near Mexico and the second largest over the equatorial central Pacific since 1979/80. The convection over these two regions experienced a remarkable wet-dry-wet cycle during the 60-day period from late December to mid-February; correspondingly, the daily snowfall over the eastern US exhibited a cohesive wet-dry-wet cycle (Fig. 3). As the MJO convection reached the central Pacific, a teleconnection pattern extends to North America, resulting in a westward-tilted deep anomalous trough anchored over the eastern US, producing a low-level

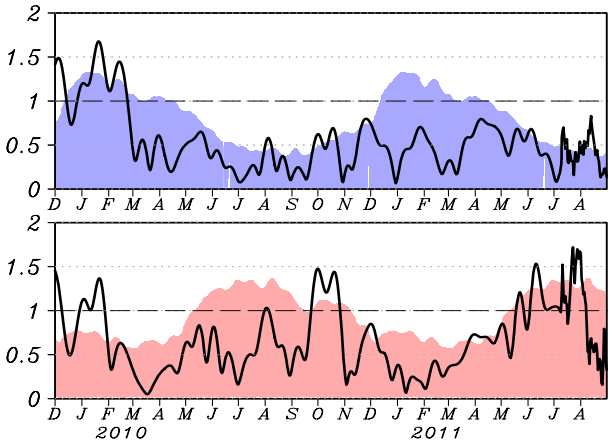

Fig. 2 Bimodal description of the tropical ISO for the period December 2009 to August 2011. The upper and lower panels show the amplitudes of the MJO and BSISO modes, respectively. The shading represents climatological annual cycle. Note the large amplitude of MJO during DJF 2009/2010.

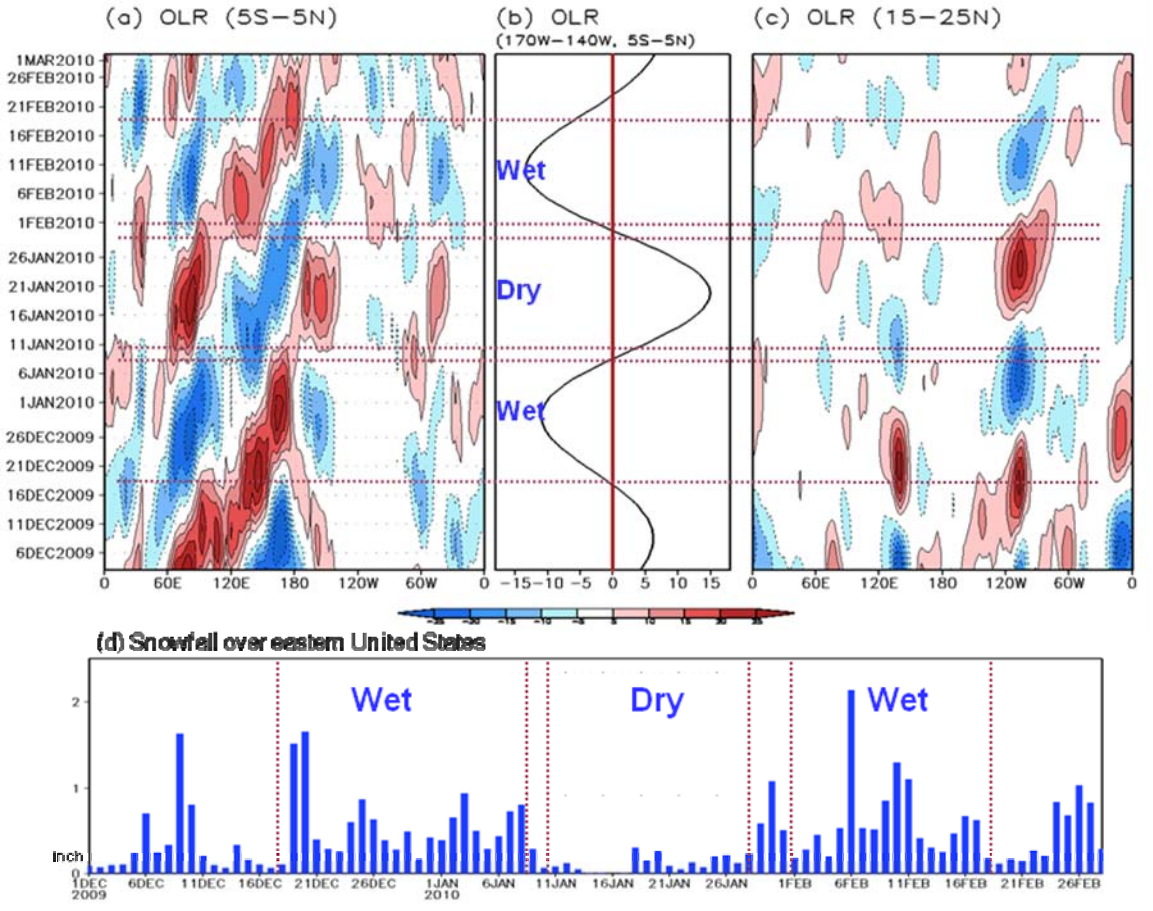

Fig. 3 MJO during DJF 2009/10 and snowfall in eastern US. (a) 30-60 day OLR anomalies along the equator (5ºS-5ºN) as a function of time. (b) Time series of the 30-60 day OLR anomalies averaged over the equatorial central Pacific (5ºS-5ºN, 170ºW-140ºW). (c) The same as in (a) except along the band between 5ºN and 15ºN. (d) snowfall amount averaged over the eastern US.

pressure dipole anomaly with an anticyclone (cyclone) centered at the US west (east) coast (Fig. 4). The convection over the Indian Ocean varied in phase with the central Pacific convection, reinforcing the extratropical atmospheric teleconnection pattern. As a result, the enhanced high-latitude cold air penetrated southward, affecting the central and eastern US. Meanwhile, warm moist air was transported from the tropical central Pacific through Mexico to the southern US along with the upper-level subtropical westerly jet. These enhanced warm moist air from the tropics and the cold air transportation from the high-latitude are also supported by the existing El Niño and negative AO (NAO), respectively, which reinforced the MJO teleconnection over the eastern US during wet cycle. As such, the eastern US was located in a convergence zone between the enhanced cold air from the high-latitude and the warm moist air supplied from the subtropics, resulting in favorable conditions for extremely heavy snowfall.

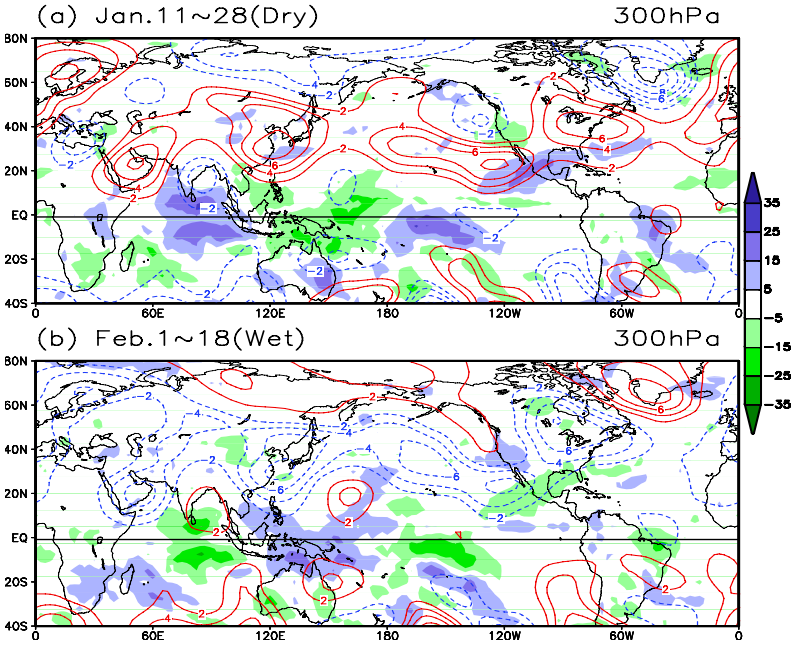

Fig. 4 Intraseasonal anomalies of OLR and 300hPa streamfunction on the days when convection over the tropical central Pacific in (a) dry and (b) wet phases. The OLR is shaded. The 300hPa streamfunction is drawn in contour.

During the La Niña development summer, *i.e.*, JJA 2010, the BSISO is generally weak except one event in October 2010, which is related to a supper typhoon activity in the western North Pacific. During the La Niña decaying phase (JJA 2011), the BSISO activity tends to be normal. There was a strong event in June 2011. This event had caused flooding conditions over the Meiyu-Baiu front in East Asia. Seoul also experienced unusual floods.

References

Moon, J-Y, B. Wang, and K.-J. Ha, 2011: ENSO regulation of MJO teleconnection. *Climate Dynamics*. In press.

Kikuchi, K., B. Wang, and Y. Kajikawa, 2011: Bimodal representation of the tropical intraseasonal oscillation. *Clim Dyn*, DOI 10.1007/s00382-011-1159-1

Wheeler, Matthew C., and Harry H. Hendon, 2004: An all-season real-time multivariate MJO index: Development of an index for monitoring and prediction. *Mon. Wea. Rev.*, **132**, 1917-1932.