2015/16 winter monsoon in East Asia

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2015/16 winter monsoon (from December 2015 through February 2016) in East Asia was weaker than normal in general as the past winters when El Niño events persisted. However, monthly mean temperature anomalies were quite different month by month. In particular, while it was warmer than normal in the most parts of East Asia in the first half of the winter, the wide area of East Asia experienced significant cold surge in late January 2016. The primary factors of the weak winter monsoon and the cold surge were examined as follows.

In the first half of the winter, the subtropical jet stream meandered southward of its normal position around southern China and northward around Japan. In the lower troposphere, temperatures were above normal in most of Siberia, and besides, the Siberian High was weaker than normal and high pressure anomalies were seen to the east of Japan, resulting in the weaker winter monsoon in East Asia. The Arctic Oscillation (AO) was in its positive phase in general. Additionally lower-level southerly wind anomalies were enhanced around the anticyclonic anomalies over the Philippines.

The suppressed convective activity around the Maritime Continent associated with the matured El Niño event is presumably one of the primary factors having contributed to the jet stream meandering and the anticyclonic circulation anomalies in the lower troposphere both around the Philippines and the seas east of Japan. In addition, Rossby wave propagation along the subtropical jet stream enhanced the meandering. Furthermore cold air tended to be trapped within the polar region associated with the positive AO.

In contrast, temperatures drastically fell over the wide area in East Asia in late January 2016 by a significant cold surge. It was suggested that cold air mass broke out of the north polar region after AO changed its polarity to negative phase in early January 2016 and then cold air streamed southward to bring this cold surge. This interpretation is based on the isentropic analysis technique of polar air mass stream based on Iwasaki *et al*. (2014), which enables diagnosis of the geographical distribution of cold air stream quantitatively. In terms of cold air mass flux passing through a latitude/longitude box of 30ºN-40ºN by 110ºE-130ºE, the intensity of the southward cold air stream of this event was the most significant at least since 1981/82 winter.

The cause of this cold surge is an amplification and extension of the cold Siberian High. A few days before the cold surge event, a wave train pattern in the upper troposphere had been clearly seen over northern Eurasian Continent accompanying a blocking high over Western to Central Siberia (around 90ºE). As the blocking high evolved, the surface Siberian High was amplified and extended southeastward to East Asia. This relation between the upper-level blocking high and amplification of the surface Siberian High can be understood by using potential vorticity (PV) inversion technique (Takaya and Nakamura 2005), which suggests that negative (anticyclonic) PV anomalies at upper level induce surface anticyclonic anomalies through vertical coupling. In this case, surface pressure anomalies estimated from PV inversion technique were comparable to observed anomalies.

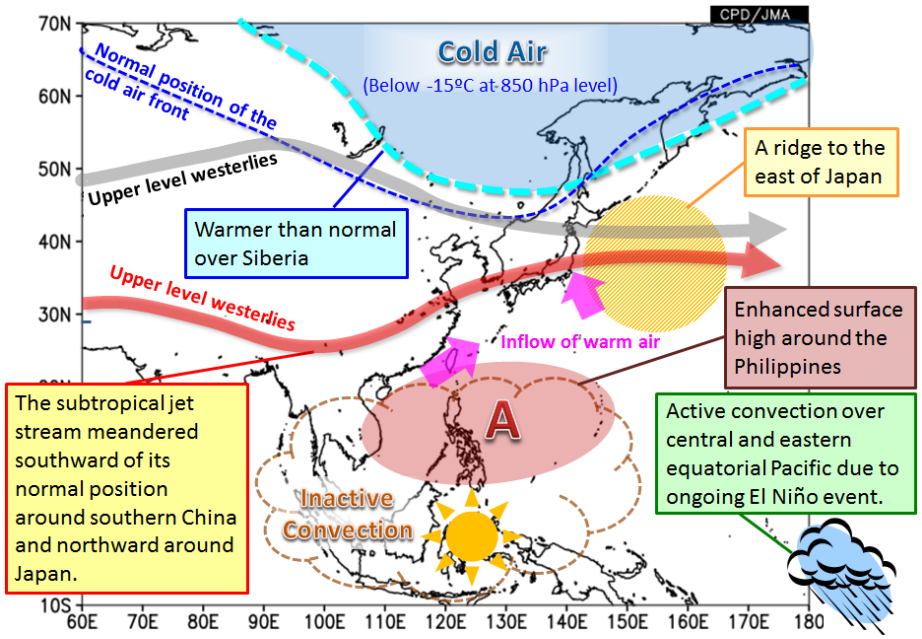
Possible primary factors contributing to (a) the weaker monsoon in the first half of the winter and (b) the cold surge in late January 2016 are summarized below.

References

Iwasaki, T., T. Shoji, Y. Kanno, M. Sawada, M. Ujiie, and K. Takaya, 2014: Isentropic analysis of cold air mass stream in the Northern Hemispheric winter. *J. Atmos. Sci.,* **71,** 2230-2243, doi:10.1175/JAS-D-13-058.1.

Takaya, K., and H. Nakamura, 2005: Mechanisms of intraseasonal amplification of the cold Siberian high. *J. Atmos. Sci.*, **62,** 4423-4440, doi:10.1175/JAS3629.1.

(a) Weak monsoon in the first half of 2015/16 winter



(b) A cold surge in late January 2016