Online Supplemental Material

Asymmetric relationships between El Niño/La Niña and floods/droughts in the following summer over Chongqing, China

Bo Xiang, Jie Zhou and Yonghua Li

Chongqing Climate Center, Chongqing, China

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Supplementary Text S1, Figures S1–S6

Text S1 Atmospheric circulation characteristics in typical drought and flood years over Chongqing

Figure S2 presents the sequence of regional precipitation index for Chongqing. According to the rank of the index values, five flood years (1998, 1982, 2007, 1980, and 1983) and five drought years (2006, 1961, 1990, 2001, and 1966) are selected as typical drought and flood years for the subsequent analysis. Can the regional precipitation index represent the consistent changes in precipitation throughout the entire region? Figure S3 shows the distribution of the correlation between the regional precipitation index for Chongqing and the concurrent precipitation at 34 stations throughout this region. Generally, the regional precipitation index in summer for Chongqing is significantly positively correlated with the precipitation at all 34 stations throughout the region (passing the 0.01 significance test). That is to say, the regional precipitation index can represent the consistent changes in summer precipitation throughout the whole region.

The precipitation anomaly percentage is composited for the five typical flood years and typical drought years separately (Figure S4). For the typical flood years, there is obviously more precipitation throughout Chongqing (Figure S4(a)), whereas for the typical drought years, the precipitation is considerably less across the entire region (Figure S4(b)). Thus, the selected typical drought and flood years can represent the consistent characteristics (more or less) of regional precipitation over Chongqing.
To analyse the atmospheric circulation characteristics of typical drought and flood years in summer over Chongqing, the concurrent atmospheric circulation is composited for the five typical years and typical drought years separately (Figure S5). For the typical flood years, at 200 hPa, the East Asian subtropical westerly jet shifts southward (Figure S5(a)). At 500 hPa, the West Pacific subtropical high is stronger than normal and shifts westward and southward, which is conducive to the transport of water vapour from the Western Pacific and South China Sea towards mainland China along the edge of the subtropical high. Moreover, there are stronger blocking highs over the Ural Mountains and Lake Baikal at high latitudes, which is beneficial for the southward transport of cold air from the north (Figure S5(b)). At 850 hPa, an anomalous anticyclone is present near the Northwest Pacific (Figure S5(c)), where the peripheral southwesterly jet provides dynamic and water vapour conditions conducive for summer precipitation over Chongqing. The mutual arrangement of the atmospheric circulation in the upper, middle, and lower troposphere contributes to the remarkable increase precipitation in summer over Chongqing.

The composition for typical drought years in summer over Chongqing show that the corresponding atmospheric circulation characteristics are nearly opposite those of typical flood years in summer over Chongqing. At 200 hPa, the location of the subtropical westerly jet moves northward, along with a clear westward shift of the jet centre (Figure S5(b)). At 500 hPa, the Western Pacific subtropical high moves eastward and northward while weakening, weaker blocking highs are present over Siberia, and there is lower cold air activity over the northern region (Figure S5(e)). At 850 hPa, the anomalous southwesterly winds that control Chongqing are distinctly weakened (Figure S5(f)). Due to the impacts of this circulation, there is considerably less precipitation in summer over Chongqing.

The distribution of the correlation between summer precipitation anomalies in Chongqing and the atmospheric circulation at various levels also shows that at 200 hPa, the East Asian subtropical westerly jet moves southward (northward) (Figure S6(a)), which corresponds to more (less) summer precipitation over Chongqing (Yang, Yang, and Ma 2014). At 500 hPa, the high-pressure ridges over the Ural Mountains and Lake Baikal are stronger (weaker) (Figure S6(b)); namely, the meridionally of the circulation over the Eurasian mid-high latitudes is higher (lower), which corresponds to more (less) summer precipitation over Chongqing. The Western Pacific subtropical high shifts southward and westward and is stronger (northward, eastward, and weaker), which corresponds to more (less)
summer precipitation over Chongqing. At 850 hPa, when Chongqing is under the control of southwesterly anomalies (Figure S6(c)), there is more precipitation over this region in summer.

These characteristics are in good agreement with the composition of typical drought and flood years for summer precipitation over Chongqing analysed in the previous section. The consistent results further demonstrate that the atmospheric circulation system influencing typical drought and flood years in summer over Chongqing mainly includes the East Asian subtropical westerly jet at 200 hPa, the Ural and Lake blocking highs and the Western Pacific subtropical high at 500 hPa, and the Northwest Pacific anticyclonic circulation at 850 hPa. In typical flood years in summer over Chongqing, the subtropical westerly jet moves southward at 200 hPa, the Western Pacific subtropical high shifts westward and southward and is intensified along with stronger Ural and Baikal blocking highs at 500 hPa, and an anomalous anticyclonic circulation is present over the Northwest Pacific at 850 hPa; otherwise, the conditions are conducive to typical drought years in summer over Chongqing.

Reference
Yang X, Yang S, Ma Z. 2014. "Influence of the position of East Asian subtropical westerly jet in summer on precipitation over Sichuan-Chongqing Region." *Plateau Meteorology*, 33:384-393. [in Chinese]
Figure S1. Distribution of 34 national meteorological stations throughout Chongqing, China.

Figure S2. Anomaly of the regional precipitation index in summer for Chongqing from 1961 to 2017.
Figure S3. Spatial distribution of correlation coefficients between the regional precipitation index and summer precipitation at 34 stations in Chongqing for the period 1961–2017.

Figure S4. Composition of precipitation anomaly percentages for (a) typical flood years and (b) drought years in summer over Chongqing (unit: %).
Figure S5. Composite (a, d) 200-hPa zonal wind anomalies, (b, e) 500-hPa geopotential height anomalies and (c, f) 850-hPa wind anomalies in summer for the typical flood and drought years (a–c) are for typical flood years; (d–f) are for typical drought years.

Figure S6. The distribution of the correlation between summer precipitation anomalies in Chongqing and (a) 200-hPa zonal wind anomalies, (b) 500-hPa heights, and (c) 850-hPa winds (shaded area passes the significance test).