Coupling of the Quasi-Biweekly Oscillation of the Tibetan Plateau Summer Monsoon With the Arctic Oscillation

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Abstract

The intraseasonal variation of the Tibetan Plateau summer monsoon (TPSM) during 1979–2011 is investigated. The TPSM shows a dominant quasi-biweekly oscillation (QBWO) in most summer seasons, and its active/break phases are closely related to more/less precipitation over the Tibetan Plateau. We suggest that the TPSM QBWO is associated with a southeastward propagating nonstationary wave train in the middle and upper troposphere. It shows equivalent barotropic vertical structures over the midlatitudes and a baroclinic structure over the eastern Tibetan Plateau. Wave activity flux analysis indicates that it originates from northern Europe, which is an active center of the summertime Arctic Oscillation (AO). The AO also shows significant QBWO signals and leads TPSM QBWO by about 13 days. Phase composite and wave activity flux analyses of AO QBWO confirmed that the wave train influences TPSM QBWO, suggesting that AO plays an important role in the TPSM on a 10- to 20-day timescale.

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Objective

Previous studies have suggested that the Tibetan Plateau (**TP**) is a centre of intraseasonal variation (ISV). Our unferstanding of the TP ISV is, however, incomplete, especially for the TP summer monsoon (TPSM). **The main motivation of this study is to figure out the dominant periodicity, propagating pathway, and source area of the TPSM.**

Data and Methods

➢**Data:** Historical 6-Hourly and daily observations; ERA-Interim Reanalysis datasets; GPCP precipitation data; AO index data.

➢**Methods:** Lanczos band-pass filtering (Duchon, 1979); TPSM index defined by Tang (1995); Phase composite analysis (Mao & Chan, 2005); Phase-independent wave activity flux (W), defined by Takaya and Nakamura (2001).

Characteristics of the TPSM ISV

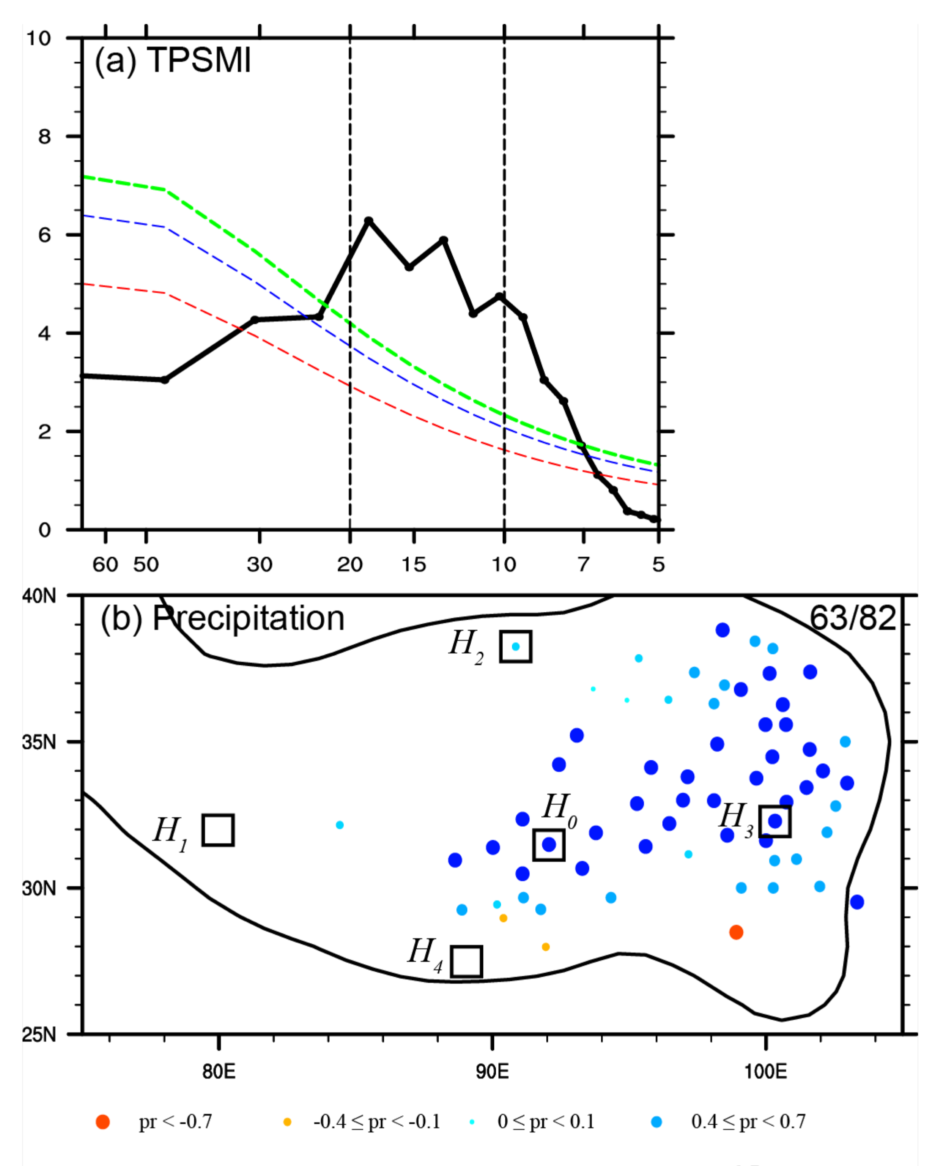
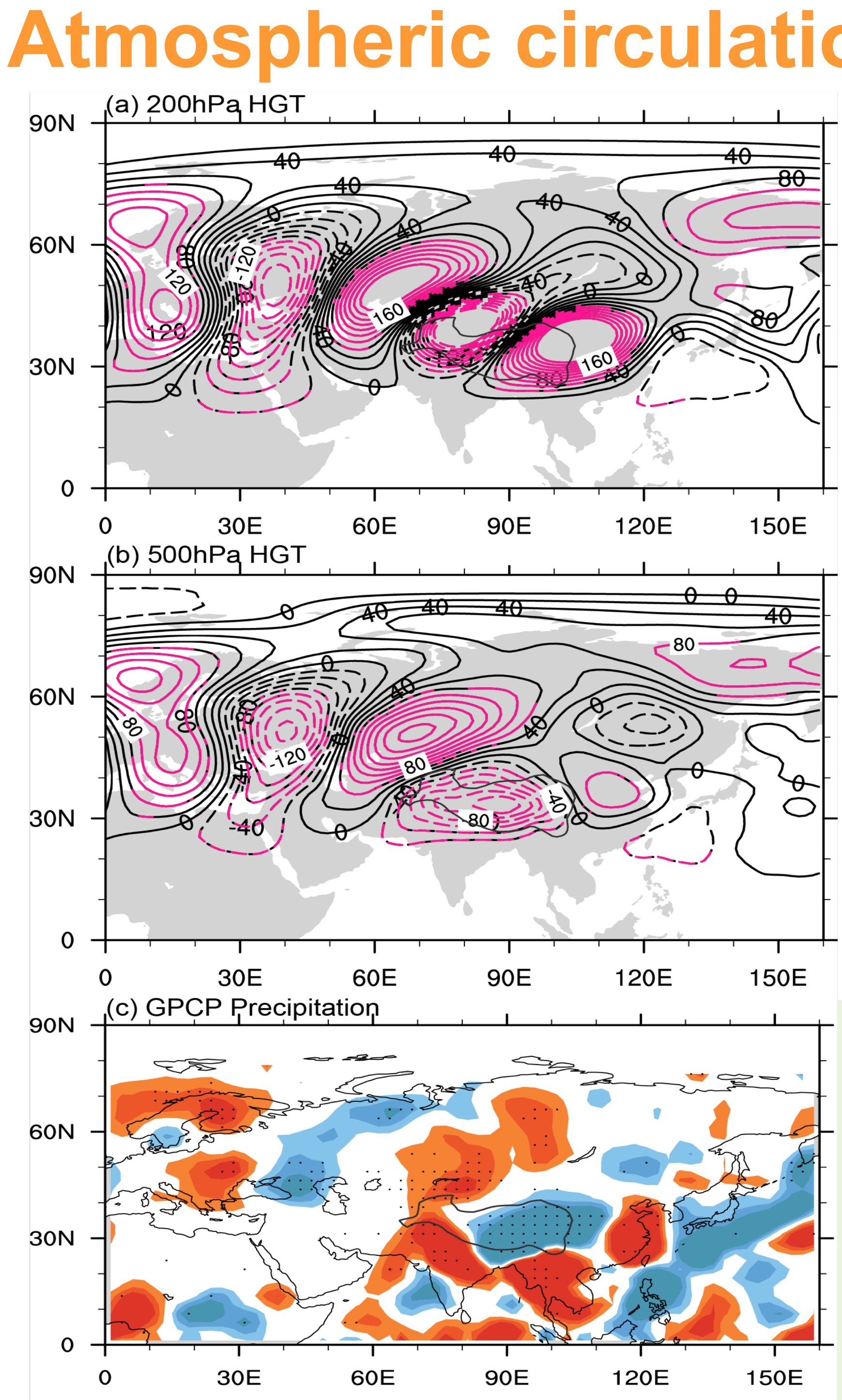


Figure 1. (a) Mean power spectra of the Tibetan Plateau summer monsoon (TPSM) index for the 33 summer seasons from 1979-2011. (b) Diference in the 10-20-day filtered observational precipitation (mm/day) over the TP between the active and break phases of the 10-20-day filtered TPSM index. The five open squares denote the stations selected to calculate the TPSM index. Sixty-three of the 82 stations with a change in precipitation that is statistically significant at the >90% confidence level are ploted. The black solid line plotted shows the region of the TP > 2000 m.

→TPSM has important effects on the patterns and variations in the local precipitation on both the climatological and QBWO timescales.

Atmospheric circulation



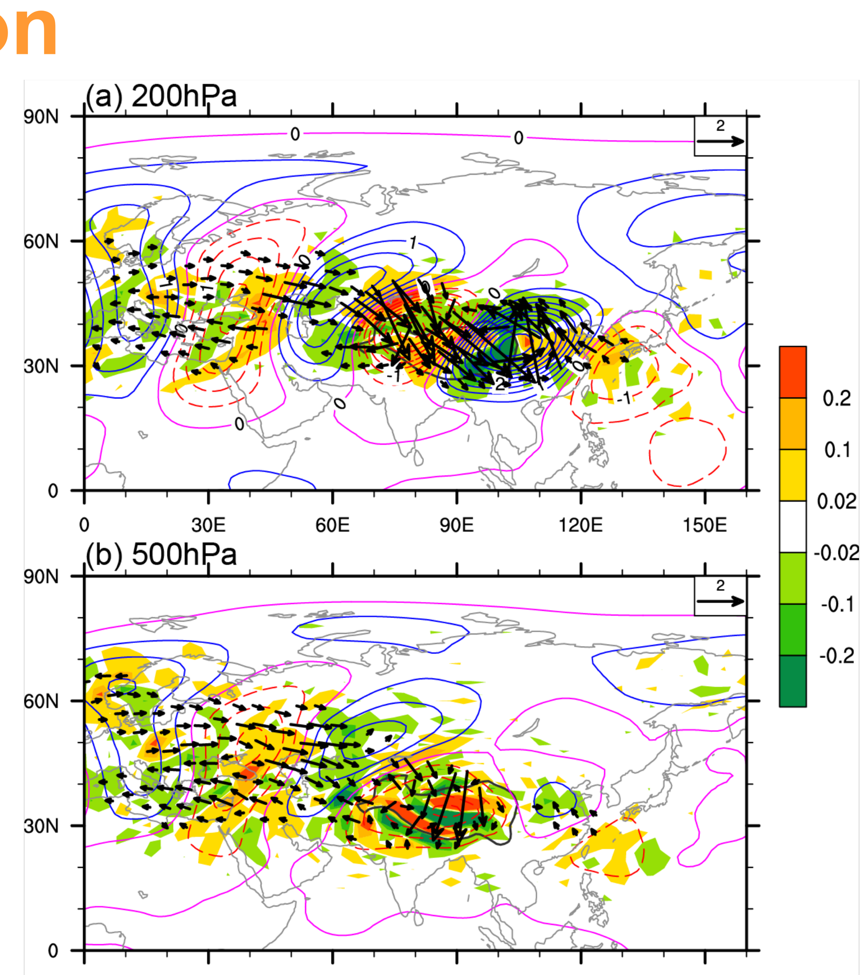


Figure 3. Distributions of the difference in the 10- to 20-day filtered stream function (contours, m^2/s), the horizontal component of the wave activity flux W (vectors, m^2/s^2), and divergence (shading, 10^{-5} s^{-2}) at (a) 200 and (b) 500 hPa. The contour interval is 0.5 $\times 10^6$ m^2/s. The red, pink, and blue lines represent the positive, zero, and positive contour values.

Figure 2. Distributions of the difference in the 10- to 20-day filtered geopo- tential height (HGT, m^2/s^2) at (a) 200 and (b) 500 hPa and the (c) Global Precipitation Climatology Project (GPCP) precipitation (mm/day) for the active and break phases of the 10- to 20-day filtered Tibetan Plateau summer monsoon index. The pink contours and dotted areas exceed the 90% confidence level.

Coupling of the TPSM QBWO With the Arctic Oscillation

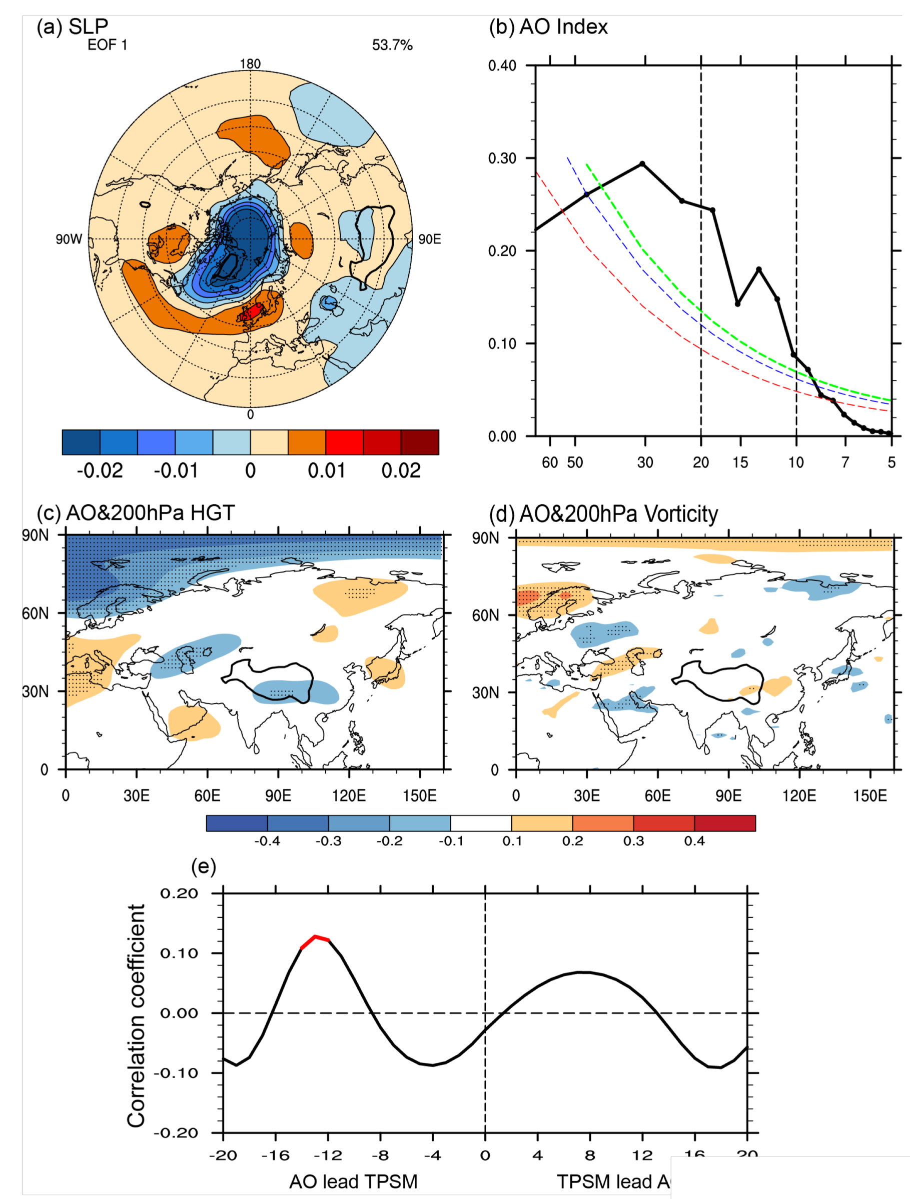
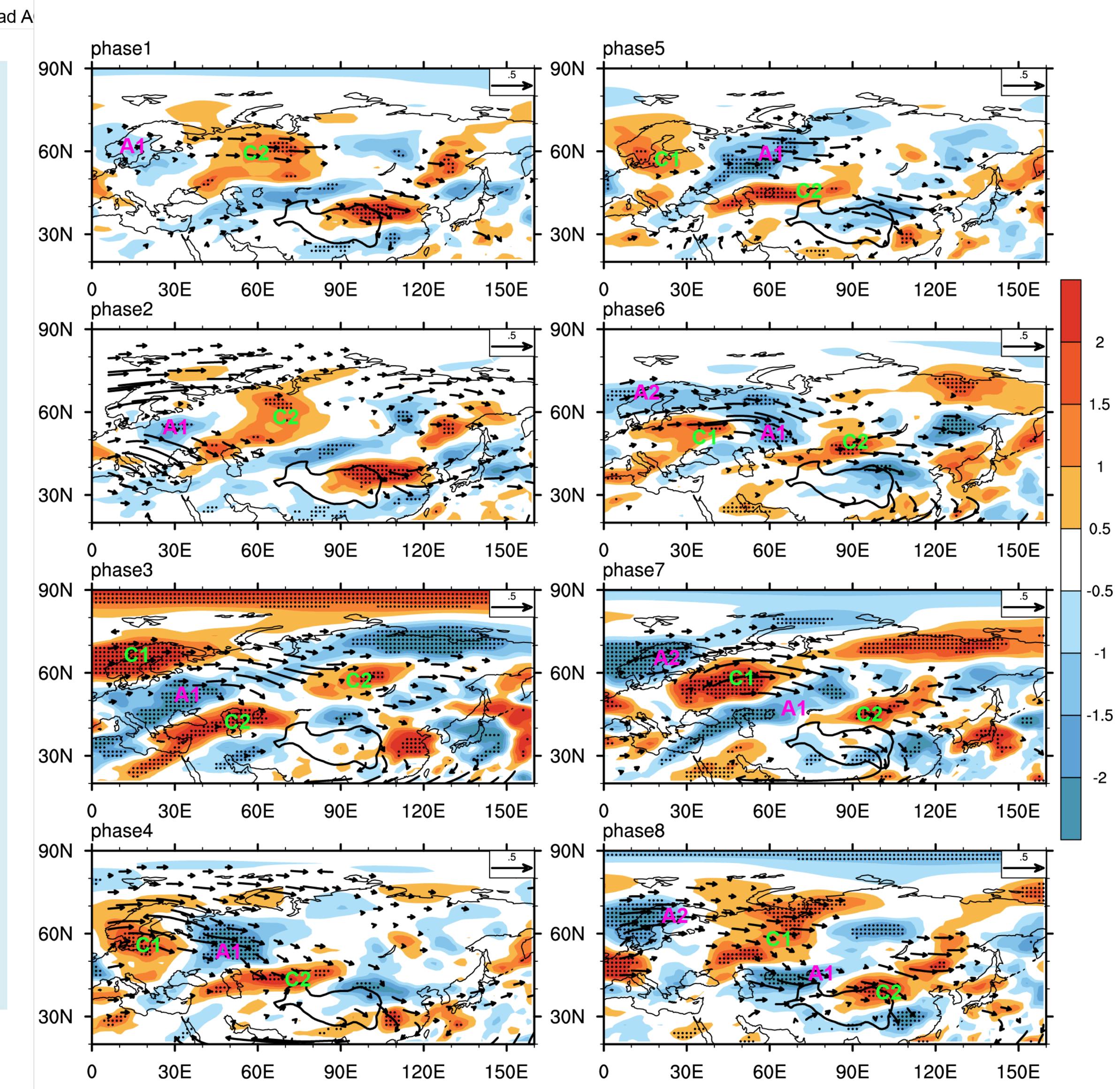


Figure 4. (a) Spatial pattern of the leading empirical orthogonal function of the unfiltered sea-level pressure (SLP; Pa) in the summer season (June–August) during the period 1979–2011. The percentage in the top right-hand corner refers to the fraction of the variance explained by the mode. (b) As in Figure 1 but for the Arctic Oscillation (AO) index. (c) Distribution of the correlation coefficients between the 10- to 20-day filtered AO index and the filtered 200 hPa geopotential height.
(d) As in (c) but for the 10- to 20-day filtered AO index and the filtered 200 hPa vorticity. (e) Lead-lag relationship between the filtered AO index and the filtered TPSM index. The dotted areas exceed the 99% confidence level. The red part of the line in (e) exceeds the 95% confidence level.

Figure 5. Composite evolution of the 10- to 20-day filtered 200 hPa relative vorticity (shading, 10^{-5} s^{-1}) and the horizontal components of the wave activity flux W (vectors, m^2/s^2) during one quasi-biweekly oscillation cycle of the Arctic Oscillation index in the summer months for Phases 1–8. The dotted areas are statistically significant at the 90% confidence level. The letters A and C in the plots indicate anticyclones and cyclones, respectively.



Concluding remarks

❐ On an intraseasonal timescale, 10- to 20-day oscillation is the dominant periodicity of the TPSM.

❐ There is a related southeastward propagating wave train in the middle and upper troposphere. This wave train retains an equivalent barotropic structure in the midlatitudes and forms a baroclinic structureover the eastern Tibetan Plateau. Analysis of the wave activity flux shows that the wave train starts from northern Europe.

❐ The 10- to 20-day periodicity is significant in the AO index in the summer months, and northern Europe is an active center of the AO QBWO.

❐ The AO QBWO signals lead the TPSM QBWO by about 13 days.

❐ Phase composite analysis of the AO QBWO clearly shows a southeastward propagating wave train influencing the ISV on the Tibetan Plateau, and the phase-independent wave activity flux also propagates in a similar manner. This implies that the TPSM QBWO is closely coupled with the QBWO activity of the AO over northern Europe.

Reference

Wang, M., Wang, J., Duan, A., Liu, Y., & Zhou, S. (2018). Coupling of the quasi-biweekly oscillation of the Tibetan Plateau summer monsoon with the Arctic Oscillation. Geophysical Research Letters, 45.

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