Analysis of Mechanism of Tibetan Plateau Vortex Frequency Differences between Strong and Weak MJO Periods

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Introduction

- The generation, development and eastward propagation of the TPV is usually accompanied by precipitation, strong winds, thunderstorms and other weather processes, resulting in a series of extreme weather events over the Tibetan Plateau (TP) and the Sichuan-Chongqing regions (Sichuan Basin) downstream of the plateau.
- In recent years, there has been a considerable amount of research conducted specifically on the atmospheric low-frequency oscillation over the TP. However, research on the influence of tropical atmospheric low-frequency oscillation on the Tibetan Plateau vortex (TPV) is limited.
- In this research, we examine the impact of tropical atmospheric low-frequency oscillation on the occurrence frequency of TPVs to reveal the mechanisms involved in the atmospheric low-frequency oscillation over the TP. However, research on the modulation of the TPV by tropical atmospheric low-frequency oscillation, and provide new ideas for short-term TPV forecasting.

Data

- This paper uses reanalysis data, acquired from NCEP/NCAR, the real-time multivariate MJO (RMM) index from the Australian Bureau of Meteorology, daily satellite-observed outgoing longwave radiation (OLR) data from NOAA; and statistical TPV data from the Chengdu Institute of Plateau Meteorology of the China Meteorological Administration from 1998 to 2010.
- The statistical method employed in this study of the TPV is to use the RMM index to examine the strength of the MJO. Two different metrics are determined using amplitudes of 1 and 0.8, where a value greater than 1 or 0.8 corresponds with an active MJO period and a value of less than 1 or 0.8 corresponds to a suppressed MJO period.
- In this paper, we count the frequency of TPVs in active and suppressed periods of the MJO separately, in addition to the frequency distribution in different phases of active MJO periods.

Method

- Wavelet analysis is also used, to determine the atmospheric oscillation cycle of the various meteorological elements over the TP and to obtain the wavelet power spectrum and wavelet variance by analyzing time series of these meteorological elements.
- Then, the Lanczos band-pass filter is used for oscillation cycle filtering. The coverage of the TP region is defined by (27.5° ~40° N, 75° ~105° E).

Results

- The results show an obvious 30-60-day cycle in the time series of the zonal wind component at 200 hPa, and the cycle is quite strong in winter and spring but relatively weak in autumn and summer (Fig. 1a). A similar result can be seen in Fig. 1b for the 500 hPa zonal wind field.
- Under both MJO measurement standards, the number of TPVs generated during strong MJO periods is obviously much more than that during weak MJO periods.
- There is a significant reduced frequency (below normal) in phase 3 and 7 corresponding to a significantly increased frequency (above normal) in TPV frequency in phase 1 and phase 2.

- During strong (weak) MJO periods, the TP is in control of a low-frequency, low-pressure cyclone (high-pressure anticyclone) system, and thus the atmospheric circulation conditions over the plateau are conducive (not conducive) to the generation of TPVs.

Conclusions

- (1) TPVs mainly generate in strong MJO periods. The number of TPVs generated in the strong MJO periods of the current study’s timeframe is 381, while the number generated in the weak MJO periods is only 126. Thus, the frequency ratio between strong and weak MJO periods is approximately 3:1, demonstrating that the modulation of TPV generation by the MJO is significant.
- (2) During strong (weak) MJO periods, the TP is in control of a low-frequency, low-pressure cyclone (high-pressure anticyclone) system, and thus the atmospheric circulation conditions over the plateau are conducive (not conducive) to the generation of TPVs.
- (3) During strong (weak) MJO periods, southerly (northerly) flow is prevalent over the east of the plateau, but northerly (southerly) flow is prevalent over the south. Over the north part of the plateau, easterly (westerly) flow predominates, while westerly (easterly) prevails over the south. Thus, the situation is conducive (not conducive) to the formation of cyclical circulation (i.e., a TPV) at low altitude over the plateau.

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