MJO和熱帶波動對亞澳季風區
次季節降雨高峰事件的影響及展期預報應用

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摘　　要

印度一太平洋暖池是北半球冬半年(十一月至四月)熱帶降雨的主要區域，次季節與季節尺度(Subseasonal to Seasonal, S2S)的對流變化反應多重尺度氣候系統如季風環流、聖嬰現象、馬登一朱利安振盪(MJO)和熱帶波動的交互作用，對全球氣候系統有重要的影響，瞭解這些氣候系統和熱帶對流活動的關係，是科技部2016-2019年進行之「南海雙島季風觀測實驗 (SCSTIMX)」的主要科學目標。本研究探討SCSTIMX期間印太暖池區次季節降雨高峰的降雨和季節特徵、季內尺度變異和熱帶波動的關係，並分析歐洲、美國、加拿大提供的S2S預報模式資料，嘗試了解模式的預報能力與產品應用。

研究發現MJO與赤道羅士比波(Equatorial Rossby Wave, ER)和羅士比重力混合波(mixed Rossby-gravity tropical wave, MT) 影響了印太暖池區次季節降雨高峰事件的發生時間；但在南北緯10度以內的赤道海洋大陸(Maritime Continent)區域由於有複雜地形作用，大尺度波動對次季節降雨高峰事件的發生時間和強度影響不大。以2017/18年發生在南海和2018/19年在澳洲東北部的次季節降雨高峰事件為例，前者發生時間和降雨強度明顯受到從西太平洋移入的ER和MT波動的影響以致在2017年12月有連續三個颱風侵襲菲律賓，後者受到從印度洋往澳洲移動的MJO以及從南太平洋往西移動的ER波動影響以致在2019年1月下旬發生近20年最強降雨高峰事件。分析S2S預報模式產出的40天展期預報資料(共20年)發現，模式可以在一週前合理預測次季節高峰事件的發生，更長期的預測模式沒有能力掌握，預測表現取決於模式對MJO和熱帶波動的預測能力。本研究揭示熱帶波動對熱帶地區極端降水的監測和預報有關鍵的角色，可作為未來改進與校驗模式的參考。

關鍵字：南海季風雙島觀測實驗、印太暖池區熱帶對流、次季節降雨預測、MJO、熱帶波動、S2S 預報。

Modulation of the Asian-Australian Monsoon Region Subseasonal Peak Precipitation Events by MJO and CCEWs in Boreal Winter and Extended-Range Prediction Application

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Abstract

The Indo-Pacific warm pool region is one of the precipitation centers in the tropics during the extended boreal winter season (NDJFMA). The abundant winter rainfall amount over this region involves multiple-scale phenomena such as the monsoons, ENSO, Madden-Julian Oscillation (MJO) and convectively coupled equatorial waves (CCEWs). This study aims at understanding how the climate variability on various temporal and spatial scales modulate the major precipitation events. The subseasonal-to-seasonal (S2S) prediction models provided by ECMWF, NCEP, and ECCC are also analyzed to understand the models' ability on predicting extreme rainfall events and their application.

The boreal winter subseasonal peak precipitation event defined as an event with maximum 15-day accumulated rainfall amount during the period from November to February is the major precipitation events focused in this study. The analysis results of the influence of MJO and CCEWs on the subseasonal peak events show noticeable modulation of MJO, Equatorial Rossby (ER) wave and Mixed Rossby-gravity wave/TD-type disturbances (MT wave) on the occurrence time and rainfall intensity of the peak events. However, because the complicated geographic and topography distribution of the Maritime Continent straddling the equator, the MJO and CCEWs modulation is not detectable in the equatorial belt between 10˚S~10˚N. The temporal and intensity modulation of tropical waves and the interaction of monsoon and weather systems are further diagnosed in two cases of extreme rainfall events during the South China Sea Two Island Monsoon Experiment (SCSTIMX) winters, one occurred in December 2017 over the Philippines and the South China Sea (SCS) and another in 2018/19 at Townsville, Australia. The former is due to three successive typhoons associated with westward propagating ER and MT wave-train emanated from Western North Pacific, while the latter was modulated by MJO and ER wave, which contribute to the record-breaking rainfall events revealed in CPC MORPHing technique (CMORPH) precipitation data.

In order to understand the current forecast status of the S2S models, we analyzed 20 years of the hindcast data of the 40-day forecast generated by three S2S models. The results suggest that the subseasonal peak precipitation events can be reasonably predicted at most one week ahead for these models. The prediction skill can be related to the predictability of MJO and CCEWs. This study reveals that MJO and tropical waves play a crucial role for monitoring the tropical extreme rainfall and its prediction, which can be provided as an observational evidence to verify and improve the prediction models.

Keywords: The South China Sea Two Island Monsoon Experiment (SCSTIMX), Tropical convection over Indo-Pacific warm pool, subseasonal precipitation prediction, MJO, convectively coupled equatorial waves, S2S prediction.