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前冬南半球环状模对春季华南降水的影响及其机理

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Impact of preceding boreal winter southern hemisphere annular mode on spring precipitation over south China and related mechanism

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摘要 利用相关、合成、奇异值分解等统计诊断和数值模拟方法,分析了前冬(12—2月)南半球环状模(SAM)对春季(3—5月)中国华南降水的可能影响及其机理.诊断分析的结果表明,前冬南半球环状模与春季华南降水存在显著的负相关关系,也即前冬SAM偏强(弱),对应春季华南降水偏少(多).为了探讨这种南半球中高纬信号影响滞后一个季节的华南降水的物理机制,需要考虑下垫面海洋的桥梁作用.诊断分析的结果表明,当前冬SAM偏强时,南半球中高纬海洋的潜热释放受到海表风速影响发生变化,导致30° S—45° S海温偏高, 45° S—70° S海温偏低,并且异常的海温信号可以持续到次年春季.这种前冬SAM偏强时的春季海温异常信号,对应着春季西北太平洋副热带高压位置偏东且强度偏弱,西北太平洋上盛行异常气旋式环流,华南地区上空对流层低层有异常东北风和风场辐散,西南水汽输送较常年减弱,为春季降水偏少提供了有利的条件.前冬SAM偏弱时,南半球中高纬的海温异常及其引起的华南区域大气环流异常相反,有利于华南降水偏多.利用CAM3进行海温敏感性试验,也证明了上述南半球中高纬海温异常对应的环流异常.模拟结果表明,SAM偏强时的海温异常,对应着华南上空对流层低层的东北风异常、风场辐散、以及下沉运动,不利于华南降水生成;SAM偏弱时的海温异常,对应的环流异常相反,有利于华南降水增多,验证了资料诊断的结论.综上,在前冬SAM影响春季华南降水的过程中,体现了海气耦合桥的作用,即:海洋储存了冬季SAM的异常信号并在春季释放,通过影响春季大气环流,进一步影响华南春季降水.因此,前冬SAM为华南春季降水预测提供了一个有意义的前期信号.

关键词 南半球环状模, 华南春季降水, 海温异常, 海气耦合桥

Abstract: The impact of the preceding boreal winter (December-February) Southern Hemisphere Annular Mode (SAM) on spring (March-May) rainfall over South China (RSC) and related physical mechanism were examined statistically by methods such as correlation analysis, composite analysis, singular value decomposition (SVD) and numerical simulation. The results show that there is a significant negative correlation relationship between the preceding winter SAM and spring RSC. That is, winters with strong (weak) SAM are often followed by less (more) RSC. In order to understand the physical mechanism of this relationship between signals from Southern Hemisphere mid-high latitudes and RSC in the following season, the role of ocean as underlying surface was investigated. It was found by diagnostic analyzing that in winters with strong SAM, latent heat fluxes change because of the change in sea surface wind speed, thus leading to positive (negative) SSTA in 30° S—45° S (45° —70° S). Because of large heat capacity of the ocean, the SSTA pattern persists to the following spring. Results from diagnostic analysis show that these SSTA lead to a series of consequence: Northwestern Pacific subtropical high weakens and the ridge extends less to west than normal years; an abnormal cyclonic circulation exists over West Pacific region; South China (SC) is controlled by abnormal northeast wind and wind divergence; water vapor transport to SC weakens, all these conditions lead to less RSC. The circulation anomalies related with SSTA caused by weak SAM are reversed, thus leading to more RSC. SST sensibility experiments carried out by CAM3 further certify above-mentioned circulation anomalies caused by SSTA. Results show that SSTA related with strong SAM lead to abnormal northeast wind, wind divergence, sinking movement over SC, thus leading to less RSC. In short, the winter SAM can impact the following spring RSC through SSTA in middle and high latitude in Southern Hemisphere, a manifestation of "ocean-atmosphere coupled bridge". The results imply that preceding

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winter SAM provides a significative prophase signature for forecasting spring RSC.

Keywords Southern Hemisphere Annular Mode (SAM), Spring rainfall over south China, Sea surface temperature anomalies (SSTA), Ocean-atmosphere coupled bridge

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