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水汽螺旋度和热力螺旋度在华北强"桑拿天"过程中的分析及应用

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Diagnostic analyses and applications of the moisture helicity and the thermal helicity for two strong "sauna" weather processes in northern China

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摘要

"桑拿天"是发生在夏季高温、高湿环境之下的重要天气现象.而过去单靠温度这一变量来诊断预报"桑拿天",有较大难度.而且从已有的研究中,"桑拿天"多发生在下沉运动或相对稳定的环流背景下.因此,寻找一个简单有效、且使用方便的物理变量来揭示"桑拿天"高湿、高湿的综合特征,显得特别重要.本文在前人研究的基础上,将以往暴雨研究中的IM (Ingredients-based Methodology)理论方法拓展至"桑拿天"的研究,将过去表征桑拿天高温、高湿、下沉运动环流特点的这些单个物理量综合进IM方法,尝试性地引入热力螺旋度(TH)、水汽螺旋度(MH)、以及湿热力螺旋度(MTH)等,对发生在2002年7月30日—8月4日和2009年7月7—9日的两次华北地区高温高湿的强"桑拿天"过程进行动力识别和诊断,并与广义湿位涡(GMPV)进行对比分析.分析结果表明,MH的异常大值区相对集中在北京及其周边的华北地区的对流层低层,并维持.而TH的异常大值区涵盖的范围远大于我们要研究的华北地区"桑拿天"的爆发范围.即使结合了温、湿效应的MTH和GMPV的异常大值区,其涵盖的范围亦逊于MH对"桑拿天"的动力识别.可见,在夏季普遍高温的大环境下,湿度是华北闷热的"桑拿天"爆发的一个决定性因素.结合了环流特征与湿度效应的MH,是对"桑拿天"进行动力识别的一个优化因子,具有较大的实际应用价值.

关键词 "桑拿天"，水汽螺旋度，热力螺旋度

Abstract：

"Sauna" weathers generally occur in high-temperature and high-humidity environment in summertime. However, it is difficult to diagnose "sauna" weather depending on the single temperature parameter from the previous studies. From the past researches, the relative stable subtropic-high circulation dominates the middle troposphere and weak sinking motion maintains during the "sauna" weather events. Therefore it is of particular importance to find a simple and convenient parameter to characterize high-temperature and high-humidity "sauna" weather. Based on previous researches, the IM (Ingredients-based Methodology) method, which is developed for rainfall studies in the past, is extended to the study of "sauna" weather in this paper. Several physical variables such as high temperature, large relative humidity, and sinking motion, which are used as single factor to describe "sauna" weather in the past studies, are combined into IM theory to diagnose "sauna" weather. Therefore, thermal helicity (TH), moisture helicity (MH), and the moist thermal helicity (MTH), are introduced to dynamically identify "sauna" weather. Two "sauna" weather events in northern China are selected to calculate above several parameters. One is from 30 July to 4 August 2002. Another lasts from 7 to 9 July 2009. And the generalized moist potential vorticity (GMPV) is used to make a comparison with them. It is found that, the MH anomalies accompany the "sauna" weather process, focus in the lower troposphere around Beijing and its peripheral areas in northern China. However, the coverage of TH anomalies is larger than our target region of this "sauna" weather event. Even for the MTH and GMPV including both temperature and humidity effects, it is also worse to use their anomalies areas to dynamically identify "sauna" weather than using MH's anomalies. It can be seen that humidity is a determining

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factor during the sultry "sauna" weather process in northern China in generally high-temperature summertime. The MH, which integrates both the atmospheric circulation characteristics and humidity effect, is a possible optimization factor to dynamically identify "sauna" weather in northern China. And it has great value to practically apply to analyze "sauna" weather.