Dynamics of Atmospheres and Oceans 68 (2014) 1–19

Contents lists available at ScienceDirect

Dynamics of Atmospheres and Oceans

journal homepage: www.elsevier.com/locate/dynatmoce

Retrieval the statistical–dynamical model of western Pacific subtropical high ridge line index and key members of Asian summer monsoon system

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ARTICLE INFO

Article history:
Received 19 January 2014
Received in revised form 15 June 2014
Accepted 26 July 2014
Available online 4 August 2014

Keywords:
Western Pacific subtropical high
Dynamical system model
Bifurcation
Mutation
Summer monsoon system

ABSTRACT

The western Pacific subtropical high (WPSH) is closely correlated with the East Asian climate. To date, the underlying mechanisms and sustaining factors have not been positively elucidated. Based on the concept of dynamical system model reconstruction, this paper presents a nonlinear statistical–dynamical model of the subtropical high ridge line (SHRL) in concurrence with four summer monsoon factors. SHRL variations from 1990 to 2011 are subdivided into three categories, while parameter differences relating to three differing models are examined. Dynamical characteristics of SHRL are analyzed and an aberrance mechanism subsequently developed. Modeling suggests that different parameters may lead to significant variance pertaining to monsoon variables corresponding with numerous WPSH activities. Dynamical system bifurcation

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http://dx.doi.org/10.1016/j.dynatmoce.2014.07.001

and mutation indicates that the South China Sea monsoon trough is a significant factor with respect to the occurrence and maintenance of the 'double-ridge' phenomenon. Moreover, the occurrence of the Mascarene cold high is predicted to cause an abnormal northward location of WPSH, resulting in the "empty plum" phenomenon.

1. Introduction

The western Pacific subtropical high (WPSH) is a significant component of the East Asian summer monsoon (EASM) system (Tao and Chen, 1987). The intensity and position of the WPSH exhibits complex seasonal evolution; WPSH variation has been significantly associated with the occurrence and timing of precipitation in China, including flooding, drought and high-intensity low-frequency rainfall events (Tao and Chen, 1987; Kurihara, 1989). Due to its significance with respect to the East Asian climate, the WPSH has come to the fore in terms of atmospheric science research and discourse. Over recent decades, comprehensive effort has been directed toward the elucidation of mechanisms underlying the WPSH process. For example, Ninomiya and Kobayashi (1999) have analyzed the impact of thermal factors including solar radiation heating, monsoon rainfall, and convective condensation heating of monsoon trough precipitation on the shape, spatial extent and stability of the WPSH. He et al. (2001) previously investigated the vertical circulation structure of the WPSH, reporting that mechanisms associated with its inter-annual variation include latent heat release, the offshore sea surface temperature (SST) and the East Asian land-sea thermal contrast. The apparent association between the WPSH position and monsoon disturbances in the South China Sea in addition to the Indian Ocean region has also recently been examined (Krishna Kumar et al., 2005). Deser and Phillips (2006) have shown the dynamical and thermal mechanisms of WPSH short-term variation to be significantly correlated with anomalies pertaining to the South Asian high pressure and high-latitude circulation system. Moreover, He et al. (2007) have described the possible mechanisms underlying Asian monsoon variations, while Wu et al. (2002) have presented findings associated with the WPSH formation and variation. Due to the inherent complexity associated with WPSH variation (Cao et al., 2002), the causative mechanisms associated with its development and continuance remain largely unknown. The aforementioned studies have typically focused on diagnostic analyses and have not attempted to examine the WPSH dynamical system model and mechanism.

In order to counteract this research paucity, Zhang et al. (2008) have recently sought to investigate the inversion of a nonlinear dynamical forecast model with respect to the WPSH index. Due to the multivariate nature of this system (Cao et al., 2002; Seager et al., 2003), the use or incorporation of a single factor has been shown to restrict model efficacy. Thus, future models should incorporate multiple, objectively selected significant influencing factors. As the WPSH is a significant causative variable within the East Asian summer monsoon system, other variables within the larger monsoon system should be incorporated to further refine the dynamical model. Our study attempts to develop a dynamic system model and subsequently analyze the likely mechanisms of WPSH processed based on system model outputs.

In the current study, the index of the subtropical high ridge line (SHRL) has been defined as a compilation of northward jumps and southward falls of the WPSH. Consequently, re-analysis of data from the past 22 years is undertaken (Section 2), followed by statistical determination of summer monsoon factors ($N = 4$) which have significant correlations with the SHRL index (Section 3). Based on these findings, a dynamics–statistics model inversion of the SHRL index and its impact factors is developed and presented, in addition to "between model" factor and parameter variations with respect to "high anomaly" and "normal" years (Section 4). The dynamic processes of the WPSH system, including bifurcation and induced mutation based upon antecedent weather data are then outlined (Section 5).