The East Asia-Western North Pacific Boreal Summer Intraseasonal Oscillation Simulated in GAMIL 1.1.1

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ABSTRACT

We evaluate the performance of GAMIL 1.1.1 in a 27-year forced simulation of the summer intraseasonal oscillation (ISO) over East Asia (EA)-western North Pacific (WNP). The assessment is based on two measures: climatological ISO (CISO) and transient ISO (TISO). CISO is the ISO component that is phase-locked to the annual cycle and describes seasonal march. TISO is the ISO component that varies year by year.

The model reasonably captures many observed features of the ISO, including the stepwise northward advance of the rain belt of CISO, the dominant periodicities of TISO in both the South China Sea-Philippine Sea (SCS-PS) and the Yangtze River Basin (YRB), the northward propagation of 30-50-day TISO and the westward propagation of the 12-25-day TISO mode over the SCS-PS, and the zonal propagating features of three major TISO modes over the YRB. However, the model has notable deficiencies. These include the early onset of the South China Sea monsoon associated with CISO, too fast northward propagation of CISO from 20°N to 40°N and the absence of the CISO signal south of 10°N, the deficient eastward propagation of the 30-50-day TISO mode and the absence of a southward propagation in the YRB TISO modes.

The authors found that the deficiencies in the ISO simulation are closely related to the model’s biases in the mean states, suggesting that the improvement of the model mean state is crucial for realistic simulation of the intraseasonal variation.

Key words: intraseasonal oscillation (ISO), East Asia-Western North Pacific (EA-WNP)


1. Introduction

The prediction of intraseasonal oscillation (ISO) can fill the gap between weather forecast and climate prediction, and is an indispensable portion of the seamless forecast. Evaluation of the model’s ISO is a necessary step towards the improvement of intraseasonal prediction. A majority of the evaluation of ISO has been focused on Madden Julian Oscillation (MJO, Madden and Julian, 1971) (e.g., Slingo and Madden, 1991; Slingo et al., 1996; Sperber, 2004; Lin et al., 2006). Prominent shortcomings highlighted in the above MJO modeling studies include higher phase speeds, shorter periods and smaller amplitudes. The uncertainties in the interactive physical parameterizations and the deficiencies to capture multi-scale interaction are considered to be major hurdles for the realistic simulation of the MJO (e.g., Chao and Deng,
Compared with the MJO simulation, the boreal summer ISO simulation in the Asian monsoon region is a more challenging task. This is primarily due to its multi-periodicity (e.g., Krishnamurti and Bhalme, 1976; Chen and Murakami, 1988; Annamalai and Slingo, 2001), more complex mean flow that the ISO interacts with (e.g., Teng and Wang, 2003; Yang et al., 2008), as well as the greater heterogeneity of the underlying surface conditions and topography that the ISO is influenced by (e.g., Liu et al., 2007). The performances of the Asian monsoon boreal summer ISO in numerical settings not only share some similar shortcomings with the MJO simulations but also have their unique problems. For instance, the study by Waliser et al. (2003) examined ten atmospheric general circulation model (AGCM) simulations to assess their representations of low frequency ISO variability associated with the Asian summer monsoon. Their results show that the ISO patterns in seven of the ten AGCMs lack sufficient eastward propagation, have smaller zonal and meridional spatial scales than the observed patterns, and often have a southwest-northeast tilt of the rain belt rather than the observed northwest-southeast tilt over the Indian Ocean.

Most previous studies of boreal summer ISO modeling are focused on the lower frequency band (namely the MJO time scale) and their concerned regions are over the western tropical North Pacific (WNP) and the Indian monsoon region. Based on observations, ISOs with various periodicities potentially affect the East Asia (EA)-WNP summer monsoon variation (e.g., Chen and Chen, 1995; Zhang et al., 2002; Chan et al., 2002; Yang and Li, 2003). Thereby, it is necessary to provide a comprehensive evaluation of the ISO simulation over the EA-WNP summer monsoon region. In particular, the subtropical EA monsoon ISO has unique characteristics of midlatitude variation (e.g., Zhang et al., 2003; Mao and Wu, 2006; Yang et al., 2008). However, in previous model evaluations, the higher frequency ISOs (e.g., the quasi-biweekly) and the ISO over the subtropical EA region have been less concerned.

Climatological ISO (CISO) and transient ISO (TISO), as two objective measures, are applied to validate the simulation of the EA-WNP summer ISO (Yang et al., 2008). The CISO represents the phase-locked component of ISO (Wang and Xu, 1997). Compared to the slow annual cycle, it is a part of the “fast” annual cycle (LinHo and Wang, 2002), which describes seasonal march (e.g., Ding, 1992; Nakazawa, 1992; Tanaka, 1992; Ueda et al., 1995) and the multi-stage onset of the Asian summer monsoon (Lau et al., 1988; Wu and Wang, 2001; Wang and LinHo, 2002). The TISO is defined as the remaining part after removing CISO from the total ISO, which represents the year-to-year varying portion of ISO. These two portions of ISO have been found to have different features and different contributions to the total ISO. For instance, during the summer of 1998 that includes two intraseasonal rainfall events, the first flooding event is mainly associated with CISO and the second is contributed by TISO (Yang et al., 2008). Therefore, this approach, which distinguishes CISO and TISO, is advantageous and necessary in evaluating the summer ISO over the EA-WNP sector.

This paper will be organized as follows. Firstly, the observational data, model and methodology are described in section 2. In section 3, we focus on the evaluations of the basic performances of the simulated CISO and TISO in an atmospheric general circulation model with a comparison to the observations. In section 4, we attempt to find possible factors responsible for model discrepancies in simulating the ISO over the EA-WNP. Finally the conclusion and discussion are given in section 5.

2. Observational data, model and methodology

2.1 Observational data

The datasets applied to document the observed ISO in convective activity and precipitation are retrieved from the following three sources: (1) National Oceanic and Atmospheric Administration (NOAA) interpolated daily outgoing longwave radiation (OLR) (Liebmann and Smith, 1996) from 1979 to 2005, which is basically regarded as a reasonable substitute of rainfall and high clouds, especially in the tropical regions; (2) the monthly precipitation data from 1979 to 2005, which are retrieved from the Global Precipitation Climatology Project (GPCP) (Huffman et al., 1997); and (3) a newly-released high-quality East Asian daily precipitation data on land (EA-Pre/L hereafter) from NOAA/Climate prediction Center (CPC) (Xie et al., 2007), which has been constructed based on 2200 stations’ observations over East Asia (5°–60°N, 65°–155°E) from 1979 to 2005.

To obtain the climatological mean states of circulation, we use the datasets from the National Center for Environmental Prediction-Department of Energy (NCEP-DOE) Reanalysis 2 (NCEP2) between 1979 and 2005 (Kanamitsu et al., 2002).

2.2 Model description

GAMIL 1.1.1 is the latest version of a grid-point atmospheric general circulation model (GAMIL), which