Model Studies of the Tropical 30 to 60 Day Oscillation

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Abstract

The tropical 30-60 day oscillation, also referred to as the intraseasonal oscillation (IO) or Madden-Julian oscillation is an important phenomenon in the tropical atmosphere on the intraseasonal timescale. The dominant characteristic of the IO is the eastward propagation of convection cells that organize themselves to super cloud clusters over the Indian Ocean and the West Pacific. The correct simulation of the initiation and propagation of the IO in General Circulation Models (GCMs) is important for the representation of convective clouds and the resulting radiation budget and precipitation in the tropical eastern hemisphere. The IO is a possible trigger of the Asian summer monsoon (Lau et al., 1998) and the Australian monsoon (Hendon and Liebmann, 1990) and affects the position of subtropical jets (Knutson and Weickmann, 1987).

The present study discusses the representation of the IO in observations, reanalyses data and GCM simulations. The Principal Oscillation Pattern analysis (von Storch, 1995; Hasselmann, 1988) is used to investigate IO activity. Case studies are performed to gain a detailed insight into the structure of the IO. The simulations are performed with (1) the fourth version of the European Centre Hamburg Atmospheric Model (ECHAM4; Roeckner et al., 1996) GCM; (2) the ECHAM4 GCM coupled to the third version of the ocean isopycnal (OPYC3) GCM to clarify possible air-sea interactions and connections of the IO and the El Niño/Southern Oscillation (ENSO) cycle; (3) ECHAM4 with increased vertical resolution and by this improved representation of the tropospheric stratification. To artificially force cooler (warmer) levels in the mid-troposphere and by this a changed stability, the melting rate for convective precipitation is doubled (halved) in two sensitivity studies. Additionally an experiment with suppressed snow melt for all precipitation is performed. (4) The horizontal resolution is increased to investigate the importance of a reasonable land-sea distribution over the maritime continent. (5) To distinguish this effect from general dynamical changes due to the changed resolution, the effects of the land-sea distribution are additionally studied in an experiment with land points associated with the maritime continent replaced by sea points. (6) The ECHAM4 GCM is forced by a T42 version of the Optimum Interpolated Sea Surface Temperature (OISST) dataset (Reynolds and Smith, 1994) to study the influence of the SST as a boundary condition.

The main results are as follows: (1) The ECHAM4 T42 standard version simulates a too fast eastward propagation and an eastward shift of the main IO activity, as is common to many atmosphere GCMs (Slingo et al., 1996). (2) The coupled version reveals no improvements, although it is shown that the IO influences the ENSO cycle and ENSO influences the interannual variability of the IO. (3) The increase in vertical resolution slightly improves the simulation of the vertical moisture profile, and thus slightly slows down the propagation speed of the IO. This result is not confirmed by the studies with artificially changed stability in the mid-troposphere. (4) Increasing the horizontal resolution from T42 to T106 results in a more precise representation of convection over the maritime continent. A consequence is a reduction of the erroneous eastward shift of the simulated IO activity, although the phase speed of the IO is increased. (5) These results are also obtained by replacing the maritime continent with sea points. (6) ECHAM4 forced by a changed SST dataset leads to the strongest improvements, since convection driving

the IO is highly sensitive to surface temperature with lower level convection leading to a slower IO due to an increased influence of surface friction. ECHAM4 forced by the changed SST, produces a reasonable IO with a mean period of 48 days and a main IO activity near 140E, as in the reanalysis. This illustrates the strong influence of the prescribed SST on the simulation of the IO.