A possible role of the air-sea coupling in the South China Sea (SCS) summer monsoon variability is studied using a coupled general circulation model (CGCM) and its atmospheric component (AGCM). The 50-year integration of the CGCM well reproduces the summer monsoon variability over SCS, where the precipitation anomaly is positively correlated with the low-level cyclonic circulation anomaly that accompanies enhanced surface westerlies. Negative sea surface temperature (SST) anomaly is found in SCS during the strong monsoon years, indicating the atmosphere driving SST through wind-induced evaporation. The 50-year AGCM run forced by historical SST obtained from the CGCM reveals the monsoon variability amplified by about 50 percent as compared with the CGCM. The absence of the air-sea coupling keeps SST warm in SCS, which decreases the local evaporation and precipitation. The enhanced precipitation over SCS may intensify surface westerly over the remote regions, resulting in an increase in the moisture flux convergence that in turn contributes to the positive precipitation anomaly. This result suggests that the air-sea coupling works to stabilize the monsoon and hence suppress the variability via the large-scale moisture transport and the wind-induced local evaporation.

1. Background and objectives

   • SCS is important in determining the climate variability of the surrounding regions (e.g. Ding 1992, Zhu et al. 2003, Lestari 2010) and key region of Asian monsoon as the onset first occurs over there (e.g. Lau et al. 1999)
   • Negative correlation between SCS SST and SCS wind speed (Ose et al. 1997) → a large wind speed may contribute to SST cooling by enhancing evaporation and ocean mixing (von Storch 2000, Wu 2002, Lau and Nath 2009)
   • Cloud radiation and wind-evaporation feedback determine seasonal SST variability in SCS/western North Pacific (WNP) → east-west SST gradient → heavy precipitation shift from SCS to WNP in summer (Wu 2002)
   • Northeastward moisture transport from SCS to East Sea contributes to reduce precipitation over SCS in summer (Lau and Nath 2009)
   • Variability of SCS/WNP summer precipitation after mature phase of El Nino and Southern Oscillation (ESO) is determined by local and remote SST forcings (Lau and Nath 2009).

   However, Role of air-sea coupling in controlling the interannual variability in mature phase of SCS summer monsoon was not yet clearly discussed → present work extend to examine this issue without special focus on different ENSO events.

2. Data and model

   • 29 years monthly basis (January 1979 – December 2007) of HadSST, CPC Merged Analysis of Precipitation (CMAP) and Japanese Reanalysis (JRA) data
   • Model used is Model for Interdisciplinary Research on Climate (MIROC) jointly developed at Atmosphere and Ocean Research Institute (formerly, Center for Climate System Research), the University of Tokyo, the National Institute of Environmental Studies, and Japan Agency for Maritime-Earth Science and Technology (Hamasu and Emori 2004). The version is MIROC5, interim model of the latest MIROC (Watanabe 2010a,b) and has T42L40 resolution
   • MIROC5 shows similar performance with MIROC3.2 for western Pacific summer monsoon, in which the model well reproduces onset and withdrawal of Asian summer monsoon (e.g. Lin et al. 2008, Li and Zhang 2009), but more realistic ENSO (Watanabe 2010,2011) and Indian summer monsoon (Kim et al. 2011)

3. Methods

   • Focus on the interannual variability of the summer (June-July-August, JJA) monsoon over SCS region (5-25N, 100-130E).

   The leading PC analysis to JJA monthly anomalies of ORL over 0-30N, 100-130E of
   a) Observation
   b) CGCM
   Both are accounting for 24% of total variance

   CGCM shows similar pattern with observation in which has opposite phase of OLR anomalies between SCS/WNP and equatorial western Pacific → indices of SCS monsoon variability is defined as the associated principal component (PC)

   • However, no reason to expect CGCM reproduces temporal behavior of natural variability → present work only discuss spatial structure and monsoon variability
   • Two model experiments to isolate the role of air-sea coupling:
     # No air-sea coupling and remote SST forcing → AGCM run with climatological SSTs (AGCM1)
     # No air-sea coupling only → AGCM with historical SSTs obtained from CGCM run (AGCM2)
   # To evaluate the relative importance of local air-sea coupling against remote forcing → moisture budget analysis:

   $E = \rho_s C_p \frac{dT}{dt} + \frac{p_w 

   $E$: evaporation, $P$: precipitation, $Q$: specific humidity, $V$: wind vector, $p$ and $p_w$: pressure and top pressures

4. Results

   Difference between AGCMs and CGCM is much larger than differences between two AGCMs → present work focuses on the AGCM2

5. Concluding discussions

   • MIROC5 well reproduces ocean surface cooling due to wind-induced evaporation during SCS summer monsoon
   • Absence of air-sea coupling → continuously SST warming → evaporation increase → SCS monsoon destabilization
   • Absence of air-sea coupling → precipitation enhances → atmospheric circulation from remote regions increase → westerlies enhance moisture flux convergence and local evaporation enhance → positive feedback to precipitation → amplify SCS monsoon variability by 50%