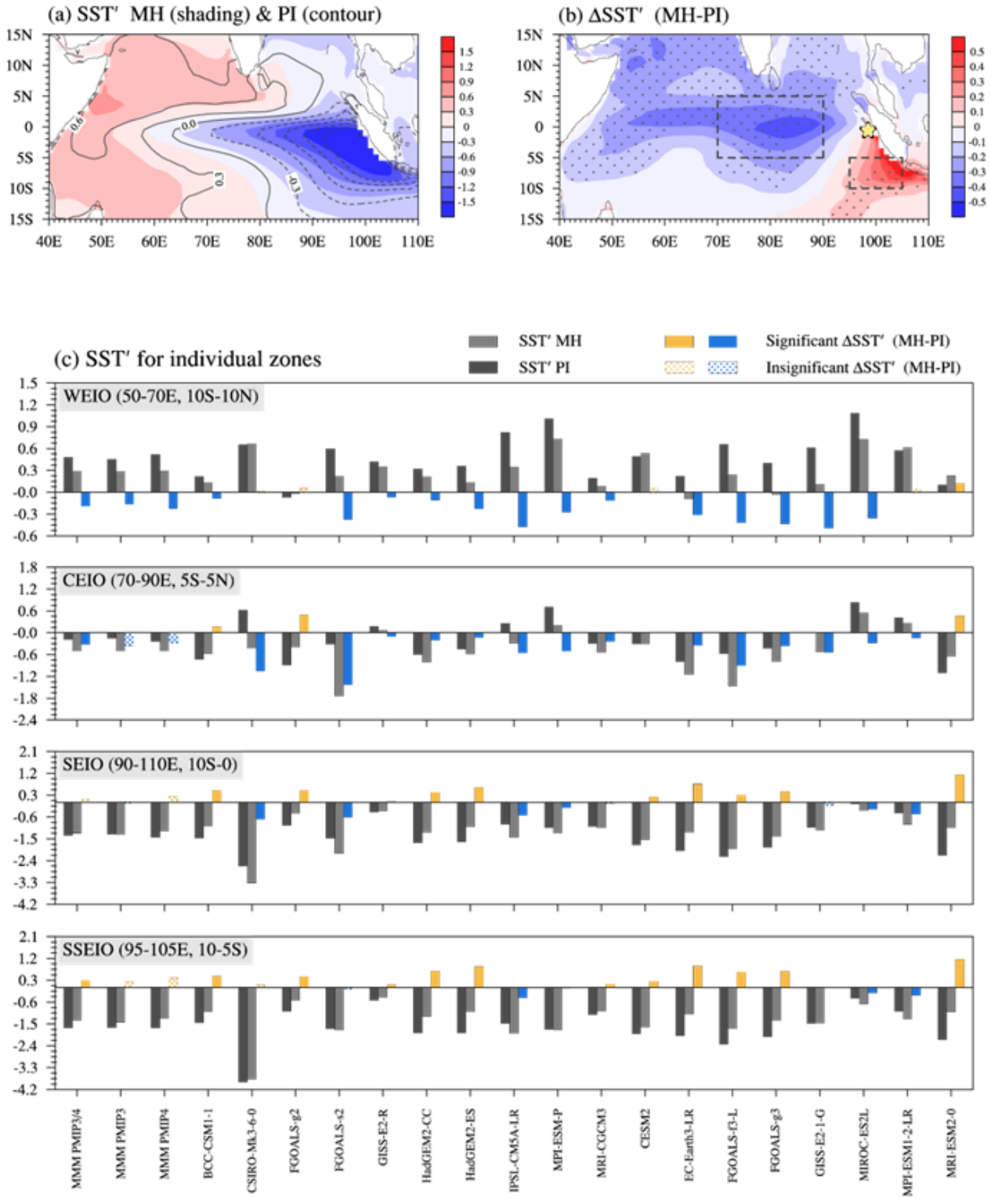
Weakening of the Indian Ocean Dipole in the mid-Holocene due to the mean oceanic climatology change

*Shanshan Liu[1], Chaoxia Yuan[1], Jing-Jia Luo[1], Xiaofan Ma[1], Xuecheng Zhou[2], Toshio Yamagata[3]

1. Nanjing University of Information Science and Technology, 2. Meteorological Service Center of Jiangsu Province, 3. Japan Agency for Marine–Earth Science and Technology

The Indian Ocean Dipole (IOD) is one of the leading modes of interannual climate variability in the tropical Indian Ocean (IO). Understanding variations in the IOD and its relationship to the altered background mean state can advance our knowledge of tropical climate dynamics. Paleoclimate provides the opportunity to address this issue under real climate scenarios in the past.
Based on 18 models from the Paleoclimate Modelling Intercomparison Project phase 3 and 4 (PMIP 3/4), we investigate IOD changes during the mid-Holocene compared to the preindustrial period. The multimodel mean reveals that the IOD variability weakens by 14% as measured by the standard deviation of the Dipole Mode Index, which is defined using the zonal sea surface temperature (SST) difference. Such attenuation is dominated by the spatially consistent suppression in the western-pole SST variability, while the eastern pole contributes little due to the opposite-signed changes in its northwestern and southeastern portions.
The primary reason for the aforementioned changes comes from the altered climatic background, which displays a positive IOD-like pattern during IOD growing seasons, with intensified westward currents along the equator and northwestward currents in the southeastern equatorial IO. Such changes in the mean-state currents modulate the strength of the IOD-related anomalous advection and subsequently cause alterations in the IOD variability. Further analyses show that the IOD attenuation in the mid-Holocene is unlikely caused by the concurrently subdued El Niño–Southern Oscillation in the tropical Pacific because of the diminished connections between the two oscillations themselves. The above simulated changes in both the IO mean climatology and IOD variability agree well with the available paleo-records in literature.

Keywords: Indian Ocean Dipole, Paleoclimate modelling, PMIP, Mid-Holocene



Spatial distribution of IOD composite SST anomalies (SST′) during August–November for (a) the preindustrial period (contour, °C) and mid-Holocene (shading, °C) and (b) the change between the two periods (ΔSST′). (c) The regional averages of SST′ and ΔSST′ for the WEIO (50°E–70°E, 10°S–10°N), CEIO (70°E–90°E, 5°S–5°N), SEIO (90°E–110°E, 10°S–0°), and SSEIO (95°E–105°E, 10°S–5°S). In (b), the stippling indicates regions where the change is statistically significant at the 95% confidence level, the yellow star marks the coral record station from the Mentawai Islands (Abram et al. 2007), and the black boxes denote the CEIO and SSEIO zones. The color-filled/dotted bars in (c) indicate the change above/below the 95% confidence level.