Abstract View

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Characteristics of the Interannual and Decadal Variability in a General Circulation Model of the Tropical Atlantic Ocean

Bohua Huang and J. Shukla

Center for Ocean–Land–Atmosphere Studies, Institute of Global Environment and Society, Inc., Calverton, Maryland

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ABSTRACT

A numerical simulation has been conducted using a general circulation model of the tropical Atlantic Ocean forced with observed monthly surface wind stress for 1964–87 and parameterized surface heat flux. The simulated sea surface temperature (SST) and upper-ocean heat content (HC) are used to examine the low-frequency variability in the ocean. A comparison with the SST observations shows that the model realistically simulates the major features of the decadal variability at the sea surface, such as the fluctuation of the SST dipole pattern (or the meridional gradient). It also produces interannual variations with timescales of two to three years.

The simulated HC anomalies are used to examine the variations of the thermocline depth and the effects of ocean dynamics. A principal oscillation pattern (POP) analysis is performed to distinguish the spatial structures of decadal and interannual variations. It is found that the interannual variations are associated with tropical oceanic waves, stimulated by the fluctuations of the equatorial easterlies, which propagate eastward along the equator and westward to the north and south, resulting in an essentially symmetric structure about the equator at these scales. The periods of these modes are determined by the meridional width of the equatorial wind anomaly. The decadal mode, however, is associated with the ocean's adjustment in response to a basinwide out-of-phase fluctuation between the northeast and southeast trade winds. For instance, forced by a weakening of the northeast winds and a simultaneous strengthening of the southeast winds, the thermocline deepens in a belt extending from 5°N in the west to the North African coast. At the same time, the thermocline shoals from the southeast coast to the equatorial ocean. The associated SST pattern exhibits a strong dipole structure with positive anomalies in the north and negative anomalies in the south. When the wind anomalies weaken, the warm water accumulated in the northern tropical ocean is released and redistributed within the basin. At this stage, the SST dipole disappears. In the framework of this separation of the variability into two dominant timescales, the extraordinarily large warm SST anomalies in the southeast ocean in the boreal summer of 1984 are a result of in-phase interference of the decadal and interannual modes.

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Headquarters: 45 Beacon Street Boston, MA 02108-3693
DC Office: 1120 G Street, NW, Suite 800 Washington DC, 20005-3826
amsinfo@ametsoc.org Phone: 617-227-2425 Fax: 617-742-8718
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