

Global ocean tripole and its climate impact

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It has been recognized that the ocean is critical to the Earth's climate system. Previous studies show evidence of warming of the global ocean using conventional measurements such as the expendable bathythermographs (XBT), bottle, mechanical bathythermographs (MBT), and Conductivity-Temperature-Depth (CTD) casts. A new strategy (Lagrangian type) was developed to sample the world ocean as the Argo floats first came into practice in early 1990s. Currently, there are 3264 Argo floats all over the world ocean. Global Temperature and Salinity Profile Program (GTSP) is a cooperative international project since 1990. The GTSP handles all temperature and salinity profile data including XBT, CTDs, thermistor chain data, and Argo observations. These data will reach data processing centers of the Program through the real-time channels of the IGOSS program or in delayed mode through the IODE system. Real-time data in GTSP are acquired from the Global Telecommunications System in the bathythermal (BATHY) and temperature, salinity & current (TESAC) codes forms supported by the WMO. Delayed mode data are contributed directly by member states of IOC. Near-real time gridded (T, S) dataset was established from GTSP since 1990 with horizontal resolution of $(10^\circ \times 10^\circ)$ and temporal increment of 1 month using the recently developed optimal spectral decomposition (OSD) method. With this new monthly varying gridded dataset, the upper ocean heat content (surface to 700 m depth) OHC700 was calculated at each horizontal grid point. The empirical orthogonal function (EOF) analysis was conducted on the temporally varying global 2D OHC700 anomaly relative to its seasonal variation. A new phenomenon, global ocean tripole, was discovered. The EOF-1 mode (44.2% variance) represents the classical El Niño/La Niña phenomenon. The EOF-2 mode (14.6%) represents the Indian Ocean Dipole mode and the El Niño Modoki. Its features and connection to climate variability is also discussed. Besides, horizontal integration of 2D OHC700 leads to the global total upper ocean heat content, which has an evident linear upward trend (with 95% confidence interval) of $1.3 \times 10^{22} \text{ J yr}^{-1}$, which is much larger than previous estimated values by Levitus et al. (2005) for 1955-2008. Interpretations of the observational results will also be presented.