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External Dynamic Mechanisms Controlling the Periodic Offshore Blooms in Beibu Gulf

Qibin Lao and Fajin Chen
Guangdong Ocean University, College of Ocean and Meteorology, China (laoqibin@163.com)

Since offshore waters are less affected by human activities and nutrient-rich water masses, existing theories on periodic offshore blooms (POB) consider that the POB is proportional to the intensity of ocean fronts (nutrient supply from enhancing vertical mixing), ignoring external nutrient supply and external forcing (climatic oscillations). This study proposes an external dynamic mechanism of the POB on the basis of field observations and long-term satellite remote sensing data (1981–2022) in Beibu Gulf, which is influenced by remarkable external forcing. Three water masses, coastal current (CC), West-Guangdong coastal current (WGCC), and South China Sea water (SCSW), were identified using dual water isotopes. The seawater in the gulf mainly originated from CC in summer and fall, while it changed to the SCSW in winter. The nutrient in the gulf was mainly from the CC in summer and fall, while it shifted to the WGCC in winter. Notably, a strong thermal front with an inverted-V structure was found in the central gulf every winter due to the strong wind stress and change of water mass mixing. The intensity of the front on the east side is weaker due to the intrusion of WGCC. However, Chlorophyll-*a* concentrations in the eastern (nutrients supplied by WGCC) and northern (nutrients supplied by vertical mixing) were obviously higher than that in the western front (limited nutrient supply) in winter. On an interannual scale, the intensity of POB in La Niña years is remarkably stronger than in El Niño years due to the stronger WGCC supplying more nutrients in La Niña. This study suggests that the intensity and range of POB are not proportional to the frontal intensity in the gulf, but are directly driven by the internal forcing (fronts and nutrient supply from WGCC), which is controlled by the external forcing.