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学 位 論 文 内 容 の 要 旨

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学 位 論 文 題 名

Impacts of tides on large scale wind driven boundary currents in climate sensitive regions

（気候敏感海域における潮汐による大規模風成境界流へのインパクト）

This study aims to investigate the tidal impacts on wind-driven boundary currents and their further modification to the large-scale circulation. After decades of silence, the tidal study is re-focused by oceanographers because it influences the nutrient transport and the vertical mixing along with the continental shelves. However, the impacts of tides on the wind-driven boundary current, which dominates the continental shelves and plays a crucial role in water exchange with marginal seas, are ignored, although the boundary currents bathed enormous tidal activities on their pathway. For instance, two basin boundaries located on high-latitude areas, the Kuril Islands and the Antarctic Shelf Break, are the worldwide tidal activity hotspots and result in the global climate. This study thus focus on the two boundary currents of these two high-latitude regions, located in the north and south hemispheres, respectively, as our case studies.

Case 1: the East Kamchatka Current (EKC)

EKC is a western boundary current (WBC) flowing along with the Kuril Islands, drives the interbasin exchange between the Sea of Okhotsk and the North Pacific by its partial intrusion into the Sea of Okhotsk. The interbasin exchange between the two basins governs the intermediate water ventilation and fertilization of the nutrient-rich subpolar Pacific and thus has an enormous influence on the North Pacific. However, the exchange mechanism is puzzling; current studies have not explained how the western boundary current of the subarctic North Pacific intrudes only partially into the Sea of Okhotsk. High-resolution models often exhibit unrealistically small exchanges, as the WBC overshoots passing by deep straits and does not induce exchange flows. Therefore, partial intrusion cannot be solely explained by large-scale, wind-driven circulation. Case 1 demonstrates that tidal forcing is the missing mechanism that drives the exchange by steering the WBC pathway. Upstream of the deep straits, tidally-generated topographically trapped waves over a bank lead to cross-slope upwelling. This upwelling enhances bottom pressure, thereby steering the WBC pathway toward the deep straits. The upwelling is identified as the source of joint-effect-of-baroclinicity-and-relief (JEBAR) in the potential vorticity equation, which is caused by tidal oscillation instead of tidally-enhanced vertical mixing. The WBC then hits the island chain and induces exchange flows. This tidal control of WBC pathways is suggested applicable on subpolar and polar regions globally.

Case 2: the Antarctic Slope Current (ASC)

The hypothesis of tidal control on the ASC pathway is illustrated in Case 2. A similar resultant of tidally-induced seamount trapped waves also occurs at Antarctica, the other climate high-sensitive region. The Totten Ice Shelf (TIS) is one of the main ice shelves that suffered rapid basal melting in the East Antarctic coast caused by warm modified Circumpolar Deep Water (mCDW) intrusion across the continental slope. Sufficient evidence suggests that the ASC, a wind-driven boundary current flowing along with the Antarctica slope, modulates the intrusion of mCDW into the shallow ice shelf. However, the mechanism of how the ASC modulates the mCDW intrusion is not clear. By 25 years long high-resolution climate model simulation, the ASC is warmer and stronger in the tidal case along with the East Antarctic coast. On the other hand, the intrusion of mCDW into the Totten Ice Shelf is gradually weaker from 2010 compared to the non-tidal case. According to each 1.5 hours model output snapshot, this study found that the Potential Vorticity front is generated along with the Antarctic slope in the tidal case. Case 2 hypothesized that the variability of resultant potential vorticity gradient on the isopycnals is reduced by the tide-induced topographic trapped waves along the slope, and thus the mCDW intrusion is regulated in the tidal case. The tide is suggested as the threshold to regulate the ice shelves melting by tidal Potential Vorticity front on the slope. The confirmation experiment and analysis are leaving for future studies..

Comprehensively, this study argues that the tides play an essential role in the high-latitude and climatically sensitive areas by modifying the boundary currents. Because of the diurnal tides' high-frequency property, it is the key factor in stabilizing climate variability, such as supplying sufficient interbrain exchange in the North Pacific and re-distributing the heat intrusion in the East Antarctic. The further investigation of local tidal dynamics is expected not only to be important to the regional study but also to global climate studies.