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A numerical study on the formation of the Kuroshio Counter Current and the Kuroshio Branch Current in the East China Sea

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Abstract—The Kuroshio Counter Current (KCC) and the Kuroshio Branch Current (KBC) are two unique features of the Kuroshio in the East China Sea. The mechanisms that generate the KCC and the KBC are studied using a barotropic inflow–outflow model with a simplified basin configuration of the East China Sea. The present study shows that the KCC can only exist on a β-plane frame of reference and its flow pattern is independent of the offshore Ryukyu Islands. In the East China Sea, the continental slope plays the role of a western boundary for the Kuroshio. Whether the Kuroshio protrudes onto the slope region, however, is found to have little influence on the KCC. Concerning the formation of the KBC, we found that the planetary β-effect and the existence of Taiwan Island are two indispensible conditions: the planetary β-effect drives part of the Kuroshio inflow to branch southwestward and Taiwan Island blocks this branched current causing it to protrude onto the continental shelf. Based on the numerical calculation, we further found that the branch current is reinforced by topographic Rossby waves induced by the repeated crossing of the Kuroshio over the continental slope.

1. INTRODUCTION

The Kuroshio originates in the North Equatorial Current and flows into the East China Sea through the passage between Taiwan and Yonakuni-jima, an island at the southwestern tip of the Ryukyu Islands. Under the constraint of the steep continental slope, the main stream of the Kuroshio in the East China Sea runs stably along the 200 m isobath at a maximum velocity of 75–150 cm s^{-1} (Nitani, 1972). After it turns eastward around 30°29′N latitude and 129°E longitude, the Kuroshio eventually flows out into the Pacific through the Tokara Strait.

Figure 1 shows schematically the Kuroshio's flow pattern in the East China Sea. Notice that a counter current flowing southwestward exists between the main stream of the Kuroshio and the Ryukyu Islands. The observational evidence of the Kuroshio Counter Current (KCC) was obtained both from the movement of drifter bottles during winter in the East China Sea (Kondo and Tamai, 1975) and from direct CTD and GEK measurements. Figure 2 shows geostrophic velocity profiles calculated by Inoue (1981) from the CTD measurements along the PN section (see Fig. 1 for its location). The KCC, as indicated by the offshore shaded regions, has a maximum speed ranging from 20 to 50 cm s^{-1} and its volume transport tends to weaken in autumn. This tendency is possibly related to the fact that the Kuroshio in the East China Sea has a smaller volume transport in

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