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The Eddy–Mean Flow Interaction and the Intrusion of Western Boundary Current into the South China Sea–Type Basin in an Idealized Model

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An ideal model of the role of mesoscale eddies in the Kuroshio intruding into the South China Sea (SCS) is developed, which represents the northwestern Pacific and the SCS as two rectangular basins connected by a gap. In the case of considering only intrinsic ocean variability, a time-dependent western boundary current (WBC) driven by steady wind is modeled under both eddy-resolving and noneddy-resolving resolutions. Almost all simulated WBCs intrude into the adjacent sea in the form of the Loop Current with multiple-state transitions and eddy-shedding processes, which have aperiodic variations on intraseasonal or interannual scales, determined by the eddy-induced WBC variation. For the parameters considered in this paper, the WBC intrusion exhibits a 30–90-day cycle in the presence of the subgrid-scale eddy forcing (SSEF) but a 300–500-day cycle in the absence of SSEF. Moreover, the roles of the grid-scale and subgrid-scale eddies in the WBC intrusion are studied by using the dynamically consistent decomposition developed by Berloff. Based on the large-sample composite analysis of the intrusion events, it is found that the Loop Current intensity is mainly determined by baroclinic processes through grid-scale, eddy–eddy interaction and subgrid-scale, eddy–flow interaction. The intrusion position and period are mainly regulated by the SSEF to the west of gap, where the balance between relative vorticity and isopycnal thickness SSEFs determines eddy detachment. Generally, the relative vorticity SSEF therein tends to induce WBC intrusion. However, the isopycnal thickness SSEF tends to induce eddy shedding, and WBC retreat thus determines the intrusion cycle through counteracting relative vorticity SSEF.