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The nonlinear optimal triggering perturbation of the Kuroshio large meander and its evolution based on a regional ocean model

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Using the Regional Ocean Modeling System (ROMS) and the conditional nonlinear optimal perturbation (CNOP) approach, the initial perturbations which are the easiest to trigger the Kuroshio transition from the non-large meander (NLM) to the large meander (LM) are investigated, here we call this kind of initial perturbations the nonlinear optimal triggering perturbations. Meanwhile, we explore their evolution and reveal the role of the nonlinear physical processes in the LM formation. The results show that the large amplitudes of the perturbations are mainly located in the upper 2000 m in the southeastern area of Kyushu: 29°N–31°N, 131°E–133°E, where the eastward propagation of the perturbations is vital to the LM formation. Then through the depth-integrated vorticity equation of the perturbations, we find that the linear advection of the perturbation field by the background field tends to move the cyclonic eddy induced by the optimal triggering perturbation eastward while the nonlinear advection of the perturbations by the perturbations tends to move the cyclonic eddy westward. This offsetting effect between the linear advection and the nonlinear advection slows down the eastward movement of the cyclonic eddy so that it has the opportunity to further develop, eventually leading to the LM formation.