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A Generalized Double-Gyre Model of the Kuroshio Extension

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The Kuroshio Extension is studied through a reduced-gravity primitive equation model forced by a stationary double-gyre wind field. The domain of integration is a box spanning the whole North Pacific and the wind, though idealized, is chosen according to the ECMWF and COADS climatologies. The oceanic response is a double-gyre circulation yielding important temporal variations due to the internal nonlinear dynamics. Despite the simplicity of the model the time-averaged Kuroshio Extension shows meanders, northern and southern recirculation regions and an overall structure that are in good quantitative agreement with the corresponding observed features of the jet. The internal variability, found to be in terms of complex oscillations of the main meanders and of the total kinetic energy of the jet, is consistent with variable features observed through TOPEX/Poseidon altimeter data. Transitions of various kinds, from more to less intense states, yield a predominant periodicity in the kinetic energy of the jet at T=5.5 years, and other energy peaks at T=2.6, 3.1, 8 years. These results suggest that the internal dynamics may contribute to the interannual changes of the Kuroshio Extension in addition to (and through nonlinear interaction with) other changes, e.g. those due to variations of the meridional Sverdrup transport produced by variable winds. Finally, by scaling the wind through a parameter q (q=1 corresponds to the realistic case), the behavior of the flow is analyzed on the basis of dynamical system theory. The first Hopf bifurcation is found at q=0.55 and the successive period-doubling leads to a very complex, yet still non chaotic evolution for q=1. For q=1.05, on the other hand, the flow shows chaotic behavior.