An Optimal Observing System Study for the Kuroshio Extension using Particle Filters

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The Kuroshio Extension – the eastward-flowing free jet formed when the warm waters of the Kuroshio separate from the Japanese coast – reveals bimodal behavior. It changes from an elongated, energetic meandering jet into a weaker, unstable jet with a reduced zonal penetration. Many of its characteristics, e.g. the decadal period and the more stable character of the elongated state, are also observed in a reduced-gravity ocean model of the northern Pacific basin with a schematic Japanese coastline driven by a constant double-gyre wind field. The success of this idealized model suggests that intrinsic nonlinear mechanisms play a major role in determining the meander pattern of the mean flow.

The low complexity of the model makes it ideal to perform an observing system study. Here, we take a new approach by using particle filters to assimilate observations into the model. An ensemble of model states is integrated over time from an initial distribution. The first approach is to pick one run as the synthetic truth. Observations are produced from this synthetic truth with an additional observation error. The particle filter technique adjusts the weight of each ensemble run – each particle – according to the observation value and the error distribution. From the ensemble and its weight distribution the expectation and probability distribution of the state vector can be computed. As the ensemble itself is not altered by the filter, different sets of observations, e.g. with different geometrical configurations, locations and/or time resolutions, can be analyzed a posteriori.

The particle filter analyses allows us to identify which observations have a large impact on reconstructing the true state of Kuroshio Extension. More precisely, which observations contribute to a (local) reduction in the entropy of the ensemble. In a way each observation is then linked to an area of influence, which permits for determining the flow of information. We will present results where observations taken along several meridians are assimilated. These results can be used to pinpoint the intrinsic mechanisms that relate to the bimodal behavior of the Kuroshio Extension. Or opposingly, whether the transition finds it cause in a westward propagation of SSH anomalies generated by the Pacific Decadal Oscillation in the eastern part of the Pacific basin. During the Kuroshio Extension System Study an array of CPIES and seven deep moorings deployed along a line where used. We will also present results were synthetic observations are acquired for these configurations. In the end this study aims to find an optimal observation system for predicting the transition between the two states of the Kuroshio Extension.