Seasonal-to-decadal variability and predictability of the Kuroshio Extension in the GFDL Coupled Ensemble Reanalysis and Forecasting system

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The Kuroshio Extension (KE), an eastward-flowing jet located in the Pacific western boundary current system, exhibits prominent seasonal-to-decadal variability, which is crucial for understanding climate variations in northern midlatitudes. We explore the representation, predictability, and prediction skill for the KE in the GFDL SPEAR (Seamless System for Prediction and EArth System Research) coupled model. Two different approaches are used to generate coupled reanalyses and forecasts: (1) restoring the coupled model's SST and atmospheric variables toward existing reanalyses, or (2) assimilating SST and subsurface observations into the coupled model without atmospheric assimilation. Both systems use an ocean model with 1o resolution and capture the largest sea surface height (SSH) variability over the KE region. Assimilating subsurface observations appears to be critical to reproduce the narrow front and related oceanic variability of the KE jet in the coupled reanalysis. We demonstrate skillful retrospective predictions of KE SSH variability in monthly (up to 1 year) and annual-mean (up to 5 years) KE forecasts in the seasonal and decadal prediction systems, respectively. The prediction skill varies seasonally, peaking for forecasts initialized in January and verifying in September due to the winter intensification of North Pacific atmospheric forcing. We show that strong large-scale atmospheric anomalies generate deterministic oceanic forcing (i.e., Rossby waves), leading to skillful long-lead KE forecasts. These curl anomalies also drive Ekman transports that form ocean memory, by sequestering thermal anomalies deep into the winter mixed layer that re-emerge in the subsequent autumn. The SPEAR forecasts capture the recent negative-to-positive transition of KE phase in 2017, projecting a continued positive phase through 2022.