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Origin of Decadal-scale Eastward-propagating Signals of Oceanic Heat Content in the North Pacific Ocean

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The mid-latitude North Pacific Ocean supports both eastward and westward moving subsurface signals. Typically studies of sea surface height anomalies report westward propagation and interpret these as the first baroclinic mode Rossby waves (RWs), while investigations of upper ocean heat content (OHC) find eastward propagation and cite mean flow advection as an underlying cause. Yet, OHC in general affects the velocity field via density change and thus also evolves as RWs. We investigate this dichotomy using a 150-year CGCM integration. Simulated OHC signals are distinguished in terms of two processes that can support eastward propagation: higher baroclinic RW modes and density-compensated temperature and salinity anomalies, a.k.a. spiciness. Our analysis suggests a unique role of the Kuroshio/Oyashio Extension (KOE) region as an origin of the spiciness and higher mode RW signals as follows. First, wind-forced, westward-propagating first baroclinic RW causes circulation anomalies in the KOE region, accompanying the meridional shift of the subarctic front. Anomalous advection of mean temperature and salinity gradients then generates spiciness anomalies, which are advected eastward by mean currents, manifested as eastward co-propagation of OHC and sea surface salinity anomalies. While being advected, the surface temperature anomaly associated with the spiciness signal is damped by air-sea heat exchange and thus generates density anomalies, which further propagate eastward as higher mode RWs. The result suggests that the commonly used indices of OHC of the upper ocean result from a mixture of different dynamics that are transformed one another in the KOE region.

Keywords: Oceanic Heat Content, Decadal Varaibility, Rossby Waves, Spiciness, Air-sea Interaction, Subarcitic Frotal Zone