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Decadal to inter-decadal sea level changes in the North Pacific

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Understanding the physical nature of sea level responses to climate change is an important aspect of climate research because of its direct impact on human society and coastal environments. Patterns of regional sea level change are principally determined by the baroclinic component, which is approximately equal to the steric sea level changes when substantial density changes are restricted in the upper part of the ocean column. Some studies using ocean models suggested that regional sea level changes are mainly associated with vertical displacement of the main pycnocline as a dynamical response to varying wind stress patterns [e.g., Yasuda and Sakurai, 2006]. Other factors, such as the variations of the water mass properties, affect regional sea level trends. However, the contribution of the substantial water mass density changes to the decadal to inter-decadal regional sea level changes have not been sufficiently well investigated.

Using gridded ocean temperature and salinity fields based on historical observations and future projections by a climate model, we have investigated decadal to inter-decadal baroclinic sea level changes in the North Pacific. We performed an Empirical Orthogonal Function (EOF) analysis to examine the spatial and temporal variability. Two typical patterns of the decadal to inter-decadal sea level changes are shown in the North Pacific. One typical pattern is characterized as the first brcoclinic mode, which represents the vertical displacement of main pycnocline. The other is affected by water mass density changes, such as subtropical mode waters. These results suggest that it is important to understand the relation between changes in water mass density and the formation of regional patterns of sea level change on decadal to inter-decadal time scales. Similar regional sea level response is shown in a future projection under CO_2-induced global warming using a climate model [Suzuki and Ishii, 2011], suggesting that the elucidation of the regional sea level response to the changes in the water mass is indispensable to improve the future projection of regional sea level change.