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Estimating regional sea level trends using CSEOF-based reconstructions

Benjamin Hamlington[†]; Robert Leben; Steve Nerem; Thomas Phillips; Kwang-Yul Kim
[†] University of Colorado at Boulder, USA
Leading author: hamlingt@colorado.edu

As a result of the relative shortcomings of tide gauge and satellite altimetry data, combining the shorter but essentially complete global coverage offered by satellite altimetry with the longer but sparsely distributed tide gauge dataset is an active research area. The ability to compare the current state of the ocean to previous ocean states is important for monitoring the changing climate and projecting sea level change in the future. Using a technique known as empirical orthogonal function (EOF) reconstruction, several attempts have been made at combining tide gauge data and satellite altimetry data. We have developed a new technique for reconstructing sea level signals from satellite altimetry and tide gauge data. Shortcomings of published sea level reconstructions stem partially from the use of EOFs, computed from the satellite altimetry record, as the basis functions for the reconstruction. Using cyclostationary empirical orthogonal functions (CSEOFs) instead of EOFs, the temporally varying spatial patterns and longer-timescale fluctuations such as those related to the annual cycle and ENSO are better represented and captured. The CSEOF reconstructed dataset can be used to estimate the regional distribution of sea level rise over the past century. One significant advantage of the CSEOF reconstruction technique over other techniques is the ability to handle the large-scale signals in the ocean. The CSEOF decomposition of satellite altimetry data yields a mode representing the traditional eastern Pacific ENSO signal, in addition to several other modes representing different patterns of ENSO variability (e.g. El Niño Modoki). By using these modes in the reconstruction procedure, we are able to reconstruct the ENSO signal back to 1900 and beyond strictly from sea level measurements. Additionally, using simple regression techniques, we explore the possibility of improving upon the sea level reconstruction by including other ocean observations such as sea surface temperature and sea level pressure in the reconstruction procedure. The improvement resulting from the inclusion of more data sources is demonstrated through comparisons of regional sea level trends and climate indices computed from the reconstructed datasets.