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Projected changes, climate change signal, and uncertainties in the CMIP5-based projections of ocean surface wave heights

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Ocean surface waves can be major hazards in coastal and offshore activities. However, wave observations are available only at limited locations and cover only the recent few decades. Also, there exists very limited information on ocean wave behavior in response to climate change, because such information is not simulated in current global climate models.

In a recent study, we used a multivariate regression model with lagged dependent variable to make statistical global projections of changes in significant wave heights (Hs) using mean sea level pressure (SLP) information from 20 CMIP5 climate models for the twenty-first century. The statistical model was calibrated and validated using the ERA-Interim reanalysis of Hs and SLP for the period 1981-2010. The results show Hs increases in the tropics (especially in the eastern tropical Pacific) and in southern hemisphere high-latitudes. Under the projected 2070-2099 climate condition of the RCP8.5 scenario, the occurrence frequency of the present-day one-in-10-year extreme wave heights is likely to double or triple in several coastal regions around the world (e.g., the Chilean coast, Gulf of Oman, Gulf of Bengal, Gulf of Mexico).

More recently, we used the analysis of variance approaches to quantify the climate change signal and uncertainty in multi-model ensembles of statistical Hs simulations globally, which are based on the CMIP5 historical, RCP4.5 and RCP8.5 forcing scenario simulations of SLP. In a 4-model 3-run ensemble, the 4-model common signal of climate change is found to strengthen over time, as would be expected. For the historical followed by RCP8.5 scenario, the common signal in annual mean Hs is found to be significant over 16.6%, 55.0% and 82.2% of the area by year 2005, 2050 and 2099, respectively. For the annual maximum, the signal is much weaker. The signal is strongest in the eastern tropical Pacific, featuring significant increases in both the annual mean and maximum of Hs in this region. The climate model uncertainty (i.e. inter-model variability) is significant over 99.9% of the area; its magnitude is comparable to or greater than the climate change signal by 2099 over most areas, except in the eastern tropical Pacific where the signal is much larger. In a 20-model 2-scenario single-run ensemble of statistical Hs simulations for the period 2006-2099, the model uncertainty is found to be significant globally; it is about 10 times as large as the scenario uncertainty between RCP4.5 and RCP8.5 scenarios.