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Marine heatwaves: Key processes, detection and attribution, and projections

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Some of the recently observed marine heatwaves (MHWs) revealed the high vulnerability of marine ecosystems and fisheries to such extreme climate events. Yet our knowledge about past occurrences and the future progression of MHWs is very limited. Although there is rapidly growing literature on individual events, the underlying drivers and the degree to which they can be attributed to global warming are currently not well known. Here, we use satellite observations and a suite of CMIP5 Earth system model (ESMs) simulations to show that MHWs have already become longer-lasting and more frequent, extensive and intense in the past few decades, and that this trend will accelerate under further global warming. Between 1982 and 2016, we detect a doubling in the number of MHW days. If temperature were to rise by 3.5 degrees Celsius by the end of the twenty-first century, the average increase in the probability of MHWs would be 41 times higher than in preindustrial times. At this level of global warming, the spatial extent of the heatwaves would be 21 times larger, their duration would increase to 112 days and their maximum intensity would rise to 2.5 degrees Celsius. The largest changes are projected to occur in the western tropical Pacific and the Arctic Ocean. An important assumption in this analysis is that the employed ESMs simulate MHWs in a sufficiently realistic manner. Whereas this is the case for the frequency and the maximum intensity of MHWs, it is not the case for the duration and spatial extent, which might be caused by the relatively coarse resolution of the ESMs. Therefore, we test the robustness of our results using a new global high-resolution ESM, the GFDL-CM2.6 with an ocean model horizontal resolution of 0.1°, to address the importance of mesoscale ocean processes in driving MHWs.