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Understanding future changes in ocean eddy kinetic energy

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Ocean eddies, which present different properties to their surroundings, play pivotal roles in transporting heat, salt, organic carbon, and nutrients around the ocean, ending up controlling regional and global climate. Eddy kinetic energy (EKE), defined as the kinetic energy of the time-varying component, is one of the most crucial indicators for observing the upwelling and downwelling induced by ocean eddies. We aim to understand the future changes in ocean eddy activities and find the possible cause of them using an ultra-high-resolution climate simulation of CESM 1.2.2, with about 25 km horizontal resolution and 30 vertical levels in the atmosphere, and about 10 km horizontal resolution and 62 levels in the ocean, under different levels of greenhouse gas conditions: Present-day run (PD, fixed CO2 concentration of 367 ppm), Doubling CO2 run (2xCO2, 734 ppm), Quadrupling CO2 run (4xCO2, 1468 ppm). Model simulation shows that compared to PD, the global EKE will increase about 6.7 % and 14.7 % in 2xCO2 and 4xCO2, respectively, but with the nonuniformed spatial distributions. The results show that the EKE increases about 12.5 % in 2xCO2 and decreases about 0.5 % in 4xCO2 in the Kuroshio Current region. In contrast, it decreases about 4.8 % (22.5 %) in 2xCO2 (4xCO2) in the Gulf Stream region. To find the underlying processes for the EKE change, we focus on identifying future changes in the energetics of eddy-mean flow interactions. Based on the energetics of eddy-mean flow interaction, the strengthened barotropic conversion will enhance the EKE in 2xCO2 over the Kuroshio Current region. Otherwise, the suppression of buoyancy flux will weaken the EKE in 2xCO2 and 4xCO2 over the Gulf Stream region.