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Mechanisms driving the projected Arabian Sea primary productivity weakening under climate change in CMIP

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The Arabian sea (AS) high primary productivity (PP) is crucial for sustaining ecosystems and fisheries, in a region where fish catches contribute significantly to food security. Previous studies have suggested a projected decline in the AS productivity in response to anthropogenic forcing, either from a limited set of coupled model experiments or idealized forced experiments. These studies had generally attributed the decline in PP to an increase in upper ocean stratification and a less efficient upward mixing of nutrients in response to the surface warming associated with climate change. Here we use 16 Coupled Model Intercomparison Project phase 5 (CMIP5) – Representative Concentration Pathways 8.5 (RCP8.5) scenario simulations with a biogeochemical oceanic component to assess the robustness of the projected PP reduction in the AS, and investigate its driving mechanism. We show that the total annual AS PP reduction discussed in previous studies occurs in all of the 16 models, with an average reduction of ∼20% (ranging from 10 to 30% in individual models) by 2100. The largest reduction occurs in the most productive regions, i.e. in the Somalia, Oman and south-western coast of India upwellings during summer, and in the Northern Arabian Sea during winter. We find a stronger control of the spatial pattern of PP change by changes in the thermocline depth (and sea level) than by changes in stratification, which challenges the previously-proposed mechanism for productivity changes in the AS region. The projected weakening of the Walker Circulation in all of the CMIP5 models we analysed yield annual-mean easterlies along the equatorial Indian Ocean, inducing a thermocline deepening in the entire southern Arabian Sea. This thermocline deepening is associated with a nutricline deepening, a reduced nutrients availability in the euphotic layer and a decrease in productivity in the Somalia and Southwestern coast of India upwellings. Further north, the projected weakening of the summer monsoon and poleward shift of the monsoon jet yield a positive wind stress curl in the Northern AS on annual average. While the wind change at the coast tends to be favorable to an increased upwelling, this effect is overwhelmed by the larger effect of Ekman downwelling in the basin interior, that then propagates to the coast as Rossby waves. The resulting deepening of the thermocline and nutricline hence also yields a PP decrease in the Oman upwelling region. The present study hence suggests that changes in the wind patterns play an important role in projected changes in PP, by influencing the depth of the thermocline and nutricline. The relative importance of this mechanism and of that related with changes in stability will have to be further explored in the future. We will also briefly describe oxygen changes in this region characterized by a strong subsurface Oxygen Minimum Zone.