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Role of synoptic activity in the projected changes in upwelling-favourable winds at the ocean's eastern boundary systems

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The climate of the ocean's eastern boundaries is strongly influenced by subtropical anticyclones. The surface wind stress is predominantly alongshore and equatorward, which promotes upwelling of nutrient-rich subsurface water that supports a high abundance of food resources. Understanding the projected response of upwelling-favourable winds to climate change has broad implications for coastal biogeochemistry, ecology, and fisheries. Here we use a reanalysis, an ensemble of global climate simulations, and an objective algorithm to track anticyclones to investigate the projected changes in upwelling-favourable wind events at the California, Canary, Humboldt, and Benguela coastal upwelling systems. Except for the north Pacific, we find consistent poleward shifts over the ocean basins. We show that the projected changes in upwelling-favourable wind events in these coastal upwelling systems are dynamically linked to a poleward shift of the subtropical ridge (STR), stationary subtropical highs, and migratory anticyclones. Synoptic-scale migratory anticyclones force intense coastal upwelling events, which become more frequent at higher latitudes and less frequent at lower latitudes in the future. Thus, we propose that projected changes in coastal upwelling systems occur in the context of large-scale climatological changes in both tropical atmospheric processes, such as Hadley Cell expansion and poleward migration of subtropical anticyclones, as well as extratropical atmospheric processes, such as trends in annular modes that can modify the frequency and intensity of short-lived strong wind events. Both processes need to be considered to fully explain projected changes at the coastal upwelling systems under anthropogenic climate change.