Justification Statement: Josey and Schroeder, Declining Winter Heat Loss Threatens Continuing Ocean Convection at a Mediterranean Dense Water Formation Site

What are the new results or developments reported in your article?

We find that continued ocean convection in the Northwest Mediterranean (NWMed) is threatened by a multidecadal decline in winter sea surface heat loss to the atmosphere. The NWMed is one of the few sites globally where convection and dense water formation occur. Ocean convection is driven by sea surface heat loss and is vulnerable to atmospheric changes stemming from global heating which can weaken heat loss. Our observation-based analysis shows a.) rising air temperature is indeed reducing the sea-air temperature difference, and thus the amount of heat lost, and b.) NWMed convection has declined by 40% from 1969 to 2018. In contrast, at a second key dense water formation site, in the Eastern Mediterranean, we find very different results as heat loss remains unchanged at multidecadal timescales. We explain this contrast in terms of regional differences in the ability of the atmospheric circulation to offset the effects of global heating.

Why are these new results or developments significant?

The results are significant as they show for the first time that multidecadal changes are taking place in ocean-atmosphere interaction which threaten continued ocean dense water production. We focus on the Mediterranean but our results are applicable to other dense water formation regions. They provide a warning about a fundamental environmental change i.e., the potential for anthropogenic warming of the near-surface atmosphere to impact the deep ocean via air-sea heat exchange. They are also relevant to efforts to address environmental change as the Mediterranean land region is a climate change hotspot as witnessed by the extreme heat and wildfire damage experienced there in recent months. The ocean is the major sink for excess anthropogenic heat in the climate system. The changes we have identified threaten this sink and thus human efforts to limit extreme heat over the adjacent land areas as reduced ocean heat uptake implies greater warming of the atmosphere.

In what way are these new results or developments timely?

The results are timely because the Mediterranean region is increasingly seen as an area that is being strongly impacted by the climate crisis (e.g., MedECC, 2020). Furthermore, they will influence researchers working elsewhere because they describe a change in a key ocean-atmosphere interaction process (winter surface heat loss leading to ocean convection) that is important at other sites. Specifically, convection and dense water formation happens at a handful of sites around the globe. These are located in the Mediterranean Sea, the high latitude North Atlantic and the Southern Ocean. Our findings point to differential shutdown of ocean dense water production in the Mediterranean which could be repeated elsewhere, particularly in the Labrador-Irminger-Nordic Seas nexus of high latitude Atlantic sites that play a key role in the Atlantic overturning circulation. In addition, our results are of interest to scientists in other disciplines e.g., a.) projections of air temperature extremes and wildfire risk over Mediterranean countries (see earlier comments), b.) marine biology, as weakened winter convection will reduce the oxygen supply to the ocean at depth. In summary, our results provide a timely warning and explanation of changes taking place in the Mediterranean Sea that are of relevance to scientists working elsewhere and in other subject areas.

MedECC (2020). Climate and Environmental Change in the Mediterranean Basin – Current Situation and Risks for the Future. First Mediterranean Assessment Report [Cramer, W., Guiot, J., Marini, K. (eds.)] Union for the Mediterranean, Plan Bleu, UNEP/MAP, Marseille, France, 632pp. DOI: 10.5281/zenodo.4768833.