# Ocean and extreme events: Better forecasting for a better prepared society

March 1 2022

Credit: CC0 Public Domain

State-of-the-art seasonal forecast systems provide predictions of unusual climate conditions in the atmosphere, ocean, land and other components of the climate. These systems are capable of predicting climate variables like temperature and precipitation months in advance. A main reason for this capability is the famous ocean–atmosphere interaction known as the El Niño Southern Oscillation (ENSO). ENSO alters the atmospheric circulation across the entire tropical Pacific and, as a result, causes

teleconnections which change seasonal climates across the world. The upper ocean acts as a "memory bank" by providing long-term heat storage for the region. Our ability to predict seasonal changes is therefore strongly influenced by the subsurface ocean heat content (OHC) in the tropical Pacific.Ocean heat content (OHC) anomalies typically persist for several months, making this variable a vital component of seasonal predictability in both the ocean and the atmosphere. However, the ability of seasonal forecasting systems to predict OHC remains largely untested. A study just published in *Climate Dynamics* led by the CMCC Foundation—Euro-Mediterranean Center on Climate Change (CMCC) presents an assessment of the predictive skill of ocean heat content in the upper 300 m in two state-of- the-art seasonal forecasting systems.

"There was no extensive validation of ocean heat content in seasonal forecasting systems, despite its important role in seasonal predictability and the potential applications", explains Ronan McAdam, CMCC researcher at Ocean Modelling and Data Assimilation Division and first author of the study. "To our knowledge, this is the first attempt to estimate the predictive skills of OHC at seasonal time scales and for the global ocean."The two forecast systems used in this research are the Seasonal Prediction System Version 3 from the CMCC Foundation (CMCC-SPS3), and the fifth generation Seasonal Forecasting System from the European Centre for Medium-Range Weather Forecasts (ECMWF- SEAS5). Since 2018 both systems have been contributing to the Copernicus Climate Change Service (C3S), which makes seasonal forecasts of precipitation, 2 m-temperature, and more, freely available online.

Overall, researchers found out that dynamical systems make skilful seasonal predictions of OHC in the upper 300 m across a range of forecast start times, seasons and dynamical environments. The upper 300 m was chosen because it encompasses many diverse phenomena across

the ocean which are either relevant for predictability or applications. To give some examples, in the tropics, the cycle of ENSO and the events correlated to this phenomenon are strongly influenced by the subsurface ocean heat content in the tropical Pacific, while in the North Atlantic OHC anomalies affect the formation of hurricanes. Marine wildlife is also affected by habitat displacement and shrinking occurring below the surface. Thus, early prediction of OHC anomalies may aid mitigation of extreme events.

The study shows that there is potential to make accurate predictions of sub-surface warming up to two seasons in advance, opening up a wide range of potential applications of marine seasonal forecasting. For example, seasonal lead times would provide an early prediction of ocean conditions which render extreme heat events more likely, and therefore provide fisheries, aquaculture farms and marine protected areas ample time to prepare for adverse events.

"Although there are some studies on the use of predictions of heat content, perhaps the potential applications are not yet widely appreciated" concludes Ronan McAdam. "An exciting and urgent task for seasonal forecasting in the near future is the prediction of marine heat waves, which either occur at depth or are driven by subsurface heat anomalies. The role of OHC in marine heatwaves is in fact twofold: increased OHC can make the heatwaves more likely to occur and can therefore be a driver of what we call an ocean-driven heatwave, or can be itself an indication that a heatwave is happening. The average duration of such events is increasing globally and is crossing into the timescales of seasonal forecasts. Fortunately, events driven by subsurface warming are expected to be more predictable than those primarily driven by relatively abrupt atmospheric disturbances. The early prediction of subsurface heating could be of great economic and practical benefit to several industries such as aquaculture and fishing, and could aid marine conservation efforts against mass-mortality

events."

Because of the potential role such forecasts could play in socio-economic decision making, the next step in marine seasonal forecasting work will therefore be the validation of indices which have socio-economic relevance, such as the number and intensity of extreme events. Any validation of this kind will require context on how key variables, such as OHC, behave in seasonal forecast systems. This study provided a first step in this direction on a global scale.

**More information:** Ronan McAdam et al, Seasonal forecast skill of upper-ocean heat content in coupled high-resolution systems, *Climate Dynamics* (2022). DOI: 10.1007/s00382-021-06101-3

Provided by CMCC Foundation - Euro-Mediterranean Center on Climate Change