Unprecedented biological changes in the global ocean

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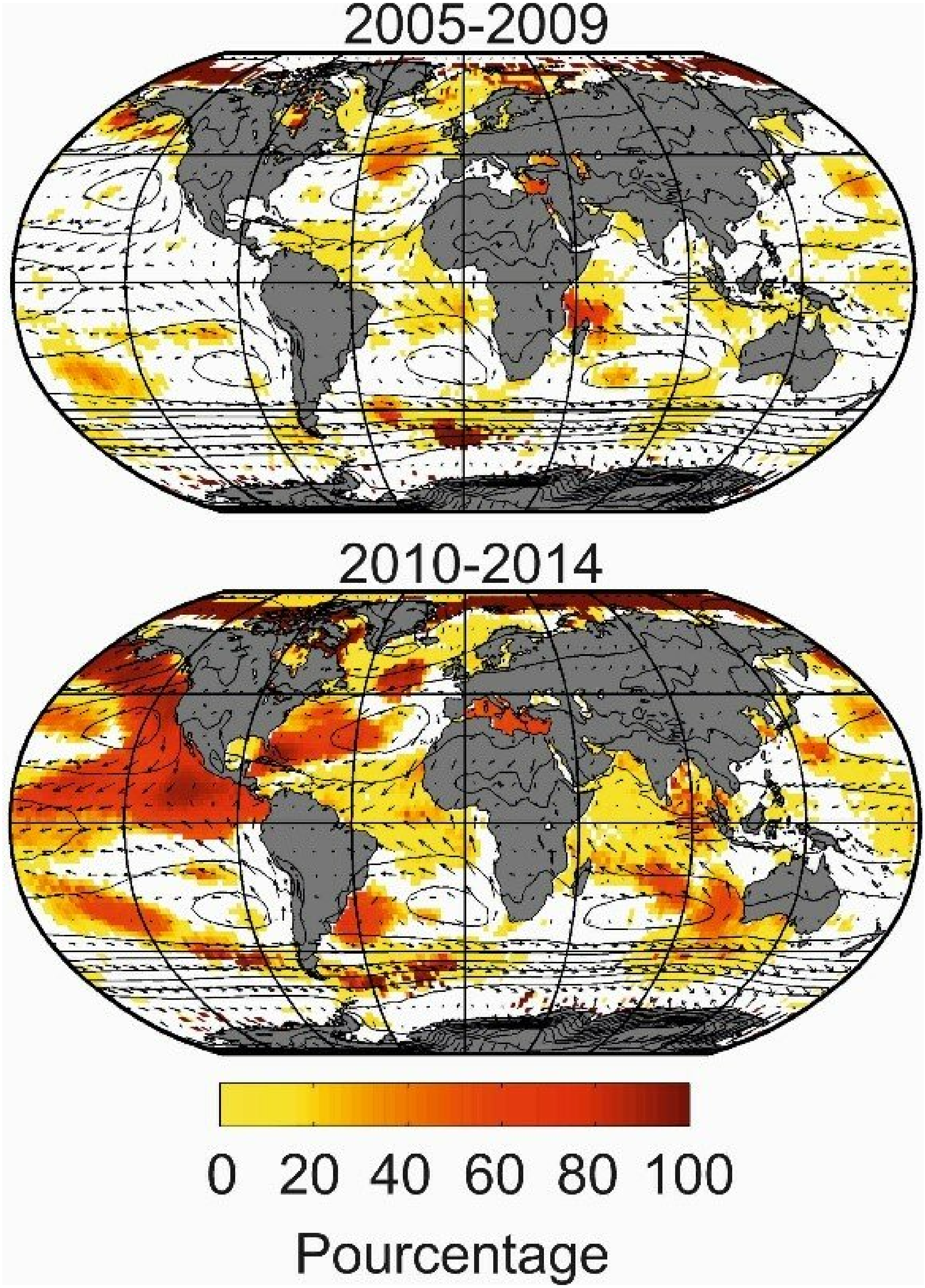
2005-2009
2010-2014
0 20 40 60 80 100
Pourcentage

By way of illustration, here are two applications of the model, for the periods running from 2005 to 2009 (top) and from 2010 to 2014 (bottom). Red indicates substantial biological changes; yellow, minor changes. No color means no change. Credit: Grégory Beaugrand

Current monitoring of marine biological systems only covers a tiny fraction of the ocean, which limits scientists' ability to confidently predict the expected effects of climate disturbances on marine biodiversity. Using a new computer model, an international team led by the CNRS and involving researchers from Sorbonne University has demonstrated that biological changes are accelerating, which has consequences for our use of marine resources. Their findings are published in *Nature Climate Change*.

Over time, marine biological systems have experienced changes of varying magnitude due to natural climatic fluctuations. Abrupt biological shifts—dubbed "climate surprises"—have also been detected in many regions of the ocean. To understand these shifts, whether sudden and unexpected or stretched out over longer periods, scientists from the CNRS and Sorbonne University, with colleagues from European, American, and Japanese research institutes, developed a novel approach based on the macroecological theory on the arrangement of life (METAL). To construct their computer model, the researchers designed a large number of simulated species ("pseudo-species") exhibiting a wide range of responses to natural temperature variations. These pseudo-species, which avoid thermal fluctuations beyond their range of tolerance, form "pseudo-communities" and gradually colonize all oceanic regions in the model.

Marine biodiversity monitoring programs only cover a small area of the ocean and usually only within regions near the coast. This new model based on the METAL theory offers global coverage and permits rapid identification of major biological shifts that can strongly impact marine biodiversity and associated ecosystem services like fishing, aquaculture, and the carbon cycle. When initially tested for fourteen oceanic regions, the model accurately predicted actual biological changes observed in the field since the 1960s. By next applying the model to the global ocean, the researchers were able to quantify the force and spatial extent of these biological shifts. The model also allowed them to draw attention to a recent, unheard-of rise in the number of "climate surprises," which may likely be attributed to El Niño, temperature anomalies of the Atlantic and the Pacific, and Arctic warming.

In most cases, the model predicts an event one year before it occurs, making it possible to identify regions overlooked by current field observation programs where biodiversity is under threat. Though marine biodiversity provides humans with 80 million metric tons of fish and invertebrates annually, the changes revealed by this new computer model may redistribute ocean communities and species worldwide in ways that may benefit or harm mankind.

More information: Prediction of unprecedented biological shifts in the global ocean, *Nature Climate Change* (2019). DOI: 10.1038/s41558-019-0420-1 , www.nature.com/articles/s41558-019-0420-1

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