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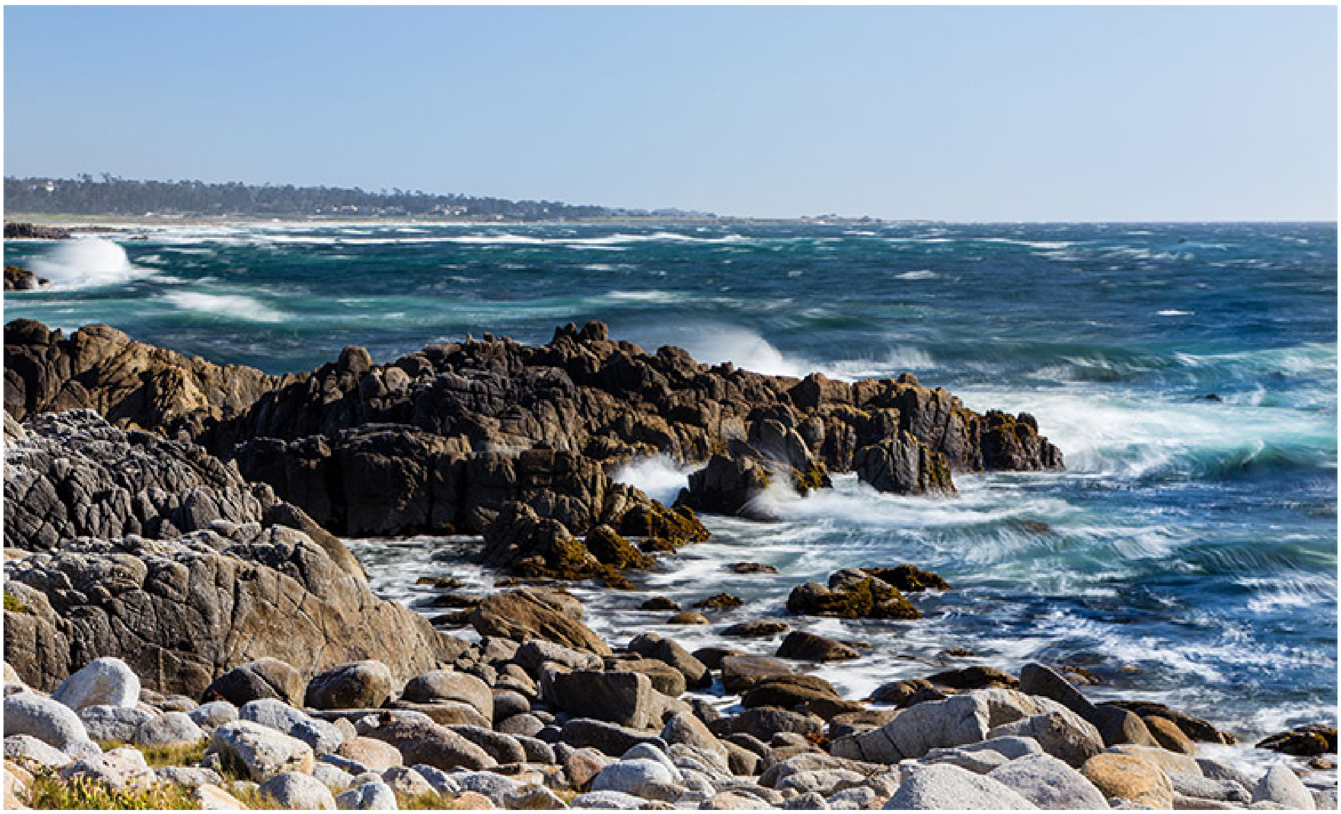
New Ocean Current Simulations Alter View of Climate Change Impacts

SDSC's 'Gordon' used to model dynamics of California current



A "more realistic" computer model, created with the aid of *Gordon* at the San Diego Supercomputer Center (SDSC) at UC San Diego, paints a new picture of global warming's impact on the complex processes that drive ocean mixing in the vast eddies swirling off the California coast.

The new model, published in the July issue of Nature Geosciences, more accurately describes how global warming affects the winds and circulation in the California Current system that runs parallel to the coast, and how previous models, based largely on offshore winds generated by global warming, misrepresented what was actually happening.

Information like this is critical since the California Current provides a habitat for one of the most populous and species-diverse regions in the world, while providing a bounty of seafood and tourism jobs for the state.

“Climate change could intensify coastal winds, but that does not imply it would increase the production of nutrients,” said Lionel Renault, an atmospheric and oceanic sciences researcher with UCLA, and lead author of the paper. “This research gives us a more realistic overview of the different ‘upwelling’ systems, the mechanisms that drives productivity (of nutrients), and how climate change can impact those mechanisms and productivity.”

‘Upwelling’ is a condition in which winds push surface water offshore and are replaced by deep waters, circulating nitrates, phosphates, and trace metals from below where they provide nutrients for the marine food chain.

For years, computer models suggested that global warming would increase coastal upwelling, implying an increase in net productivity of nutrients for marine life. However, these earlier models failed to zoom in on other features, including coastline shape and topography as well as sea surface temperatures. Together, such factors would more accurately describe realistic physics of the ocean’s biogeochemical response to global climate changes.

Unlike older and less finely-tuned computer models, these latest simulations and images show that the orography and meandering coastline are actually slackening winds closest to the California shoreline (the first 20 to 80 kilometers) along the whole U.S. West Coast, and in particular from San Francisco to south of Newport Beach. More specifically, the simulations and observations show that near-shore reduction of winds not only is weakening upwelling along the coast, but it’s also reducing the number and velocity of swirling eddies which typically would quench the flow of nutrients for biological production.

“Based on simple upwelling models, one should expect to have less production near the coast,” said Renault. “However, eddies along the U.S. west coast remove nutrients from the euphotic layer (depth extending from the water’s surface down to where sunlight falls to one percent of the surface) and therefore reduces production. By weakening the presence of eddies, a wind drop-off can therefore lead to larger production.”

On balance, the scientists conclude that the observed slackening of winds near the coast would ultimately have little effect on near-shore phytoplankton productivity despite a large reduction in upwelling velocity.

The investigation into the California Current system is part of a larger project focused on the world's eastern boundary upwelling systems (EBUs), which, aside from California and Oregon, includes Peru and Chile, southern Africa, and northern Africa. All are narrow stretches of coastal water, hundreds of miles long and located at the eastern edge of an ocean; and they share unique properties that create nutrient-laden water. The goal of this research is to develop more finely-tuned models of the EBUs to simulate the complex interaction between the ocean and the atmosphere, identify the difference between the natural variations in the ecosystems and variations due to climate change, and predict whether changes in cloud cover will allow more or less sunlight and warmth.

"Nearly a fifth of the worldwide ocean productivity is in these zones, and no one has really looked with this level of detail at the climate change implications for these precious marine areas," said Renault.

He added that this new ocean circulation model could not have been produced without access to a data-intensive, high-performance computer such as *Gordon*, based at SDSC and available through the National Science Foundation's XSEDE (eXtreme Science and Engineering Discovery Environment) program, the most advanced collection of integrated digital resources and services in the world.

"*Gordon* helped and is helping us to develop numerical coupled atmospheric and oceanic simulations that are very costly in terms of resources," said Renault. "We could not perform them without supercomputers like *Gordon*."

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