Ocean Warming in Southern Hemisphere Underestimated

Using satellite observations and a suite of climate models, Livermore scientists have found that long-term warming in the upper-700 meters of Southern Hemisphere oceans has been likely underestimated. “This underestimation is a result of poor sampling prior to the last decade and limitations of the analysis methods that estimate temperature changes in data-sparse regions,” says Livermore oceanographer Paul Durack, lead author of a report in the October 5, 2014, issue of *Nature Climate Change*. “Our results suggest global ocean warming has been underestimated by 24 to 58 percent. The conclusion agrees with previous studies, but it’s the first time scientists have estimated how much heat we’ve missed.”

The team found that climate models simulating the relative increase in sea surface height—a leading indicator of climate change—between Northern and Southern hemispheres are consistent with highly accurate altimeter observations. However, separating the simulated upper-ocean warming in the Northern and Southern hemispheres is inconsistent with observed estimates of ocean-heat-content change. These sea-level and ocean-heat-content changes should be consistent, suggesting that Southern Hemisphere ocean-heat-content changes were likely underestimated. Since 2004, automated profiling floats named Argo have been used to measure global ocean temperatures up to depths of 2,000 meters. The 3,600 Argo floats observing the ocean provide systematic coverage of the Southern Hemisphere and, with earlier data, show gradual warming.

Ocean heat storage is important because it accounts for more than 90 percent of Earth’s excess heat associated with global warming. The Southern Hemisphere oceans make up 60 percent of the world’s oceans. Given that most of the excess heat associated with global warming is in the oceans, this study has important implications for how scientists view Earth’s overall energy budget.

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Tiny Carbon Nanotube Pores Make Big Impact

Livermore scientists have created a new kind of ion channel consisting of carbon nanotubes inserted into synthetic bilayers and cell membranes to form tiny pores that transport water, protons, small ions, and DNA. The Livermore team, with colleagues at the Molecular Foundry at the Lawrence Berkeley National Laboratory, University of California Merced and Berkeley campuses, and University of the Basque Country, fabricated an efficient, biocompatible, membrane-pore channel out of a carbon nanotube (CNT), a tubelike molecule consisting of graphene.

Research showed that CNT porins display many behaviors of natural ion channels. The CNT porins spontaneously insert into membranes, switch between metastable conductance states, and display macromolecule-induced blockades. The team also found that local channel and membrane charges could control the ionic conductance and selectivity of the CNT porins. Kyunghoon Kim, a postdoctoral research team member, says, “We expect that CNT porins could be modified with synthetic gates to alter their selectivity.” Researchers have long been interested in developing synthetic analogs of biological membrane channels that could replicate high efficiency and extreme selectivity for transporting ions and molecules. However, these efforts involved problems with synthetics and have not matched the capabilities of biological proteins.

“Nanopores are a promising biomimetic platform for developing cell interfaces, studying transport in biological channels, and creating biosensors,” says Aleksandr Noy, a Livermore biophysicist who led the study and is senior author of a paper in the October 30, 2015, issue of *Nature.* “Many efficient drugs that treat diseases of one organ are quite toxic to another,” says Noy. Unlike taking a pill that is delivered to the entire body, carbon nanotubes can pinpoint an area to treat without harming surrounding organs. These carbon nanotube porins have significant implications for the future of health care and bioengineering through drug delivery, novel biosensors and DNA sequencing applications, and as components of synthetic cells.

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Holography Reveals Hidden Cracks in Shocked Targets

A research team led by Livermore scientists developed a technique for three-dimensional image processing of a high-speed photograph of a target. “We are interested in how fast-moving surfaces crack, crumble, and disintegrate after they are shocked by a laser pulse, because these details provide us important information about a material’s properties,” says David Erskine, lead author of a paper in the June 2014 online issue of *Review of Scientific Instruments*.

Most of the relevant experiments were performed at Livermore’s Jupiter Laser Facility. This technique is particularly applicable in targets that are shocked with lasers, suddenly undergoing intense energy waves. The process described uses an apparatus called a velocity interferometer, or VISAR, to measure velocities of targets (see image at top). VISAR is traditionally used to measure a target along a line or at a single point. The team instead used VISAR two-dimensionally to make snapshot images using high-resolution detectors with a short laser flash to freeze target motion. Holographic properties became apparent, making it possible to recover three-dimensional information from two-dimensional images. “We didn’t set out to do holography, but when our target moved, blurring cracks, we could refocus the data by numerical processing and bring blurred features into focus.” says Erskine.

The ability to better image cracks that are growing and changing at short timescales, even when moving and unfocused, could aid in the study of materials undergoing brittle fracture after shock loading. “We plan to explore how materials such as diamond and silicon fracture and disintegrate when they decompress from high pressure because these fundamental materials can be obtained in high purity and are used in many shock experiments,” says Erskine. “This process tells us about the strength of the material under these conditions, and this decompression process is eventually encountered in all momentary shock experiments.”

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