Uneven rates of sea level rise tied to climate change

December 3 2018

Credit: CC0 Public Domain

The pattern of uneven sea level rise over the last quarter century has been driven in part by human-caused climate change, not just natural variability, according to a new study.

The findings suggest that regions of the world where seas have risen at higher than average rates—including the Eastern Seaboard of the United States and the Gulf of Mexico—can expect the trend to continue as the climate warms.

The study, published today in the *Proceedings of the National Academy of Sciences*, was authored by scientists John Fasullo at the National Center for Atmospheric Research (NCAR) and Steve Nerem at the University of Colorado Boulder.

"By knowing that climate change is playing a role in creating these regional patterns, we can be more confident that these same patterns may linger or even intensify in the future if climate change continues unabated," Fasullo said. "With sea levels projected to rise a couple of feet or more this century on average, information about expected regional differences could be critical for coastal communities as they prepare."

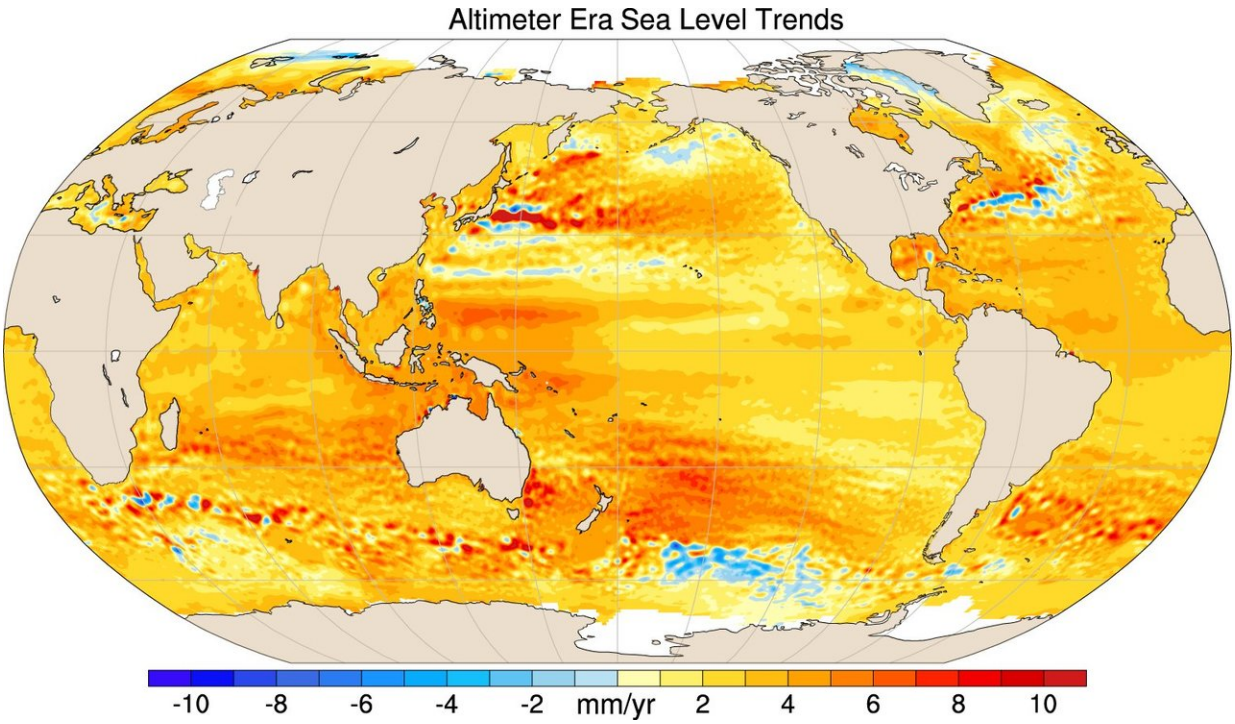
The research was funded by the National Science Foundation, which is NCAR's sponsor, the NASA Sea Level Change Team, and the U.S. Department of Energy.

Finding the signal of climate change

For the study, Fasullo and Nerem, both members of the NASA Sea Level Change Team, analyzed the satellite altimetry sea level record, which includes measurements of sea surface heights stretching back to 1993. They mapped global average sea level rise as well as how particular regions deviated from the average.

For example, the oceans surrounding Antarctica and the U.S. West Coast have had lower-than-average sea level rise, while the U.S. East Coast and Southeast Asia, including the Philippines and Indonesia, have

experienced the opposite. In some parts of the world, the rate of local sea level rise has been as much as twice the average.



Altimeter era sea level trends. Credit: John T. Fasullo

Regional differences in sea level rise are influenced by where heat is stored in the ocean (since warm water expands to fill more space than cold water) and how that heat is transported around the globe by currents and wind. Uneven sea level rise is also influenced by ice sheets, which lose mass as they melt and shift the gravitational forces affecting regional sea surface height.

Natural shifts in ocean cycles—including the Pacific Decadal Oscillation, a pattern of sea surface temperatures similar to El Niño but

longer lasting—are therefore known to affect sea levels. So scientists were not surprised to find that as the ocean rises, it rises unevenly. But it's been difficult to say whether these natural cycles were the dominant influence on regional differences.

To investigate the role of climate change, the scientists turned to two sets of climate model runs, known as "large ensembles": one created using the NCAR-based Community Earth System Model and one created using the Earth System Model at the National Oceanic and Atmospheric Administration. These large ensembles—many model simulations by the same model, describing the same time period—allow researchers to disentangle natural variability from the impacts of climate change. With enough runs, these impacts can be isolated even when they are relatively small compared to the impacts from natural variability.

The climate models suggest that in regions that have seen more or less sea level rise than average, as much as half of that variation may be attributed to climate change. The scientists also found that the impacts from climate change on regional sea level rise sometimes mimic the impacts from natural cycles.

"It turns out the sea level rise response to climate change in the Pacific resembles what happens during a particular phase of the Pacific Decadal Oscillation," Fasullo said. "This explains why it's been so difficult to determine how much of the pattern was natural or not, until now."

Improving forecasts

The research findings have implications for local officials, who are interested in improved forecasts of sea level rise for the areas they oversee. In the past, forecasters have had to rely on the global rate of change—about 3 millimeters a year and accelerating—and knowledge of the uneven regional impacts associated with continued melting of the ice

sheets covering Greenland and Antarctica.

The findings add the possibility that the regional patterns of sea level rise tied to climate change can also be included, because the models predict that the regional patterns observed in the satellite measurements will continue into the future.

"We now have a new tool—long-term satellite altimeter measurements—that we can use to help stakeholders who need information for specific locations," said Nerem, a fellow of the Cooperative Institute for Research in Environmental Sciences at the University of Colorado Boulder and a professor of aerospace engineering.

More information: John T. Fasullo el al., "Altimeter-era emergence of the patterns of forced sea-level rise in climate models and implications for the future," *PNAS* (2018). www.pnas.org/cgi/doi/10.1073/pnas.1813233115

Provided by National Center for Atmospheric Research