A stunning prediction of climate science — and basic physics — may now be coming true

Chris Mooney, Washington Post, 7-27-16

A lot of people deny climate change. Not many, though, deny gravity.

That's why a recent animation released by NASA's Jet Propulsion Laboratory — well, it came out in April, but people seem to be noticing it now — is so striking. Because it suggests the likely gravitational imprint of our changing climate on key features of the Earth in a way that's truly startling.

The animation uses measurements from NASA's squadron of GRACE satellites (Gravity Recovery and Climate Experiment), which detect changes in mass below them as they fly over the Earth, to calculate how the ocean changed from April 2002 until July 2013, based on corresponding changes in the mass of the continents. The resulting animation suggests the oceans gained mass overall, as seas rose, albeit with seasonal variations that result from water moving from the continents into the seas and back again.

But in key areas where glaciers have been melting — coastal Alaska, West Antarctica and, above all, Greenland — it suggests something very different happened. Here, the animation finds that the ocean actually fell, and in some places by as much as 50 millimeters (2 inches) over this short decadal span:

NASA created an animation showing "sea level fingerprints," or patterns of rising and falling sea levels across the globe in response to changes in Earth's gravitational and rotational fields. (NASA)

It's important to stress that the animation above shows a mathematical inference based on gravitational measurements and a model that extends them to the oceans, rather than a direct sampling of sea levels around Greenland's remote coasts. It also doesn't take into account other factors that affect sea level, such as ocean temperatures, currents and salinity.

But if it is right, well, then it's showing exactly what climate scientists have long been predicting would happen.

"When an ice sheet loses mass, for example, the gravity drops locally (remember that gravity is proportional to mass) — meaning the gravitational attraction between the continent and surrounding ocean diminishes, thus causing the ocean mass to move to the farfield," explains NASA's Surendra Adhikari, whose research is behind the animation.

The result, combined with other factors, is that "the relative sea level tends to drop locally and it tends to rise at a much higher pace than global mean (or eustatic) rate in the farfield," he said by email.

Erik Ivins, Adhikari's co-author, acknowledged that the animation does not present a direct measurement of sea level around Greenland from, say, local tide gauges. But given the strength of understanding of the core physics, he said, "we rather confidently predict these global and local sea-level rises and falls to be occurring over the same time scales as ice sheets change [their] mass."

Adhikari and Ivins were also behind recent research showing another, perhaps even more stunning consequence of mass change from the planet's ice sheets — the Earth's rotation has changed accordingly. The animation above takes into account these rotational changes as well and how they impact sea levels.

One thing is very clear: Greenland is losing large amounts of mass. Scientists recently reported that the ice-

covered island lost 1 trillion tons of ice mass to the ocean in just four years, between 2011 and 2014. The animation shows a longer and not entirely overlapping period, but one in which the total mass loss was surely even larger.

Several scientists contacted by The Washington Post said the results were intriguing, while cautioning that they did not constitute a direct measurement of sea level.

“I find the results interesting and plausible,” said David Holland, a New York University geoscientist who studies Greenland.

“For sure the ice sheet in coastal Greenland has lowered, and since gravity is a very solid physical fact, then for sure one would expect the coastal ocean to lower, close to the ice sheet where there would be a sizable gravitational impact,” Holland continued.

Holland said he has plans to more directly measure sea level around the icy island, which would confirm the results and put them on a “more solid footing.”

“I believe that the authors have calculated that there now should be a signal of locally dropping sea level near the ice sheets from the mass loss causing reduction in the gravitational attraction of the ice for the ocean, but, the authors haven’t measured that sea-level fall close to the ice sheet,” added Penn State glaciologist Richard Alley by email. “Identifying it will be complicated by the lack of tide gauges, the high latitude (the main satellite sea-level analyses just reach the southern end of Greenland), and the various complicating things such as changing winds and changing salinity affecting the local sea level, etc.”

“The ocean can adjust to these changes in gravity in the timespan of days to a couple weeks, making the impact happen quickly,” noted Christopher Harig, a geoscientist at Princeton who also conducts research using the GRACE satellites, and who said the findings fit his expectations. “The effect is also much greater than the average sea level rise you would see far away. While sea level might rise a meter far away from the ice sheets, we would see a drop several times this in the sea level on the coast of Greenland for instance.” But Harig, too, noted an important role for direct sea-level measurements to confirm the findings.

If those verify what the animation shows, incidentally, it would amount to a stunningly good example of scientific predictions about climate change being borne out.

Researchers have long predicted that we would see precisely this effect — although their calculations have more often tended to show seas falling around West Antarctica and rising around the United States, which is what you’d expect for major ice loss from the South Pole while Greenland stays relatively intact.

Yet Greenland, at least so far, has been outstripping Antarctica for ice loss because it is exposed to very warm Arctic air temperatures. Antarctica has vastly more ice to lose, but it has been more insulated from strong surface temperature change (although the oceans are melting parts of it from below). So the gravity calculations are currently weighting Greenland’s loss, and its sea level consequences, more heavily than Antarctica’s.

Accordingly, the animation suggests, sea level fall has been around Greenland, and the sea rise, in the “farfield,” has been much farther away including East Antarctica and southern Africa.

“The fall we predict follows from extraordinarily straightforward physics — the physics [of] Newton and those who brought the rigor of 19th-century mathematical physics to bear on elastic response and gravitation,” said NASA’s Ivins by email.