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Scientists piece together nearly two decades of global glacier ice loss

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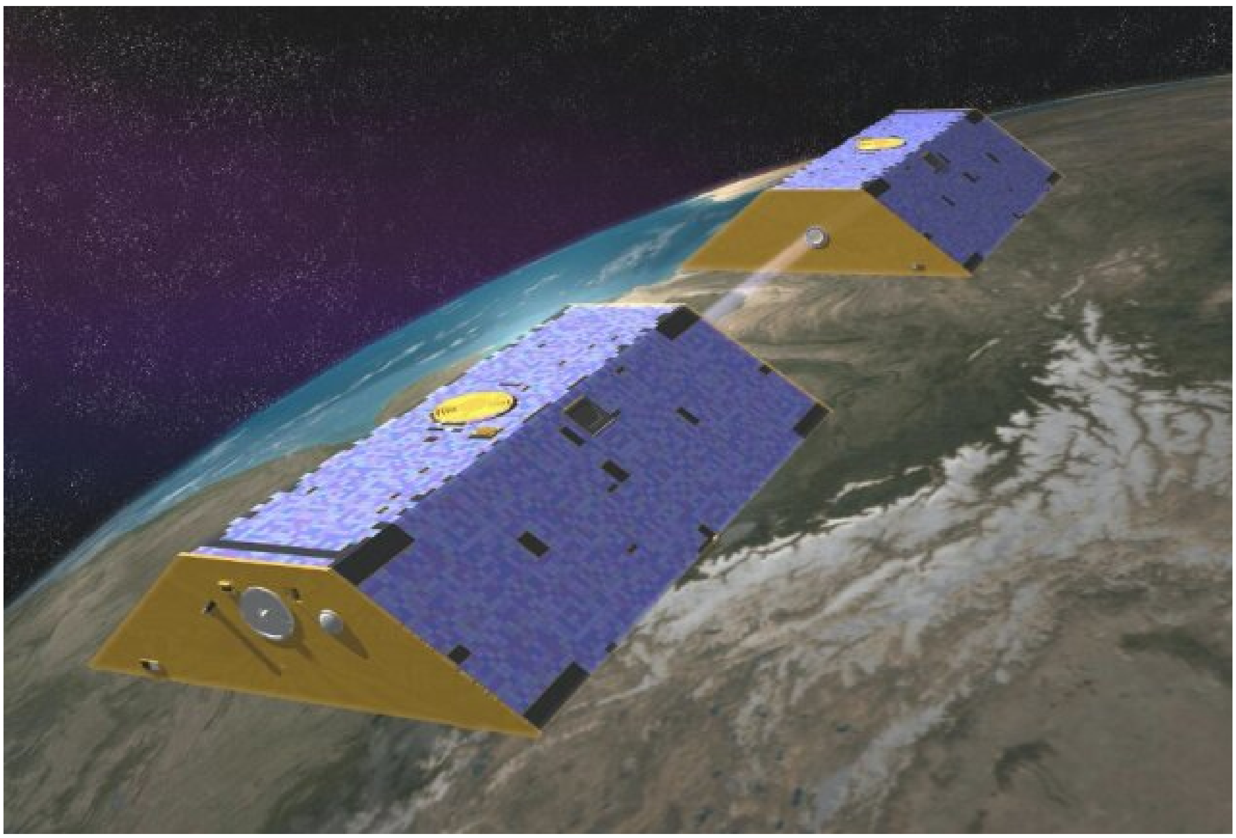

Artist impression of the GRACE satellites in orbit. Credit: NASA Jet Propulsion Laboratory

Scientists have been concerned about a gap in satellite data that was being used to monitor mass balance changes of the world's glaciers.

Using alternative data, a new study has helped to fill the gap, creating a continuous record of rates of glacier retreat around the world since 2002 until present. It is important to monitor changes in mass balance—the net changes in a glacier's mass, after accounting for gains from snowfall and losses from melting and iceberg calving—in order to generate robust predictions of sea level rise.

Remote sensing (which acquires information about Earth without making direct contact with it, such as through satellite and drone imagery) has revolutionized the study of glaciers. Satellite missions are collecting a wide range of data about our glaciers and ice sheets with high resolution and over a large scale. By comparison, pre-satellite ground measurements are spatially coarse, while physical models often do not capture local change with enough precision. "Remote sensing is the only way to survey glaciers comprehensively with a uniform method in the years to come," study co-author Isabella Velicogna of University of California Irvine told GlacierHub.

Gravity Recovery and Climate Experiment (GRACE) is one satellite mission that has been useful in the study of glaciers. It is a joint mission by NASA and the German Aerospace Center, launched in 2002. It maps variations in Earth's gravity field by taking measurements of the distance between two identical satellites separated in polar orbit, 500km above Earth. GRACE satellites detect modifications in the gravitational field that result from changes in mass; they therefore can trace the loss of mass from the world's glaciers into the oceans with unprecedented accuracy. GRACE satellites are extraordinary in the way they track each other in perfect orbit, moving in a tug and pull motion as they are deflected by the gravity field. The slight shifting in distance between the satellites as they complete their orbit tells us precise details about mass movements on Earth between each minute.

The GRACE mission ended in October 2017, after extending 12 years beyond its intended service. It has been followed by its successor, GRACE Follow-On, in 2018. GRACE-FO acquires data in the same way as GRACE, with a few slight modifications. Although GRACE-FO is producing data that matches the precision and resolution of the original mission, there was an 11 month gap in data between the two missions. Velicogna told GlacierHub "this was of great concern because scientists were unaware of what they had missed during those 11 months, especially because glaciers can change a lot from one year to the next." Though long-term trends are clear, it is the details in annual trends and regional trends which scientists were seeking to uncover during the inactivity of GRACE.

Numerous studies of glacier mass loss have used GRACE data across different time series (such as this 2019 study by Wouters et al.), making it difficult to compare averages yielded by the various studies. The new study by Velicogna and her colleagues is the first that uses the full time-series of GRACE and GRACE-FO data. They addressed the data gap by using MERRA-2 reanalysis data, which assimilates various observational data. The team calculated that the world's glaciers and ice caps lost an average of 281.5 gigatons of ice per year, which equates to 13mm of cumulative sea level rise. Alaska and the Canadian Arctic dominated mass loss, whilst the Southern Andes and High Mountain Asia came third and fourth respectively in terms of greatest mass lost per year. Isabella Velicogna told GlacierHub the success of MERRA-2 "shows reanalysis and global climate models have come a long way and are getting more and more reliable."

Filling the gap gives scientists an almost two-decade-long record of world glacier mass loss. Alex Gardner of NASA's Jet Propulsion Laboratory highlighted the importance of the continuity in this data, telling GlacierHub, "continuity is by far the most important thing, beyond the novelty of engineering."

Speaking about the implications of the gap in data and looking beyond GRACE-FO, Gardner said that achieving long-term, decade-scale observations is important. "There is a lot of noise in the system from short-term weather patterns, and we need to reduce this noise" in order to capture trends in climate, he explained.

In regards to maintaining the data continuity into the future, Gardner told GlacierHub that "As soon as one mission is launched, you have to start preparing for the next." Discussions at NASA are underway for what is to be GRACE-2. However "it is politically difficult, because as soon as you've finished one mission you are already asking for more, and you must find collaborators and more funding sources." Looking to the future, he said that "Until we have a Copernicus-type program, we will always be risking gaps." Copernicus is the European continuous Earth observation program, spanning multiple missions of the European Space Agency.

For the case of NASA, he said that it will take time to achieve a "cultural shift" towards data continuity, as NASA historically has been motivated by novelty, innovation and pushing the bounds of engineering. Gardner believes this attitude is slowly changing, however, as others are realizing the value in continuity.

It is perhaps of concern though that while attitudes internally at NASA may be shifting, those of the Trump administration are not. It has been reported that Trump's 2021 budget will see an 11 percent cut to science and research carried out at NASA, with many other major science agencies facing similar, if not greater, cuts in funding. Priorities have consistently shifted away from climate change-focused research towards space exploration and investing in technological advances for the future, such as artificial intelligence and quantum information science. A top agenda for the White House is to speed up plans for NASA's Artemis Program, to land the next people on the Moon by 2024. The Trump administration announced significant spending boosts over several years to cut the original 2028 target for a lunar landing by four years, to 2024.

These activities demonstrate the value in both GRACE satellite data and MERRA reanalysis data. The agreement between GRACE and MERRA across the data gap is a success story for future scientists who recognize the importance of consistency and uniformity in science. As the hostile environment surrounding scientific funding may lead to future data gaps in our satellite records, studies like these that find plausible alternative sources of data may become even more useful and important in the future.

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