Increased ice mass in East Antarctica does not offset losses in the West

Plain language summary

A team of glaciologists and statisticians from the University of Bristol in the UK and the University of Wollongong in Australia have investigated the mass balance (i.e. the gain and loss of ice) of the East Antarctic Ice Sheet. The analysis was carried out using Bayesian modelling – a technique which allowed them to combine prior knowledge on physical processes such as ice melt with observed data, mostly from satellites.

Three main types of data were used, spanning just over a decade from 2003 to 2013. First, satellite altimetry, which is a technique for making very precise measurements of the changing height of the ice surface using either a laser or a radar fitted to satellites. Hence, altimetry data indicates regions where ice is thickening or thinning. Second, satellite gravimetry, which determines changes in ice sheet mass via repeated and very accurate measurement of the Earth's gravity field using the two Gravity Recovery and Climate Experiment (GRACE) satellites. Changes in the gravitational pull of the Earth can also be a sign of thickening or thinning ice. Third, global positioning satellite (GPS) data from a network of fixed stations, which allow small changes in the vertical position of the bedrock under the ice sheet to be calculated. This is important, as the vertical motion of the bedrock, arising from the Earth's crust re-adjusting to historical changes in ice and snow, need to be discounted from the current-day changes in ice thickness observed using altimetry and gravimetry data.

Two processes are known to be responsible for changes in mass of the Antarctic ice sheet: (i) surface mass balance (the difference between snowfall and melt through time), and (ii) ice sheet dynamics (the flow of ice from the interior to the margins of the continent). The team undertook experiments using two different scenarios which made different assumptions about these two processes and the vertical motion of the bedrock.

The first scenario assumed that changes in ice mass driven by ice movement are less likely, though not impossible, in areas where the ice moves most slowly. If this is the case, the statistical model estimated an average increase in the total mass of the East Antarctic Ice Sheet of 57 gigatons per year between 2003 and 2013. It apportioned about a third of this change to ice movement, and two thirds to changes in surface mass balance.

The second scenario was that a long-term accumulation trend is causing ongoing thickening of the ice sheet in the interior of East Antarctica. In this case, a regional climate model was used to estimate changes in surface mass balance. Based on this assumption, the statistical model estimated the change in ice mass balance due to ice movement to be 3 to 5 times larger than in the first experiment. However, estimates of changes in the total mass of the East Antarctic Ice Sheet remained similar (an increase of 49 to 57 gigatons per year between 2003 and 2013).

Importantly for this study, and for our wider understanding of its contribution to global sea level rise now and in the future, ice mass gains in East Antarctica were exceeded by ice mass losses in West Antarctica in all experiments carried out. This indicates that the overall ice mass of Antarctica decreased between 2003 and 2013.

Full paper (open access): Martin-Español, A, Bamber JL, and Zammit-Mangion A (2017), Constraining the mass balance of East Antarctica, Geophys. Res. Lett., 44 (DOI:10.1002/2017GL072937).

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