

## Melting ice sheets and glaciers

### → Key messages

- In recent decades, the melting of ice sheets, ice caps and glaciers has increased world-wide due to the warming of the ocean and atmosphere. With the help of the gravity field missions GRACE/GRACE-FO, these changes in global ice masses can be precisely observed and quantified. This essential time series has been built up since 2002, which is to be continued and further improved with future satellite missions.
- The melting ice is a major contributor to the rise in global mean sea level. The GRACE satellites have shown that more than half of the current increase (2003–2017) is caused by mass losses of the Greenland and Antarctic ice sheets and glaciers worldwide.
- The loss of ice mass in the Arctic and Antarctic depends on the amount of precipitation, as well as surrounding air and ocean temperatures. However, differences can be observed in annual balances and seasonal fluctuations:

#### Greenland

Greenland is losing an average of around 255 billion tons (Gt) of ice per year (2002–2022). Particularly low-lying areas in the south and west of the ice sheet show decreasing mass from melting. In 2019, the GRACE-FO satellites observed a record loss of 532 billion tons of ice for the entire Greenland ice sheet.

#### Antarctica

The loss of ice mass in the southernmost continent has so far been somewhat lower, but is also contributing significantly to sea level rise. On average, around 137 billion tonnes of ice are lost here every year (2002–2022). The greatest loss is occurring in the Amundsen Sea region, in the Pacific sector of western Antarctica due to an increase in ice transport to the ocean.

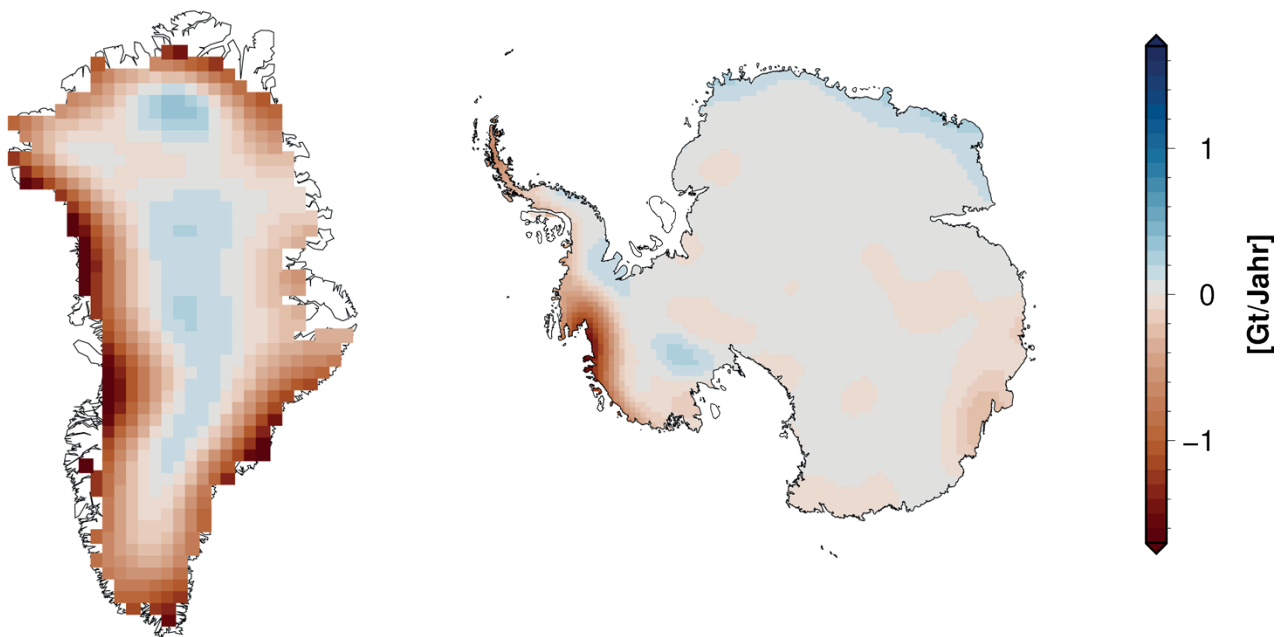
- Small-scale mass changes, such as those of mountain glaciers outside Greenland and Antarctica, are also recorded by the GRACE/GRACE-FO satellites. The greatest mass losses are recorded in Alaska, followed by northern Canada and Svalbard (Norway) in the Arctic Ocean. The contribution of glacier melt to sea level rise can be estimated with GRACE at approximately 199 billion tons of ice per year (2002–2016)<sup>1</sup>.

<sup>1</sup> Global Glacier Mass Loss During the GRACE Satellite Mission  
(frontiersin.org)

### Why is the melting of ice masses observed?

Ice streams that end in the ocean are increasingly subject to submarine melting, which reduces the supporting effect on the glacier fronts and accelerates ice flow. In addition, warming increases meltwater runoff in summer, particularly in the Arctic. The GRACE/GRACE-FO data show that these ice mass losses cause more than half of the global mean sea level rise and provide new insights into the underlying processes and drivers. This knowledge is of crucial importance for creating and improving climate projections of sea level rise.

### Decrease in ice masses in the Arctic and Antarctic



*Spatial distribution of mean annual ice mass losses in Greenland (left) and Antarctica from data of the GRACE and GRACE-FO satellite missions in the period 2002 to 2022. Particularly large mass losses are measured along the coasts in southern Greenland and in West Antarctica. (Maps: E. Börgens/GFZ)*