

Global water re-distribution with satellite gravimetry and other remote sensing techniques

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The Earth's system is subject to continuous re-distribution of water masses. Satellite gravimetry and other remote sensing techniques allow this phenomenon to be monitored, quantified, and, to a large extent, explained.

A well-known evidence of water mass re-distribution is on-going sea level rise, which exceeds in average 3 mm/year over the past decade. A combination of satellite gravimetry, satellite altimetry, and in-situ sensors permits the separation of this process into individual contributors. At the global scale, one of the major contributors is an increase in the amount of water in the ocean. To a large extent, this water comes from the Greenland and Antarctic ice sheets.

Satellite gravimetry shows that Greenland ice sheet mostly loses mass at the south-east and west coasts. Recent satellite altimetry observations confirm this finding, allowing one to identify individual outlet glaciers, where most of mass loss takes place. Furthermore, a combination of satellite gravimetry data, surface mass balance modelling, and observations of ice flow velocities can be used to analyse the major contributors to this mass loss – ice discharge and meltwater runoff.

Antarctic ice sheet is a more complicated object, since mass changes at the surface are superimposed there by the glacial isostatic adjustment – ongoing response of the Earth's interior to former glacial loads. Nevertheless, a combination of satellite gravimetry, satellite altimetry, and climate data allows these two processes to be reliably separated.

A reduction of land water storage outside Greenland and Antarctica also contributes to the increase in the ocean water mass. To a large extent, this is due to an accelerated consumption of groundwater resources in arid and semi-arid areas – northern India, Middle East, China, and others. Over-exploitation of these resources leads not only to sea level rise, but also to other negative consequences, including soil salinization and risk of fresh water deficit in the future. Satellite gravimetry is the only remote sensing technique that can directly sense mass re-distribution inside the Earth and, as such, is a promising tool to monitor and quantify a non-sustainable consumption of groundwater.