GFZ Helmholtz Centre for Geosciences

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Monitoring global sea level rise from space

Key messages

- Since 2002, the GRACE satellites observe the mass fraction of sea level rise separately and with high accuracy for the first time.
- The rise in global sea levels is caused by two main factors:
  the input of meltwater from the polar and continental ice sheets and the thermal expansion of water due to global warming caused by rising greenhouse gas concentrations in the atmosphere.
- The input from meltwater and thermal expansion each contribute approx. 50 % of the current increase of around 3.4 mm per year.
- The increase is not the same everywhere, but depends on mass trends on the continents. For example, the increase in the tropical Pacific is higher than in the polar regions. These spatial differences are referred to as the "fingerprint" of the polar ice melt and are caused by the horizontal component of the gravitational effect of the continental ice masses on sea level.

FAQ – Key questions and answers

How do we monitor sea level rise with the GRACE satellites?

The GRACE satellites measure temporal and spatial changes in the Earth's gravity field due to mass changes. In addition to tracking continental water and ice mass losses, the increase in the amount of water stored in the oceans can also be observed directly.

What is the advantage of the GRACE measurement technique?

Previous measurements of sea level using radar satellites and tide gauges show the absolute change in height of the sea surface. The GRACE satellite missions only record the change in global sea level due to mass displacements. These are primarily horizontal transports of water masses from land to sea (meltwater from the large ice sheets), but also redistributions within the ocean basins (ocean circulation). This is the first time that precise data on just one of the major factors influencing sea level rise has been collected.

What other geophysical processes have to be taken into account?

The water in the ocean basins is always moving due to the gravitational effect of the moon and sun (tides) or the frictional effect of near-surface winds. These mass shifts are also recorded by the GRACE satellites using high-precision distance measurements. In order to obtain precise data on global sea level rise due to mass inputs, other processes such as the ocean tides are predicted with numerical models and subtracted from the GRACE measurement data.

Is there a long-term trend?

Observations from the GRACE missions show a long-term mass-induced sea level rise of 1.7 mm per year (Dobslaw et al., 2020). This proportion accounts for around half of the total sea level rise of 3.4 mm per year.[2]

In which regions is the highest sea level rise observed?

Due to the gravitational effect of mass changes on the continents, the strongest sea-level rise is observed in the tropical Pacific. In the immediate vicinity of Greenland with the highest coastal ice mass losses, however, the barystatic sea level is dropping slightly.

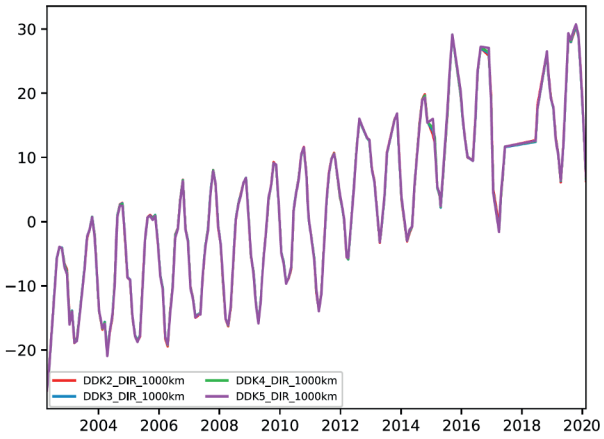

Fig. 1: *Time-series of global sea level rise from GRACE observations. (Dobslaw et al., 2020)*

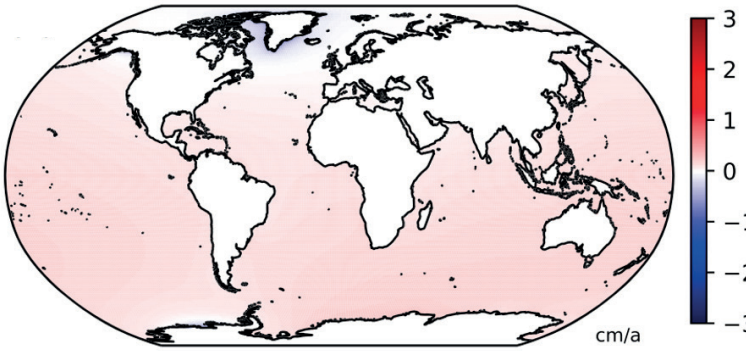

Fig. 2: *While the mass-induced sea level rises in large parts of the Earth due to the gravitational effect (red colouring), it falls on average around Greenland (blue colouring).*

Source

• Balidakis, K., Sulzbach, R., Shihora, L., Dahle, C., Dill, R., & Dobslaw, H. (2022). **Atmospheric contributions to global ocean tides for satellite gravimetry.** Journal of Advances in Modeling Earth Systems, 14, e2022MS003193. https://doi.org/10.1029/2022MS003193

• Dobslaw, H., Dill, R., Bagge, M., Klemann, V., Boergens, E., Thomas, M., et al. (2020). **Gravitationally consistent mean barystatic sea level rise from leakage-corrected monthly GRACE data.** Journal ofGeophysical Research: Solid Earth, 125, e2020JB020923. https://doi.org/10.1029/2020JB020923

[1] Period April 2002 to August 2016

[2] Based on the evaluation of current satellite altimetry data. (*https://sealevel.colorado.edu*).

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Further questions?
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