Global warming and rise of sea level

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Between 1750 and 2011, humans have caused a 40% increase in atmospheric concentration of carbon dioxide. That and other greenhouse gasses trap radiation transmitted heat from the sun in the earth's atmosphere and cause the earth's climate system to warm up.

The global mean surface temperature has risen by around 0,84°C since the industrial revolution and is expected to continue to rise exponentially if high-impact changes are not made. If carbon dioxide concentration in the atmosphere were to double, global mean surface temperature is estimated to rise 1,5-4,5°C compared to pre-industrial times.

This rise in global temperature causes melting of the world's glaciers and ice caps, which in turn raises the global sea level. The sea level has been shown to have risen around 0,19m since 1900, and the NOAA (National Oceanic and Atmospheric Administration) has estimated that by 2100 the sea level will have risen by up to 2 meters.

Among possible effects of the sea level rising is coastal flooding, erosion, fresh water contamination, altered chemistry of agricultural soil, more hurricanes and more. The reduction of inhabitable land will also decrease the carrying capacity of the human population.

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Where the land rises faster than the sea

At first glance it's a paradox: While globally sea levels are rising, they're sinking in Scandinavia, Greenland, Canada and Alaska. And also more recently in Iceland.

This is shown by an analysis of 365 measurement points over a period of 50 years, from 1961 to 2011. Some of the levels in the northern hemisphere are falling with astonishing speed: In certain areas of Alaska and Canada, the sea level falls by up to two centimetres per year. On the coasts of Norway, Sweden and Finland it falls by 0.7 centimetres per year. The explanation: It is not the sea level that's falling, it is the land that's rising. Because the glaciers are melting and the immense weight of their ice mass has disappeared. And that is why the land rises.

The phenomenon has long been known in Scandinavia. In Iceland, it's new. In 2015, an international team of scientists published a study that showed that parts of the central highlands of Iceland rise by more than three centimetres per year. Recent measurements of the national land survey authorities show a rise by one and a half centimetres in certain coastal areas.

The reason: The glaciers that once covered approximately 11 per cent of Iceland's land mass have shrunk dramatically in recent decades. It's predicted that they'll be gone completely in about 200 years time.Many countries will shrink due to climate change and the rise in sea levels. "Iceland will first grow," says Páll Einarsson, professor at the Institute of Earth Sciences at the University of Iceland. Einarsson was one of the first who explored the phenomenon in the early 1990s. "We were stunned when we started with the measurements. Meanwhile, the land elevation is taking place at a rate much faster than we had anticipated."

Any big chunk of ice like a glacier or an ice sheet pushes down on the land below it, like a person laying on a tempurpedic mattress. (This is why parts of the bedrock of Antarctica are actually below sea level.) When that ice is removed, the land slowly rebounds, just as the mattress will slowly fill in when the person gets up (called post-glacial rebound, isostatic rebound or crustal rebound)

In Scandinavia, the land has been rising for a long time; it is called the "Fennoscandian land elevation". In 1491 the residents of a settlement called Östhammar were already complaining that the coast had pulled back from the city so far that the old port had become unusable. The people at that time had no explanation for it. They suspected the sea would drain, the sea levels fall. Over the centuries, several other ports became dry, and new ones had to be built.

"During the last glacial period, one single big glacier covered what is today Scandinavia," explains Sven Knutsson, Professor of Soil Mechanics at the Technical University of Luleå in Sweden. In its center, the glacier was about 3,000 metres thick, and its immense weight pressed the ground down. As the ice retreated about 10,000 years ago, the ground began to lift. This post-glacial uplift continues today — up to nine millimetres each year.

Professor Knutsson emphasizes how much difference this makes — especially along a coast where the water is not very deep. "This means that we are talking about a land elevation of half a metre to one metre during a person's lifetime."

But there are exceptions which seem difficult to understand at first glance. Some stations on the Norwegian and Swedish coast show sea levels rising up to one millimetre per year. The explanation: These areas are the furthest away from the old Fennoscandian glacier. The land here rises only 1 to 2 millimetres per year, and sea levels rise around 3 millimetres each year globally- so the net effect is that the sea level increases slightly.

Reykjavík is another exception. Here, the sea level increased by about 2.1 millimetres per year between 1961 and 2011. The explanation: While individual parts of Iceland rise by up to three centimetres per year, the land below the capital falls due to tectonic movement. Since the launch of GPS measurements in 2007 the land around Reykjavík fell by about two millimetres per year.

Accelerated Ice Melt Causing Iceland to Rise
By Andrea Thompson

New Research Affirms Modern Sea-Level Rise Linked to Human Activities, Not to Changes in Earth's Orbit
By RUTGERS UNIVERSITY

Sea level rise in the arctic

Over the past 25 years, sea levels in the Arctic have risen an average of 2.2 millimeters per year. This is the conclusion of a Danish-German research team after evaluating 1.5 billion radar measurements from satellites using specially developed algorithms.

The Arctic oceans are often not included in the global sea level estimation. This is partly due to seasonal changes in the sea-ice cover and insufficient satellite coverage.
The enormous volumes of fresh water released in the Arctic not only raise the sea level, they also have the potential to change the system of global ocean currents—and thus, our climate.

Greenland's land ice is already thawing fast enough to raise worldwide seas 0.74 millimeter per year. The melt rate has been increasing, in large part because the ice sheet's surface thawing has picked up as global temperatures warm. This acceleration of surface melt has doubled Greenland's contribution to sea level rise. Compared with the period from 1992 to 2011.

The Arctic has other frozen land areas—mountain glaciers and ice caps—in places like Iceland, the Canadian and Russian Arctic, Alaska and Norway's Svalbard Islands.
These hold nowhere near as much water as the Greenland ice Sheet but are still a significant part of the sea level equation. Together with glaciers and ice caps in the southern hemisphere (excluding the Antarctic Ice Sheet), their complete meltdown could potentially raise oceans nearly half a meter. But the northern areas have many more icy features than southern ones. Melting glaciers and ice caps in Patagonia and the other southern places don't contribute as much as those in the Arctic.

Stine Kildegaard Rose et al. Arctic Ocean Sea Level Record from the Complete Radar Altimetry Era: 1991–2018, Remote Sensing (2019). DOI: 10.3390/rs11141672