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Importance of Northern Hemisphere Vertical Land Motion for Geodesy and Coastal Sea Levels

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Vertical Land Motion (VLM) is a composite of several earth dynamics caused by changes of earth's surface load or tectonics. In most of the Northern Hemisphere mainly two dynamics are causing large scale vertical land motion – Glacial Isostatic Adjustment (GIA), which is the rebound from the loading of the latest glacial cycle (10-30 kyr ago) and elastic rebound from contemporary land ice changes, that happens immediately when loading is removed from the surface.

With glacial mass balance data and observations of the Greenland Ice Sheet we have created an Northern Hemisphere ice history from 1996-2015 that is used to make a model for elastic VLM caused by ice mass loss that varies in time.

It shows that, in most cases, the elastic VLM model is able to close gaps between GIA induced VLM and GNSS-measured VLM, giving confidence that the combined GIA + elastic VLM-model is a better alternative to adjust relative sea level measurements from tide-gauges (where no (reliable) GNSS-data is available) to absolute sea level than 'just' a GIA-model. In particular for Arctic Sea Level, where elastic uplifts are prominent and large coastal regions have limited in-situ data available, the VLM-model is useful for correcting Tide Gauge measurements and thereby validate satellite altimetry observed sea levels, which is challenged by sea ice in the coastal Arctic.

Furthermore, our elastic VLM-model shows, that the uplift caused by the melt of the Greenland Ice Sheet (GIS) is far-reaching and even in the North Sea region or along the North American coast show uplift rates in the order of 0.4-0.7 mm/yr from 1996-2015. Interestingly, this is roughly equivalent to Greenland's sea level contribution in the same period, thereby 'neutralizing' the melt of GIS. As GIS ice mass loss continues to accelerate, the elastic uplift will have increased importance for coastal regions and future relative sea level projections. Unfortunately, the opposite effect is true for the southern hemisphere or vice versa if Antarctic ice sheet mass loss would increase.