Identifying the Drivers of Solid Earth Deformation in Southwest Greenland

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Objectives

The melting of the Greenland Ice Sheet is transferring huge quantities of mass across the Earths surface, deforming the crust and mantle. **Understanding how this deformation varies over short wavelengths remains highly challenging**, particularly in Greenland.

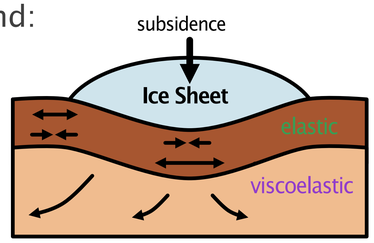
The key aims of this work are to:

- Produce high resolution DInSAR time-series of surface deformation
- Identify the key causes of surface mass transfer and model how they elastically deform the Earth
- Assess how the updated partitioning of deformation impacts calculations of viscoelastic deformation (GIA)

We focus initially on the Kangerlussuaq region due to its long remote sensing record and high GIA uncertainty.

Solid Earth Deformation

There are two main forms of solid Earth deformation in Greenland:



Schematic of the different forms of solid Earth deformation caused by ice sheet loading

Elastic deformation
- Occurs in the crust.
- Short wavelength process
- Caused by contemporary mass transfer

Viscoelastic deformation
- Dominant process in the mantle
- Occurs over longer spatiotemporal scales

Separating these components is hard due to the high spatiotemporal variability of elastic deformation

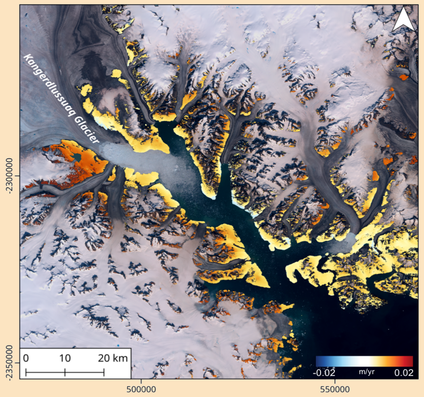
We use DInSAR, GNSS and elastic modeling to develop new ways to separate elastic & viscoelastic deformation.

Understanding Surface Deformation

Measuring Total Surface Deformation

Differential Synthetic Aperture Radar

Example DInSAR deformation map in east Greenland (Kristy Tiampo)

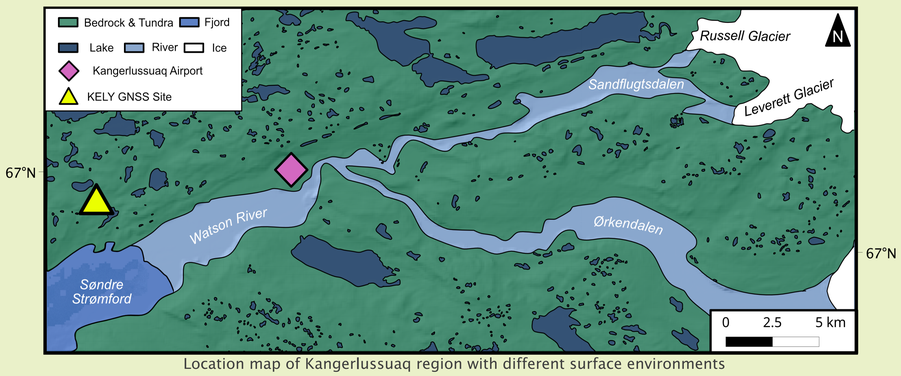


- We process Sentinel-1 images using ISCE[1] Software on CU Summit supercomputer
- We then build a deformation time-series using the MSBAS algorithm[2]

Global Satellite Navigation System Sites

- Bedrock GNSS sites record a long term point record of deformation on the ice sheet margin.
- We use these time-series to identify patterns of deformation.

Finding the Causes of Elastic Deformation



Location map of Kangerlussuaq region with different surface environments

We use the following techniques and datasets to measure how much mass is being moved around the landscape:

Water	Sediment	Ice
Watson river stage and discharge record[3]	In-situ record[3]	ArcticDEM digital elevation model time-series
Optical satellite imagery	Rates of delta aggradation[4]	Operation IceBridge, ICESat & ICESat-2 altimetry
	Delft3D fluvial modeling	

IDENTIFY TOTAL SURFACE DEFORMATION → **FIND CAUSES OF ELASTIC DEFORMATION** → **HOW MUCH ELASTC DEFORMATION OCCURS?** → **SEPARATE ELASTIC AND VISCOELASTIC DEFORMATION**

Modeling How Much Elastic Deformation Occurs

We model how much elastic deformation occurs for each of the three main sources of mass motion: water, sediment & ice.

There are three main stages:

Get elastic profiles from an earth model[5]	Calculate load Love numbers for each profile	Compute Greens functions and convolve with mass grids

Output: Map and point estimates of vertical and horizontal elastic deformation

Separating the different types of deformation

Viscoelastic Deformation = Total Deformation − Elastic Deformation

We compare our modeled elastic estimates with the DInSAR and GNSS records of total deformation to obtain values of the viscoelastic component.

Information about the directionality of surface mass change can be obtained from the horizontal deformation measurements.

Acknowledgements

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For references please see associated url or scan the QR code: