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Seismic and satellite observations of calving activity at major glacier fronts in Greenland

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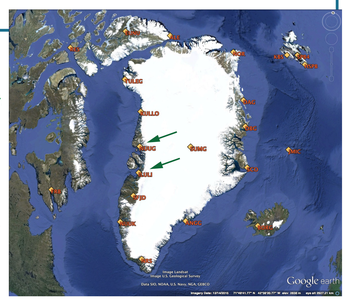
ARCA ARTICO CAMBIAMENTO CLIMATICO ATTUALE

Abstract

The interaction between oceans and large outlet glaciers in polar regions contributes to the budget of the global water cycle.
We have observed the dynamic of sizeable outlet glaciers in Greenland by the analysis of seismic data collected by the regional seismic network Greenland Ice Sheet Monitoring Network (GLISN) trying also to find out correspondence in the glacier tongue evolution derived by the observation of satellite images.
By studying the long-period seismic signals at stations located at the mouth of large fjords (e.g. ILULI, NUUG, KULLO), we identify major calving events through the detection of the ground flexure in response to seiche waves generated by iceberg detachments.
For the time spanning the period between 2010-2014, we fill out calving-event catalogues which can be useful for the estimation of spatial and temporal variations in volume of ice loss at major active fronts in Greenland.



GLISN
Greenland Ice Sheet Monitoring Network

Real-time sensor array of 33 broadband seismic stations to enhance the performance of the Greenland seismic infrastructure for detecting, locating, and characterizing glacial earthquakes and other cryo-seismic phenomena, and contribute to our understanding of Ice Sheet dynamics.
Green arrows indicate the two stations of ILULI and NUUG, respectively sited along the fjord of the Jakobshavn and Rink outlet glaciers.

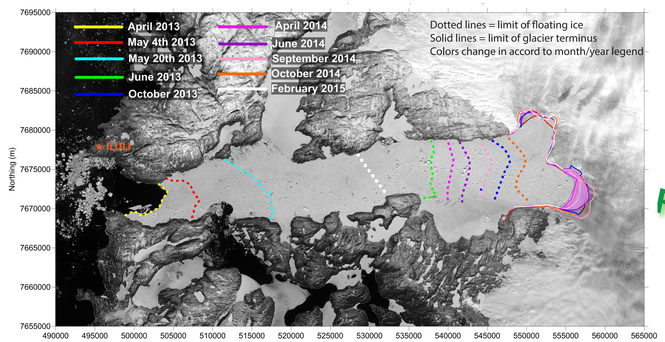
Seismic observations

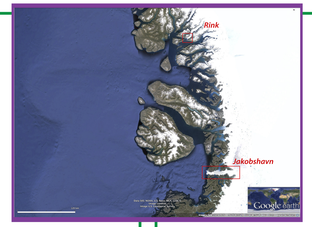
Calving events generate long period ocean waves that can be recorded by coastal broadband seismometers. Such waves are ***not dispersive, have distinct spectral peaks, persist for several hours and have similar frequency content from one event to another.***
The calving-generated waves have the characteristics of ***seiches*** , typical basin eigenmodes [Amundson et al., 2012].
The effect is caused by ***resonances in the body of water*** that has been disturbed by the detachment and capsizing of a huge mass of ice from the terminus of an outlet glacier.
Gravity controls harmonic motions in the attempt to restore the hydrostatic equilibrium and the horizontal 'undisturbed' surface.
The ***longest natural period of a seiche*** is the period associated with the fundamental resonance for the body of water—corresponding to the longest standing wave. Higher order harmonics are also observed, with periods $1/nT$ where n is the modal number.

Satellite imagery

Glacier ice front variation was observed and compared by using Landsat7TM and Landsat8TM panchromatic images (Band 8; 1 pixel=15 m;). Data are available from the U.S. Geological Survey web site "http://glovis.usgs.gov/"; USGS Products, Department of the Interior).

Jakobshavn ice front variation 2013-2015

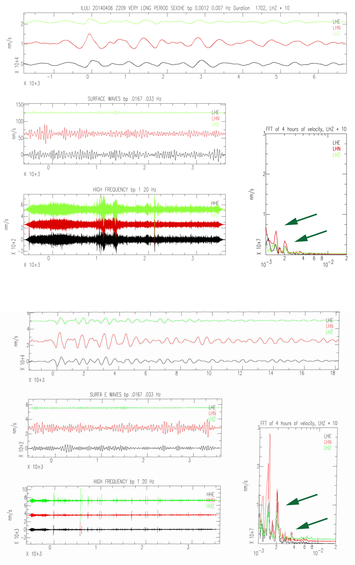




Follow the ice front online

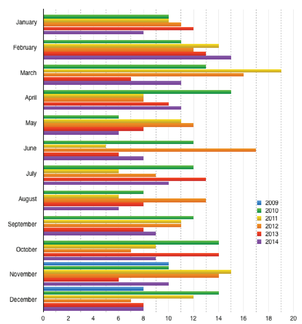
Calving events detected between April and June 2014, eventually responsible for the loss of ice at the terminus of Jakobshavn Glacier (pink area in figure).

2014 April 06 - 22:09 UTC
2014 May 02 - 16:05 UTC
2014 June 02 - 19:10 UTC
2014 June 05 - 08:44 UTC

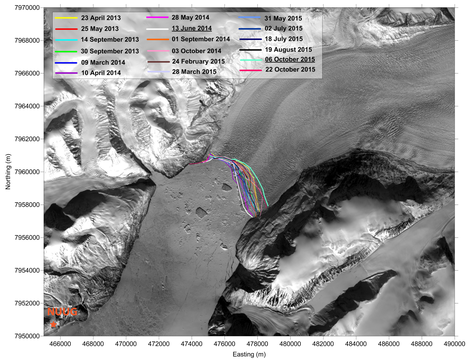


The automatic procedure for the detection of calving events first controls the duration and STA/LTA value on the very long period seismic signal.
Then, the occurence of a calving episode must be confirmed by the presence of resonance frequencies and low V/H spectral ratio (<7).

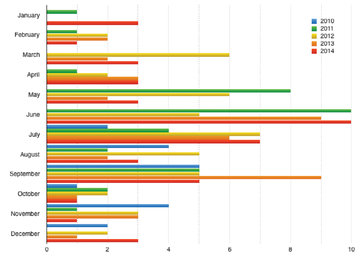
Number of calving events per month detected at station ILULI, Jakobshavn glacier

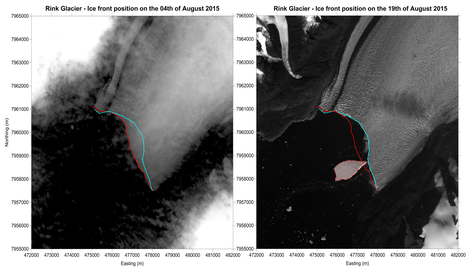


Rink ice front variation 2013-2015



Number of calving events per month detected at station NUUG, Rink glacier

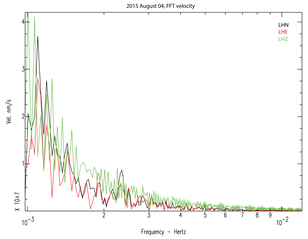


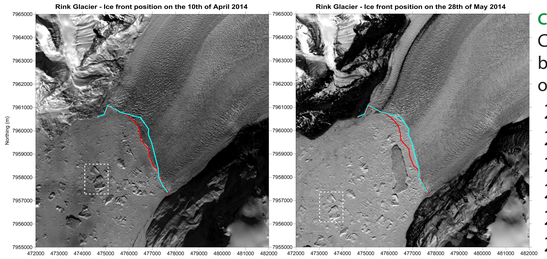


SIMPLE CASE of FALSE NEGATIVE!

Calving events potentially responsible for the loss of ice at the terminus of the Rink Glacier in August 2015 have NOT been accepted by the automatic algorithm owing to high spectral amplitude on the vertical component. Is that an effect of the free sea surface?

2015 August 04 - 20:17 UTC
2015 August 05 - 20:51 UTC
2015 August 09 - 07:09 UTC
2015 August 11- 08:17 UTC
2015 August 13 - 10:24 UTC

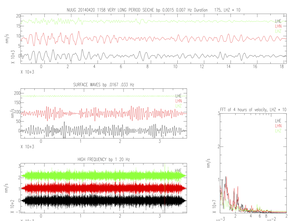




CALVING TRUE DETECTIONS!

Calving events eventually responsible for the loss of ice at the terminus of the Rink Glacier in April-May 2014

2014 April 20 - 11:58 UTC
2014 April 25 - 04:26 UTC
2014 April 26 - 22:13 UTC
2014 May 21 - 21:03 UTC
2014 May 24 - 06:50 UTC
2014 May 25 - 16:04 UTC



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