Glacial induced uplift variations in Svalbard – is it a challenge for the reference frame?

Halfdan Pascal Kierulf,
REFAG2022
18 October 2022

Co-authors:
Jack Kohler
Emily C. Geyman
Jean-Paul Boy
Anthony Mémin
Ove C.D. Omang
Holger Steffen
Rebekka Steffen

Kartverket

The GGOS2020 goal:

A reference frame with
1 mm accuracy and
0.1 mm/yr stability

The challenge:

To monitor geophysical processe
consequences of climate change

From: Gipson, John M. (GSFC-61A.0)[NVI INC] <john.m.gipson@nasa.gov>
Sent: Tuesday, April 5, 2022 7:37 PM
To: Ivs Analysis <ivs-analysis@lists.nasa.gov>
Subject: [IVS-analysis] Working Group on VLBI scale

Dear All:
At the IVS Directing board meeting this morning the issue of the VLBI scale came up. As you recall, Zuheir discussed the issue of the VLBI scale in his talk at the general meeting. For the purposes of setting the scale he through away a lot of the recent VLBI data. I forget exactly where he drew the cutoff, but was something like 2014. The issue of VLBI scale was also discussed by many ACs who participated in the analysis of ITRF2020P.

The IVS Directing Board would like to establish a Working Group on Scale to examine this issue and to clarify exactly what is happening. I am looking for people interested in participating in this Working Group.

Some specific questions to consider.

1. Do all ACs see this with all of the analysis packages?
2. Is this effect due to just a few VLBI stations as some people have suggested? For example, many people note a drift in NyAlesund's local up. Some people noticed similar things in other stations.
3. Related to 2, do all of the ACs see the same effect with these stations.
4. If this is limited to a few stations, do other techniques see the same behavior at these stations?
5. If this is limited to a few stations can we model the behavior at these stations to reduce the problem?

I am sure that there will be other questions that arise.

2. Is this effect due to just a few VLBI stations as some people have suggested? For example, many people note a drift in NyAlesund's local up. Some people noticed similar things in other stations.

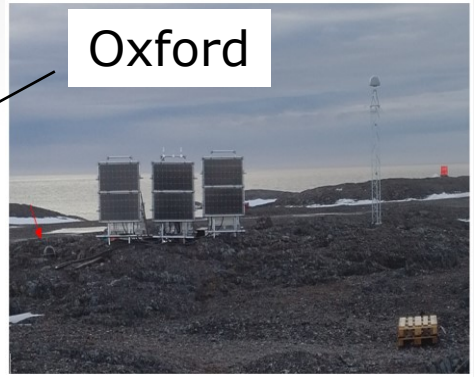
Kartverket

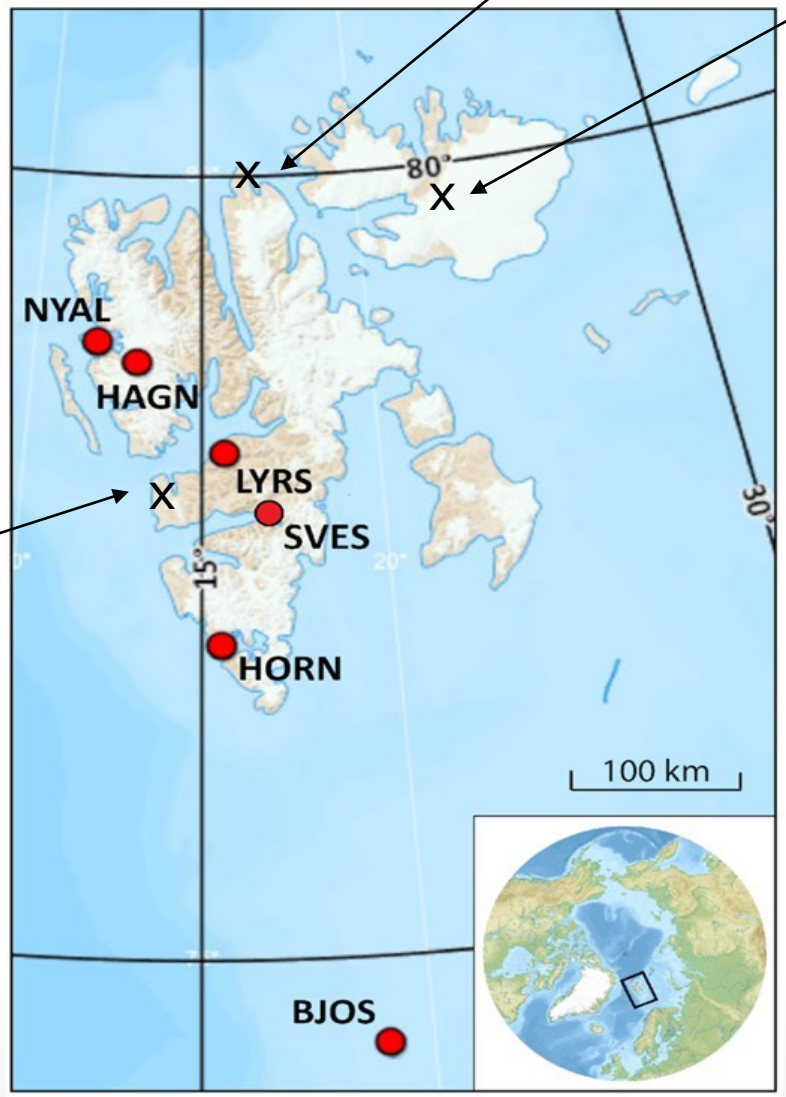
Existing GNSS stations in Svalbard

Longyearbyen

Verlegenhuken

Oxford





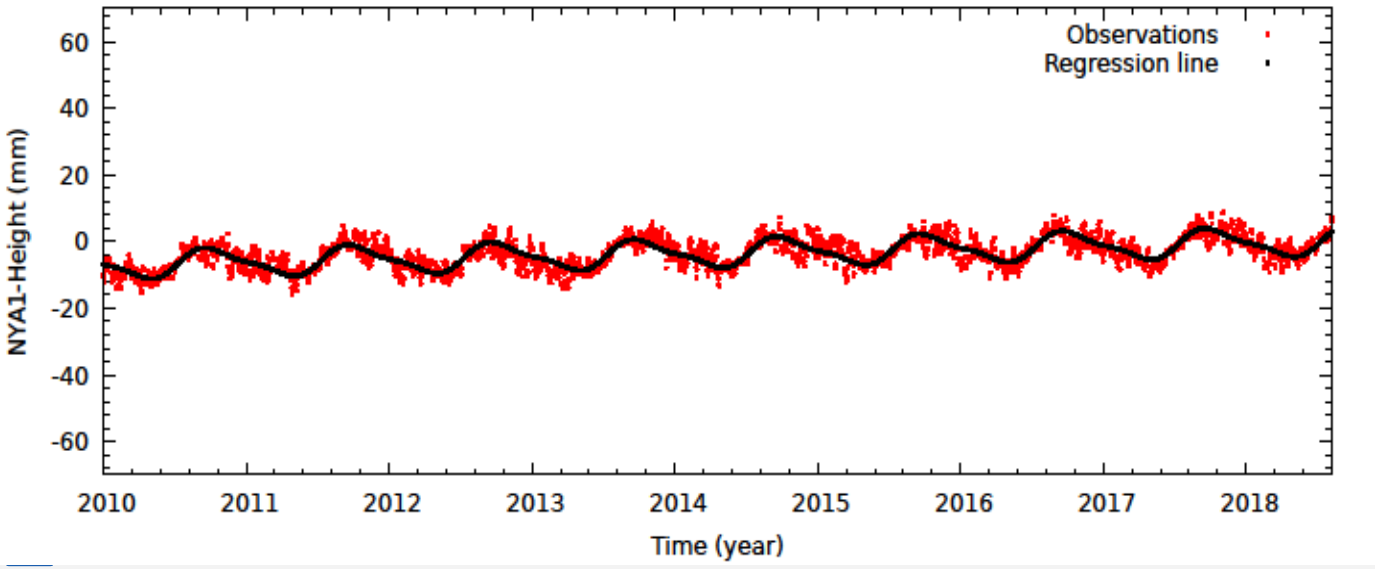
Isfjord radio

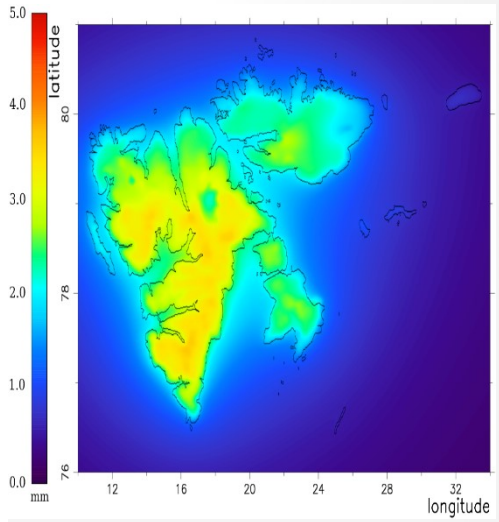
Hagen

Hornsund

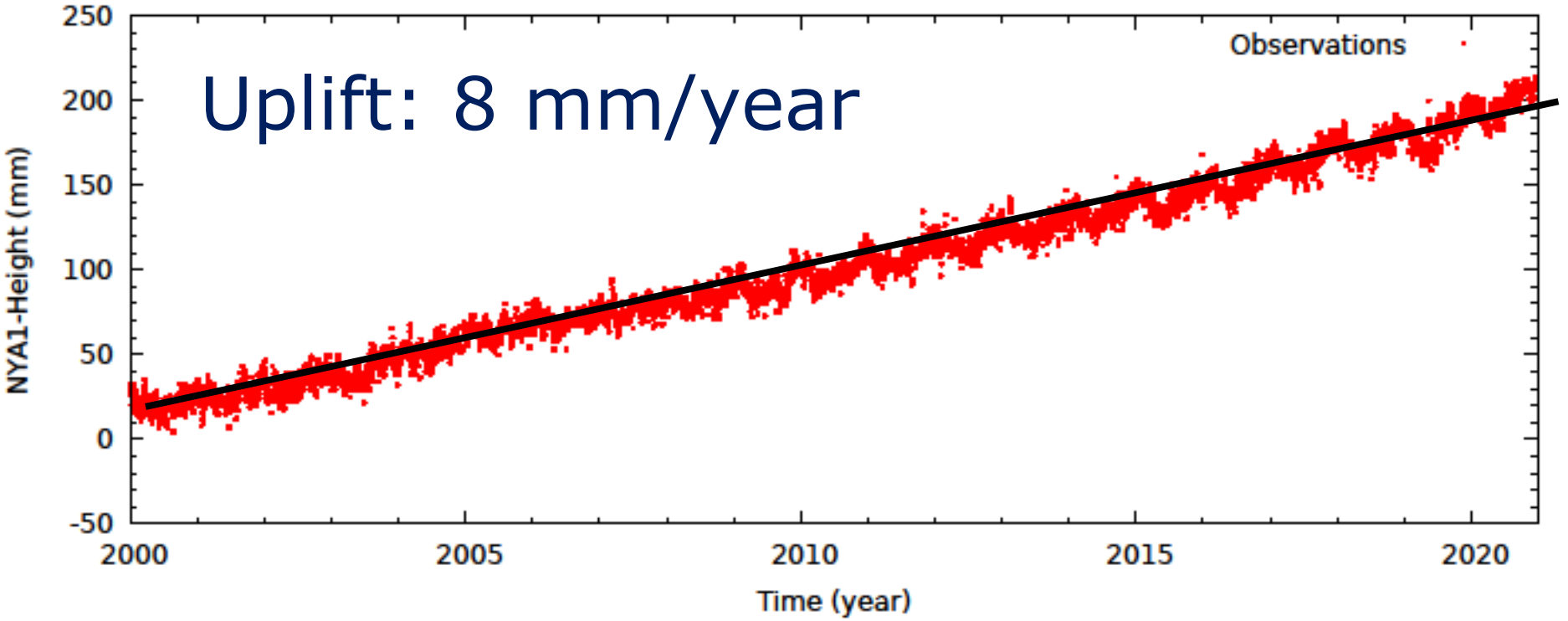
Svea

Climate induced glacial changes affect the geodetic infrastructure in Arctic

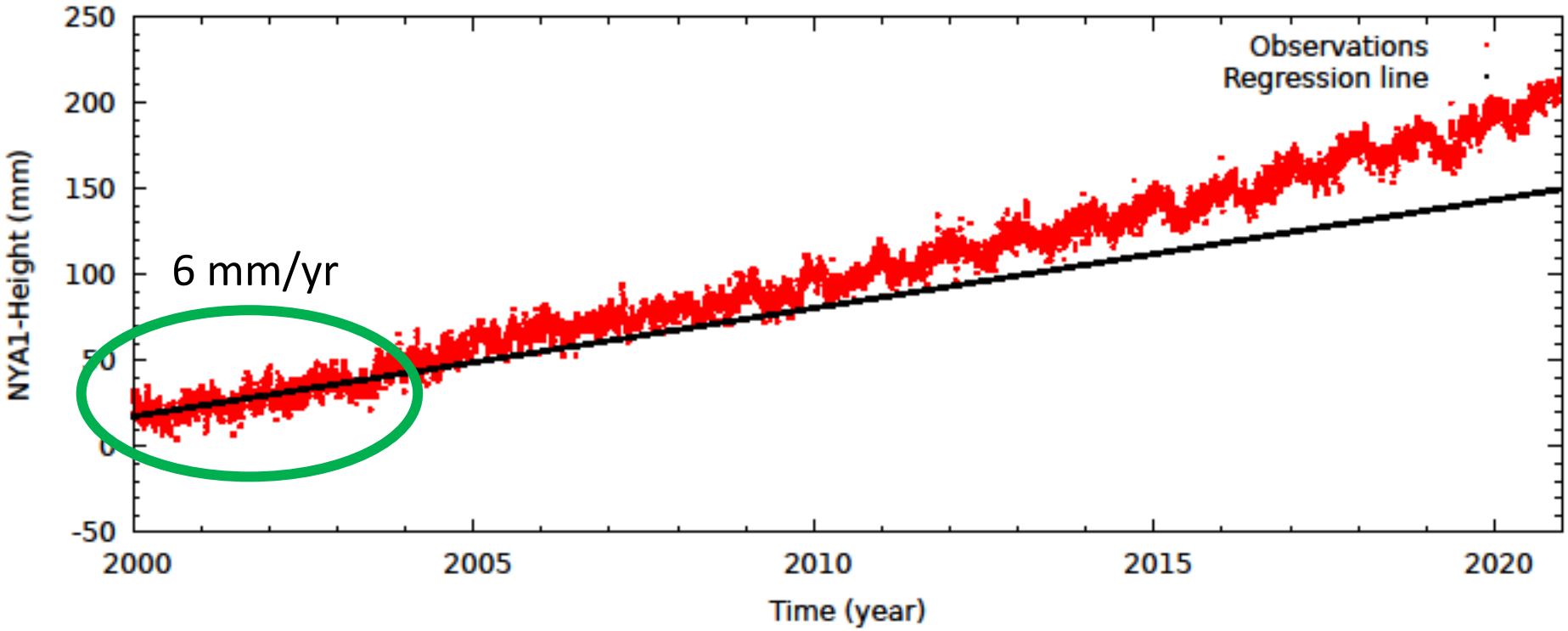




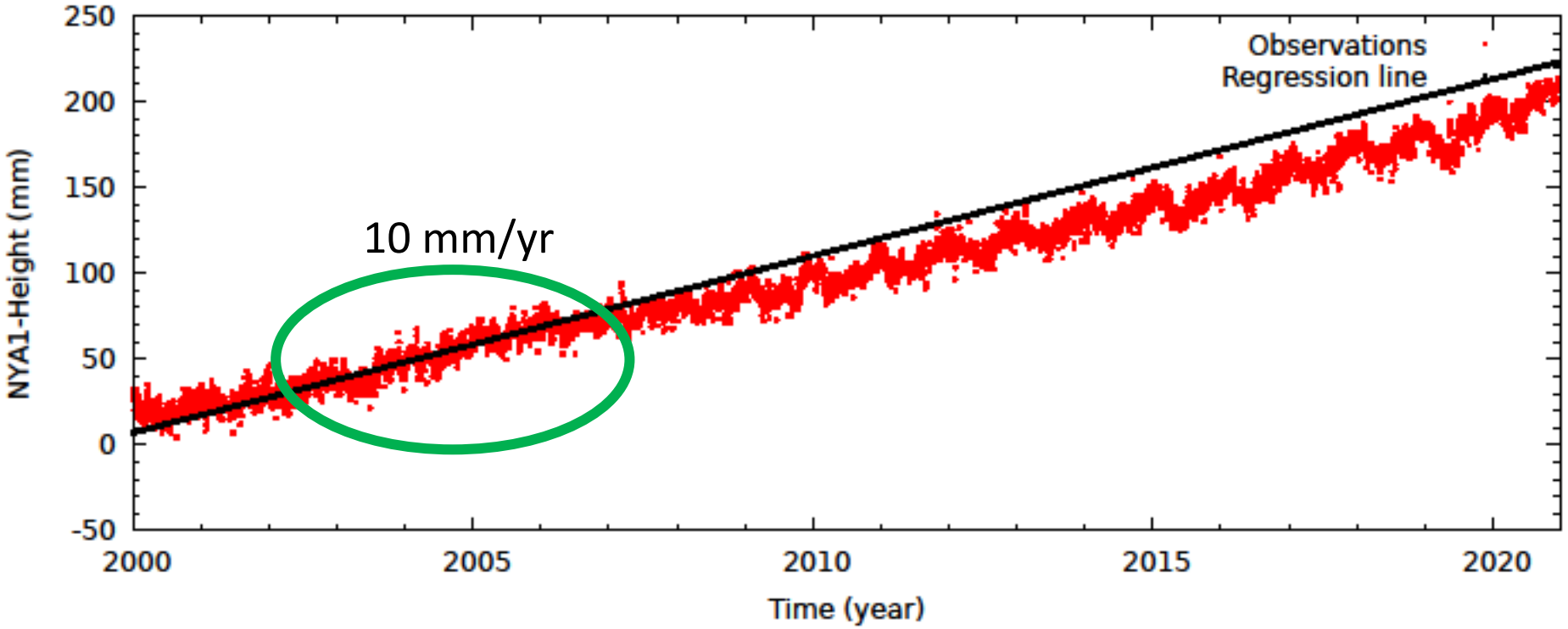
Land uplift in Ny-Ålesund



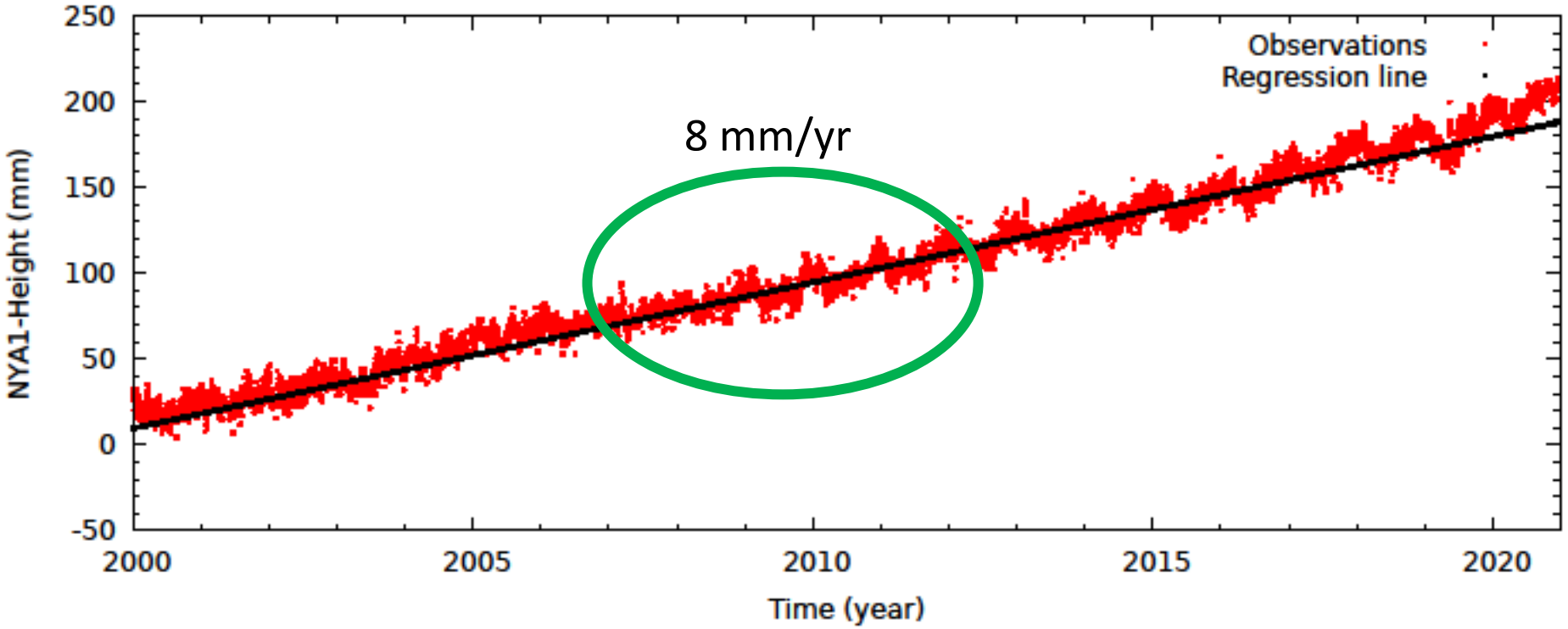
Kartverket

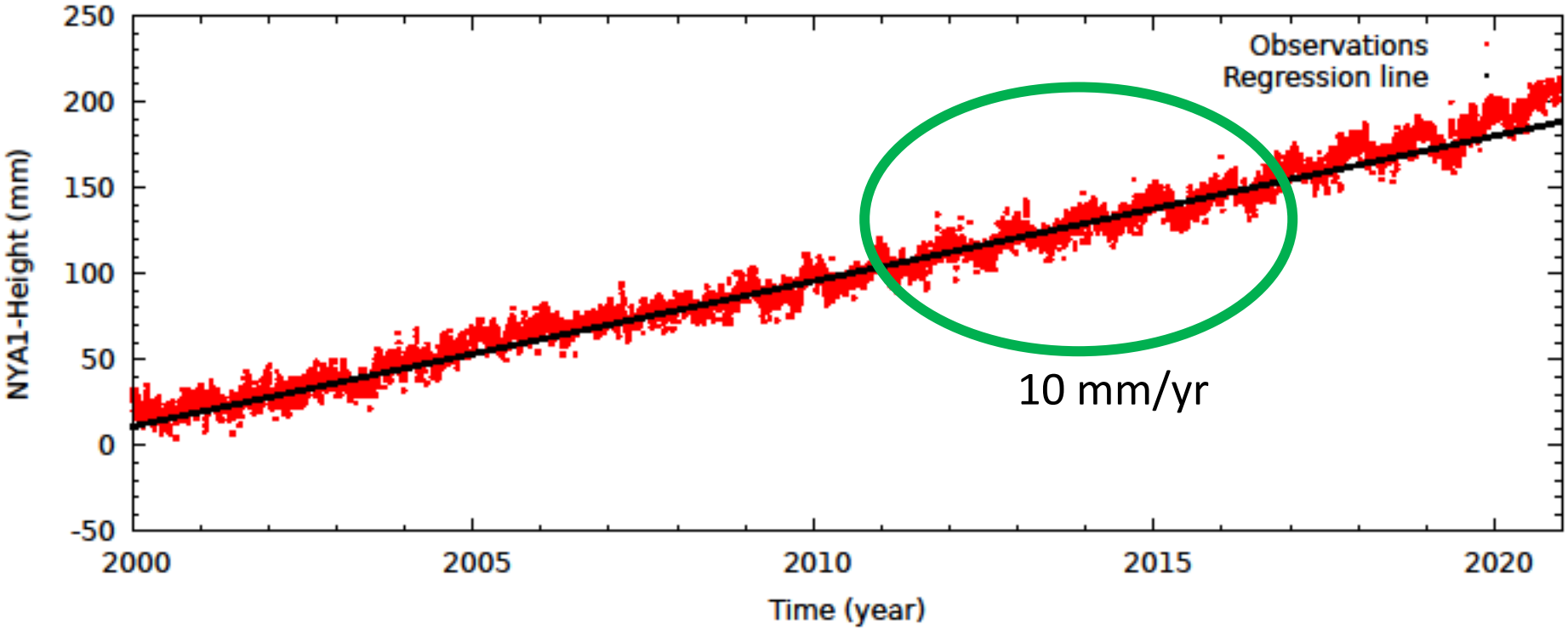

250
200
150
100
50
0
-50
NYA1-Height (mm)
2000
2005
2010
2015
2020
Time (year)
Observations
Regression line
6 mm/yr

Kartverket

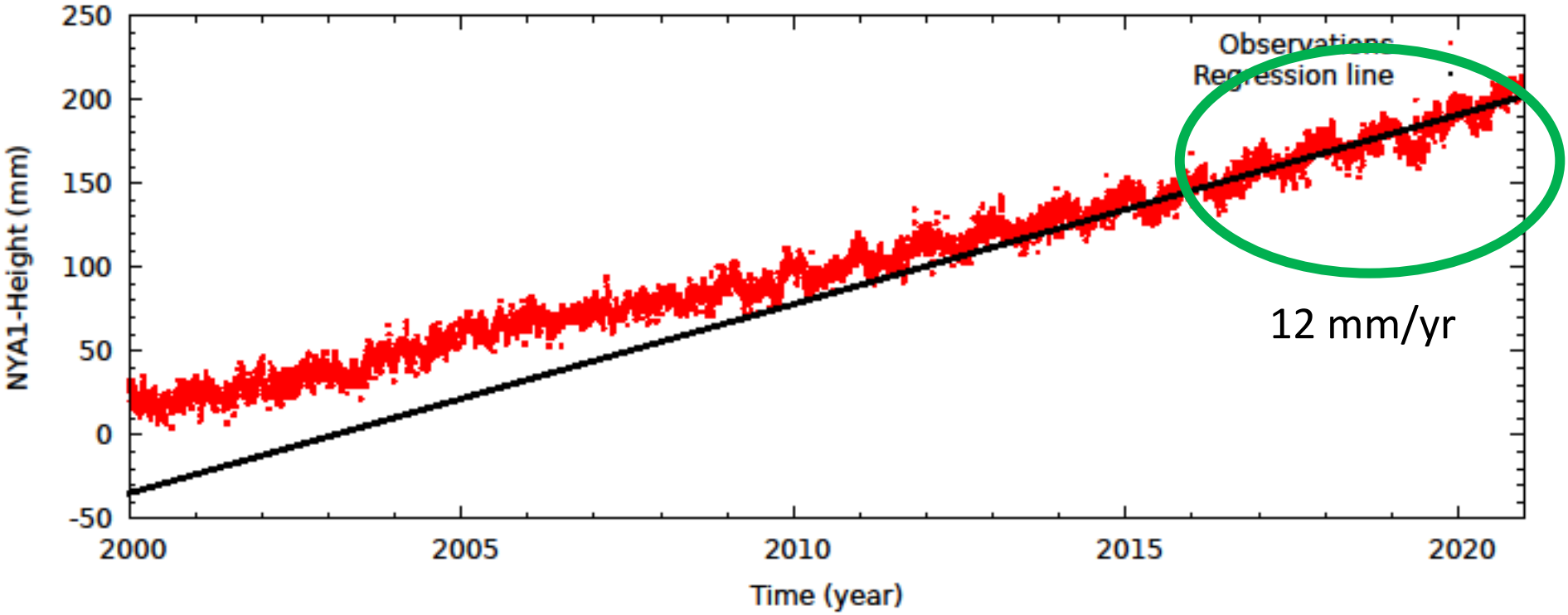

250
200
150
100
50
0
-50
NYA1-Height (mm)
2000
2005
2010
2015
2020
Time (year)
Observations
Regression line
10 mm/yr

Kartverket


8 mm/yr
Observations
Regression line
NYA1-Height (mm)
250
200
150
100
50
0
-50
2000
2005
2010
2015
2020
Time (year)

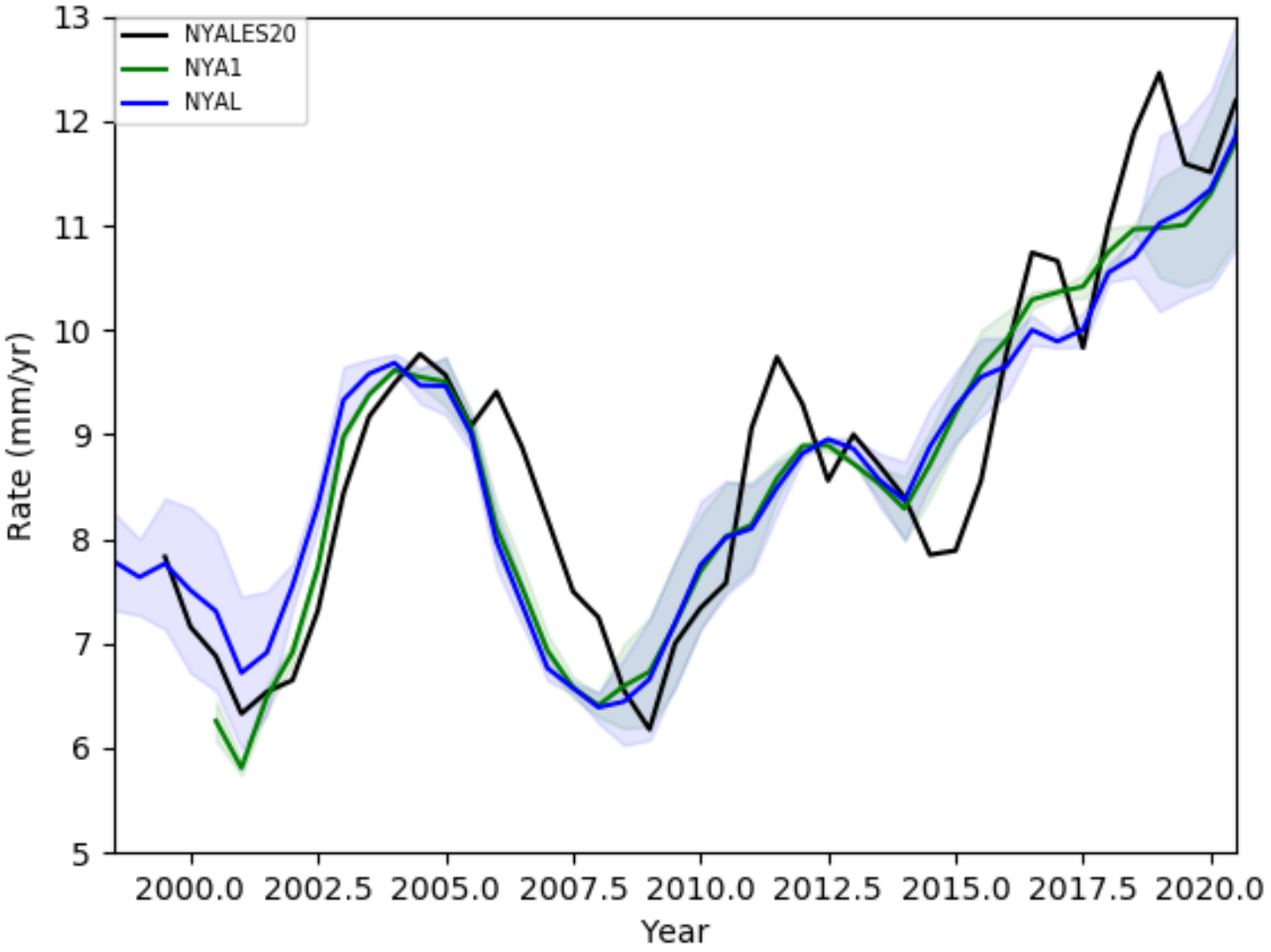

Observations
Regression line
10 mm/yr
NYA1-Height (mm)
Time (year)
250
200
150
100
50
0
-50
2000
2005
2010
2015
2020

Kartverket


250
200
150
100
50
0
-50
NYA1-Height (mm)
2000
2005
2010
2015
2020
Time (year)
Observations
Regression line
12 mm/yr

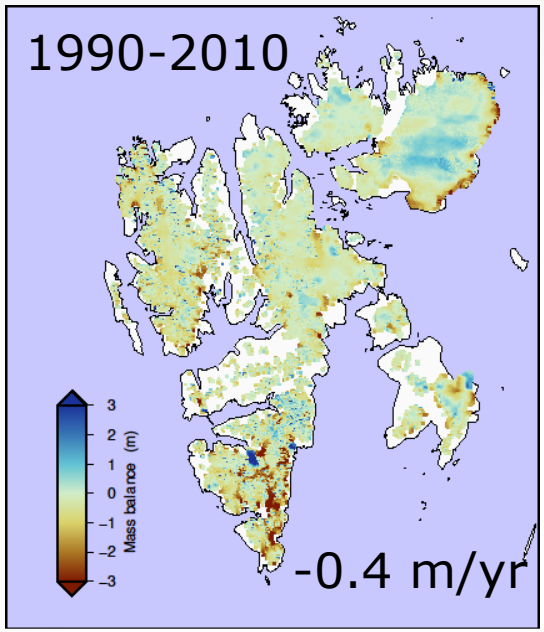
Kartverket

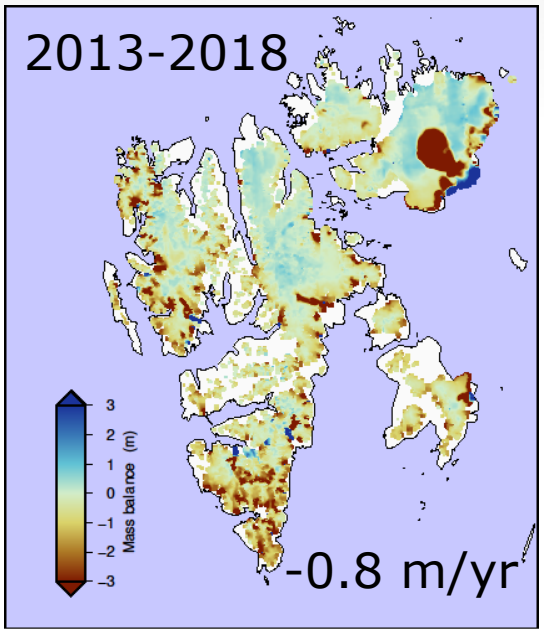
The uplift has doubled since year 2000



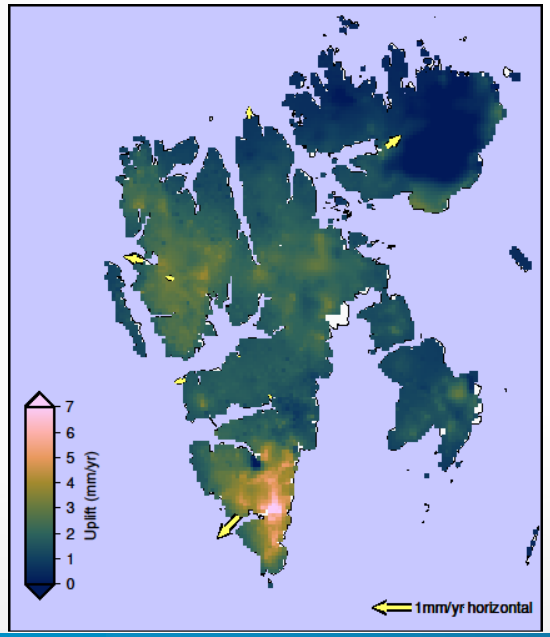
Kartverket

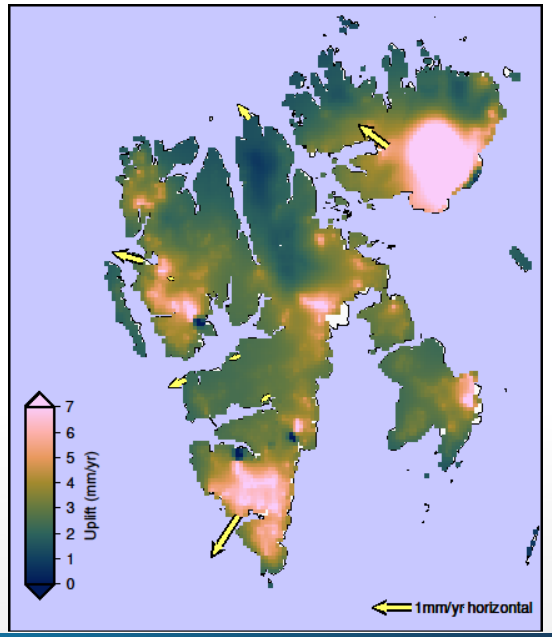
Svalbard glaciers are retreating





Ice mass variations



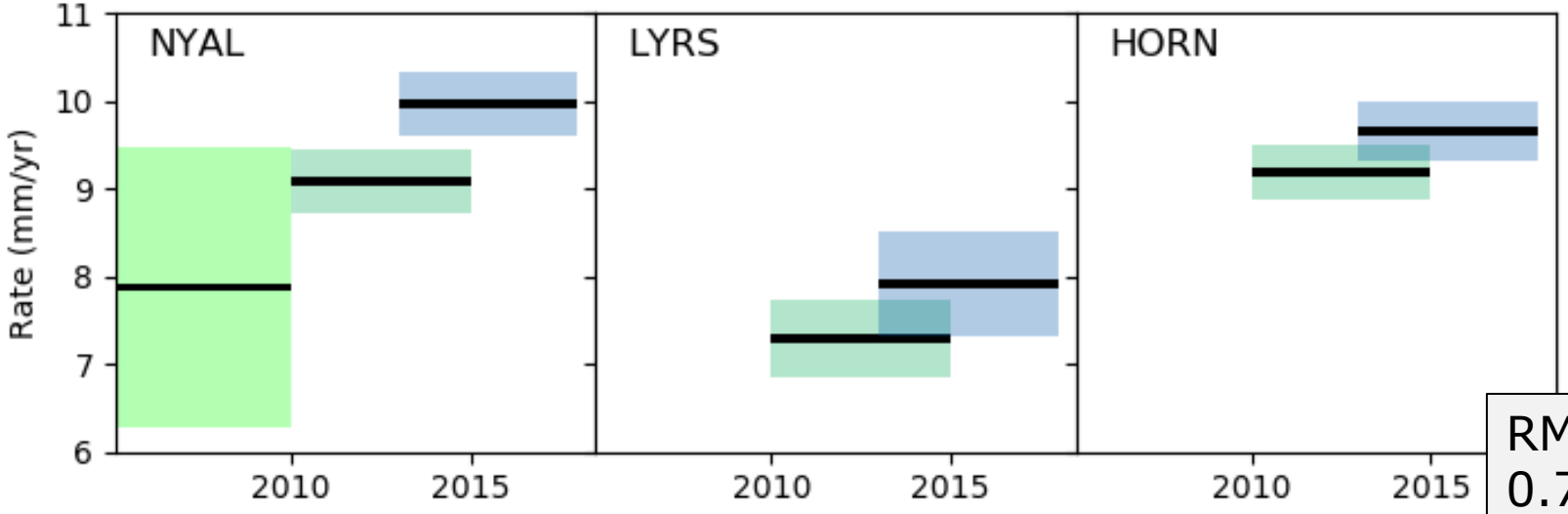


Land uplift and crustal deformations

Kartverket

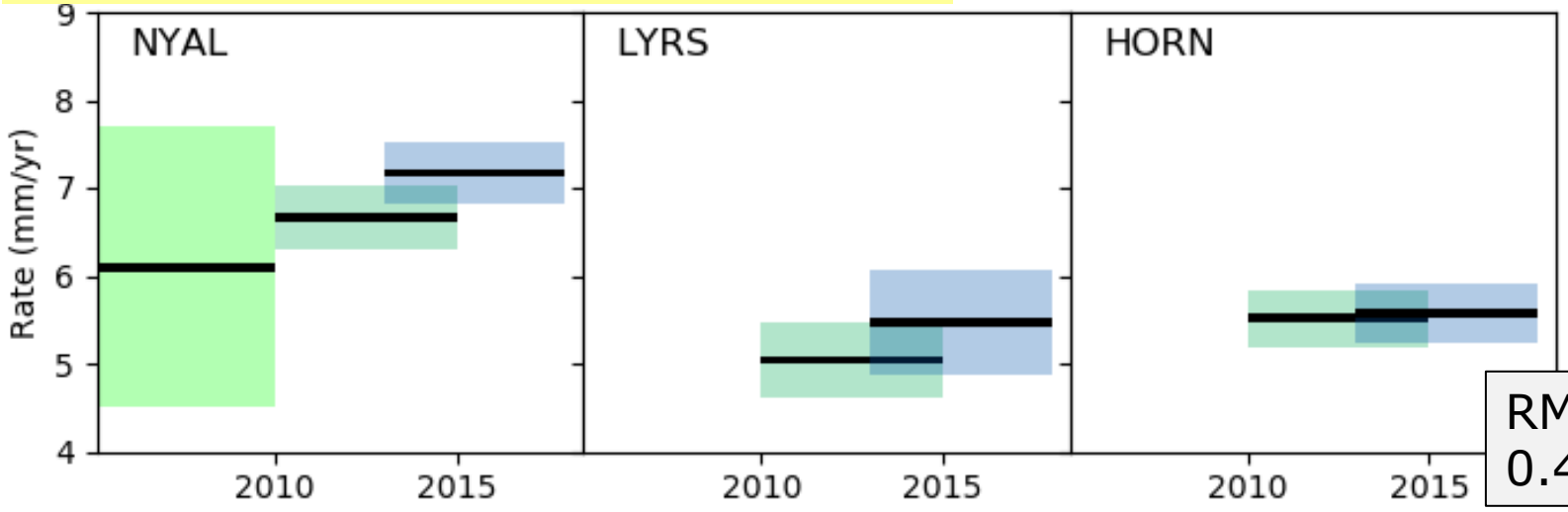
After removing the glaciers signal, we have no significant uplift changes

Uplift



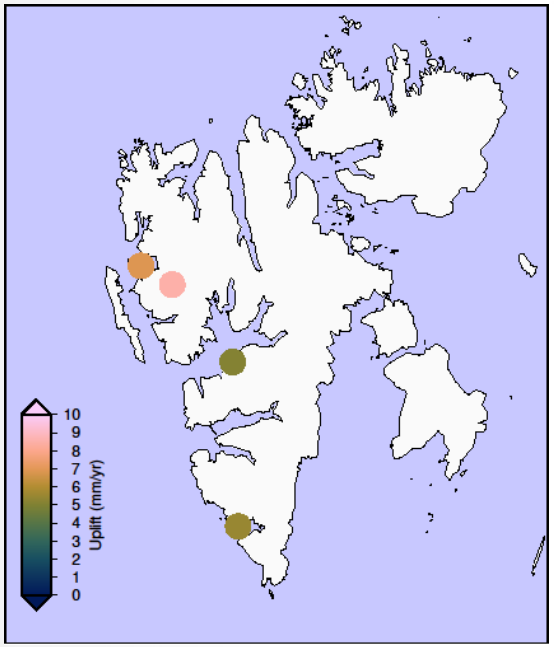
RMS:
0.7 mm/yr

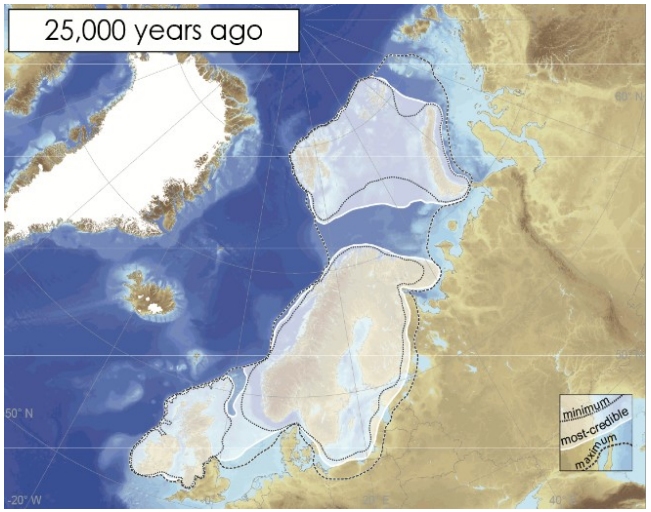
Uplift reduced with the glacier signal



RMS:
0.4 mm/yr

The remaining uplift signal is large and under investigation





Trygghamna: 1898

Photo: NP

2019

Photo: E.S. Holmlund

Lessons to be learned:

- Approaching a reference frame with 1 mm accuracy, nothing is stable
- Svalbard experience large changes in uplift on different time-scales
    - and a significant increase in uplift last 10 years
- The uplift changes can be explained by variations in glaciers
- Geodetic measurements of land uplift confirm glaciological findings

- Understanding geophysical processes affecting our stations are important for
    - Reference frames
    - Climate studies and sea-level