Onset of the growing season and plant biomass in relation to climate on Svalbard, mapped by MODIS data

By Stein Rune Karlsen

13th International Circumpolar Remote Sensing Symposium. September 8-12, 2014, Reykjavík, Iceland

Study area

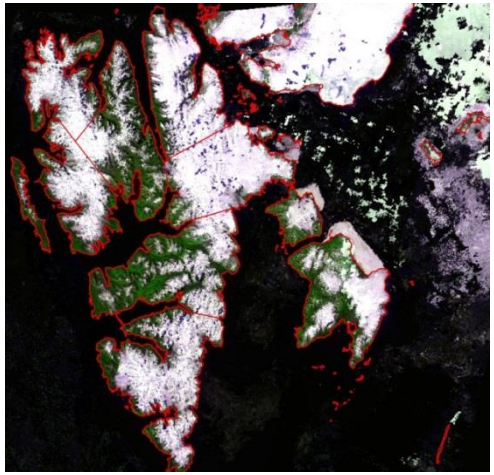
http://ngv.norut.no/Vekstsesong.m4v

MODIS data

Surface Reflectance, 8-days composite

a) MOD09A1 product: 7 band, 500m pixels

b) MOD09Q1 product: Red and NIR (NDVI), 250m



Removing clouds

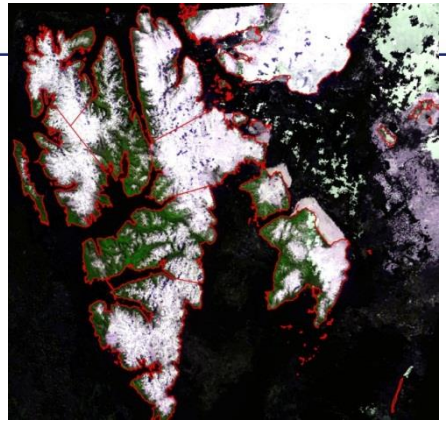
We used a combination of three cloud removing methods:
For each 8-days period we visually evaluate:

- State quality assessment (QA) values
- Own algorithms
- Manual removal

Altogether we have 15 different combination of using QA values/own algorithms/manual masking in cloud detection. For each combination we developed a python script to removed the clouds.

Time-consuming as it requires manual interpretation of cloud cover, but it is only doing once.

MODIS data



Interpolating cloudy parts

- replace the cloudy pixels based on temporal information (mean value from the periods before and after)
- Then apply Savitzky-Golay filter with down-weighting of the interpolated values.

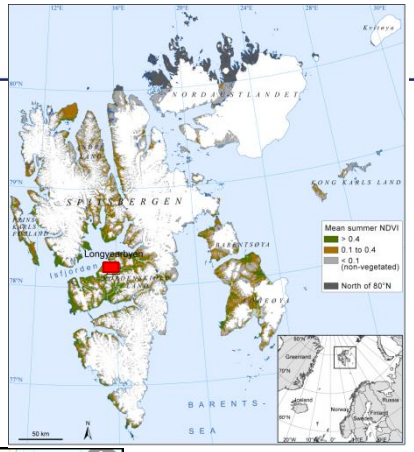
To map the onset of the growing season we use a NDVI threshold method

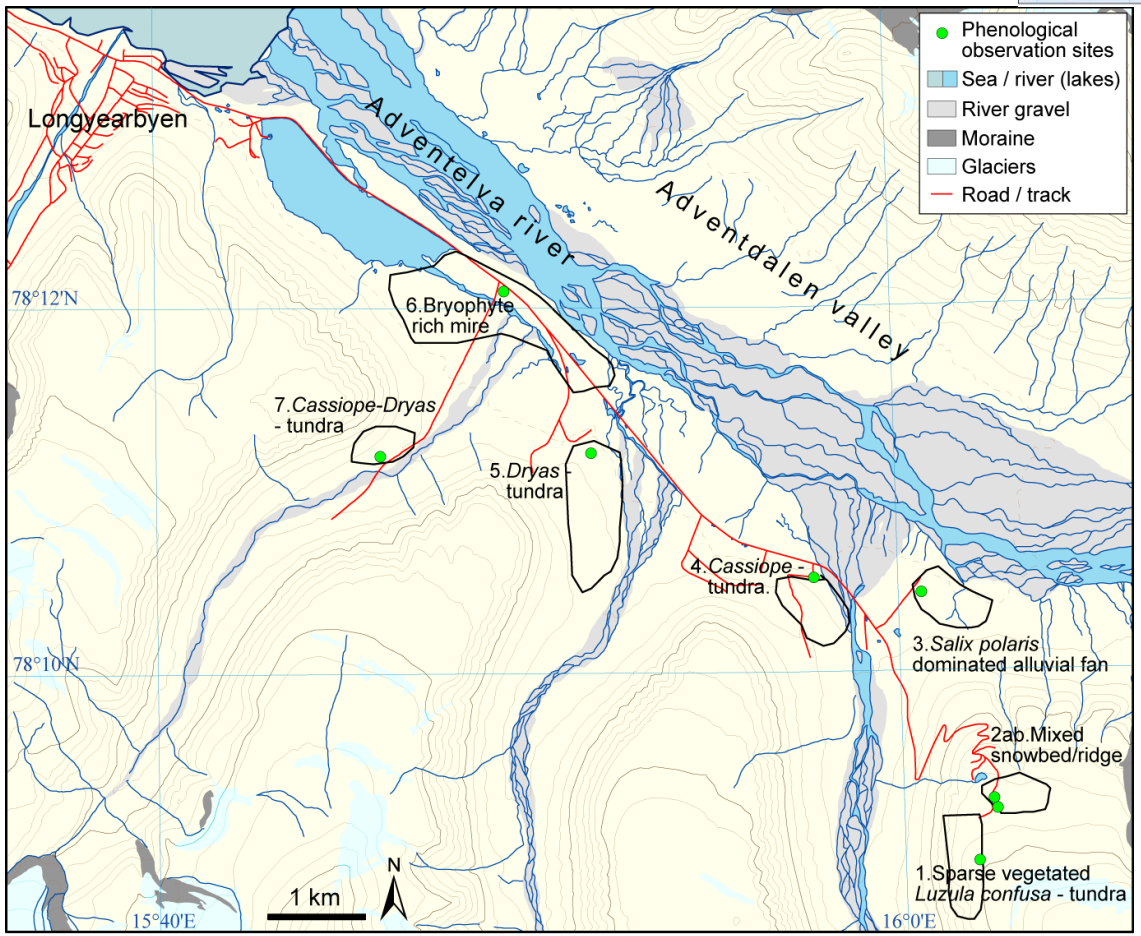
- Calculate the 14-year mean NDVI value for the 4 July to 3 August period
- Onset of the growing season occurs each year when the NDVI value exceeded 70% of this 14-years mean NDVI value

Field validation

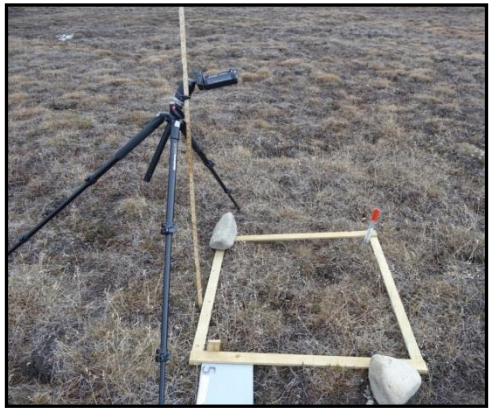
Weekly field observations since 2009 of flowering in spring, yellowing of leaves in autumn.

From 2014, automatic cameras, NDVI sensors, soil temperature

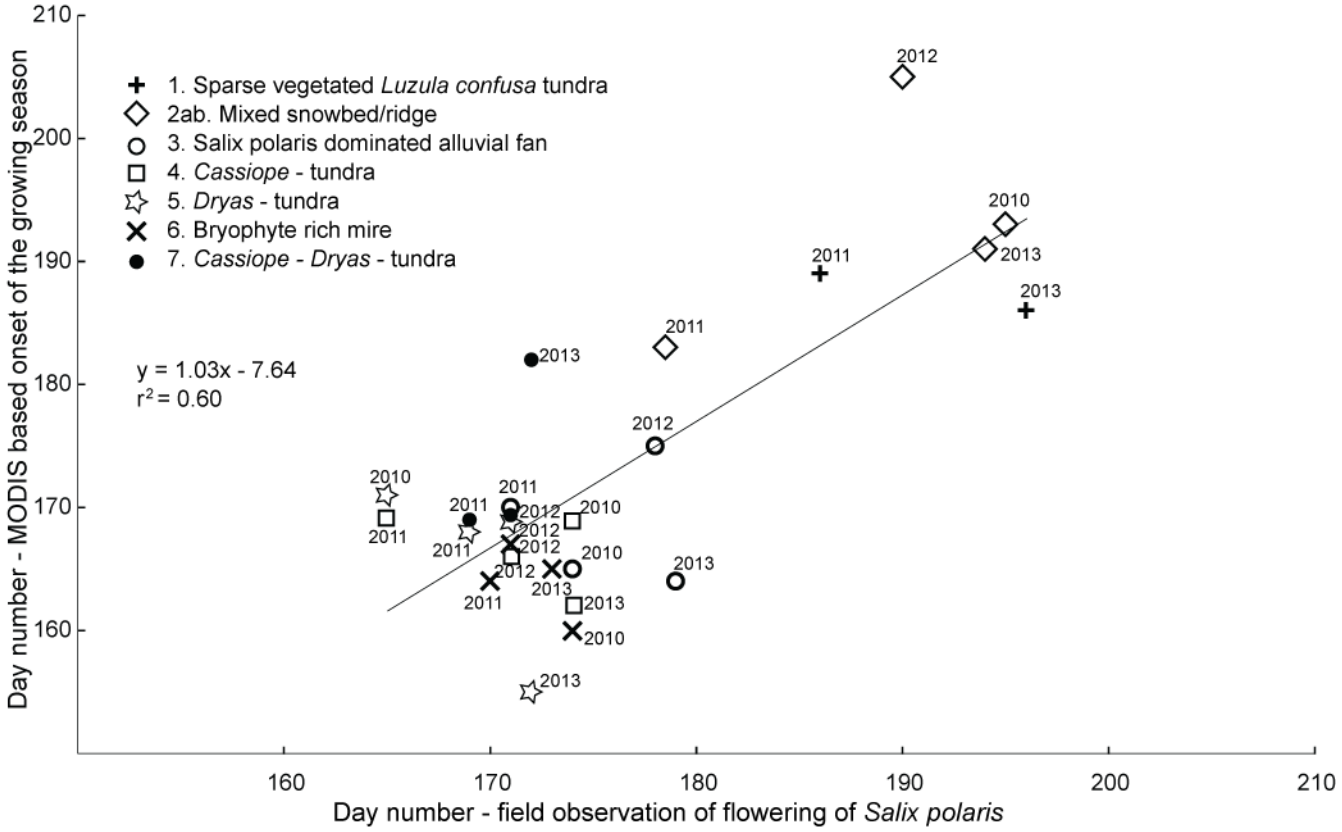




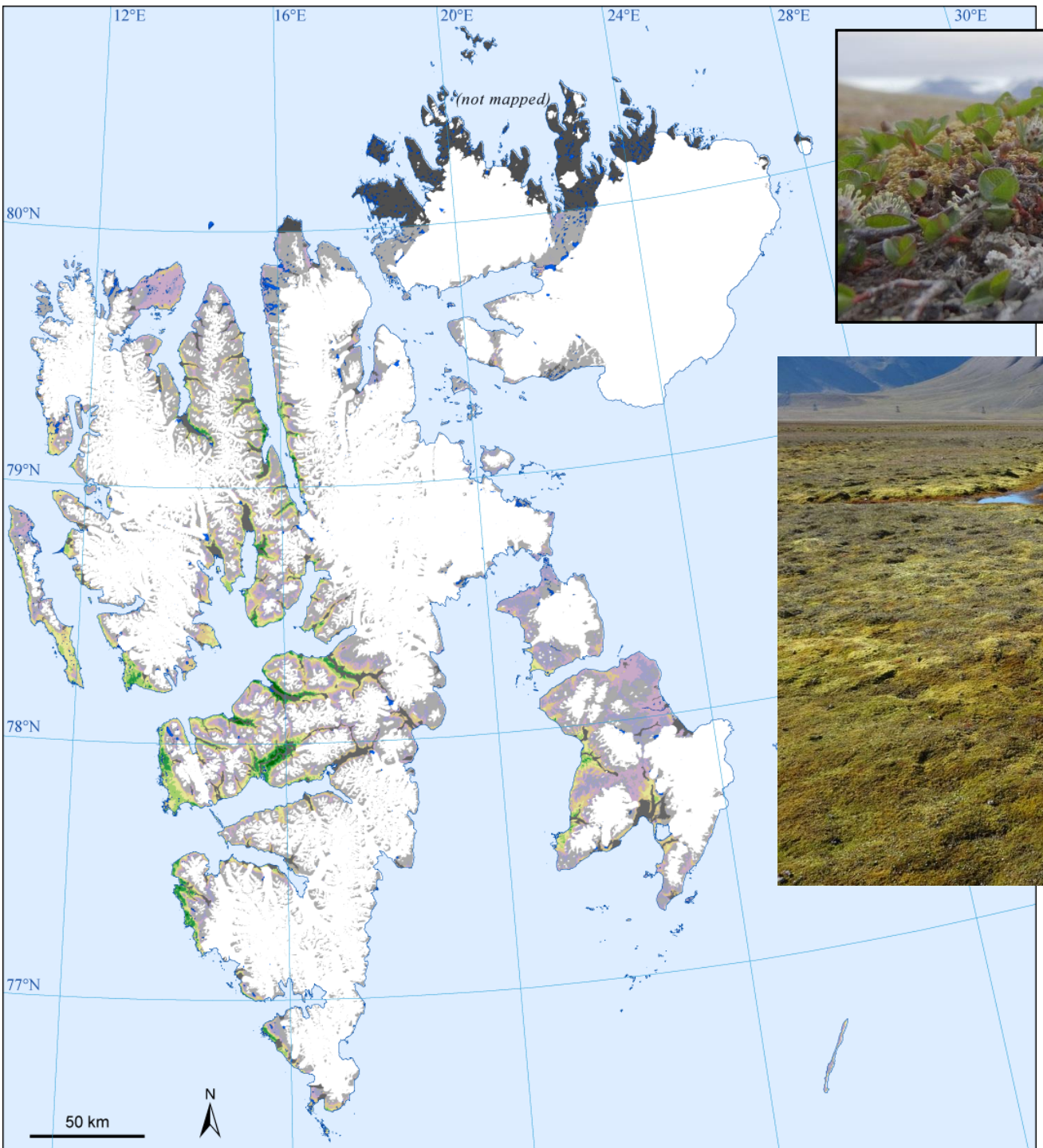
13 species, *Salix polaris* in all 8 sites

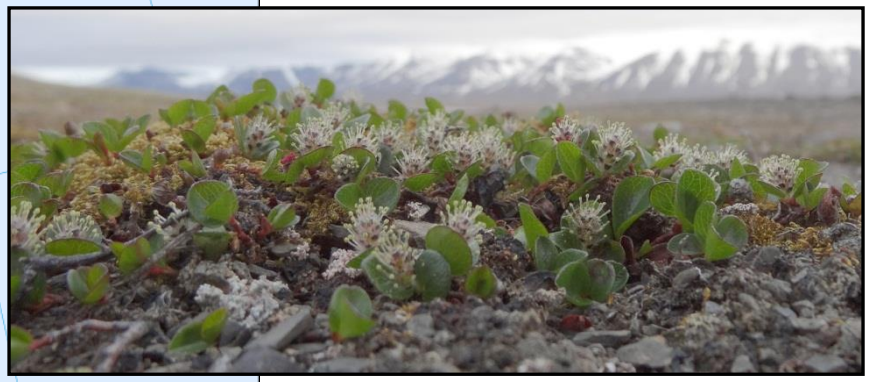


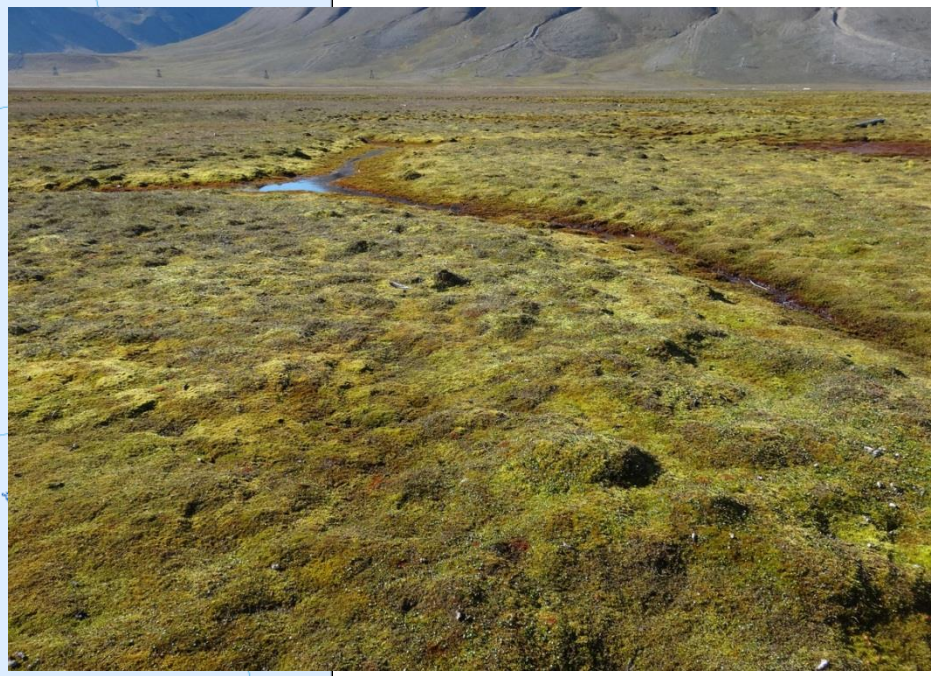
Correlation between MODIS NDVI-based onset of the growing season and time of flowering of *Salix polaris*



Karlsen et al. 2014. Remote Sensing.6:8088-8106

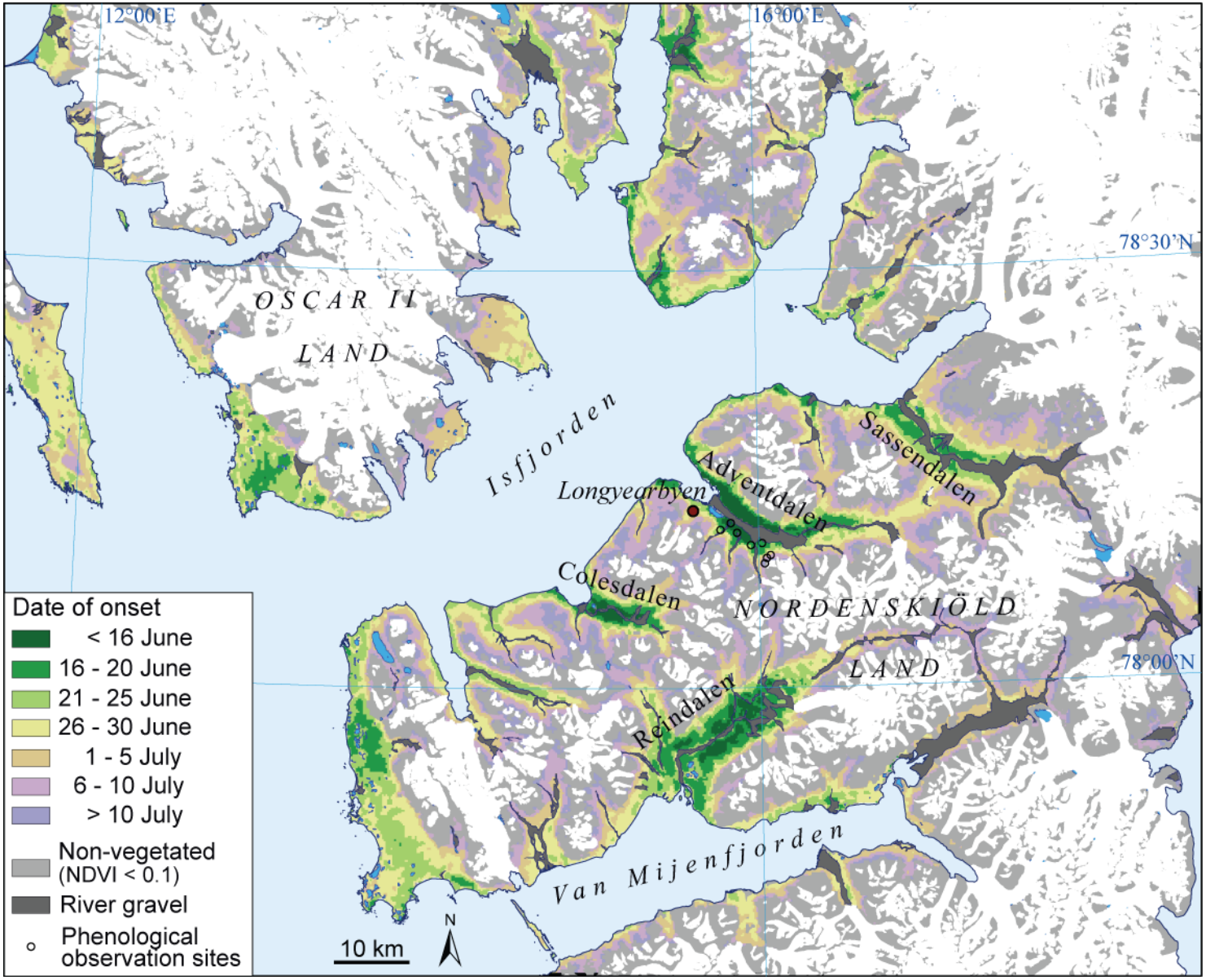


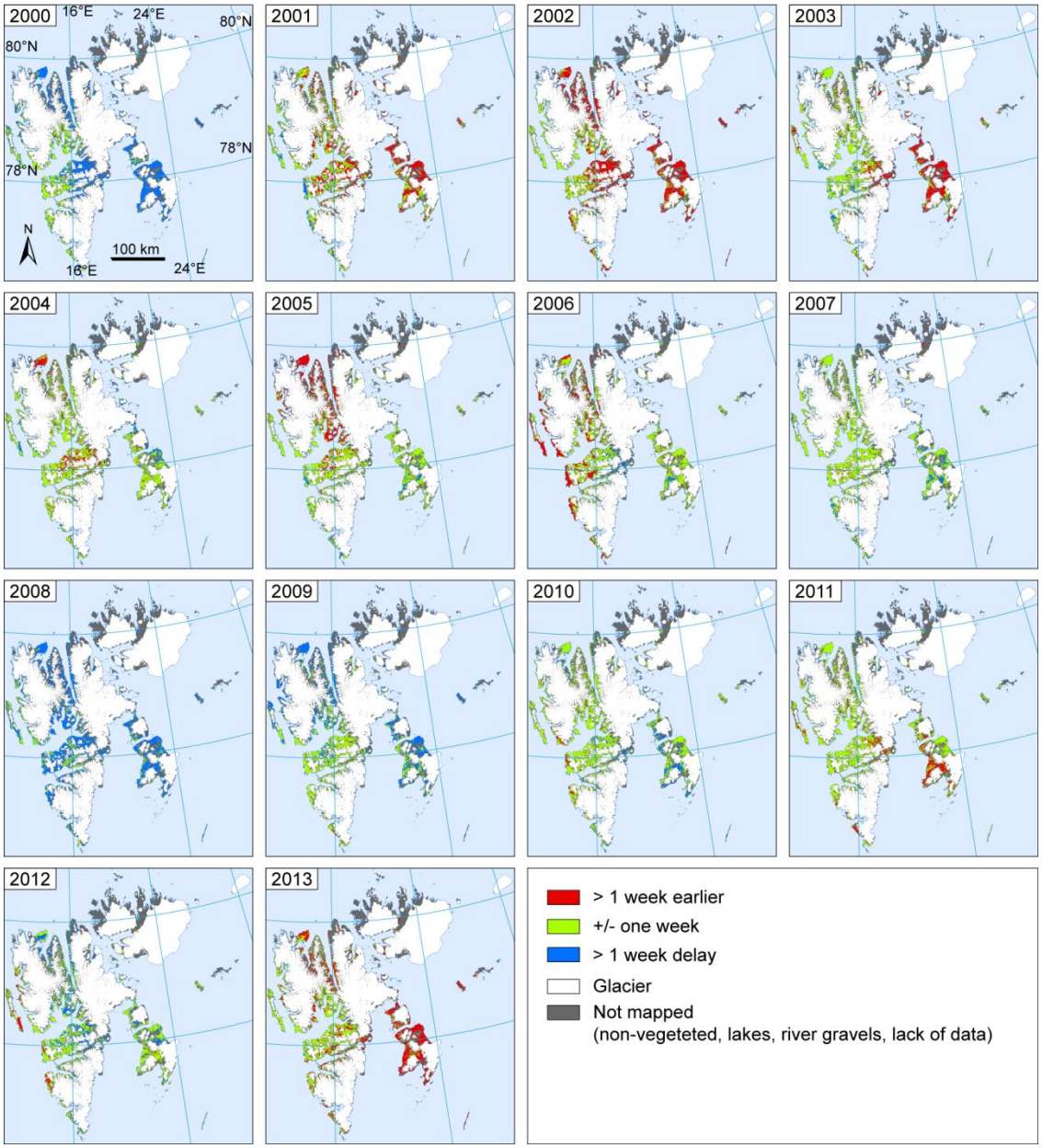




Karlsen et al. 2014. Remote Sensing.6:8088-8106

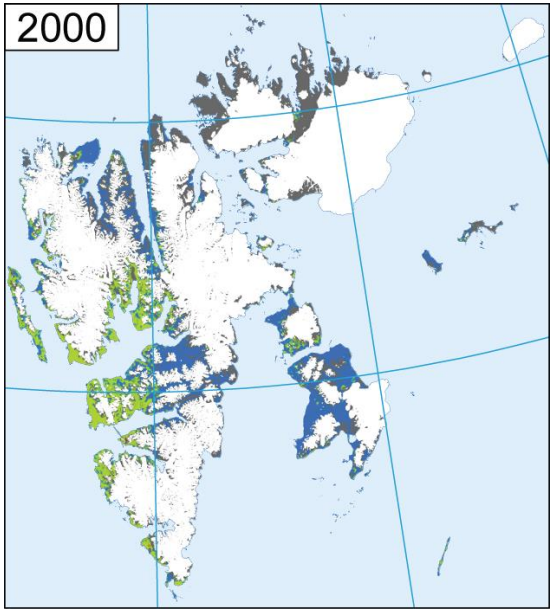
Central Svalbard. Mean date of onset of the growing season, 2000-2013

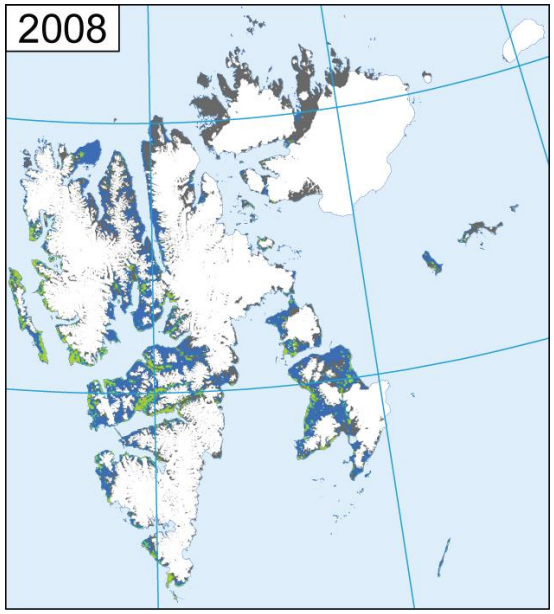




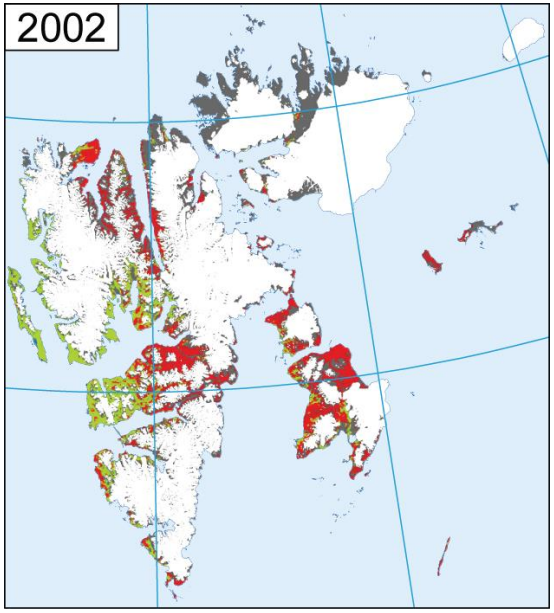
Regional variation in onset of the growing season - from the 2000-2013 average

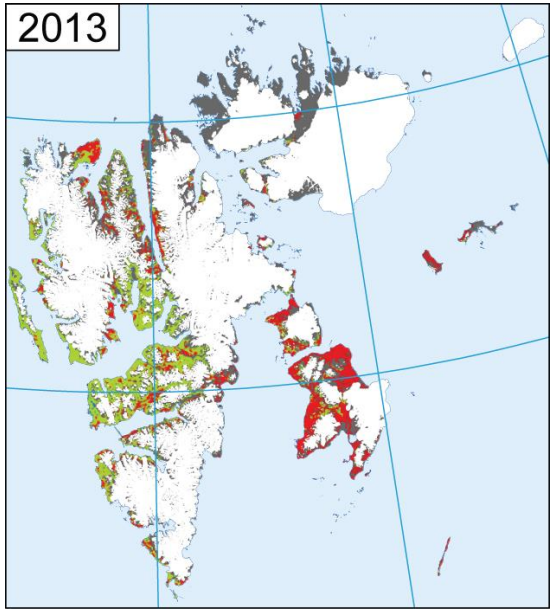
Early/late years 2000-2013





> 1 week earlier
+/- one week
> 1 week delay
Glacier
Not mapped

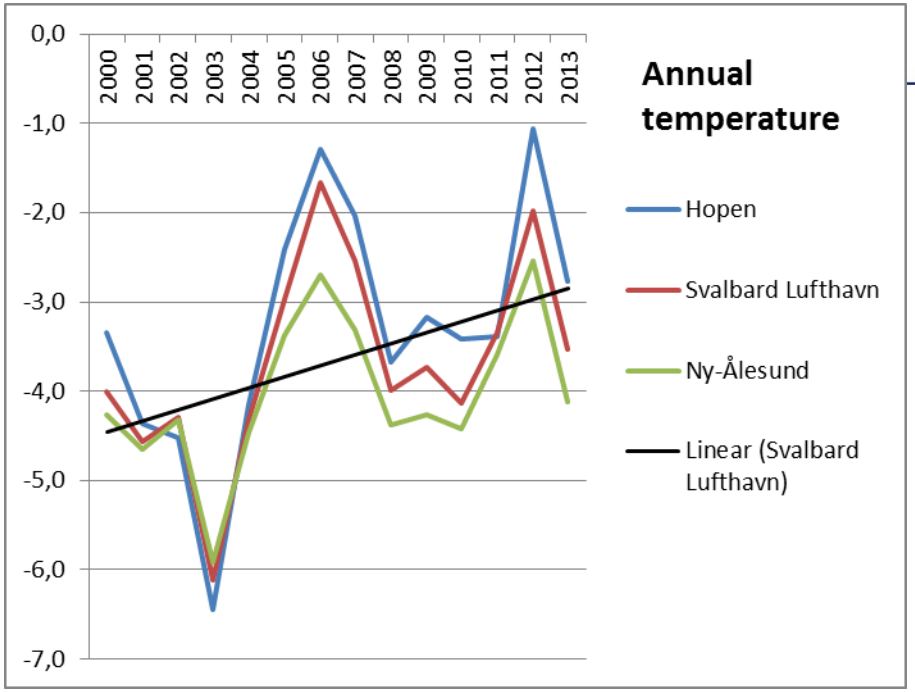


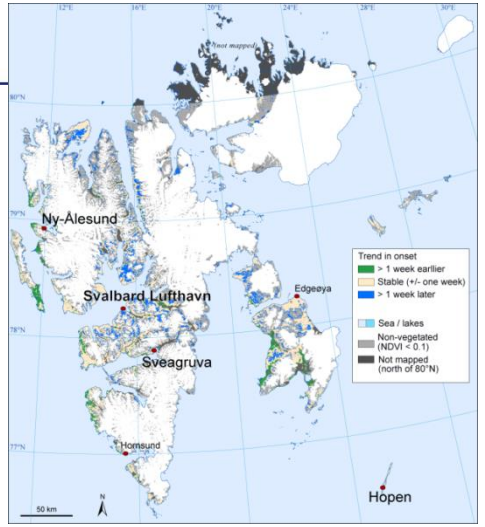


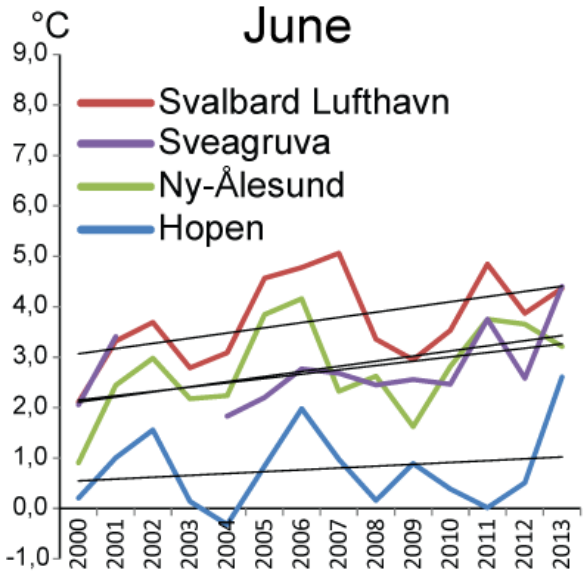
Linear trend in onset 2000-2013

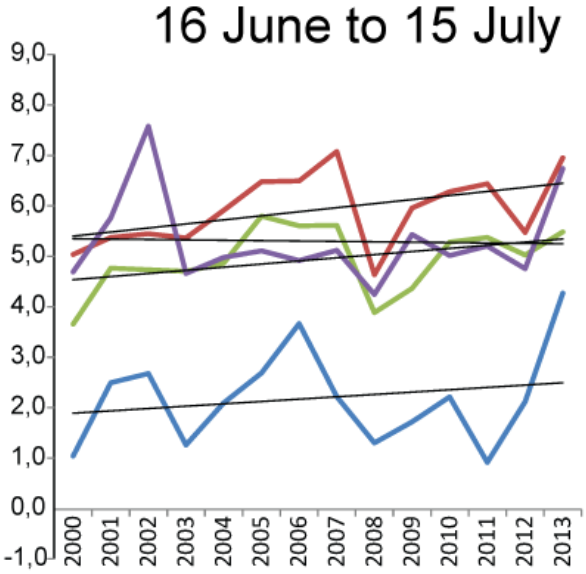
Climatic stations

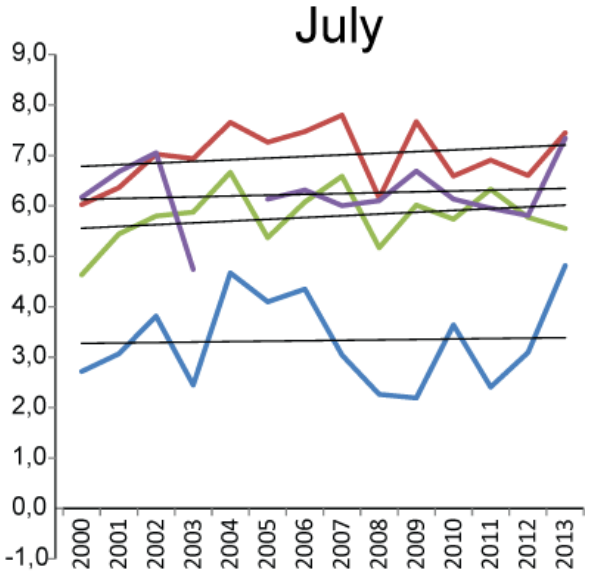
Climate


Annual temperature
Hopen
Svalbard Lufthavn
Ny-Ålesund
Linear (Svalbard Lufthavn)
0,0
-1,0
-2,0
-3,0
-4,0
-5,0
-6,0
-7,0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013

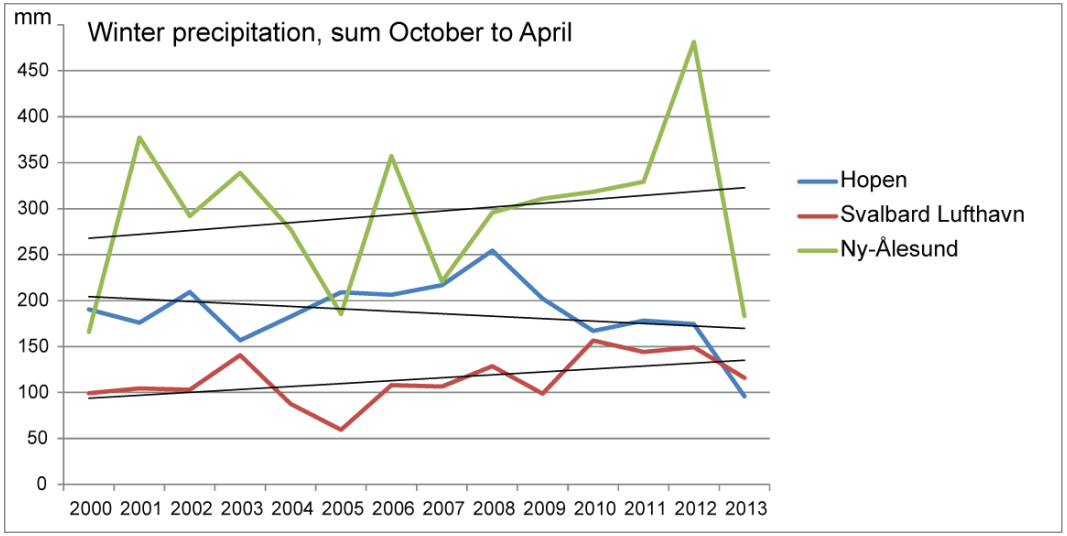

Ny-Ålesund
Svalbard Lufthavn
Edgeøya
Sveagruva
Hornsund
Hopen
Trend in onset
> 1 week earlier
Stable (+/- one week)
> 1 week later
Sea / lakes
Non-vegetated (NDVI < 0.1)
Not mapped (north of 80°N)

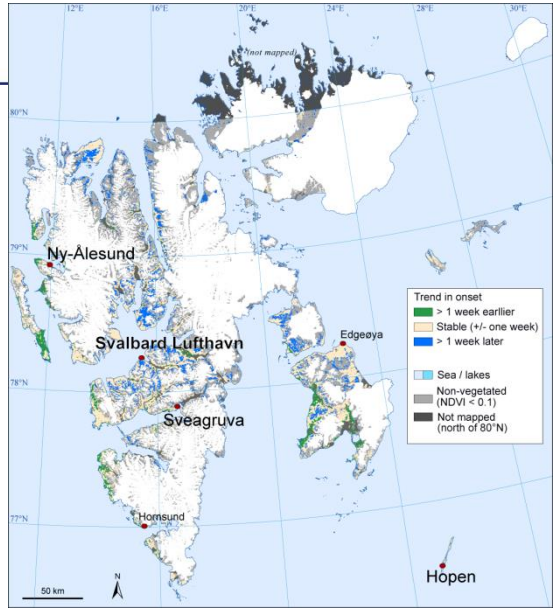

°C
June
Svalbard Lufthavn
Sveagruva
Ny-Ålesund
Hopen
9,0
8,0
7,0
6,0
5,0
4,0
3,0
2,0
1,0
0,0
-1,0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013


16 June to 15 July
9,0
8,0
7,0
6,0
5,0
4,0
3,0
2,0
1,0
0,0
-1,0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013


July
9,0
8,0
7,0
6,0
5,0
4,0
3,0
2,0
1,0
0,0
-1,0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013

Climate





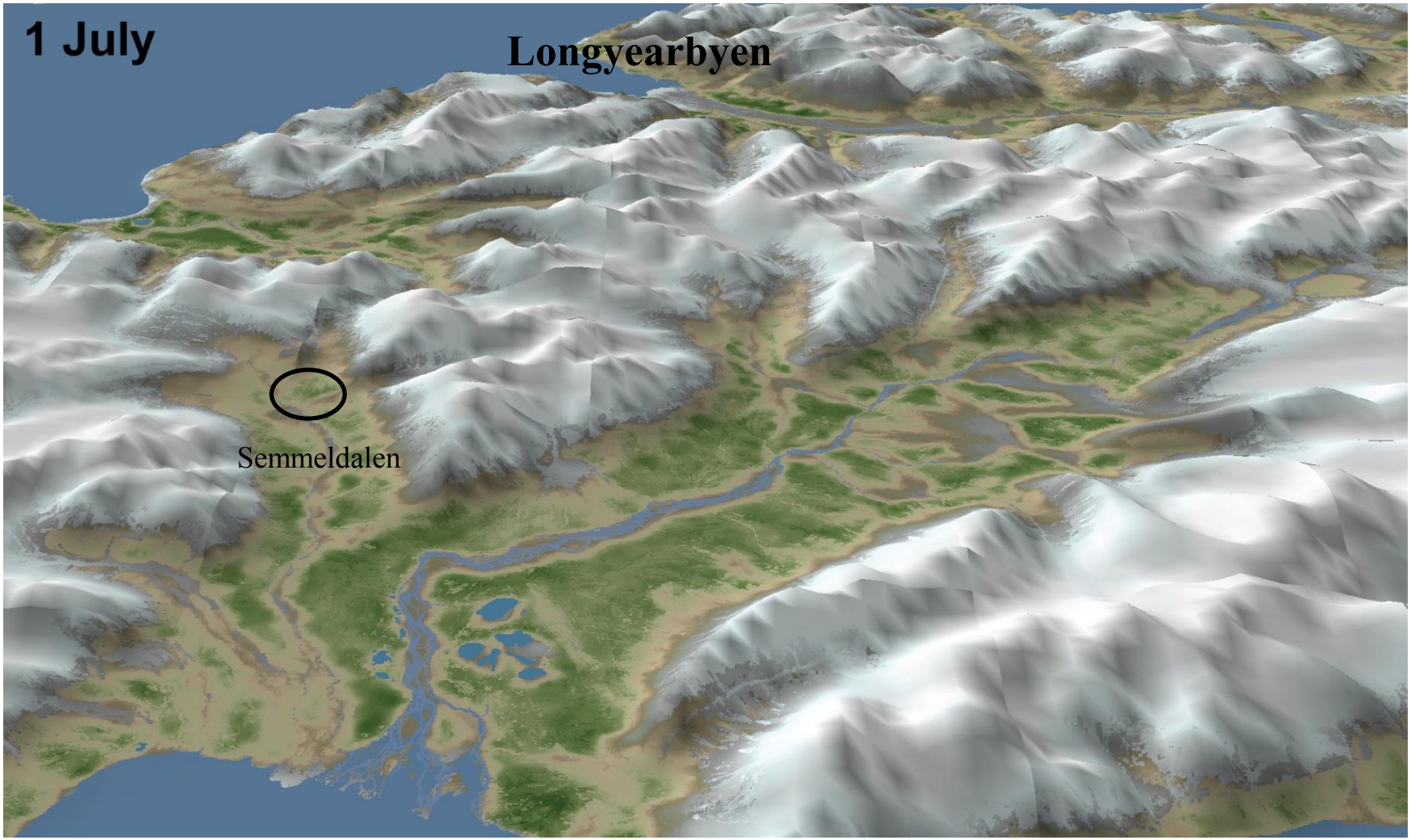
Correlation value (r)

Climatic parameters - onset of the growing season

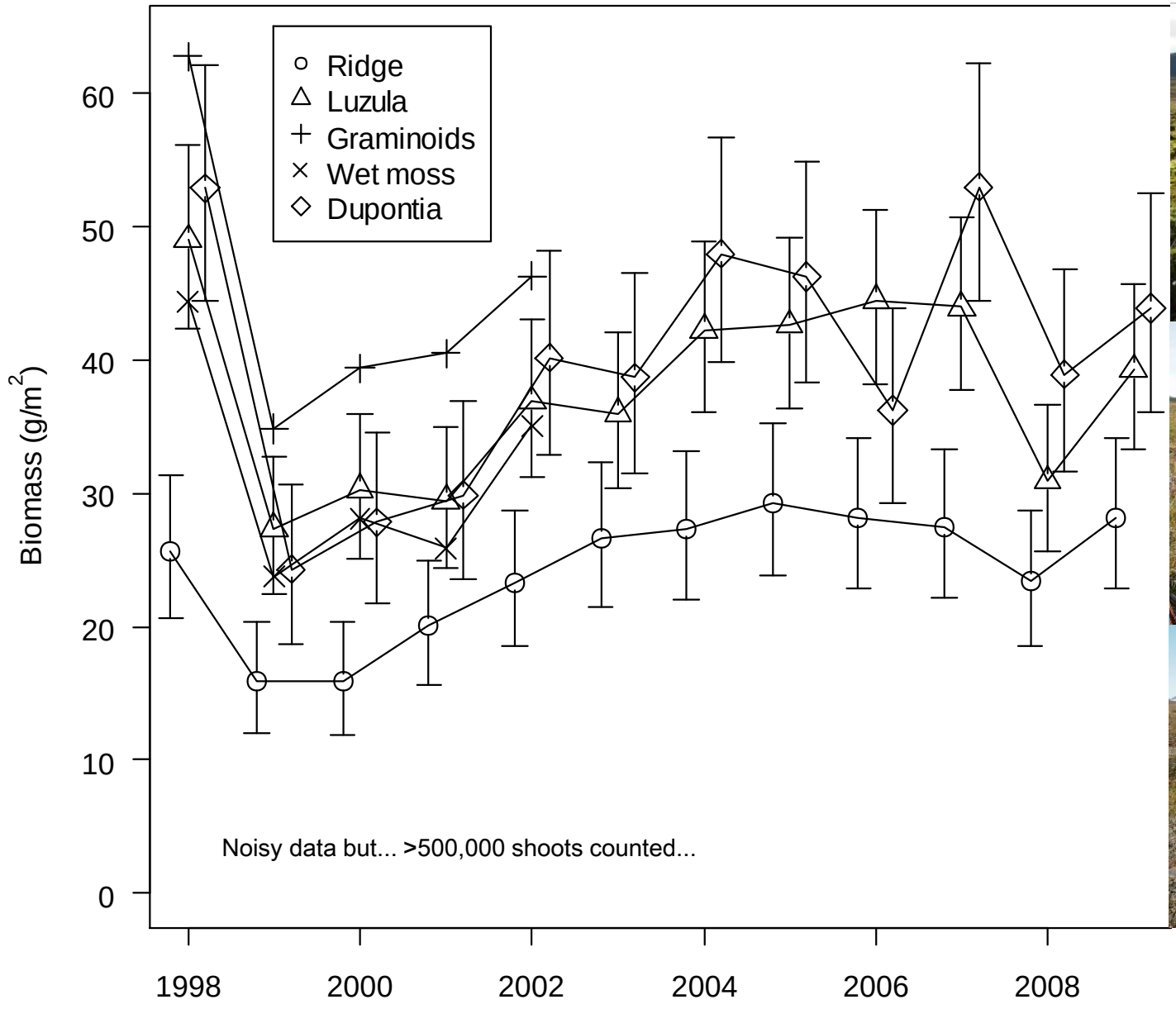
= significant 5% level, **= 1% level, *= 0.1% level*

Station		Temperature/°C			Precipitation Sum Oct.-Apr.	Temperature and precipitation
	Year	June	16 June-15 July	July		
Hopen	14		-0.77***		0.42	0.78***
Svalbard Lufthavn	14	-0.50			0.39	0.63*
Ny-Ålesund	14	-0.78***	-0.74**			
Sveagruva	14		-0.68**			
Hornsund	7		-0.84*			
Edgeøya	5		-0.87	-0.88*		

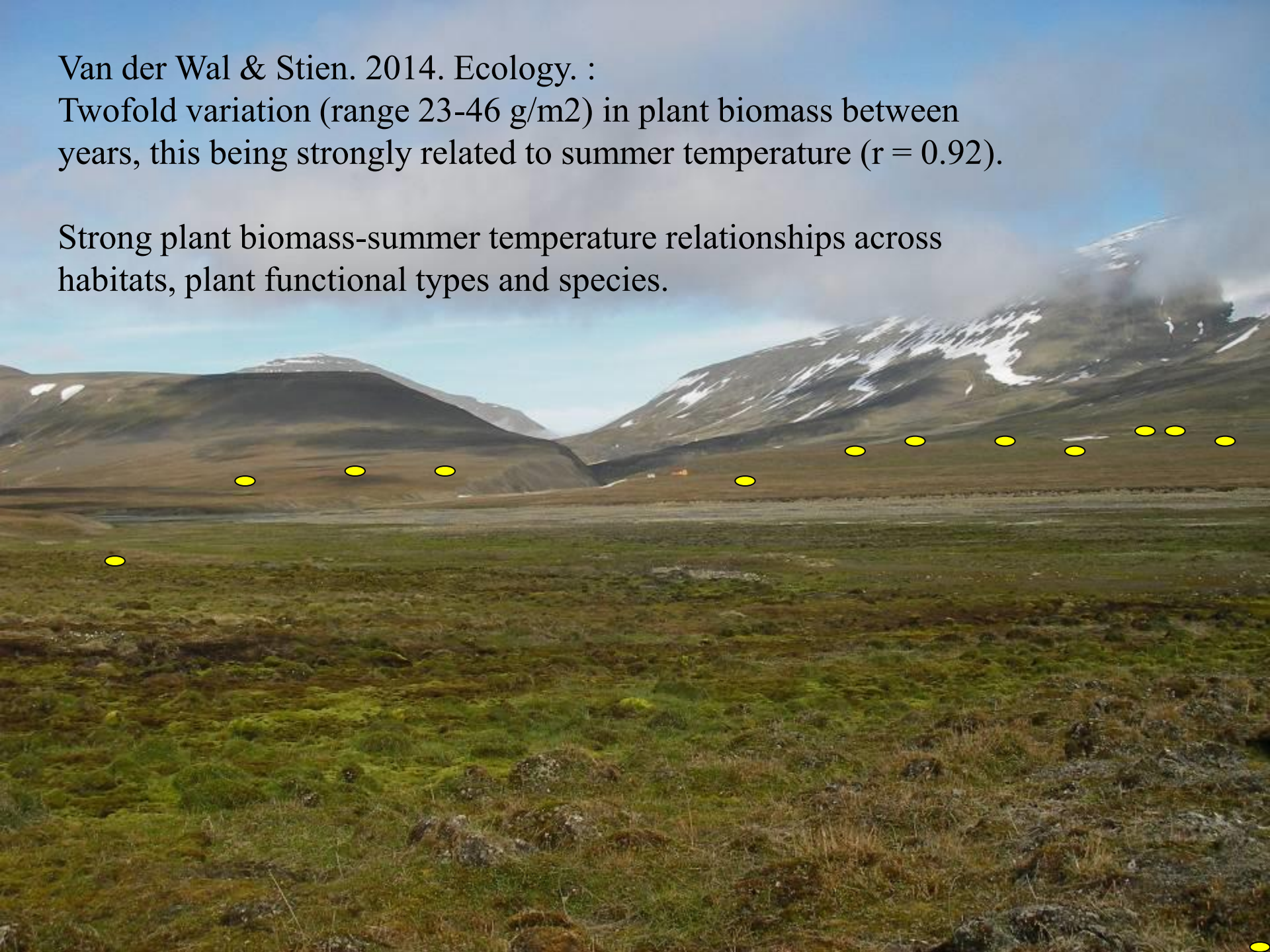
Plant production – field data from Semmeldalen



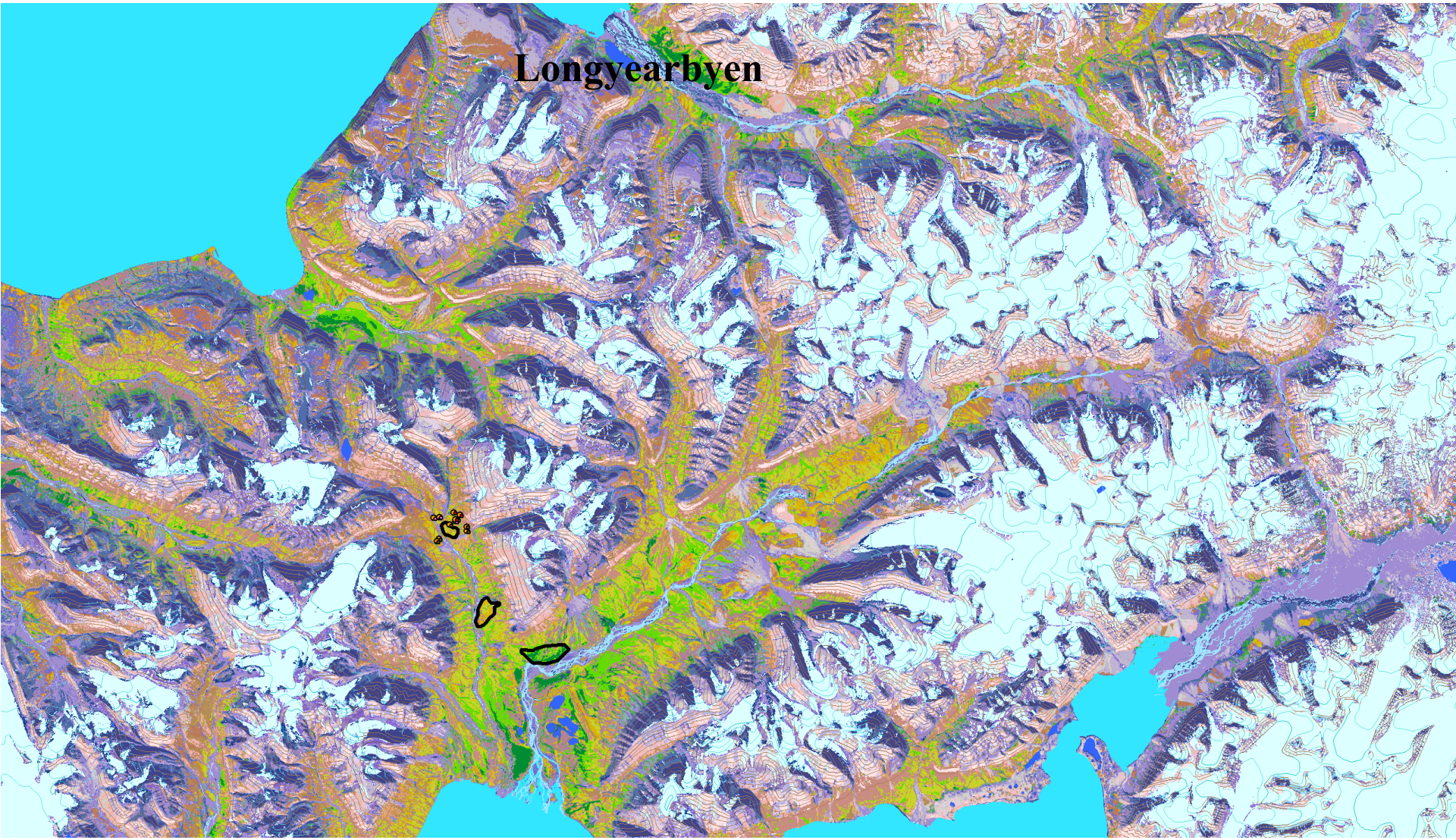
Animation



van der Wal & Stien. 2014. Ecology.


Van der Wal & Stien. 2014. Ecology. :
Twofold variation (range 23-46 g/m2) in plant biomass between years, this being strongly related to summer temperature (r = 0.92).
Strong plant biomass-summer temperature relationships across habitats, plant functional types and species.

Plant production – field data from Semmeldalen



Vegetation map: Johansen et. al. 2012. Polar Record.

Correlation value (r) between field biomass data and MODIS based NDVI/onset of the growing season

Polygon representing	Time Integrated NDVI from onset to 1 August	Date of onset of the growing season	Max NDVI
Luzula heath	0.64	-0.53	0.33
Ridge	0.76	-0.32	0.39
Dupontia marsh	0.34	-0.35	0.15
Combine all vegetation types	0.71	-0.46	

Summary

The method used for developing cloud free time-series of MODIS data is time-consuming (Stat QA + own cloud masks + visual masking), but is only done once

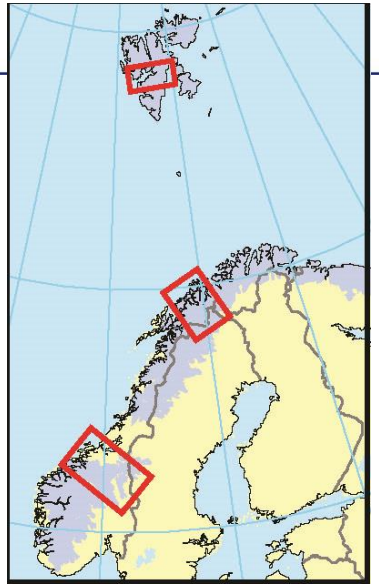
Bryophyte dominated areas - measuring timing of snow-melt?

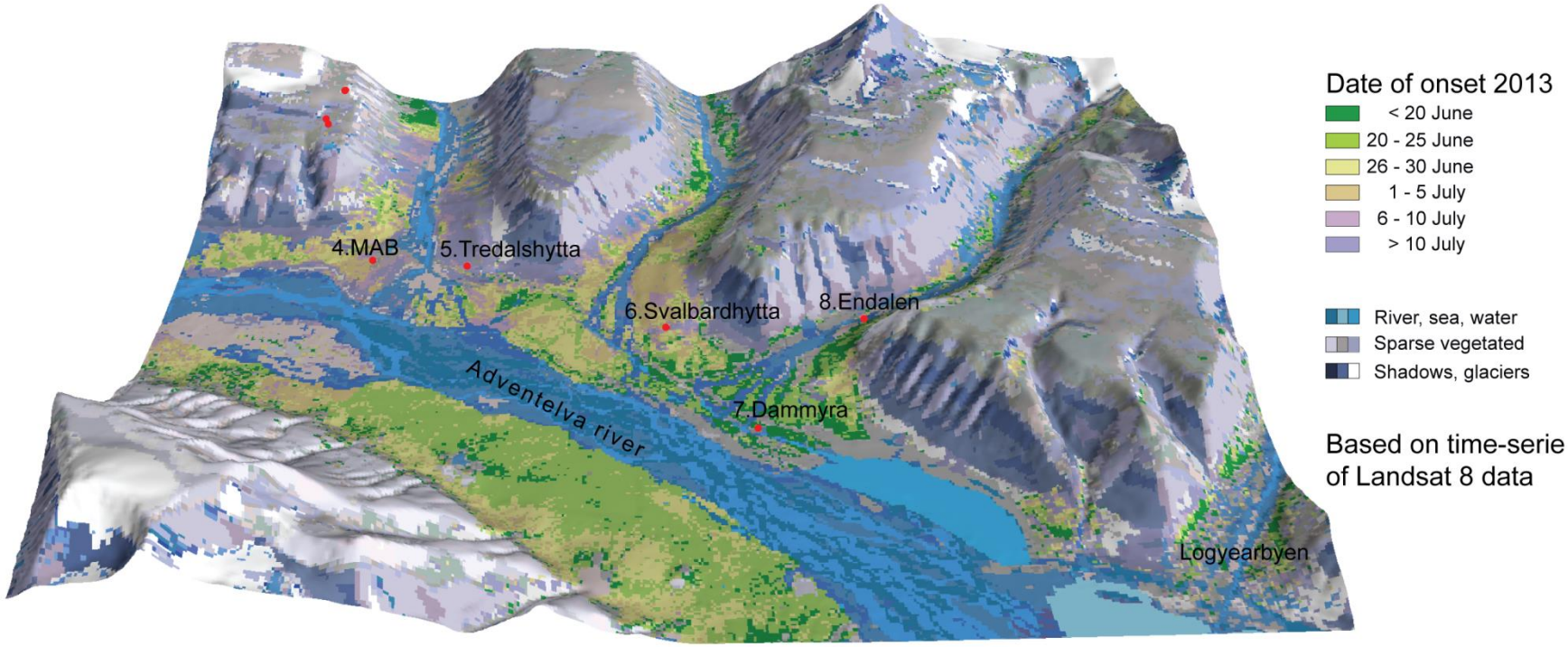
High variability between the years in onset of the growing season, in particular in eastern and northern parts of Svalbard

No clear trend in onset of the growing season, 2000-2013. No increase in temperature when the growing season starts.

Relationship between plant biomass and time integrated NDVI (Integrated from onset of the growing season to 1 August/peak of season. Two-fold variation in plant biomass between years on Svalbard.

Next step: Use of time-series of Landsat 8 data – to simulate Sentinel-2 based mapping of the growing season





Acknowledgement

This project is a part of an ongoing *Environmental monitoring system for Svalbard and Jan Mayen (MOSJ)*

Lead by the Norwegian Polar Institute

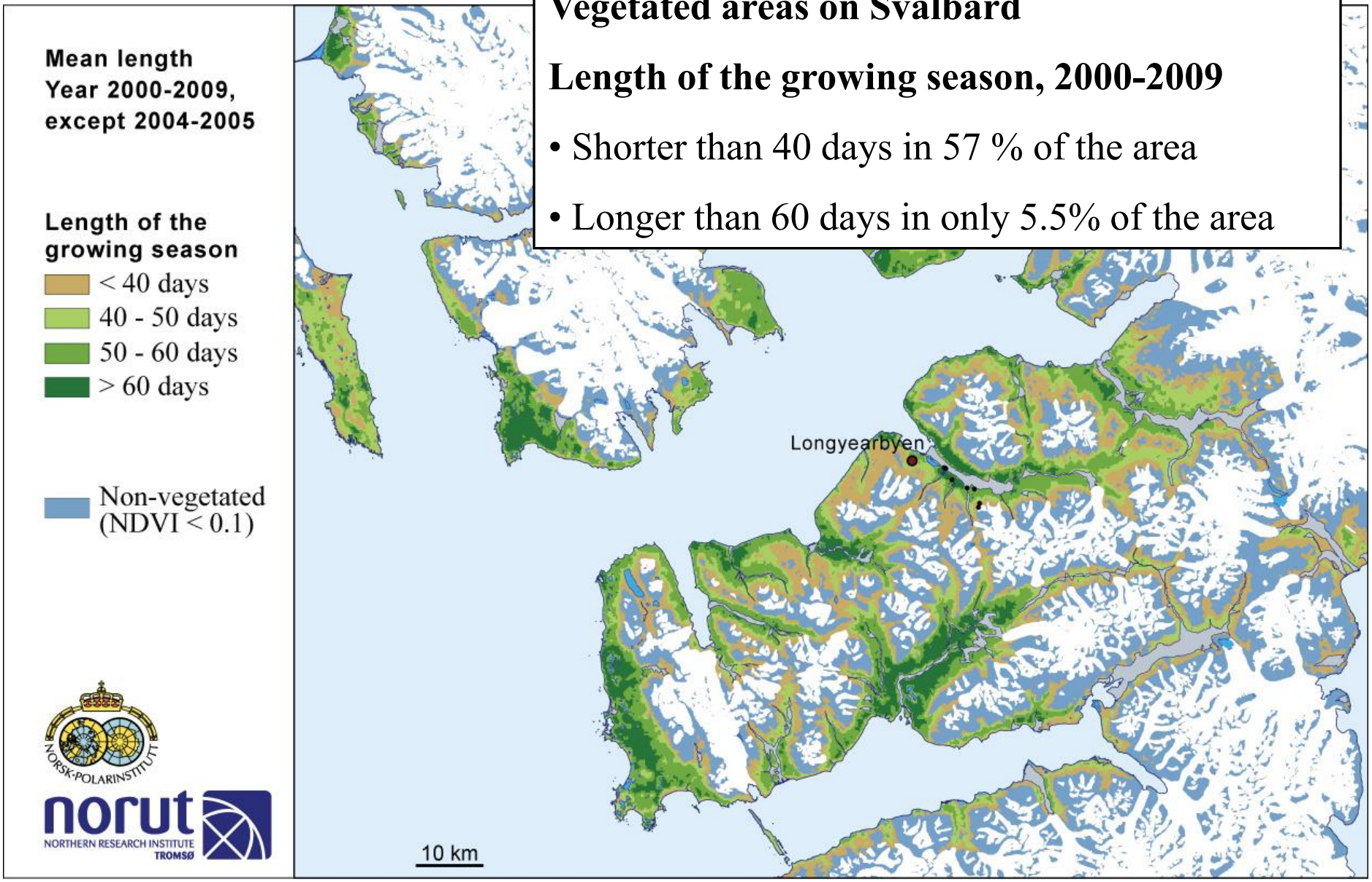

Thank you for your attention!

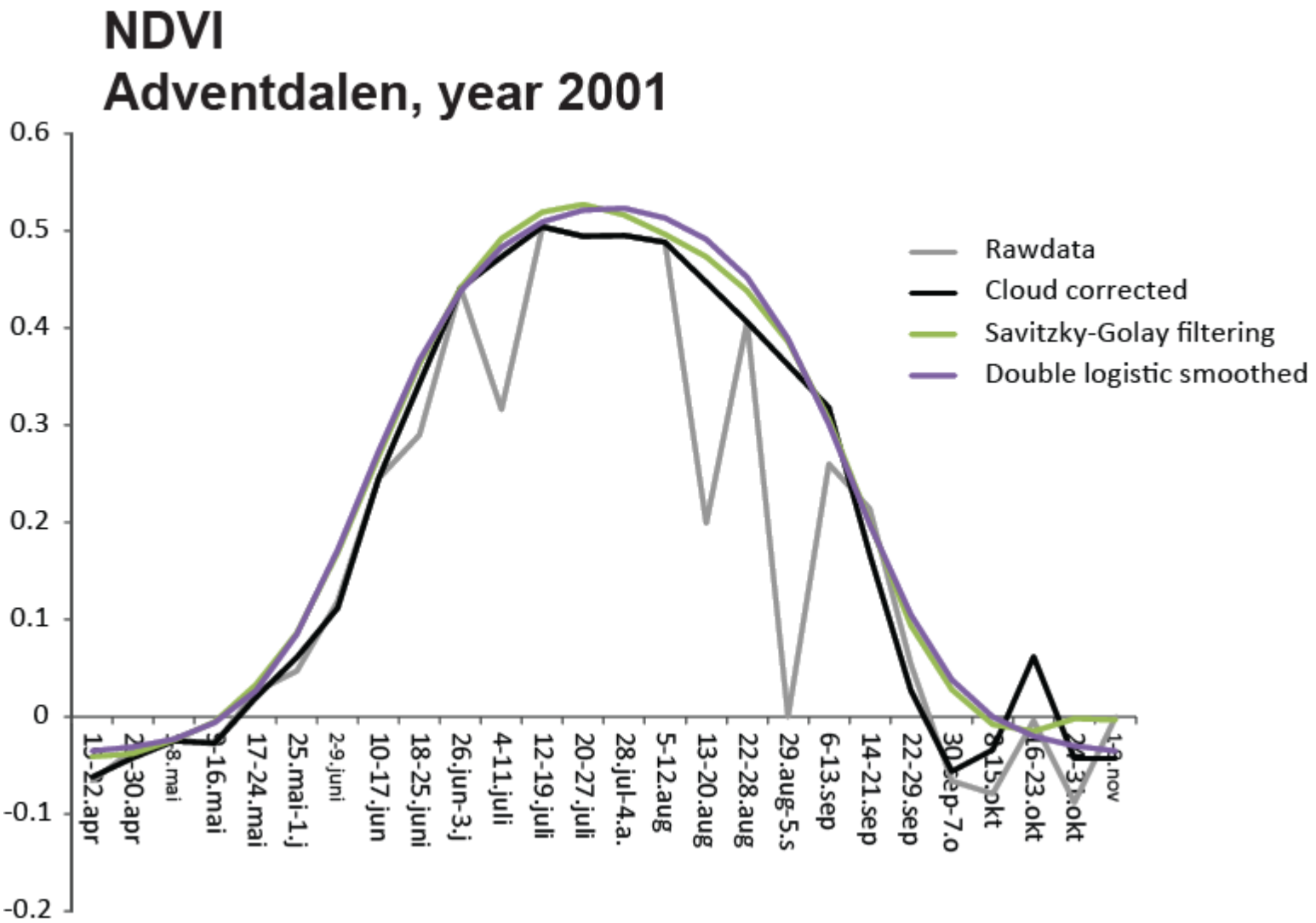

Thank you for your attention!

Vegetated areas on Svalbard

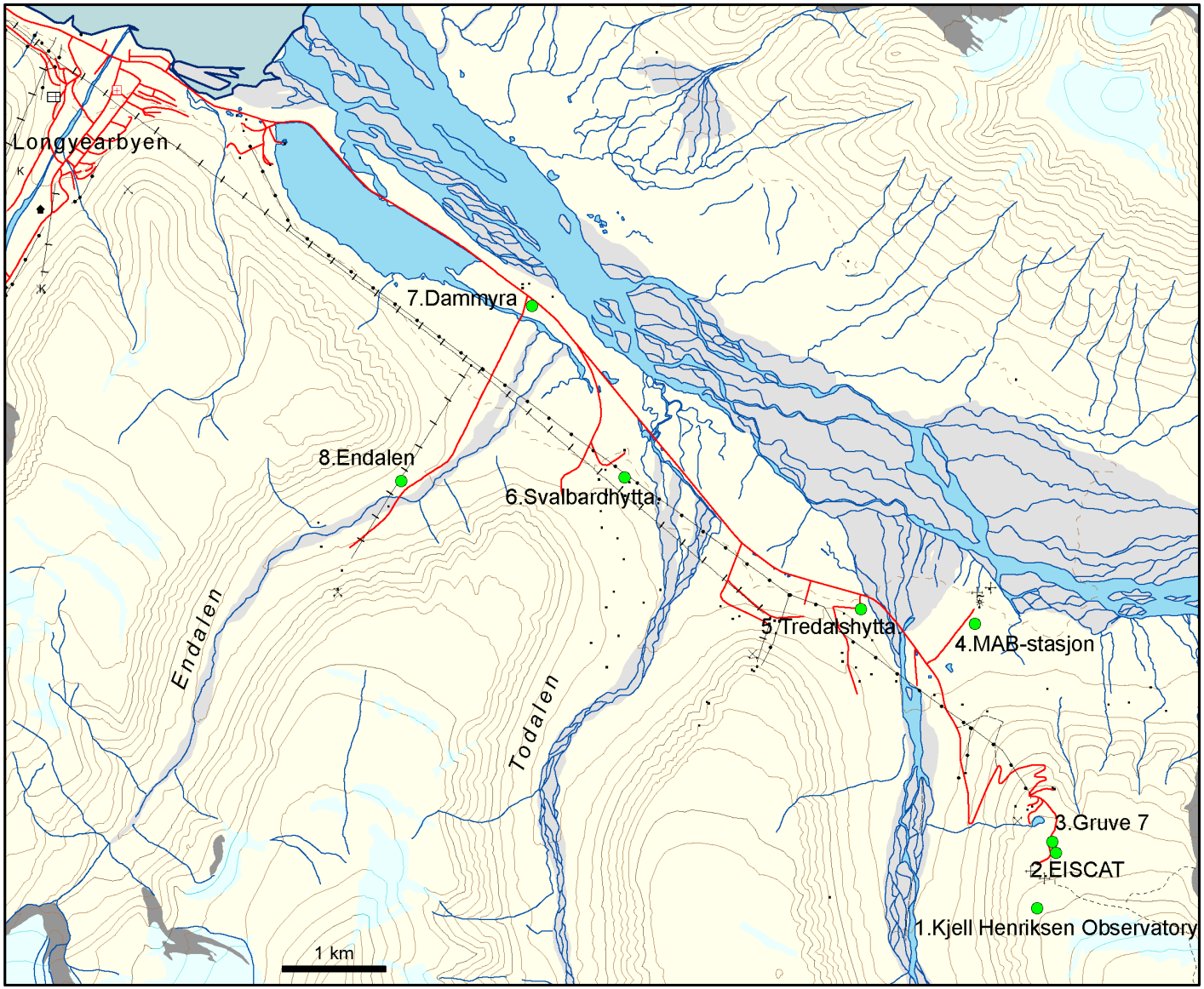
Length of the growing season, 2000-2009

- Shorter than 40 days in 57 % of the area
- Longer than 60 days in only 5.5% of the area

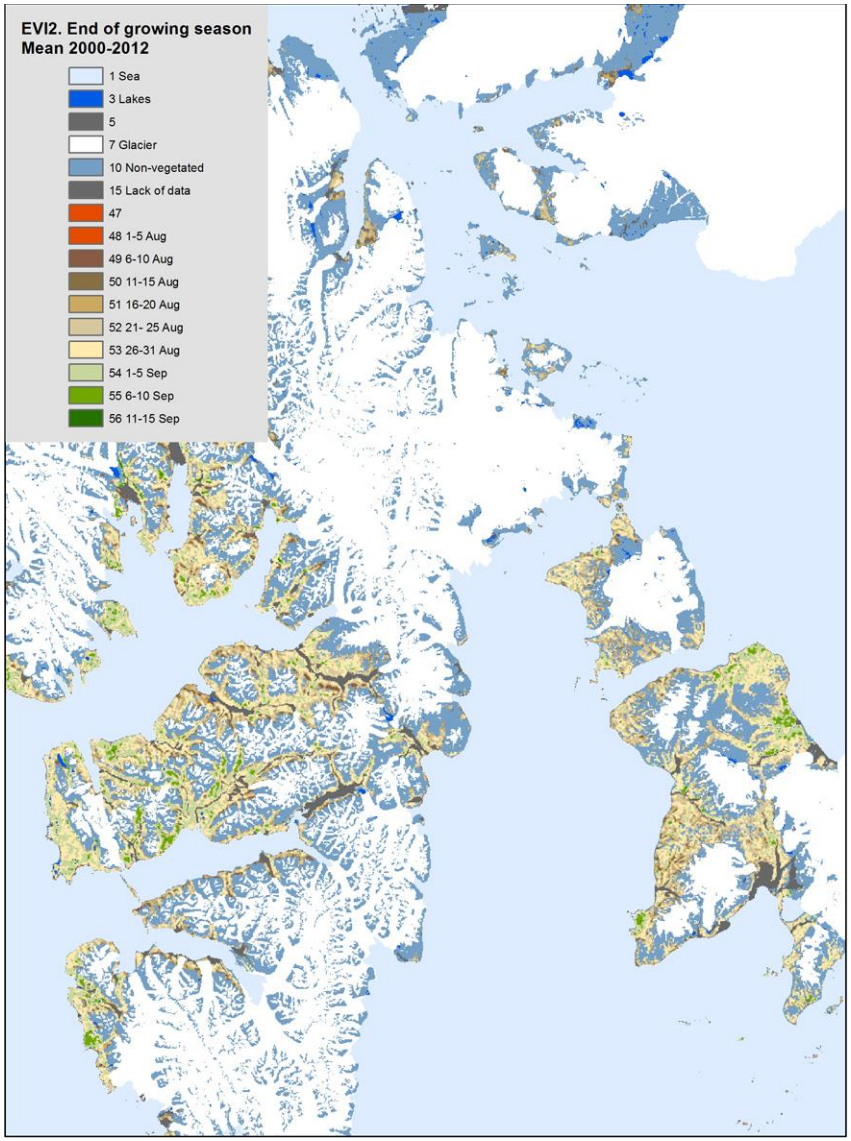


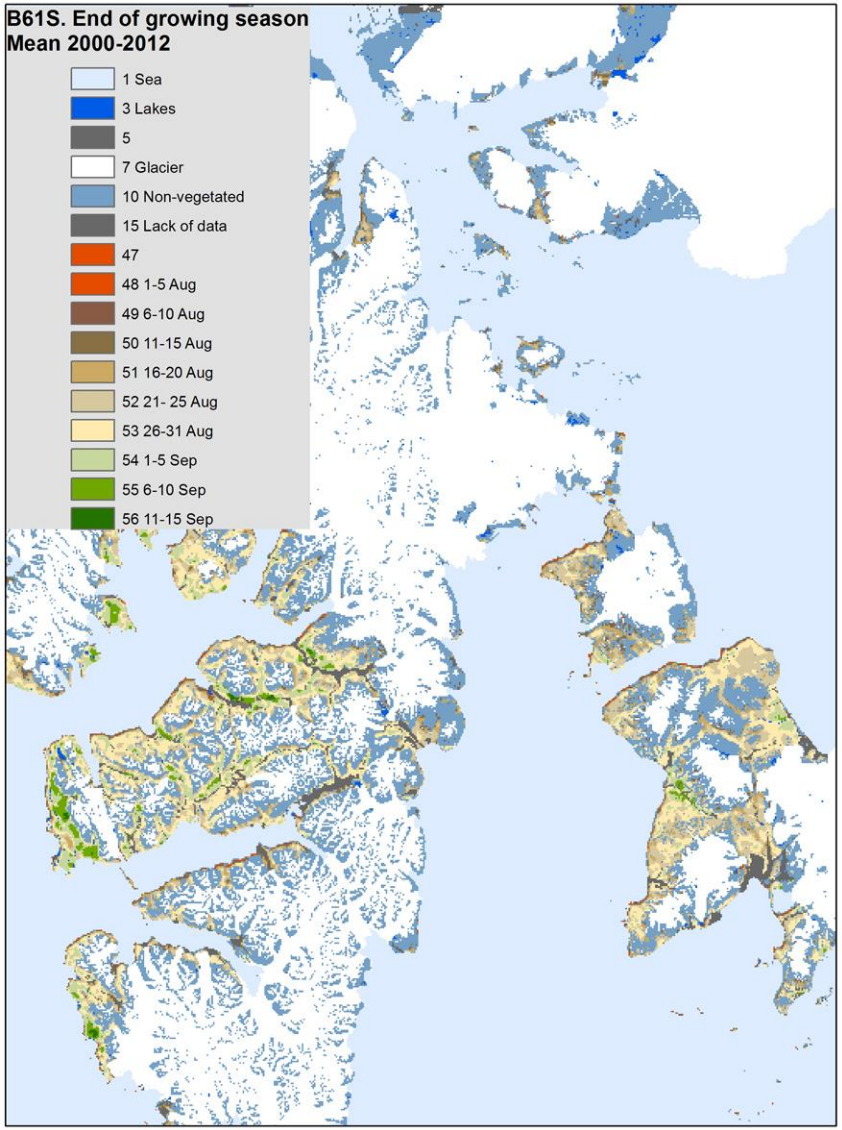

NDVI
Adventdalen, year 2001
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
Rawdata
Cloud corrected
Savitzky-Golay filtering
Double logistic smoothed
17-24.mai
25.mai-1.j
10-17.jun
18-25.juni
26.jun-3.j
4-11.juli
12-19.juli
20-27.juli
28.jul-4.a.
5-12.aug
13-20.aug
22-28.aug
6-13.sep
14-21.sep
22-29.sep
16-23.okt

Field observation of the growing season (phenology) - Adventdalen



End of the growing season, mean 2000-2012





Content

- MODIS data in mapping the growing season
- Changes in the growing season in relation to climate
- Plant biomass – NDVI relationship
- Next step, Landsat 8 and Sentinel-2