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ARKTISKE
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Delineation and characterizing of bioclimatic zones on Svalbard



Attempts to map arctic bioclimatic zones

Other Arctic bioclimate zonation approaches. Modified from CAVM Team (2003).

Russia			North America					Fennoscandia	
Alexandrova (1980)	Yurtsev (1994)	Matveyeva (1998)	Polunin (1951)	Edlund (1990) Edlund & Alt (1989)	Bliss (1997)	Daniels et al. (2000)	Walker et al. (2002)	Tuhkanen (1986)	Elvebakk (1999)
Northern polar desert	High Arctic tundra	Polar desert	High Arctic	Herbaceous and cryptogam	High Arctic	Arctic herb	Cushion forb	Inner polar	Arctic polar desert
Southern polar desert								Outer polar	
Northern Arctic tundra	Arctic tundra: northern variant	Arctic tundra	Middle Arctic	Herb-prostrate shrub transition		Northern Arctic dwarf shrub	Prostrate dwarf shrub	Northern Arctic	Northern Arctic tundra
Middle Arctic tundra	Arctic tundra: southern variant			Prostrate shrub					
Southern Arctic tundra	Northern sub-Arctic tundra	Typical tundra	Low Arctic	Low erect shrub	Low Arctic	Southern Arctic dwarf shrub	Erect dwarf shrub	Middle Arctic	Middle Arctic tundra
Middle sub-Arctic tundra	hypo-Arctic tundra								
Southern sub-Arctic tundra	Southern hypo-Arctic tundra	Southern tundra				Arctic shrub	Low shrub		Arctic shrub-tundra

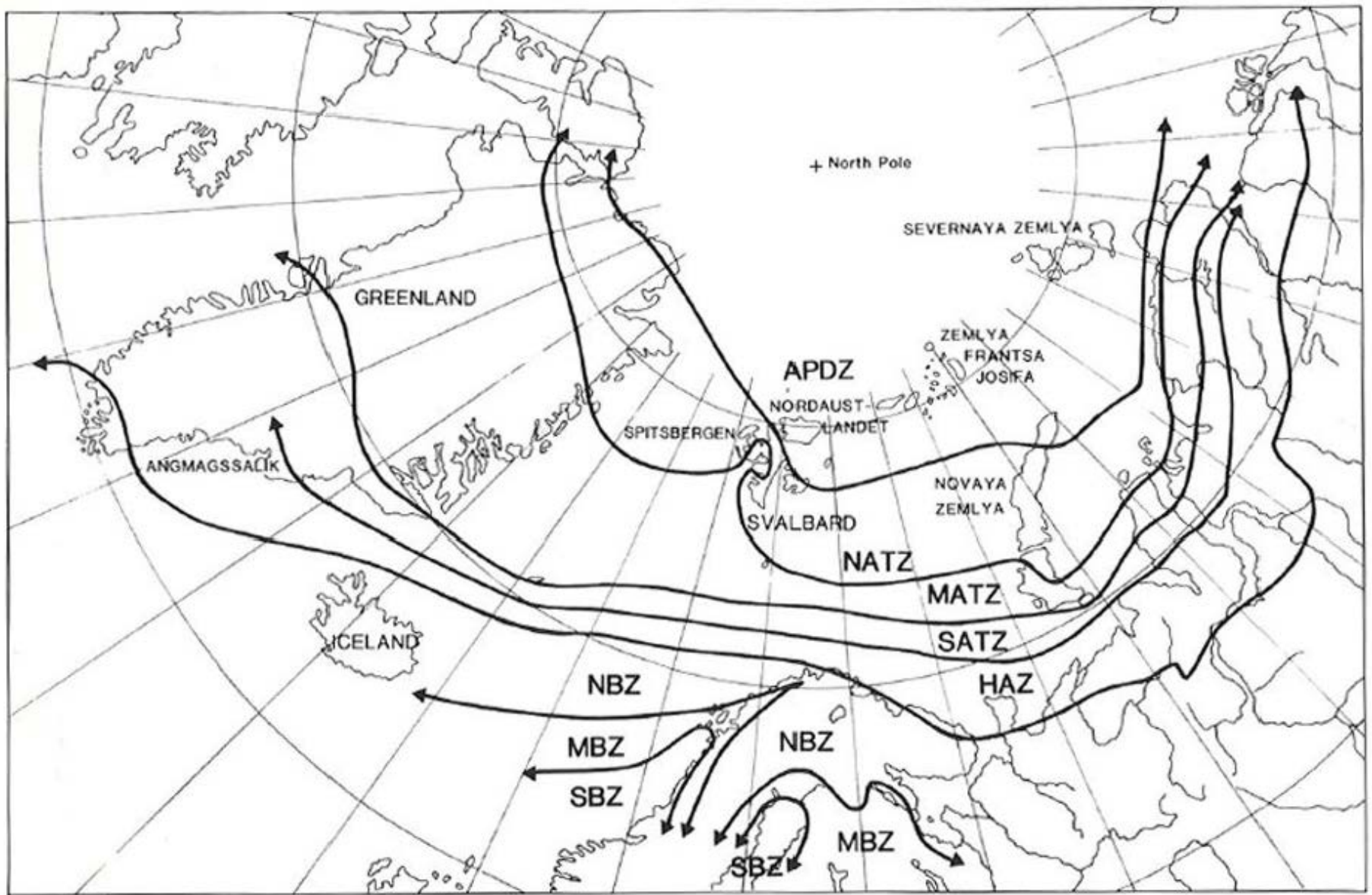
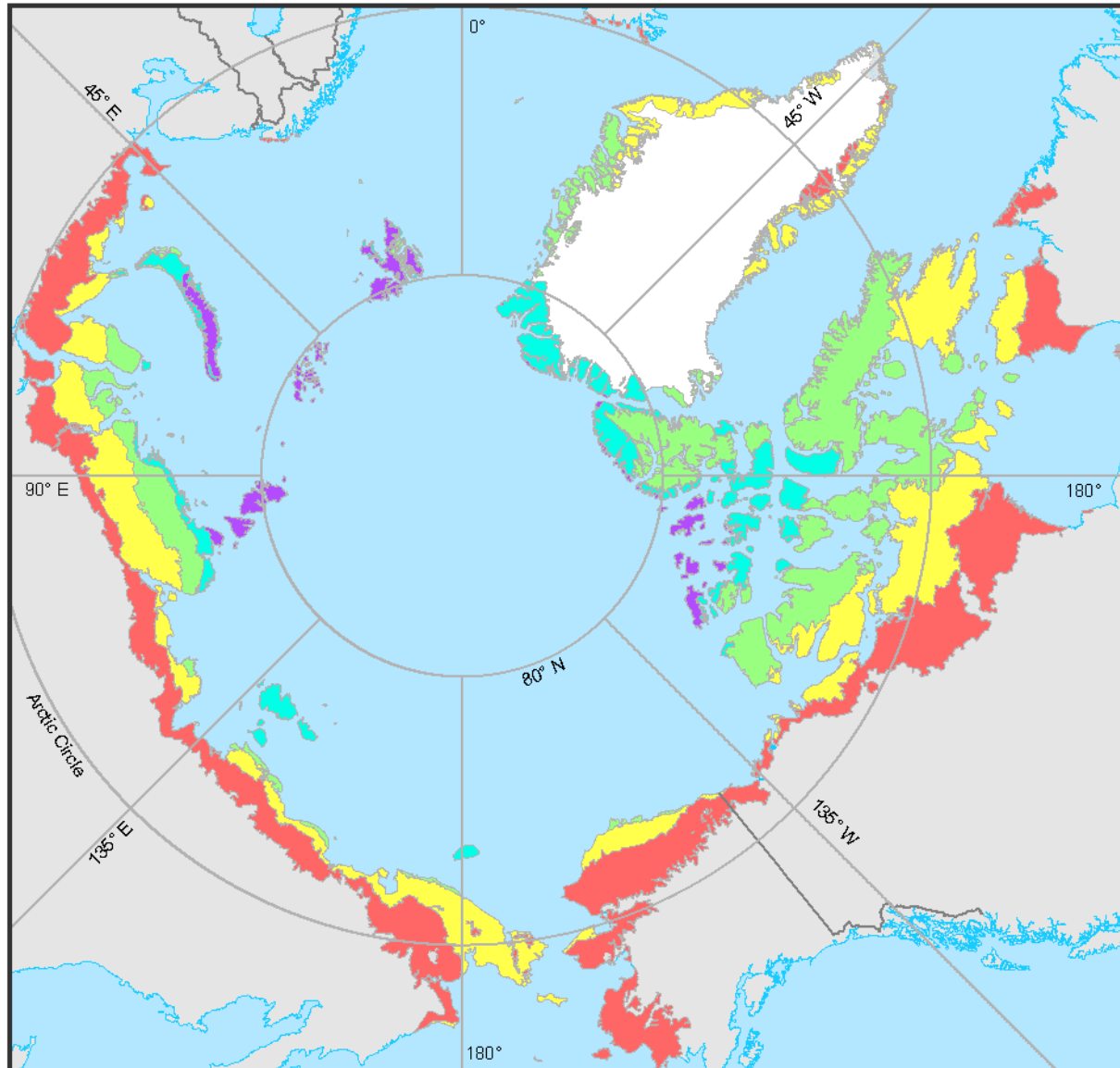


Fig. 3. Subdivision of the European Arctic and adjacent areas. APDZ = Arctic polar desert zone. NATZ = Northern arctic tundra zone. MATZ = Middle arctic tundra zone. SATZ = Southern arctic tundra zone. HAZ = Hemi-arctic zone. NBZ = Northern boreal zone. MBZ = Middle boreal zone. SBZ = Southern boreal zone. The borders drawn at sea do not represent a classification of marine areas.

Circumpolar Arctic Vegetation Mapping Project

Circumpolar Arctic Region Bioclimate Subzones



- Zone A
- Zone B
- Zone C
- Zone D
- Zone E
- Non Arctic
- Glaciers

0 250 500 750 1000
Kilometers

Lambert Azimuthal Equal Area Projection
Longitude of origin: -180°, Latitude of origin: 90°

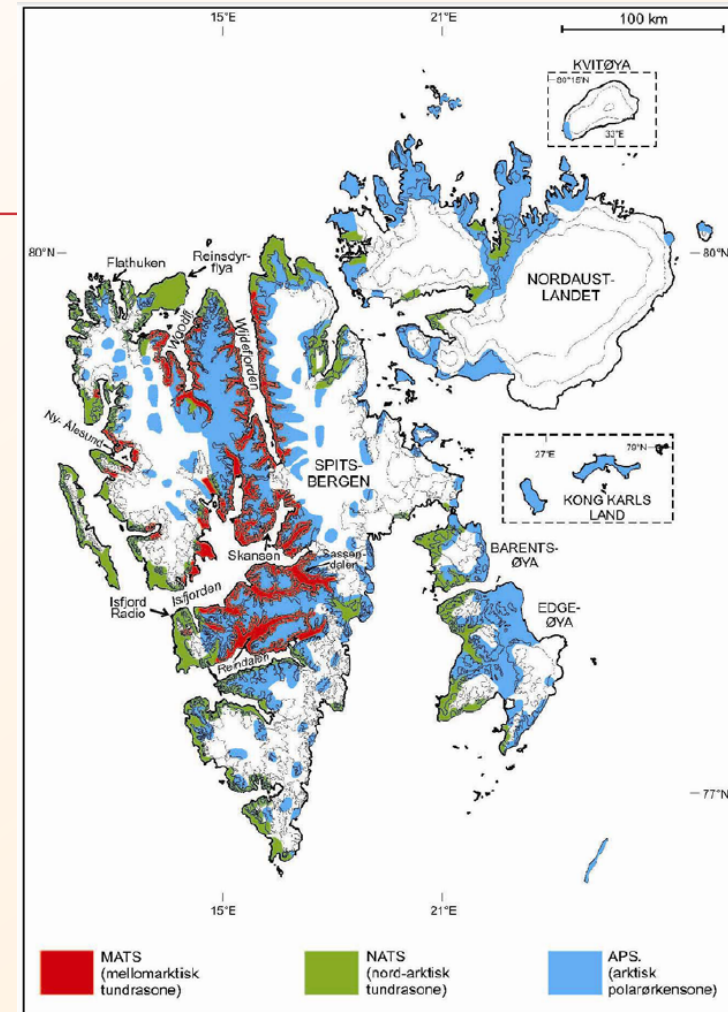
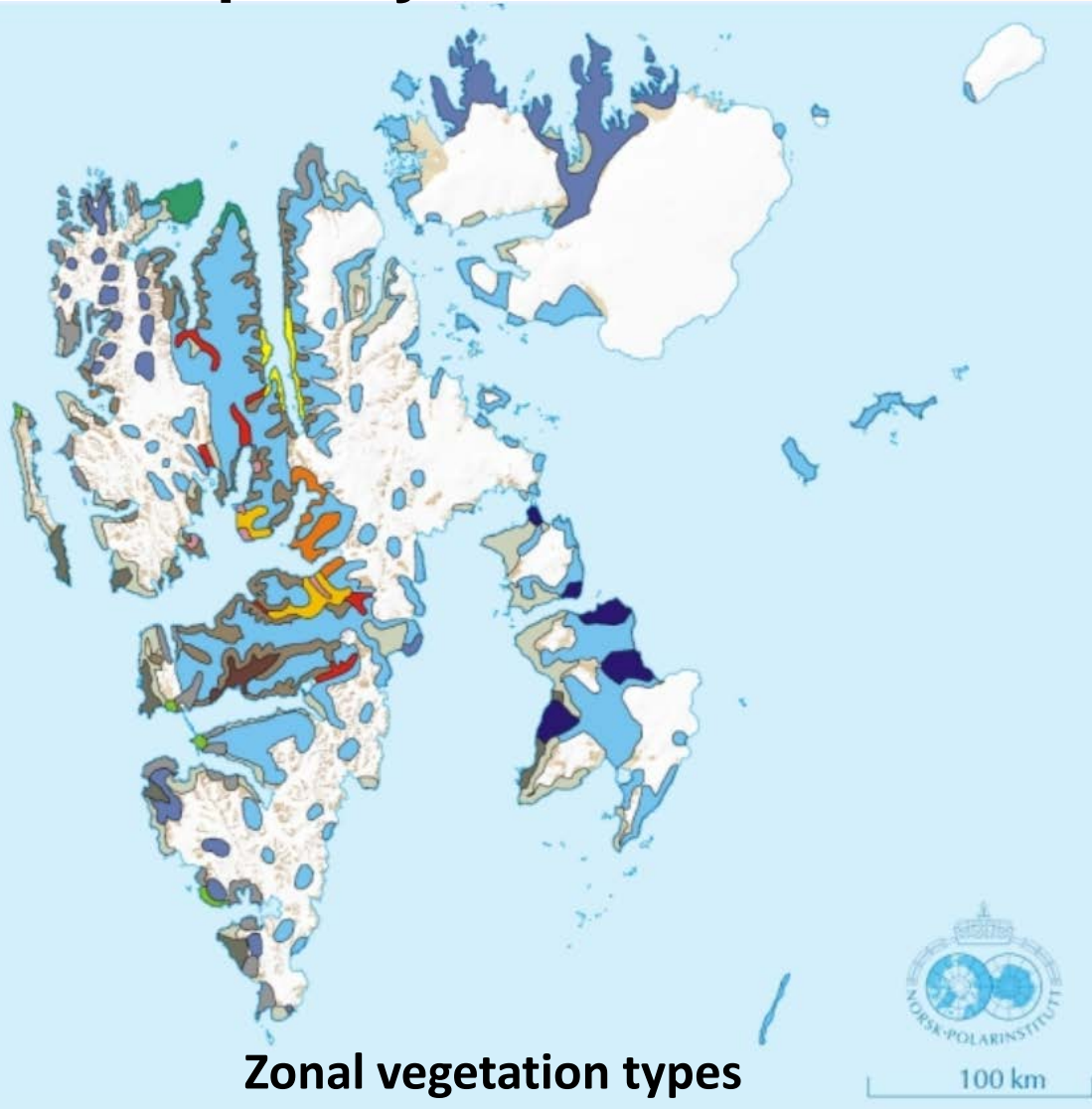
Derived from: CAVM Team. 2003. Circumpolar Arctic Vegetation Map. (1:7,500,000 scale), Conservation of Arctic Flora and Fauna (CAFF) Map No. 1. U.S. Fish and Wildlife Service, Anchorage, Alaska.

Characteristics of the bioclimatic zones according to CAVM

Table 1. Vegetation properties in each bioclimate subzone

Subzone	Mean July Temp ¹ (°C)	Summer warmth index ² (°C)	Vertical structure of plant cover ³	Horizontal structure of plant cover ³	Major plant growth forms ⁴	Dominant vegetation unit (see Detailed Vegetation Descriptions for species)	Total phyto-mass ⁵ (t ha ⁻¹)	Net annual production ⁶ (t ha ⁻¹ yr ⁻¹)	Number of vascular plant species in local floras ⁷
A	0-3	<6	Mostly barren. In favorable microsites, 1 lichen or moss layer <2 cm tall, very scattered vascular plants hardly exceeding the moss layer	<5% cover of vascular plants, up to 40% cover by mosses and lichens	<u>b</u> , <u>g</u> , <u>r</u> , <u>cf</u> , <u>of</u> , <u>ol</u> , <u>c</u>	B1, G1	<3	<0.3	<50
B	3-5	6-9	2 layers, moss layer 1-3 cm thick and herbaceous layer, 5-10 cm tall, prostrate dwarf shrubs <5 cm tall	5-25% cover of vascular plants, up to 60% cover of cryptogams	<u>npds</u> , <u>dpds</u> , <u>b</u> , <u>r</u> , <u>ns</u> , <u>cf</u> , <u>of</u> , <u>ol</u>	P1, G1	5-20	0.2-1.9	50-100
C	5-7	9-12	2 layers, moss layer 3-5 cm thick and herbaceous layer 5-10 cm tall, prostrate and hemi-prostrate dwarf shrubs <15 cm tall	5-50% cover of vascular plants, open patchy vegetation	<u>npds</u> , <u>dpds</u> , <u>b</u> , <u>ns</u> , <u>cf</u> , <u>of</u> , <u>ol</u> , <u>ehds</u> * * in acidic areas	G2, P2	10-30	1.7-2.9	75-150
D	7-9	12-20	2 layers, moss layer 5-10 cm thick and herbaceous and dwarf-shrub layer 10-40 cm tall	50-80% cover of vascular plants, interrupted closed vegetation	<u>ns</u> , <u>nb</u> , <u>npds</u> , <u>dpds</u> , <u>deds</u> , <u>neds</u> , <u>cf</u> , <u>of</u> , <u>ol</u> , <u>b</u>	G3, S1	30-60	2.7-3.9	125-250
E	9-12	20-35	2-3 layers, moss layer 5-10 cm thick, herbaceous/ dwarf-shrub layer 20-50 cm tall, sometimes with low-shrub layer to 80 cm	80-100% cover of vascular plants, closed canopy	<u>dls</u> , <u>ts</u> *, <u>ns</u> , <u>deds</u> , <u>neds</u> , <u>sb</u> , <u>nb</u> , <u>rl</u> , <u>ol</u> *in Beringia	G4, S1, S2	50-100	3.3-4.3	200 to 500

Contemporary outline of bioclimatic zones on Svalbard

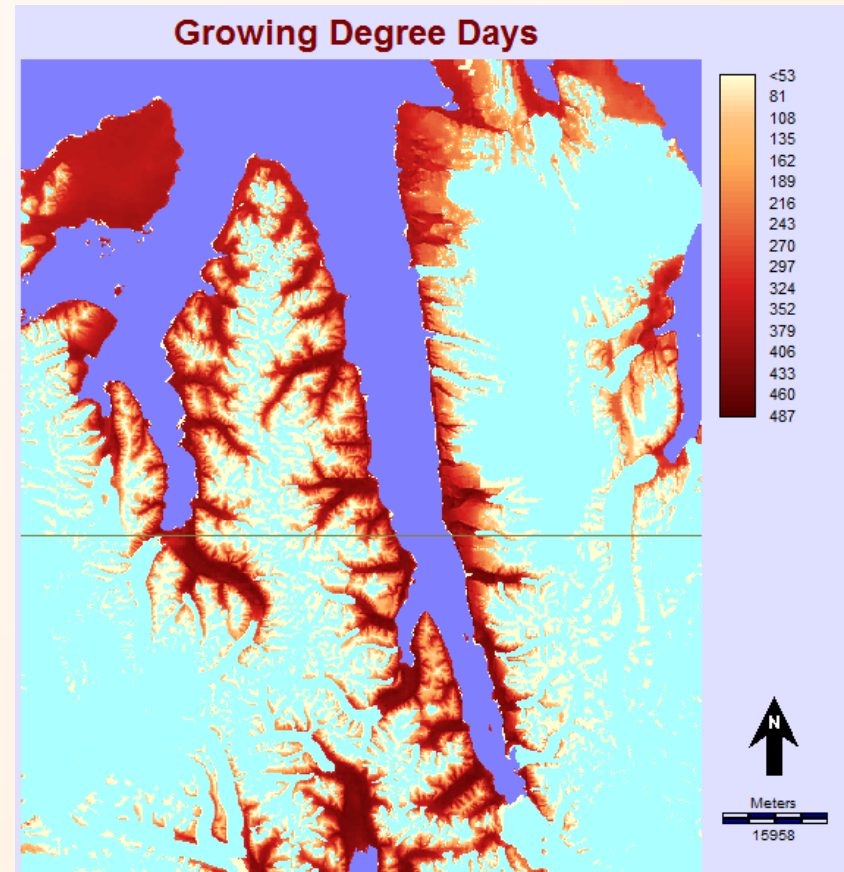
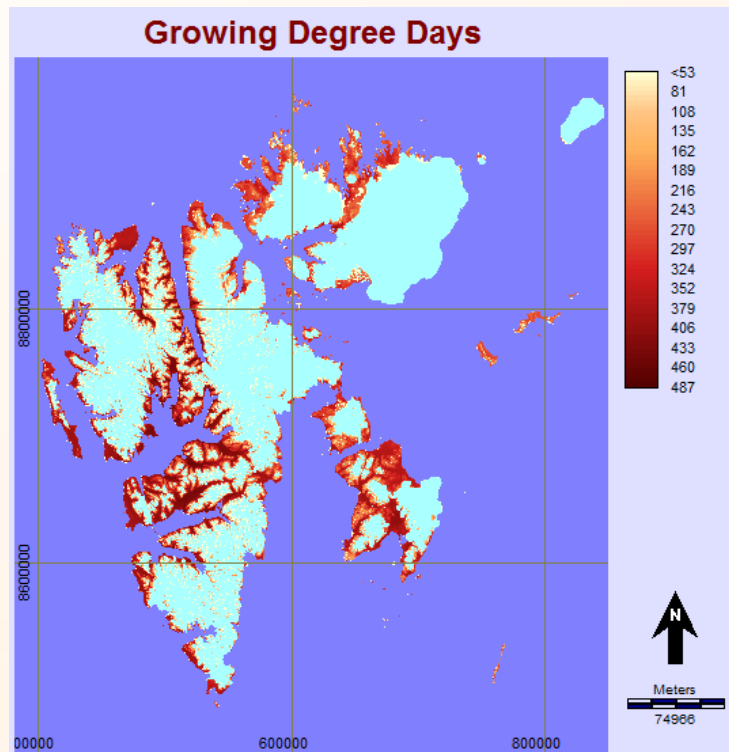


Vegetation classes

- | | | | |
|--------------------------|--------------------|------------------------|---------------------------|
| 1) Pot. pulch. steppes | 5) Unstable sedim. | 9) Mesic Luz. conf. | 13) Pap. polar des. |
| 2) Dry dryas ridges | 6) Calc. fens | 10) Poa alp. snow beds | 14) Luz. conf. polar des. |
| 3) Mesic Dryas-Tom. nit. | 7) Acidic mires | 11) Desch. alp. mires | 15) Manured polar des. |
| 4) Cass. tetr. | 8) Mesic Luz. niv. | 12) Moss tundras | |

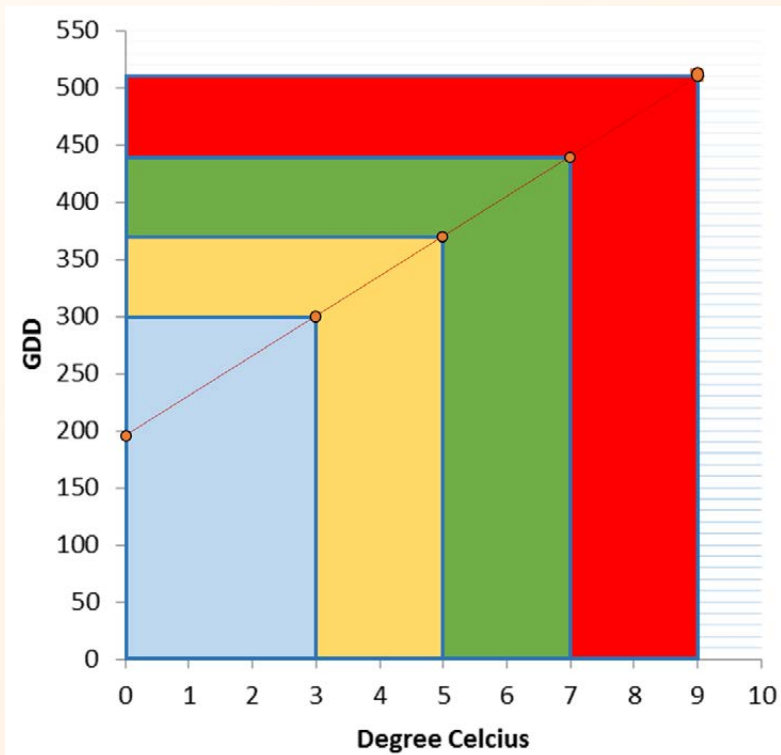
Growing Degree Days (GDD)

- Spatial modelling of contemporary thermal conditions for plant growth on an Arctic archipelago, Svalbard. (Manuscript to Biological Indicators)

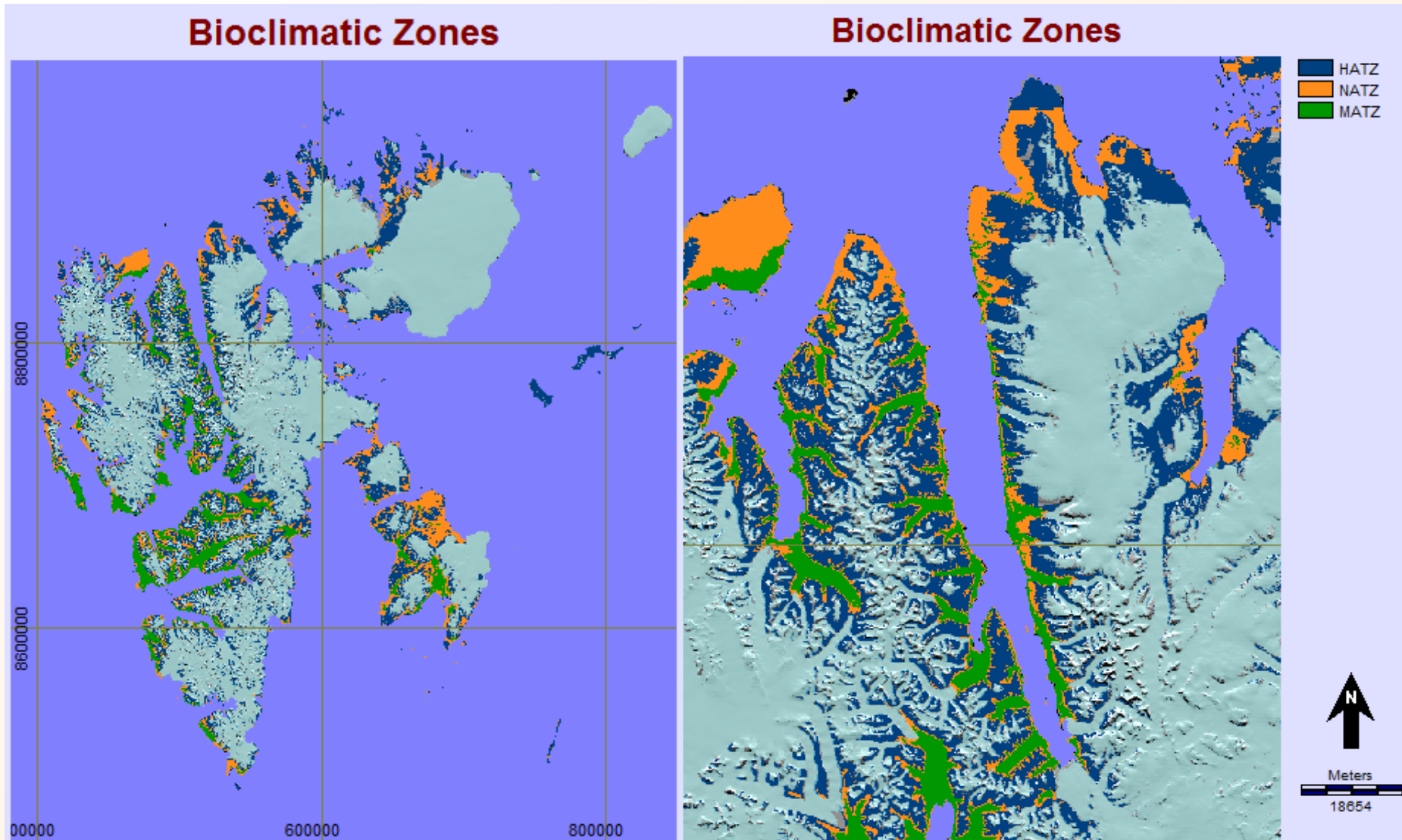


Defining the bioclimatic zones based on GDD

Bioclimatic subzones A - D		GDD	Temperature
1 2 3	A High-Arctic Tundra Zone (HATZ)	190	1
		230	2
		300	3
4 5	B Northern Arctic Tundra Zone (NATZ)	370	4
		510	5
6 8	C Middle Arctic Tundra Zone (MATZ)	440	6
		510	7
9	D Southern Arctic Tundra Zone (SATZ)	510	8
		510	9

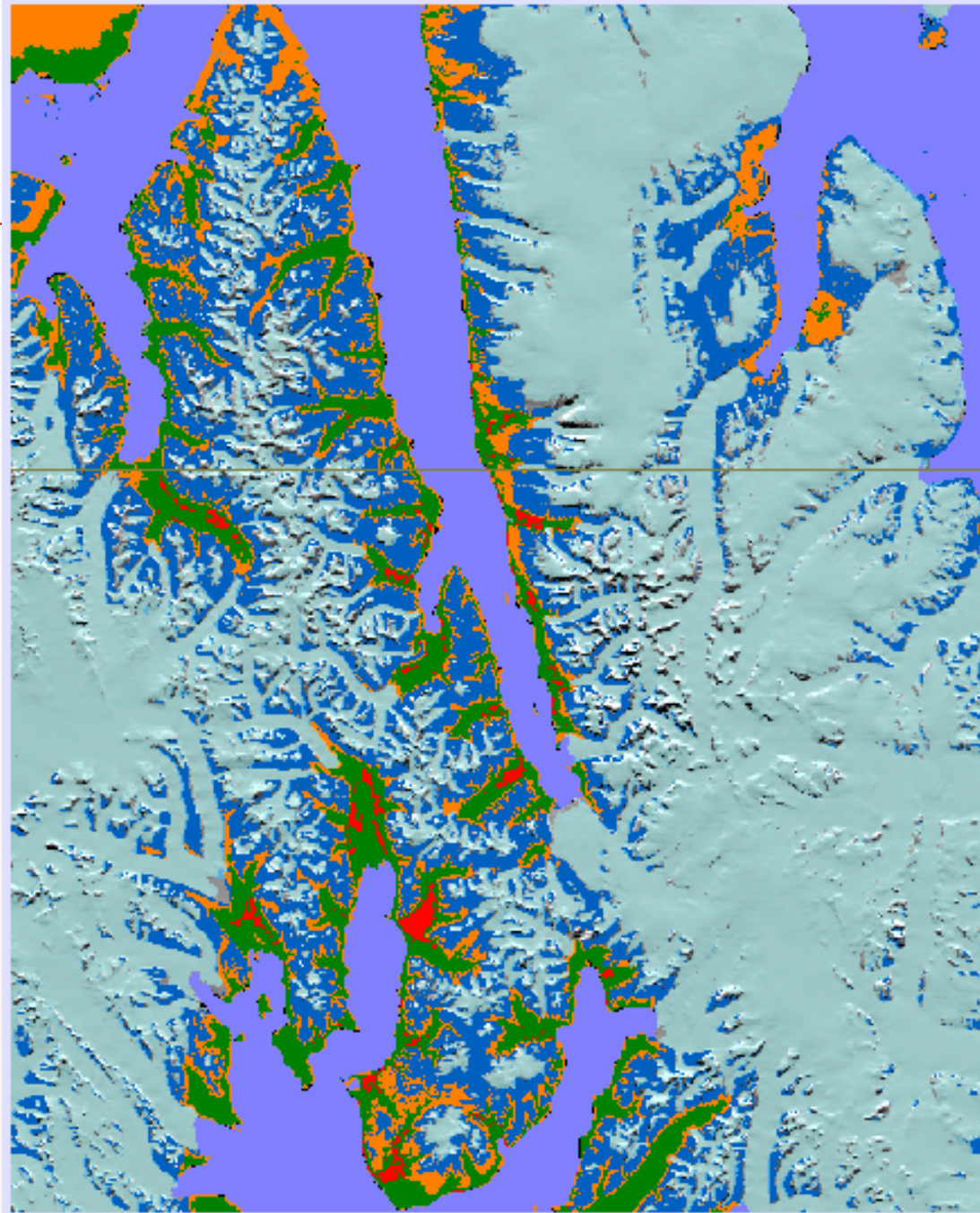


The map of traditional zones A, B and C



Bioclimatic Zones

Map of zone
A, B, C and D



- HATZ
- NATZ
- MATZ
- SATZ



Meters

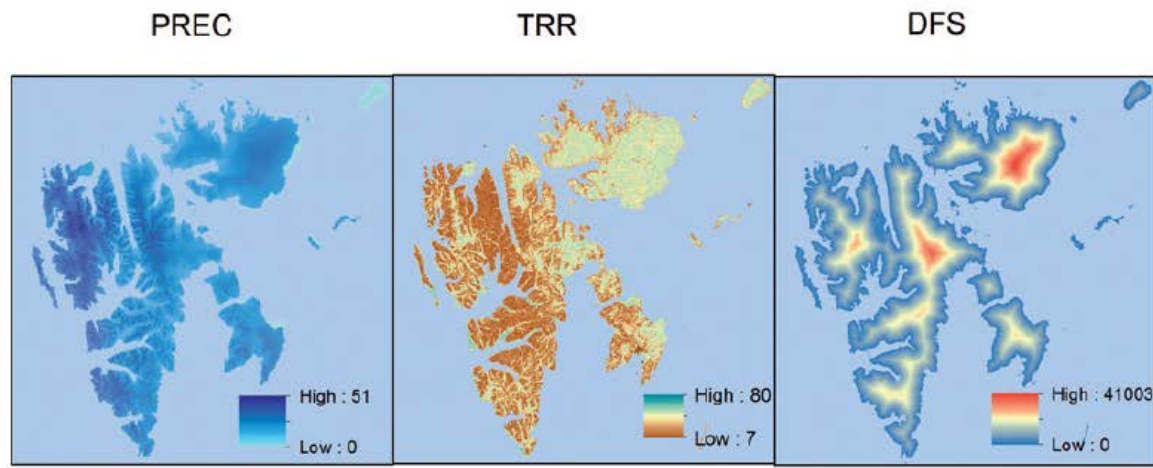
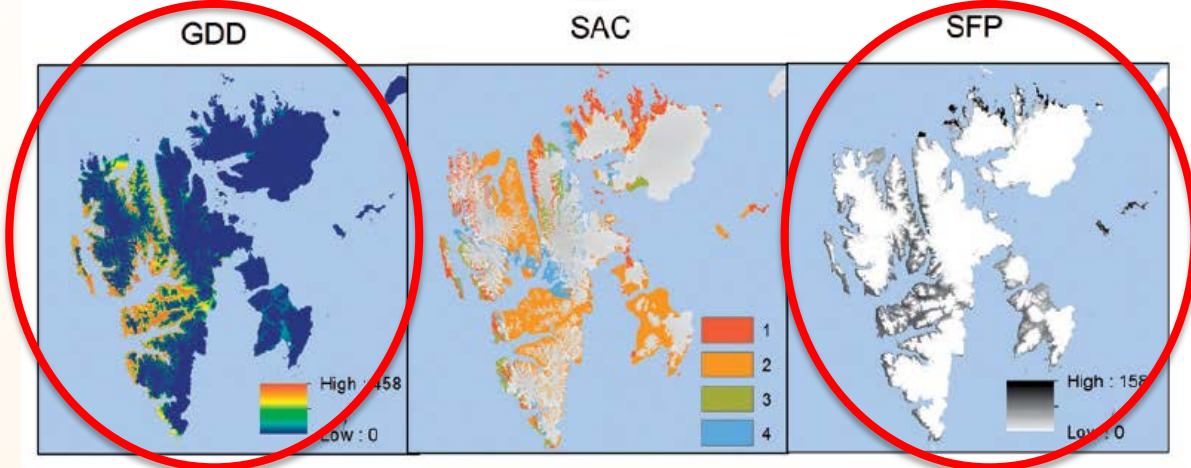
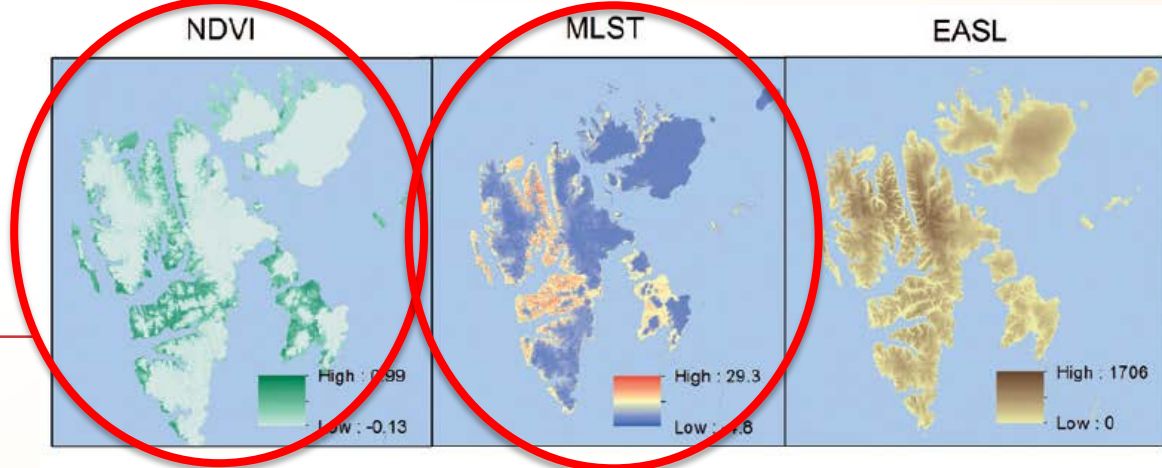


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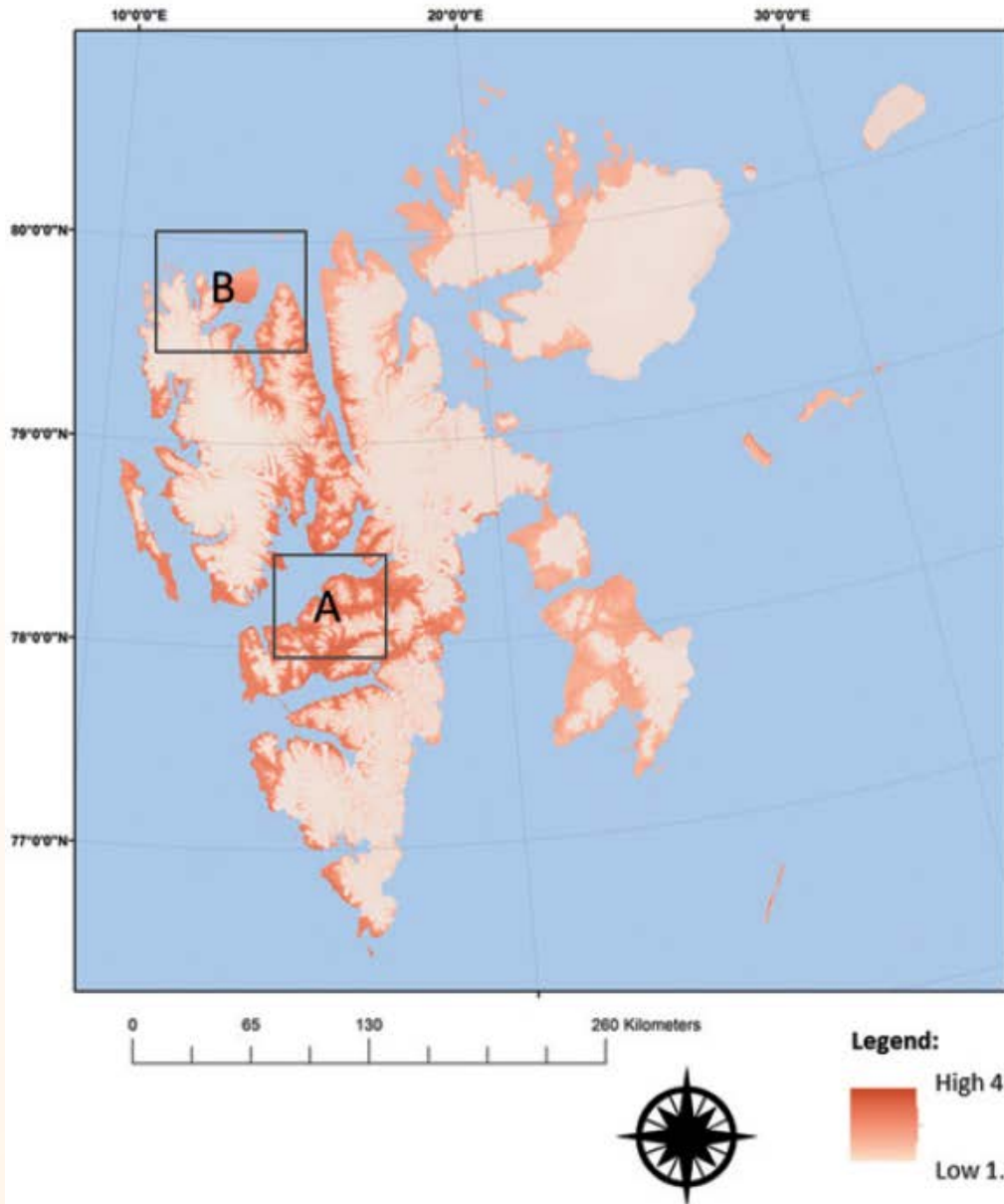
Nilsen, L., G. Arnesen, D. Joly, and E. Malnes. 2012. Spatial modelling of arctic plant diversity. *Biodiversity* 14: 67-78.

- <http://dx.doi.org/10.1080/14888386.2012.717008>

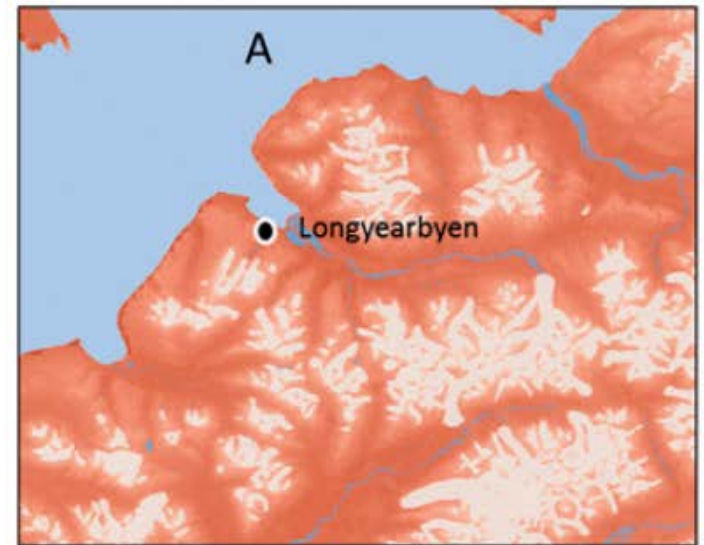
Environmental data	Derived data	Acronym	Measure	Scale	Initial pixel resolution
Digital elevation model (DEM)	Elevation above sea level	EASL	Meter	Ratio	20 m
	Aspect favourability index	AFI	Index	Interval	20 m
	Distance from glacier	DFG	Meter	Ratio	20 m
	Distance from sea	DFS	Meter	Ratio	20 m
	Topographic relative richness	TRR	Index	Interval	20 m
Terra MODIS satellite data	Normalized deviation vegetation index	NDVI	Index	Interval	250 m
	Normalized deviation wetness index	NDWI	Index	Interval	500 m
	Maximum land surface temperature	MLST	°C	Interval	1000 m
Malnes et al. 2010	Snow free period	SFP	Days	Ratio	100 m
Geology	Soil acidity classes	SAC	Class	Ordinal	100 m
	Geology relative richness	GRR	Index	Interval	100 m
Joly et al. (in prep.)	Growing degree days	GDD	°C sum	Interval	20 m
WorldClim data	Precipitation	PREC	mm	Ratio	1000 m



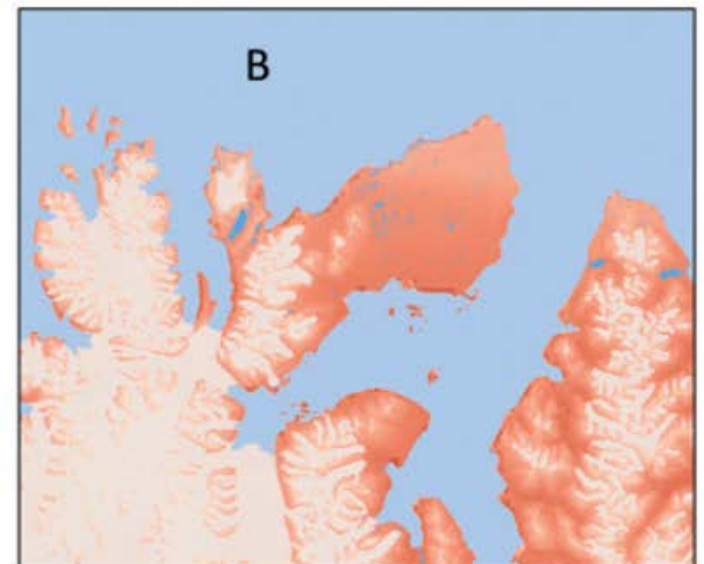
Vascular plant diversity map (SDI)



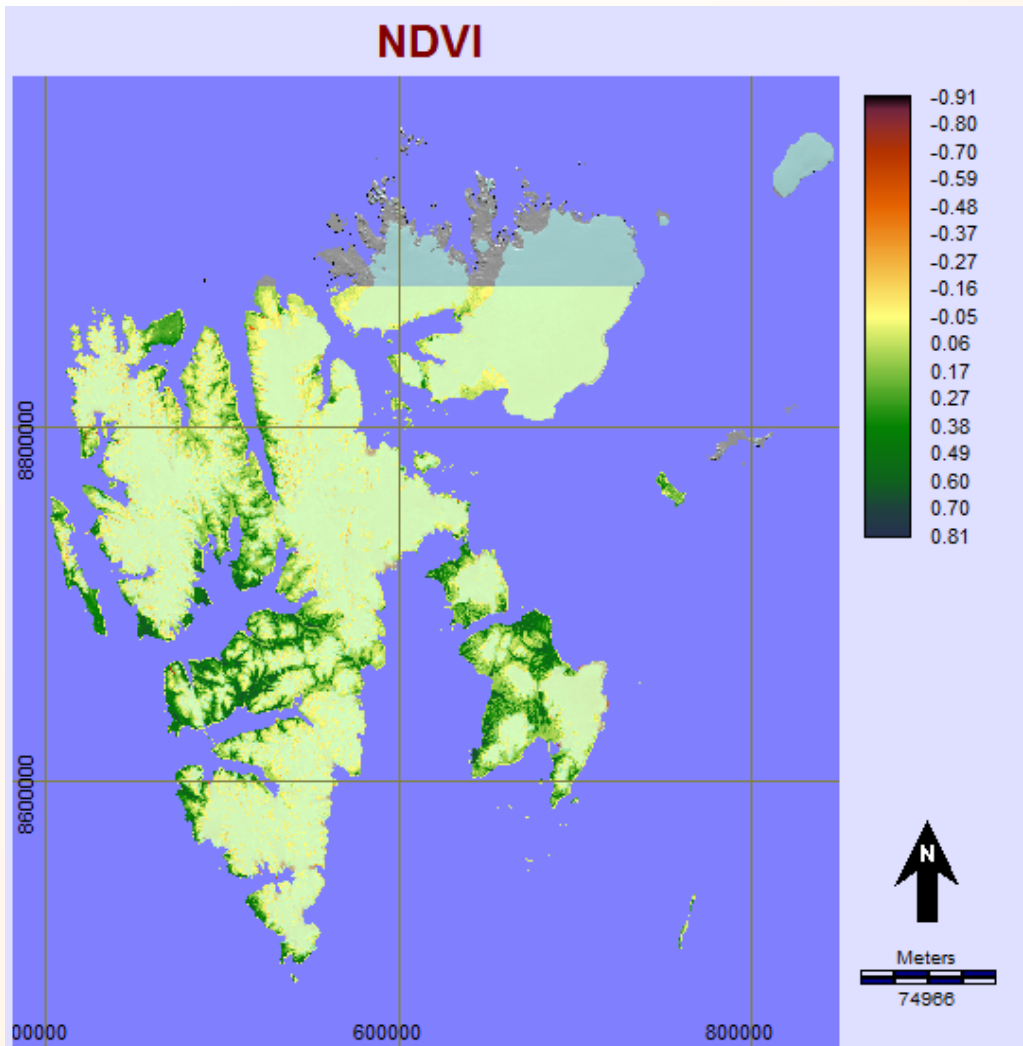
Modelled SDI for the Adventdalen area



Modelled SDI for the Reinsdyrflya area

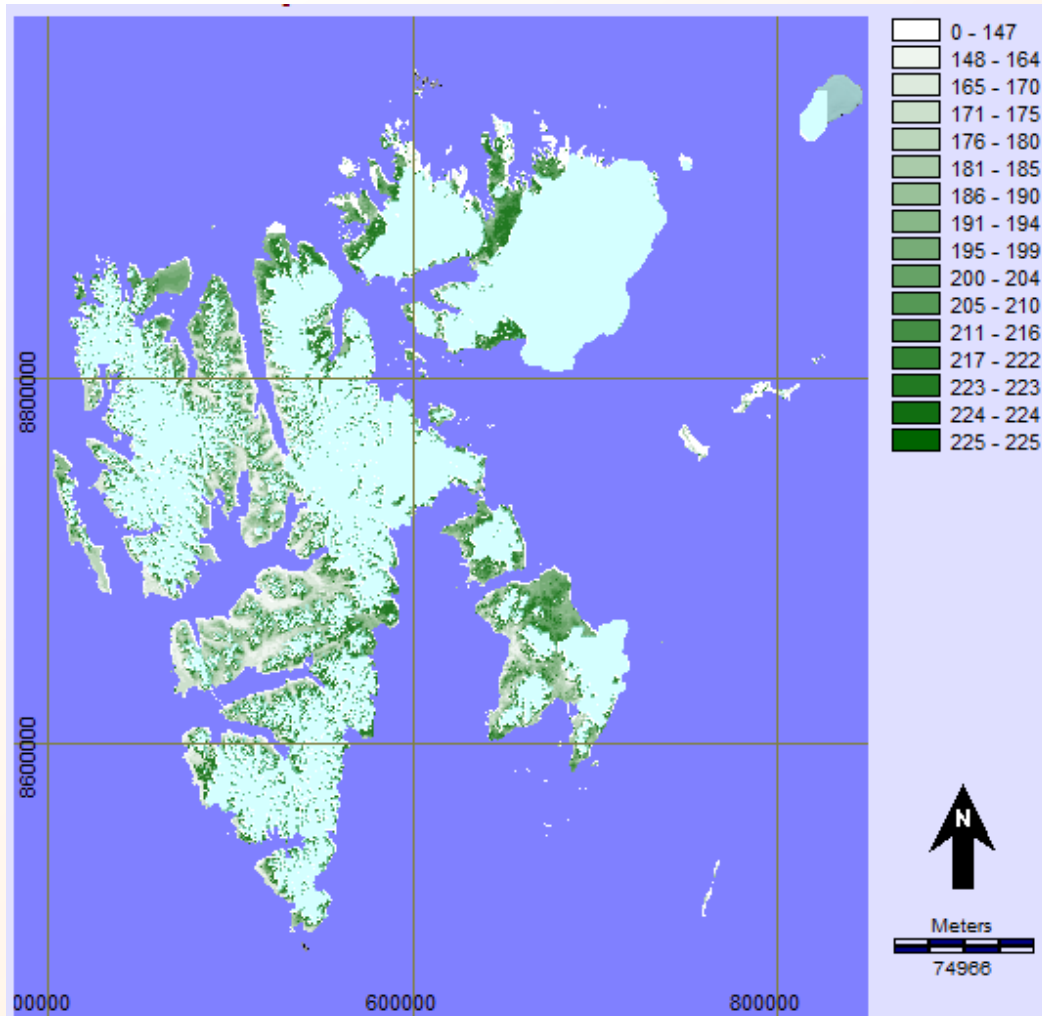


Normalized Deviation Vegetation Index



- MODIS data
 - 232 m pixel size
 - Cloud mask applied
- NDVI period 20.07 – 12.08
 - Three 8 day period
- Max average 2000 – 2014

Snowfree period March to October

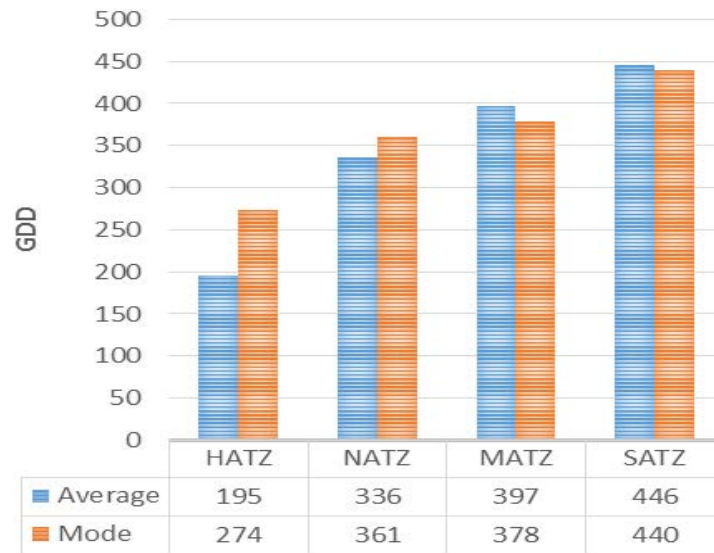
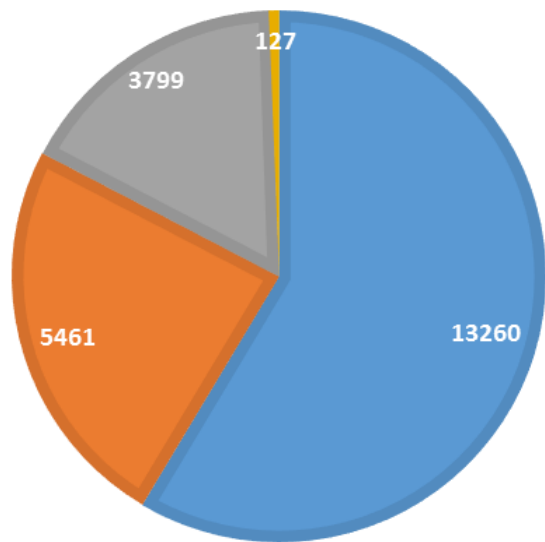


- MODIS and Envisat (ASAR)
- Snow cover fraction in each land pixel in the range 0-100%
- 10 seasons (2000-2009), March 5th to October 1th.

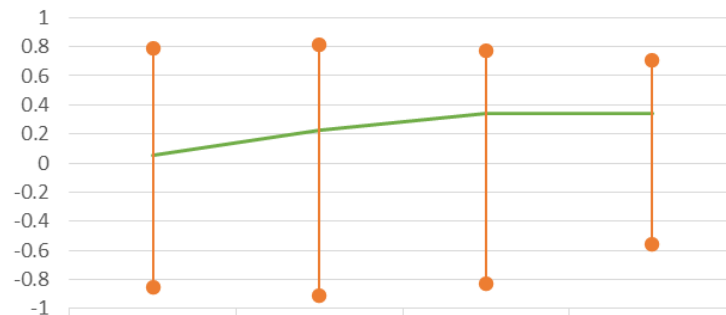
Extracting environmental information about the different bioclimatic zones

AREA (KM²)

■ HATZ ■ NATZ ■ MATZ ■ SATZ



NDVI mean



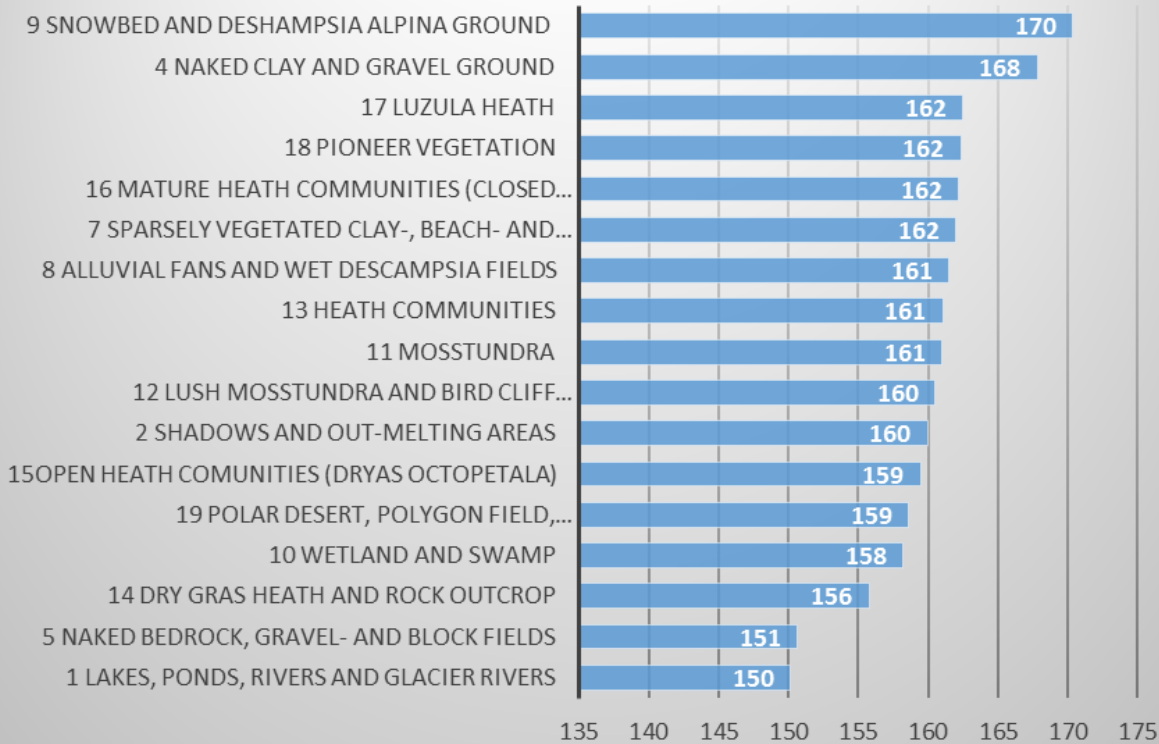
	PDTZ	NATZ	MATZ	SATZ
Minimum	-0.85	-0.91	-0.83	-0.56
Maximum	0.79	0.81	0.77	0.71
Average	0.05	0.23	0.34	0.34

BC-zones	GDD				Area km2	Precip. mm	Snowfree days	Shannon diversity index	
	Minimum	Maximum	Average	Mode				Average	Mode
HATZ	1	299	195	274	13260	28	224	2.5	2.7
NATZ	300	369	336	361	5461	27	184	2.9	2.8
MATZ	370	439	397	378	3799	27	171	3.3	2.6
SATZ	440	487	446	440	127	19	158	3.6	3.5

Johansen, B. et al. 2012. Vegetation mapping of Svalbard utilising Landsat TM/ETM+ data

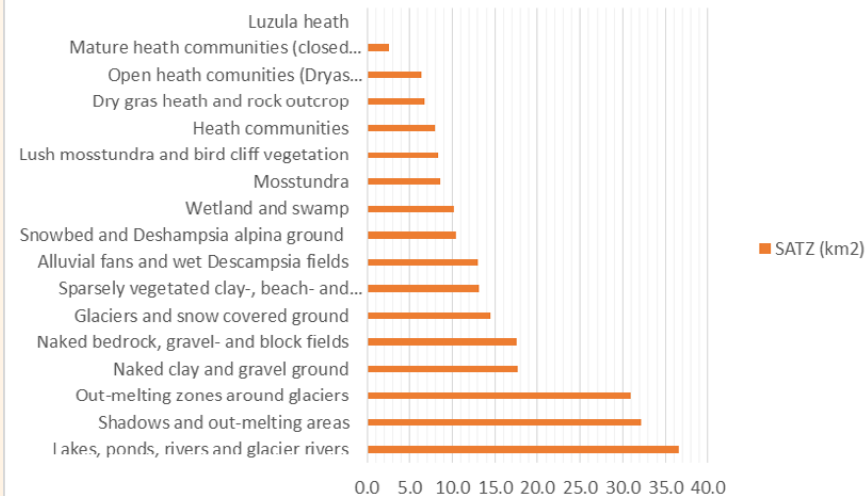
No.	Landscape types	No.	SATZ (km ²)	No.	MATZ (km ²)	No.	NATZ (km ²)	No.	HATZ (km ²)
1	Lakes, ponds, rivers and glacier rivers	7	36.6	7	830.7	7	1160.0	7	2121.4
2	Shadows and out-melting areas	17	32.1	8	433.5	19	669.5	6	1975.3
3	Out-melting zones around glaciers	13	30.9	16	428.4	5	497.3	5	1901.9
4	Naked clay and gravel ground	8	17.6	17	345.6	8	478.5	19	1518.3
5	Naked bedrock, gravel- and block fields	16	17.6	13	254.6	1	386.8	2	1442.5
6	Glaciers and snow covered ground	11	14.5	19	239.5	17	385.6	1	934.7
7	Sparsely vegetated clay-, beach- and gravel fields	4	13.1	5	207.8	16	335.4	18	712.8
8	Alluvial fans and wet <i>Deschampsia</i> fields	12	13.0	12	160.6	2	334.5	17	610.1
9	Snowbed and <i>Deschampsia alpina</i> ground	18	10.4	11	159.4	12	273.1	4	512.8
10	Wetland and swamp	19	10.2	10	148.5	18	232.8	3	473.4
11	Mosstundra	14	8.6	2	144.6	6	153.2	8	332.6
12	Lush mosstundra and bird cliff vegetation	15	8.3	1	124.4	9	132.7	16	330.2
13	Heath communities	10	8.0	14	115.1	13	104.0	12	101.1
14	Dry grass heath and rock outcrop	5	6.7	18	115.1	4	92.8	9	85.6
15	Open heath communities (<i>Dryas octopetala</i>)	2	6.3	15	89.9	14	71.9	14	76.8
16	Mature heath communities (closed vegetation)	1	2.6	4	84.9	10	59.4	13	55.1
17	<i>Luzula</i> heath	9	0.1	6	23.2	15	54.4	15	42.2
18	Pioneer vegetation			9	17.5	11	29.4	10	17.4
19	Polar desert, polygon field, solifluction soil			3	2.4	3	9.6	11	7.8

SFD (Aver.)



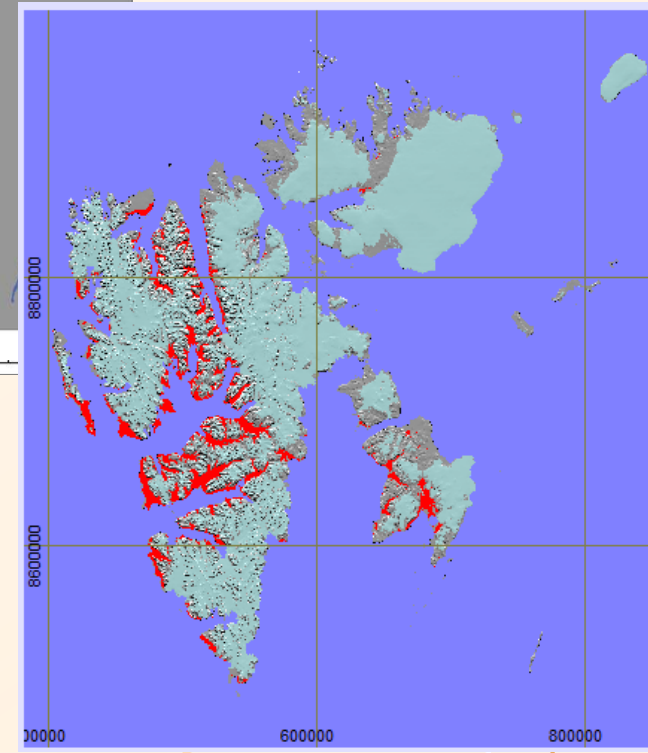
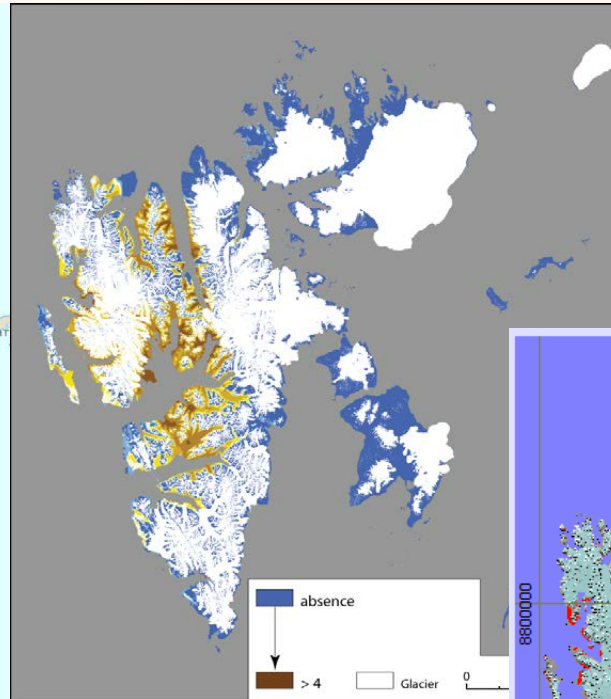
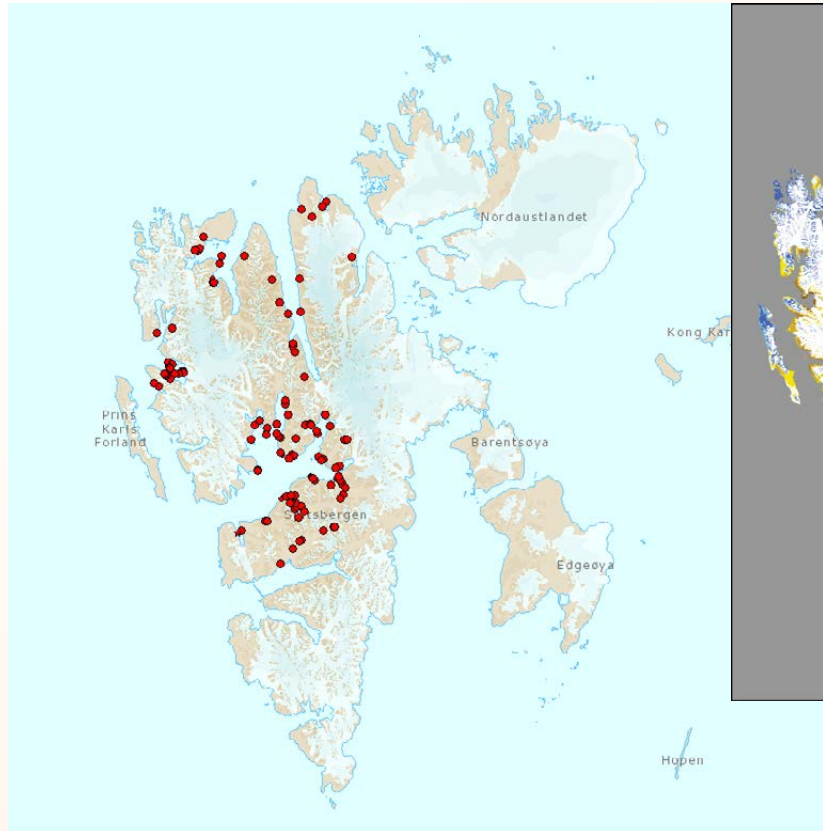
Number of snow free days of landscape types in the SATZ

Landscape class cover in the SATZ



Species distribution modeling

Cassiope tetragona



End of story.....



.....or maybe the beginning?