A landscape photograph of a tundra in Alaska. The foreground is a flat, brownish-grey tundra with sparse vegetation. In the middle ground, there is a small, winding stream. The background consists of rolling hills and mountains under a clear blue sky. The text is overlaid on the image.

Circumpolar AVHRR Surface Temperature and its Relationship Bioclimate Zones and NDVI

Martha Reynolds, Donald A. Walker,
University of Alaska Fairbanks

Overview of Presentation

Two data sets:

- Circumpolar Arctic Vegetation Map (CAVM)
- AVHRR surface temperature data



Two comparisons:

- AVHRR temperature of CAVM bioclimate subzones
 - Anomalous areas within subzones
- AVHRR temperature and AVHRR NDVI
 - Anomalous NDVI patterns
 - Comparison with CAVM attributes

Circumpolar Arctic Vegetation

(CAVM Team, 2003)

B1. Cryptogam, herb barrens
Cryptogam herb barrens with very sparse, low-growing plants such as mosses, lichens, and liverworts. Average 1 and 2 cover 7% higher elevations.

B2. Cryptogam barrens complex (bedrock)
Complex of cryptogam herb barrens interspersed with lichen and moss vegetation, as found on the Canadian Shield. Average 1 and 2 cover 10%.

B3. Nonvascular cryptogam herbaceous vegetation in mountainous tundra
The sparse and low-growing plants, mosses with vascular and herbaceous. Standing water and cold reduce the biomass volume of the vegetation. Average 1 and 2 cover 10% in higher elevations.

B4. Carboniferous cryptogam herbaceous vegetation in mountainous tundra
The sparse and low-growing plants, mosses with vascular and herbaceous. Standing water and cold reduce the biomass volume of the vegetation. Average 1 and 2 cover 10% in higher elevations.

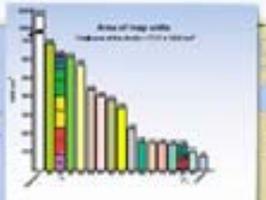
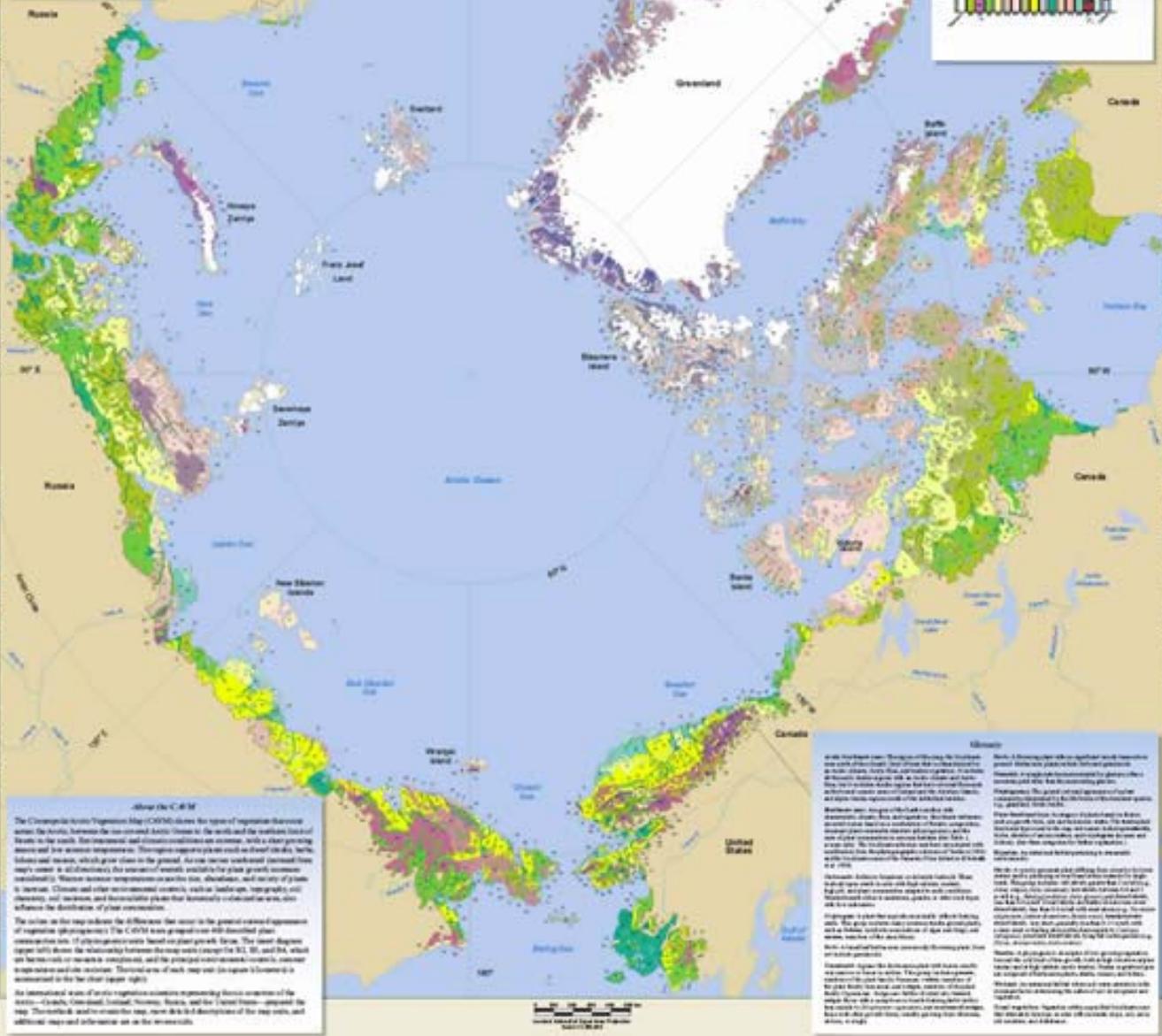
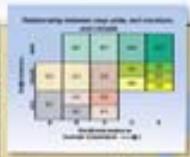
G1. Moss/graminoid, herb cryptogam tundra
Moss/graminoid tundra with moderate to complex cover of very low-growing plants. Mosses, lichens, liverworts, and liverworts. Average 1 and 2 cover 10%.

G2. Graminoid, prostrate dwarf shrub, herb tundra
Tundra with moderate to complex cover of prostrate plants, mosses, lichens, liverworts, and liverworts. Average 1 and 2 cover 10%.

G3. Nonvascular cryptogam, dwarf shrub, herb tundra
Tundra with moderate to complex cover of prostrate plants, mosses, lichens, liverworts, and liverworts. Average 1 and 2 cover 10%.

G4. Tundra with dwarf shrub, moss tundra
Tundra with moderate to complex cover of prostrate plants, mosses, lichens, liverworts, and liverworts. Average 1 and 2 cover 10%.

Wetlands
Wetlands with moderate to complex cover of prostrate plants, mosses, lichens, liverworts, and liverworts. Average 1 and 2 cover 10%.



P1. Prostrate dwarf shrub, herb tundra
Prostrate dwarf shrub tundra with moderate to complex cover of prostrate plants, mosses, lichens, liverworts, and liverworts. Average 1 and 2 cover 10%.

P2. Prostrate/Herbaceous dwarf shrub tundra
Prostrate/Herbaceous dwarf shrub tundra with moderate to complex cover of prostrate plants, mosses, lichens, liverworts, and liverworts. Average 1 and 2 cover 10%.

E1. Erect dwarf shrub tundra
Erect dwarf shrub tundra with moderate to complex cover of prostrate plants, mosses, lichens, liverworts, and liverworts. Average 1 and 2 cover 10%.

E2. Low shrub tundra
Low shrub tundra with moderate to complex cover of prostrate plants, mosses, lichens, liverworts, and liverworts. Average 1 and 2 cover 10%.

W1. Sedge/graminoid, moss tundra
Sedge/graminoid, moss tundra with moderate to complex cover of prostrate plants, mosses, lichens, liverworts, and liverworts. Average 1 and 2 cover 10%.

W2. Sedge, moss, dwarf shrub wetland
Sedge, moss, dwarf shrub wetland with moderate to complex cover of prostrate plants, mosses, lichens, liverworts, and liverworts. Average 1 and 2 cover 10%.

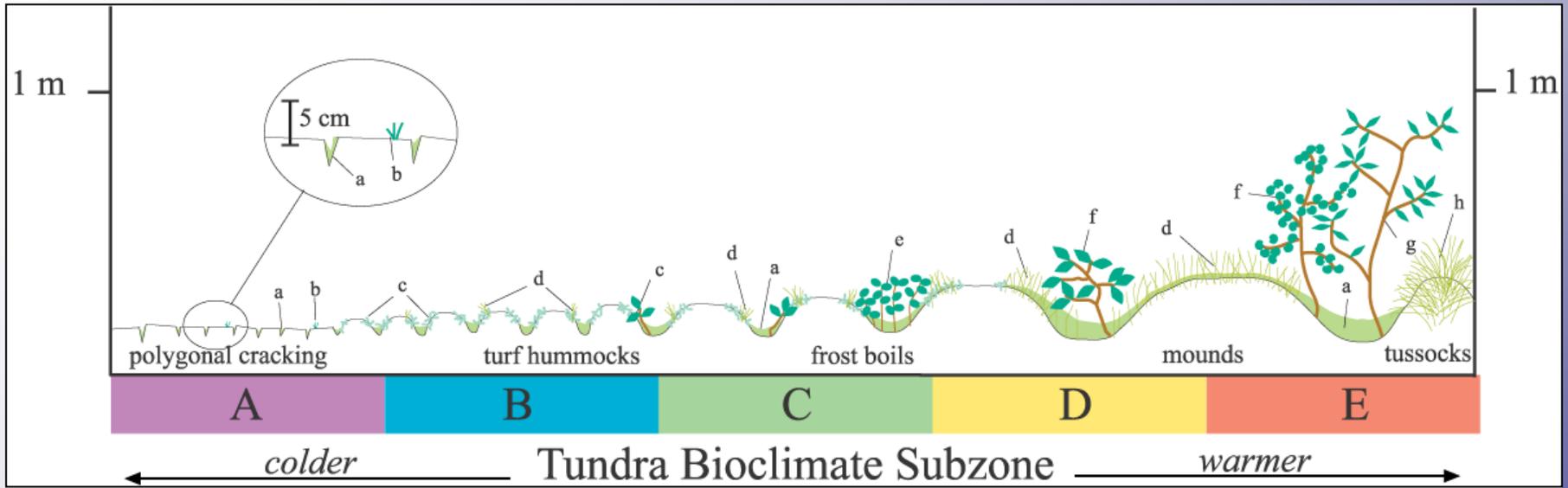
W3. Sedge, moss, sedge shrub wetland
Sedge, moss, sedge shrub wetland with moderate to complex cover of prostrate plants, mosses, lichens, liverworts, and liverworts. Average 1 and 2 cover 10%.

About the CAVM
The Circumpolar Arctic Vegetation Map (CAVM) shows the types of vegetation that occur across the Arctic, between the ice-covered Arctic Ocean to the north and the southern limit of tundra to the south. The map is based on a synthesis of data from a wide range of sources, including field observations, satellite data, and climate data. The map is a synthesis of data from a wide range of sources, including field observations, satellite data, and climate data. The map is a synthesis of data from a wide range of sources, including field observations, satellite data, and climate data.

Map Legend
The map shows the distribution of 14 vegetation types across the Arctic region. The types are color-coded and labeled as follows: B1, B2, B3, B4, G1, G2, G3, G4, P1, P2, E1, E2, W1, W2, W3. The map also shows the distribution of 14 vegetation types across the Arctic region. The types are color-coded and labeled as follows: B1, B2, B3, B4, G1, G2, G3, G4, P1, P2, E1, E2, W1, W2, W3.

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Circumpolar Arctic Vegetation Map
Circumpolar Arctic Vegetation Map (CAVM) showing the distribution of 14 vegetation types across the Arctic region. The map is a synthesis of data from a wide range of sources, including field observations, satellite data, and climate data. The map is a synthesis of data from a wide range of sources, including field observations, satellite data, and climate data.



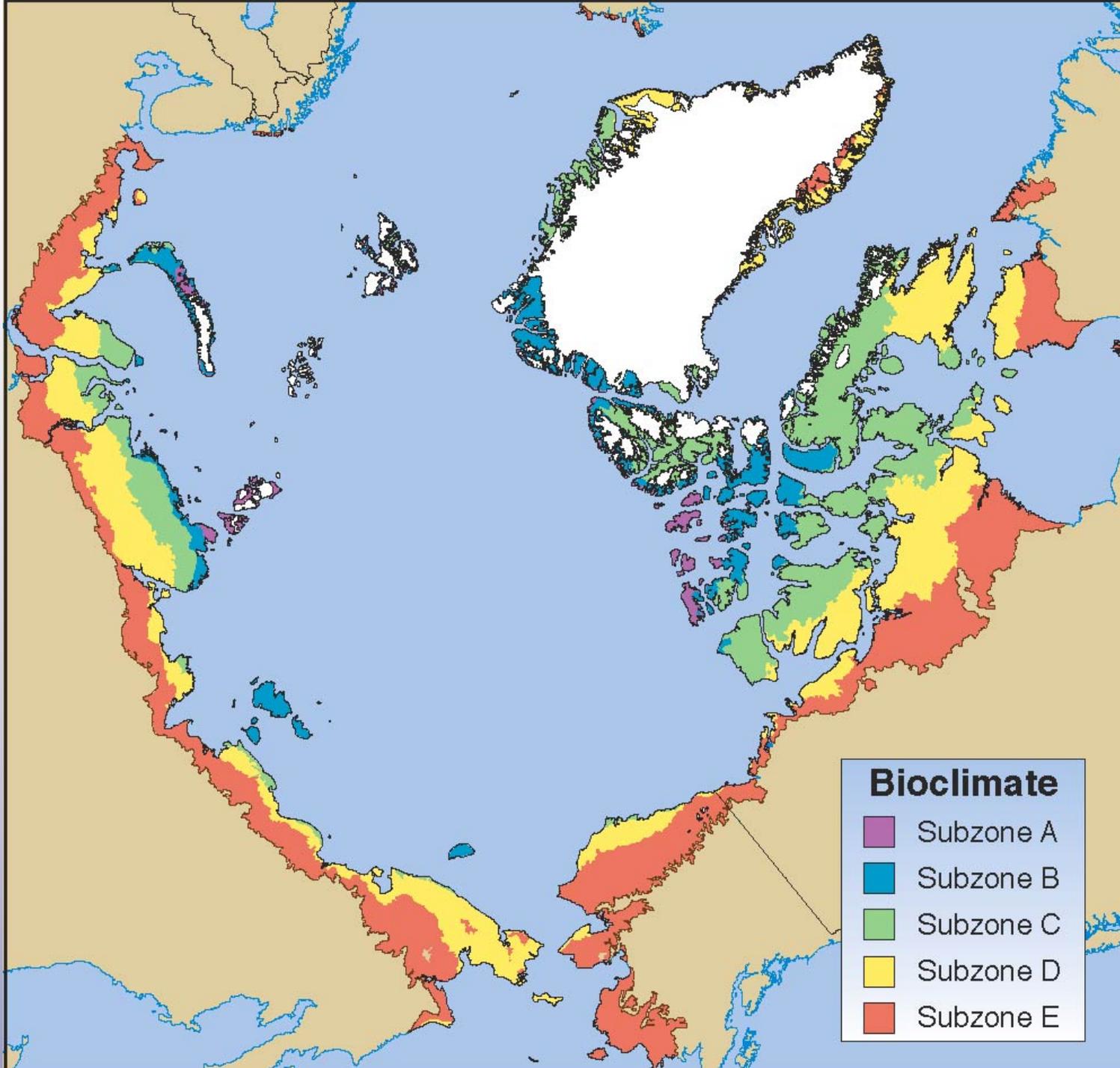
Plant physiognomy occurring in different Tundra Bioclimate Subzones: A – mosses, liverworts and lichens, B – forbs, C – prostrate dwarf-shrubs, D – non-tussock graminoids, hemiprostrate dwarf shrubs, F – erect dwarf shrubs, G – low shrubs, H – tussock graminoids.

Characteristics of Tundra Bioclimate Subzones

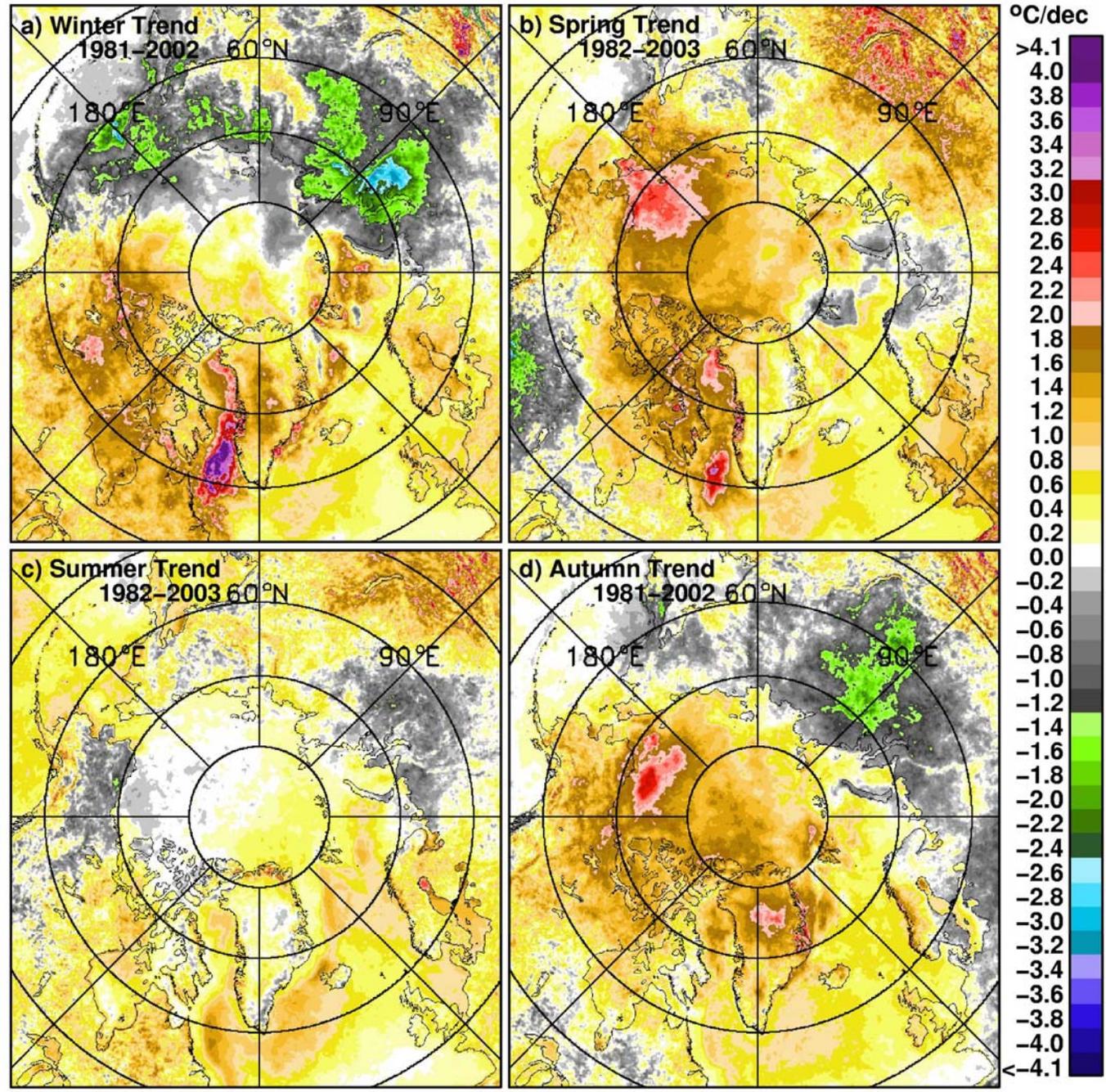
(as developed by Stephen Young (1971), Sylvia Edlund (1990), Arve Elvebakk (1999) and others (CAVM Team, 2003))

Bio-climate Subzone	Mean July Temp (°C)	Summer Warmth Index (°C)	Total phyto-mass (tons/ha)	Net annual production (tons/ha/yr)	# vascular species in flora
A	0-3	< 6	< 3	< 0.3	< 50
B	3-5	6-9	5 - 20	0.2 – 1.9	50 - 100
C	7-9	9-12	10 - 30	1.7 – 2.9	75 -150
D	9-11	12-20	30 - 60	2.9 – 3.9	125 - 250
E	11-13	20-35	50 -100	3.3 – 4.3	200 - 500

**Tundra
Bioclimate
Subzones
from the
Circumpolar
Arctic
Vegetation
Map
(CAVM
Team 2003)**



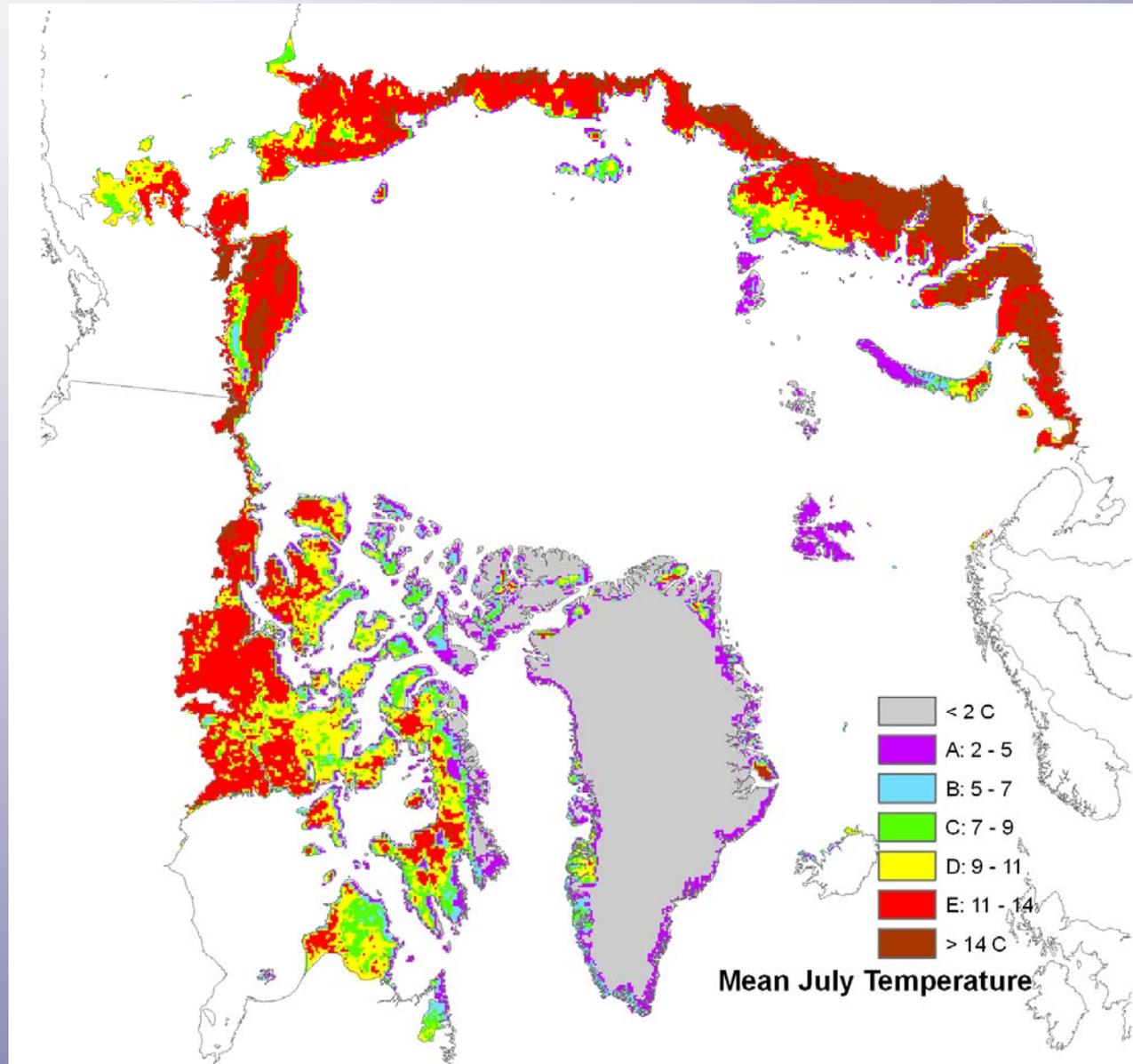
Surface kinetic temperatures calculated from AVHRR 12.5 km pixel data, summarized into monthly means



Data from J. Comiso, NASA Goddard

Mean July Temperature (MJT) from AVHRR data ten year average (1982-1991) of monthly mean July temperatures (° C)

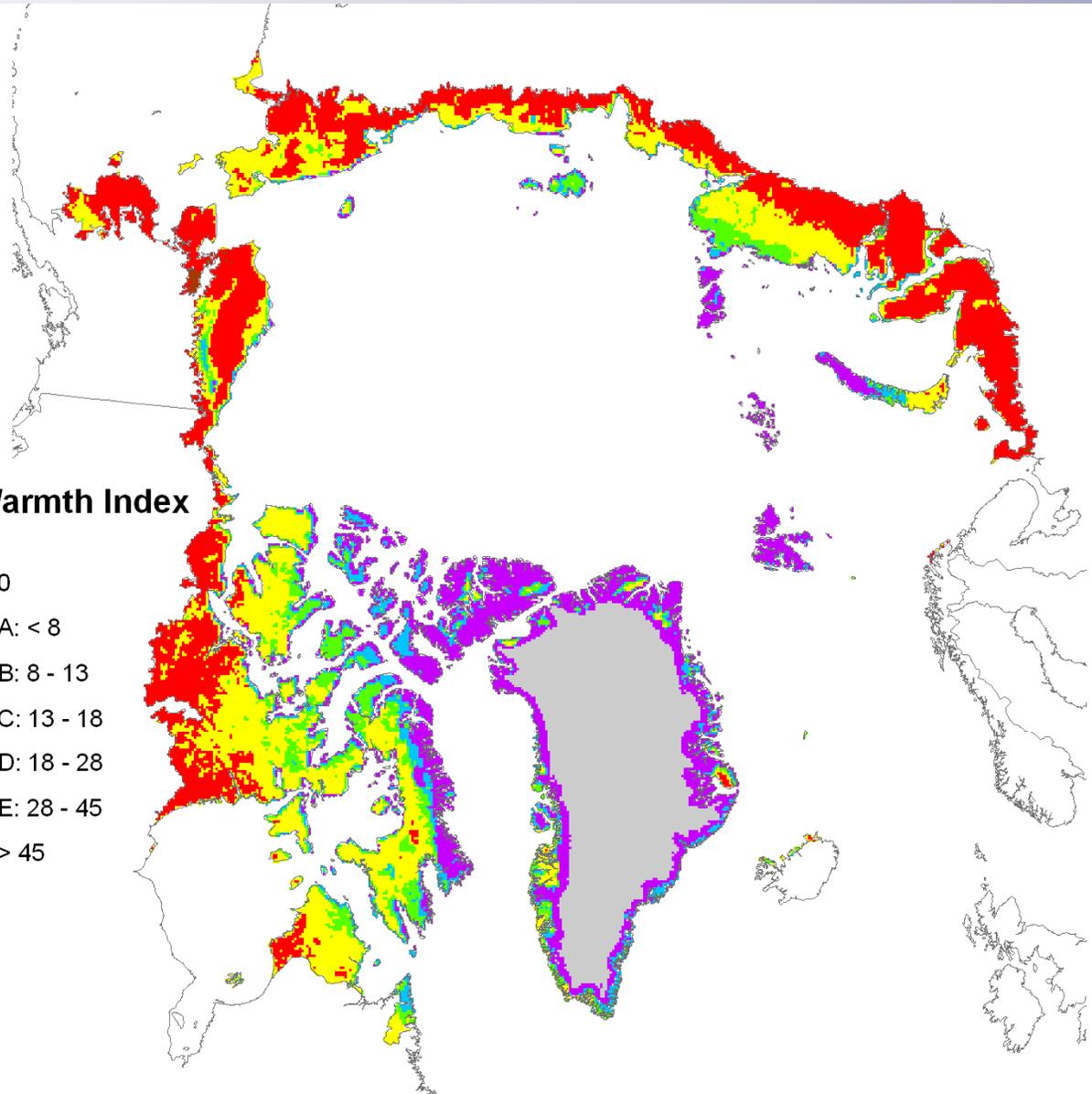
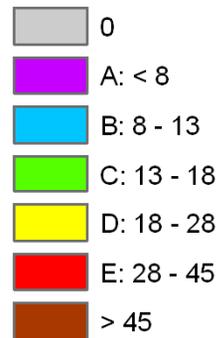
Colored according
to CAVM Bioclimate
Subzones A - E



Summer Warmth Index (SWI) from AVHRR data: ten year average (1982-1991) of sum of monthly means above 0° C

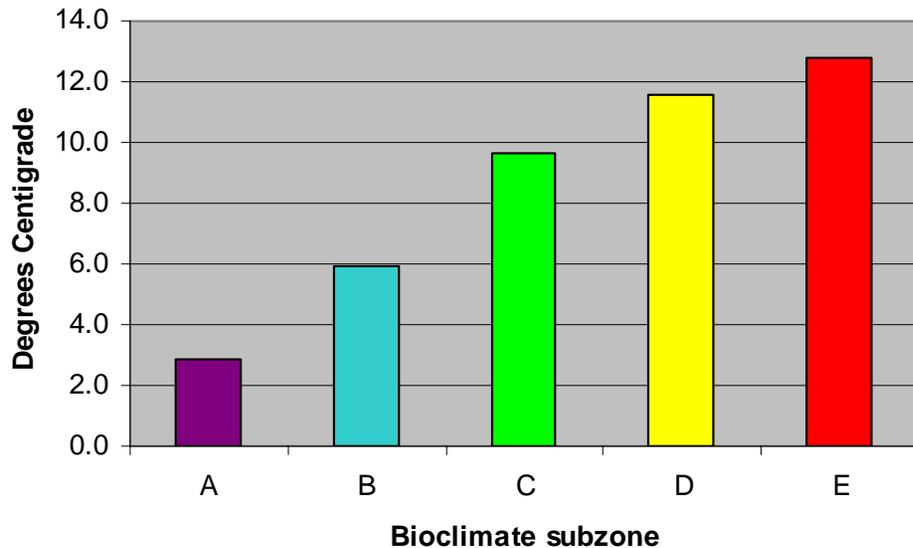
Colored
according to
CAVM
Bioclimate
Subzones A - E

Summer Warmth Index

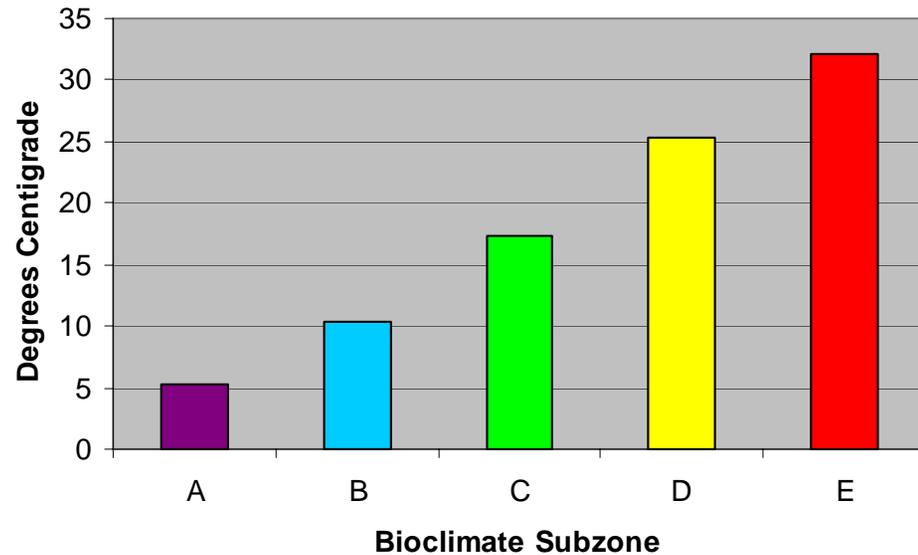


Mean AVHRR surface temperature, summarized by bioclimate subzone as mapped by the CAVM

Mean July Temperature

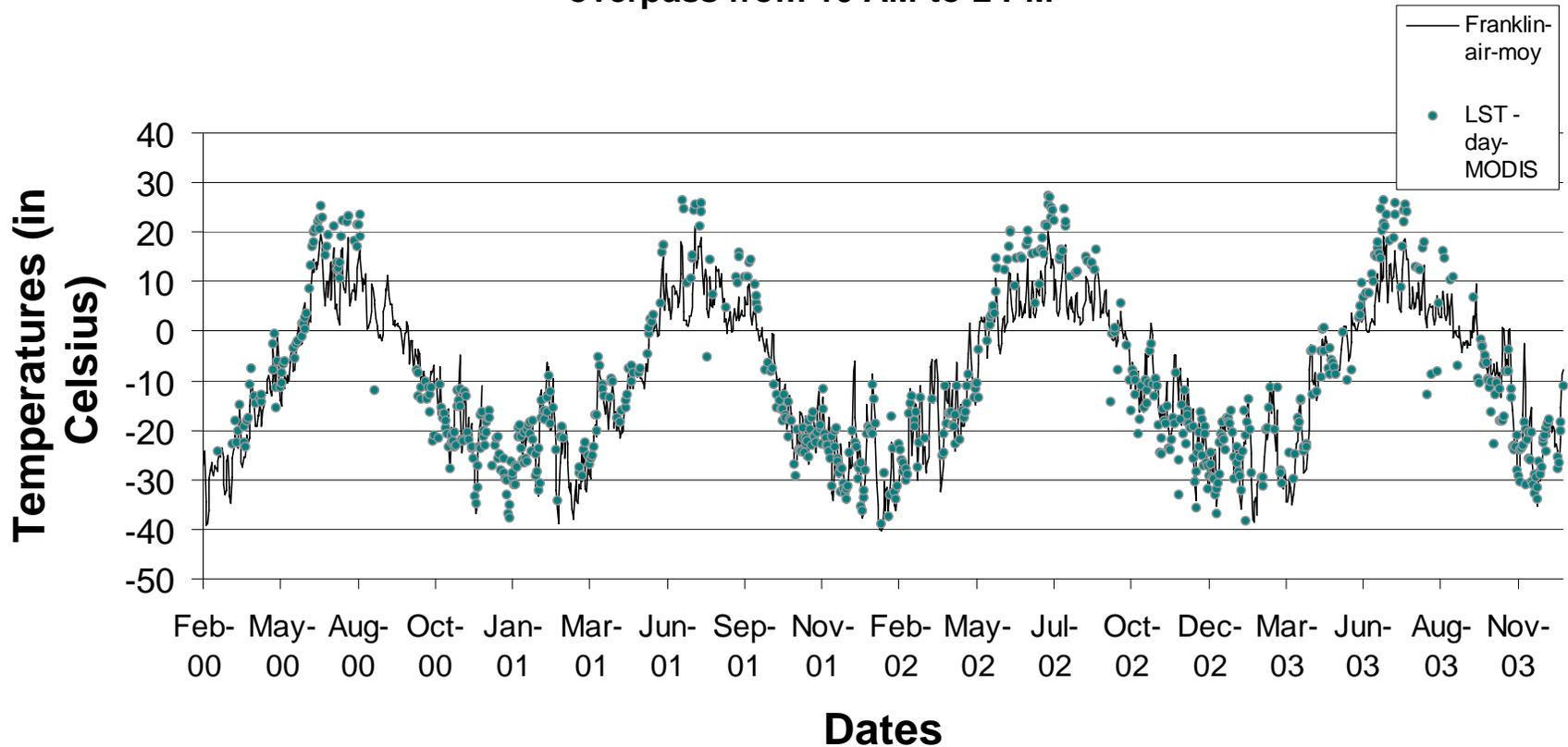


Summer Warmth Index



*Zone mean temperatures are buffered 1 pixel from coast to avoid including ocean data, and exclude areas mapped as mountains, glaciers and waterbodies.

Comparison between mean daily air temperatures measured at East Kuparuk (Franklin Bluffs) and surface temperatures retrieved from Modis on Terra at day overpass from 10 AM to 2 PM

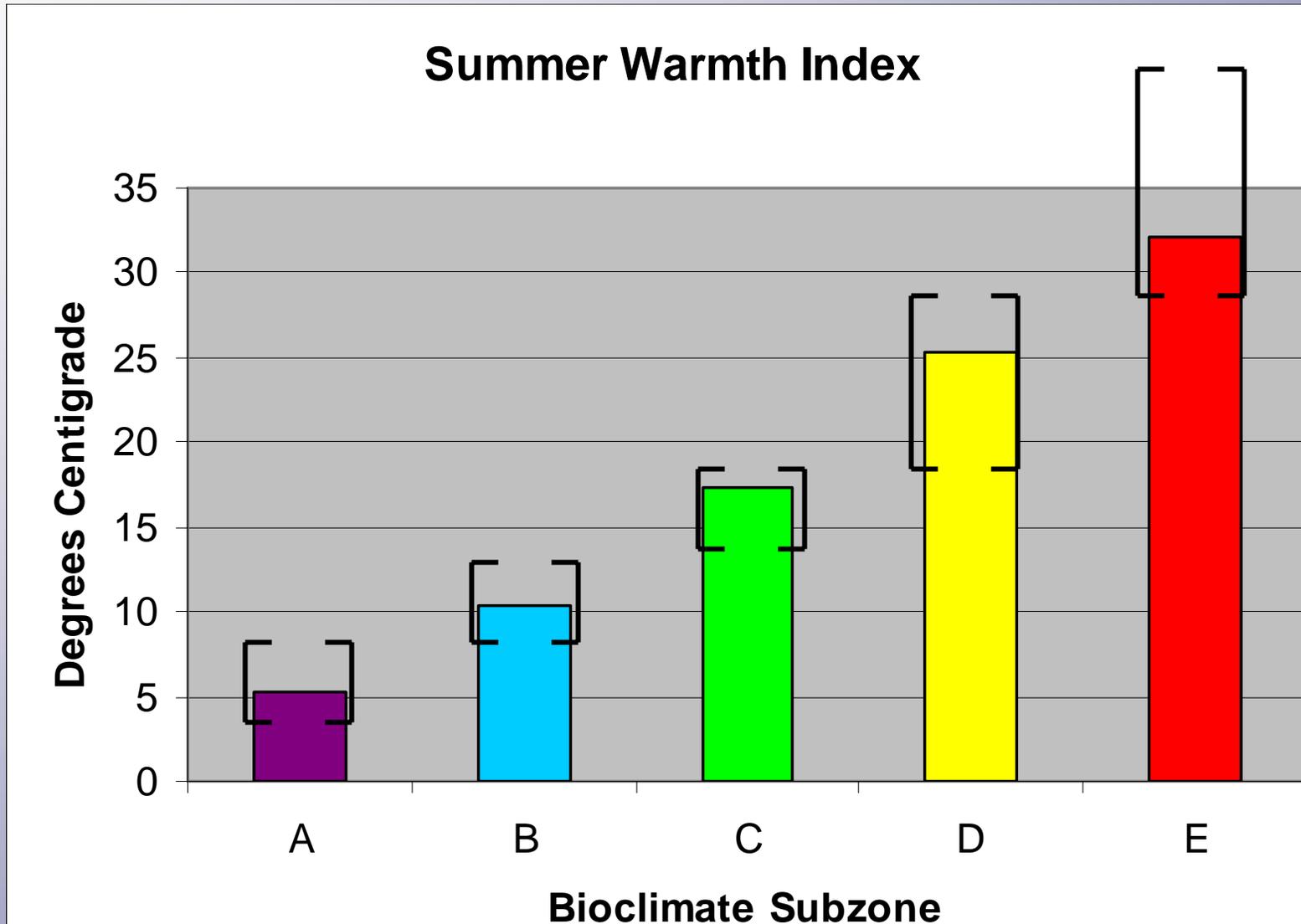


Correction factor needed between:

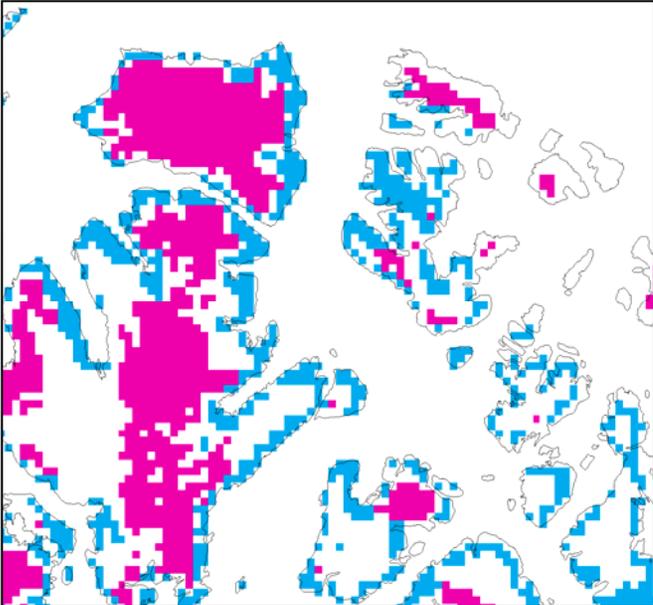
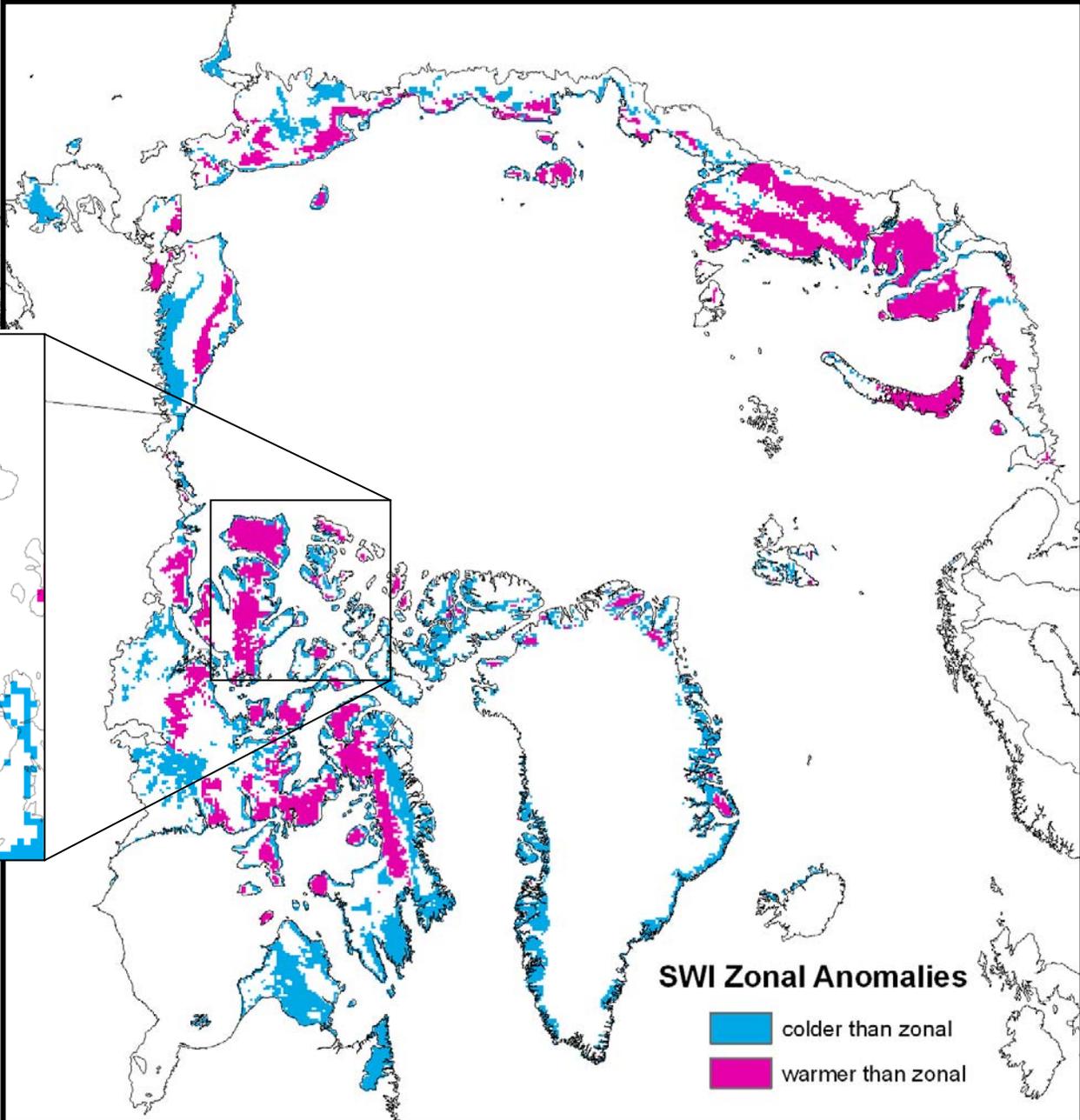
- kinetic surface temperature calculated from AVHRR satellite data
- air temperature at 1.5-2 m elevation measured at weather stations

Summer Warmth Index calculated from AVHRR surface temperature data, summarized by bioclimate subzone as mapped by the CAVM.

Brackets indicate range estimated by CAVM for subzone.



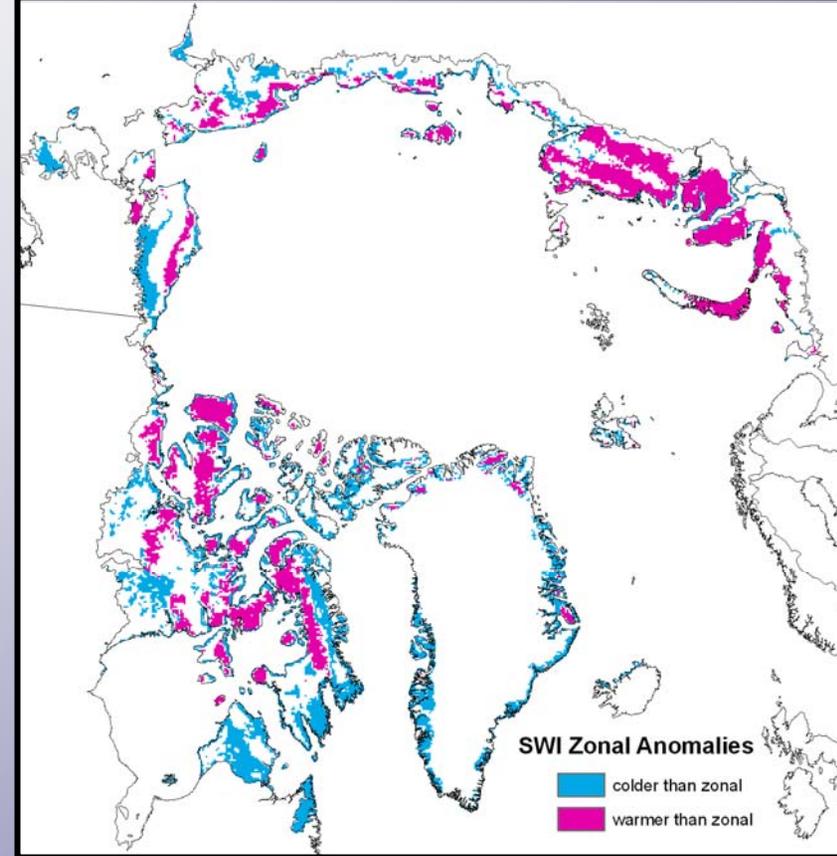
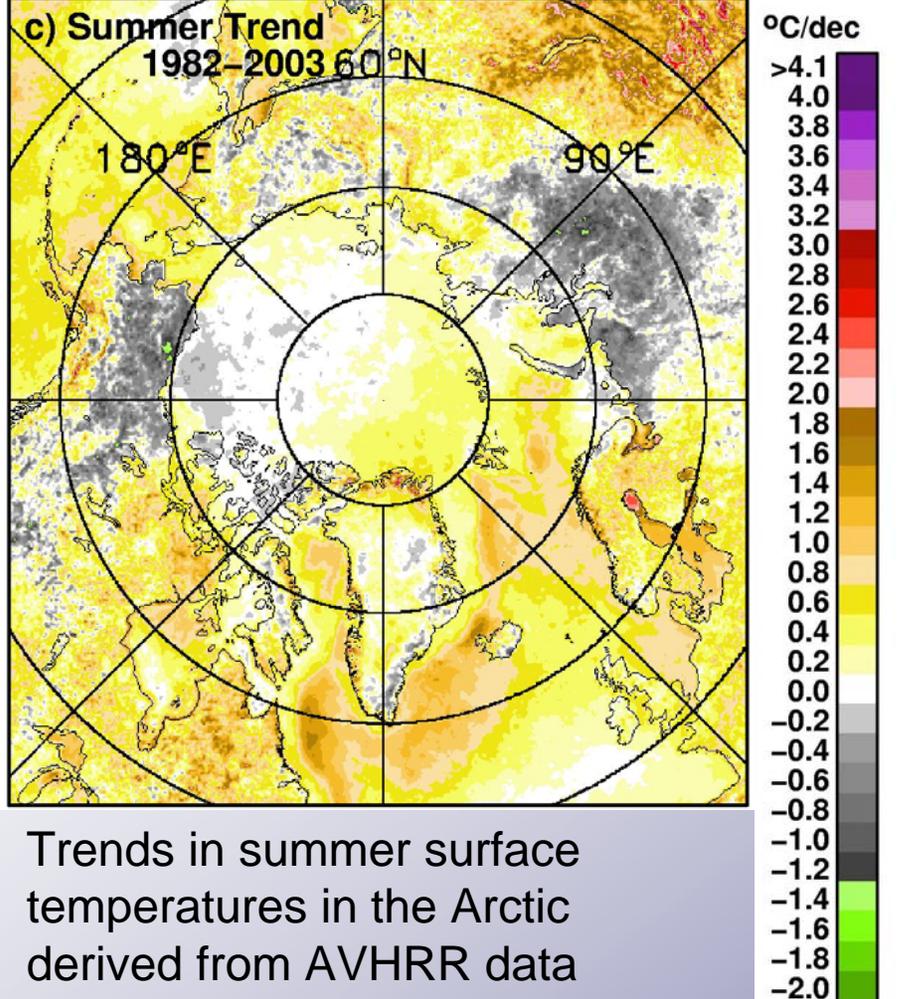
AVHRR Summer Warmth Index (SWI) compared to CAVM zonal range.



Areas colder than mapped subzone are blue, warmer than mapped are pink.

Possible reasons for difference shown on map of anomalies:

1. Problems with the mapping of the bioclimate subzones
 - Cooler areas due to increased elevation
 - Errors due differences in scale of mapping vs. pixels
 - Other mapping errors
2. Problems with the temperature data
3. Changes in climate, where vegetation has not yet had time to adapt to climate changes



No evidence of warming climate as would be indicated by correlation between trend in summer temperatures and anomaly map.

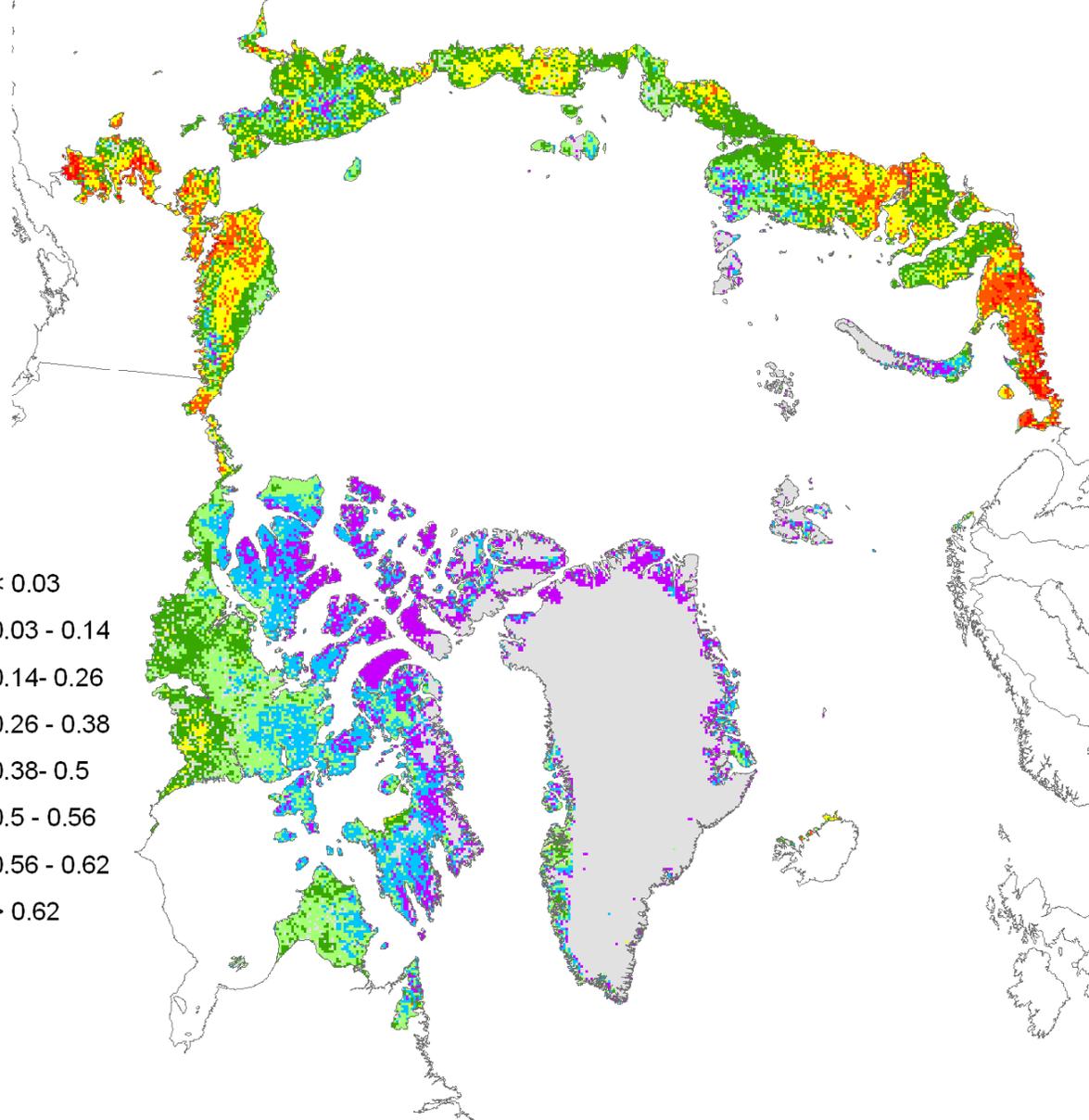
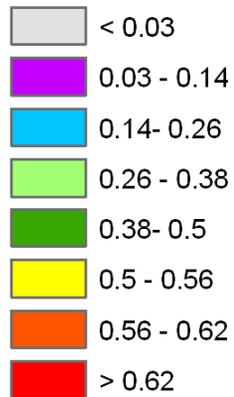
Part II

Polar bear
hand & foot

My
hand



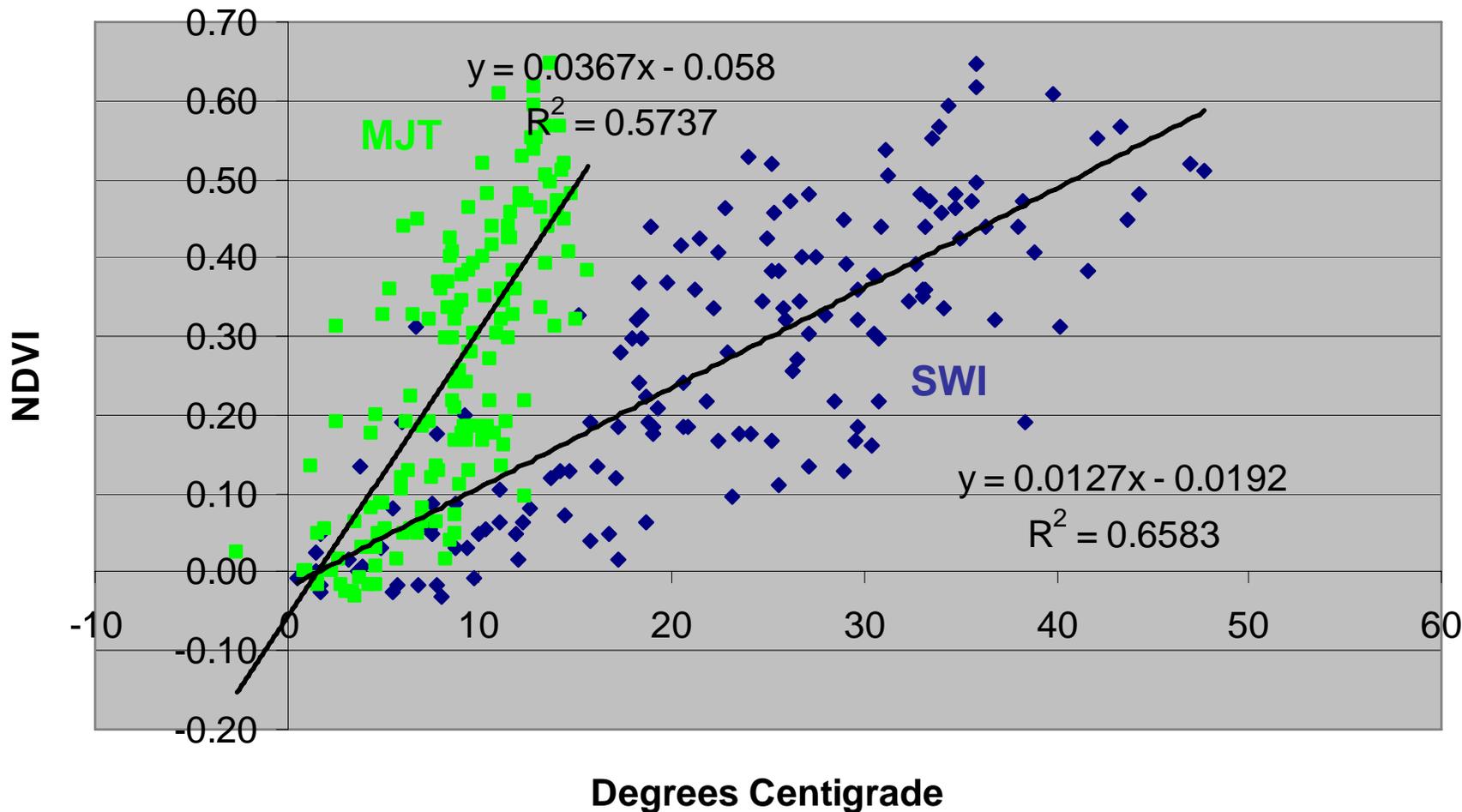
NDVI



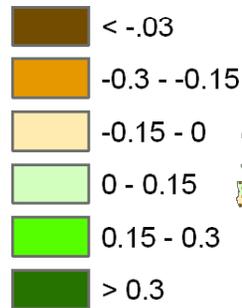
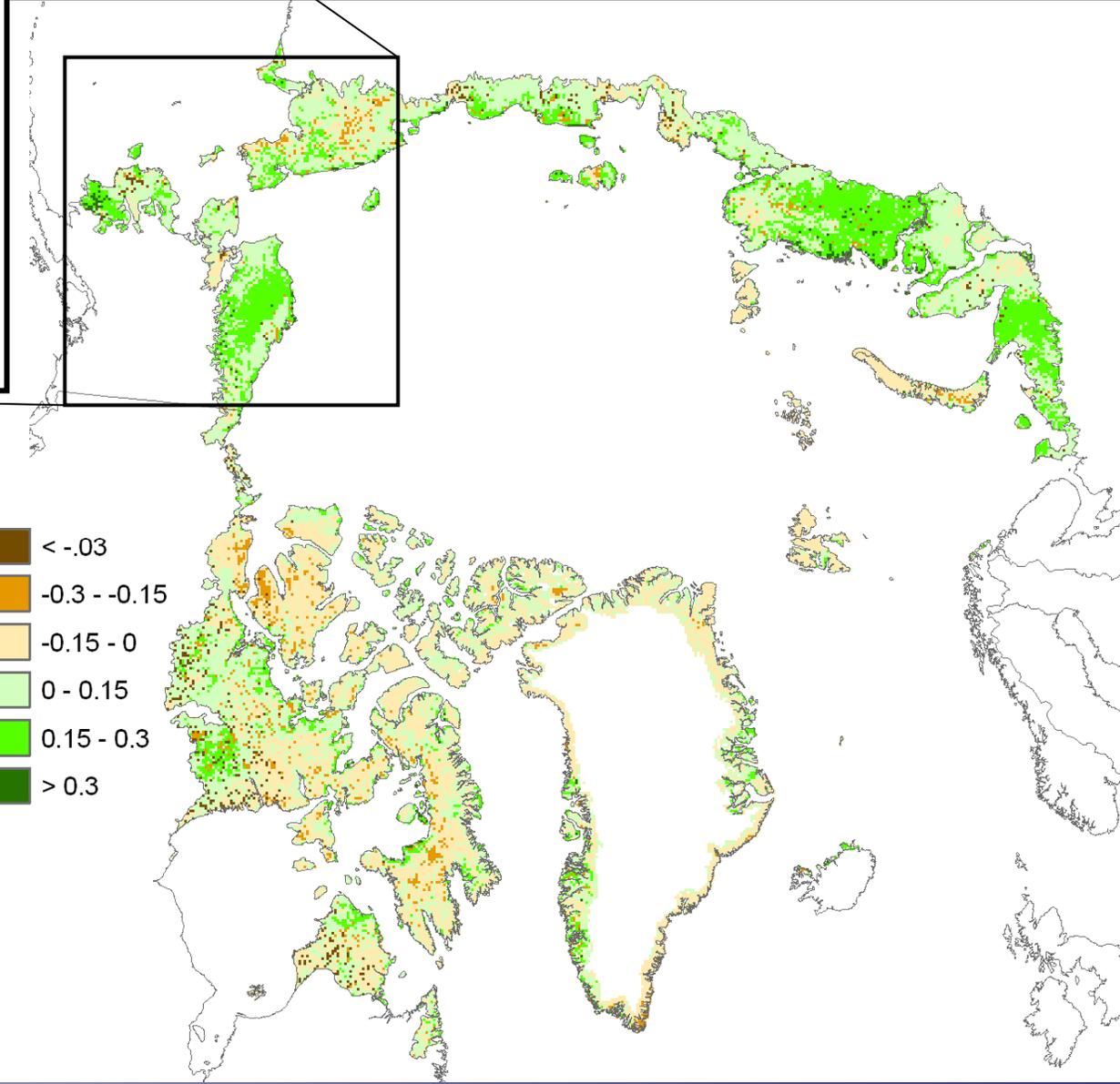
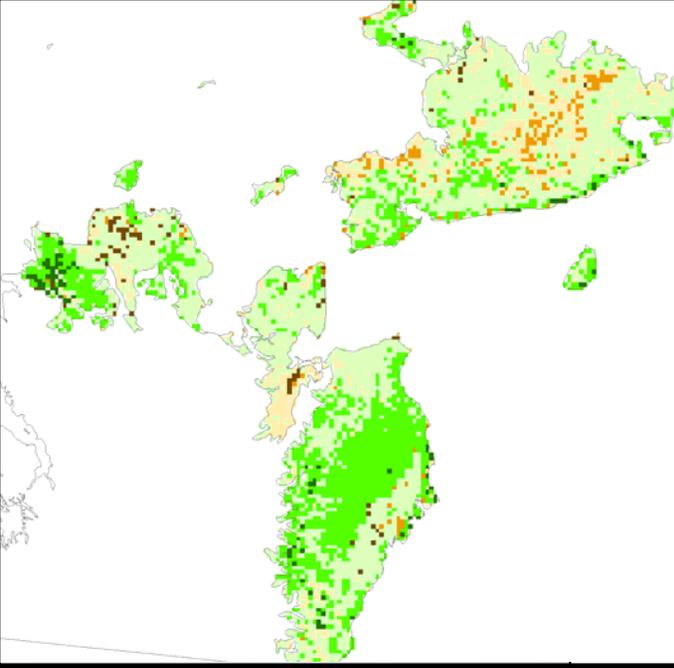
Maximum NDVI from AVHRR data 1993 & 1995 from the
Circumpolar Arctic Vegetation Map (CAVM Team, 2003)

$$\text{Normalized Difference Vegetation Index} = (\text{NIR} - \text{R}) / (\text{NIR} + \text{R})$$

Regression of Mean July Temperature (MJT) and Summer Warmth Index (SWI) against NDVI (approx. 100 random points) for 1993 & 1995



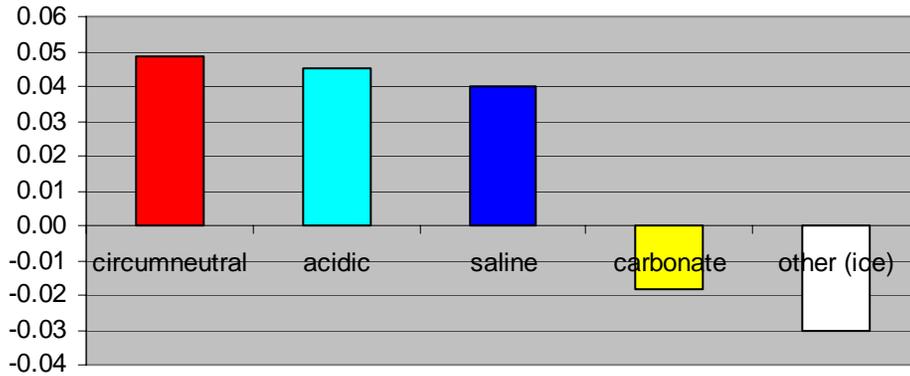
AVHRR Summer Warmth Index (SWI) compared to expected NDVI value as calculated by regression equation.



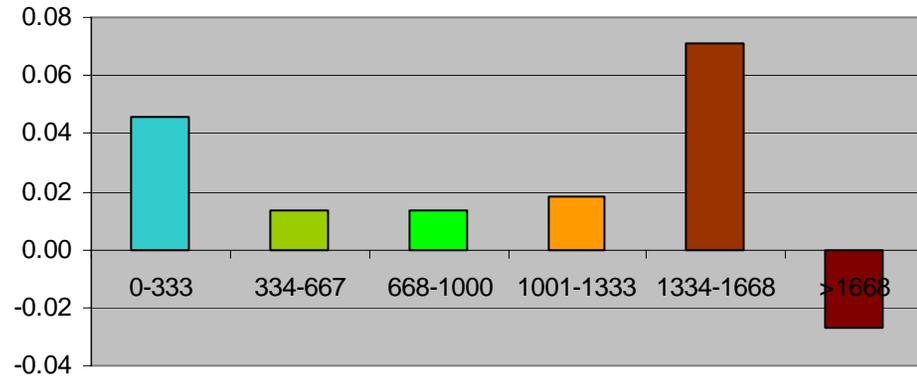
Areas with less NDVI than expected are brown, areas with more NDVI than expected are green.

Charts of anomalies between AVHRR Summer Warmth Index (SWI) and expected NDVI value as calculated by regression equation.

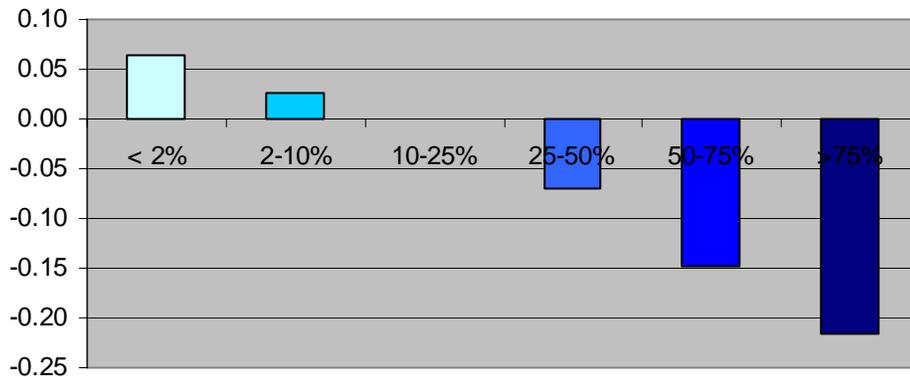
Substrate chemistry



Elevation (m)

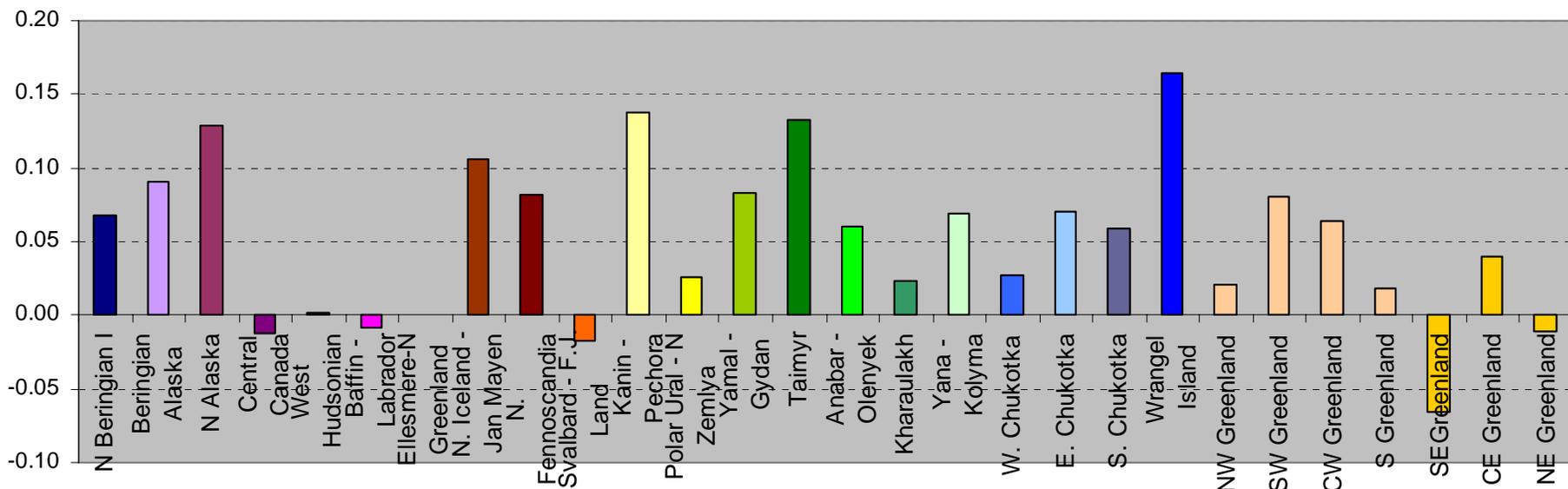


Lake cover

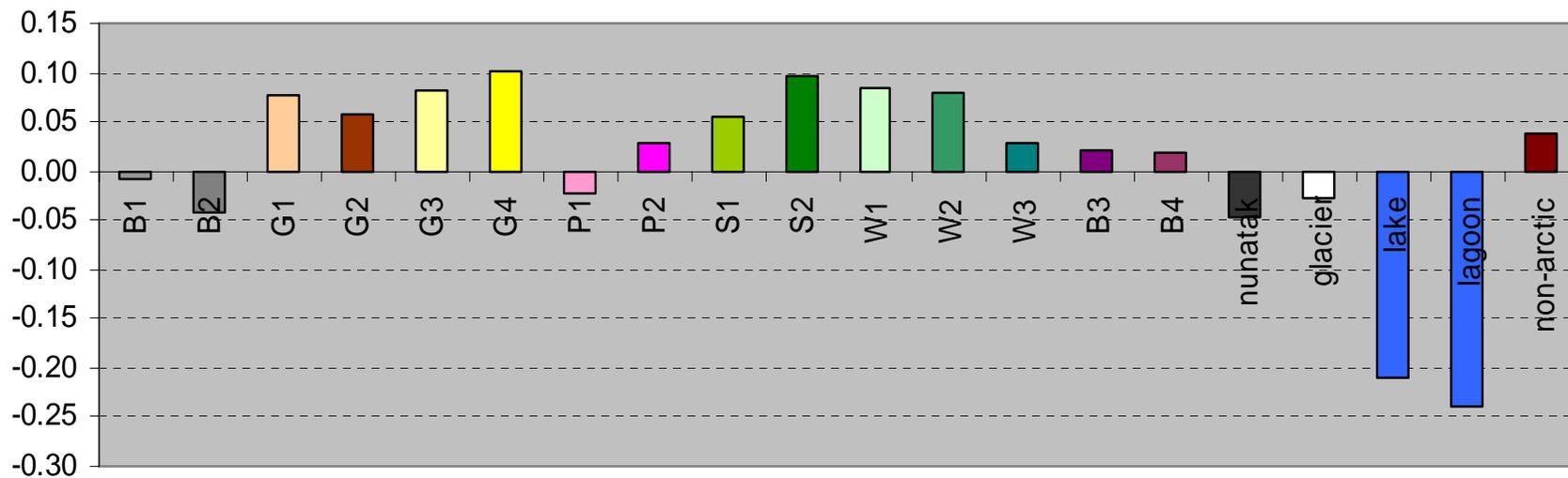


CAVM attribute classes with more NDVI than predicted by the equation are above zero, classes with less NDVI than predicted are below zero.

Floristic provinces



Vegetation types



Summary

Analysis of AVHRR kinetic surface temperature data and CAVM bioclimate subzones

- Good correspondence between means
- Can be improved by using temperature data to map refine resolution of bioclimate subzones, particularly for islands
- Some areas that do not correspond need further investigation

Analysis of AVHRR kinetic surface temperature data and AVHRR NDVI

- Positive relationship between surface temperature and NDVI
- Areas with higher than expected NDVI include:
 - Shrubby hills
 - Productive coastal areas
- Areas with lower than expected NDVI include:
 - Glaciated areas
 - Carbonate substrates
 - High mountains
 - Lakes

Acknowledgements

- Josefino Comiso for his data and advice
- Dave Verbyla & Hilmar Maier for help reading temperature data into ArcMap
- Vladimir Romanovsky for discussion about estimating ground surface temperature from air temperature
- Sam Dashevsky his review of this presentation

Citations

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- Young, S. B., 1971: The vascular flora of St. Lawrence Island with special reference to floristic zonation in the Arctic Regions. *Contributions from the Gray Herbarium*, 201: 11-115.

Questions?



Conclusions

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