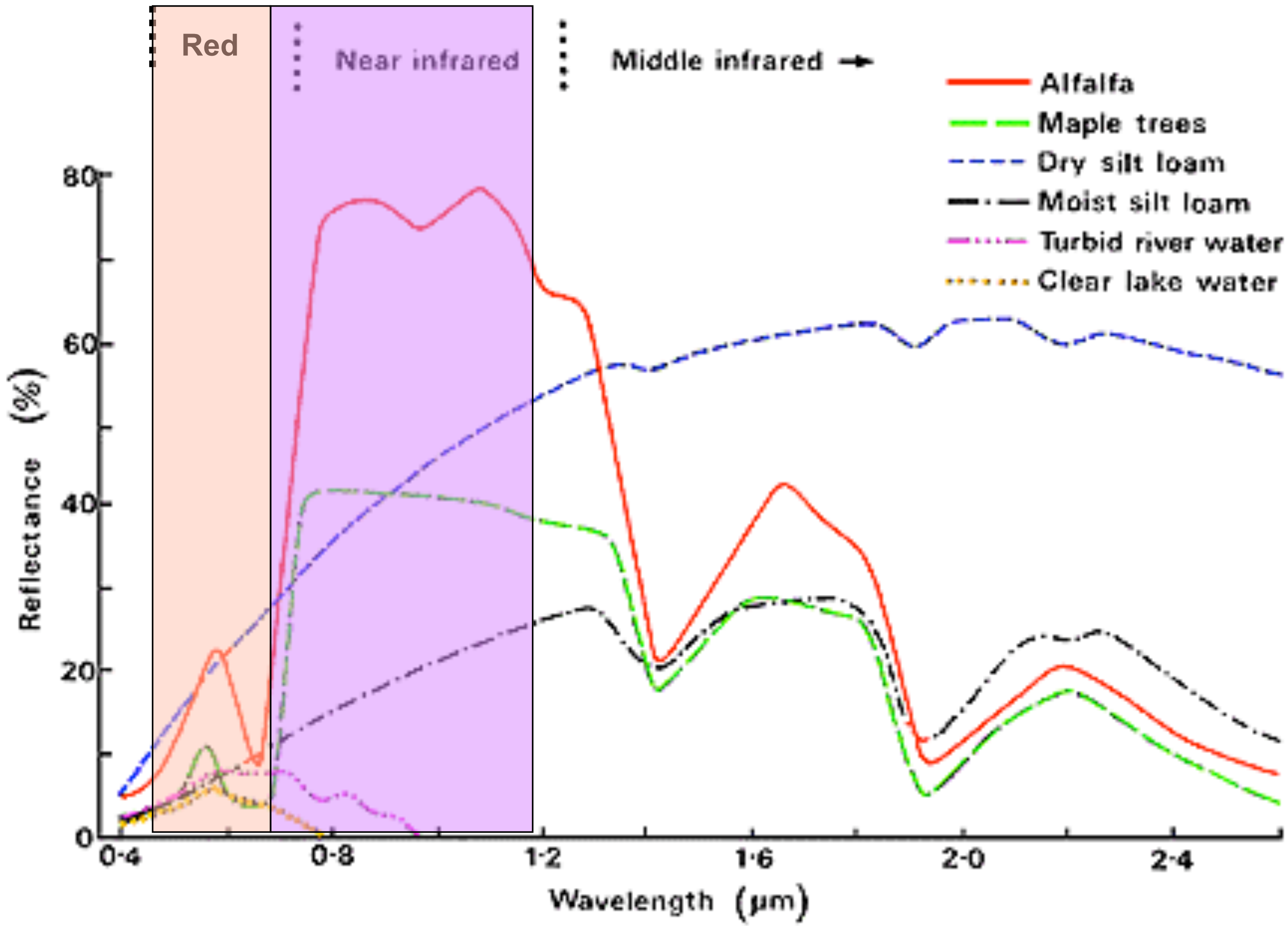
NDVI trends 1981-2008 in the circumpolar Arctic and Yamal

What is happening, where and why?

Martha Raynolds[1], Skip Walker[1], Uma Bhatt[1], Jorge Pinzon[2], Joey Comiso[2]

[1] University of Alaska Fairbanks, Fairbanks AK USA
[2] NASA Goddard Space Flight Center, Greenbelt MD USA

Normalized Difference Vegetation Index, NDVI $= \dfrac{\text{NIR - Red}}{\text{NIR + Red}}$



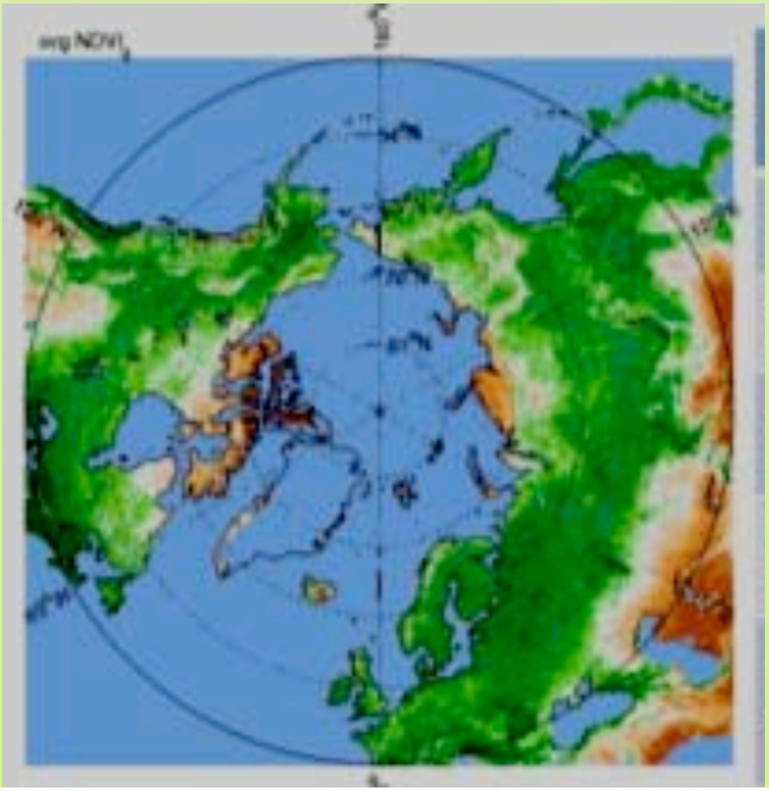
(http://internet1-ci.cst.cnes.fr:8100/cdrom/ceos1/titlep.htm)

New AVHRR NDVI data, Jorge Pinzon of NASA Goddard Space Flight Center

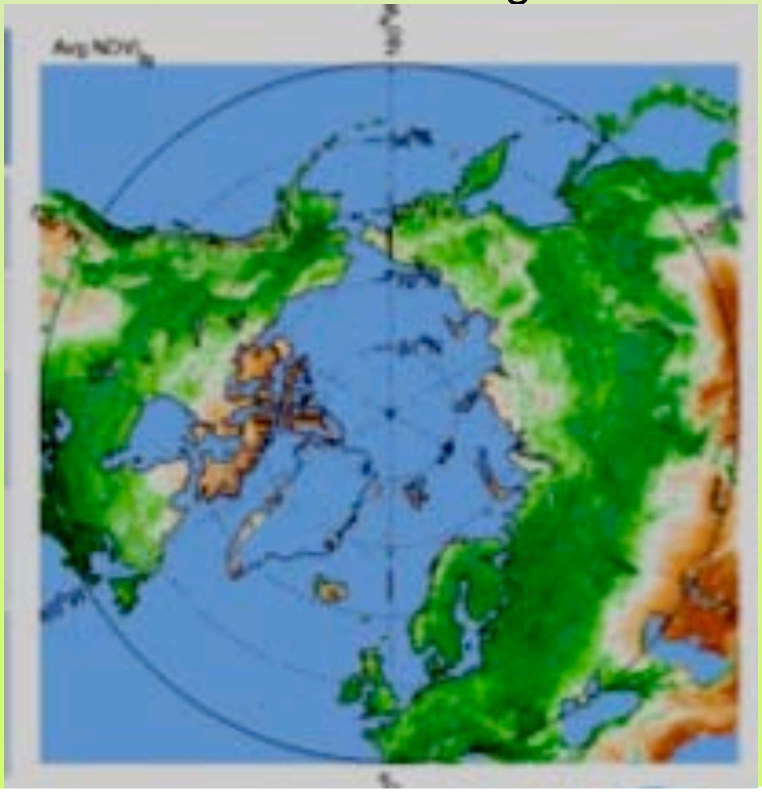
Focuses on Arctic, where NDVI data show most rapid changes

- Remedies the discontinuity at 72°N
- Uses a polar projection rather than Albers continental projections
- WGS84 datum rather than NAD27
- white & black calibrations from within the Arctic (Greenland and North Atlantic ocean) rather than Sahara & more southern oceans

Old GIMMS

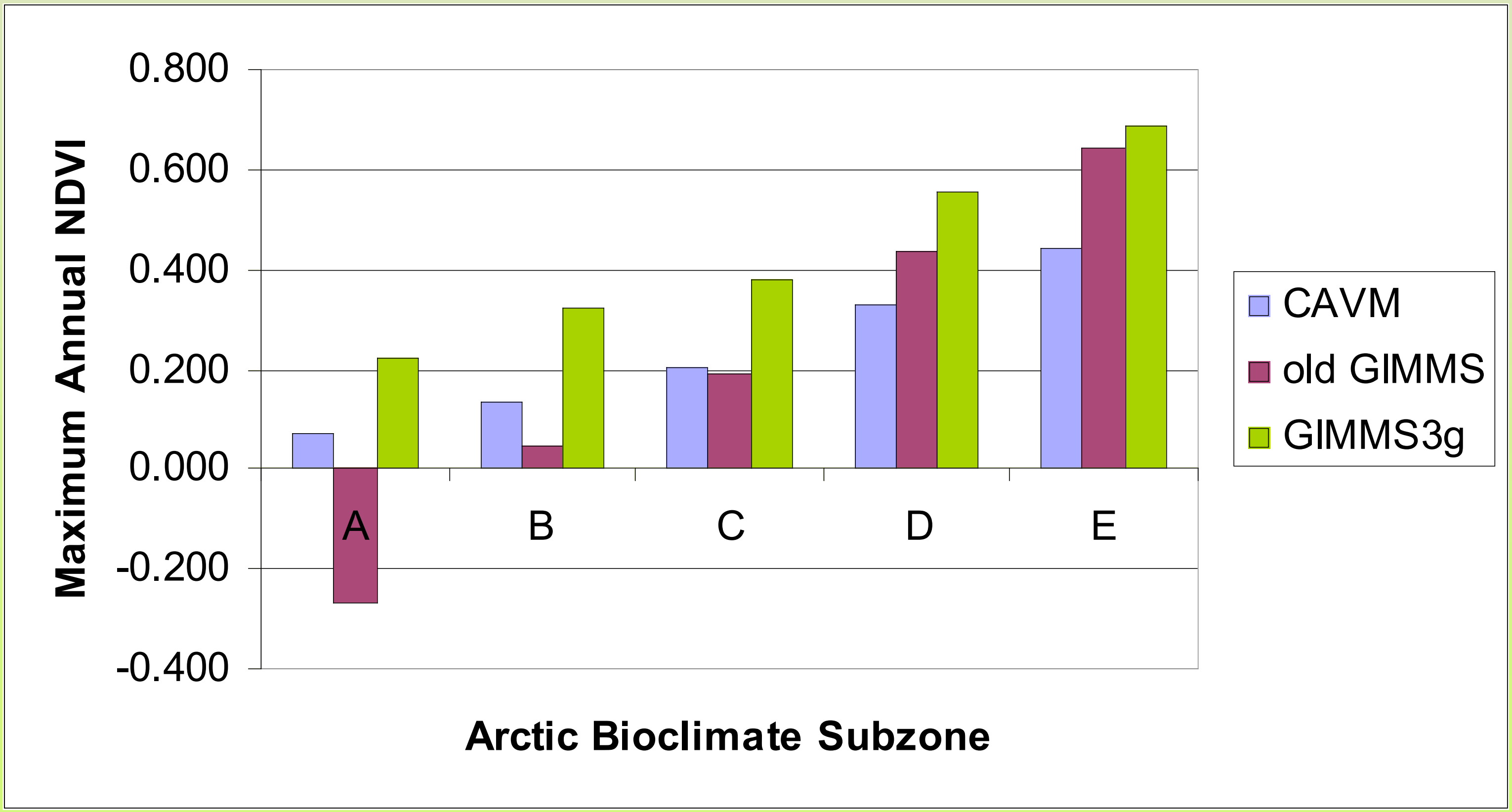


New GIMMS3g



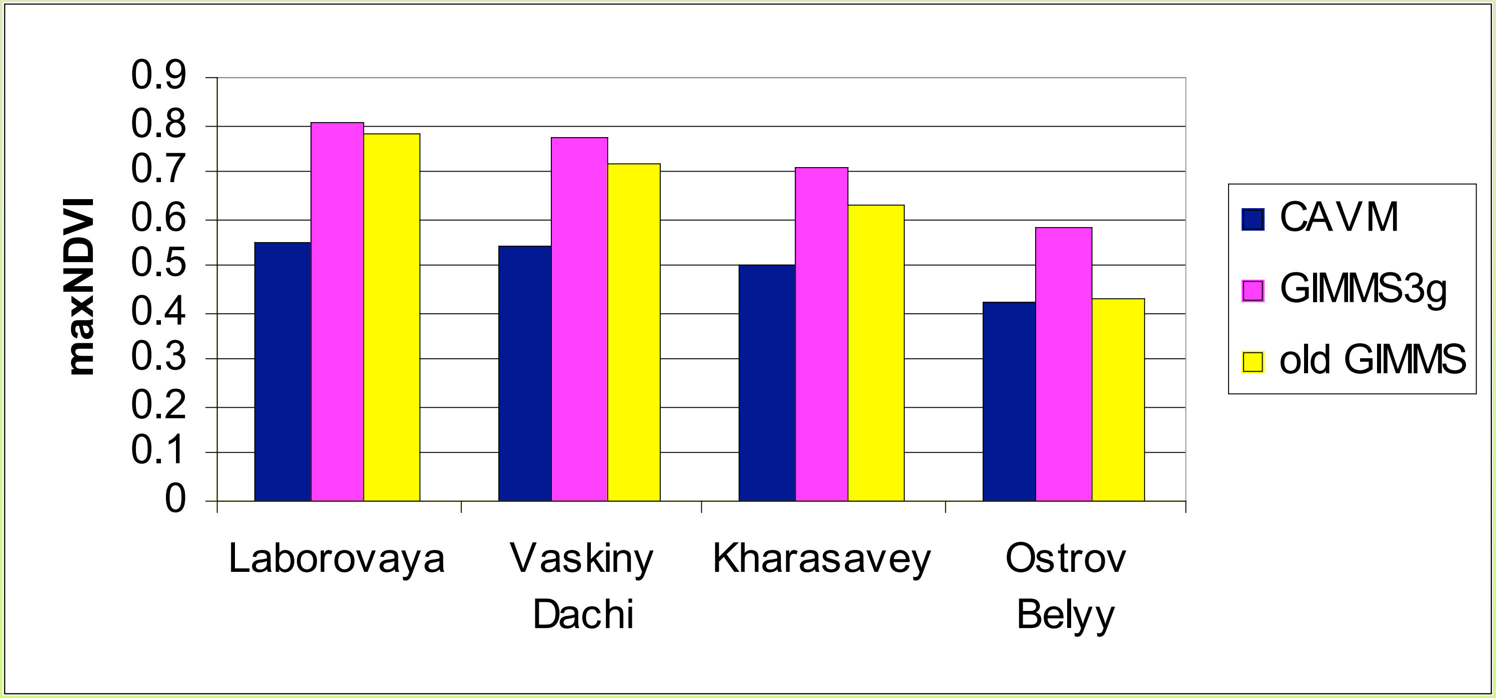
Comparison of three calculations of NDVI from AVHRR data

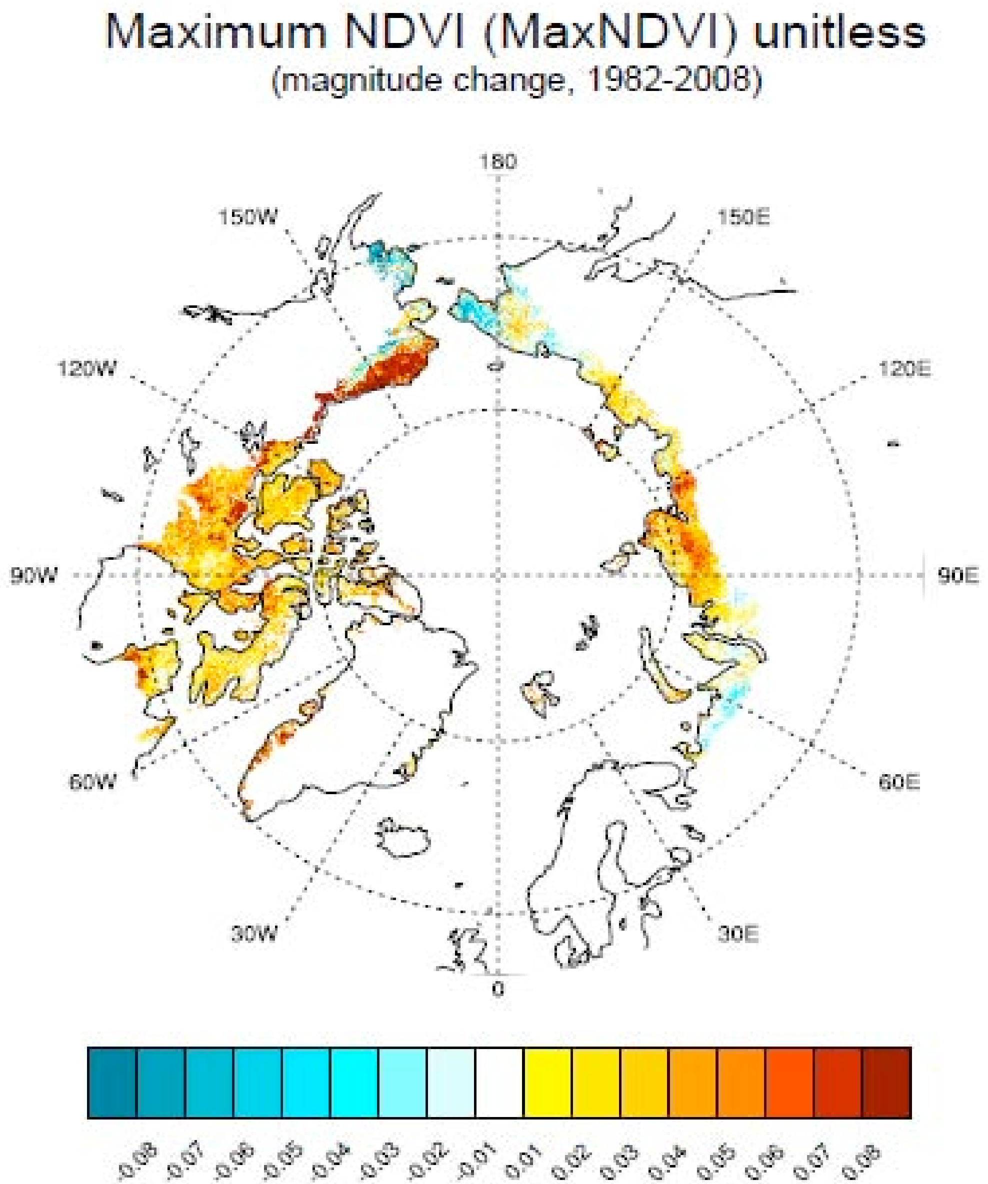
All calculated for same years: maximum NDVI for 1993 and 1995



Comparison of three calculations of NDVI from AVHRR data

Relative values are similar for Yamal sites

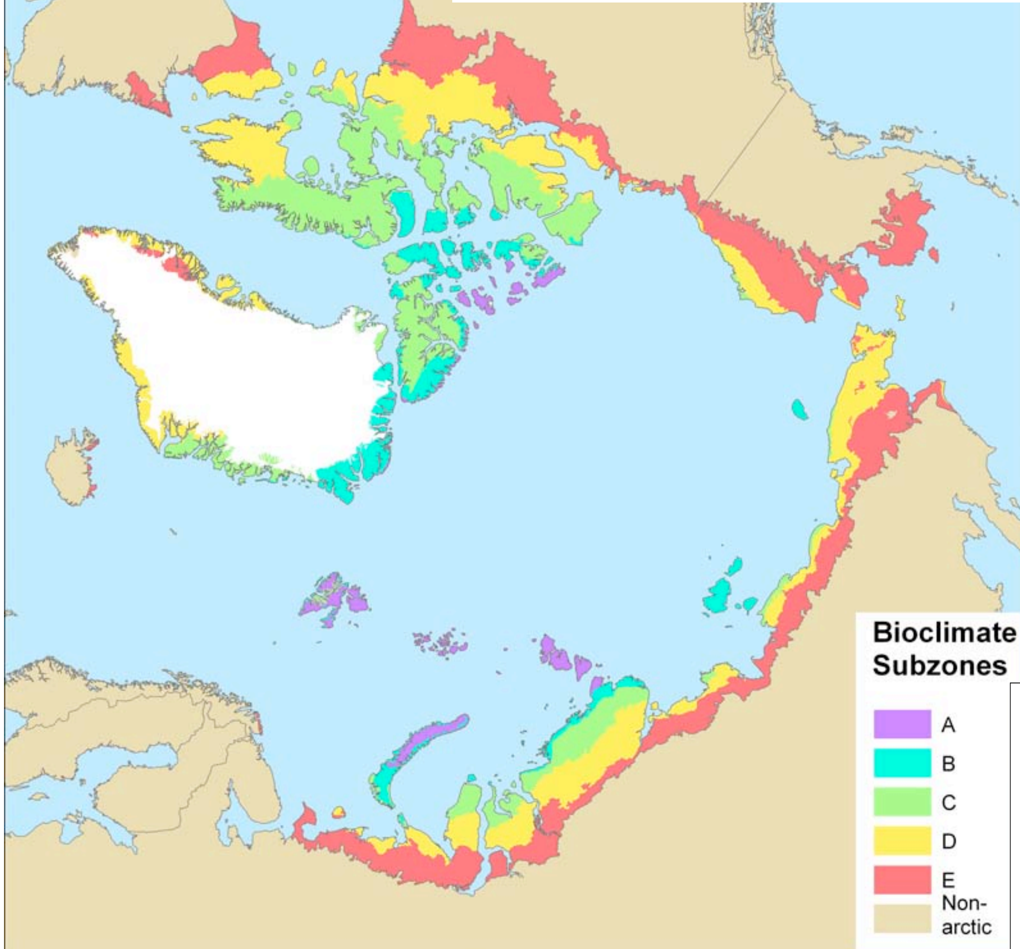


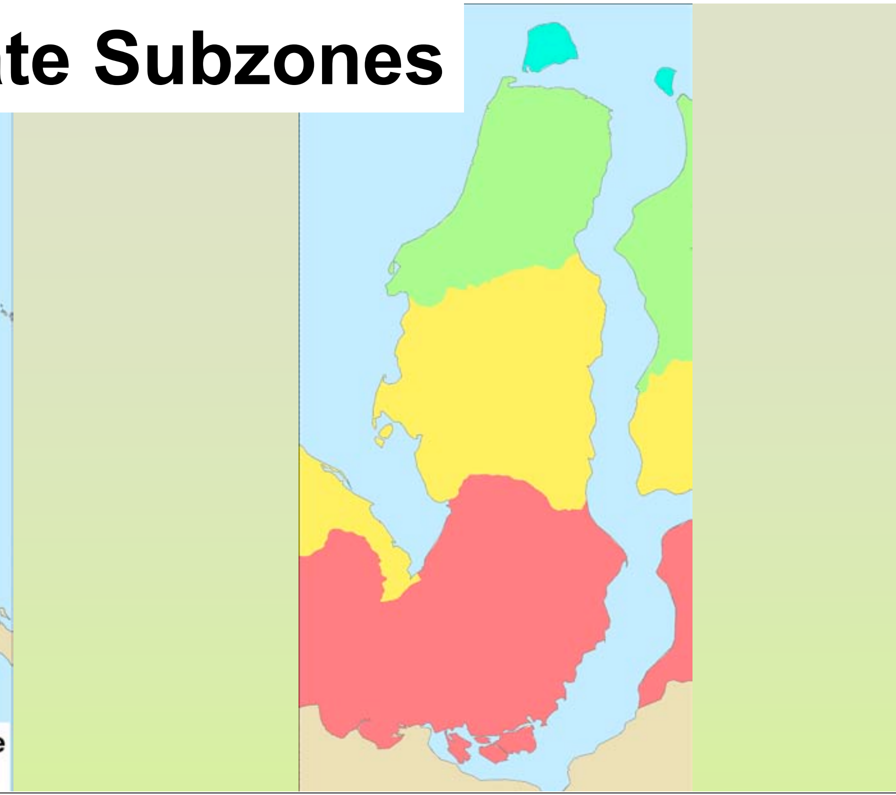


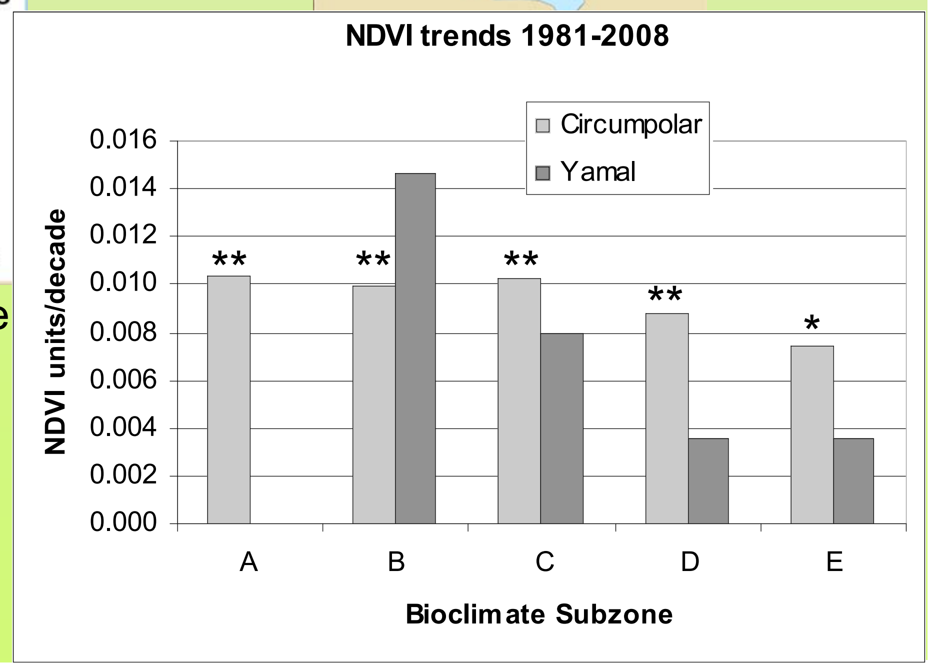
NDVI trends from new Pinzon data

Floristic Province	Trend (NDVI units/decade)
North Beringian Islands	-0.008
East Chukotka	-0.008
Southeast Greenland	-0.005
South Chukotka	-0.003
Beringian Alaska	-0.002
Kanin-Pechora	-0.001
West Chukotka	-0.001
Kharaulakh	0.004
Gydan	0.004
Yamal	**0.005**
Central-east Greenland	0.005
Yana-Kolyma	0.005
Polar Urals-Novaya Zemlya	0.007
Northeast Greenland	0.007
Baffin-Labrador	0.008*
Svalbard-Franz Josef Land	0.010*
West Hudsonian	0.011**
North Greenland-Ellesmere	0.011*
South Greenland, Iceland	0.012
Taimyr	0.013
Southwest Greenland	0.013
Central Canada	0.014***
Northern Alaska	0.023****

Arctic Bioclimate Subzones



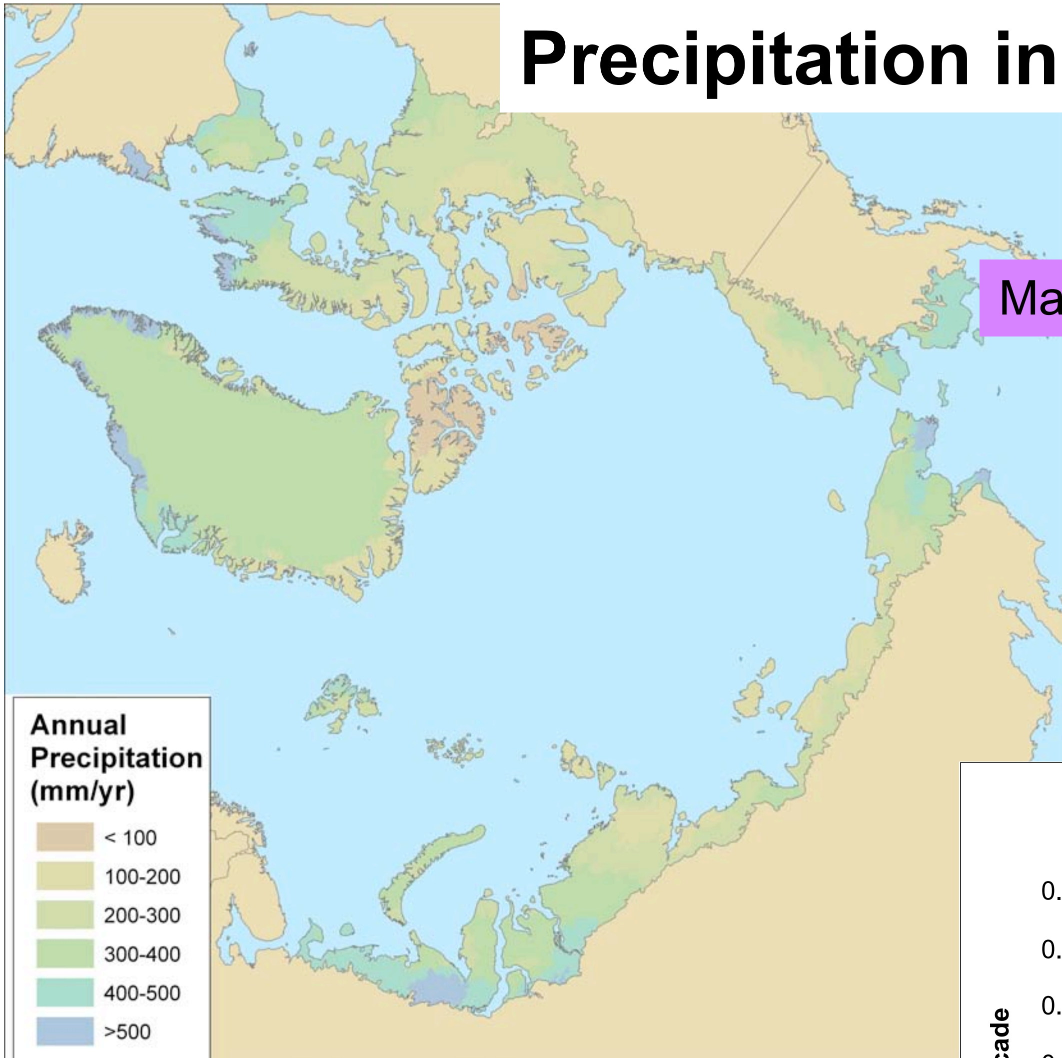


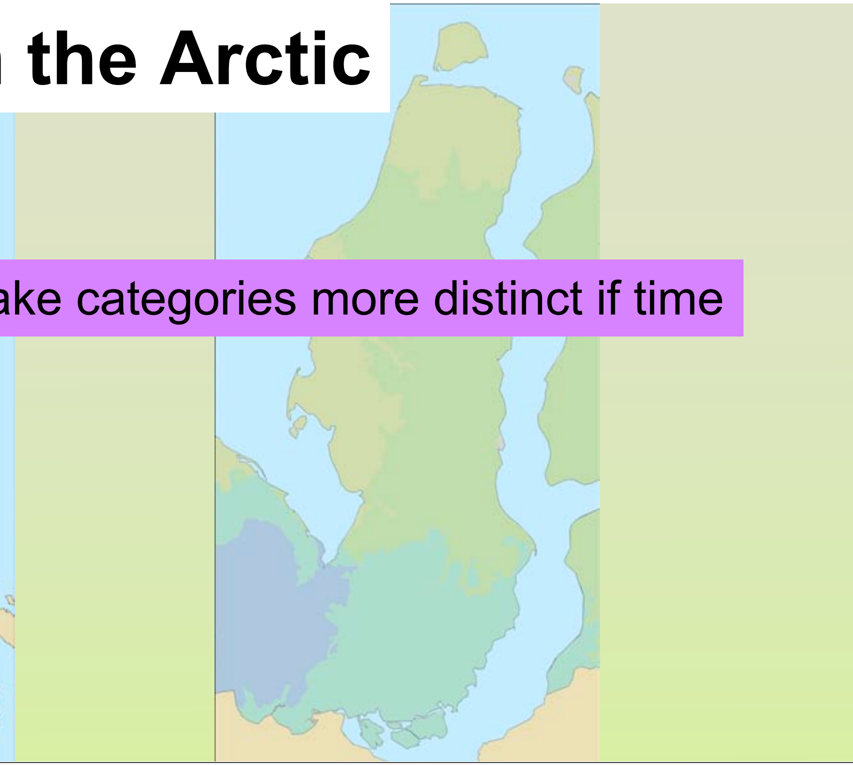


- All circumpolar subzones show significant positive trends in NDVI
- Trends increase with latitude
- Change in trend more pronounced on Yamal subset, yet none are significant

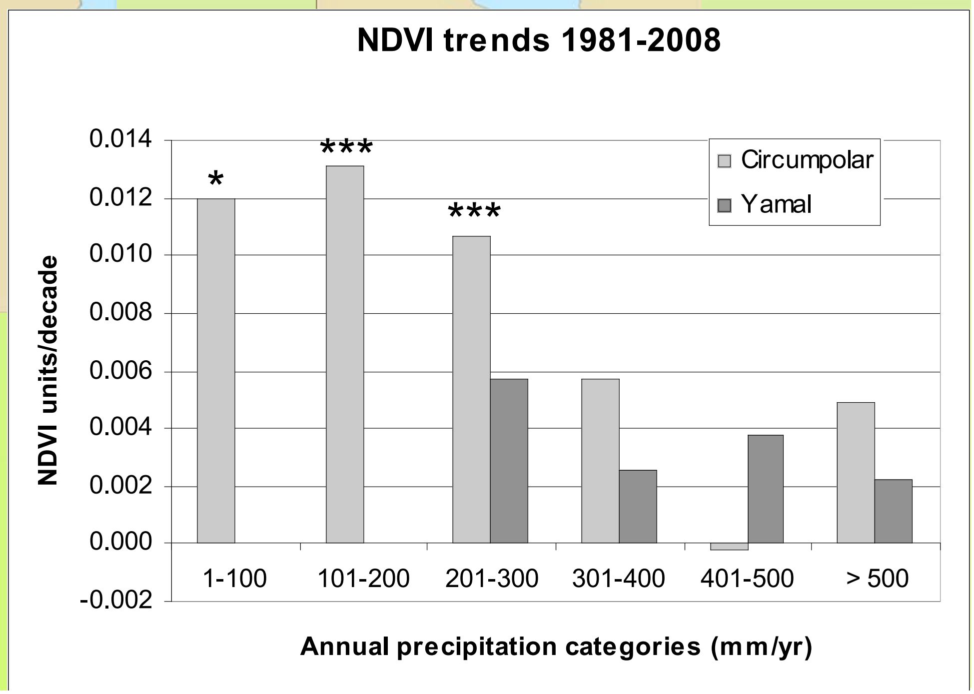
Precipitation in the Arctic

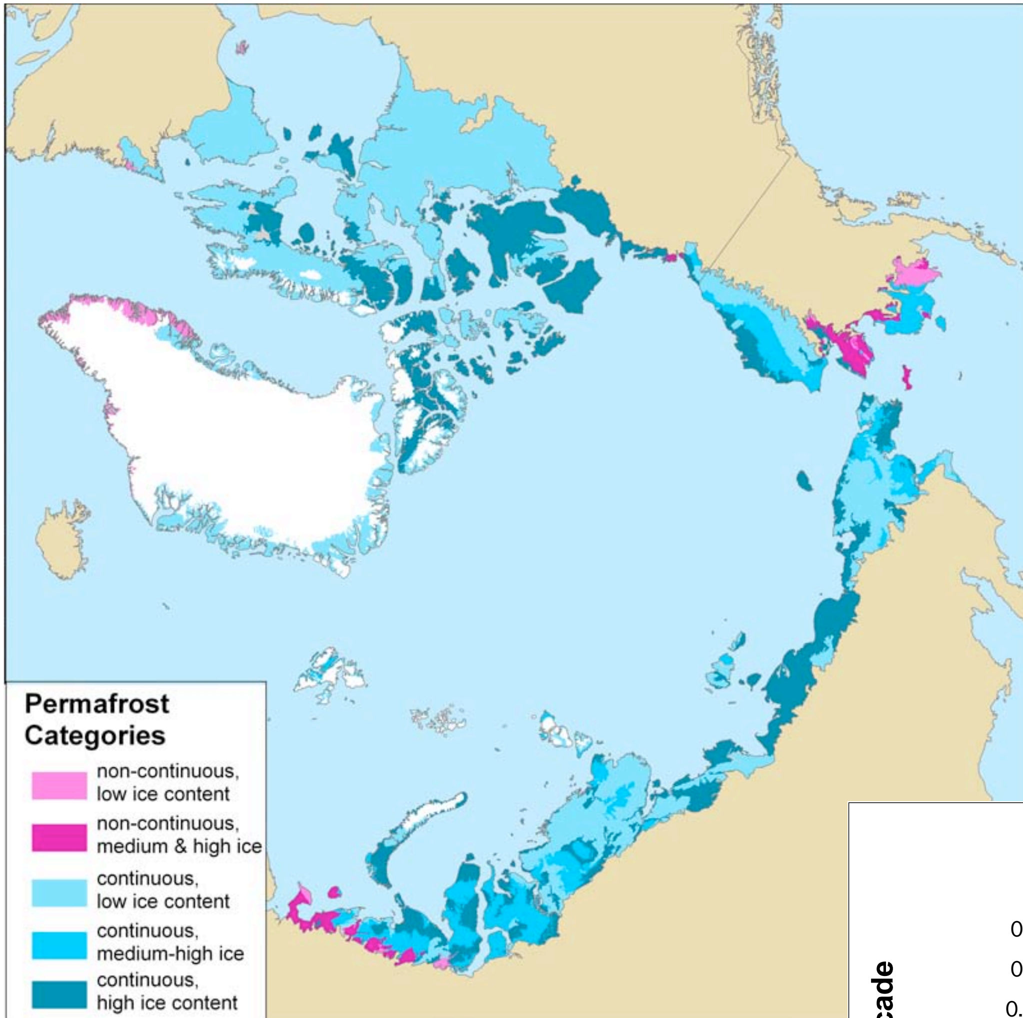
Make categories more distinct if time

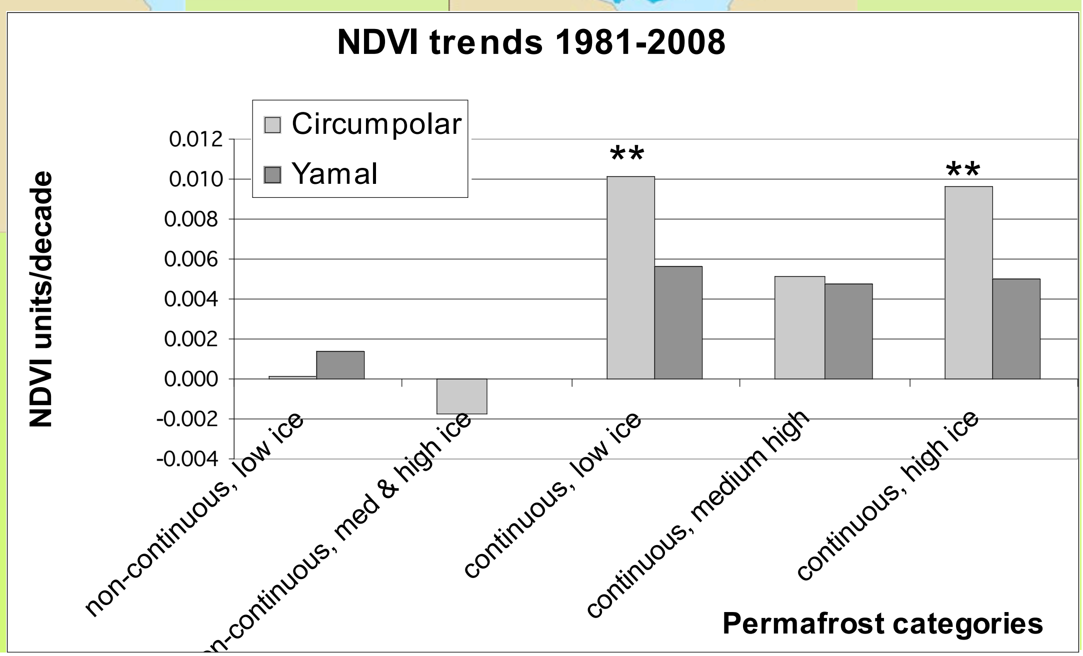




•Low precipitation categories have significant positive trends in NDVI
•NDVI trends decrease in higher precipitation categories, which are mostly in the northern areas
•Yamal patterns are similar







- Large positive trends in NDVI for continuous permafrost

- Little change for non-continuous permafrost

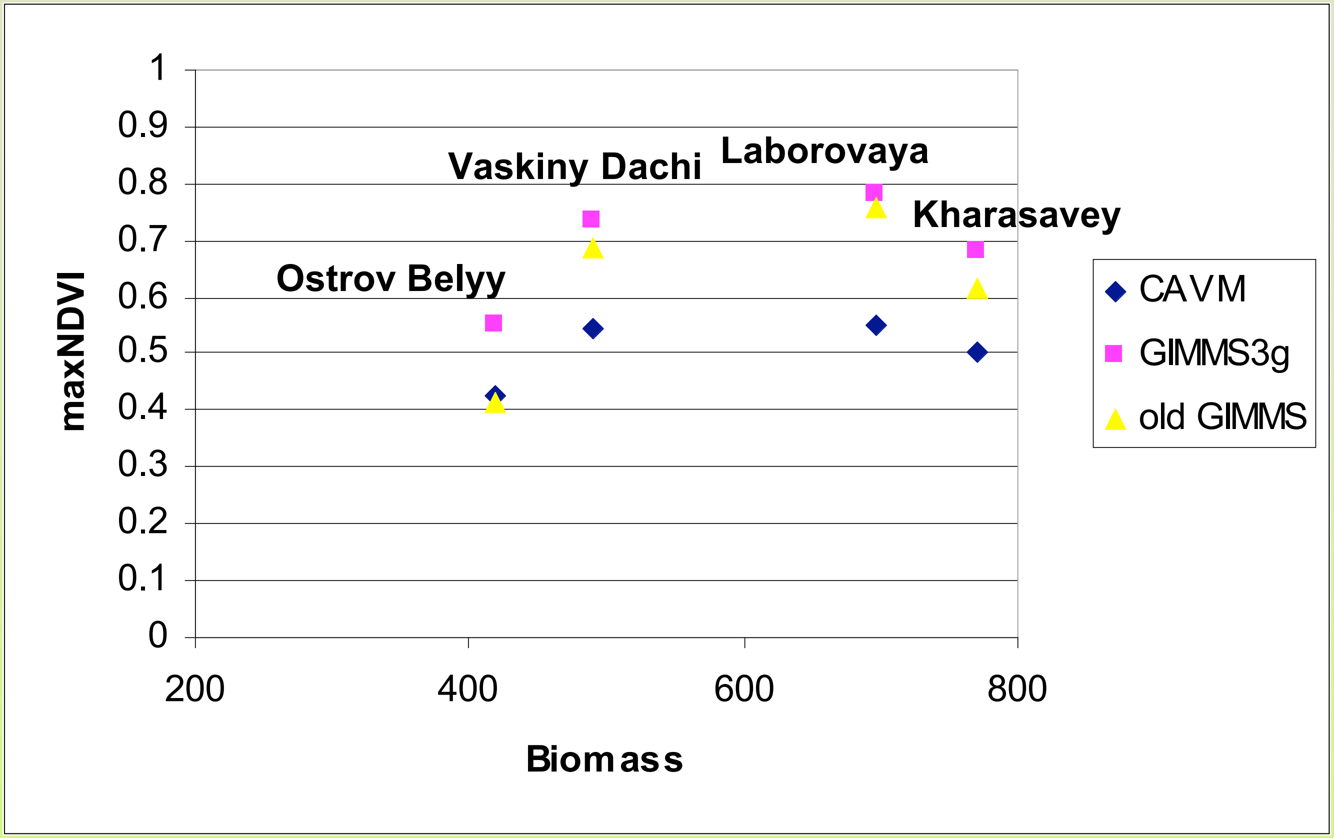
- Yamal trends similar to circumpolar

Northern areas, with low precipitation and continuous permafrost are showing the fastest increases in NDVI

Why?

Artifact due to saturation of NDVI at high biomass values?

Biomass values collected from field sites compared with AVHRR NDVI values



No sign of saturation of NDVI values at high biomass, despite overall higher scale of new GIMMS3g NDVI data

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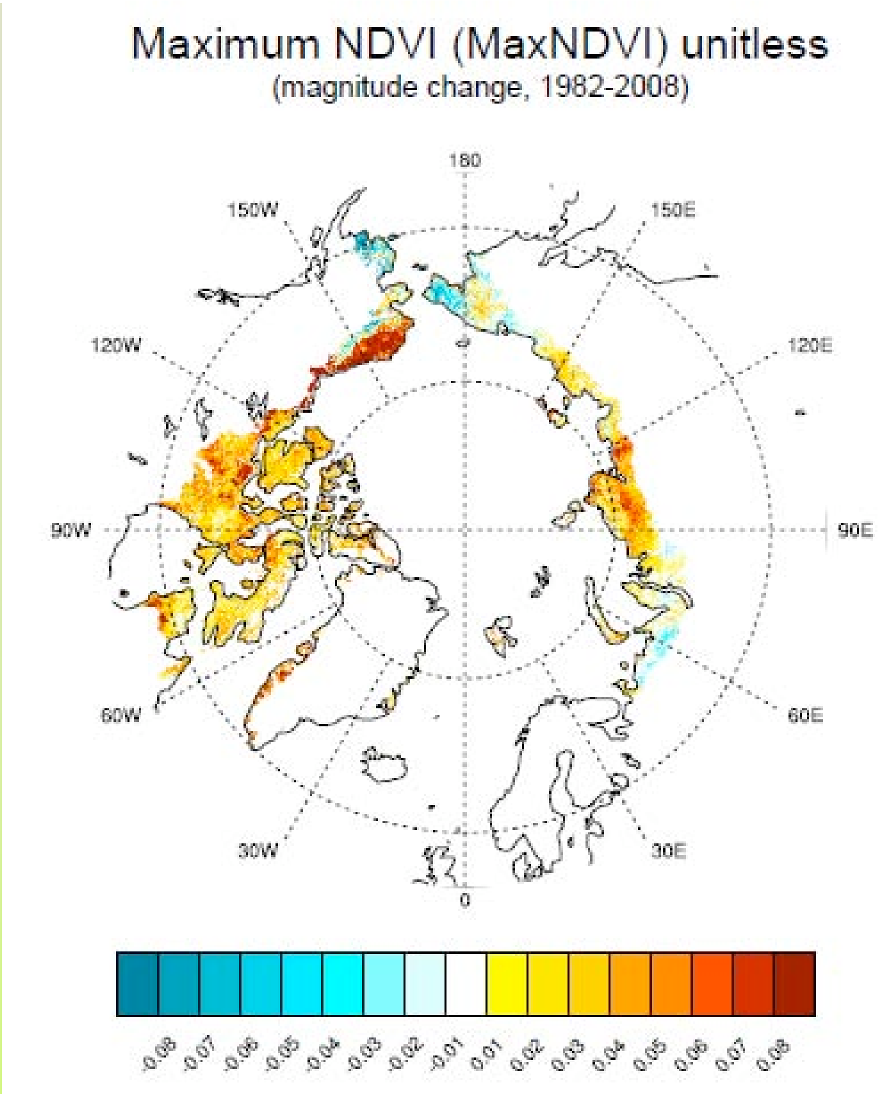
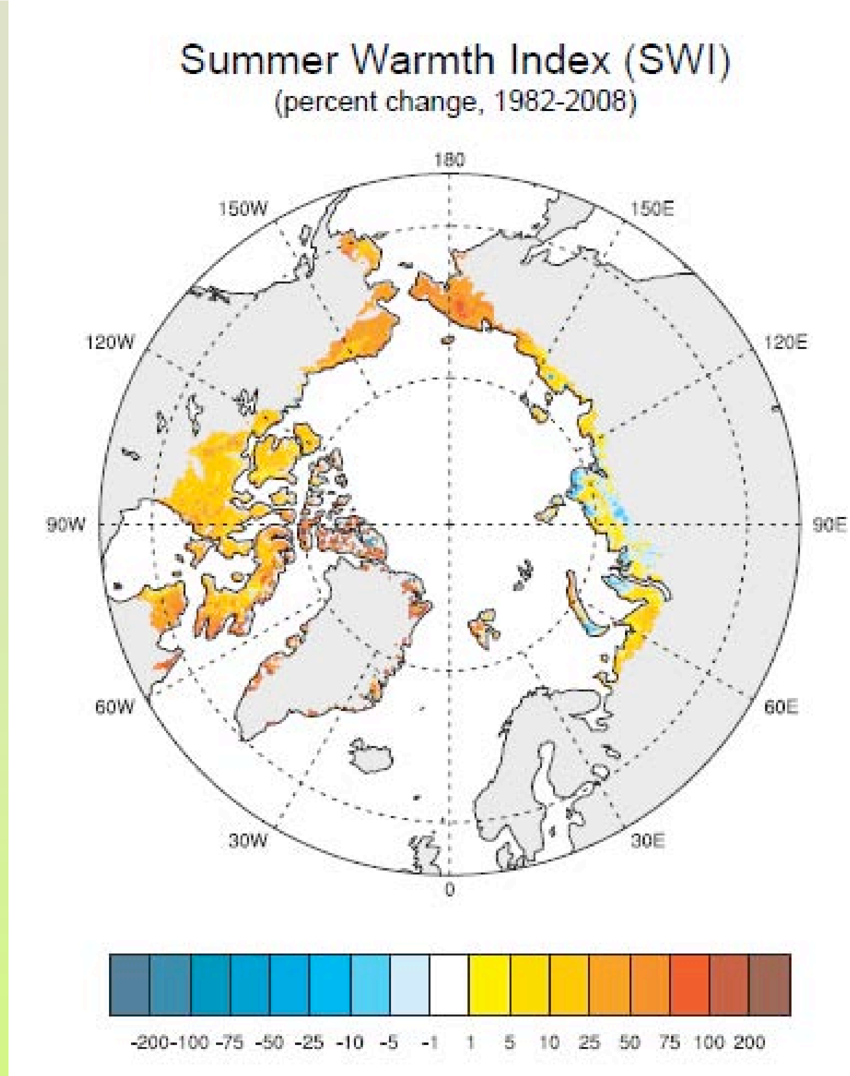
Why?

Due to increases in temperature?

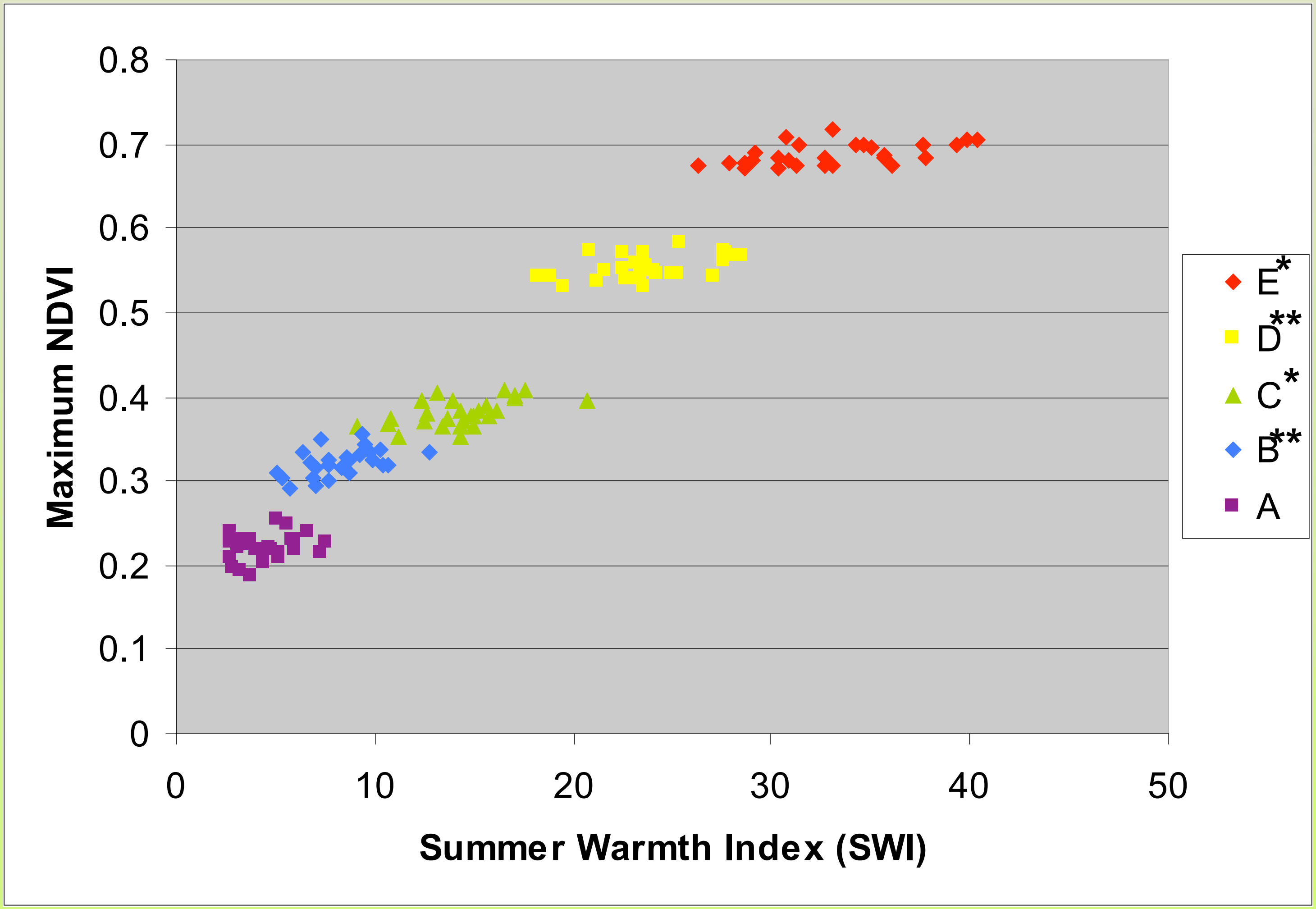




The most important factor affecting arctic vegetation is summer temperatures, so I analyzed how variation in trends of summer temperatures compared with the trends in NDVI

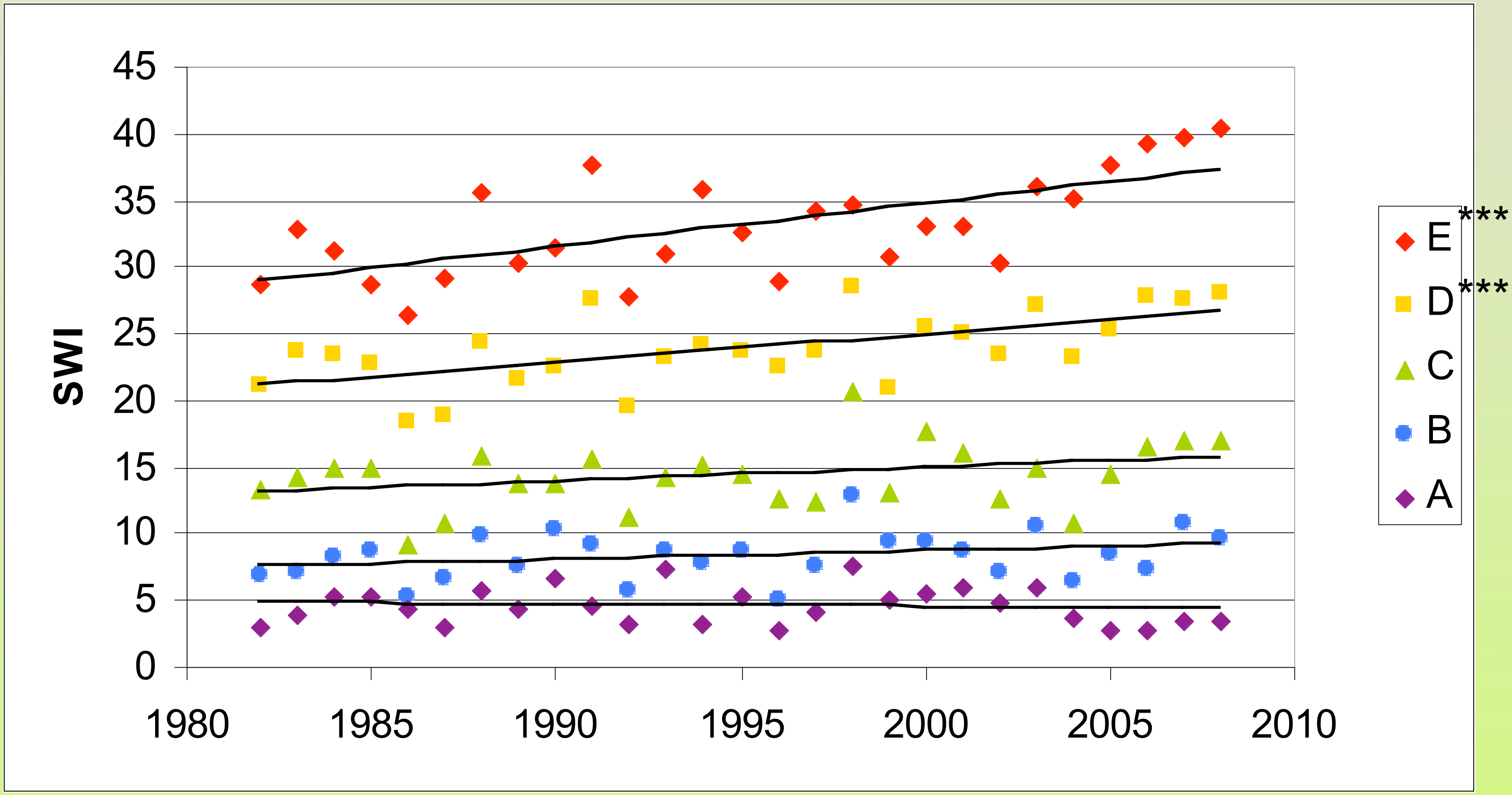
(Summer Warmth Index is the sum of monthly means > 0°C)

Summer Warmth Index and maximum NDVI for each year, 1982-2008 shown for different arctic bioclimate subzone



- *Linear correlation between NDVI & SWI is significant for all but bioclimate subzone A*
- *Also tested 1 year lag in NDVI response to SWI and found no significant correlation*

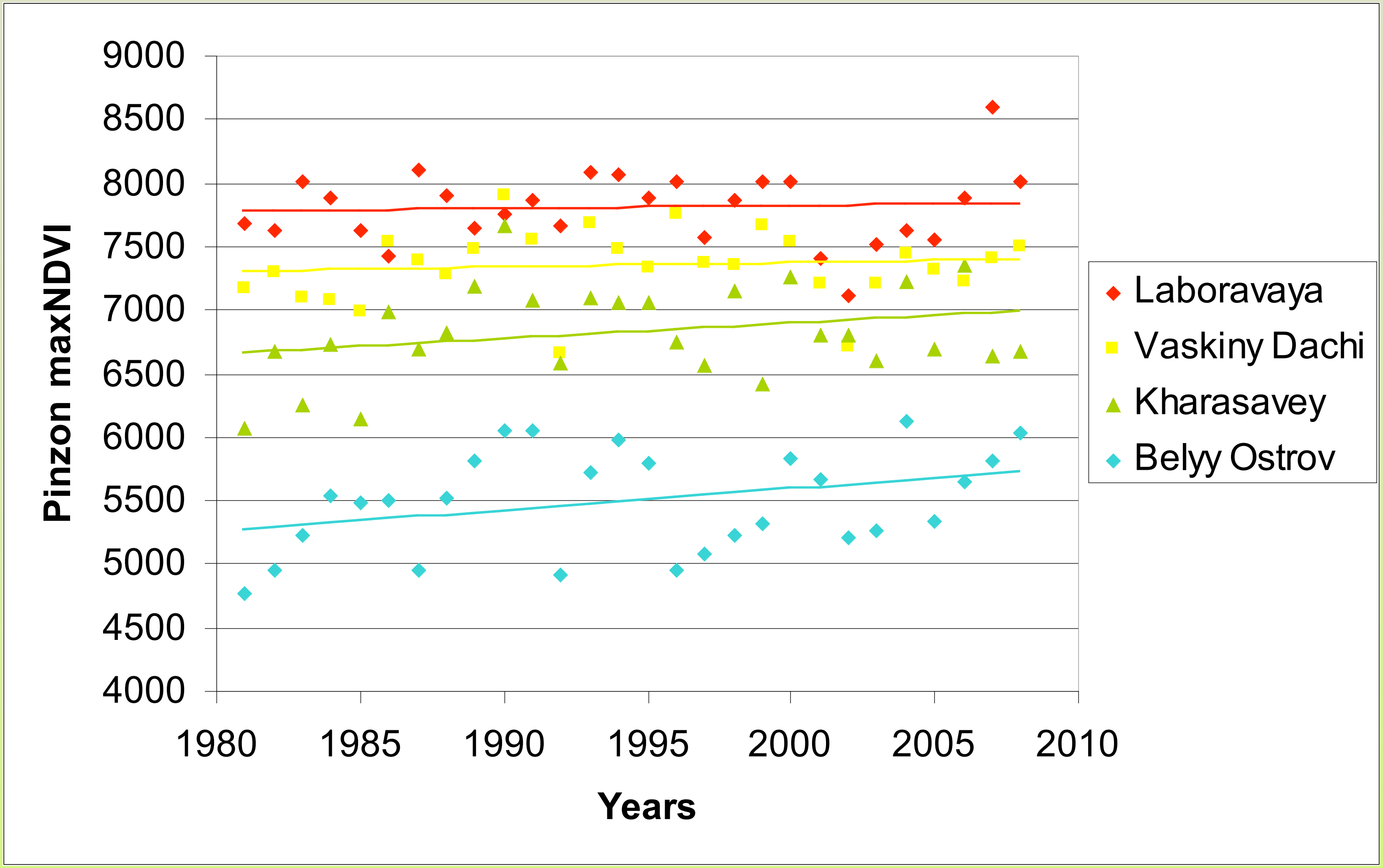
Trends in Summer Warmth Index, 1982-2008
by arctic bioclimate subzone



Trends in SWI are only significant for circumpolar bioclimate subzones D & E and not for any bioclimate subzones on Yamal subset

Northern areas, with low precipitation and continuous permafrost are showing the fastest increases in NDVI

Yet temperature increases are strongest in the southern parts of the Arctic



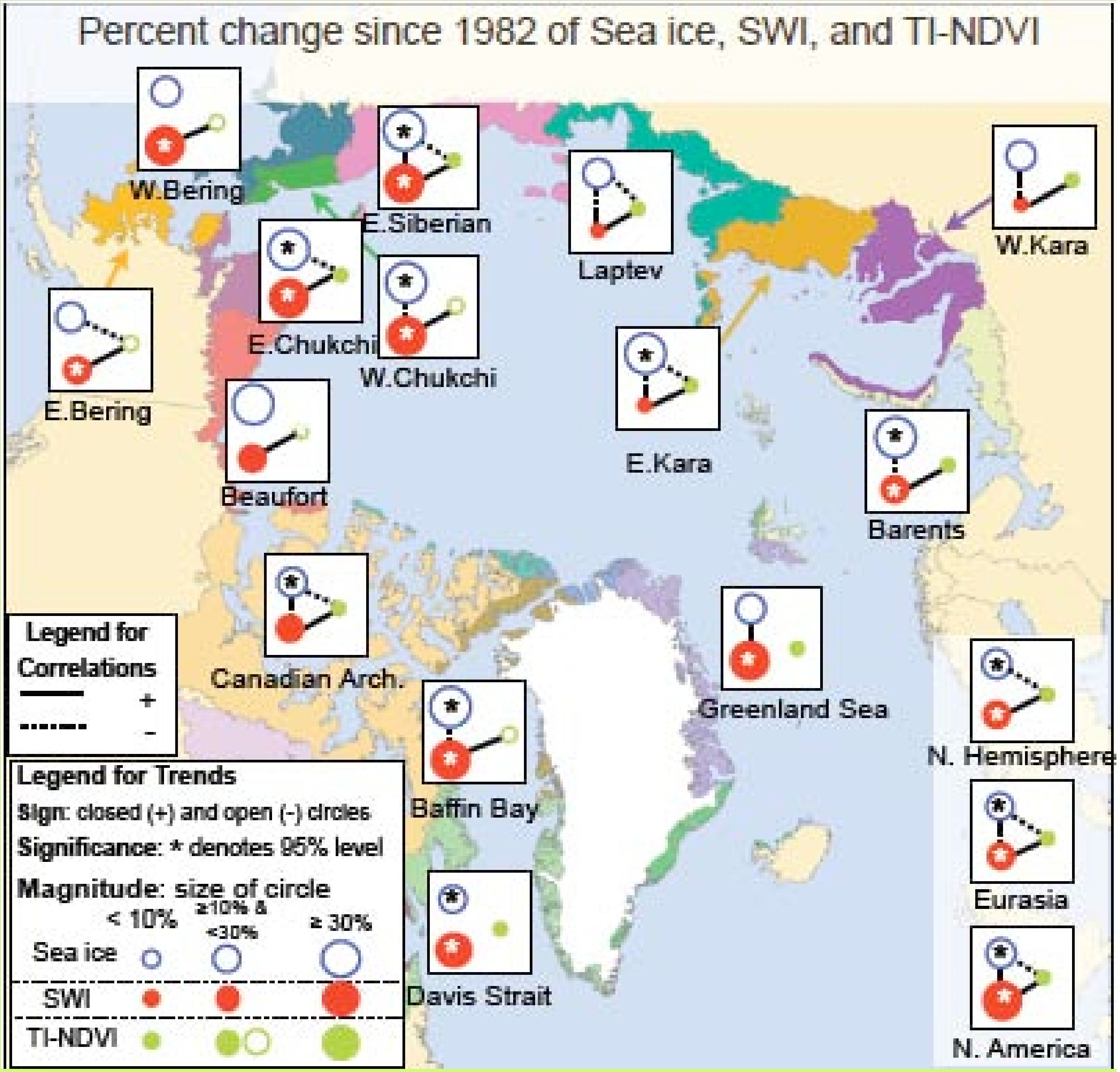
Trends for NDVI of Yamal Peninsula subzones and for specific study sites on the Yamal show same trends as circumpolar Arctic, with greatest increases in NDVI in coldest areas.

So we have not yet found what is controlling the variation in NDVI trends in the Arctic.

Issues of scale

Spatial scale

- Correlation analysis between sea ice temperature and NDVI at the scale of the Arctic, Eurasia and North America – as one would expect (Bhatt et al. 2009)



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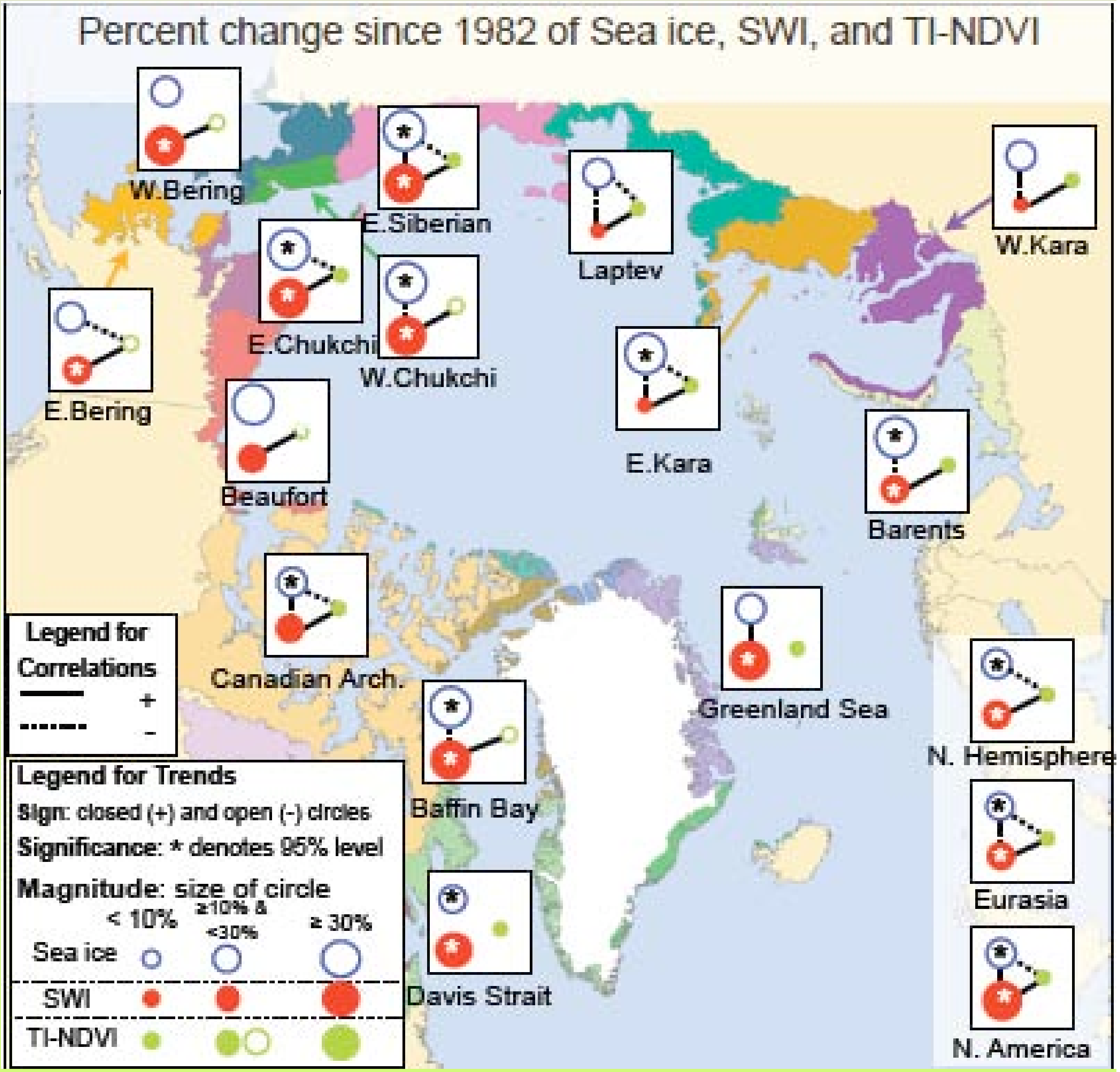

TRY TO MAKE TREND MAPS IN ARC

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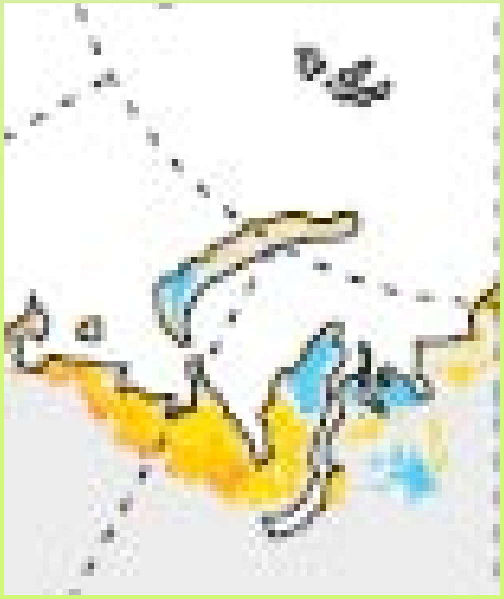
•Northern Yamal cooled slightly over the satellite record, yet showed larger changes in NDVI than southern Yamal, where SWI increased.

NDVI



SWI

Temporal scale

•There may be lags in vegetation response to temperature, but both Uma & I tested for short (1-2 year) lag effects and did not find strong ones.

•Our time scale may not adequate to detect the causes and effects in this temperature-vegetation interaction. We know the vegetation in many parts of the Arctic is still responding to changes in climate since the last glaciation.

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Role of disturbance

- Initial effect of increased temperature may lead to most disturbance in warmer areas – with discontinuous permafrost or ice rich permafrost (Lantz et al.2009)

- Initially disturbance will decrease NDVI, but if vegetation succession is faster than disturbance rates NDVI will increase over longer time periods.

- Disturbance in an area that has changed to a warmer climate facilitates the colonization of larger, higher biomass species (Frost et al., Lantz et al.)

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References

Bhatt, U. S. et al. 2009 in press. Trend and variability in the land-ocean margins of sea-ice concentrations, land-surface temperatures, and tundra vegetation greenness. — Earth Interactions

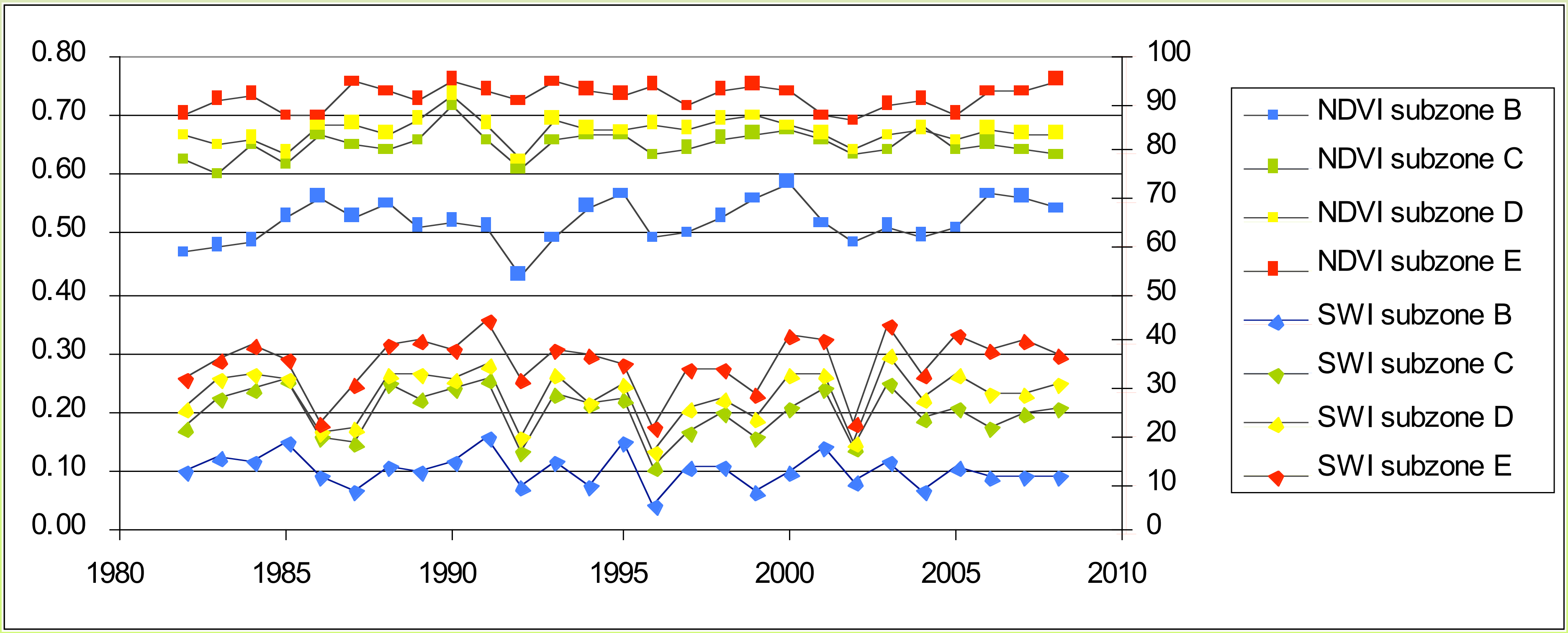
Lantz, T. C. et al. 2009. Relative impacts of disturbance and temperature: persistent changes in microenvironment and vegetation in retrogressive thaw slumps. — Global Change Biology 15: 1664 - 1675.

Lantz, T. C. et al. 2010. Spatial heterogeneity in the shrub tundra ecotone in the Mackenzie Delta region, Northwest Territories: implications for arctic environmental change. — Ecosystems 10.1007/s10021-009-9310-0:

Comiso 2003

Questions?

The pattern in Yamal NDVI trends are opposite those in SWI for bioclimate subzones: NDVI trends increase with latitude while temperature trends decrease with latitude



Trends in circumpolar SWI are opposite trends in NDVI for bioclimate subzones: circumpolar NDVI trends increase with latitude;