Deciduous shrub growth and the greening of the Arctic in West Siberia

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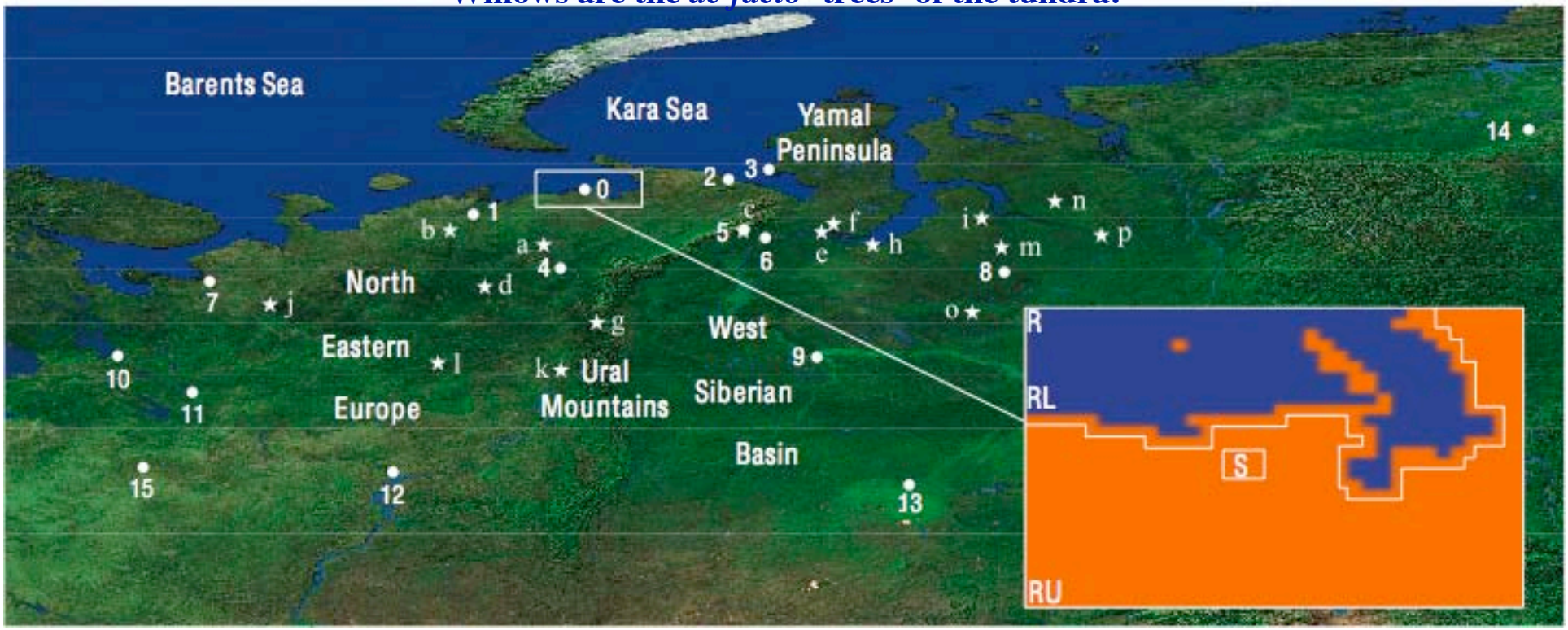
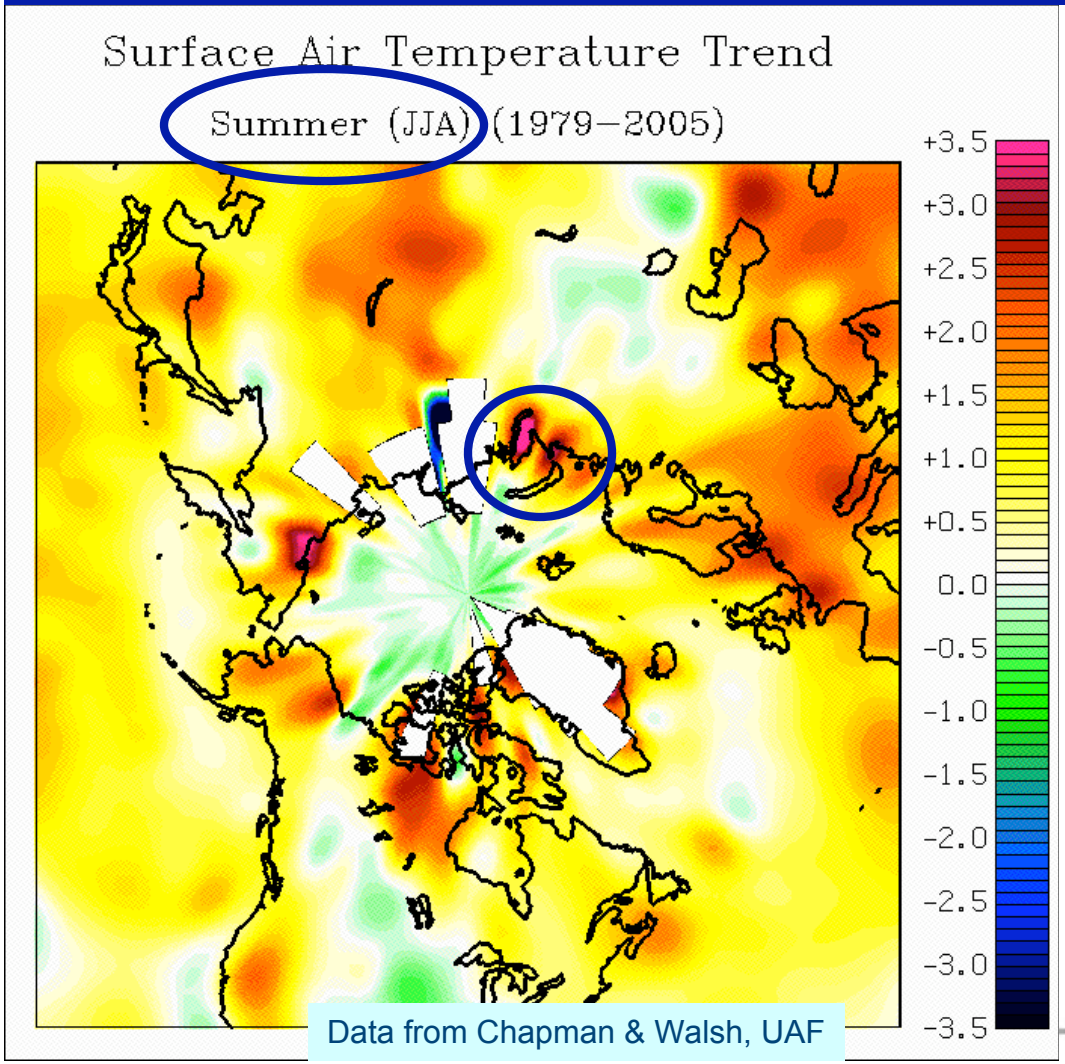
- **According to ACIA (2005) and the IPCC (2007), growth in arctic vegetation is generally expected to increase under a warming climate, particularly among deciduous shrubs.**
- **In the first phase of our study we analyzed annual ring growth for an abundant and nearly circumpolar erect willow (*Salix lanata* L.) from the coastal zone of the northwest Russian Arctic (Nenets Autonomous Okrug) (Forbes et al. *Global Change Biology* 2009).**

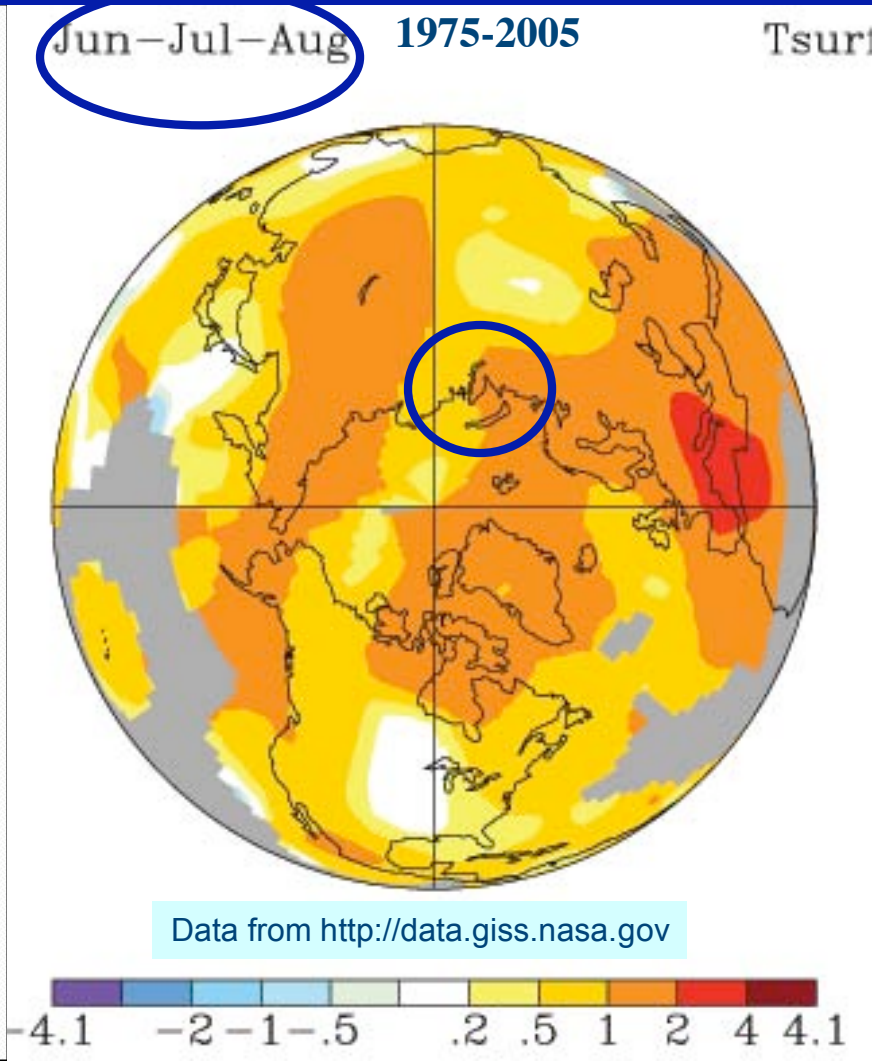
Willows are the *de facto* 'trees' of the tundra!



The summer warming trend for Nenets and Yamal-Nenets Autonomous Okrugs looks different depending on which data sets you use and over what time periods. For the ≈30 yr period from mid-late 1970s to 2005, it appears that air temperatures have increased from 1-2+°C.

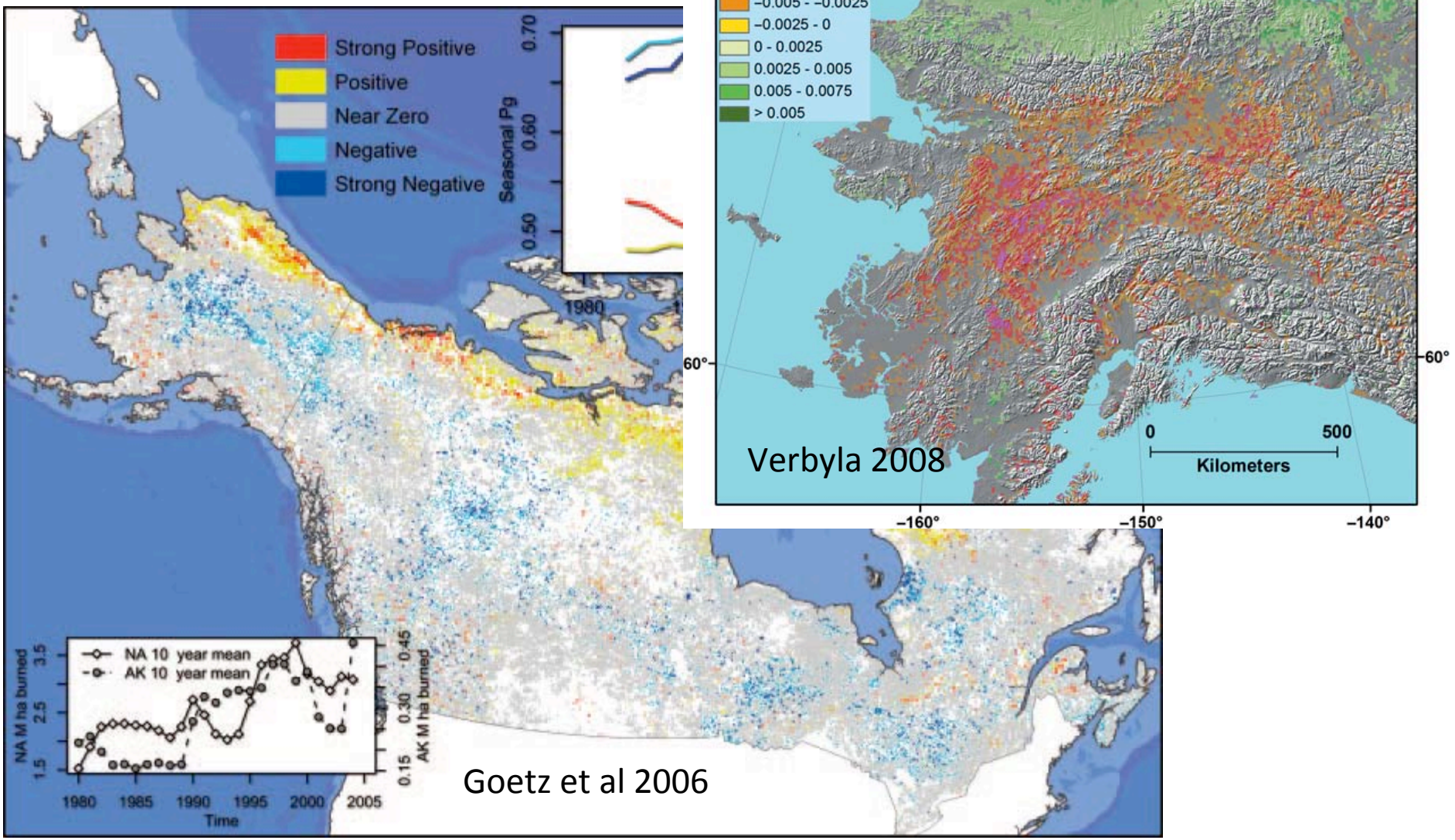


Data from Chapman & Walsh, UAF



Data from http://data.giss.nasa.gov

The Greening and the Browning of the Arctic and Boreal regions. As J.J. said, ground-level quantitative data lacking for Eurasian Arctic



The growth trend agrees with qualitative observations by nomadic Nenets reindeer herders of increases in willow size in the region

Bruce inventories *Salix* samples Varandei, July '06

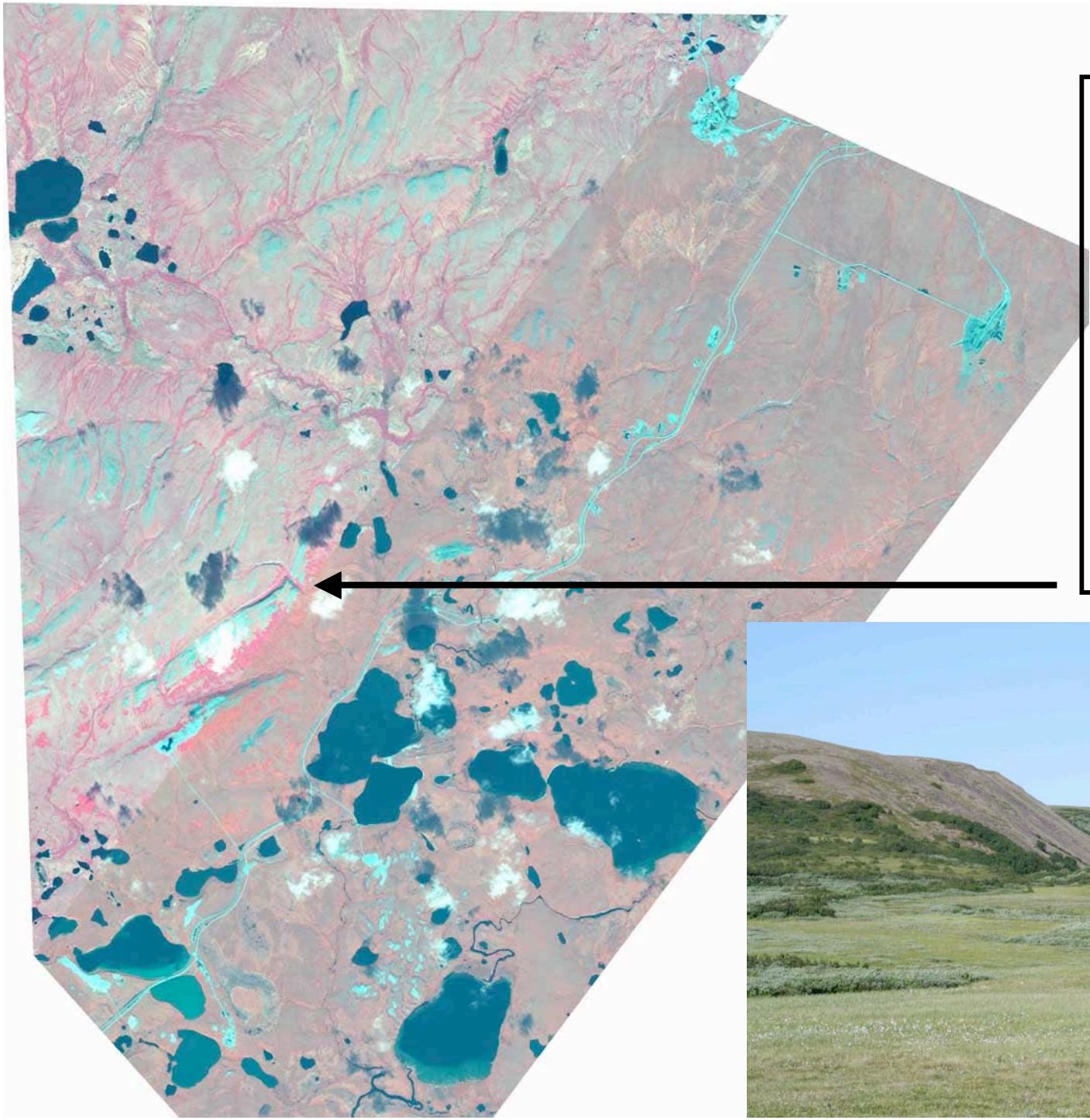
Florian cuts *Salix* samples at Bovanenkovo, July '05

Salix thickets near Varandei July ‘06

Salix thickets near Bovanenkovo July ‘05

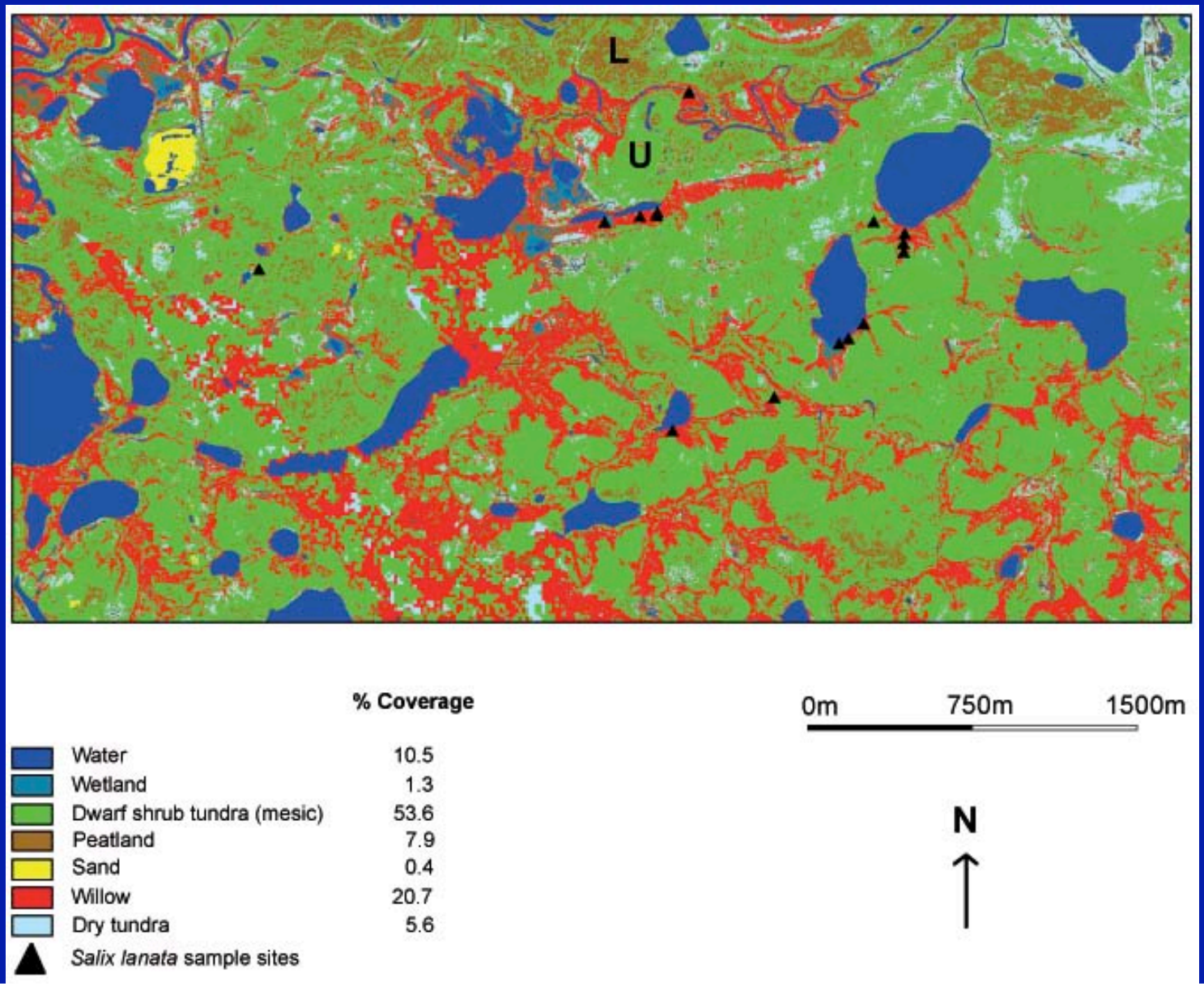
Salix and *Alnus* thickets near km 143, July ‘07

Salix and *Alnus* thickets near km 143, July ‘07

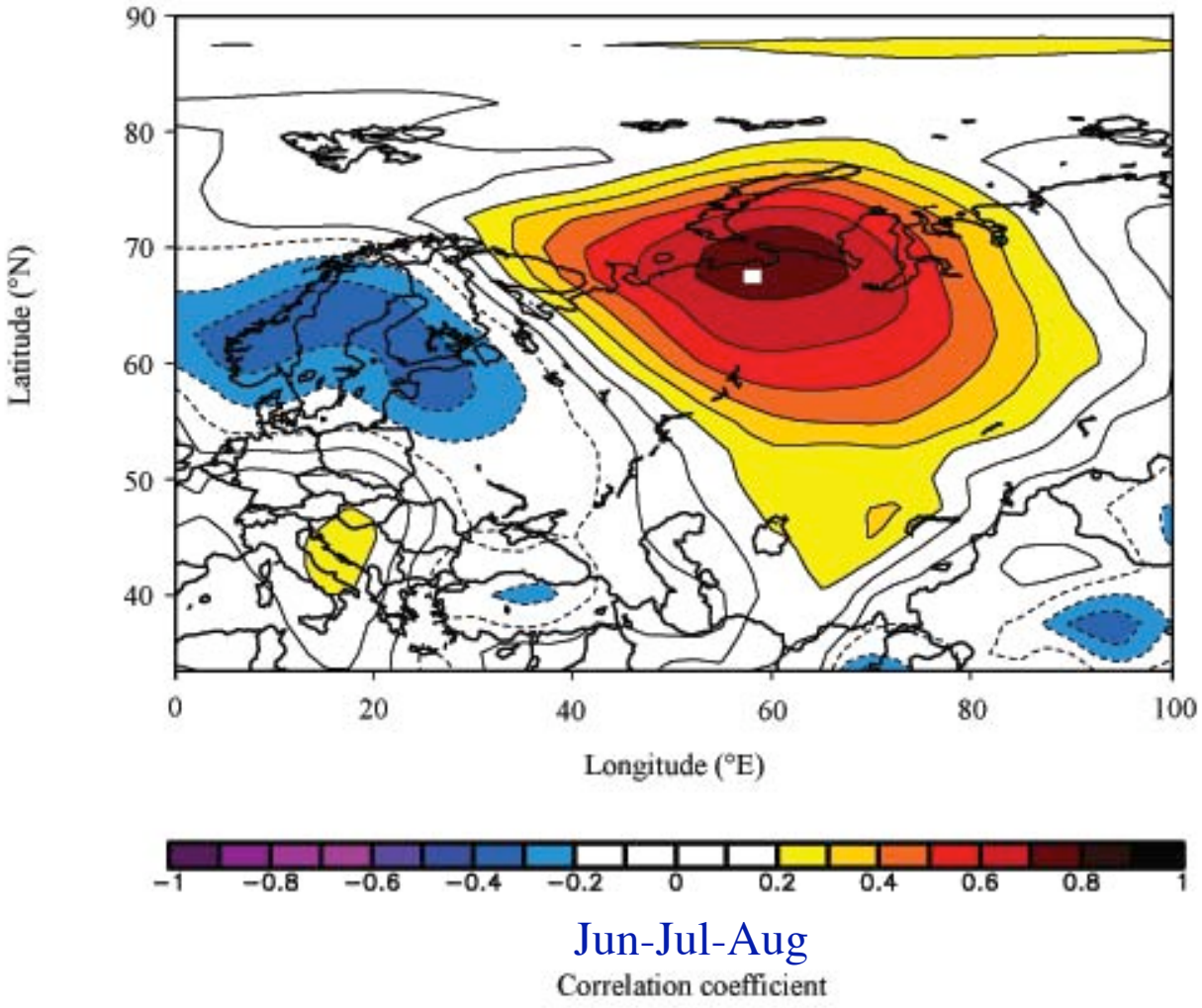


Location of *Salix lanata* and *Alnus fruticosa* sampling sites at km 143 (Laborovaya). All relatively stable sites, so individuals up to 100 yr old, as opposed to successional that J.J. mentioned.

Supervised land classification of the sampling area on a very high resolution Quickbird-2 image, taken on 5 August 2005 from Varandei tundra. The percentages of land cover for each class are shown. Note the sharp change between the upland (U) and lowland (L) at the northern edge of the image, the lowlands having a much greater proportion of peatland.

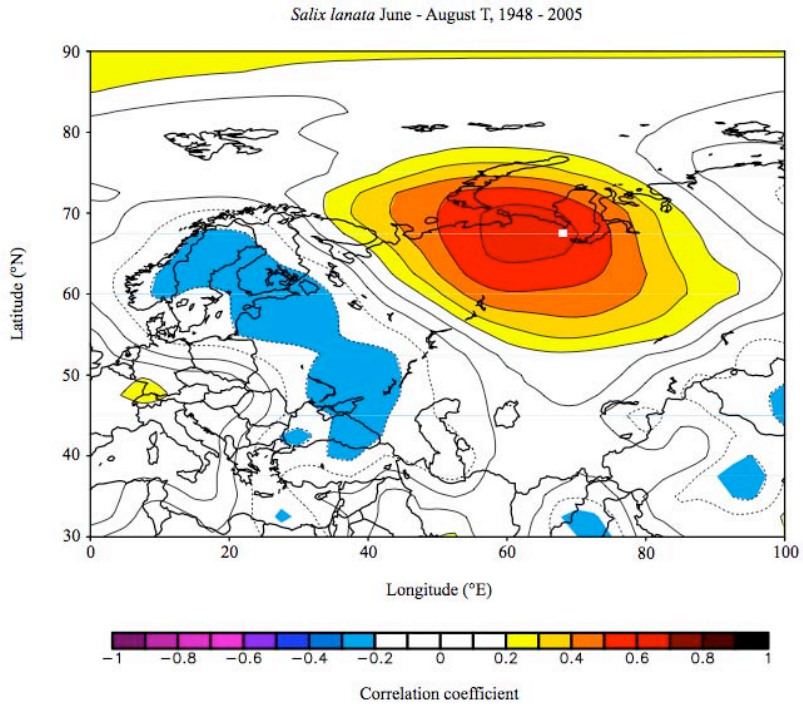


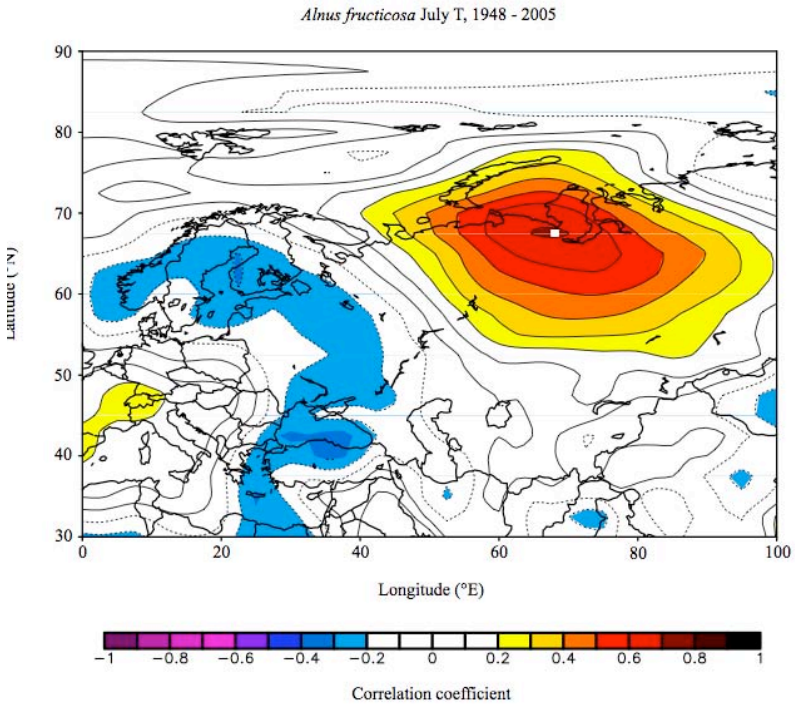
The resulting chronology from Varandei was strongly related to summer temperature for the period 1942-2005. Remarkably high correlations occur at long distances (>1600 km) across the tundra and taiga zones of West Siberia and Eastern Europe.



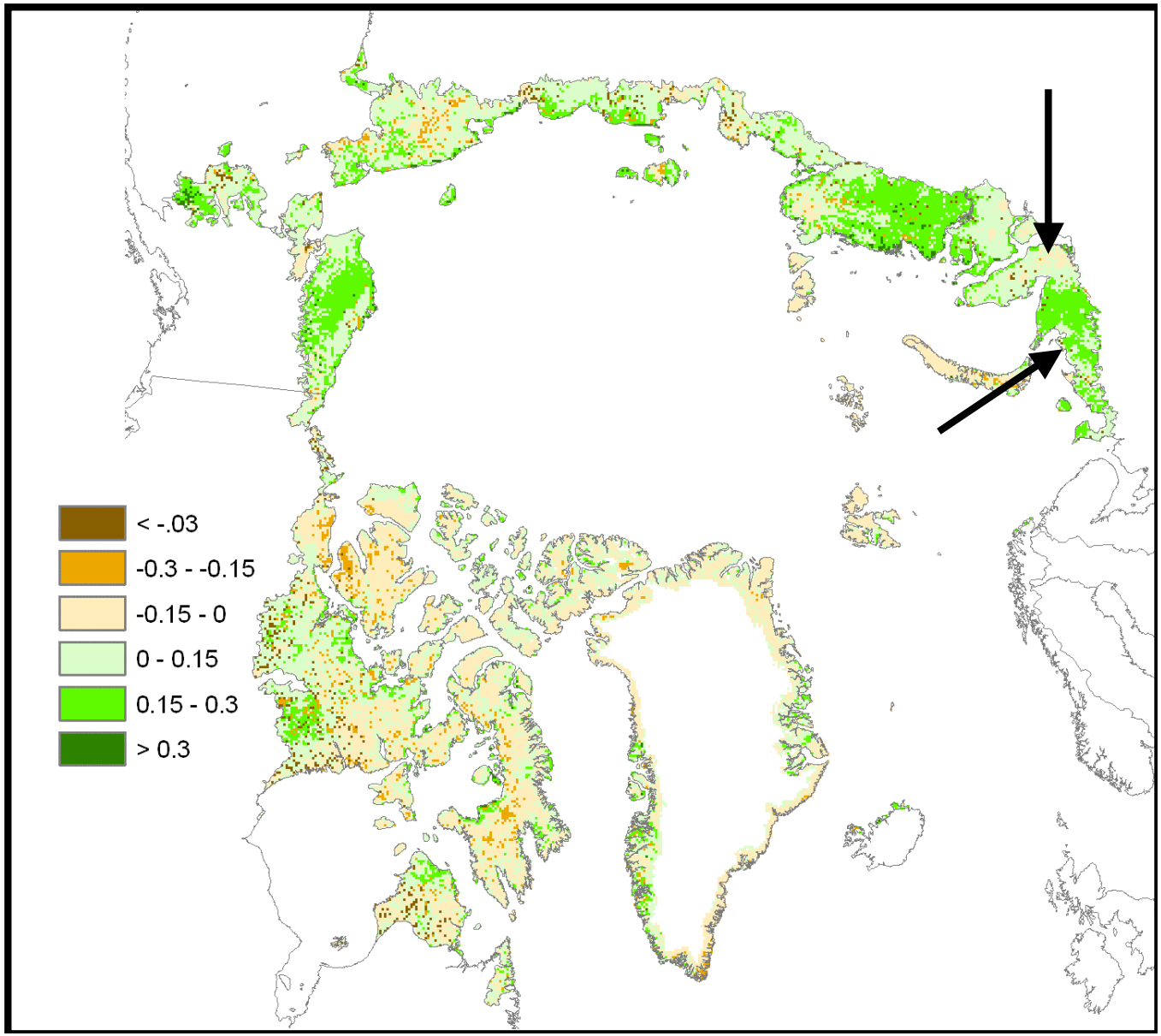
- **We also found a clear relationship with photosynthetic activity (NDVI) for upland vegetation at a regional scale for the period 1981-2005, confirming a parallel 'greening' trend reported for similarly warming North American portions of the tundra biome**

With two new chronologies from Laborovaya on Yamal, we have found that July is the main month for temperature correlation in *Alnus*, whereas it is a composite of June-August for *Salix* in both regions. In all three chronologies the correlation between ring width was high over huge territories.





Expected NDVI value as calculated by SWI regression equation

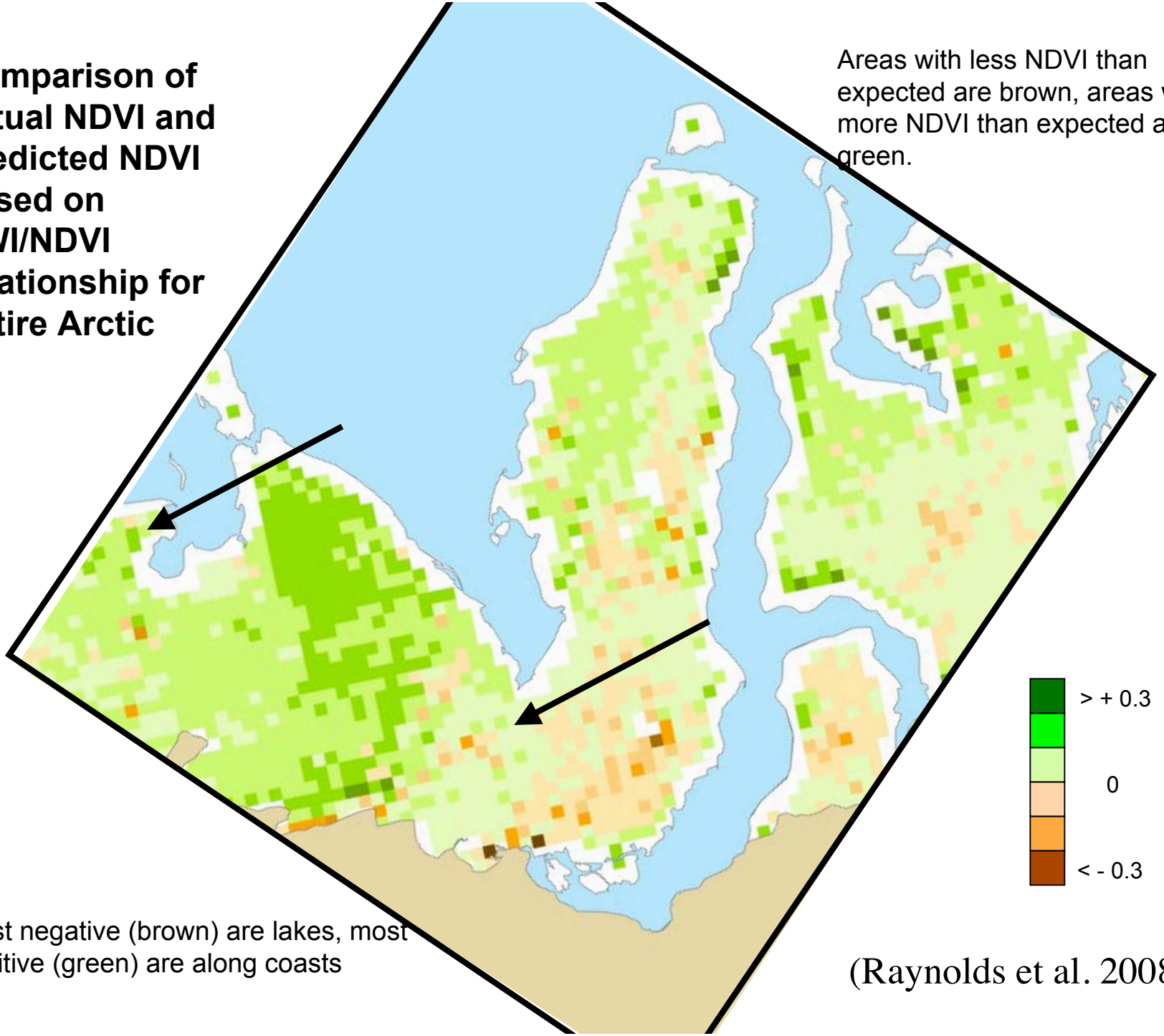


Areas with less NDVI than expected are brown, areas with more NDVI than expected are green.

(Raynolds et al. 2008)

Comparison of actual NDVI and predicted NDVI based on SWI/NDVI relationship for entire Arctic

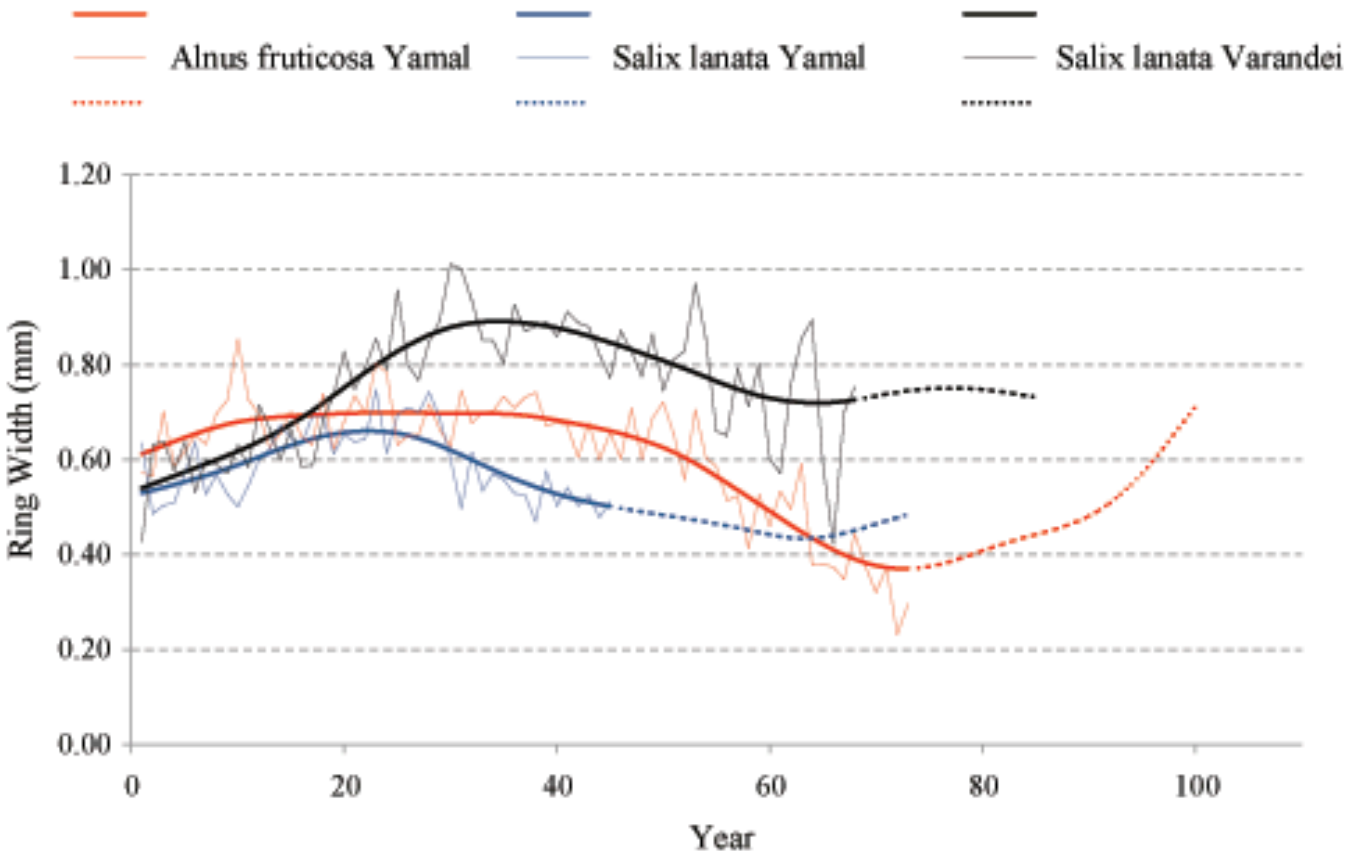
Areas with less NDVI than expected are brown, areas with more NDVI than expected are green.



Most negative (brown) are lakes, most positive (green) are along coasts

(Raynolds et al. 2008)

AGE-RELATED GROWTH CURVES



Age-related growth curves (in mm per year) for each shrub chronology. Dashed lines correspond to unreliable parts of each curve due to low sample replication. Thick smooth curves are depicted to highlight the low-frequency age-related growth trends. Note the larger overall growth in Varandei, and the similar shape of the growth curves for Salix lanata, the one in Yamal being shorter.

The hand-held NDVI data from Yamal indicate a significant difference between loamy and sandy sites.

We hypothesized that these same differences would be evident, though magnified, by comparing the chronologies of relatively loamy sites on Yamal with the extremely organic soils of Varandei.

Salix lanata from Varandei tundra 1943-2005

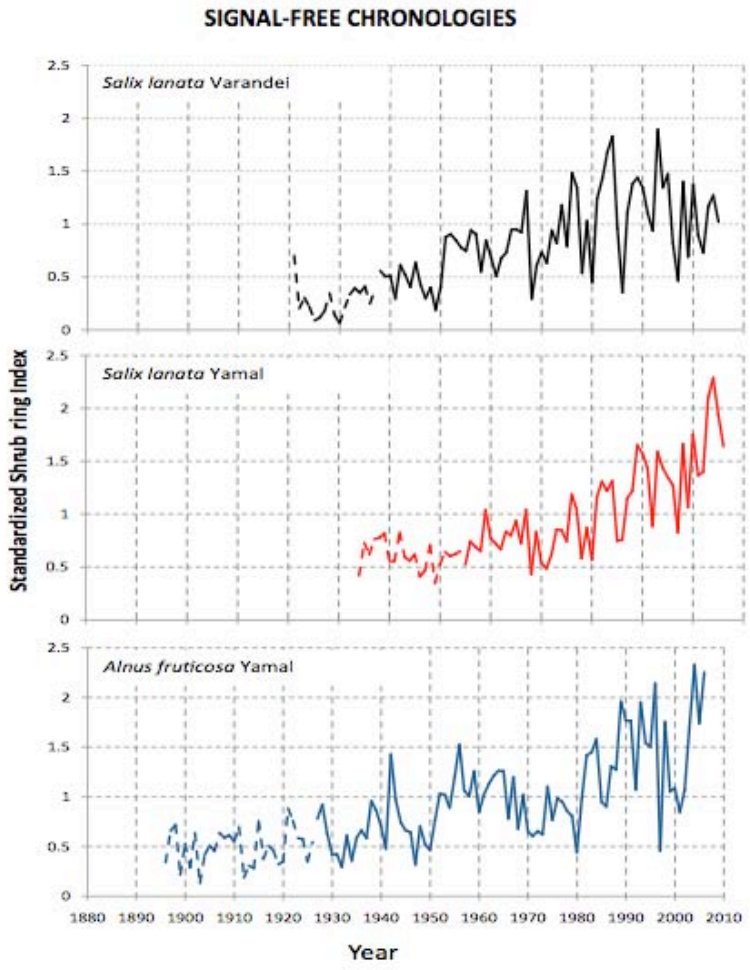
Relative growth of shrubs of same age cohort (ca. 60 years) from contrasting regions (NAO vs. YNAO) seen from stem slices in the lab. There can be different factors that might influence growth, e.g. soil conditions, competition with neighbouring shrubs (dominant or suppressed), and differences in the genotype of trees (e.g. long/tall genets with overall narrow rings vs. short/stout genets with overall largge rings).

Salix lanata from Laborovaya 1947-2007

Alnus fruticosa from Laborovaya 1943-2006

Briffa and colleagues recently proposed an even stricter approach for removing noise/distortion from standardization. Marc Macias Fauria was here last month and we applied it our data set. The standardized growth curve suggests a significant increase in shrub willow growth over the last six decades. These findings are therefore in line with field and remote sensing studies that have assigned a strong deciduous shrub component to greening signal since the early 1980s.

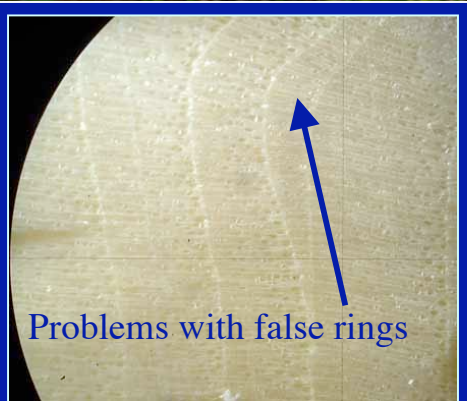
Mary Edwards et al. (2005) argue based on palaeo data (pollen/macro fossils) from E Siberia and NW Canada that *deciduous* boreal forest should be included in the range of future scenarios used to assess the probable feedbacks of vegetation to the climatic system that result from global warming at northern high latitudes. The reason is that low shrub thickets can transform *in situ* to erect shrub/forest and our data support this.



	Alnus fruticosa Yamal	Salix lanata Yamal	Salix lanata Varandei
Alnus fruticosa Yamal	1.000		
Salix lanata Yamal	0.766	1.000	
Salix lanata Varandei	0.600	0.648	1.000

Upper: Signal-free chronologies for Yamal and Varandei shrub ring-width measurements. Chronologies are the result of a standardization process that tries to minimize trend distortion (common in other standardization methods) and capture only climate-related information. The dashed part of each chronology indicates the period for which sample replication is too small.
Lower: inter-chronology pearson correlations

The quality of the chronology as a proxy for summer air temperature is exceptional. Given its wide geographic distribution and preservation in permafrost, including ancient Nenets campsites, *Salix lanata* and *Alnus fruticosa* have great potential for extended temperature reconstructions in remote areas across the Arctic. Why has this not been done before? Cross-dating of the microscopic growth rings is difficult and time consuming. This results from problems such as false growth rings and the large number of samples required because of the 'reaction wood'. Reaction wood also affects ability to model shrub biomass but Natalia U has solved this!




Thank
you!