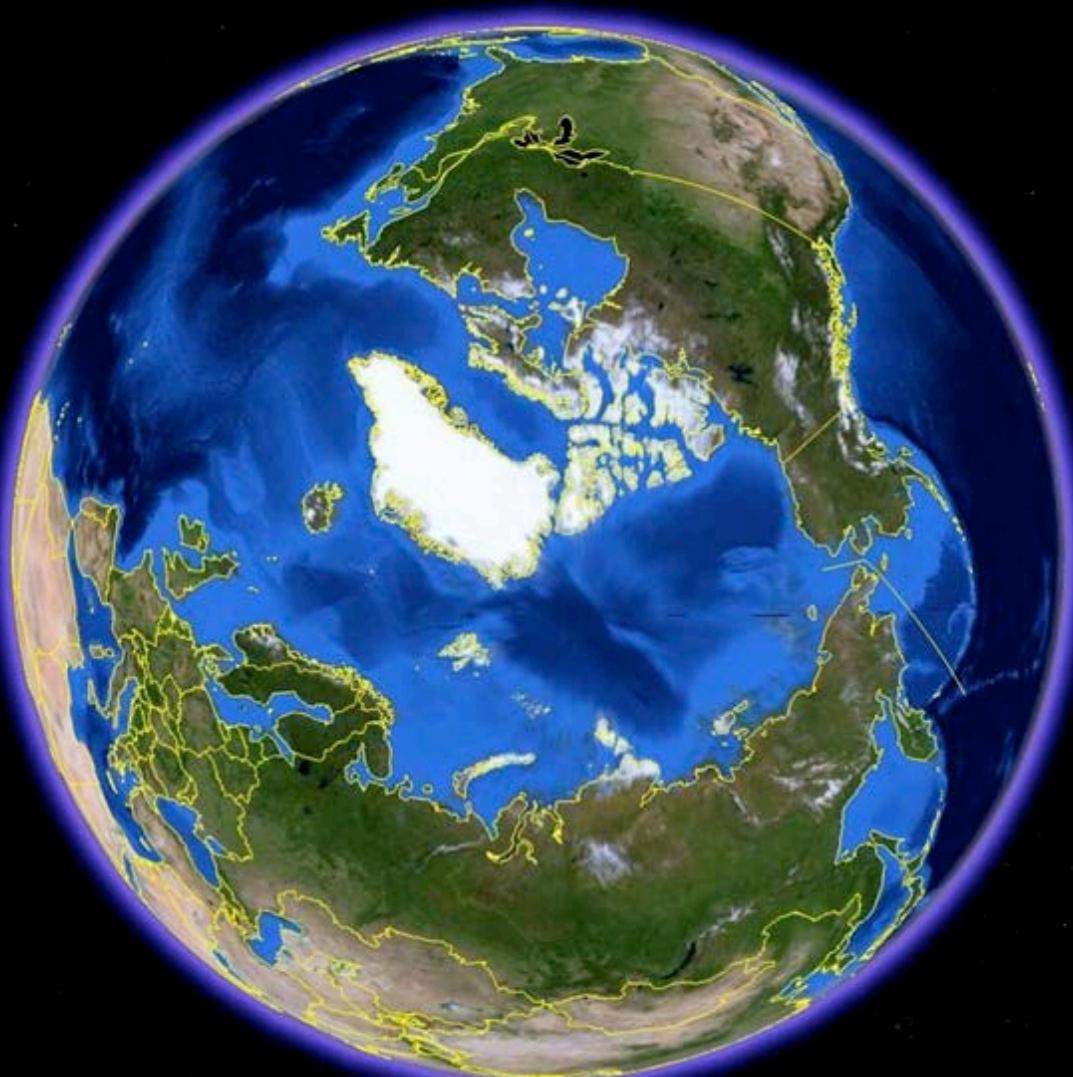


# Greening of Arctic: Knowledge and Uncertainties



Jiong Jia, Hesong Wang  
Chinese Academy of Science  
[jiong@tea.ac.cn](mailto:jiong@tea.ac.cn)

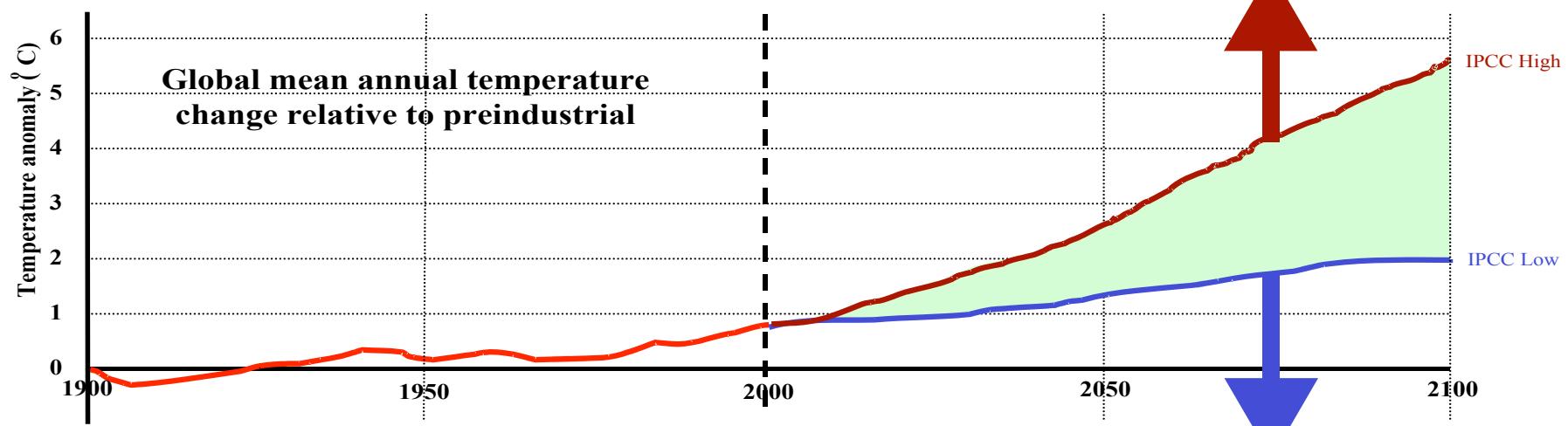
Howie Epstein  
Skip Walker

Moscow, January 28, 2008

# Global Warming and Its Impact

## IMPACTS FOR HIGH WARMING SCENARIO

OBSERVED	Some increase in extreme climate events	Risks of large scale discontinuities	Extreme and irreversible effects
	Small positive or negative net monetary impacts (most people adversely affected)	Net negative monetary impacts	Aggregate impacts
	Net negative for some regions	Net negative for many regions	Distribution of impacts
	Risks to some systems	Risks to many systems	Unique and threatened systems



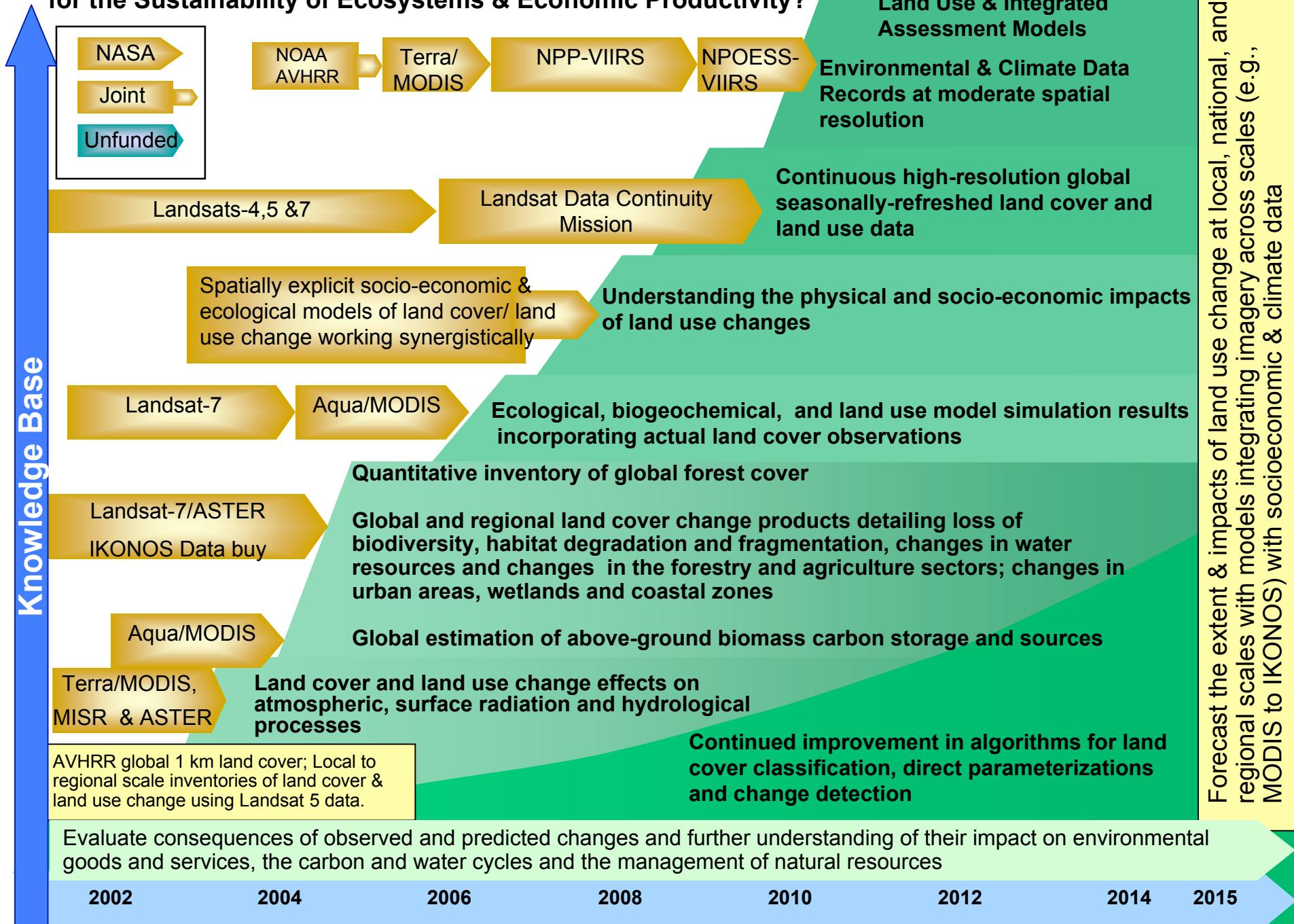
OBSERVED	Some increase in extreme climate events	Extreme and irreversible effects
	Small positive or negative net monetary impacts (most people adversely affected)	Aggregate impacts
	Net negative for some regions	Distribution of impacts
	Risks to some systems	Unique and threatened systems

## IMPACTS FOR LOW WARMING SCENARIO

# Available Data

- NASA **GIMMS** bi-monthly 8km 1981-2006
- Recent update for 2004-2006 (September 2007)
- NASA **PAL** monthly 4km 1982-1999 (Piao, Zhou, et al.)
- Long-term data record (**LTDR**), daily ~2000 (Missing data over 70 degree north)
- **MODIS** 2000-2007, collection 5, 4 (ORNL subsets)
- Landsat MSS, TM, ETM+ over many locations since early 1970s with 5-20 yr interval (Bruce, Jiong)
- Near future: NPOESS-VIIRS

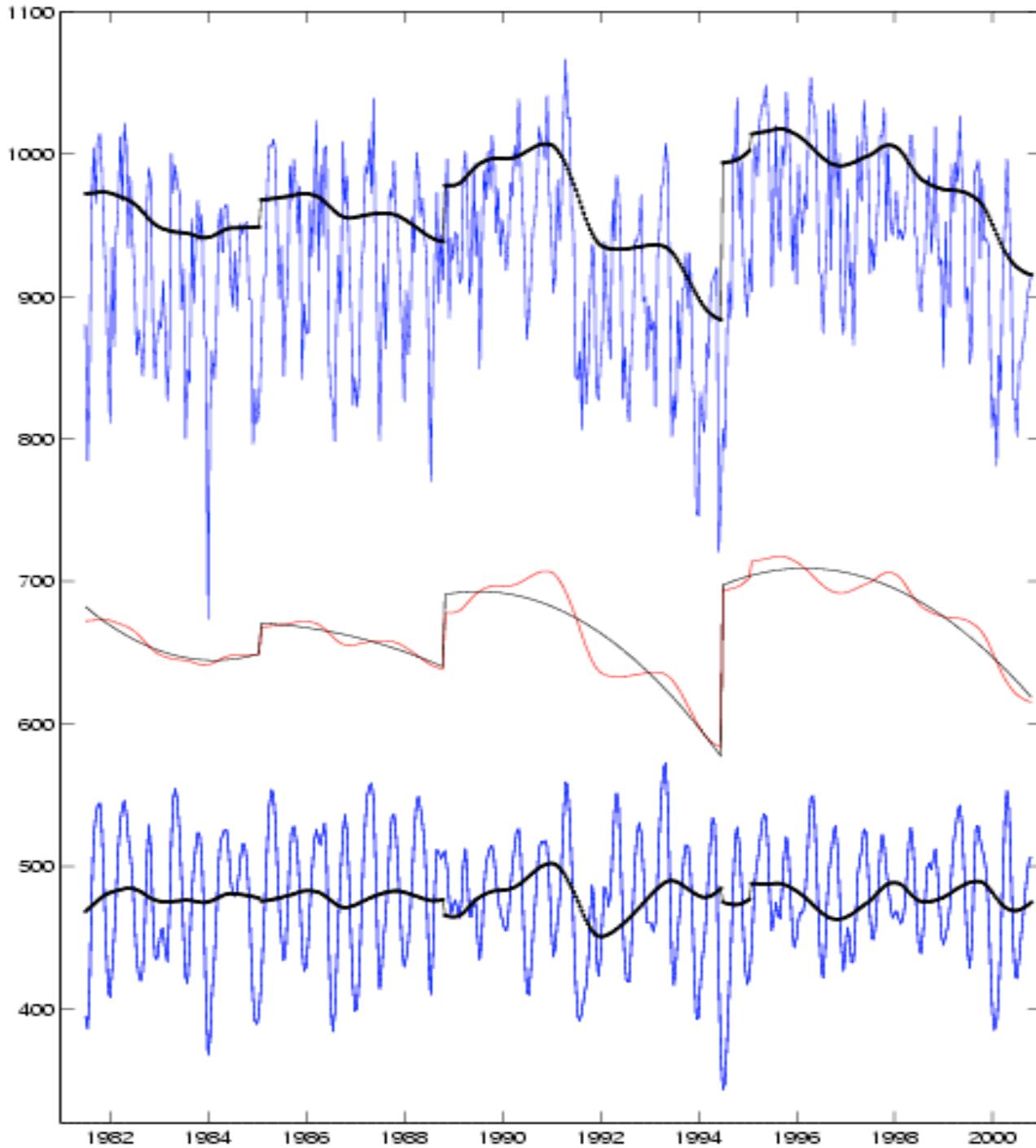
## What are the Consequences of Land Cover & Land Use Change for the Sustainability of Ecosystems & Economic Productivity?



# AVHRR Data Corrections

- Compared to newer sensors (e.g. MODIS, MISR), AVHRR lacks of onboard calibration;
- Low SNR due to cloud contamination and water vapor (Mostly corrected with MVC);
- Geometric registration errors (Mostly corrected);
- Volcanic aerosol effects for 1982-1984 and 1991-1994 (partly corrected);
- Residual sensor degradation and viewing angle effects due to satellite drift (partly corrected, problem over recent years)

Lat -1 Lon 20



Use of EMD  
technique and the  
removal of SZA-  
correlated trends

Top: Before draft  
correction,

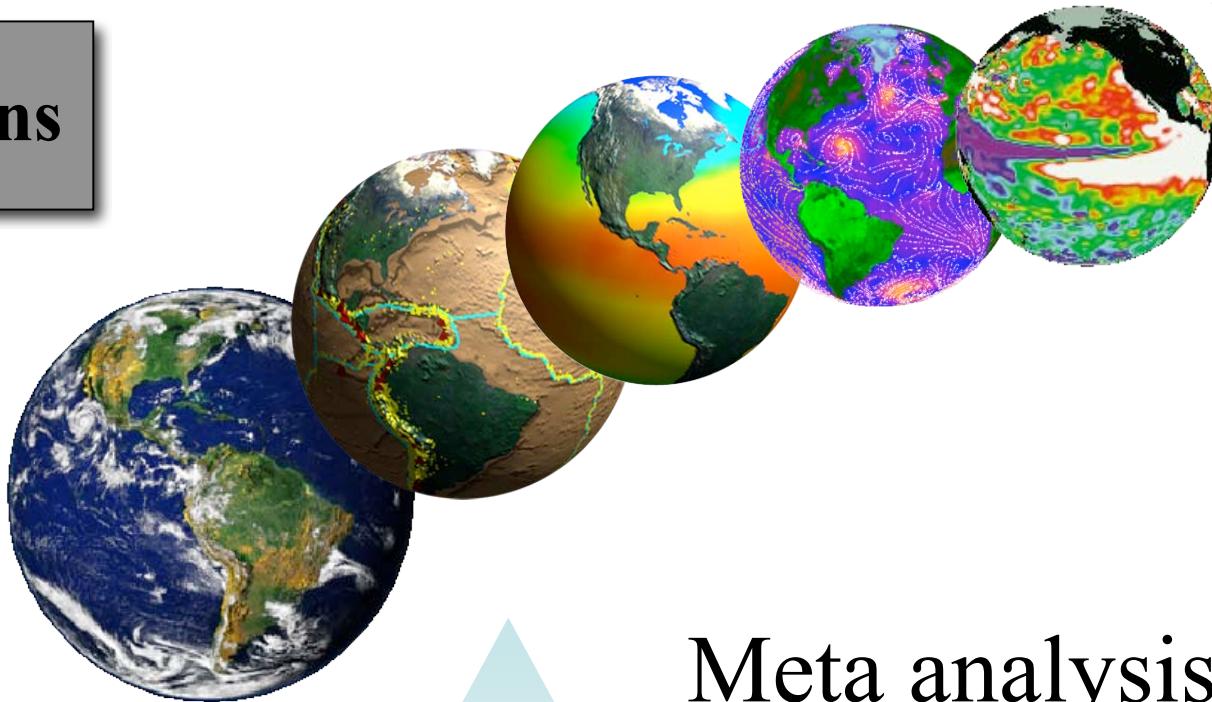
Middle: trend  
removed

Bottom: resulting  
series.

# What we have done

- Unmix the signal of vegetation and select areas with relatively homogeneous vegetation with MODIS and Landsat ETM+ for each subzone and boreal forest;
- Mask pixels of water and ice/snow in analysis;
- Temporal-spatial analysis of peak and time-integrated NDVI by continents and subzones
- Analysis of vegetation phenology
- Examining the uncertainties in interpreting trends of greenness

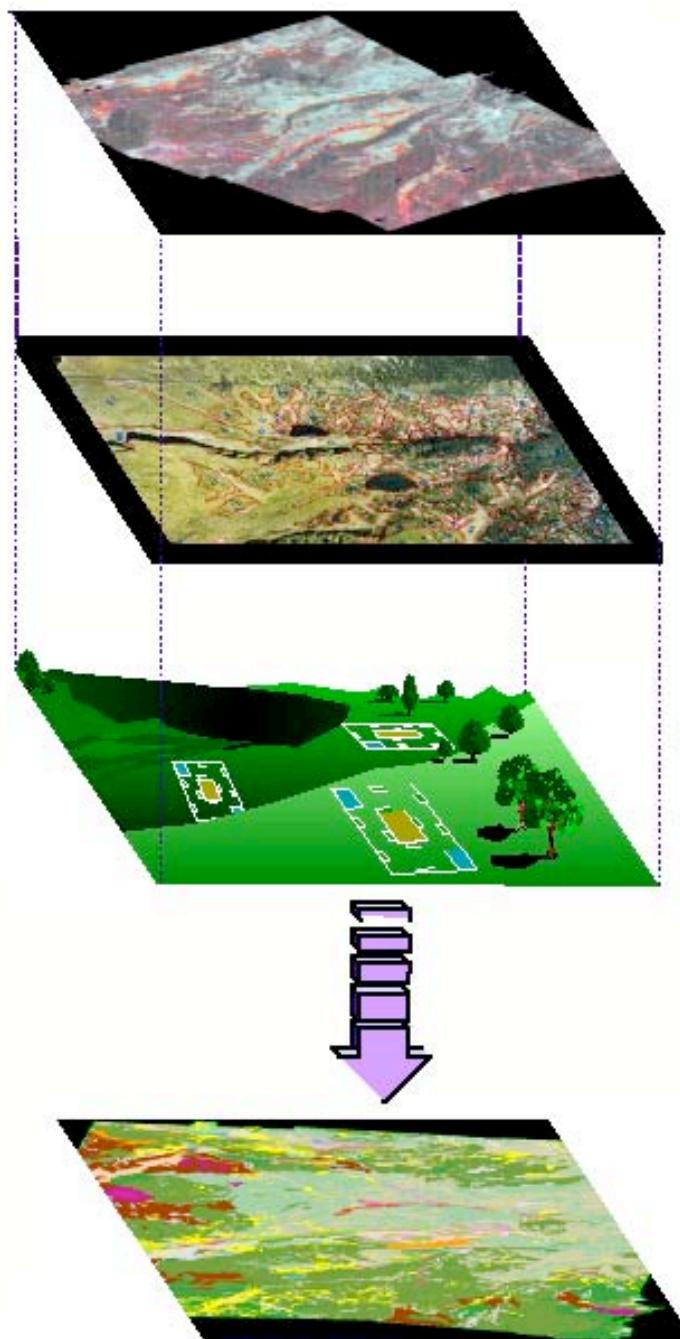
## Observations



Meta analysis  
Scaling up



Modeled Landscape



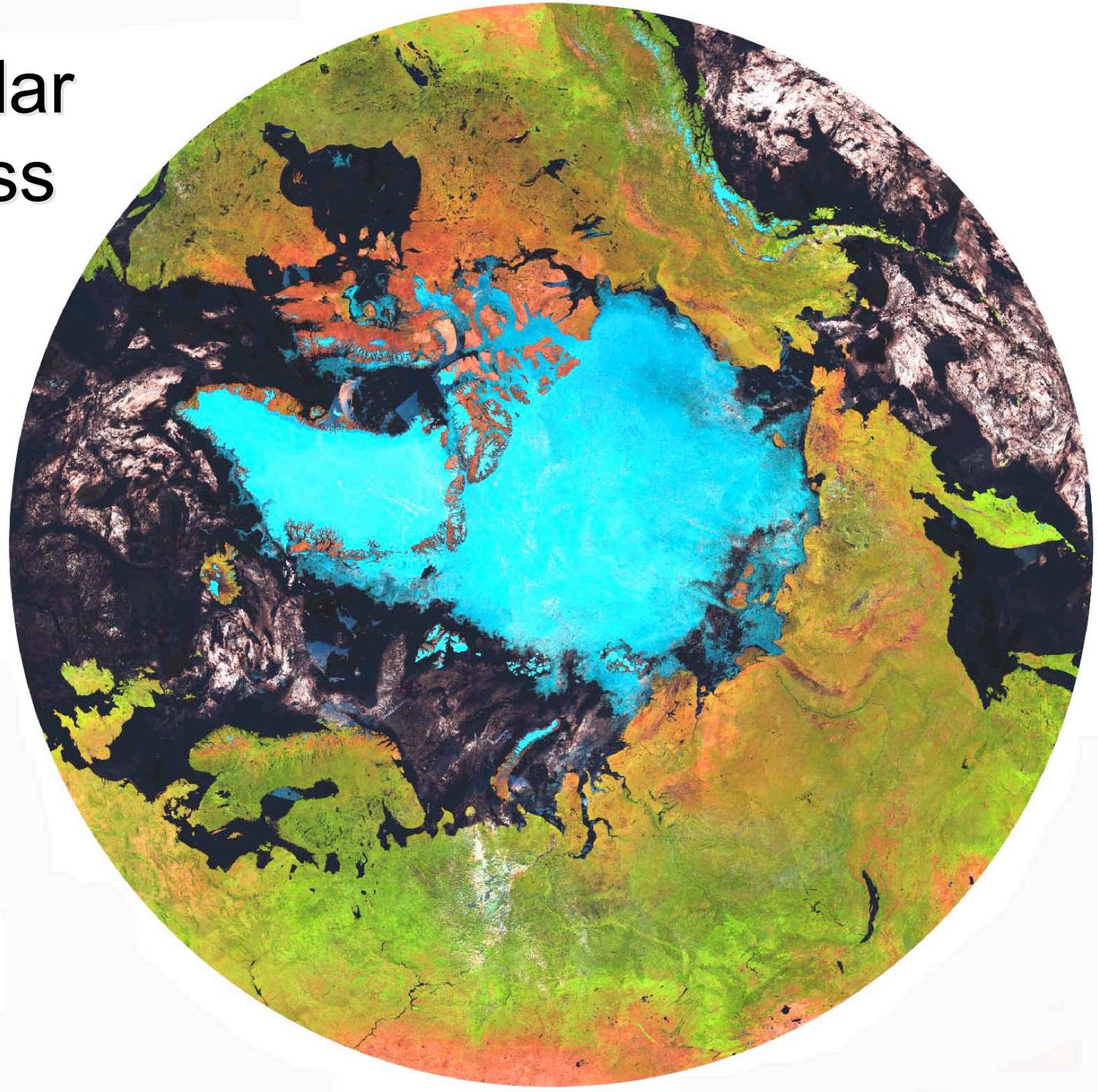
**Satellite Imagery**  
for broad-scale  
extrapolation

**High Resolution  
Aerial Photographs**  
with common and  
rare habitats  
stratified

**Field Sampling**  
subset of random  
plots selected in  
common and rare  
habitats for long-term  
monitoring

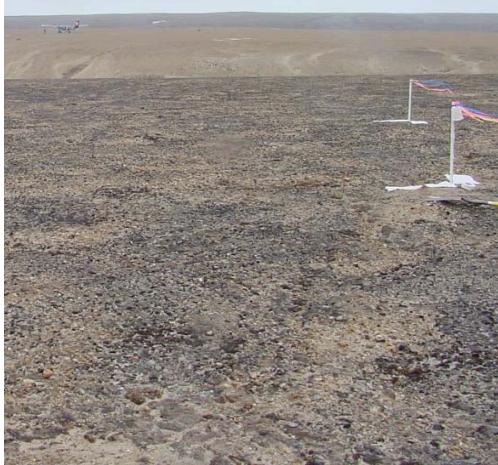
**GIS Based  
Predictive Model**  
links to causal  
mechanisms

# Circumpolar Greenness



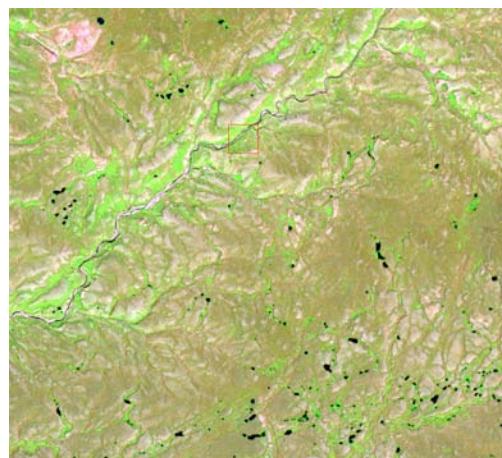
# Vegetation in Yamal



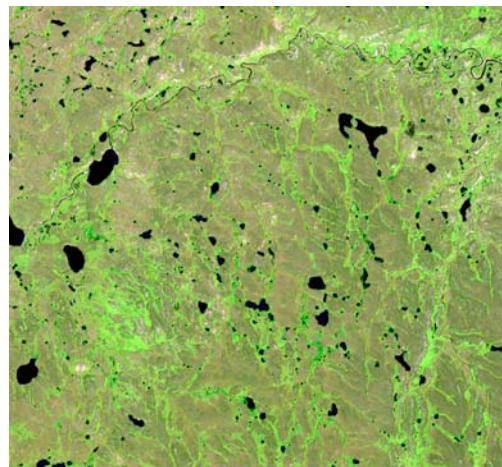


Vegetation shown on photos and  
Landsat ETM+ images

*Subzone A*



*Subzone B*



*Subzone C*

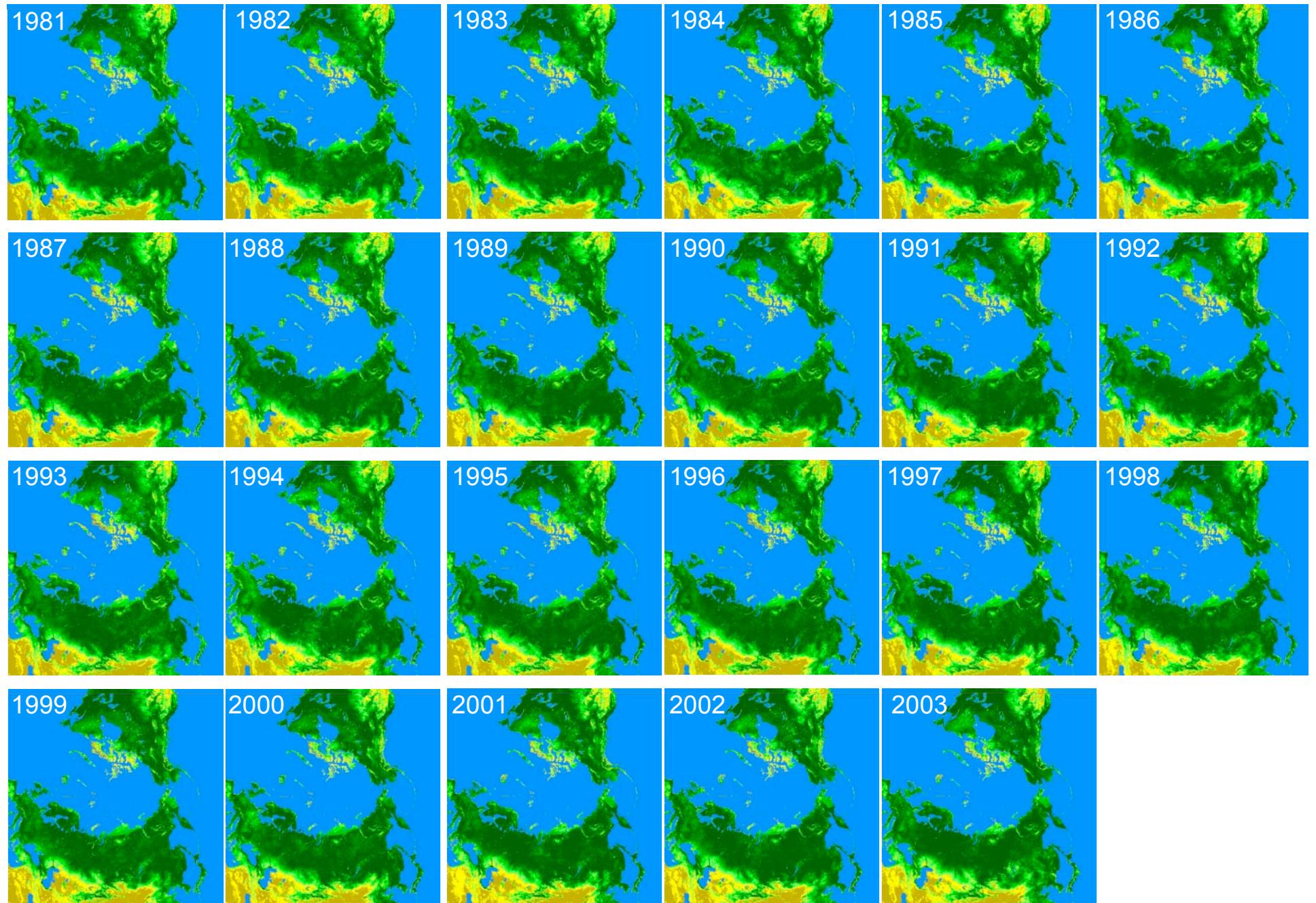
Vegetation shown on photos and  
Landsat ETM+ images



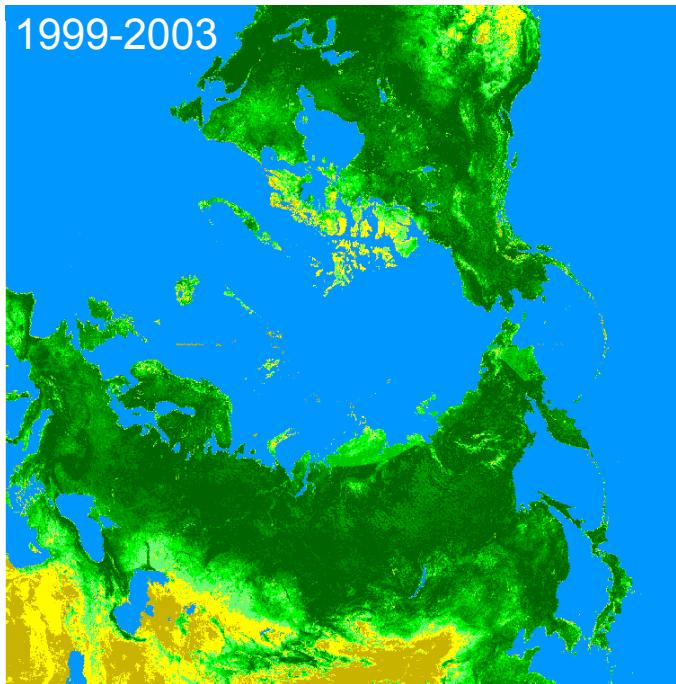
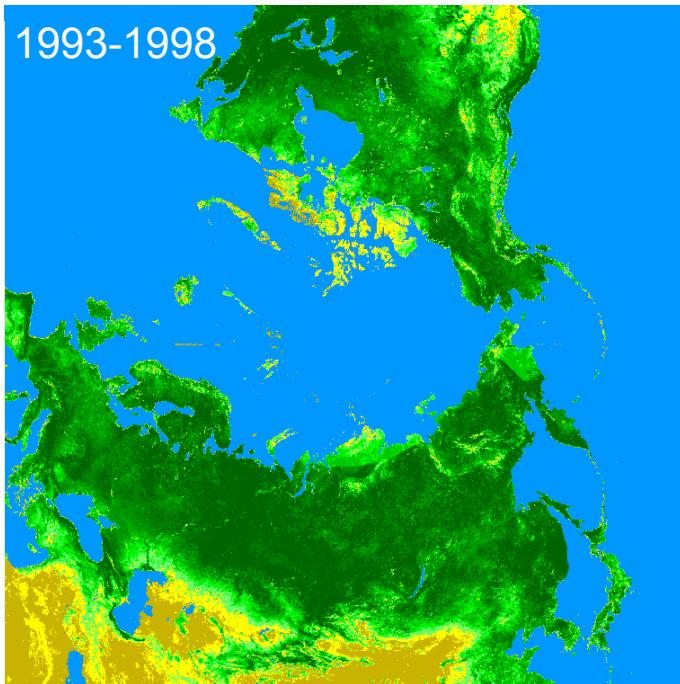
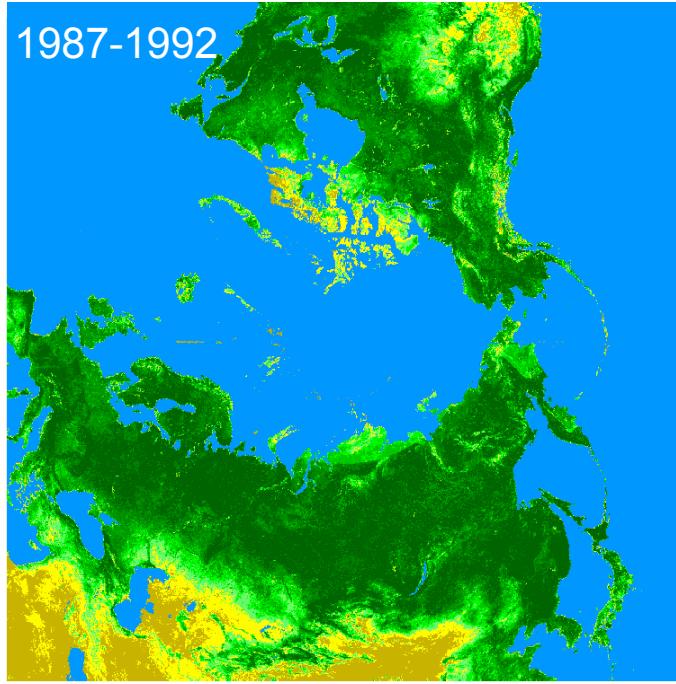
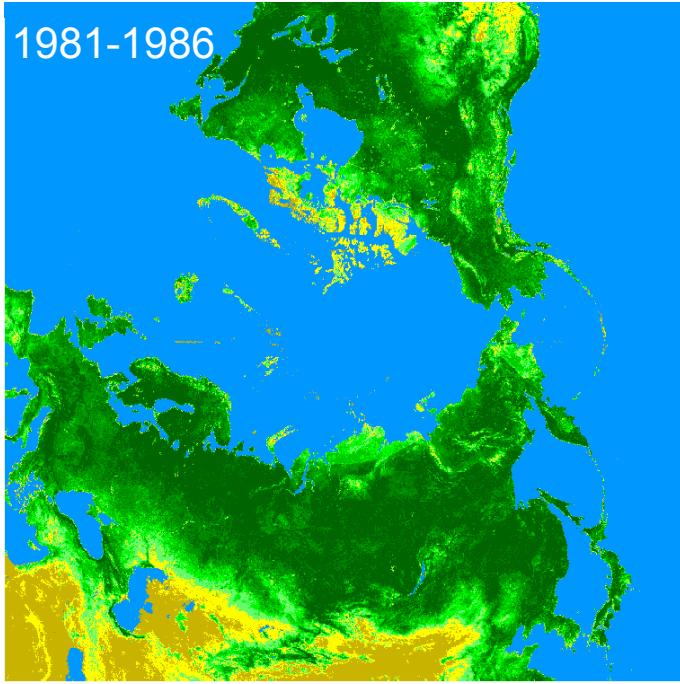
*Subzone D*



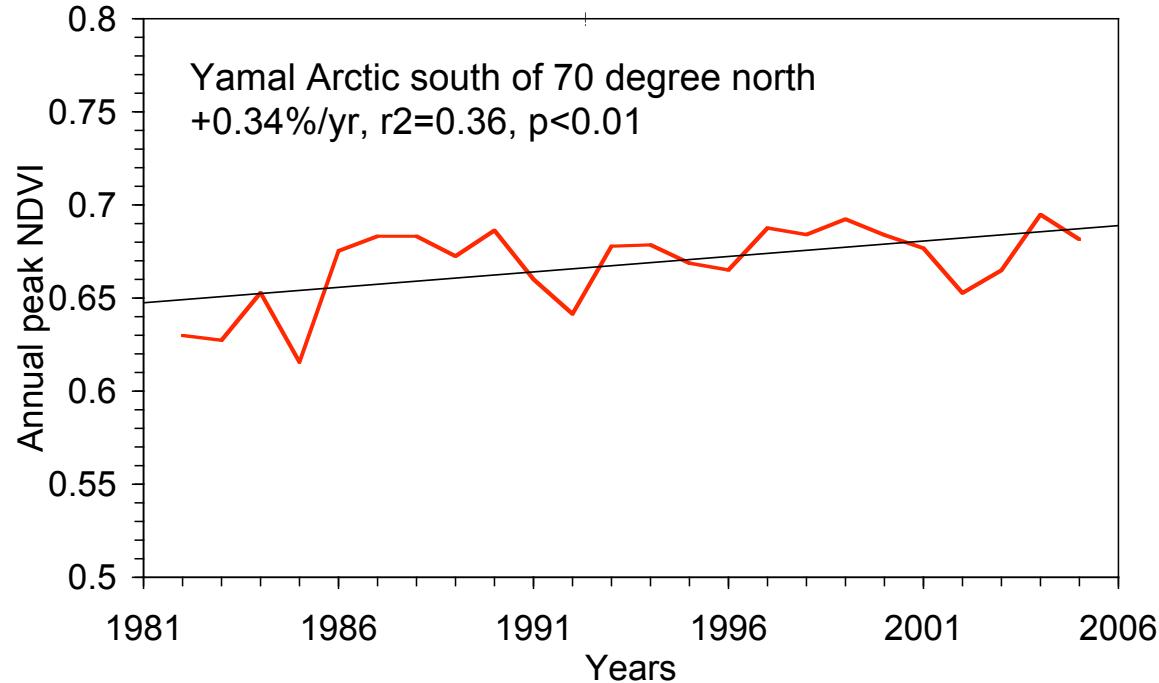
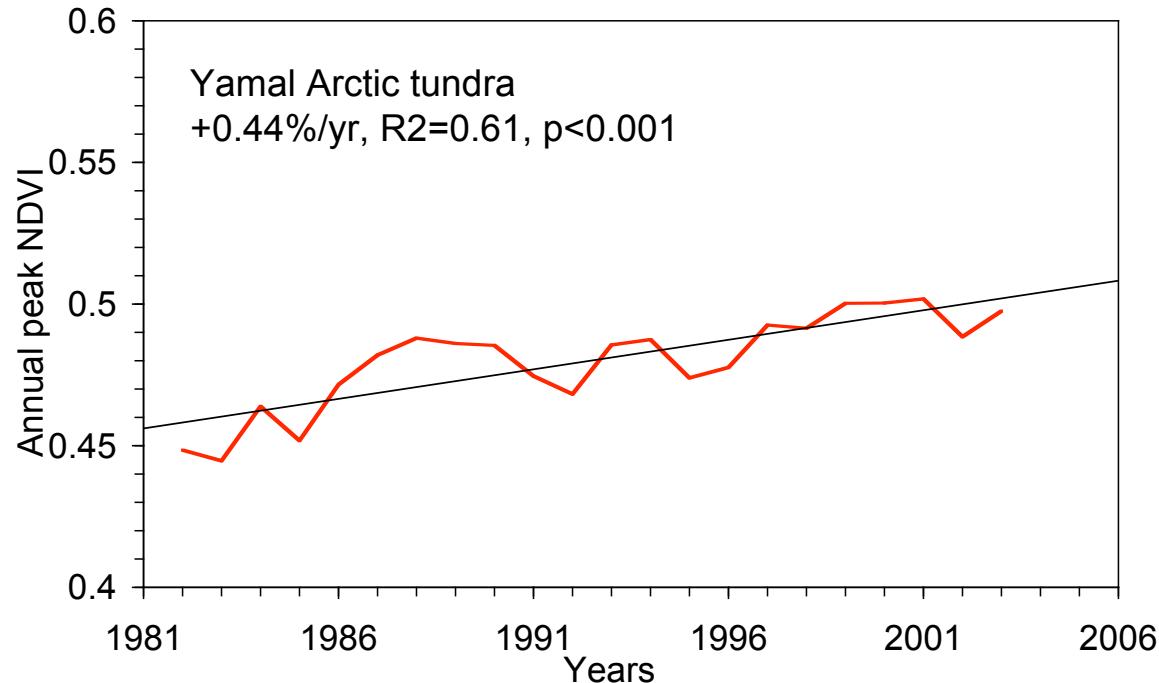
*Subzone E*



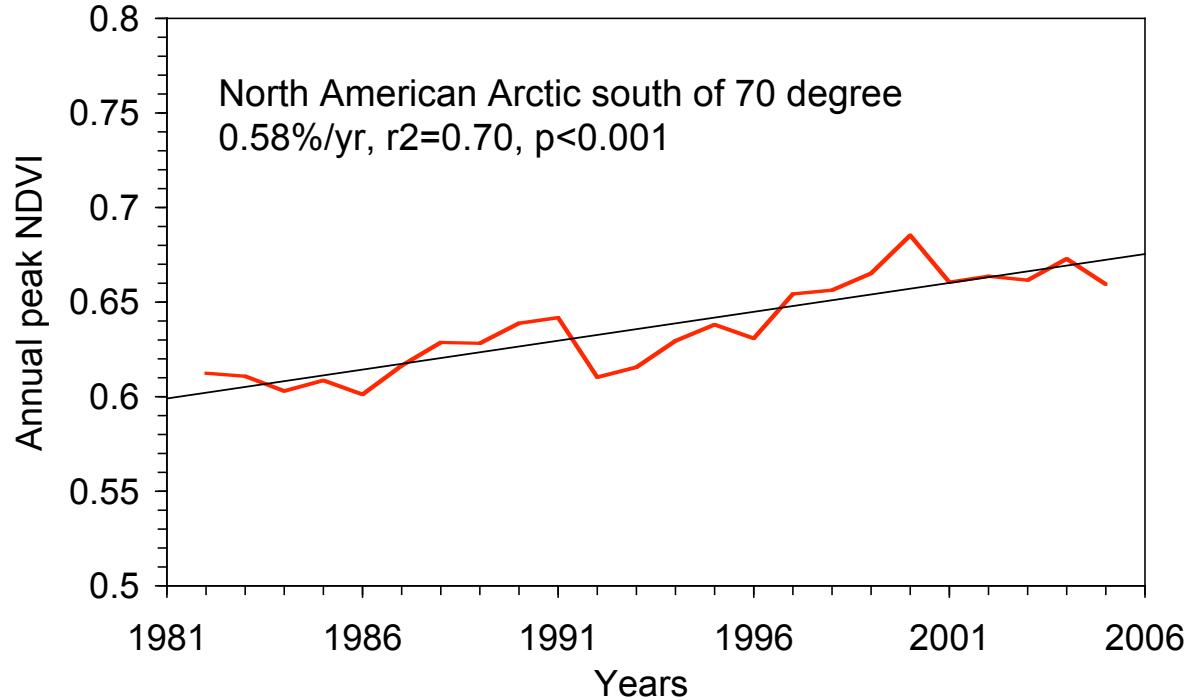
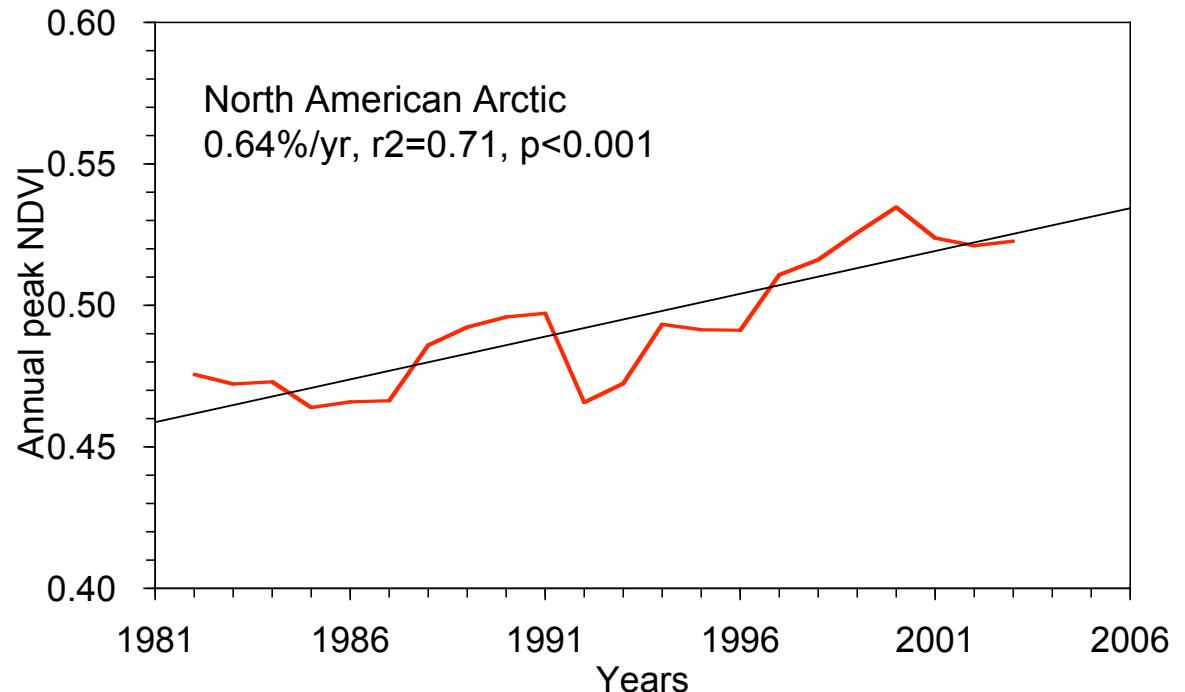
Circumpolar Peak Vegetation Greenness 1981-2003



Semi-decadal  
comparison of  
peak NDVI  
over circum-  
polar region

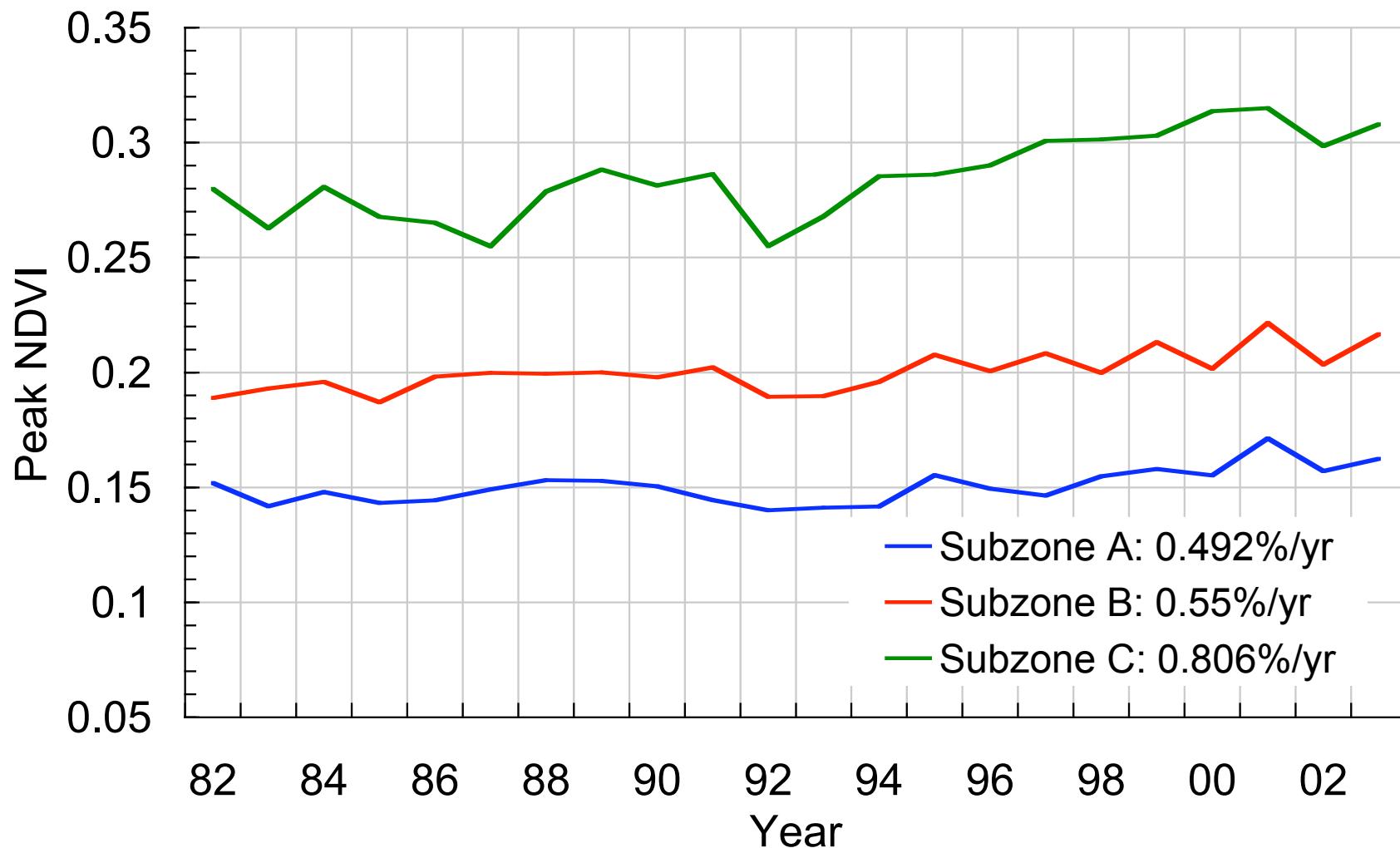


Changes of annual peak vegetation greenness (NDVI) over tundra biome from 1982-2003 (top) and below 70 degree north from 1982-2005 (bottom) in Yamal Arctic, Russia as detected by NOAA AVHRR time series data.

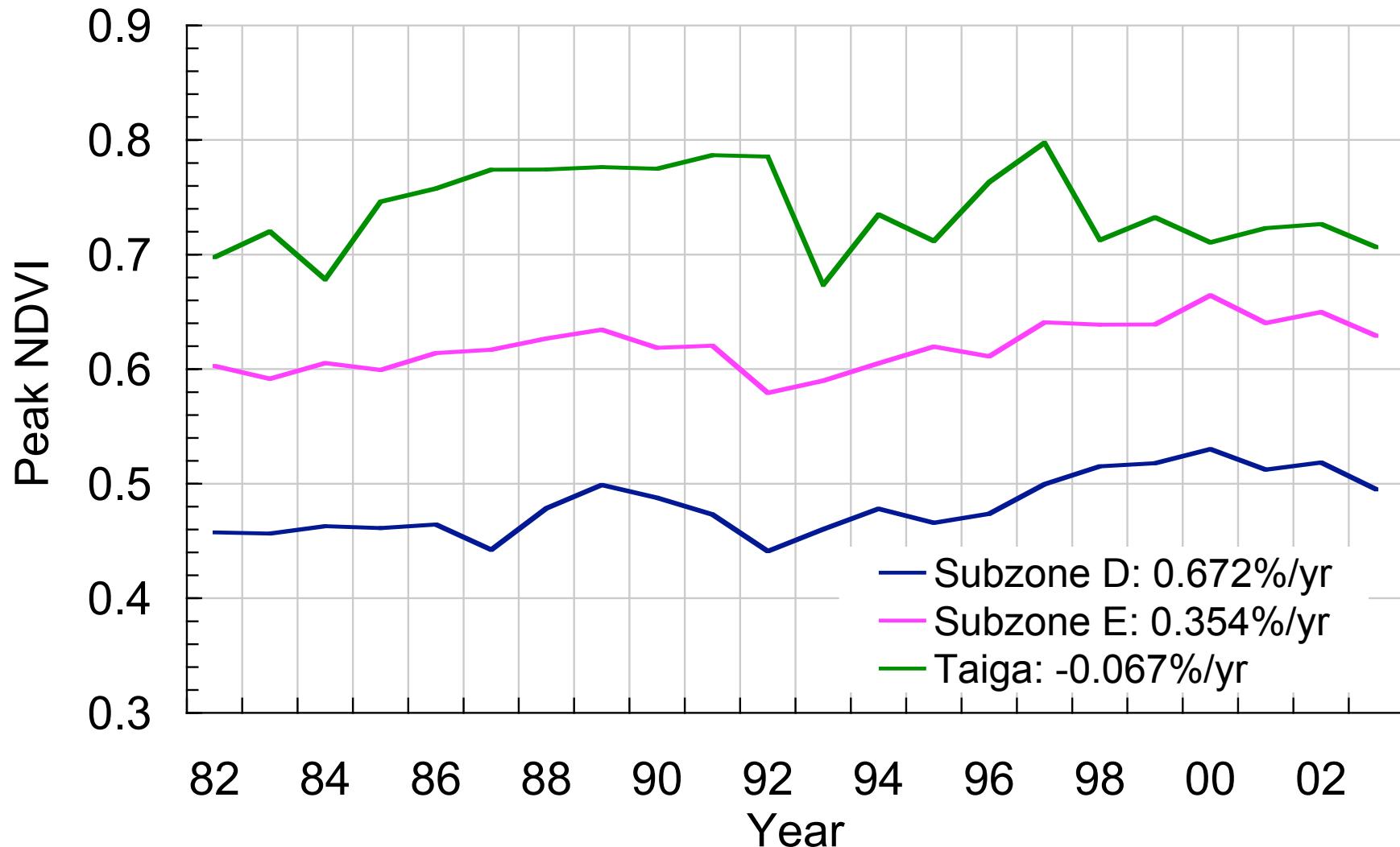


**Changes of annual peak vegetation greenness (NDVI) over tundra biome from 1982-2003 (top) and below 70 degree north from 1982-2005 (bottom) in North American Arctic (Alaska and Canada) as detected by NOAA AVHRR time series data.**

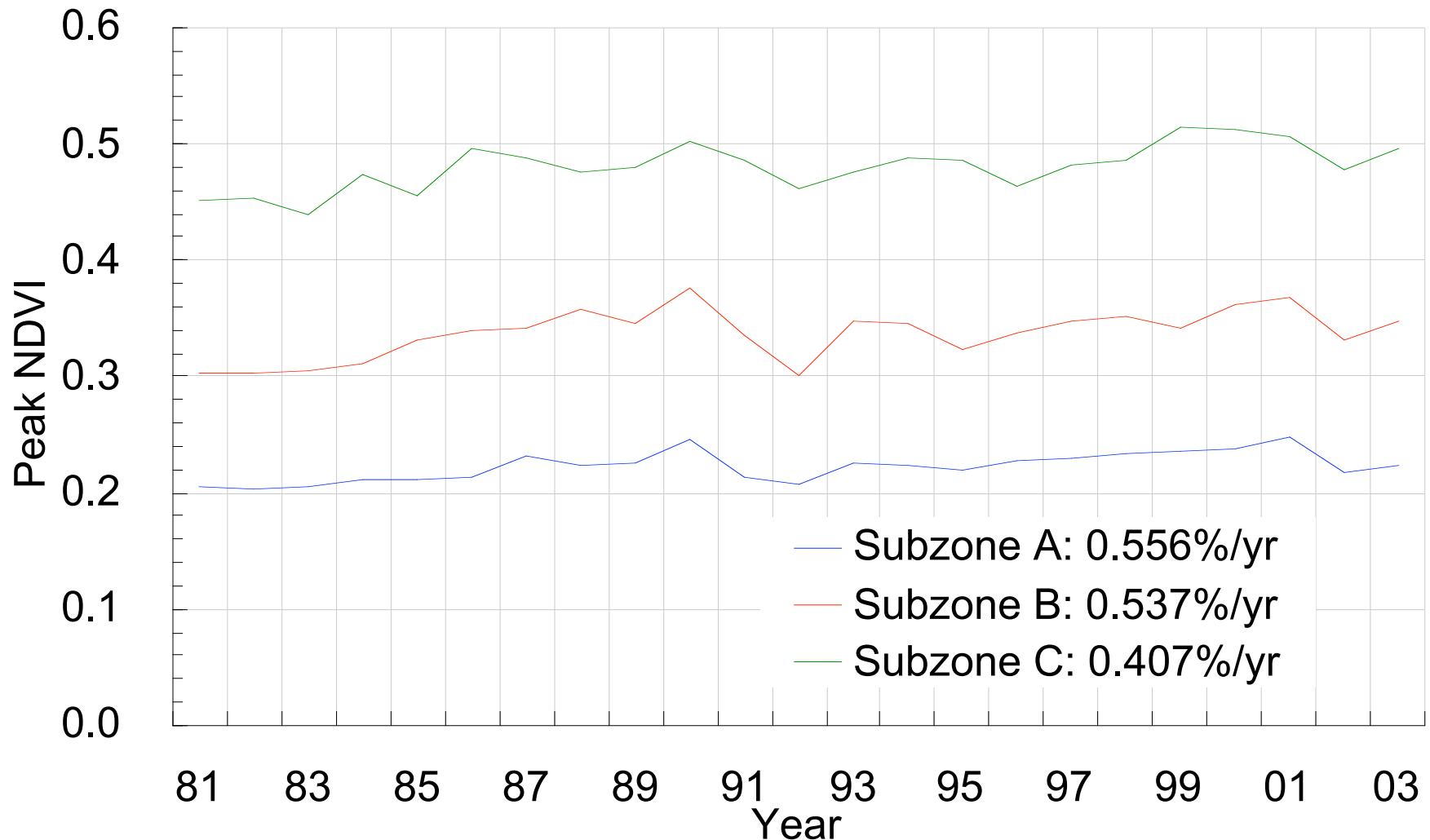
# Canadian High Arctic



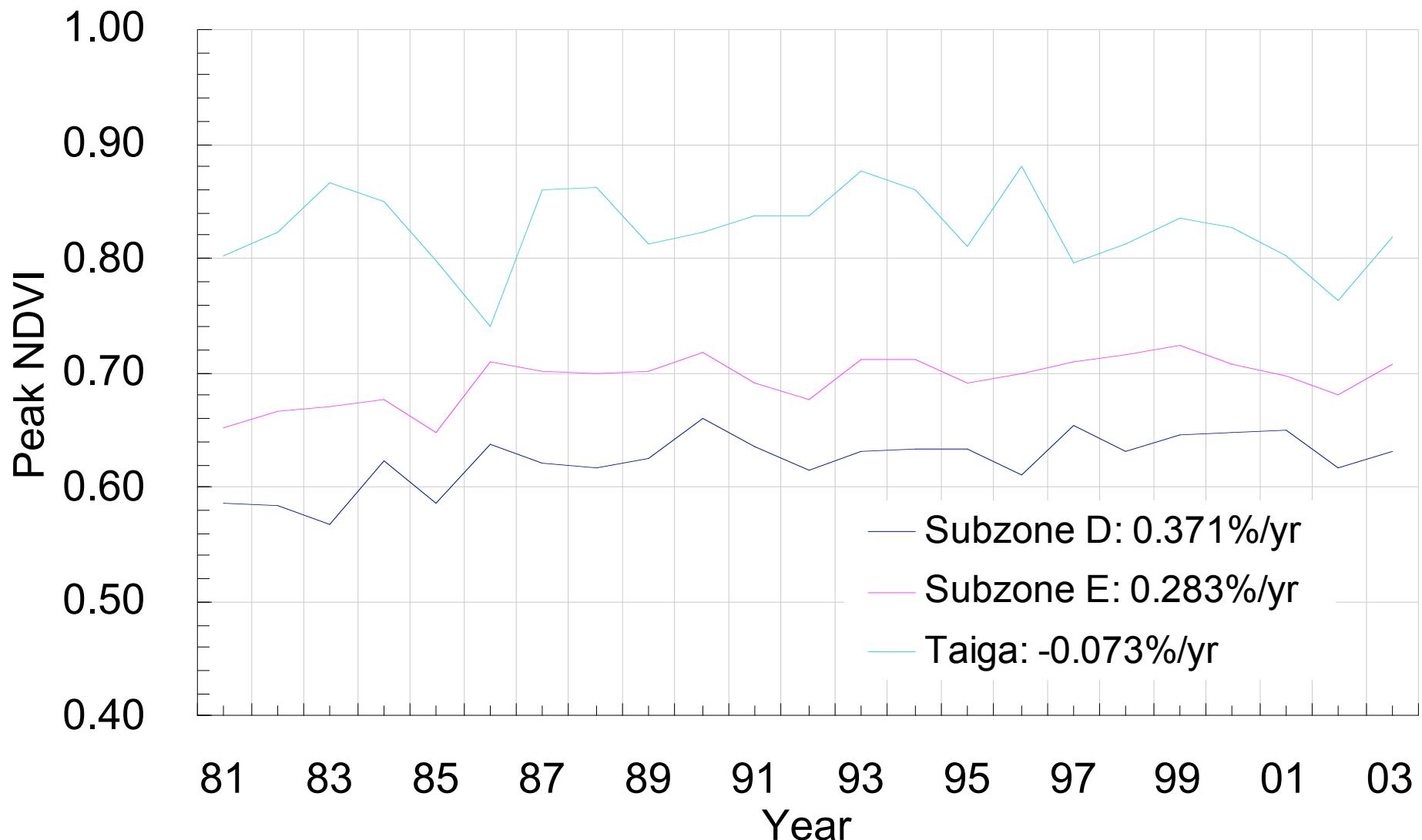
# Canadian Low Arctic



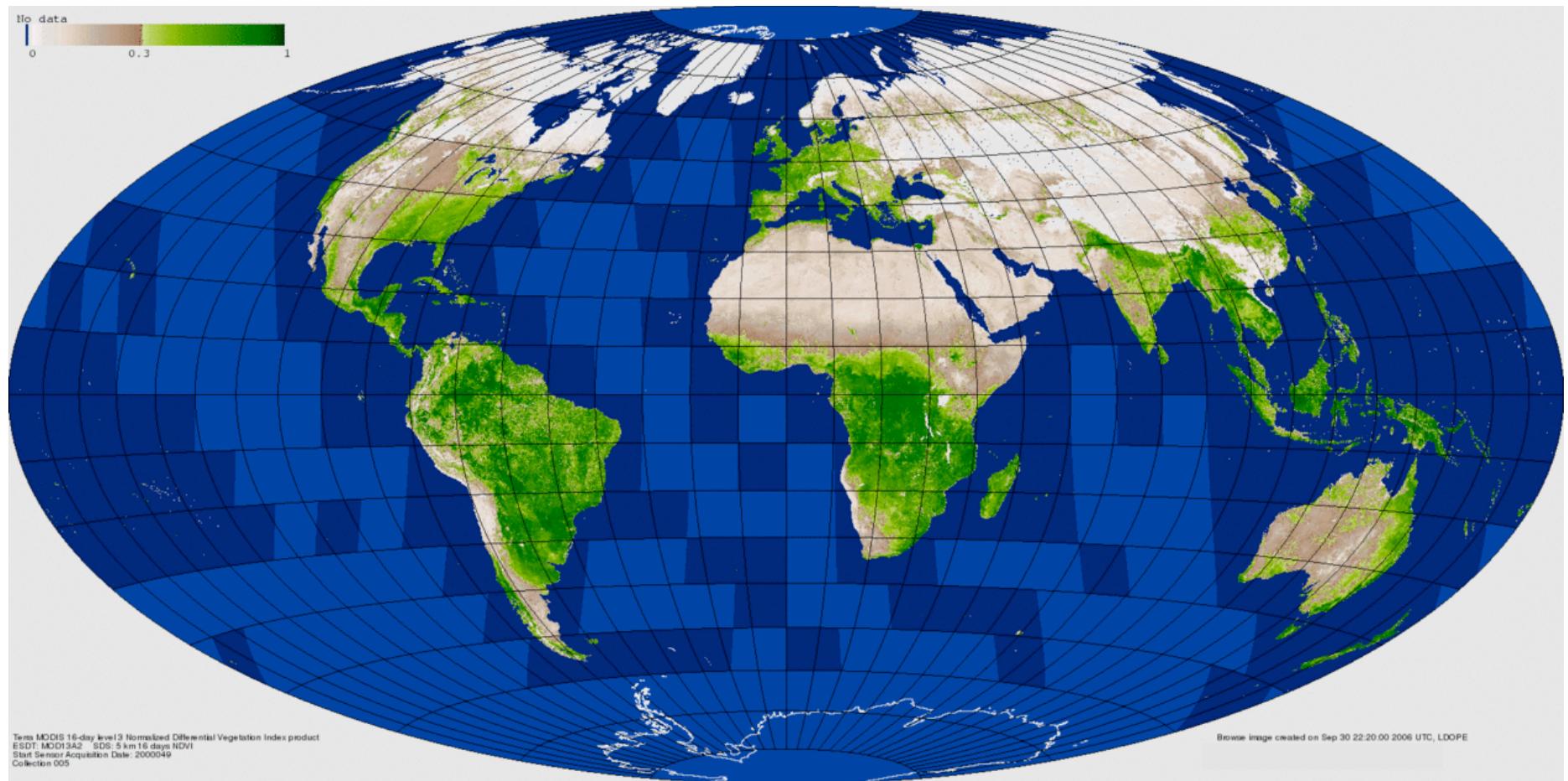
# Russia High Arctic

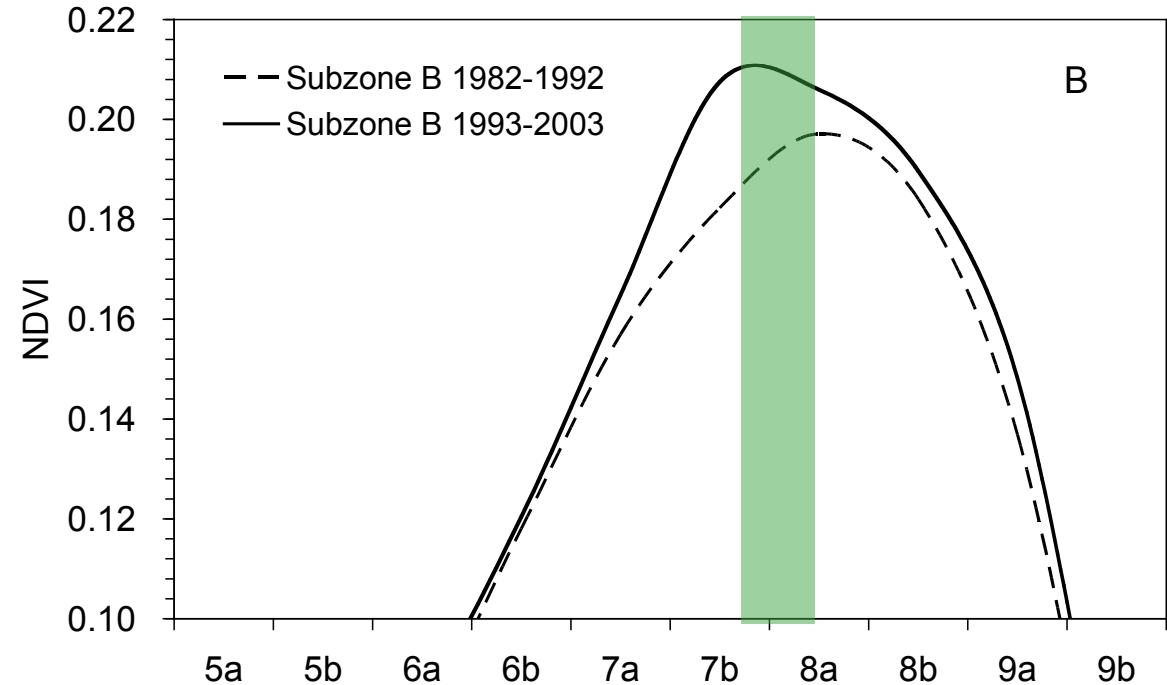
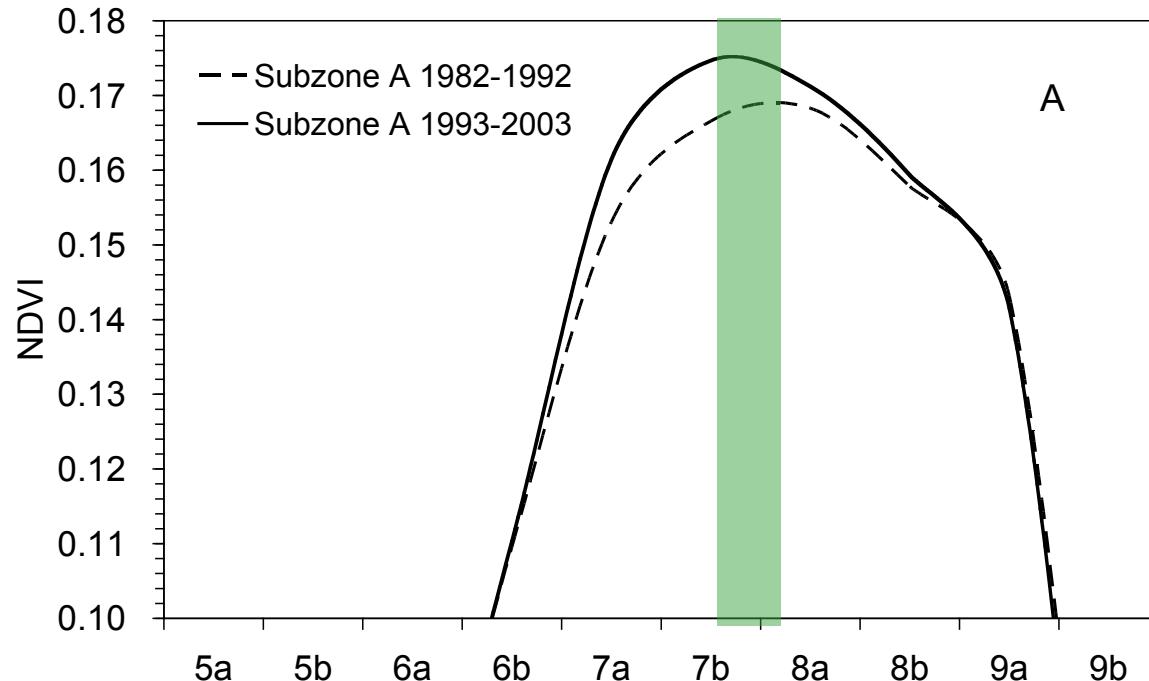


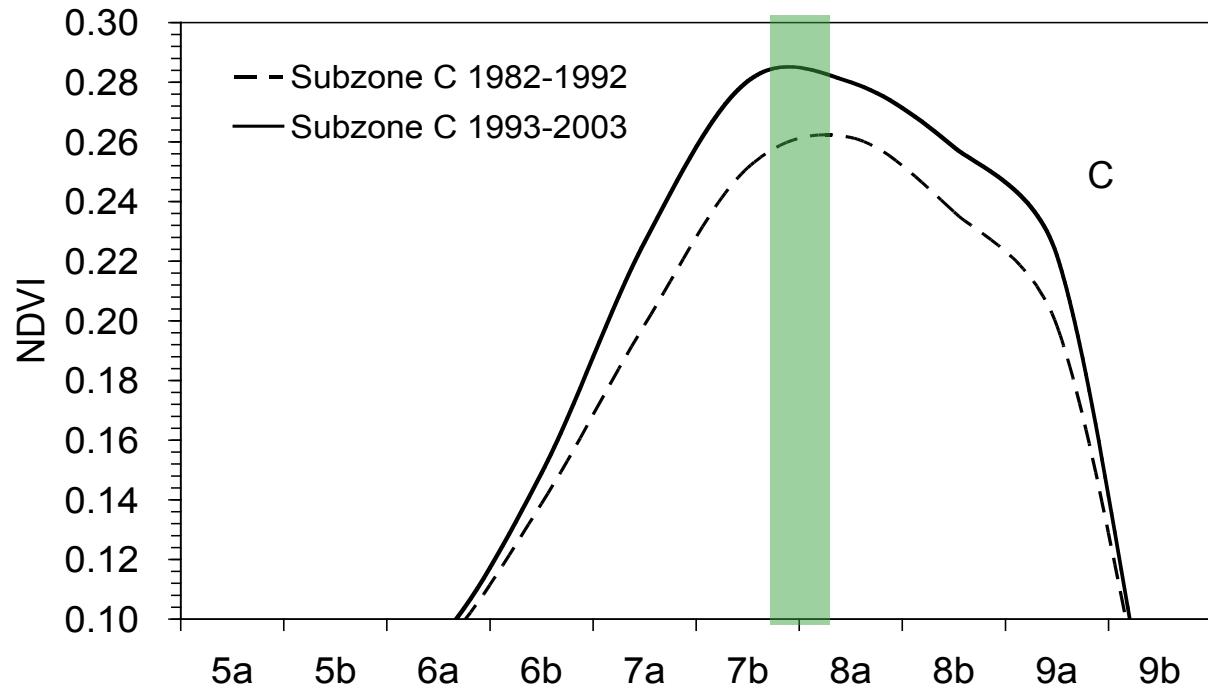
# Russia Low Arctic and Taiga



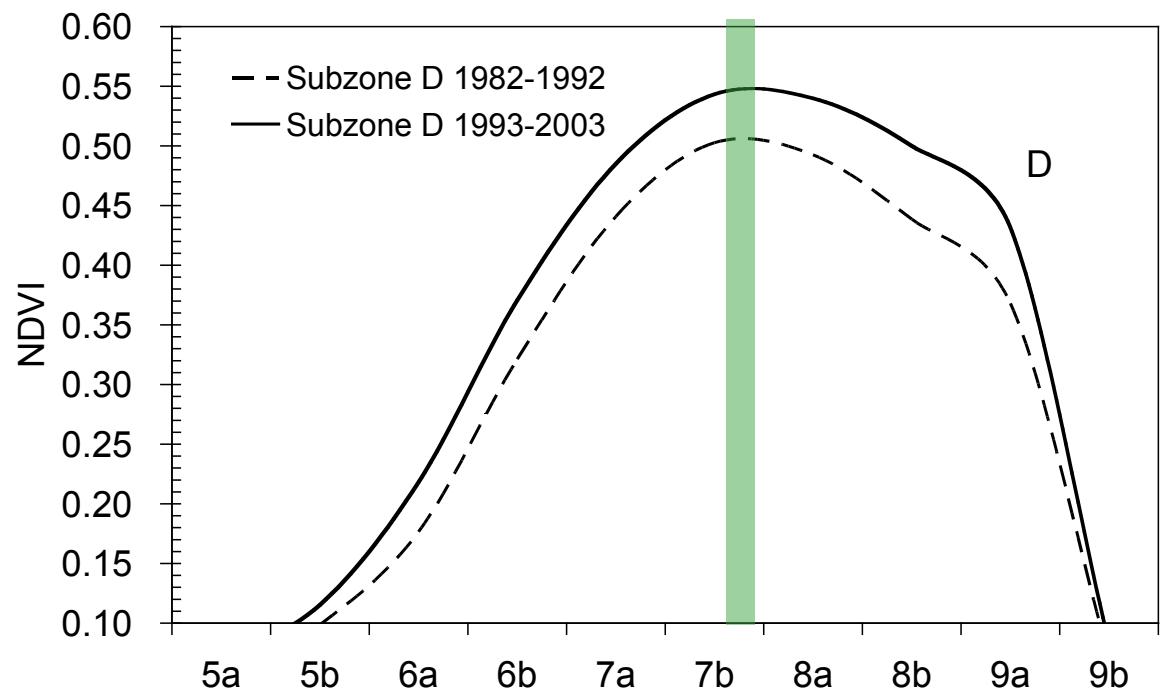
# Seasonal Pattern of Vegetation Greenness



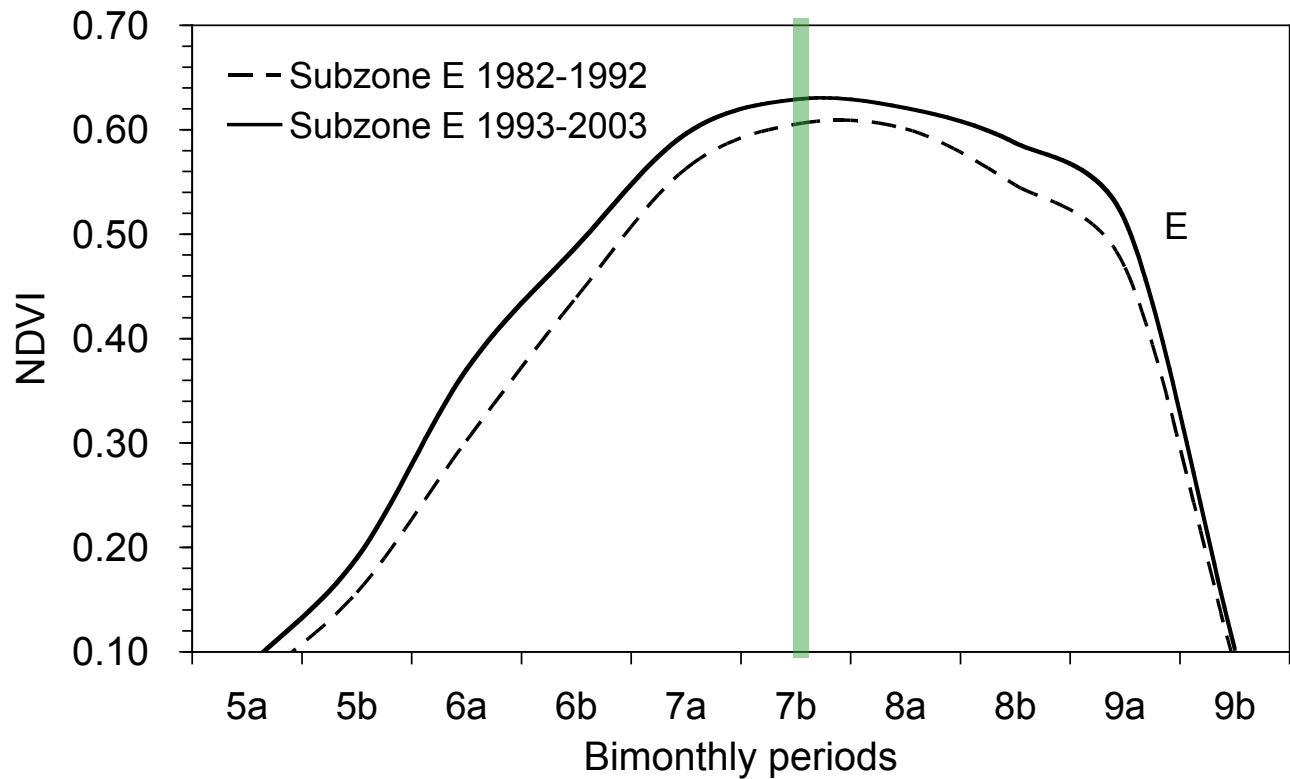




# Arctic Subzone C



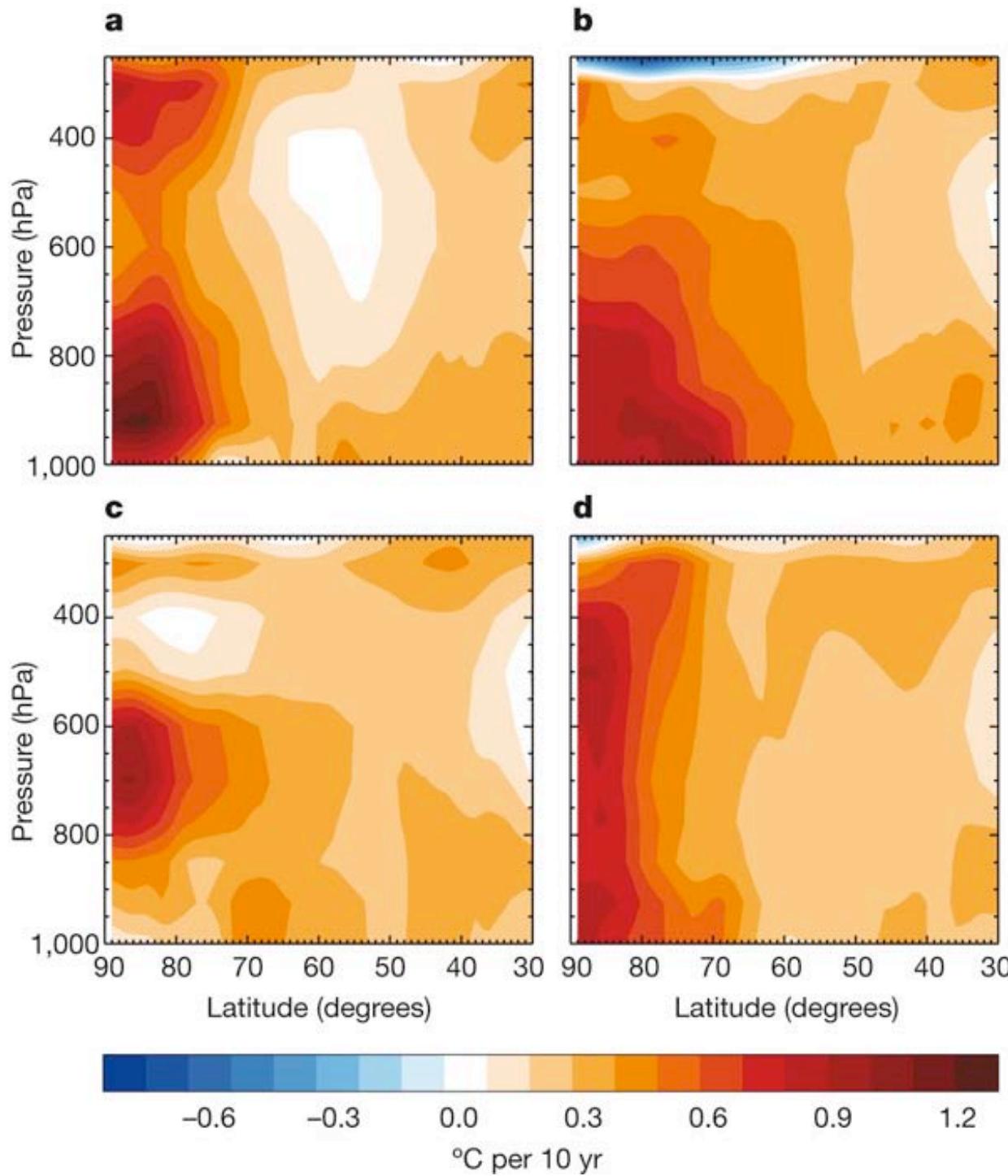
# Arctic Subzone D



Arctic  
Subzone E

# What's Behind the Greening

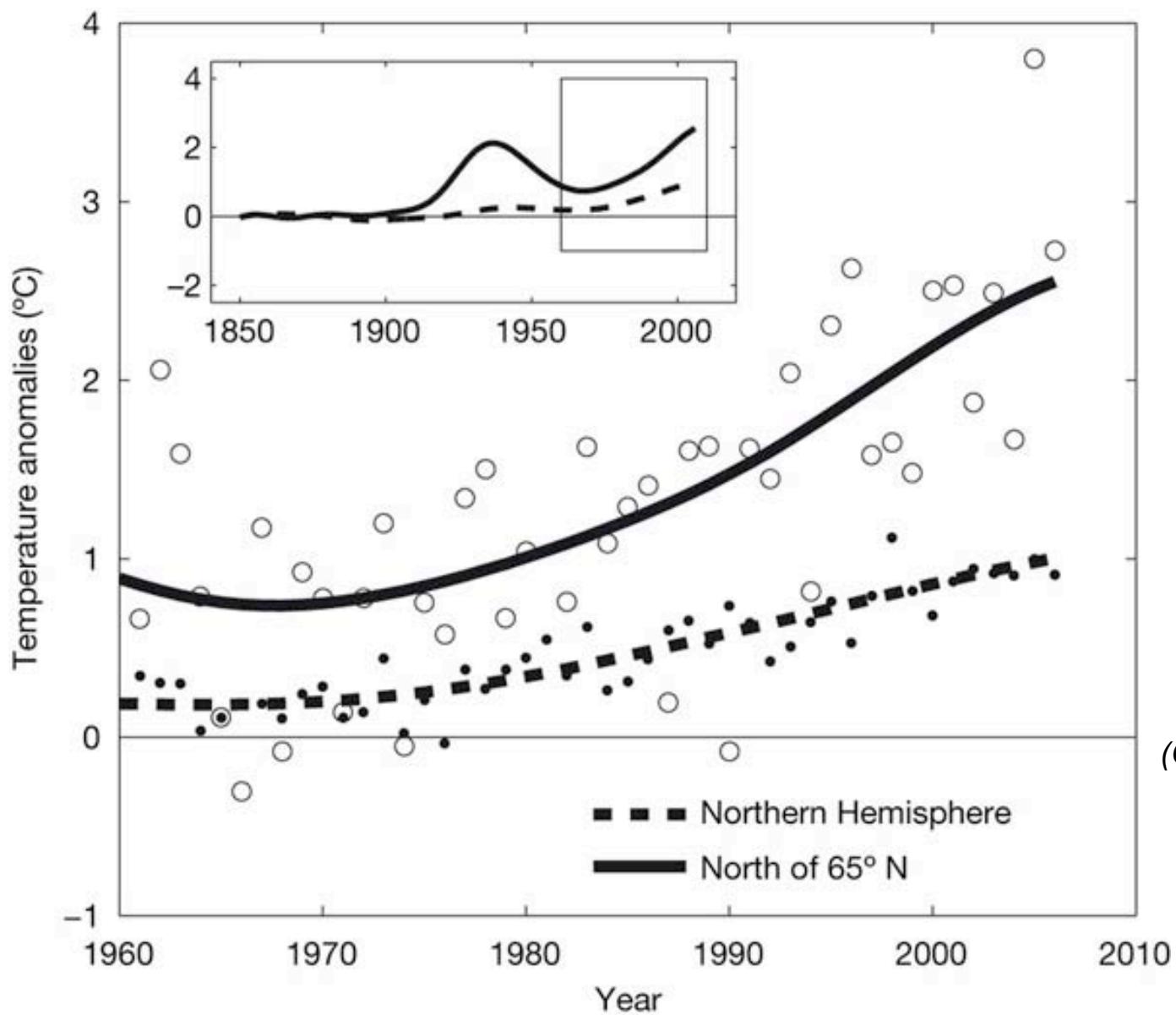
- General trend of global and regional warming
- Stronger warming signals
- Get closer to Canadian Arctic (1km ~2005)
- Revisit Arctic Alaska (1km, weekly, ~2006)
- Spatial patterns of NDVI changes
- Impact of surface temperature and sea-ice on vegetation greenness



MODIS + AVHRR  
over Siberia 1982-  
2005

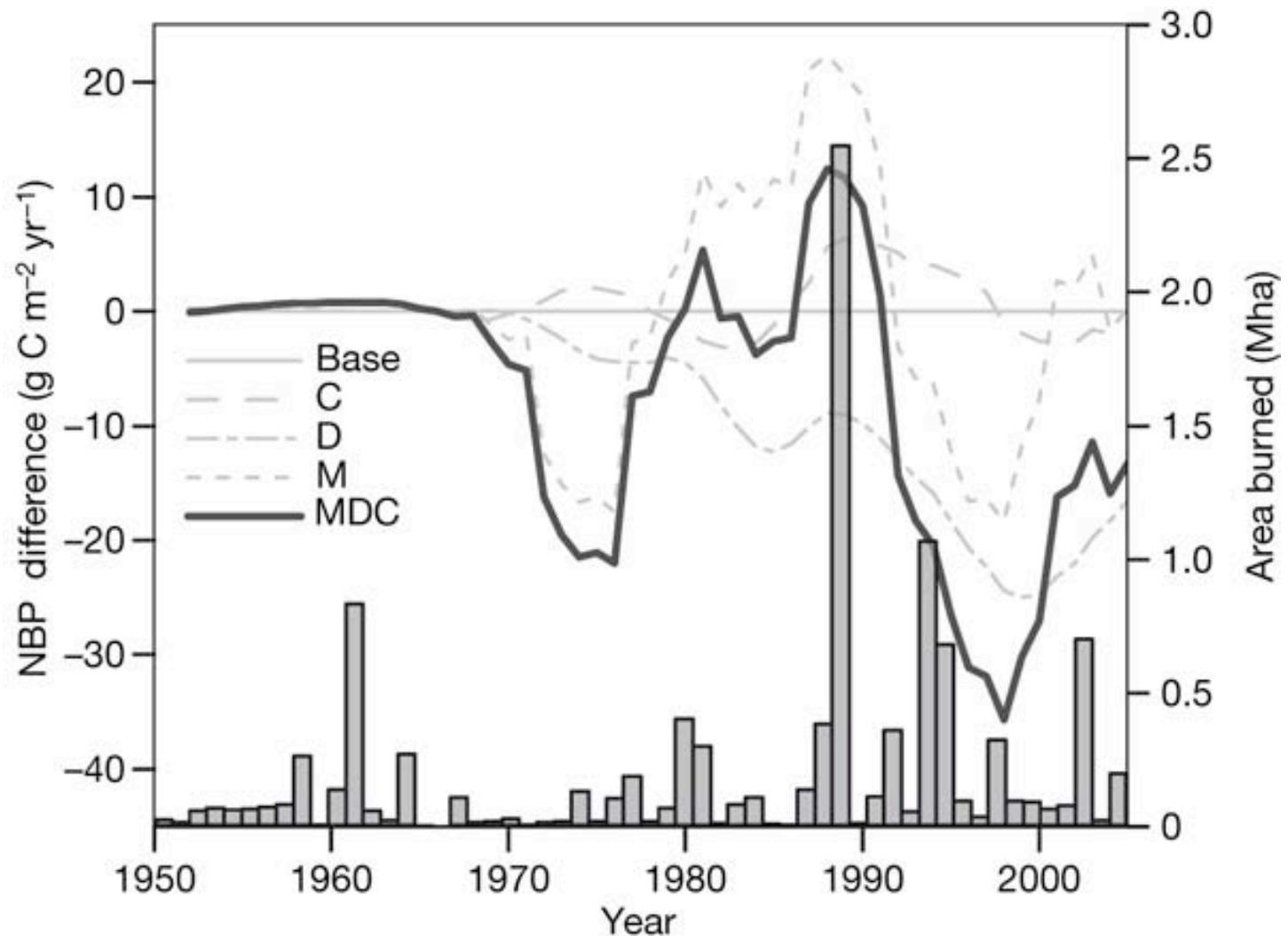
(Graversen et al, 2008, Nature)

# Temperature anomalies



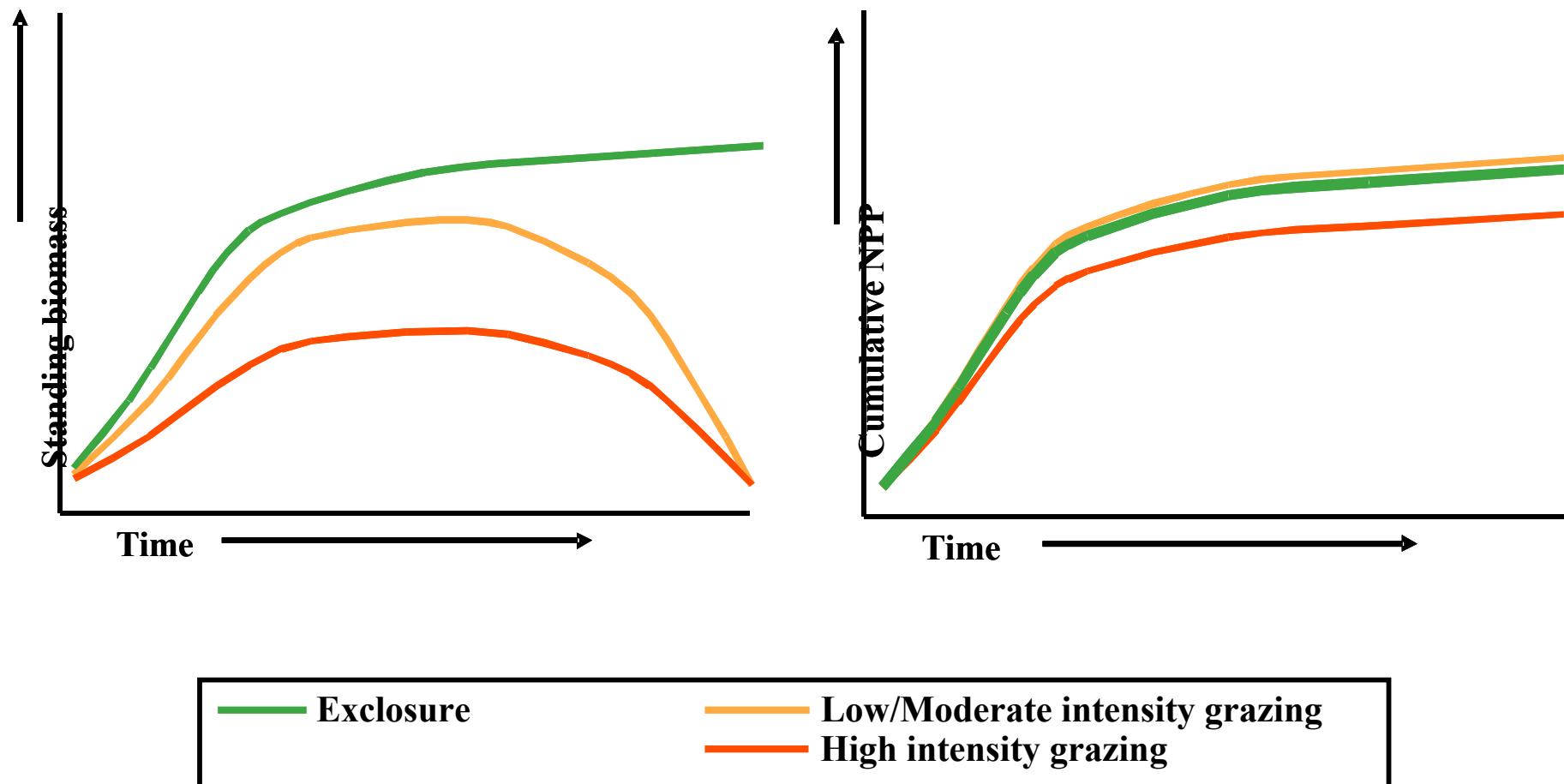
(Graversen et al, 2008, Nature)

# Fire and NPP anomalies



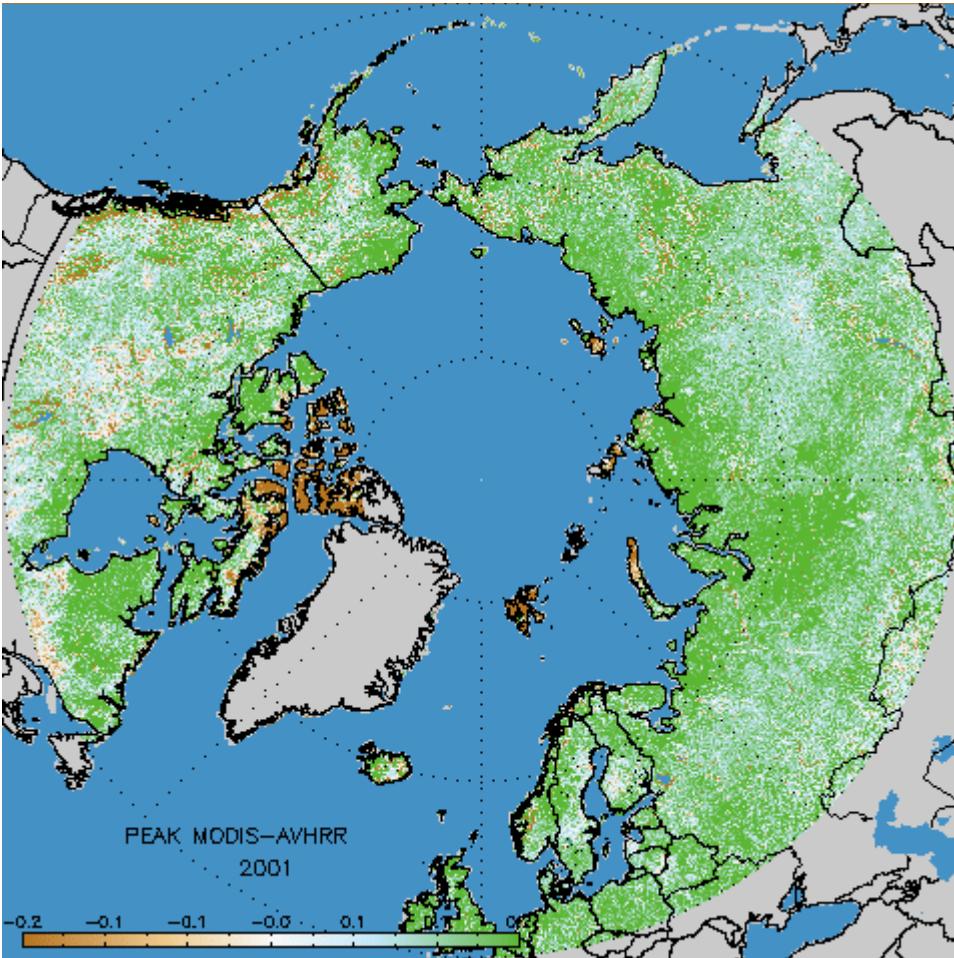
(Bond-Lamberty, 2007, Nature)

# Accumulative effect on biomass and NPP

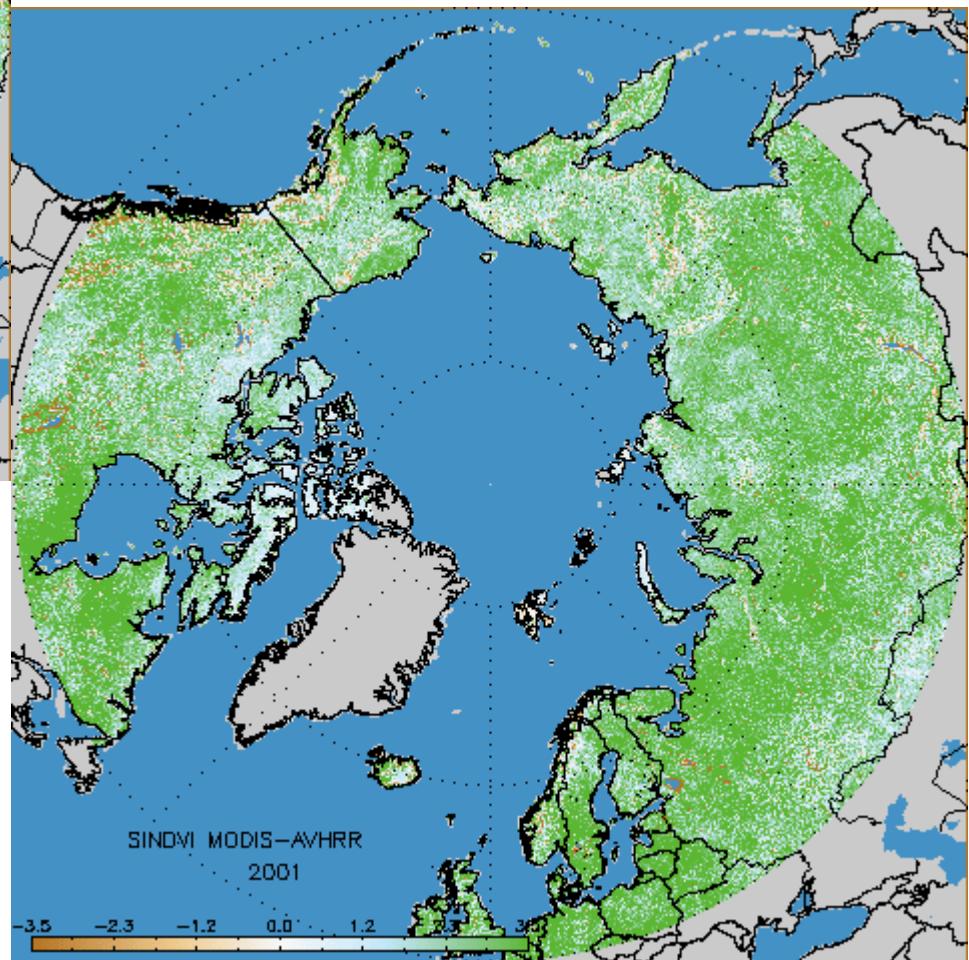


# Uncertainties

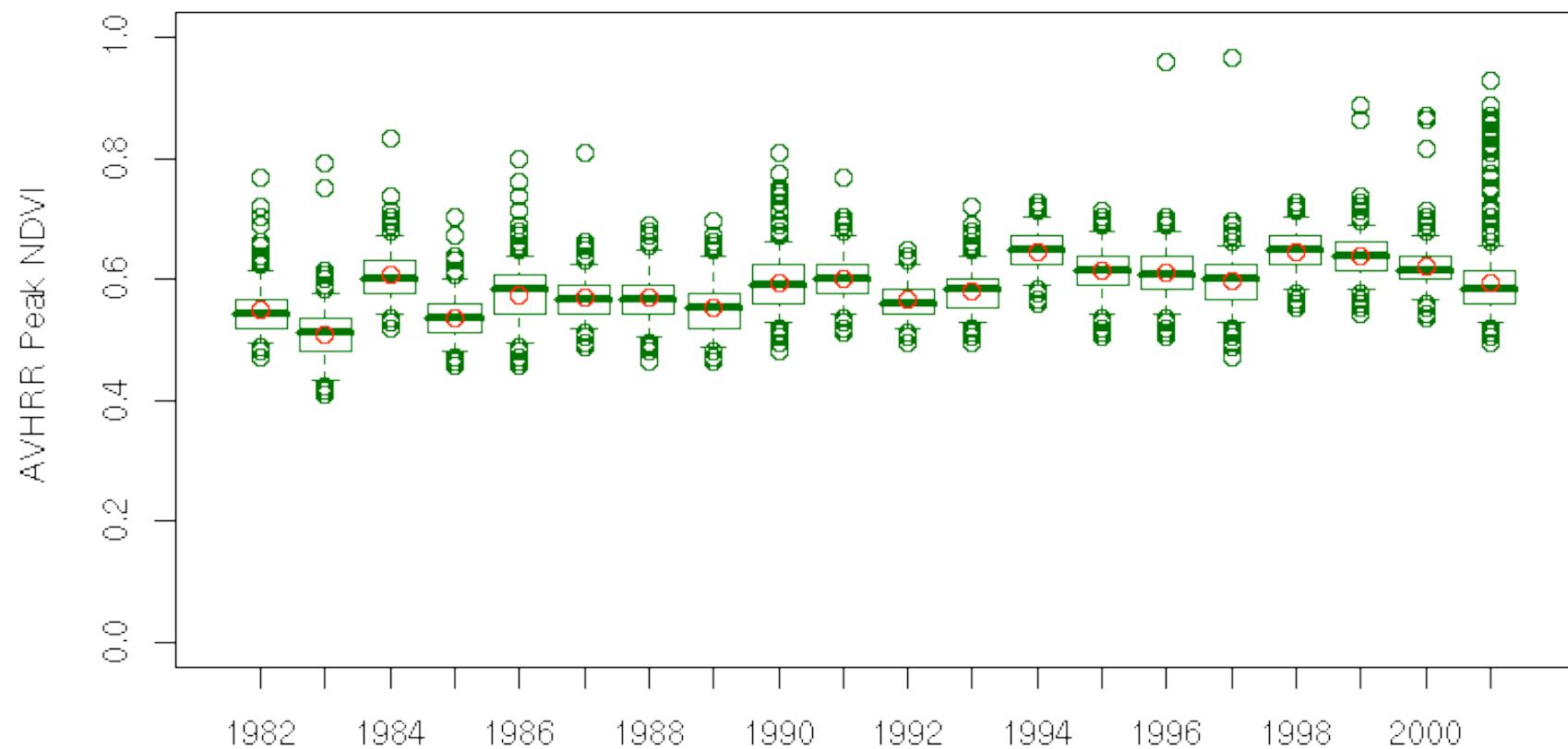
- Major uncertainties came from data calibrations;
- Draft of AVHRR sensors and differences in spectra and algorithms between AVHRR and MODIS;
- Confused from pixels contain mixture of land cover types respond to warming in different ways;
- Time periods considered in analysis;
- Geographic extents in analysis;
- Reluctance in facing the inconvenient truth



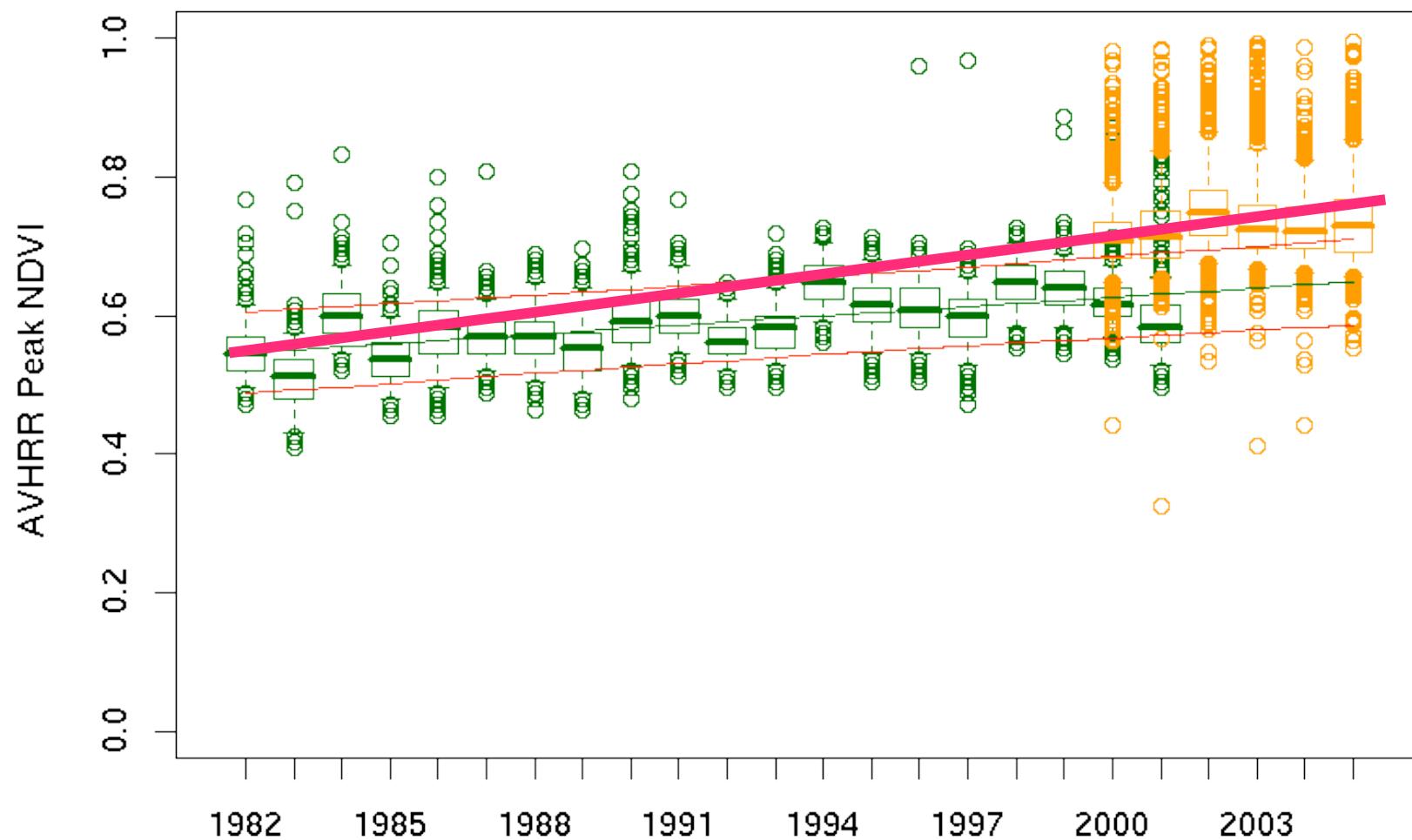
# MODIS vs. AVHRR NDVI

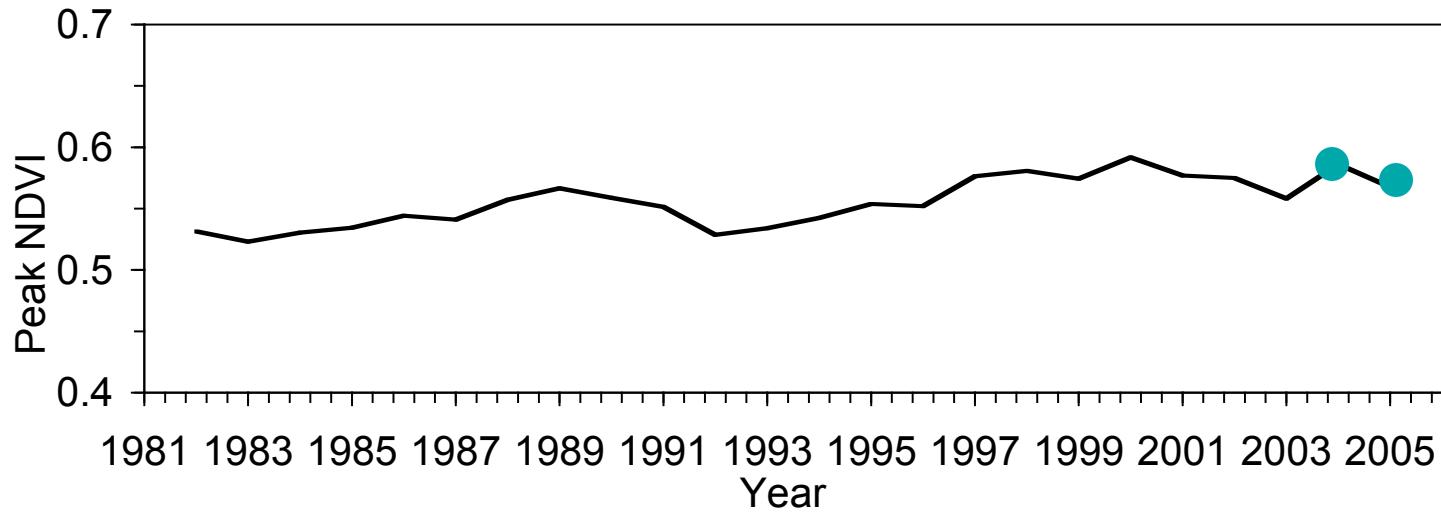
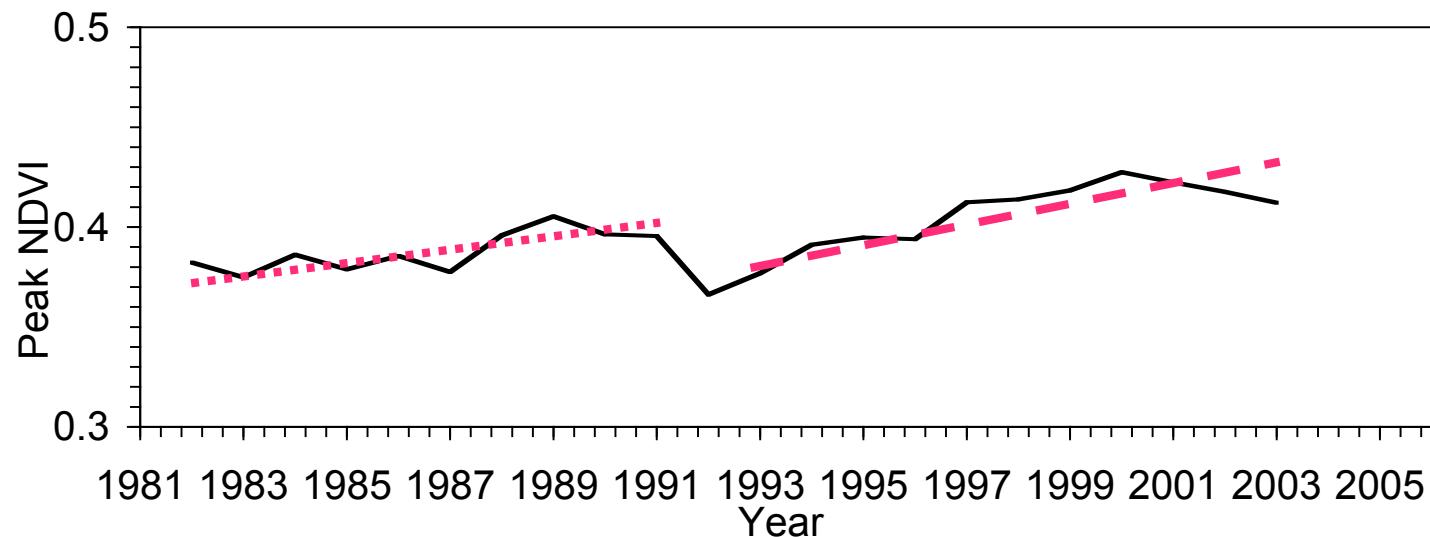


# AVHRR over Siberia 1982-2003

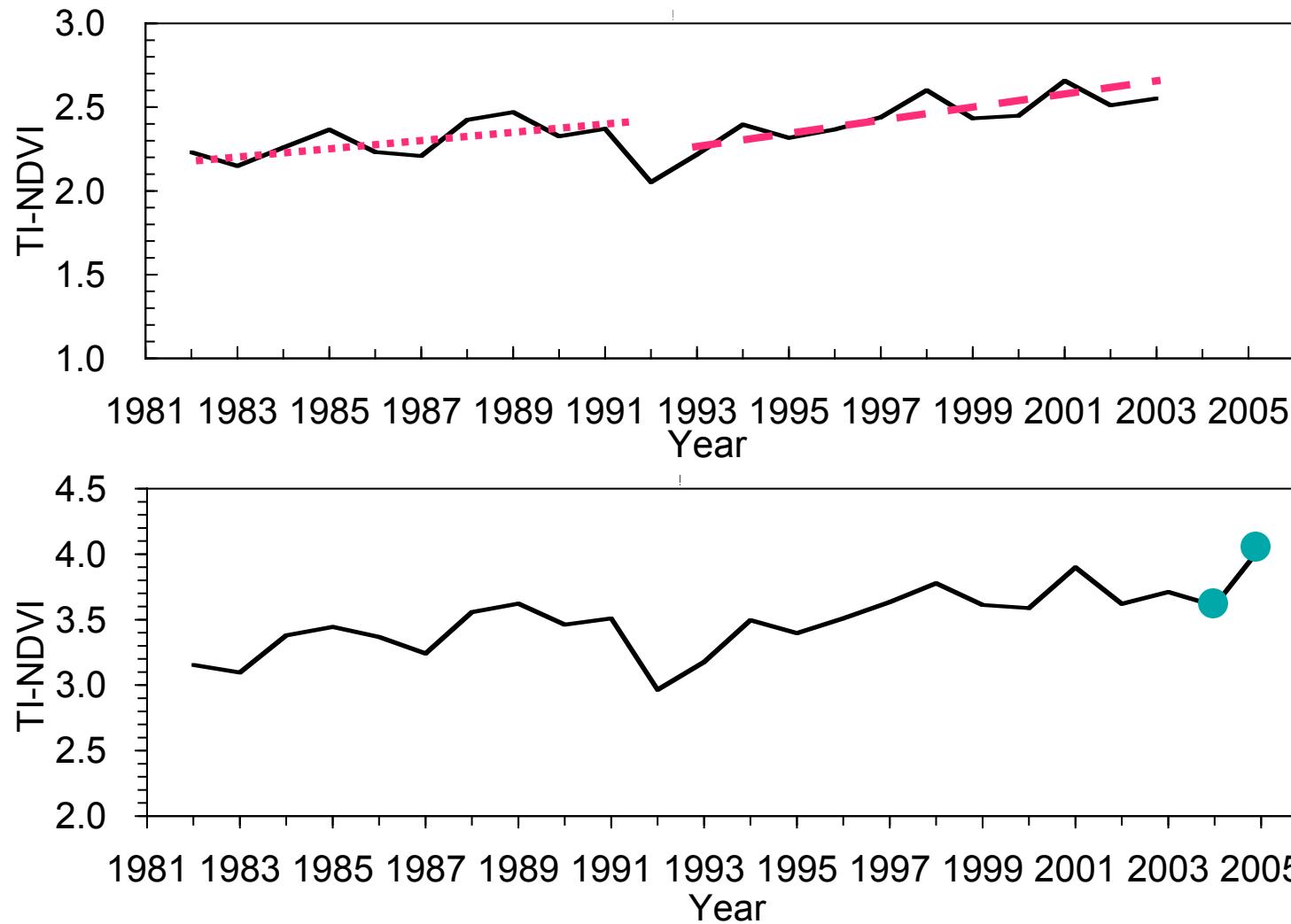


# MODIS + AVHRR over Siberia 1982-2005

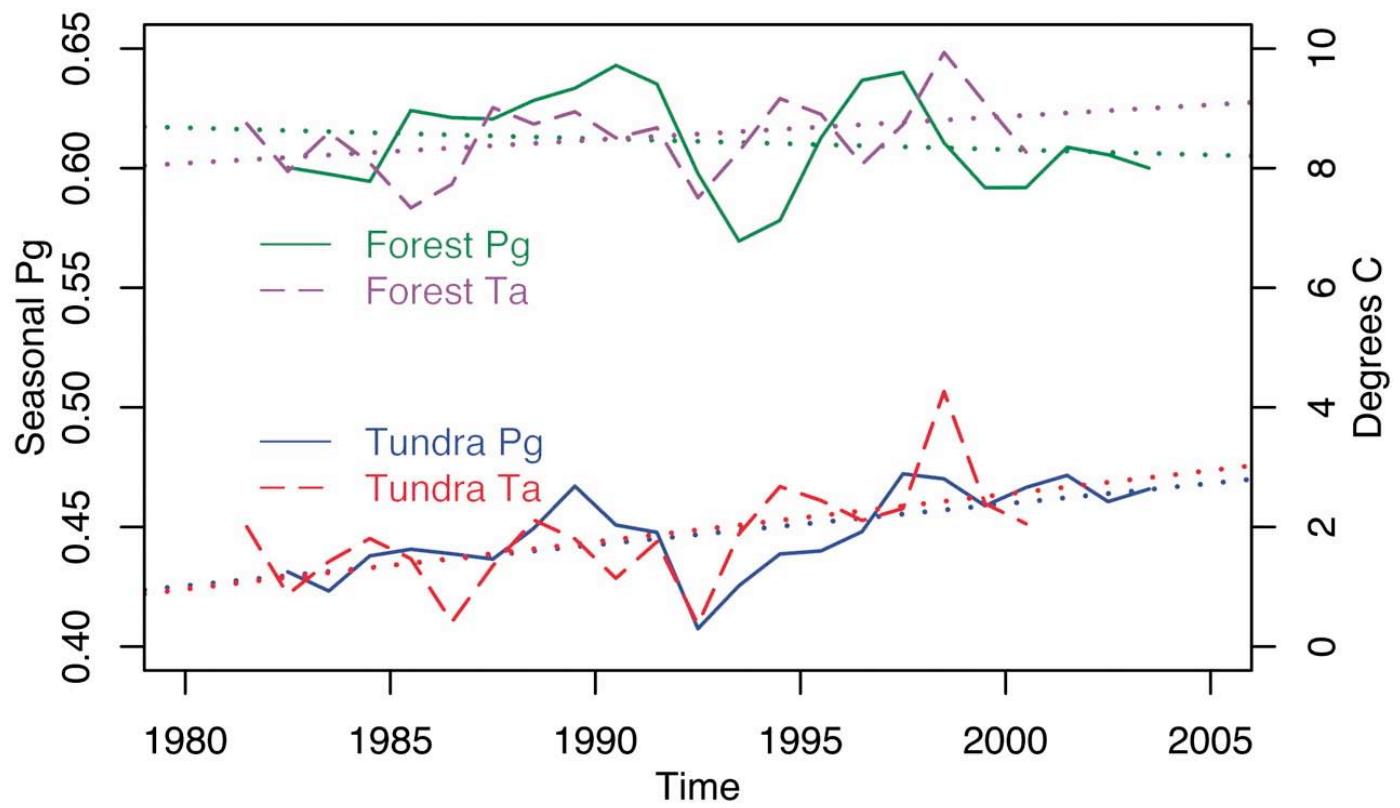




**How trend of greening is affected by the length and period of time series**

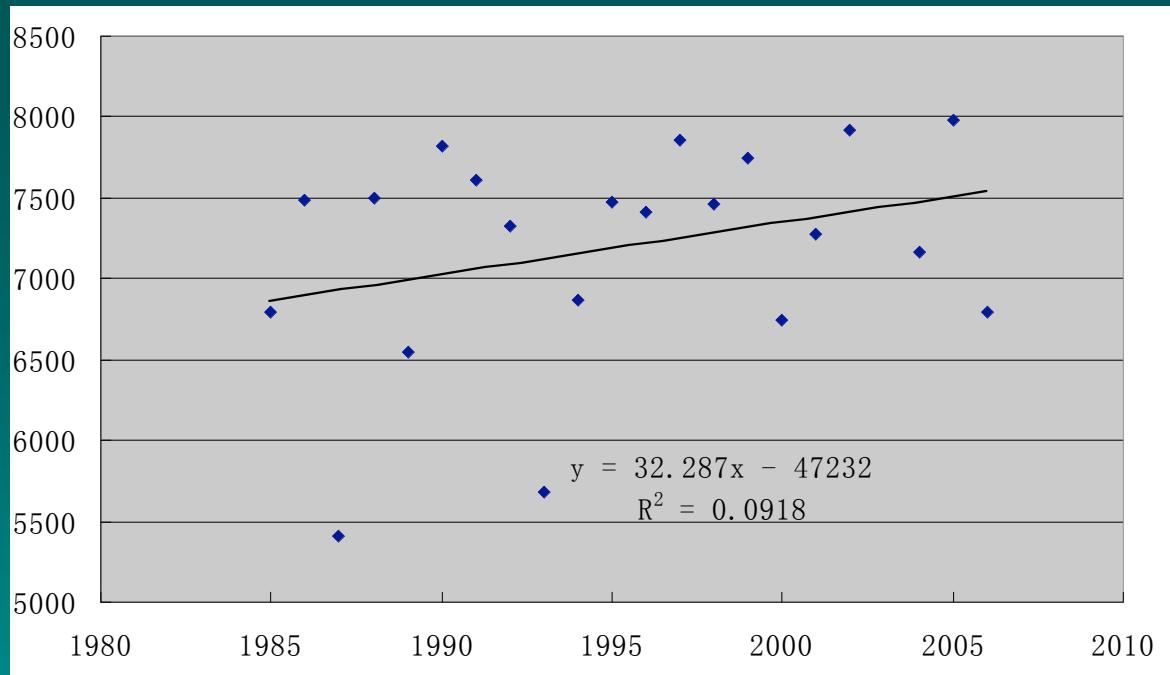


**...In case of time-integrated NDVI**

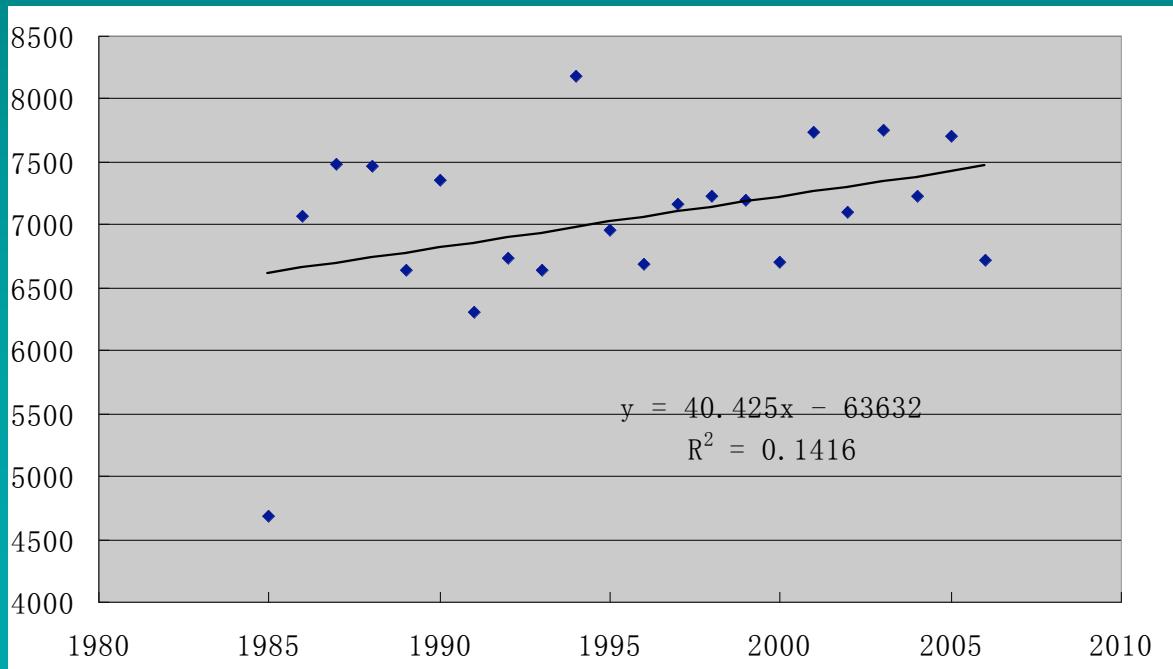


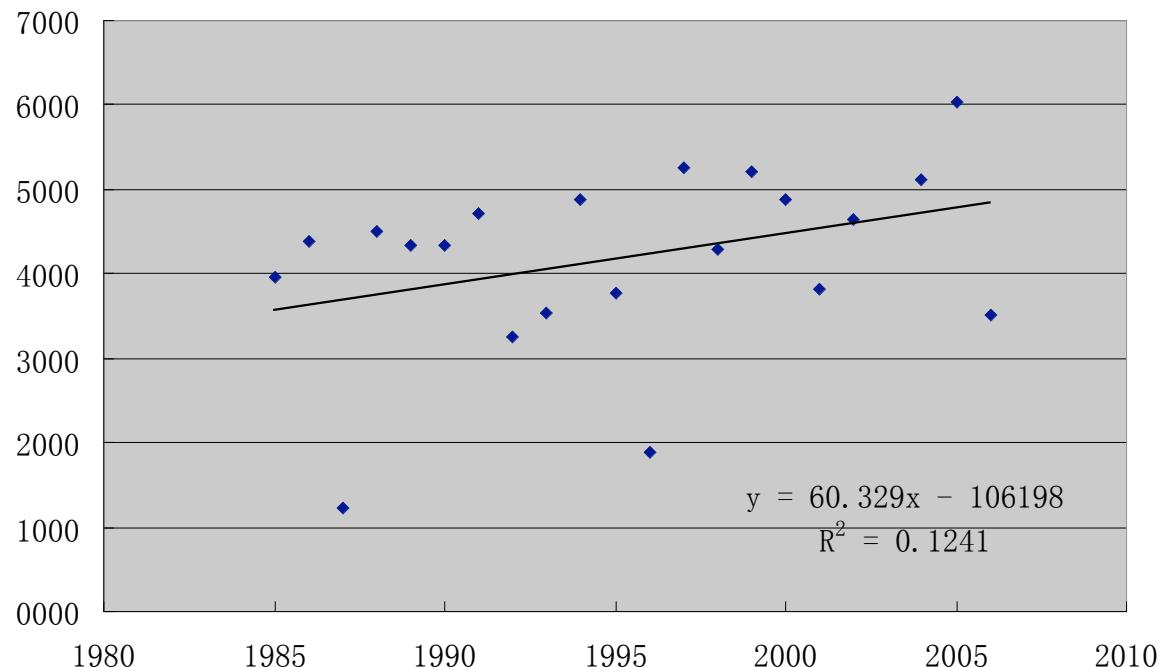
Goetz et al. (2005)

## GAC Peak NDVI NA boreal

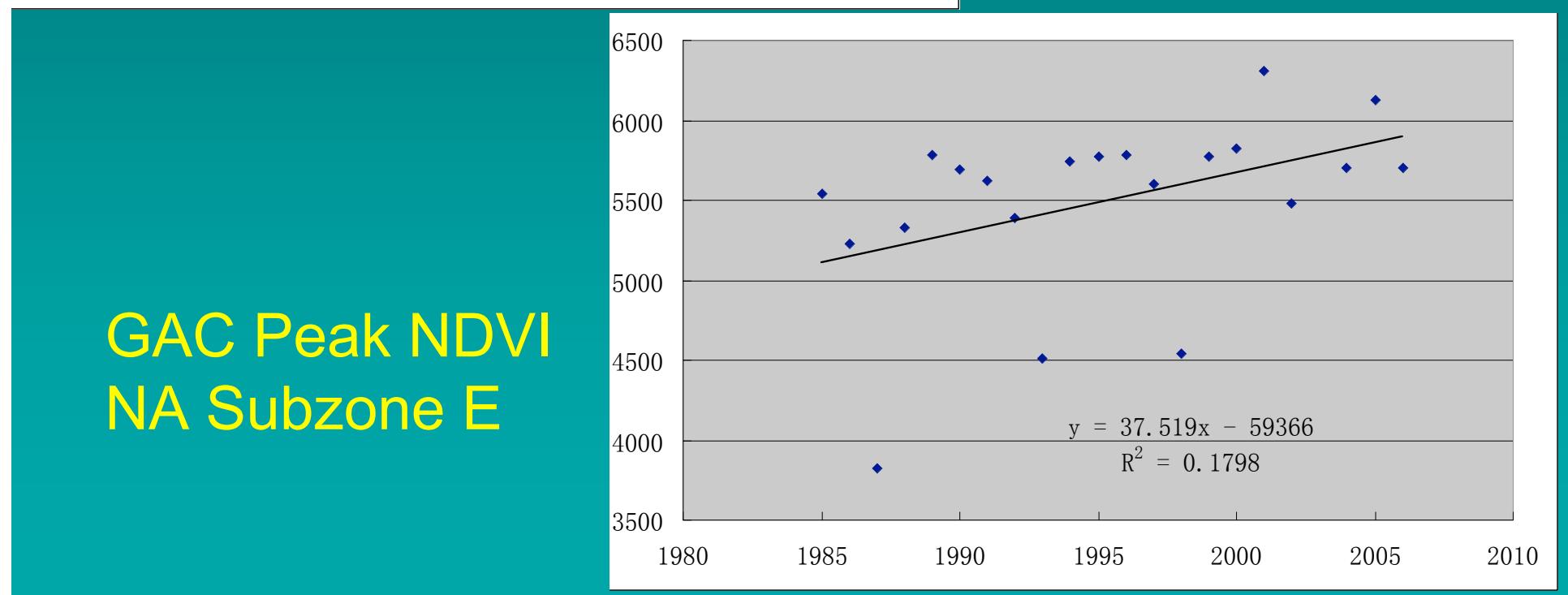


## GAC summer NDVI NA boreal





GAC Peak NDVI  
NA Subzone D



GAC Peak NDVI  
NA Subzone E

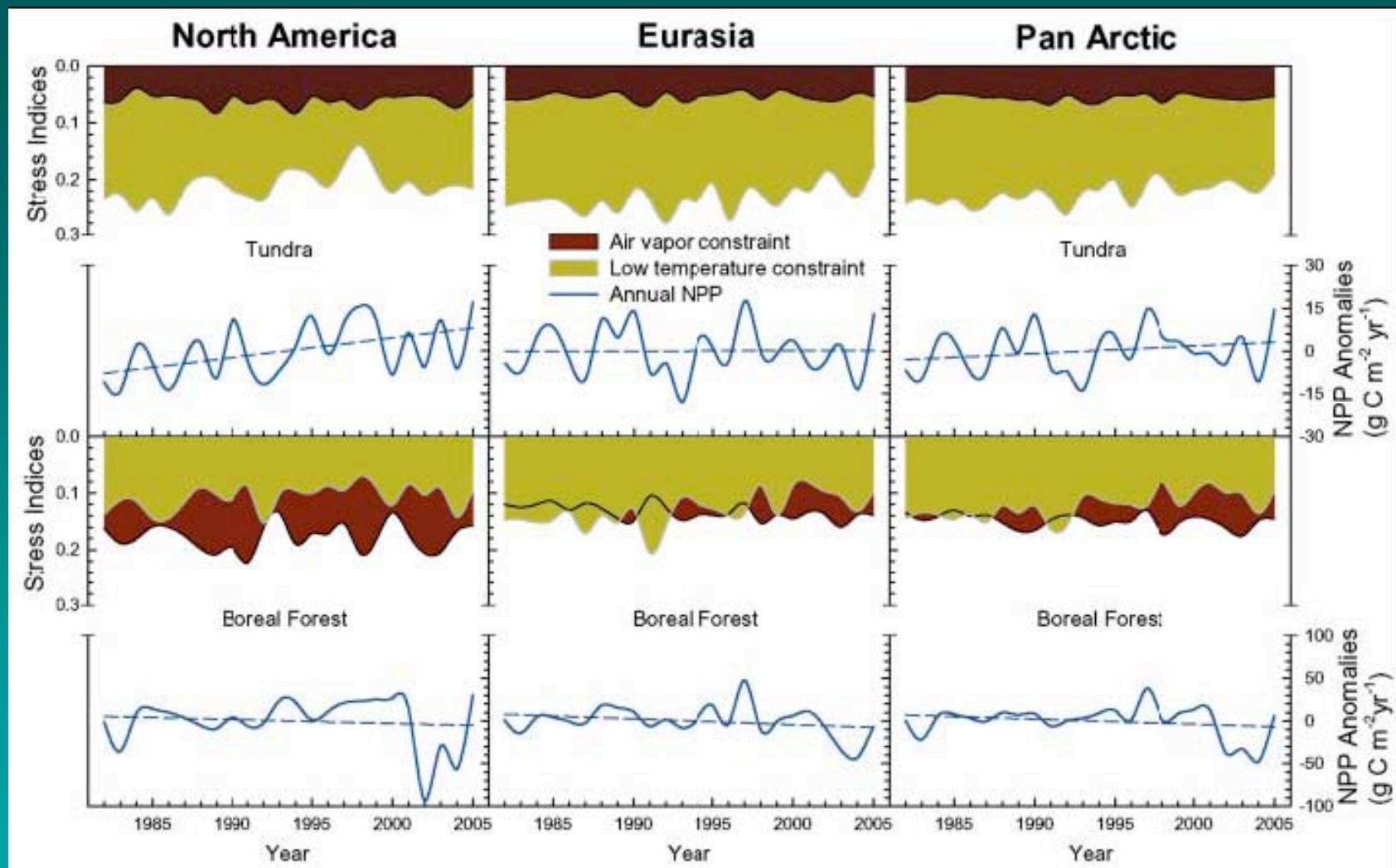
# Plans for 2008

- Revise JGR paper;
- Submit Alaska revisit paper;
- Prepare and submit global trends and uncertainty paper;
- Resubmit Arctic vegetation RS proposal to NSFC, with Howie and Skip int'l collaborators;
- Continue support a student on GOA work

# Thanks!

...Questions





Bunn et al, 2007, EOS