Trends of Vegetation Greenness in the Arctic from 1982-2005

Gensuo J. Jia *(1)(2), *Howard E. Epstein* (2), *and Donald A. Walker* (3)

1) REC-TEA, Chinese Academy of Science; 2) EVSC, University of Virginia; 3) AGC, University of Alaska Fairbanks

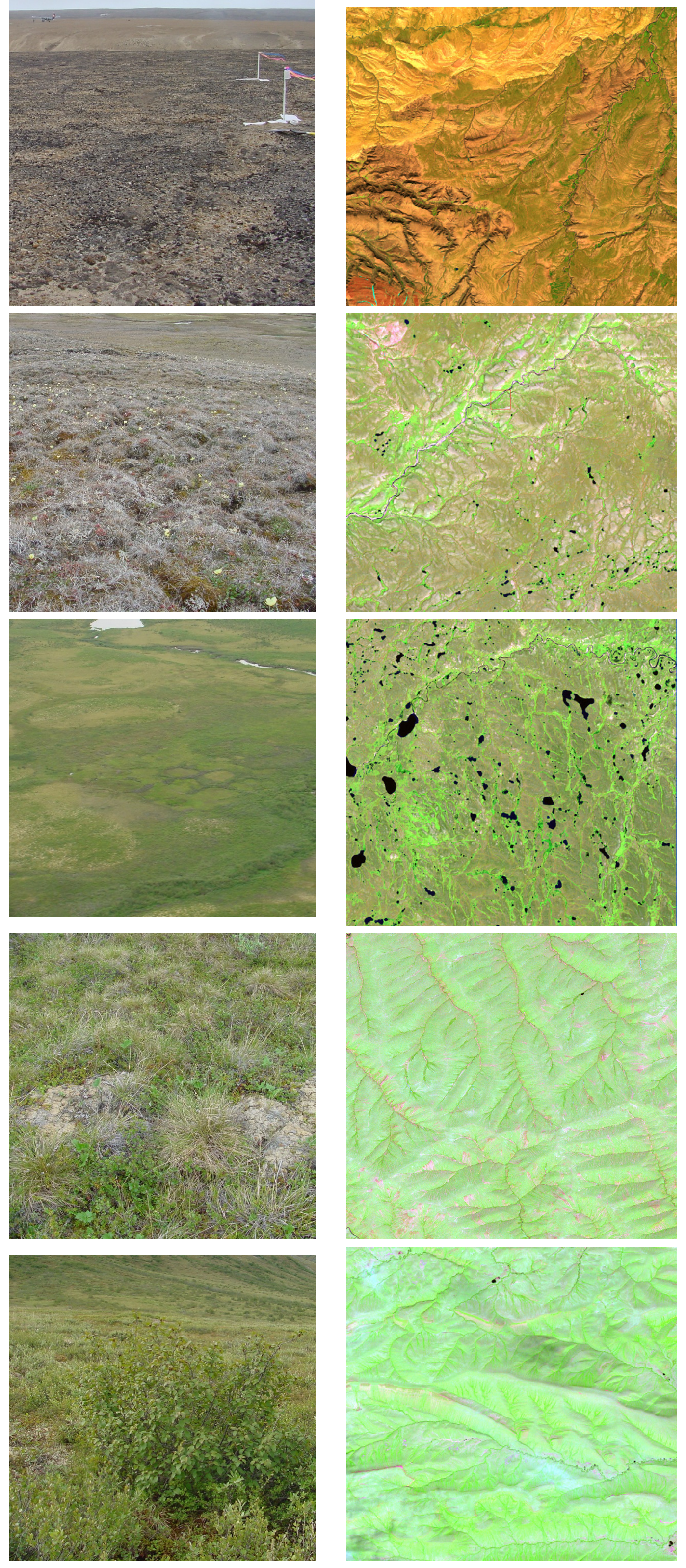
BACKGROUND

The Arctic region has experienced a continuous trend of warming during the past 30 years. Terrestrial ecosystems at high latitudes are warmth-limited and sensitive to alterations in surface temperatures and climate dynamics that are profound in the Arctic. They are therefore expected to exhibit substantial changes in terms of structure and production in response to recent warming and sea-ice decline. Meanwhile, many areas of the Arctic are undergoing large-scale industrial development, e.g. oil and gas exploration, at a rapid pace, indicating an increasing human pressure on ecosystems even in this frontier wilderness.

QUESTIONS AND OBJECTIVES

Major questions face arctic terrestrial ecologists are what will happen to the tundra ecosystems as the global climate warms and what will happen to the indigenous people way of life as land cover/use changes proceed?

Here, we combine multi-scale sub-pixel analysis and remote sensing time-series analysis to investigate recent decadal changes in vegetation photosynthetic activity along spatial gradients of summer temperature and vegetation in the Arctic tundra biome.



Vegetation shown on photographs and Landsat ETM+ images

Subzone A

Subzone B

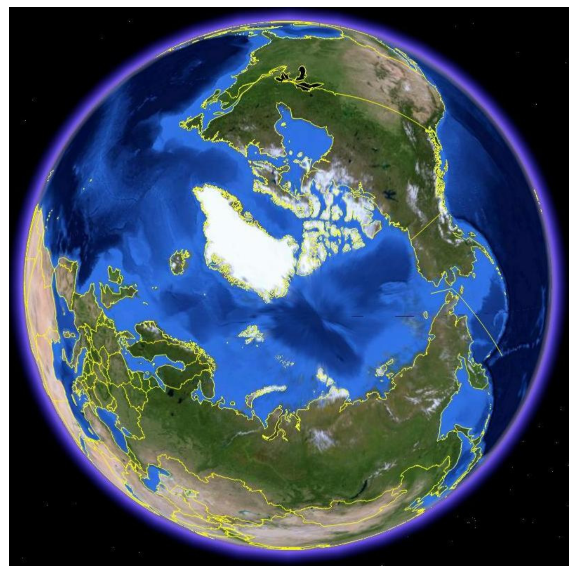
Subzone C

Subzone D

Subzone E

MATERIALS AND METHODS

DATA: The major datasets used here are NASA Gimms data time series at 8 km pixel resolution and 15 day temporal resolution, MODIS land cover data, and geolocation data of field sites.

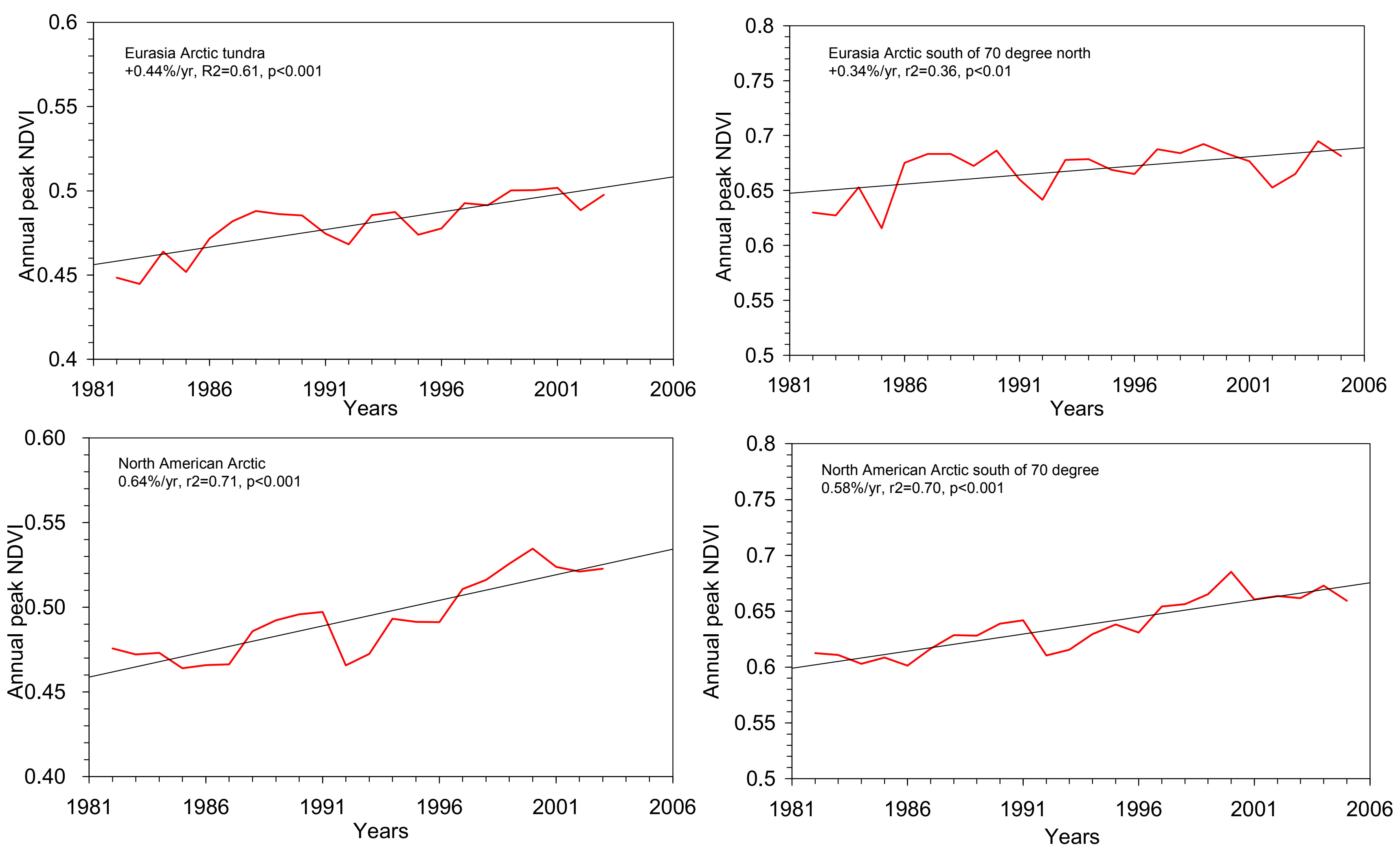


ANALYSIS: The temporal analysis was performed with a 1982-2005 time series, stratified by bioclimate subzone and land cover. We examined the changes of vegetation greenness over the period as indicated by variations of the maximum Normalized Difference Vegetation Index (NDVI), spanning Low Arctic, High Arctic and polar desert ecosystems. Subpixel fractional vegetation cover was analyzed in order to select homogenously vegetated areas of tundra. Autoregression analysis was performed on NDVI time series of those homogenous pixels for each region. Data quality is low beyond 70 degree north for 2004-2005 due to calibration errors, therefore, only pixels below 70 degree north were included for those three years.

INCREASING VEGETATION GROWTH IN TUNDRA

Linear trends in Arctic tundra vegetation greenness over period 1982-2005 were positive over Eurasia and North America, as observed with NOAA AVHRR satellite. Vegetation greenness increased systematically in arctic tundra dominated areas as shown on image difference. The rate of change was +0.64%/yr over North American Arctic compared to +0.44%/yr over Eurasia Arctic from 1982-2003. For south of 70 degree north from 1982-2005, the rate of change is +0.58%/yr over North American Arctic compared to +0.34%/yr over Eurasia Arctic. Vegetation productivities increase from north to south along bioclimatic gradient, therefore, NDVI is much higher in areas below 70 degree north compared to entire tundra biome.

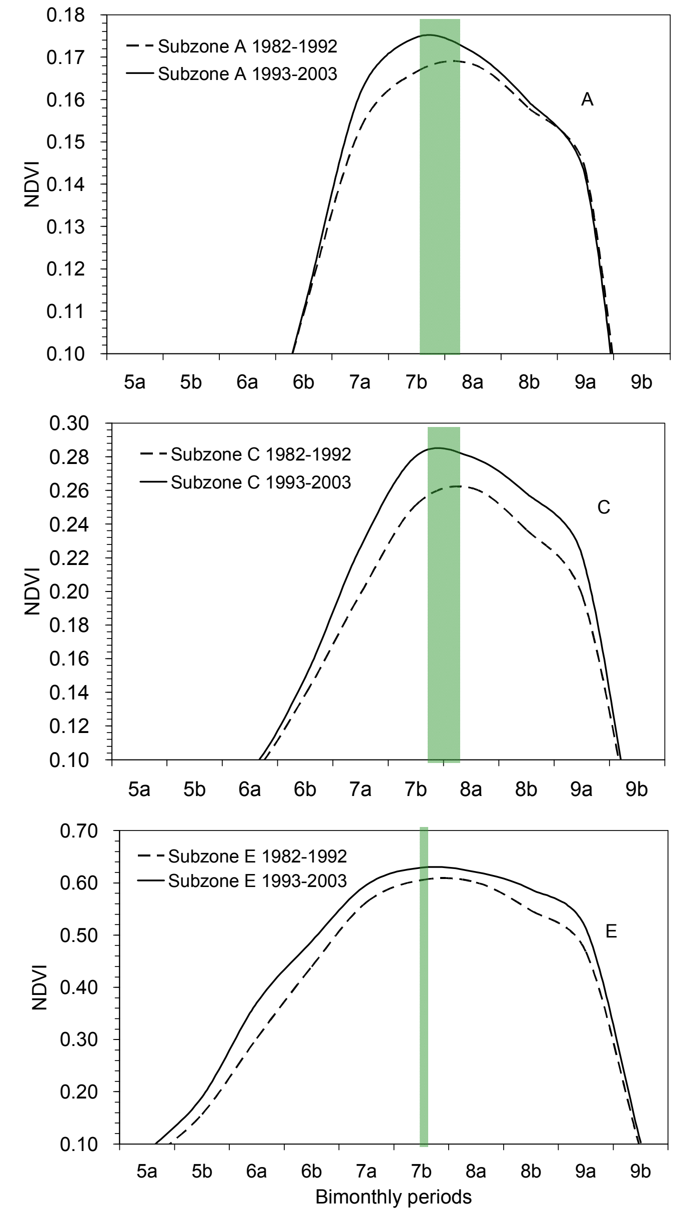
Meanwhile, the changes were heterogeneous over each region. The greatest greening trends were observed in the areas between high and low arctic, especially on islands and peninsulas, while there were less changes in polar desert in the north and shrub tundra in the south in term of peak values.



These chart show the changes of annual peak vegetation greenness over tundra biome from 1982-2003 (left) and below 70 degree north from 1982-2005 (right) in Eurasia and North American Arctic as detected by NOAA AVHRR time series data. Annual peak NDVI represents the maximum NDVI values for each year. Black lines represent linear trends.

CHANGES IN PHENOLOGY

There were changes in phenological pattern over tundra biome in the two decades as well. Increases of vegetation greenness were observed in most of the summer periods in low arctic and mid-summer in high arctic. Peak greenness appeared earlier in high arctic and declined slower after peak in low arctic. Generally, tundra plants were having longer and stronger photosynthesis activities.



These charts show seasonal changes of vegetation greenness for each Bioclimate Subzone. Solid lines represent average values for period of 1982-1992, while dotted lines are average values for period of 1993-2003. The x-axis is in bimonthly interval, e.g. 5a and 9b represent first half of May and second half of September respectively. Green shadows highlight higher and earlier peak growth.

DISCUSSIONS

The decadal increases of NDVI over tundra biome in summer periods reflect increasing vegetation production during the growing season. Field studies have observed early snow melt, thaw of permafrost, and related changes in plant communities. These changes were likely driven by the 1.1-2.3 °C warming and 7.5% decrease of sea-ice extent in the Arctic Ocean during that period.

The rate of greening detected here was higher than that reported in previous studies. This is likely due to two reasons: 1) we restricted our study area in tundra biome only with a phenological tundra-taiga boundary identification approach, therefore, have less chance to mix information of boreal forest in the south; 2) we applied homogenous vegetated area approach to avoid noise from lakes and bare ground and more likely detect initial changes over tundra vegetation.

PROJECT SUPPORT

NSF Arctic Program "Greening of the Arctic - Synthesis and models to examine pan-Arctic vegetation change: climate, sea-ice, and terrain linkages".

NASA Land Cover/Use Change Program "Application of space-based technologies and models to address land-cover/land-use change problems on the Yamal Peninsula, Russia".

*** CONTACT: jiong@virginia.edu (G.J. Jia)**