Greening of the Arctic: Spatial and temporal (1982-2010) variation of biomass and NDVI along two Arctic transects

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An International Polar Year initiative
2010 Expedition to Hayes Island, Franz Josef Land

- Ground-based observations in Bioclimate Subzone A of the Eurasia Arctic Transect.
- Northern-most permafrost borehole in Russia at 80° 37’ N.
- Completion of parallel transect studies in North America and Eurasia.
Field studies along two 1800-km Arctic transects

• North America Arctic Transect: 2002-2006 Biocomplexity of Arctic Patterned Ground Ecosystems Project (NSF).

• Eurasian Arctic Transect: 2007-2010, Greening of Arctic (NASA).

• Both transects through all five Arctic bioclimate subzones.

**Bioclimate Subzones**

<table>
<thead>
<tr>
<th>Subzone MJT (°C)</th>
<th>Shrubs</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 1-3</td>
<td>none</td>
</tr>
<tr>
<td>B 3-5</td>
<td>prostrate</td>
</tr>
<tr>
<td>C 5-7</td>
<td>hemi-prostrate</td>
</tr>
<tr>
<td>D 7-9</td>
<td>erect dwarf</td>
</tr>
<tr>
<td>E 9-12</td>
<td>low</td>
</tr>
</tbody>
</table>
Focus of the talk: Linkage of spatial and temporal trends of NDVI observed on AVHRR satellite images to ground observations along both transects.

- Climate
- Vegetation
- Soils
- Permafrost
- Spectral properties

- NDVI and LAI
- Plant species cover
- Active layer depth
- Site characterization
- Biomass
- Soil characterization
- N-factor
- Permafrost boreholes
1-km AVHRR-NDVI patterns for the Arctic along the two transects

- General pattern of reduced NDVI with higher latitude and elevation.
Variation in climate and vegetation along the transects

Summer Warmth Index

Vegetation (CAVM Team 2003)
Zonal vegetation along both transects

**Eurasia Transect**
A - Hayes Island  B - Ostrov Belyy  C – Kharasavey  D - Vaskiny Dachi  E - Laborovaya

**North America transect**
A - Isachsen  B - Mould Bay  C - Green Cabin  D - Sagwon MNT  E - Happy Valley
Plot-level biomass trends along EAT and NAAT

Major differences. Compared to NAAT, EAT has:

- Less biomass in subzone A (Wetter, much colder).
- More biomass in subzone C, (Wetter, unglaciated landscape along the EAT.)
- Much more biomass in subzone E.
- Fewer evergreen shrubs and lichens. (Reindeer?)
• Less biomass in subzone A (Wetter, much colder).
• More biomass in subzone C, (Wetter, unglaciated landscape along the EAT.)
• Much more biomass in subzone E.
• Fewer evergreen shrubs and lichens especially in subzones D and E. (Reindeer?)

Plot-level biomass trends along EAT and NAAT
Comparison of EAT and NAAT
1-km AVHRR NDVI & biomass, vs. summer warmth

• Biomass values are landscape-level averages for zonal landscapes.

• Greater biomass and NDVI for equivalent temperature along the EAT compared to NAAT.

• EAT is greener in equivalent summer climates.
Comparison of EAT and NAAT
Hand-held NDVI vs. biomass, and LAI

- For equivalent amounts of biomass and LAI, the HH-NDVI readings were much higher along the EAT.
Comparison of EAT and NAAT
Leaf Area Index vs. Biomass

- An equivalent amount of biomass has consistently much higher LAI values along the NAAT than along the EAT and the difference increases at higher biomass values.

- Reflects the different structure of the vegetation along the two transects. Higher proportion of the total biomass is non-green along the NAAT (more wood, standing dead, hairy leaves, brown moss, evergreen shrubs and lichens).
Comparison of EAT and NAAT: 1-km AVHRR NDVI and zonal landscape-scale biomass

- Very strong correlation between AVHRR NDVI and biomass along both transects and for combined data set.
Use of ground data to calibrate circumpolar AVHRR-NDVI/biomass data
Temporal patterns of in NDVI in relationship to changes in area of summer open water


New analysis based on new GIMMS 3g AVHRR NDVI data by Pinzon et al. 2010 (in progress) and sea ice data by Comiso et al. 2010.


**Oceans:** % change of May-Aug open water (1982-2010)

**Tundra land areas:** % change in TI-NDVI (1982-2010)

From Bhatt et al. 2010, *AGU Fall Meeting*
Overall MaxNDVI trend between 1985 and 2007: \(+3.2\%\) vs. \(+13.8\%\) in new GIMMS NDVI data.

- Change varies with landscape and vegetation type.
- Green areas are areas with significantly positive trends.
- Lack of corroboration for magnitude of change indicated by GIMMS 3g.
- Need for calibration of remote sensing data sets and ground measurements.
Collaborations

Institutions:

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* University of Virginia
* Earth Cryosphere Institute (RAS),
* Arctic Centre, Rovaniemi

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Members of 2010 Expedition to Hayes Island