Drivers of Recent Pan-Arctic Tundra Vegetation Variability and Change

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Main Findings

- Evolving divergent trends in North America and Eurasia
- Humidification is likely key factor in recent changes
Solar radiation absorbed by plants depends strongly on frequency.

- Green plants have low albedo in the 0.4-0.7 micron range.
- Green plants have higher albedo in the near infrared.
- NDVI index is a proxy for vegetation activity.
- MaxNDVI & TI-NDVI

Webs of social and ecological factors that influence vegetation productivity and NDVI

NDVI: Integrator of vegetation change

[Modified from Walker et al. 2009, ERL]
NDVI can be equated with aboveground biomass - global relationship

Relationship between MaxNDVI and aboveground biomass similar for both transects!

[Raynolds et al. 2012]
Mean MaxNDVI (82-10) linked to Mean Sea Ice

Main PanArctic hypothesis:
Periods of reduced sea ice should correspond to periods of warmer land temperatures and this should in turn correspond to periods of more rapid greening.

1982-2011 (30 yrs, weekly, remote sensing data)
Tundra Vegetation Trends Mainly Greening

Spring Sea Ice  1982–2011  Summer Warmth  TI-NDVI

Spring Ice reduced, Summer open water increased, SWI warming & cooling, TI-NDVI greening and browning!
Diverging patterns after about 2001:
Eurasia: flat MaxNDVI and declining TI-NDVI.
North America: strongly increasing NDVI, flat TI-NDVI.
Mid-summer cooling throughout Arctic tundra

North America

Spring Sea Ice and Summer Warmth Index

Eurasia

Diverging patterns after about 2001:
- Eurasia: strong cooling & large ice decrease in last decade
- North America: less warming & less ice loss in last decade
Mid-summer cooling & Changing Trend

- North America
- Weekly Temperature Climatology (82-11)
- Weekly Temperature Trend

Early (May10-Jun21) Middle (June28-Aug16) and Late (Aug23-Sep20)
Mid-summer cooling throughout Arctic tundra

- Weekly Temperature Climatology (82-11)
- Weekly Temperature Trend

Early (May10-Jun21)  Middle (June28-Aug16)  and Late (Aug23-Sep20)
Increasing snow over tundra in Spring

- There is more snow on the ground in the spring but it is also melting fairly quickly once it warms up.
- Model studies suggest more snow when sea ice declines. [Higgins and Cassano, 2010]
  - [Muskett, 2011]
N. America MaxNDVI; Early Season declining

15-year bi-weekly MaxNDVI trends

Early (May-Jun) Middle (Jul-Aug15) and Late (Aug15-Sep30)

- Trends are increasing during all summer periods until 2006
- Recent 15 year periods show spring Max-NDVI declines
Trends not constant Eurasia MaxNDVI

- Trends are increasing during all summer periods until 2007.
- Recent 15 year periods show fall Max-NDVI declines and spring for last 15-year period.
North America-Eurasia Contrast

Two transects through all 5 Arctic bioclimate subzones

- EAT has more aboveground biomass and higher NDVI in each subzones B, C, & D.
- EAT more humid in summer and winter than NAAT

[Yurtsev 1994, J. of Vegetation Science]
Conclusions

• Sea ice decline has slowed in N.America and increased in Eurasia.
• Warming has slowed down in N. America and it has cooled in Eurasia.
• MaxNDVI rates of change have diverged between N. America and Eurasia while TI-NDVI has declined for both in recent years.
• Midsummer cooling trends throughout Arctic and 15-year trends show recent cooling and NDVI declines during shoulder seasons.
• Why? ==>Increased humidity, clouds, and snow!

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