Changing seasonality of tundra vegetation and associated climatic variables

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Main Findings

- Sea ice continues to decline, while summer warmth and NDVI trends over the Arctic have flattened or even declined.
- Summer Warmth declines are most prominent during the middle of the summer throughout the Arctic.
- Peak summer MaxNDVI has continued to increase while MaxNDVI has declined in spring and fall, contributing to TI-NDVI declines.

Motivation and Methods

Goals: 1) Document seasonality of tundra NDVI trends
2) Understand related tundra-climate relationships

Data: 1) Use 25 km resolution SSMI passive microwave Bootstrap Sea Ice Concentration (SIC); **2)** AVHRR Surface Temperature (T_s); **3)** GIMMS Normalized Difference Vegetation Index 3G $NDVI_{3g}$ for the Arctic over the 1982-2013 period. **[Pinzon et al. 2014]**

NDVI = (NIR-R)/(NIR+R)
NIR: spectral reflectance in near-infrared band (0.725-1.1 μm) & R: red chlorophyll absorbing portion of spectrum (0.58-0.68 μm)

Methods: Standard climate trend and correlation analysis techniques applied to regional (Modified Treshnikov basins) time series of Maximum NDVI, Time Integrated NDVI, Summer Warmth Index, and sea ice concentration constructed using data within 50-km of Arctic coastlines (ocean & land) .

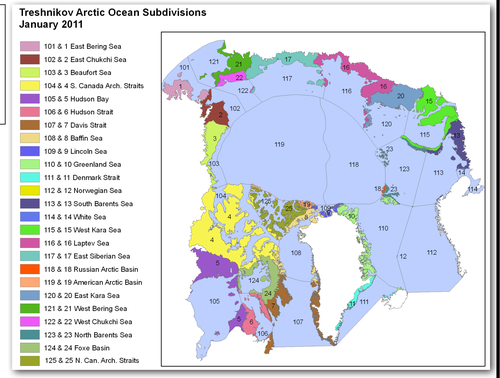

Figure 1. Updated Treshnikov divisions. **[Bhatt et al. 2013]**

Overall, summer sea ice declining, land surface warming and vegetation greenness increasing.

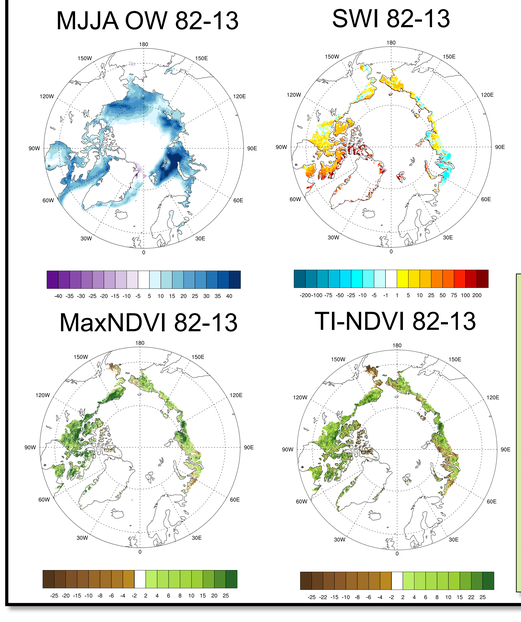

Figure 2. Updated trends of summer open water (OW) (top left), Summer Warmth Index (SWI: sum of the degree months above 0C) (top right), Maximum NDVI (bottom left), and TI-NDVI (bottom right). OW is shown as an total trend over the 32 year period (1982-2013) while SWI and NDVI are shown as percent change since 1982.

- Summer OW is increasing
- SWI is increasing overall except in W. Eurasia
- MaxNDVI increasing except in SW Alaska and W. Eurasia
- TI-NDVI increasing but has more areas with declines than MaxNDVI

Trends in SWI and TI-NDVI have flattened out!

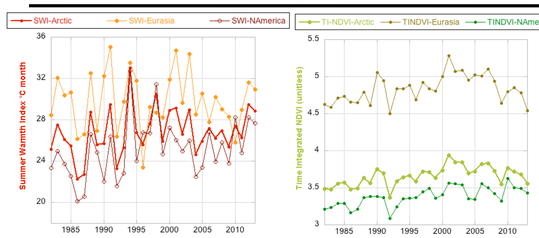

Figure 3. Time series of SWI (left panel) and TI-NDVI (right panel) for Arctic, North America and Eurasia tundra regions.

- Since ~2000, SWI shows declines over Eurasia & N. America
- Since ~2000, TI-NDVI shows declines over Eurasia

Recent trends: SWI shows cooling around Arctic, MaxNDVI continued increases while TI-NDVI shows declines

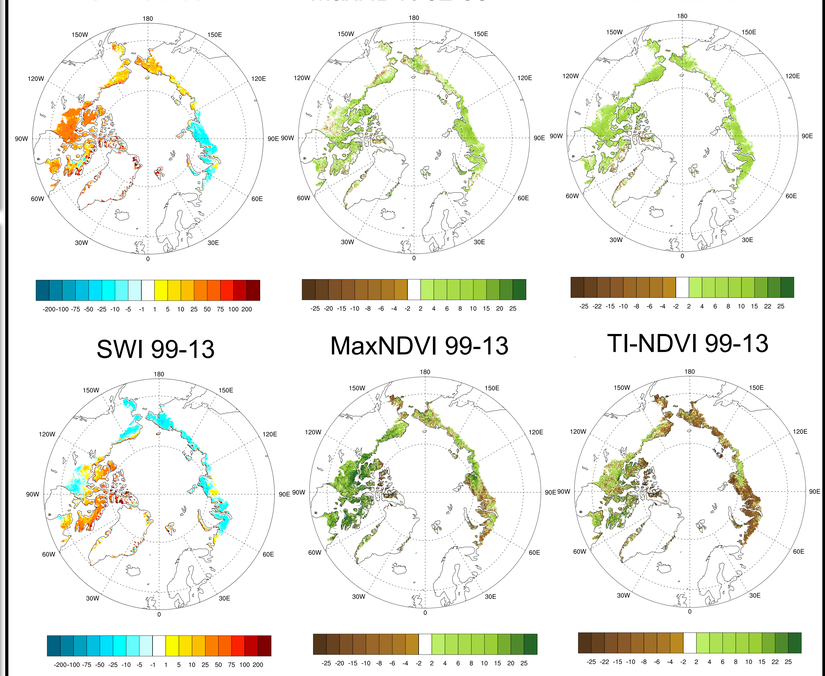

Figure 4. Percent change trends for SWI (left column), MaxNDVI (middle column), and TI-NDVI (right column) for the period 1982-1998 (top row) and 1999-2013 (bottom row).

- SWI (since 1999) declining except in Canadian High Arctic
- Max-NDVI trends are stronger (both + and -) since 1999
- TI-NDVI displays declines throughout Arctic since 1999 except over parts of the Canadian Arctic

Seasonality Changes 1999-2013: Midsummer cooling and Spring/Fall NDVI declines

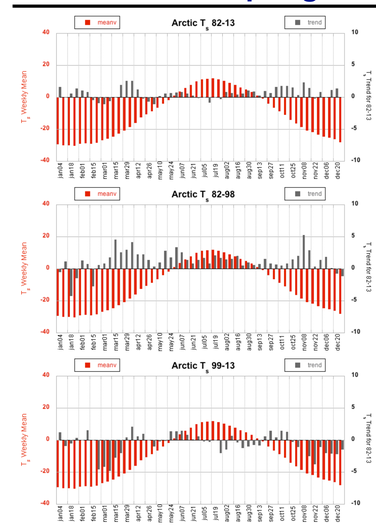

Figure 5. Arctic tundra land surface temperature weekly climatology (red bars) and trends (grey) for full period (top), 1982-98 (middle) and 1999-2013 (bottom).

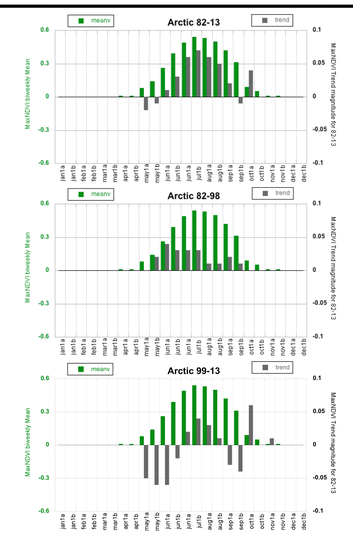

Figure 6. Arctic tundra biweekly MaxNDVI climatology (green bars) and trends (grey) for full period (top), 1982-98 (middle) and 1999-2013 (bottom).

Summary & Thoughts

- Since 1999, SWI has declined primarily due to midsummer cooling.
- SWI increases continue in early and late summer/fall.
- Bi-weekly MaxNDVI has declined in fall and spring but increased during mid-summer since 1999.

What could be causing these trend patterns?
- NDVI: Increased snow cover in spring? **[Bieniek et al. 2014]**
- SWI: Increased cloud cover in summer? Global Climate Hiatus?

This poster is a summary of a manuscript [Bhatt et al. 2014].

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