Application of space-based technologies and models to address land-cover/land-use change problems on the Yamal Peninsula, Russia: Circumpolar and regional analysis of the relationship between sea-ice variability, summer land-surface temperatures, Arctic tundra greenness and large-scale climate drivers

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Main Results

- **Summer Warmth Index over land increases (decreases) as adjacent sea ice decreases (increases)**
- **Sea ice is negatively correlated with integrated NDVI and Summer warmth Index throughout Arctic**
- **Details of the climate forcing relationships display regional variations in the Arctic.**

Motivation & Methods

GOAL: Understand tundra-climate relationships

- **80(60)% of the Arctic tundra (3.2 million km²) is within 100(50) km of ocean**
- **Positive trend in NDVI identified over Alaska, N. America & the Arctic, suggests enhanced photosynthesis. Are these Arctic tundra vegetation changes associated with (forced by) changes in sea-ice? How?**

Hypothesis: Earlier ice melt leads to increased summer warmth and higher NDVI and enhanced greenness (plant biomass & change in vegetation).

DATA: Use 25 km resolution SSMI passive microwave Bootstrap Sea Ice Concentration (SIC), AVHRR Surface Temperature (T_s), and GIMMS NDVI.

TIME: January 1982 to December 2007 (25 years, monthly & weekly) with NDVI to 2006.

AREA AVERAGING: Construct indices of SIC & T_s for total & 50 km buffer areas in Bioclimate Subzones (see reference 2) and Treshnikov divisions.

ANALYSIS: Examine the variability and trends regionally and on pan-arctic scales. Correlate detrended time series.

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)

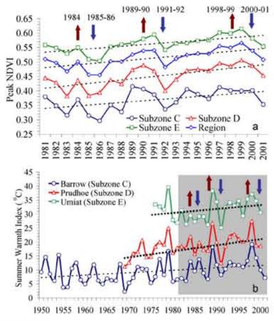
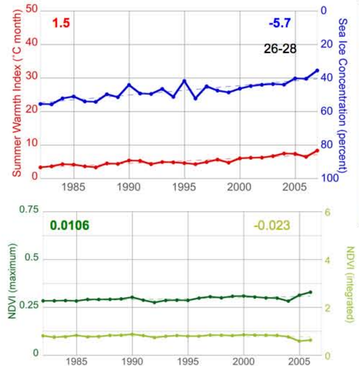


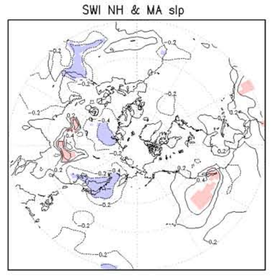
Figure 1 Time series of peak NDVI derived from 8-km resolution AVHRR data from 1981 to 2001 (a) and SWI over the past 22–50 years (b) among bioclimate subzones. Dashed lines are linear regressions. The shaded area highlights the period of SWI covered by NDVI data.

[Jia et al. 2003, Reference 1]

Pan-Arctic Scale: Sea ice decreasing & SWI increasing



- SWI (Degree months above freezing) & Sea Ice (50% occurs between weeks 26-28) are correlated at -0.52 (99% significance)
- Integrated NDVI not correlated with SWI or sea ice at hemispheric level
- Significant trends for SWI, ice & NDVI maximum (bold numbers in time series plots)

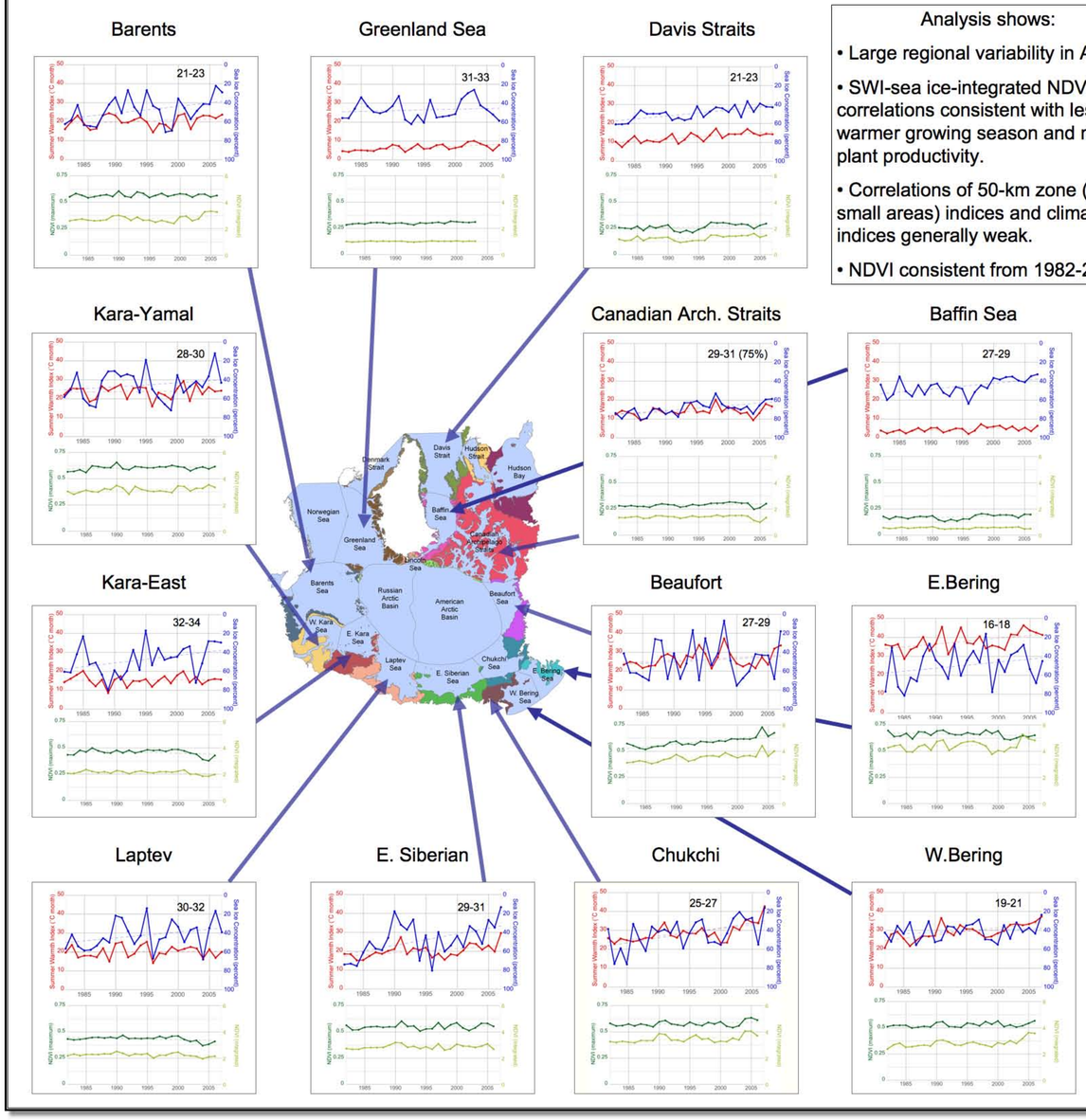


50km Buffer along Arctic Coast

- Sea ice decreasing 5.7%/decade
- SWI increasing 1.5 ˚C-month/decade
- Maximum NDVI increasing
- Large-scale climate indices weakly correlated with pan-Arctic time series

But, spring March-April SLP displays large-scale correlations with SWI. Winter preseason correlations are weak.

Regional Variability in 50-km Zones: Reduced Ice Implies Increased Summer Warmth



Analysis shows:

- Large regional variability in Arctic
- SWI-sea ice-integrated NDVI correlations consistent with less ice warmer growing season and more plant productivity.
- Correlations of 50-km zone (fairly small areas) indices and climate indices generally weak.
- NDVI consistent from 1982-2003

Correlations between SWI, sea ice, & integrated NDVI in 50-km zones
Bold (Italic) values indicate significance at > 95% (90%)

Region	SWI - Sea Ice	SWI - Integrated NDVI	Sea Ice - Integrated NDVI
N. Hemisphere	**-0.61**	**0.63**	**-0.65**
Eurasia	**-0.52**	--	--
N.America	--	--	-0.27
Barents	**-0.52**	**0.70**	**-0.51**
Kara-Yamal	**-0.41**	**0.65**	*-0.38*
Kara-East	**-0.42**	**0.57**	-0.24
Laptev	**-0.68**	**0.60**	**-0.69**
E.Siberian	**-0.61**	**0.54**	**-0.73**
Chukchi	-0.36	**0.71**	-0.31
W. Bering	--	**0.55**	--
E. Bering	--	**0.73**	-0.26
Beaufort	*-0.38*	**0.43**	-0.16
Canadian Arch	**-0.73**	**0.59**	**-0.45**
Davis Straits	-0.14	*0.39*	-0.26
Baffin Sea	**-0.53**	**0.43**	**-0.52**
Greenland Sea	**-0.46**	*0.36*	-0.19

Correlations of SWI, sea ice, & integrated NDVI in 50-km zones with climate indices during preceding winter (DJFM)
Bold values indicate significance at 90% level or greater

Correlation	SWI			Sea Ice			Integrated NDVI		
	NAO	NAM	PDO	NAO	NAM	PDO	NAO	NAM	PDO
N. Hemis.	0.25	0.14	0	**-0.42**	-0.33	0.21	0.12	0.29	-0.29
Eurasia	**0.41**	0.23	-0.23	**-0.51**	**-0.39**	*0.38*	0.25	0.26	**-0.45**
N. America	0.29	0.11	0	0.18	0.12	*-0.34*	0	0.10	0
Barents	**0.45**	0.28	0	*-0.38*	*-0.34*	0.28	0.16	0	-0.15
Kara-Yamal	0.28	0.11	0	**-0.41**	-0.31	0.32	0.11	0	-0.22
Kara-East	- 0.21	**-0.39**	0.15	0.15	0.24	0	0	0	-0.14
Laptev	*0.38*	0.23	-0.30	**-0.52**	-0.32	**0.42**	**0.56**	**0.47**	**-0.52**
E.Siberian	*0.37*	*0.38*	*-0.36*	**-0.50**	**-0.59**	**0.42**	0.31	**0.49**	**-0.60**
Chukchi	0.15	0.13	-0.18	0	-0.32	0.11	0	0	-0.19
W. Bering	0.16	0	-0.18	0	0	-0.18	0	0	0
E. Bering	0	0	0	-0.26	**-0.42**	0	0	0	0
Beaufort	**0.52**	*0.33*	0	0	-0.14	-0.28	0	0	-0.15
Canadian Arch	0.21	0	0	0.11	0	0	0	0.15	-0.18
Davis Straits	0	-0.16	0	0	0.19	-0.29	-0.21	-0.18	0.11
Baffin Sea	0.21	0	0	0	0.15	0	0	0.11	0
Grnland Sea	0.11	0.22	0	**0.48**	*0.39*	0	0	0.26	-0.19

Region (Bold-95% Sig)	SWI trend ˚C month /decade	Sea Ice trend % /decade	Integrated NDVI trend Integrated NDVI /decade
N. Hemis.	**1.5**	**-5.7**	-0.023
Eurasia	**1.1**	**-6.9**	**0.059**
N. America	**1.4**	**-5.4**	0.008
Barents	1.0	**-7.3**	**0.15**
Kara-Yamal	0.22	-4.3	**0.13**
Kara-East	0.2	**-8.0**	**-0.07**
Laptev	0.2	-6.1	*-0.07*
E.Siberian	**2.2**	**-12.1**	0.04
Chukchi	**4.0**	**-10.5**	**0.18**
W. Bering	**3.7**	-2.5	**0.26**
E. Bering	**3.1**	-6.4	0.15
Beaufort	1.6	-3.3	**0.33**
Canadian Arch	1.0	**-5.3**	-0.02
Davis Straits	**2.3**	**-6.4**	**0.15**
Baffin Sea	**0.9**	**-6.2**	0.001
Greenland Sea	**1.3**	-1.4	**-0.02**

References

1. Jia, G.G, H.E. Epstein, D.A. Walker, 2003: Greening of Arctic Alaska, 1981-2001, Geophysical Research Letters, vol. 30, p. 2067.
2. http://www.arcticatlas.org/photos/mapunits/cavmmapimgs

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