Alaska Coastal Tundra Vegetation's Links to Climate

Peter A. Bieniek[1,2], Uma S. Bhatt[1], Donald A. Walker[3], Martha K. Raynolds[3], Josefino C. Comiso[4], Howard E. Epstein[5], Jorge E. Pinzon[4], Comton J. Tucker[4], Richard L. Thoman[6], Huy Tran[1], Nicole Mölders[1], Wendy Ermold[7], Jinlun Zhang[7], and Michael Steele[7]

[1]Geophysical Institute, University of Alaska Fairbanks (UAF), [2]International Arctic Research Center, UAF, [3]Institute of Arctic Biology, UAF, [4]NASA Goddard Space Flight Center, [5]Department of Environmental Sciences, University of Virginia, [6]NOAA National Weather Service, Fairbanks WFO, [7]Applied Physics Laboratory, University of Washington

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Main Results

- Beaufort greening linked to both warming and cooling in summer and changes in the local/regional atmospheric circulation
- WRF simulation shows increase in winds speeds over the Beaufort Sea in response to warming adjacent land surface
- East Bering browning linked with decline in spring snow depth, and overall reduction in moisture of the landscape in summer

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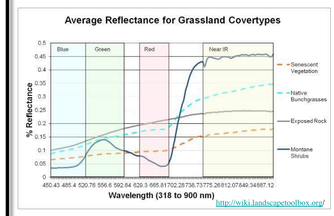
Alaska/Arctic NDVI Trends

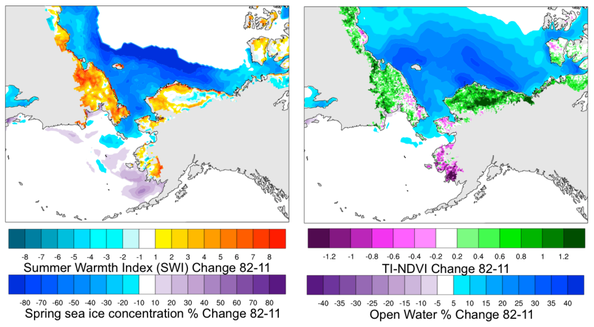


Normalized Difference Vegetation Index

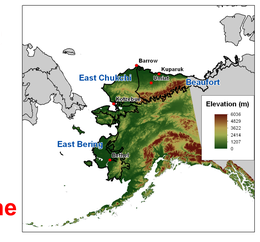
$$NDVI = \frac{NIR - RED}{NIR + RED}$$

A satellite derived indicator of above-ground biomass

- Lowest NDVI near areas with greatest sea ice concentration
- NDVI increasing throughout the pan-Arctic
- Increasing NDVI related to decreased sea ice (e.g. Bhatt et al. 2010)
- Warmer summers in most coastal Arctic tundra regions



Summer Warmth Index (SWI) = sum of monthly T > 0°C



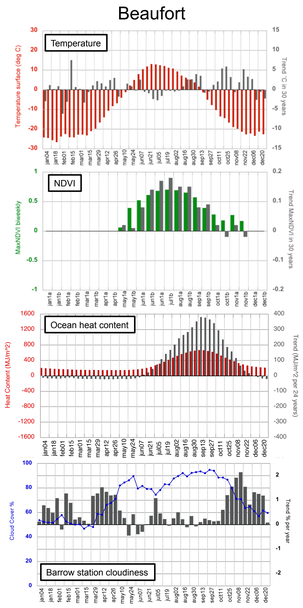
- In Alaska, increasing NDVI in Beaufort and East Chukchi, decreasing in East Bering
- Warmer summer throughout
- What are the climate mechanisms driving the changes in coastal tundra NDVI in Alaska?

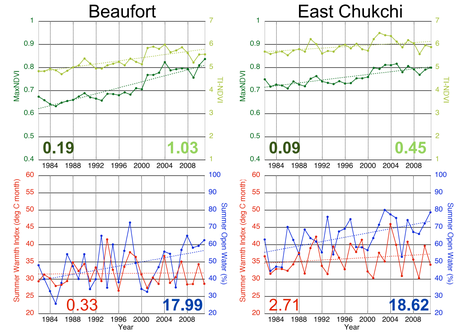
Poster based on Bieniek et al (2012, in preparation) and Bieniek (2012)

Data

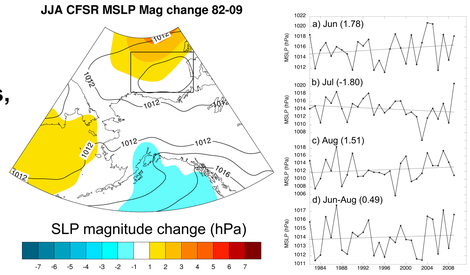
- AVHRR surface temperature, Comiso (2003)
- NDVI GIMMS3g+, Pinzon et al. (2010)
- SSM/I Snow Water Equivalent (SWE), Armstrong et al. (2007) available online: http://nsidc.org/data/nsidc-0271.html
- Climate Forecast System Reanalysis (CFSR), Saha et al. (2010) available online: http://cfs.ncep.noaa.gov/cfsr/
- Ocean Heat Content from PIOMAS, Steele et al. (2011)
- GPCP Combined precipitation data set v2.2, Huffman et al. (2011) available online: http://www.ncdc.noaa.gov/oa/wmo/wdcamet-ncdc.html

Beaufort and East Chukchi have local climate mechanism





- Increasing NDVI throughout season
- NDVI significantly correlated with SWI (Bhatt et al. 2010)
- SWI correlated with sea ice concentration
- NDVI, SWI and % open water all generally have increasing trends

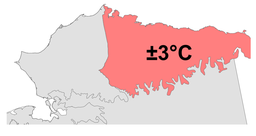


- Beaufort High has weak trends, different monthly trends
- Correlated with sea ice concentration
- Mixed trends in summer cloudiness/temperature
- Changes more local

- Sea breeze known to exist on Beaufort Sea coast (e.g. Moritz 1977)
- Land/sea temperature contrast is changing
- How is the sea breeze circulation changing?

WRF: Enhanced sea breeze with warmer land surface

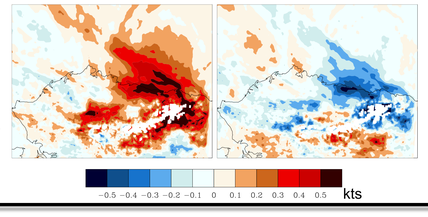
Anomaly applied to Reference (REF)



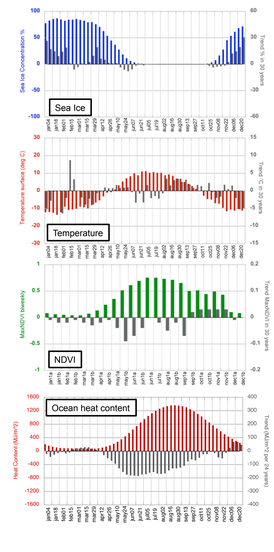
- WRF model v3.3 applied to investigate impact of warming Beaufort tundra region on local/regional atmospheric circulation
- Add/subtract 3°C anomaly to/from reference simulation
- 30 day simulation: 15 June – 15 July 2010

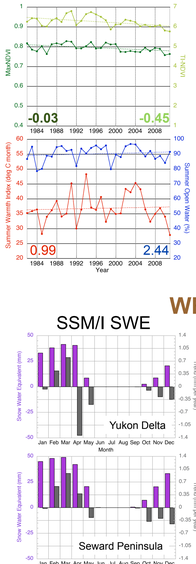
- Wind speeds are enhanced (reduced) when positive (negative) anomalies are applied in the simulation
- Sea breeze is enhanced with warmer Beaufort region
- Largest response in winds is over the ocean

June 850hPa wind speed



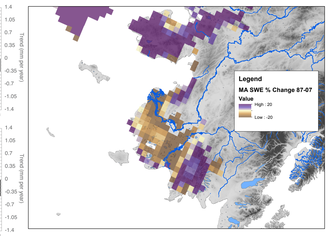
East Bering browning due to reduced snow, summer precip



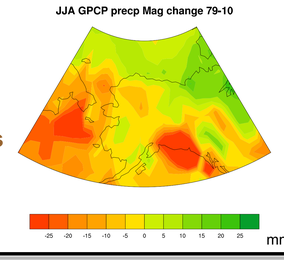


- NDVI, SWI significantly correlated (Bhatt et al. 2010)
- East Bering is nearly ice free by summer
- NDVI declining throughout summer
- Bering sea has reduced heat content

Why is NDVI declining?



JJA GPCP precp Mag change 79-10



- Spring Snow Water Equivalent (SWE) is decreasing
- Summer precipitation is also decreasing
- Lakes are drying in the region
- Similar changes noted by local Native Elders (e.g. Fienup-Riordan and Rearden 2012)
- NDVI is likely reduced due to drier conditions

Conclusions

- Beaufort and East Chukchi NDVI increase linked with both warming and cooling, changes in local/regional circulation
- East Bering NDVI decline linked with reduced spring snow water equivalent, summer precipitation and drying landscape
- Additional analysis of WRF simulation needed to address response of convection to imposed anomalies in surface temperature in the Beaufort region

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Acknowledgements

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