Influence of Regional Sea Ice Variability on Arctic Tundra

Uma S. Bhatt[1], Donald A. Walker[2], Martha K. Raynolds[2], Josefino C. Comiso[3]

[1]Geophysical Institute, [2]Institute of Arctic Biology
College of Natural Sciences and Mathematics
University of Alaska Fairbanks, Fairbanks, AK 99775
[3]NASA Goddard Space Flight Center, Greenbelt, MD

1. INTRODUCTION

Recent dramatic reductions in sea ice and changes in Arctic vegetation have been well documented and are of growing concern because of how they may impact the ecosystem at high latitudes, which includes permafrost, soils, fauna, as well as humans. The variability in sea ice cover is hypothesized to influence the nearby tundra vegetation by forcing atmosphere and land temperatures changes. It is hypothesized that an earlier ice melt leads to increased summer warmth, higher NDVI and enhanced greenness of vegetation.

To investigate this question, climate analysis techniques are applied to high-resolution passive microwave sea ice concentration and AVHRR land surface temperatures to evaluate the direct relationship between coastal ice and the adjacent land. The spatial variations of the climate-tundra relationships are examined by performing analysis regionally as defined by bioclimate subzones. We find a relationship between sea ice cover and nearby land surface temperatures that is generally consistent with the notion that cooler land surface temperatures are found with above average ice conditions. In addition, we are examining atmospheric circulation anomalies to explain the mechanisms behind the ice area – land temperature relationships.

2. DATA AND METHODS

The analysis employs 25 km resolution SSMI passive microwave Sea Ice Concentration (Comiso 1999) and AVHRR Surface Temperature (Comiso 2006, 2003) covering the 24-year period from January 1982 to December 2005. The sea ice concentration and T_s have been processed by removing the long term monthly means to form monthly anomalies.

The remote sensing data are divided over land into bioclimate subzones as defined by Circumpolar Arctic Vegetation Map (CAVM 2003) and over the ocean into basins as defined by Treshnikov (1985). A color map of CAVM is available at www.geobotany.uaf.edu/cavm. A monthly climatology over the 1982-2005 period of surface temperature is presented in Fig. 1. Subzone A is characterized by a maritime climate, while the other subzones have a more pronounced annual cycle.

Standard climate analysis techniques of correlations, regressions, and composites are applied to the data. An examination of monthly variability of surface temperature in the bioclimate subzones reveals that there is large interannual variability and temperature in the subzones generally vary together in a given month (not shown).

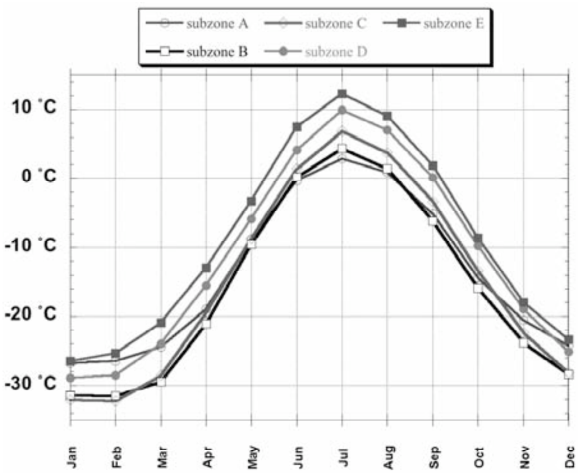

Fig. 1. AVHRR temperature monthly climatology for each of the bioclimate subzones.

3. RESULTS AND SUMMARY

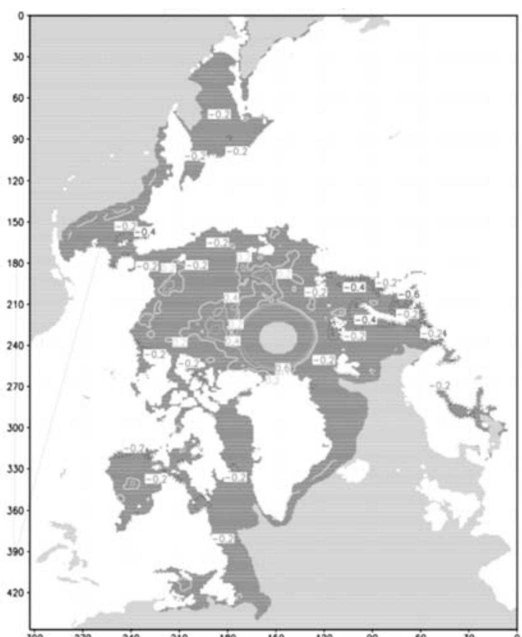

Fig. 2. Correlation for April sea ice concentration and April surface temperature in bioclimate subzone B. Correlations for other months and subzones are similar.

Preliminary analysis reveals that there is a relationship between sea ice cover and near-by land surface temperatures. Fig. 2 presents correlations between April sea ice concentration in the Arctic and a time series of April surface temperature in bioclimate subzone B. The correlations are negative in the Kara Sea region, which is consistent with the notion that reduced sea ice is associated with warmer land surface temperatures. Positive correlations in the polar drift region may be explained as follows. Enhanced southerly flow from E. Siberia causes open water, leading to enhanced ice formation. The southerly winds advect ice poleward and increase ice accumulation in central basin. Stronger southerly flow is associated with warmer temperatures. Correlation patterns in other months display similar relationships.

The robustness of the relationships will be quantified using significance testing. This analysis is being repeated using weekly remote sensing data to more clearly define the relationship between the earlier opening up of the sea ice and nearby surface temperatures. The associated atmospheric circulation is also being analyzed.

ACKNOWLEDGEMENTS

The work is supported by grants from NSF (ARC-0531180) and the NASA Landcover Landuse Change (LCLUC) Initiative.

REFERENCES

CAVM Team. 2003. Circumpolar Arctic Vegetation Map, scale 1:7 500 000. *in* Conservation of Arctic Flora and Fauna (CAFF) Map No. 1. U.S. Fish and Wildlife Service, Anchorage, Alaska.

Comiso, J. C., 2006: Arctic warming signals from satellite observations. *Weather*, **61**, 70-76.

Comiso, J. 2003: Warming Trends in the Arctic from Clear Sky Satellite Observations, *J. Climate*, **16**, 3498-3510.

Comiso, J. 1999, updated 2005: Bootstrap sea ice concentrations for NIMBUS-7 SMMR and DMSP SSM/I, June to September 2001. Boulder, CO, USA: National Snow and Ice Data Center. Digital media.

Treshnikov, A. F., Atlas of the Arctic, Moscow, 204 pp., 1985. (in Russian).