Seasonal patterns in the surface energy balance from a fen and a ridge site in northern Alaska: Preliminary findings for the autumn and winter seasons, 2007 - 2008

E.S. Euskirchen[1], G. Scott[1], S. Bret-Harte[1]

[1]University of Alaska Fairbanks, Institute of Arctic Biology

Background and Rationale

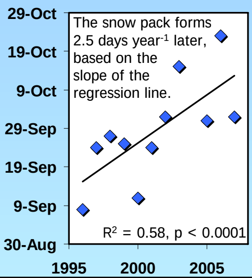


Figure 1. Changes in the date of the formation of the seasonal snow pack from 1996 - 2007 at our study site, the Imnaviet watershed in northern Alaska. Data is from the SNOTEL (SNOwpack TELemetry) network.

➢ While much attention has focused on carbon-climate feedbacks to the atmosphere, less well understood are the feedbacks associated with changes in land cover under a changing climate.

➢ In particular, in northern Alaska, the duration of the snow season has decreased by approximately 1.5 - 3.5 d decade^{-1} over the last several decades (Chapin et al., 2005, Stone et al., 2002; see also Figure 1). This is due to both the timing of snow melt in the spring, and the return of snow in the autumn.

➢ This change in the land surface has important implications for climate warming due to the well-known snow-albedo feedback loop (Figure 2). When the surface absorbs additional heat due to either a later snow return or earlier melt, the additional energy is redistributed in complex ways between the ground, sensible, and latent heat exchanges. By quantifying the seasonal radiative energy received at the surface and the partitioning among the heat fluxes at the time of snowmelt and snow return, we can understand the implications of a reduction in the snow season on atmospheric heating (Euskirchen et al., 2007; Chapin et al., 2005).

➢ ***However, despite the importance of the surface energy balance on atmospheric heating in high-latitude systems, there have been few studies published in the peer-reviewed literature that document the full annual cycle of the surface energy balance of the dominant vegetated ecosystems in the Arctic. Here, we present a preliminary characterization of the seasonal energy balance for two types of tundra ecosystems in Arctic Alaska.***

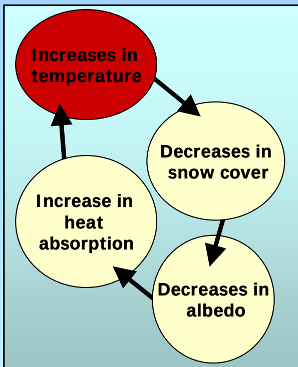
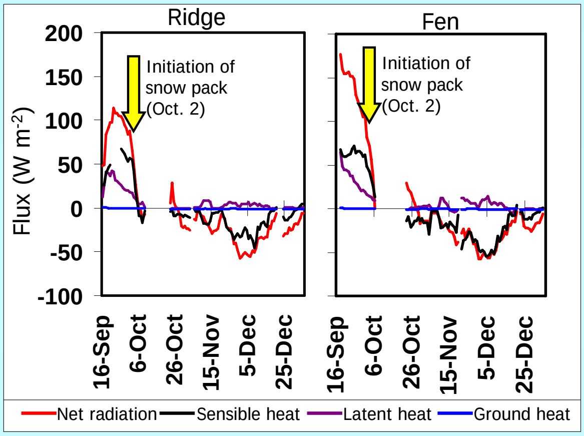


Figure 2. The snow – albedo feedback loop. Decreases in albedo due to a shorter snow season promote solar absorption, and cause further warming.

Preliminary Findings

Figure 3. Values of heat fluxes (net radiation, sensible heat, latent heat, and ground heat) between 16. Sept. 2007 – 3. Jan. 2008. Data are the means of daily data collected between 10-14 h, with a five day moving average applied for smoothing. Data between 7. -22. Oct. are missing due to technical malfunctions.



Seasonal rates of change

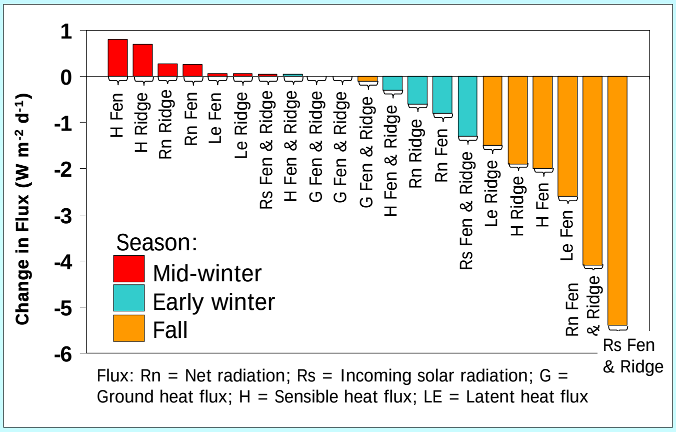


Figure 4. Changes in heat fluxes (W m^{-2} d^{-1}) across season, ordered from largest positive to smallest negative, based on the slopes obtained from linear least squares regression.

➢ Across all fluxes, changes are generally greatest and highly negative in the fall. Changes are still generally negative in early-winter, but appear to be positive again by mid-winter.

➢ The differences in rates of change of the fluxes between fen & ridge sites are not statistically significant (p>0.01).

➢The change in G is zero for both the mid-winter and early winter at the fen and ridge sites.

➢ The fluxes at the ridge site and fen site were generally similar, with the exception of net radiation, which was higher at the fen site in the fall.

➢At the time of snow pack initiation, the energy fluxes decreased dramatically. Also during this time, the albedo at the sites increased from ~0.2 to 0.8 (data not shown).

Basic Methodology

➢The study region in northern Alaska is located in the foothills of the Brooks Range, in the Imnaviat watershed, approximately 12 km north of the Toolik Field Station.

➢The two tundra sites included in this analysis include a seasonally wet fen and a drier ridge site. Both sites include tussock vegetation and a mixture of forbs, sedges, and grasses, with the ridge site including some dry heath vegetation (e.g., small deciduous shrubs).

➢Measurements of basic meteorological variables and energy fluxes were initiated in September 2007. The fluxes of latent and sensible heat were collected using eddy covariance method at 20 Hz intervals, and were later post-processed to include frequency and Walt-Pennman Leuning corrections (Massman, 2000 2001; Webb et al., 1980)

➢The seasons presented in this analysis are defined as follows:
Late Fall (Sept. 16- Oct. 6; 22 days), lasts until the beginning of the seasonal snow pack
Early Winter (Oct. 23 – Dec. 21; 59 days), lasts until the winter equinox
Mid-winter(22. Dec. - 21. March; 13 days), lasts until the spring equinox

Figure 5. Photos of the ridge site (a) and the fen site (b) taken in September 2007. In (c) the equipment is iced with hoar frost, which makes collecting data a challenge in the winter months.

Conclusions and Future Activities

➢ Measurements to date suggest large rates of change in the energy fluxes in the fall, at the time of snowpack formation. This has important implications for a changing climate, whereby the snow pack formation occurs later and/or melts earlier (e.g., see Figure 1).

➢ The changes in the energy balance will potentially be greatest during the spring melt season due to interactions between the ripening of the snowpack with air temperature and heat fluxes (see also Euskirchen et al., 2007; Rouse et al., 2003).

➢We are continuing to perform measurements at the study site. As the data become available, we will include them in our analysis to obtain energy balance data over the full annual cycle, and eventually examine interannual variability in the annual energy balance.

➢ Synthesizing the measurements over the full annual cycle from this site with those data collected over the full annual cycle at other Arctic sites would provide a valuable dataset on surface energy balance across the Arctic.

Acknowledgements Funding was provided by the National Science Foundation, under grant (fill this in!). Tracey Dahl and Roy Stehle provided valuable assistance with equipment installation at the site.

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