CHAPIN, MCGUIRE, ROMANOVSKY Group - Council science field report 1999

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UAF ATLAS homepage http://www.lter.uaf.edu/ATLAS

Objectives

The primary objectives for the summer field program at Council, Seward Peninsula, were to examine the characteristics and the mechanisms of feedback processes in land-atmosphere exchange. These data on the surface energy and moisture exchange between atmosphere ecosystem, snow, permafrost and soil will be used to investigate the mechanisms for coupling the land surface to climate on seasonal and decadal time scales. An ultimate aim is to produce realistic predictions of future outcomes of climate change in the Arctic.

The overall ATLAS-LAII project takes a comprehensive view of the study of the surface energy and moisture budgets as well as examining vegetation biogeochemical and biophysical characteristics in vegetation types representing a structural transition from tundra to forest. Detailed data analysis, model development and spatial/temporal extrapolation will also be a key component of this project. The research is entirely interdisciplinary and involves close interaction between ecosystems and physical climate system studies.

Council and the Seward Peninsula area

Council is located approximately 70 miles to the northeast of Nome on the Seward Peninsula. The Peninsula itself encompasses a diversity of landscape and ecosystem types created by the various climatic and topographical settings. The climate is somewhat continental with cool and windy summers along the coast but inland it is hotter and drier. However, the area is considerably warmer and wetter than the North Slope or interior Alaska. Hence, the Council area provided an excellent opportunity to investigate a wide variety of ecosystem types that may be important in future climate change. It also allows us to examine what may happen under warmer and wetter conditions that may represent the future climate in interior Alaska.

Ecosystems

Six different ecosystem types were selected for study in conjunction with Skip Walker (see Walker report for vegetation descriptions). These ecosystem types represented a conceptual toposequence from tundra through a gradient of shrub tundra to mature spruce forest. At each site, a 100x100 m grid was installed. We established a permanent site at both the Tundra and Spruce types. A mobile system was used to characterize the four other ecosystem types. In addition to the Council sites we also collected surface exchange data in an area of tundra that had been recently burned. The six sites were a white spruce forest, Woodland, Shrub, Lowshrub, Tundra and burned (Details are given at the end of the document).

Measurements

Terrestrial Biogeochemistry

Vegetation

In the Council grids, the following were measured: community composition, vegetation height, LAI before and during peak biomass (Licor 2000), percent cover of vascular species and moss, and spruce density and height. Peak-season harvests of above and belowground biomass (not including roots) were conducted at 10 random points within the grid in the tundra, low shrub and woodland sites. Biomass harvests in the other Council sites will occur in 2000. The vegetation data is being used in the development of a Dynamic Vegetation Model for the Pan-Arctic.

A separate study was undertaken to investigate the possible implications of increasing shrub cover and height on ecosystem structure and function. We measured soil temperature at 10cm, gravimetric soil moisture and understorey species composition and height under shrub species of varying heights.

Soil

Grid scale measurements of soil moisture were made once during the season using a hand-held Vitel and depth of frost layer/active layer were measured in early and late season. Bulk density measurements were made in all the grids.

Land-Atmosphere Coupling

Eddy covariance measurements

Measurement of surface exchanges of heat, water, momentum and CO2 were made using eddy covariance techniques on 10m towers. Two permanent sites were established at the two ends of the vegetation continuum and a mobile system was employed to characterize the four other types that were referenced to the permanent towers. Over the White spruce forest a 20 m tower was utilized and addition measurements of energy and CO2 storage were made.

Climate measurements

In addition climatic data were also collected at each site and included at minimum Temperature, Relative humidity, and Wind speed at two levels, wind direction, incoming and outgoing – long and short-wave radiation, Photosynthetically active radiation, net radiation, rainfall, barometric pressure, soil temperature (top 10cm integrated), soil heat flux (10cm depth), and volumetric soil water content.

Permafrost measurements

Four "soil climate" sites were established at the locations of the flux measurement towers (C1, C2, C3, C4). At each site, the air temperature, ground (including ground surface and 10 to 11 depths down to 80 to 104 cm) temperatures and ground moisture at three depths will be recorded hourly during the entire year. At the Tundra site (C2) we could observe many early stage thermokarst features. Two Optical StowAway micro-loggers were installed within two separate thermokarst depressions at the depths of 1.0 m and 0.77 m (the bottom of the active layer in these depressions). The temperature data from these loggers will show if the active layer in the depressions will refreeze completely during the next winter.

Chamber based measurements

A static chamber system encompassing a Licor-6262 was used to estimate fluxes of CO_2 (light and dark measurements) and water vapour from 30 collars in the Tundra site. The Tundra site was measured intensively to investigate 1) the contribution of moss and other surface types to overall grid scale fluxes of water and CO_2 2) to estimate the contribution of different functional types to overall fluxes using a mixing model. 3) Investigate the controls on moss photosynthesis, respiration and water loss.

Additional Moss measurements

In addition to chamber based measurements of fluxes collars containing homogeneous moss surfaces were instrumented with soil suction and soil water content probes to examine how water moves through the moss and organic layers and to look at how this effects water loss under varying meteorological conditions. In addition the thermal conductivity of the mosses were measured over varying soil water contents in order to better quantify moss physical parameters. In conjunction with Dr. Michelle Mack, litter decomposition was measured at both the tundra and spruce sites. Additional litter bags and buried bags were used to examine the relative importance of litter quality and substrate microclimate as controls on decomposition and net mineralization.

Boundary layer studies

An NCAR integrated sounding system and tethered balloon system were used to characterize boundary layer profiles and development simultaneously over both tundra and spruce ecosystem types in order to better understand potential influences of vegetation on larger scales. Both systems were operated between the 7/20-8/11. Data from the Radio Acoustic Sounding System and the upper air soundings will be used to develop better water vapour transport parameterization in the regional climate model (ArcSYM) and to investigate the influence of surface fluxes of heat and moisture in boundary layer development in the Arctic.

REU Program

REU and other funding provided the opportunity for students to join the research team at Council. Five students, including one local high school student, participated in the collection of field data, led journal discussions, and interacted with visiting PI's. In addition, the students were responsible for the design and implementation of their own research project. Shana Pennington compared of water and photosynthetic flux from different lichen types. Sarah Roberts worked extensively with the NCAR team, and used her experience to make a comparison of atmospheric heating above tundra and open spruce forest. Ian McHugh collected initial data for an honor's project investigation of water vapour transport and vertical mixing above tundra and spruce ecosystems. Kate Hoffman examined a recent tundra burn and the impacts of fire on vegetation and surface energy exchange. Henry Titus, a high school student from White Mountain, Alaska evaluated microscale variability in soil surface temperatures in a white spruce forest. We appreciate the dedication of these students; it is due to their hard work that we were able to achieve so much this summer.

Collaboration

The sites at Council represent a collaboration of PI's and integration of various disciplines including hydrology (Larry Hiinzman), vegetation characterization and mapping (Skip Walker), soil surveys (Chien-Lu Ping), satellite characterization of landscape change (Dave Verbyla), treeline studies (Andrea Lloyd), permafrost dynamics (Vladimir Romanovsky), snow interactions (Matthew Sturm) and regional and mesoscale modeling (Amanda Lynch and Peter Olsson). The opportunity to interact with the various investigators in the project at Council was extremely valuable and broad discussions were fostered in many areas relating to the project. New and ongoing collaboration is being further developed with most investigators.

Community Involvement

Both the local NATIVE council as well as local residents showed an overwhelming enthusiasm for the project. Several open house sessions were held to invite the community to become involved in the project and several good links were forged within the community.

Acknowledgements

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Site Details

WHITE SPRUCE FOREST (C1)

Location: N 64º 54.456' W 163º 40.469'

Elevation: 275 feet

Slope: 3.3% (3º)

Aspect: 140 º TN

Data dates: 6/18/99-8/22/99

WOODLAND (C4)

Location: N 64º 53.997' W 163º 39.863'

Slope: 5.6 % (5º)

Aspect: 140 º TN

Data dates: 6/19/99-7/13/99

SHRUB SITE (C3)

Location:N 64º56.141 W 154º44.142

Elevation: 450 feet

Slope:6.6 % (6.0 º)

Aspect: 160º TN

Data dates: 8/4/99-8/22/99

LOWSHRUB (C5)

Location: -

Elevation: 270 feet

Slope: ~9°

Aspect: 236° TN

Data dates: 7/14/99-7/27/99

TUNDRA SITE (C2)

Location: N 64°50.499’ W163°41.591’

Elevation: 160 feet

Slope: flat

Aspect: flat

Data dates: 6/18/99-8/22/99

BURN SITE

Location: N 65°12.147’ W 164°18.477 (scar length 3.15 km and 1.3 km wide)

Elevation: 450 feet

Slope: 6% (5°)

Aspect: 315 °T

Data dates: 07/28/99-0803/99