Analysis of Water and Energy Budgets in a Subarctic Experimental Watershed in Northern Québec, Canada

Georg Lackner[1], Daniel Nadeau[1], Florent Dominé[2], Francois Anctil[1], Annie-Claude Parent[1], Jean-Michel Lemieux[3], Richard Fortier[3]

(1) Department of Civil and Water Engineering, Université Laval (2) Department of Chemistry, Université Laval (3) Department of Geology and Geological Engineering, Université Laval

Motivation

Although the subarctic tundra represents a large fraction of the Earth's surface, very little climatological data are available for the validation of models used to anticipate how these changes will affect weather patterns and local hydrological processes.

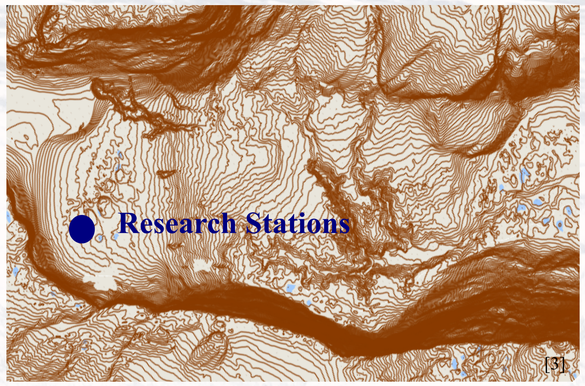
This project aims at obtaining a comprehensive climatological and hydrological image of an archetype of such an environment near Umiujaq in northern Québec, Canada. To achieve this, fluxes of water vapor and heat between soil, snow and atmosphere are traced and subsequently energy and water budgets are calculated from these fluxes.

Here, data from summer and fall 2017 is presented.

The Tasiapik Valley

Site Description

The study site is a 2.1 km^2 watershed near Umiujaq, which exhibits discontinuous permafrost and a medium slope confined by cuestas. The vegetation mainly consists of shrubs but patches of lichen and forest can be found as well.



Climatology

Mean annual temp.: -3°C; Mean temp. February: -22.4°C; Mean temp. June: 12.2°C

Total precipitation: 500-600 mm

Snowmelt: May - June; Mean wind speed: 5.9 m/s

Max. wind speed 28 m/s; Dominant wind dir. - South.

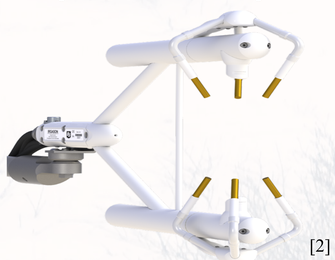
Methodology

Eddy Covariance

Turbulent flux calculation with 3D wind speed and H2O/CO2 concentration measurements

+ High frequency
+ Non disturbing
+ Continuous
- Requires turbulence
- Gap filling

Eddy Covariance System

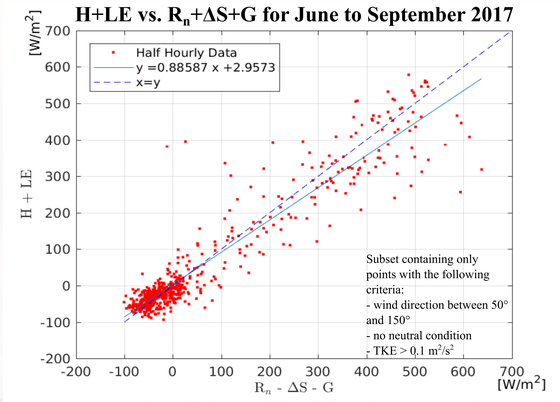


The deployed eddy covariance system, the IRGASON

Research Stations

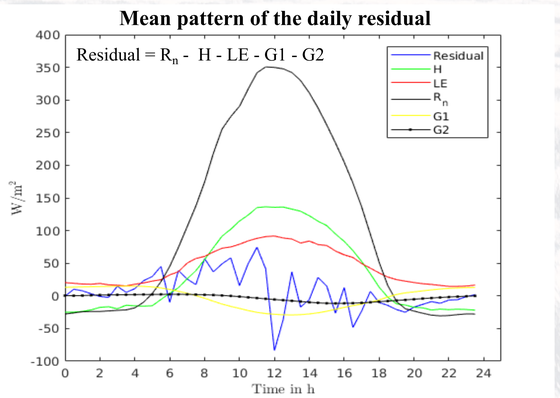
Left: Geonor precipitation measurement
Middle: SILA tower with eddy covariance measurements
Right: Tundra station with radiation measurements

Energy Budget



$$R_n = H + LE + G + \Delta S$$

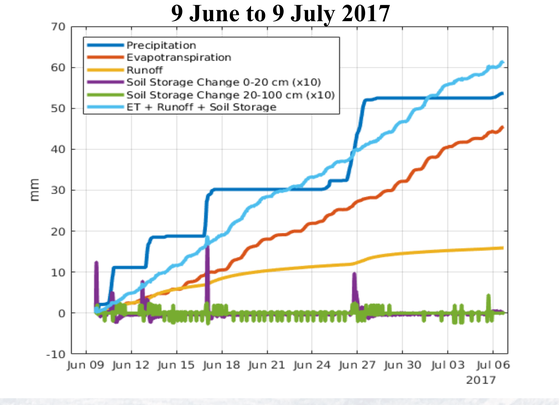
R_n: Net Radiation from a CNR4 radiometer
H: Sensible Heat from the IRGASON
LE: Latent Heat from the IRGASON
G: Ground Heat Flux derived from thermocouples (G1) and ground heat flux plates (G2)
ΔS: Storage Terms of the vegetation



Conclusions

- Underestimation of H and LE during daytime
- Energy closure of: 88.5%
➡ More energy available then being consumed by H and LE
- Main reasons for the underestimation of H and LE:
➡ Complex terrain
➡ Advection
➡ Uncertainties in the ground storage change
➡ Missing vegetation heat storage

Water Budget



$$P = R + ET + \Delta S$$

P: Precipitation measured by a rain gauge
R: River runoff through a flume
ET: Evapotranspiration from the IRGASON
S: Water storage change in soil, lakes and groundwater

Conclusions

- ET is ≈79% higher than runoff on average
➡ ET is the driving force of water loss during summer
- Minor contribution of the upper soil layer to the water storage
➡ Groundwater flows are the dominant storage terms
- ET + R is higher then the precipitation
➡ Dry out during this one month period

Future Work

-Examine the effect of the coordinate system on the energy balance closure
- Estimate storage terms of the vegetation and incorporate them into the energy balance
- Include terms of groundwater flow and water storage in lakes into the water budget
- Extend work to winter and include snow processes to analysis

Acknowledgements

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Sources

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[2] Cambell Scientific [3] Geoindex, Université Laval

Author e-mail: georg.lackner.1@ulaval.ca