# New evapotranspiration CalVal sites in interior Alaska: Preparatory science for NASA's planned HyspIRI mission

A. Prakash[1], J. Cristóbal[1], J. Fochesatto[1], D. Starkenburg[1], R. Gens[2], D. Kane[1], J. G. Alfieri[4], K. Irving[1], M. C. Anderson[4], and W. P. Kustas[4]

(1)University of Alaska Fairbanks; Alaska Satellite Facility; (3) US Department of Agriculture

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# Outline

More info:
**www.et.alaska.edu**

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2. Operational ET CalVal sites in Alaska
3. Imnavait Creek site
4. New ET CalVal sites: UAF and Caribou Poker Creek Research Watershed
5. TSEB and DTD model application in a tundra environment using MODIS and Landsat data
6. Future research

# Introduction

- Evapotranspiration (ET) is a critical component of the hydrologic cycle in Alaska
- As we witness increasing climate warming, permafrost degradation, forest fire occurrences, and significant LULC changes, ET will become more important
- Alaska has general paucity of CalVal sites that acquire essential climate variable (ECV) and ET relevant data.

Credits: Rudi Gens, ASF

Credits: David Wright, USFS

Credits: ADF&G

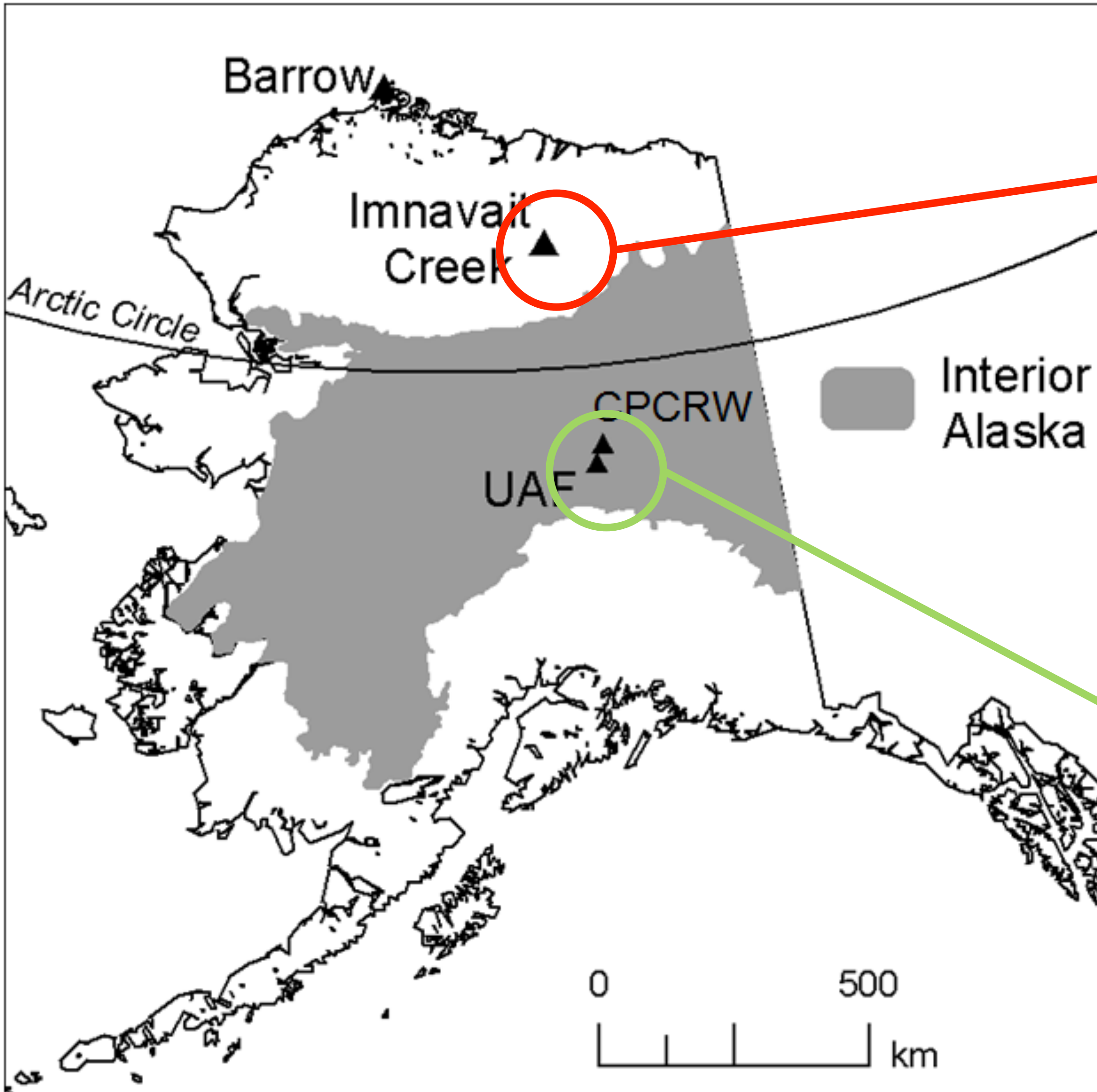
# Objectives

- To measure representative ET values for typical tundra (Arctic) and typical boreal forest (sub-Arctic) environments.
- To estimate and upscale ET from visible, near infrared, and thermal infrared remote sensing data ➔ TSEB and DTD models in summer conditions.

Credits: Toolik field station, UAF

Credits: UAF ET project team

# Operational ET CalVal sites in Alaska

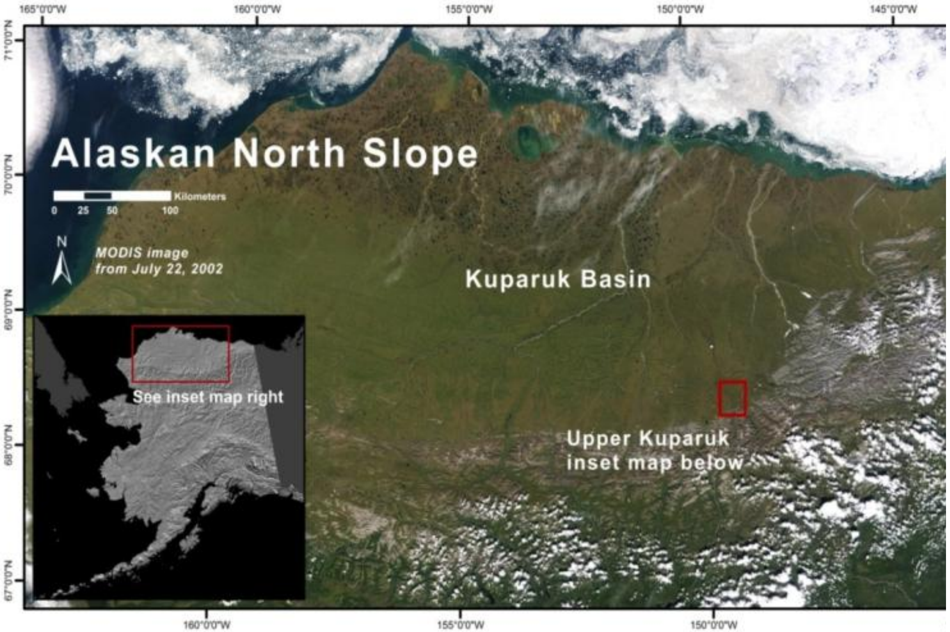


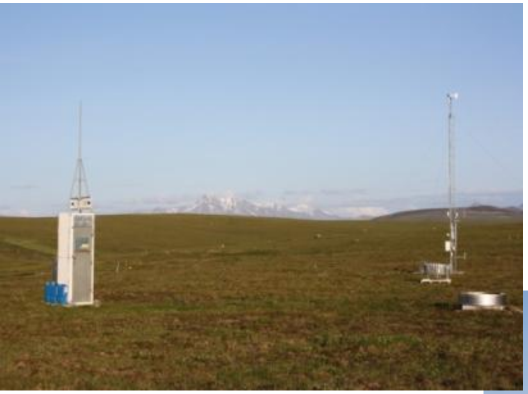

Imnavait Creek → Arctic – Tundra

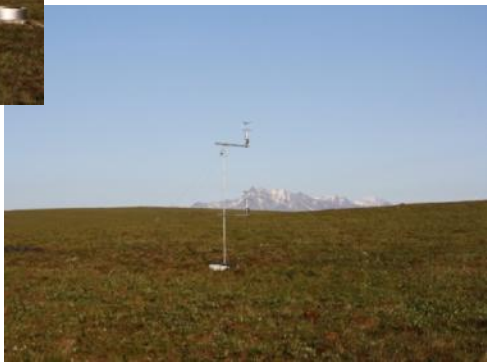
New sites →UAF and CPCRW

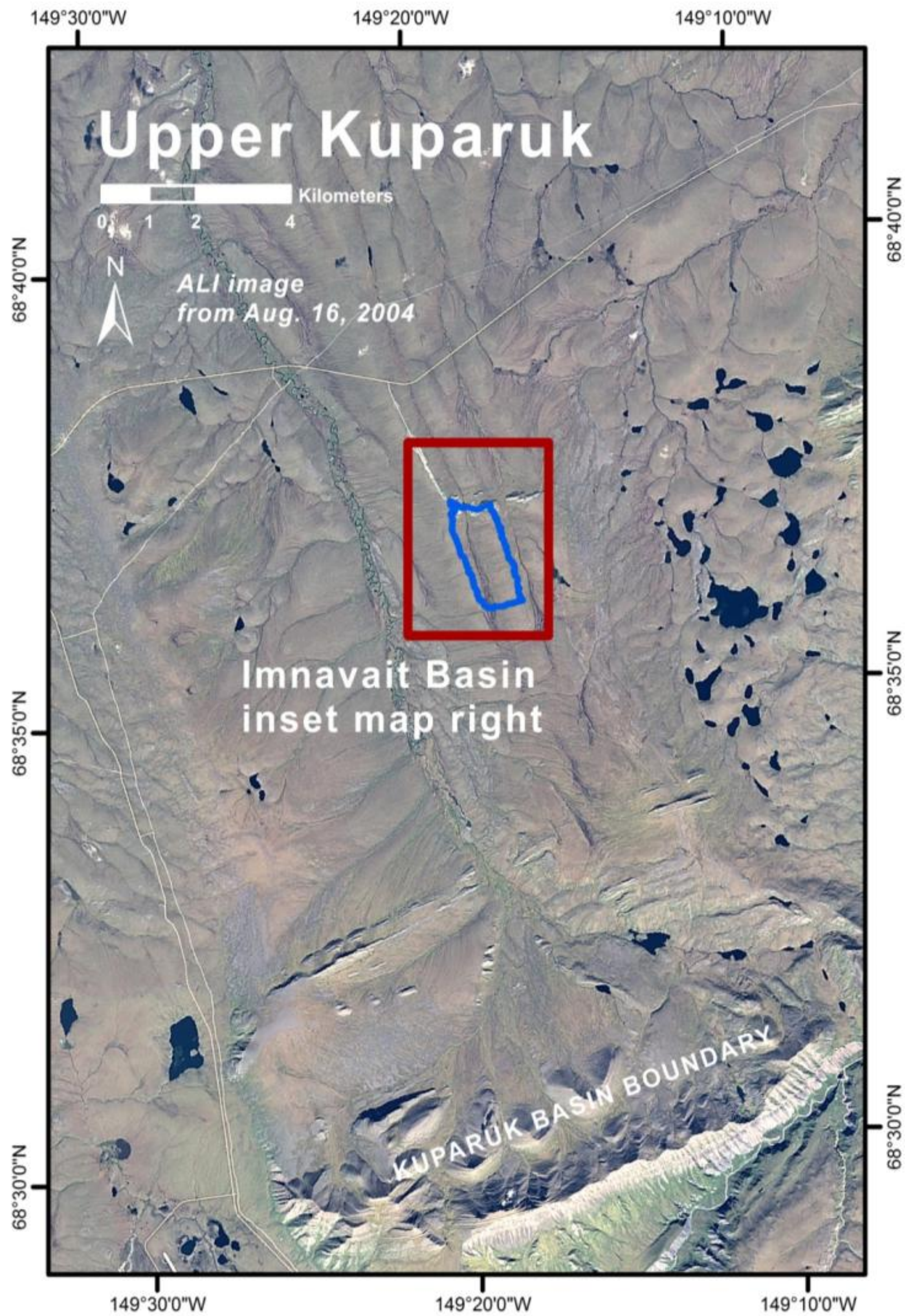
Subarctic - Boreal forest

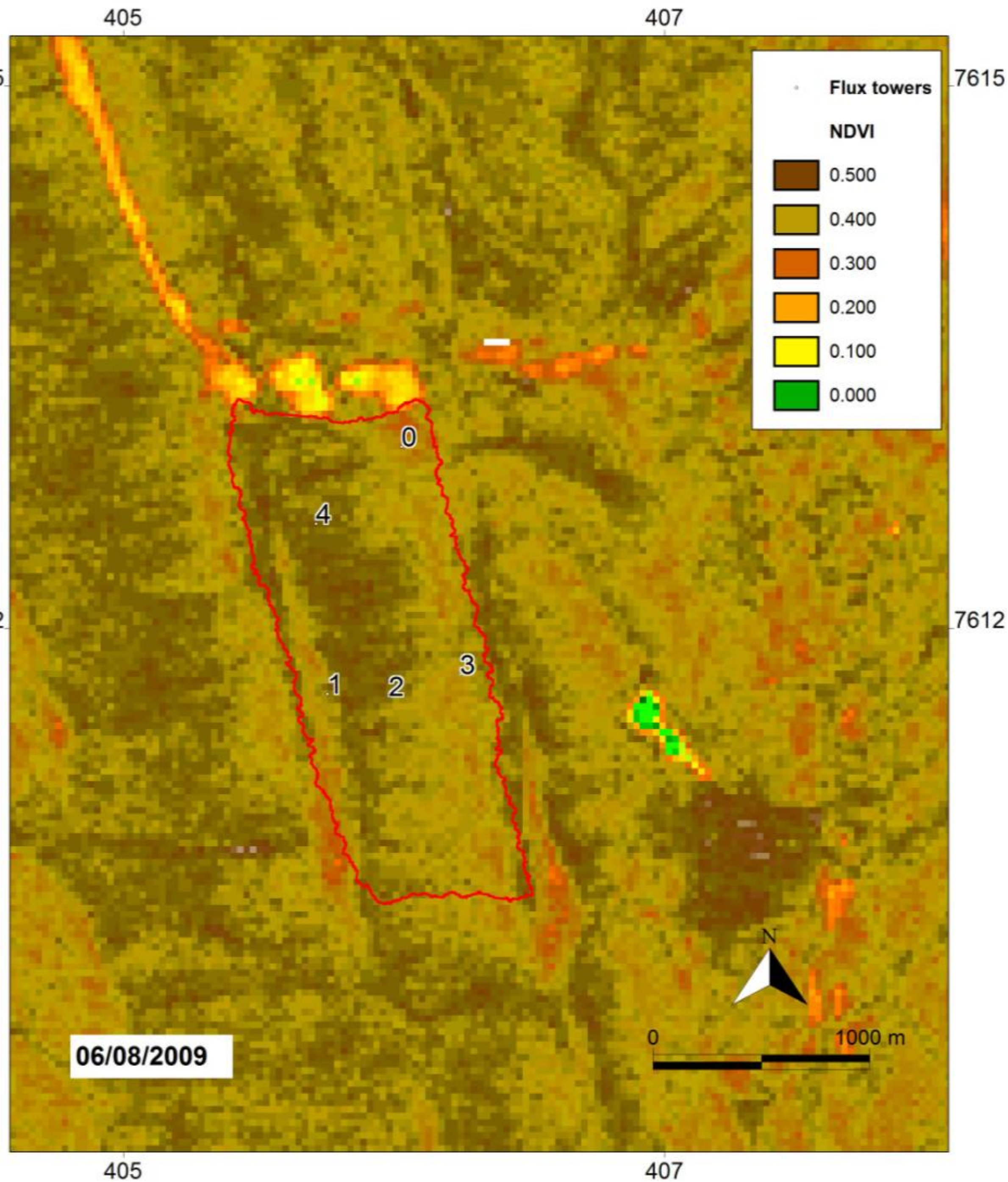
# Imnavait Creek










# Imnavait Creek

0➔ Scintillometer and meteorological station (2009-2011 summers)

1➔ Fen flux station

2➔ Tussock flux station

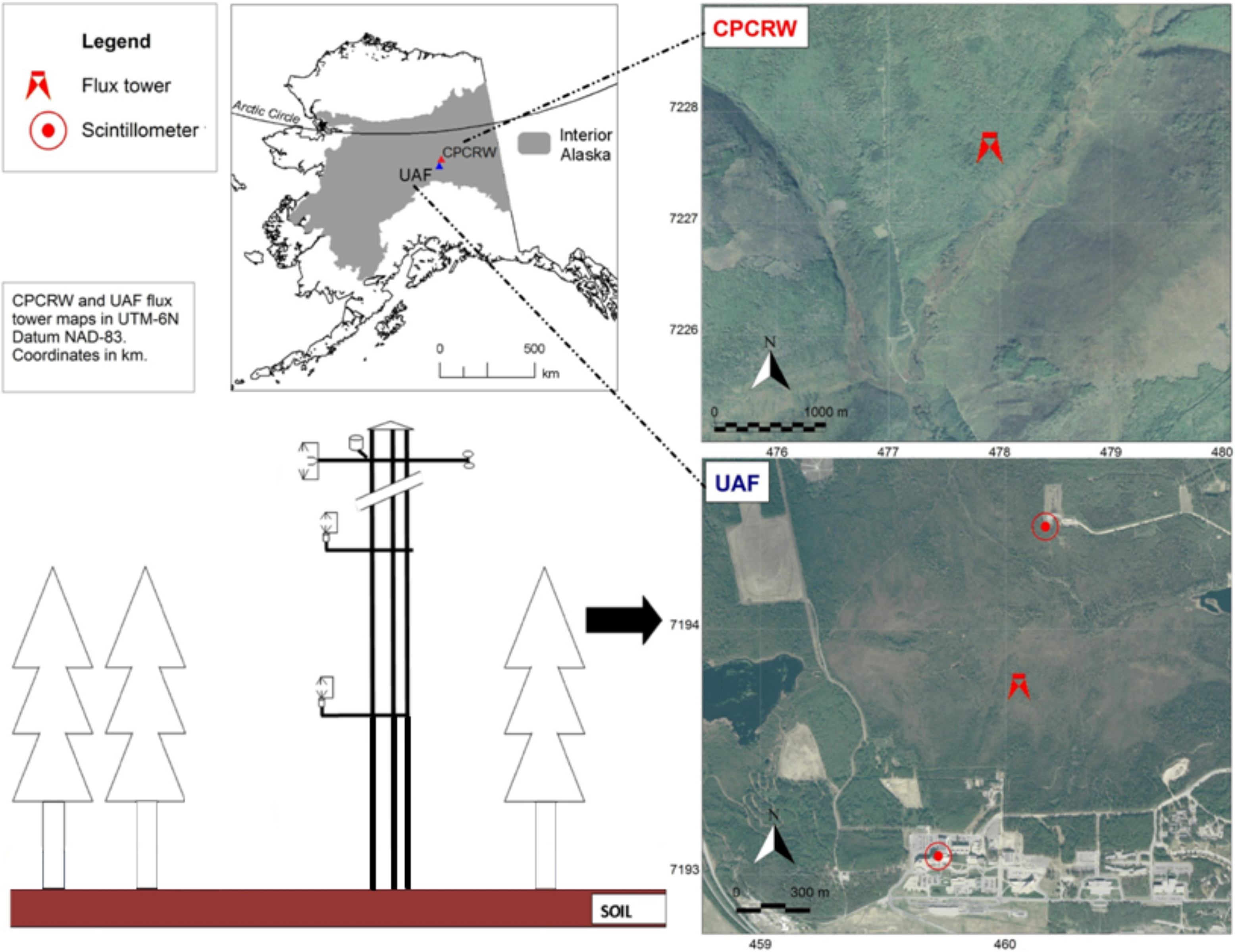
3➔ Ridge flux station

4➔ Radiation tripod

0: Managed by D. Kane and J. Fochesatto

1-4: Managed by ➔ Institute of Arctic Biology-UAF

# New ET CalVal sites: UAF and Caribou Poker Creek Research Watershed



# UAF north campus site

Needleleaf evergreen forest ➔ “flat” area

*Overstory:*

Black spruce (*Picea mariana*)

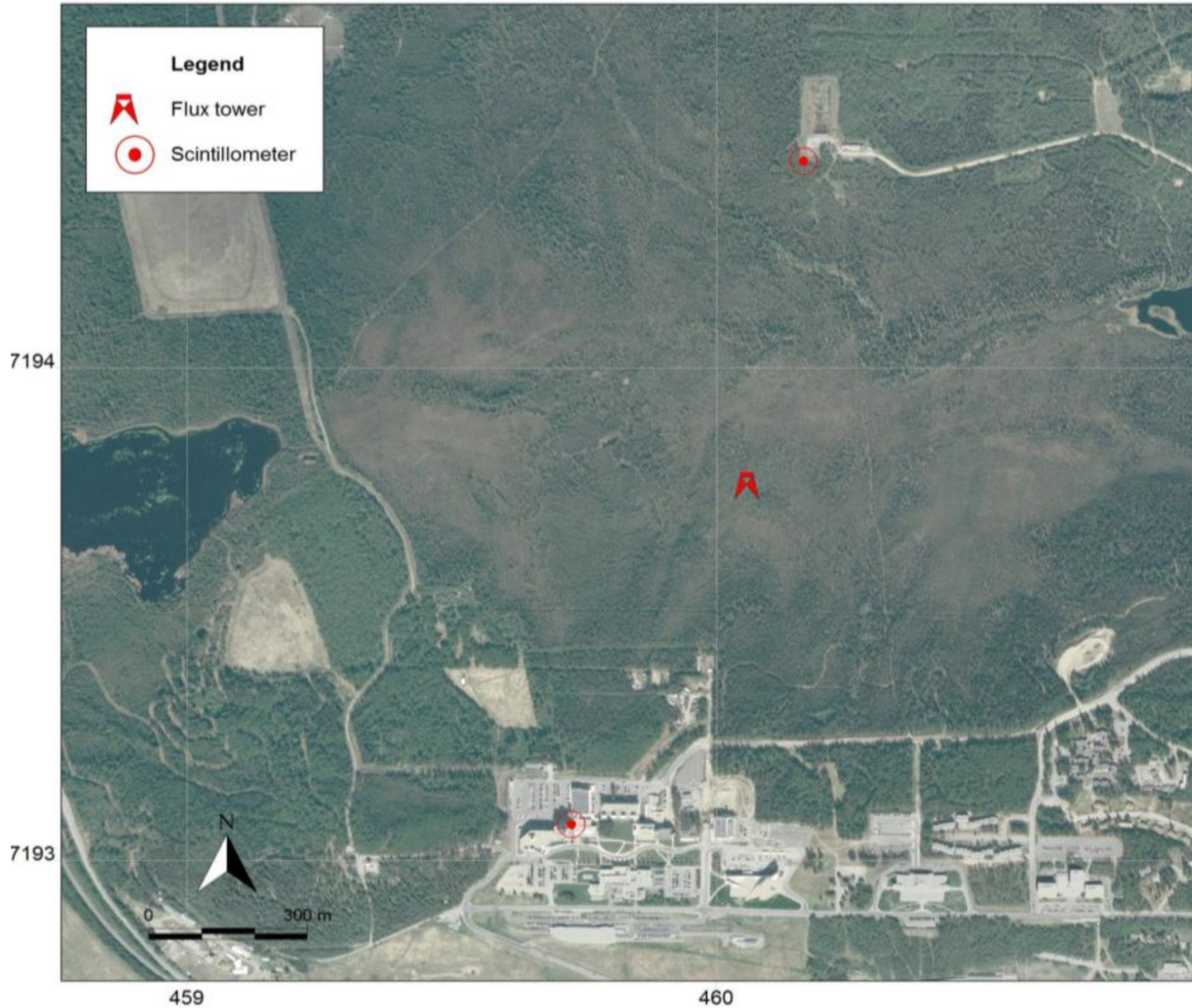
➔ cover: ~60%

➔ mean tree height: ~5 m

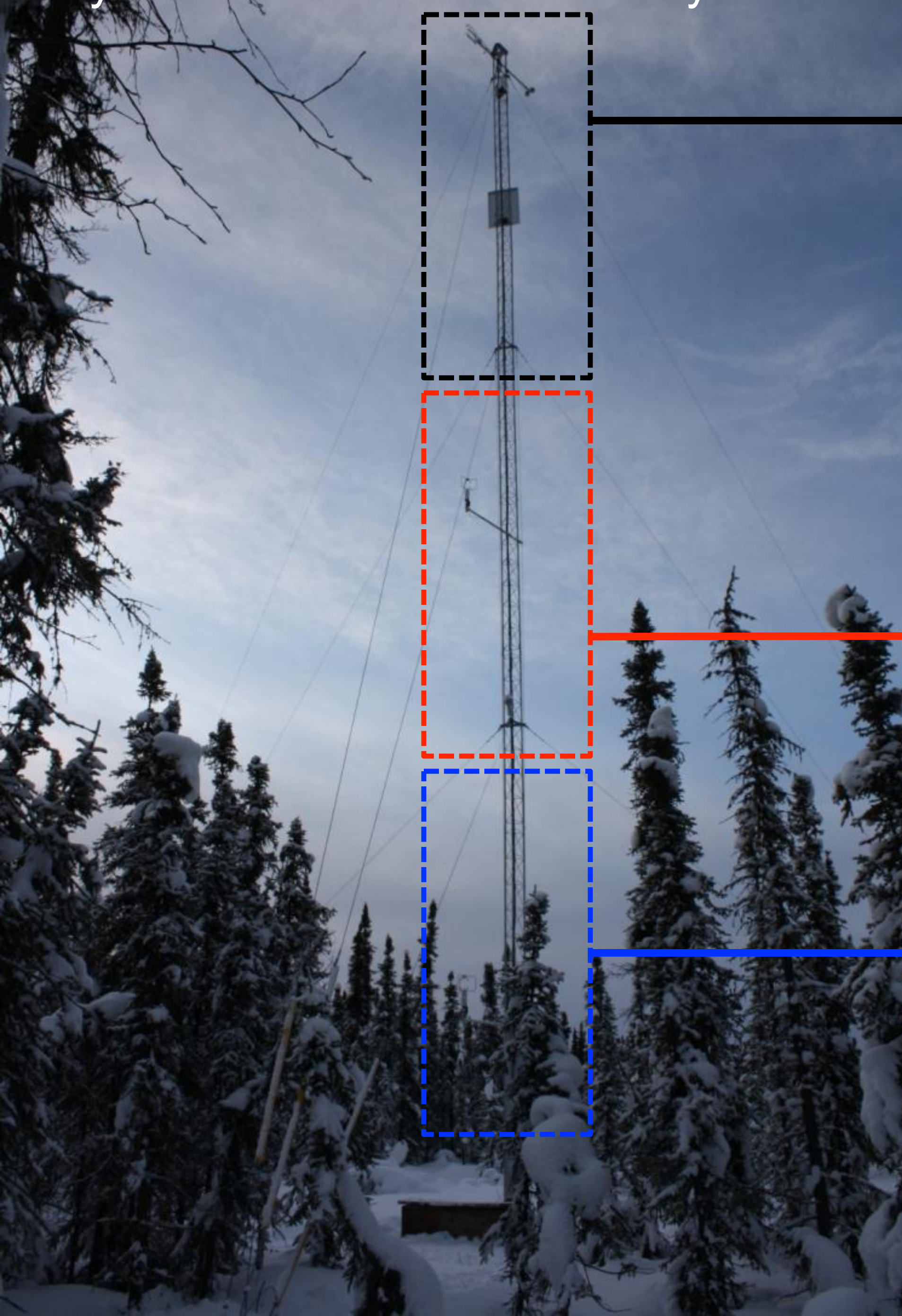
*Understory:*

➔Small shrubs: *Betula nana*, *Ledum palustre*, *Vaccinium* sp.

➔Moss layer: *Sphagnum* sp.



# Eddy covariance and radiation systems



Canopy Flow Sensors at 24 m: Sonic anemometer and gas analyzer, net radiation and air temperature.

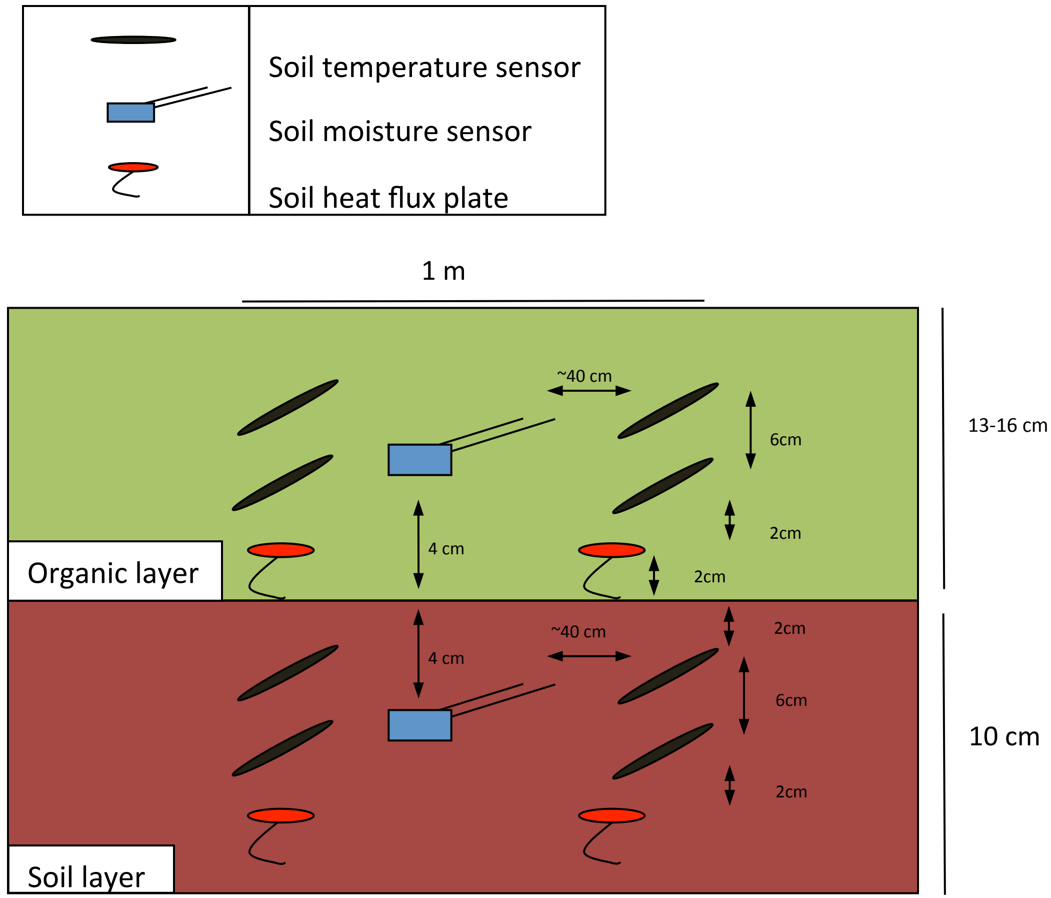
Canopy Flow Sensors at 12m: Sonic anemometer.

Air temperature at 7m.

Sub-canopy Flow Sensor at 3m: Sonic anemometer, air temperature, relative humidity and pressure.

# Geothermal flux system (G)

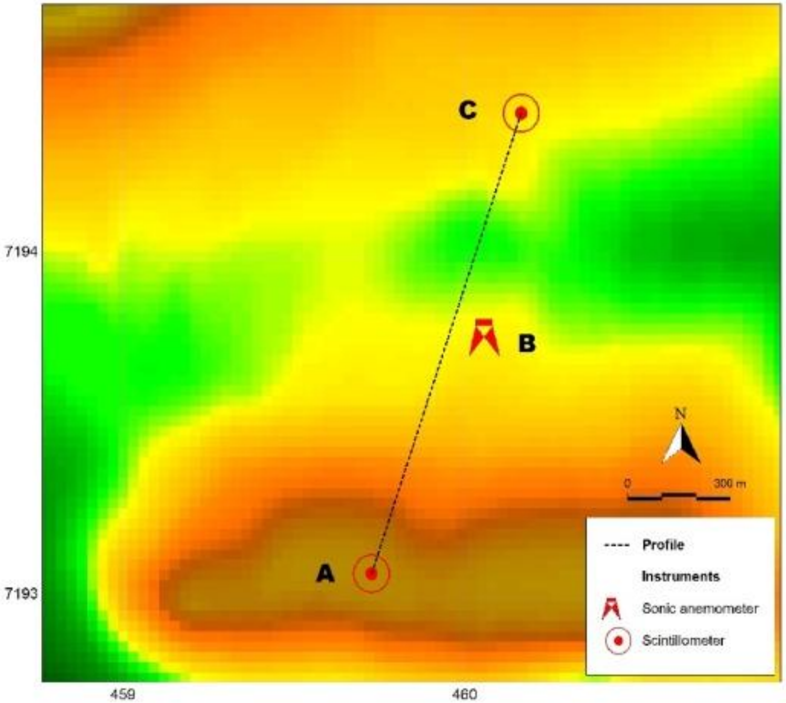
- ➔ Designed to account for both organic and soil layers
- ➔ one G system sample

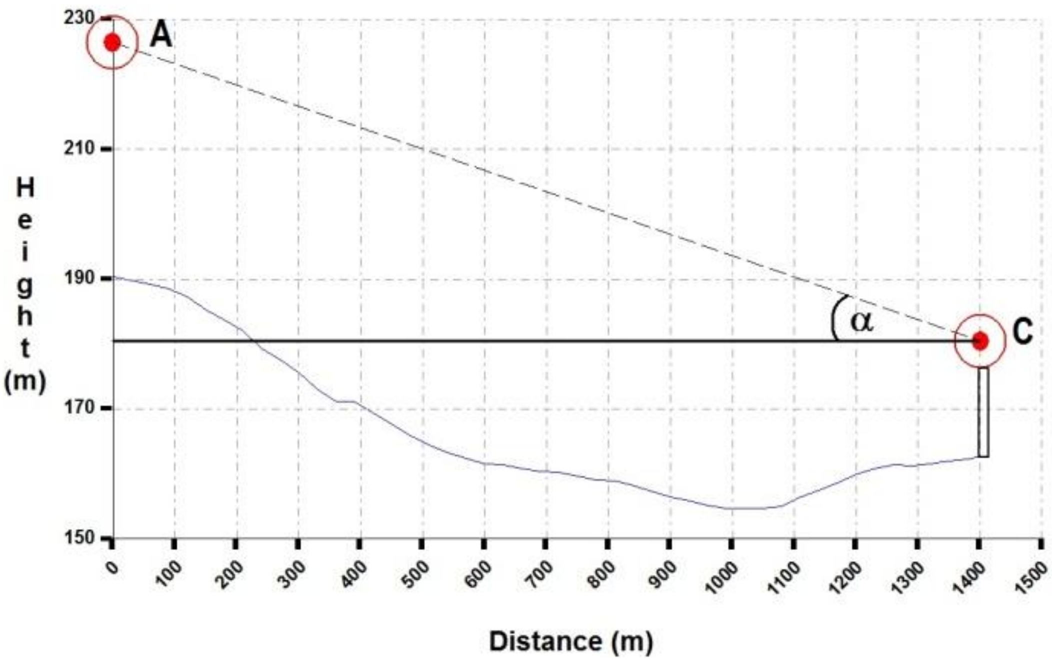


# Scintillometer configuration

At same height (24m) and path than the flux tower

→ flux upscalling



# Caribou Poker Creek Research Watershed

Deciduous forest ➔ "hilly" area

*Overstory:*

Mainly paper birch (*Betula papyrifera*)

➔ cover: ~90%

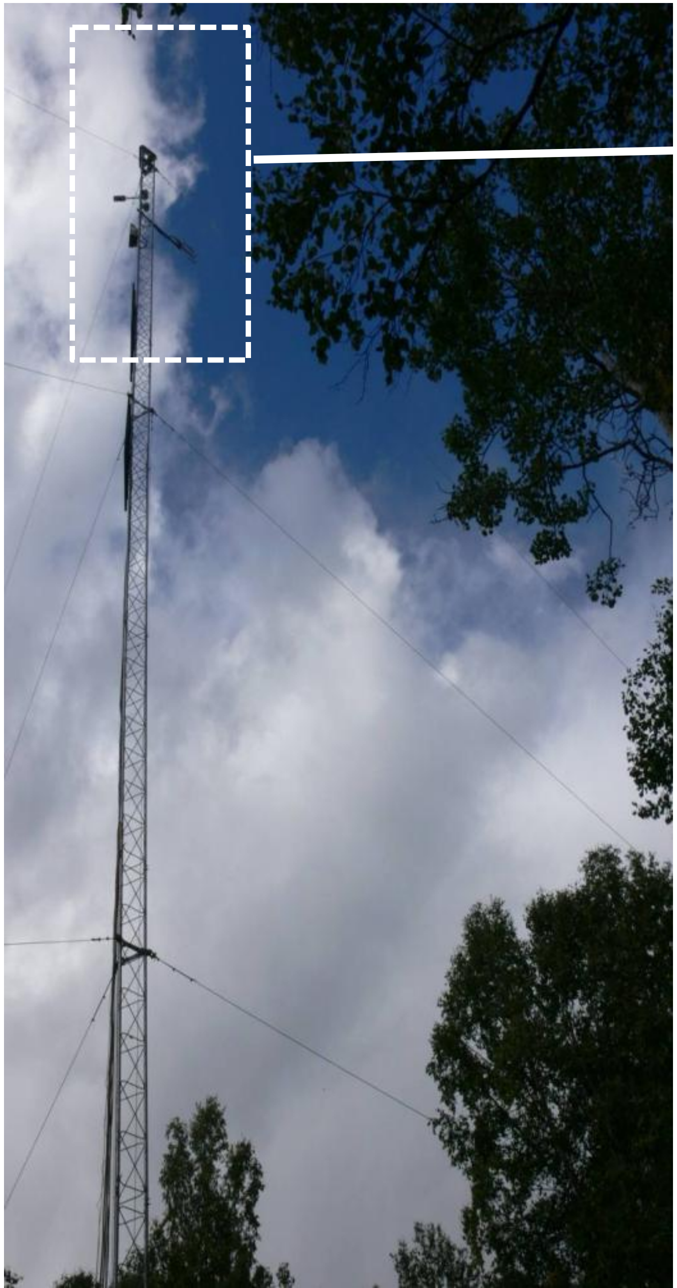
➔ mean tree height:~18m

*Understory:*

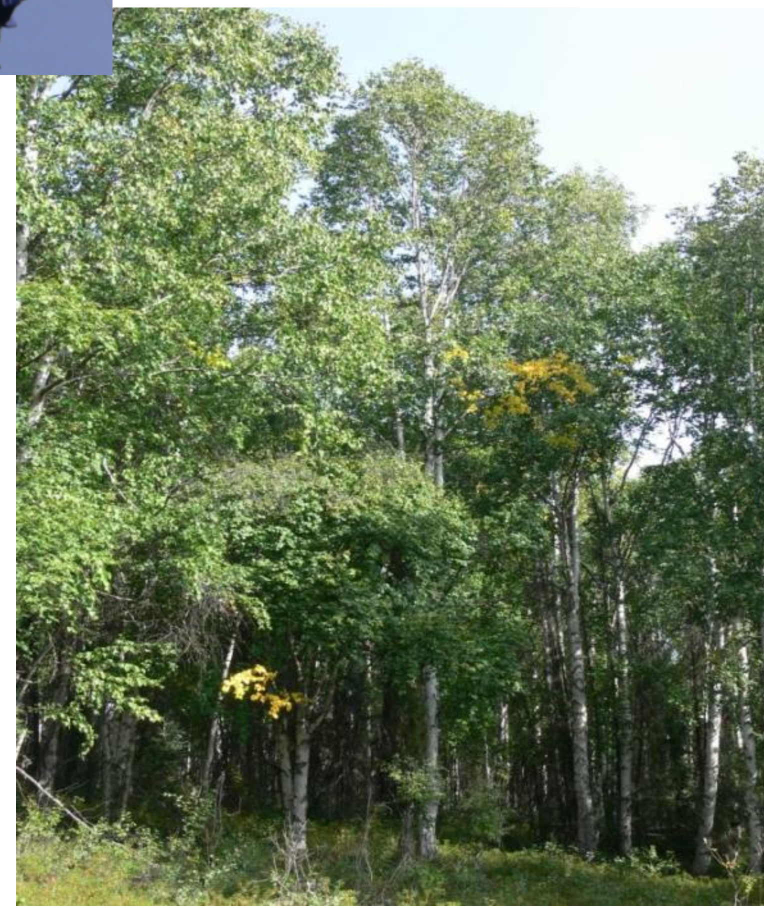
➔Small shrubs: *Ledum palustre*, *Vaccinium* sp.

➔Moss layer: *Sphagnum* sp.

# Eddy covariance and radiation systems

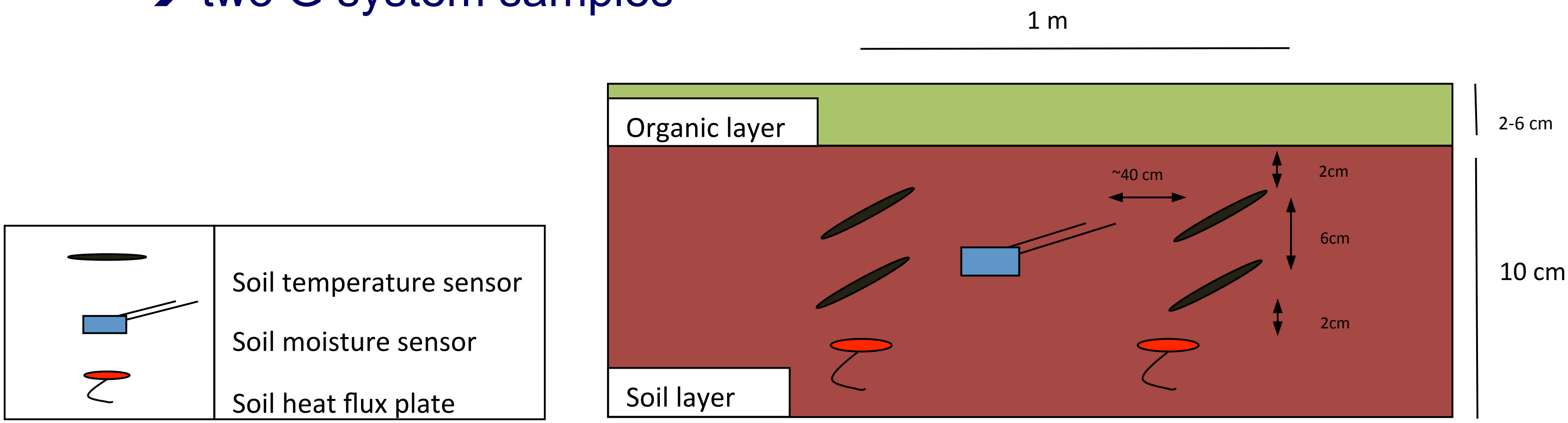


Canopy Flow Sensors at 23 m: Sonic anemometer and gas analyzer, net radiation, air temperature and relative humidity.



# Geothermal flux system (G)

- ➔ Designed to account only for soil layer ➔ thin organic layer
- ➔ two G system samples




# Challenges

- Power
- Solar illumination
- Temperature
- Subsidence
- Maintenance

# TSEB and DTD model application in a tundra environment using MODIS and Landsat data

*Dual Time Difference -DTD-* (Norman et al. 2000) *and Two Source Energy Balance -TSEB-* (Kustas and Norman, 2000) *main inputs:*

- Remote sensing data ➔ LAI and LST (TERRA/AQUA MODIS) and LST (Landsat-5 TM)
- Meteorological data ➔ Net radiation, air temperature, wind speed and atmospheric pressure

$T_A$: Air temperature

$T_{AC}$: Air temperature in the canopy

H: Sensible heat flux integration ➔ H from the canopy ($H_c$) and H from the soil ($H_s$).

$R_A$: Aerodynamic resistance

$R_x$: bulk leaf boundary layer resistance

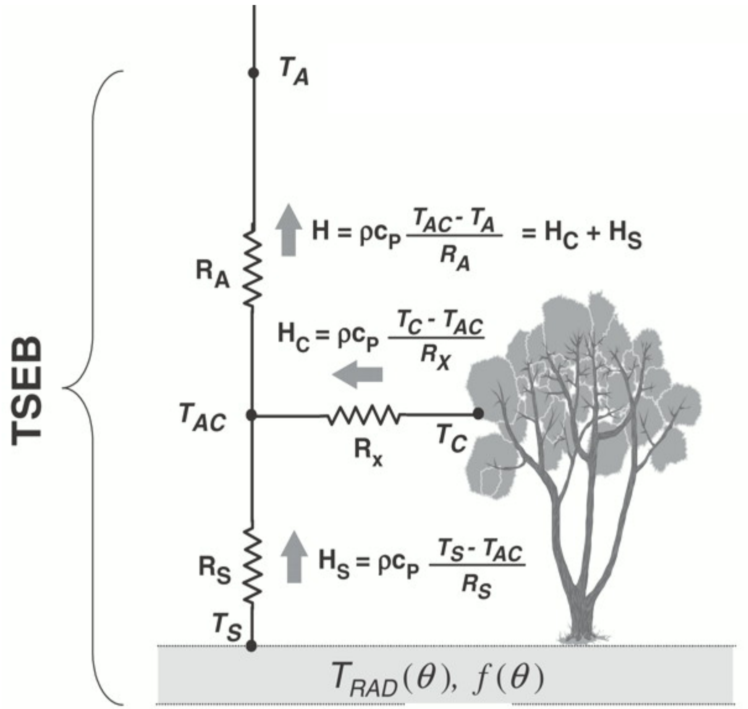
$R_s$: soil surface boundary layer resistance

$T_{RAD}$: surface temperature

f(0): Cover fraction:

➔ Clumping factor between 0.87 - 0.89

➔ LAI variability from 1.4 to 2.3



# Instantaneous energy fluxes using TSEB & DTD

## 1- DTD remote sensing data

| Period | Satellite | n | Date | Product |
|---|---|---|---|---|
| 2008 | TERRA/ AQUA MODIS | 11 | 13/07/2008<br>24/07/2008<br>13/08/2008<br>16/08/2008<br>20/08/2008<br>24/08/2008<br>01/09/2008<br>02/09/2008<br>03/09/2008<br>06/09/2008<br>07/09/2008 | •LAI (MOD15/MYD15)<br>•LST (MOD11/MYD11) |

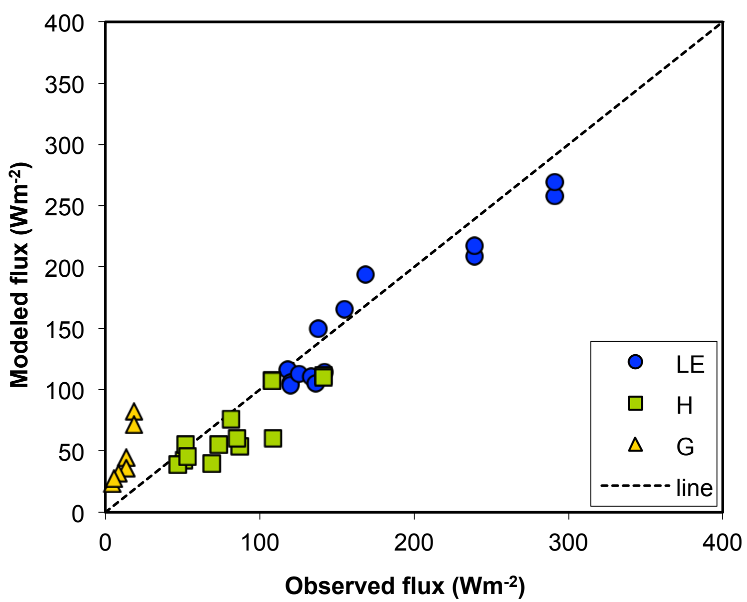
## 2- TSEB remote sensing data

| Period | Satellite | n | Date | Product |
|---|---|---|---|---|
| 2009 | Landsat-5 TM | 3 | 05/07/2009<br>21/07/2009<br>06/08/2009 | •Level-1T |
| | TERRA MODIS | | | •LAI (MOD15A2)<br>•Water vapor (MOD05) |

# DTD results: MODIS

| | LE | H | G |
|---|---|---|---|
| $R^2$ | 0.92 | 0.78 | 0.70 |
| RMSE* | 22 | 23 | 33 |
| MBE* | -13 | -18 | 31 |
| MAE* | 20 | 18 | 31 |

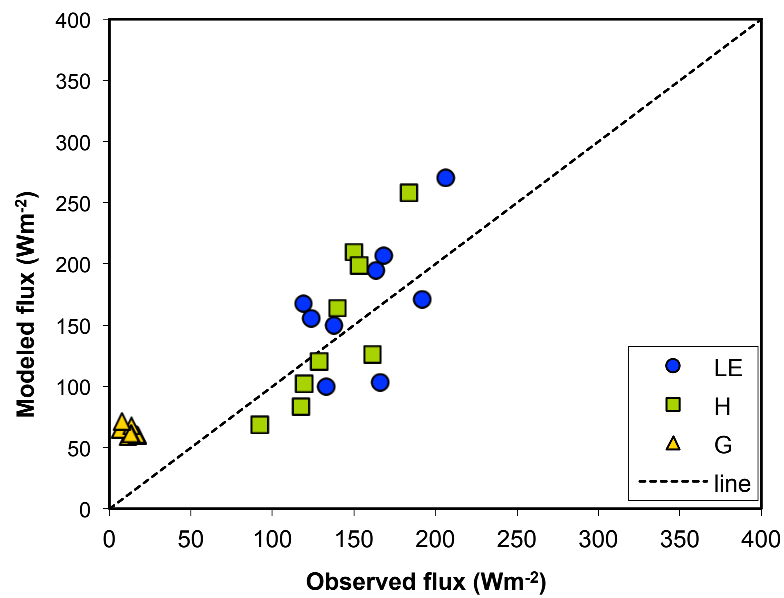
* in $W \cdot m^{-2}$




# TSEB results: Landsat

| | LE | H | G |
|---|---|---|---|
| $R^2$ | 0.36 | 0.76 | 0.40 |
| RMSE* | 41 | 41 | 51 |
| MBE* | 12 | 9 | 50 |
| MAE* | 38 | 36 | 51 |

* in $W \cdot m^{-2}$



# Conclusions & Ongoing research

1) Field sites are well positioned and working well
2) Data QA/QC in place
3) Site will provide data useful for broader research
4) Results of DTD and TSEB in the Arctic site are encouraging
5) HyspIRI will be able to provide higher spatial resolution and high temporal resolution data for high latitudes making DTD a practical model for generating satellite based ET products.

6) At new sites we will implement
   1) DTD and TSEB
   2) Daily energy flux integration using ALEXi/DisALEXI model (Anderson *et al.*, 2007).
7) Energy fluxes upscaling validated by scintillometer data.
8) Energy balance computation in snow conditions.

# Thanks for your attention