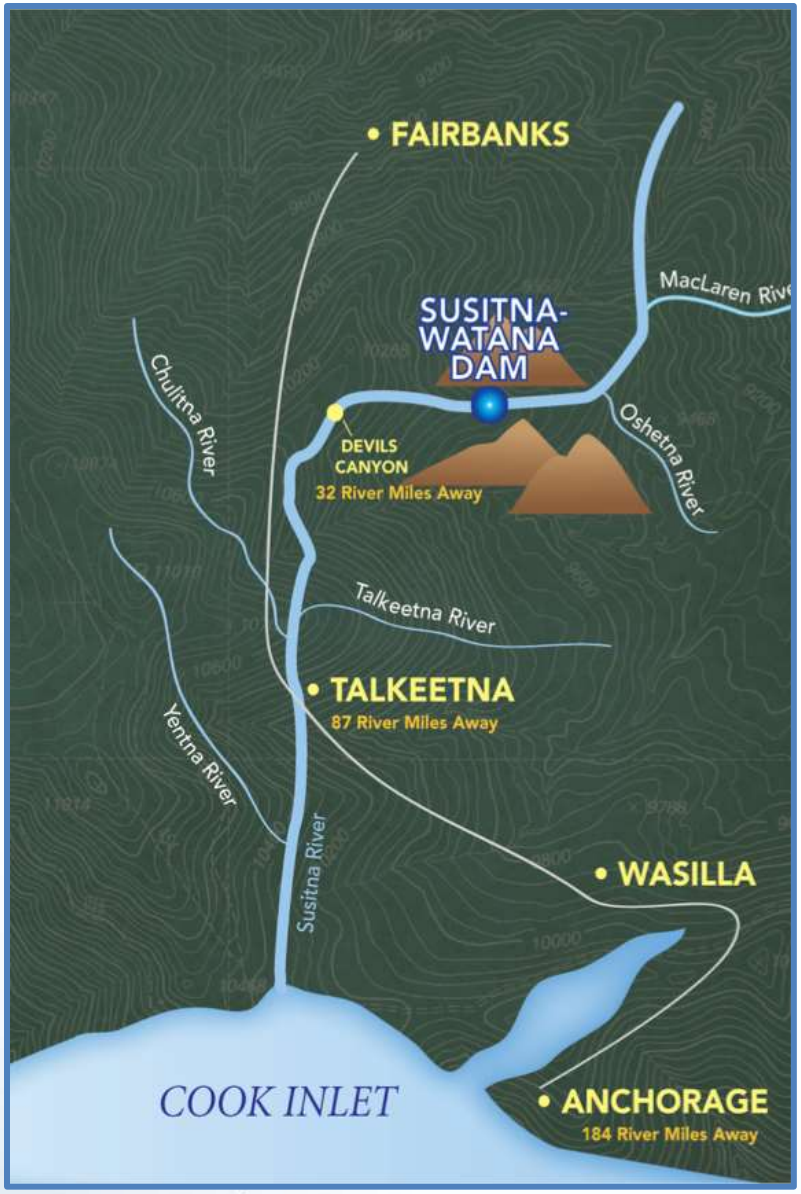


SUSITNA-WATANA HYDRO *Clean, reliable energy for the next 100 years.*

Technical WorkGroup Meeting

Q4 2013 TWG

Glacier and Runoff Changes - Update

Dec. 2, 2013

Prepared by:

Dr. Gabriel Wolken,

Alaska Div. of Geological & Geophysical Surveys

Study 7.7 – Q4 2013 Update

- Final Study Plan per FERC Study Plan Determination posted to AEA website
- FERC Final Study Plan covers literature review component of study
- The complete study as scoped in RSP is being conducted by AEA
- There are no variances to the literature review component (FERC required study component) and the intent is to have the results of the literature review with the ISR
- Updates to the remainder of the study is in the following slides

Study 7.7 – Q4 2013 Update

- Completed fall fieldwork
  - weather station servicing and additions
  - seasonal glacier mass balance measurements
- Continued QA/QC on 2013 meteorological data
- Completed 2013 snow radar processing phase I – depth
- Continued 2013 snow radar processing phase 2 – SWE
- Continued runoff model calibration/validation
- Continued runoff model module development
  - Soil heat transfer module
  - Glacier module
- Continued development of regional downscaled climate product

(All data presented are PRELIMINARY)

Study 7.7 – Q4 2013 Update

Meteorological Data

Temperature and Precipitation
→ Different Interpolation methods

1981 - 1983

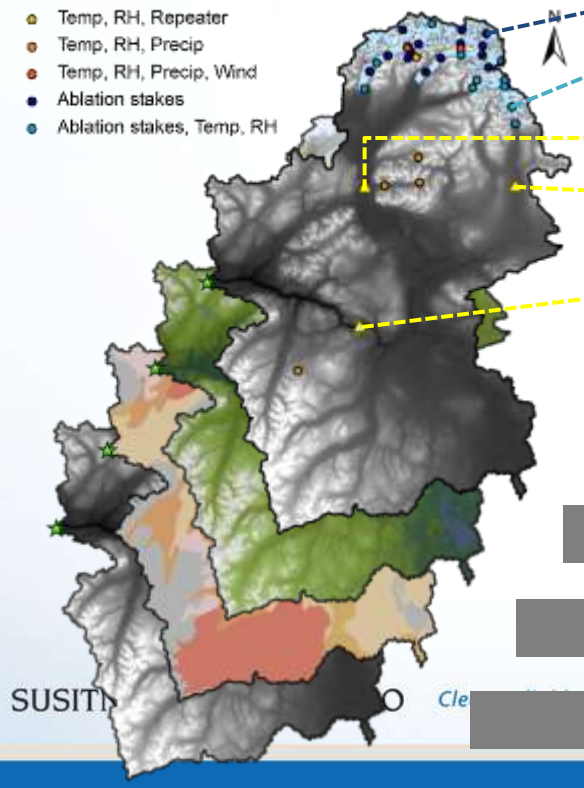
2012, 2013, 2014

Model Input

Calibration and Validation

Future Projections

Spatial Data



Glacier extent

Land cover

Soil texture

DEM

Mass balance data for 1981, 1982, 1983
2012, 2013

Glacier Mass balance

Susitna near Denali

MacLaren near Paxson

Susitna near Cantwell

Runoff data

Snow depth measurements 2012, 2013 on (off) glaciers April 2012 (2013)

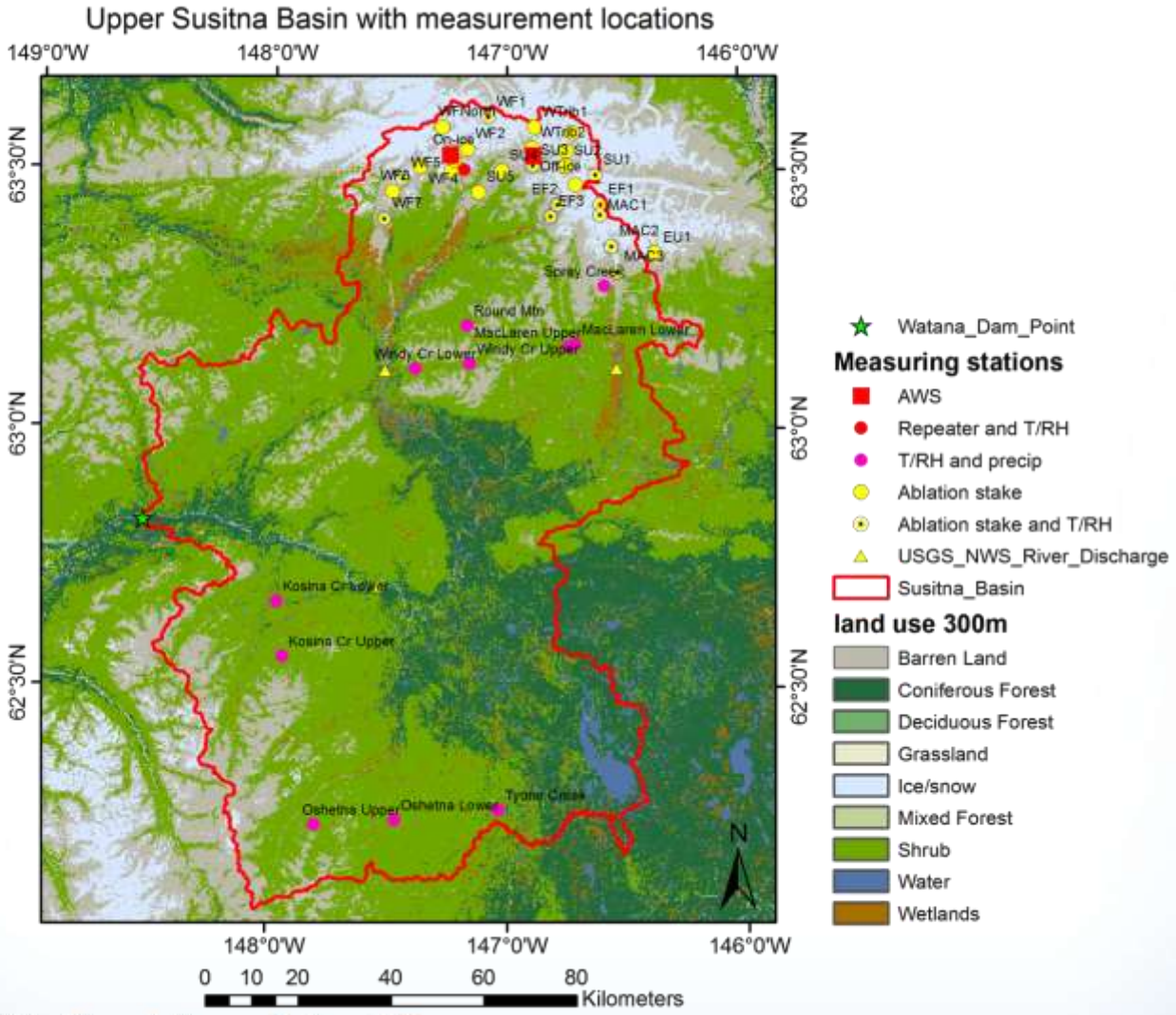
Snow depth

Insitu soint temperatures for 2012, 2013
Modeled soil temperature profiles from Permafrost Lab (1960, 1980)

Soil temperature

Until 2100

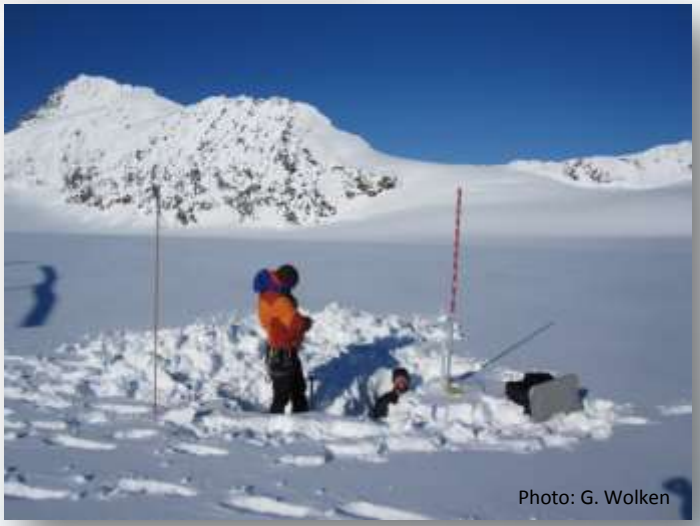
Study 7.7 – 2013 Fall Fieldwork



Study 7.7– 2013 Fall Fieldwork

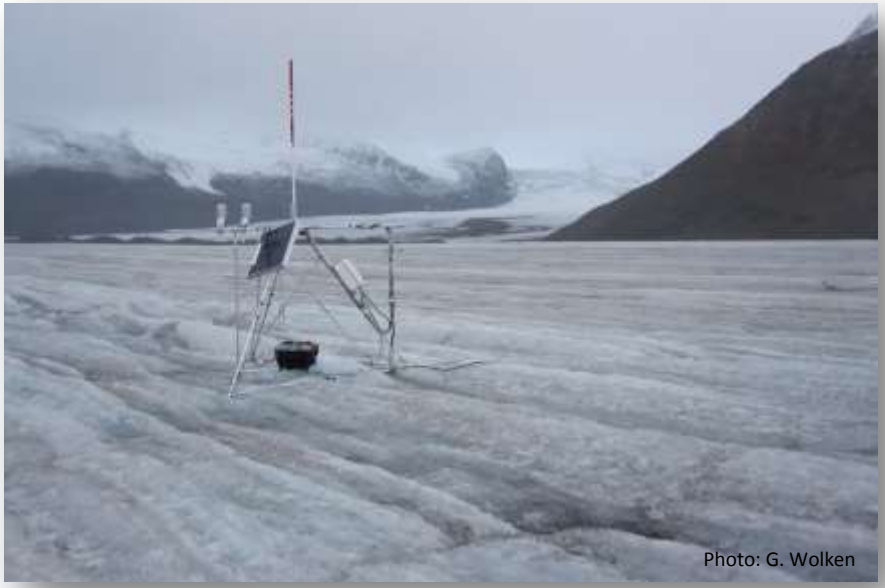
Ablation stake measurements on lower East Fork Glacier, September 2013

Ablation stake measurements on lower Maclaren Glacier, Sept. 2013



Ablation stake measurements on upper Maclaren Glacier, Sept. 2013

Study 7.7– 2013 Fall Fieldwork

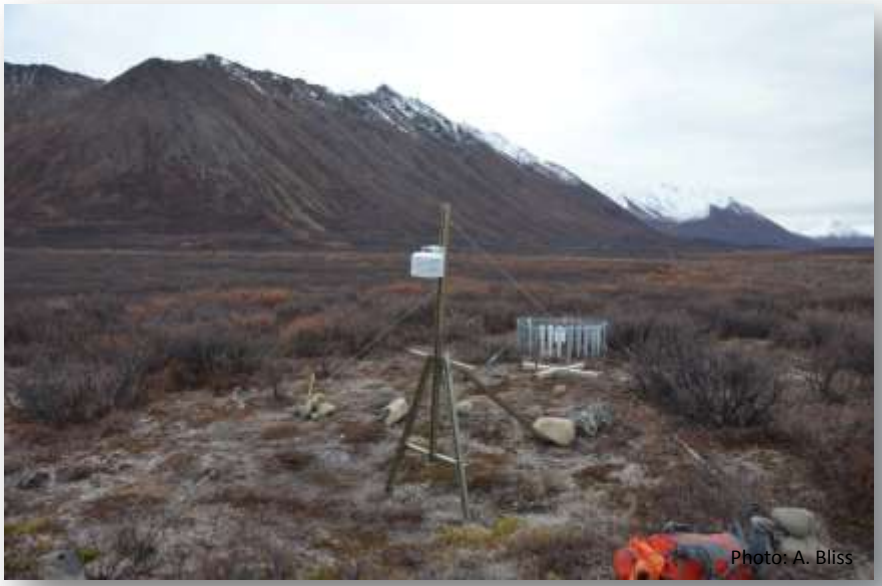


Transition to winter configuration at the on-ice AWS (ESG1), West Fork Glacier, Sept. 2013

Maintenance on the off-ice AWS (ESG2), above Susitna Glacier, Sept. 2013

Study 7.7– 2013 Fall Fieldwork

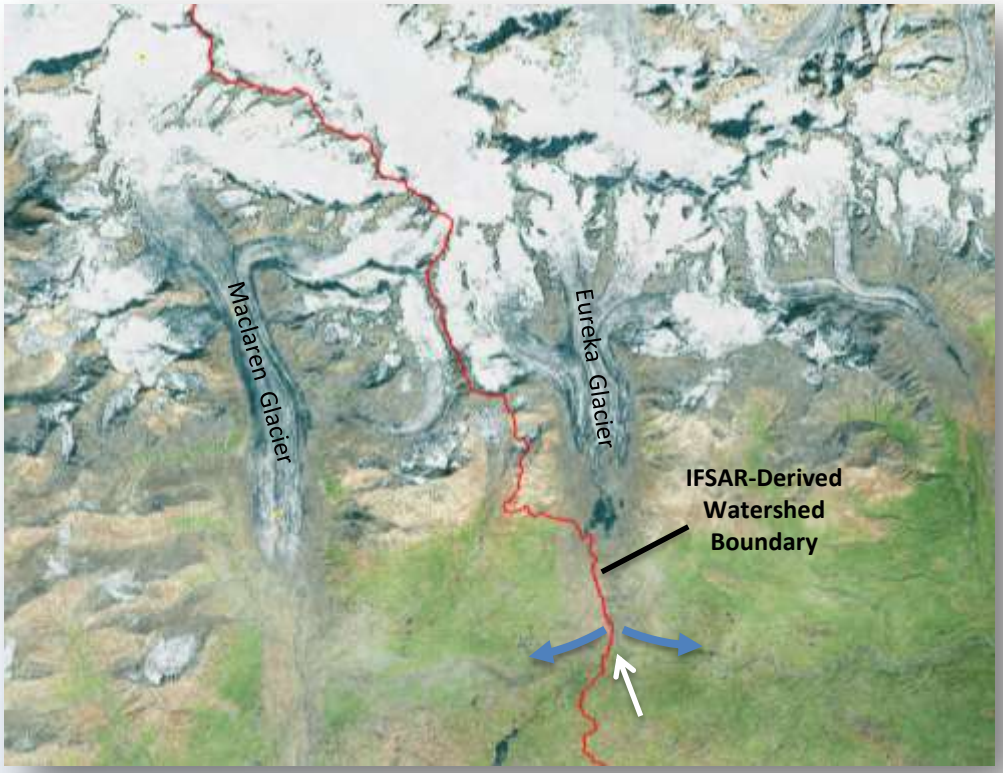
Installation of new soil temperature probes at a shrub tundra weather station near upper Kosina Creek, June 2013



Servicing a weather station at a shrub tundra site near lower Windy Creek, Oct. 2013

Study 7.7– 2013 Fall Fieldwork

Eureka Glacier is currently contributing to the upper Susitna watershed



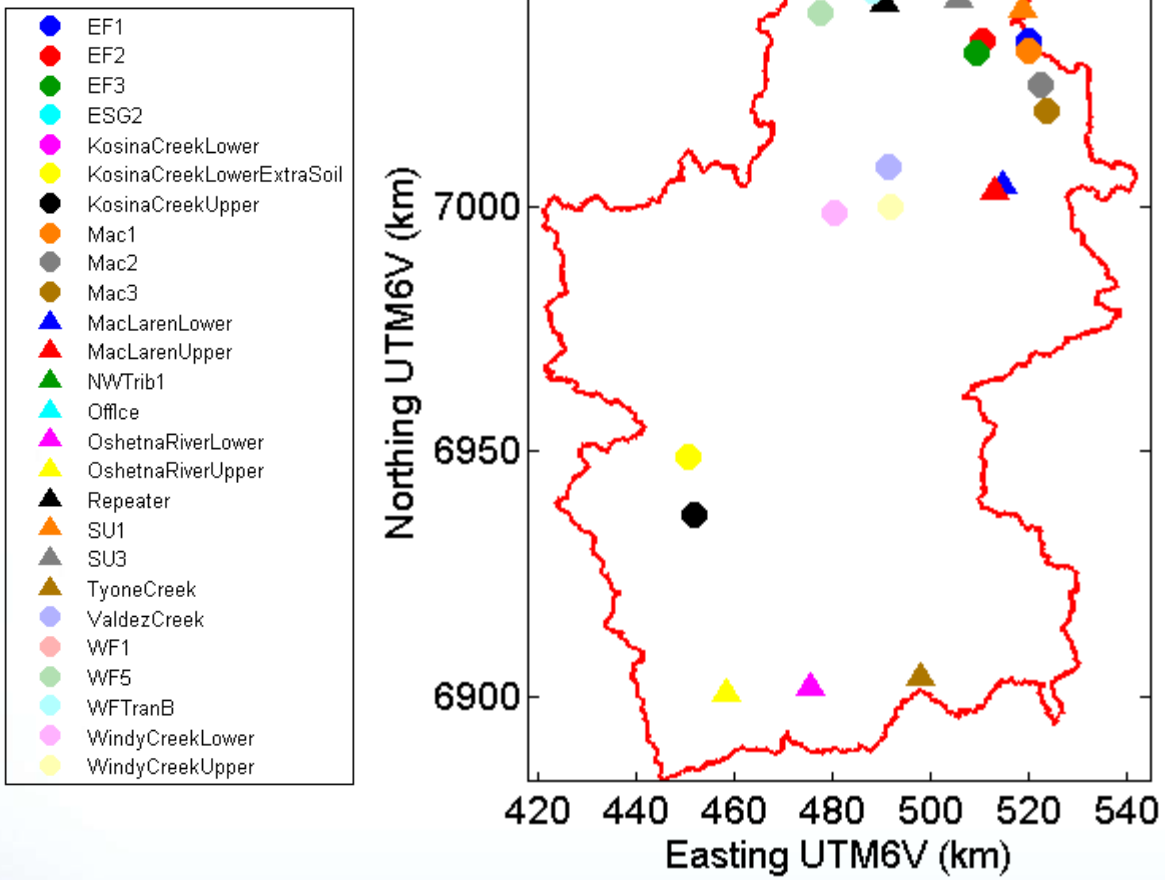
View of Eureka river looking ESE at divergence, Sept. 2013.

View of Eureka river from Eureka Glacier looking S toward divergence, Sept. 2013.

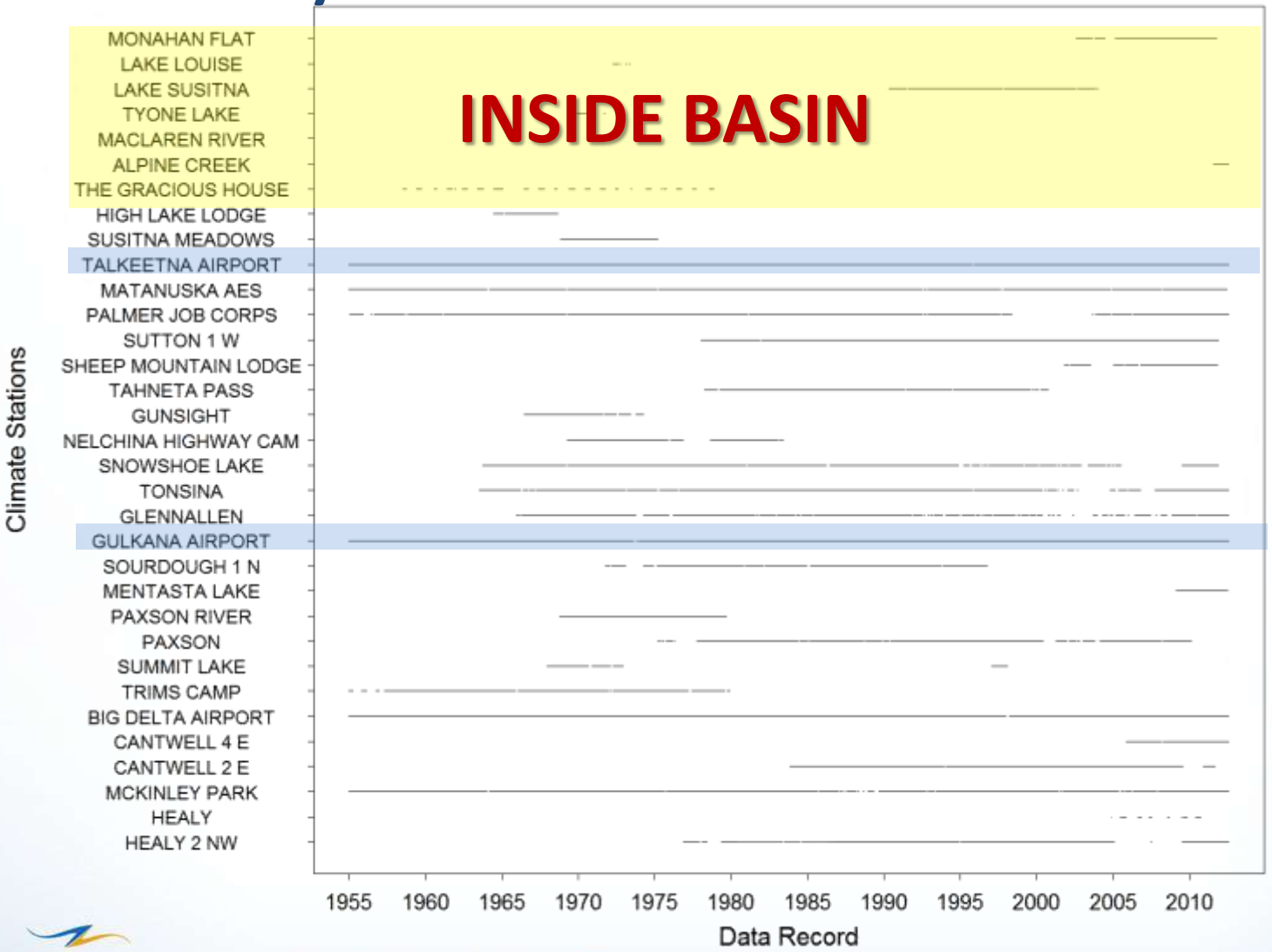
Study 7.7– Weather Stations

2012-2013

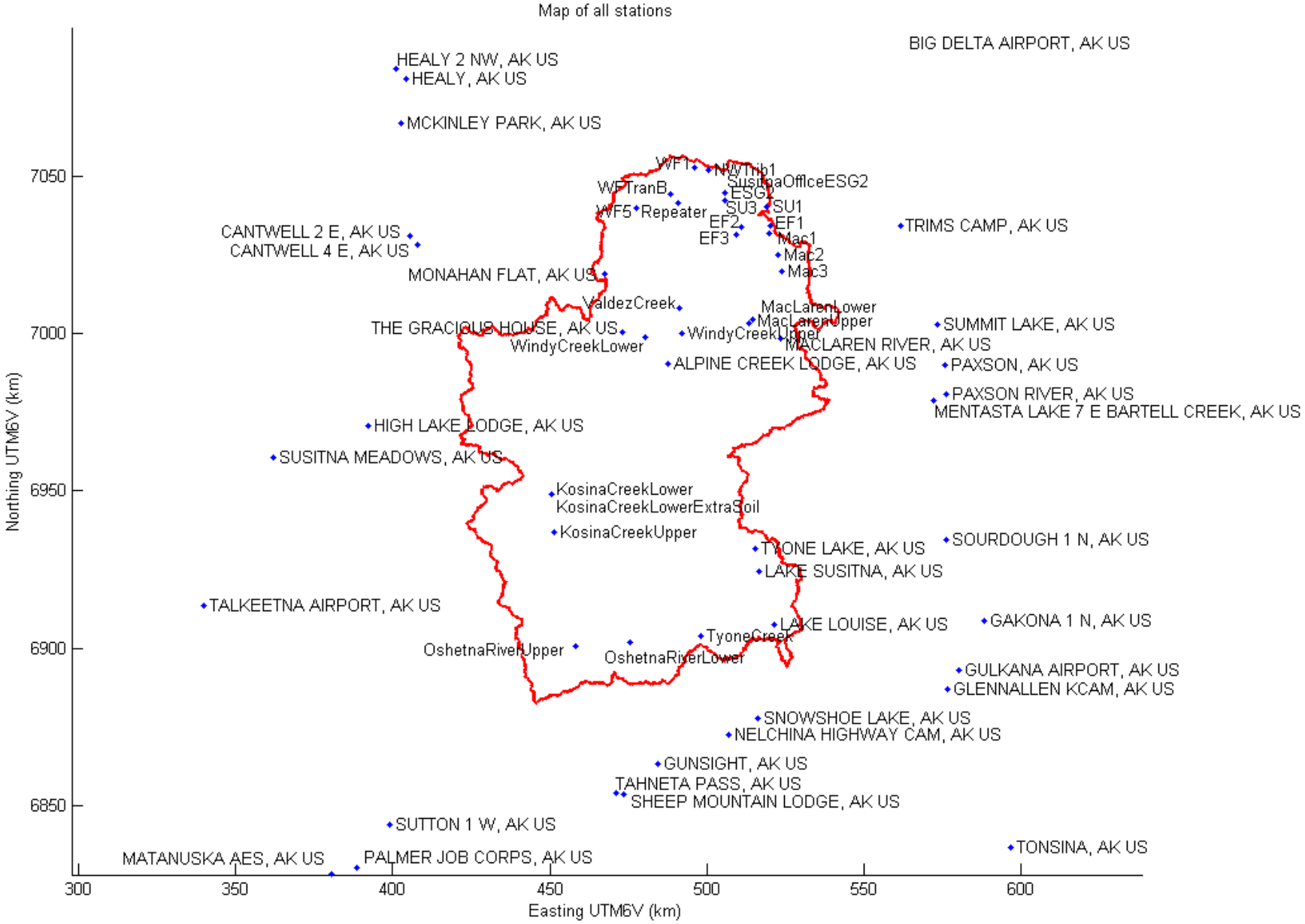
T/RH and Precipitation Stations



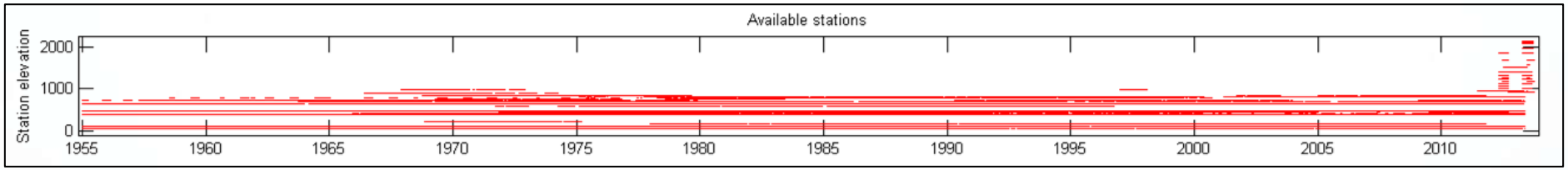
Study 7.7– Climate Stations

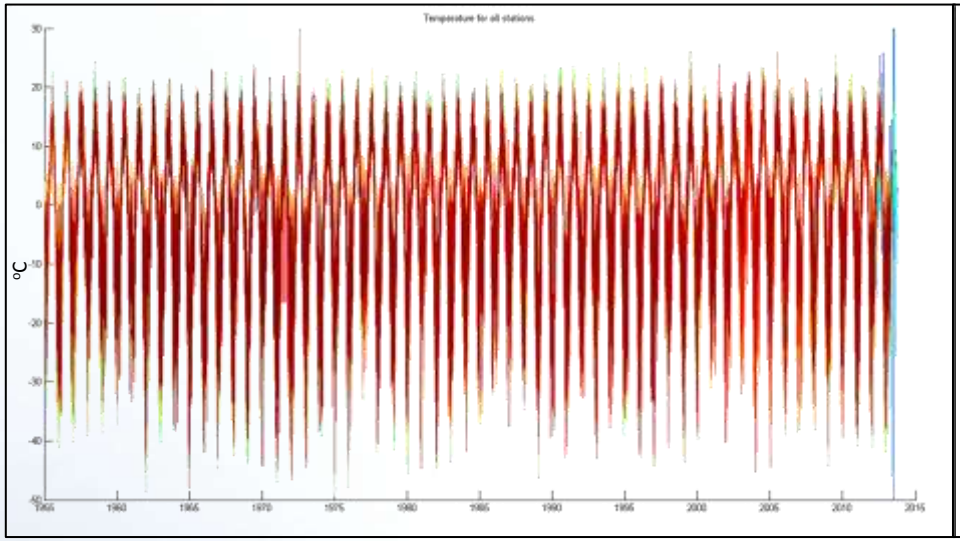


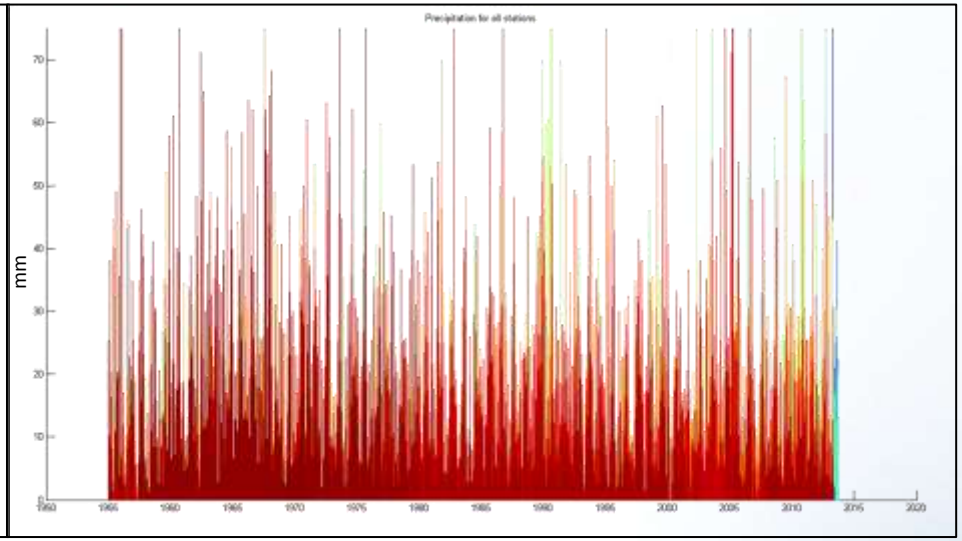
Study 7.7– Met/Clim Stations



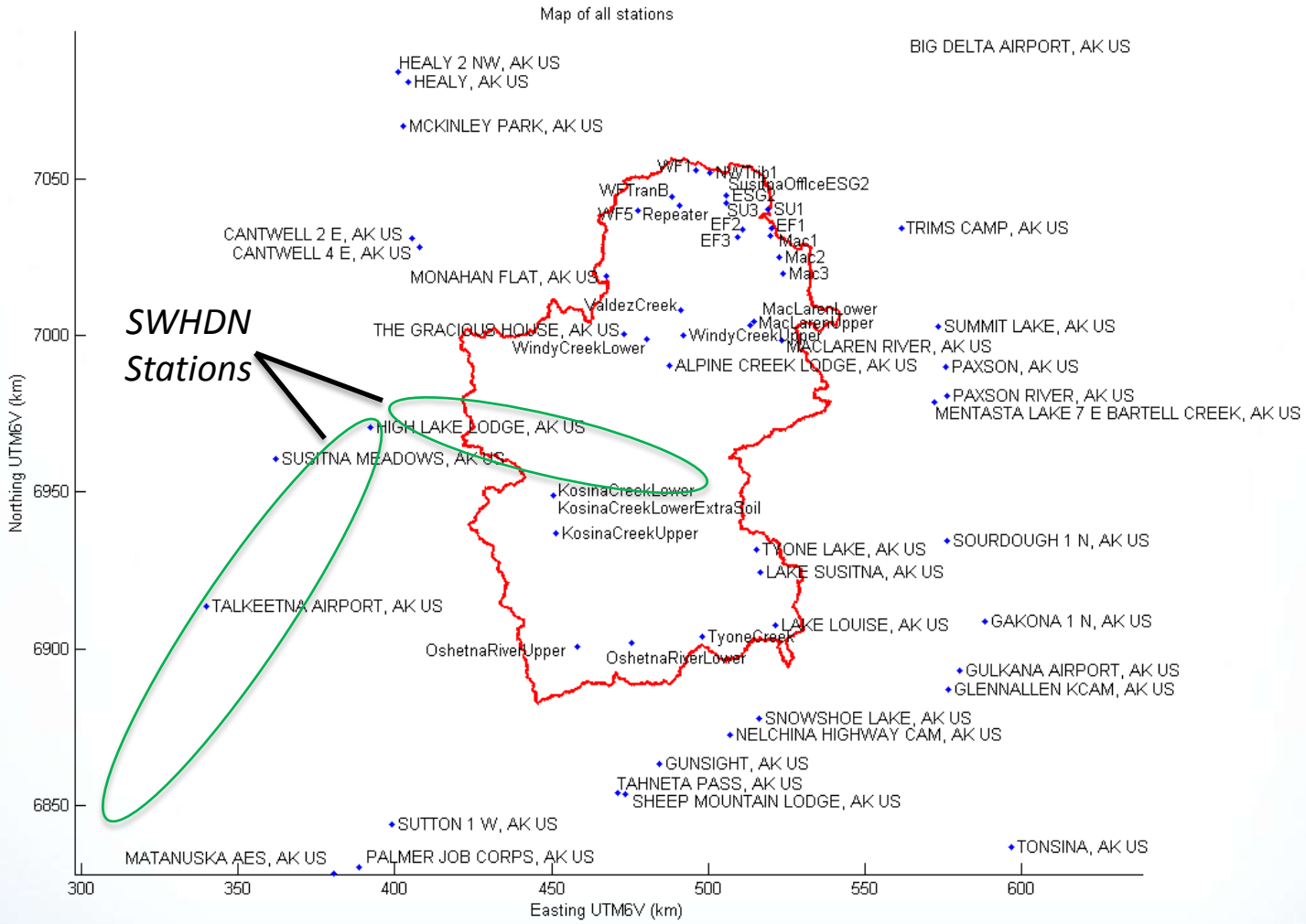
Study 7.7– Met/Clim Stations



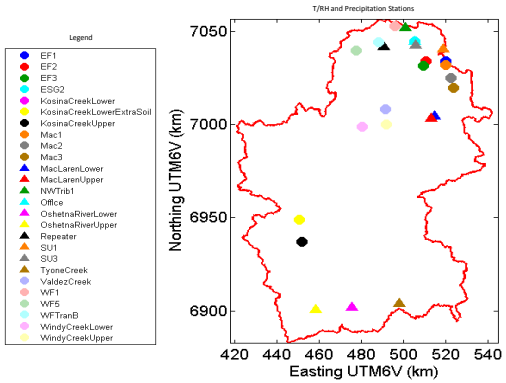




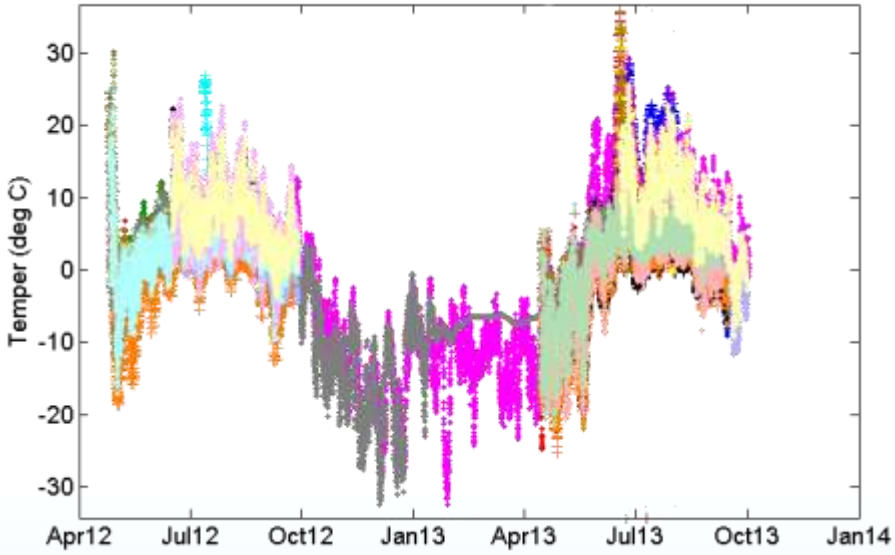
Study 7.7– Met/Clim Stations



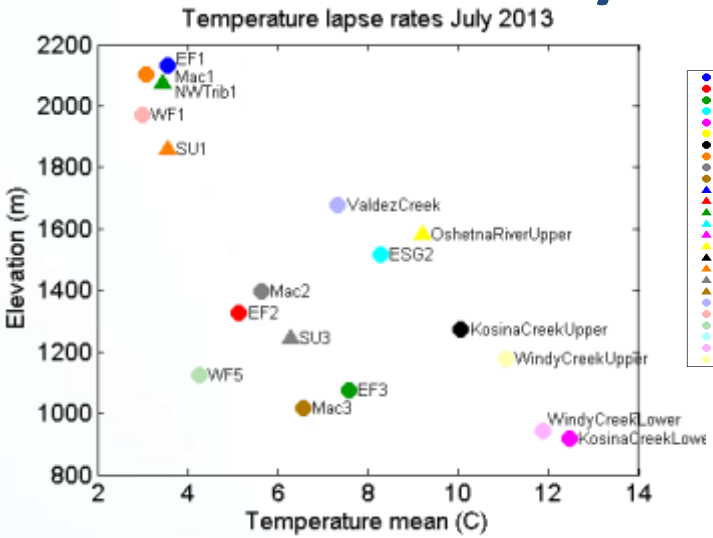
Study 7.7– Temperature

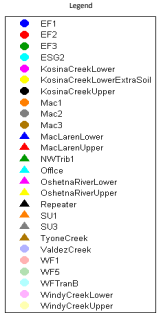


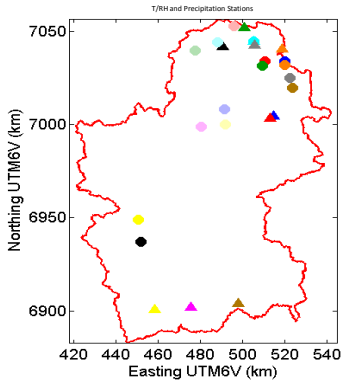
Temperature

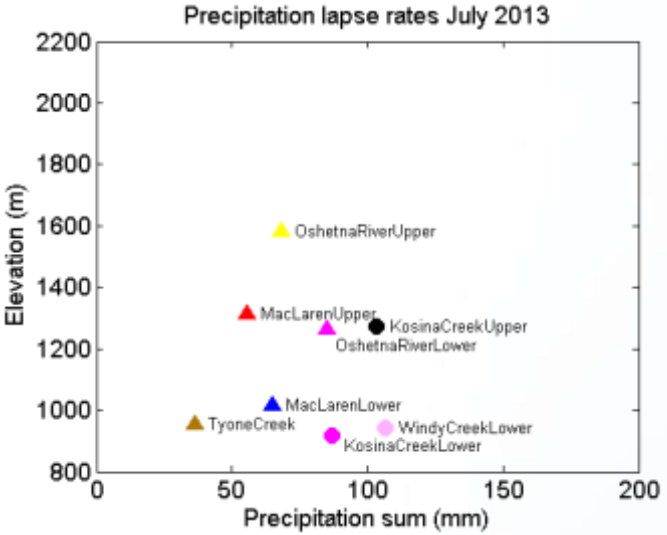


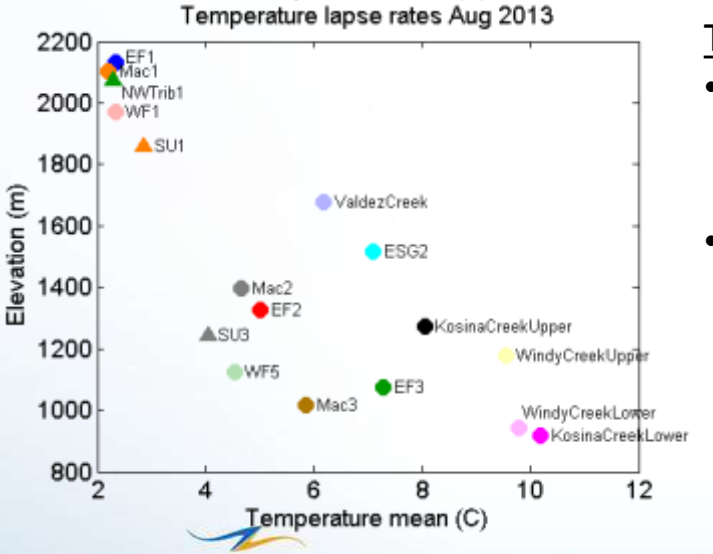
Study 7.7– Temperature





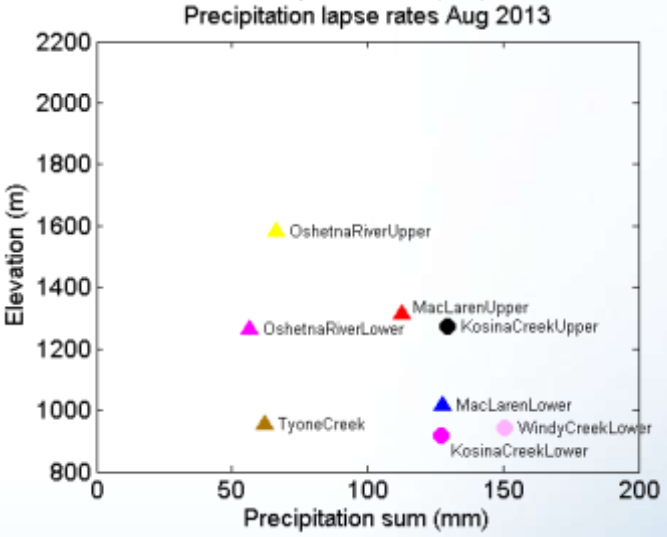




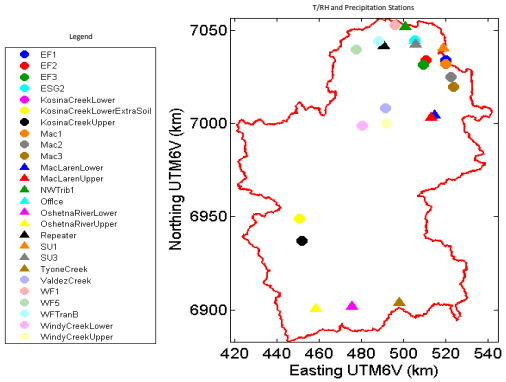


Temp. Lapse Rates (°C/km)

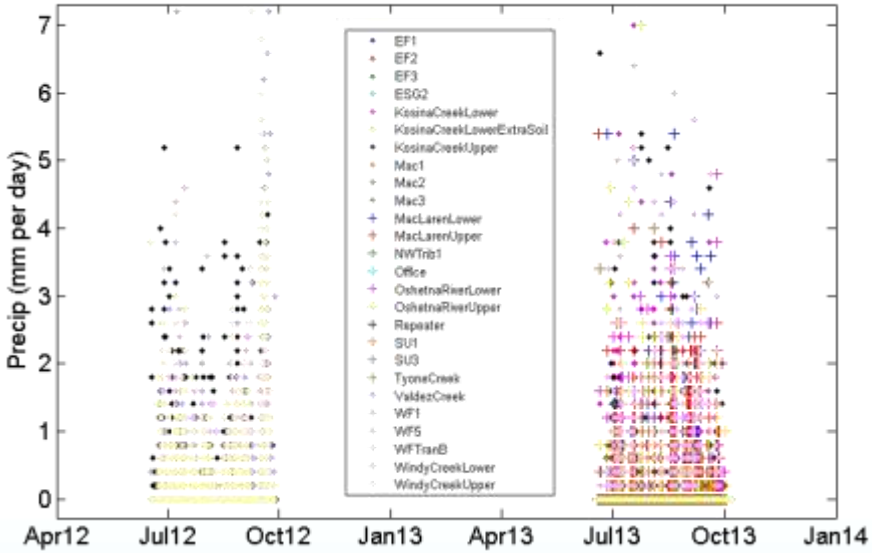
- Land
  - July – 6.0
  - Aug – 5.2
- Glacier
  - July – 3.0
  - Aug – 3.4



Study 7.7– Precipitation

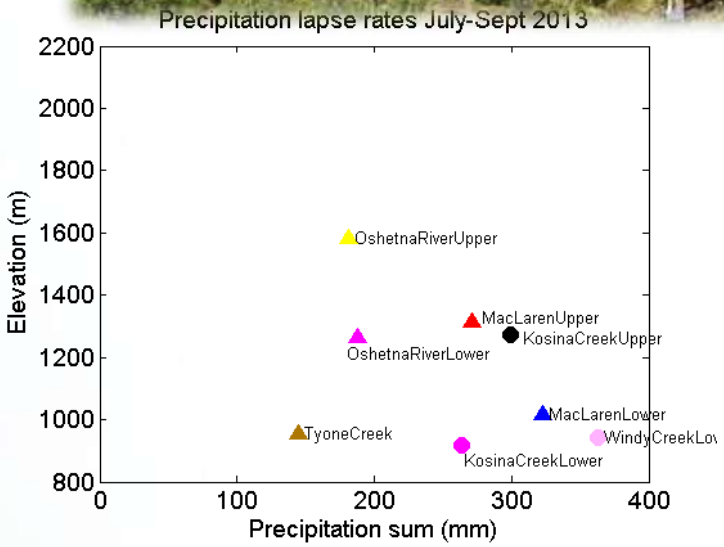


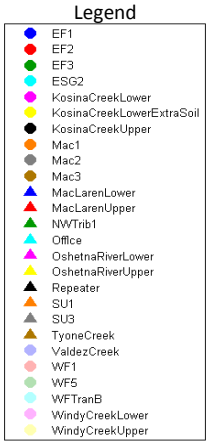
Precipitation

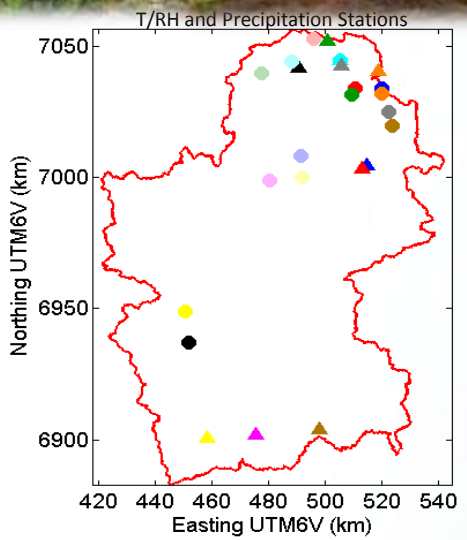


Study 7.7– Precipitation

900 masl

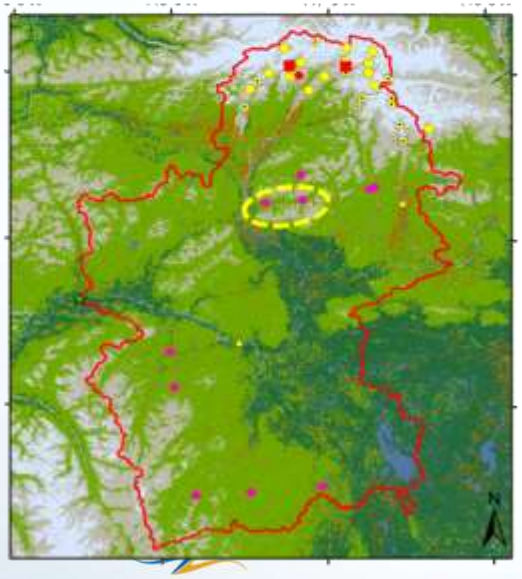


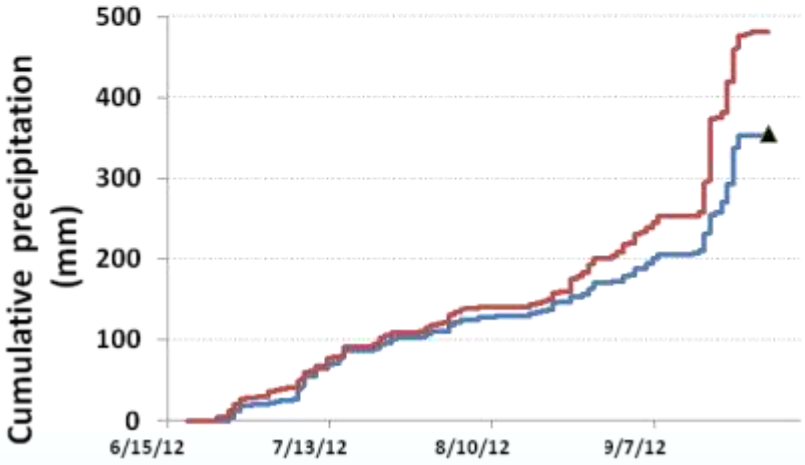




1200 masl

Study 7.7– Precipitation



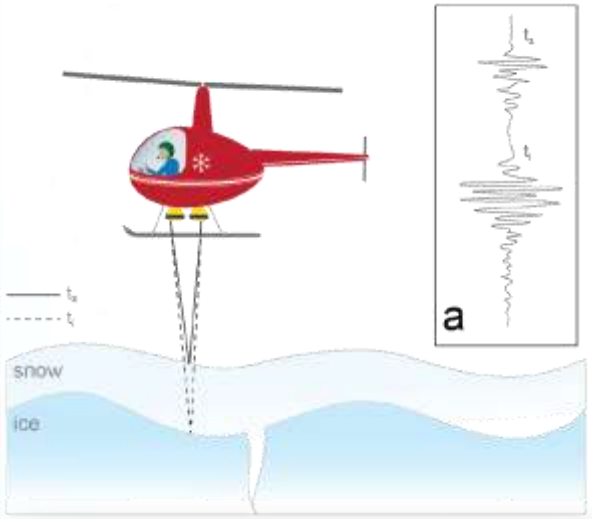


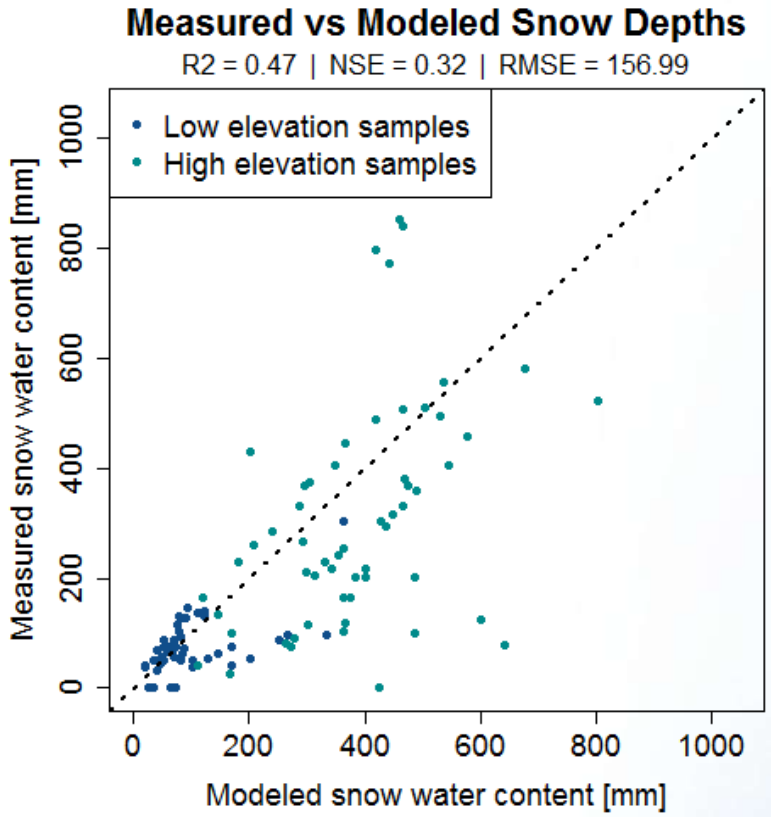
1200 masl (481 mm)

900 masl (353 mm)

Alpine Cr (355 mm) 900 masl

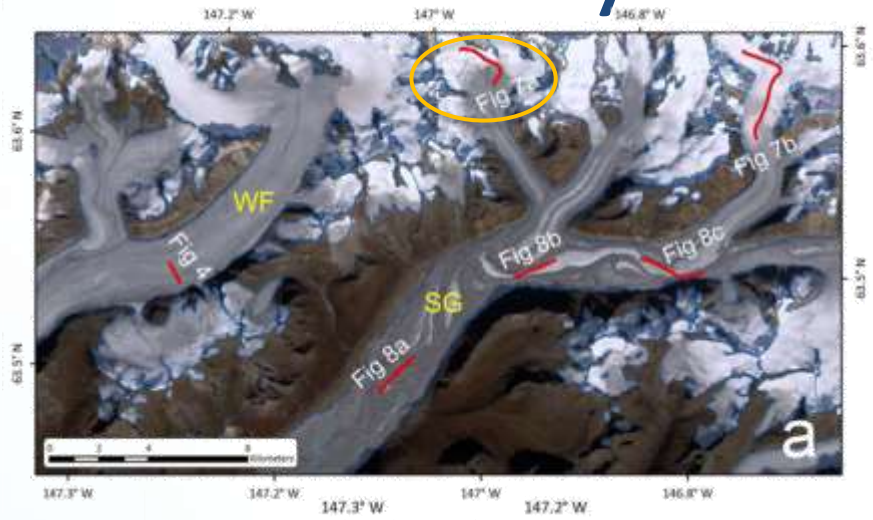
Study 7.7– Precipitation

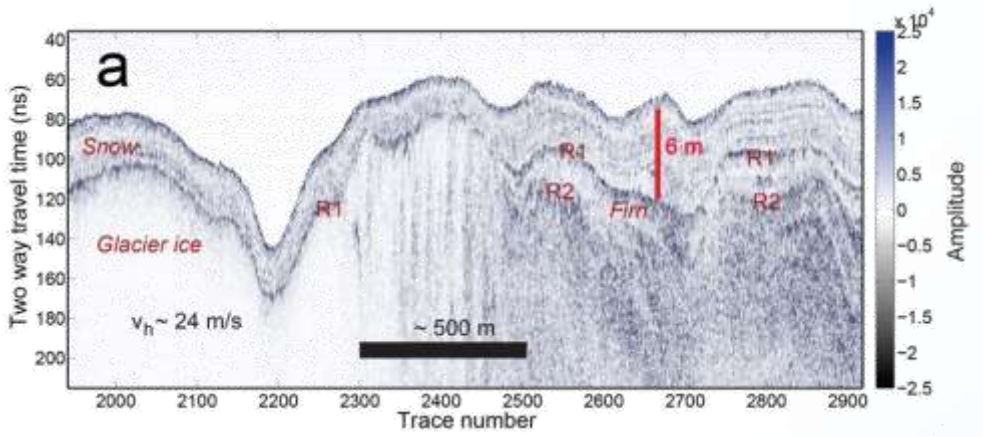


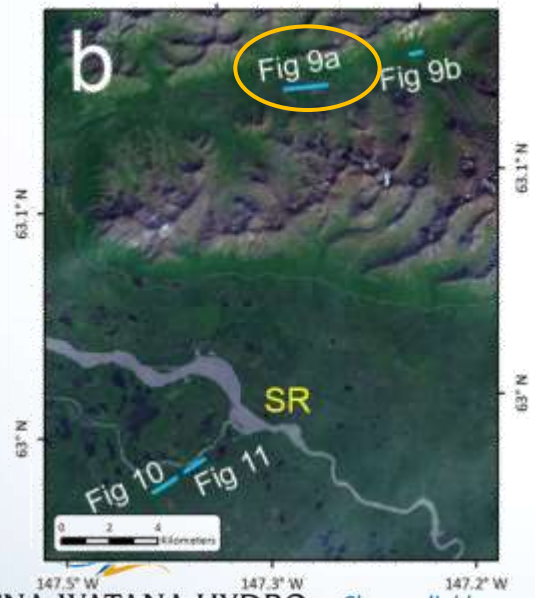


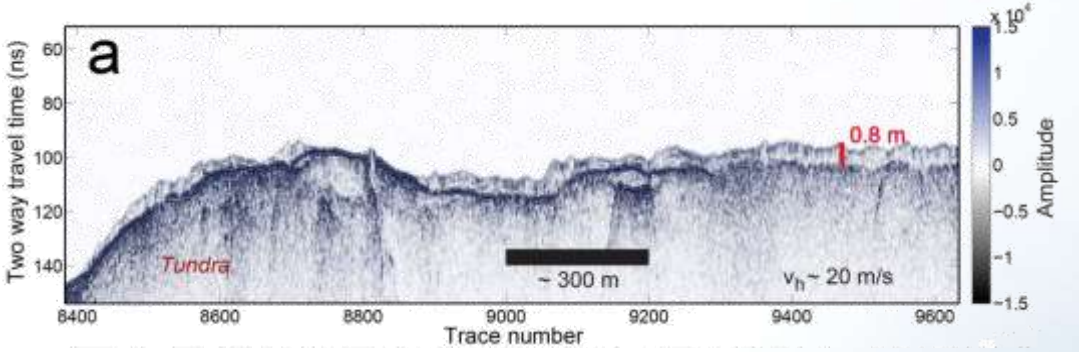
Radar-derived snow-depth validation work in the upper Susitna basin.

Study 7.7– Precipitation





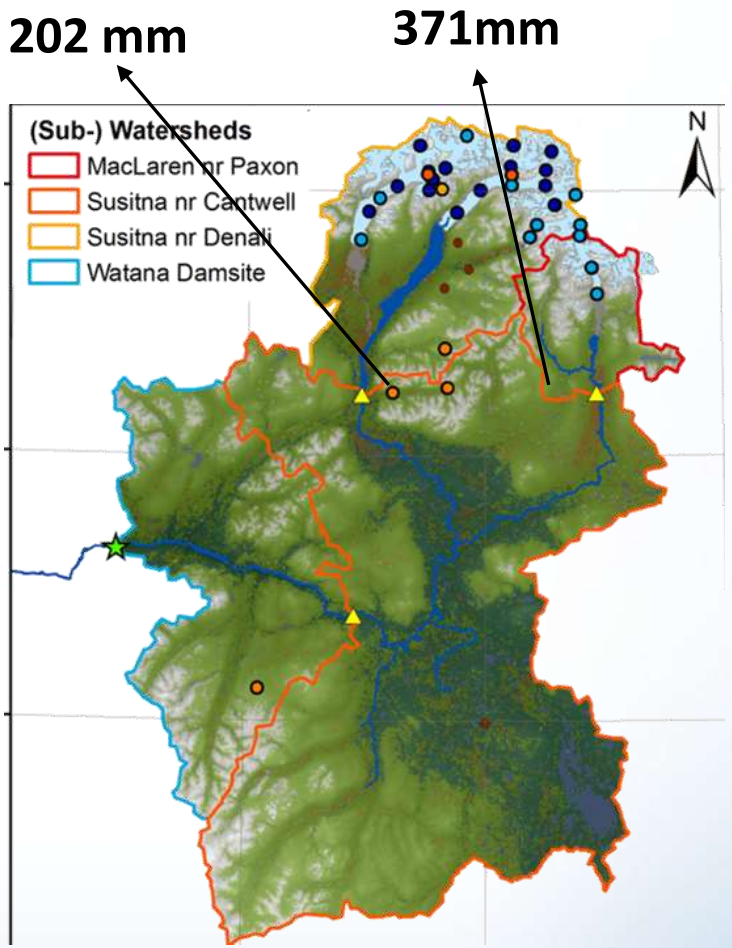




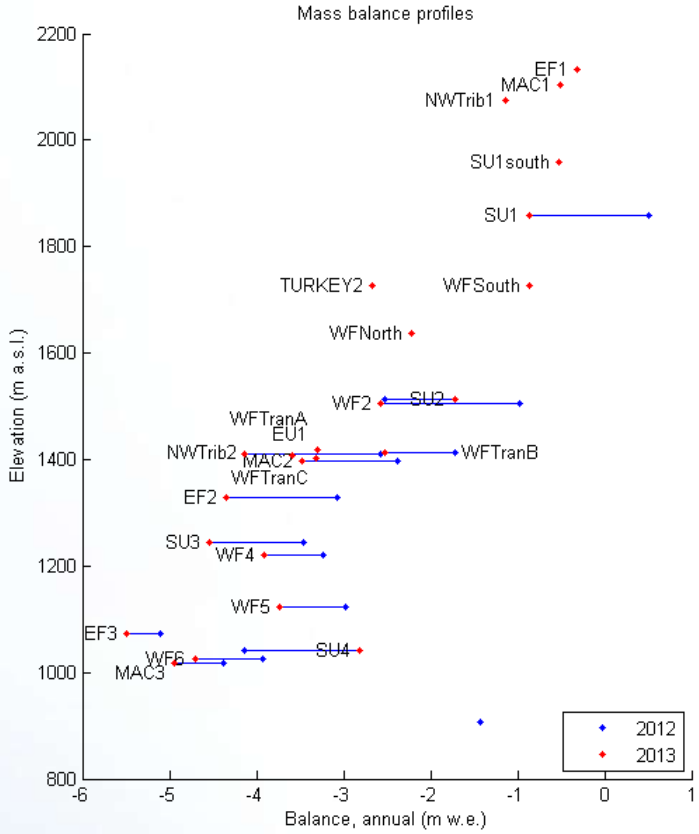
Study 7.7– Precipitation

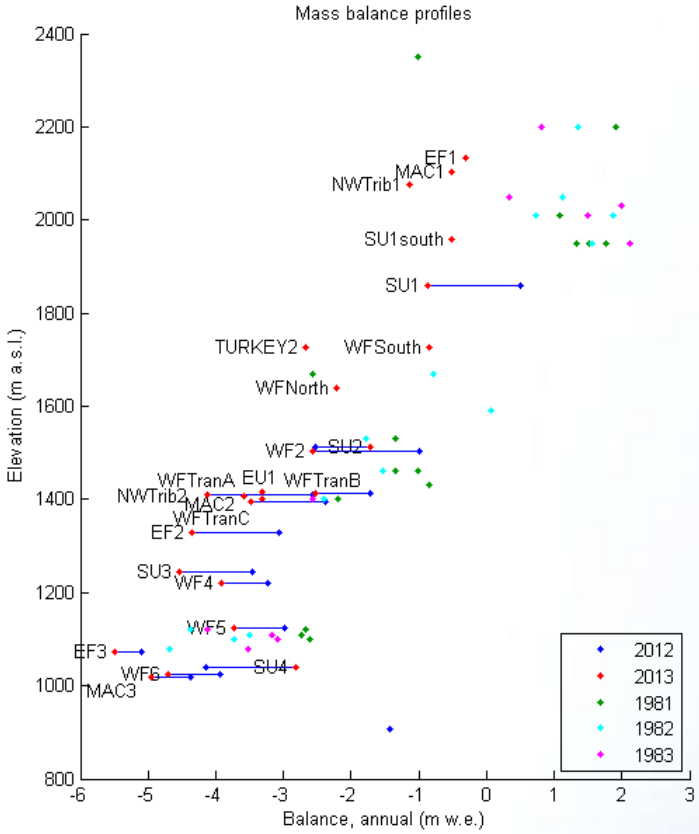
Accumulated snow water equivalent

SWE on April 4, 2012



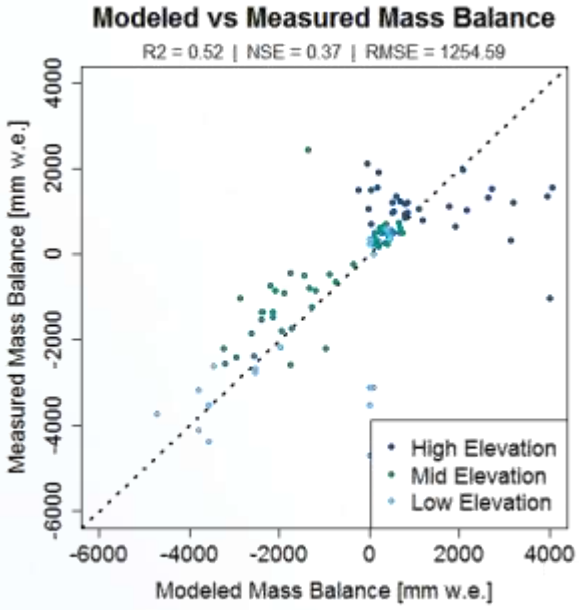
Study 7.7– Mass Balance



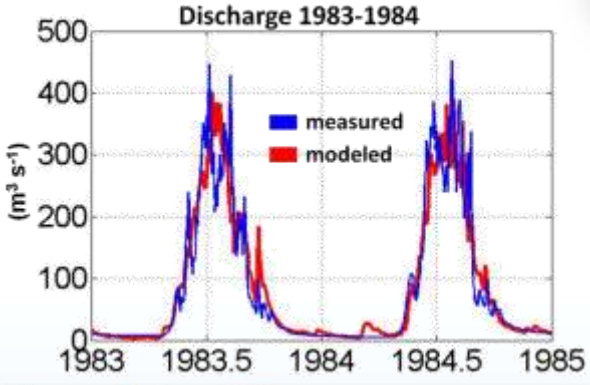


Study 7.7– Mass Balance

Mass balance model validation

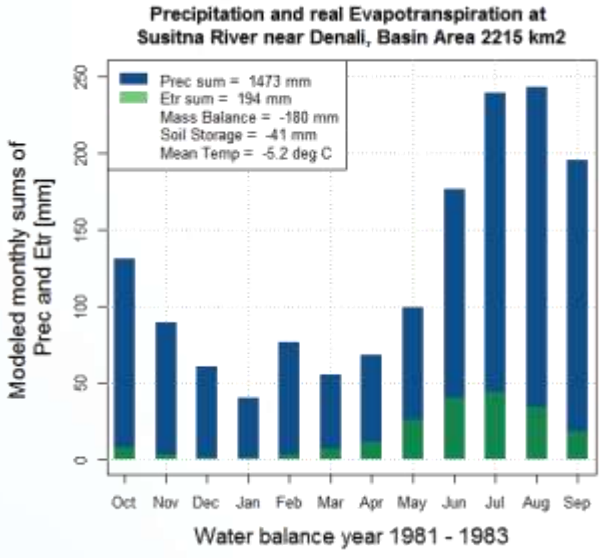


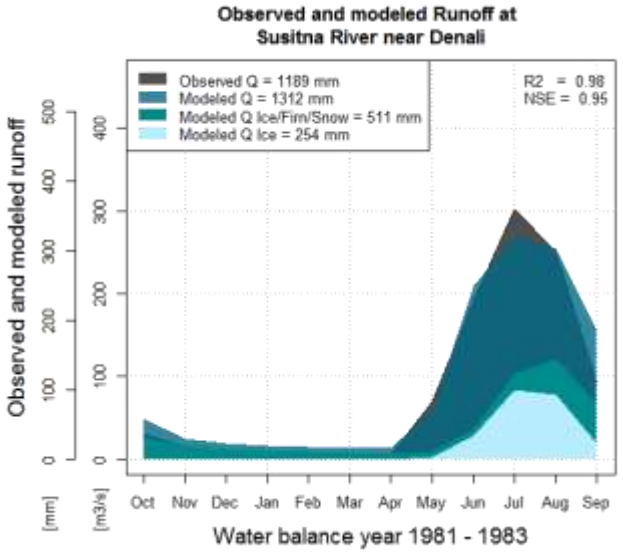
Denali Sub-basin

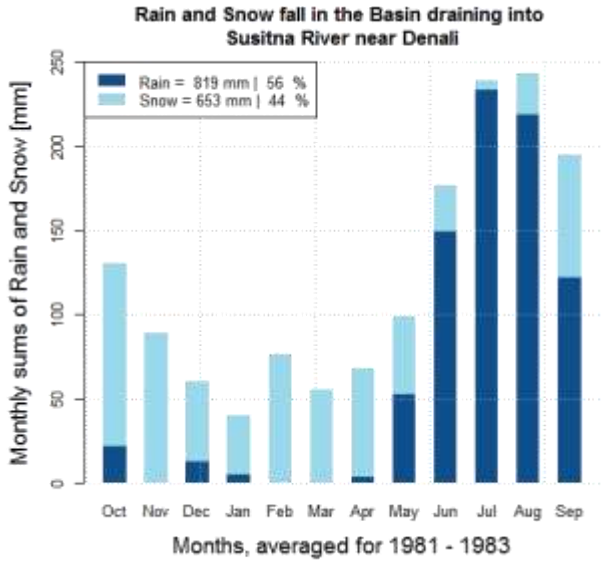


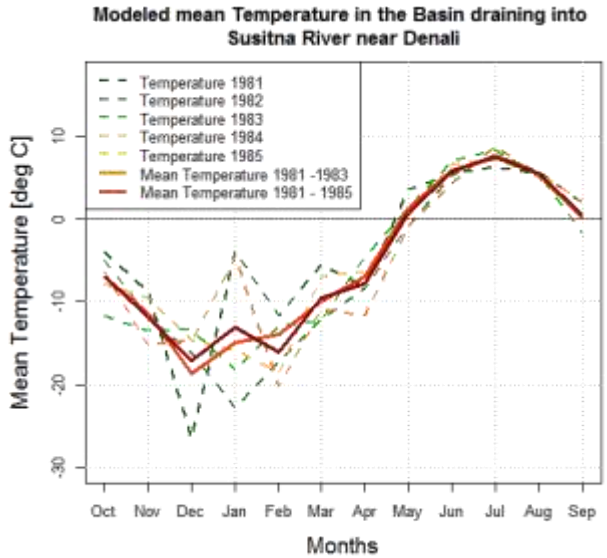
Installing an acoustic sensor for measuring/monitoring snow/ice surface change on West Fork Glacier (ESG1), Spring 2013.

Study 7.7– Model Simulations



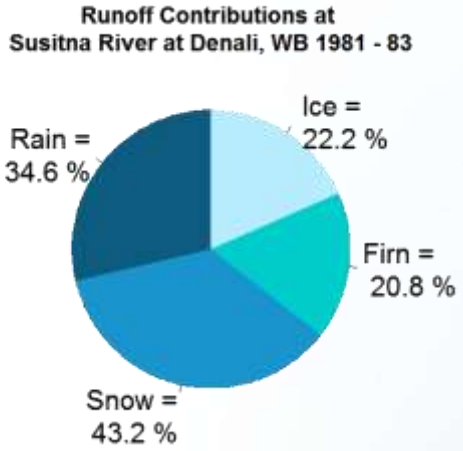






Calibration Run (PRELIMINARY):

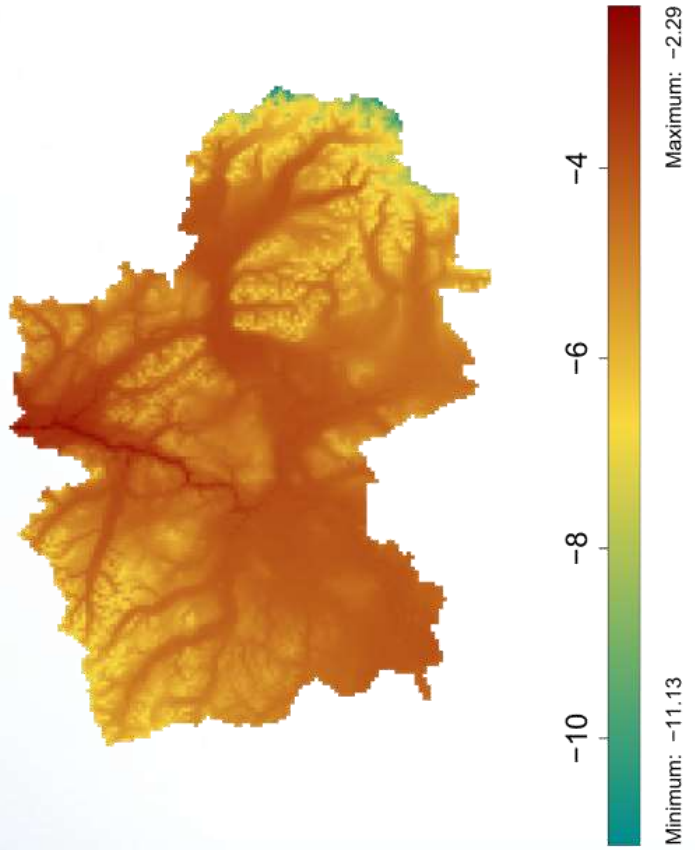
3-year Mean Water Balance for Denali Sub-Basin



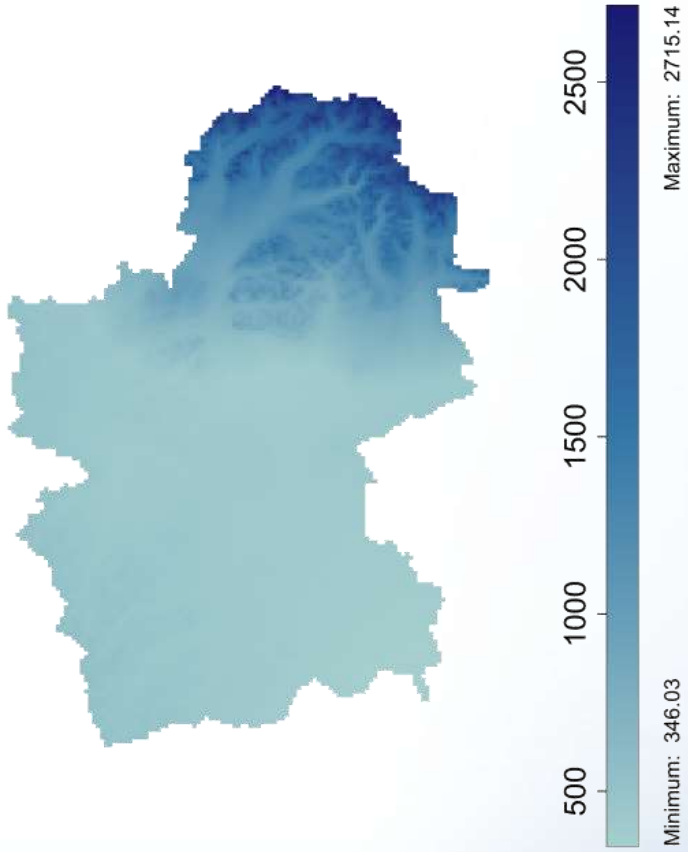
Estimated Glacier runoff contribution Clarke (1986) = 34 %

Study 7.7– Model Simulations

Mean Temperature [deg C] WB years 1981 – 1983

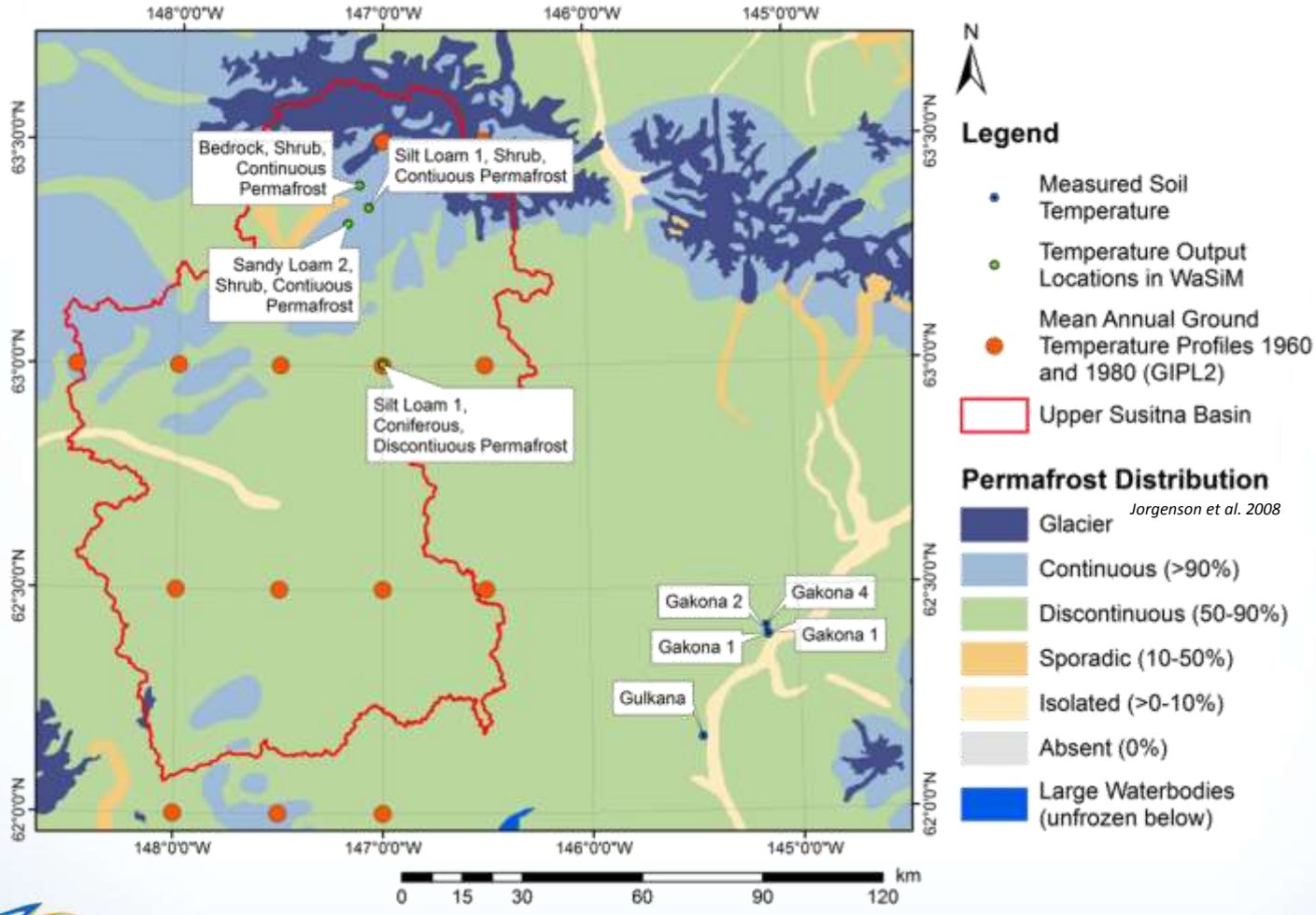


Mean Precipitation [mm] WB years 1981 – 1983



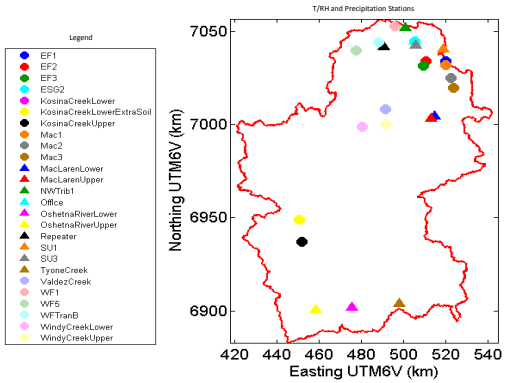
Study 7.7– Permafrost Modeling

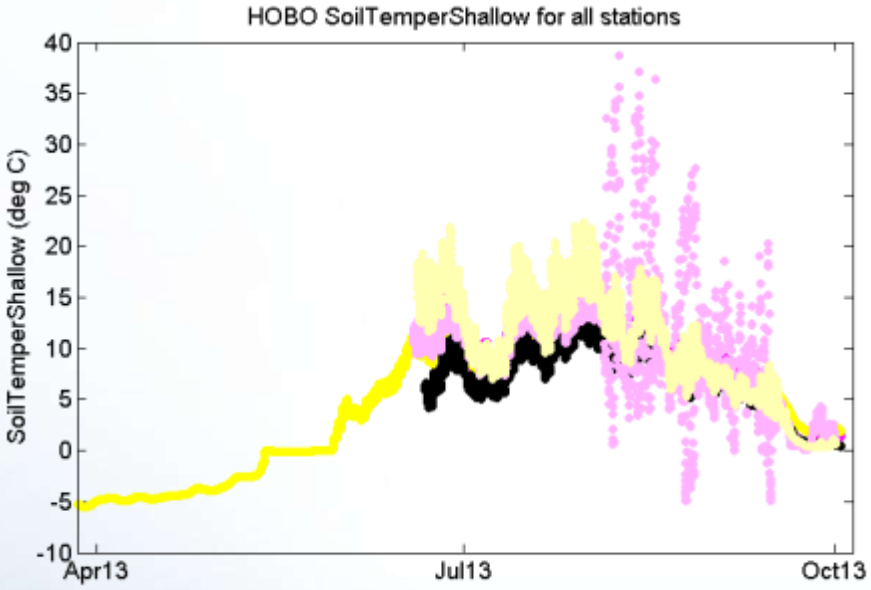
Existing measurements & modeling of permafrost

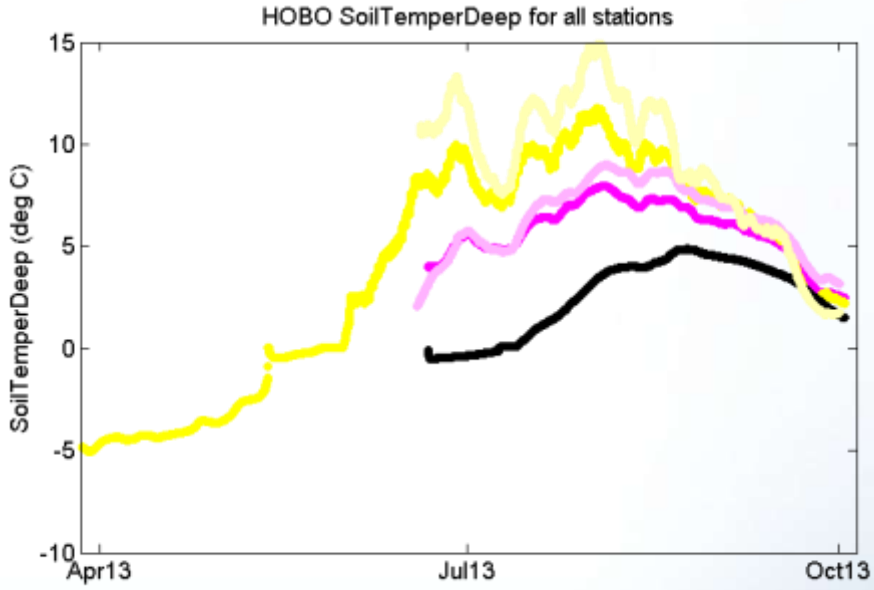


Study 7.7– Permafrost Modeling

Soil Temperature Measurements

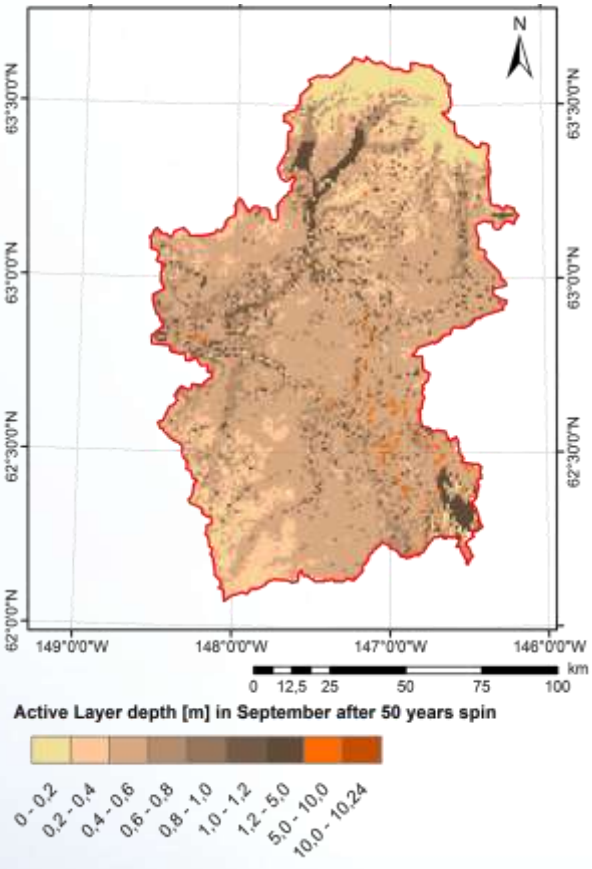


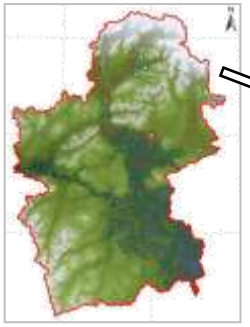


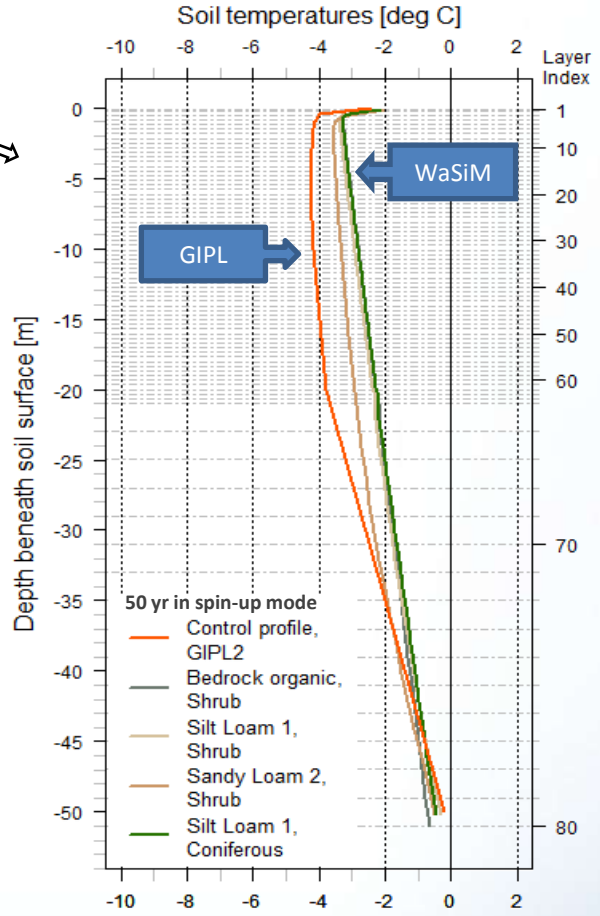


Study 7.7– Permafrost Modeling

Modeled permafrost conditions and soil temperature





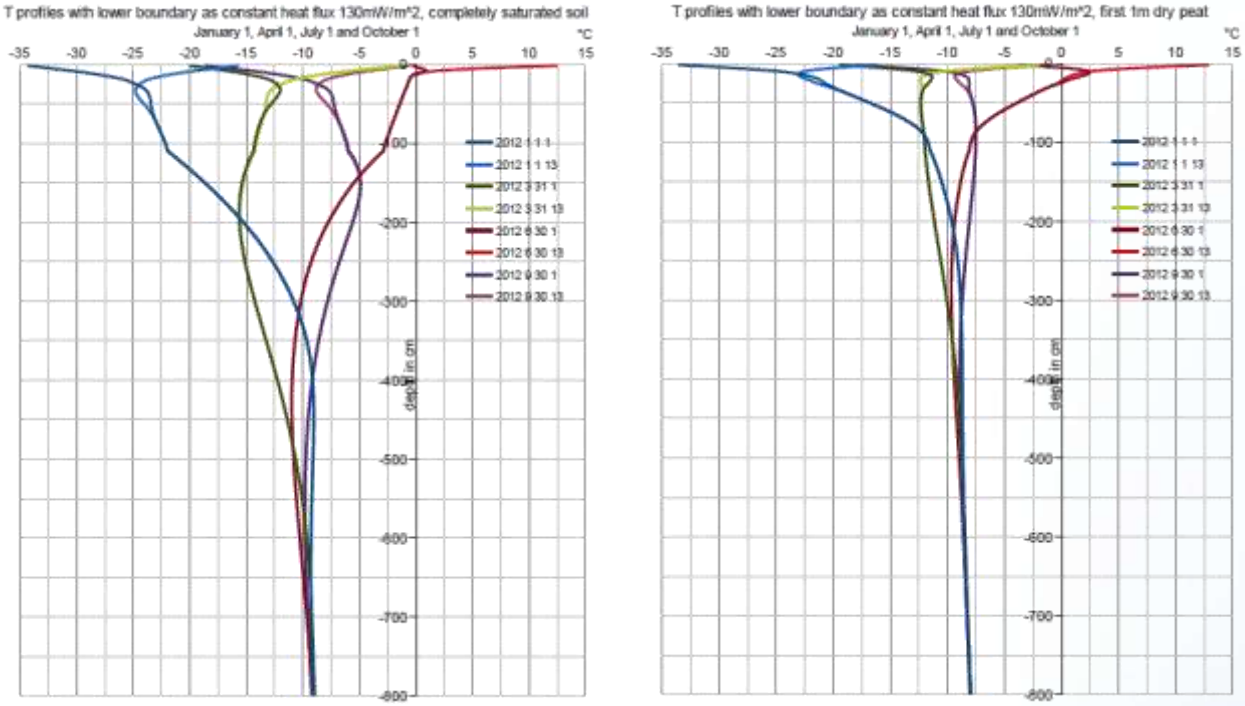


Study 7.7– Permafrost Modeling

Heat Transfer Module

Recent additions/changes:
(J. Schulla & R. Daanen)

- lower boundary heat flux rather than a fixed temperature
- thermal conductivity for variable saturation
- freezing curve adjustment for variable saturation
- hydraulic conductivity dependent only on liquid water



Saturated vs. unsaturated soil temperature profiles

Study 7.7– Q4 2013 Variances

- Added 6 new mini-AWS to off-ice localities in upper Susitna basin
- Added bi-level soil temperature sensors to all off-ice mini-AWS stations
- Added 1-D Heat Transfer Module to WaSiM
  - Added freezing curve adjustment for variable soil saturation, among other changes
- Adding refined glacier volume change algorithm to Glacier Module in WaSiM
- Developing downscaled Regional Climate Model

Study 7.7– Q4 2013 Next Steps

- Continue runoff model calibration/validation
  - Collecting *in situ* measurements
  - Precipitation distribution
  - Glacier volume changes
- Continue runoff model module development
  - Soil heat transfer module
  - Glacier module
- Continued development of downscaled climate product