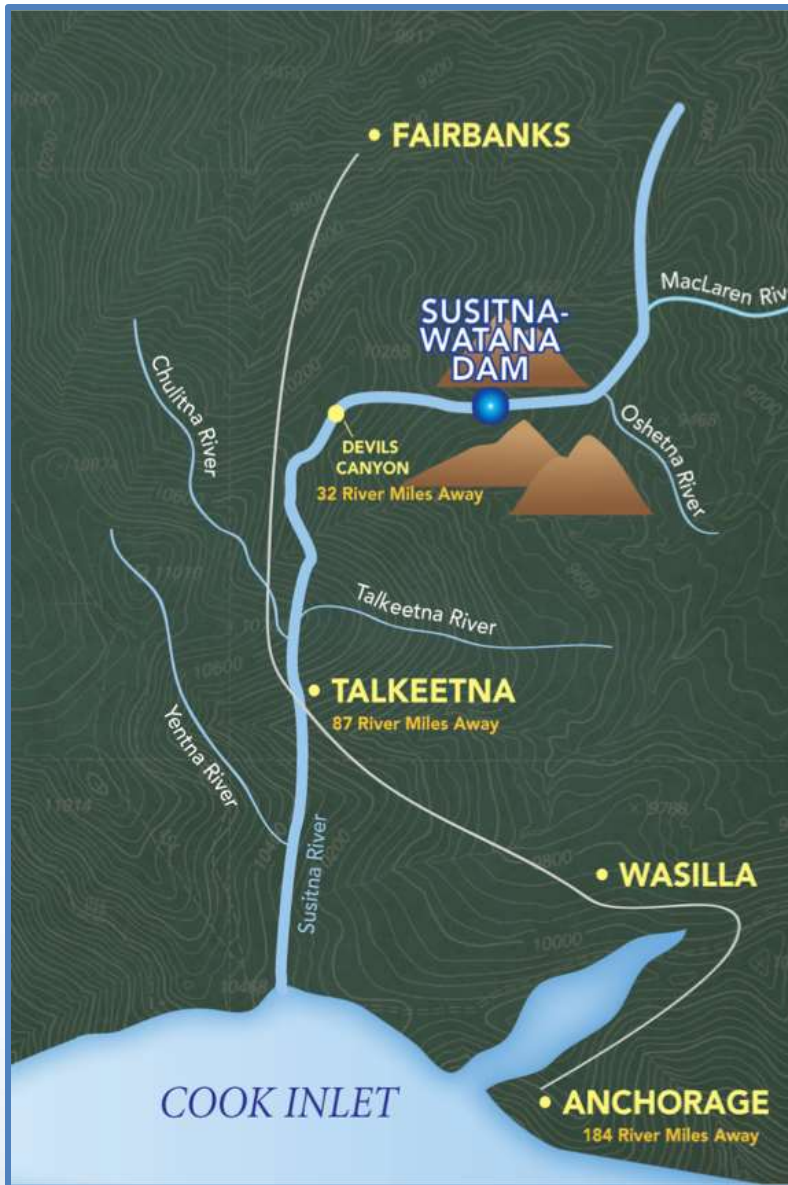


Technical WorkGroup Meeting

Glacier and Runoff Changes - Update

June 26, 2013

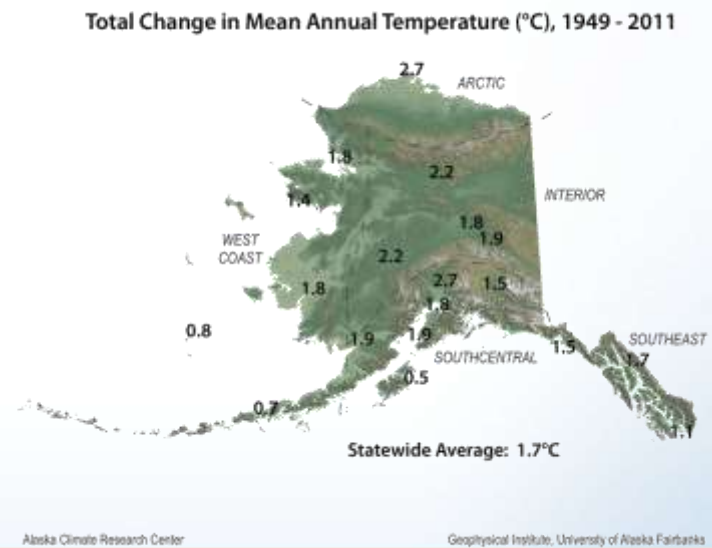
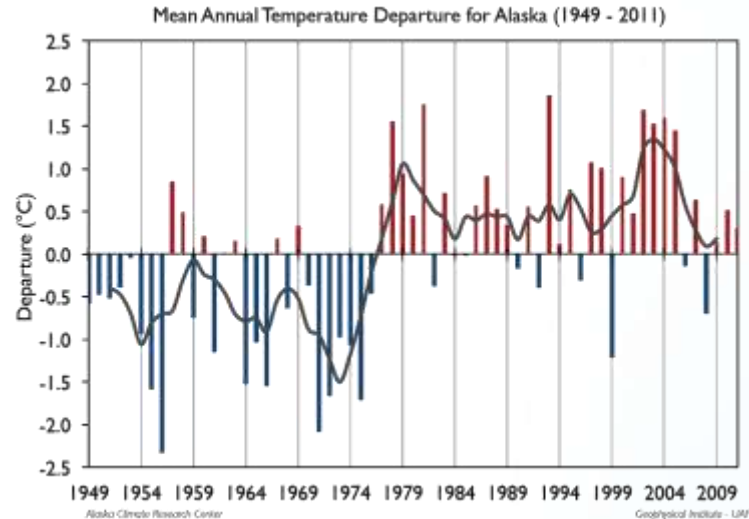
Prepared by Gabriel Wolken,
Alaska Div. of Geological &
Geophysical Surveys



Goal

Simulate future changes in quantity and seasonality of river runoff into the proposed dam...

... under climate change conditions



Field measurements

- Ablation stakes, Snow depth, Temperature, Precipitation, Relative Humidity, Wind
- Supply input data to WaSiM
- Enable multi-criteria calibration and validation

+

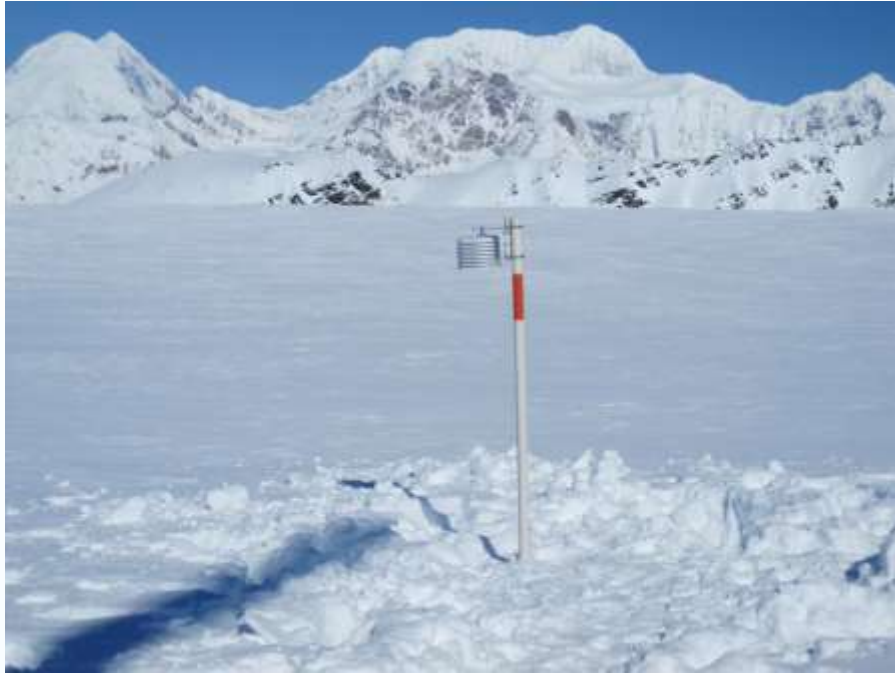
Hydrological modeling

- Reproduce:
 - historic discharge values
 - snow accumulation and snow melt
 - glacier mass balance
- Produce enhanced runoff estimates for the proposed Susitna-Watana-Dam compared to statistical flow analysis



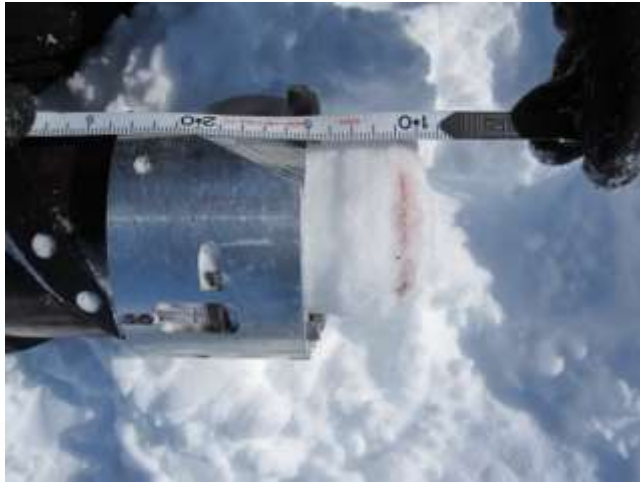






Field Measurements – Spring 2013

7



Hydrological Modeling Workflow

Meteorological Data

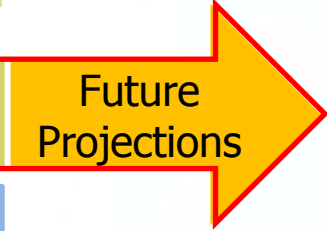
Temperature and Precipitation
 → Different Interpolation methods

1981 - 1983

2012

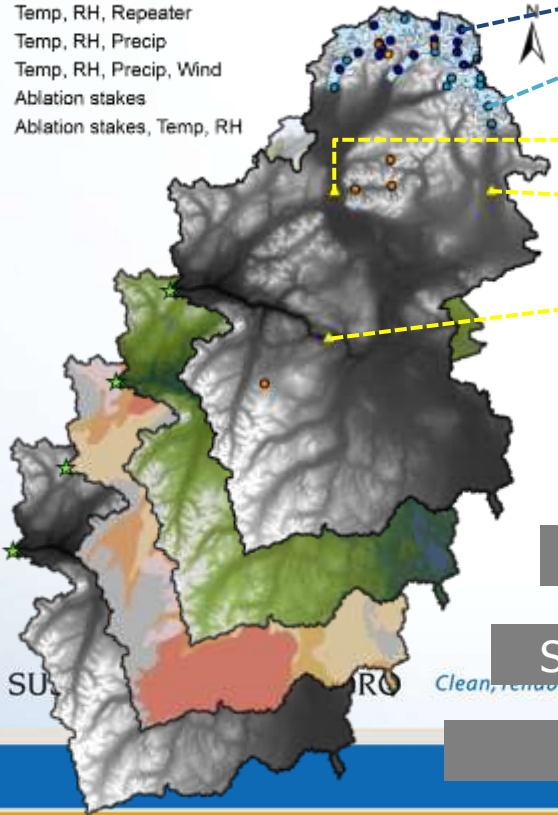
Model Input

Calibration and Validation



Spatial Data

- Temp, RH, Repeater
- Temp, RH, Precip
- Temp, RH, Precip, Wind
- Ablation stakes
- Ablation stakes, Temp, RH



Mass balance data for 1981, 1982, 1983
 2012

Glacier Mass balance

Susitna near Denali
 MacLaren near Paxson
 Susitna near Cantwell

Runoff data

Snow depth measurements 2012
 Snow radar measurements on glaciers April 2012

Snow depth

Modeled soil temperature profiles from Permafrost Lab (1960, 1980)

Soil temperature

Glacier extent

Land cover

Soil texture

DEM

Until 2100

Runoff Calibration

- Daily Runoff
- Monthly Mean Runoff
- 3 – year Mean Monthly Runoff
- Runoff Contribution

Snow Calibration

- Snow depths at specified dates

Mass Balance Calibration

- Mass Balance in specified period

Soil Temperature Calibration

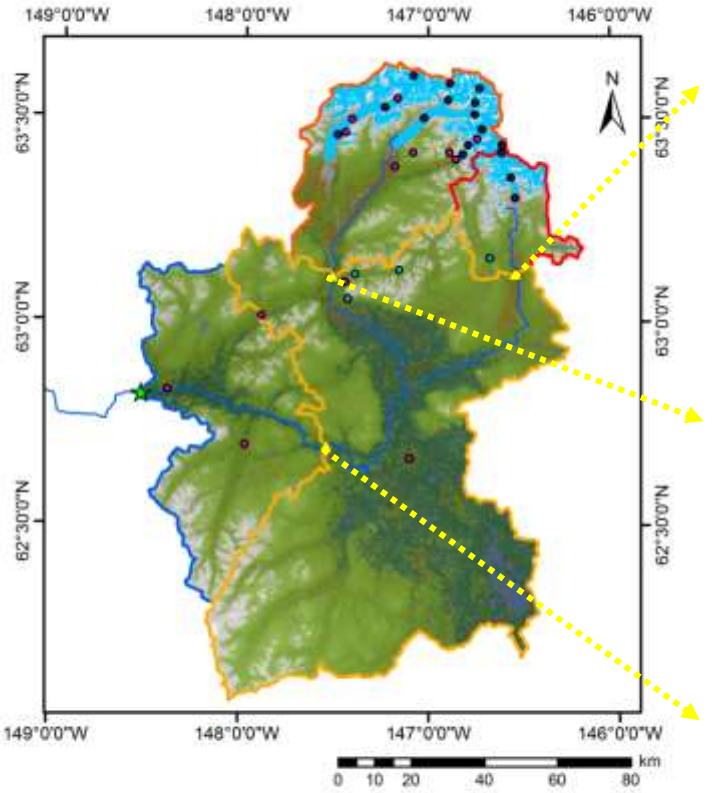
- Against Model Results from Permafrost Lab



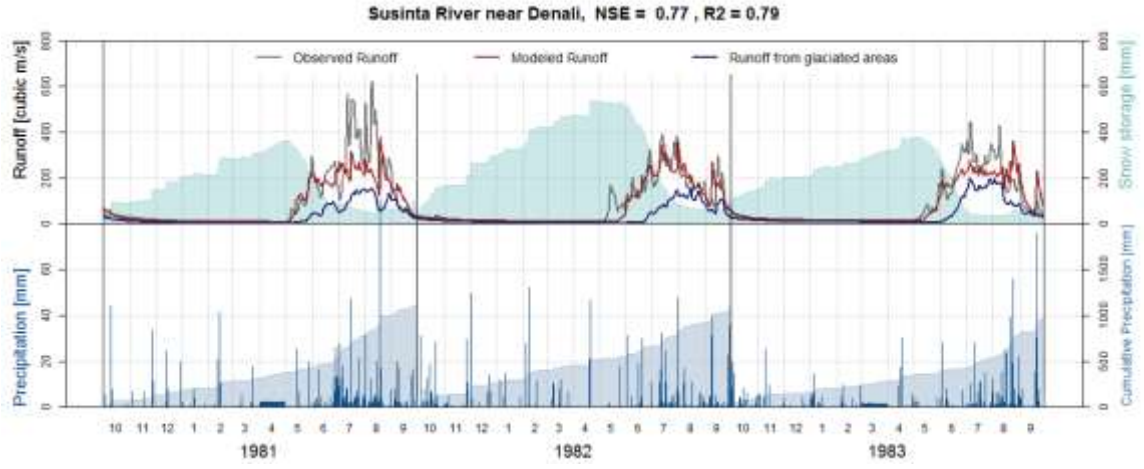
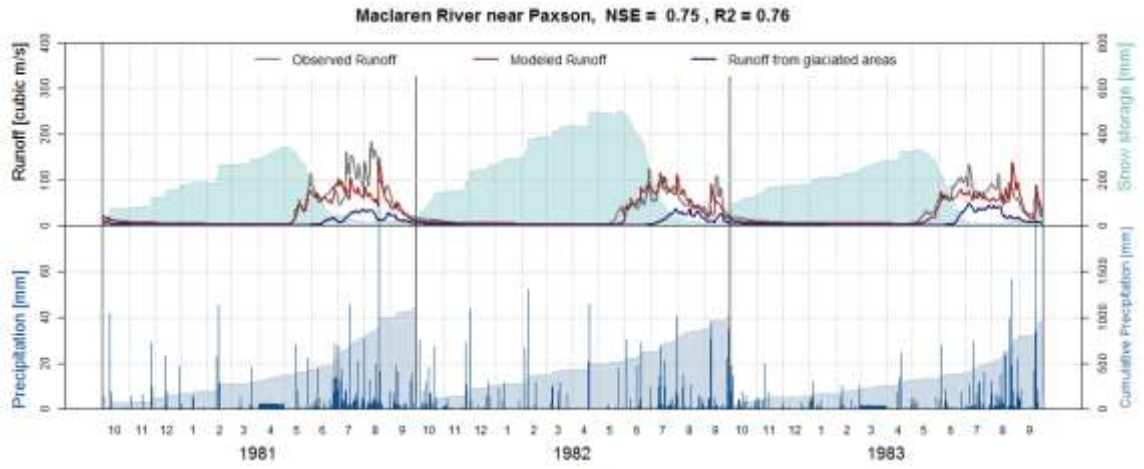
Runoff Calibration

DAILY

Location of river gauges, snow and mass balance measurements for calibration and validation

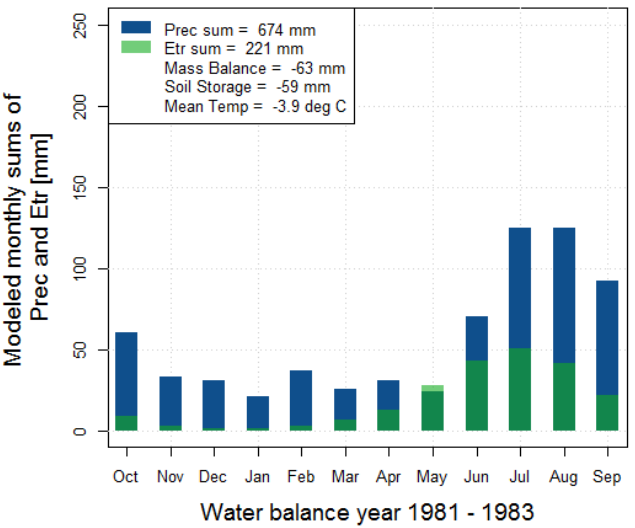


- Mass Balance 1981 - 1983 and 2012
- Snow probings 1981 - 1982
- Snow probings 2012
- ▲ USGS NWS River Discharge 1981 - 1983

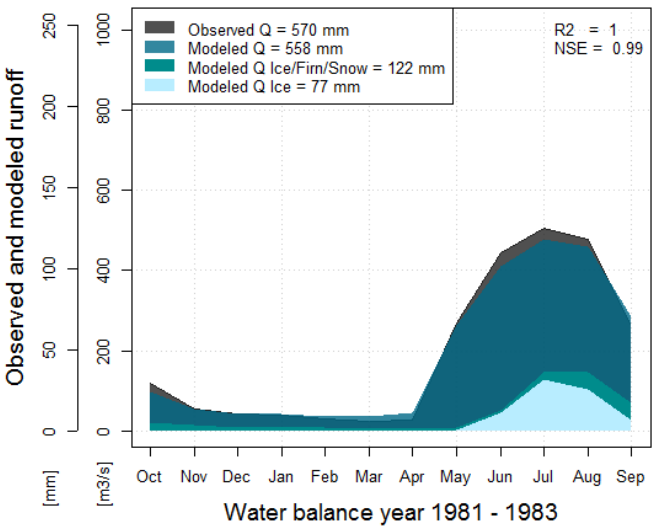


Runoff Calibration – Susitna R. near Cantwell – 3 yr mean

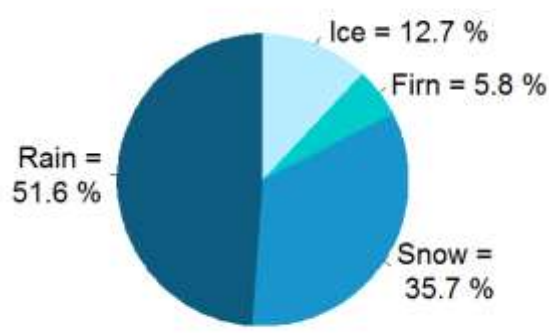
Precipitation and real Evapotranspiration at Susitna River near Cantwell, Basin Area 10673 km2



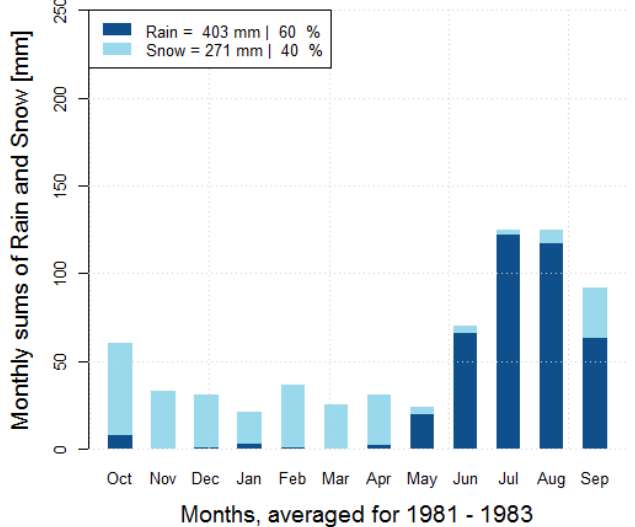
Observed and modeled Runoff at Susitna River near Cantwell



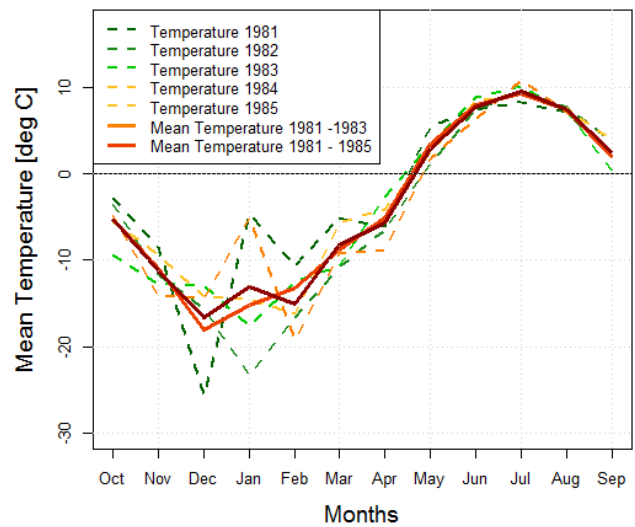
Runoff Contributions at Susitna River at Cantwell, WB 1981 - 83



Rain and Snow fall in the Basin draining into Susitna River near Cantwell

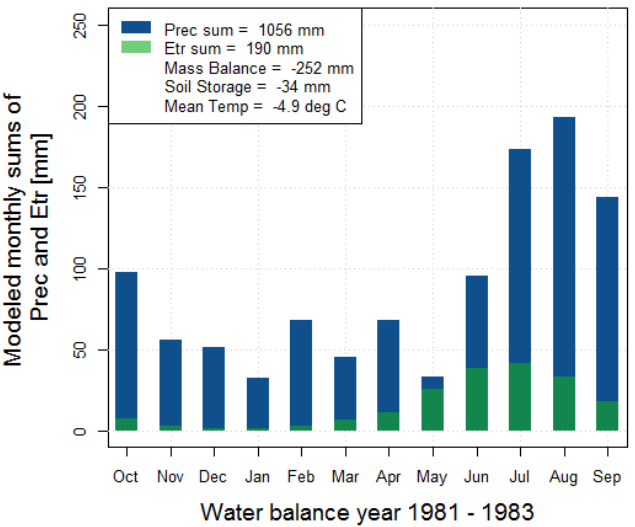


Modeled mean Temperature in the Basin draining into Susitna River near Cantwell

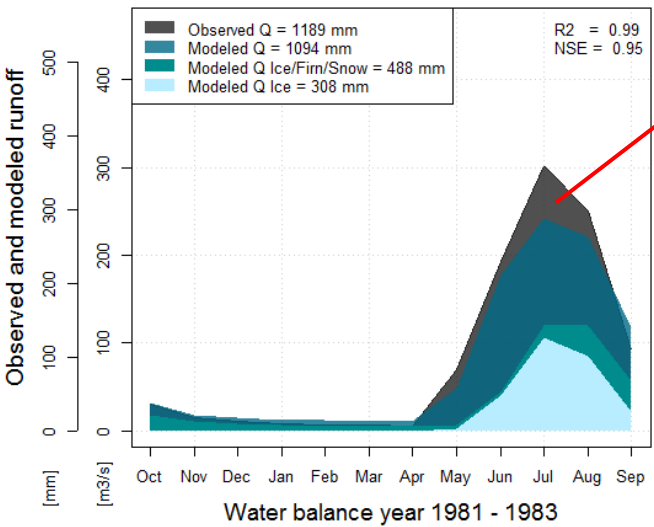


Runoff Calibration – Susitna R. near Denali – 3 yr mean

Precipitation and real Evapotranspiration at Susitna River near Denali, Basin Area 2215 km²

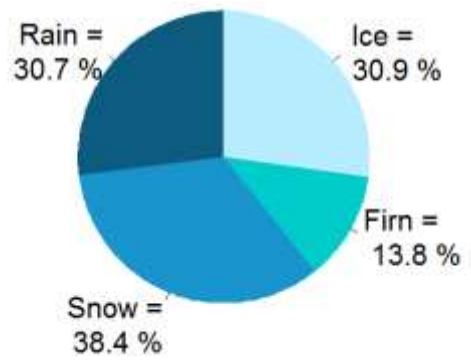


Observed and modeled Runoff at Susitna River near Denali

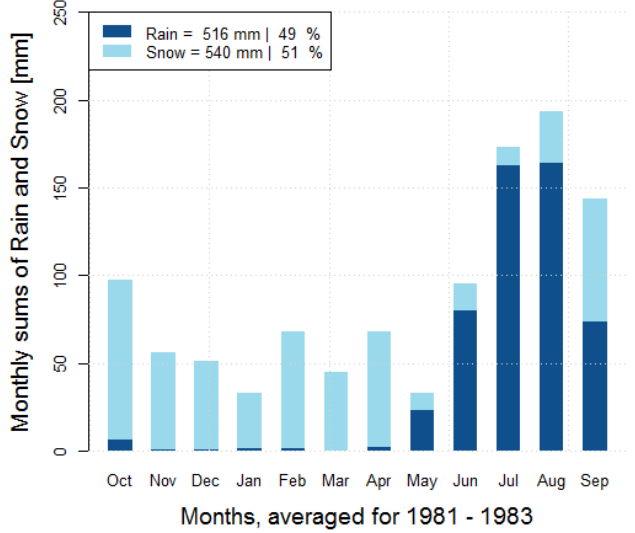


Underestimation of Glacier runoff

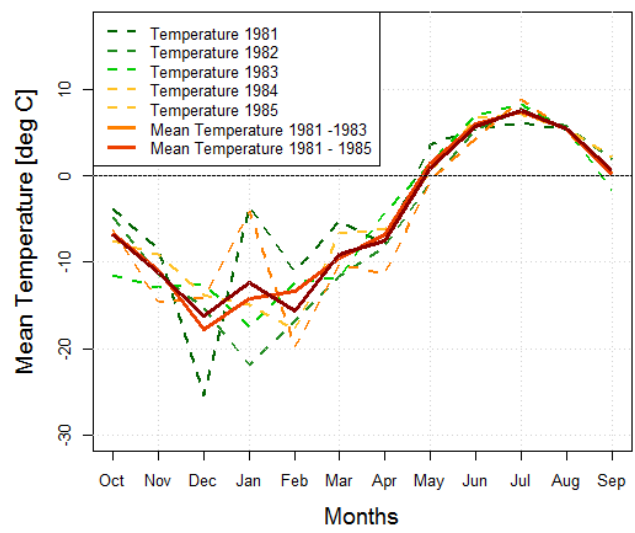
Runoff Contributions at Susitna River at Denali, WB 1981 - 83



Rain and Snow fall in the Basin draining into Susitna River near Denali



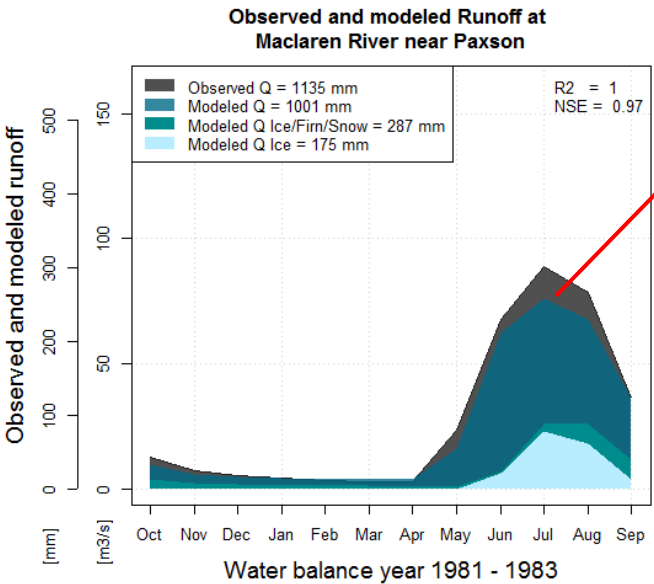
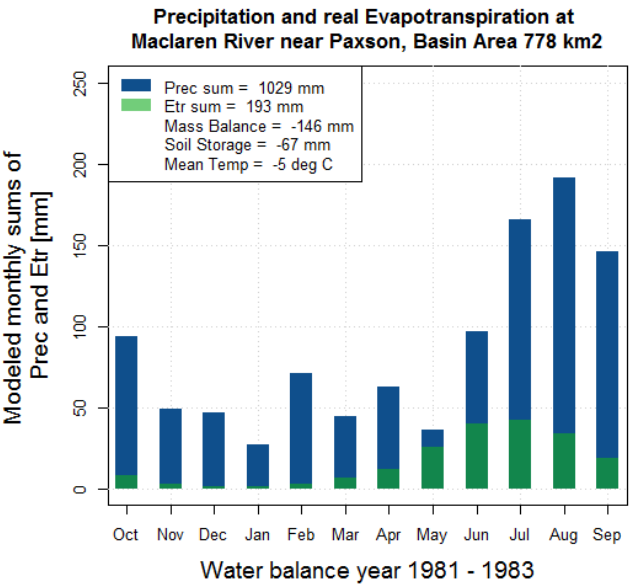
Modeled mean Temperature in the Basin draining into Susitna River near Denali



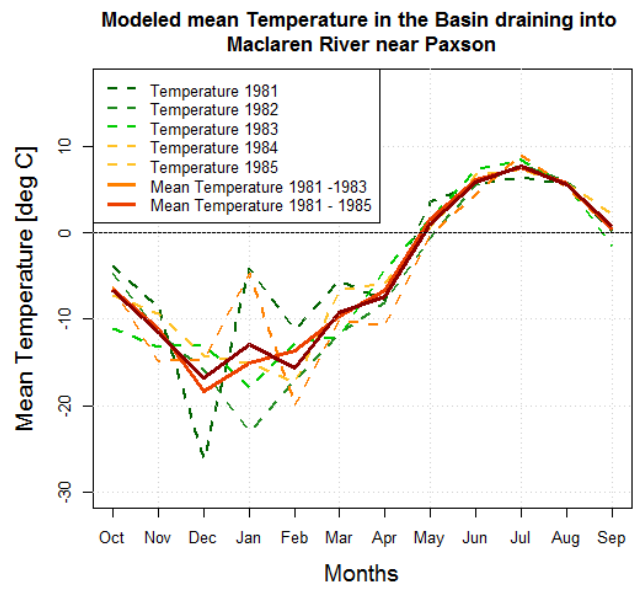
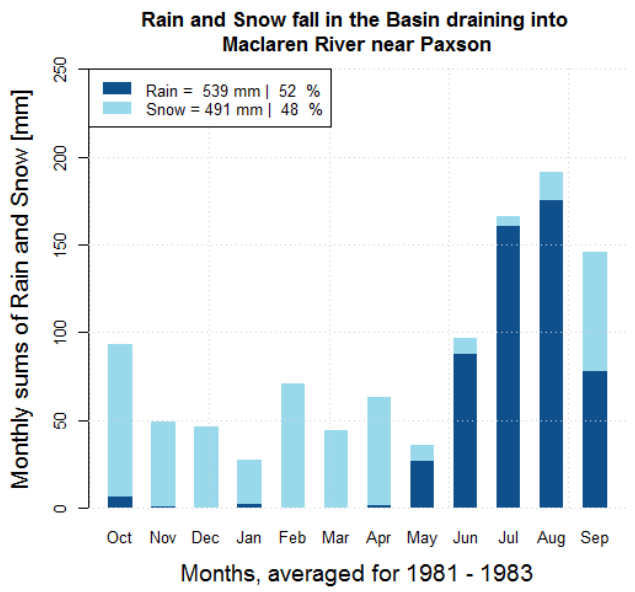
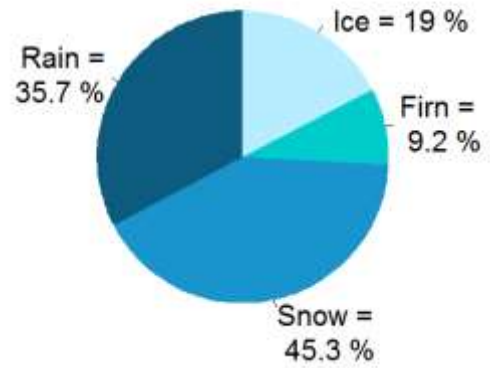
Estimated Glacier runoff contribution Clarke (1986) = 34 %

Runoff Calibration – Maclaren R. near Paxson – 3 yr mean

Underestimation of Precipitation

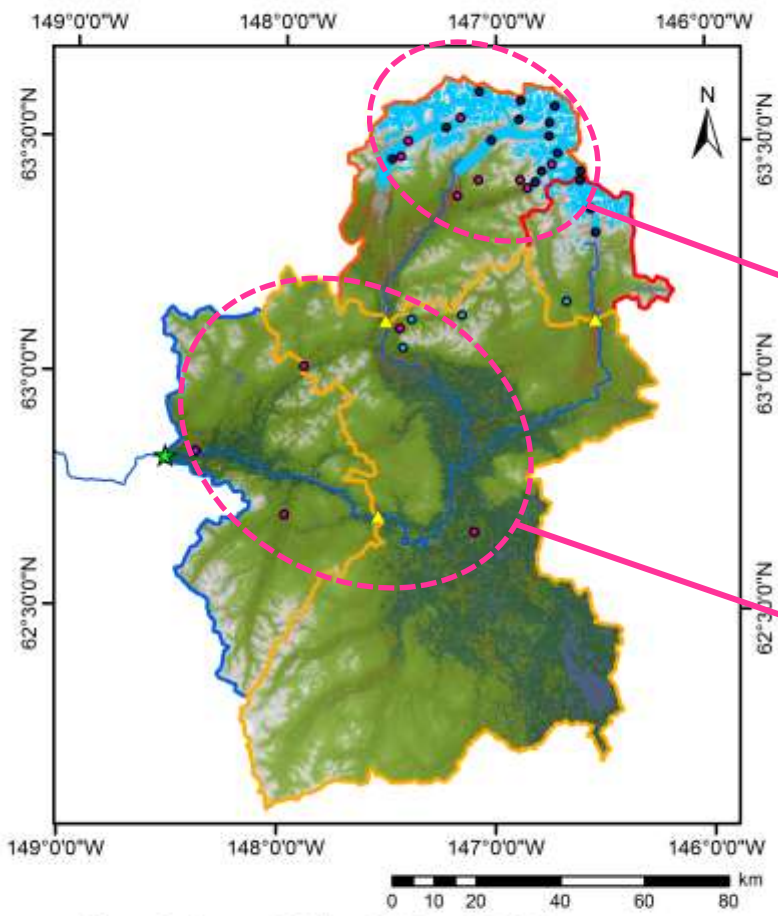


Runoff Contributions at MacLaren River at Paxson, WB 1981 - 83



Estimated Glacier runoff contribution Clarke (1986) = 19 %

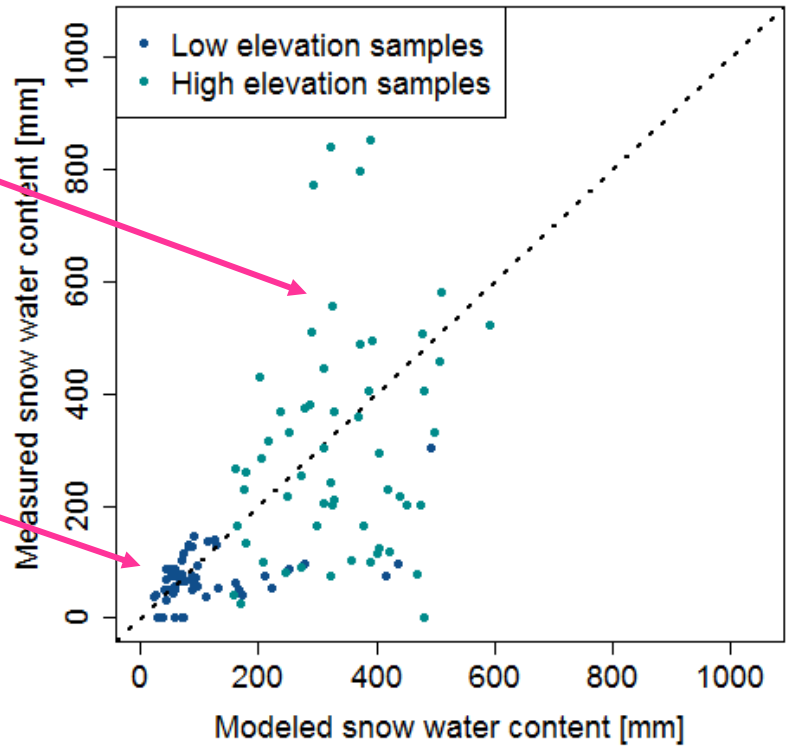
Location of river gauges, snow and mass balance measurements for calibration and validation



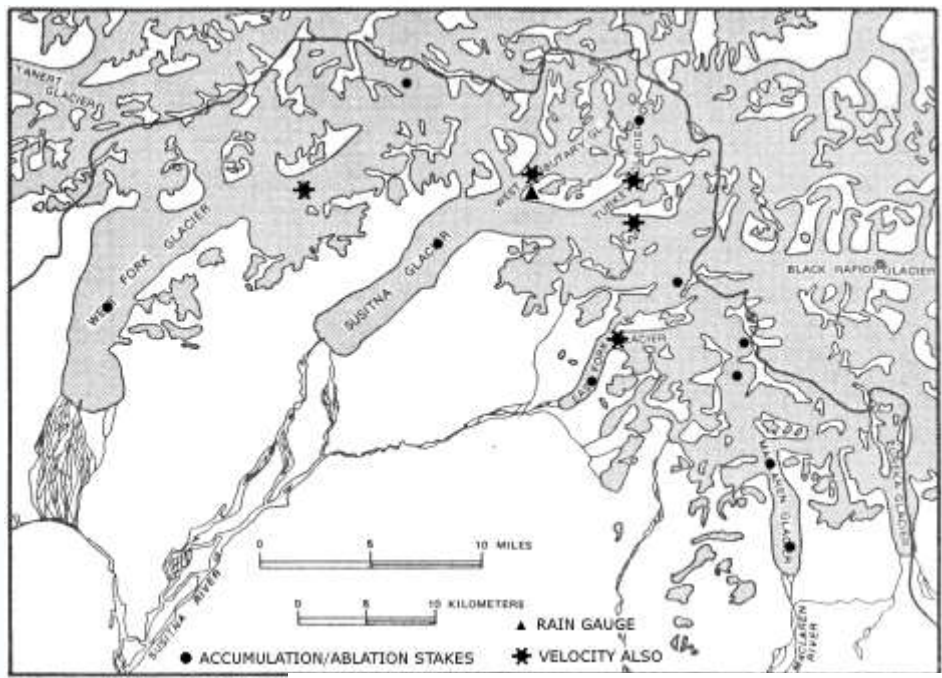
- Mass Balance 1981 - 1983 and 2012
- Snow probings 1981 - 1982
- Snow probings 2012
- ▲ USGS NWS River Discharge 1981 - 1983

Measured vs Modeled Snow Depths

R2 = 0.32 | NSE = 0.23 | RMSE = 166.92

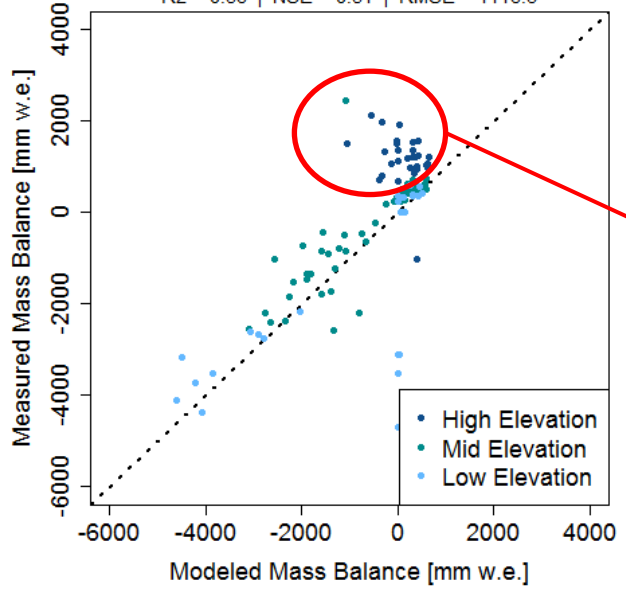


Mass Balance Calibration



Modeled vs Measured Mass Balance

$R^2 = 0.56$ | $NSE = 0.51$ | $RMSE = 1116.3$

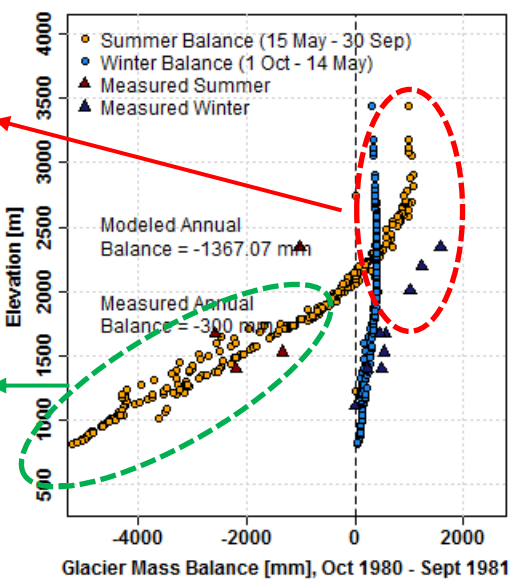


Under-estimation of Mass Balance
 → Too little accumulation in high Elevations

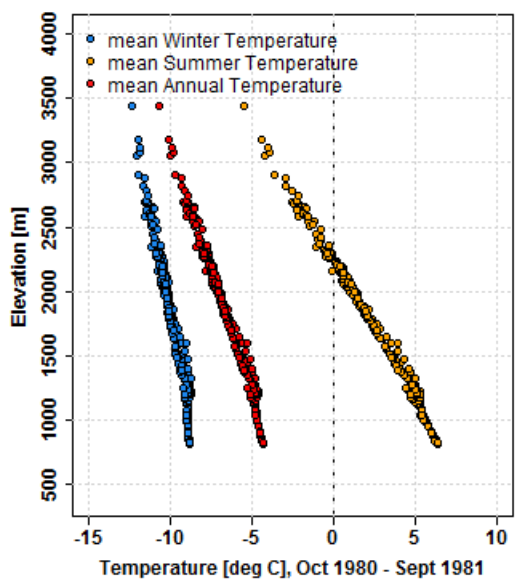
Winter accumulation
 → Underestimated above 1700 m

Summer ablation
 → good

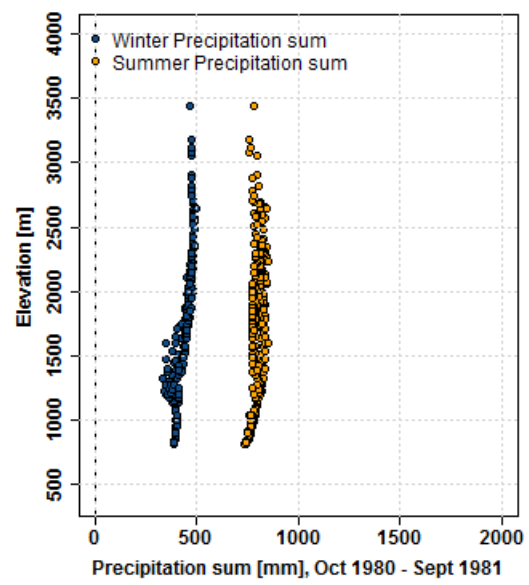
Mass Balance Susitna Glacier WB 1981



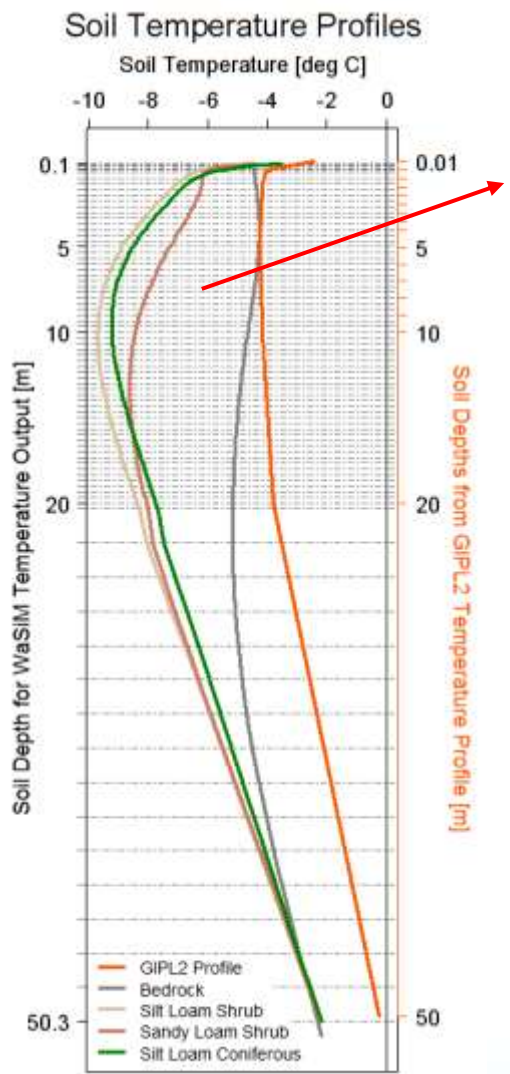
Temperature Susitna Glacier WB 1981



Precipitation Susitna Glacier WB 1981



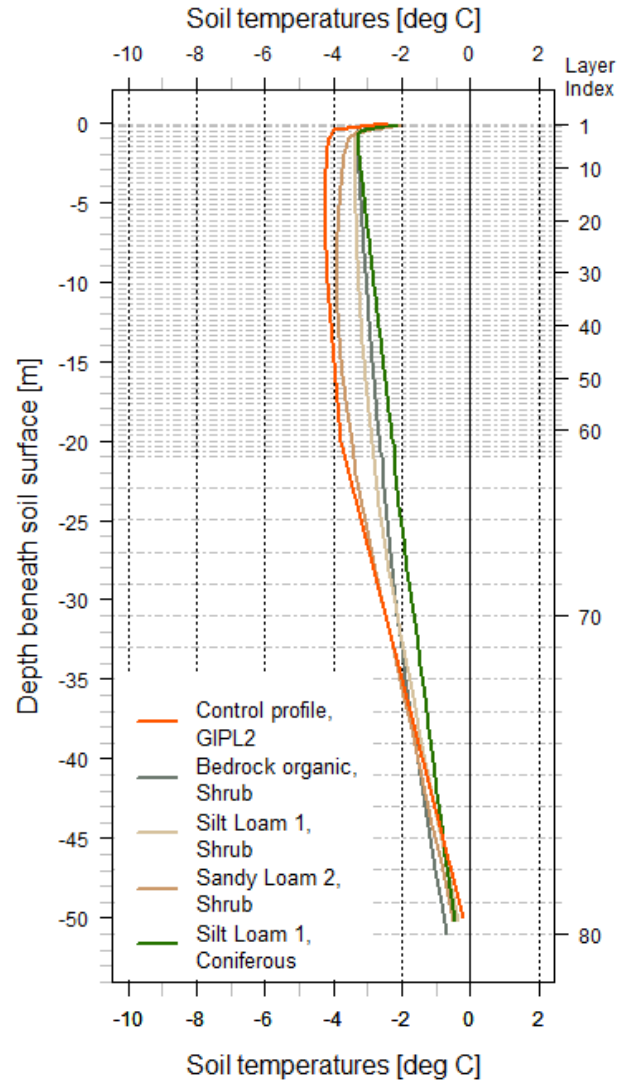
Initial Soil temperature Profiles



Too cold



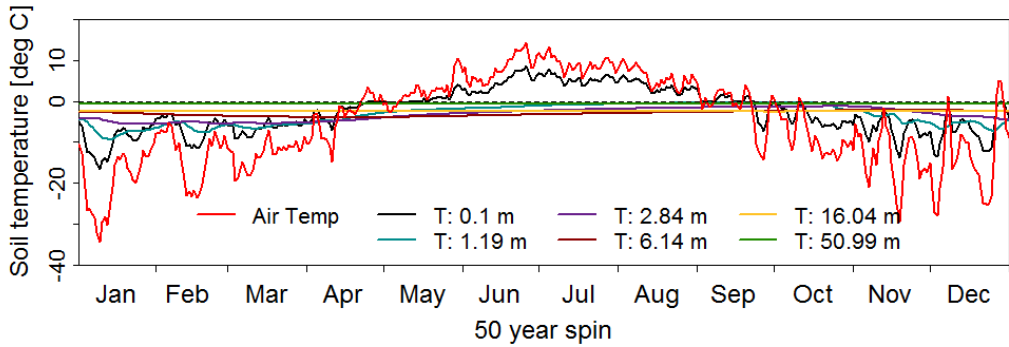
Soil temperature Profiles after Calibration



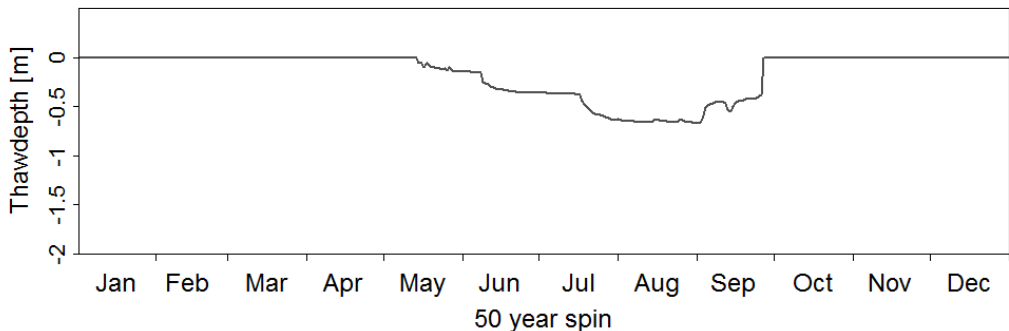
Soil Temperature Calibration

Active Layer in past Climate

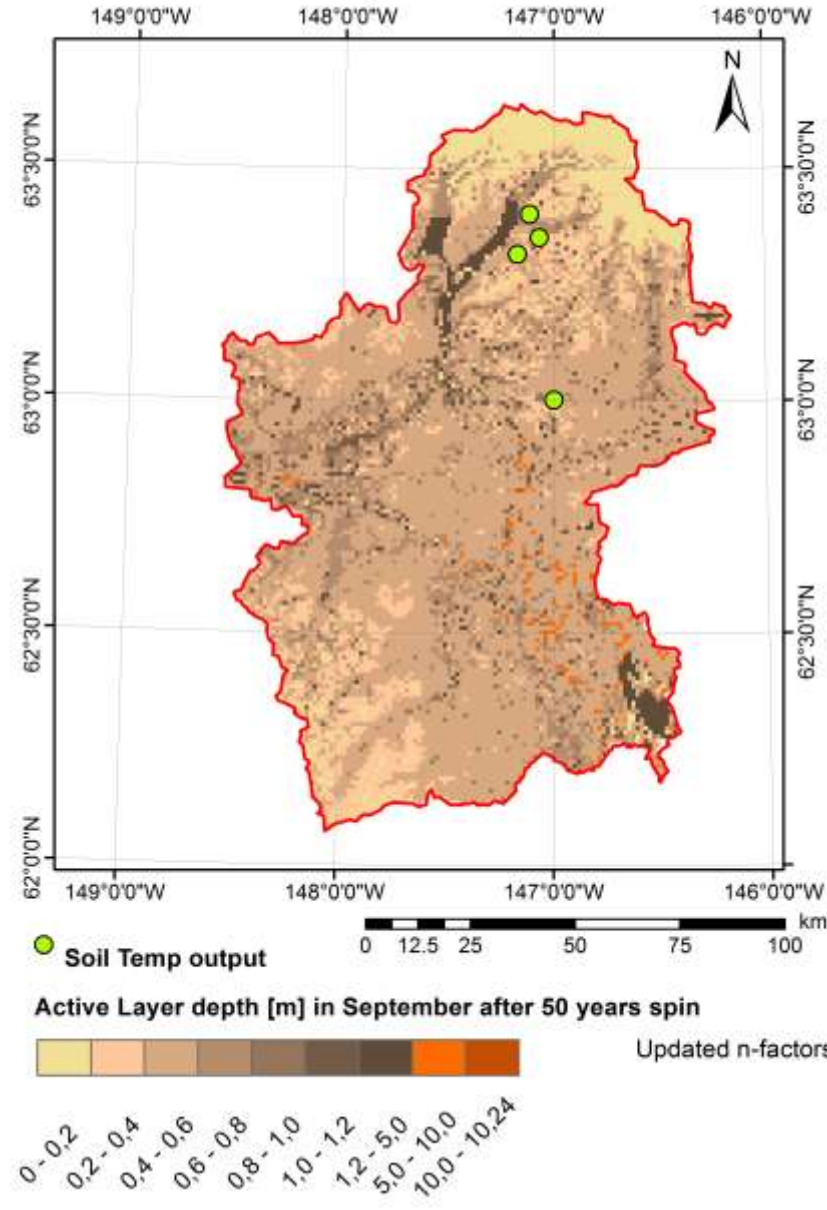
Soil Temperature at different depths on Bedrock organic, Shrub



Thaw depth on Bedrock organic, Shrub



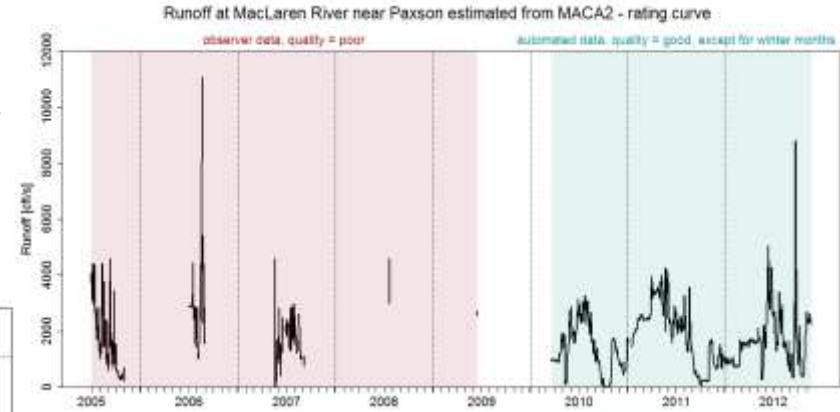
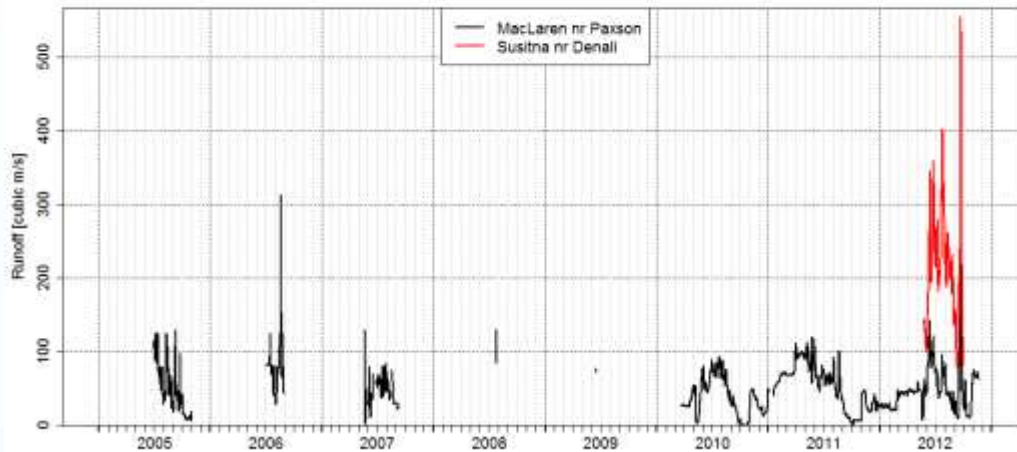
Active layer depths in September in the Upper Susitna Basin, modeled with WaSiM



Runoff Validation

- MacLaren River near Paxson →
- Susitna River near Denali

Runoff at MacLaren River near Paxson and Susitna River near Denali



Snow Validation

- Winter snow accumulation - April 2012

Mass Balance Validation

- Summer Mass Balance Data: April/May through Sept 2012

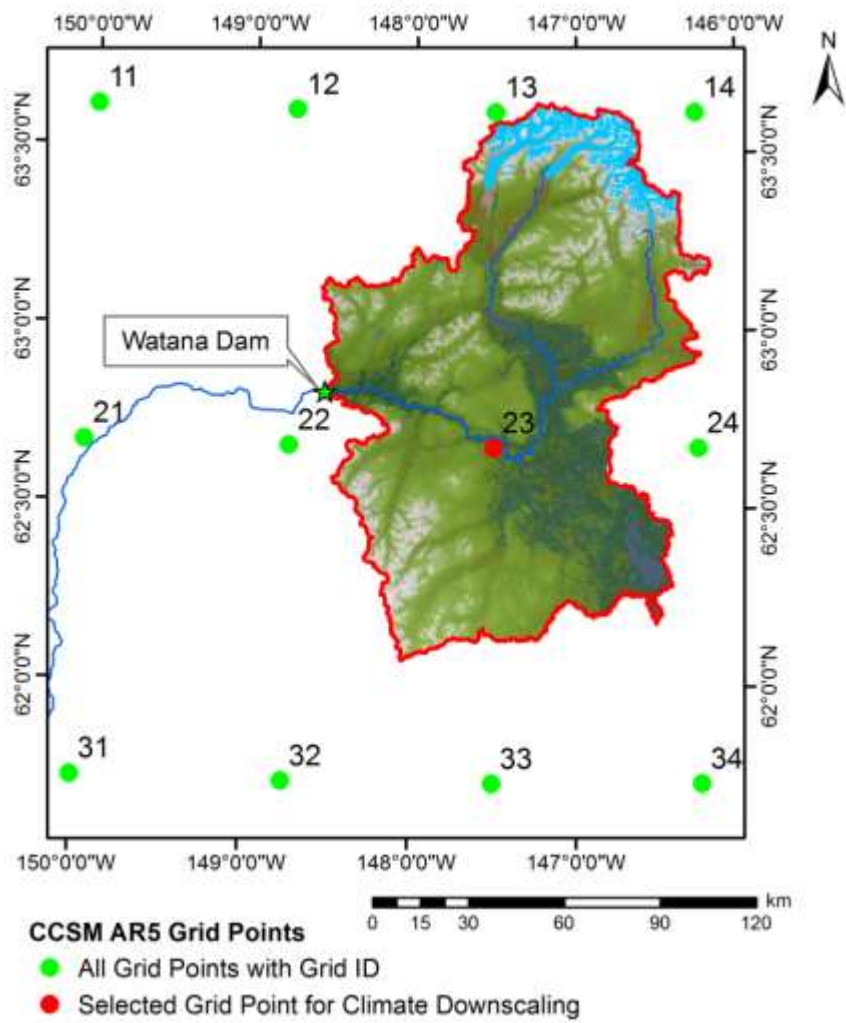
Future Projections

Combination of daily CCSM AR5 Data (daily)

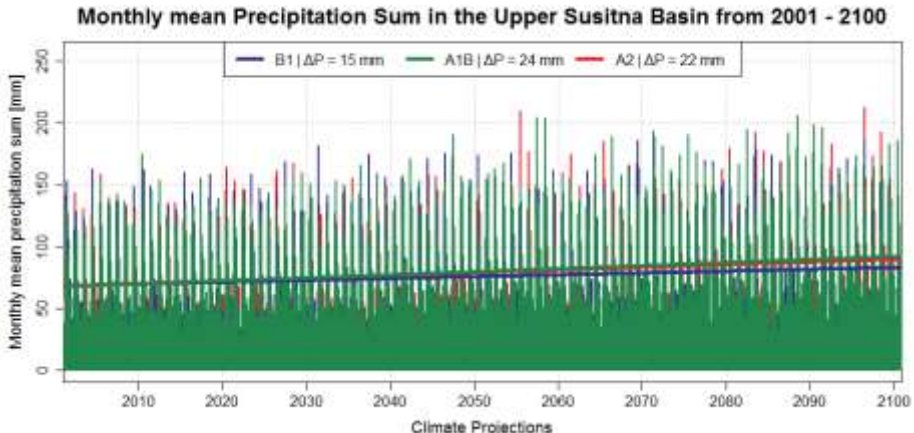
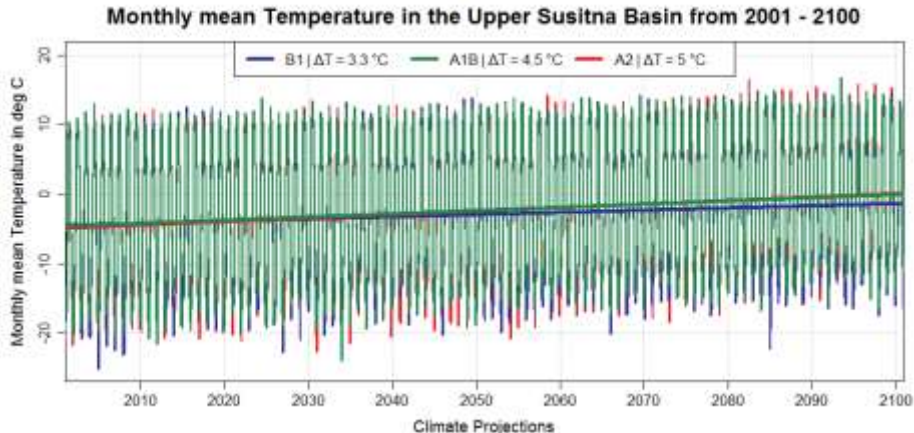


Spatially distributed SNAP Projections (monthly)

CCSM-AR5 Grid Points - Daily Climate Projections for Temperature and Precipitation from 2005 to 2100

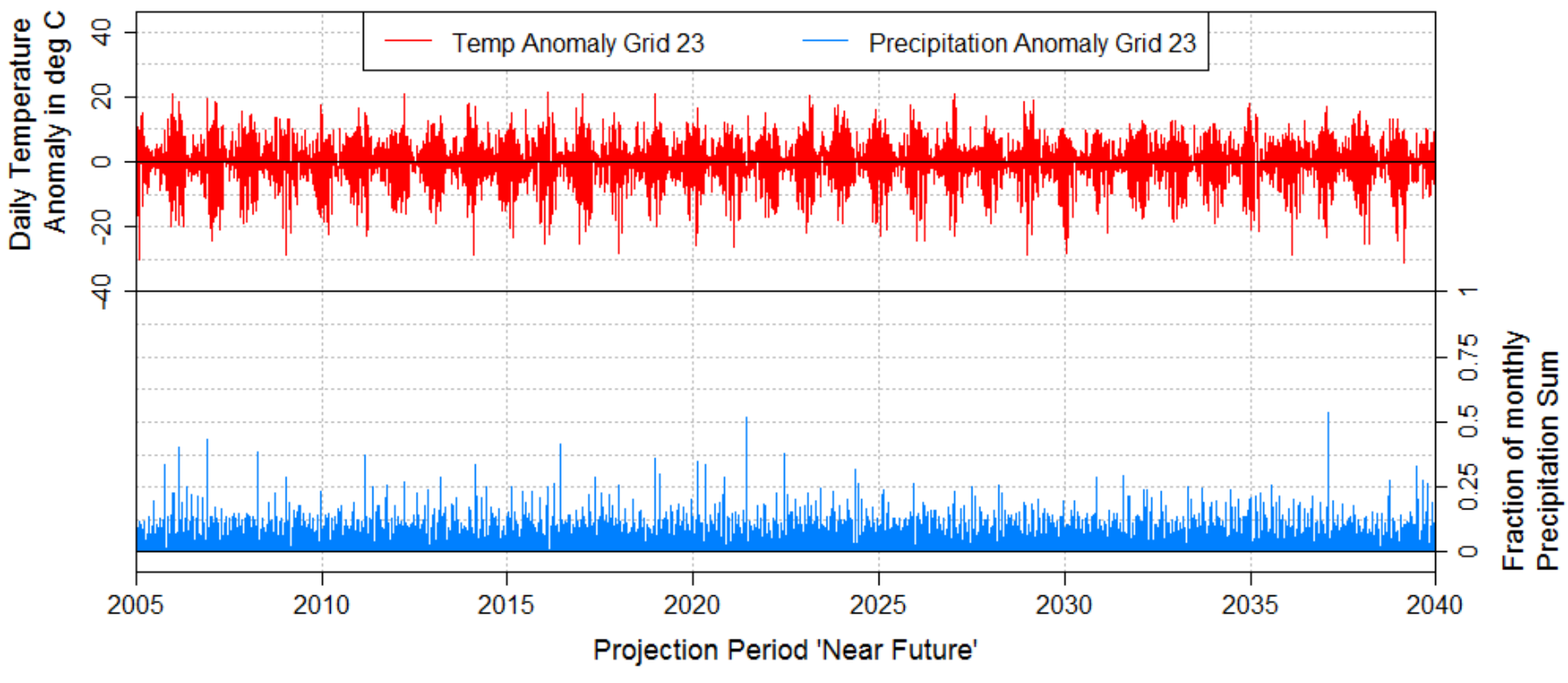


5-model mean for Scenarios:
A1B, **B1** and **A2**



CCSM AR5 Data → Extract anomalies for Temperature and Precipitation

Daily Temperature and Precipitation Anomalies for CCSM AR5 Grid Point 23 for 2005 - 2039



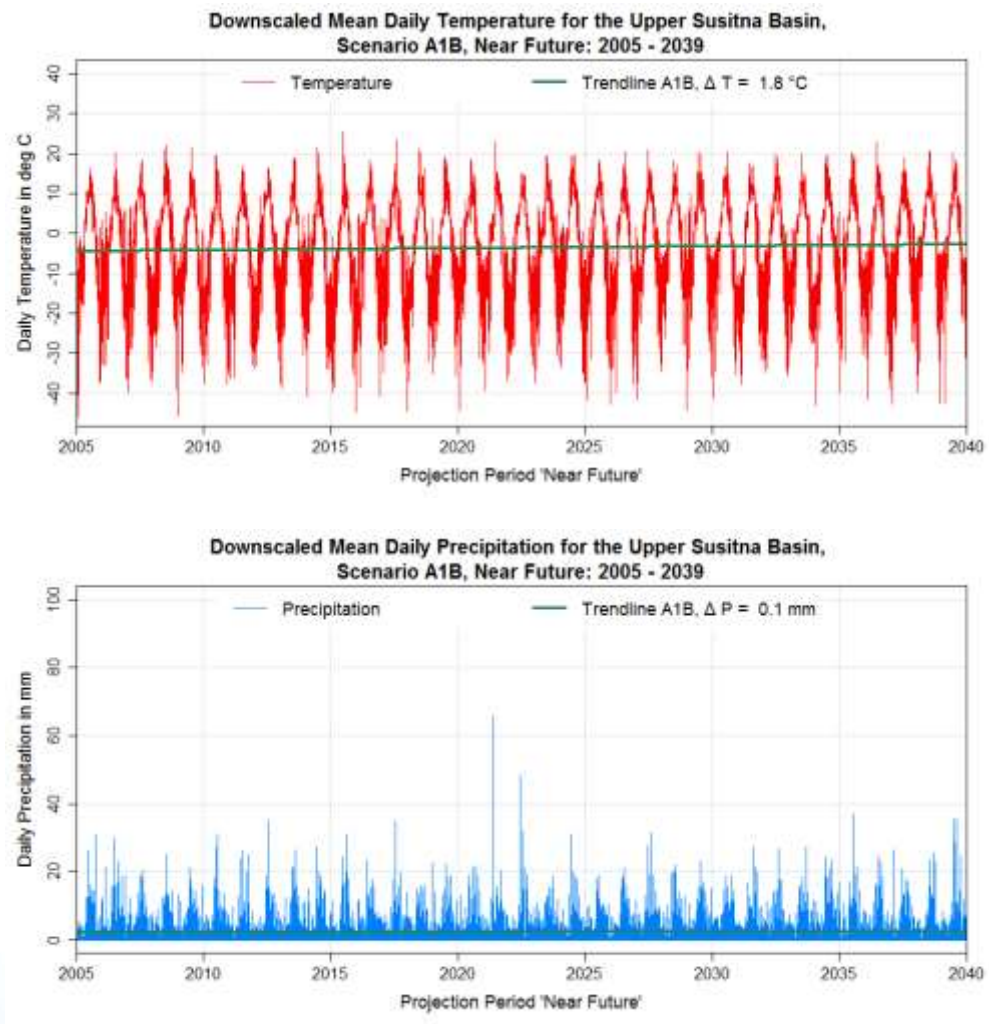
Future Projections – Near, Mid and Far

Superimpose anomalies to gridded monthly SNAP Data → 4187 “virtual” climate Stations

1. Period

NEAR FUTURE

2010 - 2039



SCENARIO A1B

Means for the whole Upper Susitna Basin