SUSITNA-WATANA
HYDROELECTRIC PROJECT

Glacier & Runoff Changes Study, 2012 Review

TWG Meeting
March 28, 2013

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Objective

- Provide projections of river runoff into the proposed dam from 1960's to 2100

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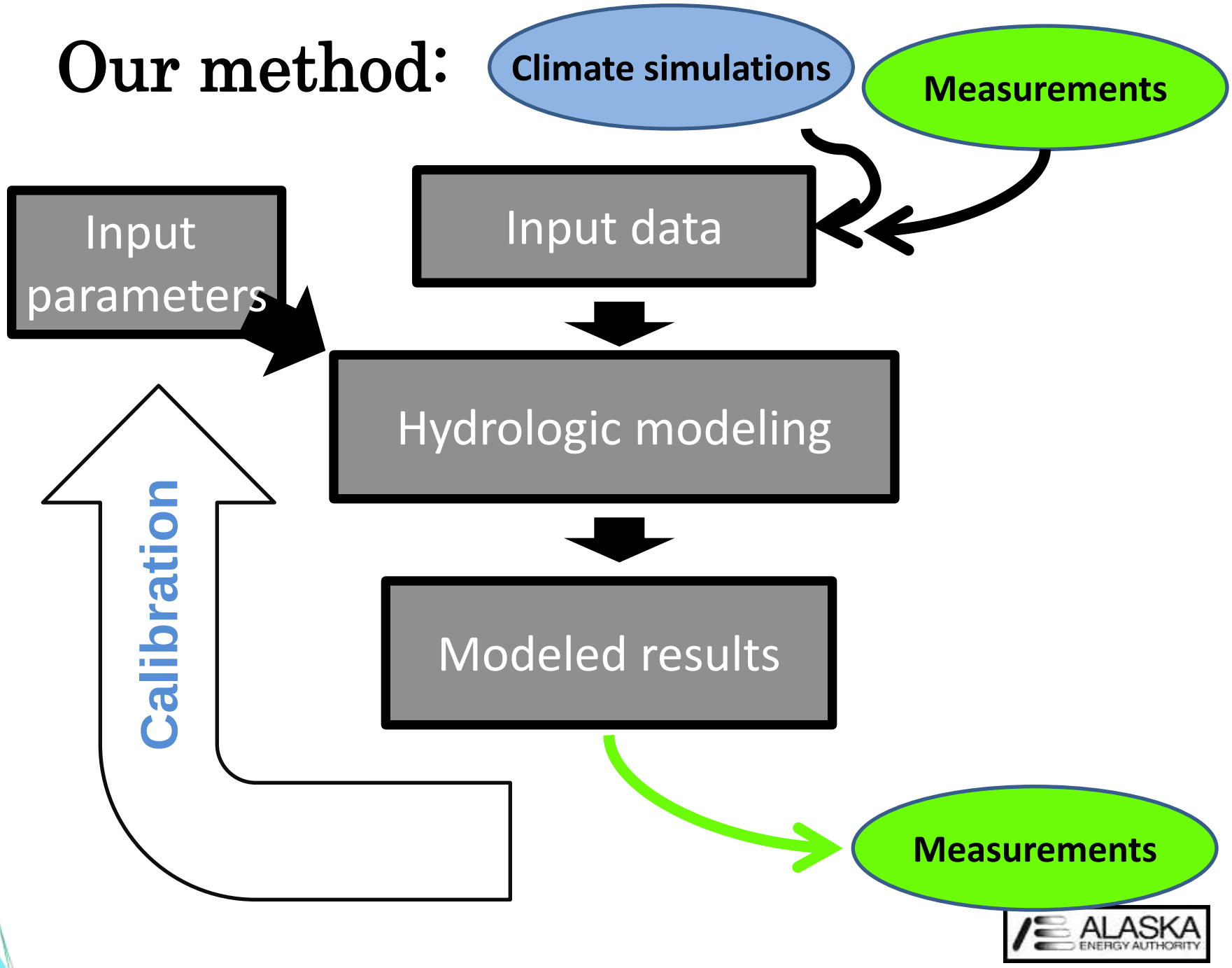
Our method:


Climate simulations
Measurements
Input data
Input parameters
Hydrologic modeling
Modeled results
Calibration
Measurements
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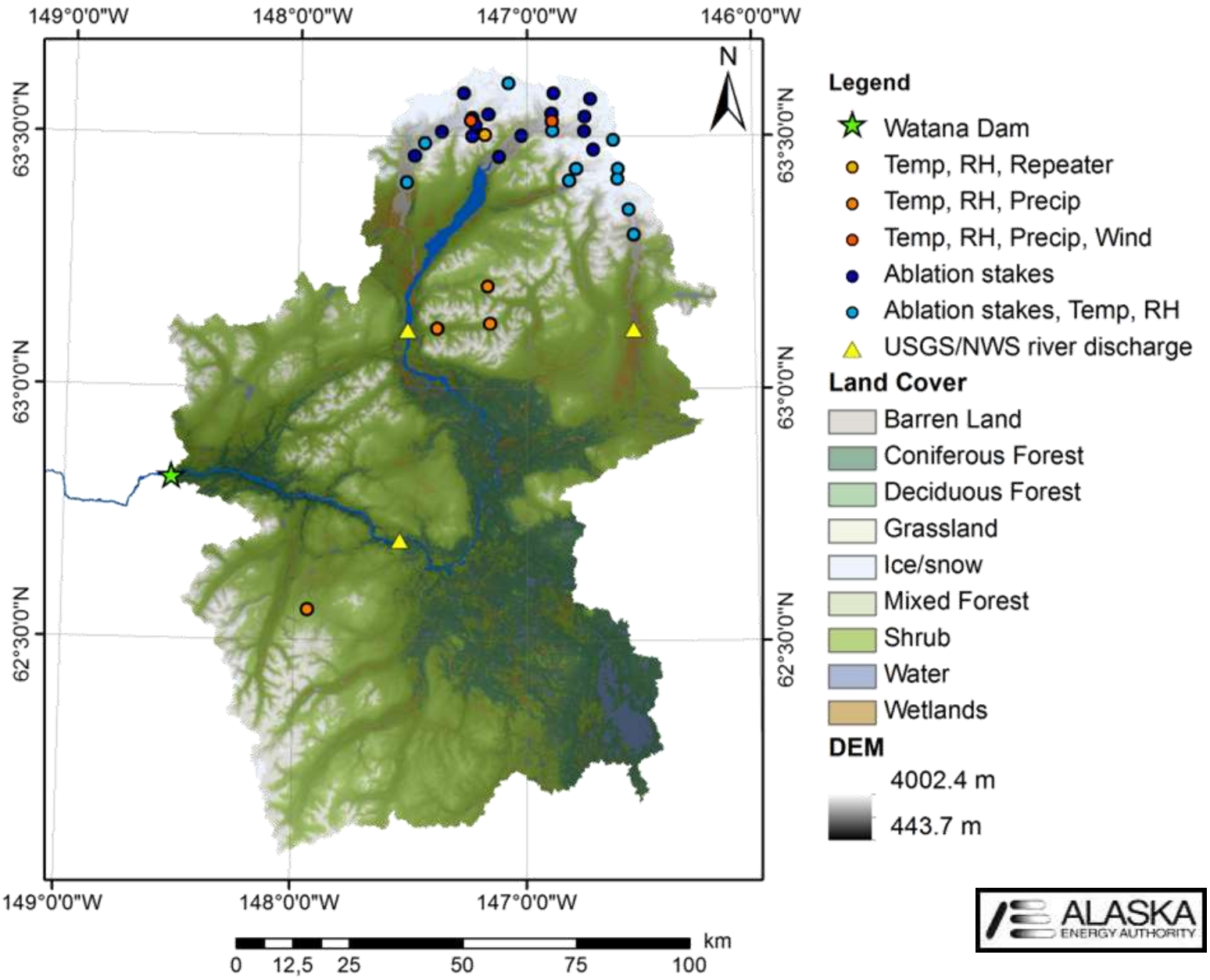
2012 Field Measurements



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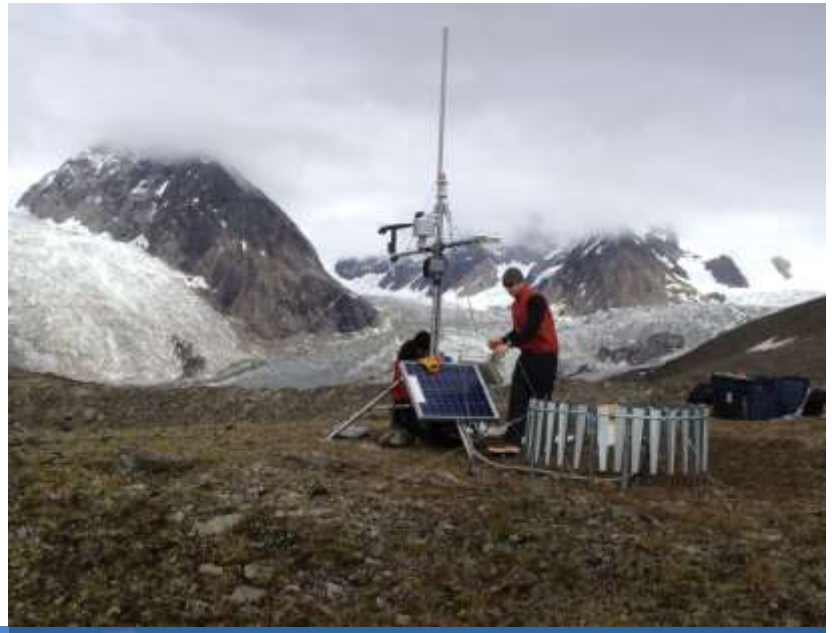
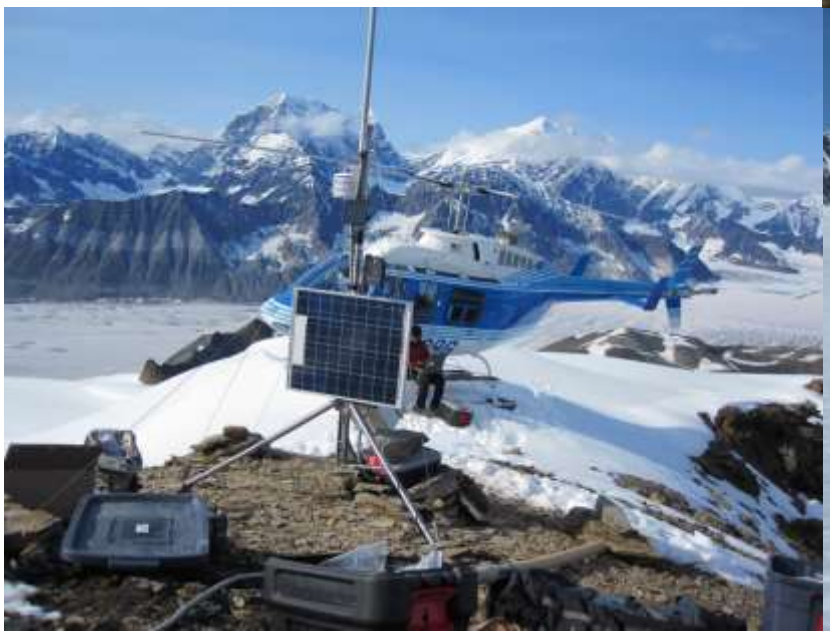
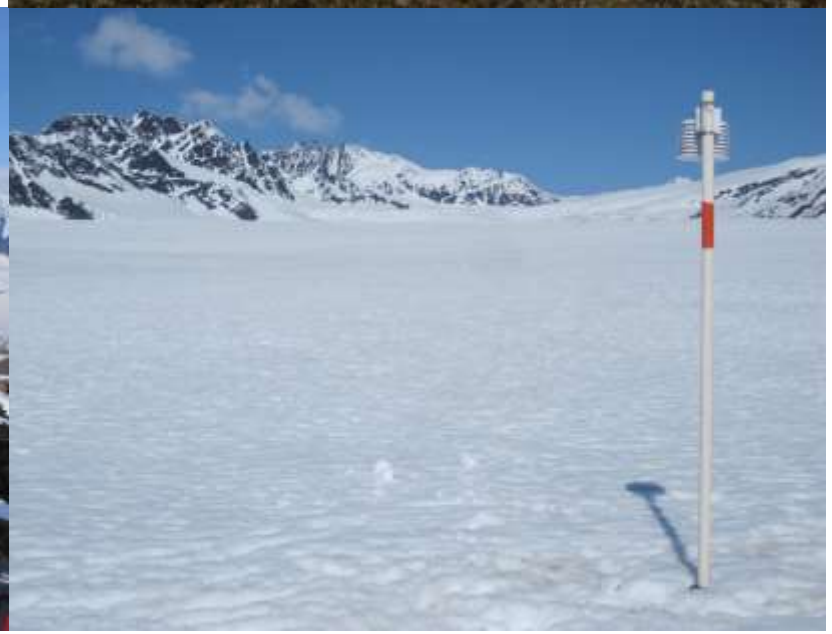
Glacierized







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Non-glacierized

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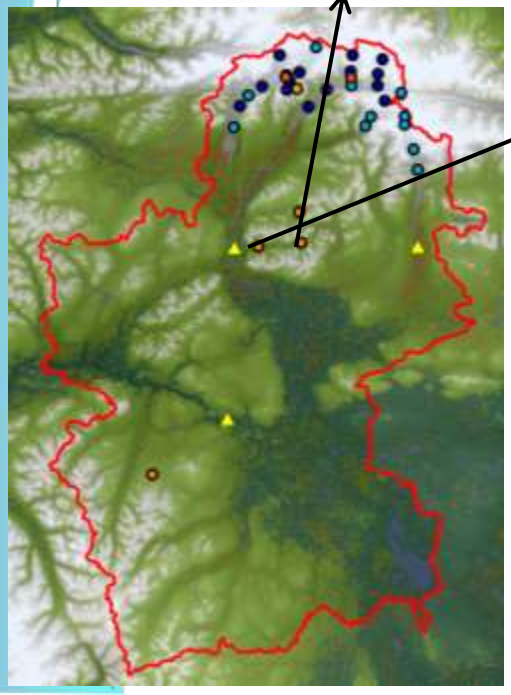
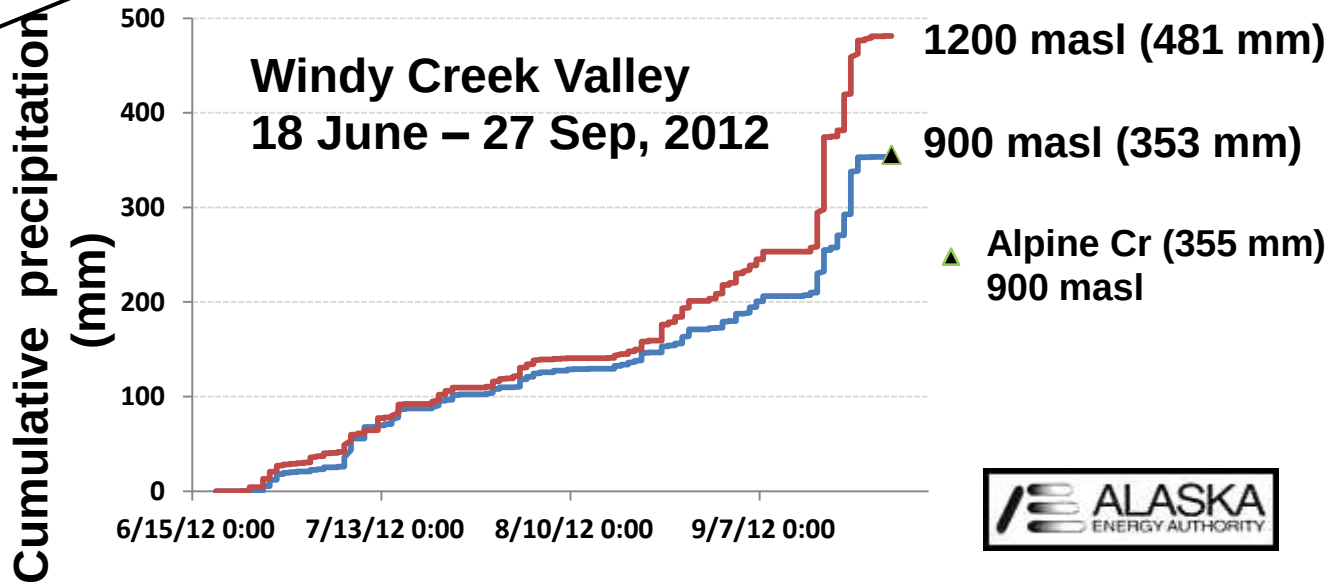
Elevation gradient in summer precipitation





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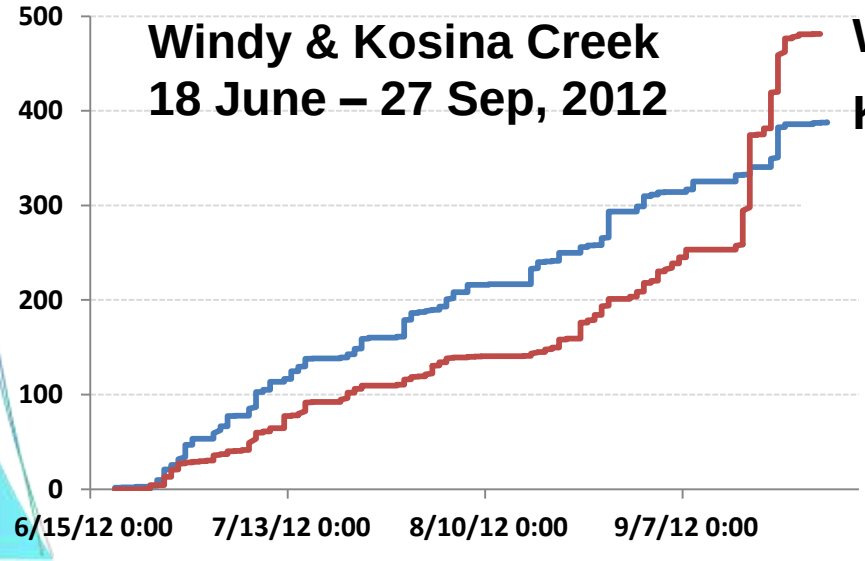
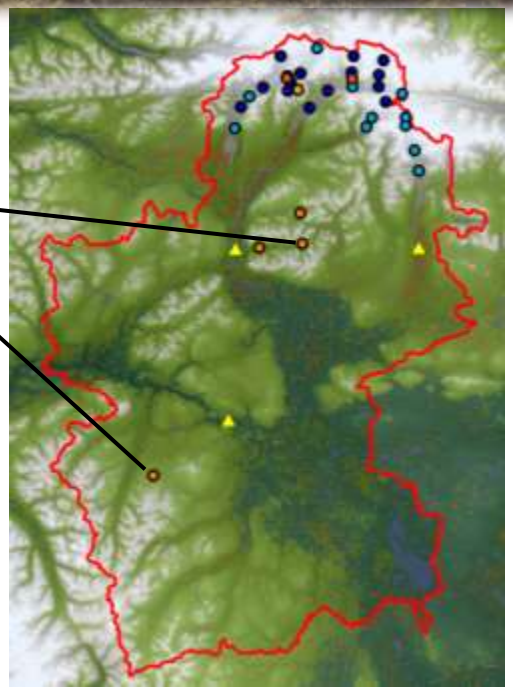
Spatial Variability in summer precipitation



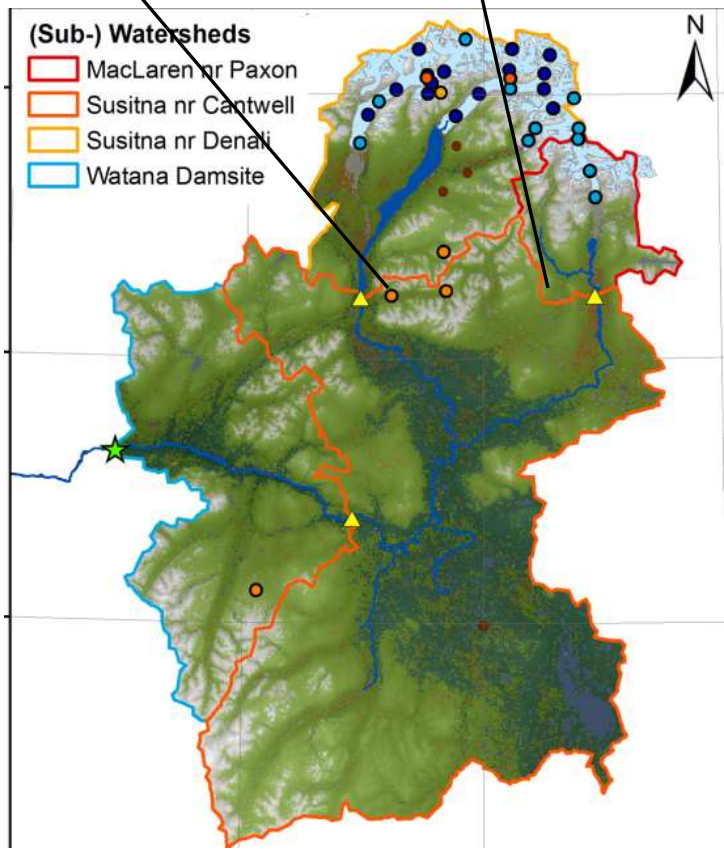


Winter accumulated snow water equivalent

SWE on April 4, 2012:

202 mm

371mm



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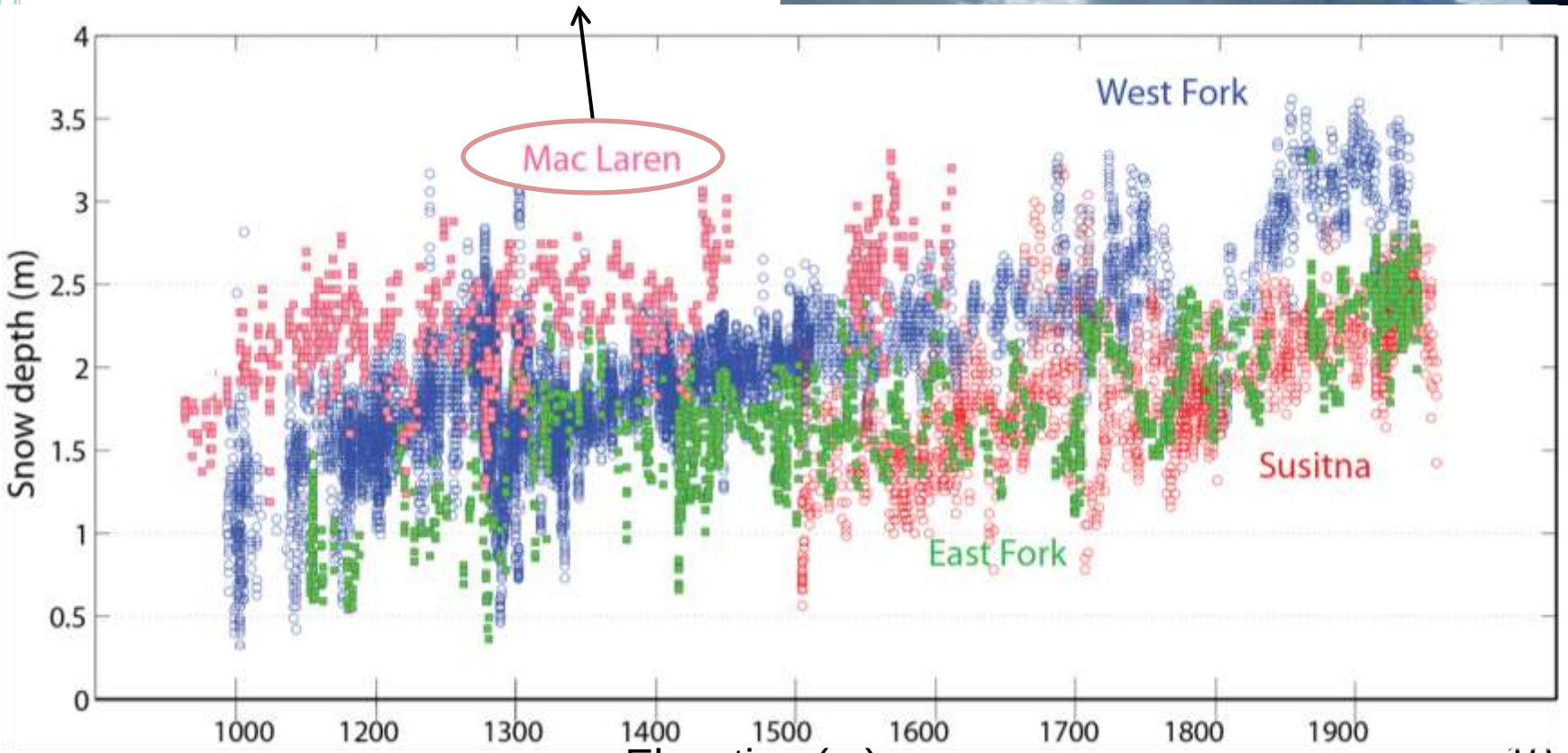
Variability in winter snow accumulation on glaciers



WaSiM
Water balance Simulation Model

1) ***3D groundwater*** confined & unconfined, overland flow.
2) ***1D soil heat transfer module*** with conduction, advection and phase change (Daanen and Nieber, 2009).
3) ***Penman-Monteith multi-layered vegetation parameterization scheme*** coupled to ***Richard's equation.*** Moss evaporation from the top soil layer.
4) ***Dynamic glacier module,*** glacier can shrink/grow, incl. debris cover.
5) ***Parallel programmed*** (OpenMP, experimental MPI version).

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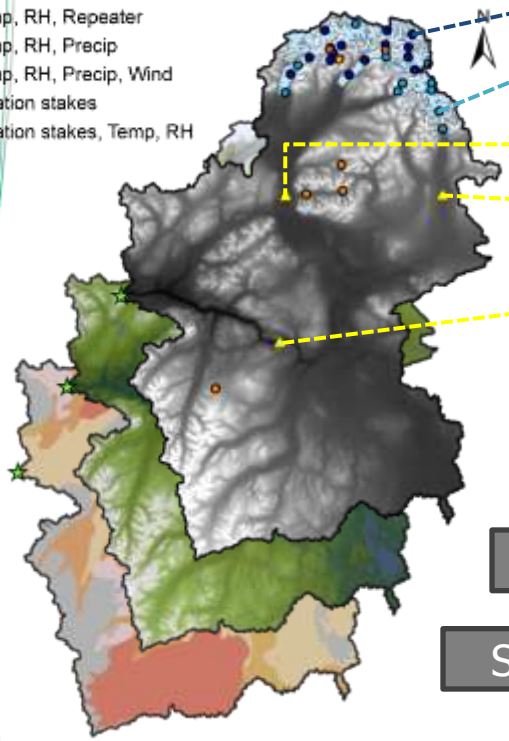
Modeling Approach

Model Input

Meteorological data

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



Glacier extent

Land cover

Soil texture

Calibration and Validation

Mass balance data for 1981, 1982, 1983 2012	Glacier Mass balance
Susitna near Denali MacLaren near Paxson Susitna near Cantwell	Runoff data
Snow depth Snow radar on glaciers	Snow depth
Modeled soil temperature profiles from Permafrost Lab (1960, 1980)	Soil temperature

Future Projections

Until 2100

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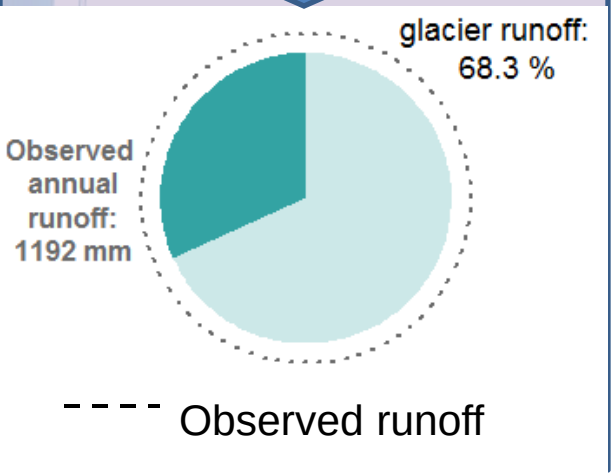
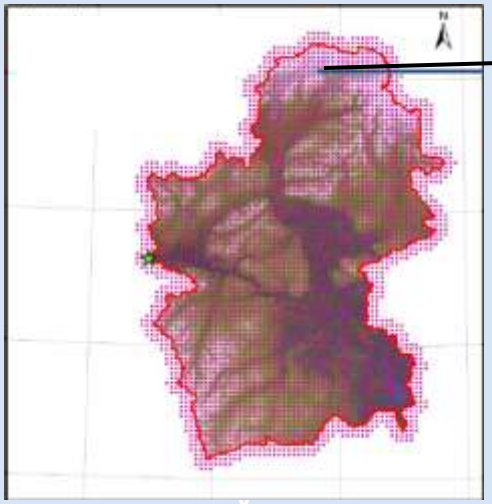
Climate forcing – key information

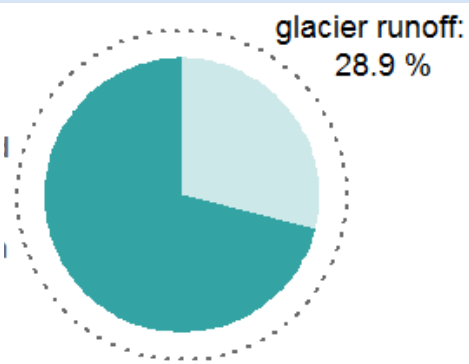
Field measurements



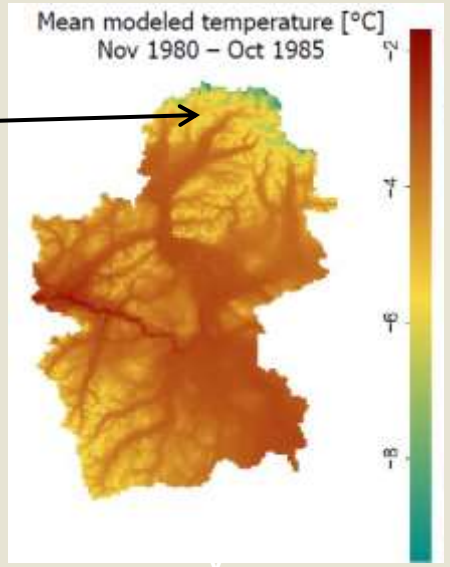
Climate projections

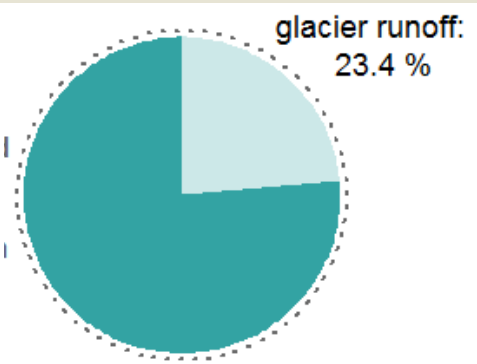
2km resolution





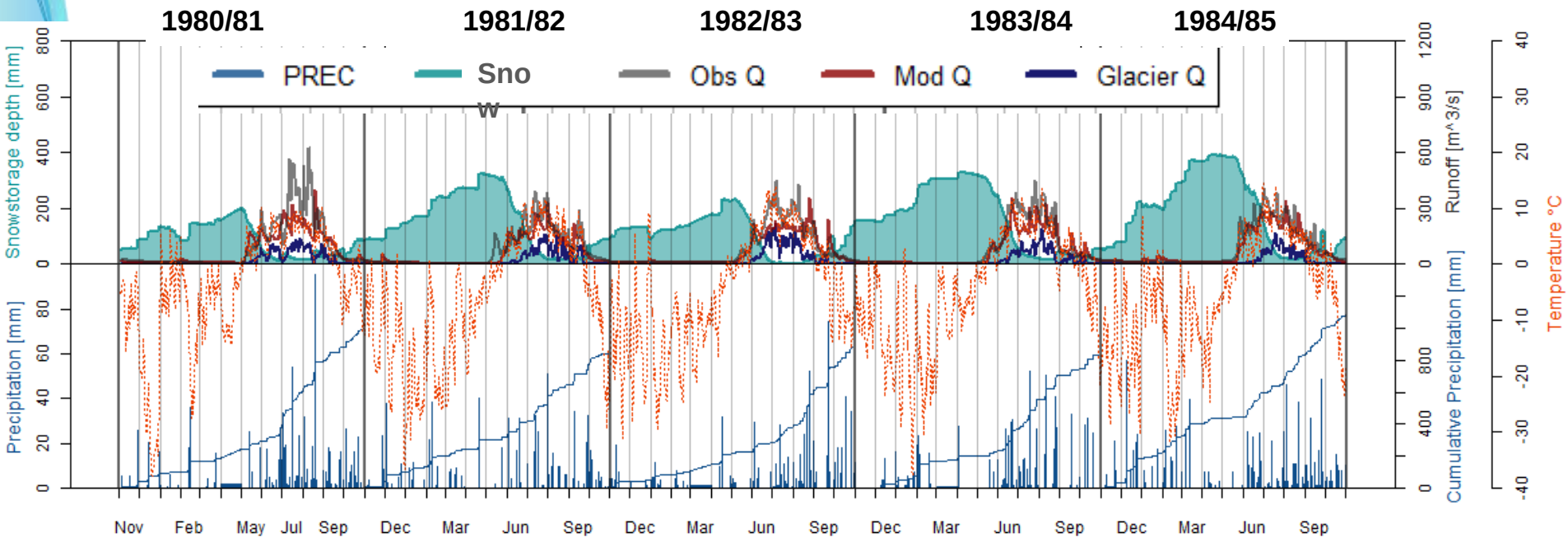
Combination





Preliminary results: Calibration phase

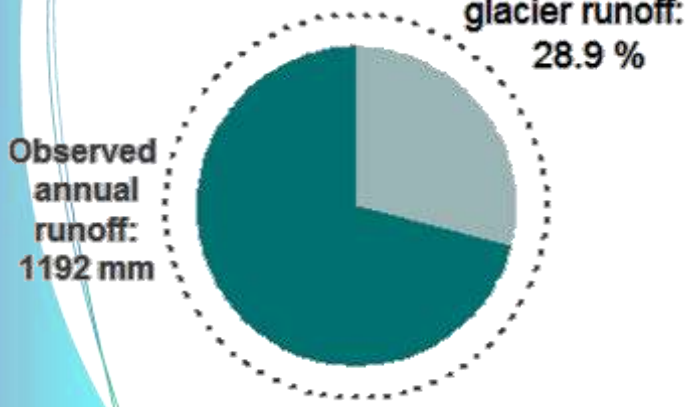
Susitna River near Denali

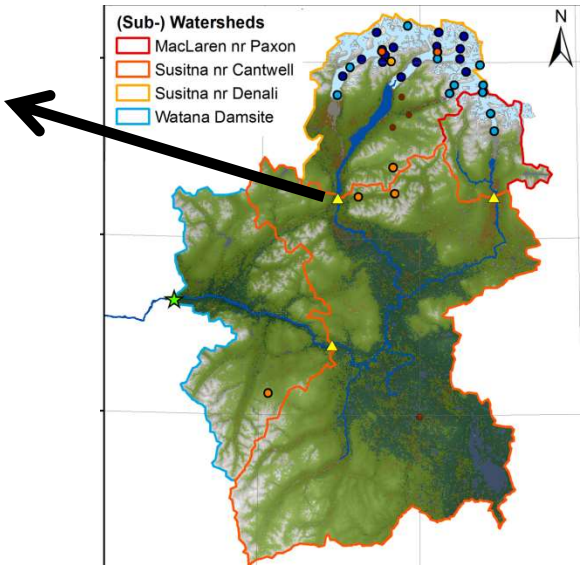


COD Q = 0.79 NSE Q = 0.76

Modeled mean annual runoff = 993 mm

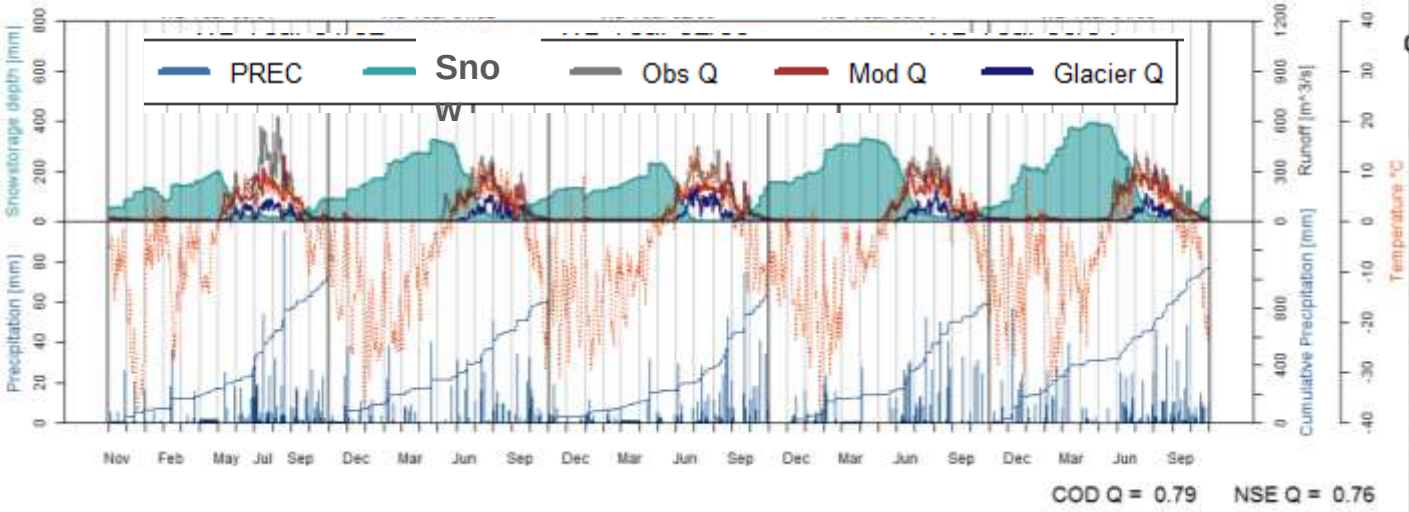
Modeled mean annual glacier runoff = 287 mm





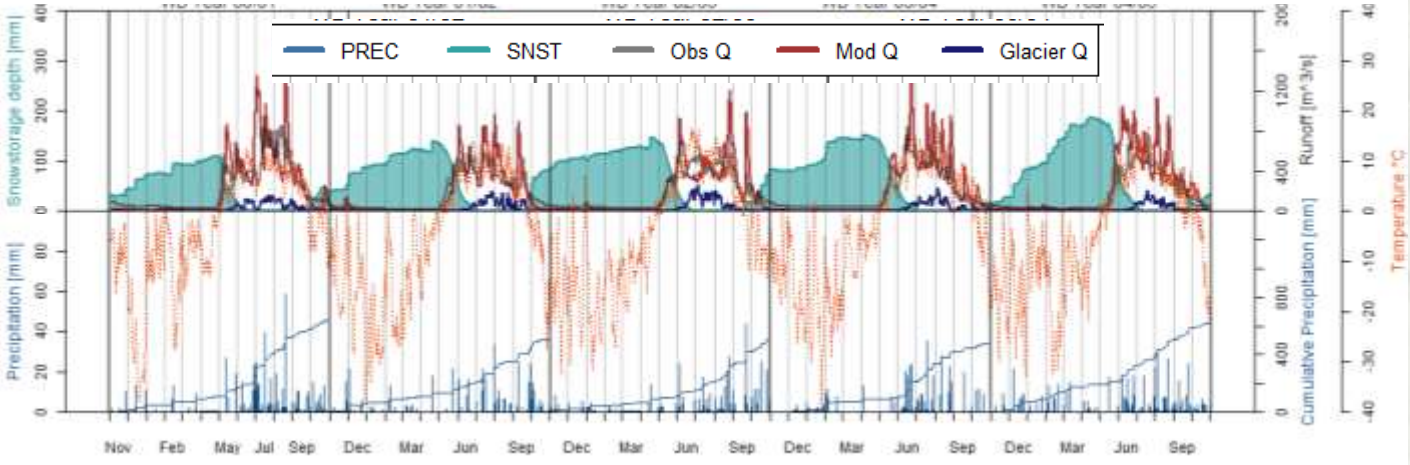
Preliminary results (calibration phase): Glacier melt 10-30% of total runoff

Susitna River near Denali



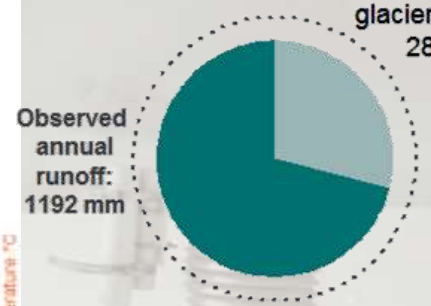
COD Q = 0.79 NSE Q = 0.76

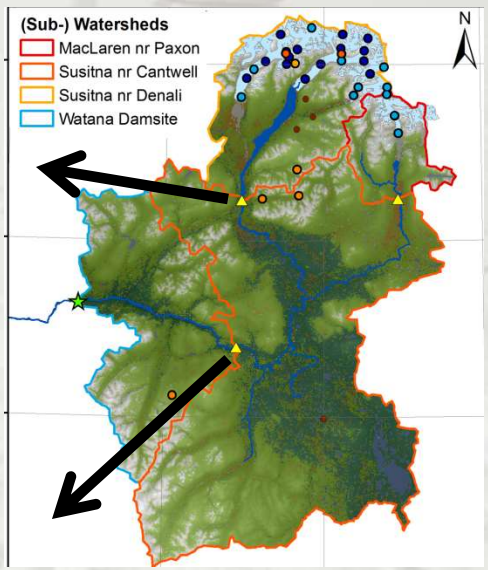
Susitna River near Cantwell



COD Q = 0.72 NSE Q = 0.43

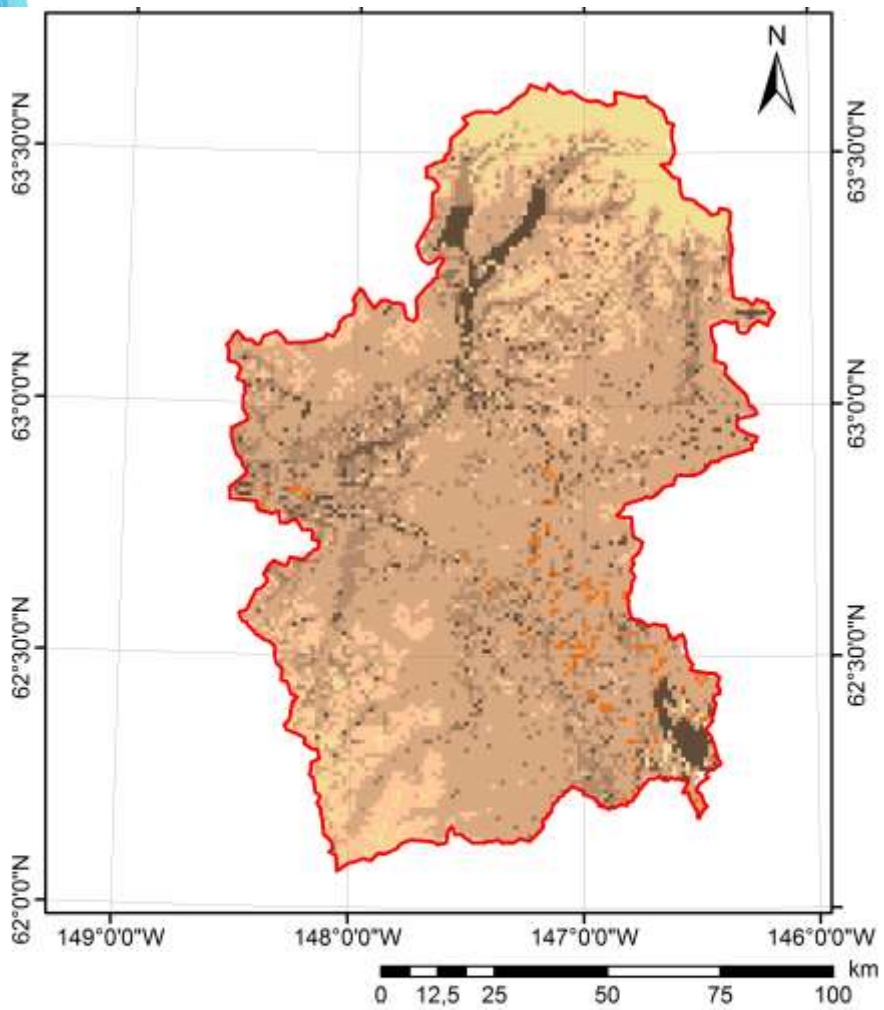
Modeled mean annual runoff = 993 mm
Modeled mean annual glacier runoff = 287 mm





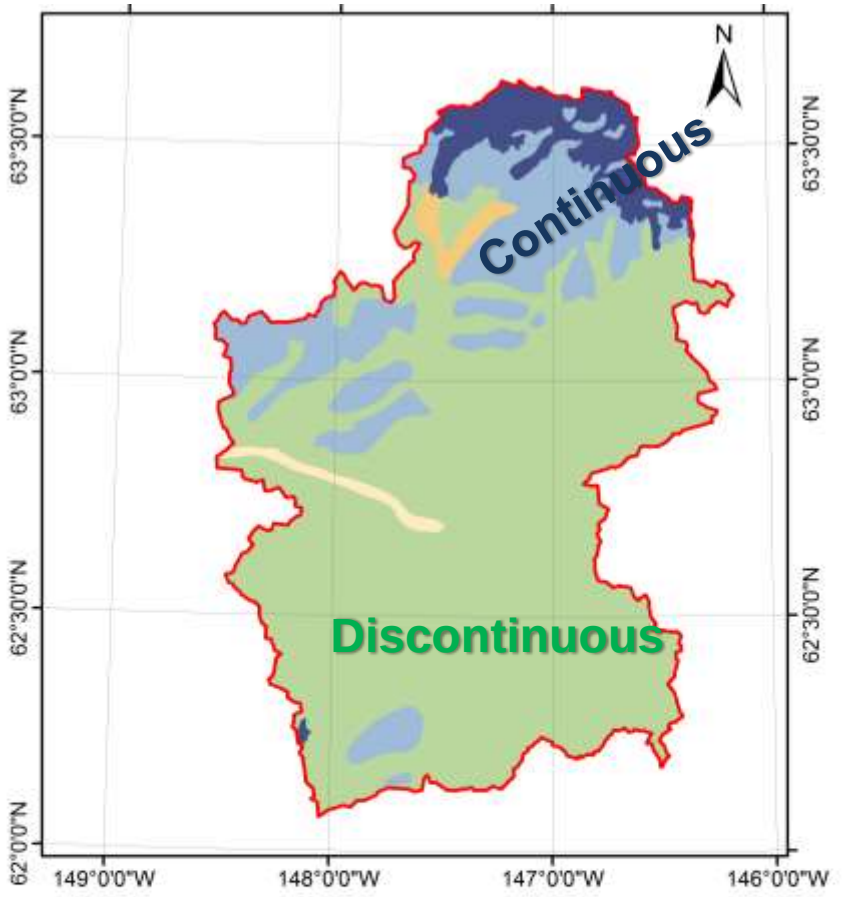
Modeled mean annual runoff = 609 mm
Modeled mean annual glacier runoff = 70 mm

Permafrost



Top of the permafrost, m

0 - 0,2
0,2 - 0,4
0,4 - 0,6
0,6 - 0,8
0,8 - 1,0
1,0 - 1,2
1,2 - 5,0
5,0 - 10,0
10,0 - 10,24



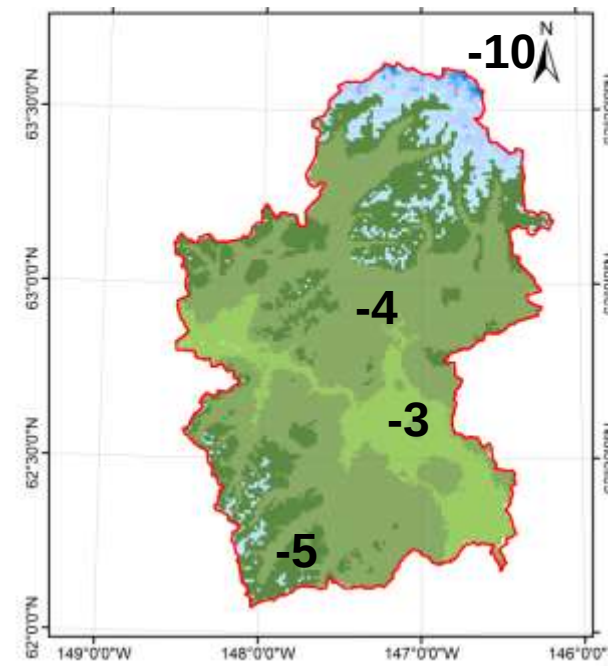
Permafrost Distribution

Glacier
Continuous (>90%)
Discontinuous (50-90%)
Sporadic (10-50%)
Isolated (>0-10%)
Absent (0%)
Large Waterbodies

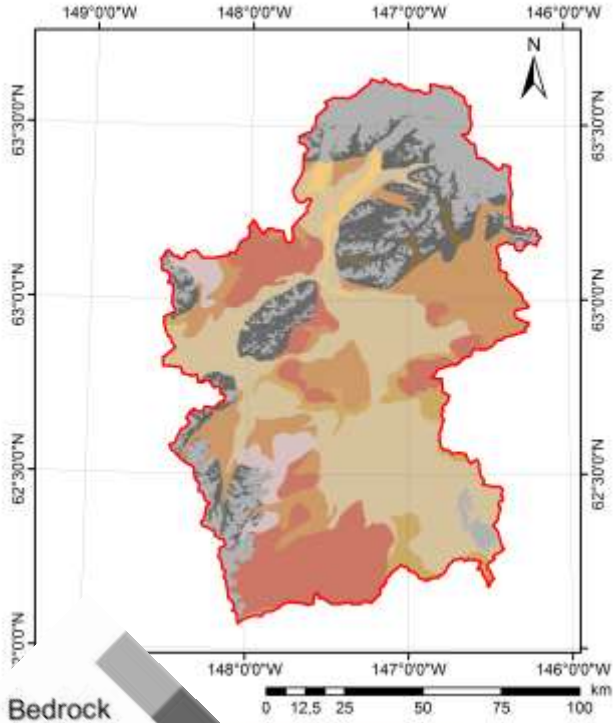
Jorgenson et al 200

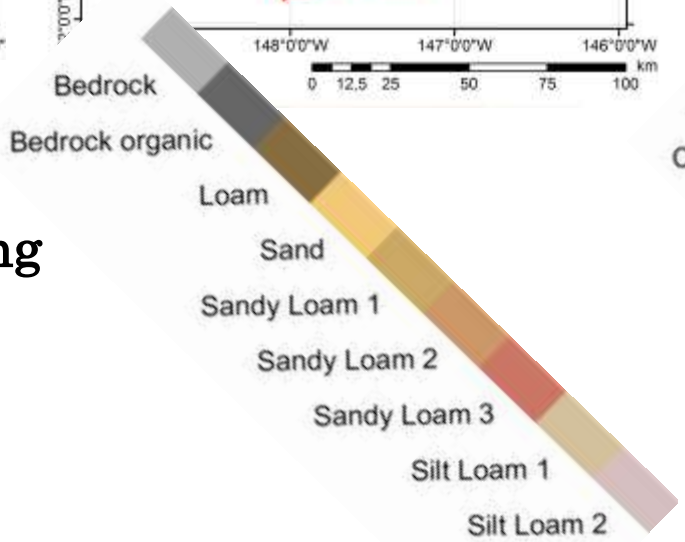
Soil Heat Transfer Modeling: Input Data

Mean annual air temperature (C)
Nov 1982 – Oct 1983

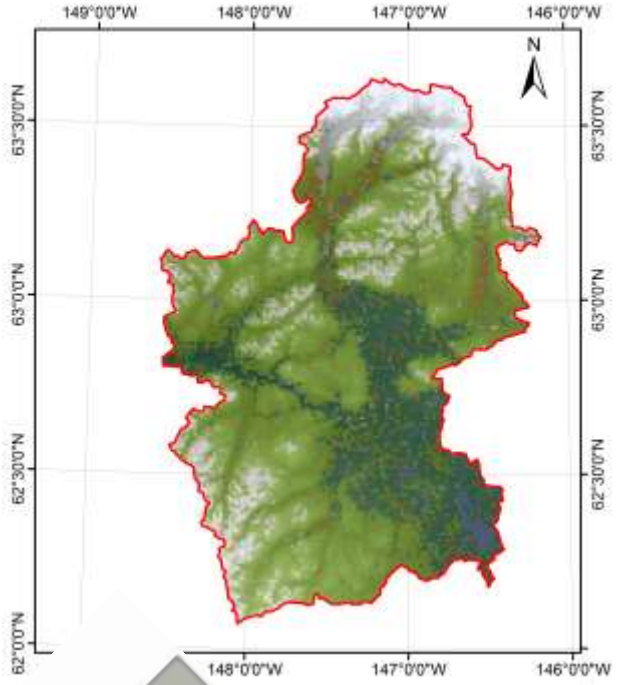


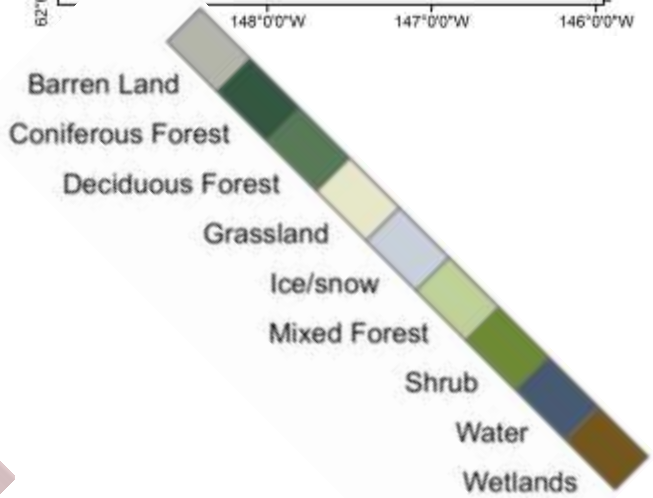
Soil types





Land cover

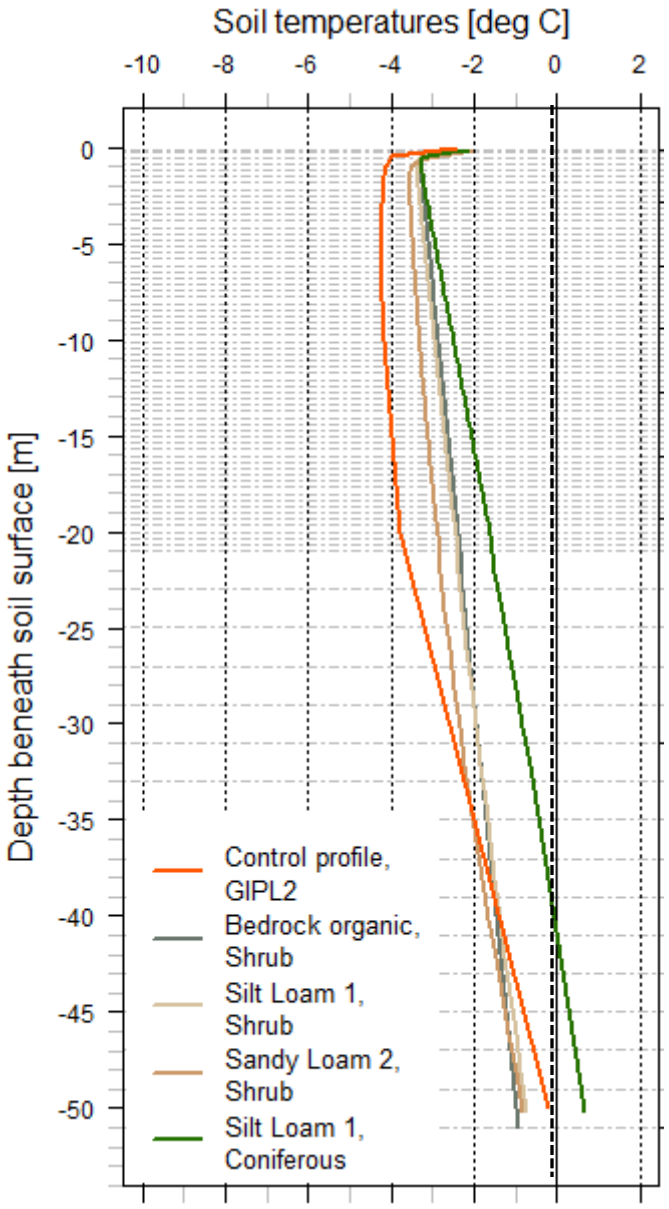




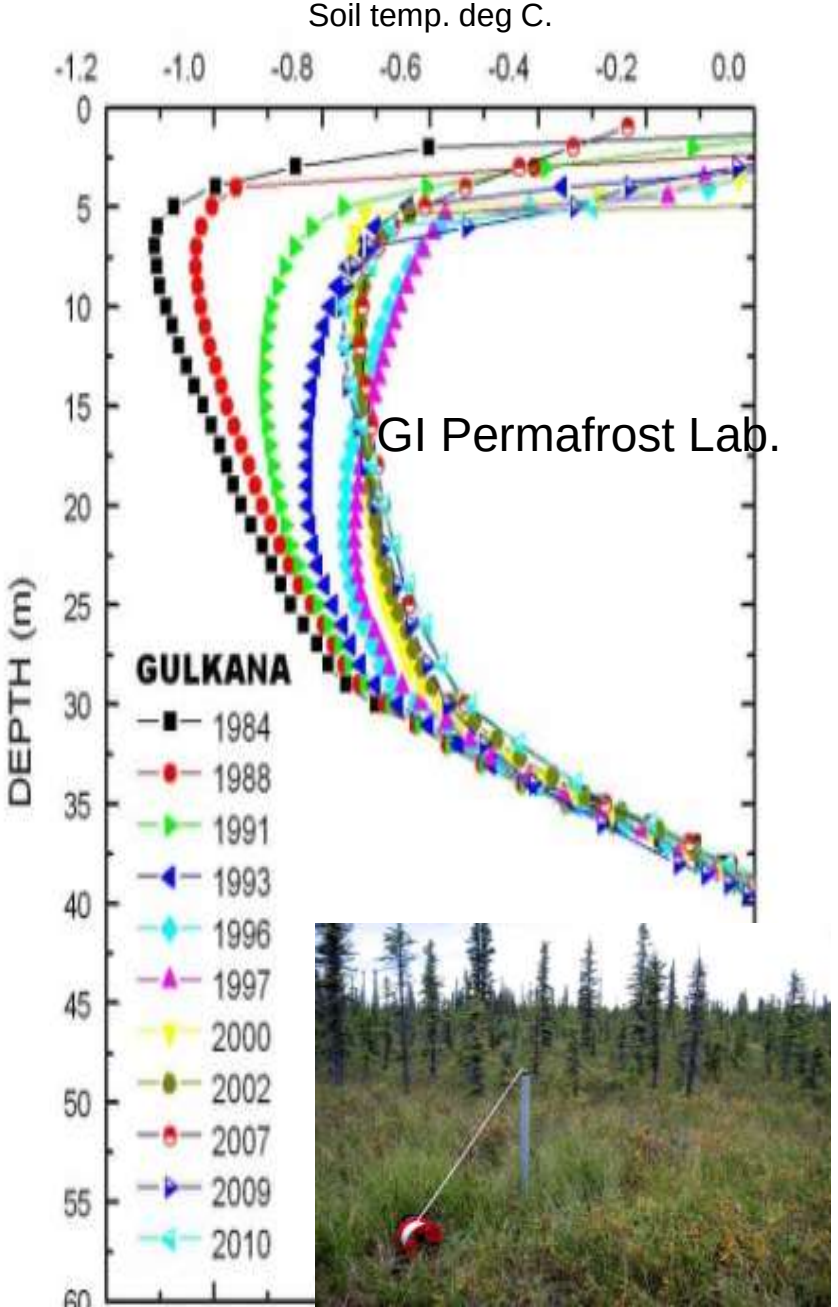
Average "spin up" forcing

Permafrost

simulated



measured



Future Work

- Continue & expand monitoring network
- Continue calibration using 1980's data
- Validate simulations on 2012 & 2013
- Generate future projections