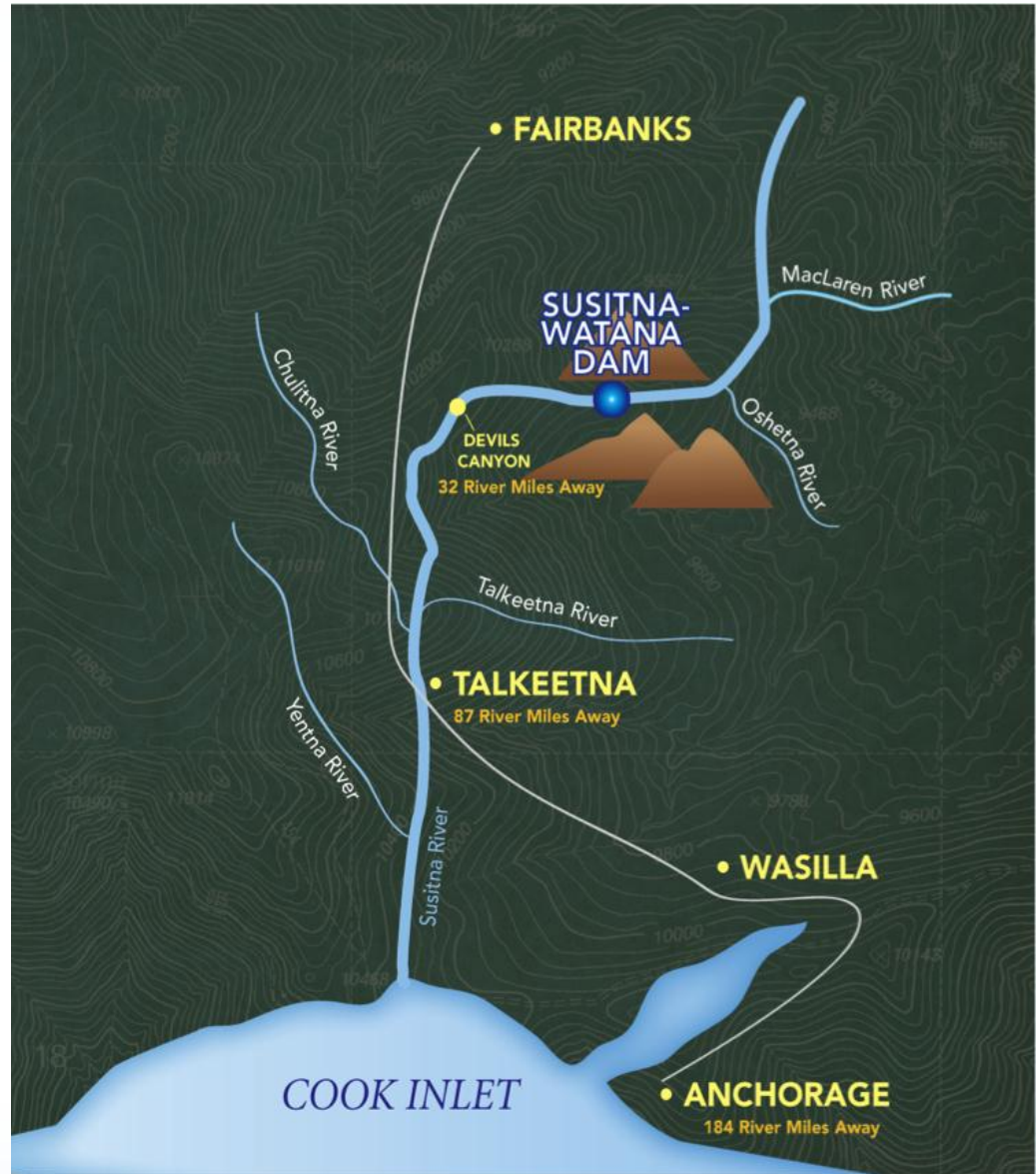


Glacier and Runoff Changes Study

Gabriel J. Wolken, Ph.D.
Alaska Division of Geological &
Geophysical Surveys (DGGs)

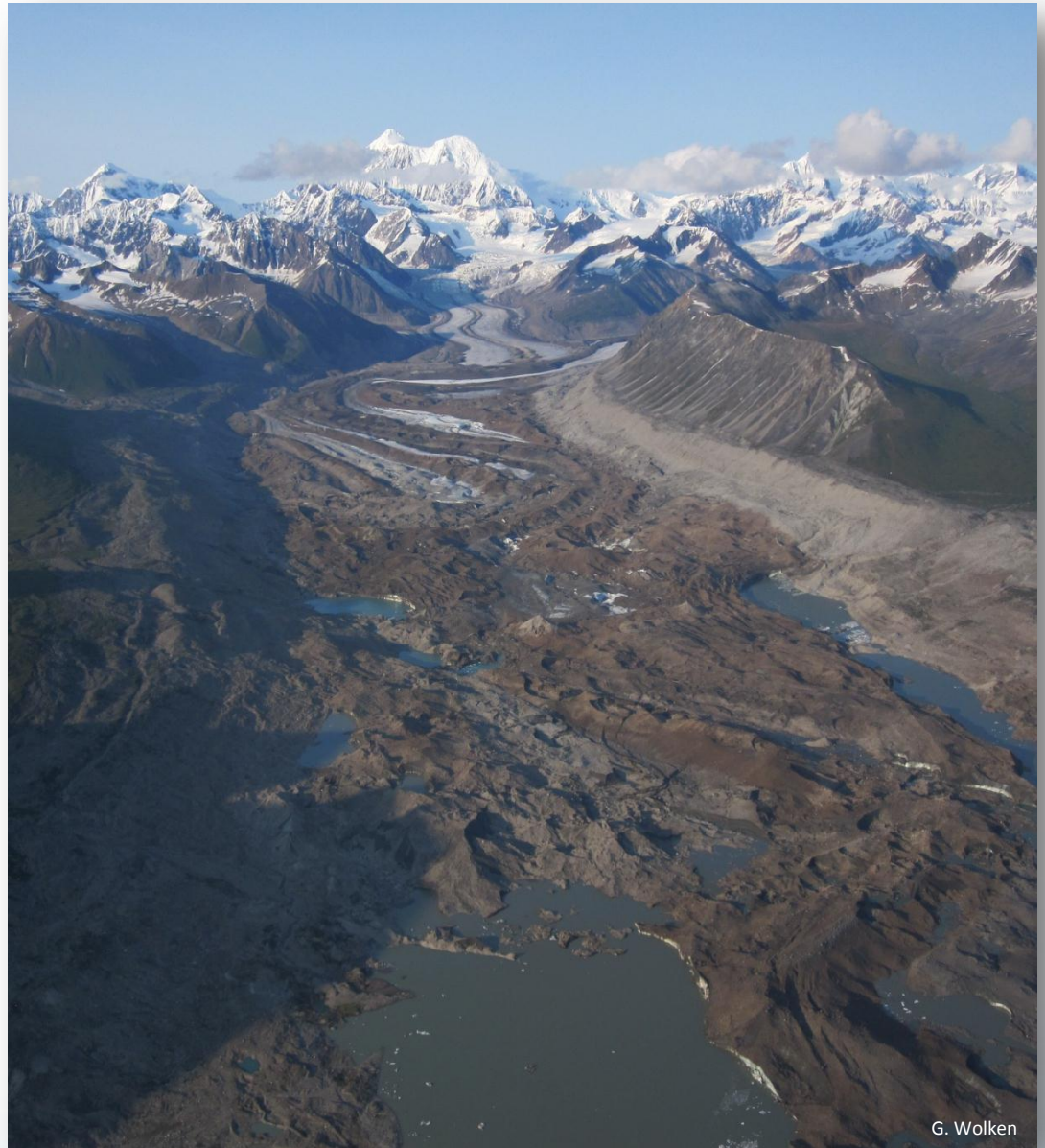
Co-Investigators:
Regine Hock (GI/UAF)
Anna Liljedahl (IARC/UAF)

Correspondence:
gabriel.wolken@alaska.gov



Motivation

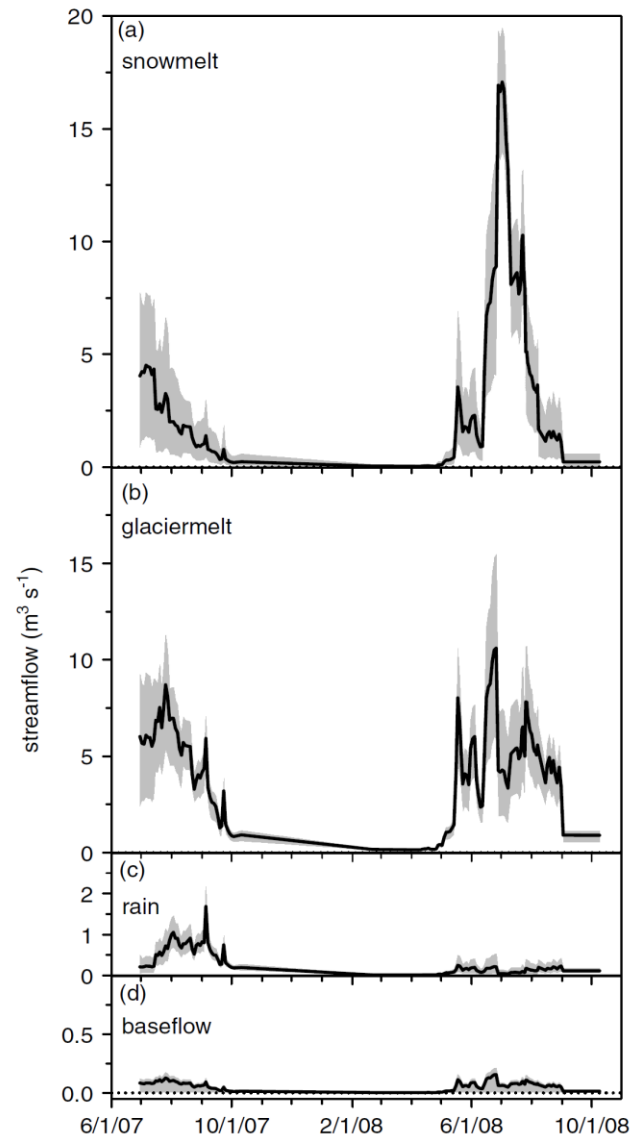
- Alaska Glaciers - general glacier recession during the last century with a pronounced acceleration in mass losses in recent years
- Alaskan glaciers may lose up to 60% of mass in next 100 years (Radic and Hock, 2011)
- Changes can modify streamflow, both in quantity and timing, even with a low percentage of ice cover



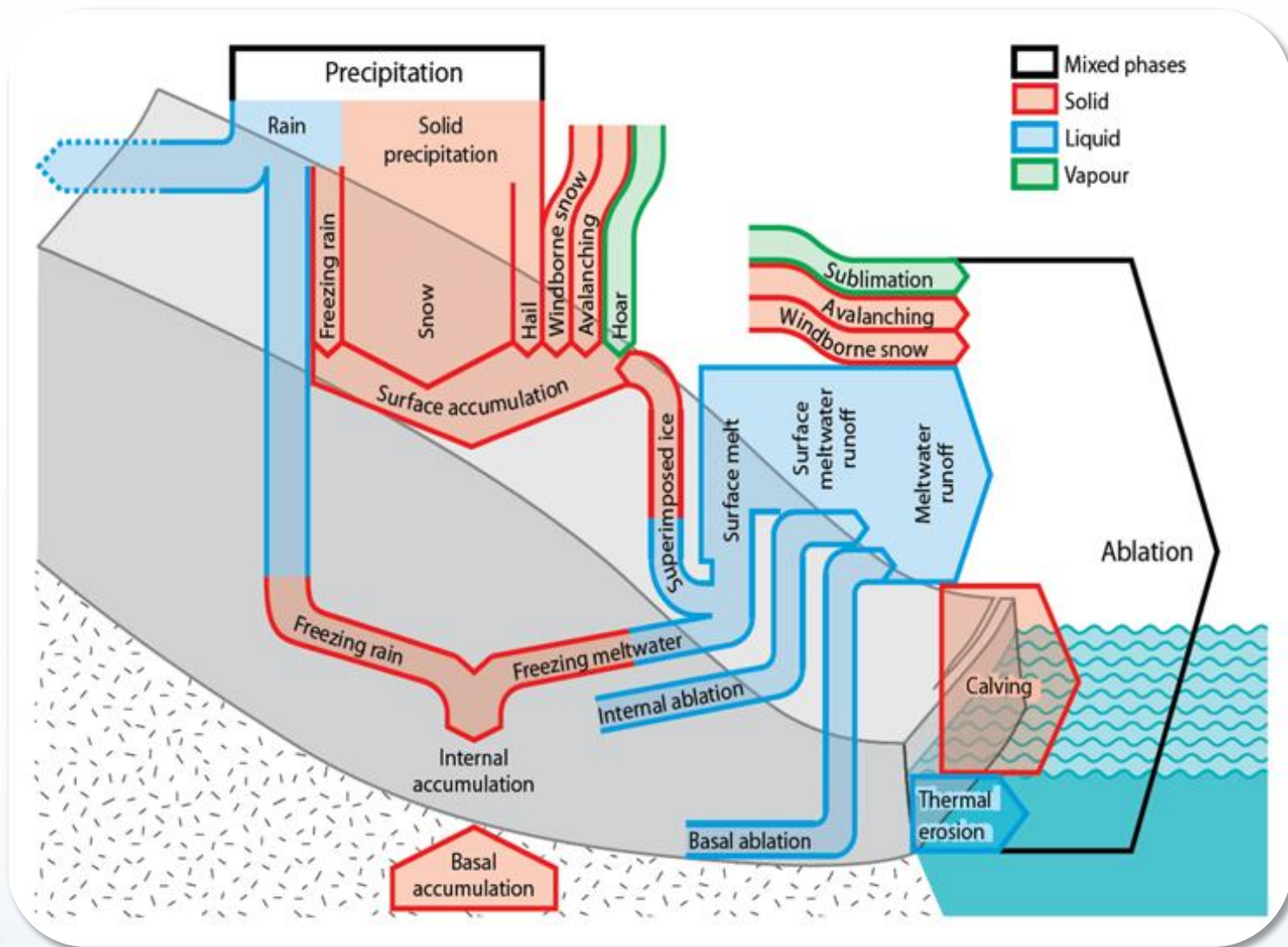
G. Wolken

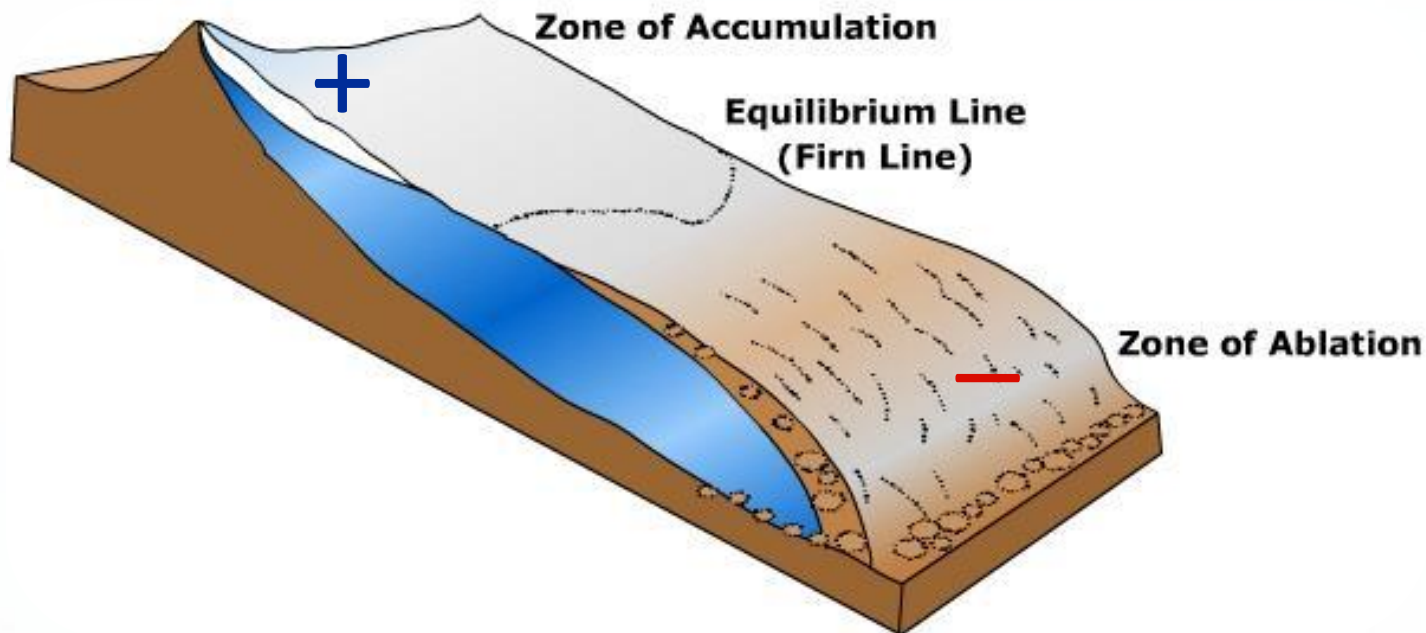
Motivation

- Glaciers tend to be only crudely represented in hydrological modeling.
- Watershed runoff response due to glacier wastage is not well understood – especially in Alaska.



Cable et al., 2011

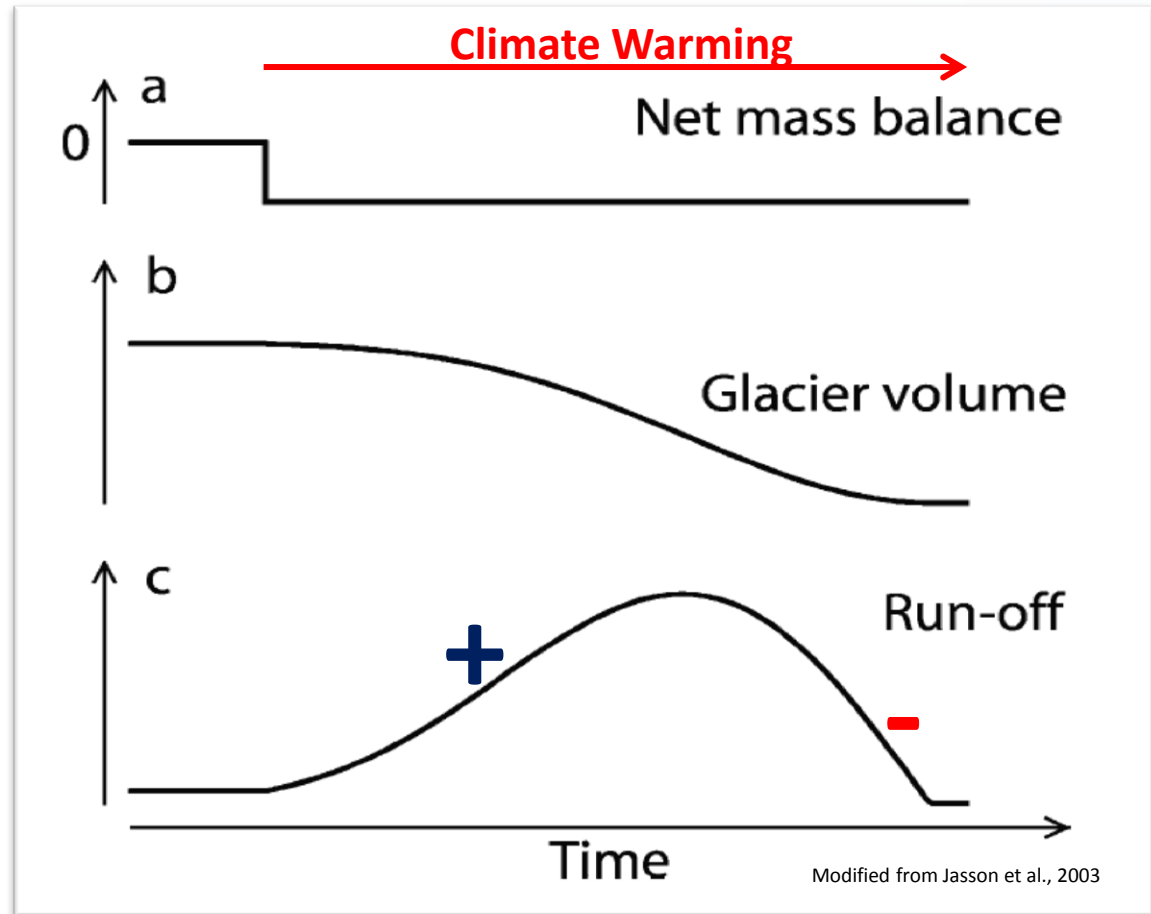




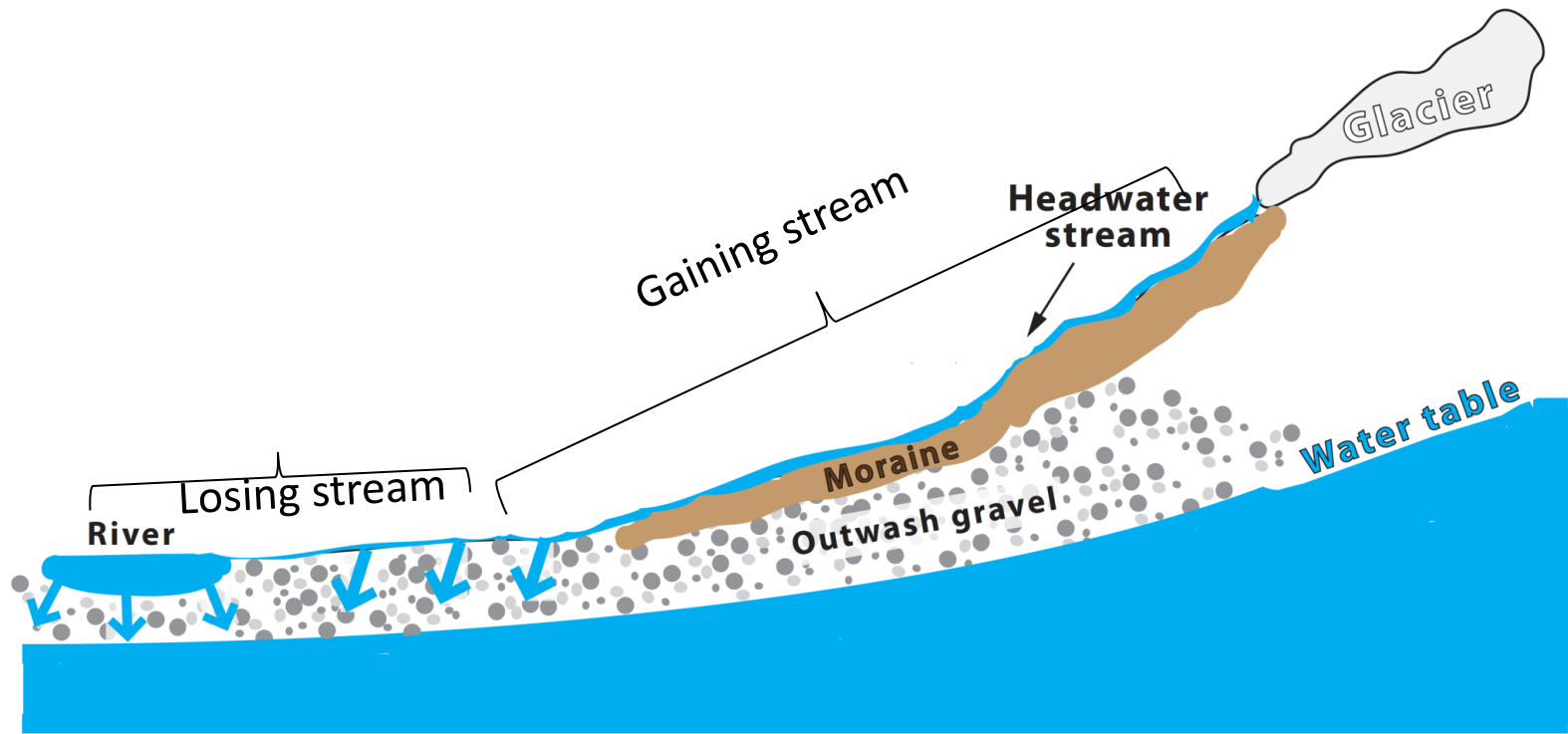
- Annual change in mass of a glacier or collection of glaciers
- Standard measure of glacier "health"
- Sum of mass loss by **iceberg calving** into the ocean (where applicable) and **surface mass balance** (*snowfall - surface melt + internal freezing*)
- Positive mb = annual mass **gain**
- Negative mb = annual mass **loss**

Glacier Change

- Glaciers modulate seasonal and interannual streamflow variations (high precip. to dry periods)
- Annual runoff from a glacierized basin is largely controlled by glacier mass balance
- Long-term changes in mass balance changes glacier size
- Changes in glacier size can alter hydrology and sediment availability and distribution



Moraine & glacial outwash gravel: “non-permeable” versus permeable



Study Objectives

1. Review of relevant literature
2. Develop a hydrological modeling framework that includes the effects of glacier wastage and retreat on runoff in the Susitna basin, and estimate potential glacier mass changes until the year 2100.
3. Simulate the inflow of water to the proposed Susitna-Watana reservoir and project this runoff from the upper Susitna basin to the year 2100 using downscaled climate projections.
4. Analyze the response of the Susitna River above the proposed Susitna-Watana dam site to changes in climate with respect to annual runoff, seasonality and peak flows.
5. Summarize the results in a Technical Report.

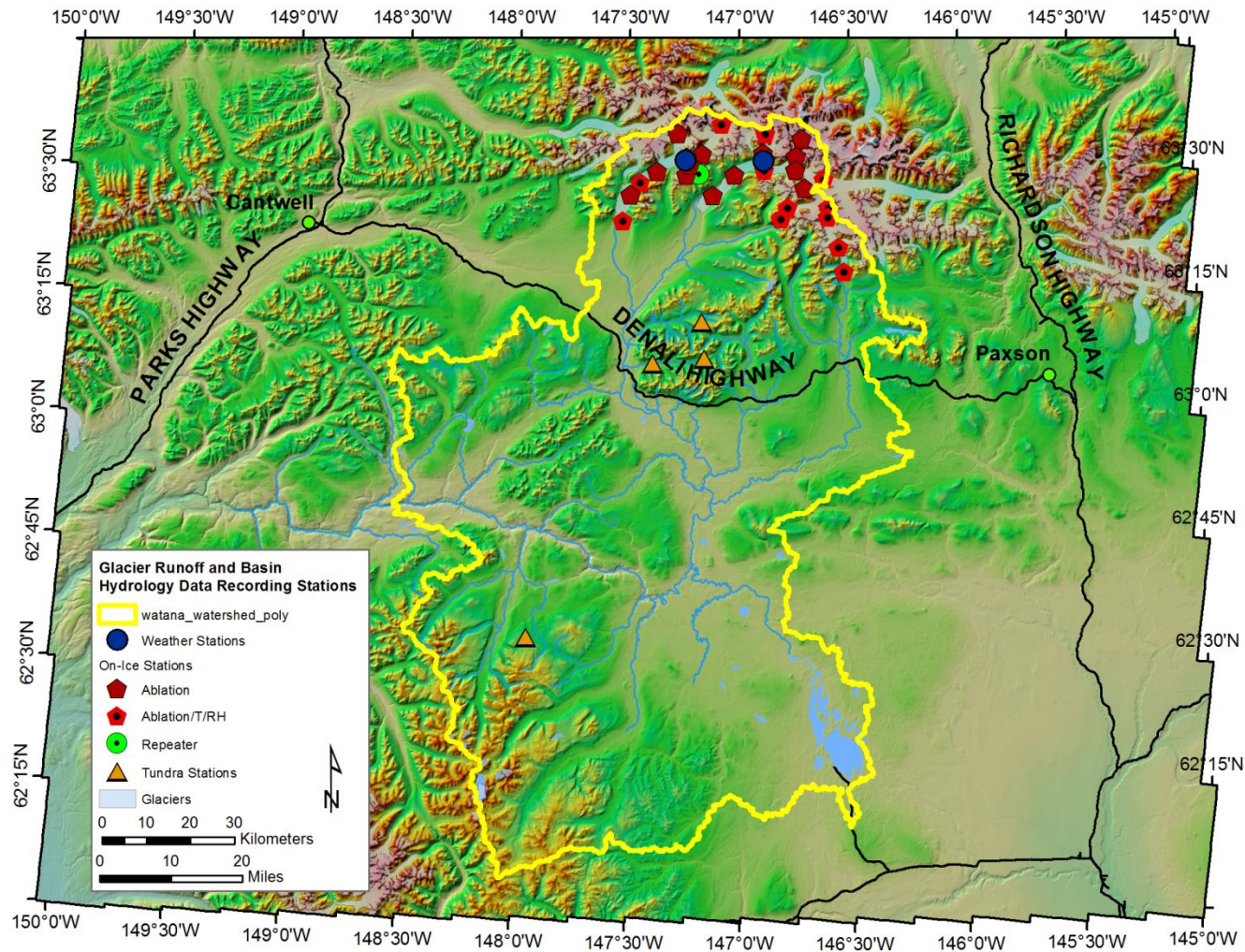
- ✓ Understand the effects of climate variability and change on glaciers and runoff in the upper Susitna Basin



G. Wolken

Future glacier and runoff changes in the upper Susitna basin

Study Area

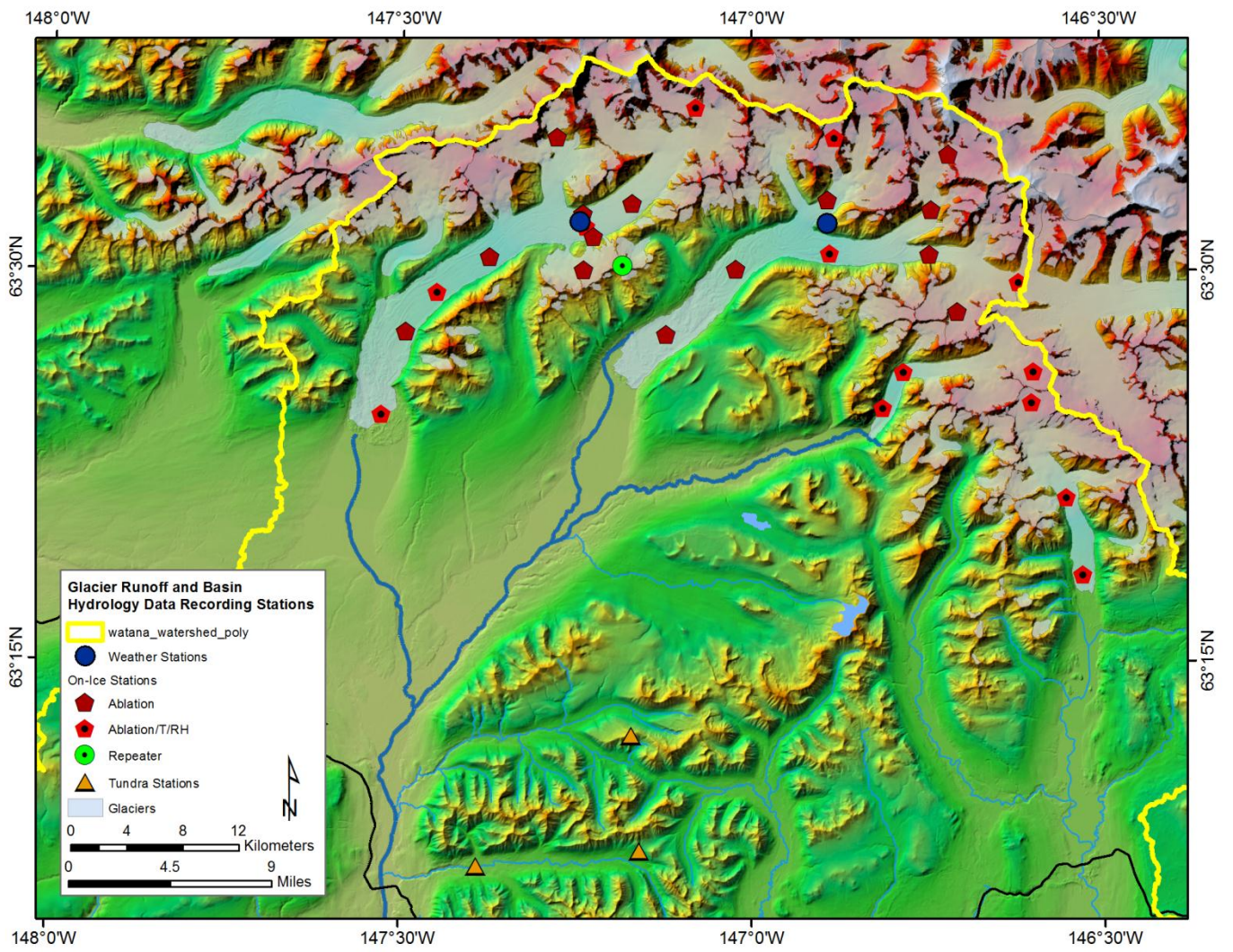


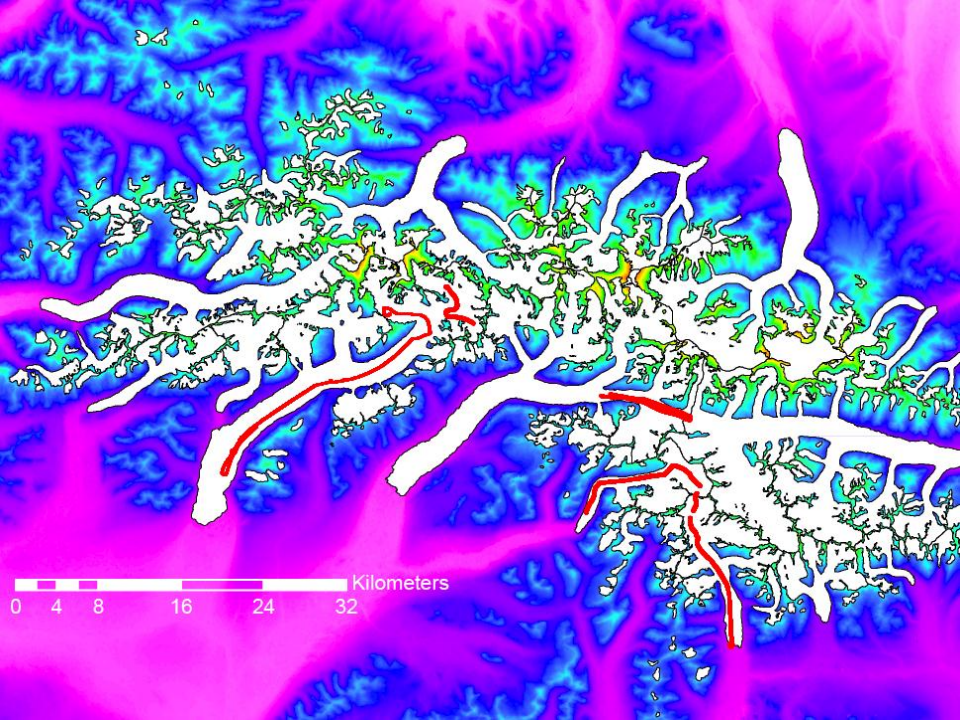
Future glacier and runoff changes in the upper Susitna basin



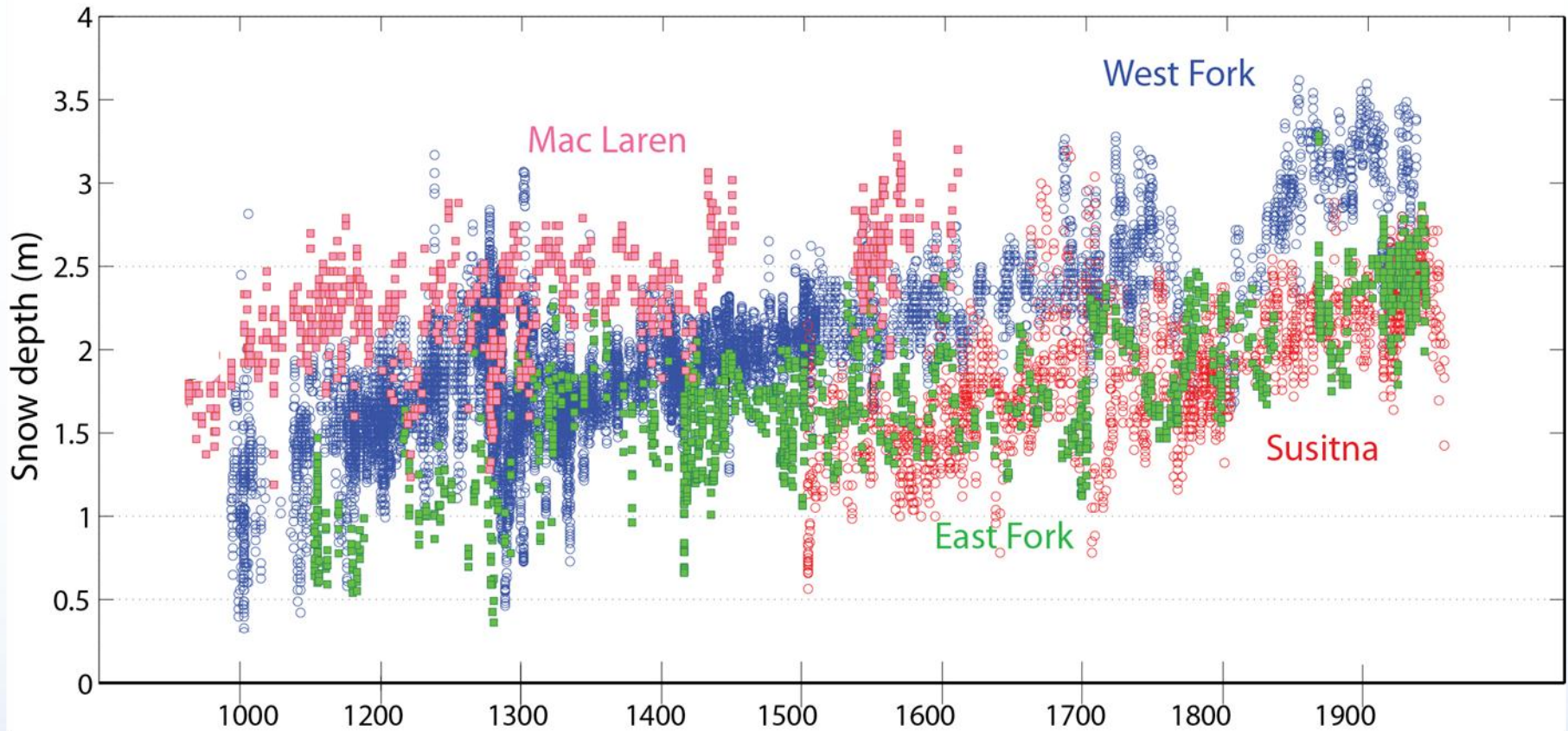
Future glacier and runoff changes in the upper Susitna basin

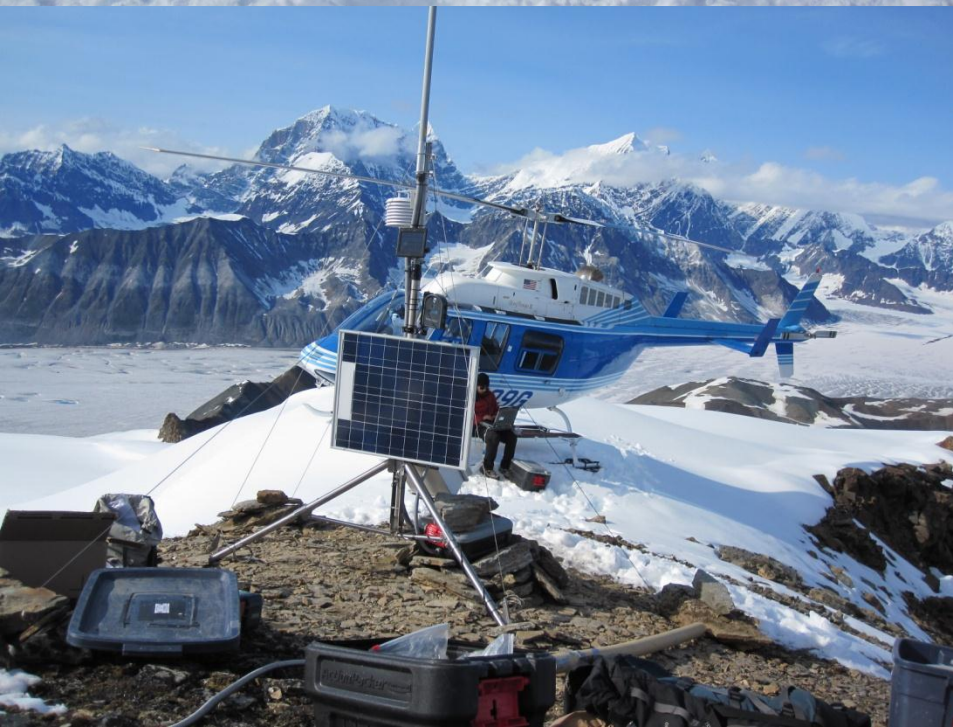
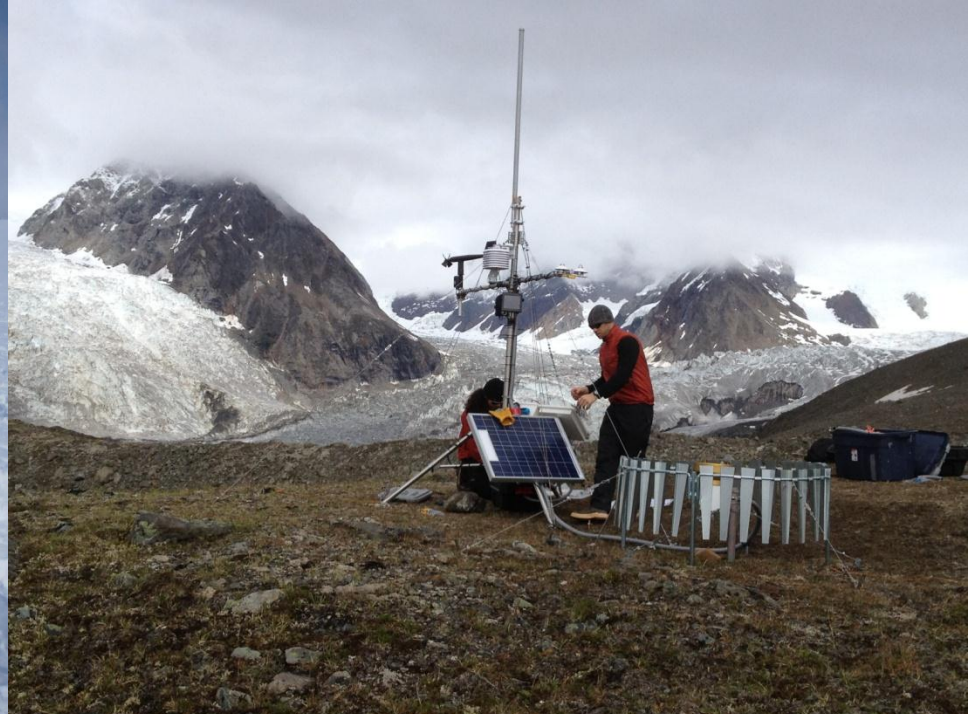
Study Area





Future glacier and runoff changes in the upper Susitna basin





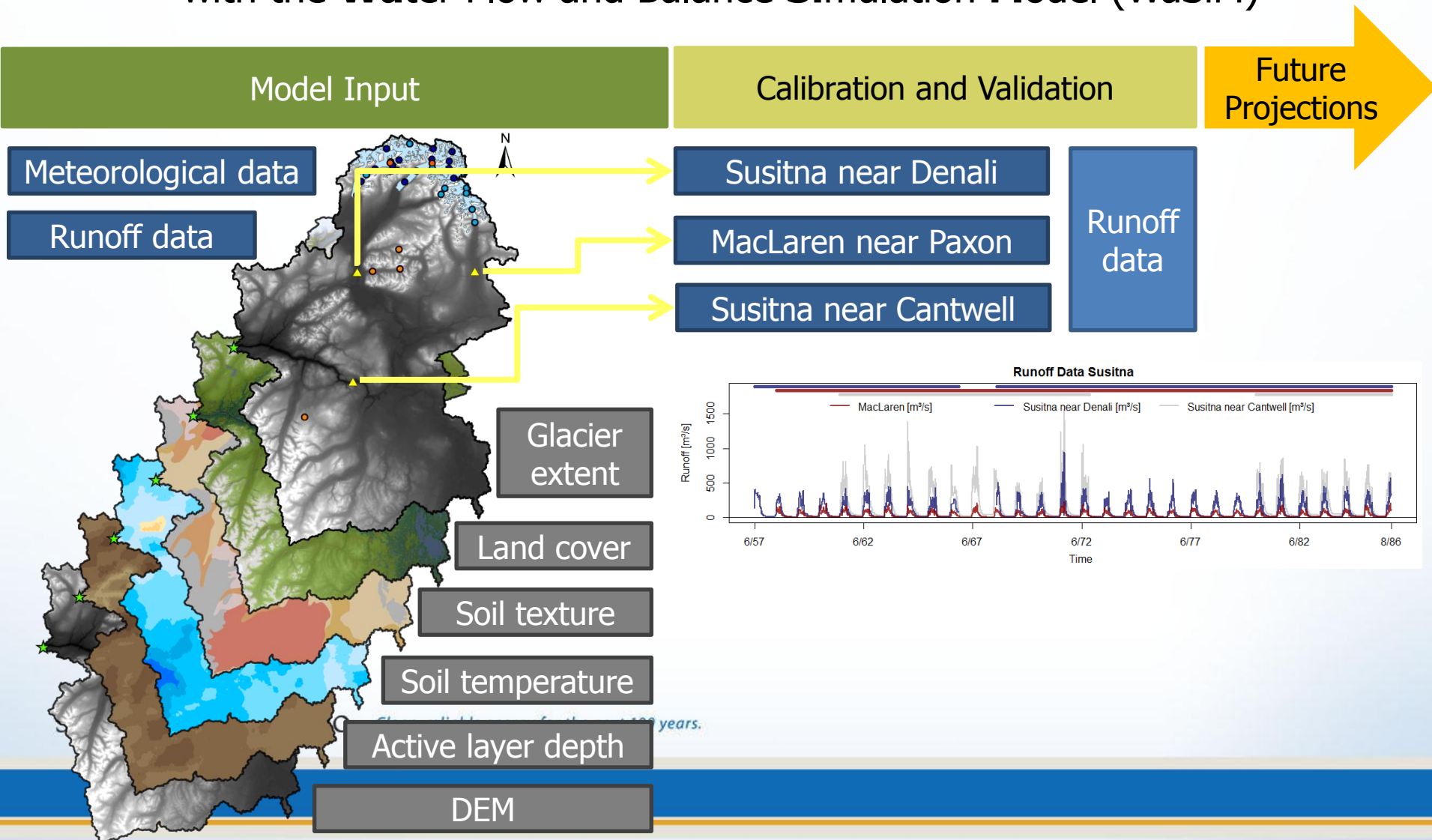
Future glacier and runoff changes in the upper Susitna basin



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

Goal

Simulations of future changes in quantity and seasonality of river runoff with the **Water Flow and Balance Simulation Model (WaSiM)**



Pre-Calibration – Susinta near Cantwell

Overestimation of winter runoff and runoff from snow during Water Balance year 1980/81 → faulty temperature interpolation; Overestimation of summer runoff peaks

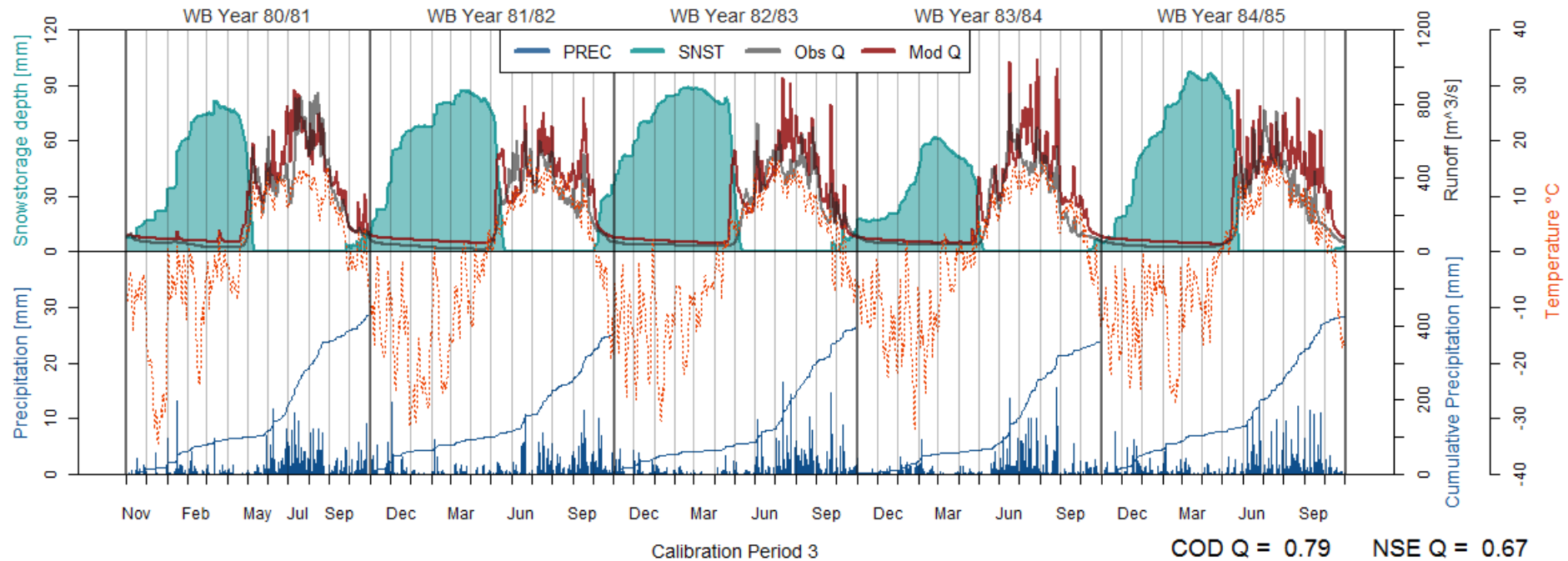
Model Input

Calibration and Validation

Future Projections

Susitna near Cantwell

Mean Temperature T, observed and modelled Runoff Q, Precipitation PR and Snowstorage SNST at Sustina River near Cantwell | Calibration Period 3 | RUN_10



Pre-Calibration – Susinta near Denali

Overestimation of winter runoff and runoff from snow during Water Balance year 1980/81

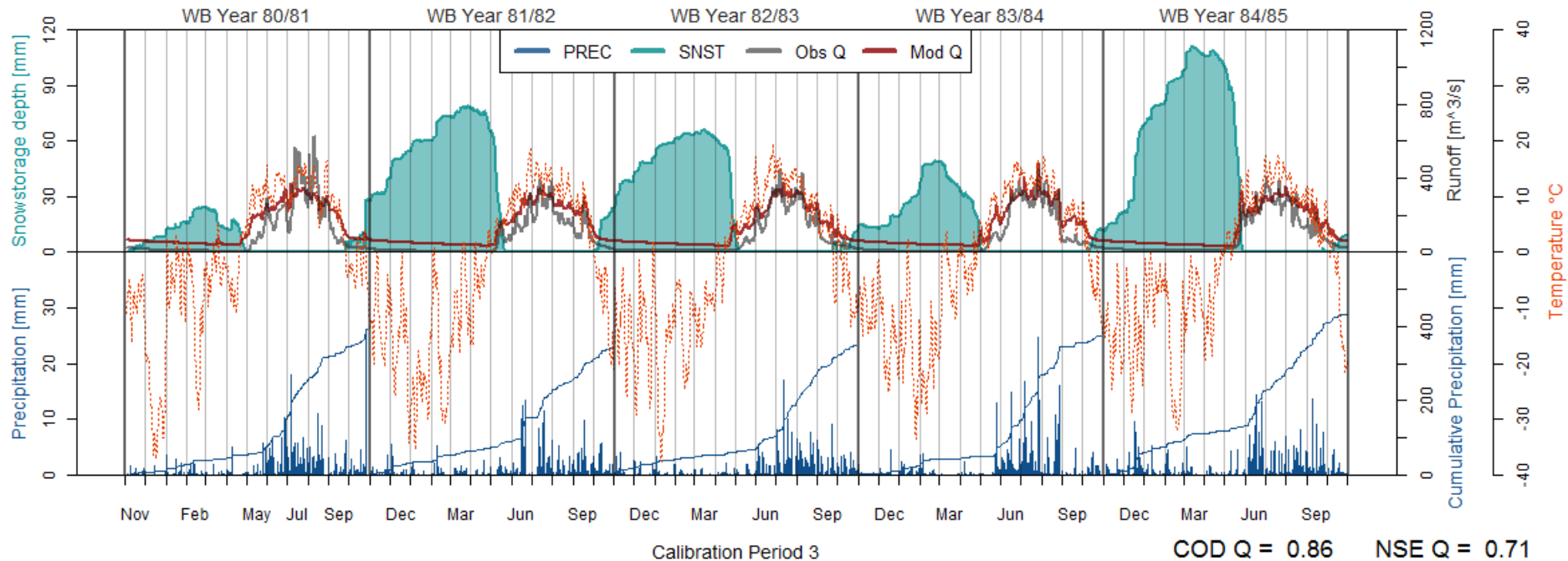
Model Input

Calibration and Validation

Future Projections

Susitna near Denali

Mean Temperature T, observed and modelled Runoff Q, Precipitation PR and Snowstorage SNST at Sustina River near Denali | Calibration Period 3 | RUN_10



Task	Description	FY 2012		FY 2013			
		3	4	1	2	3	4
	GLACIER IMPACTS						
2-1	Compile data, review glacier wastage & watershed hydrology	■	■				
2-1	Process remote sensing imagery			■	■	■	■
2-2	Glacier mass balance monitoring						
2-2	Collect summer glacier balance measurements			■			
2-2	Collect winter glacier balance measurements		■				■
2-2	Develop map(s) of glacier extent variation				■	■	
2-2	Map(s) of glacier extent variation completed						
2-4	Hydrological & glacier melt model development			■	■	■	■
2-4	Deliver initial results on Susitna River response to changing climate						X
2-4	Report on Susitna River & climate change completed						

■ Projected work flow for budgeted tasks

X Project deliverable due (excludes annual progress report, which is due at end of fiscal year 2013)