# RESPONSE OF GLACIER MELT AND DISCHARGE TO FUTURE CLIMATE CHANGE, SUSITNA BASIN, ALASKA


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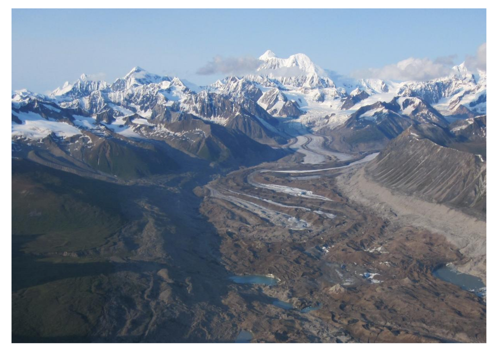
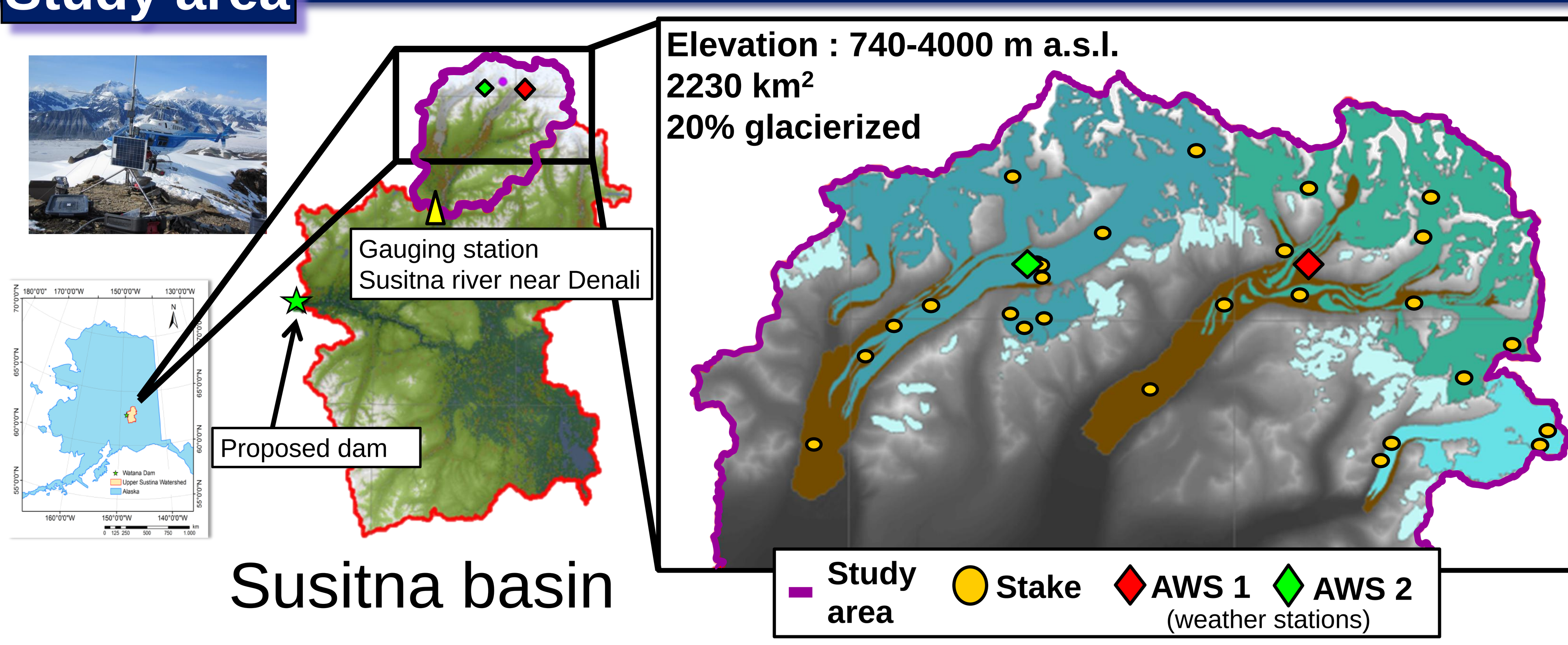
## Background and Goals

A large dam for hydropower with a 67 km long reservoir is proposed in the Susitna basin, leading to multiple studies of the basin. This study focuses on the response of climate change of the Susitna basin glaciers and the effects on basin discharge.



➢ Specific goals:
- Quantify the glacier mass change until 2100;
- Project future runoff;
- Analyze the changes in annual runoff, seasonality and peak flows;

## Study area




## Model

We used the open access distributed temperature index model (DETIM, http://regine.github.io/meltmodel/ , Hock, 1999) which uses daily precipitation and air temperature as climate forcing

- ➢ **Daily Snow and ice melt**, *M*, is computed using a grid-based temperature-index mass-balance model including daily potential direct solar radiation, $I_{pot}$, *($Wm^{-2}$)*, (Hock, 1999):

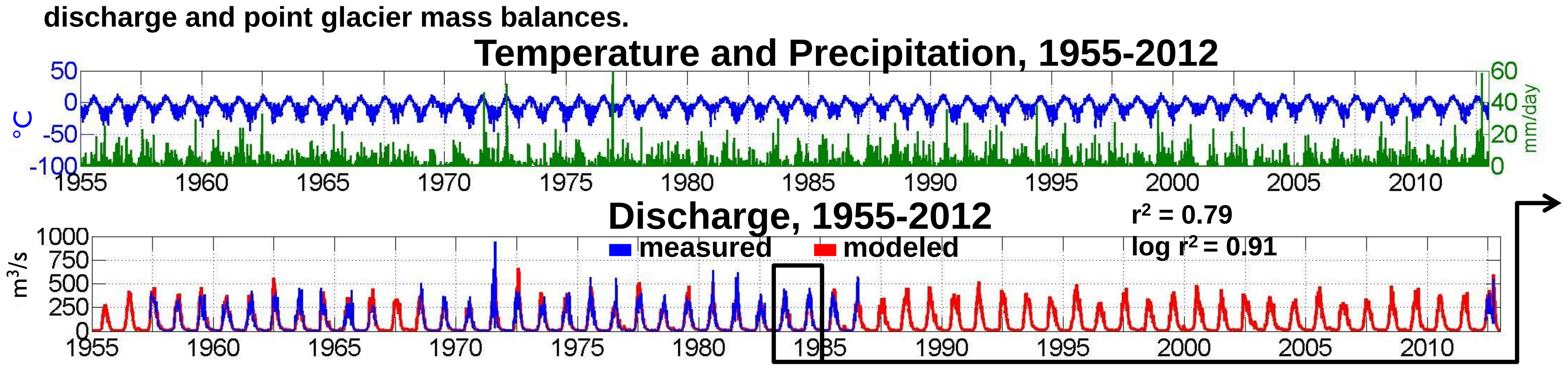
$$M = \left(f + a_{snow/ice} * I_{pot}\right) * T^{+} \quad \text{(Eq. 1)}$$

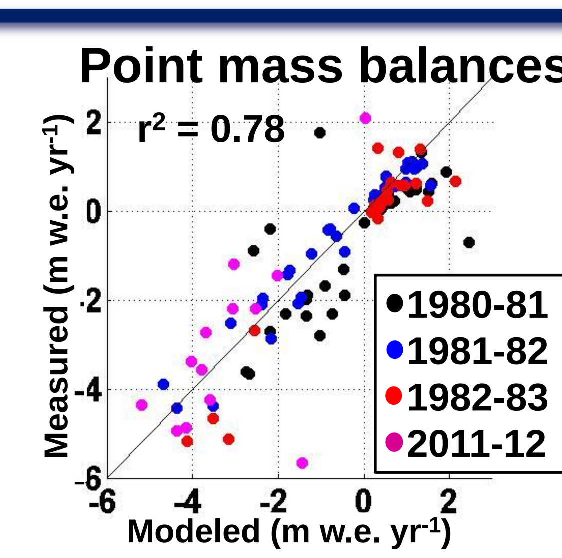
*T = daily mean air temperature (°C), f = melt factor,* $a_{snow/ice}$ *= radiation coefficients.*

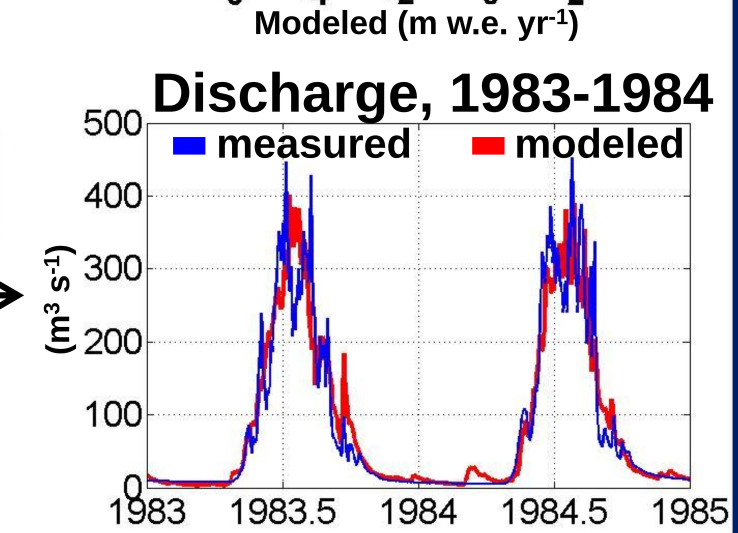
- ➢ **Snow precipitation** is computed from daily precipitation data using a temperature threshold.
- ➢ **Discharge** is computed using four parallel linear reservoirs for the firn area, the bare ice area, the snow-covered area (on and outside of glacier) and the snowfree area outside the glacier. Different storage coefficients are assigned to each reservoir to account for differences in water travel times.
- ➢ For the future scenarios a simple **glacier retreat algorithm** is implemented using volume-area scaling.
- ➢ The model has 9 model parameters (melt factor, radiation coefficient for snow and ice, temperature lapse rate, precipitation correction factor and lapse rate, storage coefficients for each reservoir).

## Calibration

- ➢ The model was calibrated over the period 1955-2012.
- ➢ **Daily temperature** at AWS1 (1516 m a.s.l.) was extended using the Talkeetna airport NCDC station (907 m a.s.l.) .
- ➢ **Daily precipitation** from Talkeetna airport was corrected by a precipitation correction factor calibrated in DETIM to represent the precipitation at AW1.
- ➢ **Daily mean discharge** data from the Susitna river near Denali highway, covering the period 1957-1966, 1968-1986 and 2012 and **109 mass balance point measurements** for years 1980-1983 and 2011-2012 were used to calibrate the model. The parameters were calibrated maximizing the agreement between measured and modeled discharge and point glacier mass balances.



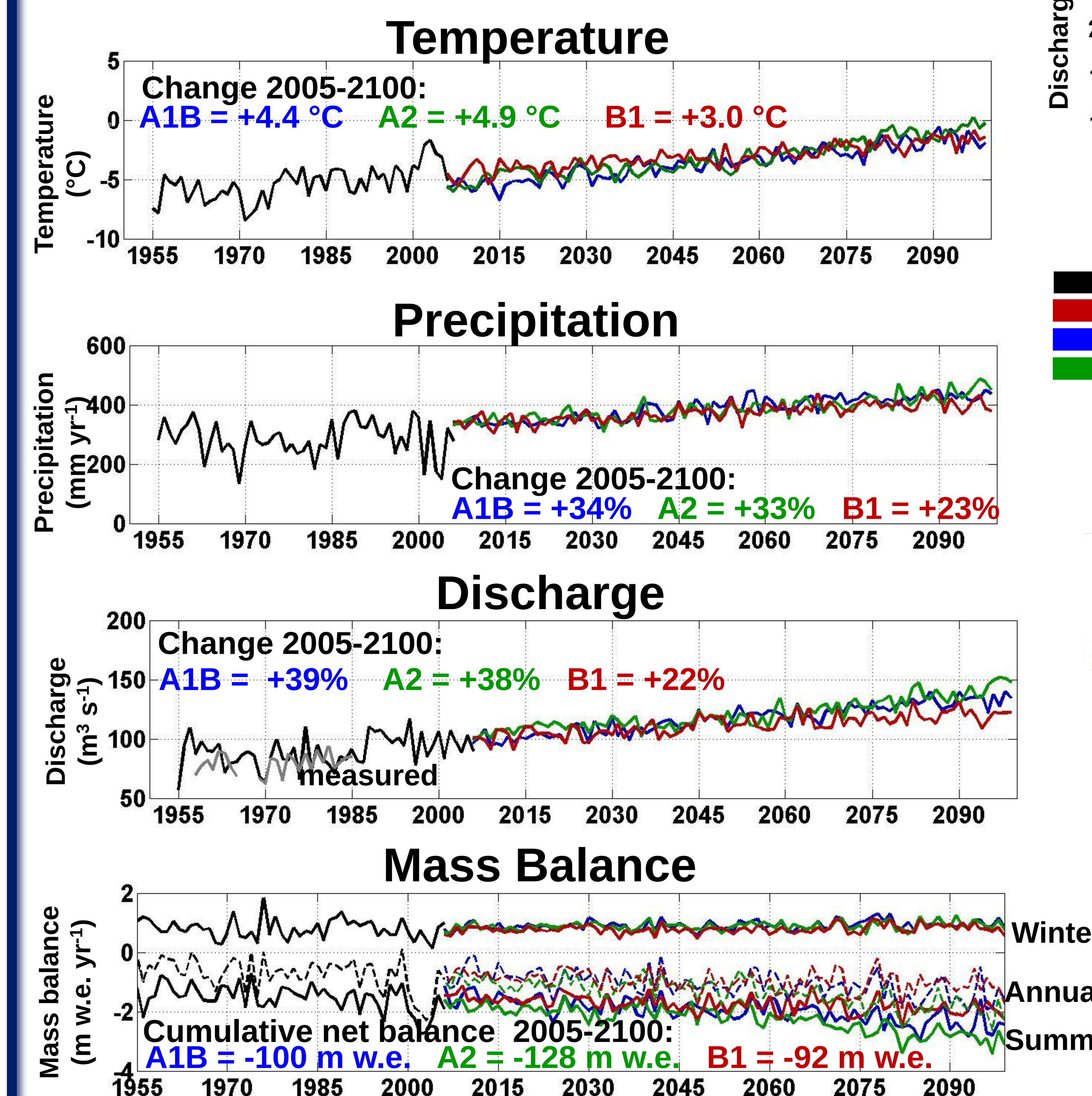



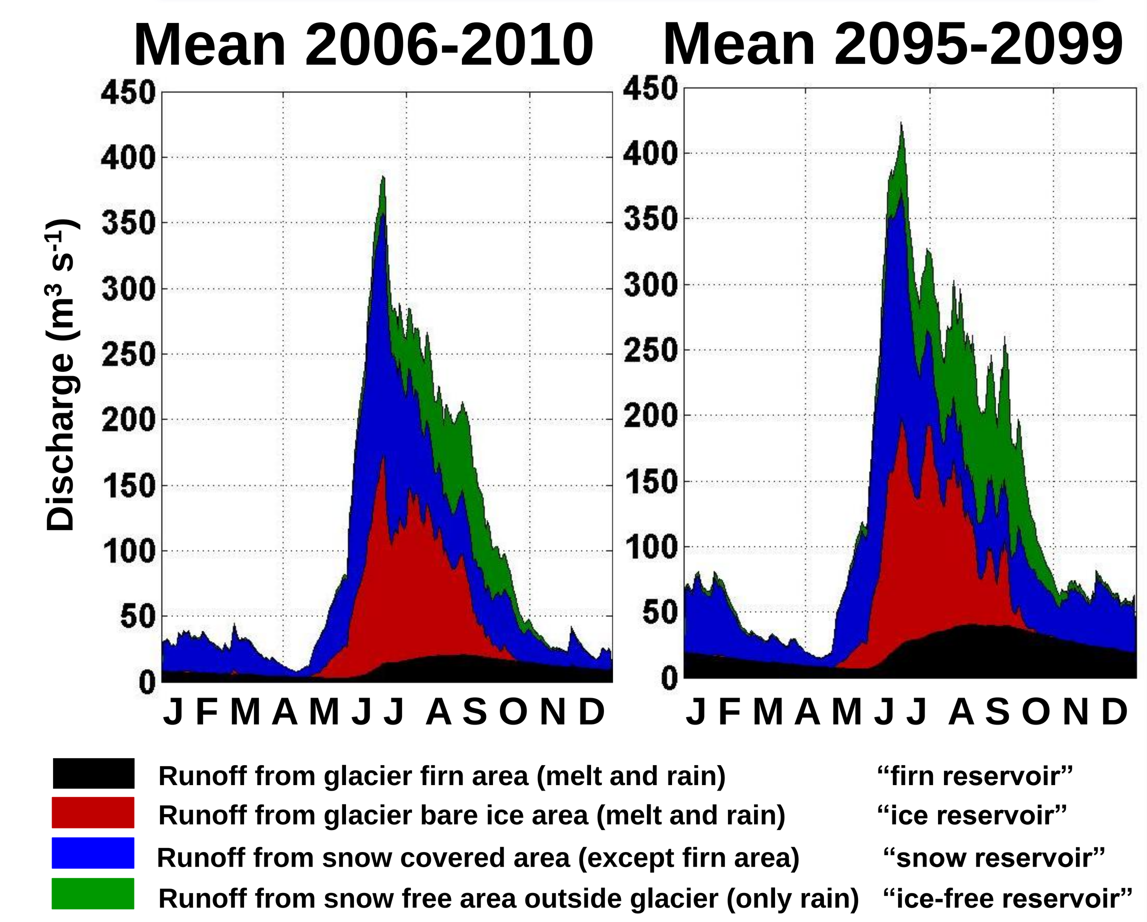

## Model Results

### Projections 2005-2100

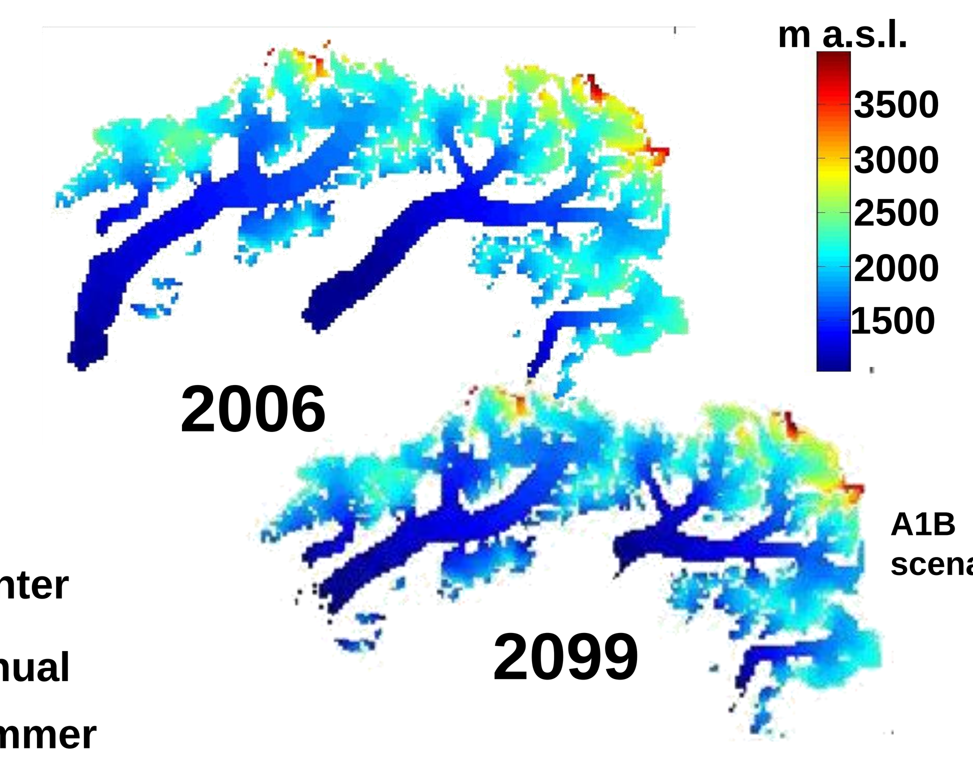
- ➢ The calibrated model was run for the period 2005-2100 using daily precipitation and temperature data from the Scenarios Network for Alaska & Arctic Planning (SNAP) project based on the Community Climate System Model (CCSM). We use data from 3 emission scenarios (A1B, A2 and B1).
- ➢ The data series of the grid point closest to AWS 1 was used and bias-corrected using data from Talkeetna and AWS 1.

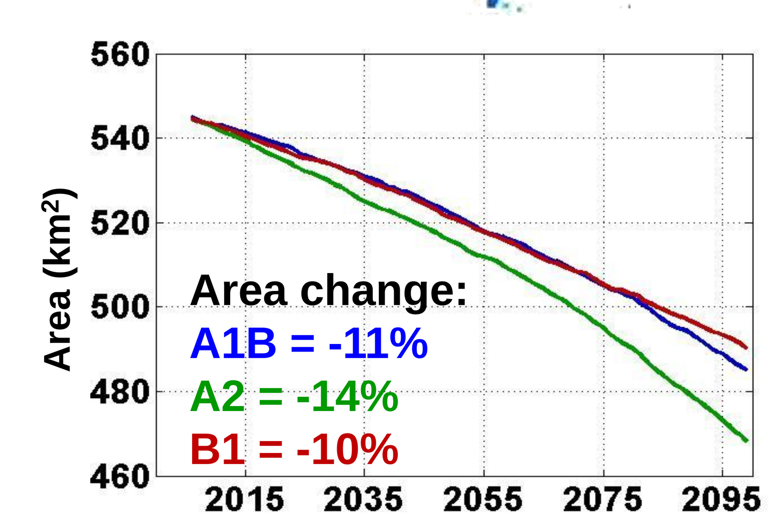



### Runoff Components




### Area evolution




## Conclusions / Summary

- ➢ Depending on the climate scenario, runoff in the glacier basins is predicted to increase by **20 to 40%** over the period 2005-2100 due to increased temperature of **3 to 5°C** and precipitation increase between **20 and 35%**.
- ➢ During the same period the glaciers are projected to lose **10 to 12%** of their area.
- ➢ The future projections show no trend in winter balance but show a trend towards more negative specific summer balances.
- ➢ The model, despite its simplicity and focus on snow and ice melt, is able to reproduce well the observation in discharge and mass balance.
- ➢ Downscaling for temperature and precipitation biases of the climate model scenarios yields better results when done on a monthly instead of annual basis.

## *Reference and Acknowledgements*


Hock, R., 1999. A distributed temperature index ice and snow melt model including potential direct solar radiation. J. Glaciology 45(149), 101-111.



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