Future glacier and runoff changes in the Upper Susitna basin, Alaska

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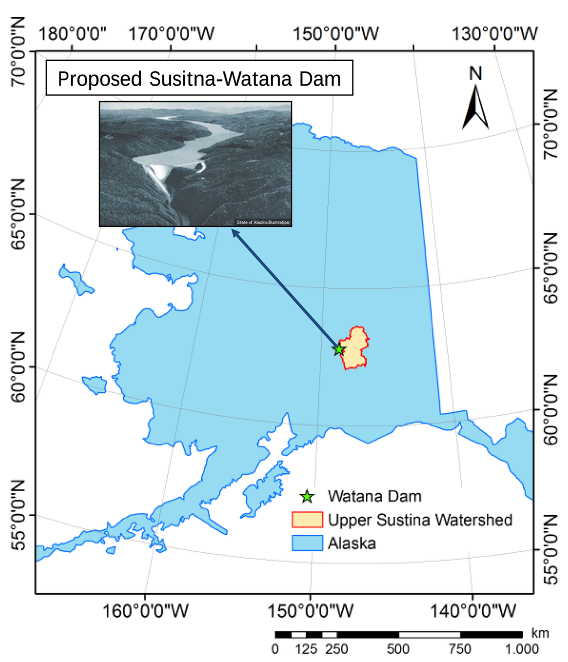
Background and Purpose

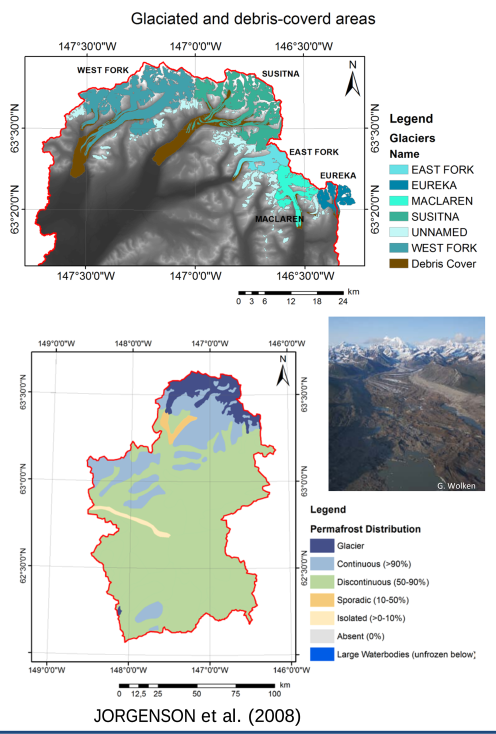
- The hydroelectric power potential of the Susitna River is being explored to conform with the Alaska Legislature directive[a] to generate 50% of State electricity from renewable and alternative sources by 2025.
- The catchment of the reservoir in the upper Susitna watershed (13,289 km², 450-4000 m a.s.l.) is 4% glacierized and is characterized by sparse vegetation, discontinuous permafrost, and little human development. Glaciers, permafrost, and the water cycle are expected to change in response to anticipated future atmospheric warming by the end of this century, thus impacting water yields to the hydroelectric reservoir.
- Our method combines field measurements and hydrological modeling to improve runoff estimates for the proposed 81 km² and 63 km long reservoir of the Susitna-Watana Hydroelectric Project.



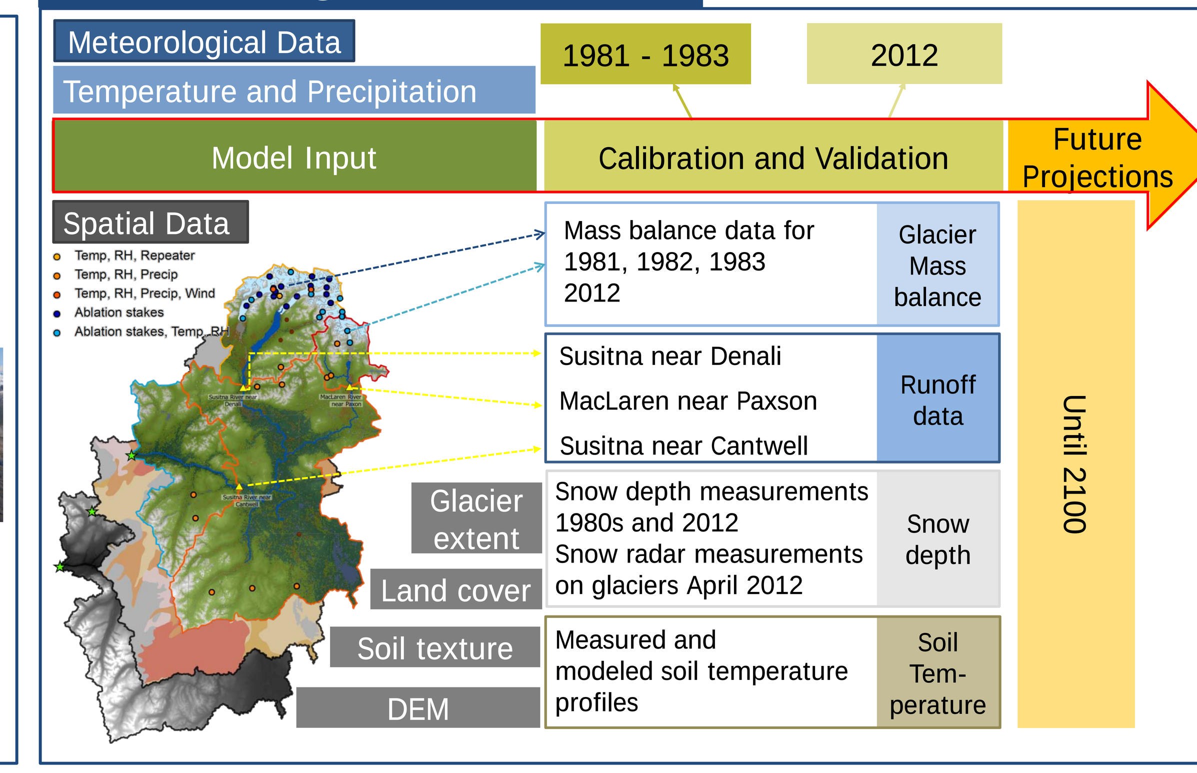
Methodology

- The influence of glacier discharge is accounted for by the integrated **dynamic glacier module** which calculates glacier mass balance and, by applying a simple volume-area scaling (BAHR et al. 1997), enables the simulation of glacier advance or retreat. This allows us to specifically evaluate the role of glacier melt on river runoff during the lifespan of the proposed dam.

  The isolating affect of debris is accounted for by the input of a debris grid.
- The widespread discontinuous and continuous **permafrost** and it's influence on the basin's hydrology is simulated by the **1-D heat transfer module,** which calculates the vertical heat fluxes in and out of the soil layers based on the first and second laws of thermodynamics.



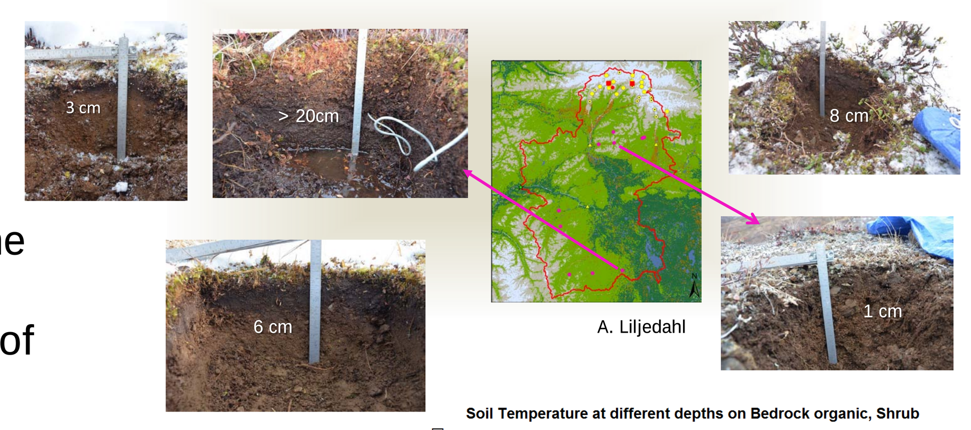
Modelling workflow

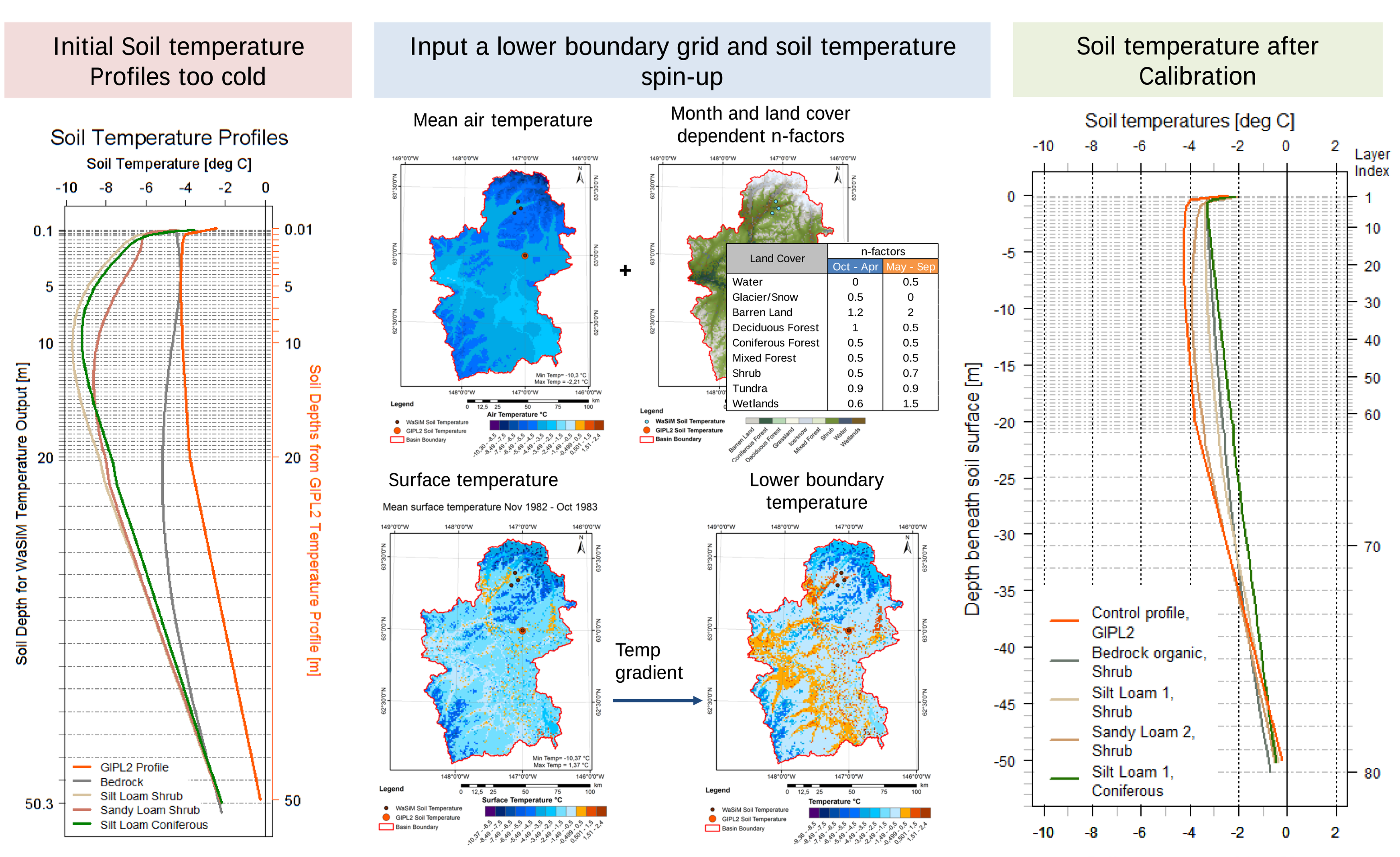


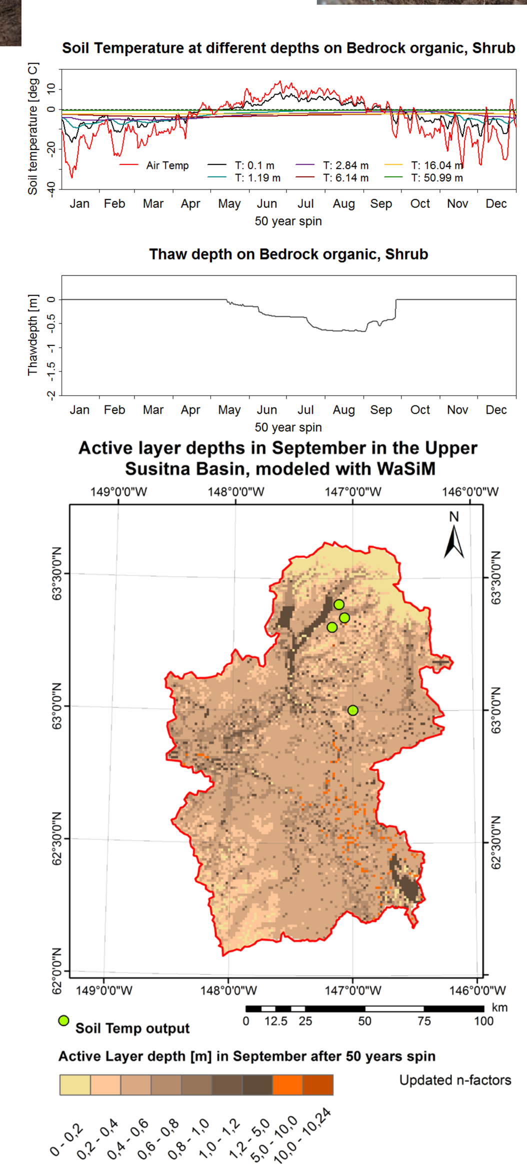
Soil temperature calibration

- Soil temperatures are influenced by the depth of the organic soil layers as well as by the insulating effect of a sufficient blanket of snow.
- Since heat transfer through snow is not yet implemented in WaSiM, the upper boundary condition is adjusted by land cover specific n-factors.
- The initial conditions are more important lower in the profile, since the influence of the dynamically changing upper boundary (air temperature, corrected by n-factor) decreases with depth. The input of a lower boundary grid may significantly reduce model spin-up times.

Field measurements
– organic soil depth and soil temperature





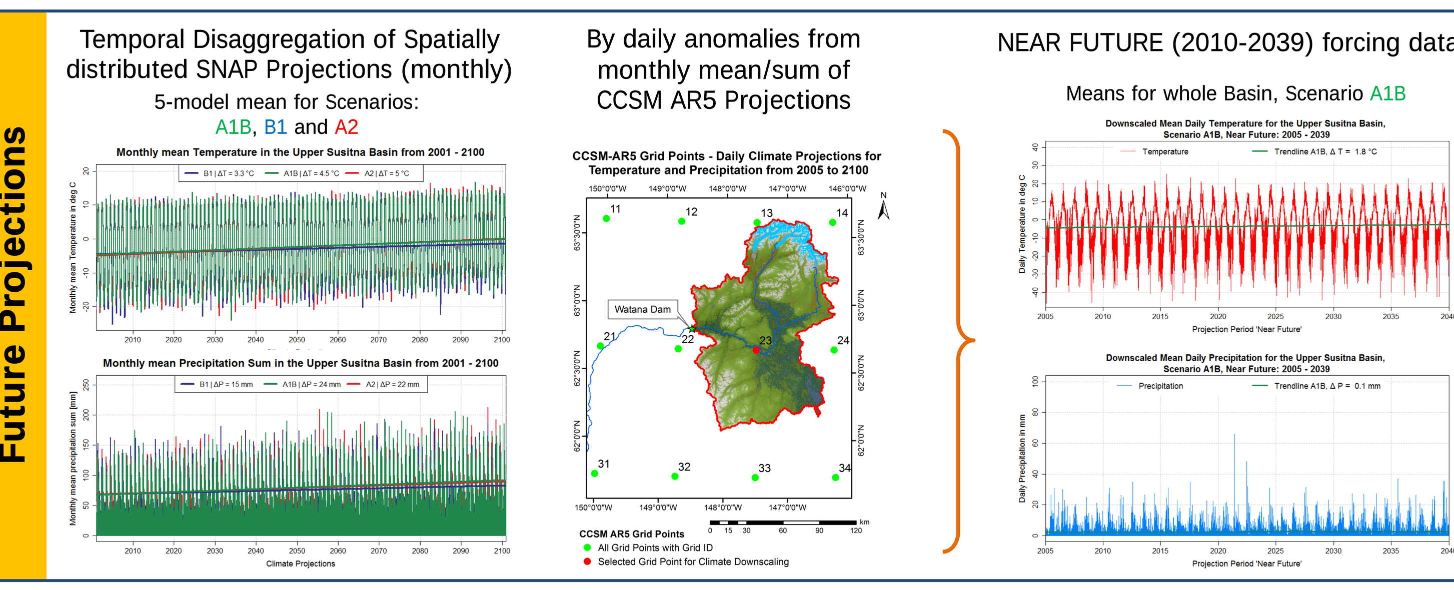


Meteorological forcing

Calibration and Validation

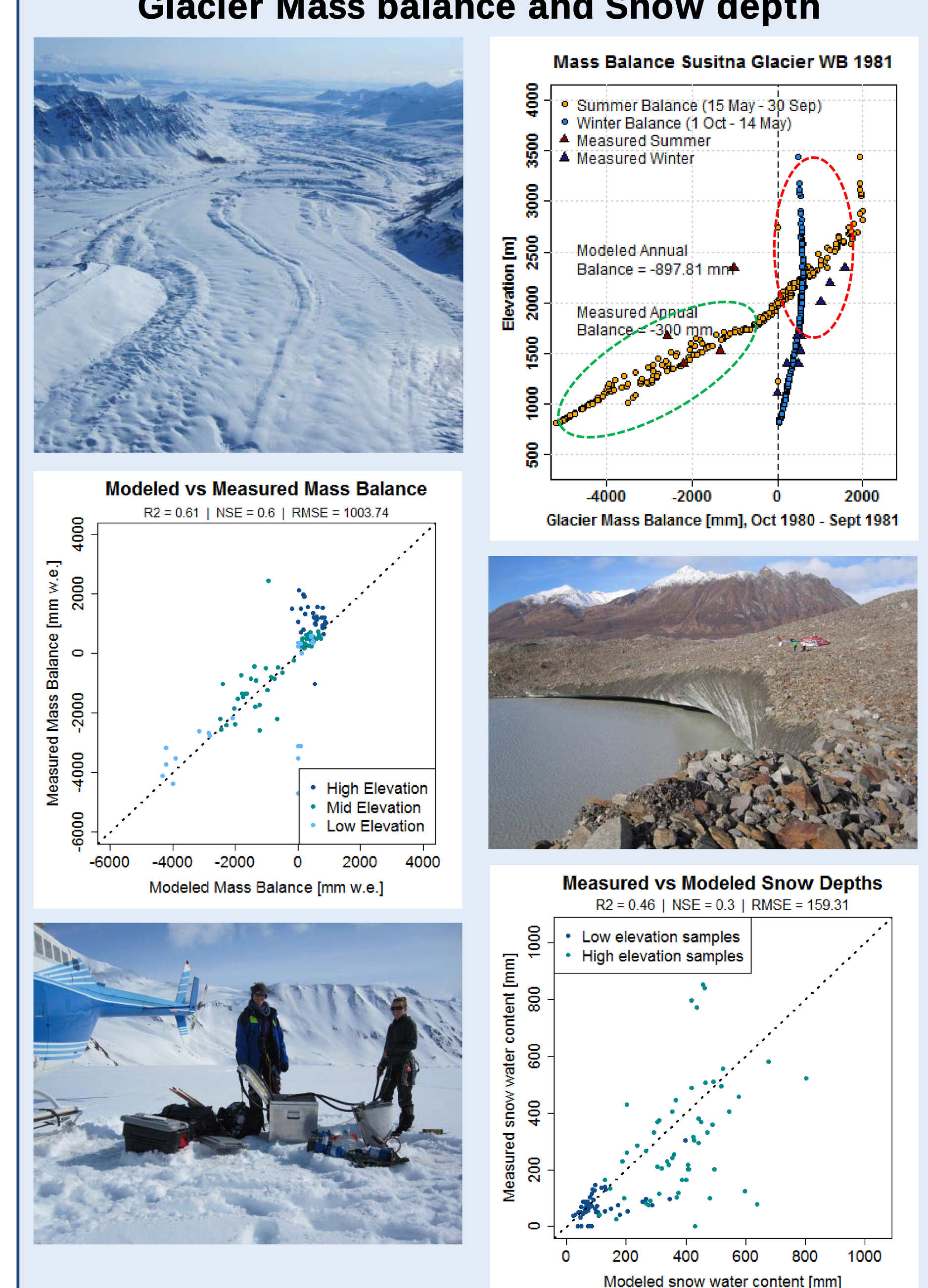
- The calibration period 1981 – 1983 and the validation period 2012 – 2014 are forced with daily temperature and precipitation data. The Basin was sub-divided into three regions in order to receive a good spatio-temporal representation of precipitation in the lower lying (yellow) areas based on measured data while achieving higher effective precipitation values in the glacierized sub-basins (purple and blue) by the application of lapse rates.

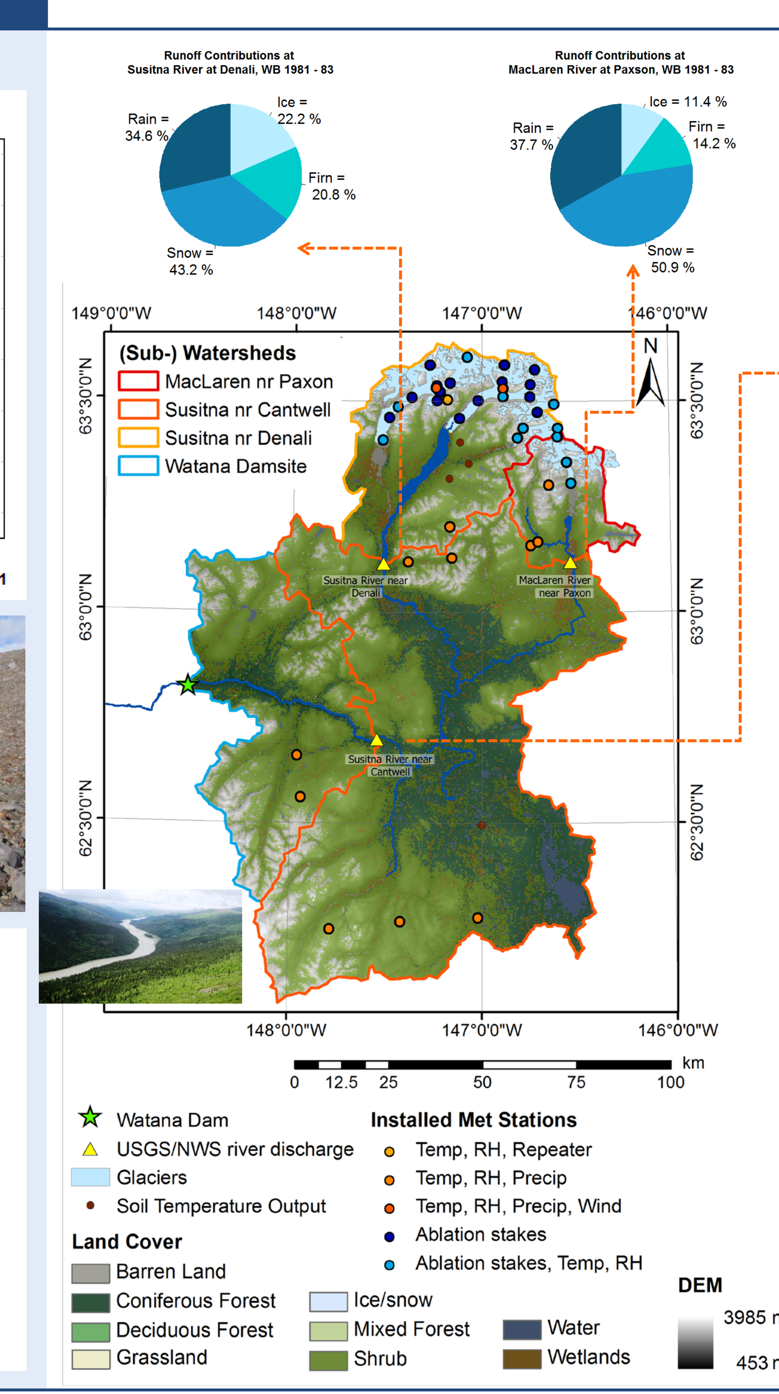
Future Projections

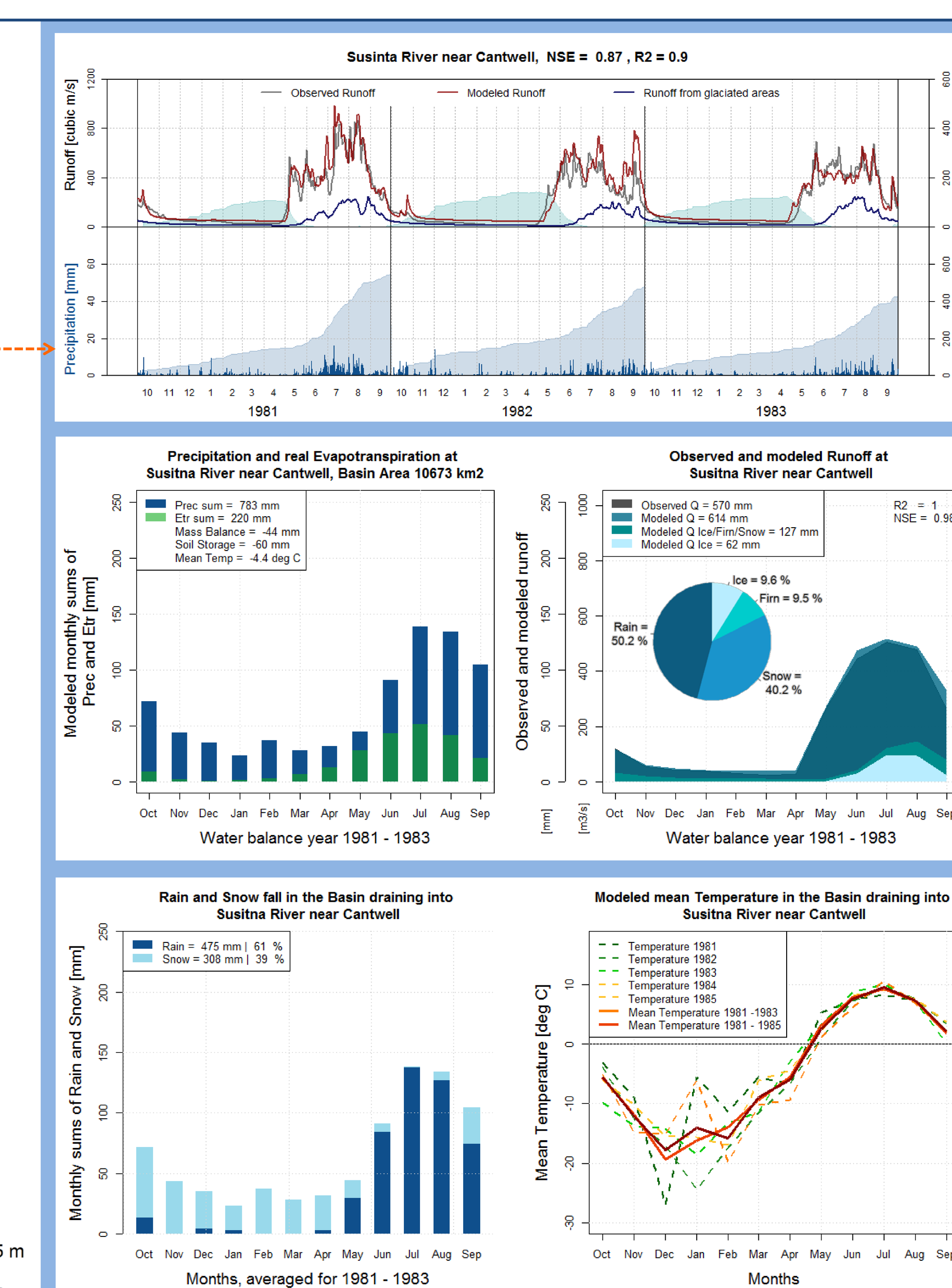


Model Results - Calibration

Glacier Mass balance and Snow depth







Conclusion and Outlook

- The model is not only capable of reproducing historic discharge values but it enables a better understanding of the diverse hydrologic processes in the Upper Susitna basin and their interaction.
- Once calibration and validation is completed, the physically sound representation of these processes is expected to lead to enhanced runoff estimates for the proposed Susitna-Watana-Dam when driven by climate projections.

References

[a] Alaska Legislature House Bill 306, 2010, [http://www.legis.state.ak.us/basis/get_bill_text.asp?hsid=HB0306F&session=26]

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