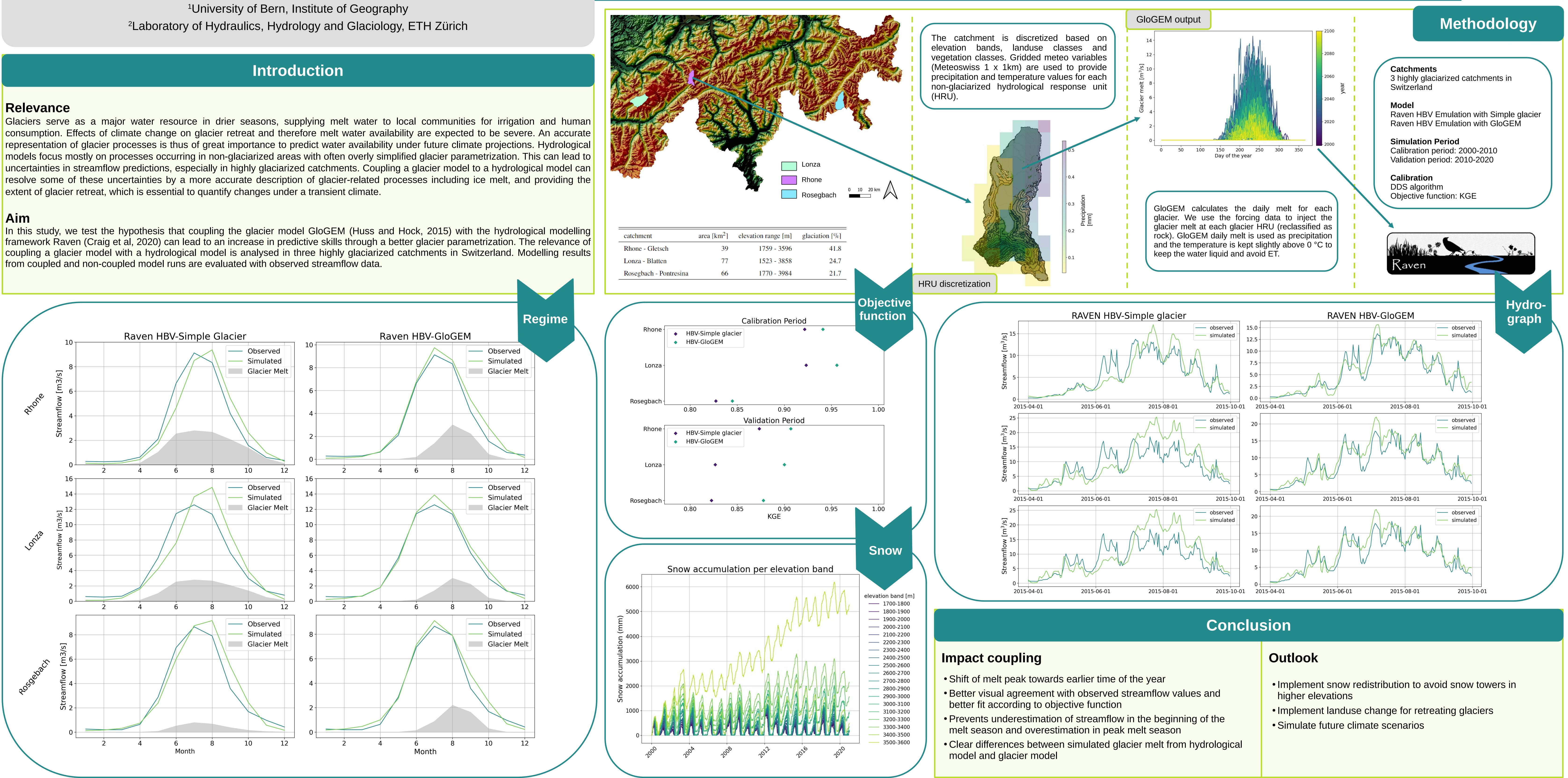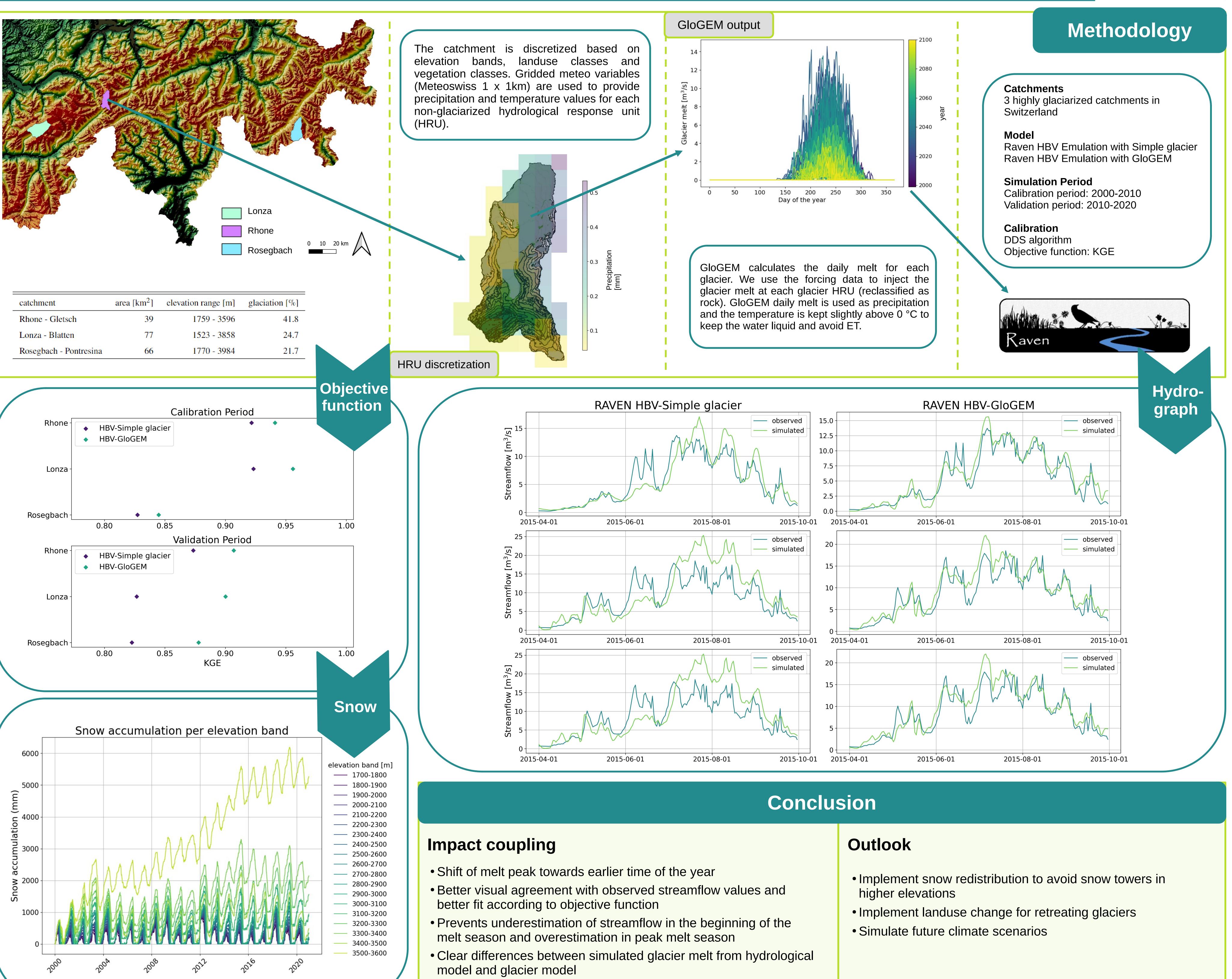# Changes in predictive skills through coupling a hydrological modelling framework with a glacier model

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OESCHGER CENTRE CLIMATE CHANGE RESEARCH

Introduction

Relevance
Glaciers serve as a major water resource in drier seasons, supplying melt water to local communities for irrigation and human consumption. Effects of climate change on glacier retreat and therefore melt water availability are expected to be severe. An accurate representation of glacier processes is thus of great importance to predict water availability under future climate projections. Hydrological models focus mostly on processes occurring in non-glaciarized areas with often overly simplified glacier parametrization. This can lead to uncertainties in streamflow predictions, especially in highly glaciarized catchments. Coupling a glacier model to a hydrological model can resolve some of these uncertainties by a more accurate description of glacier-related processes including ice melt, and providing the extent of glacier retreat, which is essential to quantify changes under a transient climate.

Aim
In this study, we test the hypothesis that coupling the glacier model GloGEM (Huss and Hock, 2015) with the hydrological modelling framework Raven (Craig et al, 2020) can lead to an increase in predictive skills through a better glacier parametrization. The relevance of coupling a glacier model with a hydrological model is analysed in three highly glaciarized catchments in Switzerland. Modelling results from coupled and non-coupled model runs are evaluated with observed streamflow data.

The catchment is discretized based on elevation bands, landuse classes and vegetation classes. Gridded meteo variables (Meteoswiss 1 x 1km) are used to provide precipitation and temperature values for each non-glaciarized hydrological response unit (HRU).

GloGEM output

Methodology

Catchments
3 highly glaciarized catchments in Switzerland

Model
Raven HBV Emulation with Simple glacier
Raven HBV Emulation with GloGEM

Simulation Period
Calibration period: 2000-2010
Validation period: 2010-2020

Calibration
DDS algorithm
Objective function: KGE

GloGEM calculates the daily melt for each glacier. We use the forcing data to inject the glacier melt at each glacier HRU (reclassified as rock). GloGEM daily melt is used as precipitation and the temperature is kept slightly above 0 °C to keep the water liquid and avoid ET.

HRU discretization

catchment	area [km²]	elevation range [m]	glaciation [%]
Rhone - Gletsch	39	1759 - 3596	41.8
Lonza - Blatten	77	1523 - 3858	24.7
Rosegbach - Pontresina	66	1770 - 3984	21.7

Raven

Regime

Objective function

Hydro-graph

Snow

Conclusion

Impact coupling
- Shift of melt peak towards earlier time of the year
- Better visual agreement with observed streamflow values and better fit according to objective function
- Prevents underestimation of streamflow in the beginning of the melt season and overestimation in peak melt season
- Clear differences between simulated glacier melt from hydrological model and glacier model

Outlook
- Implement snow redistribution to avoid snow towers in higher elevations
- Implement landuse change for retreating glaciers
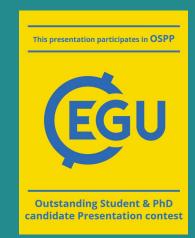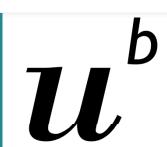- Simulate future climate scenarios

References
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