Improving snowpack and hydrological modelling by performing an undercatch correction on high resolution spatial precipitation data

Philipp Maier[1], Herbert Formayer[1], Fabian Lehner[1], Caroline Ehrendorfer[2], Mathew Herrnegger[2], Hubert Holzmann[2], Sophie Lücking[2], Thomas Pulka[2], Franziska Koch[2]
and all further project partners (Verbund Energy4Business, Uni Innsbruck, TU Wien, AIT)

[1] Institute of Meteorology and Climatology (BOKU-Met), BOKU University of Natural Resources and Life Sciences, Vienna, AT
[2] Institute of Hydrology and Water Management (HyWa), BOKU University of Natural Resources and Life Sciences, Vienna, AT

Corresponding author : philipp.maier@boku.ac.at
Project leader: franziska.koch@boku.ac.at

HyMELT-CC PROJECT OVERVIEW

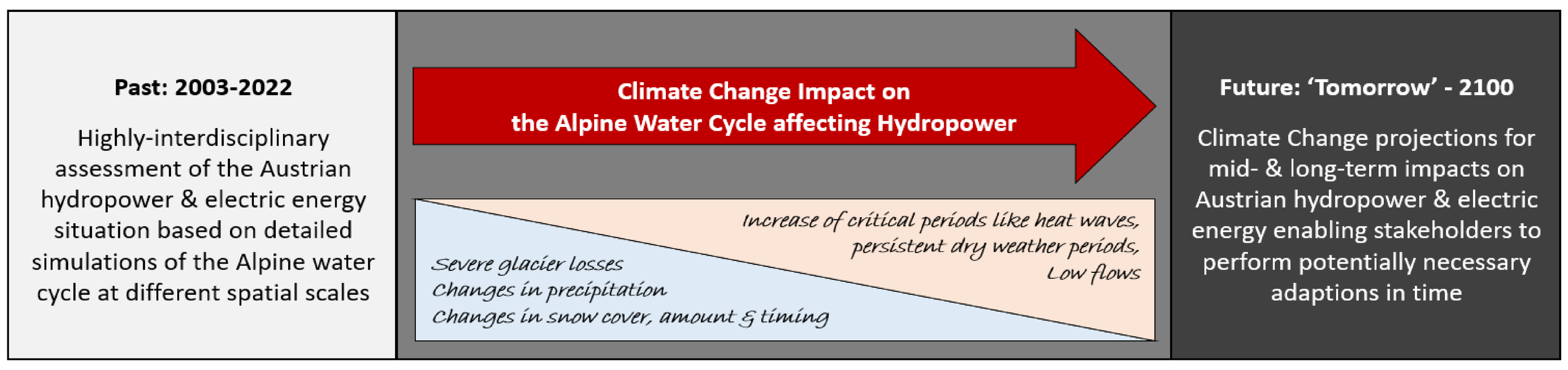

Figure 1: Scope of the project HYdro power: iMpact on the ELecTricity sector in Austria due to Climate Change in glaciated high alpine areas (HyMELT-CC).

HyMELT-CC performs a detailed assessment of the impact of Climate Change on the Alpine water cycle, including future glacier evolution, having an impact on hydropower supply and the overall electricity sector. The assessment focuses on very detailed simulations in high-alpine case study regions (Maltatal & Zillertal) as well as the upscaling to entire Austria. Specific focus is on critical situations like heat waves or low flow situations to enable timely adaptations of hydropower companies to safeguard electricity supply also in the future.

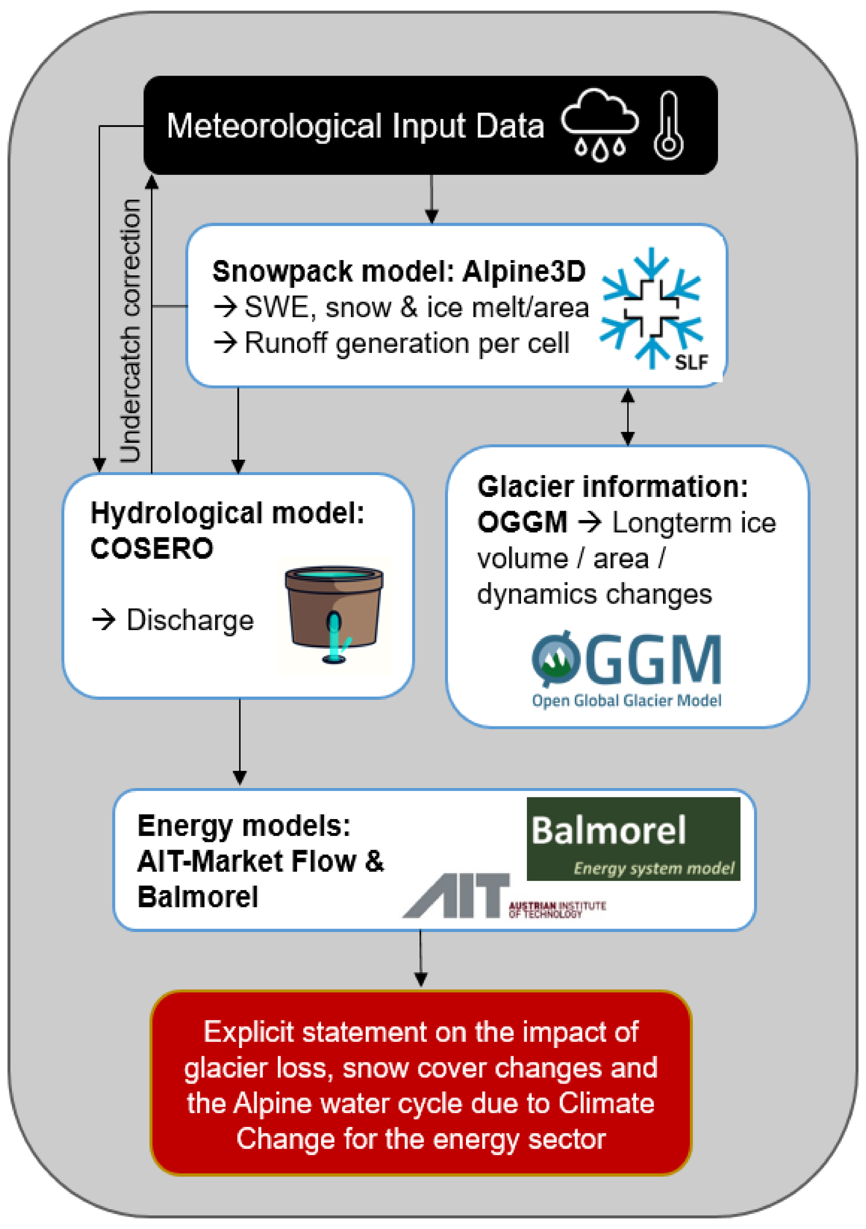

Figure 2: Methodological setup of an interdisciplinary model chain including data exchange for high resolution modelling in the study case regions. The interdisciplinary HyMELT-CC approach consists of components of the cryosphere, as well as hydrology, meteorology and includes energy system modelling.

MOTIVATION & CONTEXT FOR THIS STUDY

Hydropower is an important source of energy production in Austria [1]. With climate change and the transition towards renewable energy sources, precise modelling of runoff processes, such as snow and ice melt, is crucial to provide useful adaption strategies to stakeholders. Meteorological input data for hydrological models is characterized by high uncertainties in complex, alpine terrain, which frequently lead to simulated runoff or glacier mass balances which do not match observations. A well known issue is the undercatch of precipitation stations in high elevations. Gridded precipitation data sets [4] usually stem from a station-interpolation which doesn't consider precipitation-undercatch. Calculations to derive corrected station precipitation amounts

$$pr_{corr}[mm] = \frac{pr[mm]}{CE[\%]/100} \qquad (1)$$

using catch efficiency CE, e.g. for unshielded Hellmann gauges:

$$CE\,[\%] = 96.63 + 0.41\,wspd^2 - 9.84\,wspd + 5.95.T \; (2)$$

where $wspd$ is the wind speed in m/s, T is the temperature in °C are not applicable to gridded datasets, as information about what the meteorological conditions were at the location of the station is effectively lost in the interpolation step [5]. Therefore, a different approach for correcting precipitation data in high elevated areas, where gridded data sets are corrected dependent on the altitude, need to be discussed.

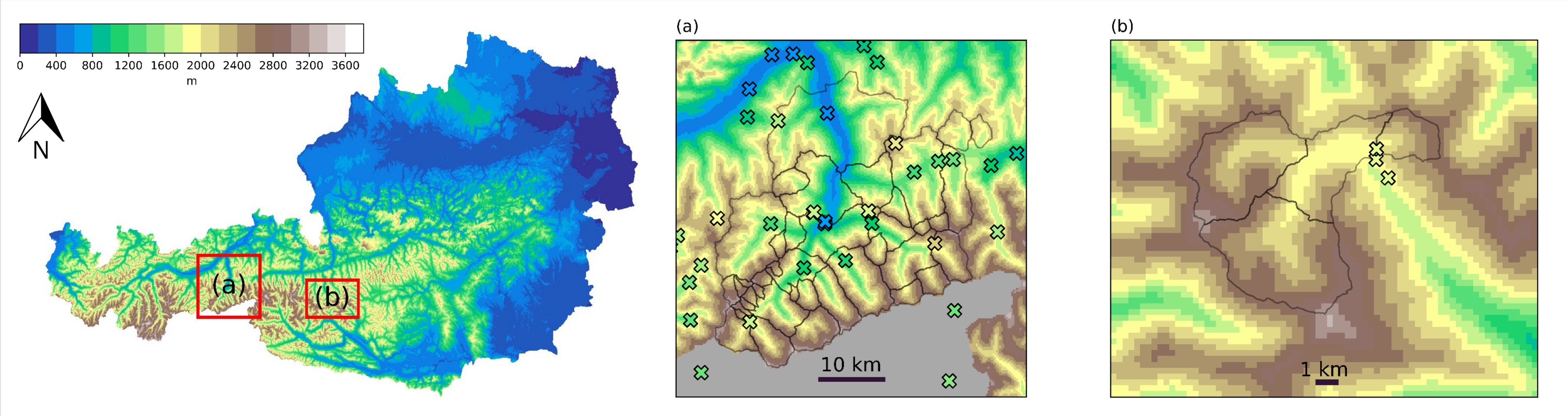

Figure 3: Elevation of (a) Austria and the two case study areas (a) Zillertal and (b) Maltatal in m.a.s.l. The study areas are shown in the two red boxes. Catchment areas are outlined in gray. Used stations are marked with crosses.

...A simple linear undercatch regression with elevation can do a lot for your hydrological model!

METHODS

Regarding the derived regressions for the precipitation undercatch correction, the fractions were calculated by correcting quality-controlled station data from both study regions using Eq. (1) and (2) and dividing the corrected amount through the nearest cell value of gridded precipitation data [4]. Afterwards, a piece-wise linear regression was applied, where a split at 1500 m a.s.l. was implemented to account for different levels of exposure. As snow measurements are even more inaccurate than rain due to higher wind transport, precipitation undercatch increases in winter when it's colder.

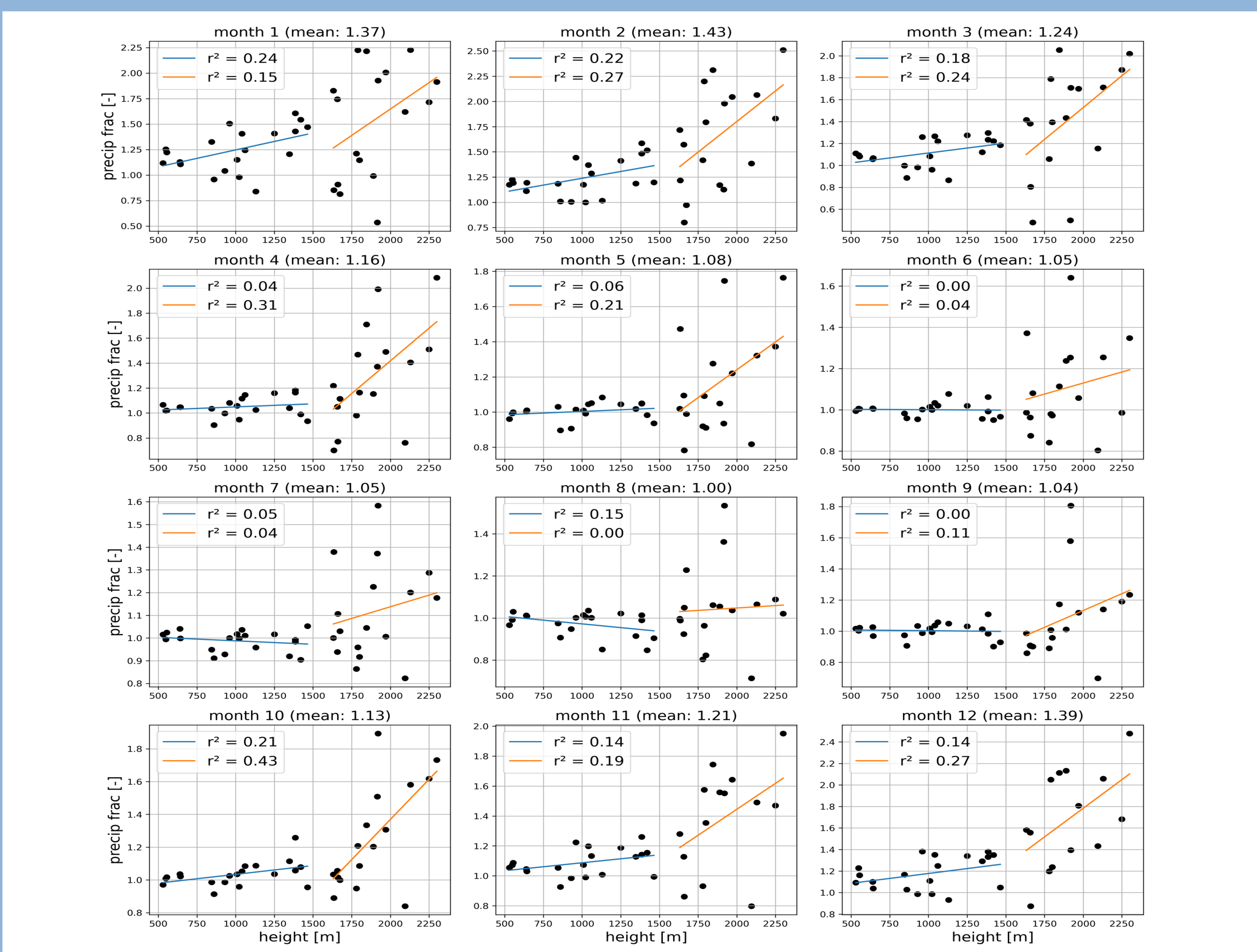

Figure 4: Monthly precipitation undercatch correction factors as a function of elevation, based on fractions of undercatch-corrected station precipitation to gridded dataset precipitation.

RESULTS & VALIDATION

The uncorrected and corrected precipitation was used as model input for snow and glacier modelling with Alpine3D [3] as well as the hydrological COSERO model [2]. The simulated discharge was compared with observed reservoir inflow and the simulated snow accumulation was compared with stereo satellite-derived snow height maps.

Table 1: Precipitation correction for the case study areas Maltatal and Zillertal

Precipitation correction	Zillertal	Maltatal
Mean annual correction amount [mm]	343	608
Mean annual correction factor [-]	1.34	1.49

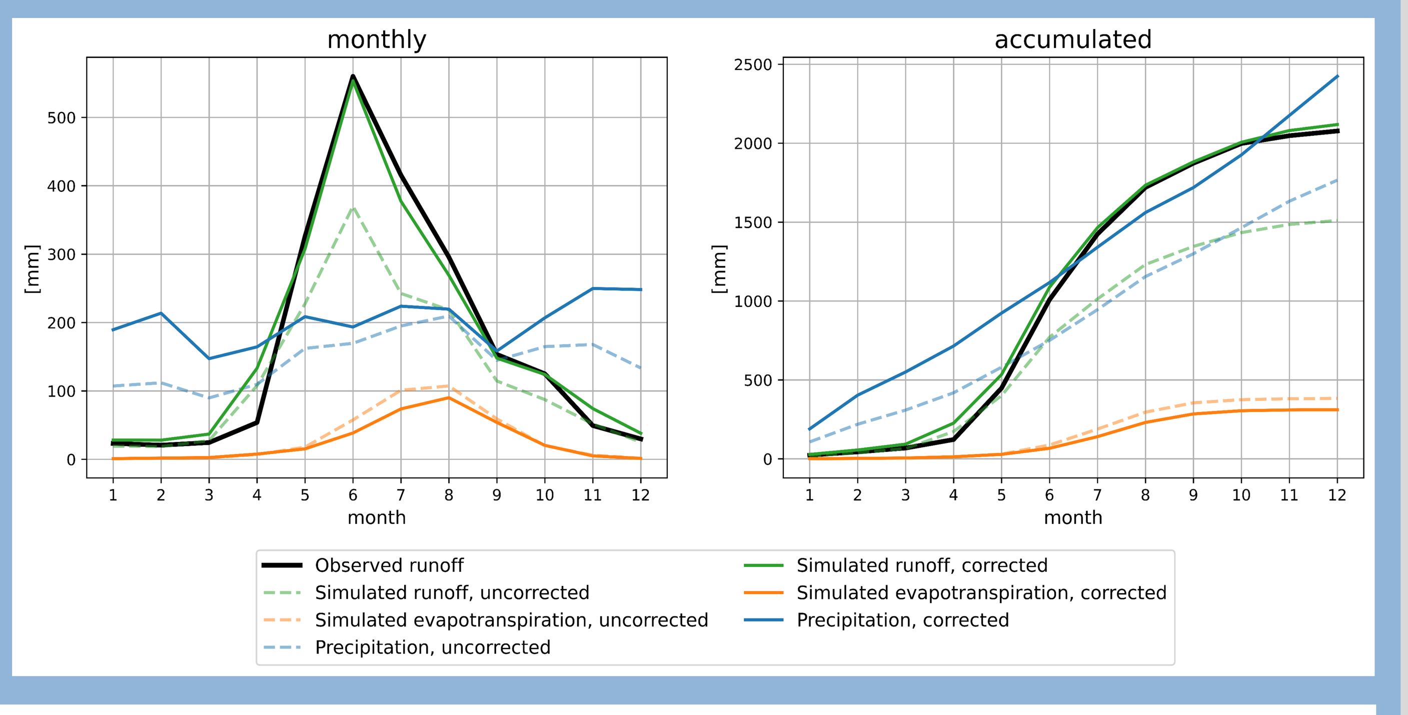

Figure 5: Comparison of the water balance (monthly and accumulated) in the Kölnbrein catchment (Maltatal) between 2015 and 2022. The simulated water balance components from the hydrological COSERO model without undercatch correction are displayed as dashed lines, the corrected ones as solid lines. The observed runoff (reservoir inflow) is displayed in black. Using the undercatch-corrected data greatly improves the performance of the hydrological model.

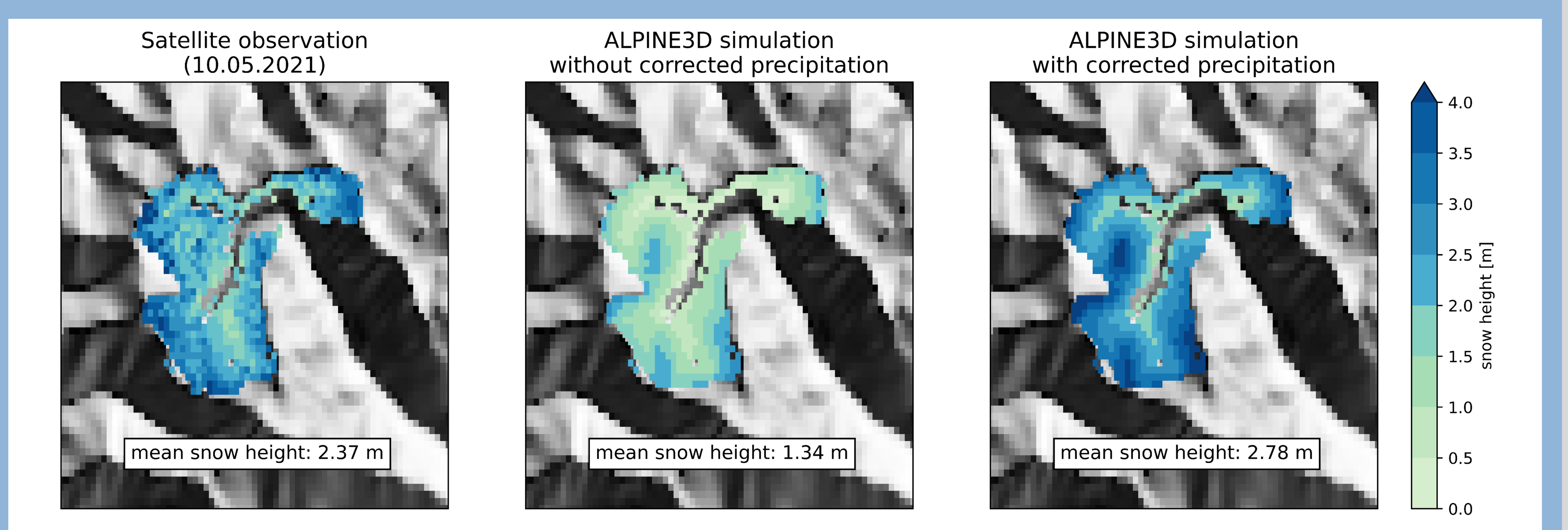

Figure 6: Comparison of snow height maps for Maltatal derived via satellite stereo images (left) as well as simulated with Alpine3D [3] (middle & right). The snow height matches the observations better when using the undercatch correction. We attribute the overestimation of snow height to missing snow drift caused by wind.

Acknowledgements: We want to thank the Klima und Energiefonds for funding this project (ACRP14 - HyMELT-CC - KR21KB0K00001) as well as the Verbund Energy4Business GmbH for providing us with reservoir inflow data and satellite-based snow cover maps.

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