



# Monitoring snow processes in the Ötztal Alps (Austria) and development of an open source snow model framework

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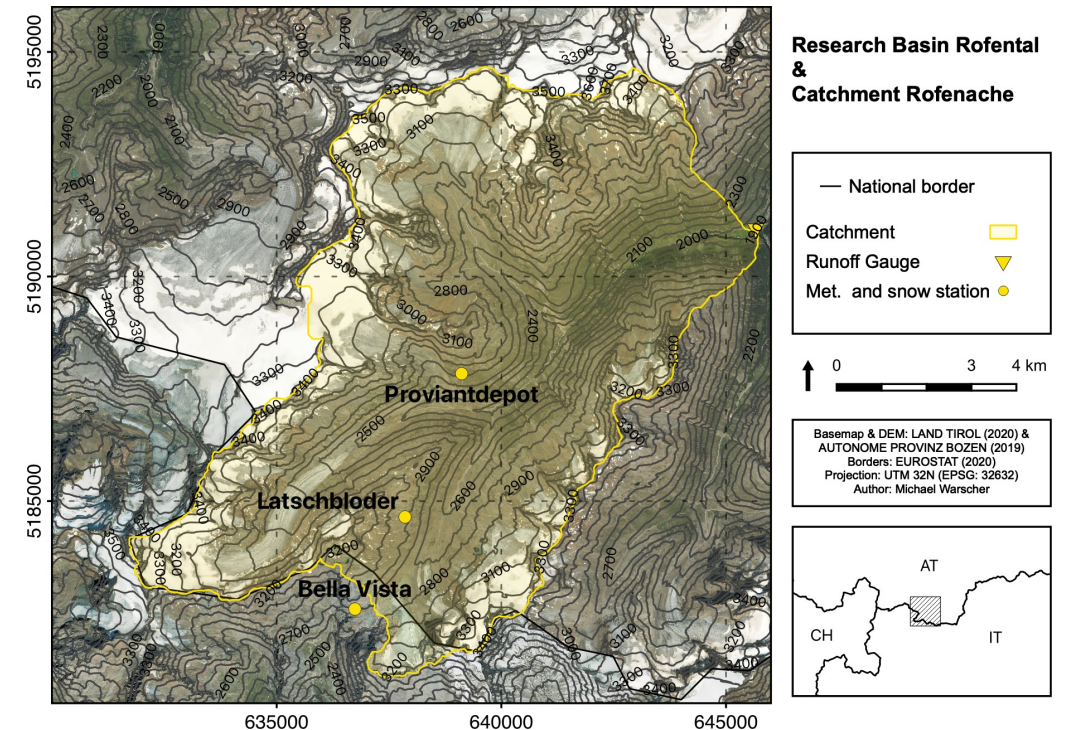
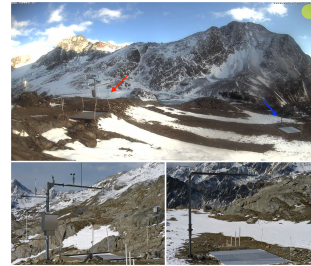
# Continuous observations of snow cover properties at three high-alpine climate stations

10-min. recordings of meteorological variables

- temperature, humidity, air pressure, wind speed and direction, SW/LW radiation (in and out), precipitation

AND snow variables

- snow depth (SD)
- snow water equivalent (SWE)
- snow surface temperature
- layered snow temperature profile
- snow drift: acoustic sensor and experimental setup with two nearby SD and SWE measurements
- liquid / solid water content (SPA)
- snow density (SWE/SD and SPA)



# Complementing and continuing a large data collection

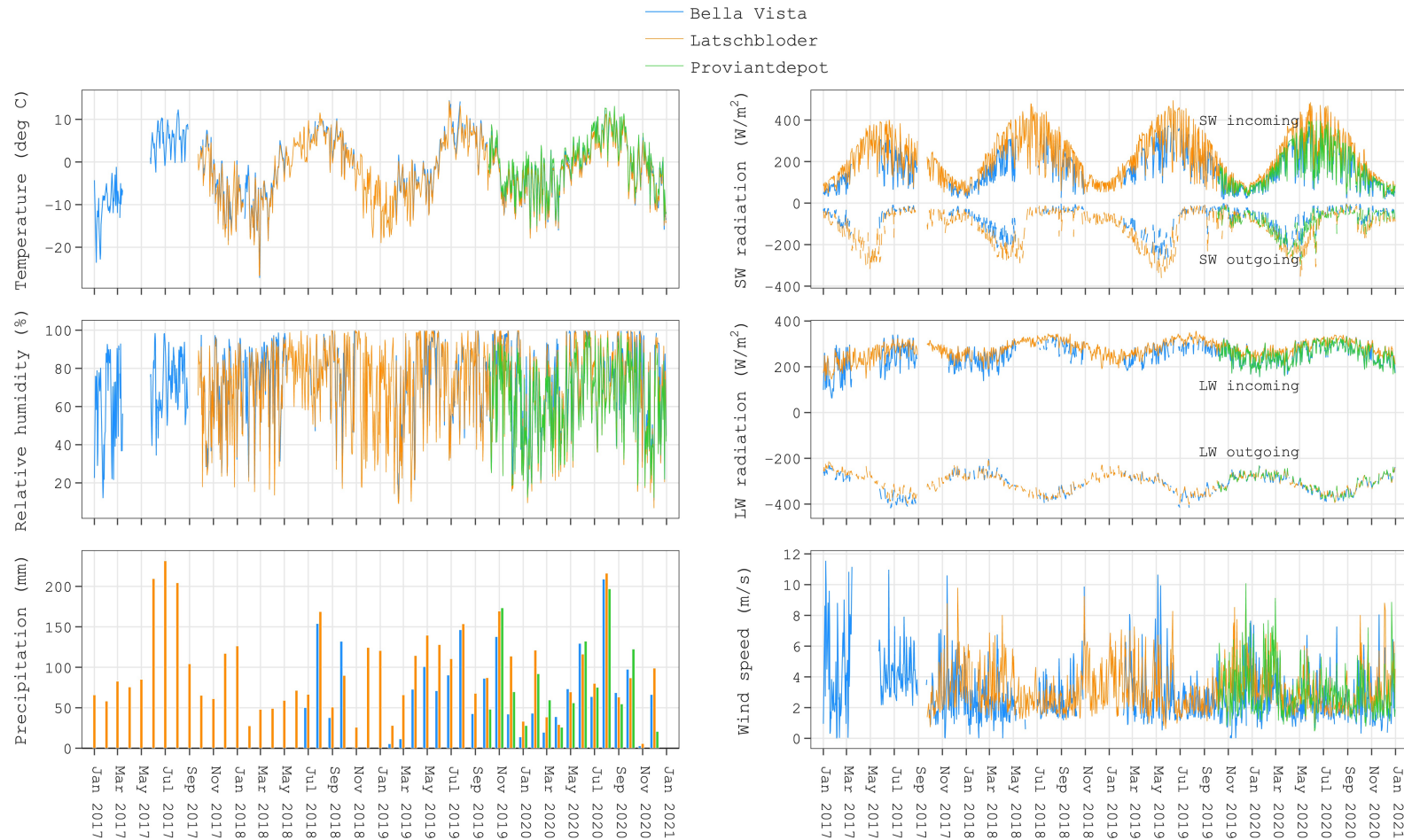
Research Basin Rofental in the Ötztal Alps (1.890 to 3.770 m a.s.l., 98.1 km<sup>2</sup>), monitoring activities since 1884 by many people and institutions (documented in Strasser et al. 2018 and Warscher et al. 2021)

Large, curated data collection available at <https://www.pangaea.de/?q=%40ref104365> and <https://doi.org/10.1594/PANGAEA.876120>

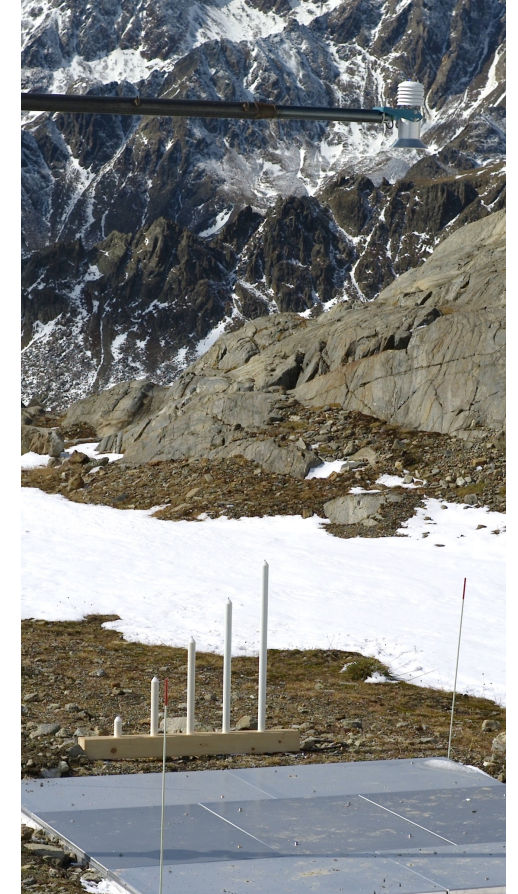
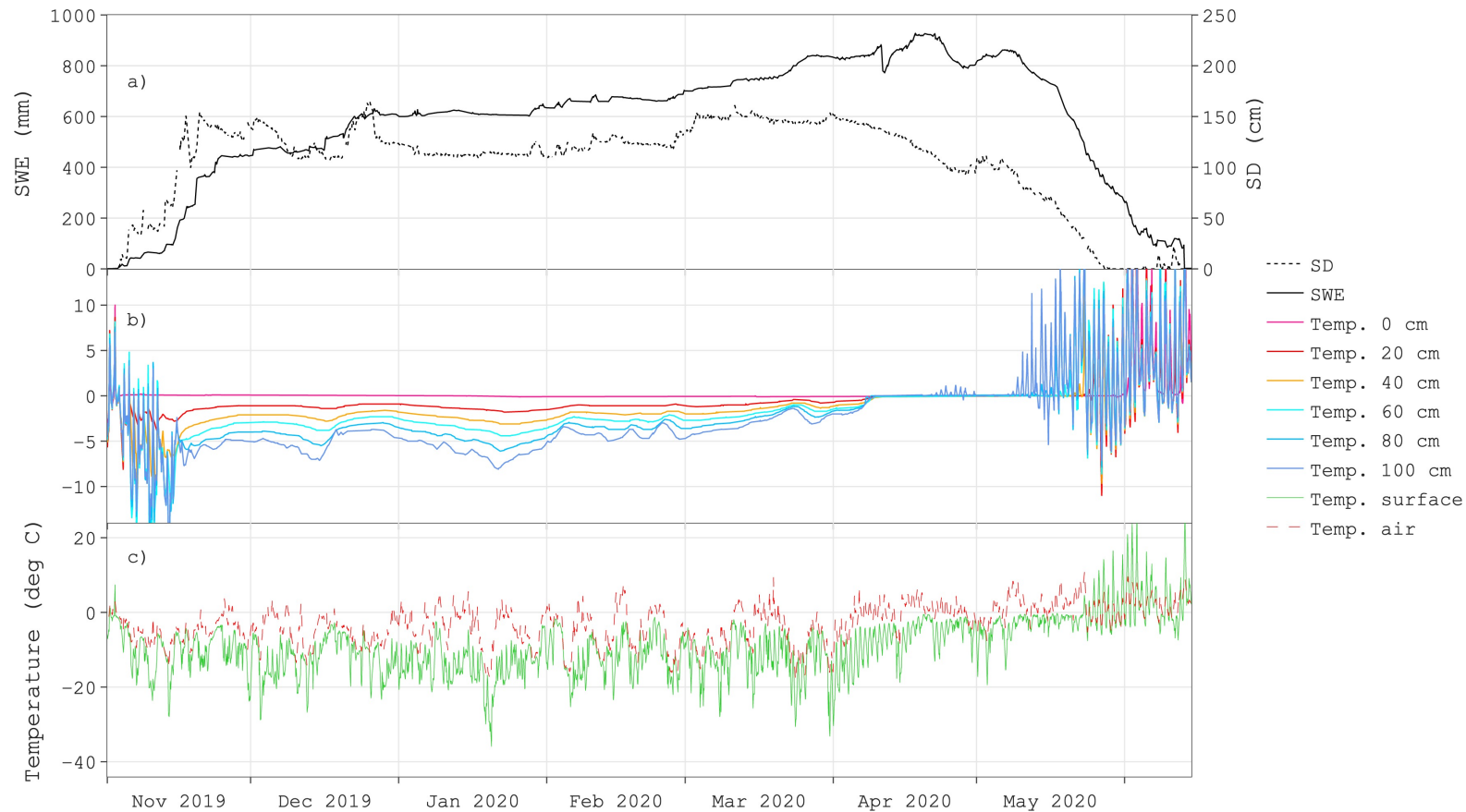
Part of international research initiatives

- UNESCO IHP <http://en.unesco.org/themes/water-security/hydrology>
- GEWEX INARCH <https://www.usask.ca/inarch/>
- ERB Euro-Mediterranean Network of Experimental and Representative Basins <http://erb-network.simdif.com>
- LTSER platform Tyrolean Alps within LTER Austria, LTER Europe and ILTER <http://lter-austria.at/ta-tyrolean-alps>
- EU Horizon 2020 INTERACT research stations <https://eu-interact.org/field-sites/station-hintereis/>

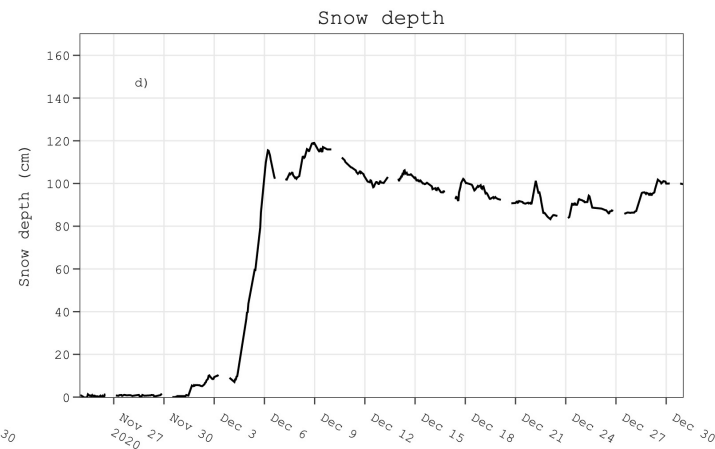
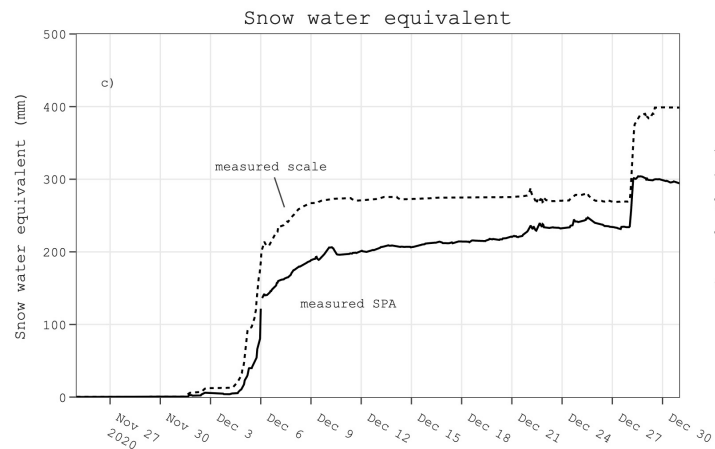
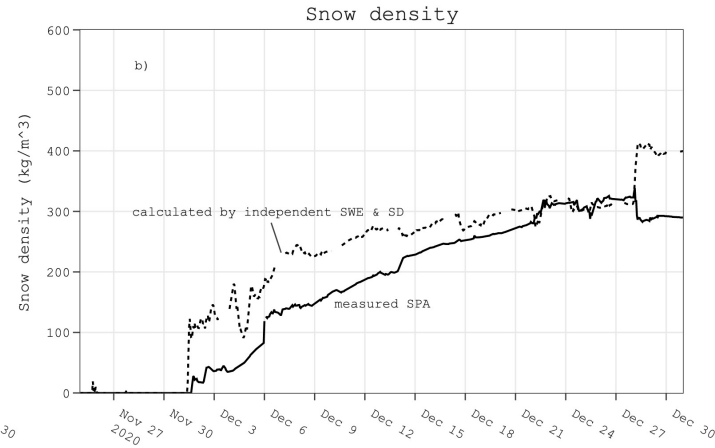
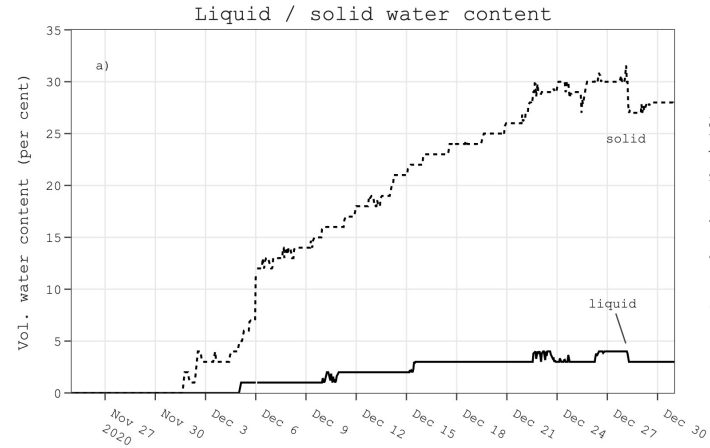
# Meteorological data (temperature, humidity, precipitation, wind speed, short- and longwave radiation)



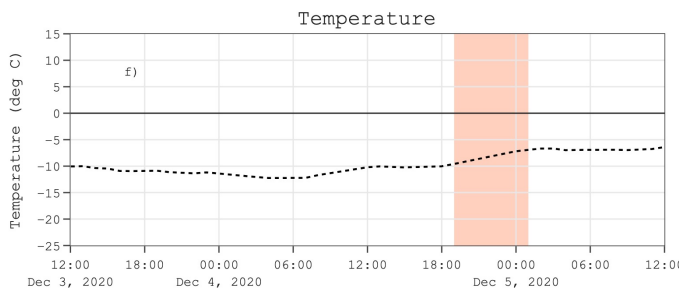
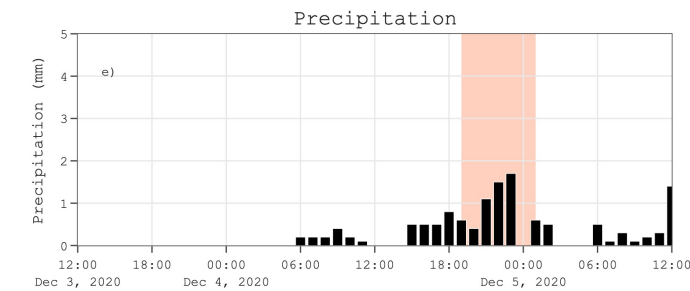
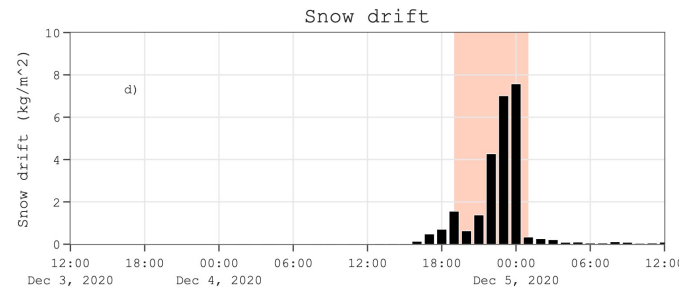
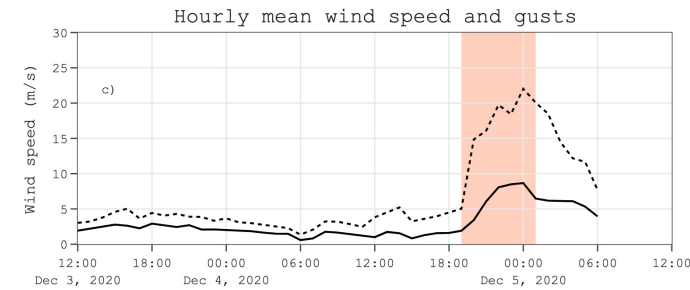
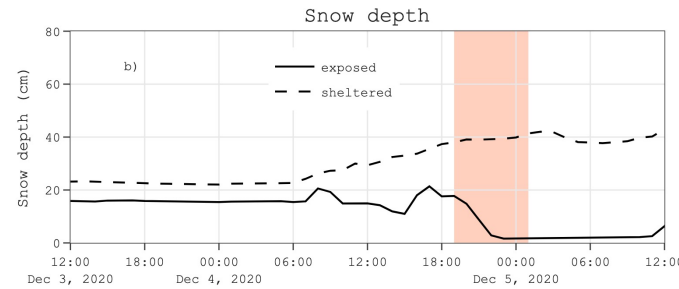
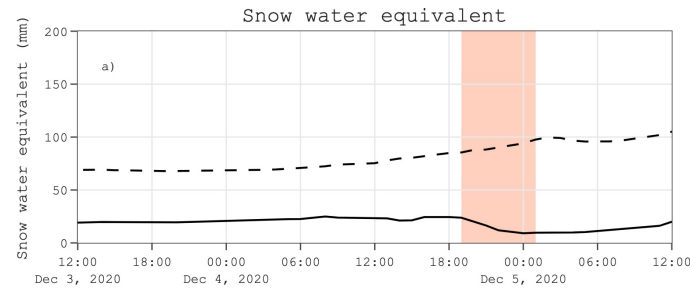
# SWE, SD, snow temperature profile, air and surface temperature



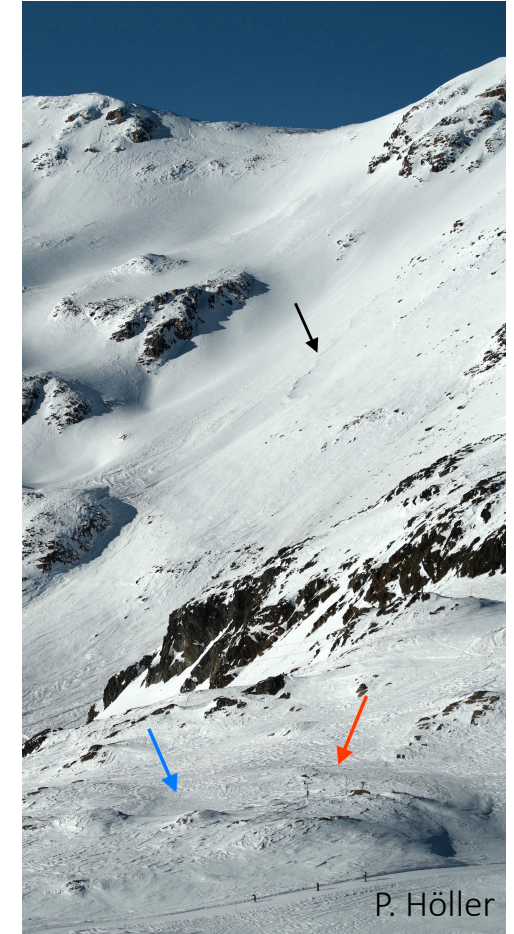
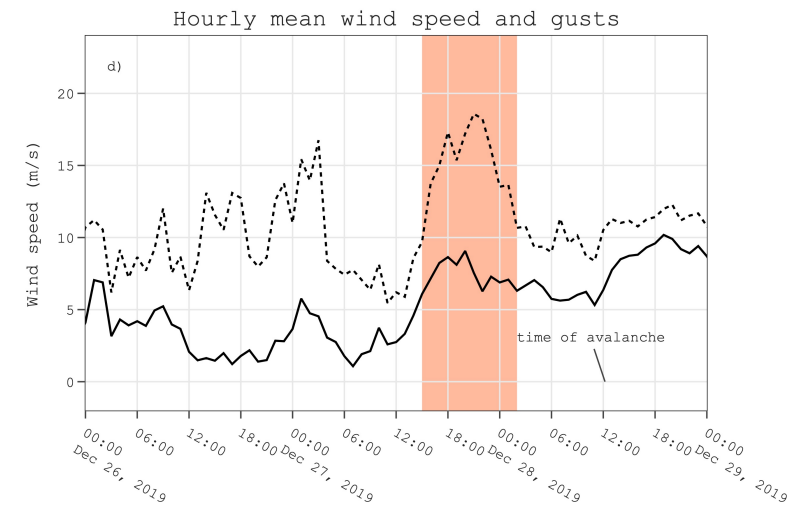
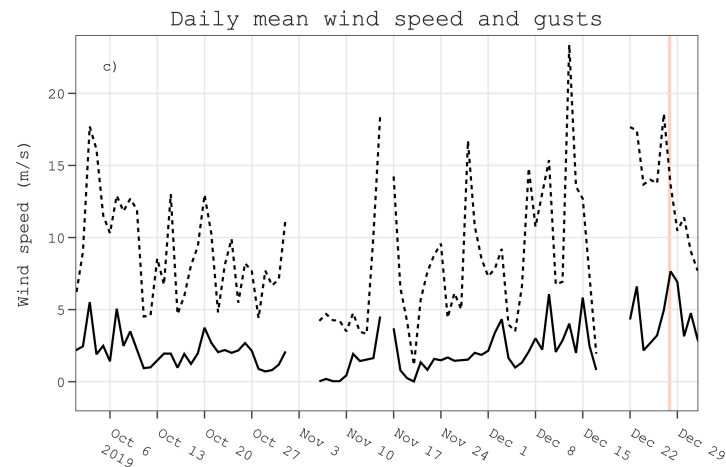
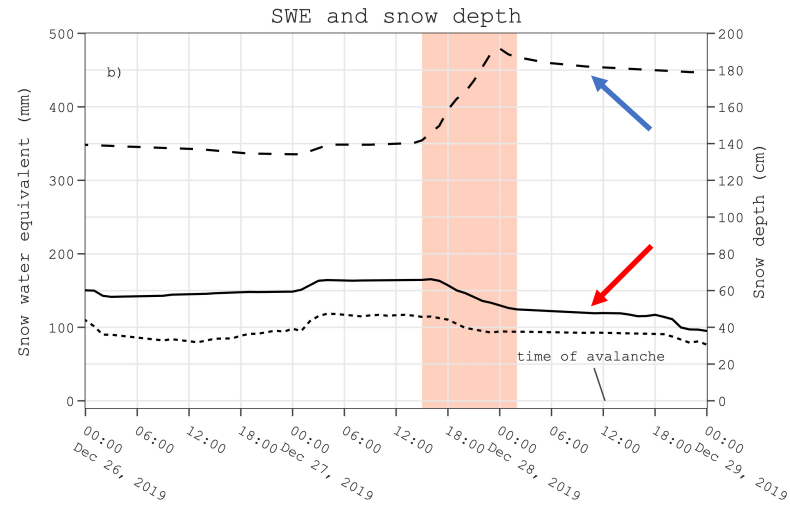
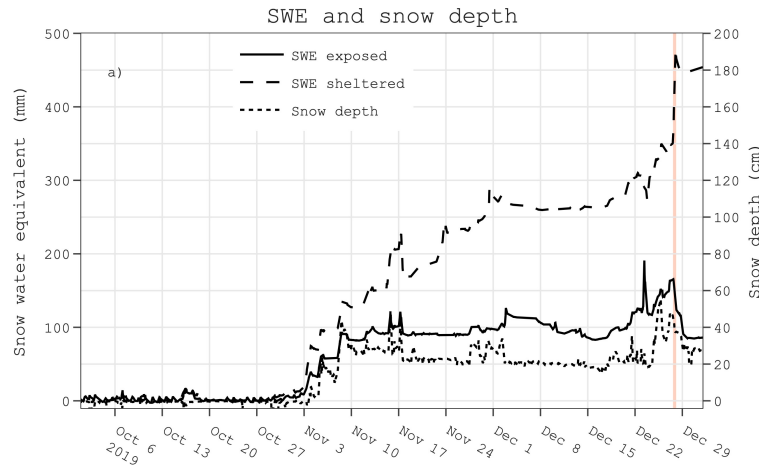
# Liquid / solid water content, snow density (Snow Pack Analyzer)



# Wind-driven snow redistribution (acoustic sensor and double SD and SWE measurement)



# Avalanche Dec. 2019 (observation of nearby snow redistribution)



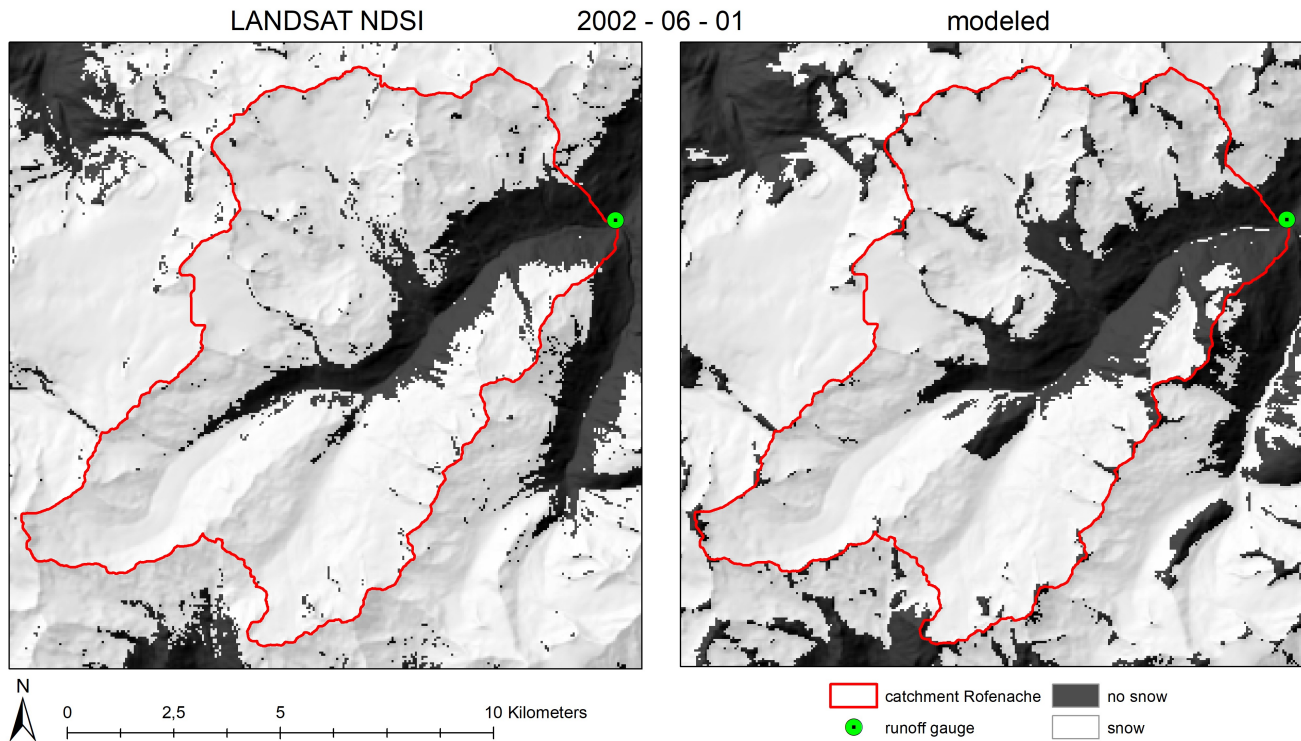


# Open source snow and hydroclimatological modeling framework “openAMUNDSEN”

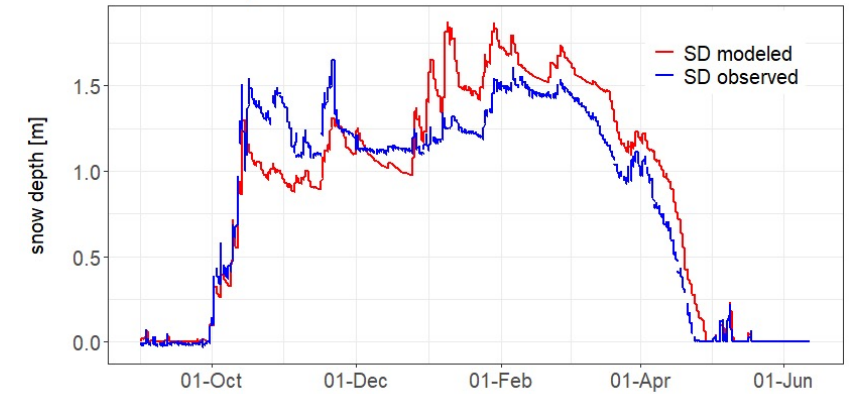
openAMUNDSEN = newly developed, open source version of AMUNDSEN

- spatially distributed, physically based model for the simulation of the mountain snow cover (accumulation, redistribution, ablation) and hydrology from meteorological observations and model outputs
- developed since 2001, many projects and publications (<https://www.uibk.ac.at/geographie/mus/>)
- validated in many alpine catchments (resolutions: 5 m to 1 km, 1 h to 1 d)
- took part in SnowMIP, SnowMIP2, and ESM-SnowMIP
- process descriptions of: spatial redistribution of meteorological forcing, radiation modeling, inside canopy micrometeorology, snow-canopy interaction, lateral snow redistribution (wind / gravitation), albedo ageing, snow density, liquid water content, cold content, different schemes for snow pack/surface energy balance (“cryolayers”, “multilayer”), option for T-Index, etc.
- completely rewritten in a modular python structure
- now open source and publicly available at: <https://github.com/openamundsen/openamundsen>

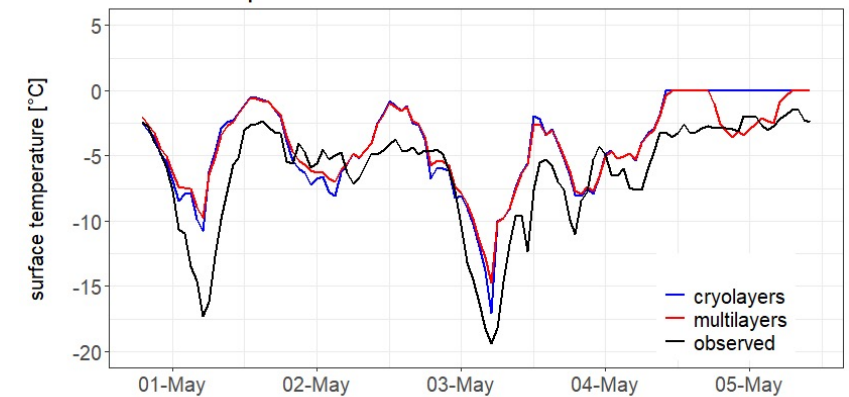
# openAMUNDSEN – Validation Rofental data



Proviandepot - season 2019/2020

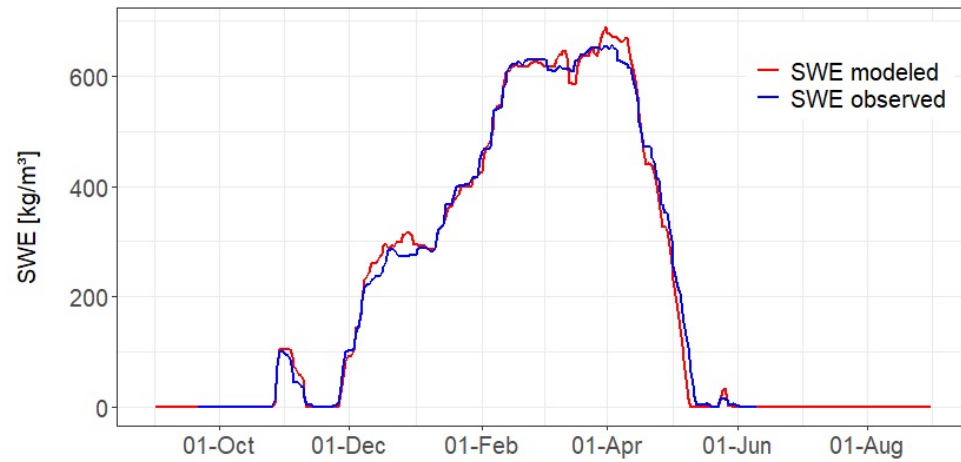


Proviandepot - season 2019/2020

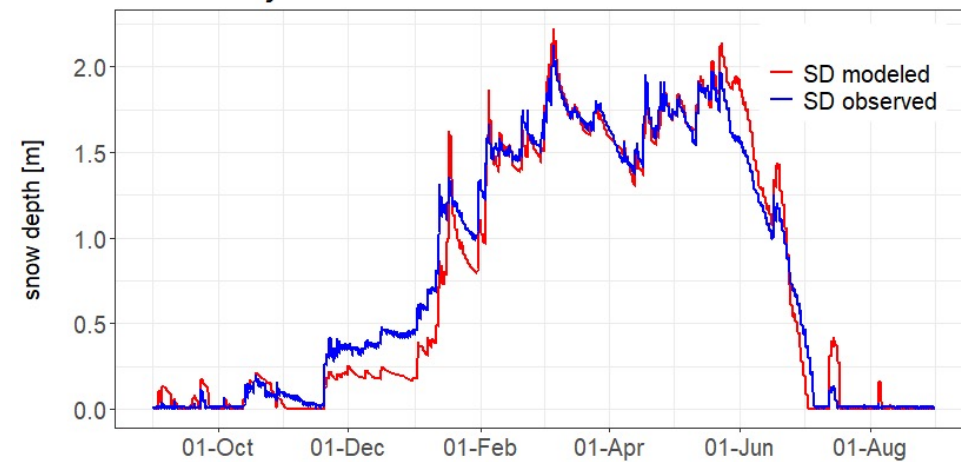


# openAMUNDSEN – Validation ESM-SnowMIP data

Col de Porte - season 2012/2013



Weissfluhjoch - season 2015/2016



# Thank you for your interest!

If you want to find out more:

- » see the new ESSDD paper: <https://essd.copernicus.org/preprints/essd-2021-68/>
- » see the previous ESSD paper: <https://essd.copernicus.org/articles/10/151/2018/>
- » download the data: <https://www.pangaea.de/?q=%40ref104365>, <https://doi.org/10.1594/PANGAEA.876120>
- » try the model: <https://github.com/openamundsen/openamundsen>
- » and don't hesitate to contact us: [michael.warscher@uibk.ac.at](mailto:michael.warscher@uibk.ac.at)