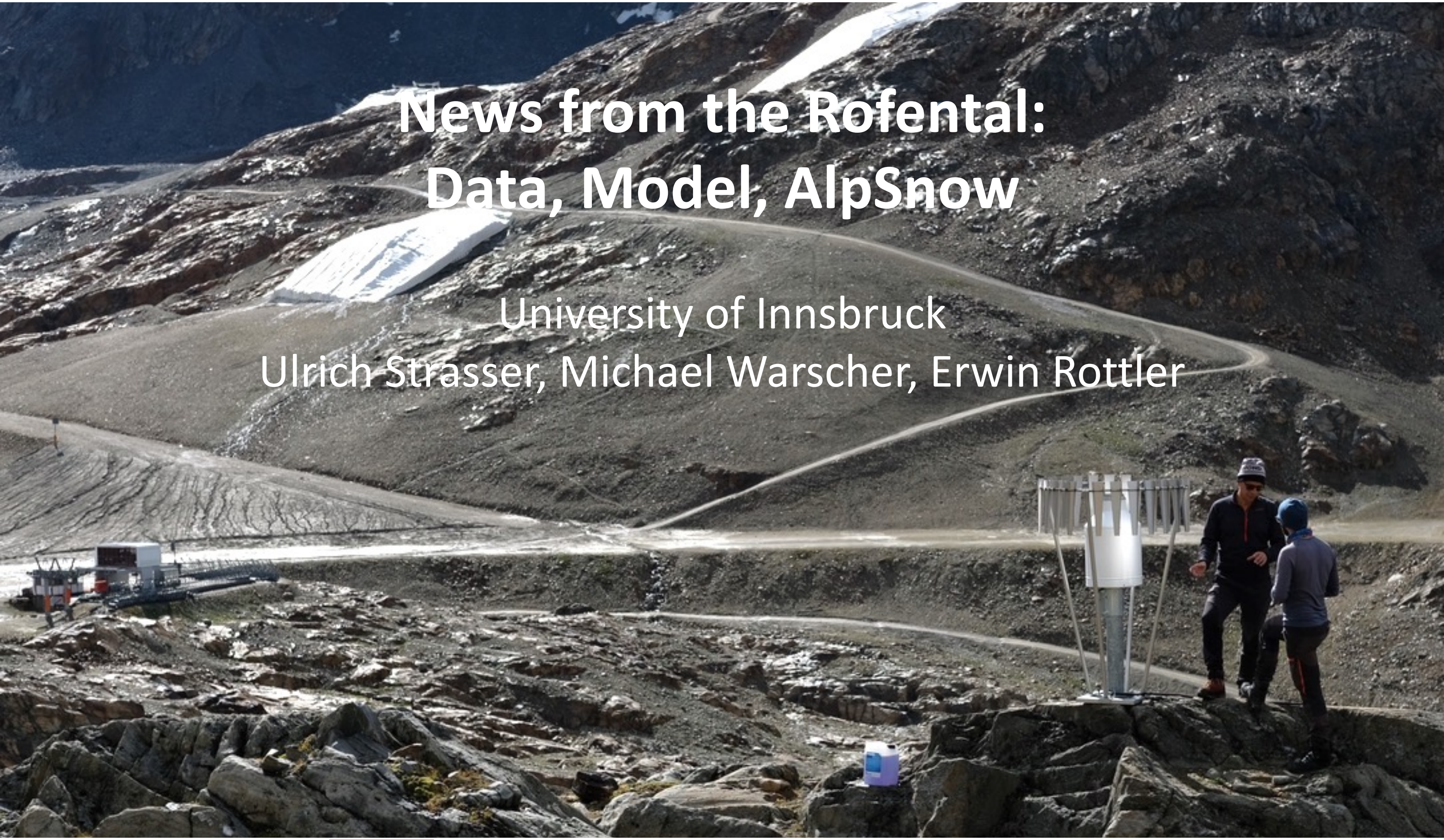
Research Basin Rofental



News from the Rofental: Data, Model, AlpSnow

University of Innsbruck
Ulrich Strasser, Michael Warscher, Erwin Rottler

LTSER tyroleanalps

AlpSnow

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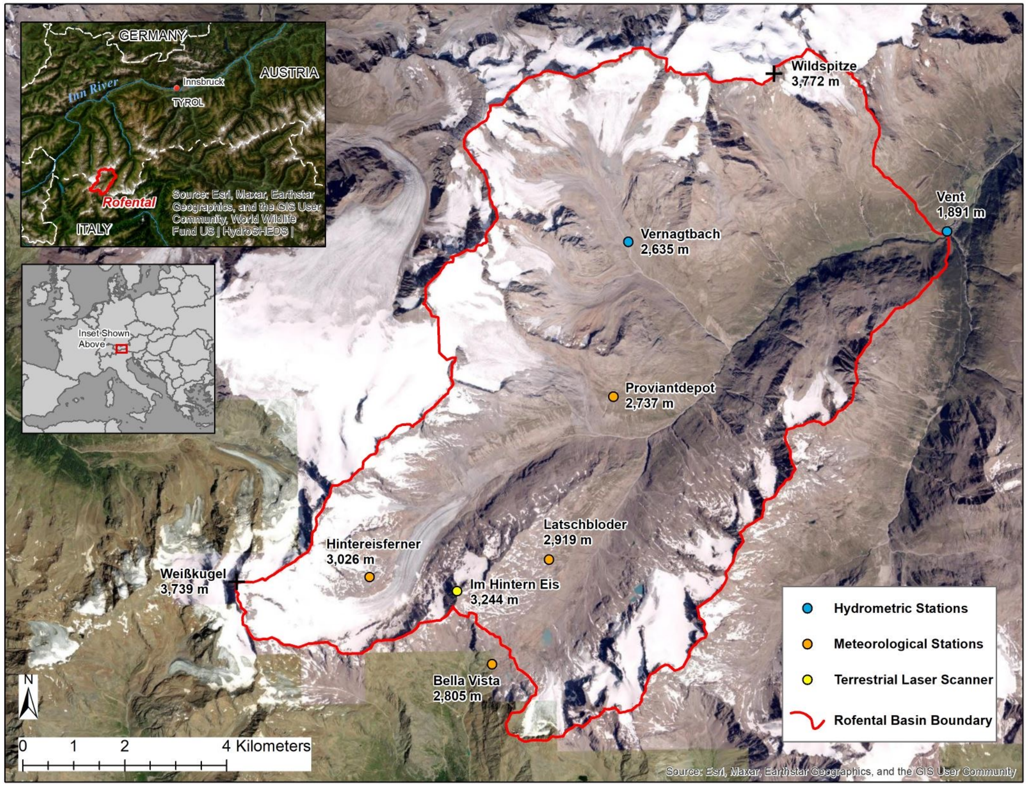
Rofental



Location:
Tyrol, Austria; 46.83°N, 10.83°E
Area: 98.1 km^2, 25% glacierized
Elevation: Mean 2930 m a.s.l.
(min. 1891 m to max. 3772 m a.s.l.)

- **Website:**
  - https://www.lter-austria.at/rofental
  - https://www.uibk.ac.at/projects/station-hintereis-opal-data/index.html.en
- **Operational Management:**
  - University of Innsbruck, Austria:
    - Department of Atmospheric and Cryospheric Sciences
    - Department of Geography
  - Bavarian Academy of Sciences, Germany
  - Hydrographic Service of Tyrol, Austria

Rofental: observational stations and sites

Type	Station Name	Latitude	Longitude	Elevation	Notes/Details
Climate and Snow Station	Bella Vista	46.78284°N	10.79138°E	2805 m	Data since July 2015 or September 2017
Climate and Snow Station	Latschbloder	46.80106°N	10.80659°E	2919 m	Data since September 2013 or September 2017
Climate and Snow Station	Proviantdepot	46.82951°N	10.82407°E	2737 m	Data since October 2019
Terrestrial Laser Scanner	Im Hintern Eis	46.79586°N	10.78277°E	3244 m	Since 2016
Meteorological	Hintereisferner	46.79867°N	10.76042°E	3026 m	Since 2010
Hydrometric	Vent	46.85722°N	10.91083° E	1891 m	Since 1967 (98.1 km^2)
Hydrometric	Vernagtbach	46.85675°N	10.82886°E	2635 m	Since 1974 (11.44 km^2)
Meteorological	Im Hintern Eis			3244 m	

Rofental: field observatin campaigns and other measurements

Measurement	Instrument Description	Spatial/Temporal Resolution and Coverage	Notes/Details
UAV Sensors			Campaigns
Time-lapse Photographs			Im Hintern Eis, Bella Vista
Snow Pits/Snow Surveys			Campaigns
Glacier Surface Elevation			Hintereis
Glacier Mass Balance			Vernagtferner, Hintereisferner, Kesselwandferner at WGMS

Earth Syst. Sci. Data, 10, 151–171, 2018
https://doi.org/10.5194/essd-10-151-2018
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Open Access Earth System Science Data

The Rofental: a high Alpine research basin (1890–3770 m a.s.l.) in the Ötztal Alps (Austria) with over 150 years of hydrometeorological and glaciological observations

Ulrich Strasser[1], Thomas Marke[1], Ludwig Braun[3], Heidi Escher-Vetter[3], Irmgard Juen[2], Michael Kuhn[2], Fabien Maussion[2], Christoph Mayer[3], Lindsey Nicholson[2], Klaus Niedertscheider[4], Rudolf Sailer[1], Johann Stötter[1], Markus Weber[5], and Georg Kaser[2]

[1]Department of Geography, University of Innsbruck, Innsbruck, 6020, Austria
[2]Department of Atmospheric and Cryospheric Sciences, University of Innsbruck, Innsbruck, 6020, Austria
[3]Geodesy and Glaciology, Bavarian Academy of Sciences and Humanities, Munich, 80539, Germany
[4]Hydrographic Service of Tyrol, Innsbruck, 6020, Austria
[5]Photogrammetry and Remote Sensing, Technical University of Munich, Munich, 80333, Germany

Correspondence: Ulrich Strasser (ulrich.strasser@uibk.ac.at)

Received: 3 August 2017 – Discussion started: 21 August 2017
Revised: 26 November 2017 – Accepted: 18 December 2017 – Published: 24 January 2018

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Snow monitoring Rofental

Meteorological data:

Temperature, humidity, wind speed and direction, air pressure, precipitation, radiative fluxes (short- and longwave, up and down) etc.

Snow data:

- Bella Vista (2805 m a.s.l.)
  Pair of snow pillow/scale with ultrasonic snow depth, snow temperature profile, acoustic snow drift

- Latschbloder (2919 m a.s.l.)
  Ultrasonic snow depth, snow temperature profile

- Proviantdepot (2737 m a.s.l.)
  Surface temperature, snow depth, snow water equivalent, layered density and liquid water content (snow pack analyzer), snow temperature profile

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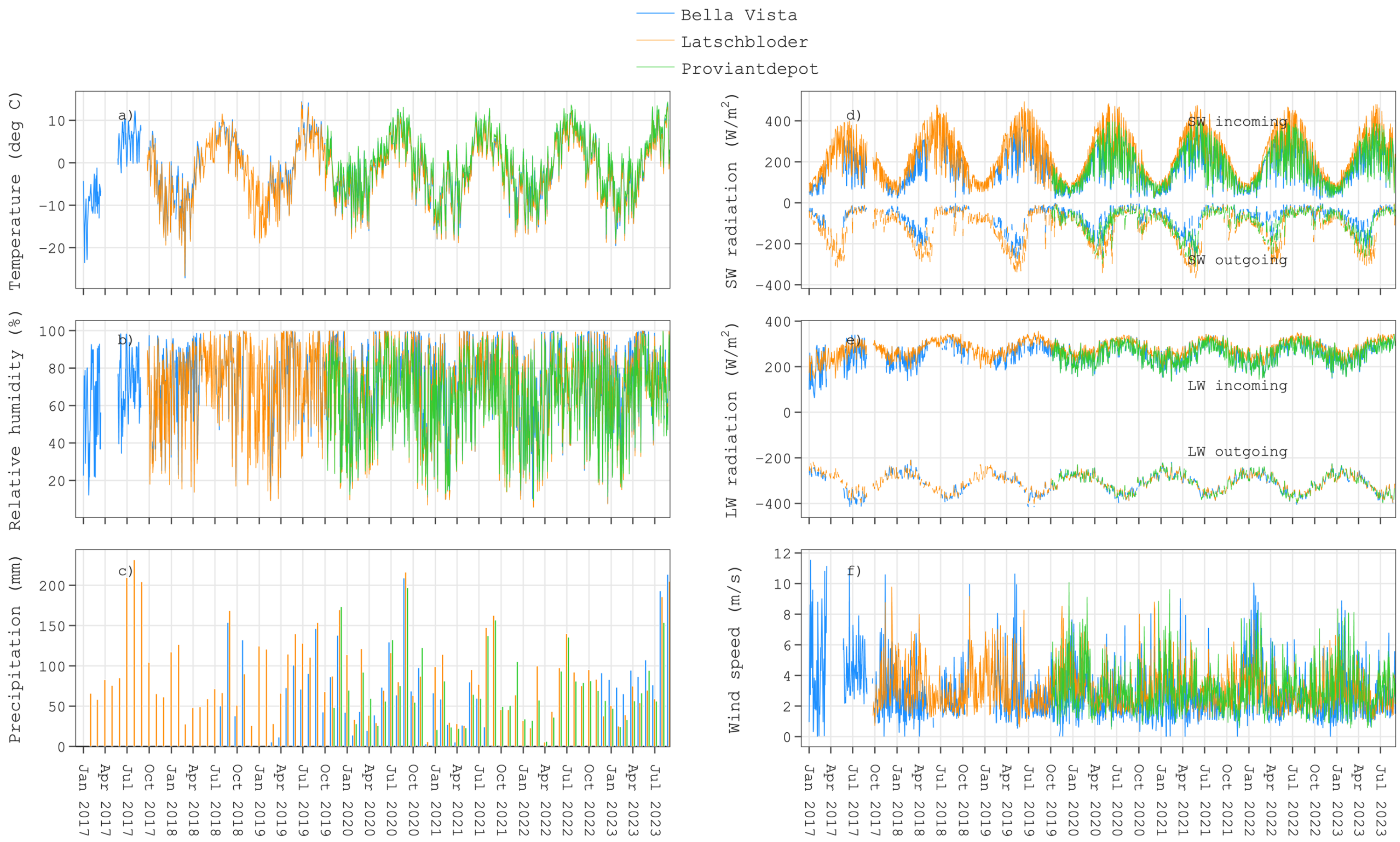
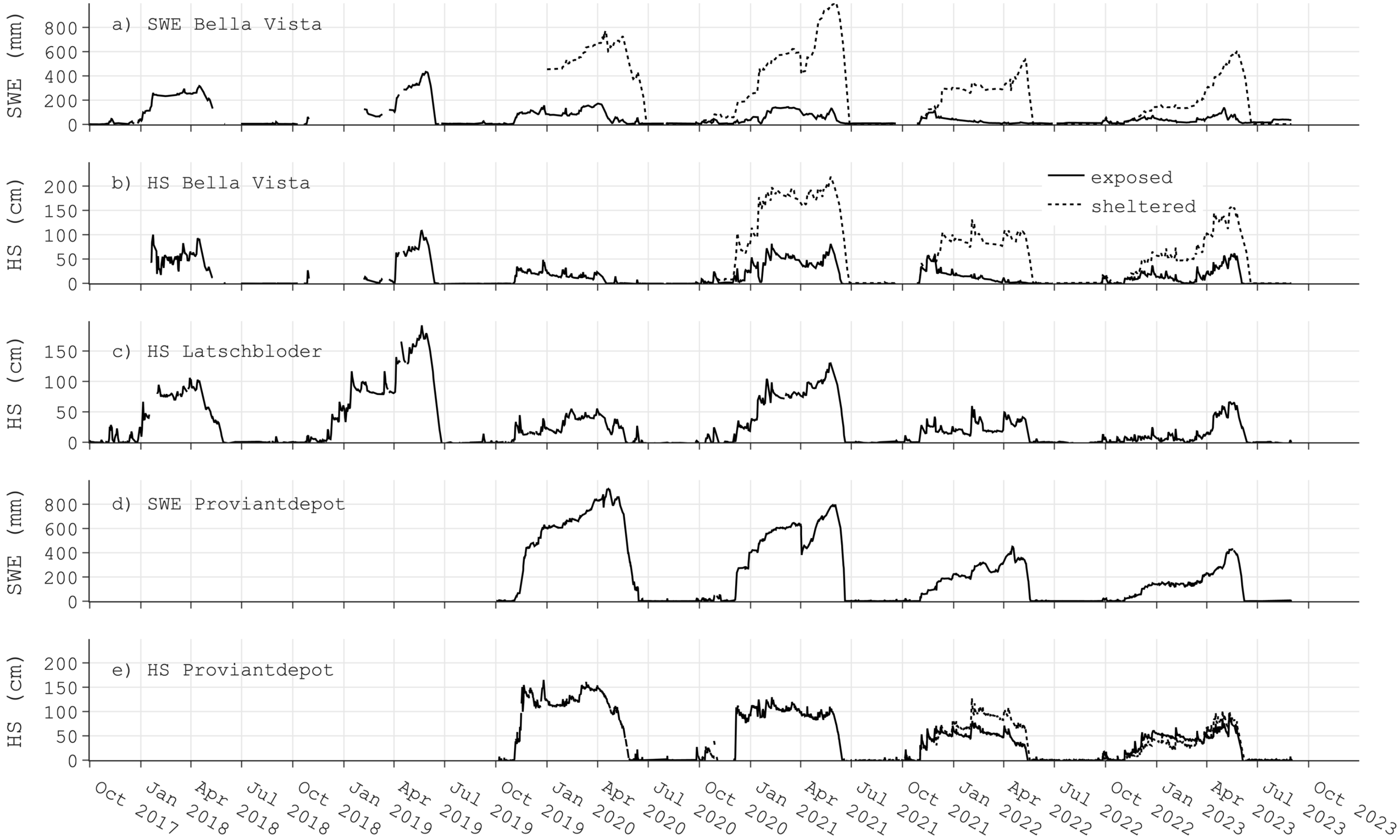
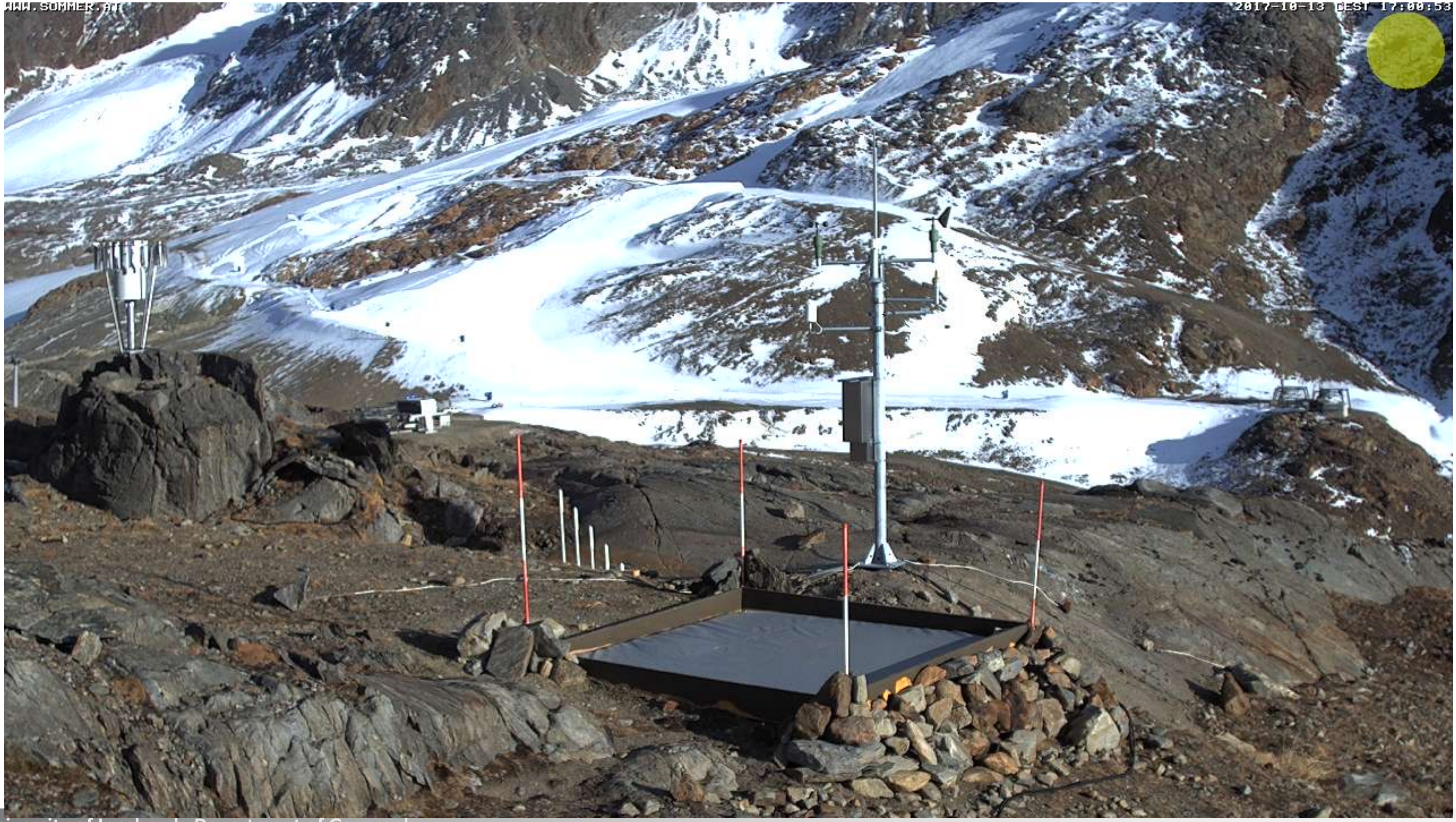
All stations: meteorological data



All stations: SD and SWE



Bella Vista: acoustic sensor, paired SD/SWE measurements



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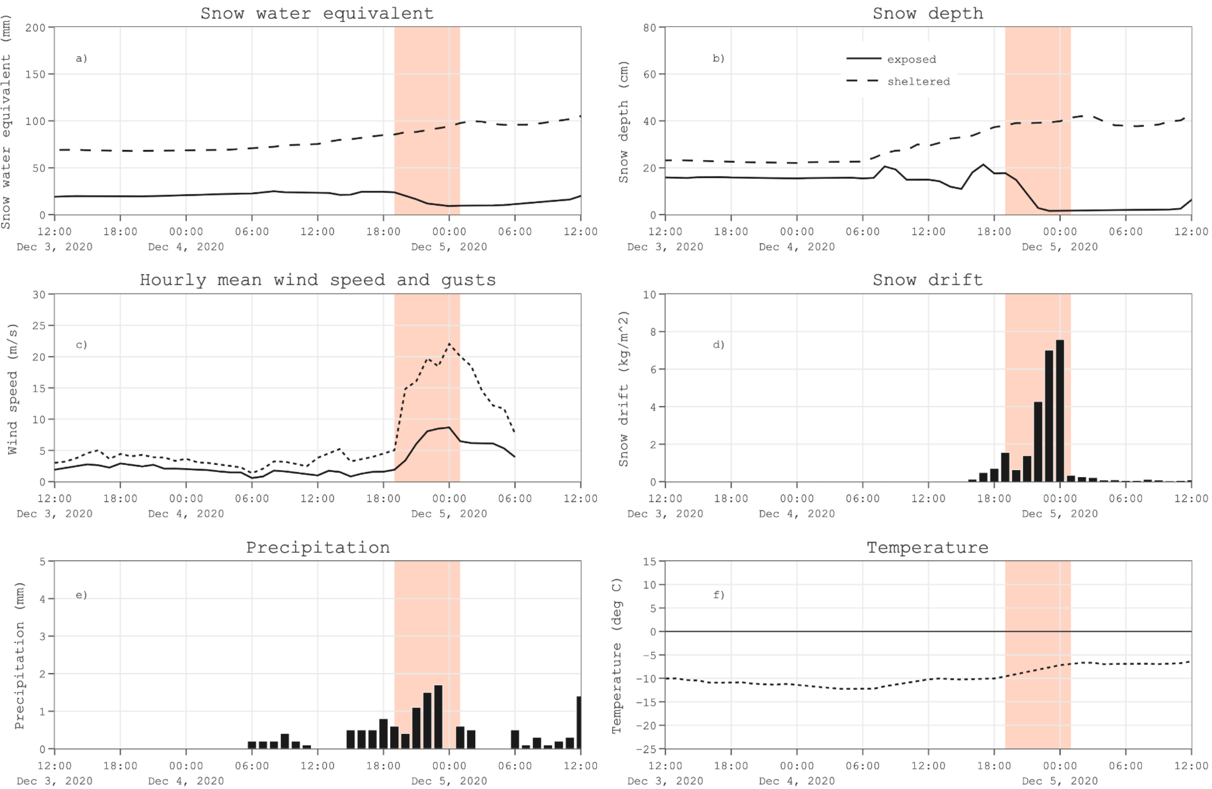
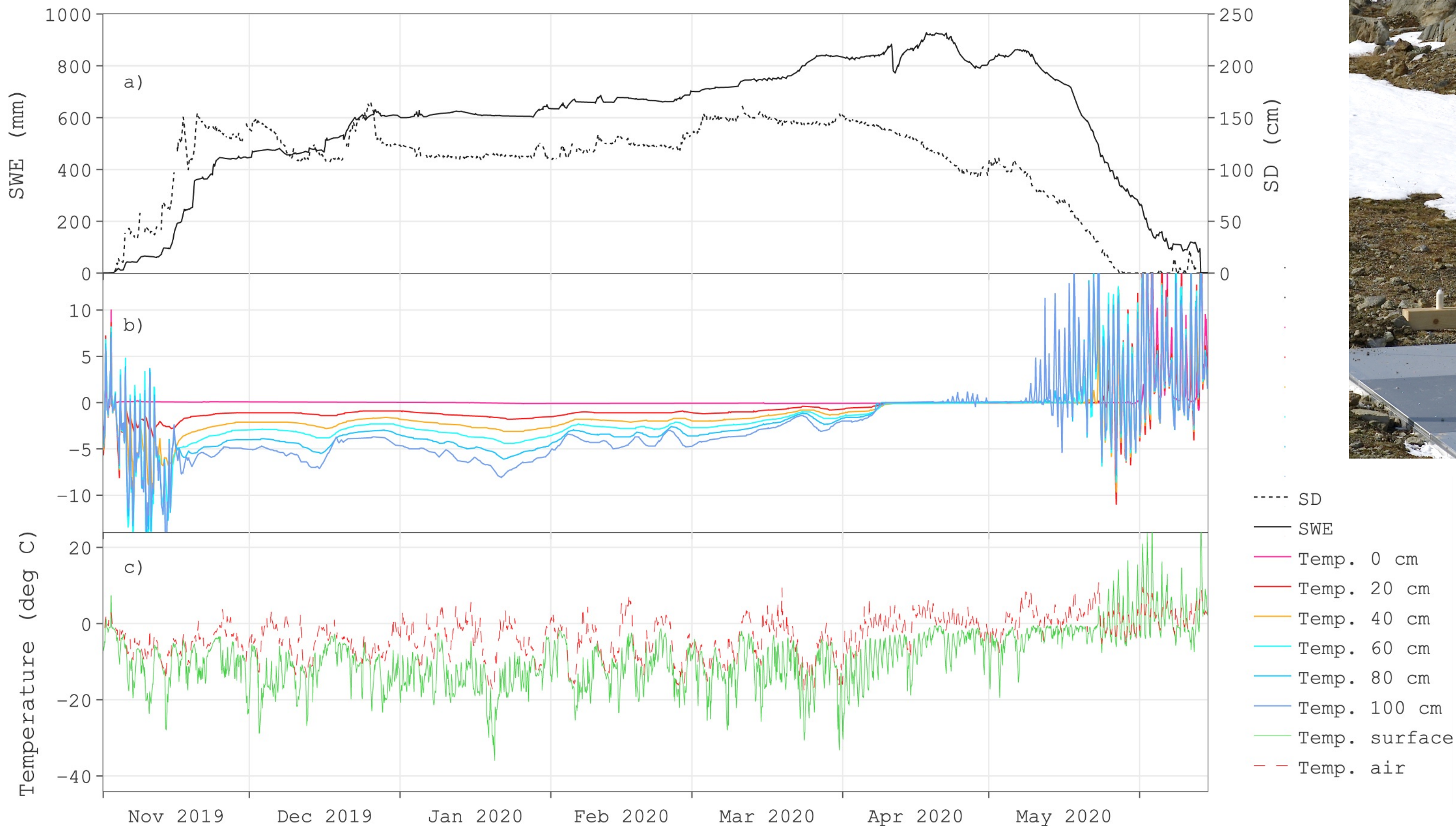
Bella Vista: acoustic sensor, paired SD/SWE measurements

Bella Vista: acoustic sensor, paired SD/SWE measurements



Bella Vista: snow data



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

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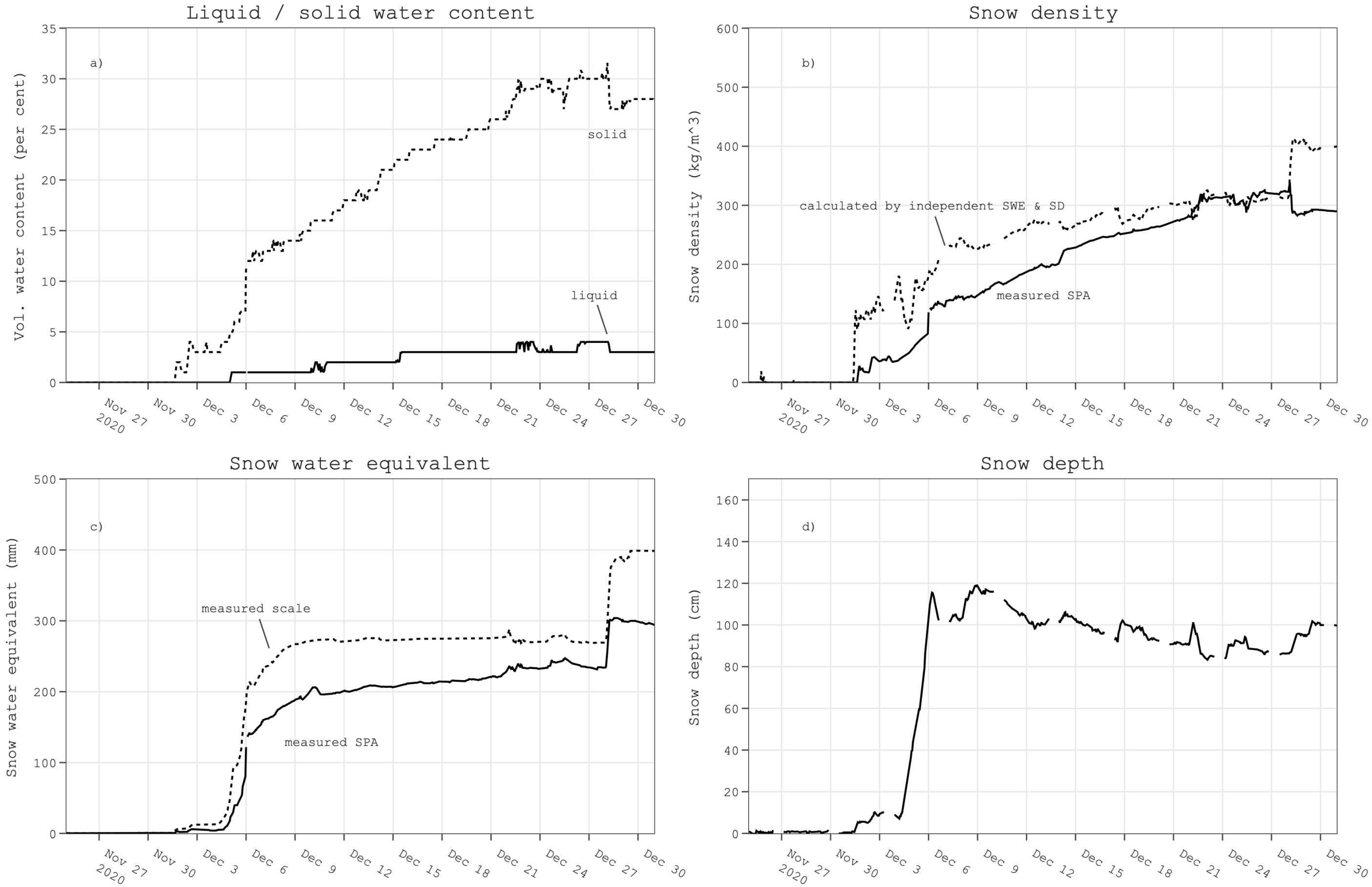
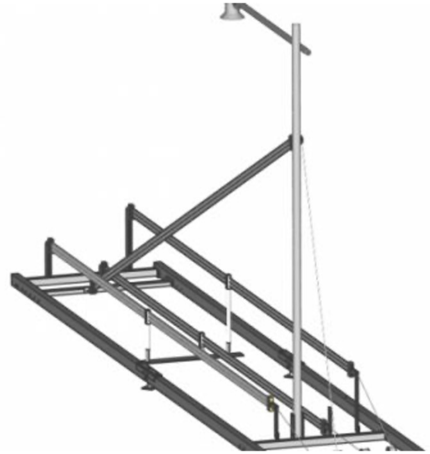
Proviantdepot: SPA data





Snow **P**ack **A**nalyzer: Liquid/solid water content, snow density, SWE and SD

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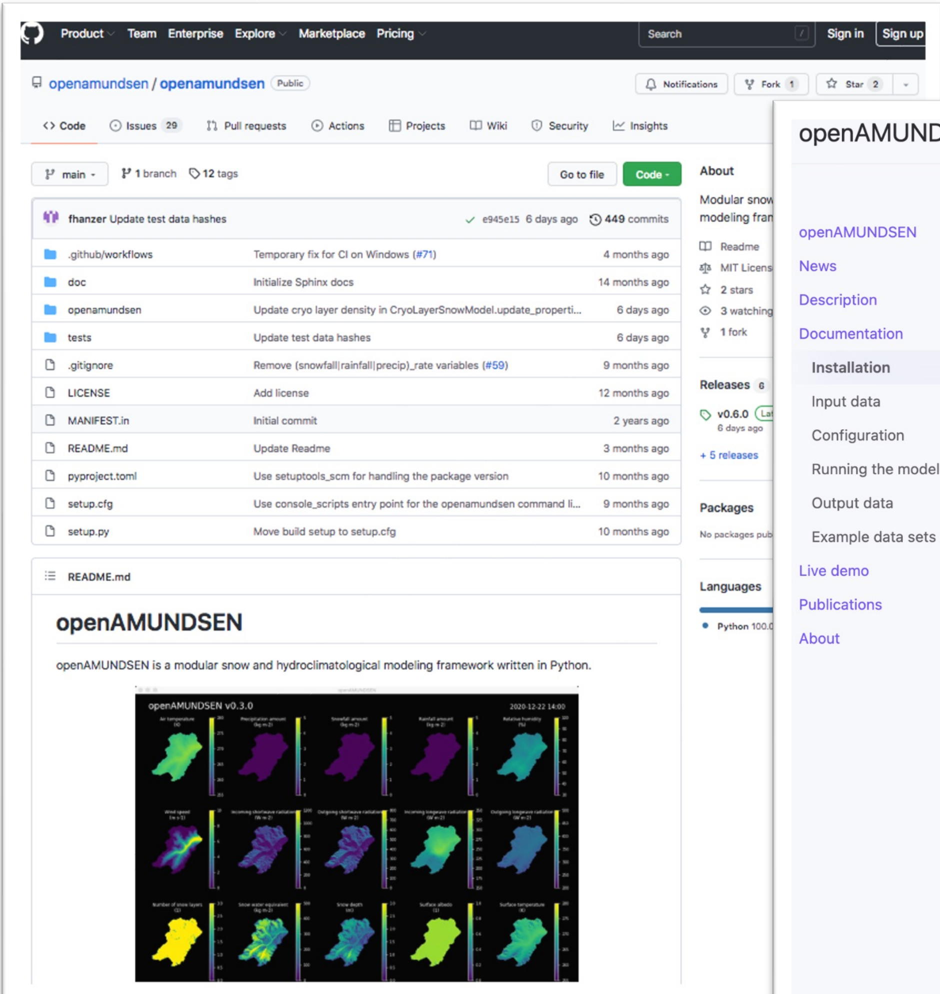
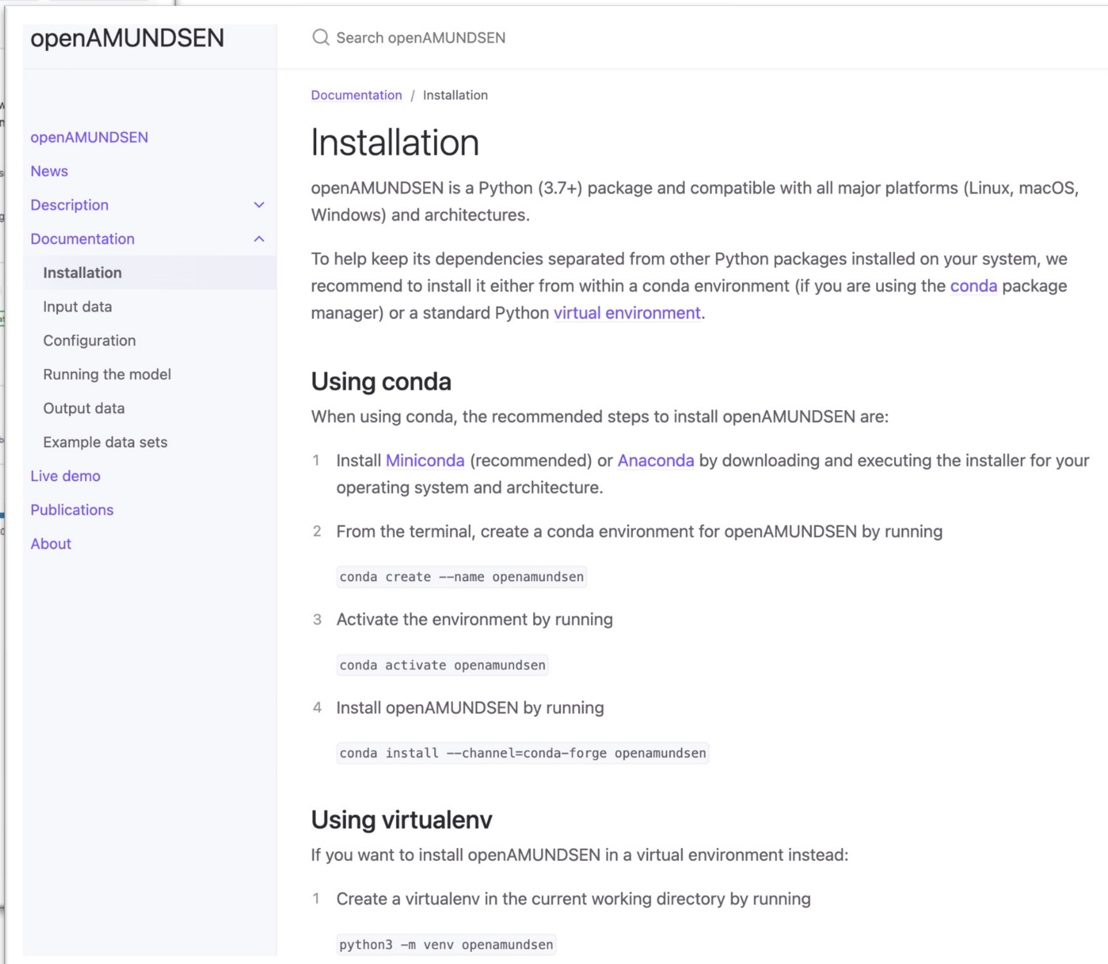
openAMUNDSEN: model code and availability

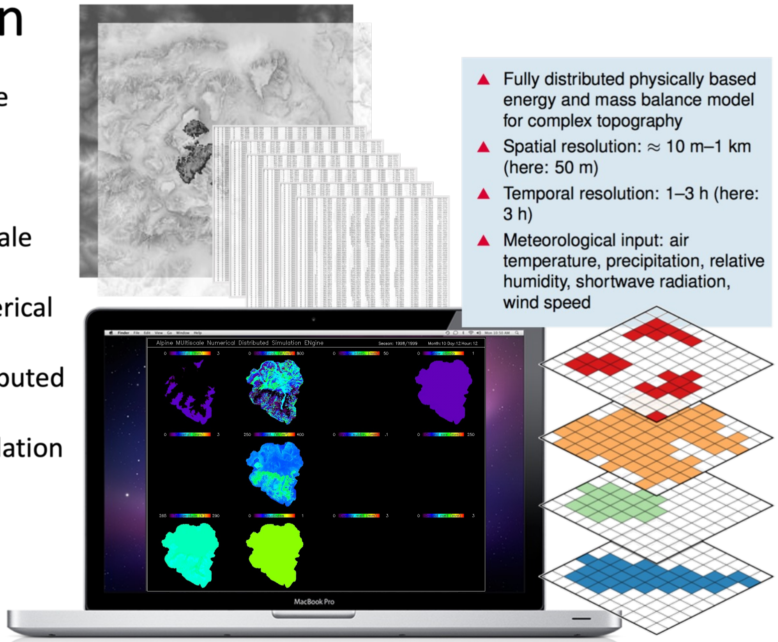




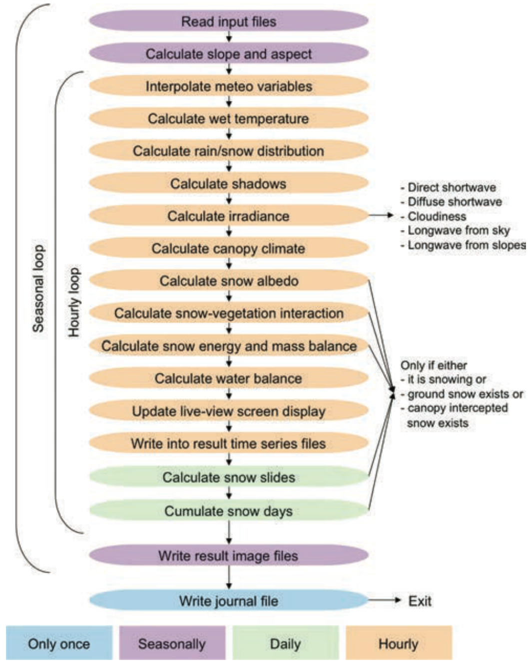
https://github.com/openamundsen/ https://doc.openamundsen.org/

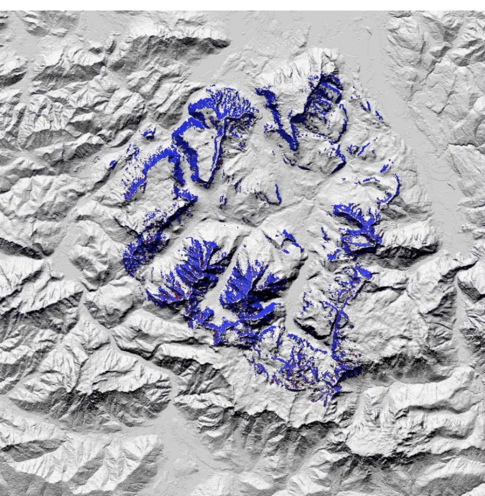
openAMUNDSEN: model design

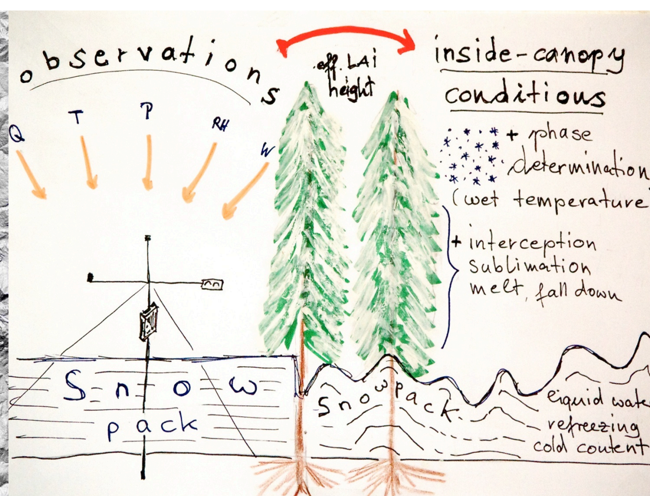
open
A lpine
M
U ltiscale
N umerical
D istributed
S imulation
E
N gine

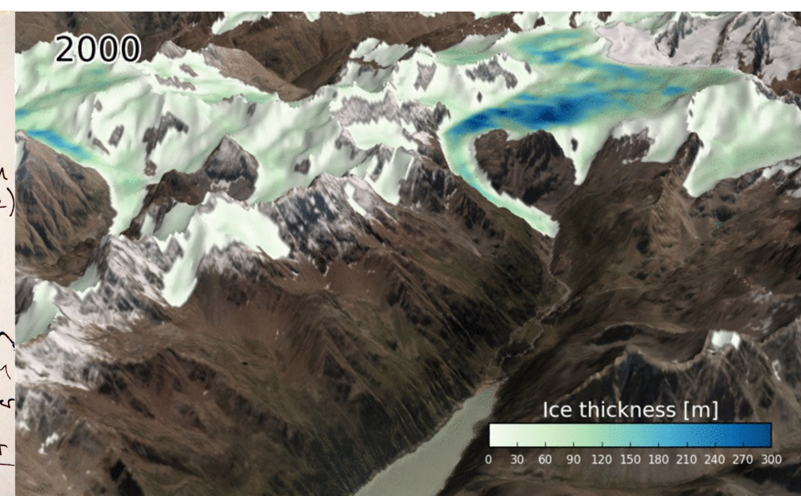


- Fully distributed physically based energy and mass balance model for complex topography
- Spatial resolution: ≈ 10 m–1 km (here: 50 m)
- Temporal resolution: 1–3 h (here: 3 h)
- Meteorological input: air temperature, precipitation, relative humidity, shortwave radiation, wind speed









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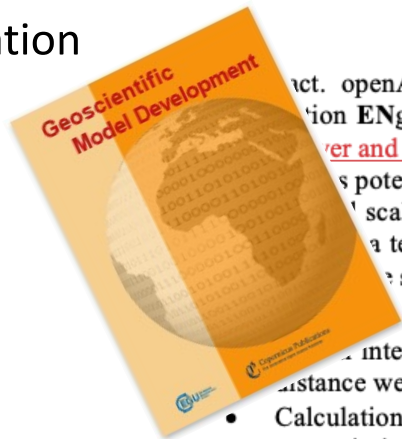
openAMUNDSEN: an open-_source snow-hydrological model for mountain regions

Strasser Ulrich[1], Warscher Michael[1], Rottler Erwin[1] and Hanzer Florian[1,2]

[1] Department of Geography, University of Innsbruck, Innrain 52, 6020 Innsbruck, Austria
[2] lumiosys GmbH, Innrain 52, 6020 Innsbruck, Austria

Correspondence: Ulrich Strasser (ulrich.strasser@uibk.ac.at)

In preparation for GMD …

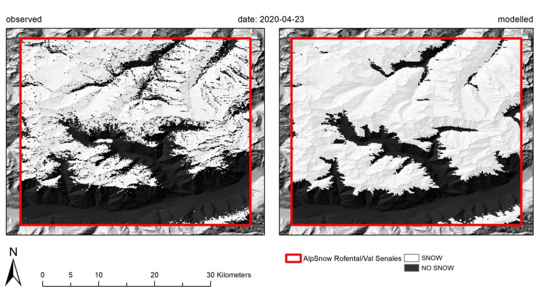


…act. openAMUNDSEN (= the open source version of the **A**lpine **MU**ltiscale **N**umerical **D**istributed …tion **EN**gine) is a fully distributed model, designed primarily for calculating the seasonal evolution of a …er and melt rates by resolving the mass and energy balance of snow and ice covered surfaces in mountain …s potential applications are very versatile; typically, it is applied in areas ranging from the point scale to …l scale (i.e., up to some hundreds to thousands of square kilometers), using a spatial resolution of 10– …a temporal resolution of 1–3 h or daily. Temporal horizons may vary between single events ~~to~~ and …e scenarios. The main features of the model include:

- … interpolation of scattered meteorological point measurements using a combined lapse rate – inverse …istance weighting scheme
- Calculation of solar radiation taking into account terrain slope and orientation, hillshading and atmospheric transmission losses as well as gains due to scattering, absorption, and reflections
- Adjustment of precipitation using several correction functions for wind-induced undercatch and lateral redistribution of snow using terrain-based parameterizations
- Simulation of the snow and ice mass and energy balance using either a multilayer scheme or a bulk- scheme using four separate layers for new snow, old snow, firn and ice
- Alternatively, a temperature index/enhanced temperature index method can be applied, the latter considering potential solar radiation and albedo of the surface
- Usage of arbitrary timesteps (e.g. 10 minutes, daily) while resampling forcing data to the desired temporal resolution if necessary
- Flexible output of time series including arbitrary model variables for selected point locations in NetCDF or CSV format
- Flexible output of gridded model variables, either for specific dates or periodically (e.g., daily or monthly), optionally aggregated to averages or totals in NetCDF, GeoTIFF or ASCII Grid format
- Built-in generation of future meteorological data time series as model forcing with a given trend using a bootstrapping algorithm for the available historical time series of the meteorological recordings
- Live view window for displaying selectable variables of the model state during runtime.

ESA Alpine Regional Initiative AlpSnow EXPRO+

- High-resolution hydrological simulations using the snow and hydroclimatological modelling framework openAMUNDSEN
- Performance assessment using in-situ data from automatic snow and runoff stations
- Use of AlpSnow products for validation of snow process modelling
- Assimilation of AlpSnow products into modelled snow cover and streamflow simulation



AlpSnow example satellite data products

AlpSnow product	Spatial res. / extent	Temporal res. / period	Related model variables in openAMUNDSEN
S3 FSC snow coverage (FSC-S3-LAMSU)	0.002° / ~ 200 m, Rofental	daily Jan 2017 - Jul 2023	FSC, SD, SWE
S2 FSC snow coverage (FSC-S2-LAMSU)	0.0002° / ~ 20 m, Rofental	5/10 days Oct 2016 - Jun 2023	FSC, SD, SWE
S2 FSC snow coverage (FSC-S2-ML)	0.0002° / ~ 20 m, Rofental	5/10 days Oct 2016 - Jun 2023	FSC, SD, SWE
S1 Wet Snow (WSM-S1)	0.001° / ~100 m, Rofental	6/12 days Mar 2018 - Aug 2021	liquid water content, snow surface temperature, snowmelt

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AlpSnow

Fractional snow cover maps for June 18, 2019

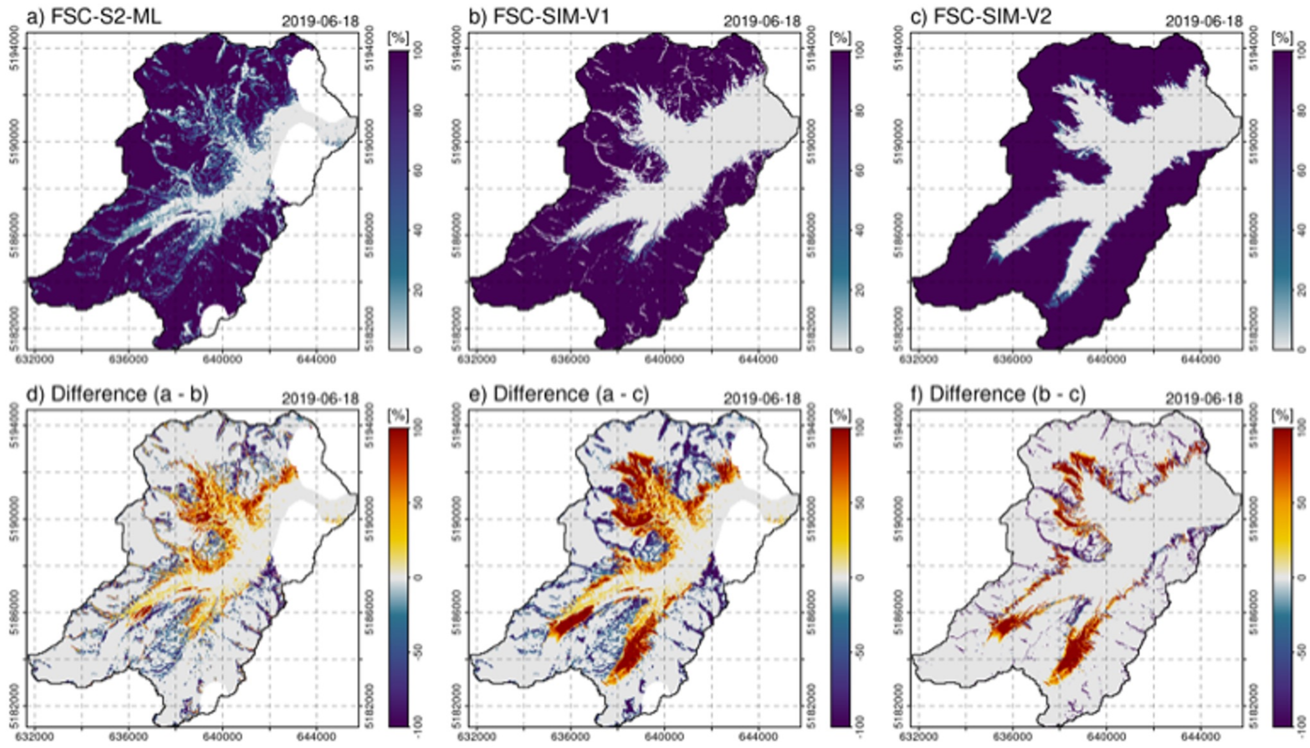

Figure 3.4: Fractional snow cover (FSC) maps based on a) S2 data processed using ML, b) openAMUNDSEN model simulations including lateral snow redistribution (V1) and c) openAMUNDSEN simulations without lateral snow redistribution processes (V2) for June 18, 2019. Panels d), e) and f) reflect the difference between the maps for the selected day.

Wet snow maps for May 31, 2018

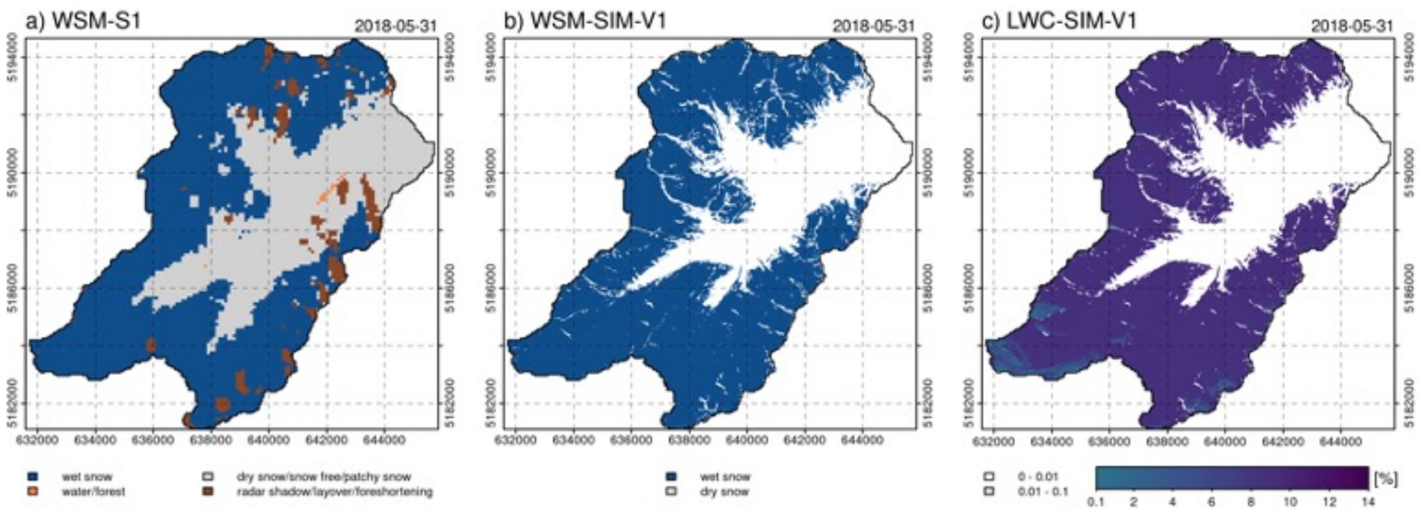

Figure 3.6: Comparison of wet snow maps (WSMs) for May 31, 2018 derived from remote sensing data (a)) and distributed physically-based model simulations using openAMUNDSEN in configuration version 1 (b)). The simulated WSM (b)) is derived from simulated liquid water content (LWC; c)), where areas with a LWC larger than 0.1 % are considered wet snow.

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Simulated wet snow areas 2018 to 2021

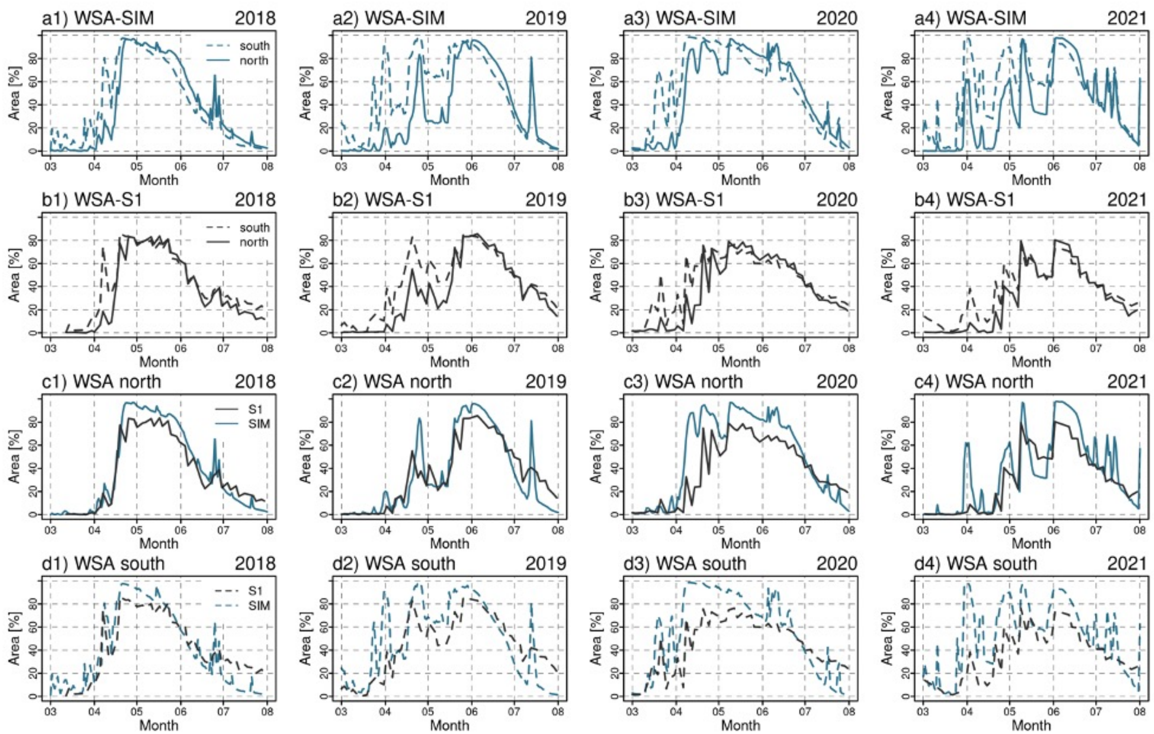

Figure 3.8: Simulated wet snow areas (WSA-SIM) for the years 2018–2021 (March–July) for south- and north-facing slopes (a1)–a4)), wet snow areas derived from S1 data (WSA-S1) for south- and north-facing slopes (b1)–b4)), comparison of simulated and satellite data based wet snow areas for north-facing slopes (c1)–c4)) and comparison of simulated and satellite data derived wet snow elevations for north-facing slopes (d1)–d4)). Values are given as the fraction of total area of north and south-facing slopes, respectively.

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Thank you!