WSL Institute for Snow and Avalanche Research SLF

Sub-grid scale analysis of snow cover variability in mountains

Michael Schirmer, Rebecca Mott, Thomas Grünewald, Christoph Mitterer, Mathias Bavay, Vanessa Wirz, Luca Egli and many others

Michi Lehning

Swiss Federal Institute for Forest, Snow and Landscape Research

WSL

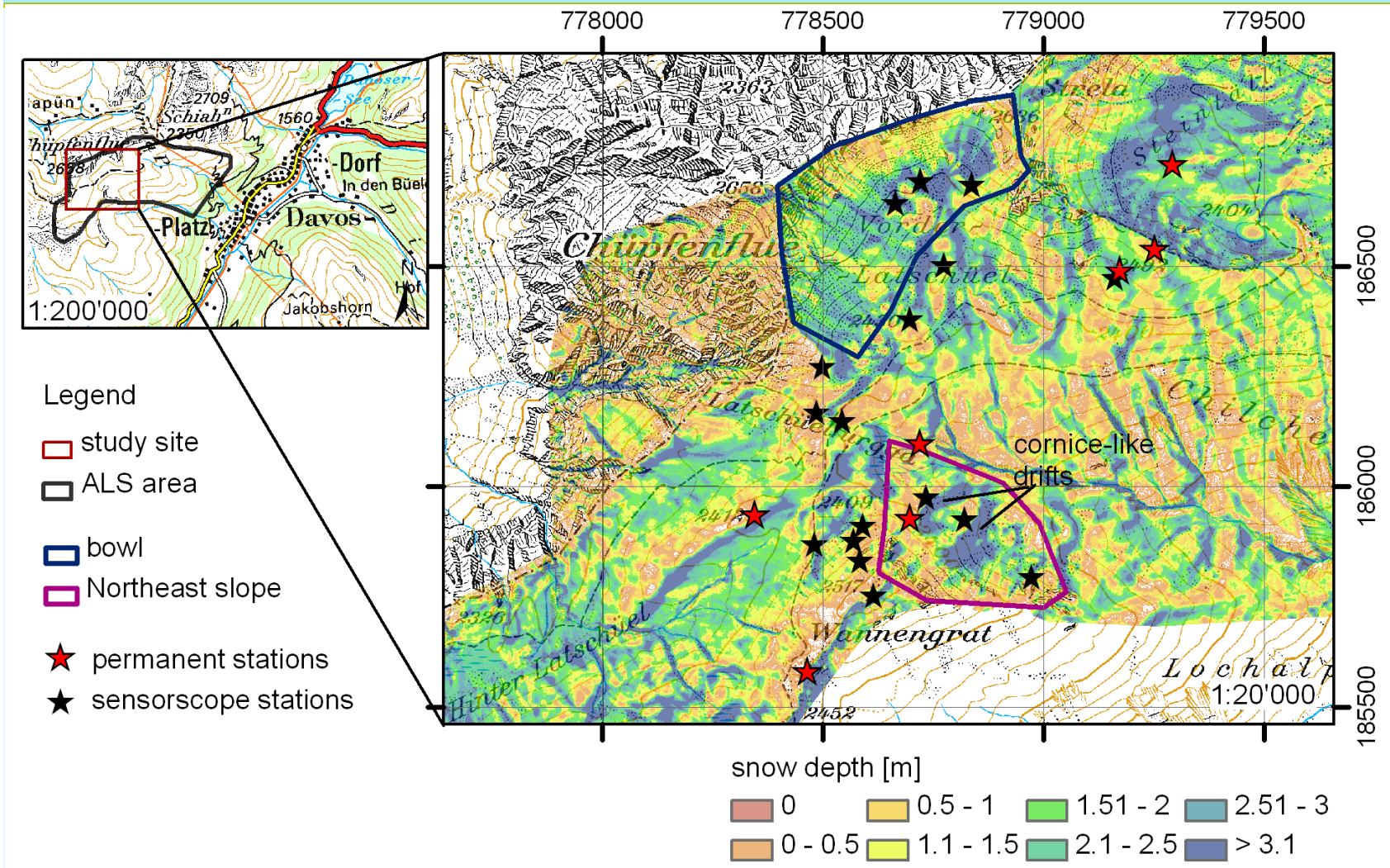
Motivation

Trying to bring descriptive order and understanding in snow cover heterogeneity

Scope

- Laser Scanner Data – peak of Winter SWE for diverse sub-areas – altitudinal gradients
- Individual storms and simple modeling of snow distribution
- Scaling and Smoothing
- Advanced Modelling with ARPS and Alpine3D
- LWC Prediction based on Distributed Modelling

Study Area: Wannengrat



Heterogeneous Alpine Space above DAVOS

New Instrumentation and Old Models

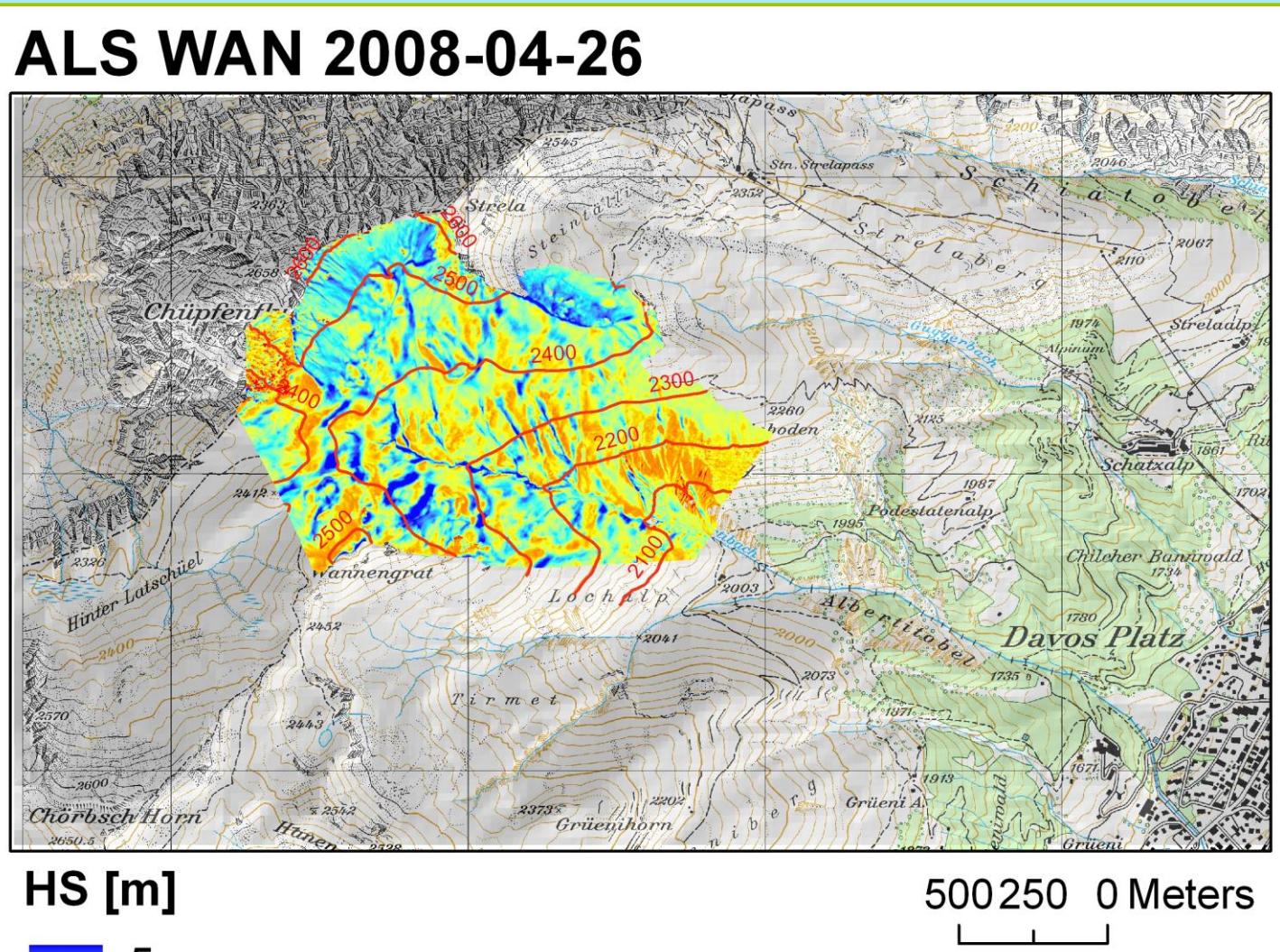
Terrestrial and Airborne Laser Scanning (TLS Riegel, ALS)

and

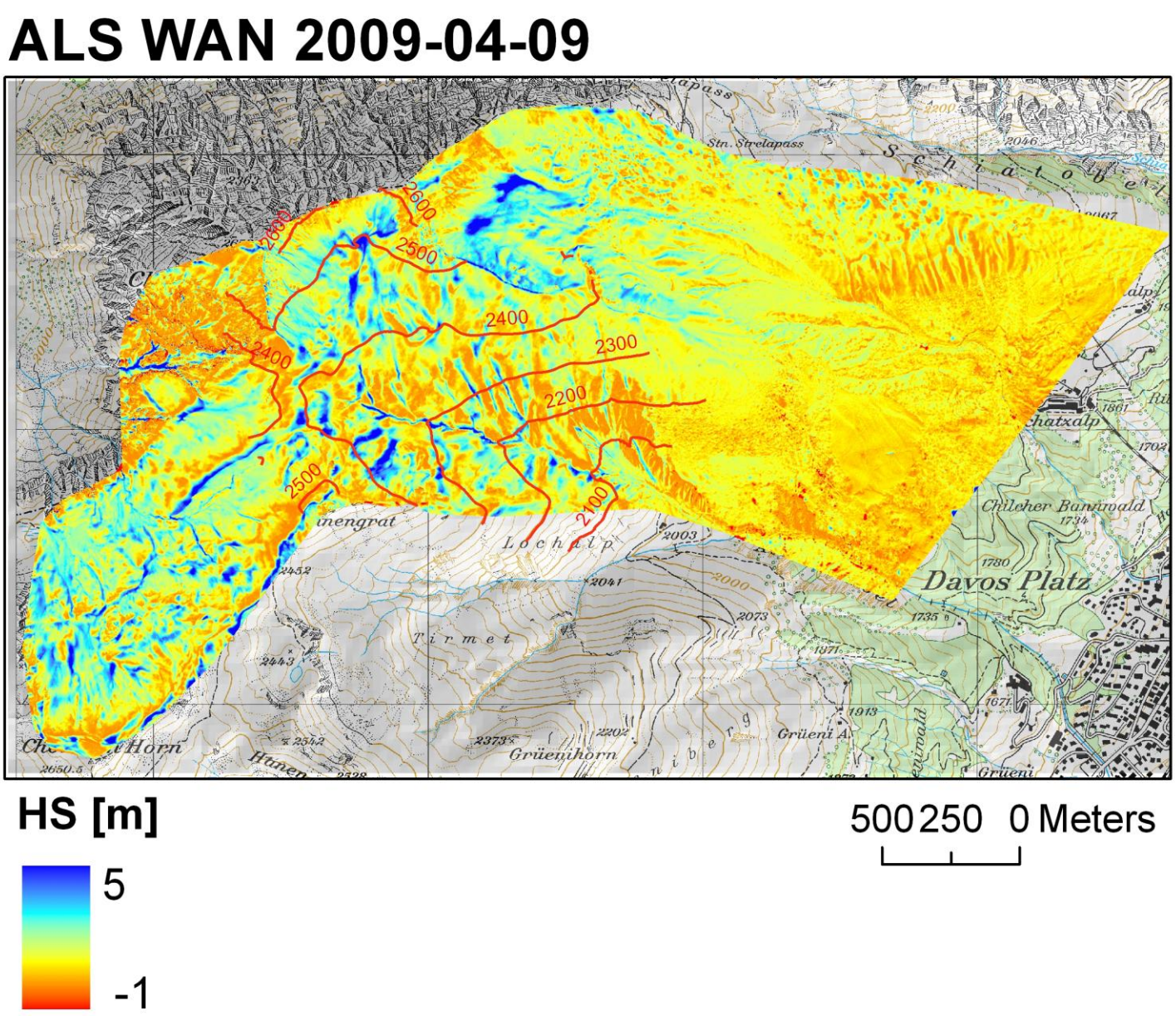
SNOWPACK and Alpine3D

ALS Peak of Winter Distribution and Total Mass

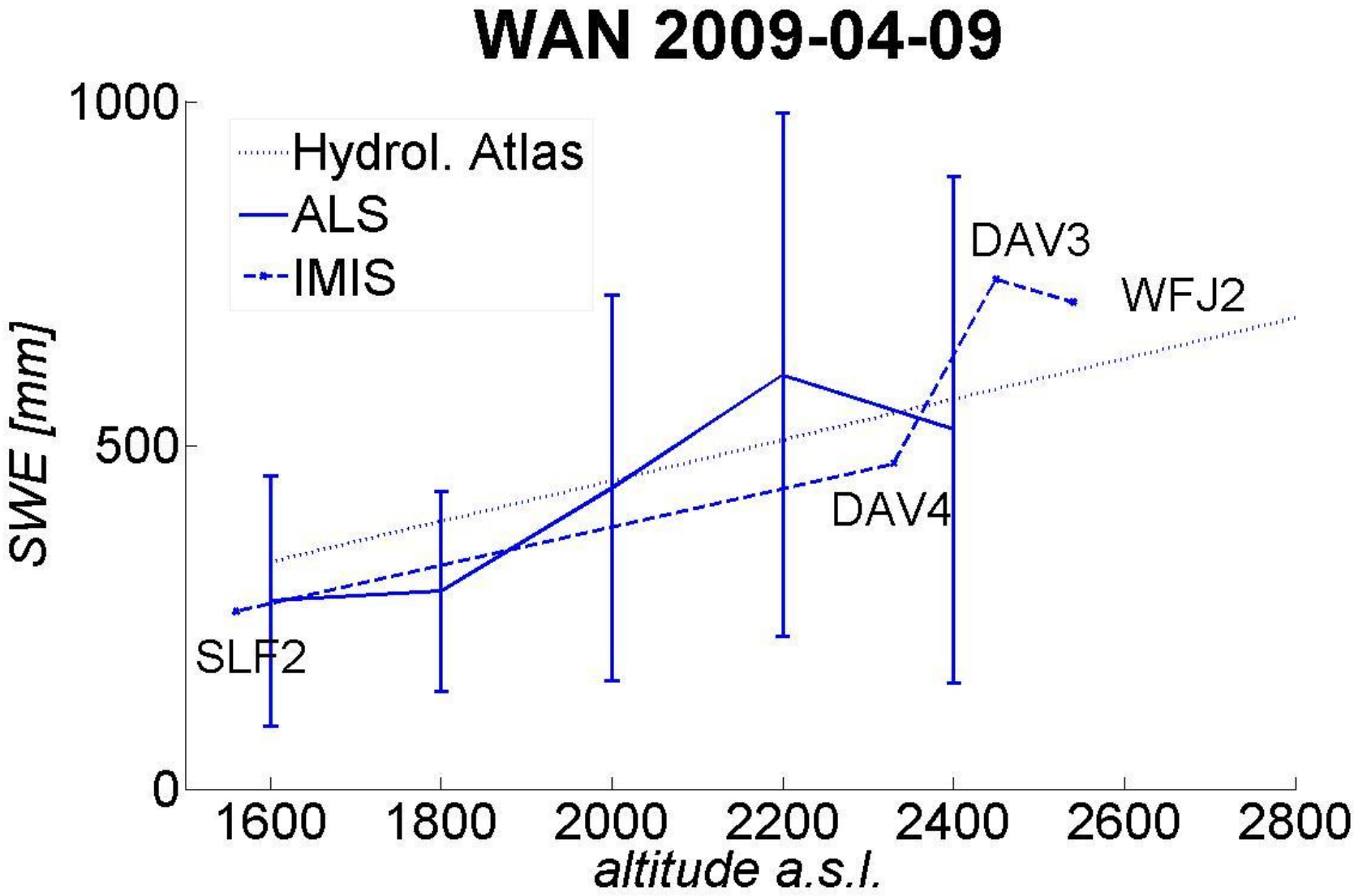
Result: ALS Wannengrat 2008



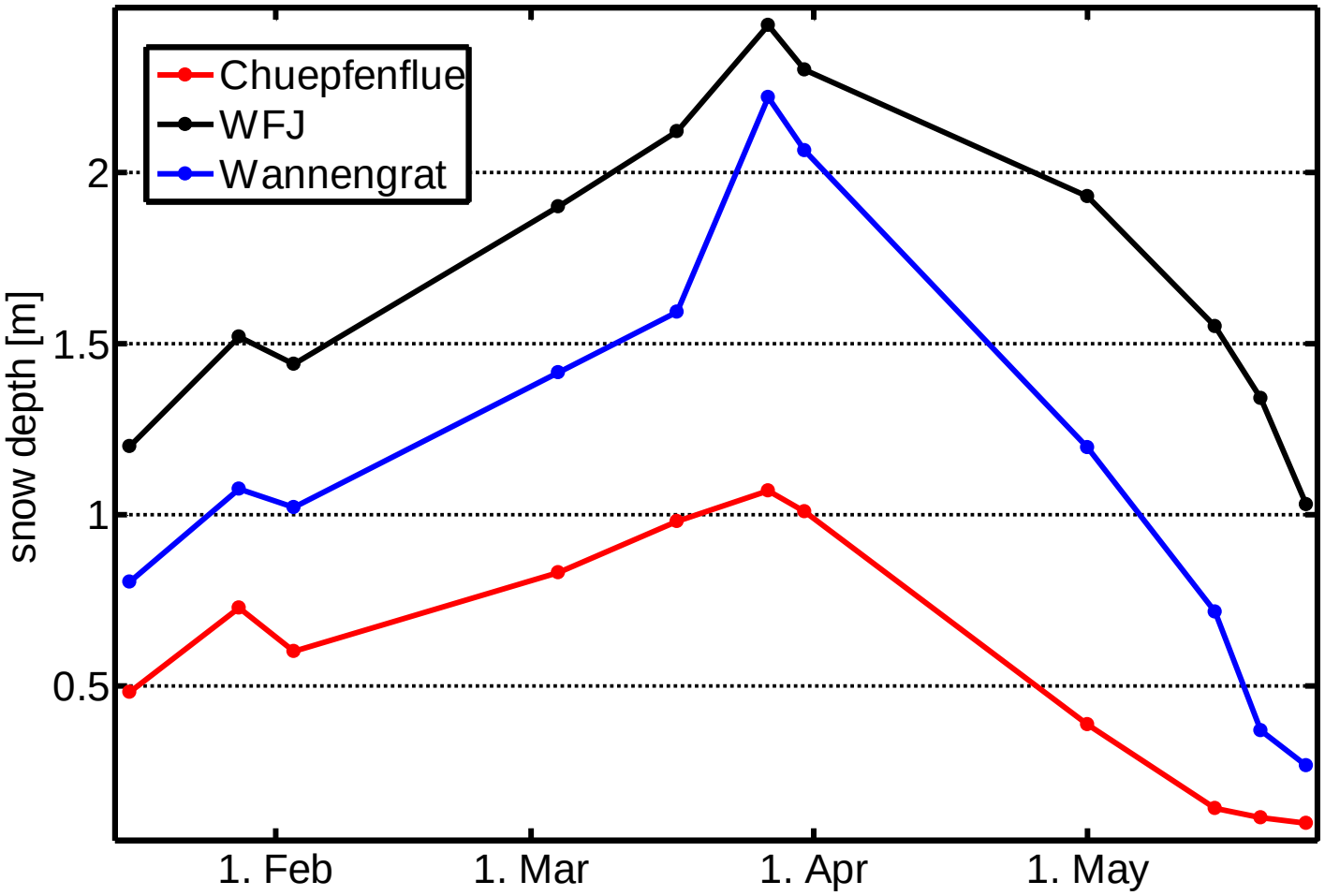
Result: ALS Wannengrat 2009



Result: ALS Altitudinal Gradient

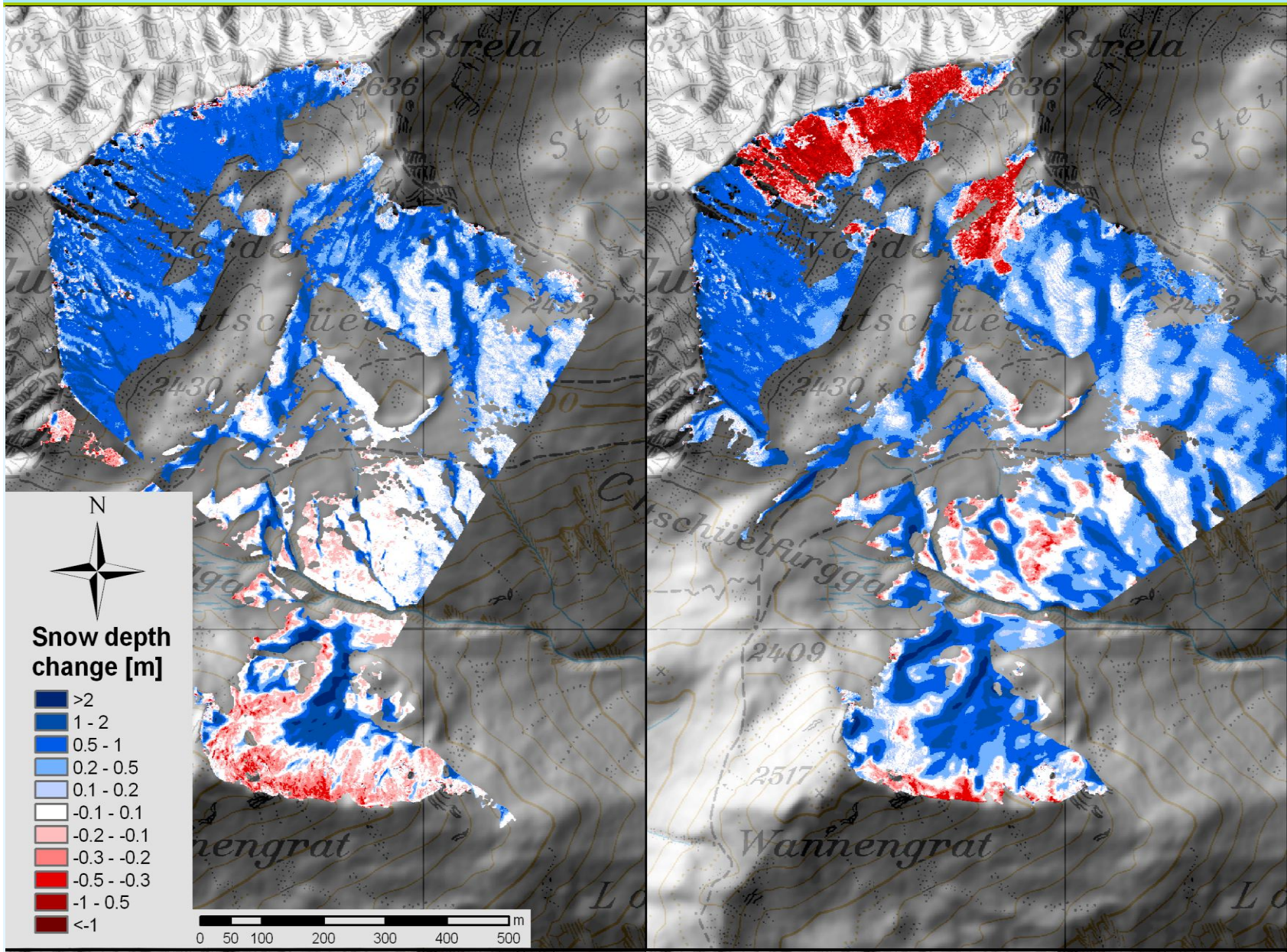


Intra-annual SWE development

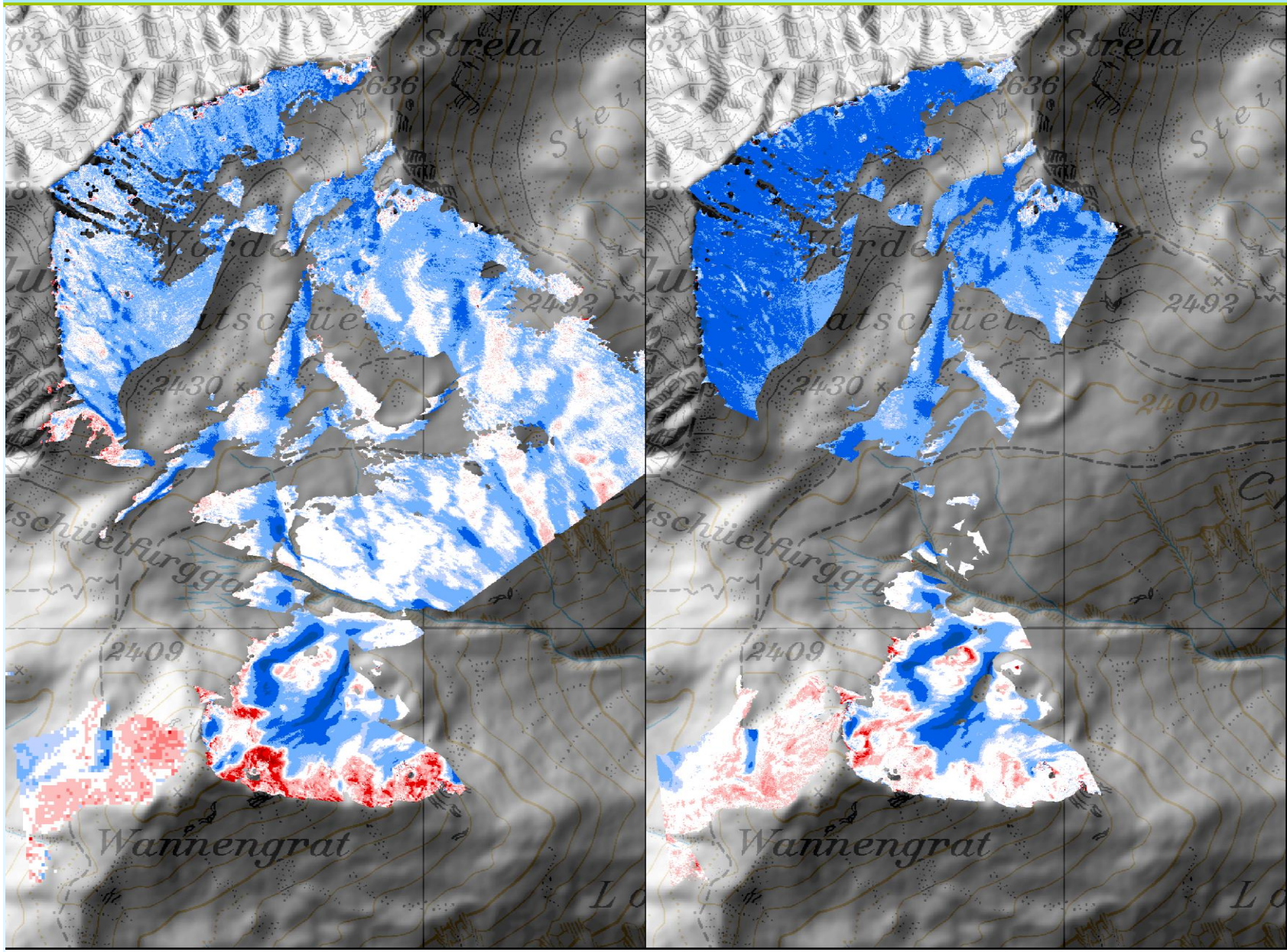


Distribution Pattern of Single Storms

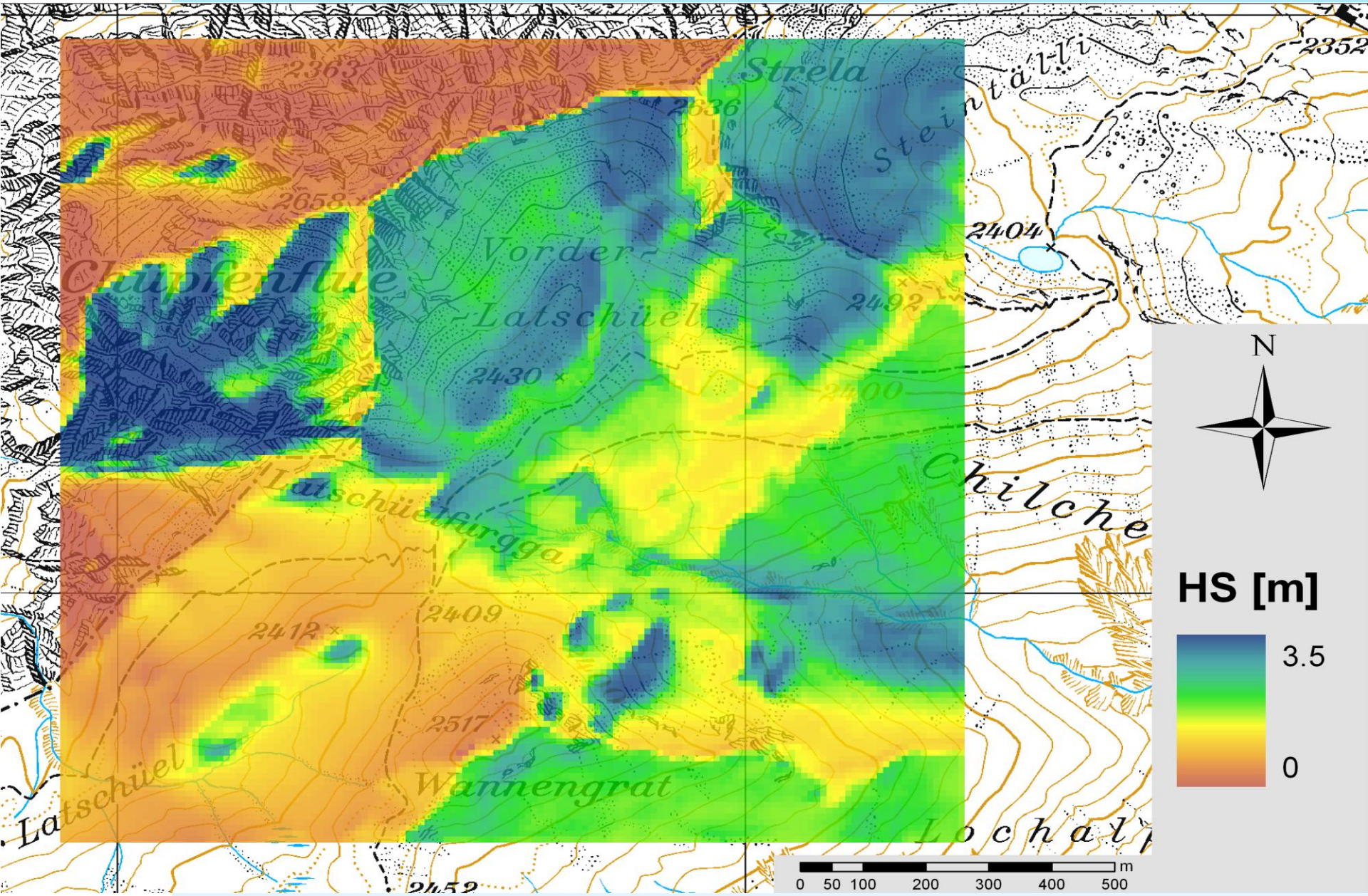
Snow Depth Changes in Time 2009



Snow Depth Changes in Time 2009



Alpine3D Output based on Winstral et al. (2002)

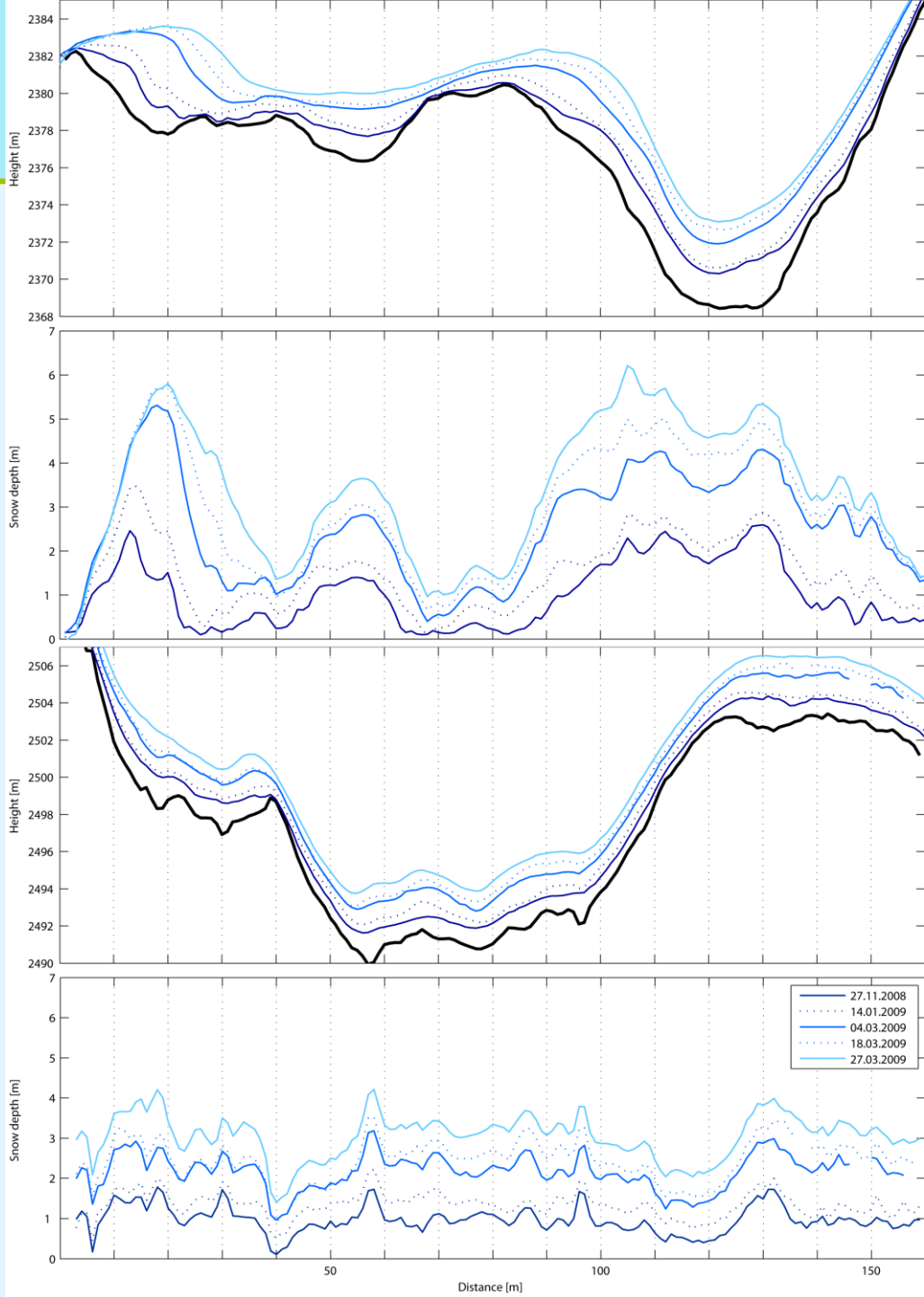


Scaling and Smoothing

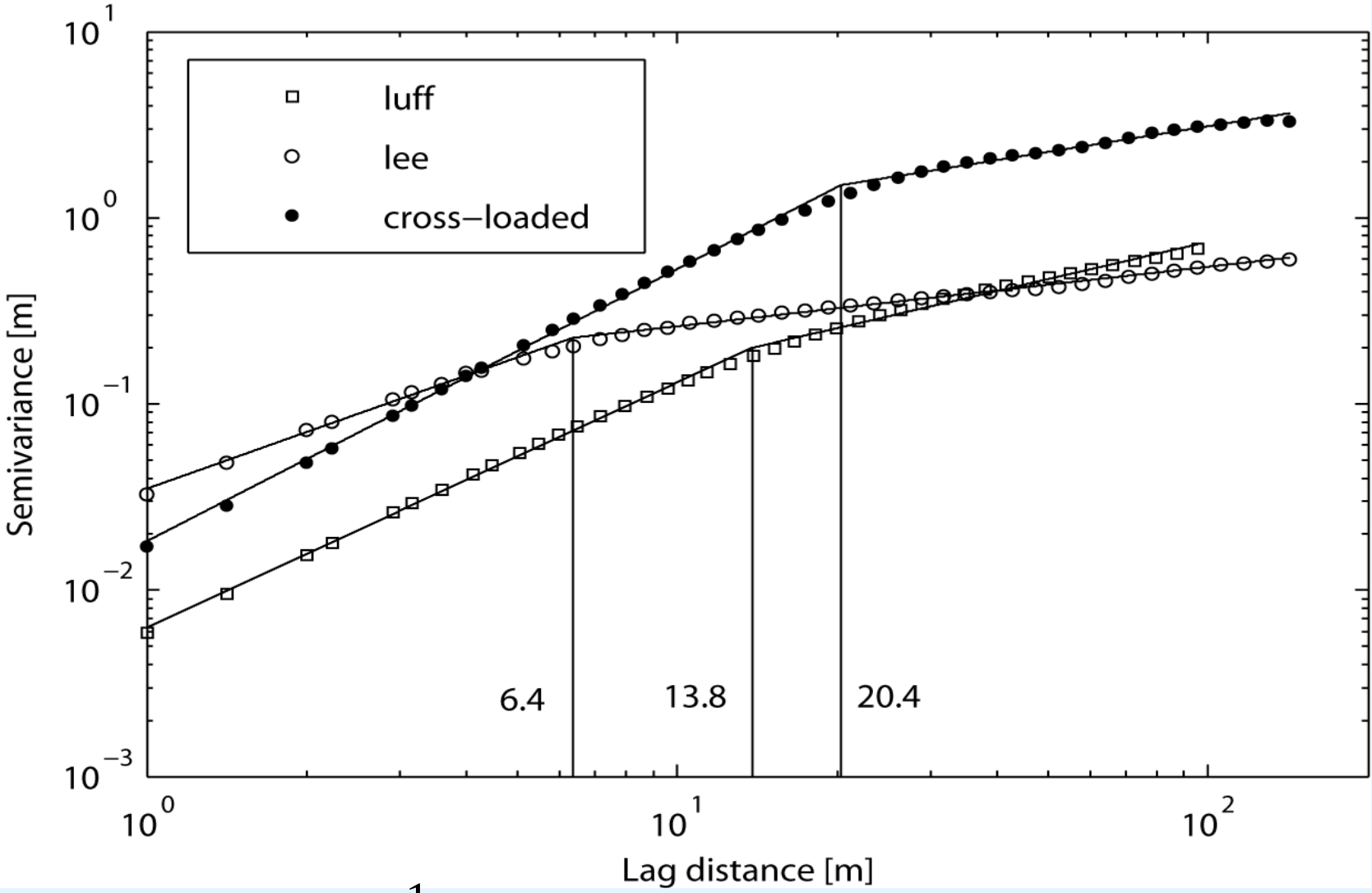
Cross Section

Cross Loaded

Lee



Scaling Properties based on Variograms



$$SV(lag) = \frac{1}{2n_{lag}} \sum_{lag} (hs(x) - hs(x + lag))^2$$

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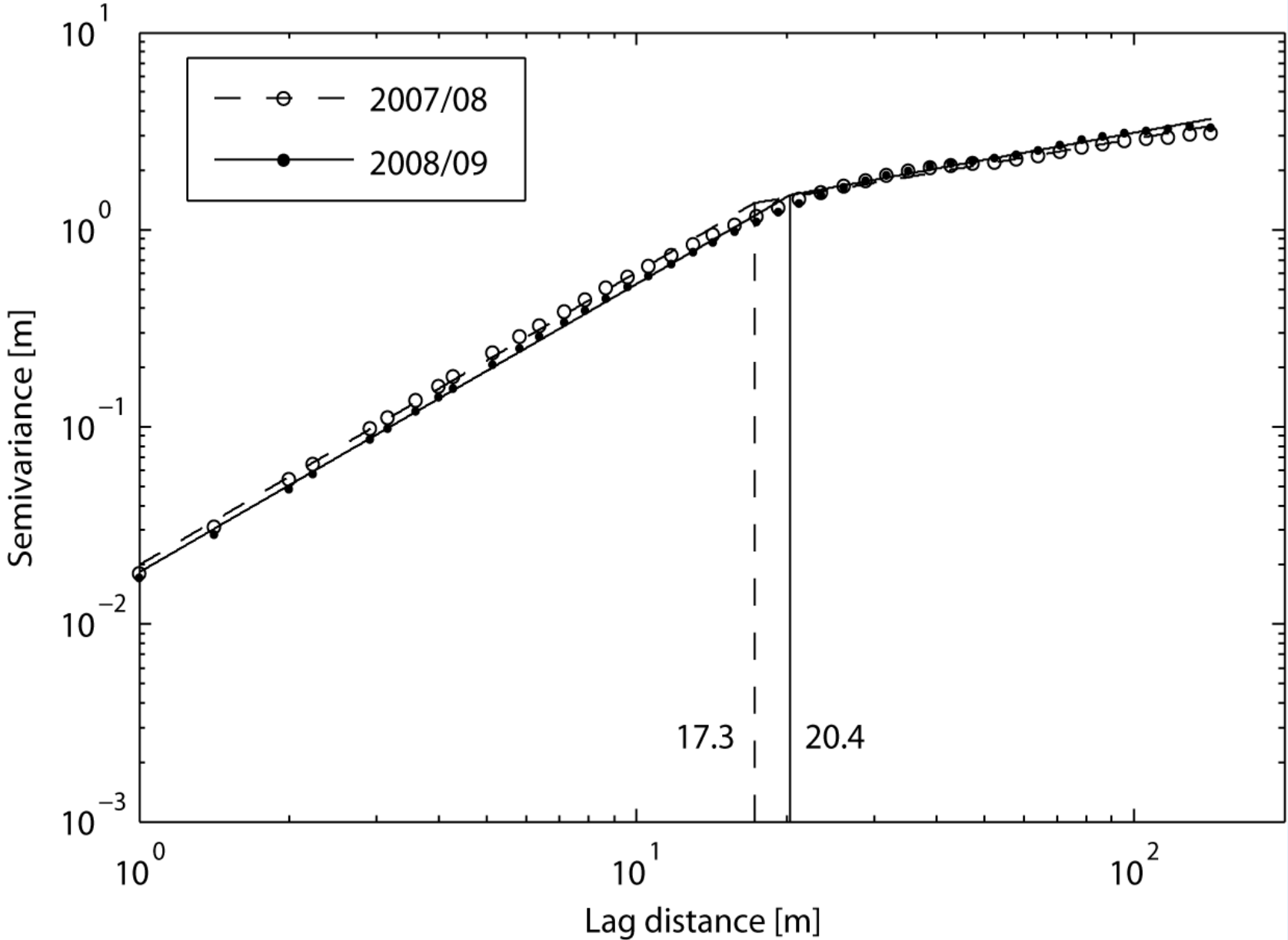

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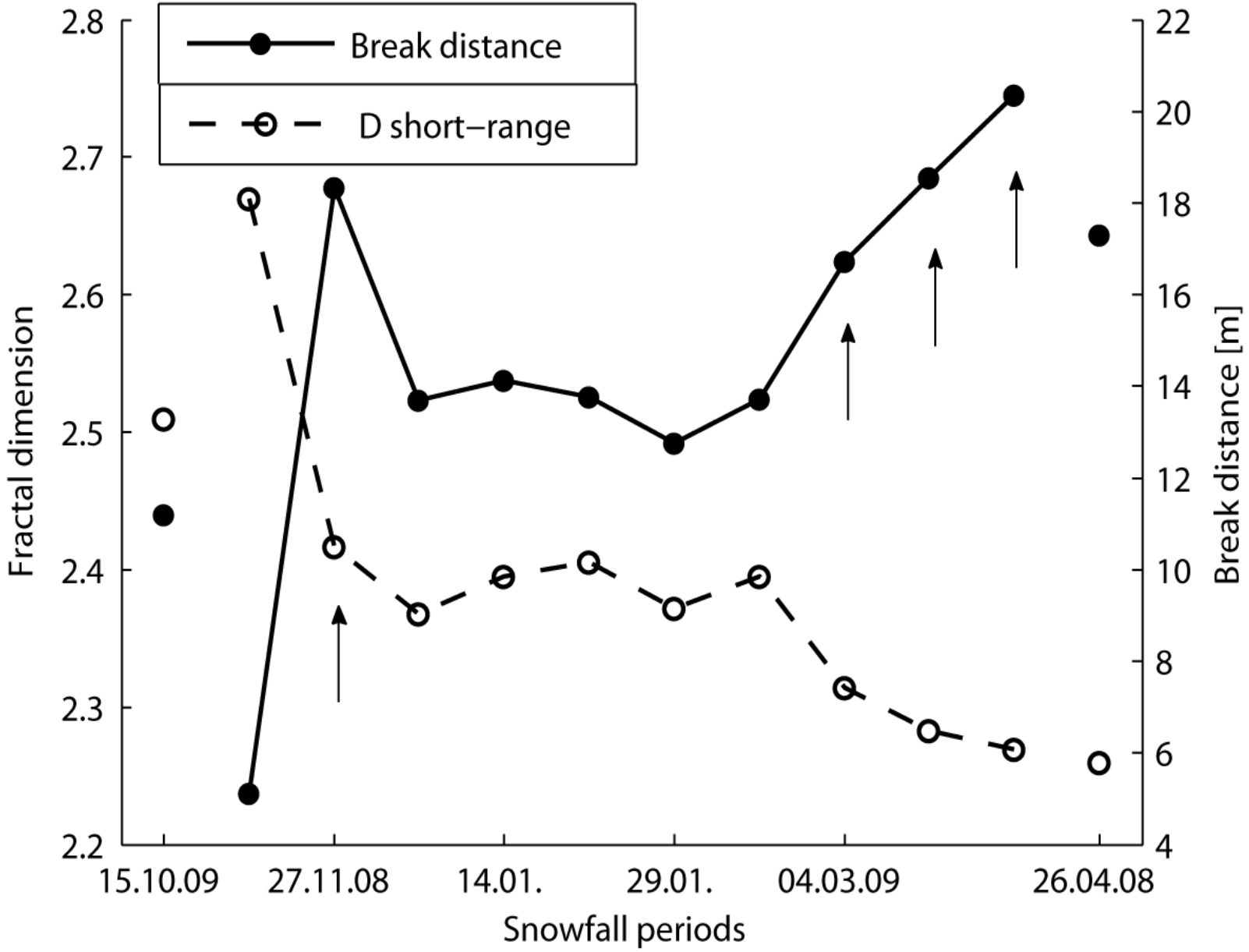
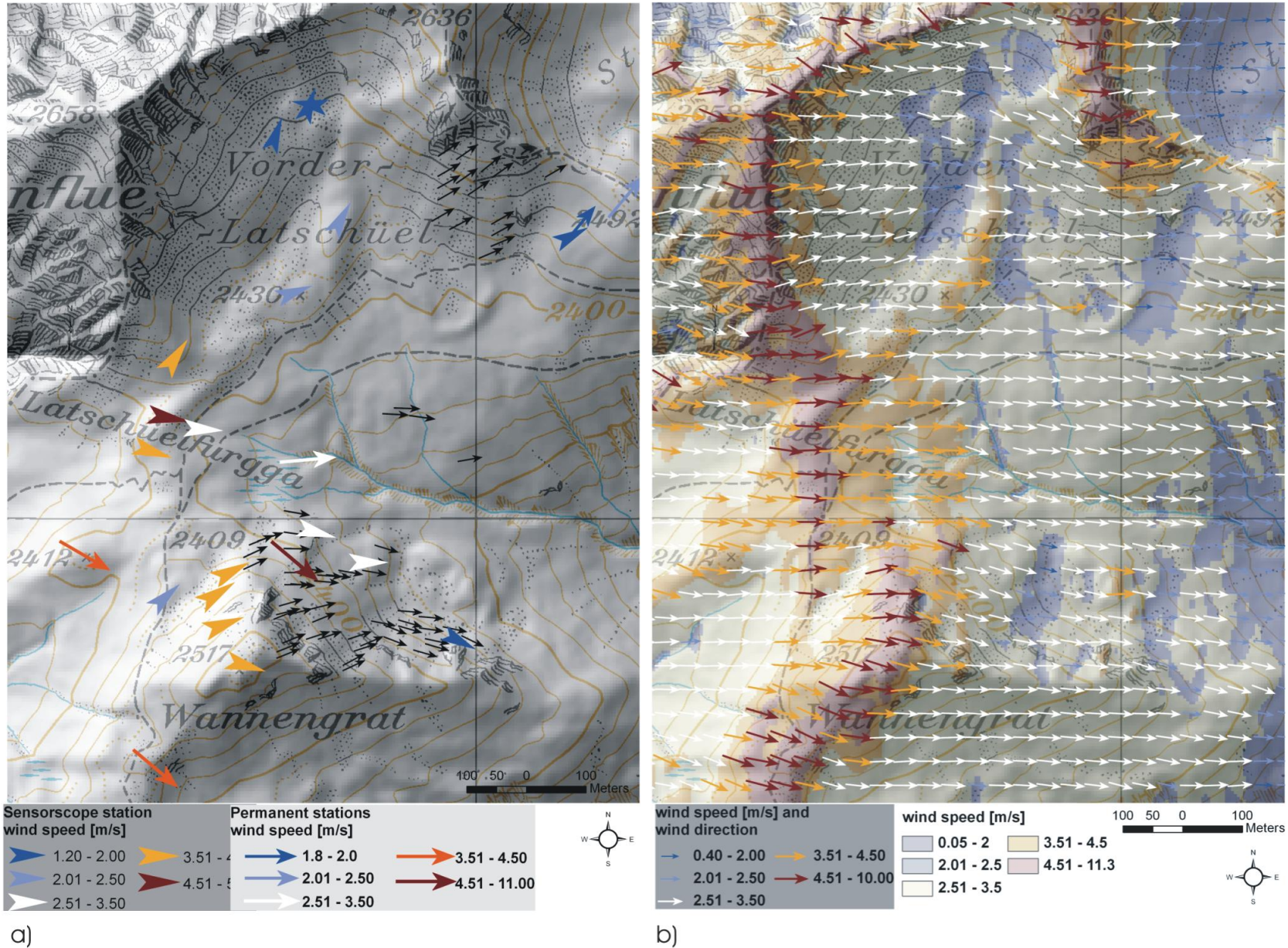


Advanced Modelling with ARPS and Alpine3D

ARPS and Alpine3D compared to ALS

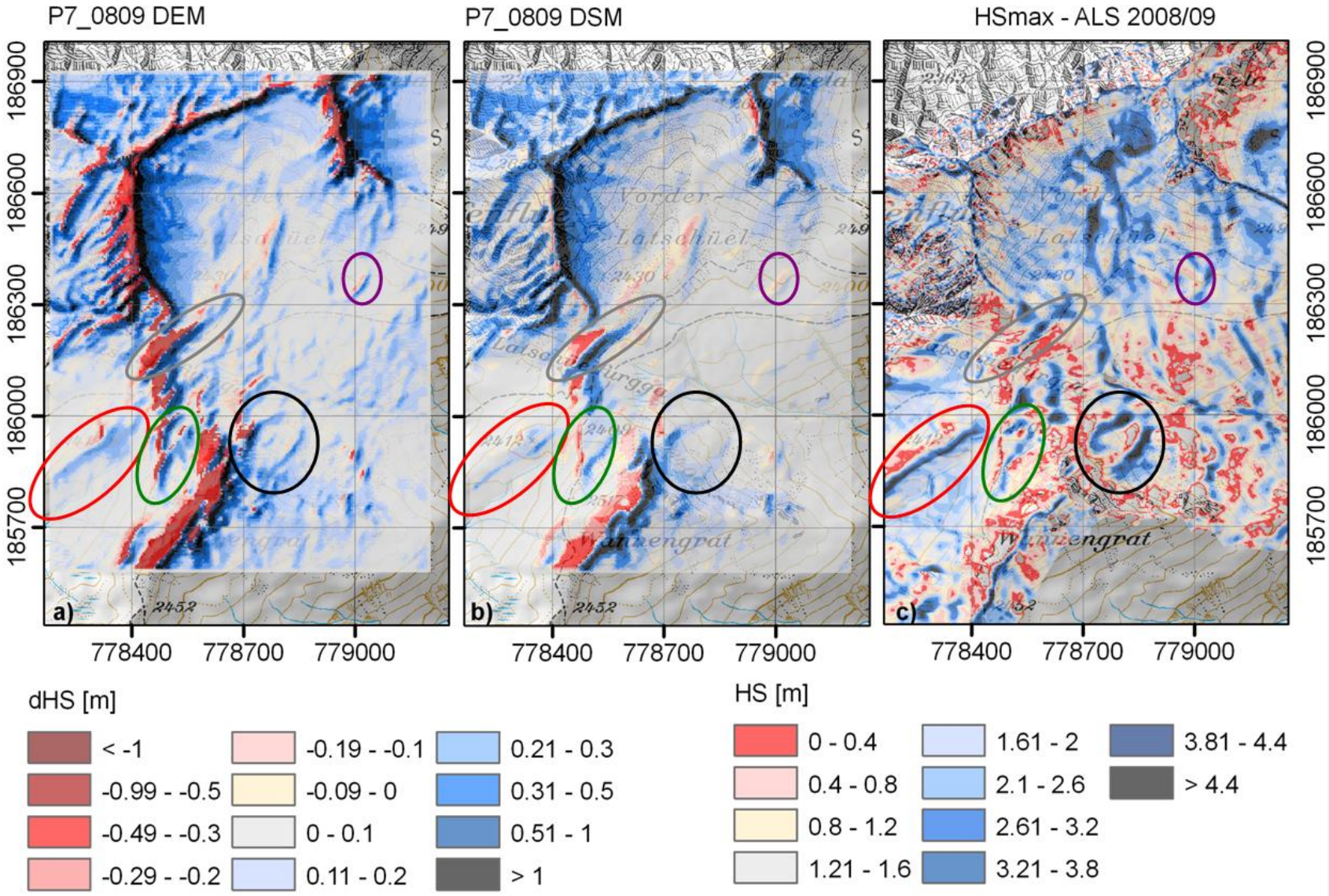
Flow features and deposition



a)

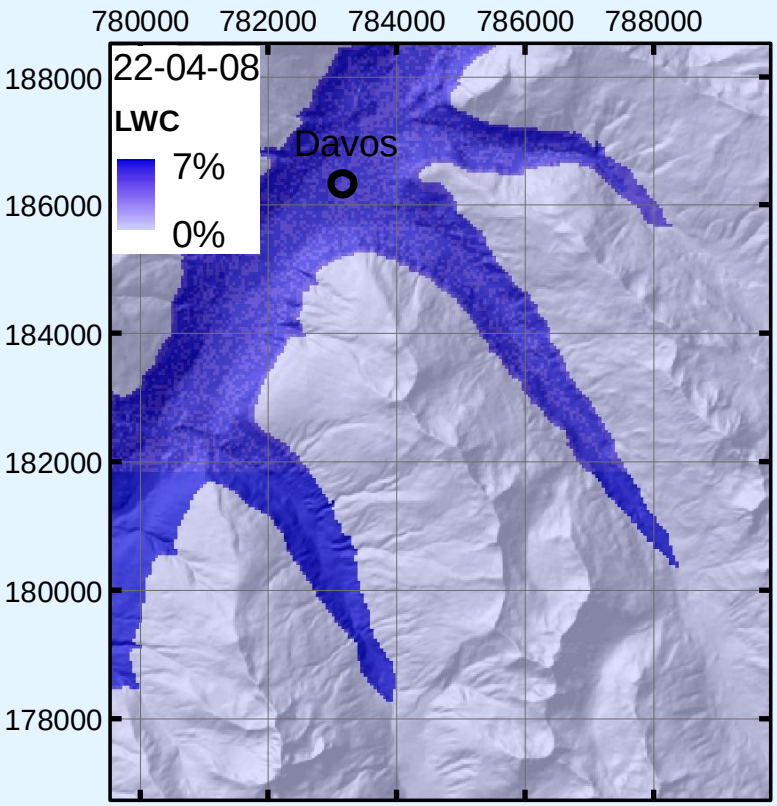
b)

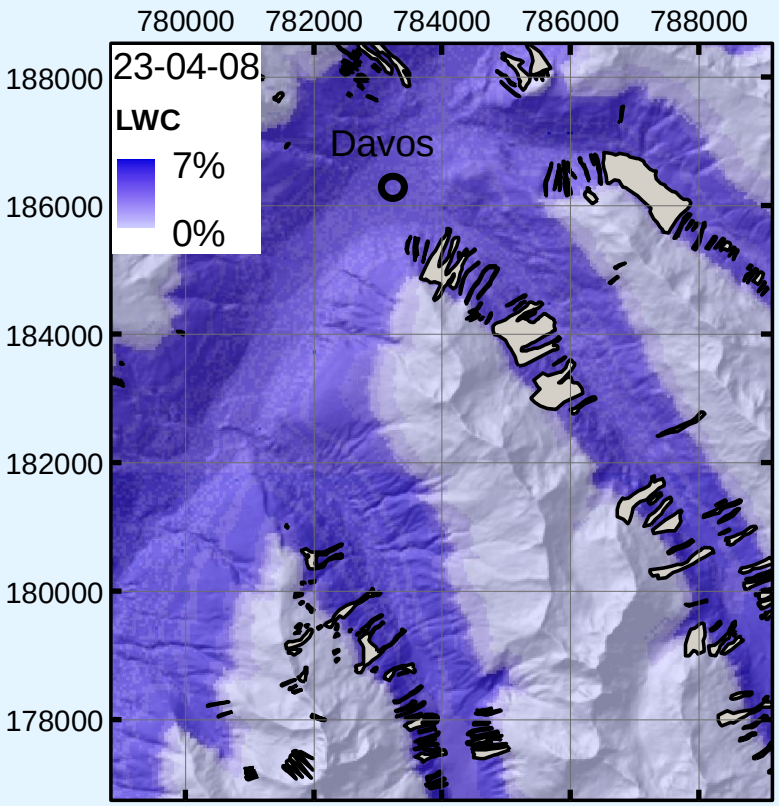
Alpine3D – Simulation @ Wannengrat



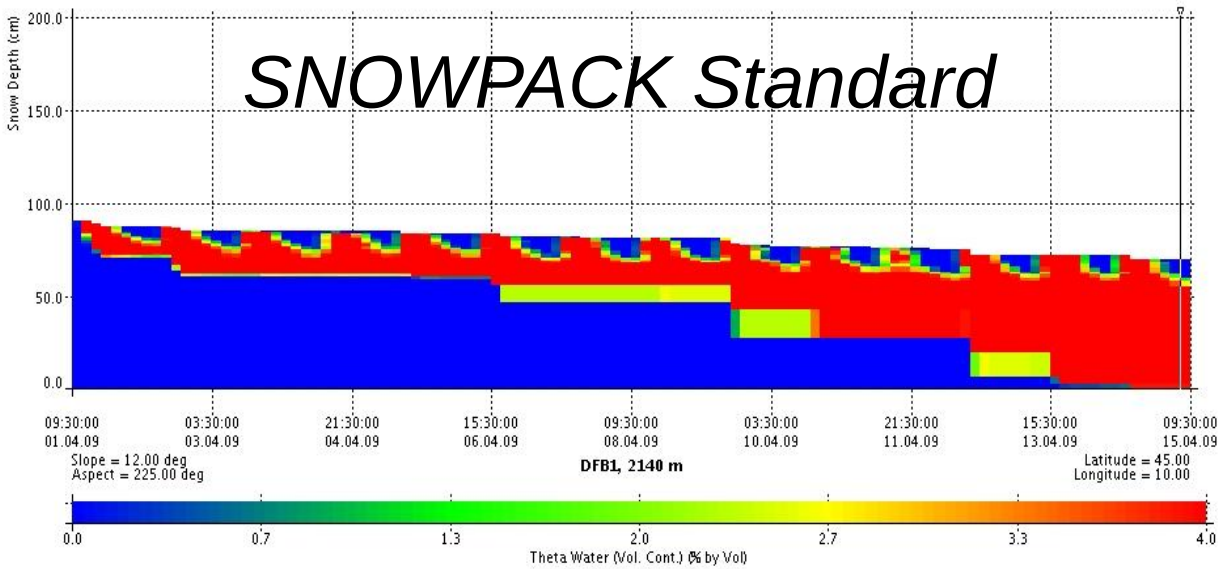
LWC Prediction for Wet Avalanches

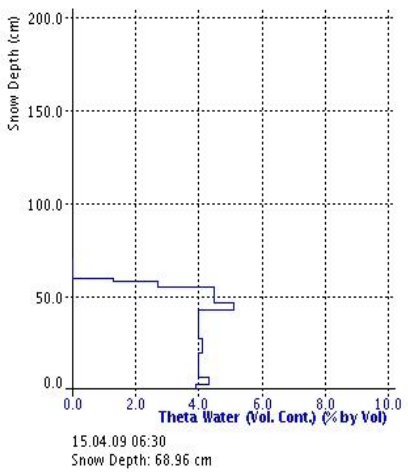
Prediction of Wet Snow Avalanches

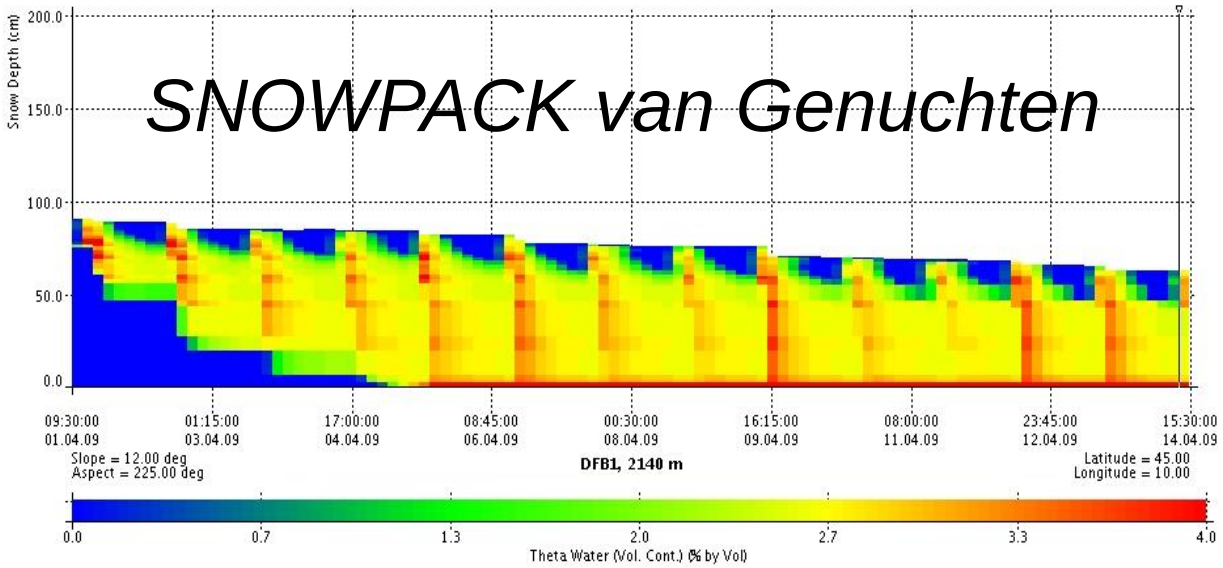


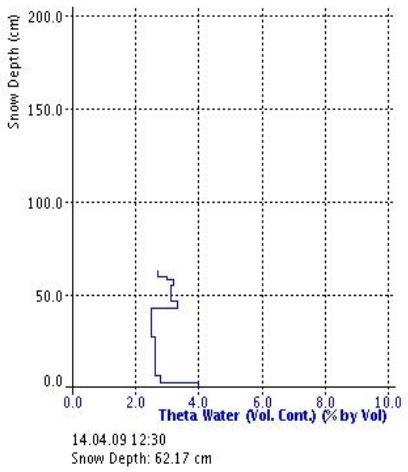


Prediction of Wet Snow Avalanches

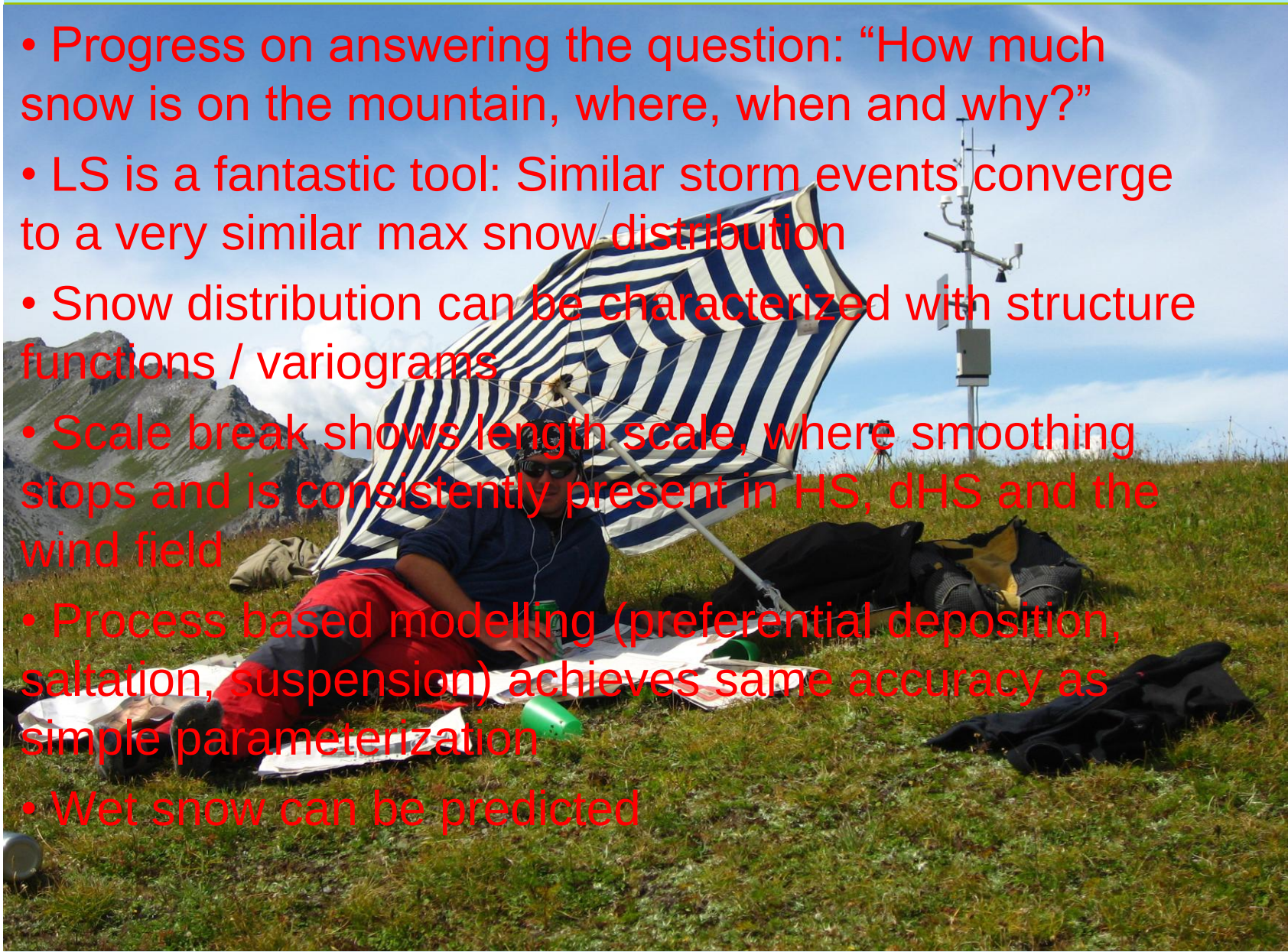








Conclusions



- Progress on answering the question: “How much snow is on the mountain, where, when and why?”
- LS is a fantastic tool: Similar storm events converge to a very similar max snow distribution
- Snow distribution can be characterized with structure functions / variograms
- Scale break shows length scale, where smoothing stops and is consistently present in HS, dHS and the wind field
- Process based modelling (preferential deposition, saltation, suspension) achieves same accuracy as simple parameterization
- Wet snow can be predicted