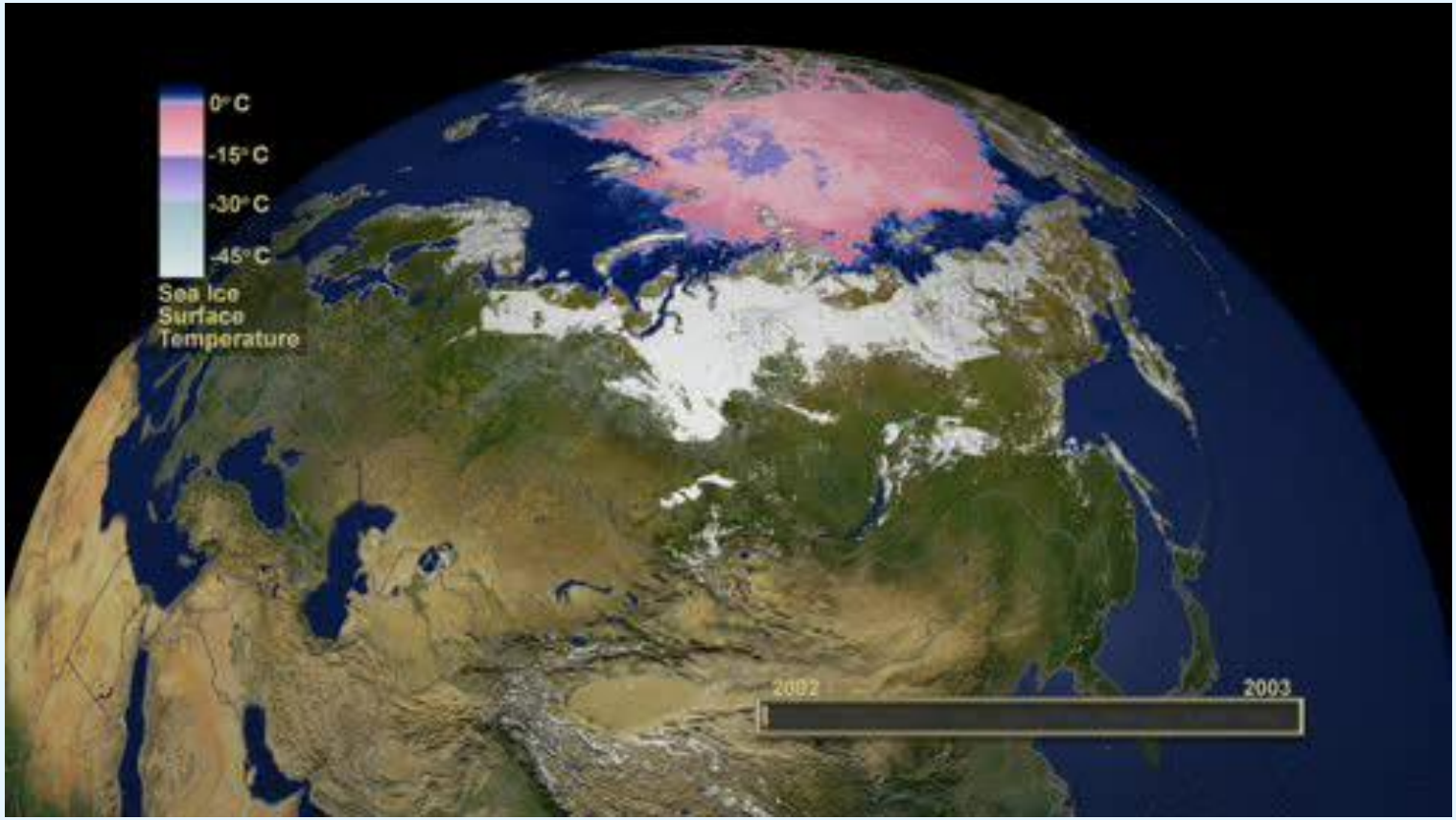
WSL Institut für Schnee und Lawinenforschung SLF Davos

Snow Distribution Today and Tomorrow

Michi Lehning

Presentation Pianeta 3000 - IL CAMBIAMENTO CLIMATICO E L'ACQUA DEL FUTURO: IL CASO DELLE ALPi

Snow – The Hemispheric View



Snow at the Slope Scale

Snow – The Avalanche

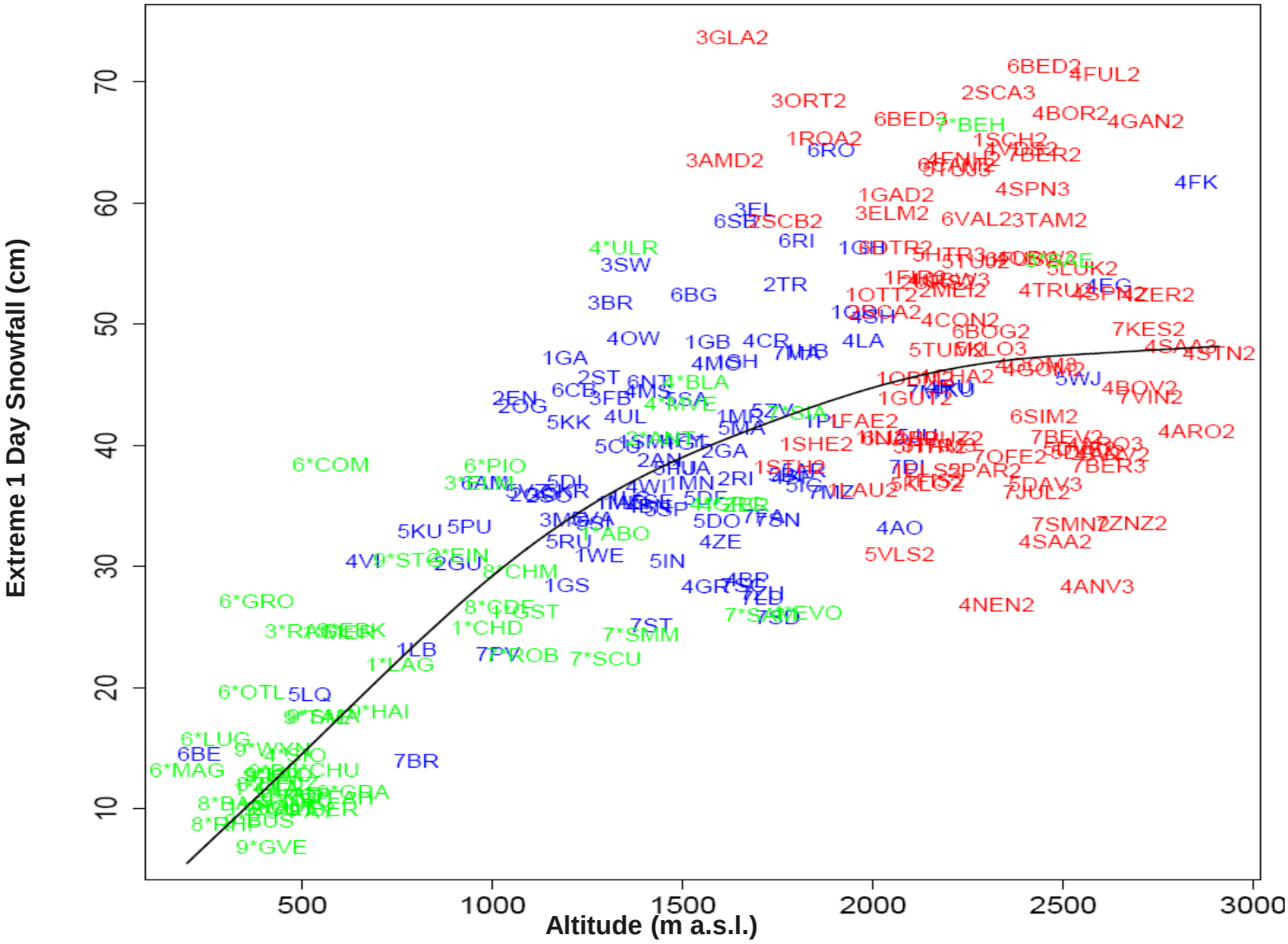
Scope of this Presentation

- Part I: Characteristics of Mountain Snow Distribution
- Part II: Process Description of Mountain Snow Distribution
- Part II: Scaling and Smoothing – Statistical Description
- Part IV: Predicted Changes of the Mountain Snow Cover

Part I

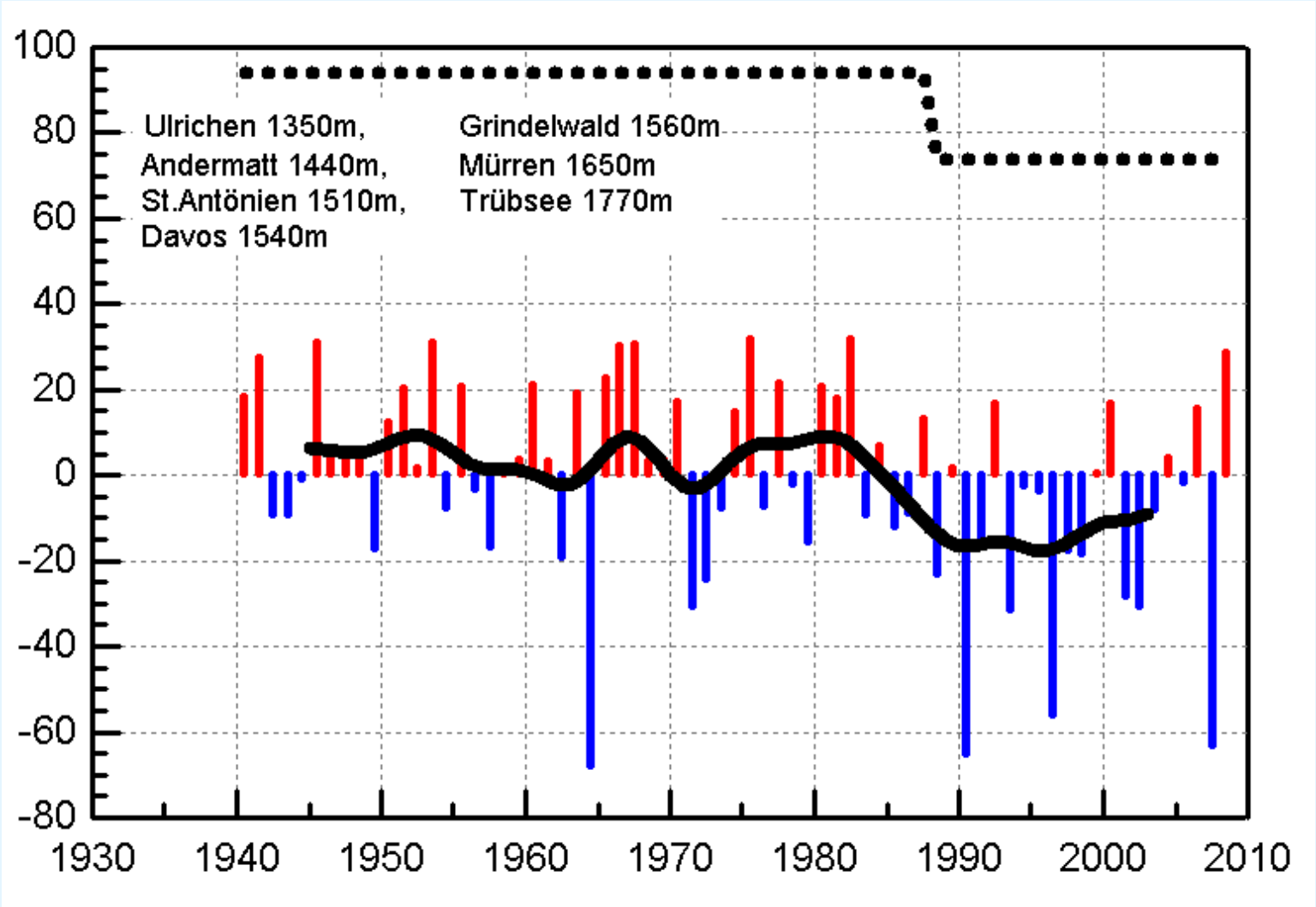
Characteristics of Mountain Snow Distribution

Extreme Snow Fall Events in Switzerland

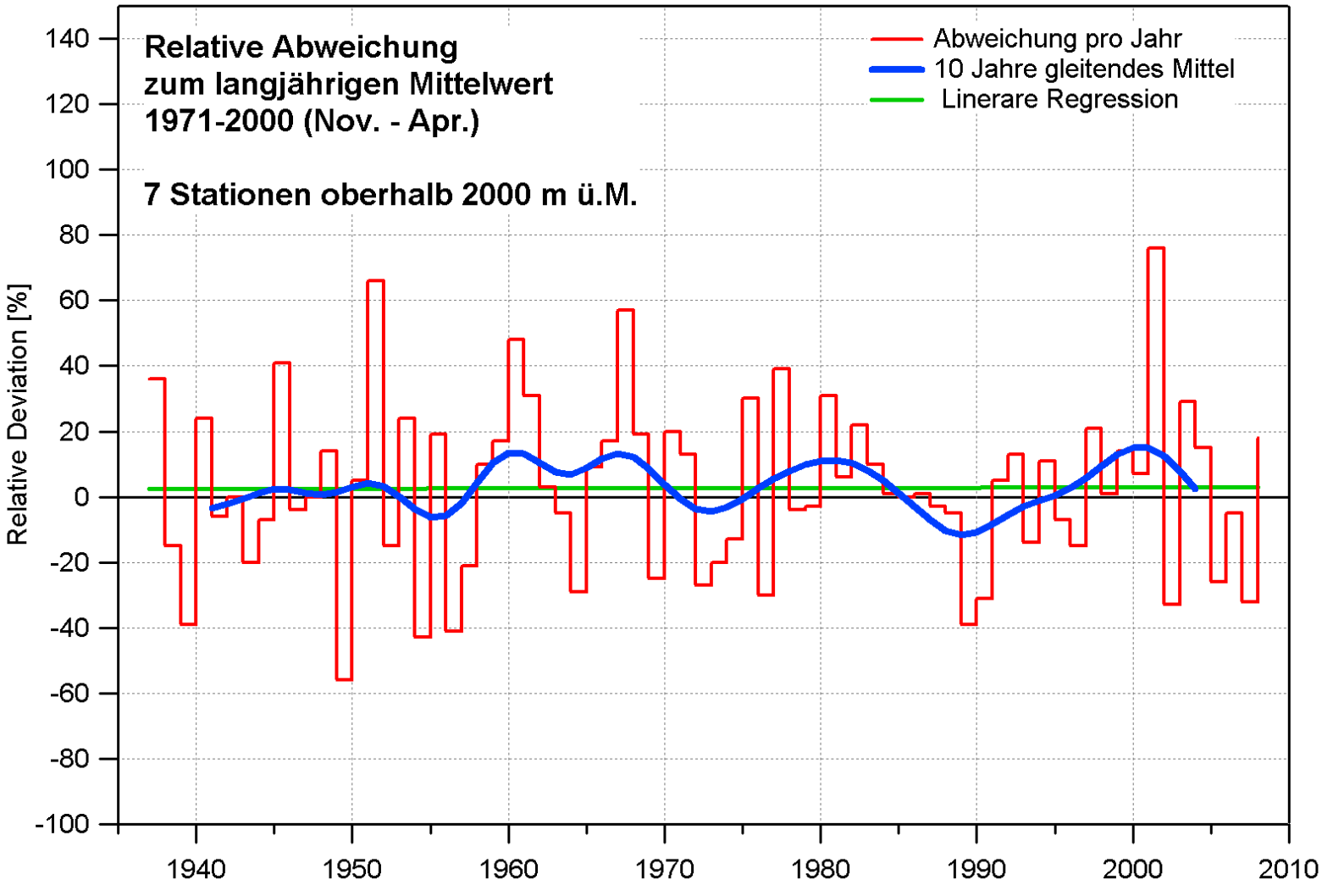


Trend in Snow Days in Northern Alps

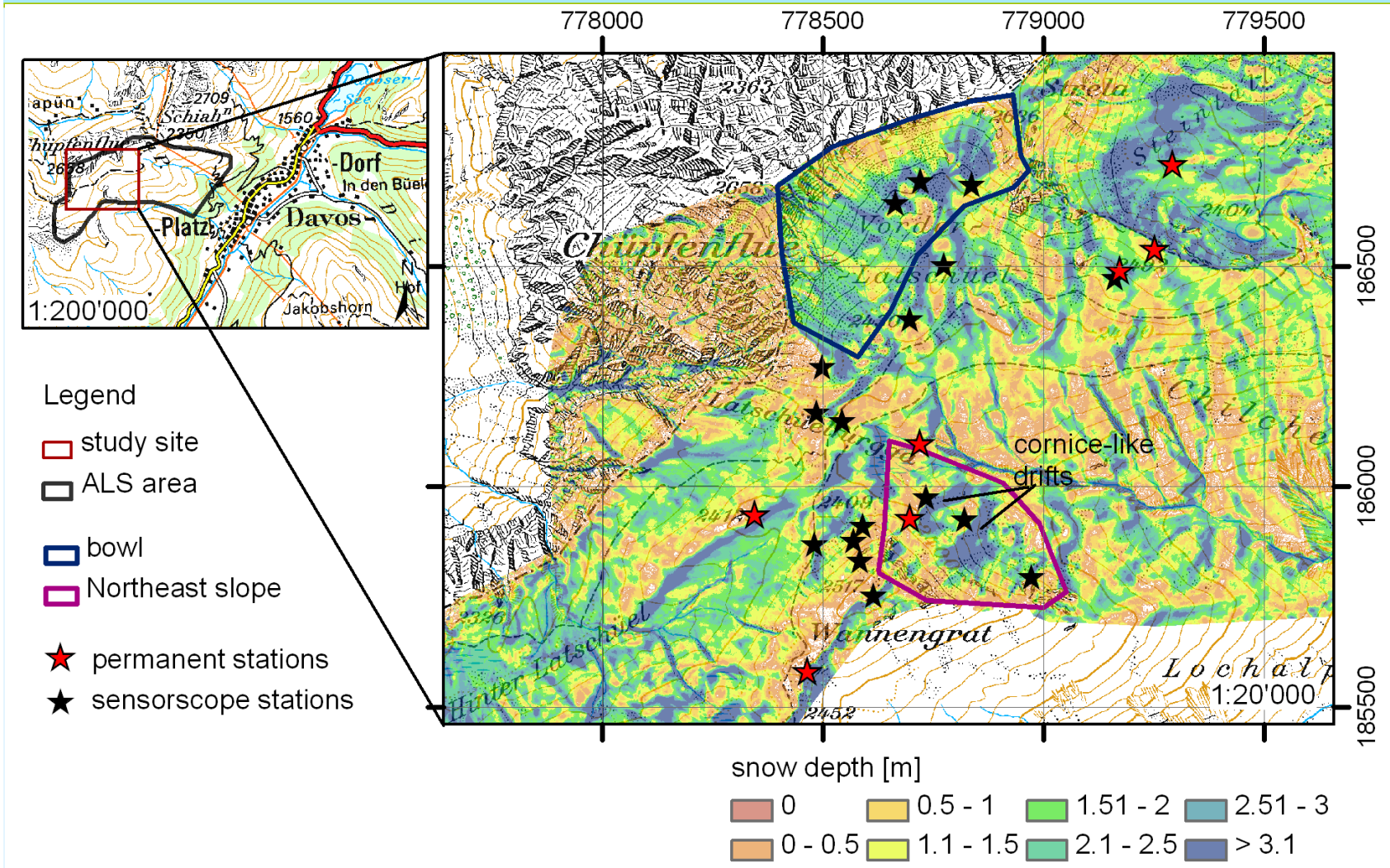
Deviation from the mean 1961-1990



No change currently above 2000 m

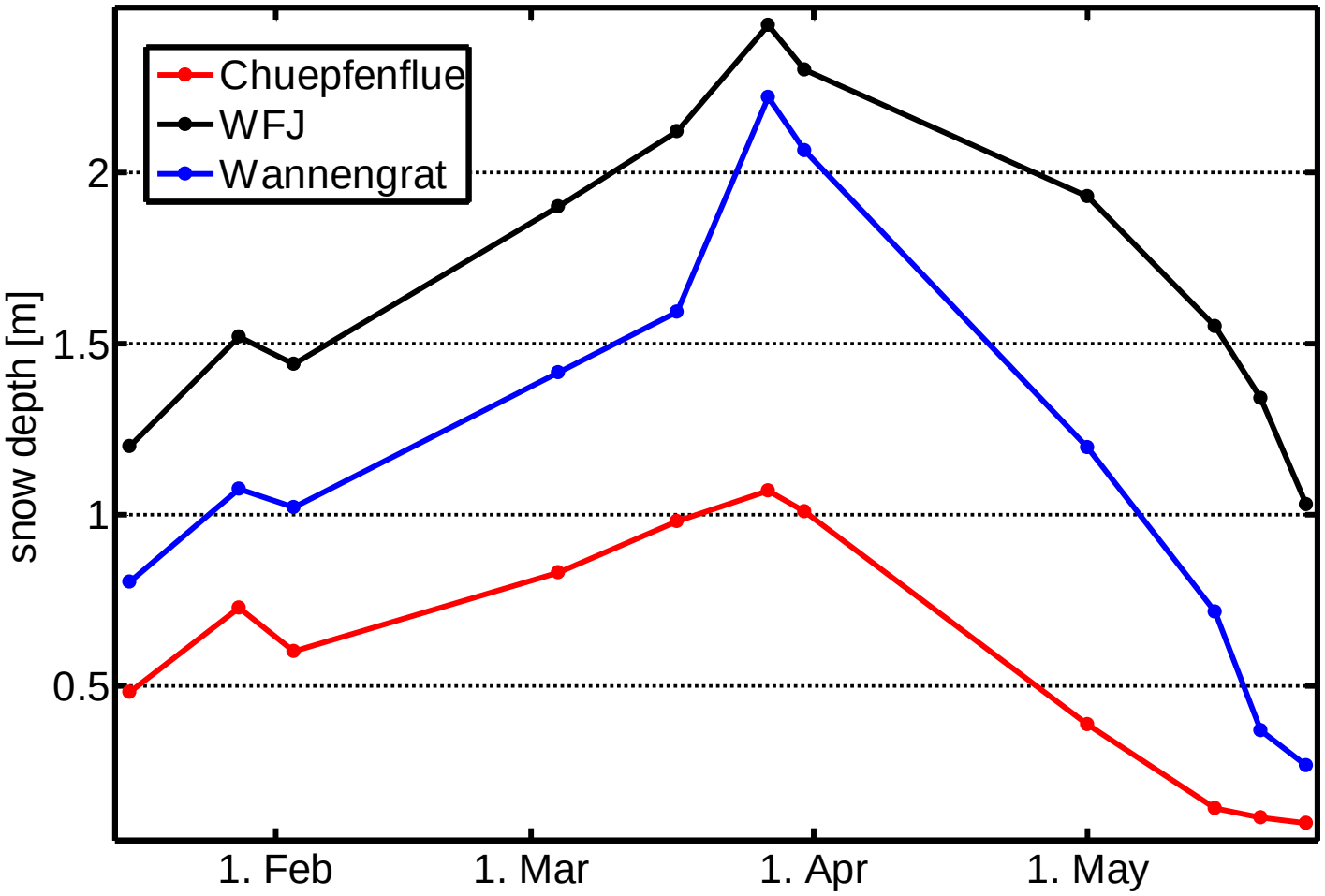


New Measurements: ALS at Wannengrat



Heterogeneous Alpine Space above DAVOS

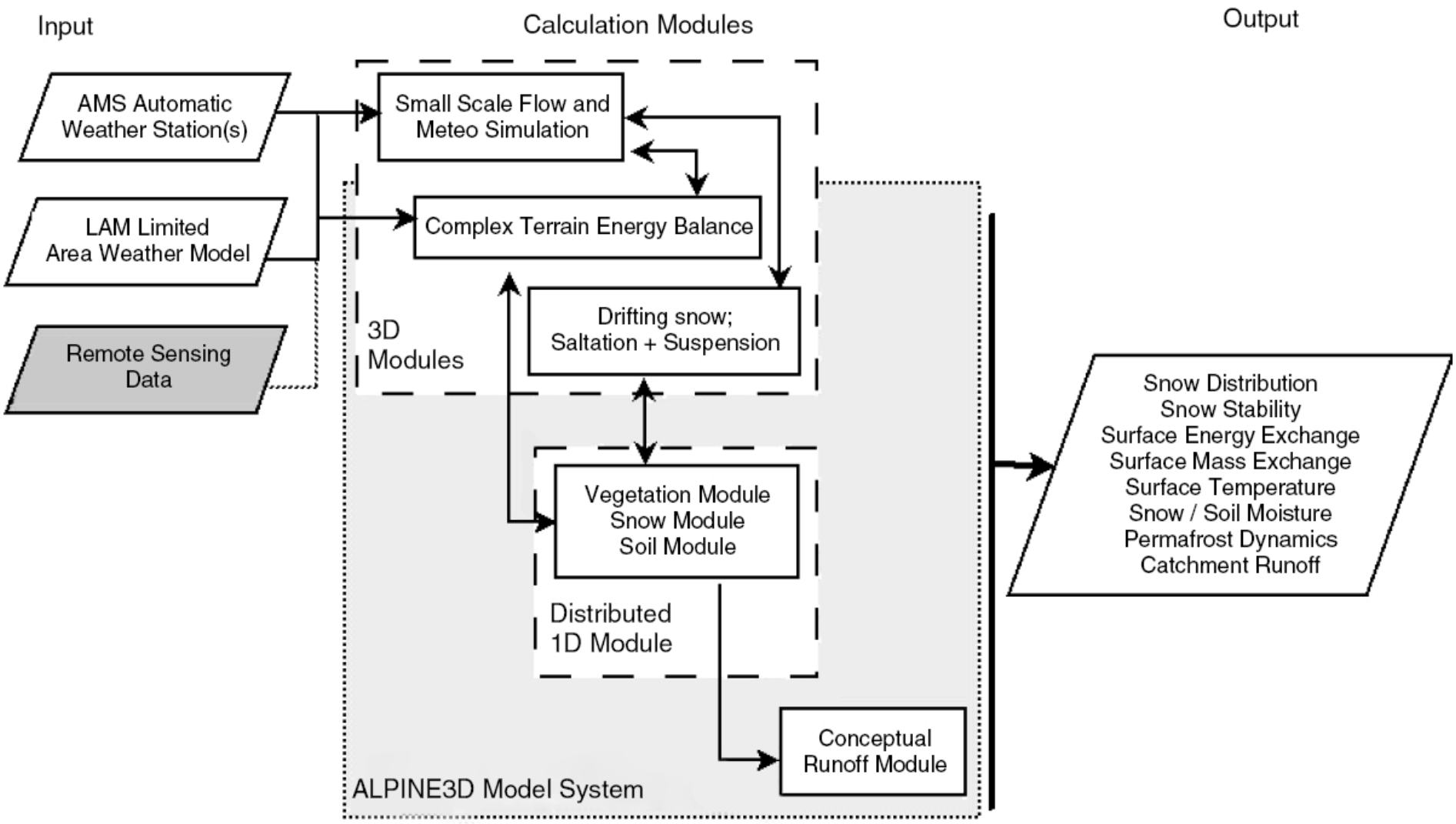
Intra-annual SWE development



Part II

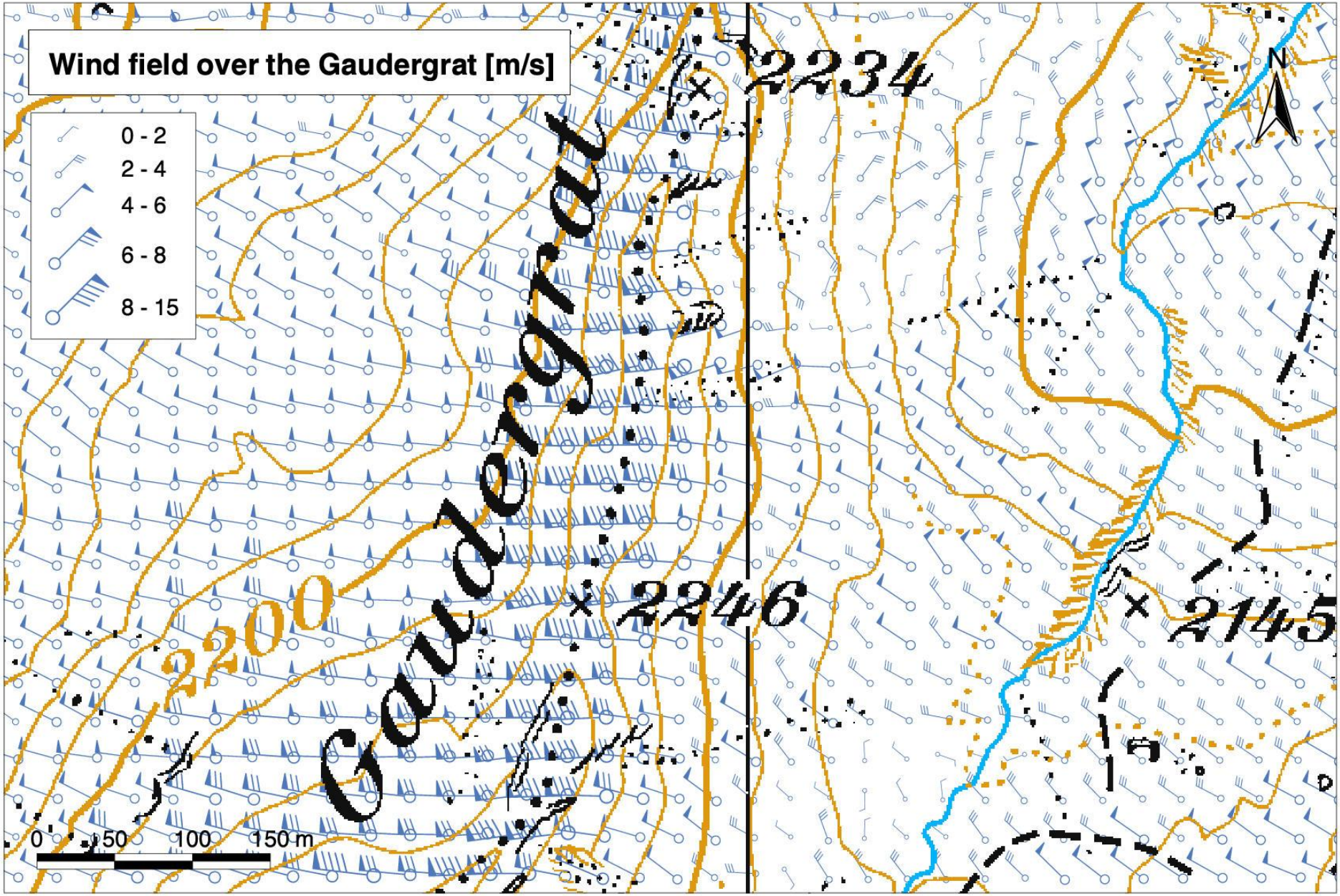
Process Description of Mountain Snow Distribution

Alpine3D: Model Overview

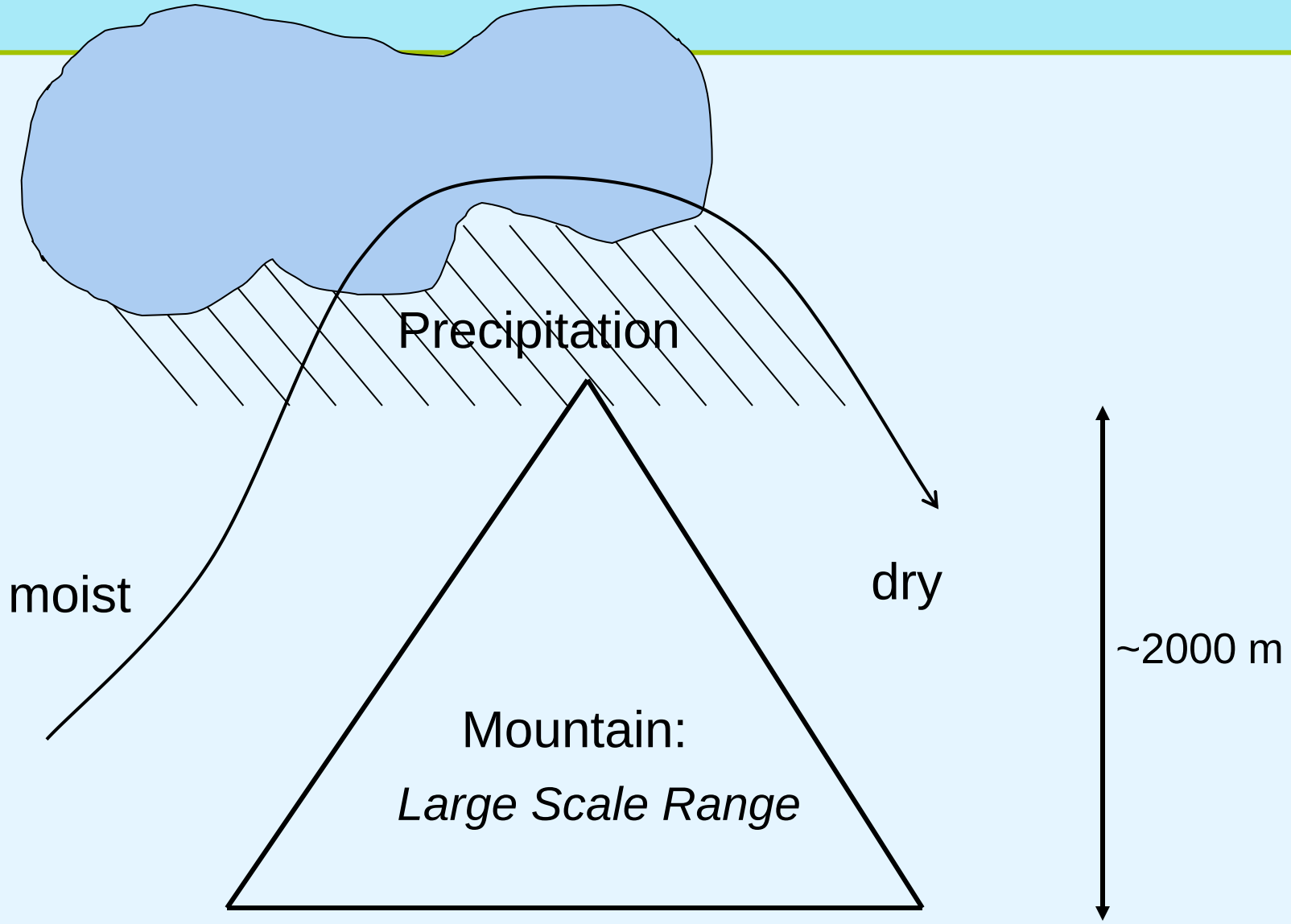


Lehning et al., HP, 2006; Lehning et al. WRR, 2008

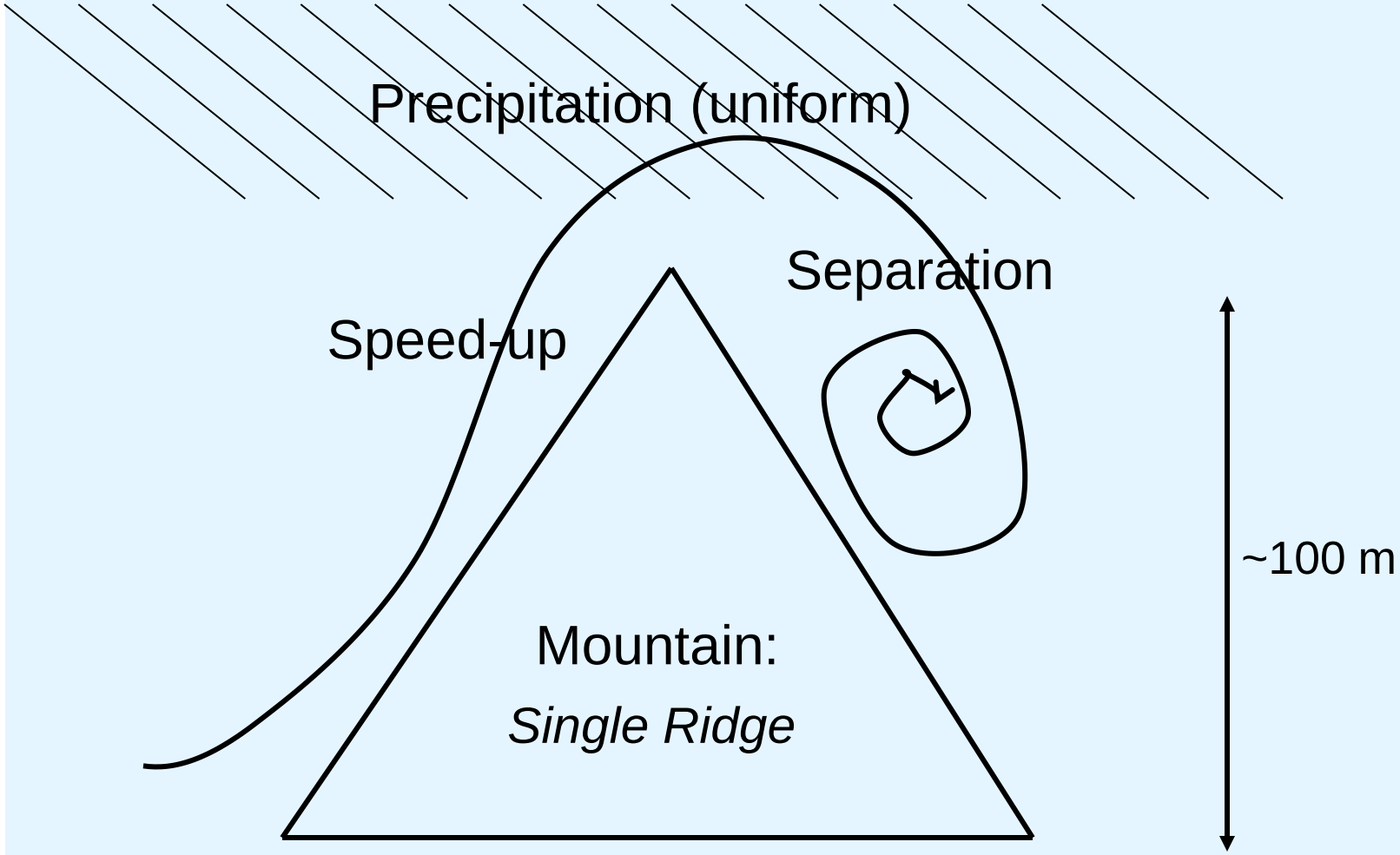
Wind Field Simulation with ARPS



Precipitation and Mountains



Precipitation and Mountains



Preferential Deposition in Alpine3D

Stationary Diffusion Equation for Snow Particles:

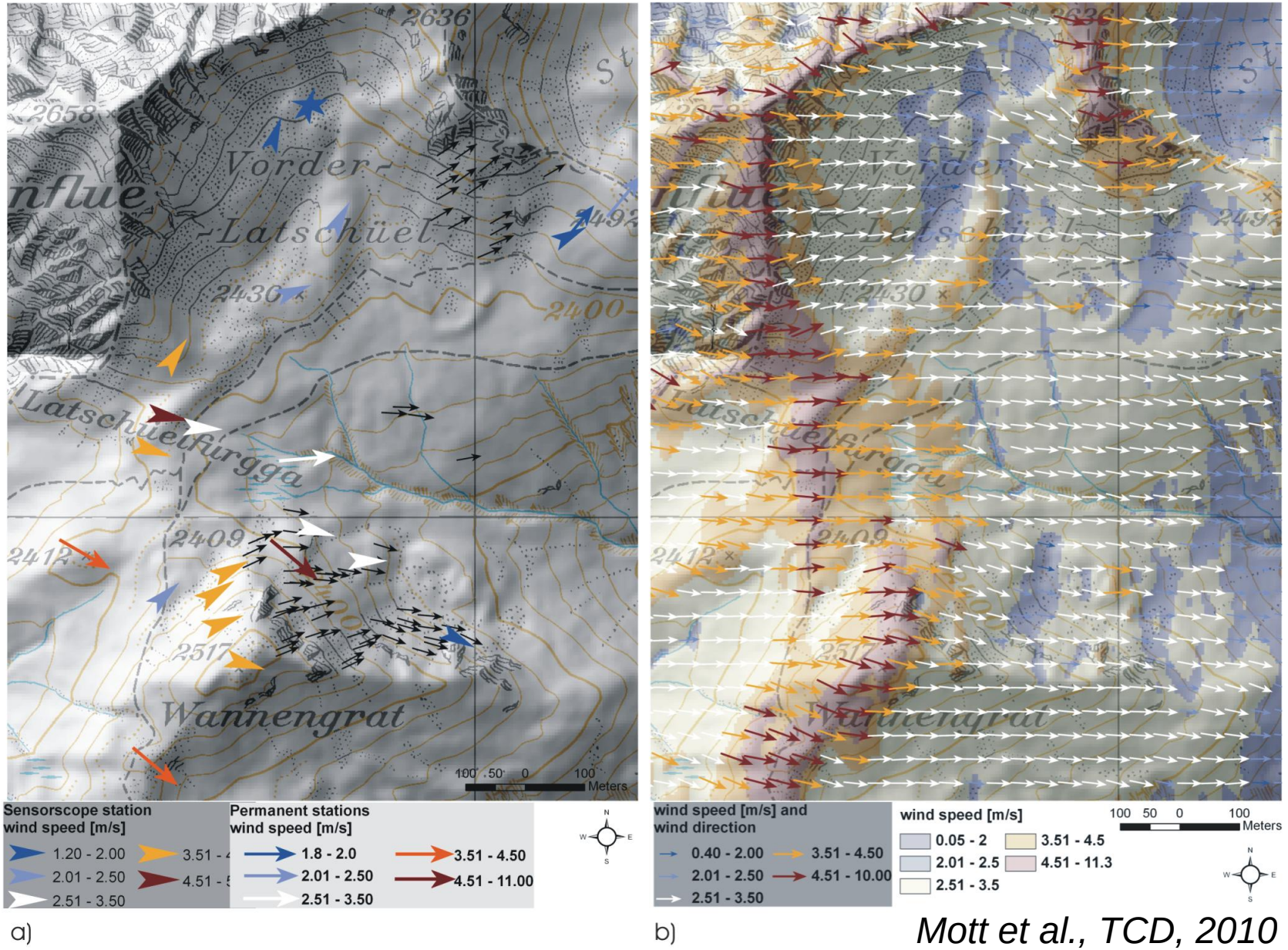
$$\nabla \cdot \Big(K(\mathbf{x})\, \nabla c(\mathbf{x}) \Big) - \mathbf{u}(\mathbf{x}) \cdot \nabla c(\mathbf{x}) = 0$$

$$\mathbf{u} = (u, v, w - w_s)$$

Lower Boundary Condition (Robin Type):

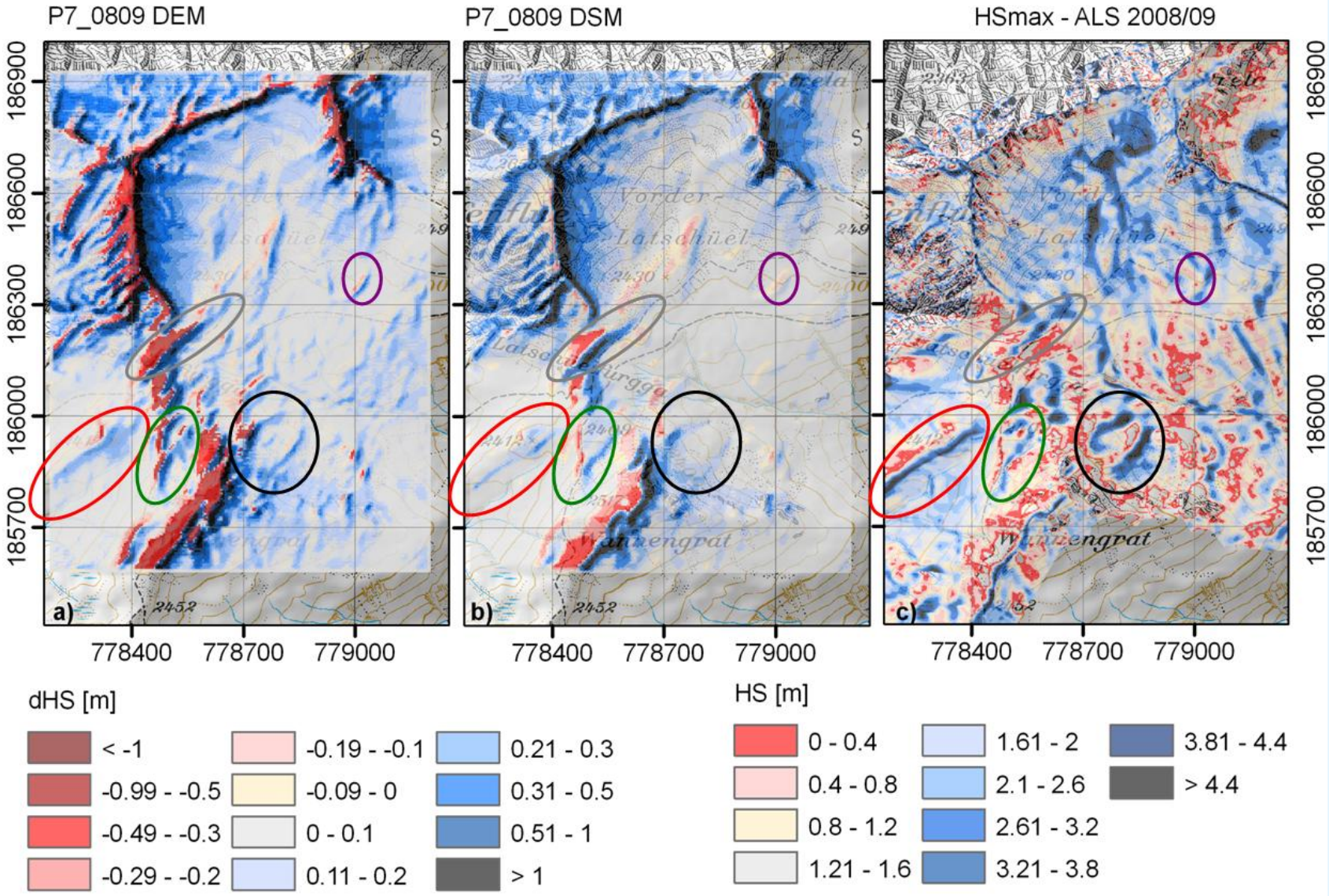
$$-\mathbf{n}(\mathbf{x}) \cdot K(\mathbf{x}) \nabla c(\mathrm{x}) = \frac{K^{\perp}(\mathbf{x})}{h_{\mathrm{ref}}} \Big[c(\mathbf{x}) - \left(c_{\mathrm{salt}}(\mathbf{x}) + c_{\mathrm{prec}} \right) \Big]$$

Flow features and deposition



Mott et al., TCD, 2010

Alpine3D – Simulation @ Wannengrat



Mott et al., TCD, 2010

Remark

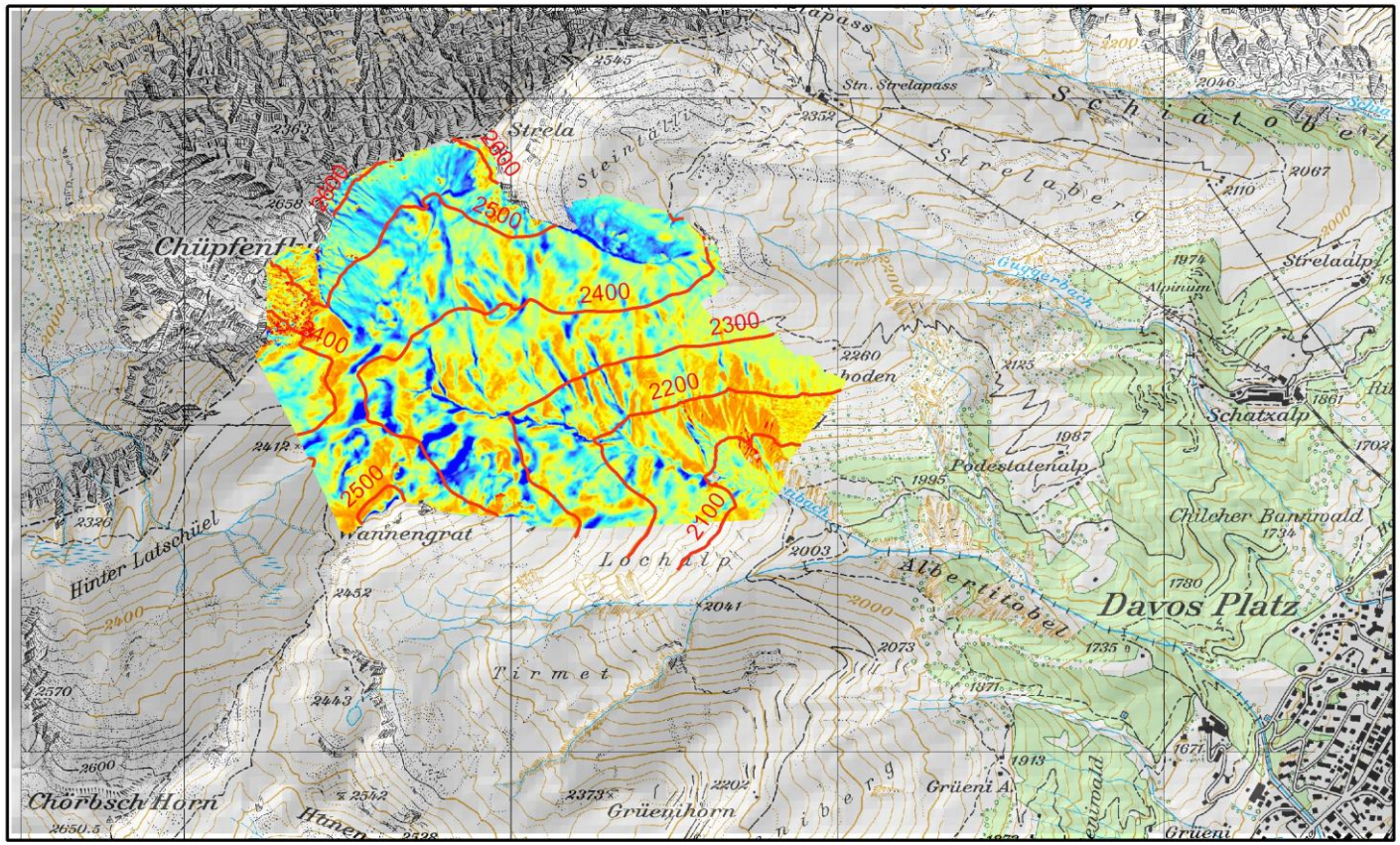
Process Description of Sublimation in Blowing Snow Clouds

Part III

Scaling and Smoothing –
Statistical Description

Result: ALS Wannengrat 2008

ALS WAN 2008-04-26



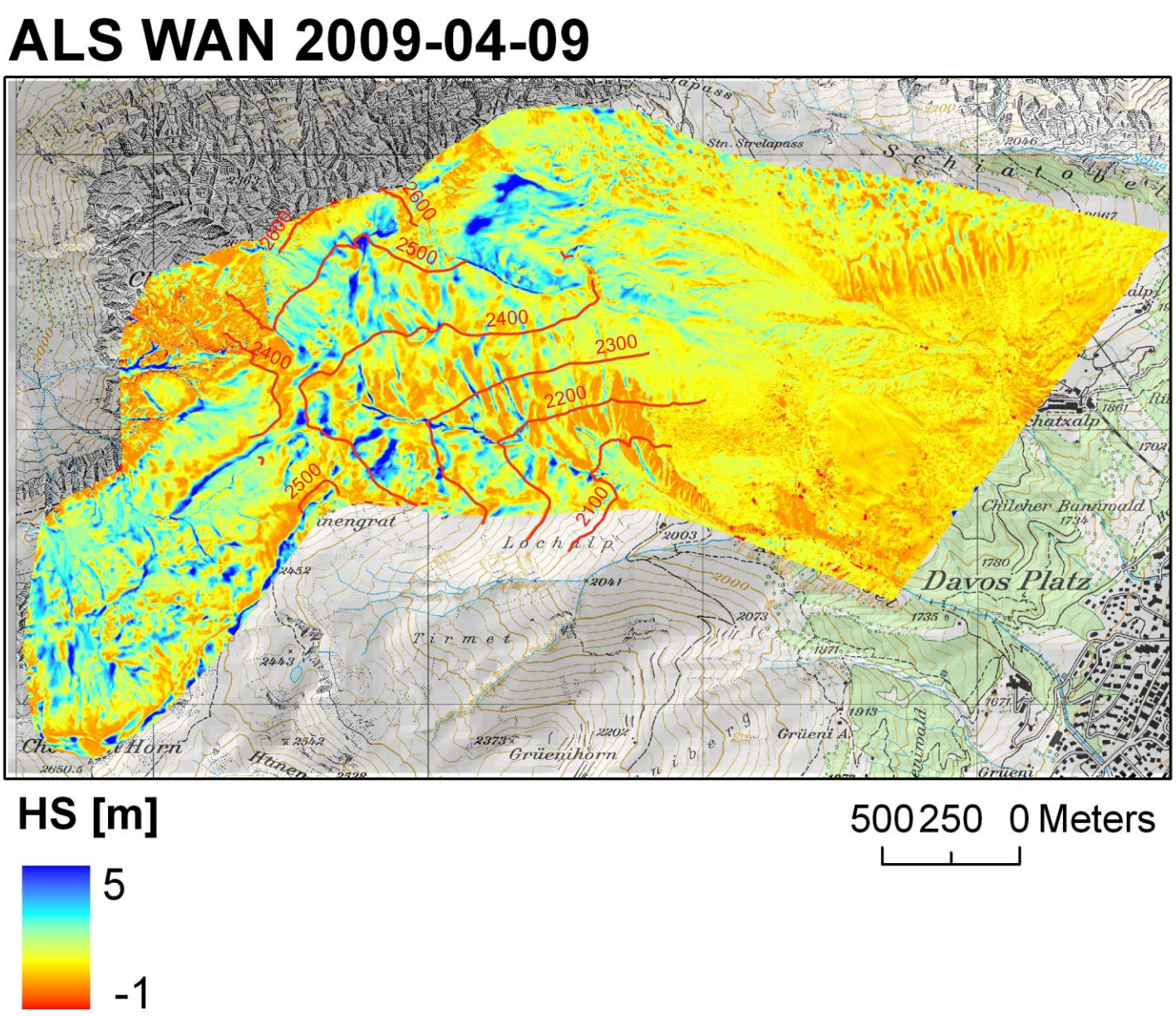
HS [m]

5

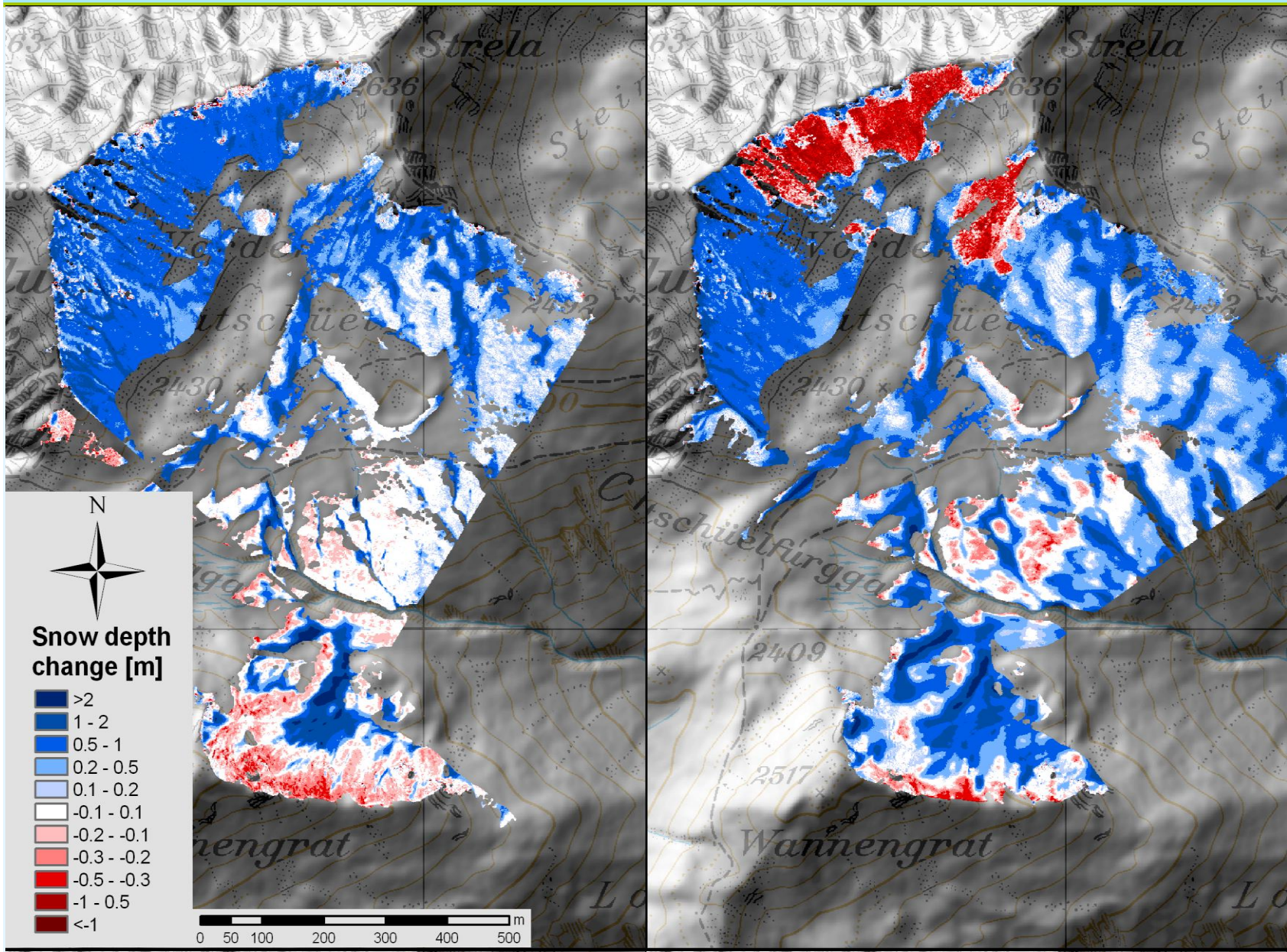
-1

500 250 0 Meters

Result: ALS Wannengrat 2009



Snow Depth Changes in Time 2009



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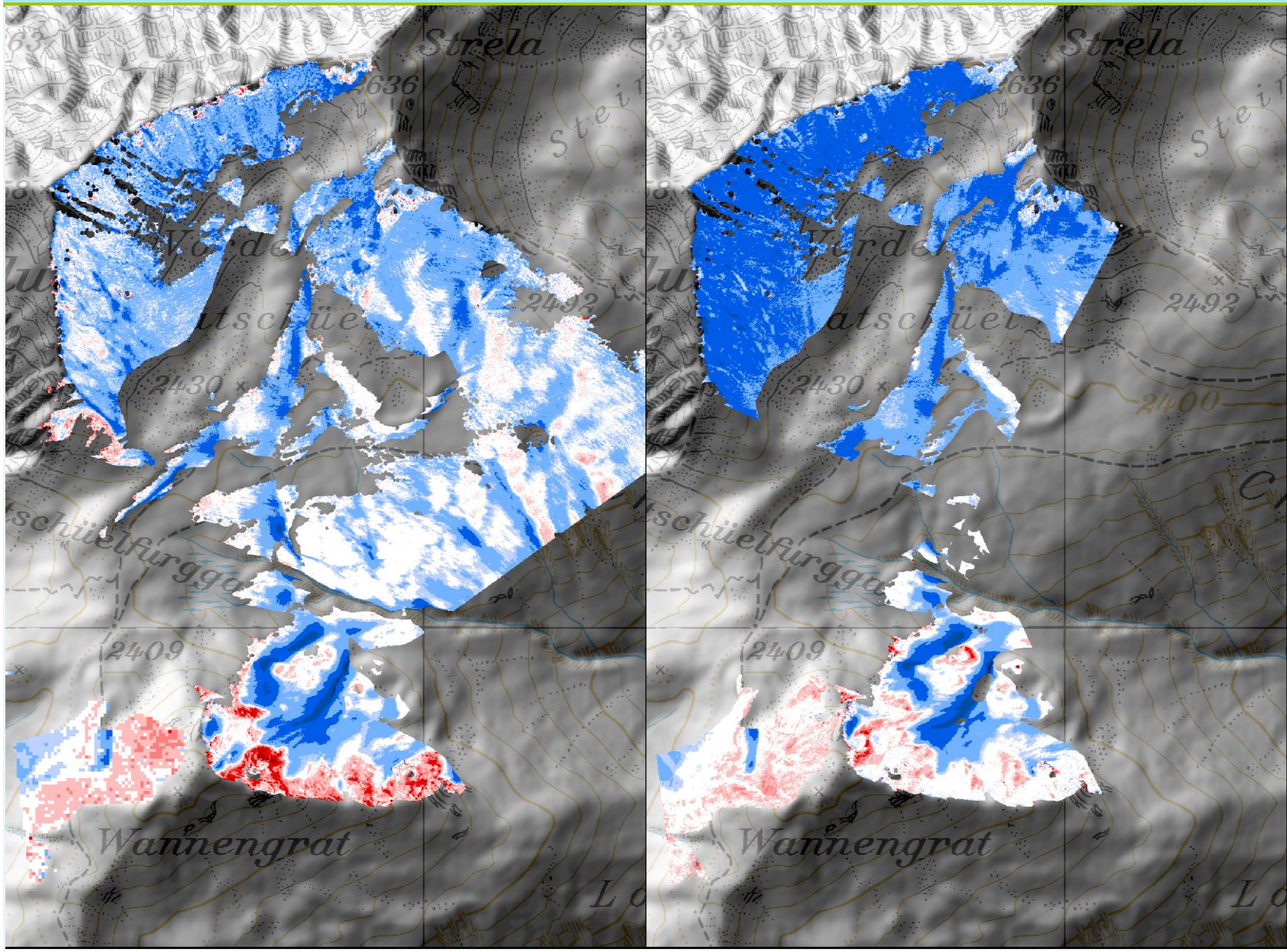
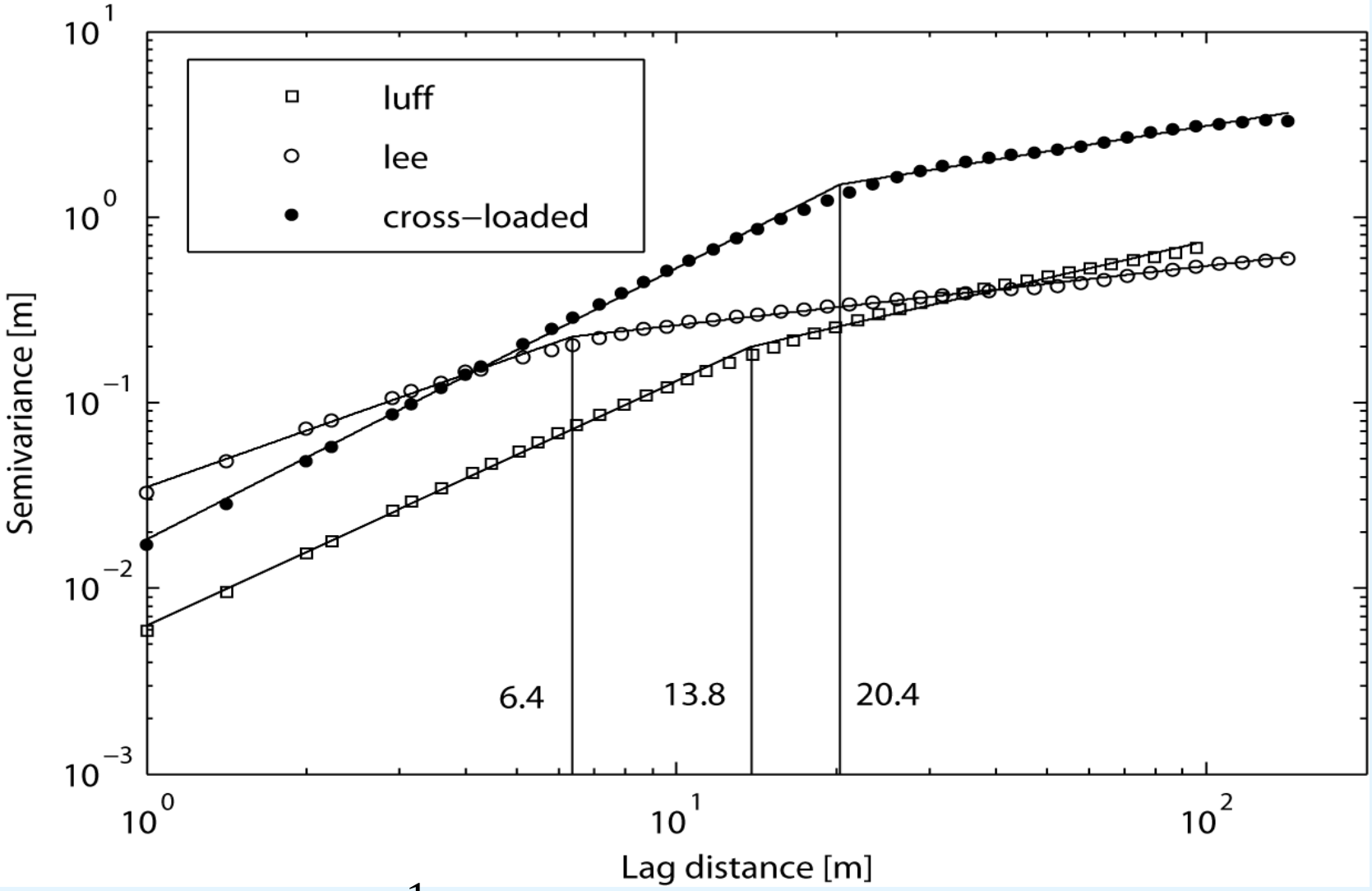
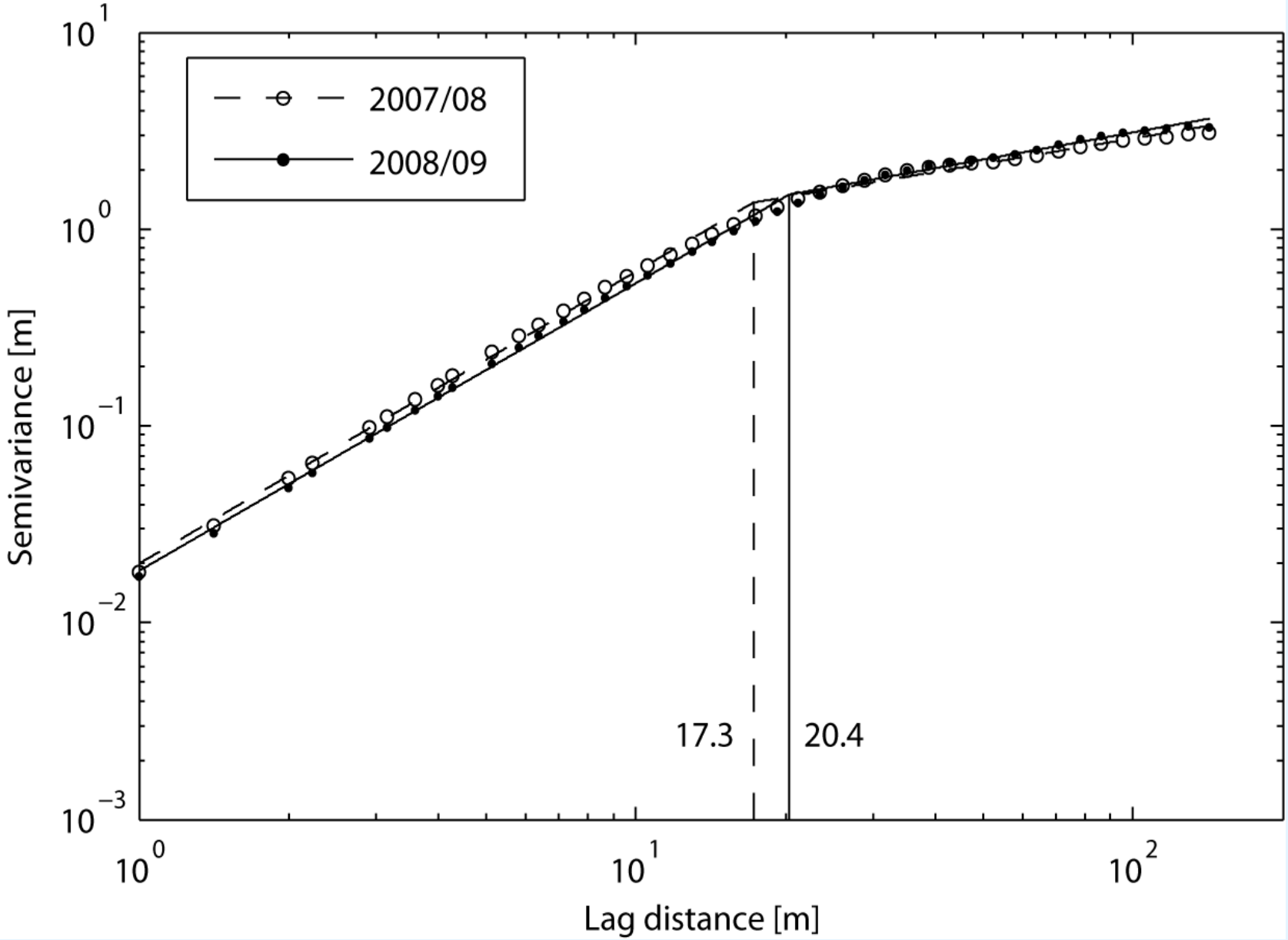


Scaling Properties based on Variograms

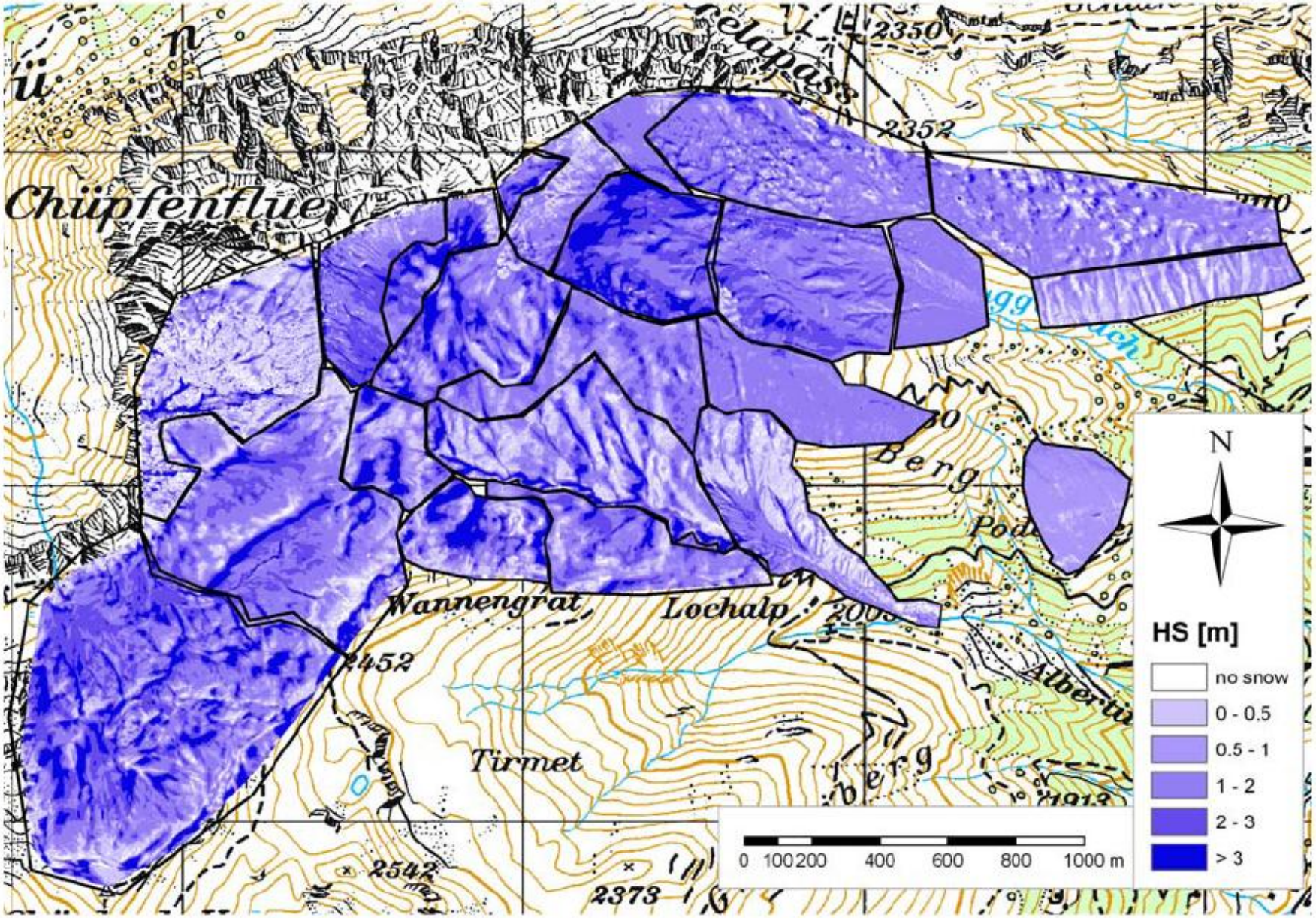


$$SV(lag) = \frac{1}{2n_{lag}} \sum_{lag} (hs(x) - hs(x + lag))^2$$

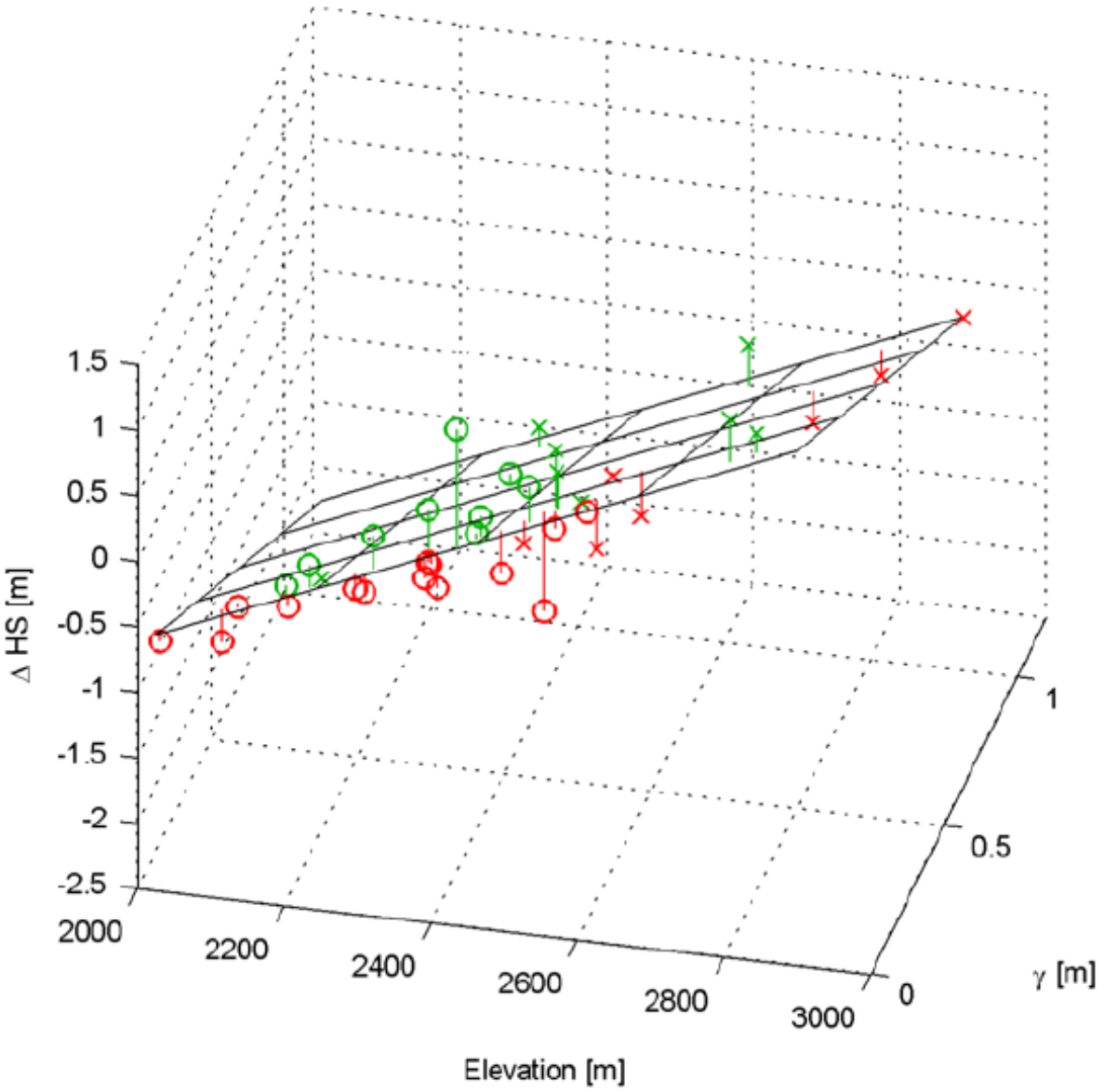
Scaling Properties based on Variograms



Prediction of Snow Depth in Sub-Areas



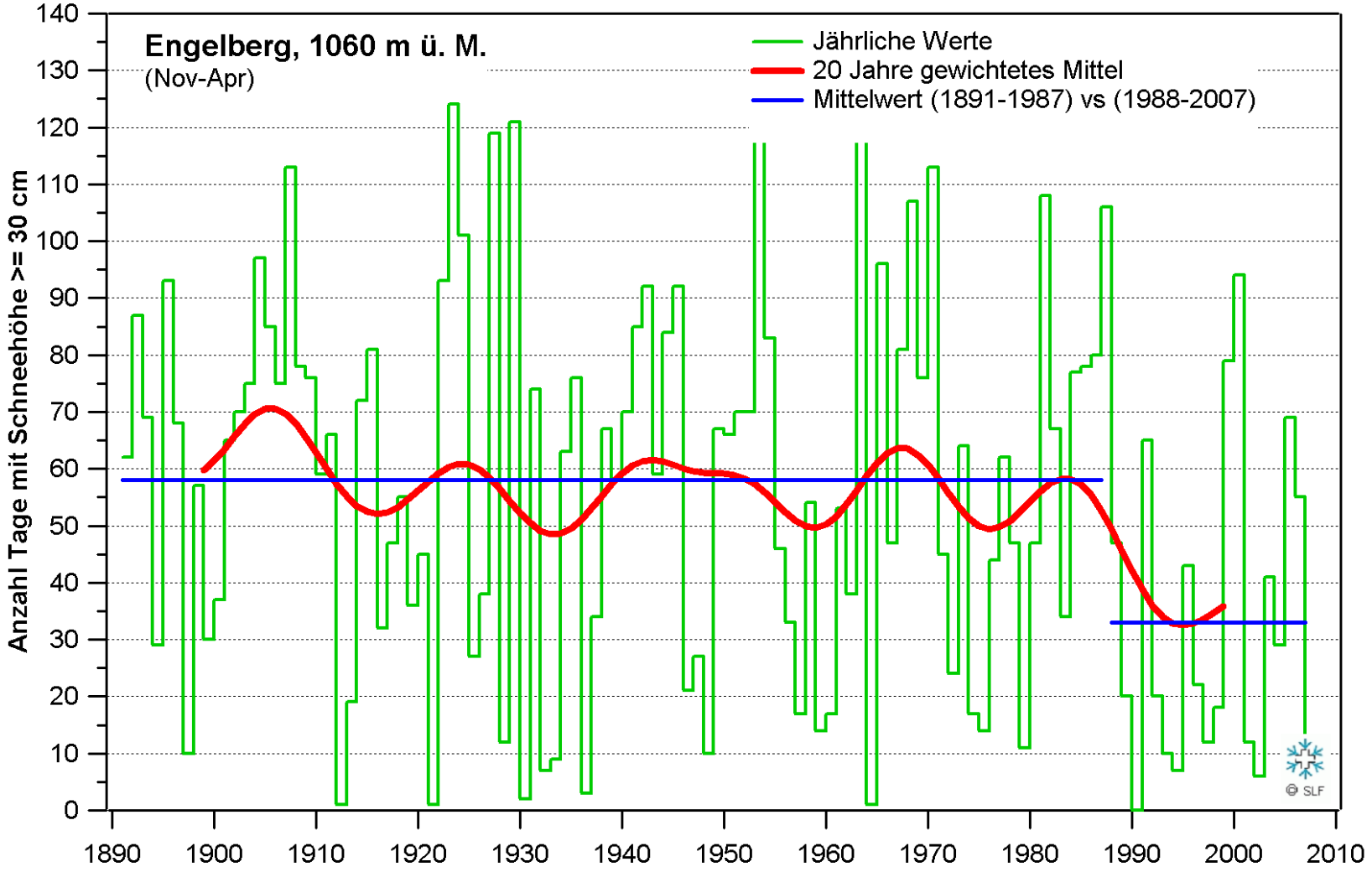
Prediction of Snow Depth with Roughness Parameter



Part IV

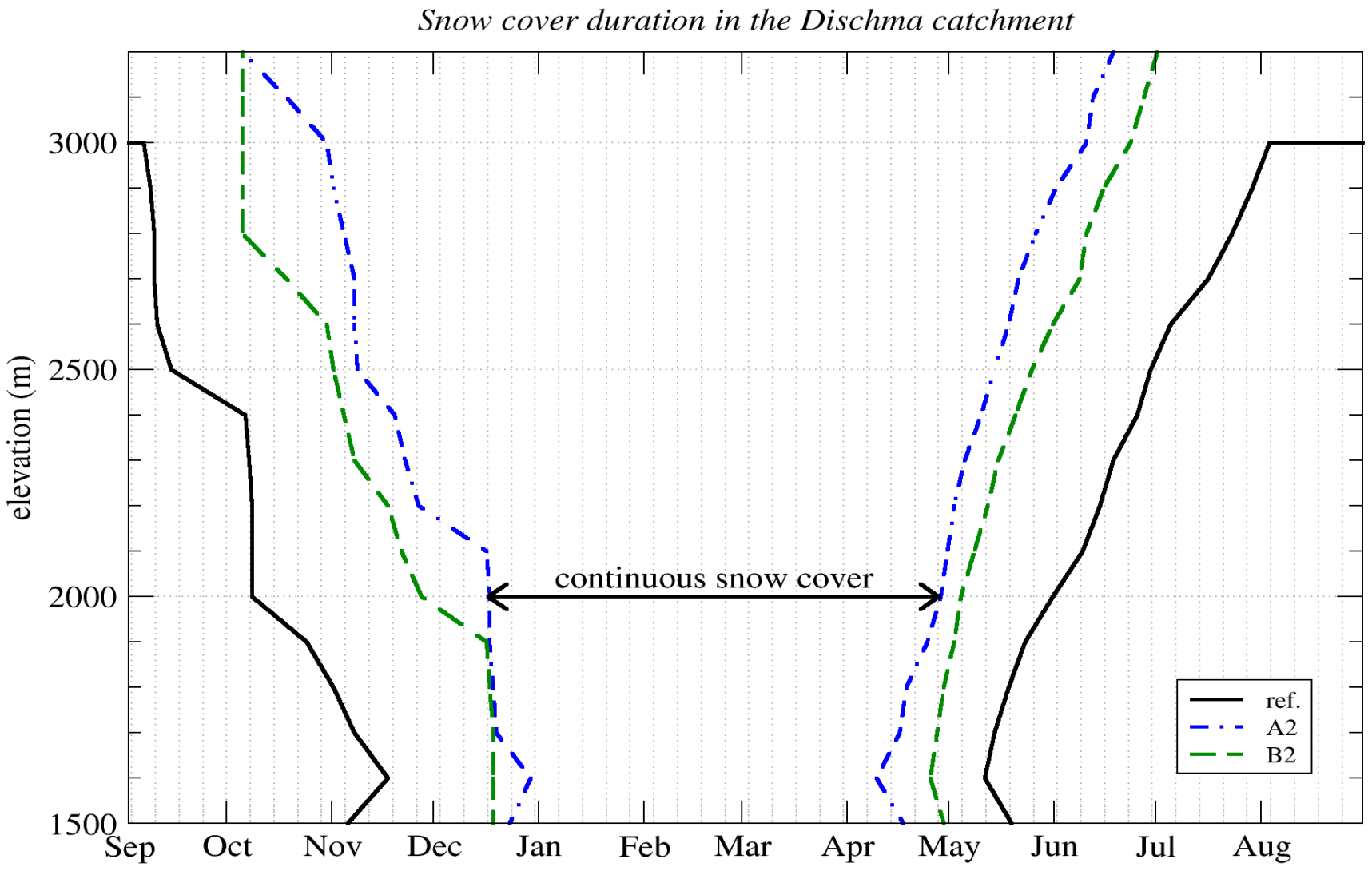
Observed and Predicted Changes of the Alpine Snow Cover

Number of snow days of the last 110 years



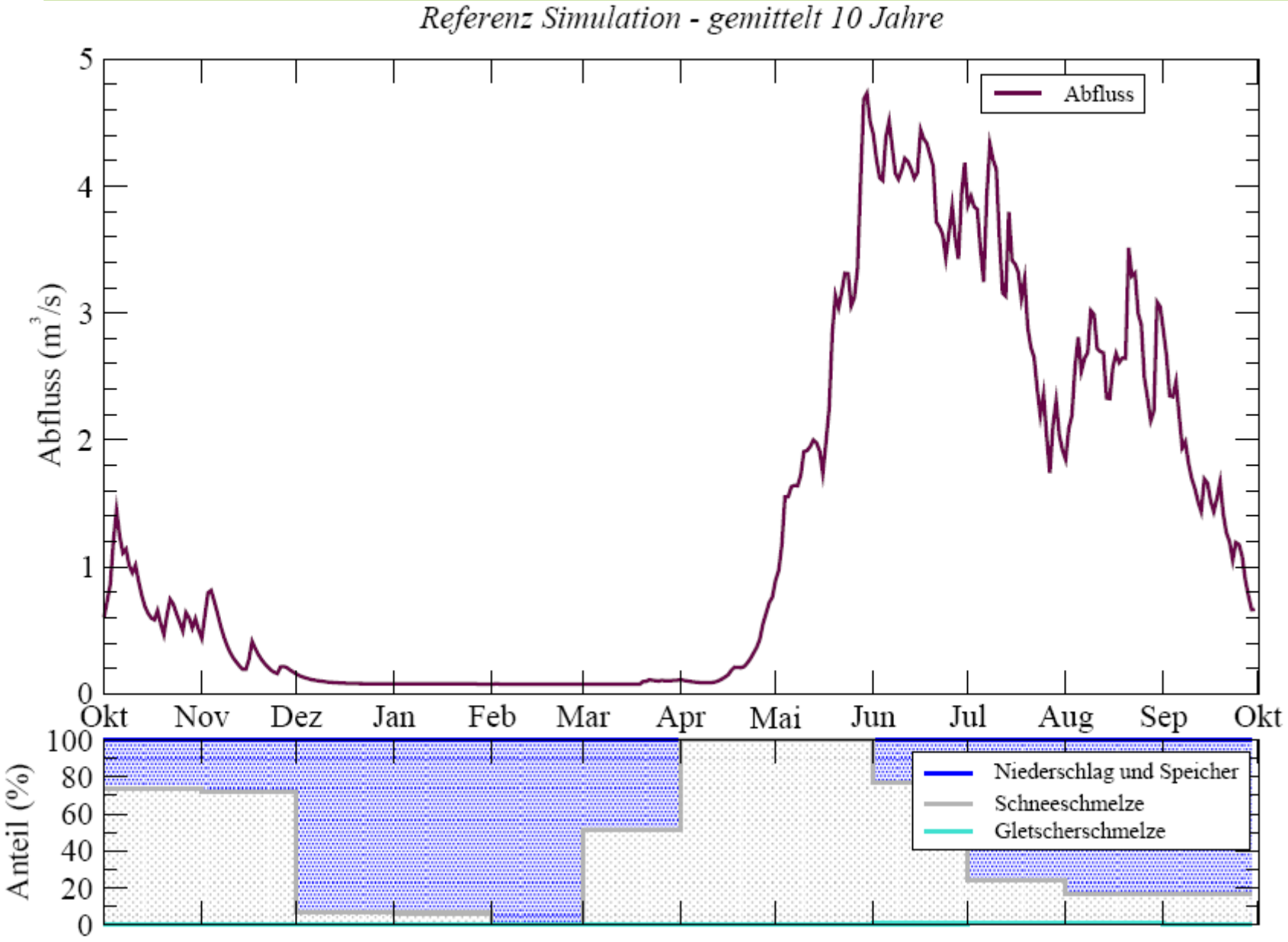
Large year to year variability and jump after 1988

Change in snow duration as a function of altitude



Bavay et al., HP, 2009

Climate Change Scenario A2



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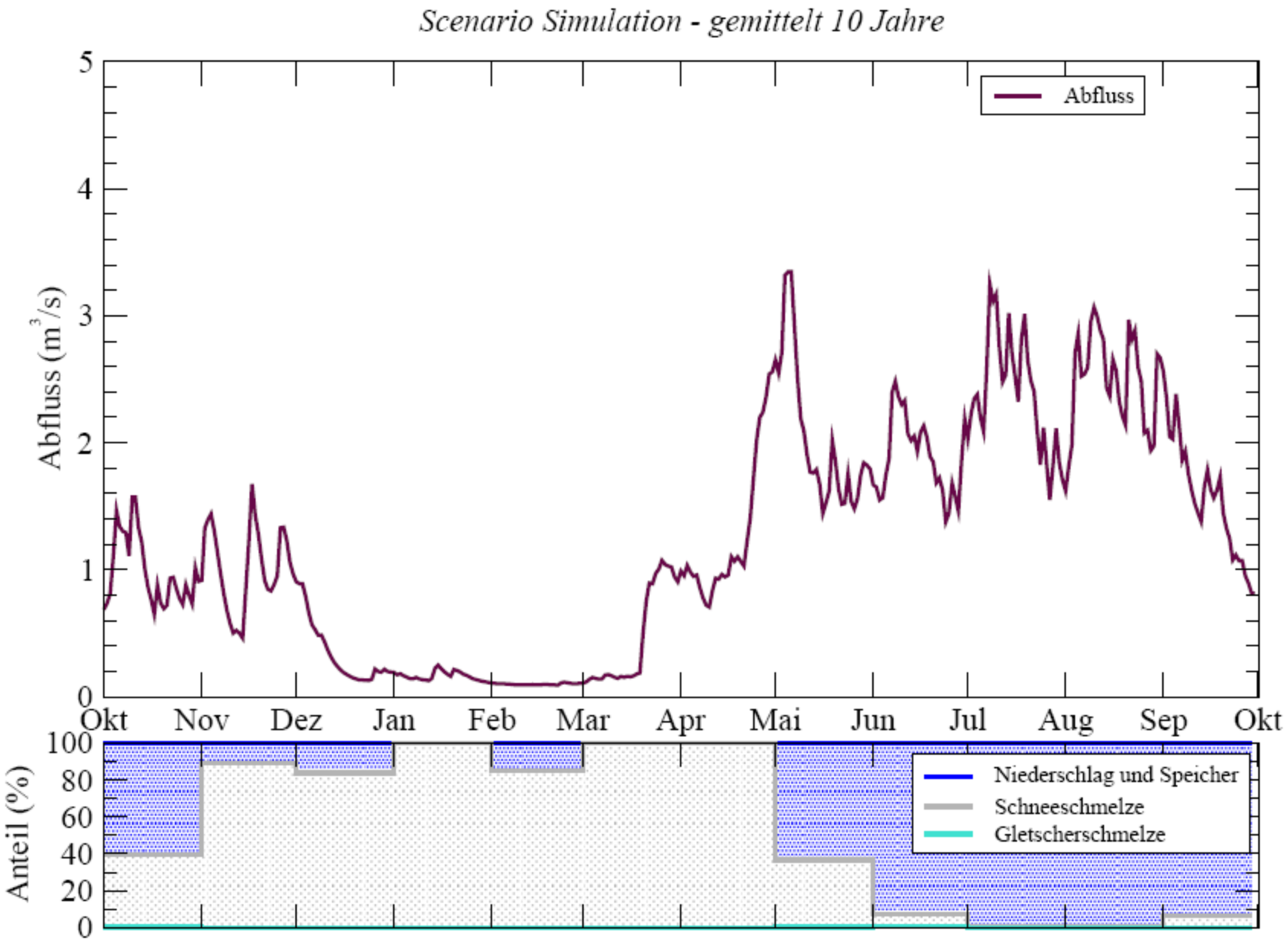

The end

- *Thanks to*

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