The potential of **airborne laser scanning** driven snow depth observations for **modelling snow cover, snow water equivalent and runoff** in alpine catchments

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Content + Motivation

- **Data for snow hydrological model set up incl. LIDAR**
- **Measured snow depth to snow water equivalent (SWE)**
- **SWE-maps for snow hydrological modelling**

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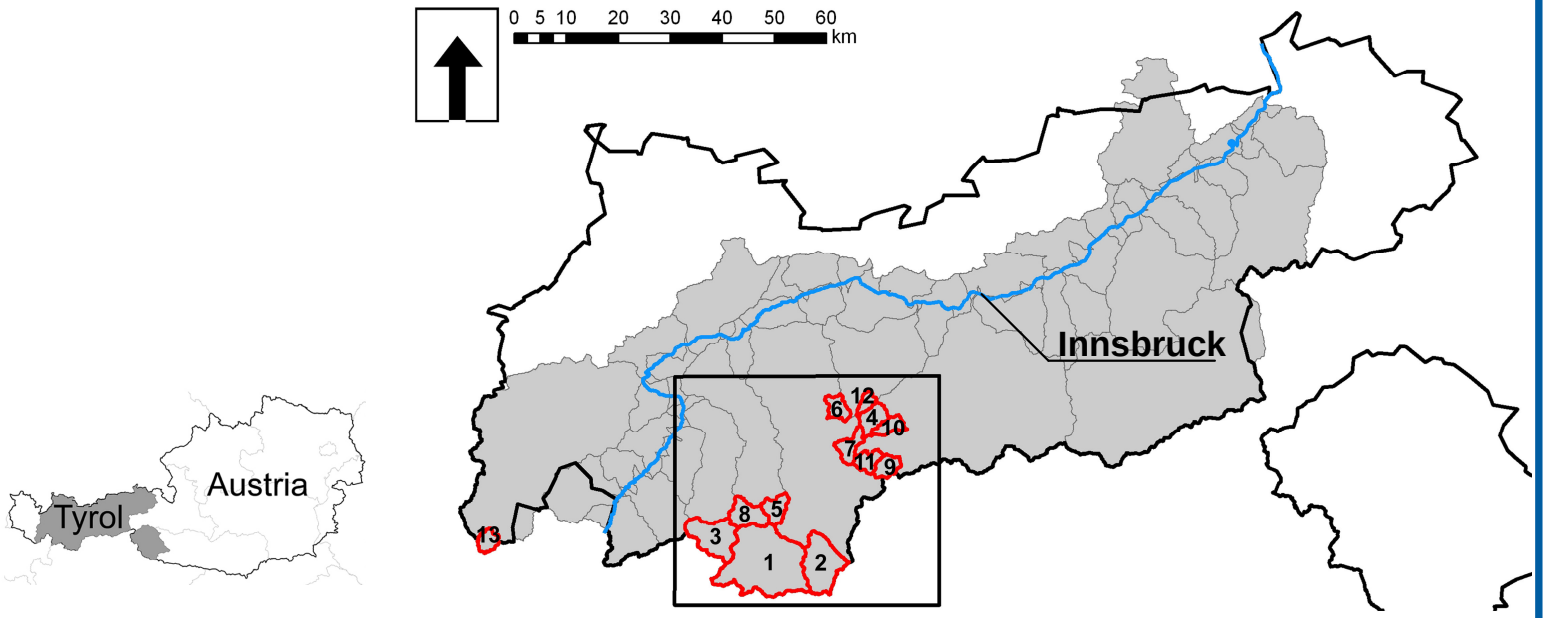
Content + Motivation



Flood forecasting system of the Tyrolean river Inn; Austria

→ Discharge Modeling of the glacierized headwaters

→ Spatially distributed energy balance model **SES**

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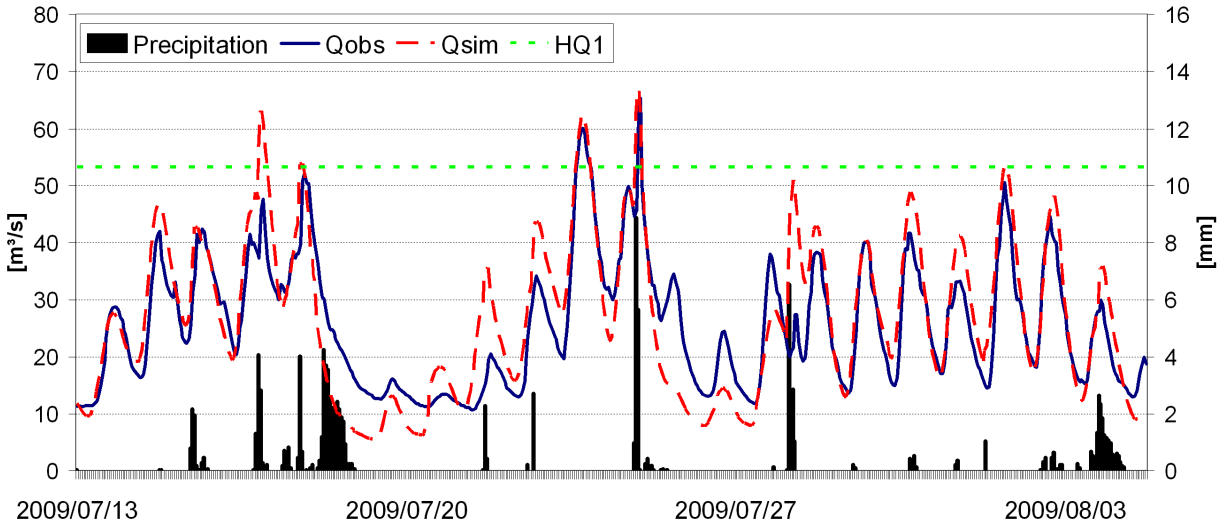
Motivation - Model Calibration

1) Runoff data



Vent – Venter Ache Gauge

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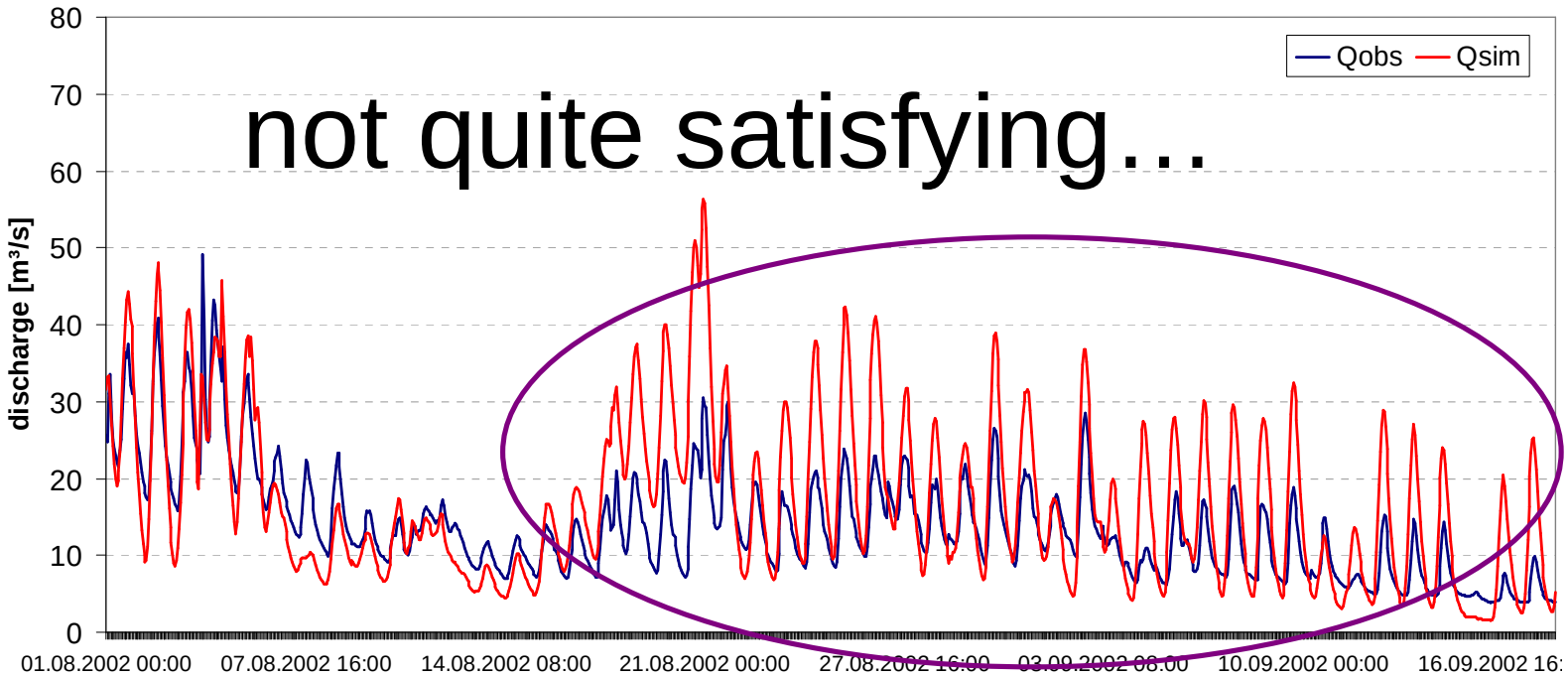
Motivation - Model Calibration

1) Runoff data

Vent – Venter Ache Gauge



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Motivation - Model Calibration

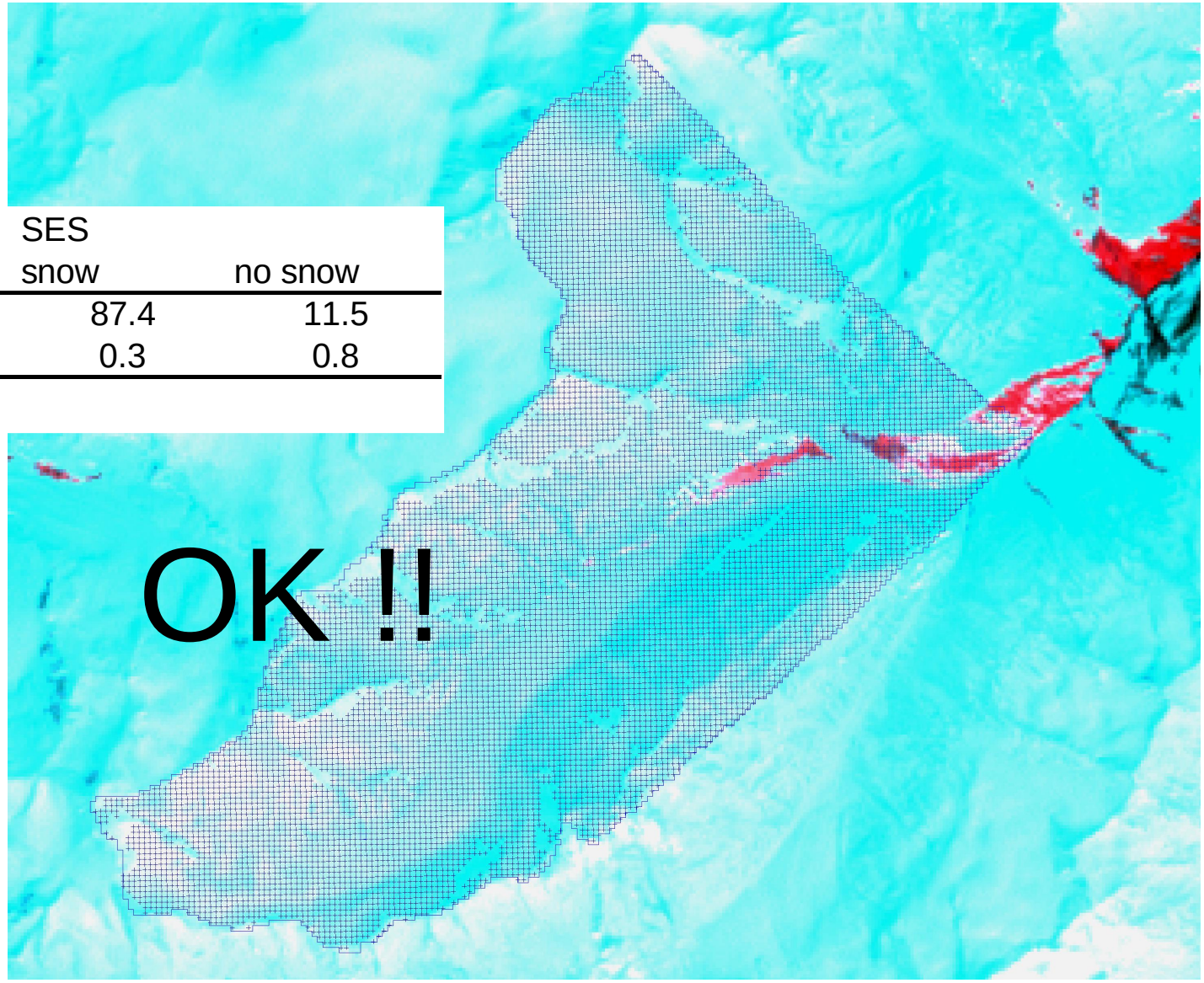
1) Runoff data

2) Remotly sensed snow cover data

Spatial distribution of snow cover

Rofental/Hintereisferner – 30 April 2002

		SES snow	SES no snow
Landsat	snow	87.4	11.5
	no snow	0.3	0.8
Overall agreement	88.2%		



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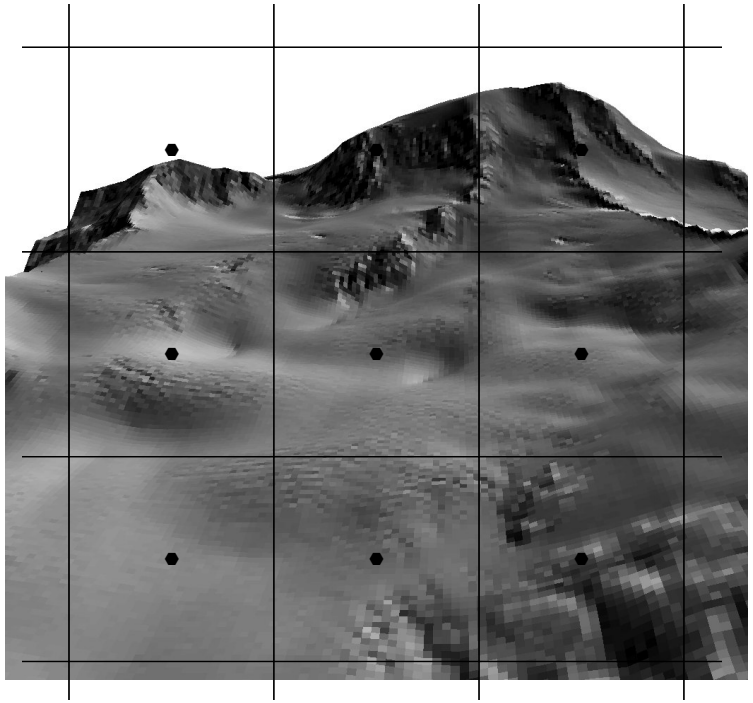
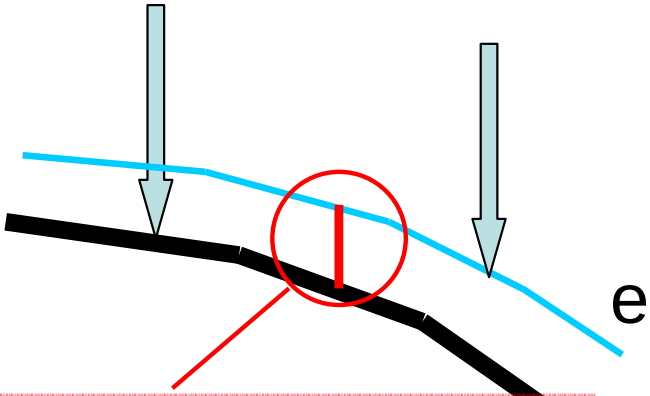
Airborne laser scanning

1) Remotly sensed snow patterns

2) Runoff data

3) Series of LIDAR data
   → Hintereisferner





end of accumulation season

Δz = snow depth (hs)

end of ablation season

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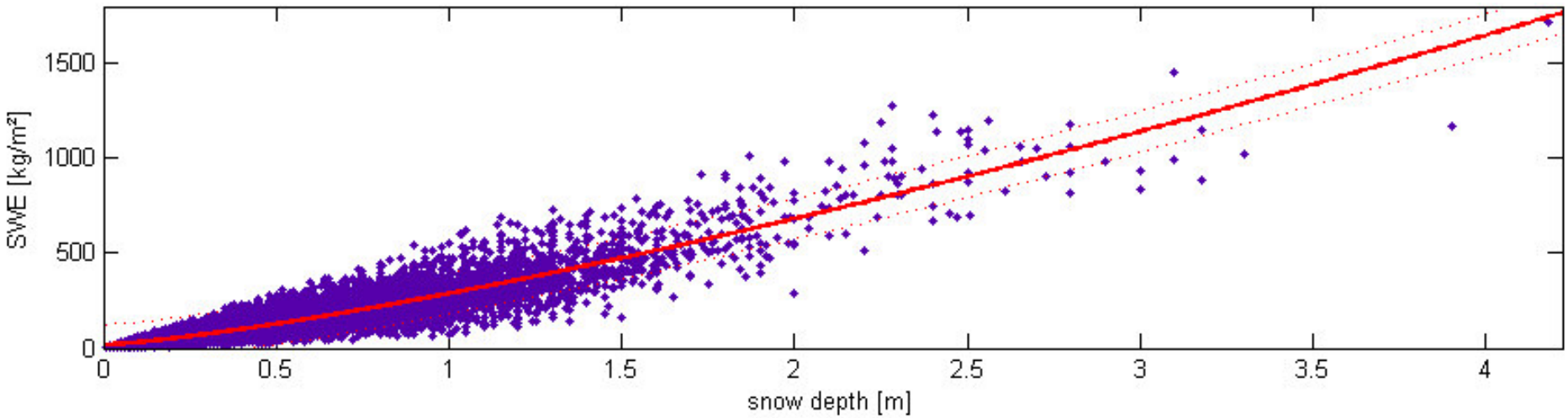
Conversion aproach hs to SWE - *Jonas et al. (2009), Sturm et al. (2010)*

$SWE = hs \, . \, \rho$

SWE-REG Tyrol

SWE-Data – Tyrol
37 Stations -1952 – 2010
~ 12.000 single measurements



Model drivers:
Snow depth, month, elevation zone

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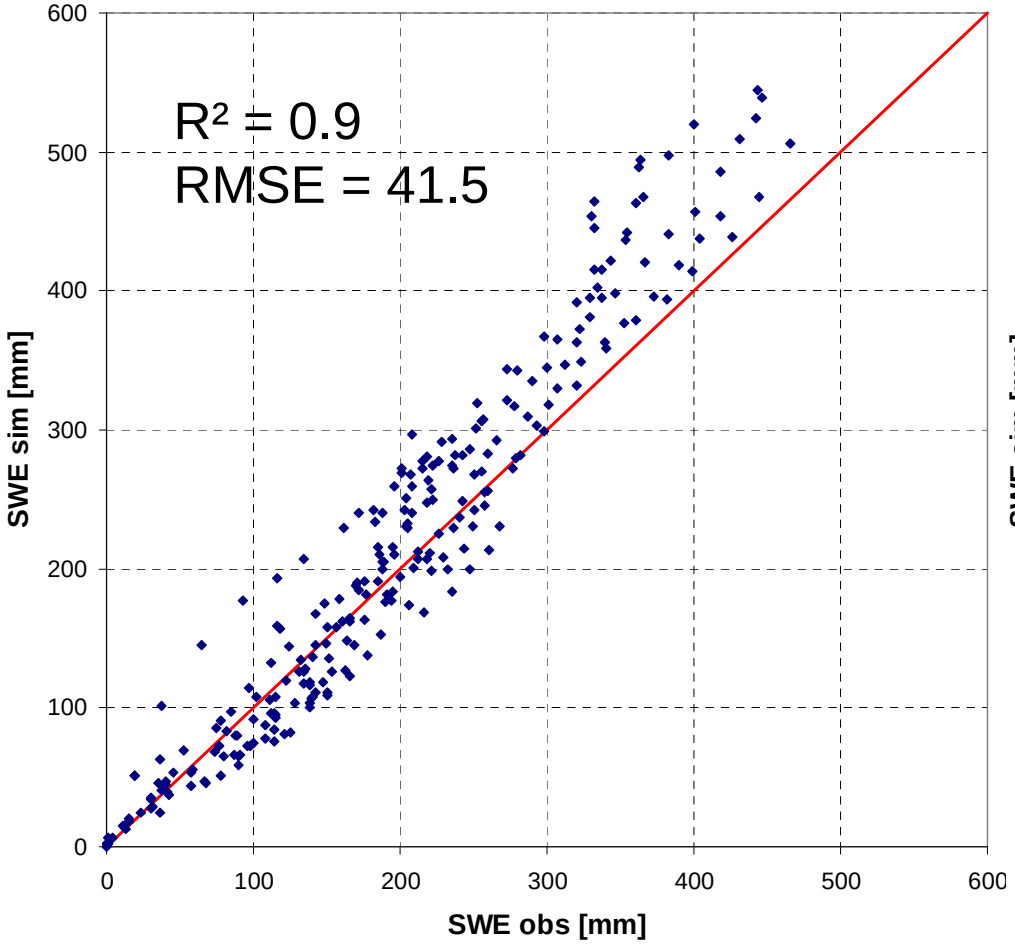
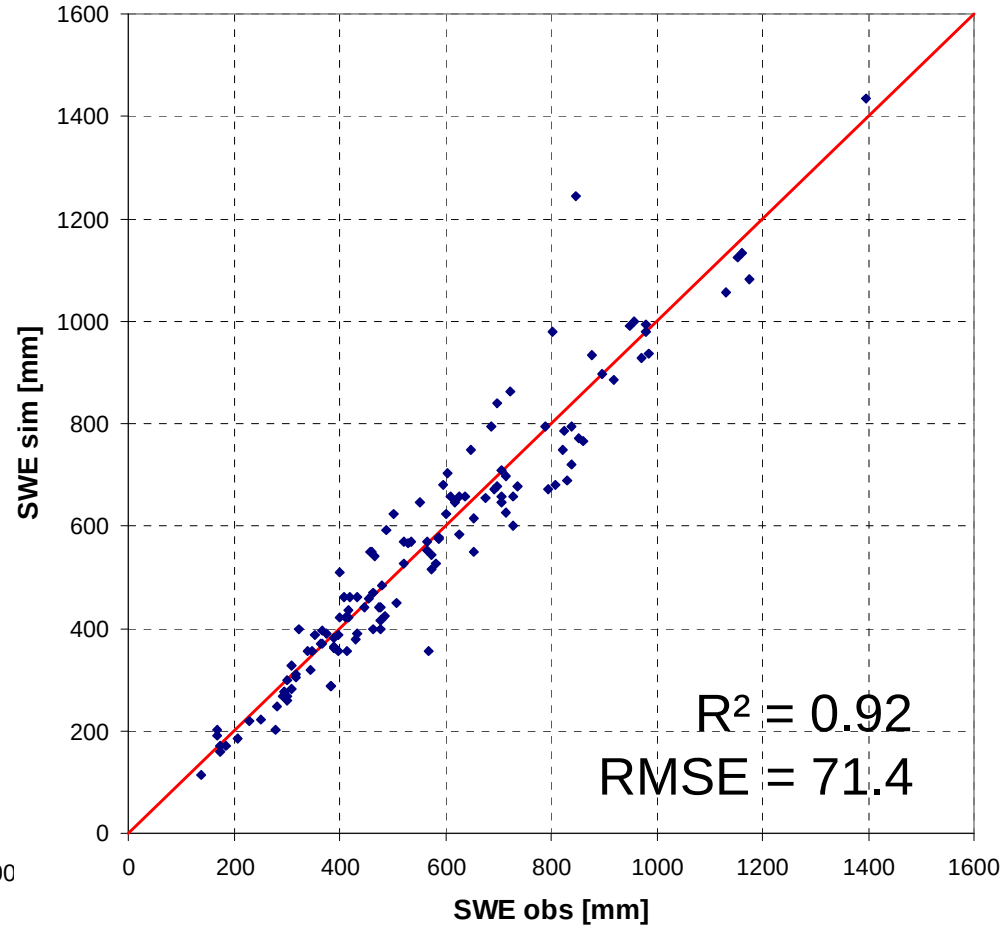
SWE-REG

Independent Validation-Data - MAY

snowpillow Kühtai - 1900 m



Glacier data Tyrol >2500 m



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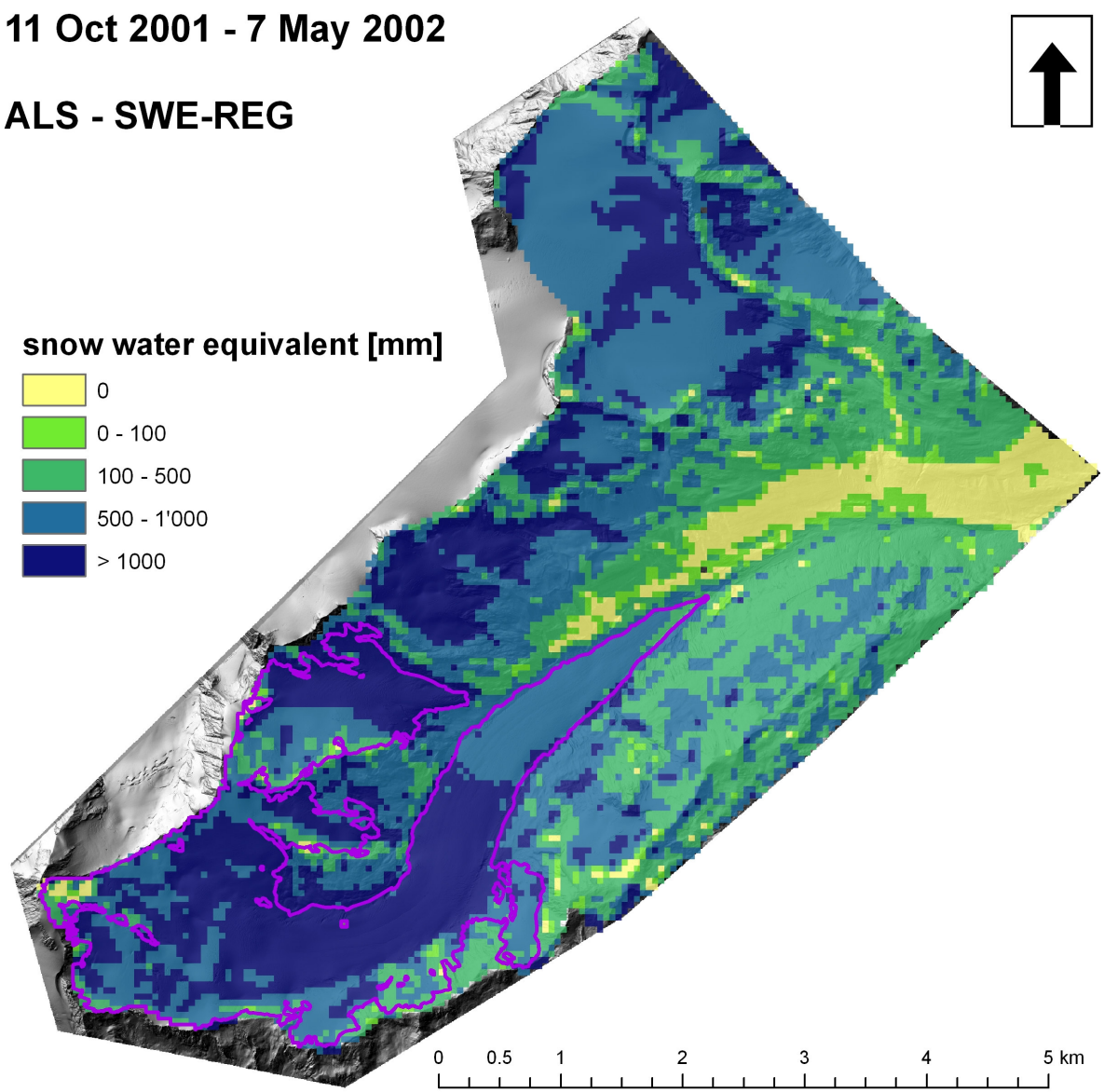
Spatial Distribution of SWE



Total catchment:
ρ_{mean} = 419 kgm^{-3}
SWE_{mean} = 869 mm

Glacier (HEF):
ρ_{mean} = 434 kgm^{-3}
SWE_{mean} = 1182 mm

Winter mass balance:
Escher-Vetter et al. (2009)

Vernagtferner:
ρ_{mean} = 360 kgm^{-3}

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ALS – SWE-REG Validation

Vernagtferner
1 May 2002
ρ_{mean} = 360 kgm^{-3}

P_{sum} = **50 mm** /
new-hs_{obs} = **47cm**

ALS - SWE
7 May 2002
ρ_{mean} = 434 kgm^{-3}

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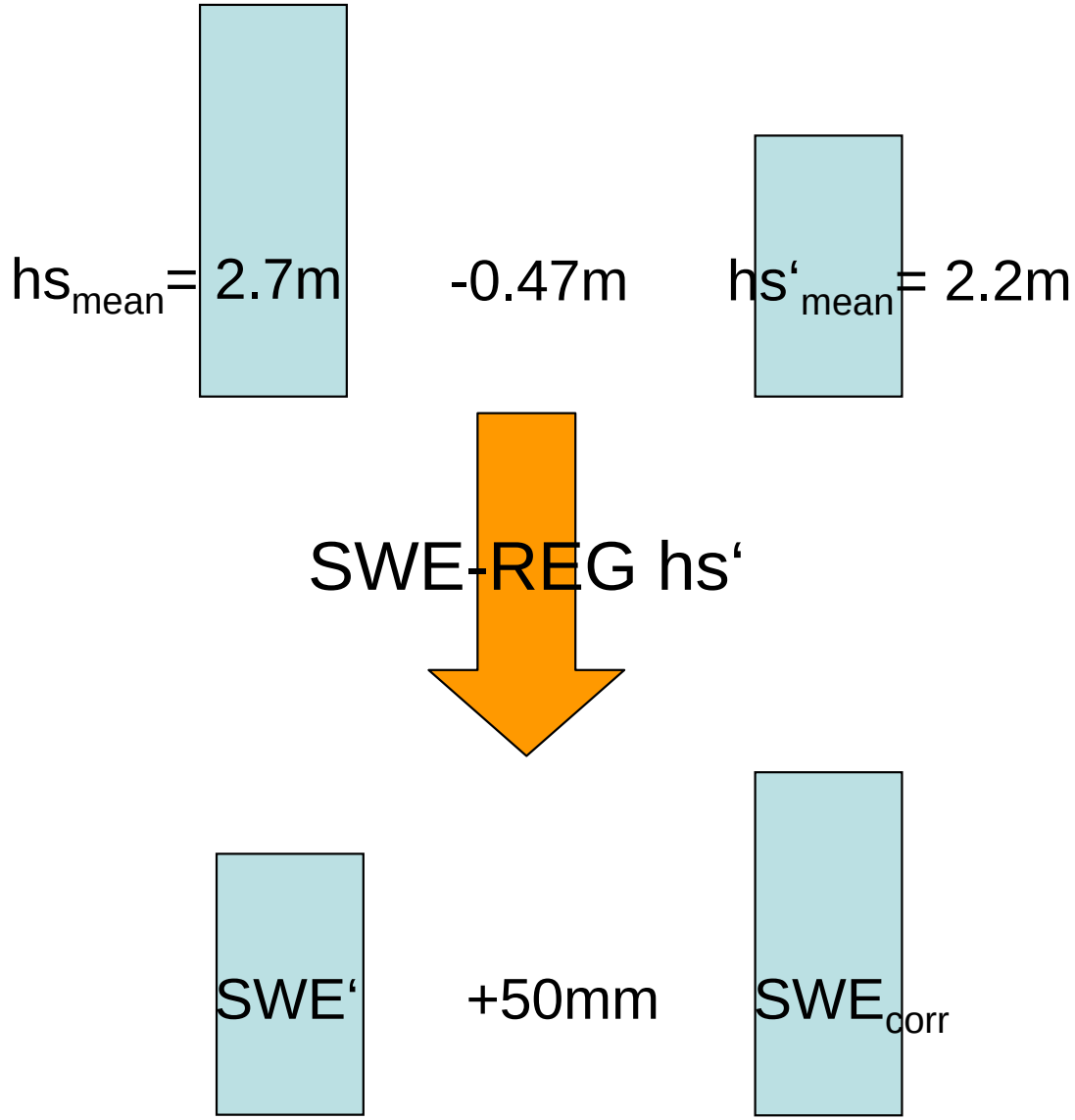
ALS – SWE-REG Validation

Vernagtferner
1 May 2002
ρ_{mean} = 360 kgm^{-3}

P_{sum} = **50 mm** /
new-hs_{obs} = **47cm**

ALS - SWE
7 May 2002
ρ_{mean} = 434 kgm^{-3}



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ALS – SWE-REG Validation

Vernagtferner
1 May 2002
ρ_{mean} = 360 kgm^{-3}

hs_{mean} = 2.7m

P_{sum} = **50 mm** /
new-hs_{obs} = **47cm**

ALS - SWE
ρ_{mean} = 363 kgm^{-3}

ALS - SWE
7 May 2002
ρ_{mean} = 434 kgm^{-3}

SWE_{corr}

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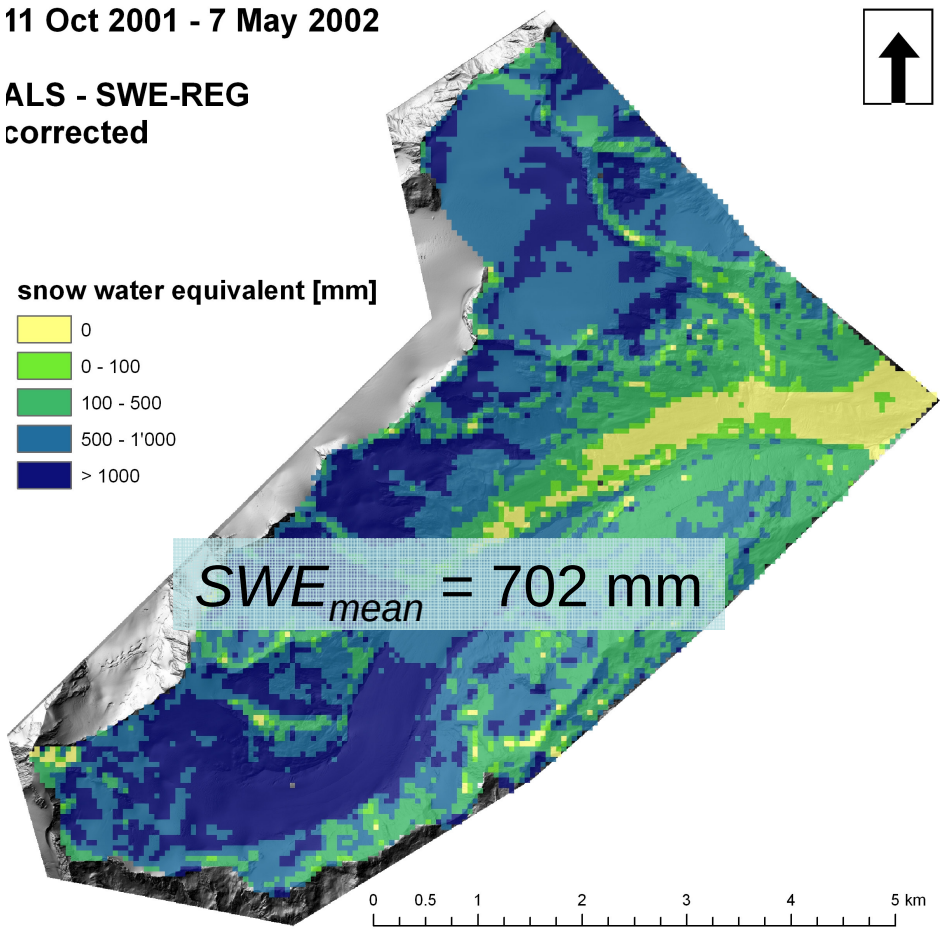
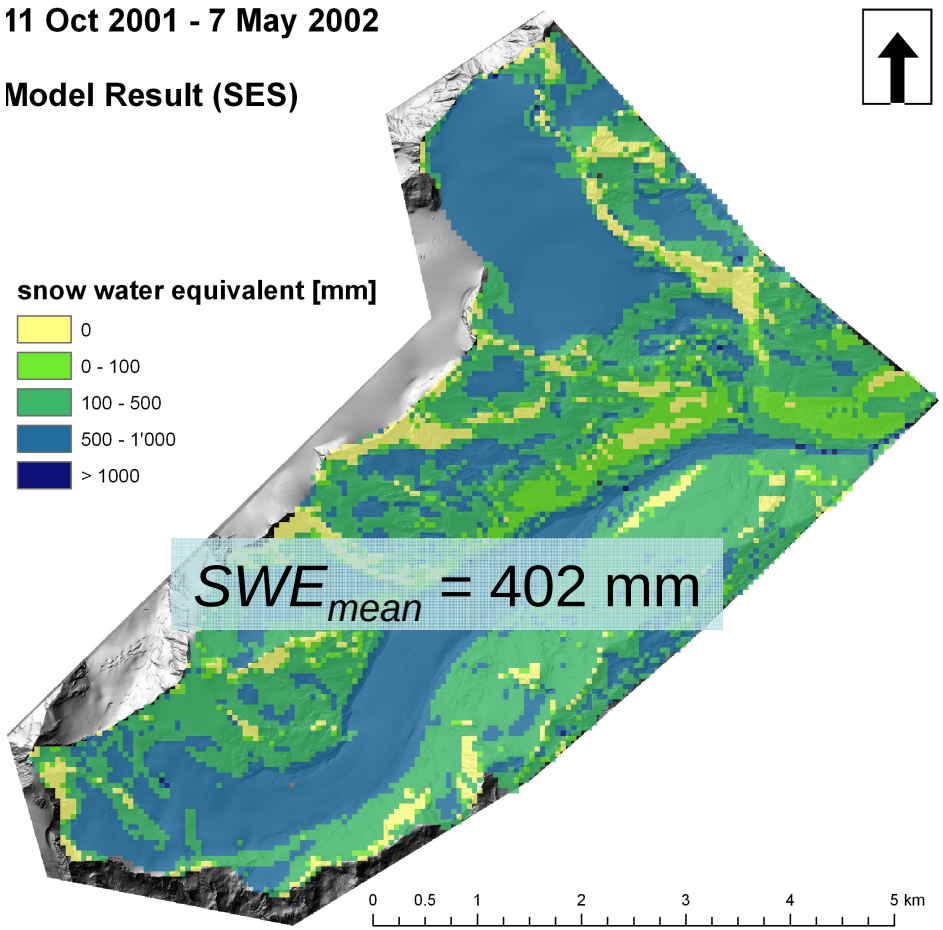
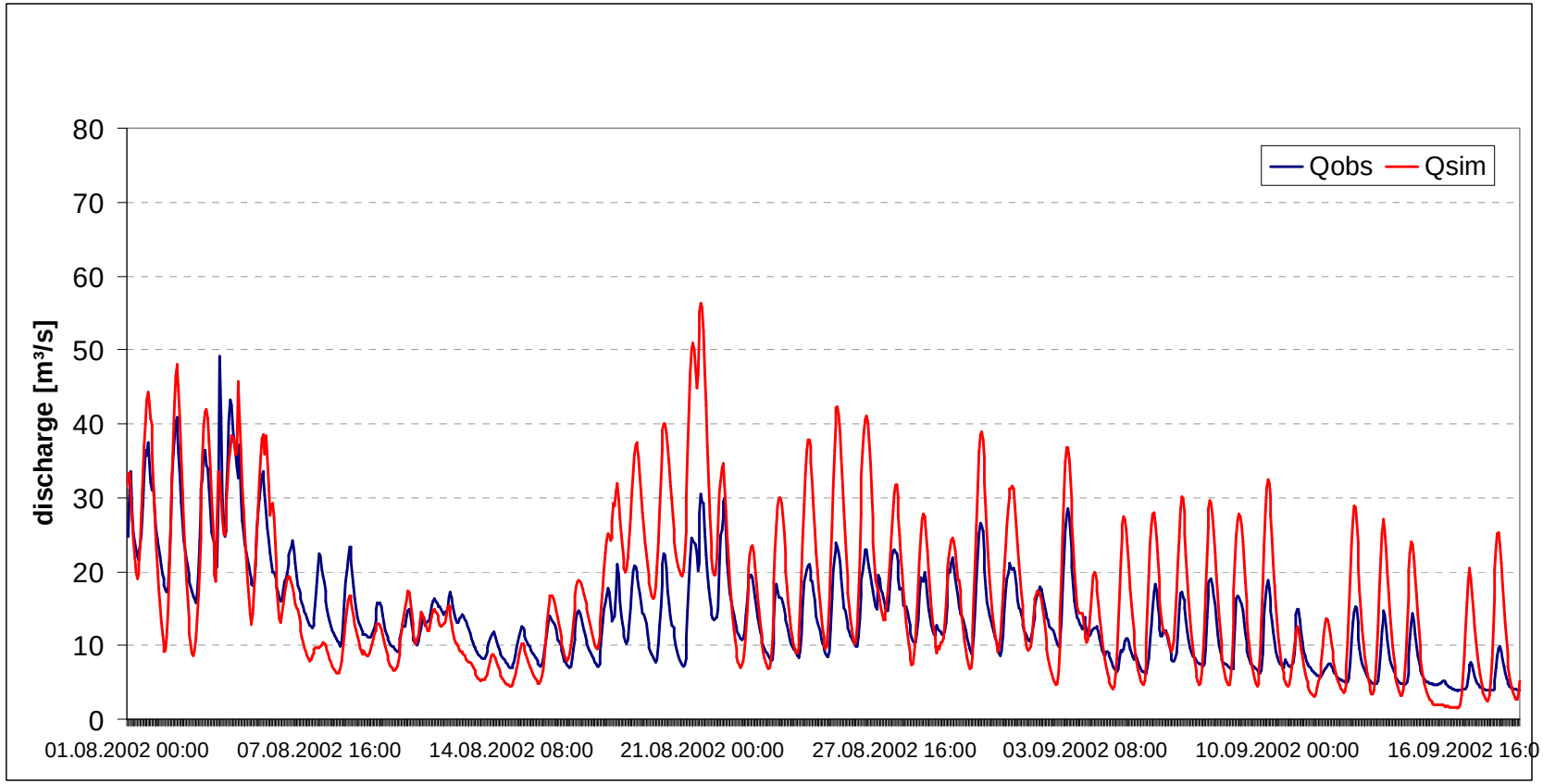
ALS-SWE vs. SES-SWE

Totalisator (HEF) = **581 mm** vs. Model Prec. Input = **270 mm**





Adapted precipitation input

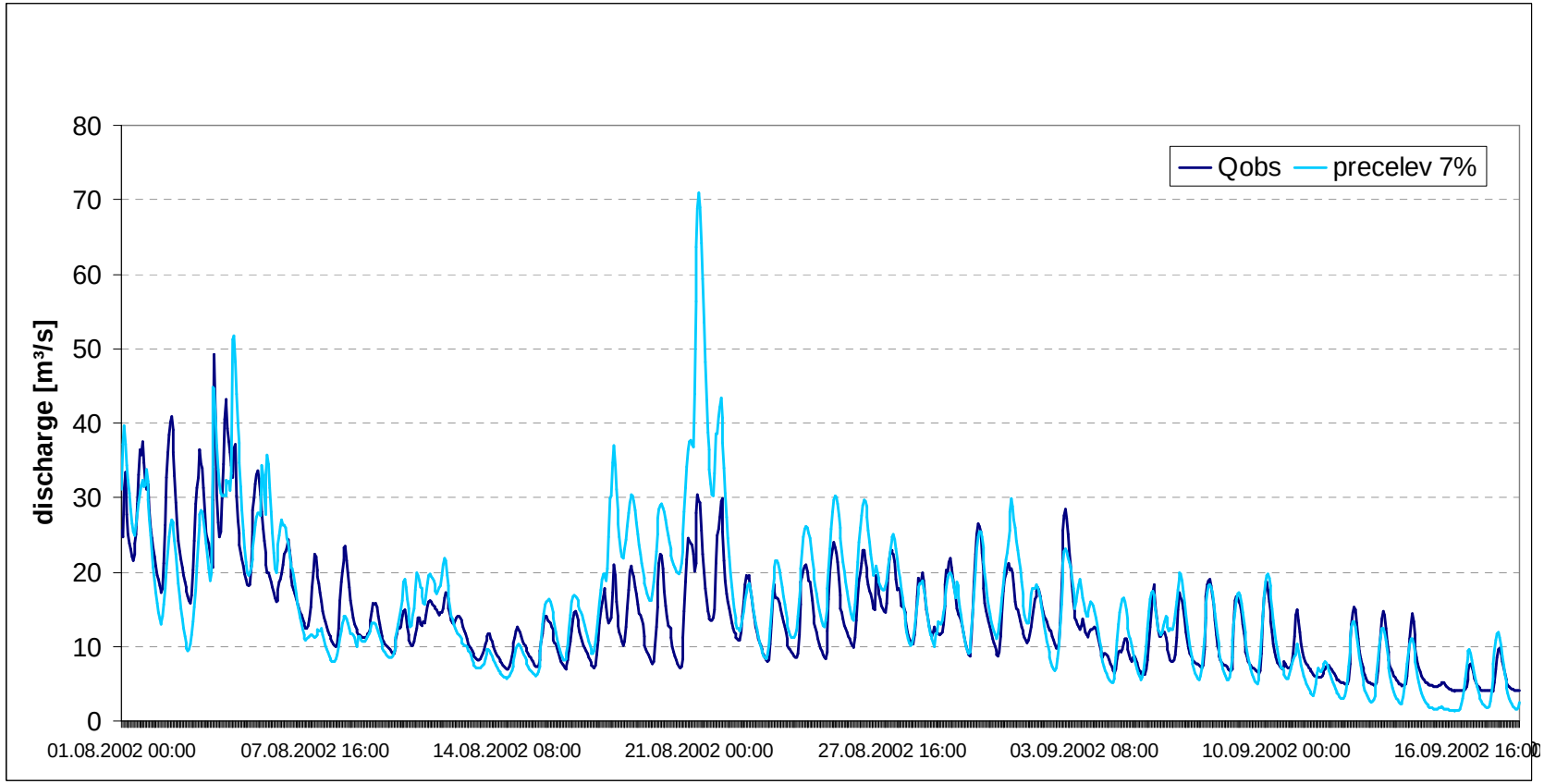


Adapted precipitation input

First sensitivity tests:

→Precipitation gradient of 7% along hillslope

→no additional recalibration of runoff module



Outlook

Input correction:

Interpolation of precipitation Input, relevant stations

snow correction factor

Increasing precipitation with elevation

Recalibration of model parameters:

Albedo, Linear storage,…

Assimilation of Data:

model state correction on a certain date

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References:

Jonas, T., C. Marty, J. Magnusson (2009): Estimating the snow water equivalent from snow depth measurements in the Swiss Alps. Journal of Hydrology 378, 161–167.

Sturm, M., B. Taras, G. Liston, C. Derksen, T. Jonas, J. Lea (2010): Estimating Snow Water Equivalent Using Snow Depth Data and Climate Classes. J. Hydrometeor, 11, 1380-1394.

Escher-Vetter, H., M. Kuhn, M. Weber (2009): Four decades of winter mass balance of Vernagtferner and Hintereisferner, Austria: methodology and results. Annals of Glaciology 50, 87-95.