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Nationalpark Berchtesgaden

UNI GRAZ

Snow cover dynamics and water balance in complex high alpine terrain

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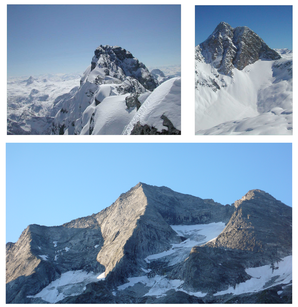
www.nationalpark-berchtesgaden.bayern.de/projekte/klimawandel/hydrologie/index.htm

INTRODUCTION

The **water balance in high alpine regions** in its full complexity is so far **insufficiently understood**. High altitudinal gradients, a strong variability of meteorological variables in time and space, complex hydrogeological situations, **unquantified lateral snow transport processes and heterogenous snow cover dynamics** result in high uncertainties in the quantification of the water balance.

We integrate a high alpine specific snow model into a physically-based hydrological model to enhance the reproduction of the processes influenced by snow accumulation and ablation.

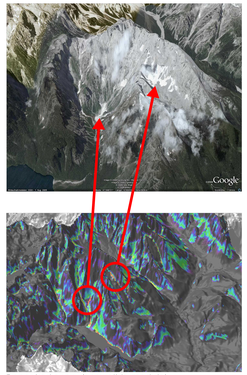


METHODOLOGY

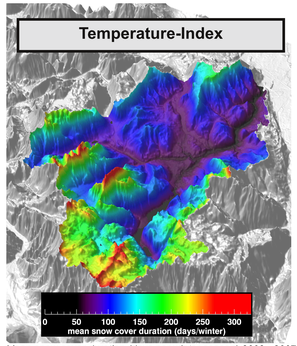
We have complemented the **deterministic hydrological model WaSiM-ETH** with a new snow module based on principles derived from the **high-alpine specific snow model AMUNDSEN**. We run the model system with a **spatial resolution of 50 m** and a **temporal resolution of one hour**.

To enhance the reproduction of snow deposition and ablation processes, the new approach calculates the **energy balance** of the snow cover considering terrain-dependent radiation fluxes and lateral snow transport processes by **gravitational driven snowslides**.

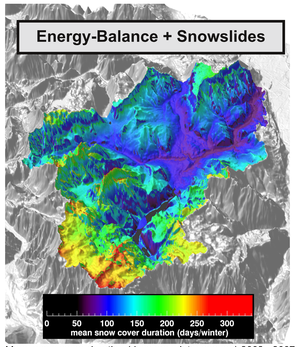
The test site for our study is the Berchtesgaden National Park which is characterized by an extreme topography with mountain ranges covering an altitude **from 607 to 2713 m.a.s.l.** About one quarter of the investigated catchment area, which comprises **433 km²** in total, is terrain steeper than 35°.



Deposited snow (snowslide module)



Mean snow cover duration (days per winter season) 2002 - 2007 WaSiM-ETH, Temperature-Index method



Mean snow cover duration (days per winter season) 2002 - 2007 WaSiM-ETH, new snow module: energy-balance and snowslides

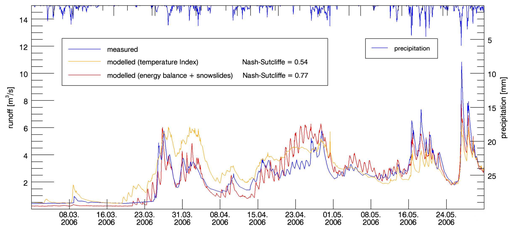
RESULTS

First results show that the integration of the new snow module generates a considerable **improvement in modeling the spatial and temporal distribution of the snow cover** and an **enhanced reproduction of the runoff dynamics influenced by melting snow**.

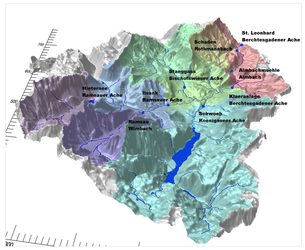
The snow cover duration represents a summarized result of the snow accumulation, ablation and transport processes throughout a winter season. Calculated with the common Temperature-Index method, snow cover evolution depends on precipitation amount and air temperature and therefore, its duration shows an increase with elevation (as a result of the used interpolation method and measured meteorological station data).

The new approach results in an exposition-dependent snow cover duration with a maximum at high elevated, northern oriented, shaded areas at the foot of steep faces where on the one hand the accumulation input is large due to high snowfall rates and snowslides and on the other hand the incoming energy input for ablation by solar radiation and air temperature is limited.

The comparison of the measured and modelled runoff shows a significant improvement in modelling the runoff dynamics during the melting period.



Measured and modelled runoff at gauge "Hintersee" during melting period (March to May 2006) in m³/s



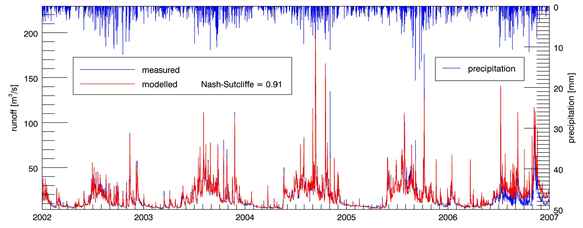
Subcatchments and gauges

	annual mean (2002 - 2007)
Precipitation (mm)	1611.4
Rainfall (mm)	1111.5
Snowfall (mm)	499.9
Evapotranspiration (mm)	493.7
Runoff (mm)	1013.3
Air temperature (°C)	1.2
Snow cover duration (days)	144

Modelled annual mean values for the total catchment area

	Nash-Sutcliffe
Hintersee (Ramsauer Ache)	0.65
Ramsau (Wimbach)	-0.31
Ilsank (Ramsauer Ache)	0.63
Schwoeb (Koenigsseer Ache)	0.38
Stanggass (Bischofswieser Ache)	0.12
Klaeranlage (Berchtesgadener Ache)	0.91
Almbachmuehle (Almbach)	0.44
St. Leonhard (Berchtesgadener Ache)	0.82

Model performance in the subcatchments (2002 - 2007)



Measured and modelled runoff at gauge "Berchtesgaden Klaeranlage" during the model period Nov. 2001 - Oct. 2007 in m³/s (routed runoff rates replaced by observed discharges)

Also have a look at the joint collaboration:
Groundwater modeling and water balance in the high alpine Berchtesgaden National Park
(Gabriele Kraller, Michael Warscher, Ulrich Strasser, Harald Kunstmann and Helmut Franz)
EGU2010-3452

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GRUBER, S. (2007): A mass–conserving fast algorithm to parameterize gravitational transport and deposition using digital elevation models. In: Water Resour. Res., 43, W06412, doi:10.1029/2006WR004868.
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STRASSER, U. (2008): Modelling of the mountain snow cover in the Berchtesgaden National Park – Forschungsbericht 55. Nationalparkverwaltung Berchtesgaden (Hrsg.). Berchtesgaden.