Observed snowmelt energetics and runoff generation during rain-on-snow

UNI FREIBURG

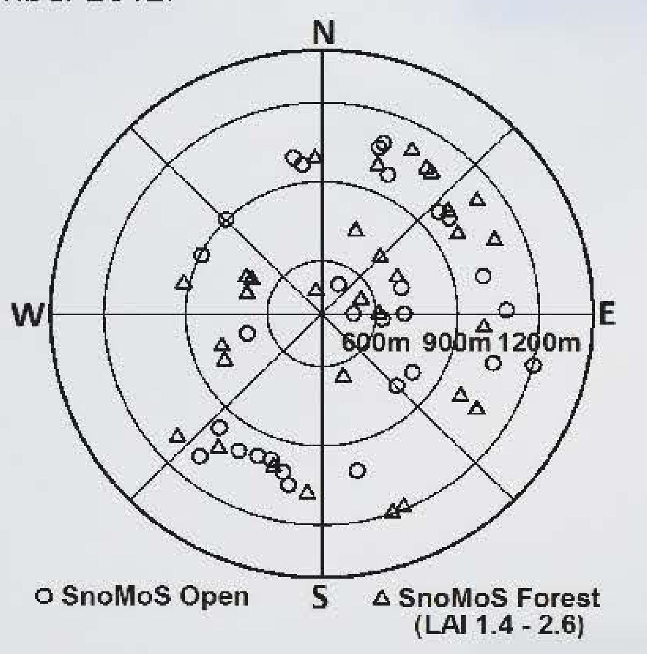
HYDROLOGY

Jakob Garvelmann, Stefan Pohl, Markus Weiler

Study area and methods

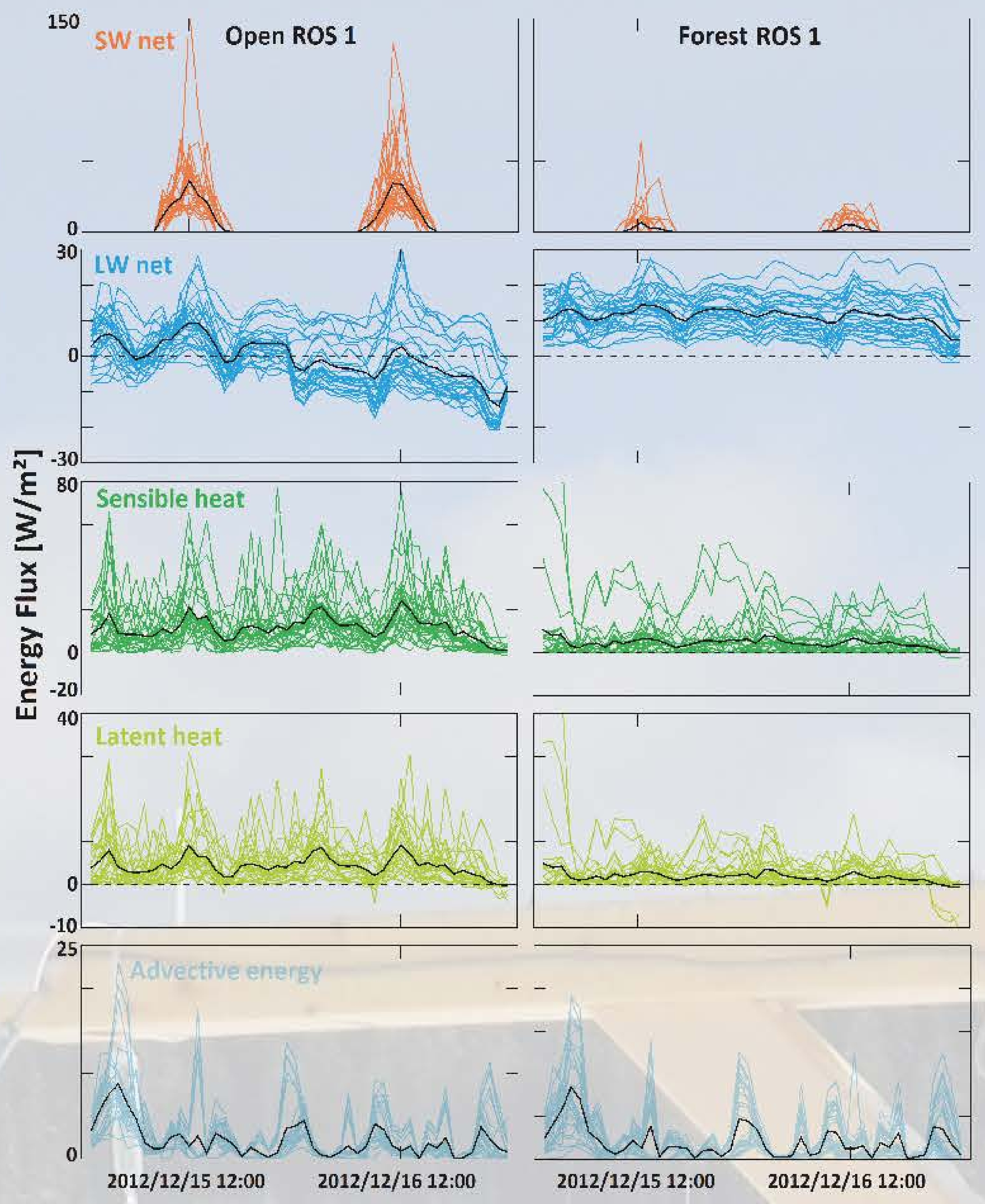
65 Snow Monitoring Stations (SnoMoS) were set-up in the winter 2012/2013 in the Black Forest region of southwestern Germany using a stratified sampling design with paired (open and forest) stations.

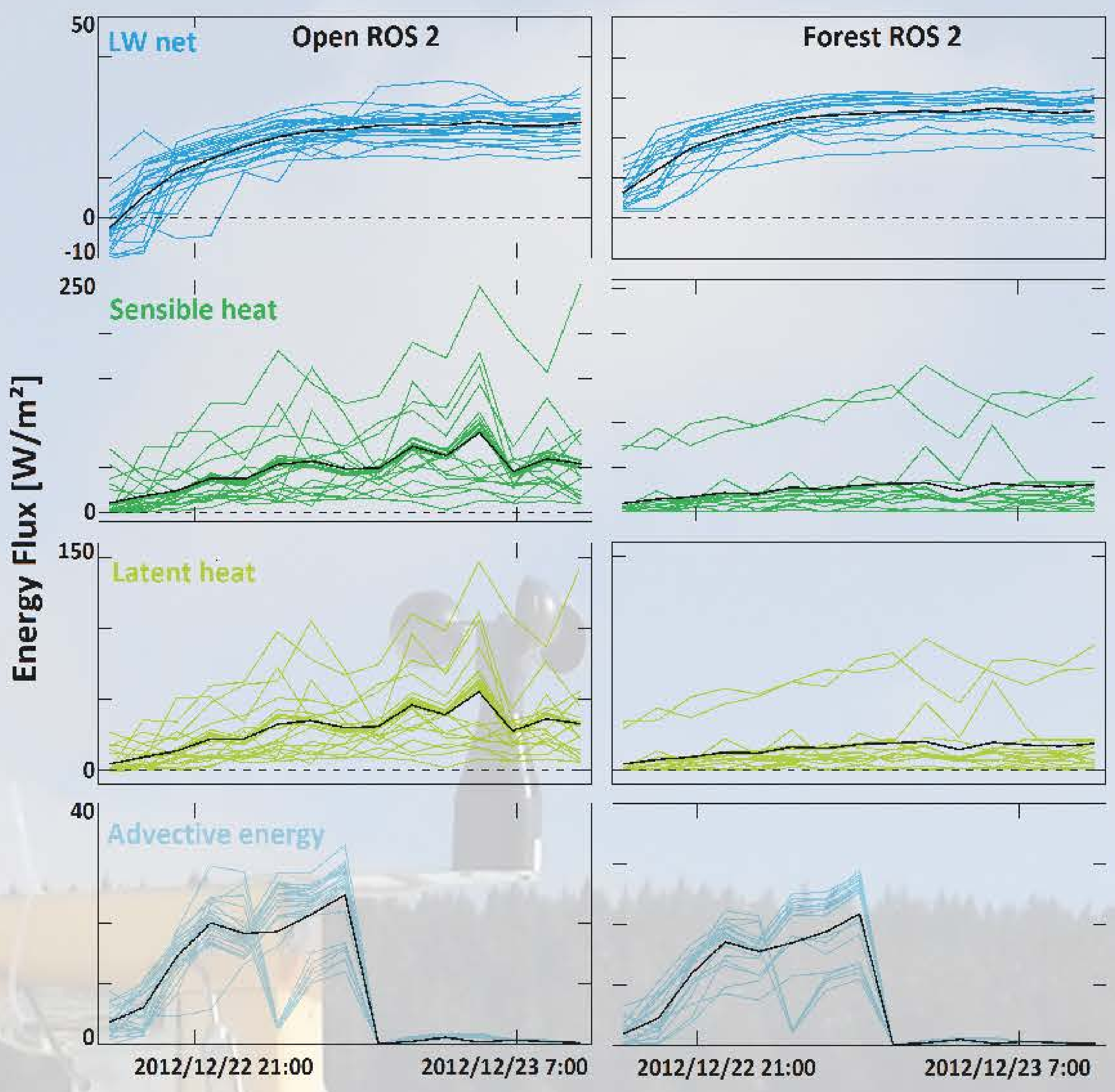
The SnoMoS measured snow depth and climatic variables in hourly resolution allowing event based analysis of snowmelt energetics and runoff generation during two rain-on-snow (ROS) events in December 2012.



	SnoMoS	Additional Information
SW in	Global radiation	
SW out		Albedo measured/calculated
LW in		after Satterlund (1979), additional LW under forest canopy after Essery et al. (2008)
LW out	Surface temperature	Stefan Boltzmann
Sens heat	Air temperature, wind speed, surface temperature, air pressure	Bulk Richardson Number, Eddy heat diffusivity
Lat heat	RH, wind speed, air temperature, surface temperature, air pressure	Saturated air/surface vapor pressure with Tetens formula
Adv energy	Precipitation, air temperature	

The measured data was used to calculate the surface energy balance using physically based empirical equations. Manual snow density measurements were used to convert the continuous snow depth measurements of 30 snow monitoring stations in the Brugga catchment (40 km²) into SWE. These values were used to calculate the SWE distribution in the catchment using multiple linear regression models for hourly time steps during the second half of December 2012 with the predictors elevation, aspect, and land cover. Rainfall was elevation dependent distributed over the catchment. The water released from the snowpack (snowmelt and rainfall) or rainfall on bare ground (=available runoff) was calculated for the entire catchment area considering a variable retention storage of the snow cover.

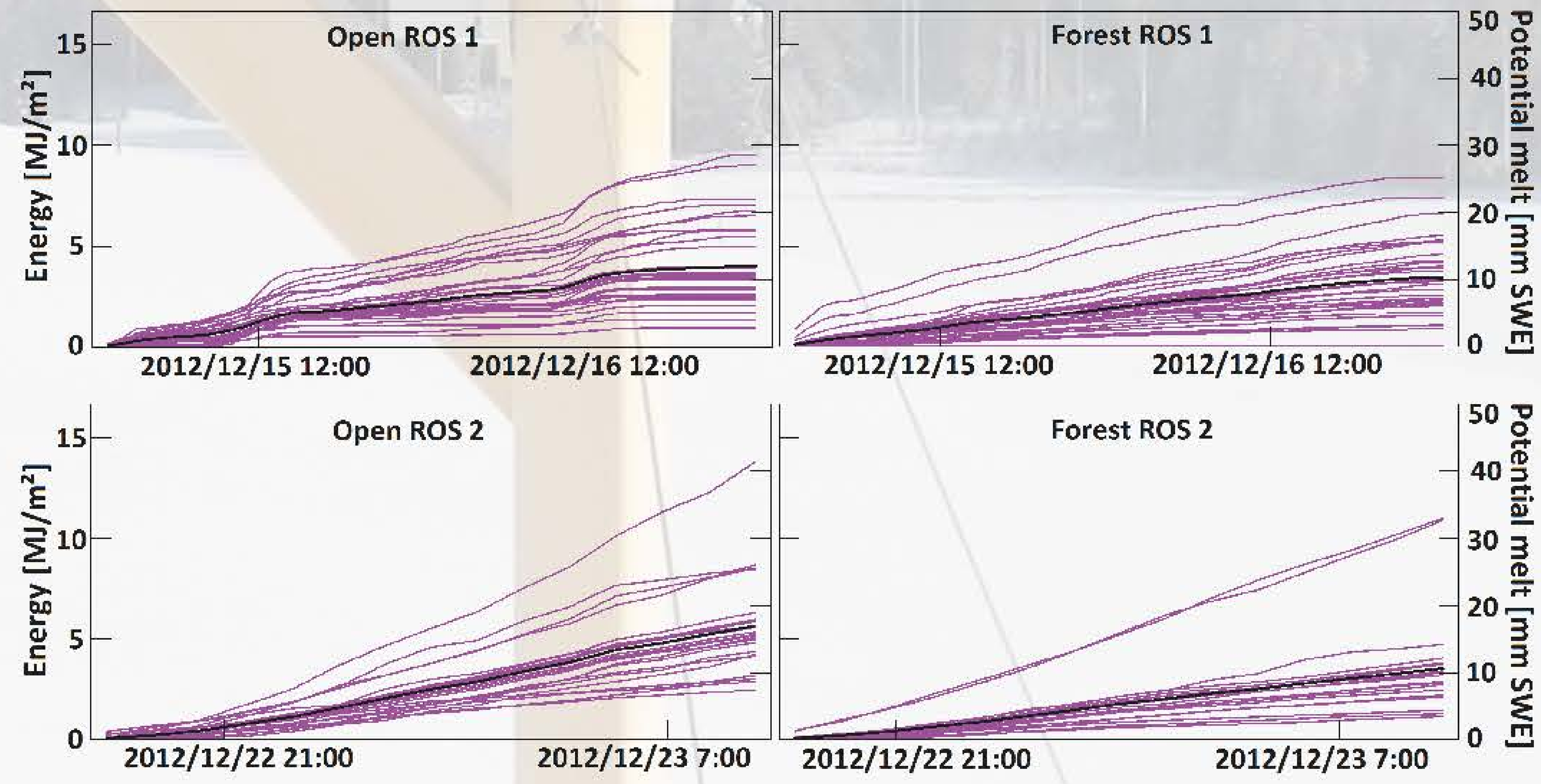


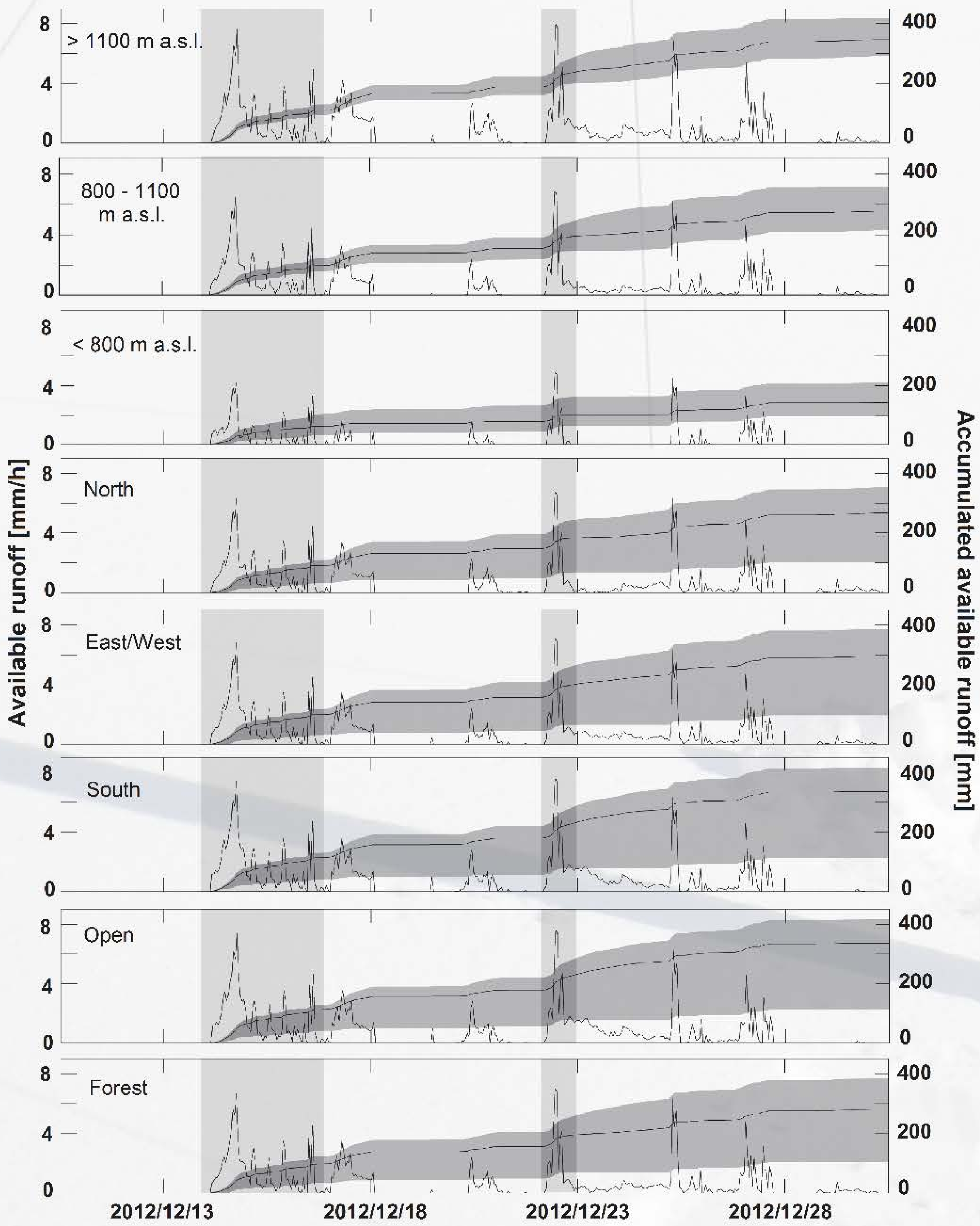


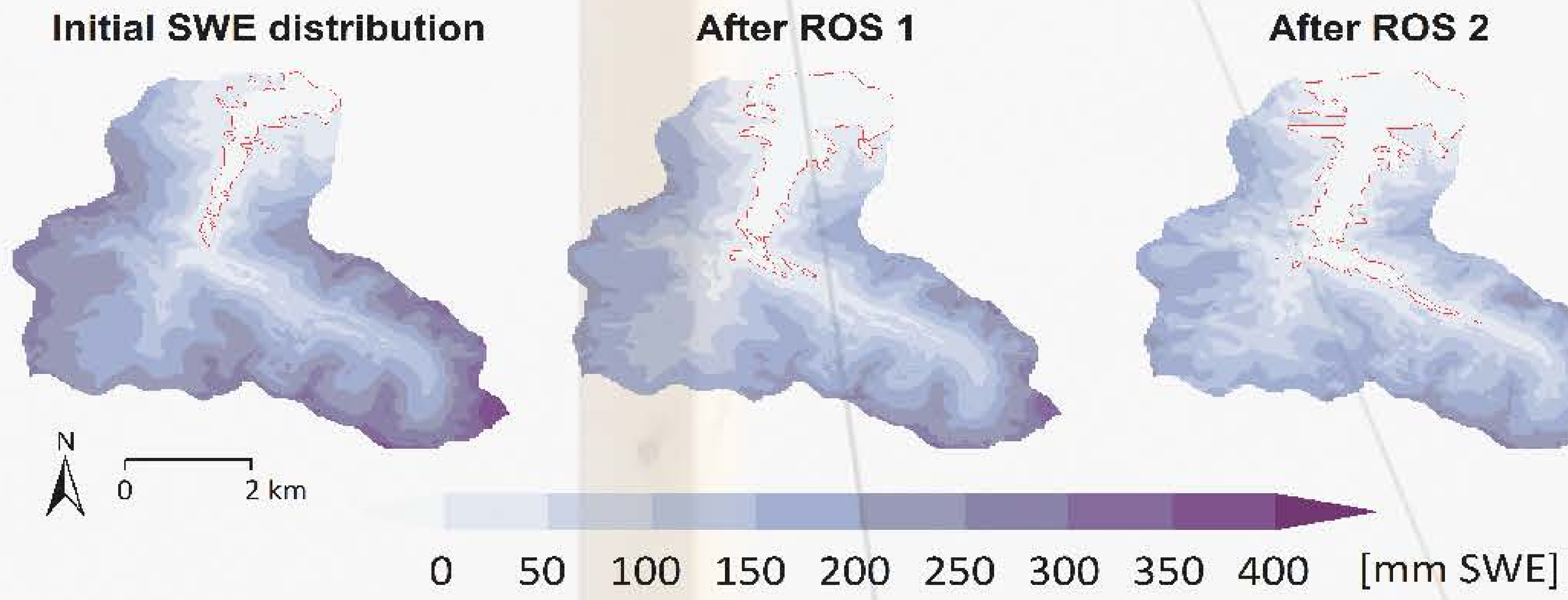
Q total = SW net + LW net + Sensible heat + Latent heat + Advective energy

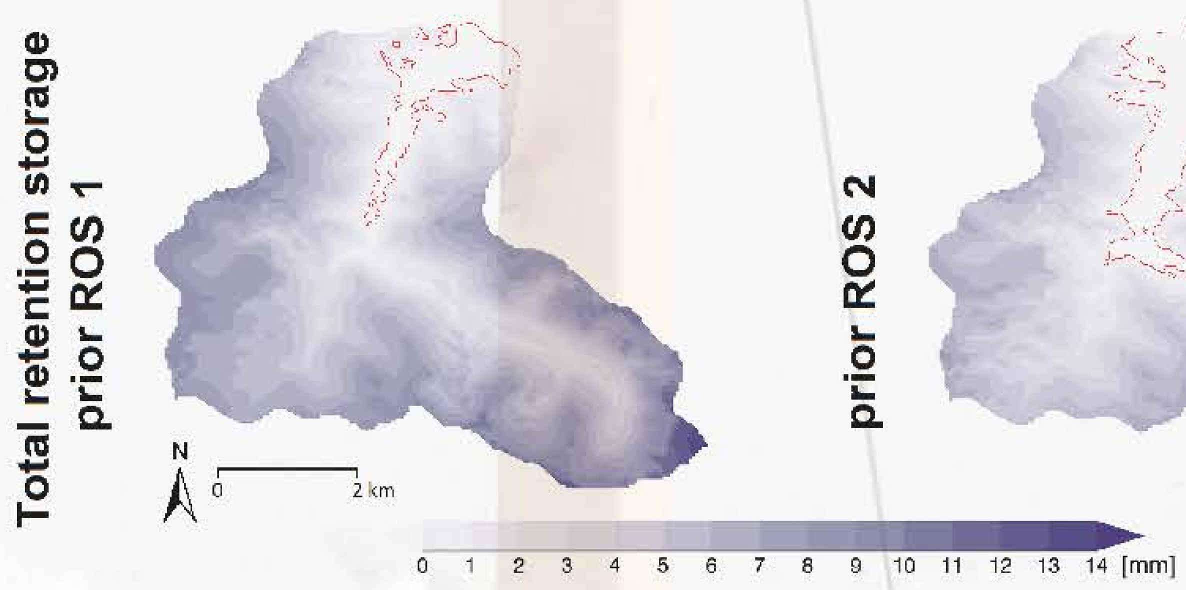
Research questions

- What are the fluxes of the individual surface energy balance terms during ROS?
- What is the spatial and temporal variability of the energy balance terms during ROS?
- How does a forest cover and the topography influence the different energy fluxes during ROS?
- How important is the initial snow cover distribution for the generation of ROS storm flow?
- Is the snowmelt evenly distributed over the catchment?
- What are the impacts of topography and forest cover on the available runoff?









Take-home messages

- Distinct spatial variability of the surface energy balance terms over a relatively small area
- Turbulent fluxes dominate during rain-on-snow (ROS)
- Almost identical energy amounts at open and forest locations during ROS with a constant positive energy flux even during night
- Snowmelt contribution was between 2% and 53% depending on the initial snow cover extent in the basin
- The highest amounts of water potentially available for runoff (snowmelt and rainfall) came from the upper catchment elevations
- Only slightly more available runoff at open areas compared to forested areas
- Retention capacity of the snowpack was fairly small
- The whole catchment areas was contributing to runoff after 11 hours during ROS 1 and 1 hour after the start of ROS 2

Chair of Hydrology, Albert-Ludwigs-University of Freiburg
jakob.garvelmann@hydrology.uni-freiburg.de www.hydro.uni-freiburg.de

Project funded by DFG