

# Stable water isotopes in catchment hydrology and hydrological process analysis

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## Specific Research Questions

- Closing the regional water cycle:  
development of ***fully coupled atmosphere-hydrosphere model systems***
- Observation & distributed modeling of ***joint water and energy fluxes***  
in complex terrain
- Quantification of **spatio-temporal precipitation variability** in complex terrain  
and poorly gauged regions
- ***Experimental hydrological process analysis using microwave devices***  
(precipitation analysis) and ***stable isotopes (water origin and process separation)***

## ***Methods: Modeling Approaches***

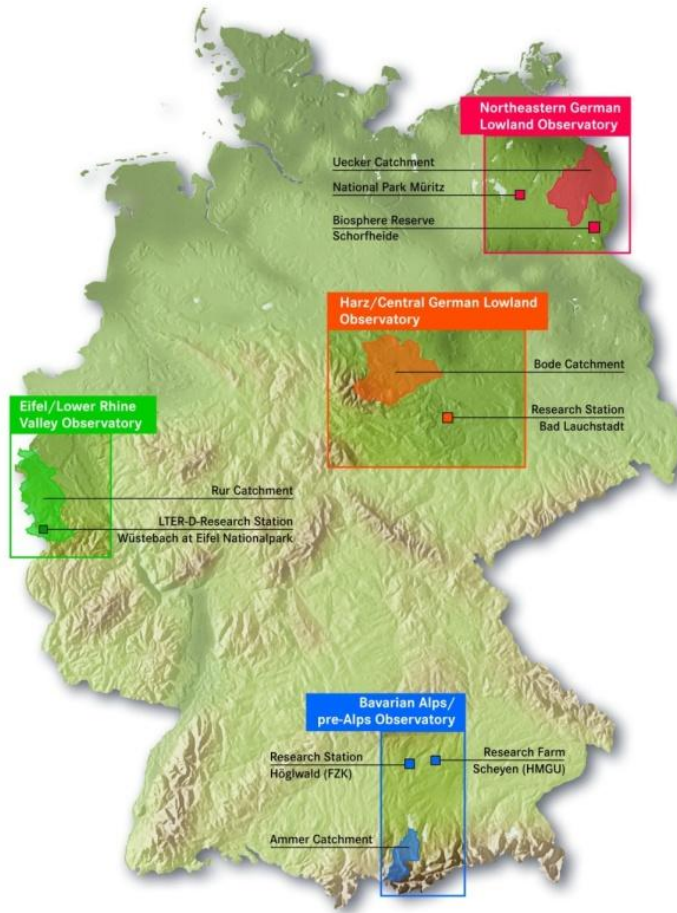
- **Dynamical Downscaling** of global meteorological fields (reanalyses, forecasts, climate scenarios): *WRF, COSMO-CLM*
- **Statistical Downscaling**: Copula-based multivariate methods, Canonical Correlation Analysis, Circulation Pattern Analyses
- **Distributed water- and energy flux modeling**: *WaSIM-ETH, NDHMS, GEOtop*
- **Coupled Atmospheric-Hydrological Model Systems**: *WRF-Hydro, WRF-NoahLSM-HMS*

## ***Methods: Measurement Techniques***

- **Water and energy fluxes** via *TERENO infrastructure: EC-Flux stations, climate stations, lysimeters*
- **Precipitation-Radar:** *DWD Hohenpeissenberg & TERENO*
- **Microwave links:** *from commercial cell phone companies (Ericsson) & own fully polarimetric phase coherent devices*
- **Stable water isotopes:** *Picarro Analyzer for  $\delta^{18}\text{O}$  and  $\delta\text{D}$*

# Hydrometeorological Test Sites

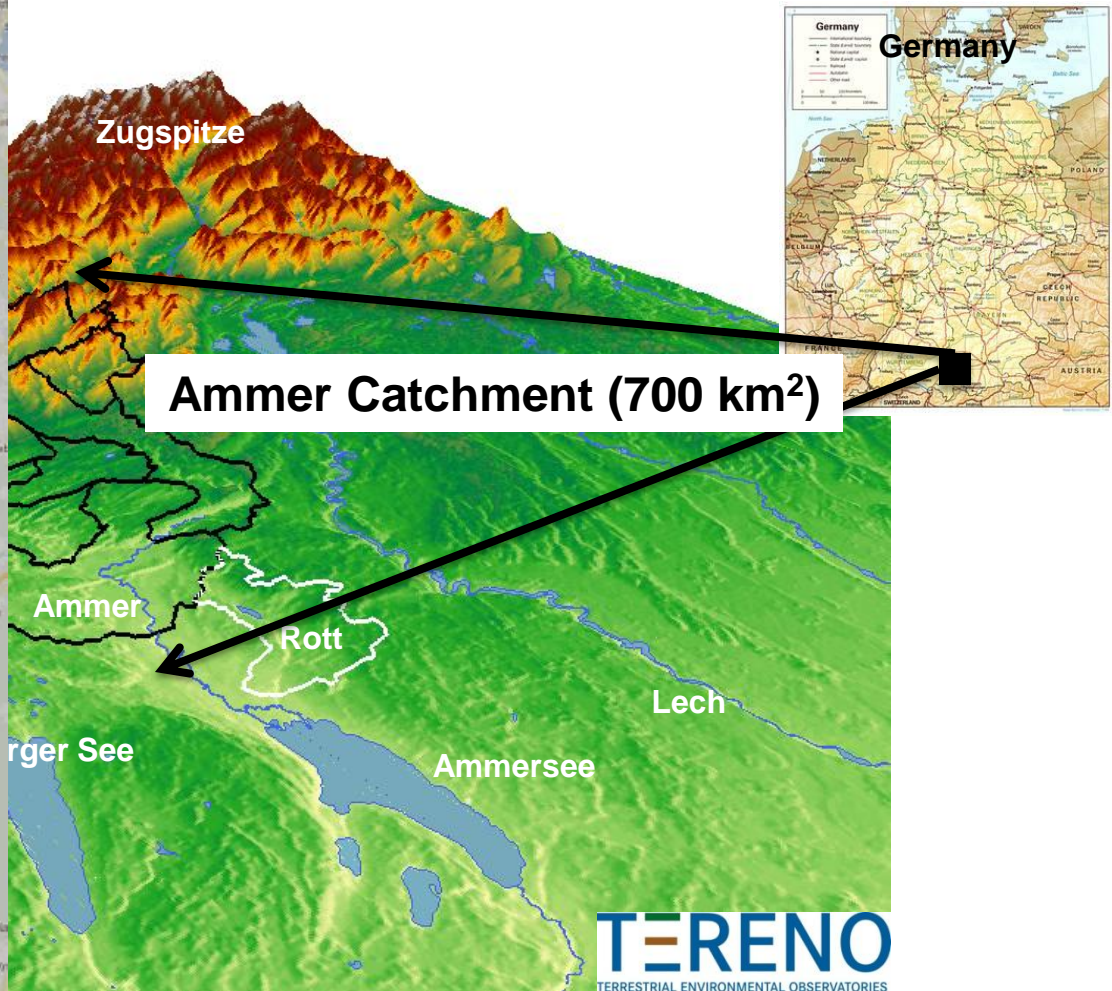
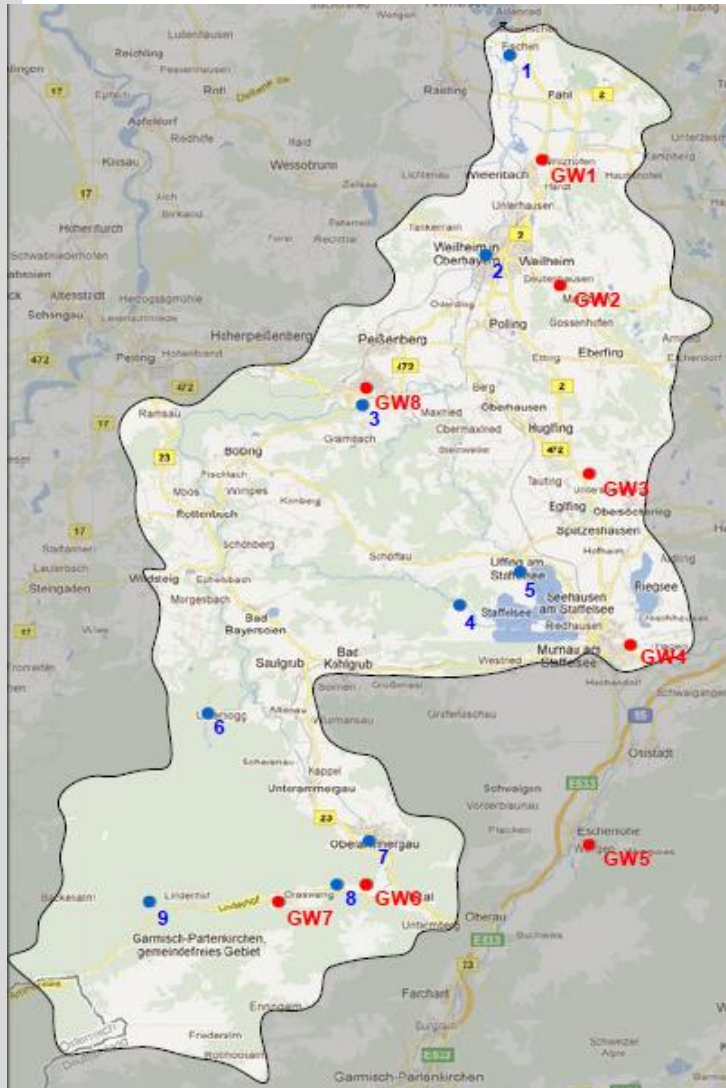
## TERENO Ammer Prealpine catchment



## Berchtesgaden National Park High alpine catchment

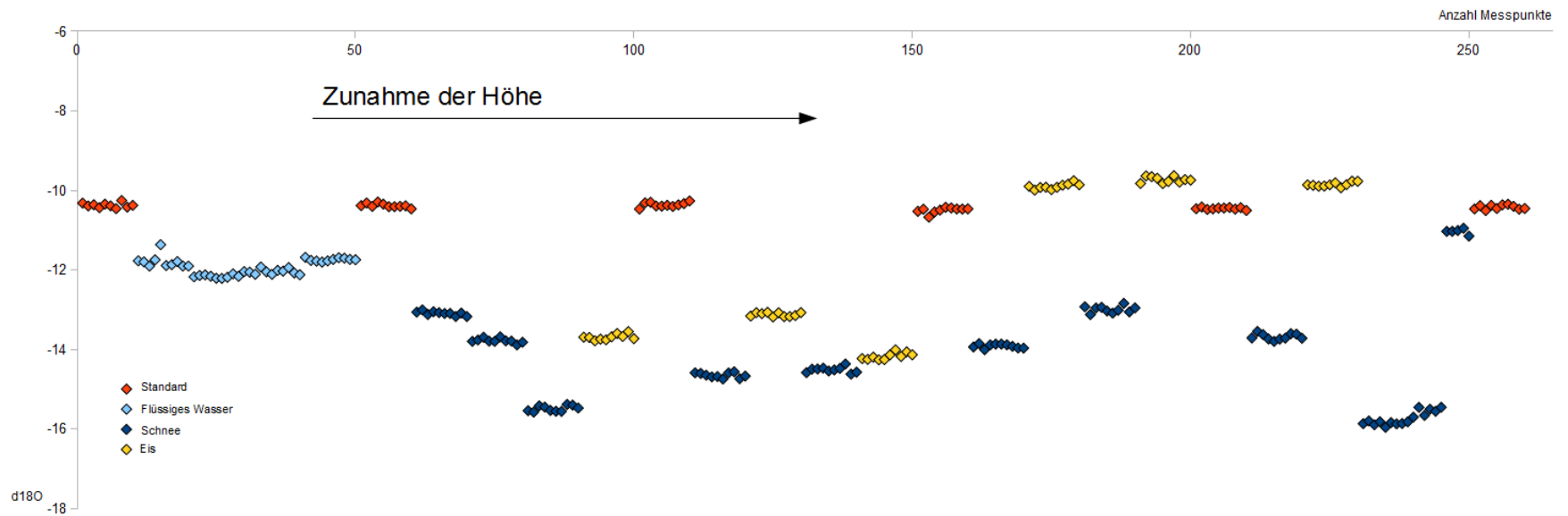
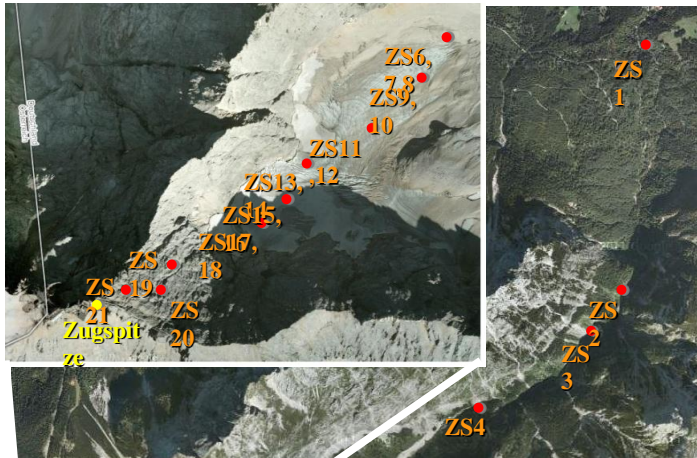


# Hydrometeorological Test Site TERENO *prealpine*



TERENO: Terrestrial Environmental Observatories (<http://www.tereno.net>)

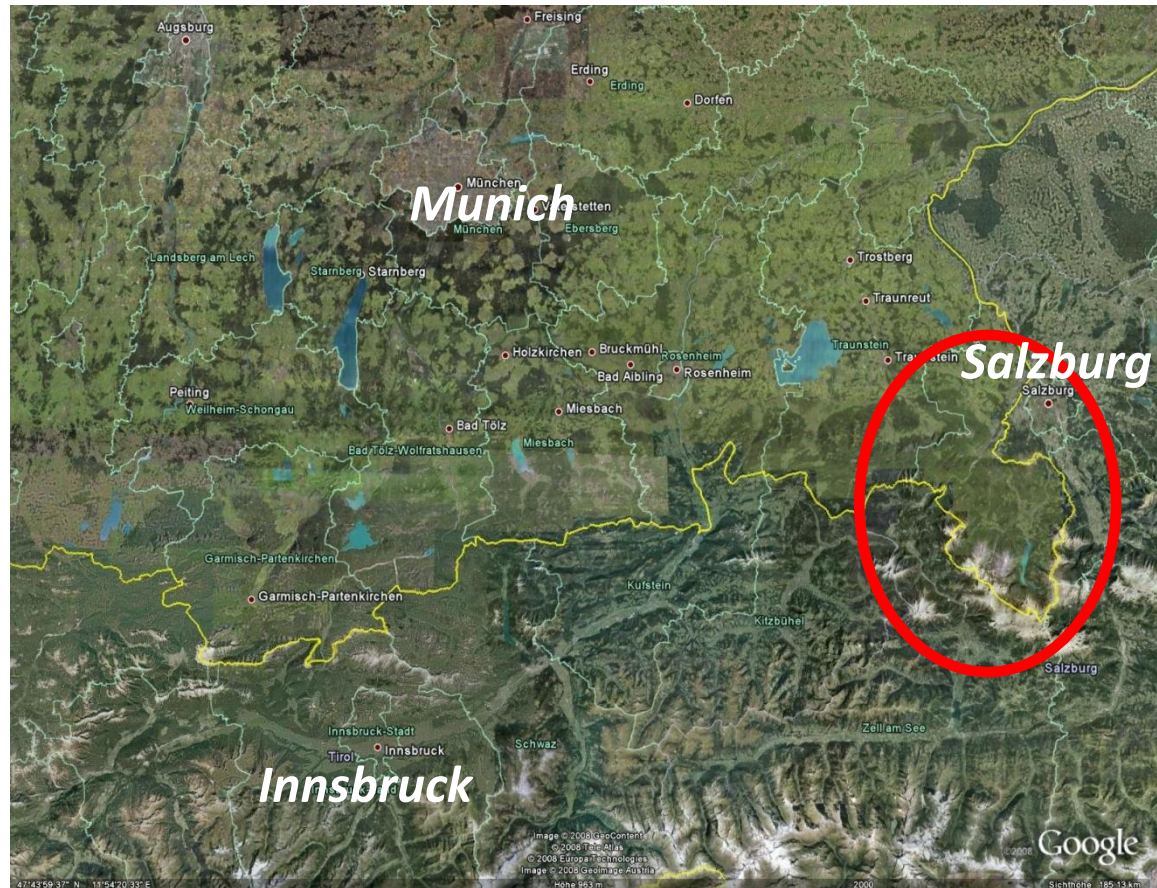
# Hydrometeorological Test Site TERENO *prealpine*



# Hydrometeorological Test Site Berchtesgaden

## Project WaterNPB

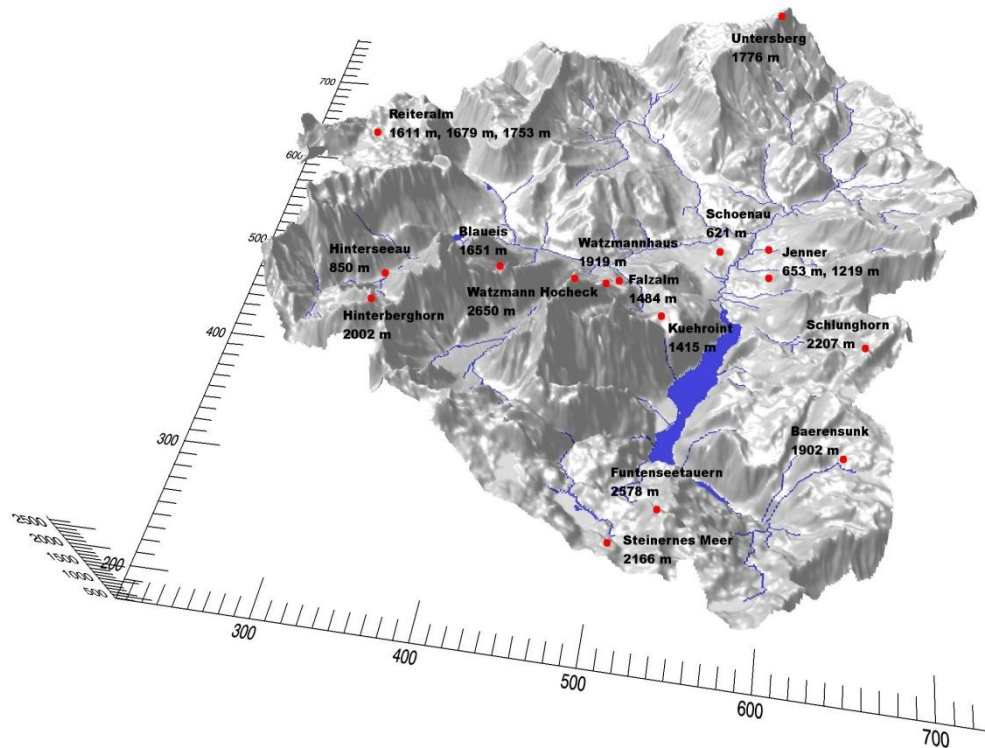
Water Balance Modeling in  
the Berchtesgaden  
National Park





# Distributed Hydrological Modeling

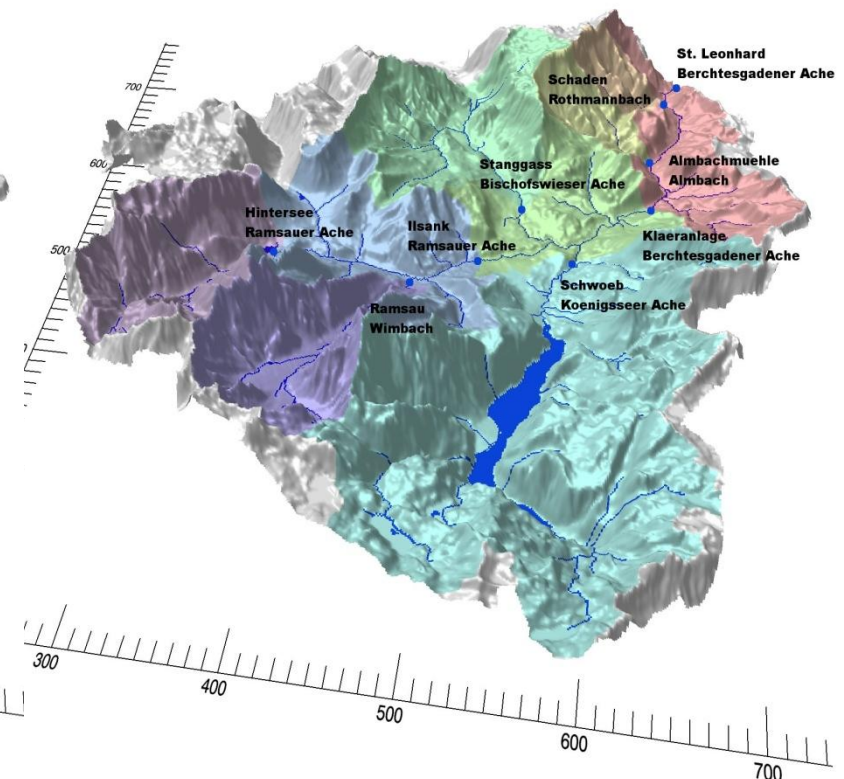
## Meteorological measurements



**33 stations (19 automatic, 14 manual)**

National Park administration, township Schoenau,  
Bavarian avalanche service,  
Central Institute for Meteorology and Geodynamics (ZAMG)

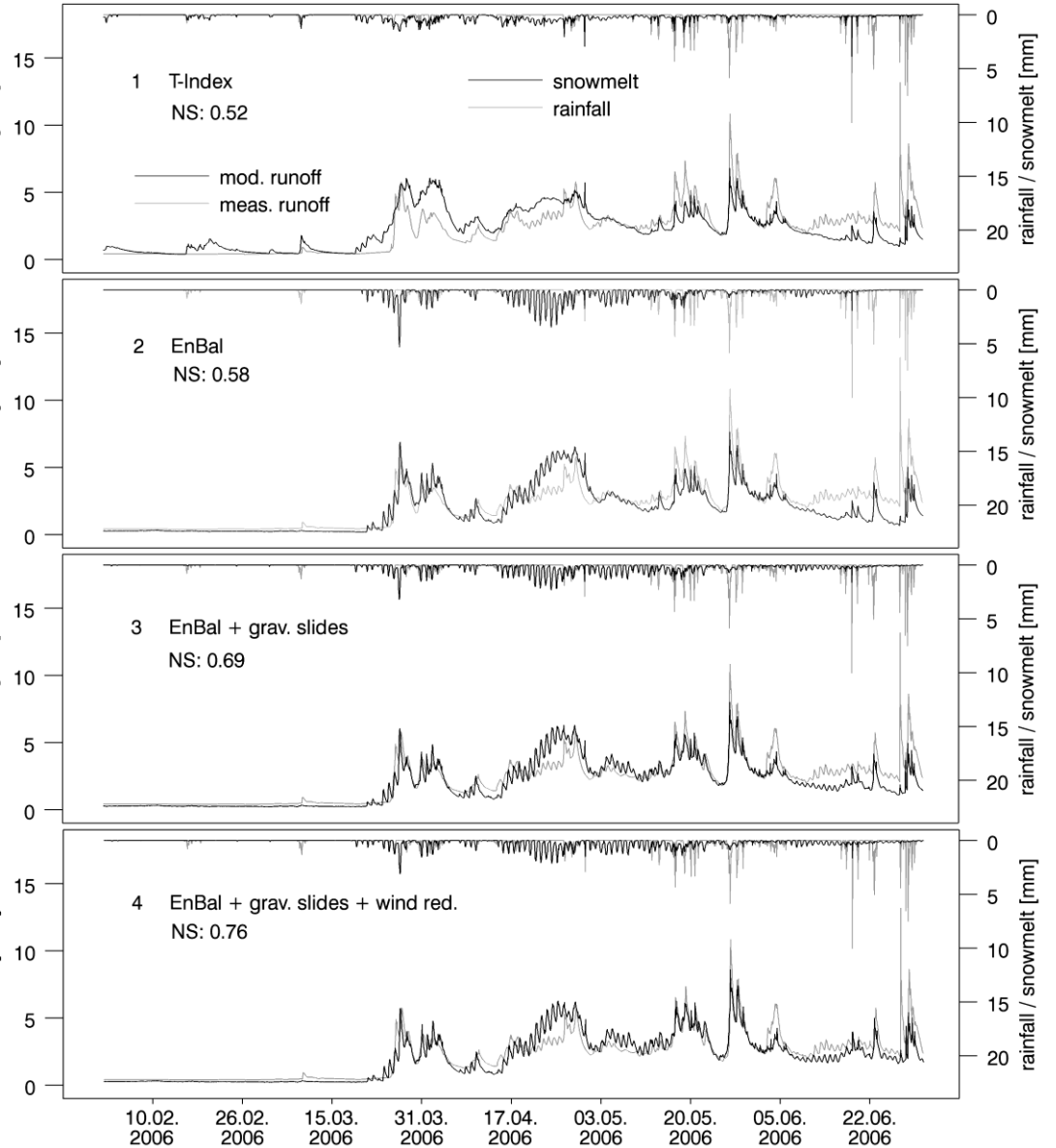
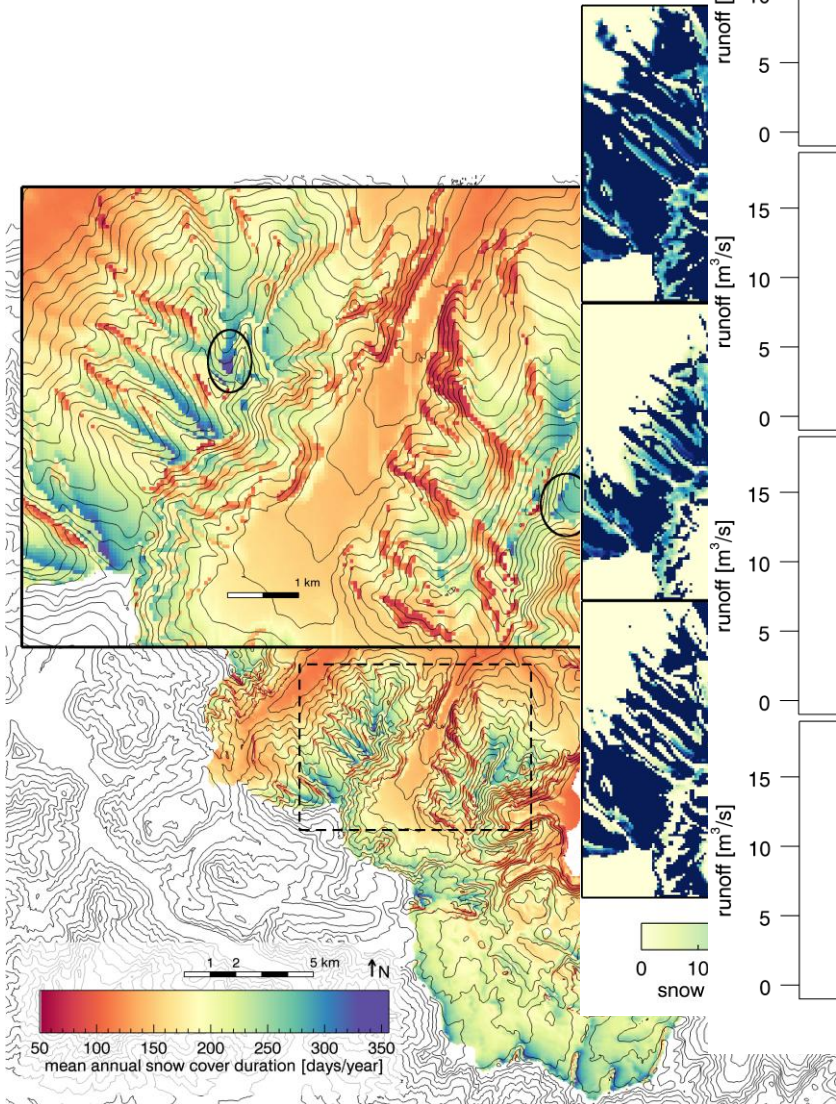
## Gauges and subcatchments



**433 km<sup>2</sup>**

**9 gauges and subcatchments**

# Snowmelt and Runoff

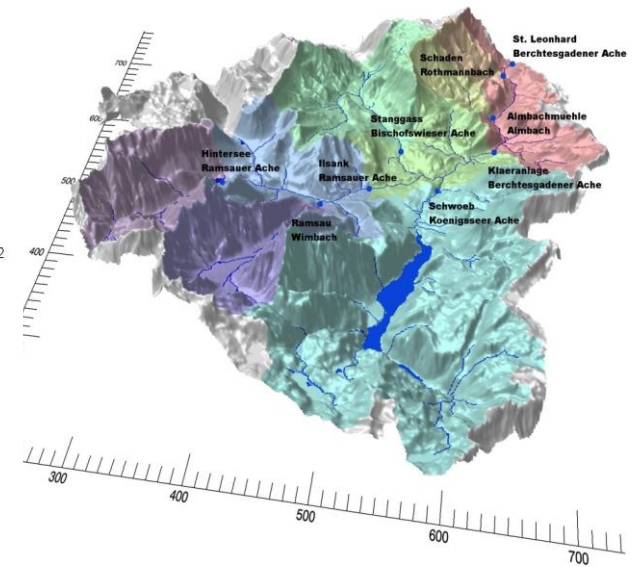
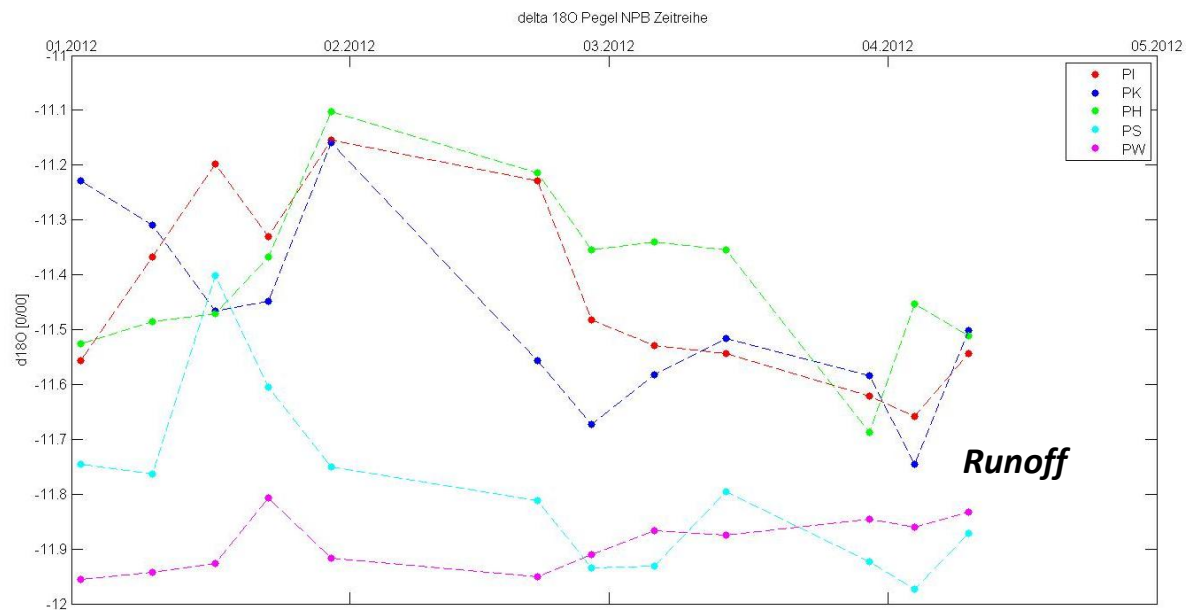
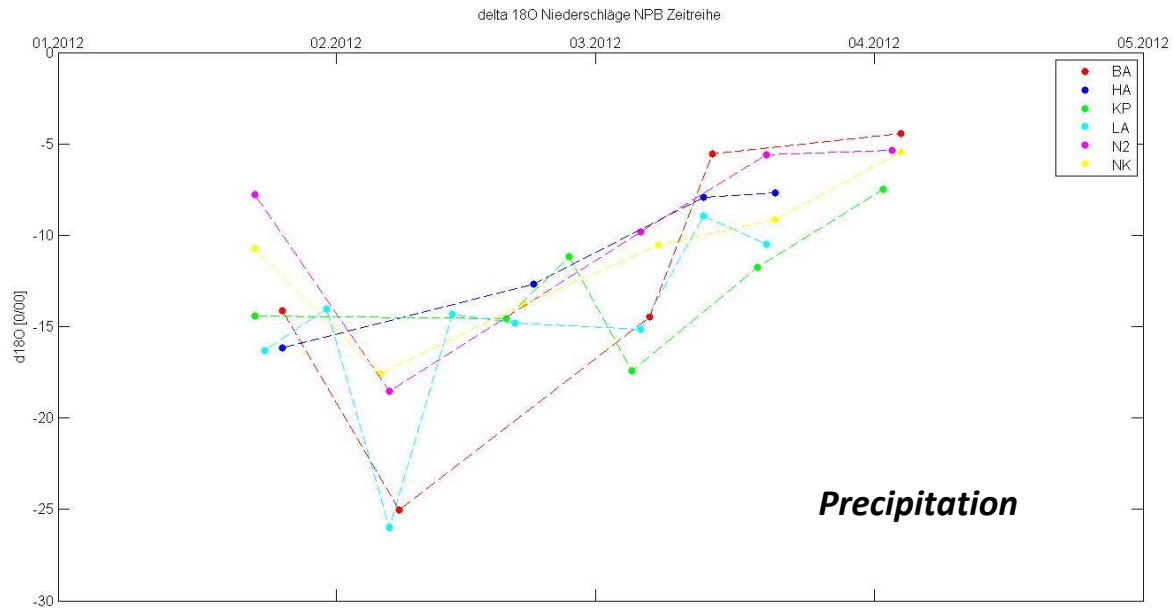


## Improved process analysis: interaction precipitation, snow dynamics, flow processes

- Stable isotopes of oxygen ( $\text{H}_2^{18}\text{O}$ ) and hydrogen (HDO) as natural tracers
- Quantification of contributors to streamflow (snow melt, springs, ...)
- Continuous sampling of springs, snow, and discharge water



**Picarro L1102-i Isotopic Liquid Water Analyzer**



- **Ammer catchment (TERENO *prealpine*)**  
Sampling campaign summer 2011 + ?
- **Berchtesgaden National Park**  
Continuous sampling of precipitation, springs, snow, and discharge water since Dec. 2011
- **Picarro Analyzer for  $\delta^{18}\text{O}$  and  $\delta\text{D}$**
- **Process studies, model validation**
- **2 Diploma theses (Benjamin Busl, Rebecca Johnson)**  
**PhD student Florian Marshall (Augsburg)**
- ...