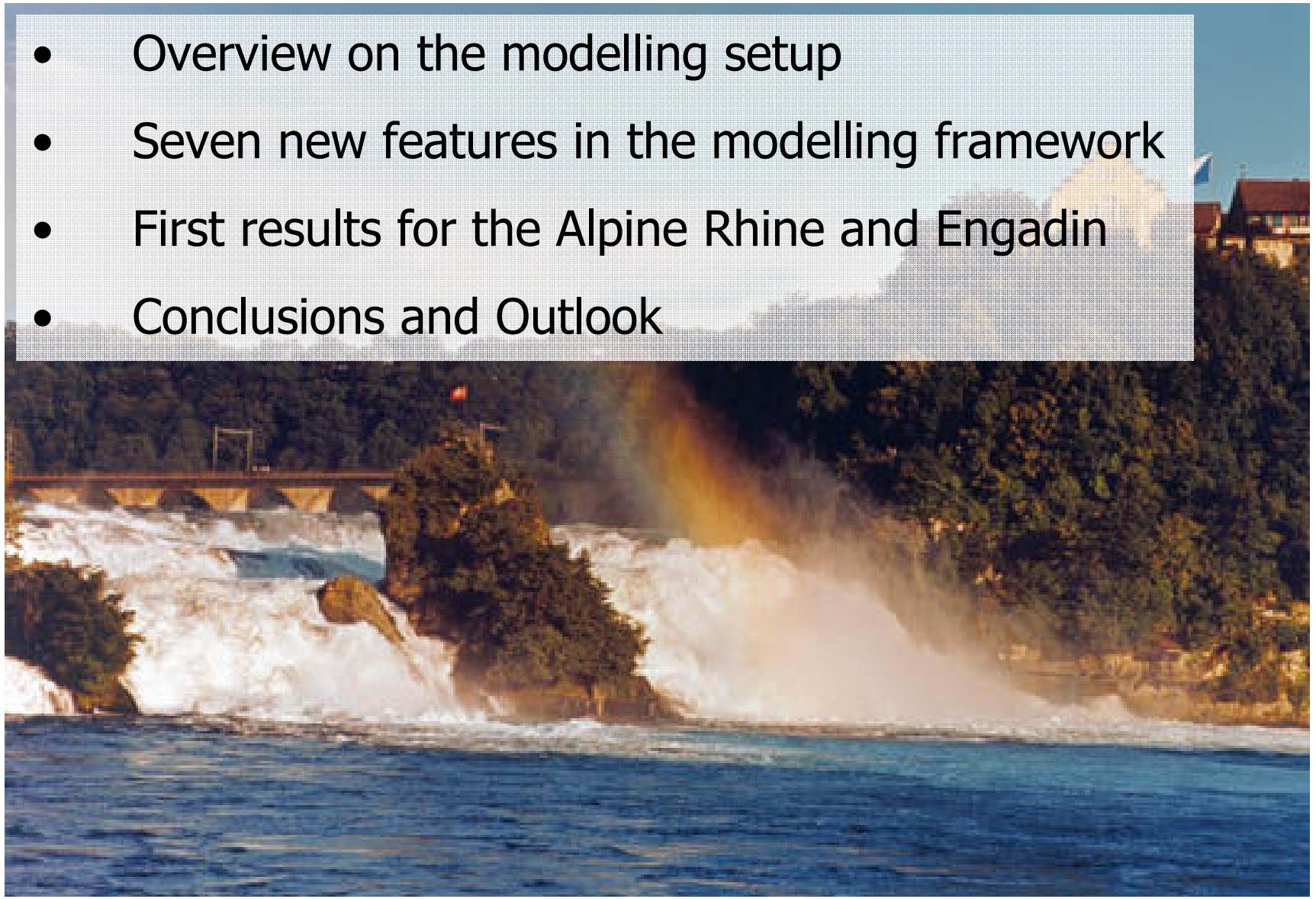
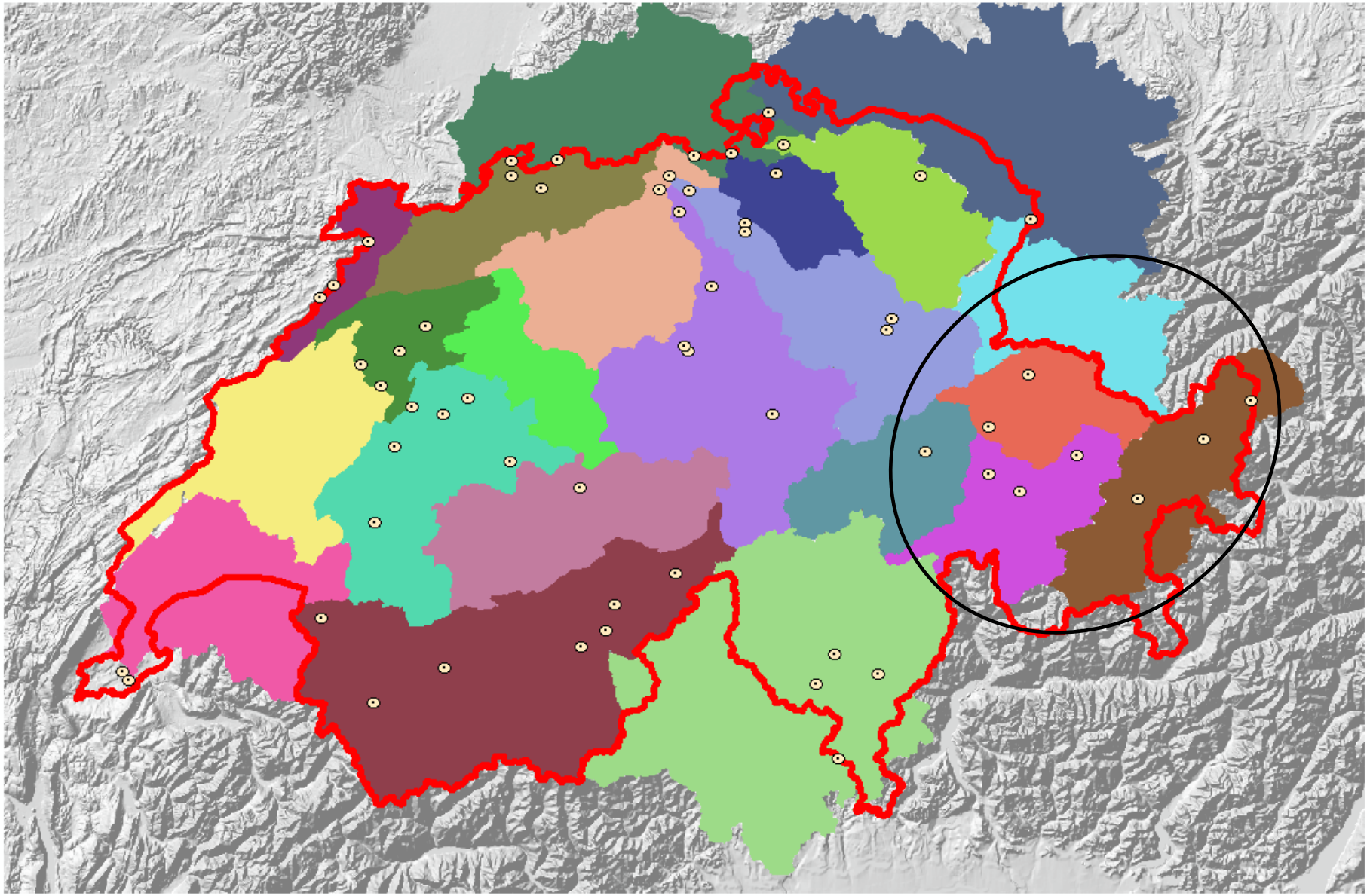
SUB PROJECT: Natural water balance of Switzerland and its most important large river basins



- Overview on the modelling setup
- Seven new features in the modelling framework
- First results for the Alpine Rhine and Engadin
- Conclusions and Outlook

Novel setup for the whole of the "hydrological" Switzerland

23 Regions (all of them at 200 m resolution)



The hydrological model PREVAH

Viviroli et al., ENSO, 2009

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An introduction to the hydrological modelling system PREVAH and its pre- and post-processing-tools

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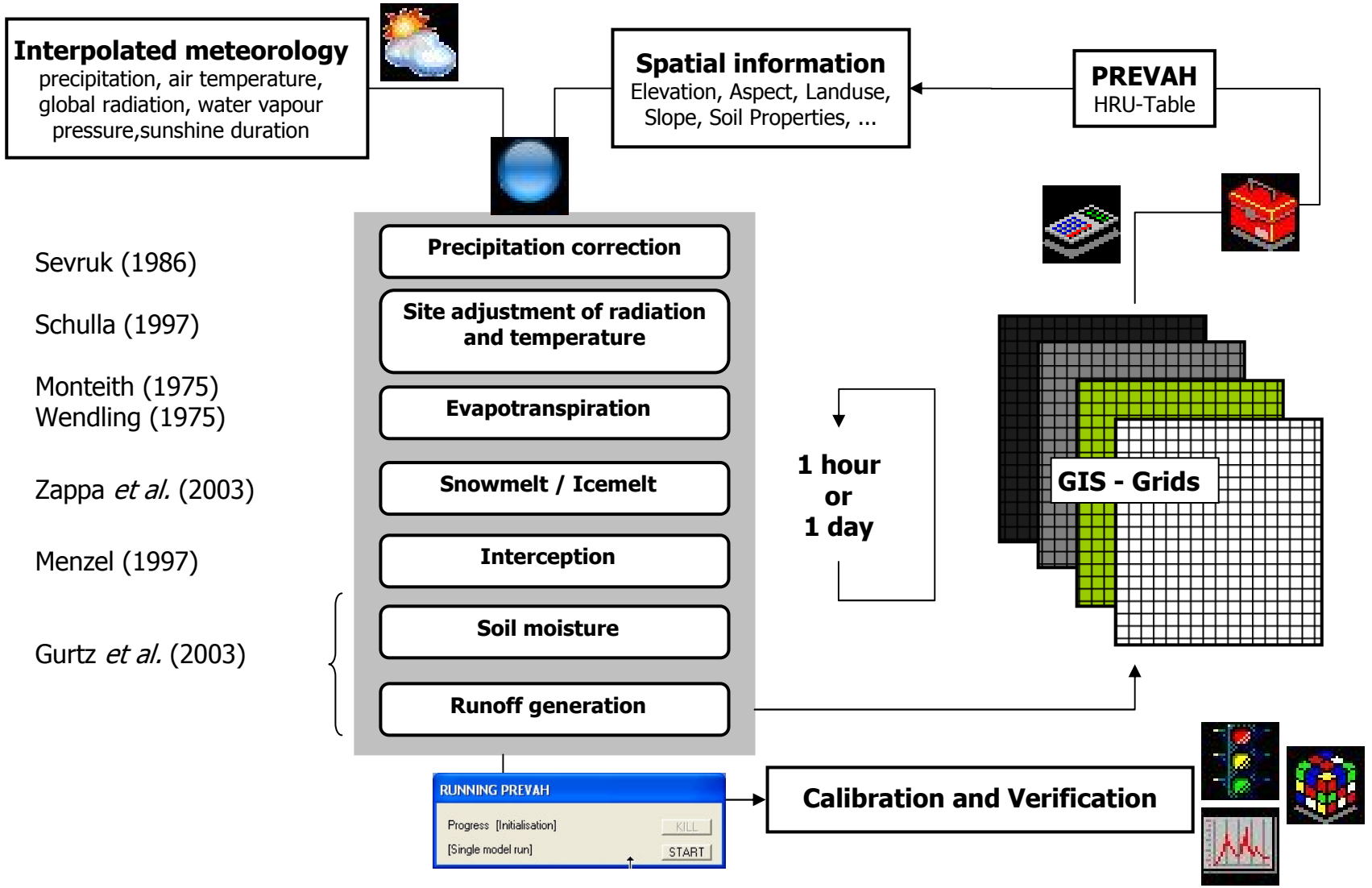
ABSTRACT

Spatially distributed modelling is an important instrument for studying the hydrological cycle, both concerning its present state as well as possible future changes in climate and land use. Results of such simulations are particularly relevant for the fields of water resources, natural hazards and hydropower. The semi-distributed hydrological modelling system PREVAH (PREcipitation-Runoff-EVApotranspiration HRU Model) implements a conceptual process-oriented approach and has been developed especially to suit conditions in mountainous environments with their highly variable environmental and climatic conditions.

This article presents an overview of the actual model core of PREVAH and introduces the various tools which have been developed for obtaining a comprehensive, user-friendly modelling system: DATAWIZARD for importing and managing hydrometeorological data, WINMET for pre-processing meteorological data, GRIDMATH for carrying out elementary raster data operations, FAOSOIL for processing FAO World Soil Map information, WINHRU for pre-processing spatial data and aggregating hydrological response units (HRU), WINPREVAH for operating the model, HYDROGRAPH for visualising hydrograph data and VIEWOPTIM for visualising the calibration procedure. The PREVAH components introduced here support a modelling task from pre-processing the data over the actual model calibration and validation to visualising and interpreting the results (post-processing). A brief overview of current PREVAH applications demonstrates the flexibility of the modelling system with examples that range from water balance modelling over flood estimation and flood forecasting to drought analysis in Switzerland, Austria, China, Russia and Sweden.

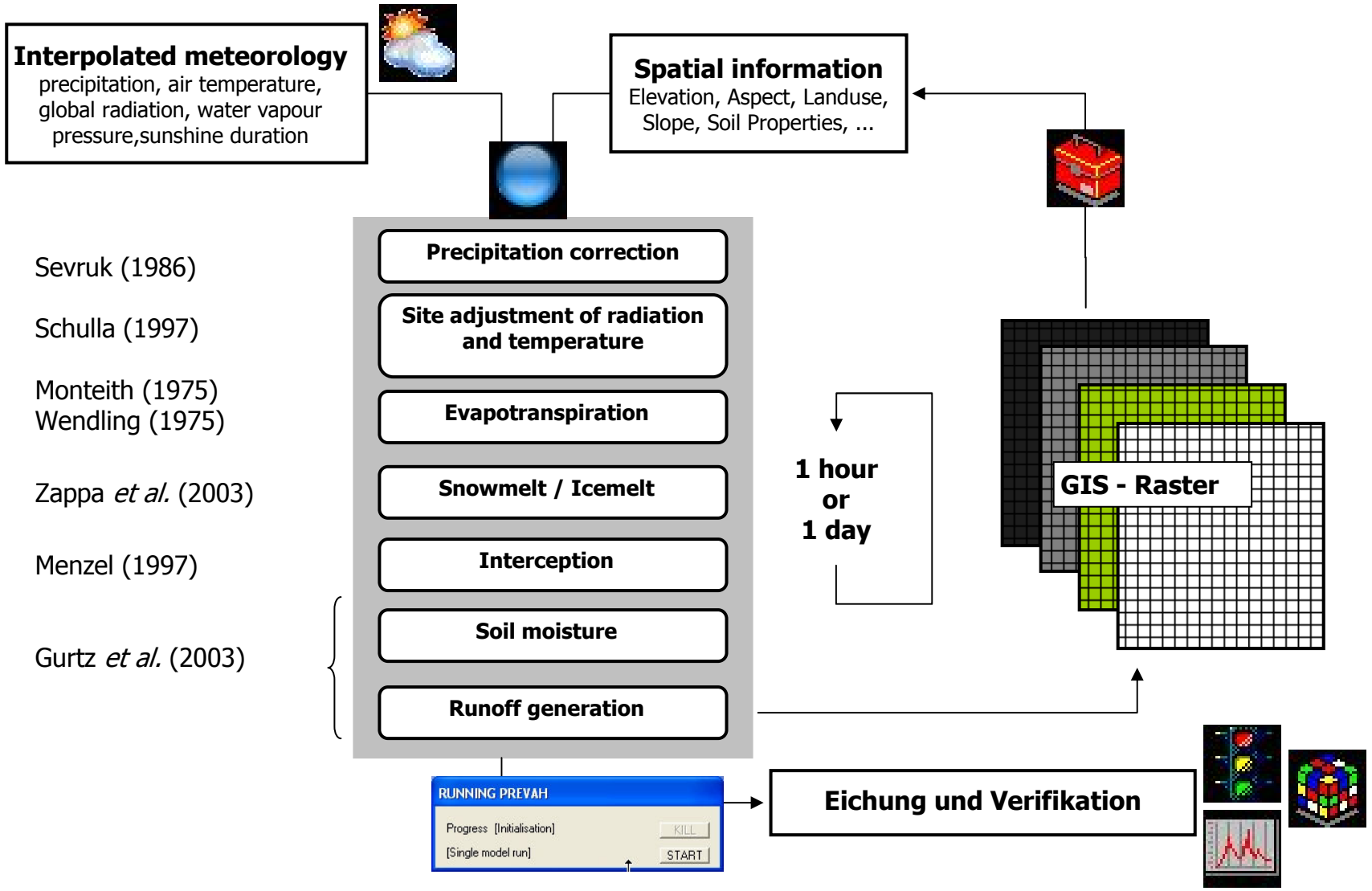
The original PREVAH-Modeling-System

Precipitation-Runoff-Evapotranspiration HRU related Model



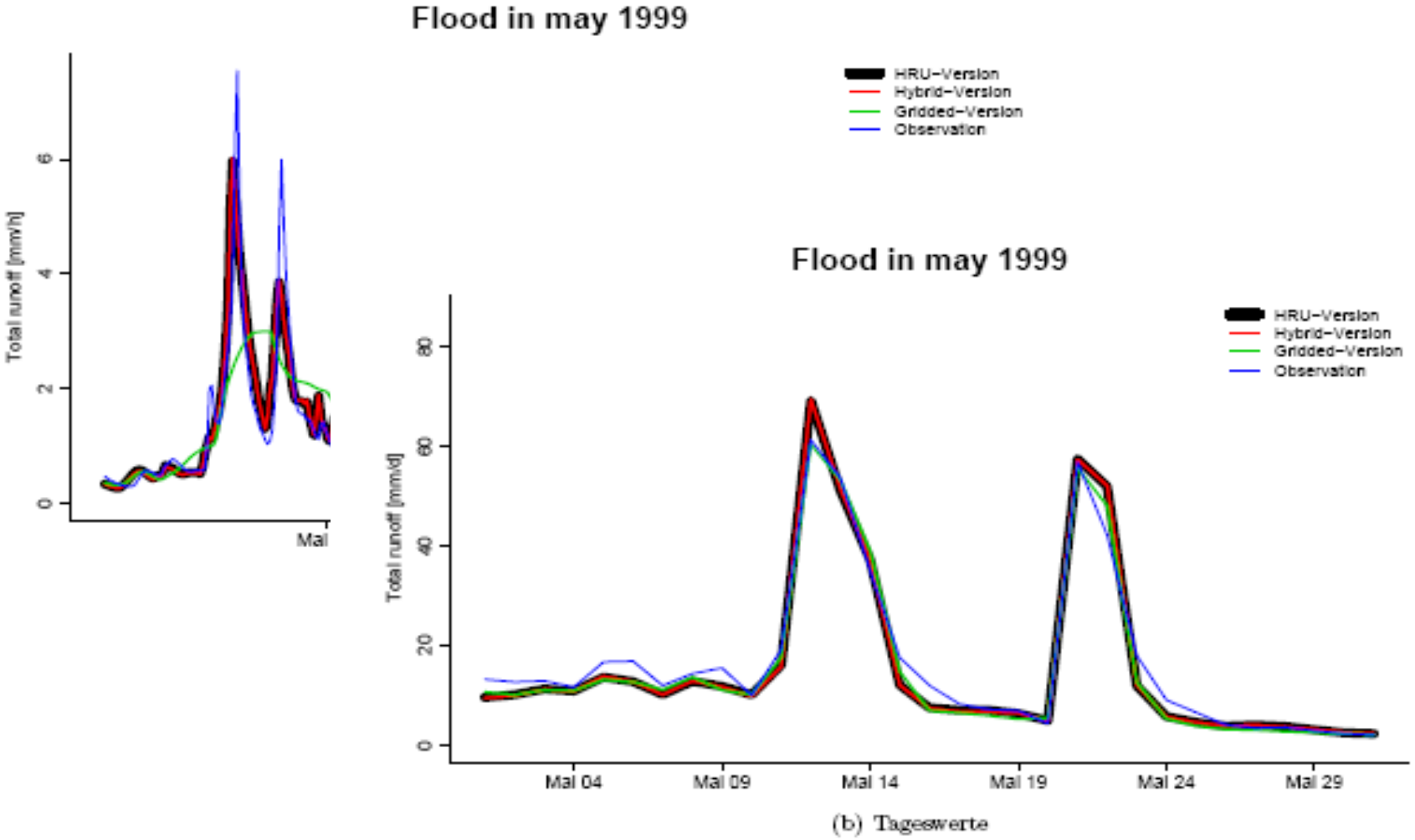
(Gurtz, Zappa, Viviroli et al., 1994-2010)

New Features (1): A Gridded Version of PREVAH



(Gurtz, Zappa, Viviroli et al., 1994-2010)

New Features (1): A Gridded Version of PREVAH - Comparison between HRU and gridded Version for the Alp (46 km²)



(b) Tageswerte

New Features (2): Regionalized model parameters

(Viviroli et al., JH, 2009 part I)

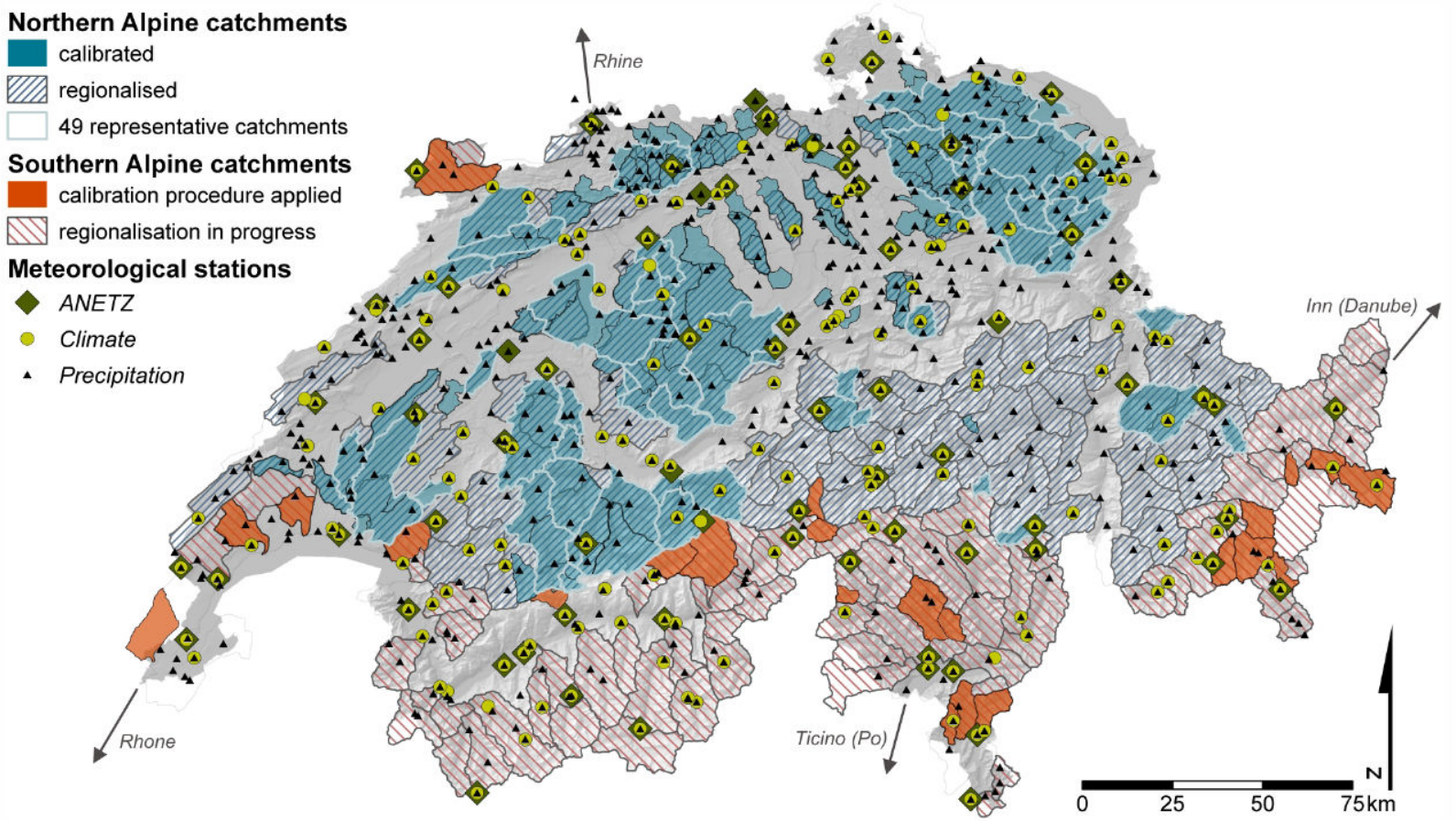


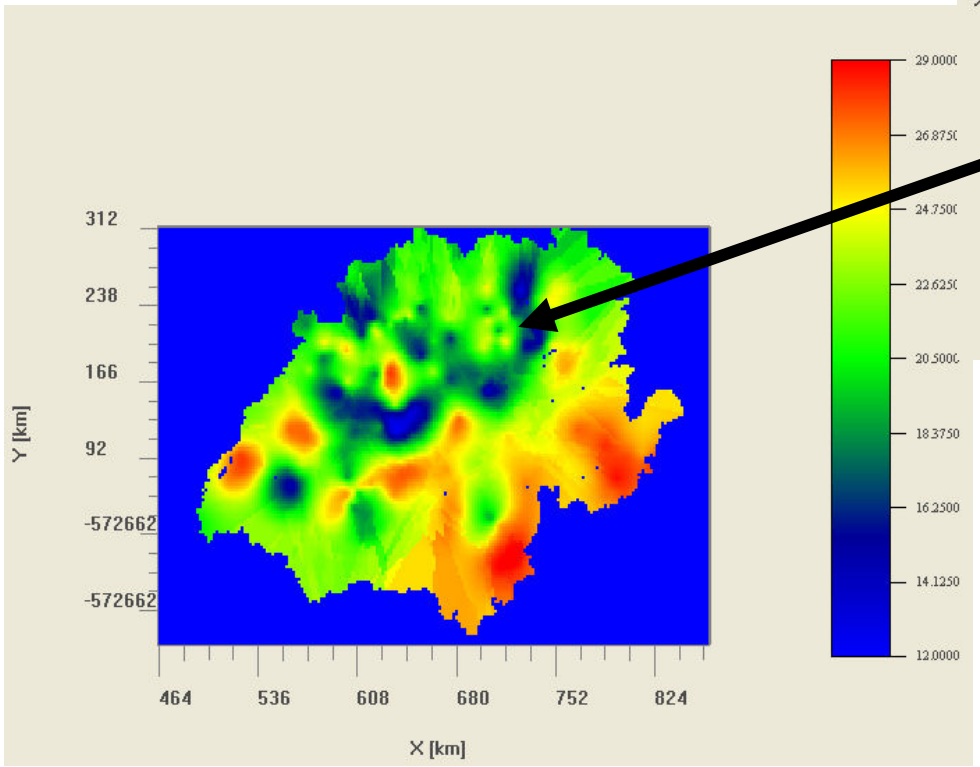
Fig. 1. Mesoscale catchments for calibration and regionalisation and meteorological network of Switzerland. Those catchments where model parameters were calibrated, validated and regionalised beforehand (Viviroli et al., 2009b,c) are indicated by blue colour, the Southern Alpine catchments presented in this study are shown in red. Note that a few catchments in northwest and west Switzerland belong to the Rhone basin draining southward.

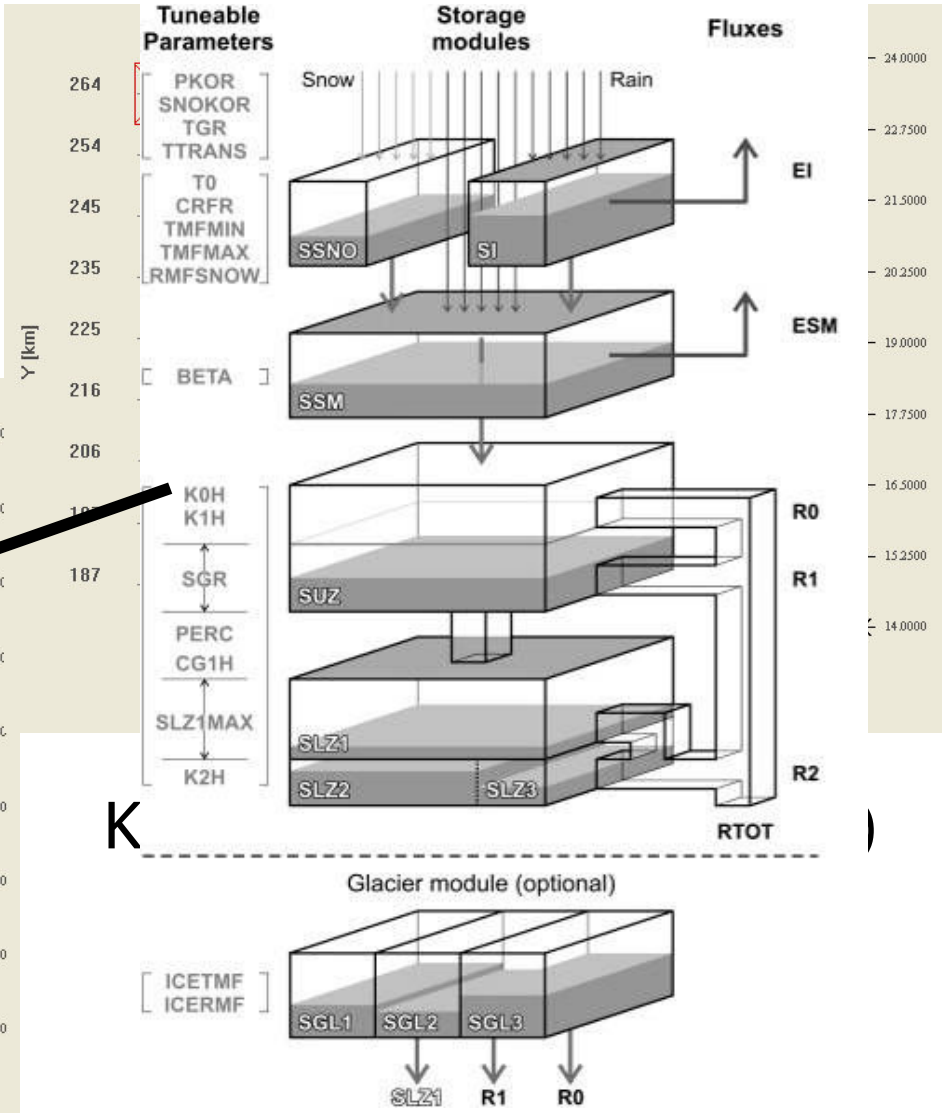
Köplin, N., Viviroli, D., Schädler, B., and Weingartner, R.: How does climate change affect mesoscale catchments in Switzerland? – a framework for a comprehensive assessment, Adv. Geosci., 27, 111-119, doi:10.5194/adgeo-27-111-2010, 2010.

New Features (2): Regionalized model parameters

(Viviroli et al., JH, 2009 part II)

K0H - Schweiz (2x2 km)

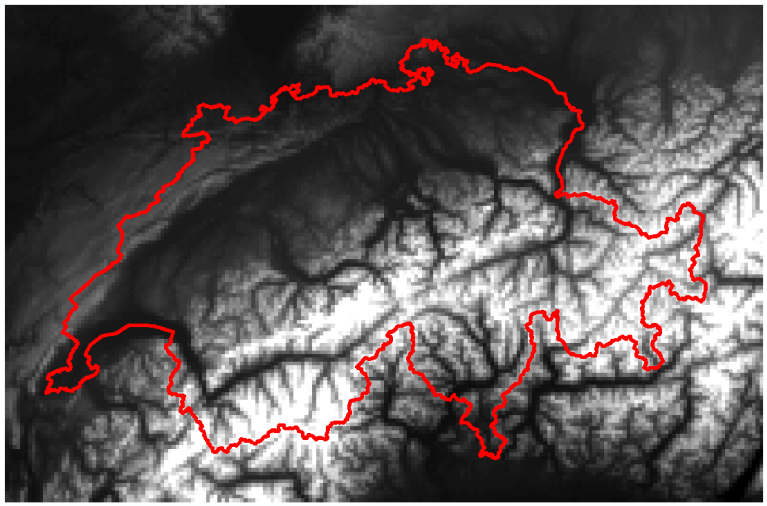




New Features (3): Gridded climatologies in 2 km resolution

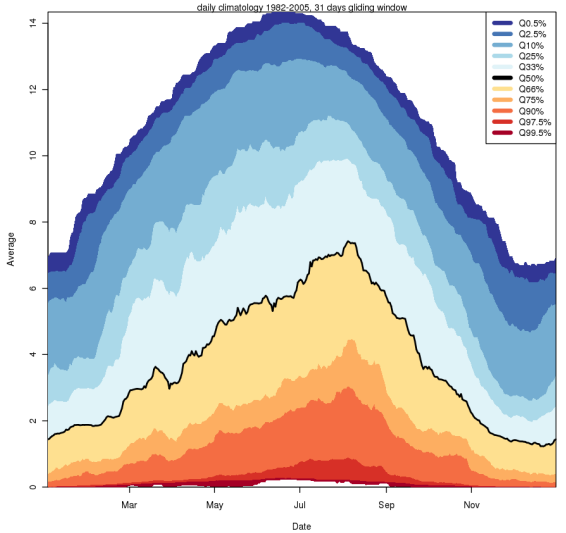
Available 1970-2009 -> downscaled to 200 m resolution during simulation runs

The Domain

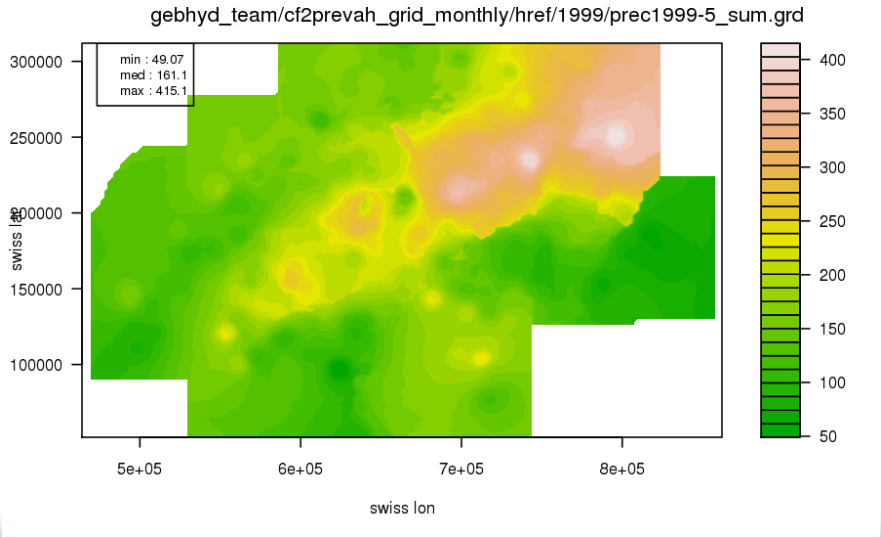


Climatology, Thunersee, 1981-2005

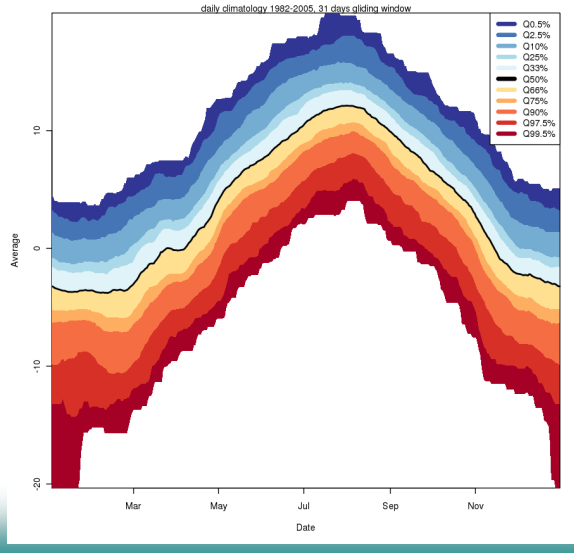
Sunshine Duration



Cumulated precipitation, Mai 1999



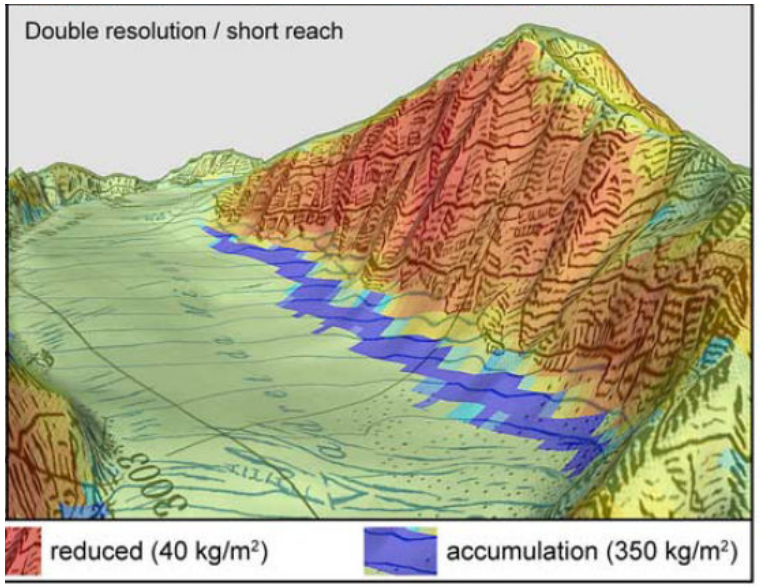
Air Temperature

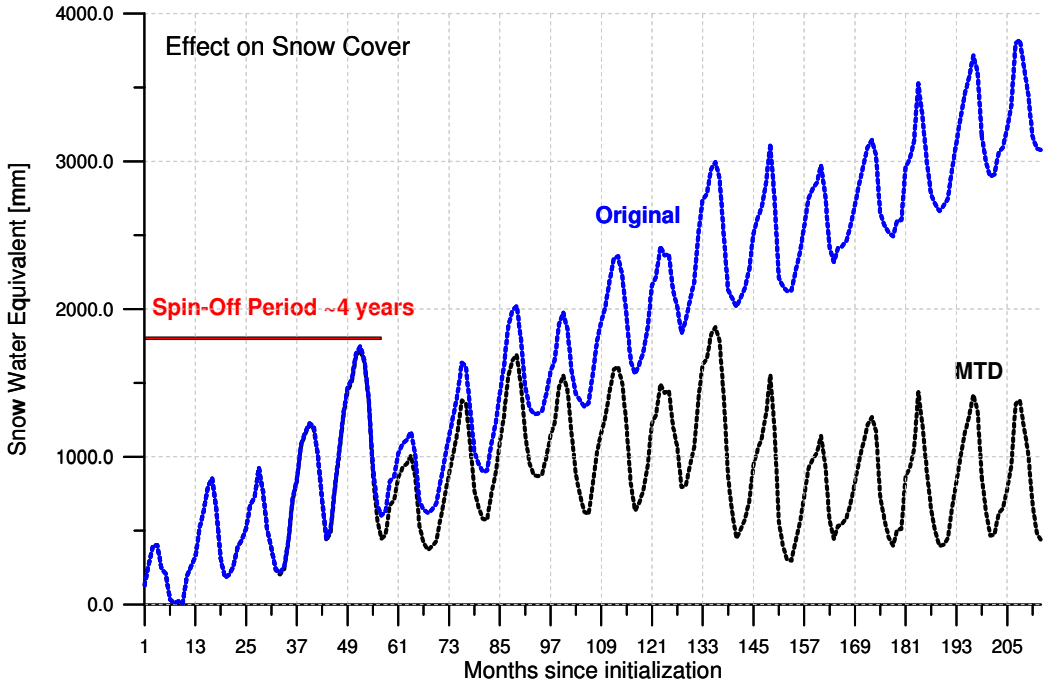


New Features (4): Mass transport and deposition (MTD)

So far perennial snow was accumulating in PREVAH on steep slopes

- MTD Algorithm of Gruber (2007) implemented
- "Snow saturation" as function of slope
- If pixel is saturated snow drops to closest lower located pixel
- "Avalanches" are generated





Citation: Gruber, S. (2007), A mass-conserving fast algorithm to parameterize gravitational transport and deposition using digital elevation models, *Water Resour. Res.*, *43*, W06412, doi:10.1029/2006WR004868.

New Features (5): Glacier maps for hydrological modelling

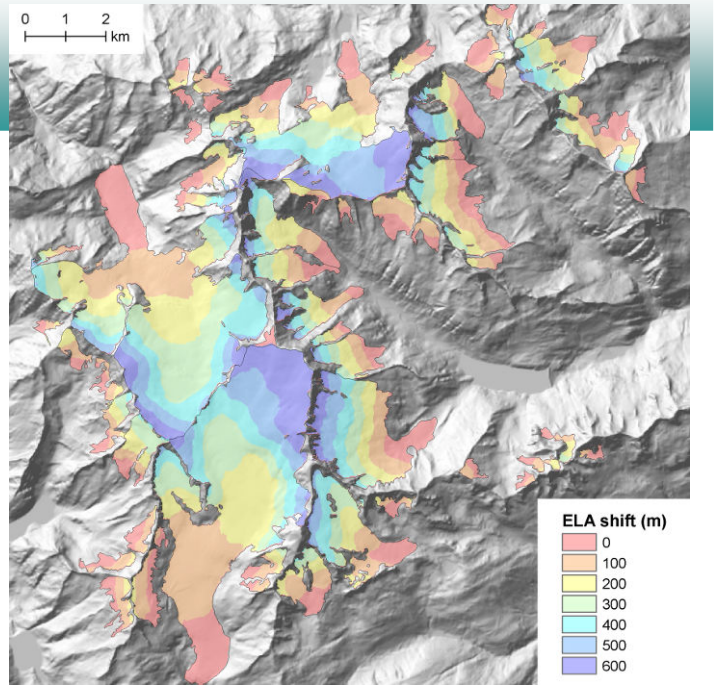
- Observed maps available for 1973, 2000, 2009

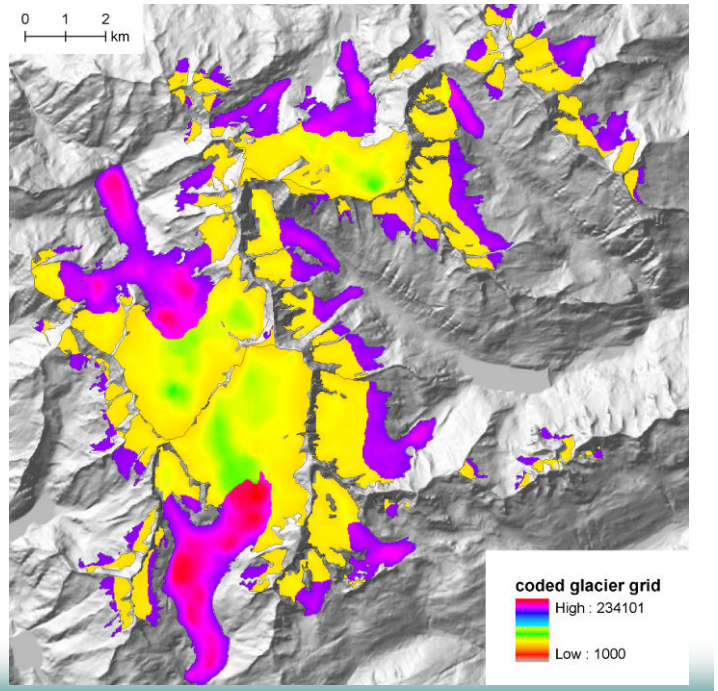
- Version 1.0: ELA-shift Model (**only Area Loss**) by Paul et al. 2007: 140 m ELA-Shif for 1 °K temperature increase

  So far only 1973 Map and ELA-Shift 200 m as representative scenario for 2021-2050

- **Version 2.0**: Phd A. Linsbauer (UZH)
  Update for 2000
  Scenarios for **2021, 2031, 2041**
  Regional changes (Area Loss)
  Consideration of **Thickness Loss**
  Parameterization of new Lakes (!)
  6-digits code in 200x200 m resolution for PREVAH

  1-23-4-56
  - 1 → 0: no glacier, 1: acc, 2: abl
  - 23 → ice thickness in 10 m
  - 4 → 0: no lake, 1: lake
  - 56 → Δh in 10 m per degree

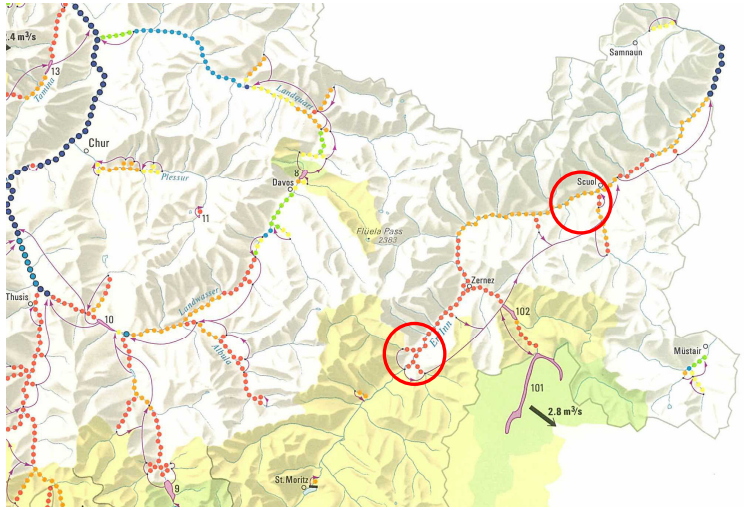




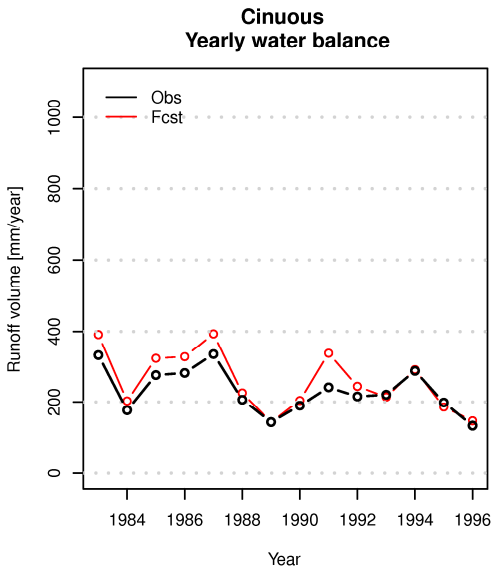
New Features (6): Consideration of mayor anthropogenic influences

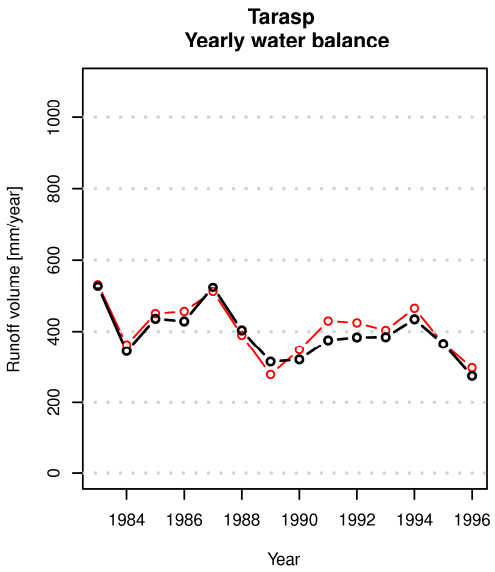
So far realized for Engadin

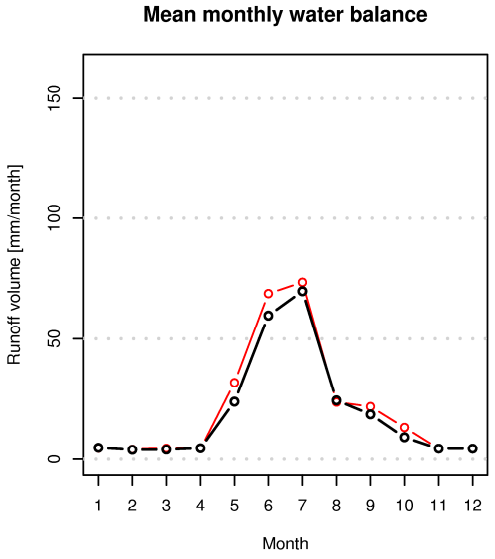
Training Period 1983-1996

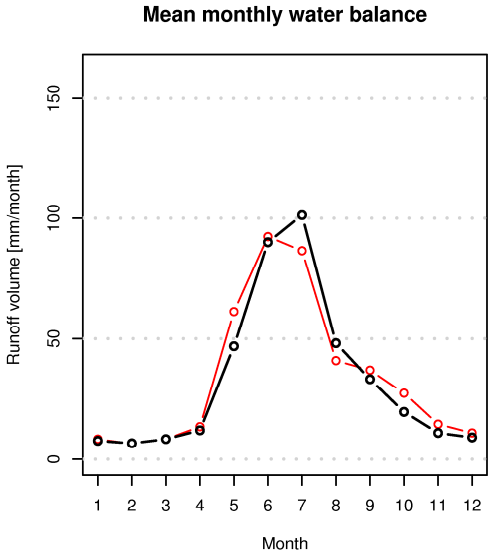


HADES 5.3



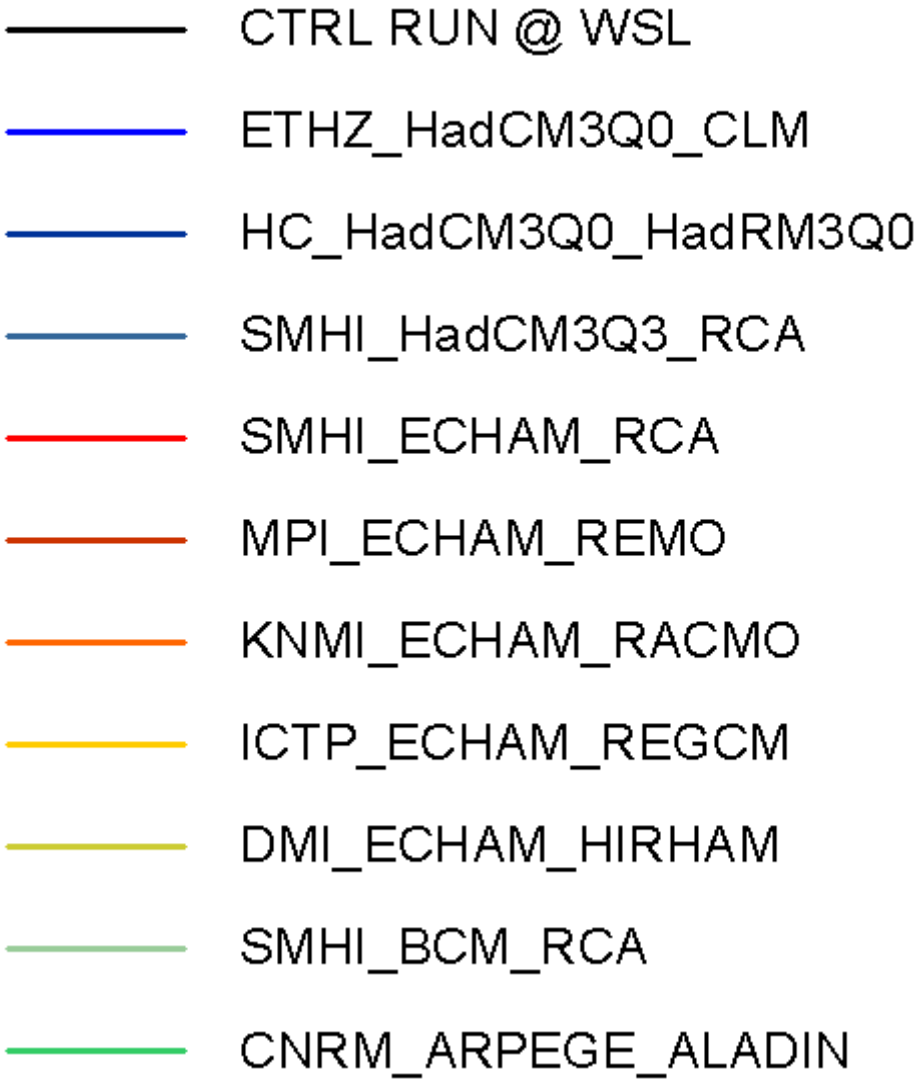






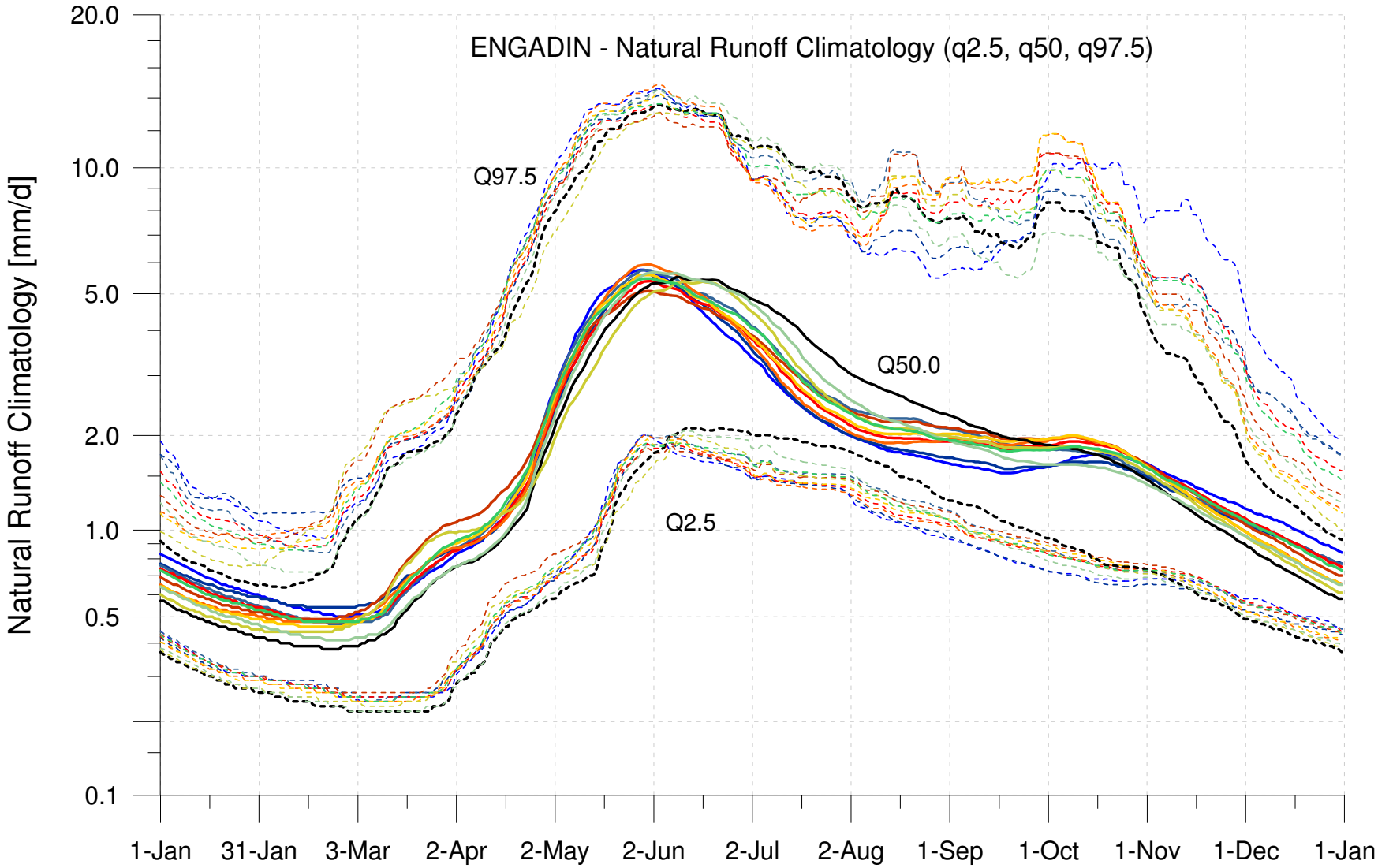
New Features (7): Daily DeltaChange Scenarios (Bosshard et al.)

- **10 Chains**
- **Spin-Off 1975-1979**
- **CTRL 1980-2009**
- **SCEN1 2021-2050**
- *SCEN2 2070-2099*

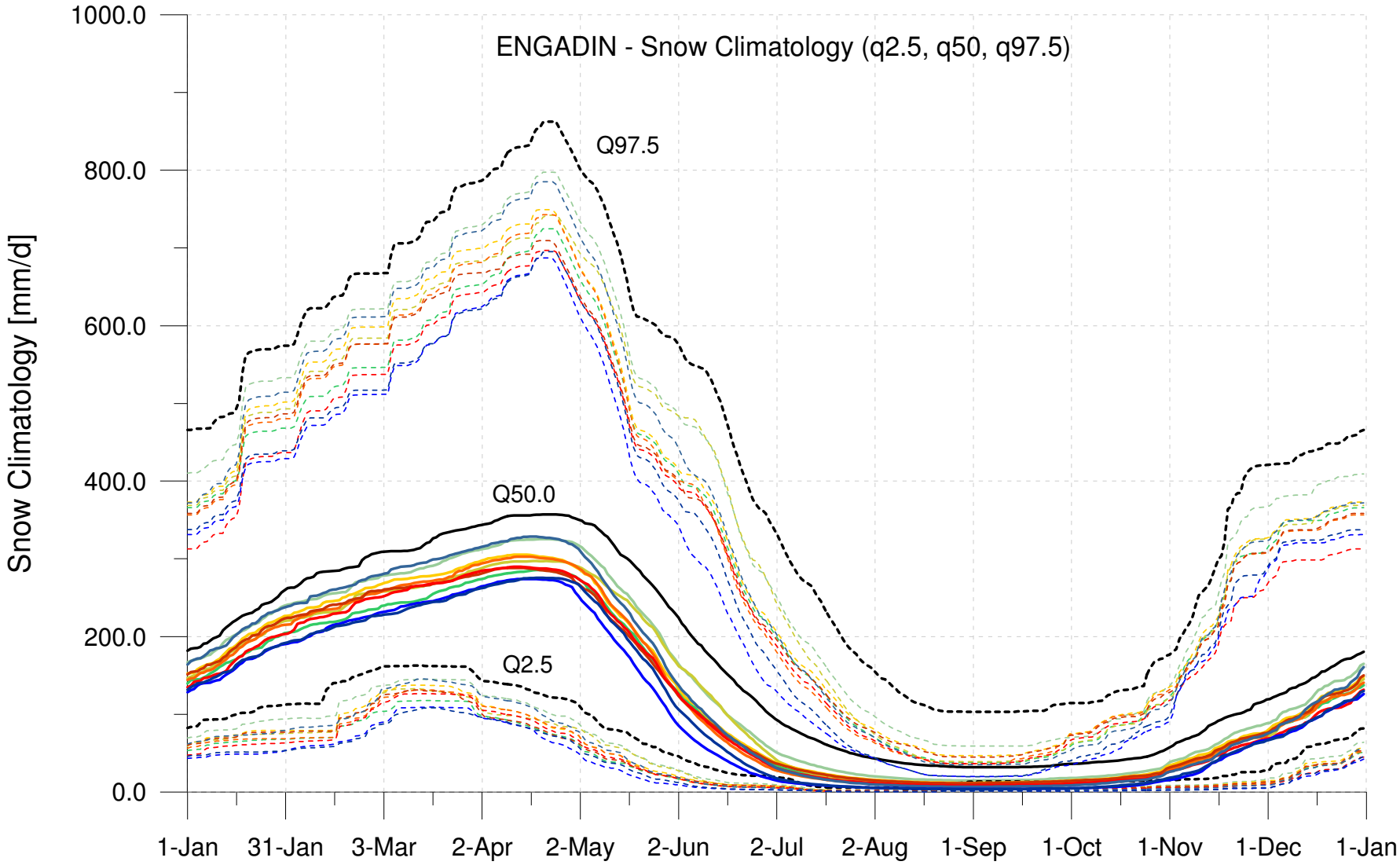


Results - Engadin: Natural runoff quantiles

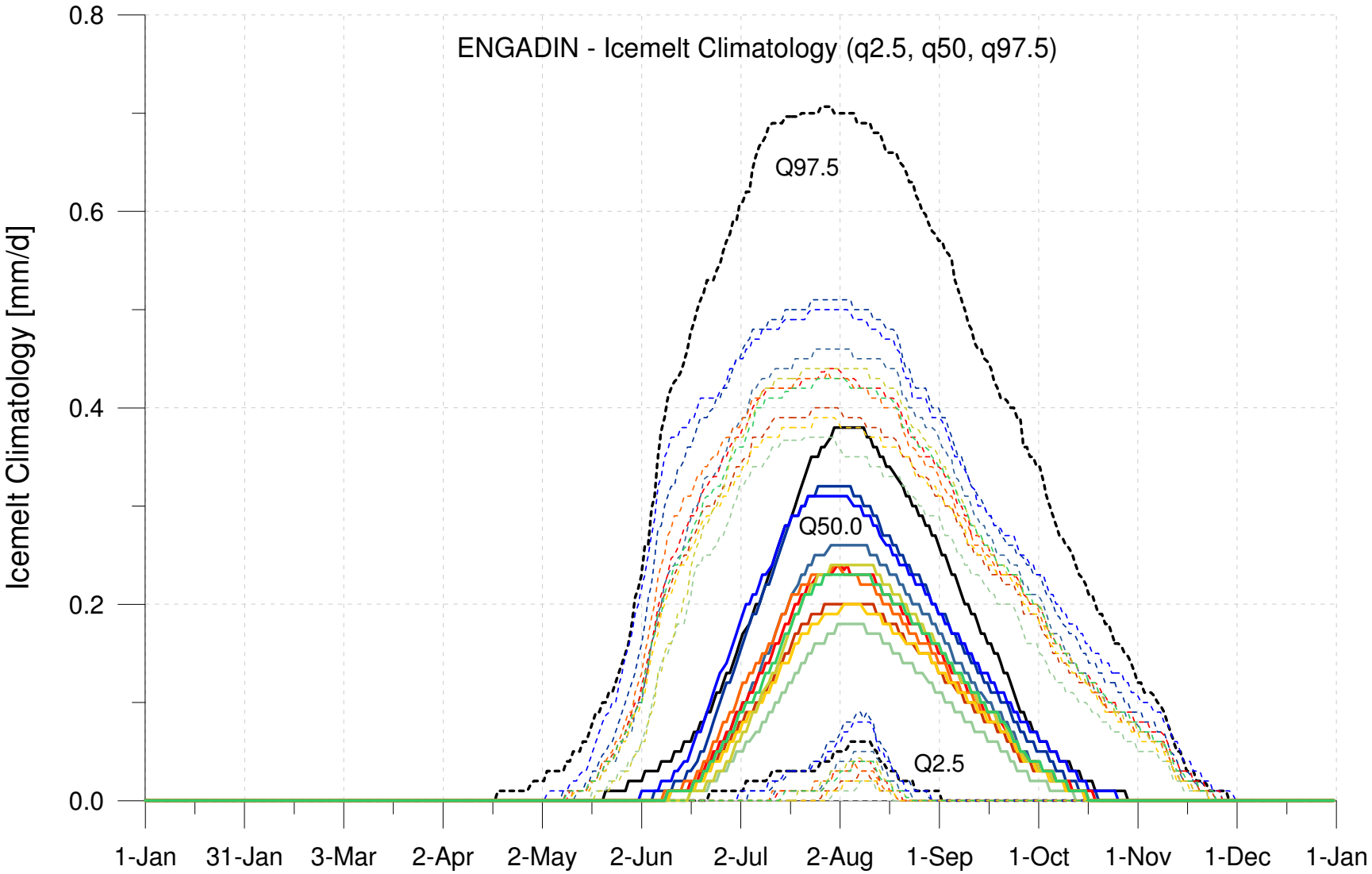
Averages and Extrems in one plot



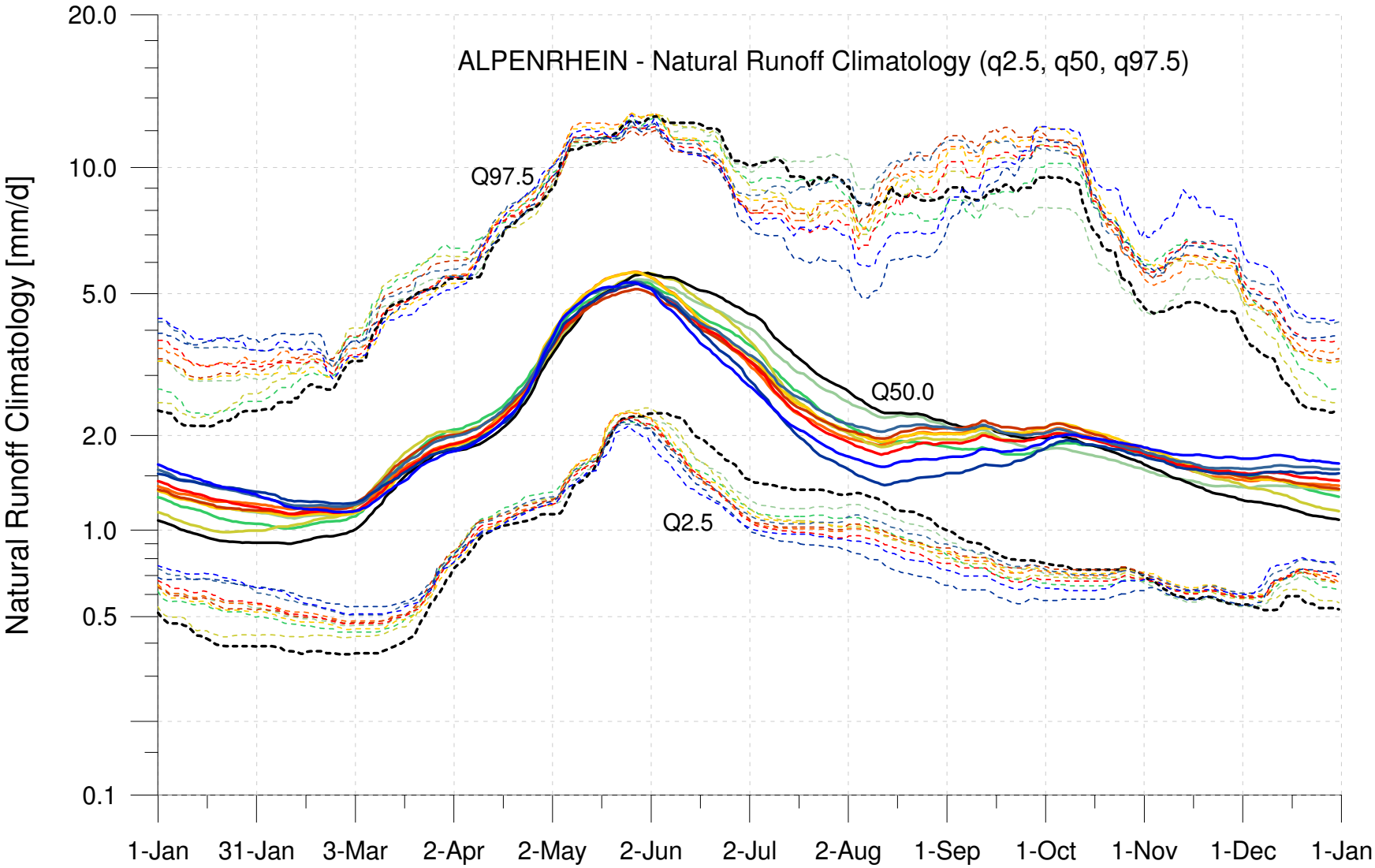
Results - Engadin: Snow Water Equivalent quantiles



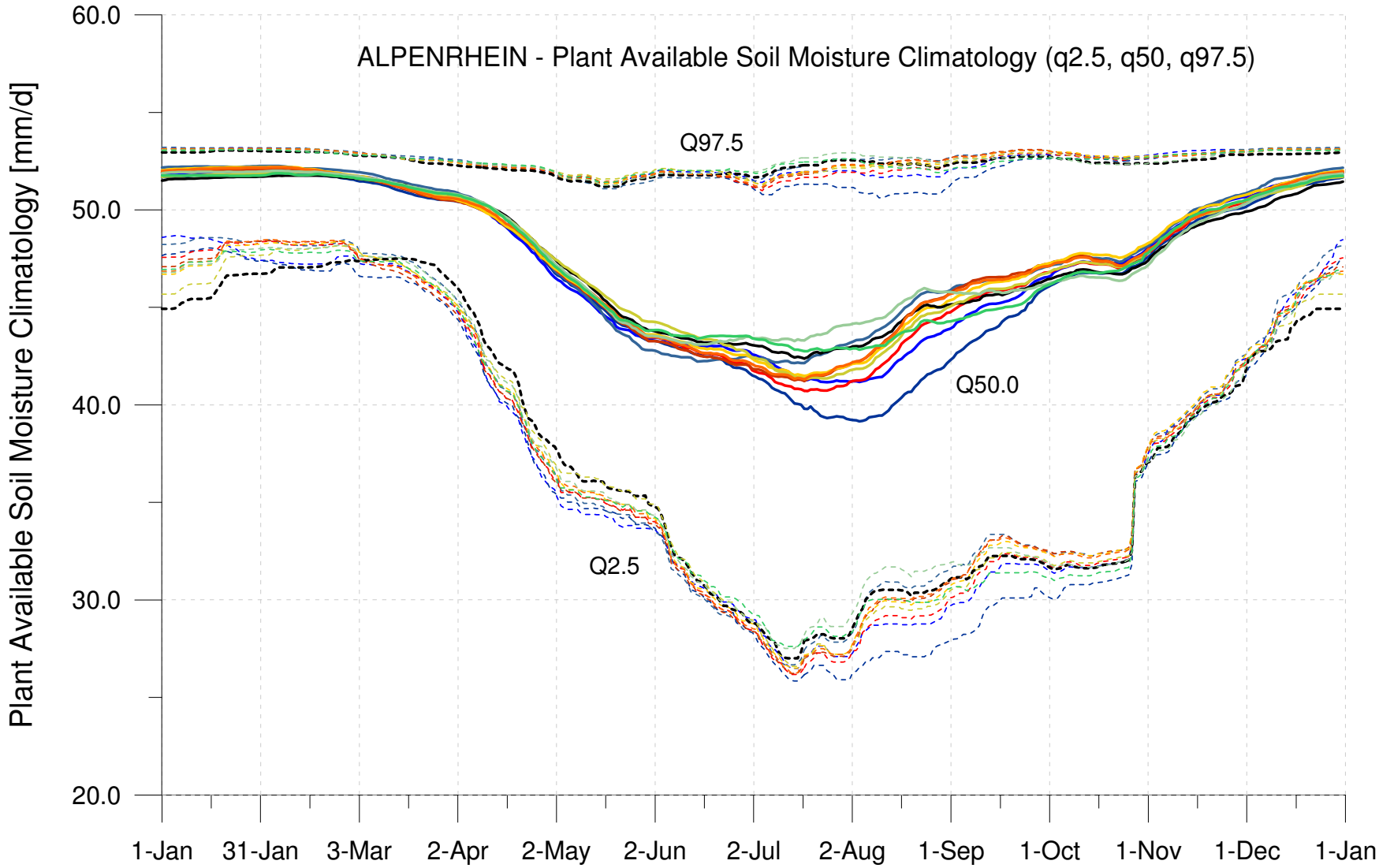
Results - Engadin: Icemelt quantiles



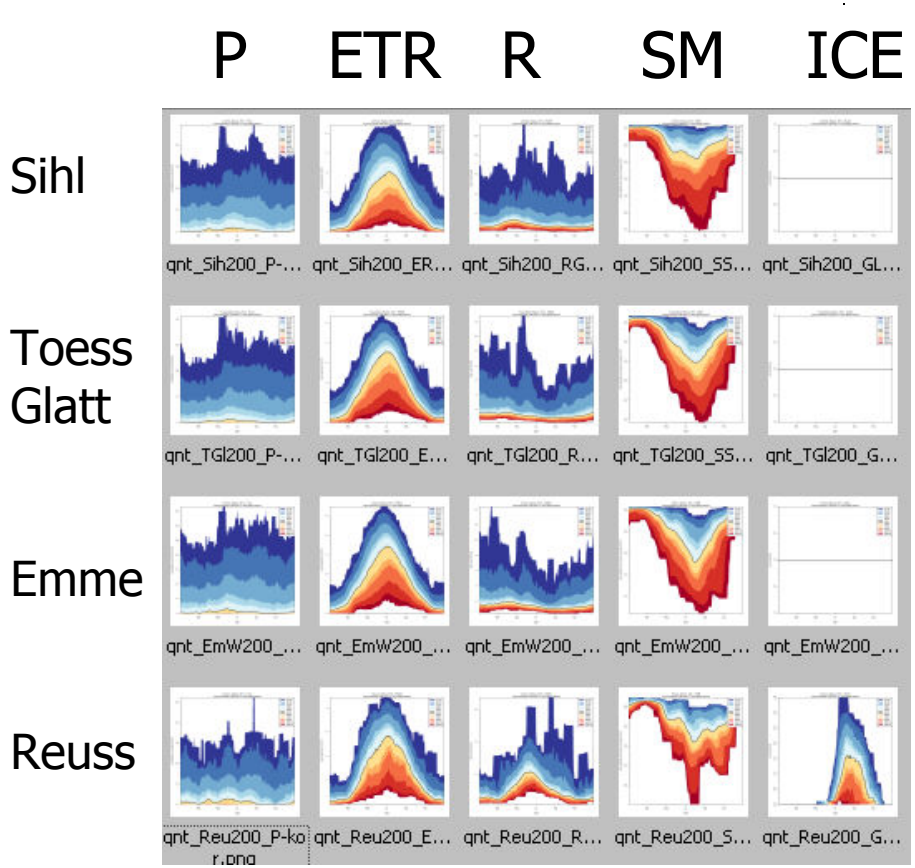
Results - Alpine Rhine (Diepolsdau): Natural runoff quantiles

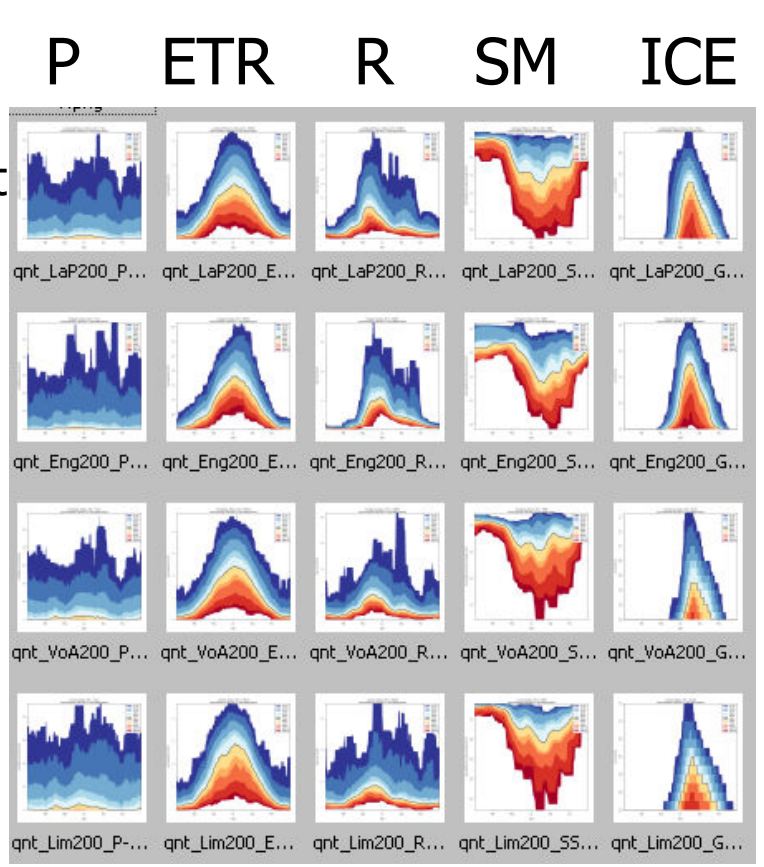


Results - Alpine Rhine (Diepolsdau): Soil moisture quantiles



Possible products: Water Resources thumbnails for every scenario and (large) river basin of Switzerland





Conclusions and further work

- Several new features implemented for new generation of hydrological scenarios for Switzerland
- New features improves conceptual deficits of previous realizations
- Novel intreface for assimilating glacier scenarios soon available
- Stable setup for the CTRL-Period 1980-2009 realized
- Consideration of impact of mayor antropogenic effects still to be completed (HADES 5.3)
- Inclusion of simple forest coverage scenarios envisaged
- First results for the period 2021-2050 to be evaluated
- Simulations for the time frame 2070-2099 possible

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