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)
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, GRD2MAT 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 visualizing 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

Spatial information
Elevation, Aspect, Landuse, Slope, Soil Properties, ...

GIS - Grids
PREVAH
HRU-Table

Interpolated meteorology
precipitation, air temperature, global radiation, water vapour pressure, sunshine duration

Sevruk (1986)
Schulla (1997)
Monteith (1975)
Wendling (1975)
Zappa et al. (2003)
Menzel (1997)
Gurtz et al. (2003)

Precipitation correction
Site adjustment of radiation and temperature
Evapotranspiration
Snowmelt / Icemelt
Interception
Soil moisture
Runoff generation

1 hour or 1 day

GIS - Grids

Calibration and Verification

(Gurtz, Zappa, Viviroli et al., 1994-2010)
New Features (1): A Gridded Version of PREVAH

Interpolated meteorology: precipitation, air temperature, global radiation, water vapour pressure, sunshine duration

Spatial information: Elevation, Aspect, Landuse, Slope, Soil Properties, ...

Sevruk (1986)
Schulla (1997)
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Precipitation correction
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Runoff generation

1 hour or 1 day

GIS - Raster


Running PREVAH
Progress [initialization] Full
[Input model data] Start

(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 km$^2$)
**New Features (2): Regionalized model parameters**
(Viviroli et al., JH, 2009 part I)

![Map of Switzerland with regionalized catchments](image)

**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.

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

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-Shift 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 major 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**

- CTRL RUN @ WSL
- ETHZ_HadCM3Q0_CLM
- HC_HadCM3Q0_HadRM3Q0
- SMHI_HadCM3Q3_RCA
- SMHI_ECHAM_RCA
- MPI_ECHAM_REMO
- KNMI_ECHAM_RACMO
- ICTP_ECHAM_REGCM
- DMI_ECHAM_HIRHAM
- SMHI_BCM_RCA
- CNRM_ARPEGE_ALADIN
Results - Engadin: Natural runoff quantiles

Averages and Extremes in one plot
Results - Engadin: Snow Water Equivalent quantiles

ENGADIN - Snow Climatology (q2.5, q50, q97.5)

Snow Climatology [mm/d]
Results - Engadin: Icemelt quantiles

ENGADIN - Icemelt Climatology (q2.5, q50, q97.5)
Results - Alpine Rhine (Diepolsdau): Natural runoff quantiles
Results - Alpine Rhine (Diepoldsau): Soil moisture quantiles

ALPENRHEIN - Plant Available Soil Moisture Climatology (q2.5, q50, q97.5)
Possible products: Water Resources thumbnails for every scenario and (large) river basin of Switzerland.

- Sihl
- Toess
- Glatt
- Emme
- Reuss
- Landquart
- Plessur
- Engadin
- Voralberg
- Limmat
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 interface 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
The Team

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ETH

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