Use of WaSiM within the Operational Flood Forecasting System of Switzerland Challenges and Current Developments

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Overview

• Hydrological forecasting at FOEN: history and challenges
• Use of WaSiM within the operational FOEN forecasting system: current and future developments
• WaSiM applications for three selected river basins in CH: Emme, Rhone and Alpenrhein
• Outlook: model requirements and possible improvements
Hydrological Forecasting at FOEN

• Until a few years ago the hydrological forecasting at FOEN was limited to the Swiss Rhine basin (focus on shipping, flood-protection, input for forecasting centres downstream).

=> No explicit legal basis to issue flood warnings!
Hydrological Forecasting at FOEN

• Change of policy after the catastrophic flood events in 2005 and 2007

Flood event in August 2005 with 6 flood fatalities (human lifes) and economic damage of more than 3 billion Swiss Francs
Flood event August 2005
Flood event August 2005

Niederschlag 48h-Summe (mm): 21. – 22. 08. 2005

Datenstand 2005-09-08

>HQ200
HQ100 - HQ200
HQ50 - HQ100
HQ20 - HQ50
HQ2 - HQ20
Development of damage 1972-2012
(taking inflation into account)
Hydrological Forecasting at FOEN

• Change of policy after the catastrophic flood events in 2005 and 2007

Start of the OWARNA project in 2008:
objective: creation of organisational and professional basis for a national warning of natural disasters

=> Improvement of communication / coordination between federal and cantonal authorities

=> Development and improvement of jointly used information tools

=> Tasks for hydrological forecasting at FOEN:
    - Improvement of the actually used forecasting tools including hydrological models
    - Extension of the forecasting area to all Swiss river catchments
Extension of the hydrological forecasting area

Hydrological Switzerland: ca. 56‘000 km²

Rhine-Basel
35‘900 km²

Doubs-Ocourt
1‘200 km²

Rhone-Chancy
10‘300 km²

Inn-Martina
1‘900 km²

Ticino-Miorina
6‘600 km²
HBV-Rhine model approach

- developed by SMHI in 2002/03
- semi-distributed setup
- 62 sub-basins
- lumped per sub-basin
- 1-h time steps

- successful integration into the FOEN flood forecasting system (FEWS) => operationally used in 2007
- problems in hydrologically challenging catchments
Hydrological Challenge – Alpine Terrain

Challenge for meteo measurements and their spatial interpolations, especially for precipitation (amounts, temporal and spatial distributions)

< 2000 m: 500 km²/station
> 2000 m: 1400 km²/station
1'330 km² glaciated areas (3.2 % of total Swiss area)
> 40 % of yearly Swiss runoff volumes are from snowmelt
Most of the major lakes are regulated

Lake regulation according to the official scheme is implemented in the models, but…
Hydrological Challenge – Hydropower

http://www.swissdams.ch

- 55 % of Swiss energy from hydroelectrical power (rest from atomic power)
- conventional hydroelectric dams (reservoirs)
- pumped-storage hydroelectric power stations
- run-of-the-river hydroelectric stations
Hydrological Challenge – Hydropower

Management of hydropower stations?
- strong daily fluctuations
- influence on local and regional water balance
- model calibration?
- forecast?

185 hydropower stations > 10 MW
Moving on to high-resolution models

HBV

PREVAH

WASIM

- HBV model approach with limited simulation accuracy, especially for hydrologically challenging catchments
- Need for integration of more powerful models with better consideration of hydrological processes
• Hydrological Forecasting at FOEN: History and Challenges
• **Use of WaSiM within the operational FOEN forecasting system - current and future developments**
• WaSiM applications for 3 selected river basins: Emme, Rhone and Alpenrhein
• Outlook: model requirements and possible improvements
Hydrological multi-model approach

Current model configuration (operational mode)
Ongoing work in 2014

Planned model upgrades within the operational forecasting system

PREVAH + RS3.0
Planned model upgrades in the next years

- Development and integration of further grid based models
- Recalibration, if necessary (new input data sets, new model approaches, after major events, …)

WaSiM Phase 1 & 2

LARSIM Phase 1 & 2
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WaSiM application for the Emme catchment

- Emme as important inflow into the major river Aare (high relevance for regulation of Bielersee)
- Emme catchment (940 km²) challenging for hydrological models (low performance of HBV appr.)
  - pronounced orography (steep and flat areas)
  - short response times on precipitation
  - poor density of meteo station network
Calibration of the upper Emme catchment

- Continuous simulation
- Groundwater model

124 km²
WaSiM application for the Rhone basin

- About 5'500 km² down to Lake Geneva
- Very pronounced orography
  => challenge for spatial interpolation of meteo data
Spatial interpolation of station-based meteo data

500 m x 500 m grid

P [mm]

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IDW-Anisotropien

Reg 2
25°, 1/0.6

Reg 1
-65°, 1/0.8
WaSiM application for the Rhone basin

- About 5'500 km$^2$ down to Lake Geneva
- Very pronounced orography
  => challenge for spatial interpolation of meteo data
- Processes of snow accumulation, snowmelt and generation of glacier runoff highly important for hydrological modelling
  => use of the dynamical glacier model
Hydrological Challenge – Glaciers

Source: CCHydro
WaSiM application for the Rhone basin

- About 5'500 km$^2$ down to Lake Geneva
- Very pronounced orography
  => challenge for spatial interpolation of meteo data
- Processes of snow accumulation, snow melt and generation of glacier runoff highly important for hydrological modelling
  => use of the dynamical glacier model
- Natural runoff regime strongly influenced by the management of hydropower stations
  => implementation of new routing features (extended rules for abstractions and reservoir management)
  => 15 reservoirs configured in WaSiM and more numerous abstractions
  => obs. data about reservoir levels or abstraction volumes not available
[Stauseen Vieuz Emosson und Emosson; Bild: Alpig]
Reservoirs within the Rhone basin

KW-Komplex Grande Dixence
400 km² div. EZG
35 Gletscher
75 Fassungen
100 km Stollen
4 Pumpstationen
400 Mio. m³ Speicher

[Staumauer Grande Dixence; Eikd; zvg]
Defined reservoir rules in WaSiM

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Regulation scheme used for Grande Dixence Res.

- Max. volume = 401 mio. cbm
- Outflow = 130 cbm/s
- Dates:
  - 31.12. - 09.03.; 31.03. - 20.12.
  - 15.11. - 30.05.
  - 31.05. - 14.11.

- Flow rates:
  - 65 cbm/s (Mo - Fr; 07 - 19)
  - 45 cbm/s (Mo - Fr; 07 - 19)
  - 20 cbm/s (Sa/So; 07 - 19)
  - 15 cbm/s (Sa/So; 07 - 19)
Configured subbasins in the Rhone setup

196 subbasins
(because of configuring glaciers, reservoirs, abstractions, routing elements, etc.)
Calibration results for the Rhone basin

Rhone – Port du Scex (2005)
Calibration results for the Rhone basin

Rhone – Port du Scex
(Nov – Dec 2005)
WaSiM application for the Alpenrhein basin

• About 6‘100 km$^2$ down to Lake Constance
• pronounced orography
• Natural runoff regime strongly influenced by hydropower activities
• Processes of snow accumulation, snow melt and generation of glacier runoff important for runoff and water balance modelling
• Spatial interpolation of meteo variables challenging
• Target area located within the overlapping zone of four countries (CH, A, FL, I) => challenge of data preparation (homogenisation)
Configured reservoirs in WaSiM-Alpenrhein
Calibration results for WaSiM-Alpenrhein
• Hydrological Forecasting at FOEN: History and Challenges
• Use of WaSiM within the operational FOEN forecasting system: current and future developments
• WaSiM applications for 3 selected river basins: Emme, Rhone and Alpenrhein
• **Outlook: model requirements and possible improvements**
Outlook: model requirements with respect to hydrological forecasting

• Optimal use of the available data basis
  - maps of landuse, soil properties, hydrogeology, etc.
  - meteorological data
    => different station networks with different data quality and availability (optimal selection of stations)
    => different grid products (NWP models, radar precipitation, correction factors, e.g. for adjustment of temperature)
  - hydrological data:
    => different station networks (more control points for model calibration)
Outlook: model requirements with respect to hydrological forecasting

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• Optimal use of lakes (unregulated and regulated)

• Optimal use of channel profiles (geometries)

• Optimal use of glacier data (glacier dynamics)
Swiss Glacier monitoring network

About 120 observed glaciers in the Swiss Alps (length variations, mass balances)
Model validation by measured glacier variations

Glacier length variations in the year 2011

- ▲ advancing
- ▲ retreating
- ▲ stationary

http://glaciology.ethz.ch/swiss-glaciers/
Consideration of glacier decline

...could be important for continuous modelling

Change of albedo

New lakes

Sub-glacial melt

Debris covering
Outlook: model requirements with respect to runoff forecasting

- optimal use of reservoir and abstraction data from hydropower companies
  - possibility of data assimilation (if data available)
Outlook: model requirements with respect to runoff forecasting

- optimal use of reservoir and abstraction data from hydropower companies
  - possibility of data assimilation (if data available)

- optimal simulation of snow cover dynamics incl. snowmelt
  - new or extended approaches (e.g. integration of lateral snow transport)
  - possibility of data assimilation (gridded SWE maps available)

=> challenge: easy to handle and operationally stable
Thanks for your attention!

Questions ?