Schweizerische Eidgenossenschaft
Confédération suisse
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Eidgenössisches Departement für
Umwelt, Verkehr, Energie und Kommunikation UVEK

Bundesamt für Umwelt BAFU
Hydrologie – Hydrologische Vorhersagen

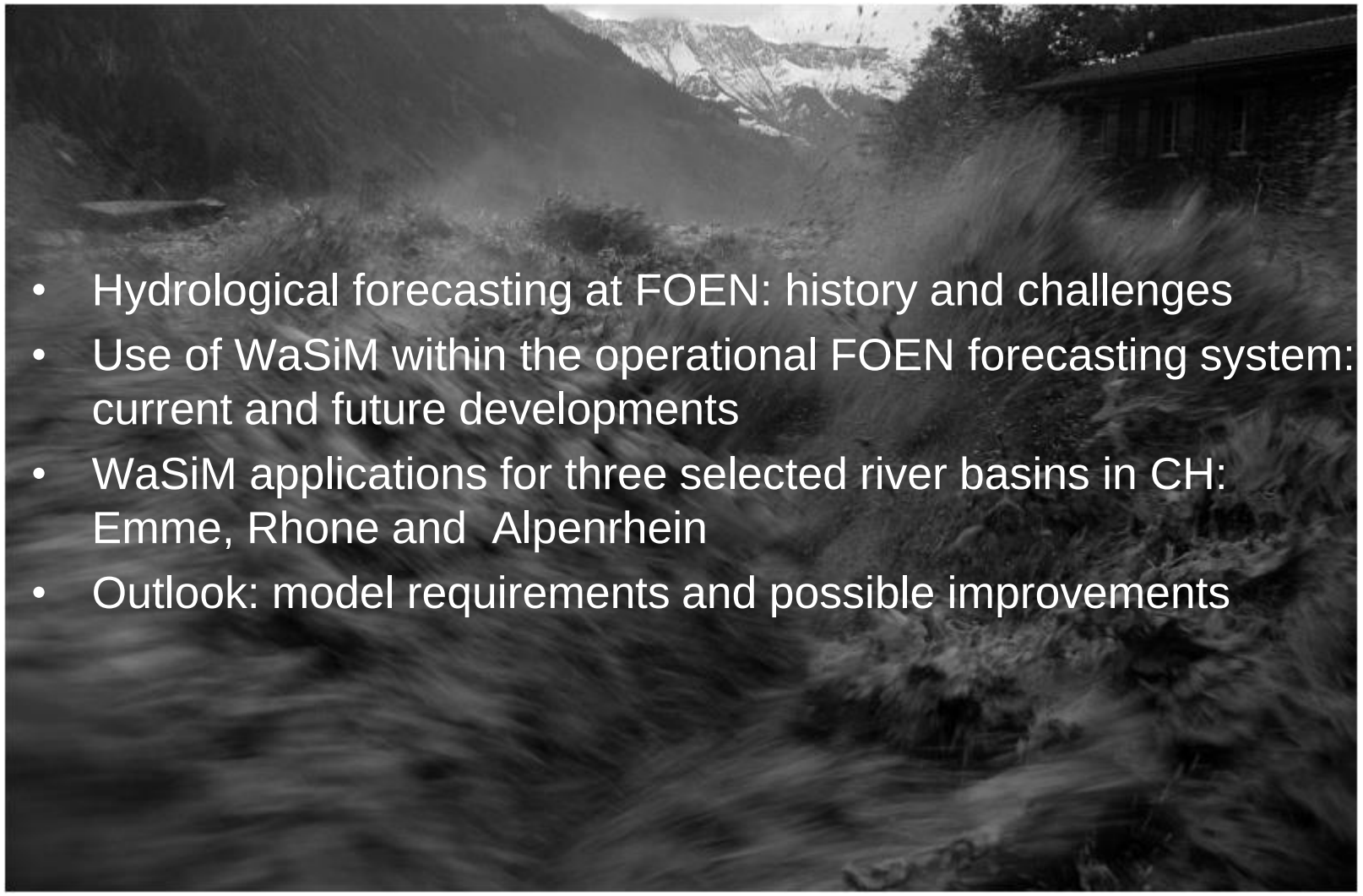
Use of WaSiM within the Operational Flood Forecasting System of Switzerland

Challenges and Current Developments

Karsten Jasper

Federal Office for the Environment of Switzerland FOEN

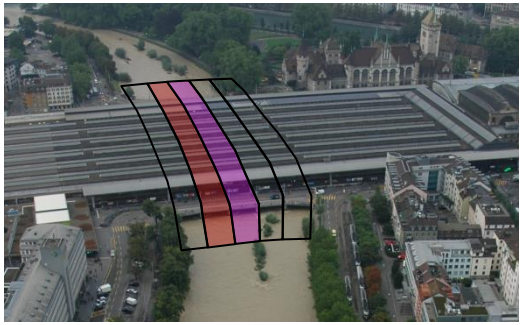
Overview

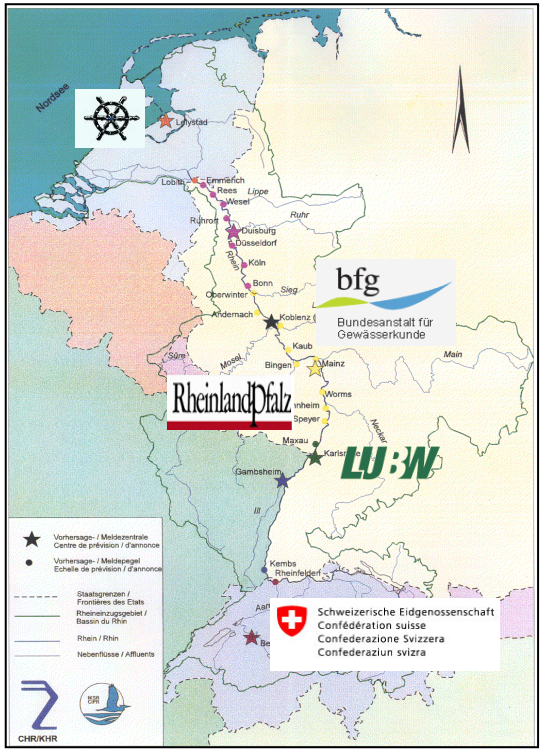


- Hydrological forecasting at FOEN: history and challenges
- Use of WaSiM within the operational FOEN forecasting system: current and future developments
- WaSiM applications for three selected river basins in CH: Emme, Rhone and Alpenrhein
- Outlook: model requirements and possible improvements

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!





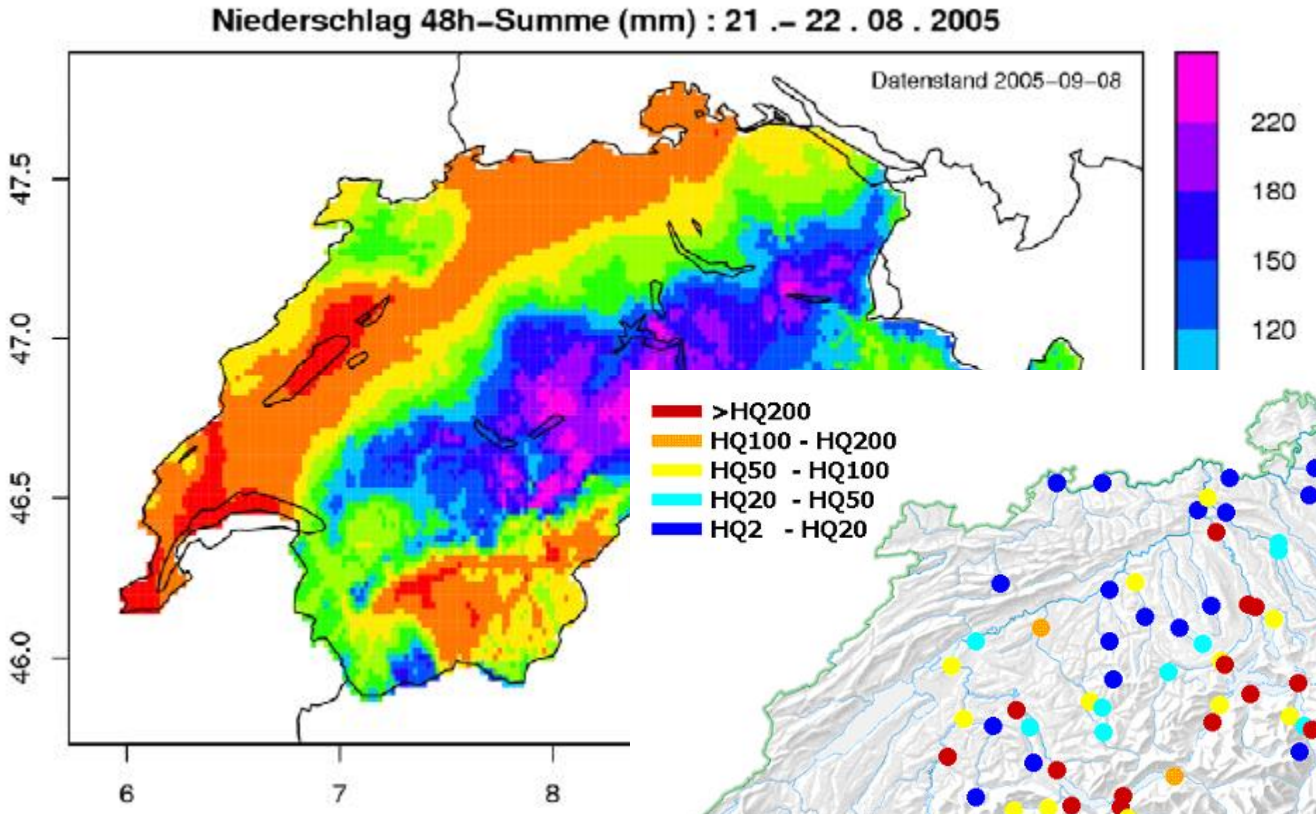
Hydrological Forecasting at FOEN

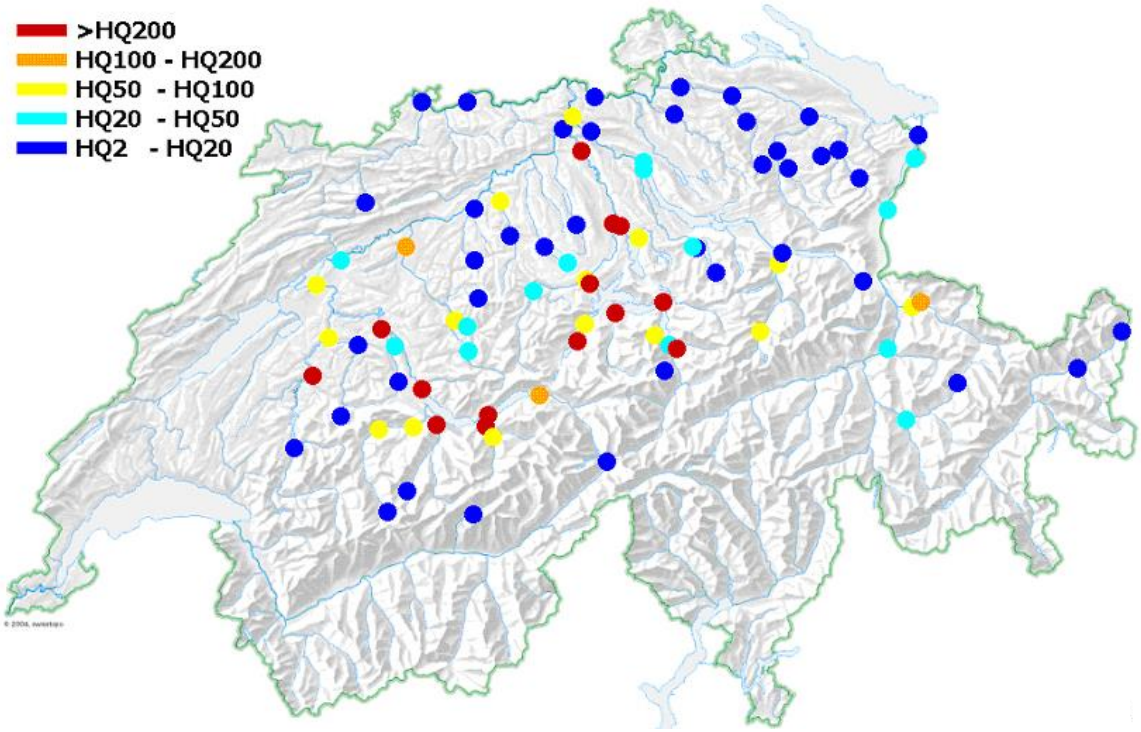
- Change of policy after the catastrophic flood events in 2005 and 2007

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

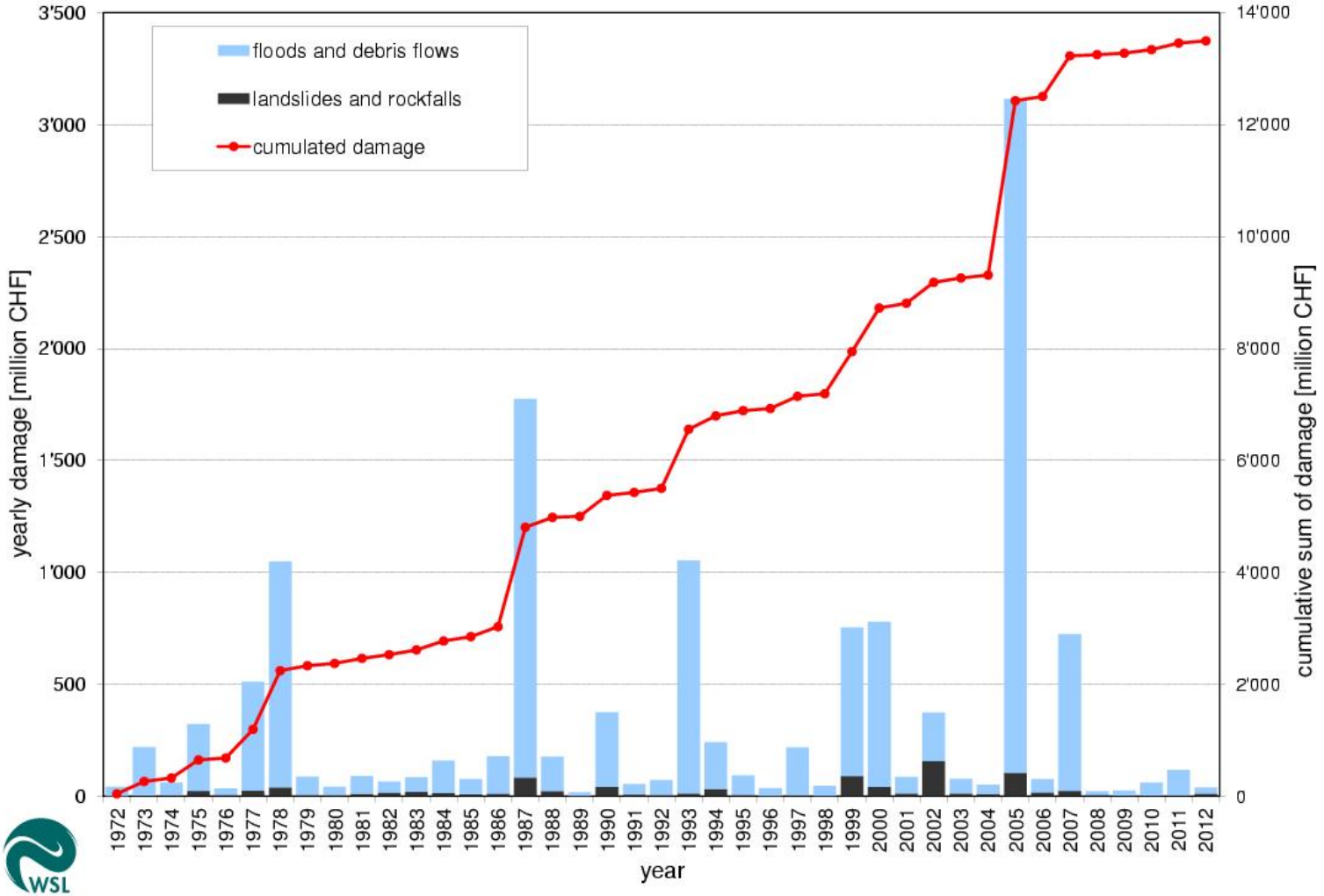
Flood event August 2005

Flood event August 2005





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

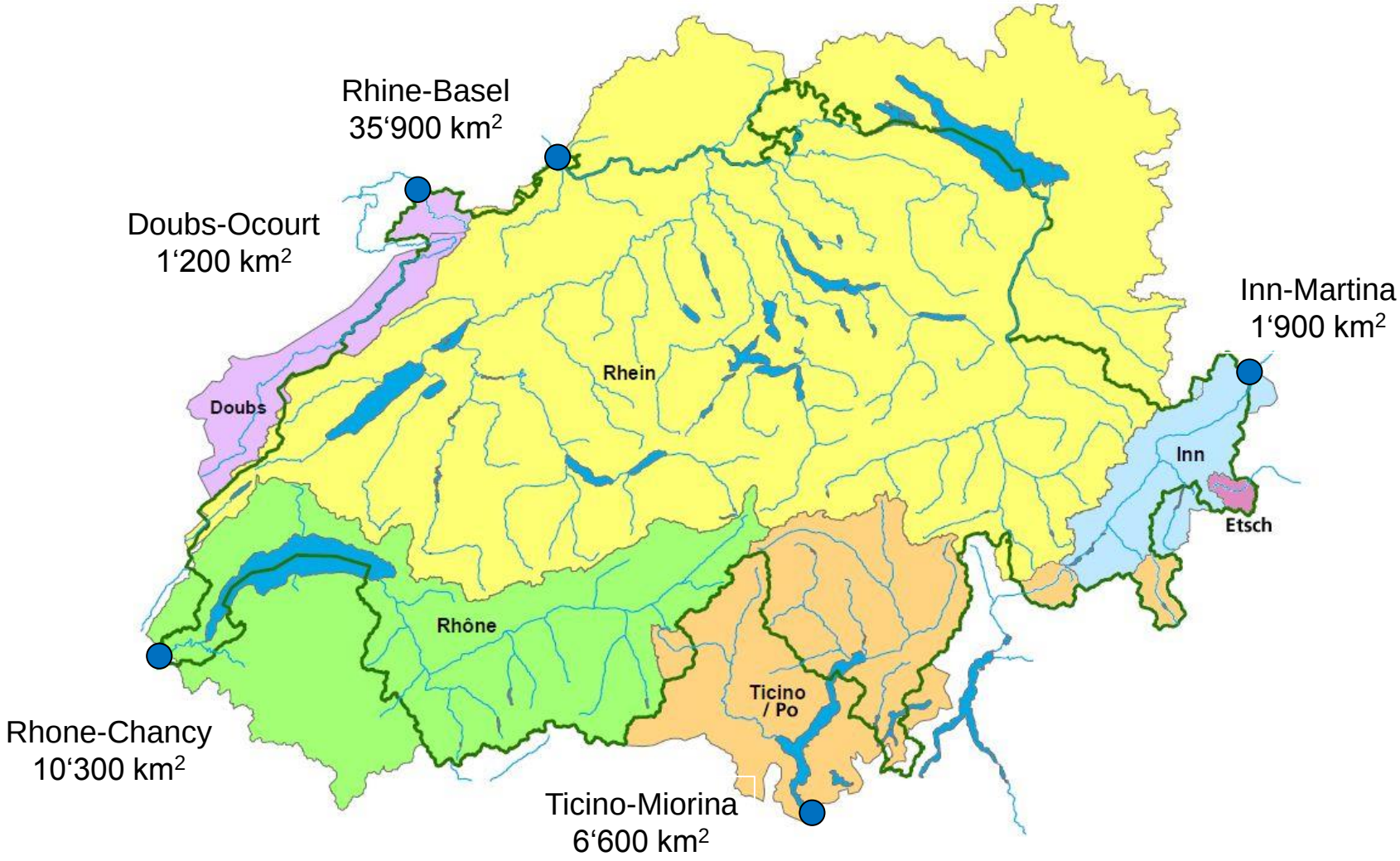
  => Improvement of communication / coordination between federal and cantonal authorities

  => 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

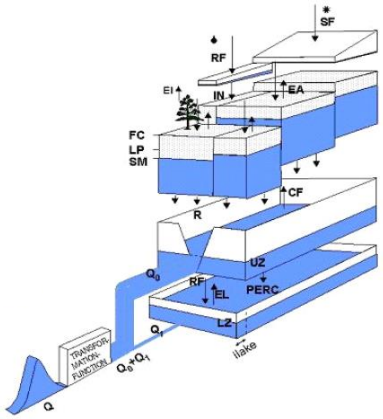
Extension of the hydrological forecasting area

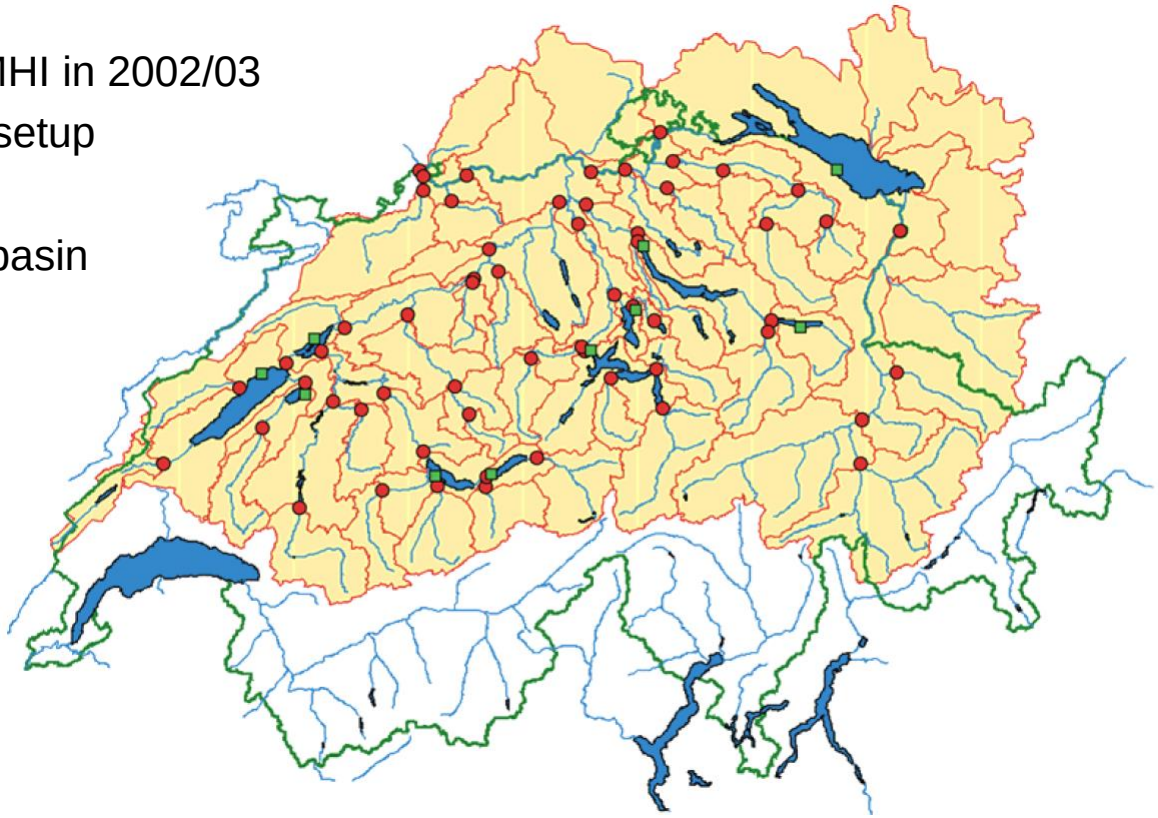
Hydrological Switzerland: ca. 56‘000 km^2



HBV-Rhine model approach

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

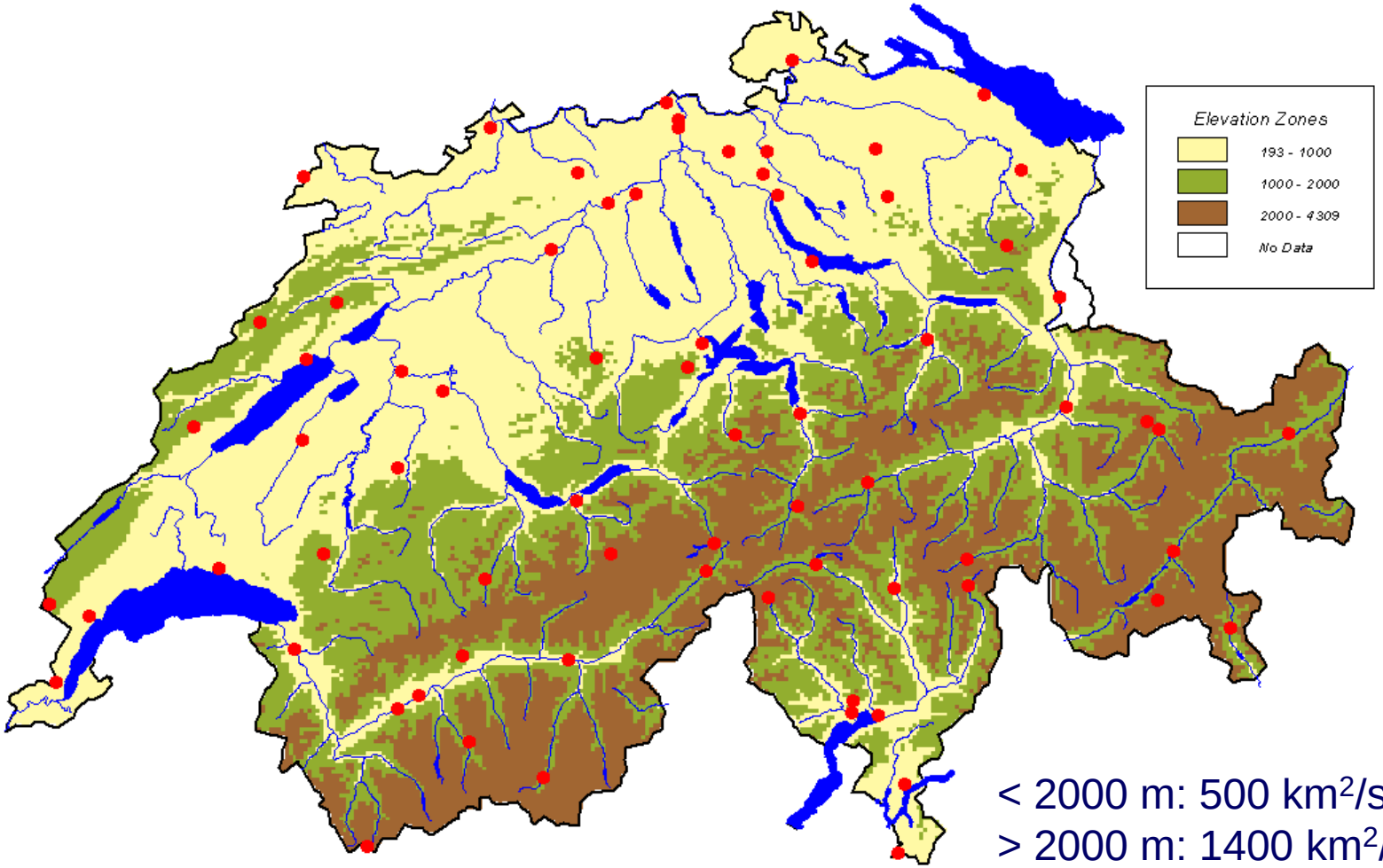




- successful integration into the FOEN flood forecasting system (FEWS)
  => operationally used in 2007
- problems in hydrologically challenging catchments

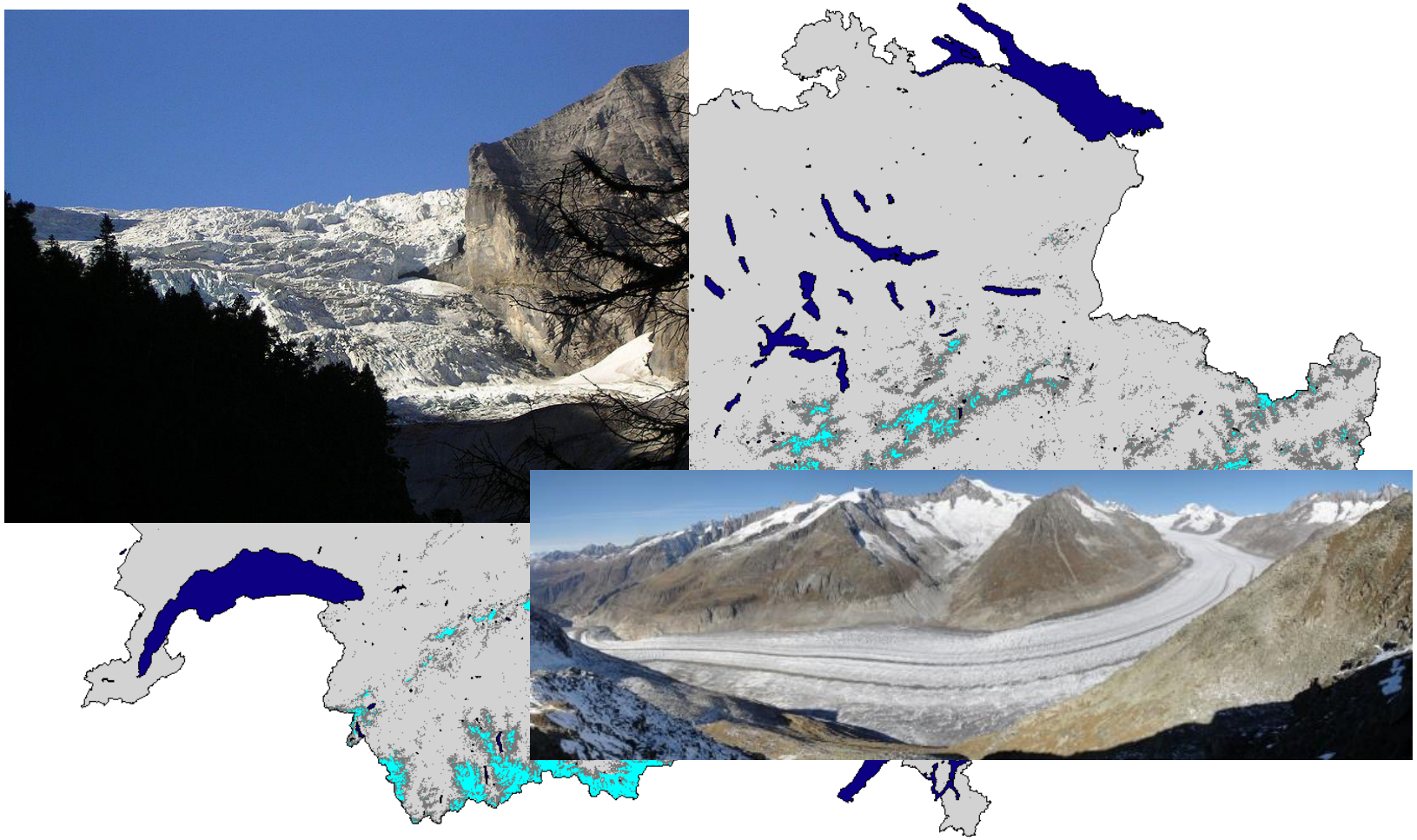
Hydrological Challenge – Alpine Terrain

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



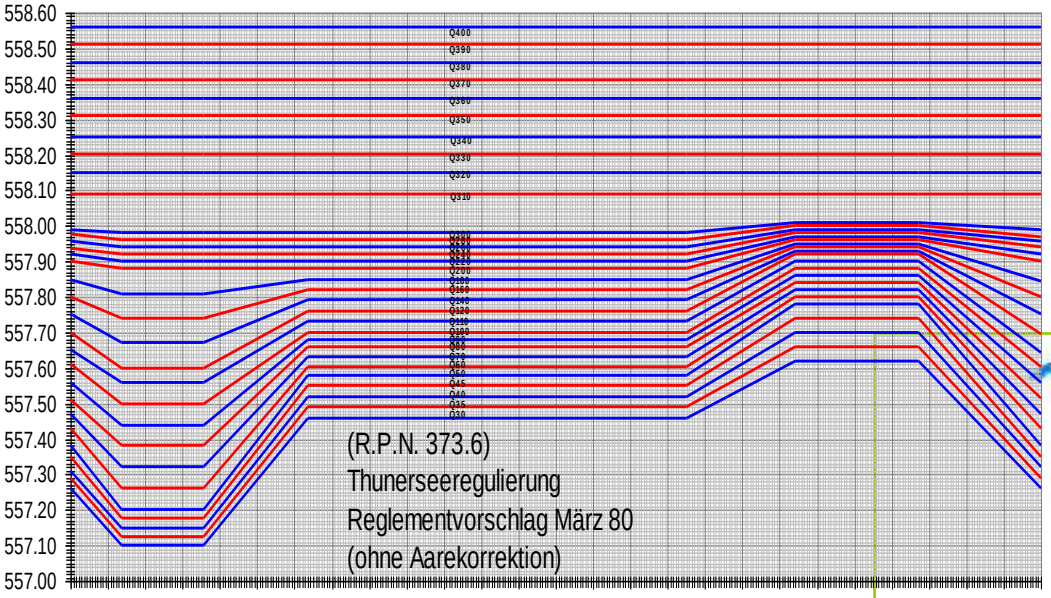
< 2000 m: 500 km^2/station
> 2000 m: 1400 km^2/station

Hydrological Challenge – Snow and Glaciers

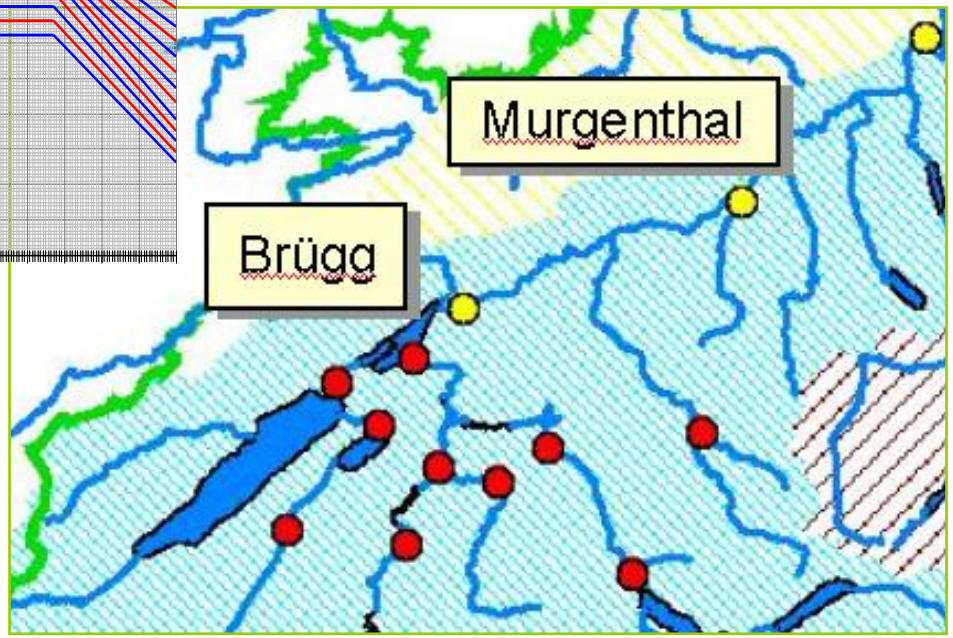


1‘330 km^2 glaciated areas (3.2 % of total Swiss area)
> 40 % of yearly Swiss runoff volumes are from snowmelt

Hydrological Challenge – Lake Regulation



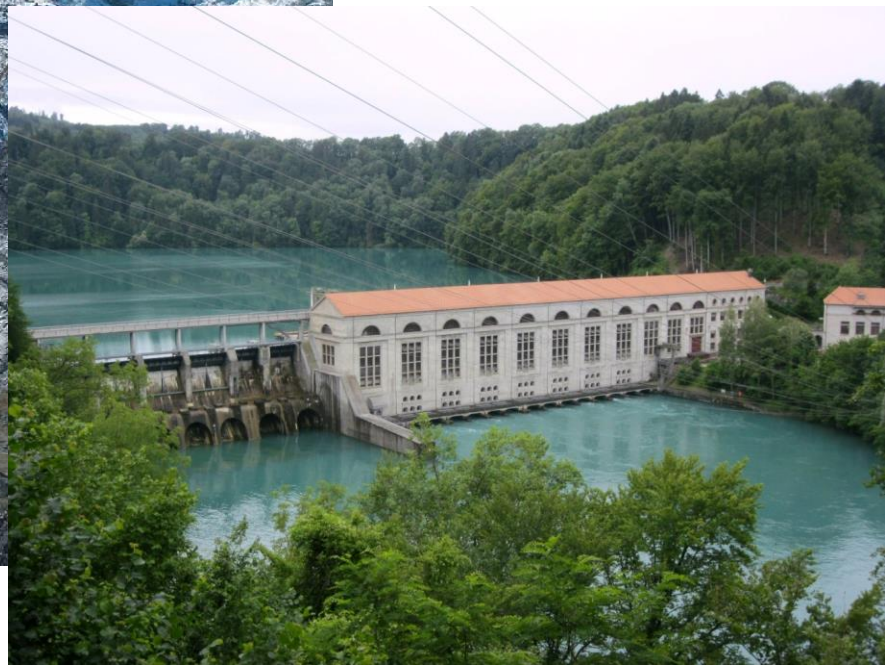
Most of the major lakes are regulated



Lake regulation according to the official scheme is implemented in the models, but…

Hydrological Challenge – Hydropower

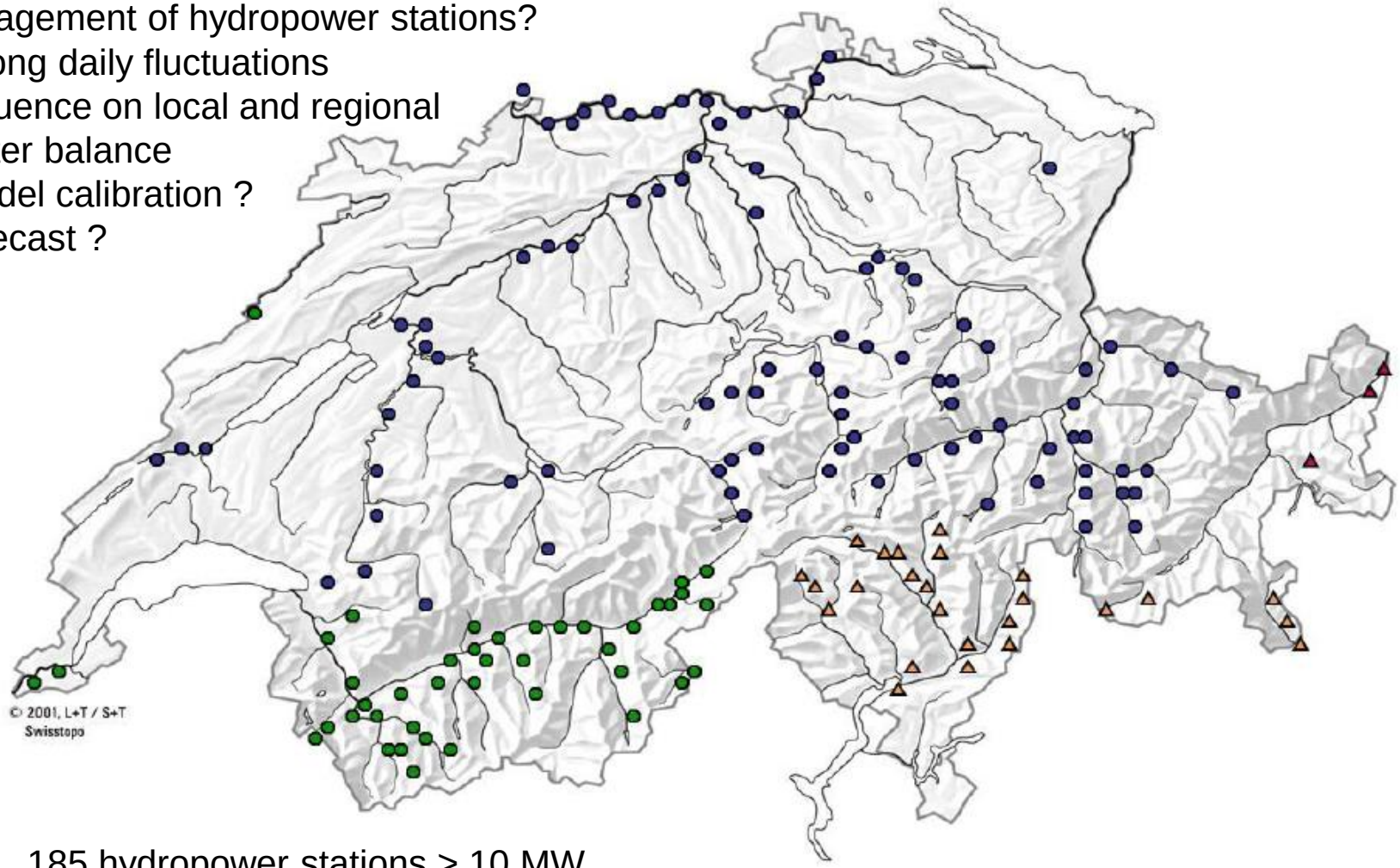
http://www.swissdams.ch



- 55 % of Swiss energy from hydroelectrical power (rest from atomic power)
- convential hydroelectric dams (reservoirs)
- pumped-storage hydroelectric power stations
- run-of-the-river hydroelectric stations

Hydrological Challenge – Hydropower

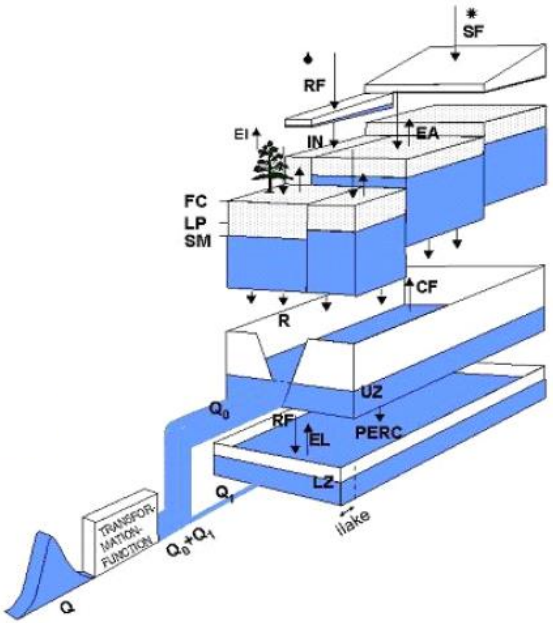
Management of hydropower stations?
- strong daily fluctuations
- influence on local and regional water balance
- model calibration ?
- forecast ?

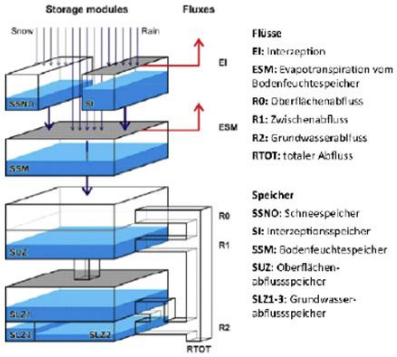


185 hydropower stations > 10 MW

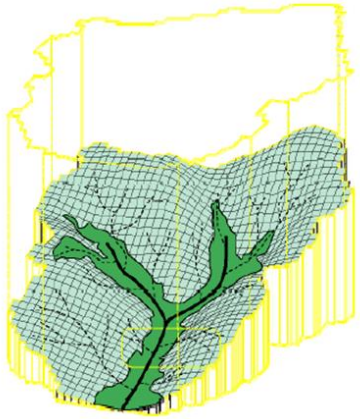
Moving on to high-resolution models

HBV



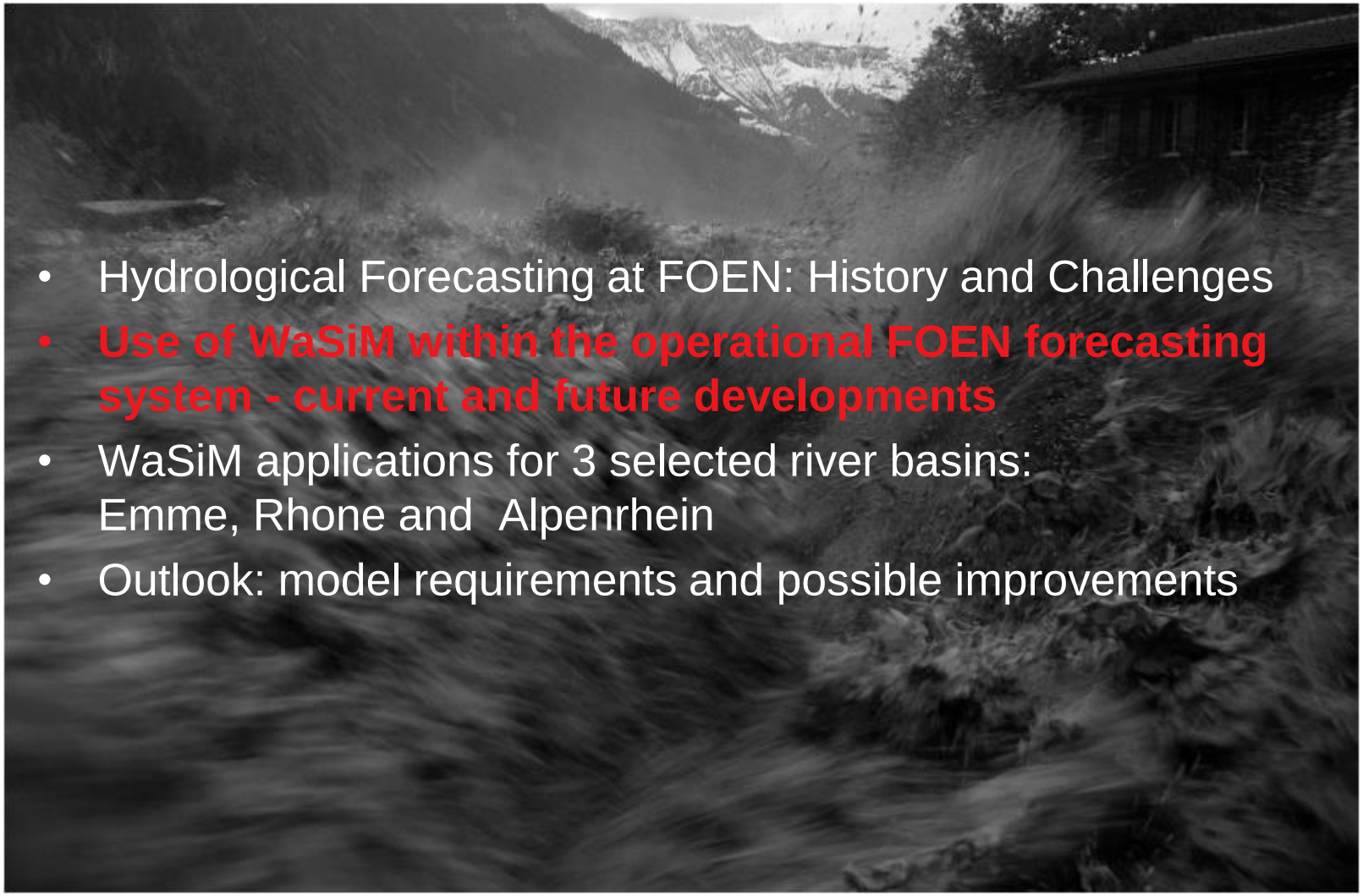


PREVAH



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



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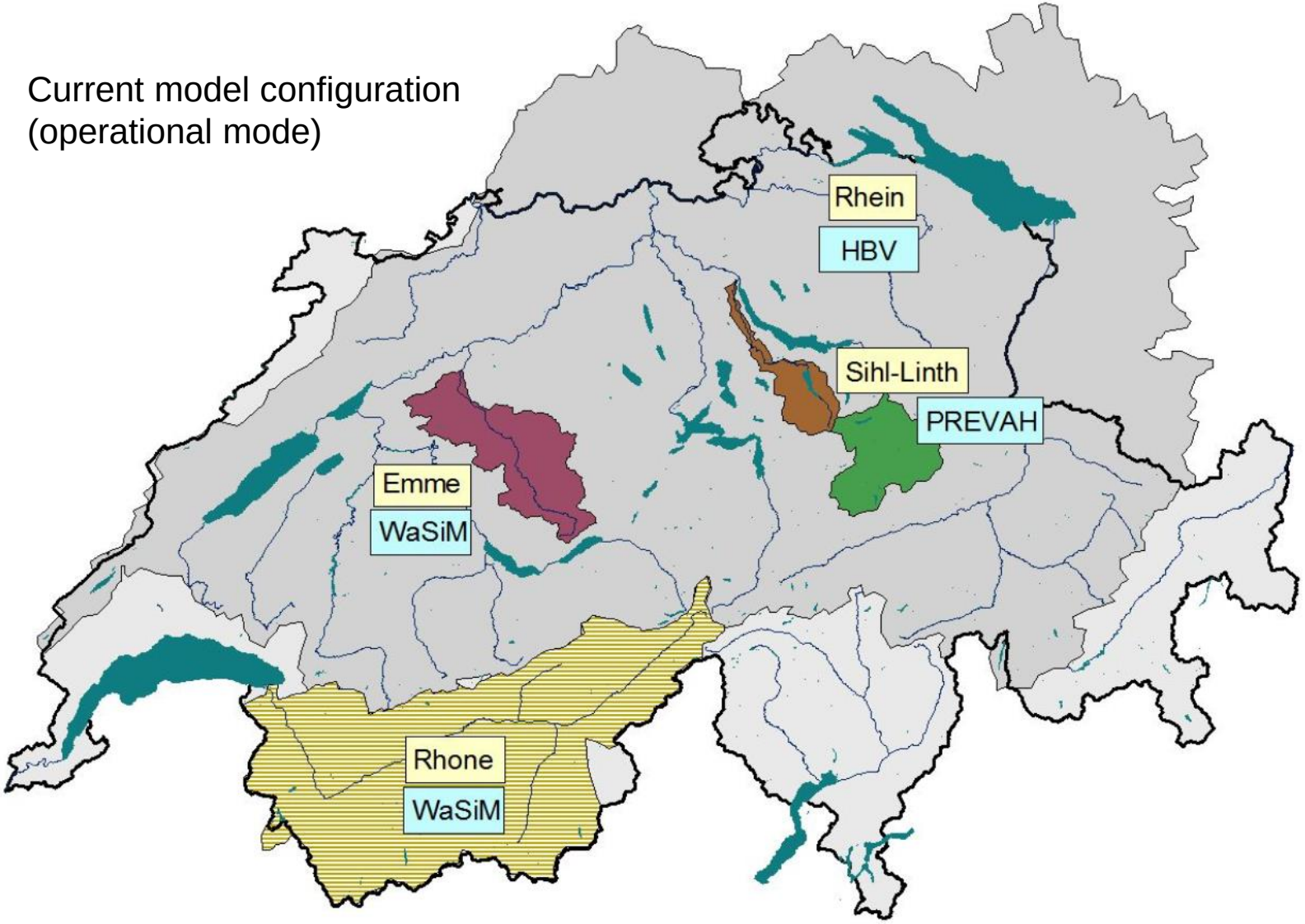
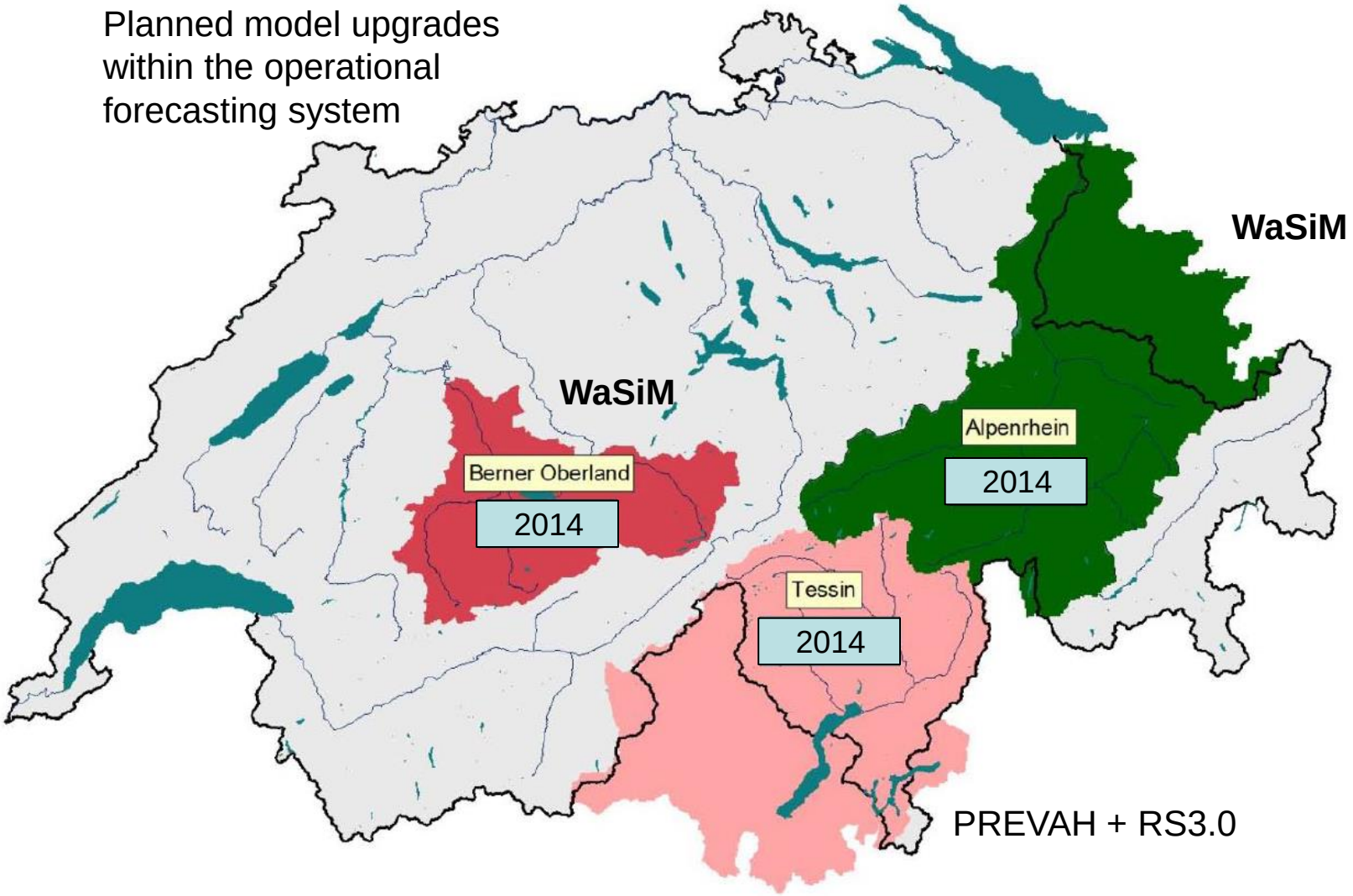
Hydrological multi-model approach

Current model configuration
(operational mode)



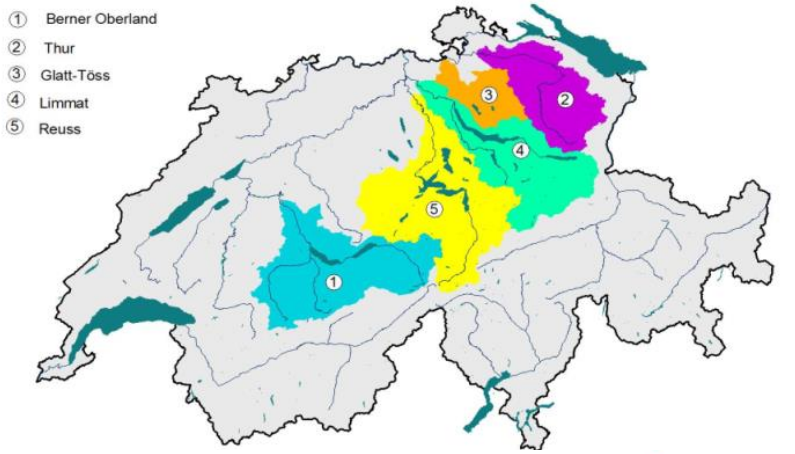
Ongoing work in 2014

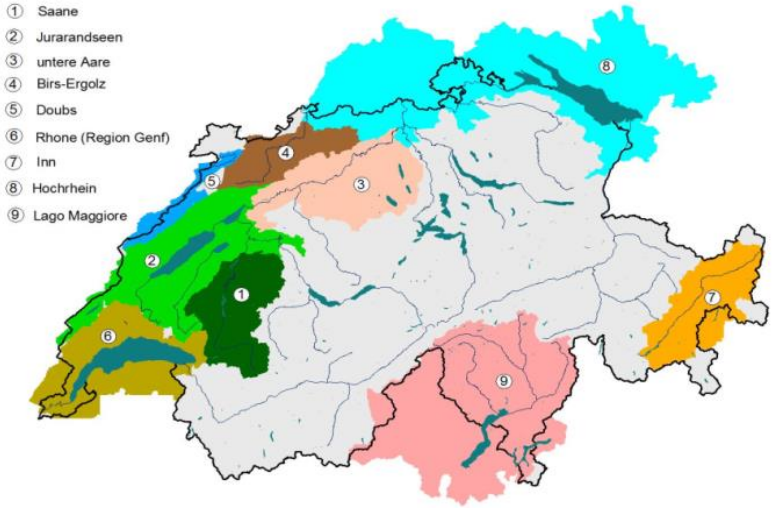
Planned model upgrades within the operational forecasting system



Planned model upgrades in the next years

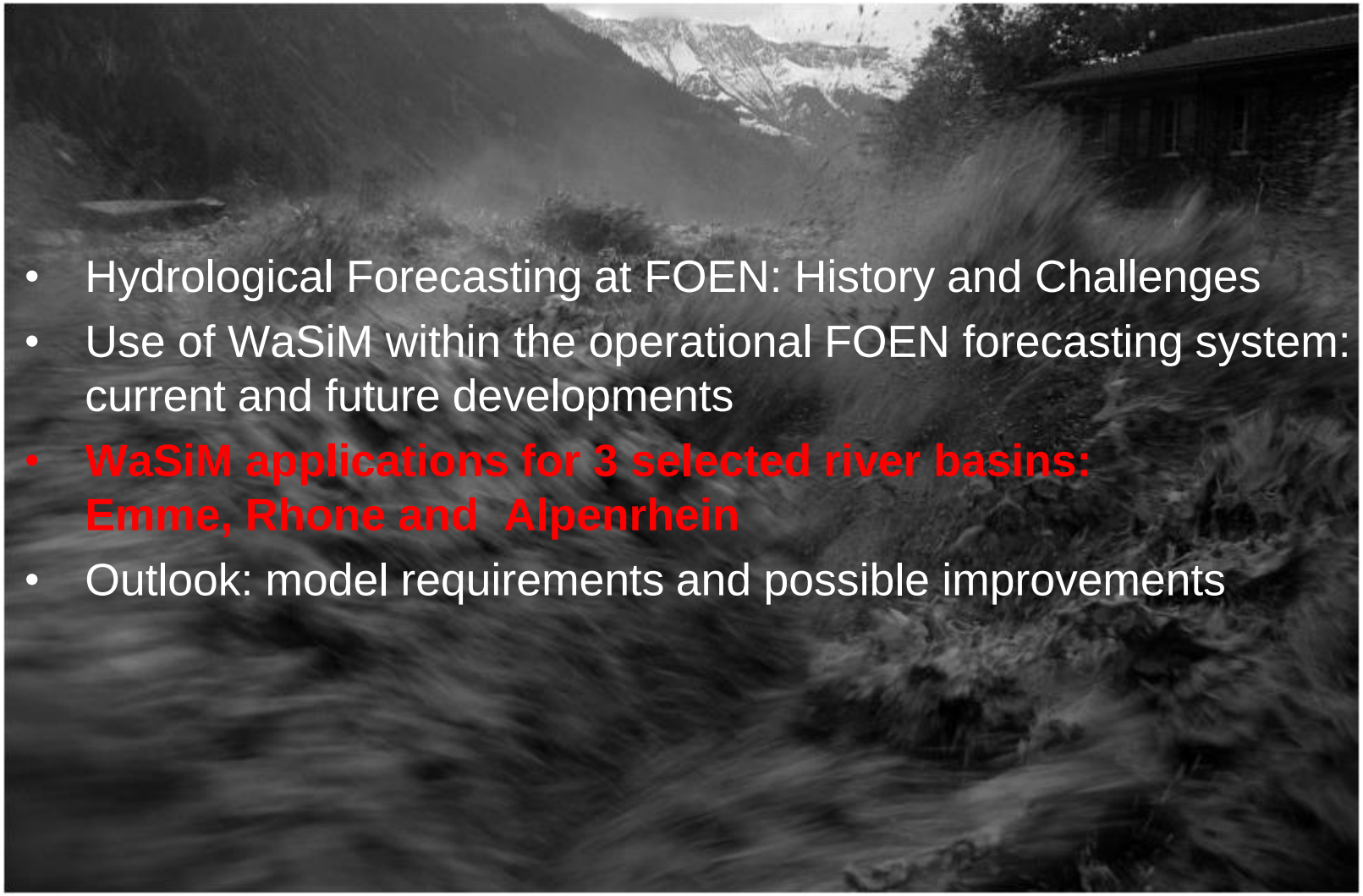
WaSiM Phase 1 & 2





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

LARSIM Phase 1 & 2



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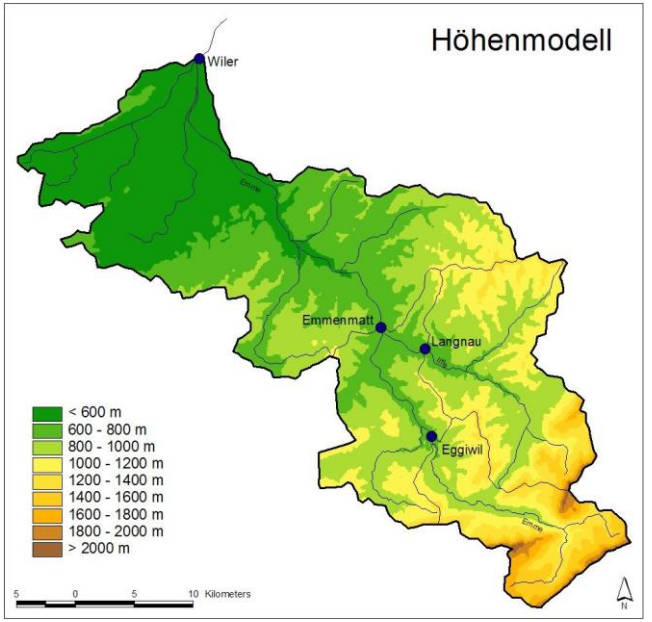
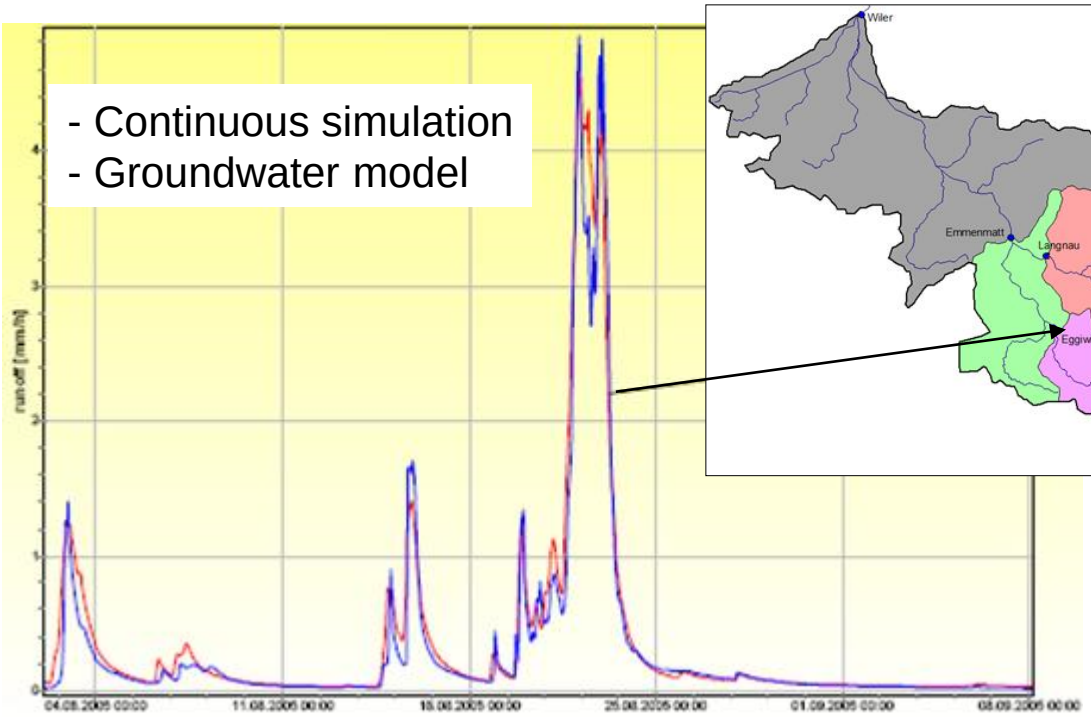
WaSiM application for the Emme catchment

- Emme as important inflow into the major river Aare (high relevance for regulation of Bielersee)
- Emme catchment (940 km^2) 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

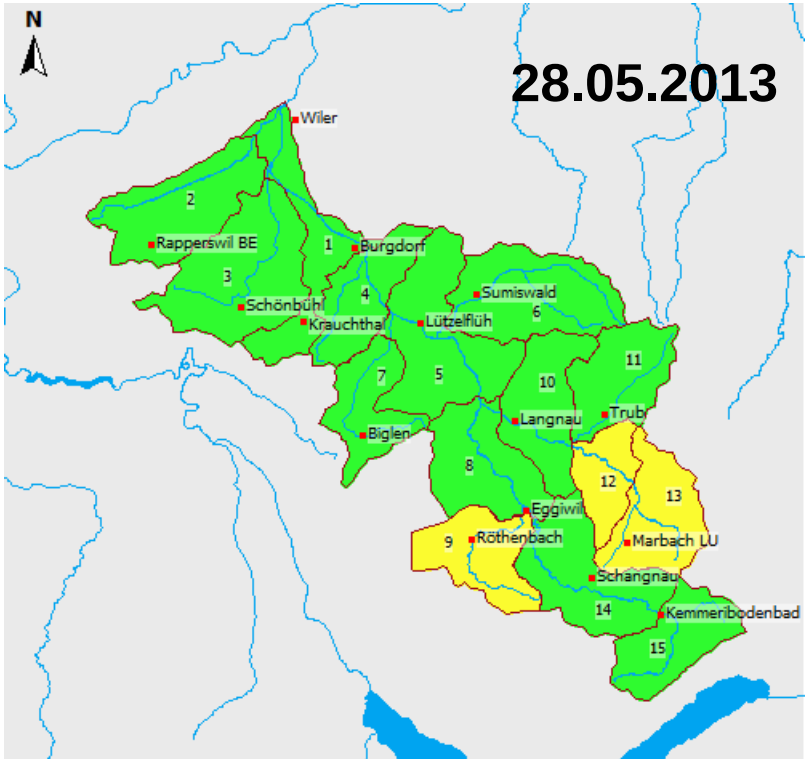


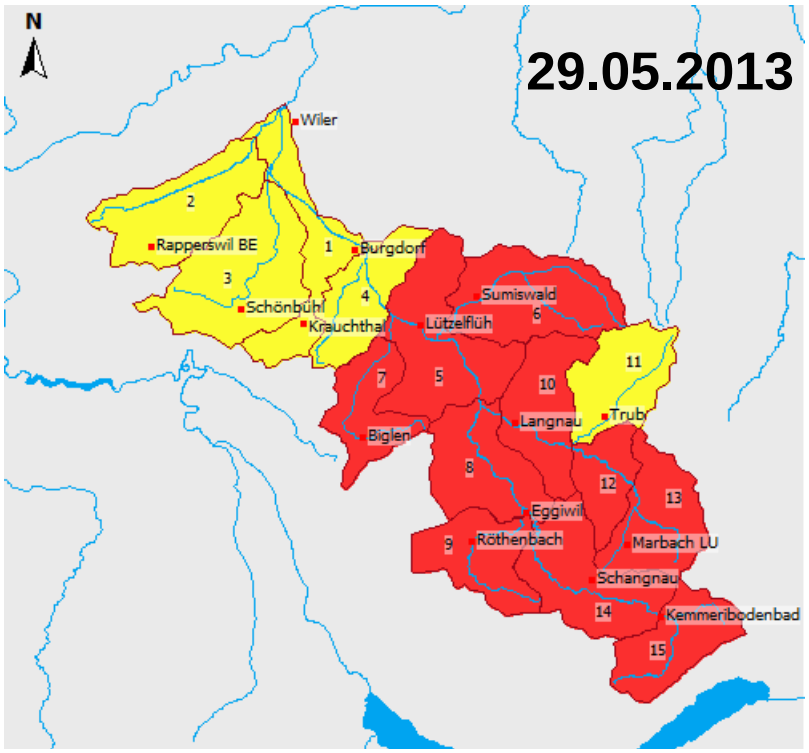
Calibration of the upper Emme catchment

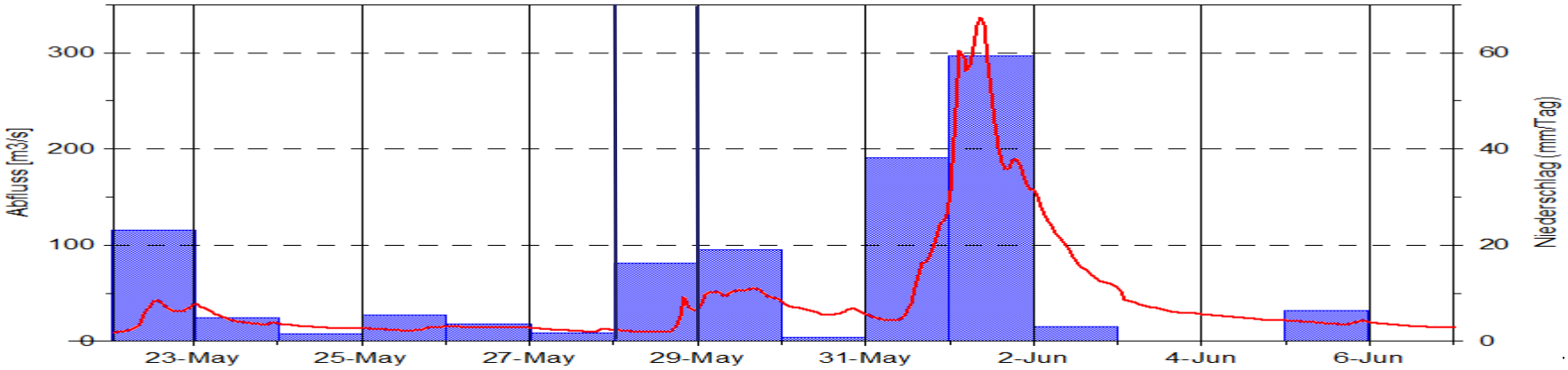


124 km^2

Runoff potential map (Emme catchment)



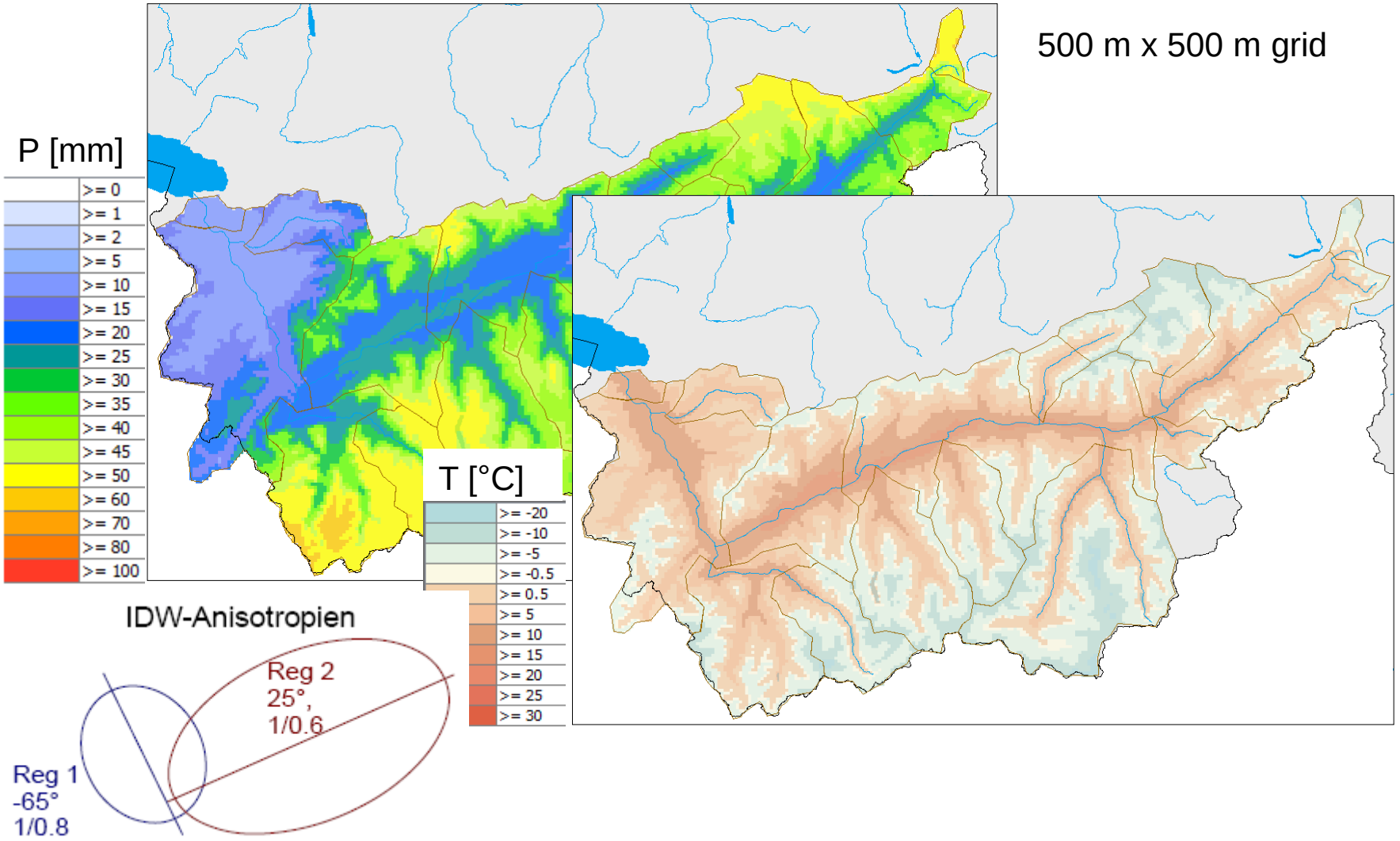




WaSiM application for the Rhone basin

- About 5‘500 km^2 down to Lake Geneva
- Very pronounced orography
  => challenge for spatial interpolation of meteo data

Spatial interpolation of station-based meteo data



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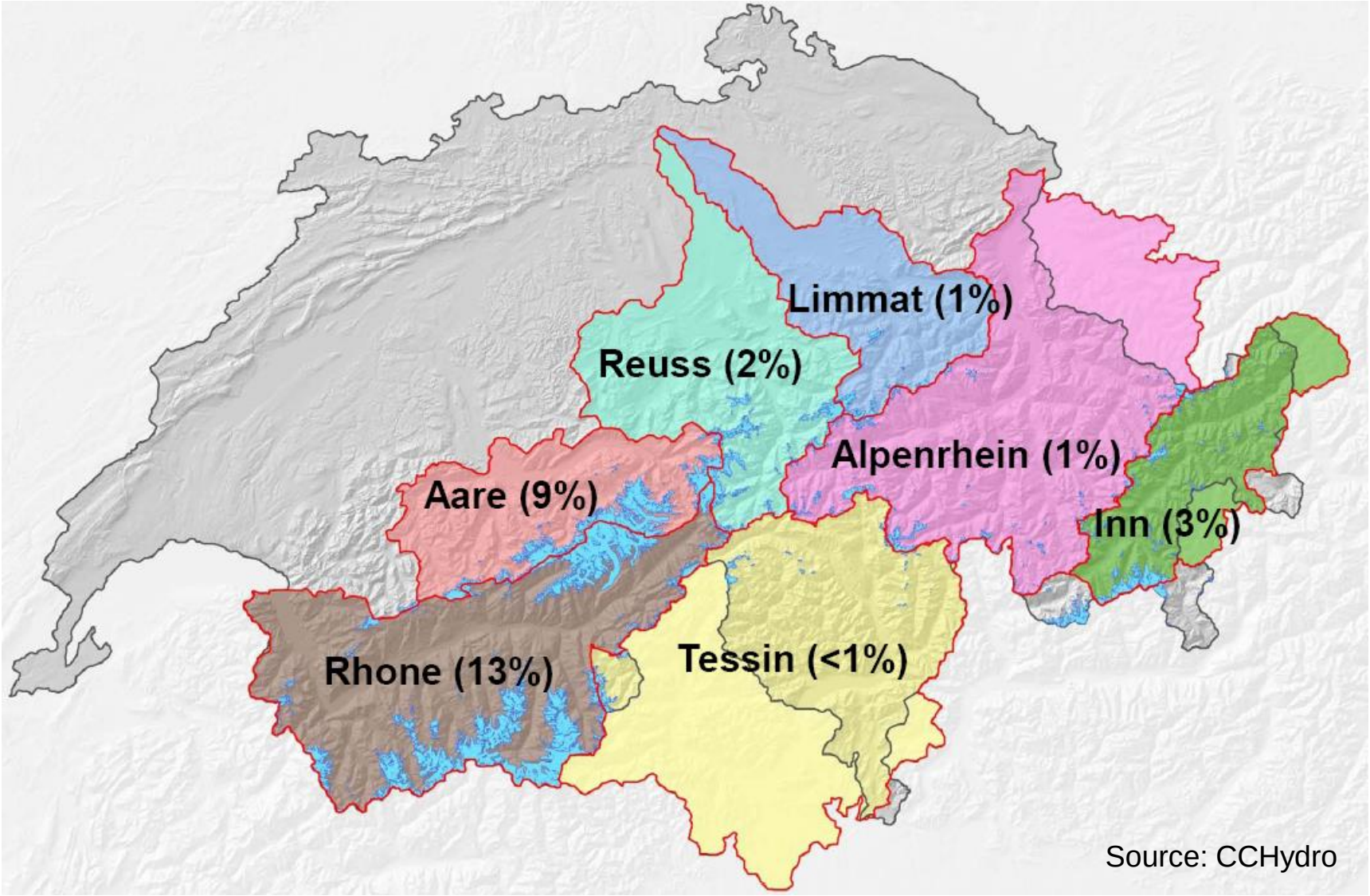
- Very pronounced orography
  => challenge for spatial interpolation of meteo data
- Processes of snow accumulation, snowmelt and generation of glacier runoff highly important for hydrological modelling
  => use of the dynamical glacier model

Hydrological Challenge – Glaciers

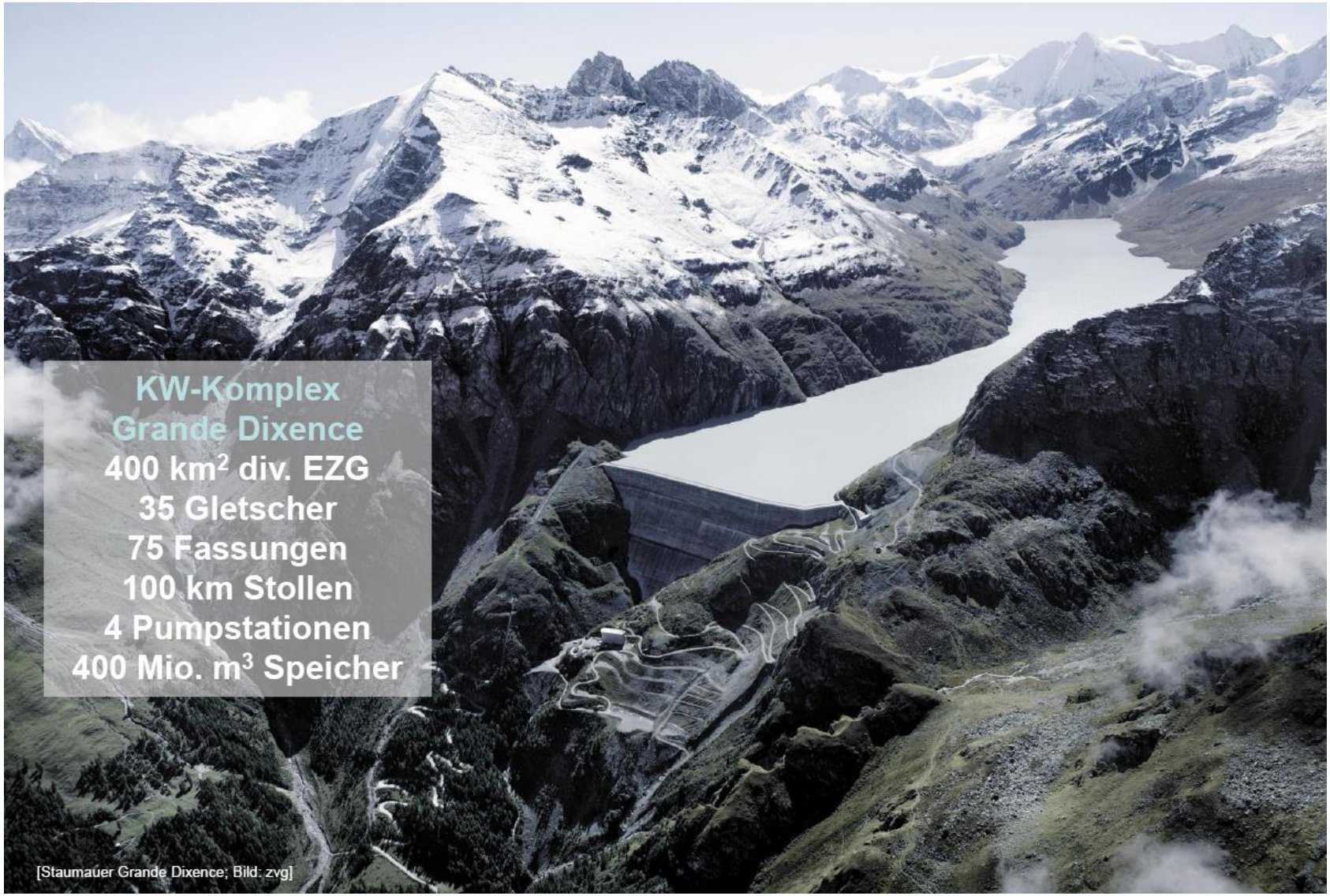


WaSiM application for the Rhone basin

- 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 Vieux Emosson und Emosson; Bild: Alpiq]

Reservoirs within the Rhone basin



Defined reservoir rules in WaSiM

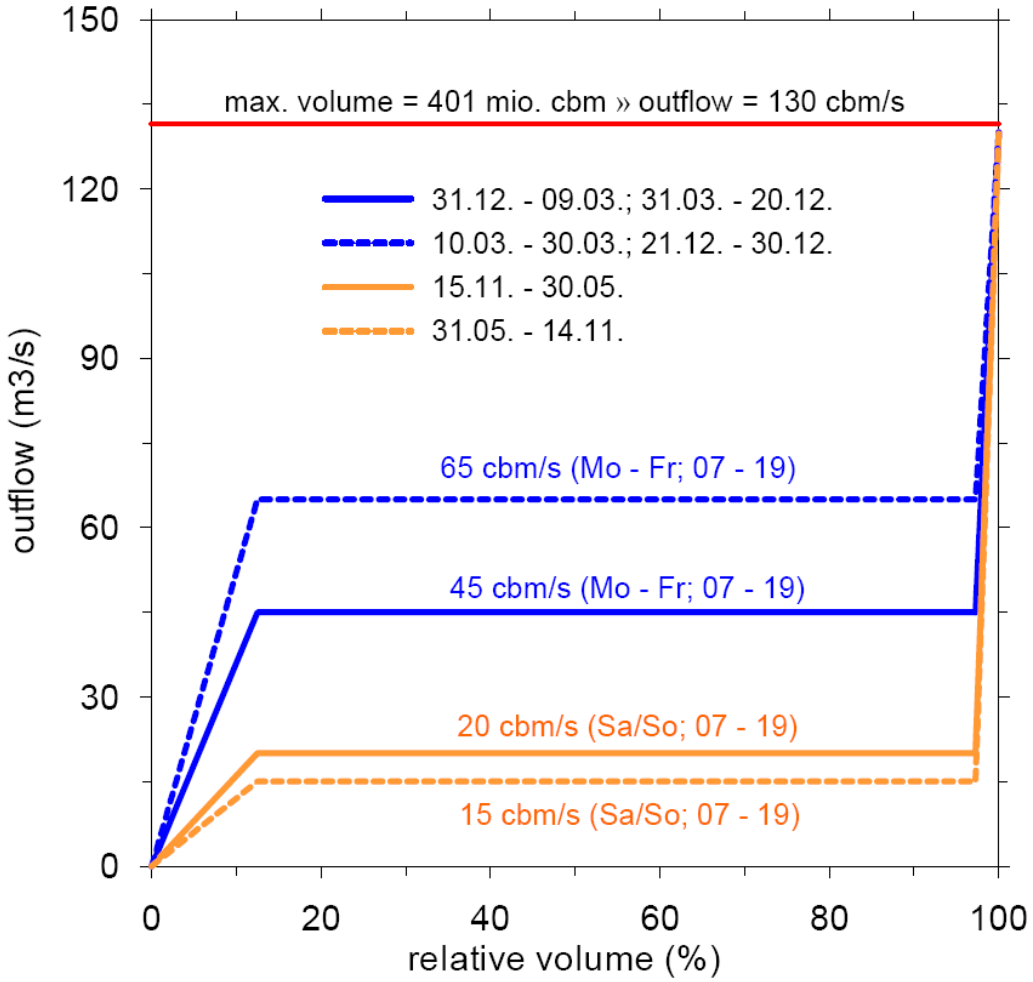
Wochentags (Mo bis Fr)

```
[abstraction_rule_abstraction_67] # power generation water working days
4           10    70    91    121   152   182   213   244   274   320   356   366   # Julian Day
0           0     0     0     0     0     0     0     0     0     0     0     0     # Content 1 abstraction for each JD
45e06       18    25    18    18    16    10    10    10    10    18    25    18    # Content 2 abstraction for each JD
215e06      18    25    18    18    16    10    10    10    10    18    25    18    # Content 3 abstraction for each JD
227e06      50    50    50    50    50    50    50    50    50    50    50    50    # Content 4 abstraction for each JD
TargetCap =360    360   360   360   360   360   360   360   360   360   360   360   # Limit for abstraction in target area
WeekDays  =12345 12345 12345 12345 12345 12345 12345 12345 12345 12345 12345 12345 # week day
start_hour=6      6     6     6     6     6     6     6     6     6     6     6     # start hour
stop_hour =18     18    18    18    18    18    18    18    18    18    18    18    # end hour
```

Wochenende

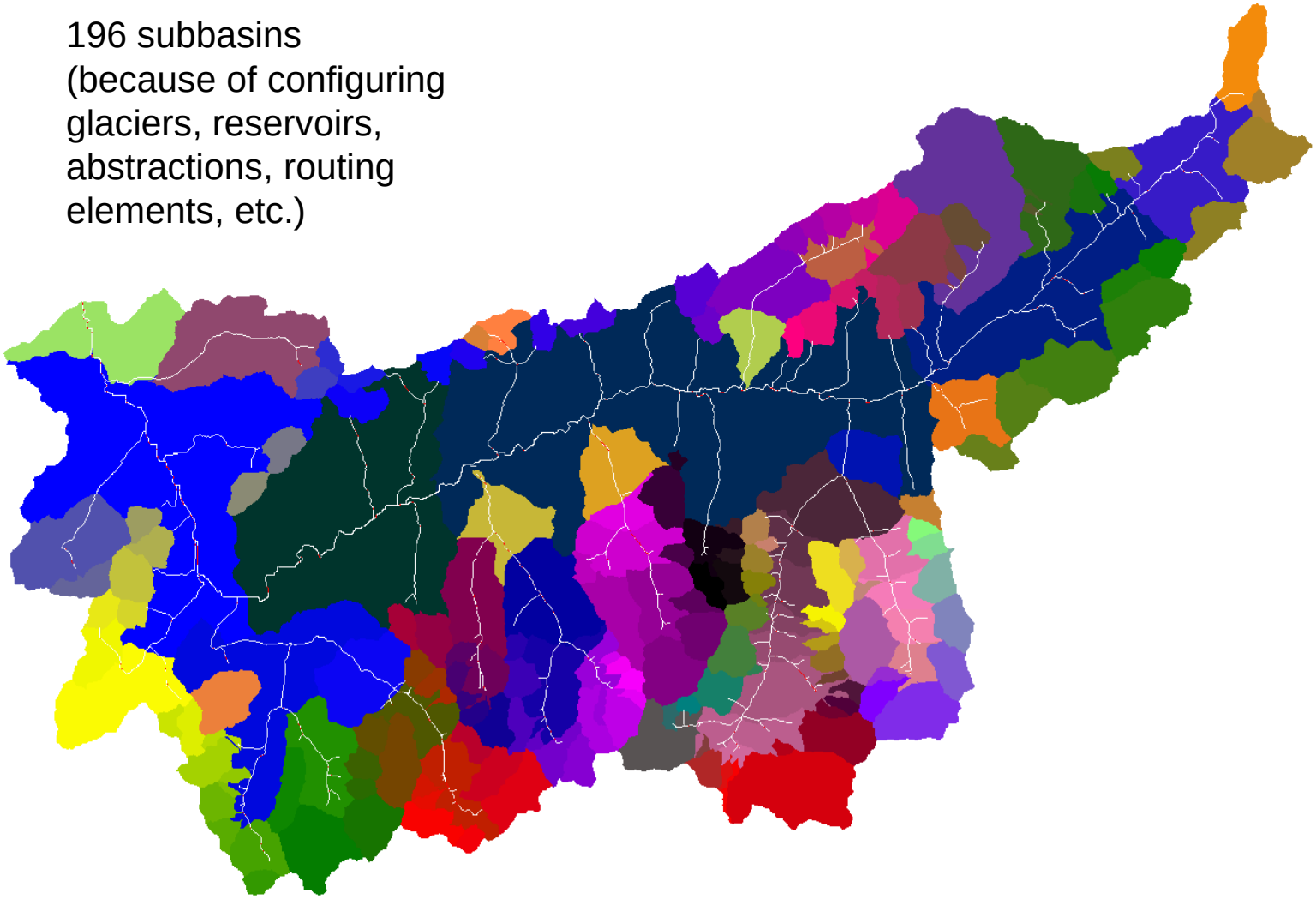
```
[abstraction_rule_abstraction_80] # power generation weekend
4           10    70    91    121   152   182   213   244   274   320   356   366   # Julian Day
0           0     0     0     0     0     0     0     0     0     0     0     0     # Content 1 abstraction for each JD
45e06       8     12    8     8     8     5     5     5     5     8     12    8     # Content 2 abstraction for each JD
215e06      8     12    8     8     8     5     5     5     5     8     12    8     # Content 3 abstraction for each JD
227e06      50    50    50    50    50    50    50    50    50    50    50    50    # Content 4 abstraction for each JD
TargetCap=  360   360   360   360   360   360   360   360   360   360   360   360   # Limit for abstraction in target area
WeekDays =  67    67    67    67    67    67    67    67    67    67    67    67    # week day
start_hour=7      7     7     7     7     7     7     7     7     7     7     7     # start hour
stop_hour =19     19    19    19    19    19    19    19    19    19    19    19    # end hour
```

Regulation scheme used for Grande Dixence Res.

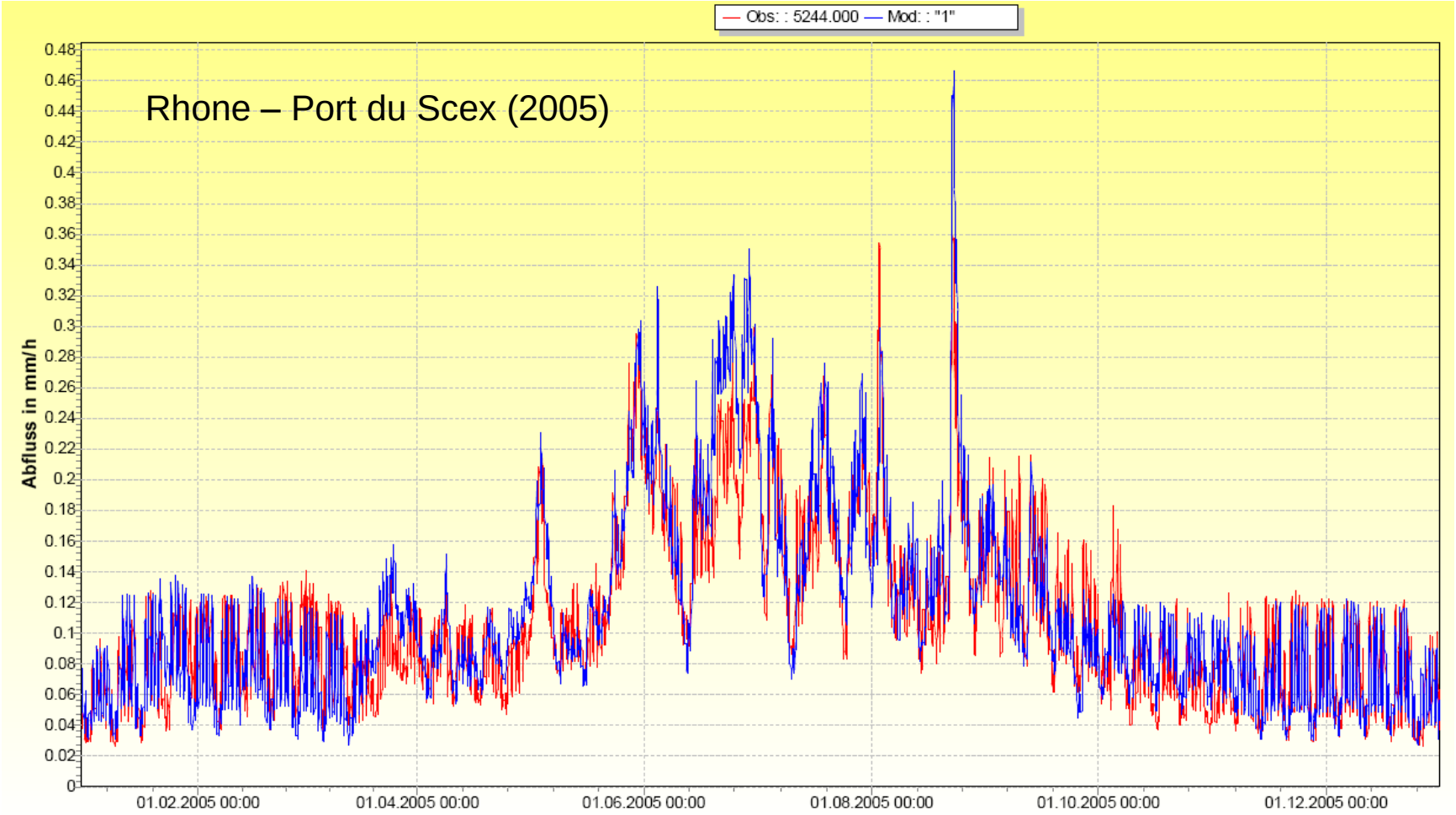


Configured subbasins in the Rhone setup

196 subbasins
(because of configuring glaciers, reservoirs, abstractions, routing elements, etc.)



Calibration results for the Rhone basin



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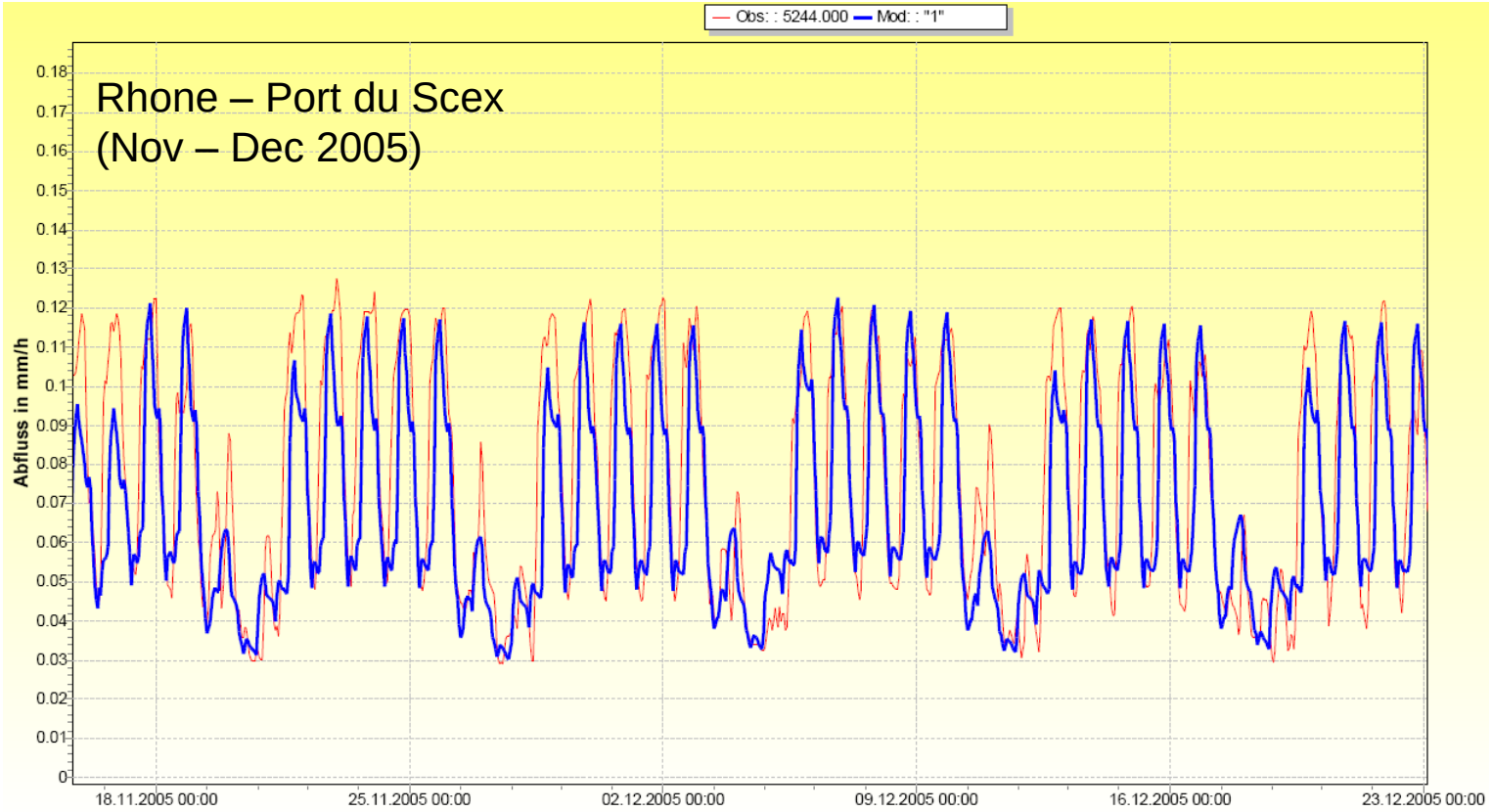
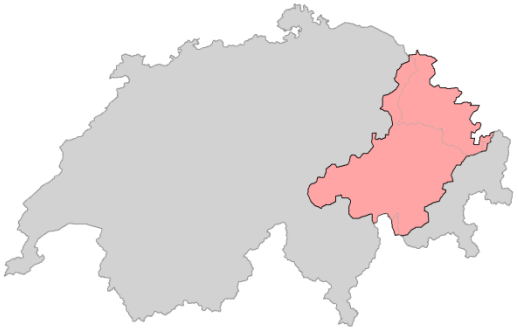
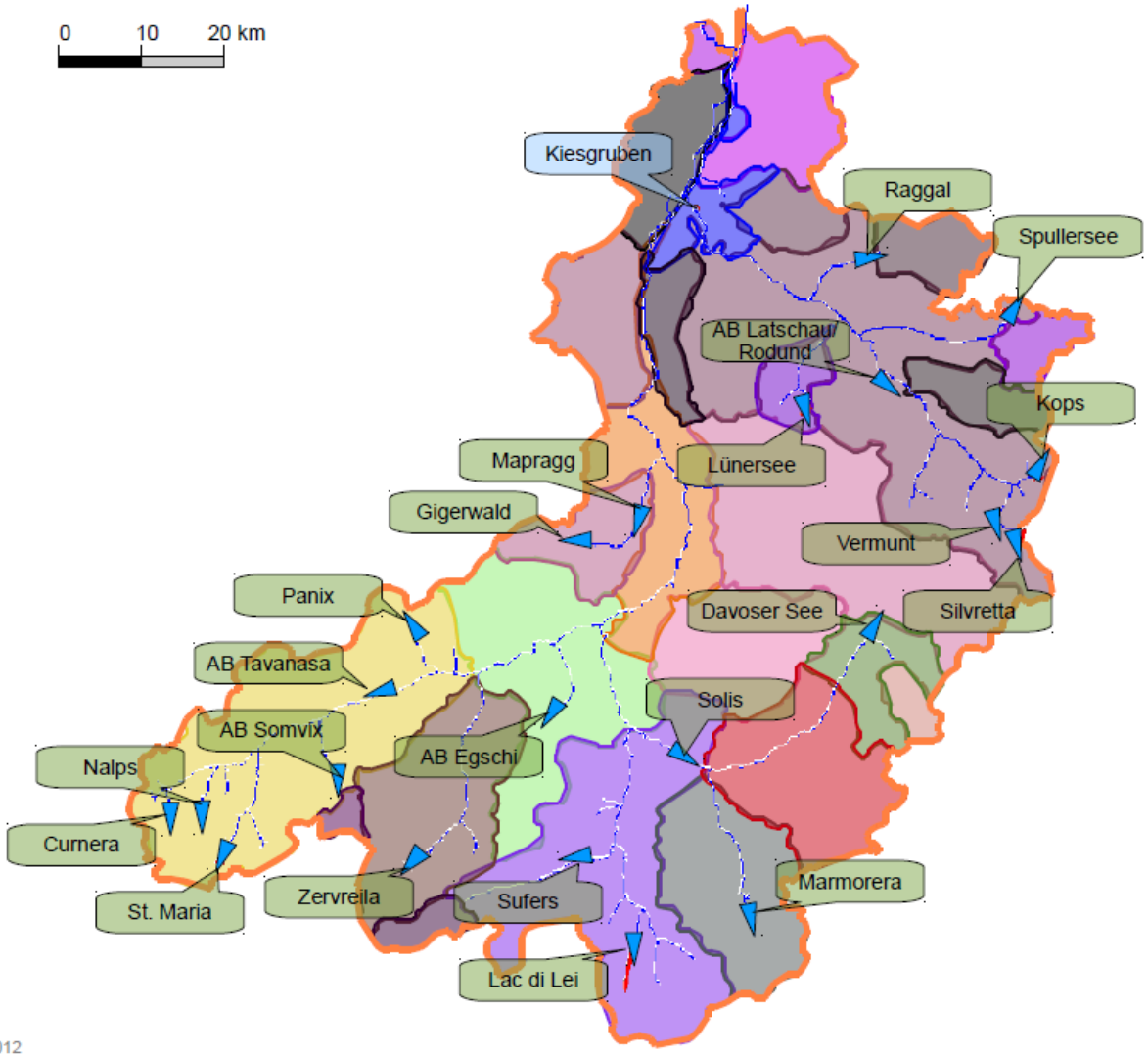


WaSiM application for the Alpenrhein basin

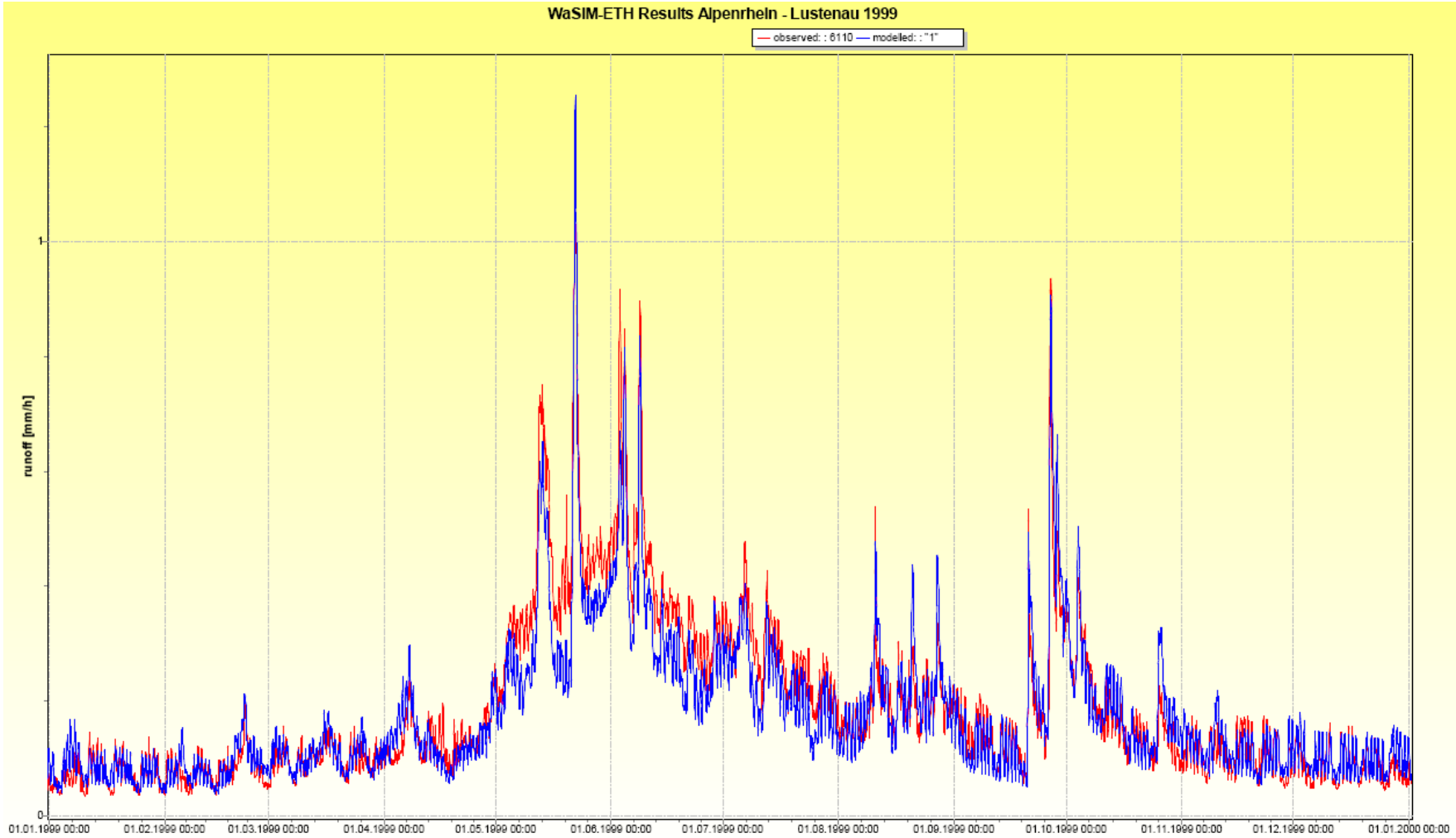


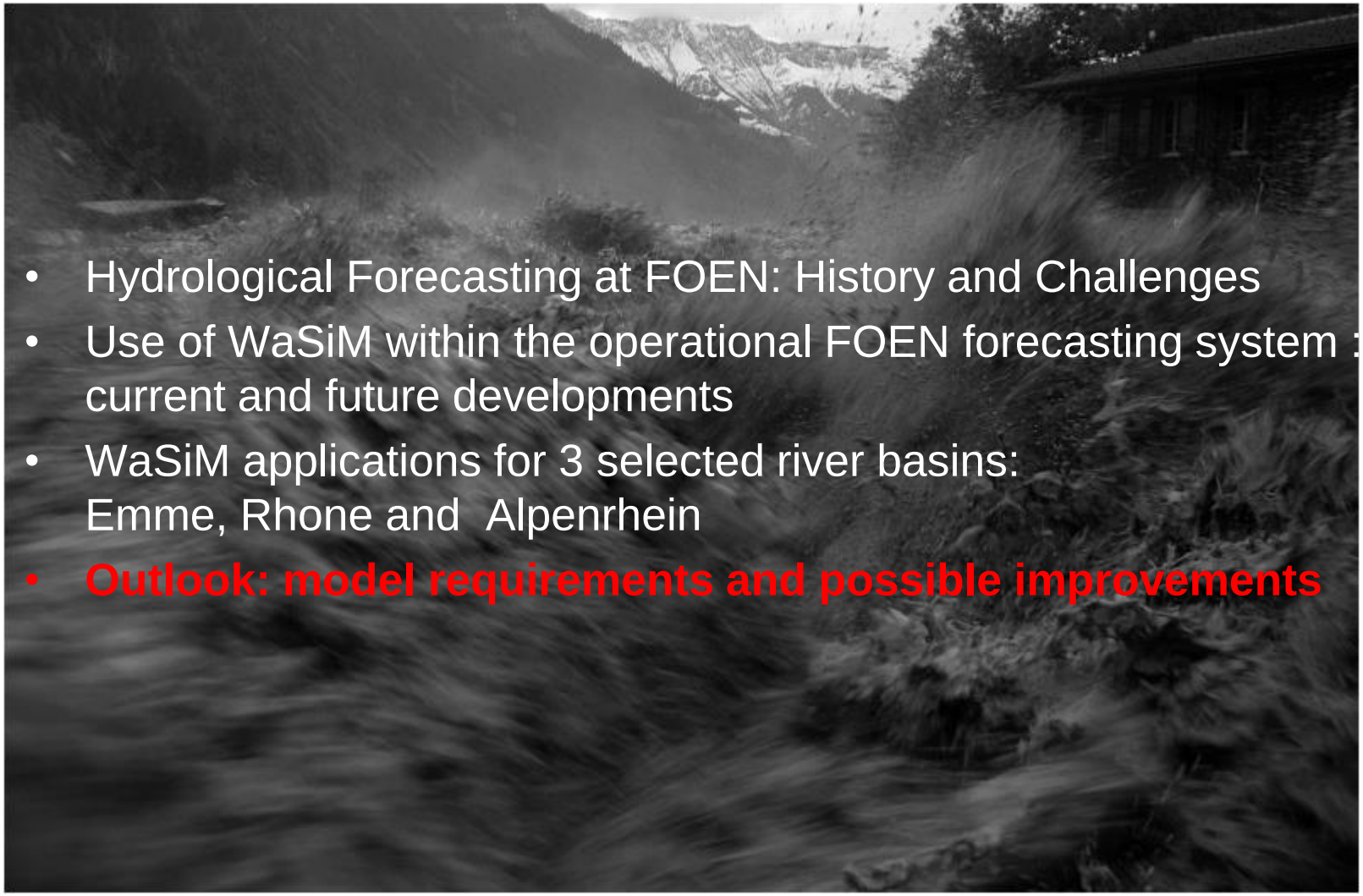
- About 6‘100 km^2 down to Lake Constance
- pronounced orography
- Natural runoff regime strongly influenced by hydropower activities
- Processes of snow accumulation, snow melt and generation of glacier runoff important for runoff and water balance modelling
- Spatial interpolation of meteo variables 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





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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)

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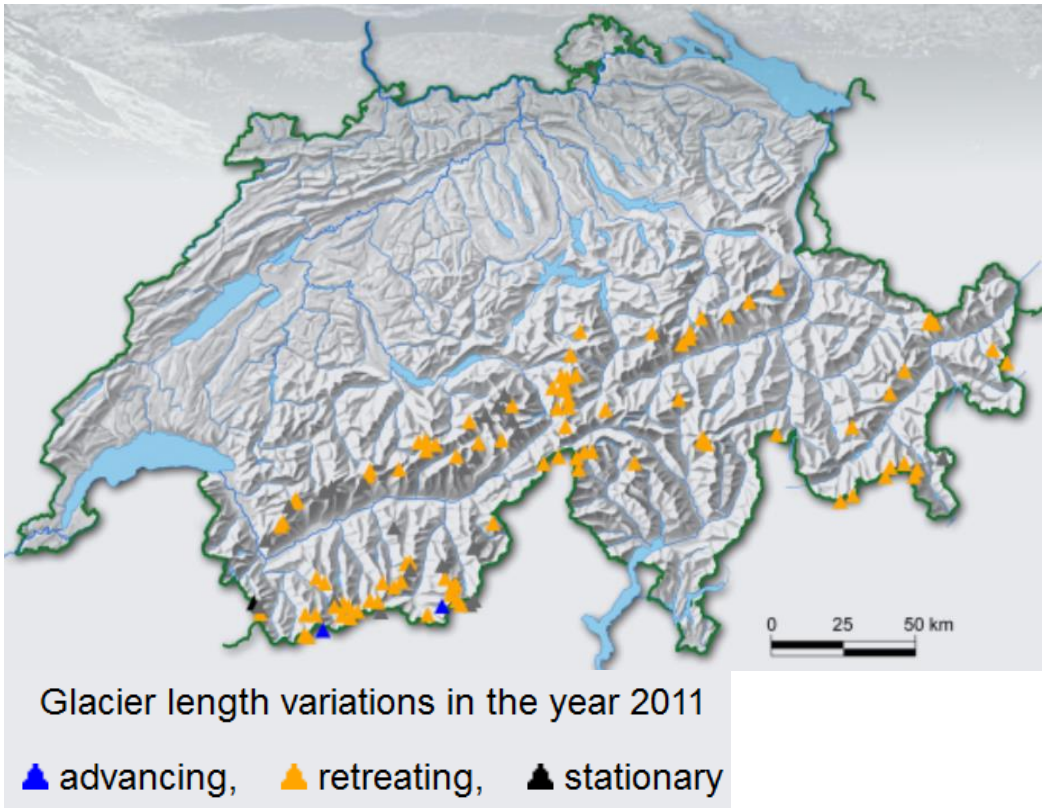
- Optimal use of lakes (unregulated and regulated)

- Optimal use of channel profiles (geometries)

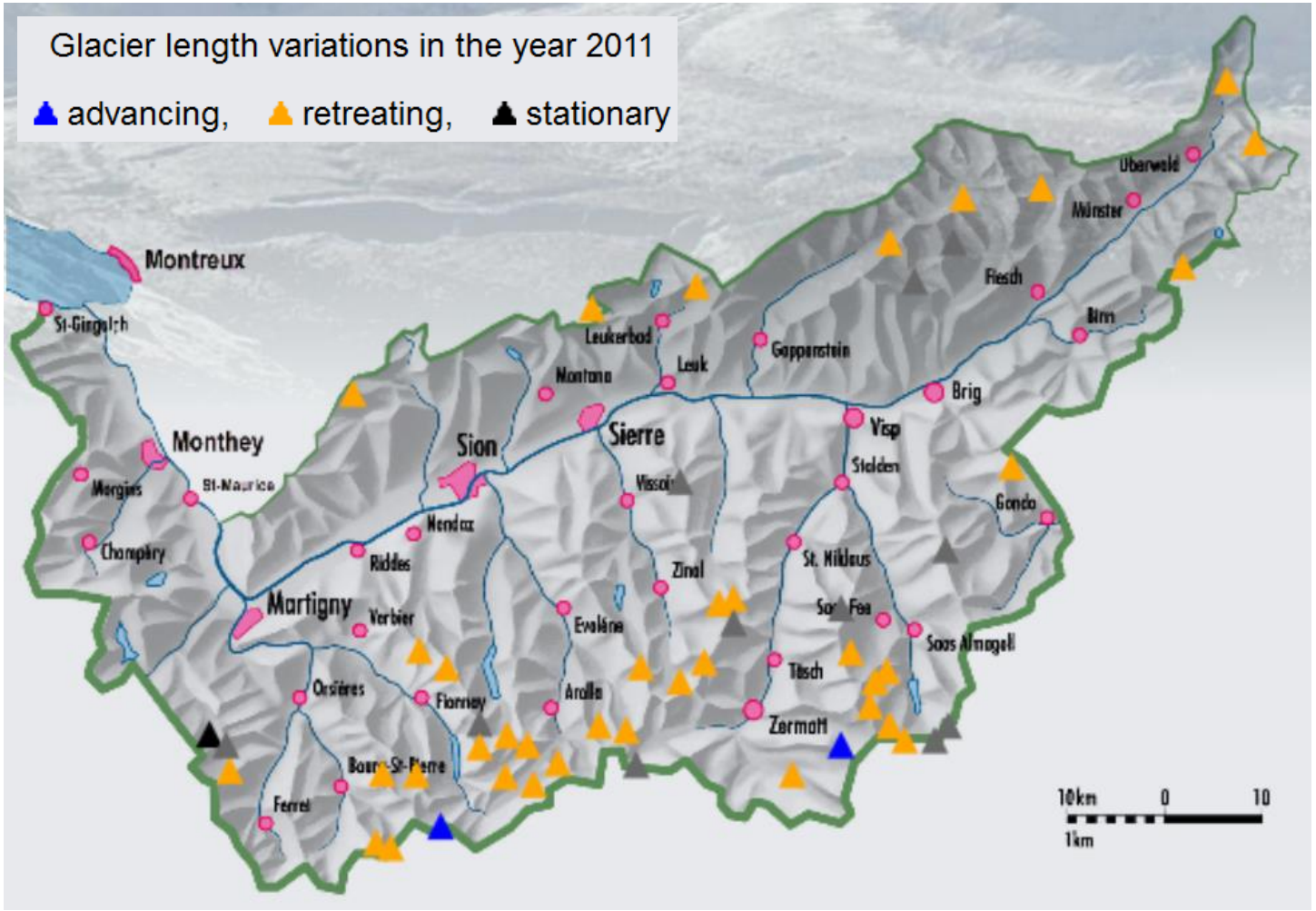
- Optimal use of glacier data (glacier dynamics)

Swiss Glacier monitoring network



About 120 observed glaciers in the Swiss Alps (length variations, mass balances)

Model validation by measured glacier variations

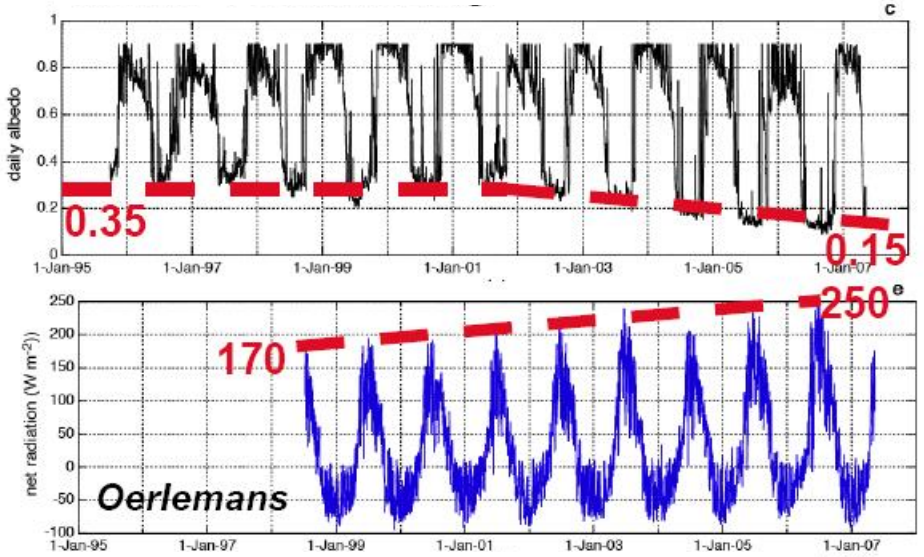


http://glaciology.ethz.ch/swiss-glaciers/

Consideration of glacier decline

…could be important for continuous modelling

Change of albedo



New lakes

Debris covering

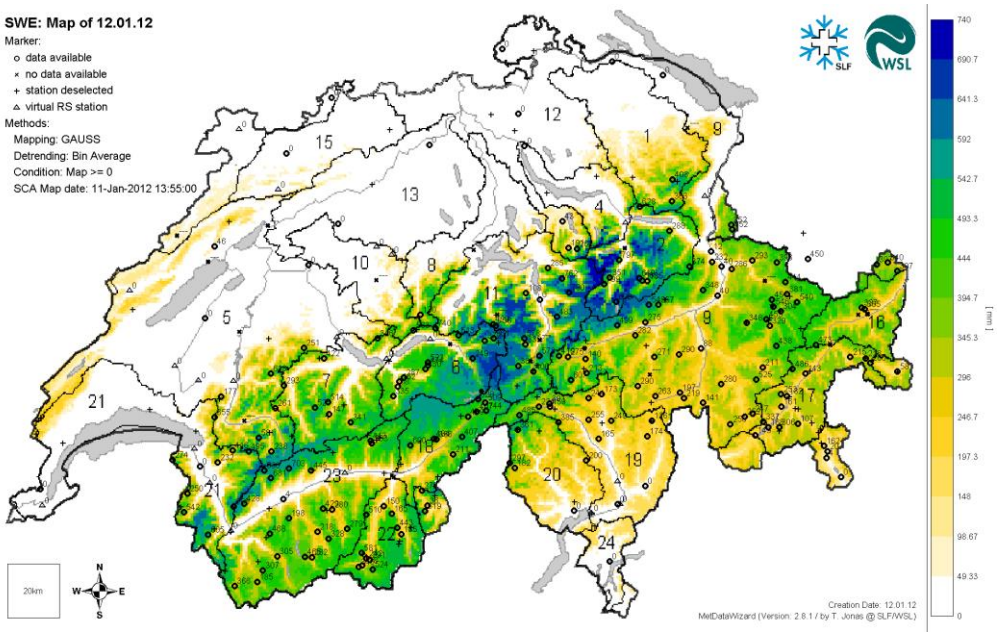
Sub-glacial melt

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 ?