# TOWARDS MONTHLY AND SEASONAL FORECASTS OF WATER RESOURCES IN SWITZERLAND

M. ZAPPA, S. JÖRG-HESS, K. BOGNER et al.

Swiss Federal Research Institute WSL.- massimiliano.zappa@wsl.ch

Some statistics for low flow prediction in the Limmat

April / Mai / Juni plots: Runoff minima [m3/s] vs Bang Time [minutes], with Observation, Linear Regression, and Prediction-Band.
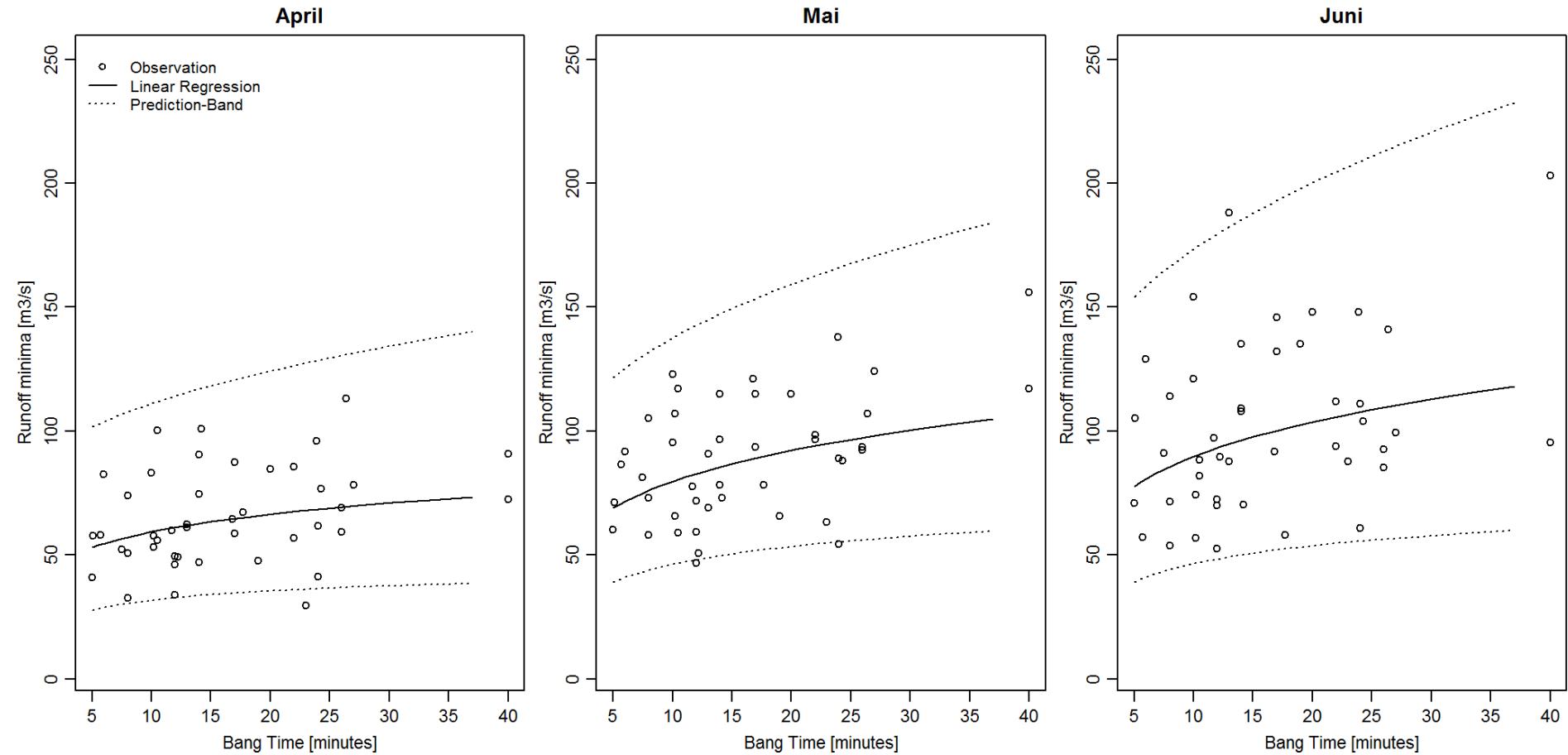
	April	May	June	July
p-value	0.076	0.01	0.032	0.393
Sigma^2	0.093	0.071	0.103	0.131
R^2	0.073	0.147	0.105	0.017

"The Böögg Bang Theory"

http://hepex.irstea.fr/boogg-bang/

2

Using mid-April SWE for the Rhine basin up to Neuhausen
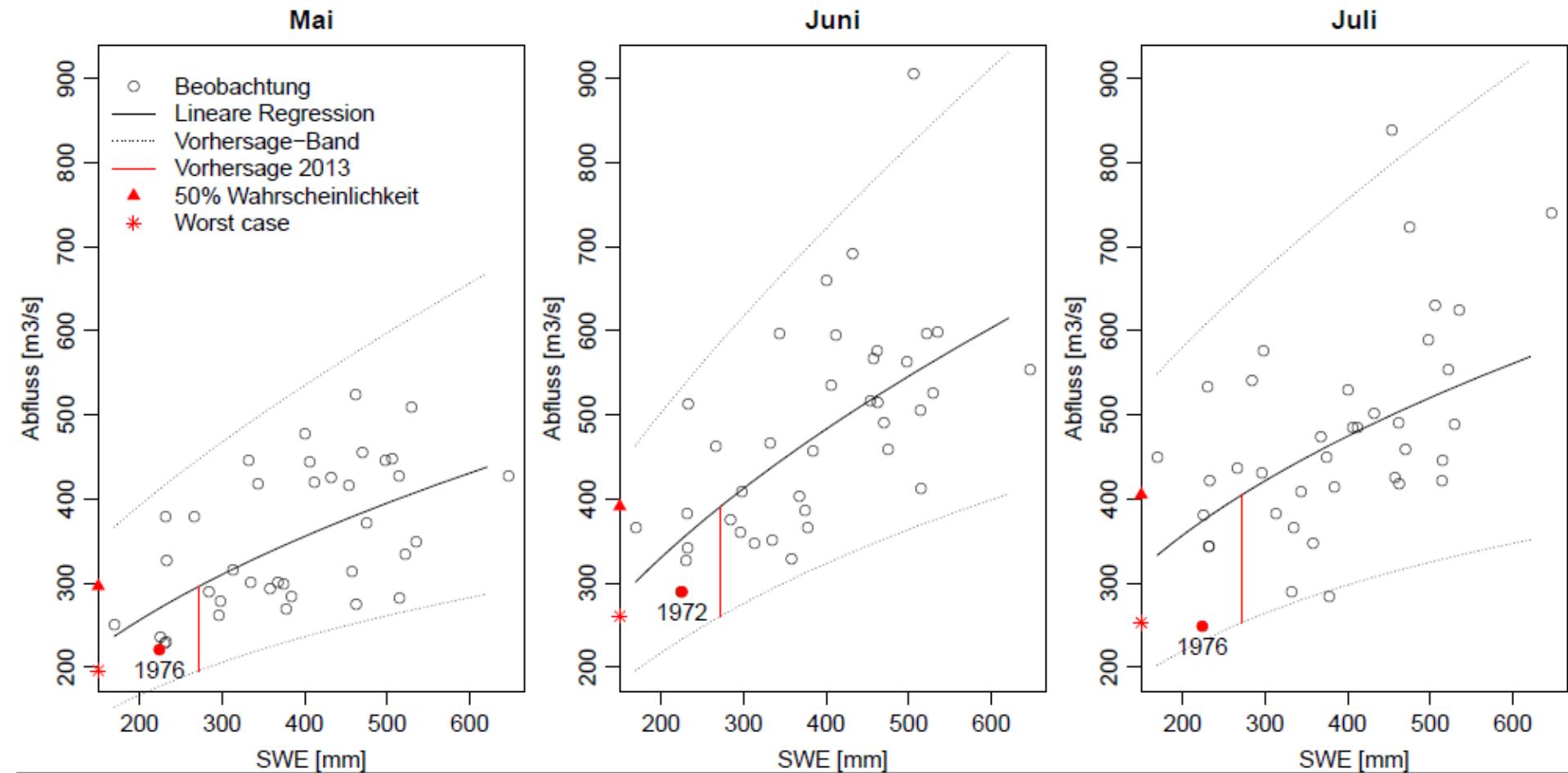
Summary

- Probabilistic Forecasts of Snow Water Equivalent and Runoff in Mountainous Areas

- Monthly forecasts for the Swiss Rhine

- Preliminary evaluation of predictions during the 2015 drought in Switzerland

- Perspectives for optimized hydropower operations (NRP70, SCCER SoE)

Probabilistic Forecasts of Snow Water Equivalent and Runoff in Mountainous Areas*

STEFANIE JÖRG-HESS

Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Birmensdorf, Switzerland

NENA GRIESSINGER

WSL Institute for Snow and Avalanche Research (SLF), Davos, Switzerland

MASSIMILIANO ZAPPA

Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), Birmensdorf, Switzerland

Eidg. Forschungsanstalt für Wald,
Schnee und Landschaft WSL

Overview

Numerical Weather prediction (NWP)

lt1 lt2 lt3 ... lt32

snow (1km x 1 km)

PREVAH

Runoff
32-day forecast

Runoff and snow
32-day forecast

Spatial verification
SWE
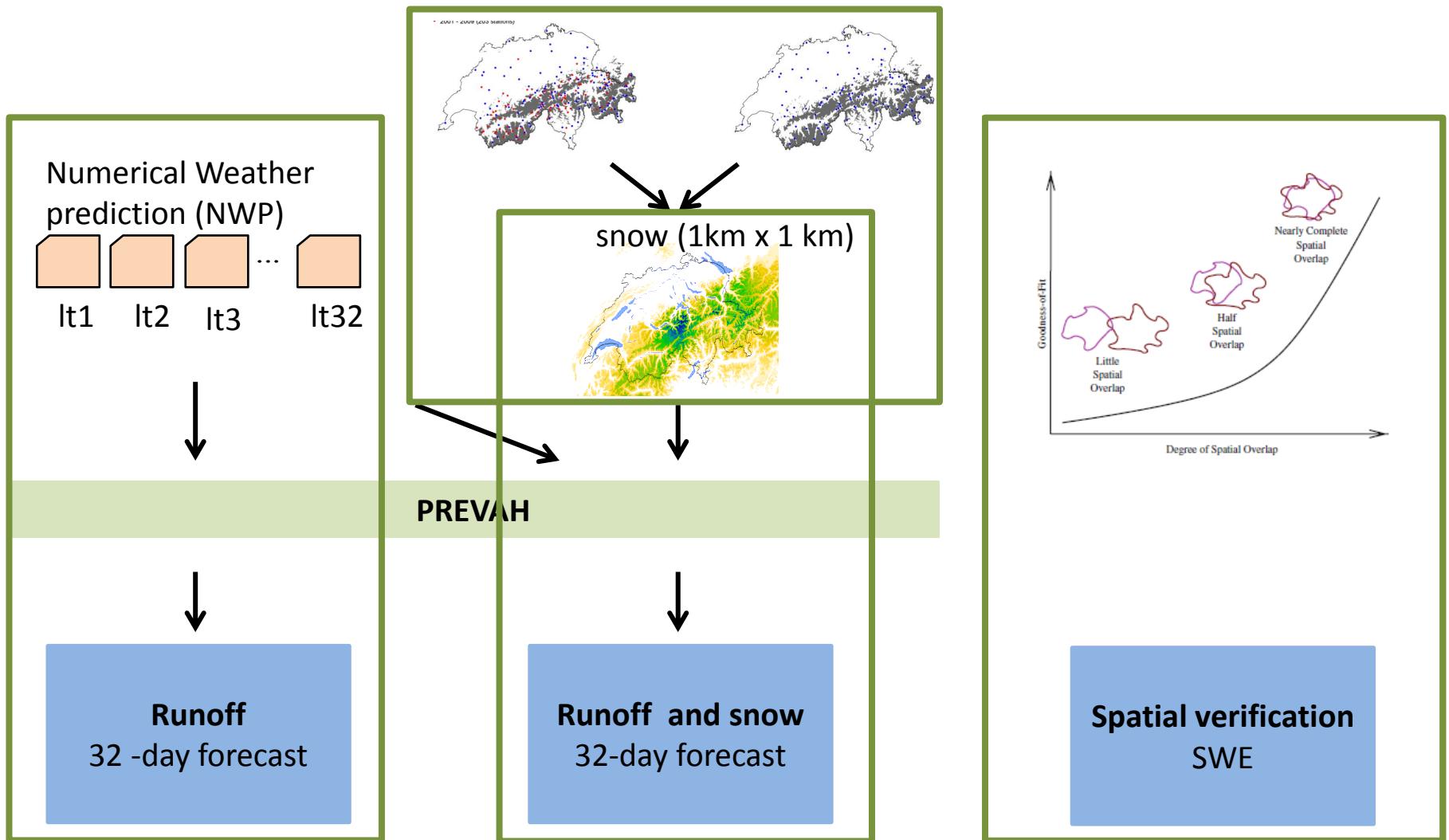
Study domains
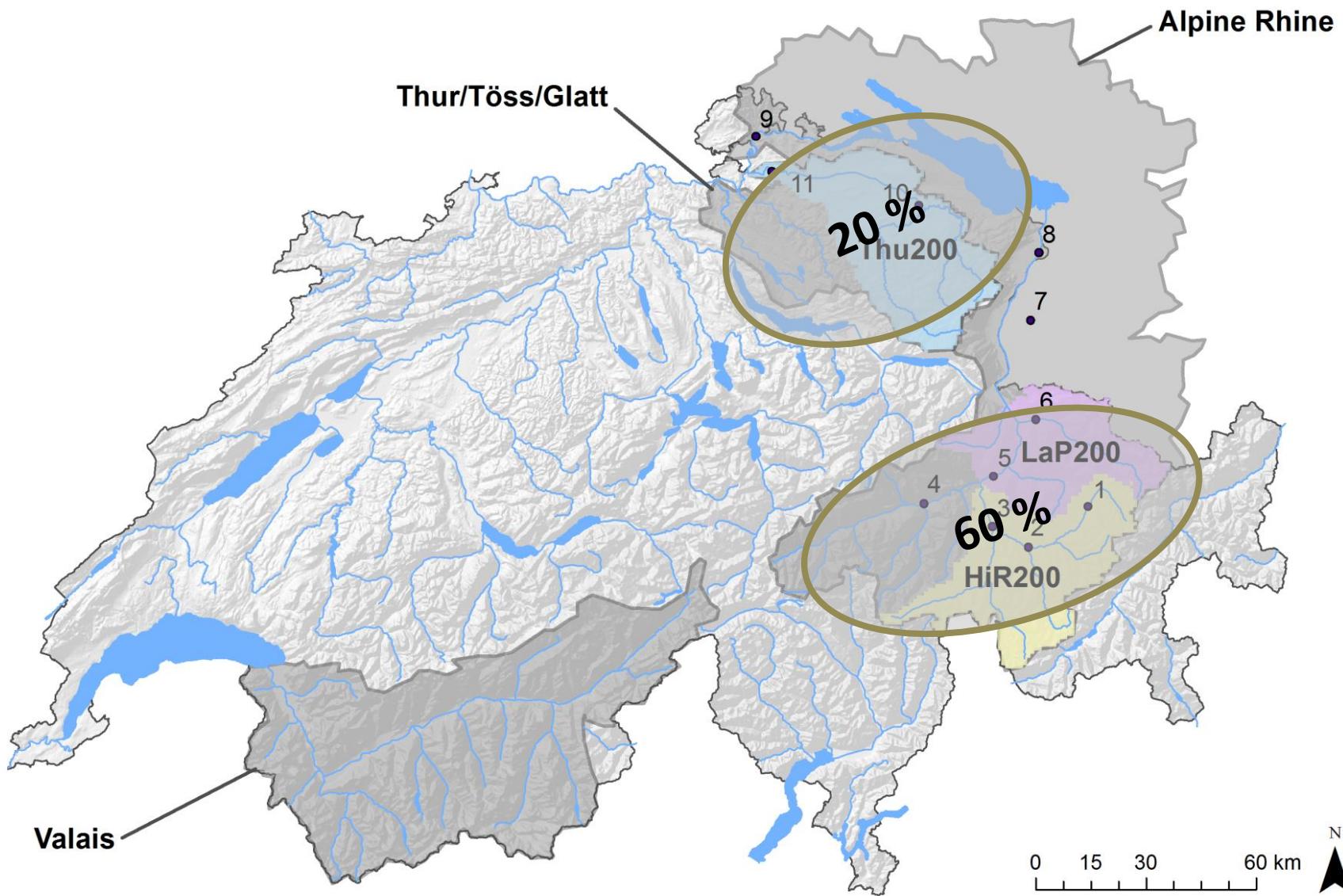
SWE maps

1)   HS → SWE

$$\text{SWE}_{mod} = \text{HS}_{obs} * \rho_{mod}$$

(Jonas et al. 2009, Journal of Hydrology)

SWE (1 km x 1 km)
October - May

2)   Mapping
 i.   detrending
 ii.   distance weighting
  iii.   retrending
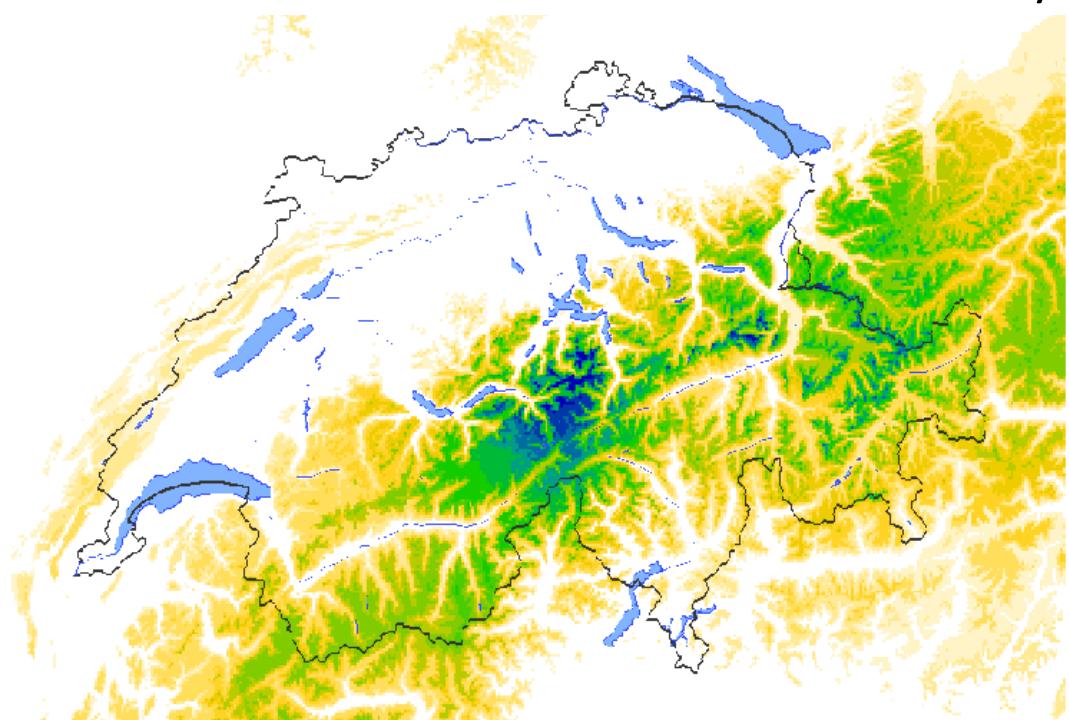
Homogenisation of SWE maps

'sparse'

'dense'

Quantile mapping

calibrated SWE maps 1971 - 2009
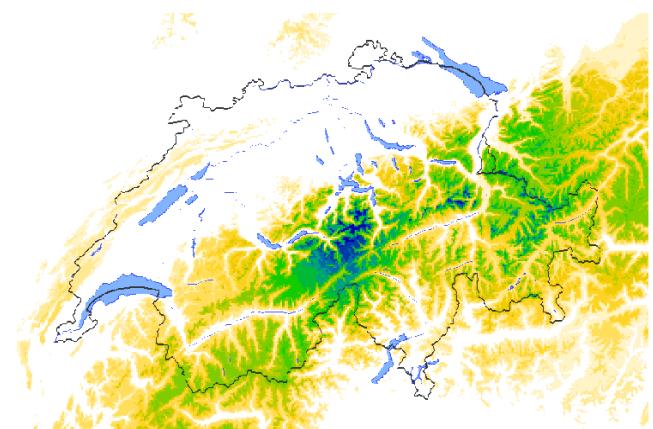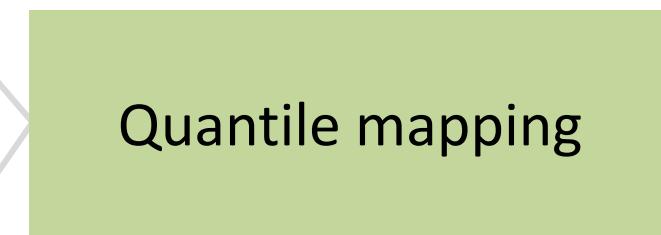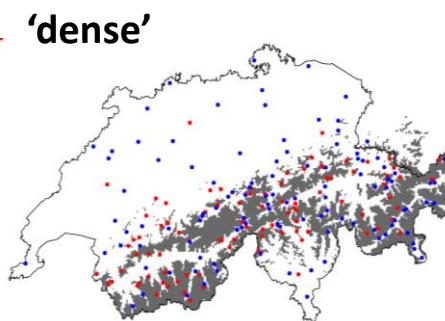

(Jörg-Hess et al. 2014, The Cryosphere)

Snow water equivalent as model input

ECMWF   VarEPS: 5 members

lt1   lt2   lt3   ...   lt32

SWE (1km x 1 km)

lt0

PREVAH grid

Q and SWE
32 days forecast
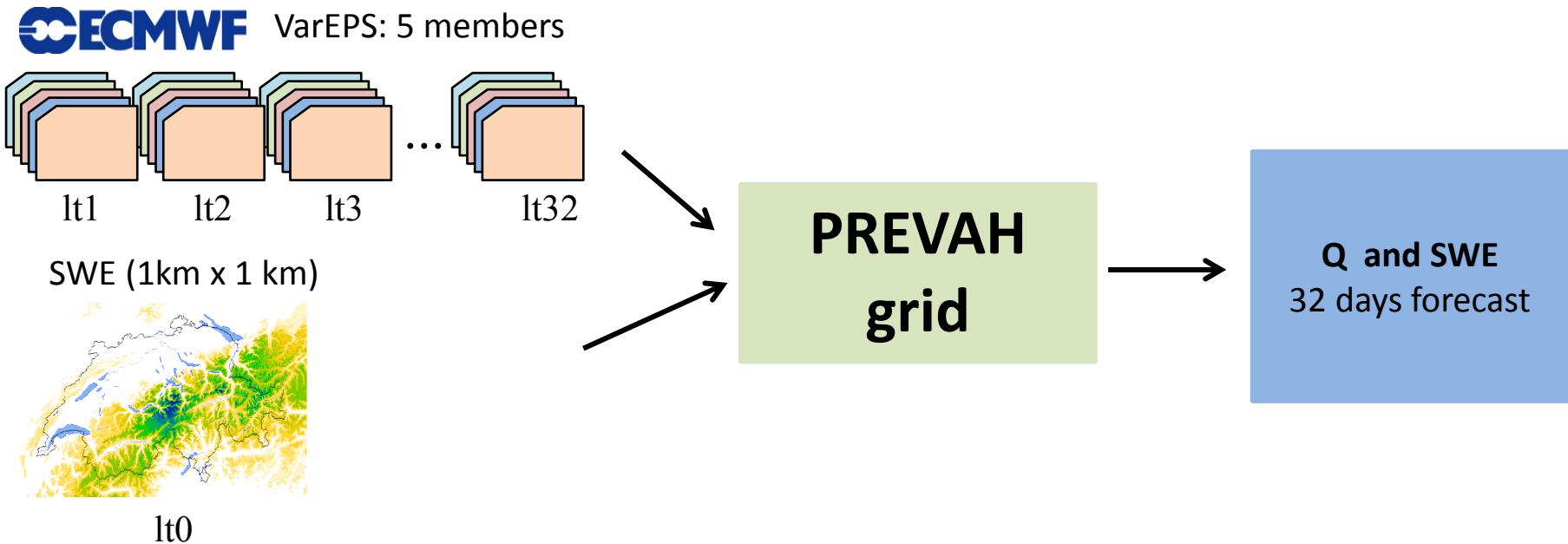
- Period 1981 – 2008

- Fully distributed

- 200 m
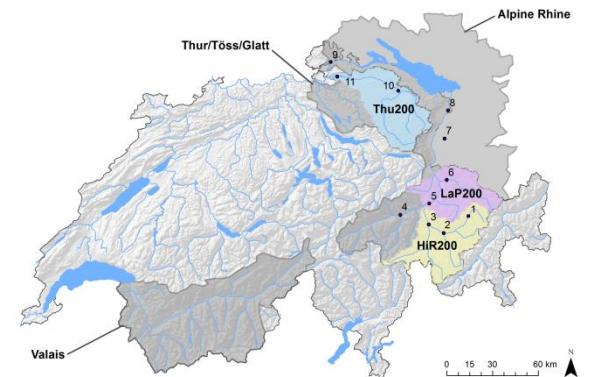
Runoff predictions with VarEPS

2AFC score
1991–2008
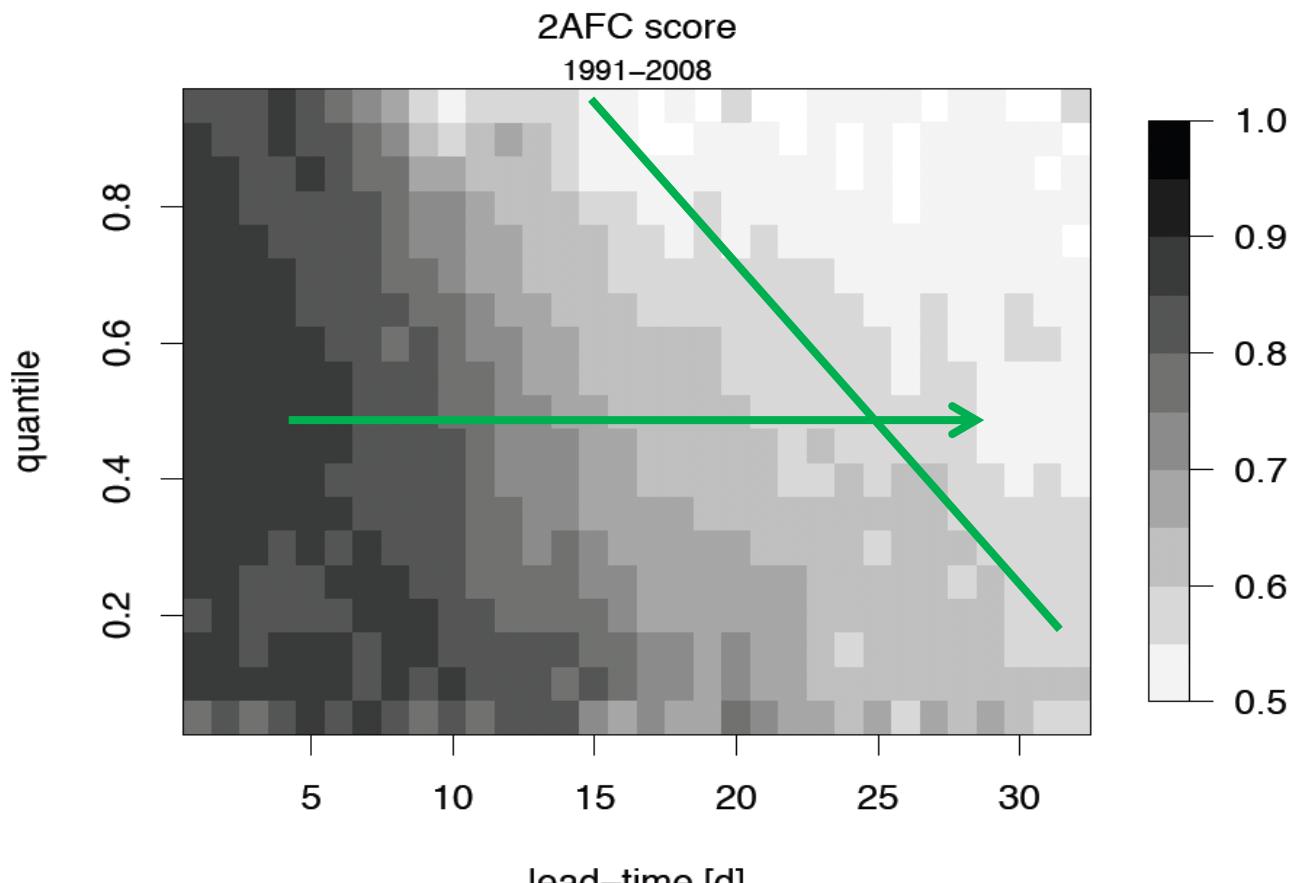
2afc = 1   perfect forecast
2afc > 0.5   better than guess

2afc score

2afc =   1   perfect forecast

2afc > 0.5   better than guess

probability of event

event occurred

no event occurred

2afc ≥ 0.5   2afc < 0.5   simulation
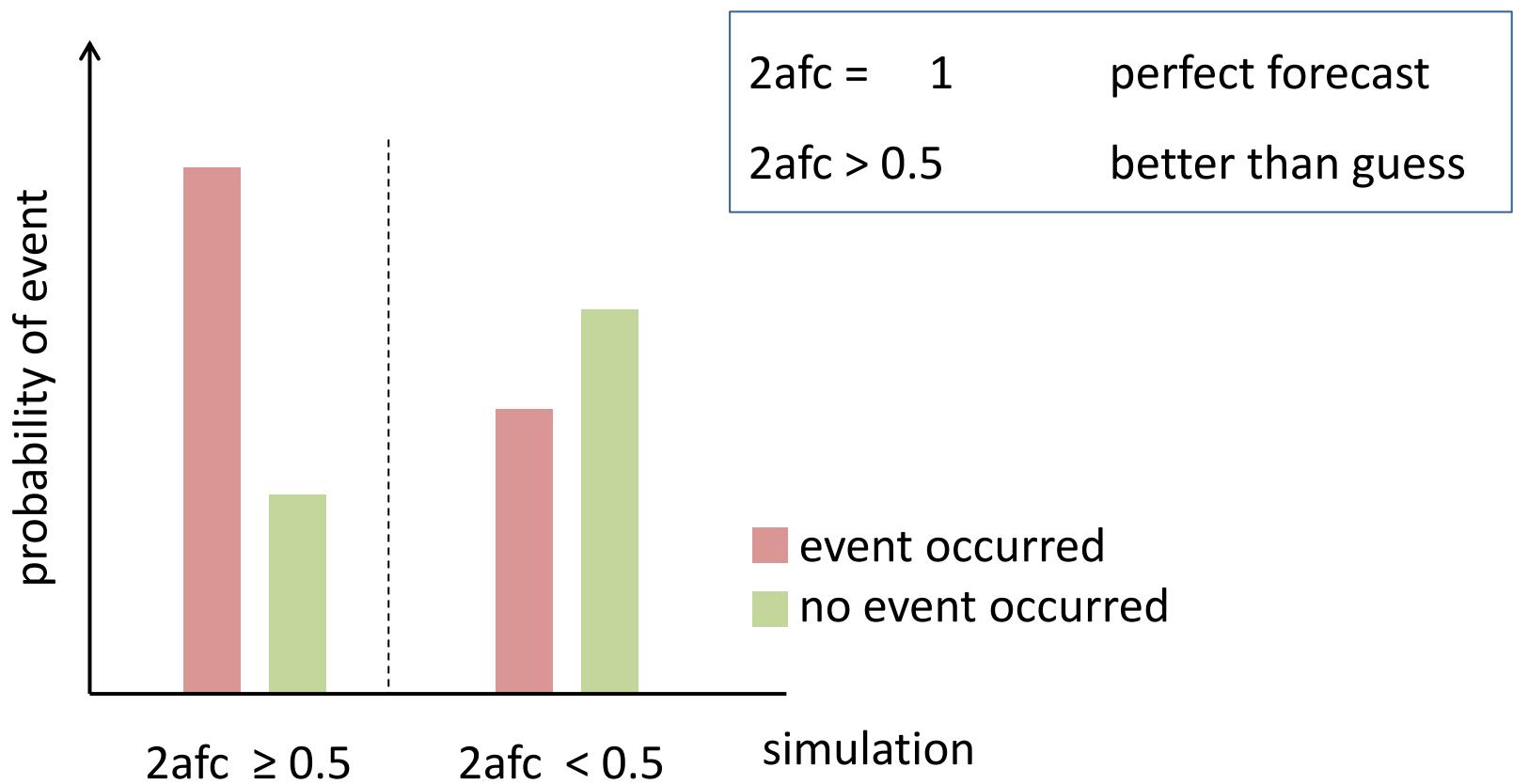
Added value of importing SWE: runoff prediction
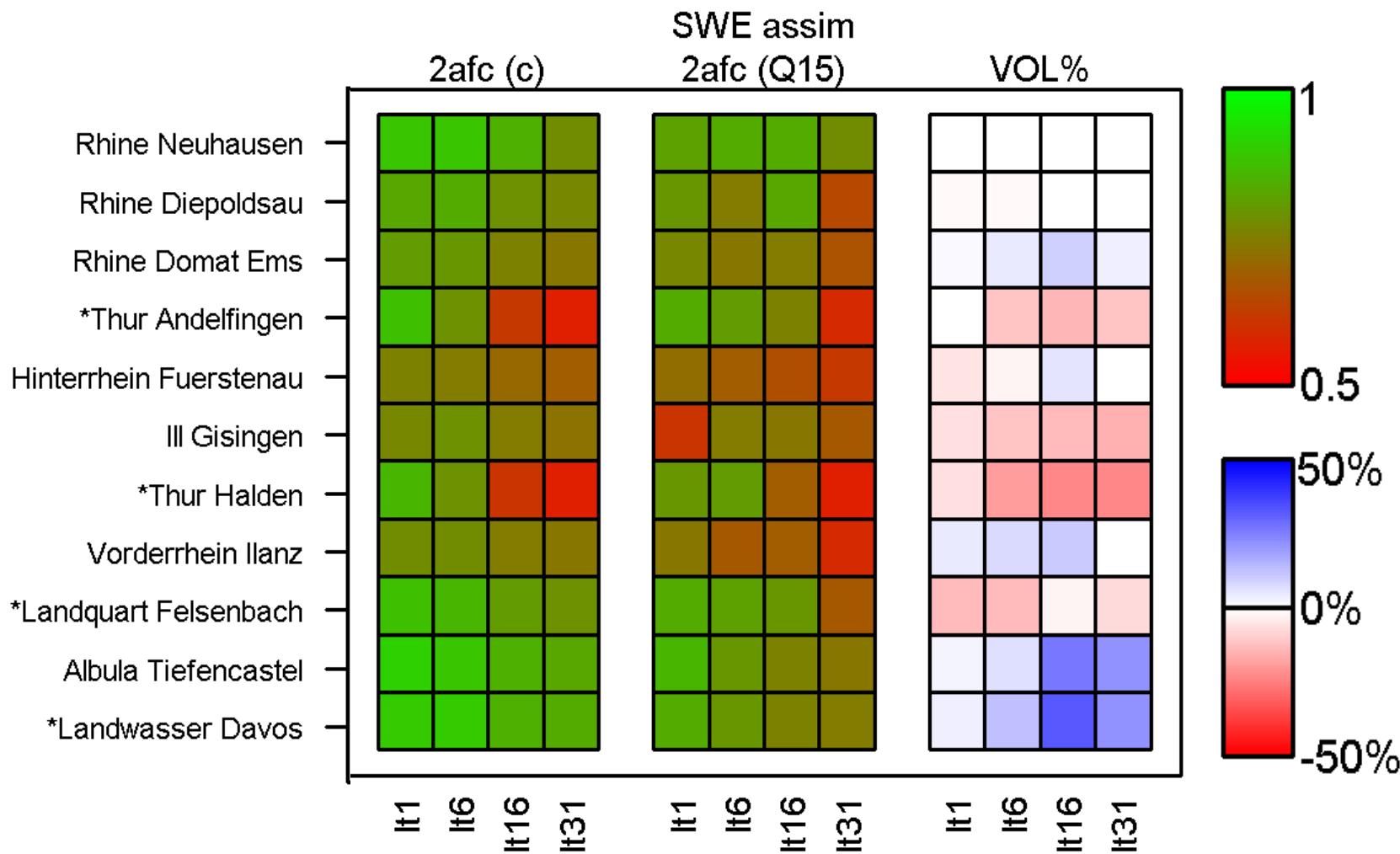
# Impact of Q15 forecasts
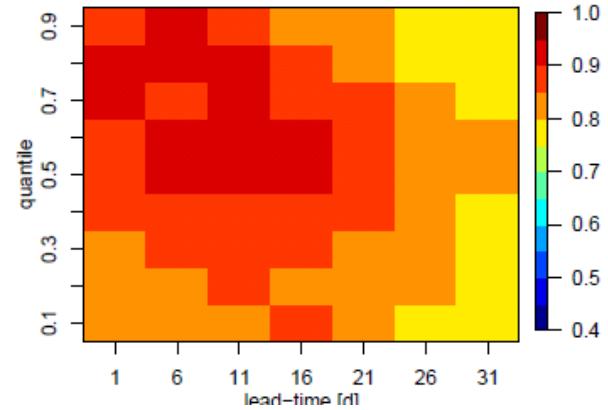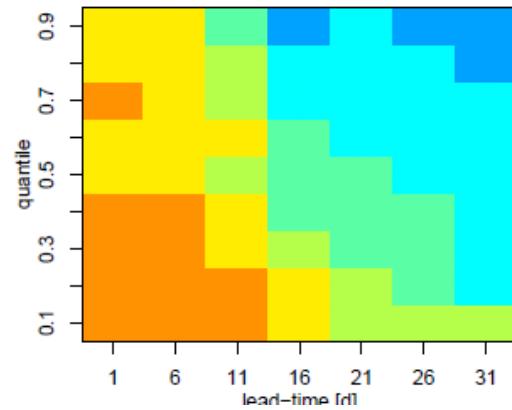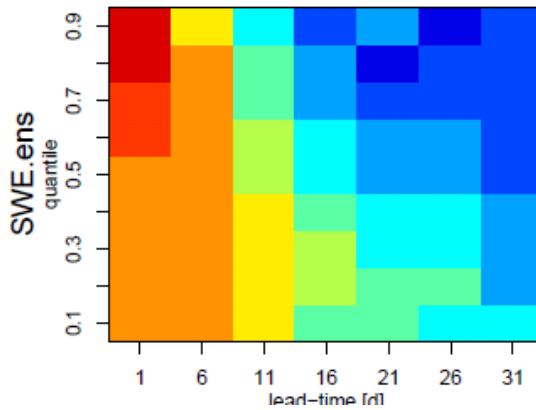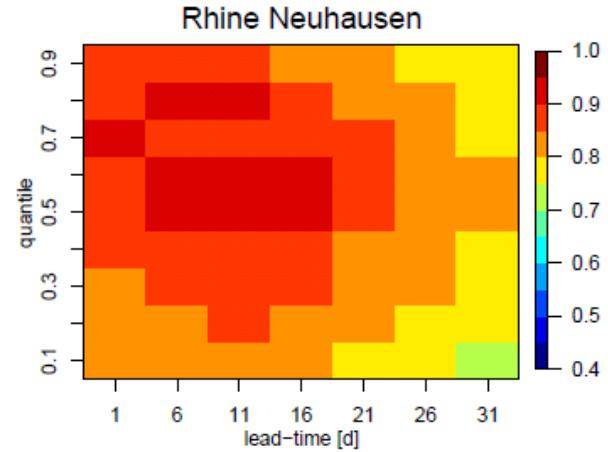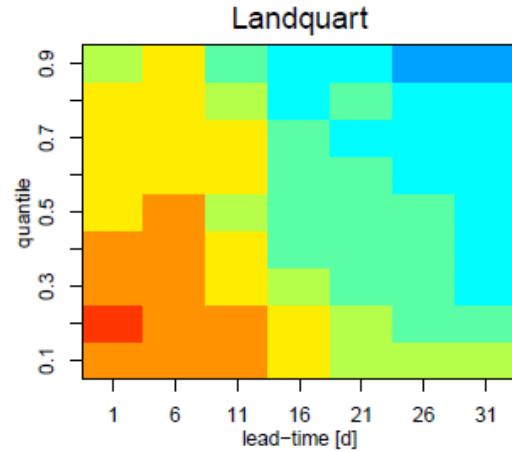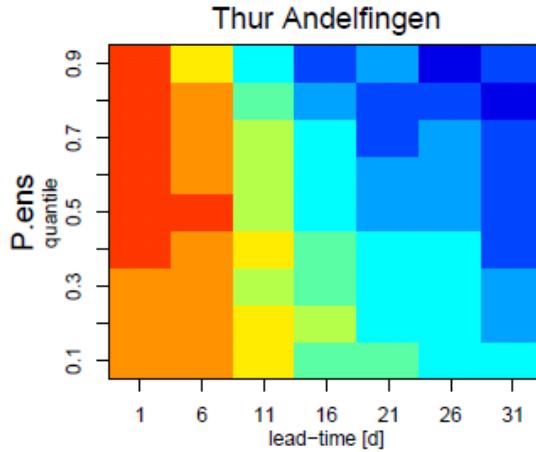
SWE predictions
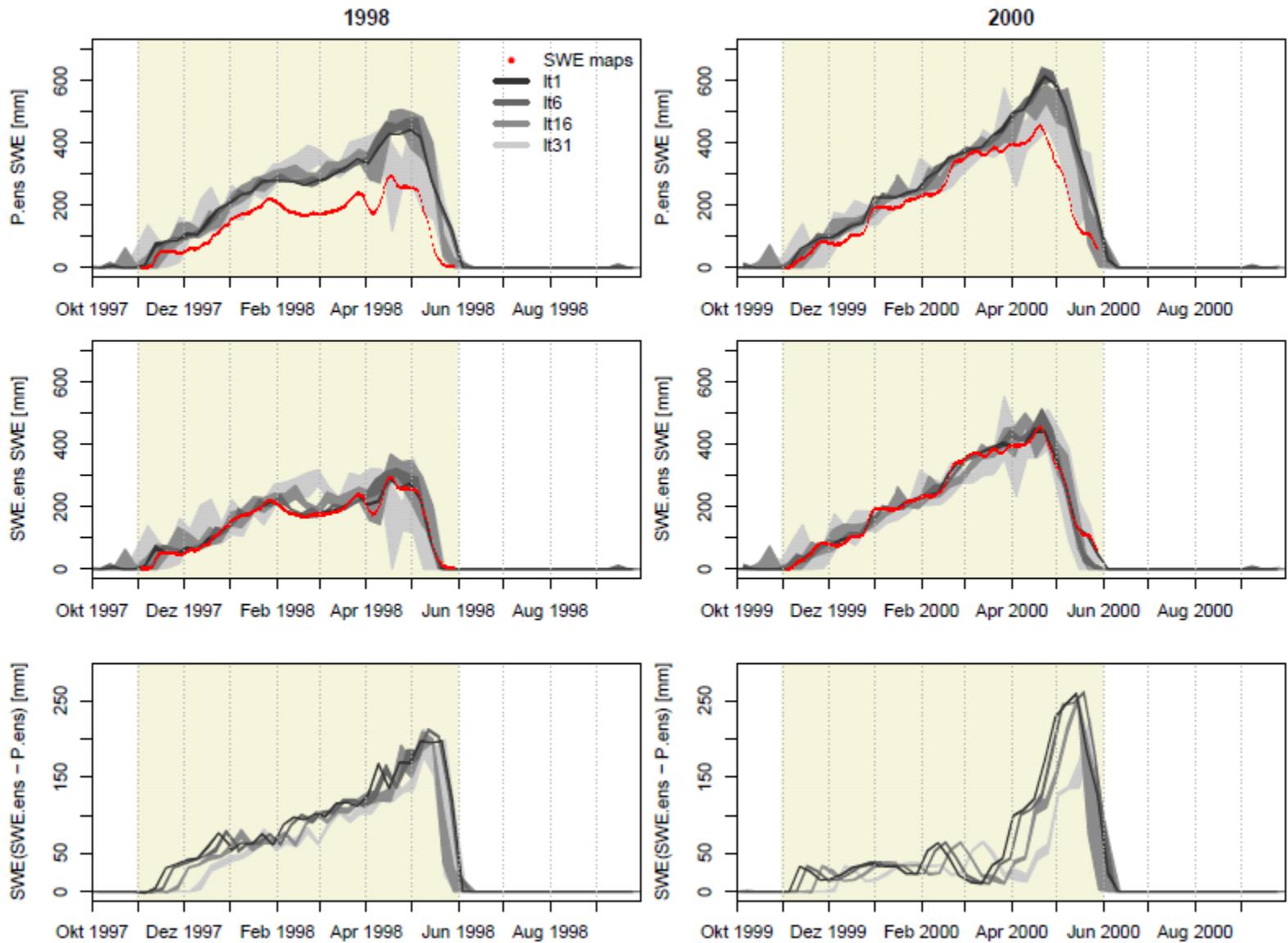
Impact on SWE forecast
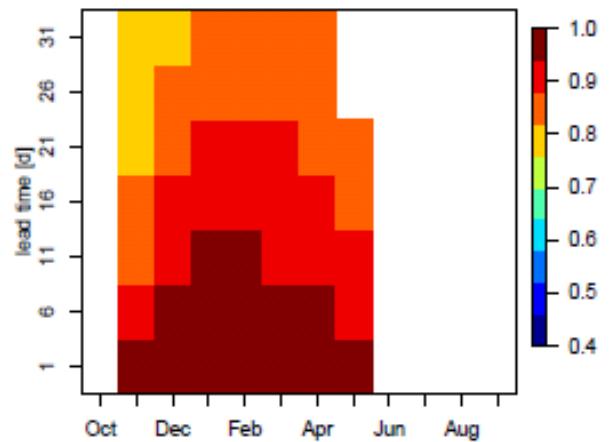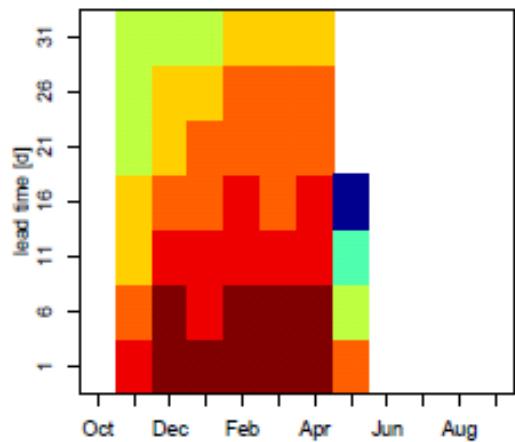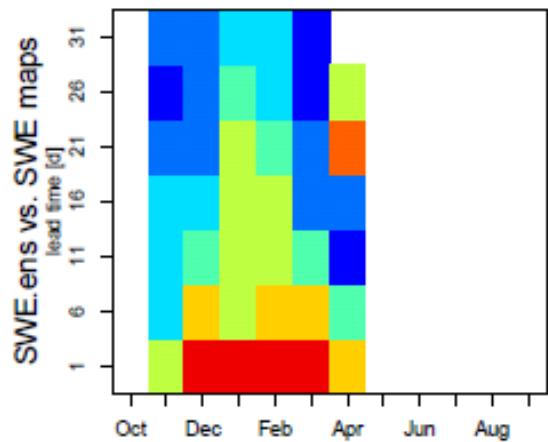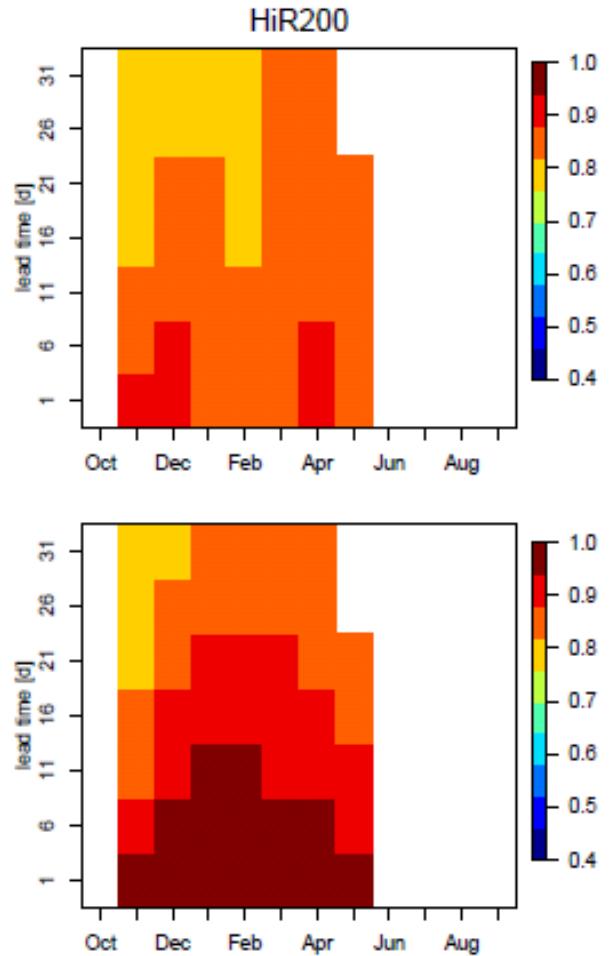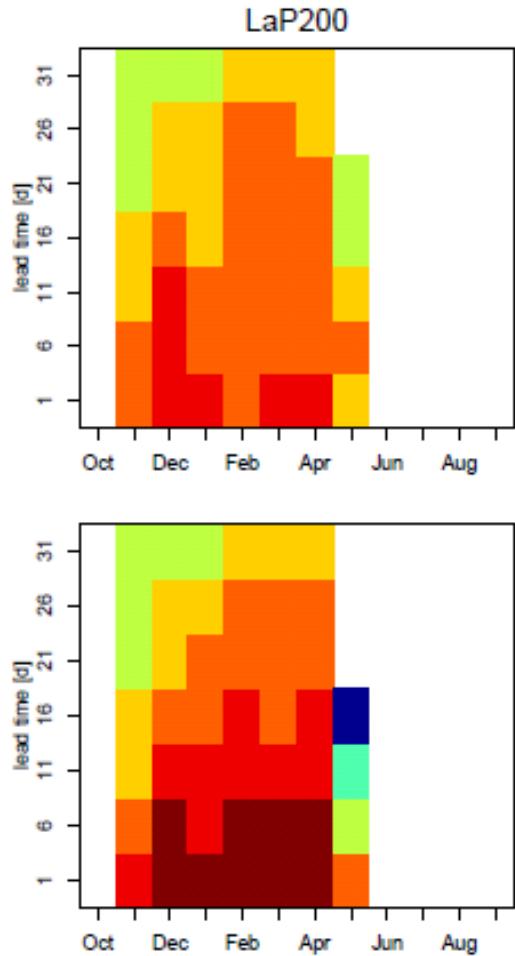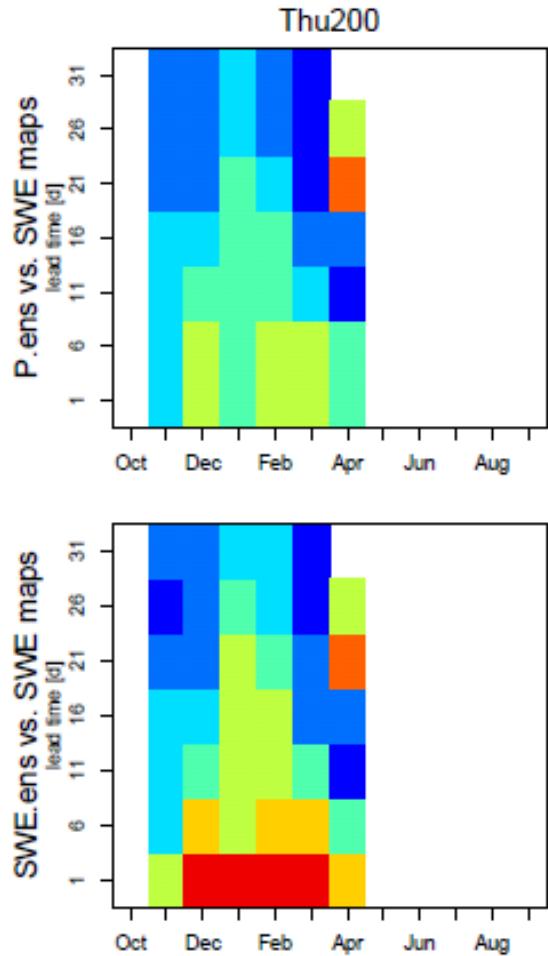
# Spatial verification : Added value of importing SWE
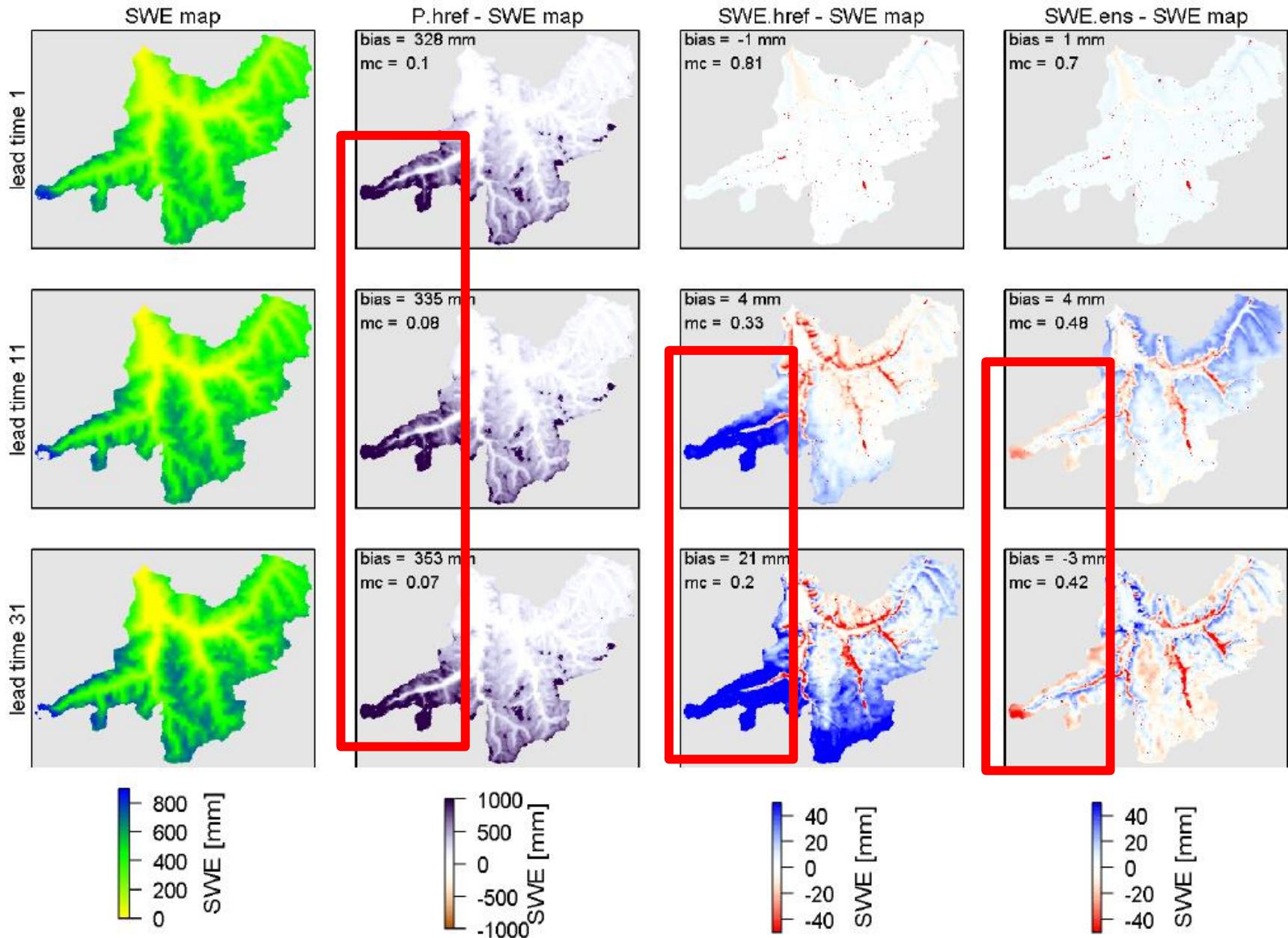
Summary

- Challenging conditions in high mountains and small basins

- Low-flow predictions initialized with numerical weather predictions provide skilful forecasts

- The import of SWE observations at initialisation
  - improves the predicted runoff volume
  - improves SWE prediction for lead times up to ~ 20 days

- Verification against Q and SWE

- Spatial verification metrics are useful

- Next: See posters on HEPS4Power

Perspectives for the Rhine
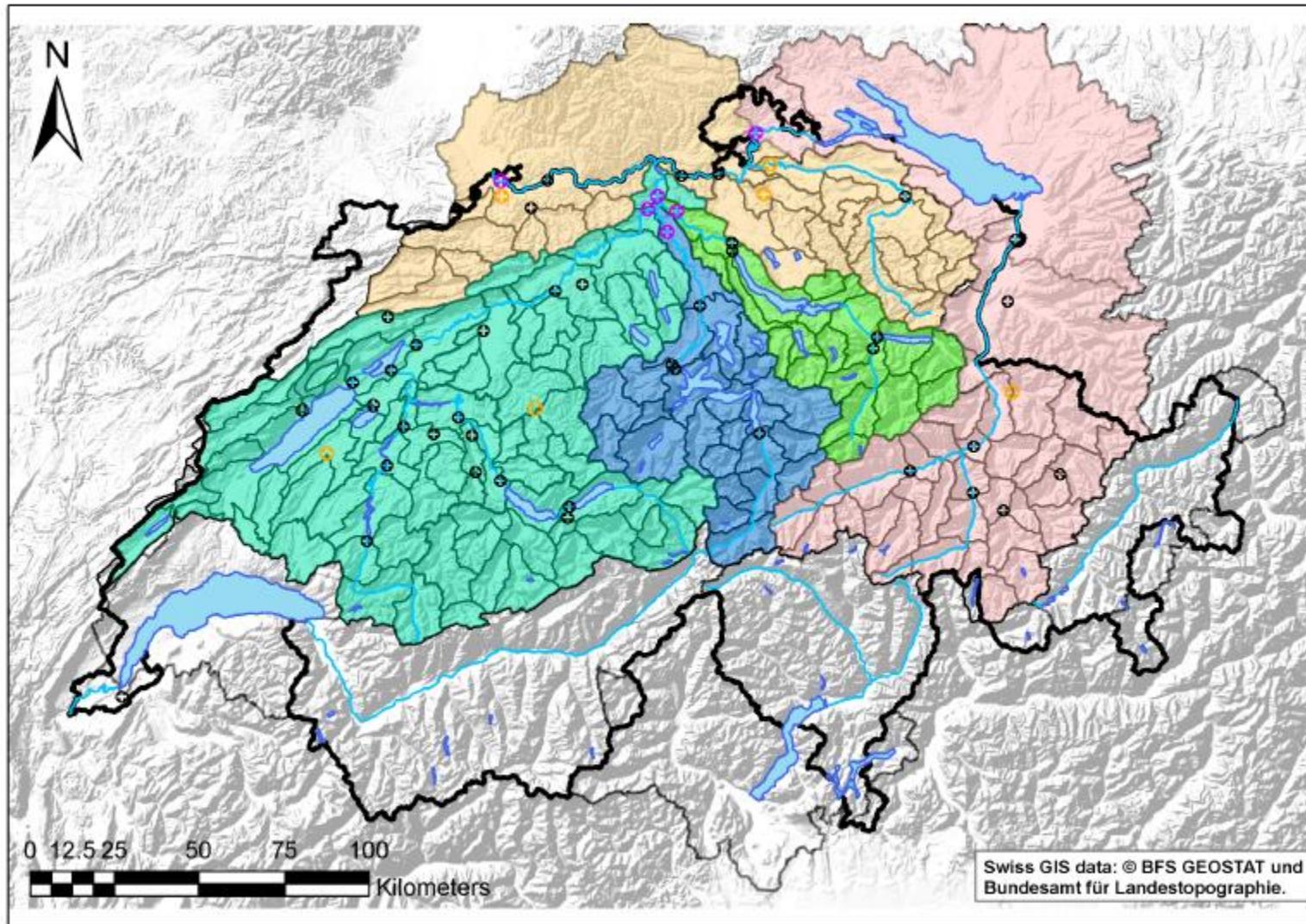
Perspectives for the Rhine

2AFC score vs. catchment size, thr: Q15 (monthly)
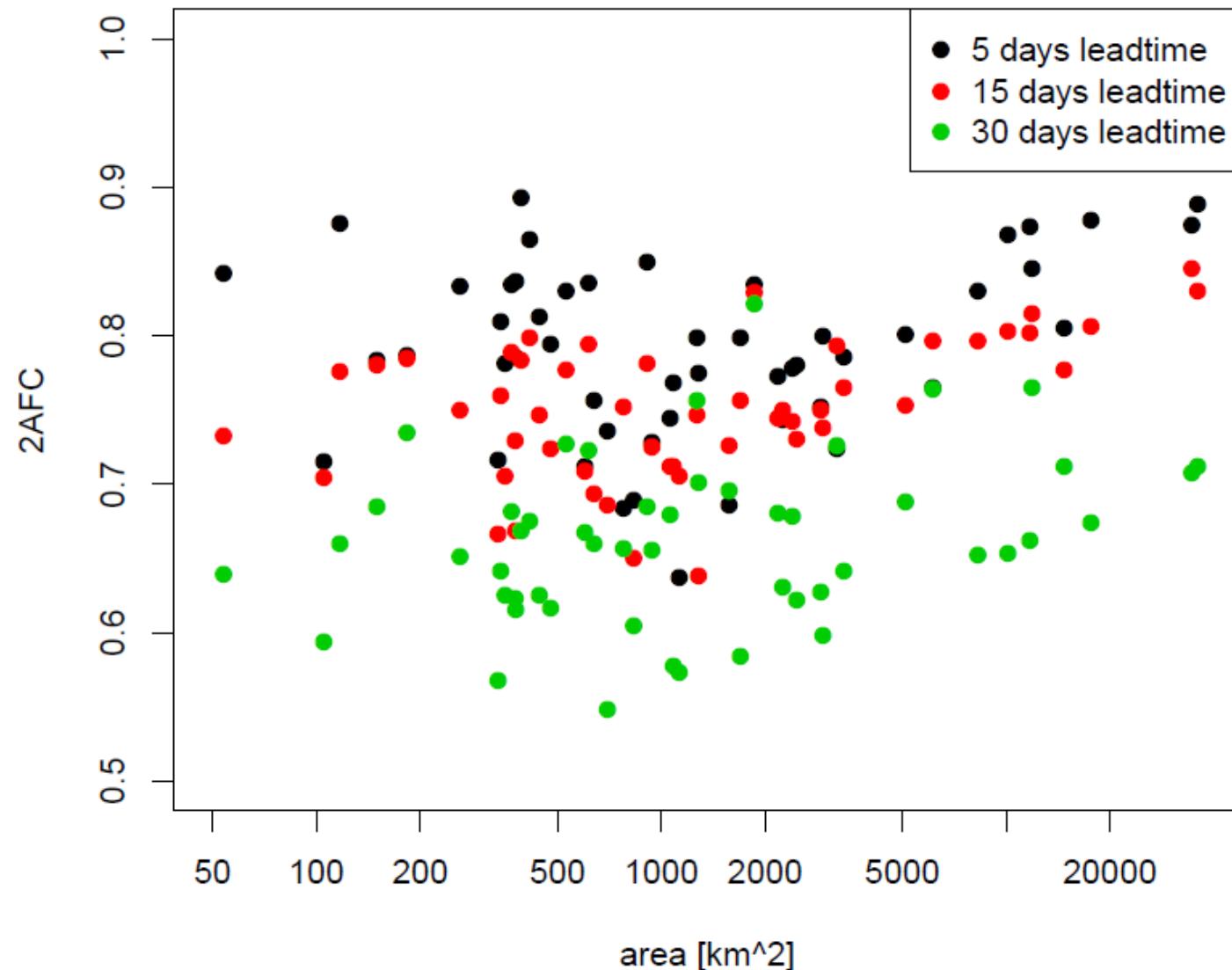
Perspectives for the Rhine

2AFC score vs. catchment size, thr: Q15 (monthly), HREF
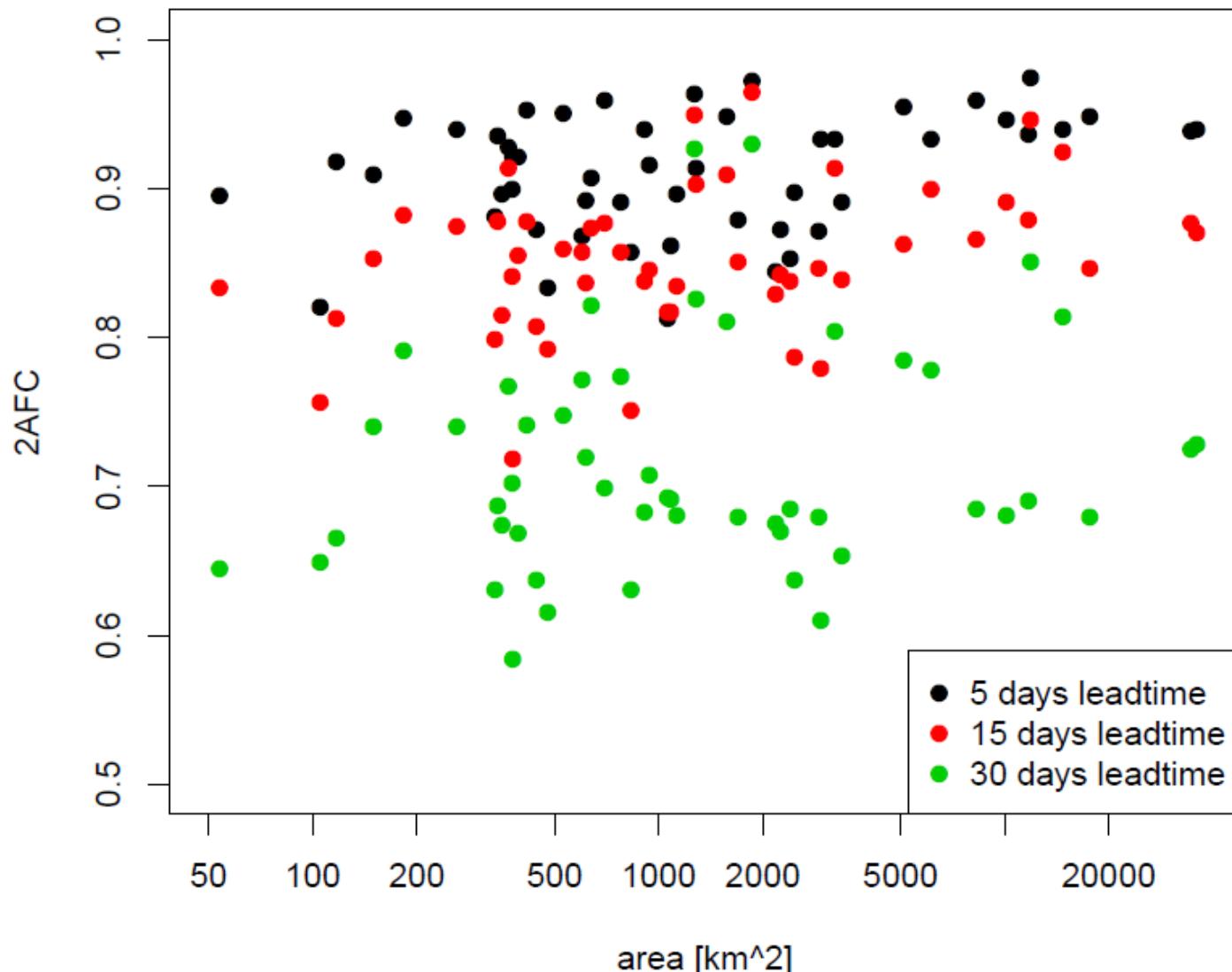
Perspectives for the Rhine

Nash–Sutcliffe efficiency VoA200

Legend:
- snow storage
- soil moisture storage
- lower zone runoff storage
- upper storage reservoir
- total runoff
- precipitation corrected

NS

leadtime [d]
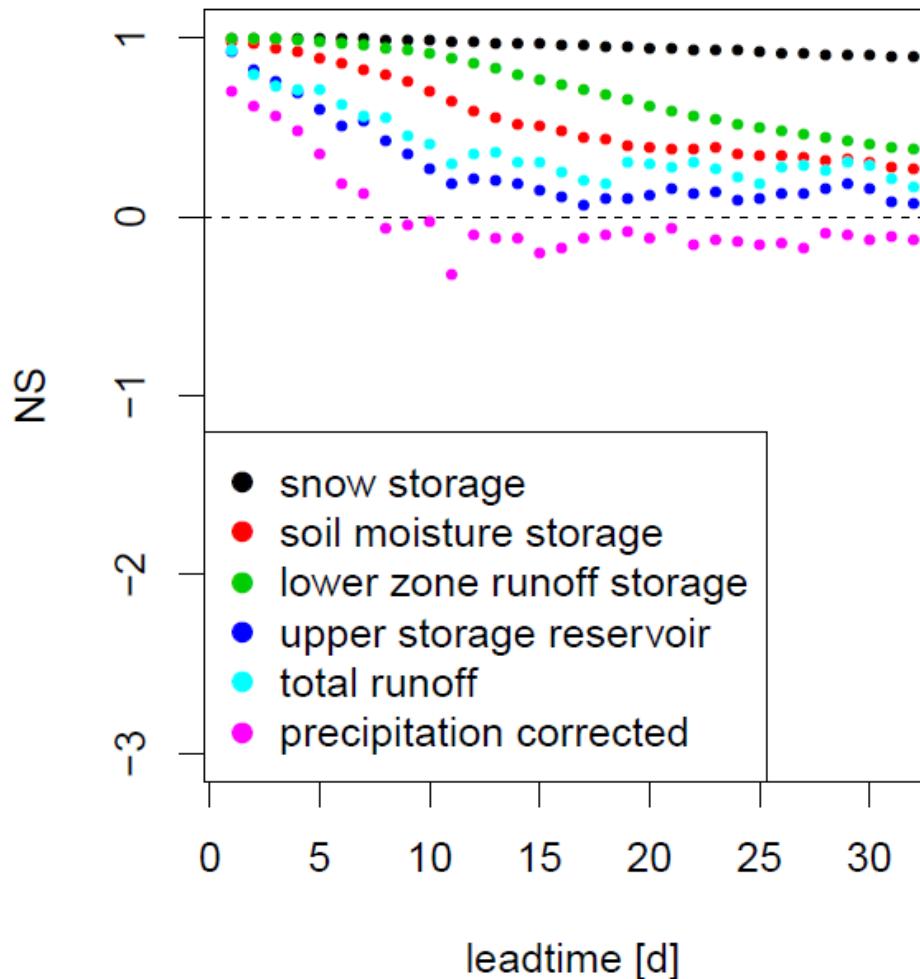
- Region Vorarlberg

- Model forecast vs model reference

- NSE of ensemble median

- Memory of storage components

Monthly ensemble low-flow predictions in Summer 2015

ECMWF

VarEPS
5 members

→ **PREVAH** →
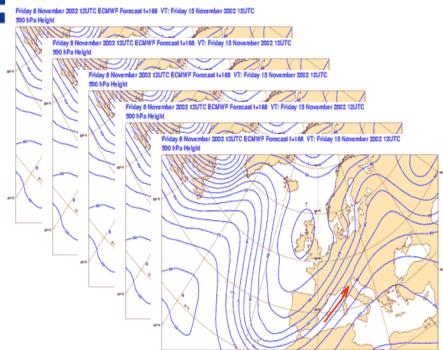
Q, SSM, SLZ
32 days forecast

- Quasi operational since April 2015

- Assessment of deviation from climatology

- FOEN Basins (Aggregation to 1000 km2 set

- Verification against reference run with observed meteorology

- Relative error and geometric average relative absolute error (GMRAE)

PROTOTYPE (c) WSL 2015-05-18

23

Forecast on October 22ⁿᵈ 2015

Runoff anomalies
Drought & Flood

Soil moisture anomalies
Drought & Flood

LT

1
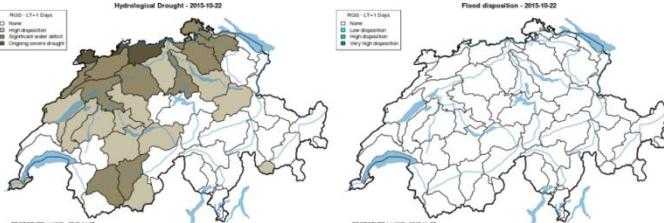
10

Quasi-operational? Forecast on October 22ⁿᵈ 2015, received on November 26ᵗʰ 21:00

15

20

30

24
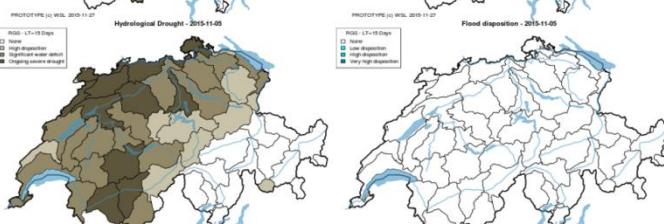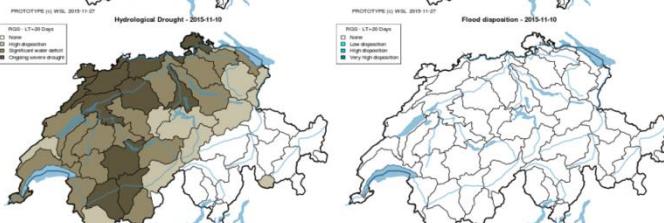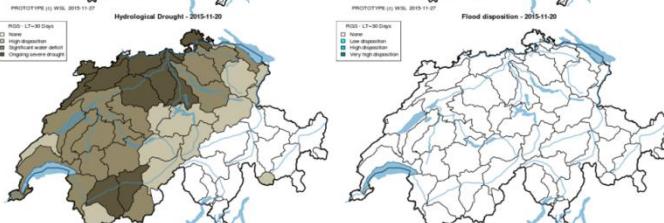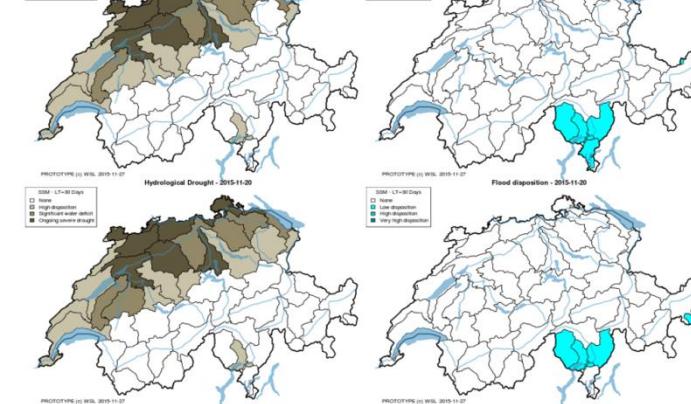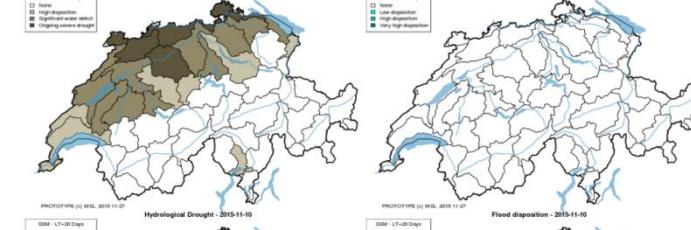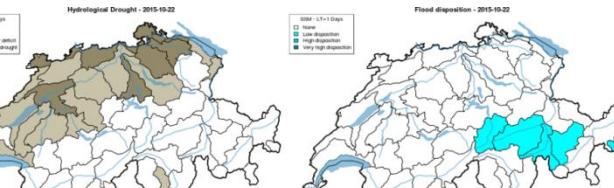
Forecast on July 16th 2015

Runoff anomalies
Drought & Flood

Soil moisture anomalies
Drought & Flood

LT

1

10

15

20

30
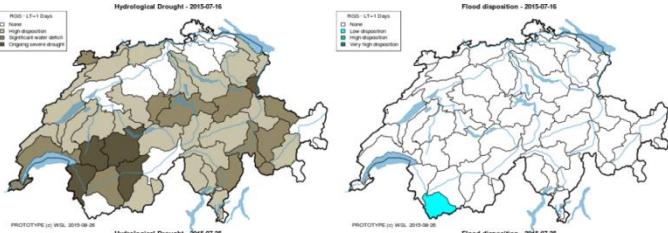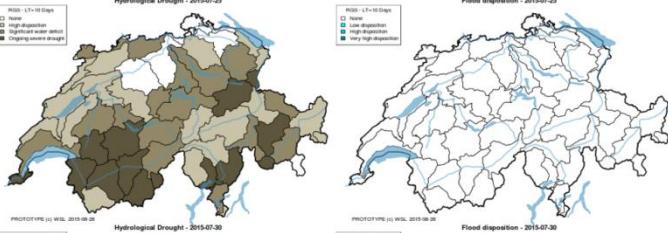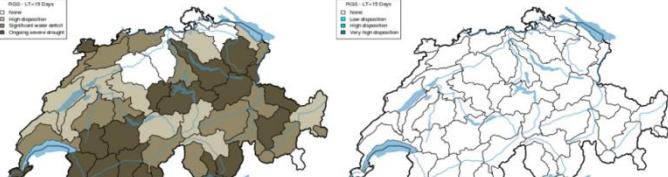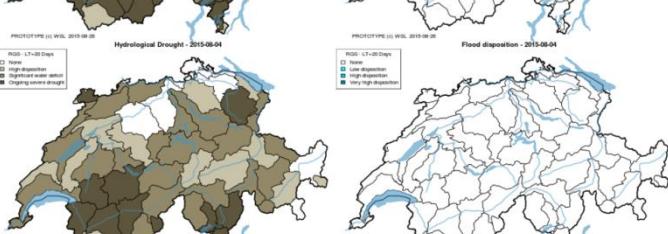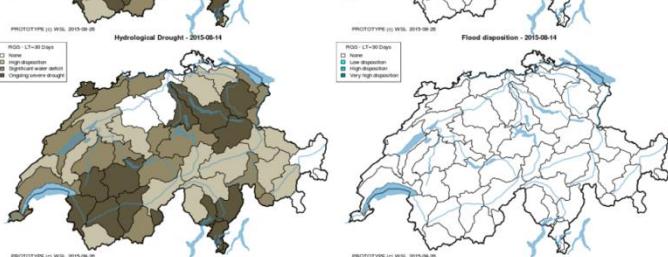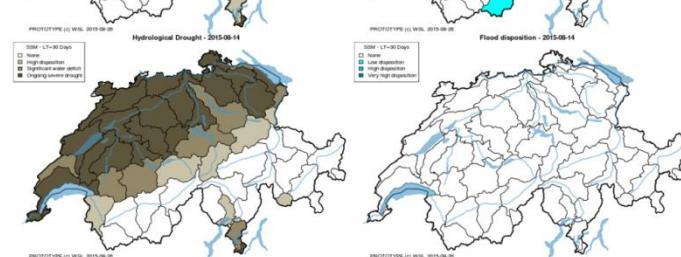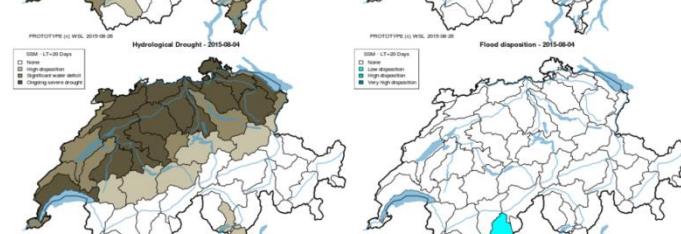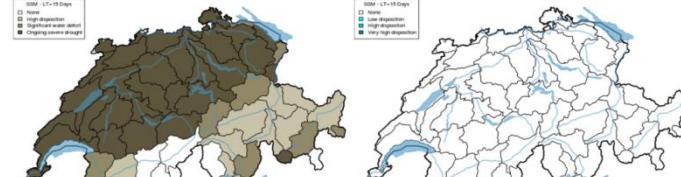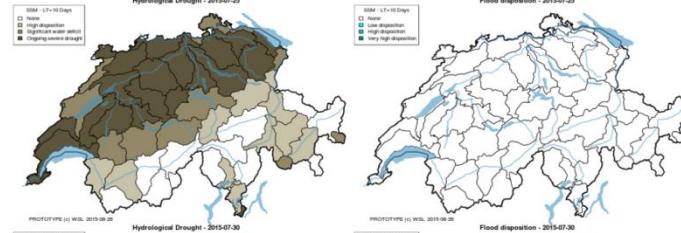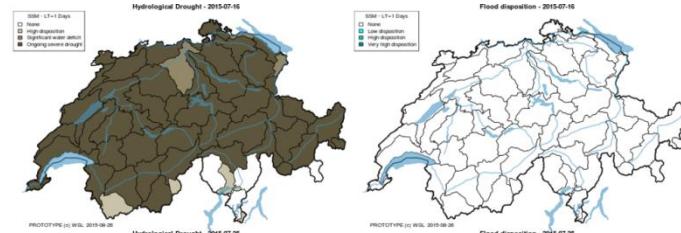
Selected monthly forecasts

RGS 2015-06-03

RGS 2015-06-10

RGS 2015-06-17

RGS 2015-06-24

RGS 2015-07-01

RGS 2015-07-08
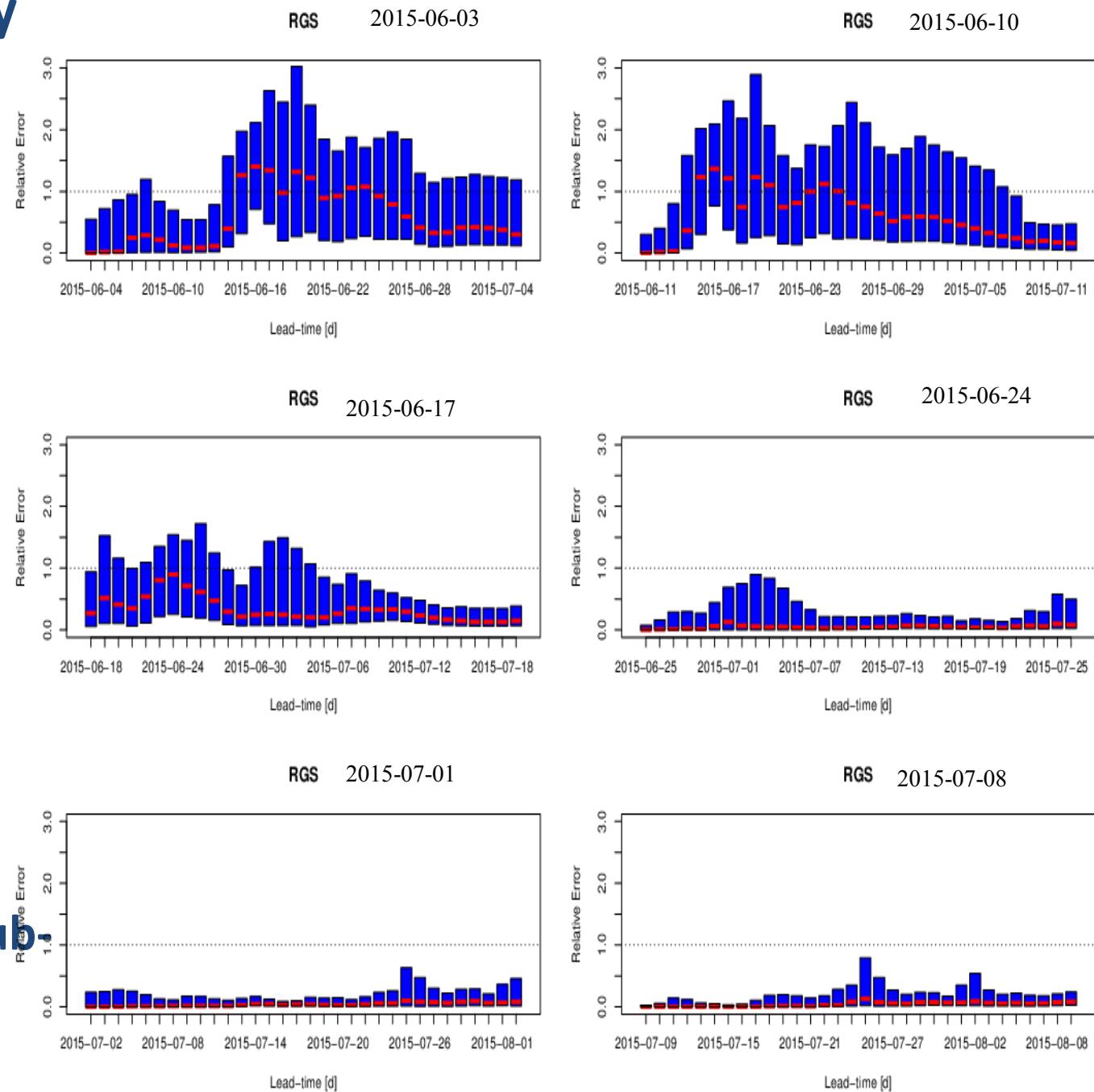
Relative error of discharge for 307 sub-basins

Räumliche Entwicklung des GMRAE:
## Abflussvorhersagen von 3 Wochen (Reihen) für Lead-times von 6, 14 und 32 Tagen (Spalten);

2015-06-03

2015-06-17

2015-07-01
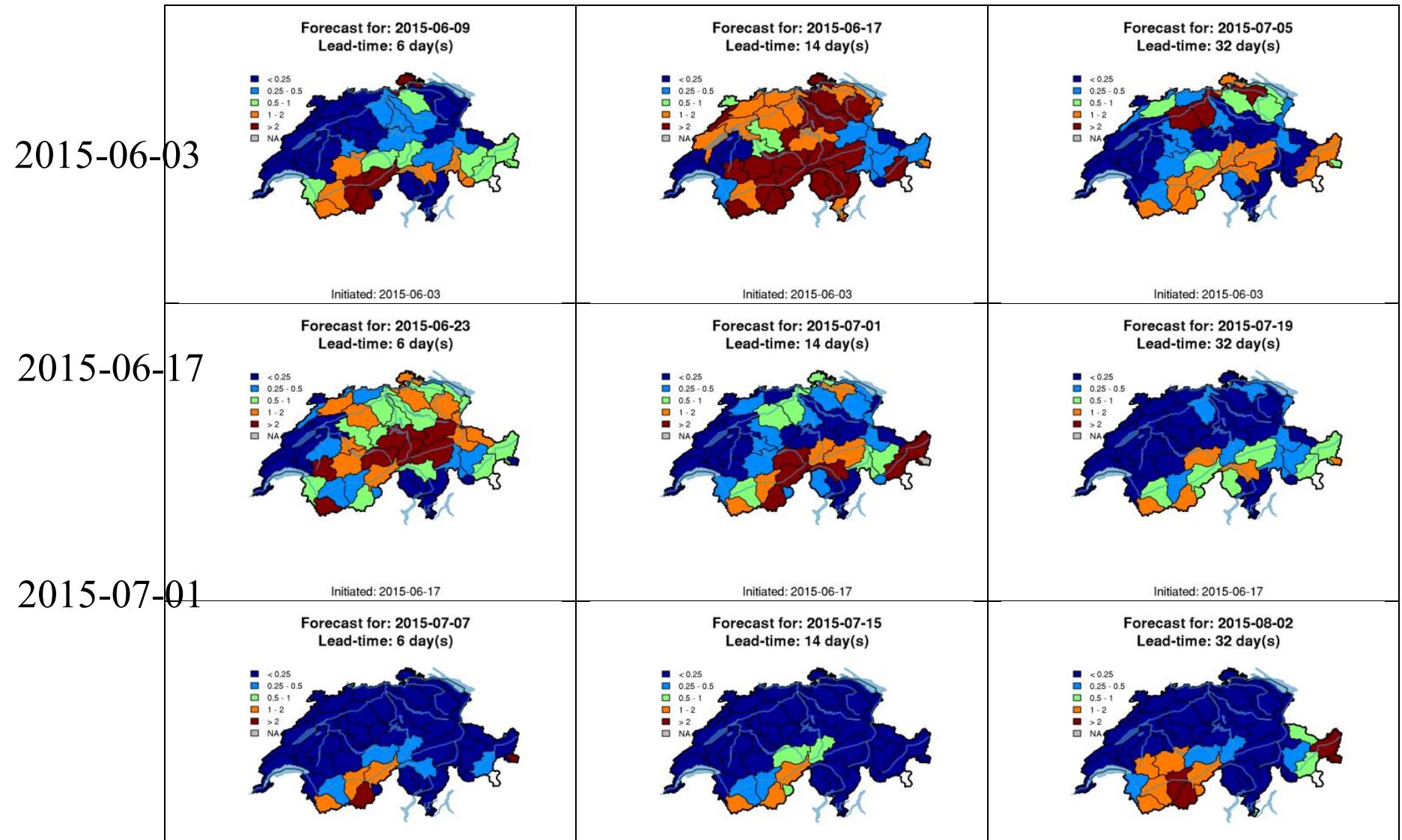
Gemittelter GMRAE über die einzelnen Monats-Vorhersagen (20 Wochen insgesamt) für: Abfluss RGS (oben), Bodenfeuchte SSM (unten)
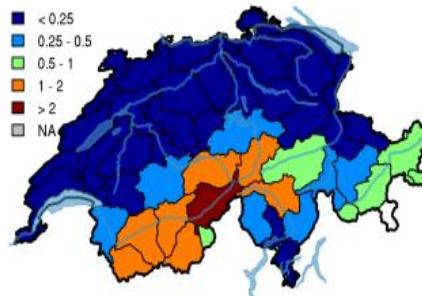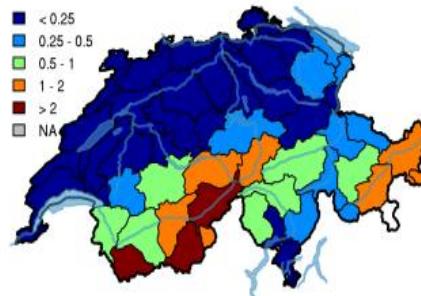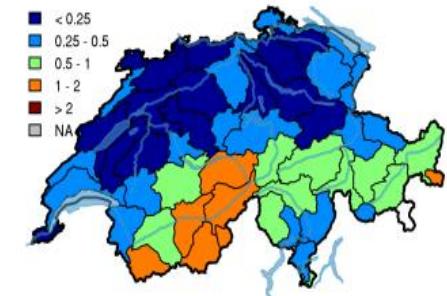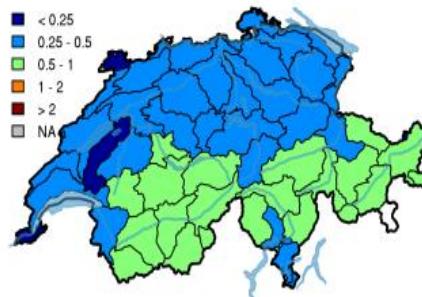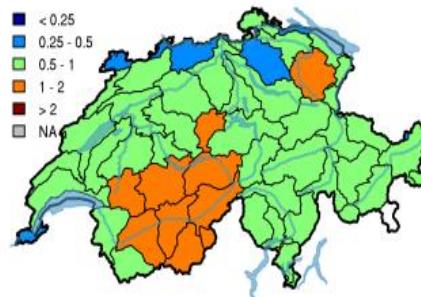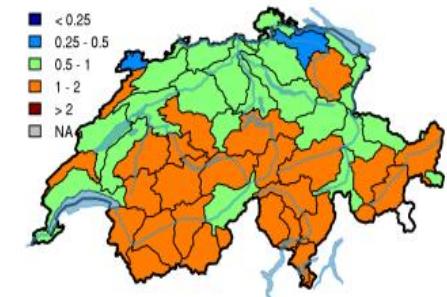
Energiewende
Nationales Forschungsprogramm NFP 70

HEPS4Power

Extended-range Hydrometeorological Ensemble Prediction System for Improved Hydropower Operations and Revenues
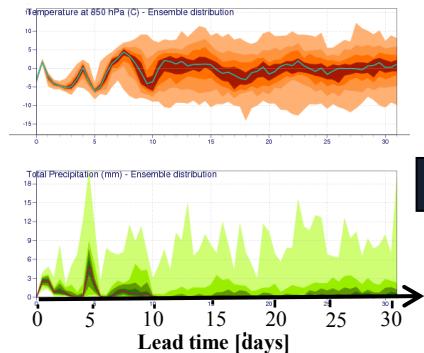
meteorological Ensemble forecasts
(ECMWF monthly forecasts)
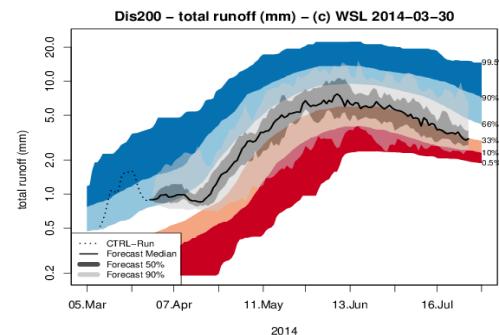
hydrological Ensemble forecasts
(different Models running at WSL)

(Foto: M. Funk, VAW)

Decision support for hydropower operations (inlcuding evaluation with economic measures)

- Connect meteorological models with hydrological models
- Providing extended-range runoff forecasts for hydropower plants
- PHD Student Samuel Monhart
- Collaboration with C. Spirig, M Liniger, Ch. Schär

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Swiss Federal Research Institute WSL.- massimiliano.zappa@wsl.ch

NOVELTY! Spatial verification: Basics
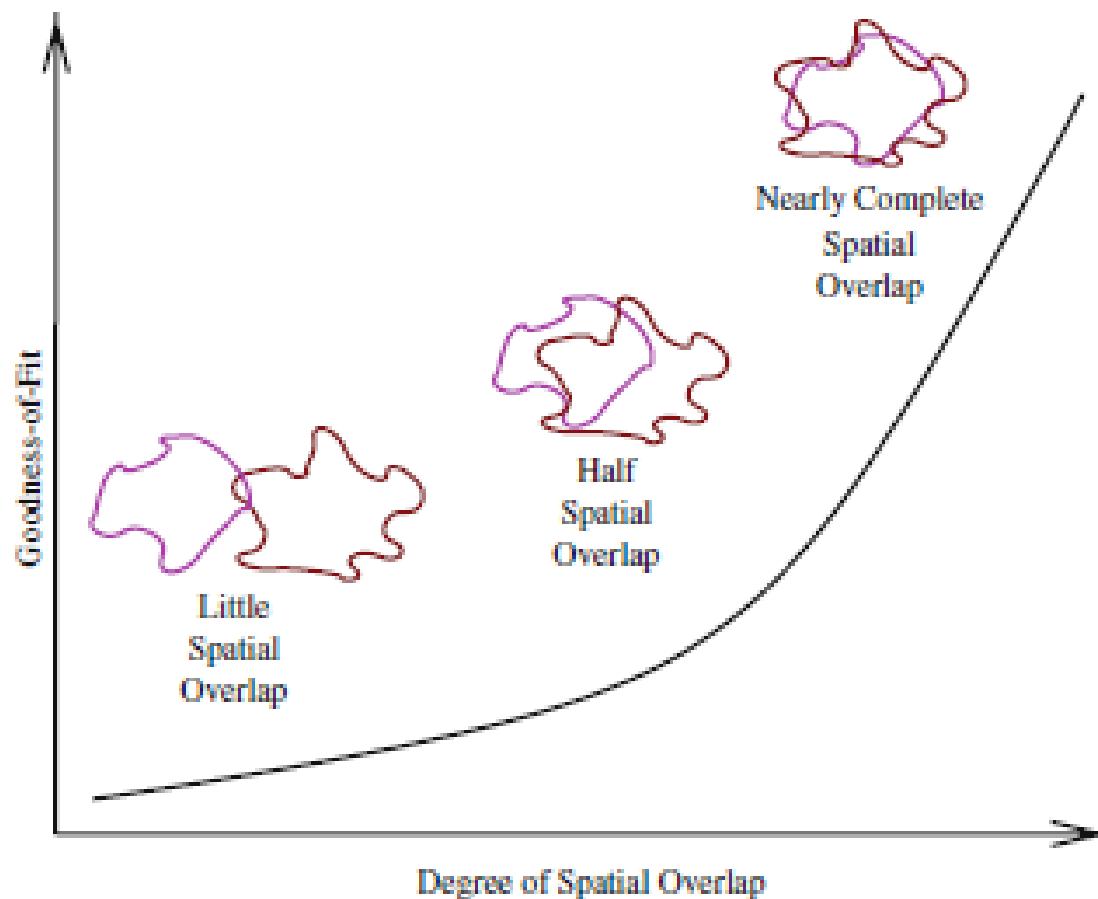
Hargrove, W. W., F. M. Homan, and P. F. Hessburg, 2006: Mapcurves: a quantitativemethod for comparing categorical maps. Journal of Geographical Systems, 8 (2), doi: 10.1007/s10109-006-0025-x.

Motivation