OPTIMISING OPERATIONAL RUNOFF FORECASTS WITH RESPECT TO WEATHER TYPES

TU VIENNA

Engineering Hydrology & Water Resources Management

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Overview

- Operational flood forecasting – some basics
- Methods, catchment and data
- Results – Mixing models to yield an optimised forecast with respect to different hydrological and meteorological situations
- Conclusions and outlook

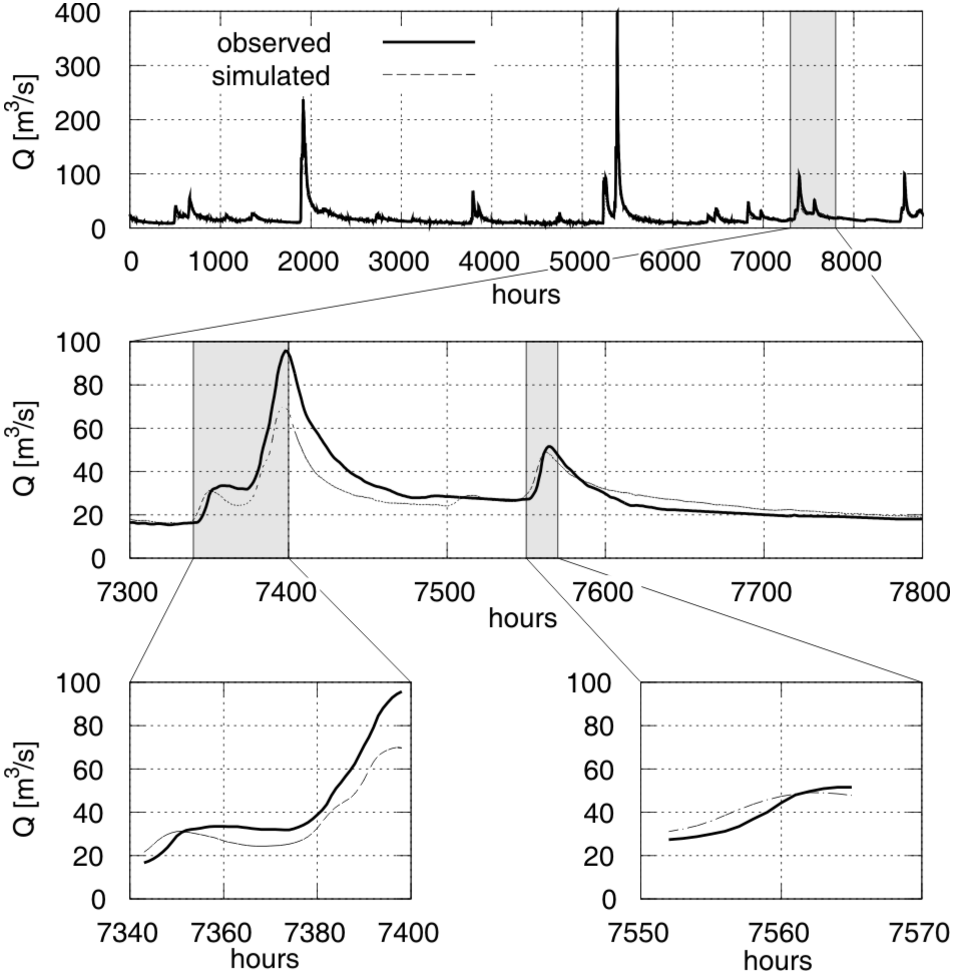
Hydrological forecasting

- Operational flood forecasting systems have often time-steps of 1h. → Gap between hydrology and meteorology
- Input data are:
  - observed discharge and precipitation (and/or temp.)
  - predicted precipitation (and/or temp.)
- The lead-time depends
  - on the physical concentration time of the catchment and
  - on the lead-time of the meteorological forecast‘s input
- The model performance depends on the ability of the model to describe the dominant process(es) of wave propagation and rainfall-runoff translation.

The performance of flood forecasting models

- The performance of different models under different hydrologic and/or meteorologic situations changes depending on the dominant process.
- Up to now weather class information is not used in operational flood forecasts. → How does model performance change with the weather type? Can this information be used in operational mode? Does the dominant hydrologic process correlate with the occuring weather type?
- Flood forecasting models should give good results during floods. (!) → Example

Example - Simulation



	one year (8760 values)	period (501 values)	rising limbs (69 values)
Q_{obs}	19.511	29.824	42.293
Q_{sim}	18.692	28.136	37.084
R^2	0.947	0.887	0.884
nme	-0.042	-0.057	-0.123
nsdve	0.268	0.233	0.195
nsme	0.940	0.784	0.755

Evaluating performance over the whole validation period does not show performance especially during floods, which can differ considerably.

→ Separation of rising limbs and everyday situation

The idea of mixing models

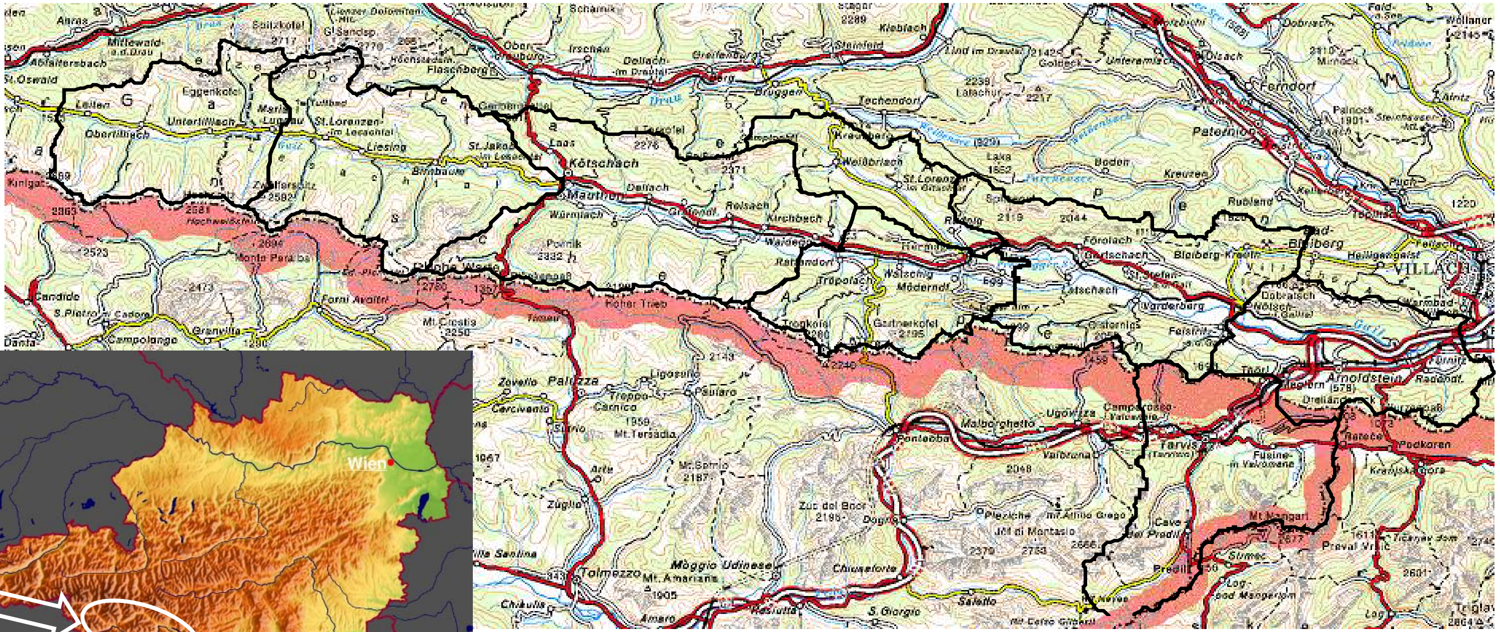
- If there are different models, each of them able to describe other processes and having therefore better results for different situations ...
- they can be combined to an optimised forecast depending on the ongoing hydrological and/or meteorological situation for improving the model performance.
- The performance of the optimised forecast should be better than the one of the best single model.

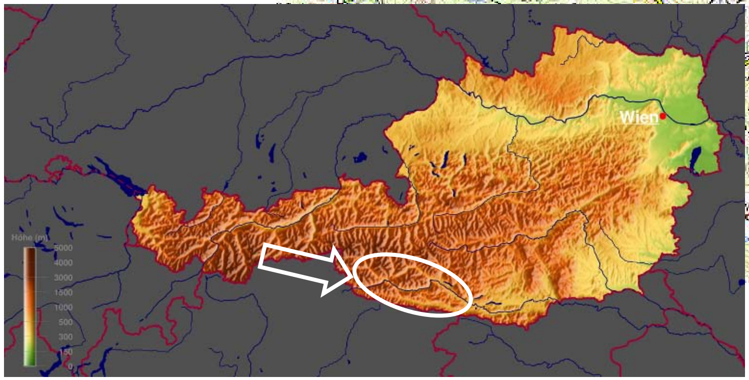
Methodology

- Deriving mixing parameters for different situations should give different weights for the single models.
- Separating hydrographs into rising limbs and everyday situation displays hydrological situations.
- Subdividing rising limbs into weather situations builds sets of hydro-meteorological situations.
- Performance measures *nsme* and R^2 are used for deriving the weights for the WAM.
- A regression model is compared to the WAM-model.

Catchment, models and weather situations

Catchment: river Gail in Carinthia, ~1400 km², 1200-1500mm/a, length ~120km, altitude 518 - 2780 m.a.s.l.





Data and Hydrological Models

Q (5 gauges) and N (areal rainfall) data 2000-2005, time-step: 1h

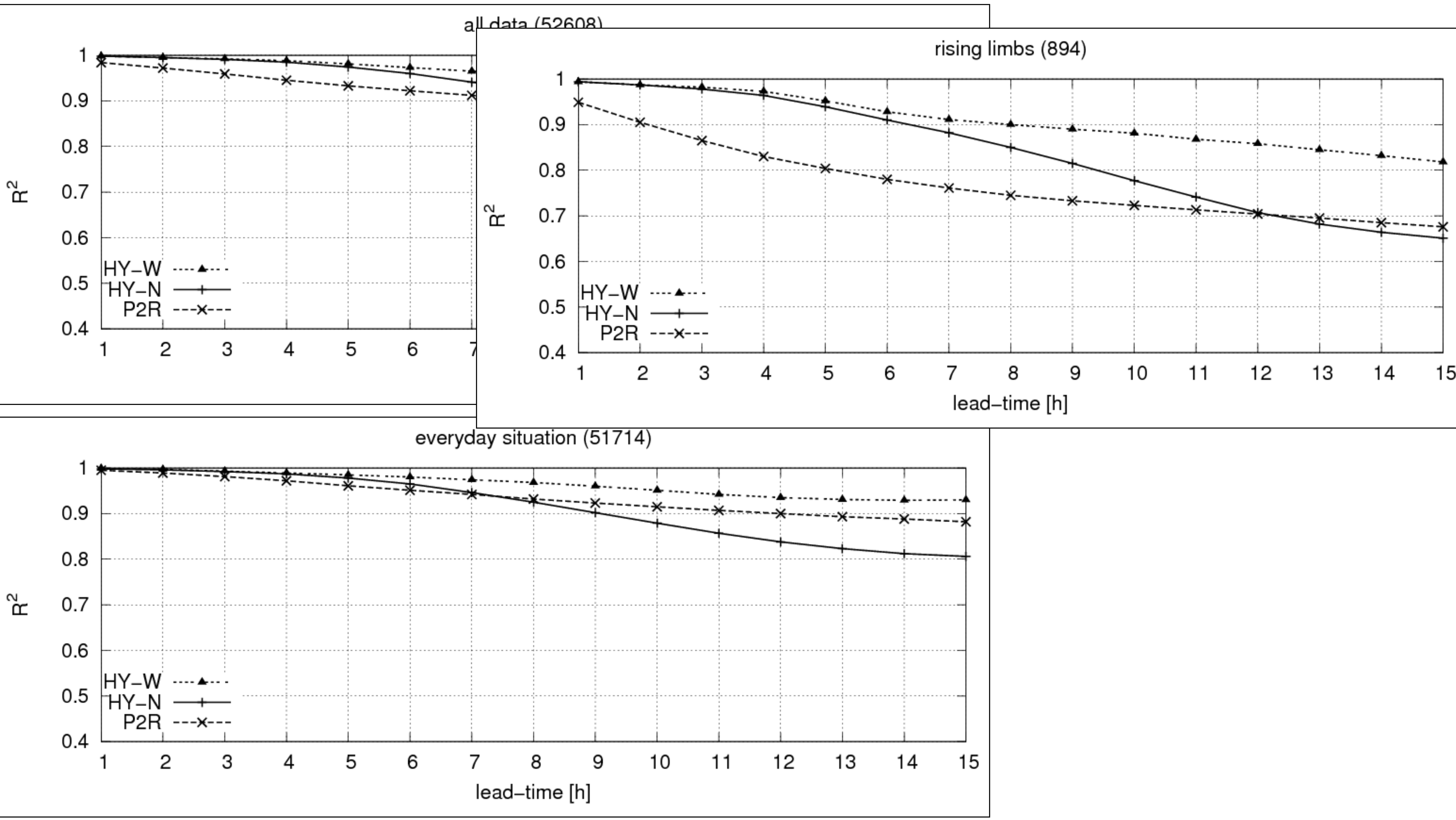
HYSIM (late 1980ies, early 1990ies for electricity company VERBUND to optimise energy production) in two configurations:

HY-W: only runoff routing from gauge to gauge (describing the everyday situation)

HY-N: runoff routing with rainfall-runoff process at the headwater catchment and lateral inflow inbetween gauges. Threshold of accumulated effective rainfall starts RR-process modelling. (describing flood waves)

P2R: HBV-type, water-balance-model including snow-accumulation and snowmelt, in this case not distributed, catchment as one unit.

Step 1: Model performance for the hydrological situations



Step 2: Weather type classification (ZAMG WLK without humidity index)

	Σ	AA	AC	CA	CC
00	130				
01 NE	1215	632	468	59	56
02 SE	627	215	123	162	127
03 SW	3088	1554	567	724	243
04 NW	3708	2374	1065	199	70
		4775	2223	1144	496

Classification for Austria 2000 – 2005 in 6h-timesteps

All data

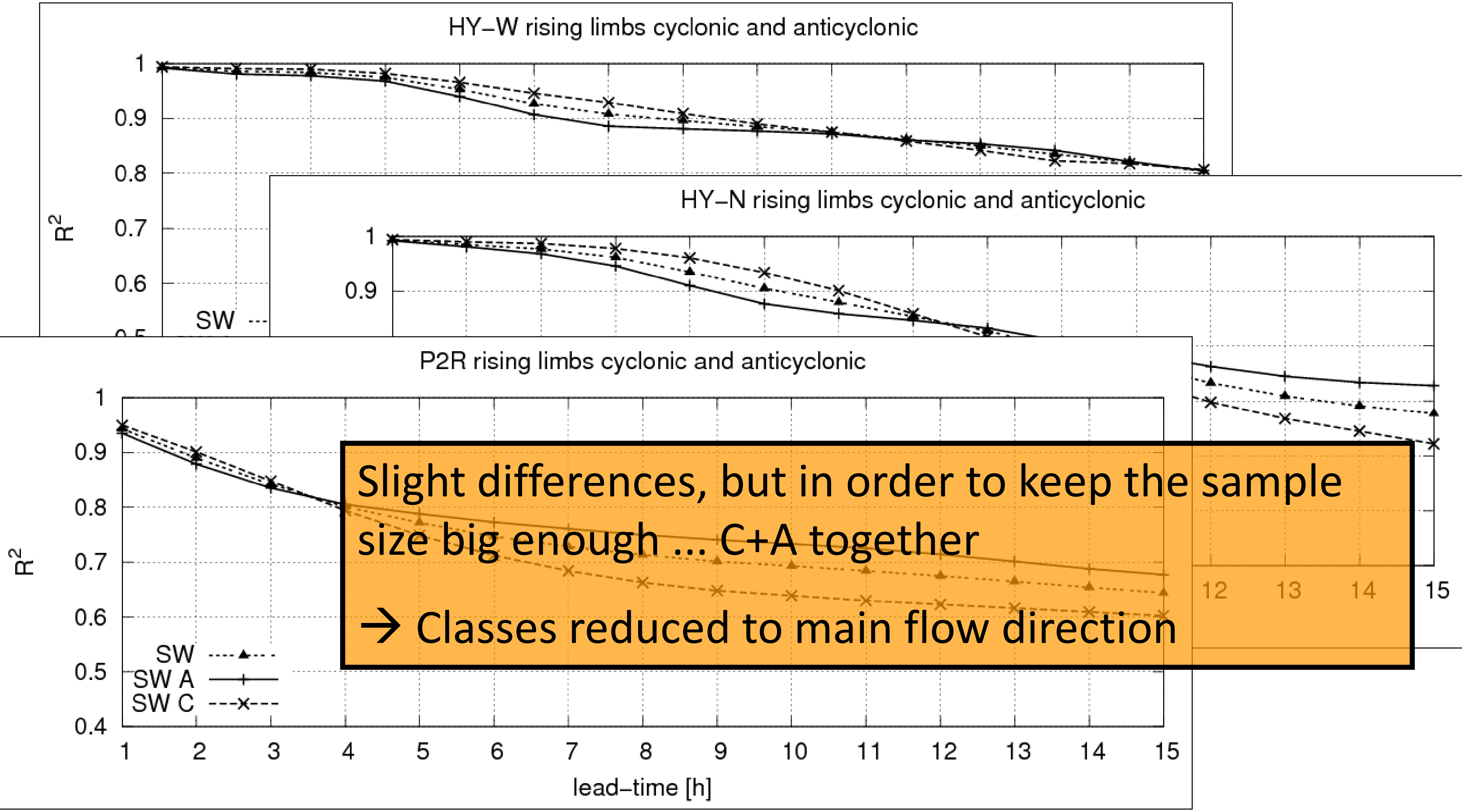
	Σ	AA	AC	CA	CC
00	12				
01 NE	55	0	25	0	30
02 SE	154	27	51	33	43
03 SW	545	122	142	175	106
04 NW	128	50	65	9	4
		199	283	217	183

Classification for the rising limbs at Villach

Rising limbs

Vb weather type, Genoa low

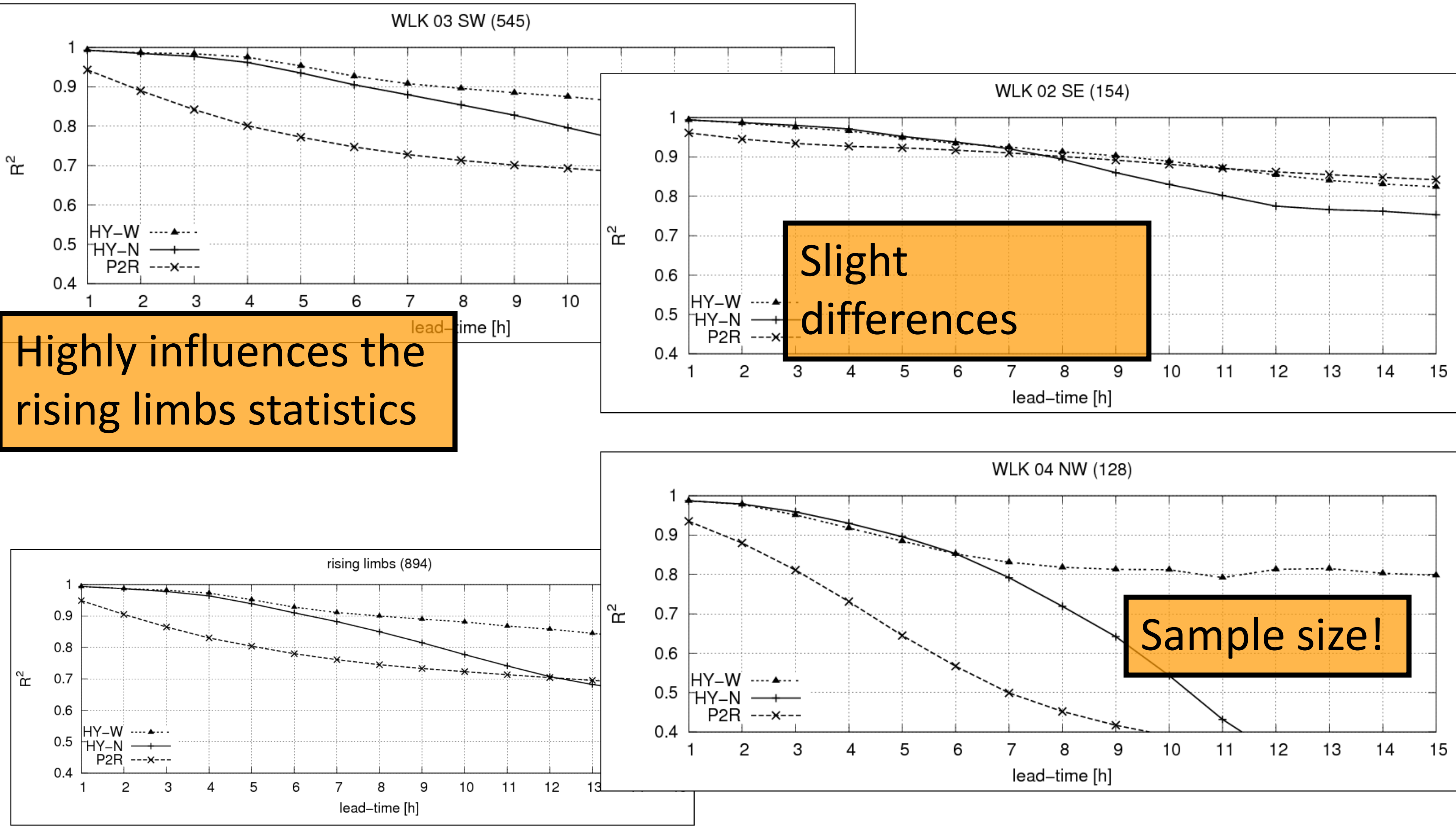
Step 2: Model performance for rising limbs cyclonic – anticyclonic conditions



Slight differences, but in order to keep the sample size big enough … C+A together

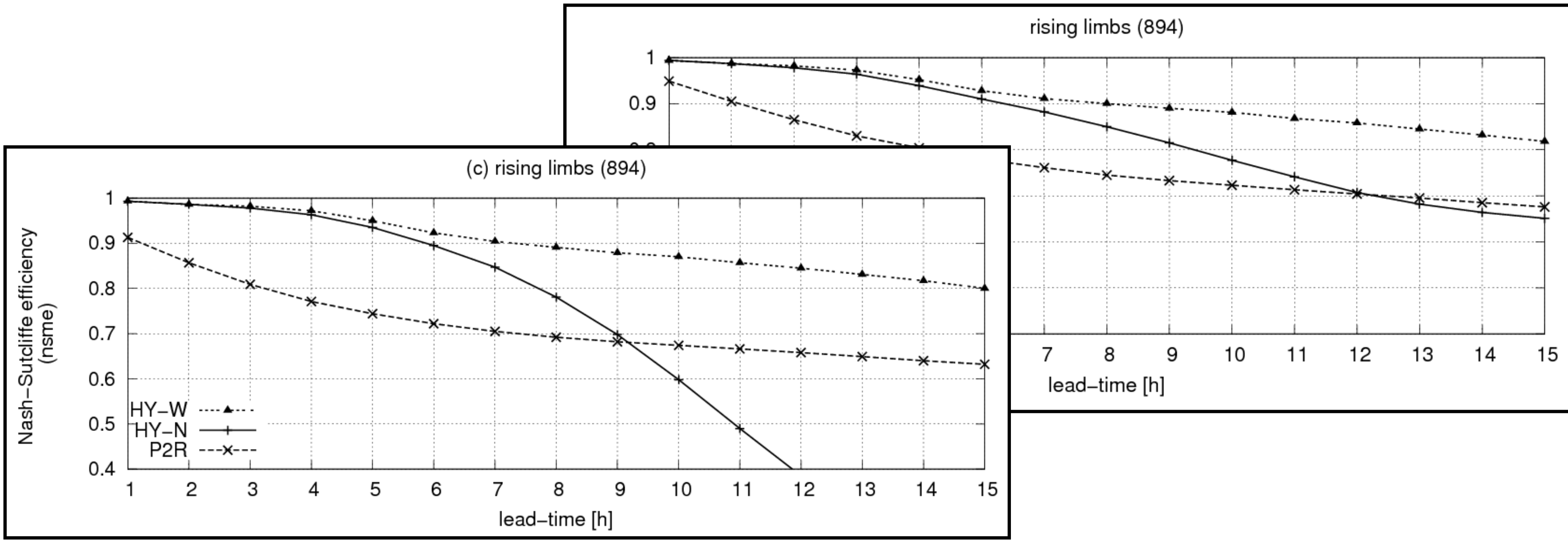
→ Classes reduced to main flow direction

Step 3: Model performance for rising limbs under different flow directions (R^2)

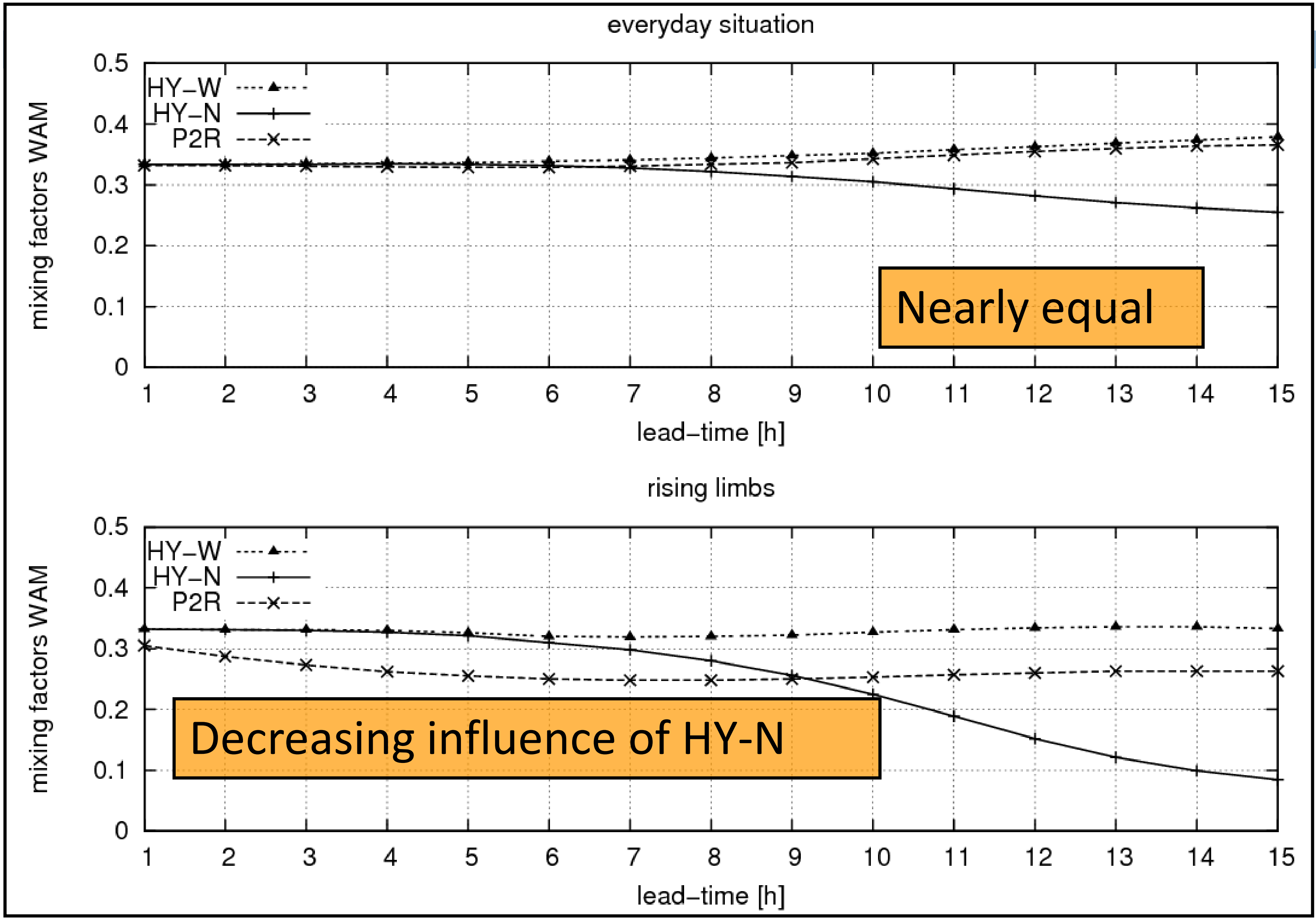


Step 4: Mixing parameters

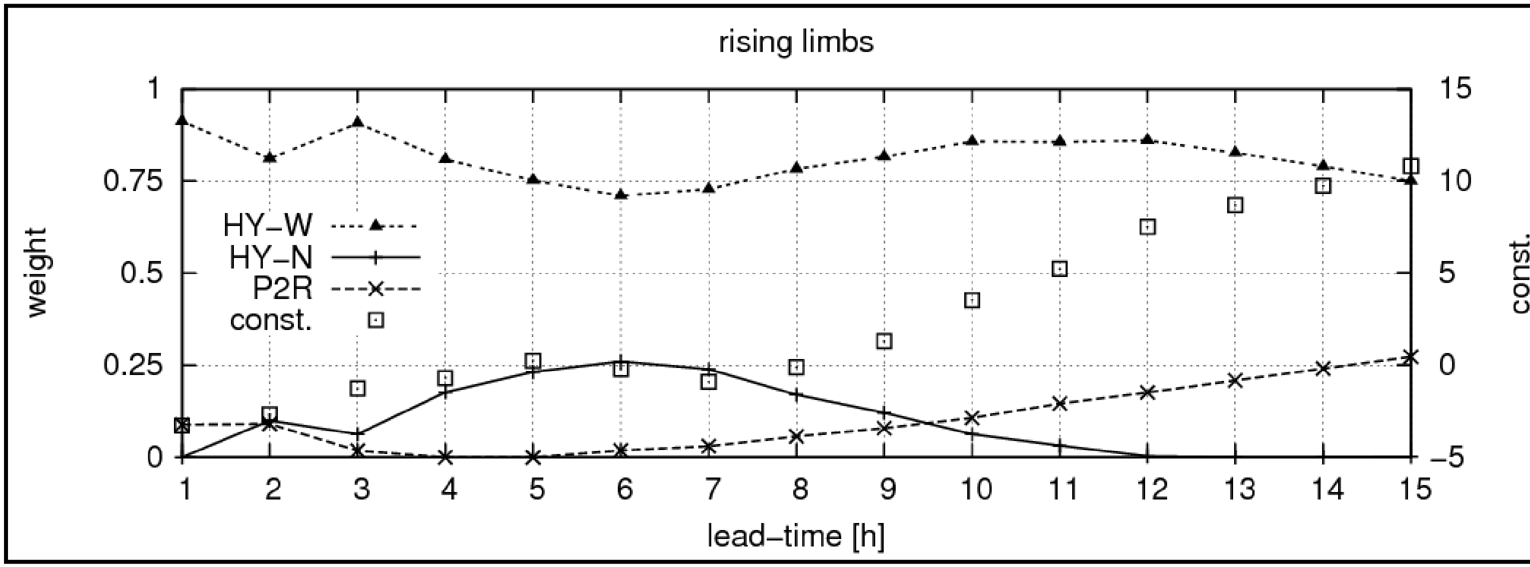
- The mixing parameters are derived from the model performance. The optimised forecast then is a weighted mean.
- Nash-Sutcliffe model efficiency differs more than R^2 (nsme is pronouncing higher floods)
  → mixing parameters are calculated from nsme.



Step 4: Mixing parameters nsme-WAM

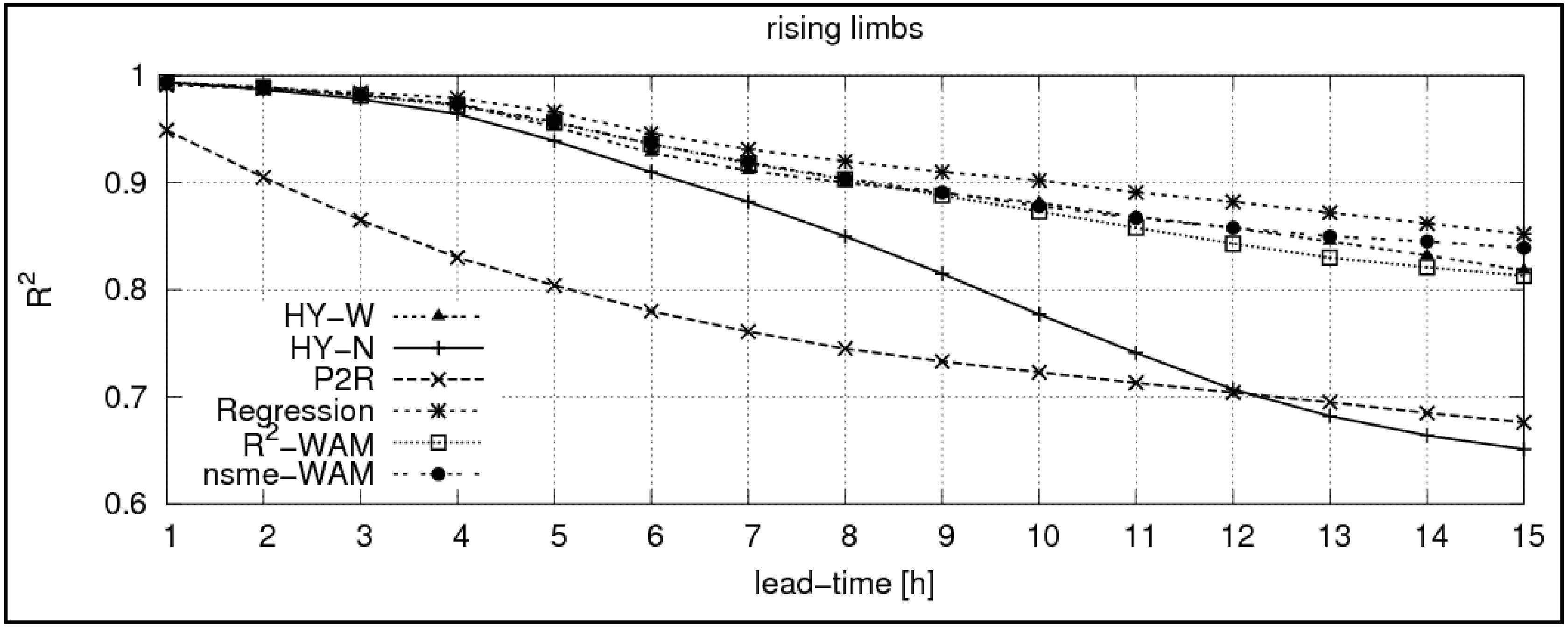


Step 4: Regression model



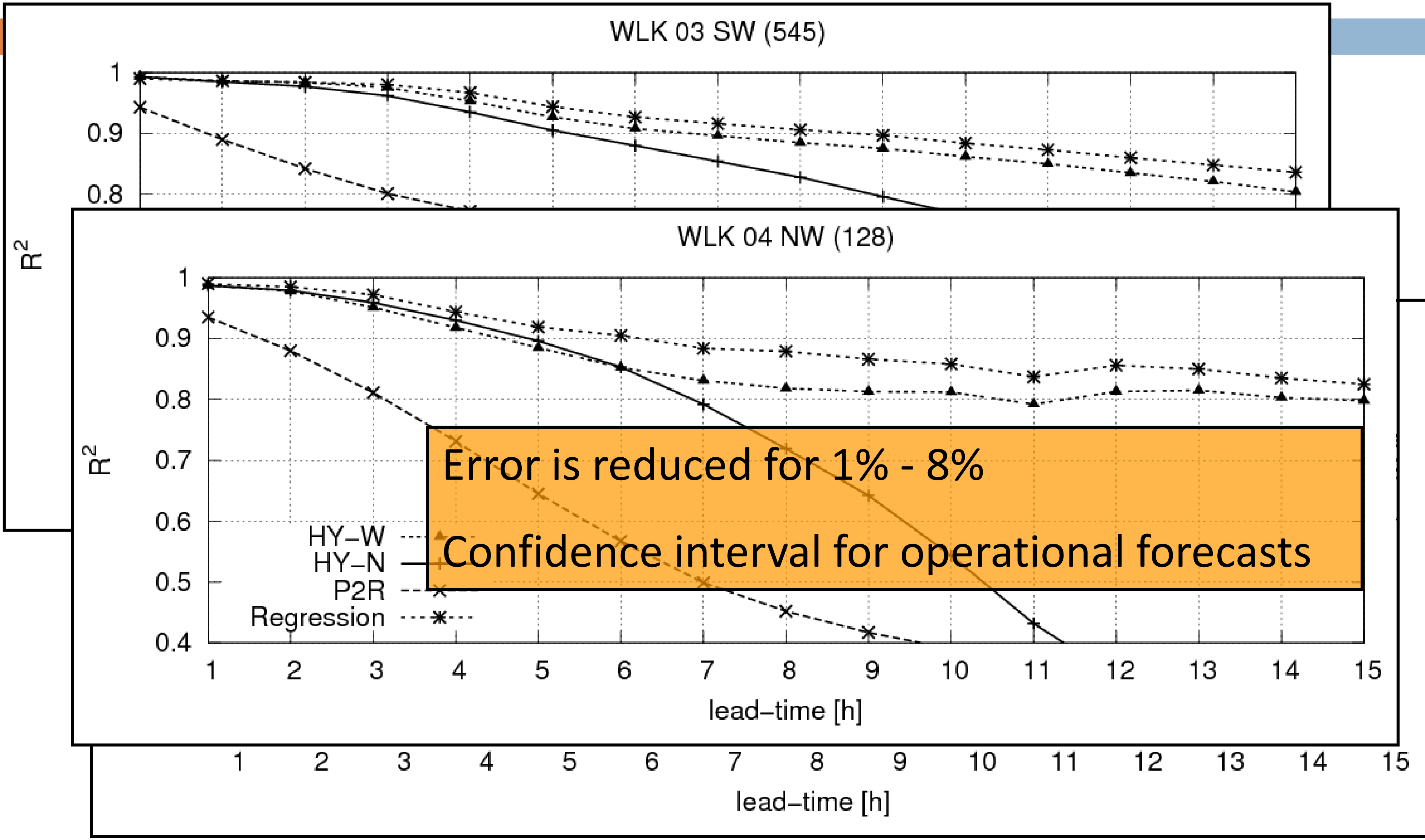
Most weight on HY-W
Bias with increasing lead-time

Performance of the optimised forecasts – rising limbs



… success!
Mixing model performance is higher than the best single model

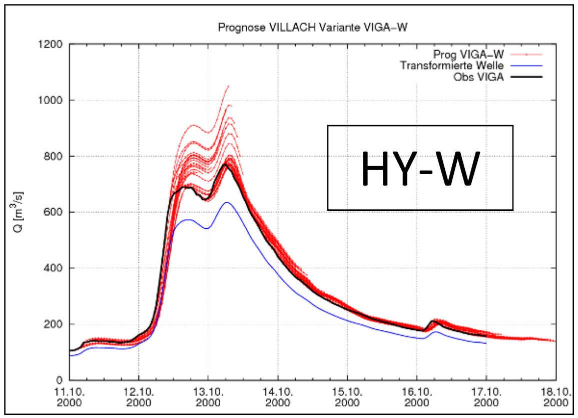
Performance of the optimised forecasts – rising limbs and weather conditions

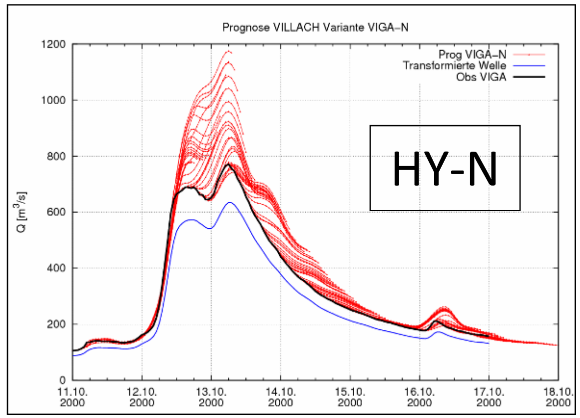


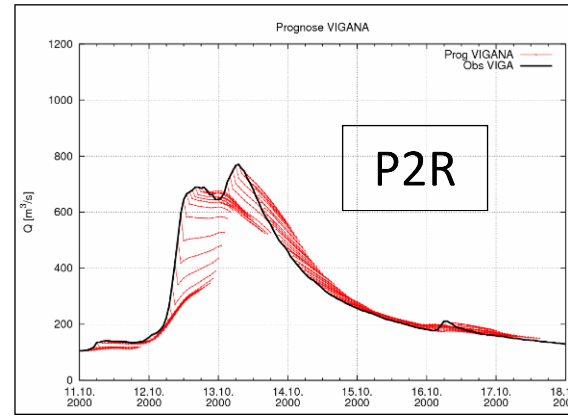
Error is reduced for 1% - 8%

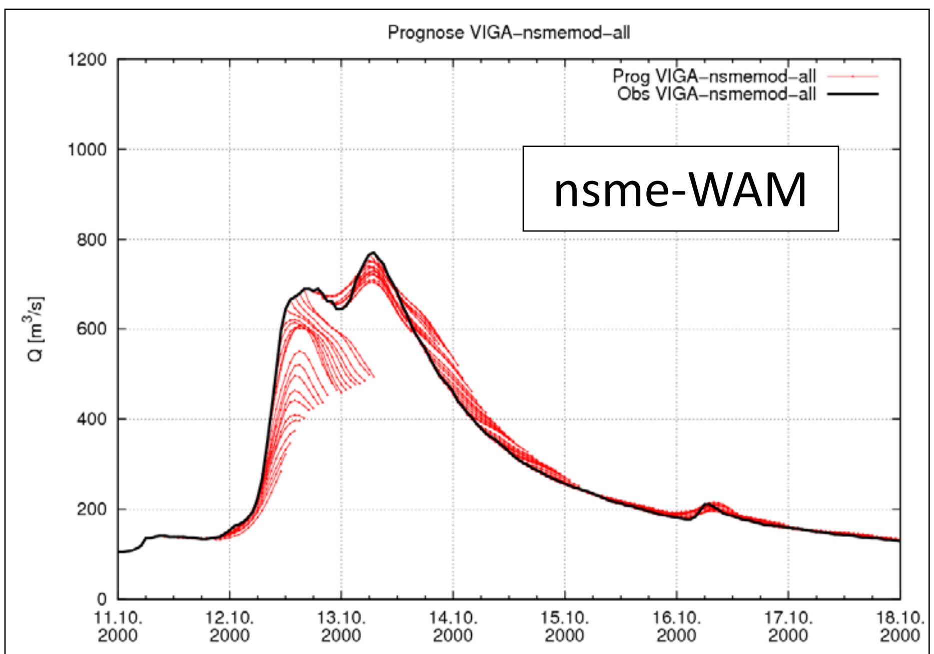
Confidence interval for operational forecasts

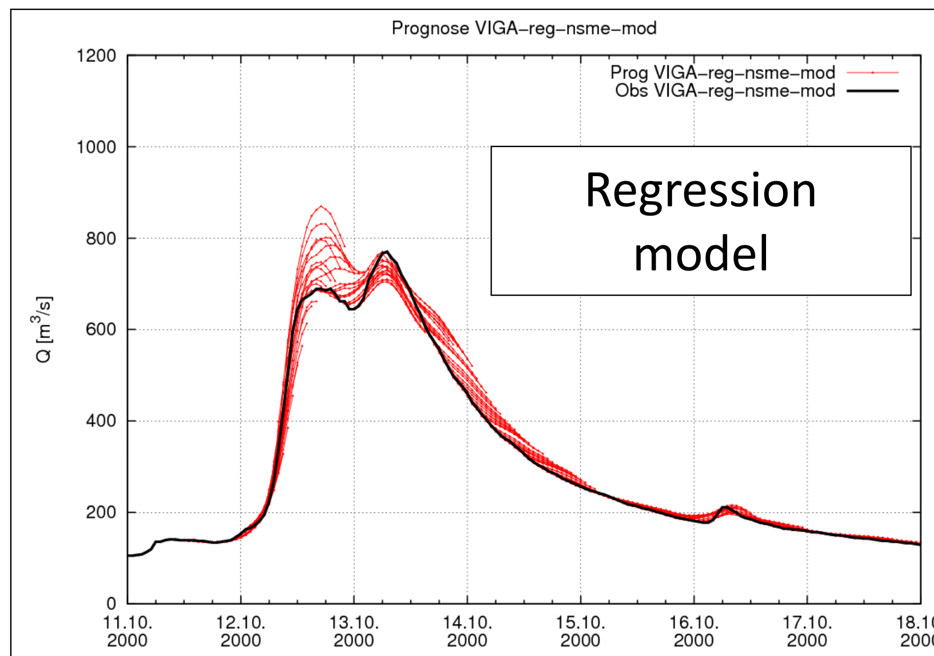
Example


Prognose VILLACH Variante VIGA–W
Prog VIGA–W
Transformierte Welle
Obs VIGA
HY-W
Q [m³/s]
1200
1000
800
600
400
200
0
11.10. 2000
12.10. 2000
13.10. 2000
14.10. 2000
15.10. 2000
16.10. 2000
17.10. 2000
18.10. 2000


Prognose VILLACH Variante VIGA–N
Prog VIGA–N
Transformierte Welle
Obs VIGA
HY-N
Q [m³/s]
1200
1000
800
600
400
200
0
11.10. 2000
12.10. 2000
13.10. 2000
14.10. 2000
15.10. 2000
16.10. 2000
17.10. 2000
18.10. 2000


Prognose VIGANA
Prog VIGANA
Obs VIGA
P2R
Q [m³/s]
1200
1000
800
600
400
200
0
11.10. 2000
12.10. 2000
13.10. 2000
14.10. 2000
15.10. 2000
16.10. 2000
17.10. 2000
18.10. 2000


Prognose VIGA–nsmemod–all
Prog VIGA–nsmemod–all
Obs VIGA–nsmemod–all
nsme-WAM
Q [m³/s]
1200
1000
800
600
400
200
0
11.10. 2000
12.10. 2000
13.10. 2000
14.10. 2000
15.10. 2000
16.10. 2000
17.10. 2000
18.10. 2000


Prognose VIGA–reg–nsme–mod
Prog VIGA–reg–nsme–mod
Obs VIGA–reg–nsme–mod
Regression model
Q [m³/s]
1200
1000
800
600
400
200
0
11.10. 2000
12.10. 2000
13.10. 2000
14.10. 2000
15.10. 2000
16.10. 2000
17.10. 2000
18.10. 2000

Conclusions and outlook

- Hydrological models show different performance under different hydro-/meteorological conditions.
- Flood forecasts can be optimised by applying a mixing model or regression model regarding to these conditions.
- There are differences in performance during different weather types
  → implementation leads to open questions
  … question of time-resolution
  … confidence interval
- The regression model (using discharge data = direct method) shows better accuracy than the both WAM-models (using performance measures = indirect method).