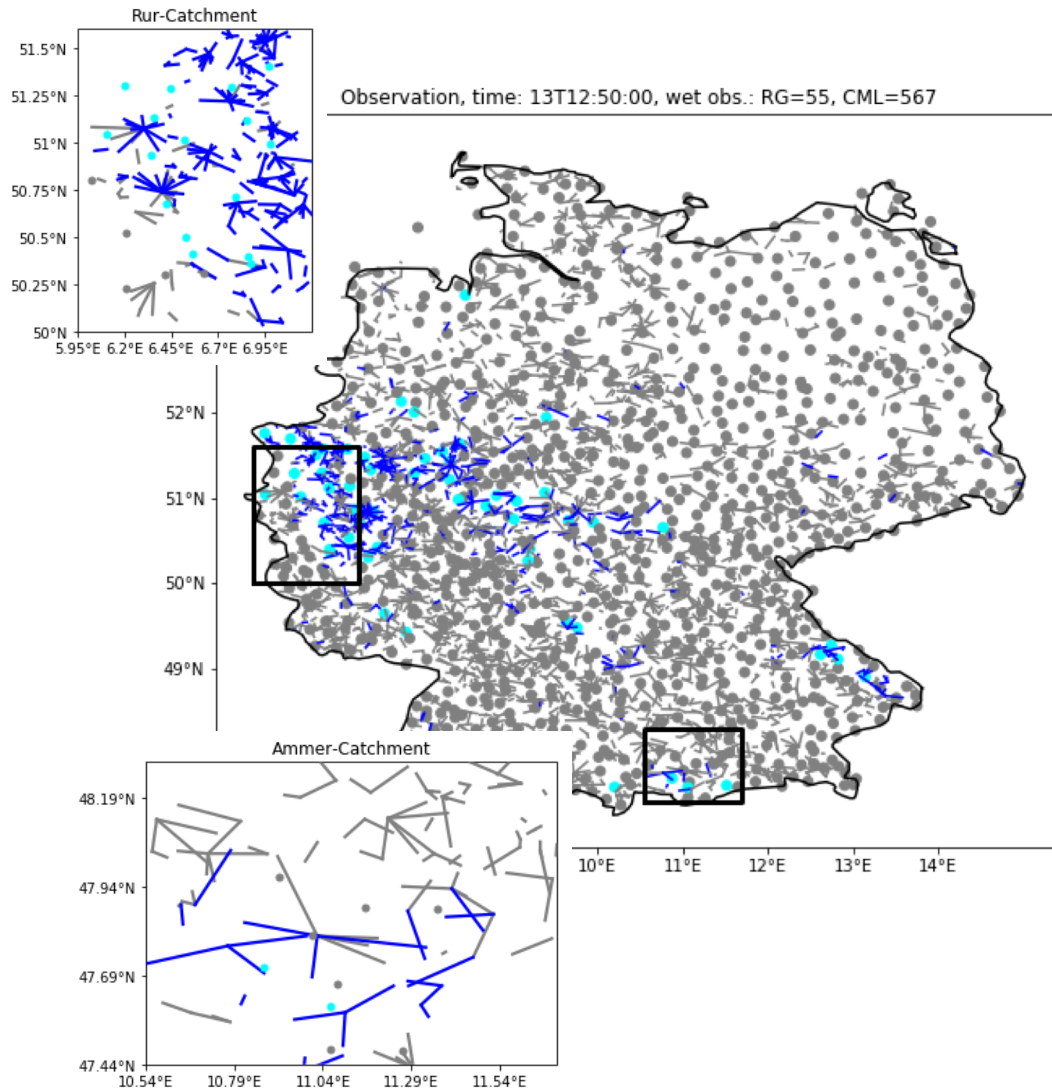


Evaluation of the spatial distribution of a stochastically reconstructed ensemble of precipitation fields using RMWSPy

Barbara Haese, Nico Blettner, Sebastian Hörning, Marco Linder, Christian Chwala, and Harald Kunstmann

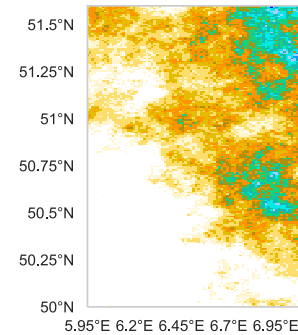
Goal: How to reconstruct continuous rainfall fields from limited and heterogeneous observations?



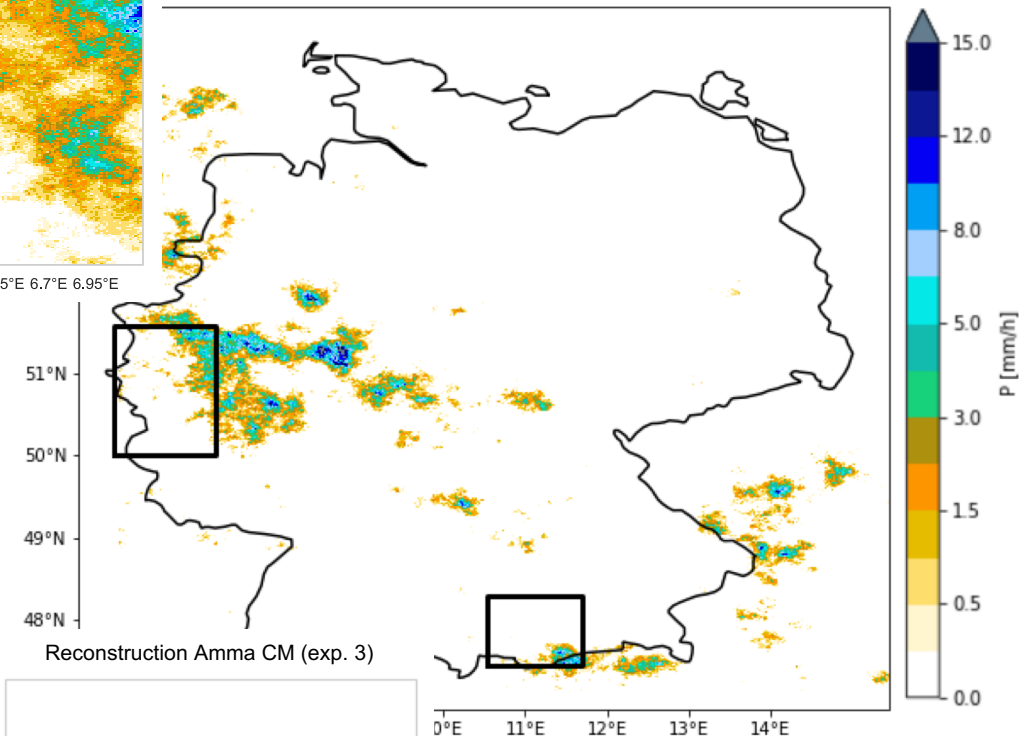
Challenges:

- Dealing with uncertainties
- Dealing with sparse data
- Reproducing the correct spatial-temporal distribution

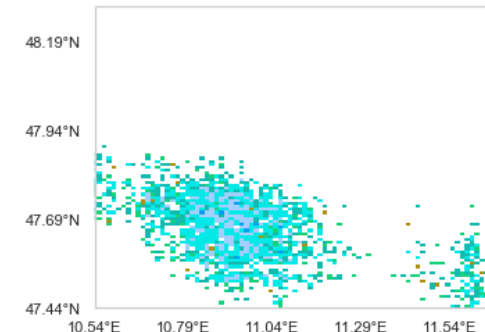
Reconstruction Rur CM (exp. 2)



Country wide reconstruction (exp 1), 2018-05-13 12:50



Reconstruction Amma CM (exp. 3)



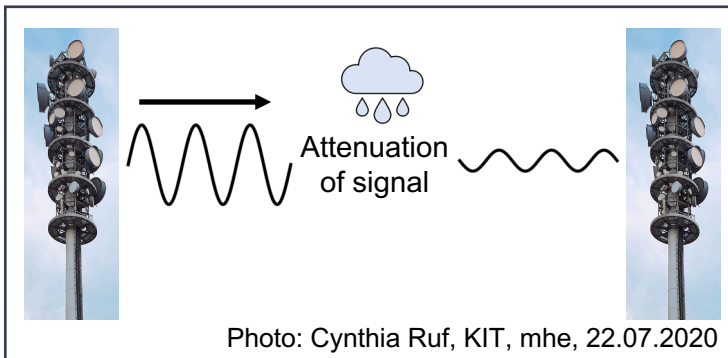
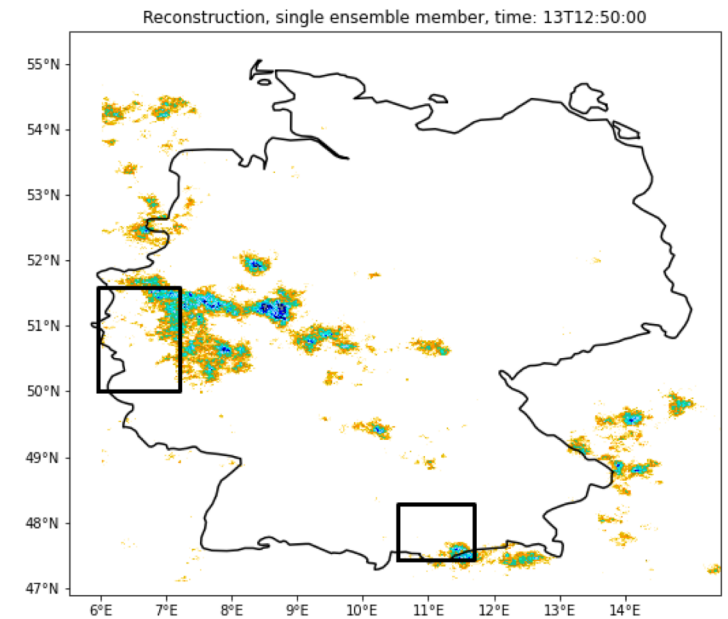
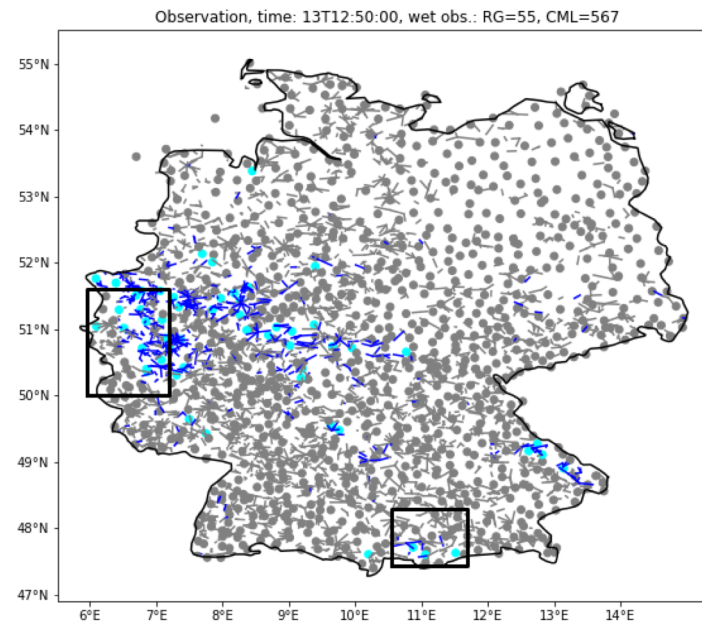
Introduction

Goal:

How to reconstruct continuous rainfall fields from limited and heterogeneous observations?

Challenges:

- Dealing with uncertainties
- Dealing with sparse and unevenly distributed data
- Reproducing the correct spatial-temporal distribution



https://www.kit.edu/kat/pi_2020_063_erste-bundesweite-regenmessung-mit-dem-mobilfunknetz.php

Method – Random Mixing Whittaker-Shannon (RMWSPy v1.1)

RMWSPy v1.1:

1.

Estimate marginal distribution of RGs

Transform RGs into Gaussian variable to build spatial model

Solve linear equation system $Z_L(x)$ given by RGs x_i :
 $Z_L(x) = \sum_{i=1}^k \alpha_i Y_i(x_i)$

$Z(x) = Z_L(x)$

Find $Z_H(x)$ with $Z_H(x_i)=0$ for all RGs x_i , described as:
 $Z_H = \cos \theta U_t + \sin \theta U_s$
 U_t, U_s are unconditional random fields

$Z(x) = Z_L(x) + Z_H(x)$

Optimizing θ to satisfy CMLs by $Z(x)$

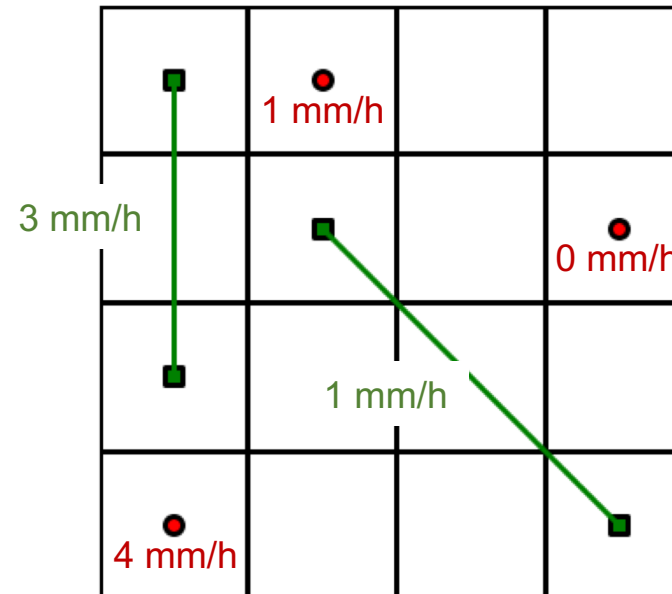
TRUE?

YES

Transform $Z(x)$ into 2d precipitation field

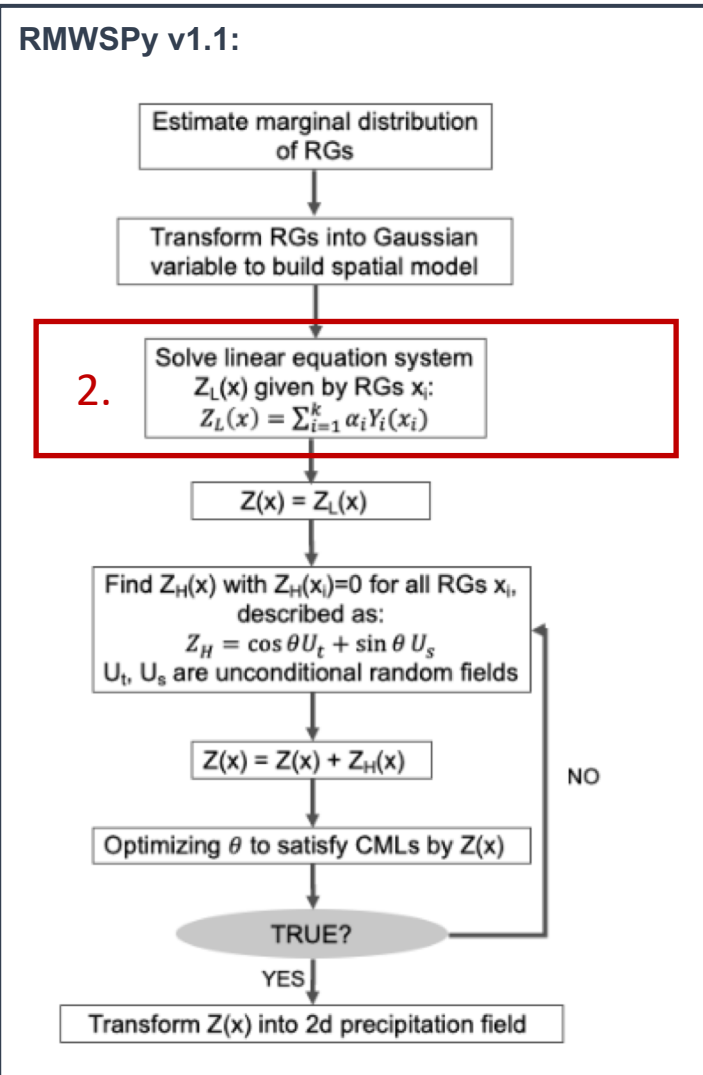
NO

1. Estimation of marginal distribution based on point observations (red, here RG) to build the spatial model ...

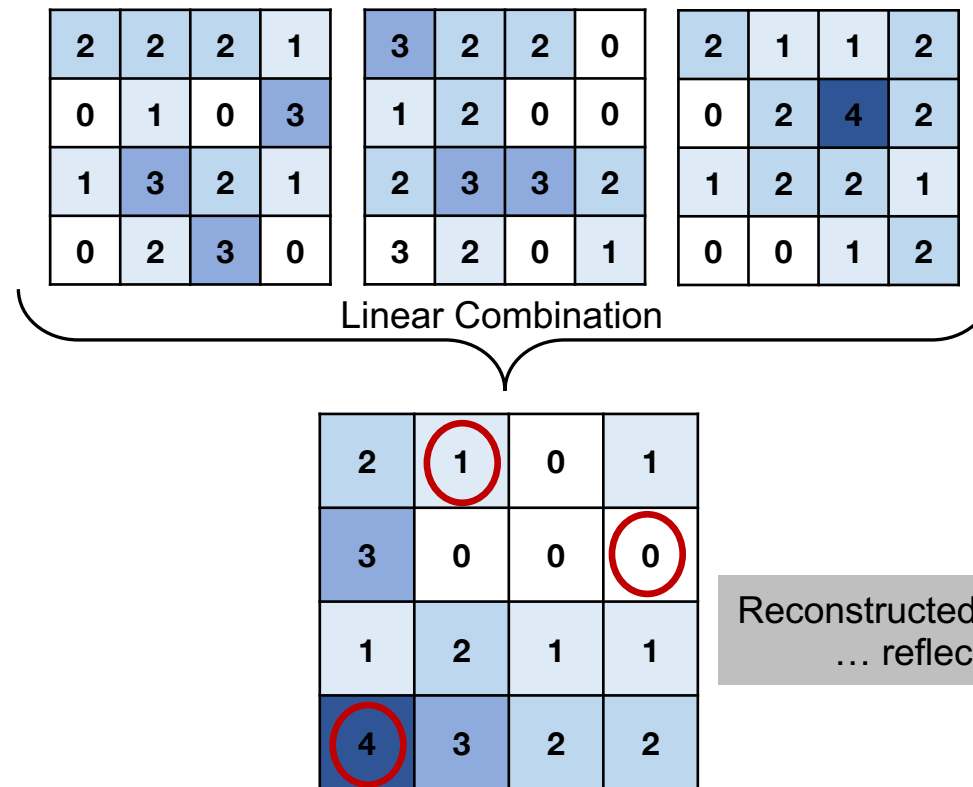


... and use the spatial model to simulate candidates for reconstruction

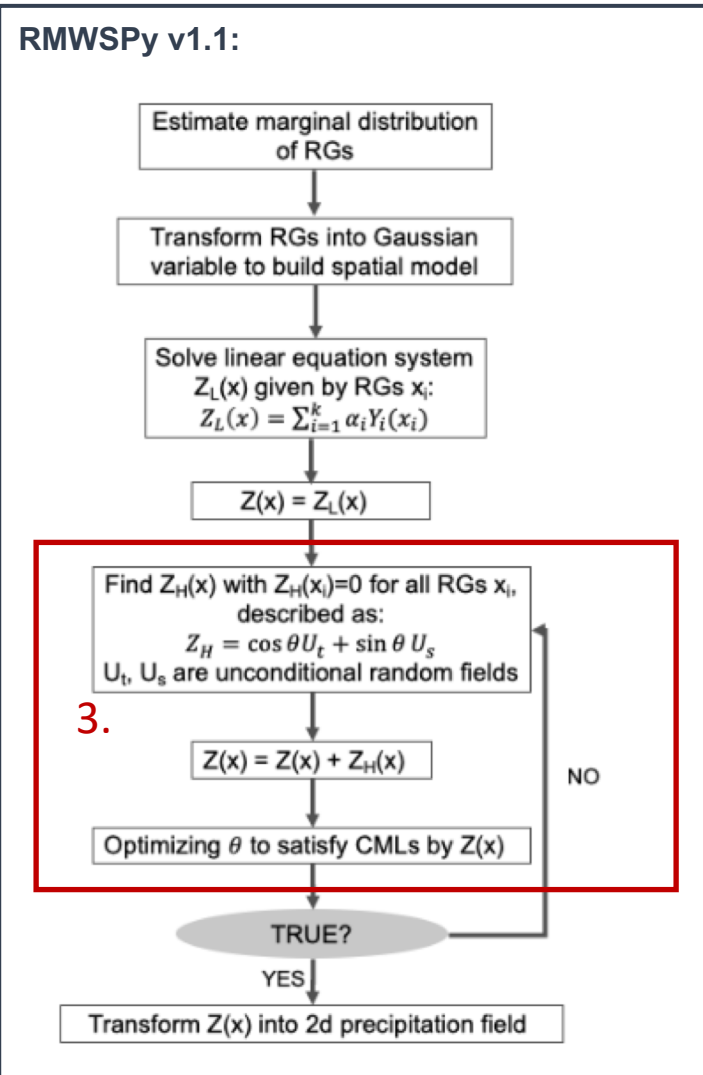
Method – Random Mixing Whittaker-Shannon (RMWSPy v1.1)



2. Solve the linear equation system and select the solution with minimized squared weights ... $\sum_i \alpha_i^2 \rightarrow \min$



Method – Random Mixing Whittaker-Shannon (RMWSPy v1.1)



3. Find homogeneous field Z_H which optimizes the representation of the CML observations

Reconstructed field (candidate)

2	1	0	1
3	0	0	0
1	2	1	1
4	3	2	2

+

Z_H

.5	0	0	1
.5	0	0	0
1	0	0	0
0	0	1	.5

=

2.66 mm/h

2.5	1	0	1
3.5	0	0	0
2	2	1	1
4	3	1	2.5

1.17 mm/h

Quality measure for optimizing: $\sqrt{\frac{(3-2.66)^2 + (1-1.17)^2}{2}} \approx 0.27$

Setup

➤ RMWSPy v1.1 has been set up for 3 different areas:

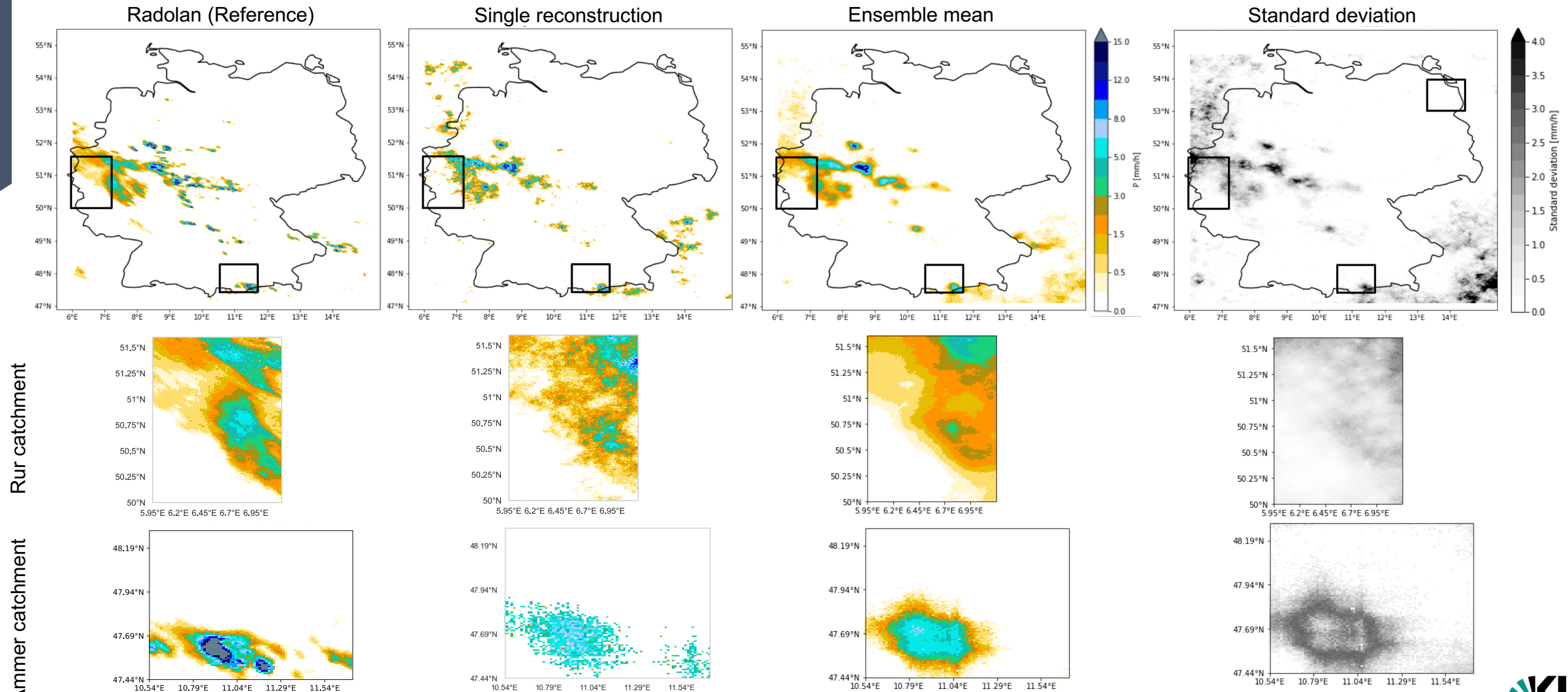
- Germany
- Rur catchment, located in West Germany
- Ammer catchment, located in South Germany

➤ The count of used observations:

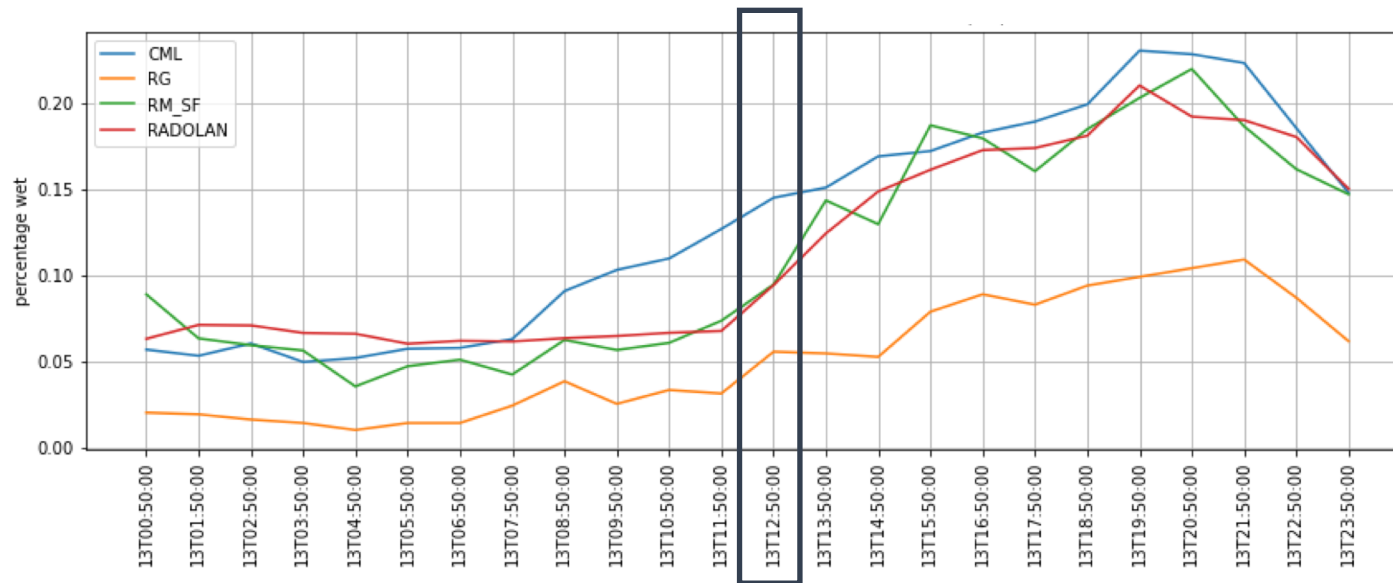
	Germany	Rur catchment	Ammer catchment
RG	988	22	9
CML	3904	262	102

➤ Reconstruction contains an ensemble of 50 hourly fields, with a 1x1 km resolution

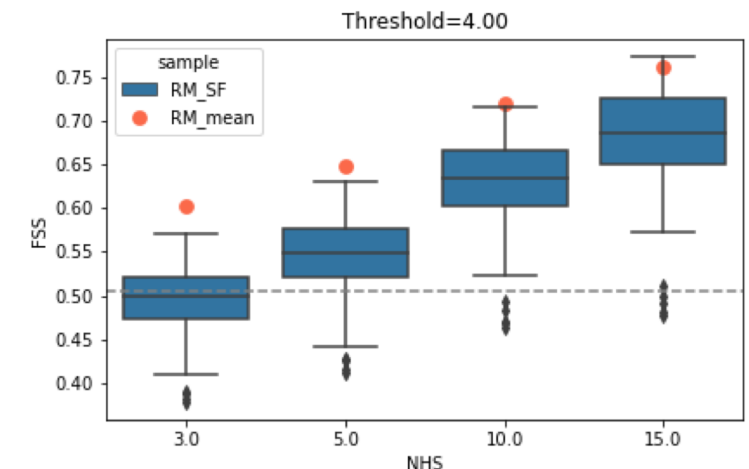
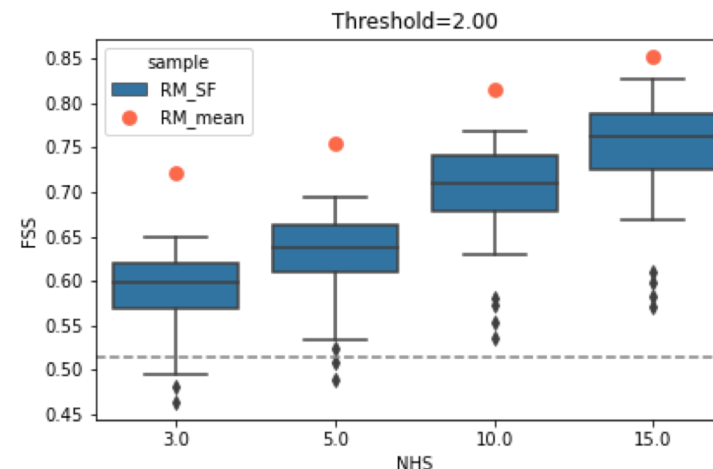
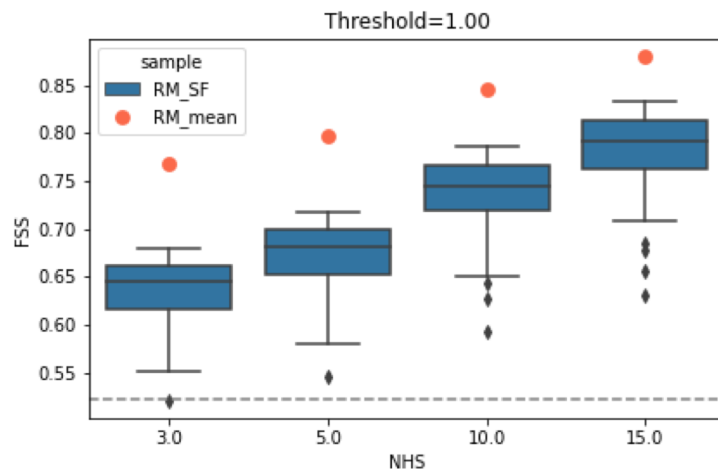
Ensemble of reconstructions (#50 fields) – example 2018-05-13 12:50



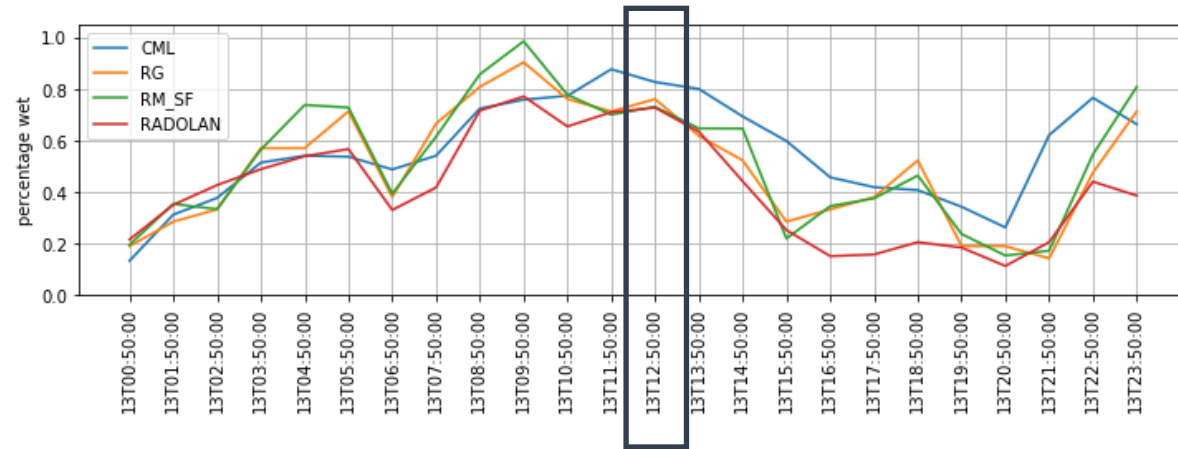
Fraction Skill Score – FSS – example 2018-05-13 12:50, Germany



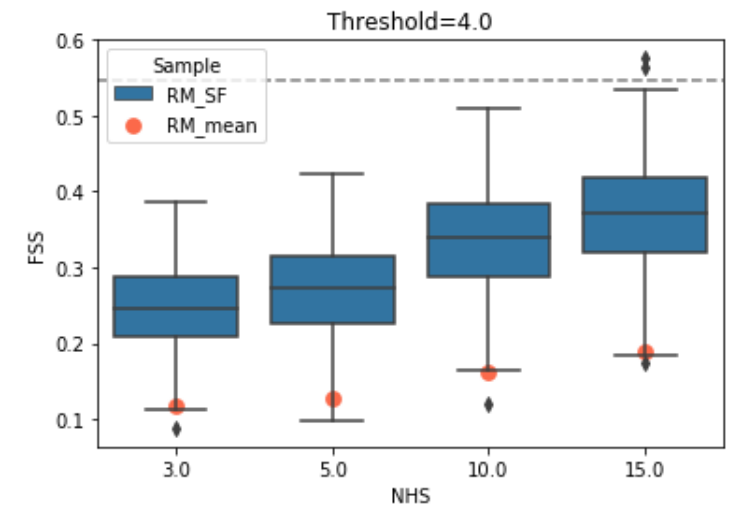
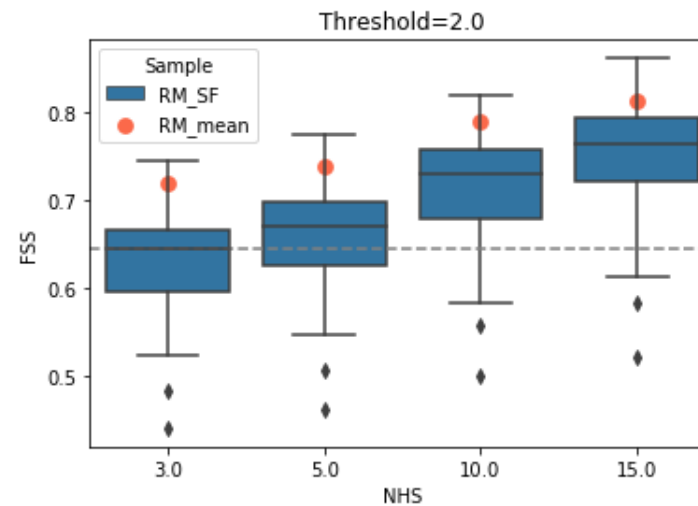
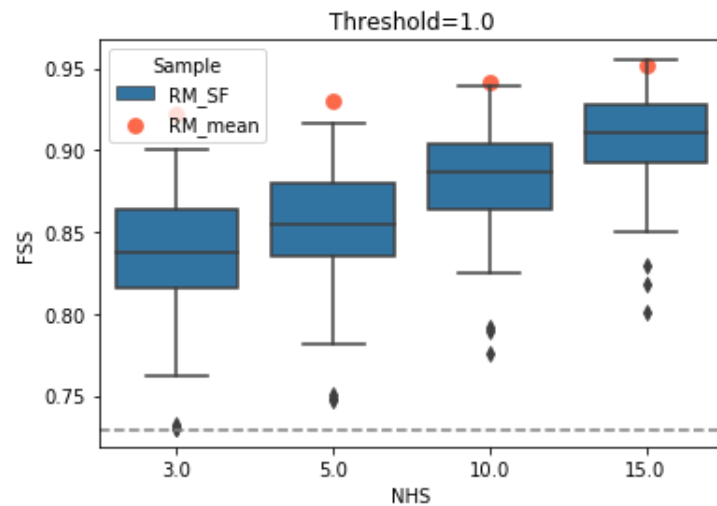
- Left: percentage of wet values for the 13th May over Germany in hourly time steps; the box marks the 12:50 time step, for which the FSS is calculated
- Bottom: FSS calculated for the thresholds 1, 2 and 4 [mm/h] and the neighborhood sizes of 3, 5, 10 and 15 grid cells, the dashed line marks the limit after which a reasonable skill has been achieved



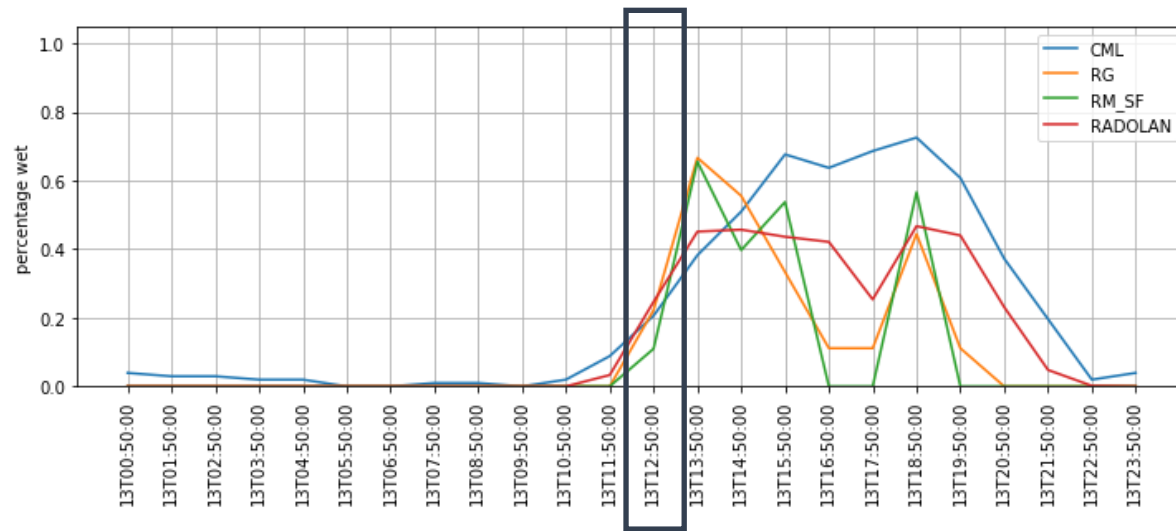
Fraction Skill Score – FSS – example 2018-05-13 12:50, Rur CM



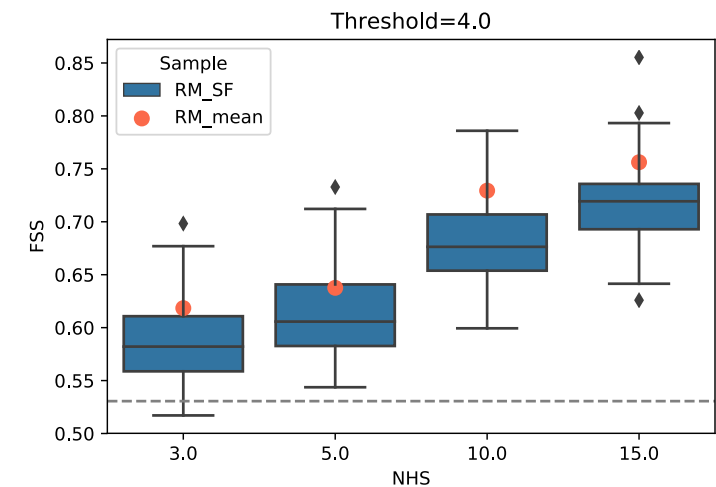
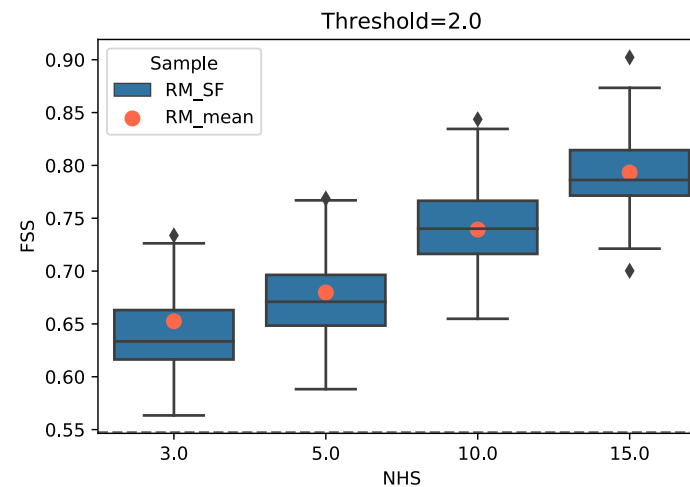
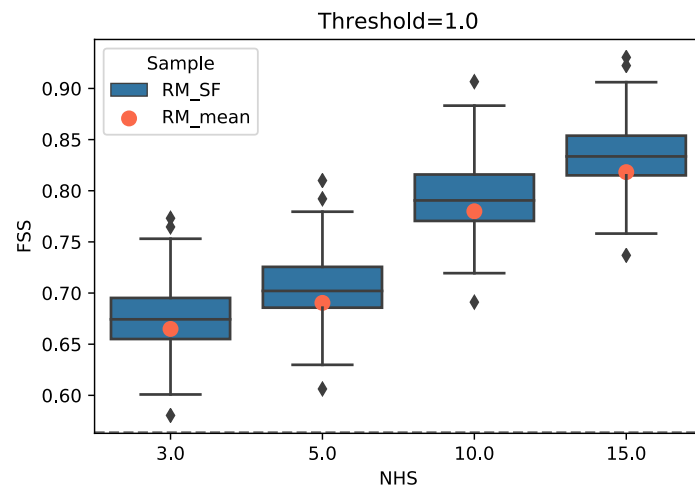
- Same figures as page 6, but for the Rur catchment



Fraction Skill Score – FSS – example 2018-05-13 12:50, Ammer CM



- Same figures as page 6 and 7, but for the Ammer catchment



Conclusion

- RMWSPy v1.1 is a suitable method to reconstruct precipitation fields for catchment areas as well as country wide
- In case observations are a representative sample, the reconstructed fields reflect the observed spatial distribution
- It allows to combine linear (here RGs) and non-linear (here CMLs) observations
- Using the ensemble spread, one can estimate the uncertainty of the reconstruction

Outlook

- Small catchments and/or sparse (lin.) datasets could lead to non representative samples (e.g. Ammer catchment) ... within the next step we will hence use the non-linear conditions (CMLs) to build the spatial model