QPE, QPF and EPS in Flood Forecasting

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Introduction

Various approaches of interpolated or radar-based methods are applied to hydrological models in order to arrive at an optimized estimation of the actual amount and the spatial distribution of precipitation. Apart from hydrological data (water level and discharge at gauging stations), data on the actual quantitative amount of precipitation (QPE) and predicted precipitation (QPF) are the most important input data in flood forecasting.

Quantitative Precipitation Estimation

At the State Environmental Agency of Rhineland-Palatinate, operating the hydrological model LARSIM [1], the station-based interpolated raster product InterMet-LfU-RLP [2] and the RADOLAN-RW and -RL-products of the German Weather Service (DWD) [3] are used as operational input precipitation products. During the Ahr flooding event 2021, the online-used radar products significantly underestimated the surface precipitation amounts [7] and more than the product InterMet-LfU-RLP [4].

During the follow-up of the event, further precipitation products were generated a posteriori to investigate the actual precipitation amount (see Figure 1):

- the post-processed RADOLAN-RL-DWD
- precipitation radar data based on improved attenuation correction from the Institute for Technical-Scientific Hydrology (ITWH) (RADAR-ITWH-Ahr) [5]
- interpolated precipitation station data taking into account additional information from private weather stations (PWS) from the University of Stuttgart (Uni-Stuttgart-PWS) [6,7]
- precipitation radar data based on Micro Rain Radar (MRR) profiles from the research unit RealPEP at the University of Bonn (Radar-Uni-Bonn) [8]

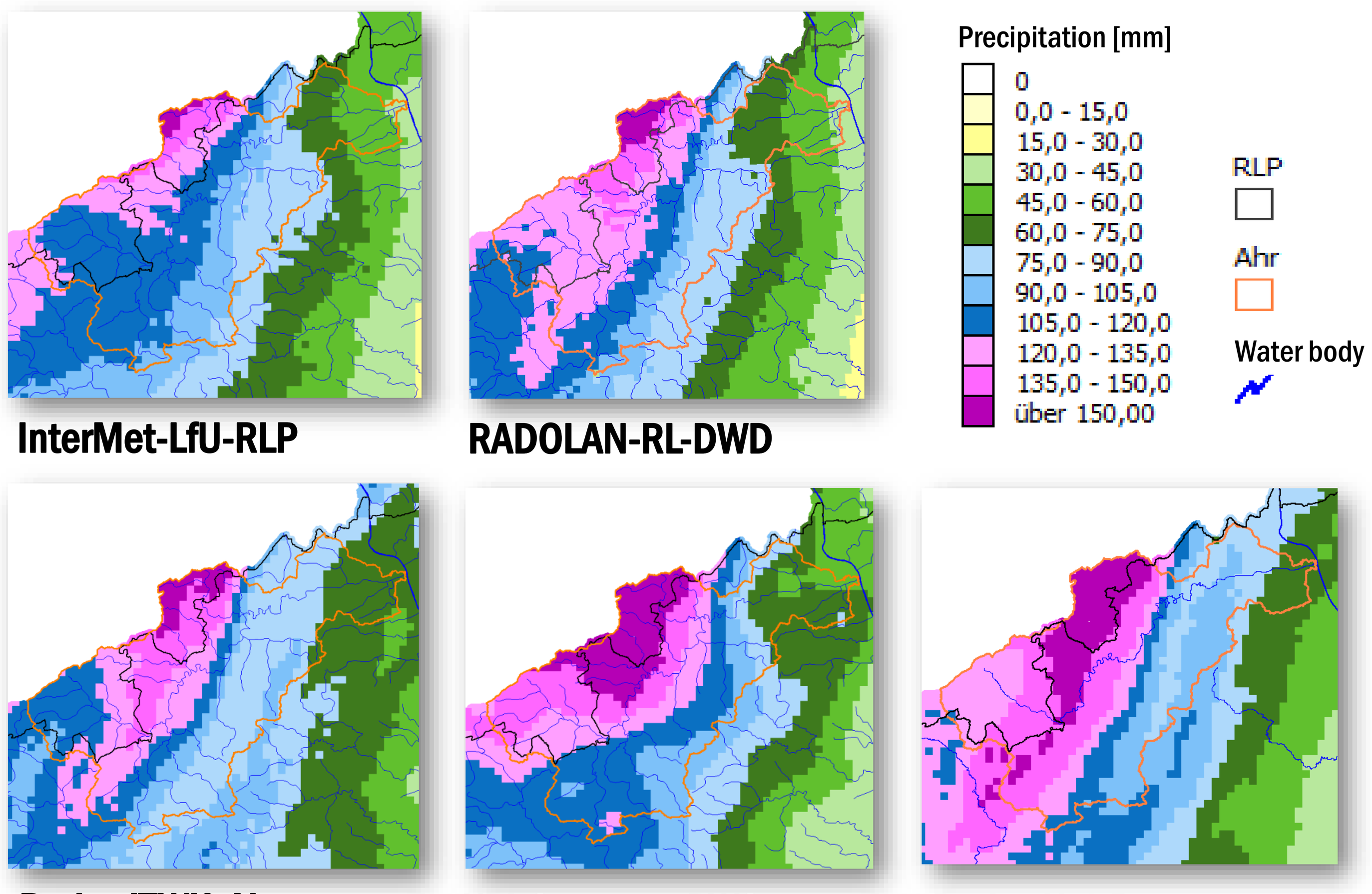

Figure 1: Spatial distribution of precipitation sums [mm] at 14/07/2021 08:00 to 22:00 CEST in the area of Ahr river basin based on different products of precipitation record (InterMet-LfU-RLP online, all other products were processed a posteriori).

Table 1: Areal precipitation in the control areas of gauging stations in the Ahr basin during the period 14/07/2021 06:00 to 23:00 CEST based on different products of precipitation record. Long-period monthly mean for July: 69 mm (*processed online)

Gauging station control area	InterMet LfU-RLP* [mm]	RADOLAN-RL-DWD [mm]	Radar-ITWH-Ahr [mm]	Uni Stuttgart-PWS [mm]	Radar-Uni-Bonn [mm]
Müsch	114*	121	115	127	134
Kirmutscheid	101*	100	94	105	116
Niederadenau	92*	94	87	115	105
Denn	84*	82	84	104	93
Kreuzberg	137*	144	149	159	169
Altenahr	121*	131	131	153	149
Bad-Bodendorf	72*	70	80	77	92
Ahr basin total (08 to 22 CEST)	102*	93*/106	106	119	123
Simulated peak at gauging station Altenahr	509 m³/s	563 m³/s	568 m³/s	801 m³/s	871 m³/s

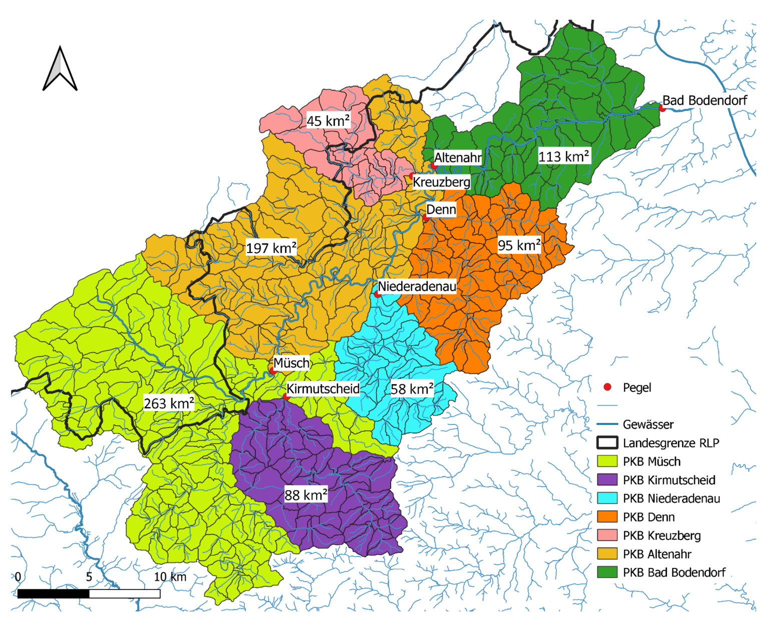

Figure 2: Control areas of gauging stations in the Ahr basin modelled by the water balance model LARSIM.

Investigations on approaches with opportunistic sensores (OS) and MRR profiles yield an improved estimation of the actual amount and spatial distribution of precipitation (see Fig. 1). This is shown by re-calculations with calibrated LARSIM-forecast variants using data from post-processed precipitation products. Results reveal more realistic simulated peak runoff at station Altenahr (approx. 750-1000 m³/s) on 15 July 2021, e.g. due to the reflection of higher precipitation in the control areas of Müsch, Kirmutscheid and Kreuzberg (see Table 1/ Fig. 2).

Quantitative Precipitation Ensemble Forecasts

A-posteriori forecasts with the SINFONY-INTENSE product (DWD) [9] produce beneficial results in the further course of the event, presumably due to improved data assimilation, capturing the end-emphasized character of the Ahr flooding event (see Fig. 3). In advance to the event, the forecast benefits are non-significant in comparison to the online used ICON-D2-EPS that was obviously suffering from insufficient initial conditions.

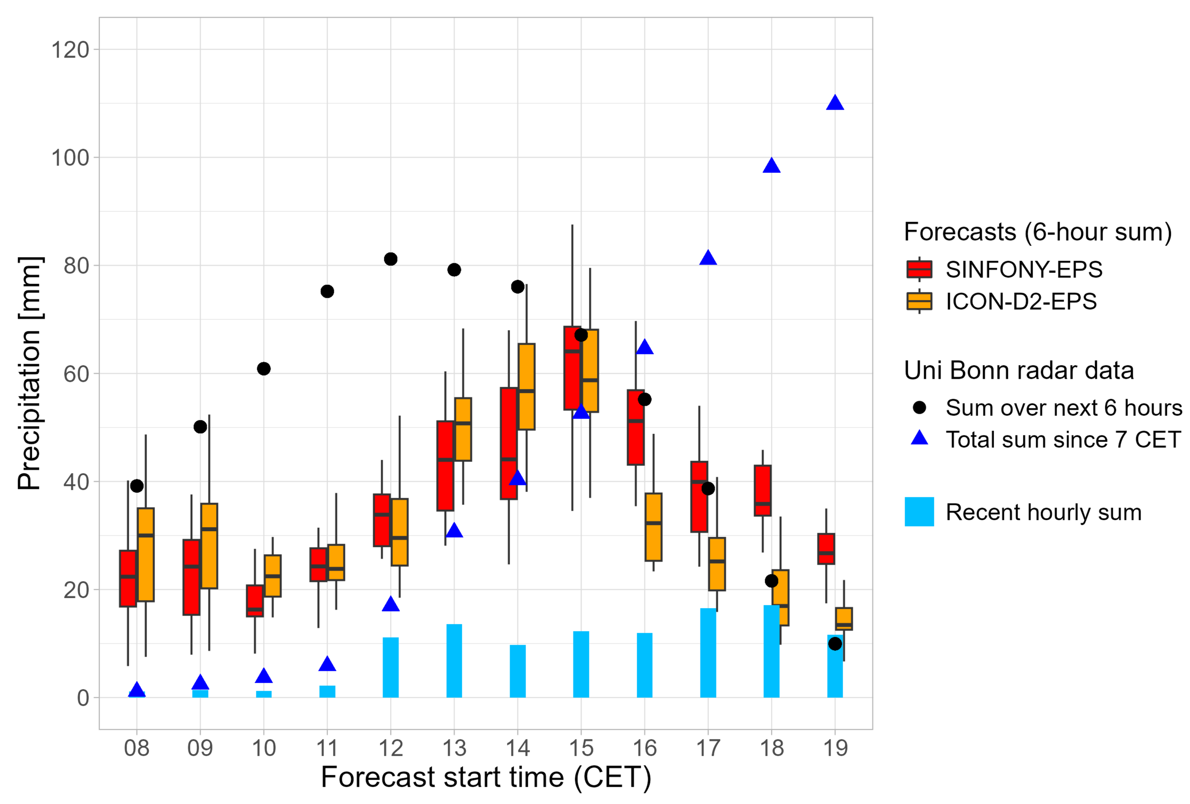

Figure 3: Predicted 6-hour precipitation sums (spatial mean) in the entire Ahr basin at 14/07/2021 by the operationally used ICON-D2-EPS (DWD) and by the product INTENSE (SINFONY-EPS) that was processed a posteriori, compared to radar data of Uni Bonn.

Conclusion and outlook

- ➢ Inclusion of PWS, commercial microwave links (CML, not shown here), and MRR-profiles offers great potential for improving the estimation of area precipitation.
- ➢ Further validation and investigation on products for the use in flood forecasting are desirable, but careful checking and correction of additional stations like opportunistic sensors is necessary.

Further needs:

- ➢ Optimization of the precipitation radar data, e.g. by improved attenuation correction. Increasing the number of rain gauge stations for adjustment.
- ➢ Finding the best possible QPE (and possibly QPF) product for the respective meteorological situation (convective/stratiform) for operational flood forecasting.
- ➢ Ongoing developments and verification improvements (e.g. project “co-design” with DWD)

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