Evaluation of standard pre-processing techniques for X-Band radar data using hydrologic modeling

Stephan Thober[1], **Philipp Kilian**[1,2], **Luis Samaniego**[1], **Diana Spieler**[1], and **Bernhard Pospichal**[2]
1 - Helmholtz Centre for Environmental Research - UFZ Leipzig; 2 - University of Leipzig, Institute for Meteorology
stephan.thober@ufz.de

1. Motivation

Precipitation is the key driver of hydrological processes on the land surface; like runoff, infiltration, and evaporation. A standard device for measuring precipitation are rain gauges which exhibit a relatively good measurement accuracy but only provide point measurements. The estimation of areal precipitation by interpolating rain gauge data is a big challenge because of the high spatial variability and intermittency of precipitation. Weather radar data provide a promising addition to rain gauge measurements for the estimation of areal rainfall. In this study, we investigate the capability of the TERENO rainscanner in the Bode observatory to improve measurement of areal precipitation rates.

2. Study domain and period

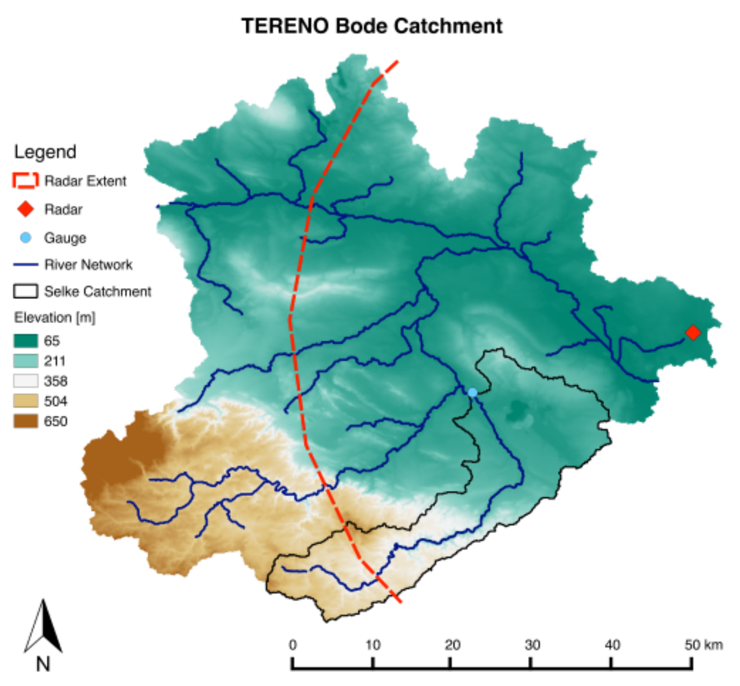

Fig. 1: Bode catchment including area covered by rainscanner (Radar)

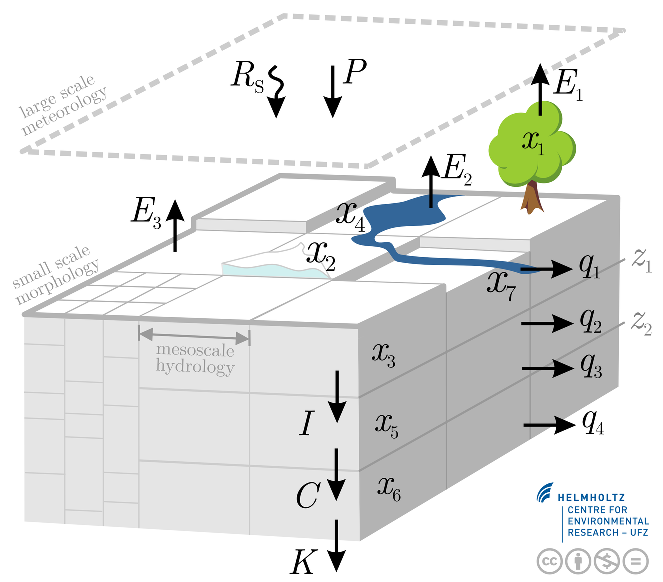

Fig. 2: Schematic representation of the process based mesoscale hydrologic model mHM [1]

The TERENO rainscanner is located in the East of the TERENO Bode observatory (Fig. 1). It is an X-Band radar manufactured by SELEX-Gematronik (9.2 cm wavelength) and has a range of 50 km with a resolution of 2° and 100 m bin width. It is operated with an elevation angle of 2.8° and a beam width of 2°. Data for the year 2013 is used within this study. The retrieved rain rates shall then be used to force the mesoscale hydrologic model (Fig. 2) for the Selke catchment (Fig. 1).

3. Data processing

The raw radar data is corrected for ground clutter (i.e., sources of constant reflectivity) and beam attenuation using the *wradlib* processing library [2]. The processed reflectivities Z are then transformed to rain rates R using a power law for the $Z-R$ relationship [3]

$$Z = aR^b.$$

Hourly precipitation measurements of ground stations have been obtained for comparison from the German Weather Service (DWD).

4. Spatial consistency

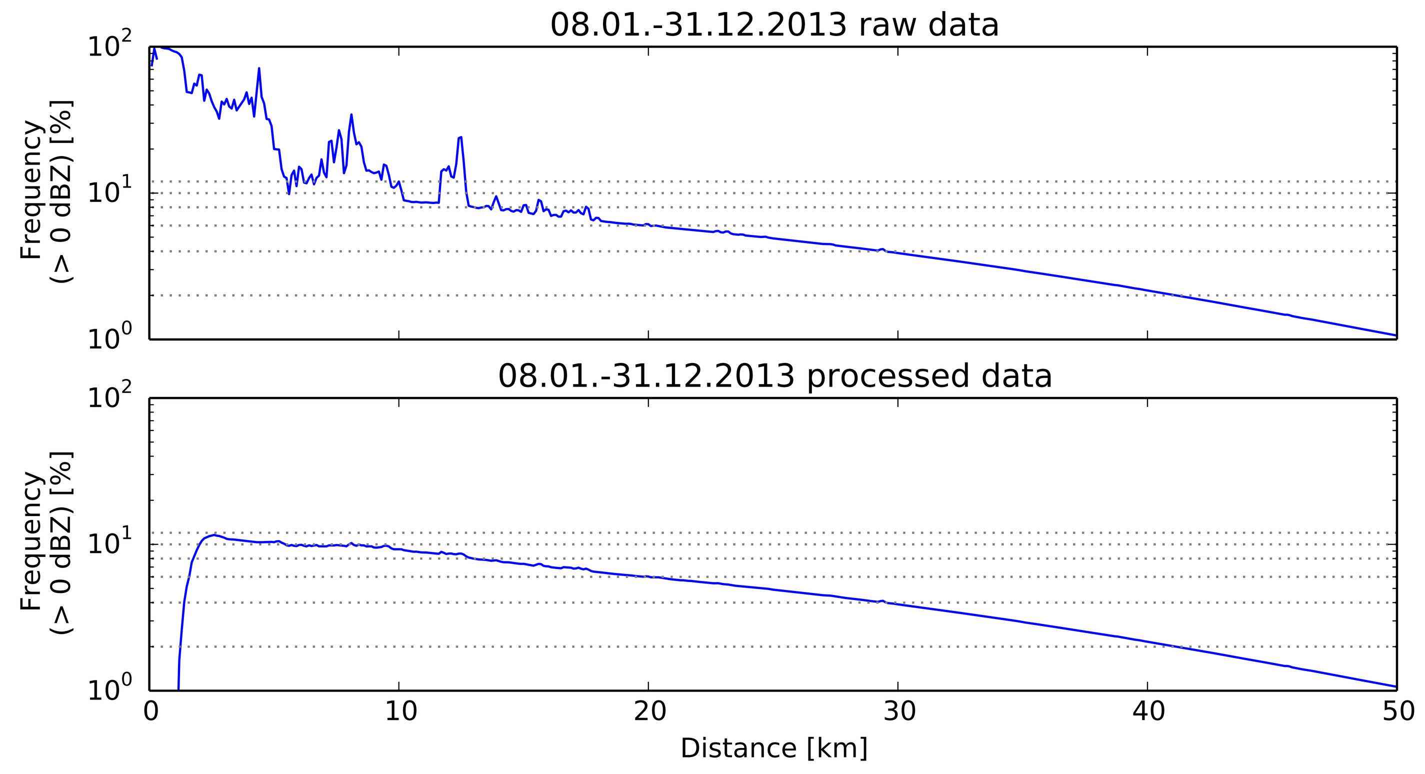

Fig. 3: Percentage of time steps above zero dBZ averaged over cells at a given distance

There is a strong decrease in occurrence of rainfall with increasing distance from the radar. This might be related with the high elevation angle. Hence, only stations within 30 km distance to the radar are considered.

5. Temporal consistency

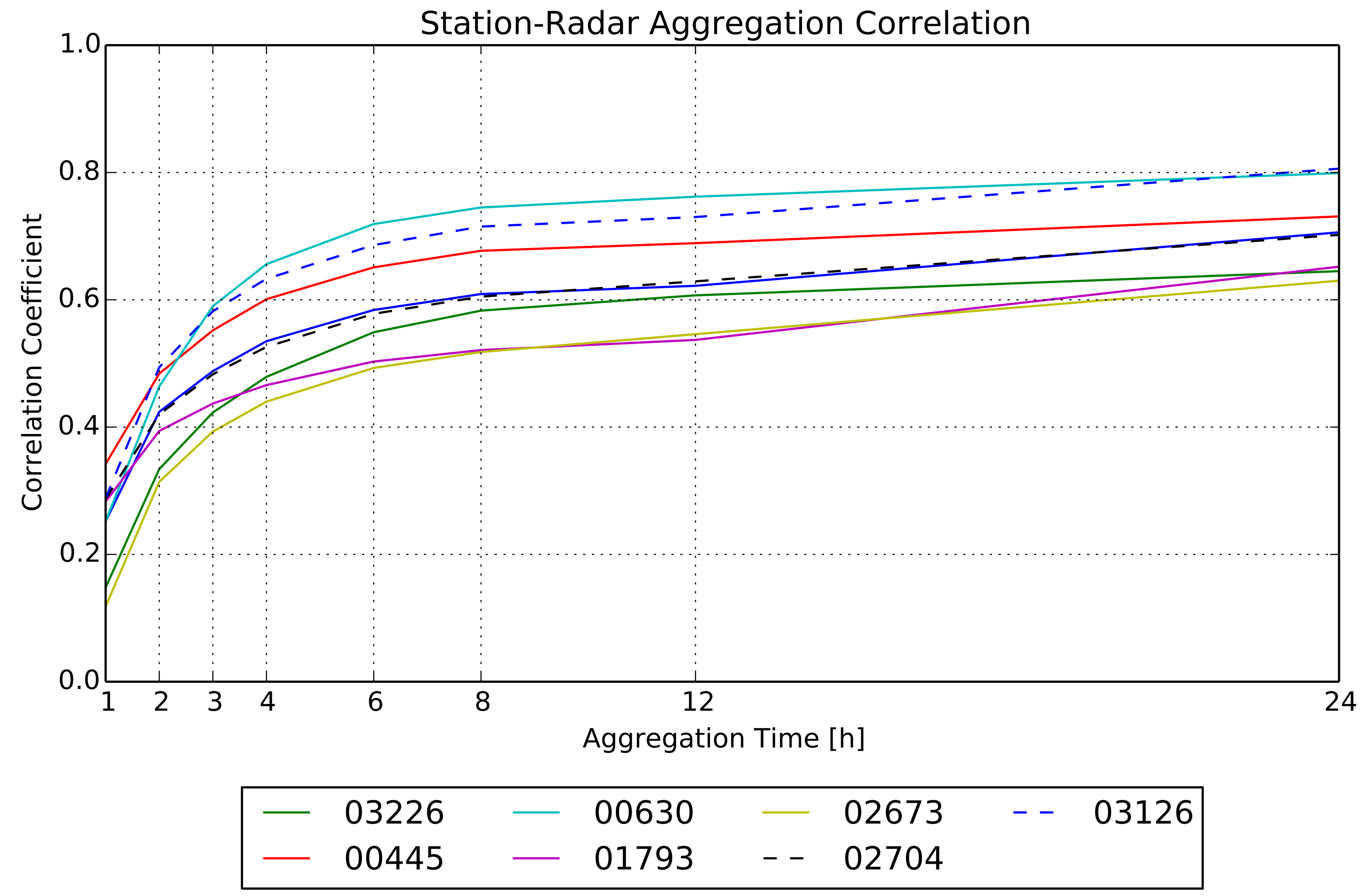

Fig. 4: Pearson Correlation Coefficient between radar and rain gauge measurement for different aggregation times

The temporal consistency between radar and rain gauge measurements increases with increasing accumulation time. This might be related to local-scale atmospheric conditions (e.g., wind shifts of rainfall) that are averaged out at larger time scales.

6. Optimal Z-R relationship

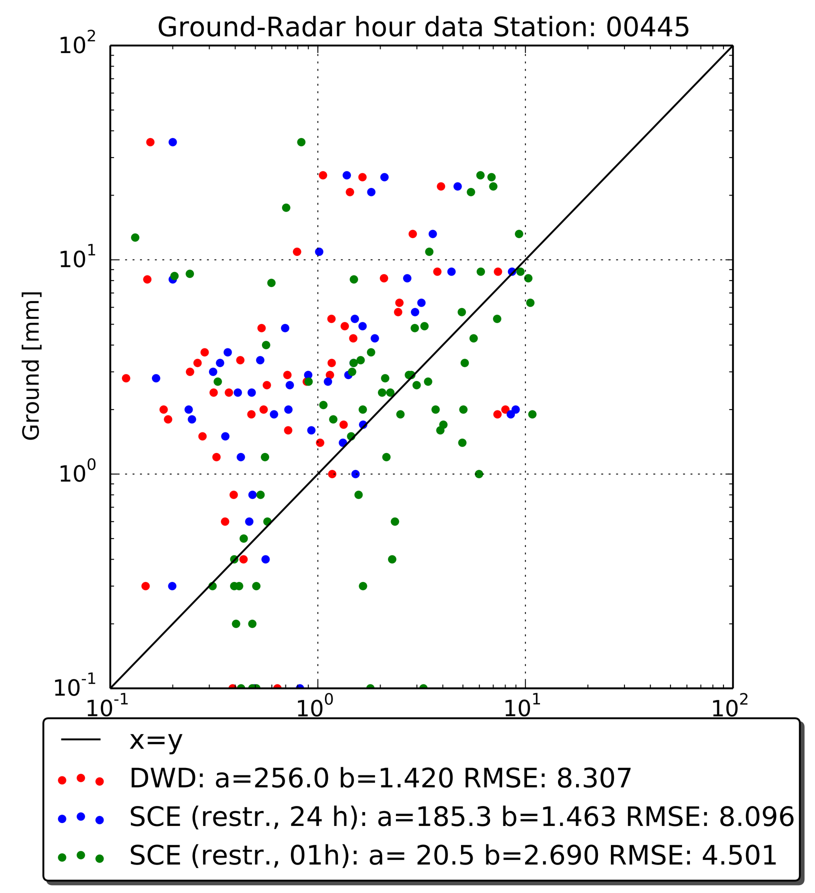

Fig. 5: Scatter plot of rain rates estimated from radar and rain gauge measurements for different $Z-R$ relationships at DWD station 00445 located at a distance of **10 km**.

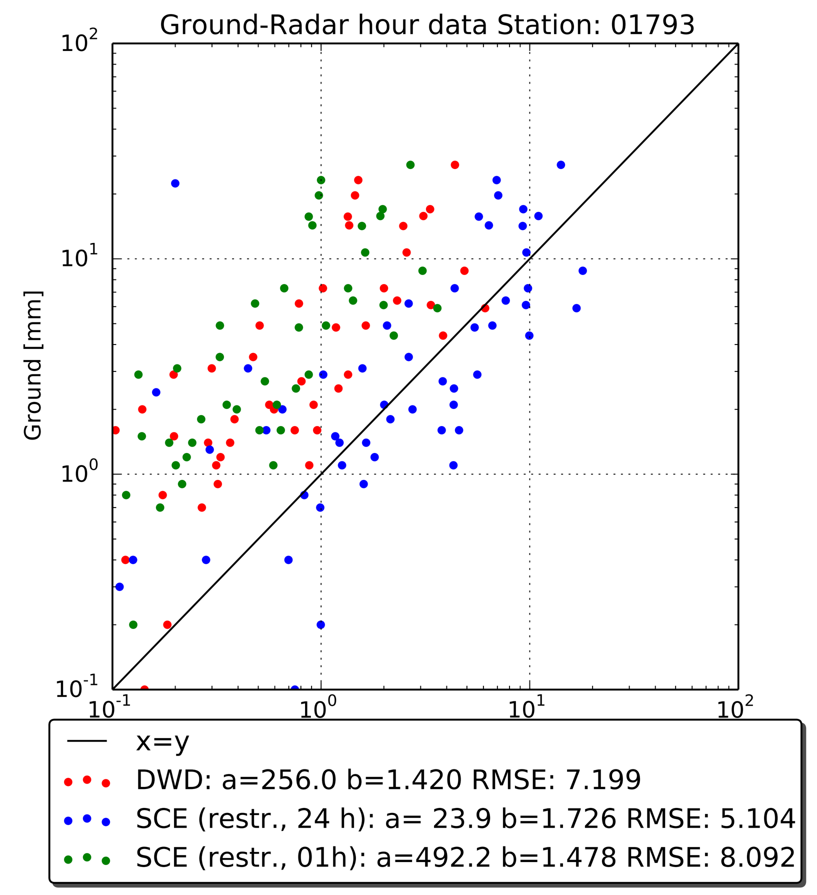

Fig. 6: Scatter plot of rain rates estimated from radar and rain gauge measurements for different $Z-R$ relationships at DWD station 01793 located at a distance **14 km**.

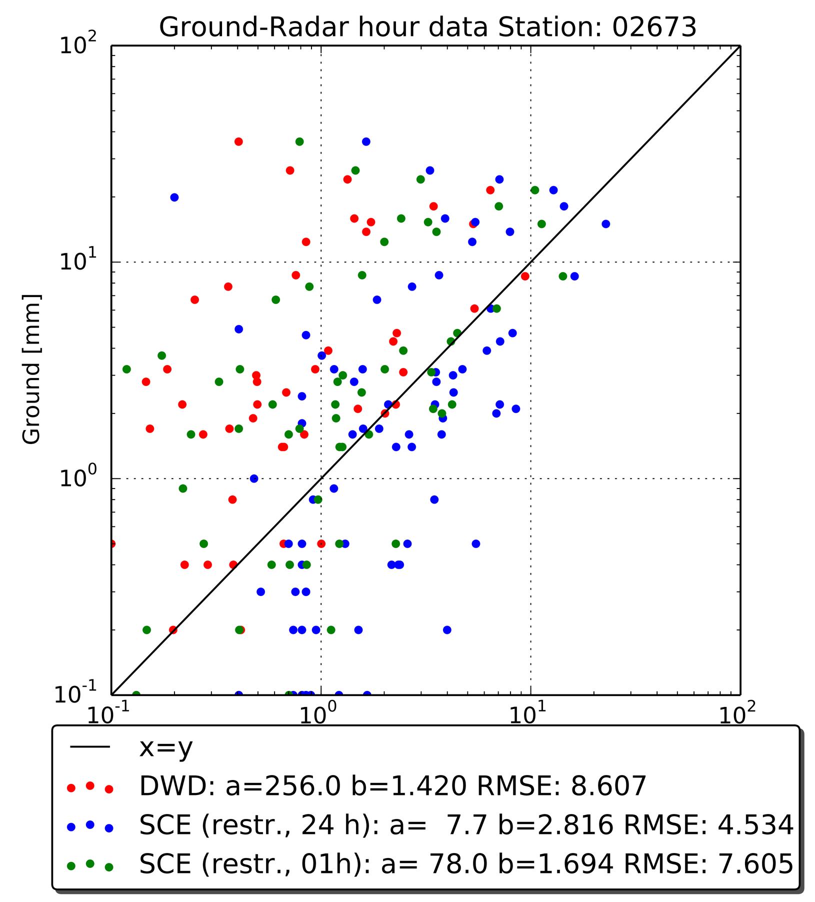

Fig. 7: Scatter plot of rain rates estimated from radar and rain gauge measurements for different $Z-R$ relationships at DWD station 02673 located at a distance **26 km**.

Figures 5 to 7 show that the optimal $Z-R$ relationship depend on the location and time scale the optimization is carried out at (using shuffled complex evolution [4]). A high value for a is obtained at location 01793 (Fig. 6) using hourly optimization providing a non-informative $Z-R$ relationship. In general, optimizing daily precipitation has lower root mean squared errors (RMSE) than optimizing hourly values. However, the level of RMSE is substantial for all obtained relationships.

7. Conclusions

There is a large discrepancy between radar- and rain gauge-based precipitation measurements. $Z-R$ relationships are showing high RMSE values which do not allow hydrologic modelling with this data. At larger distances (i.e., > 30 km), the discrepancy might be related to the high elevation angle, which has been lowered to 1.4° in July 2014.

References

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UNIVERSITÄT LEIPZIG
TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES
WESS
HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ