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Author(s):
Sikorska-Senoner, Anna E.; Seibert, Jan; Sideris, Ioannis, V; Barton, Y.; Germann, Urs

Publication date:
2019

Permanent link:
https://doi.org/10.3929/ethz-b-000347572

Does radar-based rainfall data improve runoff simulations? – A case study in a small urban Swiss catchment

A.E. Sikorska-Senoner*[1], J. Seibert[1], I. Sideris[2], Y. Barton[2], U. Germann[2]

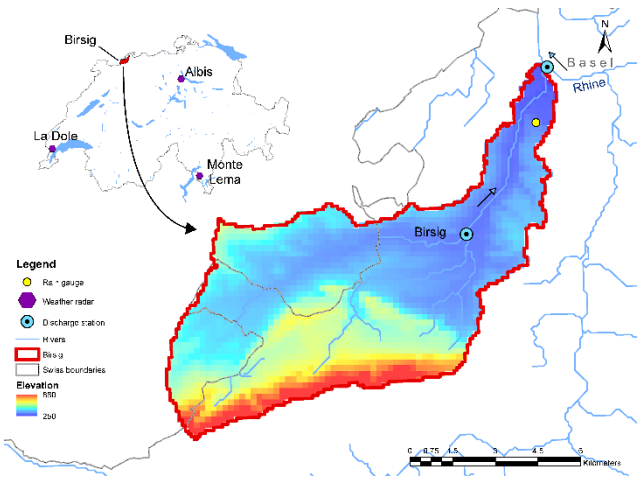
1 Dept. of Geography, University of Zurich, Switzerland (anna.sikorska@geo.uzh.ch)
2 The Federal Office of Meteorology and Climatology MeteoSwiss

*Corresponding author: anna.sikorska@geo.uzh.ch

Abstract

Urban flooding induced by heavy rainfalls leads yearly to severe damages and casualties worldwide and particularly in Switzerland. To reliably predict the magnitude and the dynamic of such flooding events, an accurate estimation of the spatio-temporal rainfall patterns of the causative event is crucial for the calibration and application of the hydrological model. Estimating the exact value of the rainfall amounts at the catchment scale is not trivial due to sparse rain gauge networks (McMillan et al., 2012, Sikorska and Seibert, 2018). Moreover, heavy rainfall may occur locally and, thus, be missed by the rain gauges. In contrast, radar-based products allow capturing rainfall fields over the entire catchment area. However, these rainfall estimates are affected by several kinds of errors (Germann et al., 2006; Sideris et al., 2014). Hence, it remains unclear which value these radar-based data products may have for preventing from severe urban flooding and how does the data uncertainty propagate through the hydrological model on model simulations.

In this study we explore the value of radar-based rainfall data for supporting modelling and prediction of floods in a small urbanized basin (Birsig catchment, Canton Basel-Landschaft, Switzerland). The radar-based rainfall data are provided from the MeteoSwiss (CombiPrecip) at 1 km spatial and 1 hour temporal resolution for the period of 3 years (2014-2016). CombiPrecip data are actually radar-data raingauge adjusted, using a geostatistical combination of radar and raingauge measurements of precipitation. These data are compared with the information obtained from a traditional gauging station located within the catchment (see Figure 1).



In particular, we investigate the model performance and the predictive uncertainty in flood estimates in such a small fast reacting catchment using a bucket-type hydrological model (HBV) with radar-based rainfall products and compare this to the use of station data. The uncertainty in model estimates is further evaluated using an external parametric error term. By comparing uncertainty estimates of model simulations for both datasets, the relative value of the radar-based rainfall products for predicting flood events can be judged. The simulations are performed with and without the error model by using a Monte Carlo technique.

Fig 1: The overview of the Birsig catchment and locations of the rain gauge and radars.

Our preliminary results (Figure 2) indicate that simulations based on the rain gauge data (without error term) are able to better represent the observed runoff but are linked with larger uncertainty bands (when error term is introduced). In contrast, simulations relying on the radar-based data

provide a slightly worse model performance (without error model) but the quantified uncertainty bands are smaller (when error term is introduced). Thus, the model predictive performance for unobserved period is higher.

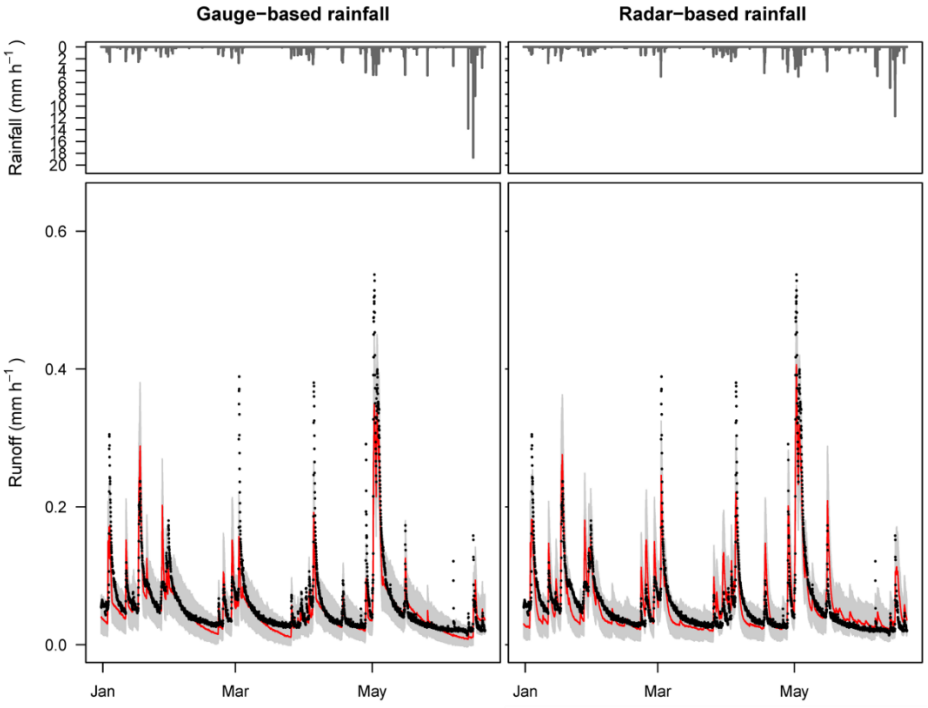


Fig 2: Rain gauge-based versus radar-based model simulations for the outlet from the Birsig catchment and the period of January – June 2015. The grey boxes present 95% uncertainty bands, black dots – observed runoff, red lines – the best model simulation.

This second finding suggests that the uncertainty in radar-based data are linked with a systematic error which could be handled by introducing the parametric error term to the model description, whereas the uncertainty in rain gauge based data are rather of a random nature and thus cannot be easily handled with an introduced error model. This issue will be investigated in details in further analysis. Also, the use of the radar-based versus rain gauged based rainfall data to model different types of extreme rainfall events such as convective and non-convective rainfall events will be investigated further.

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