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# Rainfall-runoff modelling using different estimators of precipitation data in the Carpathian mountain catchments (South Poland)

Michal Kasina, Michal Ziemski, Jerzy Niedbala, and Agnieszka Malota

Institute of Meteorology and Water Management – National Research Institute, Hydrological Forecasting Office, 30-215 Krakow, ul. P. Borowego 14, Poland (michal.kasina@imgw.pl)

## INTRODUCTION

Precipitation observations are an essential element of flood forecasting systems. Rain gauges, radars, satellite sensors and forecasts from high resolution numerical weather prediction models are a part of precipitation monitoring networks. These networks collect rainfall data that are further provided to hydrological models to produce forecasts. The main goal of this work is to assess the usage of different precipitation data sources in rainfall–runoff modelling with reference to Flash Flood Early Warning System.

## STUDY AREA

Research was carried out in the upper parts of the Sola and Raba river catchments. Both of the rivers begin their course in the southern part of the Western Beskids (Outer Eastern Carpathians; southern Poland). For the purpose of this study, both rivers are taken to comprise the catchments upstream of the gauging stations at Zywiec (Sola) and Stroza (Raba). The upper Sola river catchment encompasses an area of 785 sq. km with an altitude ranging from 342 to 1236 m above sea level, while the Raba river catchment occupies an area of 644 sq. km with an altitude ranging from 300 to 1266 m above sea level. The catchments are underlain mainly by flysch sediments. The average annual amount of precipitation for the Sola River catchment is between 750 and 1300 mm and for the Raba river catchment is in the range of 800-1000 mm.

## METHODS AND RESULTS

This work assesses the sensitivity of a lumped hydrological model DHI's Nedbør-Afstrømnings-Model (NAM) to different sources of rainfall estimates: rain gauges, radar and satellite as well as predicted precipitation amount from high resolution numerical weather prediction models (e.g. ALADIN).

The main steps of validation procedure are: i) comparison of rain gauge data with other precipitation data sources, ii) calibration of the hydrological model (using historical, long time series of rain gauge data treated as "ground truth"), iii) validation using different precipitation data sources as an input, iii) comparison of the obtained run-offs (outputs of the models) with the measurements in selected water gauge stations. Results are presented as hydrographs and statistical scores (i.e. Root Mean Squared Error, Correlation Coefficient, Nash-Sutcliffe Coefficient, Integral Square Error).

Although it was assumed that rain gauges give the most accurate point estimates of rainfall and were treated as a "ground truth", the results show that rain gauge network do not have the desired spatial density and spatial distribution. The modeled peak flows are usually 10–15% lower and occurred few hours later then observed. It also proves that rain gauges tend to underestimate precipitation.

The results obtained with H–SAF satellite precipitation products show a tendency to underestimate precipitation and thus discharges, but sometimes slight overestimations can be observed (during few days in summer satellite products estimated unrealistic values).

It seems that radar-based estimation of precipitation rate can correctly reflect precipitation pattern, but only after data quality corrections. Without this correction errors of precipitation estimates can vary over a wide range.

Precipitation from numerical forecasting model usually tend to overestimate small and mean precipitation and thus modeled discharges but underestimate high amounts of precipitation and high discharges from the model.