Using the radar- and ground-based measurements for rainfall floods modelling in small catchments (the Polomet' river, Russia)

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Introduction

For North-Western Russia flooding induced by high spring flood is the most hazardous hydrological event. However, recent research have revealed that floods could be also observed in the period of rainfall floods. At the same time, in recent years some of rivers in the region showed the highest ever maximum water discharge rates, which were formed in the period of rainfall floods and caused by abnormal precipitation. That is why modelling of rainfall floods becomes a very urgent issue. High quality of modelling in such case strongly depends on comprehensive information on both spatial and temporal variability of precipitation, which is why using of complex data (i.e. radar- and ground-based measurements) is needed.

Study Area and Data

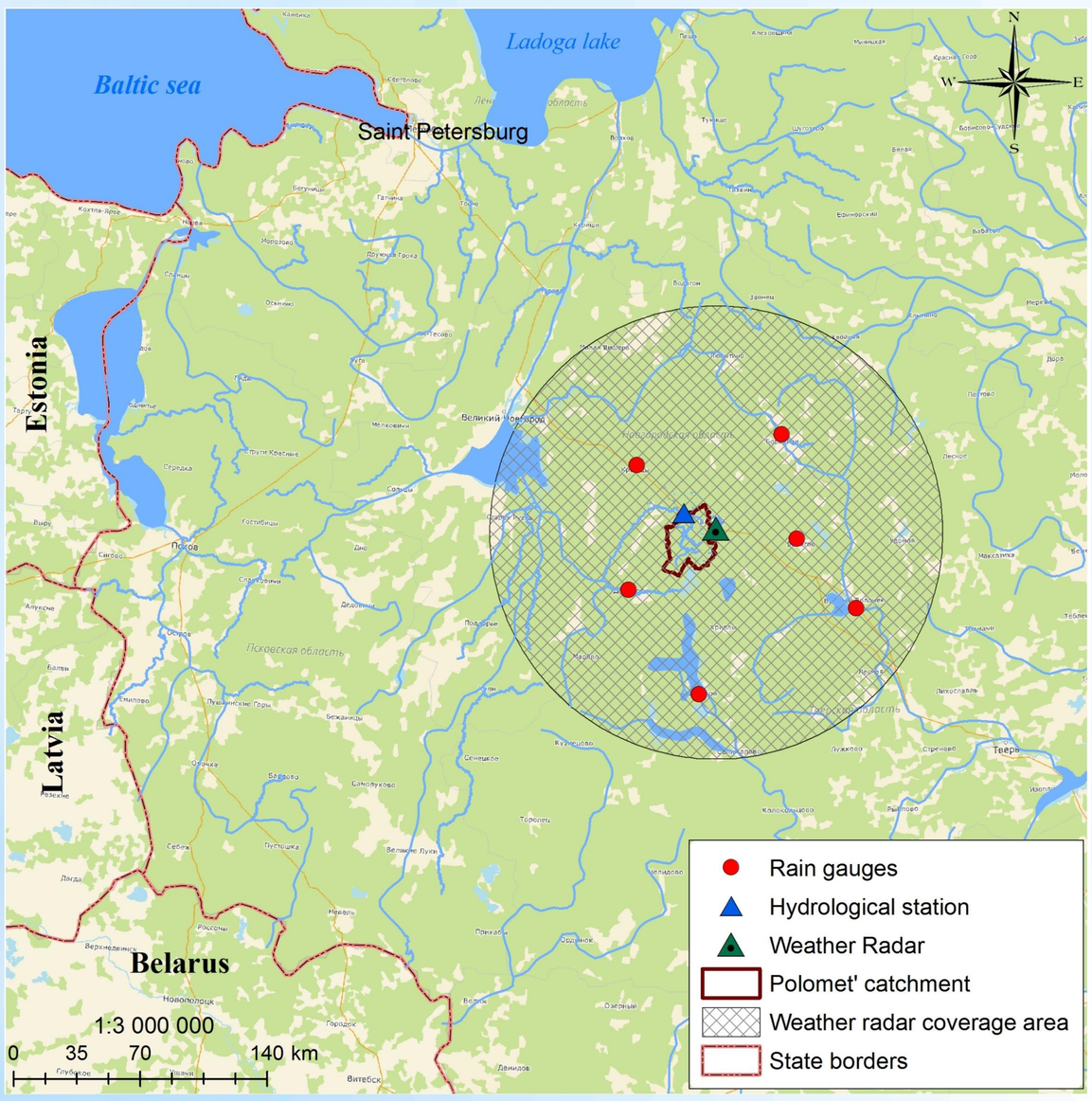

Figure 1. Study area

Input data:

1. 6 rain gauges with daily temporal resolution:
- continuous observations from 1994 to 2018
2. Weather radar with 10 minute temporal resolution, aggregated to 1 day, 2x2 km spatial resolution:
- warm period from 05/01/2017 to 10/31/2017

Methodology

1. Radar rainfall adjustment

The coefficients in the reflectivity (*Z*)-rain intensity (*R*) relationship are adjusted for the whole data period

$$Z = AR^b$$

The essence of the calibration is to select the coefficients *A* and *b*. The correlation coefficient between radar rainfall depths and rain gauge observations should be close to 1.

2. Optimization of Swat model (**Soil and Water Assessment Tool**) parameters

- **Calibration period**: 01//01/1994 – 12/31/2013
- **Validation period**: 01/01/2014 – 12/31/2018

3. Rainfall floods modelling with different rainfall inputs

- **Rain gauges data**
- **Weather radar data**
- **Rain gauge-adjusted radar data**

Difference of natural neighbor interpolated rain gauge values and radar measurements were used for correcting radar data.

4. Evaluation of modeling quality

The Nash-Sutcliffe coefficient (***NSE***), coefficient of determination (R^2) and comparison of **annual mean discharge** were used to assess the model performance (Table 1).

Results and discussion

1. The SWAT model was adapted to the conditions of river run-off formation for Polomet' river. The model simulates well different phases of hydrological regime and demonstrates fine quality of reproduction of Polomet' river hydrographs

Table 1. Assessment of modeling quality

Period	NSE	R^2	Qob, m^3s^{-1}	Qswat, m^3s^{-1}
1995-2014	0.72	0.76	7.40	6.00
2014-2018	0.68	0.72	7.12	6.06
1995-2018	0.71	0.75	7.34	6.01

2. Rainfall floods modelling with different rainfall inputs:

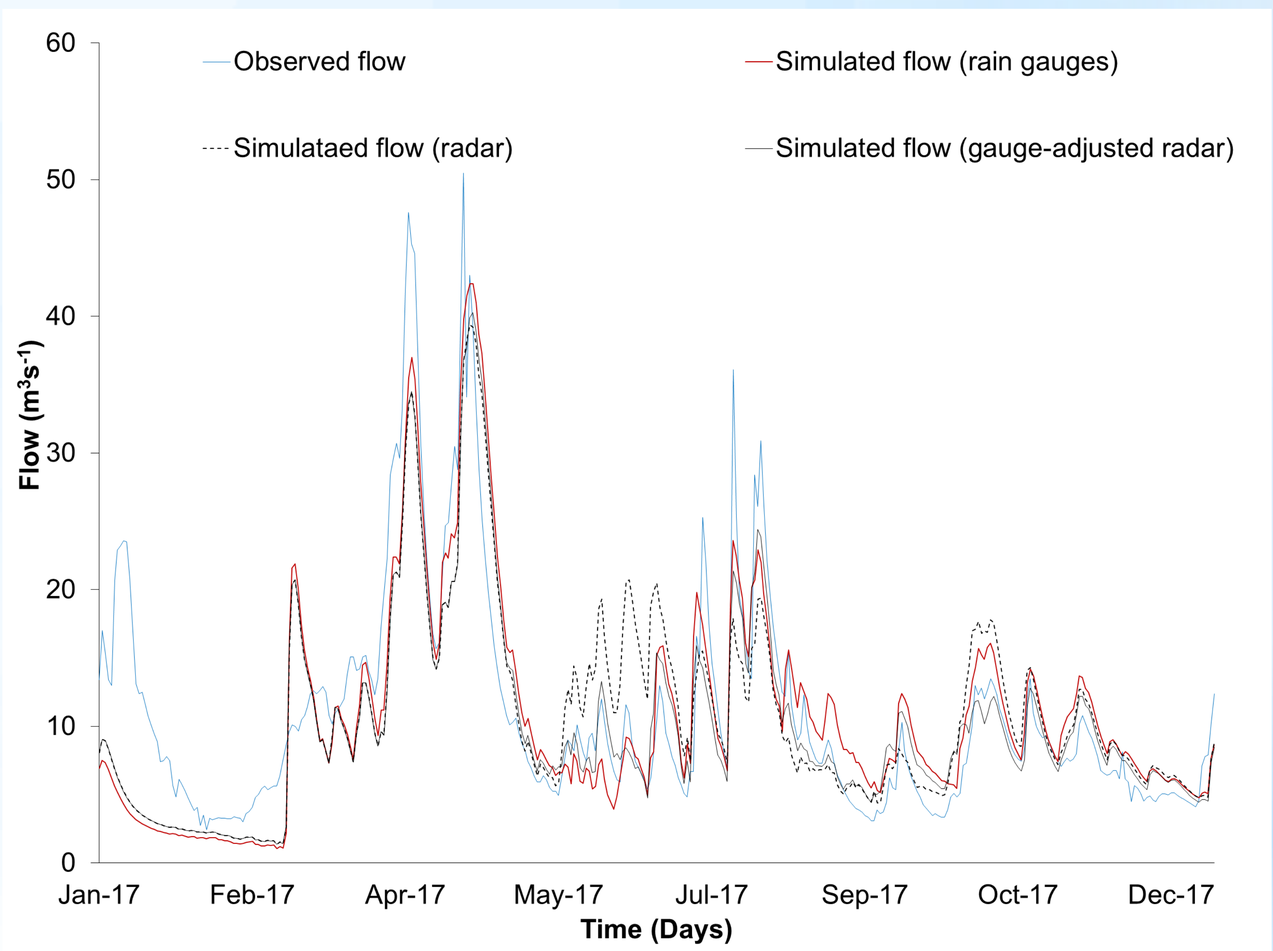

Figure 2. Hydrographs for Polomet' catchment using different rainfall inputs (2017)

- The better quality of rainfall flood modelling obtained with rain gauge-adjusted radar data input (Table 2)

Table 2. Assessment of modelling quality using different rainfall inputs

Input data	NSE	R^2	Qob, m^3s^{-1}	Qswat, m^3s^{-1}
Rain gauges	0.66	0.68	12.0	**11.2**
Weather radar	0.59	0.60	12.0	**11.2**
Gauge-adjusted radar	**0.68**	**0.71**	12.0	10.6

Conclusions

- SWAT model can be used for rainfall runoff modelling and forecasting
- Gauge-adjusted radar data can improve the skill of rainfall runoff modelling compared with based on rain gauges
- However, further for more reliable results of modelling wider dataset of radar measurements is needed

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