Short-range forecast of heavy rainfall over the Kama river basin in 2019 with the use of ICON, GFS and WRF atmospheric models

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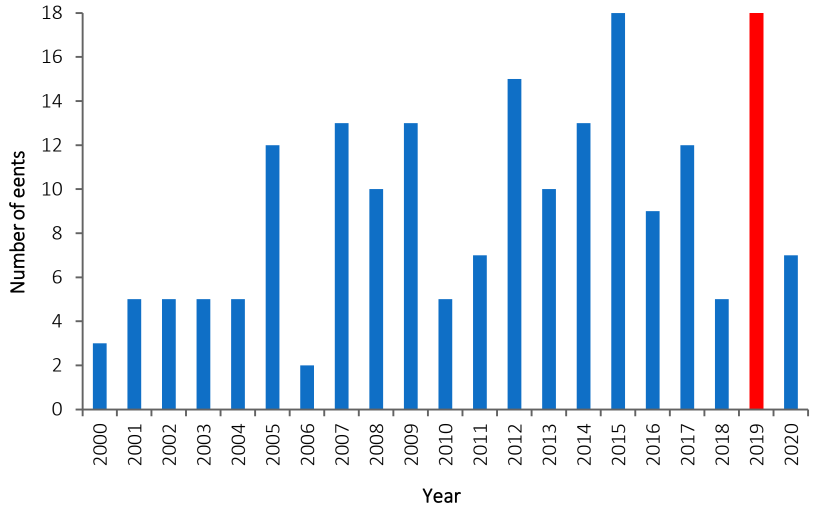
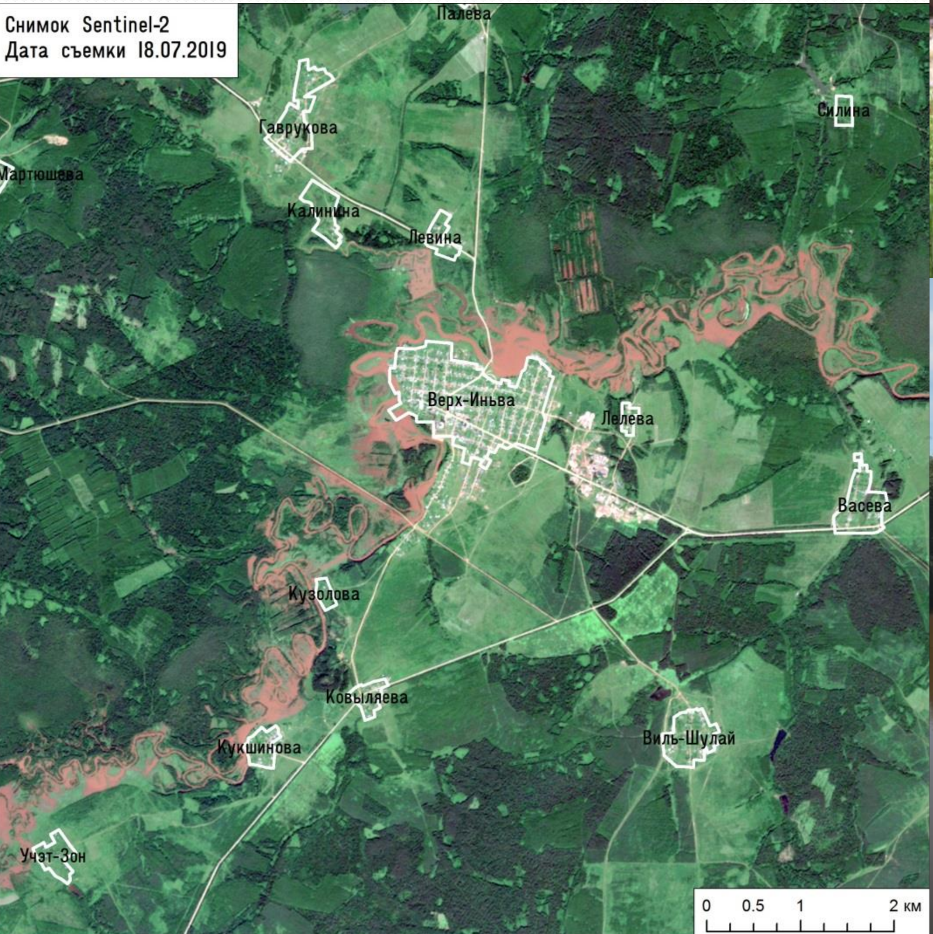
- The summer of 2019 in the Western Ural was characterized by extreme precipitation amount **(up to 300% of mean climatic values).** Several weather stations reported ≥200 mm of precipitation per month in July or in August 2019.
- **Heavy precipitation caused several rain flood events** on the rivers of the Kama reservoir basin.
- **The aim of the study is to assess the accuracy of short-range (with 15-27 h lead time) forecasts of heavy rainfall events observed in 2019 with the use of global atmospheric models ICON (Germany) and GFS (U.S), and mesoscale model WRF (with ARW dynamic core)**



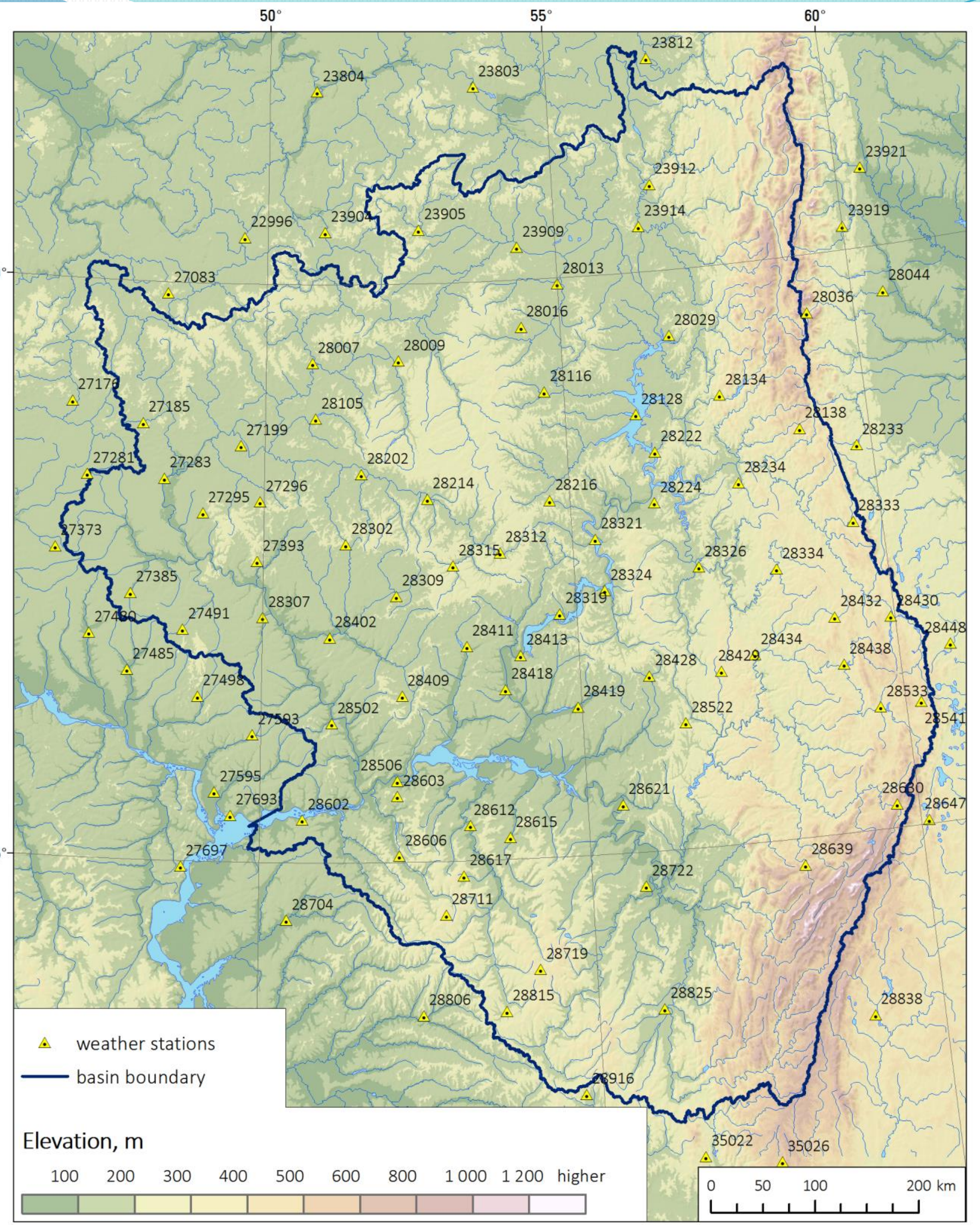
Number of heavy rainfall events (≥ 30 mm/12 h) reported at the weather stations of the Perm region over the period 2000-2020

Rain flood on July 16-18, 2019 (In’va river basin)



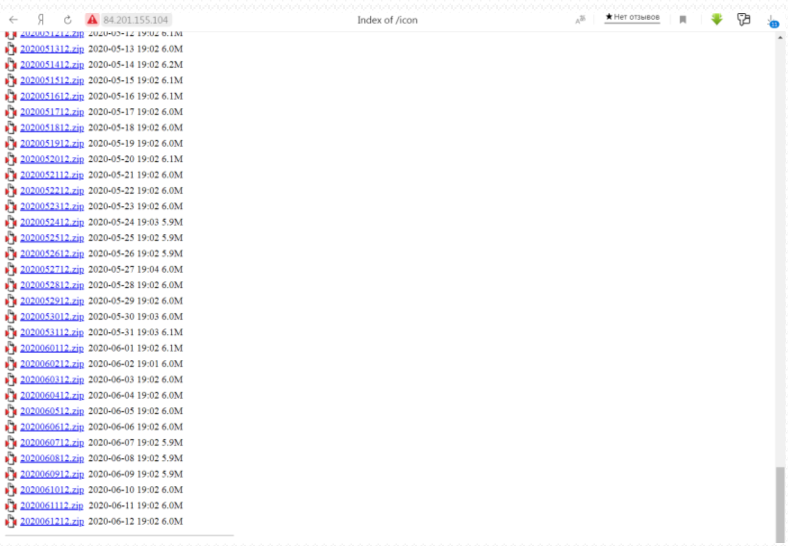
Study area and data

- The data from **95 weather stations** of Roshydromet have been used
- **72** among them are **located within the Kama river basin** and **23 – near of its boundaries.**
- **59 heavy rainfall events** (≥30 mm/12 h) and **two heavy snowfall events** (≥20 mm/12 h) have been reported
- **30 days** with heavy rainfall events
- **7 hazardous events** (≥50 mm/12 h)



NWP models characteristics

NWP model	Model grid step, km	Number of vertical levels	Grid step of output data	URL for download the data
GFS (NCEP, U.S)	13	64	0,25°	http://nomads.ncep.noaa.gov/pub/data/nccf/com/gfs/prod/
ICON (DWD, Germany)	13	90	0,125°	http://ftp-outgoing2.dwd.de/gds/ICON/grib/europe/
WRF v.4 (NCAR/Penn State University, U.S)	7	60	7 km	Computing on your server



- *http://84.201.155.104/icon/ - processed data of ICON model (geotiff)*
- *http://84.201.155.104/gfs/ - processed data of GFS NWP model (geotiff)*

Assessment of forecast accuracy

- The CSI and EDI metrics were calculated based on the contingency table of predicted and observed heavy rainfall events.

$$SCI = TP/(TP + FP + FN)$$

$$EDI = \frac{\log F - \log H}{\log F + \log H}$$

- To calculate EDI values, it is needed to preliminary calculate the number of true positive (H) and false alarms (F)

$$H = TP/(TP + FN)$$

$$F = FP/(FP+TN)$$

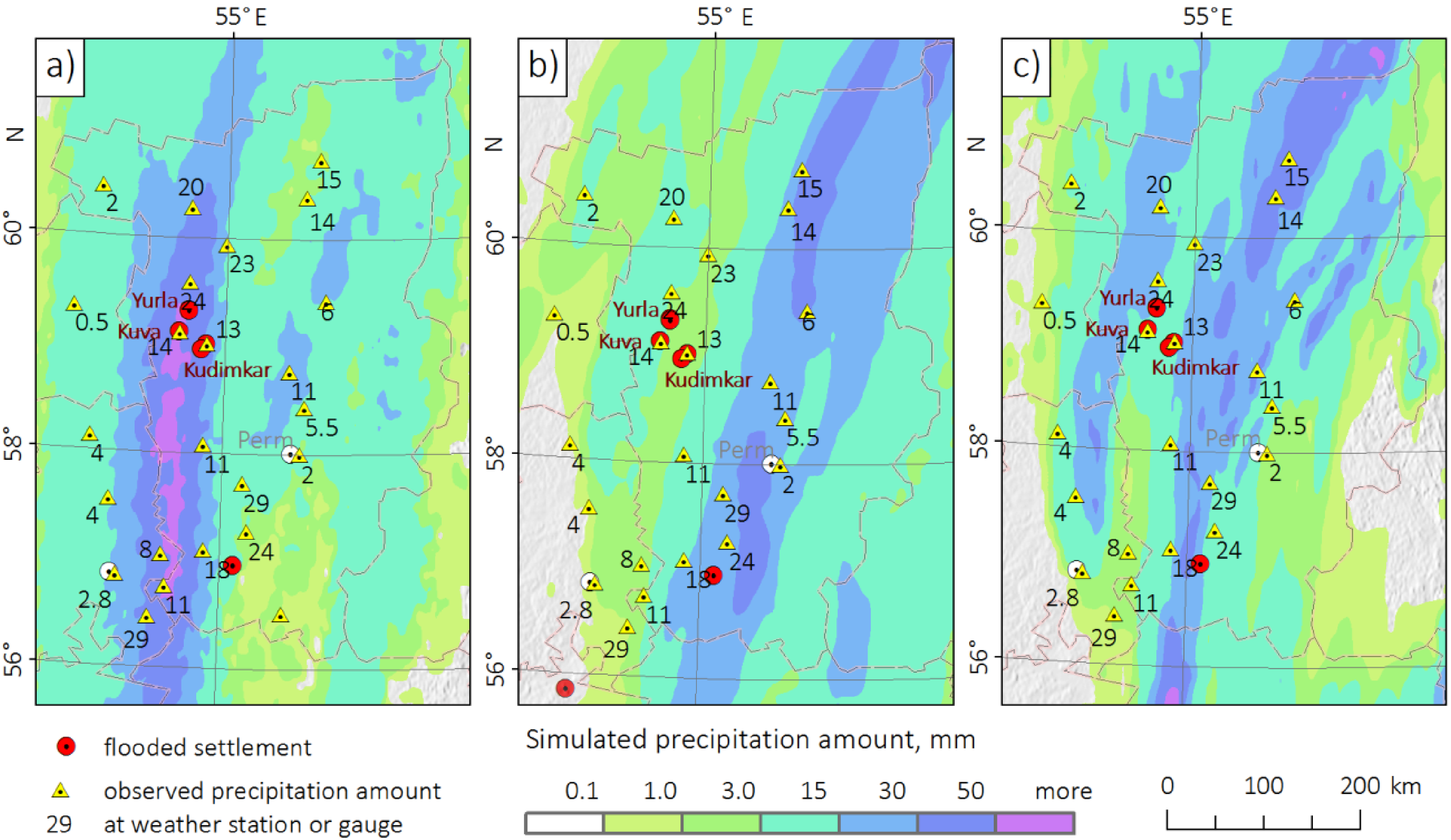
- Where *TP* is the number of true positive forecasts, *FN* – the number of false positive forecasts, *FP* – the number of false alarms and *TN* – the number of true negative forecasts.

Assessment of forecast accuracy

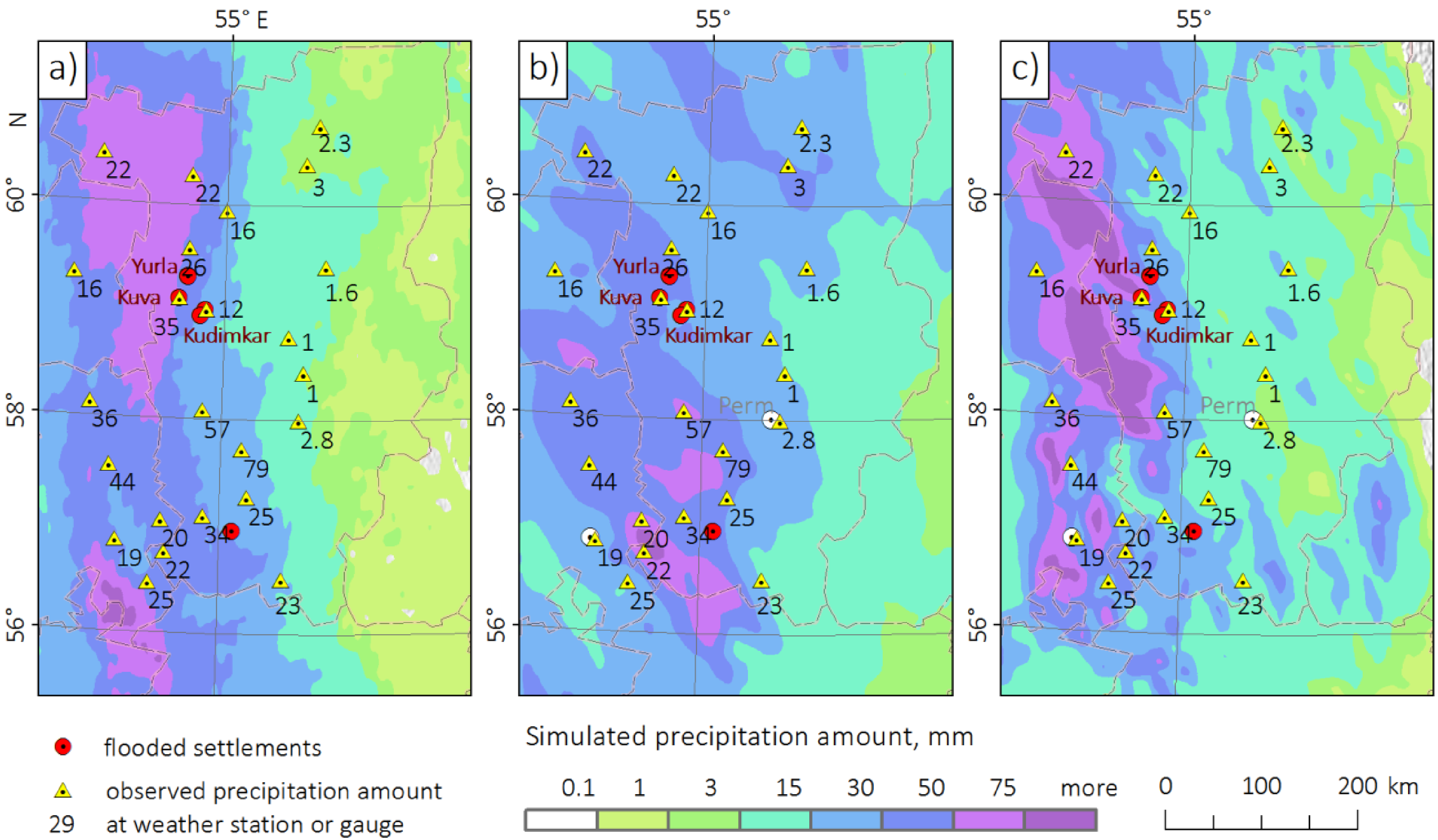
NWP model	TP	FN	FP	TN	SCI	EDI
ICON	11	51	17	3436	0.14	0.51
GFS	18	43	5	3450	0.28	0.69

- Both models substantially underestimate the precipitation amount.
- The number of FN substantially exceeded the sum of TP and FP.
- In several cases (23% of all forecasts according to the ICON model and 33% according to the GFS model), heavy precipitation (≥30 mm/12h) was not predicted not only at the weather stations, but also at any location within the study area.
- Displacement between simulated and observed precipitation zones is a substantial factor reducing the forecast accuracy.

Accumulated precipitation between 15.00 UTC July 13, 2019 and 15.00 UTC July 14, 2019 according to the ICON (a), GFS (b) and WRF (c) atmospheric models

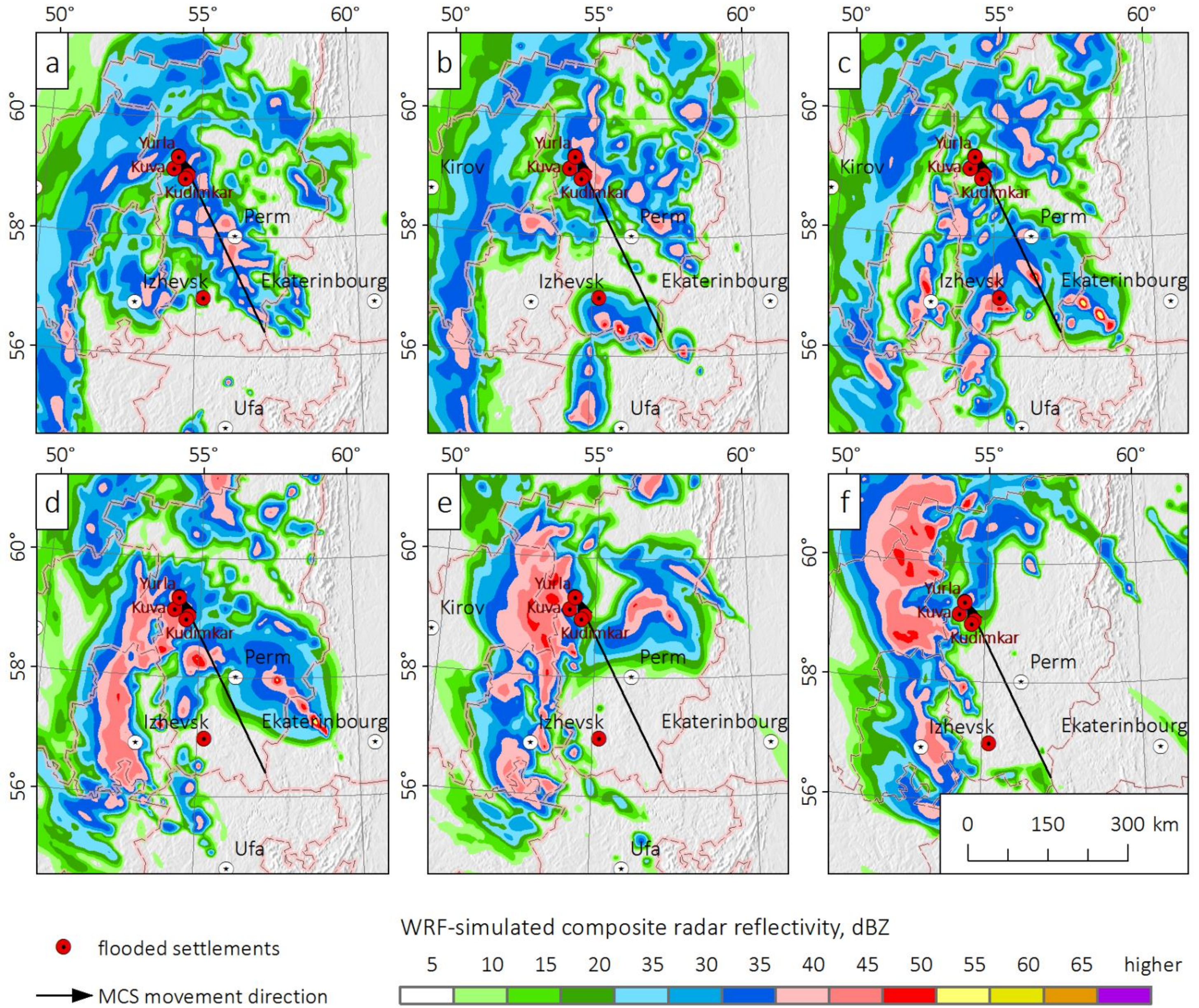


Accumulated precipitation between 03.00 UTC July 15, 2019 and 03.00 UTC July 16, 2019 according to the ICON (a), GFS (b) and WRF (c) atmospheric models



Simulated composite reflectivity at a July 15, 2019 according to the WRF model:

a – 10.00 UTC,
b – 12.00 UTC,
c – 14.00 UTC,
d – 16.00 UTC,
e -18.00 UTC,
f -20.00 UTC



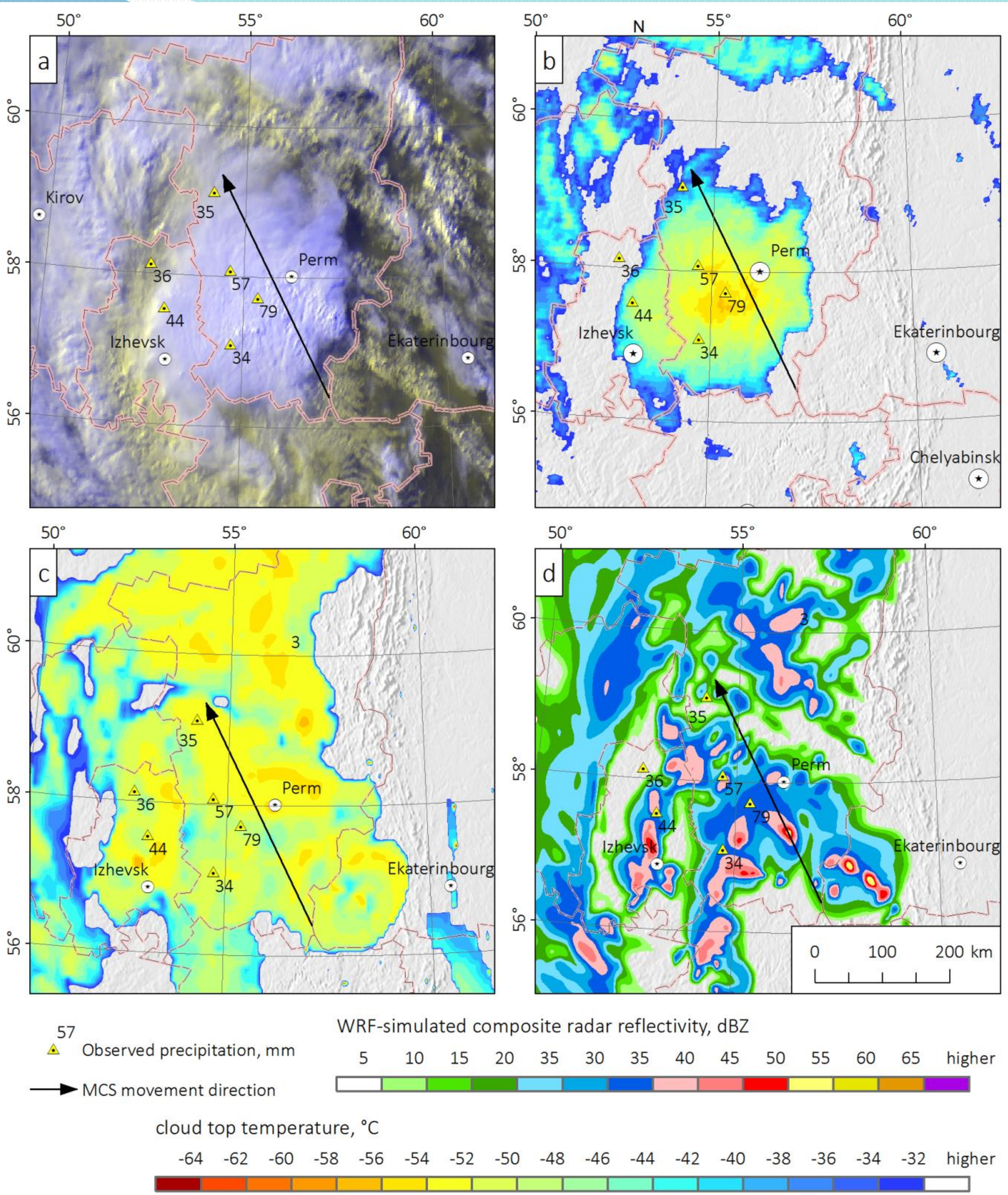
Comparison of satellite-observed and WRF-simulated characteristics of the convective storm at 14.00 July 15, 2019:

Meteosat-8 HRV cloud RGB image (a)

Cloud top temperature (b) (Meteosat-8 data)

WRF-simulated cloud top temperature (c)

WRF-simulated composite reflectivity (d)



Conclusion

- Accuracy of short-term forecast by NWP models is mainly determined by the nature of a heavy rainfall event.
- Local convective rainfall are not reproduced by the global NWP models (or their intensity is substantially underestimated)
- Heavy rainfall associated with cyclones or frontal waves are predicted quite successfully. In such cases, both overestimation and underestimation of precipitation amount is possible.
- ICON and WRF models successfully reproduced heavy rainfall in the northwest of Perm region that occurred July 15-16, 2019 and caused damaging rain flood.

Thank you for your attention

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