Automated Quality Control of Rain Gauge Data with AI Support

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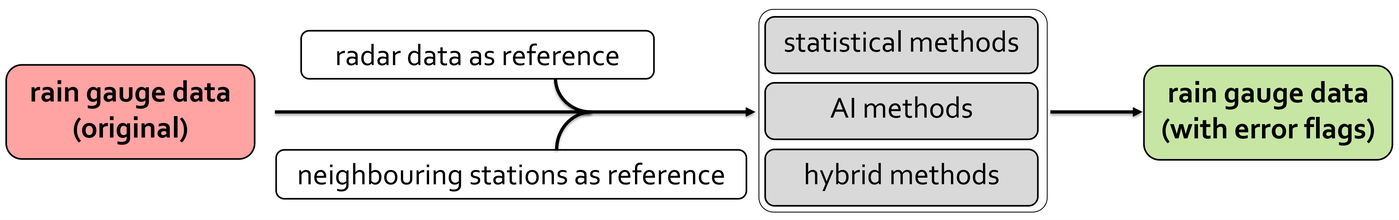
NIQKI – Niederschlagsdaten Qualitätskontrolle mit Künstlicher Intelligenz
https://fue-hydromet.de/niqki

Project NIQKI ("precipitation data QC with AI")

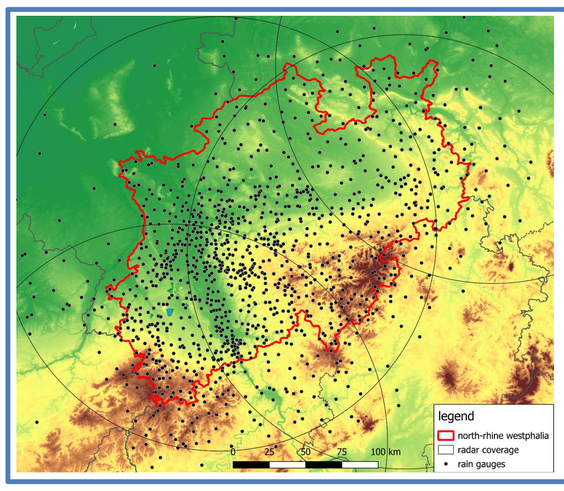
With increasing data volumes and a growing demand for high-quality precipitation data in real-time applications, automated quality control methods are becoming increasingly important. The NIQKI project aims to develop AI-supported methods to detect anomalies in rain gauge time series.



Project partners:

Technology Arts Sciences TH Köln · Hochschule Hof University of Applied Sciences · HST Systemtechnik · LANUK Kompetenz für ein lebenswertes Land

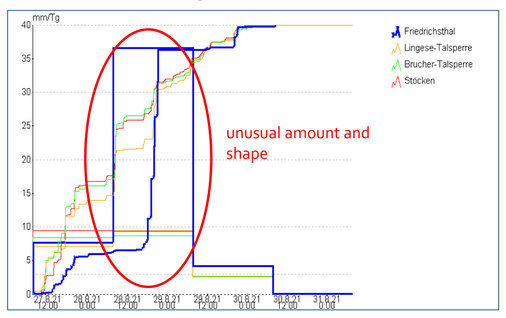
mFUND project 02/2025 – 01/2028 · Bundesministerium für Digitales und Verkehr



Dataset

- >1100 rain gauge timeseries in NRW
- 5 years: 11/2019 - 10/2024
- Corrected radar composite, timeseries for rain gauge locations
- Error protocol of manual control (9 labels)
- Basis for training AI methods

Error example



Error protocol	Timeseries description
Label 1	not rising monotonically
Label 2	(partially) missing precipitation
Label 3	time shift with value
Label 4	low precipitation
Label 5	high precipitation
Label 6	unusual amount and shape
Label 7	winter / snow
Label 8	steep rise
Label 9	unusual shape, irregular time shift

Statistical Methods

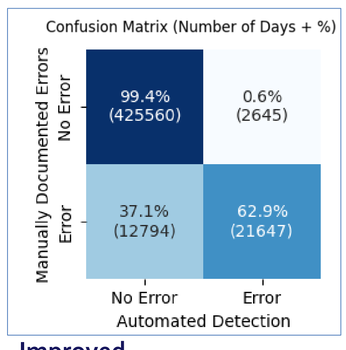
1. Extreme value detection (1, 5,60 & 1440 min. limits)
2. Extreme value detection in comparison with radar (1, 5,60 & 1440 min. limits + radar value)
3. High/low single daily values compared to neighbouring stations and radar value
4. Constant rainfall lasting more than 3 hours
5. Time shift detection using cross correlation with radar data (30 min, 1 h, 2 h, 3 h)

Machine Learning Workflow

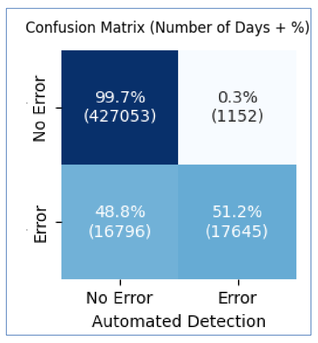
1. Block-wise feature extraction
2. Data labelling based on manually documented errors
3. Time-based data splitting
   - 4 years training data
   - 1 year test data
4. Model training with training data:
   - Tree-based ensemble methods: CatBoost (results shown, hydro&meteo), random forest, HistGradientBoosting (TH Köln)
   - Neural Networks: LSTM, CNN (TH Köln)
5. Model evaluation on the independent test dataset

First results

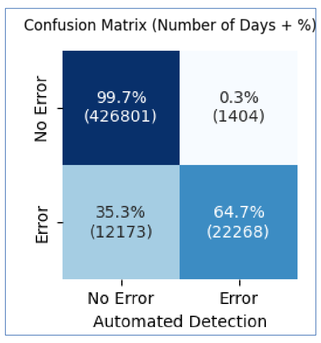
Statistical methods



AI (CatBoost)

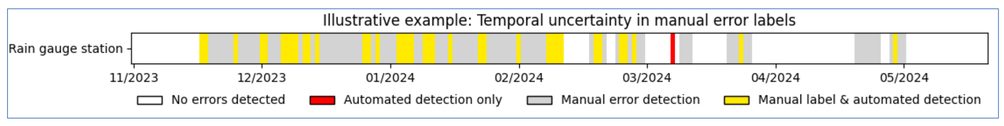


AI (+ statistical flags as features)



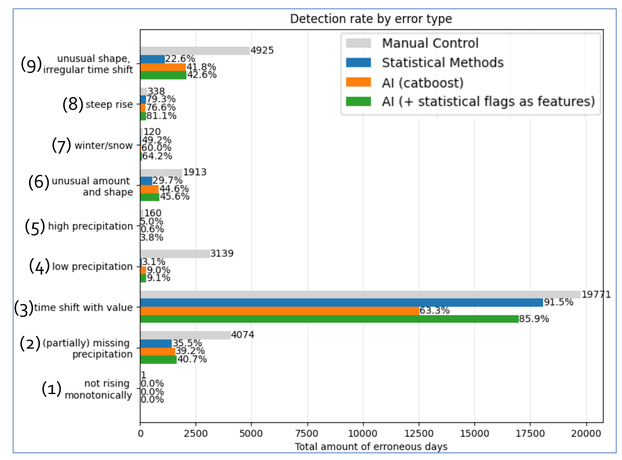
Improved recall: ~82 % · ~88 % · ~88 %

Note: Errors may be documented over extended periods, although actual faulty measurements occur on only a few days, potentially leading to an underestimated recall → "improved recall"

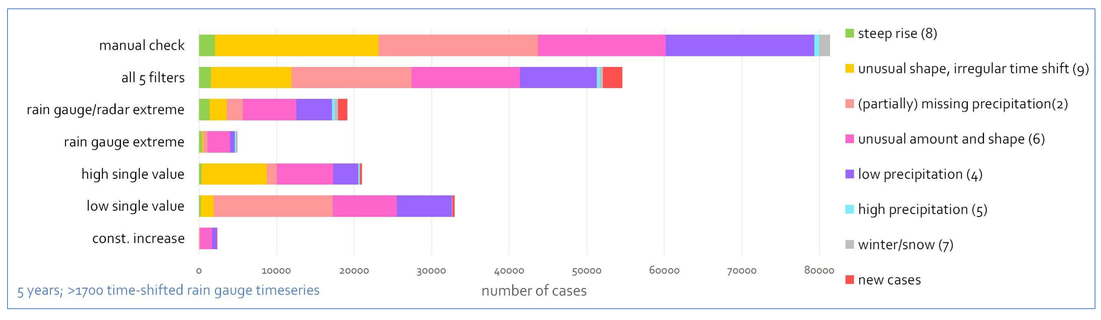


Comparison of methods for one year (11/2023 – 10/2024):

- Input: Original data (including time-shift errors)
- Confusion matrices show results of detected single days in time intervals
- Comparisons show improvements with AI support in all error categories
- AI use enhance detection of unusual shape (6 + 9) compared to statistical methods



Detection rate by error type – comparison: Statistical methods vs AI vs AI + statistical error flags. Data: ~ 1400 original rain gauge timeseries



Longterm tests (5 years) of statistical methods:

- Input: Time shift errors were corrected beforehand
- Manual check 81349 days with errors (2,58 %)
- 64,02 % detected with automated QC (found error in time interval -> whole interval set as detected)
- 0,08 % new cases (most false alarms come from extreme value detection with radar)

Conclusion/Outlook

- Statistical and machine-learning methods both show benefits in detecting measurement errors in rain gauge timeseries
- Combining both approaches in iterative or hybrid detection strategies may improve overall performance
- Validation depends on reliable manual reference labels: Human errors and uncertainties in defining the exact start and end of erroneous periods can affect the evaluation

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