Towards Probabilistic Extreme Rainfall Warnings for Belgium

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Motivation

Heavy rainfall and subsequent flooding can cause heavy damage or even fatalities in Western Europe, as recently demonstrated by the mid-July 2021 flood event. This project has the objective to

- Improve the operational extreme rainfall warnings for Belgium
- Go from a deterministic to a probabilistic system to assess uncertainties in the extreme rainfall nowcasting

Extreme rainfall return periods

Extreme rainfall is defined through Generalized Extreme Value (GEV) models based on long-term time series of rain gauge data [1], [2]:

- Spatial variability is implemented into the GEV models by allowing model parameters to vary spatially through the introduction of covariates.
- Best covariates (Fig. 1): mean annual rainfall (MAR) and topography
- The return level z(T) is defined as the value that is exceeded, on average, once every T years.

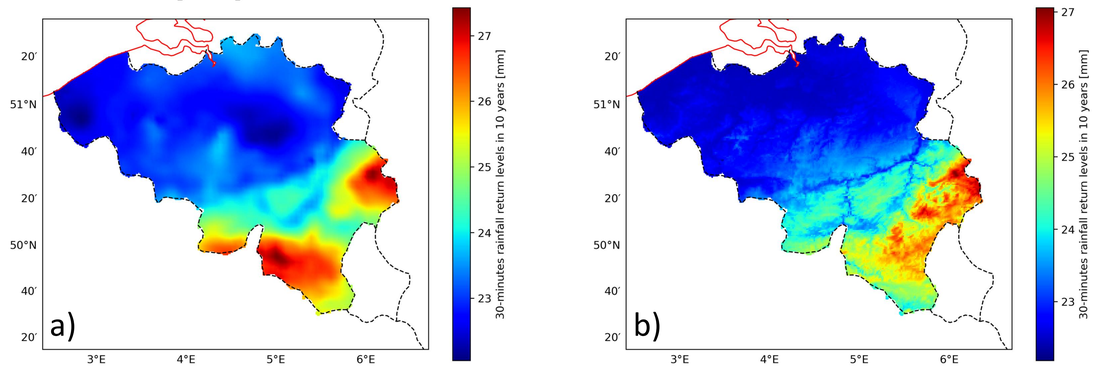

Fig. 1: Covariates of the GEV models – a) MAR, b) Topography

- Return periods (T) define the time interval over which the return level is expected to recur. Longer return periods mean more extreme rainfall.

PySTEPS-BE ensemble nowcast configuration

Built in the open-source nowcasting framework PySTEPS.
Input:

- Observations: Belgian radar-based quantitative precipitation estimation (RADQPE), 1km resolution, 5min frequency
- NWP: ALARO/AROME Mini-EPS at 1.3km, 5min accumulations

Output:

- Forecast time step of 5min for up to +6 hours lead time
- With a skill- and scale-dependent blending between observation and NWP [3]
- 24-member ensemble run every 5min using scale-dependent stochastic perturbations [4]

References

[1] Van de Vyver, H. (2013): Practical return level mapping for extreme precipitation in Belgium, Publication scientifique et technique n° 62, 30 pp., IRM.

[2] Van de Vyver, H. (2012): Spatial regression models for extreme precipitation in Belgium, Water Resour. Res., 48, W09549, https://doi.org/10.1029/2011wr011707.

[3] Imhoff, Ruben O., et al. (2023): Scale-dependent blending of ensemble rainfall nowcasts and numerical weather prediction in the open-source pysteps library, Quarterly Journal of the Royal Meteorological Society 149.753 (2023): 1335-1364.

[4] Alan W Seed, Clive E Pierce, and Katie Norman. "Formulation and evaluation of a scale decomposition-based stochastic precipitation nowcast scheme". In: Water Resources Research 49.10 (2013), pp. 6624–6641

Preliminary Results

The challenge: The figures should contain all the important information such as the return periods, the time of the events and the probability, but at the same time remain clear.

- Case study 2023-08-25 0700-1000 UTC
- Using MAR as precipitation-based covariate
- Observations (RADQPE)

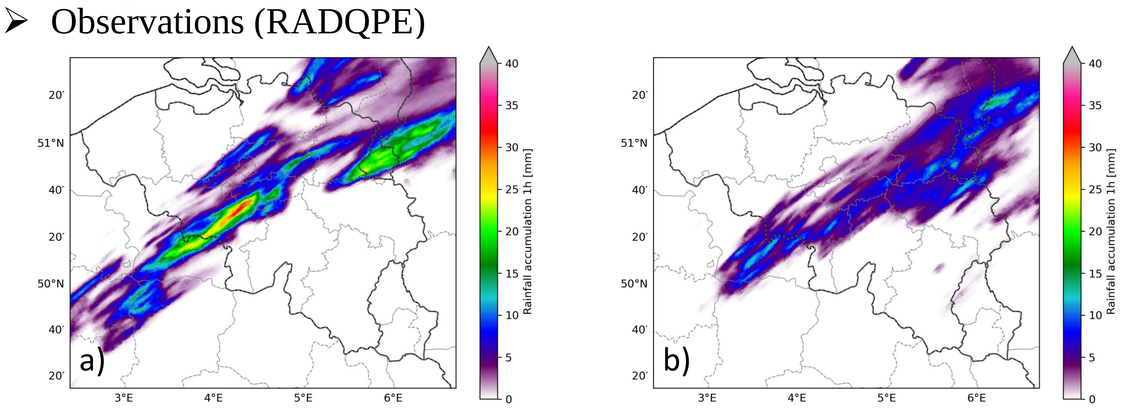

Fig. 2: RADQPE accumulation a) 0700-0800 UTC, b) 0900-1000 UTC

- 10-year return level exceedance probability with forecast history (grey)

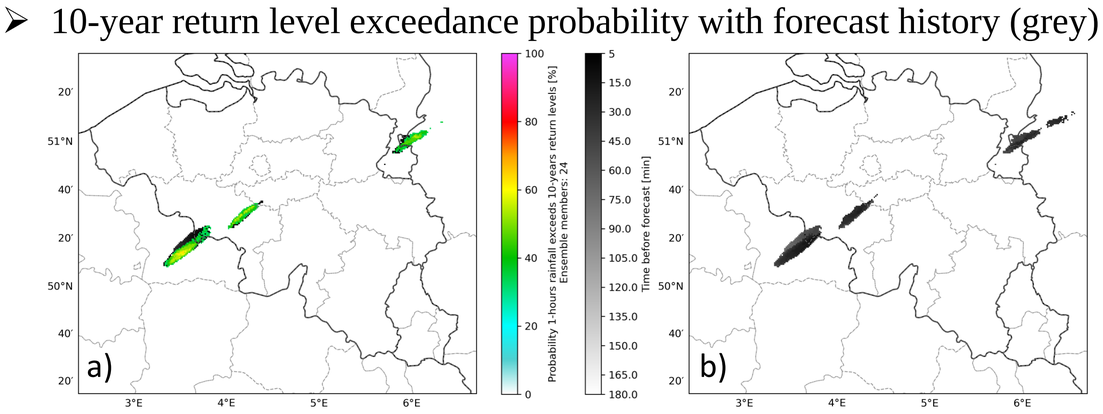

Fig. 3: Probability of 1-hour rainfall exceeding 10-year return levels at a) 0745 UTC (45min forecast), b) 0830 UTC (90min forecast)

- Exceedance probability for 4 return periods (colorbars)

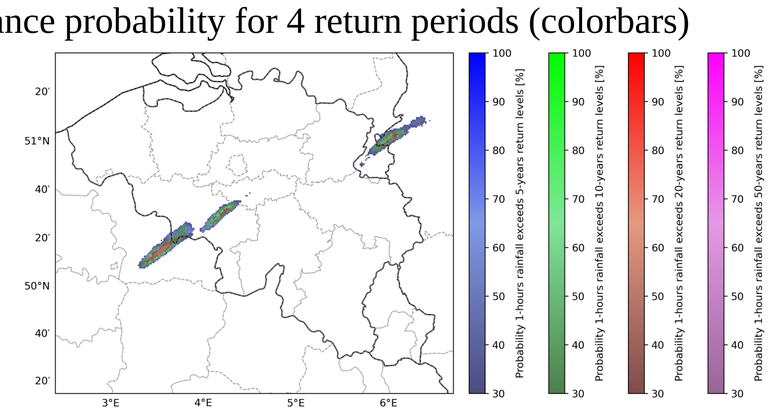

Fig. 4: Probability of 1-hour rainfall exceeding return periods of 5 (blue), 10 (green), 20 (red), 50 (magenta) years at 0745 UTC (45min forecast)

- Exceedance probability for 4 return periods (panels) and for 4 forecast times (colorbars)

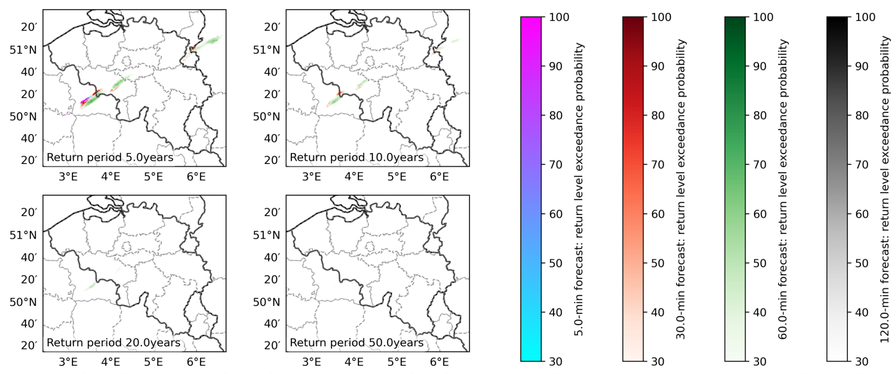

Fig. 5: Probability of 1-hour rainfall exceeding return periods of 5, 10, 20, 50 years for forecast times of 5min, 30min, 1h, 2h

Next steps

- Include extreme rainfall warnings in the operational PySTEPS-BE
- Municipality scale warnings derived from 1km×1km resolution products
- Extreme rainfall warnings in the RMI mobile app

Acknowledgements

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