Analysis of short-term precipitation for design purposes at Hungarian Meteorological Service

HungaroMet
Magyar Meteorológiai Szolgáltató Nonprofit Zrt.

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Abstract

The water cycle has accelerated, and warmer air can hold more moisture, increasing the risk of heavy and intense downpours. This intensification of rainfall makes it necessary to update the rainfall intensity-duration-frequency (IDF) curves that were originally developed for stormwater drainage design in the 1970s in Hungary. Recently the previously used uniform functions were replaced with locally tailored maximum rainfall distribution functions that better reflect the climatic conditions at the planned drainage site.

Estimating the parameters of Generalized Extreme Value (GEV) distributions to compute the return values requires time series of precipitation data for short durations such as 10, 20, or 30 minutes. Once these data are available, after fitting the GEV function, the Intensity-Duration-Frequency (IDF) curves can be constructed. These curves allow for determining the return period of a given precipitation intensity over a specified duration. HungaroMet has developed a service to support design applications, mainly used for drainage systems. The downloadable intensity values are based on automatic measurements from 100 monitoring sites.

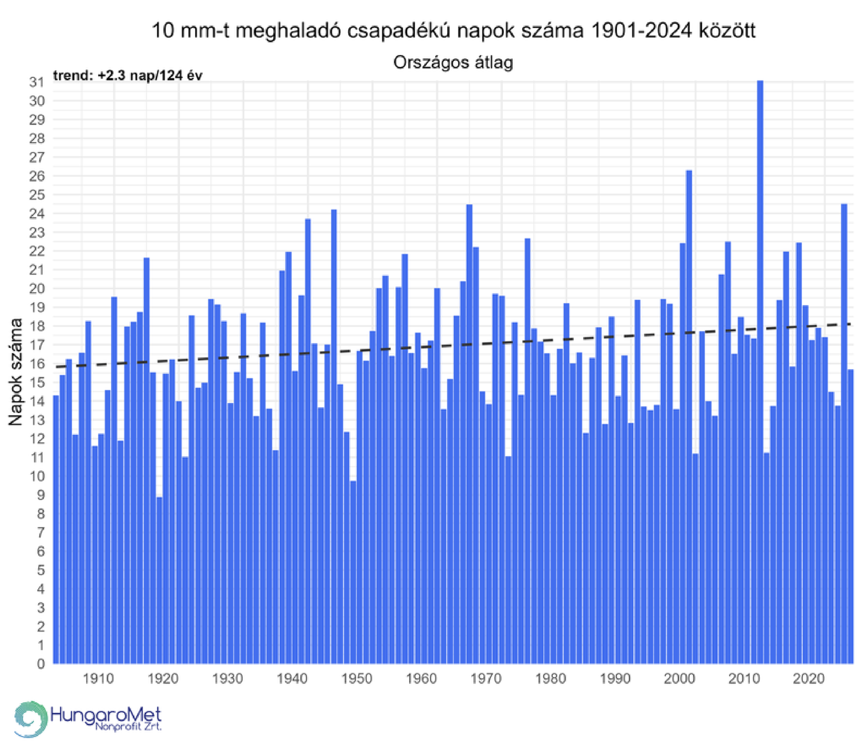
After entering the location of the planned project, users can access site-specific intensity values for planning purposes.

As the measurement time series continue to grow, the design values can be regularly updated using the most comprehensive data available in the HungaroMet database.

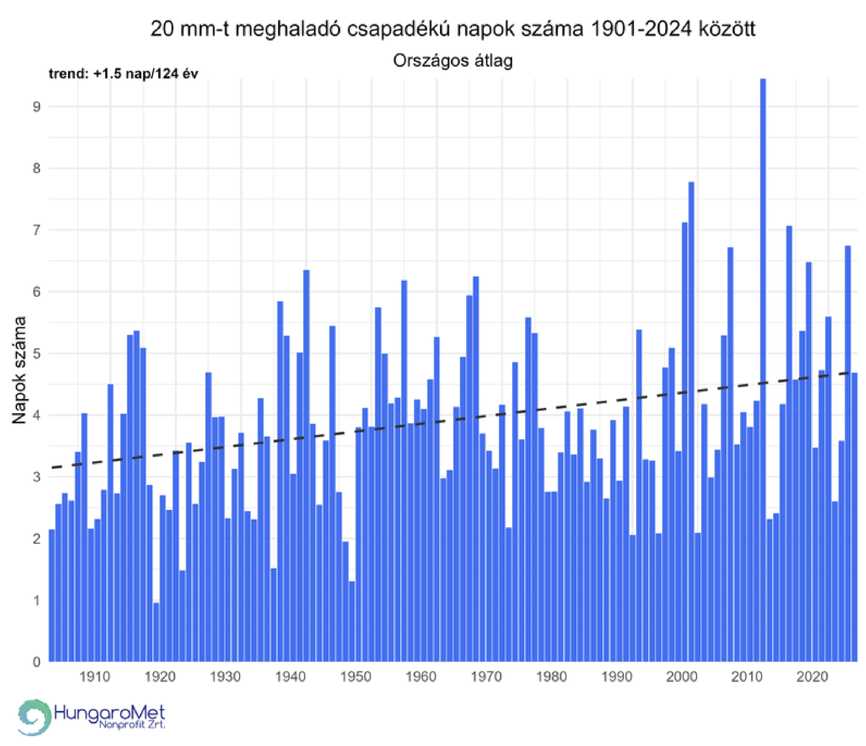
To better reflect the effects of climate change, in addition to the IDF curves based on observations, we are analysing daily maximum hourly precipitation rate values (prhmax) from six regional climate model simulations from the EURO-CORDEX selection recently used at HungaroMet Hungarian Meteorological Service. The analysis covers three emission scenarios and two future time periods: 2041–2070 and 2071–2100. The aim is to use prhmax for calculating return values of short-term precipitation for design purposes.

This work has been implemented by the National Multidisciplinary Laboratory for Climate Change (RRF-2.3.1-21-2022-00014) project within the framework of Hungary's National Recovery and Resilience Plan supported by the Recovery and Resilience Facility of the European Union.

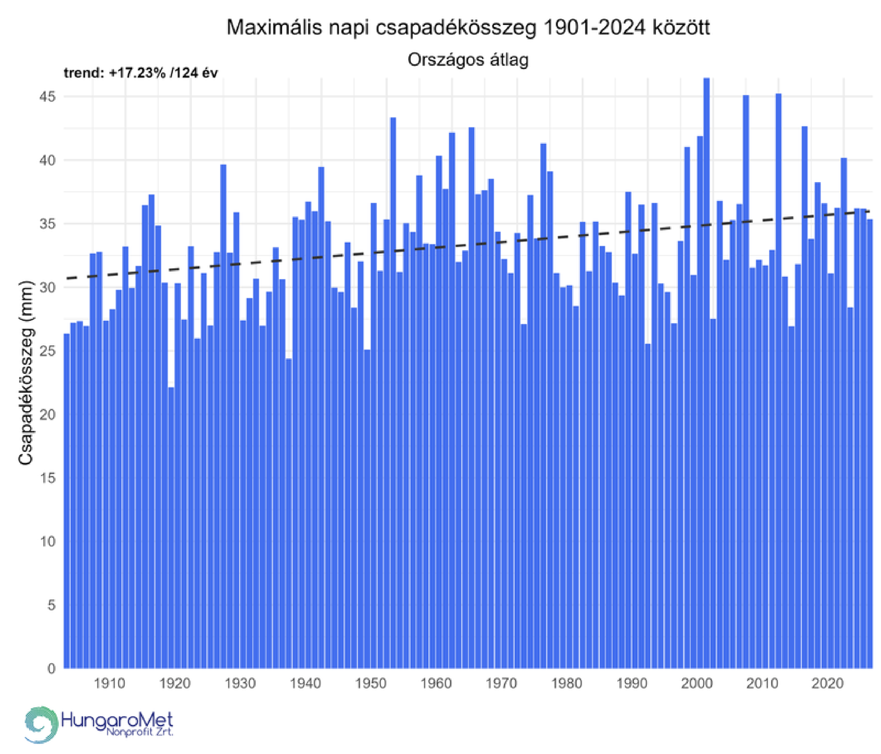
Motivation: The precipitation is intensifying - Precipitation indices (homogenized -MASH, gridded – MISH) graphs at nationwide and county level from 1901 on the webpage of HungaroMet, yearly update



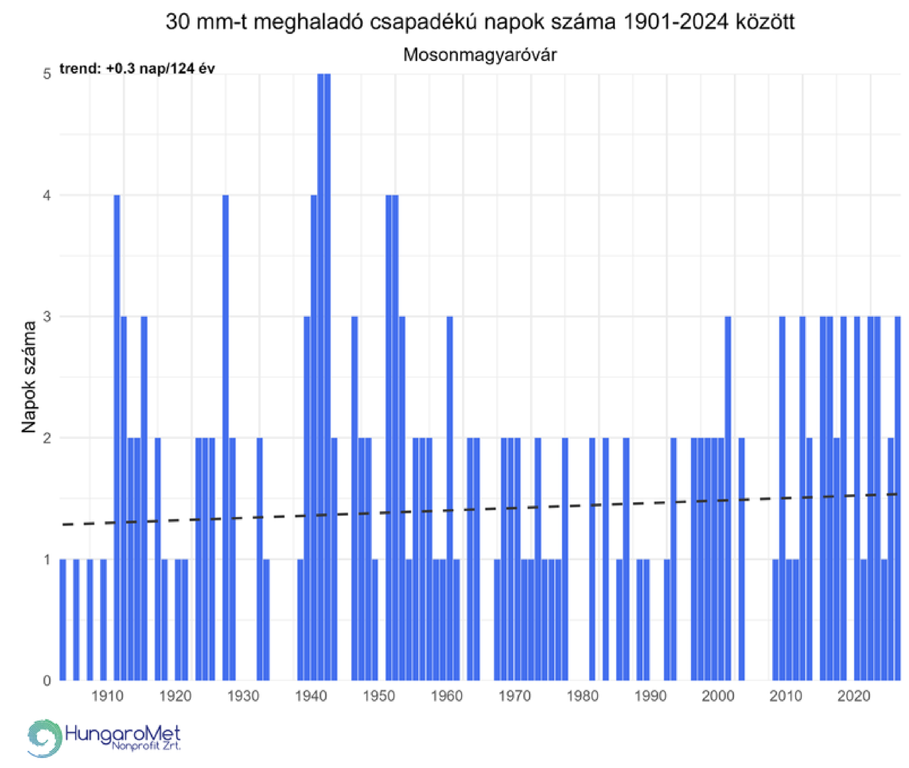
Number of days with daily precipitation > 10mm, countrywide average (fieldmean)



Number of days with daily precipitation > 20mm, countrywide average (fieldmean)



Maximum daily precipitation, countrywide average (fieldmean)

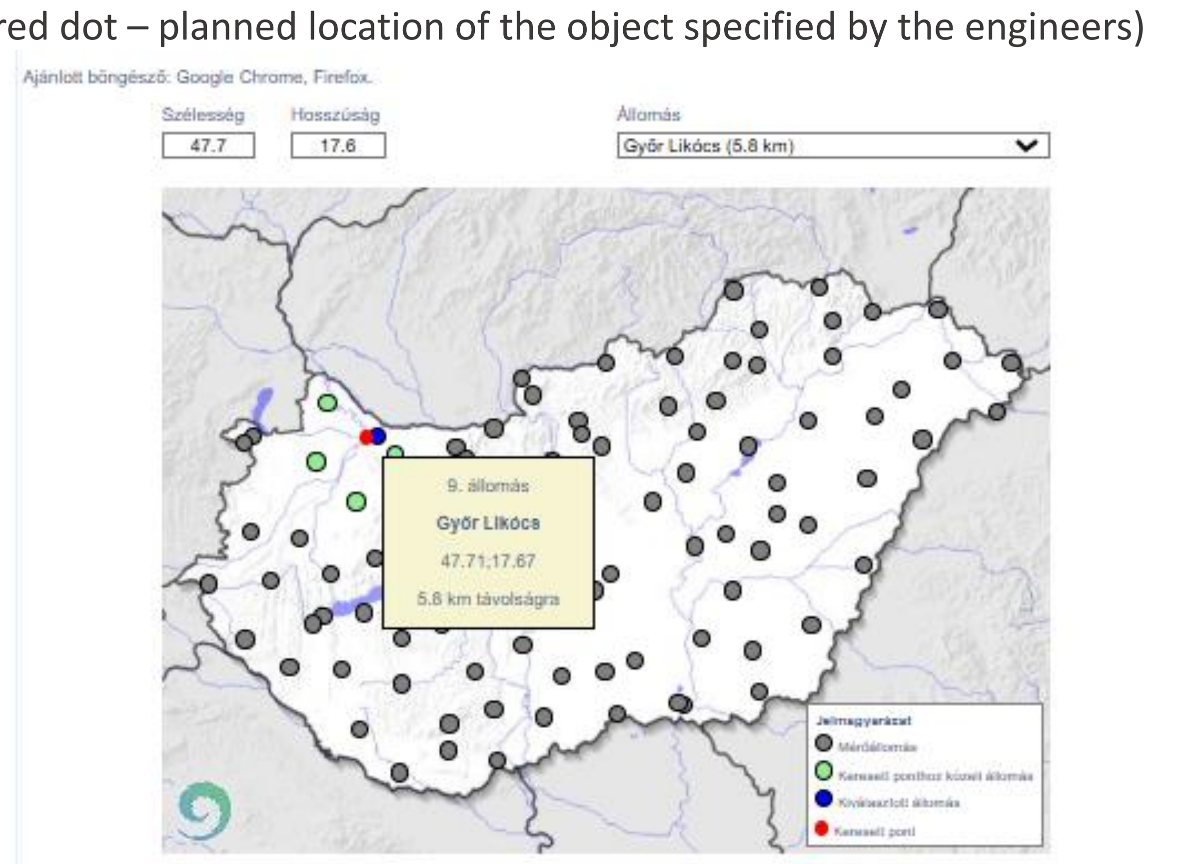


Number of days with daily precipitation > 30mm at Mosonmagyaróvár station (NW Hungary)

Public user service for design purposes

Return levels of precipitation intensity (mm/h) at 100 stations for Hungary, download in csv, pdf
Data used: AWS measurement in the period of 1998-2023, yearly update, GEV fit
Example: different return levels for meteorological station Győr (NW Hungary blue dot, green dots – nearby stations; red dot – planned location of the object specified by the engineers)

Collaboration with HungaroMet General Directorate of Water Management (OVF) Hungarian Chamber of Engineers (Water Management and Water Construction Section)



Az ingyenes tervezői adatszolgáltatás biztosításához a szükséges fejlesztést az Országos Vízügyi Főigazgatóság (Települési Vízgazdálkodási Osztály) megbízásából a Magyar Mérnöki Kamara (Vízgazdálkodási és Vízépítési Tagozat) szakmai közreműködésével a HungaroMet Nonprofit Zrt. készítette.

Mérőállomás: 9; **Győr Likócs** Koordináták: 47.71 N ; 17.67 E; 5.8 km távolságra

Intenzitás (mm/h)	10 perces	20 perces	30 perces	60 perces
1 éves, 100%-os	37,39	28,12	21,95	12,82
2 éves, 50%-os	56,69	41,48	31,68	18,89
4 éves, 25%-os	70,37	50,95	38,58	23,19
5 éves, 20%-os	74,32	53,68	40,57	24,43
10 éves, 10%-os	85,99	61,76	46,46	28,10
20 éves, 5%-os	97,19	69,51	52,10	31,62
50 éves, 2%-os	111,68	79,54	59,41	36,17
100 éves, 1%-os	122,53	87,06	64,89	39,59

1. táblázat: I_p - mértékadó intenzitás értékek mm/h - ban.

Intenzitás (l/s x ha)	10 perces	20 perces	30 perces	60 perces
1 éves, 100%-os	102,82	74,79	60,57	35,14
2 éves, 50%-os	157,60	114,06	86,49	51,00
4 éves, 25%-os	194,22	140,61	105,71	63,31
5 éves, 20%-os	205,86	148,69	111,57	67,67
10 éves, 10%-os	236,47	169,84	127,76	76,71
20 éves, 5%-os	270,17	191,15	144,33	87,90
50 éves, 2%-os	308,22	219,53	164,57	99,84
100 éves, 1%-os	339,42	241,15	179,09	109,26

2. táblázat: I_p - mértékadó intenzitás értékek l/s x ha - ban.

Az I_p becslése az alábbi módszertan alapján készült.
Tervezői segédlet

Kérdését, észrevételeit az alábbi email címen várjuk: intenzitas22@met.hu

PDF letöltése CSV letöltése

Future changes of precipitation intensity based on regional climate model simulation

Data: prhmax (Daily Maximum Hourly Precipitation Rate) for the periods 2041–2070, 2071–2100 using the 1971–2000 reference period.
The resolution of the simulations is 0.11°.
6 gridpoint selected in region Győr (NW Hungary).
Data source: EURO-CORDEX (Jacob et al., 2014; 2020)

Analysis was performed for return periods: 2, 4, 10, and 100 years based on a HungaroMet study for calculating rainfall intensity (Szabó and Zsebeházi, 2017).

GCM	RCM	Scenario
ICHEC-EC-EARTH	CCLM4-8-17	
	HIRHAM5	RCP 2.6
	RACMO22E	RCP 4.5
	RCA4	RCP 8.5
CNRM-CERFACS-CNRM-CM5	RACMO22E	
MPI-M-MPI-ESM-LR	RCA4	

Return values (mm/h) for the reference period (1971-2000) for different return periods (years) for Győr (NW Hungary)

GCM	RCM	Return values			
		2	4	10	100
ICHEC-EC-EARTH	CCLM4-8-17	2.21	2.67	3.19	4.41
	HIRHAM5	5.03	8.46	12.40	21.58
	RACMO22E	3.79	6.73	10.09	17.95
	RCA4	4.16	4.70	5.31	6.75
CNRM-CERFACS-CNRM-CM5	RACMO22E	4.26	5.54	6.99	10.40
MPI-M-MPI-ESM-LR	RCA4	1.73	2.06	2.43	3.31

Change in return values expressed in mm/h, based on 6 regional model simulations, 3 scenarios, and 4 return periods, for 2 future time periods (in blue: 2041–2070, in green: 2071–2100) for the Győr region

RCP 2.6 scenario									
Models		Retun period (year)							
GCM	RCM	2		4		10		100	
ICHEC-EC-EARTH	CCLM4-8-17	0.39	0.39	1.20	0.64	2.12	0.92	4.29	1.58
	HIRHAM5	-0.81	-1.68	-1.81	-4.26	-2.95	-7.21	-5.62	-14.11
	RACMO22E	-0.93	1.52	-2.04	2.99	3.32	4.69	6.29	8.65
	RCA4	0.72	0.23	0.19	0.21	-0.42	0.18	-1.84	0.12
CNRM-CERFACS-CNRM-CM5	RACMO22E	1.39	1.97	1.96	2.96	2.62	4.09	4.15	6.73
MPI-M-MPI-ESM-LR	RCA4	2.95	2.96	4.27	4.88	5.77	7.09	9.28	12.25

RCP 4.5 scenario									
Models		Retun period (year)							
GCM	RCM	2		4		10		100	
ICHEC-EC-EARTH	CCLM4-8-17	1.21	3.33	2.45	6.55	3.86	10.25	7.16	18.88
	HIRHAM5	2.24	2.84	0.78	7.19	-0.88	12.18	-0.78	23.82
	RACMO22E	2.29	1.08	4.85	1.53	7.79	2.04	14.66	3.24
	RCA4	0.41	0.48	0.28	0.05	0.13	-0.44	-0.23	-1.58
CNRM-CERFACS-CNRM-CM5	RACMO22E	1.83	4.18	3.23	6.50	4.83	9.17	8.56	15.39
MPI-M-MPI-ESM-LR	RCA4	2.23	1.51	3.23	1.51	4.37	1.52	7.03	1.54

RCP 8.5 scenario									
Models		Retun period (year)							
GCM	RCM	2		4		10		100	
ICHEC-EC-EARTH	CCLM4-8-17	1.46	2.21	2.33	2.67	3.34	3.19	5.69	4.41
	HIRHAM5	6.09	5.03	9.95	8.46	14.35	12.40	24.66	21.58
	RACMO22E	1.49	3.79	2.21	6.73	3.04	10.09	4.98	17.95
	RCA4	2.92	4.16	3.41	4.70	3.97	5.31	5.27	6.75
CNRM-CERFACS-CNRM-CM5	RACMO22E	5.62	4.26	10.97	5.54	17.10	6.99	31.41	10.40
MPI-M-MPI-ESM-LR	RCA4	2.21	1.73	2.33	2.06	2.48	2.43	2.81	3.31

Conclusion

Future changes in rainfall intensity in Győr depend strongly on the emission scenario. Most regional climate models project an increase during the 21st century, especially for rare extreme events, with the largest changes under RCP8.5 and the smallest under RCP2.6. Large differences between models make projections uncertain, posing challenges for infrastructure planning, particularly urban drainage. Some models, such as ICHEC-EC-EARTH HIRHAM5, indicate decreases in certain cases, reflecting the uncertainty in climate projections. To address this, assessments typically employ ensembles of multiple models and emission scenarios to more comprehensively represent the potential range of future.

References

Jacob D., Petersen J., Eggert B. et al., 2014: EURO-CORDEX: new high-resolution climate change projections for European impact research. Regional Environmental Change, 14, 563–578.
https://doi.org/10.1007/s10113-013-0499-2
Jacob D., Teichmann C., Sobolowski S. et al., 2020: Regional climate downscaling over Europe: perspectives from the EURO-CORDEX community. Regional Environmental Change, 20, 1-20.
https://doi.org/10.1007/s10113-020-01606-9
Szentimrey, T. (2017) : Manual of homogenization software MASHv3.03. Hungarian Meteorological Service, Budapest, Hungary.
Szentimrey, T. and Bihari, Z., (2014): Manual of Interpolation Software MISHv1.03. Hungarian Meteorological Service: Budapest, Hungary
Vitek, V. (2025): Analysis of short-duration precipitation partial sums based on measurements and regional climate model results in Győr (diploma thesis, in Hungarian)
Szabó P., Zsebeházi G. (2017): Study for calculating 10-minute rainfall intensity, HungaroMet internal document, in Hungarian