

# A VELENCEI-TAVI VÍZMÉRLEGSZÁMÍTÁS ZÁRÓHIBÁINAK ELEMZÉSE

## ÉS A SZÁMÍTÁSI MÓDSZERTAN FELÜLVIZSGÁLATA

Chappon Máté – PhD hallgató – [chappon.mate@sze.hu](mailto:chappon.mate@sze.hu)

Dr. Bene Katalin – docens – [benekati@sze.hu](mailto:benekati@sze.hu)

Víztudományi és Vízbiztonsági Nemzeti Laboratórium

Széchenyi István Egyetem Közlekedésépítési- és Vízmérnöki Tanszék



MAGYAR HIDROLÓGIAI TÁRSASÁG

XL VÁNDORGYŰLÉS

GYŐR

2023. 07. 05-07.

6/B szekció

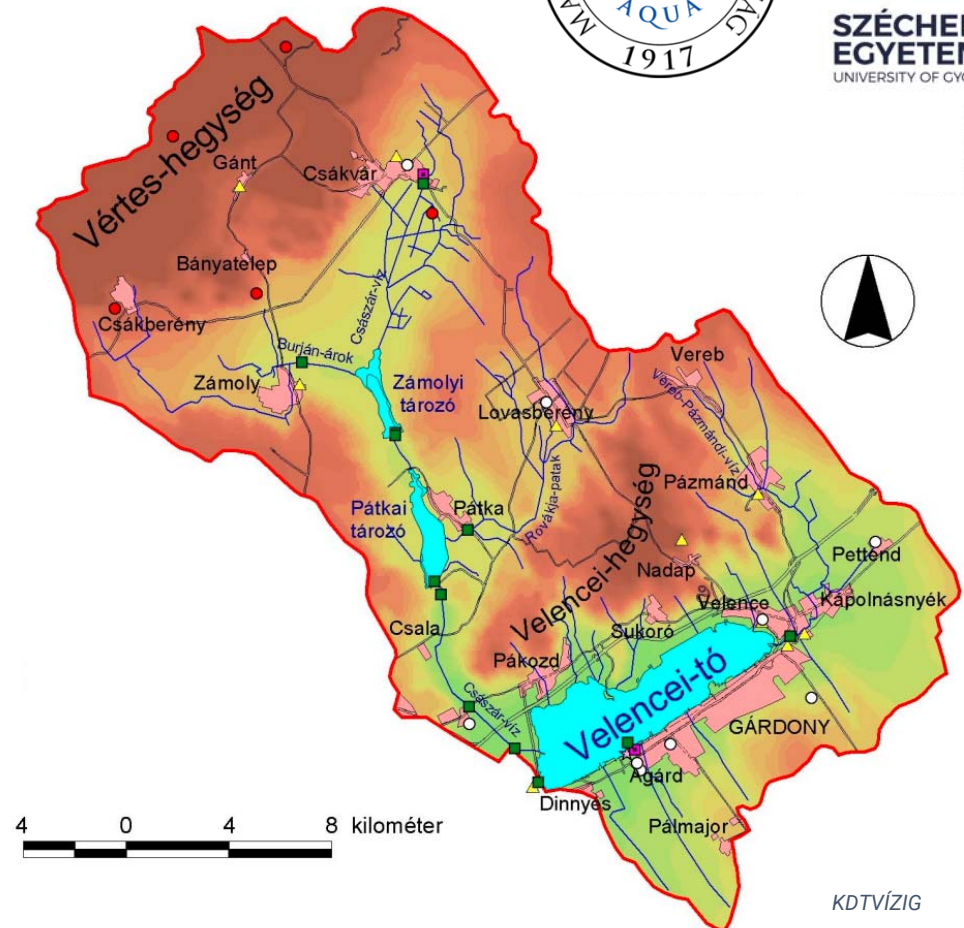
# Kutatás háttere



- Water Value Flow<sup>1</sup> koncepció
  - Integrált vízgazdálkodás
    - Hidrológia
    - Vízhasználatok (rekreáció, agrár, term.véd)
  - Hol ér legtöbbet a víz?

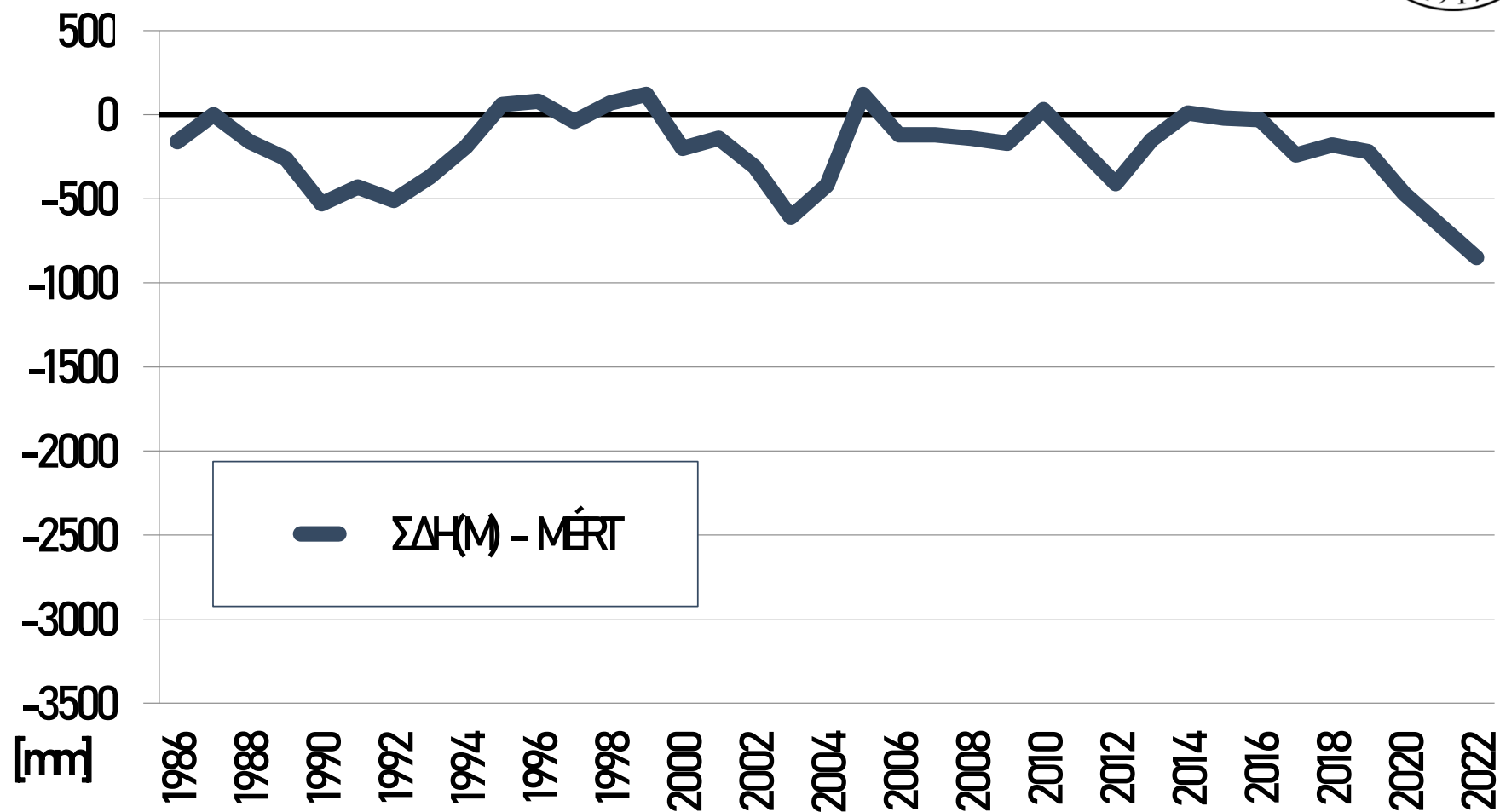
1: I. M. Seyam, A. Y. Hoekstra, and H. H. G. Savenije, "The water value-flow c Physics and Chemistry of the Earth, Parts A/B/C, vol. 28, no. 4–5, pp. 175–Jan. 2003, doi: 10.1016/S1474-7065(03)00028-7.

- Velencei-tó mint mintavízgyűjtőterület
  - Vízhez kapcsolódó konfliktusok
  - Jó adatellátottság
  - Széles társadalmi érdeklődés

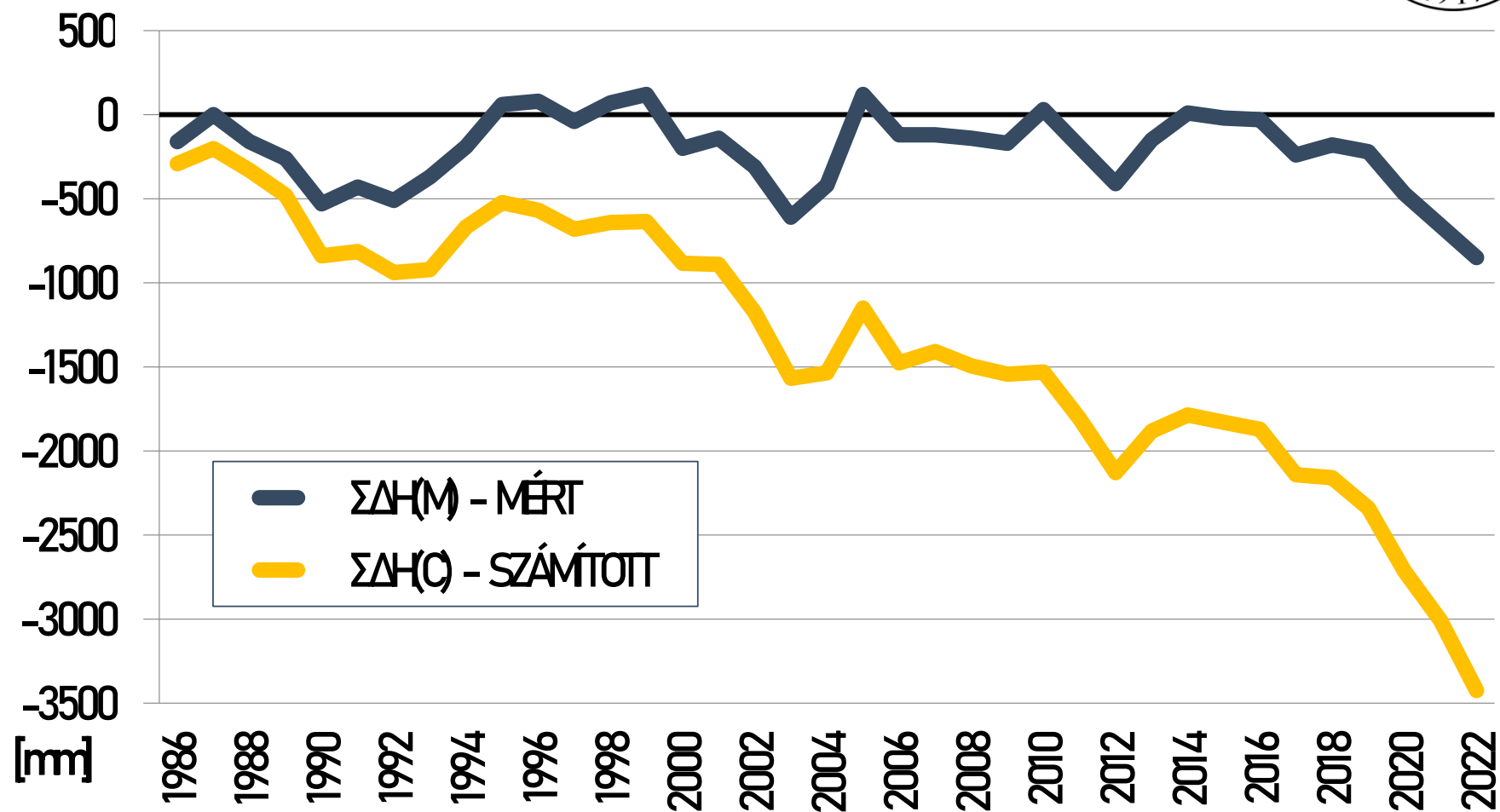


KDTVÍZIG

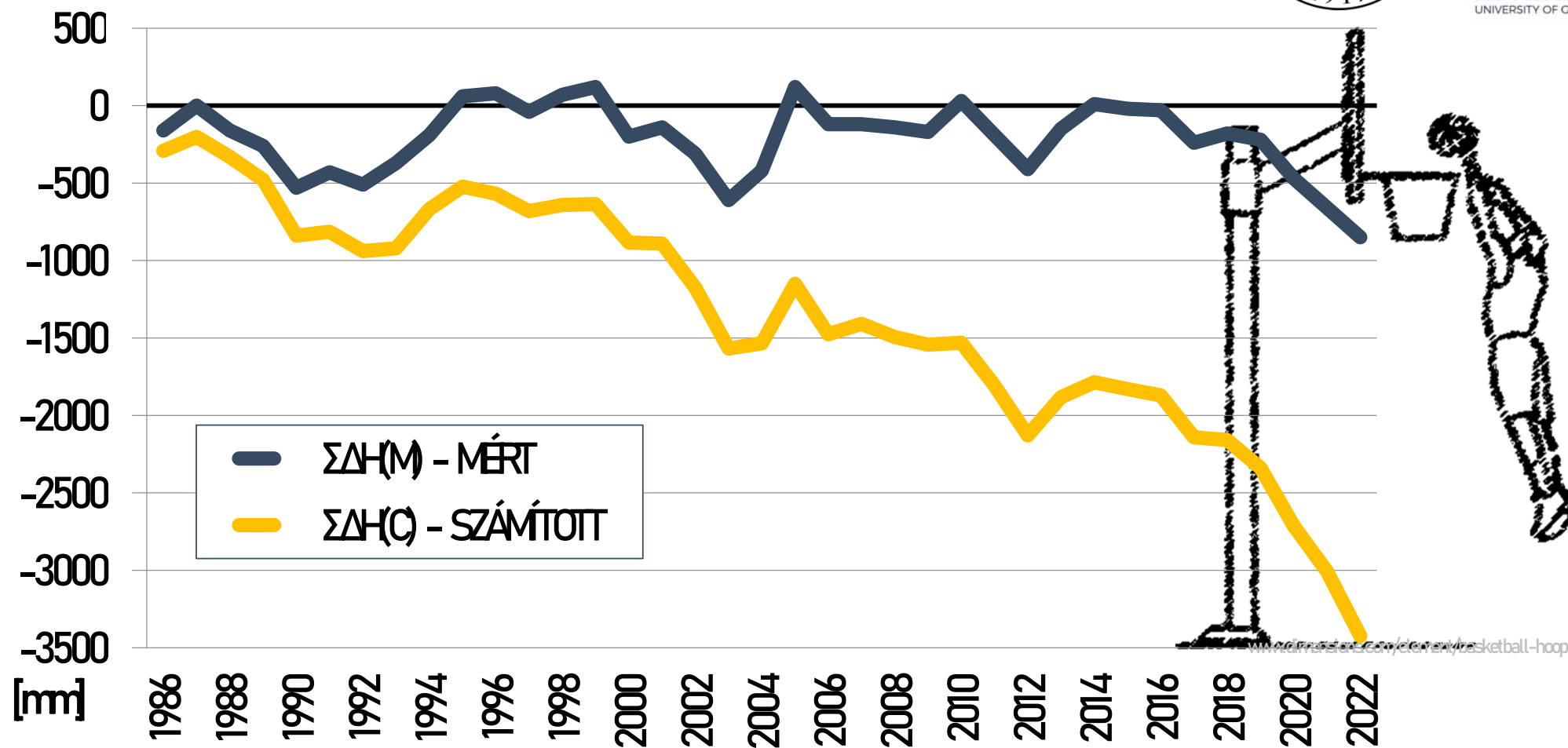
# 2022-ben rekord alacsony vízállás Agárdnál



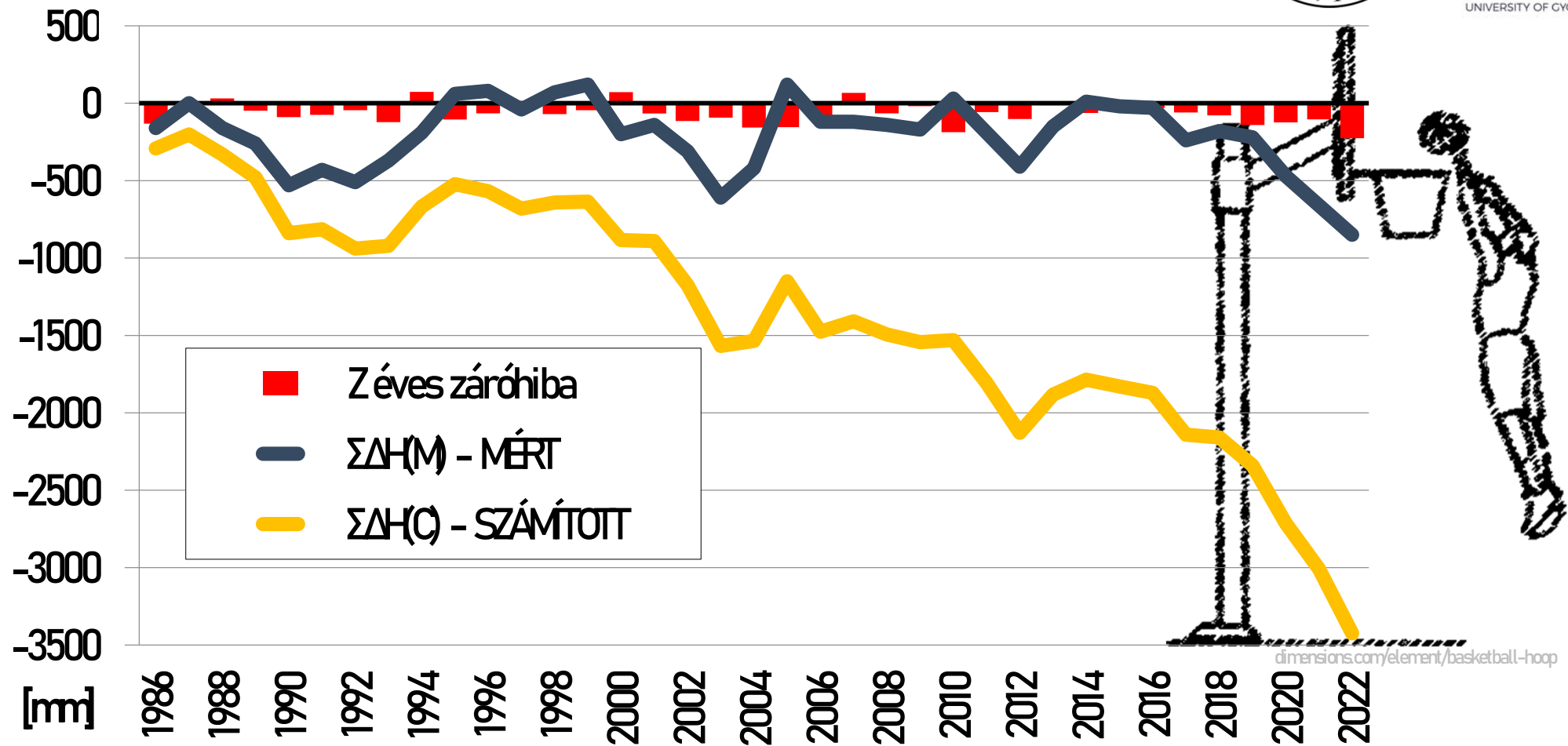
# Mi a baj a vízmérlegszámítási módszertannal?



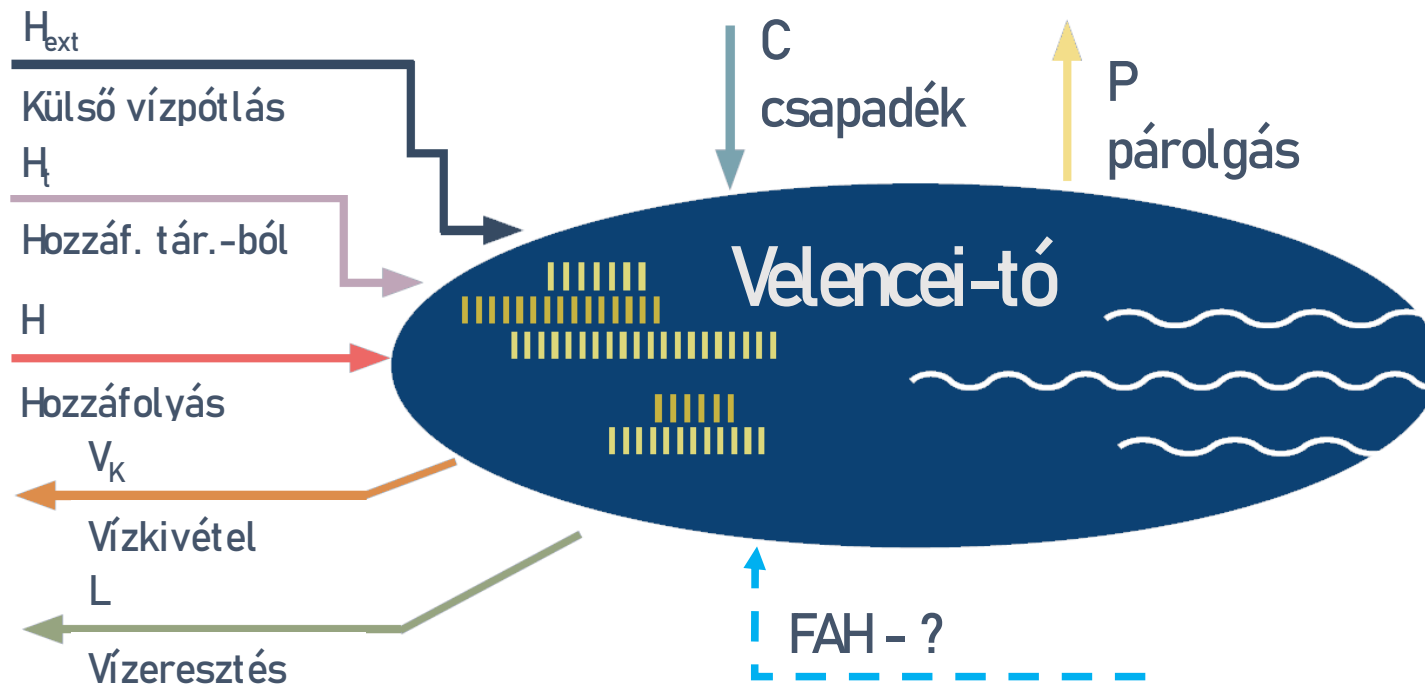
# Mi a baj a vízmérlegszámítási módszertannal?



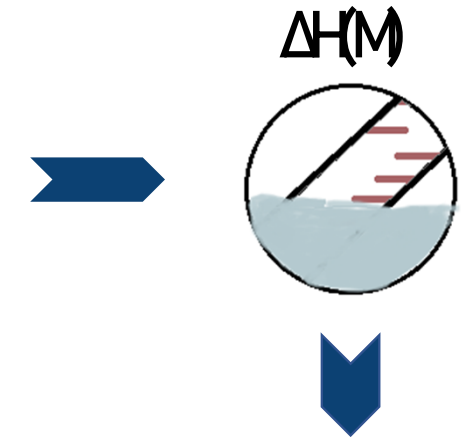
# Záróhibák rendre negatívak!



# Vízmérlegszámítási módszertan



$$\Delta H(C) = C + H + H_t + V_p - P - L - V_k$$



ZÁRÓHIBA:  
 $Z = \Delta H(C) - \Delta H(M)$

# Záróhiba – definíció

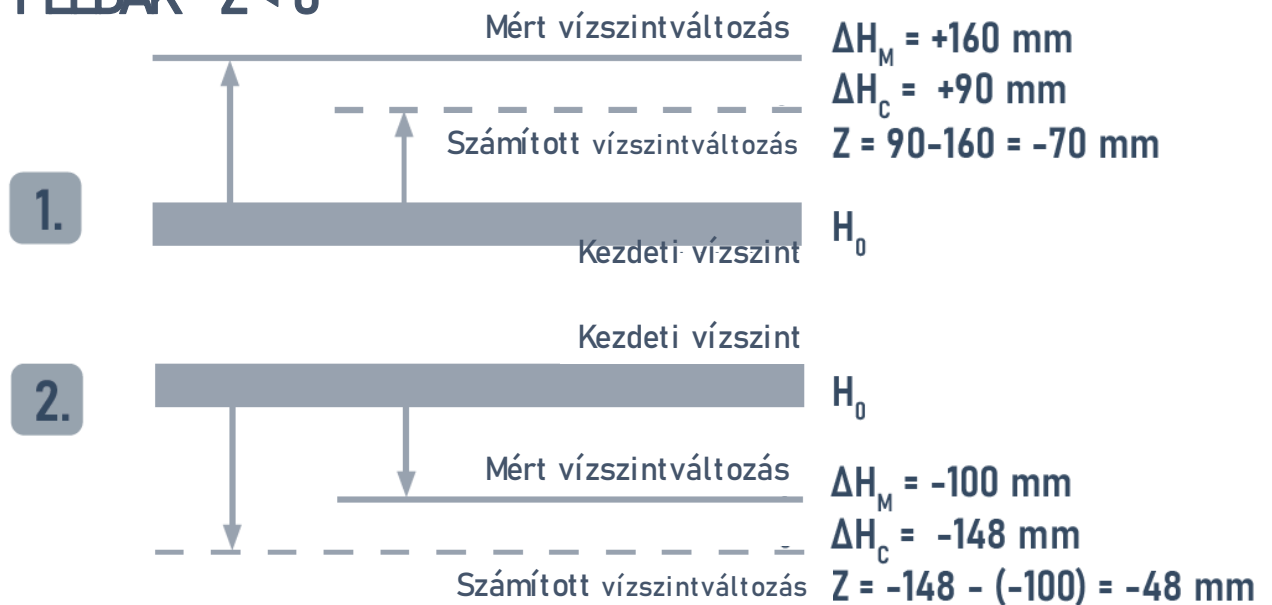


$$Z = \Delta H(C) - \Delta H(M)$$

$\Delta H(C)$  – számított vízszint-változás

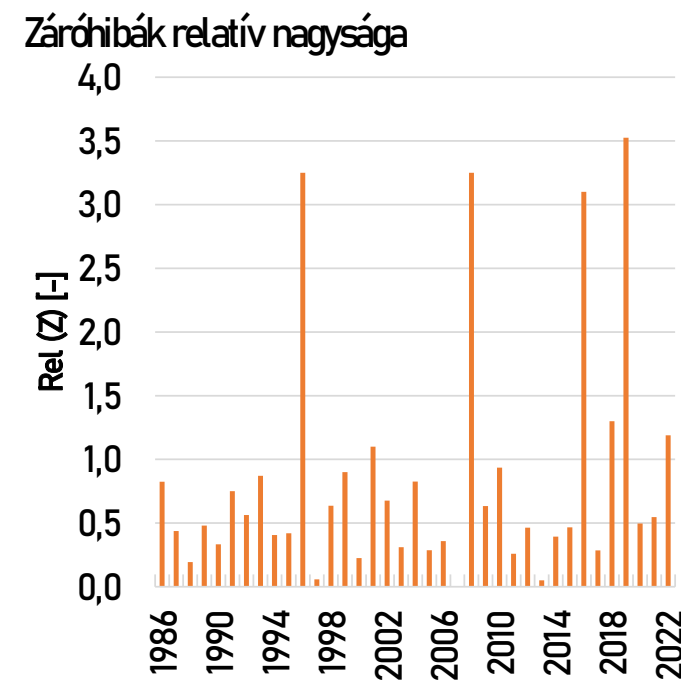
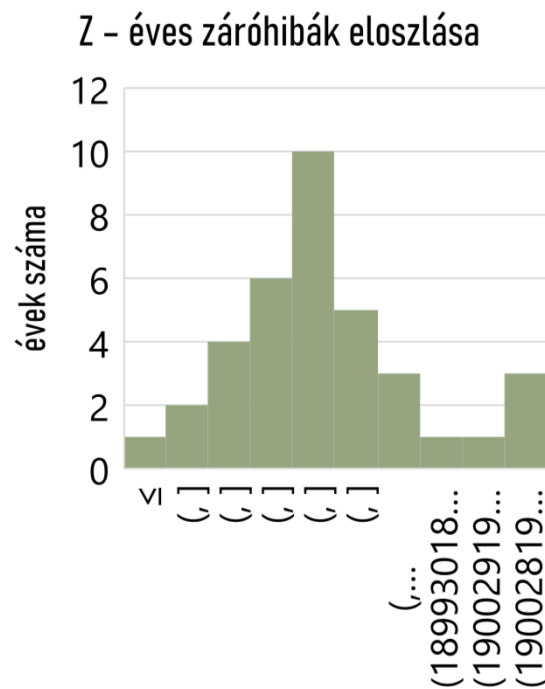
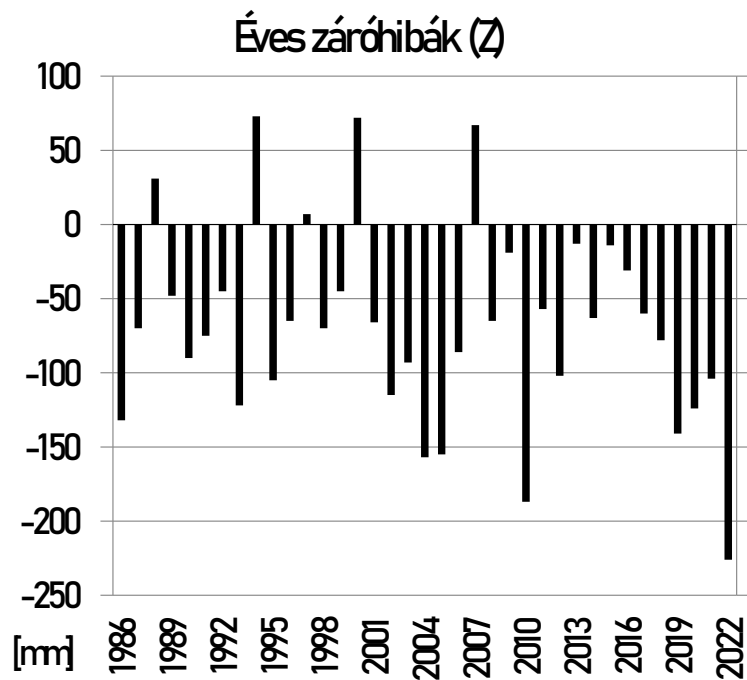
$\Delta H(M)$  – mért vízszint-változás

## PÉLDÁK $Z < 0$

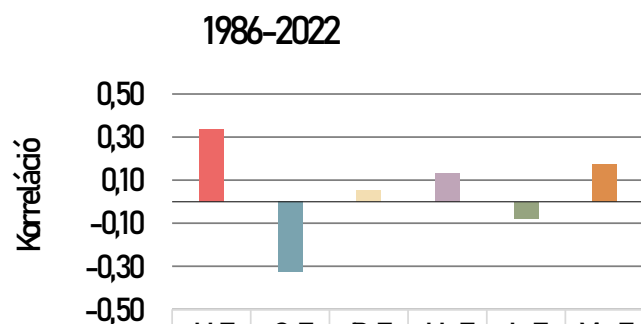




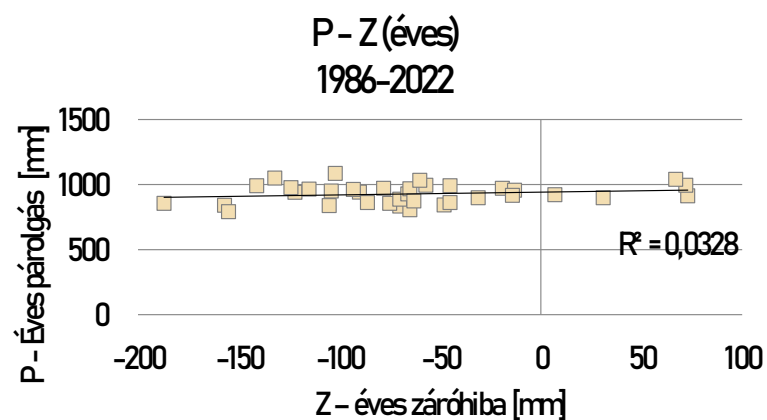
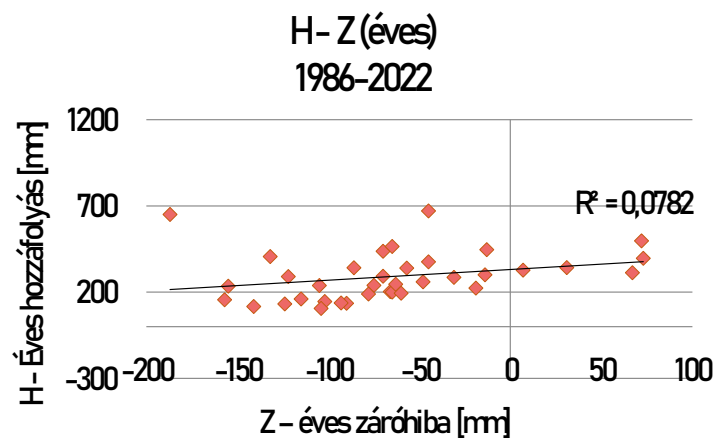
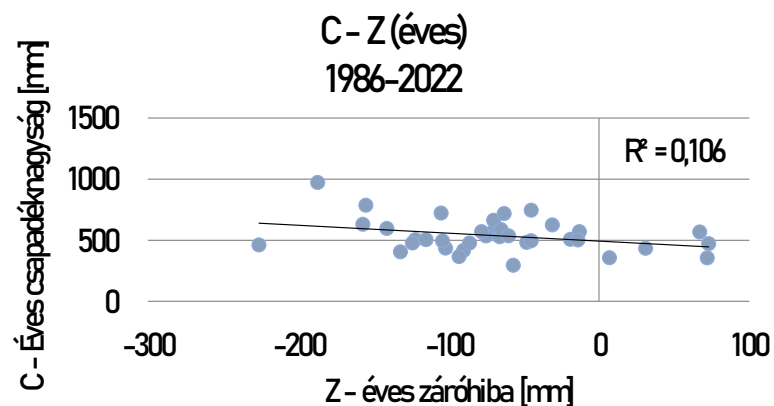
# Éves Záróhibák



# Éves Záróhibák



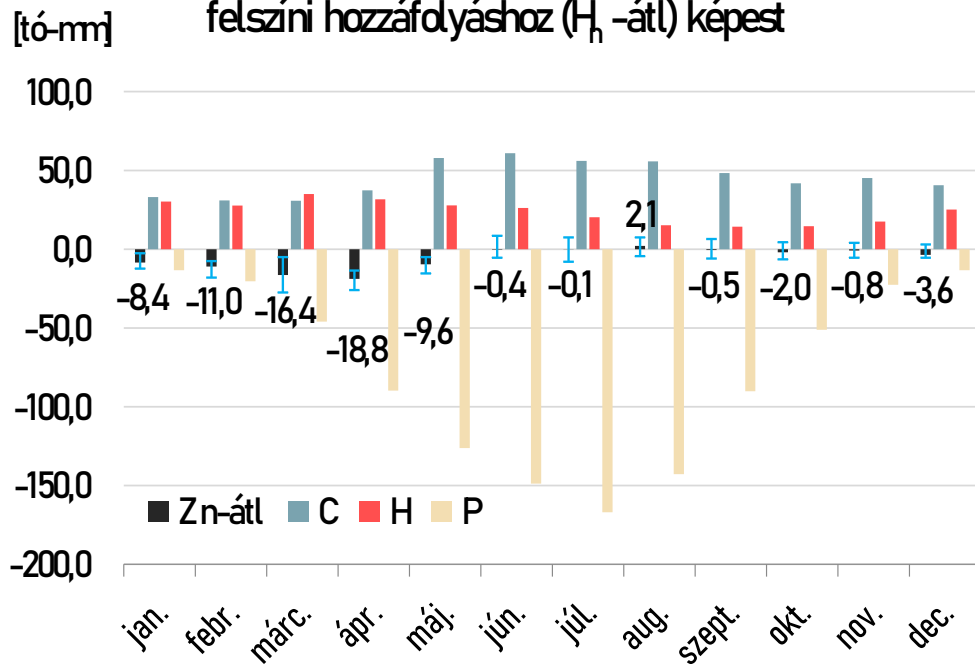
	H-Z	C-Z	P-Z	H-Z	L-Z	Vk-Z
r (korrelációs e.h.)	0,34	-0,33	0,05	0,13	-0,08	0,17
p (szignifikanciaszint)	8%	10%				



# Havi záróhibák

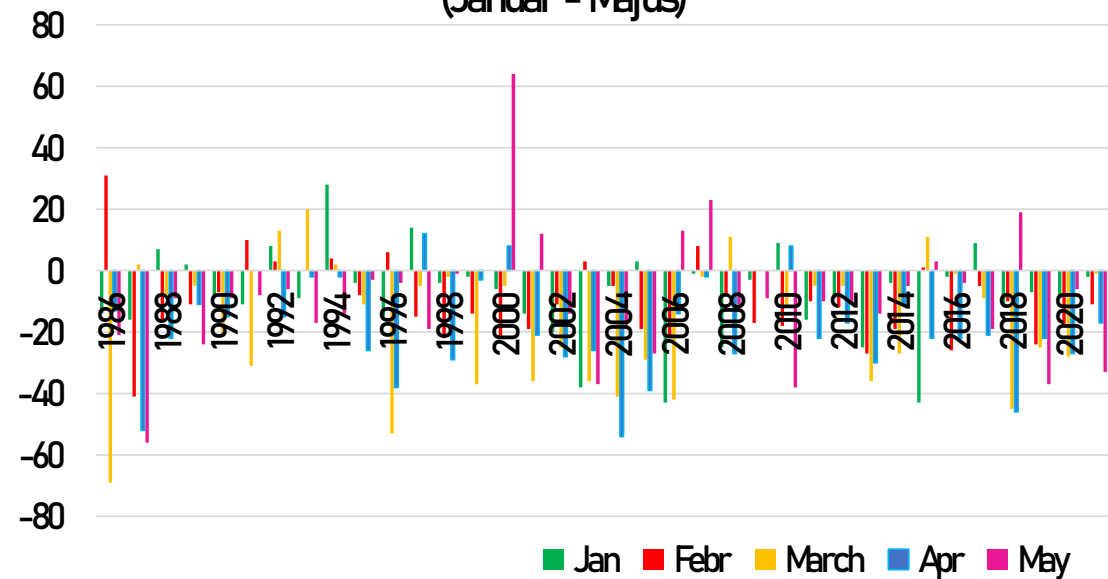


Havi átlagos záróhibák ( $Z_n$ -átl) nagysága az átlagos havi csapadék ( $C_n$ -átl), párdlgás ( $P_n$ -átl) és felszíni hozzáfolyáshoz ( $H_n$ -átl) képest

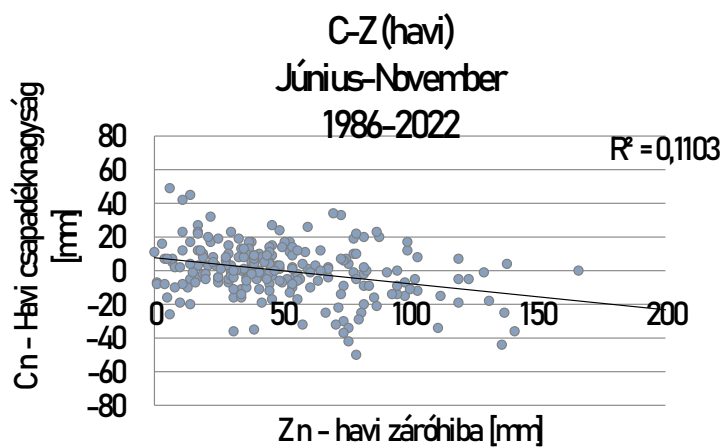
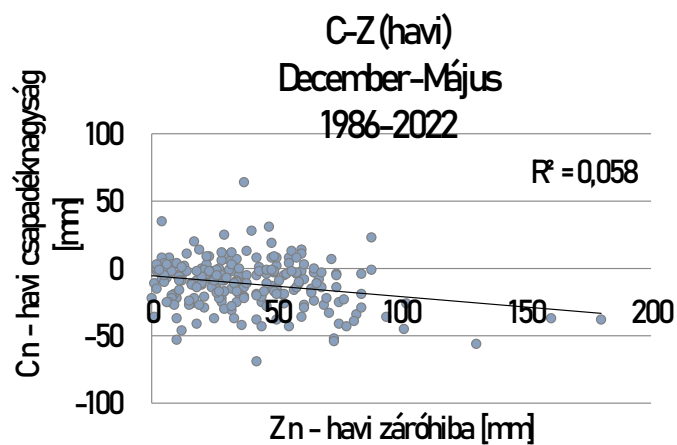
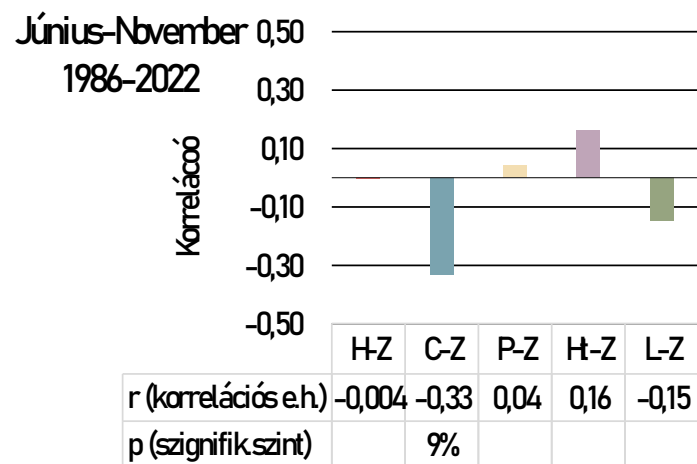
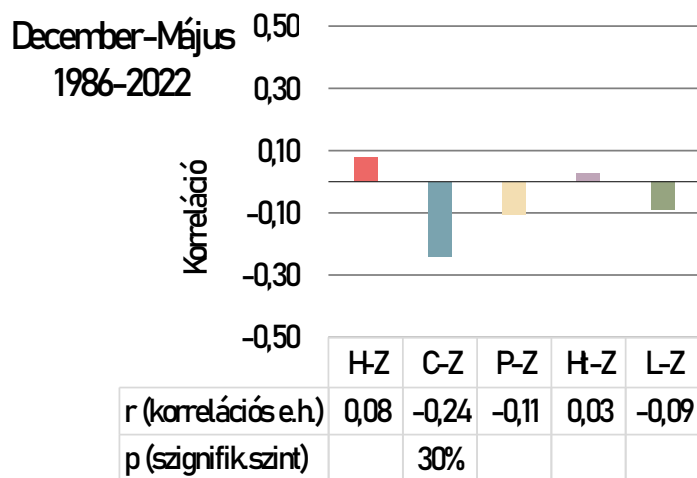


[tó-mm]

Havi Záróhibák  
(Január - Május)



# Havi záróhibák



# Havi záróhibák lehetséges okai



December - Május		KIADÁS		
		Alul becs.	Pontos	Túl becs.
B E V É T E L	Alul becs.	AA	AP	AT
	Pontos	PA	PP	PT
	Túl becs.	TA	TP	TT

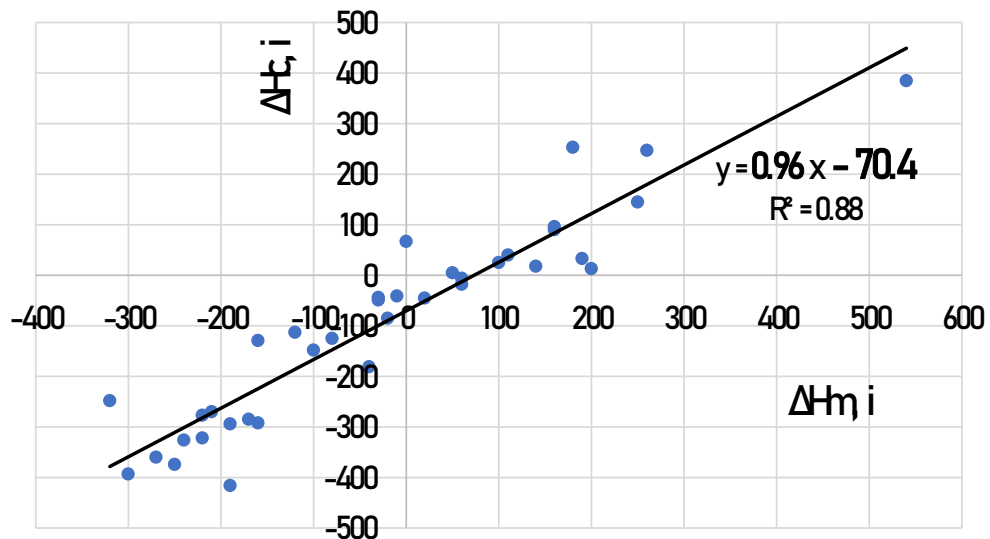
Június - November		KIADÁS		
		Alul becs.	Pontos	Túl becs.
B E V É T E L	Alul becs.	AA	AP	AT
	Pontos	PA	PP	PT
	Túl becs.	TA	TP	TT

# Havi záróhibák lehetséges okai



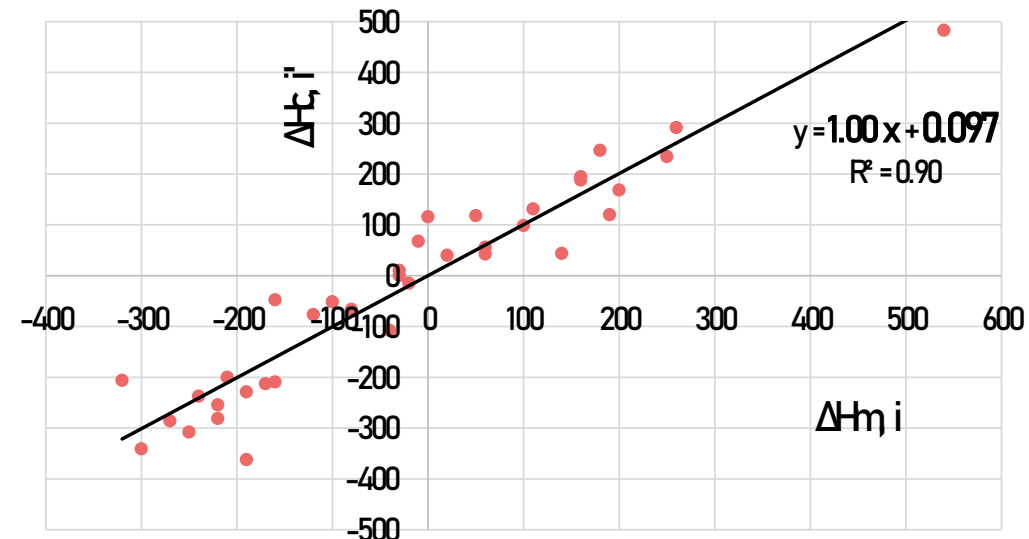
## Jelenlegi módszertan

Mért ( $\Delta H_{\eta, i}$ ) és számított ( $\Delta H_{\tau, i}$ ) vízszintváltozás  
(KOTVÍZIG - 1986-2022)



## Többváltozós lineáris regresszió

Mért ( $\Delta H_{\eta, i}$ ) és MLR-rel újraszámított ( $\Delta H_{\tau, i}'$ ) vízszintváltozás  
1986-2022



# Havi záróhibák lehetséges okai

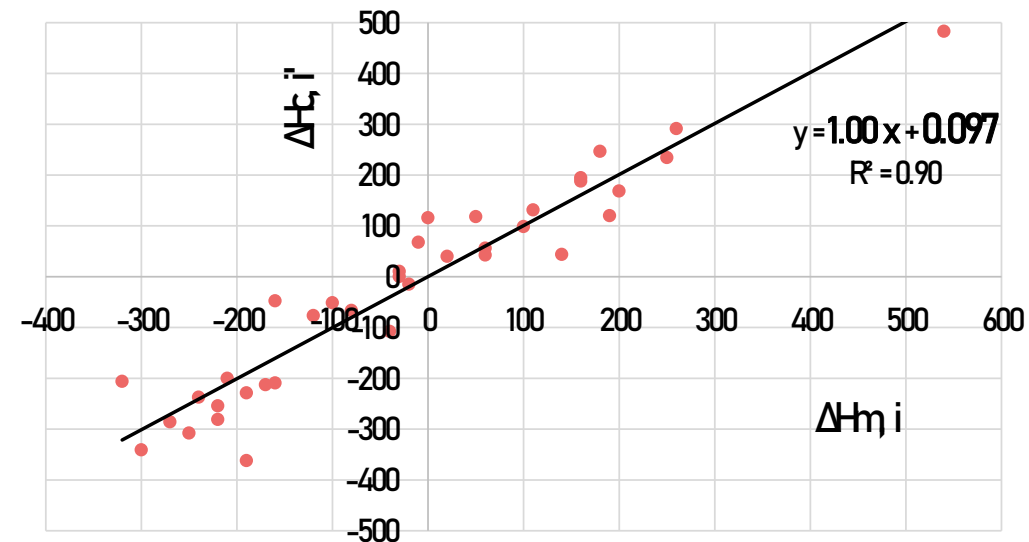


## MLR - Együtthatók

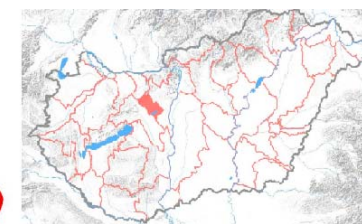
C	1.12
H	0.92
H <sub>t</sub>	0.91
H <sub>ext</sub>	0.81
P	-1.04
L	-0.92
V <sub>k</sub>	-0.54

## Többváltozós lineáris regresszió

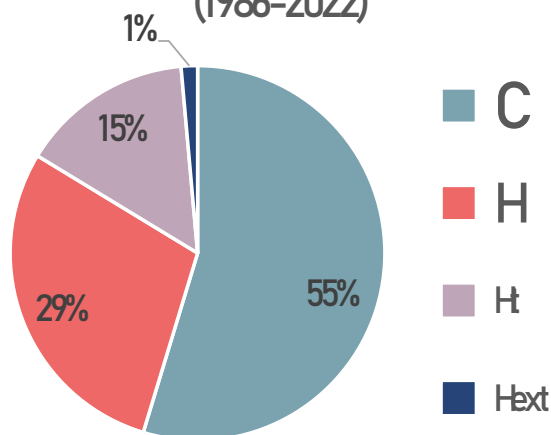
Mért ( $\Delta H_{t,i}$ ) és MLR-rel újraszámított ( $\Delta H_{t,i}'$ ) vízszintváltozás  
1986-2022



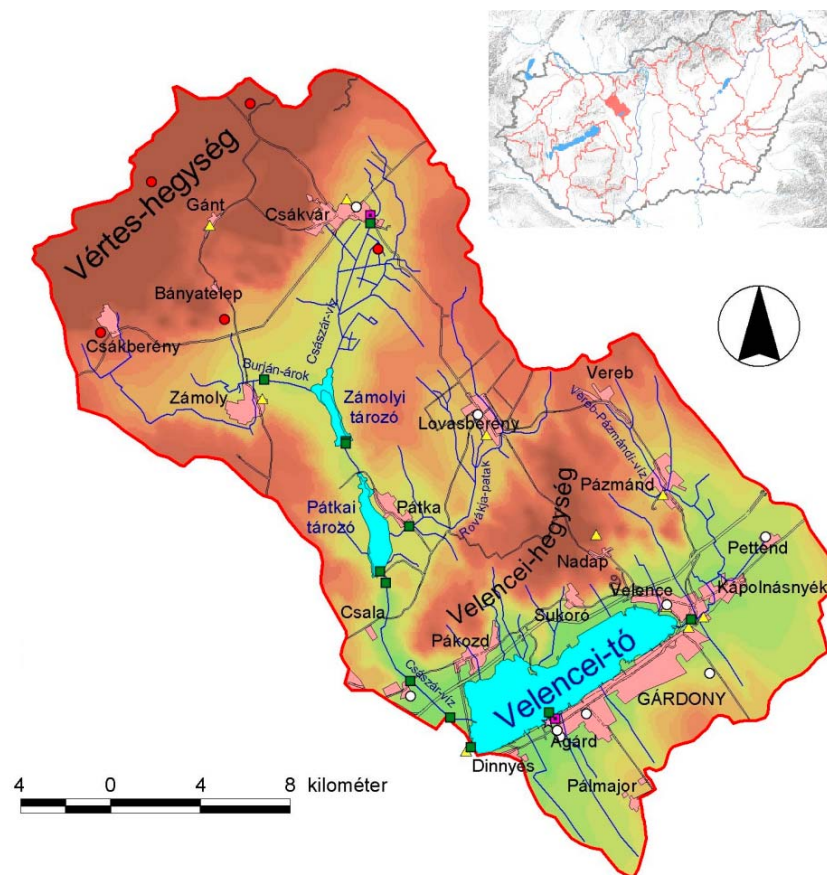
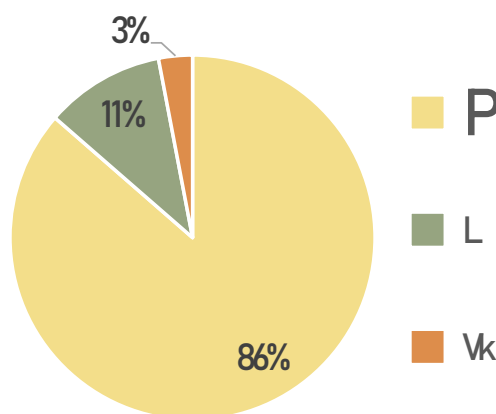
# Vízmérlegszámítási módszertan felülvizsgálata



Bevételi oldal elemeinek relatív nagysága\* (1986–2022)



Kiadási oldal elemeinek relatív nagysága\* (1986–2022)



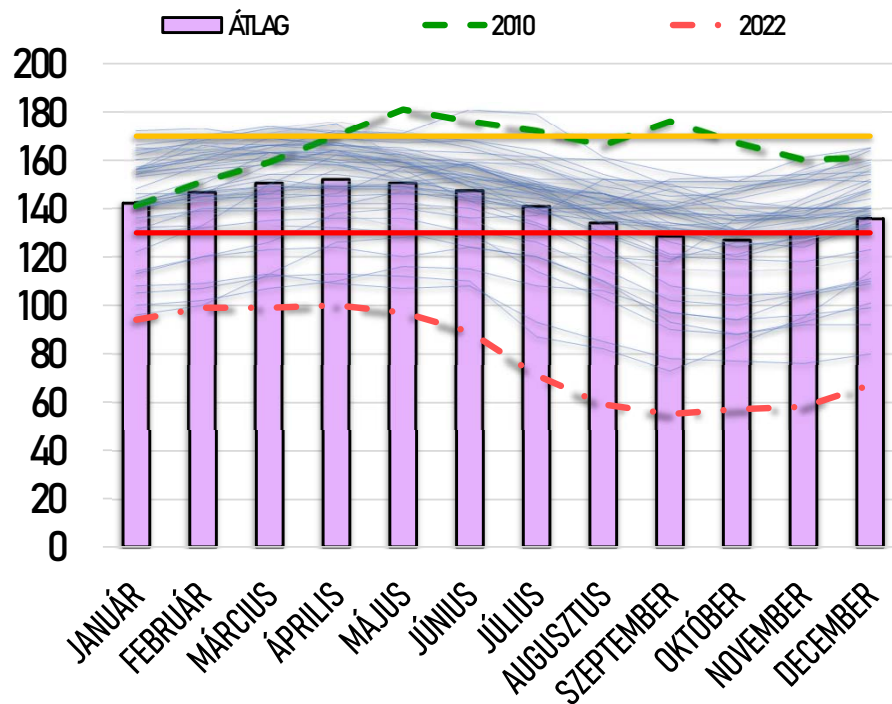
\*(a jelenlegi számítási módszertan adatai alapján)



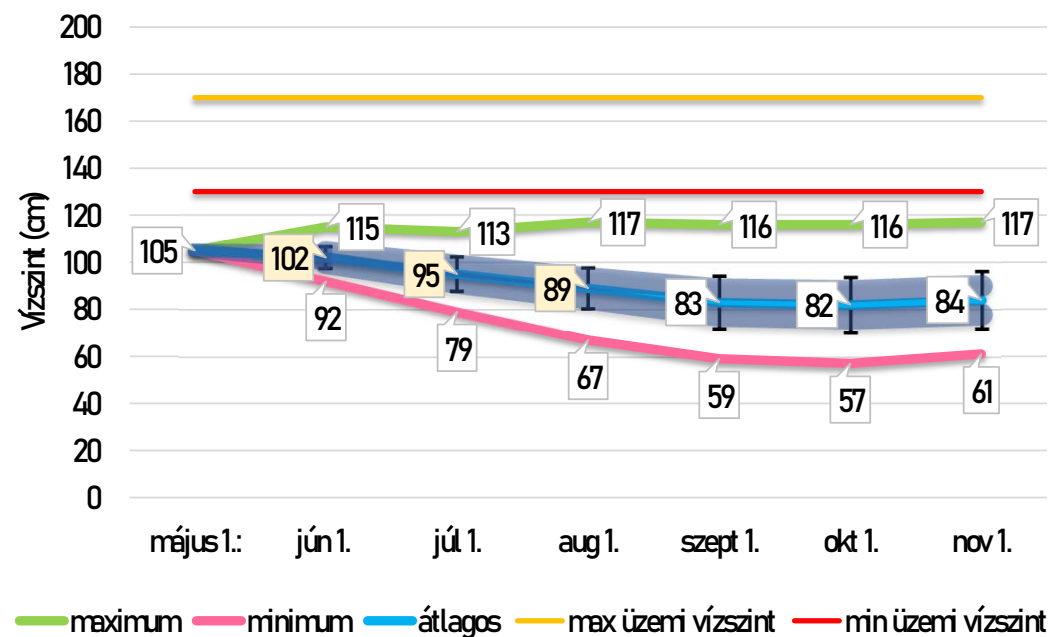


# Tudományos kihívás / tippjáték - vízszint előrejelzés

Havi átlagos vízszintek 1973 – 2022 és két kiragadott év (2010, 2022)



2023 Nyári félév várható vízszintjei az 1973 – 2022 időszak statisztikai jellemzői alapján

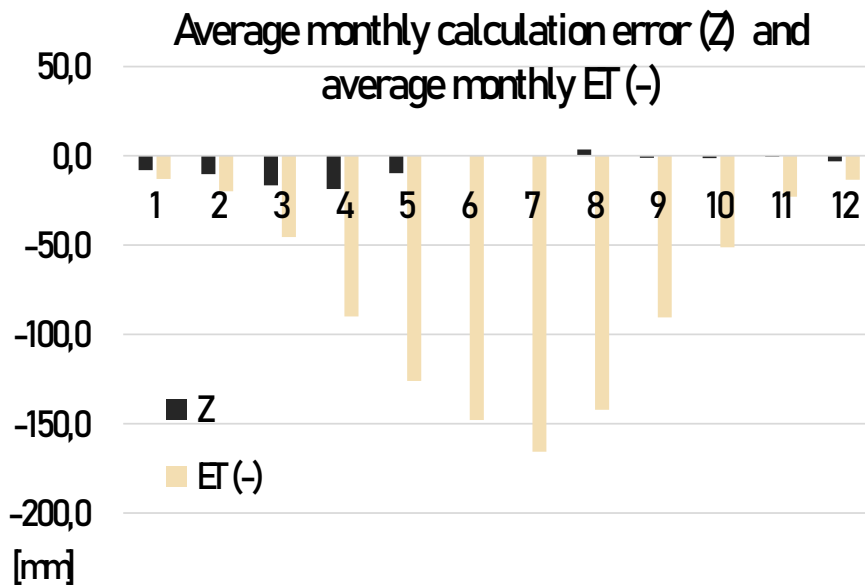


**Köszönöm a megtisztelő figyelmet!**

A prezentációban bemutatott kutatás a Széchenyi Terv Plusz program keretében az RRF-2.3.1-21-2022-00008 számú projekt támogatásával valósult meg.



# Evapotranspiration - current method



## Calculation method<sup>c</sup>

Based on ground measurements of temperature, windspeed, vapour pressure, and pan evaporation at Agárd.

### Winter:

XI. - III.: modified Meyer equation:

$$P = 0.55 \times [(E - e) / 1.33]^{0.9} \times (1 + T / 273)^9 \times (1 + 0.015 \times u)^2 \times n \quad [\text{mm/month}]$$

### Summer:

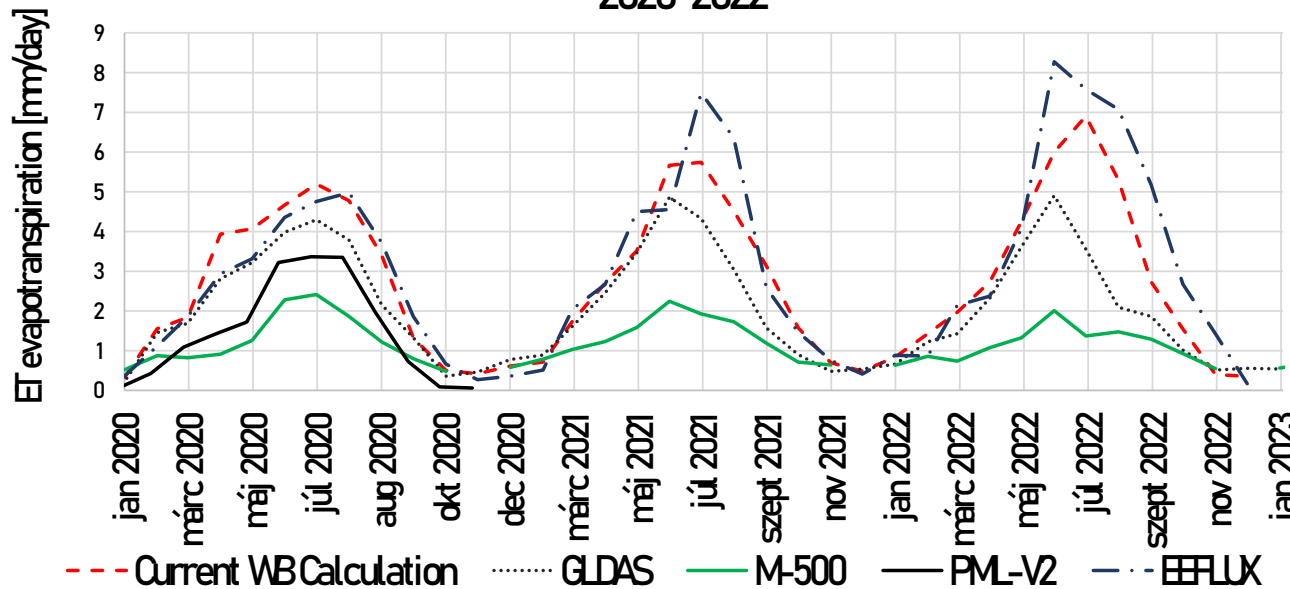
IV. - X.: pan evaporation (A), with reed constants (K):

$$P = 1.11 \times (0.58 + 0.42 \times K) \times A^{0.79} \times (1 + u)^{0.13} \times n \quad [\text{mm/month}]$$

**Main focus on the January - May period**

# Evapotranspiration – satellite data

Different satellite image and calculation products for ET  
2020-2022



Google Earth Engine ET products <sup>d</sup>:

GLDAS: Nasa GLDAS V2.1

M-500: Modis 500 m, 8 day

<sup>e</sup>PML-V2: Penman Monteith- Leuning  
(Modis500, 8day, GLDAS  
forcing data) Zhang et al., 2019

<sup>d</sup>GEE code: <https://github.com/mikhailsmilovic/Earth-Engine/blob/main/ET>

<sup>f</sup>EEFLUX: LANDSAT 30x30 m – METRIC  
method (Allen et. al 2007)

**GEE products yield low ET, EEFLUX closest to current results**

# Evapotranspiration – EEFLUX–METRIC



The screenshot shows the EEFLUX web interface. On the left, there is a navigation menu with 'Instructions' and 'FAQ'. Below that, a date and location string is displayed: '2022-05-12 / LC81880272022132LGN00 / Cloud 0% / Tier T1'. The main section is titled 'Products' and contains a list of data products, each with a 'Download Tif' button:

- BASE MAP
- TRUE COLOR
- FALSE COLOR (NIR, R, G)
- FALSE COLOR (SW2, SW1, NIR)
- CLOUD MASK
- ALBEDO
- NDVI
- DEM
- LAND COVER
- SURFACE TEMPERATURE
- ALFAFA REFERENCE ET (ET<sub>r</sub>)
- GRASS REFERENCE ET (ET<sub>o</sub>)
- ET<sub>f</sub> - std. calib.
- ET<sub>o</sub>f - std. calib.
- ACTUAL ET - std. calib.

On the right, a satellite image of a landscape is displayed, showing a mix of green and yellow fields with a dark water body. The image is overlaid with a grid and has zoom controls in the bottom right corner.

## Satellite data:

Landsat images – high resolution (30×30 meter) imagery of atmospheric variables

## METRIC method:

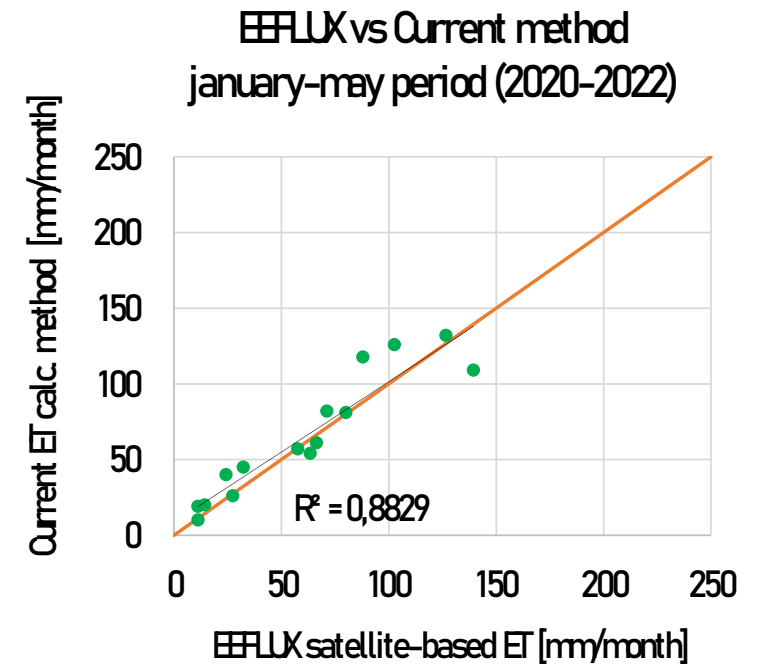
Automatic calibration of Energy Balance equations with Penman–Monteith method

## Image frequency:

~1-2 weeks, but clouds and other anomalies occur

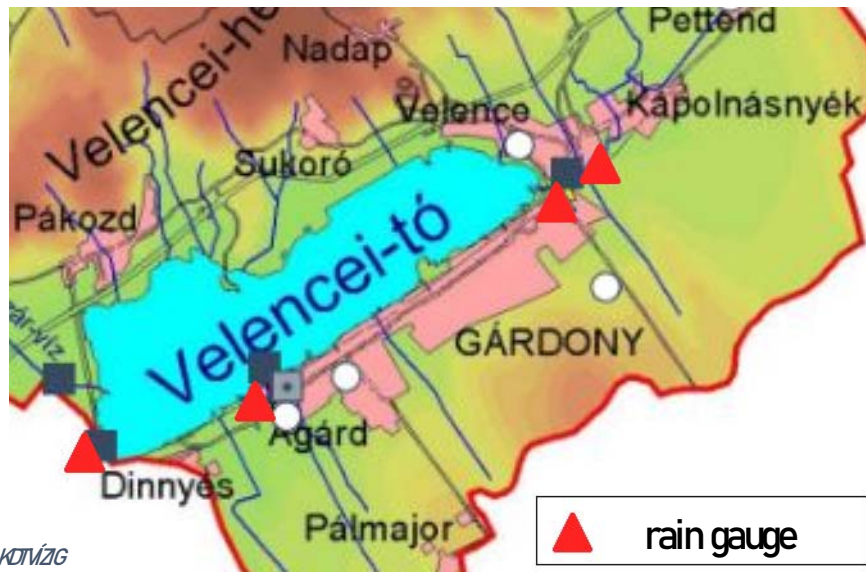
**Clouds and other anomalies can cause large time-gaps!**

# Evapotranspiration – EEFLEX-METRIC

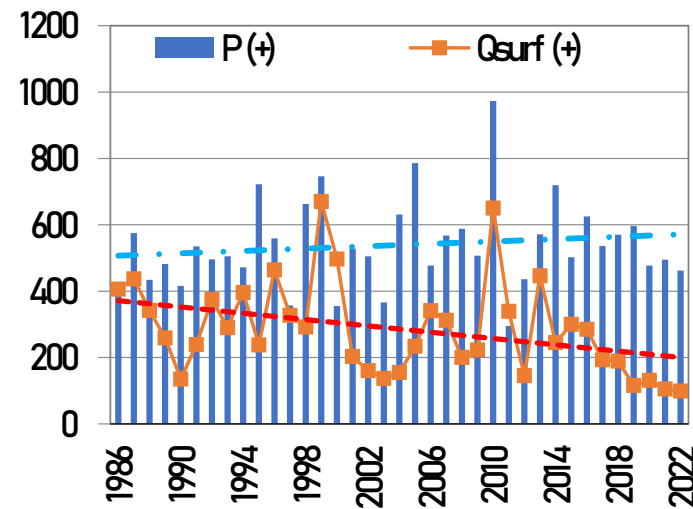


With EEFLEX slightly smaller ET values for Jan-May period!

# Precipitation – current method



[mm/year] Precipitation and surface inflow trends



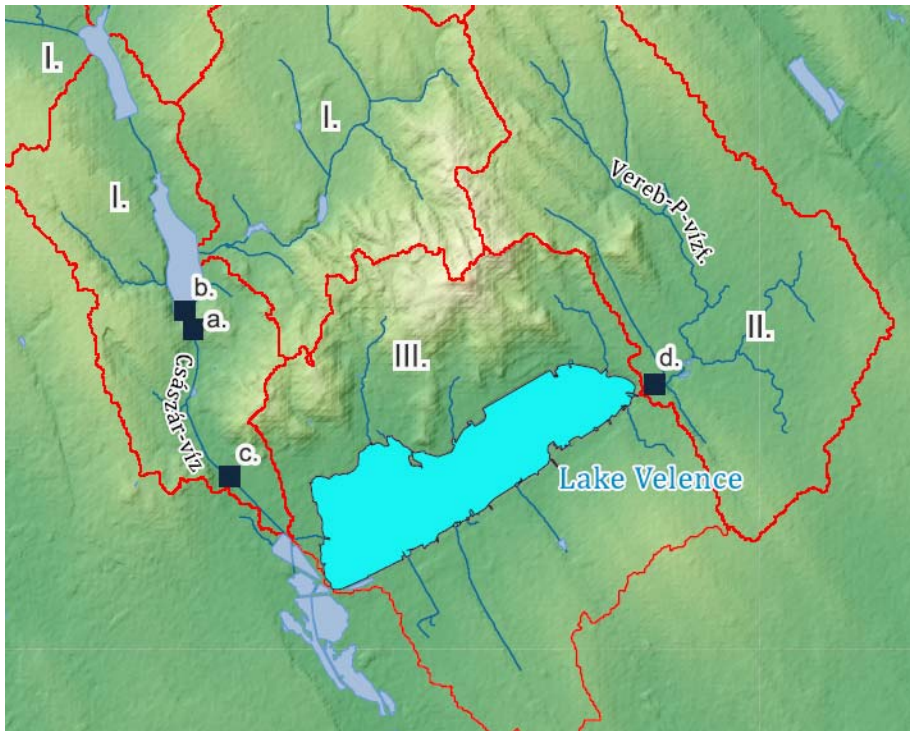
Calculation method:

Based on ground measurements, averaging data from 4 stations

No stations on the north shore of the lake.

Slight increasing trend in annual precipitation.

# Surface inflow - current method



## Calculation method <sup>c</sup>

based on hydrological analogy  
constants calculated in 1970-s

### I. Császár-víz

$$Q_{CSV} = [\text{Gauge (a.)} - \text{Gauge (b.)}] \times 2.63$$

### II. Vereb-P. víz:

$$Q_{VPV} = \text{Gauge (d.)}$$

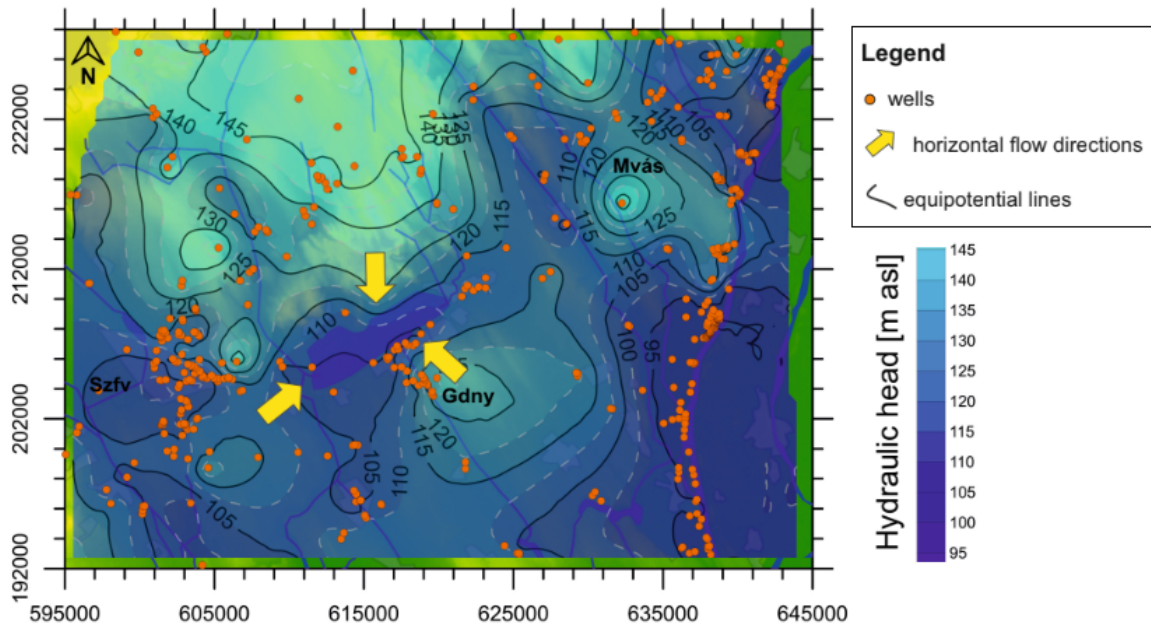
### III. Lake direct catchment:

$$Q_{LDC} = \text{Gauge (d.)} \times 0.84$$

**Need to revisit calculation method, include gauge (c.)**



# Groundwater flow mapping<sup>9</sup>



Potential map constructed for the 60-120 m asl elevation interval

P. Baják et. al, 2022

## Calculation method

Currently, the groundwater component is not included in the Lake Velence water budget calculation!

However evidence shows, that it should be included.

Modelling the groundwater flow system is in progress.

## <sup>9</sup> Research paper:

P. Baják et. al, "Integration of a Shallow Soda Lake into the Groundwater Flow System by Using Hydraulic Evaluation and Environmental Tracers," *Water* 14, 2022, 951 doi:10.3390/w14060951

GWmodelling of Lake Velence: EGU-HS8.23 – Friday

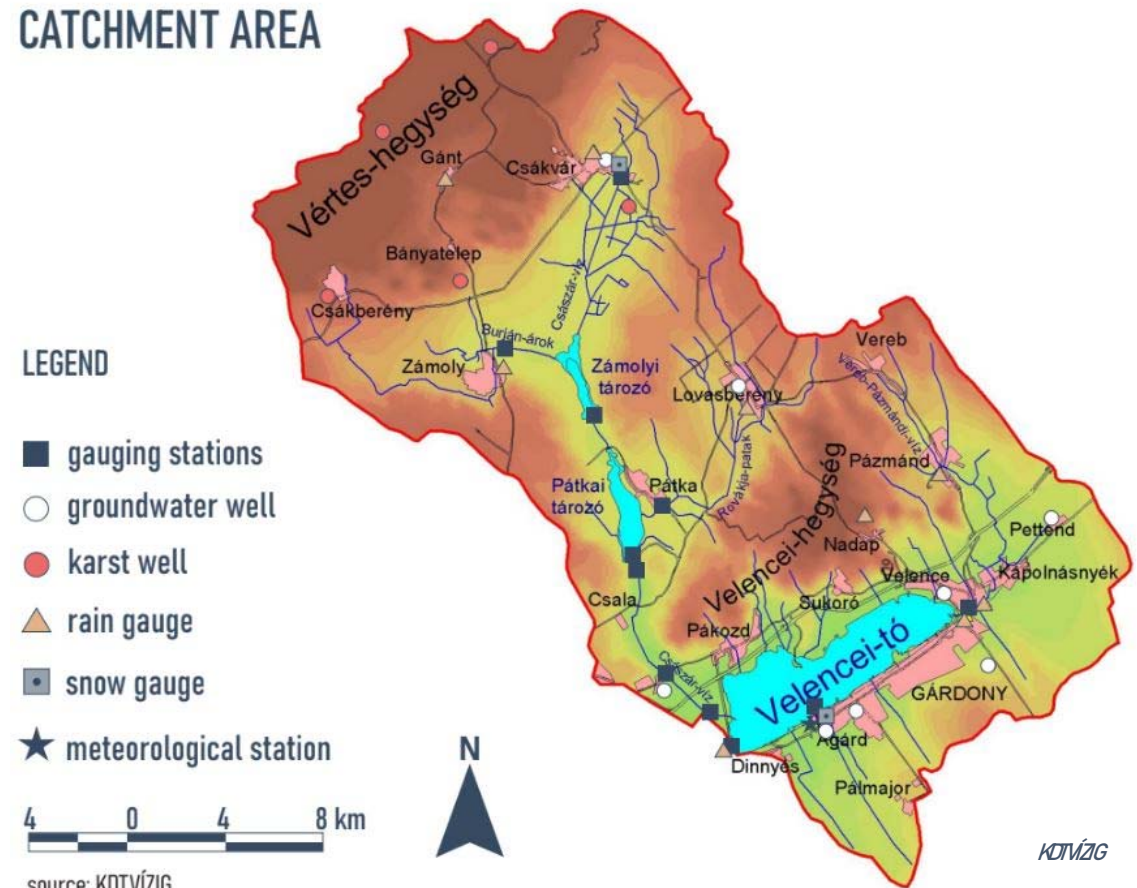
# Lake Velence, Hungary

## Catchment information

Total area:	615 km <sup>2</sup>
Elevation:	100 – 325 m.a.s.l.
Precipitation average:	540 mm/yr
Water surf. Evap. ave.:	930 mm/yr
Reservoirs:	2 large, several smaller
Lake dimensions:	L=10 km W=25 km H=1.9 m !!!



## CATCHMENT AREA



# References

- a) Water Resources Research Center Hungary (MTUK), "Hydrological and water quality characteristics of Lake Velence and its reservoirs," Budapest 1985
- b) Middle Transdanubian Water Directorate (KDTMÍZIG), "Water budget of Lake Velence: 1986 - 2021," Available at: <http://www.kdtvizig.hu/hu/velencei-to-vizmerleg> (Accessed: 21st April 2023.)
- c) Water Resources Research Center Hungary (MTUK), "Monthly water budget calculation for Lake Velence and its catchment," Budapest, 1976
- d) Google Earth Engine evapotranspiration products - EE code: <https://github.com/mikhailsmilovic/Earth-Engine/blob/main/ET>
- e) Zhang, Y., Kong, D., Gan, R., et al., 2019. Coupled estimation of 500 m and 8-day resolution global evapotranspiration and gross primary production in 2002–2017. *Rem Sens Environ.* 222, 165–182.
- f) Allen, R.G., Tasumi, M., Trezza, R., 2007a. Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) Model. *J. Irrig. Drain. Eng.* 133 (4), 380–394. [https://doi.org/10.1061/\(ASCE\)0733-9437\(2007\)133:4\(380\)](https://doi.org/10.1061/(ASCE)0733-9437(2007)133:4(380)).  
<https://eeflux-level1.appspot.com/>
- g) Baják, P.; Hegedűs-Csondor, K.; Tiljander, M.; Korkka-Nemi, K.; Surbeck, H.; Izsák, B.; Vargha, M.; Horváth, Á.; Pándics, T.; Erőss, A. Integration of a Shallow Soda Lake into the Groundwater Flow System by Using Hydraulic Evaluation and Environmental Tracers. *Víz* 2022, 14, 951. <https://doi.org/10.3390/w14060951>

The research presented in this PICO presentation was carried out within the framework of the Széchenyi Plan Plus program with the support of the RRF 2.3.1 21 2022 00008 project.