Improving methods to calculate monthly water budget for Lake Velence, Hungary

Máté Chappon – PhD candidate - chappon.mate@sze.hu

Katalin Bene PhD – associate professor - benekati@sze.hu

National Laboratory for Water Science and Water Security,
Széchenyi István University, Department of Transport Infrastructure
and Water Resources Engineering, Hungary

EGU23 - General Assembly

Section: HS 2.5.2

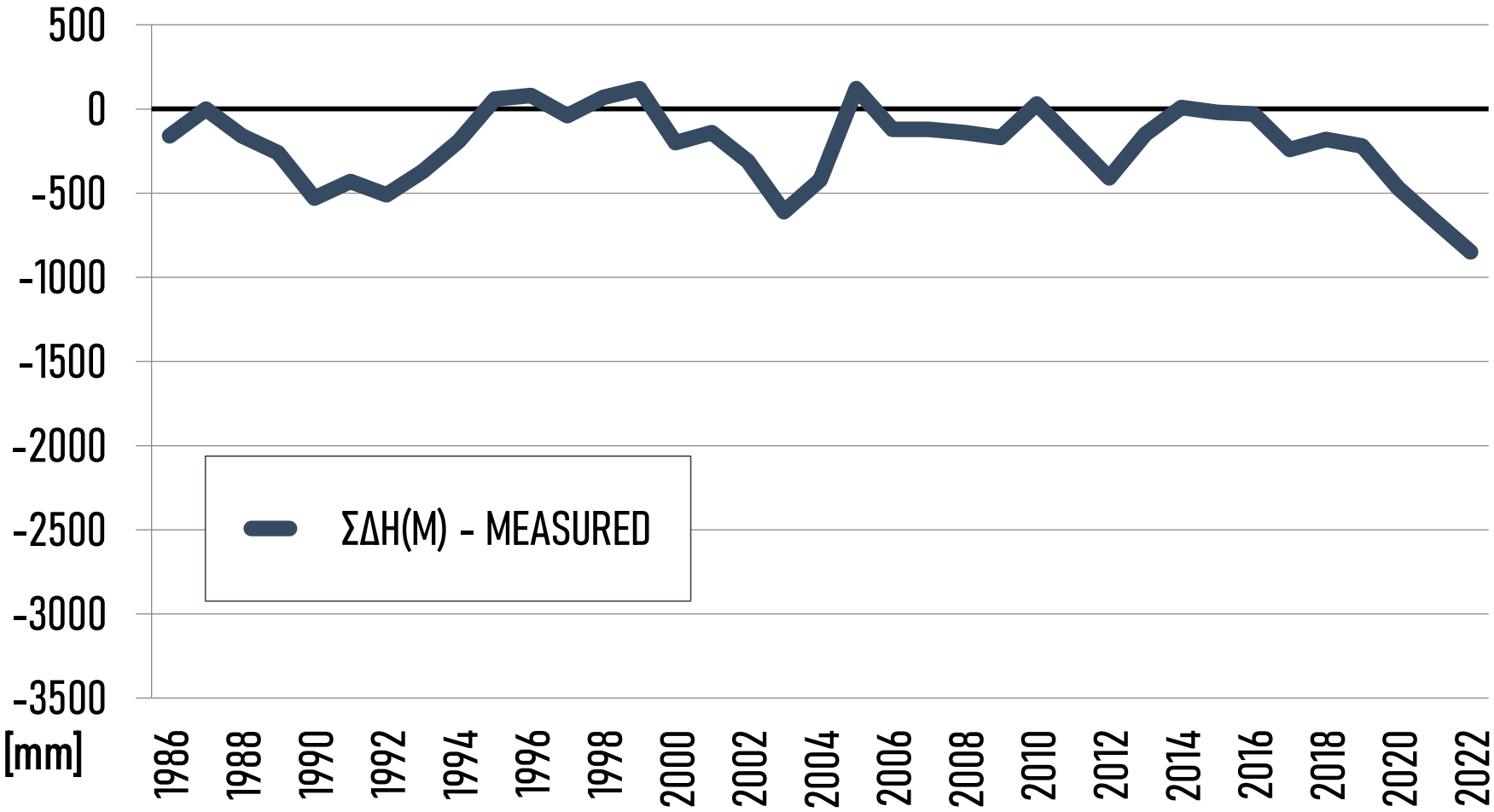
Abstract: EGU23-8334

PICO presentation

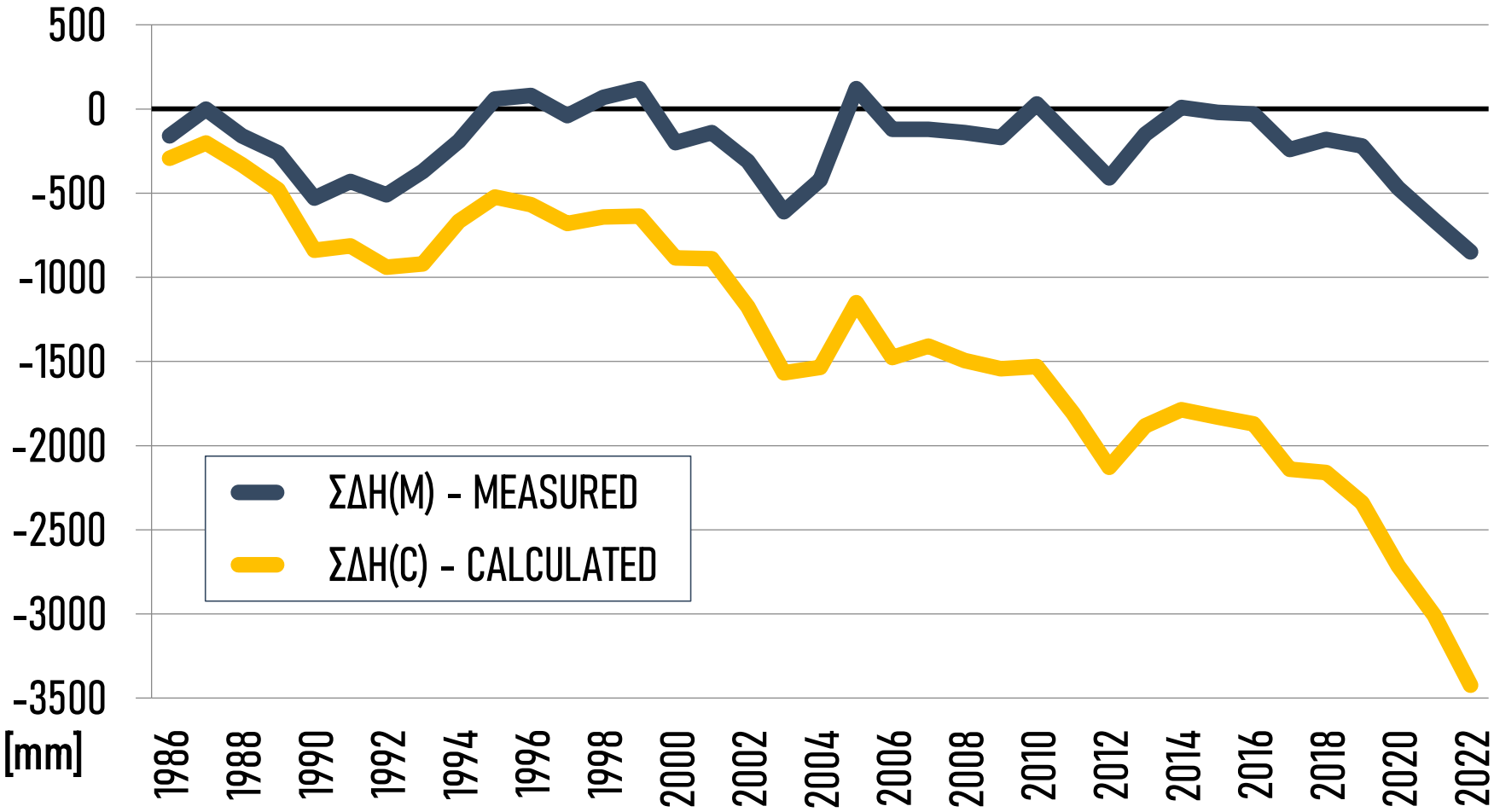
Vienna, 26th April 2023.

SZÉCHENYI EGYETEM
UNIVERSITY OF GYŐR

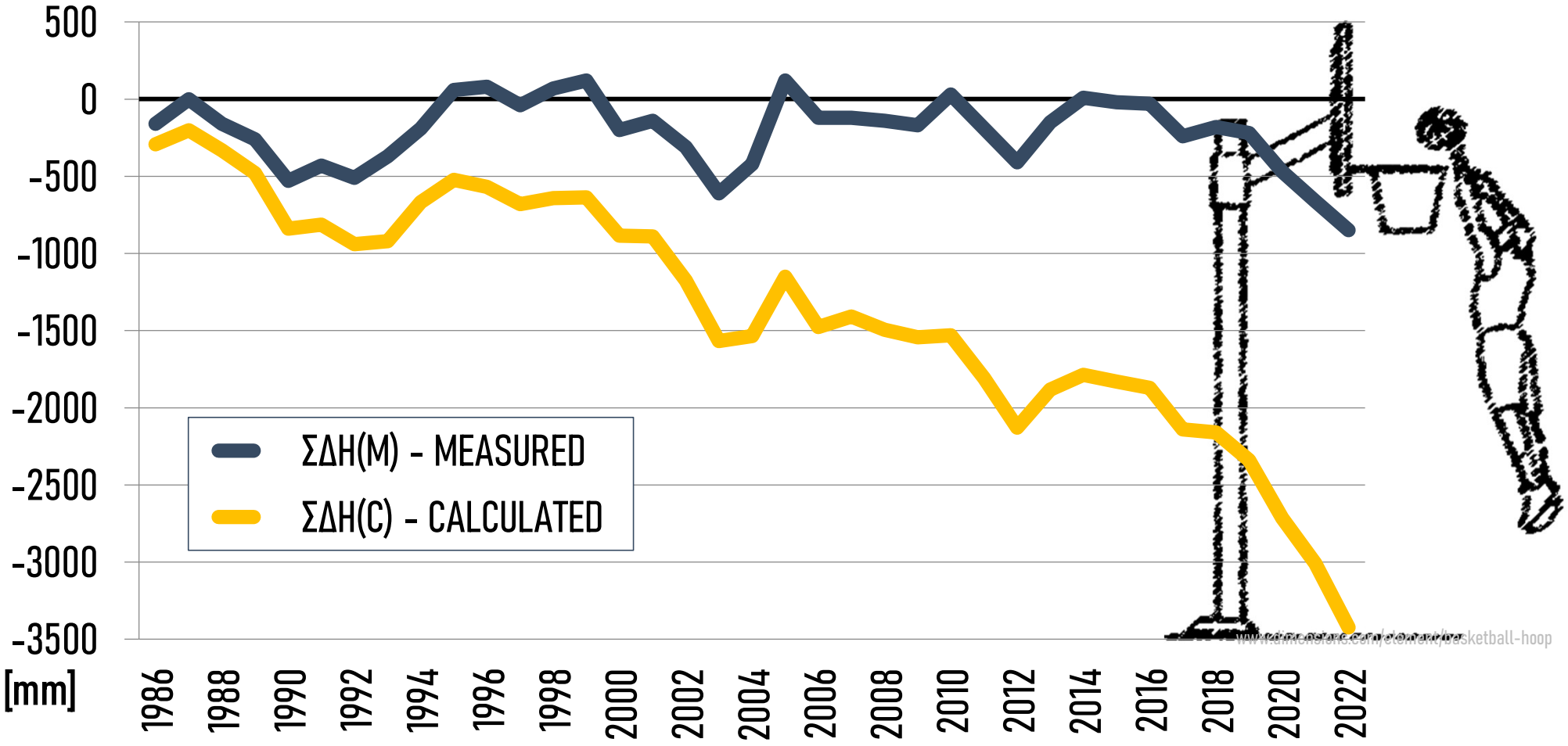
Water level hit negative record in 2022



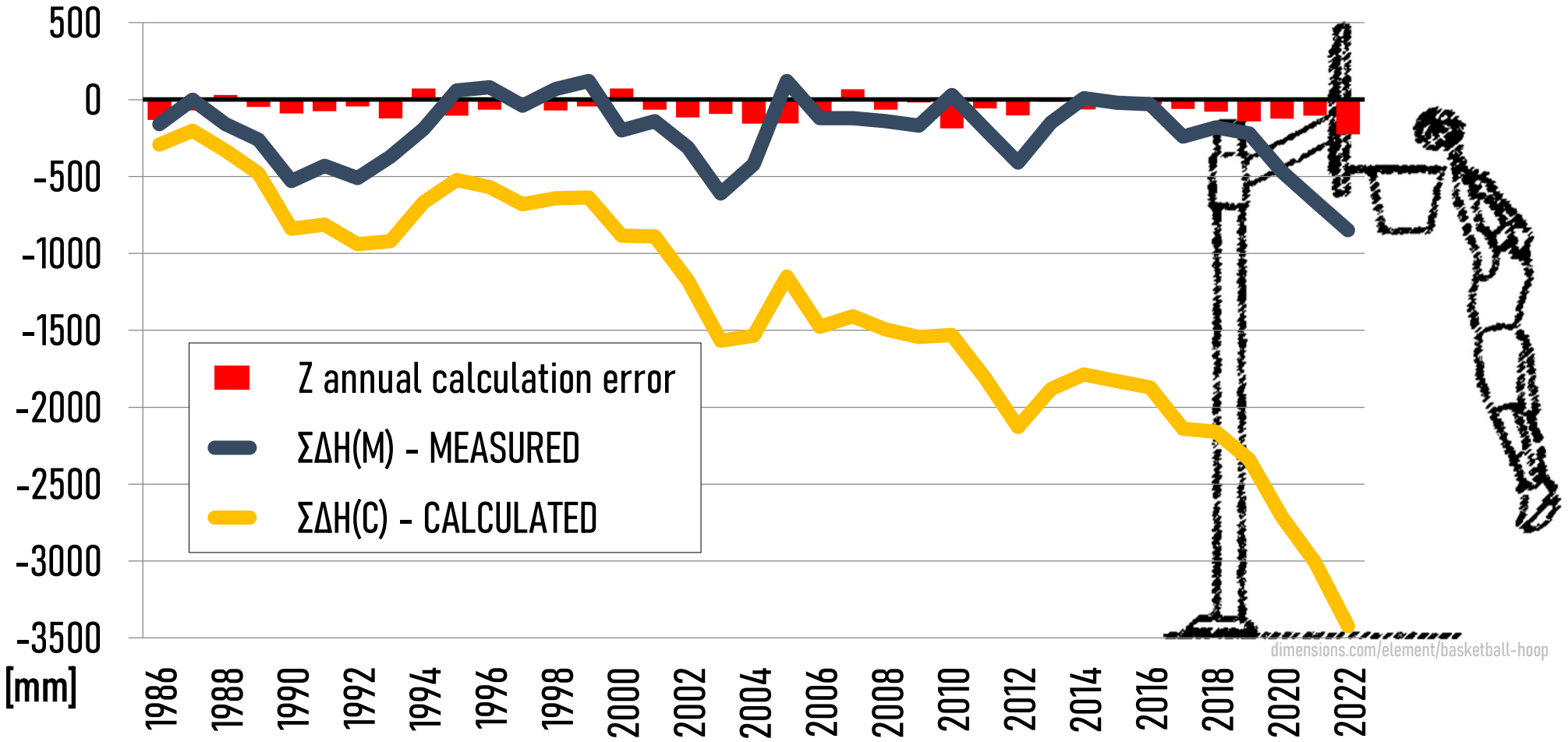
What is wrong with the current calculation method?



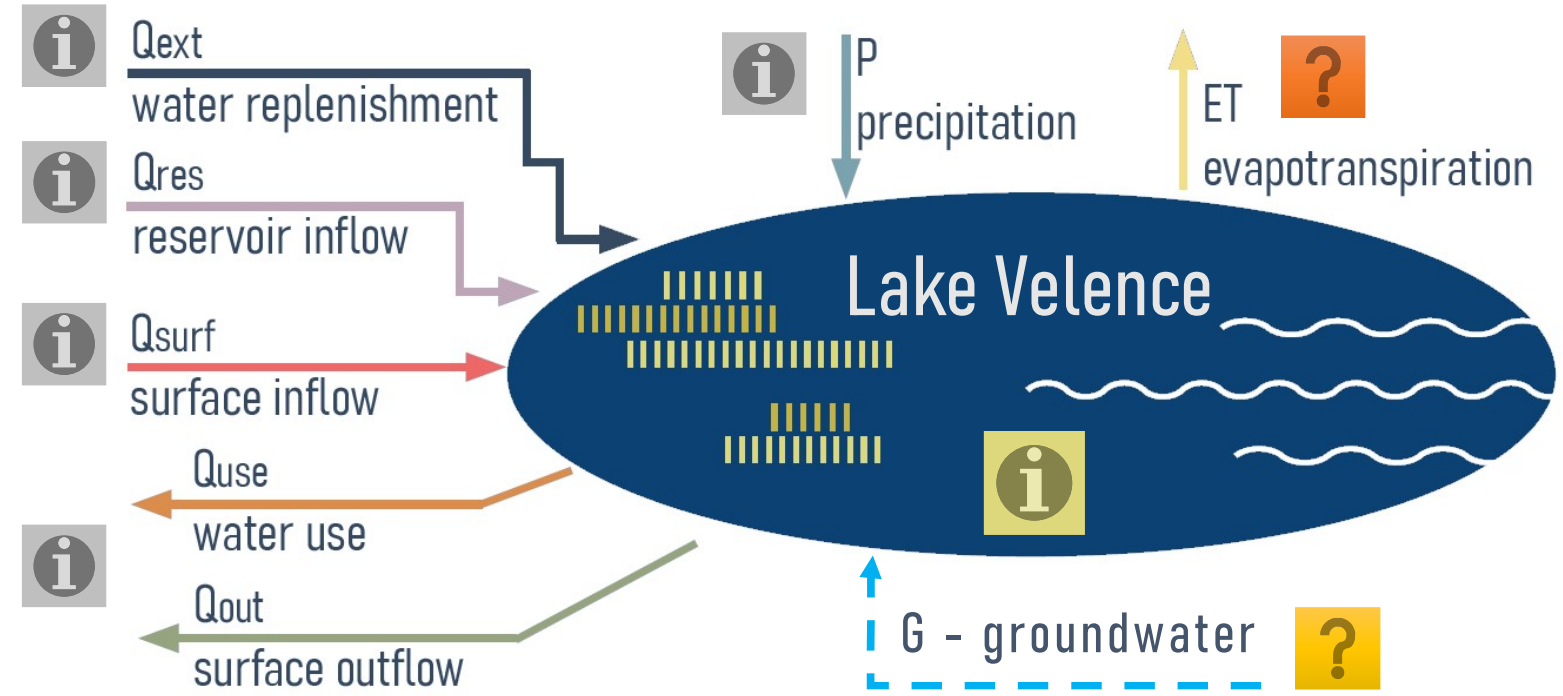
What is wrong with the current calculation method?

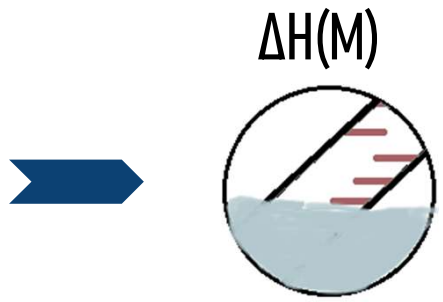


What is wrong with the current calculation method?



Water Budget calculation method





$$\Delta H(C) = P + Qsurf + Qres + Qext - ET - Qout - Quse \ ^{a}$$

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

THANK YOU FOR YOUR ATTENTION!

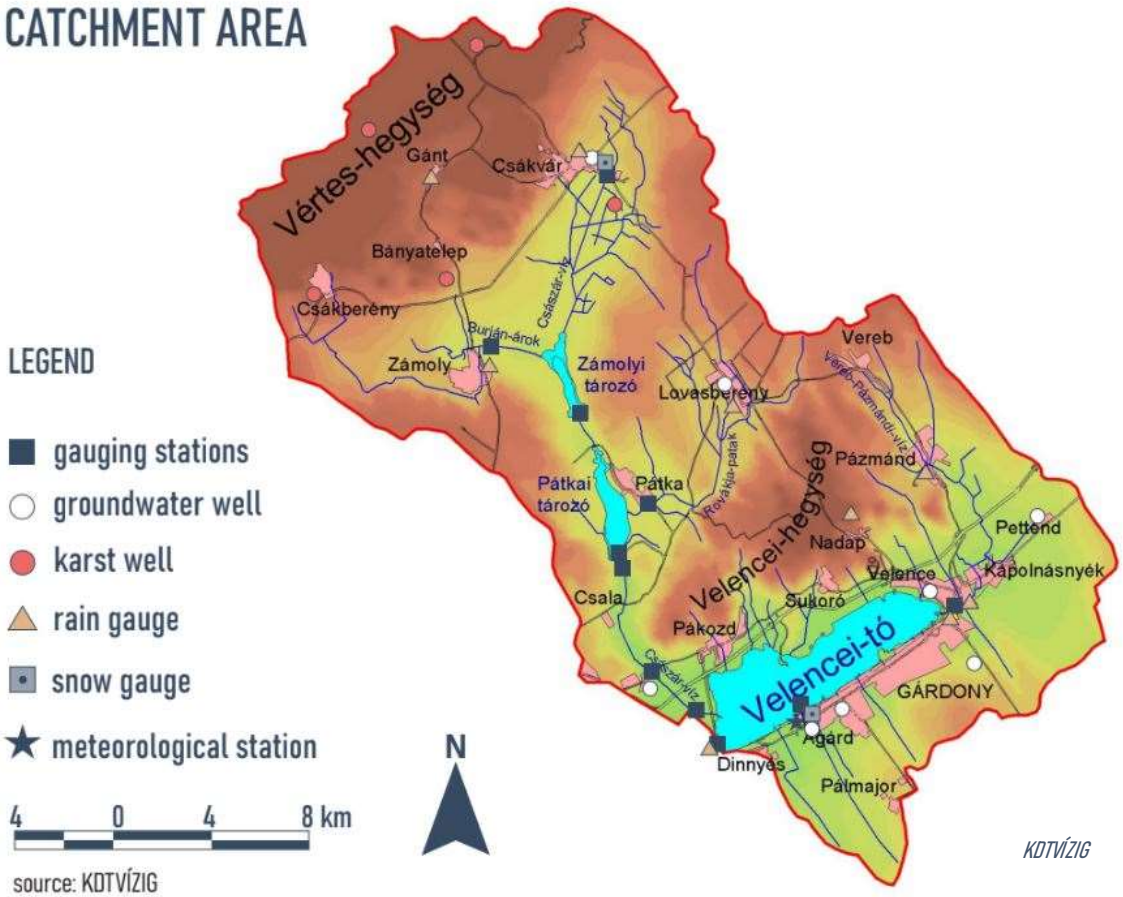
The research presented in this PICO presentation was carried out within the framework of the Széchenyi Plan Plus program with the support of the RRF 2.3.1 21 2022 00008 project.

Lake Velence, Hungary

SZÉCHENYI EGYETEM
UNIVERSITY OF GYŐR

Catchment information

Total area:	615 km2
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 = 2.5 km
	H = 1.9 m !!!

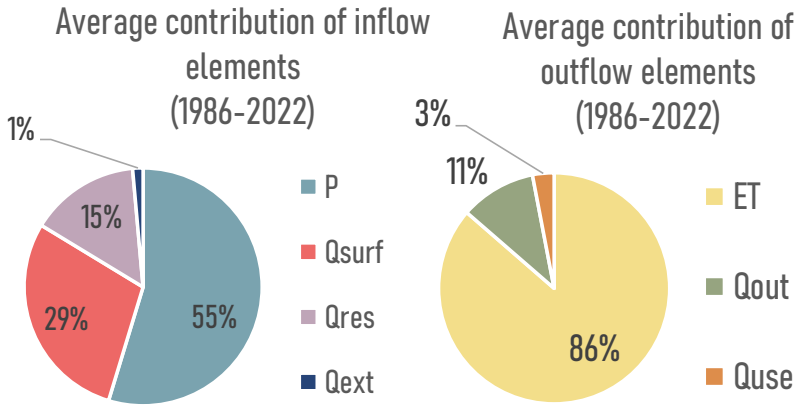


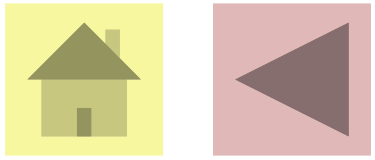
Lake Velence, Hungary

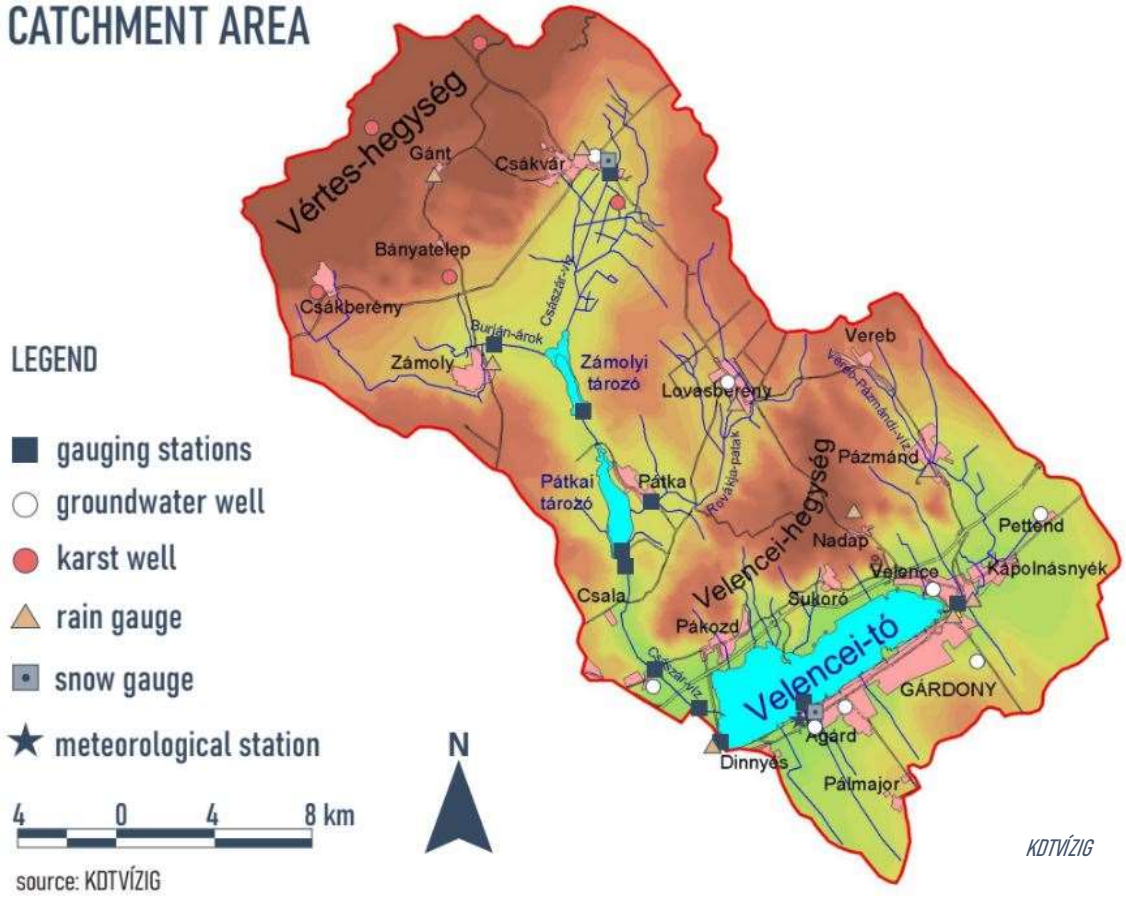
SZÉCHENYI EGYETEM
UNIVERSITY OF GYŐR

Water budget contributions

(based on the current calculation method [b])







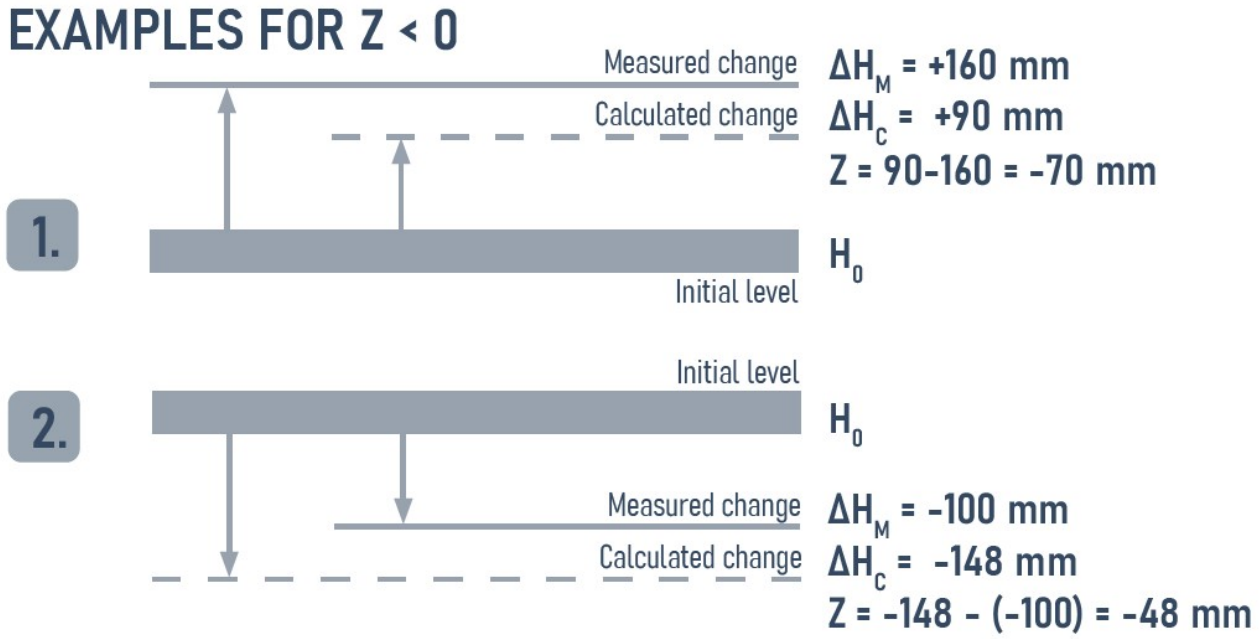
Calculation error – definition

CALCULATION ERROR: Z

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

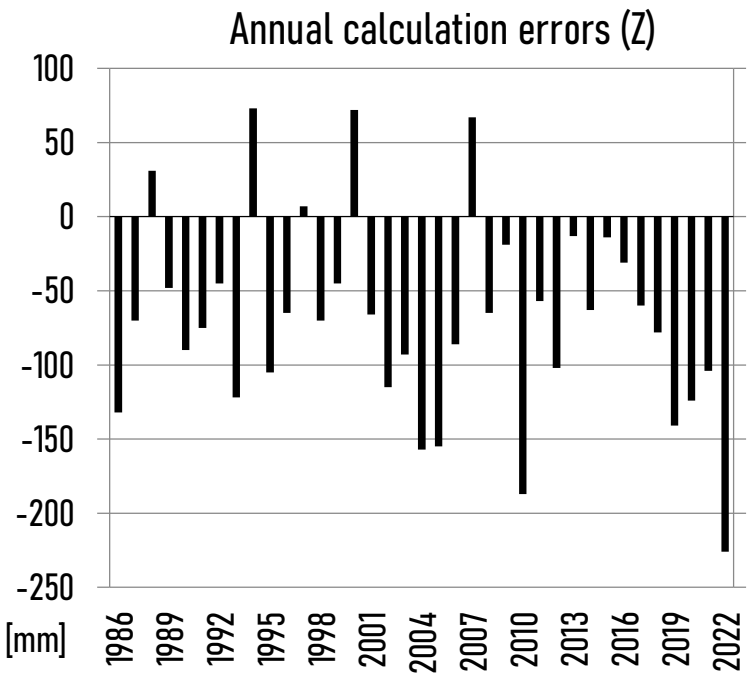
$\Delta H(C)$ – **calculated** change in water level

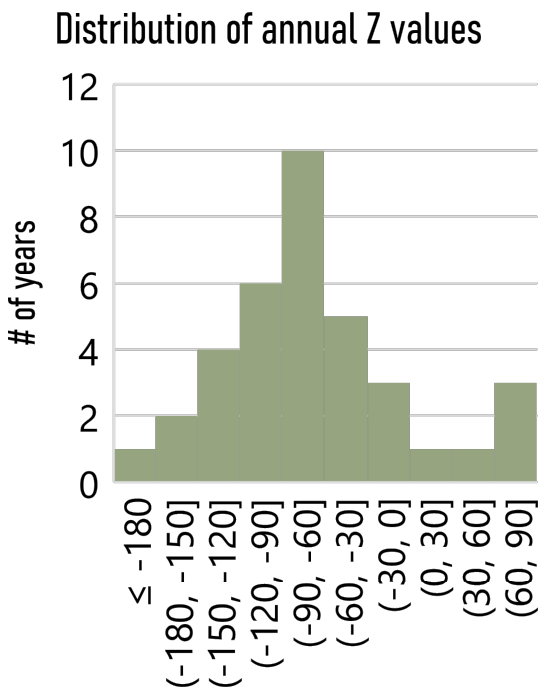
$\Delta H(M)$ – **measured** change in water level

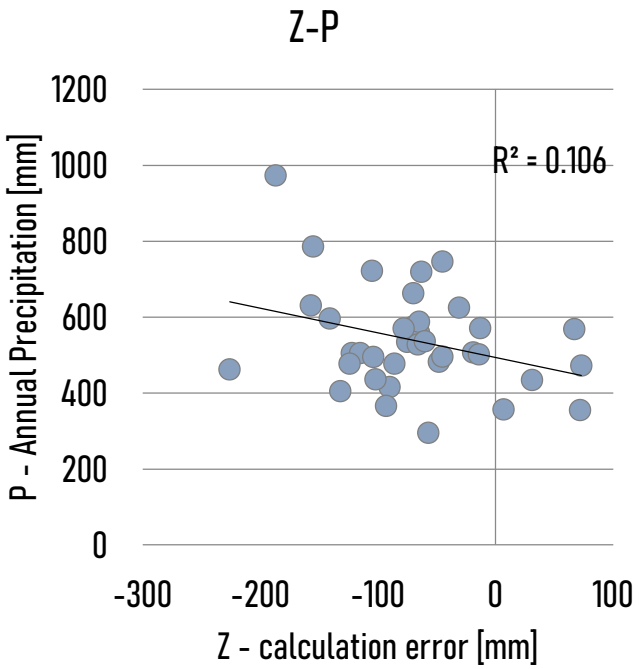


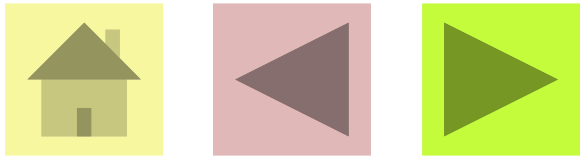
Negative Z value means underestimating influxes and/or overestimating outfluxes

Calculation error – annual values



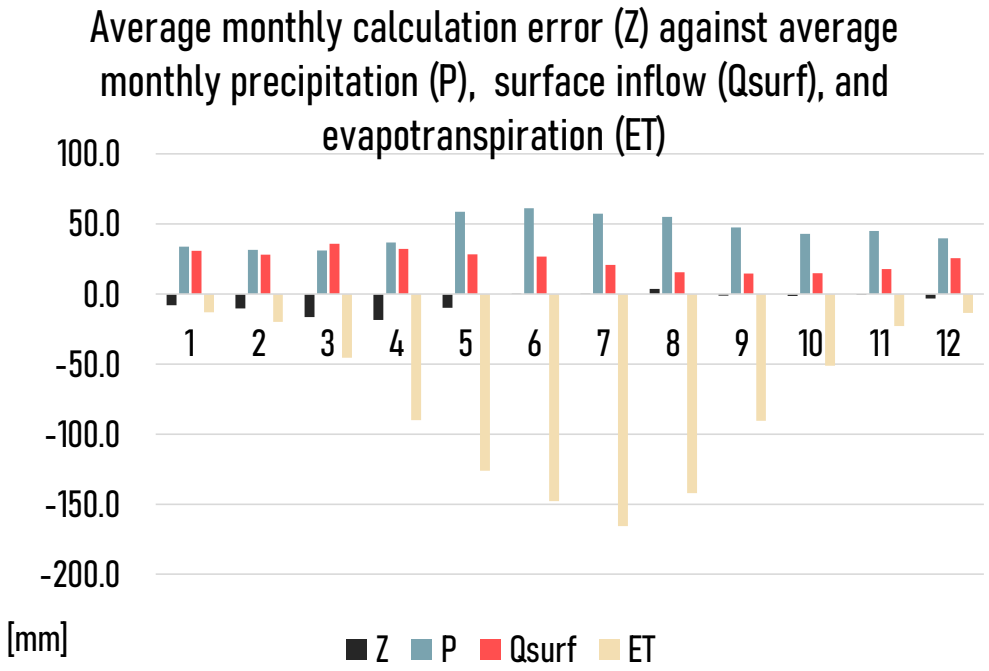


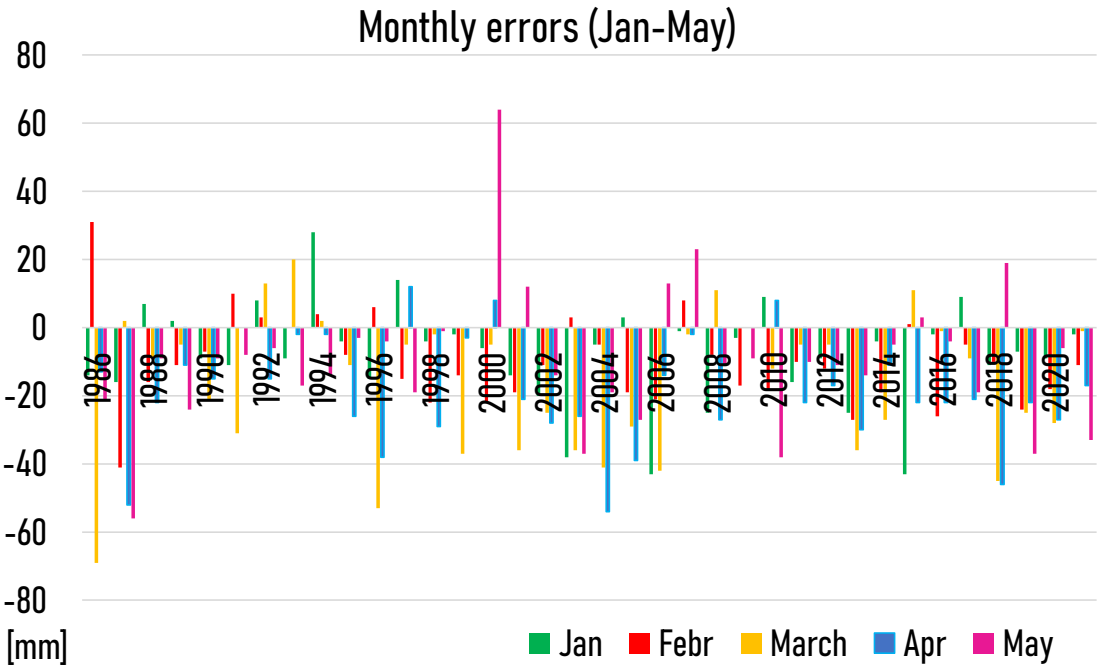




Weak negative correlation (-0.33) between P and Z

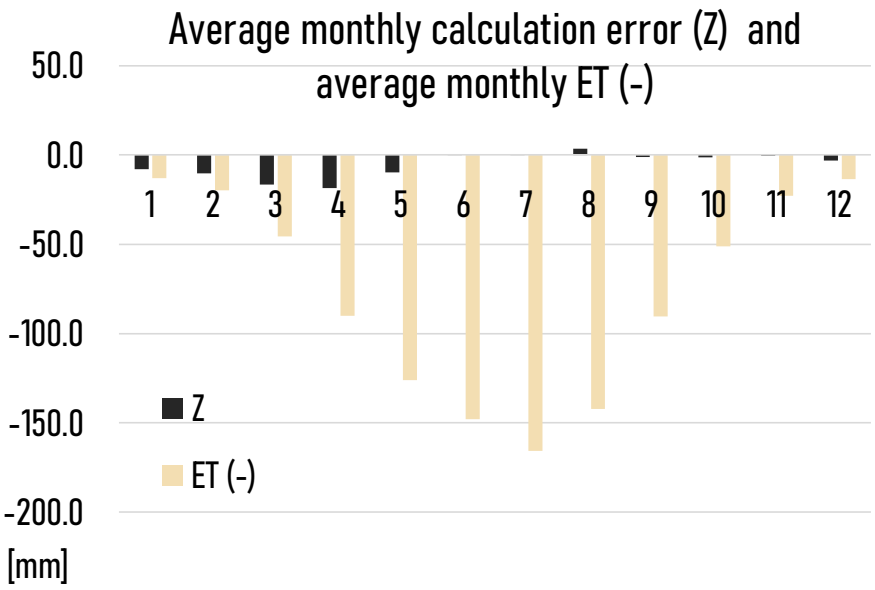
Calculation errors – monthly values





Annual errors accumulate in Jan-May period!

Evapotranspiration - current method



Calculation method: [c]

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

Winter:

XI. – III.: modified Meyer equation:

$P=0.55 \times [(E-e)/1{,}33]^{0,9} \times (1+T/273)^{9} \times (1+0{,}015 \times u)^{2} \times n$ [mm/month]

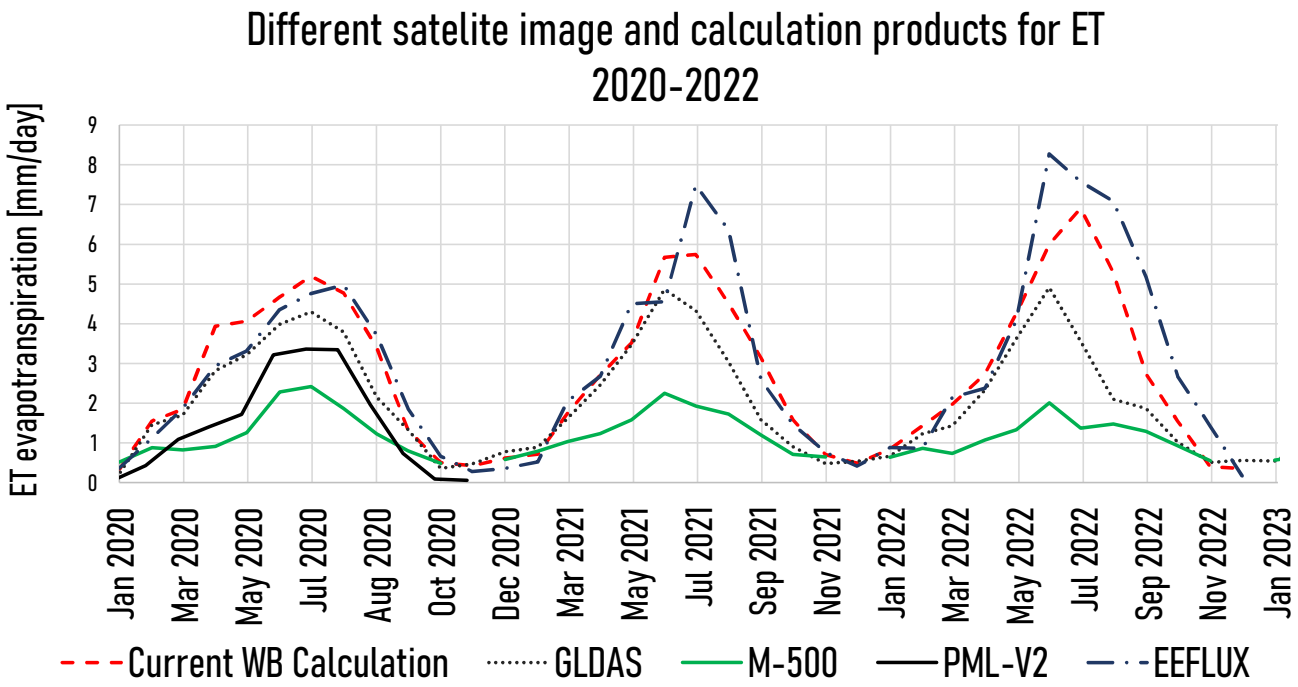
Summer:

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

$P=1{,}11 \times (0{,}58+0{,}42 \times K) \times A^{0,79} \times (1+u)^{0,13} \times n$ [mm/month]

Main focus on the January - May period

Evapotranspiration – satellite data



Google Earth Engine ET products [d]:

GLDAS: Nasa GLDAS V2.1

M-500: Modis 500 m, 8 day

[e]PML-V2: Penman Monteith- Leuning (Modis500, 8day, GLDAS forcing data) Zhang et al., 2019

[d]GEE code: https://github.com/mikhailsmilovic/Earth-Engine/blob/main/ET

[f] EEFLUX: LANDSAT 30×30 m – METRIC method (Allen et. al 2007)

GEE products yield low ET, EEFLUX closest to current results

Evapotranspiration – EEFLUX-METRIC

Satellite data:

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

METRIC method:

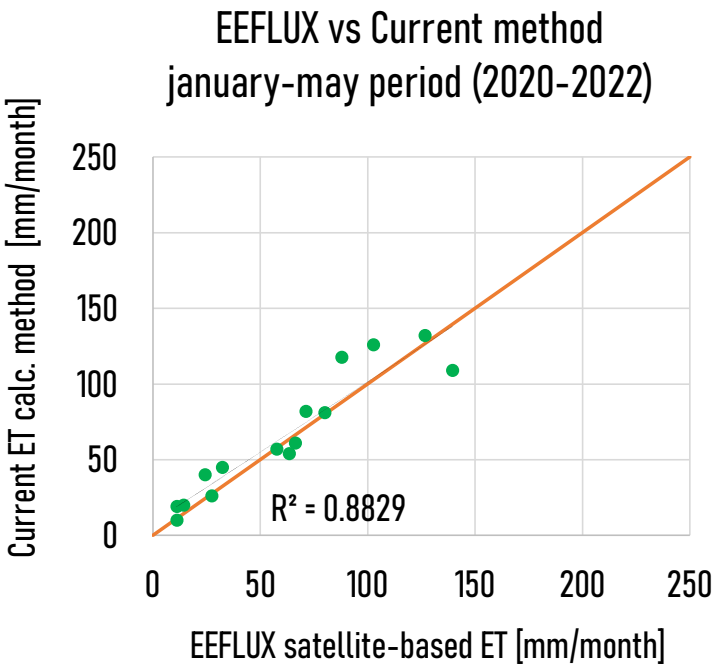
Automatic calibration of Energy Balance equations with Penman-Monteith method

Image frequency:

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

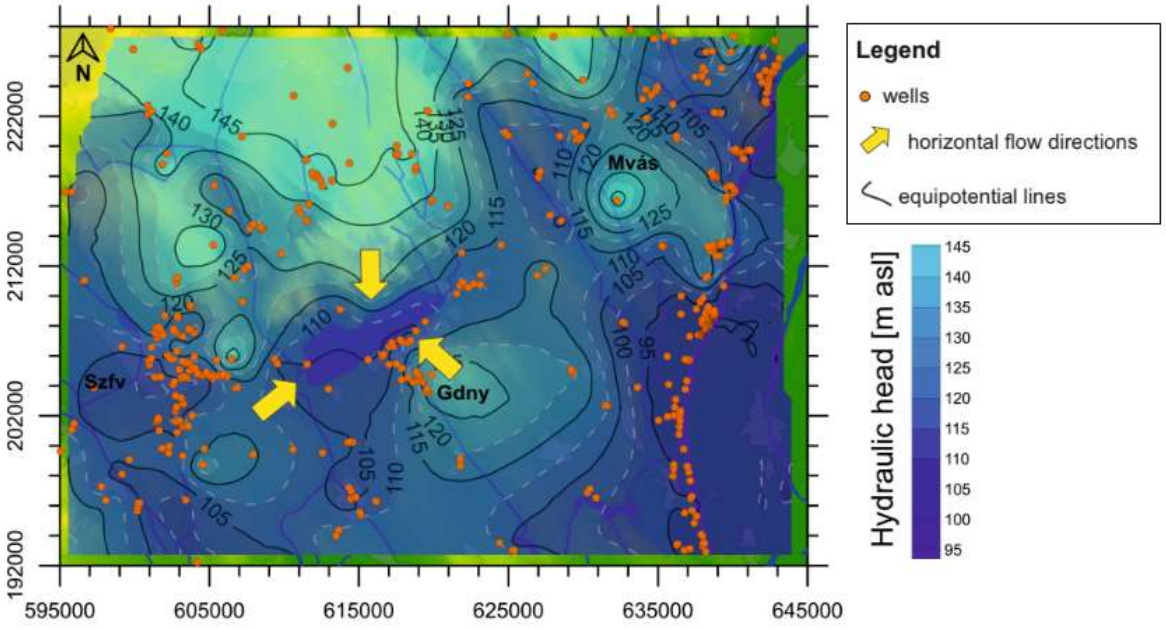
Clouds and other anomalies can cause large time-gaps!

Evapotranspiration – EEFLUX-METRIC



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

Groundwater flow mapping[g]



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

P. Baják et. al, 2022

Calculation method:

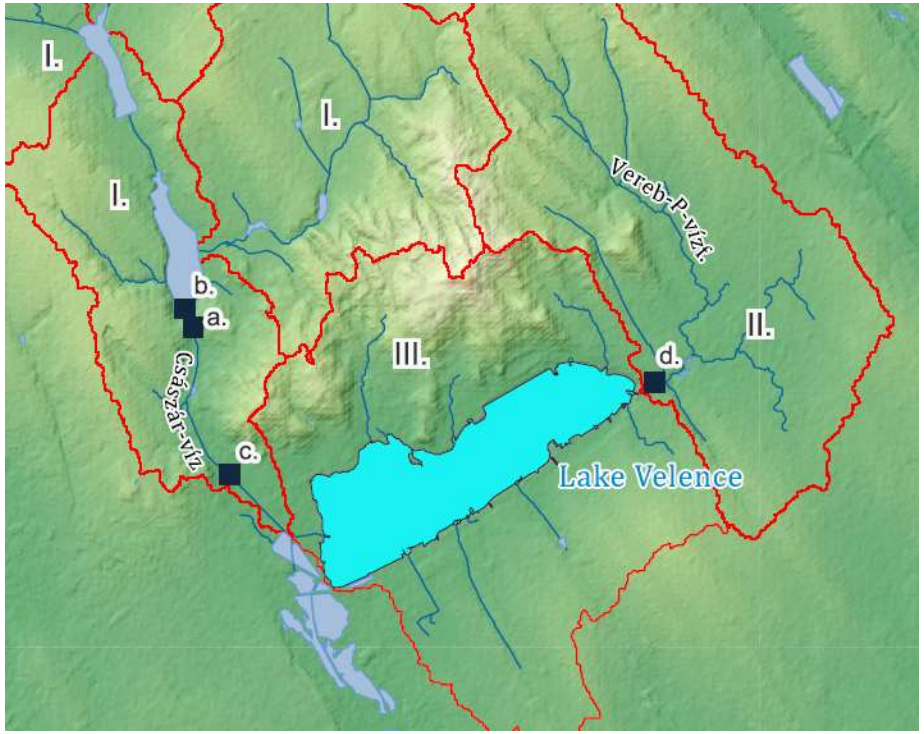
Currently, the groundwater component is not included in the Lake Velence water budget calculation!
However evidence shows, that it should be included.
Modelling the groundwater flow system is in progress.

[g] 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

GW modelling of Lake Velence: EGU-HS8.2.3 - Friday

Surface inflow - current method



Calculation method: [c]

based on hydrological analogy

constants calculated in 1970-s

I. Császár-víz:

Q_{CSV} = [Gauge (a.) – Gauge (b.)] × 2.63

II. Vereb-P. vízf.:

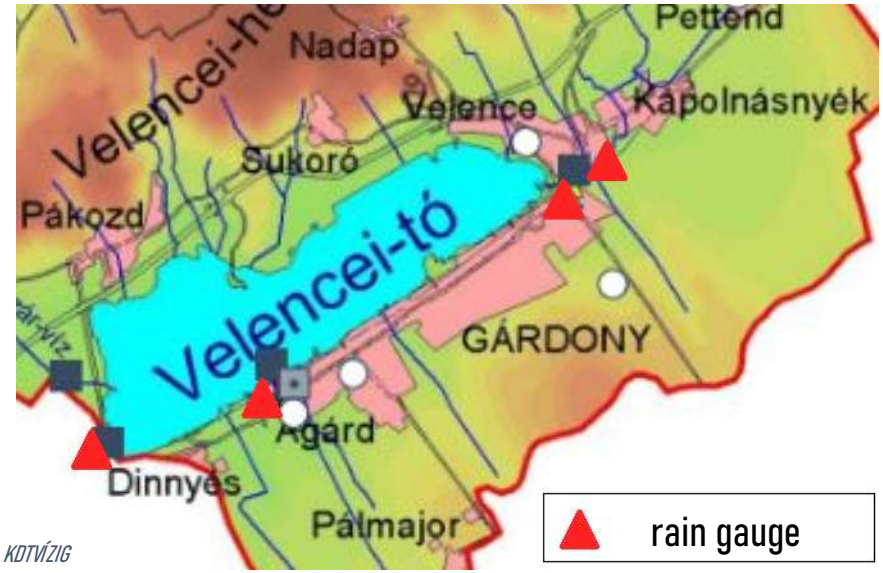
Q_{VPV} = Gauge (d.)

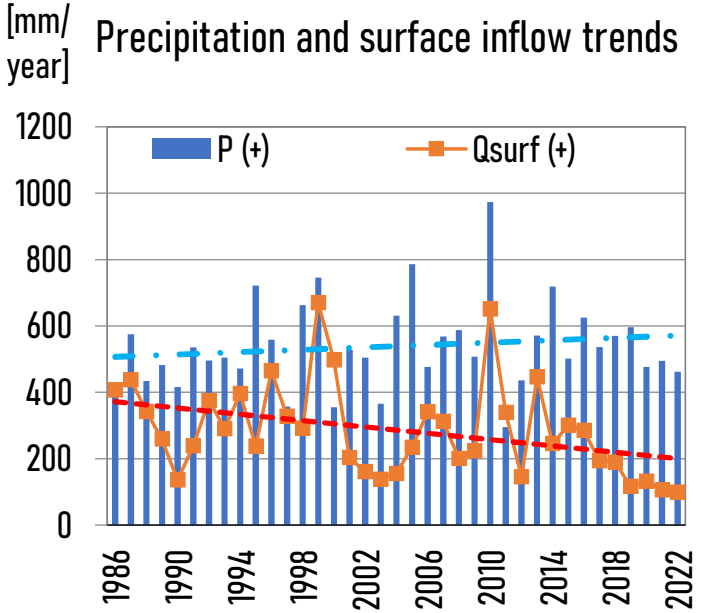
III. Lake direct catchment:

Q_{LDC} = Gauge (d.) × 0.84

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

Precipitation – current method





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.

Water replenishment from reservoirs (Q_{res})

Reservoirs:

Reservoir 1 (Zámolyi): max: 4 Mm^3

Reservoir 2 (Pátkai): max: 7 Mm^3

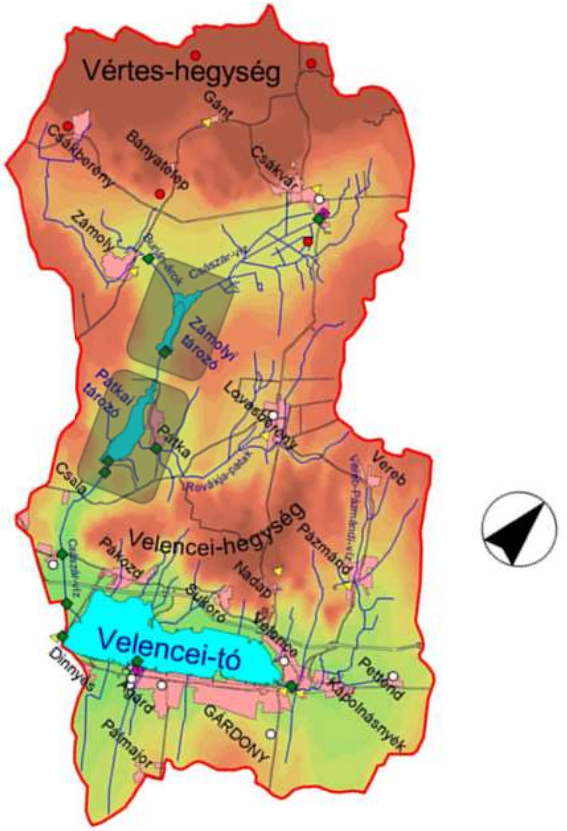
Lake Velence at stage 140 cm: 41 Mm^3

Operation:

Filling up from floods, replenishment if lake level goes below 140 cm.

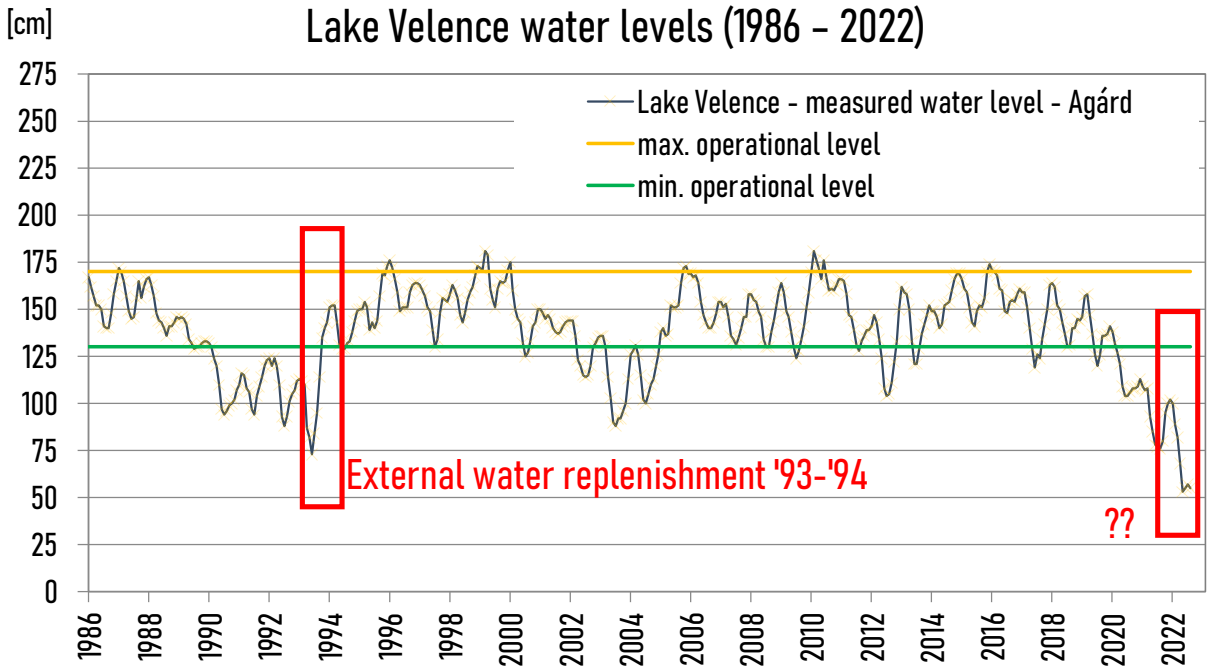
Calculation method:

Based on discharge curves of gates.



KDTVÍZIG

External water replenishment (Q_{ext})



External water replenishment in 1993-1994:

why? → water level under min. operational level for 3 consecutive years

how? → building a pipe system to divert karst water from an existing mine dewatering well

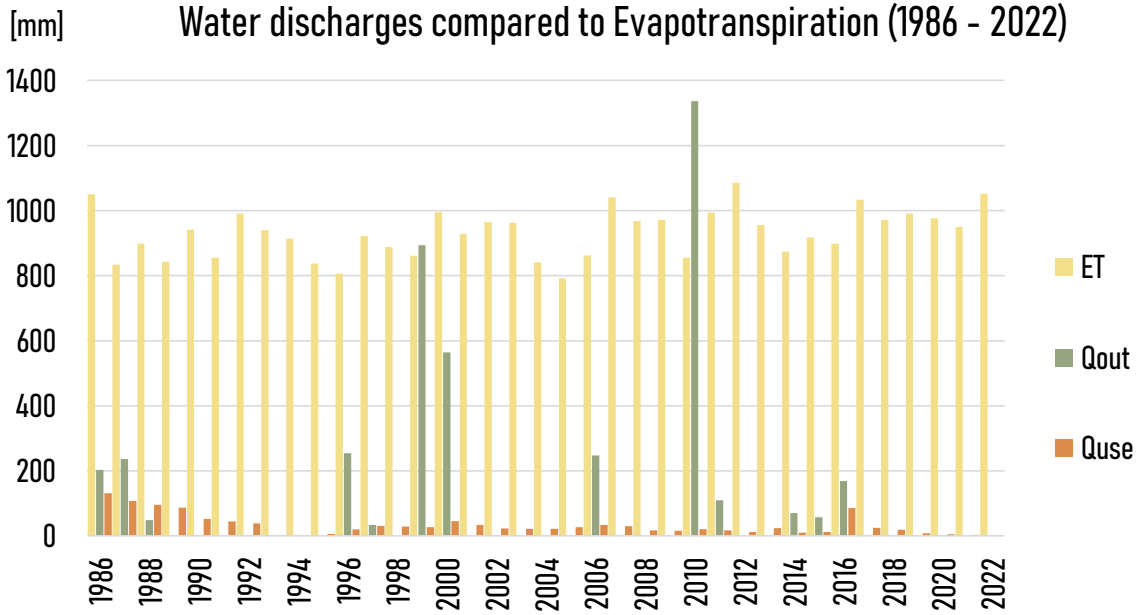
how much? → ~ 11 Mm^3

External water replenishment 2023 ?

Not yet!

But ongoing negotiations on possibilities.

Water discharges (Q_{out} ; Q_{use})



<u>Lowering water levels (Qout):</u>

When water levels in the lake exceed max operational level.
Last time the water level was lowered: 2016.

<u>Water use (Quse):</u>

Water from the main tributary of the lake can be diverted towards the Dinnyés Fish Farm.

<u>Calculation method:</u>

Based on discharge curves of gates and weirs, with high uncertainty. [b]

References

a) Water Resources Research Center Hungary (VITUKI), "Hydrological and water quality characteristics of Lake Velence and its reservoirs," Budapest 1985

b) Middle Transdanubian Water Directorate (KDTVÍZIG), "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 (VITUKI), "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://eeflux-level1.appspot.com/

g) Baják, P.; Hegedűs-Csondor, K.; Tiljander, M.; Korkka-Niemi, 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. Water 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.