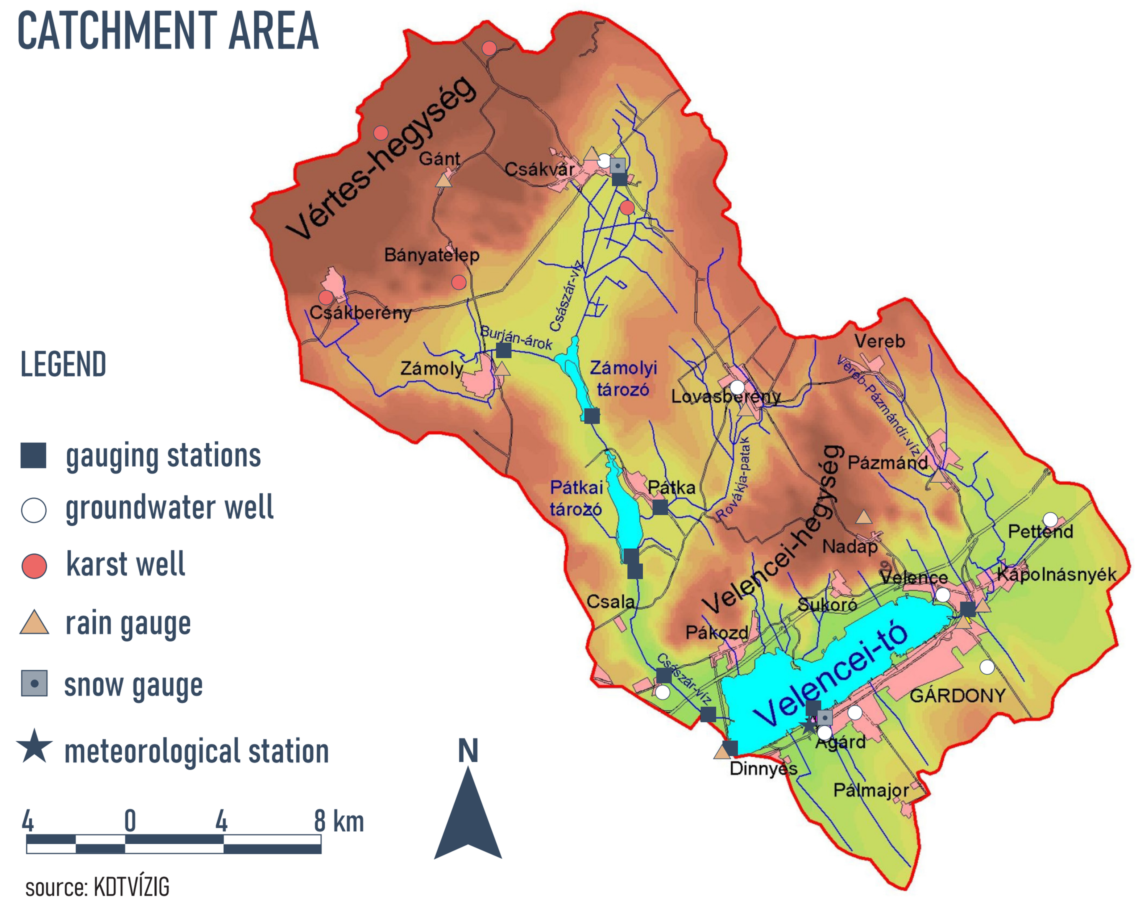
UNCERTAINTIES IN THE WATER BUDGET CALCULATION OF LAKE VELENCE

SZÉCHENYI EGYETEM
UNIVERSITY OF GYŐR

source: National Geographic

CATCHMENT AREA

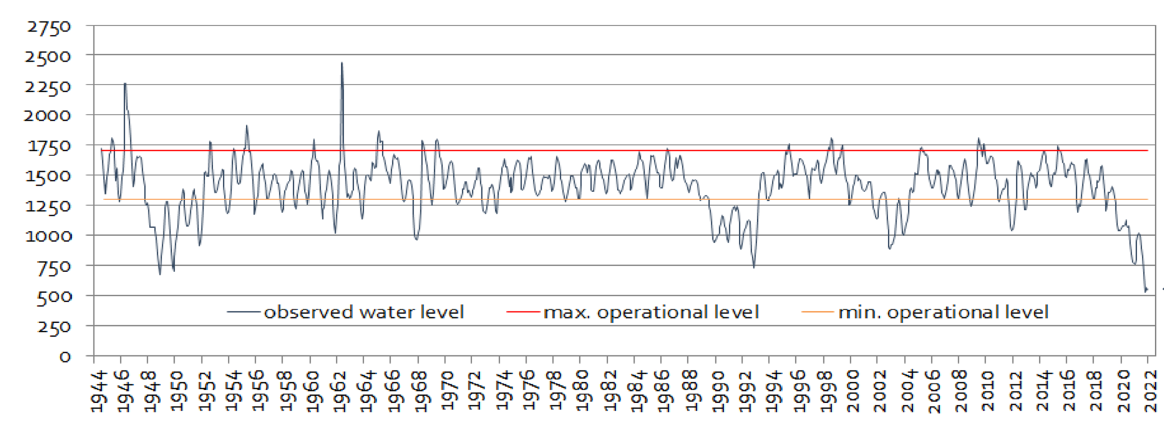


source: KDTVÍZIG

INTRODUCTION

In recent years the water levels of Lake Velence - Hungary's third largest lake - have dropped significantly due to a series of climatic and anthropogenic phenomena. Various engineering solutions are being considered to supplement the lake water from surface and subsurface sources. However, policymakers and professionals argue about the necessity and extent of such interventions.

Understanding the main processes governing lake water levels is key to manage the quality and quantity of the lake.



Record-low water level in 2022!

DATA AND METHOD

1. MEASUREMENT

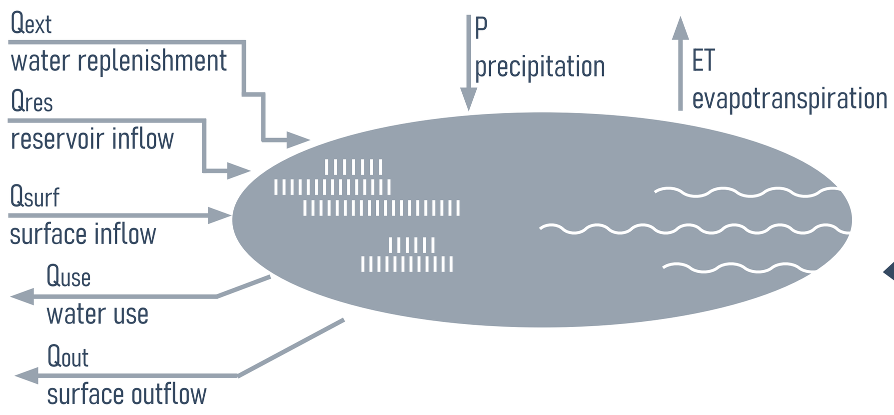
Change in water level measured: ΔH_M

Monthly time series of lake water levels for the 1986 - 2021 period - KDTVÍZIG [2]

2. WATER BUDGET CALCULATION

Change in water level - calculated [1] ΔH_C

ΔH(C) = P + Qsurf + Qres + Qext - ET - Qo - Quse



Monthly time series for each component of the water budget equation for the 1986 - 2021 period - KDTVÍZIG [2]

WHY isn't groundwater part of the equation?

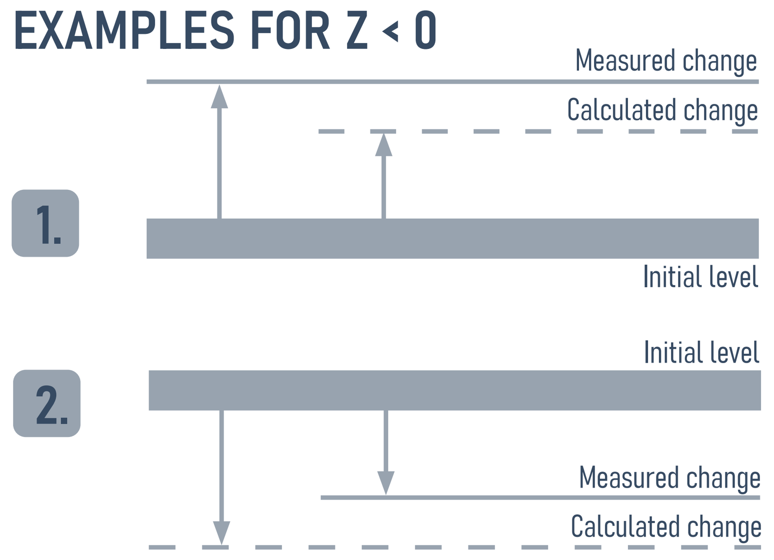
PARAMETER	CALCULATION METHOD
P – [mm] precipitation	Averaging data of 4 meteorological stations placed around the lake
Qin – [mm*] Surface inflow	Measured runoff data; Hydrologic similarity with **constant similarity factor** for ungauged inflows
Qres – [mm*] Reservoir inflow	Reservoir operation data; Discharge calculated using rating curves
Qext – [mm*] Water replenishment	Karst water pumped from outside of the catchment area; Discharge calculated using pump curves
ET [mm] Evapo-transpiration	XI. – III.: modified Meyer equation IV. – X.: pan evaporation modified values using **reed constants**
Qout – [mm*] Surface outflow	Regulated outflow from the lake; discharge calculated using rating curve
Quse – [mm*] Water use	Water use downstream from the lake; discharge calculated using rating curve
Groundwater	Not part of the currently applied calculation method, however recent ground-water flow mapping studies [3] revealed its pronounced contribution

*dimensions of discharges: $mm = [(m^3 \times s^{-1}) \times s] / (m^2 \times 10^3)$

calculation constants for ET, and Q_{surf} determined 47 years ago [4]

CALCULATION ERROR: $Z = \Delta H_C - \Delta H_M$

EXAMPLES FOR Z < 0



1. ΔH_M = +160 mm, ΔH_C = +90 mm, Z = 90-160 = -70 mm
2. ΔH_M = -100 mm, ΔH_C = -148 mm, Z = -148 - (-100) = -48 mm

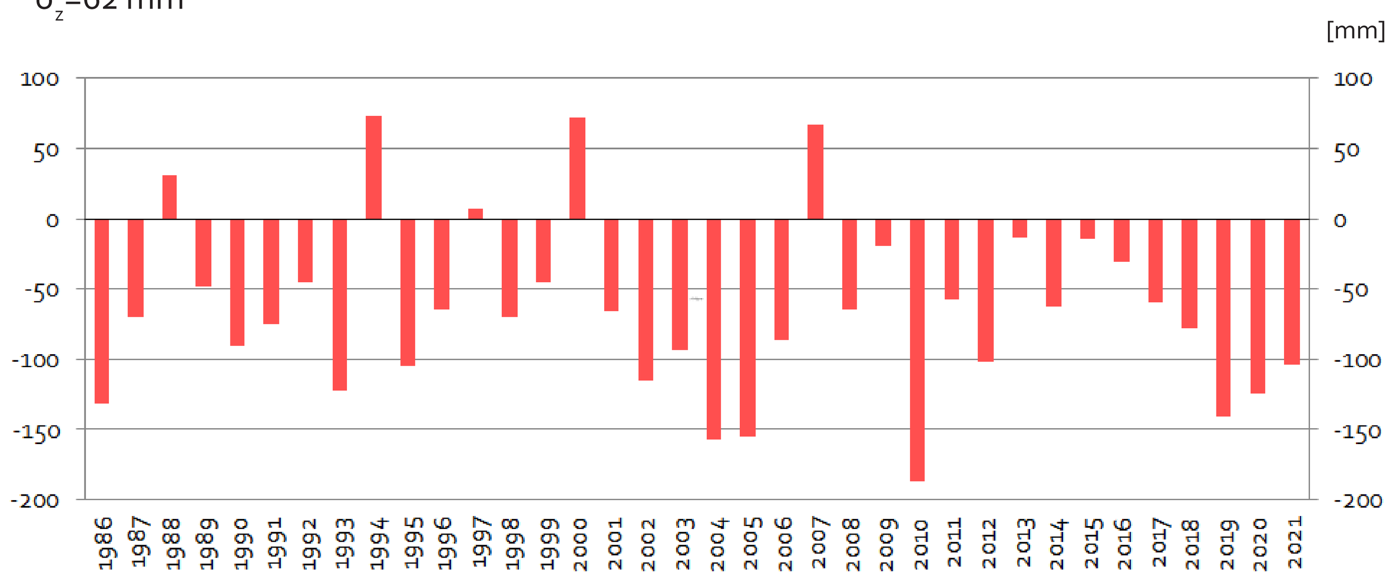
Z MEANING

- Z is negative, if the calculated water level is lower than the measured level. This can be a result of underestimating influxes and, or overestimating outflues.

+ Z is positive, if influxes are overestimated and, or outfluxes are underestimated

TIME SERIES FOR Z – ANNUAL DATA:

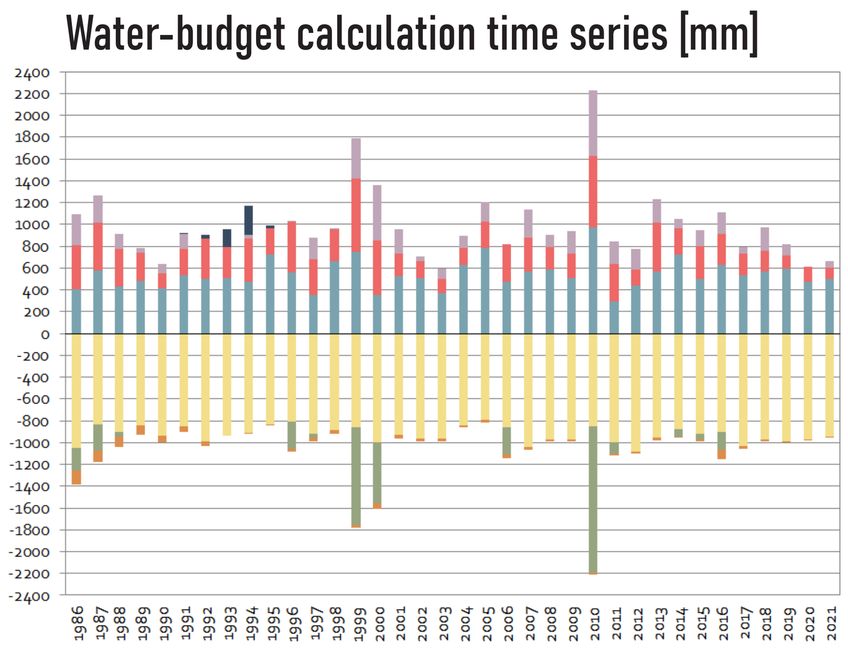
$\bar{z}$ = -65 mm
σ_z = 62 mm



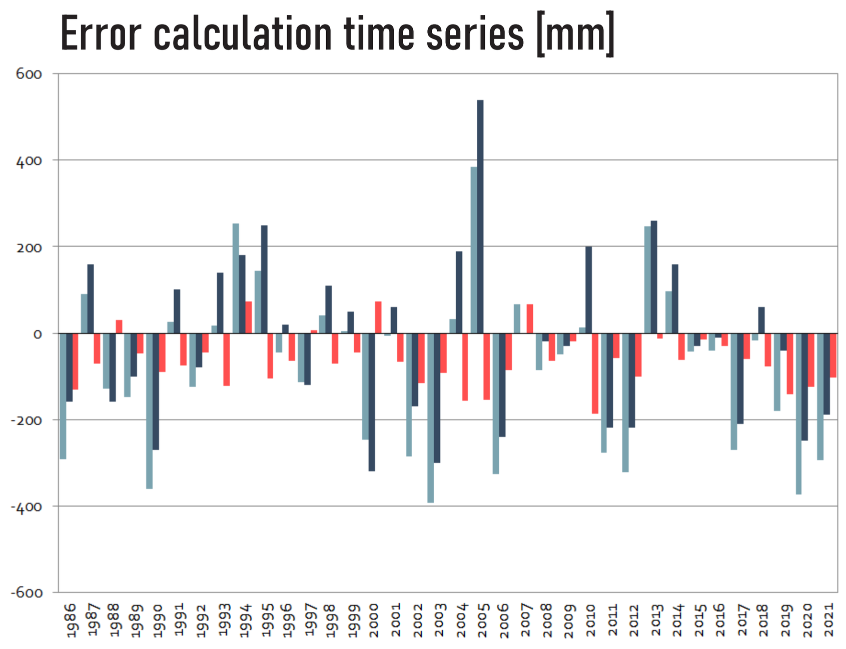
Only 5 of the past 36 years had a positive calculation error!

RESULTS

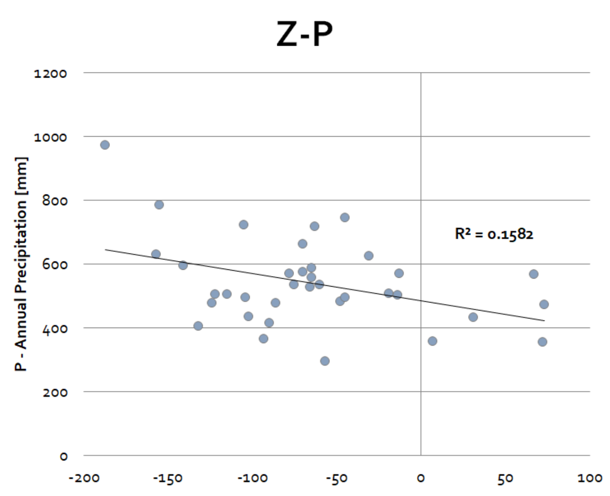
Water-budget calculation time series [mm]

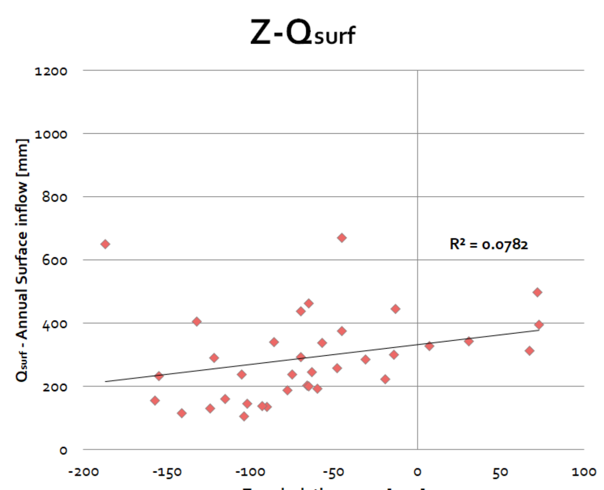


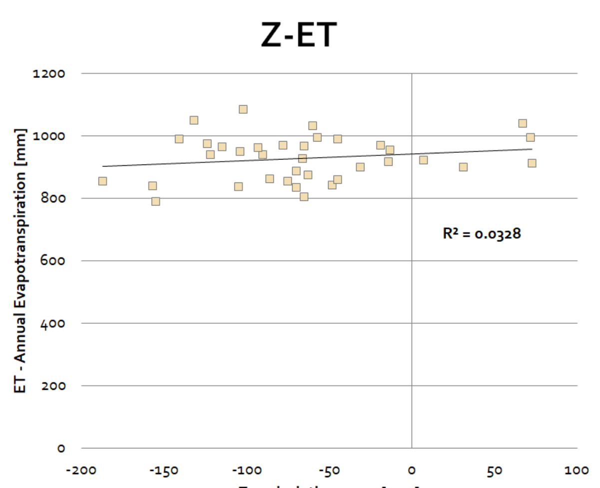
Error calculation time series [mm]

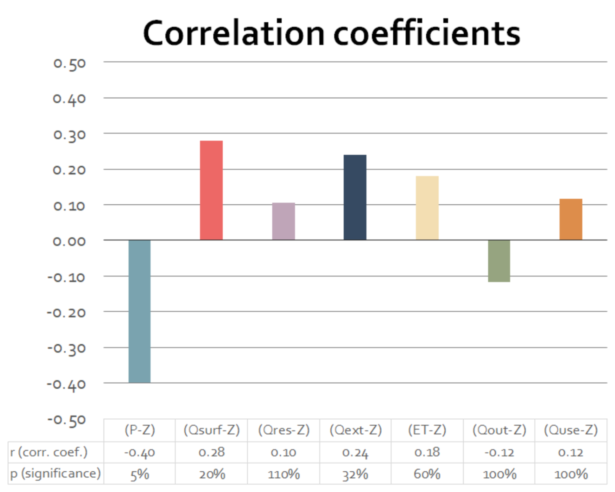


UNCERTAINTIES









Pearson Correlation of precipitation and calculation error : r_{PZ} = -0,4 (with p < 5%)

DISCUSSION

1. Groundwater flow is not part of the water budget calculation. However groundwater flow mapping[3] and other evidences detailed below suggest its contribution.
2. Calculation errors are predominantly negative, meaning, that the current water budget calculation method underestimates inflows and, or overestimates outflows.
3. A weak negative correlation with p < 5% significance between precipitation and calculation error was found. This means large negative errors (underestimating inflows / overestimating outflows) tend to occur in years with high amounts of rainfall.
4. Annual evapotranspiration and surface inflows are uncorrelated with calculation error. However the calculation method of the former two contain highly uncertain elements.

FUTURE PLANS

1. Analyzing monthly calculation errors.
2. Modelling groundwater flows.
3. Recalculating lake water budget including groundwater flow components.
4. Re-evaluating calculation errors.
5. Improving calculation methods for evaporation and surface runoff.

LET'S DO THIS!

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Literature:

[1] Water Resources Research Center Hungary (VITUKI), "Hydrological and water quality characteristics of Lake Velence and its reservoirs," Budapest 1985
[2] Middle Transdanubian Water Directorate (KDTVÍZIG), "Water budget of Lake Velence: 1986 - 2021," Available at: http://www.kdtvizig.hu/hu/velencei-to-vizmerleg (Accessed: 21st November 2022.)
[3] 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
[4] Water Resources Research Center Hungary (VITUKI), "Monthly water budget calculation for Lake Velence and its catchment," Budapest, 1976

Acknowledgements
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