ZMENA BILANCIE VODY A JEJ TEPLOTY VO VYBRANÝCH SUBPOVODIACH RIEKY DUNAJ V DÔSLEDKU RASTU TEPLOTY VZDUCHU

CHANGES IN THE WATER BALANCE AND WATER TEMPERATURE IN SELECTED SUB-BASINS OF THE DANUBE RIVER AS A RESULT OF RISING AIR TEMPERATURES

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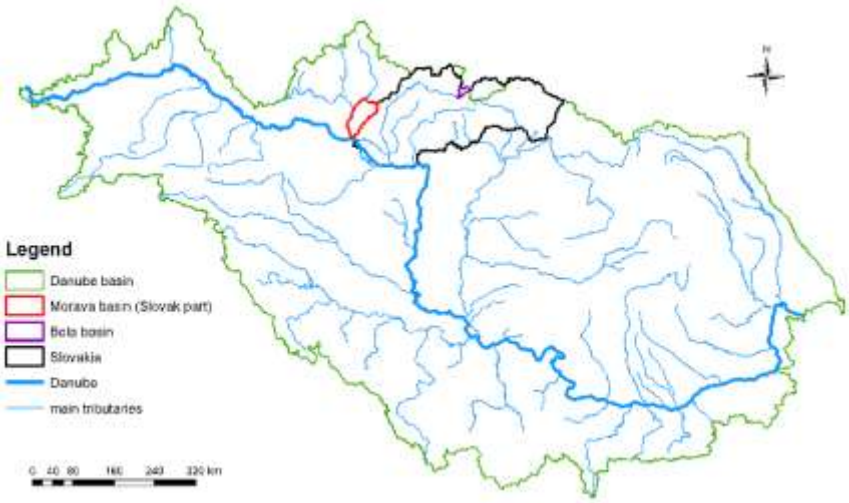
Ciele prednášky:

1. Opis povodia Dunaja a Slovenska
2. Bilancia vody vo vybraných subpovodiach Dunaja a na Slovensku
   Opis údajov, ktoré sú k dispozícii:
   - prietoky, - teplota vzduchu a vody
3. Analýza vývoja teploty vody Dunaja a slovenských riek

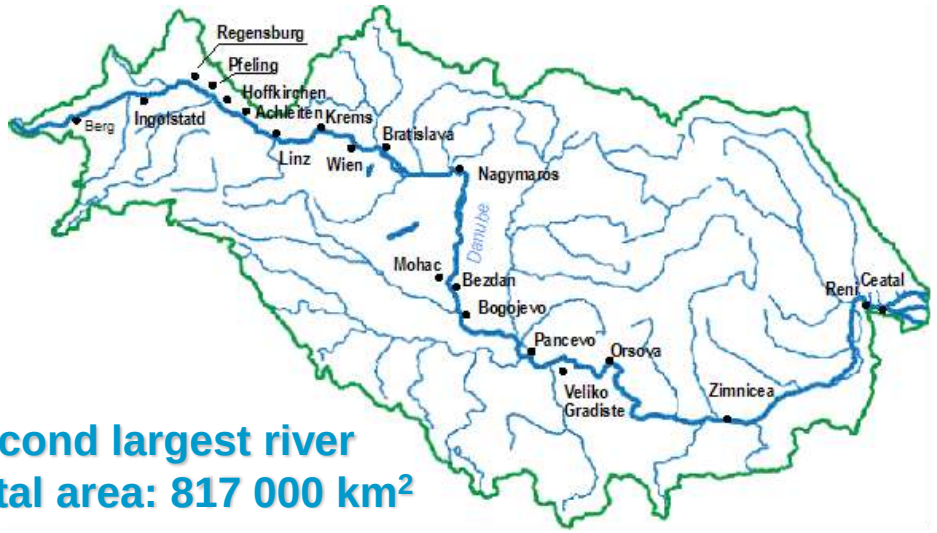
Aims of the presentation:

1. Description of the Danube basin
2. Water balance in selected basins of Danube and in Slovakia
   Data description:
   - discharge series, air and water temperature series
3. Analysis of the Danube water temperature and of the selected Slovak rivers

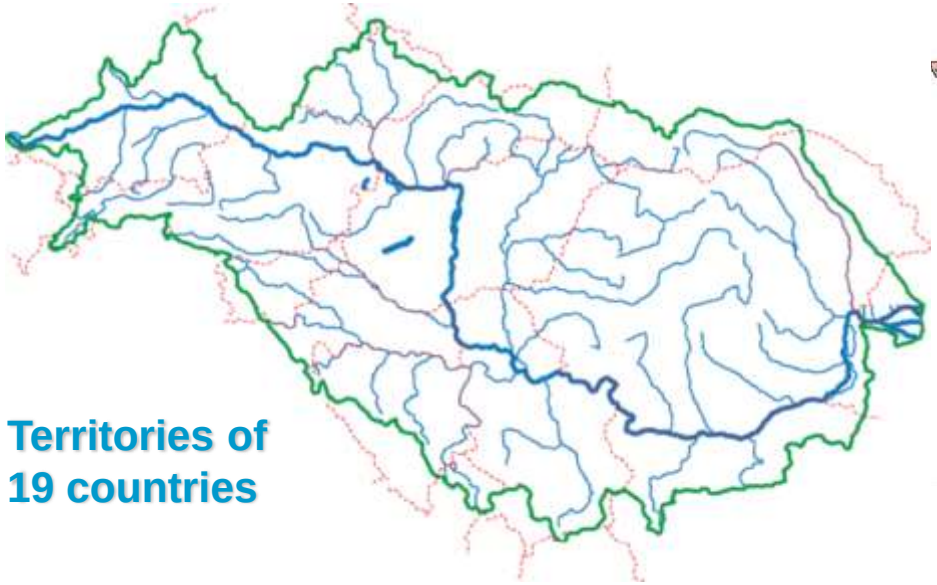


P. Pekárová, Vígľaš, May, 18, 2023

1. Description of the Danube basin



Second largest river
Total area: 817 000 km²

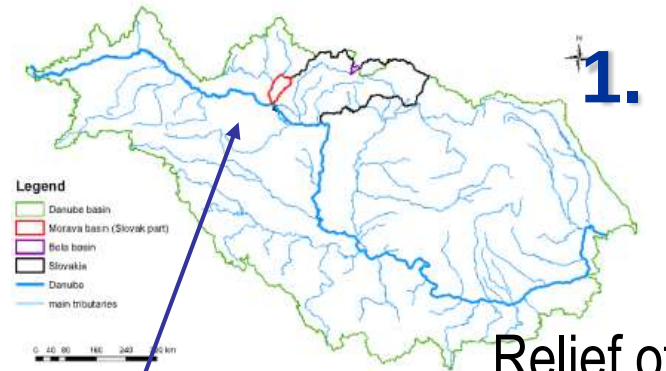


Territories of 19 countries

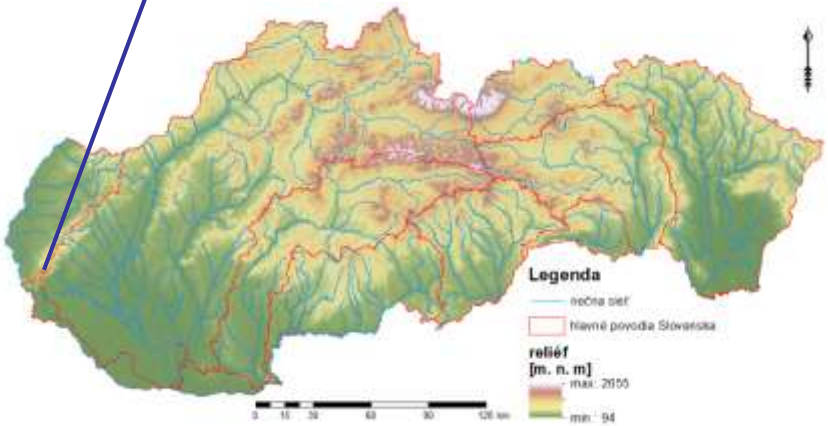
Parts:
- **Upper**
- **Central**
- **Lower Danube**
- **Danube delta**

26 major tributaries

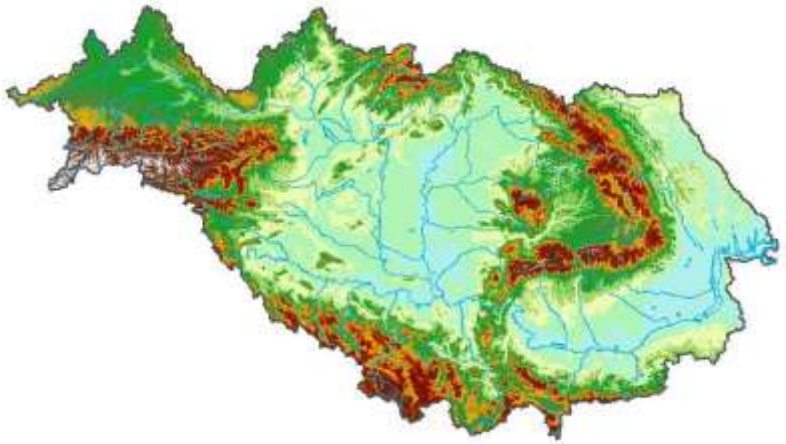
1. Description of the Slovakia

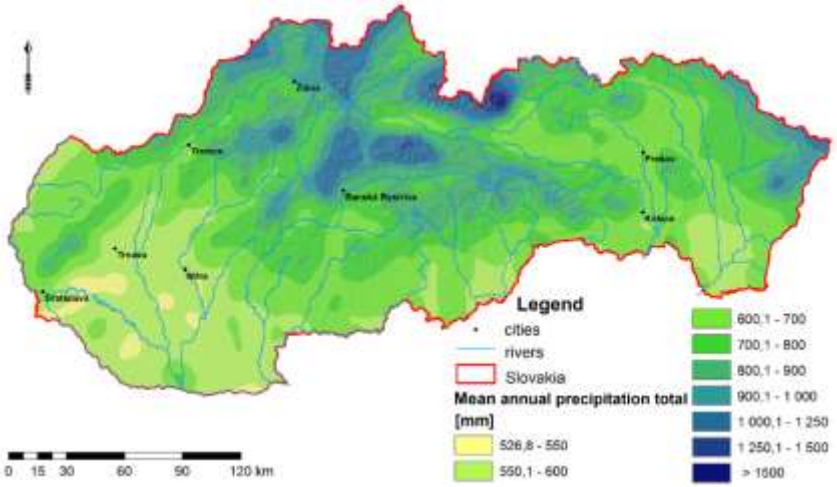


Relief of Slovakia.

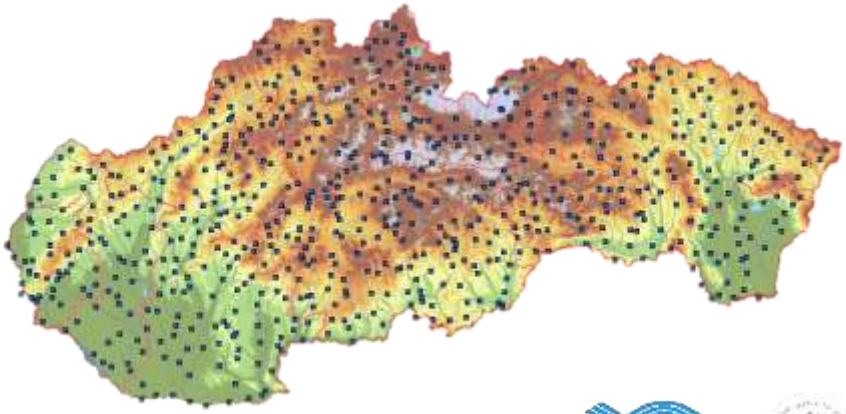


Relief of the Danube basin.





Mean annual precipitation totals in Slovakia; calculated for the period 1991–2015.



2. Bilancia vody / Water balance

$P = R + ET + \Delta S$,

kde: P – priemerný ročný úhrn zrážok [mm];

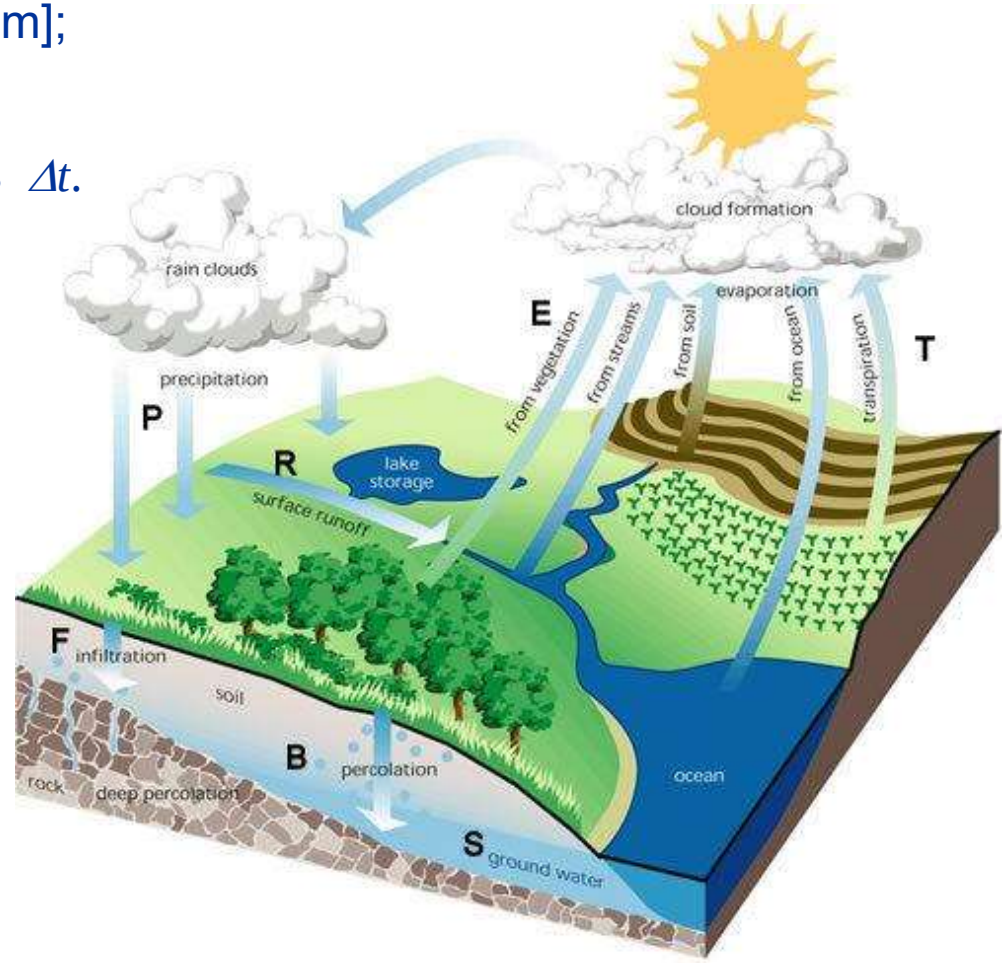
R – priemerná ročná odtoková výška [mm];

ET – bilančný výpar [mm];
ΔS –zmena zásob vody v povodí za čas Δt.

Predpoklad: ΔS za 30 rokov = O

$P = R + ET + \Delta S$

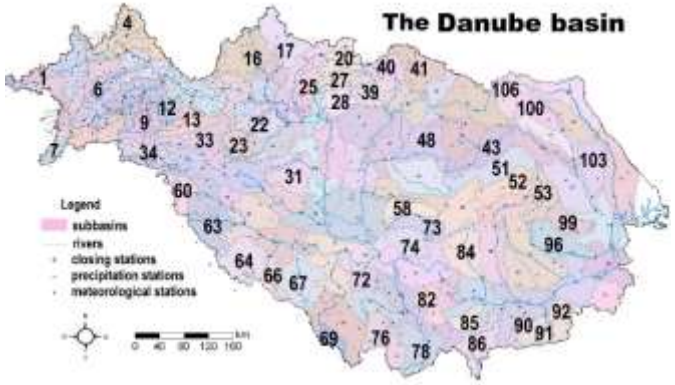
where:
P – average annual precipitation total [mm],
R – average annual runoff depth [mm],
ET – balance evaporation [mm],
ΔS – average total losses for time Δt.

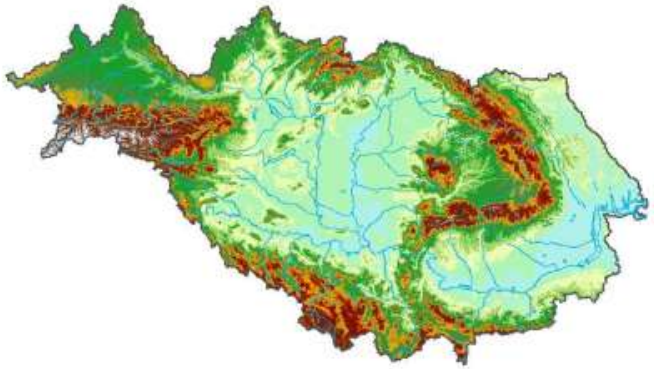


2. Water balance of the Danube basin 1961-90

Precipitation
400 - 450
450 - 500
500 - 550
550 - 600
600 - 700
700 - 800
800 - 900
900 - 1000
1000 - 1100
1100 - 1200
1200 - 1300
1300 - 1400
1400 - 1500
1500 - 1600
1600 - 1700
1700 - 1800
1800 - 1900
1900 - 2000
2000 - 2100
2100 - 2200
2200 - 2300
2300 - 2400
2400 - 2500

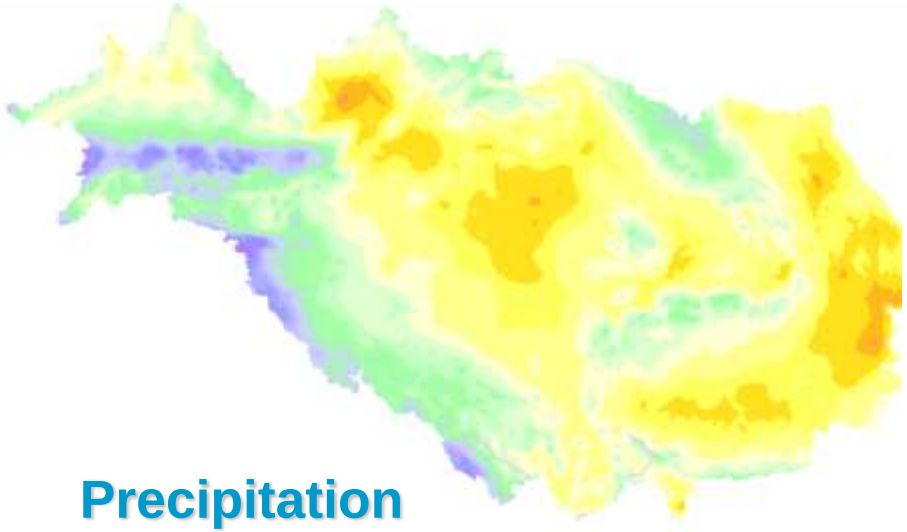
Project UNESCO Petrovič at al.



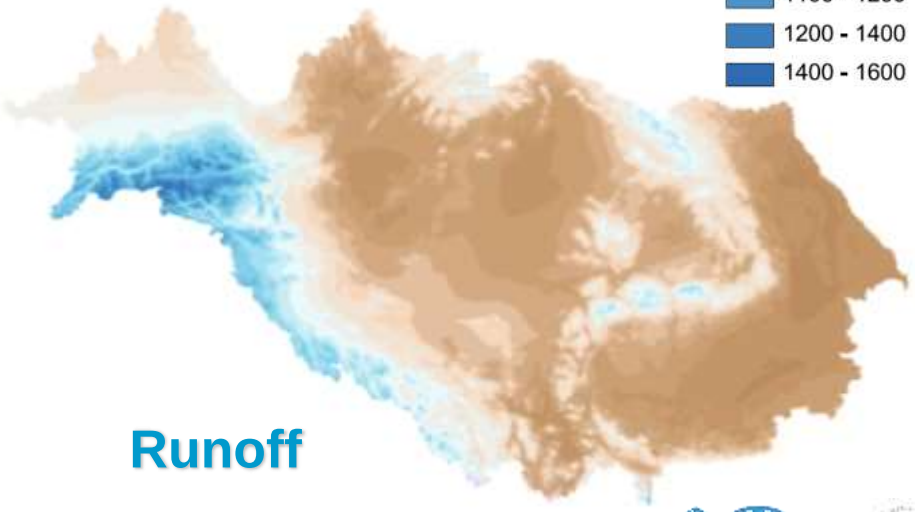


Runoff
0 - 50
50 - 100
100 - 150
150 - 200
200 - 250
250 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1000
1000 - 1100
1100 - 1200
1200 - 1400
1400 - 1600

600 precipitation stations
109 water gauges



Precipitation



Runoff

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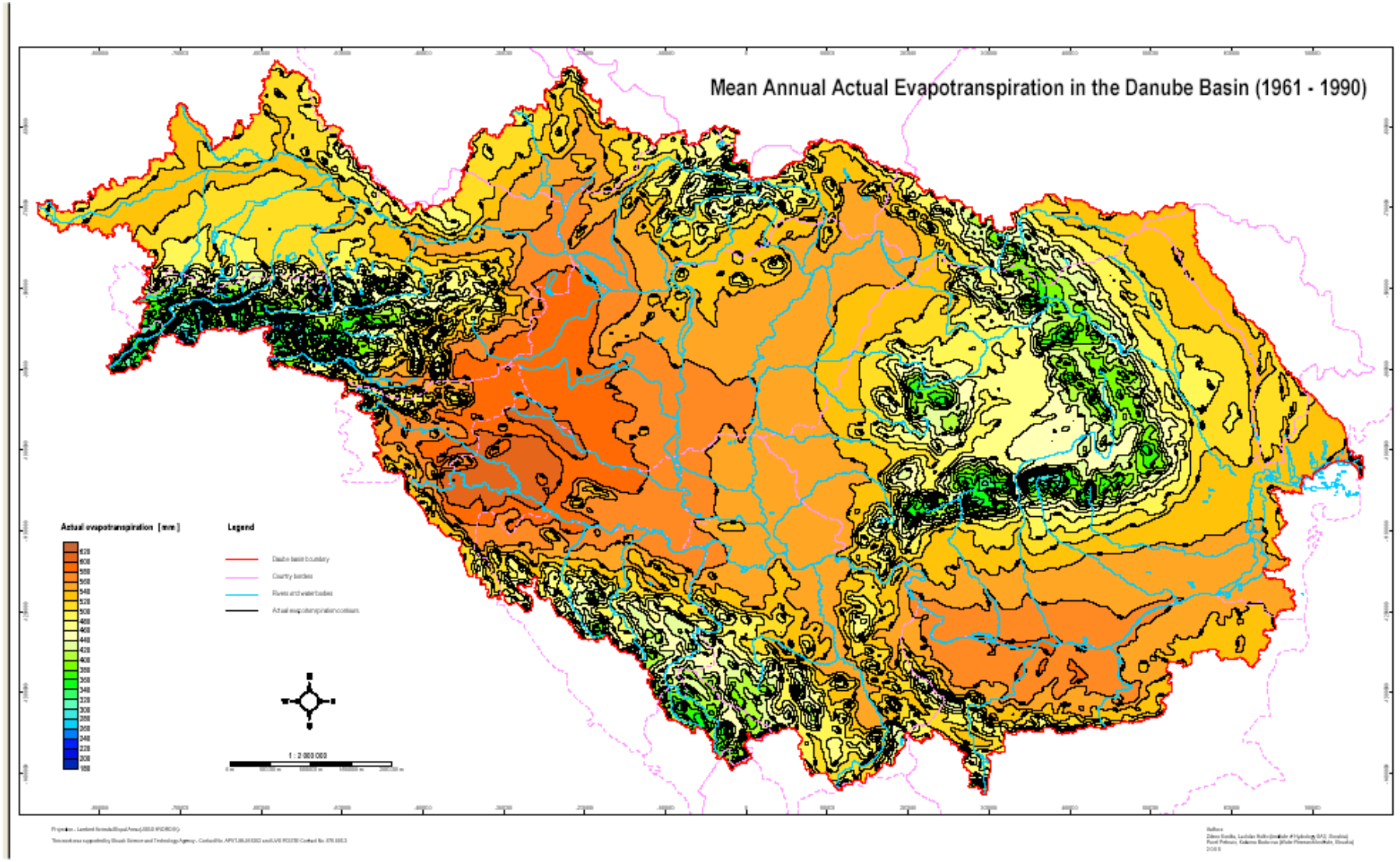
2. Water balance of the Danube basin 1961-90



Evapotranspiration

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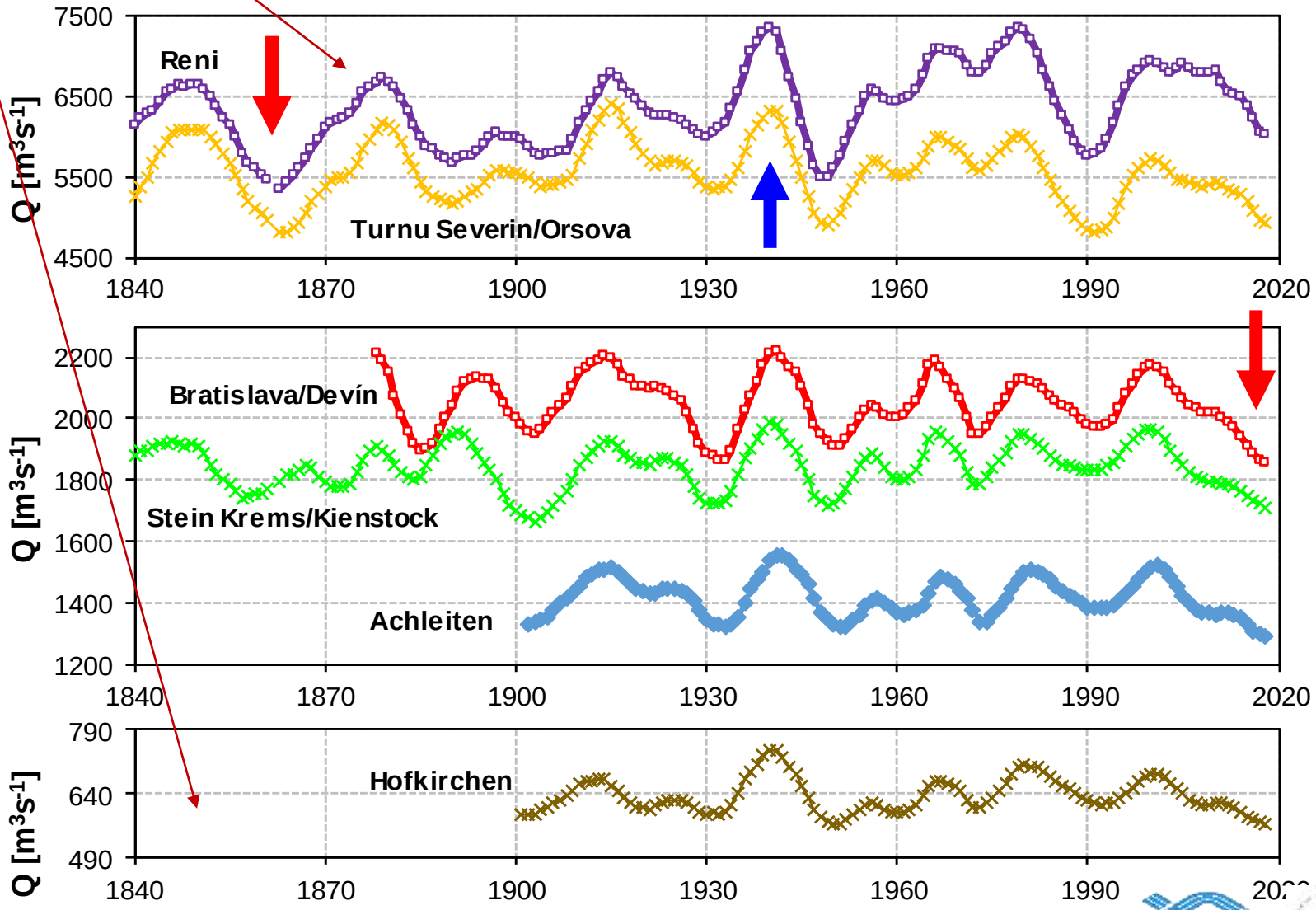
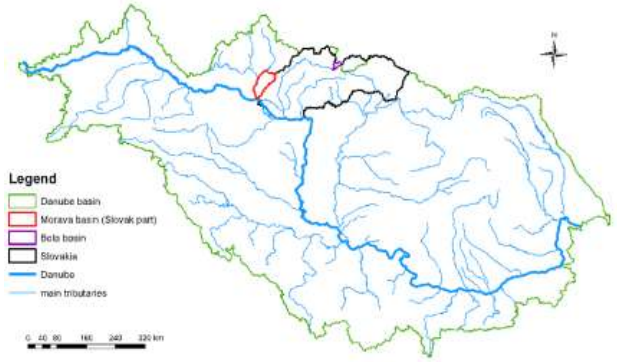
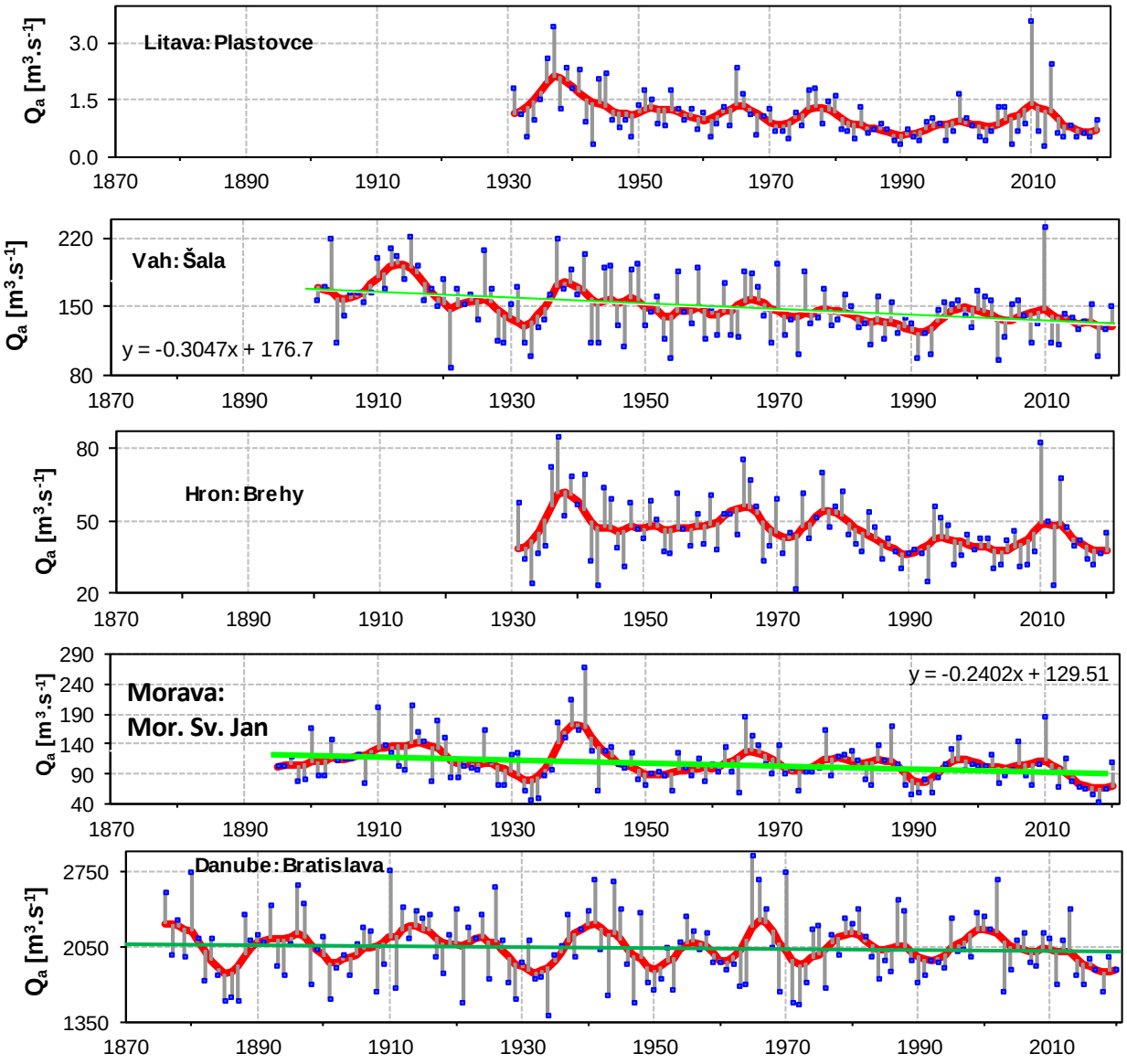
2. Data – Discharge

along the Danube River, (7-year moving average)

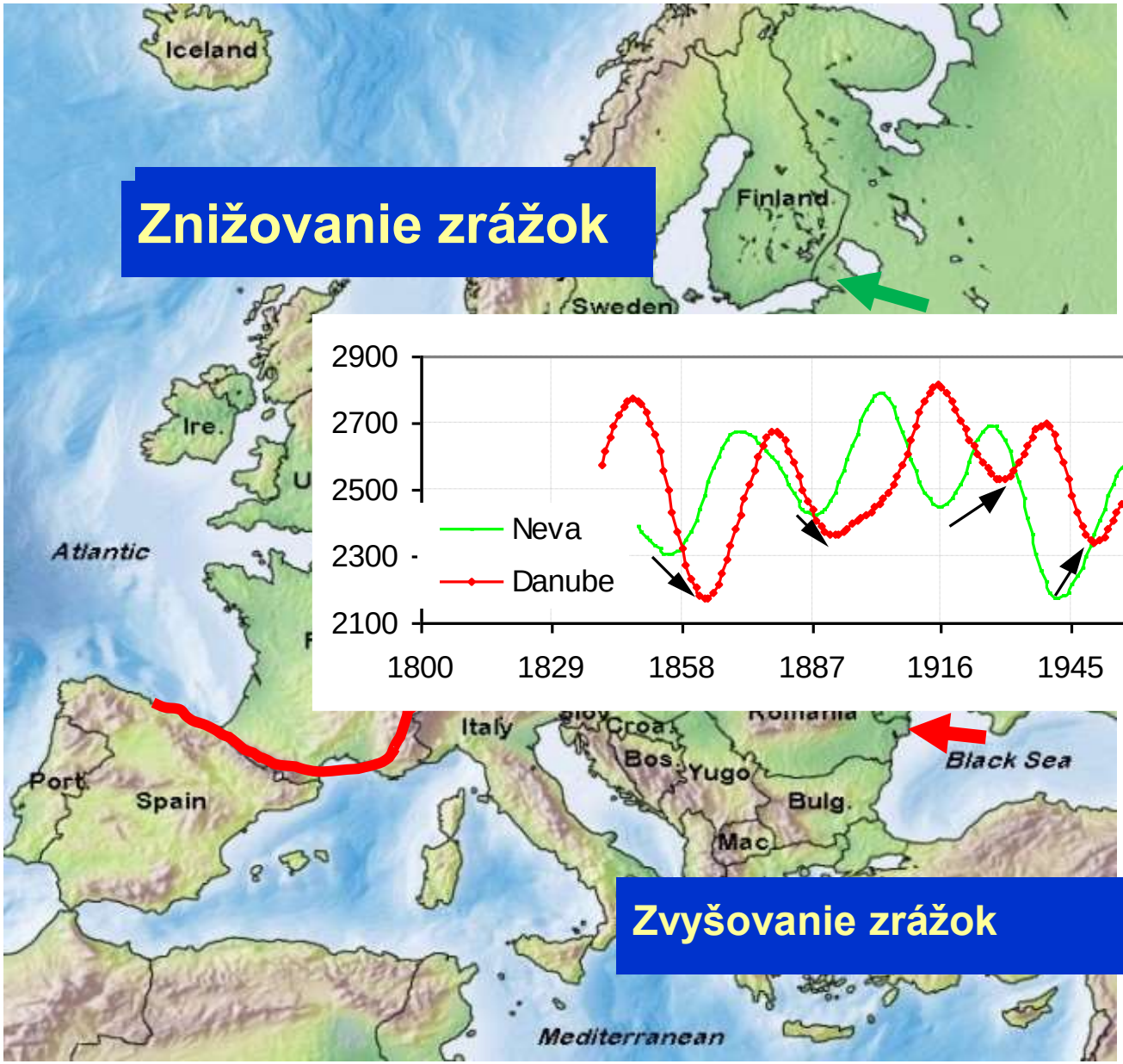


2. Data – Discharge Slovakia

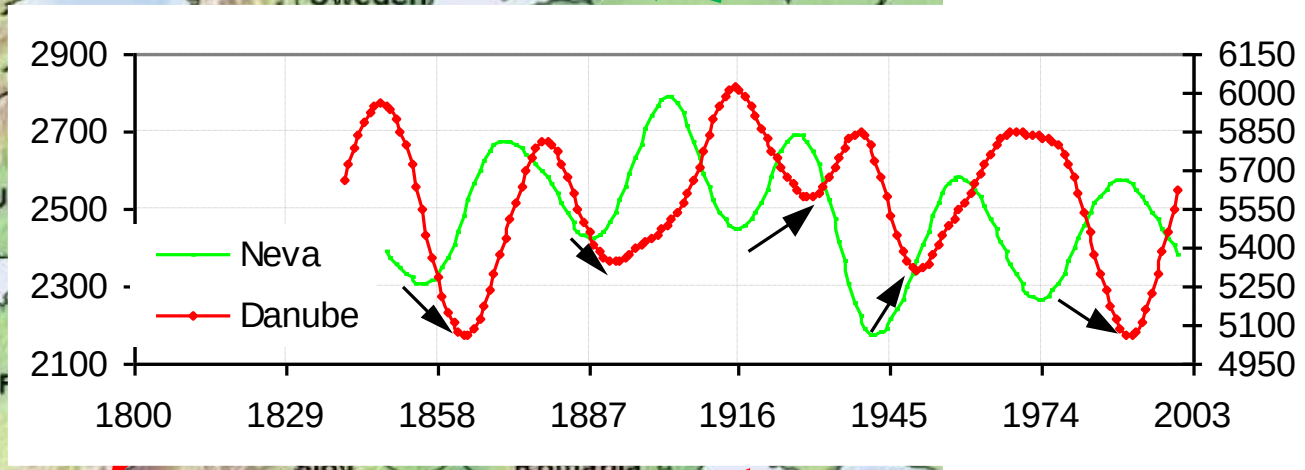




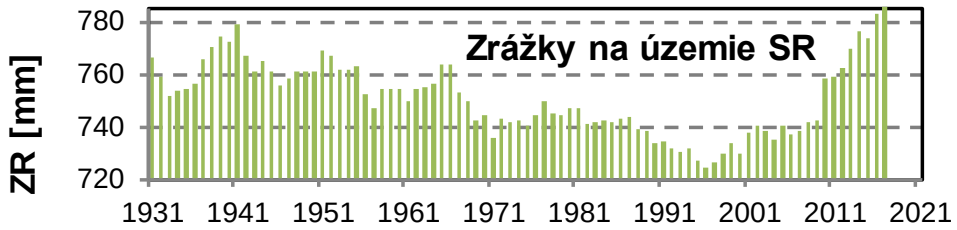
2. Data - Discharge regime analysis



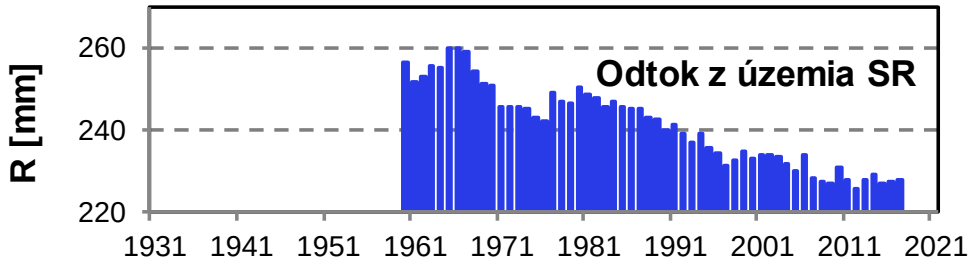
North-atlantic oscilation



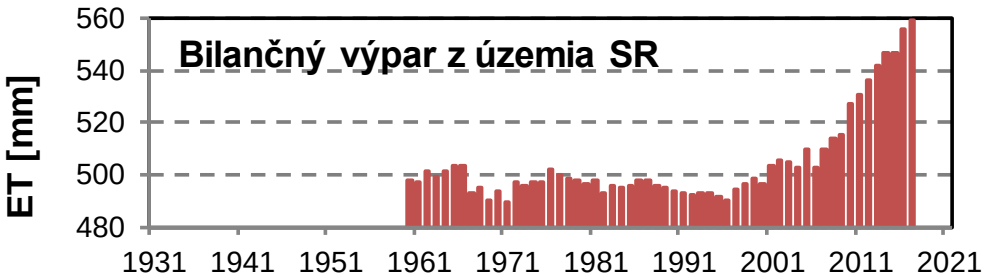
2. Data - Water balance of Slovakia ZR=R+ET



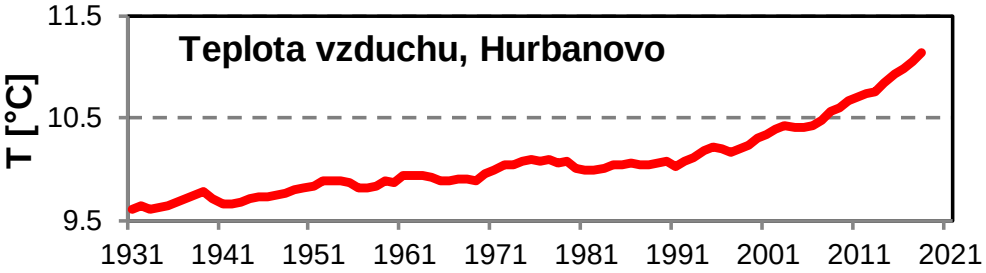
Vývoj priemerných ročných úhrnov zrážok na územie Slovenska,



odtok územia Slovenska riekami,



bilančný výpar, po roku 2000 zmena



a vývoj teploty vzduchu v klimatickej stanici Hurbanovo, obdobie 1931–2020. (na obrázkoch sú vykreslené priemery za 30 ročné obdobia, napr. pri roku 2020 je priemer za roky 1991-2020).

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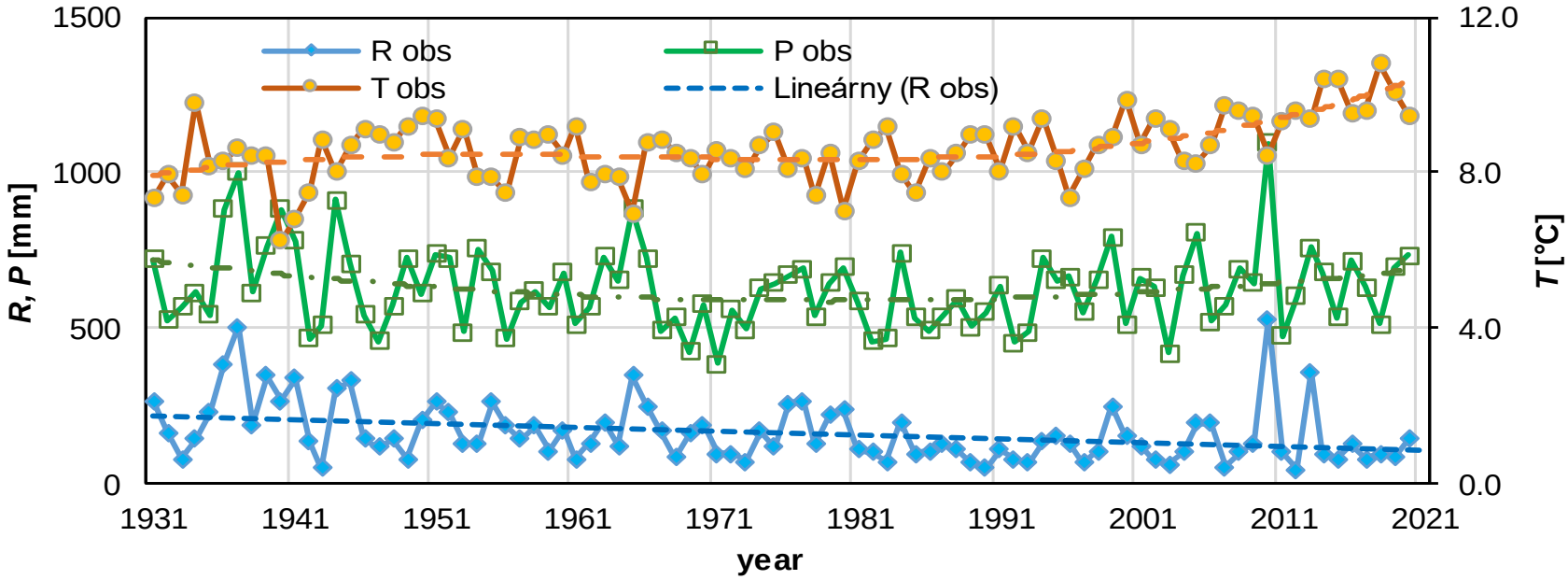
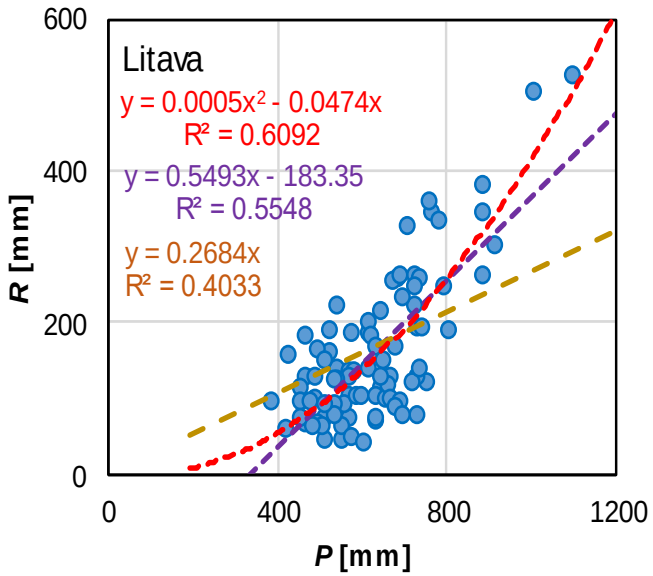
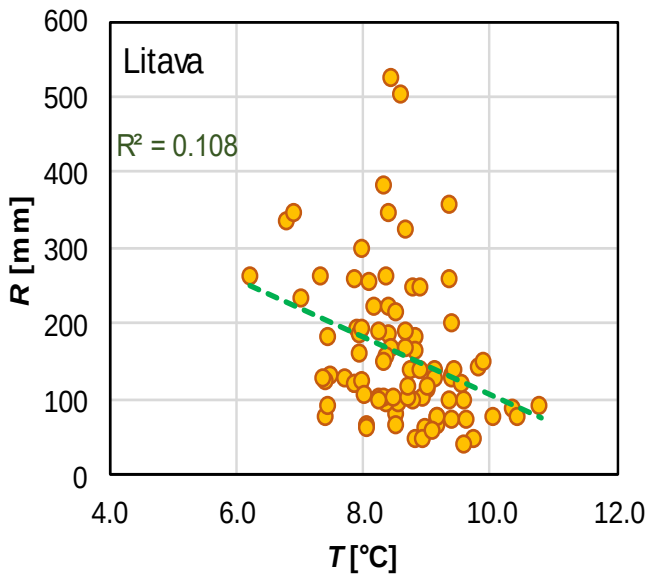
2. Water balance of Litava River



Rest – observed average annual runoff depth [mm],
P_{obs} – observed average annual precipitation total [mm],
T_{obs} – observed average annual air temperature [°C].

2. Water balance of Litava River

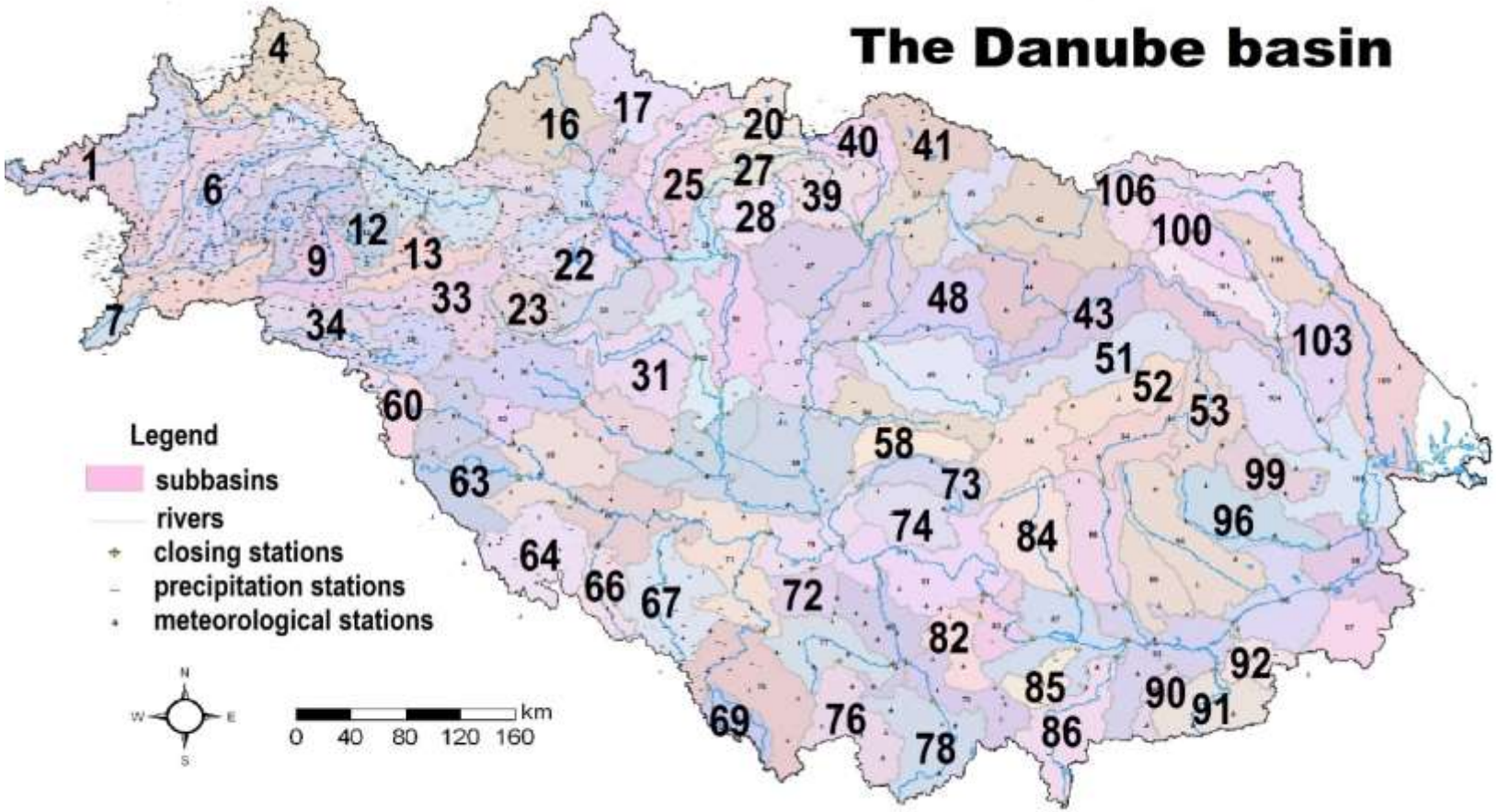




Dependence of the annual runoff on the annual total precipitation in the Litava river basin (left); dependence of the annual runoff on the average annual air temperature (right); Litava river basin, period 1931–2020.

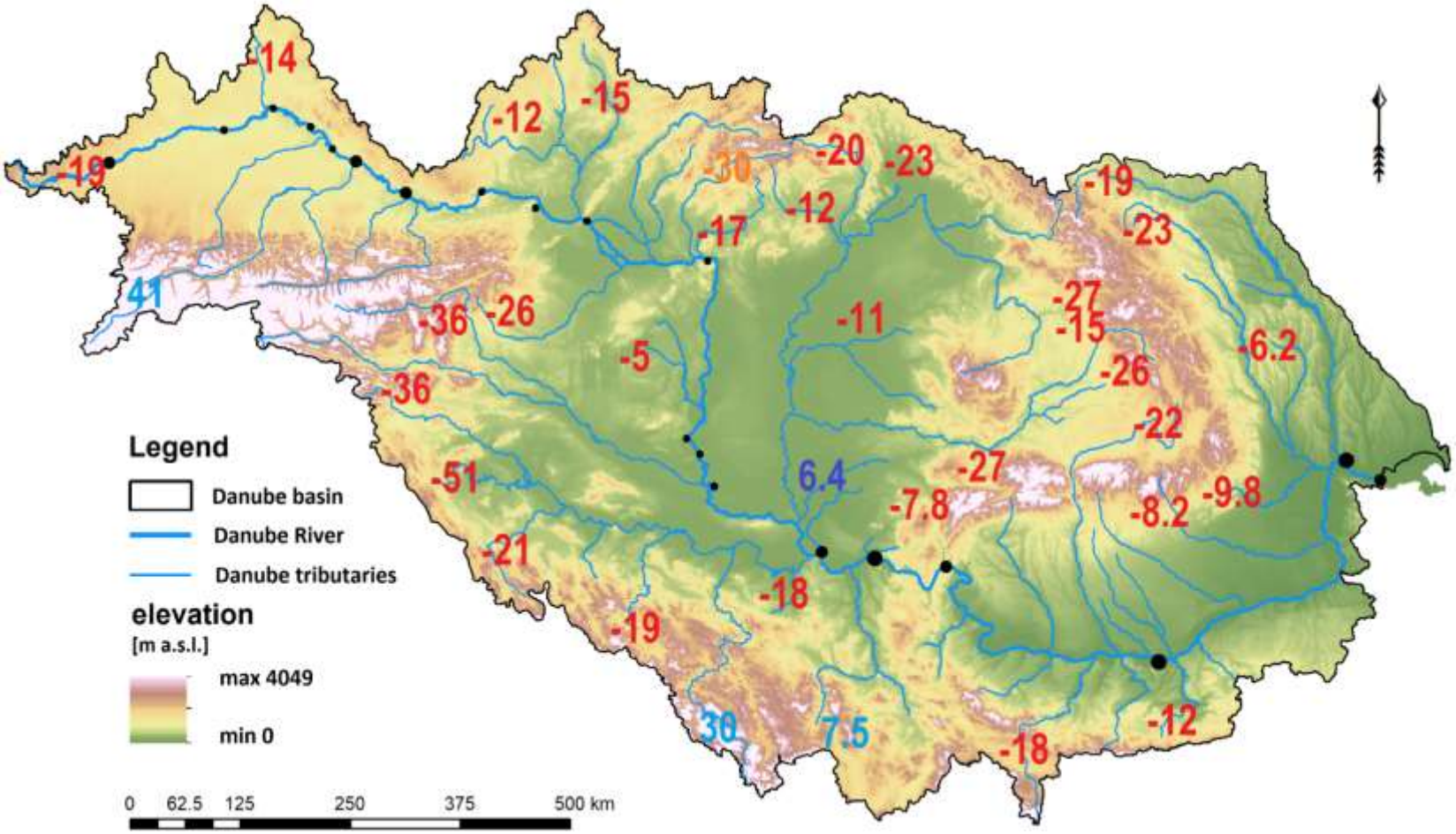
$R_{est} = 0.53*P_{obs} - 19.89*T_{obs}$ (2, Litava1931–2020)

2. Water balance of the Danube basin 1961-90

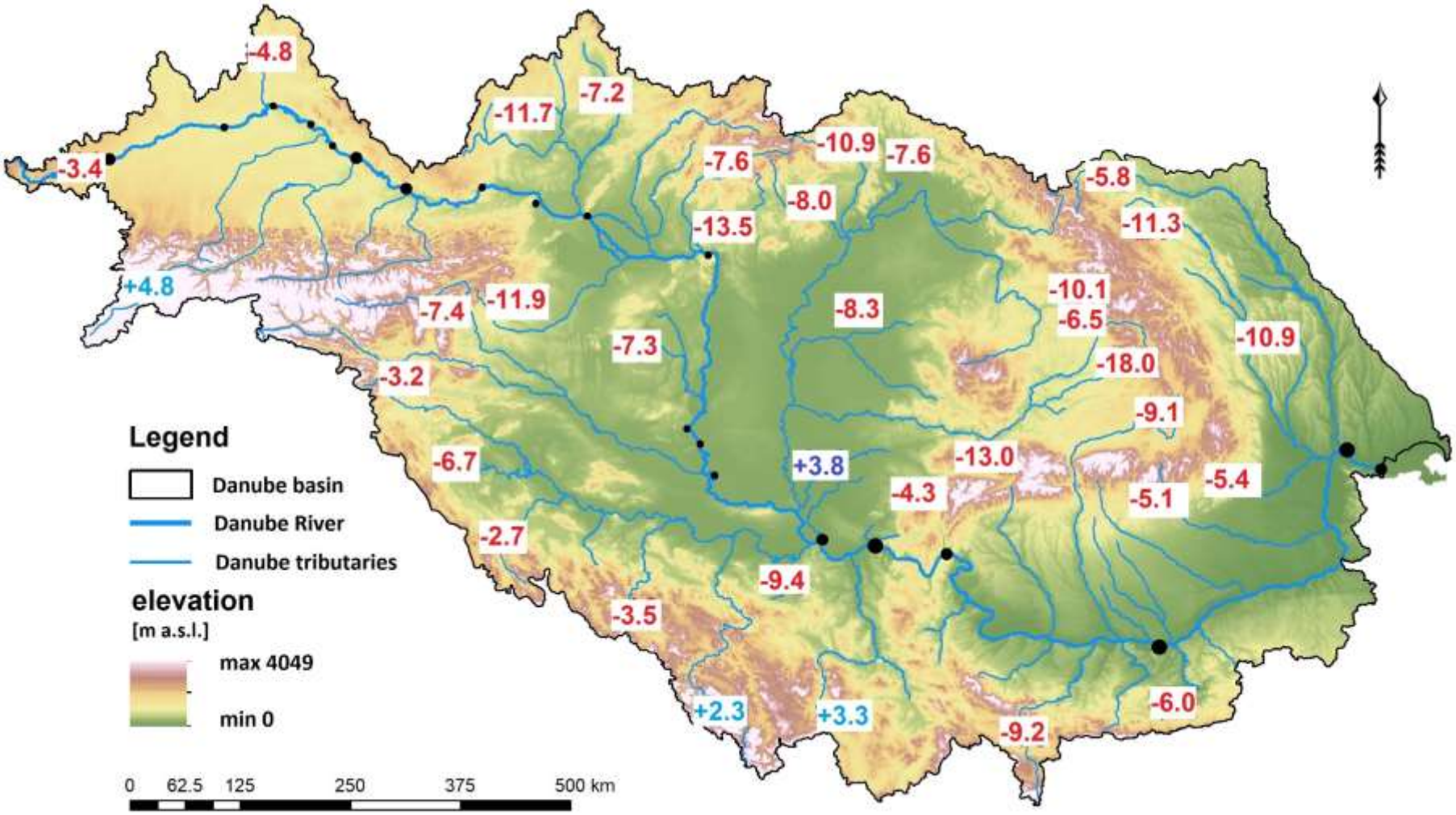


Location of the selected fifty sub-basins 1-106 in the Danube basin according to (Petrovič et al, 2006, 2010)

2. Decrease of runoff at air temperature growth +1°C

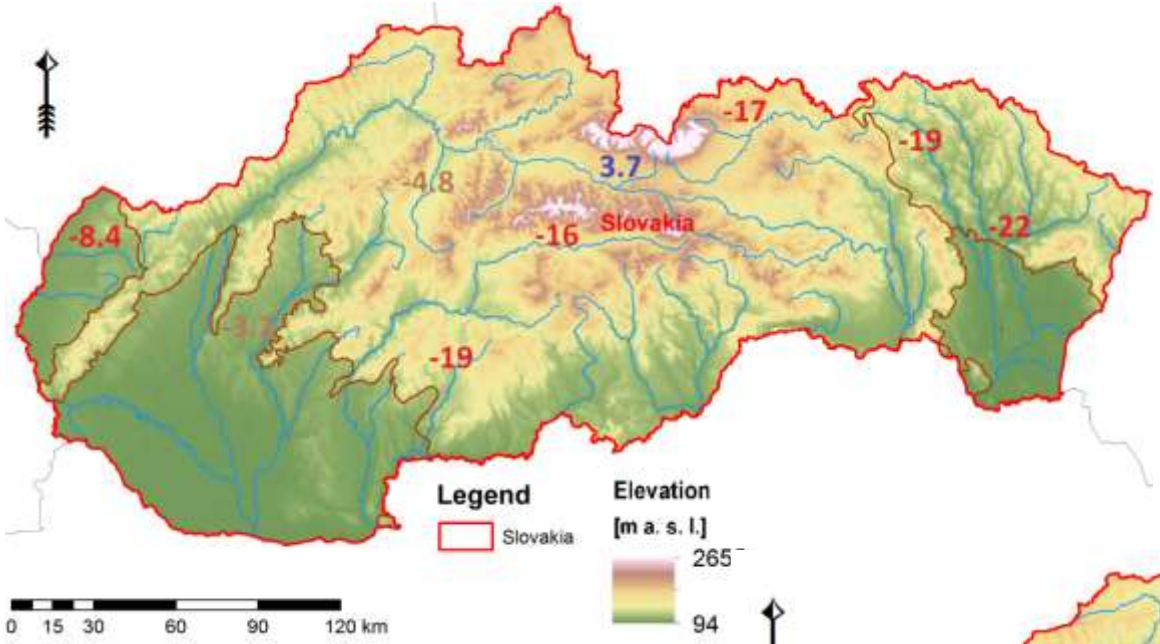


Estimated significant parameters b from model (2) $R_{est}=a*P_{obs}+b*T_{obs}$ in selected sub basins of the Danube basin. Red colour means decrease; blue colour means increase of the annual runoff in [mm] at temperature growth +1°C. Period 1961–1990.

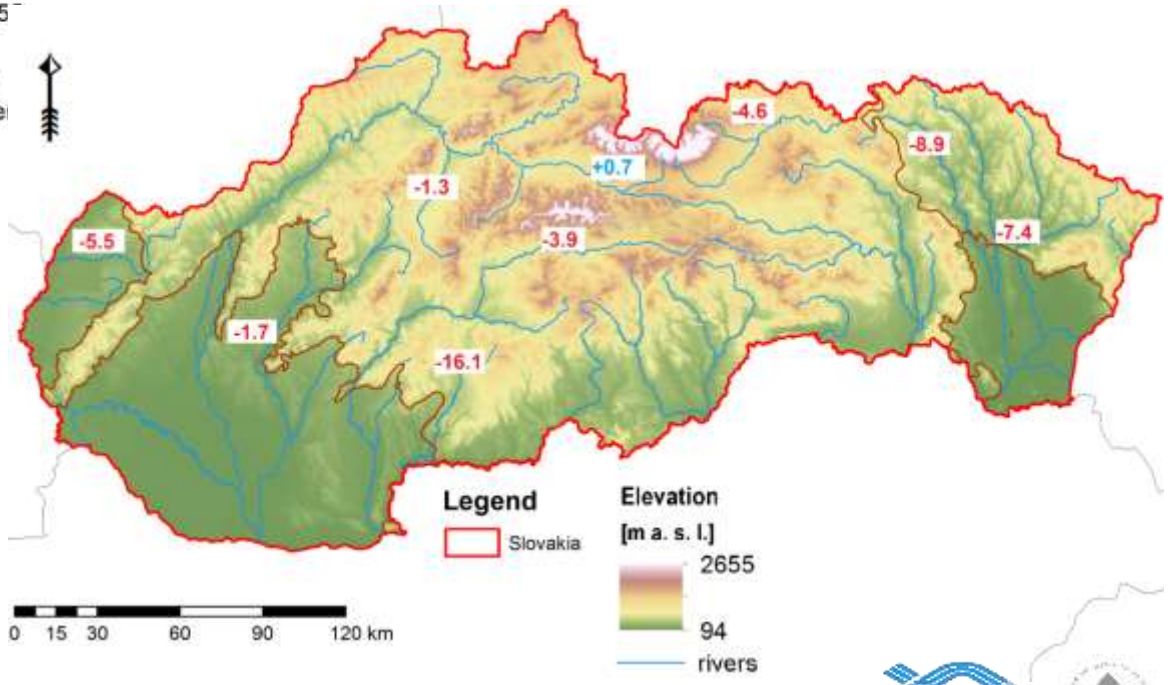


Estimated percentage change of the runoff at +1°C in selected sub basins of the Danube basin. Red colour means decrease; blue colour means increase of the annual runoff in [mm] at temperature growth +1°C. Period 1961–1990.

2. Decrease of runoff at air temperature growth +1°C

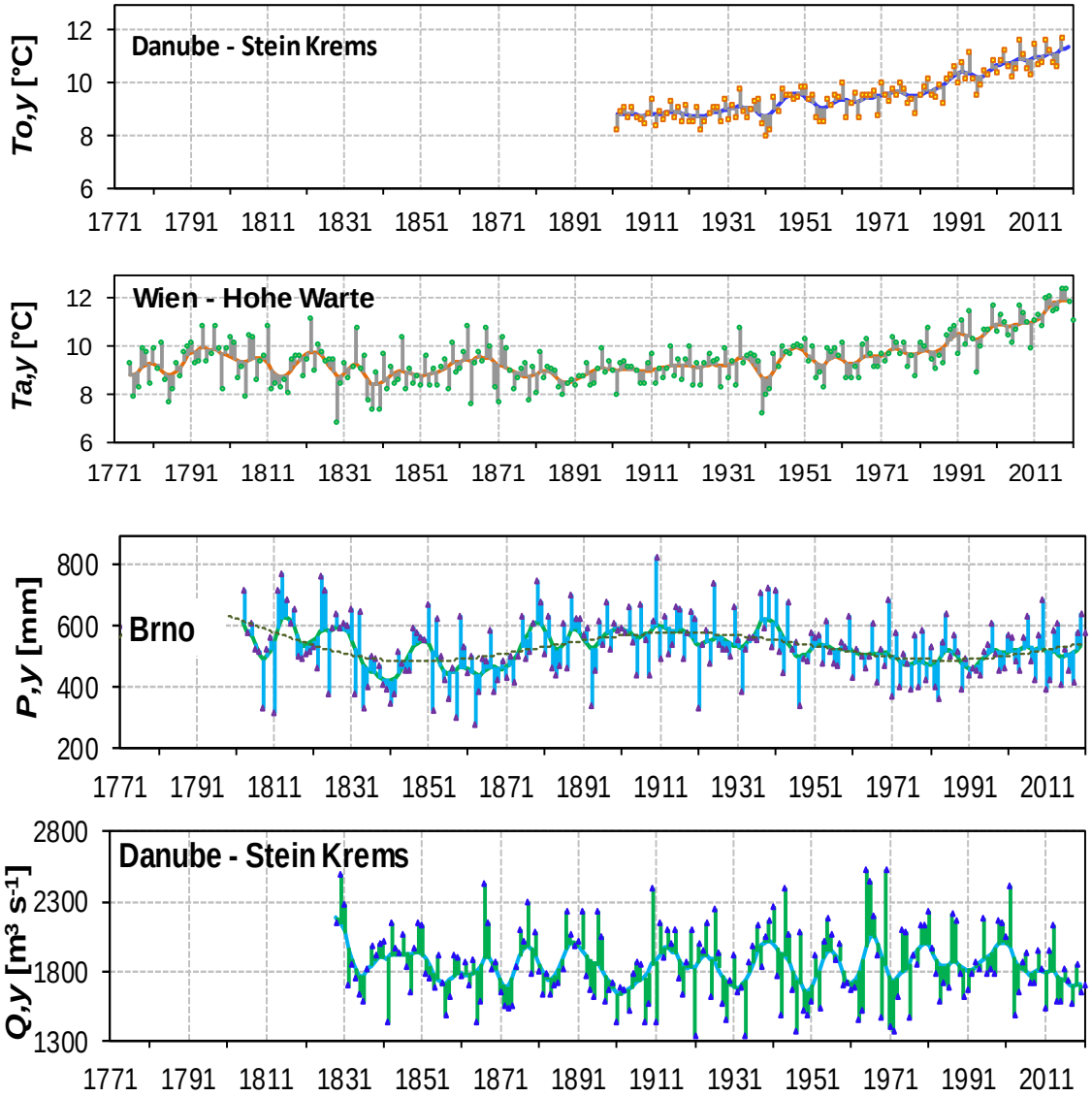


Estimated significant parameters b from model (2) $R_{est}=a*P_{obs}+b*T_{obs}$ in selected sub basins of the Slovakia. Red colour means decrease; blue colour means increase of the annual runoff in [mm] at temperature growth +1°C. Period 1981–2019.

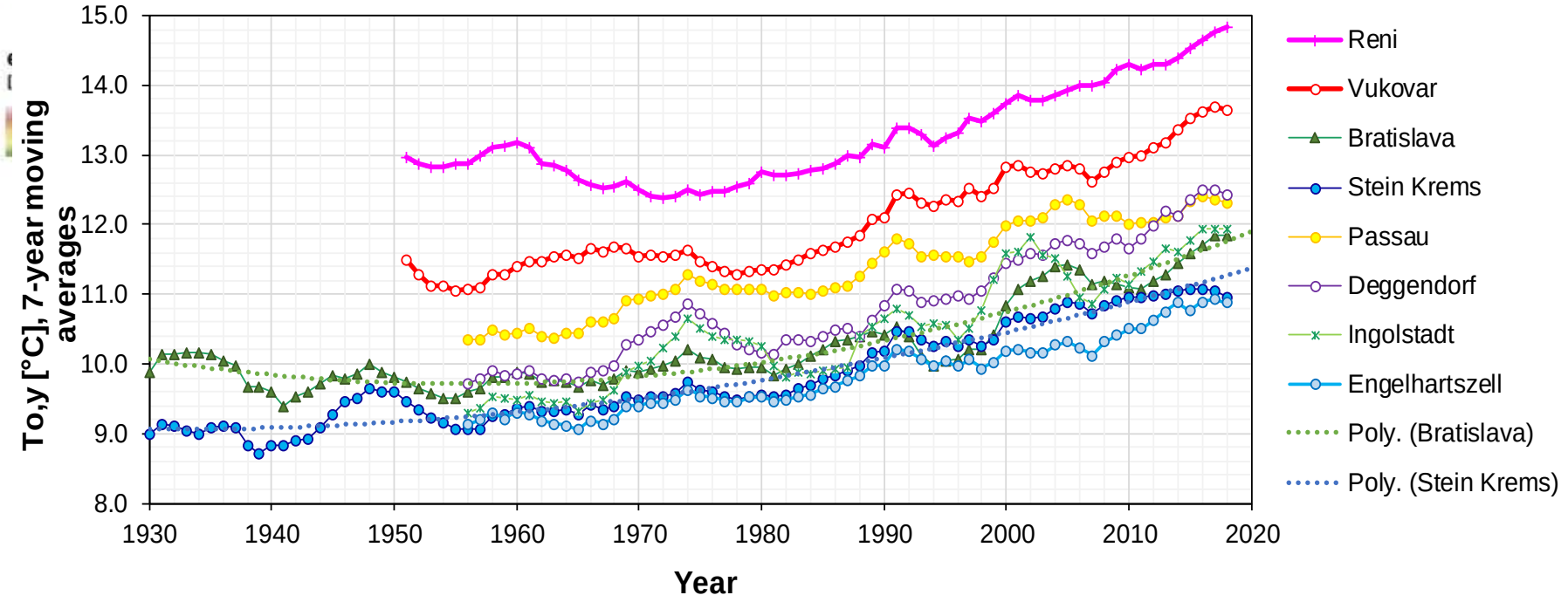


Estimated percentage change of the runoff at +1°C in selected sub basins of Slovakia. Red colour means decrease; blue colour means increase of the annual runoff in [mm] at temperature growth +1°C. Period 1961–1990.

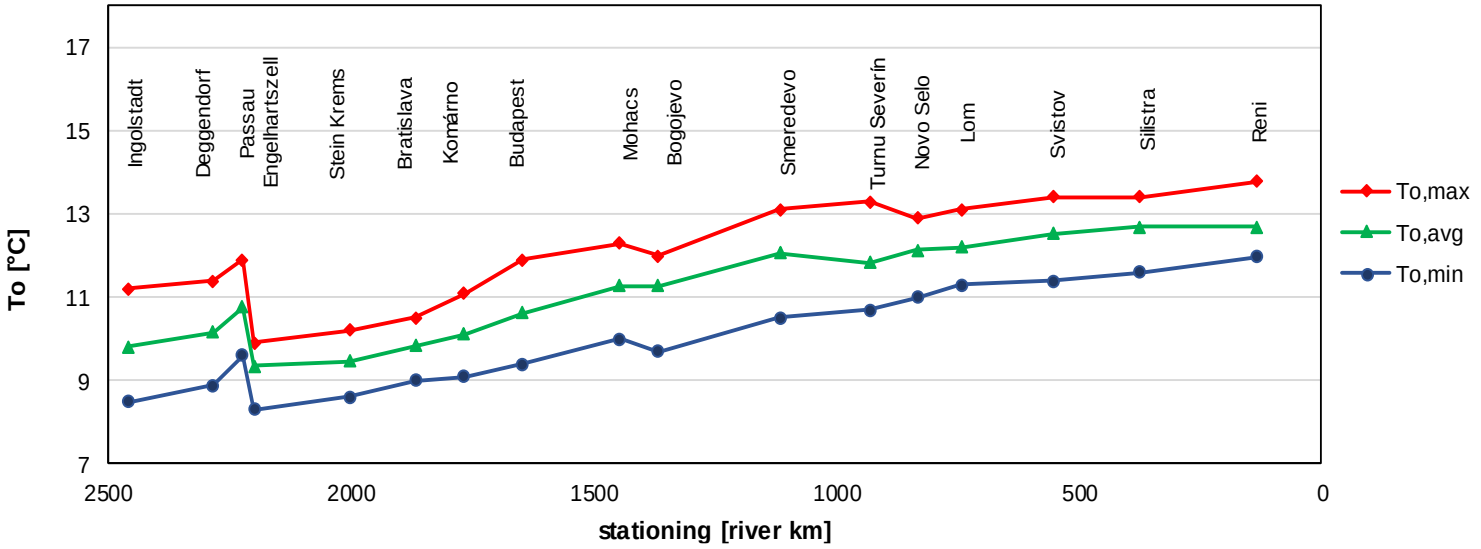
3. Water temperature - Danube River



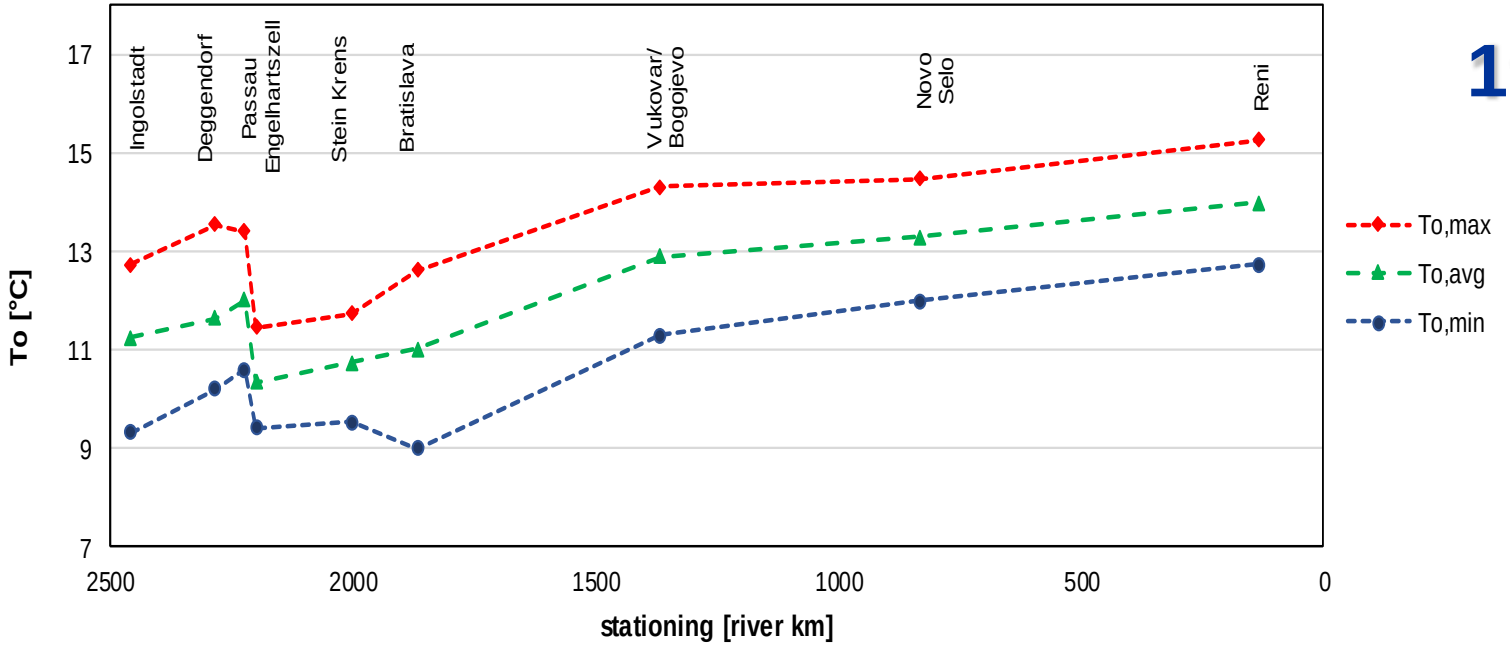
3. Water temperature - Danube River



3. Water temperature - Danube River

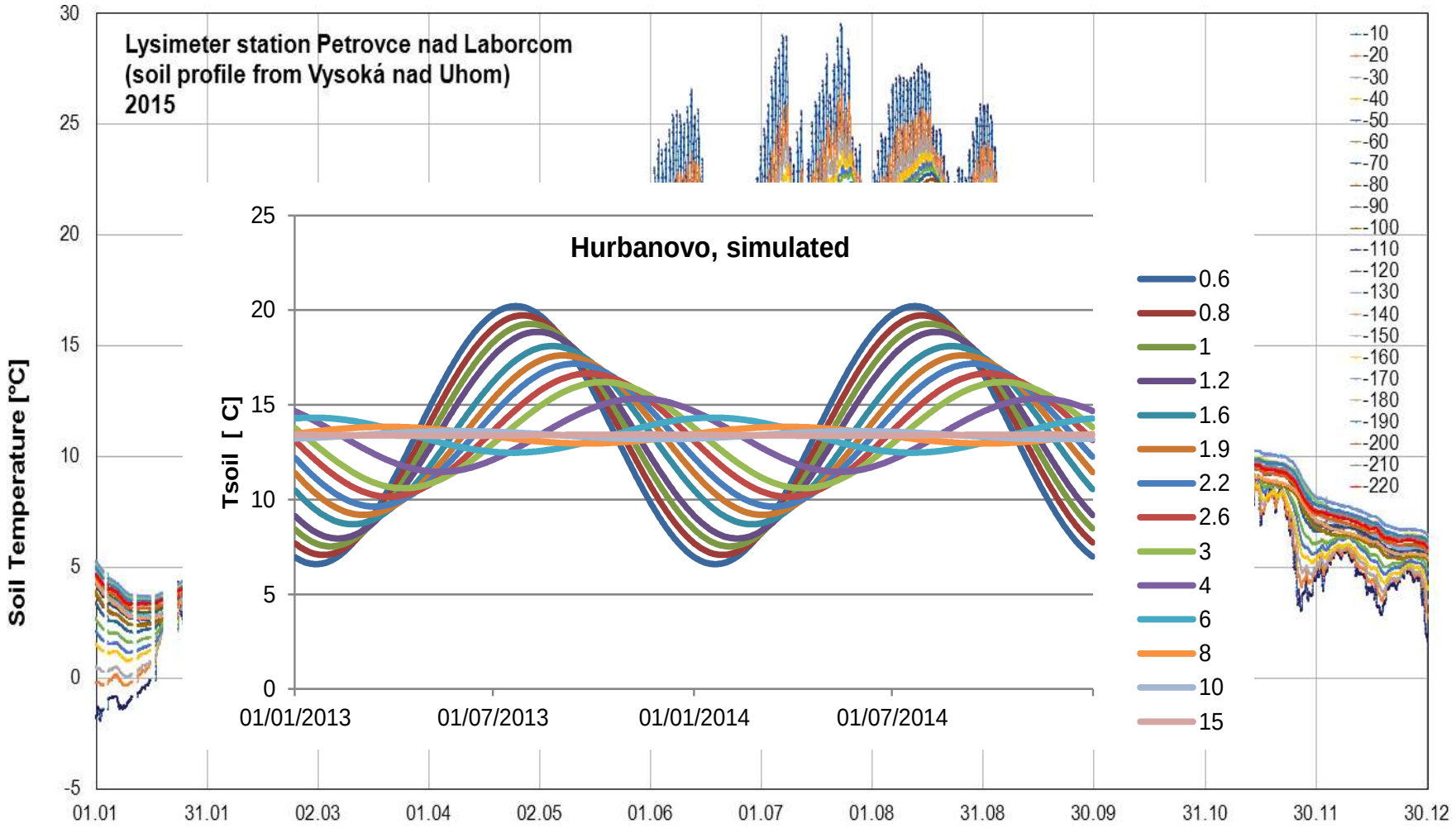


1961-1990



1991-2020

3. Ground Water temperature



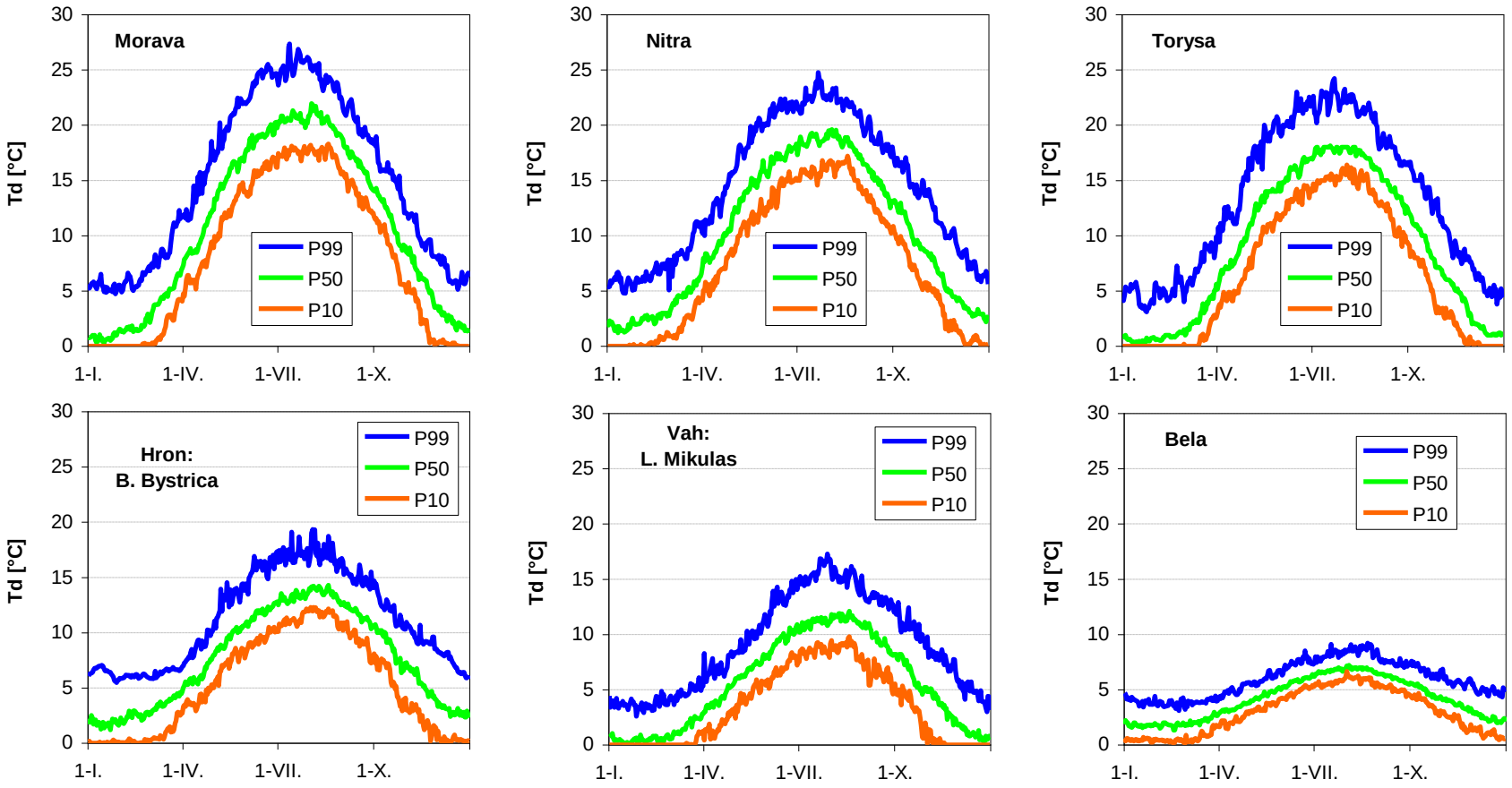
3. Water temperature, Slovakia - data

Archiváciou meraní teploty vody v súlade s Vyhláškou (2010) je poverený Slovenský hydrometeorologický ústav (SHMÚ). Merania teploty vody sú uložené v dvoch databázach:

1. V kvantitatívnej databáze povrchových vôd – denné merania teploty vody z vodomerných staníc SHMÚ o 7,00 hod do roku 2008. Od roku 2005 merania prebiehali aj v hodinovom kroku. V roku 2021 prebiehali merania teploty vody v 410 vodomerných staniciach.

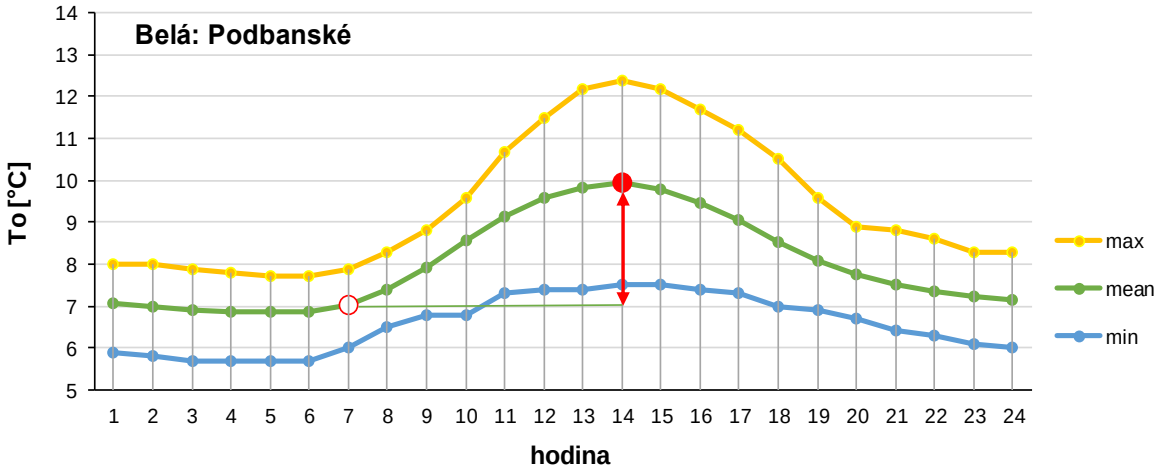
2. V databáze z monitoringu kvality povrchových vôd v SR – merania teploty vody spravidla v čase odberu vzorky vody, podľa programu monitorovania.

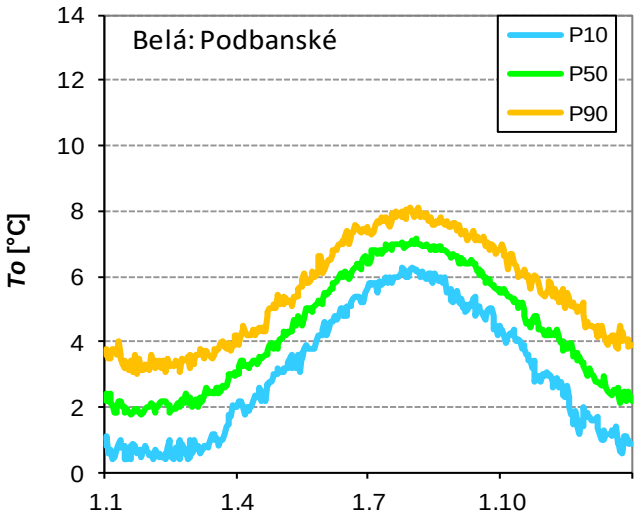
3. Water temperature - Slovakia

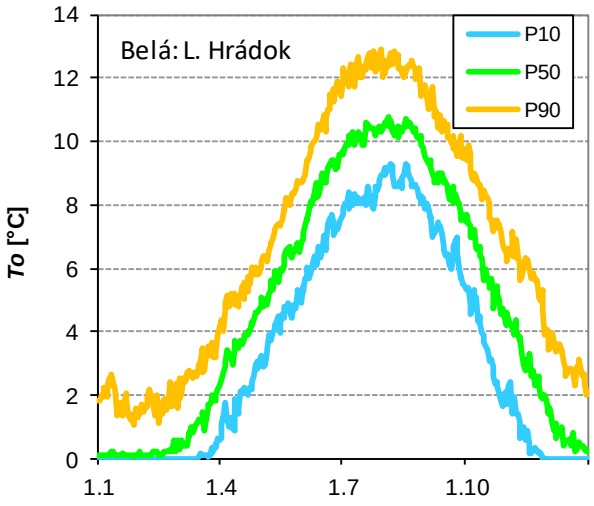


Long-term annual pattern of the daily water temperature, measured at 7.00 a.m.; selected percentiles (10-th; 50-th; and 99-th percentile) for six selected rivers, mean from the 1964 to 2003 period.

3. Water temperature - Belá River







3. Water temperature - Clasification

Klasifikačné schémy (triedy kvality) pre teplotu vody v SR

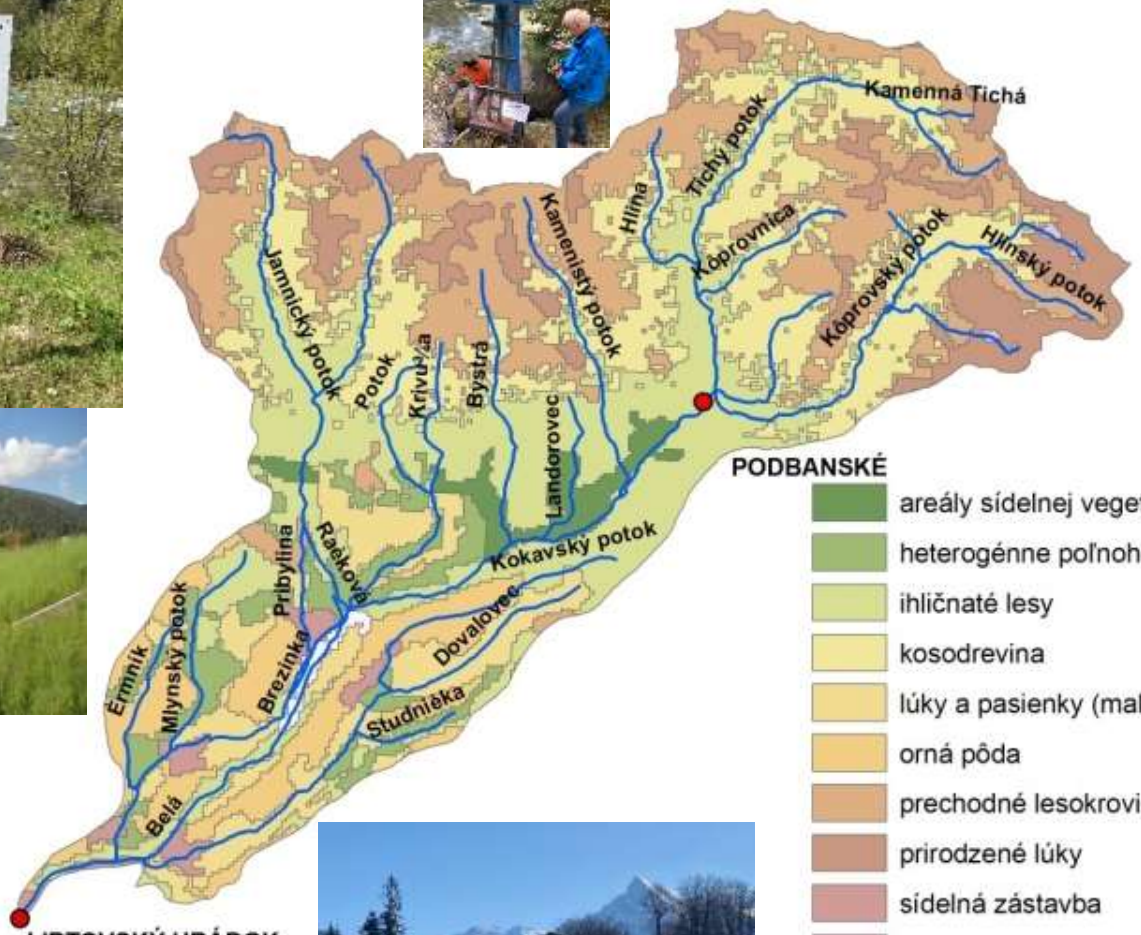
Teplota vody/[°C]				Teplota vody/[°C]			Teplota vody/[°C]
Triedy kvality NV č. 269/2010 Z. z.			Typy vodných útvarov	Triedy kvality			NV č. 296/2005 Z. z. NV č. 269/2010 Z. z.
Príloha 12				STN 75 7221			Príloha 1
I.	II.	III.		I.	II.	III.	
< 25	< 27,0	≥ 27,0	P1M, B1(P1V)	< 22	< 23	< 24	< 26
< 24	< 26,0	≥ 26,0	P1S, P2M, K2M, M1(P1V), I1(P1V), R2(P1V)	< 22	< 23	< 24	
< 23	< 25,0	≥ 25,0	D2(P1V), V3(P1V)	< 22	< 23	< 24	
< 22	< 24,0	≥ 24,0	K2S, V2(K2V)	< 22	< 23	< 24	
< 21	< 23,0	≥ 23,0	D1(P1V), D1(K2V), H2(K2V), P2(K3V)	< 22	< 23	< 24	
< 20	< 22,0	≥ 22,0	H1(K2V)	< 22	< 23	< 24	
< 20	< 21,5	≥ 21,5	P1(K3V)	< 22	< 23	< 24	
< 19	< 21,5	≥ 21,5	K3S	< 22	< 23	< 24	
< 18	< 21,5	≥ 21,5	K3M, V1(K3V)	< 22	< 23	< 24	
< 16	< 18,0	≥ 18,0	K4M	< 22	< 23	< 24	

3. Water temperature - Clasification

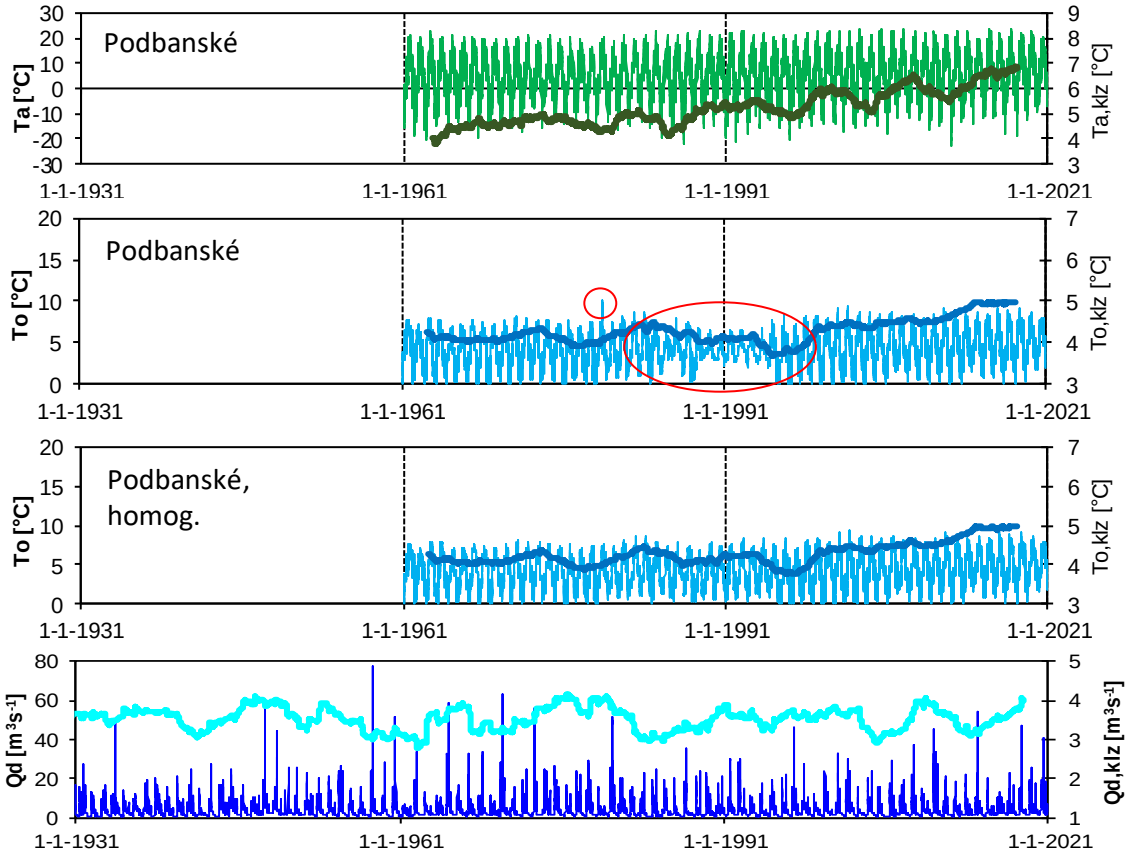
Typy vodných útvarov kategórie riek v SR. (Príloha č. 9 k vyhláške č. 418/2010 Z. z)

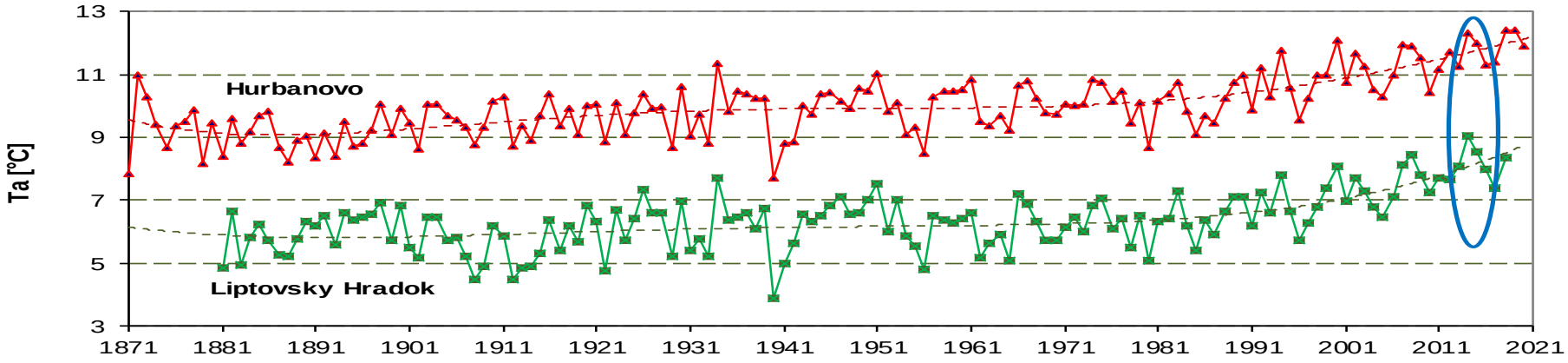
Kód typu	Kód podtypu	Názov typu / podtypu
P1M	–	Malé toky v nadmorskej výške do 200 m v Panónskej panve
P2M	–	Malé toky v nadmorskej výške 200 – 500 m v Panónskej panve
P1S	–	Stredne veľké toky v nadmorskej výške do 200 m v Panónskej panve
K2M	–	Malé toky v nadmorskej výške 200 – 500 m v Karpatoch
K3M	–	Malé toky v nadmorskej výške 500 – 800 m v Karpatoch
K4M	–	Malé toky v nadmorskej výške nad 800 m v Karpatoch
K2S	–	Stredne veľké toky v nadmorskej výške 200 – 500 m v Karpatoch
K3S	–	Stredne veľké toky v nadmorskej výške 500 – 800 m v Karpatoch
P1V	M1(P1V)	Veľké toky v nadmorskej výške do 200 m v Panónskej panve – podtyp Morava
P1V	D1(P1V)	Veľké toky v nadmorskej výške do 200 m v Panónskej panve – podtyp Dunaj v úseku Devín – Klížská Nemá
P1V	D2(P1V)	Veľké toky v nadmorskej výške do 200 m v Panónskej panve – podtyp Dunaj v úseku Klížská Nemá – št. hranica s HU
K3V	V1(K3V)	Veľké toky hornej časti povodia Váhu v nadmorskej výške 500 – 800 m v Karpatoch
K2V	V2(K2V)	Veľké toky strednej časti povodia Váhu v nadmorskej výške 200 – 500 m v Karpatoch
P1V	V3(P1V)	Veľké toky dolnej časti povodia Váhu v nadmorskej výške do 200 m v Panónskej panve
K2V	R1(K2V)	Stredná časť toku Hron v nadmorskej výške 200 – 500 m v Karpatoch
P1V	R2(P1V)	Dolná časť toku Hron v nadmorskej výške do 200 m v Panónskej panve
P1V	I1(P1V)	Dolná časť toku Ipeľ v nadmorskej výške do 200 m v Panónskej panve
K2V	H1(K2V)	Stredná časť toku Hornád v nadmorskej výške 200 – 500 m v Karpatoch
K2V	H2(K2V)	Dolná časť toku Hornád v nadmorskej výške 200 – 500 m v Karpatoch
P1V	B1(P1V)	Veľké toky v povodí Bodrogu v nadmorskej výške do 200 m v Panónskej panve
K3V	P1 (K3V)	Stredná časť toku Poprad v nadmorskej výške 500 – 800 m v Karpatoch
K3V	P2 (K3V)	Dolná časť toku Poprad v nadmorskej výške 500 – 800 m v Karpatoch

3. Water temperature - Belá River

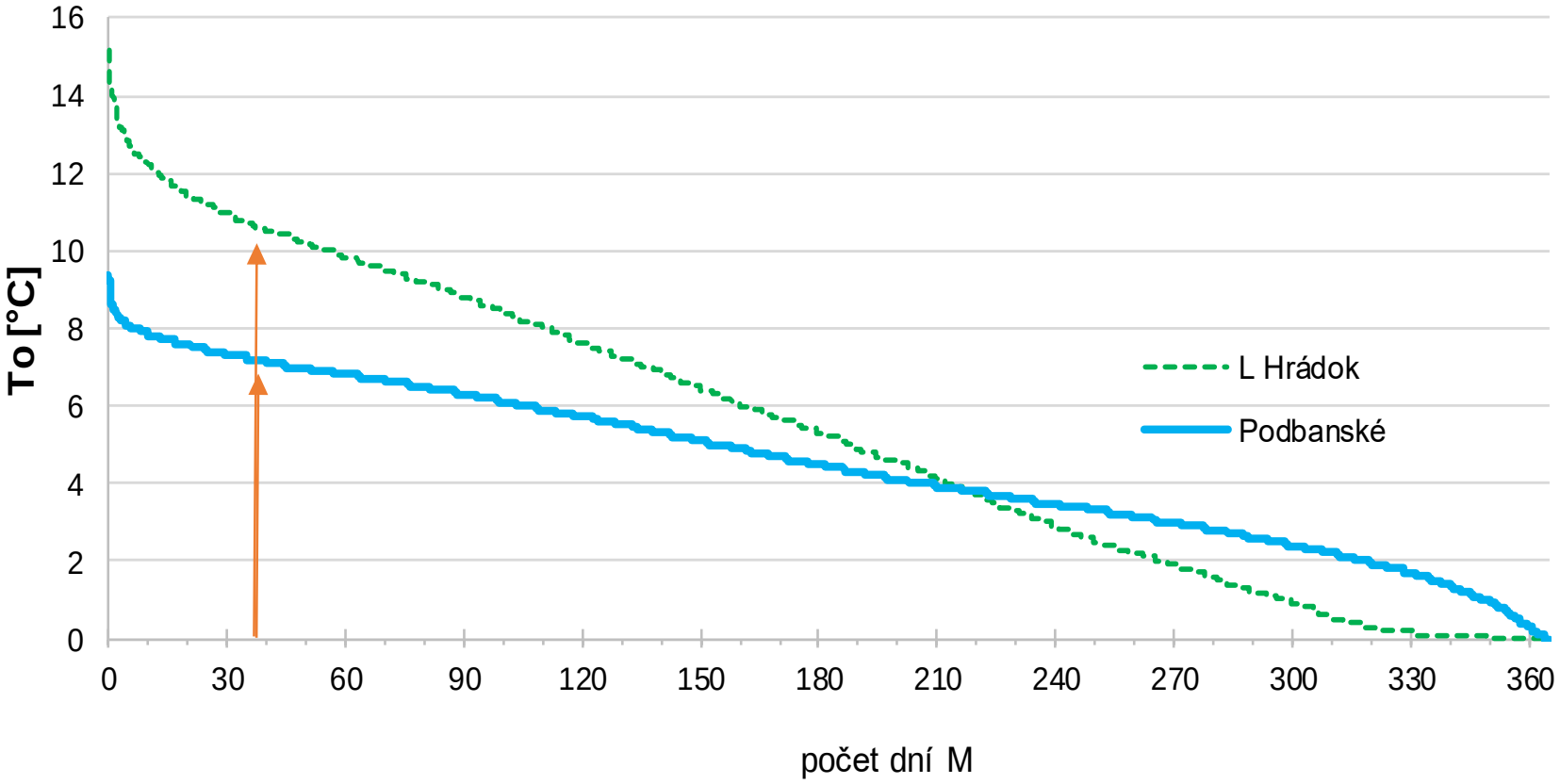


3. Water temperature - Belá River





3. Water temperature - Belá River



ZMENA BILANCIE VODY A JEJ TEPLOTY VO VYBRANÝCH SUBPOVODIACH RIEKY DUNAJ V DÔSLEDKU RASTU TEPLOTY VZDUCHU

CHANGES IN THE WATER BALANCE AND WATER TEMPERATURE IN SELECTED SUB-BASINS OF THE DANUBE RIVER AS A RESULT OF RISING AIR TEMPERATURES

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3. Water temperature - Slovakia