MINISTERUL TRANSPORTURILOR
ȘI INFRASTRUCTURII

Effects of Drought on Navigation Conditions on Danube River, Downstream of Iron Gate

Romeo SOARE - AFDJ Galati

30th of October, 2023
Bucharest, ROMANIA

The "River Administration of the Lower Danube" Galati

- After several transformations, by the **Decision of the Government of Romania** no. **492** of **April 18, 2003**, the Autonomous "River Administration of the Lower Danube" Galati was created.

- **AFDJ Galați fulfills the function of waterways authority on the Romanian sector of the Danube**
  - From rkm 1,075 to the Black Sea, on the Sulina arm;
  - On the Sfantul Gheorghe branch;
  - On the Chilia branch;
  - On the navigable arms of the Danube, Borcea, Bala, Macin, Valciu , Caleia

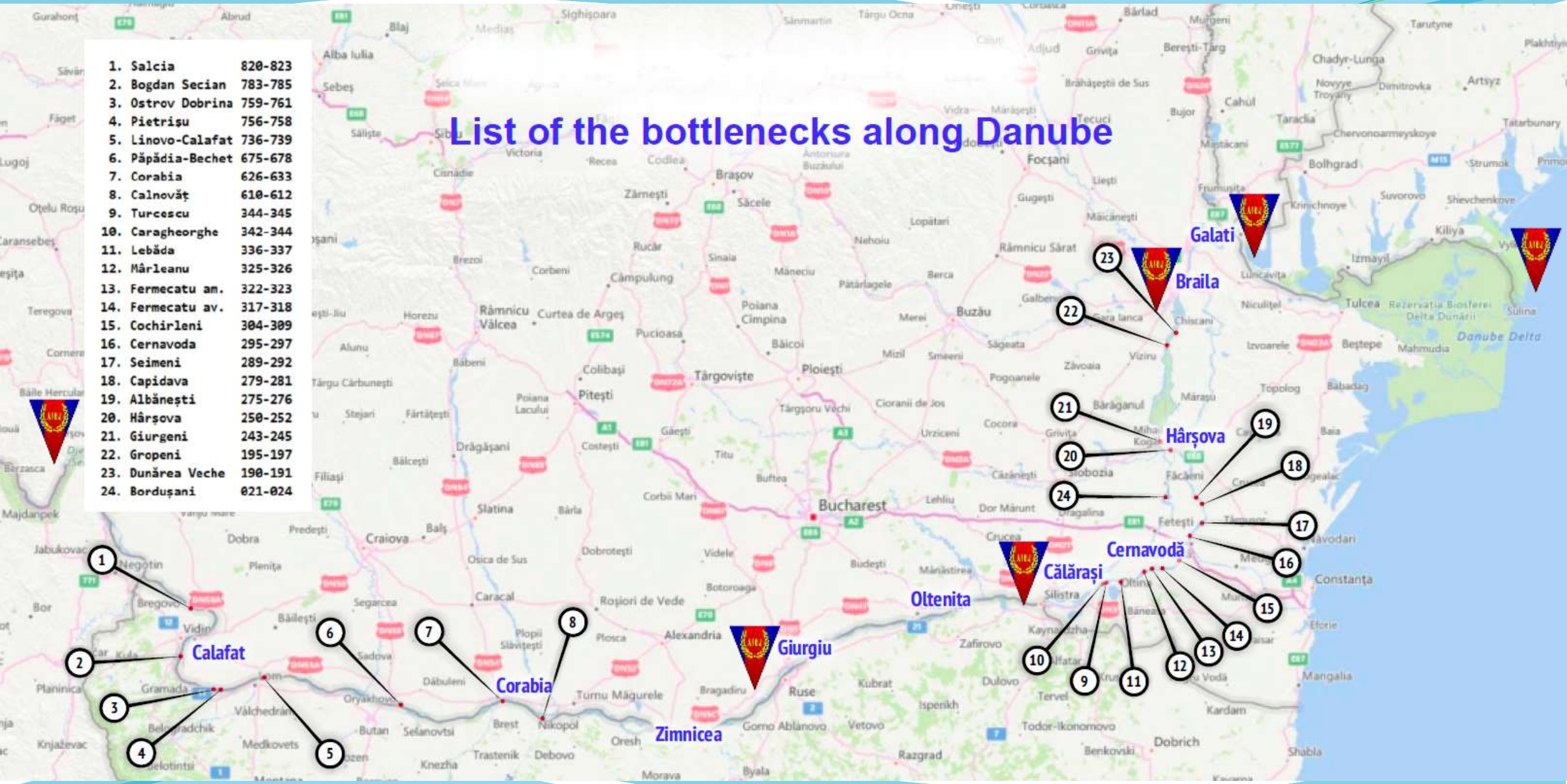
AFDJ Galați organization

In order to achieve its object of activity, the "River Administration of the Lower Danube " Galati has organized as follows:

- **Sulina Waterway Section**, *area between **Hm 100** and **Mm47**, including the Chilia arm.*
- **Brăila Waterway Agency**, *area between **rkm 175** and **rkm 300**, including the Măcin, Vâlciu and Caleia branches.*
- **Călăraşi Waterway Agency**, *area between **rkm 300** and **rkm 375**, including the Bala - Borcea branches.*
- **Giurgiu Waterway Section**, *area between **rkm 610** and rkm **845.5***.
- **Turnu Severin Waterways Agency**, *area between **rkm 845.5** and **rkm 1075**, including the Gogoşu arm.*
- **A.F.D.J. Galati**, *area between **Mm 47** and **rKm 175** and on the Sf. Gheorghe arm*.

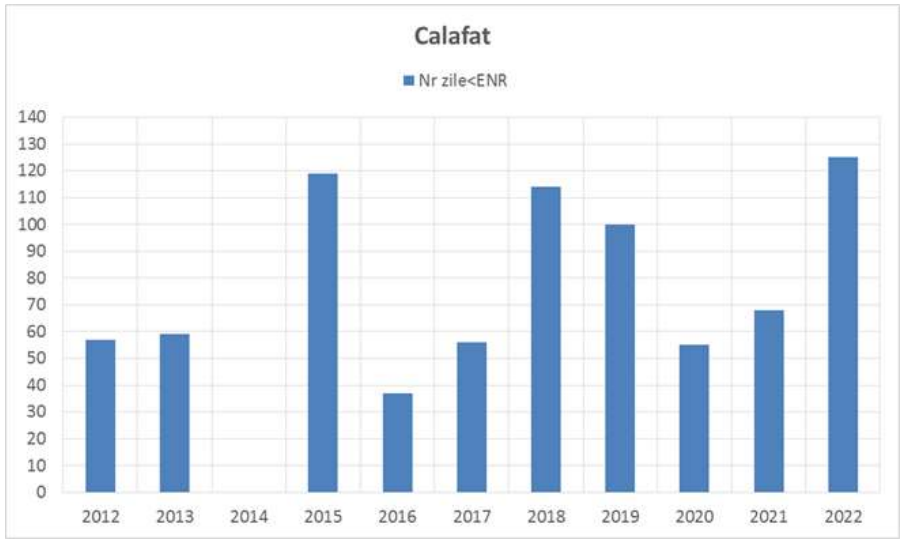
List of the bottlenecks along Danube

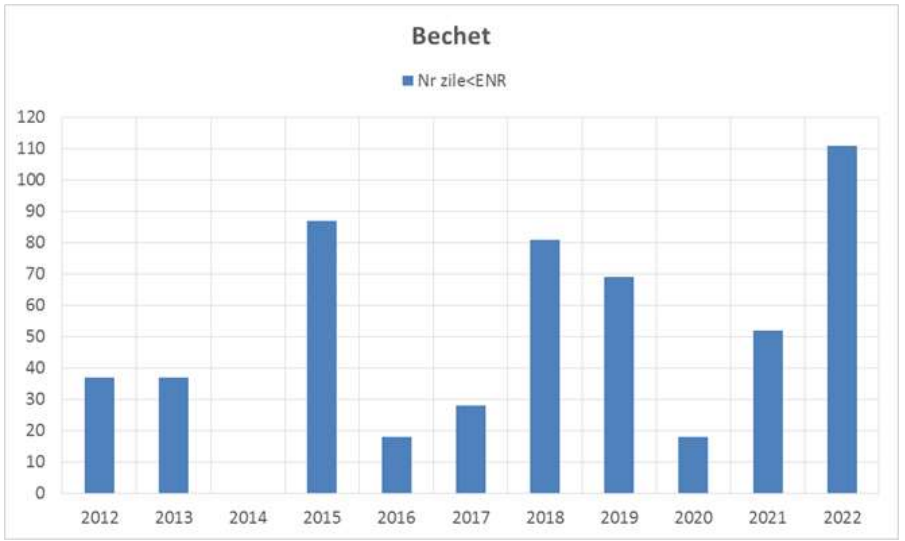
1.	Salcia	820-823
2.	Bogdan Secian	783-785
3.	Ostrov Dobrina	759-761
4.	Pietrișu	756-758
5.	Linovo-Calafat	736-739
6.	Păpădia-Bechet	675-678
7.	Corabia	626-633
8.	Calnovăț	610-612
9.	Turcescu	344-345
10.	Caragheorghe	342-344
11.	Lebăda	336-337
12.	Mârleanu	325-326
13.	Fermecatu am.	322-323
14.	Fermecatu av.	317-318
15.	Cochirleni	304-309
16.	Cernavoda	295-297
17.	Seimeni	289-292
18.	Capidava	279-281
19.	Albănești	275-276
20.	Hârșova	250-252
21.	Giurgeni	243-245
22.	Gropeni	195-197
23.	Dunărea Veche	190-191
24.	Borduşani	021-024

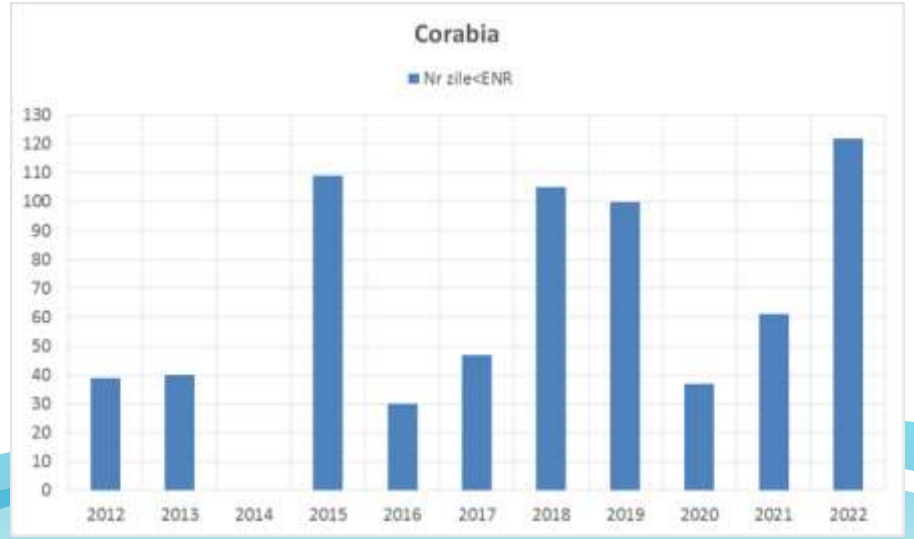


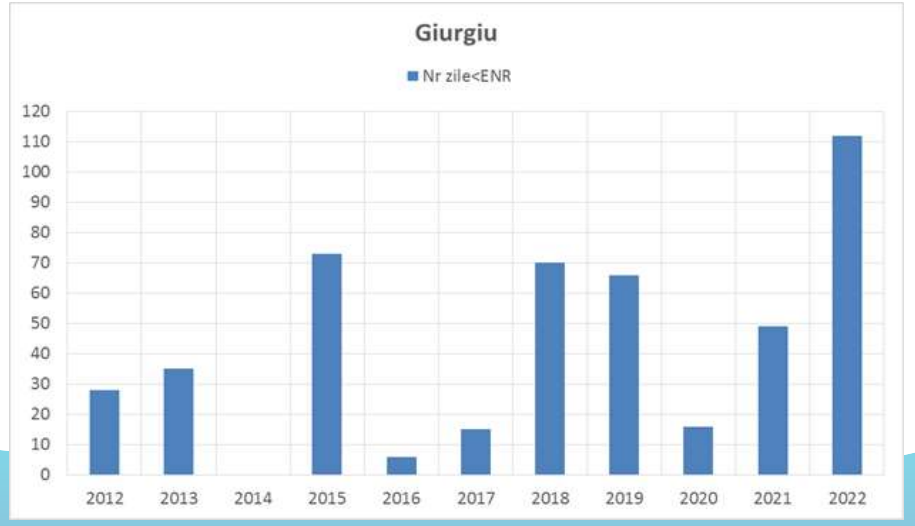
Hydrological conditions

- In recent years, the recorded water levels have shown a worsening of the hydrological conditions, with very low values, below the LNWL value, with drastic effects on ensuring navigation conditions.

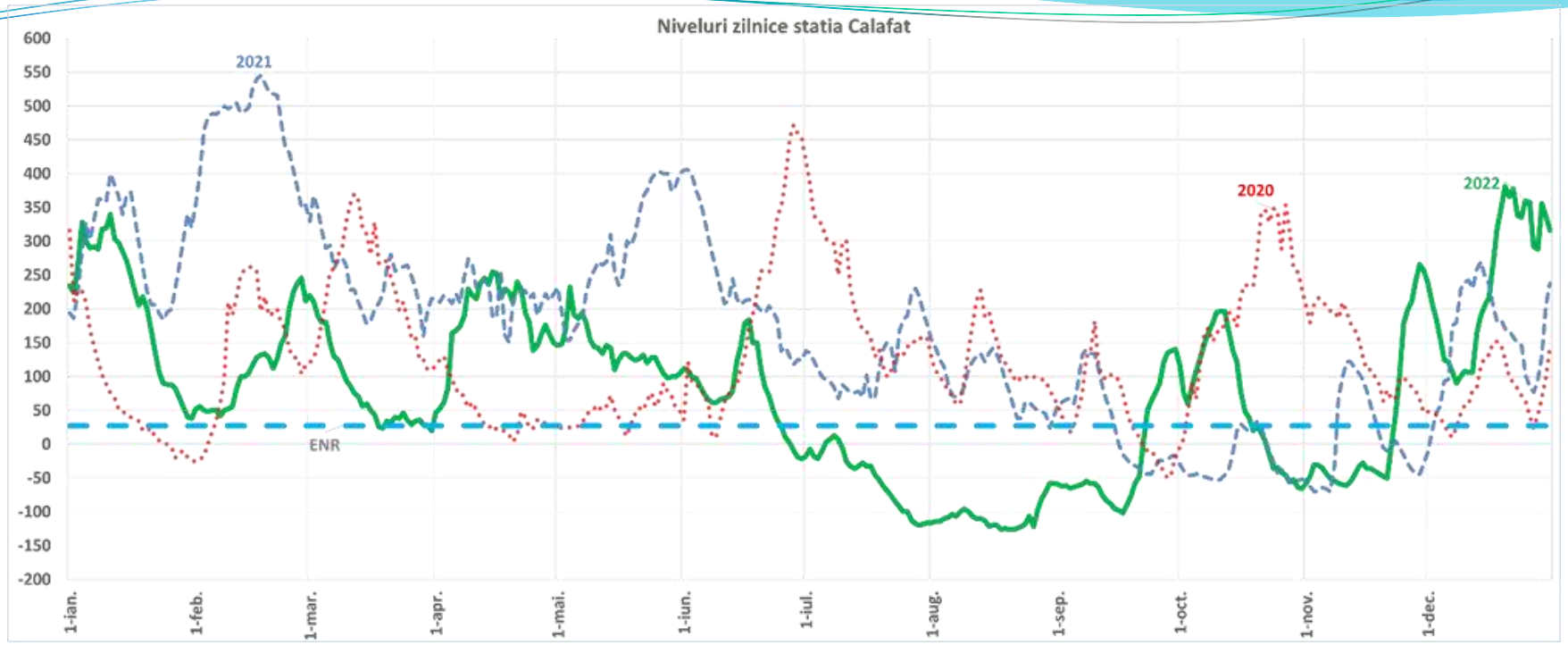




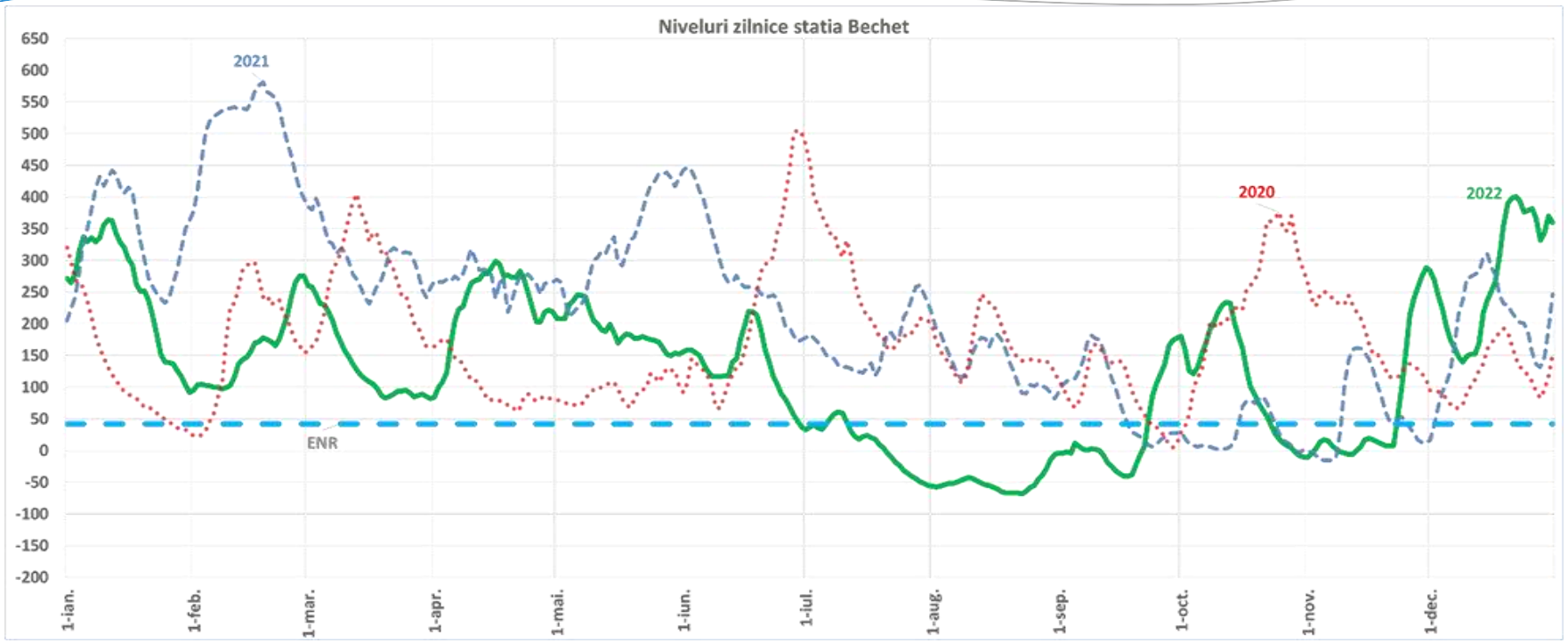




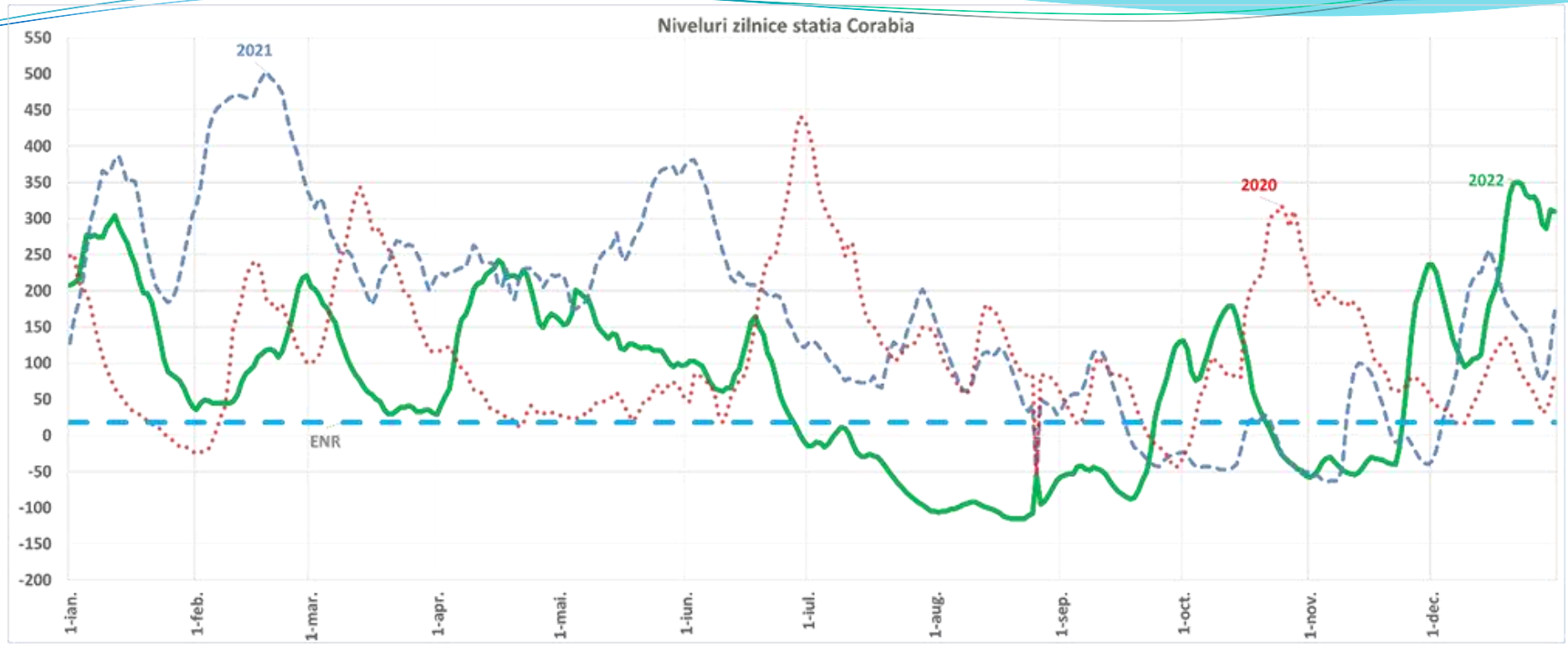
Hydrological conditions - CALAFAT

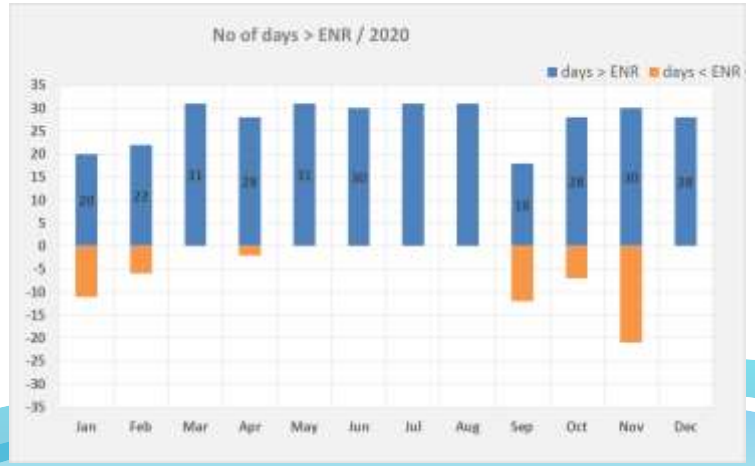


Hydrological conditions - BECHET

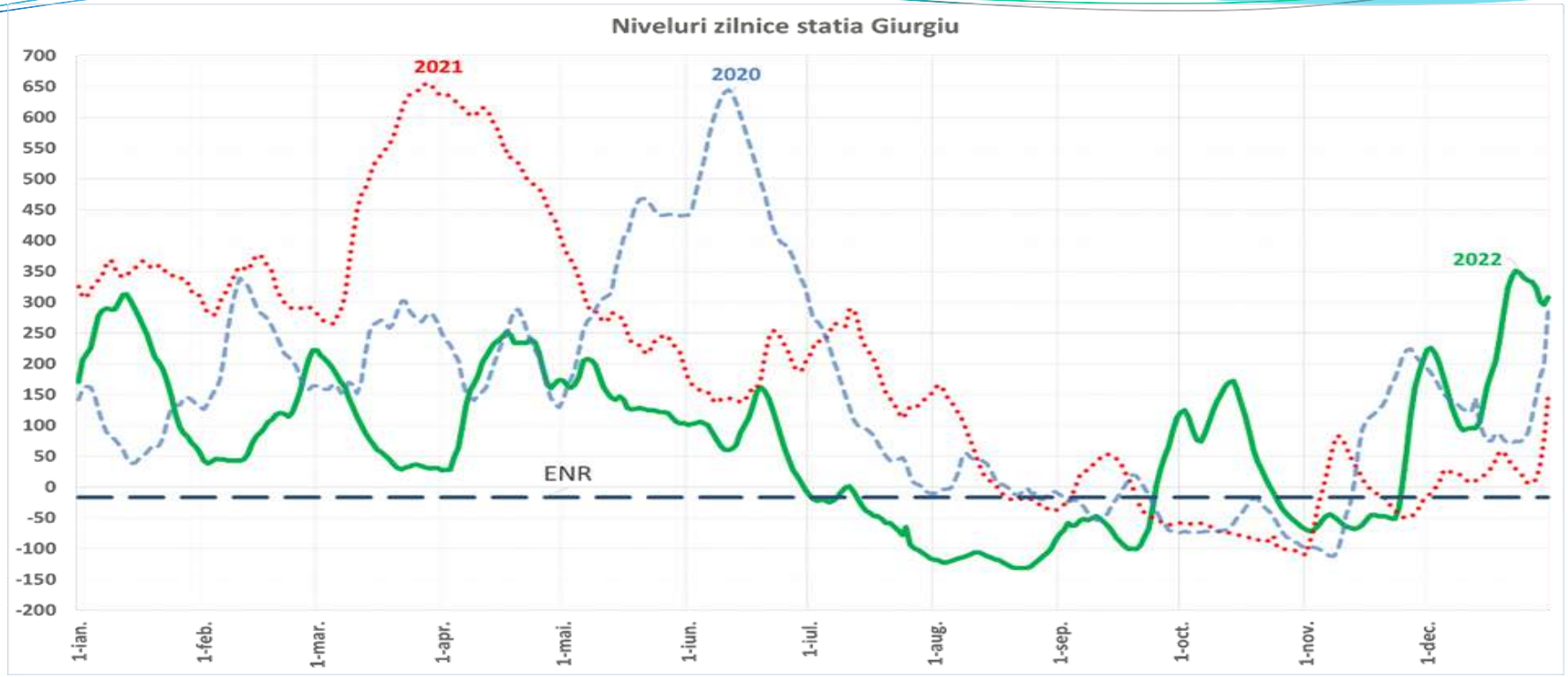


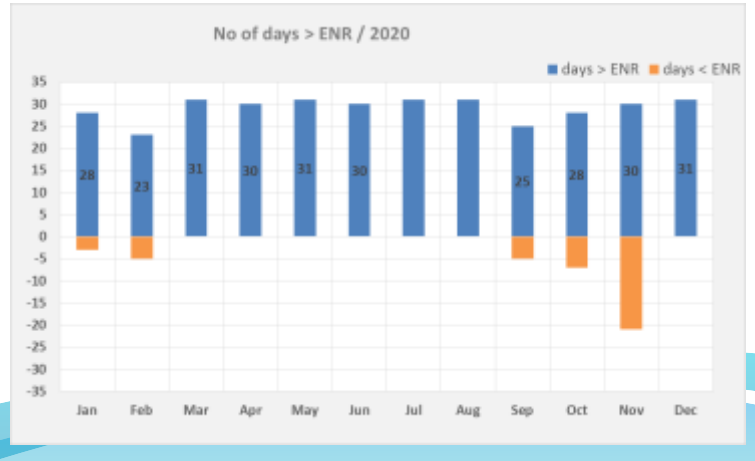
Hydrological conditions - CORABIA

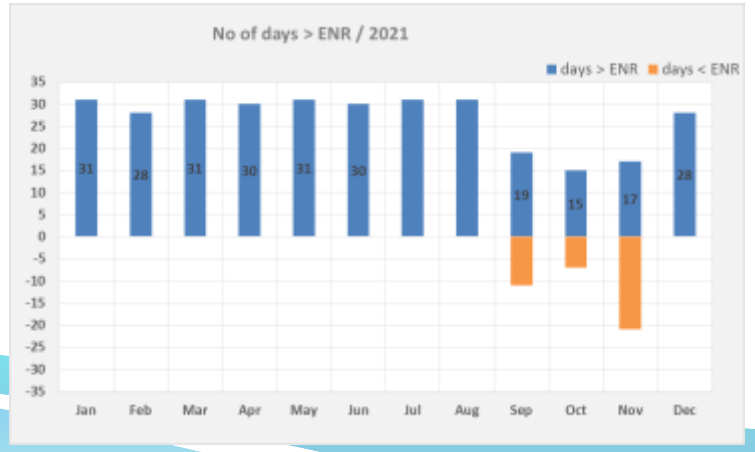


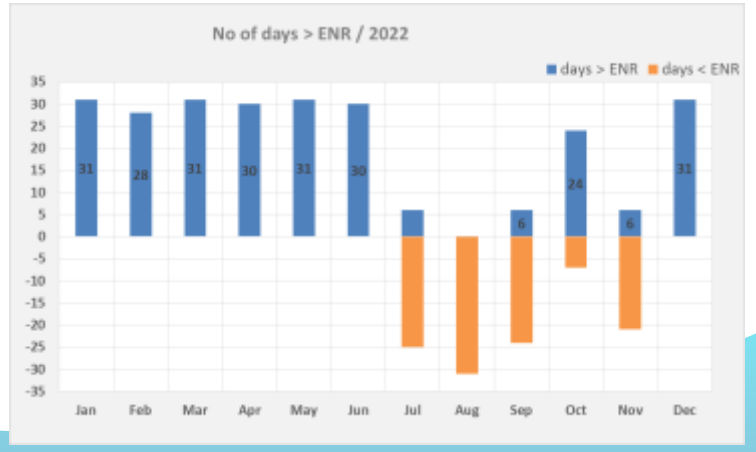


Hydrological conditions - GIURGIU



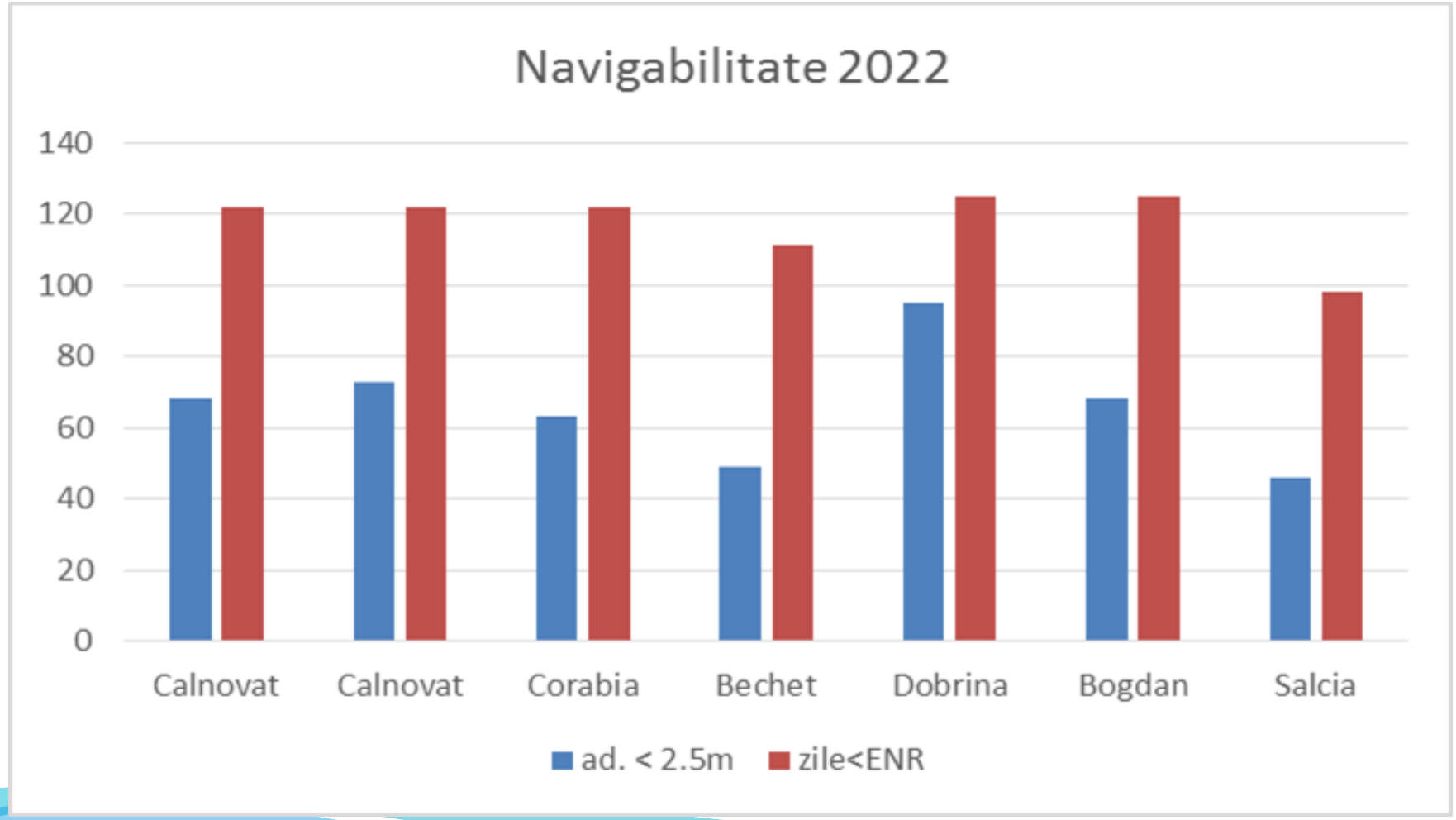




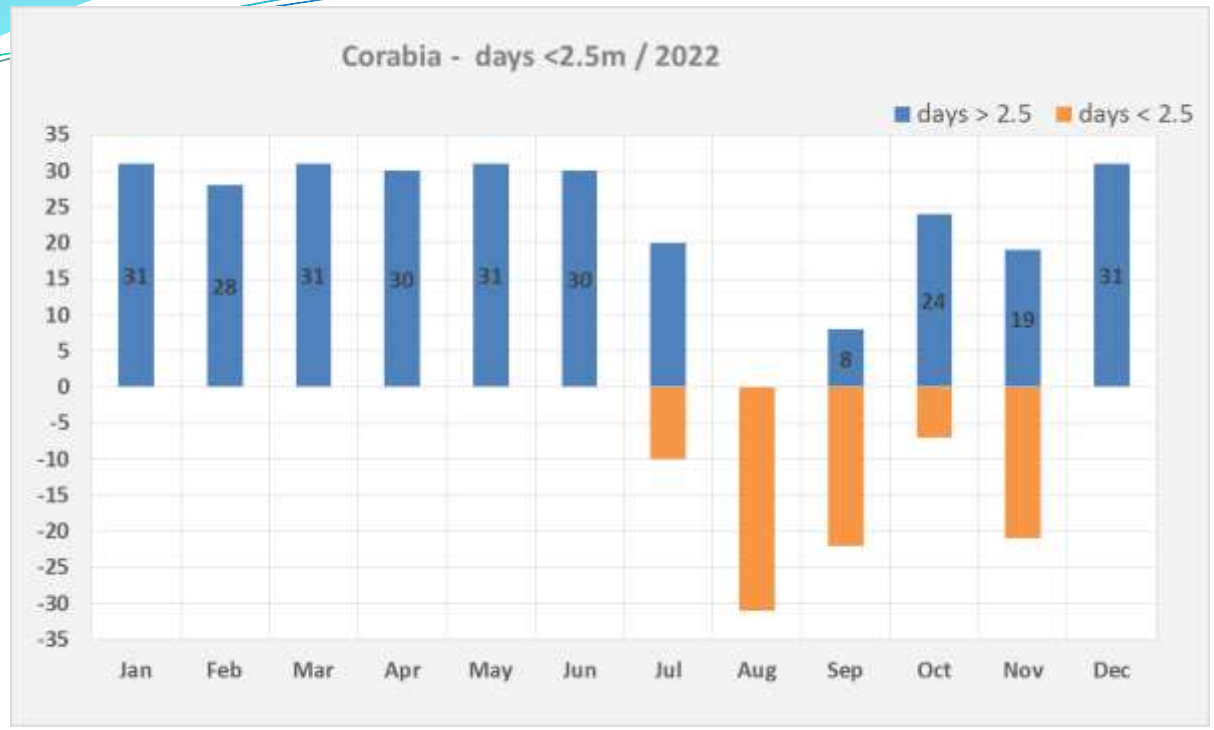


Navigability conditions – Lower Danube

The hydrological conditions of the last period determined the increasingly frequent recording of the number of days/year, with reduced parameters of the waterway (depths, widths).

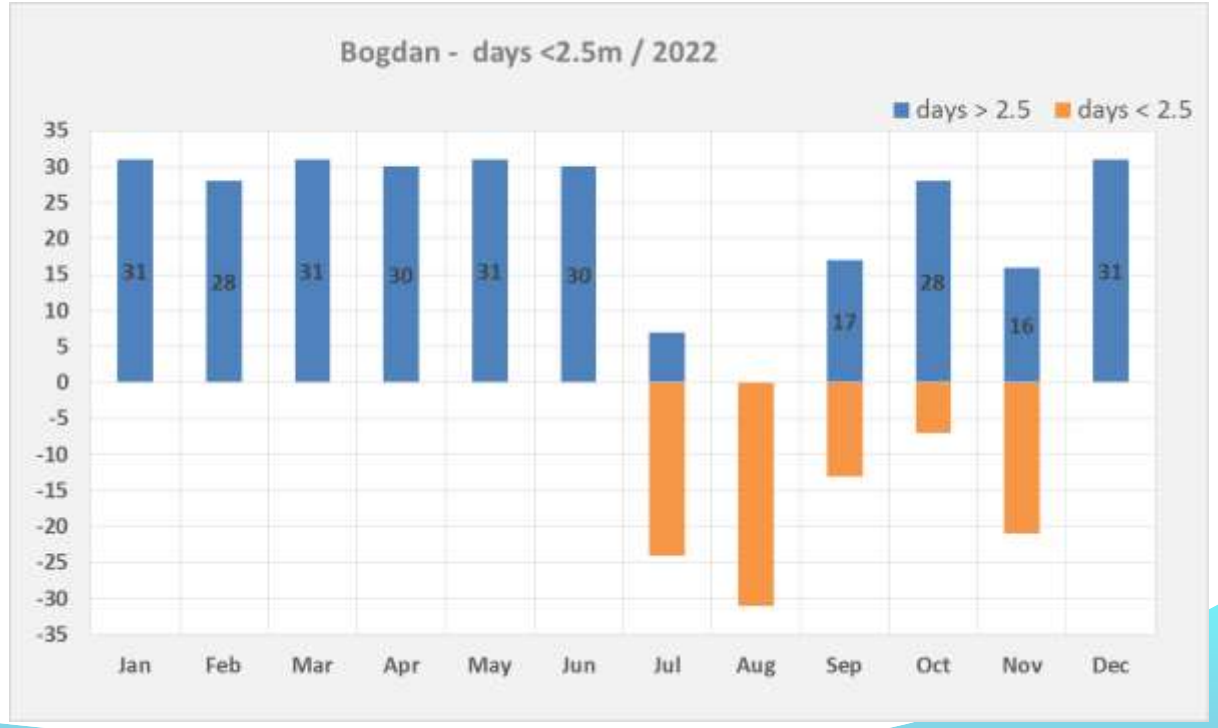


Navigability conditions – Lower Danube



Critical point, Corabia – 81

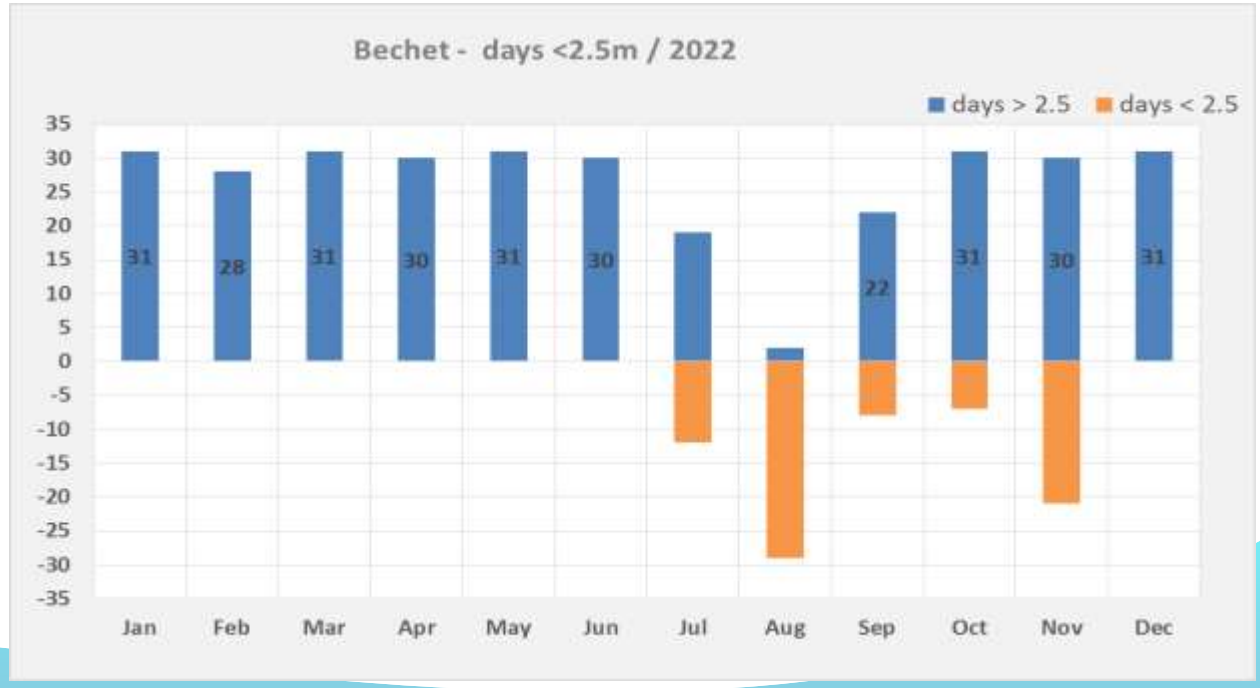
Critical Point, Bogdan-Secian - 75



Navigability conditions – Lower Danube

Critical Point, Dobrina 85

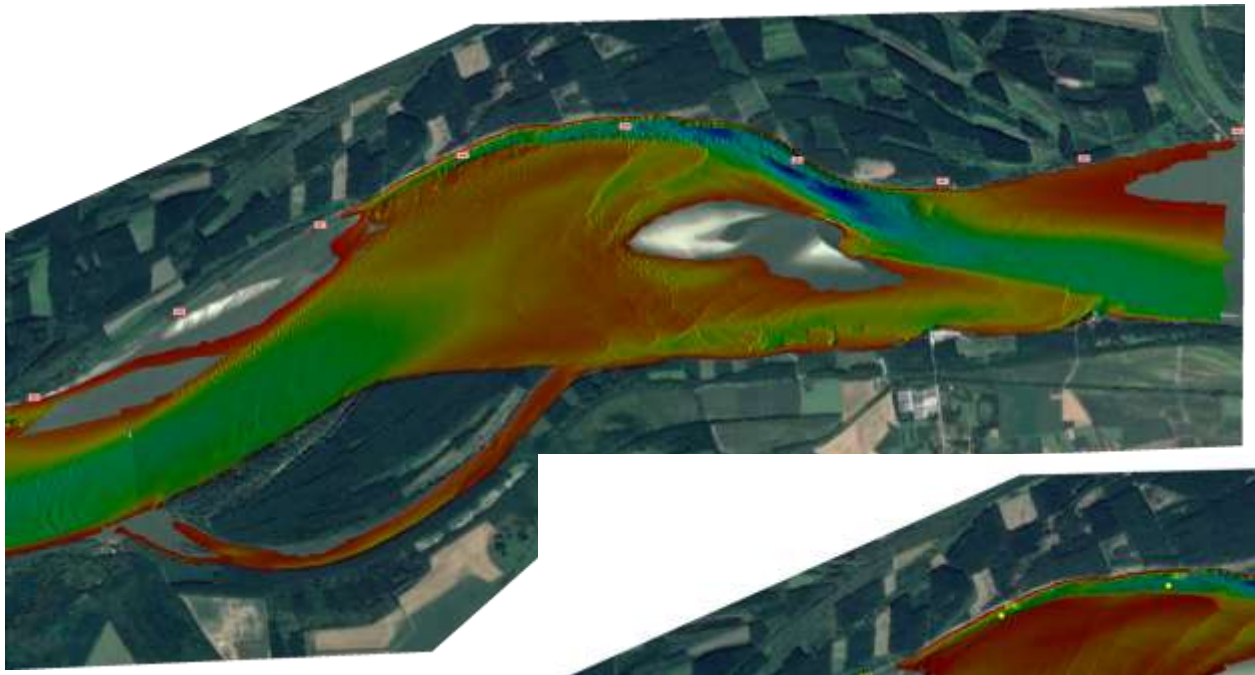
Critical Point, Bechet 49



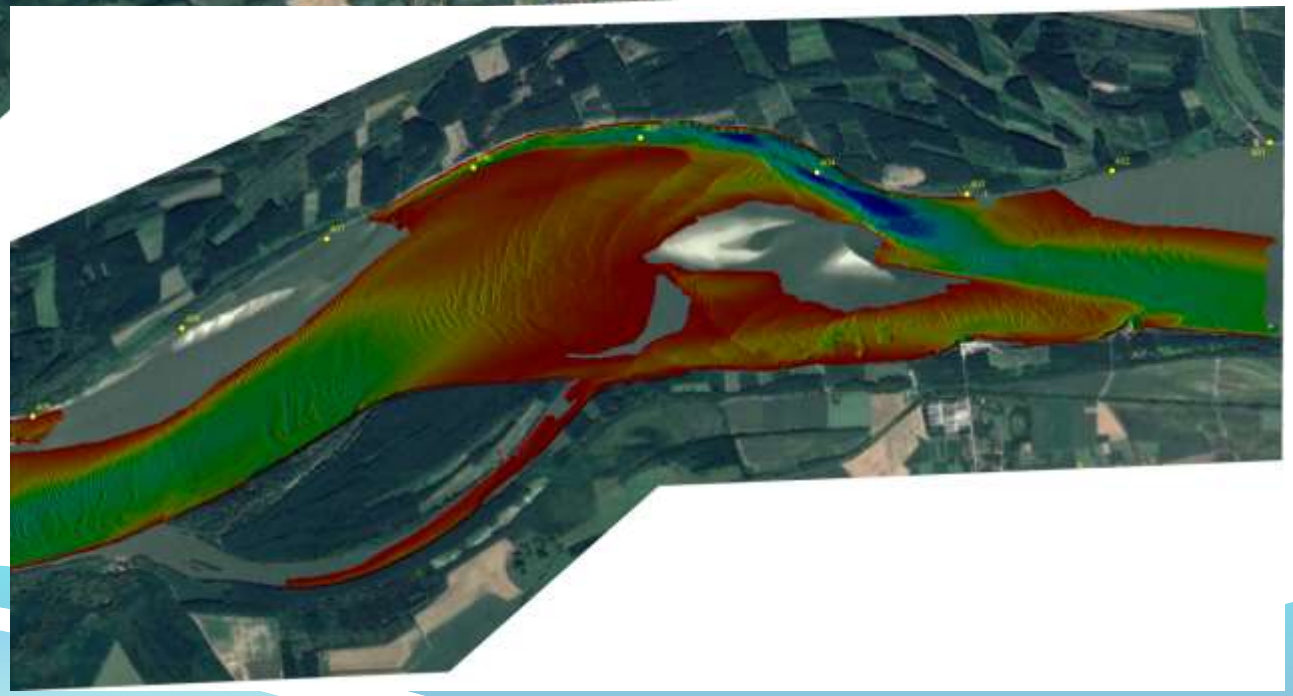
MONITORING ACTIVITIES

- **Survey activities**
  - Data gathering:
    - hydrography ;
    - hydrodynamics;
    - sediments;

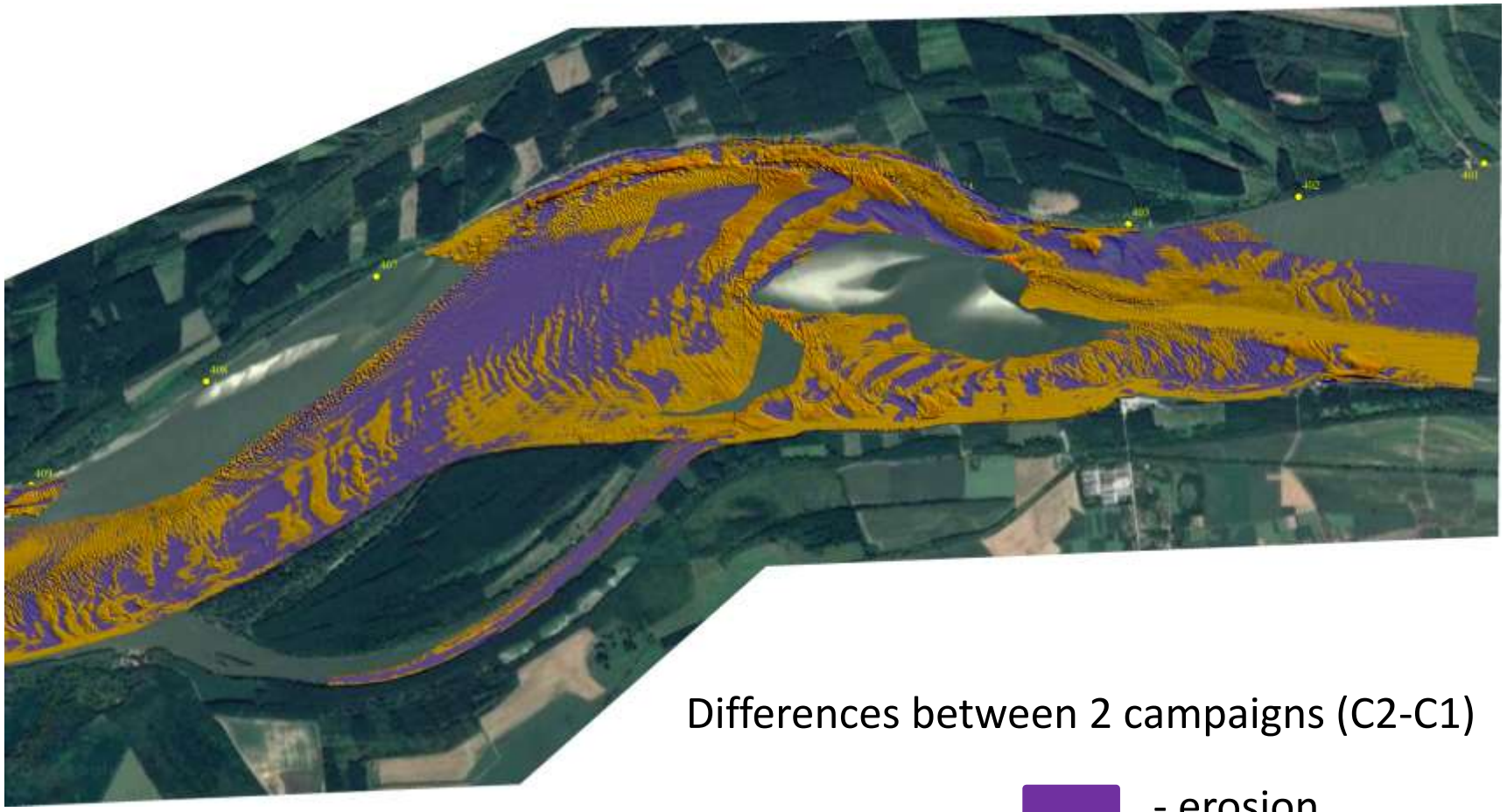
CRITICAL POINT- POPINA – KM 401-408



April – May 2017



July – August 2017

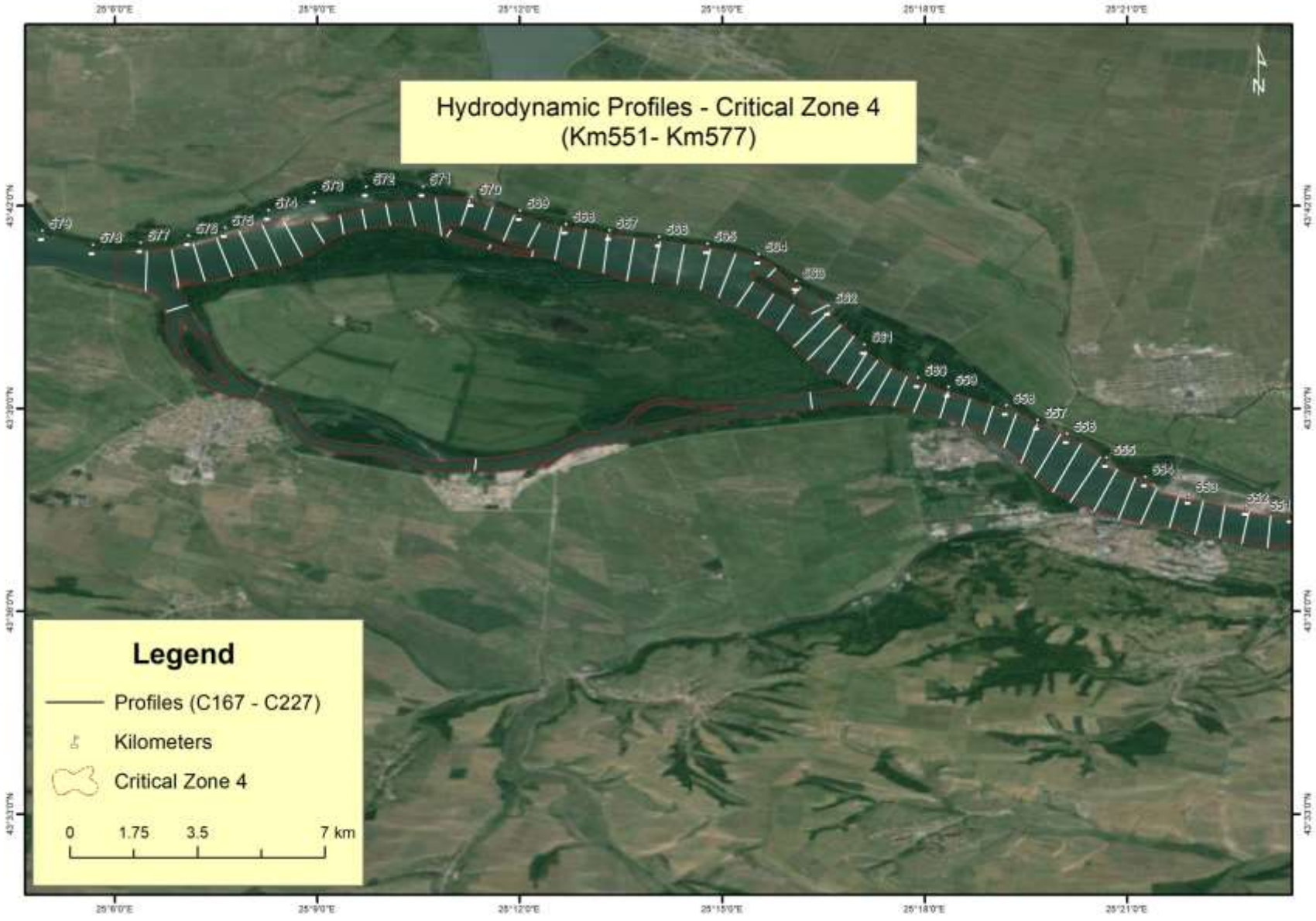


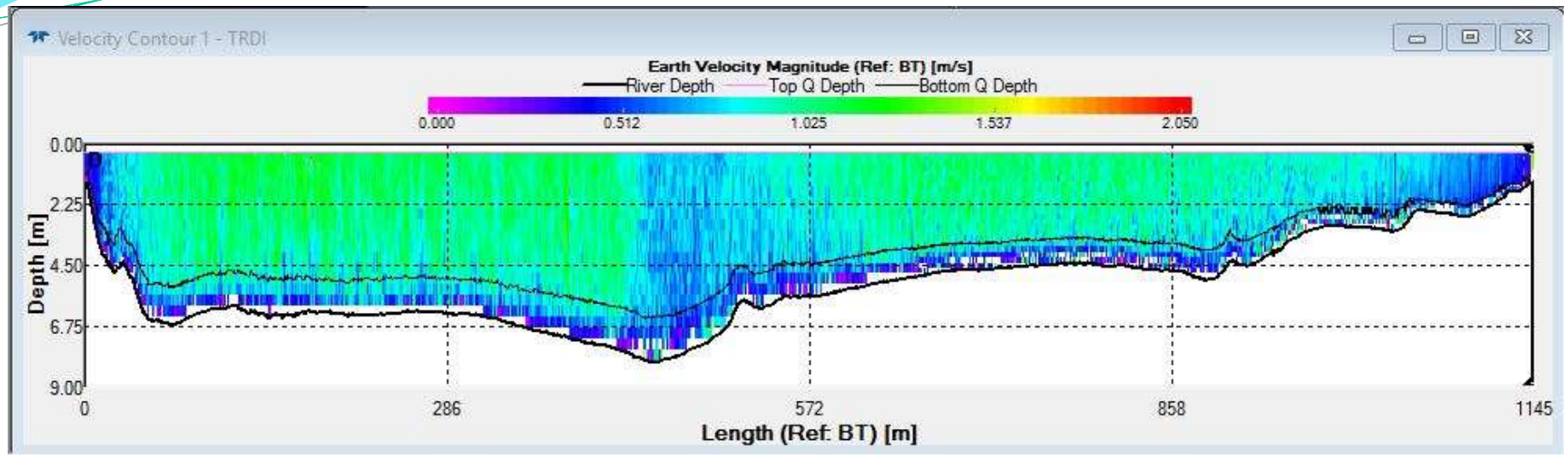
Differences between 2 campaigns (C2-C1)

- erosion

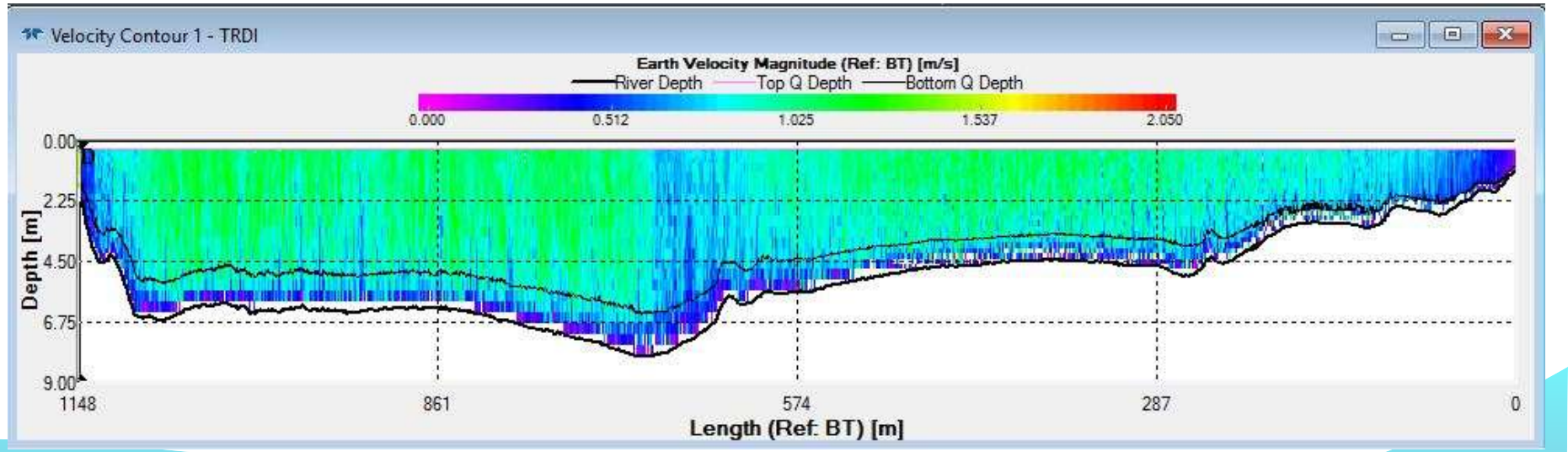
- deposition

Hydrodinamics surveys





Profils C390



Profile C390

Station Number: 756
Station Name: C390

Meas. No: 390
Date: 05/30/2017

Party:
Boat/Motor:
Gage Height: 0.000 m

Width: 1140.5 m
Area: 5880.6 m²
G.H.Change: 0.000 m

Processed by: Bracacel Adrian
Mean Velocity: 0.857 m/s
Discharge: 5,040 m³/s

Area Method: Avg. Course
Nav. Method: Bottom Track
MagVar Method: None (5.0°)
Depth: Composite (BT)
Discharge Method: None
% Correction: 0.00

ADCP Depth: 0.090 m
Shore Ens.:10
Bottom Est: Power (0.1667)
Top Est: Power (0.1667)

Index Vel.: 0.00 m/s
Adj.Mean Vel: 0.00 m/s
Rated Area: 0.000 m²
Control1: Unspecified
Control2: Unspecified
Control3: Unspecified

Rating No.: 1
Qm Rating: U
Diff.: 0.000%

Screening Thresholds:
BT 3-Beam Solution: YES
WT 3-Beam Solution: YES
BT Error Vel.: 1.00 m/s
WT Error Vel.: 10.00 m/s
BT Up Vel.: 10.00 m/s
WT Up Vel.: 10.00 m/s
Use Weighted Mean Depth: YES

Max. Vel.: 2.05 m/s
Max. Depth: 8.07 m
Mean Depth: 5.16 m
% Meas.: 74.50
Water Temp.: 21.0 °C
ADCP Temp.: 20.7 °C

ADCP:
Type/Freq.: RiverRay / 600 kHz
Serial #: 10192
Bin Size: 10 cm
BT Mode: Auto
WT Mode: Auto
WZ : 5

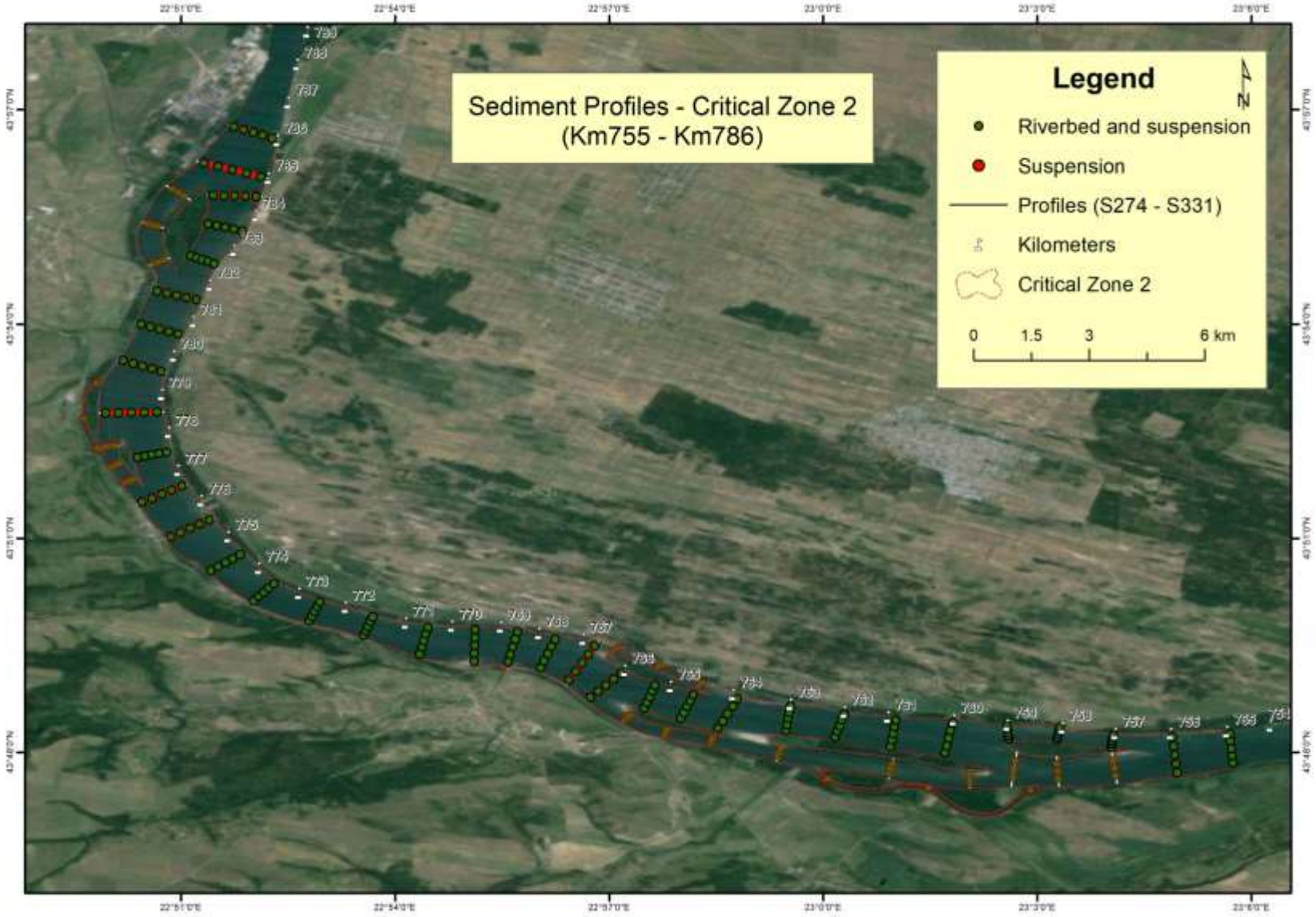
Firmware: 44.19
Blank: 16 cm
BT Pings: Dyn
WT Pings: Dyn

Performed Diag. Test: YES
Performed Moving Bed Test: NO
Performed Compass Calibration: NO Evaluation: NO
Meas. Location:

Project Name: C390_390.mmt
Software: 2.18

Tr.#		Edge Distance		#Ens.	Discharge						Width	Area	Time		Mean Vel.		% Bad	
		L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins
000	L	6.00	10.0	2154	317	3757	964	1.08	0.925	5041	1140.8	5880.6	10:38	11:09	0.63	0.86	0	0
001	R	6.00	10.0	2113	317	3754	968	1.47	0.902	5042	1140.1	5880.6	11:09	11:38	0.65	0.86	0	0
Mean		6.00	10.0	2133	317	3756	966	1.28	0.914	5041	1140.5	5880.6	**Total**	01:00	0.64	0.86	0	0
SDev		0.00	0.00	29	0.221	2.32	2.89	0.280	0.016	0.609	0.5	0.0			0.01	0.00		
SD/M		0.00	0.00	0.01	0.00	0.00	0.00	0.22	0.02	0.00	0.00	0.00			0.02	0.00		

Suspension Sediments survey



LISST-200X

DATA PROCESSING

SAMPLE STATISTICS

SAMPLE IDENTITY: **S047-1** ANALYST & DATE: ,

SAMPLE TYPE: Unimodal, Poorly Sorted TEXTURAL GROUP: Muddy Sand

SEDIMENT NAME: Medium Silty Medium Sand

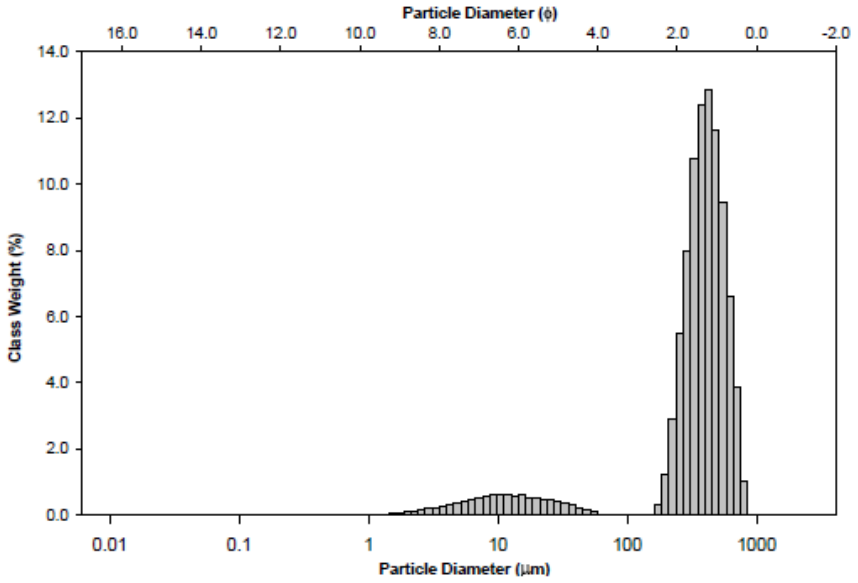
	µm	ϕ
MODE 1:	427.0	1.231
MODE 2:		
MODE 3:		
D_{10}:	33.18	0.722
MEDIAN or D_{50}:	386.8	1.370
D_{90}:	606.1	4.914
(D_{90} / D_{10}):	18.27	6.803
(D_{90} - D_{10}):	573.0	4.191
(D_{75} / D_{25}):	1.721	1.777
(D_{75} - D_{25}):	208.3	0.783

GRAIN SIZE DISTRIBUTION

GRAVEL: 0.0%	COARSE SAND: 24.5%
SAND: 89.0%	MEDIUM SAND: 58.1%
MUD: 11.0%	FINE SAND: 6.4%
	V FINE SAND: 0.0%
V COARSE GRAVEL: 0.0%	V COARSE SILT: 1.2%
COARSE GRAVEL: 0.0%	COARSE SILT: 2.8%
MEDIUM GRAVEL: 0.0%	MEDIUM SILT: 3.4%
FINE GRAVEL: 0.0%	FINE SILT: 2.4%
V FINE GRAVEL: 0.0%	V FINE SILT: 1.1%
V COARSE SAND: 0.0%	CLAY: 0.2%

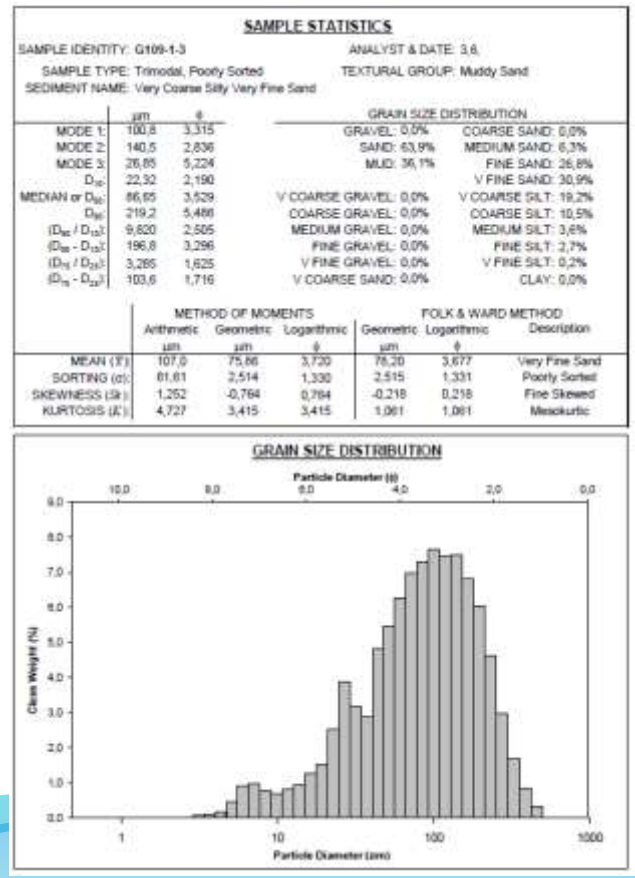
	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic µm	Geometric µm	Logarithmic ϕ	Geometric µm	Logarithmic ϕ	Description
MEAN ($\bar{x}$):	381.5	272.8	1.874	373.1	1.422	Medium Sand
SORTING (σ):	180.5	3.307	1.725	2.313	1.210	Poorly Sorted
SKEWNESS (Sk):	-0.344	-2.430	2.430	-0.435	0.435	Very Fine Skewed
KURTOSIS (K):	3.024	7.994	7.994	3.145	3.145	Extremely Leptokurtic

GRAIN SIZE DISTRIBUTION



REZULTATE – SEDIMENTE ÎN SUSPENSIE

- Bimodal distribution silty and fine sand fractions



SAMPLE STATISTICS

SAMPLE IDENTITY: G109-1-3 — ANALYST & DATE: 3,6,

SAMPLE TYPE: Trimodal, Poorly Sorted — TEXTURAL GROUP: Muddy Sand

SEDIMENT NAME: Very Coarse Silty Very Fine Sand

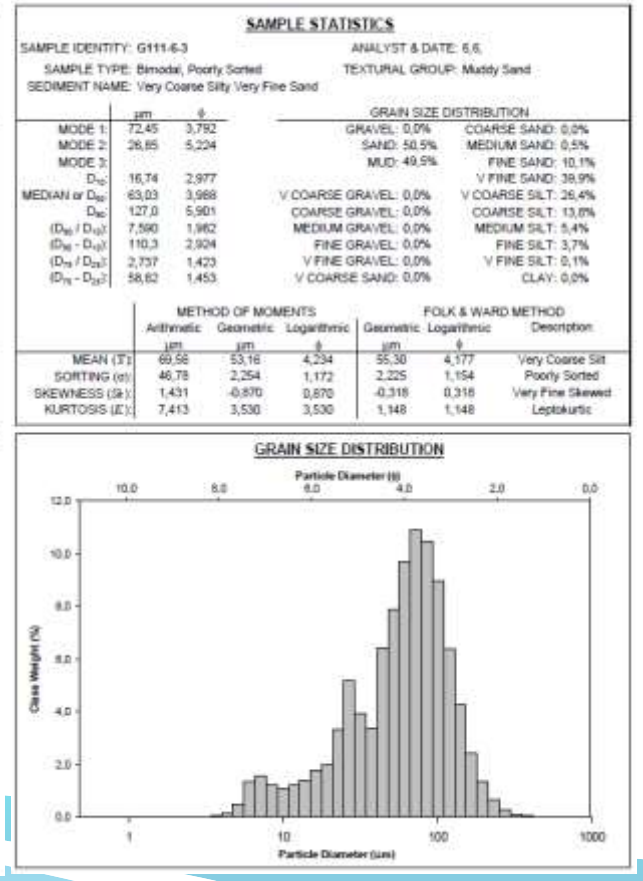
	µm	ϕ
MODE 1:	100,8	3,315
MODE 2:	140,5	2,836
MODE 3:	26,85	5,224
D_{10}:	22,32	2,190
MEDIAN or D_{50}:	86,65	3,529
D_{90}:	219,2	5,486
(D_{90} / D_{10}):	9,820	2,505
(D_{90} - D_{10}):	196,8	3,296
(D_{75} / D_{25}):	3,285	1,625
(D_{75} - D_{25}):	103,6	1,716

GRAIN SIZE DISTRIBUTION

GRAVEL: 0,0%	COARSE SAND: 0,0%
SAND: 63,9%	MEDIUM SAND: 6,3%
MUD: 36,1%	FINE SAND: 26,8%
	V FINE SAND: 30,9%
V COARSE GRAVEL: 0,0%	V COARSE SILT: 19,2%
COARSE GRAVEL: 0,0%	COARSE SILT: 10,5%
MEDIUM GRAVEL: 0,0%	MEDIUM SILT: 3,6%
FINE GRAVEL: 0,0%	FINE SILT: 2,7%
V FINE GRAVEL: 0,0%	V FINE SILT: 0,2%
V COARSE SAND: 0,0%	CLAY: 0,0%

	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	µm	µm	ϕ	µm	ϕ	
MEAN ($\bar{x}$):	107,0	75,66	3,720	78,20	3,677	Very Fine Sand
SORTING (σ):	61,61	2,514	1,330	2,515	1,331	Poorly Sorted
SKEWNESS ($\tilde{\alpha}$):	1,252	-0,764	0,764	-0,218	0,218	Fine Skewed
KURTOSIS ($\hat{\alpha}$):	4,727	3,415	3,415	1,061	1,061	Mesokurtic

GRAIN SIZE DISTRIBUTION



SAMPLE STATISTICS

SAMPLE IDENTITY: G111-6-3 — ANALYST & DATE: 6,6,

SAMPLE TYPE: Bimodal, Poorly Sorted — TEXTURAL GROUP: Muddy Sand

SEDIMENT NAME: Very Coarse Silty Very Fine Sand

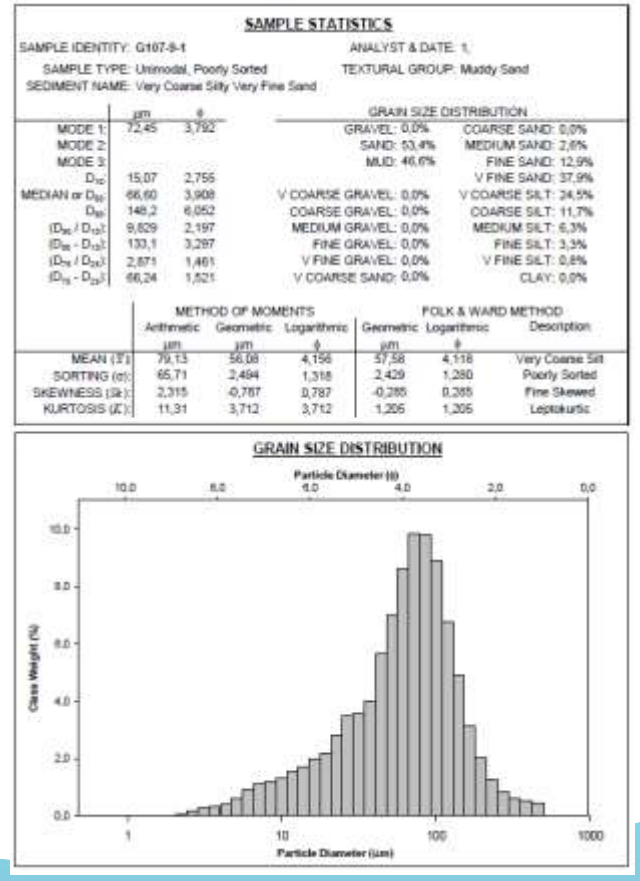
	µm	ϕ
MODE 1:	72,45	3,792
MODE 2:	26,85	5,224
MODE 3:		
D_{10}:	16,74	2,977
MEDIAN or D_{50}:	63,03	3,988
D_{90}:	127,0	5,901
(D_{90} / D_{10}):	7,590	1,982
(D_{90} - D_{10}):	110,3	2,924
(D_{75} / D_{25}):	2,737	1,423
(D_{75} - D_{25}):	58,62	1,453

GRAIN SIZE DISTRIBUTION

GRAVEL: 0,0%	COARSE SAND: 0,0%
SAND: 50,5%	MEDIUM SAND: 0,5%
MUD: 49,5%	FINE SAND: 10,1%
	V FINE SAND: 38,9%
V COARSE GRAVEL: 0,0%	V COARSE SILT: 26,4%
COARSE GRAVEL: 0,0%	COARSE SILT: 13,6%
MEDIUM GRAVEL: 0,0%	MEDIUM SILT: 5,4%
FINE GRAVEL: 0,0%	FINE SILT: 3,7%
V FINE GRAVEL: 0,0%	V FINE SILT: 0,1%
V COARSE SAND: 0,0%	CLAY: 0,0%

	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	µm	µm	ϕ	µm	ϕ	
MEAN ($\bar{x}$):	69,56	53,16	4,234	55,30	4,177	Very Coarse Silt
SORTING (σ):	46,78	2,254	1,172	2,225	1,154	Poorly Sorted
SKEWNESS ($\tilde{\alpha}$):	1,431	-0,870	0,870	-0,318	0,318	Very Fine Skewed
KURTOSIS ($\hat{\alpha}$):	7,413	3,530	3,530	1,148	1,148	Leptokurtic

GRAIN SIZE DISTRIBUTION



SAMPLE STATISTICS

SAMPLE IDENTITY: G107-9-1 — ANALYST & DATE: 1,

SAMPLE TYPE: Unimodal, Poorly Sorted — TEXTURAL GROUP: Muddy Sand

SEDIMENT NAME: Very Coarse Silty Very Fine Sand

	µm	ϕ
MODE 1:	72,45	3,792
MODE 2:		
MODE 3:		
D_{10}:	15,07	2,755
MEDIAN or D_{50}:	66,60	3,908
D_{90}:	148,2	6,052
(D_{90} / D_{10}):	9,829	2,197
(D_{90} - D_{10}):	133,1	3,297
(D_{75} / D_{25}):	2,871	1,461
(D_{75} - D_{25}):	66,24	1,521

GRAIN SIZE DISTRIBUTION

GRAVEL: 0,0%	COARSE SAND: 0,0%
SAND: 53,4%	MEDIUM SAND: 2,6%
MUD: 46,6%	FINE SAND: 12,9%
	V FINE SAND: 37,9%
V COARSE GRAVEL: 0,0%	V COARSE SILT: 24,5%
COARSE GRAVEL: 0,0%	COARSE SILT: 11,7%
MEDIUM GRAVEL: 0,0%	MEDIUM SILT: 6,3%
FINE GRAVEL: 0,0%	FINE SILT: 3,3%
V FINE GRAVEL: 0,0%	V FINE SILT: 0,8%
V COARSE SAND: 0,0%	CLAY: 0,0%

	METHOD OF MOMENTS			FOLK & WARD METHOD		
	Arithmetic	Geometric	Logarithmic	Geometric	Logarithmic	Description
	µm	µm	ϕ	µm	ϕ	
MEAN ($\bar{x}$):	79,13	56,08	4,156	57,58	4,118	Very Coarse Silt
SORTING (σ):	65,71	2,494	1,318	2,429	1,280	Poorly Sorted
SKEWNESS ($\tilde{\alpha}$):	2,315	-0,787	0,787	-0,285	0,285	Fine Skewed
KURTOSIS ($\hat{\alpha}$):	11,31	3,712	3,712	1,205	1,205	Leptokurtic

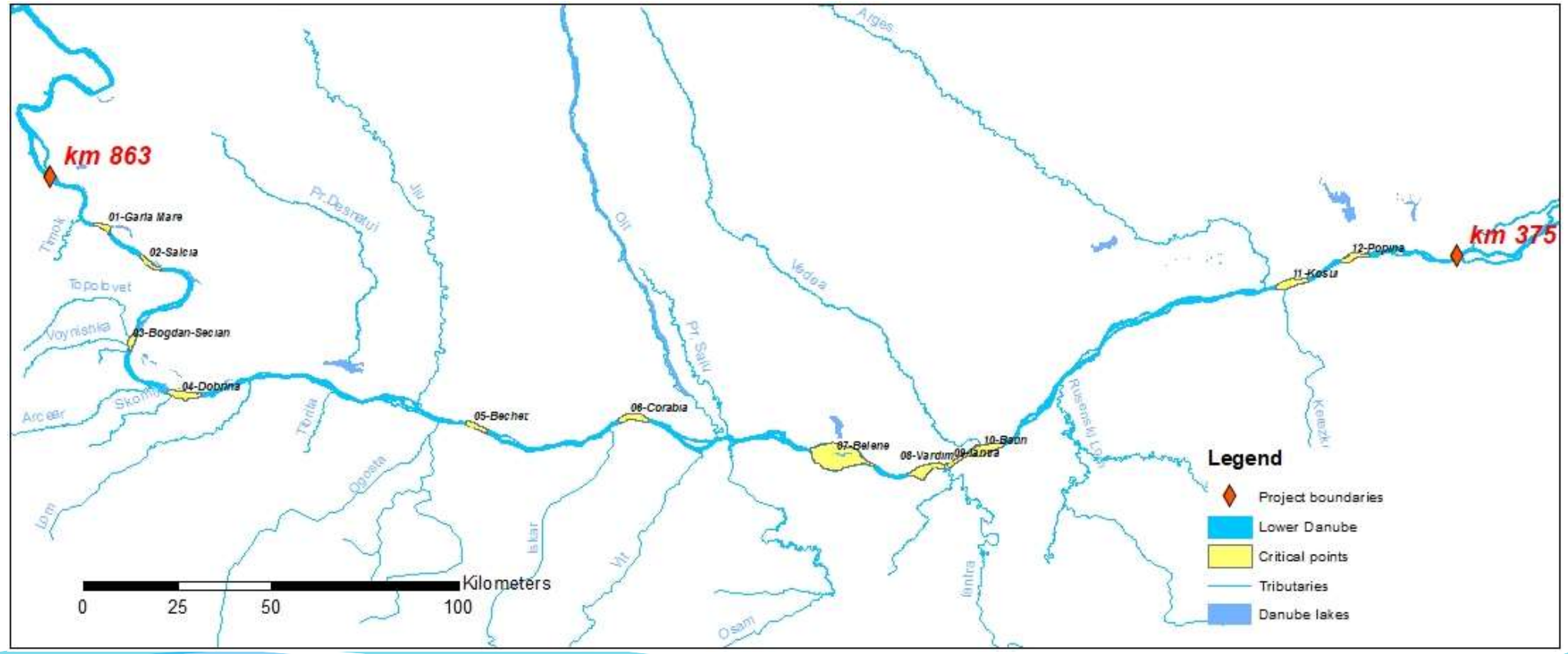
GRAIN SIZE DISTRIBUTION

MITIGATION MEASURES for EFFECTS of UNFAVOURABLE HYDROLOGIC CONDITIONS

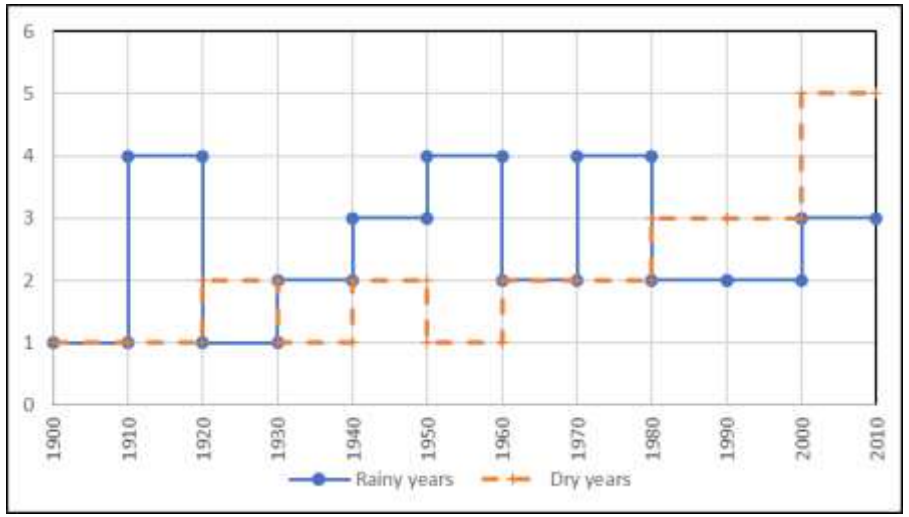
- Measures:
  - Permanently monitoring for hydrological parameters;
  - Reducing the fairway width, when water level is bellow LNWL;
  - Dredging interventions – to start at optimum water level;

Project area

- **488km river length (470.5km on the common Romanian-Bulgarian sector); the catchment area increases from 579,200 km² to 698,000km²**

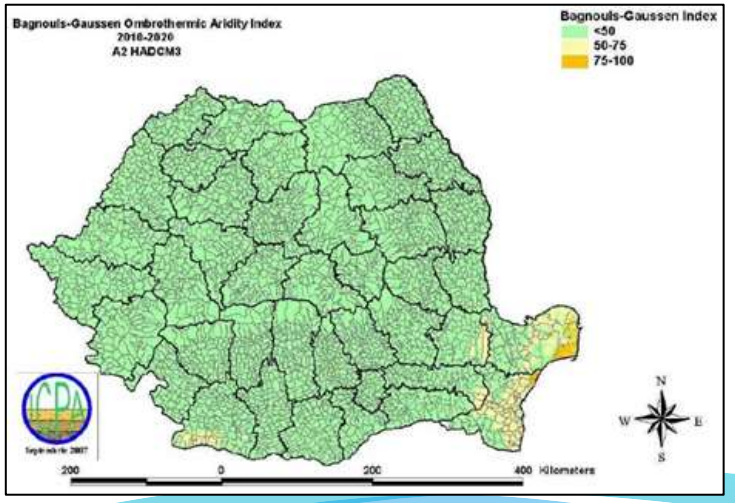


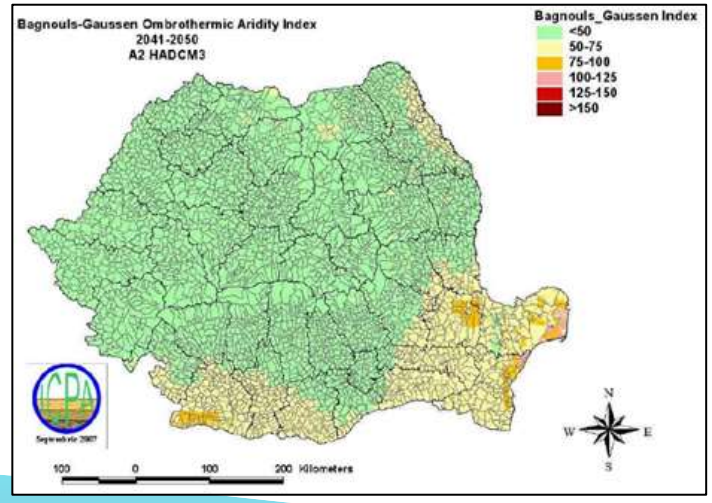
Climate trends by countries - Romania

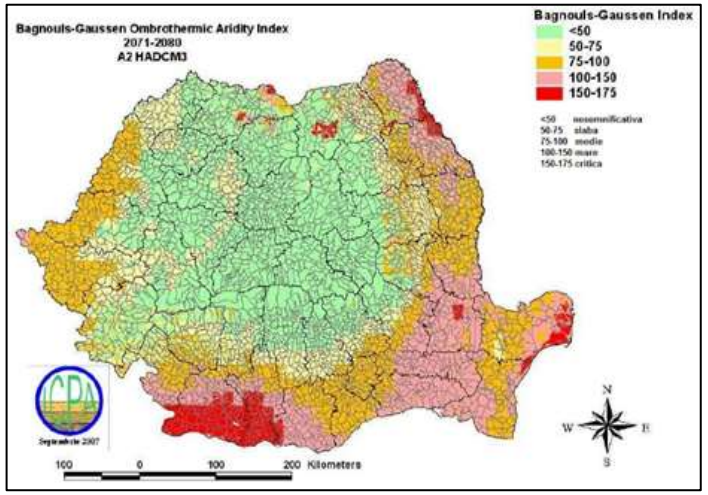


Aridisation processes:

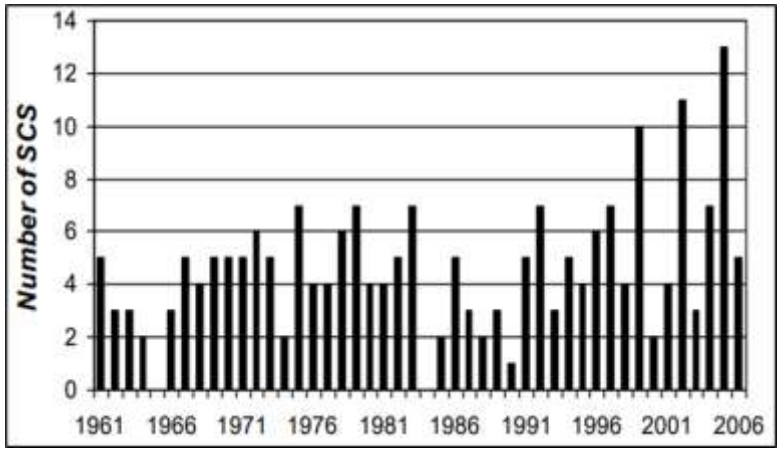
- Trends of extreme behaviors – increasing frequency by decades of rainy and dry years
- Increasing trends of drought intensity on arable land





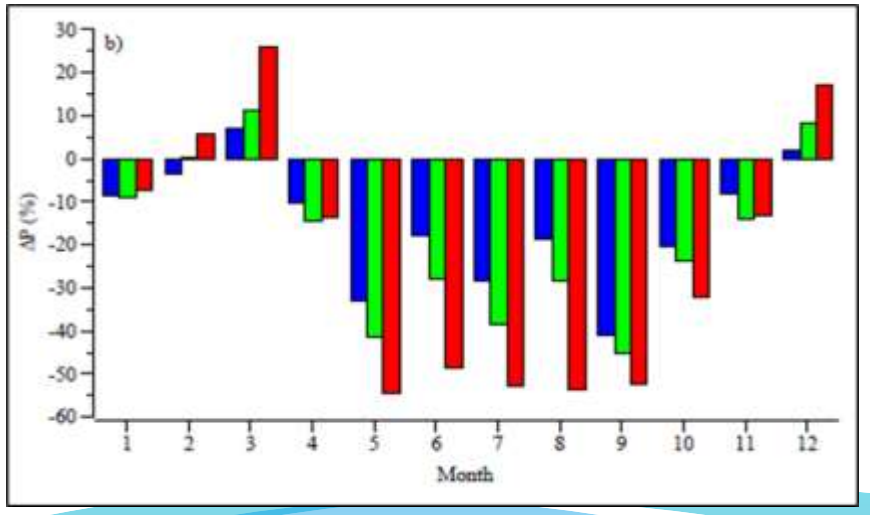


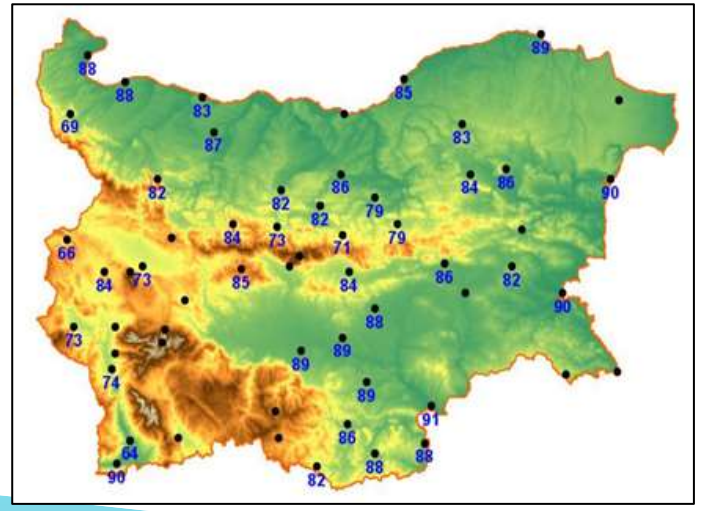
Climate trends by countries - Bulgaria

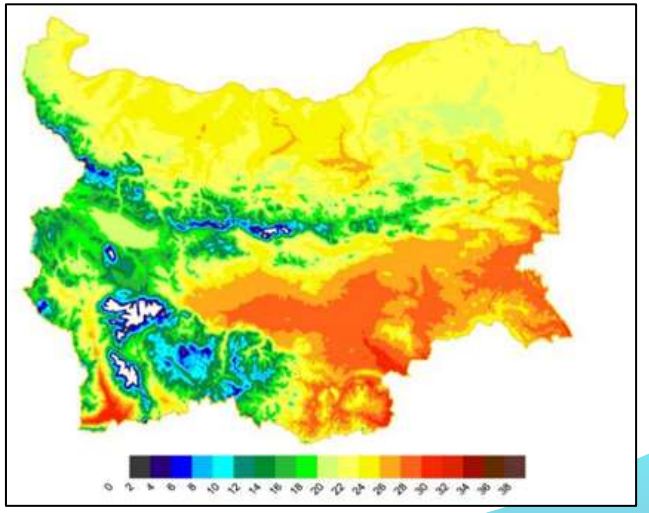


Aridisation processes:

- Trends of extreme behaviors – increasing number of severe convective storms (SCS) in summer season
- Trends of monthly precipitations;
- Forecast of summer days (Tmax > 25°C): mean values in the period 1961-1990; predicted percent increases in 2021-2050

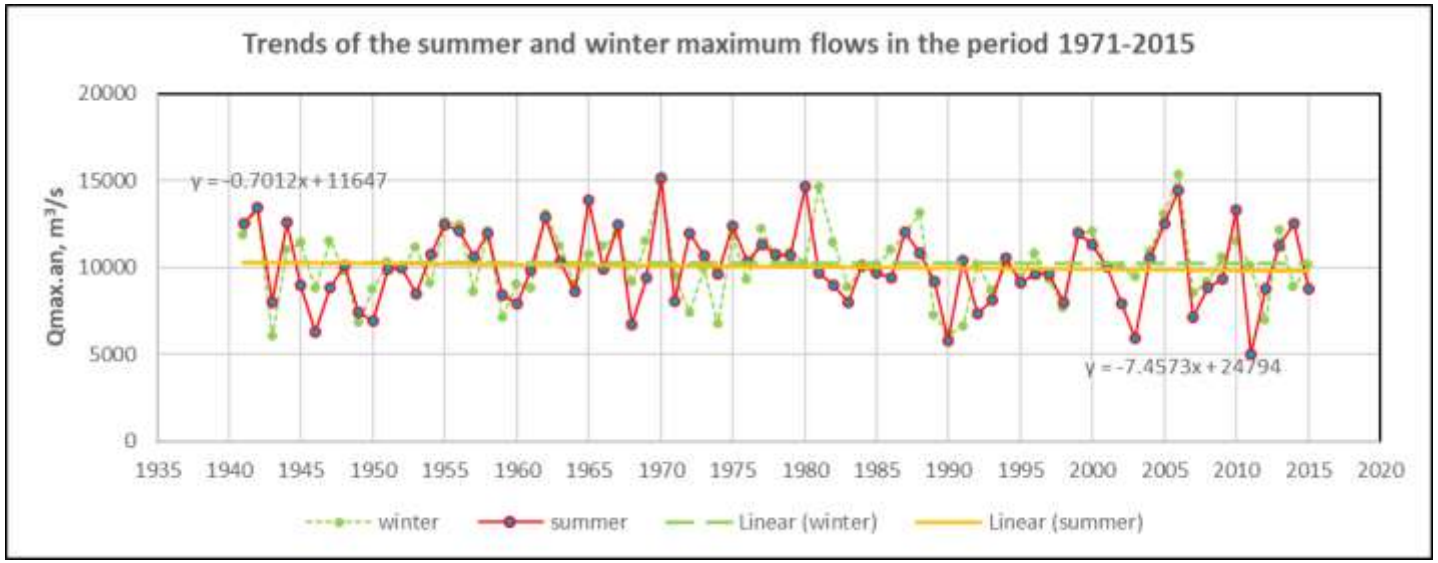




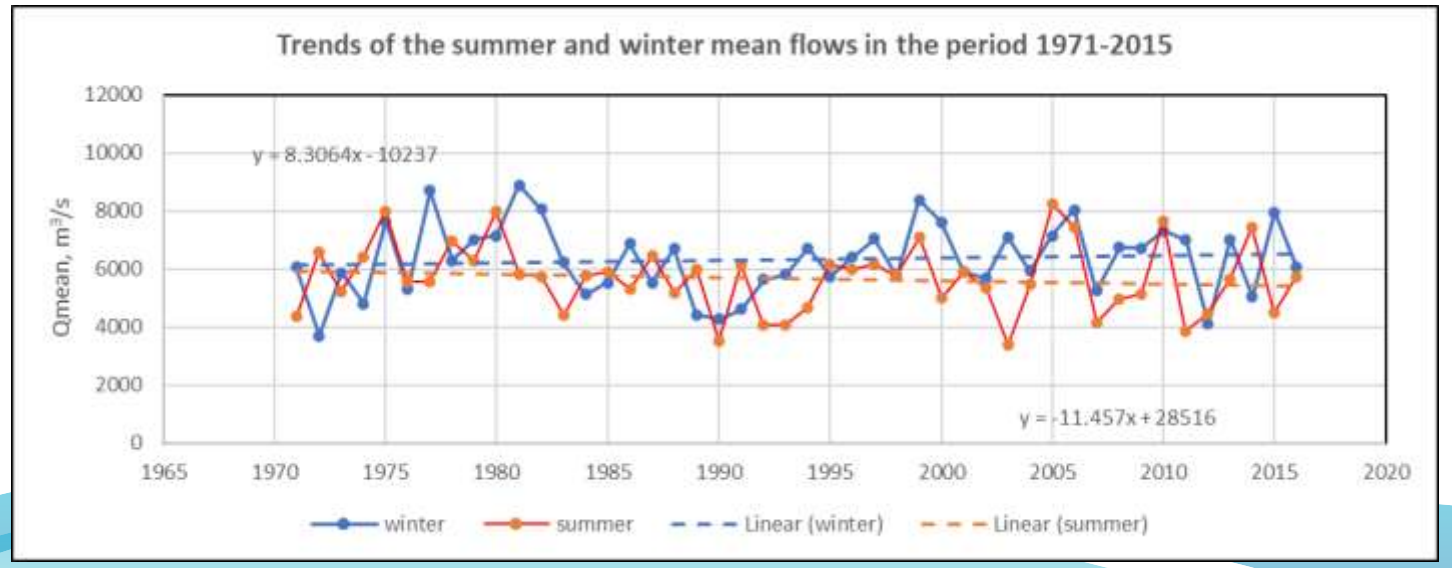


Hydrological effects of climate changes at Danube scale

- **Effects at catchment scale: changes in max and mid flow rates**



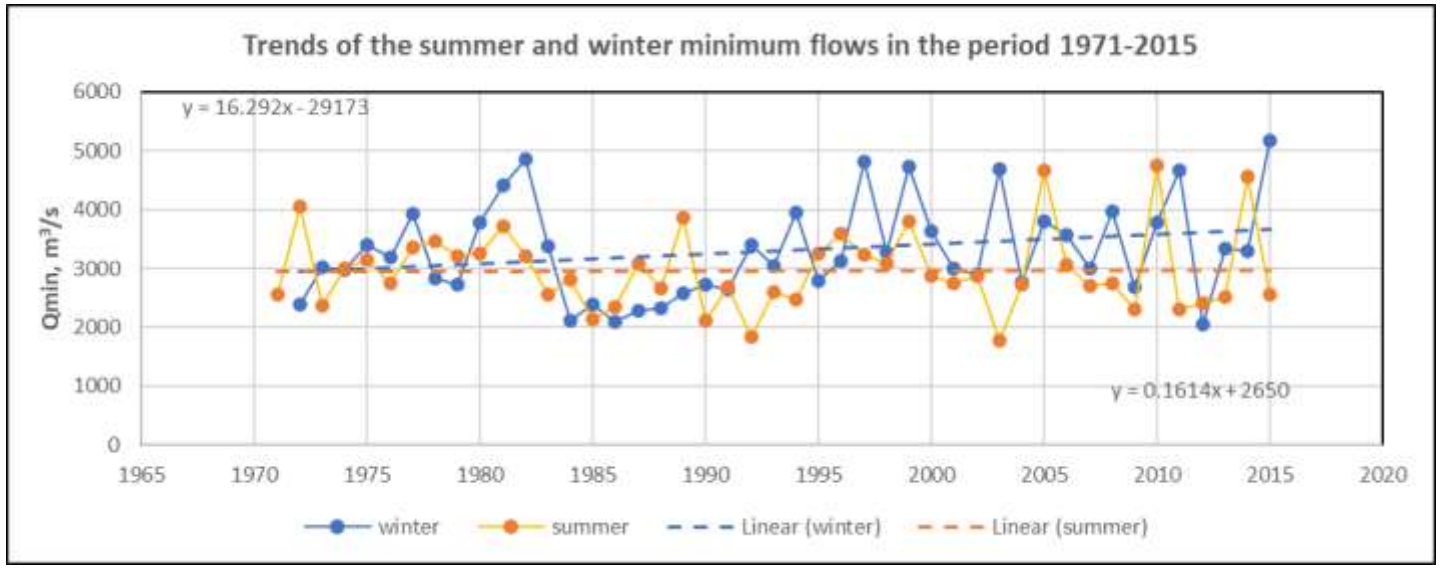
- Higher max winter flow rates with 6.5% in 2015 and 13.5% in 2065 vs those in 1971
- Lower max summer flow rates with 9.6% in 2015 and 20.5% in 2065 vs those in 1971

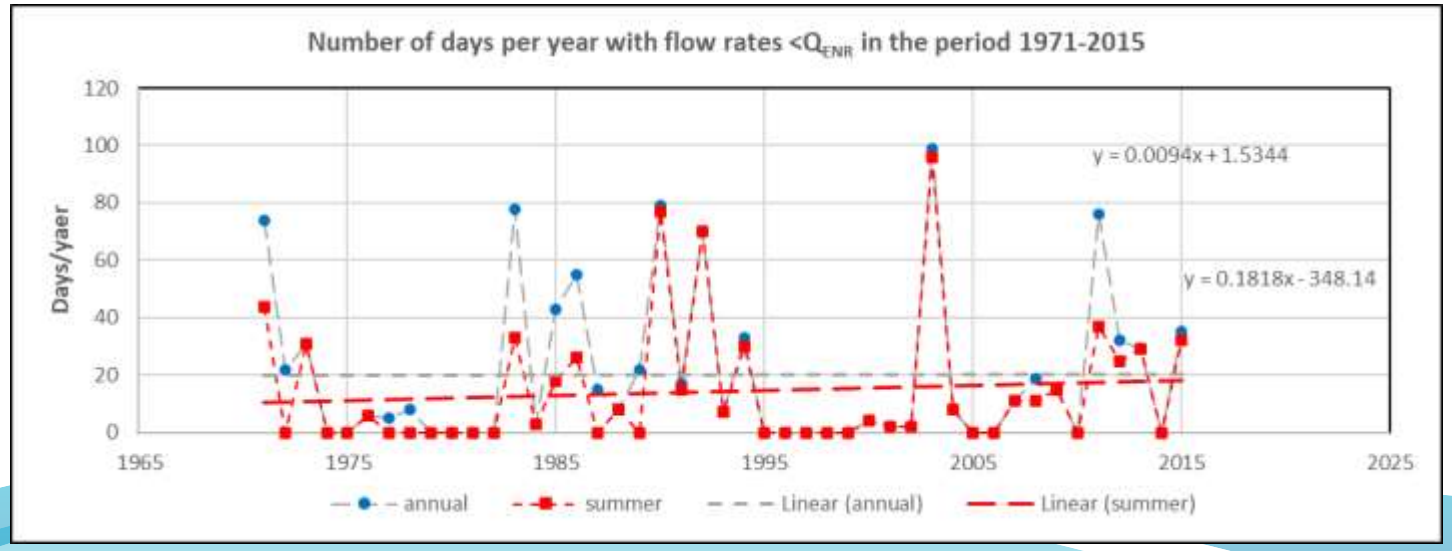


- Higher mean winter flow rates with 6% in 2015 and 13% in 2065 vs those in 1971
- Lower mean summer flow rates with 8.5% in 2015 and 18% in 2065 vs those in 1971

Hydrological effects of climate changes

- **Effects at catchment scale: changes in min flow rates and low flow durations**





- Higher min winter flow rates with 24% in 2015 vs those in 1971
- No change for min summer under the flow regulation effects within the Iron Gates reservoirs

- Mean durations of summer flow rates below Q94% (LNWL): of 10days in 1971, of 18days in 2015, and of 28days in 2065

Hydrological effects of climate changes at local scales

Higher frequency and intensity of extreme events:

- Severe convective storms: flash floods occurrence in small catchments, within near the bank area; these associate with a high erosion capacity as for significant factors of risk to riverbanks stability;
- Longer dry periods with further negative effects within the water cycle components at local scales, as well as on land cover structures;

Changes of navigation interest:

- On low flow and ice durations
- Of morphological risk, including bank instability
- Of a certain recovery from the former suspension alluvia capacity which might rebalance the erosion activity in the riverbed;

Thank you for attention !

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