Development of the Danube co-operation in the field of hydrology

Pavol MIKLÁNEK

NC IHP UNESCO Slovakia

United Nations
Educational, Scientific and
Cultural Organization

Slovak National Committee
of the International
Hydrological Programme

Milestones

1967   **Danube commission (for navigation) established**
      Working group for scientific hydrology

1971   **Water balance of the Danube basin included**

1974   **network of 8 countries**
      (CS, H, BG, SU under Danube commission and
      D, A, YU, RO under IHP UNESCO)

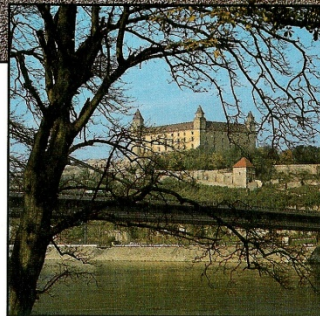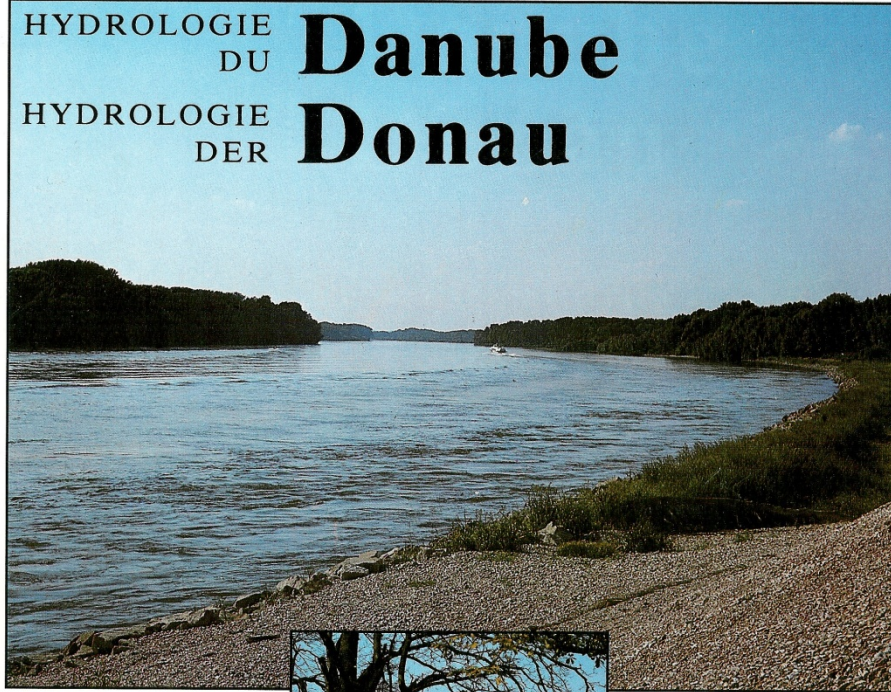**1986**   **publication of the Danube monograph**

monograph

Andrej Stančík
Slavoljub Jovanović
et al.
Hydrology
of the River Danube

1986
Príroda Publishing
House, Bratislava

4 languages

IHP National committees that signed the "Principles"

Germany
Austria
Czech Republic
Slovakia
Hungary
Slovenia
Croatia
Bosnia and Herzegovina
Serbia
Romania
Bulgaria
Ukraine
Moldova

Invited National committees for IHP UNESCO:
Switzerland
Italy
Poland
Albania
Macedonia

Continuation

IHP UNESCO

1987 Budapest
1st Working group meeting

since that 28 regular meetings
+ 7 extraordinary

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NC IHP UNESCO

Germany   1987-1992   Hofius
Austria   1993-1998   Nobilis, Behr, Gutknecht
Slovakia   1999-2002   Miklánek, Petrovič
Hungary   2003-2005   Domokos
Serbia   2006-2008   Miloradov
Croatia   2009-2011   Biondić
Romania   2012-2016   Radulescu
Slovenia   2017-   Brilly

CONFERENCES

Jahr Год Year	No. Но. No.	Land Страна Country	Stadt Город City
1961	I.	Hungary	Budapest
1963	II.	Austria	Graz
1965	III.	Romania	Bucuresti
1967	IV.	Czechoslovakia	Bratislava
1969	V.	Yugoslavia	Beograd
1971	VI.	Ukraine	Kiew
1973	VII.	Bulgaria	Varna
1975	VIII.	Germany	Regensburg

CONFERENCES

Jahr Год Year	No. Ho. No.	Land Страна Country	Stadt Город City
1977	IX.	Hungary	Budapest
1979	X.	Austria	Wien
1982	XI.	Romania	Bucuresti
1984	XII.	Czechoslovakia	Bratislava
1986	XIII.	Yugoslavia	Beograd
1988	XIV.	Ukraine	Kiew
1990	XV.	Bulgaria	Varna
1992	XVI.	Germany	Kelheim

CONFERENCES

Jahr / Год / Year	No. / Ho. / No.	Land / Страна / Country	Stadt / Город / City
1994	XVII.	Hungary	Budapest
1996	XVIII.	Austria	Graz
1998	XIX.	Croatia	Osijek
2000	XX.	Slovakia	Bratislava
2002	XXI.	Romania	Bucuresti
2004	XXII	Czech Republic	Brno
2006	XXIII	Serbia	Beograd
2008	XXIV	Slovenia	Bled
2011	XXV	Hungary	Budapest
2014	XXVI	Germany	Deggendorf
2017	XXVII	Bulgaria	Golden Sands
2019	XXVII	Ukraine	Kiew

Projects

Project 1	Regime of the suspended load and bed load of the Danube river
Project 2	Thermal and ice regime of the Danube river and its major tributaries
Project 3	Long-term fluctuations of precipitation in the Danube basin
Project 4	Flood coincidence in the Danube river and its major tributaries
Project 5	Update of the Hydrological Monograph of the Danube river basin
Sub-Project 5.1	Inventory of the main hydrotechnical structures in the Danube basin
Sub-Project 5.2	Update of the water regime analysis
Sub-Project 5.3	Update of the water balance

Finished   skipped

Projects

Project 6	**River bed conditions of the Danube river**
Sub-Project 6.1	Paleogeography of the Danube river and its catchment
Sub-Project 6.2	The Danube river channel training
Sub-Project 6.3	Fords of the Danube river channel
Sub-Project 6.4	Meandering and slope conditions of the Danube river as well as geometrical parameters of the river channel (Analysis of the morphological processes)
Project 7	**Regionalisation of the annual maximum runoff**
Project 8	**Hydrological bibliography related to the Danube basin**
Sub-Project 8.1	Hydrological bibliography related to the Danube basin
Sub-Project 8.2	Basin coding and numbering for the Danube basin
Project 9	**Flood regime of the rivers in the Danube basin**

Finished   skipped   continuing

FLOOD REGIME OF RIVERS
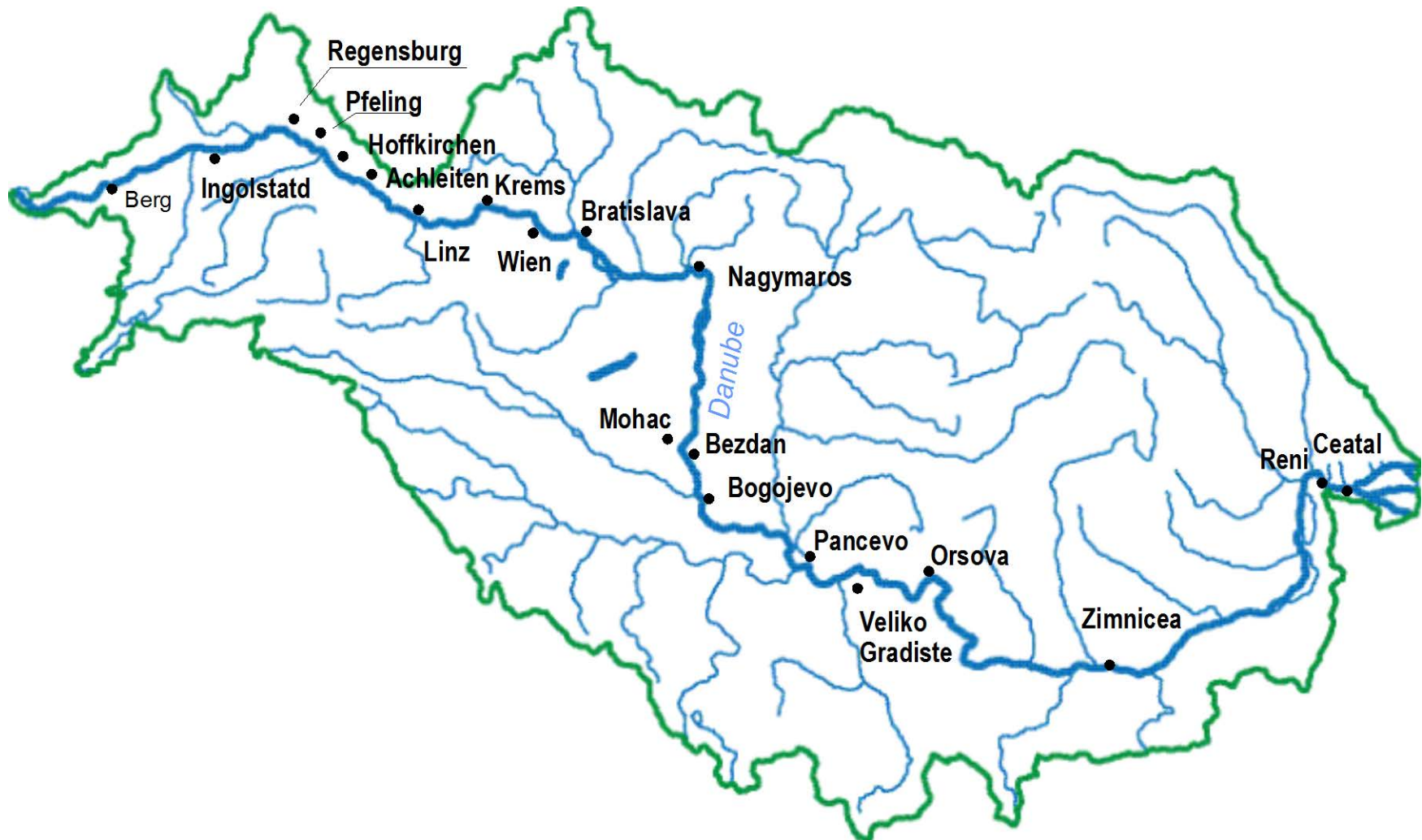# IN THE DANUBE RIVER BASIN

Pavol Miklánek
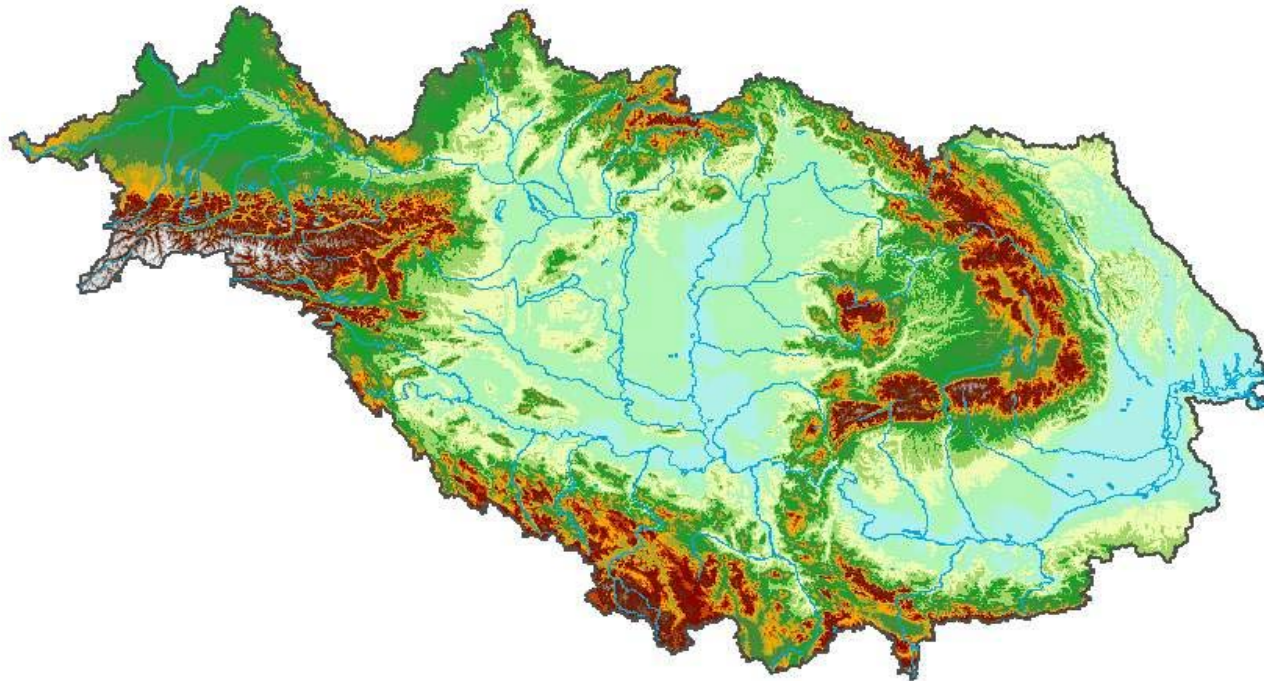
- O1: Average daily discharge and annual peak discharge series collection.
- O2: History and propagations of Danube floods.
- O3: Analysis of homogeneity of annual time series.
- O4: Analysis of cyclicity and long-term trends of annual series, and Qmax series.
- O5: Analysis of the intra-annual regime changes based on monthly series.
- O6: Development of relations between values of NAO, QBO and SO indexes and discharge series.
- O7: Statistical analyses of extreme discharges.
- O8: Regionalization of flood regimes according to magnitude of fluctuations, NAO, and their synchronicity.
- O9: Coincidence of the flood flow of the Danube River and its main tributaries.
- O10: Theoretical design hydrographs at the hydrological gauging stations along the Danube River

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Danube Tributaries Data >60 stations

Daily discharge — Danube - Bratislava

Area	131338 km^2
First Year	1876
Last Year	2008

Basic statistical characteristics

	mean	min	max	330-day	30-day	cs	cv
Q [m^{3}s^{-1}]	2057	580	10810	1037	3437	1.7	0.5
q [l.s^{-1}km^{-2}]	15.7	4.4	82.3	7.9	26.2		
R [mm]	493.9						
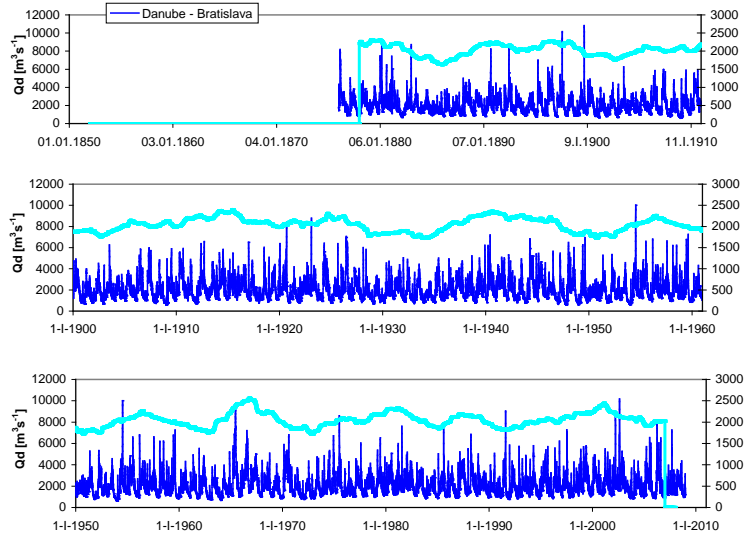
Fig. 1. Daily discharge and 4-years moving averages.
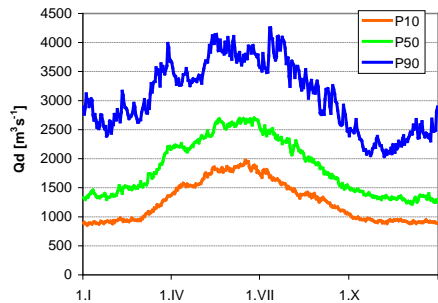
Fig. 2. Long-term percentiles of daily discharge.
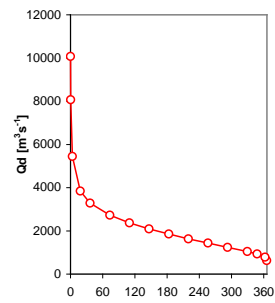
Fig. 3. M-days water.

## Mean Monthly and Seassonal Discharges in m³/s

Station	Danube - Bratislava			Elevation:	128 m
Catchment	131338 km^2			Latitude:	48.14
				Longitude:	17.11

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year	XI-IV	V-X
Qma	1636	1728	2090	2386	2681	2780	2623	2283	1908	1550	1477	1525	**2057**	1807	2304
Qmin	770	745	937	1020	1275	1493	1326	1090	737	633	812	664	**1420**	1209	1285
Qmax	5117	4366	4900	4855	5283	7324	5424	5007	4594	2919	3684	3686	**2910**	3057	3774
Vm	4.4	4.2	5.6	6.2	7.2	7.2	7.0	6.1	4.9	4.2	3.8	4.1	**65**	28.3	36.6
Rm	33.4	31.8	42.6	47.1	54.7	54.9	53.5	46.5	37.6	31.6	29.1	31.1	**494**	215.2	278.8
Vm/Va	6.8	6.4	8.6	9.5	11.1	11.1	10.8	9.4	7.6	6.4	5.9	6.3	**100**	44	56
tr	-1.688	0.024	2.100	2.771	-0.350	-1.217	-1.125	-2.222	-2.846	-0.638	1.360	2.385	**-0.124**	1.159	-1.400
cs	1.92	1.32	0.88	0.82	0.91	2.10	1.14	1.06	1.48	0.63	1.52	1.26	**0.33**	0.73	0.71
cv	0.427	0.397	0.331	0.283	0.257	0.274	0.294	0.303	0.354	0.296	0.342	0.360	**0.158**	0.196	0.186

|	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year	XI-IV	V-X
1841-1870															
1856-1885	2300	2254	2250	1975	2336	2629	2485	2244	1830	1596	1524	1724	**2095**	2004	2187
1871-1900	1842	1923	2125	2204	2624	2780	2552	2437	2102	1578	1406	1412	**2083**	1819	2345
1886-1915	1489	1566	2035	2411	2863	2852	2717	2408	2177	1581	1354	1366	**2071**	1703	2433
1901-1930	1676	1528	1868	2318	2846	2801	2707	2323	2067	1592	1443	1485	**2057**	1720	2389
1916-1945	1644	1652	1925	2375	2721	2917	2579	2345	2004	1675	1585	1445	**2074**	1771	2373
1931-1960	1458	1673	2150	2422	2521	2792	2762	2286	1765	1554	1514	1418	**2028**	1773	2280
1946-1975	1490	1682	2014	2365	2638	2826	2867	2276	1639	1383	1381	1501	**2007**	1739	2272
1961-1990	1585	1813	2044	2485	2759	2918	2631	2236	1733	1456	1408	1669	**2063**	1834	2289
1976-2005	1720	1864	2306	2486	2626	2605	2432	2135	1816	1568	1559	1717	**2071**	1942	2197
1901-2005	1592	1689	2074	2417	2697	2788	2656	2252	1855	1550	1490	1551	**2053**	1807	2300
1931-2005	1559	1754	2156	2456	2638	2783	2636	2223	1771	1533	1509	1577	**2051**	1835	2264
1951-2005	1596	1763	2151	2449	2676	2768	2657	2217	1748	1517	1486	1635	**2057**	1847	2264
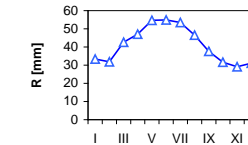
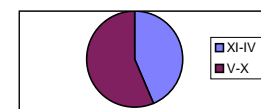Long-term monthly runoff.
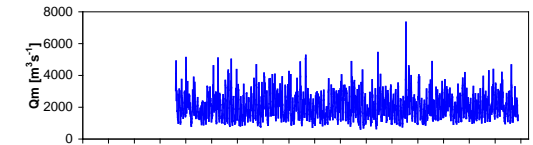
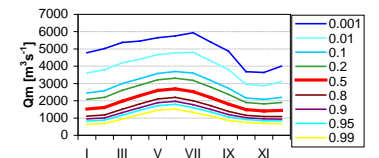Course of monthly discharges.
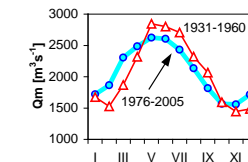
Comparision of two periods
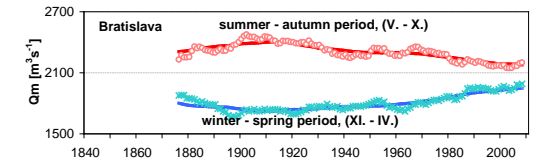
Course of moving averges of seassonal discharges.

Share of the summer-autumn discharge

Percentiles (log-normal distributions) of monthly doscharges.

River: Danube   Station: Bratislava   Area: 131.338 10^3 km²   SK

Basic statistical characteristics

	Qa m3/s	qa l/s/km2	Qmin m3/s	Qmax m3/s	cs	cv	Med. m3/s	trend	Hurst
1876-2005	2059	15.7	1420	2910	0.32	0.16	2035	-0.0609	0.525

Period	Qa	qa	Qmin	Qmax	cs	cv
1871-1880						
1881-1890	1919	14.6	1556	2363	-0.01	0.16
1891-1900	2131	16.2	1716	2640	0.35	0.14
1901-1910	2003	15.3	1575	2768	1.08	0.17
1911-1920	2169	16.5	1666	2438	-0.86	0.13
1921-1930	2001	15.2	1543	2621	0.28	0.18
1931-1940	2007	15.3	1420	2393	-0.61	0.15
1941-1950	2061	15.7	1543	2688	0.33	0.22
1951-1960	2015	15.3	1657	2342	-0.27	0.10
1961-1970	2161	16.5	1634	2910	0.48	0.23
1971-1980	1968	15.0	1511	2331	-0.36	0.17
1981-1990	2059	15.7	1719	2499	0.47	0.14
1991-2000	2057	15.7	1789	2387	0.64	0.10
2001-2006	2120	16.1	1647	2689	0.40	0.17

Period	Qa	St.dev	qa	cs	cv
1886-1915	2071	326	15.8	0.16	0.16
1901-1930	2057	327	15.7	0.16	0.16
1916-1945	2074	344	15.8	-0.02	0.17
1931-1960	2028	321	15.4	0.21	0.16
1946-1975	2007	372	15.3	0.78	0.19
1961-1990	2063	374	15.7	0.53	0.18
1976-2005	2071	268	15.8	0.38	0.13

Long term 30-year dicharge.

Average anual discharge, diferences from 7-year moving averages.

$y = -0.0152x + 2060.6$

Long term 10-year dicharge.

Autocorrelogram of yearly discharge.

Danube: Bratislava, 1876-2006
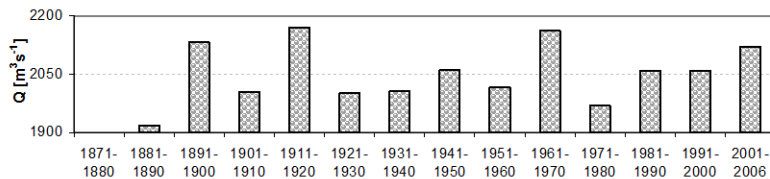
Combined periodogram of yearly discharge.

River: Danube   Station: Bratislava   Area: 131.338 10^3 km²   SK
Qmax

Basic statistical characteristics

	Qmax m3/s	qmax l/s/km2	min m3/s	max m3/s	cs	cv	Med. m3/s	trend
1876-2005	5866	44.7	3000	10870	0.86	0.28	5604	2.1121

Period	Qmax	qmax	min	max	cs	cv
1871-1880						
1881-1890	5560	42.3	3570	9062	0.68	0.39
1891-1900	6433	49.0	3619	10870	0.61	0.41
1901-1910	5253	40.0	3653	6485	-0.36	0.20
1911-1920	5958	45.4	4510	8616	1.09	0.20
1921-1930	5793	44.1	3430	8998	0.48	0.31
1931-1940	5118	39.0	3000	7260	0.17	0.22
1941-1950	5714	43.5	3153	7160	-1.09	0.20
1951-1960	6472	49.3	4431	10400	1.21	0.27
1961-1970	5855	44.6	4042	9224	1.08	0.27
1971-1980	5649	43.0	4124	8715	1.03	0.26
1981-1990	5661	43.1	3693	7686	0.39	0.24
1991-2000	6397	48.7	5268	9430	2.08	0.19
2001-2006	6798	51.8	4435	10370	0.68	0.30

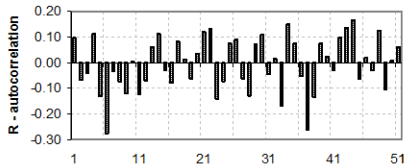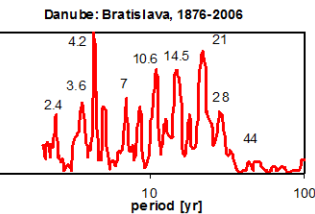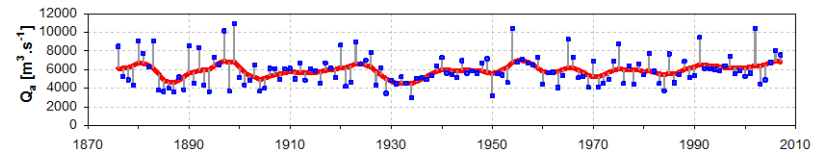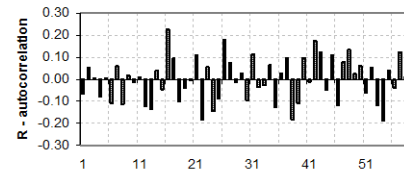| Period	Qmax	St.dev	qmax	cs	cv
1886-1915	5679	1880	43.2	1.21	0.33
1901-1930	5668	1376	43.2	0.58	0.24
1916-1945	5633	1410	42.9	0.60	0.25
1931-1960	5768	1424	43.9	0.85	0.25
1946-1975	6029	1620	45.9	0.74	0.27
1961-1990	5722	1417	43.6	0.80	0.25
1976-2005	5996	1456	45.7	1.25	0.24
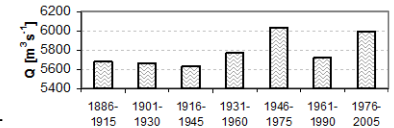
Long term 30-year dicharge.

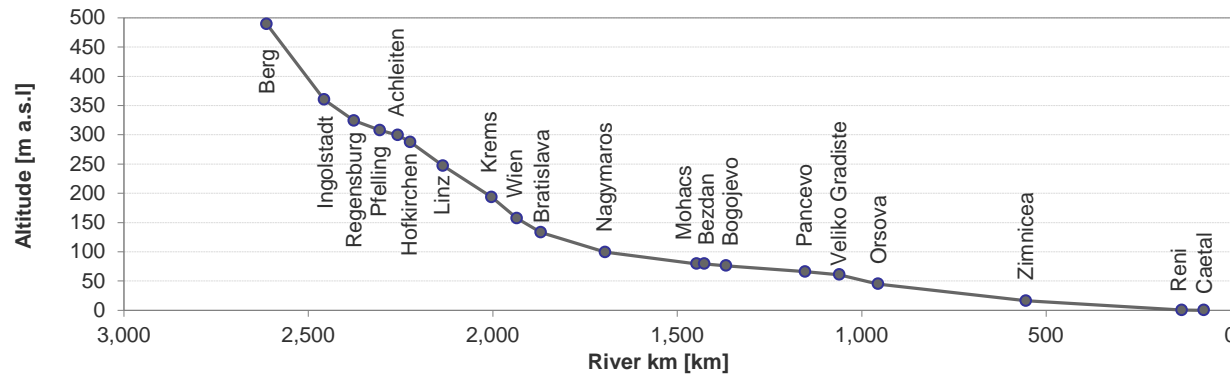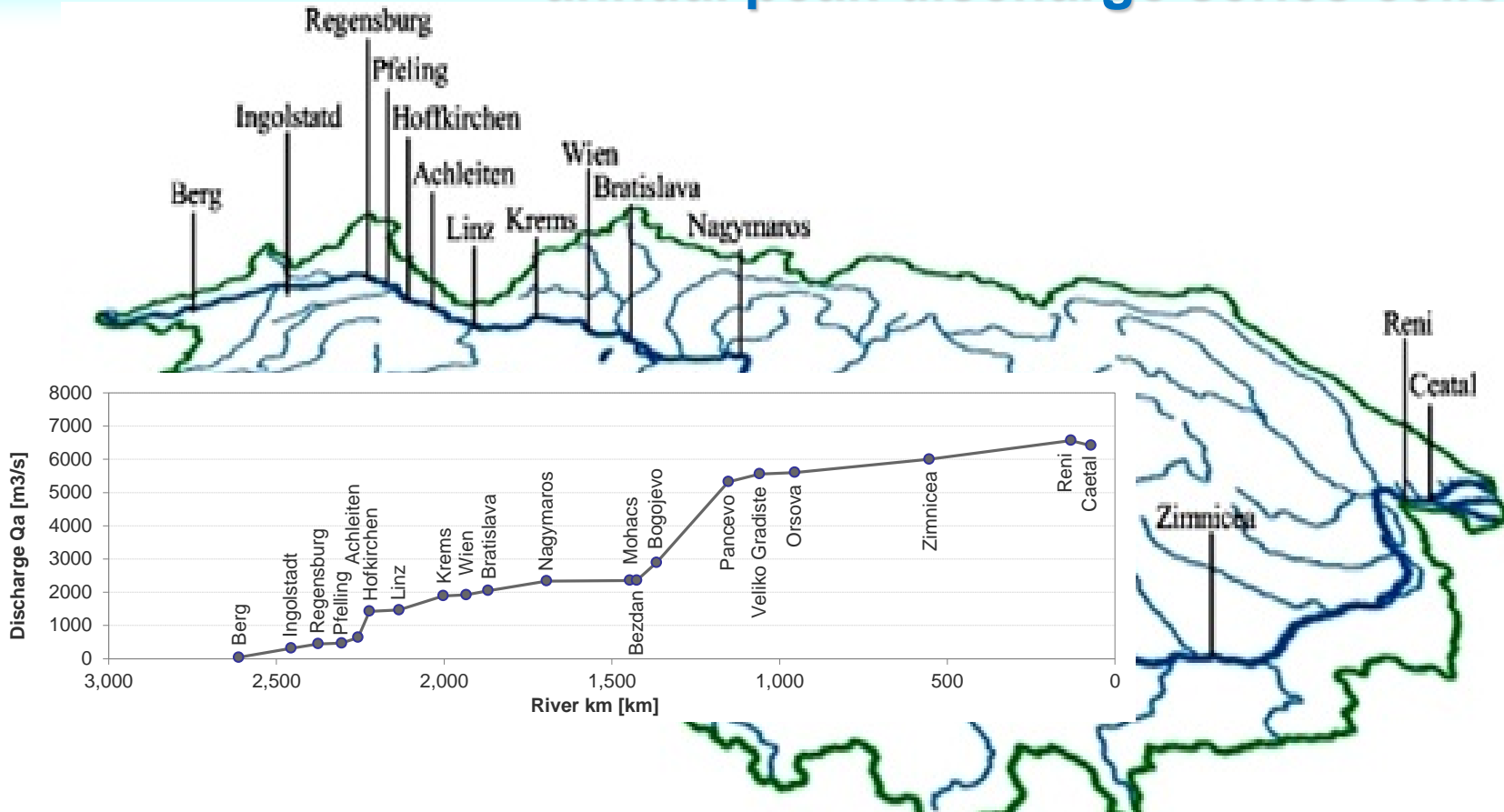*Average anual discharge, diferences from 7-year moving averages.*
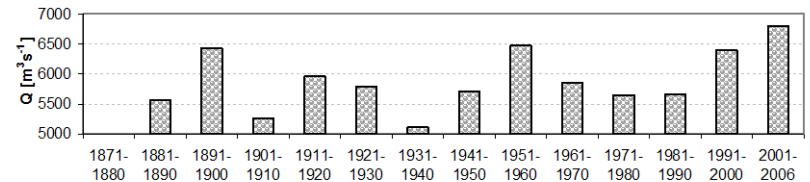
Long term 10-year dicharge.

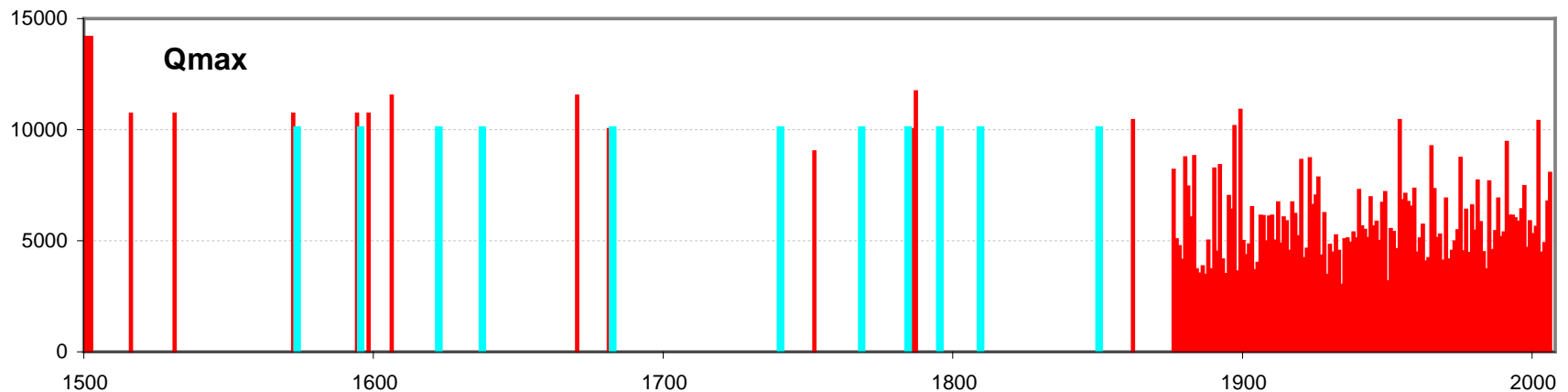*Autocorrelogram of yearly discharge.*

Historical
floods –
important
source of
informatiom

Melk,
Ferry boat station

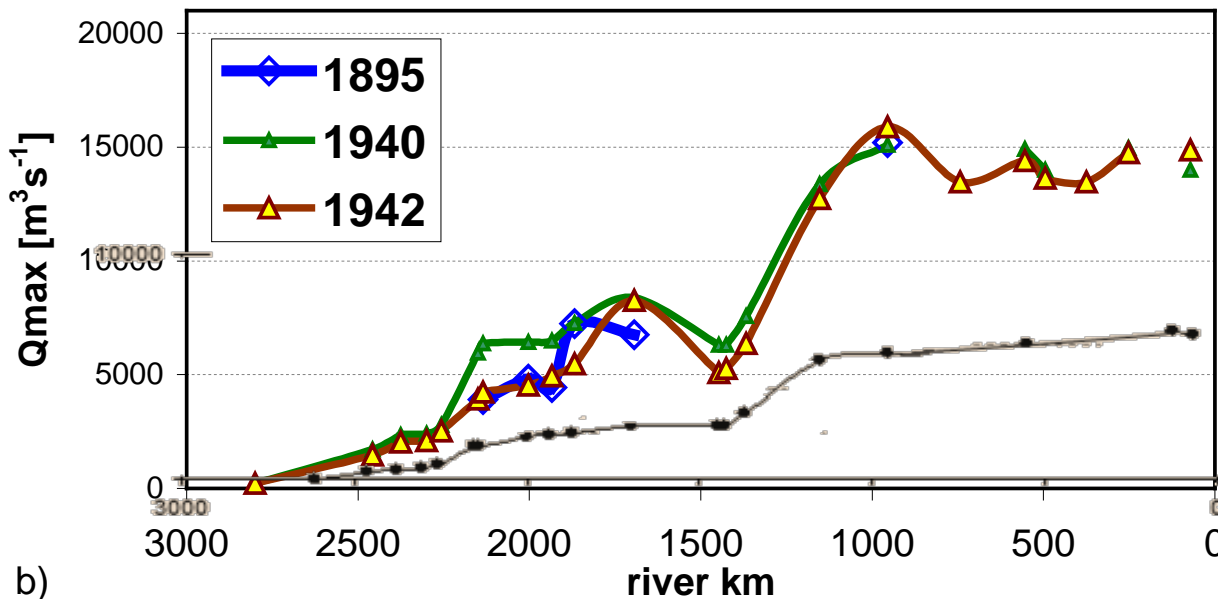# O2:History and propagation of floods

Historical Danube floods in river section Kienstock – Bratislava since 1500 up to 1876
(dark columns – summer floods, light columns – winter floods),
since 1876- the observed annual peaks *Qmax* at Bratislava

# History of the extreme floods downstream the Danube River

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a)
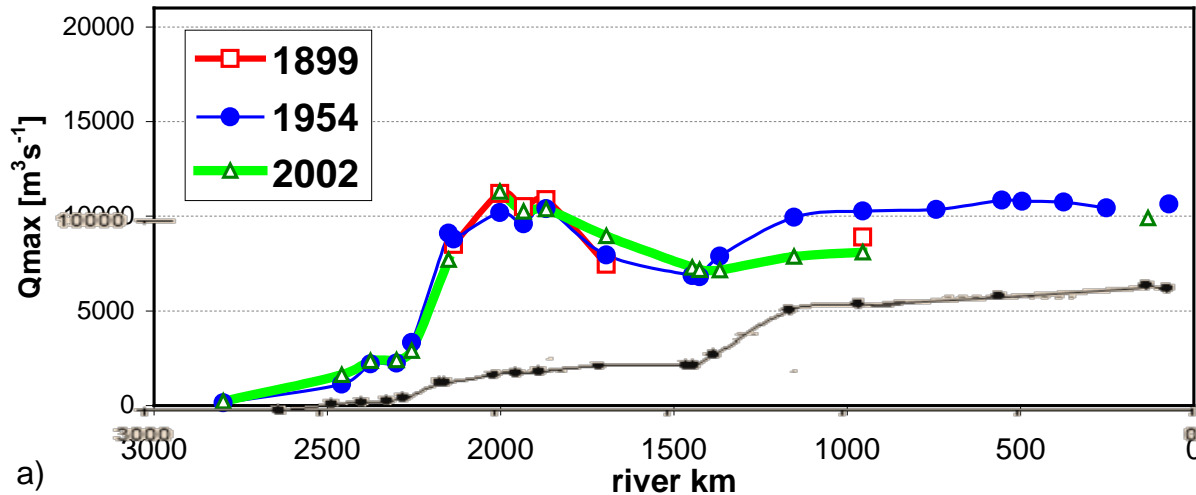
On the upper Danube from Passau city, the highest floods during the observation period occurred in years 1862, 1897, 1899, 1954, and 2002

b)

On the lower Danube it have been those in the years 1895, 1940, 1942, 1970, 1980

# History and propagation of the extreme floods downstream the Danube River

c)
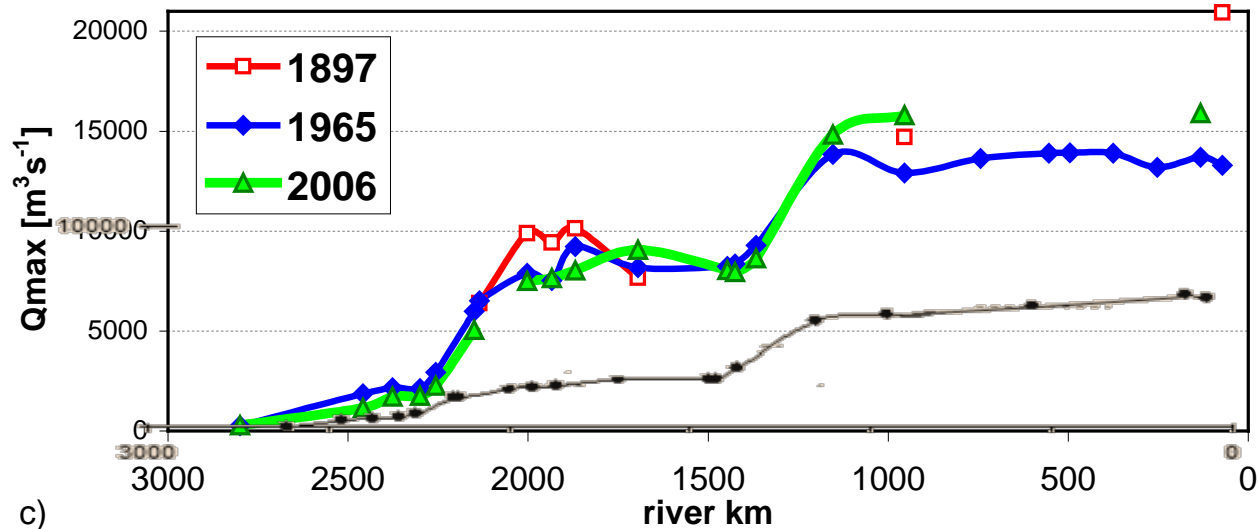
In the years 1897, 1965, or in 2006, the flood occurred in the whole Danube basin
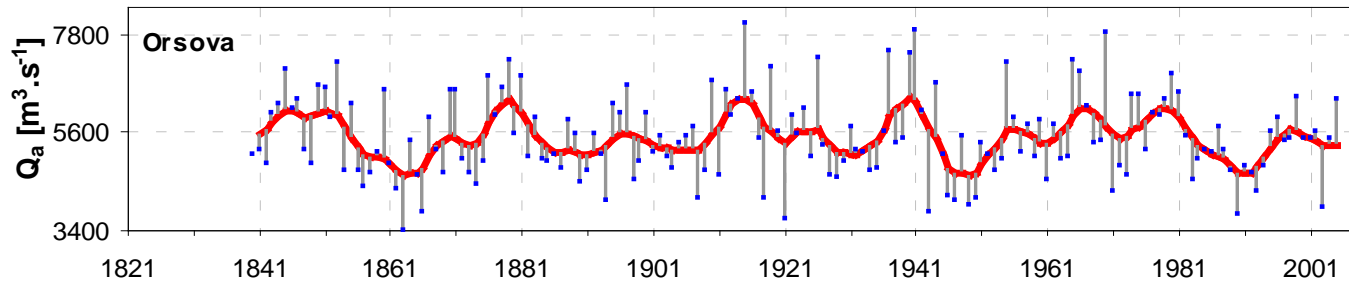
Propagation of the 50- and 99-percentiles
downstream the Danube River
and comparision with historic floods
in 1501 upper Danube, Kresser (1957),
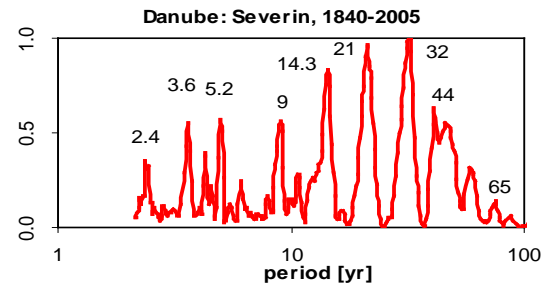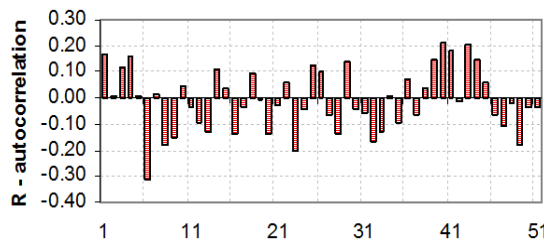## in 1897 Ceatal Izmail, Bondar & Panin (2001)
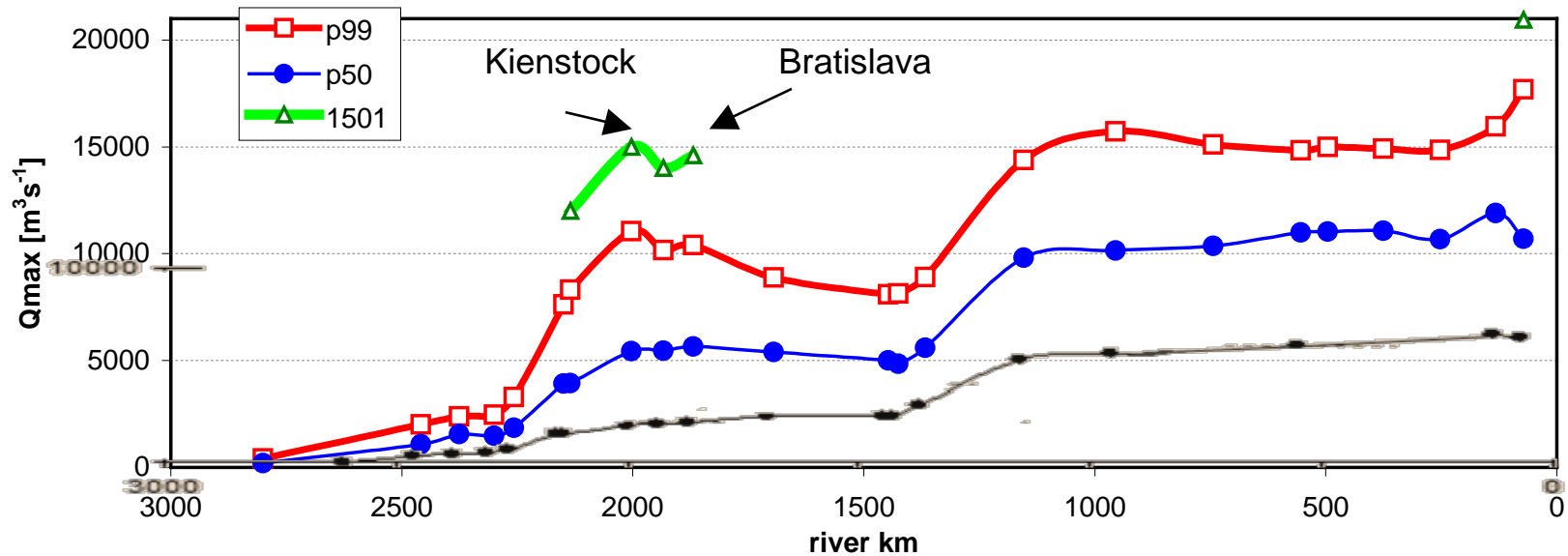
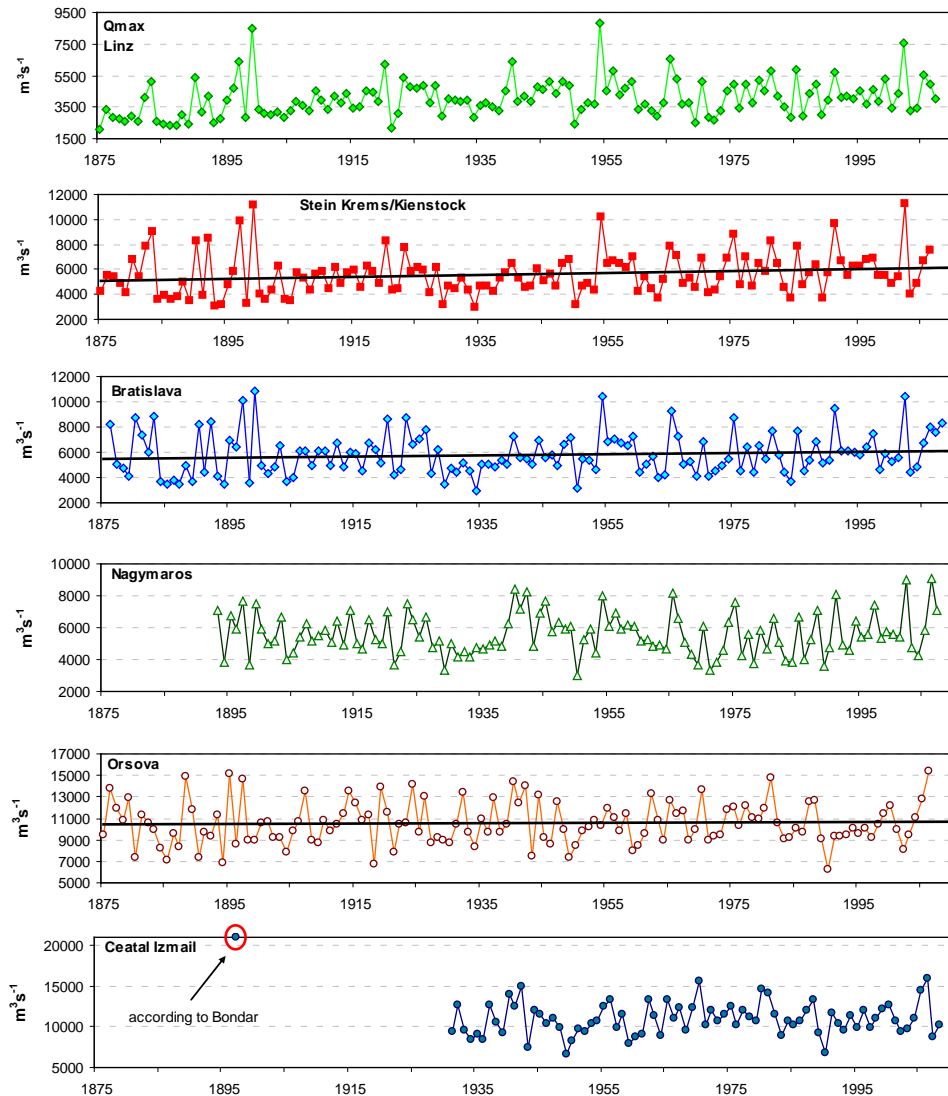# Propagation of the extreme floods downstream the Danube River
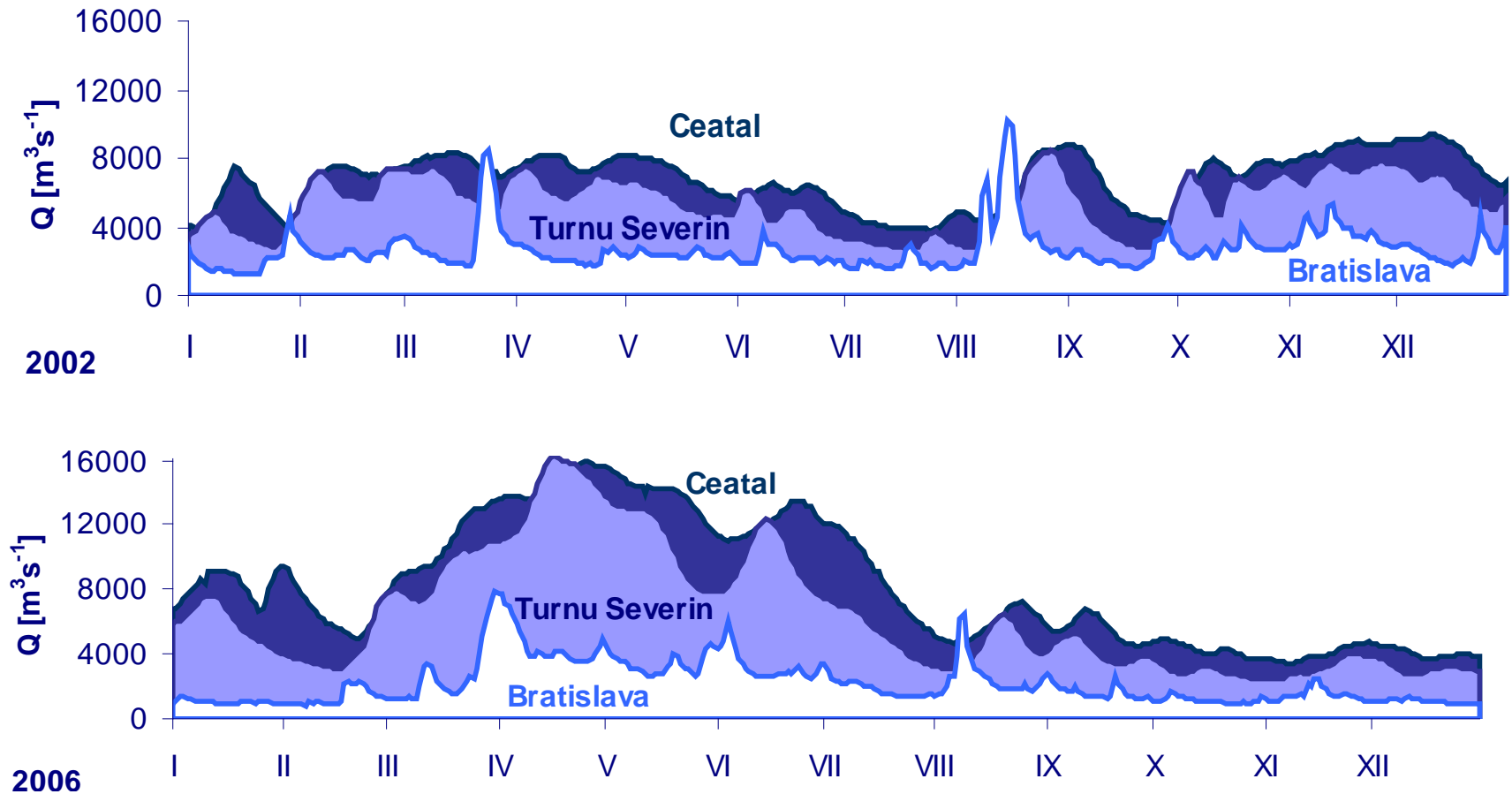
Long term linear trend of the mean annual discharge in the Orsova/Turnu Severin station, 7-year moving averages
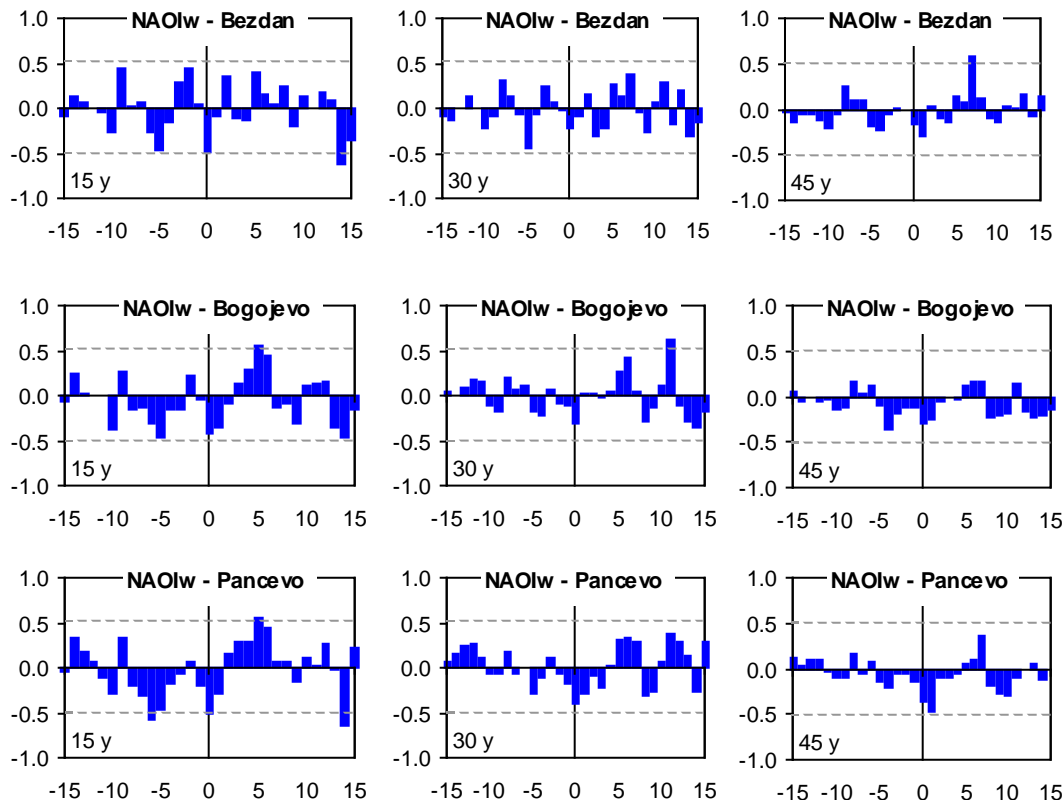

Auto-correlograms (left column), and normalized combined periodograms (right column) of the mean annual discharges in the Orsova/Turnu Severin station, significant periods.

Long term linear trends of the maximum annual discharge in the selected stations of the Danube River.

Cross-correlation between winter NAO index (NAOI,w) and mean annual Danube discharge at selected stations for three periods: 15-, 30-, and 45- years.
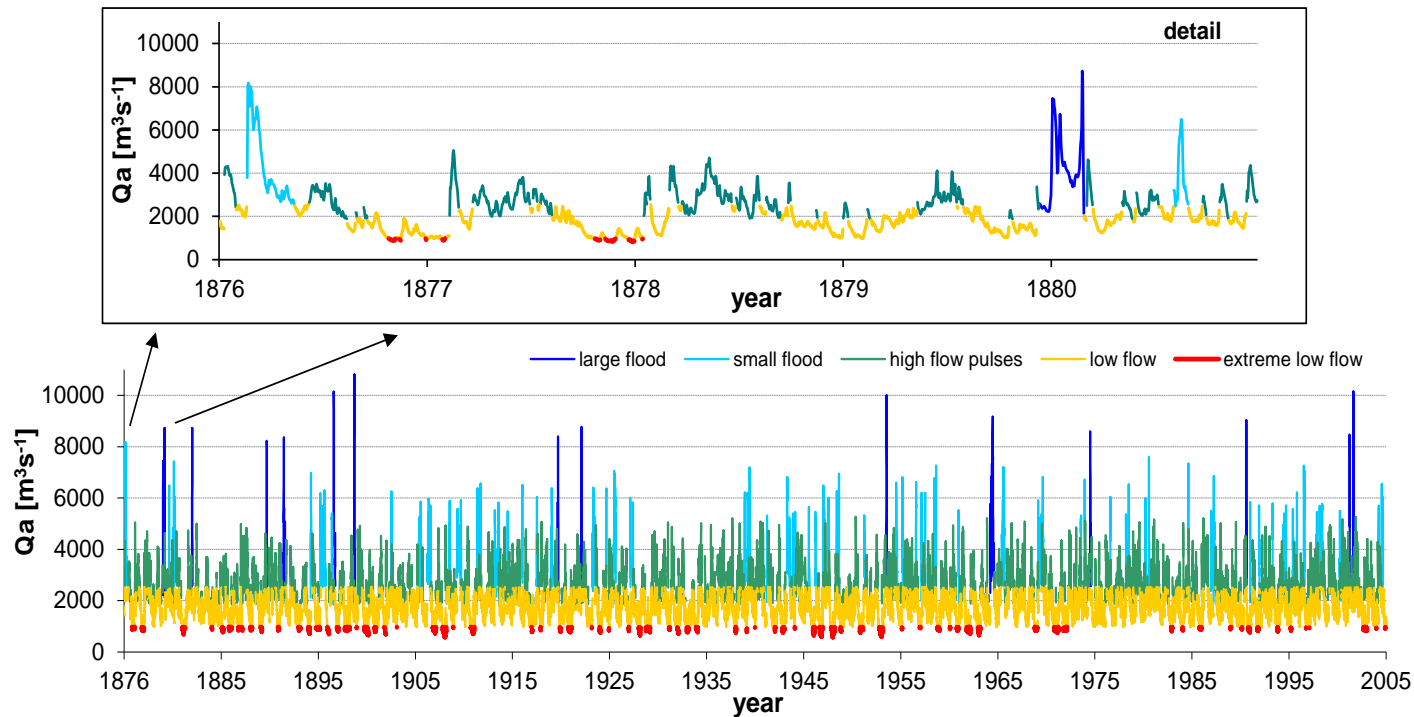
Classification of hydrographs into different flow types (large floods – dark blue, small floods – blue, high flow pulses – green), Danube: Bratislava water gauge. Detail from the years 1876–1880.
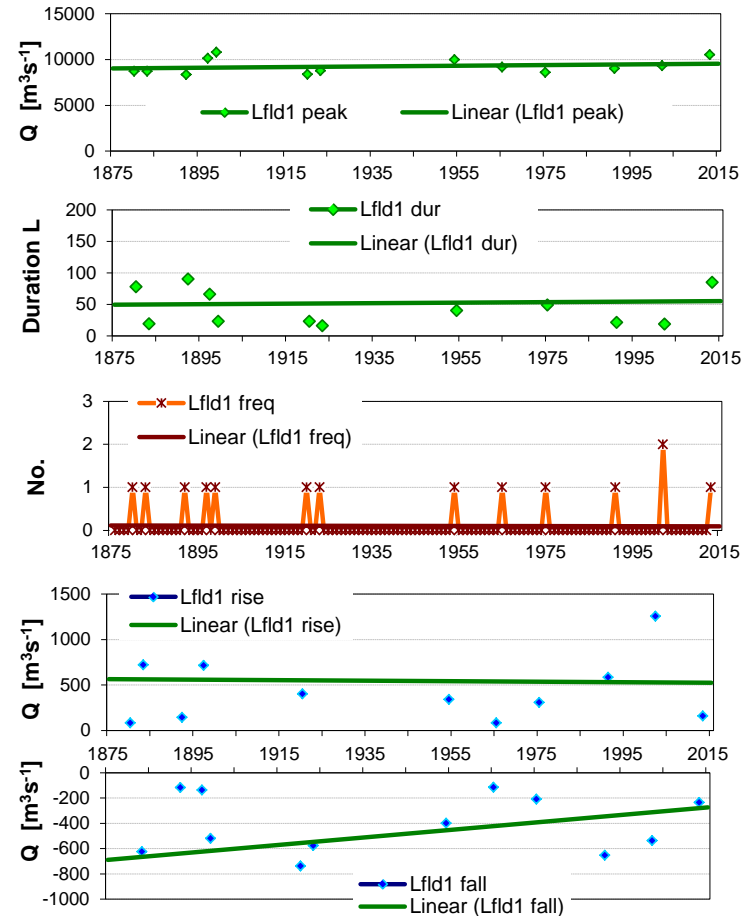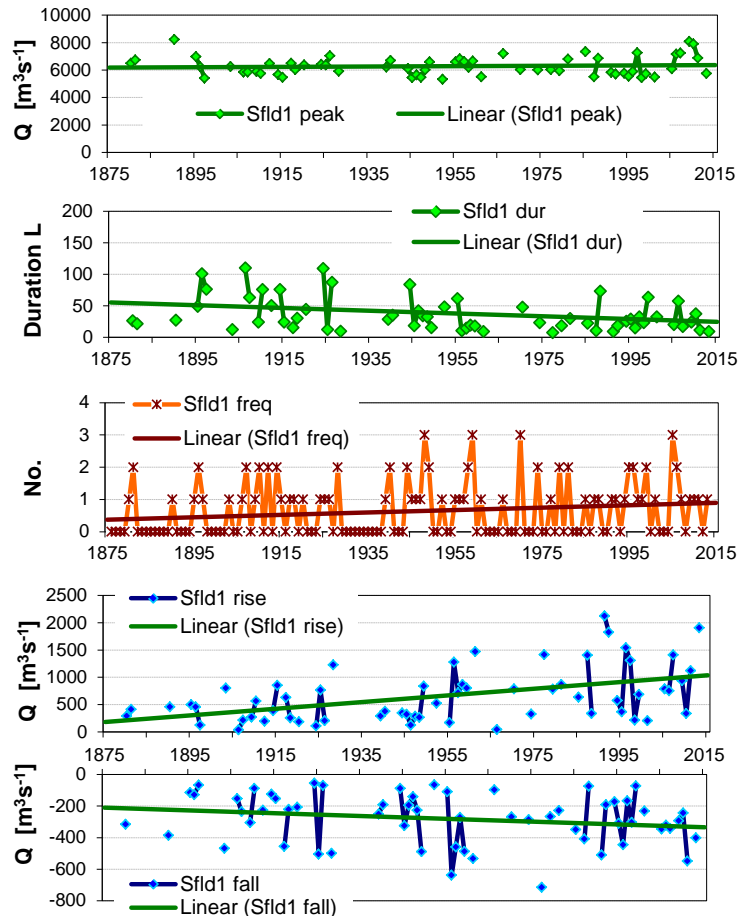
Time course (points) and linear trend (lines) of the selected discharge characteristics (peak discharges, number and duration of events, and rise and fall rates of the waves) for small and large flood categories

	Small Flood					Large Flood				
	peak	duration	frequency	rise rate	fall rate	peak	duration	frequency	rise rate	fall rate
Berg	-0.122	0.216	0.002	0.000	0.029	-0.041	0.051	0.000	-0.541	-0.068
Ingolstadt	-0.178	-0.014	0.000	0.297	-0.139	1.318	-0.018	0.000	0.109	-0.843
Regensburg	-1.112	-0.016	-0.001	1.540	0.311	1.218	0.171	0.003	-0.973	-0.308
Pfeling	-0.139	0.003	0.001	1.198	0.285	4.958	-0.173	0.002	-0.056	-0.954
Hofkirchen	0.958	-0.024	0.002	0.781	0.255	2.837	-0.121	0.002	1.277	-0.772
Achleiten	-0.198	-0.291	0.000	1.648	-0.583	-0.644	-0.259	0.002	1.347	-0.145
Linz	-2.201	-0.406	0.002	5.837	-1.879	-23.410	-0.882	0.001	4.247	-2.536
Stein-Krems	0.619	-0.098	0.003	3.467	-0.489	13.980	-0.056	0.002	2.050	-0.090
Wien	1.708	-0.139	0.002	4.699	-0.249	2.787	-0.154	0.002	5.187	-0.348
Bratislava	0.057	-0.248	0.003	**4.732**	-0.257	3.693	0.043	0.000	-0.272	2.971
Nagymaros	-2.796	-0.329	-0.001	1.958	-0.770	6.952	0.109	0.001	-0.980	-1.323
Mohacs	-2.755	-0.915	0.005	1.782	-0.971	-1.163	-0.757	0.002	-2.471	1.332
Bezdan	3.921	-1.431	-0.003	2.189	-1.197	8.742	-2.230	0.002	2.847	-1.030
Bogojevo	4.346	-1.284	-0.001	2.224	-1.330	20.990	-0.268	-0.002	-0.765	-0.545
Pancevo	5.487	-0.074	-0.004	0.032	0.131	22.400	0.566	-0.001	-1.498	-0.085
Veliko Gradiste	-6.673	-0.600	-0.003	1.883	-0.913	11.000	-0.511	0.001	1.885	-0.498
Orsova	1.861	**-0.589**	0.002	1.155	-0.692	1.030	-0.438	0.000	0.686	-0.762
Zimnicea	-8.442	-0.782	0.004	0.241	-0.231	19.580	-0.083	-0.002	-0.130	-0.660
Reni	-0.970	-1.135	0.003	1.336	-0.750	4.397	-1.536	0.002	1.910	-0.207
Caetal Izmail	-13.620	-1.155	0.004	0.102	0.135	11.100	0.610	0.002	-1.838	-0.650
		-	+	+	+	+	-			+

Thank you for your attention
and continuing collaboration