



**ARSO HYDRO**  
Slovenian Environment Agency

# Hydrological drought in Alpine regions of Slovenia

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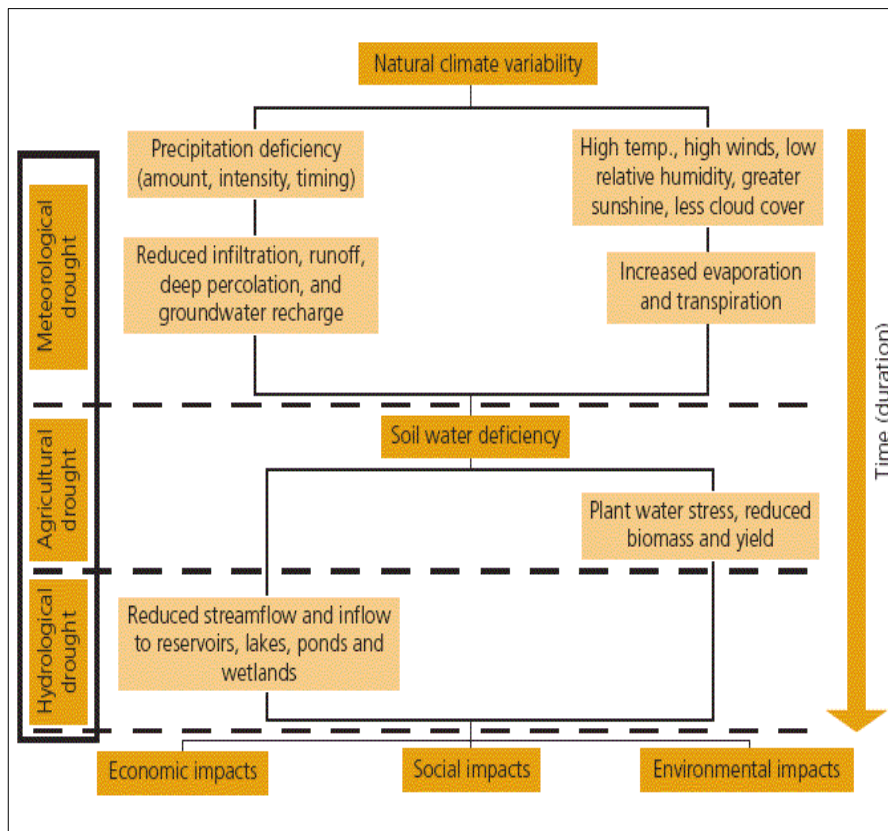
*Ajdovščina, 14th September 2017*





# What is Drought?

- Drought means lack of water (water that normally would be available in a region and to which nature and mankind adapted over centuries).
- It is a natural phenomenon, with spatial and temporal characteristics that vary significantly from one region to another.



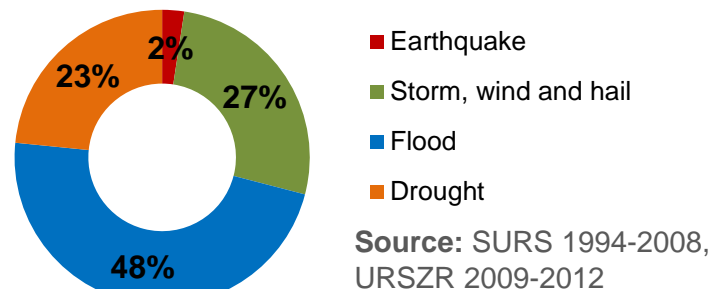
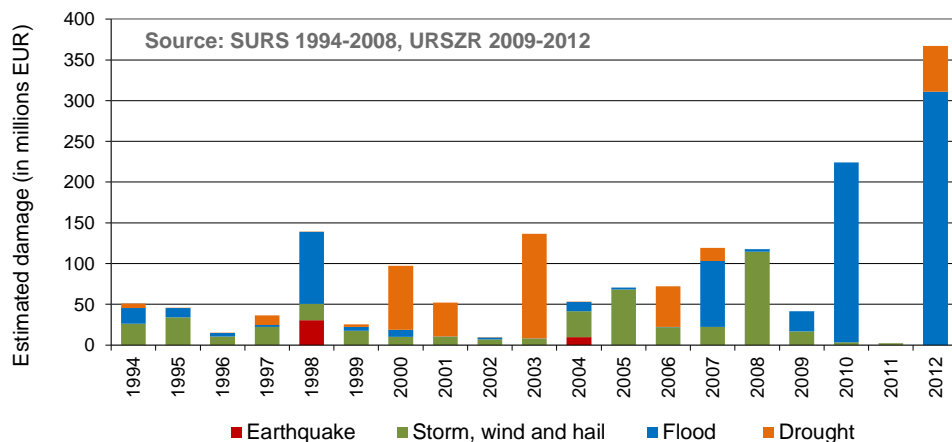
Sequence of drought occurrence and impacts for commonly accepted drought types (Source: NDMC, Nebraska, <http://drought.unl.edu>)





# Damage caused by natural disasters in Slovenia

Estimated damage caused by natural disasters in Slovenia in period 1994-2012



## Percent distribution by event in Europe:

Source:  
<http://natcatservice.munichre.com/>

Relevant natural loss events  
in Europe 1980 - 2016

Number of events:  
2,709



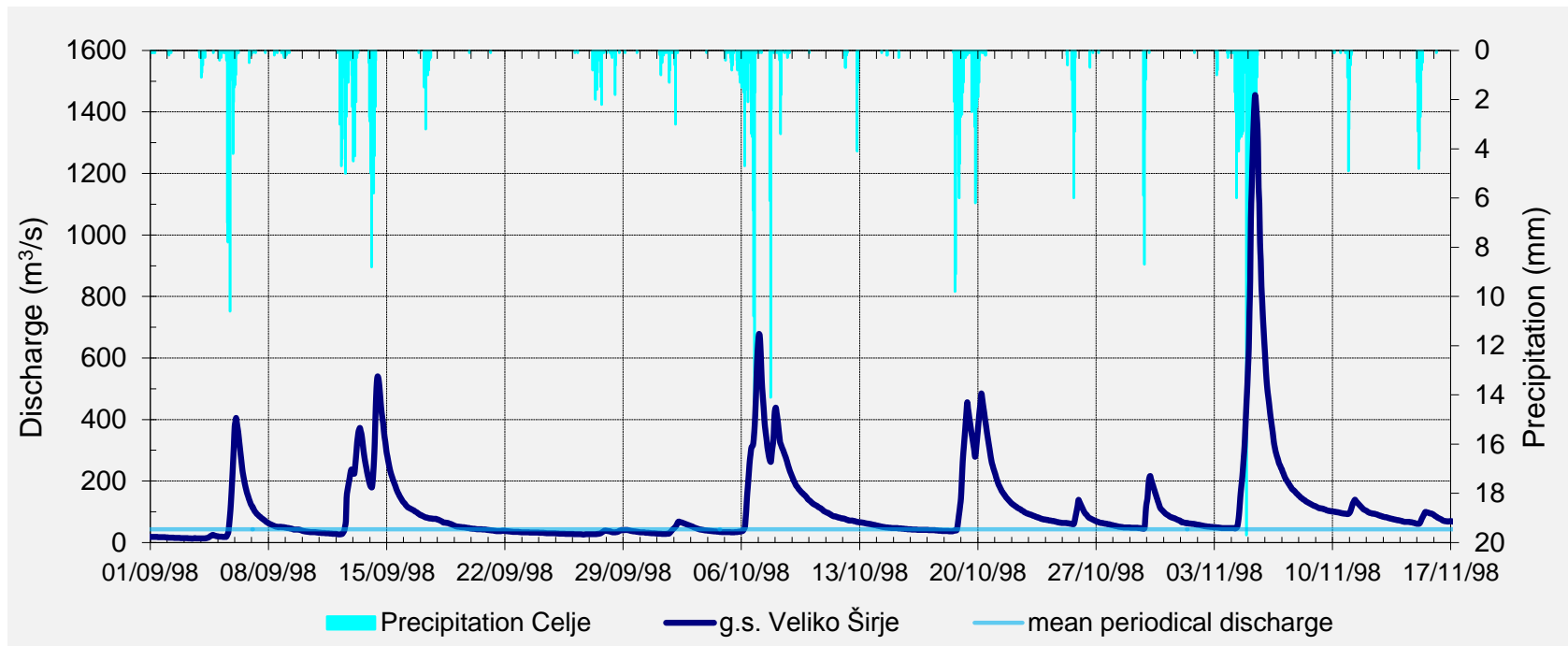
Overall losses:  
US\$ 587bn







# Time variability of Slovenian river discharges

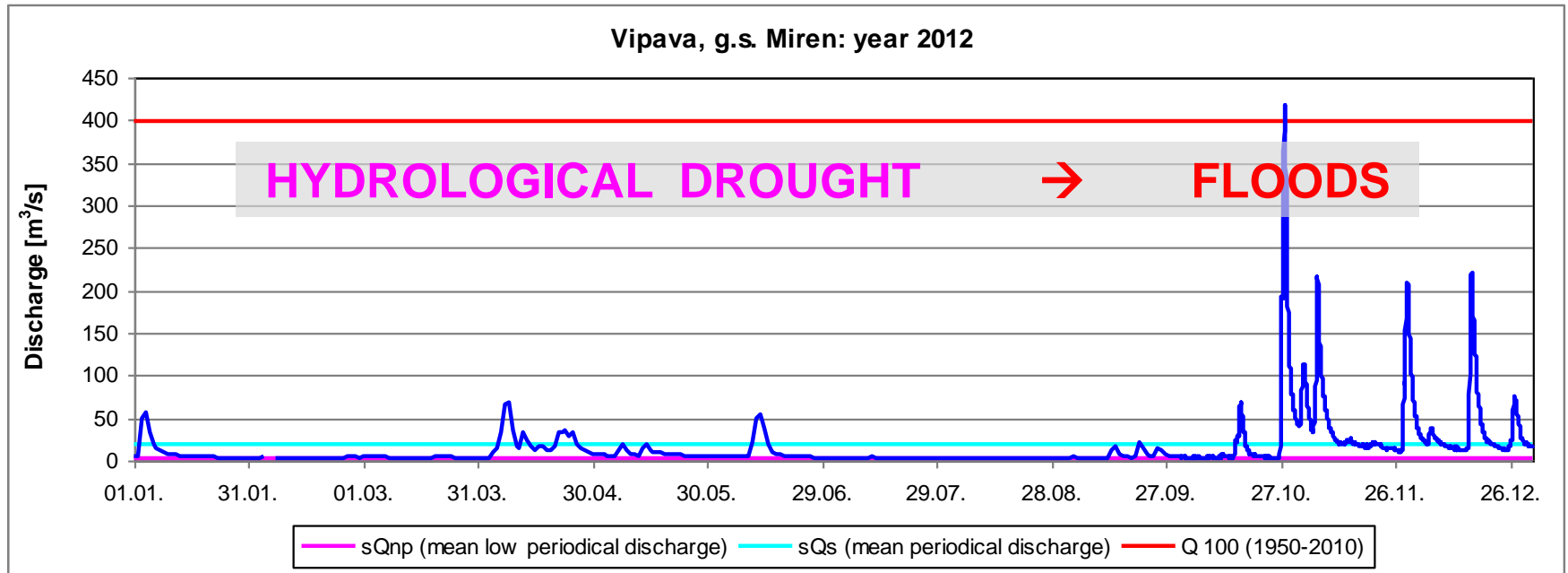


## Characteristics of Slovenian rivers:

- torrential character and fast runoff: lag time between rainfall and runoff is short (measured in hours), with the exception of karst rivers
- large variations between low, mean and high water are significant for the majority of the rivers (Sava at Litija 1:6:80; Savinja at Laško 1:10:335; Pesnica at Zamušani 1:26:714)

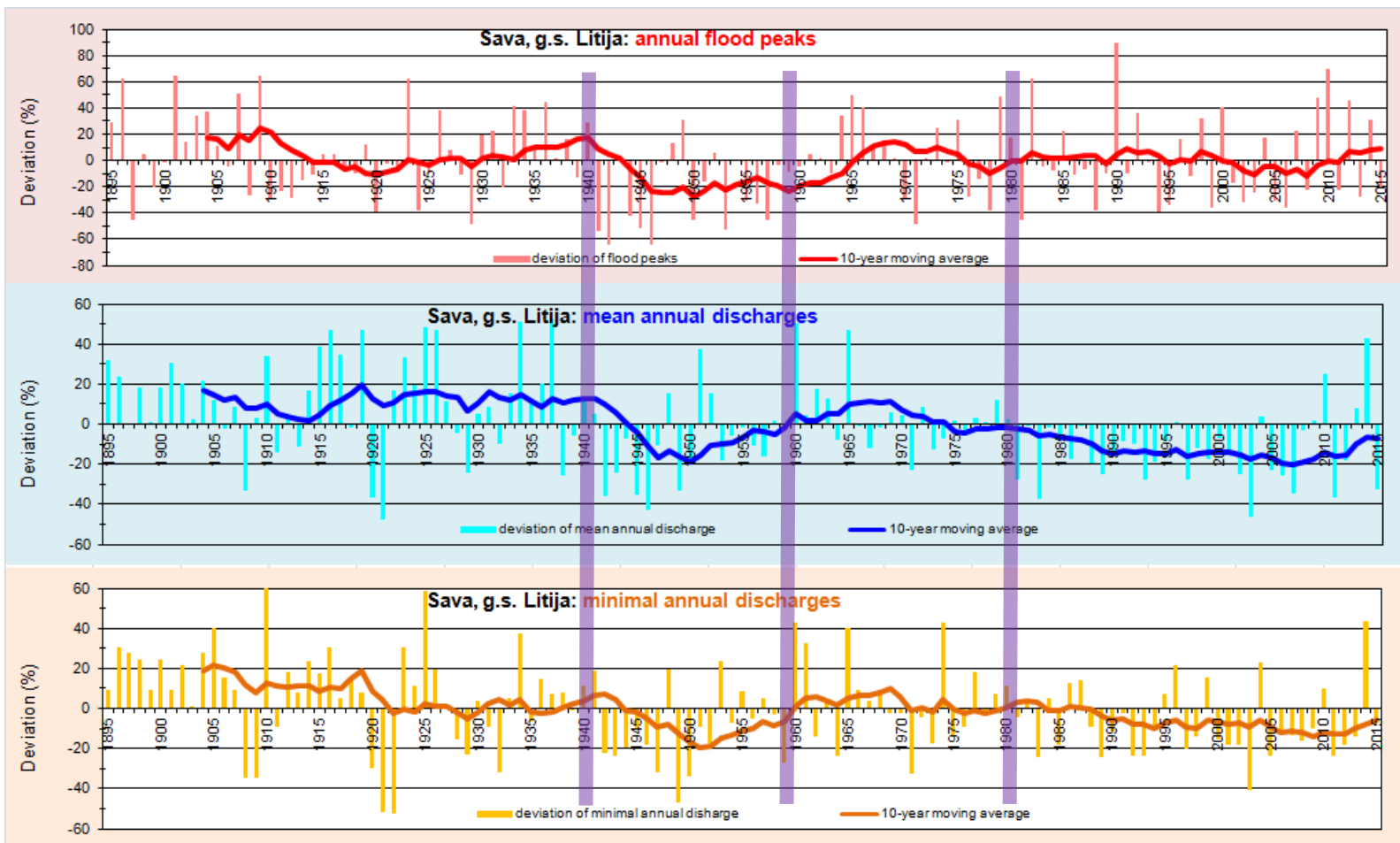


# Occurrence of hydrological extremes in Slovenia





# Changes in hydrological behaviour



Frequent  
floods

Decrease in  
mean flow

Longer and  
frequent  
drought  
periods

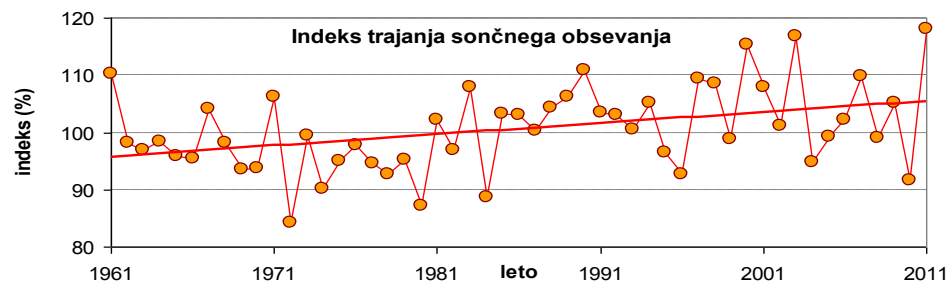
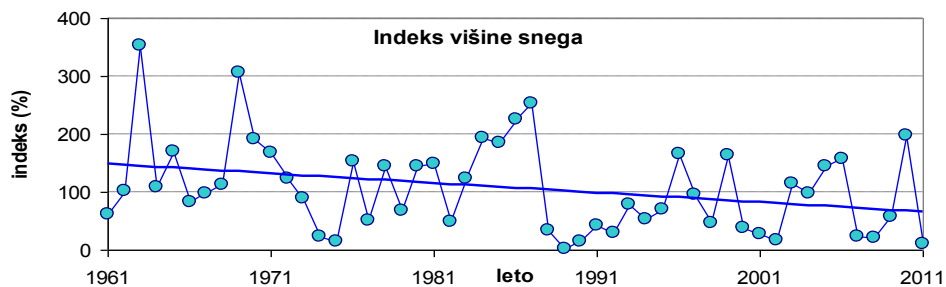
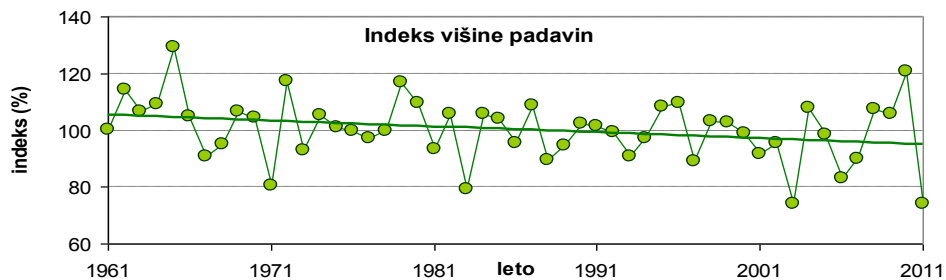
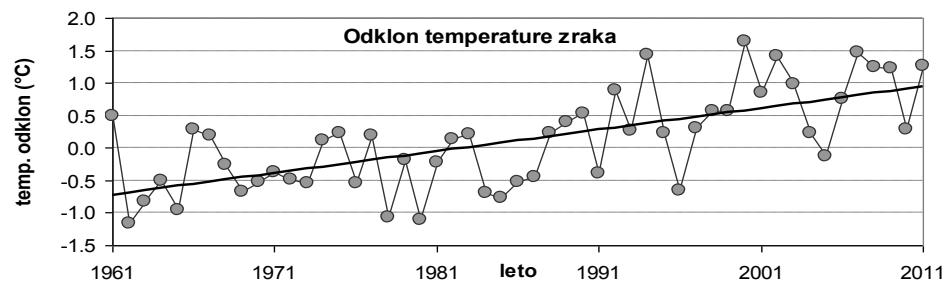
Catchment area to g.s. Litija on the Sava River: 4849,67 km<sup>2</sup>



# Observed climate variability and climate change in Slovenia

Linear time trend in Slovenia in the 50-year period 1961-2011:

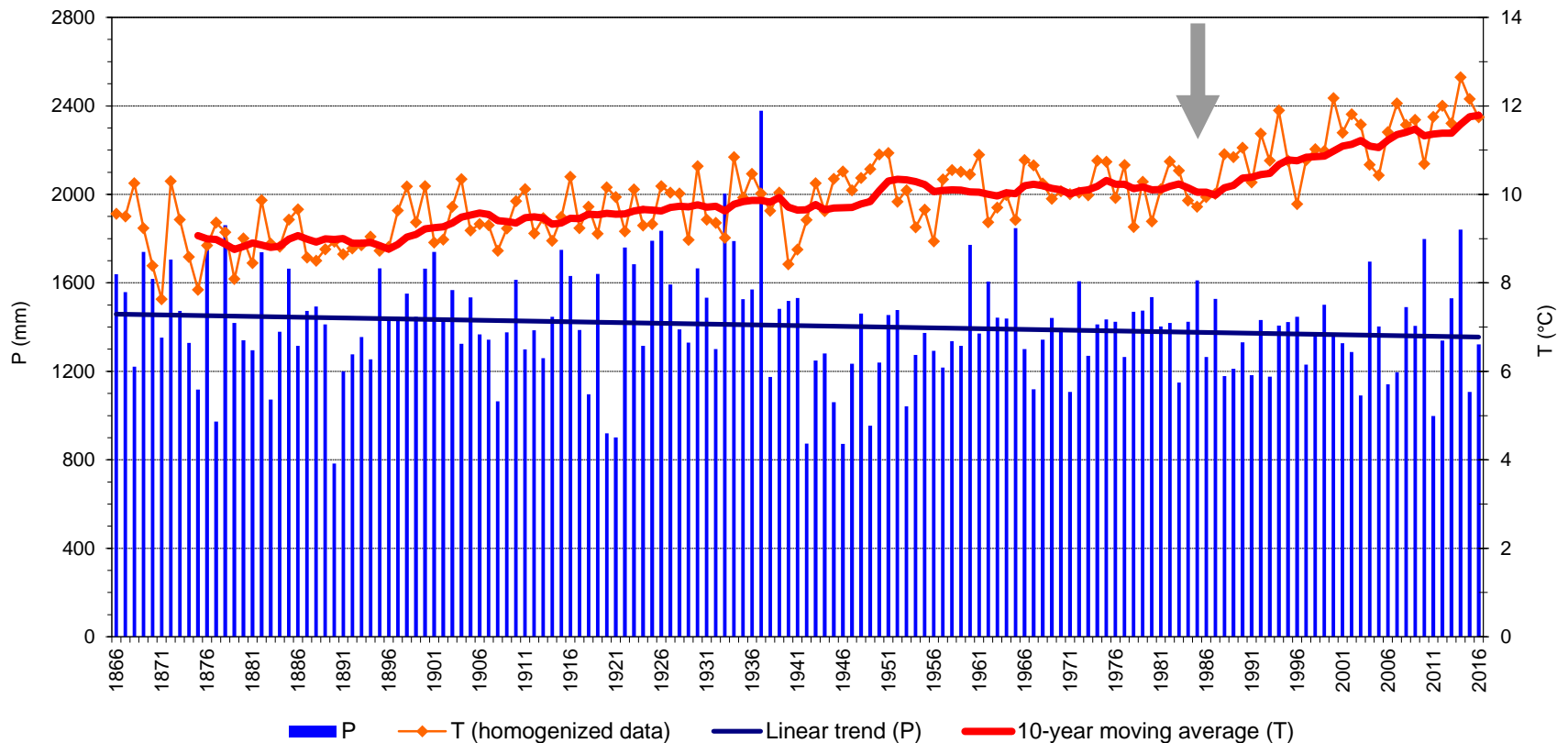
- air temperature: **+1.7°C**  
(+0.35 °C/10 let)
- precipitation: **-10%**  
(-2%/10 let)
- snow cover: **-75%**  
(-15%/10 let)
- solar radiation: **+10 %**  
(+2%/10 let)





# Observed climate variability and climate change in Slovenia

Annual precipitation (P) and mean annual air temperature (T) in Ljubljana (1866-2016)

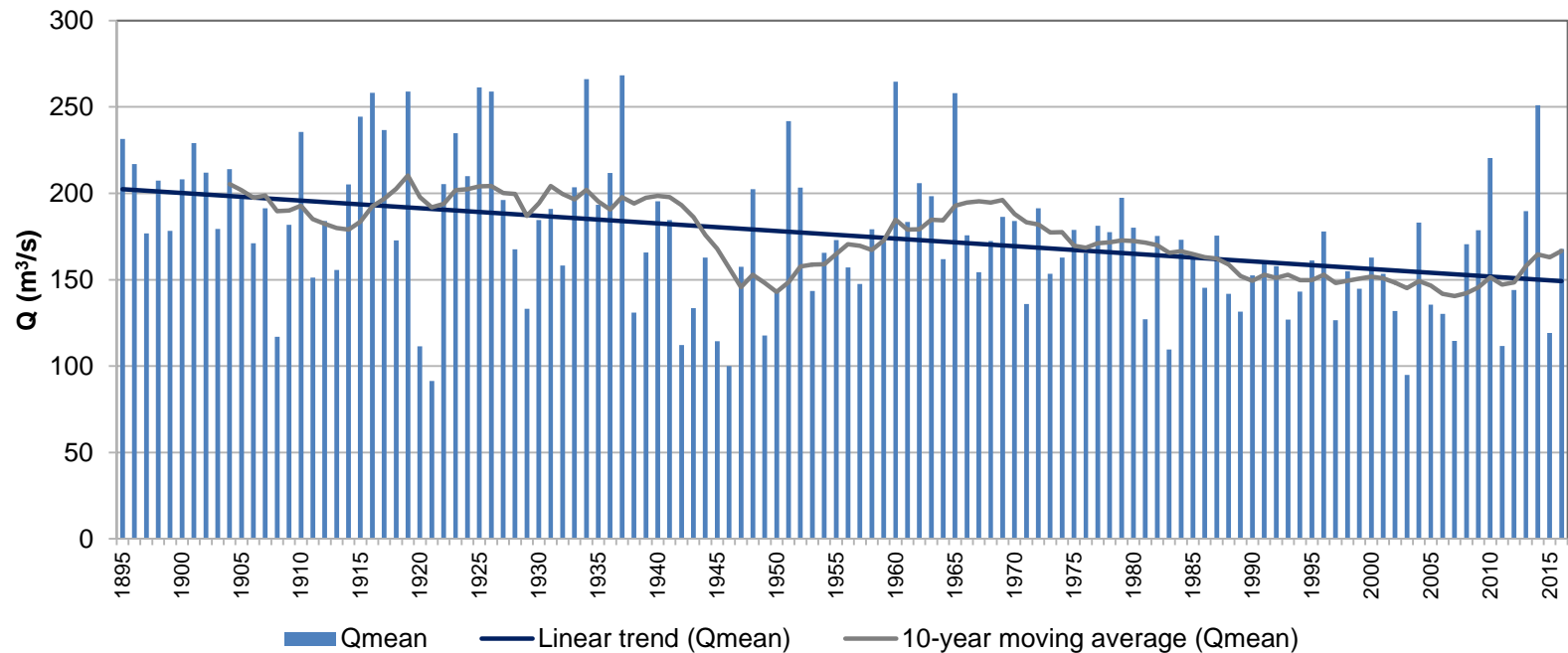






# Impact of climate variability and climate change on runoff

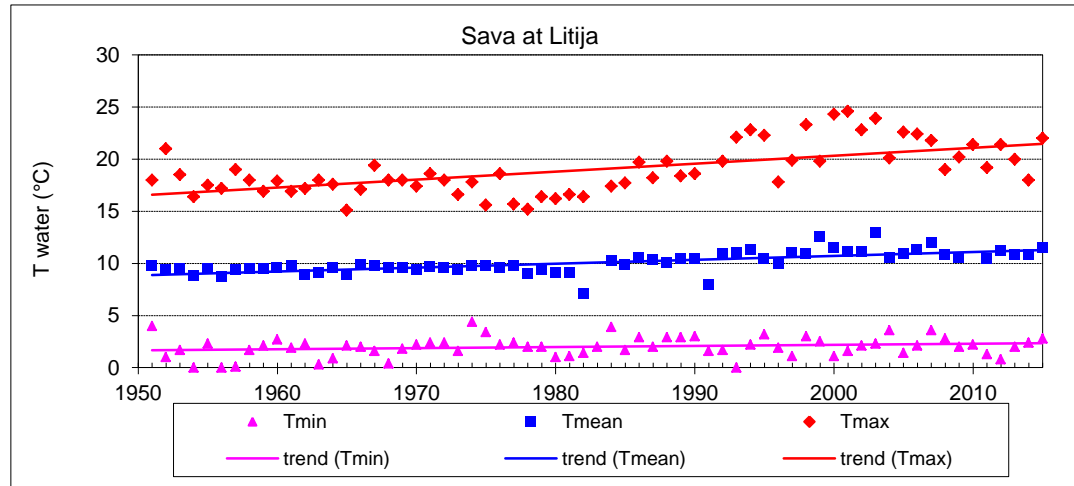
Mean annual discharge of the Sava River at Litija (1895-2016)



Linear trend gives -25% of discharge in the last 120 years (2%/10 let)!

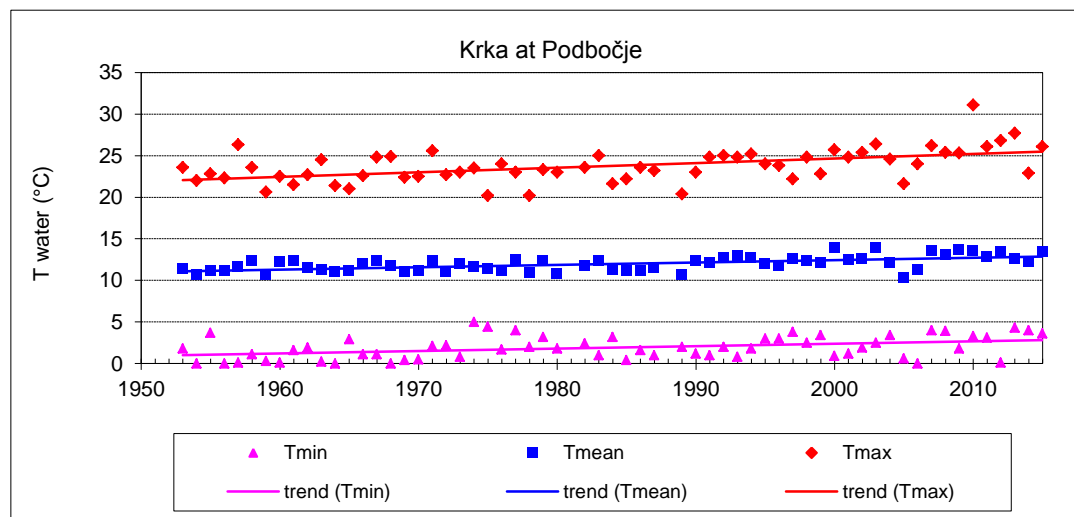


# Impact of climate change on water temperature



Linear trend of mean annual water temperature in Slovenia in the period 1953-2015: **+2.1°C** (+0,33 °C/10 let)

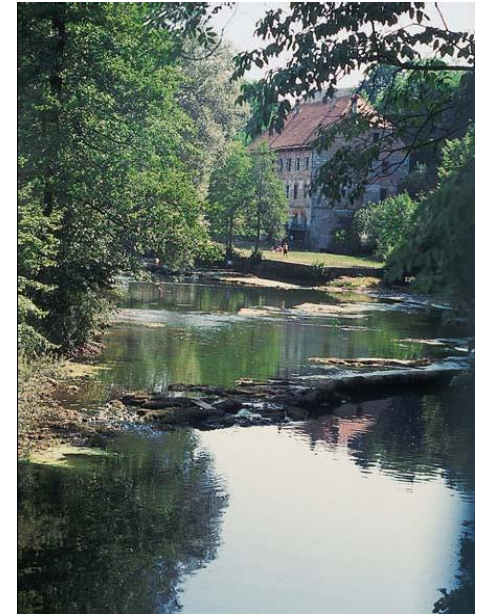
The rise is much higher at maximal temperatures





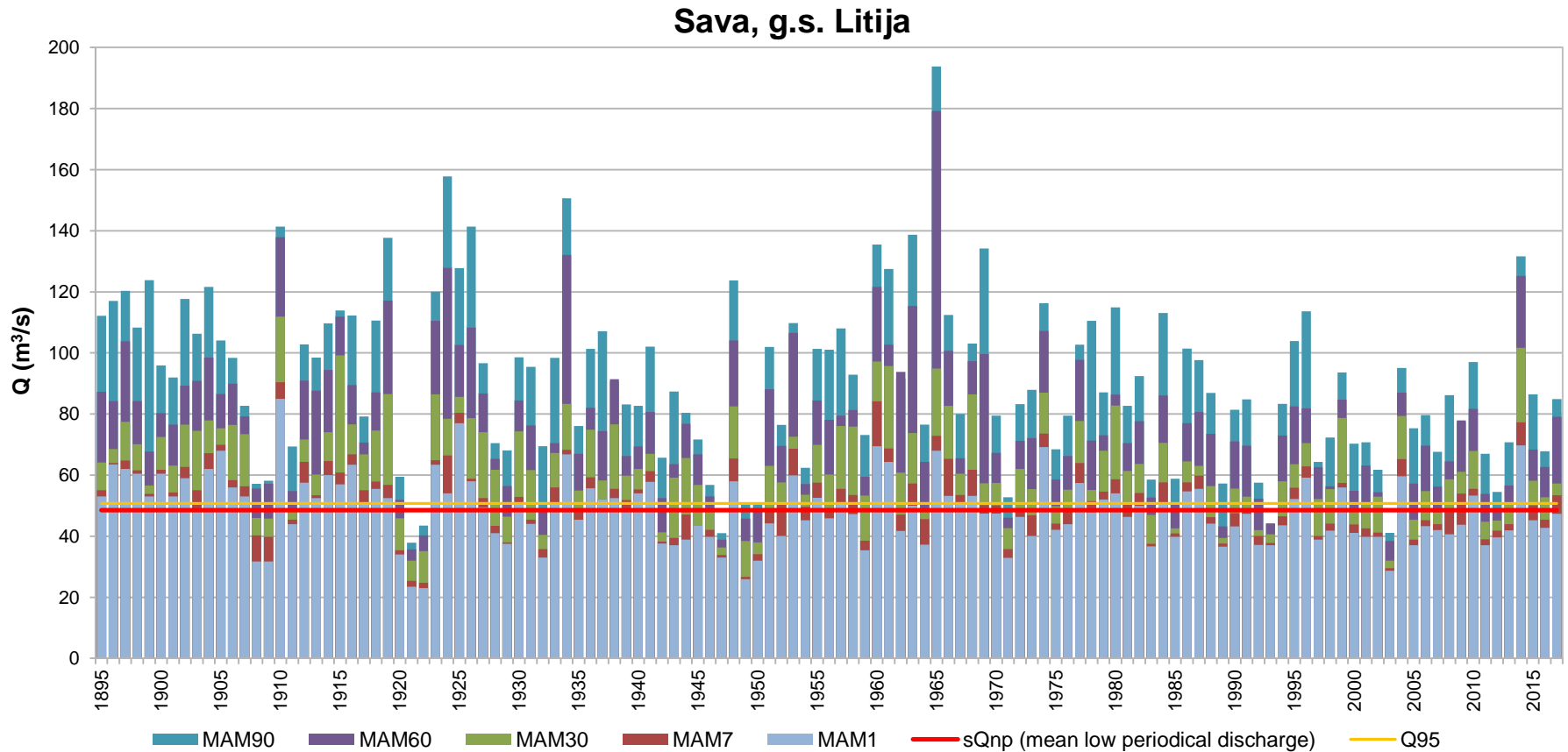
# Low flows and hydrological drought

- A low flow is a seasonal phenomenon (e.g., the "dry season") and is an important component of the flow regime in any river or stream.
- A hydrological drought is a natural event that results from an extended period of below average precipitation.
- While droughts include low flows, a continuous seasonal low-flow event is not necessarily a drought.
- A time series of low flow characteristics is suitable to characterize the hydrological regime of a river.
- Spatial aspects (area covered by drought) and the total deficit are important measures of the severity of an event.





# Hydrological low flow and drought characteristics

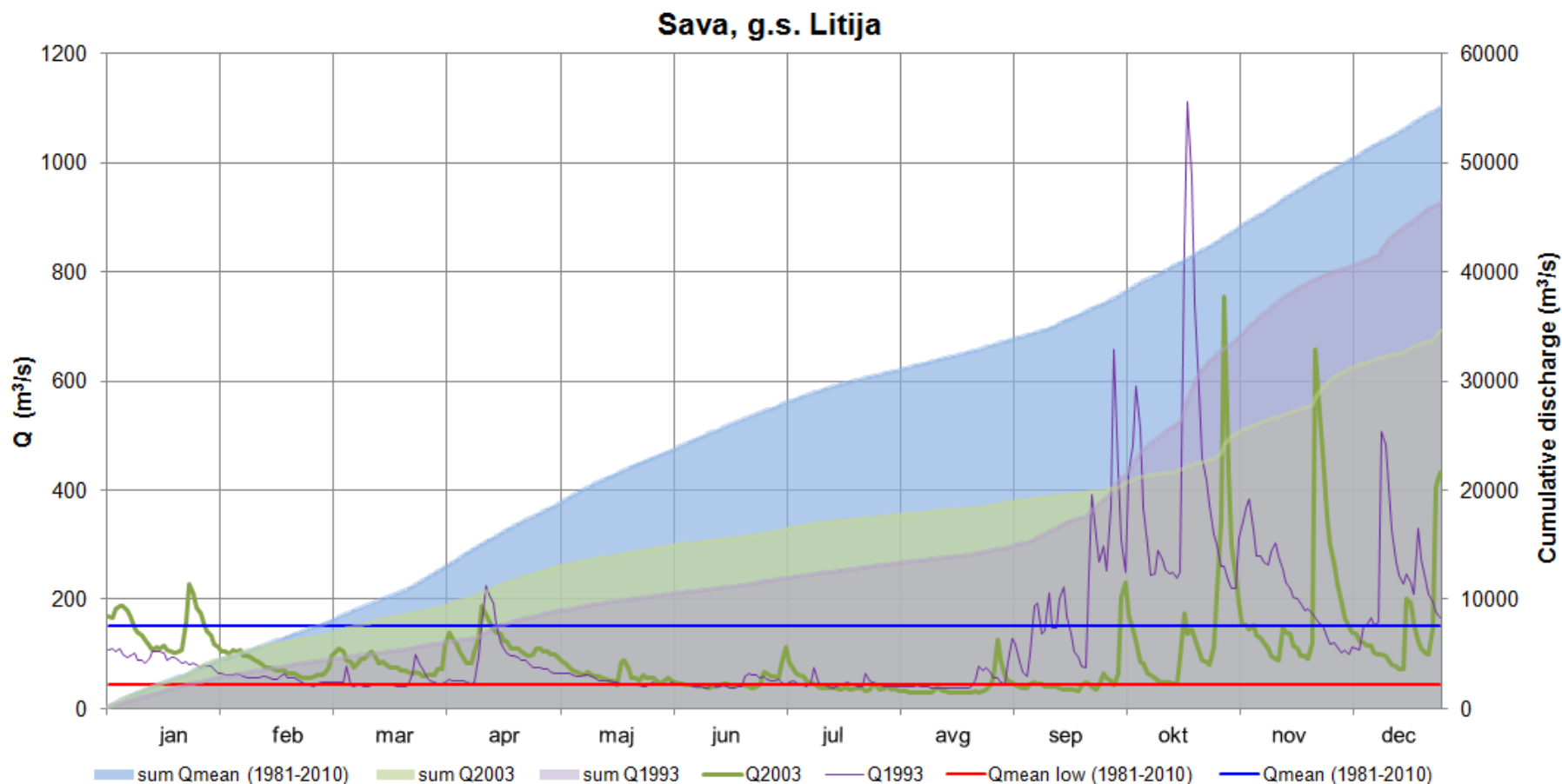


MAM(n-day) – mean annual minimum flow of n-day duration



# Hydrological low flow and drought characteristics

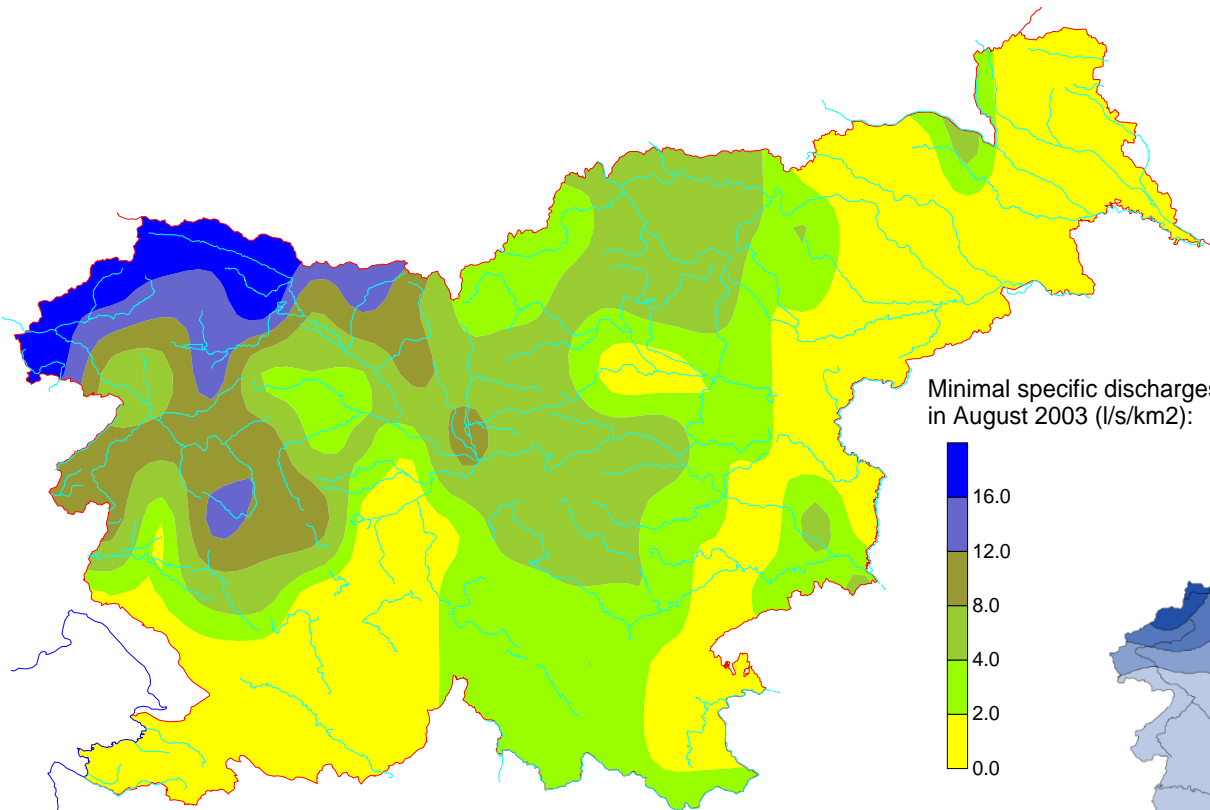
The characteristic of the most severe hydrological droughts in Slovenia is long continuous period of low flows with a duration of several months.





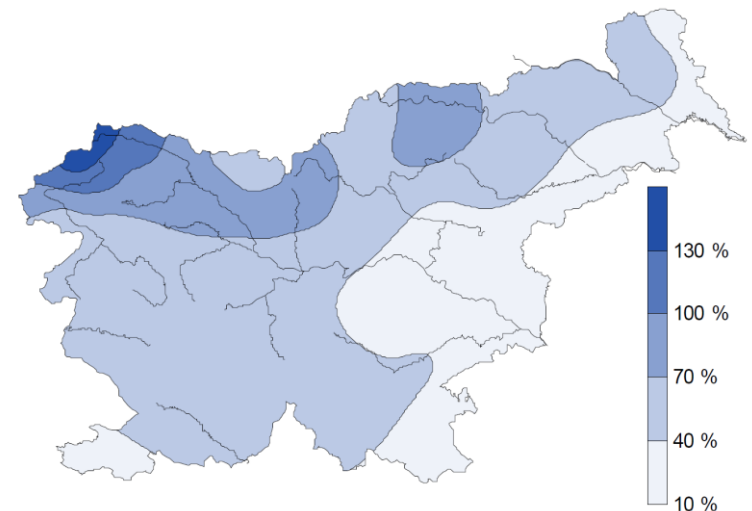


# Severe agricultural and hydrological drought in 2003



The lack of water was most evident in **north-eastern Slovenia** (Prekmurje) and **Primorska region** where streams usually dry up.

The Alpine region is less vulnerable to hydrological drought.



Precipitation amount in August 2003 compared with 1961–1990 normals



# Drought indices

**Indices** – numerical evaluation of drought severity, assessed using climatic or hydrometeorological parameters

**Examples of Indices** (WMO-No. 1173: Handbook of Drought Indicators and Indices):

Standardized Precipitation Index (SPI)

Palmer Drought Severity Index (PDSI)

Standardized Precipitation-Evapotranspiration Index (SPEI)

Soil Moisture Deficit Index (SMDI)

Surface Water Supply Index (SWSI)

Streamflow Drought Index (SDI)

Effective Drought Index (EDI)

Deciles

...many others!





# Streamflow Drought Index (SDI)

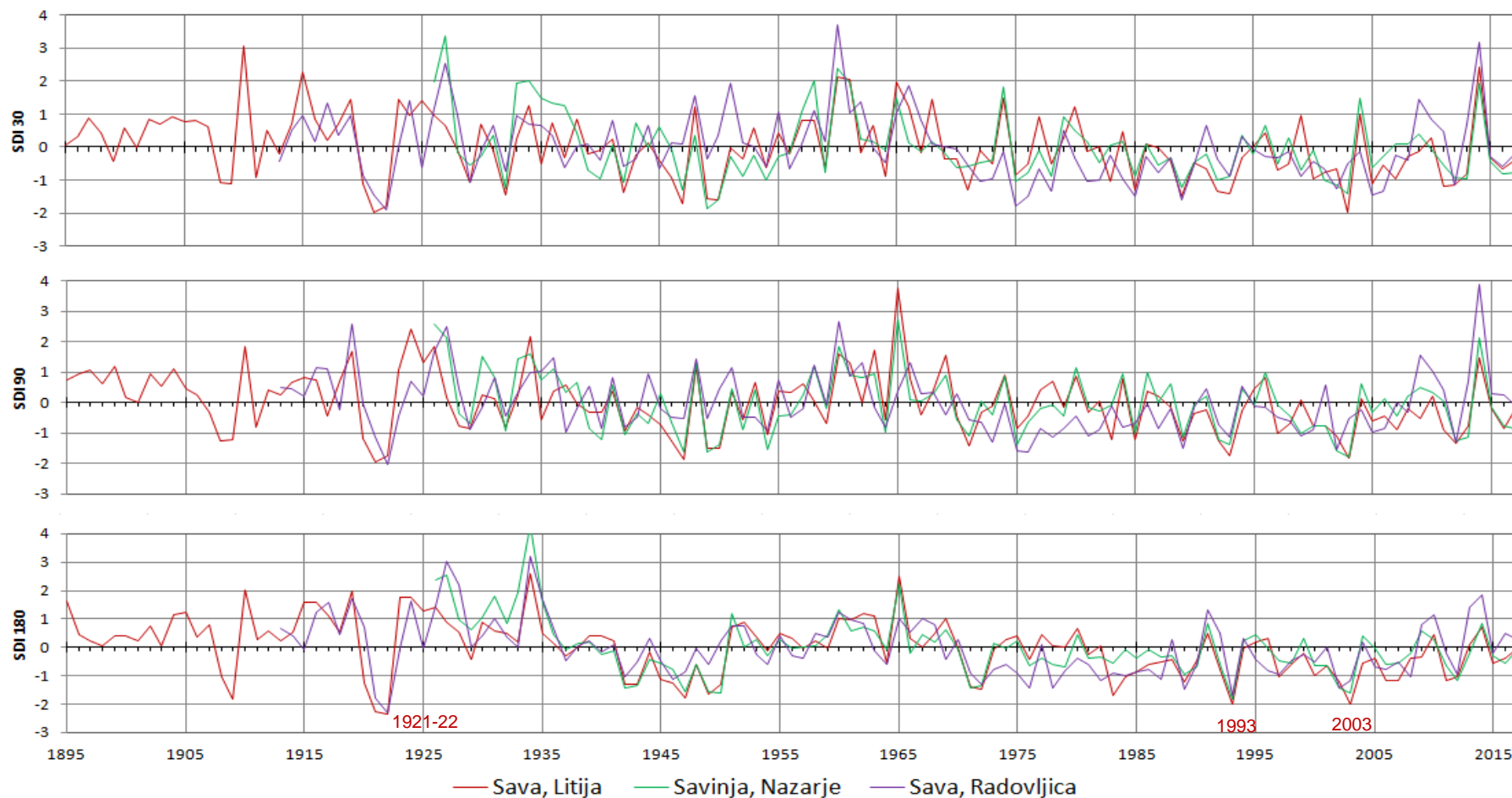
Streamflow Drought Index (SDI) - standardize discharge index based on streamflow data, similar to SPI

Criterion of SDI values	Description of state
$SDI \geq 0.0$	Non drought
$-1.0 \leq SDI < 0.0$	Mild drought
$-1.5 \leq SDI < -1.0$	Moderate drought
$-2.0 \leq SDI < -1.5$	Severe drought
$SDI < -2.0$	Extreme drought



# Streamflow Drought Index (SDI)

SDI, calculated for mean annual minimum flow of n-day duration





# Drought monitoring in Slovenia

Hidrometeorološke razmere v Sloveniji

Stanje, 24. avgust 2017

## Povzetek stanja

Nastopili so bolj vremensko prijazni dnevi, vročina je v zadnjih dneh nekoliko popustila. V preteklem vikendu je povsod po Sloveniji deževalo. Jutra so bila v začetku tedna sveža, najnižje jutranje temperature zraka so bile od 4 do 10, na Primorskem do 18 °C. Dnevi po prehodu fronte so se segreli le na od 22 do 27 °C. Za popolno slovo od suše je bilo dežja premalo. V večjem delu Slovenije so bile količine dežja med 20 in 30 mm, na Obali, v delu osrednje, jugovzhodne Slovenije ter severovzhoda pod 20 mm. Največ dežja, več kot 40 mm, je padlo le v višjeležečih predelih.

Na najbolj s sušo prizadetih območjih je dež namočil le površinski sloj tal. Količine dežja zadostujejo za nekaj dni, primanjkljaj meteorološke vodne bilance v sušno najbolj prizadetih območjih se je ponekod rahlo popravil, vendar poškodovanosti zaradi suše kmetijske rastline več ne morejo ubežati. Padavine so bile ugodne le za travnije, vzik strniščnih posevkov, jesenske zelenjadnice in trajne nasade. Še vedno pa padavine niso bile zadostne, da bi popravile padavinsko sliko letošnje vegetacijske sezone. Na jugovzhodu je v letošnjem poletju padlo le 48 % dolgoletnih padavin. Ker spet prihaja obdobje vročega vremena, se bo na najbolj ogroženih območjih stanje ponovno poslabšalo. Kmetijska suša se bo tam nadaljevala.

Vodnatost rek po državi je mala. Številni vodotoki v južni, vzhodni, jugozahodni in deloma osrednji Sloveniji imajo za poletje značilno sušno vodnatost. Najmanj vodnate, ponekod celo suhe, so manjše reke v Prekmurju, na Dolenjskem, v Slovenski Istri in na Obali ter na Vipavskem. Mura in Drava še ohranjata srednje pretoke. V prihodnjih dneh bo vodnatost rek ostala mala. Postopno zmanjševanje pretokov se bo odražalo s sušno vodnatostjo na vse več rekah. V prihodnjem tednu se bodo običajne sušne razmere površinskih vodotokov stopnjevale. Sušne razmere se bodo na vseh izpostavljenih območjih do konca avgusta še nadaljevale. Postopno zmanjševanje pretokov se bo odražalo s sušno vodnatostjo na vse več rekah. Vodnatost večine, predvsem manjših rek, bo zadnje dni avgusta predvidoma manjša od značilne poletne sušne vodnatosti.

Tudi v drugi polovici avgusta gladine podzemne vode večjega dela države ostajajo podpovprečne, izjemno nizke vodne količine pa v tem času spremljamo na prostorsko najbolj omejenih plitvih medzrnskih vodonosnikih, ki najhitreje reagirajo na primanjkljaj obnavljanja podzemne vode. Tako v Catežu na Čateškem polju in v Šentjerneju na Šentjernejskem polju beležimo najnižje gladine podzemne vode dolgoletnega obdobja meritev, zelo nizko pa so se vodne gladine spustile tudi v Vipavskem Kržu v Vipavski dolini. Vodne razmere se v primerjavi s preteklim tednom niso bistveno spremenile, zelo nizko količinsko stanje podzemnih voda se še naprej ohranja v sušno najbolj izpostavljenih vodonosnikih Krško Brežiške in Dravske kotline, kjer je padavinski primanjkljaj daljšega obdobja največji. V Gorišnici na Ptujskem polju beležimo najnižje gladine značilne za ta letni čas, ki pa še ne dosegajo ekstremnih vrednosti. Kraški izviri so podpovprečno izdatni, zelo nizke pretoke spremljamo na izvirih nizkega Dinarskega kraka na jugovzhodu države. Vremenski izgledi do 1. septembra:

V celotnem obdobju bo nad južno polovico Evrope vztrajalo območje visokega zračnega tlaka. K nam bo od jugozahoda dotekal razmeroma suh in zelo tople zrak. Prevladovalo bo sončno vreme, več dnevne oblačnosti bo v hribovitim svetu severozahodne Slovenije. Najvišje dnevne temperature se bodo dvigale nad 30 °C. Nadaljevalo se bo suho vreme, največja verjetnost za krajevne nevihte je v četrtek, 24. avgusta in v ponedeljek, 28. avgusta, pa še to le v gorskem svetu.

## Več informacij:

Dnevna hidrološka napoved površinskih voda: <http://www.arso.gov.si/vode/napovedi/>  
Trenutno hidrološko stanje površinskih voda – podatki avtomatskih hidroloških postaj:

<http://www.arso.gov.si/vode/podatki/amp/>.

Spletni bilten Agrometeorološka napoved za 15 regij v Sloveniji:

<http://meteo.arso.gov.si/met/sl/agromet/forecast/>

(aplikacija deluje v brskalnikih Google Chrome in Mozilla Firefox)

[http://www.arso.gov.si/o\\_agenciji/novice](http://www.arso.gov.si/o_agenciji/novice)

During the longer drought period Slovenian Environment Agency (ARSO) issues a weekly bulletin on “Hydrometeorological conditions in Slovenia”:

- Meteorological situation
- Surface water status
- Groundwater quantity
- Water balance of agricultural soil
- Outlook

Distributed to public and professional institutions and sectoral ministries.

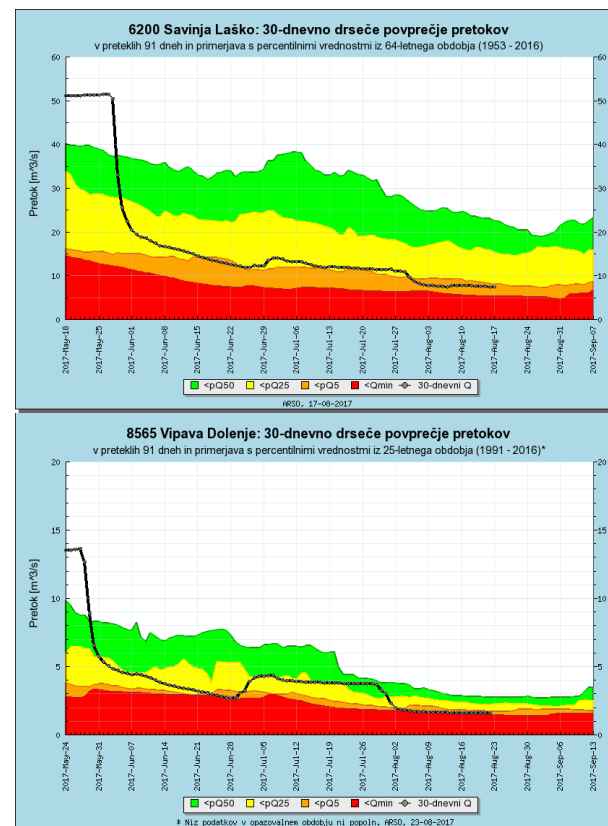
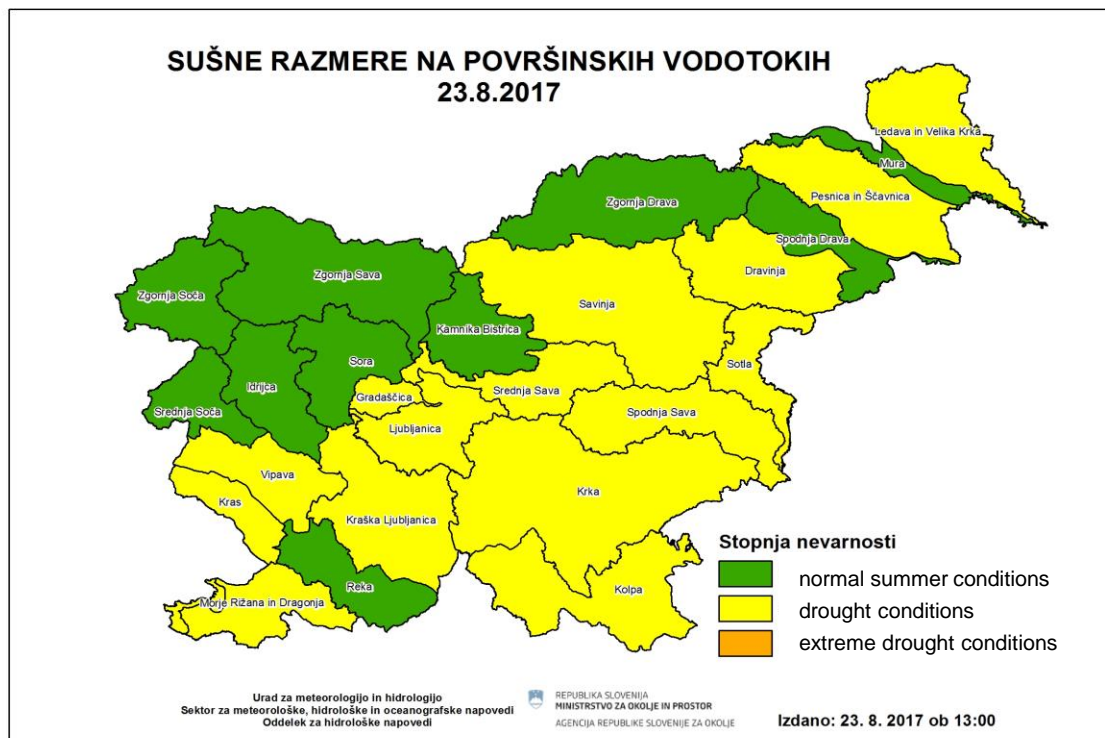




# Drought monitoring – surface water

Presentation of drought condition in river catchments  
by colour code

Current flows compared with  
percentiles in long-term period





# Conclusion

- The hydrological drought coincides with the precipitation deficit.
- Droughts phenomena and changes in the runoff regimes were observed in the 1980s in Slovenia.
- Drought is a regional phenomenon and the whole country is almost never equally affected.
- The drought is usually the most severe in southern and eastern Slovenia, while in Alpine region is not so obvious.
- In Alpine region the hydrological drought can appear in winter and summer time.
- The Alpine region is not critical part of the country because there is the highest precipitation amount.