Hydrological drought in Alpine regions of Slovenia

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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/
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)
Occurence of hydrological extremes in Slovenia

Vipava, g.s. Miren: year 2012

HYDROLOGICAL DROUGHT ➔ FLOODS

Discharge [m$^3$/s]

01.01. 31.01. 01.03. 31.03. 30.04. 30.05. ... 26.12.
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 km²
Observed climate variability and climate change in Slovenia

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

- air temperature: \(+1.7^\circ C\) (+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

Sava, g.s. Litija

MAM(n-day) – mean annual minimum flow of n-day duration
The characteristic of the most severe hydrological droughts in Slovenia is a long continuous period of low flows with a duration of several months.
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.
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

<table>
<thead>
<tr>
<th>Criterion of SDI values</th>
<th>Description of state</th>
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</thead>
<tbody>
<tr>
<td>SDI ≥ 0.0</td>
<td>Non drought</td>
</tr>
<tr>
<td>-1.0 ≤ SDI &lt; 0.0</td>
<td>Mild drought</td>
</tr>
<tr>
<td>-1.5 ≤ SDI &lt; -1.0</td>
<td>Moderate drought</td>
</tr>
<tr>
<td>-2.0 ≤ SDI &lt; -1.5</td>
<td>Severe drought</td>
</tr>
<tr>
<td>SDI &lt; -2.0</td>
<td>Extreme drought</td>
</tr>
</tbody>
</table>
Streamflow Drought Index (SDI)

SDI, calculated for mean annual minimum flow of n-day duration
Drought monitoring in Slovenia

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.
During the longer drought period, the Agency issues a newsletter weekly.

Drought monitoring – surface water

Presentation of drought condition in river catchments by colour code

Current flows compared with percentiles in long-term period

**SUŠNE RAZMERE NA POVRŠINSKIH VODOTOKIH**

23.8.2017

*Stopnja nevarnosti*

- normal summer conditions
- drought conditions
- extreme drought conditions

*Presentation of drought condition in river catchments by colour code*
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.