DROUGHT IN SLOVAKIA IN THE 21ST CENTURY – OCCURRENCE, IMPACTS AND MITIGATION MEASURES

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Abstract: This research investigates major hydrological droughts in Slovakia in the 21st Century; analyzing drought origin and severity and also the spatial distribution of surface and groundwater in relation to meteorological drought occurrence. Slovakia experienced three major droughts in 2003, 2012 and 2015, and the impacts of the 2015 drought and its crisis management are described herein. The severe impacts of the 2015 drought highlight that it imperative to prepare strategic drought risk reduction policies which supplement the crisis management measures taken during drought. Plans for future drought management should therefore be investigated and implemented forthwith.

INTRODUCTION

Drought is a natural hazard, difficult to recognize in its initial phase, specifically with slow onset, possible long duration and with non-structural, multiform impacts. Drought affects more regions and more people globally than many other natural hazards (Andreu et al., Eds., 2015), especially since hydrological surface and groundwater drought occurs increasingly frequently in northern middle latitude areas.

Perceptions of hydrological drought in the research community focus on different aspects. The most often studied questions are factors involved in its development, quantification and temporal and spatial propagation patterns. Attention to drought research is also reflected in the number of publications devoted to it. The key word “drought” inserted in the search engine of the Scopus database (https://www.scopus.com/results) identified 72,751 publications with the word drought in the title, and in 2015, these included 6,560 published papers from the various scientific disciplines. The highest numbers of publications came from hydrology, water economics, water resources, landscape ecology, geochemistry, atmospheric research and soil, agricultural and forestry sciences. There was also drought research from eco-toxicology, vegetable and zoological physiology, molecular genetics and anthropology. However, much less attention has been given to the economic impacts of drought. According to Andreu et al. Eds. (2015), droughts in the last 25 years covered more than 800,000 km^2 of European Union territory (37 %) and affected more than 100 million people (20 %). The total cost of drought over the past 30 years has exceeded 100 billion Euro.

Some papers on research community active participation in understanding and managing drought impacts and the preparation of mitigating measures and strategies

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have already been published. These include papers by Blauhut et al. (2015), Schmitt et al. (2016), van Lanen et al. (2016) and Freire-González et al. (2017, on-line first). The report by van Lanen et al. (2016) concluded that drought monitoring and forecasting should be embedded in drought policy. Wilhite (2014) also provided a template for action which could improve the drought chapter in the “River Basin Management Plans” for Europe.

The number of scientific contributions also increase following extreme drought periods affecting large areas; sometimes whole continents. Examples include (1) the Dust Bowl which affected more than 70 % of North America in 1933–1940 (Andreadis et al., 2005; Ganguli & Ganguly, 2016); (2) the long drought between 1950 and 1956 in Texas; (3) the Millennium drought in Australia between 2001 and 2009 (van Dijk et al., 2013). Severe droughts affected Slovakia in 1927, 1947–1948, 1982–1983 and 1992–1993 followed by the three major 21st Century droughts in 2003, 2012 and 2015 which affected various parts of Slovakia with different intensity.

This study examined the major 21st Century hydrological droughts in Slovakia and analyzed drought origin, severity, spatial distribution, the impacts on ecosystems and society and the mitigation measures implemented. Evaluation was conducted in the context of the global climatic situation and the actual meteorological conditions in Slovakian territory.

SHORT DESCRIPTION OF NATURAL CONDITIONS IN SLOVAKIA

Slovakia is a landlocked central European country (16° – 23° E, 47° – 50° N), bordered by Poland, Ukraine, Hungary, Czech Republic and Austria (Fig. 1). The Slovak territory covers 49,035 km^2 with almost 80 % over 720 m a.s.l altitude. The Slovak middle and northern areas are mountainous with the Western Carpathian Arch, and lowlands are typical in the South and East. The highest point is the 2,655 m Gerlachovsky Peak in the northern High Tatra Mts. and the lowest is at 94 m near Streda nad Bodrogom village in the Eastern Slovak lowland.

The climate varies between temperate and continental climate zones with relatively warm summers and cold, cloudy and humid winters. The average winter temperature is -2°C; with January the coldest month and the High Tatras the coldest area. The average summer temperature is 21°C, with July and August the warmest months and the Danubian Lowland the warmest area. Temperature and precipitation are altitude dependent, with annual precipitation ranging from 450 mm in the Southern lowlands to over 2,000 mm in the northern High Tatras.

Slovakia has the Morava, Vah, Hron, Slana, Ipel and Bodrog as main tributaries to the famous Danube River. Most Slovak territory (96 %) is in the Danube River Basin with the above rivers draining to the Black Sea while the remaining 4 % drains to the Baltic Sea through the Poprad and Dunajec tributaries of the Vistula River The main European divide between the Black Sea and Baltic Sea drainage areas follows the lower ridges and the flat landscape of the foothills of the High Tatras near Strba and Sunava villages. The long-term average water balance can be described by the equation:

$$P\ (753\ \text{mm}) = ETP\ (492\ \text{mm including other minor losses}) + R\ (261\ \text{mm})$$

where: P = precipitation, ETP = evapotranspiration and R = runoff, considerably varying between years.

Fig. 1 Location of Slovakia in central Europe

The mountainous character of the landscape and the position of mountain ranges, mostly stretching in the SW-NE direction, create conditions for orographic precipitation, and the orographic division produces heavy rains in Slovak mountainous areas.
The combination of the above factors ensure variable conditions with extreme hydrological phenomena occurrence in Slovakia.

DATA AND METHODS

Daily discharges at the 12 gauging profiles; Myjava, Vah, Oravica, Kysuca, Nitra, Zitava, Hron, Ipel, Rimava, Poprad, Topla and Torysa River basins were processed from 1.1.1981 to 30.6.2016. These selected basins cover Slovak area, and the gauging profiles present near-natural runoff conditions. The weekly groundwater level obsevations and the spring yield at 116 groundwater monitoring network sites were incorporated in our hydrological drought study basic data. The global climatic situation and regional conditions were also considered in initial causation of meteorological drought occurrence.
The Standardized Precipitation Index (SPI) of McKee, Doesken & Kleist (1993) was used to calculate index values for 6 and 12 months. This index is based on the probability of precipitation over any time scale, and its calculation for any location is based on the long-term precipitation record for a desired period; with 20–30 year monthly values and optimally set for 60–70 years. This long-term record is fitted to a probability distribution, preferably the Gama distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero. Positive SPI values indicate greater than median precipitation and negative values indicate less than median precipitation. Wetter and drier climates can also be presented in the same manner because the SPI is normalized. Table 1 records limits for wet and dry periods monitored by SPI.
The 6-month SPI indicates seasonal to medium-term trends in precipitation and it compares precipitation for that period with the same 6-month period over the historical record. A 12-month SPI is comparison of the precipitation for 12 consecutive months with that recorded in the same 12 consecutive months in all previous years with available data. Because these timescales are the cumulative result of shorter periods that may be above or below normal, the longer SPIs tend to gravitate toward zero unless a distinctive wet or dry trend occurs. SPIs on these timescales are usually tied to stream flows, reservoir levels and even groundwater levels over longer timescales (WMO, 2012).

Table 1 Limit values of the standardized precipitation index - SPI (according to McKee, Doesken & Kleist, 1993)

Standardized Precipitation index (SPI)	
SPI value	Classification
2.00 and more+	extremely wet
1.50 to 1.99	very wet
1.00 to 1.49	moderately wet
-0.99 až 0.99	near normal
-1.00 to -1.49	moderately dry
-1.50 to -1.99	very dry
-2.00 and less	extremely dry

The threshold level method with the fixed threshold of the 80th percentile of the long-term flow duration curve was used to estimate discharge drought periods. Four basic drought parameters were calculated – absolute minimum discharge ($m^3.s^{-1}$), maximum drought duration (days), maximum deficit volume (m^3) and drought intensity ($m^3.day^{-1}$). Three-parametric Weibull distribution was used to calculate the return period of the minimum value, and generalized extreme values distribution (GEV) calculated the return period of maximum drought duration, maximum deficit volume and drought intensity. The timing of drought and its seasonality were also studied.

Groundwater drought in groundwater heads and spring yields was analyzed using the SANDRE method developed by the French Data Reference Centre for Water. This is based on statistical evaluation of monthly averages and their comparison with long-term monthly averages (LTMA) for the same months in the reference period (1981–2010). The thirty-four year period 1981–2015 was used for groundwater drought assessment. Five categories were created for each month (Table 2). The threshold values used in categorizing groundwater heads were φ_{10}, φ_{40}, φ_{60}, φ_{90}, and for spring yields these were Q_{10}, Q_{40}, Q_{60}, Q_{90} with, each well or spring monitoring object classified in each month according to the criteria. The spatial distribution of values was determined by convergent interpolation (krigging, 500x500 m).

Table 2 Categories of groundwater drought evaluation (Slivova et al., 2016)

Groundwater head and spring yield	Distinctly lower than LTMA $(<\varphi_{10\%}, <Q_{10\%})$	Lower than LTMA $\varphi_{10\%}$ - $\varphi_{40\%}$, $Q_{10\%}$ - $Q_{40\%}$	Close to LTMA $\varphi_{40\%}$ - $\varphi_{60\%}$, $Q_{40\%}$ - $Q_{60\%}$	Higher than LTMA ($\varphi_{60\%}$ - $\varphi_{90\%}$, $Q_{60\%}$ - $Q_{90\%}$	Distinctly higher than LTMA $(>\varphi_{90\%}, >Q_{90\%})$
Value	1	2	3	4	5

RESULTS AND DISCUSSION

Global meteorological conditions

Meteorological and hydrological droughts occurred on a pan-European scale in the 2003, 2012 and 2015 evaluated years, and all three are included in the12 warmest years recorded since 1880. Table 3 lists the global combined land and ocean annuallyaveraged temperature ranking and anomalies for each of the 12 warmest years on record (2003, 2006, and 2007 tie as 10th warmest). As documented in the table, 2015 was the second warmest year on record with 0.9 °C; 2012 was ninth with 0.62 °C and 2003 tenth with 0.61 °C above the 20th century average of 13.9 °C (57.0 °F).

Table 3: Ranking of 12 warmest years on Earth in the 1880–2016 observation period (adopted according to https://www.ncdc.noaa.gov/sotc/global/201613)

Rank*	Year	Anomaly °C	Anomaly °F
1	2016	0.94	1.69
2	2015	0.90	1.62
3	2014	0.74	1.33
4	2010	0.70	1.26
5	2013	0.67	1.21
6	2005	0.66	1.19
7	2009	0.64	1.15
8	1998	0.63	1.13
9	2012	0.62	1.12
10 – 12	2003	0.61	1.10
10 – 12	2006	0.61	1.10
10 – 12	2007	0,61	1.10

Remark: * 1 – the warmest year, period of record: 1880–2016

The results showed that the initial pan-European climatic conditions were quite similar in all three years. There was a positive 500-hPa geo-potential height anomaly in the upper level atmospheric circulation over continental Europe; especially over central and Eastern Europe.

Precipitation, however, was quite different; the 2003 global precipitation was below the 1961–1990 average of 1,033 mm (40.7 inches) for the third year in a row. The 2003 precipitation anomalies map shows extreme dryness in western, central, eastern and southern Europe with precipitation deficit up to 250 mm (https://www.ncdc.noaa.gov/sotc/global/200313). Although total annual precipitation for 2012 was close to the1961–1990 average following the two wettest years on record (2010 and 2011), Europe experienced an unusually dry spring (https://www.ncdc.noaa.gov/sotc/global/201213#gprcp). This led to extreme drought conditions affecting crop growth and yield, water supplies and human health and it also contributed to significant wild fires. Annual precipitation for 2015 was just below the 1961–1990 average, with the Global Precipitation Percentiles map indicating notable dryness (https://www.ncdc.noaa.gov/sotc/global/201513#%20gprcp) in central Europe.

Local meteorological conditions in Slovakia

Temperatures in summer and at the beginning of Slovak fall periods in all three years were higher, but precipitation was lower than the long-term average of 1961–1990.

The average summer temperatures for 2003 were higher than the long-term 1951–2015 average throughout Slovakia, and this anomaly approched 2.1 °C, for example, at Hurbanovo monitoring station in the south-west. Precipitation totals reached the area`s average value of 573 mm (74.5 % of the long-term average) and average precipitation deficit was 189 mm (www.shmu.sk).

The temperature for 2012 was also higher than the long-term average, with the the anomaly in Hurbanovo in SW Slovakia reaching 1.9 °C. Summer months were the warmest, with three heat waves in this summer period and tropical nights even in September. The annual precipitation was classified as normal with 49 mm deficit and the highest deficit was reached in March and August with 23 and 26 % of the long-term average (www.shmu.sk).

The temperature for 2015 ranged from 2.0 °C (Hurbanovo station, SW Slovakia) to 2.3 °C (Kosice station, SE Slovakia) higher than the long-term average for 1961–1990. Five heat-waves occurred from June to September and annual precipitation was 710 mm; 94.5 % of the long-term average (www.shmu.sk). The average precipitation throughout Slovakia for the year was classified normal, with a deficit of 41 mm.

Assesment of meteorological drought

Three catchment groups with similar drought development in 2003, 2012 and 2015 were created and application of the SPI method provided the following results:

1. The largest SPI6 and SPI12 values were calculated for 2003, followed by 2012 and the lowest were for 2015 in Nitra, Zitava, Vah and Myjava River catchments in western and south-western Slovakia. The SPI values for the Poprad River catchment in northern Slovakia also reached their highest values in 2003 but the SPI12 values for 2012 and 2015 were lower; not exceeding -0.99.
2. The largest SPI6 and 12 values were calculated for 2012, followed by 2003 and the lowest was for 2015 in Torysa, Oravica, Hron, Ipel and Rimava River catchments. Most are located in central and southern Slovakia, except for Oravica in northern Slovakia and Torysa in the east.
3. The largest SPI6 and SPI12 were calculated for 2015, followed by 2012 and the lowest values, or values similar to 2012, were recorded in 2003 in Topla and Kysuca River catchments. The Topla River Basin is located in eastern Slovakia and the Kysuca River Basin in the north-west.

The following most extreme SPI6 indices were recorded; for the Vah River Basin in 2003 (Fig. 2), for the Torysa River Basin in 2012 (Fig. 3) and for the Kysuca River Basin in 2015 (Fig. 4)

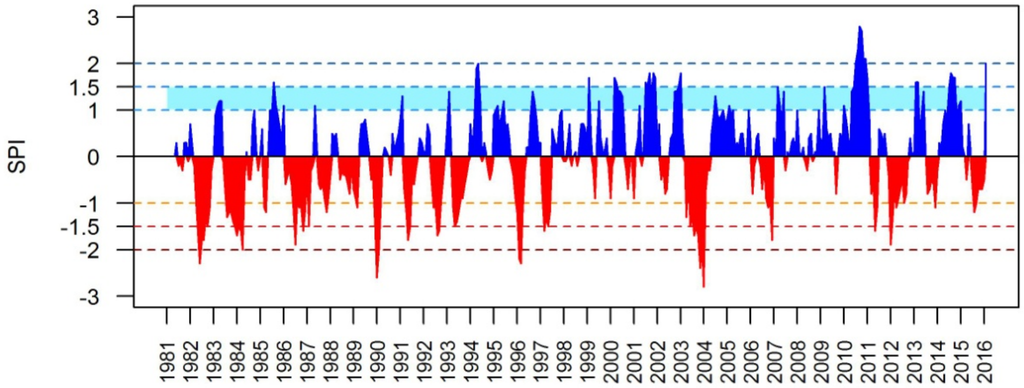

Fig. 2; Vah River Basin SPI6 values

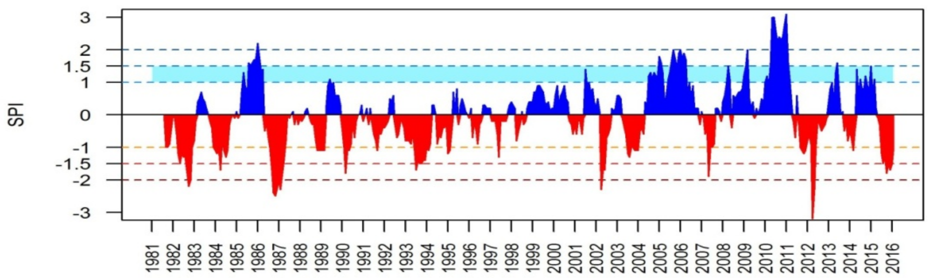

Fig. 3 Torysa River Basin SPI6 values

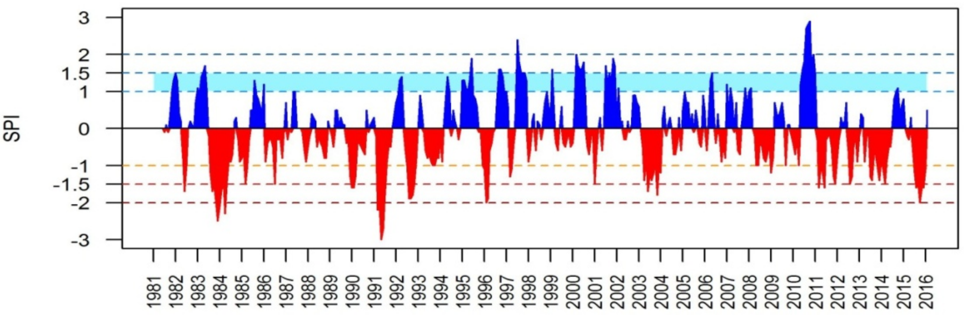

Fig. 4 Kysuca River Basin SPI6 values

Assessment of hydrological drought in discharges

Calculated hydrological drought parameters in the twelve evaluated catchments enabled classification of the catchments in the following groups:

1. Catchments where the major 2003 drought was the most intense according to drought intensity parameters were Myjava, Nitra, and Topla River catchments.
2. Catchments where the major 2012 drought was the most intense according to drought intensity parameters were Váh, Zitava, Poprad and Oravica River catchments.
3. Catchments where the major 2015 drought was the most intense according to drought intensity parameters were Kysuca and Rimavica River catchments.
4. Catchments where the major 2003 and 2012 droughts were comparable according to drought intensity parameters were Hron, Ipel and Torysa River catchments.

Summer and autumn droughts are typical for Slovak rivers. The highest return periods were as follows; (1) over 100 years for absolute discharge minima in the Torysa River catchment during the 2012 drought; (2) over 60 years for drought duration in the Hron in 2003; (3) over 80 years for maximum deficit volume in the Kysuca River and almost 20 years for drought intensity in the Torysa River in 2012.

Assessment of groundwater drought

Groundwater drought occurrence was evaluated using data from 116 observation groundwater monitoring network points approximately equally placed across Slovakia. The monitoring objects are not equally distributed in evaluated catchments, therefore the occurrence of groundwater drought in respective catchments was not possible.

Precipitation totals indicate 2003 was a dry year, with groundwater heads and spring yields decreasing continuously between August and October, with minimal values in September. Therefore, 2003 was classified as dry with values lower than the long-term average. Groundwater drought impacted on almost all Slovakia, with the exception of the central area.

Normal total precipitation was observed for 2012, but precipitation deficits in November 2011, March, April, May, August and September 2012 negatively influenced groundwater regime and spring yields. The lowest groundwater heads occurred in May and low heads and spring yields persisted throughout summer, with further minimum in September. Values lower than the long-term average were observed in north-western, northern, eastern and central southern Slovakia, and therefore 2012 was classified as a dry year.

Although total precipitation was normal in 2015, there were precipitation deficits in November and December 2014 and also in February, April, June, July and August 2015. These negatively influenced groundwater regime. Groundwater heads and spring yields indicated that all summer months were dry to very dry, and minimum values were again recorded in September in north-western, northern, central north-eastern, eastern and southern Slovakia (Fig. 5). Groundwater heads and spring yields recovered very slowly; mainly in central and southern Slovakia.

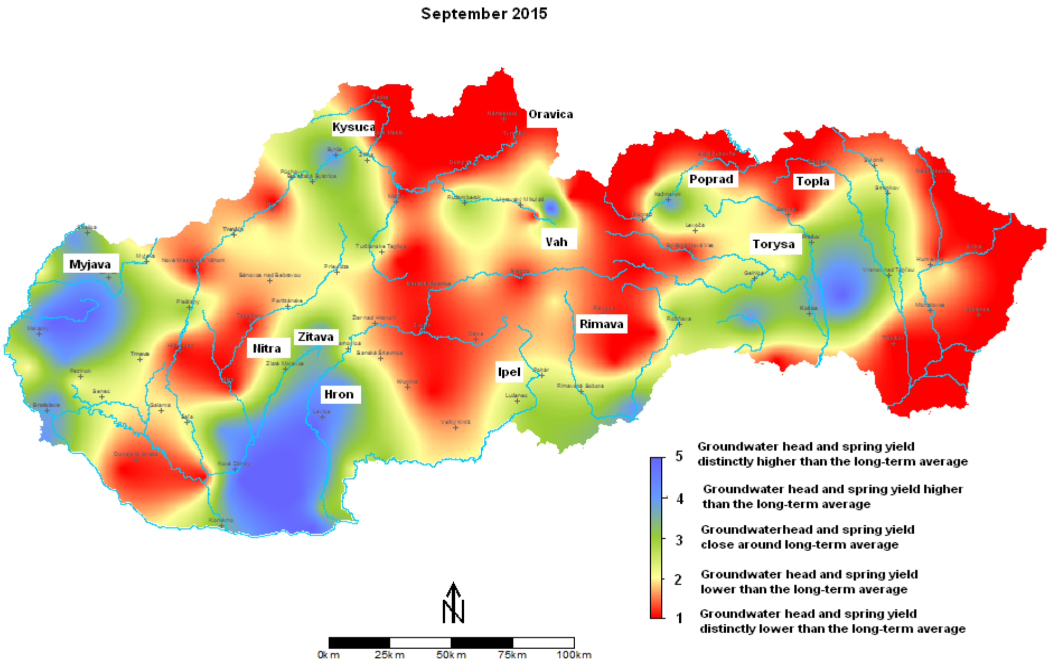

Fig. 5 Spatial distribution of groundwater drought in September 2015

DROUGHT IMPACTS

Available information on drought impacts in Slovakia differs for 2003, 2012 and 2015. Although there were some reports of drought impact on agricultural production, water supply and damage from wild fires in 2003 and 2012, no summarizing reports exist. In contrast, information on 2015 drought impacts was collected by Fendekova (van Lanen et al,. 2016). This was collated from approximately 40 Slovak Hydrometeorological Institute (SHMI) reports published on its web site (www.shmu.sk), 50 reports from newspapers and Radio and TV broadcasts, 27 messages published by The News Agency of the Slovak Republic (TASR), and Slovak News Agency (SITA) and also those from local authorities. Reports from the Climatological service of the SHMI were published during the entire year, warning of climate extremes in temperature, precipitation, and wind speed and summarizing conditions in selected periods. The highest number of these reports was published in July and August 2015.

Drought impacts were manifold across the country. The ecological impacts included deterioration of the oxygen regime in surface streams due to over-heating, drying-up of small surface streams and springs, a decrease in groundwater levels and the occurrence of wild fires. Vegetation stress resulted in lower hay harvest with less grass cut and losses in crops harvested in autumn. In particular, this caused maize loss to 60 % of the 2014 harvest and only 80 % of 2014 sugar beet production (http://www.sppk.sk/clanok/1163). Decreased production from drought also reached 50 % in some regions (http://www.sppk.sk/clanok/1095). Dried springs and consequent decreased groundwater levels resulted in shortages in inhabitant drinking water-supply and a dramatic increase was recorded in the number of people collapsing from extreme heat exhaustion; more than 1,300 people were affected in the July – August period.

Alleviating measures included creating backwaters at small streams to increase oxygen content, replacement of rock lobsters and fish and restrictions on drinking water use in the south-western, northern and central north-eastern areas of Slovakia. This was combined with street sprinkling, increased drinking-water availability in water tanks, arrangement of street sprinkling fountains for pedestrianns, lowered admission charges and prolonged opening hours of public swimming pools, increased air-conditioned railway carriages and a reduction in working hours.

FURTHER DROUGHT RESEARCH ORIENTATION AND REQUIRED POLICY MEASURES

Progress in research into the impact of droughts on surface water flow and groundwater levels is dependent on two essential corner-stones. The first is data availability. The data required for quantitative status assessment must be obtained from a comprehensive monitoring network of stream discharges, groundwater levels and spring yield measurements. The monitoring program must ensure that addequate data exists for reliable quantitative assessment, including assessment of available groundwater resources. The second corner-stone is cooperation of international multidisciplinary research teams solving problems in interrelations of meteorological and hydrological drought. This necessitates solving problems in ecological flows, ensuring that flow requirements in aquatic ecosystems are respected and that water balances remain within sustainable limits even during prolonged drought periods.

In conclusion, strategic policy measures must be prepared and implemented to ensure change from crisis management documented in measures undertaken during the 2015 drought to drought-risk reduction policy. Powerful recommendations are contained in the European Commission Technical report 2008-023 (2007) and an essential measure which should be implemented in Slovak drought mitigation policy is the development and implementation of Drought Management Plans of Slovakia in the context of the EU Water Framework Directive (Global Water Partnership, 2015).

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REFERENCES

Andreu, J., Solera, A., Paredes-Arquiola, J., Haro-Monteagudo, D. & van Lanen, H. A. J., Eds. (2015) *Drought: Research and Science-Policy Interfacing*. Taylor & Francis Group, London.

European Commission, 2007. Drought Management Plan Report Including Agricultural, Drought Indicators and Climate Change Aspects (Water Scarcity and Droughts Expert Network), Technical report 2008-023

Freire-González, J., Decker, C. & Hall, J. W. (2017) The Economic Impacts of Droughts: A Framework for Analysis. *Ecological Economics and management.* 132, 196–204.

Ganguli, P. & Ganguly, A. R. (2016) Space-time trends in U.S. meteorological droughts. *Journal of Hydrology: Regional Studies,* 8, 235–259.

García-Herrera, R., DÍaz, J., Trigo, R. M., Luterbacher, J. & Fischer, E. M. (2010) A Review of the European Summer Heat Wave of 2003. *Crit. Rev. Environ. Sci. Technol.* 40 (4), 267–306.

Global Water Partnership Central and Easter Europe (2015) *Guidelines for the preparation of Drought Management Plans. Development and implementation in the context of the EU Water Framework Directive*, Global Water Partnership Central and Eastern Europe

McKee, T. B., Doesken, N. J. & Kleist, J. (1993) The relationship of drought frequency and duration to time scales. *Proceedings of the 8th Conference on Applied Climatology, 17. – 22.1.1993.* Anaheim, California, 179–183.

WMO (2012) Standardized Precipitation Index User Guide. WMO-No. 1090. World Meteorological Organization, Geneva. Available from. http://www.wamis.org/agm/pubs/SPI/WMO_1090_EN.pdf. [Accessed 2nd August 2016].

Schmitt, L. H. M., Graham, H. M. & White, P. C. L. (2016) Economic evaluations of the health impacts of weather-related extreme events: A scoping review. *International Journal of Environmental Research and Public Health.* 13 (11), art. no. 1105.

Slivova, V., Kullman, E. & Gavurnik, J. (2016) Analysis of groundwater drought occurrence in hydrological years 2013, 2014 and 2015. *Podzemná voda.* 21(1), 40–51.

Tallaksen, L. M., Van Lanen, H. A. J. Eds. (2004) *Hydrological drought. Processes and estimation methods for streamflow and groundwater*. Developments in Water Science 48, Elsevier, Amsterdam.

Van Dijk, A. I. J. M., Beck, H. E., Crosbie, R. S., De Jeu, R. A. M., Liu, Y. Y., Podger, G. M., Timbal, B. & Viney, N. R. (2013) The Millennium Drought in southeast Australia (2001–2009): Natural and human causes and implications for water resources, ecosystems, economy, and society, *Water Resour. Res.* 49(2), 1040–1057.

Van Lanen, H. A. J., Laaha, G., Kingston, D. G., Gauster, T., Ionita, M., Vidal, J.-P., Vlnas, R., Tallaksen, L. M., Stahl, K., Hannaford, J., Delus, C., Fendekova, M., Mediero, L., Prudhomme, C., Rets, E., Romanowicz, R. J., Gailliez, S., Wong, W. K., Adler, M.-J., Blauhut, V., Caillouet, L., Chelcea, S., Frolova, N., Gudmundsson, L., Hanel, M., Haslinger, K., Kireeva, M., Osuch, M., Sauquet, E., Stagge, J. H. & Van Loon, A. F. (2016) Hydrology needed to manage droughts: The 2015 European case. *Hydrological Processes.* 30 (17), 3097–3104.

Wilhite D. A. (2014) National Drought Management Policy Guidelines: A Template for Action, Integrated Drought Management Programme (IDMP), Report, 48 pp. World Meteorological Organization (WMO): Geneva, Switzerland and Global Water Partnership (GWP): Stockholm, Sweden.

https://www.shmu.sk [Accessed 2nd December 2016].

https://www.ncdc.noaa.gov/sotc/global/200313 [Accessed 2nd December 2016].

https://www.ncdc.noaa.gov/sotc/global/201213#gprcp [Accessed 2nd December 2016].

https://www.ncdc.noaa.gov/sotc/global/201513#gprcp [Accessed 2nd December 2016].

https://www.scopus.com/results [Accessed 14th September 2016].

https://www.shmu.sk [Accessed 15th October 2016].

http://www.sppk.sk/clanok/1095 [Accessed 6th February 2017].

http://www.sppk.sk/clanok/1163 [Accessed 6th February 2017].