Journal of Hydrology: Regional Studies 3 (2015) 509–524

Contents lists available at ScienceDirect

Journal of Hydrology: Regional Studies

journal homepage: www.elsevier.com/locate/ejrh

The biggest drought events in Europe from 1950 to 2012

Jonathan Spinoni [a,*], Gustavo Naumann [b], Jürgen V. Vogt [a], Paulo Barbosa [a]

[a] European Commission, Joint Research Centre, Institute for Environment and Sustainability, 21027 Ispra, VA, Italy
[b] CONICET, National Scientific Technical and Research Council, Buenos Aires, Argentina

ARTICLE INFO

Article history:
Received 13 December 2014
Received in revised form 9 January 2015
Accepted 11 January 2015
Available online 24 March 2015

Keywords:
Climate
Drought
Europe
SPI
SPEI
RDI

ABSTRACT

Study region: Europe, including European Russia, but excluding Greenland, the Canary Islands, the Azores, and Madeira.
Study focus: Drought is a complex climate-related phenomenon that can affect different sectors causing economic, social, and environmental impacts. We focus on meteorological and hydrological droughts, defined as shortage of precipitation over several months and we discuss the biggest drought events in 1950–2012. To define such drought events we computed three drought indicators, the Standardized Precipitation Index, the Standardized Precipitation Evapotranspiration Index, and the Reconnaissance Drought Index and we merged them into a combined indicator at 3-month scale for meteorological and 12-month for hydrological droughts. The indicators have been calculated using the E-OBS gridded data (0.25° × 0.25°).
New hydrological insights for the region: Europe has been subdivided into thirteen regions and for each region we determined a list of drought events. The events have been characterized by the time, duration, severity, average area involved, peak month, and area involved at the peak month. We computed time series of the combined indicators for each region and country to determine the twenty-two biggest drought events in 1950–2012. Northern Europe and Russia show the highest drought frequency, duration, and severity in the 1950s and 1960s, where this is for the 1970s in Central Europe and the British Islands, and the 1990s and 2000s for the Mediterranean area and Baltic Republics.

* Corresponding author at: European Commission – Joint Research Centre, Institute for Environment and Sustainability – Climate Risk Management Unit, TP 124, Via E. Fermi 2749, 21027 Ispra, VA, Italy. Tel.: +39 3463266940.
E-mail address: jonathan.spinoni@gmail.com (J. Spinoni).

http://dx.doi.org/10.1016/j.ejrh.2015.01.001

1. Introduction

In the context of current global warming (IPCC, 2014), drought is a hot topic in the scientific literature (Sheffield et al., 2012; Dai, 2013; Spinoni et al., 2014a; Trenberth et al., 2014). It is a weather and climate-related phenomenon of complex nature resulting in a variety of definitions (Smakhtin and Schipper, 2008) that makes it difficult to readily detect and evaluate its onset and evolution (Trenberth et al., 2004). Drought is typically classified into meteorological, agricultural, hydrological, ground-water, streamflow, and socio-economic drought (Mishra and Singh, 2010) and, depending on the type, drought monitoring is usually performed through a wide number of indicators (Heim, 2002; Mishra and Singh, 2011; Sharma and Panu, 2014). This study deals with meteorological drought, as it is based on meteorological input variables (precipitation and temperature), but the chosen accumulation scales of the drought indicators, i.e. 3-month and 12-month, are usually respectively referred to meteorological and hydrological droughts (Mishra and Singh, 2010).

In Europe, drought does not only affect semi-arid areas such as the Mediterranean region (Hoerling et al., 2012). Extended drought events have repeatedly affected also Western- and Central Europe (Rebetez et al., 2006), the British Islands (Perry, 1976), Scandinavia (Hisdal et al., 2006), Eastern Europe (Spinoni et al., 2013), and Russia (Arpe et al., 2012; Parry et al., 2010, 2012). There is much literature on single European drought events (see Bradford, 2000, for a collection), websites providing European drought bulletins, forecasting, or reports (e.g., the European Drought Observatory or EDO, see: http://edo.jrc.ec.europa.eu/; the Drought Management Centre for South-Eastern Europe or DMCSEE, see: http://www.dmcsee.org/), and global monitoring systems from which information about European droughts can be derived (e.g., the SPEI Global Drought Monitor, see: http://sac.csic.es/spei/; the Global Integrated Drought Monitoring and Prediction System, see: http://drought.eng.uci.edu/).

However, none of the cited online services provides a complete picture of the meteorological and hydrological drought events that occurred in Europe in the last decades. For example, the EDO reports on the current drought conditions, for some special cases using a combined drought indicator (CDI, Sepulcre-Canto et al., 2012), and is mainly focused on agricultural drought. The DMCSEE provides the user with valuable monitoring products, but focuses only on South-Eastern Europe. The SPEI Global Drought Monitor offers near real-time information about drought conditions at $0.5^\circ \times 0.5^\circ$ spatial resolution and contains time series of the SPEI from 1950 onwards, but does provide a historical dataset of past drought events.

An important step towards the construction of a detailed database of past drought events is represented by the European Drought Reference (EDR) database, hosted by the website of the virtual European Drought Centre (EDC, see: www.geo.uio.no/edc). However, so far this database uses the Standardized Precipitation Index (SPI) computed at 6-month accumulation period and daily temporal scale, as the sole drought indicator. The EDR classifies eleven major European drought events (Stagge et al., 2013), considering duration, area involved, and peak date as drought characteristics. The EDR is linked with the European Drought Impact Inventory (EDII; Stahl et al., 2012), an online database which collects documents dealing with drought impacts from various sources.

The main goal of our study is to compile a list of the biggest drought events which took place in Europe from 1950 to 2012, and analyze these events. Compared to the already existing drought datasets, we introduced some important novelties. Firstly, we based our analysis on quality-checked and homogenized data (see Section 2.1). Secondly, we set a multi-indicator approach to detect the drought events (see Section 2.2). Thirdly, we defined a list of characteristics for each drought event: start and end, duration, severity, intensity, area involved, peak month, and area involved at the peak month (see Section 2.3). Fourthly, we analyzed the drought events for the whole of Europe and also separately per region and country (see Section 3).

We aimed to create a robust list of the most relevant drought events through the use of homogenized data ensuring the reliability of the analysis and avoiding misleading anomalous data for drought events or outliers for extreme events. Three indicators are used instead of one in order to consider more complete information, and to take into account the effect of temperature and potential evapotranspiration (PET). The use of a wider set of descriptive characteristics based on an objective set of thresholds and definitions allows to obtain a better understanding of the different features of the drought events. The analysis performed per country and per region permits to compile a list of the