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The reconnaissance drought index: A method for detecting regional arid climatic variability and potential drought risk

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ABSTRACT

The impact of climate variability on water demand and availability in drylands is substantial. Establishing methods to analyse precipitation (P) and evapotranspiration data sets may generate useful tools that assist in drought recognition and regional variations therein. The authors developed an index that simultaneous integrates both these variables in climate variability analysis. This study proposes the alpha and normalised forms of the reconnaissance drought index (RDI) as a single climatic index for the recognition of geographical areas with differing drought characteristics and potential weather variability. The prime application is that the RDI combines in a single index both P and potential evapotranspiration. A more consistent trend of climate variability can be identified by applying time series of different durations of RDI compared to using time series of P and potential evapotranspiration separately. The researchers explore this approach using meteorological data form 24 locations representing arid, semi-arid (Mediterranean (MD), tropical (TR), continental (CN)), and humid climatic conditions. The method is then tested through application to the semi-arid Lower Zab River basin (LZRB) in Iran and Iraq. Findings show that many regions such as the LZRB will face major droughts, indicating that there is an urgent requirement to advance water management strategies.

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1. Introduction

1.1. Background

Long-term trends in hydrological processes are potentially influenced by changing climate and anthropogenic interventions (Al-Ansari, 2013; Al-Ansari et al., 2014). Investigating such trends might support identification of such changes. Defining the climate of a region is normally based on the long-term pattern of variations in meteorological variables such as mean air temperature, P, humidity and wind. The long-term impacts of climate change (CC) are expected to affect land use, agriculture, water resources, society and environmental sustainability. Accordingly, such changes can strengthen present pressure and extreme events, thus increasing water resources system hazards and overall uncertainty (Loukas et al., 2008; Logan et al., 2010). The fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC) explained that the impacts of global warming on natural and human systems are observed on all continents and across the oceans (IPCC, 2014). Hydrological cycle alterations are considered to be one of the greatest CC impact such as floods, drought and storms (IPCC, 2007; Michel and Pandya, 2009). By the end of the 21st century, it is more likely that the global mean air temperature will increase by 1.4 °C to nearly 5.8 °C (IPCC, 2001). However, the Middle East and North Africa will likely encounter a decrease in rainfall and runoff between 10 and 25%, and between 10 and 40%, respectively, and an increase in evaporation between 5 and 20% (World Bank, 2009).

Both P and mean air temperature can be basic parameters to characterise regional climate and designate alterations in climate. However, these parameters display changeable trends for various regions. Accordingly, a compound index that integrates these parameters can be very critical for analysis of the overall climate. Evapotranspiration is considered as a more descriptive weather parameter for replacing air temperature in water resources

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management owing to its involvement in water balance studies. Analysing long-term time series of both P and potential evapotranspiration (PET) of a region can result in one of the following combinations: ++, +0, +−, 0+, 00, 0−, -+, −0 and −−, where + indicates a rise, − indicates a decline and 0 indicates no alteration for the considered parameters. It is not clear, if alterations will lead to wetter or drier climates. Trends in the availability of water may be inferred by the recorded rise of P and/or PET. Accordingly, a more beneficial method would be to study simultaneously the two key variable alterations applying a single index that will respond positively as PET decreases or P increases and vice versa.

A large number of weather-related drought indices with varying intricacy have been utilised in many climatic conditions for many purposes. Examples of some of these indices are as follows: crop moisture index (CMI), deciles, palmer drought severity index (PDSI), palmer hydrological drought index (PHDI), percent of normal, standardized anomaly index (SAI), rainfall anomaly index (RAI), standardized precipitation index (SPI), soil moisture drought index (SMDI), and surface water supply index (SWSI). Interested readers might refer to Heim (2002) for more details regarding meteorological indices. Since SPI can be estimated using various time periods adapted to the various response times of standard hydrological parameters to P delicences, the World Meteorological Organization (WMO) has put forward the SPI as a widespread index to be used (Vicente-Serrano et al., 2015). The SPI allows findings of different drought classes to impact on diverse systems and regions. However, its ability to capture a raised evaporative requirement related to CC is problematic (Tsakiris and Vangelis, 2005; Cook et al., 2014). Consequently, recent drought trend studies (Shahidian et al., 2012; Vicente-Serrano et al., 2014) under probable CC predictions (e.g., Hoerling et al., 2012; Cook et al., 2014) are dependent on indices of drought that take into consideration P and the evaporative demand of the atmosphere. Applying such indices, Cook et al. (2014) exhibited that raised evapotranspiration not only strengthens the process of regions becoming dryer, but also leads regions to experience droughts that would else witness slight drying or wetting.

Currently, a rather recently developed index, the RDI, has been suggested (Tsakiris and Vangelis, 2005; Tsakiris et al., 2007a). This

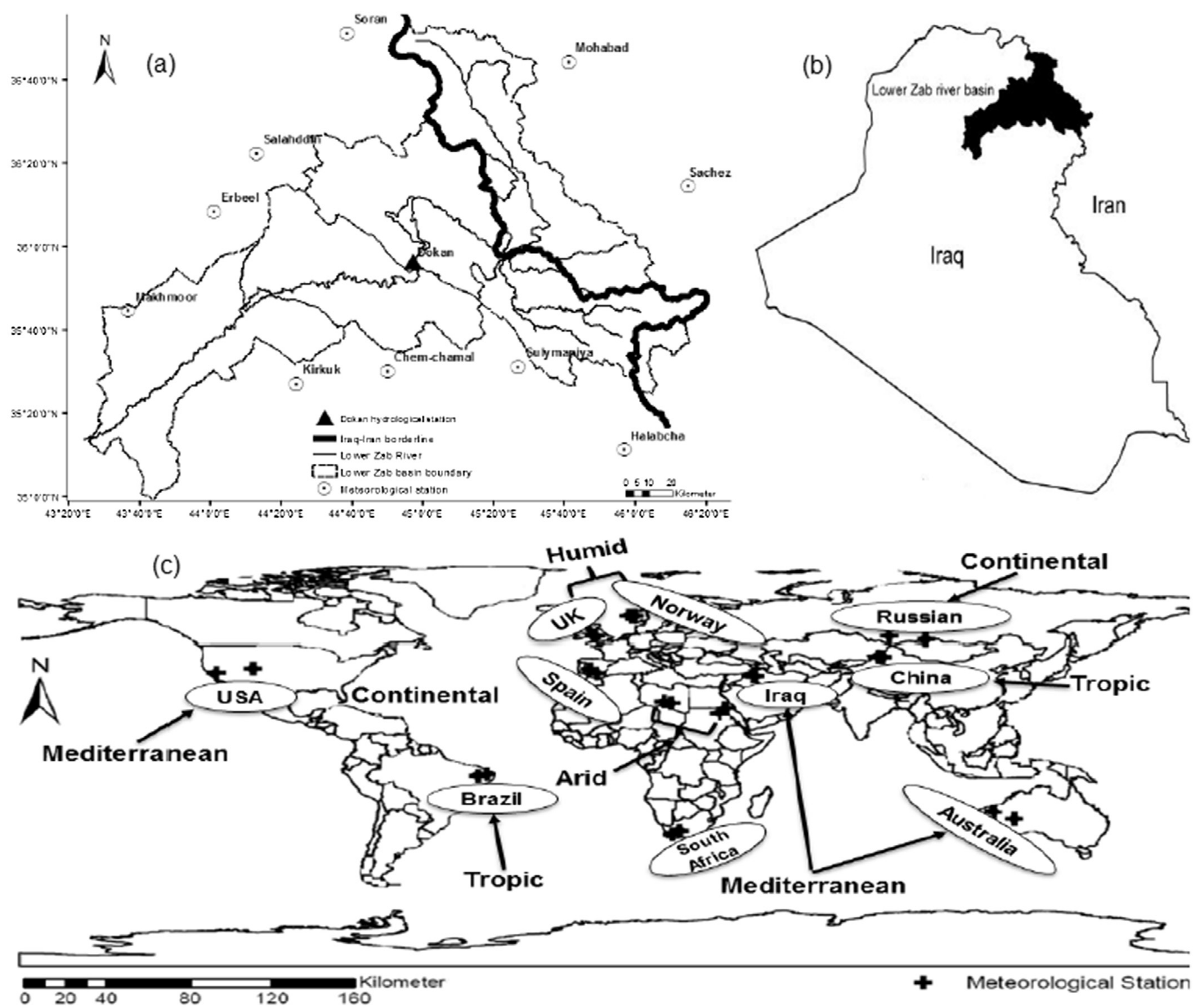

Fig. 1. (a) Meteorological stations distributed over the Lower Zab River Basin shown on (b) the map of Iraq and (c) the locations of the selected meteorological regions.

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