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# DETERMINATION OF GROUNDWATER LEVEL INDICATORS AND THRESHOLDS LEVELS FOR GROUNDWATER DROUGHT MANAGEMENT

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Monitoring the groundwater levels is required to predict groundwater drought and mitigate its impacts, so as to ensure sustainable water supplies and protection of the aquatic ecosystems. The quantitative status of the groundwater resource is assessed against specific groundwater thresholds levels, which constitute trigger levels that initiate and/or terminate management actions, e.g. early warning, enforcement of water restrictions, emergency responses, etc.

While a vast majority of the published literature is proposing methods and indicators to characterise hydrological droughts, such as the threshold level method on river flow time-series (Tallaksen and Van Lanen, 2004) or quantifying the rainfall deficit (WMO, 2016), very few are addressing the groundwater drought. In addition, methods suitable for hydrological time-series, mostly derived from statistical analyses, are seldom applicable to groundwater level time-series, because their characteristics do not fulfil the basic hypotheses for such analyses: due to aquifer inertia, groundwater level time-series are commonly auto-correlated, featuring significant trends and shifts, presenting data gaps and covering a relatively short time span. One notable exception is the recently developed Standardised Groundwater level Index (SGI) (Vernoux and Seguin, 2013 ; Bloomfield and Marchant, 2013), based upon the same methodology as the Standardized Precipitation Index (SPI, McKee et al., 1993). It can be applied to all type of aquifers, including those with multi-years cycle or displaying strong piezometric trends, and offers promising perspectives for the study of extremes events.

Such study is currently carried out in the Grand-Est region in France to improve the existing drought management trigger levels (Klinka et al., 2017). It aims at: (i) characterizing each groundwater level time-series from the main aquifers of the Grand-Est region (inertia, cyclicality, groundwater recession and recovery, magnitude of the water level fluctuations, SGI, etc.); (ii) establishing clusters of piezometers based on similar behaviour after a prolonged rainfall deficit; and (iii) proposing relevant drought management threshold levels determination methods for each group.

For each time-series, in addition to basic univariate exploratory data analysis (EDA), the correlogram, the periodogram, the recession curve analysis, the SGI and its correlogram are computed. Correlations between the SGI and the SPI are assessed to characterize the potential relationship between a prolonged rainfall deficit and groundwater drought.

Several parameters are tested to determine relevant groundwater indicators and thresholds, including:

- The mean of the mean annual minimum (MAM for groundwater time-series, by analogy with the MAM for river flows) on a monthly groundwater level time-series;
- The minimum of the groundwater MAM;
- The MAM-5 (5-years return period) when a statistical analysis is possible;
- The mean of the annual minimum on a daily time-series;
- The absolute minimum (historical low) of the time-series;
- The SGI calculated for a period relevant to the aquifer's dynamic (e.g. 1 month, 3 months, 6 months, etc.).

Statistical tools are developed in the R environment and will be made available. Methods to determine groundwater level indicators and related drought threshold levels are formulated to each identified group of piezometers of the Grand-Est region. Thresholds levels are applied to documented historical drought episodes to test their relevance and robustness.

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