

Characterising the response of groundwater systems to major, continental-scale droughts: a multidecadal European case-study

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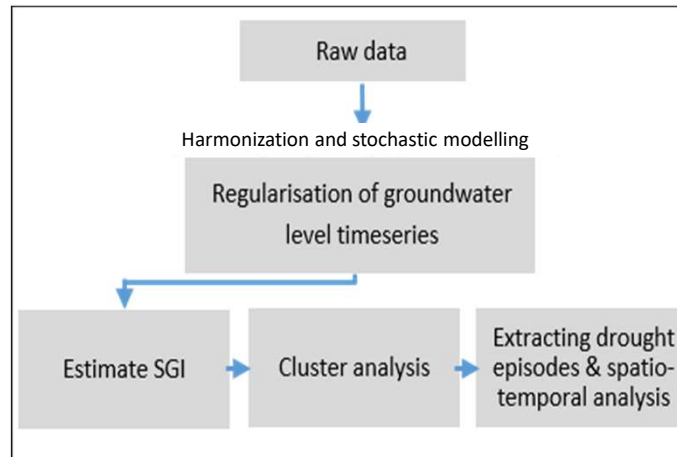
Research question

Drought events such as in 2011-12, 2015 and 2017-18 showed spatial coherence across several European regions in surface water deficits, and are likely to affect groundwater levels in a similar pattern. However, groundwater droughts may also show distinct spatial coherence based on their hydrogeological settings and recharge patterns as much as on the driving meteorology and available recharge.

The pan-European 'Groundwater Drought Initiative', GDI, evaluates spatial patterns of groundwater drought response on a continental scale from the late 1900s to present.

The spatio-temporal analysis is based on the Standardised Groundwater Index (SGI), which allows for comparison of sites from disparate regions in a consistent manner. Spatial patterns in the drought response across the continental scale were analysed.

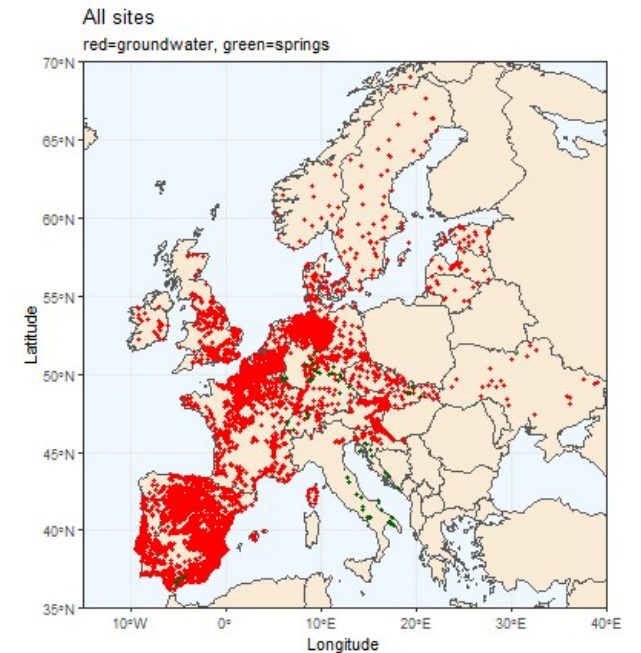
Methodology and collected data



modified from Brauns et al., The Groundwater Drought Initiative (GDI): Analysing and understanding groundwater drought across Europe, (in press at PIAHS)

Data collection

Data collection of historic groundwater level series resulted in several thousand sites across Europe, of which a selected subset will be used for analysis. Data gaps in the time series are addressed by harmonisation of the observed groundwater levels to regular monthly time steps and stochastic modelling of groundwater levels (modified from Marchant et al., 2016) to infill data gaps using the temporal correlation amongst the data.



References:

Marchant, B.P., Mackay, J. and Bloomfield, J.P., 2016. Quantifying uncertainty in predictions of groundwater levels using formal likelihood methods. *Journal of Hydrology*, 540: 699-711.



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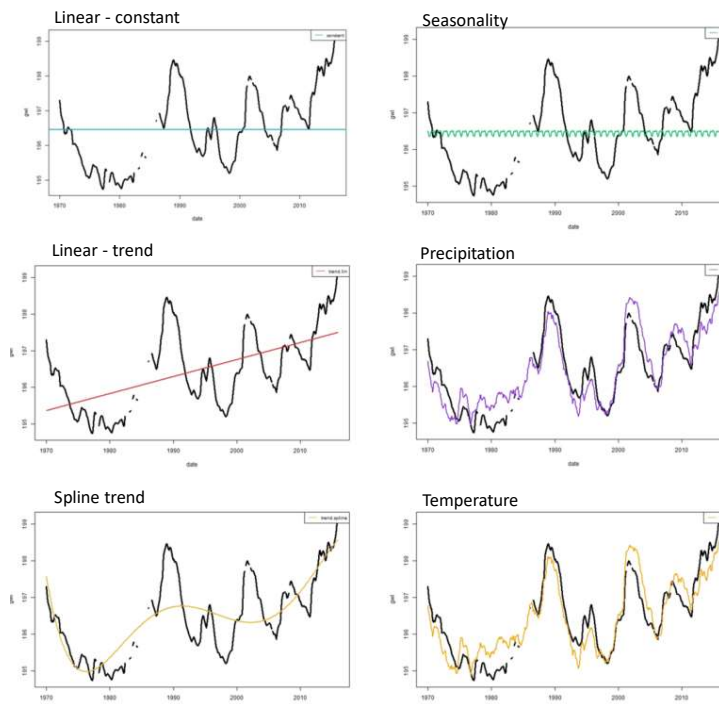
Modelling process and standardization

In the modelling process, variable and model selection are automated using Akaike's Information Criterion (AIC). Initially, models to capture trend (linear or non-linear), seasonality, and the effect of precipitation and temperature, are fitted individually and evaluated using AIC.

The algorithm selects the most appropriate models for trend, seasonality, and explanatory variable, and adds them sequentially as covariates in the final model. If the addition of a covariate increases the AIC, the algorithm halts the addition of more covariates and the current model is chosen.

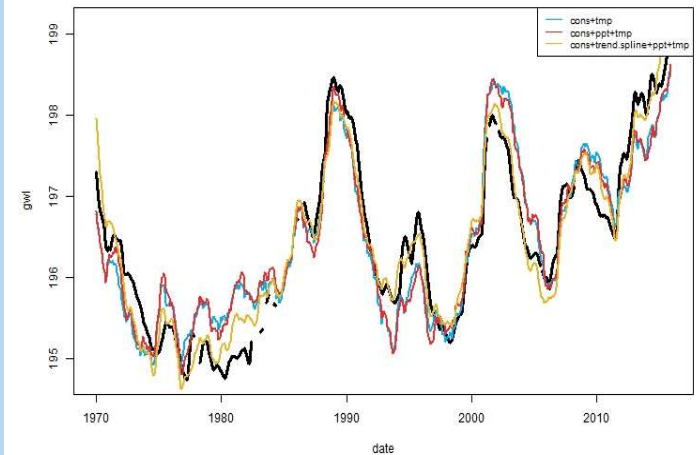
The best modelled time series is then used for standardization to the Standardized Groundwater Level Index (SGI) as described in Bloomfield and Marchant, 2013 and Marchant and Bloomfield 2018.

Individual models

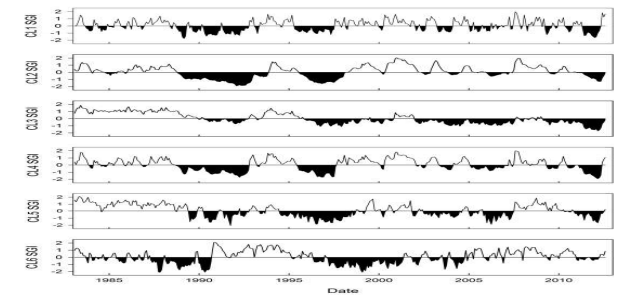


Example result used for standardization

Best fit (for this case):
Constant trend + Spline trend + Precipitation + Temperature



Standardization to SGI



References:

Bloomfield, J.P. and Marchant, B.P., 2013. Analysis of groundwater drought building on the standardised precipitation index approach. *Hydrology and Earth System Sciences*, 17(12): 4769-4787.

Marchant B.P and Bloomfield J.P. 2018. Spatio-temporal modelling of the status of groundwater droughts. *Journal of Hydrology*, 564, 397-413.

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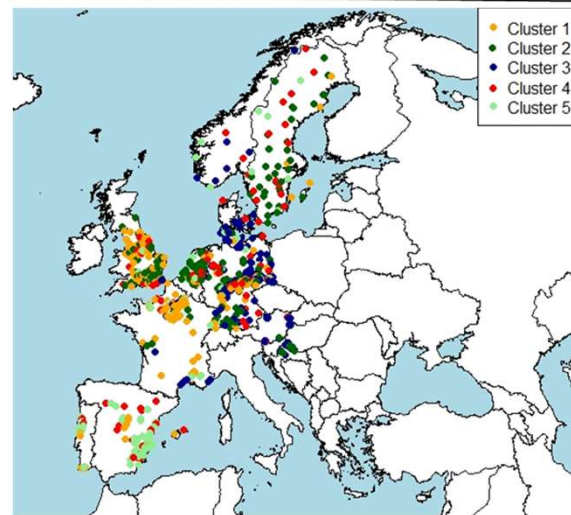
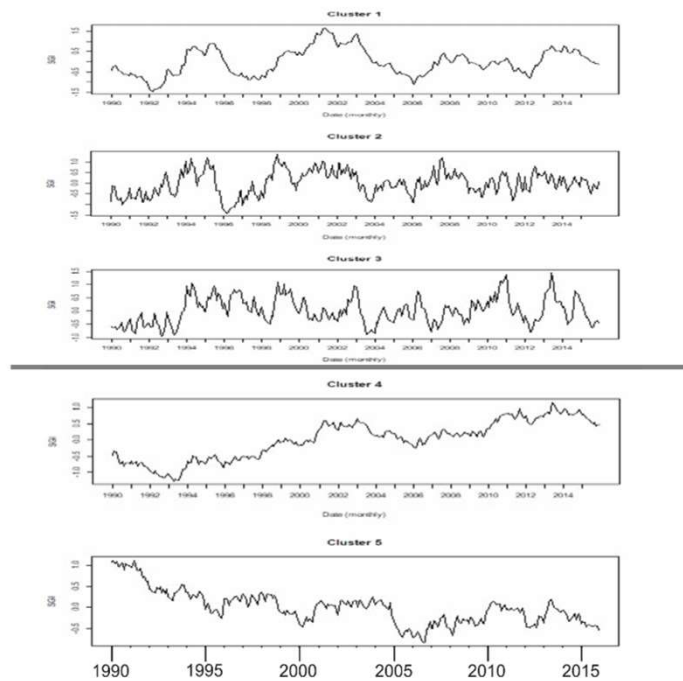
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preliminary OUTPUT Processed data (subset)



Special thanks for providing data and expertise to:

- Austria: Federal Ministry for Sustainability and Tourism (BMNT), University of Graz, Geological Survey Austria & BOKU Vienna
- Belgium: Flanders Environment Agency (VMM), Department of the Environment and Water Wallonia (SPW)
- Croatia: Croatian Geological Survey (HGI-CGS)
- Czech Rep.: Czech Hydrometeorological Institute (CHMI)
- Denmark: Geological Survey of Denmark and Greenland (GEUS)
- Estonia: Geological Survey of Estonia (EGT)
- France: Geological Survey of France (BRGM) and University of Rouen
- Germany: Federal State Agencies of Bavaria, Brandenburg, Baden-Württemberg, Hesse, Lower Saxony, North Rhine-Westphalia, Saxony, Saxony-Anhalt, Schleswig-Holstein, Thuringia, University of Freiburg
- Ireland: Environmental Protection Agency Ireland (EPA IE)
- Italy: University of Salerno, Water Research Institute (CNR-IRSA)
- Latvia: University of Latvia and Latvian Environment, Geology and Meteorology Centre (LEGMC)
- Lithuania: Nature Research Centre, Lithuania
- Luxembourg: Luxembourg Institute of Science and Technology (LIST)
- Netherlands: Netherlands Organisation for Applied Scientific Research (TNO), Wageningen University
- Norway: The Norwegian Water Resources and Energy Directorate (NVE), University of Oslo
- Portugal: Centre for Applied Ecology (CEABN) at ISA, University of Lisbon
- Slovakia: Slovak Hydrometeorological Institute (SHMU), Comenius University Bratislava
- Slovenia: Slovenian Environment Agency (ARSO)
- Spain: Institute of Environmental Sciences and Water Research (CSIC)
- Sweden: Geological Survey of Sweden (SGU)
- Switzerland: Federal Office for the Environment FEON
- Ukraine: Ukrainian Hydrometeorological Institute UHMI

The Chair of Hydrological Modelling and Water Resources at Freiburg University / WokaS database (global karst spring discharge datasets)

