British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Historic Droughts

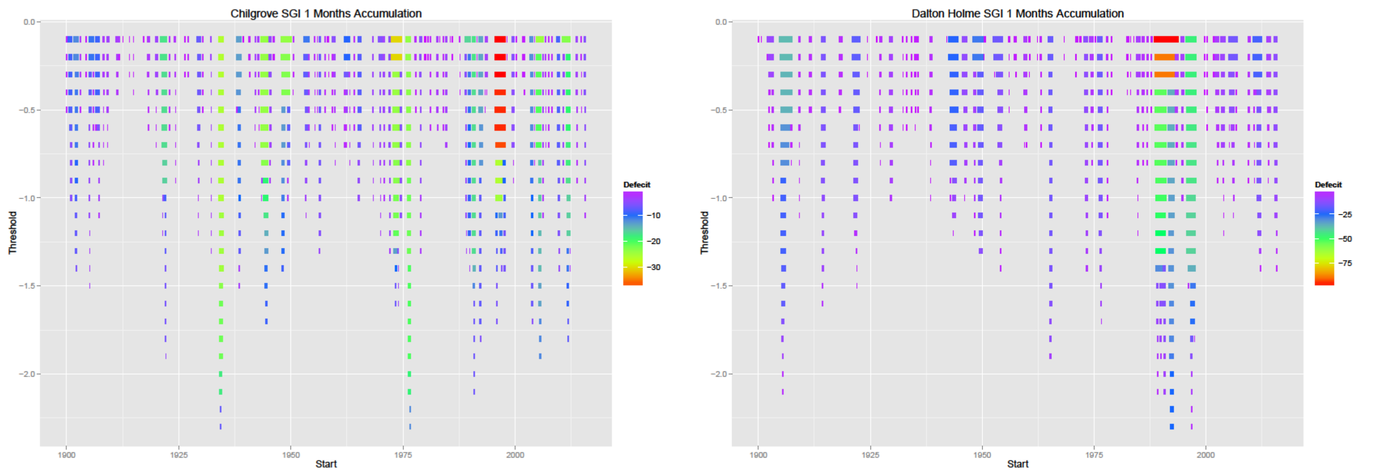
Characterising groundwater droughts, trends in duration and intensity at two sites

Defining drought

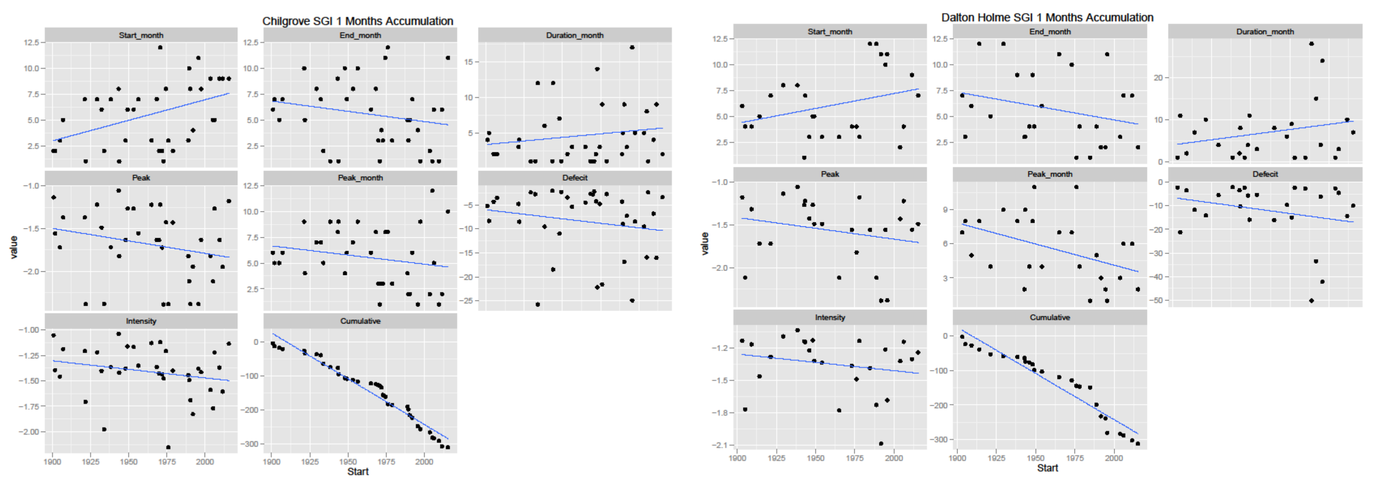
Data for two groundwater observation wells, Chilgrove in Hampshire and Dalton Holme in Yorkshire have been used to explore evidence for temporal trends in groundwater drought. These wells have been selected because they have long records (from 1836 at Chilgrove and 1889 at Dalton Holme) and are known to be relatively un-impacted by large scale abstraction. For each site a Standardised Groundwater Index (SGI) has been calculated, as well as Standardised Precipitation Index (SPI) for rainfall, locally and regionally, using a range of different accumulation periods. More details about how SGI is calculated can be found in Bloomfield & Marchant (2013).

A negative SGI implies dry conditions; and conventionally, by analogy with SPI a threshold of -1.5 is taken to define a drought. For groundwater data, even with the long historical datasets available, low values of SGI mean that few drought events are identified making trend identification limited. To test how sensitive analysis is to the exact threshold, drought events have been extracted for a full range of negative SGI thresholds. A drought episode was defined as two or more consecutive months of SGI under threshold, and single 'wet' months within a sequence of drought months are amalgamated into the drought sequence.

The data have been examined to see whether there are observable trends in the duration and intensity of droughts since 1900. Both sites exhibit similar trends of increasing intensity and duration, although in a sparse data set individual events can skew the distribution. A stronger signal emerges in the timing of drought events, with a trend for droughts to start later in the hydrological year, but to peak and end earlier in the year.



Drought incidences for different SGI threshold values for two Chalk wells



Trends for various drought parameters for two sites in the Chalk at an SPI of -1.0. For start month, end month and peak month, a hydrological year with start October 1st is used.

Probability of a 'wet- drought' Markov transition for various SGI thresholds, probabilities derived from a moving 30 year window of observations (data plotted against the centre of the 30 year window) .

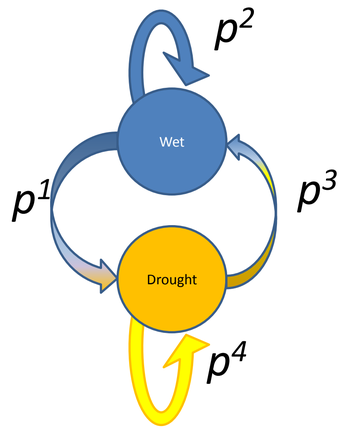
Probability of a 'drought - drought' Markov transition for various SGI thresholds, probabilities derived from a moving 30 year window of observations (data plotted against the centre of the 30 year window) .

Markov chains

The SGI data for the two sites have been used to derive a Markov model representing the probability that, in any given month, the SGI will change from 'wet' to 'drought' (p^1) or if in drought, from 'drought' to 'wet' (p^3). The derived transition probabilities can be used to stochastically generate drought sequences, to test if there is any statistical significance in the observed trends in duration or timing of droughts (work in progress).

Care needs to be taken in using the Markov models, as they assume that transition probabilities depend only on the state in an existing month – the system has no memory. Equally the simulations are binary, so say nothing about drought intensity.

Transition probabilities for 30 year rolling windows on observation data can be plotted (Wilby et a, 2015). The 'wet' to 'drought' (p^1) transition probability is effectively the likelihood of a drought occurring, and the 'drought' to 'drought' (p^4) transition probability represents the likelihood of long drought sequences. Both sites exhibit an increasing probability of entering a drought episode from the 1960s.



BLOOMFIELD, J. P., & MARCHANT, B. P. (2013). ANALYSIS OF GROUNDWATER DROUGHT USING A VARIANT OF THE STANDARDISED PRECIPITATION INDEX. HYDROLOGY AND EARTH SYSTEM SCIENCES DISCUSSIONS, 10(6), 7537-7574.

WILBY, R., NOONE, R., MURPHY, C. AND BRODERICK, C. (2015) AN EVALUATION OF PERSISTENT METEOROLOGICAL DROUGHT USING A HOMOGENEOUS ISLAND OF IRELAND PRECIPITATION NETWORK. INTERNATIONAL JOURNAL OF CLIMATOLOGY · DOI:10.1002/JOC.4253

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