SCREENING THE FLEMISH (BELGIAN) SOIL DRAINAGE CLASS MAP FOR ITS CURRENCY

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Abstract
The currency of the Flanders drainage class map was evaluated using data from two monitoring networks: one with good spatial coverage but poor temporal coverage and another with better temporal but poor spatial coverage. We combine both networks to obtain point expressions for mean highest (MHW) and mean lowest water tables (MLW) by applying time series analysis and total least squares regression. The resulting MHW and MLW point data set was used to evaluate the currency of the existing map and to identify regional differences.

Introduction
Phreatic groundwater dynamics are one of the most important land characteristics for agriculture, nature development and other land uses. In Flanders these dynamics are usually estimated from the natural drainage classes that are indicated on the Belgian soil map (1/20.000), based on data collected during the national soil survey (1947-1971). The natural drainage condition on the soil maps was derived from the depth of gley mottles and a reduction horizon and their position in the landscape. They are indicated using combined classes of the depth of reduction and the depth of mottling. However, these morphogenetic features do not always reflect recent changes in the hydrology and their expression also strongly depend on other soil properties like pH, parent material and organic carbon content.

Even though the original definition was morphological, a common interpretation (eg Van Damme 1969, Boucneau 1996) of these drainage classes is a set of mean highest and mean lowest groundwater levels. The mean highest water level (MHL) and mean lowest water level (MLW) are defined as the mean value of the three highest and lowest groundwater levels measured biweekly for at least 8 years, preferably longer (30 years) for climate representativeness (Van der Sluijs and De Gruijter, 1985).

To check the currency of the drainage class maps, mapped classes need to be compared to recent point estimates of MHW/MLW. Such estimates can be obtained from the recently established phreatic groundwater monitoring network. This network has a good spatial coverage (average density of 1/340 ha), but a poor temporal coverage since the monitoring started only in 2004-2006 and only 2 observations are made per year. This means it has to be combined with data from monitoring networks with a better temporal coverage to derive MHW/MLW statistics.
Reference time series
Two monitoring networks are used as a reference series for calculating the groundwater statistics: the shallow filters (<5m) of the primary network of Flemish Environmental Agency (VMM) and the monitoring networks installed in nature reserves. A selection was made: all locations with at least 2 years of measurements and 24 observations are included, further visual selection was made to exclude series with trends. A total number of 150 reference times series could be retained, which have a good coverage of both the drainage classes and the different considered regions.

Time Series Analysis
The monitoring period in some reference series was too short for the direct calculation of groundwater statistics. Moreover the monitoring periods have different lengths. This can lead to biased estimations since precipitation surplus is a major driving factor in groundwater fluctuations in western European climate (Knotters and Bierkens, 2000), and precipitation surplus varies by year. Therefore a time series model was fitted to the phreatic and precipitation surplus data and used to estimate the MHW and MLW over a fixed climate-representative period of 30 years (1978-2008). The time series model used is PIRFICT (von Asmuth et al., 2002). This is an impulse- response model that uses precipitation surplus with a stochastic component. A different objective for using a time series model is that data can be interpolated for days without measurements. This is needed when the data of the reference series is combined with the measurements in the phreatic groundwater monitoring network.

Phreatic groundwater monitoring network
The phreatic groundwater monitoring network (figure 1), implemented and managed by the Flemish Environmental Agency (VMM) is built as an implementation of the European Nitrate Directive (91/676/EEG). The network contains 2100 monitoring points, or a density of 1/340 ha. These points are measured 2 times per year, generally in spring and autumn. Monitoring piezometers were located more or less equally over Flanders, but with a higher density in regions more vulnerable to nitrate leaching (Eppinger and Thomas, 2007).
Combining the reference time series and the phreatic network data

To estimate ground water statistics in case only a small number of observations is available, two different methods have been proposed. Both methods use linear regression to create a relationship between observations in the reference piezometers and the observations in the short time series.

The first method (te Riele and Brus, 1991; Finke et al., 2004) was developed for estimating the mean highest and lowest water table using only two well timed observations in the short time series, in winter and summer, when the groundwater table is close to the MHW and MLW respectively. A regression relation is derived between the MHW/MLW and the observation at date X in the reference series, and applied to the measurement at the same date in the short series.

The second method (Oude Voshaar and Stolp, 1997) can be used when a larger number of observations is available. In this case linear regression is used for to fit a relationship between the observations in the short time series and the observations in each of the reference series. The best relationship (i.e. with the best fitting reference series) is than retained and used for prediction.

Total Weighted Regression

Since in many cases the reference series were not measured on the same day as the short time series, both methods had to be adjusted: they rely on a relationship between the water level measured in the reference series on a specific date and the groundwater statistics derived in these series. If no observation is available a simulated water table on that specific date had to be used. This introduces uncertainty in the explanatory variable in both methods, which excludes the standard least-squares algorithms. Instead a weighted total least square method (Markovsky and Van Huffel, 2007) is used, which incorporates (and weighs for) the uncertainty in the explanatory variable. Compared to ordinary least squares, this method suffers less from
regression towards the mean (thus covering a larger range of drainage classes), and gives less weight to the less certain predictions, also influencing the confidence levels. The resulting MHW and MLW point data set is not dense enough for mapping, but allows the identification of regional differences.

References