Methods for updating the drainage class map in Flanders, Belgium

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Abstract
Phreatic groundwater dynamics are one of the most important land characteristics for agriculture, nature development and other land uses. In Belgium, these dynamics are usually estimated from the natural drainage classes, indicated on the Belgian soil map. This information is however partly outdated, due to human intervention (artificial drainage, levelling, groundwater extraction) and –possibly- climate change. Moreover, these morphological classes were not based on actual groundwater measurements. Two groups of methods to update the old map using measured groundwater levels were applied at two locations in Flanders. A first group are 'relabeling' methods. These methods preserve the spatial structure of the old map, but assign new classes to it based on the new groundwater level observations. A second method 'remapping' uses area-wide high-resolution digital auxiliary information to remap the area and create new mapping boundaries. These methods were applied to two different locations in Flanders: the valley of river Dijle (800 ha, south of Leuven) and an area close to the village of Kluizen (300 ha, east of Ghent). Validation shows that remapping provides better results than relabeling methods, although both groups of methods improve the quality of the original map

Key Words
Digital soil mapping, water tables, uncertainty.

Introduction
Phreatic groundwater dynamics are one of the most important land characteristics for agriculture, nature development and other land uses. 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). This 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 (table 1). These morphogenetic features do not always reflect recent changes in the hydrology, and their expression is strongly related to other soil properties like pH and organic carbon content.

Table 1. Original definitions of natural drainage classes in Belgium.

Code	Depth (cm) where mottling and permanent reduction features start			
	Clay/silt textures		Sandy Textures	
	mottling	reduction	Mottling	reduction
a	-	-	-	-
b	>120	-	90-120	-
c	80-120	-	60-90	-
d	50-80	-	40-60	-
e	30-50	>80	20-40	>80
f	0-30	40-80	0-20	40-80
h	30-50	-	20-40	-
i	0-30	-	0-20	
g	-	<40	-	<40

A common interpretation (ie Van Damme 1969, Boucneau 1996) of these drainage classes as a set of mean highest and mean lowest groundwater asks for a different estimation, based on measured groundwater levels. The mean highest water level and mean lowest water level 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. Different methodologies have been proposed to update maps of groundwater dynamics using different techniques: relabeling methods (Finke 2000) and remapping methods (Finke *et al.* 2004), but these methods have not yet been applied to and compared within the same area.

Methodology

Study Areas

These methods were applied to two different locations in Flanders: the valley of river Dijle (800 ha, south of Leuven), where a large number of groundwater observations was present in 123 locations, and an area close to the village of Kluizen (300 ha, east of Ghent) where very few observations were present and 100 new observations were sampled.

Time series analysis of long measurement series

Only few locations have sufficient data for derivation of MHW and MLW, and the estimations are based on different climatic periods. However, a larger number of locations has sufficient information for fitting a time series model (von Asmuth *et al.* 2002). This model is calibrated using precipitation surplus and biweekly observations and can be used to expand the measurement serie, and to make it climate representative. Different stochastic simulations of the time series model are used to estimate MHW and MLW, and can be used to derive other parameters such as frequency of exceedence and regime curves.

Well-timed observations (winter-summer)

A number of well timed observations is used to increase the number of points where MHW and MLW can be estimated. In these points, two observations in winter/summer are made of the groundwater depth, when the groundwater is expected to be close to the mean highest/lowest water table. Linear regression between the observations in the long measurement series on the same day as the well-timed observations is used.

Relabeling methods

In relabeling methods (Finke 2000) the point data of MHW and MLW are used to assign new values to polygons of the existing soil map. This was done per polygon and per stratum.

Remapping method

In the remapping method (Finke *et al.* 2004), a set of non-correlated auxiliary variables like DEM, slope, distance (horizontal and vertical) to drainage network and the old drainage class are chosen using Mallows Cp and used with regression kriging to create a new drainage class map.

Validation

A set of 33 (Dijle Valley) and 31 (Kluizen) well timed observations is present to validate the mapping results. Additional observations in 15 locations in Dijle Valley allow a further validation including the conversion of well-timed observations to mean highest/lowest water table.

Results

In both study areas, remapping appears to be the best method, followed by relabeling using one value per stratum.

Table 2. Results of the different map upgrading methods: Remapping is the best method, followed by relabeling by stratum.

	Kluizen (MAE in cm)		Dijle (MAE in cm)	
	MHW	MLW	MHW	MLW
Old	8.8	9.1	9.6	17.7
Relabeling: polygonwise	3.3	4.8	6.9	10.9
Relabeling: Per stratum	3.0	5.5	5.0	6.7
Remapping	1.1	3.8	1.3	3.4

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