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Subsoil compaction in Flanders: from soil map to susceptibility map and risk map for subsoil compaction

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In contrast to topsoil compaction, which can be remediated by normal soil tillage and natural loosening processes, subsoil compaction must be considered as a long term threat to soil productivity as this form of compaction is much more persistent and not easy to alleviate. Therefore we focused on subsoil compaction with a view to demarcate areas prone to soil compaction in Flanders, Belgium. The susceptibility of soil material to compaction is inversely related to its structural strength which can be expressed in terms of precompression stress (PCS). In order to construct maps of subsoil susceptibility we upgraded the soil map of Flanders, originally printed at a scale of 1:20.000, by attributing a 'typical' PCS-value to the legend units. These PCS-values were estimated by means of pedotransfer functions (PTFs), valid either at pF 1.8 or pF 2.5, elaborated from PCS-measurements on soils in Germany by Lebert and Horn (1991). Predictor values for the PTFs were supplied by or derived by means of other PTFs from a historical database of georeferenced soil profiles, which were analysed between 1947 and 1971. After regional stratification, soil profiles with associated horizons were linked to soil map units based on corresponding classification units. Next, for each map unit the horizon at 40 cm of depth was selected and its characteristics retrieved for use in the PTFs. The two resulting PCS-maps (pF 1.8 or 2.5) show the susceptibility to compaction of almost uncompacted or little compacted arable soils as they were present in the period 1950-1970, when the wheel loads of the agricultural equipment of that time were much lower compared to the wheel loads that are common today. Both maps of inherent susceptibility at fixed pF were combined into a 'hybrid map' of the inherent susceptibility to subsoil compaction in spring, when the groundwater table is at its highest level and correspondingly also the susceptibility to compaction is highest. Each soil map unit was assigned the PCS-value calculated for pF 2.5 or the PCS-value calculated for pF 1.8, based on a decision rule. This rule was based on the expected depth of the groundwater table in spring, from which we calculated the expected pF-value at 40 cm of depth. Then, for each soil map unit this calculated pF was compared to pF 2.5, respectively pF 1.8 in order to determine the closest of the two pF-values and the corresponding PCS-value. Based on the developed susceptibility maps so called 'risk maps' were constructed which show the modeled maximum allowable wheel load that may be exerted on the surface of each soil map unit by either (i) a 480/80R42 tractor tyre or (ii) a 800/65R32 tyre of a sugarbeet harvester in order not to exceed the estimated 'pre-compaction PCS' at 40 cm of depth. Therefore we calculated the normal stresses generated by those tyres on the 40 cm reference depth, by making use of the analytical soil compaction model SoilFlex (Keller et al., 2007). Based on the results of a parallel study (Van Holm et al., 2010) in which different soil compaction related parameters were measured on subsoil samples (40 cm) of 17 arable fields, belonging to different soil textural classes and distributed all over Flanders, we could conclude that a severe compaction of subsoil material has taken place since the period 1950-1970 as the PCS-values determined in 2009 for those fields (by uniaxial compaction tests and the Casagrande method; Casagrande, 1936) were always (much) higher then the PCS-values retrieved for the same soil map units from the inherent susceptibility map (= historical map) for the same depth. Knowledge about actual soil bulk density is an important key to actualise the developed maps.