Recent development in preparation of European soil hydraulic maps

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1. Introduction

Reliable quantitative information on soil hydraulic properties is crucial for modelling hydrological, meteorological, ecological and biological processes of the Critical Zone. Most of the Earth system models need information on soil moisture retention capacity and hydraulic conductivity in the full matric potential range. These soil hydraulic properties can be quantified, but their measurement is expensive and time consuming, therefore measurement-based catchment scale mapping of these soil properties is not possible. The increasing availability of soil information and methods describing relationships between simple soil characteristics and soil hydraulic properties provide the possibility to derive soil hydraulic maps based on spatial soil datasets and pedotransfer functions (PTFs). Over the last decade there has been a significant development in establishment of data inventory and maps on soil hydraulic properties with continental coverage for Europe. Our aim is to provide information on the recently available European soil hydraulic datasets.

2. Available European soil hydraulic maps

European soil hydraulic maps are derived based on basic soil maps and continental hydraulic pedotransfer functions (PTFs). Most important information on most recently available European soil hydraulic maps with continental coverage is highlighted in Table 1. Resolution of the derived maps, soil information and PTFs used to derive soil hydraulic properties were determined by the purpose of the soil hydraulic mapping.

2.1 The **European Soil Data Centre's soil hydraulic properties map (ESDAC SHP)** has been calculated for the implementation of the research programme on soil quality indicators (Tóth G., Weynants, 2016). The most important soil hydraulic properties of the topsoil were mapped.

2.2. The **3D Soil Hydraulic Database of Europe (EU-SoilHydroGrids**) (Tóth et al., 2017) provides information on soil water retention at three matric head (0, -0.03, -1.5 MPa), saturated hydraulic conductivity and Mualem-van Genuchten (MVG) (Figure 1.) parameters of seven soil depths till 2 m for Europe. Soil hydraulic maps with 1 km resolution can be used for continental scale modelling applications. Finer scale (250 m resolution) provides the possibility for regional planning. EU-SoilHydroGrids ver1.0 will be updated if a newer version of SoilGrids becomes available or more efficient PTFs will be derived.

2.3. The Global data set of soil hydraulic properties (Global SHP) (Motzka et al. ,2017) shows the MVG parameters (Figure 1.) and water retention at 24 specific matric heads at 7 soil depth up to 2 m. From the global dataset aggregated MVG parameters at 0.25° spatial resolution and their subgrid variability are available. The global SHP data has been derived to serve as input information for regional and global climate models. Including sub-grid scaling variance enables downscaling of model outputs.

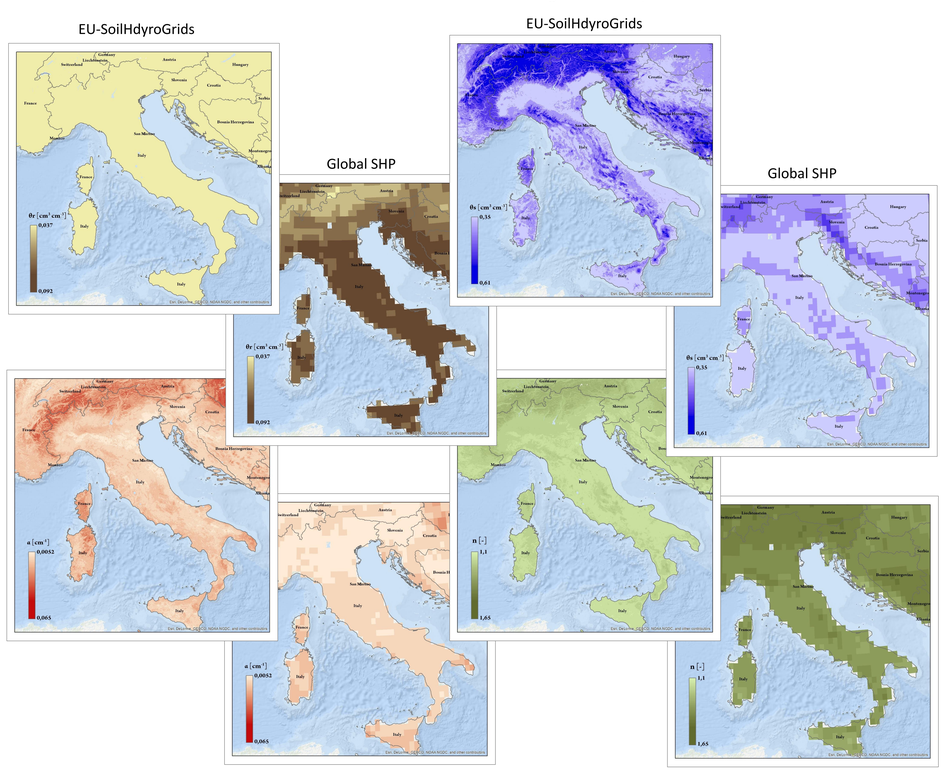

Figure 1. Parameters of the Mualem-van Genuchten model for the description of moisture retention curve at 30 cm depth from EU-SoilHydroGrids (1 km resolution) and global SHP (0.25°resolution).

Table 1. Comparison of available European soil hydraulic maps with continental coverage.*

	European soil hydraulic maps		
	ESDAC SHP	**EU-SoilHydroGrids**	**Global SHP**
Predicted soil hydraulic property	THS, FC, WP, KS	THS, FC, WP, KS, MRC (VG), MRC + HCC (MVG)	MRC + HCC (MVG), parameter of sub-grid variability
Horizontal coverage	EU, Balkan countries, Norway	Europe	global
Vertical coverage	0-30 cm	0, 5, 15, 30, 60, 100, 200 cm	0, 5, 15, 30, 60, 100, 200 cm
Resolution	1 km	250 m, 30 arcseconds (~ 1 km at the Equator)	0,25°
Projection	ETRS-LAEA	ETRS-LAEA	WGS84
Format	GeoTIFF	GeoTIFF	NetCDF
Input soil information	European Soil Database (ESDB) (Panagos et al., 2012)	SoilGrids 250 m and 1 km (Hengl et al., 2017)	SoilGrids 1 km (Hengl et al., 2017)
Soil property considered for the calculations	FAO modified soil texture classes, organic carbon content	clay, silt and sand content, organic carbon content, bulk density, pH in water, depth to bedrock	clay, silt and sand content, bulk density
Pedotransfer functions (PTFs) used for the calculations	EU-PTFs: PTF2 (THS), PTF7 (FC), PTF10 (WP), PTF14 (Tóth et al., 2015)	EU-PTFs: PTF6 (THS), PTF9 (FC), PTF12 (WP), PTF16 (KS), PTF22 (MRC), PTF 19 (MRC+HCC) (Tóth et al., 2015)	PTF ROSETTA: H3 modell (Schaap et al., 2001)
Database used to derive PTFs	EU-HYDI (Weynants et al., 2013)	EU-HYDI (Weynants et al., 2013)	UNSODA (Leij et al, 1996, Nemes et al., 2001)
Availability of the dataset	https://esdac.jrc.ec.europa.eu/	http://mta-taki.hu/en/eu_soilhydrogrids_3d https://esdac.jrc.ec.europa.eu/	https://doi.org/10.1594/PANGAEA.870605
Information about the dataset	https://esdac.jrc.ec.europa.eu/	Tóth et al. (2017)	Montzka et al. (2017)

*Abbreviations used in table: THS: saturated water content ($cm^3\ cm^{-3}$); FC: water content at field capacity ($cm^3\ cm^{-3}$); WP: water content at wilting point ($cm^3\ cm^{-3}$); KS: saturated hydraulic conductivity log_{10}(cm day^{-1})]; MRC: moisture retention curve; HCC: hydraulic conductivity curve; VG: van Genuchten model; MVG: Mualem-van Genuchten model.

3. Statistics of soil hydraulic properties

Density plots of MVG model parameters desribing the moisture retention and hydraulic conductivity curve (MRC and HCC) are presented on Figure 2-4. Soil hydraulic maps erived based on the 1km resolution SoilGrids are compared. In case of EU-SoilHydroGrids MVG parameters class PTFs has been applied which considers USDA texture classes and topsoil/subsoil distinction therefore the density plot has multiple peaks. Residual water content of MVG (θ_r) was found to be most accurate if it was 0.18 or 0.04 $cm^3\ cm^{-3}$ in EU-PTFs, therefore variance of this parameter is low in EU-SoilHydorGrids. In case of saturated water content of MVG (θ_s) the sequence of density peaks and range between minimum and maximum values at different soil depth are similar in case of EU-SoilHydroGrids and European set of global SHP (Figure 3.,4.). Parameter α and n of MVG is slightly higher in EU-SoilHydrGgrids than in the global dataset. Differences between EU-SoilHydroGrids and European set of global SHP originates from i) the difference in PTF's applied, ii) difference in soil hydraulic dataset used to derive the PTF and iii) the upscaling method of SHP.

4. Outline of the range of applications

Most important information about the maps are included in Table 1.
During the use of the different soil hydraulic maps the followings are worth considering:

- if local soil hydraulic data or local soil hydraulic PTFs and/or local soil information are available their use is recommended because spatial accuracy of global/European maps is limited, especially in pedoclimatic regions which were not covered by the soil dataset used to derive the PTFs;
  - ESDAC SHP maps:
    - lack accuracy, mostly due to the use of the dominant STU for a whole SMU,
    - the map is available for the topsoil;
  - EU-SoilHydroGrids:
    - prediction of soil hydraulic conductivity (K) has higher uncertainty than other soil hydraulic properties, conceivably due to the fact that K is highly influenced by the geometry of the pore space that is absent in continental scale datasets;
  - Global SHP maps:
    - dataset is available at 0.25°,
    - the scaling parameter variance does not cover full prediction uncertainty (Motzka et al., 2017).

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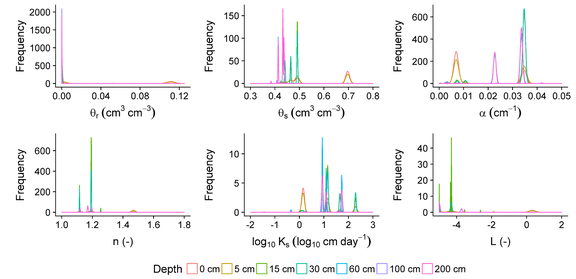

Figure 2. Density plot of the Mualem-van Genuchten parameters of European soils from the EU-SoilHydroGrids dataset (Tóth et al., 2017)

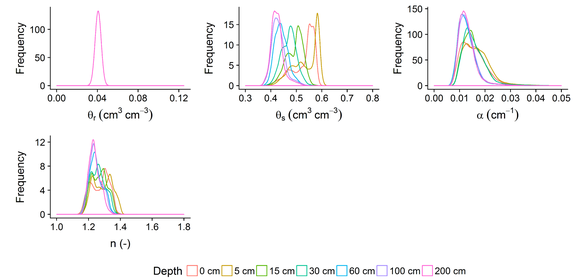

Figure 3. Density plot of the van Genuchten parameters of European soils from the EU-SoilHydroGrids dataset (Tóth et al., 2017)

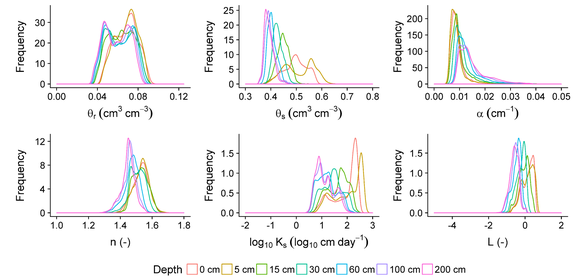

Figure 4. Density plot of the Mualem-van Genuchten parameters of European soils from the Montzka et al. (2017) SHP dataset.

References

European Soil Data Centre (ESDAC), esdac.jrc.ec.europa.eu, European Commission, Joint Research Centre

Hengl, T., Mendes de Jesus, J., Heuvelink, G. B. M., Ruiperez Gonzalez, M., Kilibarda, M., Blagotić, A., Wei S., Wright M.N., Geng X., Bauer-Marschallinger B., et al. 2017. SoilGrids250m: Global gridded soil information based on machine learning. PLOS ONE, 12(2), e0169748.

Jones, R. J. A., Hiederer, R., Rusco, E., Montanarella, L. 2005. Estimating organic carbon in the soils of Europe for policy support. European Journal of Soil Science 56, 655-671.

Leij, F. J., Alves, W. J., van Genuchten, M. T., & Williams, J. R. 1996. The UNSODA Unsaturated Soil Hydraulic Database. User's Manual Version 1.0. CINCINNATI, OHIO.

Montzka, C., Herbst, M., Weihermüller, L., Verhoef, A., & Vereecken, H. 2017. A global data set of soil hydraulic properties and sub-grid variability of soil water retention and hydraulic conductivity curves. Earth System Science Data, 9(2), 529–543.

Nemes, A., Schaap, M. G., Leij, F. J., & Wösten, J. H. M. 2001. Description of the unsaturated soil hydraulic database UNSODA version 2.0. Journal of Hydrology, 251(3–4), 151–162.

Panagos P., Van Liedekerke M., Jones A., Montanarella L.. 2012. European Soil Data Centre: Response to European policy support and public data requirements. Land Use Policy, 29 (2), pp. 329-338.

Tóth, G., Weynants, M. 2016. 'Maps of indicators of soil hydraulic properties for Europe', dataset/maps downloaded from the European Soil Data Centre Available at: esdac.jrc.ec.europa.eu [Accessed 23 November 2017]

Tóth, B., Weynants, M., Pásztor, L., & Hengl, T. 2017. 3D soil hydraulic database of Europe at 250 m resolution. Hydrological Processes, 31(14), 2662–2666.

Weynants, M., Montanarella, L., Tóth, G., Arnoldussen, A., Anaya Romero, M., Bilas, G., Borresen, T., Cornelis, W., Daroussin, J, Gonçalves, M., Haugen, L., Hennings, V., Houskova, B., Iovino, M., Javaux, M., Keay, C. A., Kätterer, T., Kvaerno, Si., Laktinova, T., Lamorski, K., Lilly, A., Makó, A., Matula, S., Morari, F., Nemes, A., Patyka, N. V., Romano, N., Schindler, U., Shein, E., Slawinski, C., Strauss, P., Tóth, B., Wösten, H. 2013. European HYdropedological Data Inventory (EU-HYDI). EUR – Scientific and Technical Research series – ISSN 1831-9424, Luxembourg. DOI: 10.2788/5936