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uas for environmental monitoring

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Obtaining soil hydraulic parameters to enhance soil moisture prediction with UAS

Brigitta Tóth, János Mészáros, Mátyás Árvai, Melanie Weynants, László Pásztor,
Tomislav Hengl – Valencia – 15/02/2018

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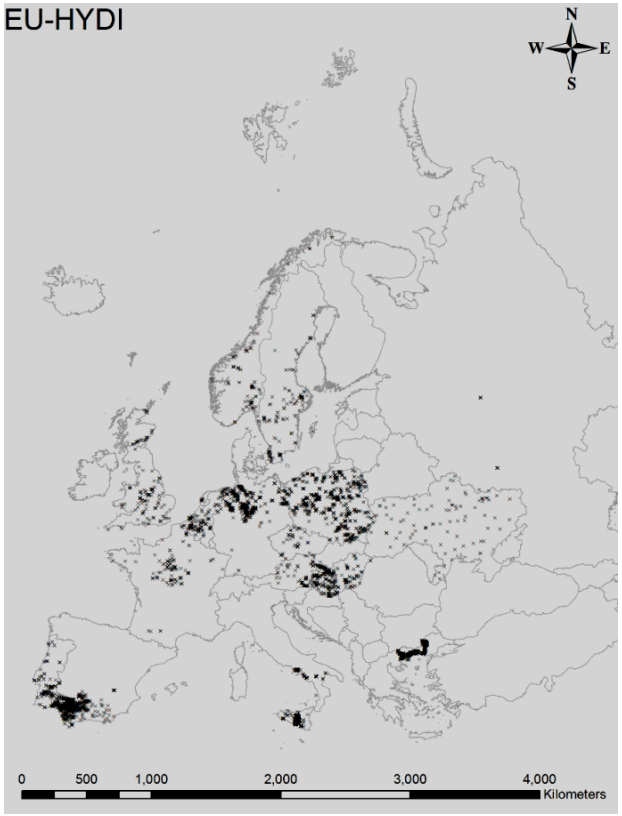
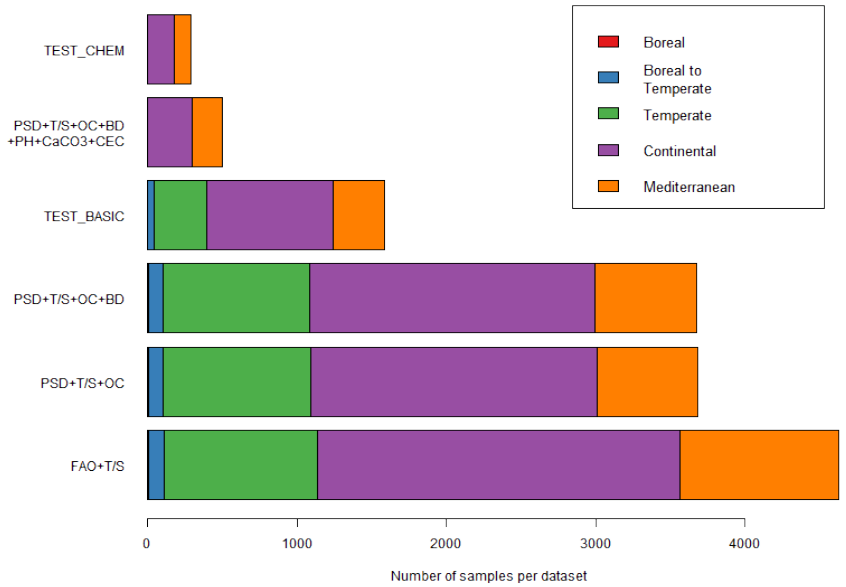
Funded by the Horizon 2020 Framework Programme
of the European Union

European Hydropedological Data Inventory (EU-HYDI)



Geographical distribution of the soil profiles of EU-HYDI



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)*** *(p. 168)*. Luxembourg: EUR

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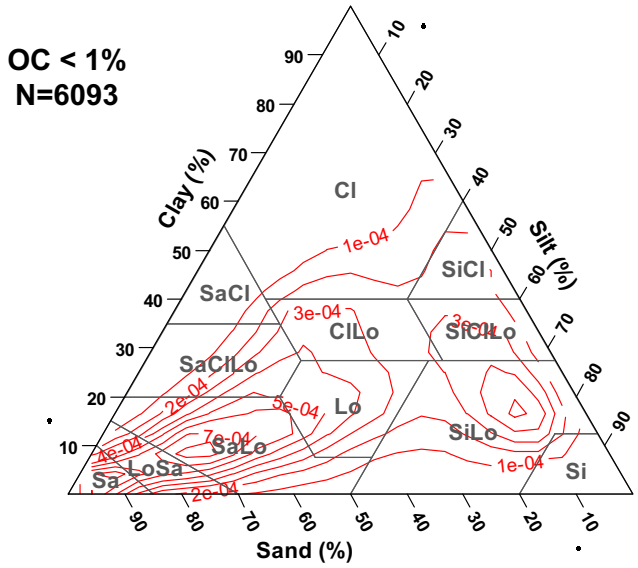
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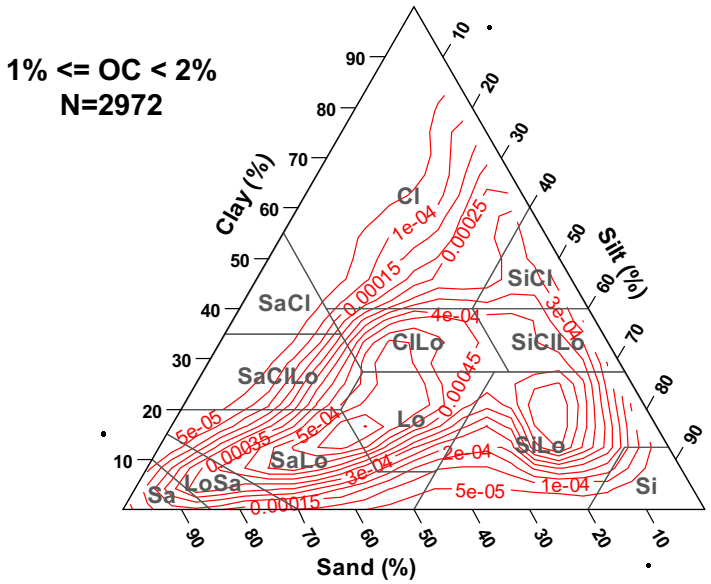
N=6093
Clay (%)
Silt (%)
Sand (%)
Cl
SiCl
SaCl
ClLo
SiClLo
SaClLo
Lo
SiLo
SaLo
LoSa
Sa
Si
1e-04
2e-04
3e-04
4e-04
5e-04
7e-04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Clay (%)
Silt (%)
Sand (%)
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SaCl
ClLo
SiClLo
SaClLo
Lo
SiLo
SaLo
LoSa
Sa
Si
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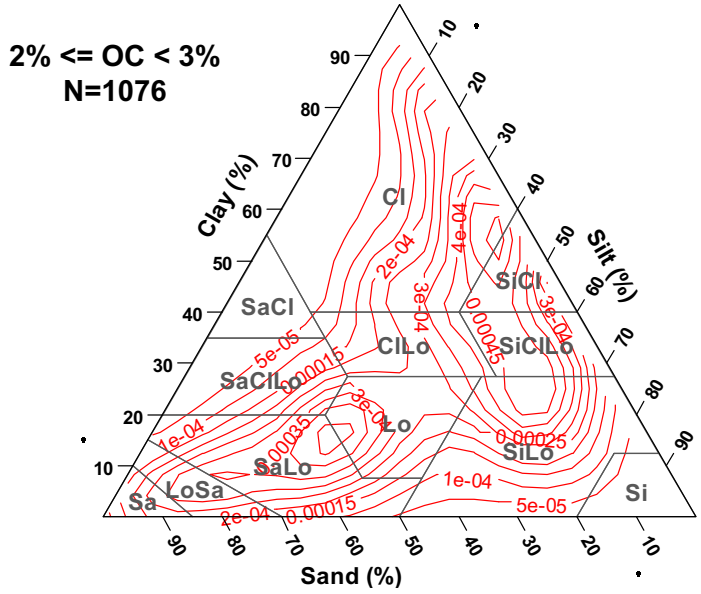
1e-04
2e-04
3e-04
4e-04
5e-04
0.00015
0.00025
0.00035
0.00045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Clay (%)
Silt (%)
Sand (%)
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SiCl
SaCl
ClLo
SiClLo
SaClLo
Lo
SiLo
SaLo
LoSa
Sa
Si
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1e-04
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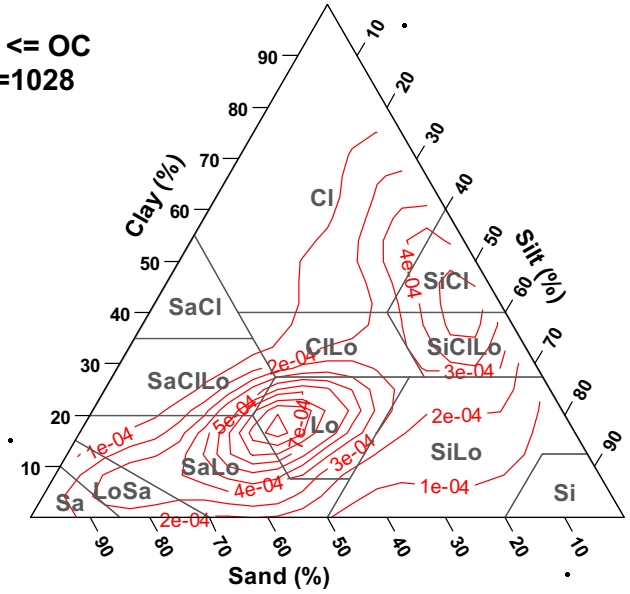
3e-04
4e-04
0.00015
0.00025
0.00035
0.00045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Clay (%)
Silt (%)
Sand (%)
Cl
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SaCl
ClLo
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SaClLo
Lo
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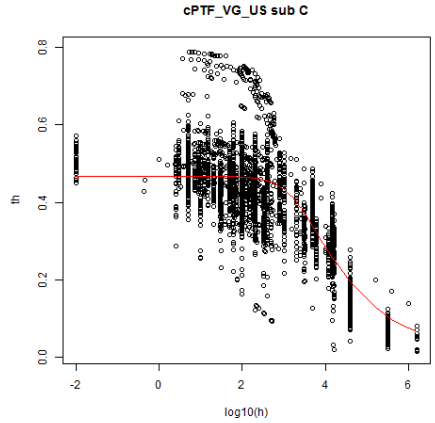
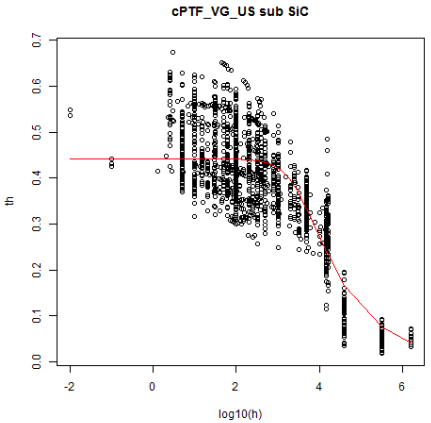
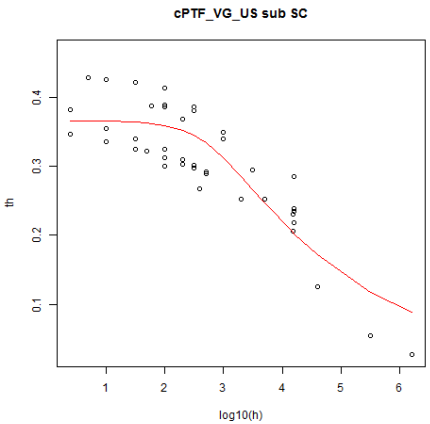
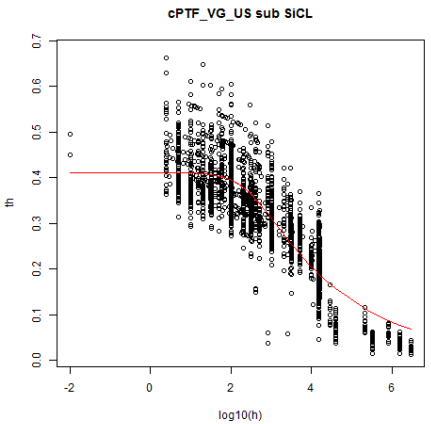
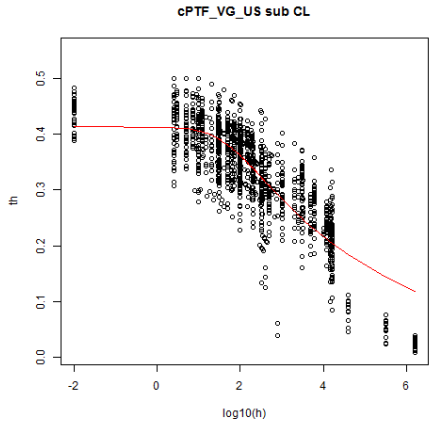
2e-04
3e-04
4e-04
5e-04

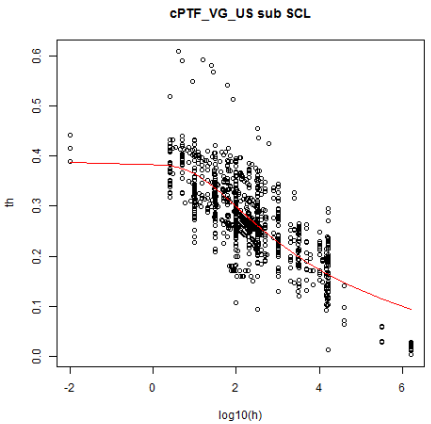


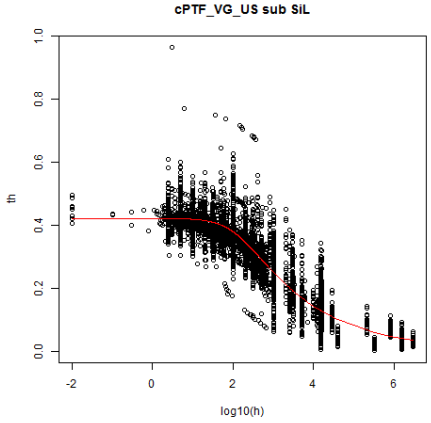


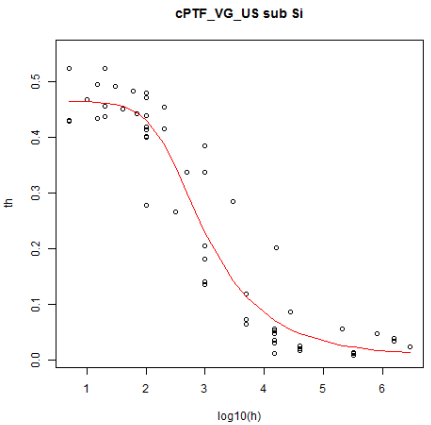


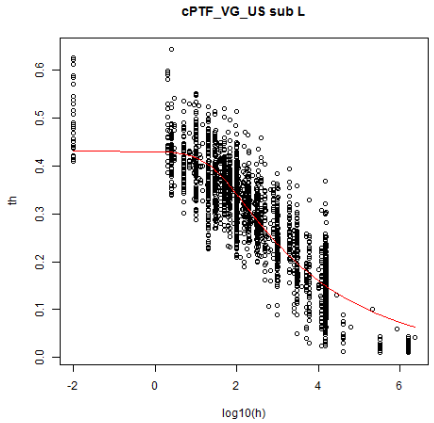


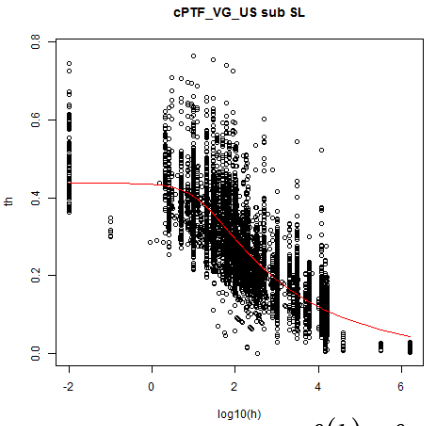


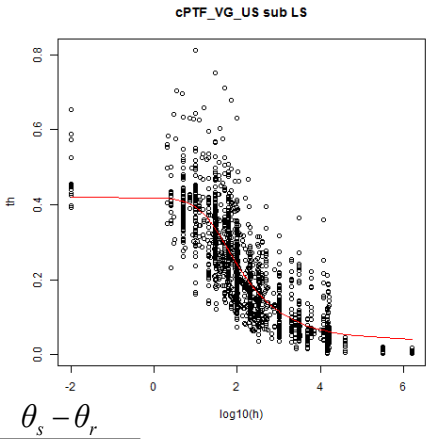


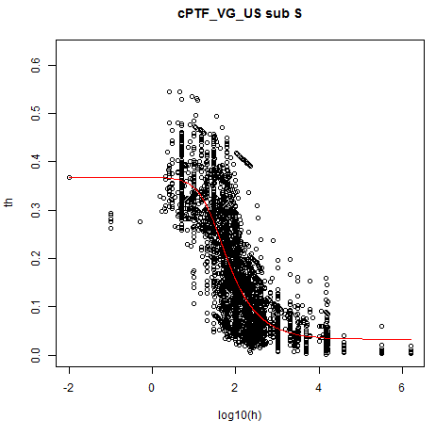












$$\theta(h) = \theta_r + \frac{\theta_s - \theta_r}{\left[1 + (\alpha h)^n\right]^{1-1/n}}$$

Tested combination of input variables	Suggested PTFs					
	θ_S (cm^3cm^{-3})	θ_{FC} (cm^3cm^{-3})	θ_{WP} (cm^3cm^{-3})	K_S [$\log_{10}$(cm day^{-1})]	MRC (cm^3cm^{-3})	HCC (cm day^{-1})
FAO+T/S	FAO+T/S_RT	FAO+T/S_RT	FAO+T/S_RT	FAO+T/S_RT	FAO+T/S_MS	FAO+T/S_MS
FAO+T/S+OC	FAO+T/S+OC_RT			FAO+T/S+OC_RT		
USDA+T/S	USDA+T/S_RT	USDA+T/S_RT	USDA+T/S_RT	USDA+T/S_RT	USDA+T/S_MS	**USDA+T/S_MS**
PSD+T/S+OC	PSD+T/S+OC_RT	**PSD+OC_LRt**	**PSD+OC_LRt**	PSD+T/S+OC_RT		
PSD+T/S+OC +pH+CaCO3+CEC				PSD+T/S+pH+CEC_LR	PSD+OC +pH+CEC_LRt	
PSD+T/S+OC+BD	PSD+T/S+OC+BD_LRt			PSD+T/S+OC_RT	PSD+T/S+OC+BD_LR	
PSD+T/S+OC+BD+pH	**PSD+T/S+BD+pH_LRt**				**PSD+T/S+OC+BD+pH _LRt2**	
PSD+T/S+OC+BD+pH +CaCO3+CEC				**PSD+T/S+pH+CEC_LR**		

Tóth, B., Weynants, M., Nemes, A., Makó, A., Bilas, G. and Tóth, G. 2015. ***New generation of hydraulic pedotransfer functions for Europe.*** European Journal of Soil Science. 66: 226–238. 10.1111/ejss.12192

PTFs are built in `euptf` R package:

Weynants, M., Tóth, B. 2014. **The euptf package.** The European Soil Portal.: 5
http://eusoils.jrc.ec.europa.eu/Library/Themes/Hydraulic_PTFs/data/euptf_vignette.pdf

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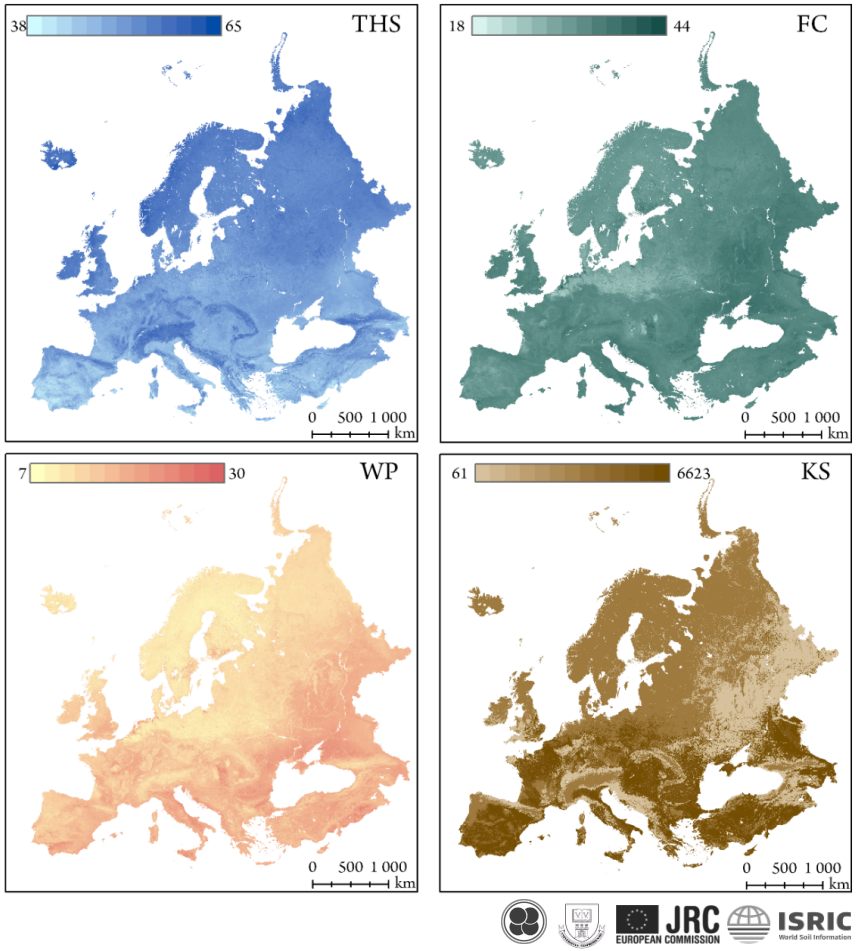
3D EU-SoilHydroGrids

- Contributing institutes:
  RISSAC, UP, JRC, ISRIC
- Input information:
  SoilGrids
- Method:
  EU-PTFs, point and parametric
- Output:
  16 soil hydraulic properties
  at 7 soil depth up to 2 m
- Resolution:
  250 m and
  1 km



Soil hydraulic properties in EU-SoilHydroGrids

- Saturated water content (THS) × 100 [$cm^3\ cm^{-3}$]
- Water content at field capacity (FC) × 100 [$cm^3\ cm^{-3}$]
- Water content at wilting point (WP) × 100 [$cm^3\ cm^{-3}$]
- Saturated hydraulic conductivity (KS) × 100 [$cm\ day^{-1}$]
- Parameters of the moisture retention curve (MRC) × 10000 on 5 bands:
  - band 1: θ_r parameter × 10000 [$cm^3\ cm^{-3}$]
  - band 2: θ_s parameter × 10000 [$cm^3\ cm^{-3}$]
  - band 3: α parameter × 10000 [cm^{-1}]
  - band 4 n parameter × 10000 [-]
  - band 5 m parameter × 10000 [-]
- Parameters of the unsaturated hydraulic conductivity curve (HCC) × 10000 on 7 bands (θ_r, θ_s, α, n, m, K_0, L)

Performance of PTFs tested on EU-HYDI test sets (adapted from Tóth et al. (2015).

Predicted soil hydraulic property	Soil information of SoilGrids used as input for calculations	Number of samples used to derive PTF	Number of samples in test set	RMSE on test set
THS [$cm^3\ cm^{-3}$]	Silt, Clay, T/S, BD, pH	1142	156	0.020
FC [$cm^3\ cm^{-3}$]	Silt, Clay, OC	2356	1005	0.055
WP [$cm^3\ cm^{-3}$]	Silt, Clay, OC	5530	2357	0.048
log_{10}KS [log_{10}(cm day^{-1})]	Sand, Silt, Clay, T/S, OC	2628	1121	1.06
MRC (θ) [$cm^3\ cm^{-3}$]	Sand, Silt, Clay, T/S, OC, BD, pH	1713	288	0.046
HCC (log_{10}K) [log_{10}(cm day^{-1})]	Sand, Silt, Clay, T/S	860	176	0.77

Performance of EU-SoilHydroGrids ver1.0 and ESDAC SHP analyzed on measured soil hydraulic values of EU-HYDI samples that have information on location.

Predicted soil hydraulic property	Name of soil hydraulic map	PTF used for calculation*	Number of samples	MAE	RMSE
THS of top 30 cm [$cm^3\ cm^{-3}$]	EU-SoilHydroGrids ver1.0	PTF06	1607	0.076	0.095
	ESDAC SHP	PTF02	1607	0.081	0.109
FC of top 30 cm [$cm^3\ cm^{-3}$]	EU-SoilHydroGrids ver1.0	PTF09	1548	0.074	0.096
	ESDAC SHP	PTF07	1548	0.085	0.110
WP of top 30 cm [$cm^3\ cm^{-3}$]	EU-SoilHydroGrids ver1.0	PTF12	2652	0.066	0.084
	ESDAC SHP	PTF10	2652	0.085	0.106
KS of top 30 cm [log_{10}(cm day^{-1})]	EU-SoilHydroGrids ver1.0	PTF16	1743	1.10	1.40
	ESDAC SHP	PTF14	1743	1.23	1.59

Use of EU-SoilHydroGrids

- data of layers deeper than the bottom of the soil are included as well → possibility to interpolate soil hydraulic properties through different depths;
- soil hydraulic properties are calculated for the fine earth fraction;
- if local data or PTFs and/or local soil information that has to be the priority;
- prediction of KS has higher uncertainty than other soil hydraulic properties.

Availability of EU-SoilHydroGrids ver 1.0

- Institute for Soil Sciences and Agricultural Chemistry Centre for Agricultural Research Hungarian Academy of Sciences: http://mta-taki.hu/en/eu_soilhydrogrids_3d

250 m	– 1370 tiles,	1350 × 7 × 16 layers,	70 GB
1 km	– not tiled,	7× 16 layers,	15 GB

- European Soil Data Centre: http://esdac.jrc.ec.europa.eu/

Plan: regularly update EU-SoilHydroGrids ver1.0

3D Soil Hydraulic Database of Europe at 250 m resolution (EU-SoilHydroGrids ver 1.0)

EU-SoilHydroGrids ver 1.0 (Maps)

The database includes information on the soil water content at the most frequently used matric potential values, saturated hydraulic conductivity, Mualem-van Genuchten parameters of the moisture retention and hydraulic conductivity curves.

Resolution:	250 m **Download**
Data format:	GeoTIFF
Spatial coverage:	Europe
Coordinate Reference System:	Projection: Azimuthal Equidistant Latitude at projection centre : 53 Latitude at projection centre: 24 False Easting : 5837287.81977 False Northing: 2121415.69617 Units: meter Datum: WGS84 Ellipsoid: WGS84

Resolution:	1 km **Download**
Data format:	GeoTIFF
Spatial coverage:	Europe
Coordinate Reference System:	Projection: Lambert Azimuthal Equal Area Latitude at projection centre : 48 Latitude at projection centre: 9

Hydrological Processes

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DATA NOTE

3D soil hydraulic database of Europe at 250 m resolution

Brigitta Tóth ✉, Melanie Weynants, László Pásztor, Tomislav Hengl

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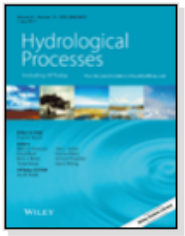
Funding Information



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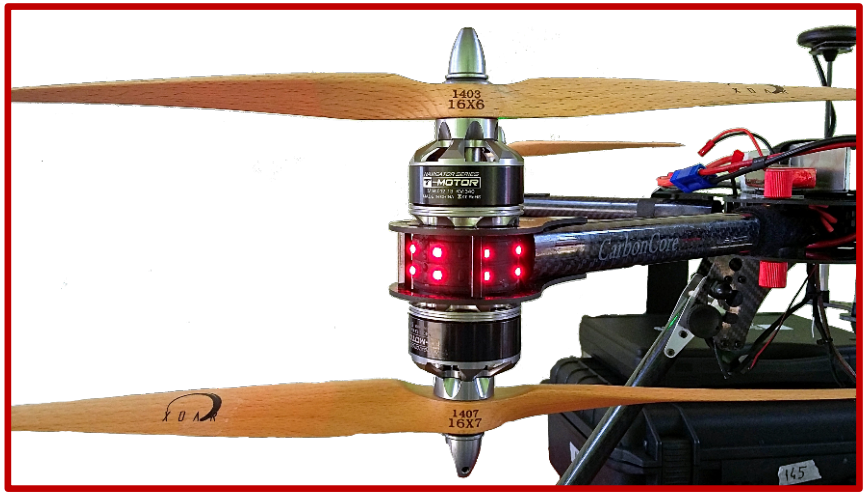
Abstract

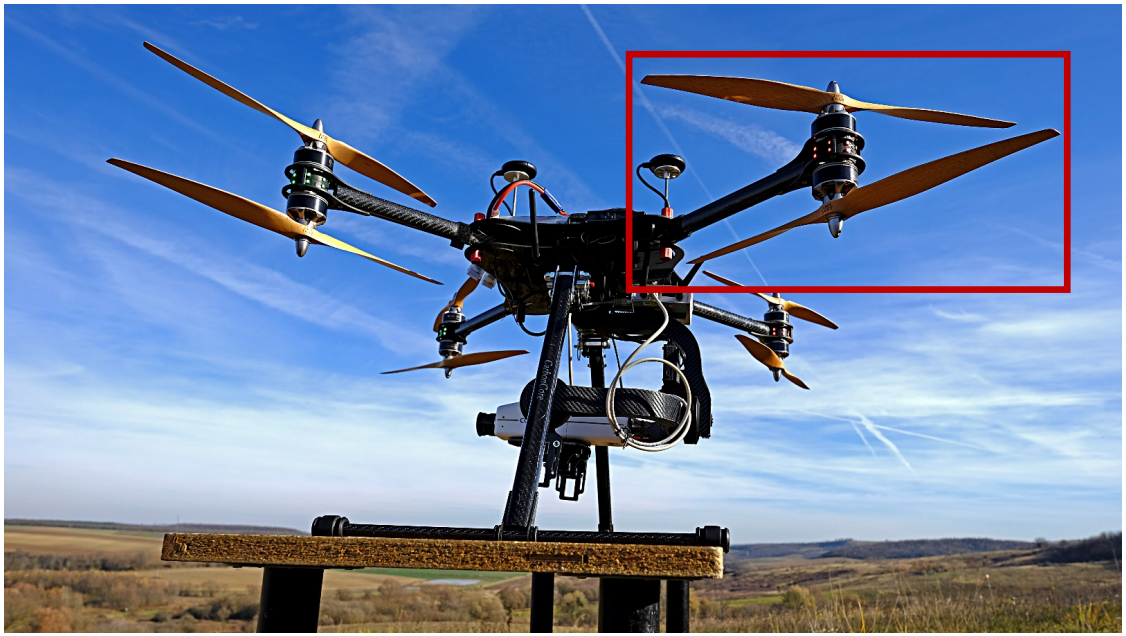
Soil hydraulic properties are required in various modelling schemes. We propose a consistent spatial soil hydraulic database at 7 soil depths up to 2 m calculated for Europe based on SoilGrids250m and 1 km datasets and pedotransfer functions trained on the European Hydropedological Data Inventory. Saturated water content, water content at field capacity and wilting point, saturated hydraulic conductivity and Mualem-van Genuchten parameters for the description of the moisture retention, and unsaturated hydraulic conductivity curves have been predicted. The derived 3D soil hydraulic layers (EU-SoilHydroGrids ver1.0) can be used for environmental modelling purposes at catchment or continental scale in Europe. Currently, only EU-SoilHydroGrids provides information on the most frequently required soil hydraulic properties with full European coverage up to 2 m depth at 250 m resolution.

CarbonCore Cortex X8 UAV

Robbe Futuba T14 SG



Zero UAV Gemini M+S
Flight control unit



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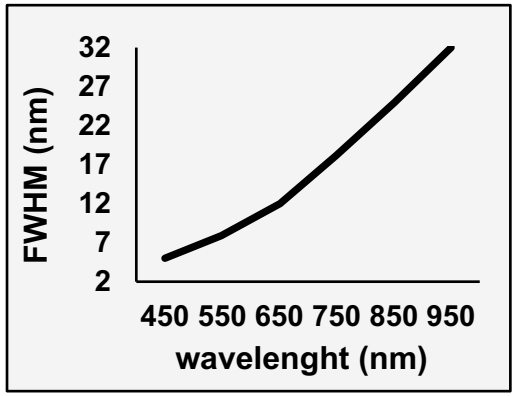
Cubert UHD-185 hyperspectral snapshot camera

Wavelength range:
450nm – 950nm,
125 channels

Spectral sampling: 4 nm

Weight: ~840 g



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Research plans with UAS

- Hyperspectral proximal remote sensing for the interaction between soil moisture, vegetation and water in agricultural fields
- Precise detection of the invasive plants species in nature reserve areas

János Mészáros: meszaros.janos@agrar.mta.hu

Mátyás Árvai: arvai.matyas@agrar.mta.hu

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- The database management is supported by the Hungarian National Scientific Research Foundation (OTKA) under Grant K105167.
- The voluntary contribution of the European soil physicians and their institutions to the EU-HYDI database provided the basis of EU-SoilHydroGrids.
- Gábor Szatmári, Judit Matus and Annamária Laborczi ISSAC CAR HAS – assistance in the control of the dataset and download site construction.