

Developing a high-resolution global digital soil map for enhanced hydrological modeling with the SWAT+ model

International Soil and Water Assessment Tool (SWAT)
Conference 26-30 June 2023

Aarhus University, Department of Ecoscience, Denmark.

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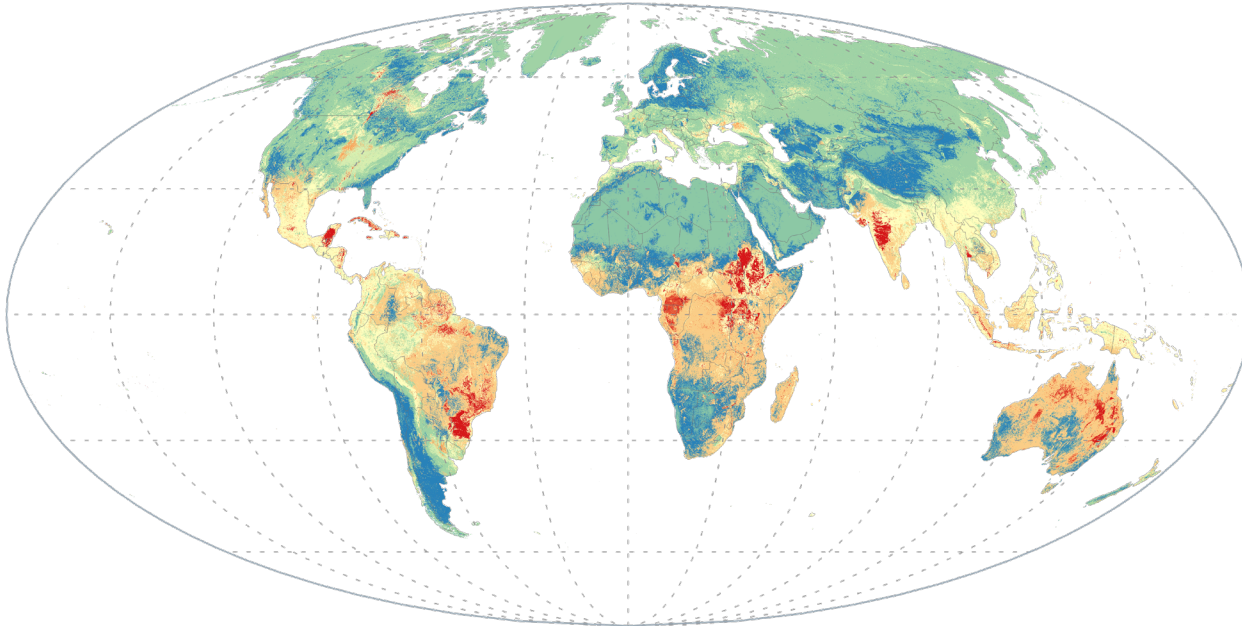
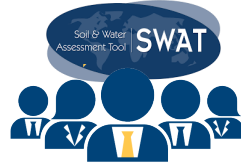
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What are we offering?



❖ DSOLMap:

- New soil map for SWAT+.
- Global scale.
- Spatial resolution 250 m.
- 6 soil horizons (up to 2 m).
- For free.

INDEX

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- Digital Soil Open Land Map (DSOLMap)
- DSOLMap flowchart

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- STEP 4

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➤ CONCLUSIONS

INTRODUCTION

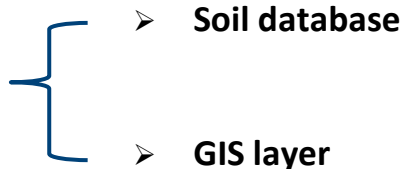
✓ Sanchez et al. (2009)

POLICYFORUM

ENVIRONMENTAL SCIENCE

Digital Soil Map of the World

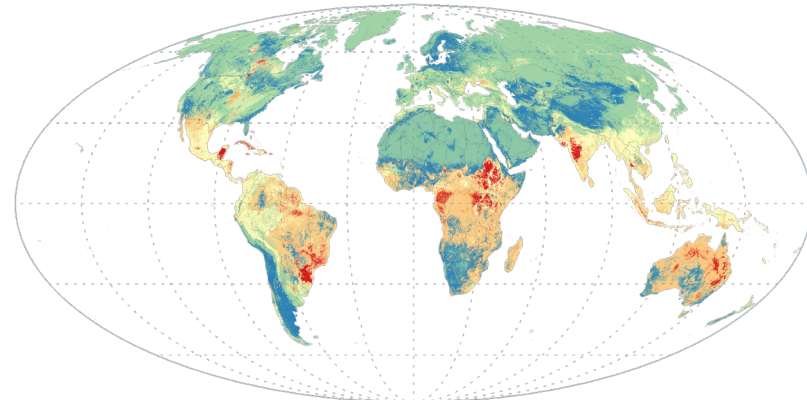
Pedro A. Sanchez, ^{1*} Sonya Ahamed, ¹ Florence Carré, ² Alfred E. Hartemink, ³ Jonathan Hempel, ⁴ Jeroen Huising, ⁵ Philippe Lagacherie, ⁶ Alex B. McBratney, ⁷ Neil J. McKenzie, ⁸ Maria de Lourdes Mendonça-Santos, ⁹ Budiman Minasny, ⁷ Luca Montanarella, ² Peter Okoth, ⁵ Cheryl A. Palm, ¹ Jeffrey D. Sachs, ¹ Keith D. Shepherd, ¹⁰ Tor-Gunnar Vägen, ¹⁰ Bernard Vanlauwe, ⁵ Markus G. Walsh, ¹ Leigh A. Winowicki, ¹ Gan-Lin Zhang ¹¹



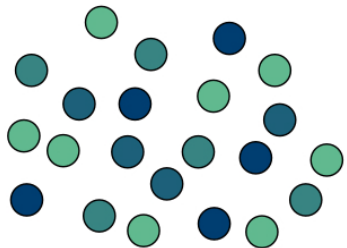
Spatial database of soil properties

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
OBJECTID	NAME	SEION	SDMA	SSID	CMPTCT	NLAYERS	HYDGRP	SOL_DMX	ANONL_EXL	SOL_CKR	TEXTURE	SOL_N1	SOL_AWK1	SOL_K1	SOL_CBN1	CLAY1	SILT1	SAND1	ROCK1	SOL_AES1	
1	150 xxx	0	150 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.257	0.189	11.64	3.942	44.3	27.77	52.84	6.555	0.000			
2	157 xxx	0	157 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.363	0.151	9.25	6.28	43.6	30.62	26.69	6.812	0.004			
3	158 xxx	0	158 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.371	0.172	6.19	6.791	41.22	38.36	20.08	5.703	0.005			
4	159 xxx	0	159 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.425	0.086	8.34	9.211	46.4	34.975	44.62	15.73	0.064			
5	160 xxx	0	160 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.235	0.1455	13.83	2.303	42.34	18.2	38.97	8.16	0.007			
6	161 xxx	0	161 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.289	0.1447	11.64	2.867	40.25	25.16	34.38	10.39	0.061			
7	164 xxx	0	164 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.12	0.13	11.08	2.8	42.8	29.8	27.8	2.6	0.007			
8	168 xxx	0	168 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.22	0.1257	18.11	1.04	41.38	18.81	39.56	3.533	0.004			
9	169 xxx	0	169 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.221	0.134	10.65	4.626	42.18	29.36	27.98	6.36	0.004			
11	170 xxx	0	170 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.403	0.171	6.837	1.87	40.66	38.97	20.14	4.43	0.006			
12	171 xxx	0	171 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.427	0.11	9.95	0.255	43.88	10.5	45	18.12	0.007			
13	172 xxx	0	172 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.2	0.1467	17.56	1.833	42.34	15.336	43	6	0.007			
14	173 xxx	0	173 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.31	0.1893	12.33	1.865	40.12	28.1	31.78	6.165	0.009			
15	180 xxx	0	180 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.458	0.1667	7.2	5.588	40.16	39	20.31	5	0.009			
16	181 xxx	0	181 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.355	0.19	11.27	2.5	40	39	21	6	0.008			
17	190 xxx	0	190 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.229	0.135	18.12	1.286	45.44	9.03	44.97	7.777	0.064			
18	193 xxx	0	193 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.422	0.0553	8.025	0.0471	45.75	9.12	45	13.234	0.267			
19	195 xxx	0	195 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.441	0.09478	7.74	0.1408	46.38	8.48	40	13.81	0.064			
20	205 xxx	0	205 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.41	0.114	10.41	0.5	40	17	43	7	0.004			
21	208 xxx	0	208 xxx	0	6.C	2000	0.5	0.5 WPT_Intertone	50	1.48	0.115	9.164	0.25	40.5	15.5	43.5	21	0.005			
22	210 xxx	0	210 xxx	0	6.C	2000	0.5	0.5 WPT_Intertone	50	1.225	0.1481	14.87	2.646	40	21.03	32.1	4.31	0.008			
23	217 xxx	0	217 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.257	0.1406	15.36	1.117	40	21.4	38.84	6.94	0.008			
24	218 xxx	0	218 xxx	0	6.C	2000	0.5	0.5 WPT_Intertone	50	1.262	0.1667	6.89	3.737	40.12	38.88	21.21	5.955	0.009			
25	220 xxx	0	220 xxx	0	6.C	2000	0.5	0.5 WPT_Intertone	50	0.9	0.1725	10.14	4.625	40.25	20.25	30.75	11.25	0.007			
26	221 xxx	0	221 xxx	0	6.C	2000	0.5	0.5 WPT_Intertone	50	1.272	0.1523	12.85	2.639	40.03	24.5	35.84	10.016	0.003			
27	223 xxx	0	223 xxx	0	6.C	2000	0.5	0.5 WPT_Intertone	50	1.165	0.2051	9.964	3.75	41.5	34.5	24.5	1.5	0.007			
28	224 xxx	0	224 xxx	0	6.C	2000	0.5	0.5 WPT_Intertone	50	1.495	0.2095	6.37	1.5	40	31	27	8.5	0.009			
29	301 xxx	0	301 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.265	0.1313	17.73	1.73	40.3	14.005	40.27	6.19	0.008			
30	302 xxx	0	302 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.188	0.1467	13.28	4.805	40.8	23.45	35.8	6.18	0.009			
31	303 xxx	0	303 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.453	0.1881	6.906	2.302	40.6	40.02	35.7	5	0.010			
32	304 xxx	0	304 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.425	0.0839	11.25	0.606	42.56	9.72	47.73	10.05	0.009			
33	305 xxx	0	305 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.32	0.11	17.67	0.5	40	15	46	13	0.003			
34	306 xxx	0	306 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.225	0.1466	17.81	2.846	38.66	19.8	42.84	6.708	0.008			
35	313 xxx	0	313 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.238	0.1282	21.1	1.954	37.72	14.15	48.12	5.44	0.003			
36	314 xxx	0	314 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.362	0.1165	21.9	1.86	38.20	15.016	49.88	5.25	0.003			
37	315 xxx	0	315 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.362	0.1874	6.187	2.154	40.3	41.7	16.19	5.2	0.009			
38	319 xxx	0	319 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.23	0.141	28.39	1.876	37.62	9.164	53.22	5.688	0.008			
39	319 xxx	0	319 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.246	0.1307	29.79	1.487	30.13	20.86	40.28	11.28	0.012			
40	318 xxx	0	318 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.136	0.1242	23.78	2.371	35.16	18.06	46.84	5.25	0.004			
41	320 xxx	0	320 xxx	0	6.0	2000	0.5	0.5 WPT_Intertone	50	1.26	0.144	8.2	5	40	40	14	13	0.002			

+



❖ Dataset vs Database:

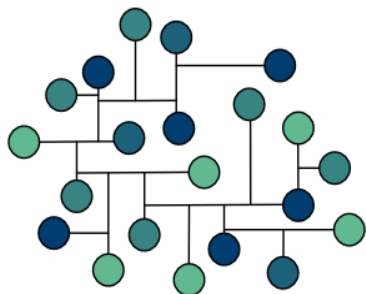


A **dataset** is a collection of data generally associated with a unique work.



OpenLandMap

www.openlandmap.org



A **database** is an organized collection of data stored as multiple datasets.

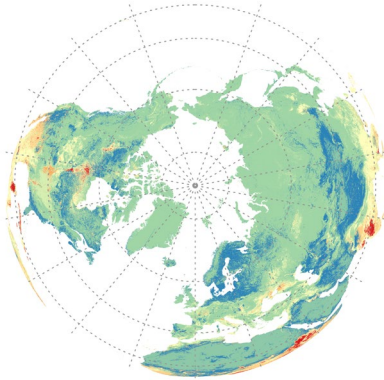


python

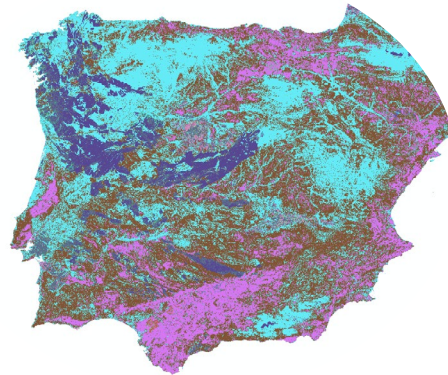
www.python.org

❖ Main features:

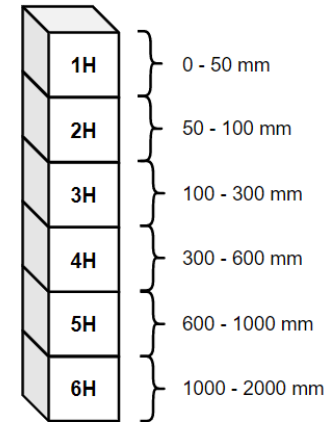
✓ **Global scale**



✓ **250-m resolution**

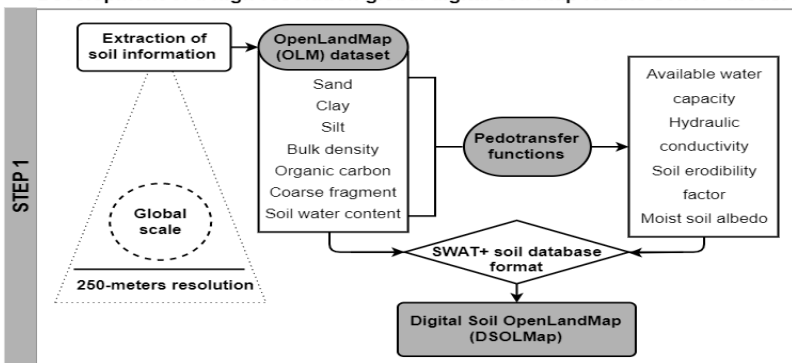


✓ **6 soil horizons**

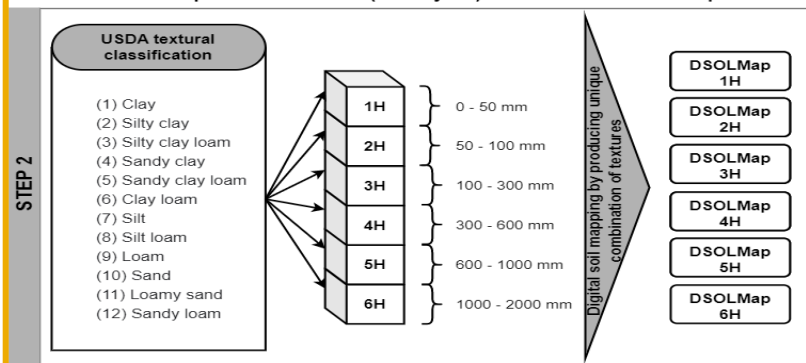


PYTHON SCRIPTING ENVIRONMENT

Development of a high-resolution global digital soil map for the SWAT+ model

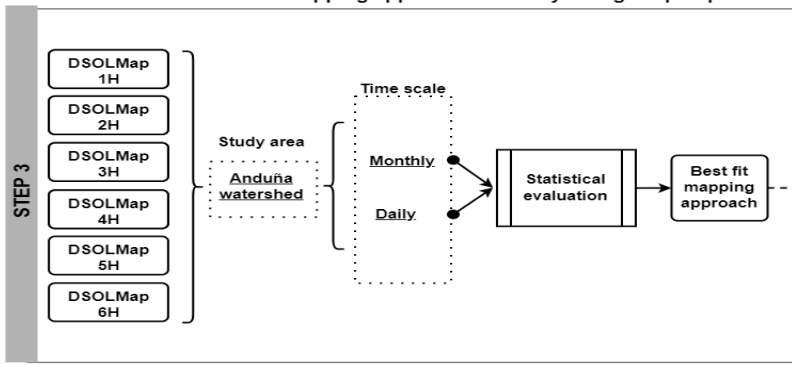


Production of spatial information (GIS layers) associated to DSOLMap

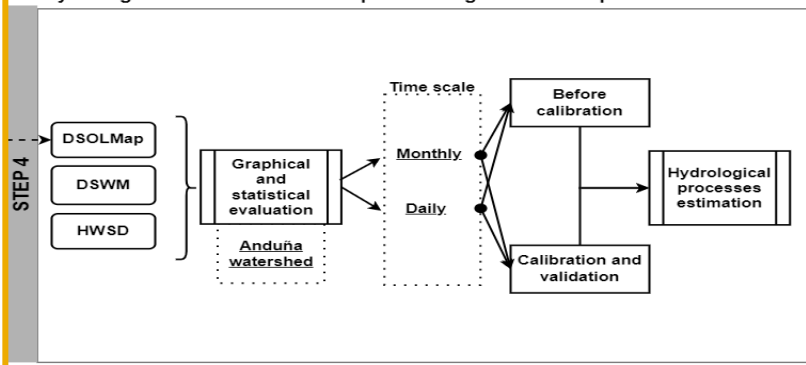


SOIL AND WATER ASSESSMENT TOOL (SWAT+)

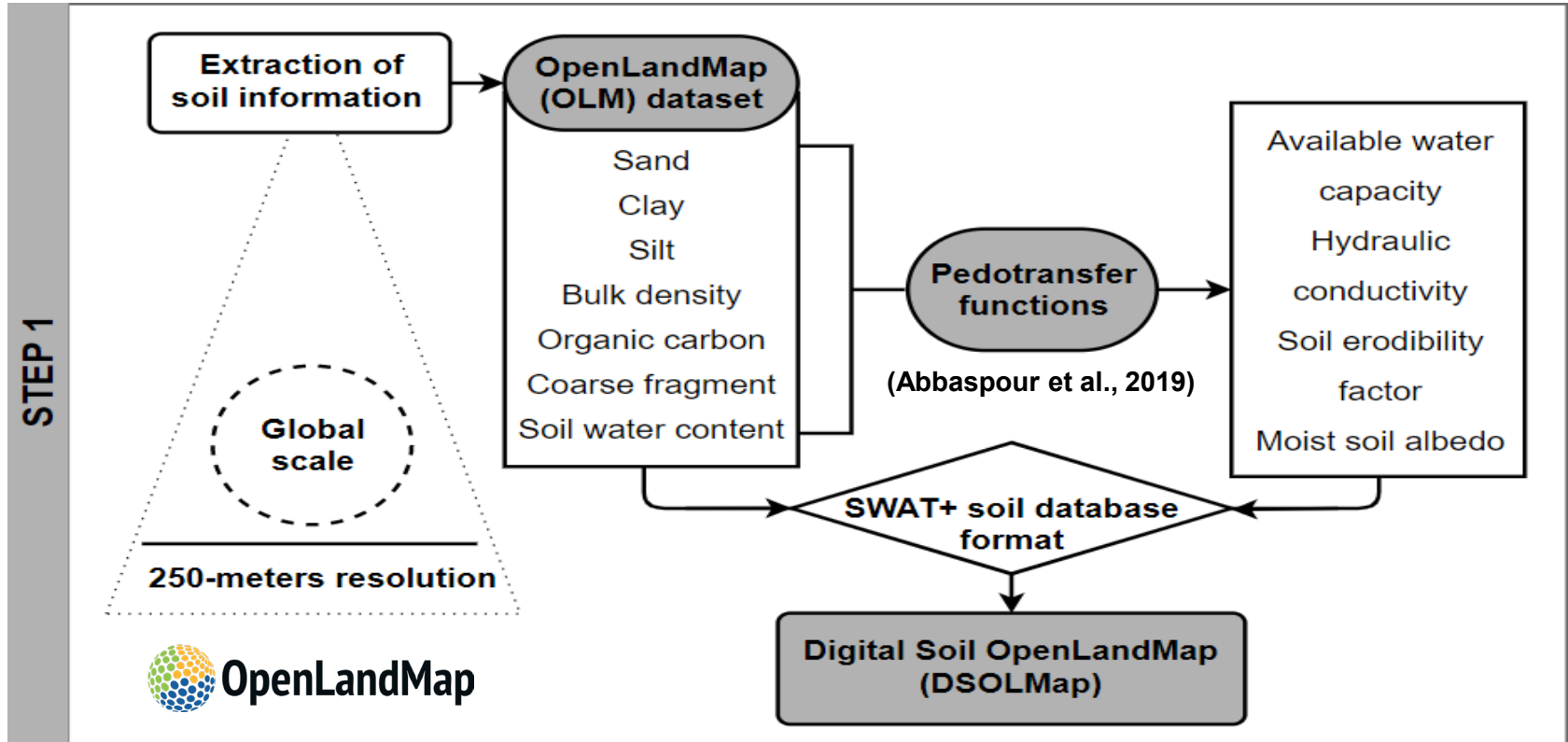
Selection of the best soil mapping approach from a hydrological perspective



Hydrological evaluation and comparison of global soil maps with SWAT+



METHODOLOGY

❖ Development a global soil database for the SWAT+ model



An **open-access web-GIS system** for **global environmental layers** created and hosted by the **OpenGeoHub foundation**.

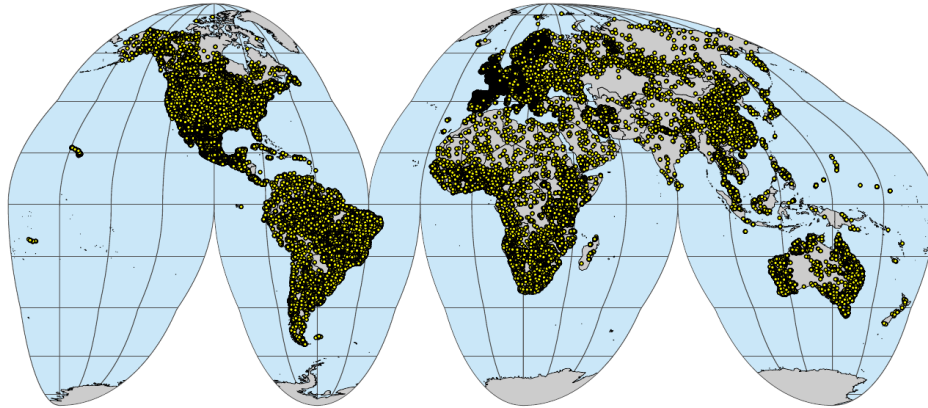
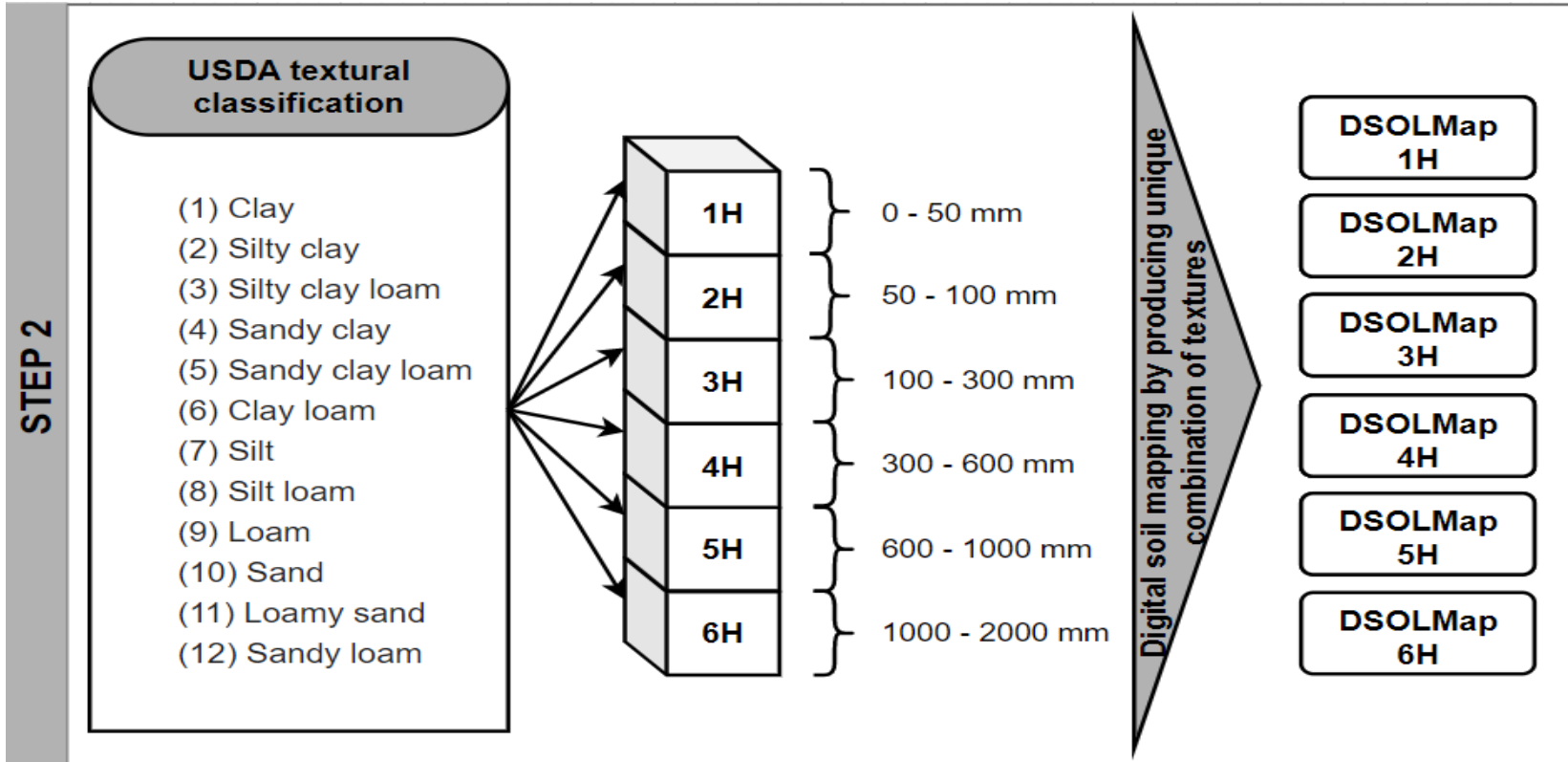


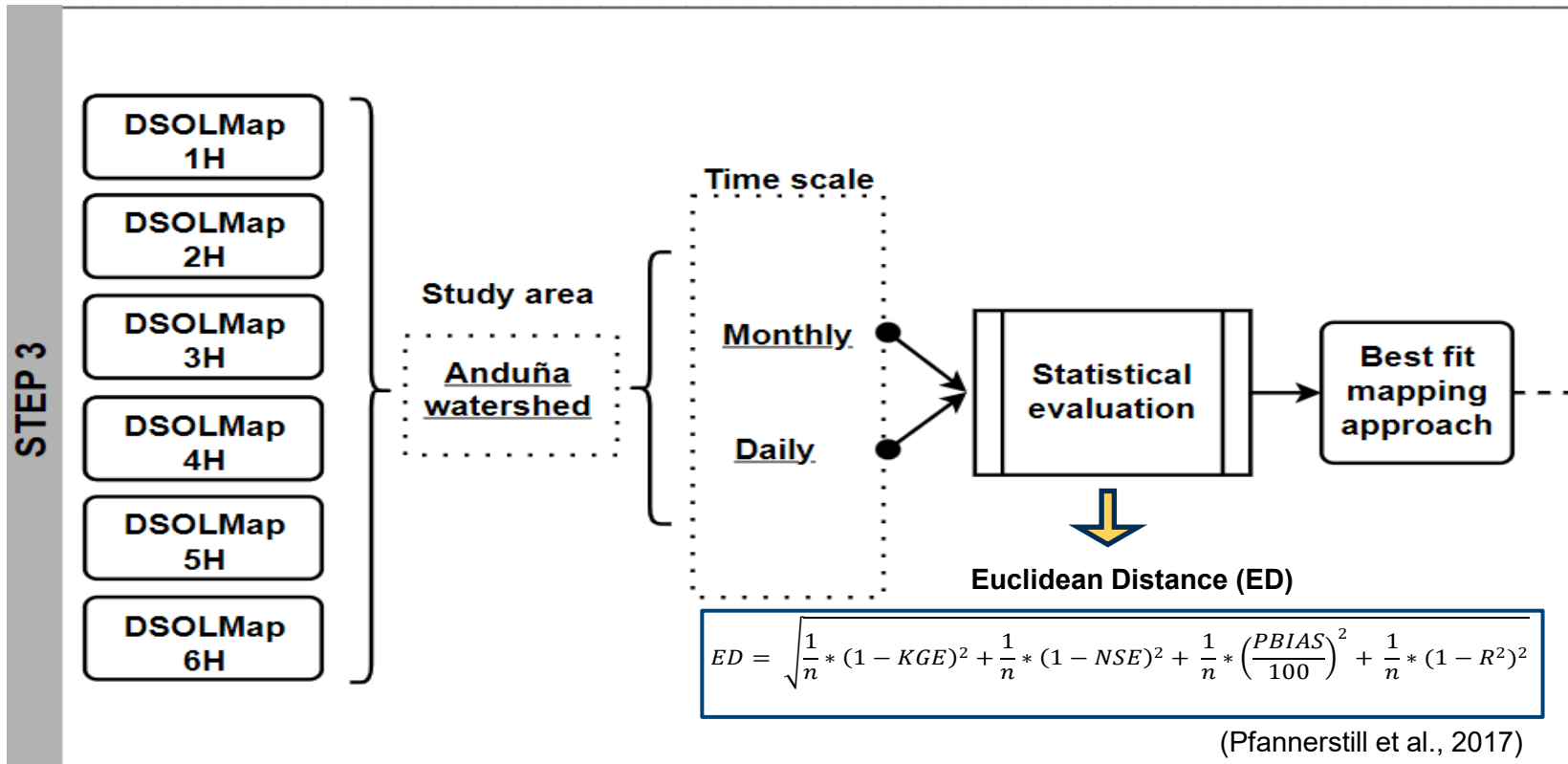
Table 1. Main national and international soil point data sources.

Source	Acronym	Reference
US Government National Cooperative Soil Characterization Database	NSCD	https://ncsslabsdatamart.sc.egov.usda.gov
Africa Soil Profiles Database	AfSP	https://www.isric.org/projects/africa-soil-profiles-database-afsp
Land Use/Cover Area Frame Statistical Survey Soil database	LUCAS	https://esdac.jrc.ec.europa.eu/resource-type/soil-point-data
Repositório Brasileiro Livre para Dados Abertos do Solo	FEBR	https://www.pedometria.org/febr/
The Northern Circumpolar Soil Carbon Database	NCSCD	https://bolin.su.se/data/ncscd/
World Soil Information Service Soil Profile Database	WoSIS	https://www.isric.org/explore/wosis

- Global soil layers.
- 3D (longitude, latitude, depth) machine learning predictions.
- >350,000 soil observations.

❖ Production of spatial information (GIS layers) associated to DSOLMap

❖ Selection of the best soil mapping approach from a hydrological point of view





Study area

Anduña watershed

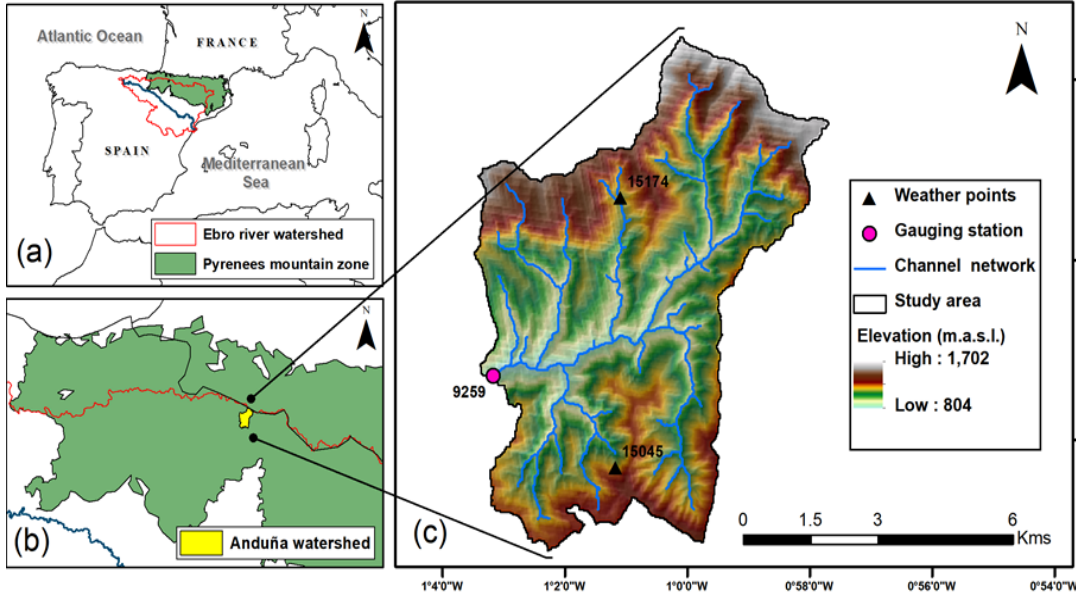
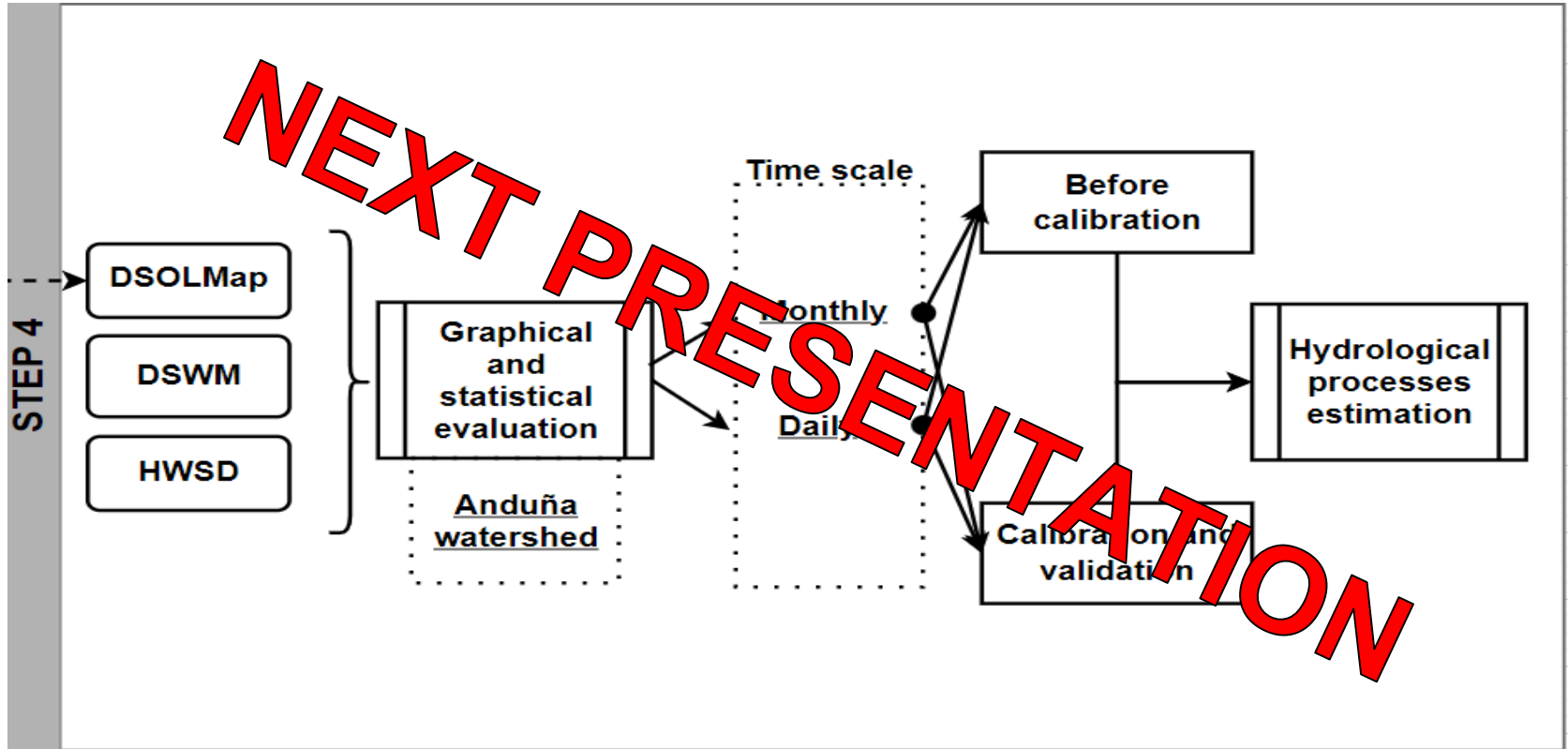


Table 2. Main characteristics of the Anduña watershed.

Anduña watershed	
Area	47 km ²
Climate	Oceanic
Precipitation	1,740 mm/year
Altitude	1,129 m.a.s.l
Land cover	~80% forest

❖ Hydrological evaluation and comparison of DSOLMap with other global soil maps

RESULTS

STEP 1: Development a global soil database for the SWAT+ model

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
OBJECTO	MUID	SEON	SNAM	SSID	CMPCTT	NLAYERS	HYDRP	SOL_ZMX	ANION_EXCL	SOL_CBK	TEXTURE	SOL_ZI	SOL_B01	SOL_AWC1	SOL_K1	SOL_CBN1	CLAY1	SILT1	SAND1	ROCK1	SOL_ALB1
2	156	xxx	0	DSOLMap_156	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.257	0.149	11.64	3.342	44.3	22.77	32.94	6.516	0.2069
3	157	xxx	0	DSOLMap_157	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.343	0.1631	9.25	6.28	42.6	30.62	26.69	6.812	0.2074
4	158	xxx	0	DSOLMap_158	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.371	0.1721	6.19	3.791	41.22	38.56	20.08	5.703	0.2075
5	159	xxx	0	DSOLMap_159	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.425	0.0991	8.34	0.2311	46.4	8.875	44.62	15.73	0.2064
6	160	xxx	0	DSOLMap_160	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.215	0.1455	13.83	2.303	42.94	18.2	38.97	8.16	0.2073
7	161	xxx	0	DSOLMap_161	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.289	0.1547	11.64	2.607	40.25	25.16	34.78	10.39	0.2081
8	164	xxx	0	DSOLMap_164	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.122	0.23	11.08	2.8	42.8	29.8	27.8	2.6	0.207
9	168	xxx	0	DSOLMap_168	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.22	0.1257	18.11	3.04	41.38	18.81	39.56	3.533	0.2074
10	169	xxx	0	DSOLMap_169	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.321	0.154	10.45	6.426	42.38	29.36	27.88	6.36	0.2074
11	170	xxx	0	DSOLMap_170	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.403	0.171	6.637	3.97	40.66	38.97	20.14	4.43	0.2076
12	171	xxx	0	DSOLMap_171	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.437	0.11	9.95	0.375	43.88	10.5	45	18.12	0.2073
13	172	xxx	0	DSOLMap_172	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.2	0.1467	17.56	1.833	42.34	15.336	43	6	0.2072
14	173	xxx	0	DSOLMap_173	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.31	0.1393	12.33	1.865	40.12	28.1	31.78	6.145	0.2079
15	180	xxx	0	DSOLMap_180	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.408	0.1667	7.2	5.168	40.16	39	20.33	5	0.2078
16	181	xxx	0	DSOLMap_181	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.05	0.19	11.22	2.5	40	39	21	6	0.208
17	192	xxx	0	DSOLMap_192	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.229	0.125	18.12	1.236	45.44	9.03	44.97	7.777	0.2064
18	193	xxx	0	DSOLMap_193	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.422	0.05353	8.625	0.1471	45.75	9.12	45	13.234	0.2067
19	195	xxx	0	DSOLMap_195	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.441	0.05478	7.74	0.1428	46.28	8.48	45	13.91	0.2064
20	205	xxx	0	DSOLMap_205	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.61	0.14	10.61	0.5	40	17	43	7	0.2094
21	208	xxx	0	DSOLMap_208	xxx	0	6 C	2000	0.5	0.5	WIT_texture	50	1.48	0.115	9.164	0.25	40.5	15.5	43.5	21	0.2091
22	216	xxx	0	DSOLMap_216	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.225	0.1481	14.87	2.566	40	23.03	47.3	6.31	0.208
23	217	xxx	0	DSOLMap_217	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.257	0.1406	15.36	3.117	40	21.4	38.84	6.94	0.208
24	218	xxx	0	DSOLMap_218	xxx	0	6 C	2000	0.5	0.5	WIT_texture	50	1.362	0.1667	6.93	3.777	40.22	38.88	21.22	5.555	0.2079
25	220	xxx	0	DSOLMap_220	xxx	0	6 C	2000	0.5	0.5	WIT_texture	50	0.9	0.1725	19.14	4.625	40.25	20.25	39.75	11.25	0.2073
26	221	xxx	0	DSOLMap_221	xxx	0	6 C	2000	0.5	0.5	WIT_texture	50	1.272	0.1523	12.35	2.639	40.03	24.5	35.84	10.016	0.2083
27	223	xxx	0	DSOLMap_223	xxx	0	6 C	2000	0.5	0.5	WIT_texture	50	1.145	0.2051	9.164	3.75	41.5	34.5	24.5	3.5	0.207
28	224	xxx	0	DSOLMap_224	xxx	0	6 C	2000	0.5	0.5	WIT_texture	50	1.495	0.095	6.37	1.5	40	33	27	8.5	0.2079
29	301	xxx	0	DSOLMap_301	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.305	0.1213	17.33	1.73	40.3	14.055	45.7	6.19	0.208
30	302	xxx	0	DSOLMap_302	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.338	0.1467	13.28	4.805	40.8	23.45	35.8	6.18	0.2079
31	303	xxx	0	DSOLMap_303	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.413	0.1681	6.098	2.332	40.6	40.03	19.72	5	0.2078
32	304	xxx	0	DSOLMap_304	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.435	0.0839	12.25	0.6704	42.56	9.72	47.75	10.65	0.2076
33	305	xxx	0	DSOLMap_305	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.32	0.11	17.67	0.5	40	15	46	13	0.2083
34	306	xxx	0	DSOLMap_306	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.275	0.1366	17.31	2.584	38.56	19.8	41.94	6.758	0.2083
35	313	xxx	0	DSOLMap_313	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.238	0.1282	23.1	1.914	37.72	14.15	48.12	5.44	0.2085
36	314	xxx	0	DSOLMap_314	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.302	0.11163	23.9	1.66	36.25	13.914	49.88	5.75	0.2092
37	315	xxx	0	DSOLMap_315	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.362	0.1674	6.387	2.154	40.3	43.7	16.19	5.2	0.2079
38	316	xxx	0	DSOLMap_316	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.23	0.141	28.39	1.876	37.62	9.164	53.22	5.684	0.2086
39	317	xxx	0	DSOLMap_317	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.264	0.1307	26.75	4.637	30.33	20.86	49.28	11.38	0.2112
40	318	xxx	0	DSOLMap_318	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.216	0.1242	23.78	2.371	35.16	18.06	46.84	5.25	0.2094
41	320	xxx	0	DSOLMap_320	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.16	0.44	8.2	5	42	45	14	13	0.2072
42	321	xxx	0	DSOLMap_321	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.178	0.155	35.4	8.95	22.66	28	50.34	10.734	0.2134
43	324	xxx	0	DSOLMap_324	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.033	0.1985	44.84	12.17	20	28	53	11.86	0.2188
44	324	xxx	0	DSOLMap_325	xxx	0	6 D	2000	0.5	0.5	WIT_texture	50	1.361	0.1373	7.734	4.937	40	40.84	14.57	3.967	0.2076

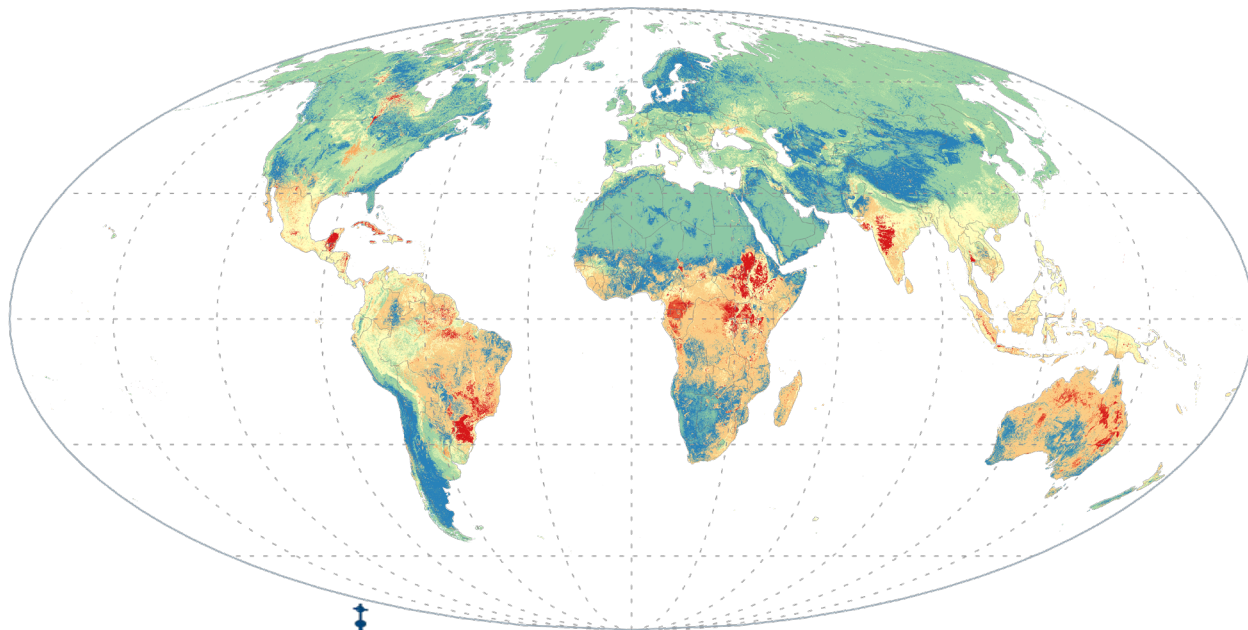
Table 3. SWAT+ required soil properties

Parameter	Description	Units
NLY	Number of soil horizons within soil profile	-
ZMX	Maximum rooting depth of soil profile	mm
Z ¹	Depth from surface to bottom of soil horizon	mm
BD ¹	Soil bulk density	g/cm ³
AWC ¹	Available water capacity	mm/mm
K ¹	Saturated hydraulic conductivity	mm/hr
CBN ¹	Organic carbon content	% of soil weight
CLAY ¹	Clay fraction	% of soil weight
SILT ¹	Silt fraction	% of soil weight
SAND ¹	Sand fraction	% of soil weight
ROCK ¹	Coarse fragment content	% of total weight
ALB	Moist soil albedo of topsoil horizon	-
USLE K	Soil erodibility factor of topsoil horizon	cm/day

¹Values per soil horizon

DSOLMap database

❖ STEP 2: Production of spatial information (GIS layers) associated to DSOLMap



DSOLMap raster layer

	A	B	C	D
1	OBJECTID	SNAM		
2	156	DSOLMap_156		
3	157	DSOLMap_157		
4	158	DSOLMap_158		
5	159	DSOLMap_159		
6	160	DSOLMap_160		
7	161	DSOLMap_161		
8	164	DSOLMap_164		
9	168	DSOLMap_168		
10	169	DSOLMap_169		
11	170	DSOLMap_170		
12	171	DSOLMap_171		
13	172	DSOLMap_172		
14	173	DSOLMap_173		
15	180	DSOLMap_180		
16	181	DSOLMap_181		
17	192	DSOLMap_192		
18	193	DSOLMap_193		
19	195	DSOLMap_195		
20	205	DSOLMap_205		
21	208	DSOLMap_208		
22	216	DSOLMap_216		
23	217	DSOLMap_217		
24	218	DSOLMap_218		
25	220	DSOLMap_220		
26	221	DSOLMap_221		
27	223	DSOLMap_223		
28	224	DSOLMap_224		
29	301	DSOLMap_301		
30	302	DSOLMap_302		
31	303	DSOLMap_303		
32	304	DSOLMap_304		
33	305	DSOLMap_305		
34	306	DSOLMap_306		
35	313	DSOLMap_313		
36	314	DSOLMap_314		
37	315	DSOLMap_315		
38	316	DSOLMap_316		
39	317	DSOLMap_317		
40	318	DSOLMap_318		
41	320	DSOLMap_320		
42	321	DSOLMap_321		
43	324	DSOLMap_324		
44	325	DSOLMap_325		

DSOLMap lookup table

❖ STEP 3: Selection of the best soil mapping approach from a hydrological point of view



(Before calibration)

- DSOLMap 1H
- DSOLMap 2H
- DSOLMap 3H
- DSOLMap 4H
- DSOLMap 5H
- DSOLMap 6H



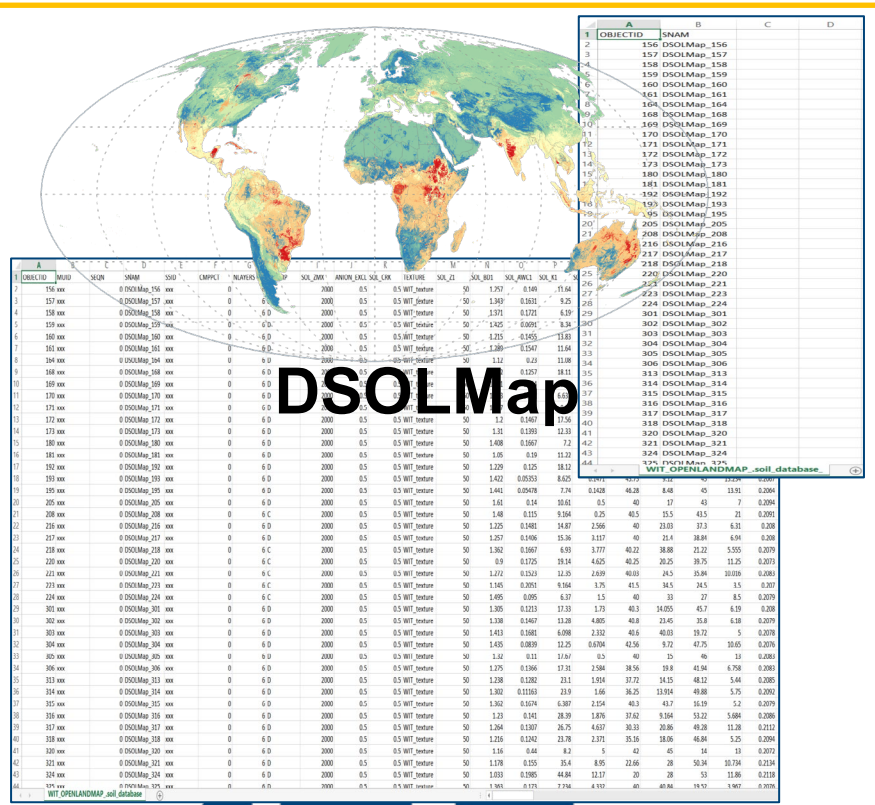
Table 4. Number of SMUs and statistical indices obtained in the Anduña watershed

Digital Soil Property Map	SMU	HRUs	Daily					Monthly				
			KGE	NSE	PBIAS	R ²	ED	KGE	NSE	PBIAS	R ²	ED
DSOLMap 1H	2	857	0.54	0.01	-0.34	0.41	0.620	0.88	0.78	-0.93	0.8	0.160
DSOLMap 2H	4	1166	0.54	0.01	-0.37	0.41	0.620	0.87	0.78	-0.95	0.8	0.162
DSOLMap 3H	5	1335	0.53	-0.02	-0.27	0.41	0.634	0.87	0.78	-0.86	0.81	0.159
DSOLMap 4H	6	1414	0.53	-0.03	-0.26	0.41	0.638	0.87	0.78	-0.85	0.81	0.159
DSOLMap 5H	9	1484	0.52	-0.03	-0.26	0.41	0.640	0.87	0.78	-0.85	0.81	0.159
DSOLMap 6H	12	1535	0.52	-0.03	-0.26	0.41	0.640	0.87	0.78	-0.85	0.81	0.159



DSOLMap 3H

Soil supplementary information



SoilID	TextureID	Order	Suborder	Group	Horizon_1	Horizon_2	Horizon_3
1	156	11010101	Vertisols	Usterts	chromusterts	clay	clay
2	157	11010102	Inceptisols	Ochrepts	xerochrepts	clay	clay
3	158	11010103	Inceptisols	Ochrepts	xerochrepts	clay	clay
4	159	11010104	Entisols	Psamment	torripsamments	clay	clay
5	160	11010105	Mollisols	Ustolls	haplustolls	clay	clay
6	161	11010106	Vertisols	Usterts	chromusterts	clay	clay
7	162	11010109	Alfisols	Udalfs	hapludalfs	clay	clay
8	163	11010201	Ultisols	Udalfs	paleudalfs	clay	clay
9	164	11010202	Inceptisols	Ochrepts	xerochrepts	clay	clay
10	165	11010203	Inceptisols	Ochrepts	xerochrepts	clay	clay
11	166	11010204	Entisols	Psamment	torripsamments	clay	clay
12	167	11010205	Mollisols	Ustolls	haplustolls	clay	clay
13	168	11010206	Inceptisols	Ochrepts	xerochrepts	clay	clay
14	169	11010301	Mollisols	Aquolls	calciaquolls	clay	clay
15	170	11010302	Entisols	Aquents	fluvaquents	clay	clay
16	171	11010401	Oxisols	Orthox	haplorthox	clay	clay
17	172	11010402	Entisols	Psamment	torripsamments	clay	clay
18	173	11010404	Entisols	Usterts	chromusterts	clay	clay
19	174	11010502	Vertisols	Usterts	chromusterts	clay	clay
20	175	11010505	Aridisols	Calcids	petrocalcids	clay	clay
21	176	11010601	Vertisols	Usterts	chromusterts	clay	clay
22	177	11010602	Oxisols	Ustox	acrustox	clay	clay
23	178	11010603	Alfisols	Udalfs	hapludalfs	clay	clay
24	179	11010605	Mollisols	Ustolls	haplustolls	clay	clay
25	180	11010606	Vertisols	Usterts	chromusterts	clay	clay
26	181	11010608	Spodosols	Orthods	haplorthods	clay	clay
27	182	11010609	Mollisols	Udolls	hapludolls	clay	clay
28	183	11010610	Oxisols	Orthox	haplorthox	clay	clay
29	184	11020102	Entisols	Fluvents	torrfluvents	clay	clay
30	302	11020103	Inceptisols	Ochrepts	xerochrepts	clay	clay
31	303	11020104	Vertisols	Xererts	chromoxererts	clay	clay
32	304	11020105	Entisols	Orthents	torriorthents	clay	clay
33	305	11020106	Entisols	Fluvents	torrfluvents	clay	clay
34	306	11020201	Oxisols	Orthox	haplorthox	clay	clay
35	313	11020202	Oxisols	Orthox	haplorthox	clay	clay
36	314	11020203	Inceptisols	Ochrepts	xerochrepts	clay	clay
37	315	11020204	Oxisols	Orthox	haplorthox	clay	clay
38	316	11020205	Inceptisols	Ochrepts	xerochrepts	clay	clay
39	317	11020206	Inceptisols	Ochrepts	xerochrepts	clay	clay
40	318	11020208	Oxisols	Orthox	haplorthox	clay	clay
41	320	11020209	Inceptisols	Ochrepts	xerochrepts	clay	clay
42	321	11020212	Inceptisols	Ochrepts	xerochrepts	clay	clay
43	324	11020213	Inceptisols	Ochrepts	xerochrepts	clay	clay
44	325	11020214	Inceptisols	Ochrepts	xerochrepts	clay	clay

USDA soil taxonomy

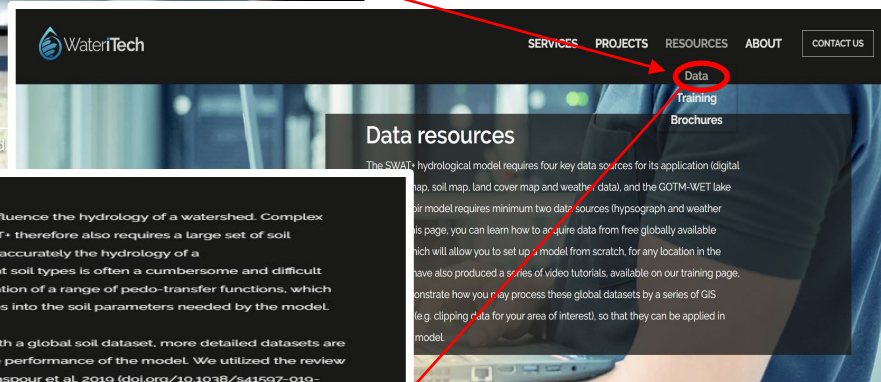
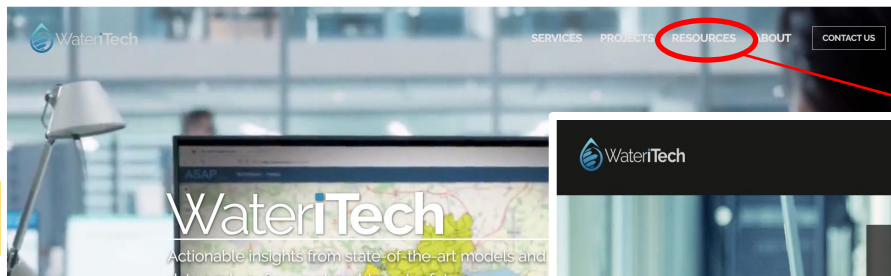
USDA texture classes

How to download:

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www.watertech.com



Soil maps

Local soil properties can greatly influence the hydrology of a watershed. Complex hydrological models such as SWAT+ therefore also requires a large set of soil parameters to be able to simulate accurately the hydrology of a watershed. Parameterizing different soil types is often a cumbersome and difficult process that often requires application of a range of pedo-transfer functions, which can translate soil textural properties into the soil parameters needed by the model.

While the SWAT+ model comes with a global soil dataset, more detailed datasets are available, which could improve the performance of the model. We utilized the review of pedo-transfer functions by Abbaspour et al. 2019 (doi.org/10.1038/s41597-019-0282-4), and derived all the required soil parameters in SWAT+ format using the median output value for a range of different pedo-transfer functions available for a given soil parameter. These unique datasets will provide you with a good basis for your model application, no matter where you are in the world.

Openland soil map

OpenLand Map is a global (except Antarctica) soil map derived from machine learning methods and hundreds of thousands soil profile observations. The raster resolution is 250m and the map includes six soil layers. Soil properties needed for the SWAT+ soil database were derived by WaterTech in collaboration with UCAM using a wide range of pedotransfer functions.

The [Digital Soil, OpenLand Map \(DSOLMap\)](#) can be downloaded right here.

- Soil Map (zipped raster, 725 MB) [Download](#)
- Soil database (SWAT+ format, 0.2 MB) [Download](#)
- Soil lookup table (SWAT+ format, 0.1 MB) [Download](#)
- Soil taxonomy (Supplementary information, 0.1 MB) [Download](#)

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DSOLMap, a novel high-resolution global digital soil property map for the SWAT + model: Development and hydrological evaluation

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ABSTRACT

This research paper addresses the ongoing challenge of developing fine-resolution global digital soil property maps for hydrological modelling applications. Hydrological models are essential for understanding watershed dynamics and the impact of human activities on water resources. Soil data, which plays a crucial role in the hydrological cycle, is a requisite model input. Global digital soil property maps usually have coarse spatial resolutions, adding considerable uncertainty to hydrological models despite calibration efforts. To address this issue, a new global digital soil property map with 250 m spatial resolution, known as Digital Soil Open Land Map (DSOLMap), was developed and evaluated in this study. The DSOLMap has a finer spatial resolution than existing global soil maps and a more detailed soil profile divided into six soil horizons. This new high-resolution global digital soil property map was tailored to the SWAT + model format. SWAT + is the latest released version of the Soil and Water Assessment Tool (SWAT), one of the most comprehensive hydrological models, and is widely used worldwide. A hydrological evaluation was conducted with the DSOLMap and its results were compared to two other global soil databases using the SWAT + model in a basin located in the north of Spain. The findings showed that using more detailed, finer-resolution soil data, such as those that the DSOLMap offers, improved the hydrological performance of the SWAT + model on a daily scale before and after calibration and validation procedures. The DSOLMap represents a global step forward in hydrological modelling, notably for regions with scarce or unavailable soil information. This new digital soil property map can help decision-makers address global challenges related to water resources and environmental issues through hydrological modelling.

CONCLUSIONS

- ✓ **A new global digital soil map with a spatial resolution of 250 m and a six-horizons soil profile is provided for direct use with the SWAT+ model.**
- ✓ **The DSOLMap represents a step forward in hydrological modelling worldwide, especially for regions where soil information is scarce or limited.**
- ✓ **The DSOLMap is available in open access to encourage hydrological modellers to further explore its capabilities in depth.**

THANKS FOR YOUR ATTENTION

“Strive not to be successful, but rather to be useful”

Albert Einstein (1879 - 1955)



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