Development and Analysis of Soil Water Infiltration Global Database

Mehdi Rahmati[1,2,*], Lutz Weihermüller[2,3], Jan Vanderborght[2,3], Yakov A. Pachepsky[4], Lili Mao[5], Seyed Hamidreza Sadeghi[6], Niloofar Moosavi[2], Hossein Kheirfam[7], Carsten Montzka[2,3], Kris Van Looy[2,3], Brigitta Toth[8], Zeinab Hazbavi[6], Wafa Al Yamani[9], Ammar A. Albalasmeh[10], Ma'in Z. Alghzawi[10], Rafael Angulo-Jaramillo[11], Antônio Celso Dantas Antonino[12], George Arampatzis[13], Robson André Armindo[14], Hossein Asadi[15], Yazidhi Bamutaze[16], Jordi Batlle-Aguilar[17,18,19], Béatrice Béchet[20], Fabian Becker[21], Günter Blöschl[22,23], Klaus Bohne[24], Isabelle Braud[25], Clara Castellano[26], Artemi Cerdà[27], Maha Chalhoub[17], Rogerio Cichota[28], Milena Císlerová[29], Brent Clothier[30], Yves Coquet[17,31], Wim Cornelis[32], Corrado Corradini[33], Artur Paiva Coutinho[12], Muriel Bastista de Oliveira[34], José Ronaldo de Macedo[35], Matheus Fonseca Durães[14], Hojat Emami[36], Iraj Eskandari[37], Asghar Farajnia[38], Alessia Flammini[33], Nándor Fodor[39], Mamoun Gharaibeh[10], Mohamad Hossein Ghavimipanah[6], Teamrat A. Ghezzehei[40], Simone Giertz[41], Evangelos G. Hatzigiannakis[13], Rainer Horn[42], Juan José Jiménez[43], Diederik Jacques[44], Saskia Deborah Keesstra[45,46], Hamid Kelishadi[47], Mahboobeh Kiani-Harchegani[6], Mehdi Kouselou[1], Madan Kumar Jha[48], Laurent Lassabatere[11], Xiaoyan Li[49], Mark A. Liebig[50], Lubomír Lichner[51], María Victoria López[52], Deepesh Machiwal[53], Dirk Mallants[54], Micael Stolben Mallmann[55], Jean Dalmo de Oliveira Marques[56], Miles R Marshall[57], Jan Mertens[58], Félicien Meunier[59], Mohammad Hossein Mohammadi[15], Binayak P Mohanty[60], Mansonia Pulido-Moncada[61], Suzana Montenegro[62], Renato Morbidelli[33], David Moret-Fernández[52], Ali Akbar Moosavi[63], Mohammad Reza Mosaddeghi[47], Seyed Bahman Mousavi[1], Hasan Mozaffari[63], Kamal Nabiollahi[64], Mohammad Reza Neyshabouri[65], Marta Vasconcelos Ottoni[66], Theophilo Benedicto Ottoni Filho[67], Mohammad Reza Pahlavan Rad[68], Andreas Panagopoulos[13], Stephan Peth[69], Pierre-Emmanuel Peyneau[20], Tommaso Picciafuoco[22,33], Jean Poesen[70], Manuel Pulido[71], Dalvan José Reinert[72], Sabine Reinsch[57], Meisam Rezaei[32, 93], Francis Parry Roberts[57], David Robinson[57], Jesús Rodrigo-Comino[73,74], Otto Corrêa Rotunno Filho[75], Tadaomi Saito[76], Hideki Suganuma[77], Carla Saltalippi[33], Renáta Sándor[39], Brigitta Schütt[21], Manuel Seeger[74], Nasrollah Sepehrnia[78], Ehsan Sharifi Moghaddam[6], Manoj Shukla[79], Shiraki Shutaro[80], Ricardo Sorando[25], Ajayi Asishana Stanley[81], Peter Strauss[82], Zhongbo Su[83], Ruhollah Taghizadeh-Mehrjardi[84], Encarnación Taguas[85], Wenceslau Geraldes Teixeira[86], Ali Reza Vaezi[87], Mehdi Vafakhah[6], Tomas Vogel[29], Iris Vogeler[28], Jana Votrubova[29], Steffen Werner[88], Thierry Winarski[11], Deniz Yilmaz[89], Michael H. Young[90], Steffen Zacharias[91], Yijian Zeng[83], Ying Zhao[92], Hong Zhao[83], Harry Vereecken[2,3]

1) Department of Soil Science and Engineering, Faculty of Agriculture, University of Maragheh, Maragheh, Iran
2) Forschungszentrum Jülich GmbH, Institute of Bio- and Geosciences: Agrosphere (IBG-3), Jülich, Germany
3) ISMC International Soil Modeling Consortium
4) USDA-ARS Environmental Microbial and Food Safety Laboratory, Beltsville, MD 20705
5) Key Laboratory of Dryland Agriculture, Ministry of Agriculture, Institute of Environment and Sustainable Development in Agriculture, Chinese Academy of Agricultural Sciences, Beijing 100081, PR China
6) Department of Watershed Management Engineering, Faculty of Natural Resources, Tarbiat Modares University, Iran
7) Department of Environmental Sciences, Urmia Lake Research Institute, Urmia University, Urmia, Iran
8) Institute for Soil Sciences and Agricultural Chemistry, Centre for Agricultural Research, Hungarian Academy of Sciences, Budapest, Hungary; University of Pannonia, Georgikon Faculty, Department of Crop Production and Soil Science, Keszthely, Hungary
9) Environment Agency - Abu Dhabi, UAE
10) Department of Natural Resources and Environment, Faculty of Agriculture, Jordan University of Science and Technology, P.O. Box 3030, Irbid 22110, Jordan

11) Univ Lyon, Université Claude Bernard Lyon 1, CNRS, ENTPE, UMR5023 LEHNA, F-69518, Vaulx-en-Velin, France
12) Universidade Federal de Pernambuco, Centro Acadêmico do Agreste, Núcleo de Tecnologia, Caruaru, Brazil
13) Hellenic Agricultural Organization, Soil and Water Resources Institute, 57400 Sindos, Greece
14) Núcleo de Atividades em Engenharia de Biossistemas (NAEB), DSEA-UFPR, Curitiba, PR, Brazil
15) 15) Department of Soil Science, Faculty of Agricultural Engineering and Technology, University of Tehran. Karaj, Iran
16) Department of Geography, Geo-Informatics and Climatic Sciences, Makerere University, P.O. Box 7062, Kampala, Uganda
17) UMR 1402 INRA AgroParisTech Functional Ecology and Ecotoxicology of Agroecosystems, Institut National de la Recherche Agronomique, AgroParisTech B.P. 01 F-78850 Thiverval-Grignon France
18) UMR 8148 IDES CNRS/Université Paris-Sud XI Bât. 504 Faculté des Sciences 91405 Orsay Cedex, France
19) Innovative Groundwater Solutions (IGS), Victor Harbor, 5211, South Australia, Australia
20) LUNAM Université, IIFSTTAR, GERS, EE, F-44344 Bouguenais, France
21) Freie Universität Berlin, Department of Earth Sciences, Institute of Geographical Sciences, Malteserstr. 74-100, Lankwitz, 12249, BERLIN, Germany
22) Centre for Water Resource Systems, TU Wien, Karlsplatz 13, 1040 Vienna, Austria
23) Institute of Hydraulic Engineering and Water Resources Management, TU Wien, Karlsplatz 13/222, 1040 Vienna, Austria
24) Faculty of Agricultural and Environmental Sciences, University of Rostock, Germany
25) Irstea, UE RiverLy, Lyon-Villeurbanne Center, 69625 Villeurbanne, France
26) Pyrenean Institute of Ecology-CSIC. AV. Montañana 1005 // Av. Victoria s / n. 50059 Zaragoza//22700 Jaca, Huesca. Spain
27) Soil Erosion and Degradation Research Group, Department of Geography, University of Valencia, Valencia, Spain
28) Plant and Food Research, Mount Albert Research Station, Auckland, New Zealand
29) Czech Technical University in Prague, Faculty of Civil Engineering, Thákurova 7, 166 29 Prague 6, Czech Republic
30) Plant & Food Research, Palmerston North, New Zealand
31) ISTO UMR 7327 Université d’Orléans, CNRS, BRGM, 45071 Orléans, France
32) Department of Soil Management, UNESCO Chair on Eremology, Ghent University, Belgium
33) Department of Civil and Environmental Engineering, University of Perugia, Perugia, Italy
34) UniRedentor University Center. BR 356, 25, Presidente Costa e Silva, Itaperuna, Rio de Janeiro, Brazil
35) Embrapa Solos, Rua Jardim Botânico, 1.024, CEP 22040-060, Jardim Botânico, Rio de Janeiro, RJ, Brazil
36) Department of Soil Science, Faculty of Agriculture, Ferdowsi University of Mashhad, Mashhad, Iran
37) Dryland Agricultural Research Institute, Agricultural Research, Education and Extension Organization Maragheh, East Azerbaijan, Iran
38) Scientific Member of Soil and Water Research Department, East Azerbaijan Agricultural and Natural Resources Research and Education center, Iran
39) Agricultural Institute, Centre for Agricultural Research, Hungarian Academy of Sciences, Brunszvik str. 2., H-2462 Martonvásár, Hungary
40) Life and Environmental Sciences, University of California, Merced, United States
41) Geographisches Institut, Universität Bonn, Germany
42) Institute of Plant Nutrition and Soil Science, Christian-Albrechts-University zu Kiel, Olshausenstr. 40, 24118 Kiel, Germany
43) Instituto Pirenaico de Ecología, Spanish National Research Council (IPE-CSIC), Avda. Llano de la victoria 16, Jaca (Huesca), 22700, Spain
44) Belgian Nuclear Research Centre, Engineered and Geosystems Analysis, Belgium
45) Soil, Water and Land Use Team, Wageningen Environmental Research, Wageningen UR, 6708PB Wageningen, The Netherlands
46) Civil, Surveying and Environmental Engineering, the University of Newcastle, Callaghan 2308, Australia
47) Department of Soil Science, College of Agriculture, Isfahan University of Technology, Isfahan 84156-83111, Iran
48) Agricultural & Food Engineering Department, Indian Institute of Technology Kharagpur, Kharagpur – 721302, West Bengal, India
49) State Key Laboratory of Earth Surface Processes and Resource Ecology, Faculty of Geographical Science, Beijing Normal University, Beijing 100875 China

50) Research Soil Scientist, USDA Agricultural Research Service, P.O. Box 459, 1701 10th Ave., S.W. Mandan, ND 58554-0459, USA
51) Institute of Hydrology, Slovak Academy of Sciences, Bratislava, Slovakia
52) Departamento de Suelo y Agua, Estación Experimental de Aula Dei (EEAD), Consejo Superior de Investigaciones Científicas (CSIC), PO Box 13034, 50080 Zaragoza, Spain
53) ICAR-Central Arid Zone Research Institute, Regional Research Station, Kukma – 370105, Bhuj, Gujarat, INDIA
54) CSIRO Land and Water, Glen Osmond, South Australia, Australia
55) PhD student at his first year. Soil Science Graduate Program (ufsm.br/ppgcs), Federal University of Santa Maria, state of Rio Grande do Sul, Brazil
56) Federal Institute of Education, Science and Technology of the Amazonas – IFAM, Campus Center of Manaus, Manaus, Brazil
57) Centre for Ecology and Hydrology, Environment Centre Wales, Deiniol Road, Bangor, Gwynedd LL57 2UW, UK
58) ENGIE Research and Technologies, Simon Bolivardlaan 34, 1000 Brussels, Belgium
59) Université catholique de Louvain, Earth and Life Institute-Environmental Sciences, Louvain-la Neuve, Belgium
60) Dep. of Biological and Agricultural Engineering, 2117 TAMU, Texas A&M Univ., College Station, TX 77843-2117
61) Aarhus University, Department of Agroecology, Research Centre Foulum, Blichers Allé 20, P.O. Box 50, DK-8830 Tjele, Denmark
62) Universidade Federal de Pernambuco (UFPE), Av. Prof. Moraes Rego, 1235 - Cidade Universitária, Recife - PE - CEP: 50670-901. Brazil
63) Department of Soil Science, College of Agriculture, Shiraz University, Shiraz, Iran
64) Department of Soil Science and Engineering, Faculty of Agriculture, University of Kurdistan, Sanandaj, Kurdistan Province, Iran
65) Department of Soil Science, Faculty of Agriculture, University of Tabriz, Tabriz, Iran
66) Department of Hydrology, Geological Survey of Brazil (CPRM), Av. Pauster, 404. CEP 22290-240 Rio de Janeiro (RJ), Brazil
67) Department of Water Resources and Environment, Federal University of Rio de Janeiro, Avenida Athos da Silveira Ramos, PO box: 68570, Rio de Janeiro, RJ, Brazil
68) Soil and Water Research Department, Sistan Agricultural and Natural Resources Research and Education Center, Agricultural Research, Education and Extension Organization (AREEO), Zabol, Iran
69) Department of Soil Science, University of Kassel, Nordbahnhofstr. 1a, 37213 Witzenhausen, Germany
70) Department of Earth and Environmental Sciences, Catholic University of Leuven, Geo-Institute, Celestijnenlaan 200E, 3001 Heverlee, Belgium
71) GeoEnvironmental Research Group, University of Extremadura, Faculty of Philosophy and Letters, Avda. de la Universidad s/n, 10071 Cáceres, Spain
72) Soil Science Department, Federal University of Santa Maria, state of Rio Grande do Sul, Brazil
73) Instituto de Geomorfología y Suelos, Department of Geography, University of Málaga, 29071, Málaga, Spain
74) Department of Physical Geography, Trier University, D-54286 Trier, Germany
75) Civil Engineering Program, Alberto Luiz Coimbra Institute for Postgraduate Studies and Research in Engineering (COPPE), Federal University of Rio de Janeiro, Avenida Athos da Silveira Ramos, Rio de Janeiro, RJ, Brazil
76) Faculty of Agriculture, Tottori University, 4-101 Koyama-Minami, Tottori 680-8553, Japan
77) Department of Materials and Life Science, Seikei University, 3-3-1, Kichijoji-kitamachi, Musashino, Tokyo 180-8633, Japan
78) Department of Soil Science, College of Agriculture, Isfahan University of Technology, Isfahan, Iran
79) Plant and Environmental Sciences, New Mexico State University, Las Cruces, New Mexico
80) Japan International Research Center for Agricultural Science, Rural Development Division, Tsukuba, Japan
81) Department of Agricultural and Bio-Resources Engineerin, Faculty of Engineering, Ahmadu Bello University Zaria, Nigeria
82) Institute for Land and Water Management Research, Federal Agency for Water Management, Pollnbergstraße 1, 3252 Petzenkirchen, Austria
83) Department of Water Resources, ITC Faculty of Geo-Information Science and Earth Observation, University of Twente, Enschede, the Netherlands
84) Faculty of Agriculture and Natural Resources, Ardakan University, Ardakan, Yazd Province, Iran
85) University of Córdoba, Department of Rural Engineering, 14071 Córdoba, Spain
86) Soil Physics, Embrapa Soils, Rua Jardim Botaˆnico, 1026, 22460-00 Rio de Janeiro, RJ, Brazil

87) Department of Soil Science, Agriculture Faculty, University of Zanjan, Zanjan, Iran
88) Department of Geography, Ruhr-University Bochum, D-44799 Bochum, Germany
89) Engineering Faculty, Civil Engineering Department, Munzur University, Tunceli, Turkey
90) Bureau of Economic Geology, John A. and Katherine G. Jackson School of Geosciences, University of Texas at Austin, University Station, Box X, Austin, TX
91) UFZ Helmholtz Centre for Environment Research, Monitoring and Exploration Technologies, Leipzig, Germany
92) College of Resources and Environmental Engineering, Ludong University, Yantai 264025, China
93) Soil and Water research Institute, Karaj, Iran

*) Correspondence to: Mehdi Rahmati (mehdirmti@gmail.com)

Abstract

In this paper, we present and analyze a novel global database of soil infiltration measurements, the Soil Water Infiltration Global (SWIG) database. In total, 5023 infiltration curves were collected across all continents in the SWIG database. These data were either provided and quality checked by the scientists who performed the experiments or they were digitized from published articles. Data from 54 different countries were included in the database with major contributions from Iran, China, and USA. In addition to its extensive geographical coverage, the collected infiltration curves cover research from 1976 to late 2017. Basic information on measurement location and method, soil properties, and land use were gathered along with the infiltration data, making the database valuable for the development of pedo-transfer functions for estimating soil hydraulic properties, for the evaluation of infiltration measurement methods, and for developing and validating infiltration models. Soil textural information (clay, silt, and sand content) is available for 3842 out of 5023 infiltration measurements (~76%) covering nearly all soil USDA textural classes except for the sandy clay and silt classes. Information on land use is available for 76 % of experimental sites with agricultural land use as the dominant type (~40%). We are convinced that the SWIG database will allow for a better parameterization of the infiltration process in land surface models and for testing infiltration models. All collected data and related soil characteristics are provided online in *.xlsx and *.csv formats for reference, and we add a disclaimer that the database is for use by public domain only and can be copied freely by referencing it. Supplementary data are available at https://doi.org/10.1594/PANGAEA.885492. Data quality assessment is strongly advised prior to any use of this database. Finally, we would like to encourage scientists to extend/update the SWIG by uploading new data to it.

Keywords: Infiltration, Land surface models, Land use, Pedo-transfer functions

Graphical Abstract

<<Figure 1 about here>>

1 Introduction

Infiltration is the process by which water enters the soil surface and it is one of the key fluxes in the hydrological cycle and the soil water balance. Water infiltration and the subsequent redistribution of water in the subsurface are two important processes that affect the soil water balance (Campbell, 1985; Hillel, 2013; Lal and Shukla, 2004; Morbidelli et al., 2011) and influence several soil processes and functions including availability of water and nutrients for plants, microbial activity, erosion rates, chemical weathering, and soil thermal and gas exchange between the soil and the atmosphere (Campbell, 1985). Infiltration plays a definitive role in maintaining soil system functions and as it is a key process that controls several of the United Nations Goals for Sustainability (Keesstra et al., 2016). The generation of surface runoff, a key factor in controlling floods, is also directly related to the infiltration process. Water that cannot infiltrate in the soil becomes available for surface runoff. Two main mechanisms are responsible for the generation of excess water that produce overland flow: Dunne saturation excess and Hortonian infiltration excess (Sahoo et al., 2008). Dunne overland flow, or saturation excess, occurs when the soil profile is completely saturated and precipitation can no longer infiltrate into soil. The Dunne mechanism is more common to near-channel areas or is generated from partial areas of the hillslope where water tables are shallowest (Sahoo et al., 2008). On the other hand, Hortonian overland flow is characterized by rainfall intensities exceeding the infiltration rate of the soil. In other words, during a rainfall event, water infiltration at the soil surface and runoff are highly dependent on the boundary conditions, namely, the rainfall intensity and the soil hydraulic properties. If the rainfall intensity is less than the soil infiltrability, water will completely infiltrate into the soil without any runoff (Hillel, 2013). In this case, the infiltration rate align with the rainfall intensity. Otherwise, if the precipitation intensity exceeds the soil infiltration rate at a certain moment in time, excess water will be generated even if the soil profile is unsaturated. In this case water will pond on the soil surface and becomes available for surface runoff. If this occurs, the boundary condition at the soil surface undergoes a shift in the dominate flow process from one governed by capillary action, to one governed by pressures of hydraulic head. Assuming that the water pressure heads remain constant at the soil surface, the infiltration rate described by a decreasing function over time, tending towards the value of the hydraulic conductivity, corresponding to the water pressure head at the surface (Angulo et al., 2016, Chow et al., 1988). In the past decades, water infiltration tests, using either ponded or tension infiltrometers have been developed to quantify the cumulative infiltration at the soil surface. In these cases, the 3D axisymmetric water infiltration corresponds to an upper boundary defined by a constant water pressure head or a series of constant water pressure heads. The infiltration process is quantified by determining the amount of water which infiltrates, over time, from which the cumulative infiltration, I(t), [L], and the infiltration rate, i(t), [L T^{-1}] can be derived. i(t) and I(t) are related to each other by derivation (Campbell, 1985; Hillel, 2013; Lal and Shukla, 2004):

$$i(t) = \frac{dI(t)}{dt} \tag{1}$$

As stated above, the infiltration rate i(t) is expected to decrease to a plateau defined by the value of the hydraulic conductivity corresponding to the imposed water pressure head plus a term related to radial water infiltration (Angulo et al., 2016). In the case of large rings, the final infiltration rate approaches the value of the hydraulic conductivity corresponding to the imposed water pressure head (gravity flow). Consequently, if water ponding is imposed at surface, i(t) tends towards the saturated hydraulic conductivity. Infiltration into the soil is controlled by several factors including soil properties (e.g., texture, bulk density, initial water content), layering, slope, cover condition (vegetation, crust, and/or stone), rainfall pattern (Smith et al., 2002; Corradini et al., 2017) and time. As soil texture and soil surface conditions (e.g., cover) are independent of time at the scale of individual infiltration events, these characteristics can be assumed to be constant during the event. On the other hand, soil structure, especially at the soil surface, can rapidly change, for instance, due to tillage, grazing or the destruction of soil aggregates by rain drop impact. In dry soils, initial infiltration rates are substantially higher than the saturated hydraulic conductivity of the surface layer due to capillary effects which control the sorptivity of the soil. However, as infiltration proceeds, the gradient between the pressure head at the soil surface and the pressure head below the wetting front reduces over time so that the infiltration rate finally reaches a constant value that approximates saturated hydraulic conductivity (Chow et al., 1988).

Infiltration measurements have been largely used to estimate soil saturated hydraulic conductivity. This soil property is a key to correctly describe all the components of the soil and land surface hydrological balance, and is essential in the appropriate design of irrigation systems. Within the literature it is clear that extensive efforts have been made to estimate this property from basic soil properties using pedo-transfer functions (PTFs). PTFs are knowledge-based rules or equations that relate simple soil properties to those properties of soil that are more difficult to obtain (Van Looy et al., 2017). Most of these efforts have been based on measurements made on samples of disturbed or undisturbed soil material. With this infiltration database, data is now made available that may contribute to better predict the saturated soil hydraulic conductivity and demonstrate the effect of e.g. vegetation and land management on the parameters of interest.

The Richards (1931), Eq. (2), written as a function of soil water content which is often referred to as the Fokker-Planck water diffusion equation can be used to derive the closed-form expression of the infiltration rate in partially saturated soils.

$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial z}\left(D_z\left(\theta\right)\frac{\partial \theta}{\partial z} + K_z\left(\theta\right)\right) \tag{2}$$

where θ is the volumetric soil water content [$L^3\,L^{-3}$], t is the time [T], z is the vertical depth position [L], $K(\theta)$ is the soil hydraulic conductivity [$L\,T^{-1}$], and $D(\theta)$ is soil water diffusivity [$L^2\,T^{-1}$], which is defined by Eq. (3) (Childs and Collis-George, 1950; Klute, 1952):

$$D_z\left(\theta\right) = K_z\left(\theta\right)\frac{\partial h}{\partial \theta} \tag{3}$$

where h is the matric potential in head units [L]. The exact relationships between soil water content, soil matric potential, and soil hydraulic conductivity are necessary to solve the Richards equation. Several solutions of the Richards equation and many empirical/conceptual/semi-analytical/physically-based models, e.g., Green and Ampt (1911); Philip (1957); Smith and Parlange (1978); Haverkamp et al. (1994); Corradini et al. (2017), have been introduced to describe the infiltration process over time, even for preferential flows, e.g. Lassabatere et al. (2014). Furthermore, several direct or indirect experimental systems have been introduced to measure soil infiltration in the laboratory or in the field under different conditions (Gupta et al., 1994; McKenzie et al., 2002; Mao et al., 2008a). Data obtained from these systems can also be used to deduce soil saturated hydraulic conductivity directly.

Methods developed to measure and quantify water infiltration in soil are generally time consuming and costly. Therefore, PTFs have been developed and applied by many researchers, e.g., Jemsi et al. (2013), Parchami-Araghi et al. (2013), Kashi et al. (2014), Sarmadian and Taghizadeh-Mehrjardi (2014), and Rahmati (2017), in order to easily parameterize infiltration models. However, these PTFs have been developed for specific regions often limiting their applicability. As already mentioned, a large number of publications reporting soil infiltration data is available, but these data are dispersed in the literature and often difficult to access. Therefore, the aim of this data paper is to present and make available a collection of infiltration data digitized from available literature and from published or unpublished data provided directly by researchers around the world. These data are accompanied by metadata, which provide information about the location of the infiltration measurement, soil properties, and land management. Finally, we will provide some first results highlighting the suitability of the database for further research. The main article is also accompanied by a supplement providing more detailed information about the different methodologies to measure soil infiltration. This is added because many of readers are likely not well-versed in soil infiltration, its limitations in measurement and modeling. For more detailed information on this, readers could refer to Smith (2002), Corradini et al. (2017), and Hopmans et al. (2006).

2 Method and Materials

2.1 Data collection

We collected infiltration measurements from different countries/regions by contacting the data owners or by extracting infiltration data from published literature. To do this, a data request was sent to potential data owners through different forums and email exchanges. The flyer asked data owners to cooperate in the development of the SWIG database by providing infiltration data as well as metadata about experimental conditions (e.g. initial soil moisture content at the start of the experiment, method used), soil properties, land use, topography, geographical coordinates of the sites and any other information relevant to interpret the data and to increase the value of the database. Infiltration data reported in literature were digitized and included in the database together with additional information provided in these papers. The digitization approach is discussed in Sect. 2.2. In total, 5023 single infiltration curves were collected of which 510 infiltration curves were digitized from 74 published papers (Table 1) and 4513 were provided by 68 different research teams (Table 2) being published or unpublished data. The references and correspondences for data supplied by direct communications with researchers are also reported in Table 2. Therefore, users may refer to these references for detailed information about the applied methods or procedures.

<<Table 1 about here>>

<<Table 2 about here>>

2.2 Data digitization

In order to digitize infiltration curves reported in literature, screenshots of the relevant plots were taken, and figures were imported into the *plot digitizer 2.6.8* (Huwaldt and Steinhorst, 2015). First, the origin of the axes as well as the highest *x* and *y*-values were defined and the diagram plane was spanned. Then, all point values were picked out and an output table with the $x - y$ pairs (time *vs.* infiltration rate or cumulative infiltration) was generated and stored.

2.3 Database structure

The SWIG database is prepared in *.xlsx with a backup file in *.CSV formats containing several datasets. Supplementary data are available at https://doi.org/10.1594/PANGAEA.885492. The first dataset, named *I_cm*, contains cumulative infiltration data in centimeter units, and are referred to as *Ixxxx*, whereby *xxxx* is the identifier of the individual infiltration test. The corresponding time intervals in hours for the infiltration data are labeled *T_Hour* and named *Txxxx*. The constant or varying pressure or tension heads (if any) during infiltration measurements are also reported in another dataset named *Tension_cm*. The database also contains additional variables and information relevant to the infiltration data provided by data owners or digitized from articles, as listed in Table 3, and which is labelled *Metadata*. Additional soil properties were determined by different standards, therefore data harmonization might be needed for some of those, especially in case of water content at field capacity, pH or wet-aggregate stability. Further information on measurement methods is available from references of the data. Since the geometric mean diameter (d_g) and standard deviation (S_g) of soil particle sizes are rarely measured, both parameters were computed using the following equations (Shirazi and Boersma, 1984):

$$d_g = \exp(a), \quad a = 0.01\sum_{i=1}^{n} f_i \ln D_i \tag{4}$$

$$S_g = \exp(b), \quad b^2 = 0.01\sum_{i=1}^{n} f_i \ln^2 D_i - a^2 \tag{5}$$

where f_i is the percent of total soil mass having diameters equal to or less than arithmetic mean of interval limits (D_i) that define three main fractions (i) of clay, silt, and sand with mean values of 0.001, 0.026, 1.025 mm, respectively. For the infiltration data, where the soil texture is unknown, *dg* and *Sg* could not be calculated and the data field in the database was left empty. The database also contains the locations of the experimental sites in another dataset named *Locations* that provides the approximate latitude and longitudes in decimal degree (dd.dd) format. Table 2 are also provided in the SWIG database in two other worksheets named *Ref. for digitized data* and *Ref. for data provided by owner* for corresponding issues.

<< Table 3 about here>>

3 Results and Discussion

3.1 Spatial and temporal data coverage

The SWIG database consists of 5023 soil water infiltration measurements spread over nearly all continents (Fig. 2). Data were derived from 54 countries (Table 4). The largest number of data sources were provided by scientists in Iran (n = 38), China (n = 23), and the USA (n = 15), whereby one data source might contain several water infiltration measurements. The SWIG database covers measurements from 1976 to 2017. A sparse coverage was obtained for the higher latitudes of the Northern Hemisphere (above 60°) including Norway, Finland, Sweden, Iceland, Greenland, and Russia. The lack of reports with infiltration data from most countries of the former Soviet Union as well as the Sahelian and Sahara countries is also notable, as well as the small number of infiltration data from Australia. Fig. 3 shows the number of samples by climatic zone (Rubel et al., 2017; Kottek et al., 2006). The majority of the data is from warm temperate, fully humid climate (49%), arid steppe climate and warm temperate climate with dry summer are the second and third most represented climate zones with 22 and 12 % respectively. Fig. 4 and 5 show the frequency of experimental sites respectively by WRB and USDA soil taxonomy systems based on the SoilGrids dataset (Hengl et al., 2017). Regarding the WRB classification system (Fig. 4), in total, 35 WRB reference soil subgroups are included among experimental sites where 55% of the experimental sites comprised four subgroup classes of Haplic Acrisols (8%), Haplic Luvisols (11%), Haplic Calcisols (15%), and Haplic Cambisols (21%). 29 soil suborders classes of USDA soil taxonomy are included in this study (Fig. 5) with Udalfs (9%), Orthents (9%), and Ustolls (9%) . Thus, the wide spatial and temporal distribution of infiltration data from this database provides a comprehensive view of the infiltration characteristics of many soils in the world which can be used in future studies.

<<Figure 2 about here>>

<<Table 4 about here>>

<<Figure 3 about here>>

<<Figure 4 about here>>

<<Figure 5 about here>>

3.2 Analysis of the database using soil properties

Textural information (clay, silt, and sand content) are available for 3842 out of 5023 collected infiltration curves (~ 76%). The infiltration measurements cover nearly all soil textural classes according to the USDA classification, except for the sandy clay and silt textural class (Fig. 6), which makes SWIG a valuable data source for comprehensive studies. To complete the large dataset, the open-access SWIG database might be amended with information regarding those soils poorly, or altogether unrepresented, by the existing database, including those less usually considered by infiltration studies, such as soils with extremely high stone content (Poesen, 2018). Loam, sandy loam, silty loam, and clay loam contributed with 19, 18, 14, and 13 % (Table 5) to the infiltration measurements, respectively. Table 5 shows that infiltration measurements are almost equally distributed among textures when these are categorized in three major classes: course- (1092), medium- (1238), and fine to moderately fine-textured soils (1447). Table 6 reports on the soil properties that are available in SWIG and it gives some simple statistics such as mean, minimum, maximum, median, and coefficient of variation. Bulk density (available for 66 % of infiltration measurements) and organic carbon content (available for 62 % of infiltration measurements) are two other soil properties besides texture that have the highest frequency of availability. Saturated hydraulic conductivity, initial soil water content, saturated soil water content, calcium carbonate equivalent, electrical conductivity, and pH are available in 22 to 38 % of infiltration data. The other soil properties have a frequency lower than 10 %.

<<Figure 6 about here>>

<<Table 5 about here>>

<<Table 6 about here>>

3.3 Infiltration measurements in the SWIG database

Different instruments were used to measure soil water infiltration (Table 8). About 32% (1595 out of 5023) of the measurements were carried out using different types of ring infiltrometers. The most frequently used methods are the disc infiltrometer methods (disc, mini-disc, and micro-disc, hood, and tension infiltrometers), which have been used in about 51% of the experiments. About 5% of the data were submitted to the database without specifying the measurement method (251 infiltration tests) and around 12 % of the measurements were carried out with other methods not listed above (Table 7).

<<Table 7 about here>>

3.4 Land use classes represented in the SWIG database

Land use is known to potentially impact soil structure and then water infiltration into soils (e.g., Ilstedt et al., 2007; Waterloo et al., 2007). Consequently, we collected information on the type of land use at all experimental sites where available. In general, the type of land use was reported in 3818 out of 5023 infiltration curves (~76 %) and this information is reported in the *Metadata* dataset. For simplicity, we grouped all reported land use types into 22 major groups (Table 8). A frequency analysis showed that agricultural land use, i.e. cropped land, irrigated land, dryland, and fallow land, is the most frequently reported land use in the database with about 53% (2019 out of 3818) of all land uses. With 22%, grasslands are the second most frequently represented land use type. Pasture with 6 % and forest with 5 % are ranked as third and fourth largest reported land use types. The 18 remaining land use types all together cover only 545 experimental sites (less than 15%).

<<Table 8 about here>>

3.5 Estimating infiltration parameters from infiltration measurements

In order to predict infiltration parameters from infiltration measurements, we classified the SWIG infiltration curves in two groups: i) infiltration curves that were obtained under the assumption of 1D infiltration and ii) infiltration curves that were obtained under 3D flow conditions. We fitted the three-parameter infiltration equation of Philip (Kutílek and Krejča, 1987), Eq. (6), to the 1D experimental data and the simplified form of Haverkamp et al. (1994), Eq. (7), to the 3D experimental data:

$$I_{1D} = St^{\frac{1}{2}} + A_1 t + A_2 t^{\frac{3}{2}} \tag{6}$$

$$I_{3D} = S\sqrt{t} + \left[\frac{2-\beta}{3} K_{sat} + \frac{\gamma S^2}{R_D(\theta_s - \theta_i)} \right] t \tag{7}$$

We reduced the number of parameters in Eq. (6) by defining A_1=0.33×K_{sat} (Philip, 1957) and A_2=A where A was assumed to be a constant. In Eq. (7), we put β = 0.6 (Angulo-Jaramillo et al., 2000) and the second term between brackets on the right hand side was assumed to be a constant. Therefore, we simplified the equations as follows:

$$I_{1D} = St^{\frac{1}{2}} + 0.33 K_{sat} t + At^{\frac{3}{2}} \tag{8}$$

$$I_{3D} = S\sqrt{t} + 0.47 K_{sat} t + At \tag{9}$$

In our analysis, we assumed that double ring infiltrometer measurements result in 1D infiltration conditions, while the different types of disc infiltration and single ring infiltrometer measurements lead to 3D flow conditions that can be captured by Eq. (9). As 1D or 3D infiltration conditions are not guaranteed for measurements made with rainfall simulators, Guelph permeameters, Aardvark permeameters, linear and point source methods as well as Hood infiltrometer measurements, these infiltration curves were not considered in our first analysis. By excluding these methods, 596 infiltration curves were excluded from the fitting to Eq. (8) and (9). In addition, 251 infiltration curves were also excluded from the fitting to Eq. (8) and (9) as no indication was available on the measurement method used. In total, 4178 infiltration curves were included in our analysis of which 828 infiltration curves reflected 1D and 3350 were considered as the results of 3D infiltration. As no sufficient information was available on the properties of the sand contact layer, we did not correct 3D infiltration measurements. Finally, the selected infiltration curves were fitted to Eq. (8) or (9) using the lsqnonlin command in Matlab™.

The fitting results of Eq. (8) to the single infiltrometer data are shown in Table 9. R^2 values were higher than 0.9 in 97 % of the cases and higher than 0.99 in 77 % of the cases. Fitting Eq. (9) to the 3D infiltration curves data, R^2 values higher than 0.9 and 0.99 were obtained in 94 and 68% of the cases, respectively. The statistics for the fitting process as well as the fitted parameters of two mentioned models are reported in the SWIG database in an additional dataset labelled *Statistics*. For infiltration curves excluded from the analysis, an empty cell is reported.

<<Table 9 about here>>

The average values of estimated K_{sat} and sorptivity (S), using Eq. (8) or (9) as well as measured K_{sat} for different soil texture classes extracted from the current database is reported in Table 10. The measured values of K_{sat} were obtained by other means by the contributors and tabulated in the SWIG database. More detailed information of how K_{sat} was calculated in individual cases can be found in the references linked to those data points. Comparison between estimated (K_{sat-es}) and measured (K_{sat-m}) values of K_{sat} (Table 10) reveals that there is reasonably good agreement between measurements and estimation, except for loamy sand (with mean K_{sat-es} = 62 cm h^{-1} *vs.* K_{sat-m} =25 cm h^{-1}), sandy loam (with mean K_{sat-es} = 32 cm h^{-1} *vs.* K_{sat-m} =41 cm h^{-1}), silt loam (with mean K_{sat-es} = 27 cm h^{-1} *vs.* K_{sat-m} =3 cm h^{-1}), and silty clay (with mean K_{sat-es} = 26 cm h^{-1} *vs.* K_{sat-m} =45 cm h^{-1}) textural classes. However, the only significant difference between measured and estimated K_{sat} values was found for the silt loam textural class (Table 10) applying an independent T test.

We also compared our estimated K_{sat} values from the infiltration measurements from the SWIG database with K_{sat} values from databases that have been published in the literature (Table 11). The validity of our estimated Ks values is confirmed by comparing the order of magnitude of difference between these values, and those tabulated in previous studies, for the various different soil classes. Some of these databases like the one of Clapp and Hornberger (1978) and Cosby et al. (1984) have been used to parameterize land surface models. Most of the K_{sat} values in the listed databases have been obtained from laboratory scale measurements often performed on disturbed soil samples. In most of the reported databases K_{sat} is controlled by texture with the highest mean values obtained for the coarse textured and the lowest mean values for the fine textured soils. This is not the case for the K_{sat} values obtained from the SWIG database. Clayey soils have a mean value that is similar to the coarser textured soils. This may be partly explained by the fact that the measurements collected in the SWIG database are obtained from field measurements on undisturbed soils. It was observed that the standard deviation of K_{sat} in the SWIG database is typically larger than the standard deviations obtained from the databases in literature. This indicates that texture is apparently not the most important control on K_{sat} values. However, one would also pose that much of the lack of correlation between soil texture and predicted K_{sat} from the SWIG database is related to the lack of soil structural information, such as macro porosity quantification or other possible soil attributes. Indeed, many of the data sets presented in our paper on saturated and near-saturated flow can be used to infer the 'state' of the soil's structure, namely its macroporosity, by using the slope of the near-saturated conductivity curve, via Philip's 'flow-weighted mean pore-size' analysis. White and Sully (1987) have discussed this in a great detail. Zhang et al. (2015) is another example of where tension infiltrometers can be used to describe the temporal dynamics of the macroporosity which characterizes 'soil structure'. This could inspire researchers to collect such information when conducting additional soil infiltration measurements, and include this in the database in the future. This finding indicates that present parameterization in current land surface models, which are mainly based on texture, may severely underestimate the variability of K_{sat}. In addition, it shows that also mean values are not dominantly controlled by textural properties. Other land surface properties such as land use, crusting, etc. may, in fact, be much more important.

<<Table 10 about here>>

<<Table 11 about here>>

3.6 Exploring the SWIG database using principal component analysis

In order to demonstrate the potential of the SWIG database for analyzing infiltration data and for developing pedo-transfer functions, principal component analysis (PCA) was performed and biplots were generated to show both the observations and the original variables in the principal component space (Gabriel, 1971).

In a biplot, positively correlated variables are closely aligned with each other and the larger the arrows the stronger the correlation. Arrows that are aligned in opposite directions are negatively correlated with each other and the magnitude of the arrows is again a measure for the strength of the correlation. Arrows that are aligned 90 degrees to each other show typically no correlation. Figures 7 and 8 show the results of two PCA. The first PCA (Fig. 7) shows the relationship between soil textural properties, S and K_{sat} based on 3267 infiltration measurements. The first two principal components explain 74.5% of the variability in the data. Figure 7 shows a positive correlation between K_{sat} and S (0.527) and the largest values for both variables are found in clay soils. Clay content appears only to be weakly correlated with K_{sat} and S as is also shown by the correlation coefficients of 0.112 and 0.025 respectively. Figure 5 shows the biplot of soil textural properties with K_{sat}, S, organic carbon content, and bulk density in the principal component space - based on 1910 infiltration measurements. The first two principal components still explain 55% of the variability. Neither S nor K_{sat} showed appreciable correlations with available soil properties. Only K_{sat} and S are correlated (arrows are aligned but small) with a value of 0.29. Organic carbon and bulk density show a negative correlation with a calculated value equal to -0.51. It also shows that for example the sandy clay loam textural class (yellow dots) shows a wide spread in organic matter content and bulk densities. These analyses show that the examined basic soil properties do not contain enough information to properly estimate K_{sat} and S. However, the SWIG database provides additional information such as land use, initial water content and slope that might prove to be good predictors. A further analysis in this respect is however beyond the scope of this paper. More importantly, the present analysis in combination with the results provided in Table 12 shows that a texture dominated derivation of K_{sat} values, as implemented in most land surface models, does not provide adequate means to estimate K_{sat}.

<<Figure 7 about here>>

<<Figure 8 about here>>

3.7 Potential error and uncertainty in the SWIG database

Similar to any other databases, the data presented in the SWIG database may be subject to different error sources and uncertainties. These include: 1) transcription errors that occurred when implementing the measurement data into the EXCEL spreadsheets, 2) inaccuracy and uncertainties in determining related soil properties such as textural properties, 3) violation of the underlying assumption when performing the experiments, and 4) uncertainty (variability) in estimated soil hydraulic properties due to the different measurement methods. Unfortunately, none of these errors or uncertainty sources are under the control of the SWIG database authors and quantification of these sources is often difficult, since the required information is often lacking. The uncertainty and variability related to the applied measurement techniques for estimated soil hydraulic properties may be assessed as information on the applied techniques is available; however, some of these methods may only have been used in few cases making a statistical analysis difficult.

With respect to the transcription error, a strong effort has been made to double check data transcription to prevent or at least to minimize any probable error of this nature. Values of soil properties such as textural composition are known to vary strongly between different laboratories and measurement methods. This is especially true for the finer textural classes like clay. Unfortunately, information on the measurement used to determine soil properties is mostly lacking or insufficient to assess the magnitude of errors or biases. Internationally, there are a number of standard methods used to measure soil properties and several methods may have been applied to measure the reported soil properties. In this regard, no conversion has been made and only raw data are reported in database. However, we have supplied the references for all data (where available) that can be used to ascertain which methodologies were used, if so desired. Although supplying such information for each soil property may facilitate the use of the database, it would have required considerable additional work that could not be performed at this stage of development. Such additions could form the basis of a second version of the database that any readers should feel free to commence.

The uncertainty with respect to the effect of measurement techniques on quantifying the infiltration process itself may be analyzed from the SWIG database as it provides information on the type of measurement technique used. This analysis is again beyond the scope of this paper. Potential error and uncertainty sources with respect to the use of different measurements are discussed in the supplementary material. The uncertainty of estimated soil hydraulic properties from infiltration measurements may be strongly controlled by the person performing the experiment but may also be due the different measurement windows of the methods in terms of measurement volume. The SWIG database provides information to quantify uncertainties introduced by difference in measurement volume and this analysis will be closely related to the assessment of the representative elementary volume, REV (see e.g. the work of Pachepsky on the scaling of saturated hydraulic conductivity).

Careful interpretation of the data, in respect to the details of the experimental and soil conditions, is also required when utilizing the SWIG. For instance, the cases of soils coded 1211 – 1420 may at first seem odd, as they display very low infiltration rates for soils of a very high (>95%) sand content; however, these unusual findings are explained by the soils being recorded as displaying water repellant characteristics. Another example is estimated values of K_{sat} from clayey soils showing high values of K_{sat} (e.g., soils coded 3746 to 3833 in SWIG). The K_{sat} values for these soils were obtained using the single ring infiltrometer method (Gonzalez-Sosa et al., 2010; Braud, 2015; Braud and Vandervaere, 2015), and were conducted in the field under ponded conditions, with vegetation cut but roots left in place. Macropores could have been activated, leading to infiltration rate much higher than expected for clayey soils. There were also instances of very high values being obtained for forested land uses, and sometimes for grassland, probably explained by the visible cracks in the soil surface present in those cases

3.8 Research potentials of the SWIG database

We envision that SWIG offers a unique opportunity and information source to 1) evaluate infiltration methods and to assess their value in deriving soil hydraulic properties, 2) test different models and concepts for point scale and grid scale infiltration processes, 3) develop pedo-transfer functions (PTFs) to estimate soil hydraulic properties such as the Mualem van Genuchten parameters, 4) identify controls on infiltration processes, 5) validate global predictions of infiltration from land surface models, 6) study more complex processes like preferential flow in soils, and 7) highlight the state of the art on understanding of the relationships between infiltration and several soil surface characteristics, for example the SWIG database has already contributed to the scope of Morbidelli et al. (2018) to advance the knowledge of infiltration over sloping surfaces.

We are confident that the SWIG database is just a first step in collecting and archiving infiltration data and we expect that increasing amounts of data will become available in the near future. These data will be archived in SWIG and thus made available to the world-wide research community. In this regard, we are interested in receiving existing or newly measured infiltration curves and for this purpose the corresponding author will serve as point of contact or data can be made available through the International Soil Modeling Consortium, ISMC (https://soil-modeling.org/), for further archiving in the SWIG.

4 Conclusion

We have collected 5023 infiltration curves from field experiments from all over the world covering a broad range of soils, land uses and climate regions. We estimated saturated hydraulic conductivity, K_{sat}, and sorptivity from more than 3000 infiltration curves and compared estimated K_{sat} values with values from different databases published in literature. We showed that contrary to the assumption made in many land surface and global climate models, texture is not the main controlling factor for K_{sat}. In addition, the variability of K_{sat} derived from these field measurements is considerably larger than reported in the literature. The collected infiltration curves were archived as the SWIG database on the PANGAEA platform and are therefore available world-wide. The data are structured into *.xlsx and *.csv files and include metadata information for further use. Data analysis revealed that infiltration curves are lacking for clayey, sandy textured and stony soils. Also infiltration curve data are lacking for the Northern and permafrost regions. Here additional efforts are needed to collect more data as these regions are particularly sensitive to climate change which will clearly affect the soil hydrology.

Acknowledgments

- First author thanks the International & Scietific Cooperation Office of University of Maragheh, Iran as well as the Research Comitee and Baord Members of the University for their assist to conduct the current work.
- The financial support received from the Forschungszentrum Jülich GmbH is gratefully acknowledged by the first author.
- Authors gratefully thank the International Soil Modeling Consortium (ISMC) and the International Soil and Tillage Organization (ISTRO) for their help in distributing our call for data among researchers in the world.
- Parts of data were gathered from the work that was supported by the UK-China Virtual Joint Centre for Agricultural Nitrogen (CINAg, BB/N013468/1), which is jointly supported by the Newton Fund, via UK BBSRC and NERC.
- The French Claduègne and Yzeron data sets were acquired during the ANR projects FloodScale (ANR-2011-BS56-027) and AVuUR (ANR-07-VULN-01) respectively.
- Parts of the database were made available through research work carried out in the framework of LIFE+ projects funded by the EC.
- The Spanish Ministry of Economy is acknowledged for support through project CGL2014-53017-C2-1-R.
- The Czech Science Foundation is acknowledged for support through project No. 16-05665S.
- Authors are greatfull for Prof. Dr. Atilla Nemes, Prof. Dr. Jan W. Hopmans and Prof Dr. Marnik Vanclooster for their time and attentions on reviewing and commenting this article. Authors do blieve that the article got improved very well using their valuable comments.

References

Abagale, F. K., Abdulai, N., and Ojediran, J. O.: Effect of shea waste slurry on soil physical porperties in peri urban Tamale, Asian Journal of Science and Technology, 4, 36-41, 2012.

Abdallah, N. A., Wua, L. T., Widaa, A., and Elamin, M. B.: Rain infiltration into loess soil under different rain intensities and slope angles, International Journal of Scientific Engineering and Applied Science (IJSEAS), 2, 179-183, 2016.

Adindu Ruth, U., Igbokwe kelechi, K., Chigbu Timothy, O., and Ike-Amadi, C.: Application of Kostiakov’s Infiltration Model on the Soils of Umudike, Abia State-Nigeria, American Journal of Environmental Engineering, 4, 1-6, 2014.

Al-Azawi, S. A.: Experimental evaluation of infiltration models, Journal of Hydrology (New Zealand), 24, 77-88, 1985.

Al-Ghazal, A.: Effect of tractor wheel compaction on bulk density and infiltration rate of a loamy sand soil in Saudi Arabia, Emir. J. Agric. Sci, 14, 24-33, 2002.

Al-Kayssi, A., and Mustafa, S.: Modeling gypsifereous soil infiltration rate under different sprinkler application rates and successive irrigation events, Agricultural Water Management, 163, 66-74, 2016.
Al Yamani, W., Green, S., Pangilinan, R., Dixon, S., and Clothier, B.: Sustainable Irrigation of Arid Forests in Abu Dhabi using Groundwater and Treated Sewage Effuent, Integrated nutrient and water management for sustainable farming, 2016.
Alagna, V., Bagarello, V., Di Prima, S., Giordano, G., and Iovino, M.: Testing infiltration run effects on the estimated water transmission properties of a sandy-loam soil, Geoderma, 267, 24-33, 2016.
Angulo-Jaramillo, R., Vandervaere, J.-P., Roulier, S., Thony, J.-L., Gaudet, J.-P., and Vauclin, M.: Field measurement of soil surface hydraulic properties by disc and ring infiltrometers: A review and recent developments, Soil and Tillage Research, 55, 1-29, 2000.
Angulo-Jaramillo, R.; Bagarello, V.; Iovino, M.; Lassabatère, L.: Infiltration Measurements for Soil Hydraulic Characterization; Springer International Publishing: New York, NY, USA, ISBN 978-3-319-31786-1, 2016.
Arriaga, F. J., Kornecki, T. S., Balkcom, K. S., and Raper, R. L.: A method for automating data collection from a double-ring infiltrometer under falling head conditions, Soil Use and Management, 26, 61-67, 10.1111/j.1475-2743.2009.00249.x, 2010.
Arshad, E. I., Sarki, E. A., and Khan, E. Z. A.: Analysis of Water Transmission Behaviour in Sandy Loam Soil under Different Tillage Operations of Mould Board Plough applying/Using Different Infiltration Models, International Journal for Research in Applied Science & Engineering Technology (IJRASET), 3, 254-266, 2015.
Ayu, I. W., Soemarno, S. P., and Java, I. I.: Assessment of Infiltration Rate under Different Drylands Types in Unter-Iwes Subdistrict Sumbawa Besar, Indonesia, Assessment, 3, 2013.
Batlle-Aguilar, J., Schneider, S., Pessel, M., Tucholka, P., Coquet, Y., and Vachier, P.: Axisymetrical Infiltration in Soil Imaged by Noninvasive Electrical Resistivimetry, Soil Science Society of America Journal, 73, 510, 10.2136/sssaj2007.0278, 2009.
Berglund, E. R., Ahyoud, A., and Tayaa, M. H.: Comparison of soil and infiltration properties of range and afforested sites in northern Morocco, Forest Ecology and Management, 3, 295-306, 1980.
Bertol, I., Barbosa, F. T., Bertol, C., and Luciano, R. V.: Water infiltration in two cultivated soils in Southern Brazil, Revista Brasileira de Ciência do Solo, 39, 573-588, 2015.
Bhardwaj, A., and Singh, R.: Development of a portable rainfall simulator infiltrometer for infiltration, runoff and erosion studies, Agricultural water management, 22, 235-248, 1992.
Bhawan, J. V.: Infiltration studies in sher-umar river doab in narmada basin, National Institute of Hydrology, Jal Vigyan bhawan, India, 1997.
Biro, K., Pradhan, B., Buchroithner, M., and Makeschin, F.: The Effects of Different Land Use Types on Soil Compaction and Infiltration Rate in the Drylands Vertisol of Gadarif Region, Sudan, Tropentag: World Food System — A Contribution from Europe, 2010.
Bowyer- Bower, T.: Effects of rainfall intensity and antecedent moisture on the steady- state infiltration rate in a semi- arid region, Soil Use and Management, 9, 69-75, 1993.
Campbell, G. S.: Soil physics with BASIC: transport models for soil-plant systems, Elsevier, 1985.

Casanova, M. P.: Influence of slope gradient and aspect on soil hydraulic conductivity measured with tension infiltrometer, MSc, Department of Soil Sciences Swedish University of Agricultural Sciences, Uppsala, 52 pp., 1998.

Chalhoub, M., Vachier, P., Coquet, Y., Darwish, T., Dever, L., and Mroueh, M.: Caractérisation des propriétés hydrodynamiques d'un sol de la Bekaa (Liban) sur les rives du fleuve Litani, Étude et gestion des sols, 16, 67-84, 2009.

Chartier, M., Rostagno, C., and Pazos, G.: Effects of soil degradation on infiltration rates in grazed semiarid rangelands of northeastern Patagonia, Argentina, Journal of Arid Environments, 75, 656-661, 2011.

Childs, E. C., and Collis-George, N.: The permeability of porous materials, Proceedings of the Royal Society of London A: Mathematical, Physical and Engineering Sciences, 1950, 392-405,

Chow, V., Maidment, D., and Mays, L.: Applied hydrology, 572 pp, Editions McGraw-Hill, New York, 1988.

Cichota, R., Vogeler, I., Snow, V. O., and Webb, T. H.: Ensemble pedotransfer functions to derive hydraulic properties for New Zealand soils, Soil Research, 51, 94, 10.1071/sr12338, 2013.

Clapp, R. B., and Hornberger, G. M.: Empirical equations for some soil hydraulic properties, Water resources research, 14, 601-604, 1978.

Commandeur, P. R., Wass, E. F., Forests, B. C. M. o., II., C.-B. C. P. A. o. F. R. D. F., and Service, C. F.: Rainfall Simulation, Soil Infiltration and Surface Erosion on Skidroad Surfaces, Nelson Forest Region, Government of British Columbia, 1994.

Coquet, Y.: Etude in situ des phénomènes de retrait-gonflement des sols: application à deux sols tropicaux peu gonflants, 1996.

Corradini, C., Morbidelli, R., Govindaraju R. S.: Infiltration Modeling, Vijay P. Singh (ed), Handbook of Applied Hydrology Second Edition, McGraw-Hill, New York, pp. 45-1; 45-9, ISBN: 9780071835091, 2017,

Coquet, Y., Vachier, P., and Labat, C.: Vertical variation of near-saturated hydraulic conductivity in three soil profiles, Geoderma, 126, 181-191, 10.1016/j.geoderma.2004.09.014, 2005.

Cosby, B., Hornberger, G., Clapp, R., and Ginn, T.: A statistical exploration of the relationships of soil moisture characteristics to the physical properties of soils, Water resources research, 20, 682-690, 1984.

Coutinho, A. P., Lassabatere, L., Montenegro, S., Antonino, A. C. D., Angulo- Jaramillo, R., and Cabral, J. J.: Hydraulic characterization and hydrological behaviour of a pilot permeable pavement in an urban centre, Brazil, Hydrological Processes, 30, 4242-4254, 2016.

Dasgupta, S., Mohanty, B. P., and Köhne, J. M.: Soil Hydraulic Conductivities and their Spatial and Temporal Variations in a Vertisol, Soil Science Society of America Journal, 70, 1872, 10.2136/sssaj2006.0201, 2006.

Delage, P., Zadjaoui, A., Cui, Y. J., Ghabezloo, S., Pereira, J. M., and Tang, A. M.: Numerical modelling of infiltration profiles in the silt Tlemcen (Algeria), E3S Web of Conferences, 9, 11015, 10.1051/e3sconf/20160911015, 2016.

Di Prima, S., Lassabatere, L., Bagarello, V., Iovino, M., and Angulo-Jaramillo, R.: Testing a new automated single ring infiltrometer for Beerkan infiltration experiments, Geoderma, 262, 20-34, 10.1016/j.geoderma.2015.08.006, 2016.

Dušek, J., Lichner, Ľ., Vogel, T., and Štekauerová, V.: Transport of iodide in structured soil under spring barley during irrigation experiment analyzed using dual-continuum model, Biologia, 68, 10.2478/s11756-013-0249-4, 2013.

Fakher Nikche, A., Vafakhah, M., and Sadeghi, S. H. R.: Efficiency Evolution of Different Infiltration Models in Different Land Use and Soil Classes using Rainfall Simulator, Iranian Soil and Water Science, 24, 183-193, 2014.

Fakouri, T., Emami, H., and Ghahremani, B.: Estimation of cumulaive infiltration using particle size distribution in different agricultural landuses, Journal of Water Researches in Agriculture, 26, 379-390, 2011a.

Fakouri, T., Emami, H., and Ghahremani, B.: Effects of different landuses on soil water infiltration, Journal of Water Researches in Agriculture, 25, 195-206, 2011b.

Fan, R., Zhang, X., Yang, X., Liang, A., Jia, S., and Chen, X.: Effects of tillage management on infiltration and preferential flow in a black soil, Northeast China, Chinese geographical science, 23, 312-320, 2013.

Fodor, N., Sándor, R., Orfanus, T., Lichner, L., and Rajkai, K.: Evaluation method dependency of measured saturated hydraulic conductivity, Geoderma, 165, 60-68, 2011.

Gabriel, K. R.: The biplot graphic display of matrices with application to principal component analysis, Biometrika, 58, 453-467, 1971.

Gharaibeh, M. A., Ghezzehei, T. A., Albalasmeh, A. A., and Ma'in, Z. A.: Alteration of physical and chemical characteristics of clayey soils by irrigation with treated waste water, Geoderma, 276, 33-40, 2016.

Ghavimi Panah, M. H., Sadeghi, S. H. R., and Younesi, H.: Role of superficial biochar mulch produced from dairy factory waste on infiltration and runoff in small experimental plots, Iranian Journal of Soil and Water Research, 48, 905-916, 2017.

Giertz, S., Junge, B., and Diekkrüger, B.: Assessing the effects of land use change on soil physical properties and hydrological processes in the sub-humid tropical environment of West Africa, Physics and Chemistry of the Earth, Parts A/B/C, 30, 485-496, 2005.

Gonzalez-Sosa, E., Braud, I., Dehotin, J., Lassabatère, L., Angulo-Jaramillo, R., Lagouy, M., Branger, F., Jacqueminet, C., Kermadi, S., and Michel, K.: Impact of land use on the hydraulic properties of the topsoil in a small French catchment, Hydrological Processes, n/a-n/a, 10.1002/hyp.7640, 2010.

Green, W. H., and Ampt, G.: Studies on Soil Phyics, The Journal of Agricultural Science, 4, 1-24, 1911.

Gupta, R., Rudra, R., Dickinson, W., and Wall, G.: Spatial and seasonal variations in hydraulic conductivity in relation to four determination techniques, Canadian Water Resources Journal, 19, 103-113, 1994.

Hatzigiannakis, E., and Panoras, A.: Report of results STU, physical,-chemical and hydraulic properties of soil, Action 6: Assess land degradation caused by erosion in a pilot agricultural area, 433p, 2011.

Haverkamp, R., Ross, P. J., Smettem, K. R. J., and Parlange, J. Y.: Three-dimensional analysis of infiltration from the disc infiltrometer: 2. Physically based infiltration equation, Water Resources Research, 30, 2931-2935, 10.1029/94WR01788, 1994.

Hazbavi, Z., and Sadeghi, S.: Potential effects of vinasse as a soil amendment to control runoff and soil loss, Soil, 2, 71, 2016.

Hengl, T., de Jesus, J. M., Heuvelink, G. B., Gonzalez, M. R., Kilibarda, M., Blagotić, A., ... & Guevara, M. A.:. SoilGrids250m: Global gridded soil information based on machine learning. PLoS one, 12(2), e0169748, 2017.

Hillel, D.: Introduction to environmental soil physics, Academic press, 2013.

Hopmans, J. W., Parlange, J. Y., Assouline, S.: Infiltration, Jacques W. Delleur (ed.), The handbook of groundwater engineering, CRC Press, Taylor & Francis Group, Boca Raton, New York, US.

Holzapfel, E. A., Mari n¯ o, M. A., Valenzuela, A., and Diaz, F.: Comparison of infiltration measuring methods for surface irrigation, Journal of irrigation and drainage engineering, 114, 130-142, 1988.

Hu, X., Li, Z.-C., Li, X.-Y., and Liu, L.-y.: Quantification of soil macropores under alpine vegetation using computed tomography in the Qinghai Lake Watershed, NE Qinghai–Tibet Plateau, Geoderma, 264, 244-251, 2016.

Huang, L., Zhang, P., Hu, Y., and Zhao, Y.: Vegetation succession and soil infiltration characteristics under different aged refuse dumps at the Heidaigou opencast coal mine, Global Ecology and Conservation, 4, 255-263, 10.1016/j.gecco.2015.07.006, 2015.

Huang, M., Barbour, S. L., Elshorbagy, A., Zettl, J. D., and Cheng Si, B.: Infiltration and drainage processes in multi-layered coarse soils, Canadian Journal of Soil Science, 91, 169-183, 2011.

Igbadun, H., Othman, M., and Ajayi, A.: Performance of Selected Water Infiltration Models in Sandy Clay Loam Soil in Samaru Zaria, Global Journal of Researches in Engineering: J General Engineering, 16, 8-14, 2016.

Ilstedt, U., Malmer, A., Verbeeten, E., and Murdiyarso, D.: The effect of afforestation on water infiltration in the tropics: a systematic review and meta-analysis. Forest Ecology and Management, 251(1-2), 45-51, 2007.Jačka, L., Pavlásek, J., Pech, P., and Kuráž, V.: Assessment of evaluation methods using infiltration data measured in heterogeneous mountain soils, Geoderma, 276, 74-83, 10.1016/j.geoderma.2016.04.023, 2016.

Jacques, D.: Analysis of water flow and solute transport at the field scale, PhD diss, 2000.

Jacques, D., Mohanty, B. P., and Feyen, J.: Comparison of alternative methods for deriving hydraulic properties and scaling factors from single- disc tension infiltrometer measurements, Water Resources Research, 38, 2002.

Jemsi, S., Sayyad, G., Jafarnezhadi, A., and KashefiPour, S. M.: Development of infiltration rate pedotransfer functions using artificial neural networks and multiple linear regressions for Khuzestan province in south of Iran, International Journal of Agriculture, 3, 766, 2013.

Kashi, H., Emamgholizadeh, S., and Ghorbani, H.: Estimation of soil infiltration and cation exchange capacity based on multiple regression, ANN (RBF, MLP), and ANFIS models, Communications in soil science and plant analysis, 45, 1195-1213, 2014.

Kavousi, S., Vafakhah, M., and Mahdian, M.: Evaluation of some infiltration models for different land uses in kojour watershed, Iranian of Irrigation & Water Engineering, 4, 1-13, 2013.

Keesstra, S. D., Quinton, J. N., van der Putten, W. H., Bardgett, R. D., and Fresco, L. O.: The significance of soils and soil science towards realization of the United Nations Sustainable Development Goals, Soil, 2, 111, 2016.

Khan, G. S., and Strosser, P.: Soil survey of Pakistan, 1-95, 1998.

Kheirfam, H., Sadeghi, S. H. R., Zarei Darki, B., and Homaee, M.: Controlling rainfall-induced soil loss from small experimental plots through inoculation of bacteria and cyanobacteria, Catena, 152, 40-46, 2017a.

Kheirfam, H., Sadeghi, S. H. R., Homaee, M., and Zarei Darki, B.: Quality improvement of an erosion-prone soil through microbial enrichment, Soil and Tillage Research, 165, 230-238, 2017b.

Kiani-Harchegani, M., Sadeghi, S. H. R., and Asadi, H.: Comparing grain size distribution of sediment and original soil under raindrop detachment and raindrop-induced and flow transport mechanism, Hydrological Sciences Journal, 2017.

Klute, A.: Some theoretical aspects of the flow of water in unsaturated soils, Soil Science Society of America Journal, 16, 144-148, 1952.

Kottek, M., Grieser, J., Beck, C., Rudolf, B., and Rubel, F.: World map of the Köppen-Geiger climate classification updated. Meteorologische Zeitschrift, 15(3), 259–263, 2006

Kutílek, M., and Krejča, M.: Three-parameter infiltration equation of Philip type, Vodohosp. Čas, 35, 52-61, 1987.

Lassabatere, L., Angulo-Jaramillo, R., Goutaland, D., Letellier, L., Gaudet, J., Winiarski, T., and Delolme, C.: Effect of the settlement of sediments on water infiltration in two urban infiltration basins, Geoderma, 156, 316-325, 2010.

Lassabatere, L., Yilmaz, D., Peyrard, X., Peyneau, P. E., Lenoir, T., Šimůnek, J., and Angulo-Jaramillo, R.: New analytical model for cumulative infiltration into dual-permeability soils, Vadose Zone Journal, 13, 2014.

Latorre, B., Peña, C., Lassabatere, L., Angulo-Jaramillo, R., and Moret-Fernández, D.: Estimate of soil hydraulic properties from disc infiltrometer three-dimensional infiltration curve. Numerical analysis and field application, Journal of Hydrology, 527, 1-12, 2015.

Li, X.-Y., Zhang, S.-Y., Peng, H.-Y., Hu, X., and Ma, Y.-J.: Soil water and temperature dynamics in shrub-encroached grasslands and climatic implications: results from Inner Mongolia steppe ecosystem of north China, Agricultural and forest meteorology, 171, 20-30, 2013.

Lichner, L., Eldridge, D., Schacht, K., Zhukova, N., Holko, L., Sir, M., and Pecho, J.: Grass cover influences hydrophysical parameters and heterogeneity of water flow in a sandy soil, Pedosphere, 21, 719-729, 2011.

Lichner, L., Hallett, P. D., Drongová, Z., Czachor, H., Kovacik, L., Mataix-Solera, J., and Homolák, M.: Algae influence the hydrophysical parameters of a sandy soil, Catena, 108, 58-68, 10.1016/j.catena.2012.02.016, 2013.

Lichner, Ľ., Holko, L., Zhukova, N., Schacht, K., Rajkai, K., Fodor, N., and Sándor, R.: Plants and biological soil crust influence the hydrophysical parameters and water flow in an aeolian sandy soil/Vplyv rastlín a biologického pôdneho pokryvu na hydrofyzikálne parametre a prúdenie vody v piesočnatej pôde, Journal of Hydrology and Hydromechanics, 60, 309-318, 2012.

Liebig, M., Tanaka, D., and Wienhold, B. J.: Tillage and cropping effects on soil quality indicators in the northern Great Plains, Soil and Tillage Research, 78, 131-141, 2004.

Lipiec, J., Kuś, J., Słowińska-Jurkiewicz, A., and Nosalewicz, A.: Soil porosity and water infiltration as influenced by tillage methods, Soil and Tillage Research, 89, 210-220, 10.1016/j.still.2005.07.012, 2006.

Ma, D., Zhang, J., Horton, R., Wang, Q., and Lai, J.: Analytical method to determine soil hydraulic properties from vertical infiltration experiments, Soil Science Society of America Journal, 2017.

Machiwal, D., Jha, M. K., and Mal, B.: Modelling infiltration and quantifying spatial soil variability in a wasteland of Kharagpur, India, Biosystems Engineering, 95, 569-582, 2006.

Machiwal, D., Dayal, D., and Kumar, S.: Estimating Water Balance of Small Reservoirs in Arid Regions: A Case Study from Kachchh, India, Agricultural Research, 6, 57-65, 2017.

Mallmann, M. S.: Water infiltration in soil conditioned by use of cover crops, M. Sc., Soil Science, Federal University of Santa Maria, Santa Maria, 72 pp., 2017.

Mao, L., Bralts, V. F., Pan, Y., Liu, H., and Lei, T.: Methods for measuring soil infiltration: State of the art, International Journal of Agricultural and Biological Engineering, 1, 22-30, 2008a.

Mao, L., Lei, T., Li, X., Liu, H., Huang, X., and Zhang, Y.: A linear source method for soil infiltrability measurement and model representations, Journal of Hydrology, 353, 49-58, 2008b.

Mao, L., Li, Y., Hao, W., Zhou, X., Xu, C., and Lei, T.: A new method to estimate soil water infiltration based on a modified Green–Ampt model, Soil and Tillage Research, 161, 31-37, 10.1016/j.still.2016.03.003, 2016.

Matula, S.: The influence of tillage treatments on water infiltration into soil profile, Plant Soil and Environment, 49, 298-306, 2003.

McKenzie, N., Coughlan, K., and Cresswell, H.: Soil physical measurement and interpretation for land evaluation, Csiro Publishing, 2002.

Medinski, T., Mills, A., and Fey, M.: Infiltrability in soils from south-western Africa: effects of texture, electrical conductivity and exchangeable sodium percentage, South African Journal of Plant and Soil, 26, 157-163, 2009.

Mertens, J., Jacques, D., Vanderborght, J., and Feyen, J.: Characterisation of the field-saturated hydraulic conductivity on a hillslope: in situ single ring pressure infiltrometer measurements, Journal of Hydrology, 263, 217-229, 2002.

Mertens, J., Madsen, H., Feyen, L., Jacques, D., and Feyen, J.: Including prior information in the estimation of effective soil parameters in unsaturated zone modelling, Journal of Hydrology, 294, 251-269, 10.1016/j.jhydrol.2004.02.011, 2004.

Mertens, J., Madsen, H., Kristensen, M., Jacques, D., and Feyen, J.: Sensitivity of soil parameters in unsaturated zone modelling and the relation between effective, laboratory andin situ estimates, Hydrological Processes, 19, 1611-1633, 10.1002/hyp.5591, 2005.

Miller, K., Elliott, J., and Friday, N.: Soils infiltration data for selected Wyoming watersheds, 1998-1999, DTIC Document, 2005.

Mohammed, A. M. E., Mohamed, H. I., and Elramlawi, H. R.: Comparison of infiltration measuring techniques for furrow irrigation in cracking clay soil, Journal of Hydrology, 8, 0-0, 2007.

Mohanty, B., Kanwar, R. S., and Everts, C.: Comparison of saturated hydraulic conductivity measurement methods for a glacial-till soil, Soil Science Society of America Journal, 58, 672-677, 1994.

Morbidelli, R., Corradini, C., Saltalippi, C., Flammini, A., and Rossi, E.: Infiltration-soil moisture redistribution under natural conditions: experimental evidence as a guideline for realizing simulation models, Hydrology and Earth System Sciences, 15, 2937, 2011.

Morbidelli, R., Saltalippi, C., Flammini, A., Cifrodelli, M., Picciafuoco, T., Corradini, C., and Govindaraju, R. S.: In situ measurements of soil saturated hydraulic conductivity: Assessment of reliability through rainfall-runoff experiments, Hydrological Processes, 31, 3084-3094, 10.1002/hyp.11247, 2017.

Morbidelli, R., Saltalippi, C., Flammini, A., and Govindaraju, R. S.: Role of slope on infiltration: a review, Journal of Hydrology, 2018.

Muhamad, A., 田中正, Budi Indra, S., and Satyanto Krido, S.: Infiltration characteristics of tropical soil based on water retention data, 水文・水資源学会誌, 21, 215-227, 2008.

Murray, C. D., and Buttle, J. M.: Infiltration and soil water mixing on forested and harvested slopes during spring snowmelt, Turkey Lakes Watershed, central Ontario, Journal of Hydrology, 306, 1-20, 10.1016/j.jhydrol.2004.08.032, 2005.

Naeth, M., Chanasyk, D., and Bailey, A.: Applicability of the Kostiakov equation to mixed prairie and fescue grasslands of Alberta, Journal of range Management, 18-21, 1991.

Návar, J., and Synnott, T. J.: Soil infiltration and land use in Linares, NL, Mexico, Terra Latinoamericana, 18, 2000.

Nikghalpour, M., Asadi, H., and Gorji, M.: Evaluation of spatial distribution of water infiltration rate and its relation with some physical and chemical properties in the Kuhin region, Journal of Soil Researches (Soil and Water Science) 30, 201-213, 2016.

Ogbe, V., Jayeoba, O., and Ode, S.: Comparison of Four Soil Infiltration Models on A Sandy Soil in Lafia. Southern Guinea Savanna Zone of Nigeria, Production Agriculture and Technology (PAT), 7, 116-126, 2011.

Ojha, S., Machiwal, D., and Purohit, R.: Infiltration modeling in submergence area of a water harvesting structure: a case study, Indian Journal of Soil Conservation, 41, 8-13, 2013.

Oliveira, M. B. d.: Performance analysis of infiltration equations and of methods of determination of field capacity for soils at a watershed in the São José de Ubá county (state of Rio de Janeiro, Brazil), Master of Science, Civil Engineering Program, Alberto Luiz Coimbra Institute for Postgraduate Studies and Research in Engineering, Federal University of Rio de Janeiro, COPPE/UFRJ, Rio de Janeiro, RJ, Brasil, 2005.

Omuto, T. C., Minasny, B., McBratney, A. B., and Biamah, E. K.: Nonlinear mixed effect modelling for improved estimation of water retention and infiltration parameters, Journal of Hydrology, 330, 748-758, 10.1016/j.jhydrol.2006.05.006, 2006.

Othman, M., and Ajayi, A.: Infiltration Characteristics of Organic Amended Soils, Global Journal of Research In Engineering, 16, 2016.

Pachepsky, Y., and Park, Y.: Saturated hydraulic conductivity of US soils grouped according to textural class and bulk density, Soil Science Society of America Journal, 79, 1094-1100, 2015.

Pahlavan-Rad, M.R. Study on spatial variability of soil infiltration and saturated hydraulic conductivity in the lands of Sistan plain using geostatistical and random forest methods. Annual report. Sistan Agricultural and Natural Resources Research and Education Center, Zabol, Areeo Iran, 2017.Parchami-Araghi, F., Mirlatifi, S. M., Ghorbani Dashtaki, S., and Mahdian, M. H.: Point estimation of soil water infiltration process using Artificial Neural Networks for some calcareous soils, Journal of Hydrology, 481, 35-47, http://doi.org/10.1016/j.jhydrol.2012.12.007, 2013.

Perkins, S. R., and McDaniel, K. C.: Infiltration and Sediment Rates Following Creosotebush Control With Tebuthiuron, Rangeland Ecology & Management, 58, 605-613, 10.2111/05-048r1.1, 2005.

Philip, J.-R.: The theory of infiltration: 1. The infiltration equation and its solution, Soil science, 83, 345-358, 1957.

Poesen, J.: Soil erosion in the Anthropocene: Research needs, Earth Surface Processes and Landforms, 43, 64-84, 2018.

Pulido Moncada, M., Helwig Penning, L., Timm, L. C., Gabriels, D., and Cornelis, W. M.: Visual examinations and soil physical and hydraulic properties for assessing soil structural quality of soils with contrasting textures and land uses, Soil and Tillage Research, 140, 20-28, 10.1016/j.still.2014.02.009, 2014.

Qi, D. H., and Liu, Z. Q.: Soil Infiltration Characteristics under Different Land at Western Yunnan Plateau, Advanced Materials Research, 2014, 694-697,

Qian, F., Cheng, D., and Liu, J.: Analysis of the Water and Soil Erosion and Infiltration Characteristic in Ziquejie Terrace, IERI Procedia, 9, 13-19, 10.1016/j.ieri.2014.09.034, 2014.

Quadri, M., Angulo-Jaramillo, R., Vauclin, M., Clothier, B., and Green, S.: Axisymmetric transport of water and solute underneath a disk permeameter: Experiments and numerical model, Soil Science Society of America Journal, 58, 696-703, 1994.

Rahmati, M.: Reliable and accurate point-based prediction of cumulative infiltration using soil readily available characteristics: a comparison between GMDH, ANN, and MLR, Journal of Hydrology, On Press, https://doi.org/10.1016/j.jhydrol.2017.05.046, 2017.

Rawls, W., Yates, P., and Asmussen, L.: Calibration of selected infiltration equations for the Georgia Coastal Plain, Report ARS-S-113 July 1976. 110 p, 2 fig, 8 tab, 25 ref, 1 append., 1976.

Rei, I., Kazufumi, I., Yuki, I., Tatsuro, S., and Yukihiro, S.: Evaluation of Infiltration Capacity and Water Retention Potential of Amended Soil Using Bamboo Charcoal and Humus for Urban Flood Prevention, Journal of Earth Science and Engineering, 6, 10.17265/2159-581x/2016.03.002, 2016.

Rezaei, M., Seay, T., Seuntjens, P., Joris, I., Wesley Boënne., Van Meirvenne, M, Cornelis, W.: Predicting saturated hydraulic conductivity in a sandy grassland using proximally sensed apparent electrical conductivity, Journal of Applied Geophysics, 126, 35-41, 2016a.

Rezaei, M., Seuntjens, P., Shahidi, R, Joris, I., Wesley Boënne., Al-Barri, B., Cornelis, W.: The relevance of in-situ and laboratory characterization of sandy soil hydraulic properties for soil water simulations, Journal of Hydrology, 534, 251–265, 2016b.

Richards, L. A.: Capillary conduction of liquids through porous mediums, Journal of Applied Physics, 1, 318-333, 1931.

Robinson, D. A., Jones, S. B., Lebron, I., Reinsch, S., Domínguez, M. T., Smith, A. R., Jones, D. L., Marshall, M. R., and Emmett, B. A.: Experimental evidence for drought induced alternative stable states of soil moisture, Scientific reports, 6, 20018, 2016.

Rodrigo-Comino, J., Sinoga, J. R., González, J. S., Guerra-Merchán, A., Seeger, M., and Ries, J.: High variability of soil erosion and hydrological processes in Mediterranean hillslope vineyards (Montes de Málaga, Spain), Catena, 145, 274-284, 2016.

Rodrigo-Comino, J., Taguas, E., Seeger, M., and Ries, J. B.: Quantification of soil and water losses in an extensive olive orchard catchment in Southern Spain, Journal of Hydrology, 556, 749-758, 2018.

Rubel, F., Brugger, K., Haslinger, K., and Auer, I. The climate of the European Alps: Shift of very high resolution Köppen-Geiger climate zones 1800-2100. Meteorologische Zeitschrift, 26(2), 115–125, 2017

Ruprecht, J., and Schofield, N.: Infiltration characteristics of a complex lateritic soil profile, Hydrological processes, 7, 87-97, 1993.

Sadeghi, S., Hazbavi, Z., and Younesi, H.: Sustainable watershed management through applying appropriate level of soil amendments, 2nd International Conference on Sustainable Watershed Management, SUWAMA, 2014, 183-185,

Sadeghi, S. H. R, Moghaddam, E., and Khaledi Darvishan, A.: Effects of subsequent rainfall events on runoff and soil erosion components from small plots treated by vinasse, Catena, 138, 1-12, 2016a.

Sadeghi, S. H. R., Kheirfam, H., Homaee, M., Zarei Darki, B., and Vafakhah, M.: Improving runoff behavior resulting from direct inoculation of soil micro-organisms, Soil and Tillage Research, 171, 35-41, 2017a.

Sadeghi, S. H. R., Hazbavi, Z., and Kiani-Harchegani, M.: Controllability of runoff and soil loss from small plots treated by vinasse-produced biochar, Science of the Total Environment, 541, 483-490, 2016b.

Sadeghi, S. H. R., Hazbavi, Z., Younesi, H., and Bahramifar, N.: Trade-off between runoff and sediments from treated erosion plots and polyacrylamide and acrylamide residues, Catena, 142, 213-220, 2016c.

Sadeghi, S. H. R., Kiani-Harchegani, M., and Asadi, H.: Variability of particle size distributions of upward/downward splashed materials in different rainfall intensities and slopes, Geoderma, 290, 100-106, 2017b.

Sahoo, A. K., Dirmeyer, P. A. , Houser, P. R., and Kafatos, M.: A study of land surface processes using land surface models over the Little River Experimental Watershed, Georgia." Journal of Geophysical Research: Atmospheres 113(D20), 2008

Saito, T., Yasuda, H., Suganuma, H., Inosako, K., Abe, Y., and Kojima, T.: Predicting Soil Infiltration and Horizon Thickness for a Large-Scale Water Balance Model in an Arid Environment, Water, 8, 96, 10.3390/w8030096, 2016.

Sándor, R., Lichner, Ľ., Filep, T., Balog, K., Lehoczky, É., and Fodor, N.: Spatial variability of hydrophysical properties of fallow sandy soils, Biologia, 70, 10.1515/biolog-2015-0182, 2015.

Sarmadian, F., and Taghizadeh-Mehrjardi, R.: Estimation of infiltration rate and deep percolation water using feed-forward neural networks in Gorgan Province, Eurasian Journal of Soil Science, 3, 1, 2014.

Sauwa, M., Chiroma, A., Waniyo, U., Ngala, A., and Danmowa, N.: Water transmission properties of a sandy loam soil under different tillage practices in Maiduguri, Nigeria, Agric. Biol. J. North America, 4, 227-251, 2013.

Schaap, M. G., and Leij, F. J.: Database-related accuracy and uncertainty of pedotransfer functions, Soil Science, 163, 765-779, 1998.

Scotter, D., Clothier, B., and Sauer, T.: A critical assessment of the role of measured hydraulic properties in the simulation of absorption, infiltration and redistribution of soil water, Agricultural water management, 15, 73-86, 1988.

Sepehrnia, N., Hajabbasi, M. A., Afyuni, M., and Lichner, Ľ.: Extent and persistence of water repellency in two Iranian soils, Biologia, 71, 1137-1143, 2016.

Sepehrnia, N., Hajabbasi, M. A., Afyuni, M., and Lichner, Ľ.: Soil water repellency changes with depth and relationship to physical properties within wettable and repellent soil profiles, Journal of Hydrology and Hydromechanics, 65, 99-104, 2017.

Sharifi Moghaddam, E., Sadeghi, S. H. R., and Khaledi Darvishan, A.: Small plot soil hydrologic components as affected by application of vinasse organicresidue, Iranian Journal of Soil and Water Research, 45, 499-508, 2014.

Shirazi, M. A., and Boersma, L.: A unifying quantitative analysis of soil texture, Soil Science Society of America Journal, 48, 142-147, 1984.

Shukla, M., Lal, R., and Ebinger, M.: Tillage effects on physical and hydrological properties of a typic Argiaquoll in central Ohio, Soil Science, 168, 802-811, 2003.

Shukla, M., Lal, R., Ebinger, M., and Meyer, C.: Physical and chemical properties of soils under some piñon-juniper-oak canopies in a semi-arid ecosystem in New Mexico, Journal of arid environments, 66, 673-685, 2006.

Sihag, P., Tiwari, N., and Ranjan, S.: Estimation and inter-comparison of infiltration models, Water Science, 2017.

Smith, R., and Parlange, J. Y.: A parameter- efficient hydrologic infiltration model, Water Resources Research, 14, 533-538, 1978.

Smith, R. E., Smettem, K. R., and Broadbridge, P.: Infiltration theory for hydrologic applications, American Geophysical Union, 2002.

Sorman, A. U., Abdulrazzak, M. J., and Ugas, M. A. S.: Application of infiltration models to field data from Wadi Tabalah, Saudi Arabia, Application of Tracers in Arid Zone Hydrolog, 232, 305-316, 1995.

Su, L., Wang, Q., Shan, Y., and Zhou, B.: Estimating Soil Saturated Hydraulic Conductivity using the Kostiakov and Philip Infiltration Equations, Soil Science Society of America Journal, 80, 1463-1475, 2016.

Sukhanovskij, Y. P., Vytovtov, V. A., Prushchik, A. V., Solov'eva, Y. A., and Sanzharova, S. I.: Assessment of soil infiltration capacity by using portable rainfall simulator, Byulleten Pochvennogo instituta im. V.V. Dokuchaeva, 78, 26-35, 2015.

Suzuki, K.: Estimation of Snowmelt Infiltration into Frozen Ground and Snowmelt Runoff in the Mogot Experimental Watershed in East Siberia, International Journal of Geosciences, 04, 1346-1354, 10.4236/ijg.2013.410131, 2013.

Teague, N. F.: Near surface infiltration measurements and the implications for artificial recharge, Masters of Science, Geological Sciences, San Diego State University, San Diego, 2010.

Teixeira, W. G., Schroth, G., Marques, J. D., and Huwe, B.: Unsaturated Soil Hydraulic Conductivity in the Central Amazon: Field Evaluations, 283-305, 10.1007/978-3-319-06013-2_13, 2014.

Thierfelder, C., Stahr, K., and Edgar, A. C.: Soil crusting and sealing in the Andean Hillsides of Colombia and its impact on water infiltration, Wollny, C.; Deininger, A.; Bhandari, N.; Maass, B.; Manig, W.; Muuss, U.; Brodbeck, F.; Howe, I.(eds.). Technological and Institutional Innovations for Sustainable Rural Development: Deutscher Tropentag 2003: International research on food security, natural resource management and rural development: Book of abstracts, Georg-August-Universität Göttingen, October 8-10, 2003., 2003.

Thierfelder, C., and Wall, P. C.: Effects of conservation agriculture techniques on infiltration and soil water content in Zambia and Zimbabwe, Soil and Tillage Research, 105, 217-227, 10.1016/j.still.2009.07.007, 2009.

Thierfelder, C., Chivenge, P., Mupangwa, W., Rosenstock, T. S., Lamanna, C., and Eyre, J. X.: How climate-smart is conservation agriculture (CA)? – its potential to deliver on adaptation, mitigation and productivity on smallholder farms in southern Africa, Food Security, 9, 537-560, 10.1007/s12571-017-0665-3, 2017.

Uloma, A., Onyekachi, C., Torti, E., and Amos, U.: Infiltration characteristics of soils of some selected schools in aba, nigeria, Archives of Applied Science Research, 5, 11-15, 2013.

van der Kamp, G., Hayashi, M., and Gallén, D.: Comparing the hydrology of grassed and cultivated catchments in the semi-arid Canadian prairies, Hydrological Processes, 17, 559-575, 10.1002/hyp.1157, 2003.

Van Looy, K., Bouma, J., Herbst, M., Koestel, J., Minasny, B., Mishra, U., Montzka, C., Nemes, A., Pachepsky, Y., and Padarian, J.: Pedotransfer functions in Earth system science: challenges and perspectives, Reviews of Geophysics, 2017.

Vogel, T., and Cislerova, M.: A scaling-based interpretation of a field infiltration experiment, Journal of hydrology, 142, 337-347, 1993.

Vogeler, I., Cichota, R., Sivakumaran, S., Deurer, M., and McIvor, I.: Soil assessment of apple orchards under conventional and organic management, Soil Research, 44, 745-752, 2006.

Votrubova, J., Dohnal, M., Vogel, T., Tesar, M., Jelinkova, V., and Cislerova, M.: Ponded infiltration in a grid of permanent single-ring infiltrometers: Spatial versus temporal variability, Journal of Hydrology and Hydromechanics, 65, 244-253, 2017.

Wang, G., Fang, Q., Wu, B., Yang, H., and Xu, Z.: Relationship between soil erodibility and modeled infiltration rate in different soils, Journal of Hydrology, 528, 408-418, 10.1016/j.jhydrol.2015.06.044, 2015a.

Wang, L., Zhong, C., Gao, P., Xi, W., and Zhang, S.: Soil Infiltration Characteristics in Agroforestry Systems and Their Relationships with the Temporal Distribution of Rainfall on the Loess Plateau in China, PLoS One, 10, e0124767, 10.1371/journal.pone.0124767, 2015b.

Wang, T., Xu, H.-l., and Bao, W.-m.: Application of isotopic information for estimating parameters in Philip infiltration model, Water Science and Engineering, 9, 287-292, 10.1016/j.wse.2017.01.005, 2016.

Waterloo, M. J., Schellekens, J., Bruijnzeel, L. A. and Rawaqa, T. T.: Changes in catchment runoff after harvesting and burning of a Pinus caribaea plantation in Viti Levu, Fiji. Forest Ecology and Management 251 (1-2): 31-44, 2007.

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.: European HYdropedological Data Inventory (EU-HYDI). Luxembourg: Publications Office of the European Union, EUR – Scientific and Technical Research series, 2013.White, I., and Sully, M.J.: Macroscopic and microscopic capillary length and time scales from infiltration. Water Resource Research, 23:1514-1522, 1987.

Wu, G.-L., Yang, Z., Cui, Z., Liu, Y., Fang, N.-F., and Shi, Z.-H.: Mixed artificial grasslands with more roots improved mine soil infiltration capacity, Journal of Hydrology, 535, 54-60, 2016.

Yang, J.-L., and Zhang, G.-L.: Water infiltration in urban soils and its effects on the quantity and quality of runoff, Journal of Soils and Sediments, 11, 751-761, 10.1007/s11368-011-0356-1, 2011.

Yilmaz, D., Lassabatere, L., Angulo-Jaramillo, R., Deneele, D., and Legret, M.: Hydrodynamic characterization of basic oxygen furnace slag through an adapted BEST method, Vadose Zone Journal, 9, 107-116, 2010.

Zhang, J., Jiao, J., and Yang, J.: In situ rainfall infiltration studies at a hillside in Hubei Province, China, Engineering Geology, 57, 31-38, 2000.

Zhang, Y., and Schaap, M. G.: Weighted recalibration of the Rosetta pedotransfer model with improved estimates of hydraulic parameter distributions and summary statistics (Rosetta3), Journal of Hydrology, 547, 39-53, 2017.

Zhang, Z., Lin, L., Wang, Y., and Peng, X.: Temporal change in soil macropores measured using tension infiltrometer under different land uses and slope positions in subtropical China, Journal of Soils and Sediments, 16, 854-863, 10.1007/s11368-015-1295-z, 2015.

Zhao, H., Zeng, Y., Lv, S., and Su, Z.: Analysis of Soil Hydraulic and Thermal Properties for Land Surface Modelling over the Tibetan Plateau, Earth Syst. Sci. Data Discuss., 2018, 1-40, 10.5194/essd-2017-122, 2018.

Zhao, H. H., Zeng, Y. Y., and Su, Z. B.: Soil Hydraulic and Thermal Properties for Land Surface Modelling over the Tibetan Plateau, Dataset, https://doi.org/10.4121/uuid:61db65b1-b2aa-4ada-b41e-61ef70e57e4a, 2017.

Zhao, Y., Peth, S., Hallett, P., Wang, X., Giese, M., Gao, Y., and Horn, R.: Factors controlling the spatial patterns of soil moisture in a grazed semi-arid steppe investigated by multivariate geostatistics, Ecohydrology, 4, 36-48, 10.1002/eco.121, 2011.

Table 1- References used to extract infiltration curves and metadata

No.	Dataset		Reference	No.	Dataset		Reference	No.	dataset		Reference
	From	To			From	To			From	To	
1	295	317	Miller et al. (2005)	26	4516	-	Delage et al. (2016)	51	4692	-	Ayu et al. (2013)
2	318	322	Adindu Ruth et al. (2014)	27	4517	4518	Ruprecht and Schofield (1993)	52	4693	4699	Rei et al. (2016)
3	542	544	Alagna et al. (2016)	28	4519	4520	Bertol et al. (2015)	53	4700	4702	Omuto et al. (2006)
4	545	-	Angulo-Jaramillo et al. (2000)	29	4521	4523	Naeth et al. (1991)	54	4703	4706	Návar and Synnott (2000)
5	546	548	Su et al. (2016)	30	4524	4529	Huang et al. (2011)	55	4707	-	Scotter et al. (1988)
6	549	550	Quadri et al. (1994)	31	4530	4537	van der Kamp et al. (2003)	56	4708	4720	Khan and Strosser (1998)
7	551	553	Qi and Liu (2014)	32	4538	-	Jačka et al. (2016)	57	4721	4724	Lipiec et al. (2006)
8	554	558	Huang et al. (2015)	33	4539	4568	Matula (2003)	58	4725	-	Suzuki (2013)
9	559	568	Al-Kayssi and Mustafa (2016)	34	4569	4586	Casanova (1998)	59	4726	4728	Sukhanovskij et al. (2015)
10	1421	1432	Bhardwaj and Singh (1992)	35	4587	4593	Holzapfel et al. (1988)	60	4729	4749	Al-Ghazal (2002)
11	1433	1435	Berglund et al. (1980)	36	4594	4605	Wang et al. (2015b)	61	4750	-	Sorman et al. (1995)
12	1436	1443	Wu et al. (2016)	37	4606	4611	Mao et al. (2016)	62	4751	4764	Bowyer-Bower (1993)
13	1444	1446	Chartier et al. (2011)	38	4612	-	Wang et al. (2016)	63	4765	4788	Medinski et al. (2009)
14	1447	1456	Sihag et al. (2017)	39	4613	4615	Qian et al. (2014)	64	4789	4792	Latorre et al. (2015)
15	1457	1460	Machiwal et al. (2006)	40	4617	4619	Fan et al. (2013)	65	4793	4795	Biro et al. (2010)
16	1461	1466	Igbadun et al. (2016)	41	4620	-	Zhang et al. (2000)	66	4796	4799	Mohammed et al. (2007)
17	1467	1469	Mohanty et al. (1994)	42	4621	4623	Wang et al. (2015a)	67	4800	4815	Abdallah et al. (2016)
18	1470	1472	Sauwa et al. (2013)	43	4624	4633	Yang and Zhang (2011)	68	4816	4819	Murray and Buttle (2005)
19	1473	1476	Arshad et al. (2015)	44	4634	4657	Wu et al. (2016)	69	4820	4831	Zhang et al. (2015)
20	1477	1488	Bhawan (1997)	45	4658	4663	Ma et al. (2017)	70	4832	4837	Perkins and McDaniel (2005)
21	1489	1495	Uloma et al. (2013)	46	4664	4681	Thierfelder et al. (2003)	71	4838	4841	Arriaga et al. (2010)
22	1496	-	Al-Azawi (1985)	47	4682	4683	Commandeur et al. (1994)	72	4842	4857	Thierfelder et al. (2017)
23	1497	1499	Ogbe et al. (2011)	48	4684	4686	Di Prima et al. (2016)	73	4858	4867	Thierfelder and Wall (2009)
24	1500	1507	Teague (2010)	49	4687	4688	Angulo-Jaramillo et al. (2000)	74	4868	4879	Abagale et al. (2012)
25	4506	4515	Muhamad et al. (2008)	50	4689	4691	Machiwal et al. (2006)				

Table 2- References and correspondence for data supplied by data owners

No.	Dataset From	Dataset To	Contact person	Email for contact	Reference
1	1	135	M. Rahmati	mehdirmti@gmail.com	Rahmati (2017)
2	136	294	A. Farajnia	farajnia1966@yahoo.com	Unpublished data
3	323	376	M. Shukla	shuklamk@nmsu.edu	Shukla et al. (2003 & 2006)
4	377	426	S. H. R. Sadeghi	sadeghi@modares.ac.ir	Sadeghi et al. (2014, 2016a, b, c, 2017a, b), Hazbavi and Sadeghi (2016), Kheirfam et al. (2017a, b) Sharifi Moghaddam et al. (2014); Ghavimi Panah et al. (2017); Kiani-Harchegani et al. (2017)
5	427	466	M. H. Mohammadi	mhmohmad@ut.ac.ir	Unpublished data
6	467	505	F. Meunier	felicien.meunier@uclouvain.be	Unpublished data
7	506	541	N. Sephrnia	n.sepehrnia@gmail.com	Sepehrnia et al. (2016 & 2017)
8	569	817	D.Moret-Fernández	david@eead.csic.es	Unpublished data
9	818	940	M. Vafakhah	vafakhah@modares.ac.ir	Kavousi et al. (2013); Fakher Nikche et al. (2014)
10	941	1060	A. Cerdà	artemio.cerda@uv.es	Unpublished data
11	1061	1079	J. Rodrigo-Comino	rodrigo-comino@uma.es	Rodrigo-Comino et al. (2016); Rodrigo-Comino et al. (2018)
12	1080	1112	H. Asadi	ho.asadi@ut.ac.ir	Nikghalpour et al. (2016)
13	1113	1119	K. Bohne	klaus.bohne@uni-rostock.de	Unpublished data
14	1120	1125	L. Mao	leoam@126.com	Mao et al. (2008b; 2016)
15	1126	1166	L. Lichner	lichner@uh.savba.sk	Dušek et al. (2013), Lichner et al. (2011; 2012; 2013)
16	1167	1210	M. V. Ottoni	marta.ottoni@cprm.gov.br	Oliveira (2005)
17	1211	1420	R. Sándor	sandor.rencsi@gmail.com	Fodor et al. (2011); Sándor et al. (2015)
18	4476	4485			
19	1508	1519	A. Stanley	ajayistan@gmail.com	Igbadun et al. (2016); Othman and Ajayi (2016)
20	1520	1521	A. R. Vaezi	vaezi.alireza@gmail.com	Unpublished data
21	1522	1536	A. Albalasmeh	aalbalasmeh@just.edu.jo	Gharaibeh et al. (2016)
22	1537	1578	D. Machiwal	dmachiwal@rediffmail.com	Machiwal et al. (2006, 2017) , Ojha et al. (2013)
23	1579	1592	H. Emami	hemami@um.ac.ir	Fakouri et al. (2011a, 2011b)
24	1593	1895	J. Mertens	jan.mertens@engie.com	Mertens et al. (2002, 2004, 2005)
25	1896	2115	D. Jacques	diederik.jacques@sckcen.be	Jacques (2000); Jacques et al. (2002)
26	2116	2139	J. Votrubova	jana.votrubova@fsv.cvut.cz	Votrubova et al. (2017)
27	2140	2143	J. Batlle-Aguilar	jorbat1977@hotmail.com	Batlle-Aguilar et al. (2009)
28	2144	2179	R. A. Armindo	rarmindo@ufpr.br	Unpublished data
29	2180	2209	S. Werner	steffen.werner@rub.de	Unpublished data
30	2210	2255	S. Zacharias	steffen.zacharias@ufz.de	Unpublished data
31	2256	2281	S. Shutaro	sshiraki@affrc.go.jp	Unpublished data
32	2282	2304	T. Saito	tadaomi@muses.tottori-u.ac.jp	Saito et al. (2016)
33	2305	2354	R. Taghizadeh-M.	rh_taghizade@yahoo.com	Unpublished data

Continued by Table 2

No.	Dataset		Contact person	Email for contact	Reference
	From	To			
34	2355	2356	W. G. Teixeira	wenceslau.teixeira@embrapa.br	Teixeira et al. (2014)
35	3644	3647			
36	2357	2436	Y. Zhao	yzhaosoils@gmail.com	Zhao et al. (2011)
37	2437	2475	A. A. Moosavi	aamousavi@gmail.com	Unpublished data
38	2476	2552	Y. A. Pachepsky	Yakov.Pachepsky@ars.usda.gov	Rawls et al. (1976)
39	2553	2643	A. Panagopoulos	panagopoulosa@gmail.com	Hatzigiannakis and Panoras (2011) + unpublished data
40	2644	2649	B. Clothier	Brent.Clothier@plantandfood.co.nz	Al Yamani et al. (2016)
41	2650	2710	C. Castellano	ccastellanonavarro@gmail.com	Unpublished data
42	3507	3597			
43	2711	2756	F. Becker	fabian.becker@fu-berlin.de	Unpublished data
44	2757	2765	I. Vogeler	iris.vogeler@plantandfood.co.nz	Vogeler et al. (2006); Cichota et al. (2013)
45	2766	2788	R. Morbidelli	renato.morbidelli@unipg.it	Morbidelli et al. (2017)
46	2789	2832	S. Giertz	sgiertz@uni-bonn.de	Giertz et al. (2005)
47	2833	2868	T. Vogel	vogel@fsv.cvut.cz	Vogel and Cislerova (1993)
48	2869	2948	W. Cornelis	Wim.Cornelis@ugent.be	Pulido Moncada et al. (2014); Rezaei et al. (2016a, b)
49	2949	3386	Y. Coquet	yves.coquet@univ-orleans.fr	Coquet (1996); Coquet et al. (2005); Chalhoub et al. (2009)
50	3705	3709			
51	3387	3506	B. Mohanty	bmohanty@tamu.edu	Dasgupta et al. (2006)
52	3598	3643	D. J. Reinert	dalvan@ufsm.br	Mallmann (2017)
53	3648	3657	M.R. Pahlavan Rad	pahlavanrad@gmail.com	Pahlavan-Rad (2017)
54	3658	3680	T. Saito	tadaomi@muses.tottori-u.ac.jp	Unpublished data
55	3681	3704	X. Li	xyli@bnu.edu.cn	Li et al. (2013); Hu et al. (2016)
56	4497	4505			
57	3710	3745	Y. Bamutaze	yazidhibamutaze@gmail.com	Unpublished data
58	3746	3833	I. Braud	isabelle.braud@irstea.fr	Gonzalez-Sosa et al. (2010); Braud (2015); Braud and Vandervaere (2015)
59	3907	4011			
60	3834	3874	M. R. Mosaddeghi	mosaddeghi@yahoo.com	Unpublished data
61	3875	3906	S. B. Mousavi	b_mosavi2000@yahoo.com	Unpublished data
62	4012	4026	M. Pulido	manpufer@hotmail.com	Unpublished data
63	4027	4457	F. P. Roberts	frapar@ceh.ac.uk	Unpublished data
	4458	4475			Robinson et al. (2016, 2017)
64	4486	4496	T. Picciafuoco	picciafuoco@hydro.tuwien.ac.at	Morbidelli et al. (2017)
65	4880	4886	M. A. Liebig	mark.liebig@ars.usda.gov	Liebig et al. (2004)
66	4887	4936	Y. Zeng	y.zeng@utwente.nl	Zhao et al. (2017, 2018)
67	4937	5018	L. Lassabatere	laurent.lassabatere@entpe.fr	Lassabatere et al. (2010); Yilmaz et al. (2010); Coutinho et al. (2016)
68	5019	5023	I. Eskandari	eskandari1343@yahoo.com	Unpublished data

Table 3- Description of the variables listed in database

Column	Supplies:	Dimension
Code	Data set identifier with 4 digits from 0001 to 5023	
Clay	Mass of soil particles, < 0.002 mm	%
Silt	Mass of soil particles, >0.002 and < 0.05 mm	%
Sand	Mass of soil particle, > 0.05 and < 2 mm	%
Texture	1: Sand; 2: Loamy sand; 3: Sandy loam; 4: Sandy clay loam; 5: Sandy Clay; 6: Loam; 7: Silt loam; 8: Silt; 9: Clay loam; 10: Silty clay loam; 11: Silty clay; 12: Clay	
Gravel	Mass of particles larger than 2 mm	%
dg	Geometric mean diameter	mm
Sg	Standard deviation of soil particle diameter	
OC	Soil organic carbon content	%
Db	Soil bulk density	g cm^{-3}
Dp	Soil particle density	g cm^{-3}
Ksat	Soil saturated hydraulic conductivity	cm h^{-1}
Theta_sat	Saturated volumetric soil water content	cm^3 cm^{-3}
Theta_i	Initial volumetric soil water content	cm^3 cm^{-3}
FC	Soil water content at field capacity	cm^3 cm^{-3}
PWP	Soil water content at permanent wilting point (1500 kPa)	cm^3 cm^{-3}
Theta_r	Residual volumetric soil water content	cm^3 cm^{-3}
WAS	Wet-aggregate stability	%
MWD	Aggregates mean weight diameter	mm
GMD	Aggregates geometric mean diameter	mm
EC	Soil electrical conductivity	dS m^{-1}
pH	Soil acidity	-
Gypsum	Soil gypsum content	%
CCE	Soil calcium carbonate equivalent	%
CEC	Soil cation exchange capacity	$Cmol_c$ kg^{-1}
SAR	Soil sodium adsorption ratio	-
DiscRadius	Applied disc radius (if any)	mm
Instrument	Applied instruments for infiltration measurement: 1: Double ring; 2: Single ring; 3: Rainfall simulator; 4: Guelph permeameter; 5: Disc infiltrometer; 6: Micro-infiltrometer; 7: Mini-infiltrometer; 8: Aardvark Permeameter; 9: Linear source method; 10: Point source method; 11: Hood infiltrometer; 12: Tension infiltrometer; 13: BEST method	
Vegetation cover		%
Land use	Dominant land-use or land cover type of the experimental site	
Rainfall intensity	Simulated rain intensity	mm h^{-1}
Slope	The mean slope of the soil surface	%
Treatment	Applied treatment in experimental site	
Crust	Yes: existence of crust; No: no crust layer	
Sand contact layer	Yes: sand contact layer is applied during infiltration measurement; No: no sand contact layer	

Table 4- Countries and the number of data sources (n) contributing to the database

Country	n	Country	n	Country	n
Iran	38	Austria	2	Indonesia	1
China	23	Chile	2	Iraq	1
USA	15	Ghana	2	Japan	1
Brazil	9	Morocco	2	Jordan	1
Spain	9	Namibia	2	Kenya	1
France	9	New Zealand	2	Lebanon	1
Germany	8	Pakistan	2	Malawi	1
India	8	Russia	2	Mexico	1
Canada	7	Senegal	2	Mozambique	1
United Kingdom	7	Slovakia	2	Myanmar	1
Hungary	6	South Africa	2	Netherland	1
Nigeria	6	Sudan	2	Poland	1
Greece	5	Zambia	2	Scotland	1
Belgium	4	Argentina	1	Tanzania	1
Italy	4	Australia	1	Telangana	1
Czech Republic	3	Benin	1	UAE	1
Saudi Arabia	3	Cameroon	1	Uganda	1
Australia	2	Colombia	1	Zimbabwe	1

Table 5- Number of soils in each soil USDA textural class for which infiltration data are included in the database.

Group	Soil texture class	Availability
Coarse-textured soils		1092
	Sand	291
	Loamy sand	111
	Sandy loam	690
Medium-textured soils		1238
	Loam	716
	Silt loam	522
	Silt	0
Fine to moderately fine-textured soil		1476
	Clay loam	514
	Clay	352
	Silty clay loam	253
	Sandy clay loam	226
	Silty clay	131
	Sandy clay	0

Table 6- Soil properties, number of data entries in the database (out of 5023 soil water infiltration curves in total), and their statistical description

Soil properties	Availability	Fr (%)	Mean	Min	Max	Median	CV (%)
Clay (%)	3842	76	24	0	80	20	64
Silt (%)	3842	76	36	0	82	37	52
Sand (%)	3842	76	41	1	100	38	63
Bulk density (g cm^{-3})	3295	66	1.32	0.14	2.81	1.35	20
Organic carbon (%)	3102	62	3	0	88	1	200
Saturated hydraulic cond. (cm h^{-1})	1895	38	41	0	3004	3	426
Initial soil water content (cm^3 cm^{-3})	1569	31	0.17	0	0.63	0.14	68
Saturated soil water content (cm^3 cm^{-3})	1400	28	0.44	0.01	0.87	0.45	24
Carbonate calcium equivalent (%)	1399	28	14	0	56	8	101
Electrical conductivity (dS m^{-1})	1113	22	25	0	358	1	249
pH	1081	22	7.4	4.7	8.6	7.6	12
Particle density (g cm^{-3})	438	9	2.52	1.73	2.97	2.56	9
Gypsum (%)	380	8	4	0	49	3	137
Cation exchange capacity ($cmol_c$ kg^{-1})	357	7	17	3	26	18	21
Wet-aggregate stability (%)	309	6	61	5	96	63	37
Residual soil water content (cm^3 cm^{-3})	263	5	0.10	0.001	0.38	0.06	86
Mean weight diameter (mm)	258	5	1	0.10	2.75	1.0	54
Gravel (%)	243	5	18	0	92	15	84
Sodium adsorption ratio	156	3	5	0	89	1	351
Soil water content at FC (cm^3 cm^{-3})	74	1	0.28	0.12	0.54	0.27	34
Soil water content at PWP (cm^3 cm^{-3})	64	1	0.18	0.05	0.36	0.20	47
Geometric mean diameter (mm)	73	1	0.6	0.4	0.8	0.6	18

Fr: Frequency (%), Min: Minimum, Max: Maximum, CV: coefficient of variation.

Table 7- Instruments used to measure soil infiltration curves

Instrument/method used		Infiltration curves
Ring	Double ring	828
	Single ring	570
	Beerkan (BEST)	197
Overall		1595
Infiltrometer	Disc	607
	Mini-disc	1140
	Micro-disc	36
	Hood	23
	Tension	752
Overall		2558
Permeameter	Guelph	181
	Aardvark	50
Overall		231
Rainfall simulator		374
Linear source method		10
Point source method		4
Not reported		251
	Sum	5023

Table 8- Number of infiltration curves with a given land use types

Land use	n	Land use	n
Agriculture	2019	Vineyards	22
Grassland	821	Upland	11
Pasture	229	Pure Sand	10
Forest	204	Brushwood	6
Garden	152	Road	5
Bare	99	Agro-pastoral	4
Urban Soils	82	Park	3
Savanna	41	Salt-marsh soil	3
Abandoned farms	39	Afforestation	2
Idle	32	Campus	2
Shrub	30	Residential	2
Available	3818	Unknown	1205

Table 9- Accuracy analysis of empirical models fitted to experimental data of infiltration

Infiltration type	n	R^2				RMSE (cm)				$R^2 >$ 0.90	R^2 >0.99
		Mean	Min	Max	STD	Mean	Min	Max	STD		
1D	828	0.985	0.529	1	0.049	0.900	1.3e-4	69.30	3.31	801	640
3D	3350	0.975	0.032	1	0.066	0.449	5.5e-12	98.95	2.95	3136	2276
All	4178	0.977	0.032	1	0.063	0.538	5.5e-12	98.95	3.03	3937	2916

STD: standard deviation

Table 10- Estimated or measured average values of infiltration parameters for different textural classes extracted from the current database

Texture class	Estimated by Eq. (8) or (9)							Measured				Independent T test between measured and estimated K_{sat}	
	n§	S (cm $h^{-0.5}$)			K_{sat} (cm h^{-1})			n§	K_{sat} (cm h^{-1})				
		Mean	Median	STD	*Mean*	*Median*	STD		Mean	Median	STD	df	T value
Sand	291	2.3	0.26	4.3	42.2	15	134.5	229	43.6	24	149	518	0.10^{ns}
Loamy sand	92	10.6	5.7	17.5	61.4	10	173.2	63	24.6	8.2	72	153	1.59^{ns}
Sandy loam	500	9.2	2.95	15.7	32	3.1	94.5	424	41.2	5.7	166	922	1.05^{ns}
Silt loam	409	9.4	1.5	19.1	26.5	1.7	61.7	165	2.9	0.96	5.1	572	4.90^{**}
Loam	583	7.9	2.4	12.9	7.8	0.28	26.7	270	4.9	1.18	13.7	851	1.69^{ns}
Sandy clay loam	185	5.9	2.1	8.6	7.4	1.4	12.8	84	5.4	2.24	6.9	267	1.35^{ns}
Silty clay loam	250	3.2	0.64	12.5	10.6	1.7	24.1	64	12.3	2.42	63.2	312	0.32^{ns}
Clay loam	467	6.8	2.1	13.6	8.3	2.3	20	166	7.6	2.97	21.3	631	0.38^{ns}
Sandy clay	-	-	-	-	-	-	-	-	-	-	-	-	-
Silty clay	121	7.7	2.2	13.4	26.2	7.8	61.5	54	44.8	6.97	88.2	173	1.59^{ns}
Clay	333	14.6	1.7	39.5	354.3	1.3	1268.5	79	148.8	2.94	458.4	410	1.42^{ns}
Silt	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	4179	8.5	2.6	18.2	46	1.8	374.8	1895	41	3.4	174	-	-

§: the number soils included in calculation
ns: insignificant and **: significant at 1 % probability level
STD: standard deviation

Table 11- Comparison of the estimated K_{sat} values from current database (SWIG) with measured K_{sat} values presented in literature

Texture class	Data source	Clapp and Hornberger (1978)	Rosetta3 (Zhang and Schaap, 2017)	Cosby et al. (1984)	Rawls database (Schaap and Leij, 1998)	Ahuja database (Schaap and Leij, 1998)	UNSODA database (Schaap and Leij, 1998)	US soils K_{sat} data (Pachepsky and Park, 2015)	EU-HYDI database (Weynants et al., 2013)
		K_{sat} (cm min^{-1})	$logK_{sat}$/STD ($\log_{10}$ cm day^{-1})	$logK_{sat}$/STD ($\log_{10}$ in h^{-1})	$logK_{sat}$/STD ($\log_{10}$ cm day^{-1})	$logK_{sat}$/STD ($\log_{10}$ cm day^{-1})	$logK_{sat}$/STD ($\log_{10}$ cm day^{-1})	$logK_{sat}$/STD ($\log_{10}$ cm h^{-1})	$logK_{sat}$/STD ($\log_{10}$ cm day^{-1})
Sand	Literature	1.056	2.81/0.59 (253)	0.82/0.39	2.71/0.51 (97)	3.01/0.45 (82)	2.70/074 (129)	1.57/0.71 (115)	0.71/1.45 (264)
	SWIG	0.704	3.01 /3.51 (291)	1.22 /1.73	3.01 /3.51 (291)	3.01 /3.51 (291)	3.01 /3.51 (291)	1.63 /2.13 (291)	3.01 /3.51 (291)
Loamy sand	Literature	0.938	2.02/0.64 (167)	0.30/0.51	1.91/0.61 (135)	2.09/0.69 (19)	2.36/0.59 (51)	1.03/0.42 (76)	0.80/1.41 (234)
	SWIG	1.033	3.17 /3.63 (92)	1.39 /1.84	3.17 /3.63 (92)	3.17 /3.63 (92)	3.17 /3.63 (92)	1.79 /2.25 (92)	3.17 /3.63 (92)
Sandy loam	Literature	0.208	1.58/0.67 (315)	-0.13/0.67	1.53/0.65 (337)	1.73/0.64 (65)	1.58/0.92 (79)	0.66/0.54 (169)	1.17/1.34 (825)
	SWIG	0.534	2.89 /3.36 (500)	1.10 /1.58	2.89 /3.36 (500)	2.89 /3.36 (500)	2.89 /3.36 (500)	1.51 /1.98 (500)	2.89 /3.36 (500)
Silt loam	Literature	0.043	1.28/0.74 (130)	-0.4/0.55	1.04/0.54 (217)	1.24/0.47 (12)	1.48/0.86 (103)	0.11/0.87 (215)	0.89/1.45 (714)
	SWIG	0.442	2.80 /3.17 (409)	1.02 /1.39	2.80 /3.17 (409)	2.80 /3.17 (409)	2.80 /3.17 (409)	1.42 /1.79 (409)	2.80 /3.17 (409)
Loam	Literature	0.042	1.09/0.92 (117)	-0.32/0.63	0.99/0.63 (137)	0.83/0.95 (50)	1.58/0.92 (62)	0.12/0.79 (81)	1.69/1.76 (411)
	SWIG	0.129	2.27 /2.81 (583)	0.49 /1.02	2.27 /2.81 (583)	2.27 /2.81 (583)	2.27 /2.81 (583)	0.89 /1.43 (583)	2.27 /2.81 (583)
Sandy clay loam	Literature	0.038	1.14/0.85 (13)	-0.2/0.54	1.29/0.71 (104)	0.81/0.80 (36)	0.99/1.21 (41)	0.12/0.94 (139)	0.73/1.45 (128)
	SWIG	0.124	2.25 /2.49 (185)	0.47 /0.70	2.25 /2.49 (185)	2.25 /2.49 (185)	2.25 /2.49 (185)	0.87 /1.11 (185)	2.25 /2.49 (185)
Silty clay loam	Literature	0.010	1.04/0.74 (46)	-0.54/0.61	0.87/0.55 (47)	1.09/0.78 (21)	1.14/0.85 (21)	-0.15/0.75 (83)	0.35/1.50 (364)
	SWIG	0.178	2.41 /2.77 (250)	0.62 /0.98	2.41 /2.77 (250)	2.41 /2.77 (250)	2.41 /2.77 (250)	1.03 /1.39 (250)	2.41 /2.77 (250)
Clay loam	Literature	0.015	0.87/1.11 (58)	-0.46/0.59	0.67/0.58 (77)	0.79/1.08 (48)	1.84/0.89 (25)	-0.03/0.94 (109)	1.10/1.54 (284)
	SWIG	0.139	2.30 /2.68 (467)	0.52 /0.90	2.30 /2.68 (467)	2.30 /2.68 (467)	2.30 /2.68 (467)	0.92 /1.3 (467)	2.30 /2.68 (467)
Sandy clay	Literature	0.013	1.06/0.89 (10)	0.01/0.33	1.33/0.33 (9)	-0.03/1.28 (2)	- (-)	-0.77/1.22 (21)	0.81/1.56 (5)
	SWIG	-	- /- (-)	-/-	- /- (-)	- /- (-)	- /- (-)	- /- (-)	- /- (-)
Silty clay	Literature	0.006	0.98/0.58 (14)	-0.72/0.69	0.82/0.55 (12)	1.15/0.16 (5)	0.92/0.71 (12)	-0.72/0.95 (22)	0.18/1.32 (349)
	SWIG	0.439	2.80 /3.17 (121)	1.02 /1.39	2.80 /3.17 (121)	2.80 /3.17 (121)	2.80 /3.17 (121)	1.42 /1.79 (121)	2.80 /3.17 (121)
Clay	Literature	0.008	1.17/0.92 (60)	-	0.94/0.31 (34)	1.03/0.83 (31)	1.41/015 (27)	-0.17/0.71 (115)	-0.08/1.41 (737)
	SWIG	5.906	3.93 /4.48 (333)	2.15 /2.70	3.93 /4.48 (333)	3.93 /4.48 (333)	3.93 /4.48 (333)	2.55 /3.10 (333)	3.93 /4.48 (333)
Silt	Literature	-	1.64/0.27 (3)	-	1.43/- (3)	- (-)	1.75/0.20 (3)	- (-)	-0.29/1.56 (11)
	SWIG	-	-/- (-)	-/-	-/- (-)	-/- (-)	-/- (-)	-/- (-)	-/- (-)

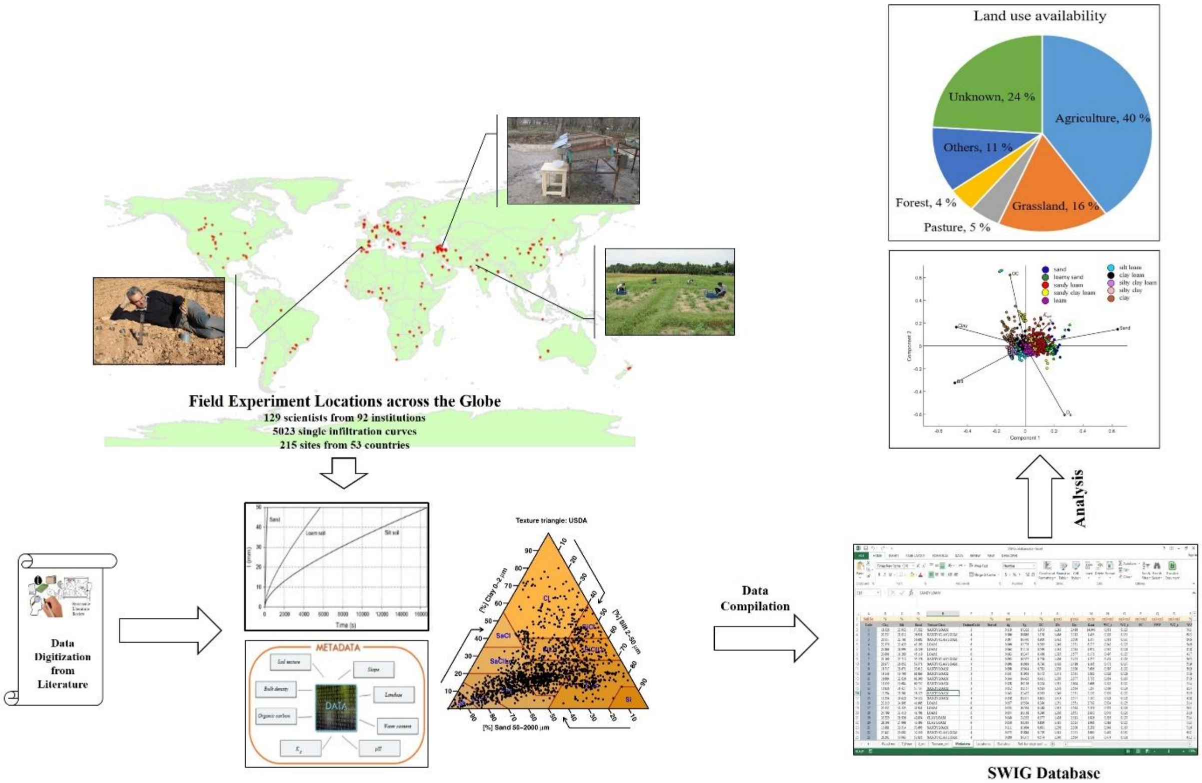

Figure 1- Graphical Abstract

Figure 2- Global distribution of infiltration measuring sites that were included in the database

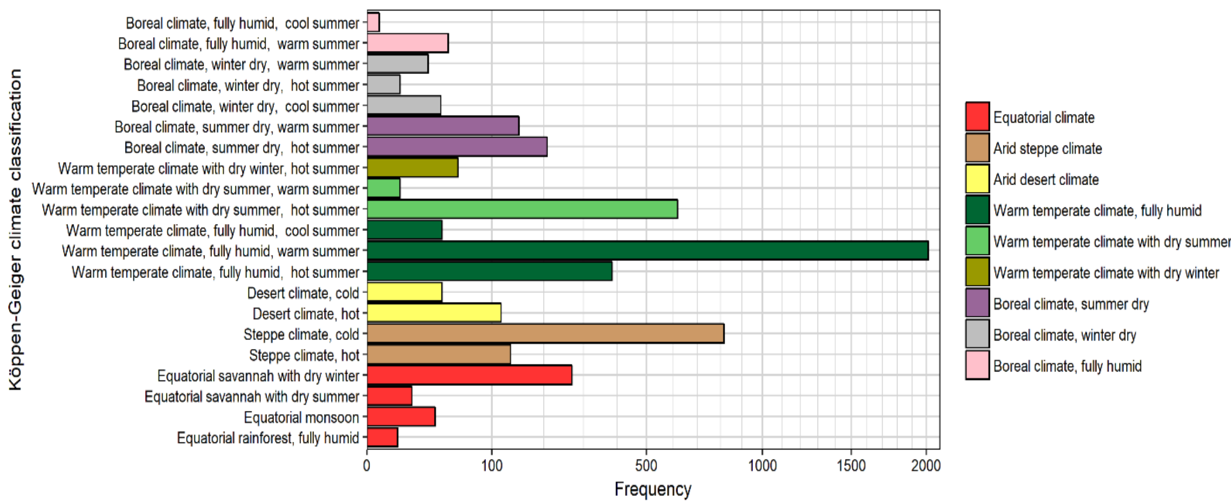

Figure 3- Number of samples by Köppen-Geiger climatic zones (Rubel et al., 2017; Kottek et al., 2006)

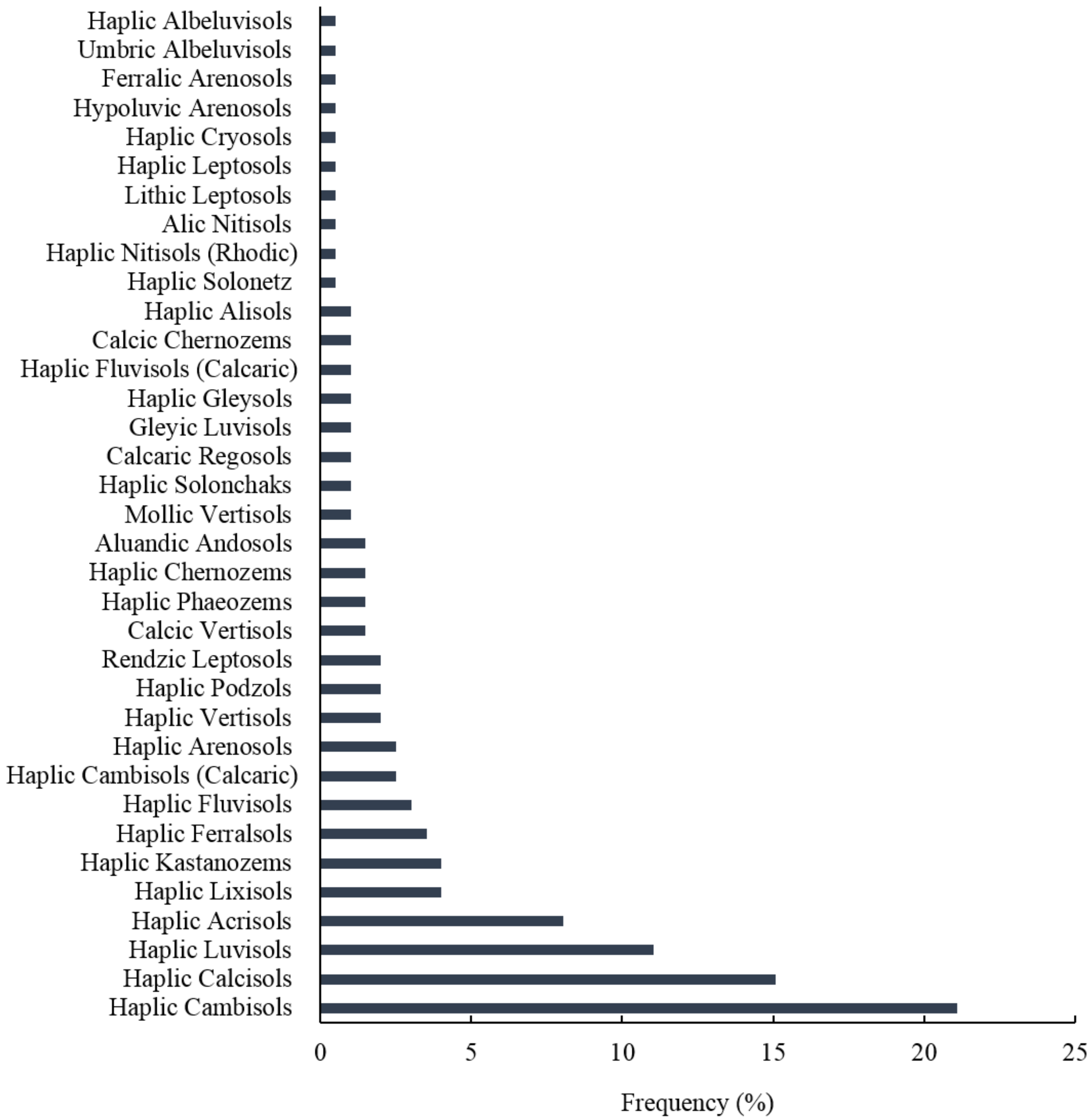

Figure 4- Frequency of WRB reference soil subgroups in experimental sites derived from SoilGrids (Hengl et al., 2017)

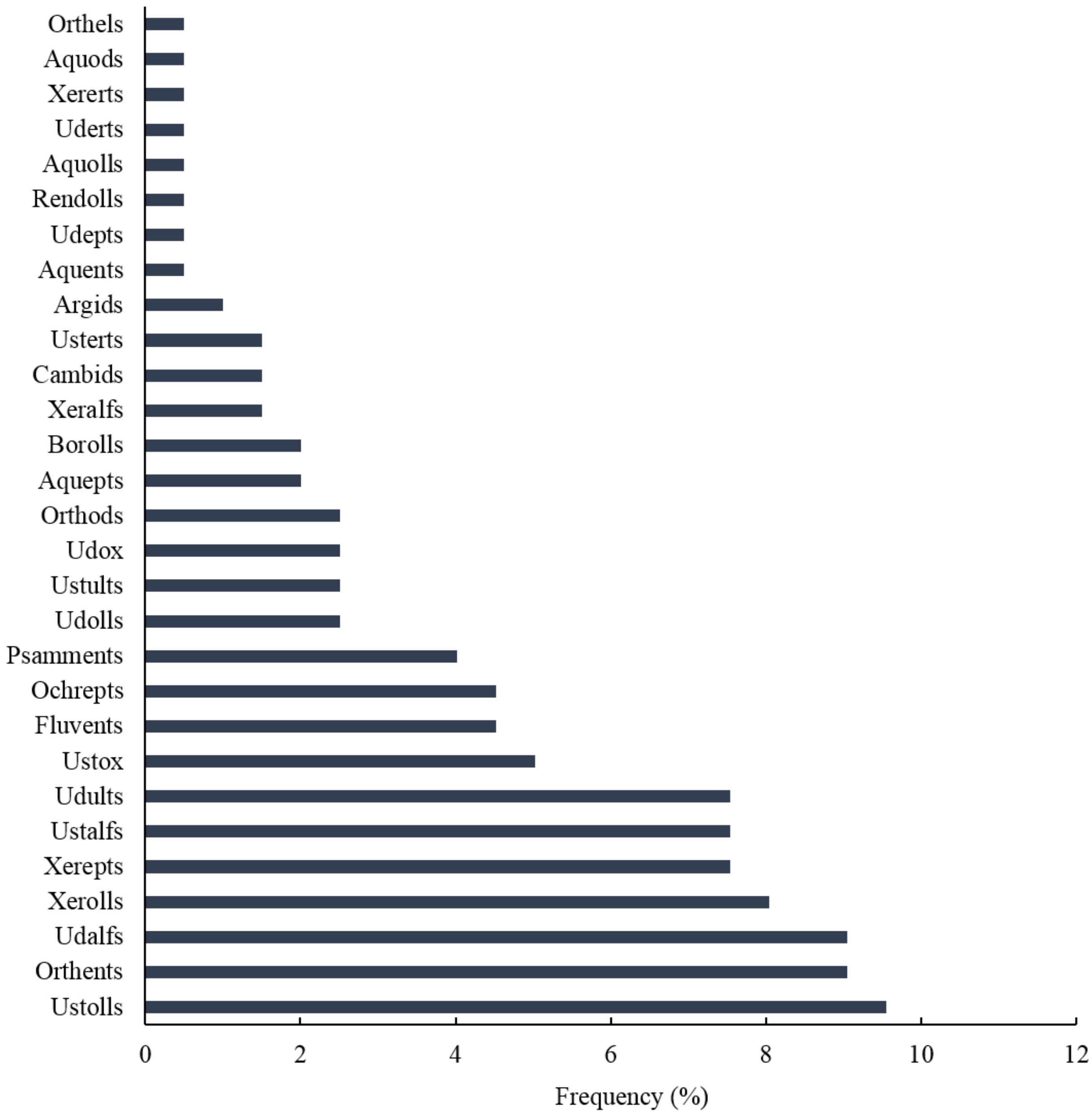

Figure 5- Frequency of USDA soil suborders in experimental sites derived from SoilGrids (Hengl et al., 2017)

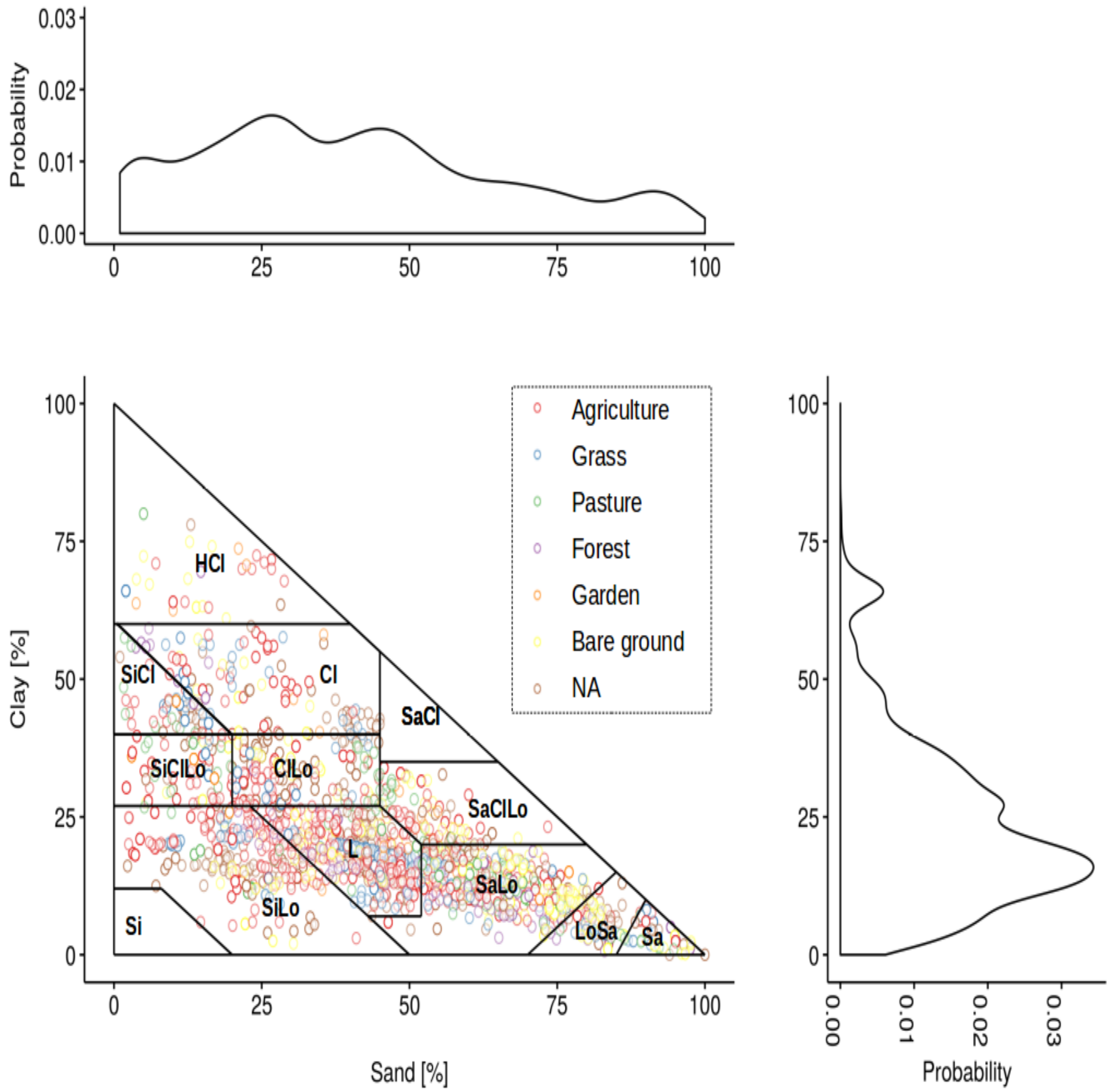

Figure 6 - Textural distribution of soils and probability density functions of clay (on the right) and sand (on the top) particles (plotted on USDA textural triangle) for which infiltration data are included in the database. Dots are colored according to their corresponding land use.

HCl: Highly clayey; SiCl: silty clay; Cl: clay; SiClLo: silty clay loam; ClLo: clay loam; SaCl: sandy clay; SaClLo: sandy clay loam; L: loam; Si: silty; SiLo: silty loam; SaLo: sandy loam; LoSa: loamy sand; and Sa: sandy

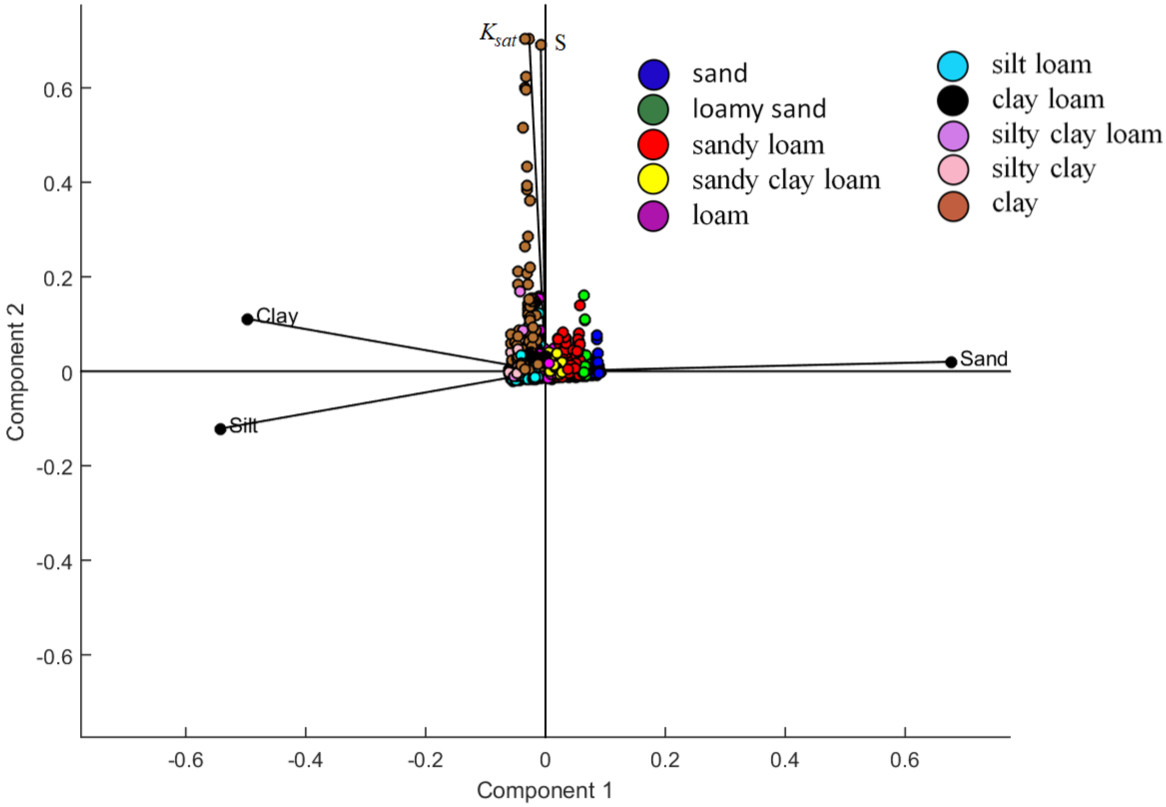

Figure 7- The relationships between clay, silt, sand contents and estimated hydraulic parameters (*S* and K_{sat})

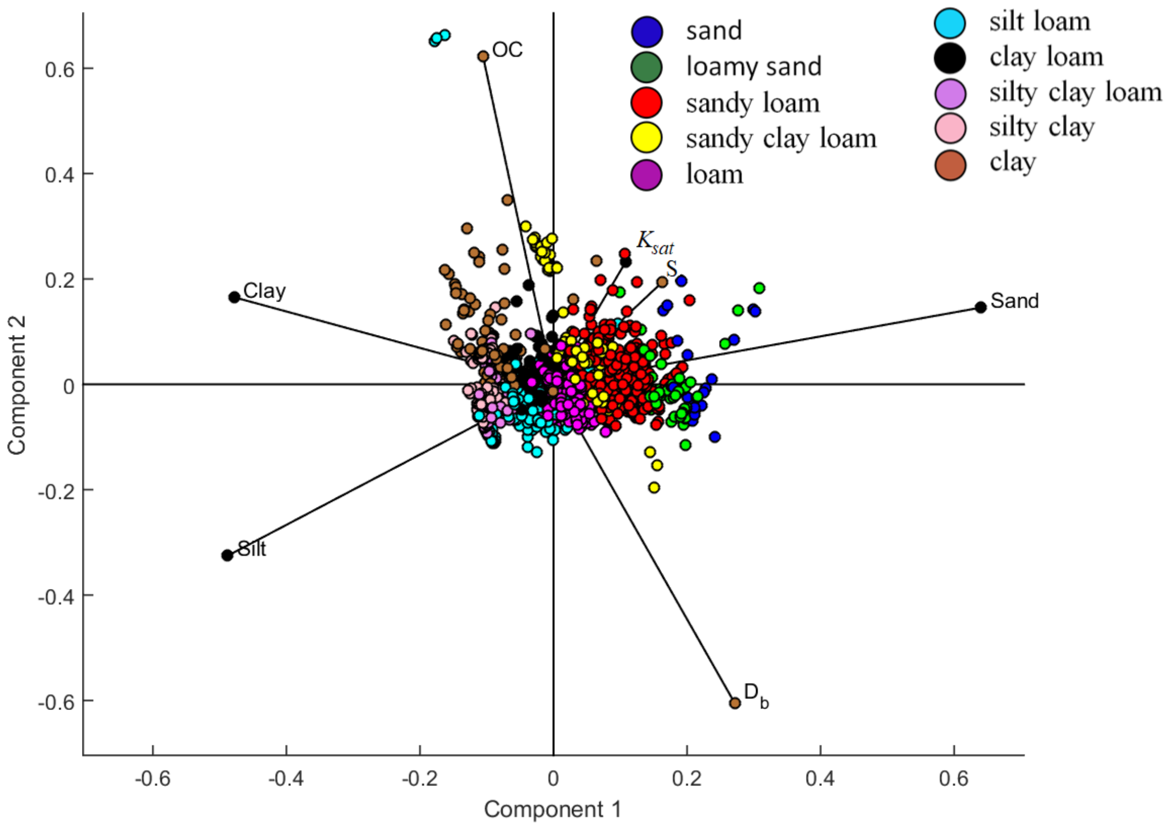

Figure 8- The relationships between clay, silt, sand contents, D_b, and *OC* and estimated hydraulic parameters (*S* and K_{sat})