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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 the 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 was gathered along with the infiltration data, making the database valuable for the development of pedotransfer functions (PTFs) 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 the 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 public domain use only and can be copied freely by referencing it. Supplementary data are available at https://doi.org/10.1594/PANGAEA.885492 (Rahmati et al., 2018). Data quality assessment is strongly advised prior to any use of this database. Finally, we would like to encourage scientists to extend and update the SWIG database by uploading new data to it.

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 become available for surface runoff. If this occurs, the boundary condition at the soil surface undergoes a shift in the dominant 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 is described by a decreasing function over time, tending towards the value of the hydraulic conductivity function for the water pressure head imposed at the soil surface (Angulo-Jaramillo 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 3-D 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, $i(t)$, ($\mathrm{L\,T^{-1}}$) can be derived. $i(t)$ and $I(t)$ are related to each other by derivation (Campbell, 1985; Hillel, 2013; Lal and Shukla, 2004):

$$i(t) = \frac{\mathrm{d}I(t)}{\mathrm{d}t}. \quad (1)$$

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 the 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 factor 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 pedotransfer 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 are now made available that may contribute to better predicting the saturated soil hydraulic conductivity and demonstrate the effect of, for example, vegetation and land management on the parameters of interest.

The Richards (1931) equation, 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.

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

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):

$$D_z(\theta)=K_z(\theta)\frac{\partial h}{\partial\theta}, \quad (3)$$

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, and physically based models – e.g., Green and Ampt (1911), Philip (1957), Smith and Parlange (1978), Haverkamp et al. (1994), and 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 and its limitations in measurement and modeling. For more detailed information on this, readers could refer to Smith et al. (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 or regions by contacting the data owners or by extracting infiltration data from published literature (Fig. 1). 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 Soil Water Infiltration Global (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 and method used), soil properties, land use, topography, geographical coordinates of the sites, and any other relevant information to interpret the data and to increase the value of the database. Infiltration data reported in the 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.

2.2 Data digitization

In order to digitize infiltration curves reported in the 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 and 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 (Rahmati et al., 2018) . The first dataset, named “I_cm”, contains cumulative infiltration data in centimeter

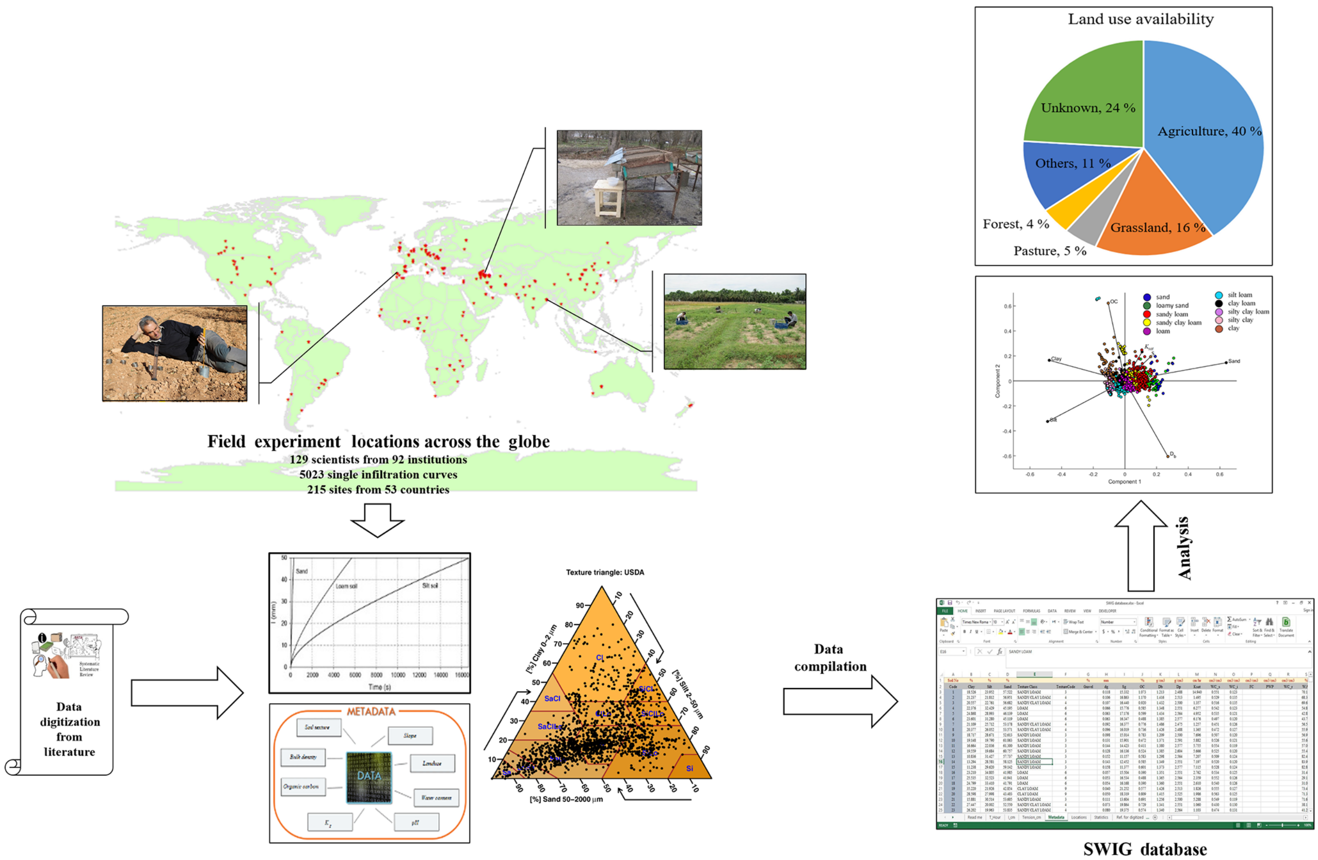

Figure 1. SWIG flowchart.

units and is 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 labeled "Metadata". Additional soil properties were determined by different standards; therefore, data harmonization might be needed for some of those, especially in the 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 the 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, and 1.025 mm, respectively. For the infiltration data, where the soil texture is unknown, d_g and S_g 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 longitude in decimal degree (dd.dd) format. Table 2 is also provided in the SWIG database in two other worksheets named "Ref. for digitized data" and "Ref. for data provided by owner".

Table 1. References used to extract infiltration curves and metadata.

Number	Dataset		Reference	Number	Dataset		Reference
	From	To			From	To	
1	295	317	Miller et al. (2005)	38	4612	–	Wang et al. (2016)
2	318	322	Adindu Ruth et al. (2014)	39	4613	4615	Qian et al. (2014)
3	542	544	Alagna et al. (2016)	40	4617	4619	Fan et al. (2013)
4	545	–	Angulo-Jaramillo et al. (2000)	41	4620	–	Zhang et al. (2000)
5	546	548	Su et al. (2016)	42	4621	4623	Wang et al. (2015a)
6	549	550	Quadri et al. (1994)	43	4624	4633	Yang and Zhang (2011)
7	551	553	Qi and Liu (2014)	44	4634	4657	Wu et al. (2016)
8	554	558	Huang et al. (2015)	45	4658	4663	Ma et al. (2017)
9	559	568	Al-Kayssi and Mustafa (2016)	46	4664	4681	Thierfelder et al. (2003)
10	1421	1432	Bhardwaj and Singh (1992)	47	4682	4683	Commandeur et al. (1994)
11	1433	1435	Berglund et al. (1980)	48	4684	4686	Di Prima et al. (2016)
12	1436	1443	Wu et al. (2016)	49	4687	4688	Angulo-Jaramillo et al. (2000)
13	1444	1446	Chartier et al. (2011)	50	4689	4691	Machiwal et al. (2006)
14	1447	1456	Sihag et al. (2017)	51	4692	–	Ayu et al. (2013)
15	1457	1460	Machiwal et al. (2006)	52	4693	4699	Rei et al. (2016)
16	1461	1466	Igbadun et al. (2016)	53	4700	4702	Omuto et al. (2006)
17	1467	1469	Mohanty et al. (1994)	54	4703	4706	Návar and Synnott (2000)
18	1470	1472	Sauwa et al. (2013)	55	4707	–	Scotter et al. (1988)
19	1473	1476	Arshad et al. (2015)	56	4708	4720	Khan and Strosser (1998)
20	1477	1488	Bhawan (1997)	57	4721	4724	Lipiec et al. (2006)
21	1489	1495	Uloma et al. (2013)	58	4725	–	Suzuki (2013)
22	1496	–	Al-Azawi (1985)	59	4726	4728	Sukhanovskij et al. (2015)
23	1497	1499	Ogbe et al. (2011)	60	4729	4749	Al-Ghazal (2002)
24	1500	1507	Teague (2010)	61	4750	–	Sorman et al. (1995)
25	4506	4515	Askari et al. (2008)	62	4751	4764	Bowyer-Bower (1993)
26	4516	–	Delage et al. (2016)	63	4765	4788	Medinski et al. (2009)
27	4517	4518	Ruprecht and Schofield (1993)	64	4789	4792	Latorre et al. (2015)
28	4519	4520	Bertol et al. (2015)	65	4793	4795	Biro et al. (2010)
29	4521	4523	Naeth et al. (1991)	66	4796	4799	Mohammed et al. (2007)
30	4524	4529	Huang et al. (2011)	67	4800	4815	Abdallah et al. (2016)
31	4530	4537	van der Kamp et al. (2003)	68	4816	4819	Murray and Buttle (2005)
32	4538	–	Jačka et al. (2016)	69	4820	4831	Zhang et al. (2015)
33	4539	4568	Matula (2003)	70	4832	4837	Perkins and McDaniel (2005)
34	4569	4586	Casanova (1998)	71	4838	4841	Arriaga et al. (2010)
35	4587	4593	Holzapfel et al. (1988)	72	4842	4857	Thierfelder et al. (2017)
36	4594	4605	Wang et al. (2015b)	73	4858	4867	Thierfelder and Wall (2009)
37	4606	4611	Mao et al. (2016)	74	4868	4879	Abagale et al. (2012)

3 Results and discussion

3.1 Spatial and temporal data coverage

The SWIG database (Rahmati et al., 2018) 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 Saharan countries is also notable, as well as the small number of infiltration data from Australia. Figure 3 shows the number of samples by climatic zone (Rubel et al., 2017; Kottek et al., 2006). The majority of the data are 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. Figures 4 and 5 show the frequency of experimental sites, respectively, by the World Reference Base (WRB) (IUSS, 2006) and USDA soil taxonomy systems (USDA, 2014) based on the SoilGrids dataset (Hengl et al., 2017). Regarding the WRB classification sys-

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

Number	Dataset		Contact person	Email for contact	Reference
	From	To			
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@gmail.com	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, 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, b)
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
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) and 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 the database.

Column	Supplies	Dimension
Code	Dataset 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	%
d_g	Geometric mean diameter	mm
S_g	Standard deviation of soil particle diameter	
OC	Soil organic carbon content	%
D_b	Soil bulk density	$g\,cm^{-3}$
D_p	Soil particle density	$g\,cm^{-3}$
K_{sat}	Soil saturated hydraulic conductivity	$cm\,h^{-1}$
θ_{sat}	Saturated volumetric soil water content	$cm^3\,cm^{-3}$
θ_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)	$cm^3\,cm^{-3}$
θ_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.	

tem (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 %). A total of 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.

3.2 Analysis of the database using soil properties

Textural information (clay, silt, and sand content) is 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 the SWIG database 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 not usually considered by infiltration studies, such as soils with extremely high stone

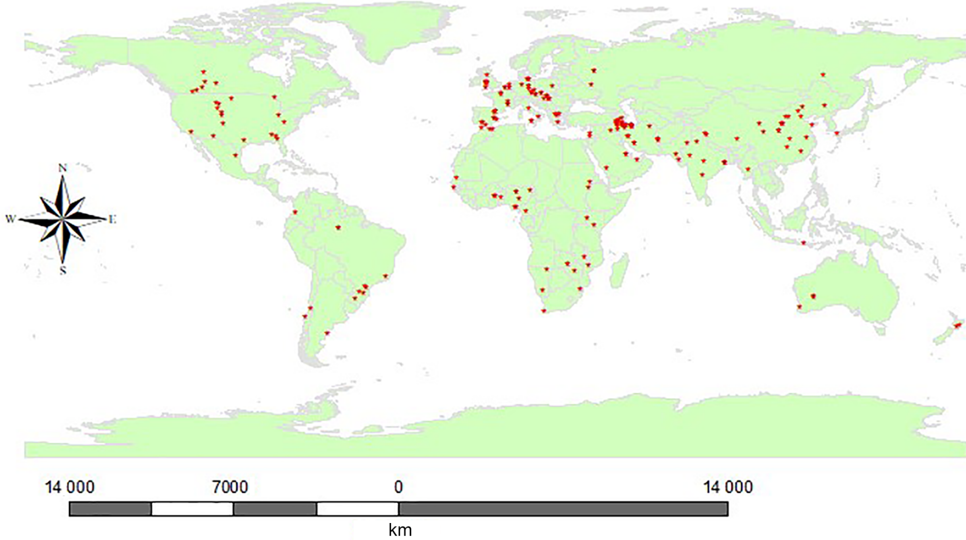

Figure 2. Global distribution of infiltration measuring sites that were included in the database.

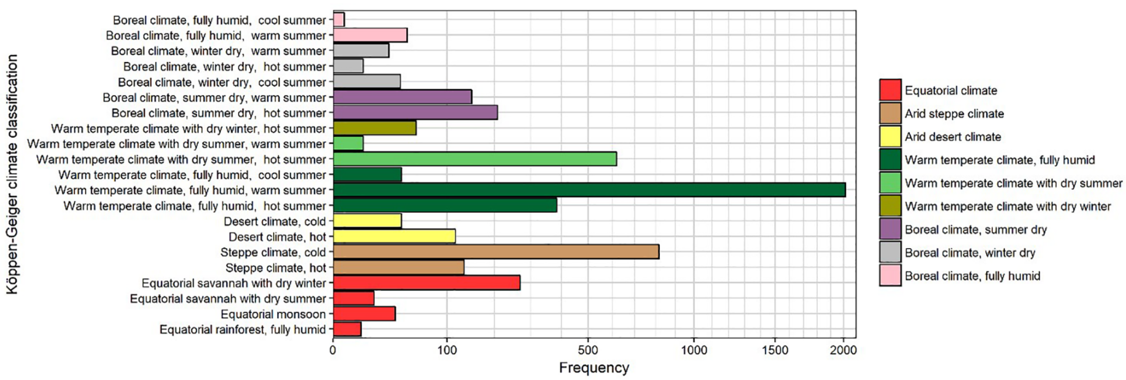

Figure 3. Number of samples by Köppen–Geiger climatic zones (Rubel et al., 2017; Kottek et al., 2006).

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 the SWIG database 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 %.

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).

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; Wa-

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

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

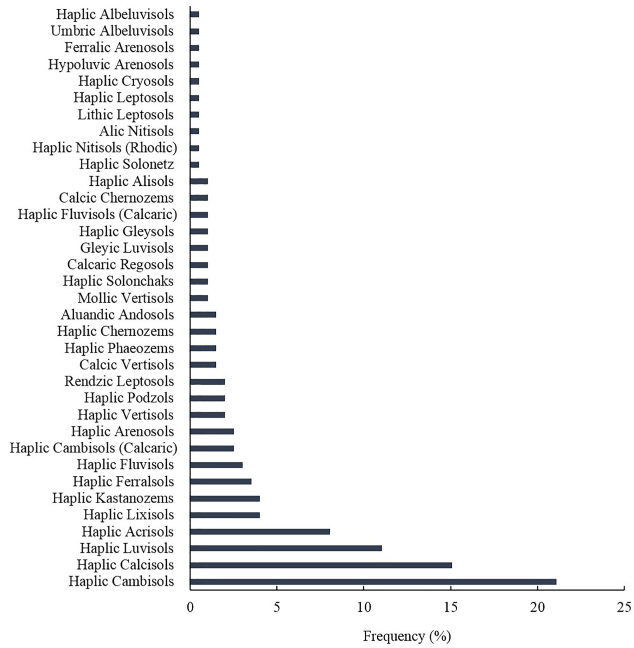

Figure 4. Frequency of WRB reference soil subgroups in experimental sites derived from SoilGrids (Hengl et al., 2017).

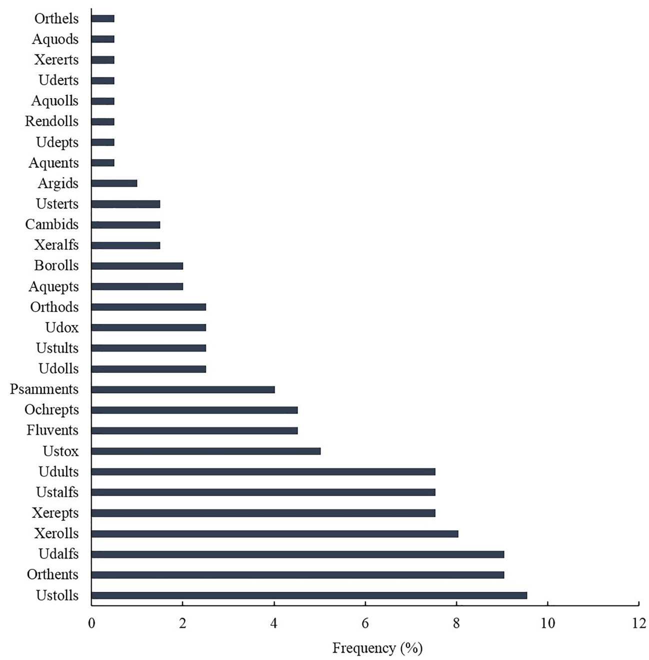

Figure 5. Frequency of USDA soil suborders in experimental sites derived from SoilGrids (Hengl et al., 2017).

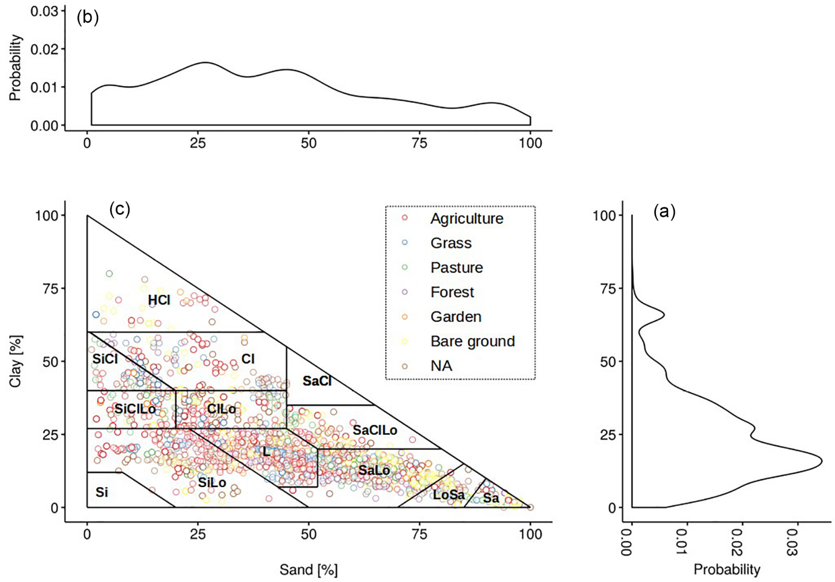

Figure 6. Textural distribution of soils **(c)** and probability density functions of clay **(a)** and sand **(b)** particles (plotted on the USDA textural triangle) for which infiltration data are included in the database. Dots are colored according to their corresponding land use. HCl: highly clayey; 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.

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 type.

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
Savannah	41	Salt-marsh soil	3
Abandoned farms	39	Afforestation	2
Idle	32	Campus	2
Shrub	30	Residential	2
Available	3818	Unknown	1205

terloo 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 the third- and fourth-largest reported land use types. The 18 remaining land use types all together cover only 545 experimental sites (less than 15 %).

3.5 Estimating infiltration parameters from infiltration measurements

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

$$I_{\text{1-D}} = S\,t^{\frac{1}{2}} + A_1 t + A_2 t^{\frac{3}{2}}, \tag{6}$$

$$I_{\text{3-D}} = S\sqrt{t} + \left[\frac{2-\beta}{3}K_{\text{sat}} + \frac{\gamma S^2}{R_{\text{D}}\left(\theta_{\text{s}}-\theta_{\text{i}}\right)}\right]t. \tag{7}$$

We reduced the number of parameters in Eq. (6) by defining $A_1 = 0.33 \times K_{\text{sat}}$ (Philip, 1957) and $A_2 = A$ where A was assumed to be a constant. In Eq. (7), we put $\beta = 0.6$ (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:

$$I_{\text{1-D}} = S\,t^{\frac{1}{2}} + 0.33 K_{\text{sat}} t + A\,t^{\frac{3}{2}}, \tag{8}$$

$$I_{\text{3-D}} = S\sqrt{t} + 0.47 K_{\text{sat}} t + A\,t. \tag{9}$$

In our analysis, we assumed that double-ring infiltrometer measurements result in 1-D infiltration conditions, while the different types of disc infiltration and single-ring infiltrometer measurements lead to 3-D flow conditions that can be captured by Eq. (9). As 1-D or 3-D infiltration conditions are not guaranteed for measurements made with rainfall simulators, Guelph permeameters, Aardvark permeameters, linear and point source methods, and 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 Eqs. (8) and (9). In addition, 251 infiltration curves were also excluded from the fitting to Eqs. (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 1-D and 3350 were considered as the results of 3-D infiltration. As no sufficient information was available on the properties of the sand contact layer, we did not correct 3-D 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 3-D 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 labeled "Statistics". For infiltration curves excluded from the analysis, an empty cell is reported.

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, are 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 ($K_{sat\text{-}es}$) and measured ($K_{sat\text{-}m}$) values of K_{sat} (Table 10) reveals that there is reasonably good agreement between measurements and estimation, except for loamy sand (with mean $K_{sat\text{-}es} = 62\,cm\,h^{-1}$ vs. $K_{sat\text{-}m} = 25\,cm\,h^{-1}$), sandy loam (with mean $K_{sat\text{-}es} = 32\,cm\,h^{-1}$ vs. $K_{sat\text{-}m} = 41\,cm\,h^{-1}$), silt loam (with mean $K_{sat\text{-}es} = 27\,cm\,h^{-1}$ vs. $K_{sat\text{-}m} = 3\,cm\,h^{-1}$), and silty clay (with mean $K_{sat\text{-}es} = 26\,cm\,h^{-1}$ vs. $K_{sat\text{-}m} = 45\,cm\,h^{-1}$) 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 K_{sat} values is confirmed by comparing the order of magnitude of the difference between these values, and those tabulated in previous studies, for the various different soil classes. Some of these databases like that 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 soils 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 the 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 datasets 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 and crusting may, in fact, be much more important.

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 pedotransfer 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 of the strength of the correlation. Arrows that are aligned 90° to each other show typically no correlation. Figures 7 and 8 show the results of two PCAs. 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 to only be weakly correlated with K_{sat} and S as is also shown by the correlation coefficients of 0.112 and 0.025, respectively. Figure 8 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 informa-

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	SD	Mean	Min	Max	SD		
1-D	828	0.985	0.529	1	0.049	0.900	1.3×10^{-4}	69.30	3.31	801	640
3-D	3350	0.975	0.032	1	0.066	0.449	5.5×10^{-12}	98.95	2.95	3136	2276
All	4178	0.977	0.032	1	0.063	0.538	5.5×10^{-12}	98.95	3.03	3937	2916

SD: 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[a]	S (cm h$^{-0.5}$)			K_{sat} (cm h^{-1})			n[a]	K_{sat} (cm h^{-1})			df	t value
		Mean	Median	SD	Mean	Median	SD		Mean	Median	SD		
Sand	291	2.3	0.26	4.3	42.2	15	134.5	229	43.6	24	149	518	0.10[b]
Loamy sand	92	10.6	5.7	17.5	61.4	10	173.2	63	24.6	8.2	72	153	1.59[b]
Sandy loam	500	9.2	2.95	15.7	32	3.1	94.5	424	41.2	5.7	166	922	1.05[b]
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[c]
Loam	583	7.9	2.4	12.9	7.8	0.28	26.7	270	4.9	1.18	13.7	851	1.69[b]
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[b]
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[b]
Clay loam	467	6.8	2.1	13.6	8.3	2.3	20	166	7.6	2.97	21.3	631	0.38[b]
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[b]
Clay	333	14.6	1.7	39.5	354.3	1.3	1268.5	79	148.8	2.94	458.4	410	1.42[b]
Silt	–	–	–	–	–	–	–	–	–	–	–	–	–
Total	4179	8.5	2.6	18.2	46	1.8	374.8	1895	41	3.4	174	–	–

[a] The number soils included in calculation. [b]ns: insignificant; [c]**: significant at 1 % probability level. SD: standard deviation.

tion 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 11 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}.

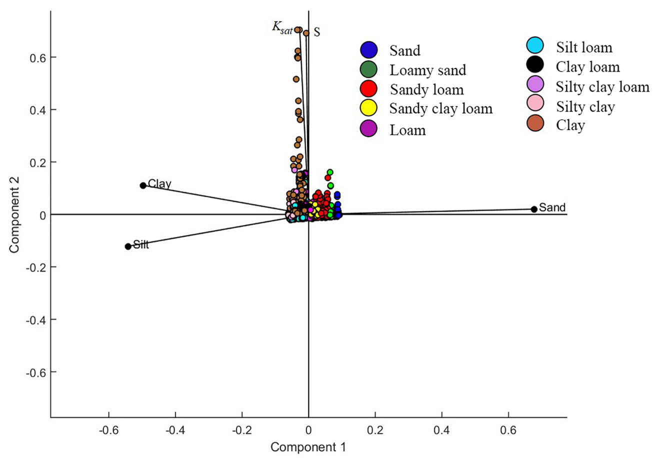

Figure 7. The relationships between clay, silt, sand contents and estimated hydraulic parameters (S and K_{sat}).

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

Texture class	Data source	Clapp and Hornberger (1978)	Rosetta3	Cosby et al. (1984)	Rawls database	Ahuja database	UNSODA database	US soils K_{sat} data	EU-HYDI database
			(Zhang and Schaap, 2017)		(Schaap and Leij, 1998)			(Pachepsky and Park, 2015)	(Weynants et al., 2013)
		K_{sat} (cm min^{-1})	$\log K_{sat}$ (SD) ($\log_{10}$ cm day^{-1})	$\log K_{sat}$ (SD) ($\log_{10}$ in h^{-1})	$\log K_{sat}$ (SD) ($\log_{10}$ cm day^{-1})	$\log K_{sat}$ (SD) ($\log_{10}$ cm day^{-1})	$\log K_{sat}$ (SD) ($\log_{10}$ cm day^{-1})	$\log K_{sat}$ (SD) ($\log_{10}$ cm h^{-1})	$\log K_{sat}$ (SD) ($\log_{10}$ 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	–	–/– (–)	–/–	–/– (–)	–/– (–)	–/– (–)	–/– (–)	–/– (–)

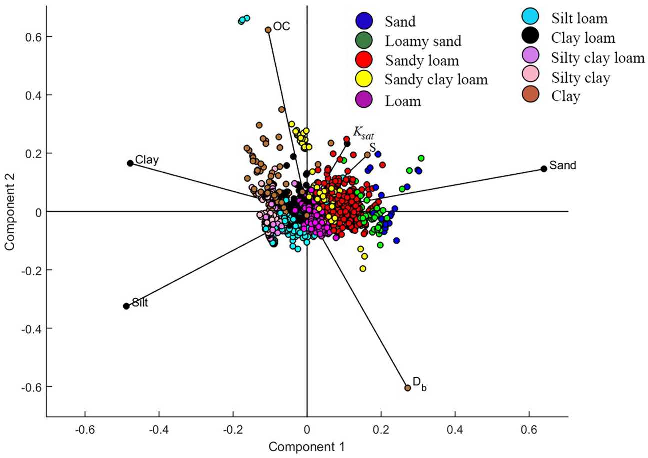

Figure 8. The relationships between clay, silt, sand contents, D_b, and OC and estimated hydraulic parameters (S and K_{sat}).

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 the 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 Supplement. 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, for example, the work of Pachepsky on the scaling of saturated hydraulic conductivity).

Careful interpretation of the data, with respect to the details of the experimental and soil conditions, is also required when utilizing the SWIG database. 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 the SWIG database). 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 an 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, which is 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 the SWIG database 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 pedotransfer functions 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 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 the SWIG database and thus made available to the worldwide 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/, last access: 1 July 2018), for further archiving in the SWIG database.

4 Data availability

All collected data and related soil characteristics are provided online in *.xlsx and *.csv formats for reference and are available at https://doi.org/10.1594/PANGAEA.885492 (Rahmati et al., 2018). We add a disclaimer that the database is for public domain use only and can be copied freely by referencing it.

5 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 the 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 worldwide. 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.

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Author contributions. The idea of globally collecting soil infiltration data was put forward by MR and HV. Published data from literature were digitized by MR, LW, NM, and MK. Data contributors are MR, YAP, LM, SHS, HK, ZH, WAY, AAA, MZA, RAJ, ACDA, GA, RAA, HA, YB, JBA, BB, FB, GB, KB, IB, CC, AC, MC, RC, MC, BC, YC, WC, CC, APC, MBdO, JRdM, MFD, HE, IE, AF, AF, NF, MG, MHG, TAG, SG, EGH, RH, JJJ, DJ, SDK, HK, MKH, MKJ, LL, XL, MAL, LL, MVL, DM, DM, MSM, JDdOM, MRM, JM, FM, MHM, BPM, MPM, SM, RM, DMF, AAM, MRM, SBM, HM, KN, MRN, MVO, TBOF, MRPR, AP, SP, PEP, TP, MP, DJR, SR, MR, FPR, DR, JRC, OCRF, TS, HS, CS, RS, BS, MS, NS, ESM, MS, SS, RS, AAS, PS, ZS, RTM, ET, WGT, ARV, MV, TV, IV, JV, SW, TW, DY, MHY, SZ, YZe, YZh, and HZ. The data were collected by MR, HV, LW, and KVL. The data analysis was conceived, designed, and performed by MR, HV, LW, JV, SHS, CM, KVL, BT, FM, and RTM. The article was written by MR, HV, LW, LM, and HK. The article was actively revised several times by MR, LW, HV, YAP, MHY, SHS, MS, JP, ZH, AC, YC, LL, FM, RM, DMF, RS, WGT, HA, NS, RAA, IB, FPR, and SR. All authors checked the accuracy and/or commented on the contents of the paper.

Competing interests. The authors declare that they have no conflict of interest.

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