README

***** Quantitative visual soil examination to evaluate soil functions on dairy farms *****

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*** General introduction and terms of use ***

This dataset contains data belonging to the manuscript ‘Quantitative visual soil examination to evaluate soil functions on dairy farms’.

Data is being made public as supplementary data for the manuscript (Van Leeuwen et al., in review), and to be used by others for further research.

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*** Purpose of the data collection ***

The data were collected to evaluate whether quantitative visual observations (as part of Visual Soil Evaluation) can be used to assess soil functions that determine the soil quality.

*** Methodological information ***

Quantitative visual observations were collected at five dairy farms in the Netherlands (that participated in the ongoing project 'Koeien & Kansen'), on 25 sampling sites in total. Sampling period: 12 September 2016 - 5 October 2016. For the same sites, soil moisture retention characteristics were determined in the laboratory using Wind's evaporation method. Obtained data were further processed using the Hydrus1D software package, to obtain soil hydraulic functions. The ecohydrological model SWAP (Soil-Water-Atmosphere-Plant) was used to quantify soil function indicators for crop production (plant available water, yield gap, oxygen and drought stress for a wet year (2001), a dry year (2003), and a 'normal' year (2016)) and storing, filtering, and transforming nutrients and water (water storage capacity). For more information about soil sampling, laboratory measurements, fitted parameters and model settings, please refer to Van Leeuwen et al., in review.

*** Description of the data in this data set ***

Value '-999' means that data were not collected.

Column headers			**Measurement unit**	**Explanation**
		Farm	n/a	Identifier of the dairy farms. For locations of the farms: see Section 2.2 in Van Leeuwen et al., in review.
		Field	n/a	Identifier of sampled locations. For locations of the fields: see study area in Van Leeuwen et al., in review.
		X	m	X coordinate of the sampled location (coordinate system: RD_new).
		Y	m	Y coordinate of the sampled location (coordinate system: RD_new).
		Crop	n/a	Grass or maize (assessed during fieldwork, 12 September 2016 - 5 October 2016). **NOTE:** In SWAP, all maize fields were modelled as grass (Van Leeuwen et al., in review).
SWAP input: LAYER 1			n/a	Two or three soil layers were specified in SWAP. Layer 1 is topsoil.
SWAP input:		**Thickness1**	cm	Layer 1 is topsoil. Thickness of the first soil layer.
	Laboratory measured		n/a	

LAYER 1	**Laboratory measured**	**Qs**	$cm^3\ cm^{-3}$	Saturated water content.
		Ksat_measured	$cm\ d^{-1}$	Saturated hydraulic conductivity
	Hydrus outputs: Fitted Water Flow Parameters		n/a	Hydrus1D software package was used to obtain the Fitted Water Flow Parameters for the measured core samples, sampling depth: 10-20 cm. **Note:** For Farm 5, Field 2, the estimated Ksat was initially very low (0.56 $cm\ d^{-1}$). We replaced those estimated Hydrus parameters by those of light textured clay (obtained from the Staring Series class B10, Wösten et al., 2013), to have more realistic values for the texture of this site.
	Hydrus outputs: Fitted Water Flow Parameters	**Qr**	$cm^3\ cm^{-3}$	Residual water content.
		Alfa	cm^{-1}	Empirical shape factor
		Npar	[-]	Empirical shape factor
		Ksat	$cm\ d^{-1}$	Saturated hydraulic conductivity
		Lexp	[-]	Shape parameter set by default to 0.5.
	Measured by Koeien&Kansen (2012)		n/a	Soil texture (below) was obtained from the project 'Cows and Opportunities'. For Farm 1 Field 1, and Farm 3 Field 1, texture was measured from the sampled soil cores of 2016, between 10-20 cm depth.
	Measured by Koeien&Kansen (2012)	**Depth**	cm below surface	Sampling depth, starting from the surface (0 cm). **Note:** for Farm 1 Field 1, and Farm 3 Field 1, texture was measured between 10-20 cm depth; in the dataset the depth is therefore set at 20 cm.
		PSAND	Fraction	Fraction sand, silt or clay, measured from composite sample from the entire field where the site was located, sampled at 0-10 or 0-25 cm depths. **Note**: for Farm 1 Field 1, and Farm 3 Field 1, texture was measured at one location (see X and Y column) instead of using a composite sample, between 10-20 cm depth. All samples were analysed with near infrared spectroscopy in mass % and converted to fraction. Corrected for fraction soil
		PSILT	Fraction	
		PCLAY	Fraction	

				organic matter (column SOM%), so that the fraction sand + silt + clay + SOM = 1
	Measured (2016, 0-20 cm)	**SOM%**	%	Soil organic matter content. Measured in 2016. Measured with composite sample from the entire field where site was located, sampled at 0-20 cm depth, analysed with near infrared spectroscopy.
SWAP input: LAYER 2			n/a	Two or three soil layers were specified in SWAP. Layer 2 is the second layer in specified in SWAP.
SWAP input: LAYER 2		**Thickness2**	cm	Thickness of the second soil layer.
	From Staring Series (Wösten et al., 2013).	**Qr**	$cm^3\ cm^{-3}$	Residual water content.
		Qs	$cm^3\ cm^{-3}$	Saturated water content.
		Alfa	cm^{-1}	Empirical shape factor
		Npar	[-]	Empirical shape factor
		Ksat	$cm\ d^{-1}$	Saturated hydraulic conductivity
		Lexp	[-]	Shape parameter.
	Soil profile visual observations		n/a	Soil texture was estimated in the field up to a depth of 120 cm, using the texture triangle of FAO (2006). The most representative texture below the topsoil up to a depth of 120 cm was used for the second layer in SWAP.
	Soil profile visual observations	**Sand**	%	Visually and tactically estimated sand mass fraction, including gravel.
		Silt	%	Visually and tactically estimated sand mass fraction.
		Clay	%	Visually and tactically estimated sand mass fraction.
SWAP input: LAYER 3				Only for two sites (Farm 2, Field 3 and 4) a third layer was specified in SWAP, as for these sites ice pushed sediments were found that had a low permeability.
SWAP input: LAYER 3		**Thickness3**	cm	Thickness of the third soil layer.
	From Staring Series (Wösten et al., 2013).		n/a	
	From Staring Series (Wösten	**Qr**	$cm^3\ cm^{-3}$	Residual water content.
		Qs	$cm^3\ cm^{-3}$	Saturated water content.

	et al., 2013).	**Alfa**	cm^{-1}	Empirical shape factor
		Npar	[-]	Empirical shape factor
		Ksat	$cm\ d^{-1}$	Saturated hydraulic conductivity
		Lexp	[-]	Shape parameter.
	Soil profile estimations		n/a	Estimated soil texture.
	Soil profile estimations	**Sand (%)**	%	Estimated mass sand fraction, including gravel.
		Silt (%)	%	Estimated mass sand fraction.
		Clay (%)	%	Estimated mass sand fraction.
Soil function indicators			n/a	Soil function indicators for crop production, and storing, filtering and transforming water and nutrients.
Soil function indicators	**SWAP outputs**		n/a	SWAP outputs focus on grass production. **NOTE:** In SWAP, all maize fields were modelled as grass.
	SWAP outputs	**Ygap16**	Fraction of potential yield.	Modelled yield gap for the year 2016. Fraction is calculated as actual yield / potential yield.
		Ygap01	Fraction of potential yield.	Modelled yield gap for the year 2001. Fraction is calculated as actual yield / potential yield.
		Ygap03	Fraction of potential yield.	Modelled yield gap for the year 2003. Fraction is calculated as actual yield / potential yield.
		Yact16	kg dry matter $ha^{-1}\ y^{-1}$	Modelled actual yield in 2016.
		Yact01	kg dry matter $ha^{-1}\ y^{-1}$	Modelled actual yield in 2001.
		Yact03	kg dry matter $ha^{-1}\ y^{-1}$	Modelled actual yield in 2003.
		rStr_w16	Fraction of potential transpiration	Relative plant oxygen stress (too wet conditions) was simulated as reduced transpiration rate (potential transpiration – actual transpiration), as fraction of potential transpiration. Year 2016.
		rStr_d16	Fraction of potential	Relative plant drought stress (too dry conditions) was simulated as reduced transpiration rate (potential

			transpiration	transpiration – actual transpiration), as fraction of potential transpiration. Year 2016.
		rStr_w01	Fraction of potential transpiration	Relative plant oxygen stress (too wet conditions) was simulated as reduced transpiration rate (potential transpiration – actual transpiration), as fraction of potential transpiration. Year 2001.
		rStr_d01	Fraction of potential transpiration	Relative plant drought stress (too dry conditions) was simulated as reduced transpiration rate (potential transpiration – actual transpiration), as fraction of potential transpiration. Year 2001.
		rStr_w03	Fraction of potential Transpiration	Relative plant oxygen stress (too wet conditions) was simulated as reduced transpiration rate (potential transpiration – actual transpiration), as fraction of potential transpiration. Year 2003.
		rStr_d03	Fraction of potential transpiration	Relative plant drought stress (too dry conditions) was simulated as reduced transpiration rate (potential transpiration – actual transpiration), as fraction of potential transpiration. Year 2003.
	Water retention characteristics		n/a	Water retention characteristics were determined with laboratory evaporation experiments and Hydrus1D.
	Water retention characteristics	**PAW**	cm^3 cm^{-3}	Plant available water between field capacity (pF = 2.0 or h = -100 hPa) and wilting point (pF = 4.2 or h =-15000 hPa).
		WSC	cm^3 cm^{-3}	Water storage capacity between saturation (pF = 0 or h = 0 hPa) and field capacity (pF = 2.0 or h = -100 hPa).
Visual soil observations			n/a	
Visual soil observations		**length**	cm	Length (cm) of one of the sides of the excavated topsoil block. The topsoil block was used for visual soil quality observations.
		width	cm	Width (cm) of one of the sides of the excavated topsoil block. The topsoil block was used for visual soil quality observations.
		height	cm	Height (cm) of one of the sides of the excavated topsoil

			block. The topsoil block was used for visual soil quality observations.
	Grass	%	Grass cover on surface: % covered with grass in 1 m^2 around the place to be sampled – before extracting a soil block.
	Biopores	Count per 20x20 cm	Number of biopores (often earthworm burrows) >2mm, on a surface area of 20x20 cm, approximately at 20 cm depth (bottom of soil block).
	Biopores_corr	Count per 20x20 cm	Number of biopores (often earthworm burrows) >2mm, on a surface area of 20x20 cm, approximately at 20 cm depth (bottom of soil block). Number was corrected when soil surface was not exactly 20x20 cm, using the actual size of the block length and width (see column ‘length’ and ‘width’).
	Roots	Count per 10x10 cm	Number of roots on a surface area of 10x10 cm, at 20 cm depth (bottom of soil block).
	Col_Hue	n/a	Munsell soil colour Hue at 20 cm depth (bottom of the soil block), of moist soil. Hue refers to the used soil colour card of the Munsell soil colour charts.
	Col_Val	n/a	Munsell soil colour Value at 20 cm depth (bottom of the soil block), of moist soil. 'Value' indicates the darkness of the soil and is assessed with Munsell soil colour charts.
	Col_chr	n/a	Munsell soil colour Chroma at 20 cm depth (bottom of the soil block), of moist soil. 'Chroma' indicates the colour of the soil and is assessed with Munsell soil colour charts.
	Gley	%	Percentage of gley mottles (spots of iron oxides) covering the surface, approximately at 20 cm depth (bottom of soil block).
	Struc_sc	Score	Overall shape of soil structure in the 10-20 cm layer. Score 2= good condition: granular shape. 1=moderate condition: subangular shape. 0=poor condition: angular shape. See also Shepherd (2009). The 10-20 cm layer of the soil block is gently crumbled by hand following natural cracks, before soil structure is assessed.

	Struc_percent	%	The percentage (%) of largest soil structural elements. Obtained from the crumbled 10-20 cm layer of the soil block. Soil structural elements are ordered based on their size, on a plastic bag, before assessment.
	Struc_sizeL	cm	The mean **size** (cm) of the **largest** soil structural elements in the 10-20 cm layer. The 10-20 cm layer of the soil block is gently crumbled by hand following natural cracks, and structural elements are ordered based on their size before soil structure is assessed.
	Struc_shpL	Score	Overall **shape** of the **largest** soil structural elements in the 10-20 cm layer. Score 2= good condition: granular shape. 1=moderate condition: subangular shape. 0=poor condition: angular shape. See also Shepherd (2009). The 10-20 cm layer of the soil block is gently crumbled by hand following natural cracks, and structural elements are ordered based on their size before soil structure is assessed.
	Struc_sizeS	cm	The mean **size** (cm) of the **smallest** soil structural elements in the 10-20 cm layer. The 10-20 cm layer of the soil block is gently crumbled by hand following natural cracks, and structural elements are ordered based on their size before soil structure is assessed.
	Struc_shpS	Score	Overall **shape** of the **smallest** soil structural elements in the 10-20 cm layer. Score 2= good condition: granular shape. 1=moderate condition: subangular shape. 0=poor condition: angular shape. See also Shepherd (2009). The 10-20 cm layer of the soil block is gently crumbled by hand following natural cracks, and structural elements are ordered based on their size before soil structure is assessed.
	Worms	Count in 20x20x20 cm	Total number of earthworms in soil block of 20x20x20 cm.
	Worms_corr	Count in 20x20x20 cm	Total number of earthworms in soil block of 20x20x20 cm, corrected for volume when soil block volume was deviating.

	Epigeic	Count in 20x20x20 cm	Number of epigeic earthworms in soil block of 20x20x20 cm.
	Endogeic	Count in 20x20x20 cm	Number of endogeic earthworms in soil block of 20x20x20 cm.
	Anecic	Count in 20x20x20 cm	Number of anecic earthworms in soil block of 20x20x20 cm.
	Comp_d	cm below surface	Soil compaction depth, cm below surface. See also Shepherd (2009).
	Comp_sc	Score	Soil compaction score/degree: 2: no compaction, 1: moderate compaction, 0: strong compaction. See also Shepherd (2009).
	Root_d	cm below surface	Root depth of approximately 85% of all roots, which is visible as the depth of the bulk of the roots. Assessed on one of the sides of the soil pit.
	Ahor	cm below surface	Depth of topsoil horizon where organic matter is accumulated.
	MHG	cm below surface	Mean highest groundwater table. From augered soil profile, the shallowest depth is assessed where gley mottles appear.
	MaxRoot	cm below surface	From augered soil profile, the maximum root depth is assessed. **NOTE:** if roots were still visible in the deepest augered core (120 cm below surface), then depth was set to 150 cm.
	TextClass	n/a	Soil texture class observation in the topsoil horizon, according to FAO (2006): SCL: Sandy clay loam SC: Sandy clay SiC: Silty clay C: Clay VFS: Very fine sand FS: Fine sand CS: Coarse sand LVFS: Loamy very fine sand

*** References ***

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