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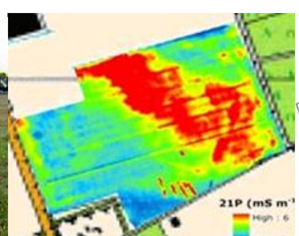
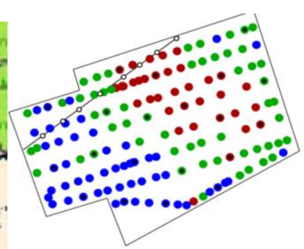
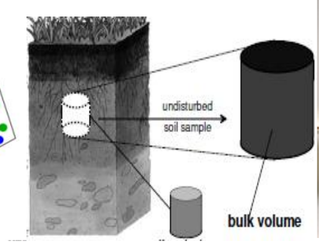
Islamic Republic of Iran
Ministry of Science, Research and Technology

UNIVERSITEIT GENT

Estimation of the spatial distribution of soil hydraulic characteristics using apparent soil electrical conductivity as proxy data

By: **Meisam Rezaei**

Co -authors: Piet Seuntjens, Ingeborg Joris, Wesley Boënne, Wim Cornelis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❖ Introduction

- what are the purposes of up-scaling soil hydraulic properties?

Accurate digital mapping (soil water holding capacity, ET mapping…)
To predict and understand flow, solute and energy fluxes
water balance study and precision irrigation

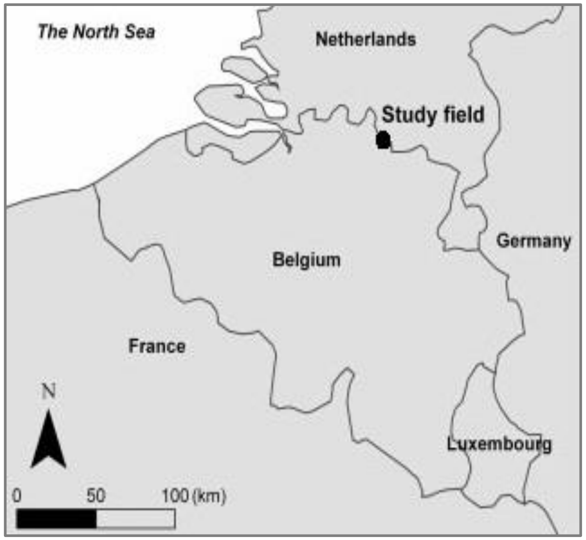
- Why using ECa, as proxy data to predict hydraulic properties?

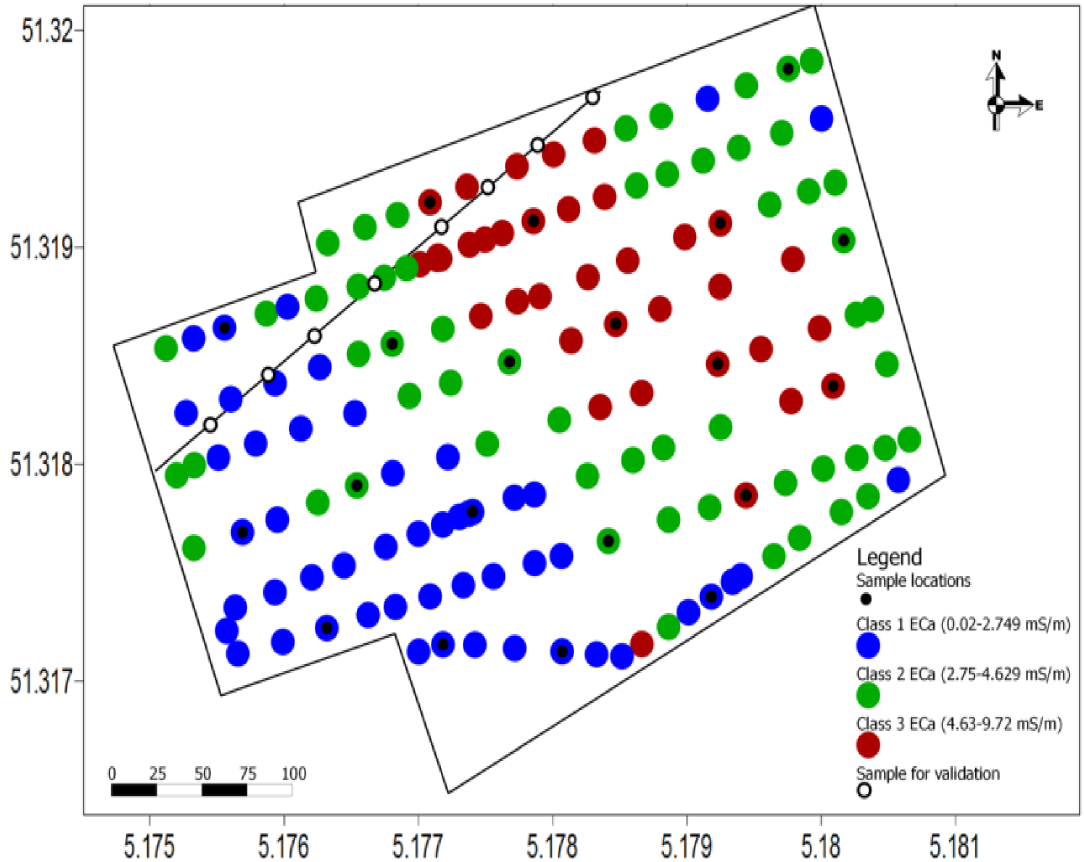
❖ Research aim and question

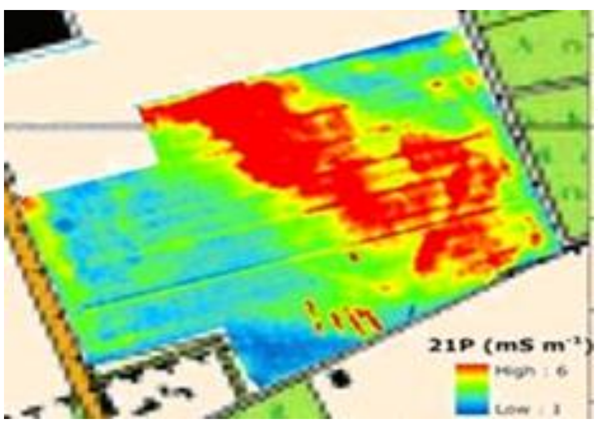
1. To evaluate relationship between soil hydraulic properties and ECa at the field scale.

2. To investigate how empirical-theoretical relationships of the field ECa, Ks and SWR data could be applied to predict Ks and SWR data and parameters.

❖ Field site location and methods







- **ECa data:** **(DOE: 0-50 and 0-100 cm)**

  DUALEM-21S 2011

  EM38 2013

- **Soil sampling strategy** (Fuzzme(Minasny and McBratney 2002), ESAP (Lesch 2006))
- **soil samples analysis** (Ks, pF, texture, ECsat)

❖ Theory

The VGM model (van Genuchten (1980) and Mualem (1976)):

$$S_e = \frac{\theta - \theta_r}{\theta_s - \theta_r} \qquad (1)$$

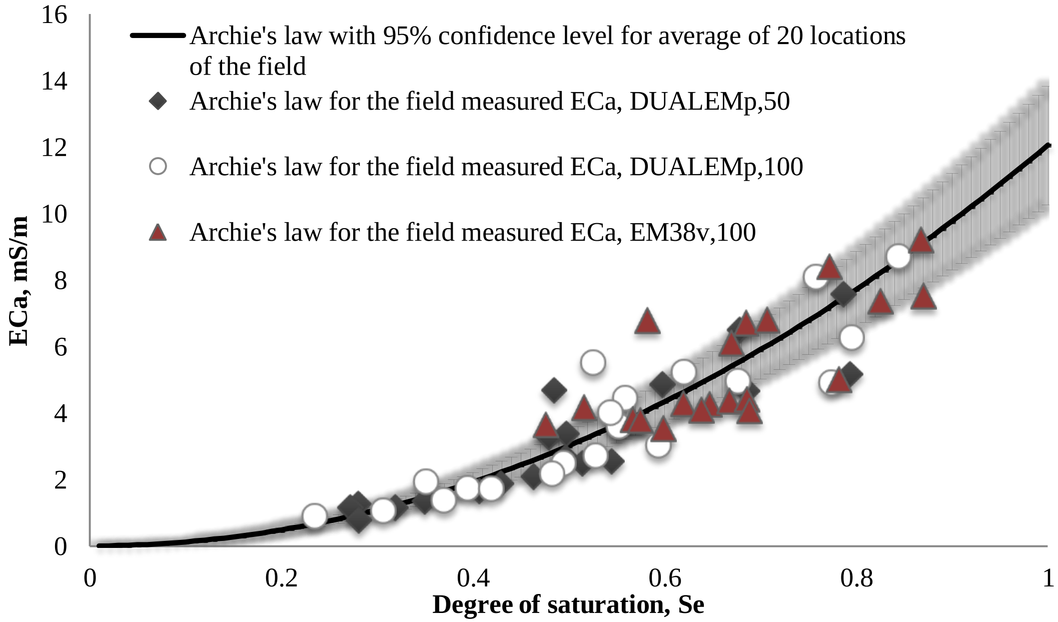
$$S_e(h) = (1 + |\alpha h|^n)^{-m} \qquad h < 0;\ \ where\ m = 1 - \frac{1}{n} \qquad (2)$$

The empirical Archie's law (1942):

$$\frac{EC_{sat}}{EC_a} = FF = \frac{1}{A}\phi^{-1.5} \qquad (3)$$

$$EC_a = EC_{sat}\,.\,\phi^{1.5}.\,{S_e}^2 \qquad (4)$$

$$S_e = \sqrt{\frac{EC_a}{EC_{sat}\,.\,\phi^{1.5}}}$$



❖ Predictive modelling approaches

i) a simple linear regression approach

ii) a curve fitting approach; Applying combined Archie's law – the MVG equation for saturated to unsaturated conditions.

Eq. 2 and 4 ⇒ $$\mathrm{EC_a(h)} = \mathrm{EC_w} \,.\, \phi^{1.5} .\, (1 + |\alpha h|^{n})^{-2m} \qquad (5)$$

Eq. 1 and 4 ⇒ $$\mathrm{EC_a(h)} = \mathrm{EC_w} \,.\, \phi^{1.5} .\, \left(\frac{\theta(h)-\theta_r}{\theta_s-\theta_r}\right)^{2} \qquad (6)$$

❖ Results and discussion

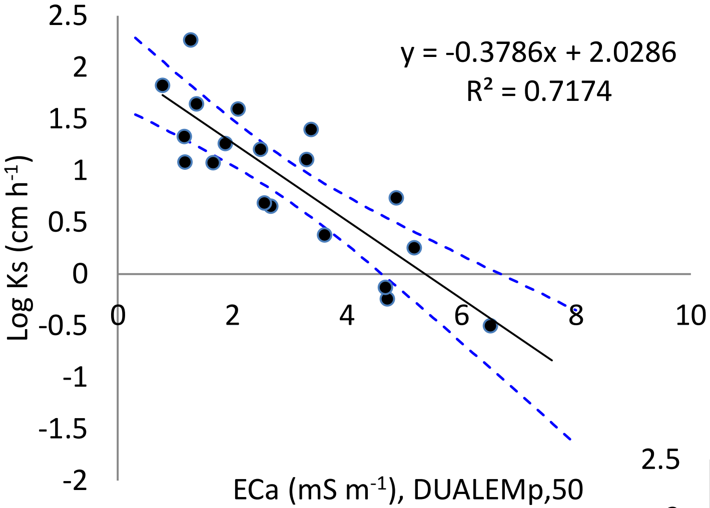
Variable	Mean	Std	CV
$EM38_{v,50}$	9.32	1.08	11.59
$EM38_{v,100}$	5.28	1.65	31.25
$DUALEM_{p,50}$	3.28	1.92	58.54
$DUALEM_{p,100}$	3.95	2.29	57.97
EC_w	49.23	11.36	23.08
Sand (%)	90.92	1.34	1.47
Clay (%)	1.79	0.62	34.64
porosity	0.39	0.02	5.13
Θr	0.0185	0.004	21.62
Θs	0.36	0.01	2.78
K_s	2.99 (3.05)	1.97 (2.34)	65.89 (76.72)
α	0.012	0.004	33.33
n	1.50	0.09	6.00
Se (10 cm)	0.97	0.01	1.03
Se (30 cm)	0.95	0.03	3.16
Se (50 cm)	0.91	0.03	3.30
Se (70 cm)	0.85	0.05	5.88
Se (100 cm)	0.71	0.10	14.08
Se (340 cm)	0.41	0.07	17.07
Se (1020 cm)	0.33	0.06	18.18
Se (1530 0cm)	0.17	0.03	17.65

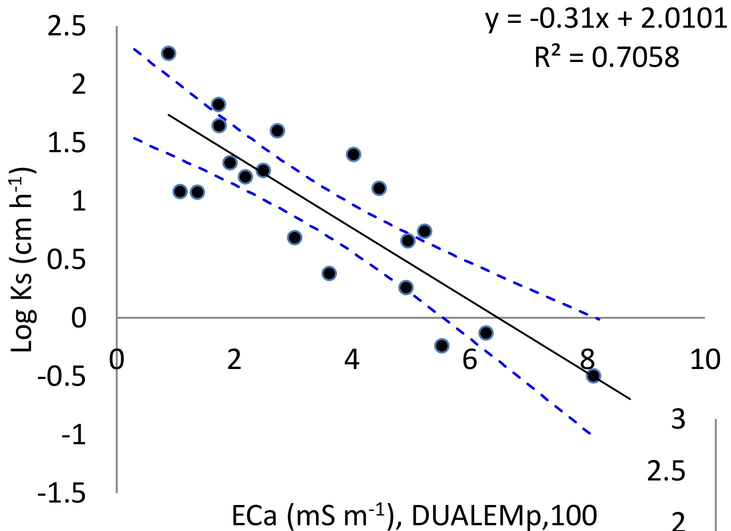
Pearson correlation coefficient for hydraulic parameters and apparent electrical conductivity

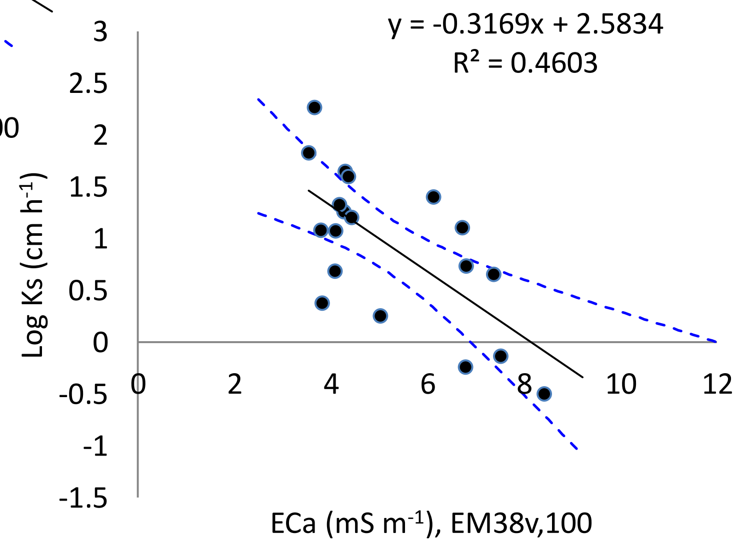
Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 $EM38_{v,50}$	1													
2 $EM38_{v,100}$	0.92**	1												
3 $DUALEM_{p,50}$	0.48**	0.62**	1											
4 $DUALEM_{p,100}$	0.54**	0.67**	0.97**	1										
5 Ks	-0.31	-0.48*	-0.69**	-0.69**	1									
6 α	-0.19	-0.23	-0.01	0.00	0.20	1								
7 n	-0.44*	-0.55**	-0.69**	-0.61**	0.67**	0.14	1							
8 Θr	-0.16	-0.15	-0.08	-0.10	0.35	0.15	-0.10	1						
9 Θs	-0.11	-0.06	-0.21	-0.24	0.29	0.23	0.03	-0.07	1					
10 Porosity	0.10	0.04	-0.14	-0.16	0.25	0.54*	0.07	0.02	0.88**	1				
11 Se (100 cm)	0.44*	0.56*	0.69**	0.64**	-0.82**	-0.77**	-0.75**	0.43*	-0.08	-0.13	1			
12 Se (340 cm)	0.46*	0.61**	0.69**	0.63**	-0.69**	-0.59**	-0.92**	0.40	-0.02	-0.00	0.79**	1		
13 Se (1020 cm)	0.55*	0.65**	0.70**	0.66**	-0.73**	-0.67**	-0.90**	0.49*	-0.023	-0.02	0.89**	0.94**	1	
14 Se (15300 cm)	0.43	0.543*	0.77**	0.67**	-0.74**	-0.63**	-0.82**	0.38	0.06	0.02	0.88**	0.86**	0.88**	1

❖ Simple regression approach

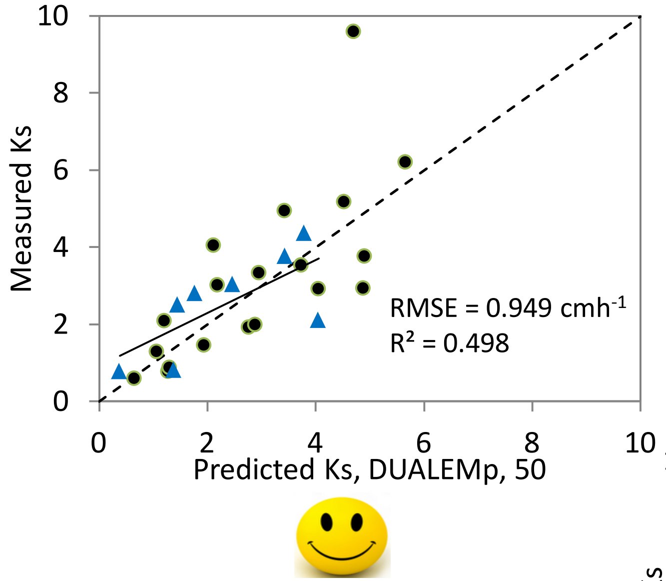
Semi-log (log Ks-Eca)

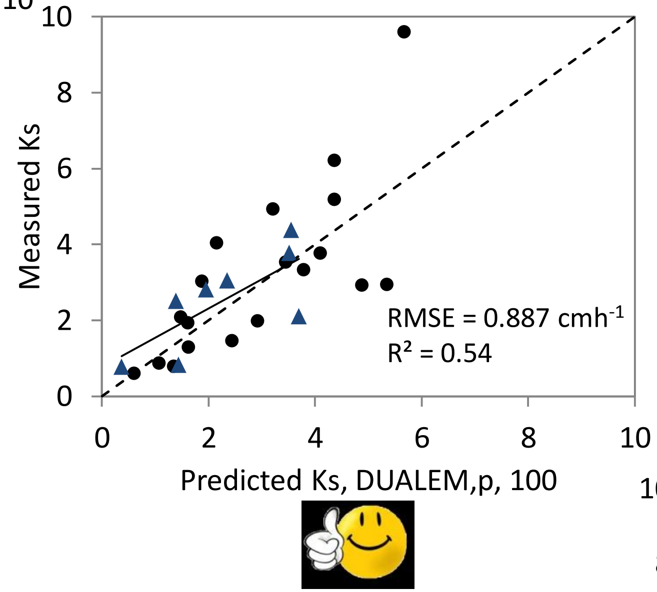


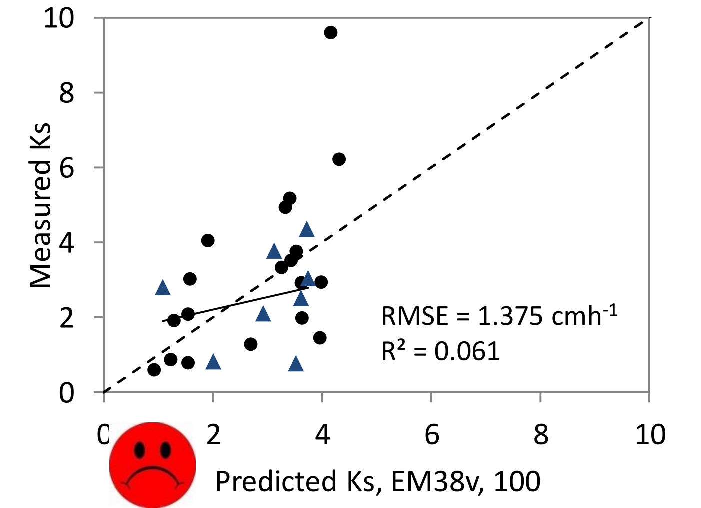


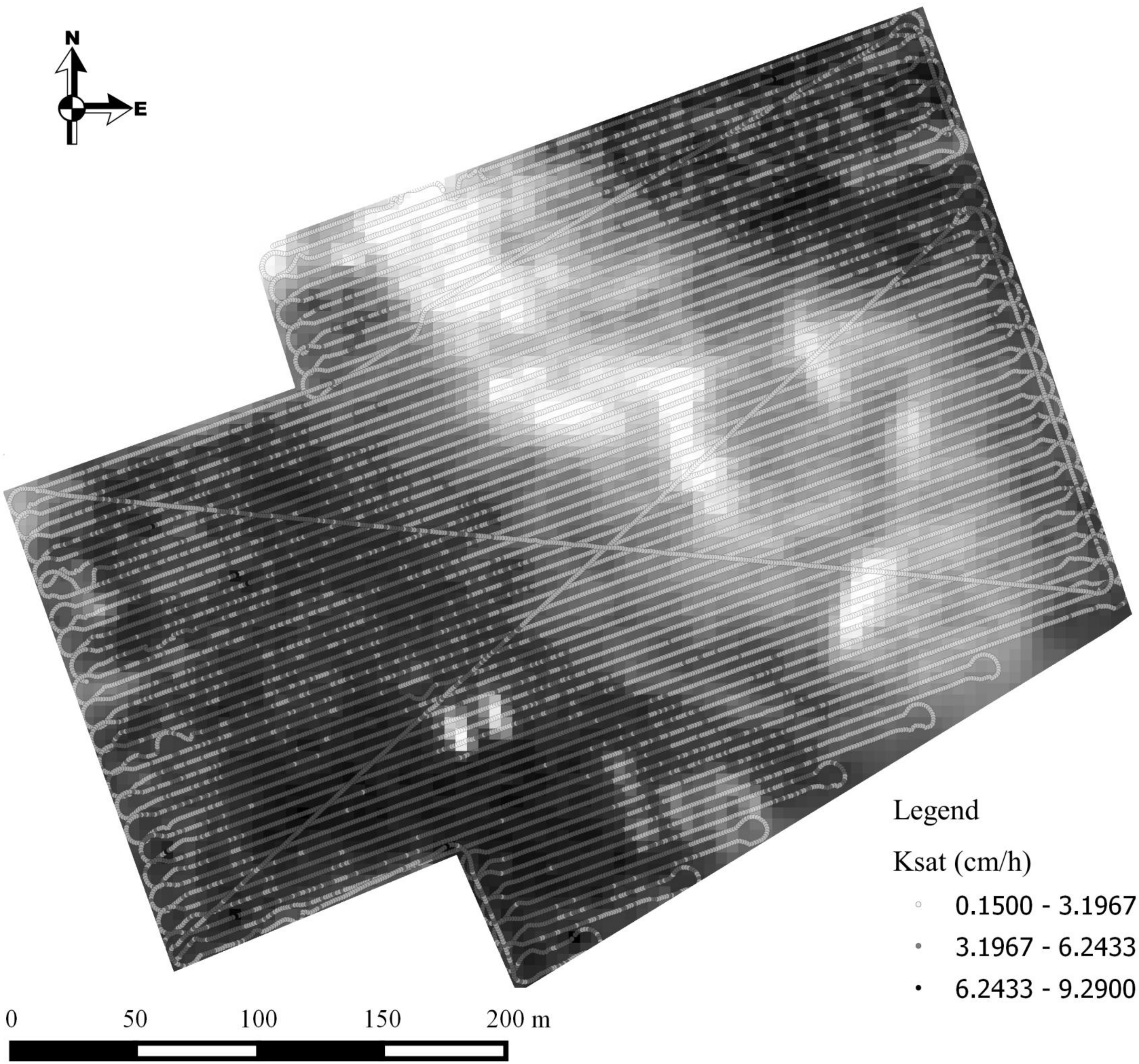


Validation Simple regression model log Ks-Eca





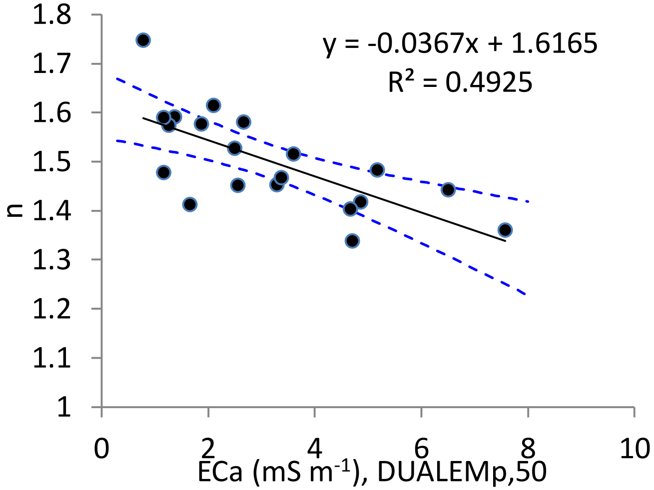


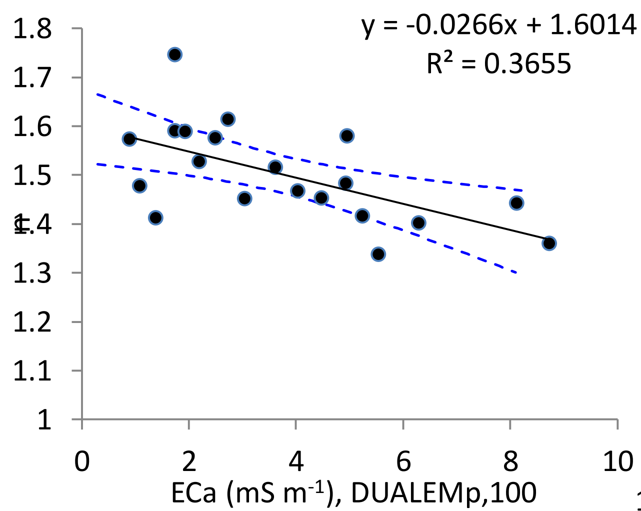


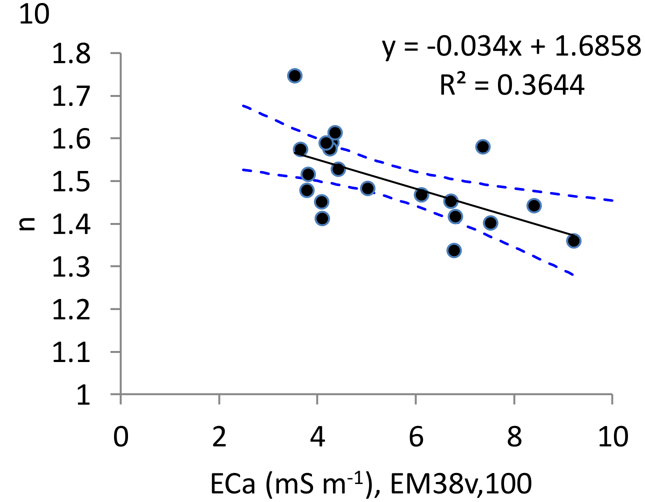
N
E
Legend
Ksat (cm/h)
0.1500 - 3.1967
3.1967 - 6.2433
6.2433 - 9.2900
0
50
100
150
200 m

❖ Simple regression approach

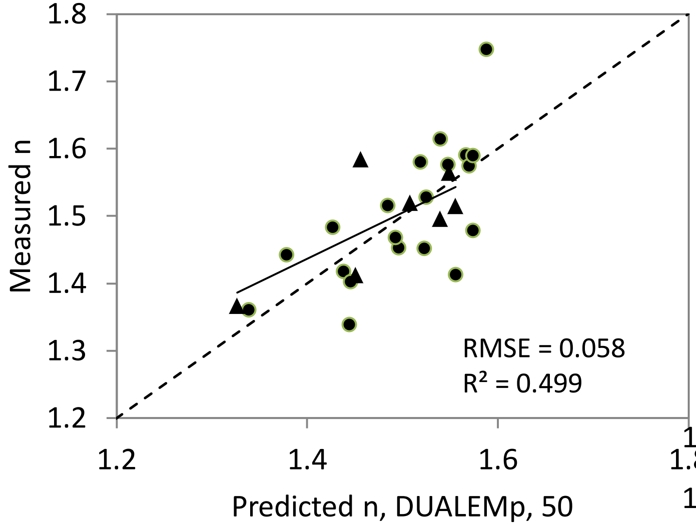
n-Eca

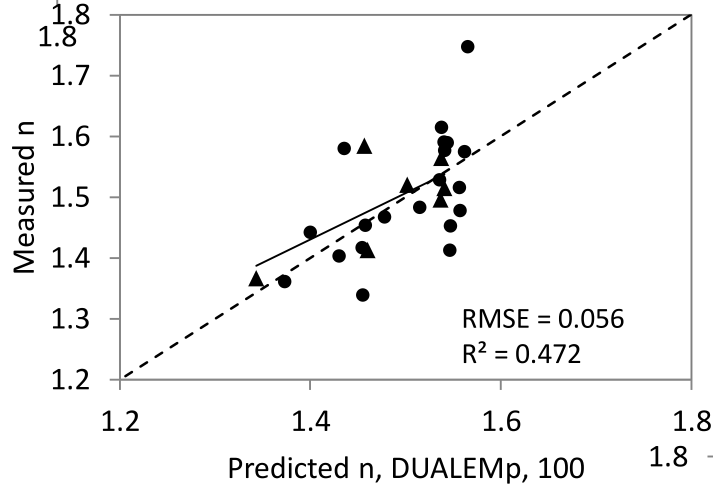


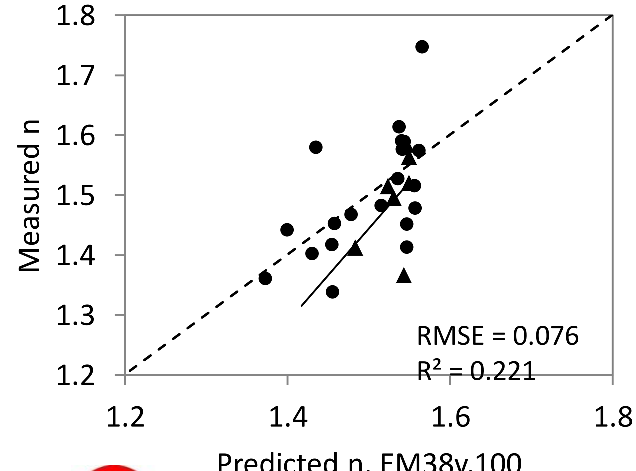




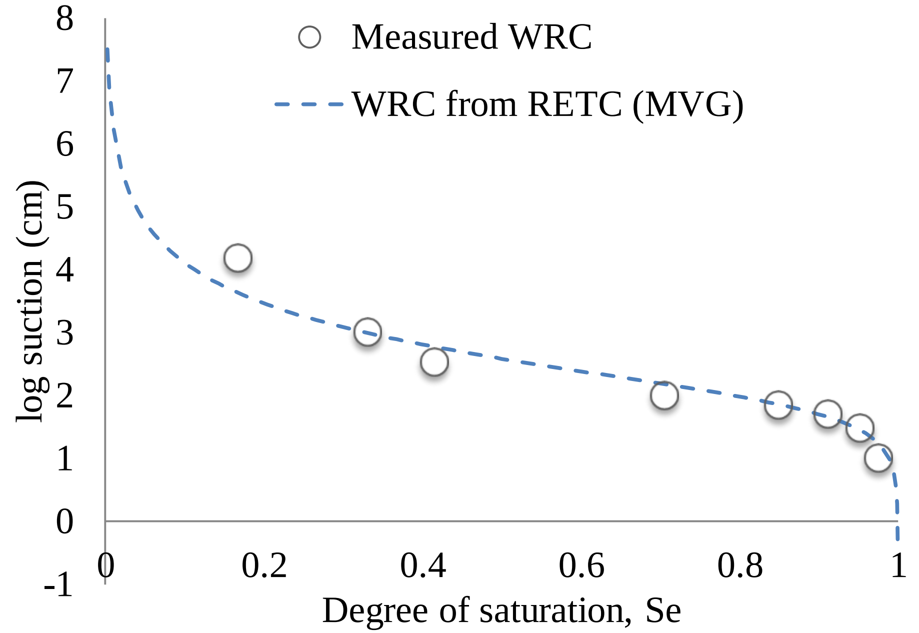
Validation Simple linear regression model n-Eca



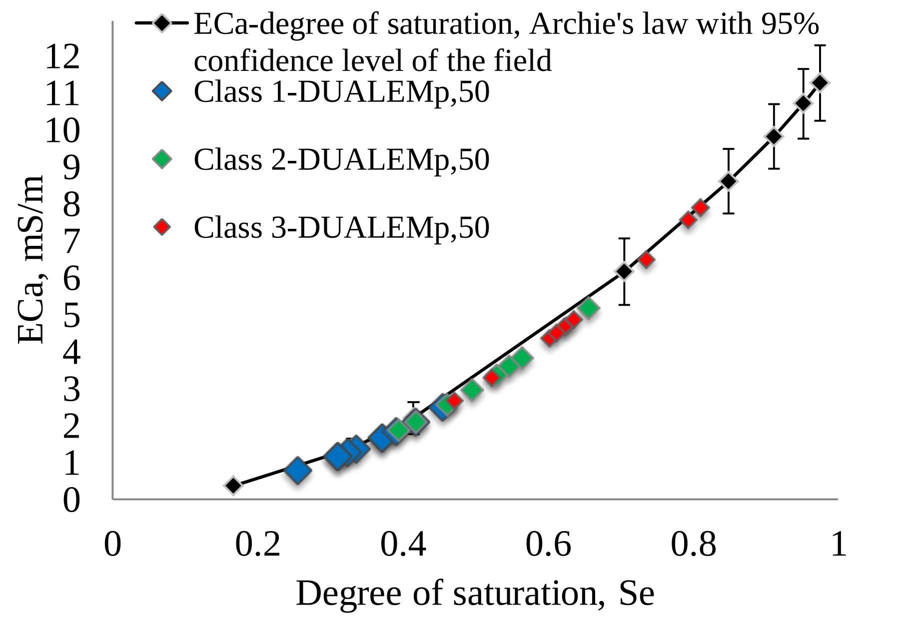




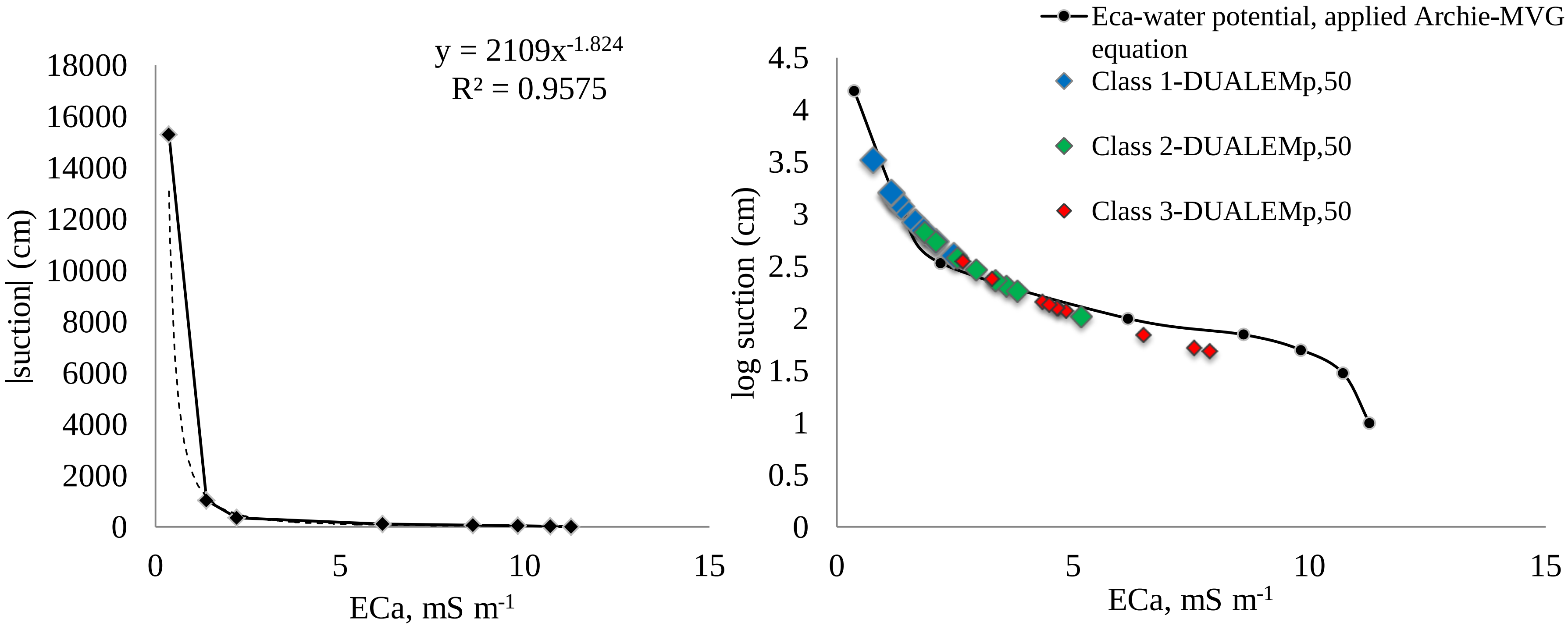
❖ Curve fitting approach



From Eq. 6



The suction (matric head) corresponding to EM-ECa values can be determined using regressed Eq. (below) or using Eq. (5) and taking predicted value of water retention parameters *n* and *α* for each location.



❖ Conclusion

a) The semi-log linear regression and simple linear regression were developed and validated to estimate the spatial distribution of the Ks and n respectively using different ECa datasets.

b) ECa data and water retention data (Se) were highly correlated, then using combination of empirical Archie's law and MVG equations could be a way forward to predicate available water for plant and soil water status from data point to the field scale for soil water balance, digital ET mapping and crop yield modeling studies.

c) Knowledge of water potential in aim of combined electrical and hydraulic measurements and predictions could be an efficient tool to predict spatial distribution of water fluxes and irrigation management.

Acknowledgments

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