



Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences



Digital soil data as input for spatial modelling of pesticide losses

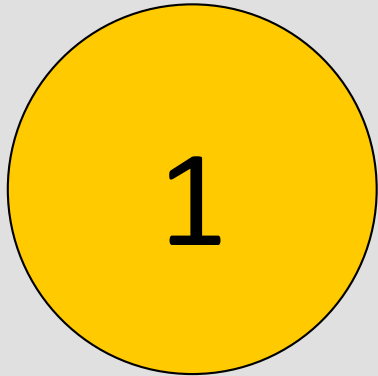
Kristin Piikki & Mats Söderström, Swedish University of Agricultural Sciences (SLU), Sweden



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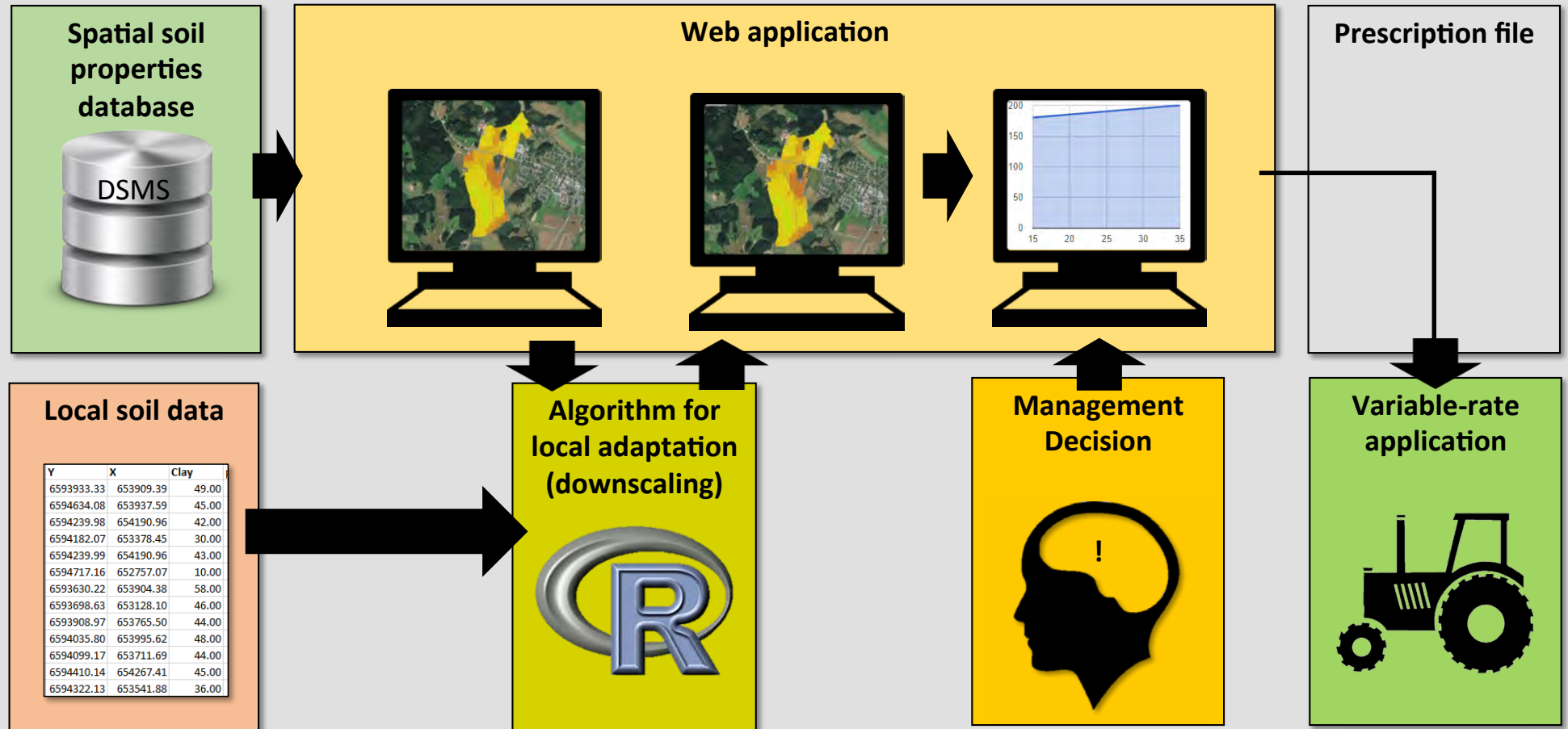


1. **Markdata.se – a free web application for farmers**
2. **Digital soil map of Sweden (DSMS)**
3. **Detailed mapping by proximal soil sensors**



Markdata.se
A web application
for practical use of
soil data

Swedish example of implemented pedometrics for precision agriculture

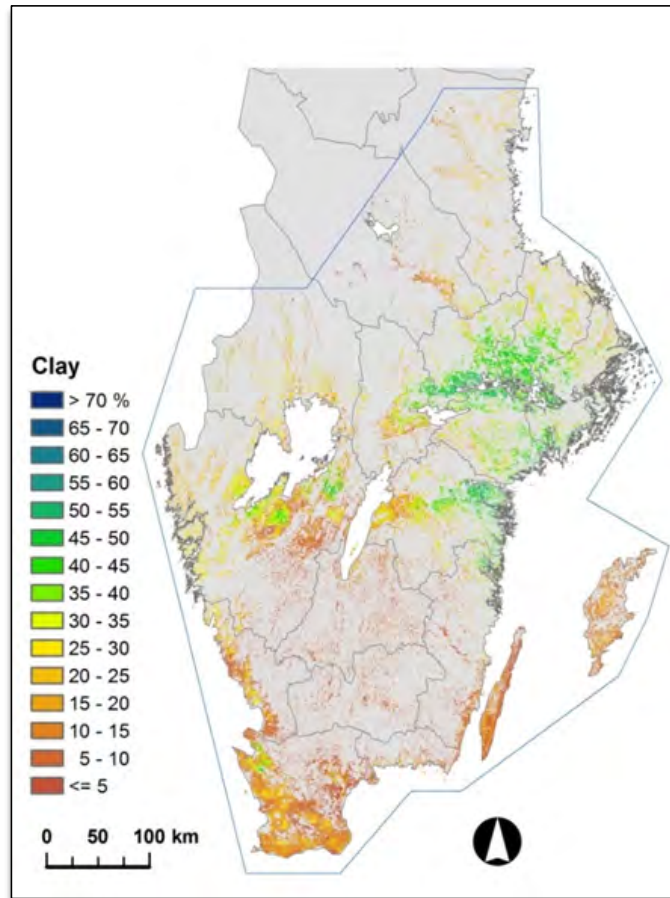
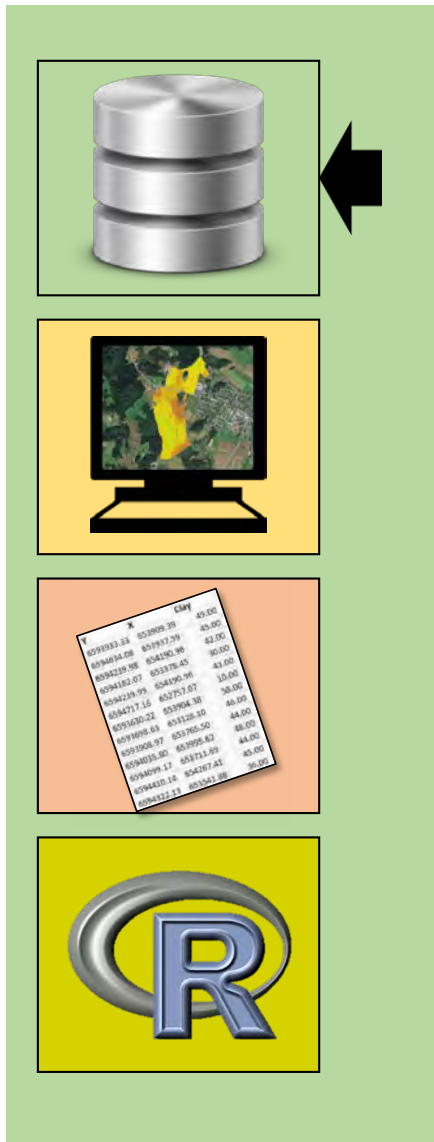


A tilted icon of a data table with columns and rows of numbers, representing a dataset or database table.

	X	Clay
6099933.22	602809.39	43.00
6096434.28	603937.39	43.00
6096229.98	603490.96	43.00
6094262.07	603176.45	43.00
6094229.99	604196.96	43.00
6084271.16	602757.07	58.00
6093620.22	603904.96	43.00
6093608.43	603128.40	44.00
6093608.97	603766.50	48.00
6094031.80	603995.62	44.00
6094079.12	603711.39	43.00
6094403.14	604267.41	43.00
6094222.12	603541.88	40.00



Spatial Soil Properties Database: **DSMS**



2.4 million ha of arable land

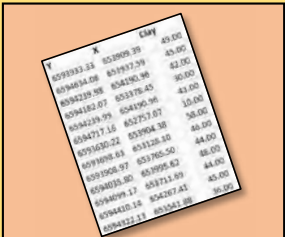
More info on DSMS later.....



	A	B	C
6099933.22	602809.39	43.00	
6096434.28	603937.39	43.00	
6096229.99	603490.36	43.00	
6094282.07	603176.45	43.00	
6094229.99	604190.96	43.00	
6084271.16	602757.07	43.00	
6093620.22	603904.36	43.00	
6093608.43	603128.40	44.00	
6093608.97	603760.50	44.00	
6094031.80	603995.62	44.00	
6094079.17	604971.89	43.00	
6094403.14	604287.41	43.00	
6094222.11	603541.88	43.00	



Free decision support application:
Markdata.se



Markdata.se

markdata.se

Sök

Markdata.se

Hitta block och välj markdata

1. Leta reda på det skifte du vill titta närmare på. Skriv in adressen (ex. sockennamn) i rutan uppe till vänster. Du kan också zooma in och ut med + och - tecknen eller förflytta dig genom att dra karta dit du vill.
2. Markera ett eller flera block i bakgrundskartan
3. Du kan sedan dela blocket om det innehåller flera skiften. Välj verktyget Rita delningslinje i kartan

Visa block

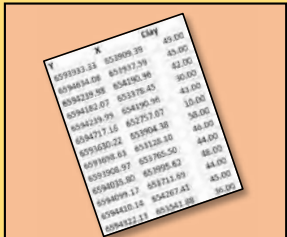
Föregående Nästa

Om Markdata.se

Sollebrunn, Sverige

Google

Bilder ©2017 CNES / Airbus, DigitalGlobe, Lantmäteriet/Metria, Användarvillkor Rapportera ett kartfel



Markdata.se

markdata.se

Sök

Markdata.se

Fyll i önskad giva

Nu kan du se variationerna i dina fält. Skriv in önskad mängd för tilldelning i respektive intervall.

Lerhalt	kg/ha	Area
10-15	<input type="text"/>	6,89 ha
15-20	<input type="text"/>	8,24 ha
20-25	<input type="text"/>	18,06 ha
25-30	<input type="text"/>	41,12 ha
30-35	<input type="text"/>	7,85 ha

Förbättra kartan

För att göra din lerhaltskarta bättre kan du importera egna markkarteringsdata. Det är en textfil som du fått i samband med att du karterade. Karteringen måste innehålla lerhalt för att fungera.

Släpp din markkarteringsfil (textfil) här eller klicka på knappen nedan för att välja filen.

Välj fil

Avbryt

Mer info

Mer info om utsäde

Föregående

Nästa

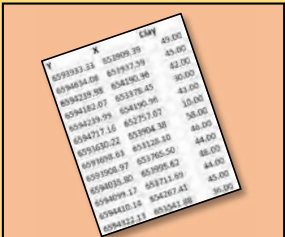
Mer info strukturkalkning

Om Markdata.se

Sollebrunn, Sverige

Google

Bilder ©2017 CNES / Airbus, DigitalGlobe, Lantmäteriet/Metria | Användarvillkor | Rapportera ett kartfel



Markdata.se

markdata.se

Sök

Markdata.se

Ange filnamn

Nu kan du ladda ner en karta och tilldelningsfil för ditt block. Har du ingen GPS i din traktor kan du ändå titta på kartan och följa variationerna i ditt fält manuellt.

kg/ha

Filnamn Skiftesnamn, ej åä

Medel (kg/ha) 186.41

Total mängd 15 315

Justera givan på kartan

Välj filformat att ladda ner

Trimble Trimble-display

JOHN DEERE JD-display

Shape-fil

JPG-bild

Textfil

Spara till DataVäxt Mobil

Du kan spara din fil till DataVäxt Mobil för att visa den i din mobil eller surfplatta. För att visa filen i DataVäxt Mobil krävs licens för funktionen Positionsdata. Klicka på knappen för att logga in eller skapa ett konto.

DataVäxt Mobil

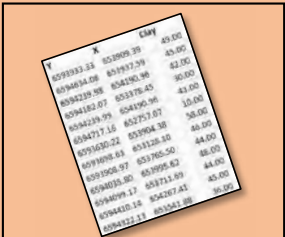
Föregående Avsluta

Om Markdata.se

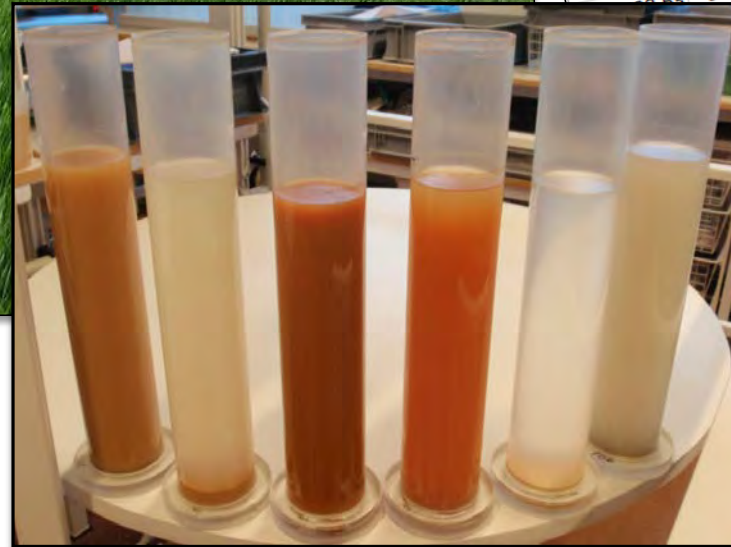
Sollebrunn, Sverige

If available:

Often one sample per 3 ha

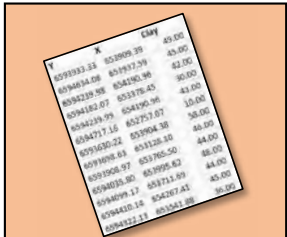


Y	X	Clay
6593933.33	653909.39	49.00
6594634.08	653937.59	45.00
6594239.98	654190.96	42.00
6594182.07	653378.45	30.00
6594239.99	654190.96	43.00
6594717.16	652757.07	10.00
6593630.22	653904.38	58.00
6593630.22	653128.10	46.00
6593630.22	653128.10	44.00
6593630.22	653128.10	48.00
6593630.22	653128.10	44.00
6593630.22	653128.10	45.00
6593630.22	653128.10	36.00



A tilted rectangular icon containing a table of numerical data with three columns and several rows.

Automated algorithm : **Maps.R.Interactive**



Markdata.se

markdata.se

Sollebrunn, Sverige

Fyll i önskad giva

Nu kan du se variationerna i dina fält. Skriv in önskad mängd för tilldelning i respektive intervall.

Lerhalt	kg/ha	Areal
10-15	<input type="text"/>	6,89 ha
15-20	<input type="text"/>	8,24 ha
20-25	<input type="text"/>	18,06 ha
25-30	<input type="text"/>	41,12 ha
30-35	<input type="text"/>	7,85 ha

Förbättra kartan

För att göra din lerhaltskarta bättre kan du importera egna markkarteringsdata. Det är en textfil som du fått i samband med att du karterade. Karteringen måste innehålla lerhalt för att fungera.

Släpp din markkarteringsfil (textfil) här eller klicka på knappen nedan för att välja filen.

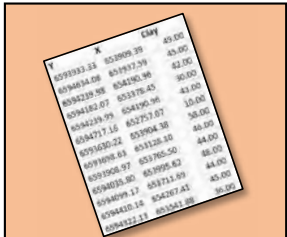
Välj

Avbryt

X	Y	Provnummer	Märkning	P_AL_klass	P_AL	P_HCl_klass	P_HCl	K_HCl_klass	K_HCl	Cu_HCl	Jordart	K_Mg_Kvot	C
353426.81765903900	6445536.97971727000	J021880-16	2016-06-02	1	III	7.4	4	65	3	190	10	mrmOLL	3
353502.57478117900	6445513.90923361000	J021881-16	2016-06-02	2	III	5.2	3	52	4	220	9.5	mmhmjLL	1
353459.54250063000	6445442.31436165000	J021882-16	2016-06-02	3	III	5.7	5	110	4	280	28	lm	1
353307.00589645000	6445327.43089271000	J021883-16	2016-06-02	4	III	4.1	4	73	3	200	11	mmhmjLL	1
353505.36562878700	6445292.94494088000	J021884-16	2016-06-02	5	III	4.9	4	66	4	210	9	mrmOLL	1
353618.72879886200	6445225.56109494000	J021885-16	2016-06-02	6	III	6.5	4	73	3	150	8.6	mmhmjLL	1
353747.08854033700	6445334.37080478000	J021886-16	2016-06-02	7	III	5.6	4	69	4	320	15	mrML	0
353933.26945189200	6445610.99188531000	J021887-16	2016-06-02	8	III	3.2	4	66	3	170	7.1	mmhmOLL	1
354001.79527408700	6445476.51668935000	J021888-16	2016-06-02	9	II	3.9	4	65	4	270	10	mrML	1
353788.34686051400	6445035.92183105000	J021889-16	2016-06-02	10	II	2.7	3	60	4	220	9.6	mrML	1
353652.25621548500	6444911.21888960000	J021890-16	2016-06-02	11	II	2.7	3	60	4	220	9.6	mrML	1

Google

Bilder ©2017 CNES / Airbus, DigitalGlobe, Lantmäteriet/Metria | Användarvillkor | Rapportera ett kartfel



Markdata.se

markdata.se

Sök

Markdata.se

Fyll i önskad giva

Nu kan du se variationerna i dina fält. Skriv in önskad mängd för tilldelning i respektive intervall.

Lerhalt	kg/ha	Areal
10-15	<input type="text"/>	9,67 ha
15-20	<input type="text"/>	9,00 ha
20-25	<input type="text"/>	41,71 ha
25-30	<input type="text"/>	21,09 ha
30-35	<input type="text"/>	0,69 ha

Förbättra kartan

För att göra din lerhaltskarta bättre kan du importera egna markkarteringsdata. Det är en textfil som du fått i samband med att du karterade. Karteringen måste innehålla lerhalt för att fungera.

[Förbättra kartan](#)

Originalkartan är uppdaterad!

x	y
15	0.0
20	0.0
25	0.0
30	0.0
35	0.0

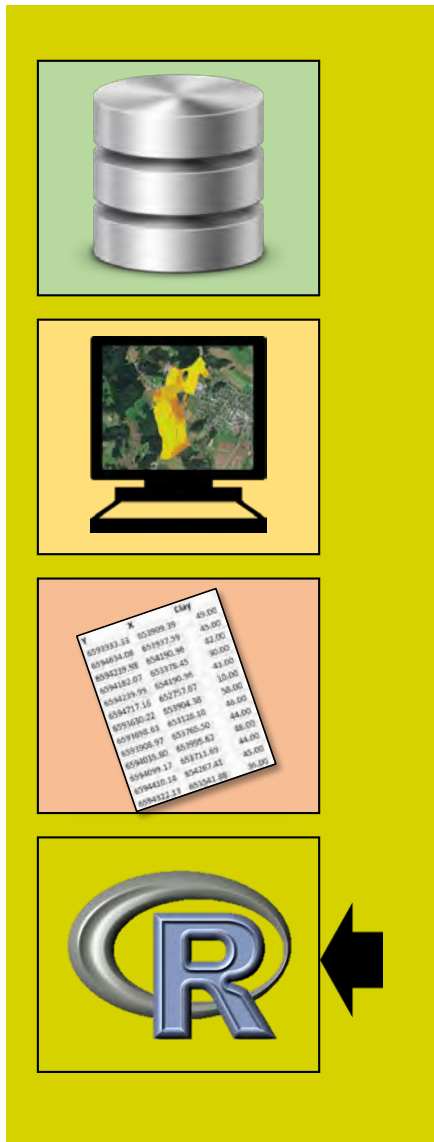
[Mer info om utsäde](#) [Föregående](#) [Nästa](#)

[Mer info strukturkalkning](#)

Om Markdata.se

Google

Bilder ©2017 CNES / Airbus, DigitalGlobe, Lantmäteriet/Metria | Användarvillkor | Rapportera ett kartfel



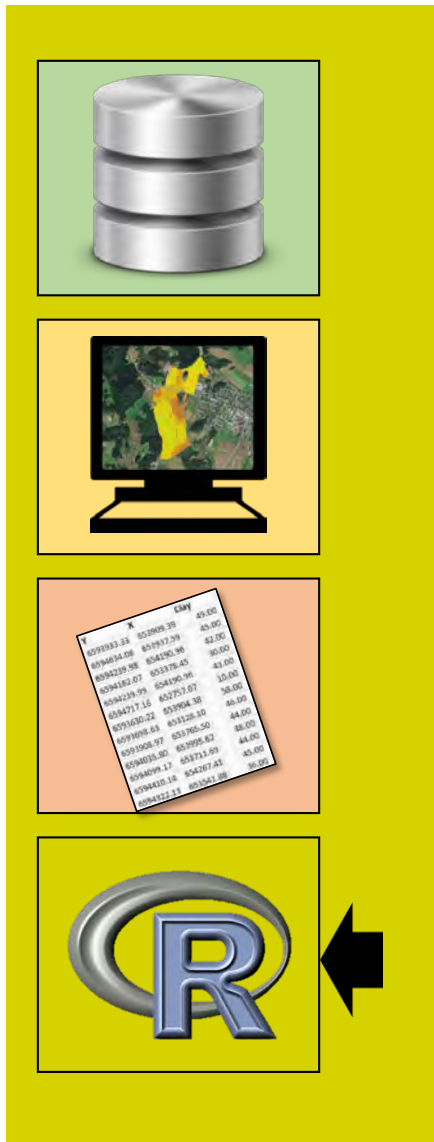
DSMS

Map based on local data only
(ordinary kriging)

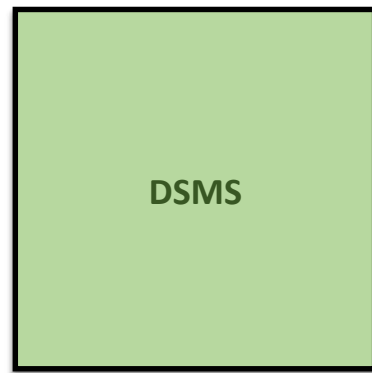
Adapted DSMS 1
(residual kriging)

Adapted DSMS 2
(regression kriging)

Four maps



Independent validation

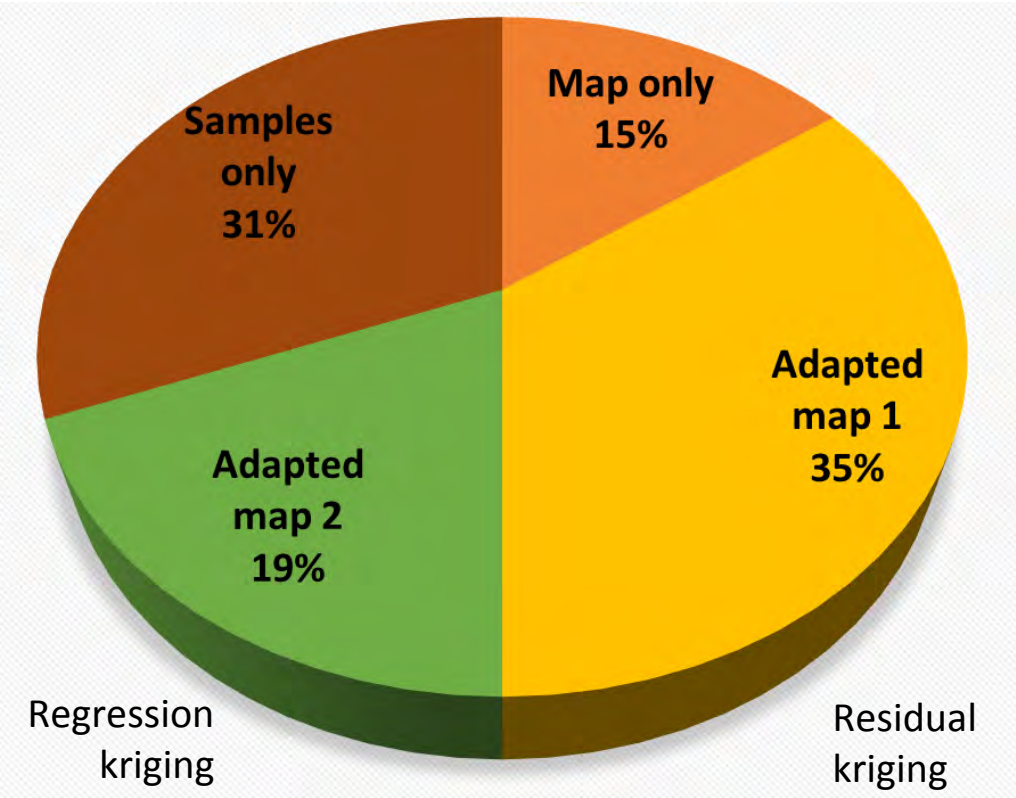


Leave-one-sample-out cross-validation

Validation



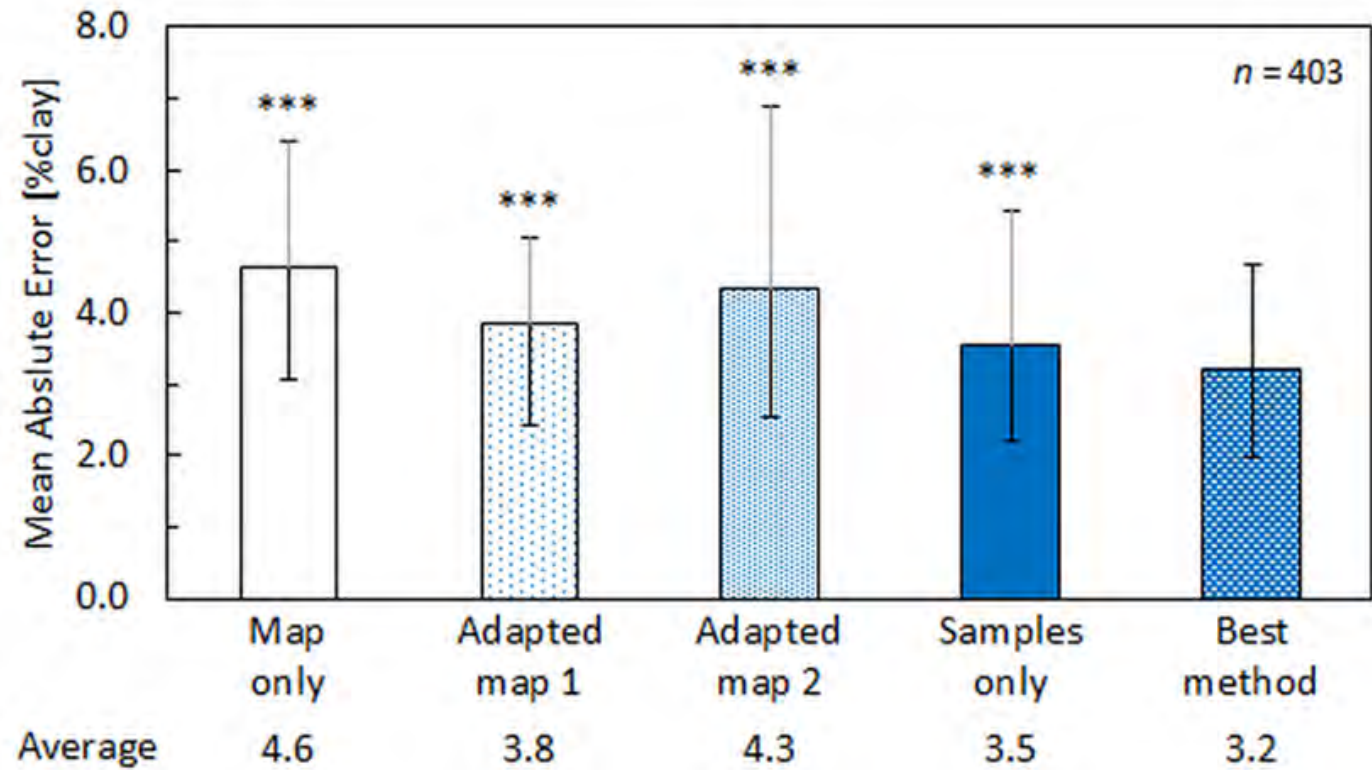
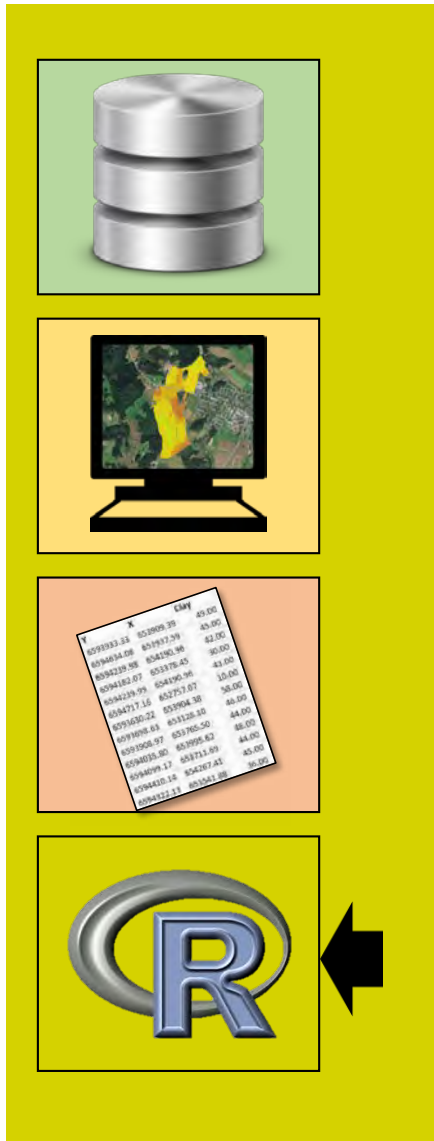
	X	Y	
1	6599933.22	652809.39	43.00
2	6599933.22	652809.39	43.00
3	6599933.22	652809.39	43.00
4	6599933.22	652809.39	43.00
5	6599933.22	652809.39	43.00
6	6599933.22	652809.39	43.00
7	6599933.22	652809.39	43.00
8	6599933.22	652809.39	43.00
9	6599933.22	652809.39	43.00
10	6599933.22	652809.39	43.00
11	6599933.22	652809.39	43.00
12	6599933.22	652809.39	43.00
13	6599933.22	652809.39	43.00
14	6599933.22	652809.39	43.00
15	6599933.22	652809.39	43.00
16	6599933.22	652809.39	43.00
17	6599933.22	652809.39	43.00
18	6599933.22	652809.39	43.00
19	6599933.22	652809.39	43.00
20	6599933.22	652809.39	43.00



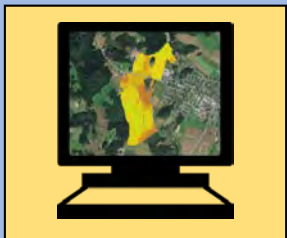
Percent of 403 farms, where the map had the lowest MAE

MAE = Mean Absolute Error

Validation



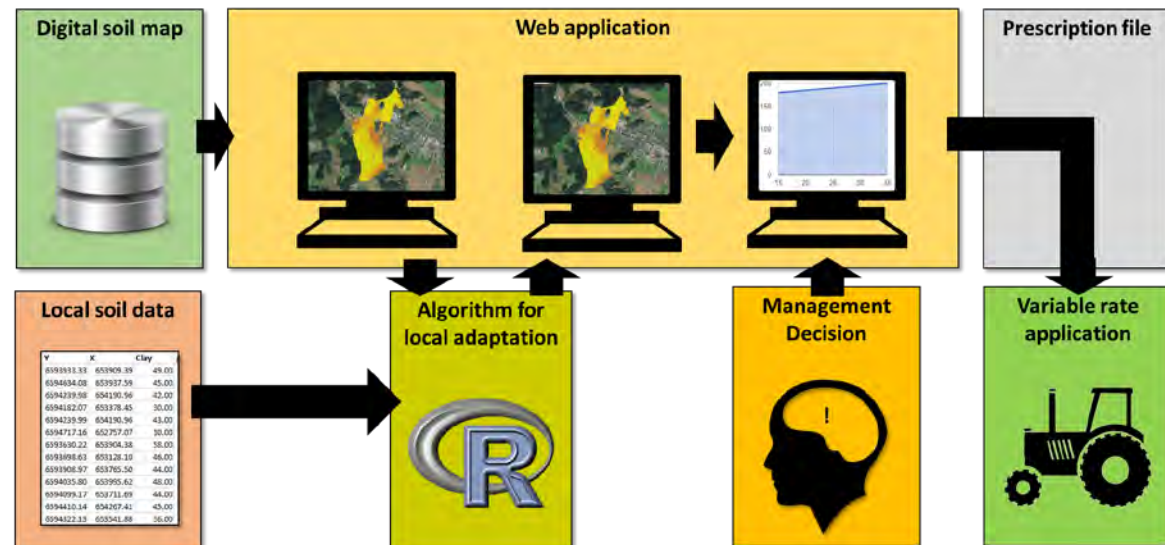
Use the locally best map

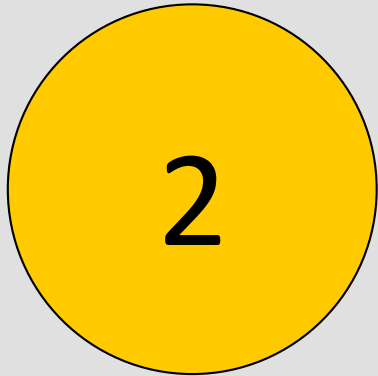


v	K	Clay
6093933.32	603909.39	43.00
6094034.08	603937.39	43.00
6094239.98	603490.96	43.00
6094282.07	603176.45	43.00
6094239.99	6042196.96	10.00
6094271.16	602757.07	38.00
6093620.22	603904.96	44.00
6093630.43	603128.50	44.00
6093608.97	603760.50	48.00
6093608.97	603760.50	44.00
6094031.80	603995.62	44.00
6094031.80	603711.89	43.00
6094410.14	604267.42	43.00
6094222.12	603541.88	40.00



- An algorithm was developed for local adaptation (downscaling) of a national digital soil map.
- Implemented in a free web-based decision support application for precision agriculture (markdata.se).





What is DSMS (the digital soil map of Sweden)?

DSMS properties

Format: Raster

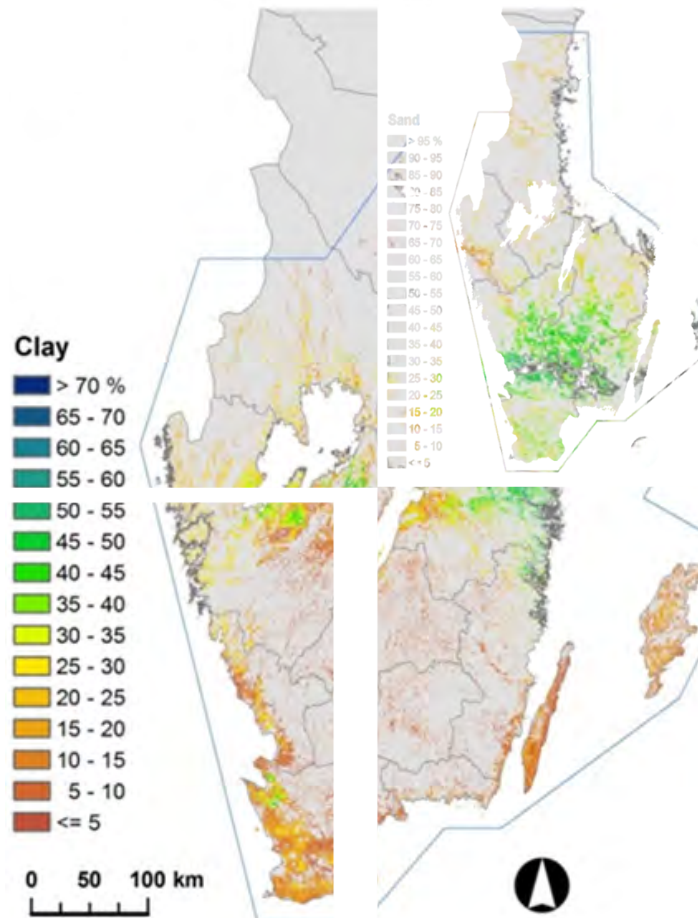
Cell size: 50 m × 50 m

Extent: 2.4 million ha
>90% of the arable land
! Except organic soils

Attributes: Topsoil clay content
Topsoil sand content
Topsoil silt content
Topsoil FAO texture class

License: CC-BY

Download site: http://bit.ly/DSMS_download



Data

Lattice point location data:

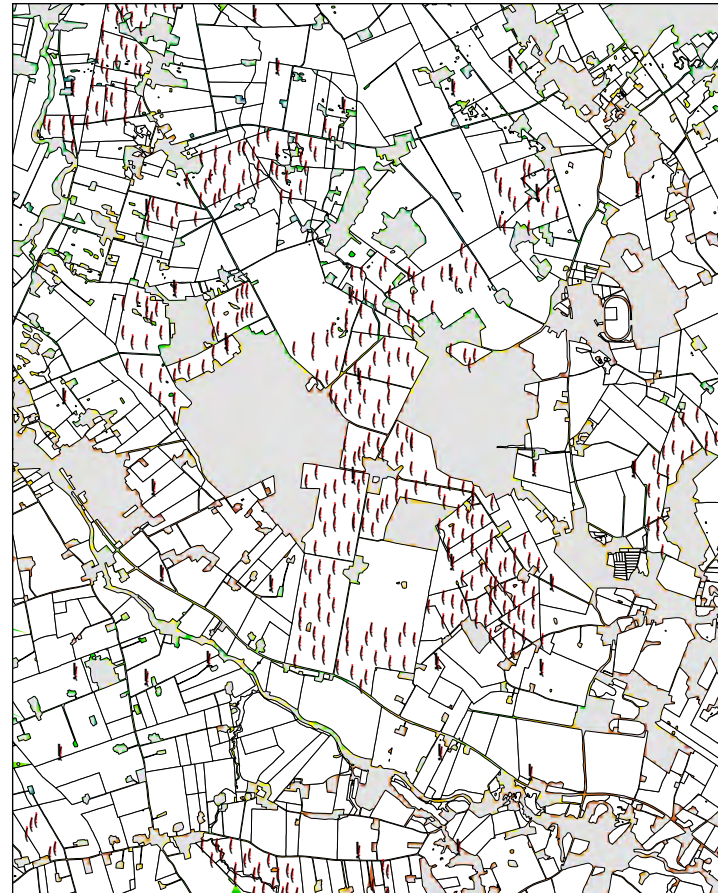
Texture and organic matter (OM) content in 13,600 soil samples taken in a $\sim 1 \text{ km}^2$ square grid

Clustered point location data:

Texture and OM content in 24,000 soil samples at 544 farms: 1 sample / 3 ha

Polygon data

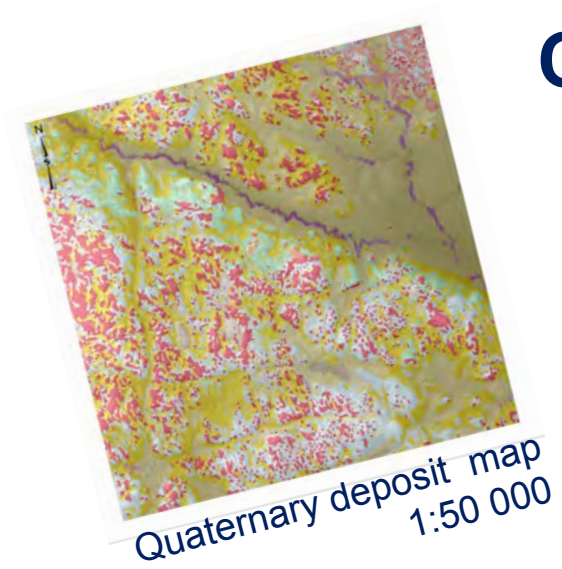
Field boundaries and field classifications



o

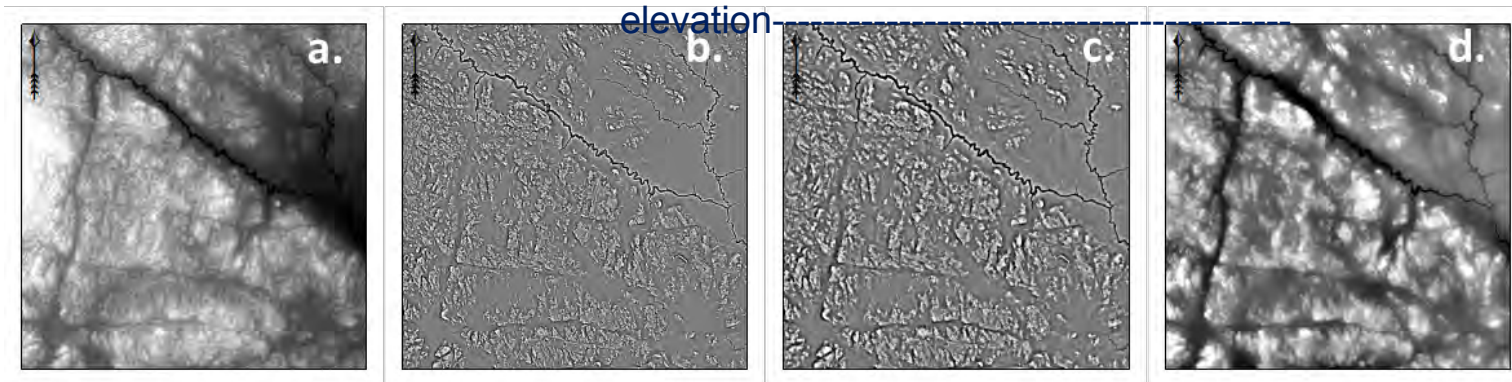
0 1 2 km

Covariates

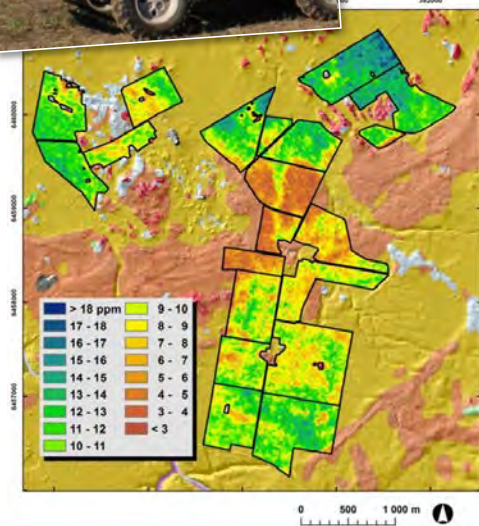


Elevation

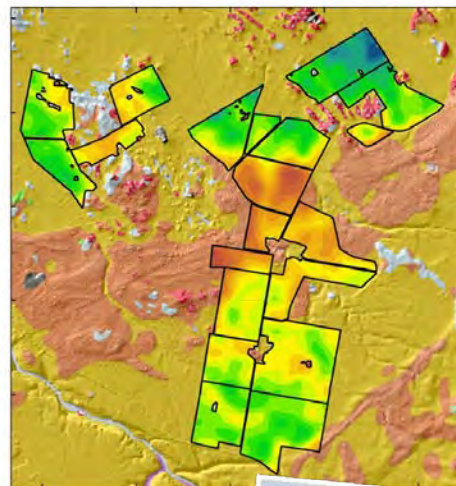
Relative



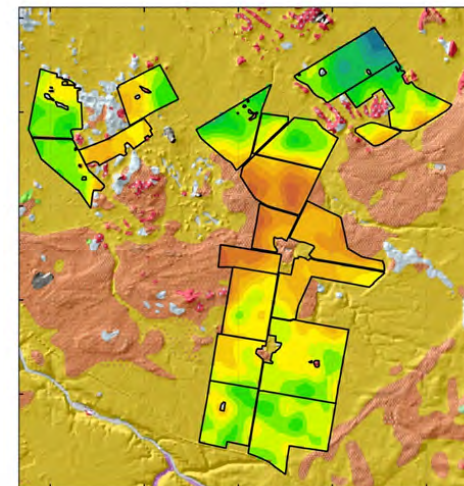
Gamma radiation data



Th, proximal
0.2 m height
24 m spacing



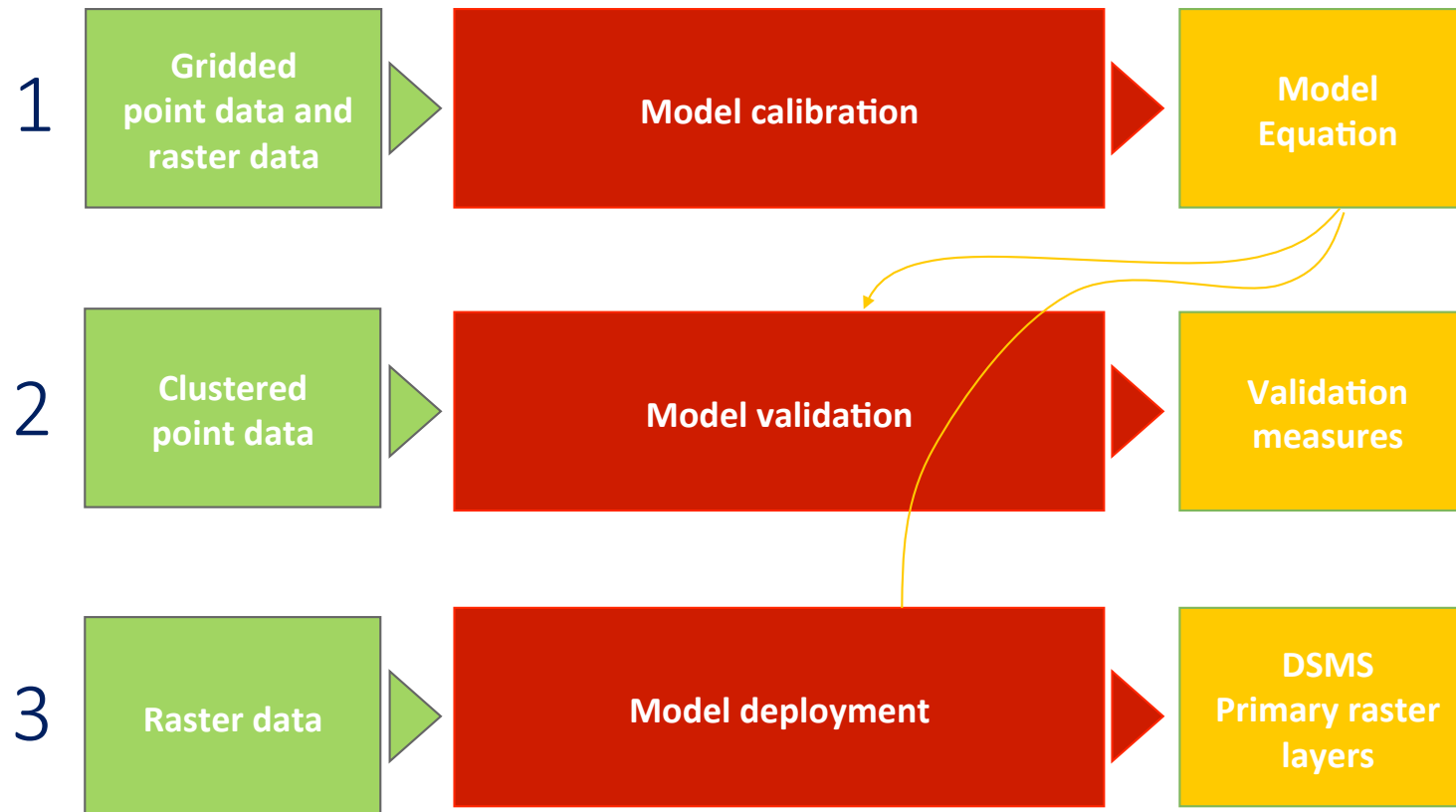
Th, airborne
30 m height
100 m spacing



Th, airborne
60 m height
200 m spacing



Mapping strategy



Mann

**Model:
Multivariate
adaptive
regression
splines
(MARSplines)**

1

Grid
point c
raste

Model
Equation

2

Cluste
point c

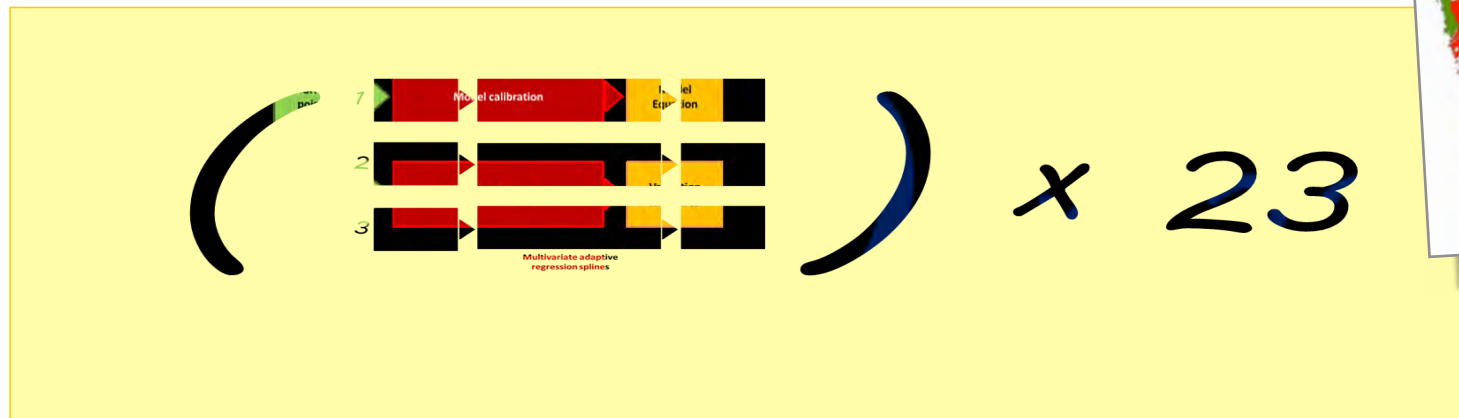
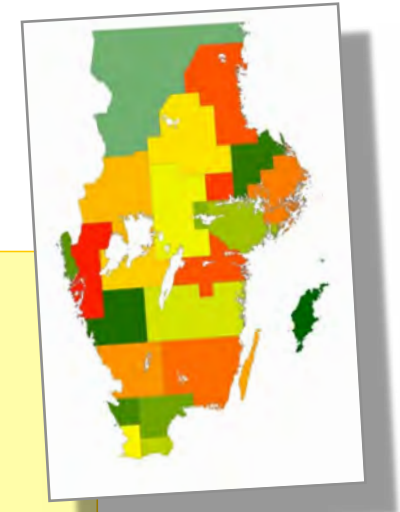
Validation
measures

3

Raster da

DSMS
Primary raster
layers

Mapping strategy



4

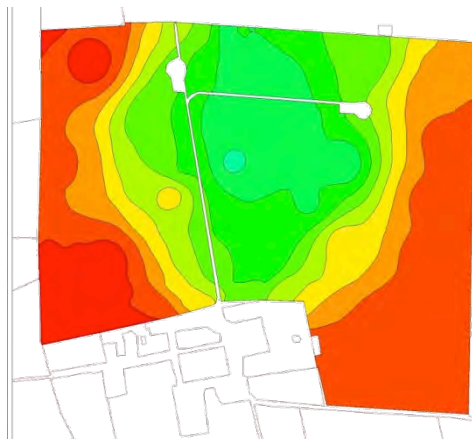
Applying pedotransfer functions

DSMS
Secondary
raster layers

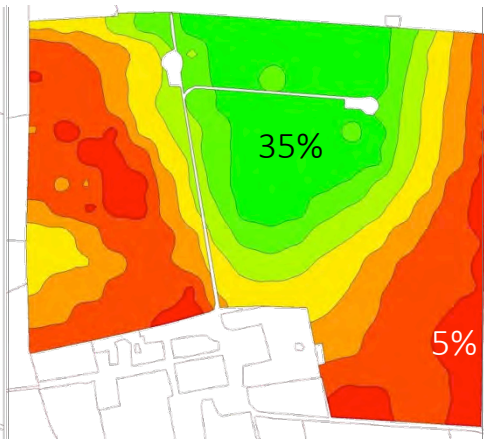
-Buffering capacity
-Target pH
etc....

Clay content at one 55 ha farm...

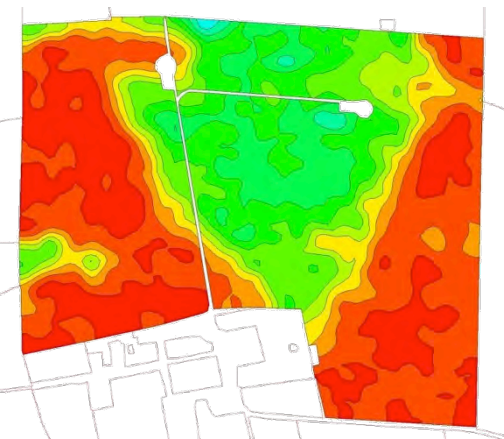
Soil samples only
1 sample/3 ha

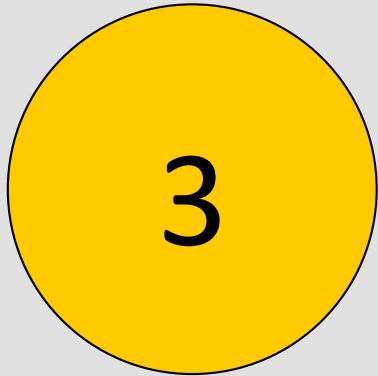


DSMS



Proximal sensing
"the truth"





Detailed local
soil maps derived by
proximal sensing

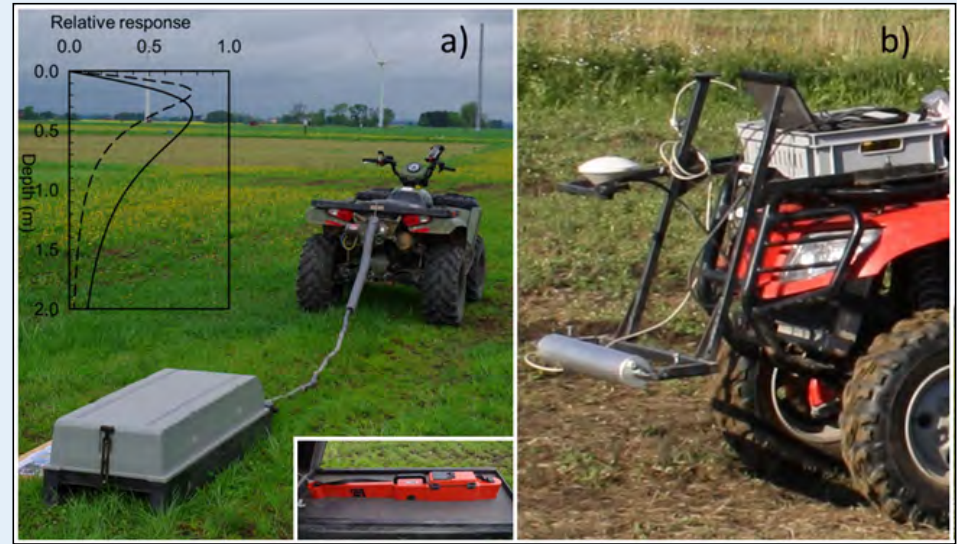
Lab analyses are:

- More expensive
- Less uncertain



Foto: Christina Öhman, SLU

640 :- /st



Proximal sensor measurements *in situ* are:

- Less expensive
- More uncertain



Gamma spectrometry

Registers:

- Natural gamma radiation of ^{40}K , ^{238}U och ^{232}Th in the topsoil

Can be related to:

- Soil parent material
- Soil texture
- Cadmium content in some areas



Excellent for
topsoil clay
content

Electromagnetic induction sensor

Registers:

- Apparent electrical conductivity and magnetic susceptibility over multiple depth

Can e.g. be related to:

- Soil texture
- Moisture content
- Salinity
- Organic matter content

Any relationships are site-specific



Hydraulic probe

Registers
depth
profiles!

Registers :

- Apparent electrical conductivity
- Insertion force
- visNIR reflectance spectra

Can be related to:

- Soil texture
- Moisture content
- Salinity
- Organic matter content



Vis-NIR/MIR spectroscopy



Suitable for
small plots

Registers :

- visNIR reflectance spectra

Can be related to:

- Soil texture
- Moisture content
- Organic matter content
- Other properties.....(?)

PXRF

Registers :

- X-ray fluorescence of elements from Mg →

Can be related to:

- Total concentration of many elements



Direct
measure-
ments

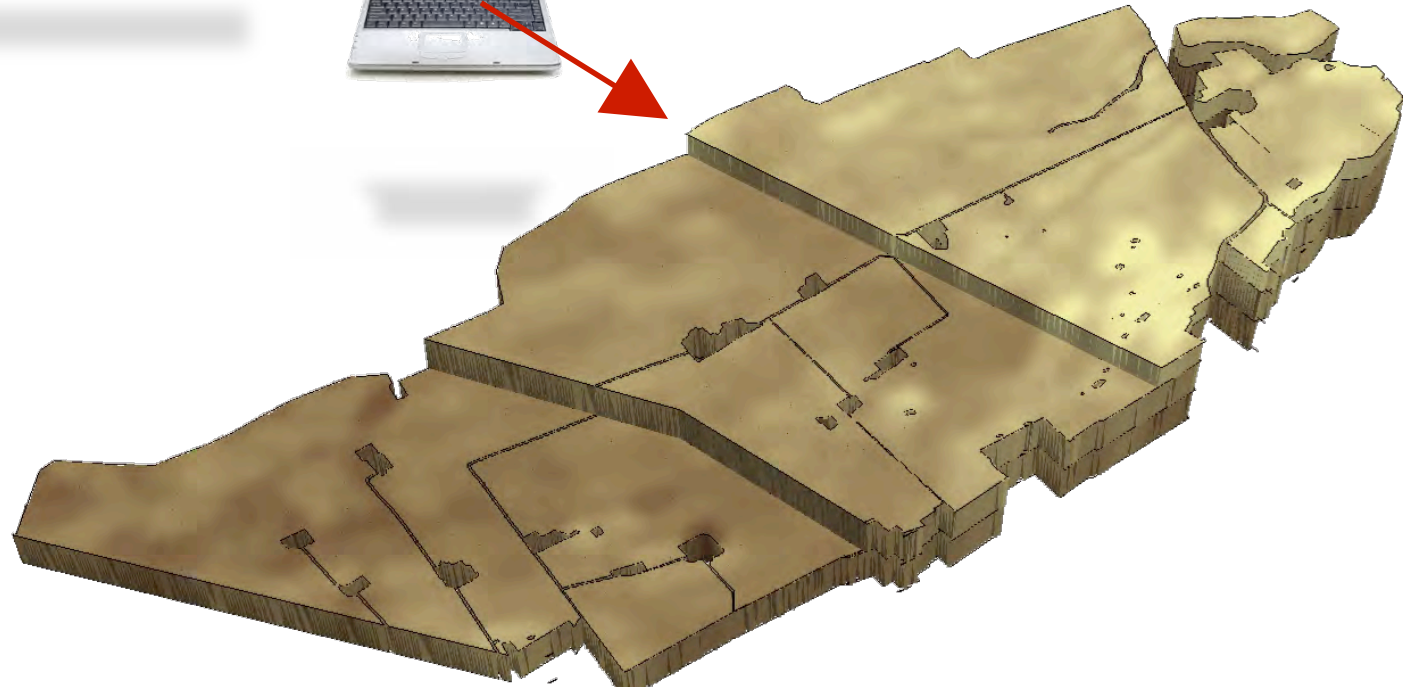
Proximal
sensor data

Digital
elevation
model

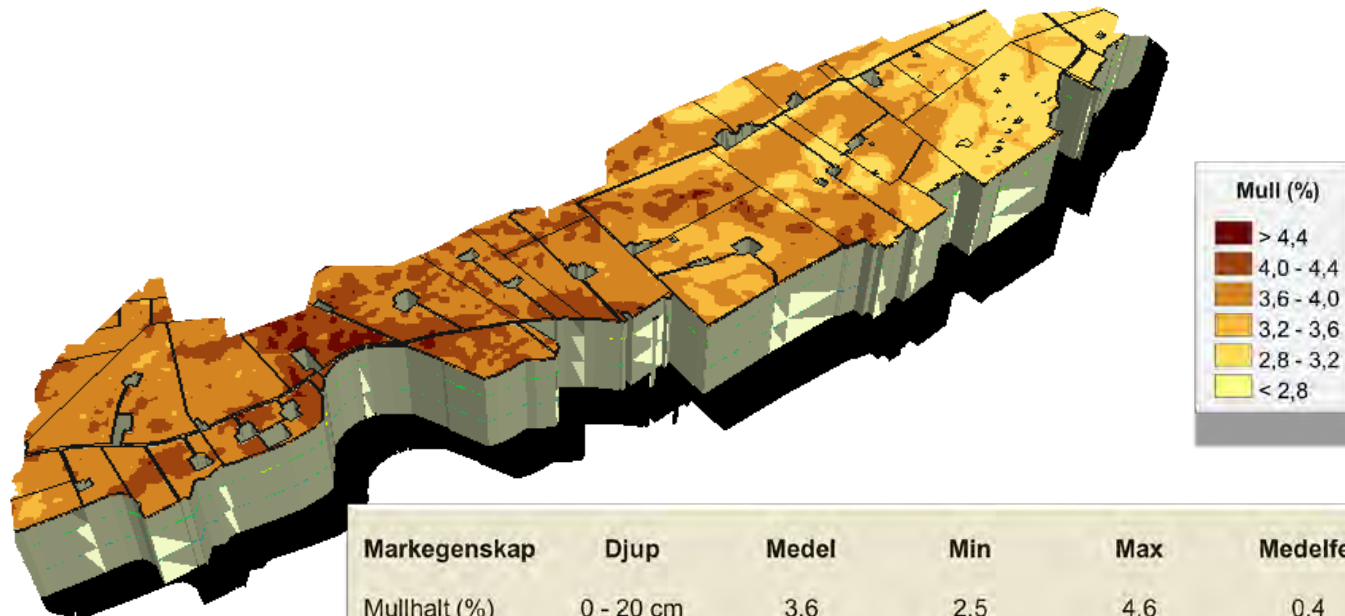
Lab analyses
of soil
samples



Digital Soil Mapping



Organic matter content 0-20 cm

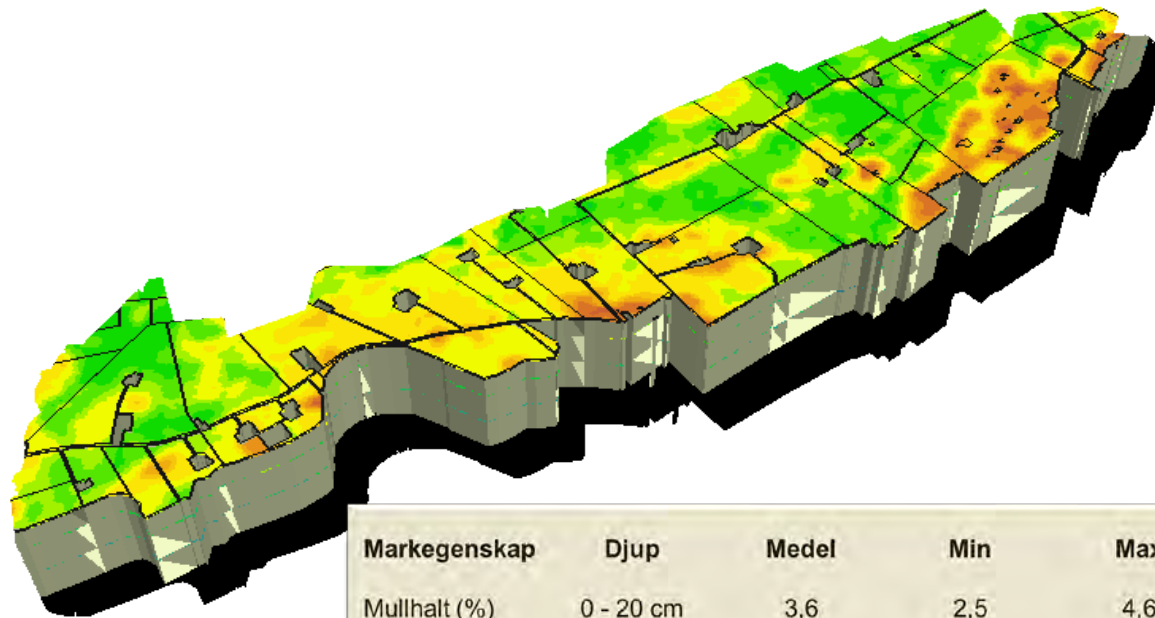


Markegenskap	Djup	Medel	Min	Max	Medelfel
Mullhalt (%)	0 - 20 cm	3,6	2,5	4,6	0,4
Lerhalt (%)	0 - 20 cm	40,4	21,5	48,7	3,5
Lerhalt (%)	20 - 50 cm	51,2	31,2	58,7	4,6
Lerhalt (%)	50 - 80 cm	55,6	44,0	60,8	3,9

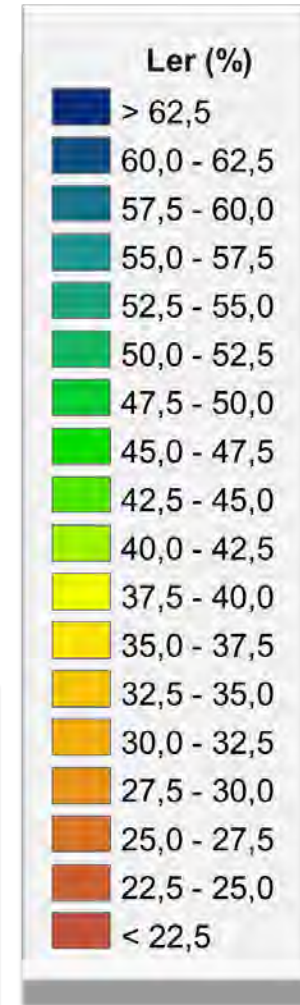
Example:

- Watershed of 800 ha
- 50 soil samples * 3 depths
- 800 000 registrations of ECa and gamma radiation
- Digital elevation model from RTK-GPS
- Multivariate prediction modelling

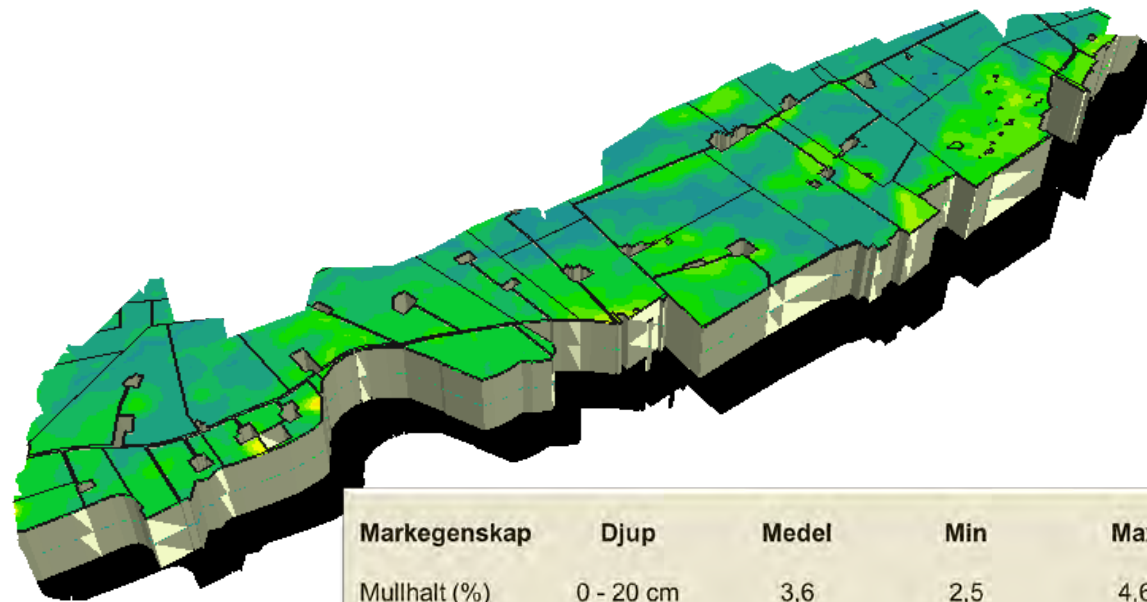
Clay content 0-20 cm



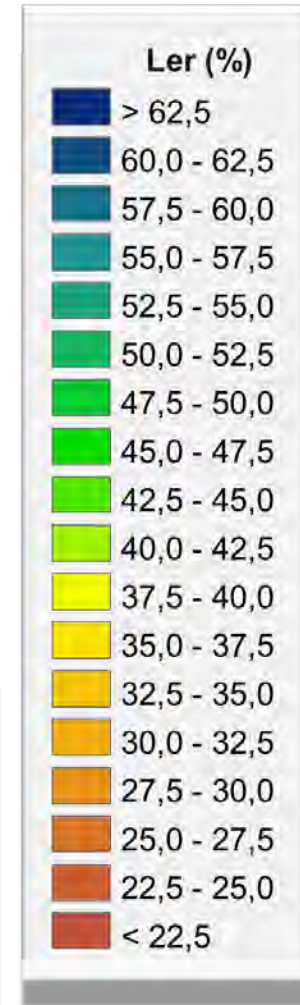
Markegenskap	Djup	Medel	Min	Max	Medelfel
Mullhalt (%)	0 - 20 cm	3,6	2,5	4,6	0,4
Lerhalt (%)	0 - 20 cm	40,4	21,5	48,7	3,5
Lerhalt (%)	20 - 50 cm	51,2	31,2	58,7	4,6
Lerhalt (%)	50 - 80 cm	55,6	44,0	60,8	3,9



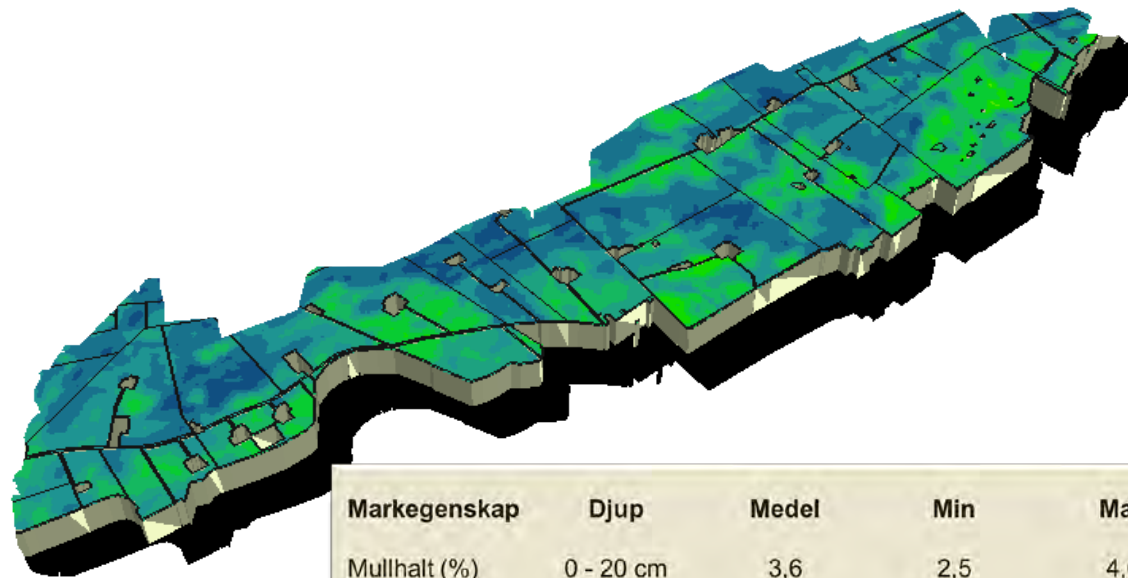
Clay content 20-50 cm



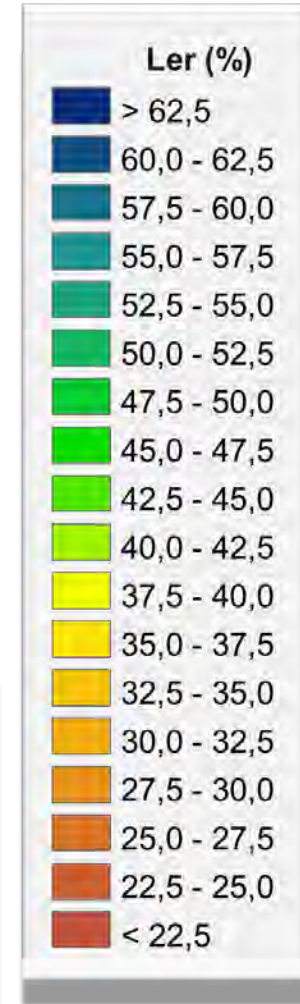
Markegenskap	Djup	Medel	Min	Max	Medelfel
Mullhalt (%)	0 - 20 cm	3,6	2,5	4,6	0,4
Lerhalt (%)	0 - 20 cm	40,4	21,5	48,7	3,5
Lerhalt (%)	20 - 50 cm	51,2	31,2	58,7	4,6
Lerhalt (%)	50 - 80 cm	55,6	44,0	60,8	3,9



Clay content 50-80 cm

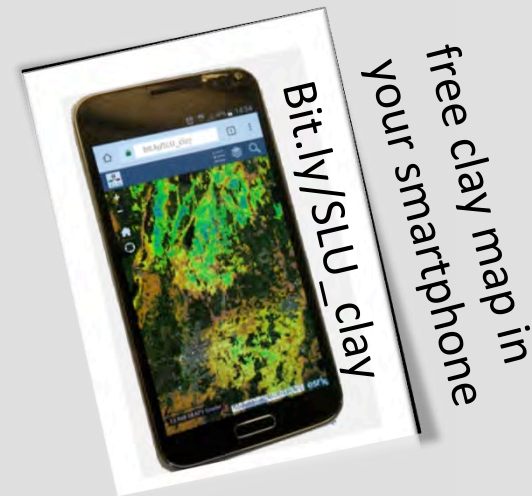


Markegenskap	Djup	Medel	Min	Max	Medelfel
Mullhalt (%)	0 - 20 cm	3,6	2,5	4,6	0,4
Lerhalt (%)	0 - 20 cm	40,4	21,5	48,7	3,5
Lerhalt (%)	20 - 50 cm	51,2	31,2	58,7	4,6
Lerhalt (%)	50 - 80 cm	55,6	44,0	60,8	3,9



Summary

- DSMS is a free map of topsoil texture with 50 x 50 m spatial resolution.
- Markdata.se is one example of an application that transfers soil data to useful information available for public use.
- More detailed spatial soil information and information on subsoil properties can be produced by proximal sensing.



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