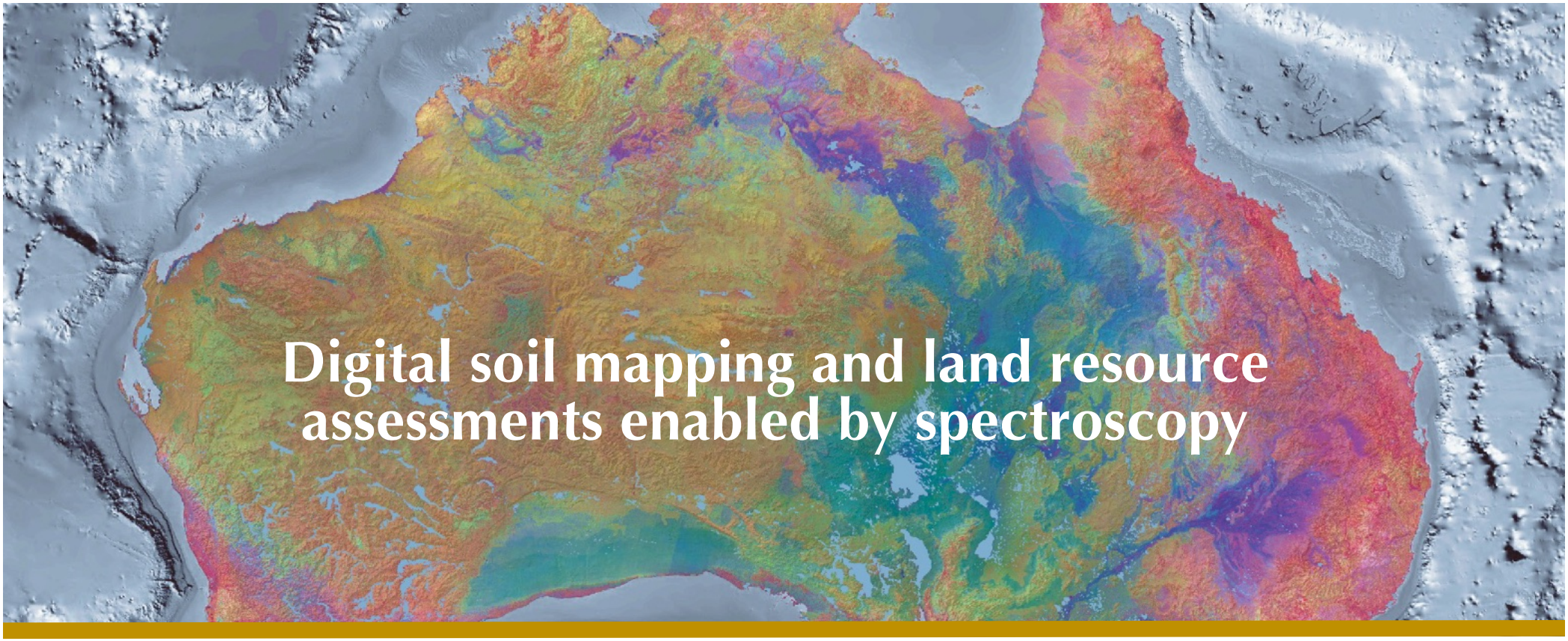

Digital soil mapping and land resource assessments enabled by spectroscopy

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Soil & Landscape Science, Curtin University

7th INSII Meeting, 9-10-11 November 2021

soil & landscape science lab

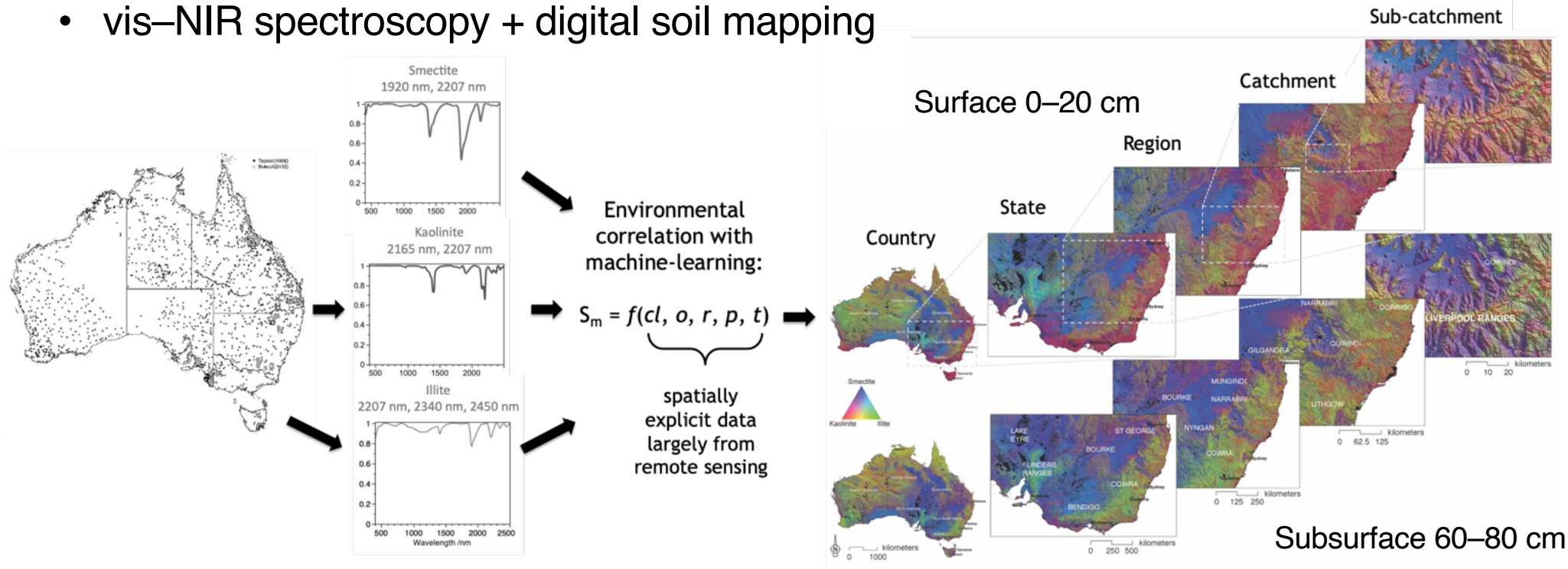
Curtin University

Digital mapping of the information content of soil spectra

Digital soil mapping requires large volumes of data, which spectroscopy can provide

Direct spectral measures of clay mineralogy

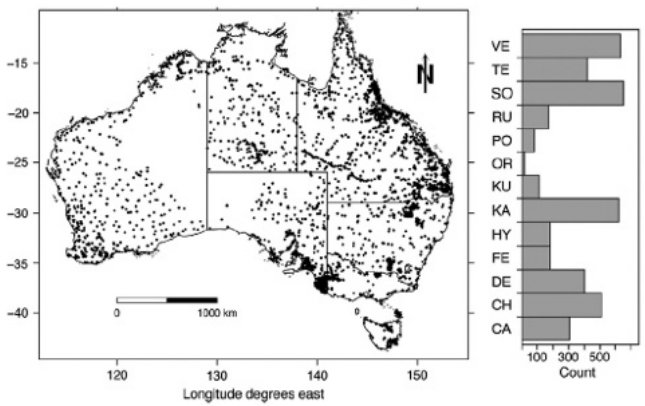
- vis–NIR spectroscopy + digital soil mapping



- Filling a gap in soil clay mineral information

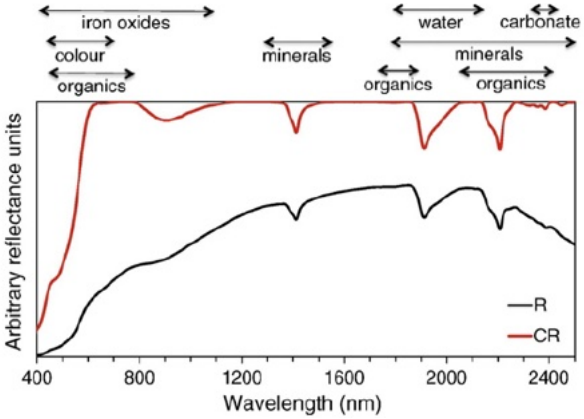
Digital soil maps of kaolinite illite, smectite
90 x 90 m

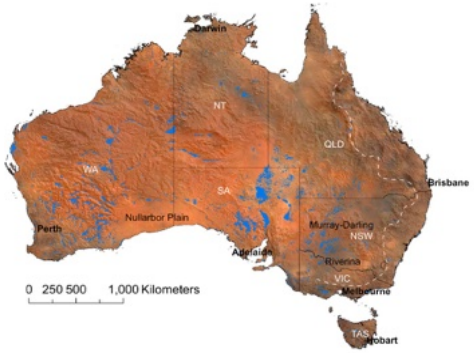
Quantifying soil colour, iron oxides, organo-mineral composition



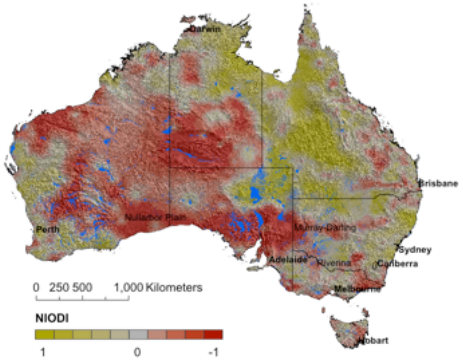
Measured vis–NIR spectra of 5,000+ archived representative soil samples from Australia

The vis–NIR spectra itself are informative, so digitally mapped their information content

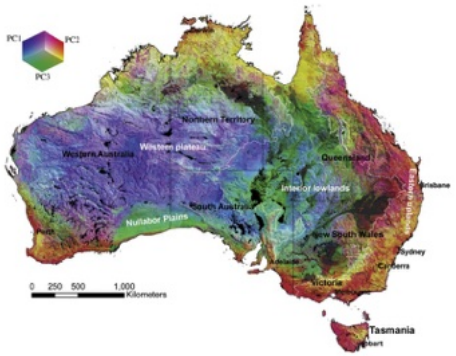




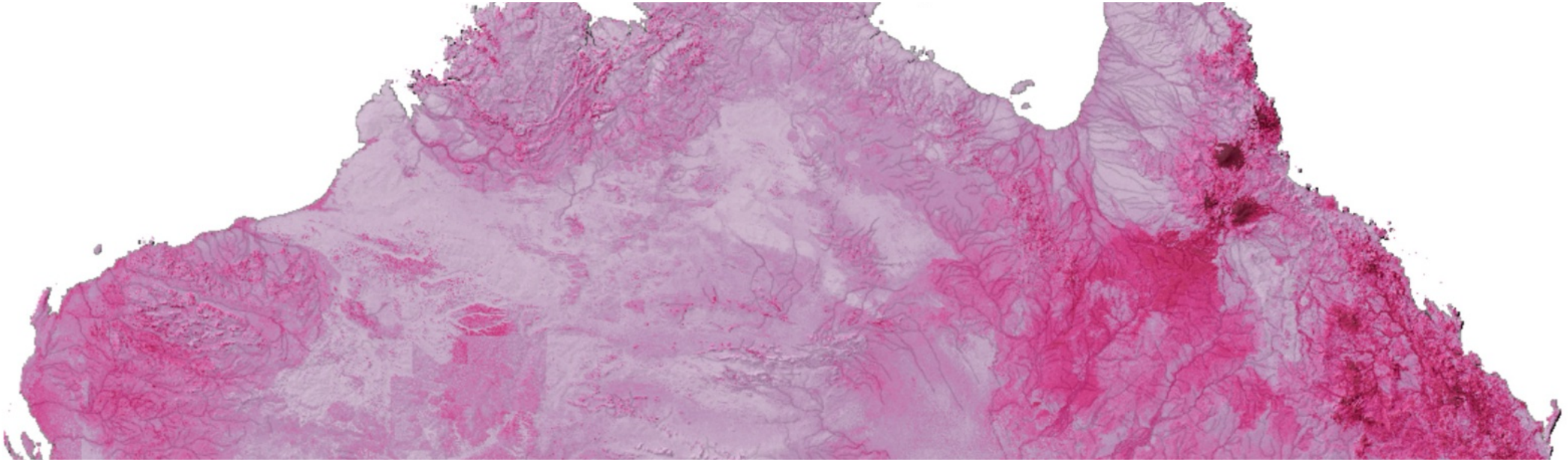
RGB composite but also maps of Munsell HVC



Probability of hematite or goethite



Proxy for soil type 90 x 90 m

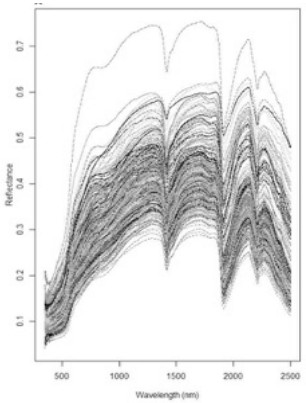


Soil spectral libraries and digital soil property mapping

Modelling soil properties requires soil spectral libraries

For example, the Australian spectral library

$y = (f)\, x$



- CSIRO's soil archive holds 50,000+ soil specimens from with an incomplete set of analytical data
- Measured 20,000+ soils with vis–NIR (& mid-IR)
- Spectroscopic modelling predicted soil attributes

Soil attribute	Mean	RMSE	SDE	ME	RPD
θ_{FC} /m^3 m^{-3}	0.32	0.06	0.06	−0.004	1.68
θ_{PWP} /m^3 m^{-3}	0.16	0.04	0.04	−0.001	1.95
$\text{Log}_{10}(W)$	0.56	0.21	0.21	0.005	1.54
Bulk density /g cm^{-3}	1.32	0.15	0.15	−0.003	1.87
Clay /%	32.0	8.49	8.48	0.51	2.35
Silt /%	12.5	5.50	5.47	0.58	1.63
Coarse sand /%	30.4	13.56	13.50	1.29	1.61
Fine sand /%	26.1	9.77	9.74	0.74	1.60
Total sand /%	55.1	12.00	12.00	−0.13	2.06
Log_{10}(Organic C)	-0.26	0.25	0.25	−0.01	2.17
Log_{10}(Total K)	-0.50	0.33	0.33	−0.04	1.87
Log_{10}(Total N)	-1.30	0.25	0.25	0.001	2.11
Log_{10}(C:N)	1.18	0.19	0.19	−0.001	1.40
Log_{10}(Total P)	-1.66	0.27	0.27	0.00	1.75
Log_{10}(Available P)	0.91	0.42	0.42	0.007	1.39
pH_{Ca}	5.31	0.57	0.57	0.05	2.16
pH_{Water}	6.95	0.63	0.63	0.002	2.28
CEC /cmol(+)kg^{-1}	15.6	7.08	7.06	0.51	2.13
Log_{10}(Exch. acidity)	0.42	0.28	0.28	0.009	1.49
Exch. Ca^{2+} /cmol(+)kg^{-1}	7.91	3.77	3.77	0.17	2.34
Log_{10}(Exch. K^+)	-0.49	0.34	0.34	−0.02	1.65
Exch. Mg^{2+} /cmol(+)kg^{-1}	5.49	2.58	2.58	0.16	2.30
Log_{10}(Exch. Na^+)	-0.41	0.37	0.37	0.0005	2.10
Extractable Fe /%	4.65	2.61	2.61	0.05	1.81

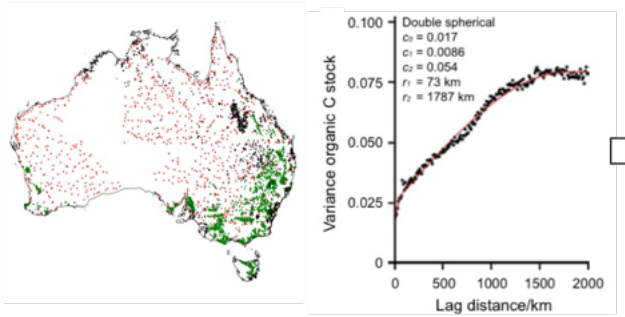
The Australian soil organic C baseline – facilitated by spectroscopy

Years 2000 to 2013 only

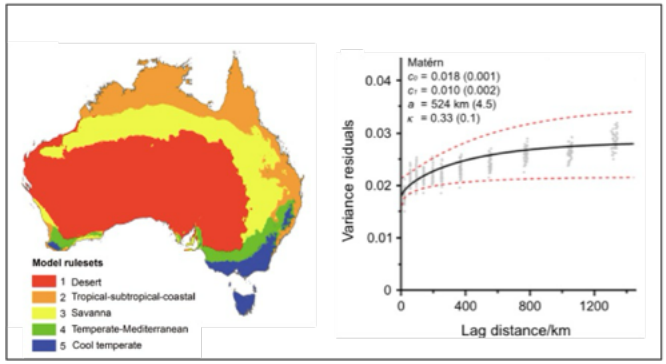
SCaRP data | vis–NIR estimates | Legacy data

Harmonised to 0–30 cm

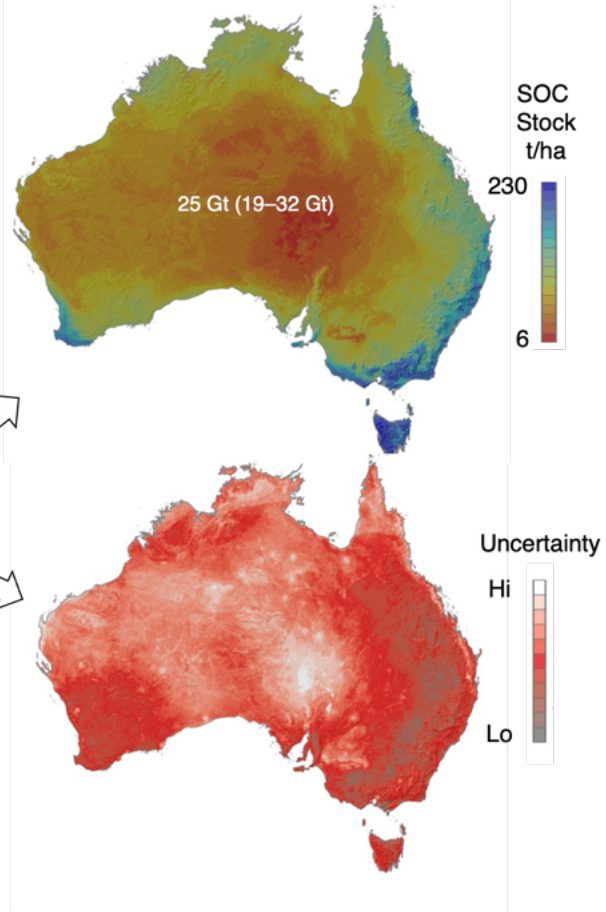
$C_S = (C \times \rho) \times (1-g)$



$$\hat{C}_S^b(\mathbf{u}_0) = \hat{\mu}_S^b(\mathbf{u}_0) + \hat{\varepsilon}_S^b(\mathbf{u}_0)$$



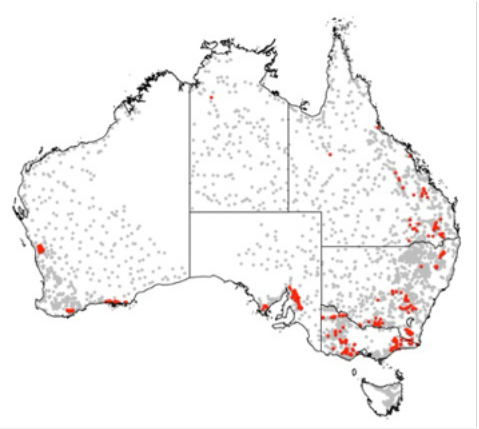
Continentally, climate is the biggest driver in the modelling. Regionally, soil, mineralogy, terrain and vegetation are important.



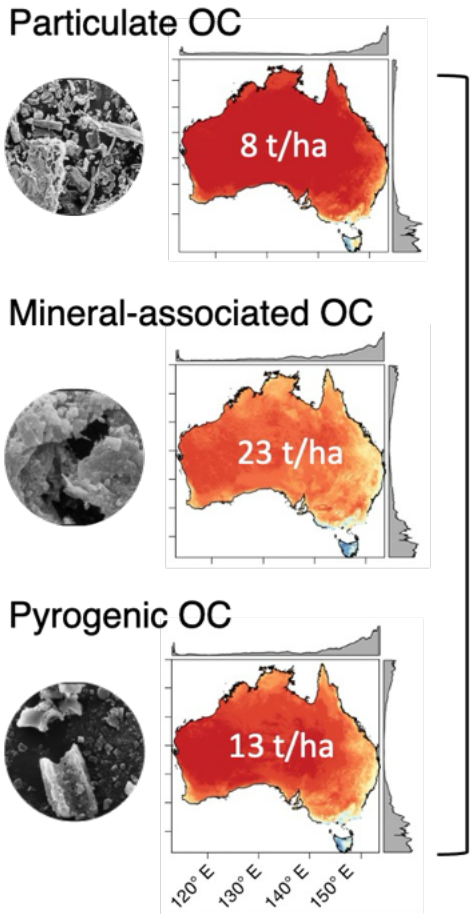
Viscarra Rossel et al. (2014)

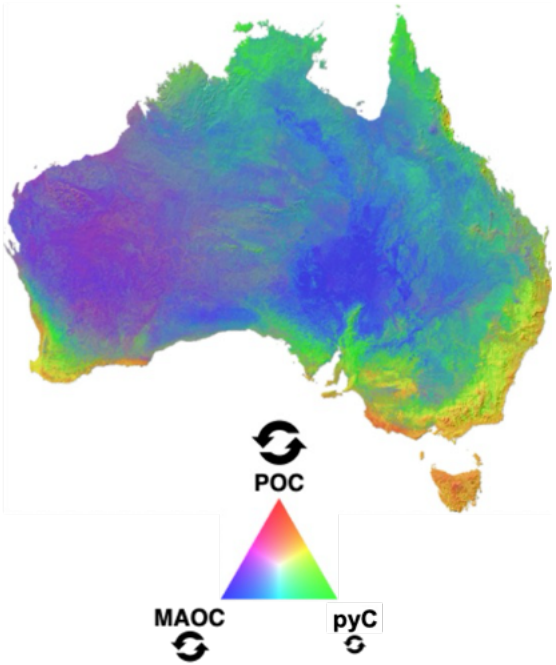
Spatial modelling of soil C composition – facilitated by spectroscopy

- Physical fractionation & NMR
- Spectral estimates of the POC, MAOC, PyC



- Digital soil mapping of the C fractions using environmental correlation with machine learning

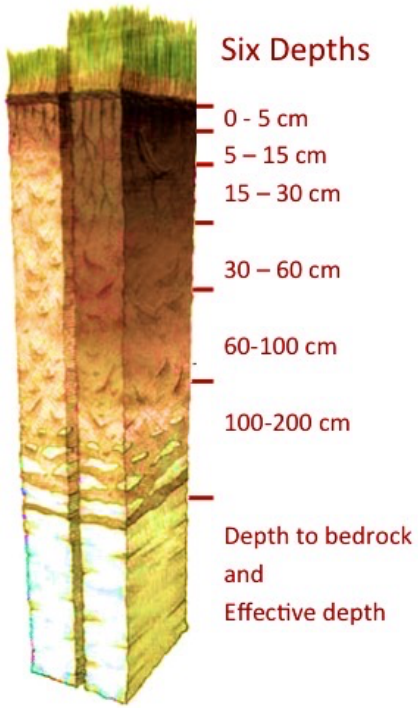


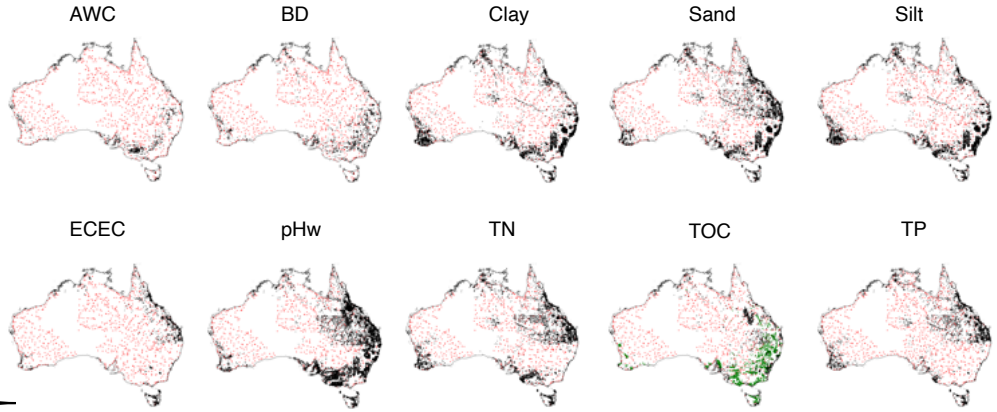


Baldock et al. (2013); Viscarra Rossel & Hicks (2015); Viscarra Rossel et al. (2019)

Australian digital soil property mapping enabled by spectroscopy

SLGA project to derive spatially explicit soil information to better understand interactions with other ecosystem components.



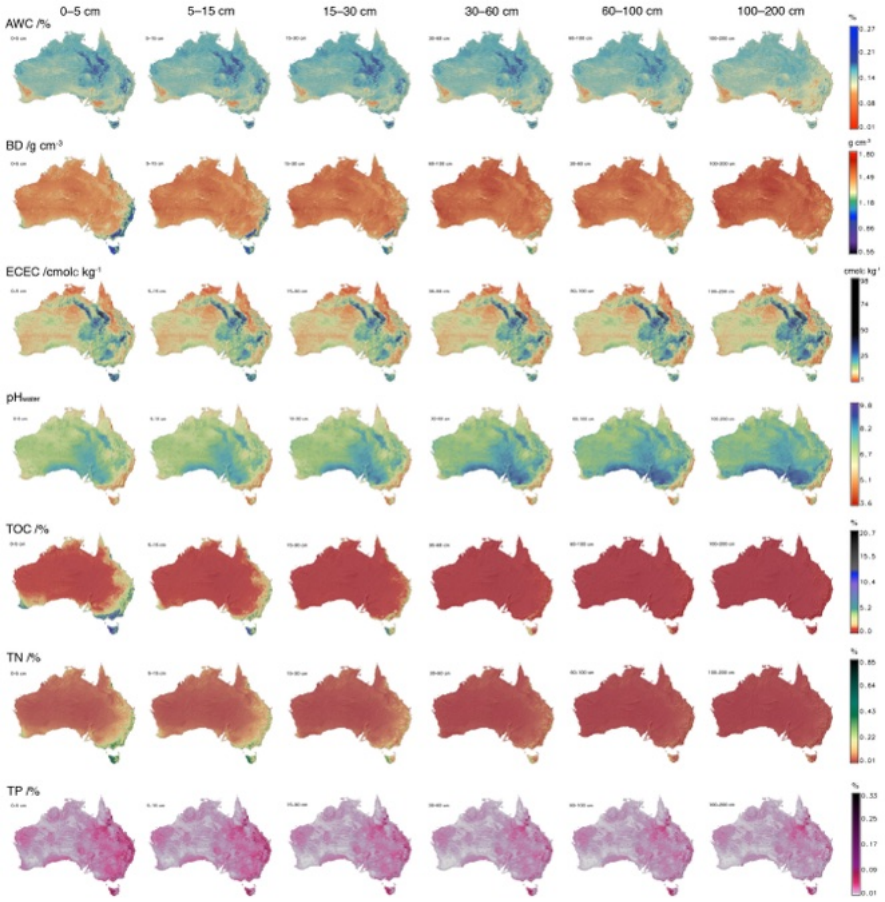


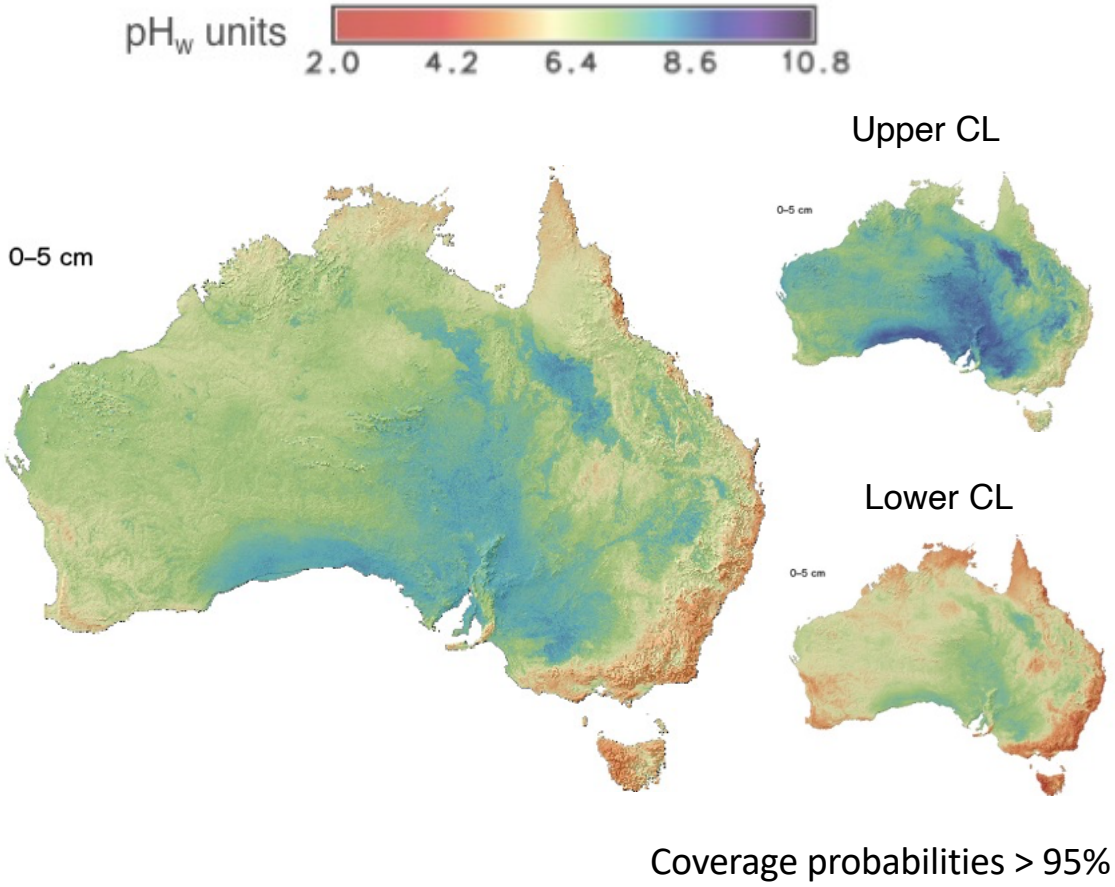
Combined soil property data + **spectroscopic predictions** of soil attributes **enabled continental scale digital soil mapping:** $S_a = f(cl, o, r, p, t)$

$$\widehat{S}^b_{\mathrm{A}}(\mathbf{u}_0, d) = \widehat{\mu}^b_{\mathrm{A}}(\mathbf{u}_0, d) + \widehat{\varepsilon}^b(\mathbf{u}_0, d)$$

Viscarra Rossel et al. (2015); Grundy et al., (2015); Behrens et al. (2015) SR Special Issue

3D maps of soil properties





Coverage probabilities > 95%

Viscarra Rossel et al. (2015); Grundy et al., (2015); Behrens et al. (2015) SR Special Issue

Thank you.

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