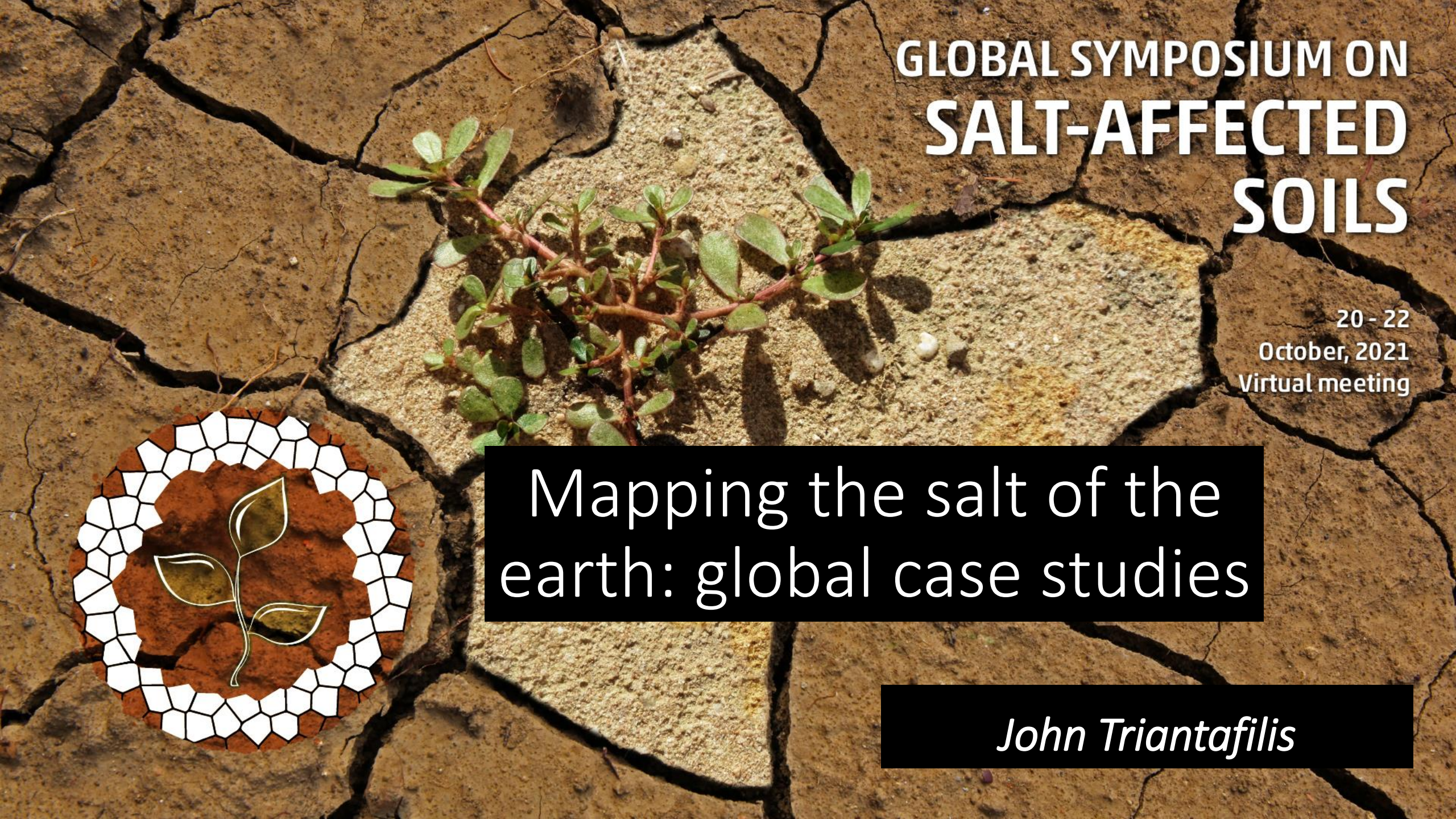
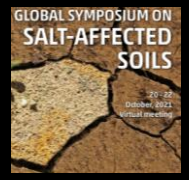



# Mapping the salt of the earth: global case studies

*John Triantafilis*




# Tēnā koutou katoa

(Greetings to you all)

Manaaki Whenua
Landcare Research

Our Land, Our Future
Tō tātou whenua, mō āpōpō

Home / About us / Our people

## John Triantafilis

Portfolio Leader - Managing Land & Water

Soils & Landscapes

"Pepeha"

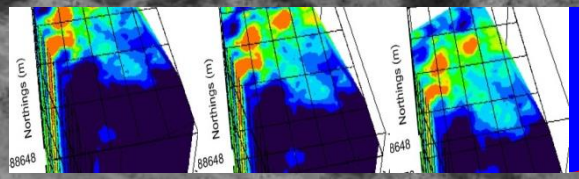
The "Acropolis" is the mountain that speaks to my heart
The "Parramatta" is the river in Sydney that alleviates my worries
I recognise the ancestral/spiritual landmarks of "Aoteaora-New Zealand; the land of the long white cloud"
My name is "John Triantafilis (literally "thirty petals" in Greek which means a rose flower)"
I am from "the land of droughts and flooding rains"

# Quasi-3D modelling of dryland and irrigation salinity using a DUALEM data and EM4Soil inversion modelling

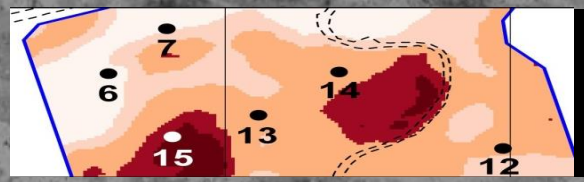
Huang J, Kiliminster T, Zare E
Barrett-Lennard E, Monteiro Santos FA, Triantafilis J

Problem Definition?

Materials and Methods



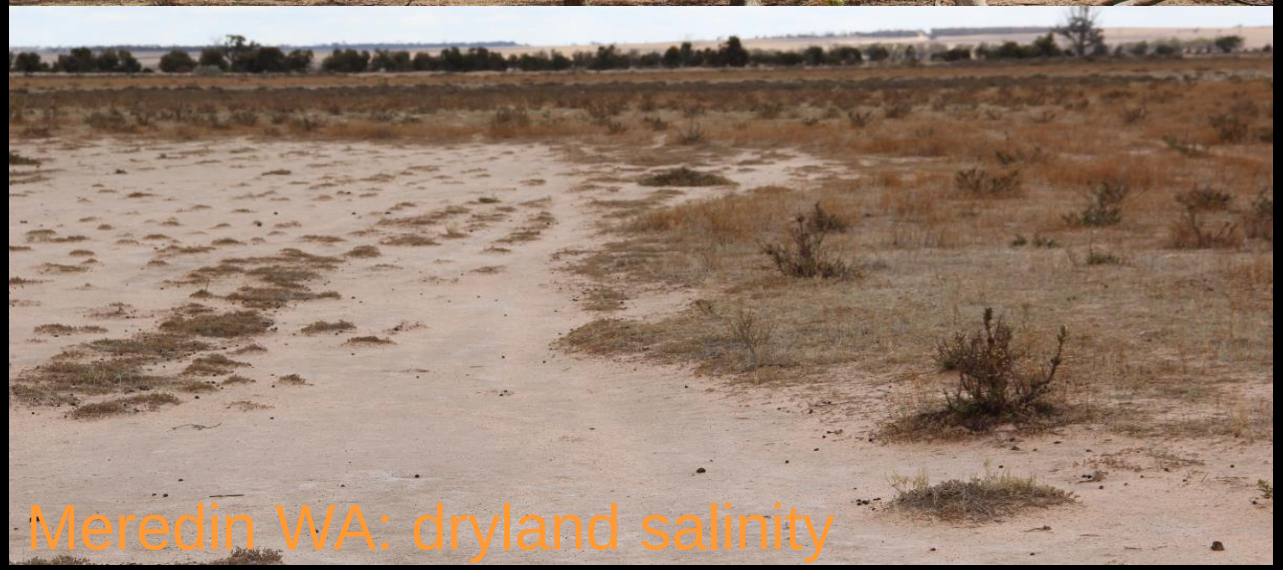

EM4Soil




Results, Discussion & Conclusions

## Talk Outline

# Problem definition (dryland salinity)



Meredin WA: dryland salinity

## Significance of soil salinisation

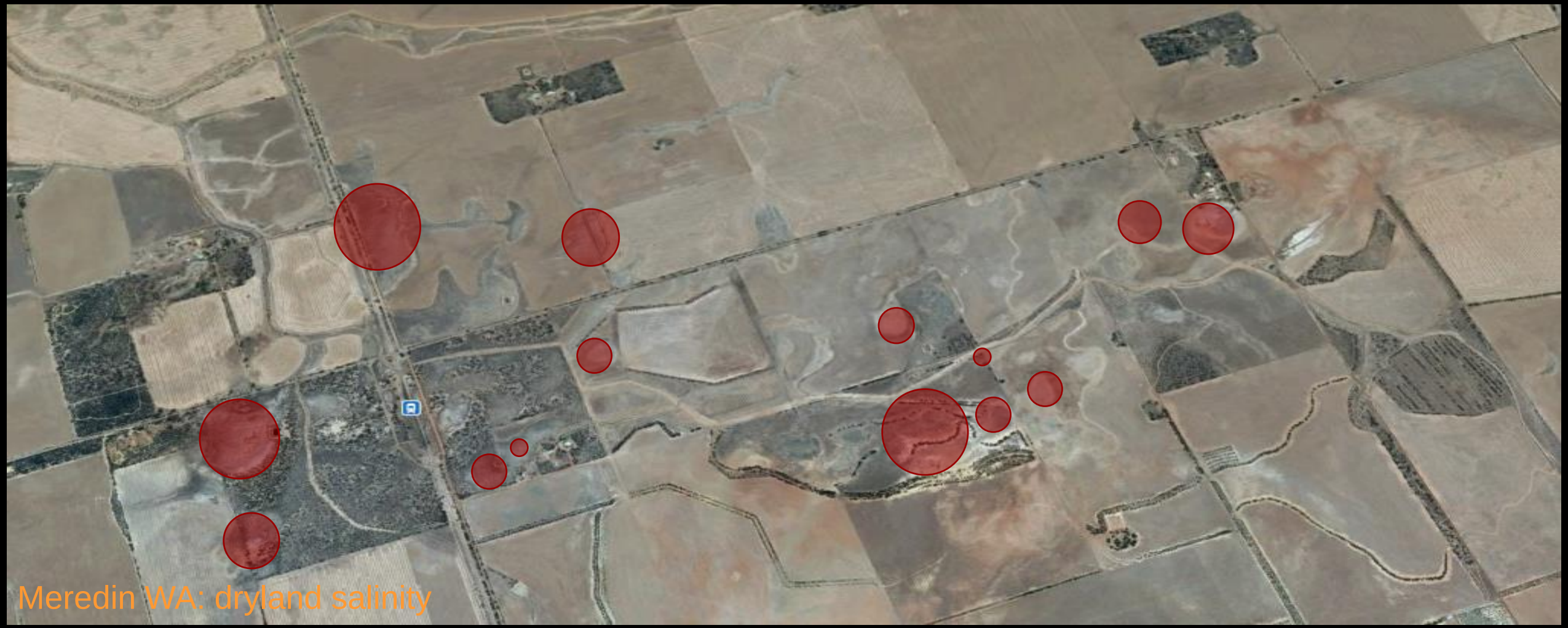
In the wheat-sheep belt of WA a substantial area of land is affected by dryland salinity, due to saline shallow watertables.

This is because perennial native vegetation that used most rainfall, replaced with annual crops/pastures, that use less

This leads to deep drainage and mobilisation of stored Aeolian, cyclical and connate salts.

# Problem definition (dryland salinity)

**This is because it is insidious**



Meredin WA: dryland salinity

# Problem definition (irrigation salinity)

Bourke NSW: irrigation salinity

## Significance of soil salinisation

In many part of the highly productive Murray-Darling Basin irrigation salinity, is due to saline shallow watertables.

This is because irrigation inefficiencies have resulted in mobilisation of stored Aeolian, cyclical and connate salts.

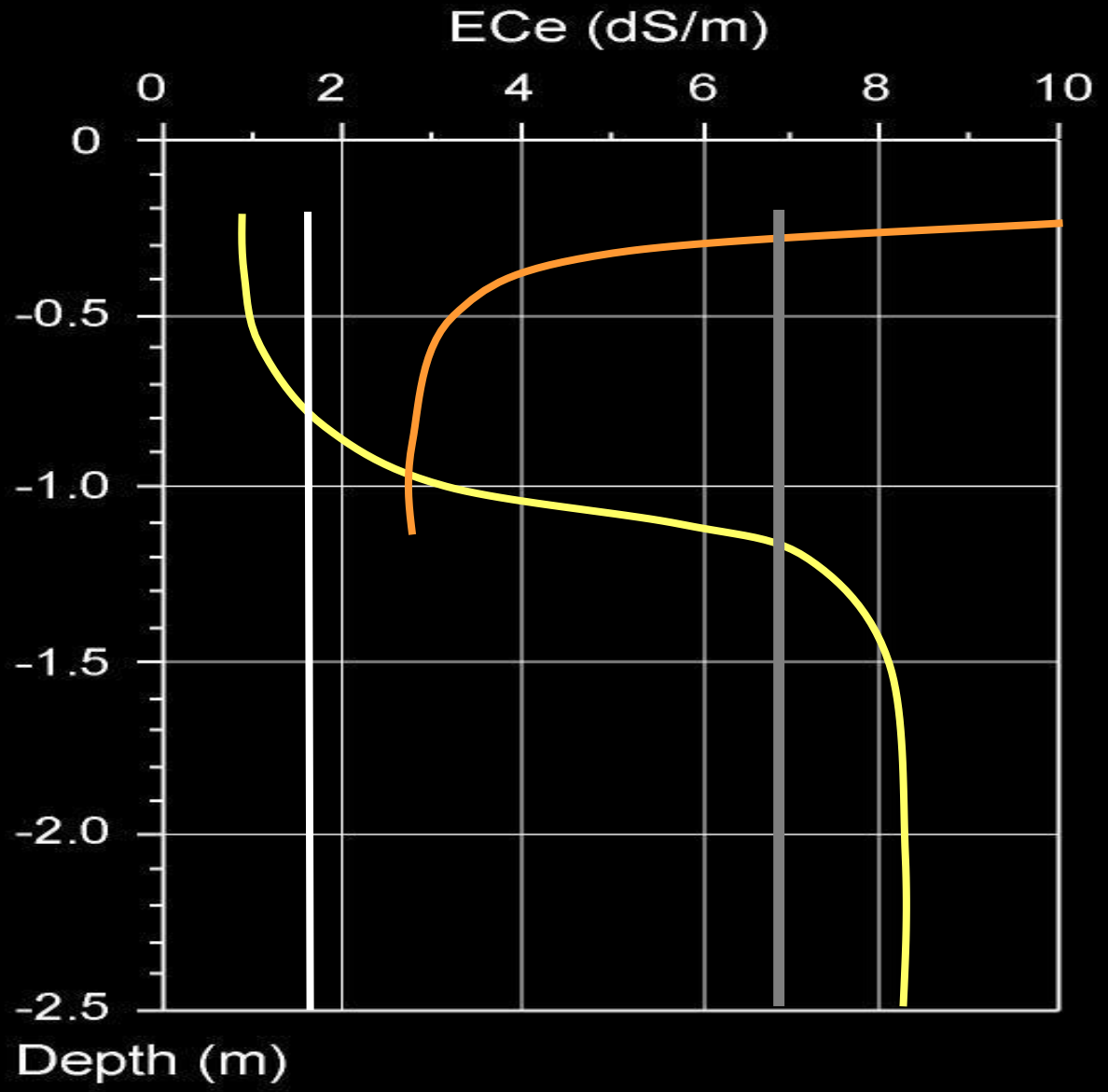
To understand limitation and determine best management, concentrations of salt needs determination with variation mapped.

# Problem definition (irrigation salinity)

**This is because it is insidious**

Bourke NSW: irrigation salinity

# Problem definition




**Salinity Profiles**

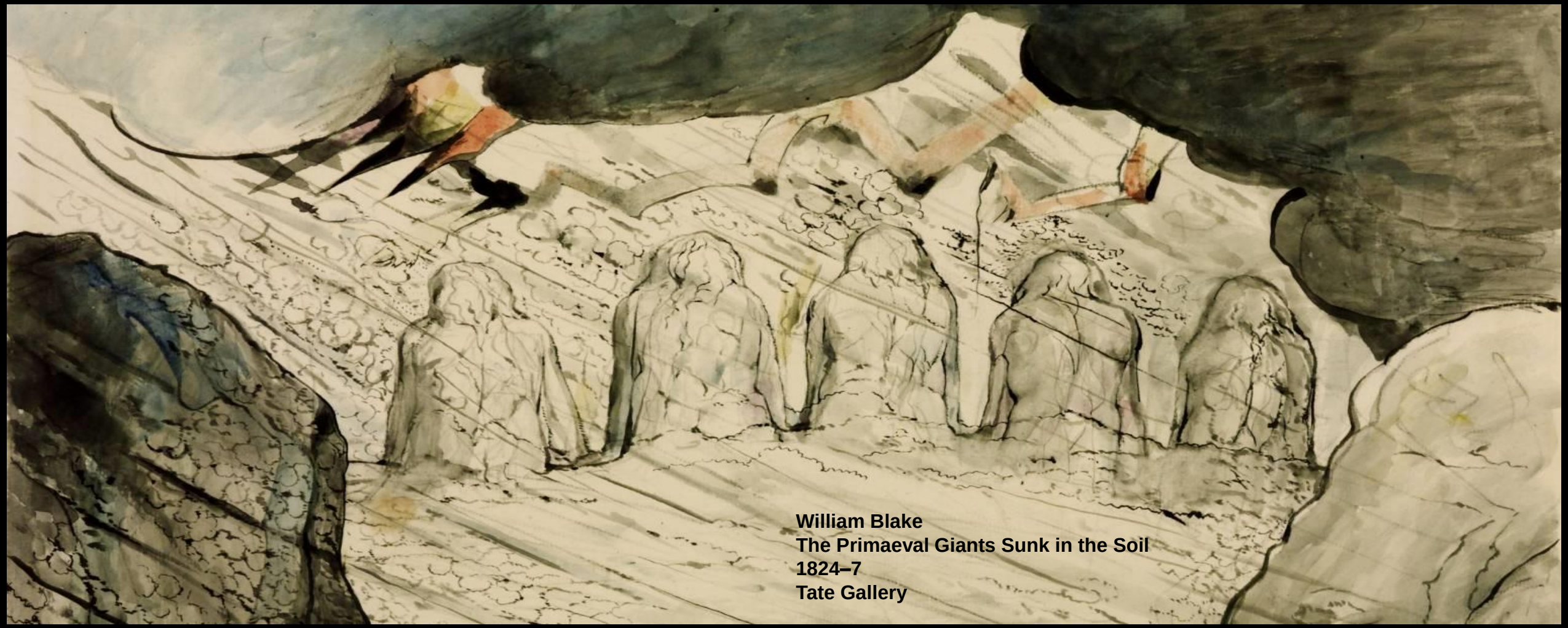
Normal:
salinity increases with depth to a maximum, whereby older soil generally more salt accumulates

Leached:
non-saline indicates deep drainage of good quality irrigation water and saline indicates application of saline irrigation water

Inverted:
salinity increases toward surface and suggests presence of water table, capillary rise and mobilization of salts into topsoil

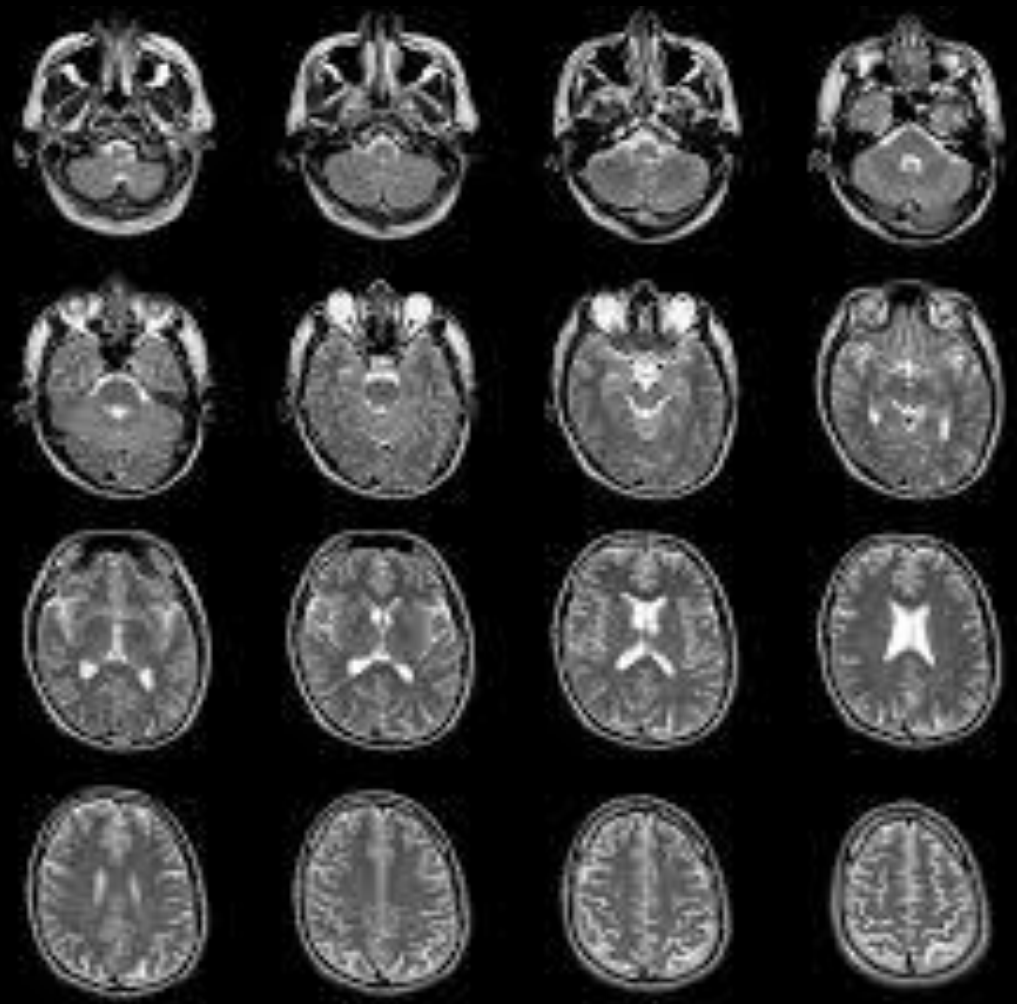
# Can we map salinity in 2/3D?

**Where to from here?**



**William Blake**
**The Primaeval Giants Sunk in the Soil**
**1824–7**
**Tate Gallery**

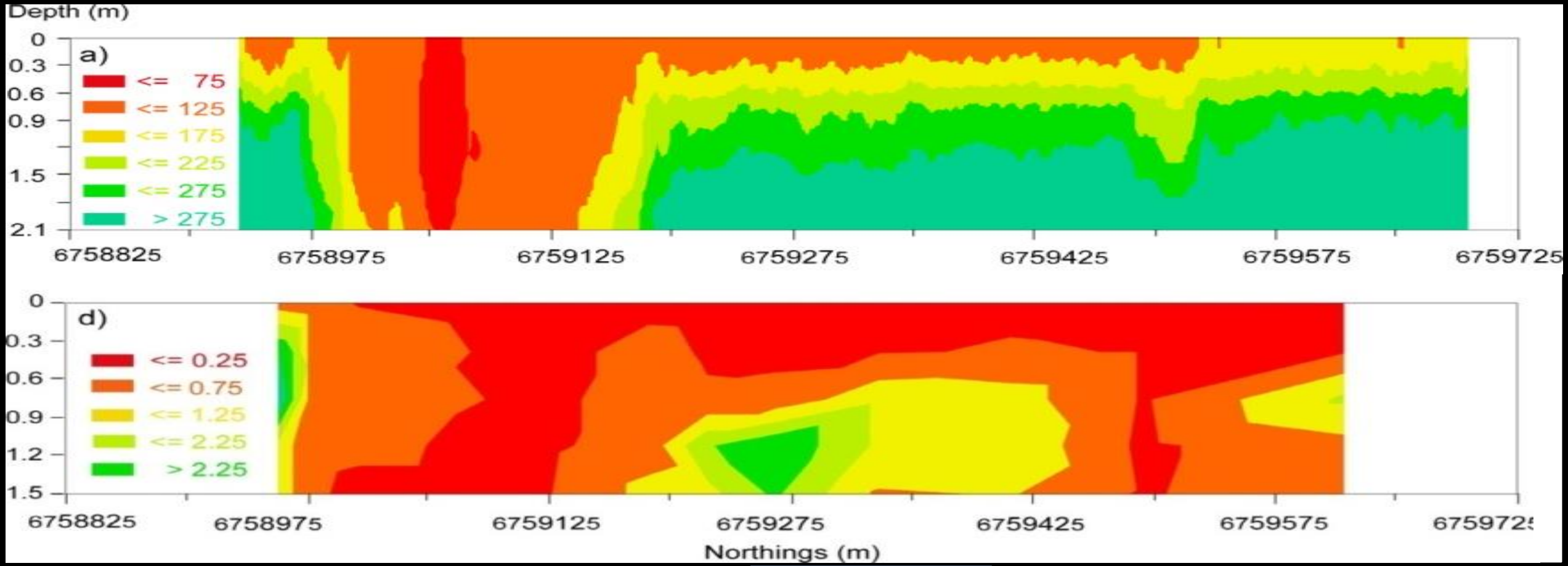
# In medicine



**Magnetic Resonance Imaging (MRI)**

# Electromagnetic conductivity imaging (EMCI) of soil using a DUALEM-421 and inversion software (EM4Soil)

Triantafilis, J.
Monteiro Santos, F.A.




GEODERMA 211-212, 28-38

# Materials and methods



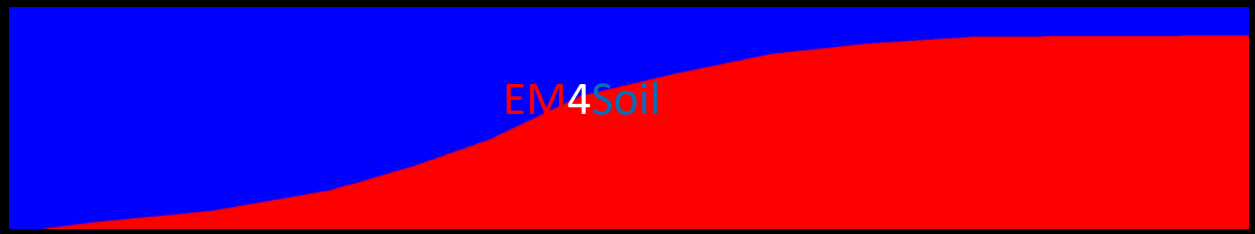
**Research Question**

Can we use a
single frequency and
multiple array



+

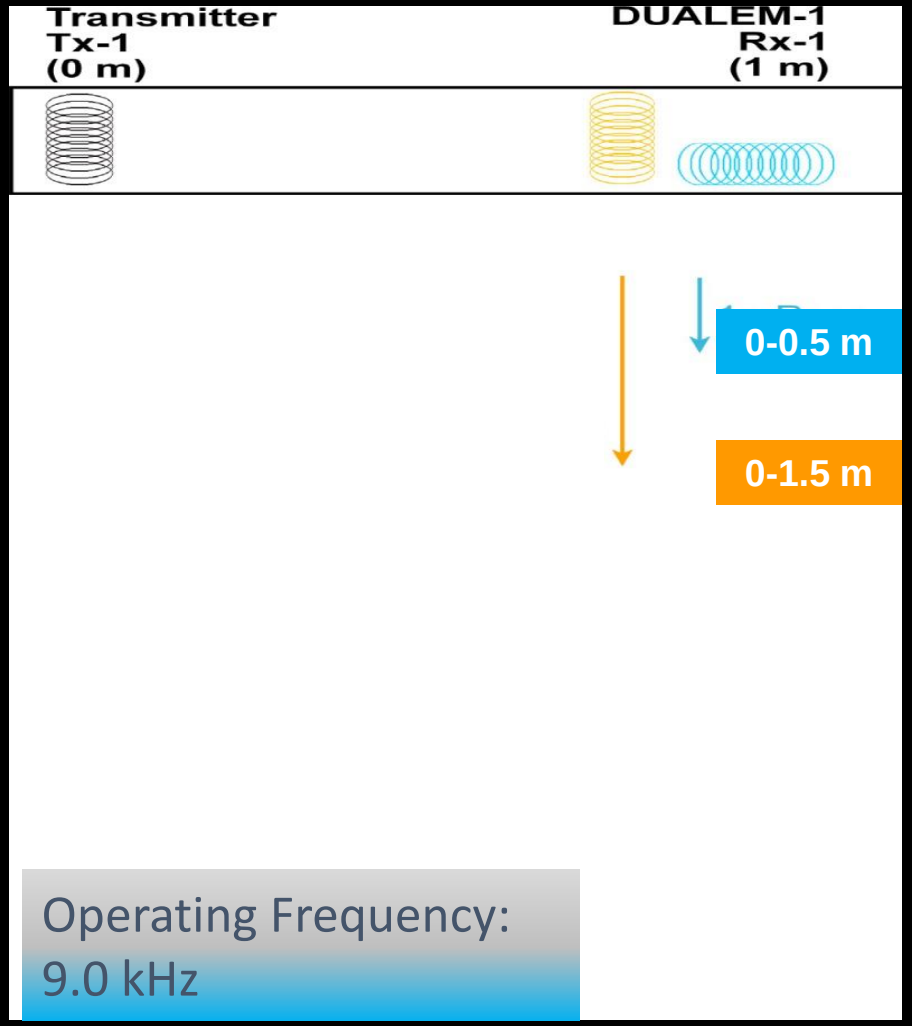
1-dimensional inversion software




To generate quasi-3d EMCI
to represent
dryland and irrigation salinity status

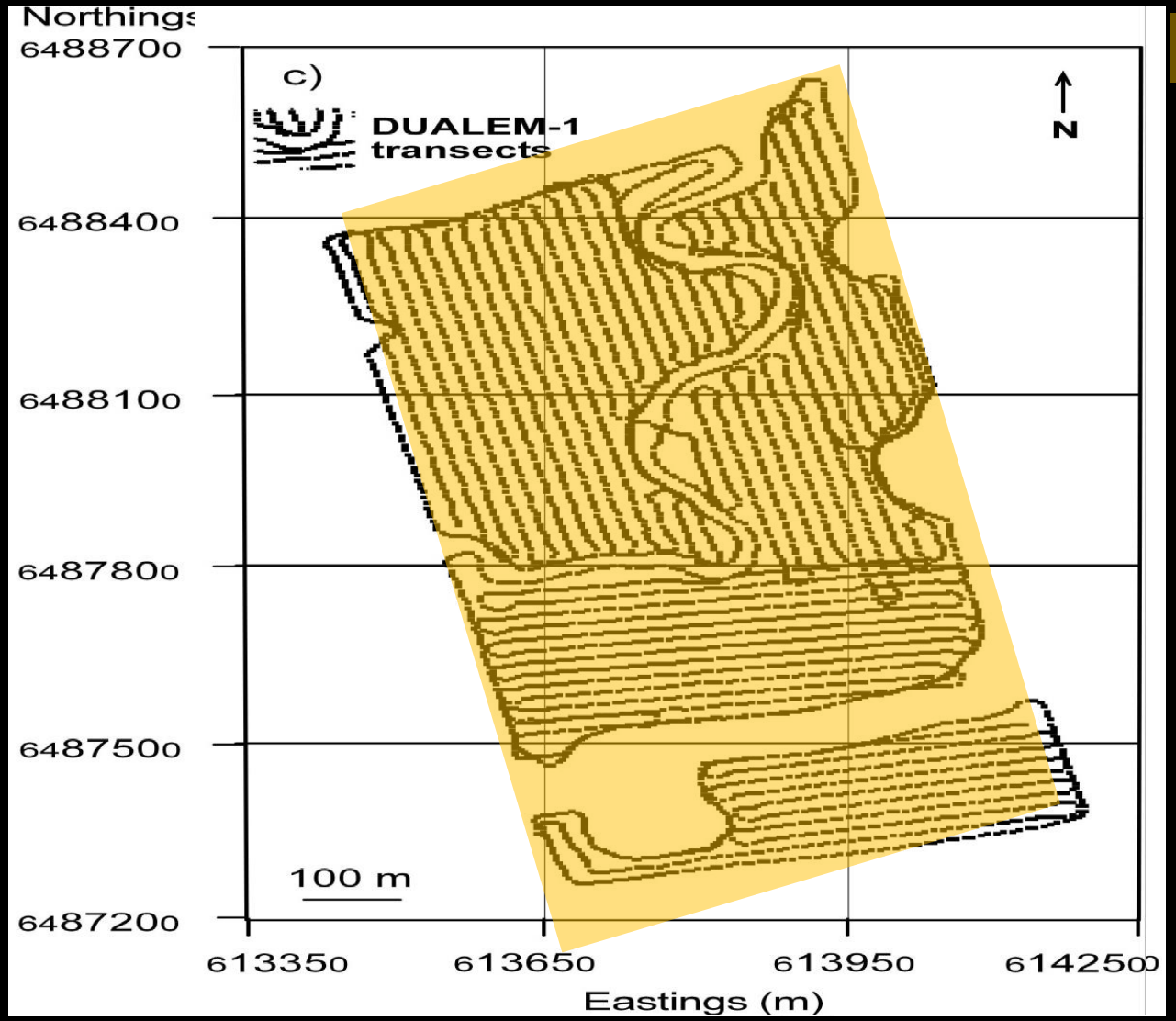
# DUALEM- 1

**Theoretical depth of $\sigma_a$ measurement**




Operating Frequency:
9.0 kHz

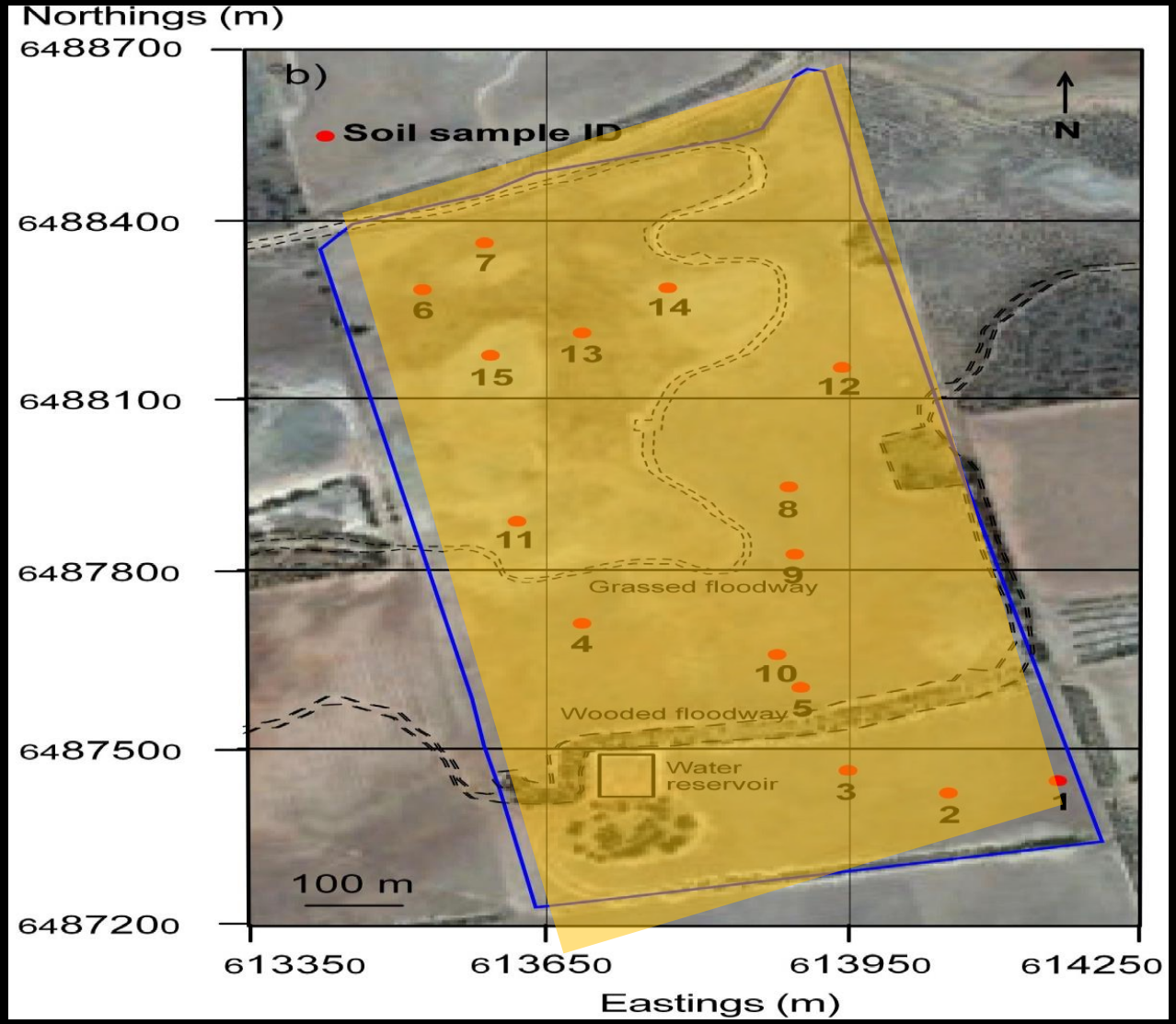
# Materials & methods (dryland salinity)




**DUALEM- 1 Survey**

Area: 36 ha.
Sites: 10,000
Spacing: 20 m

# Materials & methods (dryland salinity)



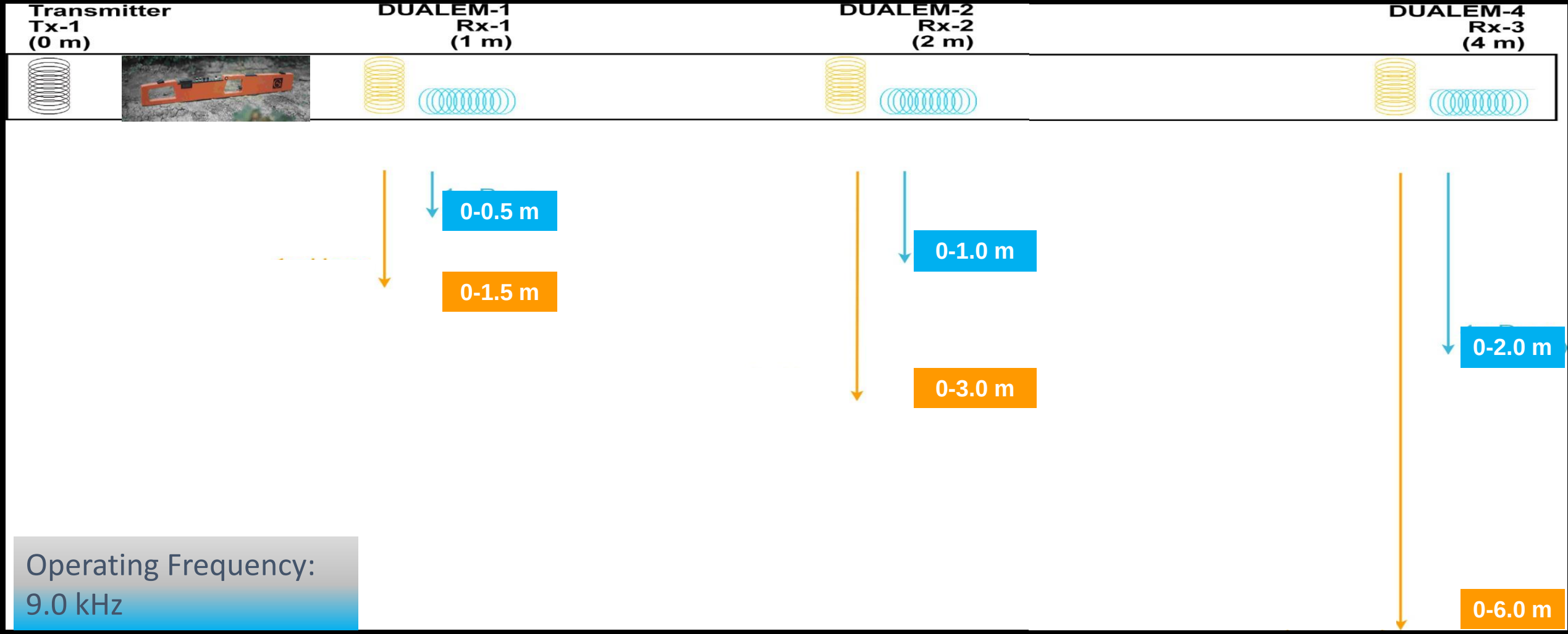

## Soil sampling

Sites: 15 (7th percentile)

Depths: 0.00-0.25 m,
0.25-0.50 m,
0.50-0.75 m, &
0.75-1.00 m

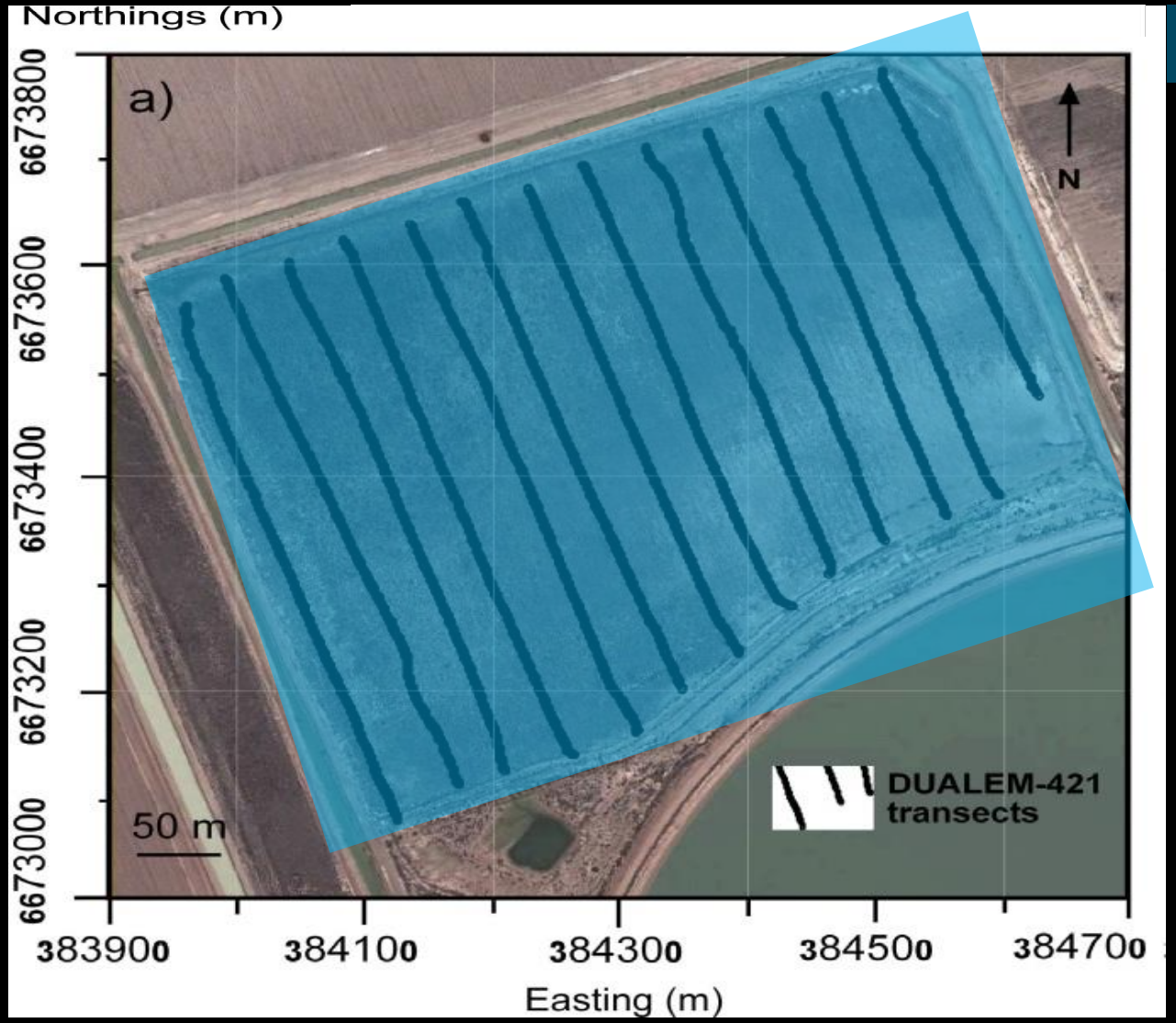
# DUALEM-421

## Theoretical depth of $\sigma_a$ measurement



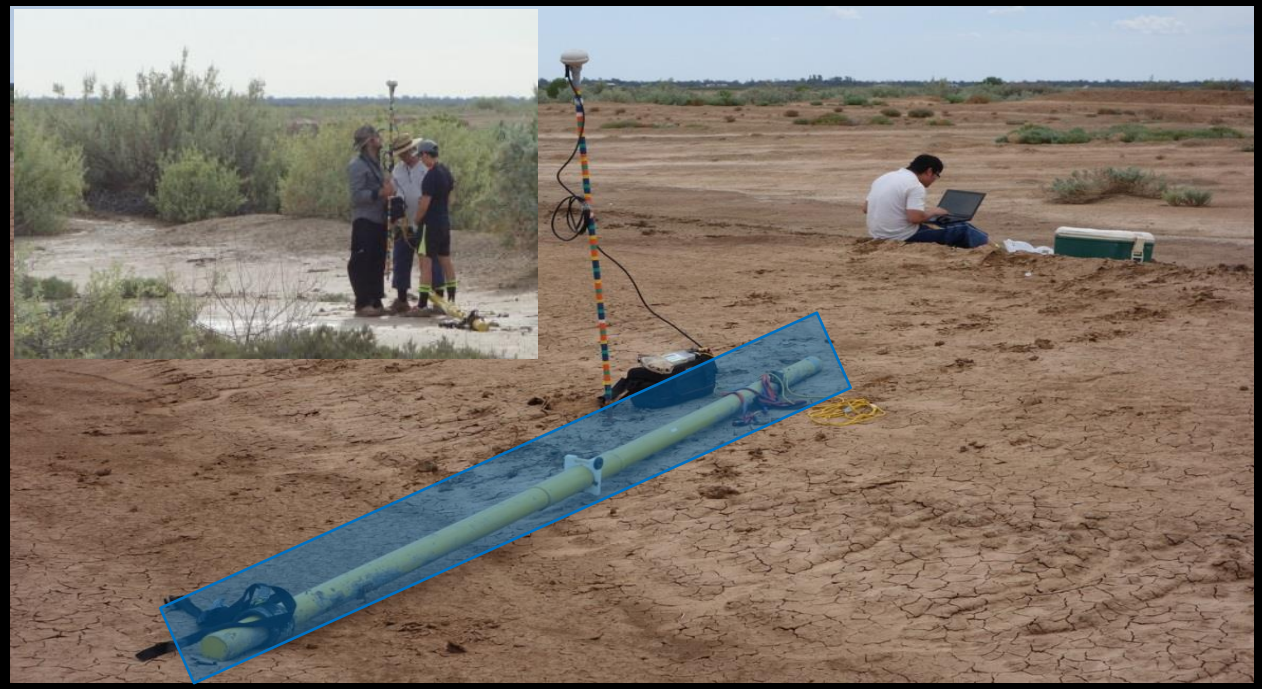

Operating Frequency:
9.0 kHz

# Materials & methods (irrigation salinity)

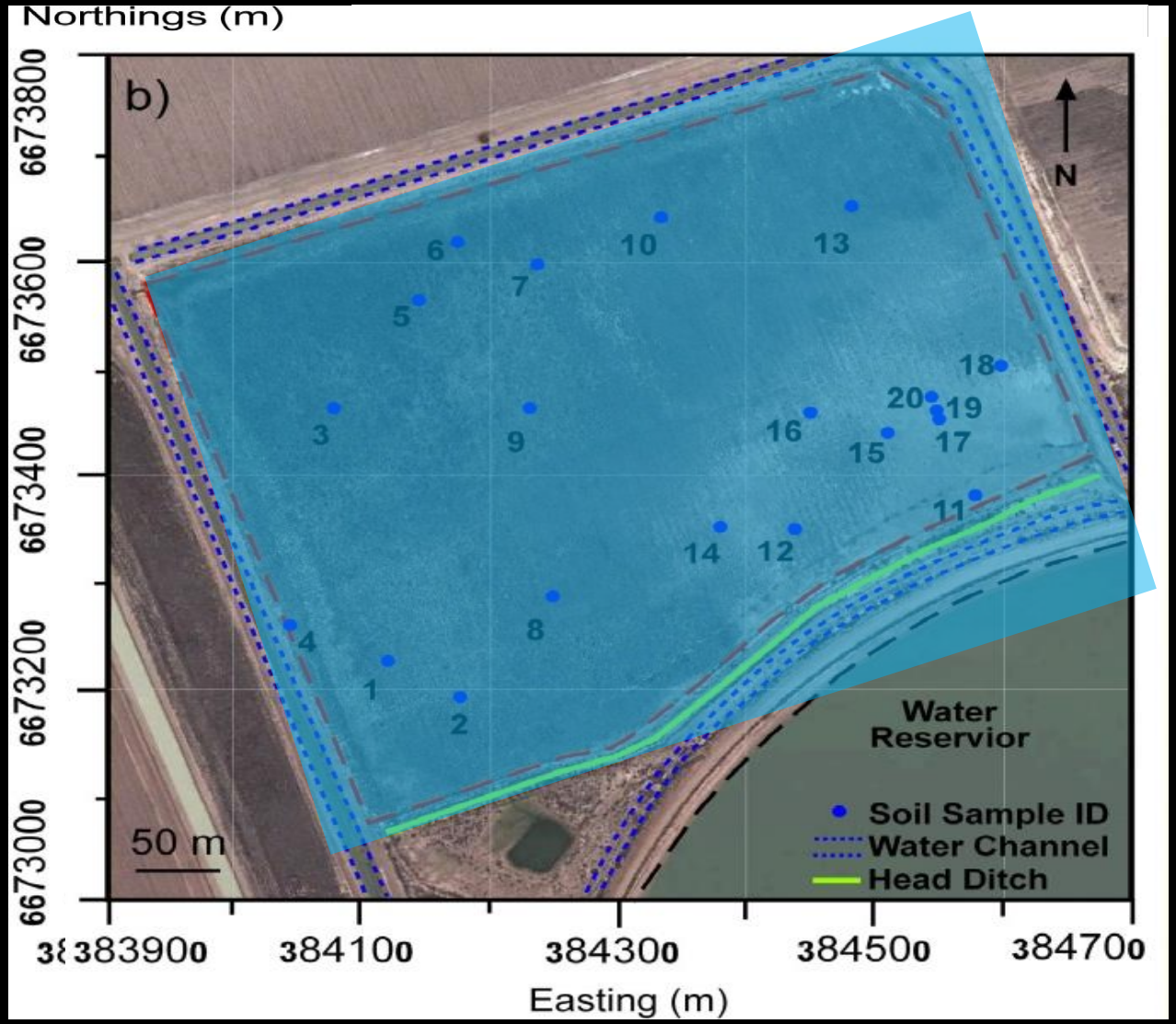



**DUALEM-421 Survey**

| | |
|---|---|
| Area: | 30 ha |
| Sites: | 5,000 |
| Spacing: | 50 m |



# Materials & methods (irrigation salinity)




## Soil sampling

Sites: 20 (5th percentile)

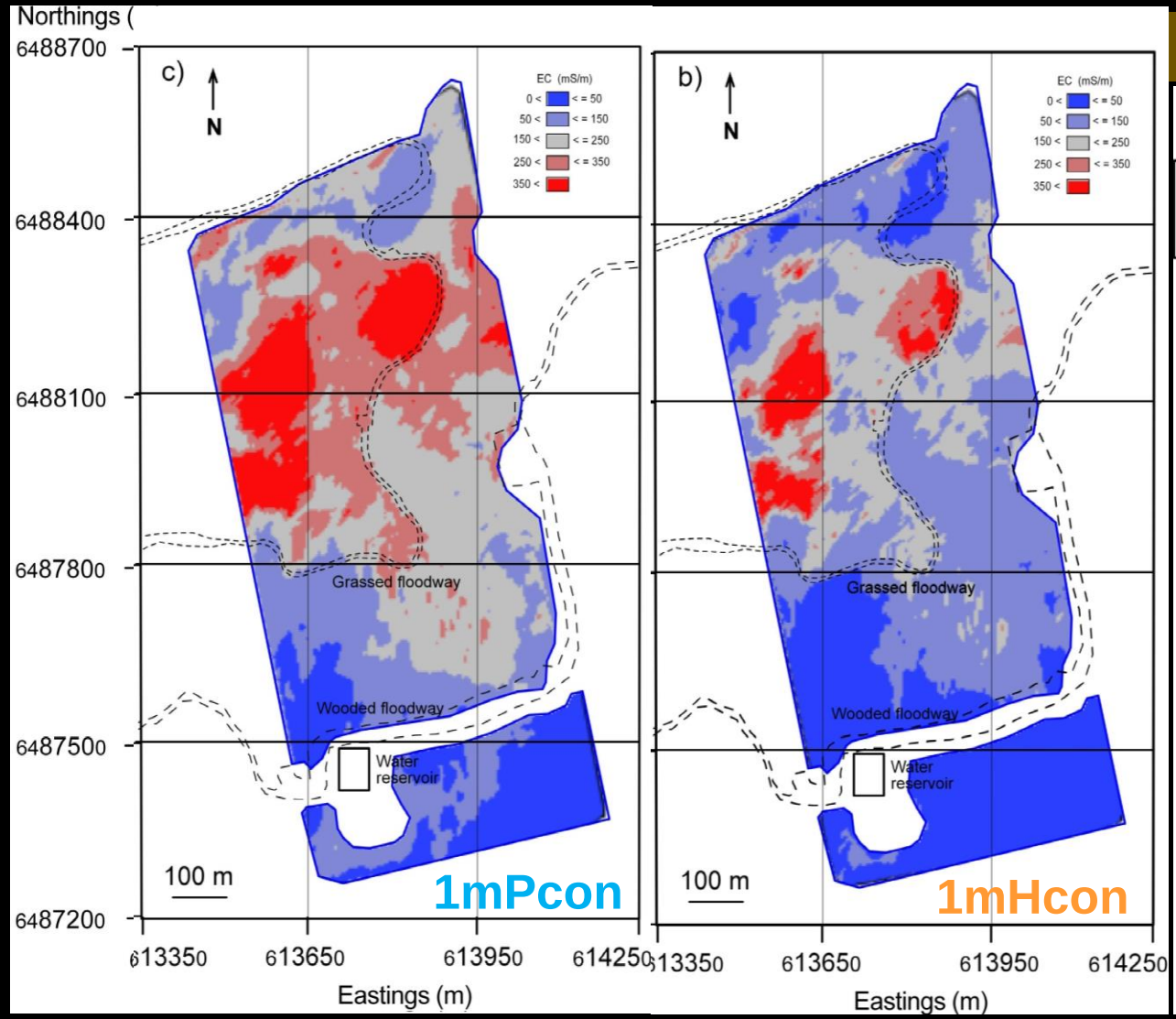
Depths: 0-0.3,
0.3-0.6 m,
0.6-0.9 m, and
0.9-1.2 m

# Materials & methods

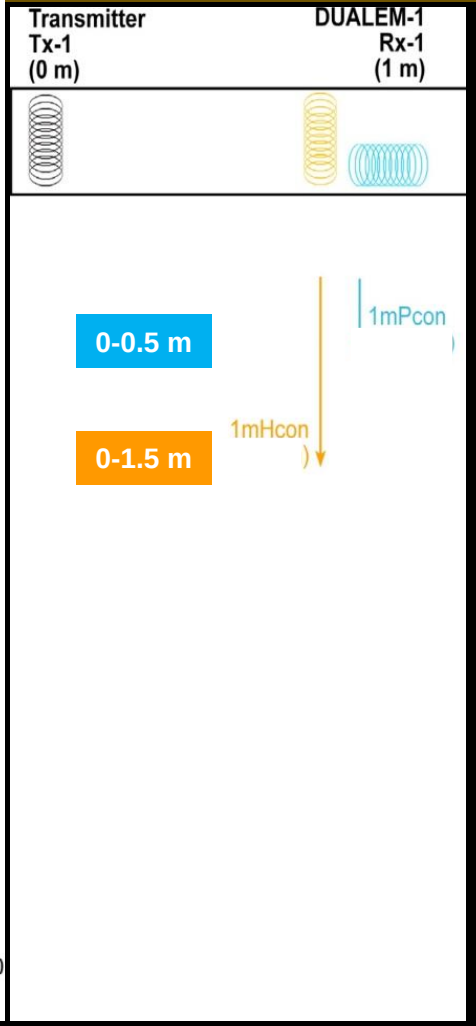
**Laboratory analysis**

$EC_e$ – dS/m

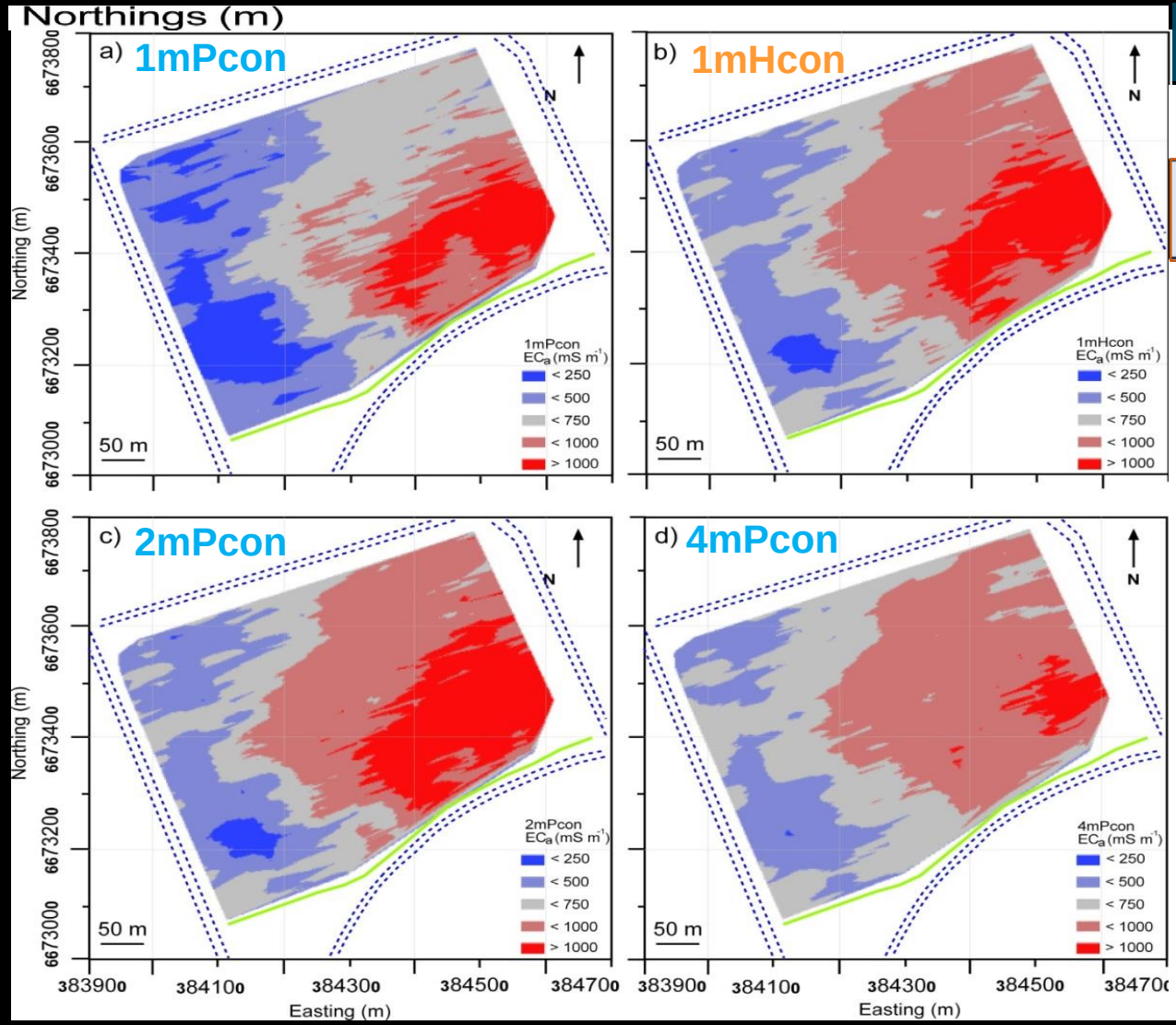
# Results & Discussion (dryland salinity)



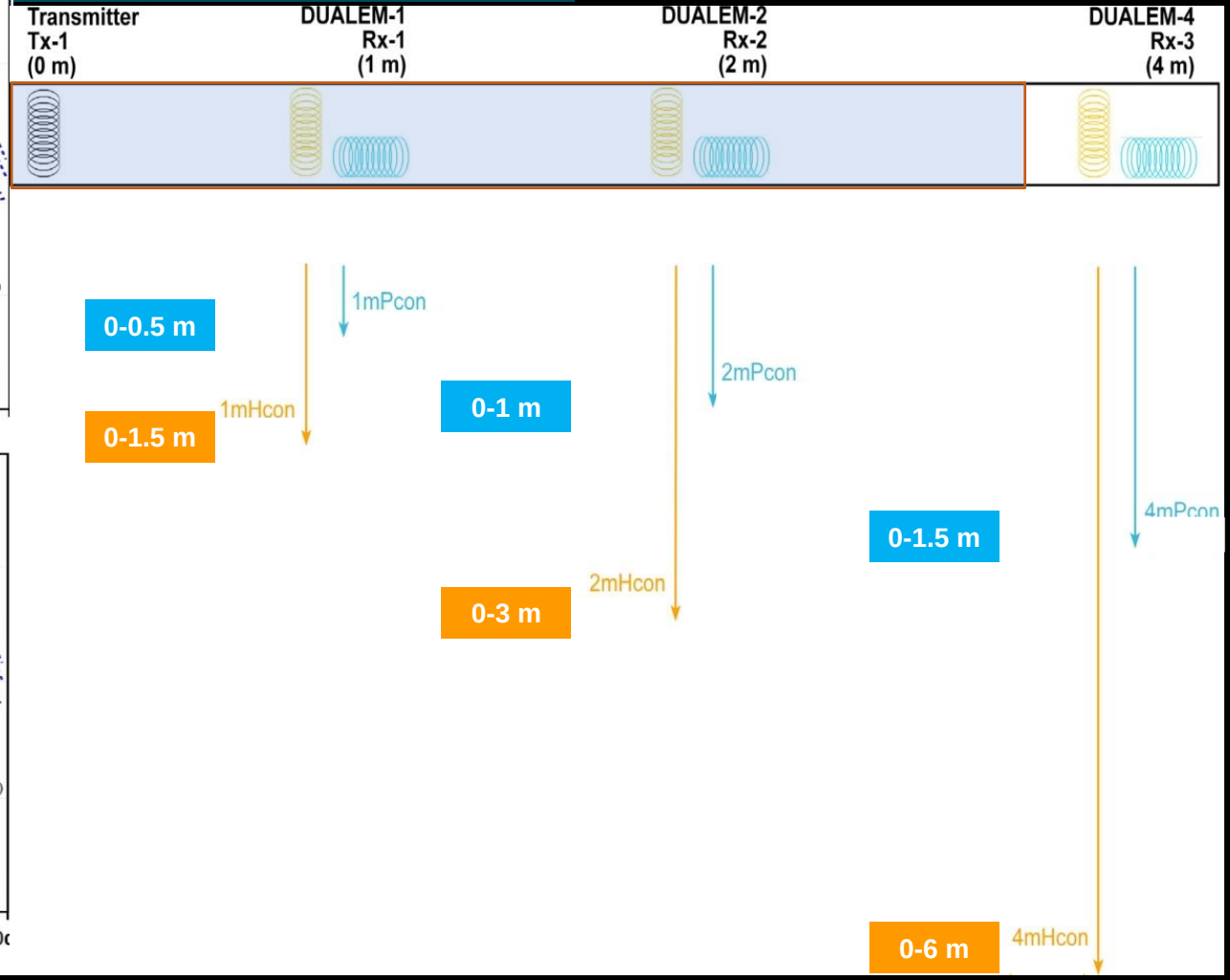

**DUALEM- 1 Survey**

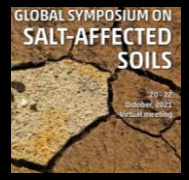


# Results & Discussion (irrigation salinity)




## DUALEM-421 Survey






# EM4Soil

**Quasi-2d and 3d inversion software**

EM4Soil-v1: EM Laterally Constrained Inversion

Exit Survey Input Data Processing Inversion Display Settings Save Print Help About

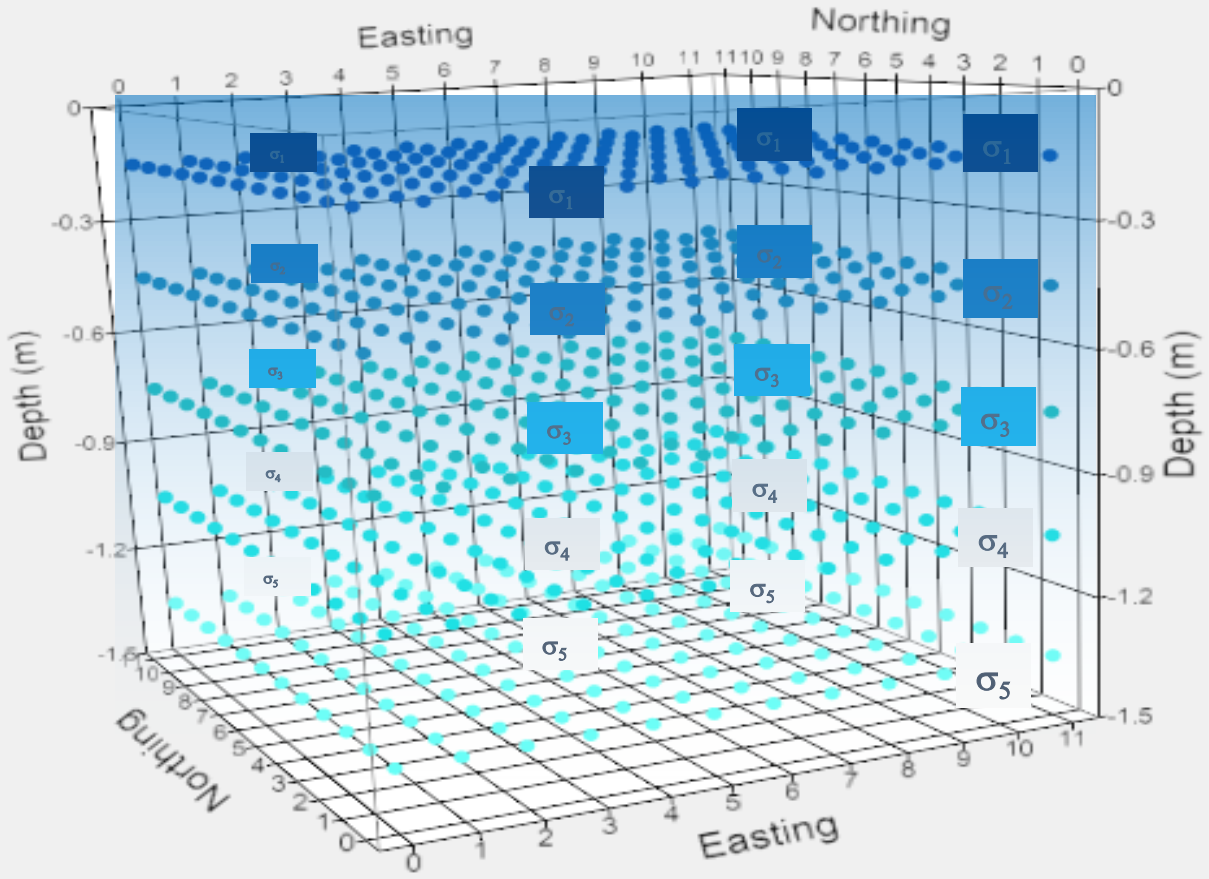
Action:

- Plot Raw Data
- Plot Filtered Data
- Plot Decimated Data
- Plot Noise Analysis
- Plot Neg.Corrected
- Plot B-L Corrected
- Plot Initial Model
- Plot Inverted Model
- Plot Data/Response
- Plot DOI
- Quit

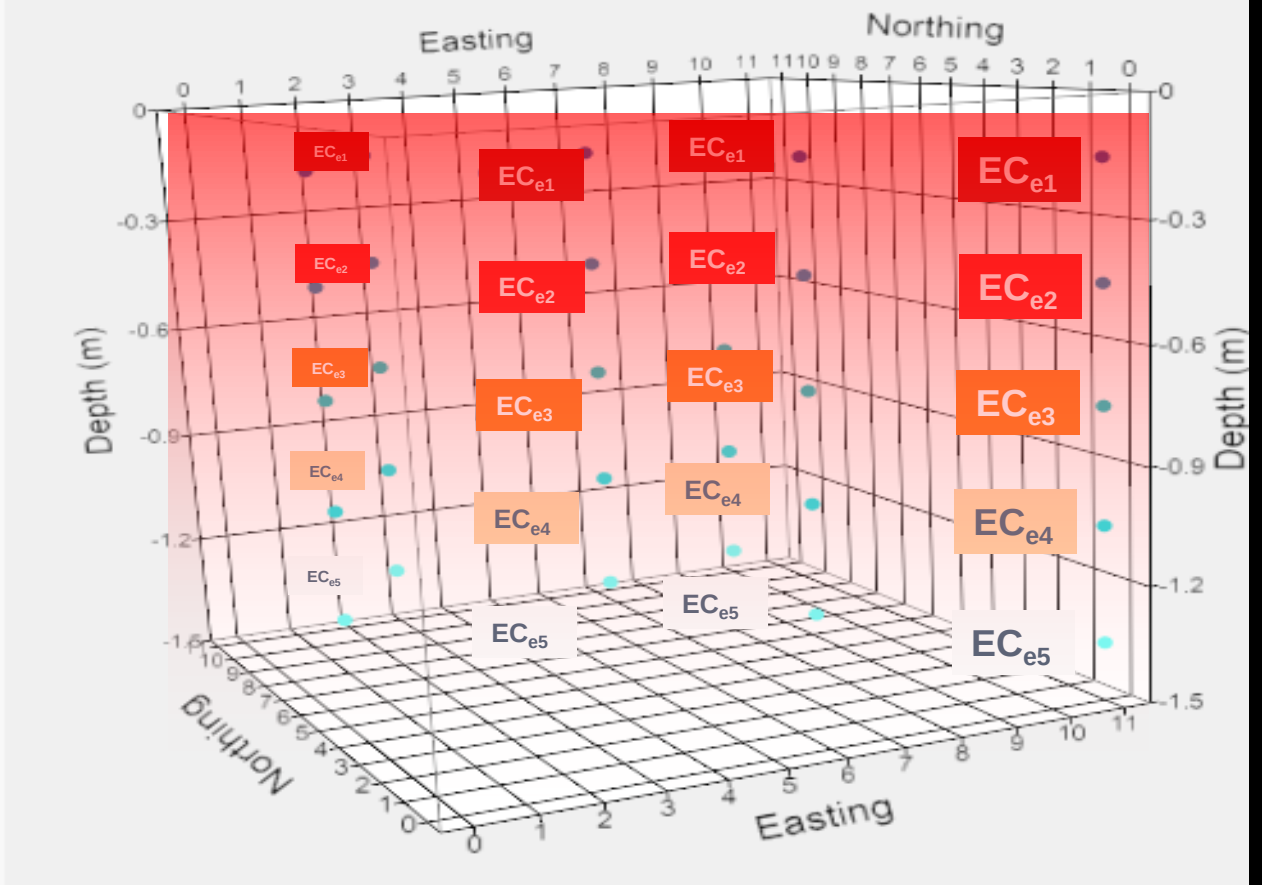
https://emtomo.blogspot.com/

# Results & Discussion

## Predicted σ from EM4Soil modelling

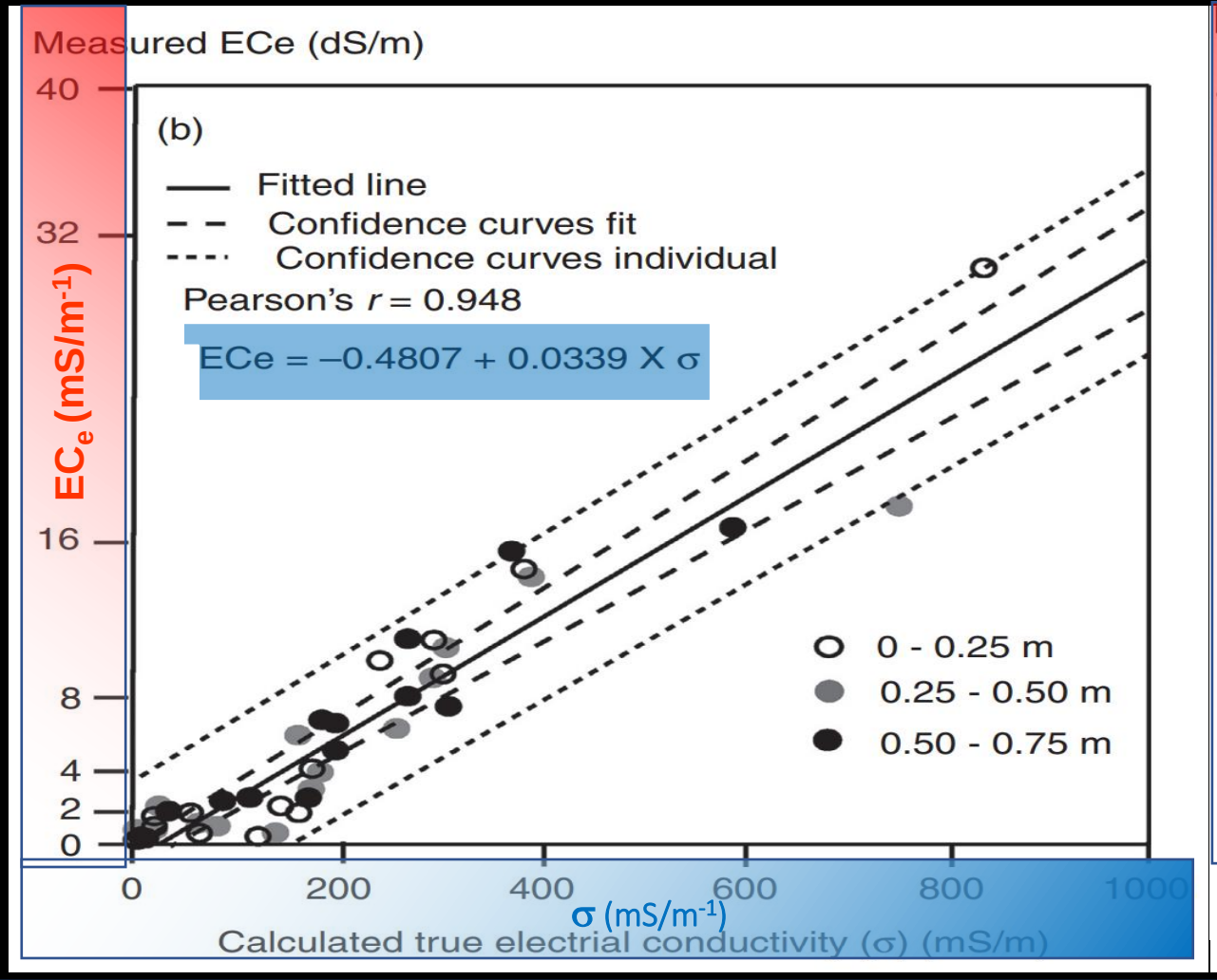



## Soil sampling and laboratory $EC_e$

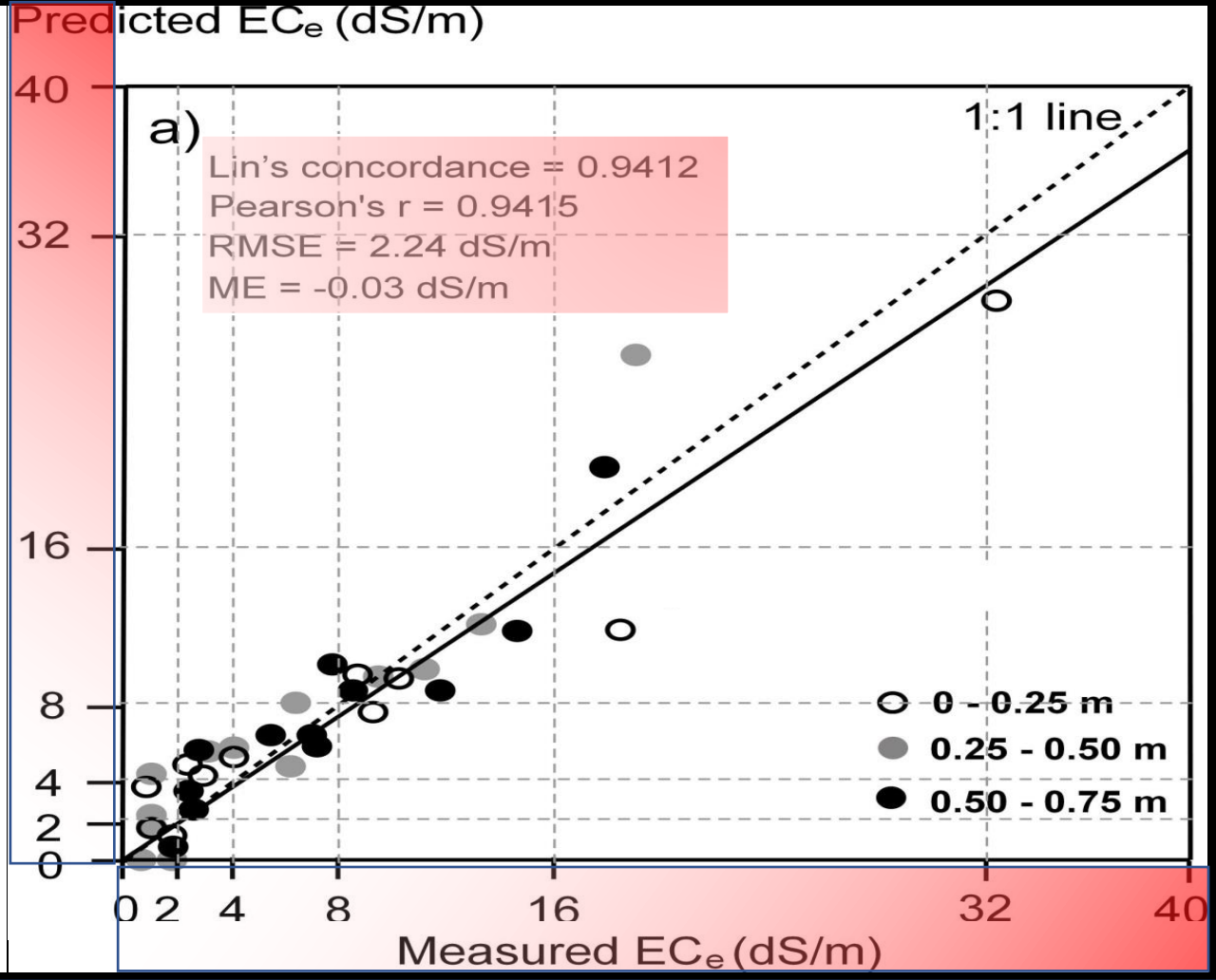


# Results & Discussion (dryland salinity)

## Calibration

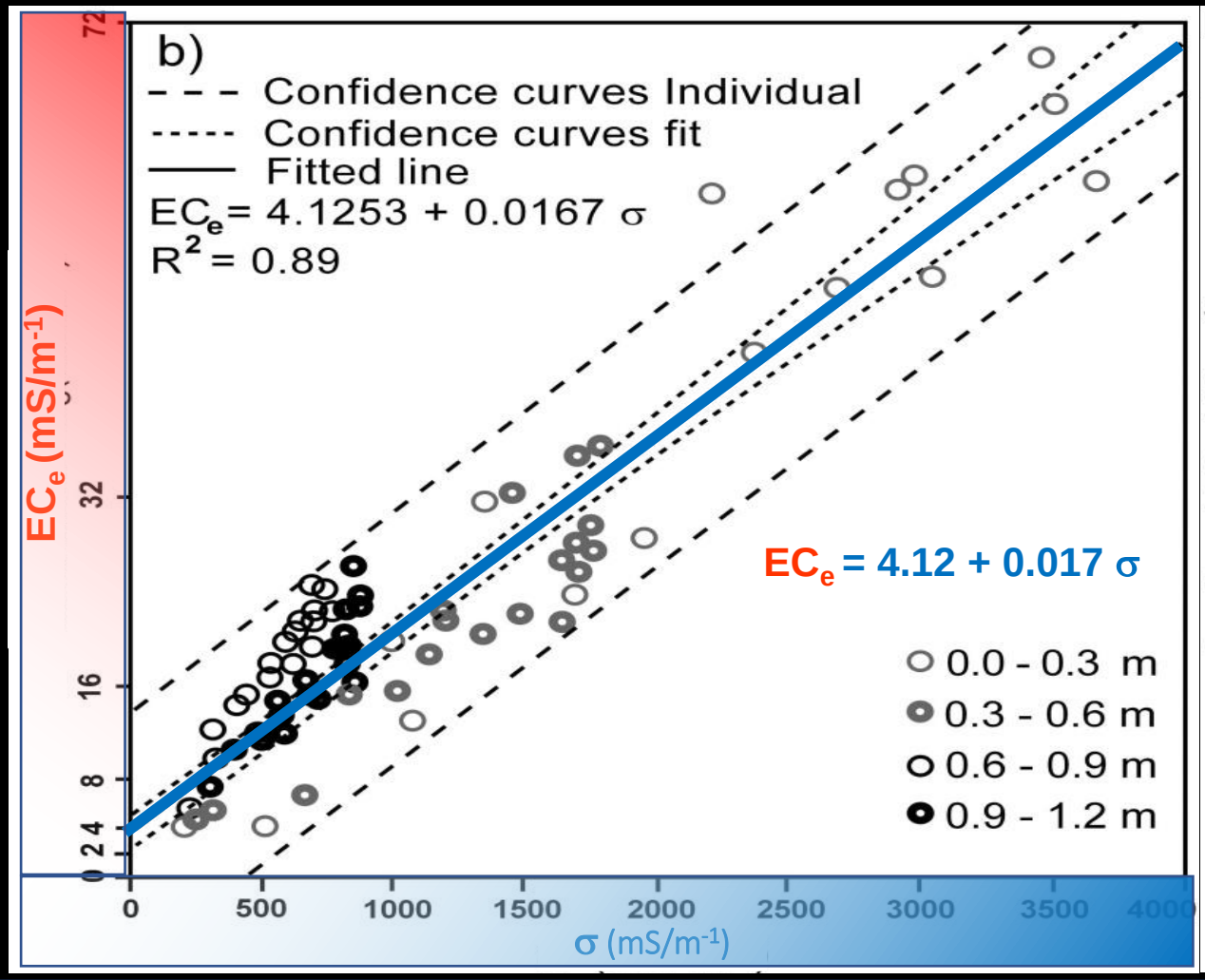



## Validation

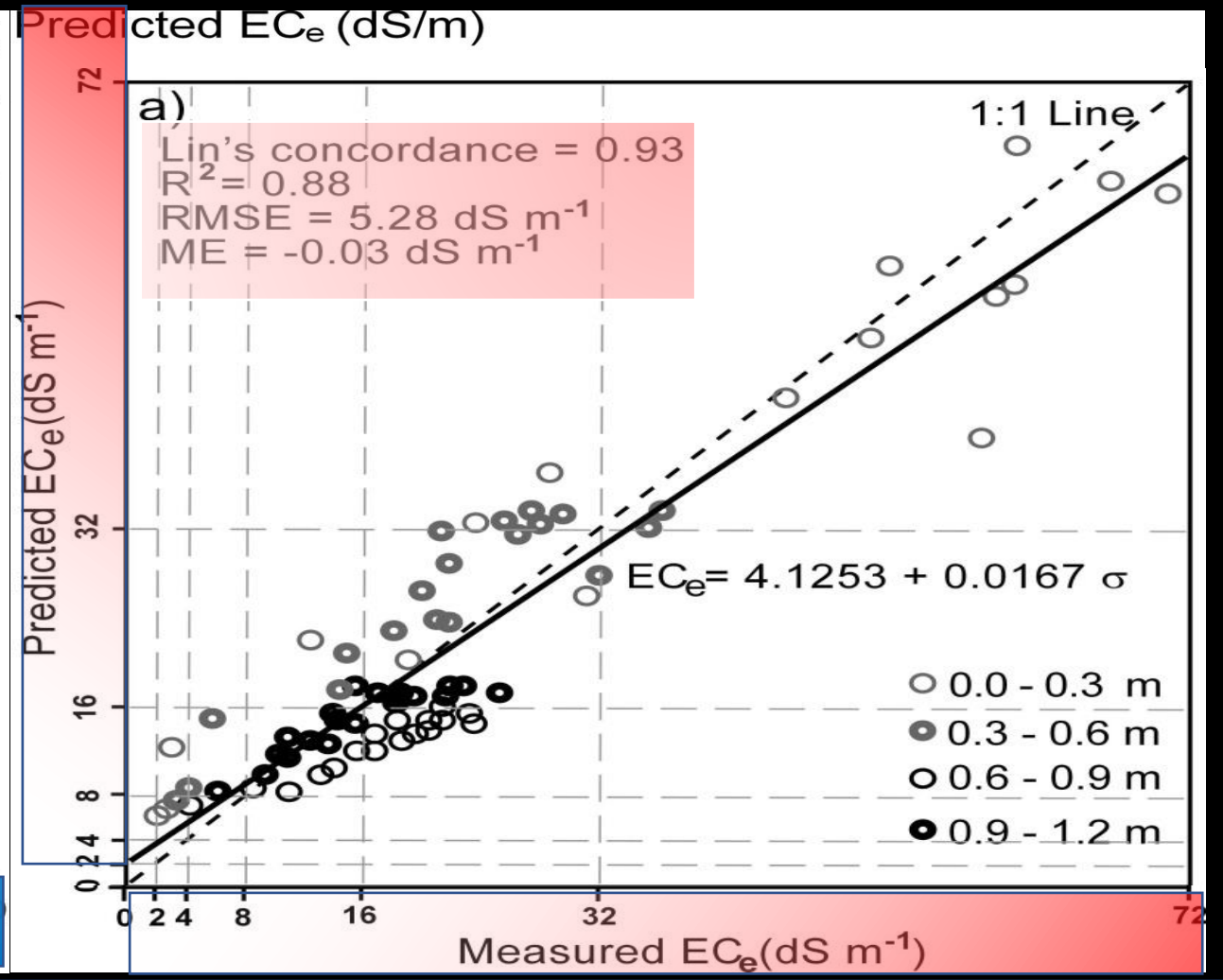


# Results & Discussion (irrigation salinity)

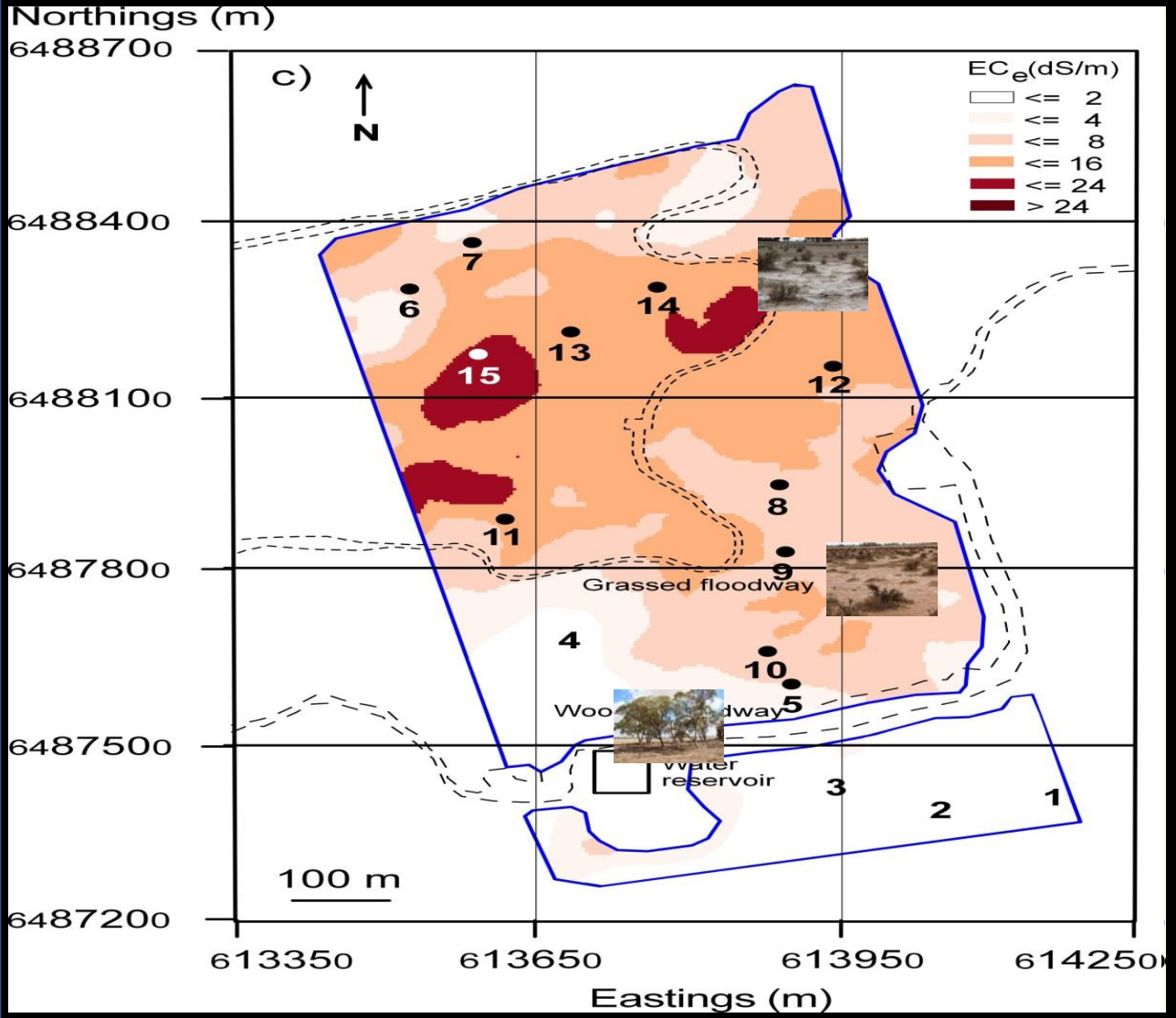
**Calibration**




**Validation**



# Results & Discussion (dryland salinity)



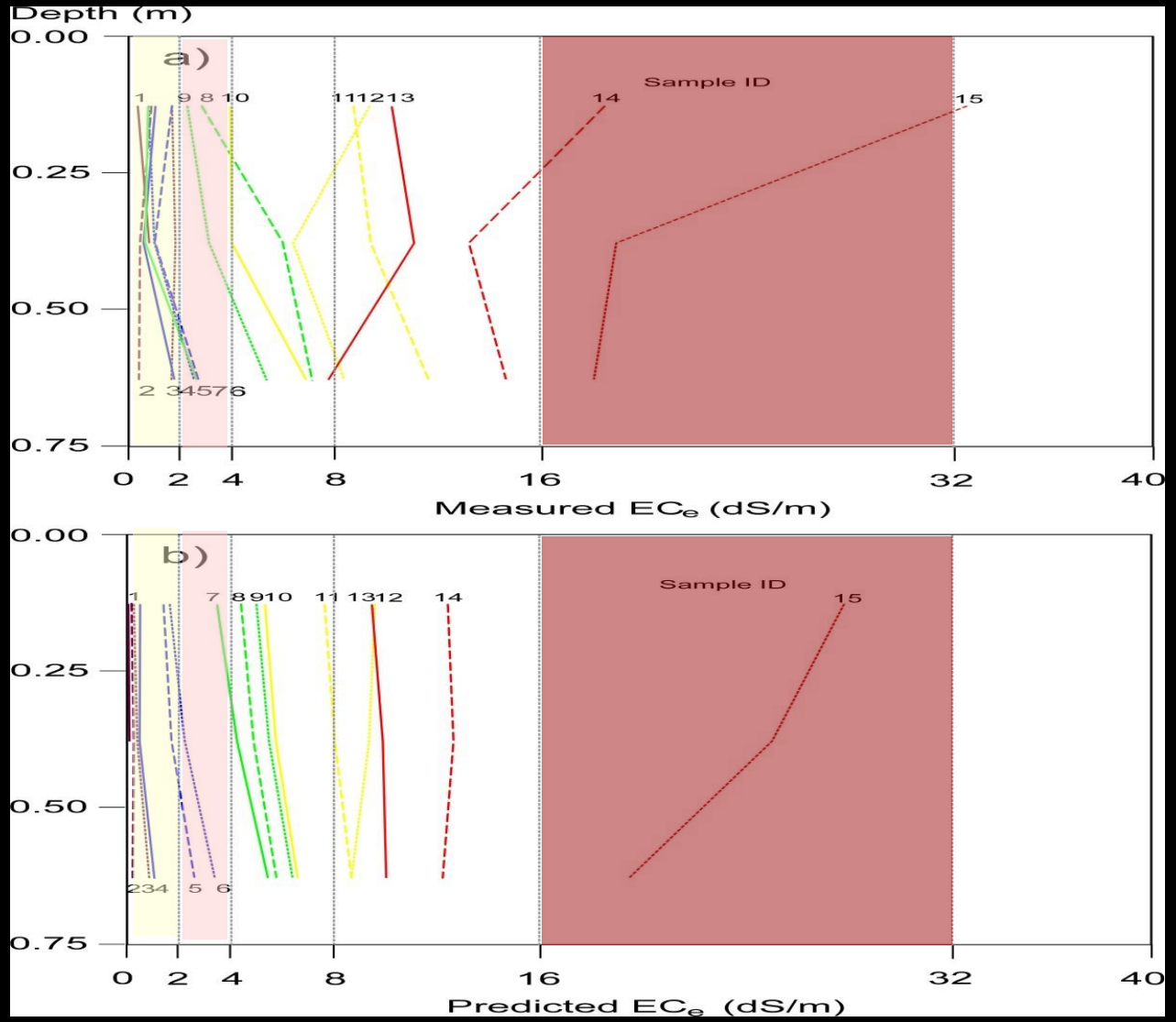

0.00 - 0.25 m
0.25 - 0.50 m
0.50 - 0.75 m

**16 - 24 dS/m**

**2 - 4 dS/m**

**0 - 2 dS/m**

# Results & Discussion (dryland salinity)

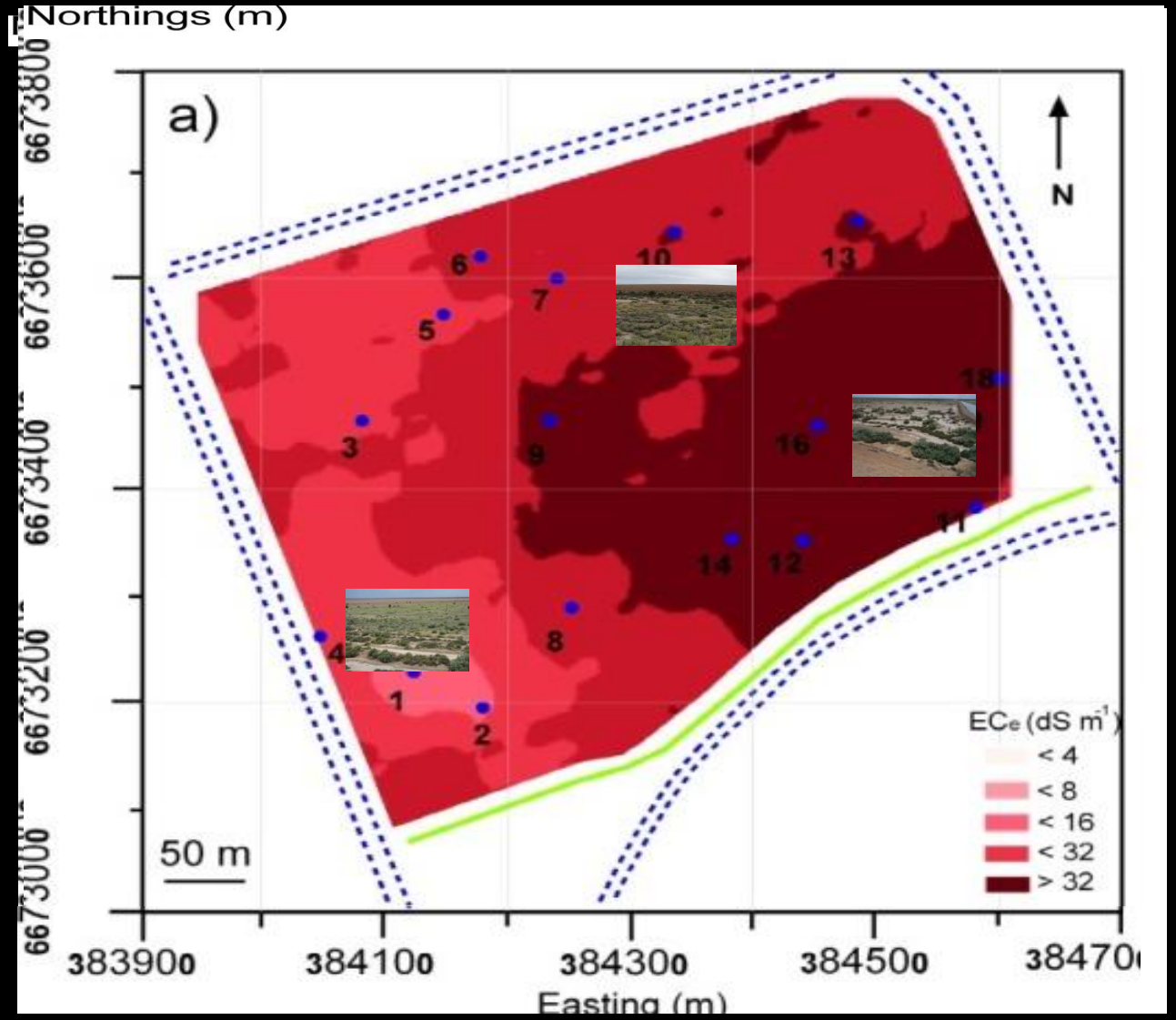



**16 - 24 dS/m**

**2 - 4 dS/m**

**0 - 2 dS/m**

# Results & Discussion (irrigation salinity)



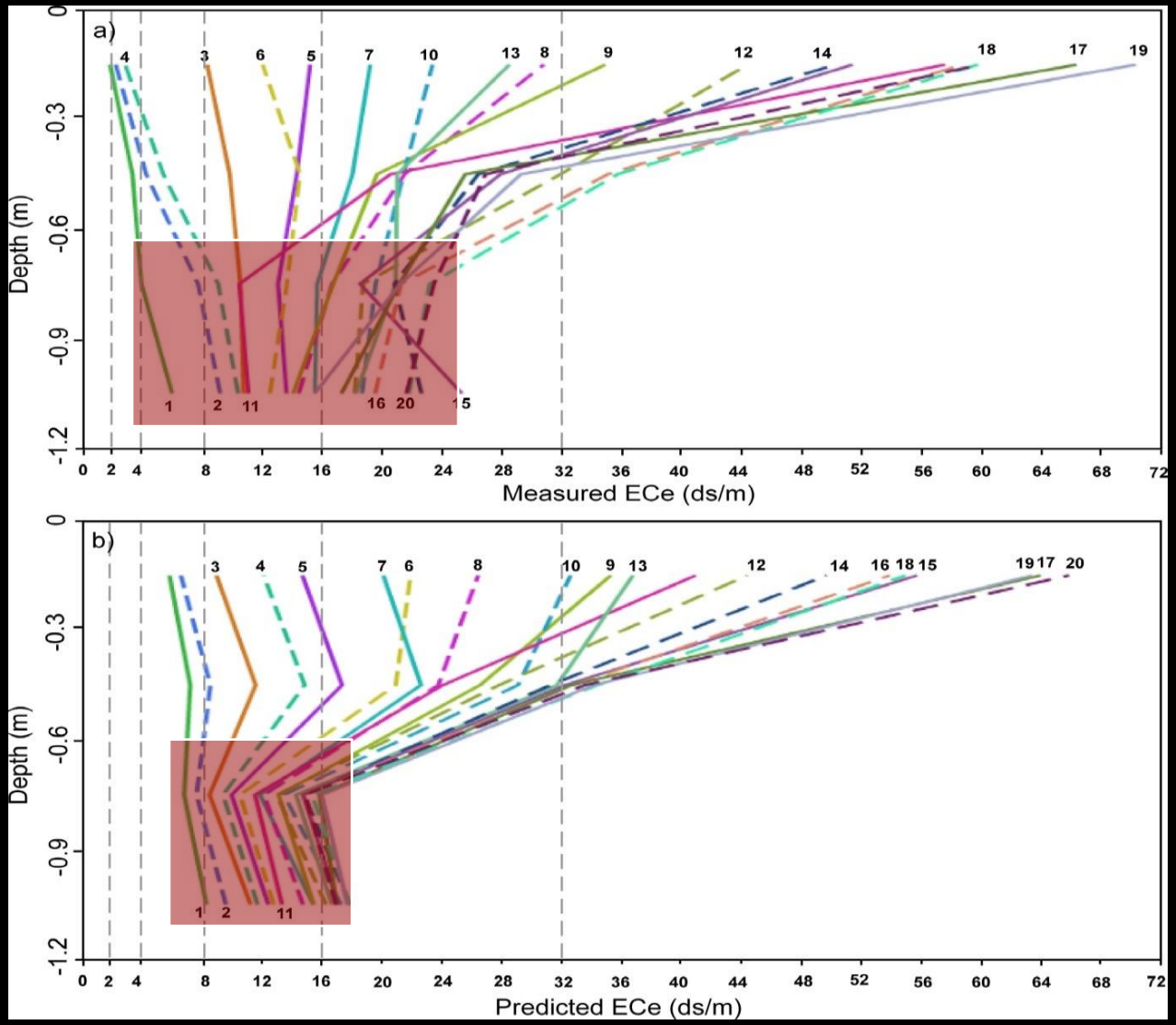

0.00 - 0.25 m
0.25 - 0.50 m
0.50 - 0.75 m
0.75 - 1.00 m

**> 32 dS/m**

**16 - 32 dS/m**

**4 - 8 dS/m**

# Results & Discussion (irrigation salinity)




**> 32 dS/m**

**16 - 32 dS/m**

**4 - 8 dS/m**

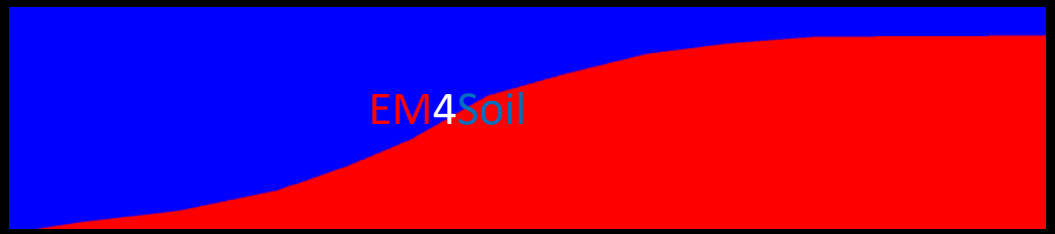
# Conclusion

**Research Question**

YES WE CAN use a
single frequency and
multiple array

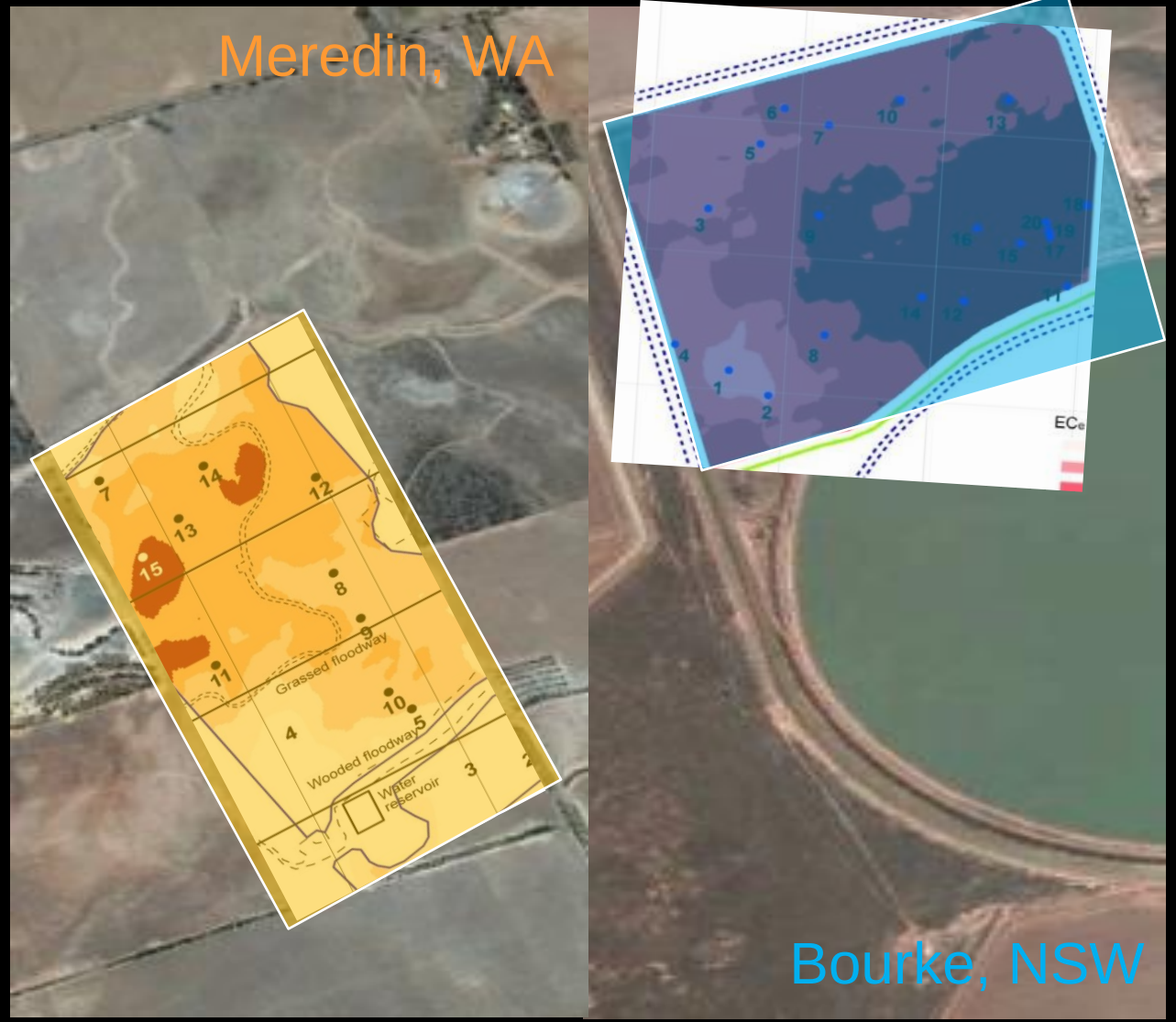

+

1-dimensional inversion software




To generate quasi-3d EMCI
to represent
dryland and irrigation salinity status

# Conclusion




## Research Question

EMCI is a viable means of mapping $EC_e$ at field scale with sufficient resolution and accuracy for irrigation/dryland management.

Capability has ramifications including ability to monitor salinity using time-lapse for;

(i) improved timing and uniformity of irrigation across a field, and

(ii) sufficient control of site-specific irrigation to optimize water use.

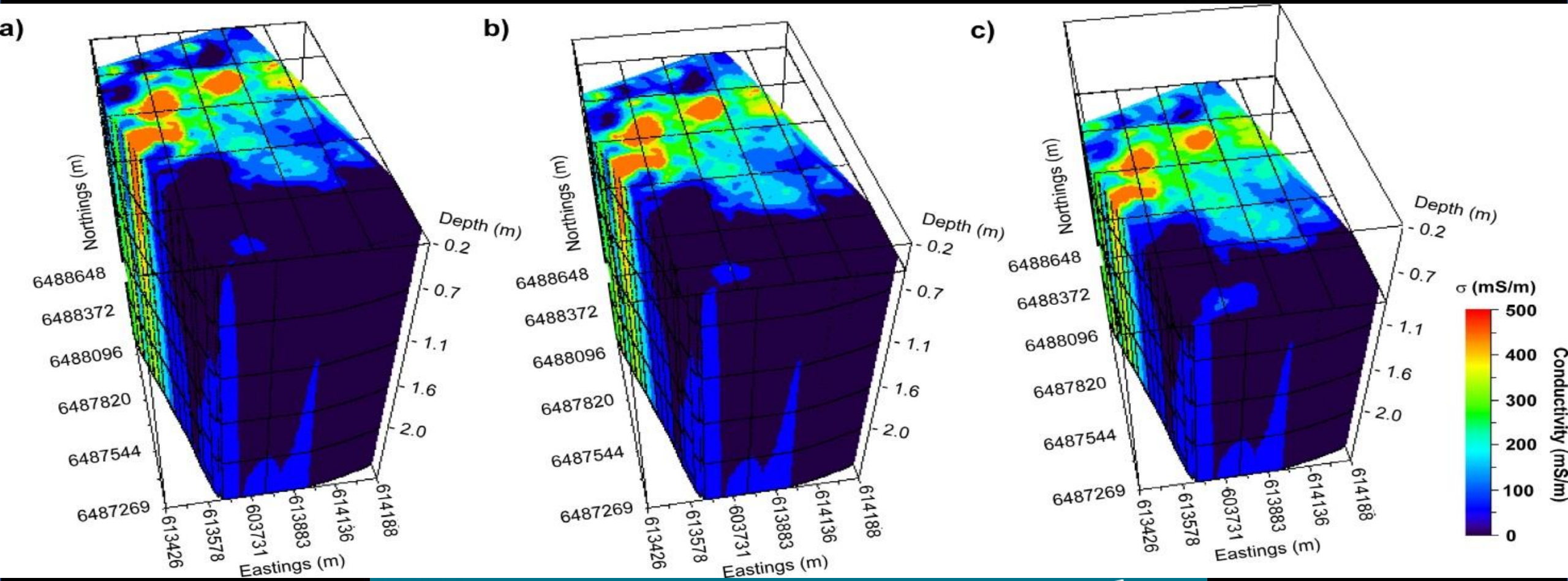
Capability has ramifications including ability to monitor salinity using time-lapse for;

(i) Revegetate landscape upslope, and

(ii) Rotation cropping to use water in landscape year round.

# Characterisation of field-scale salinity with depth by quasi-3D inversion of DUALEM-1 data

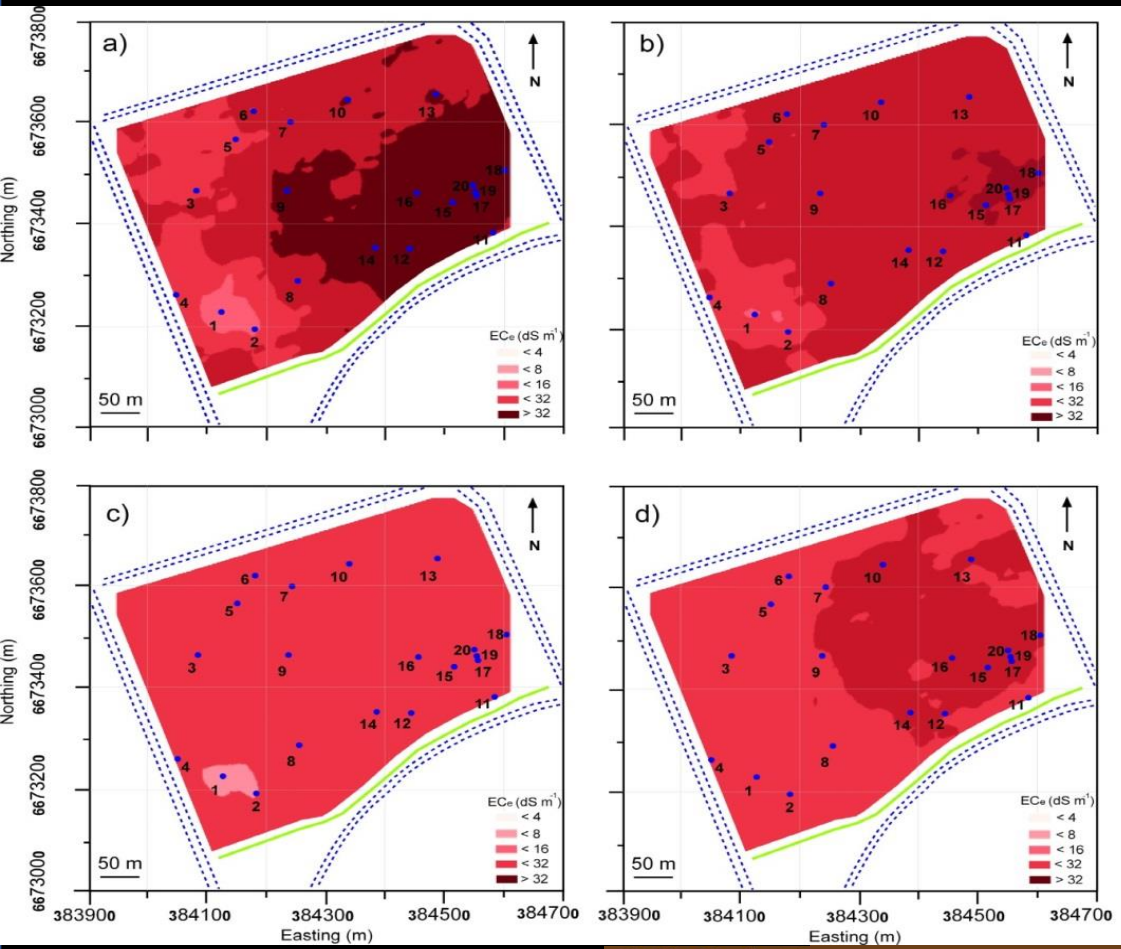
Huang J, Kilminster T,
Barrett-Lennard, E, Triantafilis J

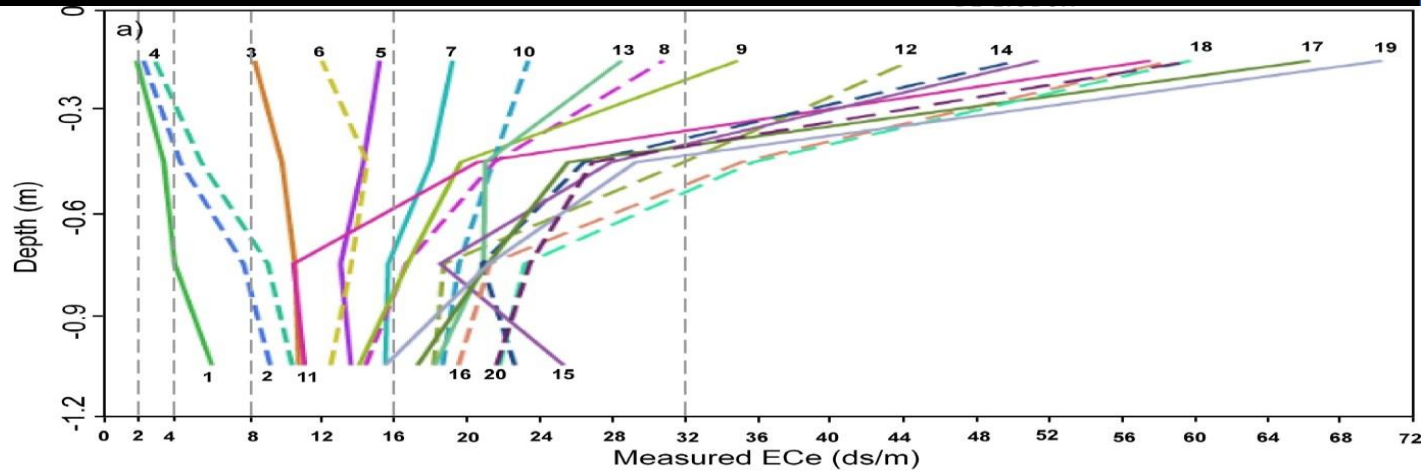


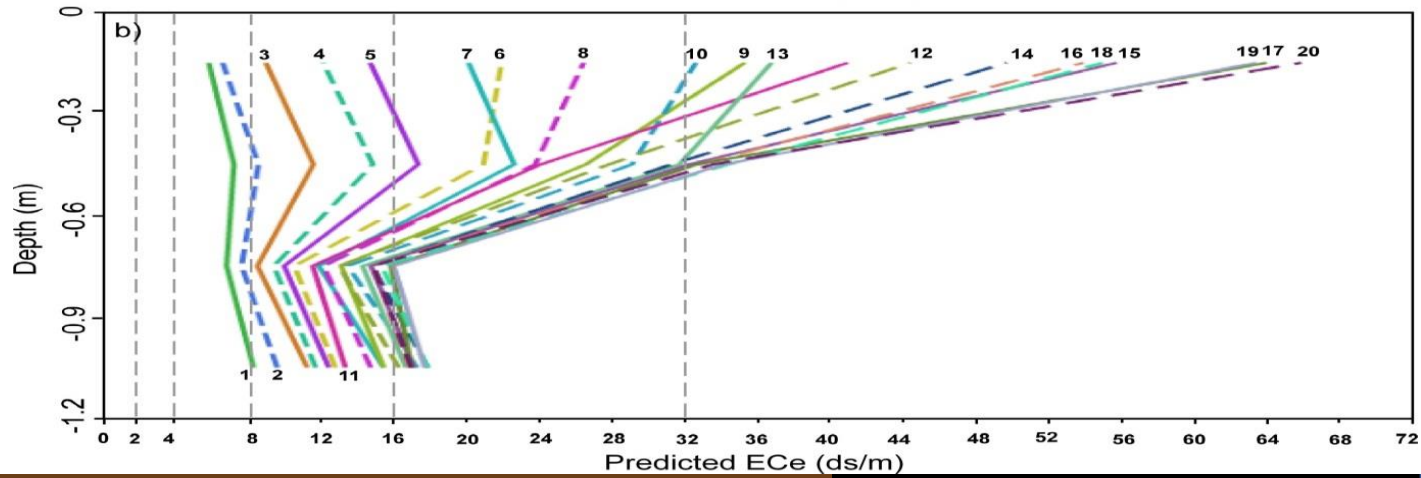

Soil Use and Management
https://doi.org/10.1111/sum.12345
BRITISH SOCIETY OF SOIL SCIENCE

# Mapping salinity in three-dimensions using a DUALEM-421 and EM inversion software

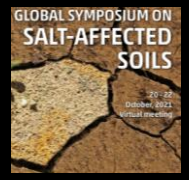
Zare E, Huang J,
Monteiro Santos FA, Triantafilis J




SSSAJ SOIL SCIENCE SOCIETY OF AMERICA JOURNAL
http://dx.doi.org/10.2136/sssaj2015.06.0238




# Want to know more?

## Further reading

Thailand:
Khongnawang T; Zare E; Srihabun P; Triantafilis J, 2020, 'Comparing electromagnetic induction instruments to map soil salinity in two-dimensional cross-sections along the Kham-rean Canal ', *Geoderma*, vol. 377, http://dx.doi.org/10.1016/j.geoderma.2020.114611

India:
Narjary B; Meena MD; Kumar S; Kamra SK; Sharma DK; Triantafilis J, 2019, 'Digital mapping of soil salinity at various depths using an EM38', *Soil Use and Management*, vol. 35, pp. 232 - 244, http://dx.doi.org/10.1111/sum.12468

Portugal:
Farzamian M; Paz MC; Paz AM; Castanheira NL; Gonçalves MC; Monteiro Santos FA; Triantafilis J, 2019, 'Mapping soil salinity using electromagnetic conductivity imaging', *Land Degradation and Development*, vol. 30, pp. 1393 - 1406, http://dx.doi.org/10.1002/ldr.3317

Morocco:
Dakak H; Huang J; Zouahri A; Douaik A; Triantafilis J, 2017, 'Mapping soil salinity in 3-dimensions using an EM38 and EM4Soil at the reconnaissance scale in central Morocco', *Soil Use and Management*, vol. 33, pp. 553 - 567, http://dx.doi.org/10.1111/sum.12370

USA:
Huang J; Scudiero E; Clary W; Corwin DL; Triantafilis J, 2017, 'Time-lapse monitoring of soil water content using electromagnetic conductivity imaging', Soil Use and Management, vol. 33, pp. 191 - 204, http://dx.doi.org/10.1111/sum.12261

Iran:
Moghadas D; Taghizadeh-Mehrjardi R; Triantafilis J, 2016, 'Probabilistic inversion of EM38 data for 3D soil mapping in central Iran', Geoderma Regional, vol. 7, pp. 230 - 238, http://dx.doi.org/10.1016/j.geodrs.2016.04.006

# GLOBAL SYMPOSIUM ON SALT-AFFECTED SOILS

20 - 22
October, 2021
Virtual meeting

*triantafilisj@landcareresearch.co.nz*