SAGEEP2021

14-19 MARCH 2021 | ONLINE

PORTATIVE SENSORS FOR MEASURING SOIL ELECTRICAL PARAMETERS IN SITU

Larisa Golovko (Landviser), Yuri Manstein (SiberGeo & KB Electrometry), Dmitry Romanov (TerraZond), Lev Pozdnyakov (MGU)

33rd Symposium on the Application of Geophysics to Engineering and Environmental Problems

1st Munitions Response Meeting

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Overview

- Despite the advantage of the satellite and UAV imagery platforms and wide-spread utilization of GIS analytics, the detail information about topsoil and near-surface layers is still difficult to obtain without soil sampling and laboratory analysis, which is expensive and time-consuming.
- Electrical resistivity (RES), conductivity (EC) and self-potential (SP) are fundamental soil properties directly related with soil salinity, texture, water and stone content and other properties affected by the density of mobile electrical charges.
- Unlike other soil properties, electrical parameters can be easily, repeatedly, and reliably measured *in-situ* and in lab with various geophysical instruments; therefore, are **universal soil characteristics** useful for mapping and monitoring.
- This review provides a brief introduction to modern portable geophysical instruments of direct current – for RES/EC/IP (LandMapper by Landviser, USA; SibER by SiberGeo, Estonia), electromagnetic induction (Geovizer and AEMP-14 by KB Electrometry, Russia), and 3D GPR by TerraZond, Russia.

Сибирское отделение Российской академии наук

- The theory, applications, and new system integrations with RTK GPS, mobile UFV platforms, connected sensor monitoring LoRa network, and unified **3-step approach to in-depth site characterization** using imagery, GIS analytics and RES/EC measured with LandMapper is presented.

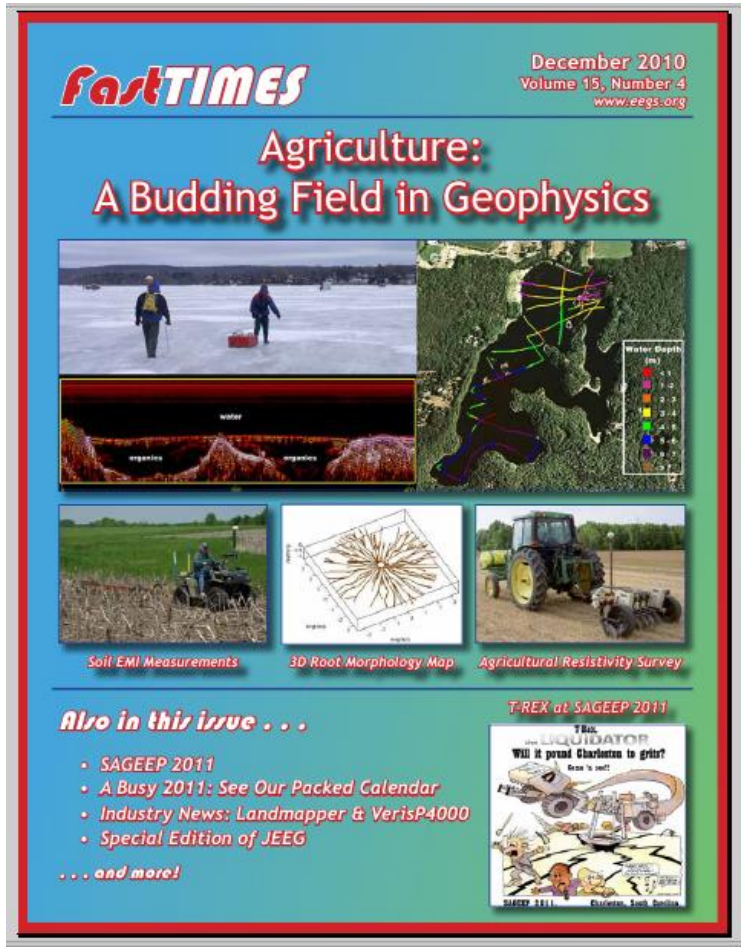
How Landviser started…

By Larisa Golovko (Pozdnyakova):

- 1995: Ph.D Thesis “Mapping and monitoring of alluvial soils with electrical geophysical methods “ – Moscow State University, Russia
- 1999: Ph.D Thesis “Electrical properties of soils” – University of Wyoming, USA
- 2002: Landviser incorporated in NJ, USA
- 2003: LandMapper ERM-01 – handheld resistivity meter introduced to the market

Landviser Research® Enlightening

Imagery vs Geophysical Subsurface Surveys



Imagery:

Complete coverage

Vegetation mapping

Fast

Sensors:

Point data

Multiple depths

Monitoring

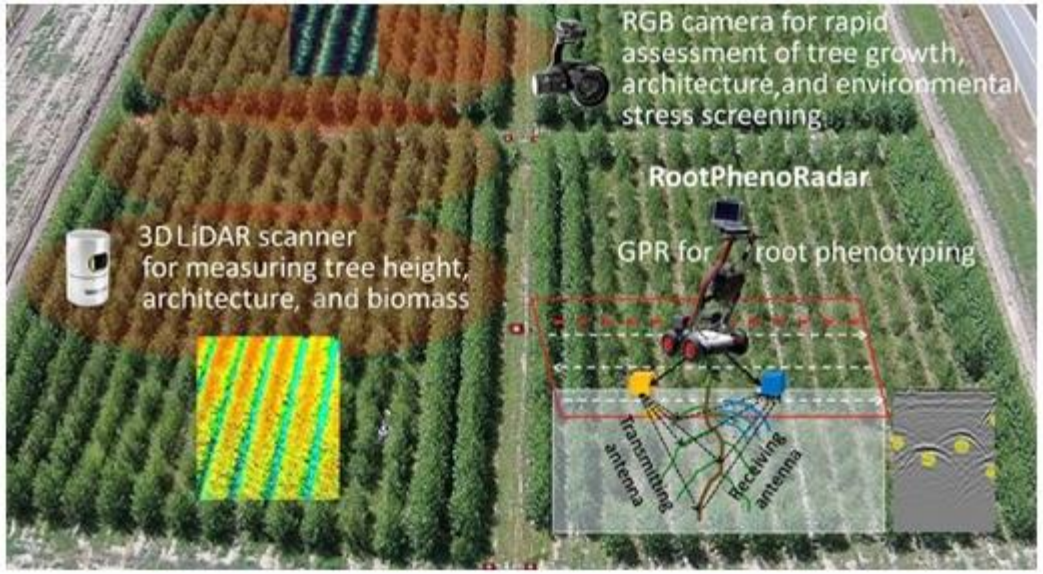
Geophysical Imaging:

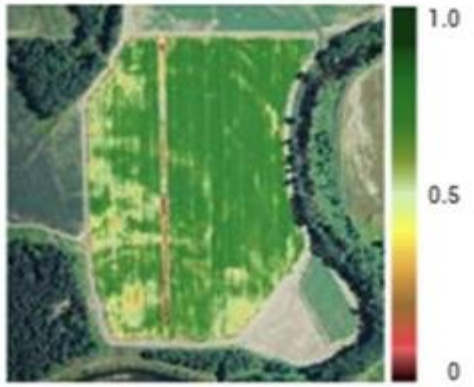
Mapping & Monitoring

2D/3D Subsoil Models

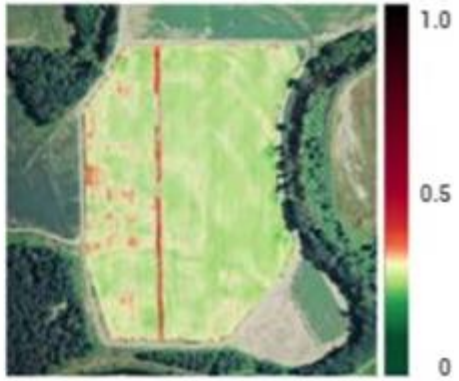
Contact DC & EM

On Ground: walk, ride, **fly?**...





Yield Potential



Quad-Band Vegetation Stress

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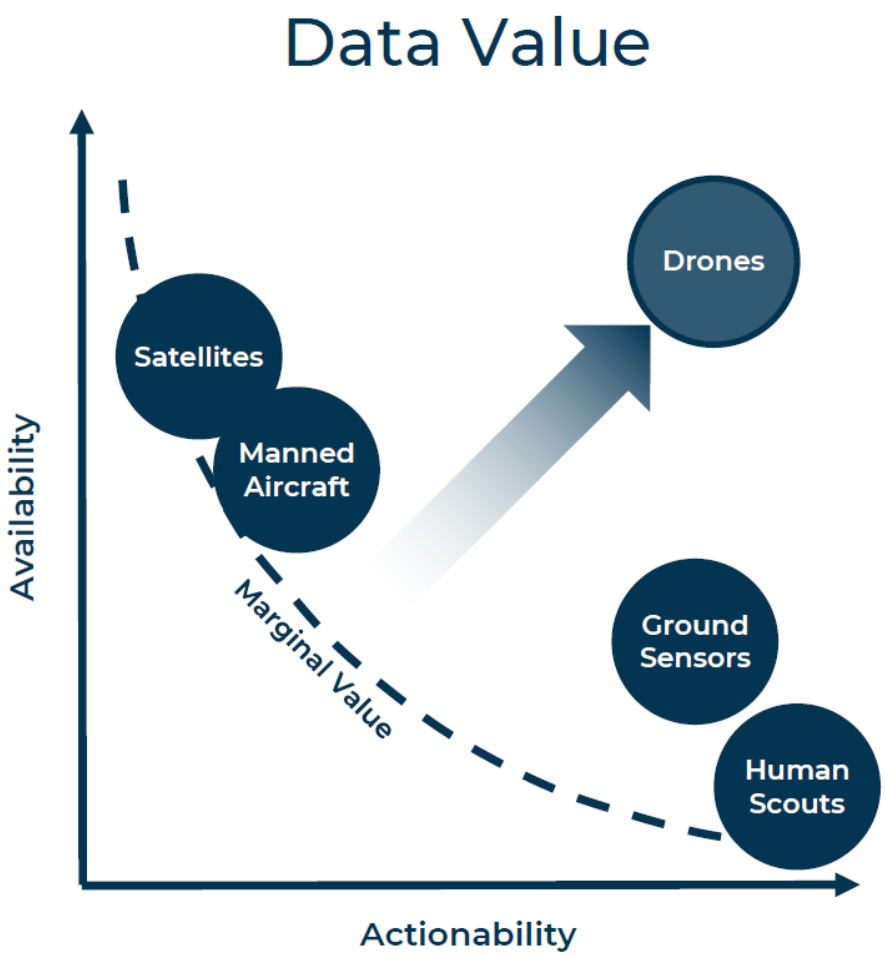
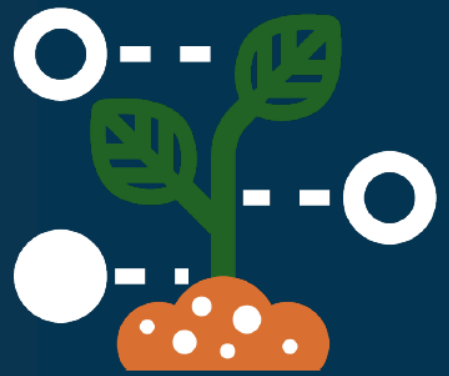
Now Sensors are Plentiful and Provide a lot of DATA…



New **remote sensing & analytics tools**, enabled by commercial drone systems, can deliver valuable crop data where alternatives have been constrained



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Data ≠ Knowledge, but Knowledge = Power!

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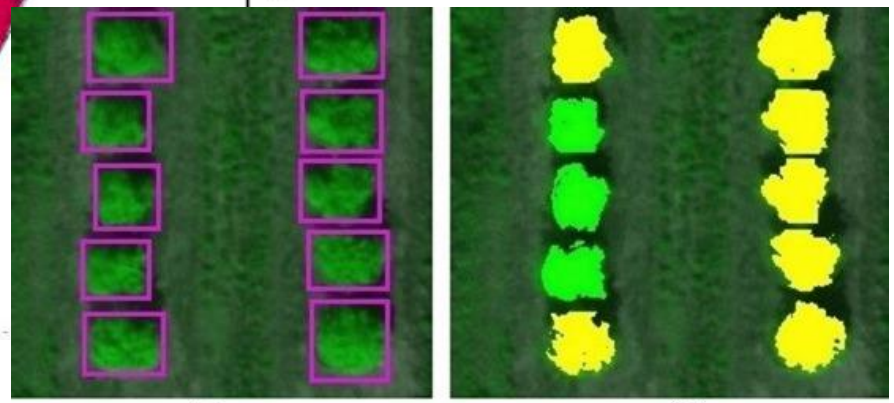
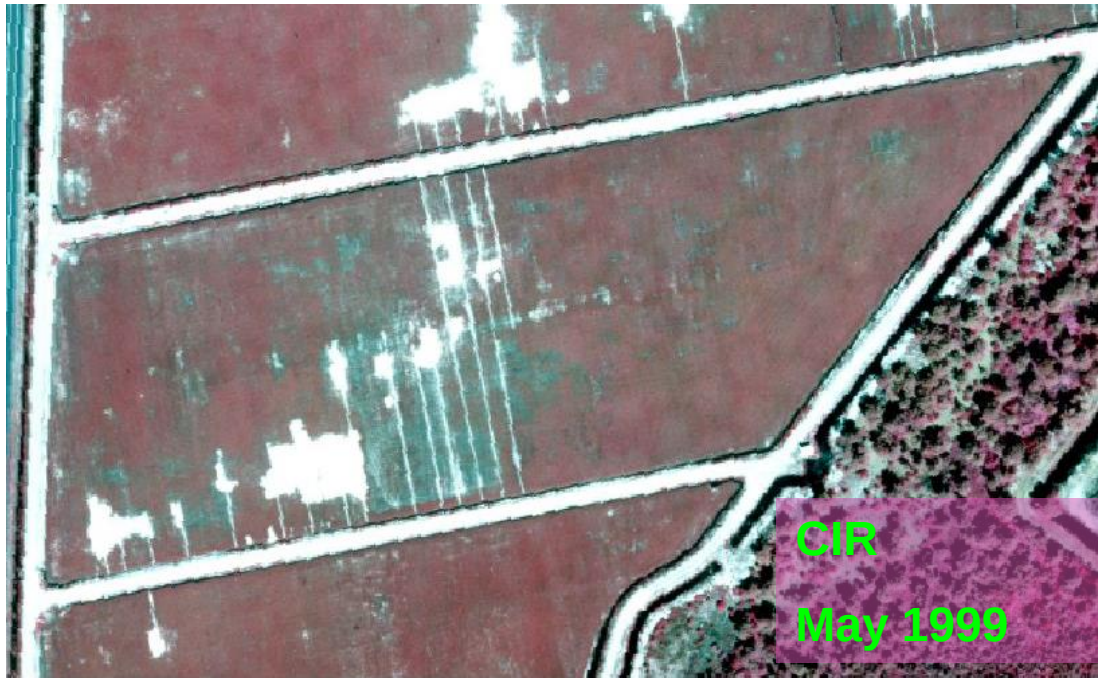
UAV Imagery Benefits



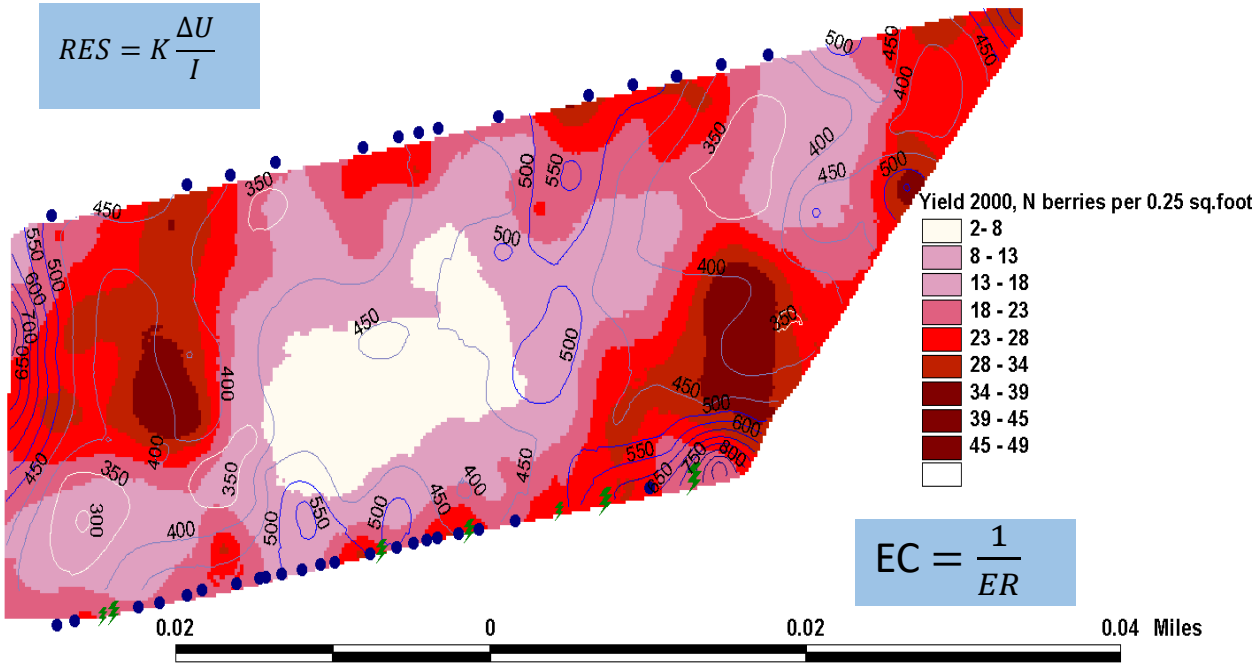
- UAV vs Satellite
  - High Resolution
  - Unaffected by Cloud cover
- Tree-level Accuracy
- Multispectral/Hyperspectral
- ID diseases
  - Citrus Canker
  - Citrus Greening

Ref: https://www.sciencedirect.com/science/article/pii/S0168169919311123#f0020

Low ER/high EC shows water-logged low-yielding areas of cranberries



$$RES = K\frac{\Delta U}{I}$$



$$EC = \frac{1}{ER}$$

Phytophthora Root Rot

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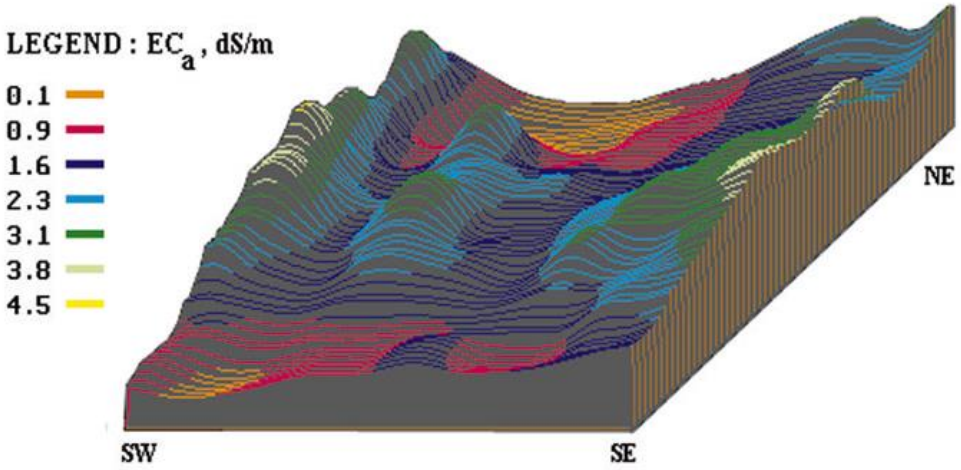
Salinity: persistent, not visible, EC-related

No salts are visible, but rice seedlings die



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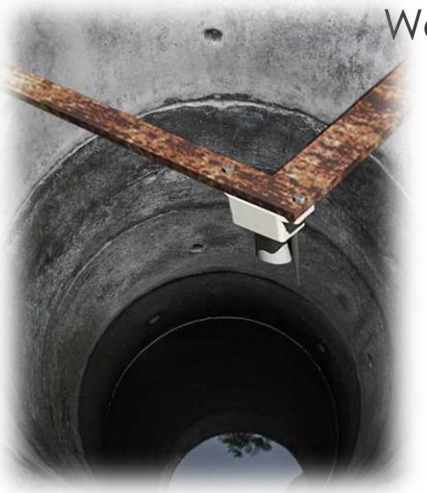
RES/EC in Ag and Ecological Studies

Soil RES/EC is of particular interest for land management:

- Newly developed technologies allow obtaining fast, dense, and accurate GIS-compatible soil EC or RES measurements.
- soil EC is related to several soil properties important for plant growth and can be used to outline management zones
- EC-directed soil sampling
- unlike Imagery, geophysical sensors can measure EC in subsoil at a range of depths essential for plant growth.
- on-the-go EC sensors measure soil EC non-destructively *in-situ* providing a more accurate assessment of the real conditions in soil, which makes them particularly suitable for soil monitoring and time-series statistical studies of the anthropogenic changes in cultivated soils.

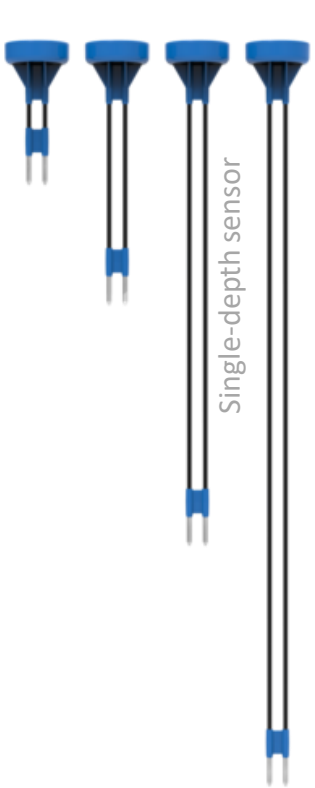
Stationary Monitoring Sensors

Weather



Water Level & Quality

Soil Nutrient



Soil Moisture

Woodpecker Microsystems

Sap Flow / Stem Water Content

Soil EC/Temp

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Contact Mobile EC Mapping Systems

USDA Salinity Lab

Veris Technologies

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Electromagnetic multi-frequency profilers

AEMP-14

TECHNICAL SPECIFICATION

Working frequencies: 2.5-250 kHz;
Measurement time: 0.3-2 sec;
Generator power: maximum 90 W;
Receiver sensitivity: 1 mV;
Dimensions: 275x30x10 cm;
Working time: about 6 hours;
Weight: 9 kg;
Sofware compatibility: Android, Windows.

AEMP-14 is a patented device for 7-m depth earth sounding that comprises a transmitter, two receiver coils, and a backing coil. This device can operate at a set of operating frequencies picked up from 14 available frequencies (within the range from 2.5 to 250 kHz). The arrangement of receiver coils cancels the primary field in air by a factor of 1000, so there is no need for preliminary calibration for a specific ground.

Multi-Array Ground Radio Tomographic Scanner (3D GPR) "GRT-XX"

Frequency range	**0.5-3 GHz**
Number of antennas in transceiver modules	**от 8 до 32**
Sample per trace	**512/1024/+**
Continuous sounding on the go	**more then 110 km/h**
Scan resolution along antenna array	**up to 7.5 cm**

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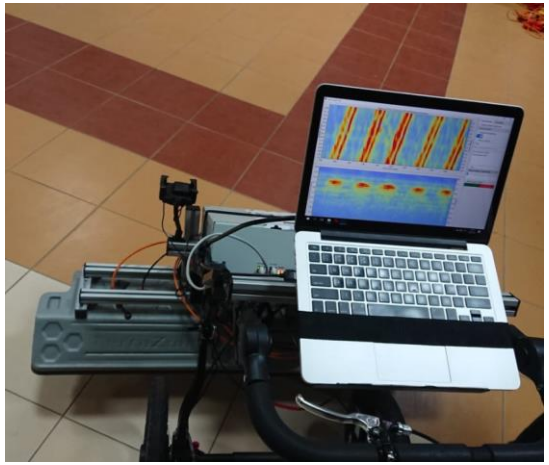
Variants of TerraZond 3D GPR “GRT-XX” integration



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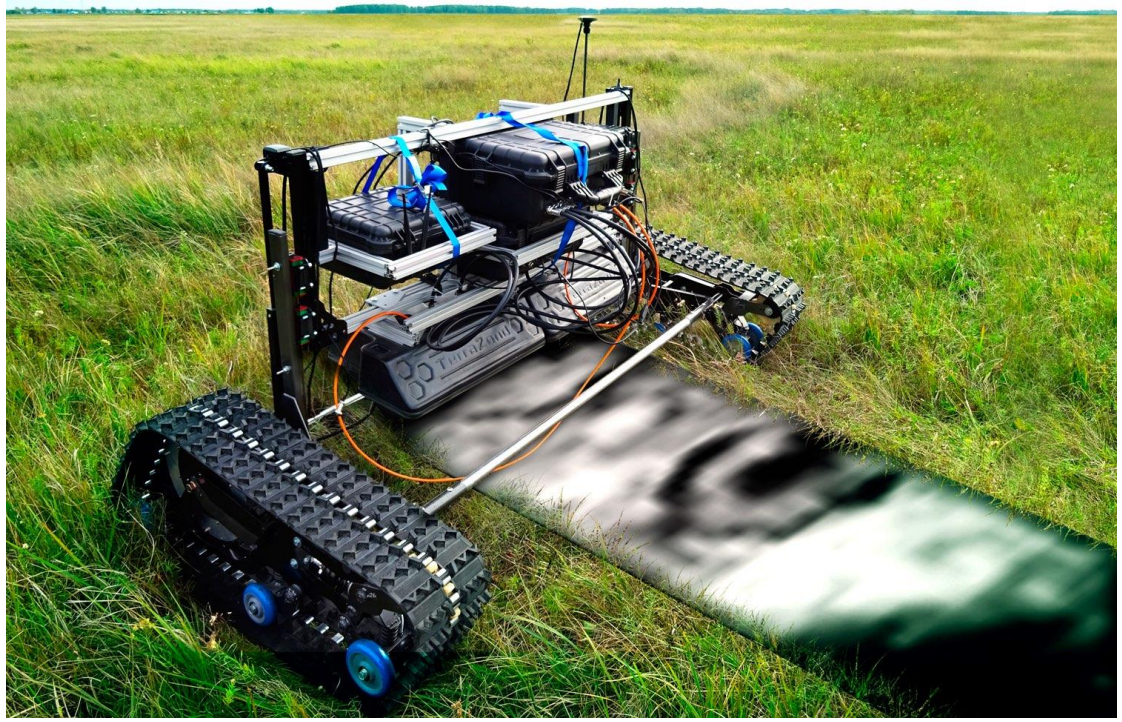
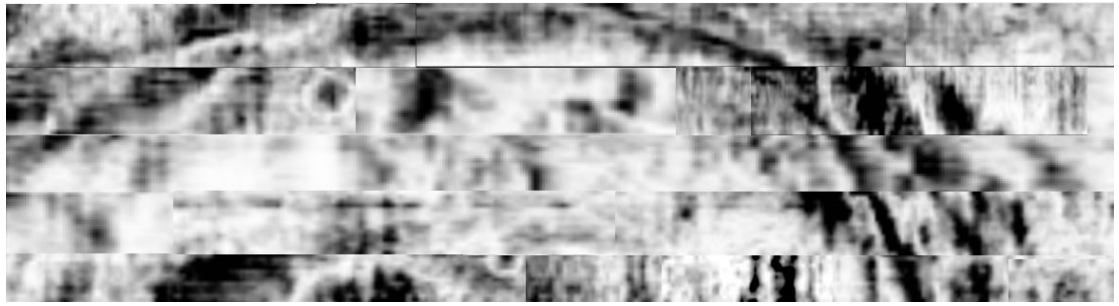
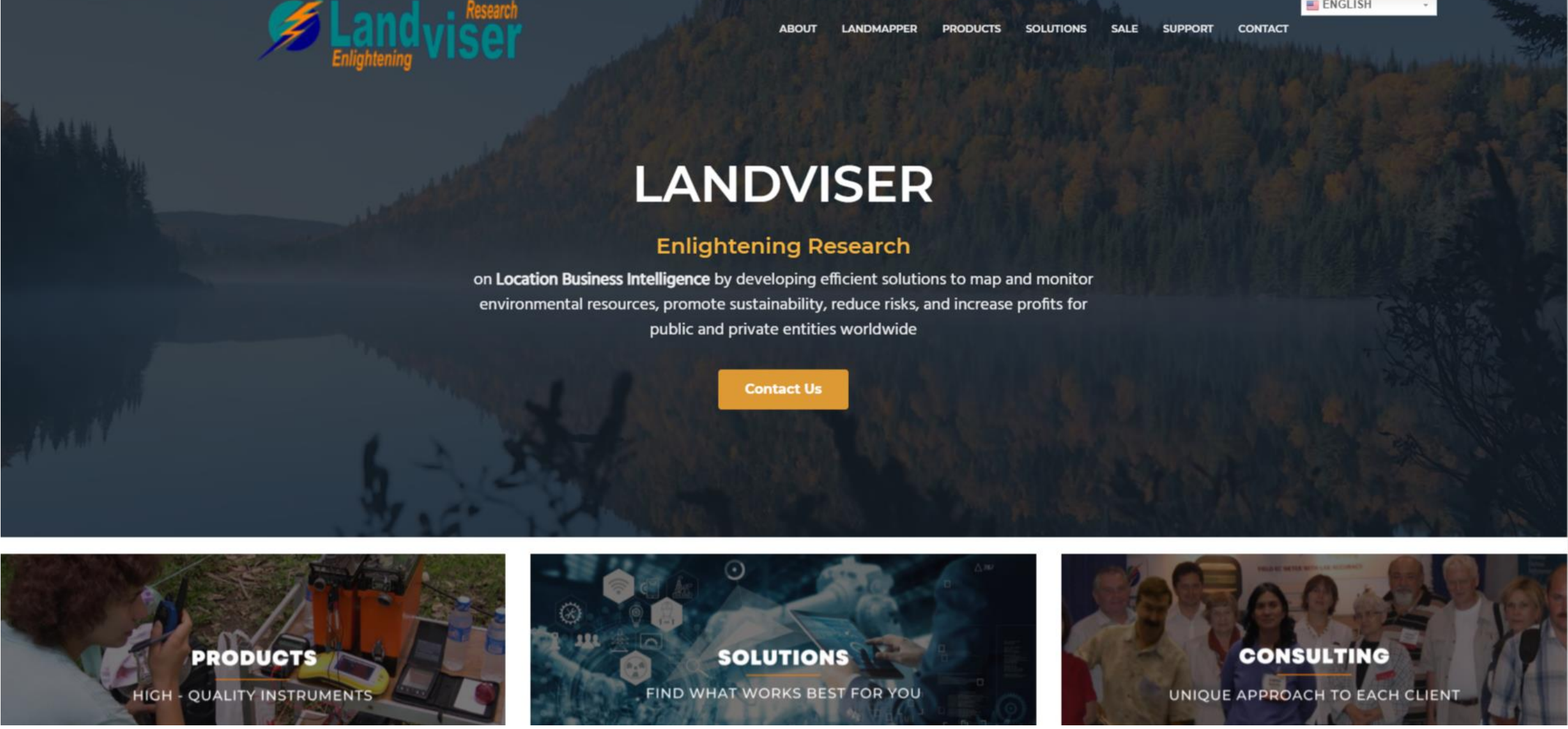
Automatization for big field scanning with 3D GPR





Amplitude maps in real-time
(horizontal slice) from one scan



Users are Overwhelmed with Technologies…

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Our 3-steps Approach: Land Survey & Monitor

1. Build a Web Mapping Dashboard of Land Resources for a Client

2. Gather and Analyze available Soil & Land Use Maps, Satellite Imagery, Climate Variables

3. Map RES/EC at Key Depths with LandMapper and Convert to Maps of Soil Properties

(4). Incorporate Live Tracking of Severe Weather and Public Health Risk (**Landviser**)

(5). Install IoT Sensors with LoRa Tower and Network to monitor resources (WP Microsystems)

(6). Arrange and schedule UAV/MAV imagery collections, UAV spraying (Air Data & Hylio)

(7). **Supply users and train** on geophysical instruments and software for 2D / 3D deep subsurface geophysical surveys to detect contamination plumes, dam stability, assessments for sinkholes and quick sands (SiberGeo, KB Electrometry, TerraZond, AGS/GeoTomo Software)

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AIR DATA BY LAND. BY AIR. BY SEA.

hylio

SiberGeo OÜ

TerraZond

esri Partner Network Bronze

Woodpecker Microsystems

AGS Aarhus GeoSoftware

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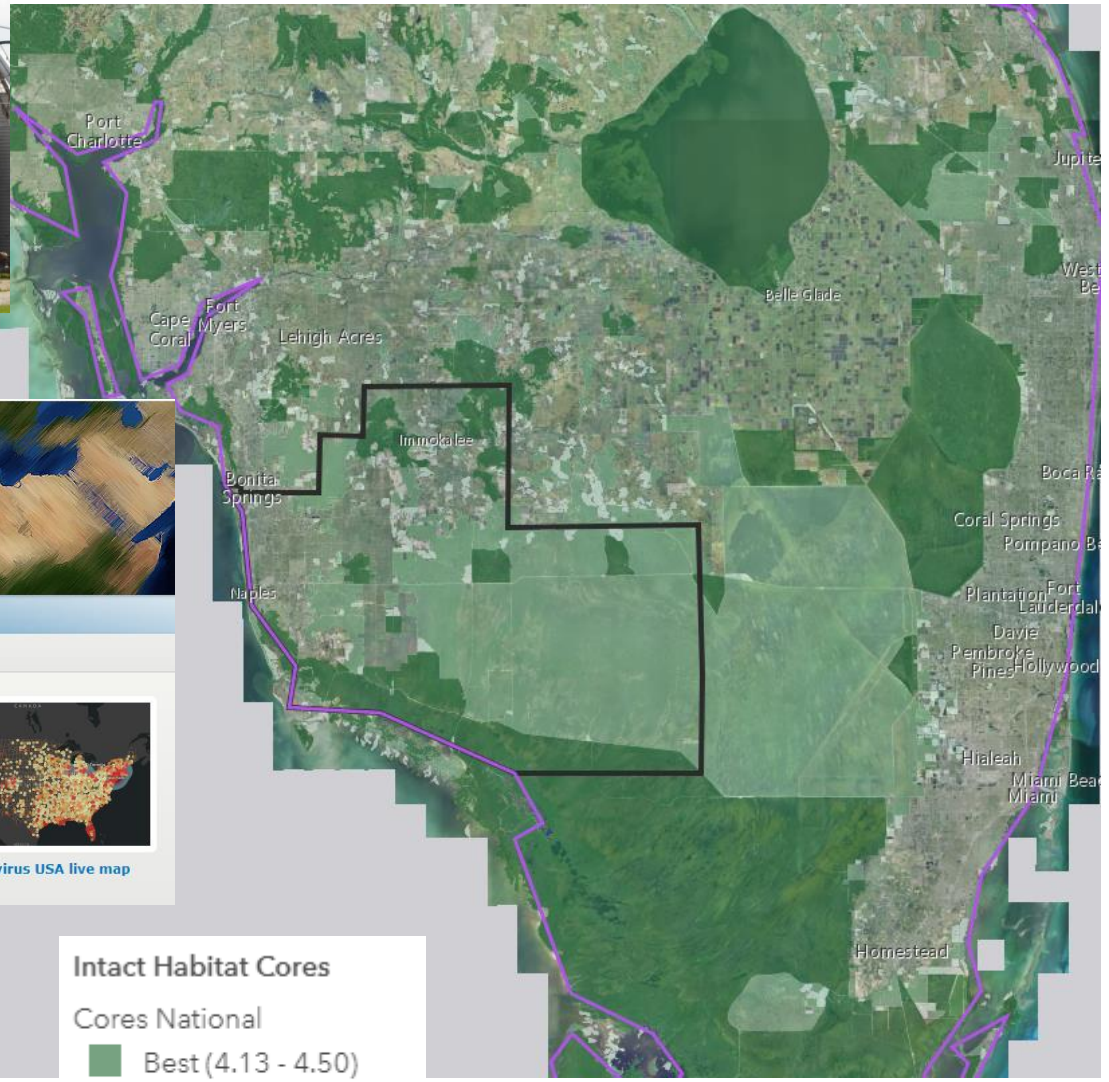
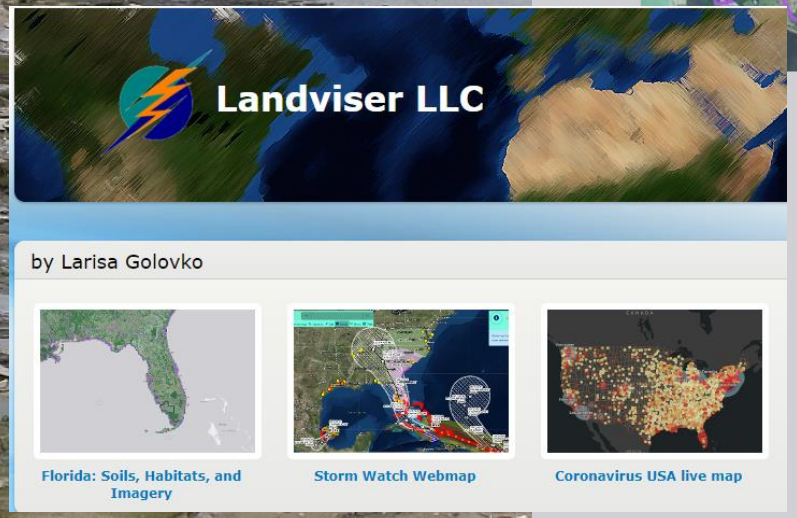
1-2. Build a Custom GIS Dashboard for Land Resources

esri Partner Network Bronze





(4) Our Interactive Disaster Monitoring Mapping Portal:
– COVID19 USA – Storm & Flooding Watch – Harvey Damage -

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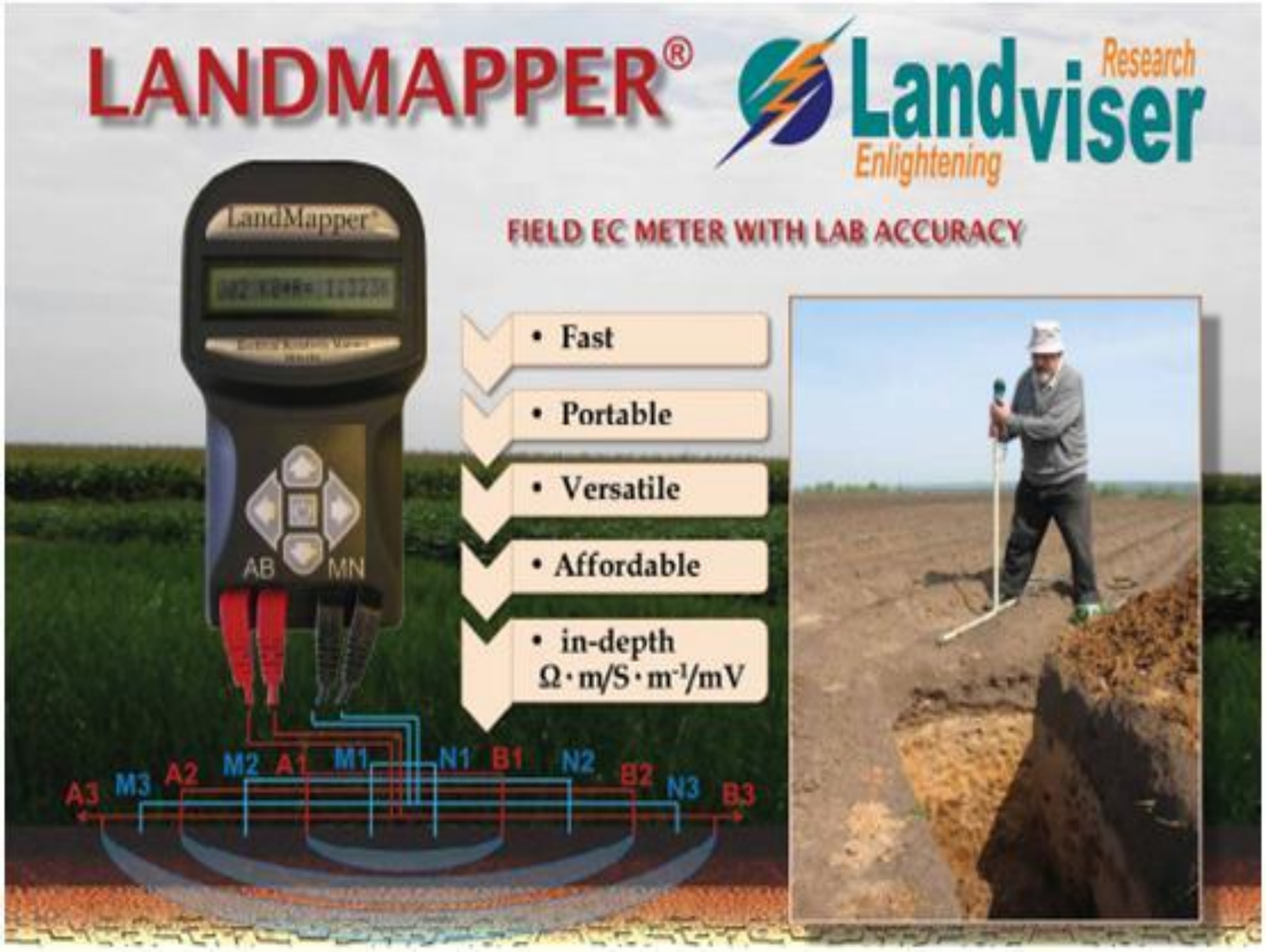

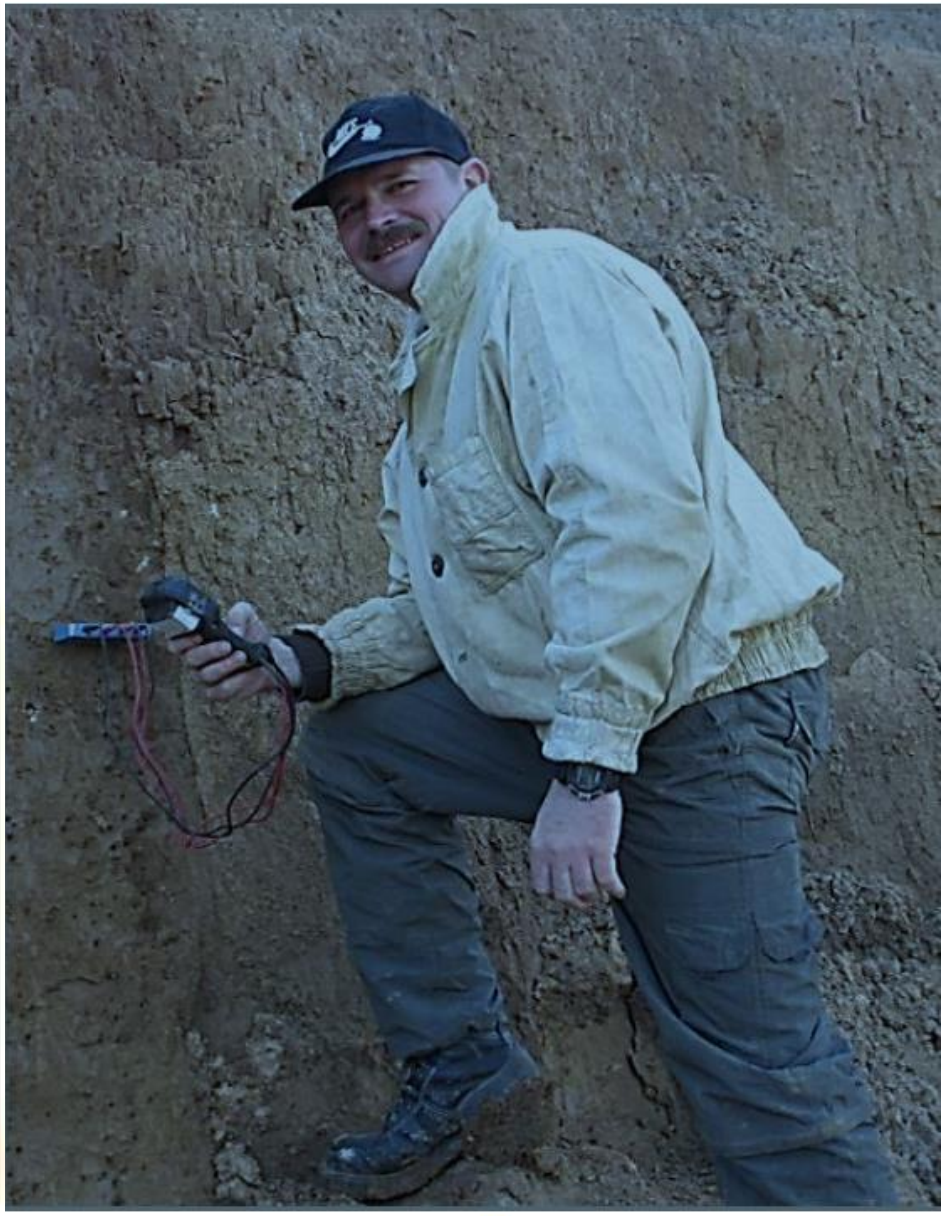

3. Select AOI, do detailed RES/EC mapping at key depths and map soil properties

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LandMapper… is Portable and Scalable!

- Fits in shirt pocket
- Works all season from standard 9V battery
- Measures EC/RES in irrigation water, saturated soil paste, and in the field soils from 2 cm to ~20 m depth

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Enlightening

LandMapper is… Easy and Fast!

- No calibration – EC output calibrated once for each probe size.
- Push a button – get EC value in 4 seconds!
- Stores 1000 EC values – can be merged with concurrently taken GPS data to produce quick maps.
- NEW: real-time stamps, unassisted monitoring, ergonomic design, standard USB cable, rugged for field work.

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Surveying Soil Physical Properties with RESISTIVITY

on the farm supplying potatoes to McDonald's chain (Moscow area, Russia)

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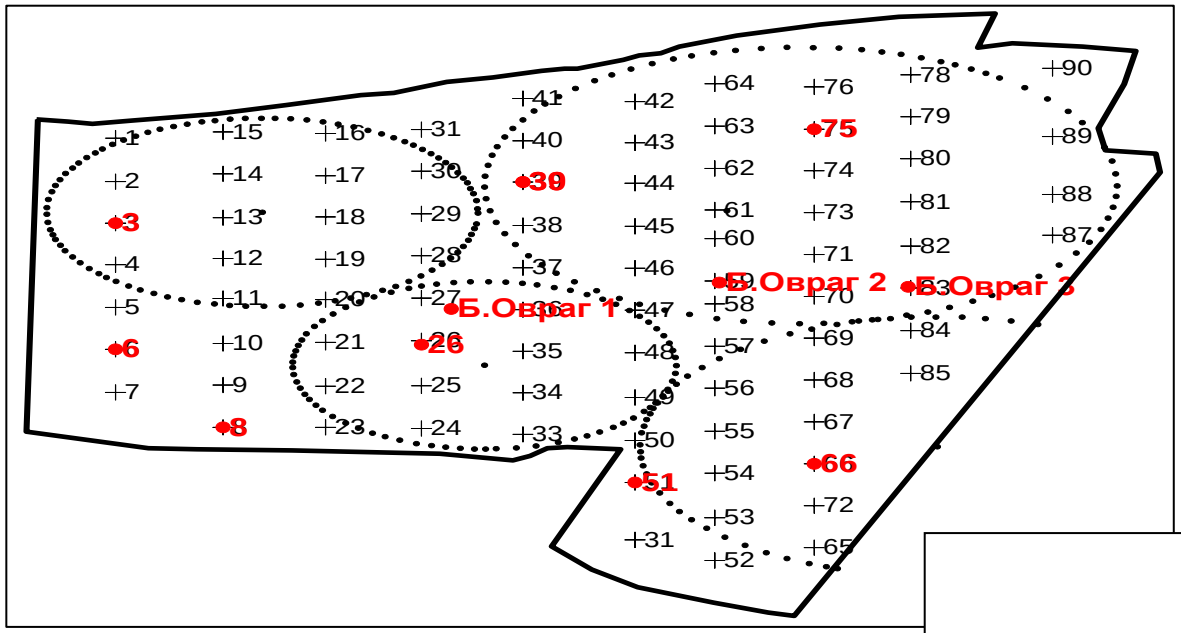
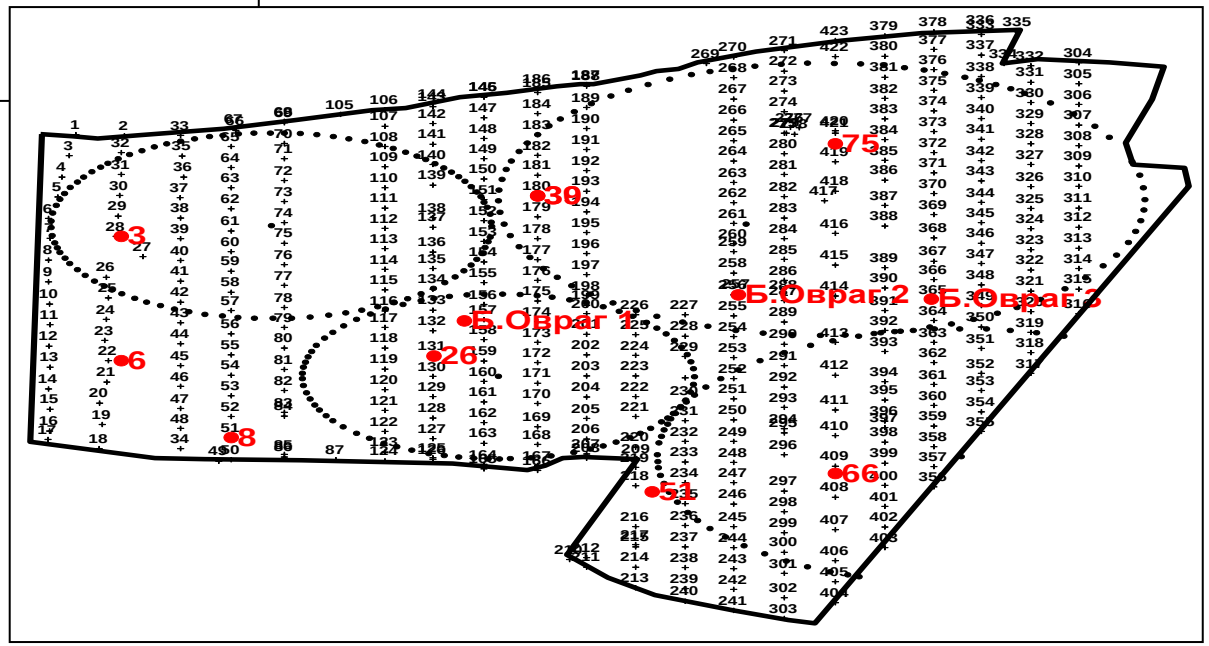
Intensively grown and irrigated potato field on cultivated Alfisols



~400 acres

10 soil pits and multi-layer sampling

90 VES locations



423 multi-depth EC mapping locations

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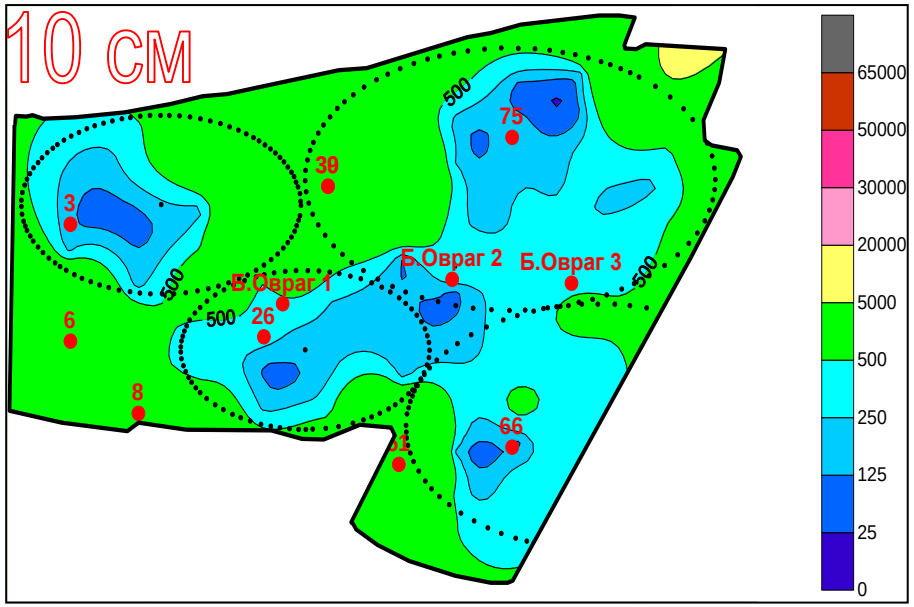
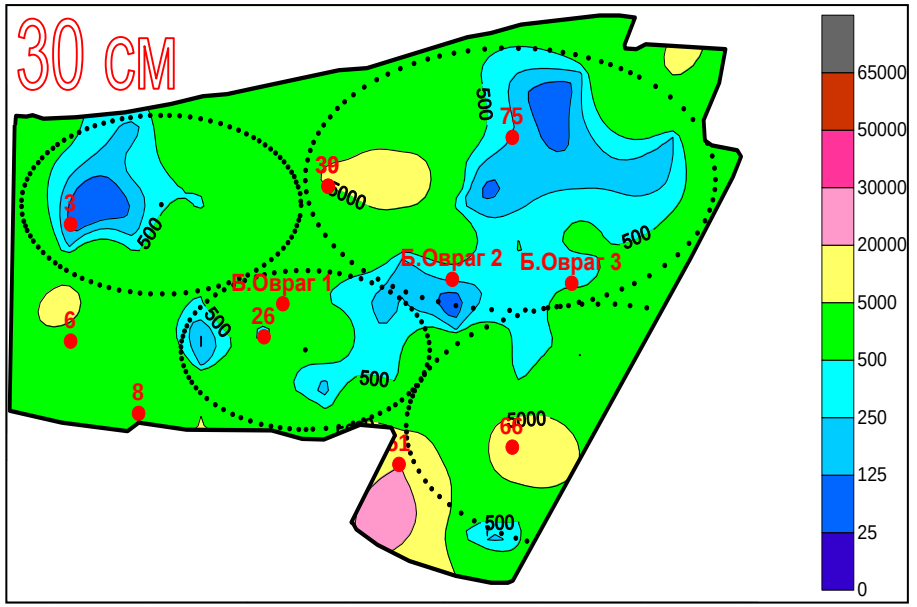
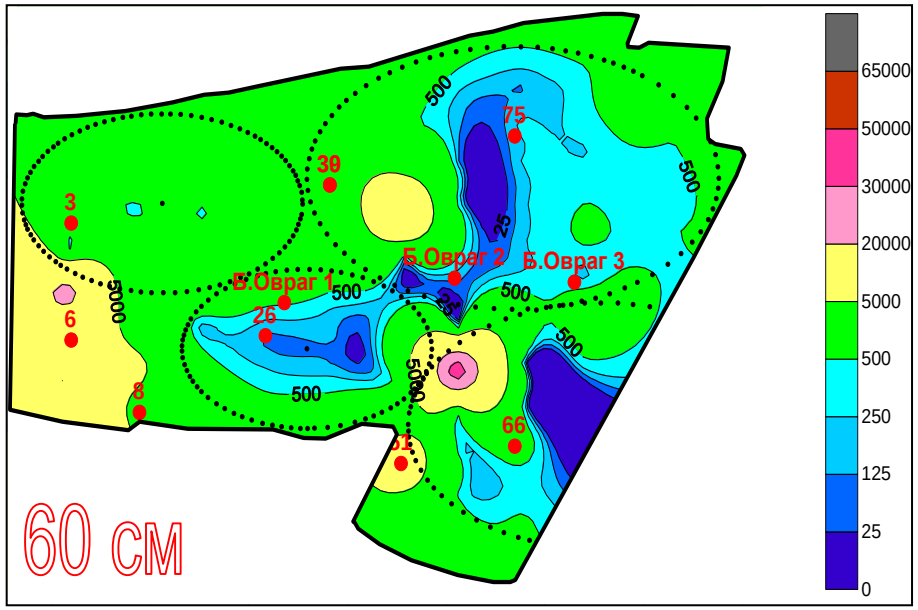
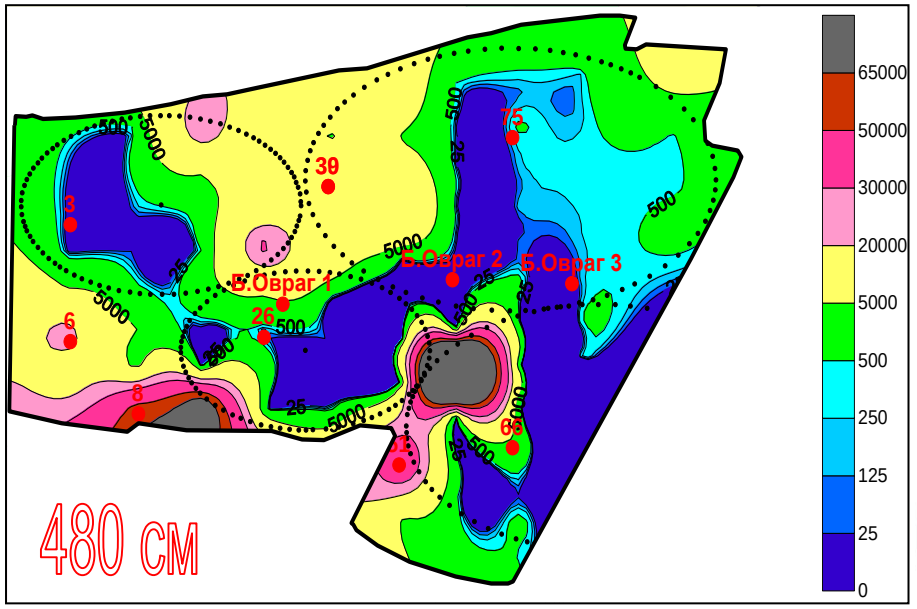
RES maps of soil at different depths (VES + El.Profiling)









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Measuring RES of saturated soil paste of the collected samples in standard four-electrode cells to correlate with in-situ RESISTIVITY

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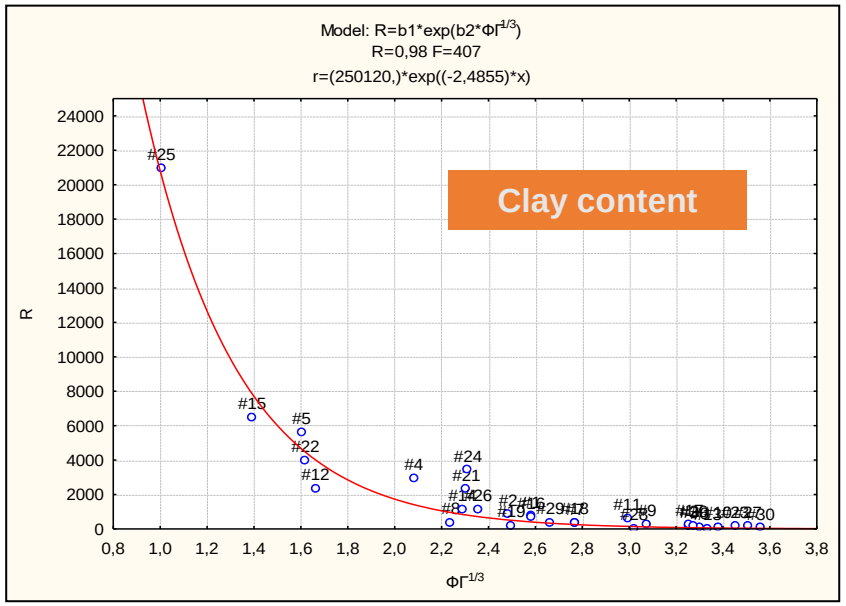
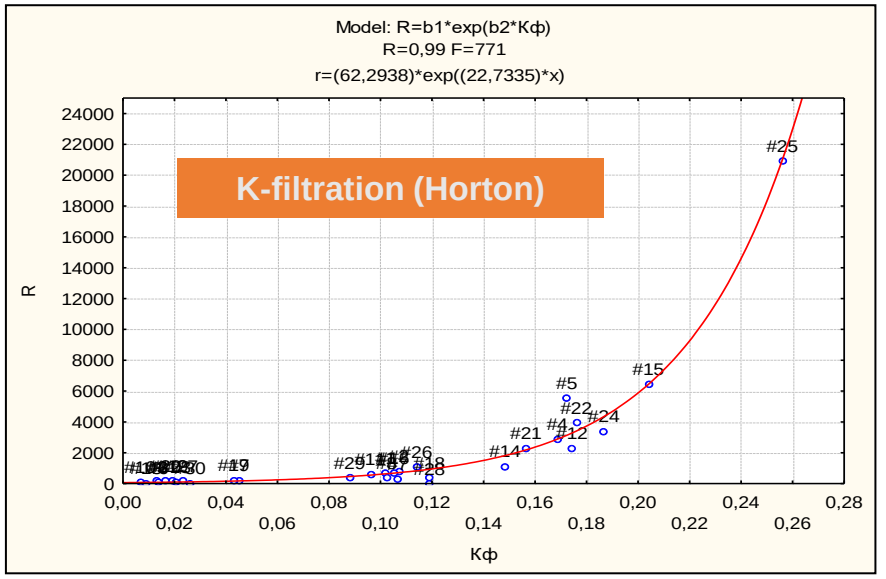
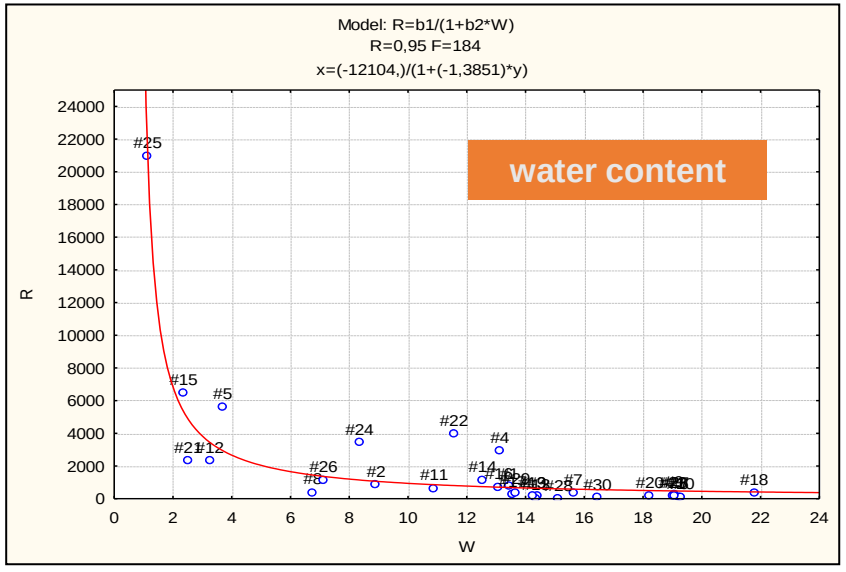
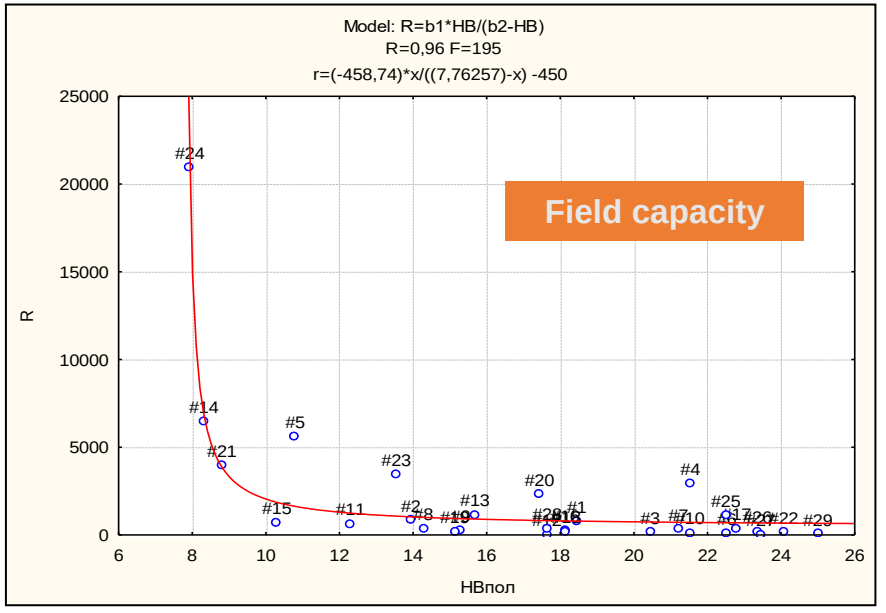
Key Soil Physical Properties vs RESISTIVITY









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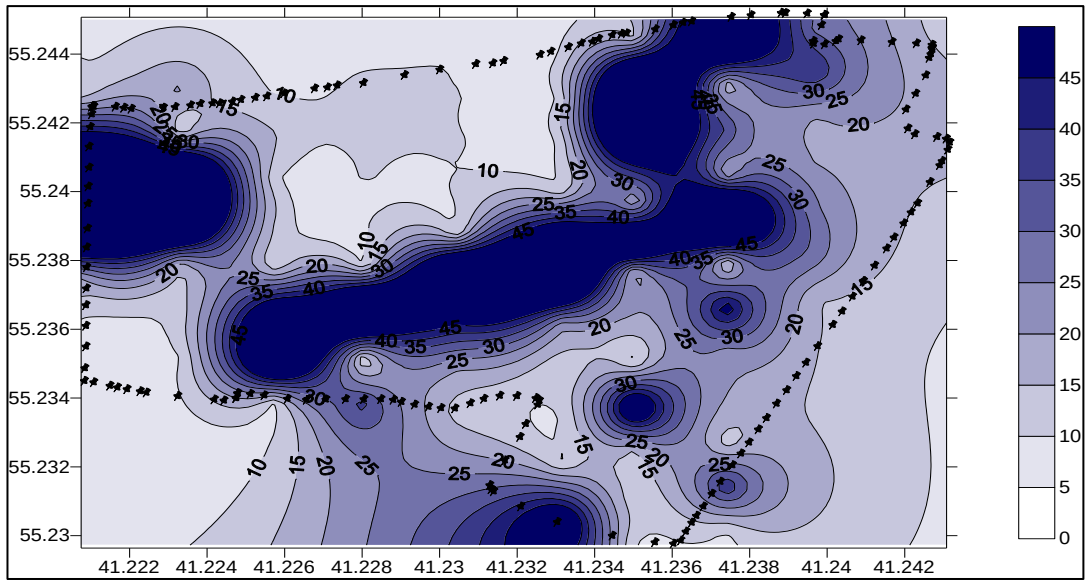
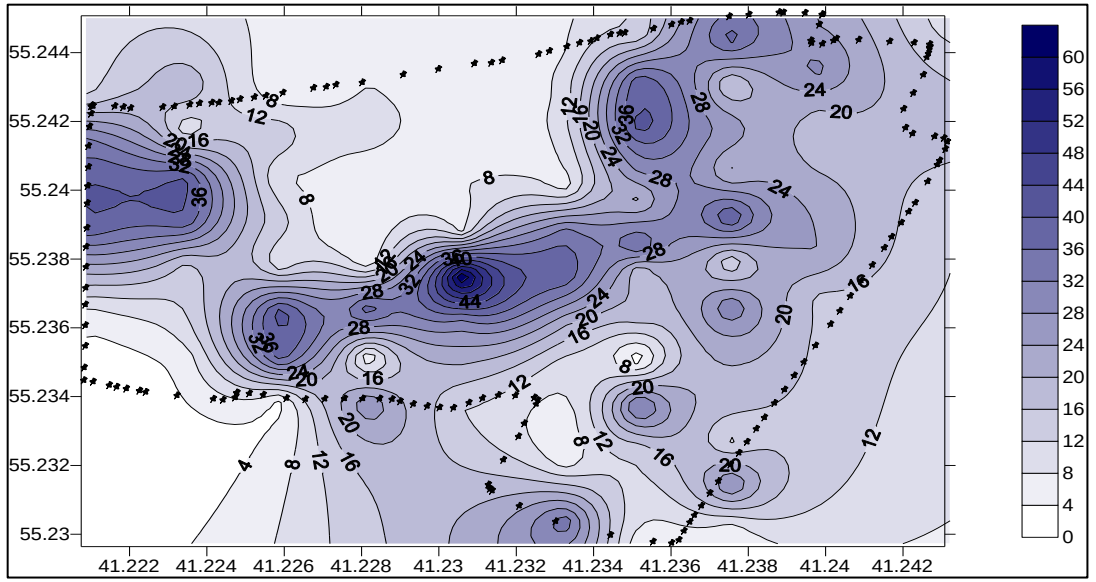
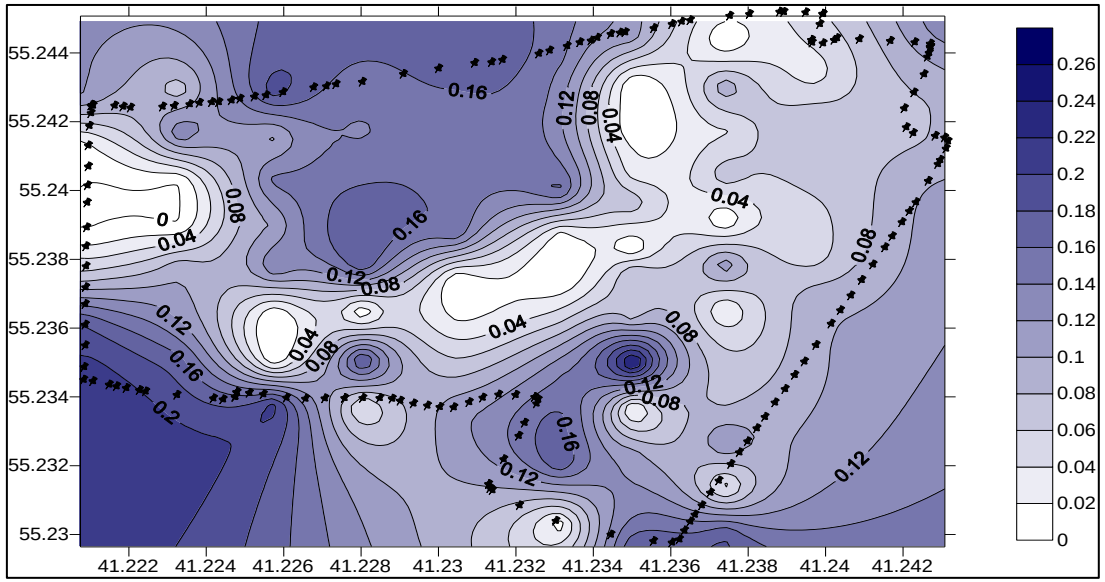
Soil Properties Maps at 16’ depth inverted from field EC mapping



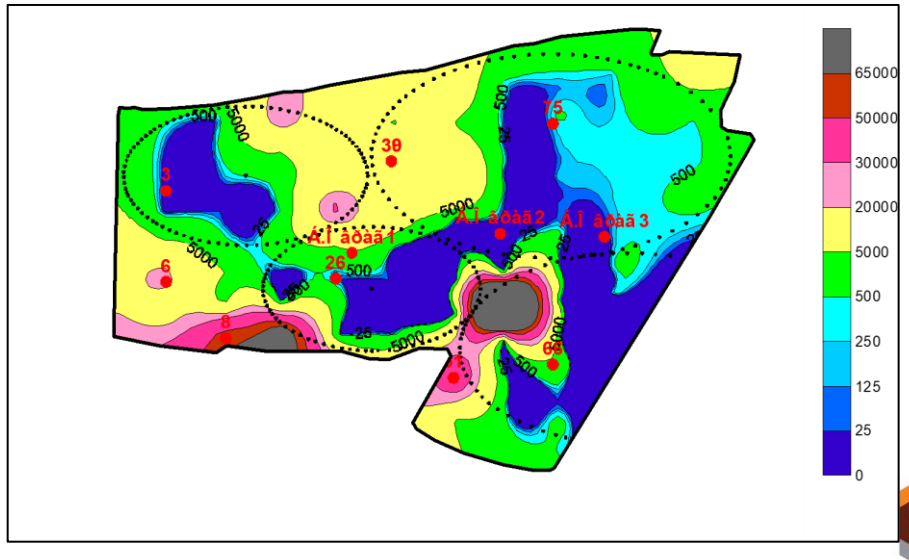
Field capacity,



Clay Content



Filtration coefficient



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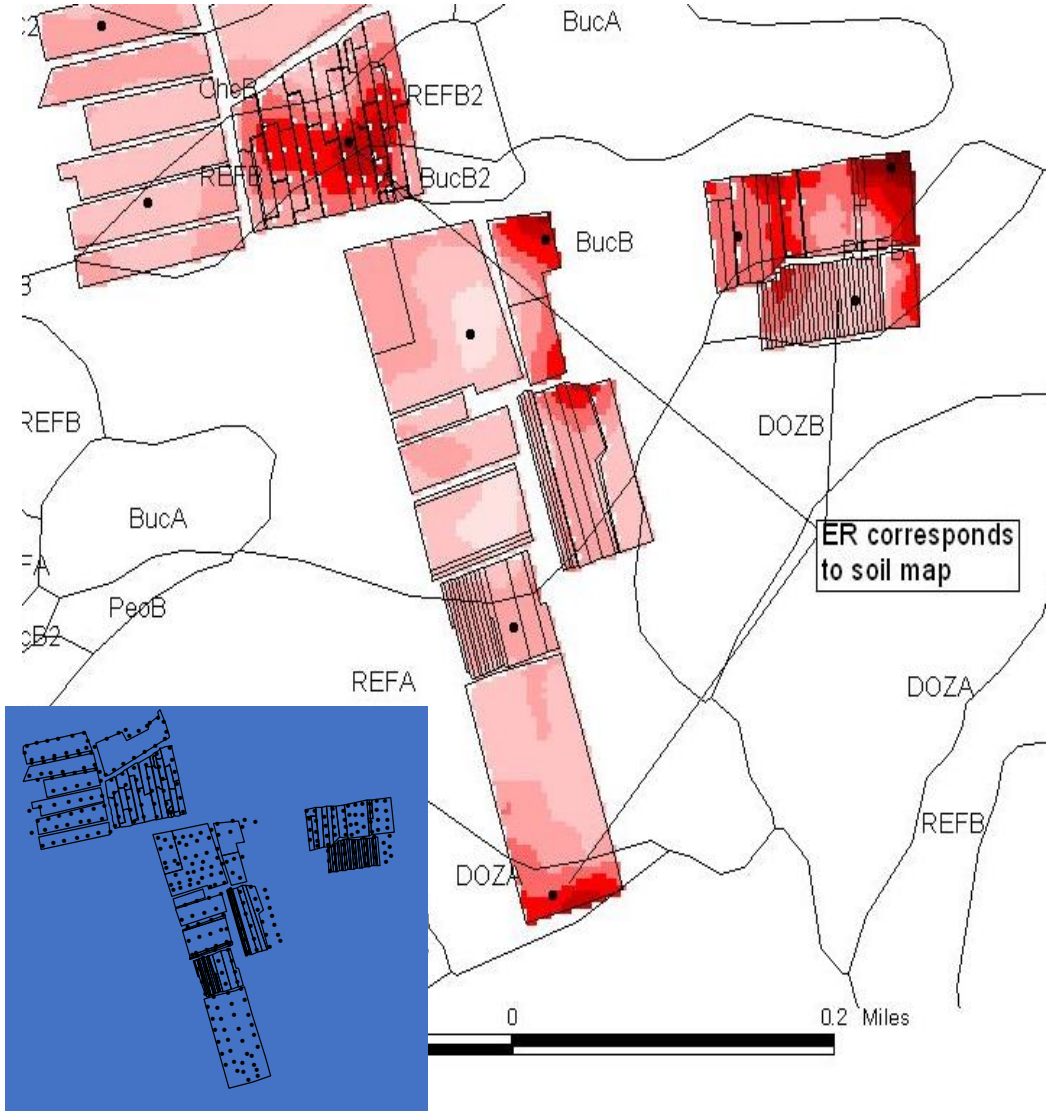
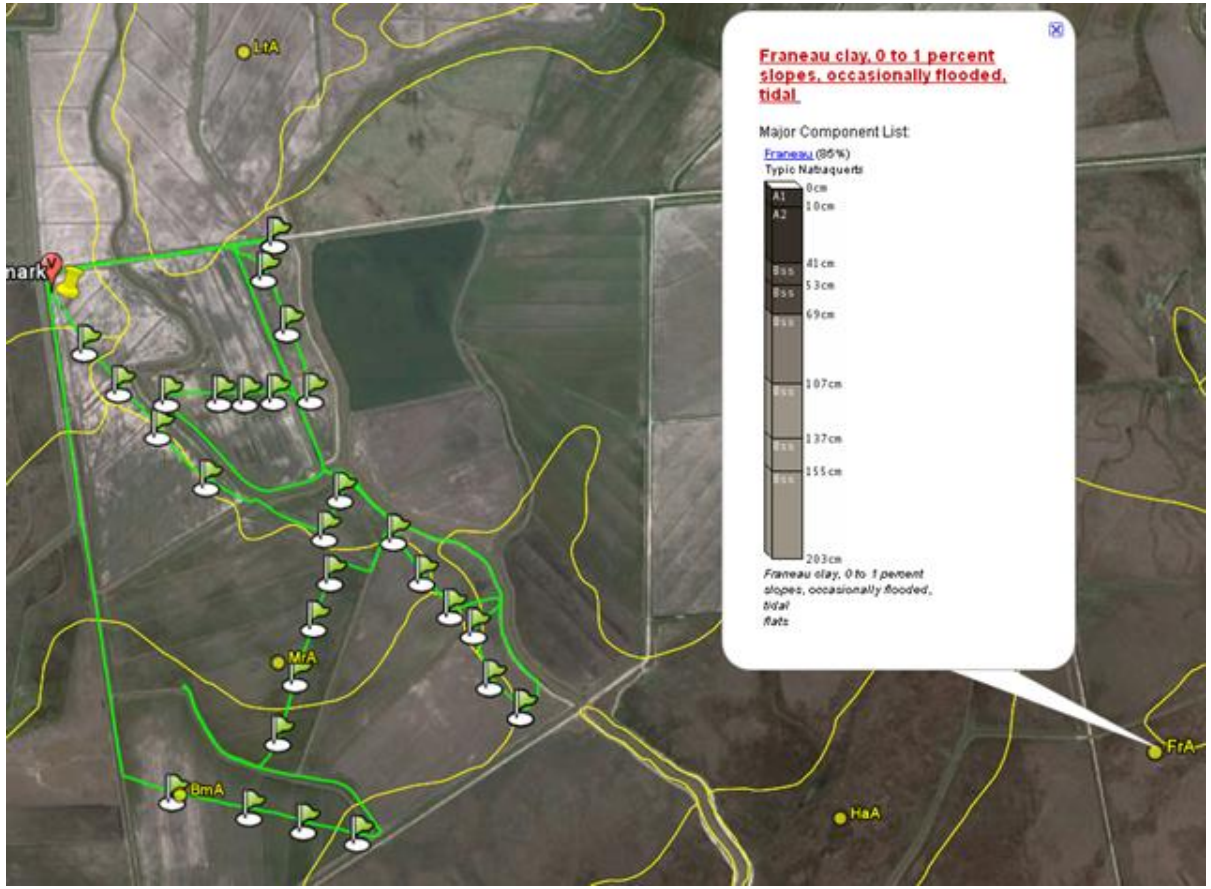
RES map outlines Management Zones on Berry Farm in NJ



Quick scouting for soil salinity (EC) with LandMapper and phone GPS on Rice Farm in TX



Previous Case Studies

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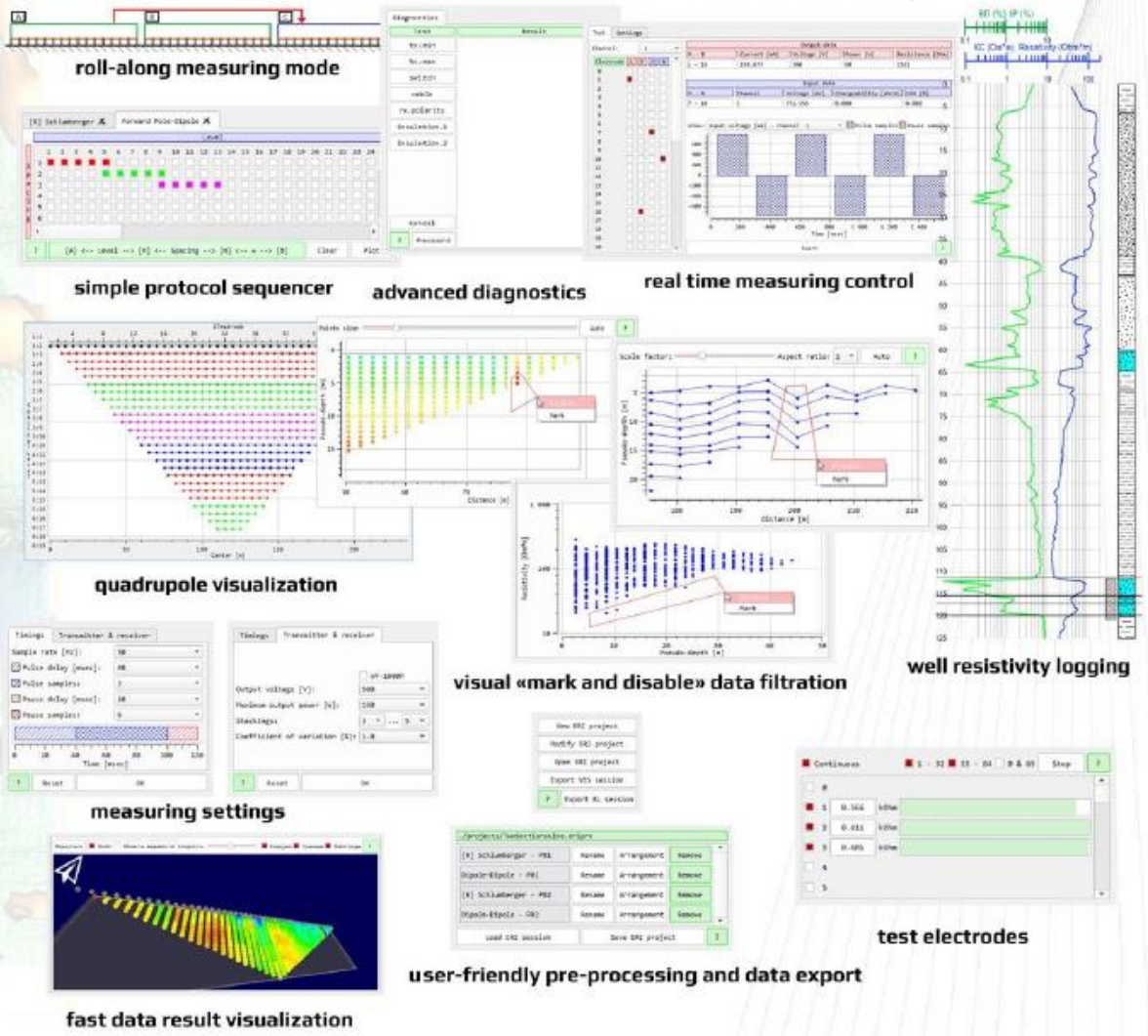
(7). Deep Subsurface 2D/3D Electrical Tomography

SibER 32K4

TRANSMITTER, 4x RECEIVER CHANNELS AND SWITCH FOR 32 x ELECTRODES IN ONE COMPACT CASE!

Easy to use multi-platform software «Xeres» for control and pre-processing



- for assessing and monitoring soil/rock layers and groundwater
- SibER 48K12 and SibER 64K15 also available

SiberGeo OÜ

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SibER48 Training in Indonesia, 2015

SiberGeo OÜ

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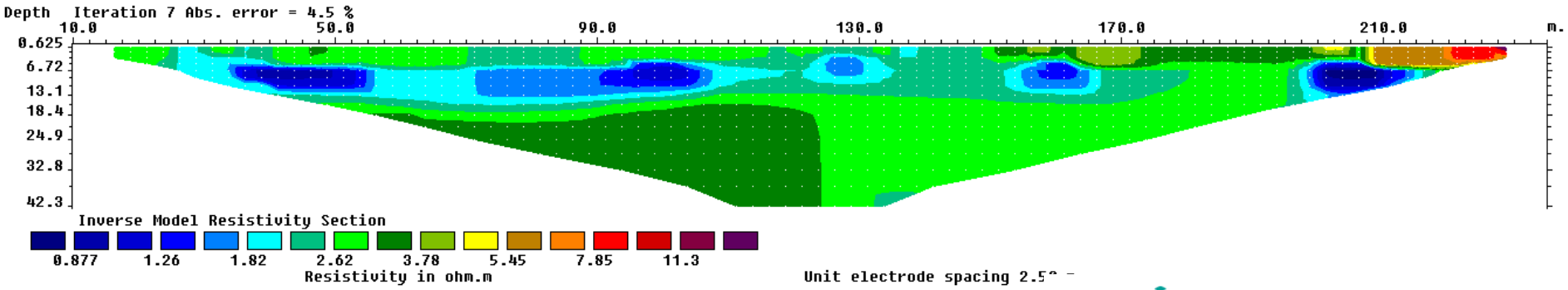

AGS Aarhus GeoSoftware

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Enlightening Research Through Collaboration

PARSEC

Team

computomics®
machine learning-based data analysis

Expertise:
Plant Genetics
Data Integration Interface
Machine Learning
SaaS Provider
Start-up Success

SiberGeo OÜ

Expertise:
Geophysical Technologies
Electromagnetic Sensors
Electrical Resistivity Imaging
Induced Polarization Survey
Geophysical Instruments
Data Interpretation

Landviser Research®
Enlightening

Expertise:
Remote Sensing and GIS
GxE Data Integration
Precision Agriculture
Climate and Crop Modeling
Agricultural Geophysics

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824478.

PARSEC

ACCELERATOR

Crop Predictions Take Flight

Integrating Genomics and Geophysics for a Sustainable Future

A Collaboration between Computomics GmbH (#100PARSEC, German), Landviser s.r.o. (Czech), and SiberGeo OÜ (Estonian)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824478.

Open Call II **June 2020**

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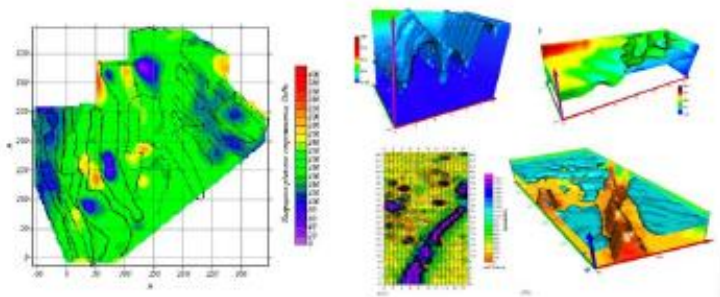
EM Scanner for UAV Payload

EmsControl (Windows Mobile)



2D and 3D visualisation on PC

Geovizer

TECHNICAL SPECIFICATION

Working frequencies: 12 kHz, 40 kHz, 111 kHz;
Measurement time: 0.3-0,9 sec;
Generator power: maximum 60 W;
Receiver sensitivity: 1 mV;
Dimensions: 90x75x25 cm;
Working time: about 6 hours;
Weight: 4.5 kg;
Sofware compatibility: Android, Windows.

Perspective development with innovative primary field compensation method.

SiberGeo OÜ

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Integrating Earth Observation Data with Plant Genomics to Feed the World!

Agriculture produces 30 megatons less grain that needed to feed the world

Changing climate affects current crops

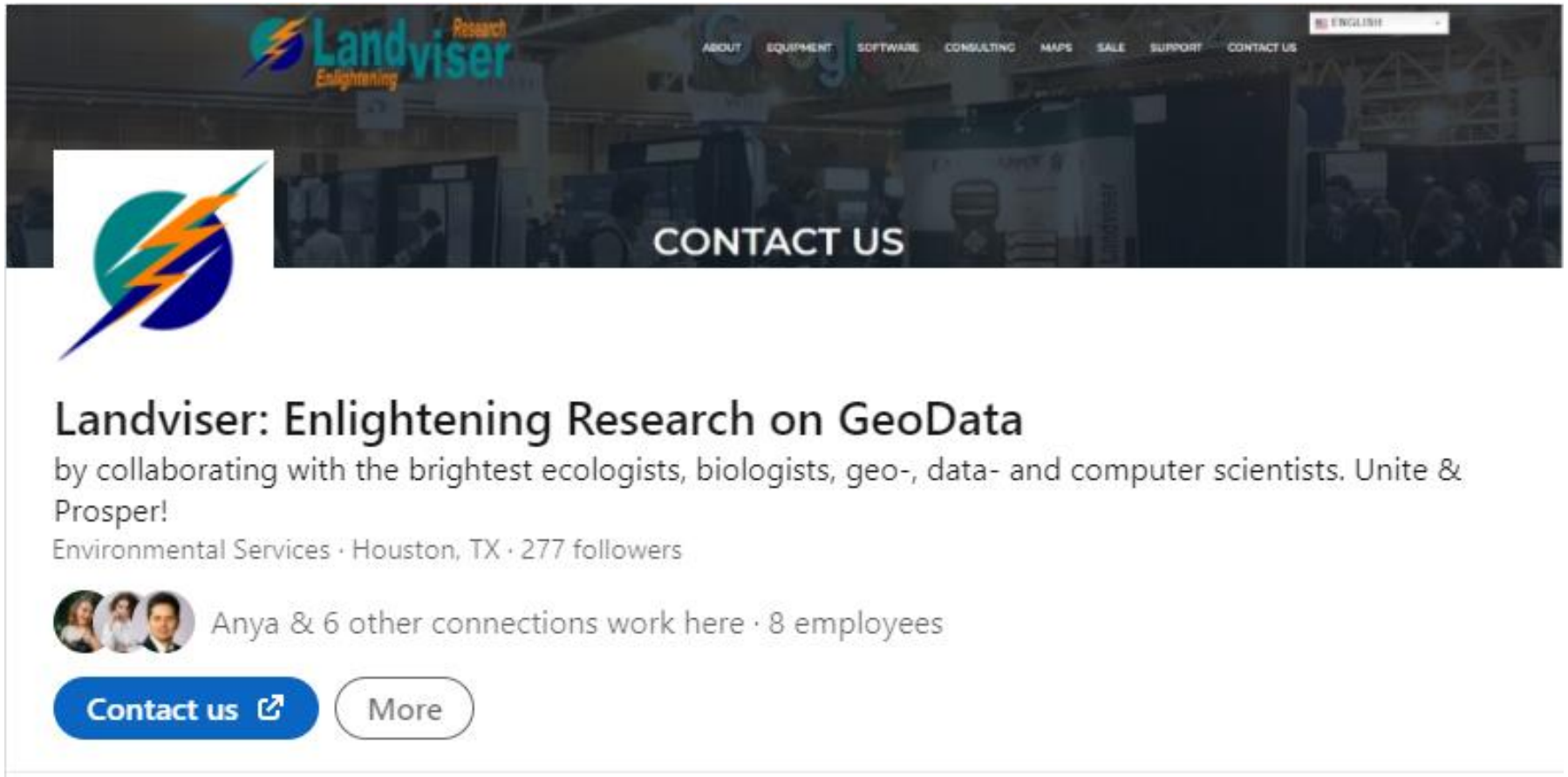
~13 years to breed a new variety

To solve this problem, breeders are collecting more and more data **but have no way to integrate it all!**

- Necessary to capture the full scope of G (Genotype) x E (Environment) x M (Management) non-linear, higher-order interactions to fully simulate phenotypes
- **Unique: No system allows integration of crop-relevant EO data with genetics**

SAGEEP2021 ONLINE

Thank You! Let's Connect!



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