NOVEL FLYING EM SENSOR FOR AGRICULTURAL RESEARCH

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Landviser Research® Enlightening

SiberGeo OÜ

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

On the Farm – it All starts with Soil...

- 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) and conductivity (EC) are fundamental parameters directly related with soil salinity, NPK fertilizer uptake, pH, texture, organic matter, water content and other properties affected by the density of mobile electrical charges in soil layers.
- Unlike agronomic 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 farmlands.
- Portable geophysical instruments of direct current – for RES/EC/IP/SP (LandMapper by Landviser, USA; SibER by SiberGeo, Estonia) and electromagnetic induction – for RES/EC (Geovizer and AEMP-14 by KB Electrometry, Russia).

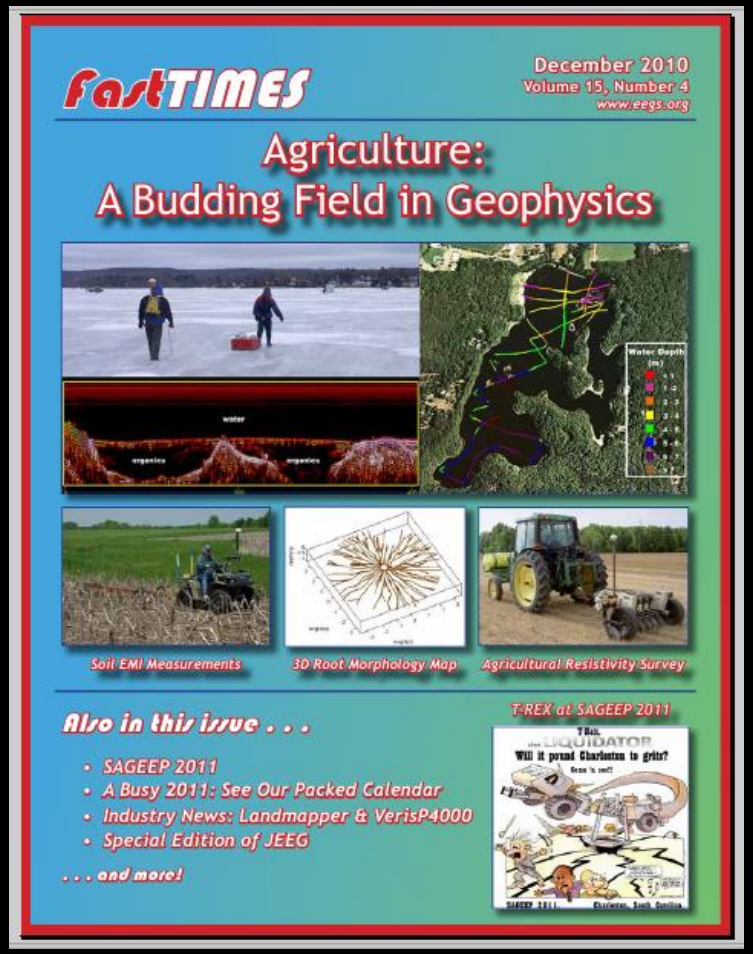
SiberGeo OÜ

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

Imagery vs Geophysical Subsurface Surveys



Imagery:

Complete coverage

Vegetation mapping

Fast

Sensors:

Point data

Multiple depths

Monitoring

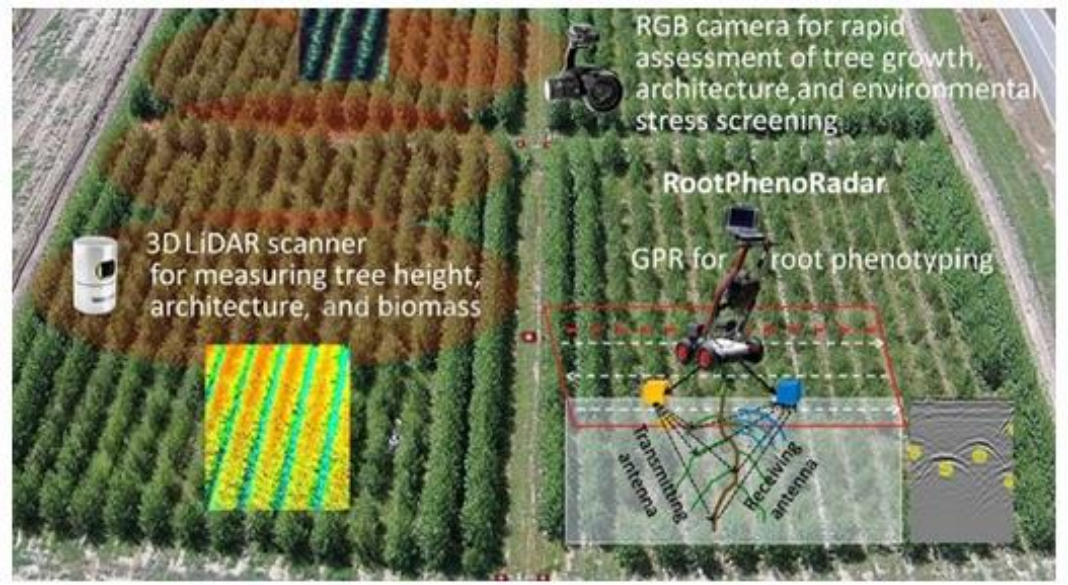
Geophysical Imaging:

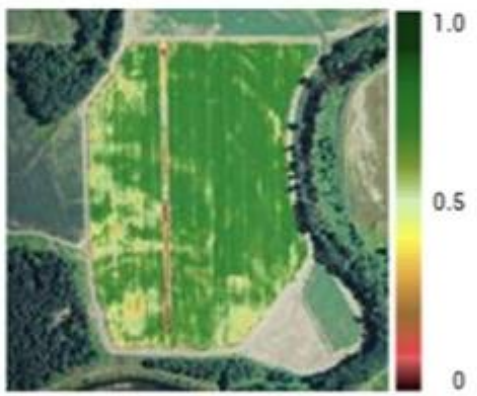
Mapping & Monitoring

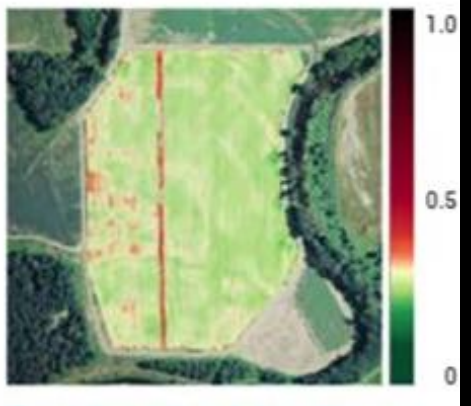
2D/3D Subsoil Models

Contact DC & EM

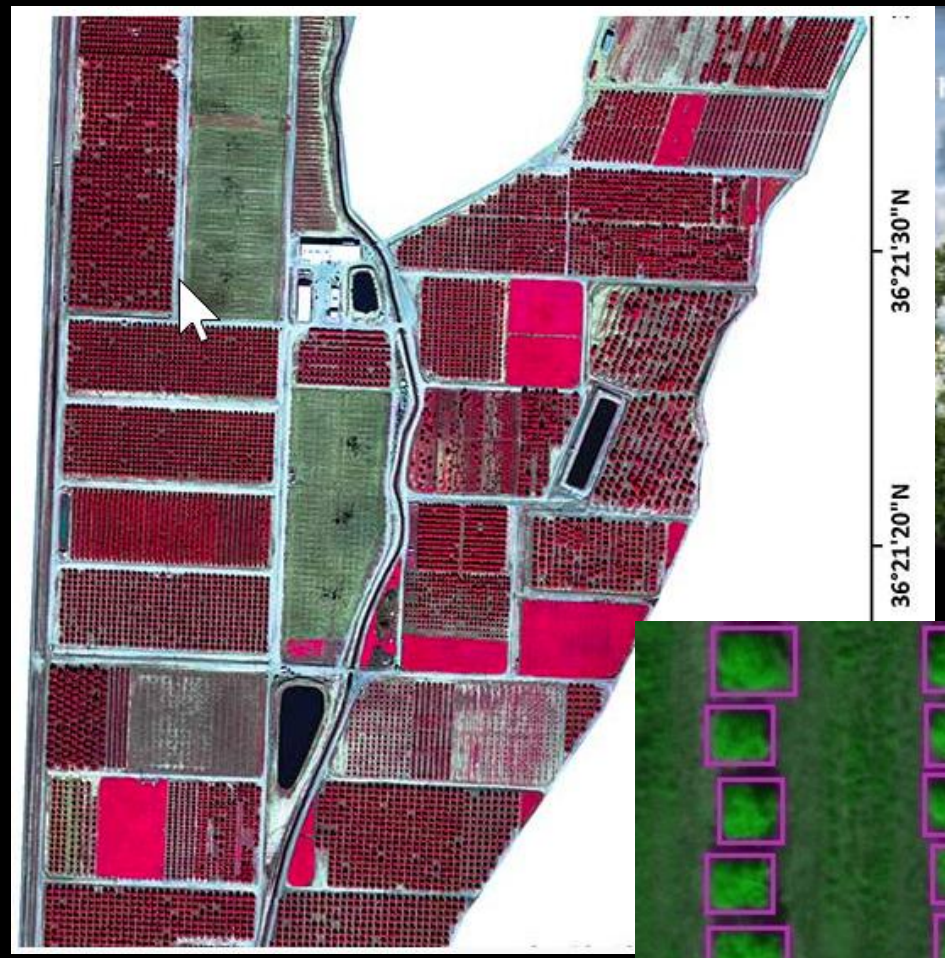
On Ground: walk, ride, **fly?**...

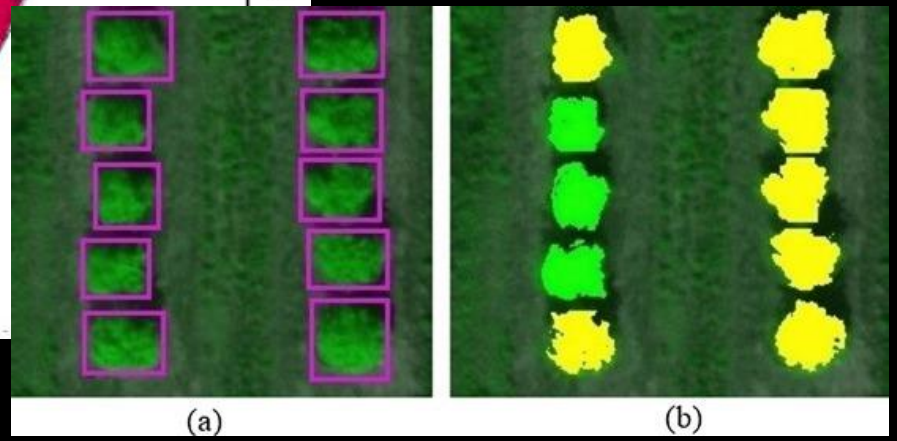






UAV Imagery Benefits





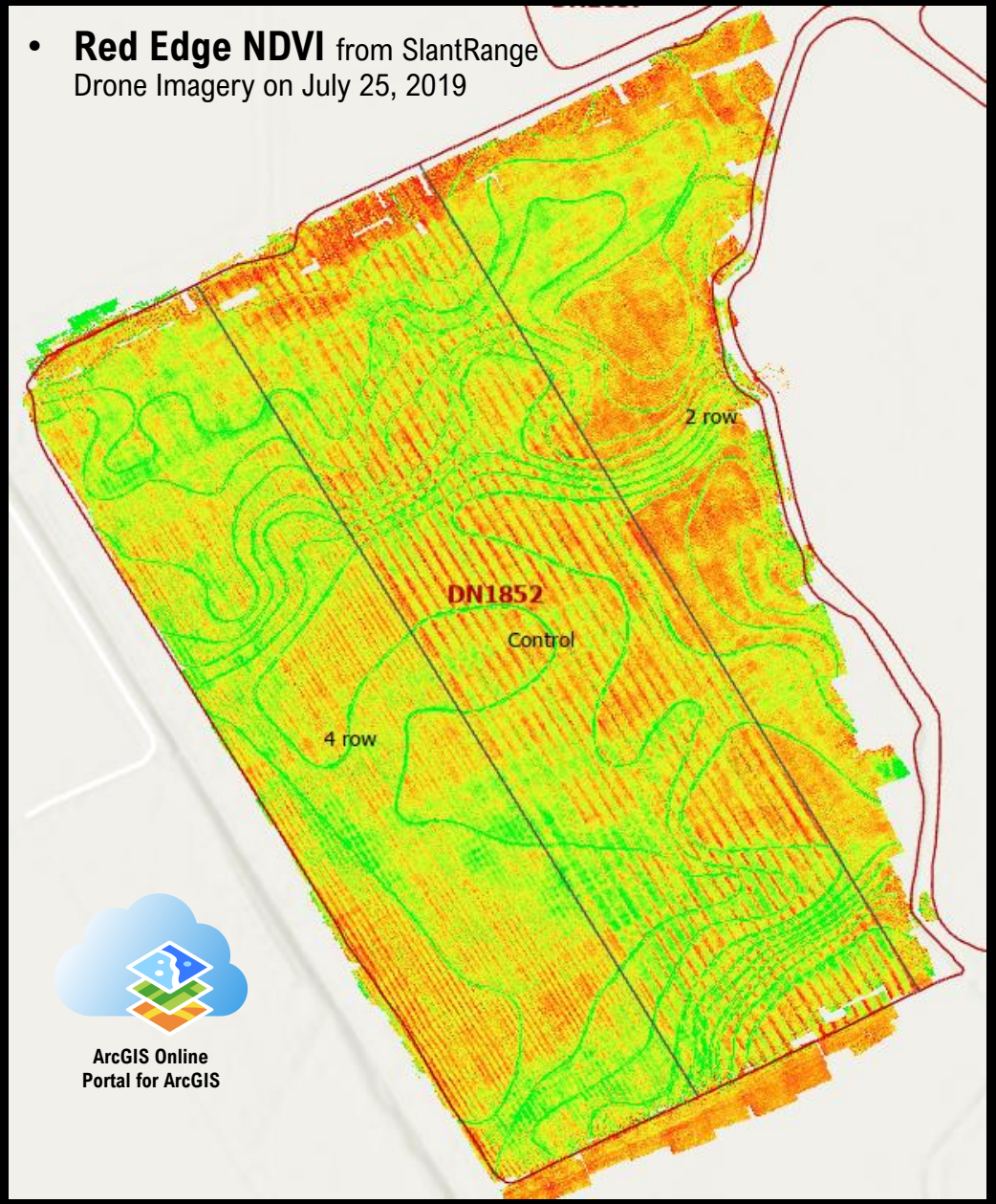
Ref: https://www.sciencedirect.com/science/article/pii/S0168169919311123#f0020

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

Yield Predictions from Drone Imagery during Plant Growth

Yield Prediction

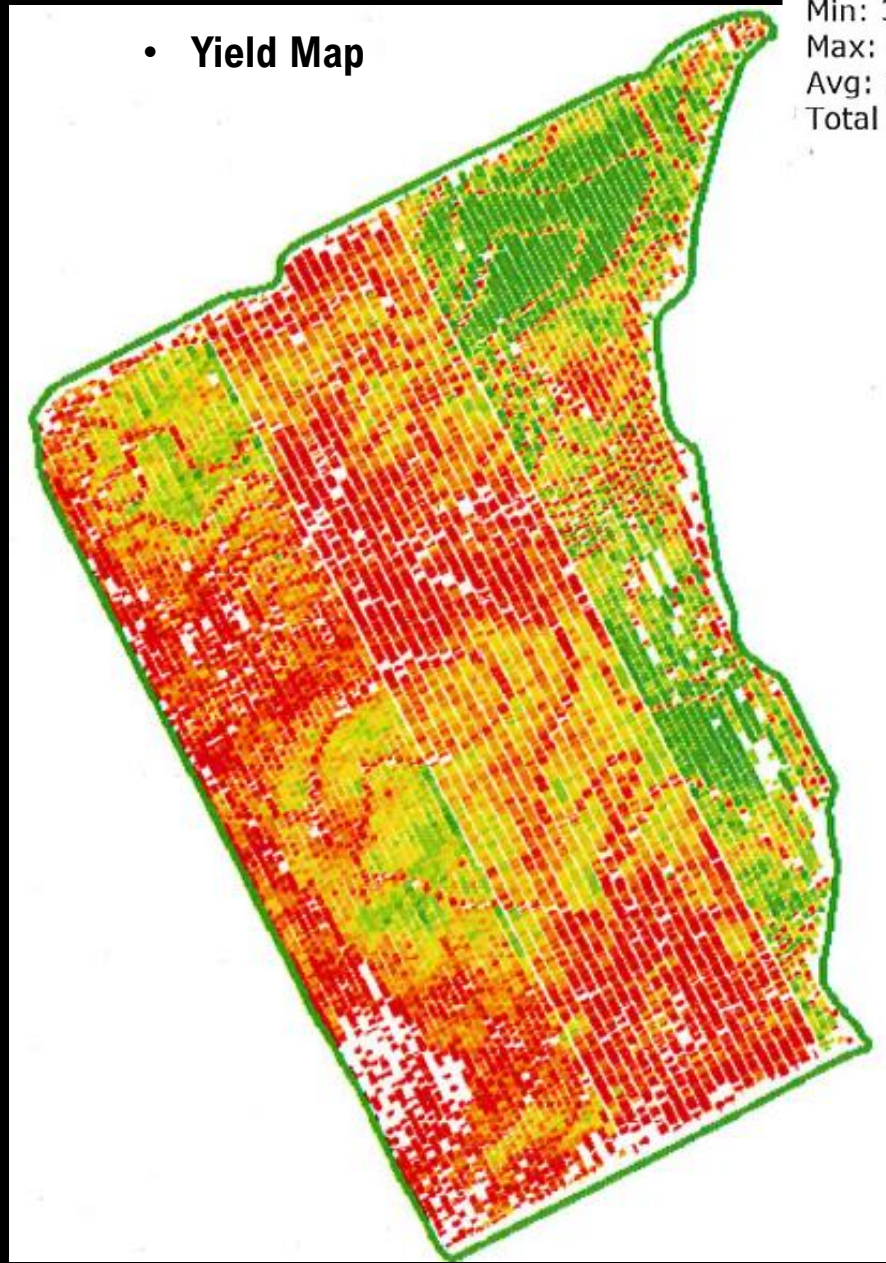
- **Red Edge NDVI** from SlantRange
  Drone Imagery on July 25, 2019

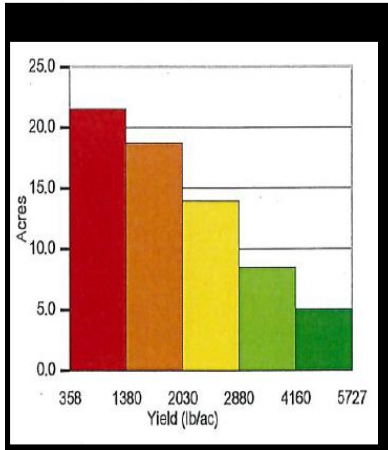


- **Yield Map**

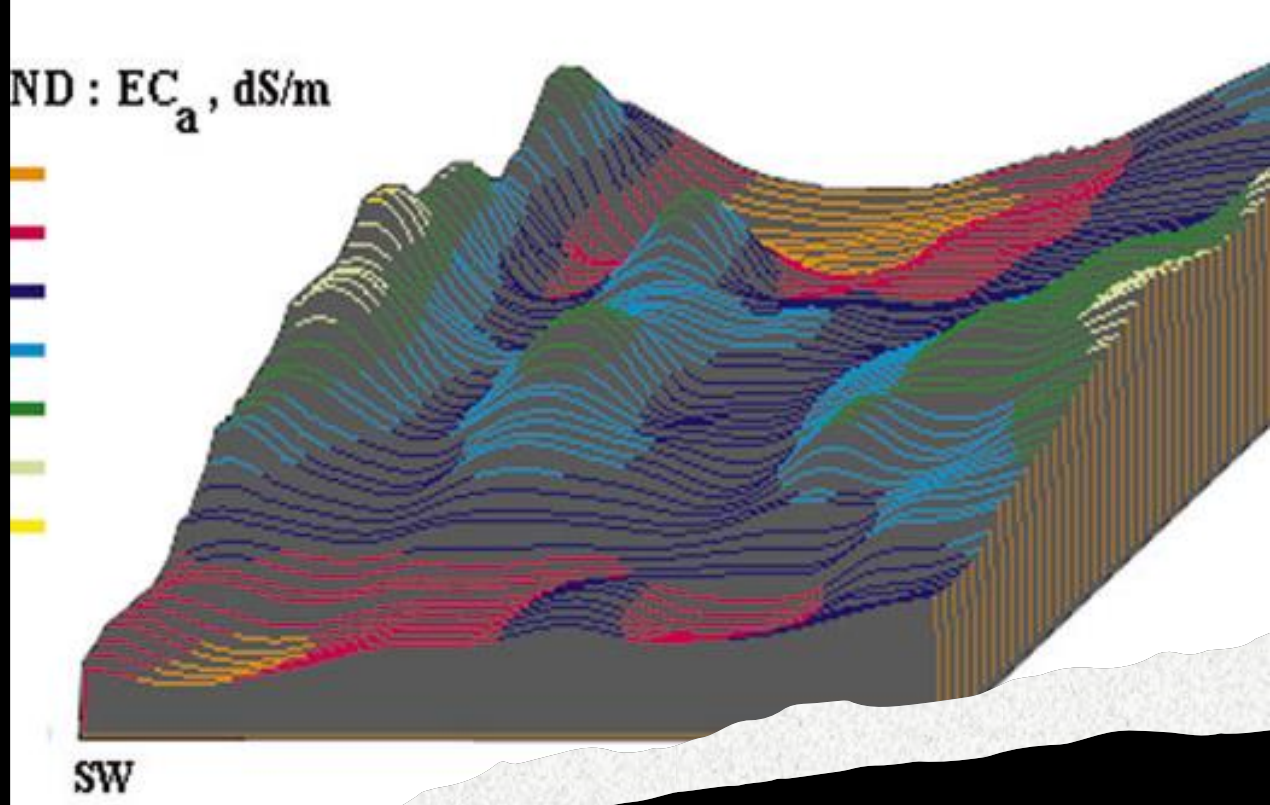
Crop Season: 2019
Harvest Date(s): 8/3/2019

Harvested Area: 67.56 ac
Min: 358.08 lb/ac
Max: 5,727.27 lb/ac
Avg: 2,090.45 lb/ac
Total Product: 141,239.99 lb





Landviser Research Enlightening ®

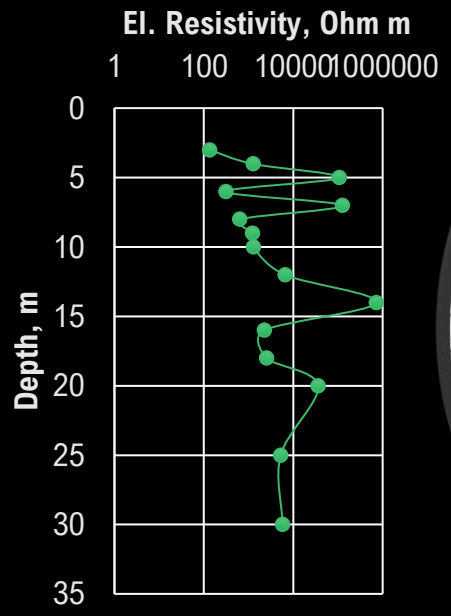


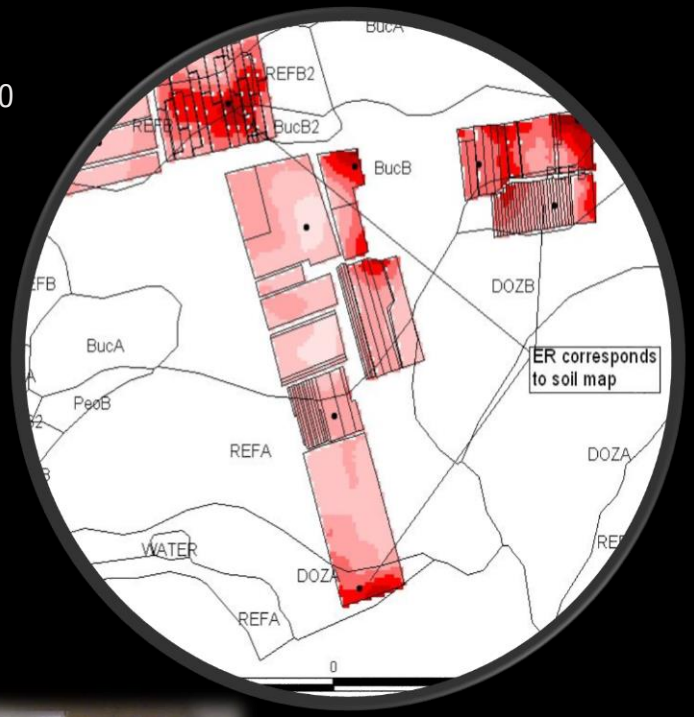
Salinity: persistent, not visible, EC-related

- No salts are visible, but rice seedlings die

Landviser Research® Enlightening

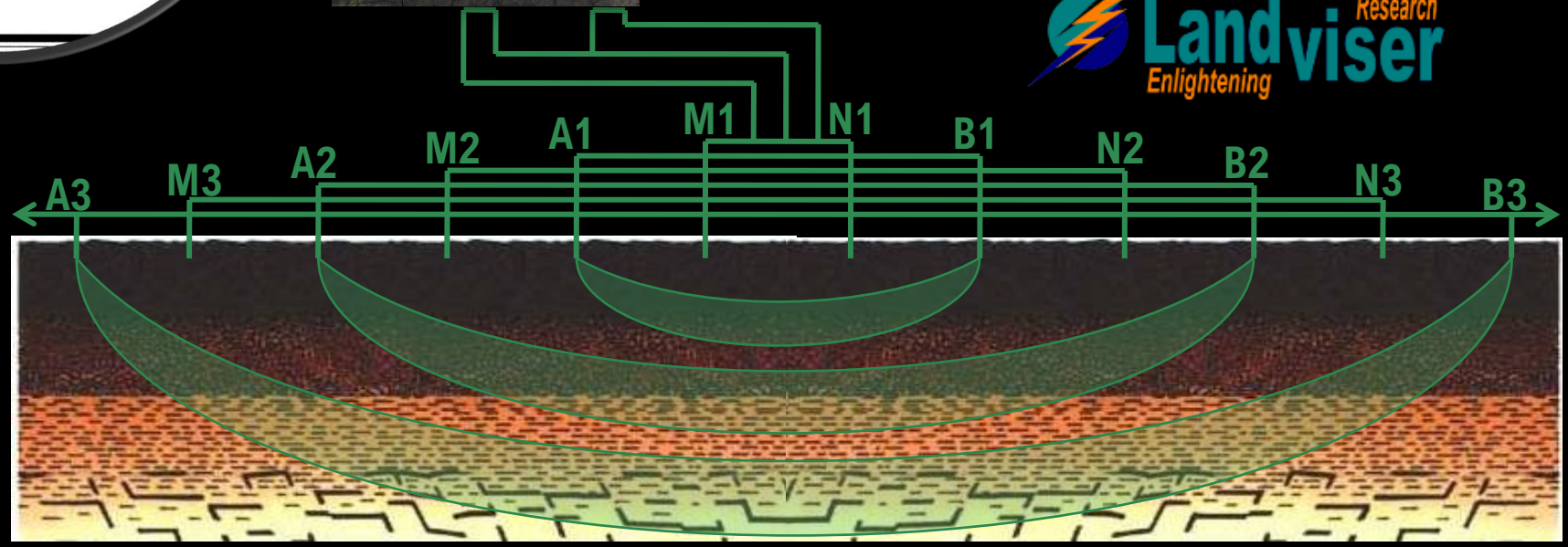
LandMapper® is... Portable and Scalable!



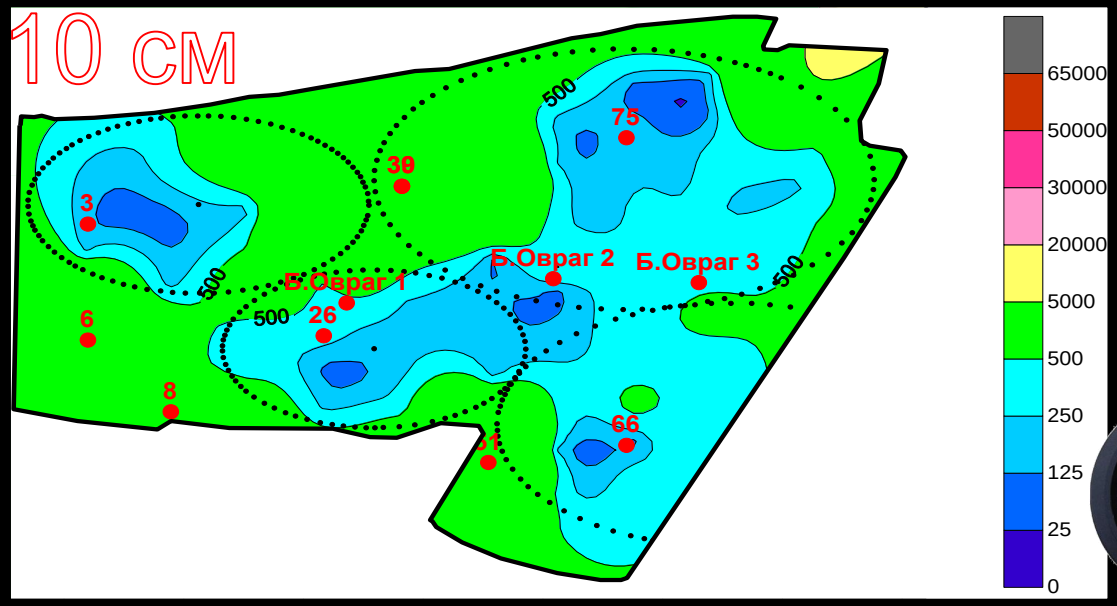


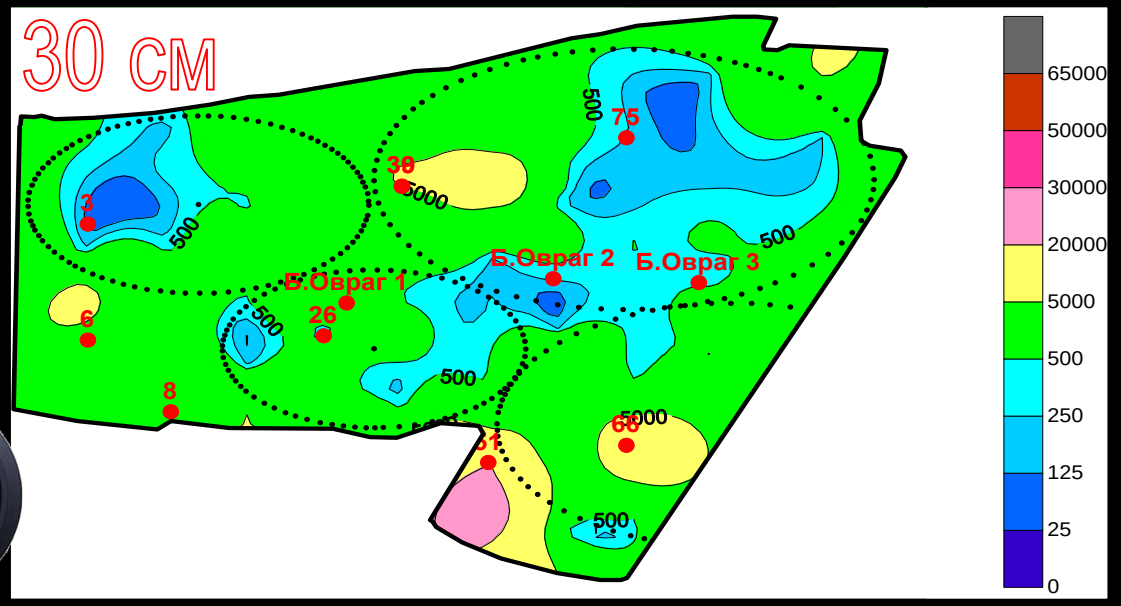
- Fits in a shirt pocket
- Runs all season from standard 9V battery
- Measures EC/ER in irrigation water, saturated soil paste as well as in the field soils from 2 cm to ~30 m depth (manual 1D VES)

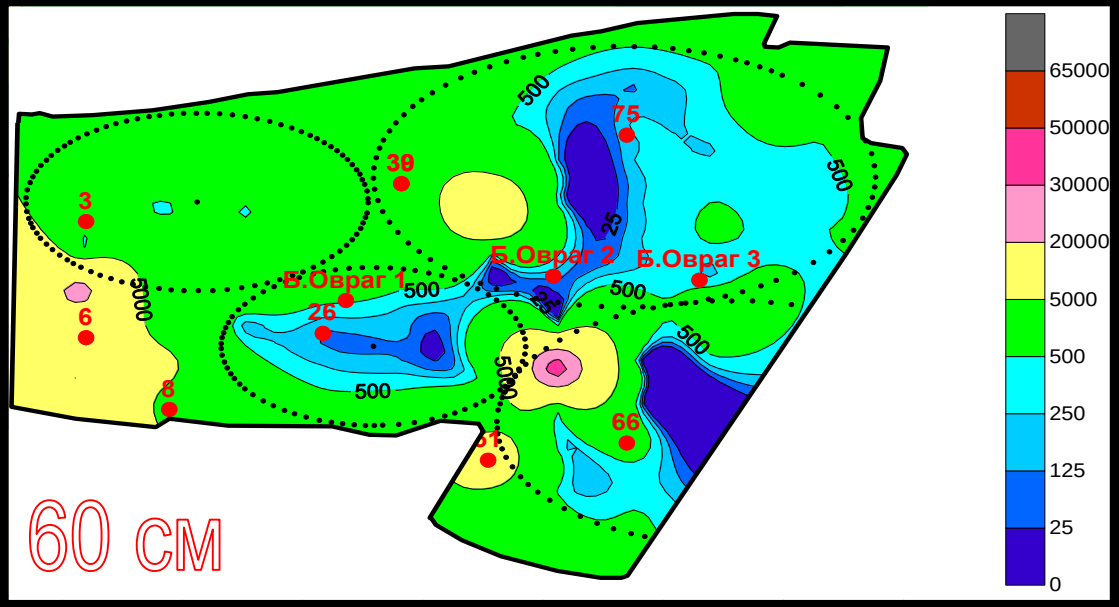
Landviser Research® Enlightening

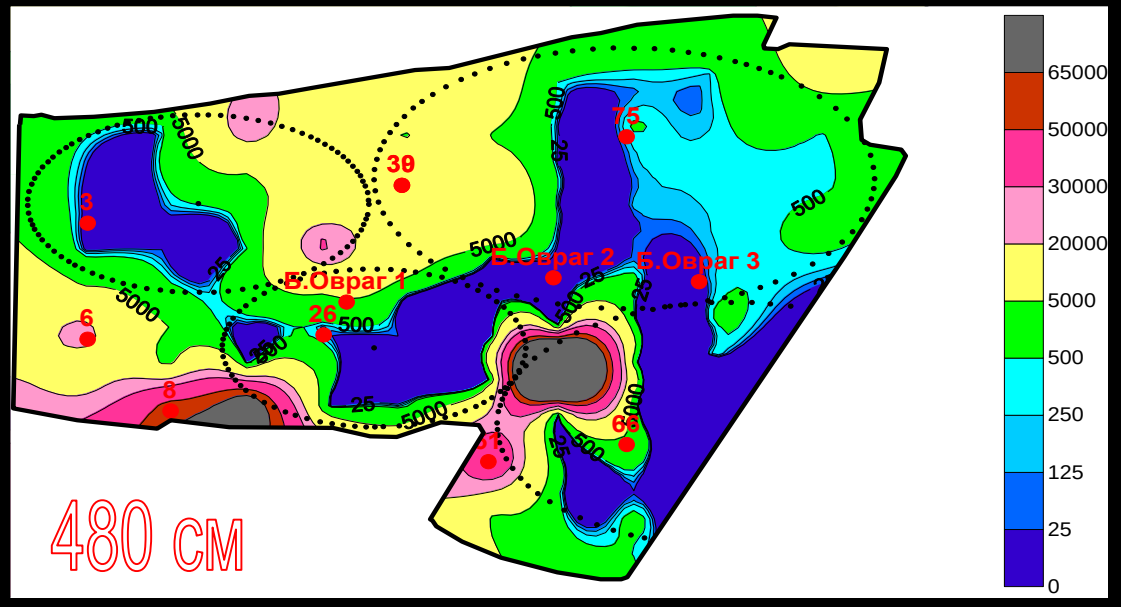


RES maps of soil at different depths (VES + El.Profiling)

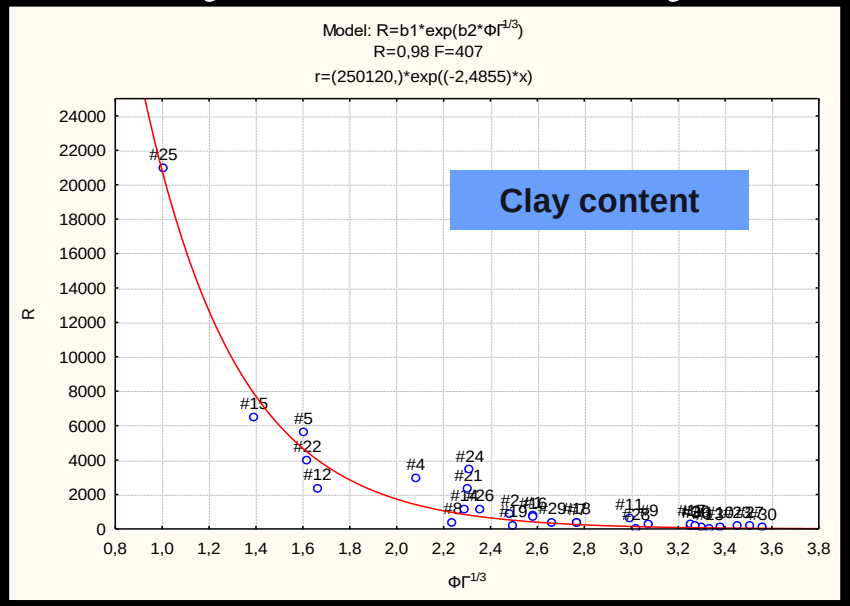


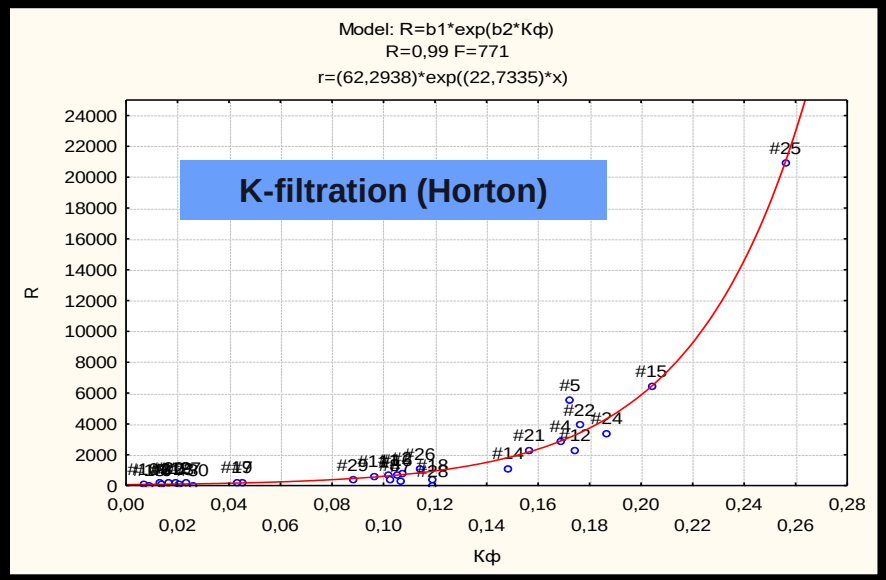


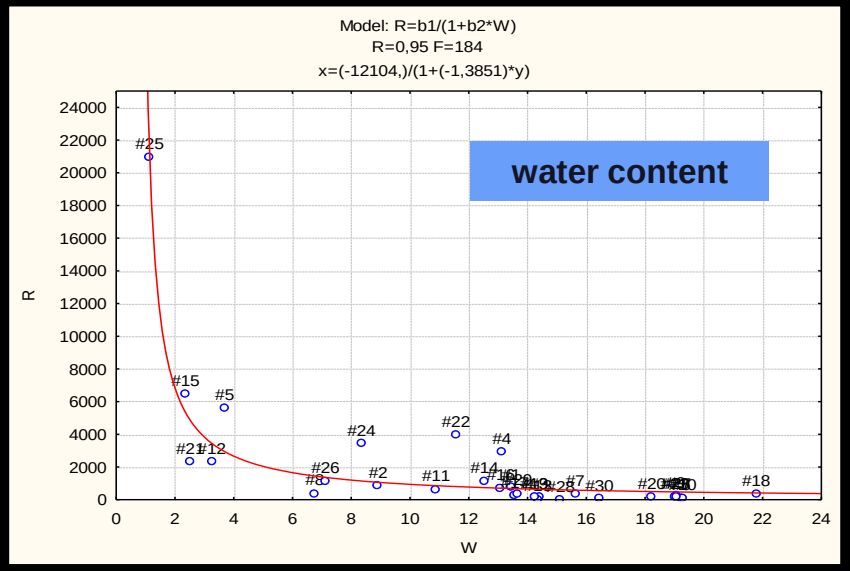


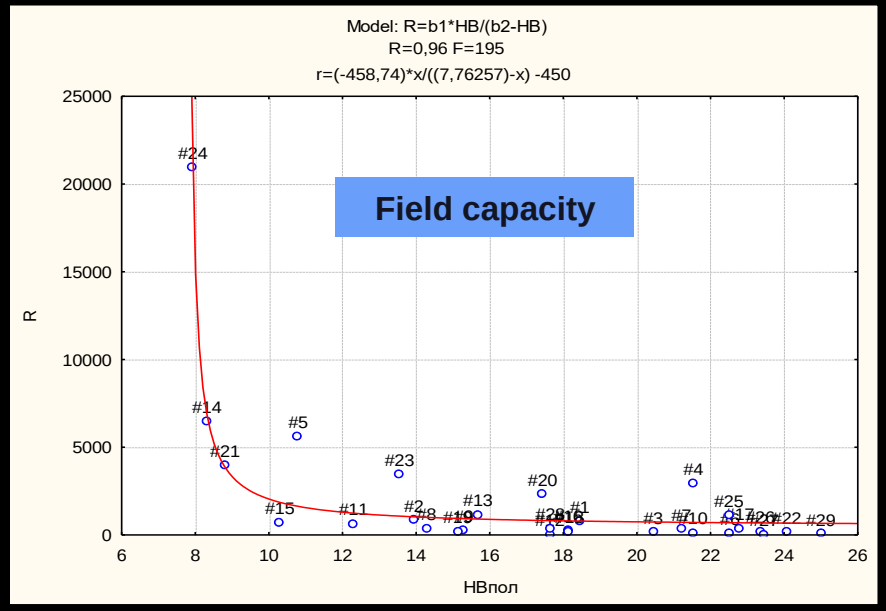


Key Soil Physical Properties vs RESISTIVITY

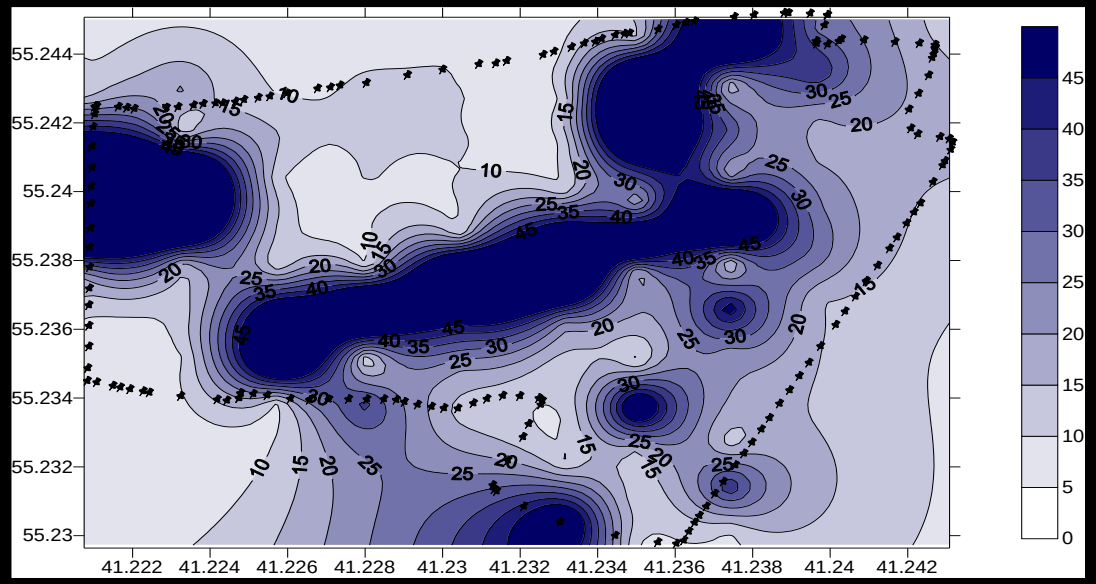




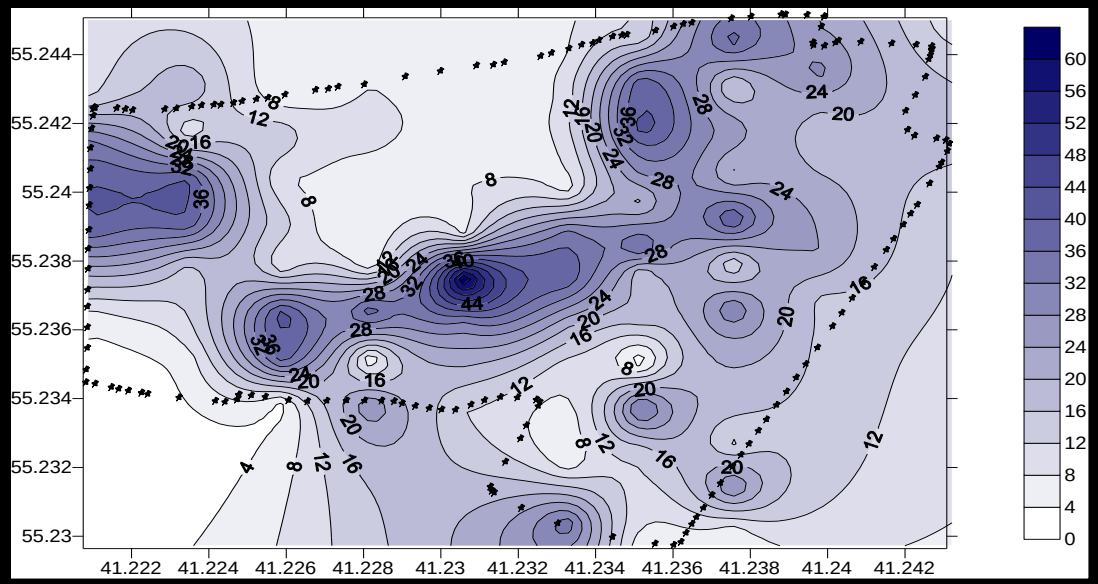




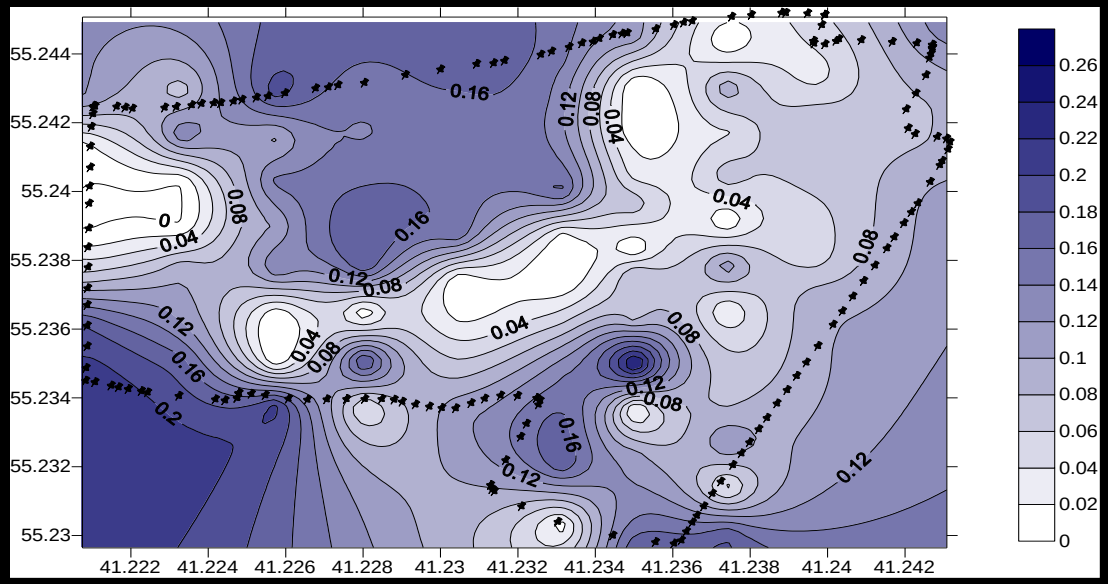
Soil Properties Maps at 5 m depth inverted from field RESISTIVITY



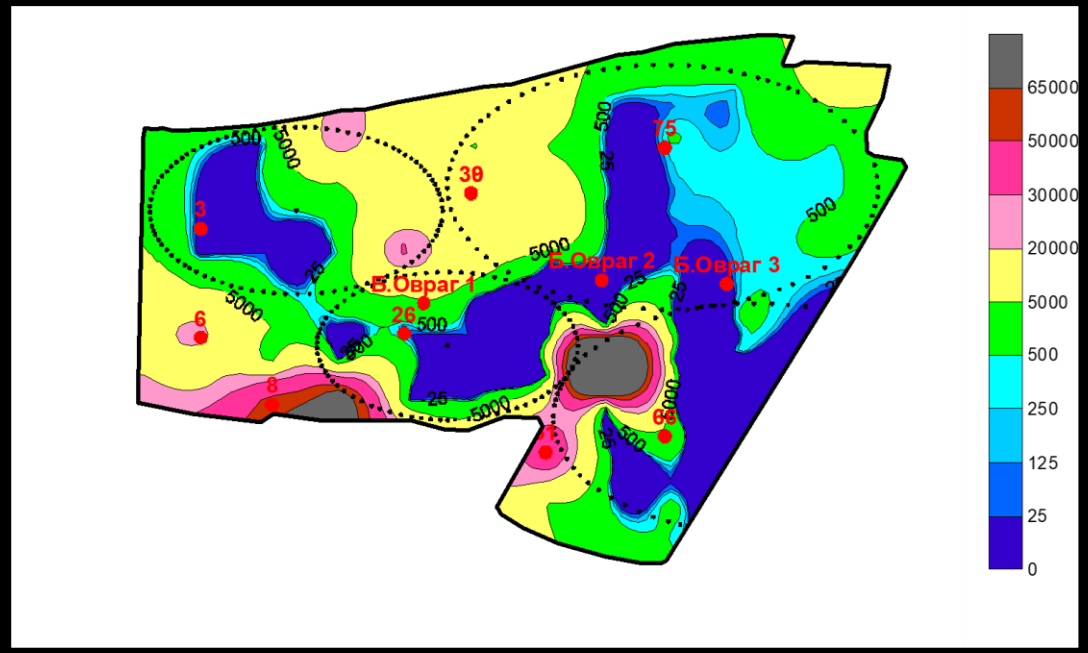
Field capacity,



Clay Content,

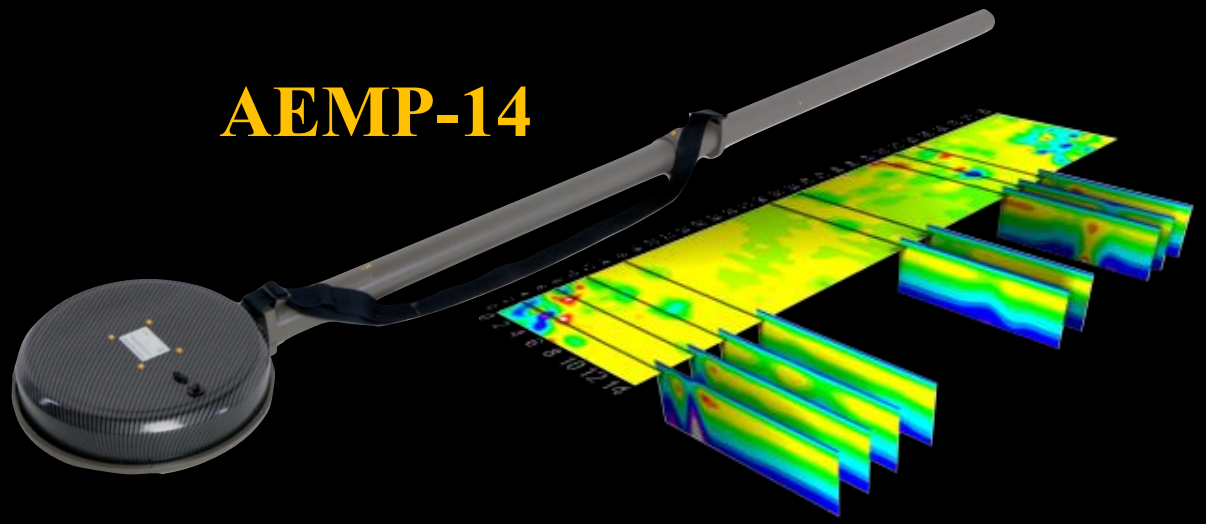


Filtration coefficient



Multi-frequency Electromagnetic (EM) Profiling

AEMP-14

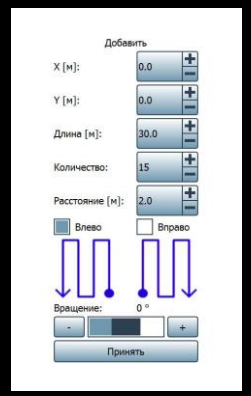


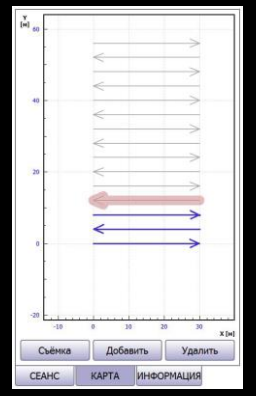
GEOVIZER

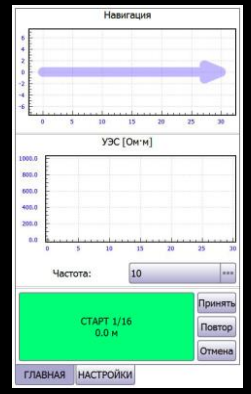
Electromagnetic profiling on any set of 3 (Geovizer) or 14 (AEMP-14) fixed frequencies in range 2.5 - 250 kHz, with automatic GPS referencing and previewing of 2D/3D models!

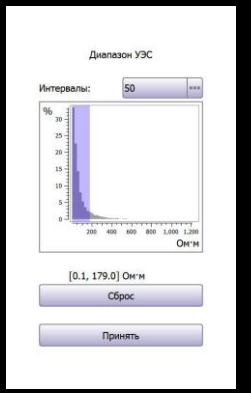
With EM Profiling YOU can:

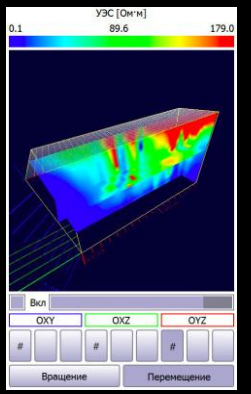
- monitor the status of underground utilities
- determine the location of pipelines, cables, tunnels
- map groundwater and its pollution
- research archaeological sites
- assess agricultural land
- monitor contamination by fuels and lubricants
- conduct engineering surveys for construction











Profiling and Visualization of 2D/3D data, as well as preparing reports is easy with **Android** (Qzond) and **Win** (iiSystem) **software** (included)

Geophysical Instruments

	LandMapper	Geoviser	AEMP-14
Properties	EC/ER/SP	EC/ER	EC/ER
Mobile Mapping	Yes, grounding	Yes, <20 km/h	Yes, <20 km/h
1D profiles	Yes*	No	Yes
2D / 3D	Yes*	No	Yes
Resolution	2 cm – 1 m	3 depths / freq. 12, 40, 104 kHz	14 depths / freq. in 2.5-250 kHz
Max Depth	~30 m	~3 m	~8-10 m

**LandMapper handheld only supports manual movement of each 4-electrode combination for 1D VES profiles and 2D imaging, wire sets are supplied or easily made by user*

Landviser Research Enlightening

конструкторское бюро КБЭ ЭЛЕКТРОМЕТРИИ

SiberGeo OÜ

Steps to develop Ag EMGeoDrone

Test AEMP-14 on Ag fields – which frequencies best describe soil agronomic properties?

Lighten Geovizer sensor and put it on OTS DJI UAV

Develop New Ag sensor with “Ag” target frequencies and partner with drone manufacturers

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Enlightening

Electromagnetic multi-frequency profilers

AEMP-14

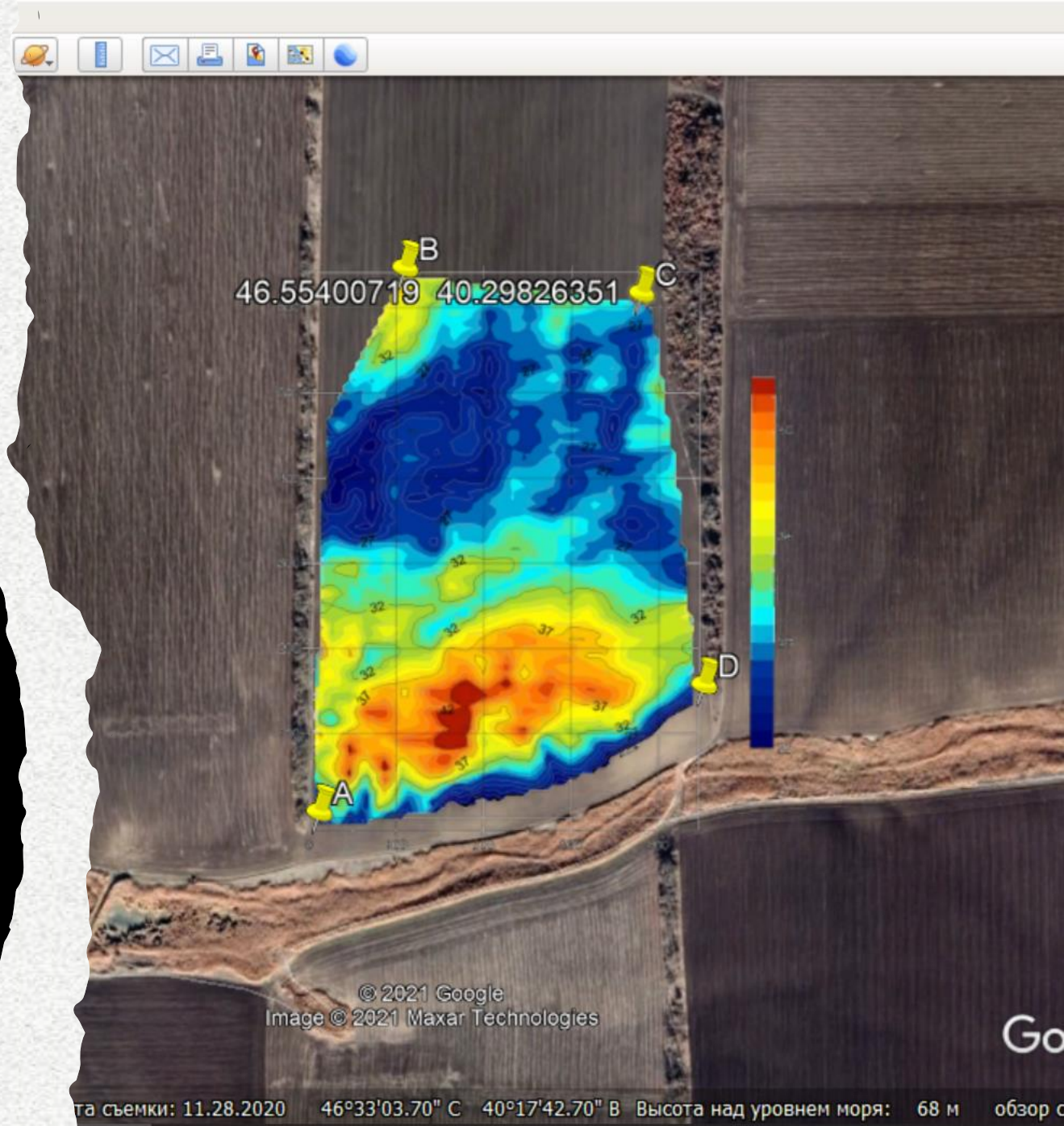
TECHNICAL SPECIFICATION

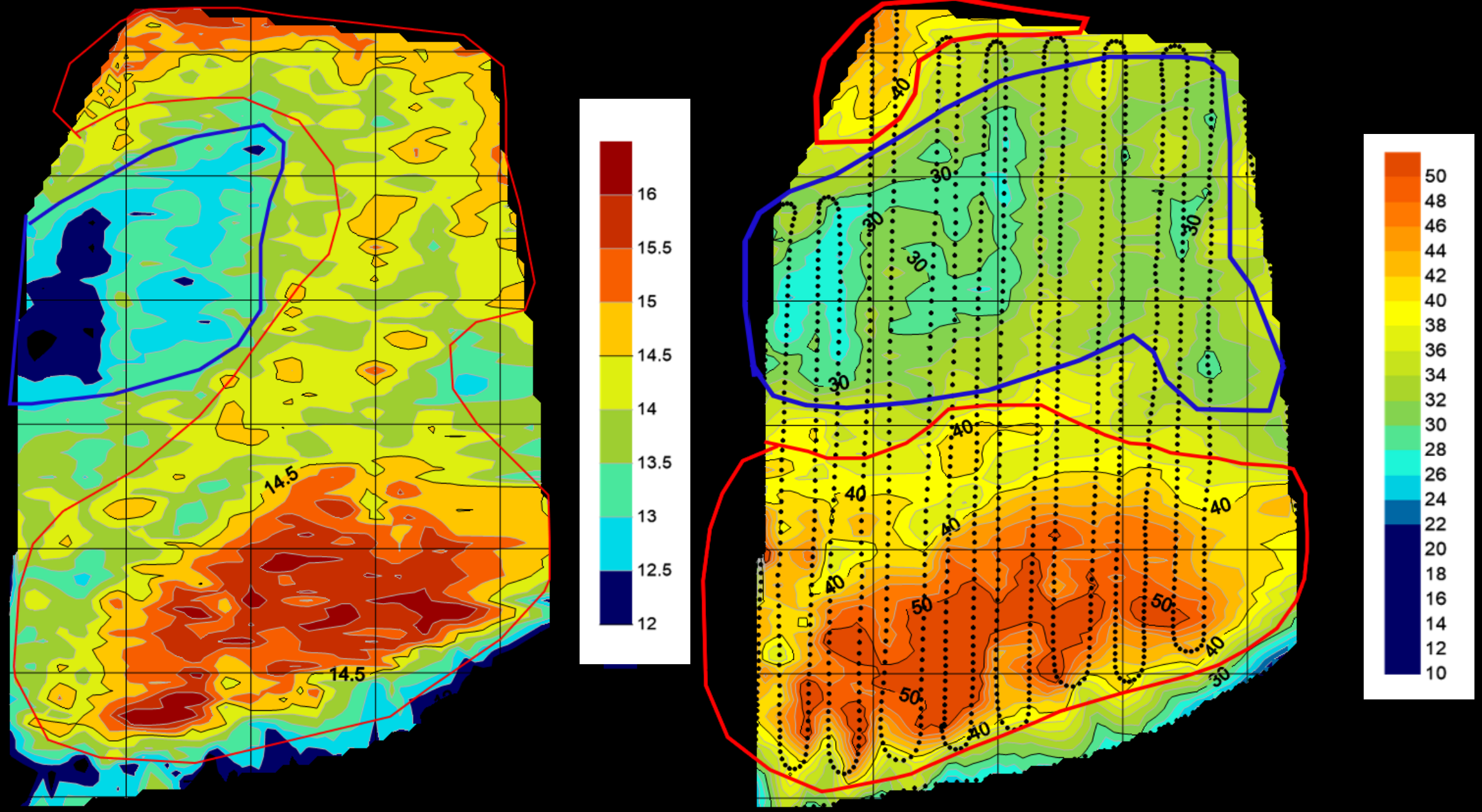
Working frequencies: 2.5-250 kHz;
Measurement time: 0.3-2 sec;
Generator power: maximum 90 W;
Receiver sensitivity: 1 mV;
Dimensions: 275x30x10 cm;
Working time: about 6 hours;
Weight: 9 kg;
Sofware compatibility: Android, Windows.

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.

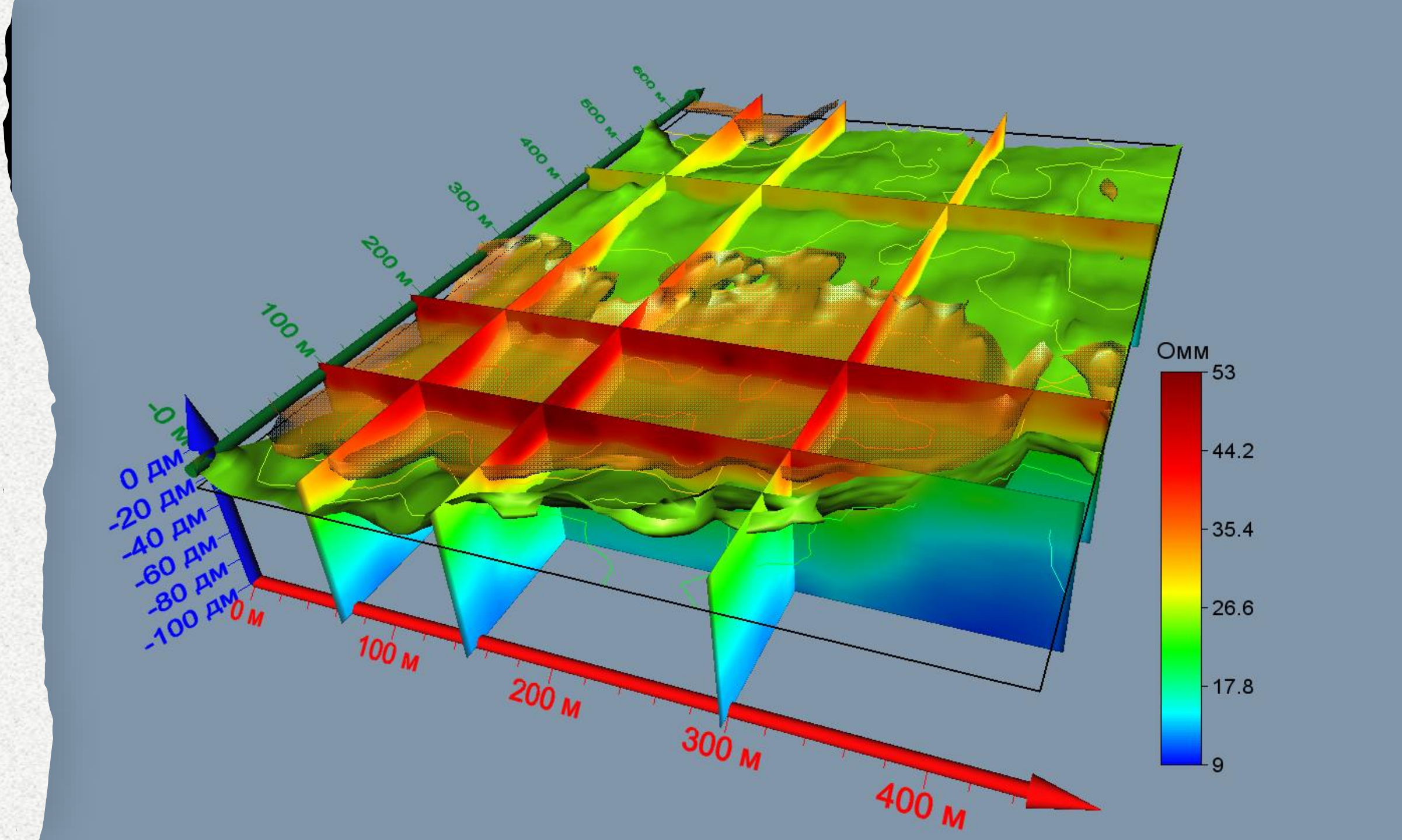
AEMP-14 tests on Ag Fields

- Near Rostov-on-Don, Russia
- July 2021
- After harvest of wheat, over stubble
- Plot 1; 61 kHz





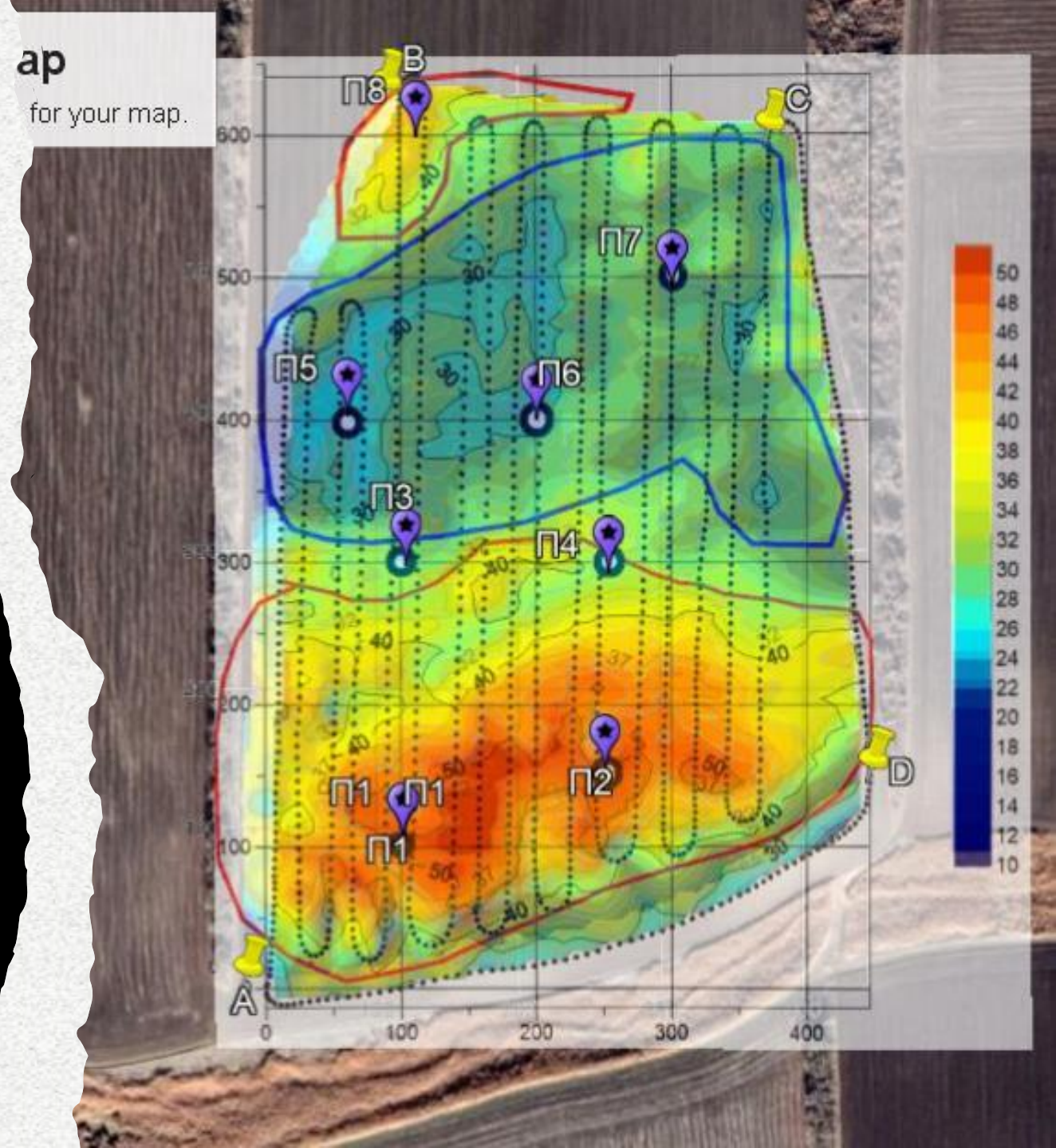
Maps of the distribution of the apparent resistivity at 5 kHz (left) and 111 kHz (right)


600 м
500 м
400 м
300 м
200 м
100 м
0 м
0 дм
-20 дм
-40 дм
-60 дм
-80 дм
-100 дм
0 м
100 м
200 м
300 м
400 м
Омм
53
44.2
35.4
26.6
17.8
9

Frequencies vs Soil Properties (samples)

- ER at lower frequencies (15-25 kHz) correlated with **available water** at 50-70 cm (R^2 = **-0.87**)
- ER at higher frequencies (60 kHz) correlated with **pH** at 10-20 cm (R^2 = **0.81**)

AEMP#	Freq_kHz	Geovizer	Freq_kHz
1	2.5		
2	3.1		
3	3.9		
4	5.1		
5	6.9		
6	10.0		
7	12.3	1	12
8	**15.6**		
9	**20.4**		
10	27.8		
11	40.0	2	40
12	**62.5**		
13	111.1	3	104
14	250.0		



EM Scanner for UAV Payload

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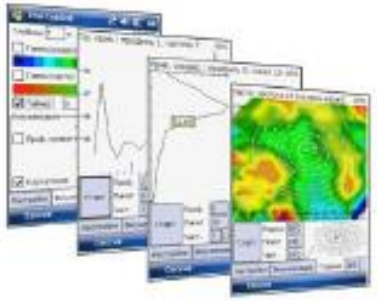
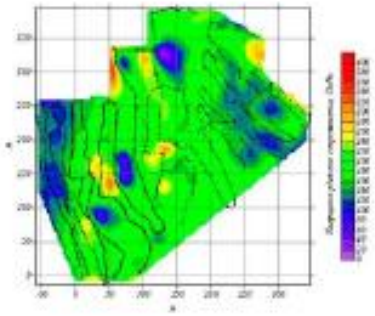
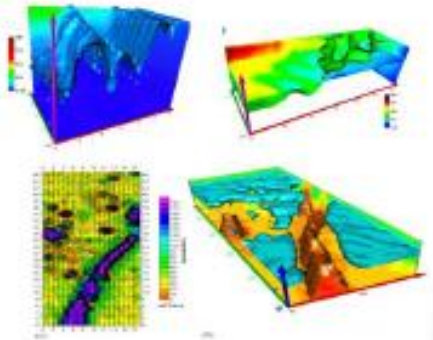


EmsControl (Windows Mobile)





2D and 3D visualisation on PC

Geovizer

TECHNICAL SPECIFICATION

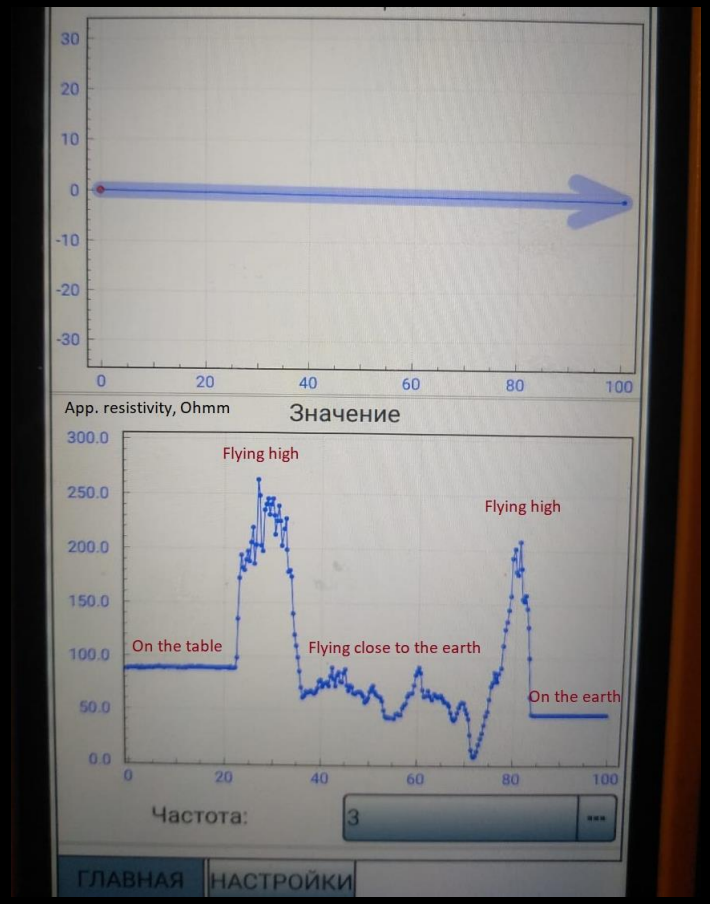
Working frequencies: 12 kHz, 40 kHz, 111 kHz;
Measurement time: 0.3-0,9 sec;
Generator power: maximum 60 W;
Receiver sensitivity: 1 mV;
Dimensions: 90x75x25 cm;
Working time: about 6 hours;
Weight: 4.5 kg;
Sofware compatibility: Android, Windows.

Perspective development with innovative primary field compensation method.

Let it Fly!

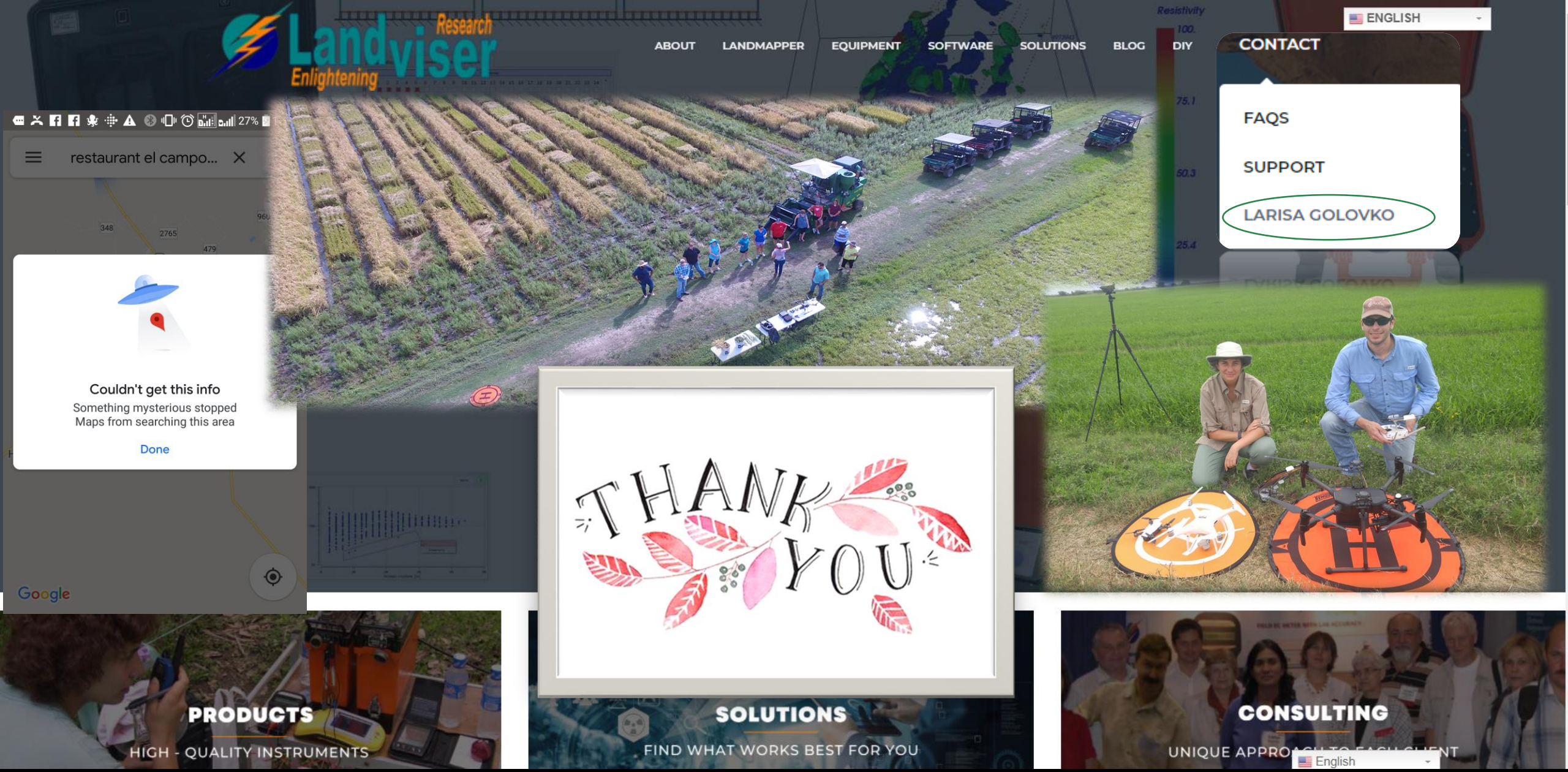
- To make the proper UAV platform we used DJI S1000 frame with a max payload of 6 kg.
- We changed all the control units to PixHawk flight controller and ARDUPILOT platform.
- To keep the precise height, a lidar sensor was added.
- The max speed was limited to 1 m/sec, with max angles to 35 degrees.

Harness and Target Proximity Tests



New EMGeoDrone parameters

- Generator diameter: 300 mm
- Number of turns in generator coil: 21/2
- Pump supply voltage: 8.5 V
- Receiver diameter: 50 mm
- Number of turns in receiving coil: 42
- Preamplifier gain total: 2000
- Total weight of the device without handle and footrest: 3328 g
- Distance from UAV (rope) 4 m
- Distance from ground ~ 0.8 m



Landviser provides LAND Advice and explains GEO TECHNOLOGIES