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Deliverable 8: Phase I Report

Partners in charge: Landviser, Computomics, SiberGeo

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Acronym	CROPTF
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Project Coordinator	Computomics

Document History

Version	Issue date	Stage	Changes	Contributor
V1	26.02.2021		Combined report of all 2-8 deliverables written	Computomics, SiberGeo, Landviser
V2	03.03.2021		Separated deliverables	Landviser
V3	07.03.2021		Final edits, add attachments	Landviser

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Executive Summary

During Phase I - collaborative R&D of CROPTF Business Consortium (Computomics and SiberGeo, full members, and Landviser, a subcontractor and GIS integrator of EO data) we came to major conclusions and developed three core products and services, Intellectual Properties to which held as described below:

1. Addition of EO data significantly improved phenotype prediction ML model for the test dataset. Enhanced **xSeedScoreEO** data analytics service for breeding companies was developed, Deliverable 5 (IP Computomics).
2. Unlike weather data, the availability of data on the soil properties from the existing datasets is either too coarse or do not show information about multiple layers impacting plant growth. Existing geophysical instruments of SiberGeo and Landviser, such as Geovizer and LandMapper, although provide soil information from multiple depths, at present form are not adopted to fast mapping from UAV platform. Novel flying EC sensor **EMGeoDrone** was developed, Deliverable 7 (IP SiberGeo).
3. EO data platforms, both public and private, are already plentiful, but are intimidating for the end users to navigate and select the environmental data relevant to their case study. A comprehensive, easy-to-use EO Data Store / GIS analytical service, geared toward Ag businesses – seed companies, large agri-holdings – haven't existed until now. **Landviser**^{SM} (EO data aggregation and geo-analytical service, aka **AgrGxEO**) workflow was developed under this PARSEC OC2 CROPTF, Deliverable 8 (IP Landviser).

The development of **Landviser**^{SM} **-** EO data aggregation and geo-analytical service (IP Landviser) is well underway and would be marketed for Agricultural Clients as **AgrGxEO** module during the PARSEC OC2 Phase II. This PaaS would provide storage, anonymous aggregation with user private business data, and retrieval of the near-surface soil parameters measured with the new UAV EC sensor **EMGeoDrone** (Deliverable 7), other sensors of SiberGeo and Landviser (Deliverable 6), as well as convenient access to global EO data (weather re-analysis and climate change models, satellite imagery, soil properties) for further trainings and fine-tuning of **xSeedScoreEO** module (Delivarable 5) to all clients of Computomics, SiberGeo, and Landviser.

The on-going collaboration of the three companies in expected moving forward and our respective expertise is illustrated in Fig.1. Landviser and SiberGeo would be presenting an overview of soil EC sensors on upcoming Symposium on Applied Geophysics to Engineering and Environmental Problems (PDF slides - Deliverable 8, Attachment 1), including announcement about R&D completed under this PARSEC OC CROPTF "Crop Predictions Take Flight" Business Accelerator Consortium.

Enlightening Research Through Collaboration

PARSEC

Team

computomics®	SiberGeo OÜ	Landviser
Expertise:	**Expertise:**	**Expertise:**
Plant Genetics	Geophysical Technologies	Remote Sensing and GIS
Data Integration Interface	Electromagnetic Sensors	GxE Data Integration
Machine Learning	Electrical Resistivity Imaging	Precision Agriculture
SaaS Provider	Induced Polarization Survey	Climate and Crop Modeling
Start-up Success	Geophysical Instruments	Agricultural Geophysics
	Data Interpretation	

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GxE (Genotype x Environment) Interactions Impact Crop Performance

The performance of a plant for a phenotype, e.g. an agronomic trait such as yield, is influenced by two main factors: the plant's genetics, which is the heritable part that breeders aim to improve, and the environment in which the plant is growing, which is not heritable, not controllable, and highly variable both spatially and temporally. As previously shown by us and in the scientific literature for many crops, environmental effects influence as much as 41% of the phenotype expression (f.e. yield) and is *on par* with the genotype effects (Fig. 2).
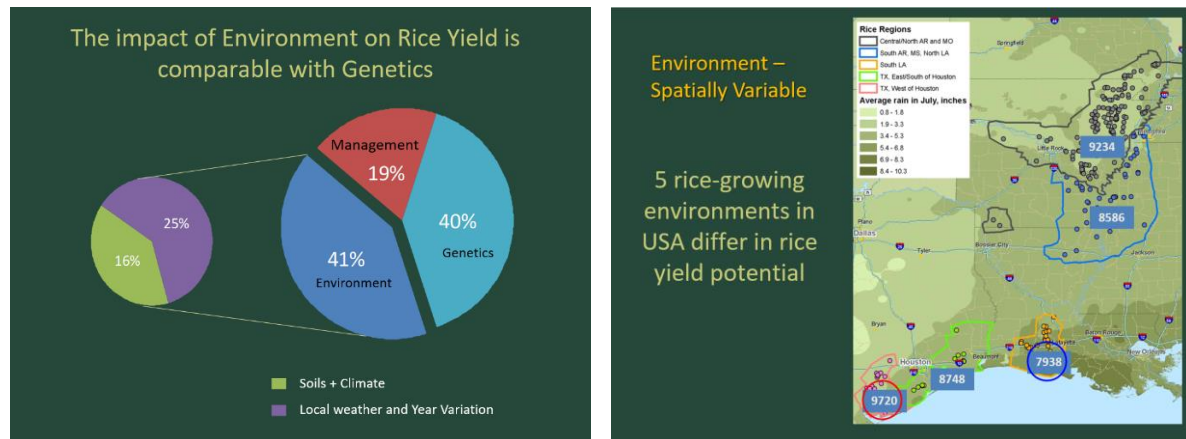
Figure 2: Quantifying Environmental Impact on Crop Yield. Results from a statistical analysis of >20,000 year-location-variety rice yield field trial results over eleven years showing the major segregation in yield potential of the five rice-growing environments in the Central USA: the higher total precipitation in July, the lower attained yield. The geo-spatial analysis were conducted by Landviser, LLC in 2007 from the field trials' data of a private seed company and public Universities' breeding programs, presented at the SSSA-CSA-ASA meeting in 2008, but unpublished. A similar magnitude of Environmental Impact on other crop performance can be found in multiple scientific publications.

In a field test of new plant varieties, each variety is planted in trial plots in different test locations and often also in different years to assess the performance of the variety in different environments. This helps breeders to get a picture of the performance of a specific genetic makeup in different conditions. It also allows controlling for the effects of unforeseen environmental events like extreme weather occurring in one location that biases test results. This is a valuable approach to assess the new varieties performance, however, it is hindered by both availability of environmental (Earth Observation, EO) data, namely weather and soil characteristics, at the specific trial locations during the growing season and by the mechanism to integrate and analyze EO data together with genomic information.

A comprehensive machine learning (ML) model that aims to predict the performance of plant varieties for agronomic traits has to incorporate both sources. The model can then be asked questions about the expected performance of a plant variety in specific target environments and can help breeders select the most promising varieties.

Developing Landviser PaaS – AgrGxEO module

History

Landviser LLC was started by Larisa Golovko (https://landviser.com/larisa-golovko/) in 2002 in USA specifically to provide "Land Advise" to variety of businesses dealing with land resources management and sustainability, primarily agriculturists, with geotechnical tools and services for mapping and monitoring environmental data. At the time of PARSEC OC2, Landviser as a company was not present in Europe, therefore was not able to directly participate in this CROPTF (Crop

Predictions Take Flight - *Integrating Genomics and Geophysics for a Sustainable Future*) Business Accelerator.

Landviser in European Union

To expand our geo-analytical services to Europe and fully participate in Research and Business Activities under PARSEC Business Accelerator Consortium, Landviser s.r.o. was formed in Prague, Czech Republic (https://www.google.com/maps/place/Landviser+s.r.o.).

Consequently, Landviser s.r.o. was able to take a course on Copernicus Climate Change Service (C3S User Learning Services online regional training event, Slovakia | Czech Republic, Jan 12 – Feb 11, 2021) to evaluate the weather re-analysis service of Copernicus Data Store, which offers both better spatial (0.1 x 0.1 decimal degree grid) and temporal (hourly, since 1950) than previously used by us NASA NOAA historical daily weather data source.

Our Use Case for Climate Service Adaptation was selected to be used for group training and Landviser s.r.o. has led a small group of students and made a presentation at the final Week Six of the C3S User Trainings in Slovakia, see video recording of the presentation at https://youtu.be/N103g8efQ6M?t=4116 , starting 1:08:00. The detailed Deliverable 2 includes Attachment 1 (Climate Service case abstract) and Attachment 2 (PDF of the slide deck).

Landviser's USA, EU, and Global IPP

Landviser LLC also applied and received in February 16, 2021 a Service Mark from USPTO for "Landviser" geo-analytical services (Fig. 3, Deliverable 8, Attachment 2) and would be seeking global and EU trademarks for the **Landviser – AgrGxEO** PaaS described here in Deliverable 8.

Figure 3: Landviser – mapping and geo-analytical Service Mark granted by USPTO.

Better EO Data Sources for Computomics' Clients through AgrGxEO module

To improve the breeding process and reduce the time-to-market of new crop varieties for Computomics' clients (breeding companies), Landviser and Computomics investigated the incorporation of environmental data like soil and weather into existing ML solution xSeedScore based only on the genetic data, developed **xSeedScoreEO** (IP Computomics, Deliverable 5).

Environmental data from many available EO platforms, including weather parameters (Copernicus Climate Services, NOAA Historical Weather API), soil properties (global – Big Data Toolbox and HWSD, and regional - USA-SSURGO), satellite imagery (RASDAMAN, ArcGIS Living Atlas) were evaluated (Deliverable 2). Technologies to manipulate data and automate data pipelines were developed and the improvement to the phenotype prediction of xSeedScore ML technology with incorporated EO data was quantified.

Better visualization of EO Data for Computomics' and Landviser's Clients

The **Landviser - AgrGxEO** module is going beyond **xSeedScoreEO** ML solution (Deliverable 5) and would provide customers with a visual overview of the environmental data used in the models for their breeding experiments. The Deliverable 3 shows the examples of possible visualizations. interactive mapping app for the test data locations with soil and weather layers, DEMO of the test data used for **xSeedScoreEO** model training and testing, as well as interactive maps for some other Agriculture-related projects of Landviser (including map for "Climate Adaptation Service" project – Deliverable 2, attachments 1&2) are available at Landviser's Mapping Portal (https://landviser.maps.arcgis.com).

The Deliverable 3 also includes Attachment 1 - sample (anonymized) PDF report for one of the clients – a breeding company looking for suitable places in South America to conduct phenotypical studies of new varieties and was concerned about temperature and precipitation ranges during growing season.
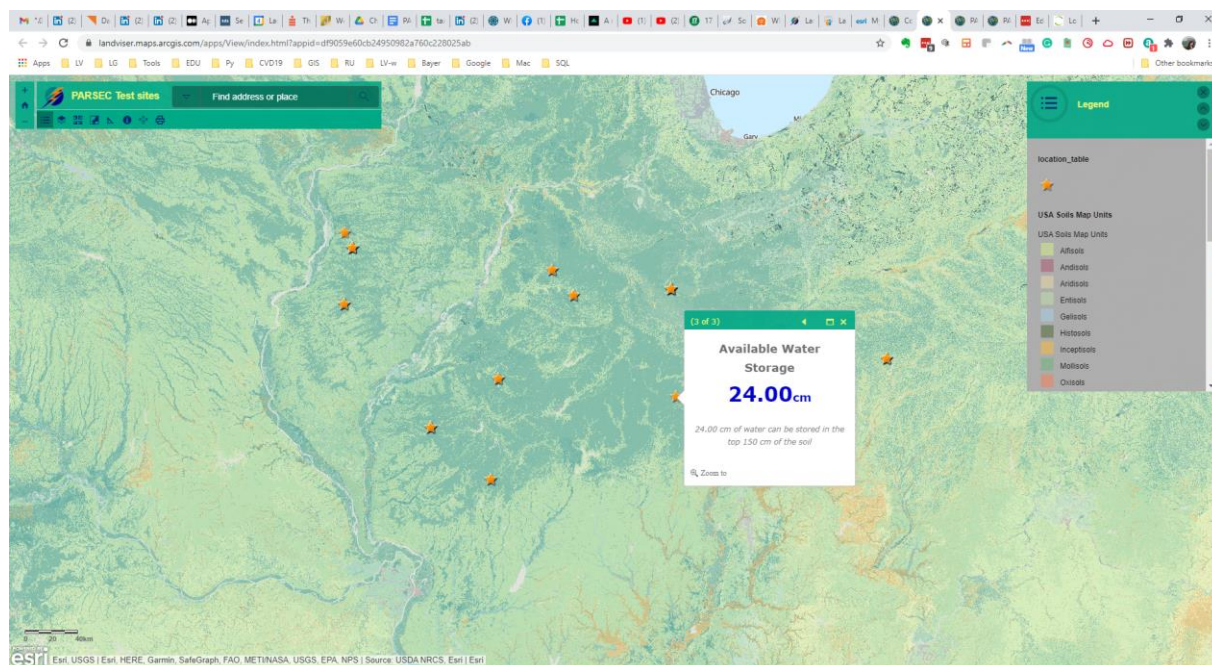

Figure 4: Pins showing the locations of field trials from more detailed SSURGO soil data set. Different soil properties layers can be viewed on the interactive web app
https://landviser.maps.arcgis.com/apps/View/index.html?appid=df9059e60cb24950982a760c228025ab

Better Soil Data in Landviser PaaS by incorporating UAV sensors of SiberGeo

While evaluating various EO (Earth Observation) data sources potentially usable for enhancement of **xSeedScoreEO** ML module of Computomics, we confirmed the limitation of the existing soil data (including suggested through PARSEC In-Situ Data Hub). Therefore, SiberGeo have tested a new mobile universal soil EC sensor (EM) as payload on the octocopter UAV, results would be presented on upcoming Symposium on Applied Geophysics to Engineering and Environmental Problems (slides - Deliverable 8, Attachment 1, Fig. 5). The full recording of the presentation is accessible on YouTube https://www.youtube.com/watch?v=7OpPphWtNU8&t=1248s , announcement about R&D under PARSEC "Crop Predictions Take Flight" Business Accelerator start at 28:09.
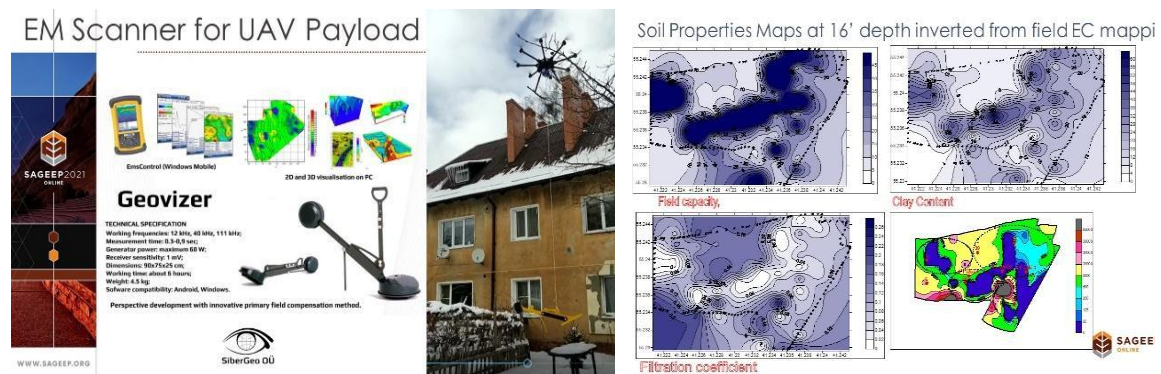

Figure 5. a. SiberGeo new airborne **EMGeoDrone** sensor for UAV measuring soil EC at three depths, developed specifically under PARSEC Business Accelerator.

b. Example of the detailed maps of soil properties at the deeper layer inverted from the soil EC map measured on potato field with LandMapper – EC sensor of Landviser, similar to a new **EMGeoDrone**, but not integrated as UAV Payload yet.

The mobile UAV EC sensor **EMGeoDrone** (IP SiberGeo) would provide detailed data on soil properties **at multiple depths** for future breeding trials analysis for Computomics' clients, which would be especially beneficial for those who work on developing stress-resistant (salinity, drought) and nutrient-efficient (N fertilizer utilization) crop varieties.

Fast Prototyping of Landviser PaaS by Partnering with GIS Industry Leader

Landviser has become a Bronze ESRI Business Partner and is using this relationship and GIS software development authorization to build an integrated **Landviser** PaaS - "EO and Geophysical Data in the Cloud" to make EO data from multiple public platforms readily available through a secure unified Online Portal (https://landviser.maps.arcgis.com). Landviser continues "*Enlightening Research*" through partnerships and collaborations with many global technology organizations, specifically in environmental data acquisition, management, and analytics space (Fig. 6).

OUR 4-STEPS APPROACH: AG LAND SURVEY & MONITOR

1. Build a Web Mapping Portal for Client's AOI, encrypt private IDed business data

2. Gather and Analyze EO Data (Soil Properties, Satellite Imagery, Climate Variables) for AOI

3. Client Maps/Monitor Soil EC at multiple depths with Ag Geo Tools (Landviser and SiberGeo)

4. BI Analysis and Visualization in AgrGxEO and/or xSeedScoreEO (Landviser and Computomics)

Optional:
☐ Incorporate Live Tracking of Severe Weather and Public Health Risk (Landviser)
☐ Install IoT Sensors with LoRa Tower and Network to monitor resources (Woodpecker Microsystems)
☐ Arrange for UAV/MAV imagery collections, EMGeoDrone, UAV spraying (SiberGeo, Air Data & Hylio)

Figure 6: Landviser PaaS Workflow is a simple yet comprehensive approach to Agricultural Land Surveying and Monitoring, which incorporating EO data and showing our extensive collaboration with other environmental hardware, software, and consulting companies globally.

AgrGxEO module of Landviser PaaS for Seed Breeding Programs

AgrGxEO module would be part of **Landviser PaaS** specifically geared toward end users from the breeding companies and allowing them to easily merge EO data with Client's proprietary field trial data on crop performance. Such a portal would then allow Computomics to quickly and conveniently link EO data and phenology with Genomic information and train the **xSeedScoreEO** ML module for different Clients (Deliverable 5).

The EO information from **AgrGxEO** would allow breeding companies not only to reduce years and locations for testing new varieties but also provide their customers (farmers) with the insurance and warranties for seed performance and suitability for a particular farm and season (seasonal forecasts would be made available by utilizing Copernicus Climate Change Services, R&D at Landviser is underway).