



MICROSERVICES

Newsletter 2

April 2023

Did you know that just even a tiny amount of soil can contain 1 billion microbes? These microbes are vital to ecosystem functions. But what happens when climate change begins to damage the soil and affect them? This is where the MICROSERVICES project enters. In order to study the effects of climate change as well as the dynamic crop-soil-microbiome system, a combination of natural climate gradients and in-situ field manipulations are being used.

PROJECT RECAP

The main goal of the MICROSERVICES project is to improve the forecasting capacity of the cascading effects of climate change on: Crop-associated microbial diversity, crop-microbe interactions, and agricultural ecosystem services delivered by the microbiome. This is done in the hopes of actively contributing to a sustainable agricultural sector: fostering widespread benefits across the agricultural economy, society, and environment, positively impacting conservation, developing sustainable policy briefs for decision-makers, and raising public awareness of the importance of soil biodiversity both on the local level as well as across the world.

The vision of MICROSERVICES is to understand and predict the impact of climate change on the crop-associated microbiome and its ecosystem functions in European wheat cropping systems. This international and multidisciplinary research project funded under the Horizon 2020 ERA-NET COFUND scheme BiodivERsA will target the following objectives:

1. Provide scientific insights into future impacts of climate change on the crop microbiome and associated ecosystem services
2. Promote political and public awareness of the importance of microbial diversity for sustainable agriculture
3. Establish interactions between research institutions, agricultural stakeholders and policymakers to influence policy agendas at the national and European level

The project tasks are divided across 6 Work Packages (WPs):

- WP1: Project management & stakeholder engagement
- WP2: Establishing natural climate gradients in Europe with forecasted progression through Earth Observation based regional climate models
- WP3: Assessing patterns of wheat-associated microbiomes, crop-microbe interactions, and ecosystem multifunctionality across the European climate gradients
- WP4: Using in-situ field manipulation to stimulate the effect of drought the crop-soil-microbiome nexus under different long-term management regimes
- WP5: Evaluating machine learning algorithms to make predictions on climate related shifts in biodiversity and associated ecosystem services
- WP6: Dissemination, outreach, and policy impact





PROJECT METHODOLOGY

The **MICROSERVICES** project is a multidisciplinary project, bringing together various types of expertise and methodological knowledge in order to tackle a global challenge.

Indeed, addressing global sustainability related issues, at the intersection of the economy, society, and the environment, requires refining the institutional research structure and leveraging global expertise and know-how through a transnational approach. Not only does a multidisciplinary approach bring in actors from across Europe, but also from across disciplines: climatic threats on soil biodiversity can only be addressed through a collective approach. This allows for more accurate guidance in shaping climate change adaptation strategies.

Within the **MICROSERVICES** consortium, consortium members cover a wide range of expertise:

- Earth-observation (EO) -based climate modelling to predict region-specific future climatic conditions across Europe (WP2);
- Various molecular technologies that monitor diversity and functioning of crop-associated microbiome and their interactions under natural and simulated climatic conditions (WP3 and WP4, respectively);
- Machine learning regression models that have the ability to forecast the delivery of ecosystem services by the crop microbiomes within different future climatic conditions (WP5);
- Participatory methods in order to engage with an extensive network of both stakeholders and policymakers across the continent (WP6).



More specifically, the project brings together individuals with a specific set of skills, from environmental sciences (microbial ecology, crop physiology, agronomy, and climatology), computation sciences (bioinformatics, statistics, climate modelling, and artificial intelligence), to social sciences (communication and dissemination).

This transnational, multidisciplinary aspect brings much added value, which directly fosters contributing to the European territorial strategy and policy, establishing partnerships for future projects, as well as examines the potential of improving Europe's competitiveness by opening new markets related to biodiversity and computational science.

On top of this, the indirect added value of having such a transnational team relies on considering differentiating view points of project partners as a strength and source of additional knowledge, fostering a European identity through research, and acquiring a new set of skills and capacities that can influence decision making processes across scales.



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PROJECT PARTNERS

ETH zürich

Established in 1855 as the Federal Polytechnic School, ETH Zurich has, from the outset, been a national centre for education with international appeal, attracting talent from all over the world and is one of the driving forces behind industrialisation in Switzerland: it brought the necessary expertise into the country, trained technical specialists and helped set up groundbreaking national infrastructures.

More specifically within ETH, it is the Sustainable Agroecosystems Group (SAG) of ETH that is working on the project, that is a part of the Institute of Agricultural Sciences in the Department of Environmental Systems Science (D-USYS). Its research focuses on the feedback between ecosystem management options, global change, and biogeochemical cycling. More specifically, it studies the complex interactions between plants, soil biota, and the carbon and nitrogen cycles in terrestrial ecosystems, especially agroecosystems. Its general approach is to integrate field sampling, laboratory analyses, and mathematical modelling to investigate whole system dynamics under current and future environmental conditions. Furthermore, bio-economic modelling is conducted in collaboration with economic and social scientists to assess the sustainability of agriculture.

Agroscope is the Swiss centre of excellence for agricultural research, and is affiliated with the Federal Office for Agriculture (FOAG). Agroscope makes an important contribution to a sustainable agriculture and food sector as well as to an intact environment, thereby contributing to an improved quality of life.



Agroscope researches along the entire value chain of the agriculture and the food sector. Its goals are a competitive and multifunctional agricultural sector, high-quality food for a healthy diet, and an intact environment. In pursuing these aims, the research institute gears itself to the needs of its service recipients. Agroscope deals with issues in the following spheres: Plant Breeding, Plant Production, Plant Protection, Plant Products; Livestock, Feed, and Products of Animal Origin; Food and Nutrition; Cropping Systems, Protection of Natural Resources, Agricultural Economics and Agricultural Engineering. With its research on new plant production and animal husbandry systems as well as the breeding of robust plants and animals, Agroscope contributes to the continued productivity of the agricultural sector under changed climate conditions. With its research, Agroscope helps to optimise agricultural production, and hence plant protection according to agroecological principles. Agroscope also investigates new cropping techniques such as agr photovoltaics, agroforestry, and vertical farming under Swiss conditions.



The National Observatory of Athens (NOA) was founded in 1842, the first research centre of Modern Greece. Its history is inextricably linked with the evolution of basic and applied research, the development of services provided to the Greek State and society at large, and the promotion and popularisation of science. Basic research is at the forefront of NOA's enduring scientific legacy and is committed to applied research through participation in international and national research programmes, to acquiring and processing data through measurements and computational tools, conducting relevant studies and enhancing provision of innovative services, and providing information and support to public authorities, the private and public sectors and the general public.

It currently operates more than 550 land-based measurement stations covering the entire Greek territory, which are equipped with antennae and satellite signal receivers so that they can access numerous satellites for acquiring high-fidelity data. NOA enjoys high international recognition; it participates actively in the global Earth Observation and Monitoring Programme for natural disaster and humanitarian crises management, providing assistance to Civil Protection Services and local government authorities around the world at least once a month.





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INRAE is France's new National Research Institute for Agriculture, Food and Environment, created on January 1, 2020. It was formed by the merger of INRA, the National Institute for Agricultural Research, and IRSTEA, the National Research Institute of Science and Technology for the Environment and Agriculture.

Their union has generated a critical research mass and has pooled their major infrastructures (e.g., observatories, technical platforms, data repositories), including some that are one of a kind in Europe. As a result, INRAE is uniquely suited to perform valuable research on numerous topics, including water resources, regional agricultural strategies, the preservation and restoration of biodiversity, risk anticipation and management, and digital agriculture. It will use research, innovation, and support for public policies as tools to guide the emergence of sustainable agricultural and food production systems. It will also be important to consider more regional issues such as living conditions, farmers' salaries, the economic competitiveness of companies, land use, and universal access to healthy and varied diets.

The University of Kassel (UoK) is a young, modern and vibrant university, characterized by its **U N I K A S S E L** openness to new ideas in every single area of its work. **V E R S I T Ä T**

Receptivity, initiative, transdisciplinary thinking and unconventionality are welcomed traits in studies, research and teaching, but also in knowledge transfer and entrepreneurial ventures. UoK has an unconventional profile with fields of expertise in nature, technology, culture and society. Questions relating to the future of the planet and humanity's existence such as globalisation, climate change, environmental protection as well as questions regarding the evolution of technical systems or demographic change are characteristic of UoK's research and teaching profile. Extending the development of academic fields beyond their boundaries is another marker for many University of Kassel research centres searching for sustainable answers to most important contemporary questions. This focus offers scholars and scientists exciting challenges and also paves the way for students into their lives and careers.



LEITAT is a non-profit organization, specialised in material, device, and production technologies. LEITAT develops R&D activities in the areas of material sciences, environment, surface treatments, biotechnologies and low carbon energies with deep knowledge and experience in technologic transfers to several industrial sectors (chemistry & material, transport, health, packaging, energy, textile, detergency, environment, cosmetic, pharmacy, building, food, sport, maritime, and security).

In essence, LEITAT manages technologies to create and transfer sustainable social, environmental, economic and industrial value to companies and entities, by means of research and technological processes. LEITAT's results over the past years proves that the organisations' passionate commitment to knowledge generation and the transfer is an effective model for the fast, efficient, and sustainable growth of the economy. LEITAT is recognized by the Spanish government as a CIT (Centre of Technological Innovation) and is one of the 5 Technology centres which are accredited by the Regional Government of Catalonia.

The European Landowners Organization is a unique federation of national associations from the EU27, which represents the interests of the landowners, land and forest and building managers, and rural entrepreneurs at the European political level. The ELO's statutory commitment is to defend and promote sustainable development, conservation and protection of the environment, cultural heritage, renewable energies, and responsible use of natural resources.



The efficiency of the organization relies on its ability to gather together rural actors, land and forest managers, scientists, businesses and political decision makers at local, regional, national and European levels. Its network of more than 64 organizations throughout Europe represents several millions of land, forest and historic building managers and provides the ability to voice positions shared by a huge number of stakeholders, as well as to analyze the local effects of the implementation of the EU legislation. The ELO is regularly invited to EC working groups and debates, Directors meetings, and organizes high level conferences focusing on CAP/Forestry/Biodiversity/Natura 2000, environmental services including cultural ecosystem services, estates/countryside management at EU and national level.





PROJECT MEETING - DEC/2022

In mid-December 2022, all project partners got together in Zurich, Switzerland at the office of project coordinator ETH to discuss updates on project progression as well as look to the future and adequately plan out the remainder of the project work.

Here, work package by work package, updates were provided, justifications given, and co-design of future work was achieved. ETH led the way by reminding partners of their administrative tasks (WPI), as well as clearly outlining the collaborative tool and vision required to accomplish the project goals. The first academic publication of the project, done by NOA, was announced to the consortium as well as future plans for publishing. Regarding the European natural climate gradients with forecasted progression through Earth Observation (WP2), NOA, who had created the maps of the gradients early on in the project, provided updates on the role they may play in reaching project objectives as well as presenting this research at academic conferences (tbc). In terms of assessing the microbial patterns and ecosystem functioning (WP3), a plan for assessing alternative sources of data through the European Joint Research Centre (JRC) is being examined. This data will play a key role in analysing microbial interactions throughout Europe, rather than in a controlled environment.

Following the latter, the simulations of drought effects on the crop-soil-microbiome nexus under various management regimes in a controlled environment (WP4), were performed successfully in a rainout-shelter experiment in one of the world's longest running agricultural field experiments comparing different conventional and organic farming systems since 1978

the DOK trial in Switzerland, highlighting the positive sampling experience and a prospective timeline of when the results will come forth, which will be a combined effort from Swiss, German, Spanish, and French partners. Moving on to utilising machine learning algorithms to predict biodiversity and associated ecosystem services shift based on the collected data (WP5), it was agreed upon that there would be a closer focus on soil microbiome diversity as well as including spectral indices from auxiliary Earth Observation (EO) data, provided by NOA. Finally, dissemination and outreach strategies of the project (WP6) were presented, alongside the updated leaflet, as well as plans for the website update (<https://microservices.ethz.ch/>). A group discussion also took place to co-design the plan for an animated project video, to present that project, who the project partners are, and what the project is trying to achieve. A prospective release date of the video is May/June 2023.

Putting all six WPs together, the results and project outcomes will be made operative and accessible for stakeholders and policymakers through a communication and dissemination plan operating at the national and European level.



Photo credit: Daniel Monteleone (ELO)



PUBLICATION

As mentioned previously, it was at the meeting in Zurich in December 2022 that it was announced that NOA had published an academic paper utilising the methodologies presented in WP2 of the project. Their paper is titled “Towards assessing agricultural land suitability with causal machine learning” and was co-authored by Georgis Giannarakis, Vasileios Sitokonstantinou, Roxanne Suzette Lorilla, and Charalampos Konteos in EARTHVISION 2022. The open-access paper [can be found in this link here](#) and the [journal can be found here](#).

Abstract of the paper “Towards assessing agricultural land suitability with causal machine learning” by Giannarkis G., Sitokonstantinou, G., Suzette Lorilla R., and Konteos C. (2022), <https://arxiv.org/abs/2204.12956>

Understanding the suitability of agricultural land for applying specific management practices is of great importance for sustainable and resilient agriculture against climate change. Recent developments in the field of causal machine learning enable the estimation of intervention impacts on an outcome of interest, for samples described by a set of observed characteristics. We introduce an extensible data-driven framework that leverages earth observations and frames agricultural land suitability as a geospatial impact assessment problem, where the estimated effects of agricultural practices on agroecosystems serve as a land suitability score and guide decision making. We formulate this as a causal machine learning task and discuss how this approach can be used for agricultural planning in a changing climate. Specifically, we extract the agricultural management practices of “crop rotation” and “landscape crop diversity” from crop type maps, account for climate and land use data, and use double machine learning to estimate their heterogeneous effect on Net Primary Productivity (NPP), within the Flanders region of Belgium from 2010 to 2020. We find that the effect of crop rotation was insignificant, while landscape crop diversity had a small negative effect on NPP. Finally, we observe considerable effect heterogeneity in space for both practices and analyze it.



FUTURE NEWSLETTERS

Make sure to stay tuned on our twitter account and website for the release of more information and upcoming newsletters. Our project newsletters are expected to be released every six months and will focus on project updates, interesting aspects of the project, as well as further input from the partners! For any further questions, please email coordinator Martin Hartmann at martin.hartmann@usys.ethz.ch