

Earth Observation for Monitoring Cereal Crop Responses to Multiple Stressors (EO4Cerealstress)



Synergizing EO and In-Situ Data for Crop Stress Detection and Monitoring

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Task lead

University of Southampton, UK

Task Partners:

BOKU,
Austria
UoSev, Spain
ITC,
Netherlands
AAFC, Canada

DOCUMENT RELEASE SHEET

	Name	Signature	Date
Task lead	Zaib un nisa (UoS)		
Contributing Authors	Victor Rodriguez-Galiano (UoSev), Roshanak Darvishzadeh (UT-ITC), Omid Ghorbanzadeh (BOKU), Catherine Champagne (AAFC)		
Approval (internal)	Jadu DASH (UoS)		
Approval (ESA)	Espen Volden		
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Webinar: Synergizing EO and In-Situ Data for Crop Stress Detection and Monitoring

Summary

The webinar on Earth Observation (EO)-based approaches to agricultural stress monitoring brought together 38 participants, including seven guest speakers from leading institutions. The organizers hosted the online event to foster collaboration and share cutting-edge insights. Dr Espen Volden (ESA) opened the session by presenting ESA's Agriculture Science Cluster, setting the stage for a series of intuitive presentations. Prof Victor F. Galiano (University of Seville) showcased how Sentinel-2, EnMap, and UAV data work together to detect and monitor multiple crop stressors. Prof Roshanak Darvishzadeh (ITC) followed with a presentation on integrating in-situ measurements with Sentinel-2 and EnMAP data to estimate wheat lodging. Dr Omid Ghorbanzadeh (BOKU) explained drought assessment methodologies in Canada using Sentinel-2-based monitoring. Dr Catherine Champagne (Agriculture and Agri-Food Canada) outlined JECAM's collaborative case studies on crop stress monitoring. Dr Alice Laborte (IRRI) shared stress management strategies for rice cropping systems in the Philippines, while Mr Emanuel Büechi (YIPEEO) introduced a transfer learning framework designed to improve crop yield forecasts in data-scarce environments. The webinar wrapped up with a panel discussion on future research directions and collaborative opportunities, featuring Prof Jadu Dash, Dr Volden, Dr Laborte, and Dr Champagne. Participants exchanged knowledge actively and emphasized the critical role of EO technologies in advancing crop stress detection and monitoring.

Highlights

- **Multi-source synergy is essential:** Combining Sentinel-2, EnMAP, UAV, and in-situ data improves detection of complex crop stressors like salinity, nutrient deficits, and lodging.
- **Machine learning and AI are central:** Advanced models (e.g., transfer learning, deep neural networks) enhance prediction accuracy, especially in data-scarce regions. Projects like YIPEEO show how transfer learning can forecast yields with minimal data, especially under climate stress.
- **Validation is critical:** In-situ data remains vital for calibrating satellite observations and building trust in EO-based products.
- **ESA's Agriculture Science Cluster** fosters collaboration across projects, emphasizing shared resources and joint experimentation.
- **JECAM's global network** supports harmonized data collection and validation
- **Earth Code and Agriculture Virtual Lab** aim to centralize tools, data, and algorithms for reproducible science, though they're currently geared toward researchers.
- **User-centric framework is key:** Tools must answer real questions (e.g., early detection) and deliver data in usable formats (e.g., interactive maps).
- **Capacity building matters:** Training and bulletins (e.g., pest alerts in the Philippines) help farmers act on EO insights.
- **UAV protocols** need to be standardised to support precision agriculture at scale.
- **Scaling from field to national level** requires adaptable, validated methodologies.

- **Funding for in-situ data collection** is essential to support EO calibration and trust-building on the produced results.

1. Introduction

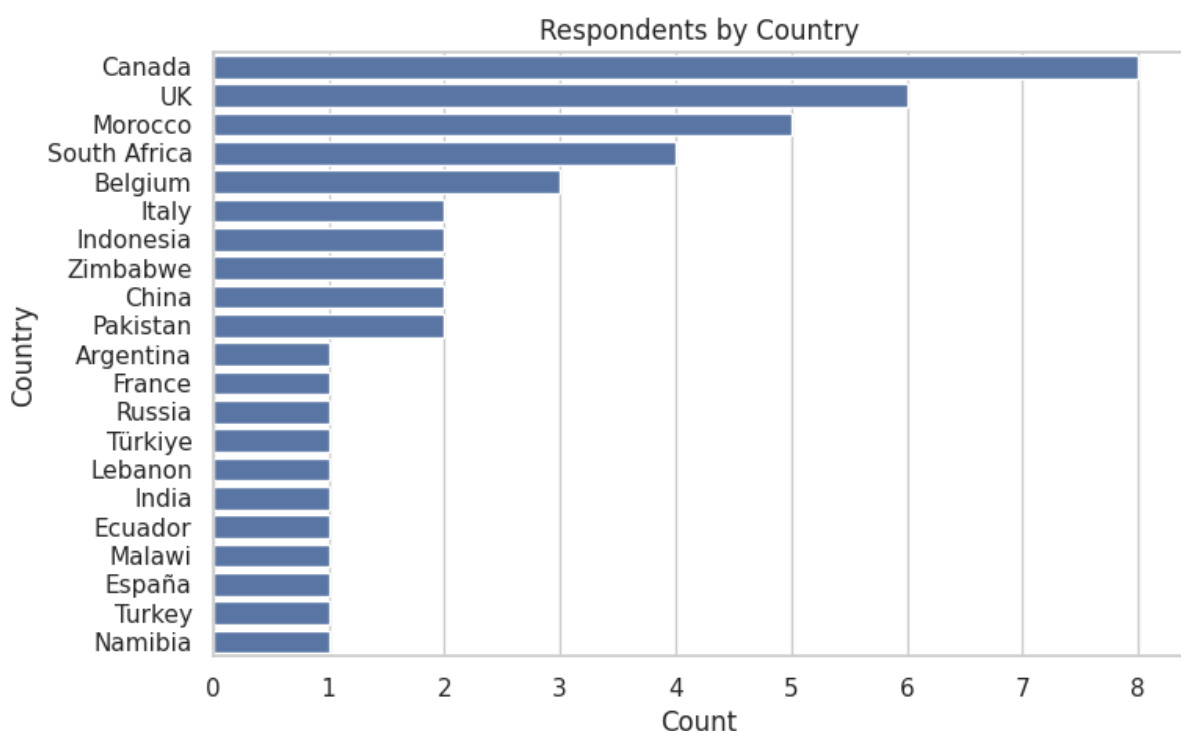
This report presents an overview of the international webinar hosted by the University of Southampton, UK. The event brought together experts, researchers, and professionals from across the globe to discuss cutting-edge EO-based approaches for agricultural stress monitoring.

Registration for the event was widely promoted across professional and academic networks, attracting attendees of diverse age groups and geographical backgrounds, primarily from the fields of Earth Observation, Remote Sensing, Geoinformatics, and Agriculture. A blog also published on the event [University of Southampton International Webinar – Synergizing EO and In-situ Data for Crop Stress Detection and Monitoring \(20 May 2025\)](#)

The report provides visual summaries of participant demographics, professional roles, and research domains that highlight the broad engagement of the EO community and underline the growing global interest in data-driven approaches for stress monitoring.

2. Participants Overview

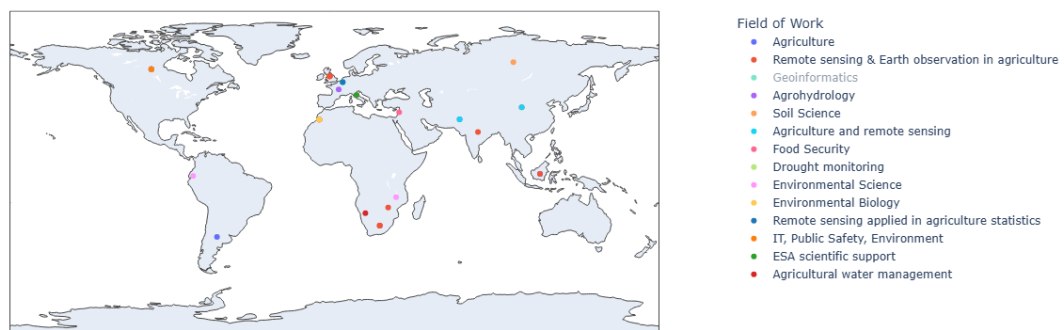
The webinar drew a highly diverse and multidisciplinary group of participants, reflecting the growing global interest in utilizing Earth Observation (EO) for agricultural remote sensing research. Overall, attendees came from more than 20 countries around the world, representing various academic levels, institutional backgrounds, and research areas. Participants included individuals from countries such as Canada, South Africa, Morocco, China, Indonesia, Pakistan, India, Namibia, Turkey, Lebanon, the UK, Germany, France, Spain, Belgium, Ecuador, Malawi, and Russia. This broad international involvement highlights the global importance of remote sensing in tackling agricultural issues, especially those related to climate stress, food security, and sustainable land management.



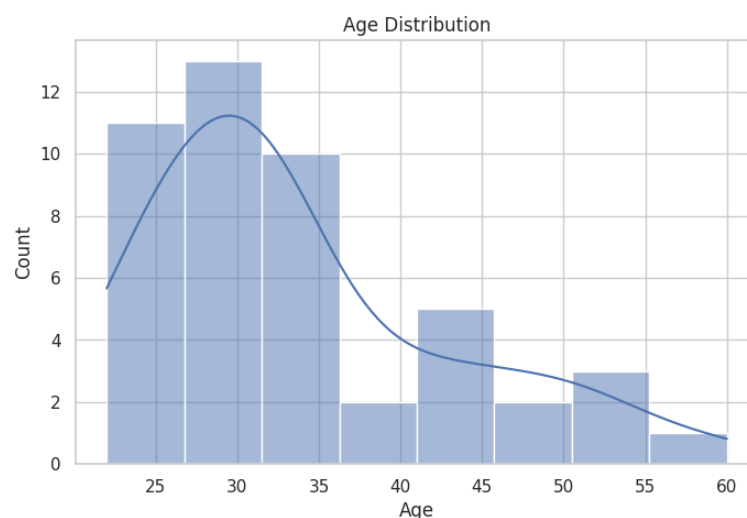
A mix of institutions was represented, including Government agencies such as the Canadian Space Agency, National Physical Laboratory (UK), and various agricultural research councils. Academic institutions like the University of Pretoria, University of Southampton, Cadi Ayyad University, and Mohammed VI Polytechnic University. Research institutes such as IRD France, CNRS Lebanon, and AIRCAS China; International networks and industry stakeholders, including Farmdar (Pakistan), Satellite Applications Catapult (UK), and Smart Traceability (Indonesia).

Participants' roles covered the full research and operational spectrum: Senior scientists and professors in remote sensing, soil science, geoinformatics, digital agriculture, and vegetation monitoring; PhD candidates and postdoctoral researchers focusing on hyperspectral imaging, drought monitoring, crop yield modelling, and precision agriculture; Technicians, analysts, and GIS specialists supporting data management, tool development, and validation efforts; Managers and programme officers representing policy-making and EO implementation bodies.

Respondents by Country



Notably, several participants are affiliated with key institutions involved in ESA-funded projects, GEOGLAM initiatives, and crop modelling consortia, reinforcing the collaborative and integrative focus of the webinar. They came from different disciplines such as Geospatial analytics, Agro-hydrology, Environmental biology, IT and data systems for public safety, Education and capacity-building, and AI integration in agriculture. A balanced mix of early-career researchers and senior academics was observed.



3. Agriculture Science Cluster (first presentation)

The webinar provided an overview of the European Space Agency's (ESA) Agriculture Science Cluster, highlighting its evolution from a forum for information exchange to a structured framework for active collaboration. While previous workshops and panel discussions were instrumental in fostering dialogue and identifying synergies among projects, it became evident that more tangible forms of collaboration were necessary to fully realise the potential of these interactions. In response, the Agriculture Science Cluster was established to enable multiple research initiatives to engage in joint efforts, moving beyond the mere sharing of state-of-the-art developments.

The inaugural meeting of the cluster, held in 2023, convened representatives from 19 projects funded through various mechanisms, with the aim of exploring avenues for coordinated data sharing and the use of shared resources. A notable example of this collaborative approach is the integration of research on crop stressors with yield modelling initiatives, enabling enhanced yield prediction by deepening the understanding of the complex interactions between environmental stress factors and crop performance. This strategic alignment is designed to ensure that collective outcomes surpass what individual projects could achieve in isolation.

Since its inception, the cluster has continued to grow, with several new projects joining its ranks. These include Digital Twin and EO4Crop, which investigate specific crop stressors while simultaneously developing new analytical tools. In parallel, the Advanced Agriculture Monitoring initiative is preparing for the deployment of future hyperspectral, thermal, and Synthetic Aperture Radar (SAR) satellite missions, expected to commence in 2029. A new project currently under selection will address biotic stressors such as pests and diseases, aiming to integrate satellite data, in situ observations, and artificial intelligence to enhance detection capabilities.

In addition to stressor-related studies, the cluster also covers projects focused on irrigation monitoring and crop nutrient estimation, with a particular emphasis on expanding testing activities across the European continent. Yield prediction remains a central objective, with stressor-specific insights contributing directly to the development of more accurate forecasting models.

The cluster is being introduced at the Living Planet Symposium in Vienna to facilitate further collaboration, disseminate research progress, and reinforce the cluster's role as a cornerstone of ESA's agricultural science initiatives.

4. Synergizing Sentinel-2, EnMap, and UAV Data for the Detection and Monitoring of Multiple Crop Stressors (second presentation)

The University of Seville presented findings from the EO4Cereal Stress project, which investigates the impact of multiple abiotic stressors on rice cultivation across a 36,000-hectare agricultural region in southern Spain. This area is characterised by persistent challenges related to heat waves, soil salinity and nutrient deficiencies, which significantly affect rice productivity.

Data from comprehensive field campaigns conducted in 2023 and 2024 included extensive soil and crop sampling, hyperspectral imaging using unmanned aerial vehicles (UAVs), and multi-source satellite images from various platforms, i.e., EnMap, PRISMA, and Sentinel-2. These datasets were used to monitor key soil parameters such as electrical conductivity, organic carbon content, and macronutrients, as well as critical crop biophysical and biochemical traits, including chlorophyll concentration and water content.

Through the application of advanced machine learning techniques and radiative transfer modelling, the research team successfully derived accurate spatial estimates of both soil and crop variables.

Salinity is the predominant stressor within the study area, exerting a marked negative influence on photosynthetic performance and water retention in rice plants. In contrast, the presence of heavy metals was found to be negligible and did not pose a significant threat to crop health.

Overall, the study proved the value of integrating high-resolution hyperspectral data with in-situ measurements to assess the combined effects of multiple stressors on crop systems. These findings have important implications for precision agriculture and stress management in rice cultivation, particularly in regions facing similar agro-environmental constraints.

5. Mapping Wheat Lodging: Integration of in-situ, Sentinel-2, and EnMAP Data for Lodging Estimation (third presentation)

The University of Twente's Faculty of Geo-Information Science and Earth Observation (ITC) presented research on wheat lodging, a critical constraint in cereal production that significantly reduces both yield and grain quality. The study was conducted on a commercial-scale farm in Italy, where its temporal and spatial overlap with a concurrent nutrient estimation project enabled streamlined fieldwork and efficient data collection from April to May 2023.

A multi-scale data collection framework was implemented, capturing physiological, biophysical, and biochemical parameters at three spatial resolutions: microplot (1 m²), subplot (15 m²), and plot (90 m²). These measurements were synchronised with remote sensing acquisitions from Sentinel-2 and the EnMAP hyperspectral satellite. Field-based spectral measurements were obtained from 189 plots using portable spectroradiometers, providing fine-grained spectral data coinciding with or immediately following documented lodging events.

Analysis revealed that reflectance in the near-infrared region increased in correspondence with lodging severity, a result attributed to altered leaf surface orientation. To model and classify lodging severity, a suite of machine learning algorithms, including random forest, Gaussian process regression, and support vector machine, was employed. Among these, random forest models using hyperspectral data achieved the highest classification accuracy, reaching up to 81%. Slightly lower accuracies were observed when using satellite-derived data, due to atmospheric and sensor-induced noise.

Importantly, lodging was found to compromise the retrieval accuracy of physiological parameters such as nitrogen and sulphur, with significantly more reliable estimates in unaffected plots. Nonetheless, spatial maps of lodging severity generated from Sentinel-2 and EnMAP data showed coherent and consistent spatial distributions, validating the potential of hyperspectral-based monitoring.

This integrated approach provides an RS-based framework for timely, scalable, and cost-effective monitoring of lodging severity. The outputs support more informed decision-making around harvest planning and yield loss assessment, contributing to more resilient and efficient cereal production systems.

6. Drought assessment in Canada by implementing Sentinel 2-based Drought Monitoring (fourth presentation)

The University of Natural Resources and Life Sciences, Vienna (BOKU), presented recent findings from its work on drought assessment using Earth Observation (EO) data, with a particular focus on the application of Sentinel-2 imagery, field-based surveys, and Deep Learning (DL) techniques to model and simulate drought-related water stress in agricultural systems.

The primary site for method development was a maize field within a semi-arid Marchfeld region known for its drought vulnerability. Machine learning (ML) models were trained on Sentinel 2-derived data

and temporally validated using data spanning seven growing seasons (2018–2024). These models were subsequently transferred and evaluated spatially using an independent study site in the Manitoba region of Canada, where BOKU leveraged high-quality validation data from the Canadian Drought Monitor (CDM), a nationally recognised system that classifies drought severity on annual and monthly scales.

To address the challenge of frequent cloud cover in Sentinel-2 data, BOKU developed a modified gap-filling algorithm, enabling the generation of near cloud-free composites at two-week intervals. Approximately 20 vegetation and drought-related indices, such as the Normalised Difference Vegetation Index (NDVI), Short-Wave Infrared (SWIR) indices, and moisture stress metrics, were extracted from these composites. These EO-derived features were then combined with local climate and soil data as inputs to a range of models, including traditional machine learning approaches (Multi-Layer Perceptron, Support Vector Machines, Random Forest, and Gradient Boosting) and two deep learning architectures: a deep neural network and a one-dimensional convolutional neural network (1D-CNN).

Empirical results indicated that deep learning models outperformed conventional machine learning techniques in predicting and mapping drought severity in the Austrian context. Among traditional models, Random Forest consistently yielded the highest performance. In the Canadian case study, Random Forest also proved effective, with model outputs demonstrating strong agreement with CDM classifications. The models were validated using CDM data for years with differing drought intensities: 2018 (moderate drought), 2021 (severe drought), and 2022 (no drought), and were found to capture temporal variation in drought severity with generally high accuracy. Some misclassifications were observed, particularly in intermediate severity classes and extreme drought scenarios, highlighting areas for potential improvement.

Spatial drought maps produced for maize fields in Canada exhibited strong concordance with CDM drought categories, justifying the use of the modelling framework for operational drought monitoring across regions. The study has proven the potential of integrating Sentinel-2 time series data, ground-based observations, and DL methods to provide timely and spatially resolved assessments of drought stress in agriculture.

The classification performance will be improved, particularly at drought extremes, through improved model calibration and higher-resolution input data. Expansion of the approach to additional crop types and agroecological zones is also planned to support more resilient and adaptive agricultural management under increasing climatic variability.

7. Overview of JECAM: Case studies on monitoring crop stress (fifth presentation)

Agriculture and Agri-Food Canada (AAFC) presented an overview of the Joint Experiment for Crop Assessment and Monitoring (JECAM), a longstanding, open, and collaborative research network operating under the auspices of the Group on Earth Observations Global Agricultural Monitoring (GEOGLAM) initiative. Established in 2009, JECAM is built upon existing national research activities and functions through opportunistic funding, with a strong emphasis on voluntary scientific collaboration.

JECAM's central objective is to advance international cooperation in agricultural monitoring by promoting the use of standardised protocols, best practices, and joint experiments. This approach supports the development of a "system of systems" aimed at enhancing global food security and improving the sustainability and profitability of agriculture. The network is composed of volunteer researchers who share in situ data, methodologies, and expertise to develop validated agricultural datasets that underpin national-level operational monitoring.

A key component of JECAM's strategy is the execution of coordinated experiments across diverse agroecological zones. These include intercomparison studies employing Synthetic Aperture Radar (SAR) for crop type and condition mapping, the harmonisation of ground-based validation data, and the application of hyperspectral remote sensing for complex crop classification tasks. The integration of satellite data with field observations from multiple member sites facilitates joint validation activities and enhances the reliability of monitoring outputs. In addition, the network plays an important role in capacity building, supporting participating countries in the refinement of crop monitoring methodologies and enabling them to generate high-quality, locally validated data.

JECAM's efforts are aligned with GEOGLAM's broader goals, particularly in the development of essential agricultural variables and the harmonisation of data collection standards. A key ambition is to empower countries to produce their own national crop condition assessments, reducing reliance on generic global maps and fostering informed local decision-making.

The Canadian Drought Monitor (CDM) was cited as a prominent operational product that exemplifies the value of long-term EO-based agricultural monitoring. It integrates satellite data (e.g., MODIS vegetation and evaporative stress indices) and climate information to generate weekly crop condition assessments and evaluate drought severity. MODIS remains a preferred source due to its reliability, temporal resolution, and extended historical archive dating back to 2000.

Looking ahead, JECAM is encouraging a shift from relative vegetation indices (e.g., NDVI) toward more physically based plant health indicators, such as Leaf Area Index (LAI), to enhance the physiological interpretability and accuracy of monitoring outputs. The network's scientific progress and ongoing collaborative experiments will be featured in upcoming sessions at the Living Planet Symposium, further showcasing its contribution to advancing EO-based agricultural science.

8. Stress management practices for rice crops in the Philippines (sixth presentation)

The International Rice Research Institute (IRRI) presented a comprehensive overview of its research and operational innovations in rice crop management in the Philippines, a country acutely vulnerable to recurrent climate shocks, including typhoons, droughts, heatwaves, and flooding. These climatic events, coupled with pest and disease outbreaks responsible for an estimated 37% of annual yield losses, pose a substantial threat to national food security and farmer livelihoods. In this context, timely interventions and accurate information systems are critical for enhancing resilience among smallholder rice farmers in the Philippines.

To address these challenges, IRRI has developed and institutionalised the Philippine Rice Information System (PRISM), an operational satellite-based rice monitoring platform. PRISM integrates remote sensing technologies with crop growth modelling to deliver timely and spatially detailed data on rice cultivation. Specifically, rice area is mapped using time-series Synthetic Aperture Radar (SAR) data from Sentinel-1, in combination with a rule-based rice detection algorithm. Yield estimates are produced via a calibrated crop simulation model that incorporates SAR data alongside meteorological and soil information.

Since 2015, PRISM has generated high-resolution rice maps with classification accuracies exceeding 95%. One of its critical capabilities is the detection of rice planting dates, which provides early updates on potential delays or shortfalls in production. This data is made available in advance of official statistics. Furthermore, in the aftermath of extreme weather events, such as floods, PRISM enables rapid damage assessment to identify affected areas. This supports government response measures, including the timely distribution of seeds for replanting, allowing farmers to salvage their cropping

season. Long-term use of PRISM data has also facilitated the identification of flood-prone areas, enabling the targeted deployment of flood-tolerant rice varieties.

Since its institutionalisation in 2018, PRISM has been managed by the Philippine Rice Research Institute, which now routinely provides monthly updates on rice area, mid-season conditions, and end-of-season yields. The system also supports damage assessments following extreme events, contributing to a more responsive and data-driven agricultural support framework.

In response to the growing impact of climate change, IRRI has been pioneering scalable risk transfer mechanisms to mitigate the vulnerabilities of smallholder farmers. Traditional indemnity-based crop insurance schemes in the Philippines have been hindered by delayed claims processing, subjective damage assessments, and high administrative burdens. In contrast, IRRI, working in partnership with the Philippine Crop Insurance Corporation and the Philippine Rice Research Institute, has developed an area-based yield index insurance solution. This system determines payouts based on average yields within defined insurance zones, derived from satellite-based historical yield datasets generated by PRISM. This eliminates the need for labour-intensive field inspections and improves the speed, objectivity, and cost-effectiveness of insurance claims. In 2024, IRRI conducted a farmer engagement campaign to assess willingness to pay for this insurance model.

To further support crop health monitoring, IRRI has implemented a nationwide pest surveillance protocol. Field teams equipped with mobile devices collect standardised observations in designated rice fields, generating automated monthly reports and seasonal bulletins with pest management advisories. An automated pest alert system has also been developed to deliver real-time notifications of elevated pest activity, based on field technician observations. IRRI is currently collaborating with the University of Twente to explore the potential of remote sensing in enhancing pest and disease monitoring frameworks.

In parallel, IRRI is working closely with the Philippine Department of Agriculture and private service providers to develop and standardise drone application protocols for rice cultivation. These include precision management of direct-seeded rice, targeted pest and disease control, and variable-rate input applications. Supported by recent government funding, these initiatives aim to scale up drone-based agricultural practices while addressing regulatory, technical, and sustainability challenges associated with their broader adoption.

Through these integrated approaches, combining remote sensing, crop modelling, pest surveillance, and technology-enabled risk management, IRRI is contributing significantly to climate-resilient rice production systems in the Philippines for farmer resilience and national food security.

9. YIPEEO - Transfer learning to boost crop yield forecasts in data-scarce situations (seventh presentation)

The Technical University of Vienna presented the outcomes of the ESA-funded YIPEEO project, which concluded in 2025. The primary objective of the project was to enhance food security in the context of a changing climate by improving the accuracy and scalability of crop yield forecasting at both field and regional levels.

The YIPEEO project applied advanced machine learning techniques, in particular, transfer learning, to address one of the major limitations in agricultural modelling, which is the scarcity of high-quality field-scale input data. The transfer learning technique allows models pre-trained on larger regional-scale datasets to be adapted for field-level forecasting, significantly reducing the volume of site-specific data required. This is particularly advantageous in regions where detailed agricultural records are sparse or difficult to access.

The modelling framework was developed using two key types of data: detailed crop yield data from hundreds of individual fields in Czechia, spanning the years 2017 to 2022, and broader regional-scale crop statistics for both Austria and the Czech Republic. While data privacy regulations imposed constraints on the full sharing of field-scale datasets, several publicly accessible datasets have been made available through the project's dissemination channels, with further technical documentation hosted on the YIPEEO project website.

Experimental results showed that transfer learning outperformed traditional machine learning algorithms, particularly in data-constrained environments. For instance, in the case of maize, transfer learning achieved forecasting accuracy comparable to classical methods while requiring only 10% of the training data. This marked efficiency suggests considerable promise for the application of transfer learning to other crops and agro-climatic contexts.

The methodology is particularly suited to forecasting under extreme climate scenarios, such as drought events, where limited observations make conventional modelling approaches unreliable. Although the project's investigations into drought-specific impacts remain at a preliminary stage, initial results indicate that transfer learning has the potential to significantly improve forecasting accuracy in such high-risk conditions by maximising the utility of sparse datasets.

The YIPEEO project represents an important advancement in the field of EO-driven agricultural monitoring and highlights the potential of machine learning innovations to support climate-resilient decision-making in the agri-food sector.

10. Panel Discussion Summary

a. **THEME 1: Enhancing Crop Stress Monitoring through EO and In-Situ Data Integration for Scalable and Accurate Decision-Making**

The panel discussion focused on the critical theme of integrating Earth Observation (EO) and in situ data for scalable, accurate, and timely crop stress monitoring. Panellists addressed both the challenges and emerging opportunities in the use of multi-source datasets, including advances in data fusion techniques, hyperspectral sensing, and the implications of forthcoming satellite missions.

Responded to Specific question: *What are the key challenges in integrating multi-source data for crop stress monitoring, and how can innovations such as multi-sensor, multi-temporal data fusion, hyperspectral data integration, and upcoming satellite missions overcome these barriers to improve the scalability, accuracy, and timeliness of stress management?*

European Space Agency (ESA) highlighted the technical complexity of integrating data from a growing number of satellites, up to 66 from current and forthcoming missions, into cohesive monitoring systems. One of the most promising future missions is the Fluorescence Explorer (FLEX), designed to measure solar-induced chlorophyll fluorescence with an unprecedented signal-to-noise ratio and resolution. Although its spatial resolution (300 metres) is not ideally suited for field-scale agricultural applications in Europe, FLEX offers potential for early stress detection and photosynthesis-based yield estimation.

ESA acknowledged that while FLEX is primarily a scientific mission at present, its long-term influence could be significant if integrated into the Copernicus programme or future mission designs. Complementary use of Sentinel-3 data may help mitigate FLEX's temporal resolution limitations, and research into combining FLEX outputs with higher-resolution sensors such as Sentinel-2 remains a key priority. Ultimately, FLEX exemplifies how experimental missions may contribute to improving the scientific basis and operational relevance of EO for agriculture.

The University of Southampton (UoS) framed the integration of multi-sensor data as both a challenge and a unique scientific opportunity. They emphasised the value of combining spatial, temporal, and spectral information from different satellite systems to improve biophysical models, particularly those related to photosynthesis and stress detection. UoS also points out the indispensable role of in situ data for model calibration and validation. Platforms such as JECAM were noted as critical to enabling international data sharing, harmonisation, and trust-building. Moreover, UoS highlighted the importance of bidirectional integration: satellite data should be validated using in situ observations, while feedback from field-level validation can refine algorithms and enhance EO-derived data products. A key challenge remains the upscaling of localised experimental results to national or global operational frameworks.

The Joint Experiment for Crop Assessment and Monitoring (JECAM) elaborated on the practical difficulties of collecting in situ data, especially complex variables such as chlorophyll concentration and nutrient content. While simpler variables such as soil moisture and crop condition surveys are more commonly collected, the lack of sustained funding for detailed, long-term in situ monitoring remains a critical bottleneck. JECAM called for increased recognition of the funding needs required to maintain robust field-based datasets that can serve as ground truth for EO validation. They reiterated that trust in EO products, particularly for adoption by national agricultural agencies, depends on rigorous benchmarking against real-world conditions.

The International Rice Research Institute (IRRI) offered an operational perspective, noting that for EO-based monitoring to be scalable, methods must be both scientifically robust and operationally feasible in diverse and often challenging local environments. Geographic factors such as mountainous terrain and river systems can hinder consistent ground-based data collection, reinforcing the need for simplified, adaptable, and cost-effective monitoring approaches. IRRI stressed that transitioning from research prototypes to nationally scalable systems require methodological practicality, strong institutional partnerships, and context-sensitive implementation strategies.

Across all contributions, there was consensus on the transformative potential of integrating EO and in situ data for crop stress monitoring. However, the discussion also highlighted persistent technical, institutional, and funding challenges. Innovations in data fusion, missions like FLEX, LSTM, CHIME, and collaborative networks such as JECAM will be instrumental in advancing operational scalability. Equally, the need for robust validation, practical implementation, and sustained investment in both satellite infrastructure and field campaigns was emphasised as foundational to achieving actionable, science-based agricultural decision-making at scale.

b. THEME 2: Translating Scientific Research into Actionable Tools for Farmers – The Role of Best Practices, Adaptive Tools, and Global Collaboration

Responded to a Specific question: *What steps can be taken to bridge the gap between remote sensing data and actionable applications for farmers? How have EO-based methods already been developed into practical tools that farmers can implement on the ground? What types of data and tools from stress monitoring experiments would provide the most value to farmers for day-to-day operations, particularly for monitoring and responding to crop stress in real time?*

In response, ESA reflected on its past and current efforts in platform development, noting that an earlier one-off agricultural platform, while operational for several years, did not achieve the intended scale or uptake. ESA has now developed a more targeted solution, the Agriculture Virtual Lab, which has since undergone testing by early adopters, particularly within the JECAM network. ESA is currently gathering user feedback to improve both functionality and relevance. However, as a space agency, ESA

faces structural constraints in maintaining operational platforms over the long term. Exceptions are made for specific initiatives such as Earth Code, a strategic programme aimed at fostering open science through the sharing of project outputs, in situ datasets, and algorithms. Earth Code is designed to promote reproducibility and transparency in EO-based research. The Agriculture Virtual Lab is expected to be gradually integrated into Earth Code, which aspires to become a comprehensive and enduring resource for data, tools, and analytical methods.

Other panellists emphasised the importance of aligning platform development with user needs and operational constraints. They highlighted that while platforms are often designed with technical sophistication, real-world utility depends on responsiveness to end-user requirements. UoS underlined the essential role of field data for validation, stressing that the collection, curation, and formatting of datasets represent a substantial investment of time and resources. Ultimately, the decision to share such data lies with the original data providers, and thus, efforts to foster a culture of data sharing must be underpinned by trust, transparency, and appropriate attribution mechanisms.

The IRRI reinforced the principle that tools must be designed to address practical user questions. Drawing on experiences from the PRISM project, IRRI illustrated the importance of user-centred design. Government agencies, for example, expressed a preference for more frequent and timely rice yield estimates, monthly or every ten days, rather than the conventional end-of-season reports. This granularity is vital for making informed import and food security decisions. Furthermore, data products must be delivered in accessible formats, such as tabular outputs in addition to geospatial visualisations, to meet the needs of non-technical stakeholders. IRRI also stressed on the need for sustained training and capacity-building to ensure that users not only understand but also trust the data products being provided. Without such efforts, even the most technically advanced platforms risk limited adoption.

The discussion highlighted that while technological platforms offer powerful capabilities for agricultural monitoring, their long-term impact depends on institutional sustainability, user engagement, data interoperability, and trust. Initiatives like Earth Code represent a promising step toward open, shareable infrastructures, but their success will rely on ongoing feedback and alignment with the needs of the communities they aim to serve.

11. Key Questions addressed by the Speakers

Q1. Does JECAM organize and contribute to STEM activities such as training?

JECAM doesn't officially organize formal, regular training sessions, but as a network and many of our members lead technical training sessions (for example, JECAM has had in-person and online trainings on applications of Synthetic Aperture Radar for agricultural monitoring)

Q2. Since drought work involves two different regions, have you considered applying any transfer learning strategies to assess drought across one of the regions?

We did not use traditional transfer learning techniques, such as transferring model weights, because the environmental conditions and agricultural practices in Austria and Canada can be different. These differences, including variations in climate, soil properties, and growing seasons, make it difficult for a model trained on one region to generalize well to the other. However, we used insights from the feature selection process in the Austrian case to guide the modeling in Canada. In particular, the most relevant features identified in Austria were tested on the Canadian dataset, which helped improve model performance. This approach represents a form of knowledge transfer, even though the models were retrained from scratch for the Canadian context.

Q3. What made you choose MODIS data when working with color information, especially since you also used Sentinel-2, which has higher spatial resolution? Could you compare MODIS and Sentinel-2 for your use case? why did you choose to use a one-dimensional model instead of two-dimensional or three-dimensional models? Why did you choose to work with data from Canada, even though the Sentinel-2 data you used is from Austria?

The Canadian drought map produced from MODIS data is used as a reference. That's why I used MODIS as the reference in Canada. But my model training did not rely on MODIS directly. Both Sentinel-2 data (from Austria) and MODIS data (from Canada) were used, but for different purposes.

Regarding CNN, since the task is regression, I opted for a one-dimensional model.

Q4. I'm currently working on estimating both nutrient levels and irrigation in rice fields, which I find quite challenging using Sentinel-1 (C-band) data. Could you clarify which parameters are important for nutrient estimation, and whether it's feasible to estimate them using Sentinel data? Similarly, what are the key parameters for estimating irrigation levels, and how reliable is Sentinel-1 for this purpose?

Regarding nutrients, we have focused on nitrogen. However, we have not evaluated irrigation levels, as the Andalusian Federation of Rice Growers controls the flooding of the rice fields. All fields have the same water table, and the amount of water is kept constant. It is just the salinity content that varies. We have no experience in using S-1 for this purpose.

Q5. Whether the UAV and satellite (Sentinel-2) images were taken simultaneously or close in time, how the timing of UAV data acquisition with Sentinel data was managed to ensure consistency in the analysis.

UoSev tried to coordinate UAV flights closely with Sentinel satellite overpasses but faced challenges due to the area being a National Park with flight restrictions and proximity to an airport. Weather conditions like strong winds and heat also caused delays or cancellations. Operating the large, noisy UAV often scared away flamingos, which helped reduce their interference during data collection, although initially it required some effort to make the birds leave.

Q6. When the crop is severely lost in condition, that means the vertical height is about 0. So, in that condition, how are you measuring the LAI in the field?

LAI is not measured in the field using optical instruments once lodging has occurred. Lodging causes canopy deformation, making destructive sampling the only reliable method to collect LAI data. This involves physically collecting all the leaves within a small, defined area (e.g., half a meter squared) and measuring their area using a leaf area meter. Sampling strategies can be adjusted by scaling from small, sampled areas to the larger plot level.

Q7. Does JECAM have data sharing policies, and do they have a repository for us? If somebody wanted to collaborate with these members of JECAM, they would have to contact them individually.

JECAM functions as a community with a data-sharing policy, but it is specific to each experiment. We do not have a centralized repository where someone can simply log in and build a machine learning model using all the data. This question comes up often, but that's not how our process works. Typically, when a space agency or another organization has datasets, we issue a call to our community, inviting members to contribute relevant data for a particular experiment. Contributors then share their data within the network to support that experiment. We are always open to new partners who want to leverage the network for experimentation and collaboration. However, data sharing and collaboration

happen on a case-by-case basis. If we were to make all data openly available without restrictions, it could be misused. We want our members to be actively involved in the process. This approach helps build trust and capacity within the community; it's not just about collecting data for someone else to use but about creating a feedback loop where methods developed are shared back with the contributors. This way, the techniques can be improved, scaled up, and eventually used in national monitoring systems.

Q8. Is there a plan to organize demonstrations or events targeted at other user groups, for example, national users or stakeholders outside the research community, primarily not researchers? Is there any intention to engage these broader audiences with Earth Code or related platforms?

Both the Agriculture Virtual Lab and Earth Code are primarily targeted at scientists and developers. Their goal is to facilitate open science and data sharing among researchers and application developers, rather than serving end users directly.

Q9. Where is the biggest gap in terms of applications for agriculture? Is there agreement on that? Specifically, is the gap more in data availability or in application development using Earth observation data? What is missing right now to continue advancing your tools and products?

In JECAM, we recently completed a session on essential agricultural variables to identify the key measurements needed. We examined gaps both in scientific methodologies for extracting these variables and in sensor technologies, including data availability. While this doesn't fully answer your question, it helps pinpoint where gaps exist. For example, priorities include evapotranspiration, crop yield, and crop yield boundaries, as well as irrigation mapping. These have been identified as global priorities where gaps need addressing. We aim to analyze these gaps and collaborate with both research partners and agency partners to help fill them and advance the tools and products.

Q10. Given that rice is quite dominant in Southeast Asia, is there a plan to take IRRI's PRISM approach to other countries beyond the Philippines? Have you been doing this already?

The initial methodology was tested across 13 sites in Southeast Asia. However, uptake has been limited outside the Philippines. Currently, the system is only operational in the Philippines with the government's investments. In other countries, the work was mostly limited to pilot sites. For example, in Cambodia, insurance companies have shown interest in using it for index-based insurance.

The implementation and progress differ by country. Some countries have competing technologies supported by their governments, so they have taken different directions. The success in the Philippines is largely due to government investment and institutionalization, which allowed the project to continue beyond donor funding. In other words, for such projects to sustain, the country or an organization needs to adopt and fund them long-term. The Philippines is an example where this has happened.

Q11. Regarding transfer learning, is it crop-specific, or can it be made crop-independent? Is there a way to develop a more general model that applies across different crops?

There has been at least one study that addressed this exact topic, where a general crop forecasting model was trained first and then fine-tuned for specific crops. That approach worked well. Although YIPEEO hasn't tested it yet, this method is promising and could significantly improve data efficiency by making the model more crop independent.

Annexure

Webinar Programme



Date: 20th May 2025 (Tuesday)

Time: 13:00 – 15:30 (UK Time)

Venue: 2085 Meeting Room, University of Southampton

Participants: 29

Guest speakers: 7

Organizers: 2



Presentations	Speakers
ESA's Agriculture Science Cluster	Dr. Espen Volden (ESA)
Synergizing Sentinel-2, EnMap, and UAV Data for the Detection and Monitoring of Multiple Crop Stressors	Prof. Victor F. Galiano (UoSev)
Mapping Wheat Lodging: Integration of in-situ, Sentinel-2, and EnMAP Data for Lodging Estimation	Prof. Roshanak Darvishzadeh (ITC)
Drought assessment in Canada by implementing Sentinel 2-based Drought Monitoring	Dr. Omid Ghorbanzadeh (BOKU)
Overview of JECAM: Case studies on monitoring crop stress	Dr. Catherine Champagne (Agriculture & AgriFood Canada)
Stress management practices for rice crops in the Philippines	Dr. Alice Laborte (IRRI)
YIPEEO - Transfer learning to boost crop yield forecasts in data-scarce situations	Mr. Emanuel Büechi (YIPEEO)
Discussion on Future Directions: Opportunities for Collaboration and EO-based Innovations in Agriculture and Stress Monitoring	Panel Members (Prof. Jadu Dash, Dr. Espen Volden, Dr. Alice Laborte, Dr. Catherine Champagne)