First Scientific Advisory Group Meeting (ONLINE)

DATE – 8th May 2024 (Wednesday)

Time – 11:00 am – 1:00 pm (UK Time)

Members of the Scientific Advisory Group

- Dr. Richard Fernandes, Research Scientist, Natural Resources Canada (NRCan).
- Prof. Tobias Benedikt Hank, Professor, University of Munich, Germany.
- Dr. Sven Gilliams, Head of the Global Agriculture Monitoring Program (GEOGLAM).
- Dr. Alice G. Laborte, Geospatial Scientist, International Rice Research Institute (IRRI), Philippines.

Summary of Feedback and Recommendations from the SAG Meeting

The Scientific Advisory Group (SAG) provided valuable recommendations and insights to guide the project's development and implementation.

- The SAG appreciated the extensive fieldwork conducted for stressors, recognizing its importance in providing in-depth knowledge and practical insights. Field data at this scale is important for understanding the interconnectedness of crop physiological responses and stressors, also parameterizing models. It will have a potential impact on upscaling.
- The project's contribution in identifying stressors is suitable for mapping using hyperspectral imagery for future ESA missions.
- A strong emphasis is given to research efforts toward the utilization of upcoming ESA missions.
- Combining research findings with thermal data, might help on water stress detection and monitoring.
- Product consistency was considered a crucial factor for long-term stress management, emphasis is given to consistent data streams and their role in product development and market impact.
- The importance of replicability and alignment with existing producers' standardized approaches for easy proliferation was emphasized, highlighting the need for robust and replicable field and EO methodologies.

  SAG members shared their recommendations on four specific questions prepared for the scientific roadmap.

1. **Even though we are still some way from delivering final outputs, what criteria can the SAG suggest for evaluating those outputs?**

The SAG suggested several criteria for evaluating project outputs, including the availability of input data, field observation requirements, product accuracy, consistency, and usefulness, as well as method/algorithm reproducibility and generalizability. Central to their recommendations was the importance of establishing robust methodologies and results, supported by rigorous measurements and standardized data-sharing practices within the scientific community.

- The discussion emphasized the need to identify the most significant and replicable crop biophysical parameters, specific to each stressor. Additional sensor data, such as microwave sensors, and thermal sensors, could be explored. SAG suggested looking into structural

components with crop biochemical and biophysical parameters as they can improve the accuracy of detection, especially directional area scattering factor in case of Lodging stress.

- SAG suggested documenting replicable experimental plans, standardized protocols for field measurements on stressors, and specifying crop stress-related parameters while addressing specific stressors and following a strategy of fiducial reference measurements. Its guidance can be obtained from the GBOV network that is developing standardized approaches and protocols for processing (https://gbov.land.copernicus.eu/).
- Filed data protocol should built upon existing work on Fiducial Reference Measurements (FRM) and where possible characterize the uncertainty in the field measurements. Projects such as FRM4VEG could be used as guidance.(https://frm4veg.org/).
- From a methodology aspect, the use of gradient boosting regression inversion systems, or RTM inversion using GPR, could be effective due to its spatial robustness and potential application for large-scale implementation. One successful example is referred to as. https://developer.nvidia.com/blog/neural-network-generates-global-tree-height-map-reveals-carbon-stock-potential/
- Final algorithms can be documented in easy-to-deploy formats, like GitHub Python or R notebooks, to facilitate user testing and adoption.
- New workflows and stress prototype algorithms using hyperspectral imagery and Sentinel-2 data are recommended to align with new missions like FLEX and CHIME. (https://earth.esa.int/eogateway/missions/flex) (https://space.oscar.wmo.int/instruments/view/chime) to maximize potential benefits from product consistency and long-term data availability from EO4CerealStress.

2. **Which stakeholders and other networks should we consult with? In terms of potential users of EO-based crop stress identification methods and/or products, potential scientific, collaboration with plant breeders, agronomists, economists, etc. who are also working on, understanding the impact and mitigation of crop stresses.**
   - SAG members suggested early engagement with user stakeholders and future product generators, the consultation strategy should prioritize those who are potential users of EO-based crop stress products, Like.
   - World Cereal (https://esa-worldcereal.org/en)
   - Global Agricultural Monitoring (GEOGLAM) (https://earthobservations.org/geoglam.php)
   - Agriculture market information system (AMIS)- (https://www.amis-outlook.org/)
   - FAO GIEWS - Global Information and Early Warning System on Food and Agriculture (https://www.fao.org/giews/en/),
   - FAO Land and Water Division (https://www.fao.org/land-water/home/en/)
   - NASA Harvest (https://nasaharvest.org/)
   - IGAD Climate Prediction and Application Centre - ICPAC (https://www.icpac.net/agriculture-and-food-security/)
   - Buenos Aires Grain Exchange - Argentina Agriculture and food security
   - CGIAR (https://www.cgiar.org/)
   - Radiant Earth (https://radiant.earth/)

   The SAG emphasized involving potential implementers early in the co-development journey of the EO product. This strategic integration may yield long-term advantages for cereal stress detection. For example, the Rice Consortium - Rice Business Innovations System (RiceBIS Community), and Strategically Modernized and Robust Technologies for Competitive and Secure Rice Industry (SMARTerRice) engage government bodies, universities, and organizations, for product

development and scientific research along the way. Such collaboration can also operationalize the EO-based stress detection framework and can lead to robust implementation at a large scale. This process will also facilitate continued testing for a long period. By doing so, both scientific and commercial stakeholders (cash crop producers) can benefit from the early adoption of the stress detection framework. Such collaboration will pave the way for impactful and industry-aligned solutions in the realm of early stress detection. However, the SAG realized that this was a pilot/proof of concept project where the focus was more on scientific understanding.

Furthermore, the SAG suggested that EO4Cerealstress can benefit from existing operational agricultural networks collecting field datasets like the Joint Experiment for Crop Assessment and Monitoring (JCAM network) (https://jecam.org/) supported by GEOGLAM and CEOS, which can provide practical advice and tools for standardized protocols of sharing field datasets. The potential to organize a joint workshop with JECAM was proposed.

One interested user party could be experts from thermal missions that are exploring synergies between hyperspectral and thermal data, there's significant potential in tapping into these synergies, considering thermal data, particularly, offers substantial leverage for stress detection and monitoring.

3. **Are there other completed or ongoing initiatives/communities that are also looking at crop stress that we should consult with? These may or may not have an EO component, and responses/ideas from the SAG may be closely linked to the previous question.**

A few potential communities/ initiatives were highlighted:

- The community associated with new thermal missions, for example, the two small satellites of the agency's PREFIRE mission launching in Spring 2024 and LSTM - Copernicus Land Surface Temperature Monitoring to be operational in 2028.
- The community of Sun Induced Fluorescence (SIF) users and producers i.e., https://www.nceo.ac.uk/data-tools/datasets/ , https://climatesciences.jpl.nasa.gov/sif/ for S-5P TROPOMI Far-Red SIF, S-5P TROPOMI Red SIF
- The World Cereal program is potentially useful and known for its mapping of global agriculture at the field scale (https://esa-worldcereal.org/en)
- Geo-initiatives in China for applying artificial intelligence (AI) to pest and disease detection.

4. **Which other stresses, that we did not cover, would you suggest that ESA target for future missions and why? stresses that are emerging in new areas due to changing climate and environments, and combinations of stresses that may co-occur more frequently in the same place & season. This can help guide the expansion of the ESA_EC Earth System Science Initiative**

Considering the emerging stresses due to changing climates and environments, as well as the increasing co-occurrence of multiple stresses in the same location and season, it's advisable to target pest and disease management for future missions. This stressor, which affects numerous regions globally, including Canada, is of significant interest. Methodologies for pest and disease detection also overlap with EO4CerealStress, and combining their methods can contribute to the expansion of the ESA_EC Earth System Science Initiative.