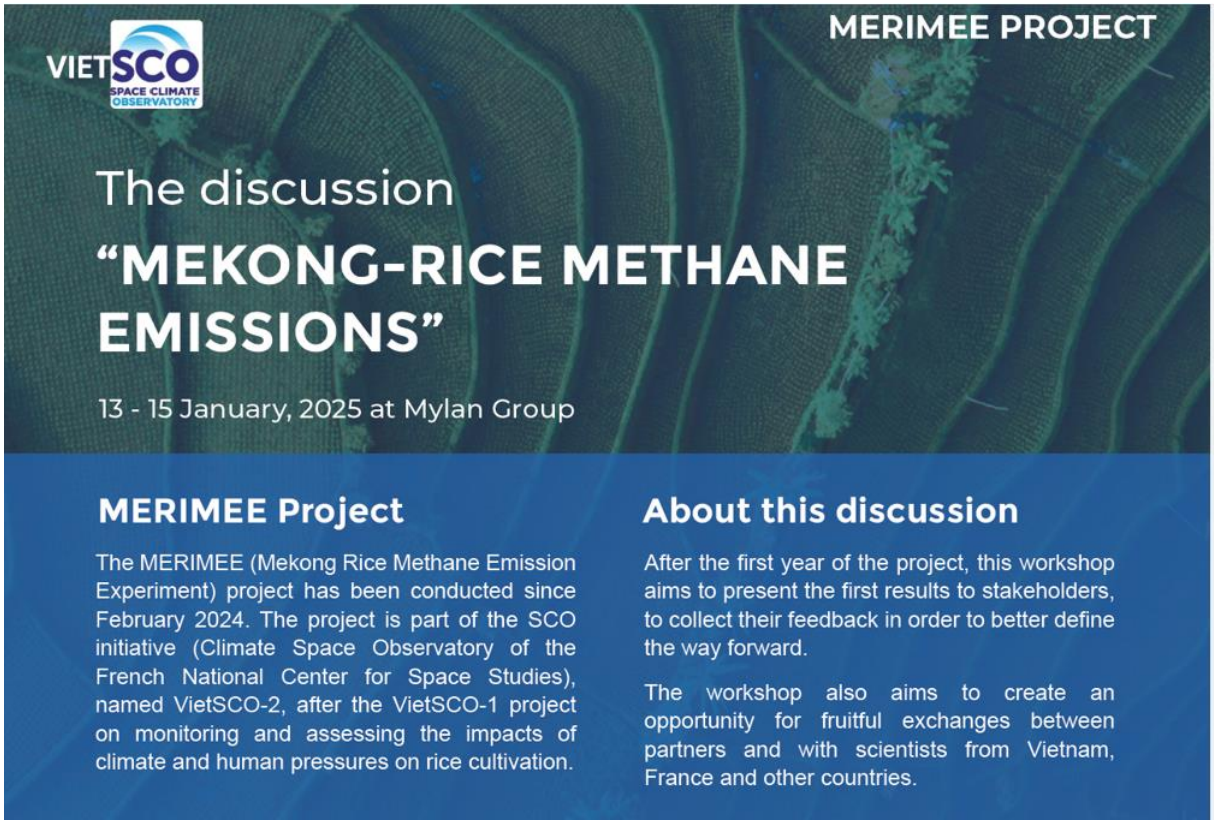
Report on the VietSCO- MERIMEE Workshop

January 13-15, 2025, Tra Vinh, Vietnam



Authors: Thuy Le Toan, Linda Tomasini for the GLOBEO-CESBIO team: Stéphane Mermoz, Alexandre Bouvet, Juan Doblas, Thierry Koleck, Thao Nguyên

I. Workshop background and objective

To slow global warming, reducing man-made methane emissions is considered the most effective short-term strategy, and the least costly. This is the path chosen by 155 countries which, since 2021, have committed to reducing their methane emissions by 30% by 2030.

For Vietnam, the first objective is to reduce methane emissions from rice paddies. In flooded rice paddies, the decomposition of organic matter in an oxygen-free environment produces methane. Traditionally, rice paddies are flooded throughout the plant cycle, but intermittent drainage has been shown to significantly reduce methane emissions (by 40-50%) and the volume of water required (by 30%) without affecting rice yields.

To estimate methane emissions from rice paddies and plan subsequent actions to reduce emissions in a large region, tools are needed to monitor the flooding status of rice paddies at each stage of plant growth.

To this end, the MERIMEE (Mekong Rice Methane Emission Experiment) project has been underway since February 2024. The project is part of the SCO (Space for Climate Observatory of French Space Agency CNES) initiative, named VietSCO-2, after the VietSCO-1 project on monitoring and assessing the impacts of climatic and human pressures on rice cultivation.

The aim of MERIMEE is to use remote sensing data to extend the knowledge gained from in situ observation and IoT measurements to a large region such as the Mekong Delta in Vietnam. The final products will be dynamic maps of rice fields at different stages of growth, their flooding status and maps of seasonal methane emissions estimated in the field. The products will be displayed on the VietSCO platform, which can be used for methane emission inventory purposes.

The tool should be useful to governmental, non-governmental, corporate and international organizations that provide financing to farmers through low-carbon incentive credits.

Workshop objectives

After the first year of the project, this first user workshop was organized to present the initial results to the stakeholders, in order to collect their feedback to refine the subsequent phases of the project.

The workshop also aims to create an opportunity for fruitful exchanges between partners and with scientists from Vietnam and other countries.

II. Venue and participants

The MERIMEE project user workshop was held from January 13 to 15 in Tra Vinh, a city in the Mekong Delta, at the facilities of Rynan Technologies, the project's industrial partner. Some fifty participants were present. In addition to the project partners, participants included experts, researchers in the field of remote sensing and space technologies; representatives from the Departments of Agriculture and Rural Development, Science and Technology, Natural Resources and Environment of the Mekong Delta provinces; and representatives from an international private company and a NGO.

Project partners

- Thuy Le Toan (CESBIO/GlobEO), Stephane Mermoz (GlobEO), Juan Doblas (GlobEO), Alexandre Bouvet (CESBIO), Thierry Koleck (CNES/CESBIO), Linda Tomasini (CNES), Thao Nguyên (CESBIO)
- Lam Dao Nguyen, Hoang Phi Phung, Pham thi Mai Thy (VNSC)
- Nguyen Thanh My, Hong Quoc Cuong, Le Thanh Trieu (Rynan Technologies)
- Pham Duy Tien (An Giang University)
- Ngo Duc Khanh (Bac Lieu University)

guests

- Nuntrikorn Kitratporn, and Champunut Chayawat, GISTDA, Thailand
- Lim Kim Hwa and Kumiawan Tjandra : CRISP, National University Singapore
- Le Viet Phu: Fullbright University, HCM City
- Nguyen van Hoang, Southern Institute of Hydrology, HCM City
- Lam Quoc Nam, Tra Vinh University

Private Company

- M. Kurihara and M. Du, Sojitz Vietnam (interested in carbon credits)

NGO

- Jo Mihyeon and Thai Thanh Hiep, Merry Year International (an international NGO that supports various activities, including initiatives to combat climate change)

Local authorities: Representatives of:

- Department of Agriculture and Rural Development, Tra Vinh, An Giang, Bac Lieu, Dong Thap
- Department of Science and Technology, Tra Vinh
- Department of Natural Resources and Environment, Dong Thap
- Department of Information and Communication, Tra Vinh

III. Agenda and content of presentations and discussions

The workshop took place in three sessions: the opening session on January 13, two technical sessions on January 14 and the visit to the experimental site on January 15.

3.1 Opening session

13 JAN, 2025 Opening Session

14:00 - 17:00

14:00	Welcome Remarks by Dr. Le Toan Thuy, Dr. Lam Dao Nguyen, Dr. Nguyen Thanh My
14:10	Overview of the CNES Space Climate Observatory by Dr. Linda Tomanishi
14:20	The VietSCO project - Objectives and Methodology by Dr. Le Toan Thuy
14:50	Presentation of the VietSCO Rice monitoring platform. Design of methane emissions mapping by Dr. Juan Doblas and Dr. Stephane Mermoz
15:10	RYNAN AIoT (water level and methane emission measurement) by Mr. Hong Quoc Cuong
15:30	Tea Break
16:00	Feedback of Users and Stakeholders DARD, MARD, DONRE, MONRE, etc.
17:00	End of the sesion.

The aim of the first session was to present a summary of the project (background, objective, methods, initial results) to potential users, i.e. representatives of local, provincial and national authorities, as well as non-governmental organizations and companies.

After welcoming remarks by the organizers, the Space for Climate Observatory was introduced by Linda Tomasini to set the scene for the MERIMEE project. She also mentioned the two previous SCO projects on Vietnam, Viet-Arro and Vimesco-Rice.

The objective of MERIMEE, the phases of the project, the broad outlines of the methodology and the first results obtained were introduced by Thuy Le Toan.

The VietSCO user platform was presented interactively by Stéphane Mermoz. Rice crop monitoring (rice area, growth stage, number of crops per year) using the platform was demonstrated. The new MERIMEE results were then presented: monitoring of rice inundation status and estimates of methane emissions. For the latter, the aim was to gather feedback from potential users before integrating these results into the platform.

The development of ground measurement devices (IoT, Internet of Things) was presented by Rynan Technologies. Nguyen Thanh My, Chairman of the Board of Rynan technologies' My Lan Group, highlighted the novel methane emission measurement device for rice paddies.

Discussions at the end of the session focused on several points:

- The development of ground-based measuring devices represents a technological advance that will enable us to better understand the relationship between irrigation practices and methane emissions,
- The solution proposed by the project through the use of remote sensing data seems suitable to extend the information collected from field observations and IoT measurement devices over a vast area such as the Mekong Delta in order to estimate methane emissions from rice fields.
- For the user representatives, this information, as presented on an accessible platform, has the potential to be used for methane emission control purposes,
- However, these tools should be the subject of training courses and tested by users before they are actually used.

3 .2 Applied and Technical Session

14 JAN, 2025 Applied Session

09:00 - 10:30 Preparing for Operational Use of Satellite data in Rice Monitoring and Estimation of Methane Emissions

- 09:00 The VietSCO approach to use satellite data in rice monitoring and estimations of Methane emissions by Dr. Le Toan Thuy
- 09:30 VietSCO Operational Rice Monitoring by Dr. Alexandre Bouvet
- 09:50 Land Use and Rice Monitoring in the Vietnam Mekong Delta using Satellite Data by Dr. Lam Dao Nguyen
- 10:10 Discussions on Rice monitoring tools
- 10:30 Tea Break

11:00 - 16:30 **Technical Session**

Research & Development on Assessment of Methane Emission

- 11:00 In-situ data collection: field survey by Dr. Hoang Phi Phung
- 11:20 Methane emissions measurements by Dr. Nguyen Thanh My
- 11:50 Lunch break
- 14:00 Detection of rice inundation status by satellite data by Dr. Stephane Mermoz
- 14:20 Estimation of methane emissions using Activities data and Emission factors following IPCC good practices by Dr. Le Toan Thuy
- 14:40 Regional project: CH4Rice by Dr. Lam Dao Nguyen
- 15:00 Thailand Rice methane project by Dr Nuntikorn Kitratporn
- 15:20 Discussions on Technical issues
  Discussions on Carbon credit
  Way forward
- 16:30 End of day 2

The two sessions held on January 15 were designed to present the technical details of the various stages of the project. The aim is to encourage exchanges between experts, researchers in the field of remote sensing, and engineers from user organizations. The first session focused on the difficulties encountered and solutions to be found to make a rice monitoring tool operational. The second session focused on R&D advances in the field of methane emissions from rice paddies.

The range of approaches using satellite data for rice monitoring and estimation of methane emissions was presented by Thuy Le Toan, who also highlighted the monitoring of climatic impacts on rice cultivation in the Mekong Delta.

3.2.1 Rice field monitoring

The VietSCO project's rice field monitoring methods were presented by Alexandre Bouvet. The algorithms were initially developed as part of the Vimesco-Rice project for the period 2018 to 2020. They are currently being updated to take account of changes in farming practices. The 'cropping density' product (number of crops per year) from 2018 to 2023 has been integrated into the VietSCO

platform. The other products will be validated or improved following field visits to the Mekong Delta on January 16-18, prior to their integration into the platform.

Lam Dao Nguyen, Director of VNSC-STAC, described his team's projects using radar data to map land use and monitor rice cultivation in the Mekong Delta.

- With regard to the methods used, those of VietSCO are more automatic in the processing chain, while those of VNSC require more manual handling. The solution of automated methods for the production of results at VNSC was discussed, which would require more ad-hoc material resources in Vietnam,
- It was stated that the algorithms needed to be updated to take account of changes in farming practices (particularly climate change),
- Rice monitoring needs differ according to the users' objectives. At the scale of the Mekong Delta or Vietnam, open-access cartographic products are well suited. At commune or district level and for specific needs (concerning crop type, spatial resolution, product precision), the methods to be developed could be the subject of a dedicated service.

3.2.2 Estimating methane emissions

To estimate methane emissions from a rice field, the method recommended by the IPCC (in IPCC good practices) is to use specific emission factors for fields that are continuously flooded, and those that have one or more drainage episodes.

Detecting the state of flooding in rice paddies using satellite data has, until now, been very limited. Optical sensors or short-wave radar cannot penetrate dense, wet canopies up to 1 m high. Among existing sensors, only L-band radar can penetrate well-developed canopies down to ground or water level. However, L-band radar data (ALOS-PALSAR, SAOCOM) are not systematically acquired, and are not freely available (like Sentinels). For this project, we were able to benefit from ALOS-PALSAR data, supplied by JAXA as part of the CH4Rice initiative (see page 8), as well as SAOCOM data, acquired as part of a request to CONAE for GlobEO research. In the future, L-band radar data will be supplied by JAXA ALOS 4 and NASA's NISAR satellite (scheduled for launch in April 2025), and by ESA's Rose-L program.

The method for detecting the flooding status of rice fields using L-band radar data includes a learning phase involving the collection of field data (flooding status, growth stage) on a sampling of rice fields. The data collected were used to develop models based on AI/ML (machine learning), linking the state of flooding to radar observables, both in intensity and polarimetric. The model selected is used for the spatial extension over the entire observed region by the L-band radar data. Among the input data, the map of rice pixels and the corresponding growth stage are taken from Sentinel-1. The method thus exploits the synergy of these 2 sensors.

The first monitoring results of rice inundation status presented by Juan Doblas seemed very promising and aroused a great deal of interest (Figure 1).

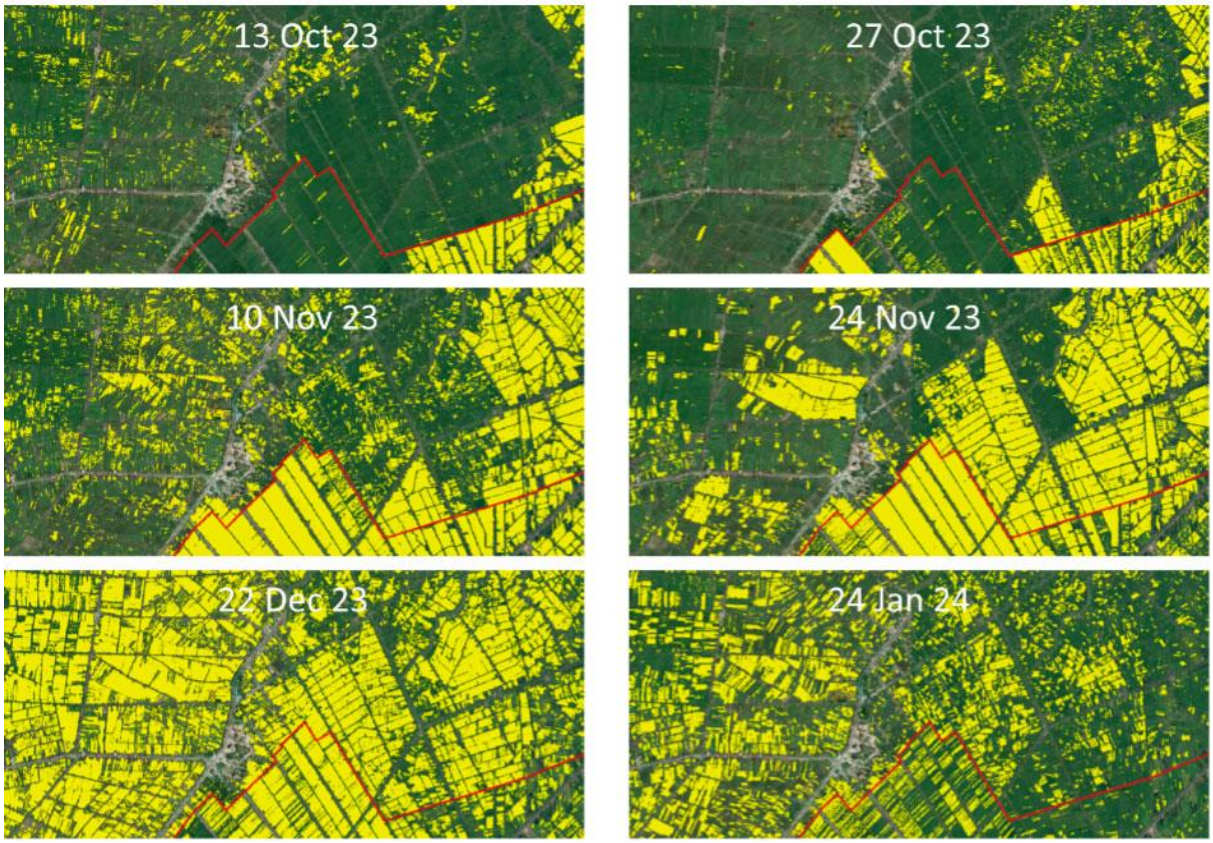


Figure 1: Map of flooded (yellow) and non-flooded rice fields for the period October 13, 2023 to January 24, 2024. © GlobEO

Hoang Phi Phung, from VNSC-STAC, presented the in situ data collection program. This involves field observations on 100 rice fields distributed in the provinces of An Giang and Bac Lieu, starting in October 2023. The main information to be collected for each ALOS/SAOCOM data acquisition is rice presence, flooding status, rice variety and growth stage. The data, collected by the Universities of An Giang and Bac Lieu, present a substantial database for statistical approaches.

The ground measurement equipment is an innovation compared with the state of the art. The automatic water level measurement device enables continuous monitoring of water level variations in the fields. The measurement of methane emissions from rice paddies makes it possible to monitor emissions on a continuous basis, thus providing information on diurnal, seasonal and annual variations. The aim of using the 2 in situ systems together is to gain a better understanding of emissions as a function of flooding and drainage sequences. The water level sensors should also provide reference measurements for training and validating flooded rice detection algorithms.

Hong Quoc Cuong, from Rynan technologies, presented the equipment developed. The project benefits from 30 water level sensors (20 in An Giang province and 10 in Bac Lieu province). After a period of fine-tuning (changing from laser to microwave sensors), the systems are now operational, and analyses are underway. The project is also benefiting from measurements taken by the methane emissions measurement system, prototypes of which are being used for the current rice season.

- The measurements obtained by the water level gauges have been analyzed to highlight and understand their diurnal and seasonal variations, to be taken into account in the acquired satellite data. They will be incorporated the algorithm training and validation stages.

- Analysis of the methane emissions measurements has enabled us to evaluate the IPCC recommendations: the recommended values for emissions appear to be lower than those measured at the Tra Vinh sites, and the recommendation to carry out emissions measurements at 10 a.m. seems to underestimate the significant diurnal variations observed in the field.

The methods for calculating methane emissions recommended by the IPCC (for Tier 1) were presented by Thuy Le Toan. This involves multiplying activity data (surface area of rice fields, number of crops per year) by an emission factor given by the IPCC for flooded rice fields, and a reduction factor for rice fields with single or multiple drainage. The first results were presented by Stéphane Mermoz (on January 14), along with a simulation of an action lever to encourage adoption of intermittent drainage (Figure 2).

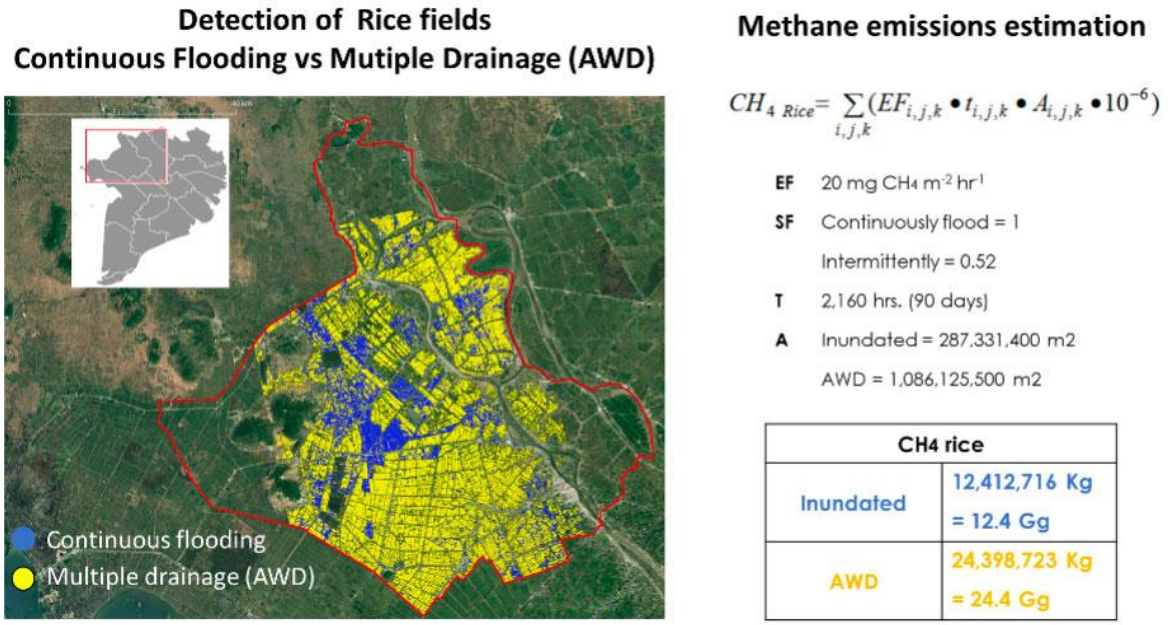


Figure 2: Left: Detection of rice fields with continuous flooding (blue) and multiple drainage (yellow) in the An Giang province, for the rice season from 13 Oct 2023 to 24 Jan 2024. Right: Estimates of methane emissions in the imaged area. © GlobEO

The scientific theme of reducing methane emissions is currently the focus of numerous research initiatives and programs in Asia. Lam Dao Nguyen presented JAXA's CH4Rice initiative, which coordinates experiments to measure water levels and detect the state of flooding in rice paddies using ALOS PALSAR in several countries: Japan, Vietnam, Thailand, Indonesia and Bangladesh. Nuntikorn Kitratporn presented the research carried out at Gistda in Thailand.

Results concerning the flooding status of rice paddies in these countries were limited in most cases by parametric models linking radar measurements to in situ measurements. The latter were obtained only with automatic measuring devices, which were very few.

- Given the complexity of the interaction between the radar signal and a flooded or unflooded rice canopy at different phenological stages, training with a large number of reference measurements is necessary. In addition, parametric models such as simple or multiple regression, based on physical knowledge, are ill-suited to the task. Machine learning models, capable of revealing complex non-linear patterns associated with a large number of predictors, are more effective. This is the approach used in MERIMEE.
- The potential of the results presented is recognized to help provide estimates of methane emissions, a) for MRV reporting by provincial and national authorities, b) to verify changes in irrigation practices, and methane emission reductions by organizations practicing carbon crediting. The modalities for achieving this will be studied in collaboration with users.

A visit to the site where the water level and methane emission measuring instruments are installed was organized on January 15. The implementation and multiple improvements made by Rynan were well explained.

The workshop was closed after this visit.

IV. Post-workshop visit to the Mekong Delta

In the days following the workshop, the VietSCO team made field visits to two Mekong Delta provinces: Bac Lieu on January 16 and An Giang on January 17. These visits enabled us to meet farmers and ask them questions about their farming practices, as well as the university partners in charge of installing and maintaining the in-situ stations. Valuable lessons were learned for the project in terms of crop calendars and the links between farming practices, soil type and climate.

- To fine-tune the detection algorithms, information on farming practices according to soil type (e.g. different watering and drainage times for clayey and sandy soils), and on changes in farming practices (number of crops per year, farming calendar) to adapt to climatic effects could be used. Furthermore, the information (soil type, areas subject to saline intrusion) could provide additional indicators in a machine learning approach.

A protocol visit to the University of Bac Lieu, a partner in the project, identified opportunities for raising awareness among the local authorities of the Provincial People's Committee of the issues involved in rice-growing and reducing methane emissions.

- It is important to involve local authorities and the Provincial People's Committee as potential users in implementing mitigation measures to reduce methane emissions.

V. Summary of achievements and future work

User perspective

- For users, this work has the potential to be used on a national scale for MRV, and by organizations that practice carbon crediting for methane emissions reduction. How this is to be achieved has yet to be defined.

- Rice monitoring needs differ according to the users' objectives. For MRV on the scale of the Mekong Delta or Vietnam, open-access cartographic products are well suited. At commune or district level, for specific needs, the methods to be refined could be the subject of a dedicated service.
- The use of the platform presented appears to be appropriate. However, these tools should be the subject of **training courses** and **tested by users** before they are actually used.

On remote sensing techniques

- It was considered necessary to update the rice field monitoring algorithms in response to changes in farming practices,
- Machine learning models are more suitable for detecting the underlying flooding of rice canopies. The method developed using ALOS-PALSAR L-band radar data can be applied to data from future L-band radar satellites (ALOS4, NISAR, Rose-L).

On IoT

- The measurements obtained by the automatic water level gauges have enabled us to highlight and understand their diurnal, seasonal and annual variations. They will be incorporated into the algorithm training and validation stages.
- The analysis of methane emission measurements has made it possible to evaluate the IPCC recommendations. The measurements obtained will be tested for the Tier 2 approach to estimating methane emissions.

The next stage of the MERIMEE project

- Generalize inundation status detection algorithms for rice fields,
- Evaluate the methane emission factors recommended by the IPCC, using in situ measurements of methane emissions,
- Update the VietSCO platform and integrate methane emission maps based on agricultural practice scenarios.
- Prepare user training.

Gallery

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