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Final report

Covering the project activities from 01/09/2021[1] to 31/08/2025

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Data Project

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Data Beneficiary

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[1] Project start date

[2] Include the reporting date as foreseen in part C2 of Annex II of the Grant Agreement

1. Table of contents

2. List of key-words and abbreviations

AASQA: *Association Agréée de Surveillance de la Qualité de l'Air*
ABAA: Ammonia Britanny in Ambiant Air
ADEME: *Agence De l'Environnement et de la Maitrise de l'Energie*
API: Application Programming Interface
BAT: Best Available Techniques
CAP'2ER® : *Calcul automatisé des Performances Environnementales en Elevage de Ruminants* (https://idele.fr/detail-article/cap2err)
CEREMA: *Centre d'Etude et d'expertise sur les Risques, l'Environnement, la Mobilité et l'Aménagement*
COMIFER-GEMAS : *Comité Français d'Etude et de Développement de la Fertilisation Raisonnée (https://comifer.asso.fr/)*
COPIL: *Comité de Pilotage*
CAB: *Chambre Régionale d'Agriculture de Bretagne*
CFA *: Congrès Français sur les Aérosols*
CREAA : *Connaître et Réduire les Emissions d'Ammoniac*
CUMA: *Coopérative d'Utilisation de Matériels Agricoles*
DSS: Decision Support System
ETA: *Entreprise de Travaux Agricoles*
GEEP: *Gestion Environnementale des Elevage Porcins (https://geep.ifip.asso.fr/)*
INRAE: *Institut National de Recherche pour l'Agriculture et l'Environnement*
ISEA: Inventaire Spatialisé des Emissions Atmosphériques
JRC: Joint Research Center
KPI: Key Project Indicators
LCA: Life Cycle Analysis
LCSQA: *Laboratoire Central de Surveillance de la Qualité de l'Air*
LNE: *Laboratoire National d'Essai*
NEC: National Emission Ceiling
NH_3: Ammonia
NOx: Nitrogen dioxide
PM: Particular Matter
PPA : *Plan de Protection de l'Atmosphère*
PREPA: *Plan national de Réduction des Emissions de Polluants Atmosphériques*
RMT: *Réseau Mixte Technologique*
SO_2: Sulfur dioxide
SPACE: *Salon des Productions Animales – Carrefour Européen*
Syst'N : A tool developed by the INRAE to assess nitrogen leaks at the crop system scale (http://www.rmt-fertilisationetenvironnement.org/moodle/course/view.php?id=8)
UGPVB: *Union des Groupements de Producteurs de Viande de Bretagne*

The key words and abbreviation detailed in this list are mentioned with a * in the following text.

3. Executive Summary

The main objective of the ABAA* project is to reduce ammonia emissions of agricultural origin in the ambient air. Currently, 94% of ammonia in France is emitted by the agricultural sector. Brittany alone represents 17% of national emissions while the region covers only 5% of the territory. In addition, to comply with the NEC* 2016/2284/EU directive and the PREPA*, France will have to set up additional measures to reduce air pollution. The proposal for revisions to European directives, made by the European Commission on 10/26/2022, refers to the importance of reducing ammonia emissions and better understanding their effects on the environment and health. In fact, ammonia is a precursor of fine particles whose effects on health are now proven. To achieve this reduction in ammonia emissions, the ABAA project relied on a partnership that was set up during the first months of the project, with a network of volunteer farmers, called the pioneer group, in a pilot area. This work was based, among other things, on the use of a decision support system (DSS*), AgrivisioN'air. This ammonia emissions management application is fed by the production of a set of joint information on air quality and agriculture.

Various actions have been implemented by Air Breizh and the Regional Chamber of Agriculture of Brittany (*CAB**) to fulfill these main objectives:

- Use of measurement data to improve knowledge of ammonia and fine particles levels measured in the ambient air. Carrying out measurements, initially on a dense zone of plots of the pioneer group where the agricultural practices are well known, to facilitate the interpretation of the results obtained.
- Characterization of agricultural practices to improve the support of farmers as well as the inventory of emissions. The implementation of the inventory will also make it possible to quantify changes in practices on ammonia emissions.
- Implementation of forecasting tools using the model developed during the ABAA project providing information on the risks of ammonia volatilization or fine particle pollution episodes.
- Development of innovative tools and methods to support farmers in the application of low-emission practices

These actions have been carried out in parallel with supporting farmers in the implementation of less emissive practices. The DSS*, AgrivisioN'air will help them in this process and will be evaluated at the same time.

Finally, the project aims to replicate the concept implemented on the pilot area throughout the Brittany region. One of the goals is also to lay the foundations for the extension to other French and European regions, to reduce ammonia emissions at a larger scale.

The project has been scientifically enhanced by two reports (mid-term and final) and by presentations at various specialized events as well as at a regional conference on air quality. The results have also been popularized and valued in a popularization report, available soon on the dedicated website, as well as by the distribution of paper supports during agricultural events, to raise awareness in the agricultural world and the public on the theme "ammonia, agriculture and air quality".

However, some problems were met but measures have been taken to overcome the problems. For example, there was a delay to create the quiz for farmers of the pilot territory (B.1.1) and to recover answers by mailing surveys, so other ways to recover the data needed have been used and the survey was then carried out by telephone calls. Some delays took place to set up the monitoring device so extension of the measurement period is planned. The delay in the delivery of the decision support tool created a delay in the appropriation of the tool by the users and in the reporting of information towards the inventory part. So, organisation of workshop with the pioneer group to ease the appropriation of the decision support tool and a work on other agricultural data sources is in progress to compare with inventory data.

Regarding the main results of the project, the creation of the Air Breizh-CAB partnership is an innovation of the ABAA project and will continue on this and other topics, such as pesticides in the air. Moreover, the individual diagnostics and action plans implemented during the project with the pioneer group farmers led to an average reduction of 11.7% of ammonia emissions per farm for the dairy farms. Furthermore, AgrivisioN'air has won awards in two national competitions, allowing an effective promotion to all farmers and agricultural actors: a 2-stars award at SPACE* 2023, the international

livestock exhibition in Rennes, and the first price in the category of tools for farmers, in the innovation competition organised by the national network of chambers of agriculture. This visibility, as well as the networking actions carried out by the two partners led to the transfer of AgrivisioN'air in 5 other French regions, by the local binomial AASQA* – Agricultural Chamber. Finally, the raising-awareness actions among the agricultural actors were very successful (agricultural exhibitions, technical workshops, spreading demonstration, intervention in agricultural education...): more than 4,500 farmers sensibilized and almost 10,000 technicians and scientists.

4. Introduction

In Europe, over half-million people die prematurely every year due to ambient air pollution including fine Particulate Matter PM2.5. In particular, the French National Public Health Agency acknowledges a figure of 50 000 excess deaths annually in the country. Ammonia (NH_3*) was shown to be a major precursor of atmospheric PM*. NH_3 is a very reactive and soluble alkaline gas, which originates from both natural and anthropogenic sources, with the main source being agriculture. NH_3 reacts with acid pollutants such as the products of sulfur dioxide (SO_2*) and nitric oxide and nitrogen dioxide (NOx*) emissions to produce fine particulate matter. While NH_3 has a lifetime of one day, fine particles generally have a lifetime of 7-10 days, which allows particulate matter to be transported far from the sources.

The agricultural sector is currently responsible for the vast majority of NH_3 emissions in the European Union (EU). Agricultural activities in 2015 resulted in the emission of 3,7 million tons of NH_3, corresponding to 94% of the total NH_3 released in Europe, and contributed to PM pollution. In France a total of 549 kilotons of NH_3 was released in 2023, including 527 kilotons by agricultural sector[3]. Although Brittany only covers 5% of the French territory, the agricultural sector of the Region contributes annually to 18% of the national NH_3 emissions (i.e., close to 100 kilotons).

As of 2010, France was required to meet its emission ceiling set for NH_3 in the National Emissions Ceilings (NEC*) Directive 2001/81/EC. The NEC* Directive 2016/2284/EU replaced earlier legislation to set 2020 and 2030 emission reduction commitments for NH_3 compared to the amount emitted in 2005. NH_3 emission reduction for France is set to 4% for any year during 2020-2029 and 13% for years after 2030. The implementation of the NEC* Directive has been assessed in 2020. The report "demonstrates the need for additional measures in order to reduce air pollution. Efforts are especially needed in agriculture to reduce ammonia emissions, which is the most common and severe implementation challenge across the EU".

From 2008 to 2018, the trend in ammonia emissions in Brittany is not downward, emissions remain stable. A decrease has been observed since 2020: a 4% reduction in ammonia emissions has been calculated in Brittany between 2008 and 2020 (Air Breizh, v5.1). However, this decrease is mainly due to a reduction in livestock numbers in the region and not to changes in practices to reduce ammonia emissions.

In July 2019 (updated Dec. 2020) a French agency (ADEME*) released a Guideline to support information and training on good agricultural practices to reduce NH_3 emission in farms. They are based on techniques commercially available called the Best Available Technics (BAT*). However, the agronomic experts from CAB working day-by-day with the farmers confirm largely the information released in the NEC* assessment report: the use of good agricultural practices in the field seems insignificant. The main reason is that reducing NH_3 emissions looks complex and expensive for farmers who are usually working alone.

As a result, the solution here is to develop a specific program integrating all the existing tools, possibilities and stakeholders (good agricultural practices, knowledge, financial support, agencies, societies, etc.), making the action friendly, as "plug-and-play" as possible for the farmers.

In conclusion, the ABAA project will address the urgent need to promote and facilitate the use of the good agricultural practices by the farmers, through an integrated and close-to-the-stakeholder action.

[3] Secten report, edition 2025, CITEPA (https://www.citepa.org/donnees-air-climat/donnees-gaz-a-effet-de-serre/secten/)

The purpose of ABAA is to develop and implement a demonstration system at the scale of the Brittany Region to reduce NH_3 emissions by 15% in the pilot territory at the end of the project, and by 15% and 5% respectively in Brittany and Europe, 5 years after the project. This reduction will lead to a reduction of particulate matter levels. The principle is based on the development of a network of farmers, involved in the NH_3 emission reduction, thanks to the use of good agricultural practices based on the BAT*. To do so, an integrated and innovative method is to develop tools and methods such as a decision support system (DSS*) focused on a new and unique NH_3 emission management module, fed by the production of an original set of joint information on air quality and farming.

Objectives are:

1. Thanks to action B1 to B3, to develop original tools -experimental, virtual, etc.- jointly in the fields of air quality (measurement, modeling, forecast) and farming.
2. To carry out the concept to a Pilot Territory based on 30 voluntary farmers, supporting them to reduce the NH_3 emission, to gain information to 250 farms in the area of influence of 450 farms so that they will be prepared step by step to join.
3. To assess and to optimize the global concept (action B4).
4. To replicate the concept to all Brittany Region from 30 up to 750 (M24), then up to 9 000 farmers at the end of the project (action B5).
5. To support the replication and transfer of the concept to other French and European regions (action B5).

To realize these objectives, concrete actions must be put in place:

- Have a link (technical, human, communication tools, training tools, etc.) that allows to get in touch with farmers, then to make them aware of the theme and gradually get them to get involved,
- Provide a set of elements (tools, information, agronomic contact, etc.) allowing farmers to implement the method on their farm,
- Provide day-to-day information, which allows farmers to adapt their activity to reduce emissions,
- Develop a relational fabric making it possible to prepare for transfer and replication to other regions.

A reduction in rural NH_3 emissions transported by prevailing winds to more populated areas will result in the reduction of PM levels in urban areas. At the end of the project, the environmental objective is to improve ambient air quality, by reducing NH_3 emissions in Brittany and so reducing the annual average PM concentrations and the number of PM peak pollution. The ABAA project will develop a group of experts and end-users from different scales: local, national, European, and international (action E2). They will bring technical and scientific expertise, network and feedback from stakeholders and will advise the members of the project. That group will also facilitate the integration of the project in the community at the European level, supporting diffusion of the results, replication and transfer. Stakeholders from other key European NH_3 emissive areas (particularly Netherlands and North Italy) will be invited to join.

The structure of the ABAA project is divided into three parts. In relation to objective 1, the first part is focused on the development of the concept. From M1 to M12, all the necessary tools will be developed, tested, prepared in the frame of specific actions (B1 to B3): monitoring stations, digital systems (communication, emission inventories, modelling, etc.), training packages, working groups (famers from the Pilot Territory; group of experts, etc.). These tools will be performed and optimized throughout the project. Investment will be made to support the monitoring in the Pilot Territory (action B1.2); during the replication part, analyzers will be moved to support NH_3 monitoring in the entire region (action B4.2/B.5). From M12 to M48, the complete concept of the project will be implemented in the pilot territory (objective 2) (action B4). The concept will be assessed and improved (objective 3) (action B4.4). The third part of the project is focused on the replication and transfer of the concept, on the one hand in Brittany (objective 4) (action B5.1) and on the other hand in Europe (objective 5) (action B5.3).

That activity will grow continuously from the second year to the last year of the project. At the beginning of the implementation (M12) and after 6 months of implementation (M18), the project team will take stock about progress. From that starting point, the area surface of Brittany involved in the project will increase, for example with already volunteered territories such as *Oust-Broceliande* that will be invited to join at that point of the process. That process will support the extension of the concept to the entire region during the project, sharing the DSS* largely (action B5.2). From year 1 to year 3, the group of experts will develop a strong collaboration with a selection of French and European Regions; year 4 will be focused on the replication and transfer of the concept to these regions. During year 4, the concept will be introduced in the permanent activities of Air Breizh and CAB. That phase will ensure the continuity of the concept in Brittany after the end of the project. CAB will endorse the technical support of the DSS*, in the frame of its commitment regarding “Mes Parcelles”. Air Breizh will include definitively the feeding of the DSS* in its daily forecast activity. The objective of ABAA is to involve 14 000 farmers in Brittany, that is to say 50%, five years (possibly 3 years) after the end of the project. A program of communication and dissemination will be carried out all along the project (from M1 to M48) and after the project.

The continuous ambient ammonia measurements will be integrated into the existing operational air quality monitoring network. Combined with the warning system still in place 5 years after the project ends, it is expected to see long-term health benefits for the public, including less exposure to particulate matter (PM) pollution, and the reduction of the number and intensity of pollution peaks. At the end of the project, a 15% reduction in ammonia emissions in the Pilot Territory is anticipated, representing 13.500 ha (50% of the surface of the Pilot Territory). During and after the project, CAB will communicate continuously with the farmer community, to increase the number of farmers informed and involved, especially thanks to the DSS*. The target is to switch from 30 to 750 then 9,000 farmers informed and involved, all along the project, reaching 30% of the community at the end of the project, representing 540 000 ha (30% of the surface in Brittany). Thanks to the early warning system, a reduction in the number of polluted days from 15 polluted days per year by 2-3 days (-20%) is expected. Five years later, the involvement of 14,000 farmers (50%) is planned - that is to say 45% of the regional surface - leading to a 15% reduction in ammonia emissions in Brittany, representing a decrease of 14.000 tons/year.

5. Technical part

B.1: Development of field tools

B.1.1 Pilot area organisation (action led by the CAB)

1. Creation of the pioneer group

The pilot area lies at the West side of the city of Brest and includes localities in the following territories: *Brest-Métropole*, *Pays d'Iroise* and *Pays des Abers*. The first step of the organisation was to recruit members to form a group of 30 farmers, and at least 5 ETA* and CUMA*.

At the project submission, 10 farmers, 2 ETA* and 1 CUMA* already pre-committed themselves. A first information meeting took place on the 24th February 2022 with the presence of both partners and a representative for the CUMA* network in the area. 10 farmers belonging to 7 different CUMA* and 1 ETA* attended to this first meeting. Counting 6 new farmers interested identified by the CUMA* network and the local CAB advisors, and 7 farmers pre-committed that couldn't come to the meeting, 23 farmers were interested by the project and 10 of them claimed or renewed their commitment at the end of February 2022.

To continue the recruitment, a connexion with the installation of measuring stations (action B1.2.) was necessary. The objective to link measures and agricultural practices in this action requires a very high knowledge of the agricultural practices in the area measured. To ensure this knowledge, the remaining part of the recruitment has been focused on specific areas to densify the plots of lands committed in the pioneer group. The collaboration with local facilitators working at the CAB took place as follows: the facilitators called the farmers identified together to present the project and set up meetings, then Léna Oddos conducted interviews to meet the farmers. Two periods of recruitment have been conducted in June 2022 with 10 interviews and 7 newly committed farmers and in October 2022 with 14 interviews and 9 newly committed farmers. A parallel work has been ensured to recruit new ETAs on the area, which led to the commitment of 1 ETA*.

Thus, at the end of October 2022, the pioneer group involved 2 ETA* and 26 farmers belonging to 7 CUMAs. At the end of the project in August 2025, the pioneer group included 21 famers belonging to 6 CUMAs, and 2 ETAs.

The first group meeting, held on 8th December 2022, with the participation of Amélie Le Bloas, Anne Guézengar and Léna Oddos, enabled the group to collectively establish its operating rules and the specifications for farmers' commitments. The first workshop was dedicated to scenario building for the simulation of various assumptions on the regulation hardening and to highlight levers to work on, risks and lacks (link with action B.4.1).

2. Individual diagnostics on ammonia emissions

The aim of this action is to diagnose ammonia emissions on each farm of the pioneer group. 5 CAB experts worked on this according to their area of expertise: Klervi Geoffroy on the bovine section, Anne-Sophie Langlois for the pork section, Stéphane Roffi for the poultry section, Léna Oddos and Anne Guézengar for the crop section, and the CUMA* federation for the machinery section. 19 diagnostics have been completed on the dairy farms, 1 on the only poulry farm, and 5 on the pig farms (some of the farms having mixed production, dairy and pig). Concerning the emissions during spreading, 4 diagnoses have been completed but around 15 farmers have attended the AgrivisioN'air training workshop and are able to use it independently.

For the dairy farms, Klervi Geffroy made 19 diagnostics with the existing device CAP'2ER®*. Ammonia emissions were calculated for each farm. At first, the results of the pioneer group were

compared to the results of all farms diagnosed by the CAB in Brittany. Secondly, potential levers were identified with each farmer to establish a personalized action plan.

For the only poultry farm, Stéphane Roffi made 1 diagnostic with the same device, adapted to this sector. Only a test version was available at this time, that didn't give results at the same level of detail than the bovine device CAP'2ER®*: ammonia emissions were calculated but only general levers could be given to the farmer at this point.

For the pork farms, Anne-Sophie Langlois carried out 5 diagnostics with the existing device GEEP* on the farms where pork is the main production as well as on farms with mixed production (dairy and pork). As for the dairy diagnostics, individual interviews were carried out to choose the levers to be tested.

For the spreading ammonia emissions, Léna Oddos and Anne Guézengar carried out 4 diagnostics with the device AgrivisioN'air developed during the project. Individual levers were highlighted but overall, spreading practices (more precisely the type of machinery used) were already very good within the pioneer group (and the pilot territory – see section 3), which is why, given the delay in this action, the completion of four assessments was considered satisfactory.

For the diagnostics of the CUMA* organisations in the pilot area, with regard to their spreading activities, the CUMA* network was commissioned in 2023. The aim was to assess the volumes of liquid effluent spread, the types of spreading equipment used, spreading practices, the organisation of spreading sites and the available workforce, and to draw up proposals for change. Twenty CUMA* cooperatives were assessed. The following points emerged in terms of summary and outlook for this work:

- There are two main types of CUMA*: those experiencing a decline in activity (13 CUMA*) and those maintaining/increasing activity (7 CUMA*).
- There are four main factors that impact the dynamics of the slurry business: the volumes spread, the availability of spreading equipment suited to members' needs, the capacity to invest in and renew equipment, the availability of labour on members' farms.
- A few avenues for supporting CUMA* cooperatives were put forward: Individual interviews, member surveys, local meetings between CUMA* cooperatives, work on low emission spreading techniques, technical training, support for CUMA* cooperatives with a view to renewal.

In 2024, work continued with the aim of gathering feedback from the 16 identified CUMA* cooperatives that still use the pallet nozzle (for some or all of their volume). Six main obstacles to the use of low-emission spreading equipment were highlighted by the CUMA* cooperatives surveyed. The two main obstacles (cited 13 and 6 times respectively) are: the excessive cost of low-emission spreading equipment, and an insufficient volume of liquid effluent to spread to justify the investment. For many of these 16 CUMA* cooperatives, the nozzle is a quick system to use and has no particular constraints. However, only five CUMA* cooperatives say they are satisfied with their slurry operations today. Most CUMA* cooperatives are aware of nitrogen losses due to volatilisation. However, several of them have noticed a decline in slurry activity volumes due to members leaving for agricultural contractors, and this decline has also made it difficult to amortise equipment. The CUMA* network remains available to CUMA* members for any support requests, particularly regarding renewal projects. Technical visits will be offered. In 2025, the CUMA* federation updated the survey data for CUMA* cooperatives in the region. The volumes spread decreased by approximately 14%, with some members turning to agricultural contractors because the equipment of certain CUMA* cooperatives is ageing and they are increasingly opting for a delegation approach. Plans to merge CUMA* cooperatives are under consideration, and one project has been supported by the FRCUMA. For well-equipped CUMA*

cooperatives, volumes are tending to increase as the service is adapted with high-quality spreading equipment. It can be assumed that the spreading of effluent via paddle nozzles will gradually decline.

The follow-up of the B1.1 actions consists in the setting-up and development of the foreseen actions in B4.1 during the project. The results of the diagnostics are detailed in deliverable B.1.1 for the dairy cattle and poultry workshops, and deliverable B.3.1. 2024 for the pig and manure spreading workshops, and for the CUMA* diagnostics.

3. State of play of agricultural practices on the pilot area

Start date: actually sent in March 2023

End date (final analysis of results): May 2025

The aim of this action is to set a state of play of the agricultural practices of the area linked to ammonia emissions (type of livestock buildings, manure storage, manure application equipment available, type of farms, type manure applied to each crop…). One of the goals is to compare the results with the data used in the ammonia emission inventory and to improve it if necessary.

Method of constructing surveys and distributing questionnaires

To best meet the objective, two means of survey had been selected: individual interviews with agricultural contractors by CAB expert Anna Mathurin, and with the CUMA* by the CUMA* network, and an e-mailed survey to every farmer of the area for the information on livestock equipment and agricultural practices.

For the creation of the survey sent by e-mail, discussion with Antonin Mahévas and livestock ammonia emissions experts at the CAB (Solène Lagadec, Anne-Sophie Langlois, Tanguy Bodin, Nicolas Genot) allowed Léna Oddos to refine the technical information needed during 2022. The survey was e-mailed on the 20th of March 2023 by Anne Guézengar and the CAB communication service to every farmer on the pilot area, but only 2 answers were returned spontaneously.

To increase the chances to collect enough answers, Individual telephone interviews were conducted by Anna Mathurin during the end of 2023 and 2024. Qualitative discussions were then held with the voluntary participants to gather the views of agricultural stakeholders on the future of slurry spreading. Charlotte Rolland, CAB expert, then realised the final analysis of data collected by the three surveys in the pilot area.

Results

Of the 300 farms surveyed in the pilot area, 58 farmers responded to the survey. For the supplementary surveys, 19 CUMA* cooperatives and 5 ETA* contractors in the pilot area responded to the interviews. Most farmers (over 36%) use CUMA* tools for spreading liquid manure. Around 28% delegate this work to agricultural contractors, and 15.5% of farmers prefer to use their own tools. 21% of farmers spread manure in a mixed organisation, meaning that they can call on several actors for spreading. However, with regard to the volumes spread, the distribution among operators is fairly even (32% by CUMA*, 37% by ETA* and 32% spread by the operators themselves).

CUMA* cooperatives mainly use nozzles, which account for nearly 47.5% of the volumes spread. The ETAs are characterised by a marked predominance of injector use, which account for over 53% of the volumes spread (62.3% for the 5 ETAs who participated in the interviews). In terms of farmers and their own equipment, the distribution is more balanced between injectors (41%) and trailing hose (39%), with a significant proportion of nozzles also being used (14%).

The results of statistical tests carried out on farmer surveys show that the way in which spreading is organised is closely linked to the structure of agricultural holdings. Cattle farms, particularly medium-

sized ones, rely heavily on collective structures, while large mixed farms favour autonomy. Pig farms, particularly smaller ones, are increasingly reliant on outsourcing via agricultural contractors. These dynamics reflect strategic choices influenced by technical, economic and regulatory factors specific to each type of farm.

There is significant room for improvement in terms of making low-emission tools more accessible to farmers and CUMA* through economical, technical and collective levers. The territory's agricultural contractors are already well equipped with low-emission, innovative tools incorporating precision technologies. Farmers in the area are generally willing to change their spreading practices. Although the expected ban on emissive tools in 2025 is causing some confusion, the majority of stakeholders say they are prepared to invest in more efficient equipment, with the main obstacle remaining economic.

B.1.2 Installation of an NH_3* monitoring device in the field (action led by Air Breizh)

Sub action B1.2 involves deploying a field surveillance network on the pilot territory. The objectives of these measures are as follows:

- Enhance understanding of ammonia dispersion mechanisms across the region and its contribution to fine particles (Action B.4.2: NH_3 Monitoring).
- Facilitate model calibration (Action B.2.2: Ammonia and Fine Particulate Modelling).

The setup was intended to be operational 12 months (M12) after the project's launch (September 2022).

Actions carried out:

1. Purchase and metrological validation of measurement devices and mobile units.

This action, planned from month M3 to M6. As of June 30, 2023, the entire materials (measurement equipment + mobile units) were available.

2. Identification and preparation of measurement sites.

This action was scheduled within the project's first 6 months (M0 to M6). In spring 2022, after discussions with the CAB (Anne Guézengar and Léna Oddos), considering the locations of project partner farmers at this stage, the Plouarzel sector was deemed suitable for hosting the measurement equipment by Olivier Cesbron and Meryll Le Quilleuc. Several meetings were organized to refine the measurement protocol and criteria for selecting measurement sites in this sector: positioning of the three measurement sites in a triangle, placement of equipment on agricultural farms, selecting an area with a high density of project-integrated farms (better understanding of practices). Three farms were targeted (see B.1.1). The three stations were installed between 10th of March and 25th of September 2023.

3. Installation of equipment by Air Breizh

The devices were supposed to be installed between months M6 and M12. Due to the delays encountered in the previous two steps, the stations are operational (by technical service of Air Breizh) as of September 26, 2023, as detailed in the following table:

Sites	Measurement equipment	Date of commissioning
North site	NH_3 measurement continuously PM10 measurement continuously Weather parameters continuously PM10 sampler for chemical analyses	9 March 2023
West site	NH_3 measurement continuously PM10 measurement continuously	6 July 2023
South site	NH_3 measurement continuously PM10 measurement continuously	25 September 2023

Because of the delay for these installations, measurement campaign planned for one year will be extended in 2024.

Figure 1 : Trailer on west site (left) and mobile truck, outside and inside, on the north site (center and right)

A deliverable presents the work to install the monitoring system, and it is filed on butler in September 2023. A summary of this report has been sent with the mid-term report.

B.2: Development of numeric tools

B.2.1 Emission inventory (action led by Air Breizh)

A little delay has been taken to stard the sub-action because of a workload plan that is too heavy at the start of the project for the person in charge of the action.

Context and Objectives

Sub-action B2.1 of the LIFE ABAA project focused on the development and upgrading of the *Inventaire Spatialisé des Émissions Atmosphériques* (ISEA), the regional spatialized emissions inventory managed by Air Breizh. In 2020, regional agricultural emissions reached nearly 100,000 tonnes, with major contributions from manure spreading, livestock housing and storage, and grazing. The observed decline in Brittany between 2008 and 2020 was limited to 4%, showing the difficulty of achieving future targets (directive NEC*). The action aimed at refining emission estimates at regional and pilot-area scale, by combining official statistics, local surveys, and complementary observational tools such as satellite data.

Methodological Adjustments with the Chamber of Agriculture

A central element of the action was the close collaboration with the CAB. Methodological discussions between Antonin Mahévas, Anne Guézengar and Léna Oddos focused on emission calculation steps for spreading, storage, grazing, and livestock, particularly regarding the application of adjustment factors. CAB conducted surveys to collect information on the use of spreading equipment and low-emission practices (see B.1.1).

Results and Comparison of Scales

The results of the CUMA* surveys were integrated, by Antonin Mahévas, into the inventory calculations and compared with the ISEA* v5.1 baseline. Maps of adjusted NH_3 emissions show clear differences depending on the scale of analysis:

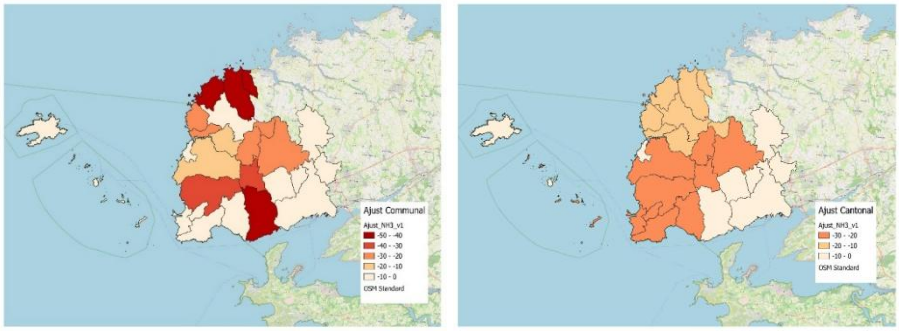

Figure 2: maps of ammonia emission reductions in the pilot area by integrating CUMA survey data*

- At **communal** level (left map), the reduction in NH_3 emissions appears stronger, with several municipalities showing decreases of more than 40%. This reflects the effective use of low-emission spreading techniques locally identified in the surveys.
- At **cantonal** level (right map), the reductions are much less marked, generally below 20%. This is closer to the national average factors usually applied in ISEA*.

These contrasting results highlight the sensitivity of emission inventories to the spatial scale used. Local, commune-level data reveal a stronger mitigation potential, while more aggregated calculations dilute the impact of local practices. However, uncertainties remain due to the incomplete representativeness of CUMA* surveys data (not including ETA* or farmers' data) and the need to refine the geographical scope of their activities.

Satellite-based NH_3 Observations

In parallel, to enrich the work carried out on emissions inventories and in addition to the initial objectives, an exploratory analysis was carried out, by Marion Delidais, using satellite data. The IASI instrument aboard the MetOp satellites was used to retrieve NH_3 atmospheric column concentrations over France and Brittany from 2014 to 2023.The analysis produced annual and seasonal maps as well as time series, revealing clear seasonal cycles with higher NH_3 levels during spring and summer, consistent with spreading periods. Comparisons with ground-based analyser measurements deployed by Air Breizh showed encouraging coherence, despite differences in units (column vs. surface concentration) and the coarse resolution of satellite data (12 km). These results demonstrate the potential of satellite observations to complement regional inventories and modelling.

Perspectives

The work carried out under Sub-action B2.1 paves the way for more refined regional inventories. Future steps include:

- Incorporating additional data from ETA*,
- Cross-checking with national statistics (CITEPA, with CREAA* project) to improve the representativeness of agricultural emission factors, which will continue efforts to better quantify and reduce agricultural NH_3 emissions.
- Further developing adjustment factors for manure storage and spreading practices,
- Strengthening the integration of satellite data, notably within the framework of the AQACIA-ROSAS project (2024–2026), to evaluate representativeness and usability of IASI retrievals for emission inventory purposes,

Overall, Sub-action B2.1 provided a robust update of Brittany's emissions inventory, enriched through methodological collaboration with agricultural stakeholders and innovative use of satellite data, while highlighting the remaining challenges in achieving emission reduction objectives.

B.2.2: Air quality modelling (action led by Air Breizh)

The action was scheduled to start in September 2021 and started on time. The work on this action was led by Nicolas Moreau. The objective of action B2.2 is to collect and analyze NH_3 air quality model data, compare it to on-site measurements (from action B2.1), and produce an assimilated model for integration into Air Breizh's forecasting system.

Numerical tools

To handle the volume and complexity of air quality data, several tools were developed or deployed:

- Demetrios, a Python package created to automate the collection and storage of model outputs.
- Airpy, developed by Airparif and adapted by Air Breizh, allows exploration of Demetrios-stored data for visualization and analysis.
- ScoresModel, a tool created within the project, enables comparison between models and observations using standard statistical indicators.

These tools form the backbone of the model evaluation and data assimilation workflows.

Model-Measurement analysis

Models were compared to NH_3 measurement data collected in 2022 and 2023. The evaluated models included:

- **EsmeraldaHR and EsmeraldaBR** (produced by the ESMERALDA platform),
- **COPERNICUS Ensemble**, **Mocage** (Météo-France), **Chimere** and **Prevair** (INERIS).

Measurements were sourced from local AASQA* networks and the GEOD'AIR national database. Statistical metrics such as RMSE, mean bias, and correlation were used to evaluate performance by year, station type, and region.

Results showed:

- Consistent underestimation of NH_3 concentrations across all models,
- Better performance in urban areas versus rural/agricultural zones,
- COPERNICUS models generally outperform national or regional ones.

Data assimilation and statistical forecasting

Assimilation with ModelBLUE

To improve model accuracy, Air Breizh implemented ModelBLUE, a geostatistical assimilation method developed by Airparif. It corrects model output using available measurements via debiasing and spatial interpolation.

Tested over Brittany, assimilation led to improve the statistical metrics (RMSE, Pearson and mean bias). However, the method is constrained by limited measurement coverage and current reliance on hyperparameters derived from other pollutants due to lack of robust NH_3 data

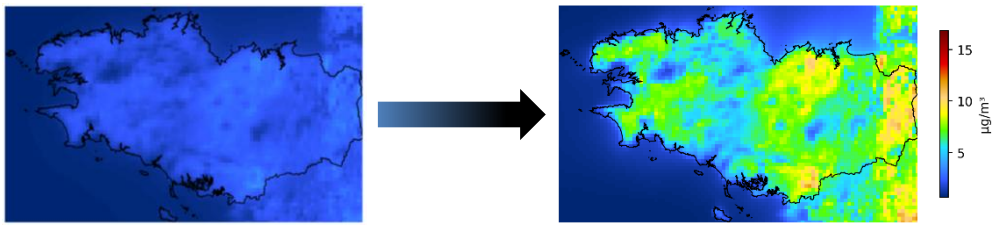

Figure 3: Evolution of mean ammonia concentrations between EsmeraldaHR raw (left) and EsmeraldaHR after the data assimilation (right)

Statistical Forecasting

A short-term forecasting approach was added using recent model outputs and observations. Based on 7-day regressions, the method reconstructs expected NH_3 values (pseudo-observations) for J+1 and J+2, which are then assimilated into the base model. The resulting forecast will be integrated into Air Breizh's operational tools (action B4.3).

After LIFE

The modelisation work started here will continue further after the ABAA Project through the CREAA* Project. In the latter, an analysis will be performed on ammonia data provided by INRAE*.

B.2.3 Decision Support System (action led by the CAB)

The aim of this action was to create a Decision Support System (DSS*), called "AgrivisioN'air", that aims to predict ammonia volatilization for the application of livestock manure and nitrogen fertilizers for the following days.

The first period of work lasted from January to June 2022 to draft the specifications with a working team comprising AB and CAB engineers (Simon Leray, Nicolas Moreau, Meryll Le Quilleuc, Laure Beff) and led by the CAB (Léna Oddos). Preference was given to rely on an external provider to clear the precise goals, the considered functionalities, and the overall data flows to anticipate. The launch of a tender was made on July 2022 to choose a provider for the DSS* development in September 2022, for a development planned from September to January 2023. Given time limitations, the only provider to apply was Agaric-IG, for the IT infrastructure part, in a consortium with EMQu Solutions, for the general and graphic design part. Thus, AgrivisioN'air has been developed and is currently kept up to date by Agaric-IG and EMQu Solutions.

AgrivisioN'air's homepage (Figure 4) gives access to two types of information. First, information on air quality at the district level is provided with the index « ATMO », daily calculated by Air Breizh. Users also have the possibility to register to a warning newsletter for pollution episodes. Then, the simulation of ammonia volatilization is available whether freely (without creating an account), or in a connected mode that gives access to greater functionalities.

The types of input data used in the simulation are characterized by the:

- Type of fertilizer and its emission factor (EF)[4]
- Type of livestock manure, its nitrogenous and ammonia content[5] [6] [7] and its EF[2] [8]
- Spreading equipment used and its allowance factor (AF)[5]
- Tillage delay to bury the livestock manure after spreading and its AF [5]
- Volatilization indicator created by Air Breizh and its EF (see below)
- Daily weather indicators (accumulation of rain, average wind speed, average temperature)

Figure 4: AgrivisioN'air homepage

A key output of B2.2 is the volatilization index that quantifies the likelihood of NH_3 volatilization based on:

- Atmospheric stability, through the Monin-Obhukov length.
- Wind speed.

[4] Database OMINEA edition 19.1, 2022
[5] 2018 LBC_MethodeGC_Annexe03_referentiel engrais
[6] ADEME projects: ConceptDig, 2019 ; FertiDig, ongoing
[7] RMT Elevage et Environnement, Brochure « Valorisation des effluents d'élevage et environnement », 2019 v1
[8] CITEPA, Inventory of air pollutants emissions in France under the convention for long-distance transboundarie air pollution and the european directive for the reduction of national emissions of some air pollutants,

- Precipitation and specifically rain

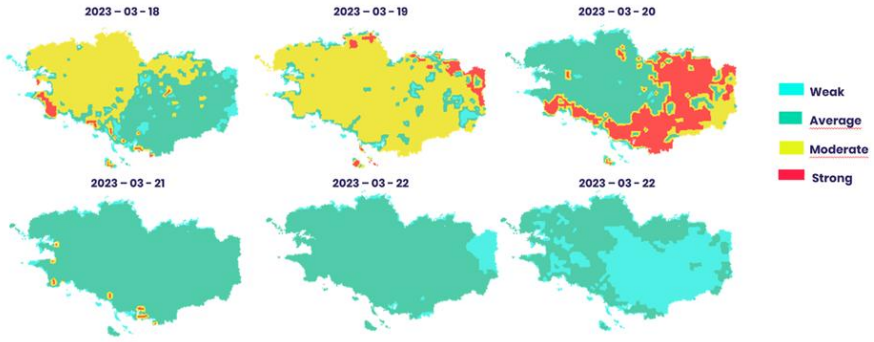

Figure 5: Examples of volatilization index in Brittany during 6 days

These parameters and especially the Monin-Obhukov length are explained in detail in the full report and were also the subject of a bibliographic search. Daily values are calculated for each model grid cell, then aggregated at the municipal level. Thresholds for wind and rain were fine-tuned through sensitivity analysis. The index is delivered daily to the application via API- and monitored for reliability developed by Simon Leray.

The variation range for the impact of the volatilization indicator on the estimation of ammonia lost was calibrated using the ALFAM[9] model, based on field experimentations.

The result of the simulation provides (Figure 6):

- An estimation of the amount of ammoniacal nitrogen (N-NH3*) lost due to volatilization for the D to D+2 days,
- A "spreading quality" indicator depending on the percentage of N-NH3* lost against the total nitrogen (Ntot) applied,
- A "spreading equipment performance" indicator that reflects the cross performance of the equipment and tillage delay to reduce volatilization,
- A "volatilization risks of the daily weather conditions" indicator that is the same as the volatilization indicator created by Air Breizh,
- An overview of the data entered to describe the spreading practice.

Figure 6: Simulation results page of AgrivisioN'air

A third part is available in a connected mode. Users can register by creating an account that give them access to many other features:

- To customize their practices (e.g., choose the types of livestock manure used in the farm),
- To create new types of livestock manure (customizing nitrogenous and ammonia content, mixing slurries),
- To register their practices all along the year,

[9] Hafner, S. D., Pacholski, A., Bittman, S., Burchill, W., Bussink, W., Chantigny, M., Carozzi, M., Génermont, S., Häni, C., Hansen, M. N., Huijsmans, J., Hunt, D., Kupper, T., Lanigan, G., Loubet, B., Misselbrook, T., Meisinger, J. J., Neftel, A., Nyord, T., Pedersen, S. V., Sintermann, J., Thompson, R. B., Vermeulen, B., Vestergaard, A. V., Voylokov, P., Williams, J. R., and Sommer, S. G. (2018). The ALFAM2 database on ammonia emission from field-applied manure: Description and illustrative analysis. . Agricultural and Forest Meteorology, 258:66-79.

- Access annual and personal synthesis presented in an educational graphics form (Figure 7).

Figure 7: Examples of graphs generated in the personal synthesis (connected mode)

AgrivisioN'air has won two national awards:
- a 2 stars "INNOV'SPACE" award at the 2023 SPACE*.
- The 1st prize in the 'tools for farmers' category at the 2024 national innovation competition organised by the chambers of agriculture

AgrivisioN'air was supposed to be a part of the national software Mes Parcelles. No data flows between the devices could be implemented but a link providing access to AgrivisioN'air via Mes Parcelles has been set up. This link gives AgrivisioN'air a greater visibility among Mes Parcelles users. The work was completed in June 2025, which made it impossible to invoice this work on ABAA. The development was handled on CREAA*.

B.3: Development of the accompaniment

B3.1 Training and agronomic support (action led by the CAB)

1. Individual trajectories

Following the completion of the individual diagnostics, personalized action plans have been built for each farmer by the same 5 CAB experts, according to their area of expertise: Klervi Geoffroy on the bovine section, Anne-Sophie Langlois for the pork section, Stéphane Roffi for the poultry section, Léna Oddos and Anne Guézengar for the crop section, and the CUMA* federation for the machinery section. For the dairy and pig farms, new simulations were carried out using the same tools to evaluate the of NH3 emission reductions achieved by the action plans.

For the dairy farms: two strategies have been identified to reduce emissions, reducing nitrogen inputs (balance animal feed, increase grazing, adjust fertilization to crop needs, etc.) and reducing nitrogen losses to the air (cover slurry pits, use low-emission equipment, manage ventilation in livestock buildings, reduce the number of animals that do not produce meat or milk, etc.). The average reduction rate per farm in ammonia emissions achieved by applying the levers identified was of 11,7%.

For the poultry farm: no personalized action plan could be built because the test version of the diagnostic tool available at this time didn't give results at a sufficient level of detail. Only general levers could be given to the farmer, based on the BATs*.

For the pig farms: All farmers chose to simulate the installation of a pit cover. The results presented show that applying this lever reduces ammonia nitrogen emissions by 0.5 tons compared to the current scenario.

For the spreading practices, the spreading equipment used were mostly already satisfactory. The levers identified with the 4 farmers who were diagnosed were the replacement of nozzle spreading by hanging ramps or grassland disc injectors on grassland, or to improve fertilization management practices. This

last lever has been addressed during a group training session in 2024. The individual advice provided by the chamber was not as described in the contract (annual fertilization monitoring, crop protein levels, introduction of legumes), as the group's wishes were identified more in relation to herd management and livestock equipment.

2. Collective trajectory

After 2022, a year dedicated to building the group and securing the support of farmers, 3 group meetings per year were organised by Léna Oddos and Klervi Geoffroy, involving Anne Guézengar or Anne-Sophie Langlois depending on the topic covered. The first year (2023), one representative of the CUMA* network was present at each meeting, and the work had been focused on:

- Identify five of the most realistic levers to put forward to reduce ammonia volatilisation.
- Propose actions to support farmers in implementing these levers: training, experimentation, tours, etc.
- Create a training session program for farmers
- Presentation of the first results: diagnostics, survey...

The second year (2024), the work has been focused on:

- Collective workshops on topics identified following the individual diagnostics (mostly for the dairy farms): balancing the diet of dairy cows, grass management and nitrogen fertilization
- A training session with a CUMA* machinery expert on “spreading and machinery”
- The creation of the farmers’ account on AgrivisioN'air, enter their personal details and learn how to use the tool
- Creating standard technical cultivation itineraries, which were used for action C1-LCA*
- Presentation of the first results of the experiments (see below) and identify the topics to work on for the following year

The last year (2025), the collective work has been focused on:

- Working on the last topic identified following the individual dairy diagnostics: herd renewal management
- Reviewing the ABAA project and discussing everyone's wishes for the future
- The prestation of the Air Breizh measurement campaign results on ammonia and PM concentrations on the pilot territory
- The organization of an open door to one of the group’s farms, to present the ABAA results to the other pilot territory farmers

3. Experimentations

The first meetings of 2023 led to several questions for the group which for the answer identified was to implement a field testing. The questions were as follows:

- Does the frequency of slurry scraping in cattle buildings influence volatilization?
- Does grinding and mixing cattle manure in pits affect volatilization?
- As spreading equipment reduces nitrogen losses to the air, does this improve crop performance (yield or nitrogen uptake)?

To answer the two first questions, ammonia concentration measuring equipment has been installed on three of the group's farms. The results are presented in the deliverable B.3.1 2025. Following these results, it can be assumed that either the weather variable has such an influence that it masks the effects of scraping on ammonia concentration measurements, or that the effects of scraping on ammonia concentrations are not sufficient to be measured with the available tools. Regarding measuring ammonia concentrations near an open pit, no conclusive measurements could be taken. Discussions with an expert from INRAE* highlighted areas for improvement in the protocols for possible future projects.

To answer the third question, spreading platforms have been installed on plots of two of the group’s farms. The results are presented in the deliverable B.3.1 2024. The low-emissive machineries improved the yield and nitrogen uptake of fodder rapeseed and maize, quite significantly, particularly for rapeseed. These results led to a better appropriation of the effectiveness of low-emission materials. For the grassland platform the results led a better understanding of the best practices for using low-emission equipment.

B3.2 Guidelines for the use of BAT* in spreading activities (action led by the CAB)

1. Development of a spreading machinery effectiveness evaluation protocol

A protocol for assessing the quality of spreading with regard to volatilization was developed between May 2022 and September 2022 by Didier Debroize, Anne Guézengar and Léna Oddos, and called "The framework method". In total, 63 spreading sites were monitored during the project (figure below), by CAB and FRCUMA agents, covering 3 spreading campaigns and 6 spreading machineries.
Nozzles are the most emissive, followed by trailing hose, then trailing shoes, then tine injectors and finally disc cultivator injectors, with 75 and 88, 34, 23, 8 and 6 % of the soil surface covered by slurry, respectively. These results are coherent with scientific literature, but within these results, differences were observed by type of equipment. The analysis of these differences have been used to draw up an initial list of technical recommendations on how to use spreading equipment to minimise the risk of volatilisation: keep the trailing hose ramp on the ground, carry out soil preparation before spreading if the two operations are carried out in succession, check that the tractor power is appropriate for the spreading equipment used, etc.

This protocol remains available after the end of the project and has been added to the training provided to advisors to support farmers in reducing ammonia emissions. The counsellors trained during the project will also be able to diffuse the method and supplement the initial data collected.

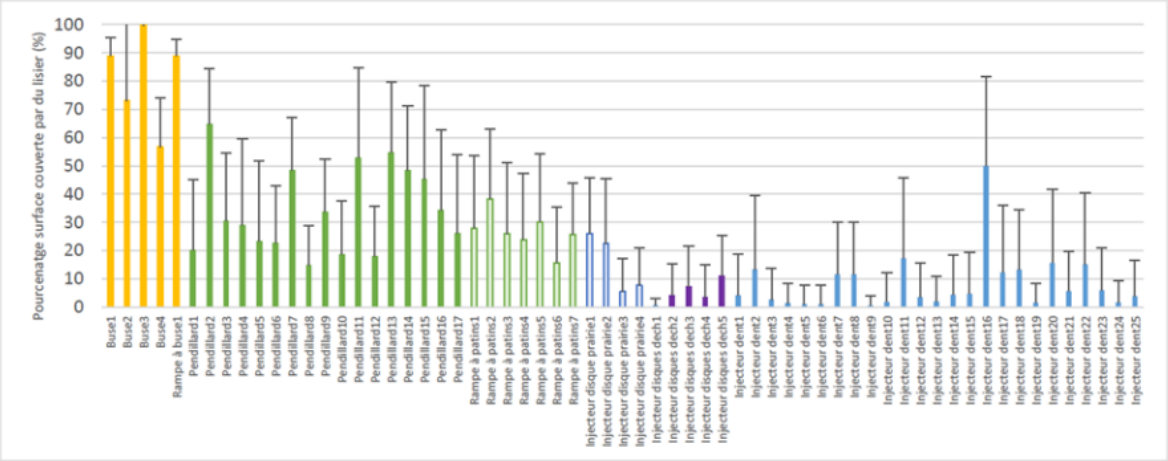

Figure 8: Result of the 63 ratings realized on the pilot territory

B3.3 – Helping operators make the right investment (action led by the CAB)

Some farmers in the group requested assistance in submitting applications for subsidies for spreading equipment. The necessary information was provided to enable them to choose the best option and compile their applications more easily. The merger of 3 CUMAs in the area to maintain the slurry activity was supported by the CUMA* federation as part of the agri-equipment market.

The survey conducted in the pilot area (B1.1) was extended to the region to improve knowledge of investment needs in spreading equipment. 167 CUMA* were audited out by the FRCUMA, of the 306 CUMA* cooperatives operating in the region. Nearly two-thirds of volumes are spread using lower-emission equipment (48% for trailing hose and 14% for injectors). Most volumes spread fall into the 16 m³ to 21 m³ category of tank. This category of slurry tankers is mainly equipped with trailing hose. However, the category of tankers over 21 m³ is almost entirely equipped with lower-emission equipment. One-third of the volumes spread are pig manure (higher proportion of ammoniacal nitrogen for this type of product). Concerning the spreading activity of agricultural contractors, 62 contractors were surveyed by the CAB. The results reveal a clear shift in spreading practices towards localised

techniques, mainly the trailing hose. Large slurry tank capacities are preferred to optimise the management of large volumes, while older equipment, such as nozzles, is being used less and less. The injectors, although less widespread, is becoming more popular in sensitive areas such as the pilot territory.

B.4: Use of tools

B.4.1: Following of pilot territory (action led by the CAB)

The goal of this action is to use the tools developed during the first part of the project to reduce ammonia emissions on the pilot territory. The pioneer group worked on a fictional scenario of 10 days of spring alerts disrupting spreading with Amélie Le Bloas, Anne Guézengar and Léna Oddos (B.1.1). What emerged was a desire to adapt the agricultural practices over time, rather than alert by alert. To achieve this, the need is to reduce the time spent on road transport during spreading (separate work task, temporary storage, grouping of plots) and invest in low-emission equipment. With more low-emission equipment available, and shorter travel time, it should be easier to quickly adapt the spreading practices during the alerts. Individual efforts on background emissions were also mentioned and have been worked on with Klervi Geffroy and Anne-Sophie Langlois during the definition of action plans (B.3.1). There were no pollution episodes on the pilot territory during the project, so the first goal couldn't be tested. For the time being, a newsletter (email) is available to notify the farmers of the alerts. However, the use of AgrivisioN'air allowed the farmers to react more easily to highly volatile weather conditions, according to the scenario created during group meetings. Then, the pioneer group partly applied the personalised levers produced by the individual diagnostics to reduce background ammonia emissions. Some of the levers require more structural changes or significant investment and will be implemented in the longer term. The delay in setting up the pioneer group in B1.1 and in producing AgrivisioN'air, meant that AgrivisioN'air could not be used until March 2023. The continuous improvement of AgrivisioN'air is described in section B.4.4.

B.4.2: Ammonia monitoring (action led by Air Breizh)

This sub-action begun with the provision of measurement data on the pilot territory to allow the modelling team to have data quickly. There was a delay for the installation of measuring stations linking to the recruiting of pioneer group, alternatives have been found to give assess to ammonia measurement to the modelling team.

The aim of this action is to improve the knowledge about the ammonia dispersion and this capacity to form particulate matter. Ammonia and particulate matter (PM10) concentrations measured on the 3 sites on the pilot territory were used. In parallel with the installation of the ammonia and fine particle monitoring system (B.1.2), a comparative study of ammonia measurement techniques was conducted at the rural station in Kergoff by Olivier Cesbron and Meryll Le Quilleuc (described in B.3.1). These comparisons are detailed in a deliverable already send with the first report. A summary was already sent. After her internship at Air Breizh; Sarah Guillot was hired to work on the analysis of this set of data with the help of Olivier Cesbron, Raphaële Falhun and Meryll Le Quilleuc. This work has been done between the end of 2024 and the beginning of 2025. The delay with the calendar is linked to the date of installation of the stations.

As all the studies with pollutants measurement, the meteorological context has been studied as well as the characteristics of each farm where stations were installed. Then, the concentration of ammonia and PM10 at the 3 sites has been studied. The north site was also equipped with a particles sampler on filters to analyse the chemical composition on PM10. This chemical composition allows to determine the source of the particles. The significant duration of the campaign (15 months) made it possible to study temporal changes in greater detail and to cover the same season several times, such as spring, which often causes an increase in fine particle levels due to agricultural activities.

Findings on ammonia

The three measurement sites show background levels higher than those observed at stations in the regional measurement network, around two to three times higher than those observed at the rural background site in central Brittany (Kergoff). This finding is justified by the locations chosen, namely the heart of agricultural operations, to facilitate understanding of changes in the concentrations measured. In addition, spatial variation is also observed within the pilot area, with differences in both the amplitude of the peaks and the temporal profiles.

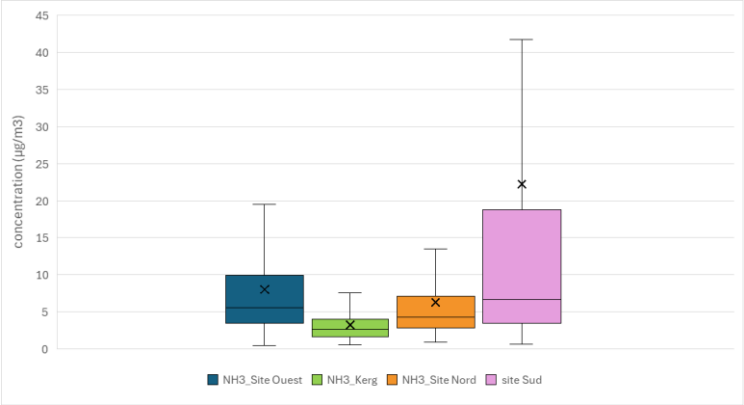

Figure 9: Levels in ammonia on the North, West, South site and at Kergoff from 26th September 2023 to 5th June 2024

Seasonal variations in ammonia concentrations were observed at two of the three sites (cattle farms). The impact of spreading in the vicinity of each site was observed. In addition to these seasonal variations, there is also the influence of specific activities unique to each farm. The site located within the poultry farm, which is also next to a composting facility, stands out clearly from the other two sites due to occasionally very high ammonia values and a higher background level.

Findings on PM10 fine particles

The average PM10 levels recorded at two of the three farms are similar to those measured in the urban center of Brest. As there are many sources of fine particle emissions, the spatial and temporal variability of PM10 concentrations is lower than that of ammonia. Over the measurement period, the main sources were sea salts. Although fine particles mainly originate from sea salt, the impact of agricultural activities is highlighted by the presence of ammonium nitrate. Its contribution to PM10 varies greatly, reaching a seasonal maximum of 13% in spring 2023. This season coincides with the period when spreading is most frequent. The highest concentrations of ammonium nitrate generally coincide with the highest levels of ammonia on the same day or several days earlier. This result confirms that the presence of ammonia in the atmosphere, accompanied by spring weather conditions, is conducive to the formation of ammonium nitrate.

A complementary action has been realised by the Institute of Environmental Geosciences (IGE) that carried out the analysis of the PM10 sampler: the analysis of the oxidizing potential. This work is valued by the IGE through the writing of a scientific article currently published to the journal Nature and will be value by Air Breizh in the CREAA* project, funded by the ADEME-. After the end of the project, the CREAA* project will allow to study the ammonia concentrations. Also, the ammonia monitoring will be perpetuated and the data of the monitoring device will be exploited. This work will be described in action B.5.

B.4.3: Air quality forecast (action led by Air Breizh)

Action B4.3 of the ABAA project, done by Nicolas Moreau, was dedicated to improving the exploitation of modelling and measurement data in order to strengthen Air Breizh's forecasting capacity, particularly for ammonia. Building on outputs from other actions, especially modelling from Action B2.2, this work package aimed to integrate ammonia into daily operational forecasts. It also aimed to modernize the internal IT tools used for forecasting. The description of the volatilization index developed for the DSS* is presented in the summary of sub-action B.2.3. The DSS* presented in B.2.3 allows to inform farmers when a pollution peak occurs.

A central part of this effort was the modernization of Cartprevi, the internal Python-based forecasting engine. Within the project, Cartprevi was upgraded to version 3.0 with a redesigned architecture. The tool now manages modelling outputs in two-dimensional datasets rather than one-dimensional tables, which greatly improves consistency, reduces processing time, and simplifies the overall workflow. Parallel computing was introduced, allowing forecasts to be generated more efficiently, while the system gained the capacity to calculate several indices in one run — including the ATMO index, ammonia, and pollen. Importantly, the spatial domain of Cartprevi was extended beyond Brittany to cover the entire northwest of France, which enhances regional context for forecasts.

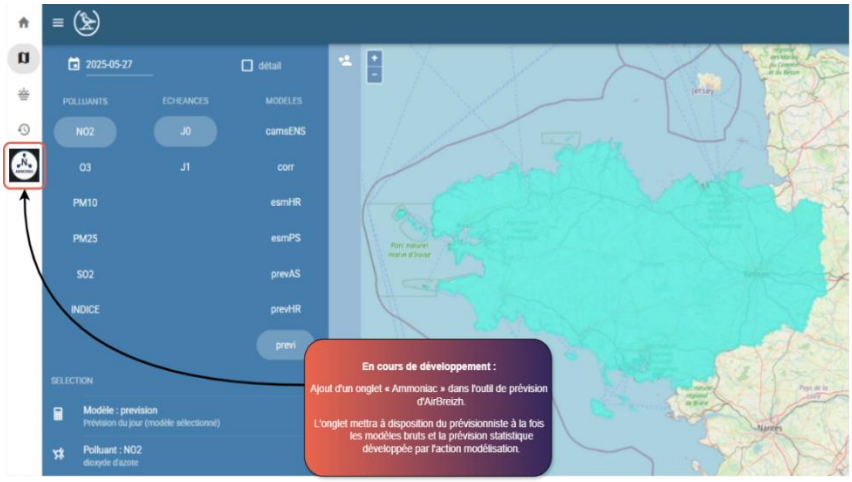

Figure 10: Example of possible integration of ammonia data into Cassandre

Cassandre, the intranet platform that manages daily forecasting and ATMO indices, is being updated to integrate Cartprevi's extended products, including NH_3 and statistical forecasts. This modernization began at the end of ABAA and will continue within the CREAA* project, with planned upgrades of its Django backend and VueJS frontend, database adaptations for new products, and broader-domain visualization to align with Cartprevi's outputs. In other words, the Cassandre work is underway but intentionally scheduled to carry forward in CREAA*.

Cartprevi was re-engineered to handle 2D datasets, run in parallel, and cover a wider domain, enabling ammonia forecasts alongside ATMO and pollen. Cassandre's modernization has begun and will be completed in CREAA*, ensuring full integration of these enhanced products.

B.4.4: Feedback and improvement of tools (action led by Air Breizh)

The goal of this sub-action is to assure a continuous assessment and feedback of the tools and continuous improvement work to optimize their performance. Even if some actions got late, feedback have been done.
The survey on livestock equipment among farmers in Brittany did not receive enough responses to be usable. The collection of this data will continue in the CREAA* project. However, the survey among CUMA* and ETA* in Brittany was carried out and the results are described in B.3.3.

An evaluation of AgrivisioN'air's performances was ensured by Anne Guézengar, Léna Oddos and Anna Mathurin all along the project with the feedback from the pioneer group users. The members committed themselves to use the tool during spring fertilization and spreading season to give their feedback on the functionality, usability and information quality. Since its launch in March 2023, AgrivisioN'air has been tested by the ABAA project's group of farmers, then made available to all farmers in Brittany at SPACE* 2023. During this first year of familiarisation and deployment of the tool, its use by the pioneer group provided accurate feedback on its ergonomics and the effectiveness of its features. A second version of the tool was therefore developed by Agaric-IG and EMQU Solutions in collaboration with Léna Oddos in early 2024, then put into production after a testing phase in July 2024 to address this feedback (details in the deliverable B.3.1. 2024).

AgrivisioN'air is being deployed on 5 other french regions (B.5.3) and discussions with chambers of agriculture and air quality monitoring associations in these regions have already yielded ideas for

improvement. The tool will then be tested by advisors and farmers in these regions. The creation of a consortium with all the relevant organisations will enable AgrivisioN'air to be further improved as it is rolled out.
The two ABAA partners committed themselves to maintain the DSS operational and to ensure the training and assistance of users.

B.5 Replication (action led by Air Breizh and the CAB)

The action of replication includes a replication from the ABAA pilot territory to all the Brittany region, from CAB to organization of productors and from Brittany to other French and European regions. The two first actions (B.5.1 and B.5.2) had not begun in September 2022 due to the delay in recruiting the pioneer group in B.1 action, but started in May 2022.

B.5.1: From the pilot territory to the region (action led by Air Breizh and the CAB)
For the regional replication, strategies have been developed for the transfer of ammonia measurements and the transfer of agricultural actions and tools. Moreover, the territory of *Rennes Métropole* finances actions on this territory using the PPA* since 2025 and probably until 2027. The *Oust Brocéliande* territory, contacted before the beginning of the project, was requested to participate at the project.

1. Transfer of ammoniac measurement

The best locations for ammonia measurements have been chosen with the help of the ammonia inventory and an analysis of different ammonia models (made by Nicolas Moreau). This analysis allows to determine 5 areas to implement an ammonia analyser: center of Brittany, east of *Ille et Vilaine*, west of *Finistère,* north cost of Brittany, south-east of *Morbihan*. Presently, ammonia analysers are installed at different points: one on the pilot territory until the end of the project, on at the *Mordelles* station in the territory of *Rennes Métropole*, and one on the *Oust Brocéliande* territory (in addition to this, outside the LIFE program: one at the *Kergoff* station and one at the *Saint-Malo* station). After the end of the project, the deployment of the ammonia analysers will be preferred in stations of the Air Breizh network and basing on the analyses of different ammonia models. More information is available in the deliverable “Assessment and recommendations of replication and transfer” linked to action E.2.

2. Transfer of agricultural actions

Tools and methods for the agricultural sector (farmers, agricultural contractors, cooperative machinery associations, technicians, etc.) were developed in the pilot area in collaboration with the pioneer group from the outset of the project (see B.1.1, B.2.3, B.3.1, B.3.2, B.3.3, B.4.1, B.4.4). These methods and tools have therefore been proposed in several regions to work on the issue of reducing ammonia emissions, drawing on feedback from the pilot region. The strategy used to replicate these methods was to contact different regions to assess whether local dynamics could enable actions to be launched with farmers motivated by the issue. Initial contact has been made through various strategies (local authority climate, air and energy plan, internal CAB events over the region, public events aimed at the agricultural sector or the general public and proposition of joint agricultural actions to the Air Breizh contacts). Then, the equipment needed for awareness raising events or evaluation protocols is available at several strategic points of the region. Agricultural advisers located in various territories will also be trained. As planned in the contract the territories that had already expressed an interest in setting up the project were given priority (*Oust Brocéliande* territory). The *Rennes Métropole* territory is an area where replication has been particularly effective thanks to a public funding plan for air quality (PPA*).
The spreading machineries demonstrations organized all over the region (see D2) give the opportunity to sensitize farmers and other actors to the subject of ammonia and to present the project. 12 demonstrations were planned by Anne Guézengar or Léna Oddos, and organized by the CUMA* network and local CAB advisors or territorial facilitators (see D.2.1), which may ease the appropriation and replication locally. For instance, the demonstration organised in *Hillion* on the 7th of June 2023, was planned with local advisors who usually work on nitrate leakage risks. This event was then integrated to their plan of demonstrations and events on this area and led to further exchanges in their

local networks. In total, 1547 participants attended to these demonstrations (farmers, agricultural advisors, students, agricultural contractors), of which 1200 participated to one demonstration which was part of a bigger event (*Méca-élevage* on May 25, 2023).

B.5.2: From the CAB to other producer organization (action led by the CAB)
Replication to regional producer organisations has not been effective at the end of the project. Discussions have taken place since the start of the project with several structures, agricultural cooperatives and producer organisations (Cooperl, Evel'up, UGPVB*, etc.), but have not led to the implementation of concrete replication actions. Some of these organisations are invited to and participate in various events (seminars, conferences) organised by the ABAA team. In particular, regular contact is maintained with UGPVB* in relation to the collection of field data to improve the references in the emissions inventory.
However, the transfer to regional agricultural education structures was not provided for in the ABAA contract but was made possible, through the project's certification by *RMT Bouclage* and the presentation of AgrivisioN'air at SPACE*. Several tutorials on 'air quality - ammonia' were developed based on the use of AgrivisioN'air and ABAA actions. This work is now included in the CAB catalogue of interventions offered to agricultural education institutions.

B.5.3: From Brittany to other french and european regions (action led by Air Breizh and the CAB)
The third action (B.5.3) has begun in advance. Indeed, from spring 2022, contacts have been established with colleagues from the AASQA* of *Pays de la Loire* and *Centre Val de Loire* to present them the project. This meeting (gathering colleagues from Air Breizh and CAB: Meryll Le Quilleuc, Olivier Le Bihan, Anne Guézengar, Léna Oddos and Charlotte Quénard) could happen because the project manager begun (Meryll Le Quilleuc) early the networking planned in the action E.2 (group of experts). Colleagues from these two regions have been very interested by the project and asked to be kept informed of the progress. During the Automn 2022, *Air Pays de la Loire* has informed us of a project submission for the ABAA project with *Nantes Metropole*. This submission has been done via a program around a "territorial agricultural project – sustainable food sovereignty" within the framework of the "PIA4". Olivier Le Bihan and Meryll Le Quilleuc helped Air Pays de la Loire for the submission. The answer of the investment program asks them to work again the project for a new submission. This first attemps didn't work but subsequently, another attempt via another call for proposals was successful.
The ADEME* call for projects "AgriQair", published in spring 2023, was an opportunity to propose to work together with target regions. *Atmo Bourgogne Franche Comté* and *Atmo Auvergne Rhône Alpes* contacted Meryll Le Quilleuc following her message of partnership to express their interest. Meetings have been organised with AASQA* and agricultural Chamber of these two regions to discuss how they can replicate the ABAA project in their regions. Colleagues from *Atmo Auvergne Rhône Alpes* and chamber of agriculture of *Auvergne Rhônes Alpes* were very interested by the thematic but the deadline to deposit a project was too short and the teams were too busy. They planned to keep this thematic on their subjects and to keep contact with the ABAA team project. Colleagues from *Atmo Bourgogne Franche Comté* and chamber of agriculture of *Bourgogne Franche Comté* deposed a project in AgriQair but they decided to turn their project to a different viewpoint.
In spring 2024, the "AgriQair" call was republished. Several projects were deposited and accepted by ADEME*. These projects regroup AASQA* and Chamber of agriculture of each region: *Pays de La Loire*, *Centre Val de Loire*, *Auvergne Rhône Alpes*. In their project, they planned to transfer the AgrivisioN'air tool on their regions. Moreover, among the 2023 winners, a project led by the FR CUMA Ouest and in partnership with *Atmo Normandie* and the Chamber of agriculture of Normandy also planned to transfer the AgrivisioN'air tool, although it was not planned at the beginning of the project. Finally, the Chamber of agriculture of *Grand Est* and *Atmo Grand Est* obtained funding from an "PEI". On of their actions is that transfer AgrivisioN'air in Grand Est. Some other tools for farmers will be also share with the different Chambers of the agriculture. At the end of ABAA project, these 5 regions are currently testing a trial version of the tool, and production is scheduled to begin in early 2026. The creation of the link to AgrivisioN'air on the national Mes Parcelles tool will also facilitate deployment to other regions in the future.

First attempts to make contact have been made with organisms in Italy and Netherlands in the spring 2022 but without success so far. This works will be continued. During autumn 2024, an English 4 pages document will be created to share the objectives of the project to international structures. A webinar has been organised to present the project to European structures (see D.2.2)

After the end of the project, it is still planned to maintain the skills developed in Brittany and other regions. The new projects in Brittany and in other regions will be helping to maintain the tools.

C.1 and C.2: Environmental impact indicators and socio-economic indicators (action led by Air Breizh and the CAB)

The project manager arrived in November 2021, that's why the activation of the LPI Webtool has not begun in September 2021. The indicators have been defined, by Meryll Le Quilleuc, during the first months of the project with the help of the representant of the Monitoring team and the data was entered into the tool in May 2022. Monitoring is also carried out internally every year. Indicators such as ammonia emissions in the pilot territory and in Brittany obtained from the CAP2ER tool, the number of farmers involved in the process, or the hectares covered by the process are studied, for example. These indicators have been updated every year when it was possible and are presented in part 7 of this report. The indicator as the number of visit on the ABAA website were followed every year. It is clear that the number of visits increase when new on the website or post on Linkedin is published.

In this action, it was also planned to realize a Life Cycle Analysis (LCA*) to evaluate the approach, the impacts of the pilot territory, the relevance and the effectiveness of the ammonia emission reduction tracks implemented over time of the project. To realize this mission, it was necessary to choose an external service provider by a call for tenders. A first external service provider has also been hired to help the team to write the specification for the call for tender. Finally, the selected external service provider was *INRAE* Metys*, a private branch of the national public agricultural research institute, *INRAE**. Internally, the work involved cattle, pig and agronomy experts from the ABAA team: Klervi Geffroy, Anne-Sophie Langlois, Anne Guézengar and Léna Oddos.

Firstly, the work consisted of characterising the pilot area in order to model it. Four archetypes of dairy farms and three archetypes of pig farms present in the pilot area and their distribution across the territory were defined by the ABAA team (details in deliverable C.1.2). To this end, the data used came from the pioneer group's assessments, results to the survey, local databases and the opinions of local experts. Farmers in the pioneer group were also asked to validate the work. This first part of the work lasted from April 2024 to May 2025. There were significant delays to the initial schedule because the amount of work required to complete this part was greatly underestimated by both parties. The second part of the work consisted of modelling the impact of archetypes on the territory through standard LCA* indicators, including ammonia emissions, nitrogen leaching into water and GHG emissions (produced by INRAE* Metys). This part of the work was completed by the service provider by the end of August 2025.

The environmental indicators most affected by the modelled farms are climate change, acidification, fine particulate matter and marine eutrophication. The results detail the share of each item (crops, concentrates, enteric emissions, buildings, storage, etc.) in the impact of each indicator by archetype. For example, for the four cattle archetypes, the item that has the greatest impact on climate change is enteric fermentation. Similarly, the factor that has the greatest impact on acidification is crop management for three types of cattle. For the fourth type, where cows are always kept indoors, emissions from buildings have as much impact on this indicator as emissions from fields.

Work continued after the end of the project to achieve the planned objective and enhance the value of the work carried out. Based on the modelling results and the work carried out with the pioneer group, the project team proposed levers for reducing ammonia emissions to model their impact on all

environmental indicators. The aim is to develop a scenario for changing agricultural practices in the pilot area that would reduce ammonia emissions without adversely affecting other environmental impacts. As a result, the most effective levers for reducing the impact on climate change are covering slurry pits and replacing Brazilian soya with French soya. To reduce the impact on environmental acidification and fine particles linked to ammonia emissions, the most effective lever is to increase the use of low-emission spreading equipment. Ultimately, the measures taken to reduce ammonia emissions did not have a negative impact on other environmental indicators. On the contrary, some measures helped to improve other impacts, to varying degrees, such as climate change and marine eutrophication. The second part of this study, which focused on modeling drivers and developing scenarios, was carried out in a simplified manner to meet the project's deadlines. Further work should be conducted in a future project to expand on these findings and provide more specific and actionable recommendations.

D.1: Communication (action led by Air Breizh)

The creation of a graphic charter and a website dedicated to the project

Led by the Air Breizh communication's team, (Manuel Chevé, Meryll Le Quilleuc & Karine Le Méhauté), this stage consisted of drawing up specifications for the development of the showcase website before contacting several service providers capable of designing it within the given timeframe, as the website had to be online by the end of the first six months, in March 2022. The website dedicated to the ABAA project, www.lifeabaa2021.eu, was thus able to go live on schedule, thanks to the strong mobilisation of Air Breizh's internal communications team during these first few months, as well as the involvement and responsiveness of the service providers working on the project at Voyelle in March 2022.Since then, this dedicated project interface has been regularly updated throughout the project, including, from 2024 onwards, the publication of reports on each action and the dissemination of ABAA results in the region on the four key themes developed since 2021: ammonia measurements, digital tools, awareness-raising and work carried out with the pioneer group. The content of the website then evolved as the various actions progressed throughout 2022 and 2023. A Questions/Answers (FAQs) page was also integrated, allowing for a better understanding of the issues related to air quality in Brittany and the download of the corresponding support in pdf format.

Figure 11: First page of the ABAA website

Designing communication materials (banners/signs/flyers/quarterly newsletter/popularisation report)

At the beginning of 2022, the partners of the Brittany Chamber of Agriculture joined forces with the Air Breizh communications team to form an ABAA Com' group. From the very first months of the project, it was important to ensure consistency between the various general communication activities and those carried out at each stage and milestone of ABAA, which focused more specifically on 'field' and 'technical' communication activities aimed at the agricultural community, mainly carried out by employees of the Chambers of Agriculture of Brittany.

This group, consolidated over the months through regular exchanges based on a common ABAA communication plan, made it possible, through the computer graphics work carried out by the Voyelle agency, to design various communication materials and visuals such as a kakemono presenting the objectives and benefits of the project, and a flyer for general communication about ABAA during participation in various events such as trade shows, conferences, etc.

Figure 12: Kakemono and flyer

With a view to promoting news and developments relating to the project over its final two years (2024/2025), a quarterly newsletter aimed at partners and stakeholders in the agricultural sector was launched at the end of 2023. This has helped to boost project monitoring by highlighting its major milestones and significant events.
Finally, the last year of the project, 2025, was devoted to the design and drafting of the popularisation report expected at the end of any project, aimed both at promoting the collaborations undertaken in the region and at making the technical and scientific results that emerged from them accessible.

Dissemination and relaying to the general public, the media and partners in the agricultural world via social networks and event-based communication.

Figure 13: Air quality & agriculture meetings - Décember 2024

General communication about the project and its technical and scientific advances was carried out on an ongoing basis by the two partner organisations, either jointly or separately, using the project's specific digital communication channels.
In addition, press conferences and participation in professional and public events have been organised over the last four years in close collaboration with the CAB. This includes regular participation in trade fairs such as SPACE*, held annually and attracting significant involvement from regional agricultural stakeholders (as mentioned in D2); participation in technical and interprofessional days; exchange days between collaborators in the pilot area at the mid-point in 2023; organisation in December 2024 of a targeted regional conference on 'Air and Agriculture' for scientific experts and partner communities, with video recordings available online via the ABAA website. These recordings provide access to the presentations of the various speakers and the constructive discussions that took place on this occasion, thereby extending ABAA's scope to other extra-regional projects.

D.2: Dissemination (action led by the CAB)

D.2.1: Technical dissemination to professionals in the agricultural sector (action led by the CAB)
Various actions were carried out throughout the project by Anne Guézengar and Léna Oddos, in line with the planned objectives:

- 12 spreading machinery demonstrations have been organized during the project, in partnership with FRCUMA (1 in 2021, 4 in 2023, 4 in 2024 and 3 in 2025). The first goal was to organize 8 demonstration per year, but it was revised with a goal of 4 per year, or 1 per department per year. Finally, 12 demonstrations took place, with a total of 327 farmers attending to these demonstration (not including technicians, students, advisers, and contractors, see B.5).
- 1 open day was organized on the pilot territory at the end of the project to present the results to the local professionals (B.1.1)
- 4 training sessions or technical workshops were organised in the region during the project, with around 60 farmers receiving training.
- 3 technical articles were written in the Chamber's magazine, with around 5 000 farmers reading the newsletter. Numerous articles were also written following various events (press conferences, trade shows, demonstrations, reports, etc.) by the local or specialised agricultural press.
- AgrivisioN'air, has been presented with daily interactive demonstration displayed on a large or small screen, at the 2023 and 2024 SPACE*. A conference on ABAA's results was given at the 2025 SPACE* by Léna Oddos, Meryll Le Quilleuc and FRCUMA.
- AgrivisioN'air was presented in March 2024 at the National Innovation Day of the Chambers of Agriculture.
- Midterm results were presented in April 2024 by Léna Oddos ans Meryll Le Quilleuc at a "RMT Bouclage" event.

- 2 posters were presented by Léna Oddos and Anne Guézengar at the COMIFER GEMAS* national fertilisation conference in November 2023. Klervi Geffroy and INRAE* Metys will give an oral presentation on the methodology used for the territorial LCA* at the COMIFER GEMAS* national fertilisation conference in November 2025.

D.2.2: Dissemination throughout the country and Europe to develop networking on the territory and with other LIFE projects (action led by the Air Breizh)

The project manager Meryll Le Quilleuc arrived in November 2021; it is why this action has really begun in November 2021. The project has been presented to various events since spring 2022. Next, some notable examples of national or European dissemination.

The Atmo France Federation and the Permanent Assembly of Chambers of Agriculture organized a conference on January 17, 2023: "Air quality: a national issue, agriculture is taking up the challenge". The LIFE ABAA project was presented by the president of Air Breizh and by a farmer and elected member of the Brittany Chamber of Agriculture.

The CEREMA*, public establishment under the supervision of the Minister of Environment, organized a webinar series on air quality during the spring 2022. The project manager of LIFE ABAA, Meryll Le Quilleuc, organized the webinar about agriculture on April 4, 2023. During this webinar, she presented, with her colleague agronomist from the CAB, Léna Oddos, the LIFE ABAA project. Moreover, a colleague from *Air Pays de la Loire* presented a project of replication in Nantes (see action B.5).

Meryll Le Quilleuc and Léna Oddos presented the ABAA project at the Pollutec trade fair on the LIFE stand in November 2024, thanks to an invitation from the funder.

The work on ammonia modelling was presented at Atmosf'air, a French congress, on October 2024.

A first poster was done on March 2022 to present the project on the CFA* (French Congress on Aerosol). On March 2025, another poster was done to present major results of the project on the CFA*. This poster won the price of the best poster.

A 3 pages-article was published on the EU Research journal (https://euresearcher.com/) during summer 2025. AgrivisioN'air, actions of sensibilization and work on modelling are presented on this article.

The 22nd of May 2025, a webinar has been organised to present the project and the potential actions to European network which work with the Chamber of agriculture of Brittany. There were 29 registrants from different countries.

Regarding the project's After-LIFE phase, an open day at a pig farm was organised for a group of Swedish farmers on 17 October 2025 in conjunction with another European project, Climate Farm Demo, as part of CREAA*. The results of the ABAA project, and more specifically AgrivsioN'air, were presented to them.

Since actions will be sustained after the end of the project (such as training on ammonia or use of AgrivisioN'air), member of the project team will continue to attend to similar events. For exemple, Meryll Le Quilleuc and Léna Oddos will be presenting ABAA to a LIFE Networking Meeting on Addressing Ammonia Emissions in Agriculture under the Revised Industrial Emissions Directive (IED 2.0), taking place online on 28th October 2025. They will both also participate to another LIFE Networking meeting called "To identify knowledge gaps and future needs and provide feedback to policy makers", in the "Effective measures to reduce air pollution", on the 4 and 5 March, 2026.

E.1: Management (action led by Air Breizh)

The project manager arrived in November 2021, it is why this action has really begun in November 2021. The project manager, Meryll Le Quilleuc follows the project almost full time. She was solicited for other projects, since May 2023, on the construction of solution sheets on mobility, or since November 2023, on the CREAA* project, another ammonia project financed by ADEME*. Steering committees are organised approximately every month with Air Breizh and CAB members. These committees allow to validate decisions to be made in connection with the project, planning of financial elements, and report on the progress of the project.

The project manager makes the link between the contributors of each sub-action and particate to the meeting to keep a global vision of the project all the time.
A kick-off meeting has been organised, by Meryll Le Quilleuc, Olivier Le Bihan, Anne Guézengar and Léna Oddos, the 1rst of March 2022 in Rennes with the team. Community representatives of pilot territory, CUMA*, representants of Samson Pichon company and of the Brittany region were there. An intern seminary was organised the 28th of March 2023, by Meryll Le Quilleuc, Anne Guézengar and Léna Oddos, to assess the progress of the sub-actions. This event allowed all contributors to meet and discuss.
Another meeting was organised, mostly by Meryll Le Quilleuc and Léna Oddos, in October 2022 on the pilot territory to present the project to all the actors of the territory concerned. Farmers of the pioneer group were there and representatives of state services. On the 14th of December 2023, a mid-term seminary was organized on the pilot territory to present the first results of the project.

Figure 14: Picture of participants of meeting in pilot territory, October 2022 (top left), picture of project team during the intern seminary in March 2023 (top right), picture of project tea in December 2023 (left).

E.2: Group of experts (action led by Air Breizh)

The project manager arrived in November 2021, it is why this action has really begun in November 2021. This action contains three sub-actions, very linked between them and with other actions as B.5 and D.2.2: Feedback, recommendations and evaluations (E.2.1); networking (E.2.2) and relay development in areas with potential for replication and transfer.
Events have taken place regularly since the start of the project. First, in May 2022, CAB presented the project to the "*RMT Bouclage*", group of experts on fertilization. This was an opportunity for the CAB to lead a workshop to present the decision support tool. Since then, the ABAA project has been labelled by the "*RMT Bouclage"* and therefore provides concrete support to the project.
Moreover, meetings are organized regularly with colleagues from different AASQA* to discuss various themes (measurement, forecasting, modelling) or project with similarities (for example, CAPARA project of Atmo *Hauts de France*, …). Contacts have also been made with the different AASQA* and

Chamber of Agriculture with a view to transfer as mentioned in B.5 and D.2; but also, with t*he LCSQA*,* the *LNE** or the *JRC** to have their opinions on specific subjects, about possible transfers in Europe, or discuss our respective projects. The project has been presented to some events as it is described in D.2.
Every year, all the *AASQA** meet during the *technical air days* to share and exchange on their respective work. This event was held for the first time since the covid pandemic in March 2023. This event gathers all the *AASQA** and the public member of air quality. A work of networking was done by the head of studies department, Olivier Le Bihan, in Air Breizh. The head of project, Meryll Le Quilleuc, presented some result at the *technical air days* in October 2024.
Some events listed in D.2.2 also meet the objectives of this action to exchange with expert groups: In November 2023, Léna Oddos and Anne Guézengar have presented first results at the congress *COMIFER-GEMAS*.* In October 2024, Nicolas Moreau presented his work on ammonia models at the congress *Atmos'fair*.
The first meeting of expert group was planned in March 2022. There is no one experts' group but many experts' groups by theme. The dialog with experts has been transferred to sub-action level: each sub-action manager manages his own network and timetable, flexibly and autonomously, as close as possible to his needs; this usually takes the form of an effective one-off vision exchange. In March 2022, there was the first meeting about measurement between *Air Breizh* and *Atmo Bourgogne Franche Comté*. The first milestone of the action has been done in the delay.
A deliverable "Report and recommendations on the scientific and technical progress of the project to M18" was sent at the beginning of April 2023 as planned. A similar deliverable "Report and recommendations on the scientific and technical progress of the project to M30" has been send at M39 (in December 2024 instead of March 2024). Indeed, the conference on air quality organised in the action D.1 in December 2024 was an opportunity to gather the opinions of the air quality and agricultural scientists invited that day. A last deliverable was sent, as planned, in Spring 2025 about "Assessment and recommendations of replication and transfer". This deliverable is linked to actions B.5 and D.2.
Advance was taken on the milestone "Selection of a list of regions with high potential for replication and transfer" planned in September 2023. Indeed, an important work was already done as mentioned in part B.5.
This work is very rewarding and should be continued after the project and in general in the activities of Air Breizh and of the chamber of agriculture.

E.3: After LIFE (action led by Air Breizh)

The After LIFE strategy was designed for the different actions of the project: the developed tools on the field, the numeric tools, the actions of transfer to other territories. Depending on the actions, the work has been done at different periods of time. The fundings of the projects on other French regions was accorded in Automn 2024, so, the After LIFE strategy was designed since this period.
At the beginning of the year 2025, Léna Oddos and Klervi Geffroy worked with the pioneer group on the continuation of the actions carried out by the group. The ammonia analysers have already been deployed and will continue to be deployed after the end of the project.
Some actions as sensibilization to farmers and agricultural advisors, ammonia inventory emissions and modelling will continue with the help of new funding as ADEME* which finances the CREAA* project.
Concerning the transfer of the actions on other Brittany territories, the territory of Rennes Métropole gave fundings via the *PPA* *since 2025 and until 2027.

All the details about this action is detailed in the deliverable "After LIFE plan exploitation".

6. Analysis of benefits

The objectives of the project are:

- To have a link (technical, human, communication tools, training tools, etc.) that allows to get in touch with farmers, then to make them aware of the theme and gradually get them involved,
- Provide a set of elements (tools, information, agronomic contact, etc.) allowing a farmer to implement the method on his farm,
- Provide day-to-day information, which allows a farmer to adapt his activity to reduce emissions,
- Develop a relational fabric making it possible to prepare for transfer and replication to other regions.

During the four years of the project, several results have been observed linked to these objectives. First, the pioneer group was created and a real human link exists today between the pioneer group and from several experts of CAB (Anne Guézengar, Léna Oddos, Klervi Geffroy, …). Moreover, several technical information was provided to the pioneer group through demonstrations of materials, work meetings, … The DSS* AgrivisioN'air is available for the pioneer group since March 2023 and allows them to have information on air quality, risk of volatilization due to weather or materials used. Spreading machinery demonstrations in other areas in Brittany are a good way to diffuse information on ammonia emissions and the tools and methods developed in the LIFE ABAA project which available for farmers and agricultural actors.
Otherwise, five binomial AASQA*/Chamber of agriculture in other regions obtained funding to work on ammonia emissions from agriculture on their regions. One of the objectives of their project is to transfer AgrivisioN'air on their regions. This should be effective in all five regions in 2026. Others binomial AASQA*/Chamber of agriculture have been identified and are interested in the transfer of AgrivisoN'air in their region but have not yet but have not yet found the right funding programme. Nonetheless, exchanges between ABAA team and theses structures continue.

Quantitatif environmental benefits

Some quantitative environmental benefits of the projet have been calculated. The diagnostics and support of farmers allowed to reduce ammonia emissions. Regarding the dairy farms, the average reduction rate per farm in ammonia emissions achieved by applying the levers identified was of 11,7%. Taking the pioneer group's total emissions, the application of the identified levers has reduced emissions of the group by 9% (part 7).
The levers for reducing ammonia emissions modelled in the LCA* scenario have led to improvements in other environmental impacts - to varying degrees depending on the indicator concerned - such as climate change, fine particulate matter and marine eutrophication. For example, one of the combinations of levers tested at the territorial level reduces the impact on climate change by 40% compared to the initial scenario.

Qualitative environmental benefits

Some qualitative environmental benefits could be observed since the beginning of the project. First, the work with the pioneer group allows to sensibilize them to the problematic of ammonia emissions in ambient air. The members of pioneer group seem very interested by the project and the thematic. They understand the economic gain of avoiding ammonia emissions. Secondly, the tool AgrivisioN'air has been created with a goal of sustainability in time and geographically. It was built to set up easily in other regions in case of transfer and this transfer is, today, effective. This transfer strengthens the sustainability of the tool in the future. Furthermore, the pioneer group wishes to continue to work as group and would like to incorporate other topics such as the carbon impact of farms. The topic of reducing ammonia emissions enabled the group to examine their practices more closely with a view to further improving them. Finally, the transfer to regional agricultural education structures was not

planned in the ABAA contract but it is a good opportunity to raise awareness among future farmers, who will be able to take this issue into account as soon as they set up their farms.

Economic benefits

The ABAA project allowed to create 2 jobs in Air Breizh and 2 jobs in CAB. Moreover, AgrivisioN'air is a real tool for farmers to avoid ammonia emissions and nitrogen losses, and by the way save money.

Replicability, transferability, cooperation

This action is a success. Indeed, 5 regions of France (Pays de La Loire, Normandie, Centre Val de Loire, Grand Est and Auvergne Rhône Alpes) are transfering AgrivisioN'air with a binomial AASQA* and Chamber of agriculture and the help of funding (ADEME*, PEI for Grand Est). This success of transfer is, maybe, associated with the European and French regulation about ammonia emissions and the reduction to achieve in 2030. Territories and stakeholders must grasp the subject quickly. Moreover, the success of the transfer in Brittany is linked to the Atmo France Federation and the network of the Chamber of agriculture. Indeed, both AASQA* and Chamber of agriculture of different regions are used to working together between regions.

Innovation and demonstration value

In other regions, a partnership between AASQA* and Chamber of Agriculture already exists (Hauts de France or Grand Est for example). In Brittany, thanks to the LIFE ABAA project, Air Breizh and the Chamber of Agriculture worked together for the first time. This first partnership allows to initiate other partnerships as on pesticides in the atmosphere.

The DSS* AgrivisioN'air is an innovative solution. The development of the volatilization index by Air Breizh is an innovative result. The integration of this index into the estimation of the amount of ammonia volatilized for a spreading by the CAB is another innovative result. AgrivisioN'air is quick and easy to use, very intuitive and bring together agricultural practices and weather forecast over a single instrument. That gives access to the users to unknown information and allow them to become more effective to optimize the value of their livestock manure.

The protocol developed to improve the assessment of spreading machineries and its use is an innovative tool and will improve the support given for farmers by their advisers. As it is a simple and cheap tool, it can be disseminated easily in Brittany and other regions or countries.

Also, the work to integrate real information of spreading equipment used by the CUMAs of the pilot territory in the emissions inventory of Air Breizh is a very innovative work. Indeed, it was never done before, and it shows the difference in term of ammonia emissions between the reference value informed in the inventory based on the national methodology and the real practices on the little territory. It seems difficult to do this work on all the country but doing this work on different place on the region will allow to know better the practices and estimate if the ammonia emissions from the national methodology are under or overestimated.

Policy implications

The ABAA project is based on European and French regulation about ammonia emissions. The goal of the project is to help the farmers to set up agricultural practices to reduce ammonia emissions, based on the BAT*. For example, the French regulation about ammonia emissions included in the PREPA* plan (plan to reduce atmospheric pollutant emissions) provides for the prohibition of the nozzle within 1 or 2 years. The actions developed in ABAA could facilitate the application of this regulation by facilitating the use of low emissions equipment: training of advisors and farmers, innovative tools (AgrivisioN'air, framework method) ... The results of the surveys could also help identify the actors who should be given priority support. More globally, ABAA results could contribute to improving or providing more precise guidance on the implementation of BATs*, particularly regarding fertiliser application.

7. List of figures