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ATMO-ACCESS GHG Emissions Monitoring and Avoidance Strategy

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GHG Emissions Monitoring and Avoidance Strategy

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1. Carbon Footprint Assessment Background

The latest Intergovernmental Panel on Climate Change reports¹ signal the urgent need to reduce global greenhouse gas (GHG) emissions. The main sources of GHG emissions globally are electricity and heat (31%), agriculture (11%), transportation (15%), forestry (6%) and manufacturing (12%), with energy production accounting for 72% of total emissions². In parallel, literature points to a high carbon footprint of some individual researchers in the exercise of their profession^{3,4,5,6} which multiplies at the scale of large research institutes and project consortia involving numerous partners from various countries. This constitutes a **paradox**: despite the awareness of the climate emergency, some specific practices present in the research profession are not in line with the objectives of the Paris Agreement⁷. The same researchers involved in sustainability studies and fully aware of the contribution of human activities to climate change, are sometimes reluctant to changing their habits. **If scientists strive to convince society to change their behaviour, research institutions ought to be consistent role models** by monitoring their own emissions and implementing GHG emissions avoidance policies. The challenge lying within this is reducing the carbon footprint of research without affecting the high-level quality of international cooperation⁸.

There is a reduced number of studies related to the carbon footprint of the research sector, often only focusing on one entity (e.g., university, laboratory), a specific event (e.g., conference) or a single emitting source (e.g., air travel). **Currently, research projects funded by the European Commission (EC) do not encompass a carbon footprint assessment.** Estimating the carbon footprint of EC-funded research projects can therefore increase our overall understanding of the contributors of GHG emissions within the research sector. **Such knowledge can inform the concerned stakeholders and funders, for these to design mitigation actions.**

Being a pilot EC-funded research project, **ATMO-ACCESS is the ideal setting to test the implementation of a reproducible tool for the measurement and monitoring of GHG emissions at the project scale.** It is our common understanding in ATMO-ACCESS that a project aimed to support society in tackling the climate emergency should consider the necessity of reducing the carbon footprint of its own activities. The main objectives of ATMO-ACCESS are (a) to provide coordinated open physical, remote and virtual access to state-of-the-art facilities and services in atmospheric RIs; (b) to engage facilities and their national stakeholders and direct them towards improved harmonisation; (c) to explore and test new modalities of access that build on the complementarity and synergies among atmospheric RIs of access procedures and (d) to identify the most suitable conditions for establishing sustainable access procedures across the EU. **ATMO-ACCESS is therefore potentially carbon-intensive, due to the inherent mobility related to access.** ATMO-ACCESS will thus engage in limiting GHG emissions connected to the project via the implementation of avoidance actions and by promoting new modalities for remote and virtual access, with the ambition of **proposing guidelines for low-impact access strategies.** The credibility of the actions in ATMO-ACCESS and of the recommendations issued to the EC from this pilot experience will be in fact considerably strengthened if they are fully consistent with the social measures championed by climate scientists.

Although we acknowledge that the impact that such assessment can have is limited to the project-scale, other EC-funded projects could make use of such tool and implement a GHG emissions monitoring and avoidance strategy, which could become a standardised practice in the future. **Carbon footprint assessments**

have the potential to become a pillar of EC-funded projects, exemplary of a global-scale commitment to reduce GHG emissions.

1.1. Task Objectives

The main objectives of the carbon footprint assessment task are:

Objective 1. Measure and monitor the project impact in terms of carbon footprint. This entails the definition of a **perimeter** (activities to be included in the assessment) and of a **methodology** for monitoring, tracking and converting activities into CO₂ equivalent emissions.

Objective 2. Implement actions to avoid and reduce GHG emissions coming from the project activities via the definition of **priorities** (main emission sources to target).

Objective 3. Integrate recommendations for sustainable access provision, modalities for considering the carbon footprint of access and strategies for emission reduction.

Objective 4. Implement a collaborative approach to achieve the first three objectives and **promote community engagement** throughout the project.

The task objectives were first presented to the ATMO-ACCESS community during the kick-off meeting (May 10-12th 2021, Appendix 1a). This initiated a compelling discussion among partners (Appendix 1c), demonstrating a high interest level among the project participants.

1.2. Document Focus

This document mainly focuses on objectives 1 and 2 by outlining the GHG emissions monitoring and avoidance strategy that ATMO-ACCESS aims to undertake. A strategy for objective 4 is also outlined and will be further explored throughout the project duration. Aspects of objective 3 are touched upon, but final recommendations will be issued only at the end of the project. **Results, recommendations and community engagement avenues will be reported in the final document issued to the European Commission (D11.6, due in M47).**

2. Objective 1: GHG Emissions Monitoring Strategy

Objective 1. Measure and monitor the project impact in terms of carbon footprint. This entails the definition of a **perimeter** (activities to be included in the assessment) and of a **methodology** for monitoring, tracking and converting activities into CO₂ equivalent emissions.

The method described below is based on the general principles of calculation of GHG emissions of the non-market services sector (including public services, administrative bodies, health and education services, collectives and religious organisations) recommended by the French Environment and Energy Management Agency (ADEME)⁹. The standardized calculation methods for GHG accounting¹⁰ were used as guidelines but were deemed too constraining to suit the objectives of this task, since several standard activities are not included in the carbon assessment carried out for ATMO-ACCESS (see section 2.2. below).

2.1. Definition of a Perimeter

A carbon assessment is an inventory of GHG emissions related to the activities of an entity. The first step therefore consists in identifying the perimeter of project activities which need to be included, monitored and converted into **CO₂ equivalent emissions** (CO₂eq). This unit is commonly used in carbon assessments to describe and compare different GHG emissions, and it allows to bundle multiple GHGs into a single number. In this case, the GHGs included in the carbon assessment are CO₂, N₂O and CH₄ as detailed below.

One of the main issues emerging from the exchanges during the kick-off meeting was the perimeter of activities to include in the assessment (Appendix 1c). In order to collect the partners' suggestions more thoroughly, a survey was developed to collectively decide **which emitting activities to monitor**. The survey was sent to all project partners (38 beneficiaries and 17 Linked Third Parties) of the ATMO-ACCESS project, in order to put into practice a collaborative decision-making approach (Obj. 4). The survey response is reported in section 5.2.

The decision on which activities to include was based on the main emitting activities identified by the Project Office after a thorough analysis of the ATMO-ACCESS Work Packages' content as well as on the survey response (Obj.4). **The project activities were clustered and divided into two categories**, based on their inherent nature:

1. **Institutional category:** transversal category of activities common to most EU H2020 and Horizon Europe projects. These include **activities that either require physical travel or that can be carried out remotely**. Examples include official annual meetings (e.g., kick-off meeting), mid-term review meetings, stakeholder workshops, dissemination conferences, Work Package leaders' meetings, EU cluster project meetings (e.g., ENVRI week, in the case of Environmental RIs).

2. **Project-specific (ACCESS) category:** activities specific to the project of interest for the assessment. In this case, it includes activities carried out and provided by **ATMO-ACCESS users and stakeholders**, in the form of **physical access (PA)** and **remote access (RA)** activities such as transnational access (TNA) of users to atmospheric research facilities (central laboratories, simulation chambers, observational facilities, mobile platforms, training and educational activities) and **purchases** (e.g., equipment, informatics tools etc.).

A third category - the **Digital services category** - was initially identified to be included in the carbon footprint assessment. This category included activities related to the **use of virtual tools and databases**. In the case of ATMO-ACCESS, these are the activities related to **virtual access (VA)** to online services, products for data curation, cloud modelling tools etc. After consulting with datacentre experts within ATMO-ACCESS on the feasibility and relevance of the carbon footprint calculation for the digital services, it was decided to exclude this category from the assessment. Although **we acknowledge the potential non-negligible contribution of the digital sphere to the overall carbon footprint of the project (e.g., data processing and transfer, storage, downloads, emails, community network activities)**, the lack of relevant literature and the absence of an established methodology hampers the conversion of the digital emissions into CO₂ equivalent mass. However, including the carbon footprint of the digital category remains a future aim.

It is important to note that the above activity categorization differs from the standard methodology for GHG accounting¹⁰. The standardized methods generally group the relevant activities into three different categories (or scopes)⁹: **(1) direct emissions**: fixed combustion sources, biomass, fugitives; **(2) indirect emissions**: electricity/vapour/heating consumption; **(3) other indirect emissions**: purchase of goods and services, waste, transport of goods, professional travel, visitor travel, home-workplace commuting, investments.

The objective of this task is monitoring the carbon footprint of an EC-funded research project, notably ATMO-ACCESS. Several activities present in the standard carbon assessments are therefore not considered in this type of assessment. For example, the specific local emissions linked to a given research facility (scopes 1 and 2) and the emissions deriving from individual professional activities or (scope 3) are not included within the ATMO-ACCESS carbon assessment. **These activities are purposely excluded to distinguish the project related activities** from any other (emitting) activity which is not specific to the project of interest. Moreover, functioning tools for monitoring and measuring the carbon footprint at the institutions, households and individual scales already exist (e.g., “labos1point5”¹¹ for professional emissions, “carbon footprint calculator”¹² for individuals and households) although often differing between countries and institutions¹⁰. These existing tools could be used to complement the project-scale activities assessment, where appropriate.

In summary, **the methodology for the ATMO-ACCESS carbon footprint assessment is specifically chosen to measure the impact of the project activities** (Institutional and Project-Specific i.e., ACCESS), and is therefore not strictly abiding to conventional methodologies. Although we recognise the limitations that this set perimeter implies, the decisions were made critically to allow the inclusion of all project participants (including users) and to focus on project-level emitting activities that would be **relevant for stakeholders and decision-makers for the implementation of emissions avoidance actions**.

2.2. Calculation Method

The tool for the measurement of the carbon footprint of the project was developed in the form of an open-access Excel spreadsheet, accessible to project partners via a link shared on the project-internal management platform “ATMO-CONNECT”. The link will be provided to users and Associated Partners by the Project Office via mailing lists. An Excel tool handbook (Appendix 2) is made available to all interested parties.

Based on the data inputted into the spreadsheet, **each emitting activity is associated with the appropriate emission factor** (amount of GHG emissions generated by a unit of activity) extracted from benchmark databases (Appendix 3) to obtain the activity’s CO₂ equivalent mass (**kgCO₂eq**). In fact, ‘CO₂eq’ is a common unit used to describe different GHG emissions and allowing to bundle GHGs into a single number¹³. Non-CO₂ GHGs (N₂O and CH₄) are converted into CO₂eq emissions using their **Global Warming Potential** values (GWP100). The GWP100 is a measure of how much energy the emissions of 1 kg of a gas will absorb over 100 years relative to the emissions of 1 kg of carbon dioxide, with CO₂ taken as reference (GWP100 of CO₂ = 1). This allows to compare the global warming impact of different gases.

The total carbon footprint is calculated using the formula below, by summing together the products of each emission source times the appropriate emission factor, to obtain total CO₂ equivalent mass (Appendix 1b). This formula is based on the work of “labos1point5”¹¹, a collective of researchers from various sectors of the academic world that carried out a scientific study on the carbon footprint of the French public research. This study was supported by the ADEME, the CNRS (National Scientific Research Centre) and the INRAE (National Institute of Agricultural Research).

$$\sum_{ATMO-ACCESS} \text{emission sources} \times \text{emission factors} = \text{CO}_2 \text{ equivalent mass (kgCO}_2\text{eq)}$$

Data will be inputted yearly to obtain estimates of the carbon footprint of each year of project operation. At the end of the project, the tool will indicate an estimate of the **total carbon footprint for the ATMO-ACCESS project** and its related uncertainty percentage (Appendix 3b, Table 4). The results will allow the **main emission sources** to be identified and targeted with GHG emissions avoidance actions. Emissions avoidance actions will however be taken from the onset of the project and their effectiveness assessed year by year.

Physical activities emissions calculation method from « labos1point5 »¹¹

To calculate the emissions of physical activities (i.e, project-related travel), emissions of all trips of the year of interest must be aggregated. The unit of measure convertible into CO₂ equivalent mass (kgCO₂eq) for physical activities is **distance travelled (km) from departure to arrival location, considering the mode of transport** (plane/train/bus/road, if road, fuel type). To calculate emissions of one trip, the formula¹¹ below is used:

$$\text{Trip emissions} = \text{travelled distance (km)} \times \text{emission factor for mode of transport}$$

The travelled distance is calculated using an open-source distance calculator¹⁴ giving distance as the crow flies between departure and arrival city. Since the real distances travelled on the Earth's surface are greater than the distances as the crow flies, the following coefficients¹⁵ are multiplied to the distance value: 1.3 for car travel; 1.2 for train travel; 1.5 for bus. For air travel, 95km are added to the distance as the crow flies to conform to the rule retained by the common system for emission quota exchange for air travel¹⁶. In case of a return trip, the emissions are multiplied by two.

Remote activities emissions calculation method from « Greenspector »^{17, 18}

The units of measure convertible into CO₂ equivalent mass (kgCO₂eq) for **remote activities (remote access to research infrastructure, training etc.)** are **duration (h) of remote event** and number of **participants (n)**, considering if webcams were kept on/off, and if screensharing was kept on/off. The calculation can be done using average emission factors values from Greenspector, a well-recognised French company specialised in digital services energetic performance (Appendix 3a, Table 2). To calculate emissions of one remote meeting, the formula¹⁸ below is used:

$$\begin{aligned} &\text{Remote meeting emissions} \\ &= \text{participants (n)} \times \text{duration(h)} \times \text{emission factors for webcams and screensharing} \end{aligned}$$

Emissions avoidance through remote activities¹⁹

To quantify the avoided GHG emissions resulting from the provision of remote access, rather than physical access, two formulae can be used. **The absolute GHG emissions avoidance (ΔGHG_{abs})** is the difference between the emissions that would occur in the absence of remote access (reference scenario, Ref_{GHG}) and the emissions occurring from remote access (Rem_{GHG}), with the result expressed in kgCO₂eq.

$$\Delta\text{GHG}_{abs} = \sum (\text{Ref}_{\text{GHG}} - \text{Rem}_{\text{GHG}})$$

The relative GHG emissions avoidance (ΔGHG_{rel}) is the quotient of the absolute GHG emissions avoidance (ΔGHG_{abs}) and the emissions that would occur in the absence of remote access (reference scenario, Ref_{GHG}), with the result expressed as a percentage (%).

$$\Delta GHG_{rel} = \frac{\Delta GHG_{abs}}{\Sigma Ref_{GHG}}$$

The scale of the project (comprising 43 research facilities in 22 different European member states, with European and international users) makes the definition of reference scenarios (emissions that would occur in the absence of remote access) extremely complex. For example, if we wanted to calculate the GHG emissions avoidance of having remote training (c.a. 40 participants) instead of hands-on training that would have been held in a defined location, we would need to collect additional data from the training participants including: the location they would have departed from and the mode of transport they would have taken if the training had been held in person. Alternatively, arbitrary assumptions would need to be made resulting in an inaccurate estimate of avoided emissions.

The same reasoning applies if we wanted to calculate the GHG emissions avoidance through remote institutional activities rather than physical institutional activities considering the project consortium comprises 38 beneficiaries and 17 Linked Third Parties. In this case, the calculation would be even more complex since often the physical meeting location is not defined at all, if an online meeting is arranged instead. Moreover, since institutional activities (like annual meetings) group a significantly higher number of people (e.g., c.a. 200 participated in the online kick-off meeting) than any access activity, this would require an even larger effort in terms of data collection to define reference scenarios or – again – arbitrary assumptions would be needed.

The strategy proposed is therefore to **proceed in a case-by-case fashion**: at the end of year 1, once the data have been collected (see section 2.4. below) and the carbon footprint has been calculated, two activities (one from the Institutional category and one from the ACCESS category) will be selected to compute the GHG emissions avoidance calculation on. These example activities will be selected based on the willingness of different groups of people to engage in the initiative by providing the information required for the calculation. This will allow to get an indicative quantification of avoided GHG emissions through remote activities, which could be converted into a ratio and used for future calculations, avoiding time-consuming data collection and inaccurate assumptions.

However, **GHG emissions avoided will be qualitatively described** already from year 1 using the Excel tool “Emissions_avoidance_initiatives” sheet (Appendix 2), which will indicate which avoidance actions were implemented and which emitting actions were avoided.

Purchases emissions calculation method¹⁷

Purchases have been found to be the main GHG emission source in the lab-based carbon footprint assessment carried out by the Laboratoire des Sciences du Climat et de l'Environnement (Appendix 1b). It was therefore deemed appropriate to consider this emission source within ATMO-ACCESS. To convert purchases into CO₂ equivalent mass, purchase type (e.g., computer, tablet, server etc.) are associated with the appropriate emission factor extracted from benchmark databases.

$$Purchase\ emissions = purchase\ type \times emission\ factor$$

Only purchases relevant to ATMO-ACCESS and related to remote access provision will be included in the assessment.

2.3. Data Collection and Curation

The data collection process (Table 1) is one of the key parts of the assessment. **Data will be collected delegating responsibility to the sensibilised (section 4.1) partners, their local team and TNA users.** The Excel form can be circulated to all the partners' representatives and returned to the Project Office once filled with their team's data. Some specific WP activities can be filled directly by the WP leaders. Associated Partners' (AP) interest in participating in the activity will be collected in the AP application form and interested APs will be asked to fill the Excel form if they participate in activities which require monitoring. **Data on remote activities should be centralised and inputted by one person out of all the participants** (e.g., Project Office inputting data for the 200 participants of the online kick-off meeting). Since remote meeting participants located in different parts of the world will have different energy providers, this aspect will not be taken into account in the calculation.

Specifically to ATMO-ACCESS, adjustments will be included in the TNA documentation in order to measure the GHG emissions of the TNA access activities. Users **from the TNA programme will be requested to indicate in the TNA application whether they commit to engage in the carbon assessment task by monitoring their activities.** Prior to the TNA, users will be made aware of the carbon assessment task via an informative webpage (<https://www.atmo-access.eu/carbon-footprint-assessment/>) and a decision tree (Fig.3, section 3.2.) will be made available to guide their choice between physical and remote access to have the lowest environmental impact. TNA users that have committed to the carbon assessment task will be required to indicate relevant information about their travel mode and/or online activities in case of remote access in the post-access report. This data will then be transferred onto the Excel spreadsheet by the Service and Access Management Unit (SAMU) team in charge of coordinating the TNA to users (Table 1).

Purchases will mainly be made by access providers to meet remote access needs. Purchases will therefore be inputted into the spreadsheet by the access providers (Table 1) and appropriate emission factors will be associated to them. This will allow purchases emissions to be integrated in the overall carbon footprint calculation.

Emissions avoidance actions will also be collected in the Excel spreadsheet. Individuals, team-leaders, work-package leaders or project leaders will input the data depending on the scale of implementation of the specific avoidance action (Table 1).

The Project Office will ensure the appropriate usage of the Excel tool and the compliance with the handbook's guidelines (Appendix 2), and check that the Institutional category is complete. **Year by year, the Project Office will synthesise the results of the carbon assessment.**

Table 1: Data collection strategy summary.

Activity type	Who needs to fill in the Excel?	Example
Institutional remote activities	One person out of all the meeting participants fills in the Excel	Project Office member fills in data for online kick-off meeting
Institutional physical activities	Partner main representative fills in the Excel for themselves and their local team or delegates to team members	WP leader fills in data for themselves and their team travelling to a given destination for the midterm review
Access remote activities	SAMU team fills in the Excel collecting data from TNA post-access reports	SAMU team fills in data for team of scientists participating in online training
Access physical activities	SAMU team fills in the Excel collecting data from TNA post-access reports	SAMU team fills in data for team of scientists participating in measurement campaign at given destination
Purchases	Access providers	Access provider of facility of interest fills in data for computers purchased for remote training activities
Emissions avoidance actions	Individuals, team-leaders, work-package leaders or project leaders depending on the scale of implementation of the emissions avoidance action	Project Office fills in data for collective decision of holding annual meeting online instead of in-person

3. Objective 2: GHG Emissions Avoidance Strategy

Objective 2. Implement actions to avoid and reduce GHG emissions coming from the project activities via the definition of **priorities** (main emission sources to target).

The carbon footprint assessment will be carried out on a yearly basis. Year by year, actions will be implemented based on which sources emerge to be the priority to target to avoid emissions (e.g., « Given air travel contributes (...) % of total project emissions, if we cut this source by (...) %, the total carbon footprint would be reduced to (...) kgCO₂eq »).

It was deemed appropriate to determine that **the project's first year of operation will serve as trial and sensibilisation year, to test the data collection method and Excel tool efficiency, to increase general awareness and engagement on the issue and to experiment some initial emissions avoidance actions.** By making use of the tools developed to gather community engagement (Obj. 4), different sensibilisation actions will be implemented from the onset: TNA users will receive sensibilisation information on the TNA webpage and a decision tree (Fig.3) will be made available for stakeholders and users. Alternatives to standard meetings will be explored, such as hybrid or remote options. Considering the continuity of the COVID crisis, innovative solutions for the provision of access and for knowledge transfer will be envisaged and tested throughout the different WPs.

During the following years, and based on the results of the monitoring process, a collective and inclusive approach will be taken to decide which avoidance actions to implement at the project-level (Obj.4). **The effectiveness of the avoidance actions will be assessed on a yearly basis**, based on the carbon assessment results and the comparison with the previous year's result (Fig.1). Different actions will be considered if the

environmental impact of the project remains unaltered. Based on community interest, a **yearly reduction goal** (-%) and/or a **threshold of emissions** could be established after year 1-2 results.

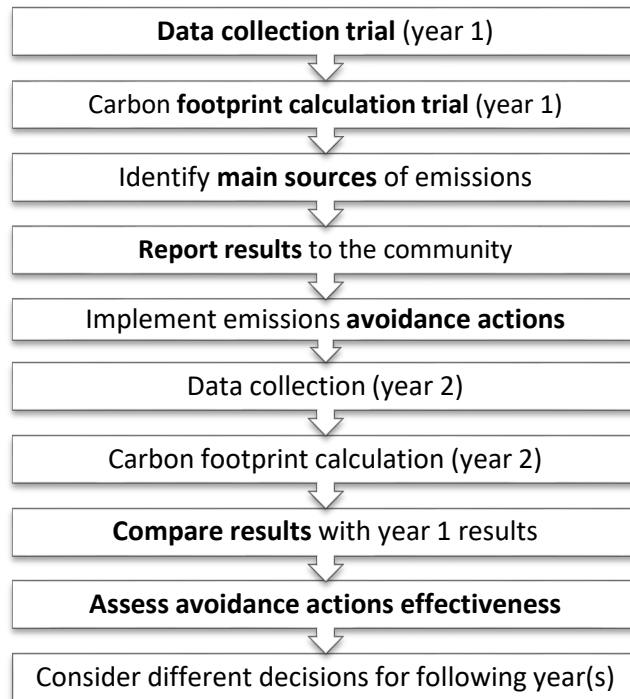


Fig. 1. GHG emissions avoidance strategy workflow schematic.

3.1. Reporting Results

Results will be visualised using **donut charts (Fig.2)** or pie charts. This will enable the identification of the main emission sources. **The figure below was made using dummy data (not representative numbers) and displayed with the sole purpose of visualising how the assessment results will be synthesized.**

Carbon footprint (kgCO₂eq) by source (Year n)

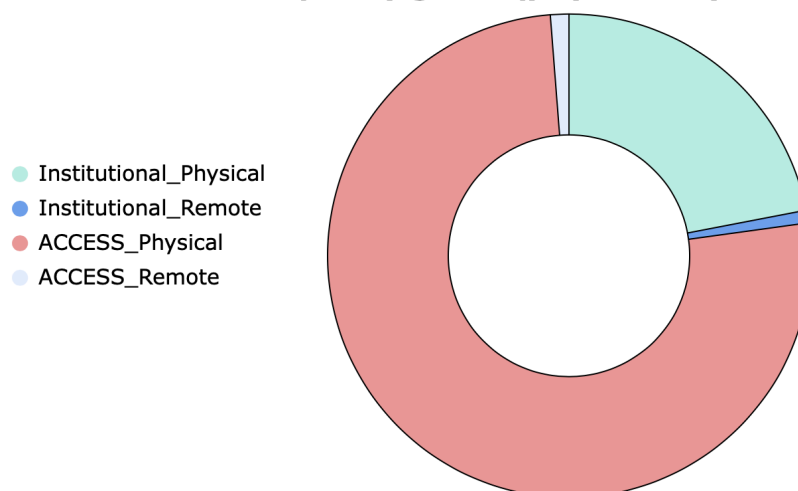


Fig.2. Model donut chart of ATMO-ACCESS carbon footprint made using dummy data (non-representative). Legend shows activity categories (Institutional and Project-Specific i.e., ACCESS) and activity type (Physical or Remote).

The results will be communicated by the Project Office year by year during the official annual meetings, to keep the community continuously updated (Fig.1). Emissions avoidance actions implemented by the community will also be object of report in annual meetings. **The results and recommendations will be summarised in a report addressed to the European Commission (D11.6, M47), and presented in the final meeting of ATMO-ACCESS.**

3.2. Decision Tree of Emissions Avoidance Strategies

The Project Office will present the assessment results to the community year by year. Stakeholders will be able to make decisions on the avoidance actions to implement accordingly, with the help of a **decision tree (Fig.3)**. **This tool will guide their decision-making process in order to implement relevant actions to minimise their carbon footprint** (options shown in pink boxes, Fig.3), and commit to individual, WP-specific or project-scale emissions avoidance actions. The participation in “Ma Terre en 180 minutes” workshop²⁰ (designed in the form of a role-play game in which the participants’ goal is to reduce the carbon impact of the lab they belong to by coming up with low-impact alternatives) helped define these low-impact actions. Decision trees similar to the one below have already been utilised by large organisations such as Lund University²¹, to encourage carbon emission avoidance. The decision tree will also be provided to users of ATMO-ACCESS facilities to aid their choices for sustainable access (Fig.3).

The decisions will be based on a series of **criteria** (Fig.3), that will serve as bases to help privilege one choice over another. These criteria are based on literature examples^{20,22} as well as needs expressed directly by the ATMO-ACCESS community via the survey (section 4.2.). **Integrating these criteria into project actions will allow to test various options so that successful ones can be incorporated into the project.**

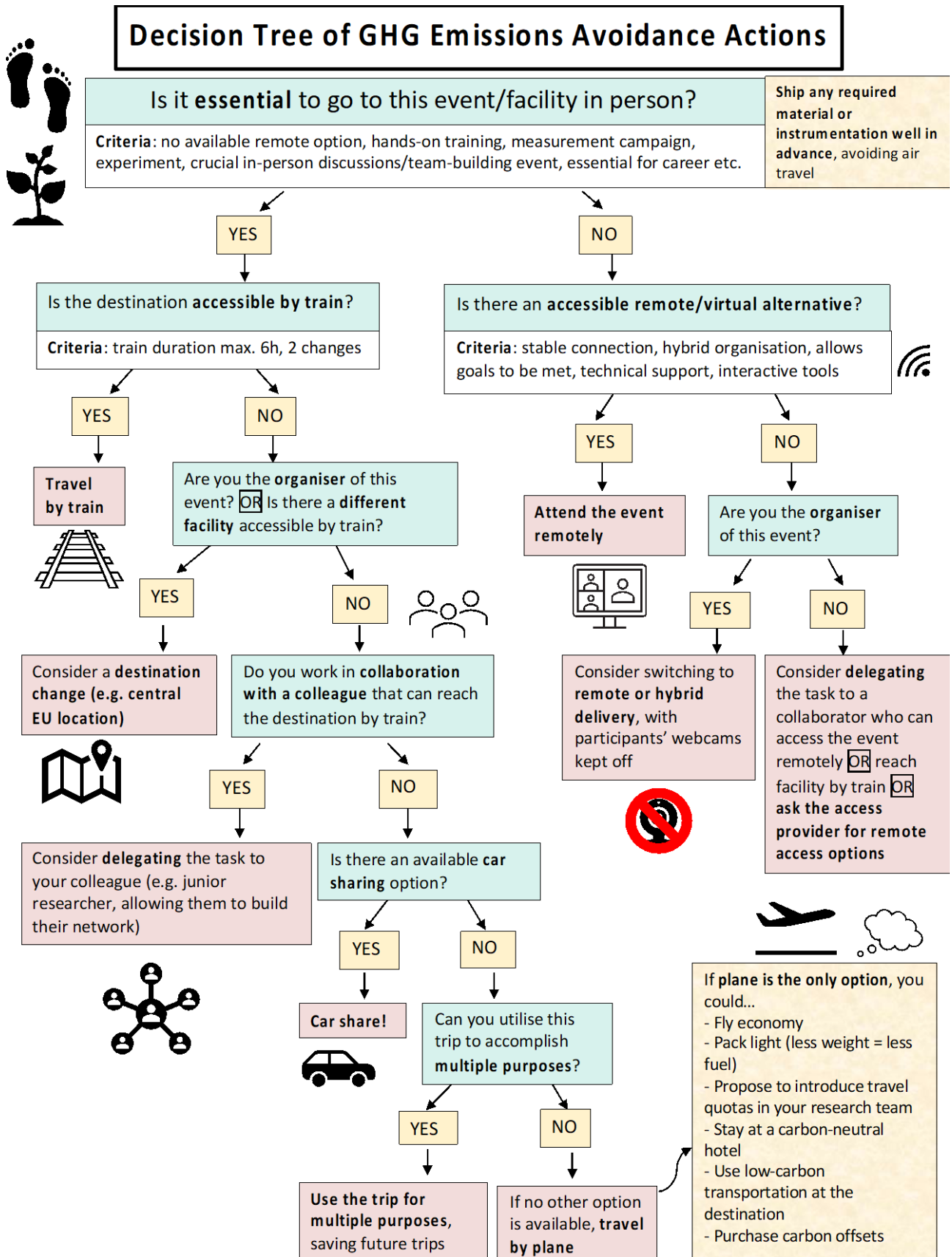


Fig.3. Decision tree of emissions avoidance actions for EC-funded project stakeholders (all partners and Linked Third Parties, Associated Partners, external experts, scientific board, companies etc.) and users of ATMO-ACCESS facilities.

4. Objective 3: Recommendations for Sustainable Access

Objective 3. Integrate recommendations for sustainable access provision, modalities for considering the carbon footprint of access and strategies for emission avoidance.

The strategy to make recommendations for sustainable access provision is to put into practice objectives 1, 2 and 4. The experience of the four years of project will enable final recommendations to be issued to the European Commission (D11.6, M47), once the total carbon impact of the project has been estimated and different GHG avoidance actions have been tested and assessed. The final measures recommended will be the ones that had the largest impact in terms of carbon footprint reduction (i.e., most popular and impactful actions).

Recommendations will also include **further development ideas and strategies to overcome the difficulties** and limits encountered while designing the GHG assessment strategy and data collection tool. Finally, the report will outline **future investment needs in terms of resources for sustainable access provision**, improvement of the carbon assessment accuracy (e.g., including the digital services category) and data collection tools.

4.1. Early Recommendations

Despite the recent start of the project, some early recommendations can already be made based on (a) the COVID experience, which marked the proposal writing phase and is still influencing the initial months of the project and **(b) a series of emission avoidance actions that have been taken in the research domain.**

- (a) ATMO-ACCESS will capitalise on the lessons of the current world situation forcing changes in many research practices by strongly investing in remote and virtual access provision. In order to ensure high-quality of research and satisfaction of the users and providers' requirements, **investments should be made to facilitate and improve remote access efficiency.** As suggested by the survey responses (section 5.2.), this could be achieved by:
- ensuring reliable software
 - providing training via virtual access provision
 - increasing technical support
 - improving virtual resources (breakout groups, increasing collaborative work by having facilities for interactive writing etc.)

Although it is important to acknowledge that **purchases have been found to be one of the highest GHG emission sources in lab-based carbon footprint assessments** (Appendix 1b), the investments described above – although costly and high in GHG emissions - are likely to have lifetimes lasting through (and possibly beyond) the whole project duration. This would allow **future** emissions deriving from physical activities to be avoided or reduced (e.g., air travel being replaced by high-tech virtual meetings).

- (b) Carbon footprint reduction measures are being taken in the research world in different domains. **The list below consists in a series of indicative examples that may be used in ATMO-ACCESS.**

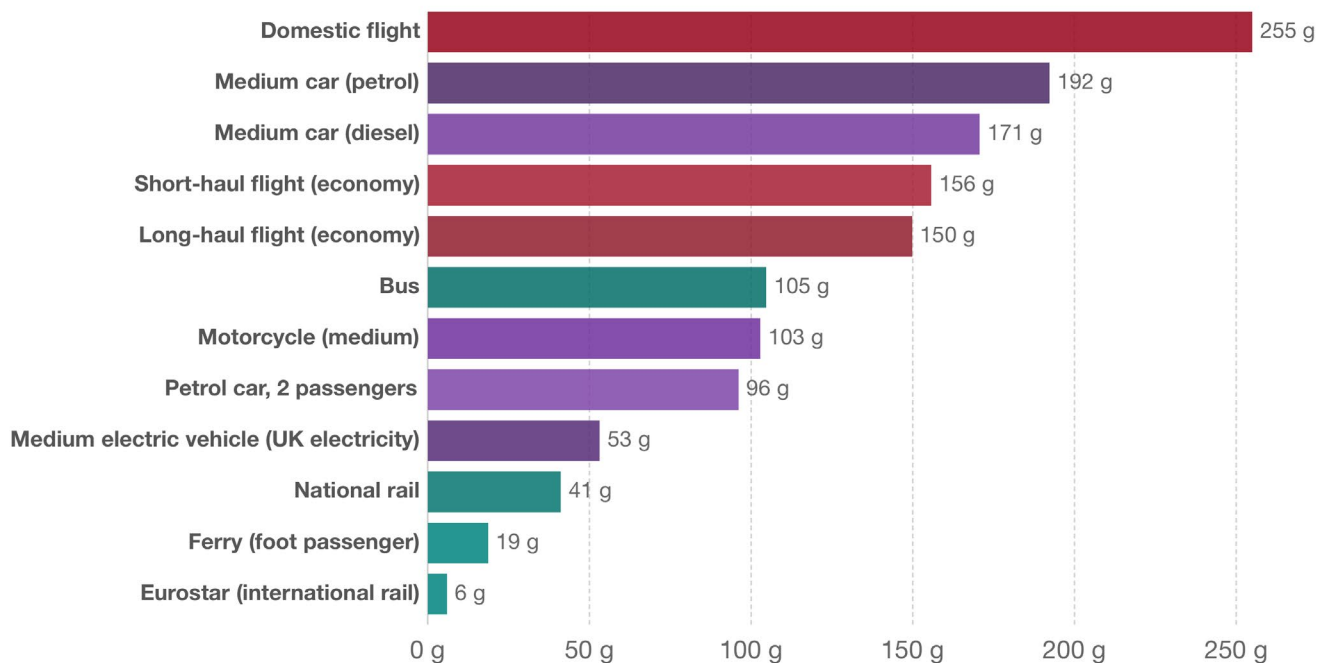
Measures for reducing the GHG emissions of physical activities:

- First and foremost, **trips could be ordered in terms of importance**. Essential meetings that must be attended in person or hands-on training should be prioritised.
- Taking a train for medium-length distances emits ~80% less than travelling by car and ~84% less than catching a domestic flight (Fig.4)²³. **The most accessible location by train should therefore be selected** for in-person meetings, taking into consideration where the attendees will travel from. When a set destination is clearly inaccessible by most attendees with low-carbon transport, a **destination change** should be considered. In the case of Europe, well-connected **central locations** should be privileged for meetings.

Carbon footprint of travel per kilometer, 2018

Our World
in Data

The carbon footprint of travel is measured in grams of carbon dioxide equivalents per passenger kilometer. This includes carbon dioxide, but also other greenhouse gases, and increased warming from aviation emissions at altitude.



Source: UK Department for Business, Energy & Industrial Strategy. Greenhouse gas reporting: conversion factors 2019.

CC BY

Note: Data is based on official conversion factors used in UK reporting. These factors may vary slightly depending on the country, and assumed occupancy of public transport such as buses and trains.

Fig.4. Carbon footprint of different means of transport, per km.

- When **two researchers are working in close collaboration**, an arrangement could be made so that only one of them attends a relevant meeting - the person that can more easily access the meeting location - and then reports back to the other. For instance, **senior researchers could delegate their younger colleagues to attend a meeting**. This would also give them the chance to build a **network** and make themselves known to the scientific community.
- At the project or laboratory level, a **limit should be set in terms of km travelled or flights taken per person per year**. A **quota on individual or team transport** could be set like the LOCEAN²² laboratory did

in France. An incentive could be **not reimbursing flight tickets if there is a train alternative of less than 6-8 hours**, implemented for instance at the Paul Scherrer Institute²⁰.

- A yearly **emissions reduction goal** could be set. At IGE²⁴ laboratory, for example, the eight research teams committed to a yearly 10% emissions reduction, adjustable on a yearly basis.
- At the system level, **institutions should facilitate the choice of train travel over air travel** through their internal booking platforms.
- When possible, **one trip should be taken advantage of by accomplishing multiple purposes** at once (meetings, conferences, field trips etc.) to avoid the environmental costs of multiple trips.
- A **hybrid approach** could be set up for most meetings, having an **accessible remote alternative** for participants who are unable to physically attend. Researchers could consider only attending a certain meeting in person every other year and participating remotely the rest of the times. **Individuals responsible for the organisation of the meetings should consider organising them remotely in the first place**, avoiding physical travel of attendees. Smaller meetings should always be undertaken remotely where possible (e.g., task meetings in case of EU projects).

Measures for reducing the GHG emissions of remote activities:

- Users' **webcams should be kept off** during online meetings unless otherwise specified by the meeting host. In fact, on average one minute of online meeting (just audio) emits 61% less than an online meeting with activated webcams, and 5% less than with activated screensharing¹⁸.
- According to Greenspector, the three servers to prioritise to reduce CO₂ equivalent emissions are the ones in the table below¹⁸:

Table 2: Low-carbon online meeting servers.

Audio only	Audio + webcam	Audio + screenshare
Microsoft Teams	Big Blue Buttons (via Chrome)	Microsoft Teams
Google Meet	Click Meeting	GoToMeeting
Infomaniak Meet	Google Meet	Tixeo

- Laboratories should **prioritise non-fossil fuel energy generation** to power their servers and software.
- Prioritise the use of **shared platforms to exchange documents rather than email attachments**. The Shift Project, a carbon transition think tank, found that using shared platforms over email attachments could leverage a yearly 40% reduction in CO₂ equivalent emissions²⁵.

5. Objective 4: Collaborative Approach

Objective 4. Implement a collaborative approach to achieve the first three objectives and **promote community engagement** throughout the project.

5.1. Community Engagement

Sensibilisation activities should be undertaken for partners and users to actively contribute to the data collection process and for the GHG emissions avoidance measures to be decided bottom-up. Psychology research shows that the most effective and sustainable behavioural changes and habits arise from an intrinsic, self-determined decision rather than from external coercion. These are in fact the principles of the **self-determination theory**²⁶. Objective 4 therefore aims to increase the community's intrinsic and autonomous motivation to take action against climate change and thereby **encourage pro-environmental behaviour**²⁷.

The majority of the ATMO-ACCESS community is **willing to engage with the carbon footprint assessment task** by participating in workshops and dedicated sessions during annual meetings (61.3%) and by replying to questionnaires and surveys (54.8%). Emerging from the initial survey results (section 5.2), the community is willing to further engage in the task throughout the project (Fig.5).

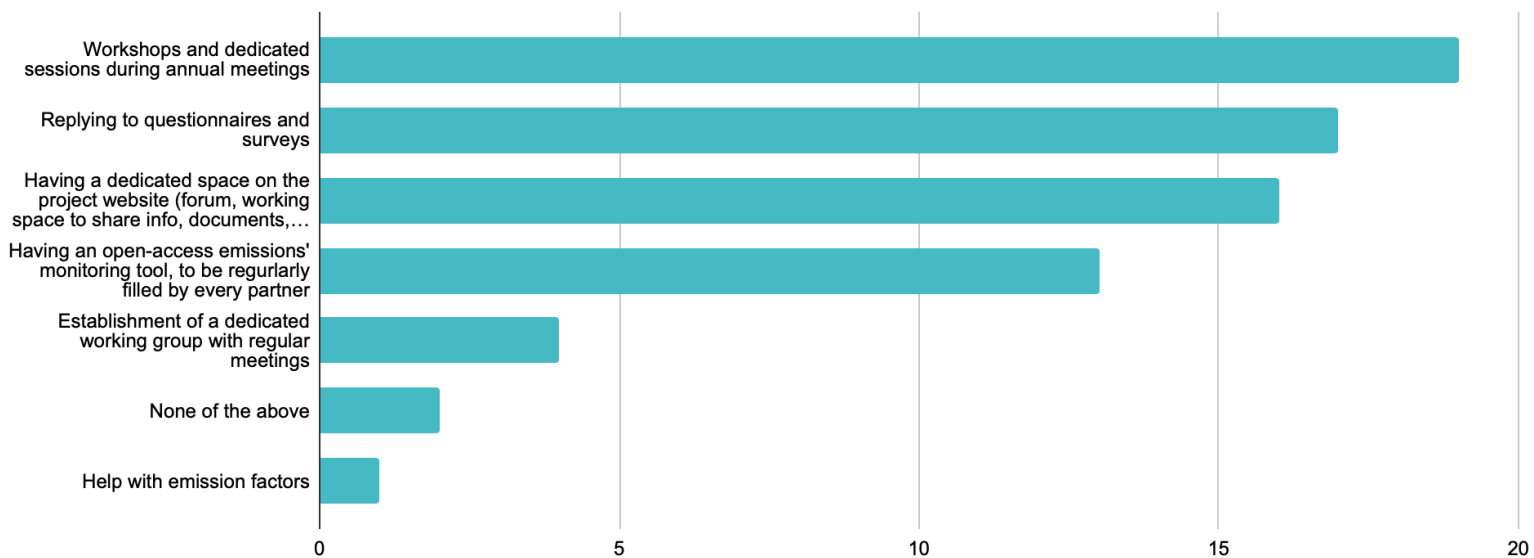


Fig.5. Survey results illustrating the engagement of the ATMO-ACCESS community towards awareness initiatives on GHG emissions avoidance measures.

Examples of possible engagement activities include **carbon footprint sensibilisation workshops**, dedicated presentations and discussions. These activities will be organised by the Project Office and delivered according to the community's availability and interest. Feedback requests will be periodically sent out to assess community satisfaction with the carbon assessment activities.

Engagement resources:

- **The Carbon Literacy Project**²⁸, a collaborative charity project offering everyone a day's worth of Carbon Literacy learning, covering climate change, carbon footprints and how to reduce carbon emissions. Training is currently being delivered by a wide range of organisations, to workplaces, communities and places of education in the form of e-learning, workshops, and/or self-directed learning.

- **Carbon footprint Ltd software**¹², leading calculation package with over 1,000,000 users worldwide allowing raise awareness, measure emissions, reduce costs and engage staff in a carbon management programme. The open-access carbon footprint calculator allows to estimate the emissions at the individual, business and product scales.
- **Campus de la transition**²⁹ (French only), non-profit organization: a place of teaching, research and experimentation created in 2018 by a collective of lecturer-researchers, entrepreneurs and students united by a common will to “promote an ecological, economic and humanist transition”. The Campus is an academic laboratory that offers new multidisciplinary teaching programs and various forms of training, to students, teachers and professionals, as well as accompanying companies and institutions in their transition.
- **“Ma Terre en 180 minutes”**²⁰ collaborative workshop developed by the academic world as part of labos1point5 experimental group. The workshop is designed in the form of a role-play game: the participants’ goal is to reduce the carbon impact of the lab they belong to by coming up with low-impact alternatives. The workshop is carried out in French but an English version is currently being envisaged.
- **Informative documents from Institut Pythéas Observatoire des Sciences de l’Univers AixMarseille Université**³⁰ on climate change. This is an open-access collection of documents, articles and resources on climate change, biodiversity, energy and environmental sciences. There are documents in both English and French.
- **Institut Pierre-Simon Laplace (IPSL) – Sciences du Climat**³¹ (French only) encompassing seven laboratories working on reducing their professional emissions. “IPSL is a unique place for scientific exchange at the intersection of many areas of expertise which come together to meet the ever-growing demand for knowledge, training and the development of innovative solutions to protect the environment.”
- **Ecometrica GHG Factsheet**: information about video conferencing and business Travel³². Ecometrica is a rapidly growing sustainability certification service.

5.2. Initial Survey Response

A survey was designed by the Project Office and sent out in the month of June 2021 (M3) to the ATMO-ACCESS community. The survey asked respondents:

- a. To contribute to the main identified categories of project activities (section 2.1).
- b. To provide suggestions on investments to improve remote access provision.
- c. To express interest in possible means of engagement of the community, in order to increase awareness and form the basis for a sustainable carbon monitoring and emissions avoidance policy for the duration of the project.

The survey remained open for three weeks and 31 members of the ATMO community participated in it. The most relevant responses are reported below:

Respectively 90.3% and 74.2% of the ATMO-ACCESS community consider that the ‘Access category’ and the ‘Institutional category’ are **the most relevant activity clusters to be included in the assessment (Fig.6)**.

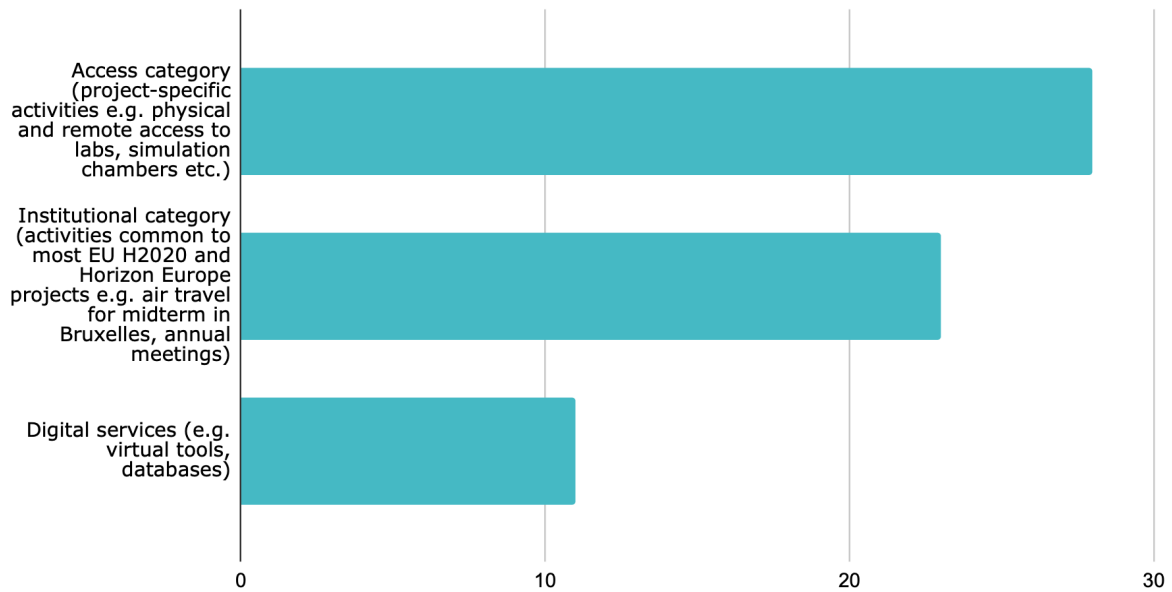


Fig.6. Survey results illustrating the opinion of the ATMO-ACCESS community on the relevance of activities to include in the assessment.

The majority of the ATMO-ACCESS community considers SSC meetings (24.1%), annual meetings (17.2%) and trainings (13.8%) as the activities that could be most **easily switched into a remote version (Fig. 7)**.

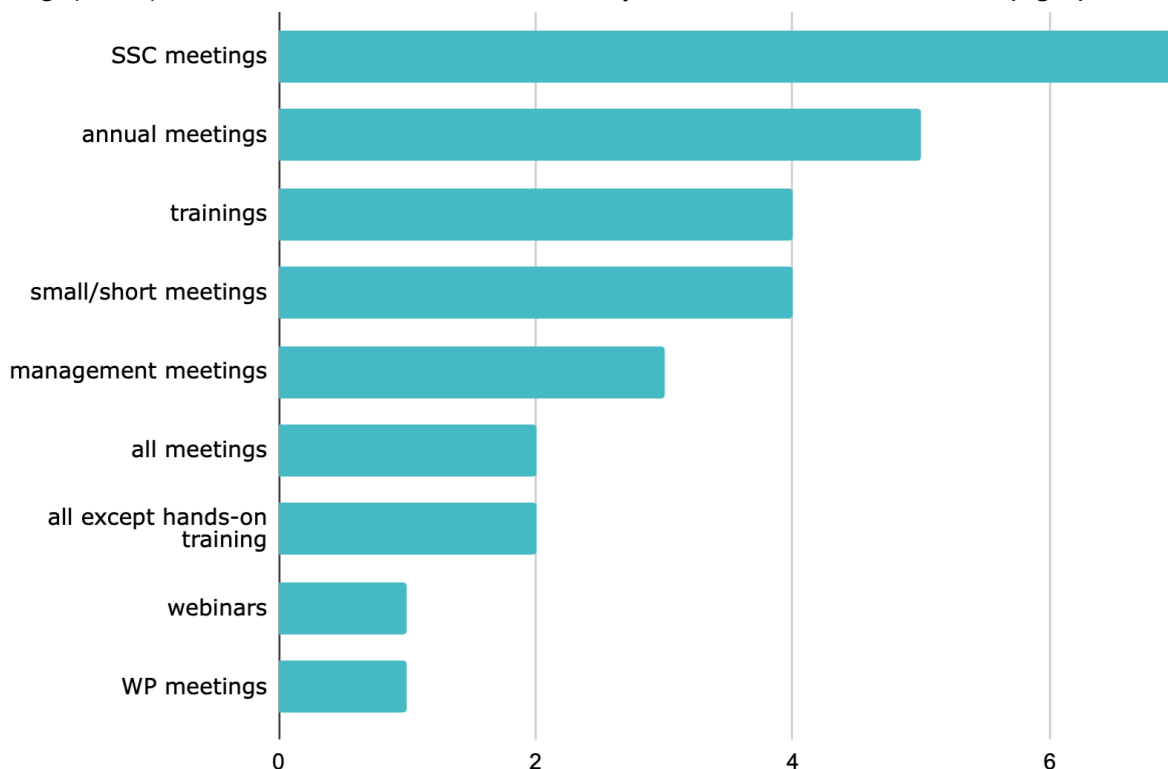


Fig.7. Survey results illustrating the suggestions of the ATMO-ACCESS community on the activities that could be easily switched to a remote version.

The ATMO-ACCESS community considers annual meetings (23.4%), hands-on training (23.4%) and young scientists' training (19.1%) as the main activities that are **essential to remain in person (Fig.8)**.

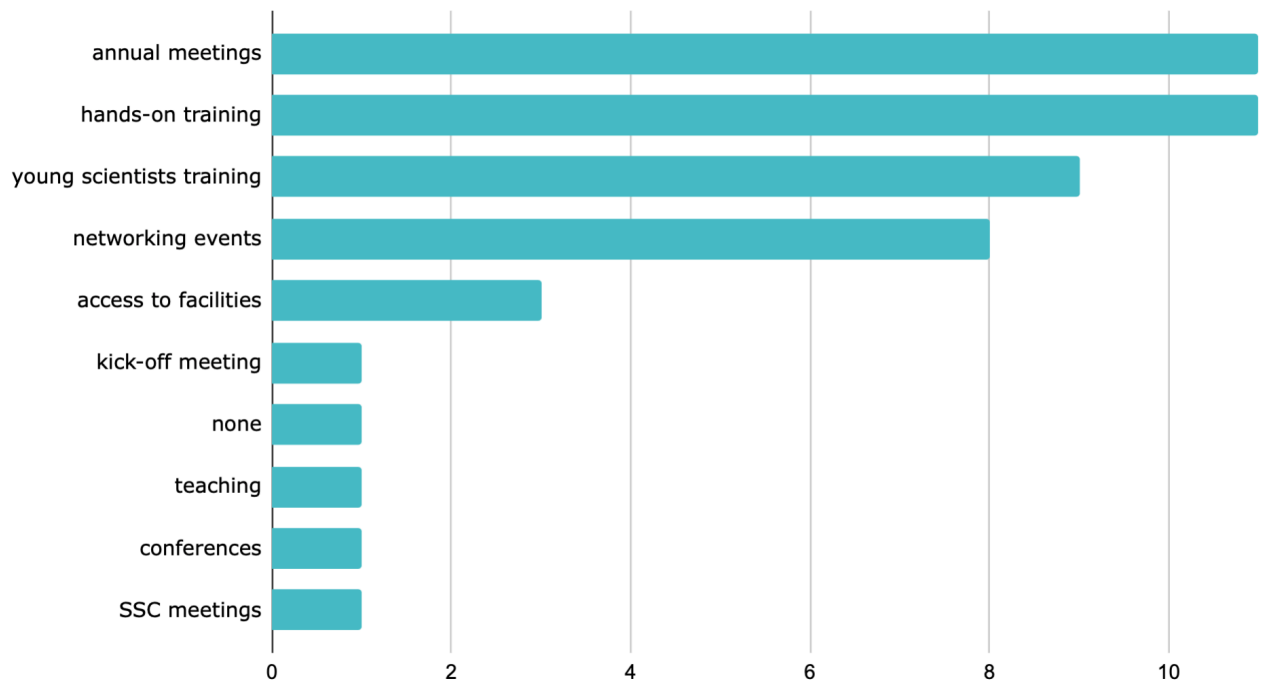


Fig.8. Survey results illustrating the suggestions of the ATMO-ACCESS community on the activities that should be carried out in-person.

Suggestions provided to the question “Which **resource(s) and structural changes** do you think should be invested on **to facilitate remote work?**” include:

- communication/presentation tools
- remote control of measurement devices
- computer technology (headphones, microphones, monitors)
- IT support
- rooms devoted to remote meetings
- internet connection speed
- Flexible work time models
- hybrid approach
- availability of processing servers with API access to data bases
- Version Control System
- DynDNS Services
- shared platform
- training for virtual tools
- interactive tools
- mailing lists
- clear rules of organizing meetings
- break-out rooms in online meetings

The replies provided raise the following issues:

- The need for **balance between remote and in-person activities** e.g., at least one physical annual meeting per year, regular events could be once in-person, once remote.

- **Inclusivity, accessibility and equality** are better ensured in remote meetings rather than in-person meetings. Remote meetings could allow the involvement of more people with disabilities and junior researchers.
- Annual meetings and trainings would be best **as a combination of virtual and physical**.
- The need **for stricter rules on work availability**, to undermine the perception that colleagues are always available for remote work or meetings.

In summary, the main activities that partners consider essential to keep in person are annual meetings, hands-on training (especially for young scientists) and networking events (Fig.8). The respondents indicated that short or small meetings such as SSC meetings, with people already familiar with each other, and some (but not all) annual meetings could be easily run remotely (Fig.7). Remote work could be improved by investing in interactive tools, technical support, shared platforms as well as setting clear rules for the structuring of remote meetings.

The survey response was analyzed before final decisions were made on the design and development of the assessment tool. **Given majority consensus, it was decided to include the Institutional and Project-specific (ACCESS) categories within the assessment and to measure and monitor CO₂eq emissions, in order to account for all the relevant GHGs.**

6. Conclusion

The ATMO-ACCESS community appears to be ready to engage in the carbon footprint reduction of the project activities. The GHG monitoring and emissions avoidance strategy detailed in this document will be used as a guideline for the ATMO-ACCESS community throughout the project duration. **Given the first year of project operation will be a trial and sensibilisation year, we expect challenges to arise as the various activities unfold.** The data collection process and calculation methodology may thus be adjusted accordingly, and the engagement activities designed to suit community preferences and needs. Moreover, **given the ongoing global pandemic, the first year will be affected by travel restrictions and sanitary measures and will thus not be representative of an ordinary year of project operation.**

The **next steps** to take will be to organise **workshops** dedicated to the carbon footprint assessment task, to keep the interest high among the community and increase awareness of the initiative among stakeholders and users of ATMO-ACCESS facilities.

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Appendix 1: Kick-off Meeting Minutes

Appendix 1a: Integrating the Carbon Footprint dimension in ATMO-ACCESS - Matilde Oliveri

Objectives:

1. **Measure and monitor the project impact in terms of carbon-footprint**
 - Definition of **perimeter**: monitoring access and meeting travelling, organisation, use of data, remote access etc.
2. **Implement actions to avoid/reduce CO₂ emissions coming from the project activities**
 - Definition of **priorities**: e.g., reduce/avoid access and meeting travelling
3. **Integrate recommendations** for sustainable access provision, modalities for considering the CO₂ - footprint of access (including in the access costs) and strategies for limitation/compensation
 - Definition of perimeter and priorities (Obj.1 and 2)
 - **Methodology**: establish monitoring tools and a calculation method to track and convert activities into CO₂ emissions.
 - Define ways to implement reduction/avoiding actions of prioritized activities.
4. **Implement a collaborative approach to achieve the first three objectives**
 - Collective and inclusive approach to agree on priorities and actions via surveys and feedback requests, dedicated sessions and working groups during annual meetings, working package leaders communication role, shared monitoring tools available to the whole community etc.

Reflecting on scale:

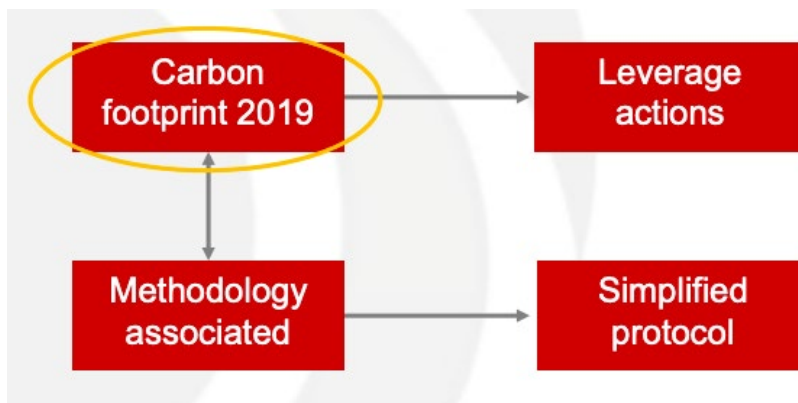
Currently, **European projects do not encompass a carbon footprint assessment**. Being a pilot, the ATMO-ACCESS project is the ideal setting to test the implementation of an ecological monitoring tool at the EU project scale. Although the impact that such small-scale assessment can have is limited, there are many different types of EU-funded projects which could make use of such practice, that could become compulsory in the future. **Carbon impact assessments have the potential to become a pillar of EU-funded projects, becoming representative of a global-scale attempt to monitor and cut our carbon emissions.**

Appendix 1b: Case study - Carbon footprint of the CNRS-LSCE - Jeanne Gherardi-Scao

Example of collective approach to engage a science community to commit and reduce CO₂ emissions linked to scientific activities.

Context:

- CNRS Laboratoire des Sciences du Climat et de l'Environnement (LSCE): 350 employees, 3 research topics with 17 teams, 3 supporting teams (IT, Admin, Health & Safety), LMC14 (national instrument, in charge of measuring 14C samples), 3 funding agencies
- 2019, setting up of working group with the objective to reflect on the ecological footprint of the laboratory activities and make a proposal to the Board regarding this subject
- Group made up of volunteers, representative of lab community i.e. PhD students, engineers, researchers, technicians, supported by the Board
- Tackling the need for consistency for climate experts working in the lab in the message being communicated, and the need of monitoring the C impact of the research activities
- **The carbon footprint:** first step of the initiative
 1. **Overview** of the situation: Calculating carbon footprint of the LSCE for 2019 (year pre-covid, more representative of lab activities)
 2. **Monitor:** Establish a protocol to perpetuate the approach each year
 3. **Analyse:** Identify the leverage actions using a collaborative approach



Methodology :

- **Carbon footprint = GHG emissions inventory associated to the activities of an entity**
 - **Identify activities emitting CO₂ and associate them to their emission factors** (extracted from database) to obtain CO₂ equivalent mass.
 - Reference database which emission factors are derived from: ADEME (Agence de la transition écologique), used as benchmark in France.
 - **Taking into account other GHG as well as CO₂, using GWP to make the conversion.** N.B. Global Warming Potential over 100 years (GWP100): GWP_CO₂ = 1; GWP_CH₄ = 28, GWP_N₂O = 265.

$$\sum_{LSCE} \text{activity data} \times \text{emission factor} = \text{CO}_2 \text{ equivalent mass (kgCO}_2\text{eq)}$$

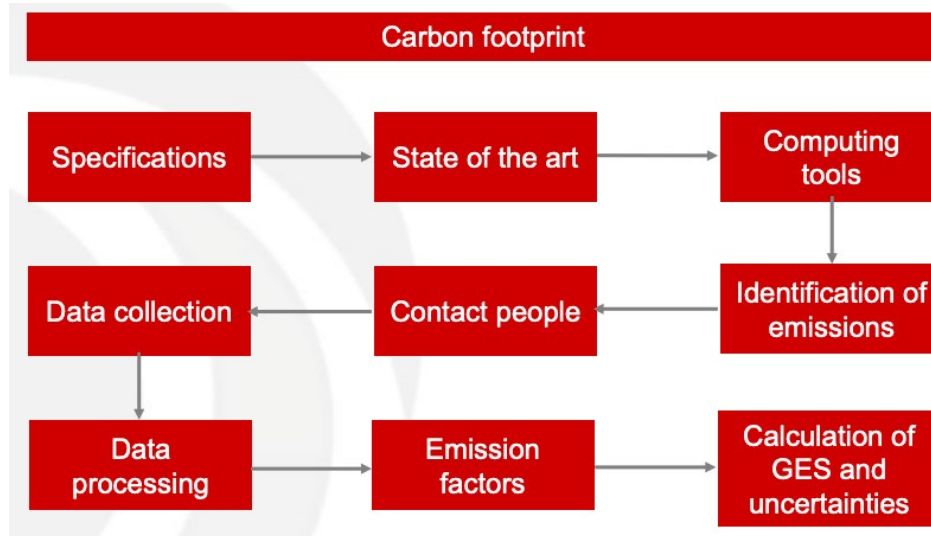
- **Comprehensive methodologies:** applicable to any type of entity
 - 3 scopes
 - 24 criteria

Emission category	Criterion number	Emission source	Examples
Direct emissions (scope 1)			
Indirect emissions (scope 2)			
Other indirect emissions of GHGs (scope 3)			

- **Steps of the calculation process:**

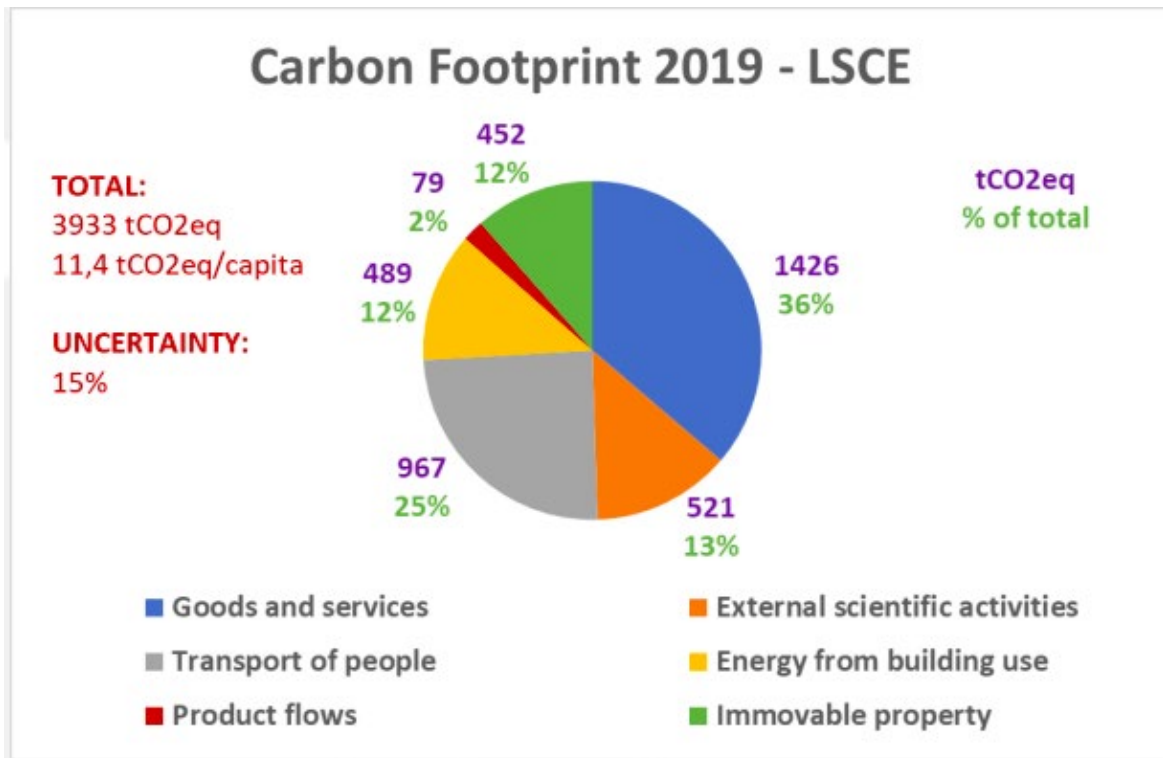
1. **Specifications:** since the methodology is rather global, LSCE made specific choices and decided to look more closely at the subjects of research of the lab and the support team. The framework constructed was specific for the laboratory, and did not follow national rules. Investigated the 3 scopes above.
2. **Baselines:**
 - In 2007, 1st initiative of evaluating C footprint of the lab.
 - Collective labos1.5: encompassing all French labs, studying ecological and C impact of research. Used their C footprint calculation as methodology. Labos 1.5 provides a tool to evaluate the C footprint at the lab level, but does not encompass all types of emissions. The tool is constantly being updated.
3. **Computing tools:** made the framework as easy and accessible as possible, via excel tables
4. **Identification of activities sources of emission within the lab**
5. **Identification of people** from the team in charge of different aspects (purchase, emissions abroad)
6. **Data collection**
7. **Data processing** and hypotheses for uncomplete/unclear data
8. Use of **emission factors from ADEME** database and filling gap (specificities to the lab) using the American database CEDA (for scientific equipment and purchases related to research)

9. Calculation of carbon footprint



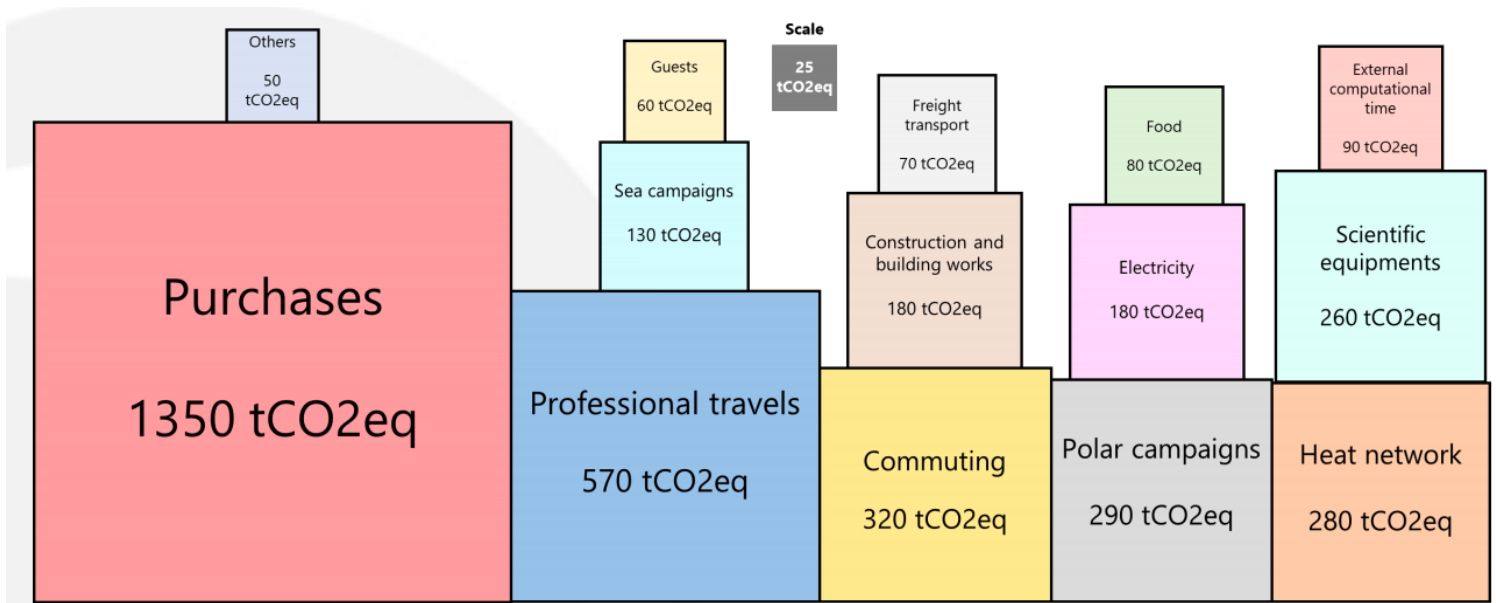
Results:

- **Emission sources** treated within the project:
 - **Energy from building use:** refrigerated fluid, electricity, heat network
 - **Transport of people:** service vehicles, commuting, professional travels, guests
 - **Immovable property:** buildings, parking lots and roadways, land use change, scientific equipments, service vehicles
 - **Goods and services:** purchase of goods and services, food
 - **External scientific activities:** external computational time, campaigns (at sea, polar)
 - **Product flows:** freight transport, waste
 - **Digital use:** mails, videoconferences. N.B this was negligible in the calculation, so not taken into account



Main findings:

- **Total C footprint of LSCE in 2019 = 3933 tCO₂eq**, i.e. 11,4 tCO₂eq/capita with uncertainty ~ 15% (i.e. professional C footprint of each person). N.B. 1 average Frenchman footprint = 11 tCO₂eq/year. Therefore an LSCE employee should add up his professional and his personal footprint. To achieve Paris Agreements warming < 2°C, the average C footprint should be 2 tCO₂eq/capita. This means we are far from the objective.
- Emission sources repartition in order of importance:
 1. Goods and services are the most important source of emission
 2. Transport (¼ of total emissions).
 3. Scientific activities not being carried out within the lab, but still connected with it
 4. Immovable property and energy from building use
 5. Digital use footprint= 50 kgCO₂eq, i.e. 0,001% of the total carbon footprint

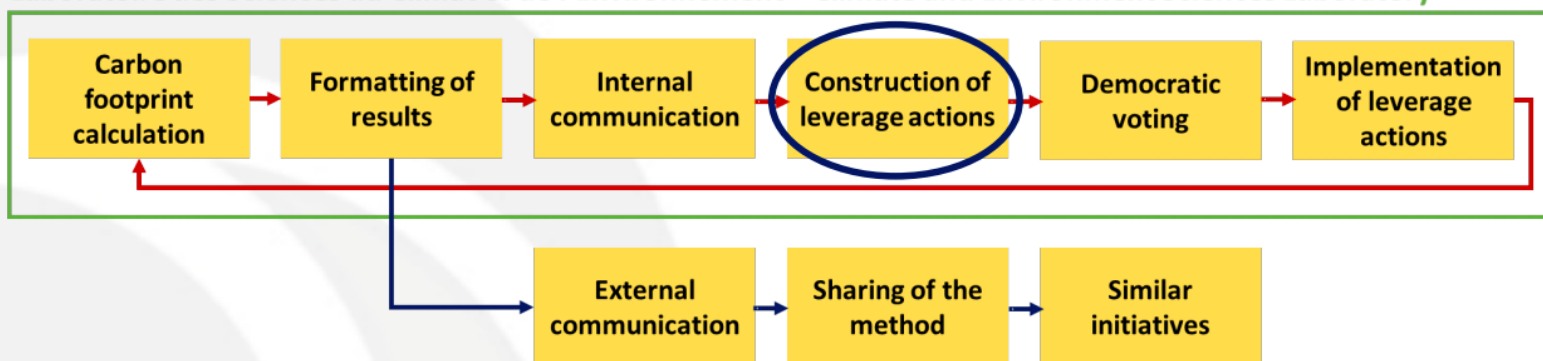


- Emission sources responsible for $\frac{3}{4}$ of the total emissions: the most important source of CO₂ emissions was purchases, followed by professional travels, commuting, polar campaigns (activity specific to the lab) and heat network (does not depend on lab, but a larger network)
 - Emission items included in « Others »: Service vehicles (transport and immobilisation), Land use change, Refrigerant fluids, Parking lots and roadways, Waste, Digital (mails, videoconferences)

What's next?

Suggested reduction approach:

Laboratoire des Sciences du Climat et de l'Environnement = Climate and Environment Sciences Laboratory



- **Two types of leverage actions:**
 1. **Facilitate the carbon footprint assessment** (data collection and processing)
 - List of faced obstacles
 2. **Reduce GHG emissions**
 - Workshops open to all staff, organized by the WG-EF and resulting in 80 reduction proposals

- Participation in the pilot phase of the 1point5 experiment
- **What can be done at a european project level ?**
- a. **Facilitate the carbon footprint assessment:**
 - Make it compulsory for any EU projects?
- b. **Identify financial tools allowing for compensation:**
 - Financial tools allowing for compensation when no other options are feasible
- c. **Reflection on research projects impact and on sobriety of research approach**
 - e.g., identify best place to locate meetings

Appendix 1c: Meeting chat

Questions:

- C footprint or Ecological footprint?
- Why only monitoring CO₂?
 - Reducing Black C is a good way to reduce impact on climate, but is it generally co-emitted with CO₂?
- Is there a tool or code that could calculate the "best place" (in terms of travel CO₂ costs) to host a meeting depending on the home location of potential attendees?
 - tool where you find an optimized location to host a workshop based on the distances that people would have to travel and transportation means available
- What do we know about the carbon **footprint of remote meetings**?
 - we already know that email storage is a significant source of GHG. To this respect our various projects have large possibilities of improvements
 - leaving your camera off during a web call can reduce these footprints by 96% (<https://www.sciencedaily.com/releases/2021/01/210114134033.htm#:~:text=Just%20one%20hour%20of%20videoconferencing,size%20of%20an%20iPad%20Mini>) .

Comments:

- Reducing CO₂, in 99% of the cases all the other pollutants will decrease (linearly) also. Exception is when replacing fossil fuel with biomass, this idea is still supported by EU rules, but should be banned.
- Reducing other constituents contributing to warming helps on the short run, but if we continue CO₂ emissions, we will overshoot our targets due to the **long lifetime** of CO₂ in the atmosphere.
- According to the UN Environment Programme (UNEP), the **N₂O emissions** are going to double by 2050 making it not only an important greenhouse gas but also - as a consequence of its atmospheric lifetime of more than 130 years - the most important ozone destructing compound in the stratosphere, which will overcompensate our measures to reduce CFCs according to the Montreal protocol. N₂O and CH₄: that is where agriculture and meat consumption come in. **CH₄ reduction** can be a target as well, with favouring more vegetarian meals at (physical access) workshops. Reducing CH₄ could ease the pain of reducing CO₂ in the long run.

- All the **local initiatives** are sympathetic and work well to make people aware of the climate crises but fall short in actually achieving anything when compared to the effort. We need more **systemic changes**.
- Electricity generated by **nuclear power** is not really sustainable and not free of CO₂ emissions. It is also expensive, but if your country has nuclear military ambitions this is a strong incentive as well.
- 50% of meeting participation should be **virtual**.
- **Collaborative approach** is key.

Main issues :

- Local change vs systemic change.
- Carbon footprint vs ecological footprint.
- In person impact vs remote meeting impact.

Appendix 2: Excel Tool Handbook

Find below the instructions to use the Excel spreadsheet 'ATMO_FOOTPRINT'. These can also be found on the front cover of the Excel tool (README). Access the spreadsheet at: <https://docs.google.com/spreadsheets/d/1LOWefO0m6ATyUNTvY10mzkOyKT6OMQXJaIvPWAUSE9c/edit?usp=sharing>



Carbon Footprint Assessment Tool

An open-access tool to monitor and measure an EU-funded research project's carbon footprint

Activity Categories

Institutional category

transversal category of activities common to most EU H2020 and Horizon Europe projects. These include activities that either require physical travel or that can be carried out remotely

ACCESS category

activities specific to the project of interest for the assessment. In this case, activities carried out and provided by ATMO-ACCESS project, in the form of physical access (PA), remote access (RA) and related purchases

How to use this spreadsheet:
Please read the post-it notes on the top right corner of each column title
Sheet: 'Institutional_Physical': <ul style="list-style-type: none"> - Fill with physical activities belonging to the institutional category - Pick the appropriate options from the drop-down menus (year, travel mode etc.) - If you travelled with multiple means of transport, please treat these as separate journeys and compute the data on a new line - If you used car sharing, please fill in just ONE line for all passengers - Use the distance calculator (https://www.distance.to) to find the distance "as the crow flies" between departure and arrival locations
Sheet: 'Institutional_Remote': <ul style="list-style-type: none"> - Fill with remote activities belonging to the institutional category - Pick the appropriate options from the drop-down menus (participants, duration etc.) - For online meetings taking place over a number of days, estimate total duration of meeting (mins)
Sheet: 'ACCESS_Physical': <ul style="list-style-type: none"> - Fill with physical activities belonging to the project-specific (ATMO-ACCESS) category - Follow the same instructions as for the 'Institutional_Physical' sheet
Sheet: 'ACCESS_Remote': <ul style="list-style-type: none"> - Fill with remote activities belonging to the project-specific (ATMO-ACCESS) category - Follow the same instructions as for the 'Institutional_Remote' sheet
Sheet: 'Purchases': <ul style="list-style-type: none"> - Fill in with purchases relevant to ATMO-ACCESS project and related to REMOTE access only - If your purchased item is not included in the drop-down list, pick the closest available option OR contact us.
Sheet: 'Emissions_avoidance_initiatives': <ul style="list-style-type: none"> - Fill in with the emissions avoidance initiatives that you have taken either at the individual/team/project scale - Detail which emitting activity you have avoided

Appendix 3: Database

Appendix 3a: Emission Factors

For the physical activities (Table 1), the chosen emission factors derive from research carried out by “labos1.5”³³ based on the “**Base Carbone**” database from the **French Environment and Energy Management Agency (ADEME)**³⁴. This is a benchmark database that is widely used in France to carry out carbon assessments and all emission factors are freely available on the ADEME website³⁴. In particular, the emission factor for air travel “avec trainées” (“with contrails”) was chosen to carry out the carbon assessment as exhaustively as possible, including the emissions deriving from the contrails³⁵.

Table 1. Physical activities emission factors

Travel mode	Coefficient	Emission factors (kgCO ₂ eq/kg)	Uncertainty	Source
Car (fuel)	1.3	0.2344	0.6	Base carbone, ADEME
Car (hybrid)	1.3	0.1828	0.7	Base carbone, ADEME
Car (electric)	1.3	0.1034	0.7	Base carbone, ADEME
Train (< 200km)	1.2	0.018	0.6	Base carbone, ADEME
Train (> 200km)	1.2	0.003	0.2	Base carbone, ADEME
Train (international)	1.2	0.037	0.6	Base carbone, ADEME
Air (< 1000km)	95	0.258	0.7	Base carbone, ADEME
Air (1001 - 3500 km)	95	0.187	0.7	Base carbone, ADEME
Air (> 3500km)	95	0.152	0.7	Base carbone, ADEME
Bus	1.5	0.146	0.6	Base carbone, ADEME

For the remote activities (Table 2), the chosen emission factors are average values taken from **Greenspector Test Runner**¹⁸. In a comprehensive comparative study, Greenspector measured the CO₂ equivalent emissions of one-minute one-to-one online meetings using 19 different servers. **Average values are selected to get an indicative estimate of the carbon impact of online meetings, without accounting for the specificities of single servers.** In fact, different members and groups within the same project will privilege different servers for their meetings. Moreover, Greenspector does not provide emission factors of different conference types (just audio, audio and webcams, audio and screenshare) for all 19 servers.

Table 2. Remote activities emission factors

Conference type	Emission factor (kgCO ₂ eq)	Uncertainty	Source
Just audio	0.000155	-	Greenspector
Audio + webcams	0.000403	-	Greenspector
Audio + screenshare	0.000163	-	Greenspector

For the purchases (Table 3), the chosen emission factors were extracted from the “**Base Carbone**” database from the **French Environment and Energy Management Agency (ADEME)**³⁴. The items listed under ‘Purchase type’ were chosen being the most relevant to ATMO-ACCESS, related to remote access and whose emission factors were present in the database mentioned above. More purchase types may be added in the future if necessary.

Table 3. Purchases emission factors

Purchase type	Emission factor (kgCO2eq)	Uncertainty	Source
Computer	169	0.5	Base carbone, ADEME
Tablet	63.2	0.5	Base carbone, ADEME
TV	371	0.5	Base carbone, ADEME
Server	600	0.5	Base carbone, ADEME
Screen	222	0.8	Base carbone, ADEME
Projector	145	0.5	Base carbone, ADEME
Modem	82.9	0.5	Base carbone, ADEME
Speaker	8.98	0.5	Base carbone, ADEME

Appendix 3b: Data Uncertainty

The following uncertainty percentages (Table 4) are based on ADEME Bilan Carbone³⁴, and they were also used in the EU Parliament’s Carbon Footprint assessment³⁶.

Table 4. Internal uncertainty for collection of data

Data collection method	Uncertainty (%)
Bills, meter readings	0-5
Database extraction	15
Survey	40
Statistical data	50
Order of magnitude data	80

The formula³⁶ used for total GHG calculation uncertainty is:

$$Total\ uncertainty = 1 - (1 - emission\ factor\ uncertainty) * (1 - data\ uncertainty)$$

- For physical activities and purchases, the formula below was used:

$$Total\ uncertainty = 1 - (1 - emission\ factor\ uncertainty\ for\ each\ travel\ mode) * (1 - survey\ data\ collection\ uncertainty)$$

It was decided to use the ‘survey’ uncertainty value (40%) because the data will be inputted by the project stakeholders and users by answering the questions asked in the Excel sheet.

- For remote activities, Greenspector does not provide emission factors uncertainty values. **It was therefore decided to estimate an 80% uncertainty** value since the information required will be inputted by project participants and users as estimates (e.g. estimated number of participants to online conference, estimated duration of online meeting etc.).