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N.B. Dear editor, this work implies dozens of co-authors (see section: Credit authorship contribution statement). At this stage, we would appreciate to save time, by submitting our original manuscript before filling in the addresses of the co-authors. Thank you for your kind understanding.

Abstract :

A growing portion of scientists realizes the need to not only alert about climate change, but also change their professional practices. A range of tools have emerged to promote more sustainable activities, yet many scientists struggle to go beyond simple awareness-raising to create concrete transition actions. Here we propose the game-based Transition Support System (TSS) *Ma Terre en 180 Minutes,* that has been designed to build scenarios of greenhouse gases (GHG) emissions reduction in the academic community, and present its deployment during the year 2021, including six hundred participants from nine countries and 50 cities. After building a common scientific background about the context (global warming, its causes and consequences) and challenge (50% reduction of our carbon budget by 2030), the participants immerse themselves into fictional characters, to simulate the 2ehaviour of real research groups. Results show clear pathways for GHG reductions between 25 and 60%, and a median reduction of 46%. The alternatives allowing the greatest reduction are video communication tools (36%), followed by mutualization of professional activities and voluntary cancellation or reduction, that represents 22 and 14% of reduction, respectively. The remaining 28% of reduction is composed by the use of trains as a transport alternative, the relocation of professional activities, the duration extension of some missions, etc… In addition, the analyses pointed out the importance of guided negotiations to bring out some alternatives such as relocation, local partners and computing optimization. An added value of this TSS is that the information it collects (anonymously) will be used to answer pressing research questions in climate change science and environmental psychology regarding the use of serious games for promoting changes in attitudes and behaviour towards sustainability, and including broader questions on how network structures influence “climate 2ehaviour”, knowledge, and the governance of the commons.

Keywords: climate change engagement, games, gamification, serious games, role-playing, research agenda

1. Author summary

For the last centuries, humans upscale their socio economic structures and globalized their interactions; and these unprecedented developments have been largely driven by our capacity to extract energy from the Earth. You and me were born in a carbonized world, were unlimited access to fossil resources and derived goods became the norms. Generations after generations, homo sapiens switched and installed themselves in the ideology of a no limit planet. For some decades now, scientists warm about the inadequacy between this commonly shared belief and the physical and biogeochemical limits. In simple world, the "carbonized sapiens" now know the threats but miss guidelines to reinvent himself. Modestly, Ma Terre 180' offers an innovative game-based transition support system to build scenarios of greenhouse gas emission (GHG) reduction in the academic community. It is no question of tokens on a gameboard and adjustment of practices, it is a question of brainstorming about a possible and desirable way of remodelling research and teaching communities and embrace a new paradigm. After tens of workshops involving hundreds of participants from more than fifty cities and nine countries, our results show clear pathways for reaching up to 50% GHG reductions and stress the importance of guided negotiations to bring out alternatives to carbonated activities. This first attempt reinforce our belief that scientific engagement is at the heart of the international development agenda and a key way to remove the institutional barriers that inhibit the transformation needed to achieve a more sustainable society.

2. Introduction

Since the Paris agreement on climate change in 2015, and the IPCC Special Report on Global Warming of 1.5°C (IPCC, 2018[1]), 191 states have committed to set ever more stringent policies of greenhouse gas (GHG) reduction (UNFCCC report, 2021[2]). In this context, the European Union has set the target of achieving, at least, a 55% reduction in GHG by 2030, compared to 1990. On July 8 2021, the European Central Bank took a historic step by announcing, for the first time, the integration of climate change into its monetary policy. Earlier in 2021, the International Energy Agency called on governments to ensure that their economic recovery plans focus on clean energy investments in order to create the conditions for a sustainable recovery and long-term structural decline in carbon emission (IEA report, 2021[3]).

At the global scale, a systemic change through moderate to low GHG emissions can only be reached if both individuals and communities endorse a dual responsibility to inform policy makers and citizens about the threatening situation for humans and life on Earth. It requires action to promote a form of frugality (Vaden et al., 2020[4]) and embody a socio-ecological transition toward low carbon societies (IPCC, 2018[1]; Otto et al., 2020[5]). In France, this dual responsibility is unavoidable since individual actions, such as commitments and financial investments, can at best reach a 45% reduction of GHG emission (Carbone4 report, 2019[6]).

GHG emissions of the academic activities can no longer be ignored. As highlighted by IPCC (2018), limiting global warming to 1.5°C or even 2°C requires a drastic and rapid reduction of GHG emissions that must concern all sectors of activity, particularly in developed countries (Mahlstein et al., 2011[7]). In this respect, the academic world is not an exception (Attari et al., 2016[8]). Besides, cognitive dissonance is high in all spheres and perhaps even more within the academic world, which can no longer afford to only raise awareness and alarm about the upcoming crisis, but must act as pioneers and embody changes (Schrems and Upham, 2020[9] ; Whitmarsh et al., 2020[10]).

Defining a robust strategy of emissions reduction implies, firstly, to accurately monitor GHG emissions. In the academic sector, a group of French researchers, named Labos1point5 (https://labos1point5.org/), developed an open-source tool called 'GES1point5' to help research labs to calculate their carbon footprint (Mariette et al., 2021[11]). Monitoring is a first step but it is insufficient to lead to in-depth changes of our professional behaviour (Hulme, 2020[12]). Yet, a growing portion of the scientific community realizes the need to not only alert but also change their professional practices. Moreover, according to Attari et al. (2016), the credibility of scientists and of their warnings is increased when they behave in a non-dissonant manner. According to a study carried out among 6000 people (Labos 1point5, 2020), 88% of French researchers "completely agree" or "somewhat agree" that the climate emergency requires profound changes in their practices ; however, the structural and functional framework of the academic sector and the evaluation of academic performances do not favour the emergence of sustainable trajectories. On the contrary, it largely promotes researchers' behaviours that lead to high carbon pathways (e.g. international travel, promotion of international network, use of high-technology and unique scientific instruments).

Nowadays, whether for conferences, field surveys, highly specific instrument experiments, thesis defense or project meetings, the emissions linked to researchers' mobilities areare an important (and sometimes predominant) contribution of a laboratory GHG footprint (Whitmarsh et al., 2020). In addition, travel practices are inequitably distributed among individuals, reaching per instance for a professor 10.8 tCO2e per capita on average at the University of Montreal, Canada, (Arsenault et al., 2019[13]) and 7.5 tCO2e at the University of British Columbia (Wynes et al., 2019[14]). The use of aircraft is a predominant source of GHG emissions and according to some authors (Wynes et al., 2019), it would not necessarily bring a clear benefit in terms of career development and enhancement of professional relations.

A range of tools, of varying degrees of entertainment and constraint, are gradually emerging, but many of them struggle to go beyond simple awareness-raising to create concrete transition actions (Galeote, et al., 2021[15]). In France, as in many other countries, a growing number of researchers organize themselves to change their work habits and embrace more sustainable practices ; a trend that was accelerated due to the COVID pandemic crisis and the increase of video communications. Some alternatives need to be done to enlarge the scientific community involved, but also to provide an overall vision of possible pathways of GHG emissions reduction. Ongoing approaches include incitative measures (carbon tax, ecological money), regulatory measures (carbon quotas, green charter, carbon offsetting) and gamification approaches (the Climate Fresk, ClimaTicTac, Carbon Lean, 2 Tonnes). The latter can take the form of serious games, which simulate multi-actor systems for tackling the complexity of environmental issues and their interplay with many other domains (Oliver, 2016[16]).

In the context of climate change, digital serious games have been used for almost forty years (Robinson and Ausubel, 1983[17]). In their literature review, comprising tens of gamified approaches, Galeote et al. (2021) showed that serious games stimulate cognitive engagement, affect the perception of climate change-related topics and behavioral engagement with others, by combining learning and entertainment. Serious games create a sphere of thinking around a complex topic while maintaining a playful atmosphere. As players, participants then embody positions or roles that are not necessarily their own, and relate more easily with issues that do not concern them directly or by which they did not think they were concerned. Moreover, serious games generate dynamics of opposition or cooperation involving the players' emotions to immerse them further in their character and promote the players’ empathy towards roles different from their real-life conditions (Wiemeyer et al, 2016[18]). They favor moments that create links and encourage sincere exchanges. According to Gee (2008)[19], serious games need to be moderately funny or

"pleasantly frustrating" to be serious enough. This characteristic makes the adaptation of serious games on the theme of climate change or socio-ecological concerns perfectly appropriate. Indeed, these topics are surely some major concerns of our time, and at the same time the most postponed ones. In this context, there are more and more serious games being set up to raise awareness on these issues among the various social, political and economic stakeholders (Onencan et al., 2016[20]; Terti et al., 2019[21]; Undorf et al., 2020[22]).

In this perspective, we developed MaTerre180' (i.e. MyEarth180'), a Transition Support System including a game-based participatory tool, that aims at raising awareness regarding the carbon footprint of the academic world, and identifying ways of reductions through social interactions. MaTerre180' particularly focuses on the predominant proportion of air travel in the academic carbon footprint, but also includes other means of transportation (train, car or boat for oceanographic surveys) as well as additional sources of emissions such as numerical simulations and the access to highly technologic and unique scientific instruments (e.g., particle collider). MaTerre180' goes beyond the mere framework of learning by first identifying solutions, then embracing action and bringing to light concrete solutions to reduce academic GHG emissions.

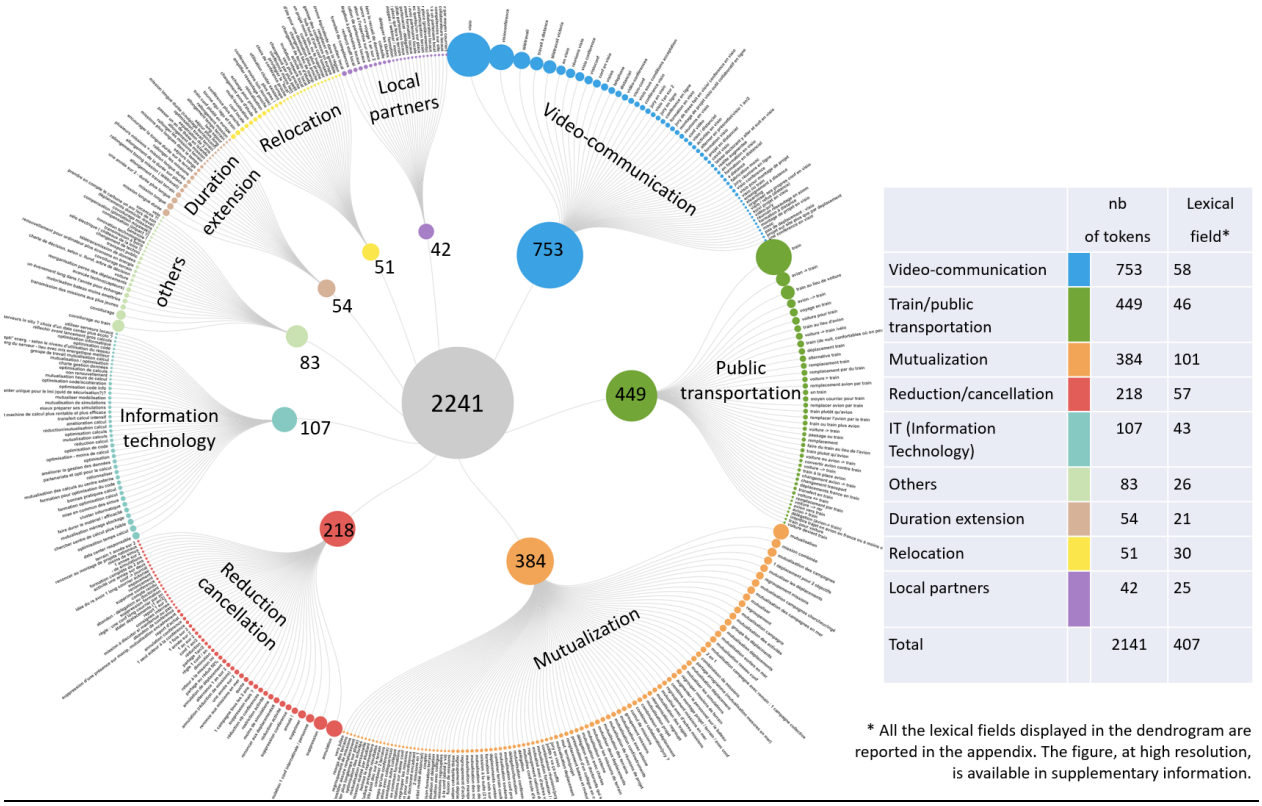
After a general description of the timeline, materials and methods, results focus on the analysis of the eighty five game-based phases played to date. These games have been analyzed in order to discuss the applicability of the suggested solutions for GHG emission reduction within the academic world. In particular, it has been possible to assess the robustness of the proposed alternatives through indicators of their spontaneity and popularity. Finally, we questioned the indicators used to measure academic performance and their consistency with the GHG emission reduction objectives in order to open discussions on the possible and most effective ways to implement the proposed strategies.

3. Results

From November 6th 2020 to June 18th 2021, eighty-five games (*N=85*) brought together more than six hundred participants (mostly academic professionals) from nine countries and more than fifty cities.

a. Alternative categorization

Fig 3 summarizes the categorization of alternatives in the form of a dendrogram sketch, the size of the circles being proportional to the number of alternatives that fall within each category, or subcategory.



	nb of tokens	Lexical field*
Video-communication	753	58
Train/public transportation	449	46
Mutualization	384	101
Reduction/cancellation	218	57
IT (Information Technology)	107	43
Others	83	26
Duration extension	54	21
Relocation	51	30
Local partners	42	25
Total	2141	407

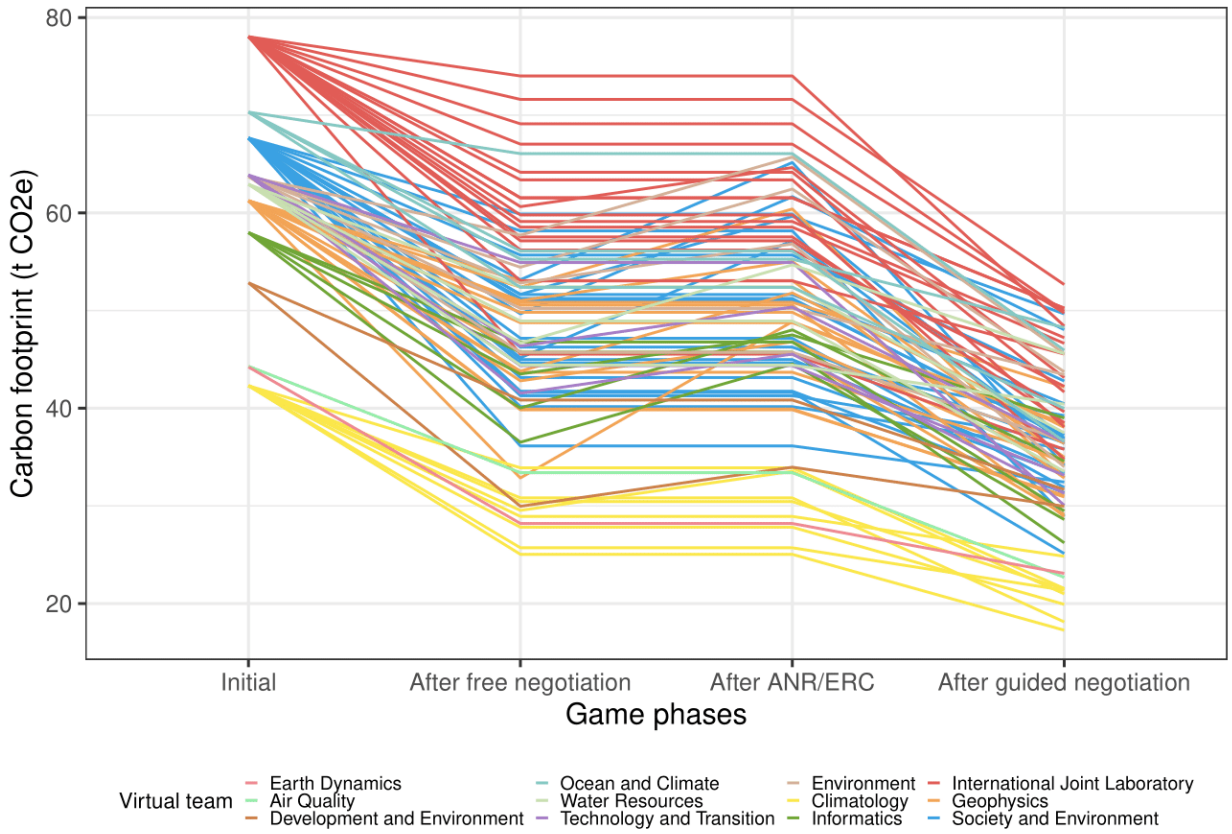
* All the lexical fields displayed in the dendrogram are reported in the appendix. The figure, at high resolution, is available in supplementary information.

Fig 3. Circular dendrogram of the classified alternatives by categories. All the lexical fiels displayed are reported in the appendix. The frequency of appearance is described in the legend.

In total, 407 different alternatives were expressed ; some of them being considered by many participants, so that the total individual number of actions (move of tokens) performed to reduce carbon footprint was 2141. The three most popular alternatives (by numbers) are video communication (35%), public transportation (i.e. train travels, 21%) and mutualization (18%). By nature, this latter alternative requires a degree of interaction between two, or more, characters, and thus covers a great lexicological plurality. More than one hundred (101) different wordings of this alternative were voiced by participants, as shown here above in Fig 3 (orange dots).

b. Trajectories of the different game tables

The GHG emissions trajectories are first presented through the absolute reduction of GHG of each game table (Fig 4a, *CF*) ; then, the relative reduction is shown (Fig 4b, *R*) to facilitate intercomparison given that not all the game tables/teams start with the same initial emission level (Table 1).


80
60
40
20
Carbon footprint (t CO2e)
Initial
After free negotiation
After ANR/ERC
After guided negotiation
Game phases
Virtual team
Earth Dynamics
Air Quality
Development and Environment
Ocean and Climate
Water Resources
Technology and Transition
Environment
Climatology
Informatics
International Joint Laboratory
Geophysics
Society and Environment

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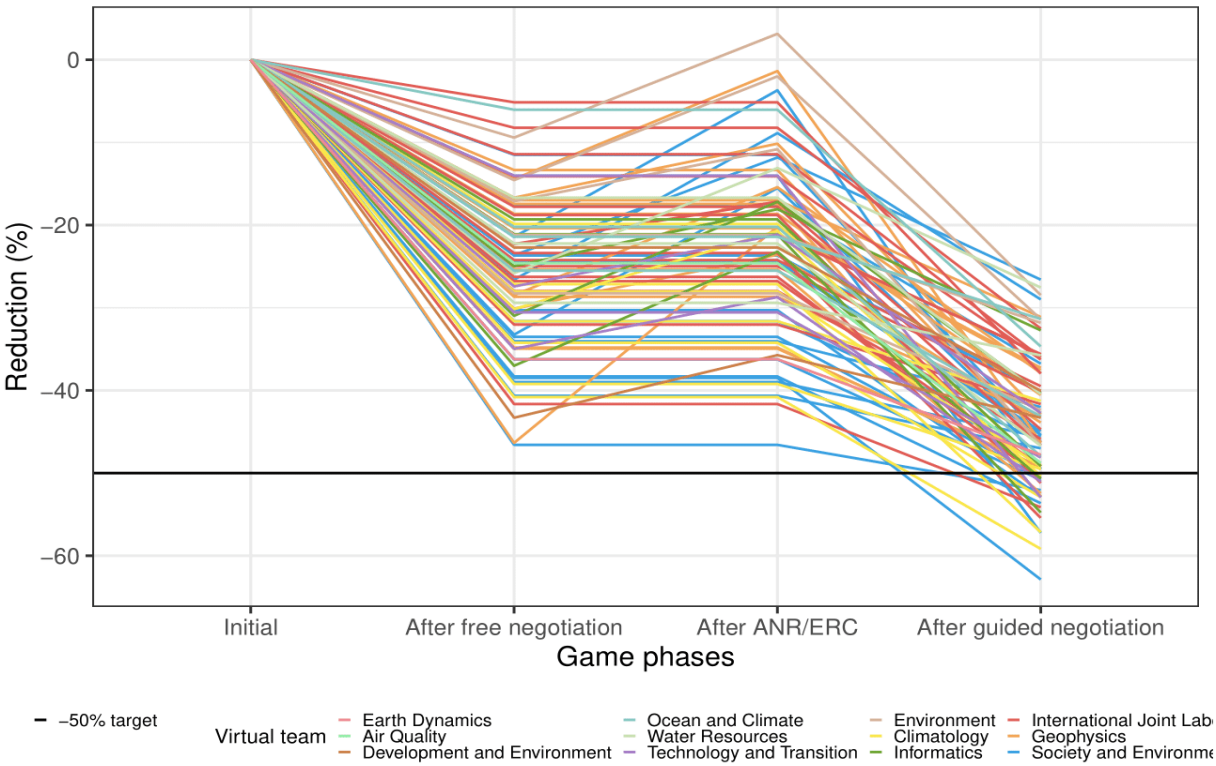
0
−20
−40
−60
Reduction (%)
Initial
After free negotiation
After ANR/ERC
After guided negotiation
Game phases
−50% target
Virtual team
Earth Dynamics
Air Quality
Development and Environment
Ocean and Climate
Water Resources
Technology and Transition
Environment
Climatology
Informatics
International Joint Lab
Geophysics
Society and Environme

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Fig 4. Virtual GHG footprint trajectories. (a) Absolute and (b) relative GHG trajectories for 85 game tables coloured by virtual teams. The horizontal solid black line represents the 50% reduction goal.

The x-axis reports the four successive sub-phases of the role-playing game, namely the initial footprint of the different virtual teams, as previously detailed in section IIA, the GHG footprint decrease after the free negotiation phase, ANR and ERC project grants, and the final reduction after the guided negotiation phase. Beyond the general decreasing trajectory of all broken lines observed in Figures 4a and 4b, we can emphasize a strong variety of initial budget (ranging from 42 tCO_2e to 78 tCO_2e per virtual teams), and of games trajectories.

Overall, all games managed to reduce their carbon footprint after the free negotiation phase. The variability of the final emissions at the end of the games overpasses the variability of initial GHG footprint, which clearly highlights the importance of the interactions between players during the game.

To compare the trajectories of the different tables, we displayed the relative reduction in GHG footprint (Fig 4b). Here, all tables start from 0% and reach between 5% and 45% reduction at the end of the free negotiation phase. As previously pointed out in Fig 4a, the successful application to ANR and ERC funding programs increases some of the footprints, sometimes wiping out the efforts that have been made during the free negotiation (e.g. one game of the Environment virtual team in brown). Finally, the range of reduction after guided negotiation is narrowed down to a final average reduction of 44% and a median of 46%.

The variability between games is high, the less efficient groups of participants reducing by 25-30% their emissions, while the most efficient ones reach reductions close to 60%. Despite the variety of situations, the virtual reductions obtained during all games are promising and show that substantial opportunities for GHG emissions reduction exist within the academic world. The high variability between games suggests that the reduction does

not depend on the intrinsic characteristics of the twelve virtual teams (initial carbon footprint, distribution of motives, psychological profiles, etc.), but rather on the way participants of a game interplay through the ten characters they embody. To go further in the analysis, it is interesting to show the density distribution of the final relative GHG reductions, which is represented in Fig 5.

On this figure, no color clusters are observable, suggesting that the final GHG footprint of virtual teams are approximately evenly distributed. For example, among the twenty games of the "Society and Environment" virtual team (blue squares), there is one at each extreme (-27.5% and -62.5%): the final result therefore depends more on social interactions that have been created during the game between participants, than on the characteristics of virtual teams played. However, in addition to this observation, there is a threshold effect related to the target of -50% proposed to win the game: before this target, the distribution increases gently and gradually, whereas after -50%, it suddenly drops. The target seems to affect the result obtained so that, as long as the target is not reached, the participants imagine solutions to reduce by 50% their emissions, but as soon as the target is reached, there is no reason to do more than necessary. The distribution peak, observed for a value of 50%, seems to indicate that the motivation of the participants is highly driven by the objective to be reached.

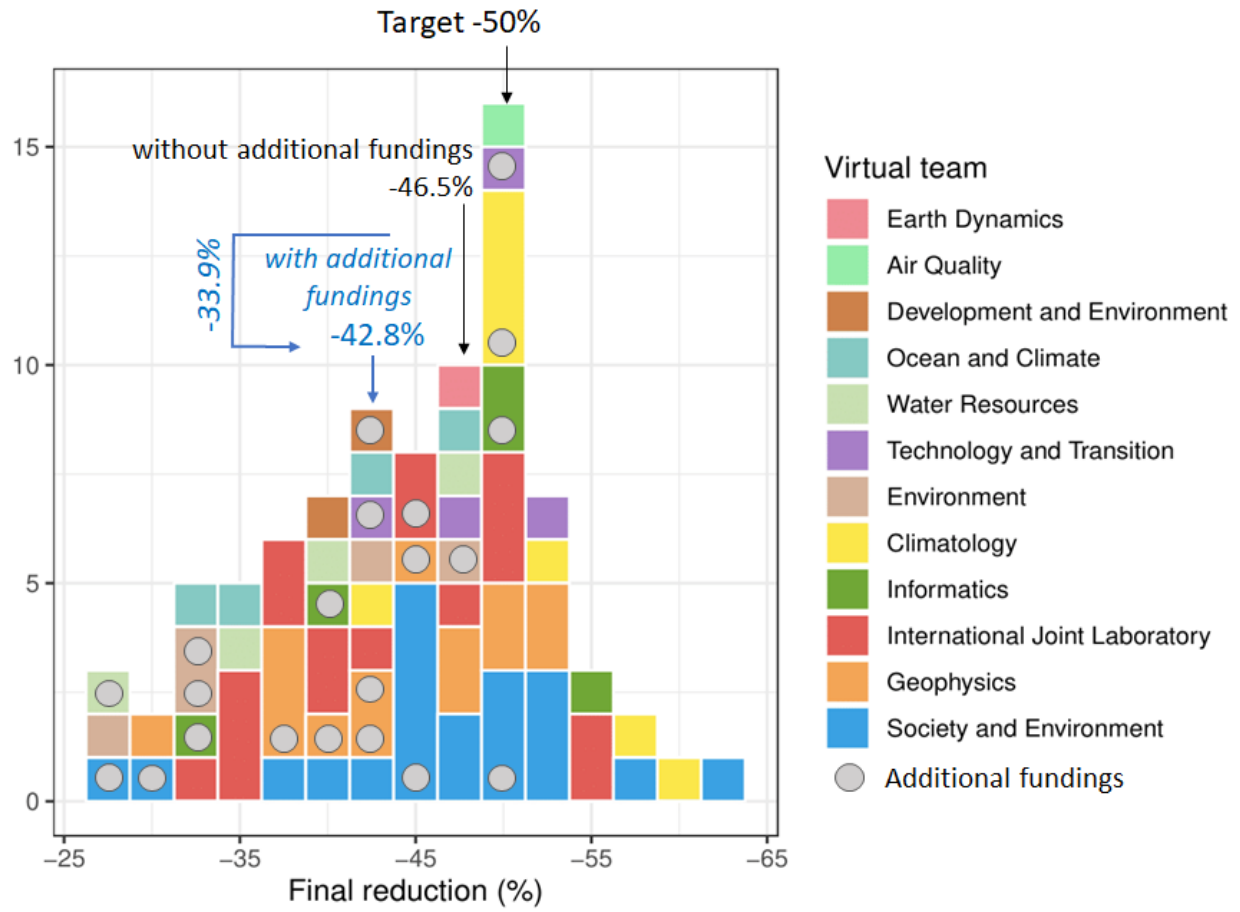

Fig 5. Density distribution of the final GHG reduction. It synthesized data presented in Fig 4b, for the 85 game tables colored by virtual teams.

Another interesting aspect concerns the impact of additional fundings on the final GHG footprint. In Fig 5, games that did not receive additional fundings (i.e. additional GHG emissions) have an average reduction of -46.5%, logically beyond the ones that were overloaded by additional emissions. For games receiving additional fundings, the corresponding additional GHG emission average 12.8%. If participants were not influenced by these "penalties" the reduction of GHG emission should be around -33.9%, which is actually not the case. After the guided negotiation phase, the average GHG emission reduction was established at -42.8%. It means that corresponding participants made a substantial effort (+8.9%) to reduce their footprint and tentatively reach the targeted -50%

of reduction. It is worth noting that none of the games with additional funding overpasses the target, while 14 of the 64 games without additional fundings overpass the target.

c. Alternatives chosen and motives

The previous section indicates that the interaction between the participants and the resulting synergies predominate in the achievement of the reduction objective. However, are the alternatives chosen by the participants of the different games the same or, on the contrary, are they very diverse and dependent on the synergies specific to each game table?

To answer the question, the games were also analyzed and compiled to emphasize the alternatives selected by participants, in the nine categories detailed previously (Table 4) and categorized in Fig 3. Results are reported in Fig 6.

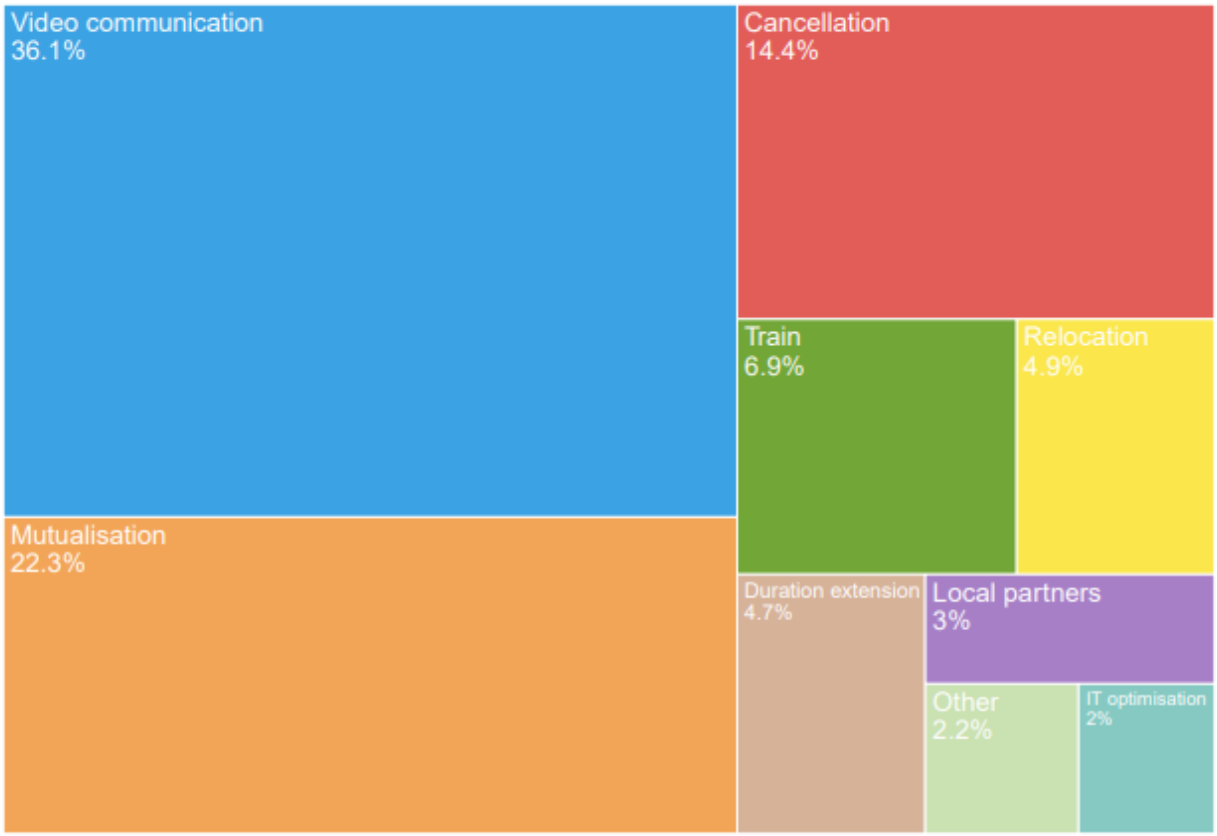

Fig 6. Repartition of the total GHG reduction by categories. The GHG reduction is, by average, 44% of the GHG initial footprint. The alternative categories are the ones expressed by participants and synthesised in Fig 3.

The predominant alternative (36.1%) is the use of video communication tools. It is followed by the mutualization of some professional activities (22.3%) and by voluntary cancellation or reduction of research activities (14.4%). Train (6.9%), relocation (4.9%) and duration extension of journeys (4.7%) contribute a smaller part to the total virtual reduction. Finally, local partners (3.0%), IT optimization of numerical calculations (2.0%) and others (2.2%) account for a small share of the virtual emission reduction. Overall, almost 80% of the reduction is achieved through four categories of alternatives. Reduction of the GHG footprint through the implication of "local partners" category is believed to be underestimated, probably as a result of mixing with the mutualization category. The relatively low effect of IT optimization is attributed to the small fraction of emissions from computer simulations present in the 12 virtual teams considered. At a global scale, IT optimization is probably much more important.

Fig 7 shows which alternatives were chosen for each of major research activities, their corresponding alternative proportion, and how much GHG emissions were reduced.

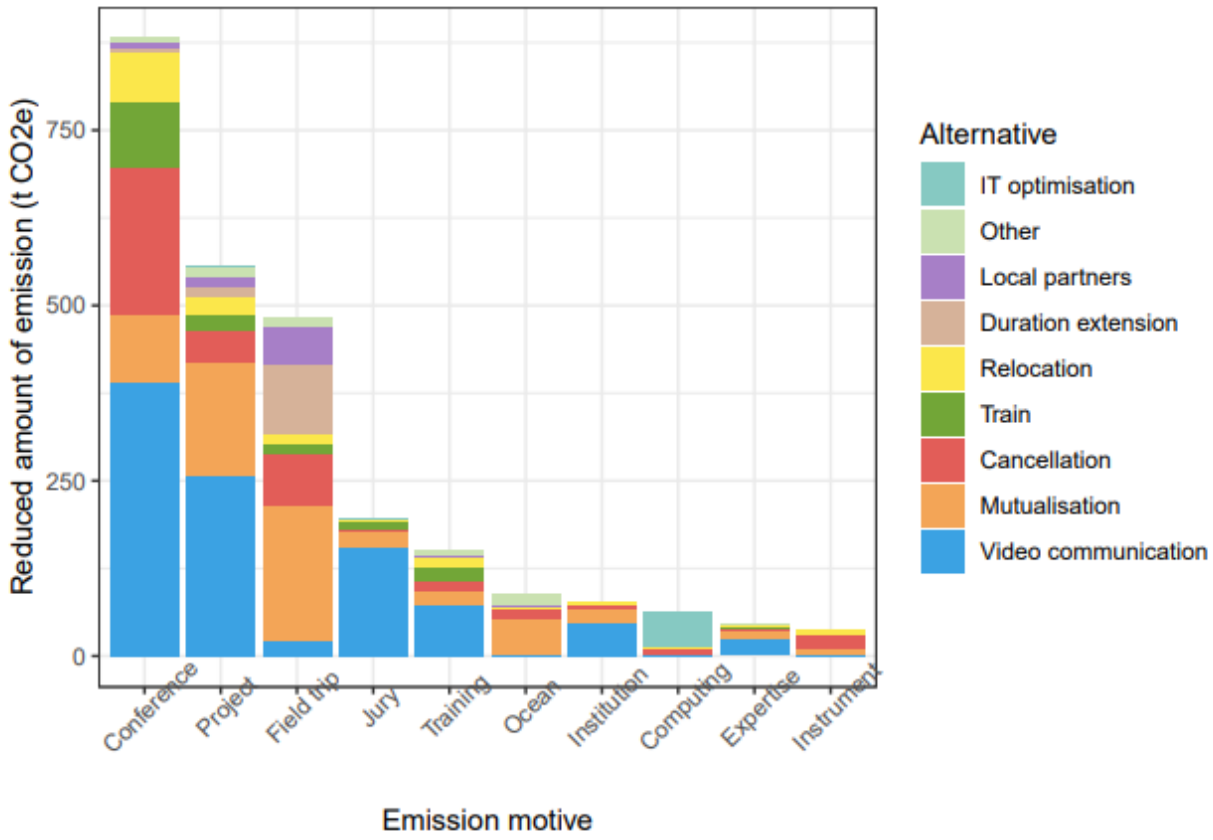

Fig 7. Absolute GHG reduction distribution. The reduction is subdivided by alternative categories depending on the emission motives: air travel to reach a conference, to meet for a project, for field trip, jury, for training, oceanographic campaigns, air travel for institutional meeting, cost of numerical computing, air travel to make an expertise, to access to a large unique instrument.

Video communication (blue bars) is an efficient factor to reduce GHG footprint for six emission motives, by replacing physical meetings for conferences, projects, juries (PhD, staff recruitment, etc.) as well as training, institutional and expertise meetings by some distant video interactions. Field trips (on the continent or at sea), which are highly contributing to GHG footprint, are most often mutualized.

In general, the alternatives are dependent on the motives. A diversity of alternatives are required to maximize the reduction, which emphasizes the complexity and richness of interaction between participants.

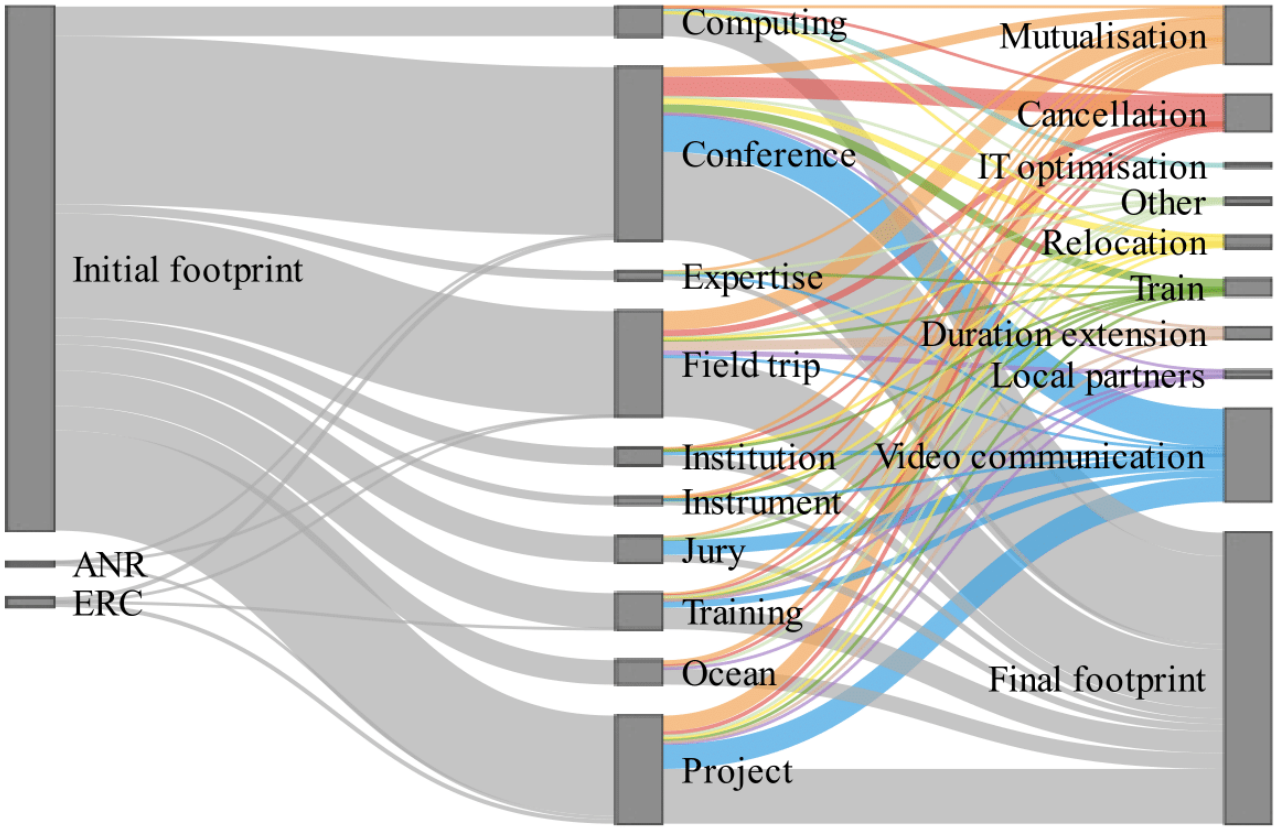

Fig 8. Distribution of the GHG emissions from the role-play initial balance to the selected alternatives and the final balance. On this Sankey diagram, the initial distribution of emissions can be seen, to which the emissions generated by the funded ANR/ERC projects during the game can be added. The initial distribution according to the motives can be seen in the centre of the diagram. On the right-hand side are the selected alternatives and the remaining emissions. The flow bands indicate the distribution between motives and selected alternatives.

Fig 8 shows in more detail the distribution of GHG emissions and pathways for reductions. The grey vertical bars and colored bands are proportional to the global GHG emissions for the 85 games considered. This Sankey diagram complements the information given in Fig 7. It becomes clearer why the total emissions from conferences are predominant: it is also the largest share of the initial distribution. Some motives appear to be

difficult to substitute, for instance intensive computing and sea cruises, while others seem easier to reduce, juries in particular.

d. Frequency, spontaneity and emission intensity

As the role-playing phase takes place in two sub-phases of 20 and 25 minutes each, it is interesting to look at the influence of the time when the tokens are replace for a given alternative. Three characteristics are particularly meaningful: first, the spontaneity of an action, i.e. the minimum time of appearance of the variable (motive or alternative) ; secondly, its frequency of appearance on all the games and finally its reduction intensity in kg CO_2e per token.

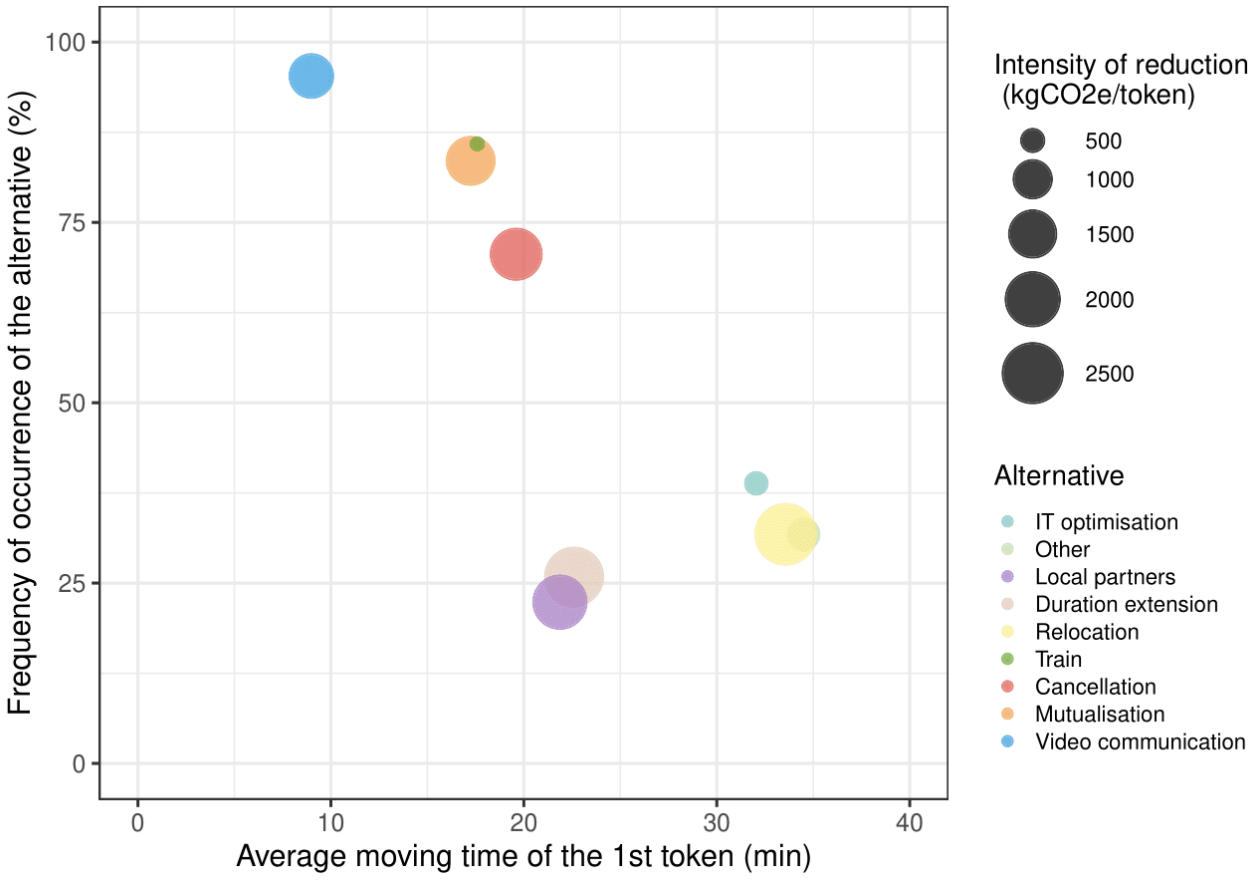

Fig 9. Spontaneity of the different alternatives sized by reduction intensity.

Fig 9 depicts the frequency of appearance of each alternative as a function of its spontaneity. The size of the bubbles is proportional to the reduction effectiveness of the alternative in $kgCO_2e$ per token. Overall, four clusters of bubbles can be observed. First is the "video communication" alternative, which is very spontaneous (less than 10 minutes for its first appearance), very frequent (proposed by 95% of games) and rather effective. Cluster two includes three alternatives, namely "mutualization", "cancellation" and "train", which also come fairly early during games and remain fairly frequent but are unequally effective in reducing GHG emission, especially "train" which is rather low as it cannot substitute long-distance air travels. The following cluster is composed of the "duration extension" and "local partners" alternatives, which are proposed later and are less popular (around 25% of occurrence) but rather effective in terms of intensity of reduction. The last cluster includes "relocation", "IT optimisation" and "others". It arrives very late in the games, on average during the guided negotiation phase (after 30 minutes on average), is infrequent and unequally effective: "relocation" is the most effective alternative, while "IT optimisation" appears to be poorly effective.

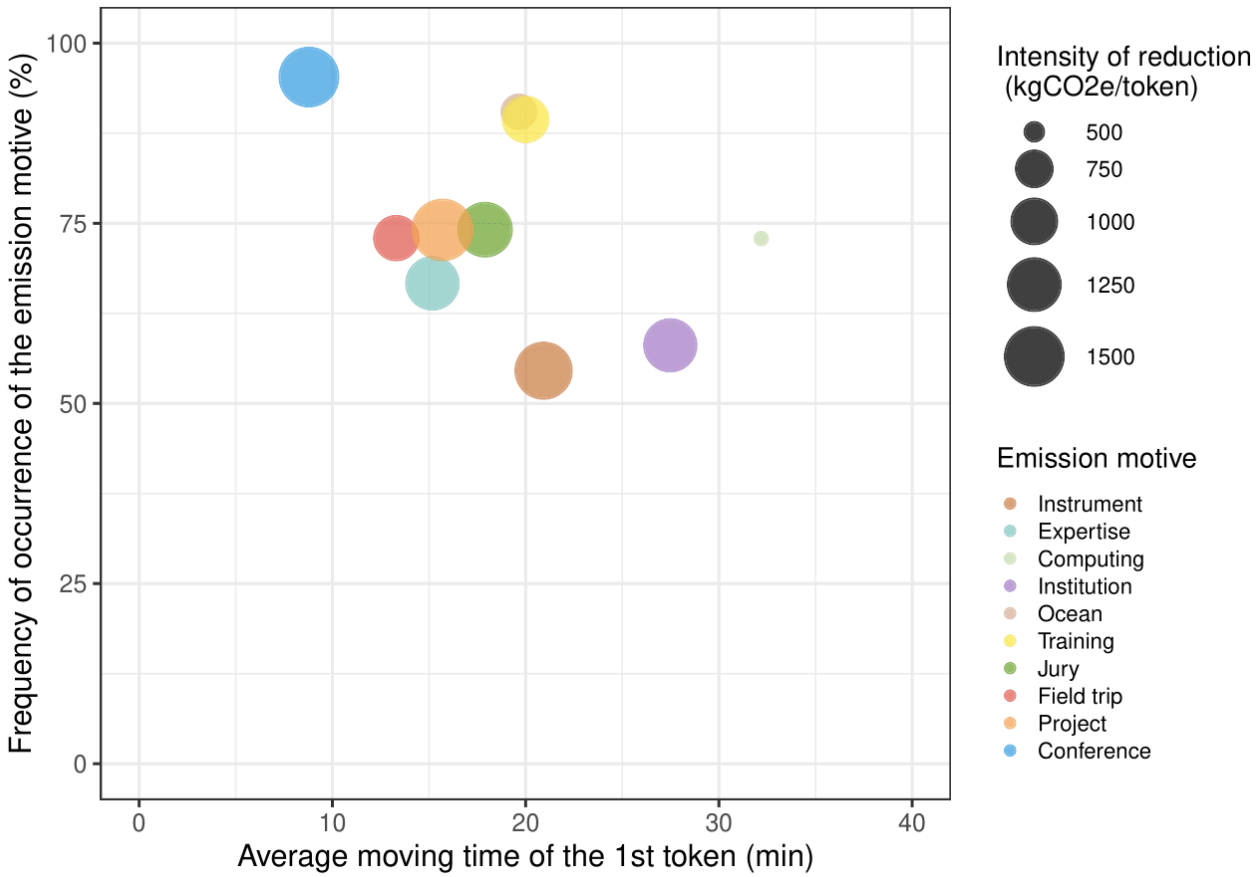

Fig 10. Spontaneity of the different emission motives removal. It is sized by reduction intensity. The size of the bubbles is proportional to the reduction effectiveness of the motive removal in kg CO_2 equivalent per token.

Fig 10 represents the frequency of each motive removal as a function of its spontaneity. The participation in international conferences is globally the only motive to be withdrawn frequently (more than 95% of games played) and getting a high spontaneity (<10min). In contrast and logically, flight to access to "unique instruments" are the least frequently removed (just over 50% of game tables initially having them), which is understandable as it is the core of some research activities and cannot be substituted. Finally, IT optimization is less spontaneously mentioned (beyond 30 minutes of play).

The effectiveness of reduction, represented by the size of circles, is also rather variable, ranging from more than 1500 kg CO_2e per token for projects and conferences meetings, to less than 500 kg CO_2e equivalent per token for computing.

4. Discussion

a. Synergy during the games and influence of the target

According to Pohlmann et al. (2021)[23], the normalisation of climate-friendly behaviors in a given social group will not occur through the sum of individuals. Gamification thus often provides interactive spaces where reality can be experienced and transformed, which is a rich basis for knowledge creation (Kolb, 2014[24]).

Our study shows that most of the variability of the results can broadly be explained by two independent factors: the synergy that was created between the participants during each game and the target that is given to win the game (in our case -50% of GHG footprint). As far as synergy between participants is concerned, an in-depth anthropological and sociological work would be needed to assess the brakes and leverages to GHG footprint reduction (Whitmarsh et al., 2020). An in depth analysis of this hypothesis in this study goes beyond our scope but is a key perspective for further analysis of the data collected during the games.

Focusing on a more quantitative analysis, some interesting elements can be deduced from final GHG footprints (Fig 5). In this figure, the density distribution shows an asymmetry, which corresponds to a threshold effect: below 50% of reduction, the game tables are distributed rather gradually, but once the objective is reached, the density distribution suddenly drops. Thus, as long as the objective is not reached, the participants make all the efforts they can and as soon as the objective is reached, the participants stop making efforts. The question then arises whether setting a target of 75% would also result in this threshold effect with an average reduction slightly below the target. We may hypothesize that a reduction of 50% finally remains acceptable and reachable, but a target at 75% would probably discourage participants and require more profound and systemic changes of the academic sector practices. It is worth noting that the final reduction was

about 45% (mean and/or median) which is believed to be a positive signal for reaching significant reduction of GHG emission in real life.

b. Frequency, spontaneity and effectiveness of alternatives

Here, our interest was to identify how to articulate the emission motives and the alternatives, as expressed in Fig 8, in order to build realist scenarios for reducing the carbon footprint of the academic world. In order to analyze the reduction choices made by the participants, it was decided to focus the study's attention on specific characteristics. To do this, it is important to understand which emission motives are favoured for reduction and towards which alternatives by looking at the frequency, spontaneity, effectiveness and efficiency of these choices (Figures 9 and 10). However, passing from the virtual space of a role playing game to the real world of research, may introduce unexpected difficulties due to the current functioning of research, which promotes individual performance and competition (van Dalen, 2021[25]) instead of bulding bridges toward global sustainability (Irwin et al., 2018[26]).

Our results showed that 80% of the GHG reduction was possible thanks to four alternatives, namely video communication, mutualization of means or activities, cancellation of activities and lower carbon emission transportation (train). The use of video communication is the most spontaneous and frequent proposal, which enables the greatest reduction (16.2%), because it can be adapted to a large number of activities, with the notable exception of field/sea campaigns. The spontaneity and efficiency for video communication have probably been propelled by the COVID-19 pandemic crisis that has recently imposed such means of communication due to lockdowns and remote working (Nguyen et al. 2020[27]). Video communication practice had however already been raised within the scientific community as an alternative to conferences (Jordan and Palmer, 2020[28]). Nevertheless, the advantages and disadvantages of virtual conferences are debated. Another suggested option is to attend

conferences in person, but to be more selective (see below, cancellation). The second option is the mutualization of activities or means, which also leads to a strong overall reduction of GHG footprint (10.0%) by combining several field trips of different purposes or by delegating specific tasks to limit the number of participants during field/sea campaigns. Yet, experts of oceanographic campaigns consider that a reliable mutualization of onboard activities is an uneasy task. In real life, one can anticipate non-negligible organizational obstacles and an expected resistance of researchers and their stakeholders (community, hierarchy, partners) for such suggestions. While grouping several activities on a personal basis is not excessively complex, mutualization between colleagues requires a high degree of communication, preparation and trust. At present, mutualization is not sufficiently recognized by academic institutions to become popular, in view of the time required and the risks involved for careers, in case of failure of uneasily rescheduled campaigns. According to Shove and Walker (2014)[29], individual actions are embedded in institutional, social and infrastructural frameworks, which ensure that climate-damaging behaviors remain the norm. The academics need to be proactive to shift these norms through more mutualized and frugal research. The third alternative concerns cancellation or rationalisation of research activities. It is by nature very simple to be done technically, but seems to be over-represented in our results. The main limitation is the psychological acceptance by participants, in link with social habits and pressures (Gifford, 2011[30]). The lack of institutional recognition of the efforts made and risk-taking by researchers in the case of a cancellation or drastic reduction of field/oceanographic surveys seems also to be a limitation. It is the same in the case of limitation to in-person meeting participation. As long as the carbon quota or any other indicator, based on the sustainability of activities, is not put in place by academic institutions, reducing one's activity brings at best a saving of time and an improved work-life balance, at worst, a devaluation of research performance and researcher’s recognition. An in-depth analysis of costs and benefits for the society should be

454 considered. The fourth alternative is train travel, which is often mentioned in the literature
455 as a solution for decarbonizing research. However, train travel quickly reaches its limits in
456 the sense that it is neither easily accepted to take the train if several train changes are
457 required or heavy/cumbersome equipment needs to be transported. Trains cannot
458 substitute long-distance air travel. For most regional activities however, train is even very
459 efficient (Ciers, et al., 2019[31]). The train must thus be promoted both as an efficient
460 practice on a regional scale, and as a marker of change in our practices.

461 The remaining 20% of the reduction is made up of solutions that occurred less
462 frequently and were less spontaneous, but which can compensate for the limitations of the
463 first four. Relocation, coupled with the use of train, is thus very efficient as it directly
464 addresses long-distance air travel, particularly for conferences. The extension of the mission
465 duration is similarly very interesting but is proposed more specifically for field trips or sea
466 cruises which allow for more expatriation. Local partners and expatriation are specific to
467 some research groups and thematics. Reducing the corresonding GHG footprint will require
468 first understanding people's beliefs, values and norms, second to engage in depth
469 discussions between all actors and policy makers to break psychological and other limits
470 (Gifford, 2011).

471 Regarding the emission motives, they are globally withdrawn from the playmat in
472 proportion to their initial distribution within the eighty five tables. Conferences are naturally
473 removed the fastest and most often, but this should not overshadow the other motives for
474 the teams' emissions, as is often the case in scientific works that consider conferences for the
475 most part. However, this raises the question of the acceptability of replacing a conference
476 with a videoconference or cancelling it, and the valuation of conferences in the research
477 indicators. There are also many motives that can be played on. Indeed, one motive in
478 particular is over-reduced: thesis juries, essentially carried out by videocommunication, for
479 which there is a greater propensity to reduce activity, with a gain in personal life quality.

Conversely, certain motives are under-represented, like oceanographic surveys, intensive computing or travel for the use of unique instruments, as they are specific to the activity of the research labs and so more difficult to reduce, which may explain the lower spontaneity and frequency for the latter two.

c. Steps and timetable for achieving the -50% target by 2030

The key point now is to consider how to transform the virtual pathways of GHG, expressed during the role play phase, into real measures. In the virtual format, participants detach themselves from their emotions but have the difficult task of projecting themselves into the skin of a fictional character. Some participants may find it difficult to make this change of posture and to become imbued with the personal motivations, posture and convictions of the embodied characters. The difficulty is even greater when each participant plays two characters, and when these characters' behavior and profile are different from their own (for instance when a PhD student must play a senior researcher). The complexity therefore lies in knowing to what extent the proposals emanating from fictional discussions can be directly transposed into the everyday life of an actor in the academic world. Nevertheless, no justification could discredit an alternative a priori. It is still necessary to encourage their implementation in order to judge their acceptance in the framework of a functional research group. Two main directions for their implementation can be distinguished:

First, promoting and recognizing the efforts made by individuals to reduce one’s GHG footprint would be a preliminary step. One point that came up several times in the discussions during the debriefing phases was the importance of indicators of academic performance. Indeed, the current indicators encourage productivity and do not take into account the social and ecological impact of research and education activities, in particular in terms of GHG footprint. It seems inappropriate to keep the same evaluation criteria for academia in the

506 context of the socio-ecological transition. We know that conferences play a major role in the
507 dissemination of work and the construction of a professional network. They are all the more
508 important for young researchers compared to senior ones who have already obtained
509 permanent positions and built up their network. Nevertheless, it is the latter who travel the
510 most to participate in international conferences (Wynes, 2019). The evolution of indicators
511 and evaluation criteria therefore appears to be a relevant option for taking better account of
512 criteria compatible with global limits.

513 The second option is for the functional teams to take control of the results. The digital
514 interface used during the role-playing phase of MaTerre180' constitutes a powerful tool for
515 developing new techniques of communication and negotiation between peers. We can
516 imagine that some research groups could take advantage of this TSS to experiment with
517 various strategies of research projects and define the ones that best balance benefits for
518 society and sustainable GHG footprint.

519 In their exhaustive review, Flood et al. (2018)[32] reported various climate related
520 games or role playing focusing on water management, long term farming or risk disasters; but
521 none of them was dedicated to the academic world and its non-negligible GHG footprint.
522 Knowing the peculiar role of scientists in Society, we may hope that the use of a tool such as
523 Ma Terre en 180' could accelerate a shift in the scientific community and provide a persuasive
524 argument for a broader shift in other sectors.

525 Transition support system could certainly facilitate the transition, but this will depend
526 on our capacity to follow at least two recommendations (Galeote et al., 2021): first, it is
527 important to promote interventions in emerging and developing countries and to extend the
528 target to young students and more social, political, and economic actors. Secondly,
529 gamification and TSS techniques should be massive and lead to large data series in order to
530 get statistically robust and unbiased scenarios of reduction. Some collaboration with widely
531 distributed research institutions, could favorably help for reaching these recommendations.

5. Conclusion

The authors of this study are convinced that the state of scientific knowledge on the current and coming social and ecological crises, caused or enhanced by global warming, is not enough to bring about a systemic and rapid change that is commensurate with the issues at stake (Hulme, 2020). In this context, the academic world is not an exception and must act and embody changes (Attari et al., 2016 ; Whitmarsh et al., 2020). For that purpose, authors created a game-based TSS, Ma Terre en 180 minutes (https://materre.osug.fr/), to build scenarios of GHG emissions reduction in the academic community. The TSS has been deployed during the year 2021 with around 600 participants. The analysis of all the games played is encouraging and expresses clear pathways for reductions: the range of GHG reduction at the end of the game-played phase is between 25 to 60% with a median reduction of 46%, independently of the virtual research team played and given a target of 50% reduction. This result highlights that, virtually, the objective of 50% of GHG emission reduction in 2030 is reachable for the academic world.

More in-depth analyses were conducted in order to understand the dynamics of reduction, the remaining obstacles to endorse a reduction strategy, and to spark all ideas about possible alternatives. The alternatives allowing the greatest reduction are the video communication tools (36%), followed by the mutualization of the professional activities and the voluntary cancellation or reduction that represents 22 and 14% of reduction, respectively. The remaining 28% of reduction is composed by the use of trains as a transport alternative, the relocation of professional activities, the duration extension of some missions, the optimization of the information technology and other marginal ideas. Our results also confirm the necessity of alternatives adapted to specific research activities: the most effective tool to

reduce the GHG emissions from conferences, projects and juries is, as expected, the video communication tool whereas mutualization and duration extension are the most important alternatives for field trips. The initial footprint of the research activities explain the dominance of some activities to the total emission that remains even after the game phase (like conferences). It also shows the small part of cancellation in the GHG emission reduction from the different categories, except for conferences, and thus shows the relatively easy way for the academics to reduce their emissions without tremendously affecting their research activities. Finally, the analyses of all the game dynamics, i.e. when, which and how often the alternatives are proposed, show some obstacles to use some types of alternatives and the necessity to have a person that guides the discussion (second part of the game phase): relocation, local partners and computing optimization need more guided discussions than individual choices of video communication, and free discussion for mutualization.

Diverse game reviews from the last decade show that the tendency of gamification has only grown in recent decades (Reckien and Eisenack, 2013[33]; Flood et al., 2018 ; Galeote, 2021). However, to the best of our knowledge, this is the first time that such a role-playing game is deployed and used to determine the possible scenarios to reduce GHG emissions in the academic world. Gamification is relevant because it allows participants to fail with low consequence (Plass et al., 2015[34]). Some further session of MaTerre180' need to be performed in order to consolidate the results and explore the participants sociological synergies during the workshops: changing the 50% target of GHG emission reduction, using virtual teams exploring other field of research, adding other kinds of virtual characters, incorporating the purchases (consumables, materials and equipments) into the initial carbon budget, etc.. Additionally, deploying MaTerre180' at different scales and within varied academic contexts (universities vs. national research institutes, students vs.university staff) will help to tackle possible biases. Last but not least remains the transition between virtual

583 and real world, i.e. to find the method to adapt the scenarios imagined with the virtual game-
584 based tool into the real world of academic research. This probably requires the participation
585 and involvement of the institutional governance of research organizations.

586

587 6. Material and methods

588 a. Ethics statement

589 All aspects of the experimental procedures were reviewed and approved by the
590 "scientific board" of the French National Research Institute for Sustainable Development
591 (IRD-France, approval n° D2S-2022-002. All participants gave consent to the facilitators prior
592 to their participation: once the online session was opened, the facilitator of each table asked
593 to each participants of the workshop for the right to record the videos as a source of raw data
594 for further non-profit research. When the agreement was not obtained for all individual
595 participants, the session was not recorded and the corresponding table was not considered
596 for further analysis. When the agreement was obtained the session was recorded and the
597 facilitator notify it by signing a letter agreement. We do remind that each participants role-
598 play two fictive characters ; no personal information on individuals were collected, only on
599 the actions of their fictive characters during the game.

600

601 b. MaTerre180', a game-based participatory tool

602 MaTerre180' is a Transition Support System organized in four distinct phases, through
603 which an academic institute/group will seek to change the organisation of its academic work
604 to reach a target GHG emission reduction . Fig 1 summarizes the timeline. The deployment of
605 MaTerre180' lasts 180 minutes (+ a 30 minutes debrief time). It runs over two half-days, to
606 help the participants gain sufficient introspection and encourage their cognitive engagement.

As an adaptation to the COVID pandemic, MaTerre180' has been designed to be deployed online, which proved to be particularly useful for the massification and the digitization of this game-based approach.

In this paper, the analysis focuses only on the role-playing phase of the MaTerre180' workshop (phase 3 in Fig 1).

Each MaTerre180' individual workshop gathers a facilitator, (four to) six participants, one of them playing the role of team leader, and an advisor.

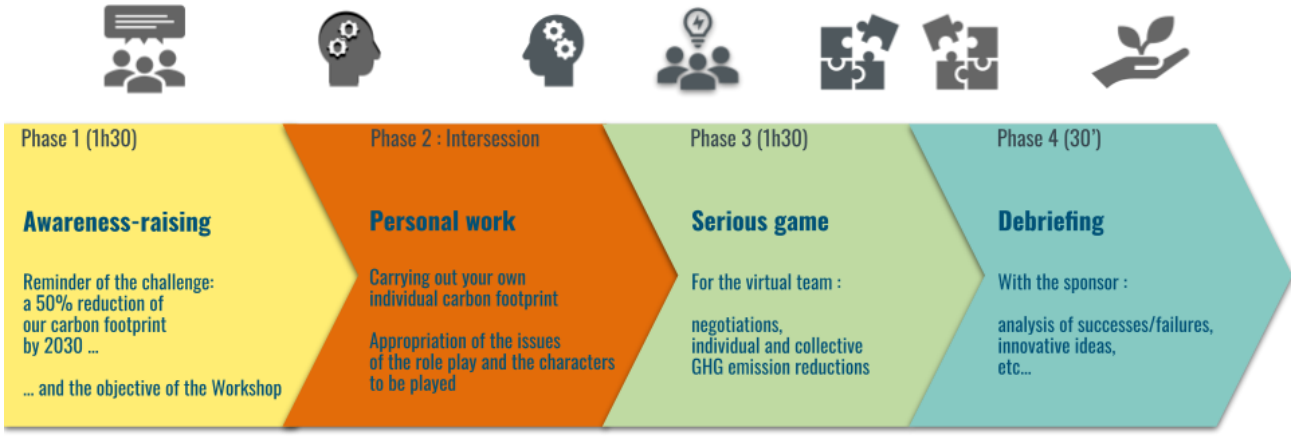

Fig 1. Timeline of the MaTerre180' Transition Support System (TSS). Each workshop is composed of four phases to raise awereness (phase 1), make some introspection (phase 2), participate to a role-playing serious game (phase 3) and debrief about results and postures (phase 4).

Phase 1: the awareness-raising phase.

This first phase intends to build a common background on the topic among participants, and to offer them the opportunity to know each other, a key prerequisite before the further discussions and negotiations. Phase 1 is based on a set of documents containing general ecological statements: the crossing of four of the nine global limits (Rockstrom et al. 2009[35]

627 ; Steffen et al. 2015[36]) and the theory of the doughnut economy (Raworth, 2012[37]). Then
628 follows a more specific section on climate change, with an overview on global temperatures
629 (https://showyourstripes.info/) and their possible evolution in France (Bador et al,
630 2017[38]). The rest of the awareness-raising documents deal more specifically with the
631 academic world, presenting the carbon footprint of some French research groups (IGE,
632 ISTerre and LOCEAN), the impact of some research activities at the individual scale (Berthoud
633 et al., 2019[39]) and the results of the survey on academic practices and awareness "Les
634 personnels de la recherche face au changement climatique" conducted by Labos 1point5
635 (Labos 1point5, 2020[40]). Emerging initiatives in some French research groups are then
636 presented. The awareness-raising phase ends with a debrief time for sharing feelings,
637 reactions, personal experiences and opinions through discussions. The next phases of
638 MaTerre180', including the role-playing phase, are also introduced during this first ninety
639 minutes session.
640 **Phase 2: the intersession phase.**
641 Participants are invited, in the few days between the two sessions, to calculate their personal
642 carbon footprint with an open access simulator
643 (https://avenirclimatique.org/micmac/simulationCarbone.php). They also familiarize
644 themselves with the two characters (char.) they will play during the role-playing (i.e. game-
645 based) phase, each related to a technicien, researcher, or professor profiles (see below).
646 **Phase 3: the role-playing phase.**
647 During the role-playing phase, five out of the six participants play the roles of two different
648 characters resulting from a fictitious research group. The sixth participant takes on the role of
649 team leader, which will be detailed hereafter.
650 Up to now, twelve virtual research teams, each composed of ten characters, have been
651 designed to simulate groups working on distinct topics with distinct approaches (laboratory

652 experiments, numerical simulations, field surveys…). Each of them has its own characteristics
653 and has been inspired from a real research group.
654
655 Their full description is available at https://materre.osug.fr/-Les-jeux-. Table 1 lists
656 the different virtual teams available so far, the team's initial GHG footprint and some
657 keywords related to the scientific topics addressed.
658
659 Table 1. List of the 12 available virtual teams with their characteristics.

Name of the virtual team	Initial GHG footprint (sum in tCO_2e/year for ten characters)	Topics and keywords
Climatology	42.0	Climate change, local field studies, glaciers, snow science
Geophysics	62.0	Earthquakes and volcanoes, near and far field studies, databases, modelling
Earth Dynamics	43.5	Near and far field studies, geochemistry, partnerships with southern countries
Environment	48.0	Environmental sciences, geochemistry, mineralogy, unique instrument, near and far field studies
International Joint Laboratory	78.0	International laboratory, partnerships with southern countries (e.g. in South-eastern Asia), oceanography campaigns, numerical

		modelling
Society and environment	68.0	Sociology, anthropology, ecology, near and far field studies, collaborations with Southern partners
Ocean & Climate	70.0	Oceanography, high sea missions, high performance computing
Computer science (Informatics)	58.0	Parallel programming, artificial intelligence, image processing
Water Resources	63.0	Hydrology, critical zone, field studies (e.g. in Patagonia), with strong partnership with European partners (e.g. France and Germany)
Development & Environment	53.0	Near and far field studies
Air quality	61.0	Geochemistry, near and far field studies, biological and chemical analysis
Technology & transition	63.0	Automation, signal processing, control

660

661

662 During phase 3, each participant received two cards describing his/her fictive
663 characters' and their respective activities. The set of 10 characters per virtual team includes
664 senior and junior permanent researchers, PhD and postdoc students, engineers, technical and

administrative staff. their links with the other team members, their academic reputation and lastly, their "ecological awareness profile" (EAP). There are five types of EAP, ranging from a person fully concerned about climate change and already involved in collective actions (profile "Time for actions"), to someone considering that his/her career and duties justify a high carbon footprint (profile "I make the difference"). A game facilitator is in charge of animating the game, and an advisor (ideally chosen outside of the academic community) brings his/her external vision on the discussions and comments on the final results of the negotiations. In total, eight people are involved during the role-playing phase : the game facilitator, five participants that embody the 10 characters, one participant acting as team leader and one adviser, which ensures rich and open-minded social interactions. In case of registered participants not showing-up during the role-playing phase (or unable to attend), the game can be played with down to four participants (instead of six), with some participants playing up to three characters and the team leader. Tokens, with a surface area proportional to the GHG emission (Table 2), visually represent the carbon footprint of various activities, each of them being symbolized by a specific icon.

Table 2. Token sizes, related CO_2e emissions and corresponding characteristics of emission sources considered so far (Mariette et al., 2021). Details on tokens can be found in appendix A.

Token Size	CO_2e emissions (in kg)	Characteristics of emission sources
Small	20	• 500 km journey by train
Medium	100	• 500 km journey by car • 2500 km journey by train
Large	500	• Short and medium-haul journey by plane • 300,000 hours of CPU calculation

		• 1 day of coastal ship mission
X-Large	3000	• Long-haul journey by plane • 1,800,000 hours of CPU calculation • 3 days of deep-sea ship mission

683

684 The activities considered in the different virtual teams available so far are listed in Table 3.

685 They will be further referred to as “emission motives”.

686

687 Table 3. Emission motives considered in the 12 virtual teams available so far

Emission Motives / Scientific activity	Description	Icon
Conference	Travel to a conference or workshop	
Jury	Travel to be part of a jury (thesis, accreditation to supervise research, recruitment)	
Institutional meeting	Travel related to meetings in the field of research organisation	
Project meeting	Travel related to the setting up of projects and their implementation	
Field trip	Travel to acquire field data on a specific area	
Instrument	Travel and use of (very) high technology and unique scientific instruments (e.g. particle collider)	

Expertise	Travel related to consultancy for a state, an NGO, etc.	
Training, capacity building	Travel for teaching, capacity building and summer school etc.	
Oceanographic campaign	Campaign at deep-sea or coast for measurements	
Computing	Modelling using high performance computing facilities	

The role-playing phase is described in Figures 1 and 2. It takes place in three sub-phases: a free negotiation phase (20 min), a phase of publication of results of research funding applications (about 10min), and a guided negotiation phase (25 min).

Fig 2. Digital interface used during the role-play phase. Example for the geophysics research team. The upper left hand panel is the bank of tokens, the lower left hand panel is the project's related tokens, the right hand panel is the area for low carbon alternatives. All research teams' interfaces are freely available from http://51.178.55.78/MT180/mt180.htm (the digital interface is coded in javascript).

During the "free negotiation" sub-phase, the virtual characters played by the participants discuss how to reduce by half the GHG footprint of their virtual research team. Each decision leads to an action: the game facilitator moves tokens on the virtual play mat, in or out of the game board and writes down the suggested alternatives through the digital interface (Fig 2). Tokens can be substituted by others of smaller sizes, for instance if an intra continental (or domestic) travel by plane is substituted by a train journey. All proposed alternatives are eligible as long as they are accepted by the game facilitator, and co-opted by the participants and the advisor. The free negotiation phase ends by a short debriefing (5-10 minutes) during which the mid-term GHG footprint is presented by the advisor. The advisor also comments on the negotiations, shares his/her feelings and motivates the team to go beyond the efforts already undertaken.

The funding application sub-phase then begins. Before the free negotiations sub-phase, the characters were given the possibility to apply for French (ANR) or European (ERC) research funds. Each application has a ⅙ probability of being awarded, close to the current real life situation in France. Handling such projects implies additional travels that were estimated at 4.0 and 8.0 tCO_2e per year for French (ANR) and European (ERC) projects, respectively. During the research funding application sub-phase, the results of the applications are published and presented by the facilitator. The success (or failure) of project application is determined by simply rolling a digital dice. Additional tokens are then granted

to the successful characters for each awarded project and displayed on the playmat, so that the GHG footprint of the team is increased.

Thirdly, the "guided negotiation" sub-phase led by the team leader takes place. He/she manages the negotiation phase as a research group leader and is free to choose his/her management strategy (authoritarian, consensual, persuasive…). This guided negotiation phase is also timed and lasts 25 minutes. At the end of the three sub-phases, the final GHG footprint is presented and a debriefing period starts.

The objective for the team is to perform their research while reducing the carbon footprint of their virtual team to a given target of fifty percent (50%). In MaTerre180' TSS, the role-playing phase allows participants to put their own research activities and professional constraints into perspective. Working in groups stimulates context-specific abstraction and active experimentation (Morris, 2020[41]).

Phase 4: the debriefing phase.

This last 30-minutes phase closes the workshop. During the debriefing phase, the advisor gives his/her opinion on the suggested alternatives, on the way the characters were played and on the highlights of the role-playing phase. The team, the facilitator and the advisor come back to the highlights, share their opinions on the game-based phase and discuss the relevance and robustness of the proposals made to reduce the research team GHG emissions.

c. Database management

The role-playing can take place in a classical – i.e., physical – way around a table with all the material previously prepared (game board, character cards, tokens). The role-playing can also be performed online on an open access digital interface (Fig 2 and http://51.178.55.78/MT180/mt180.htm).

In the digital interface, game information is recorded automatically. Each action (e.g. removing a token) is associated with the name of the character to whom the token belongs, the motive for the removal of the token and its value in kg CO_2e. Some additional information concerns the phase of negotiation (free or guided) during which the action was played, and whether the token was attributed as a success to a research project application (ANR or ERC projects), the name of the alternative to which the token was moved, the reduction in kg CO_2e induced by this alternative and the time in seconds at which the token was last moved.

Each record is then concatenated in a database to group together all the games that have been played. Four meta information are thus added to identify individual games. Lastly the category of the alternative (see section on "alternative categorization" below). The database obtained is then cross-referenced with another one containing information specific to each virtual team as described in section II A (initial CO_2 balance, characters, psychological profiles, etc.) for further analysis. This makes it possible, for example, to analyse the results by table, by character, by sessions of the workshop, or by alternatives, in order to pay attention to specific points and decision processes.

d. Alternative categorization

As mentioned above, the suggested alternatives that emerged were expressed freely by each individual participant. They cover a rich and varied lexical field that had to be categorized in order to analyse them. These alternatives (translated in the appendix B from French to English) were classified in nine categories that were neither too general nor too specific in order to obtain a fair balance in the information provided. This categorization stems from reading the recorded games by some experts, which consequently involves a degree of subjectivity. Categories are described in Table 4.

770 Table 4. Description of the alternatives' categories identified so far

Alternative category	Description
Video communication	All telecommunication activities between people, whether or not there is interaction. This includes video conferencing/communication, teleworking, e-learning such as Massive Open Online Courses (MOOCs), webinars, etc.
Mutualization	Pooling of a large diversity of activities. It includes the use of the terms: mutualization, merging, combination, pooling, association, grouping, etc.
Reduction/cancellation	Covers voluntary reduction of activity. It includes the words: cancellation, deletion, reduction, halving, etc.
Train / public transportation	Contains all plane or car trips replaced by train, long-distance buses and all types of public transportation.
Relocation	Brings the location of an activity at a closer distance, for example by preferring regional conferences or local field areas. This can be associated with the use of public transportation. The words used by participants can be: relocation, bringing closer, regional, local, etc.
Duration extension	Includes extension of the time spent on-site after travelling to avoid returning to the same place several times, or combination of several missions. Can sometimes be related to mutualization. This includes the terms: extension, expatriation, prolongation, long, duration, etc.

IT (Information Technology) optimization	Any solution that aims at reducing the energy consumption of intensive calculations, for example by making the codes less complex and/or better optimized. It covers the words: calculation, optimization, computing, data, etc.
Other	Includes some hardly classified alternatives and some original but infrequent ones. For example, the use of sailing boats for missions at sea, volunteer work or carbon offsetting inspired by Miyawaki forest restoration methods, etc.
Local Partners	Explicitly cite some local partners from foreign countries to mutualize some activities

771

772 ## e. Studied parameters

773 ### i. Trajectories of the different games, in terms of GHG footprint

774

775 For each game, we look at the evolution of its GHG footprint according to the
776 modifications (increase or reduction) of the absolute quantity of emissions Q_j^i in tCO_2e,
777 where subscripts refer to each specific sub-phase *j* and superscripts to the indvidualgame
778 number *i*.

779 Here, the potential emissions added or removed during the game, linked for instance
780 to new funded projects or to behavioural changes are taken into account in Q (e.g. using train
781 instead of aircraft for a domestic journey both introduces several tokens of 20 $kgCO_2e$ for the
782 train, the number depending on the distance, and removes the 500 $kgCO_2e$ token for the
783 plane).

- *Initial time (j = 0)*: the initial carbon footprint of the virtual team is equal to the initial GHG emission assigned to each game (see Table 2):

$$CF_0^i = Q_0^i$$

- *After the free negotiation phase (j = FN)*: the new carbon footprint CF_{FN}^i is obtained by subtracting the emission reductions Q_{FN}^i that were proposed during the free negotiation phase

$$CF_{FN}^i = Q_0^i - Q_{FN}^i$$

- *After results of ANR/ERC* project calls *(j =ANR/ERC)*: depending whether research projects are granted or not, an emission surplus $Q_{ANR/ERC}^i$ can be added to the carbon footprint before the guided negotiation phase:

$$CF_{ANR/ERC}^i = Q_0^i - Q_{FN}^i + Q_{ANR/ERC}^i$$

- *After the guided negotiation phase* ($j = GN = f$) : the final (index *f*) carbon footprint is calculated by subtracting the additional emission reductions Q_{GN}^isuggested

$$CF_{GN}^i = CF_f^i = Q_0^i - Q_{FN}^i + Q_{ANR/ERC}^i - Q_{GN}^i$$

These absolute *CF* can be converted into a cumulative relative reduction *R*, for the corresponding phase *j*, using:

$$R_j^i = \frac{CF_j^i - CF_0^i}{CF_0^i}$$

ii. Alternatives and motives : frequency, spontaneity and intensity of reductions

We also consider the amount of CO_2e avoided from the emission motive *m* to the alternative *a*. This allows us to describe in more detail pathways of GHG reductions for each emission motive and thus to deduce the total amount of GHG avoided by each alternative. It

802 will also help to describe whether the emission motives are removed to alternatives or
803 retained in the final GHG footprint of the team.

804 We define the frequency of a given alternative (see Table 4) as the ratio between the
805 number of games that have used this alternative and the total number of games. For motives
806 (Table 3) a weighted calculation of the frequency of appearance is applied, since games
807 present various initial types and numbers of activities.

808 Then, the spontaneity of the alternative (respectively motive) preferentially chosen
809 (respectively removed) is defined as the minimum time before it first appears (respectively,
810 is removed) in the game. This minimum time is then averaged for each variable to deduce its
811 average spontaneity.

812 Finally, we are interested in the GHG reduction intensity caused by an alternative or
813 motive, i.e. the ratio between the total absolute reduction and the number of tokens moved.
814 This allows us to estimate the ability of an alternative or the reduction motive to decrease
815 the team's GHG footprint more or less efficiently. Thus, the more this ratio tends towards
816 3000 kg CO_2e per token (activity of maximum CO2 emission for X-Large token, as presented
817 in Table 2), the more efficient the variable considered is, in terms of reduction intensity.

818

819 7. Competing interests

820 The authors have no conflicts of interest to declare that are relevant to the content of
821 this article.

822

823 8. Credit authorship contribution statement

824 Conceptualization, N.G., J.K., M.C., O.D., S.J., M.C., G.S., G.P., B.H., N.C., J.M. ; Methodology,
825 N.G., J.K., M.C., O.D., S.J., M.C., G.S., G.P., B.H., N.C., J.M.; Software, P.B. ; Supervision, N.G., A.D.

Visualization ,J.K., M.C. ; Investigation, all authors. Writing original draft, N.G., J.K., M.C., Writing review and Editing, all authors.

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11. Supporting information

S1. Details on tokens and characters of the "geophysics" research team.

The twelve research teams follow the same template

Details of character cards (typologies)

Recognition

Subjective evaluation of professional activity

★★★☆☆

50% top 30% top 5%

Scientist :

Bibliometry, h_i grade, etc.

Teacher Researcher :
Science + Courses

ST/SA :
Skills recognition by peers

Psychological profile of character

I make the ≠
Leader in his community, an active and structuring member, who can (or not) think that his dynamism exempts him from the sobriety of air travel. He/she believes in technology to get us out of the climate mad

What's the point ?
Rather follower. Sensitive to environmental issues, but puzzled : what's the point ? If all other countries do not get involved, the efforts will be in vain.

Concerned
Aware of the climate emergency. He/she has started to question his practices, but not sure where to start.

Colibri Every single drop
Sensitive to environmental issues, and involved in practical and conscience changes.

Activist
Aware of the climate emergency, involved personally and in collective actions to try to change the system.

Travel goals

Conferences,
International workshops

Formation en présentiel,
Ecoles d'été, rfct capacité

Field mission, on large instruments or in other labs
Measurements, data collection, surveys, etc.

Institutional
Meeting, in the field of research and its organization. ANR member, etc., project review, specialist comission

Jury
Thesis defence, recrutement jury, HDR

Expertise
For a NGO, a state, etc. Societal application.

Setting up (and monitoring) of projects
Meetings for editing, monitoring, feedback (excluding conferences)

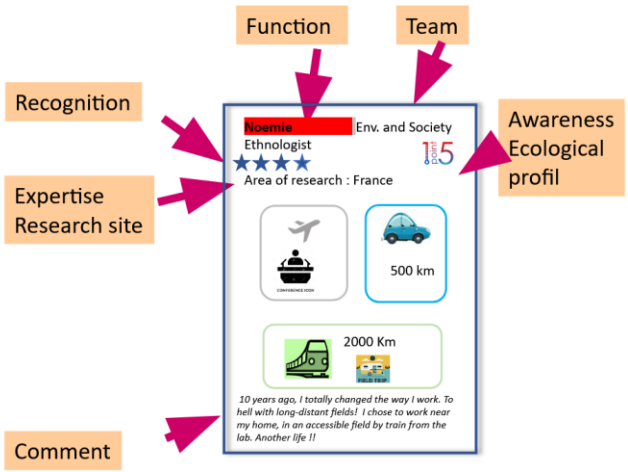
Other emitting activities

Sea missions

Modelling

955

956



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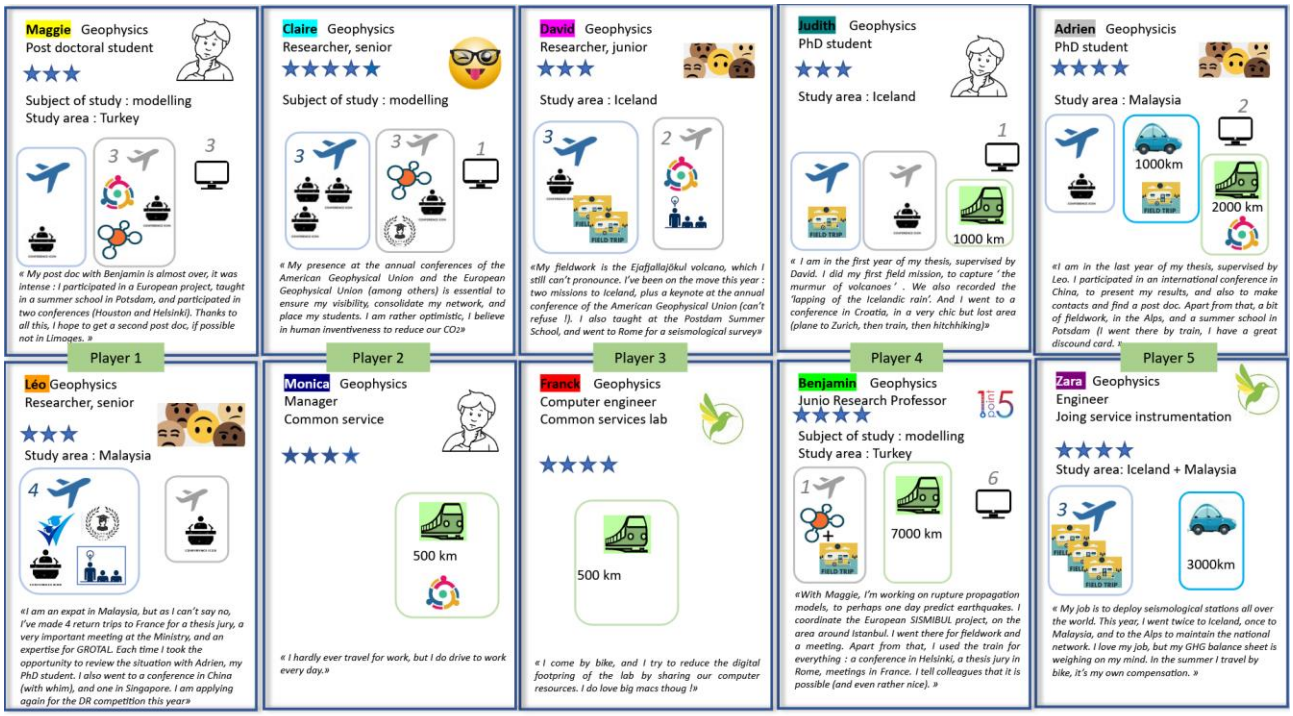
Maggie Geophysics
Post doctoral student
Subject of study : modelling
Study area : Turkey
« My post doc with Benjamin is almost over, it was intense : I participated in a European project, taught in a summer school in Potsdam, and participated in two conferences (Houston and Helsinki). Thanks to all this, I hope to get a second post doc, if possible not in Limoges. »
Player 1
Claire Geophysics
Researcher, senior
Subject of study : modelling
« My presence at the annual conferences of the American Geophysical Union and the European Geophysical Union (among others) is essential to ensure my visibility, consolidate my network, and place my students. I am rather optimistic, I believe in human inventiveness to reduce our CO2»
Player 2
David Geophysics
Researcher, junior
Study area : Iceland
«My fieldwork is the Ejafjallajökul volcano, which I still can't pronounce. I've been on the move this year : two missions to Iceland, plus a keynote at the annual conference of the American Geophysical Union (can't refuse !). I also taught at the Postdam Summer School, and went to Rome for a seismological survey»
Player 3
Judith Geophysics
PhD student
Study area : Iceland
1000 km
« I am in the first year of my thesis, supervised by David. I did my first field mission, to capture ' the murmur of volcanoes ' . We also recorded the 'tapping of the Icelandic rain'. And I went to a conference in Croatia, in a very chic but lost area (plane to Zurich, then train, then hitchhiking)»
Player 4
Adrien Geophysicis
PhD student
Study area : Malaysia
1000km
2000 km
«I am in the last year of my thesis, supervised by Leo. I participated in an international conference in China, to present my results, and also to make contacts and find a post doc. Apart from that, a bit of fieldwork, in the Alps, and a summer school in Potsdam (I went there by train, I have a great discound card. »
Player 5
Léo Geophysics
Researcher, senior
Study area : Malaysia
«I am an expat in Malaysia, but as I can't say no, I've made 4 return trips to France for a thesis jury, a very important meeting at the Ministry, and an expertise for GROTAL. Each time I took the opportunity to review the situation with Adrien, my PhD student. I also went to a conference in China (with whim), and one in Singapore. I am applying again for the DR competition this year»
Monica Geophysics
Manager
Common service
500 km
« I hardly ever travel for work, but I do drive to work every day.»
Franck Geophysics
Computer engineer
Common services lab
500 km
« I come by bike, and I try to reduce the digital footpring of the lab by sharing our computer resources. I do love big macs thoug !»
Benjamin Geophysics
Junio Research Professor
Subject of study : modelling
Study area : Turkey
7000 km
«With Maggie, I'm working on rupture propagation models, to perhaps one day predict earthquakes. I coordinate the European SISMIBUL project, on the area around Istanbul. I went there for fieldwork and a meeting. Apart from that, I used the train for everything : a conference in Helsinki, a thesis jury in Rome, meetings in France. I tell colleagues that it is possible (and even rather nice). »
Zara Geophysics
Engineer
Joing service instrumentation
Study area: Iceland + Malaysia
3000km
« My job is to deploy seismological stations all over the world. This year, I went twice to Iceland, once to Malaysia, and to the Alps to maintain the national network. I love my job, but my GHG balance sheet is weighing on my mind. In the summer I travel by bike, it's my own compensation. »

961 **S2. Details on the 2241 expressed alternatives**

962

Expressed alternative by recurrence (in french)	Expressed alternative (translated in english with DeepL ©)	Categories of alternatives
visio	videoconference	video communication
visiconférence	videoconferencing	video communication
télétravail	teleworking	video communication
travail à distance	telework	video communication
télétravail victoria	telework victoria	video communication
en visio	videoconferencing	video communication
réunions visio	video meetings	video communication
visio conférence	video conference	video communication
visioconf	visioconf	video communication
conf en visio	videoconference	video communication
visios	visios	video communication
téléphone	telephone	video communication
distanciel	remote	video communication
vidéo-conférences	video conferencing	video communication
visio-conf	videoconferencing	video communication
visio sous conditions acceptables	visio under acceptable conditions	video communication
conférence visio	video conference	video communication
jury en visio	visio jury	video communication
visio 1 an sur 2	visio 1 year out of 2	video communication
jury en ligne	online jury	video communication
conférence en ligne	online conference	video communication
formation en visio	video training	video communication
jury de thèse fait en visio / conference en visio	thesis jury made in visio / conference in visio	video communication
montage de projet visio outil collaboratif en ligne	visio project set-up online collaborative tool	video communication
réunions en visio	video meetings	video communication
conf vidéo	video conference	video communication
visio / distanciel	visio / distance learning	video communication
activités en visio	visio activities	video communication
atelrner en présentiel/visio 1 an/2	face-to-face/visio training 1 year/2	video communication
formation visio	video training	video communication
projet en distanciel	remote project	video communication
covid visio	covid visio	video communication
laisse doctorant y aller et suit en visio	let doctoral student go and follow in visio	video communication
réalité augmentée	augmented reality	video communication
en formation en visio	visio training	video communication
formation en distanciel	distance learning	video communication
a distance	distance learning	video communication
fabrication mooc	making mooc	video communication
jury, réunions en ligne	jury, online meetings	video communication
visio conference	videoconferencing	video communication
visio pour montage de projet	visio for project set-up	video communication
visio ou train	visio or train	video communication
enseignement à distance	distance learning	video communication
e learning	e-learning	video communication

organiser ses propres conf en visio	organising your own conferences by videoconference	video communication
visio / refus (distance)	visio / refusal (distance)	video communication
suivi projet en visio	project follow-up by video	video communication
vidéo-jury	video jury	video communication
réunion réseautage en zoom	networking meeting in zoom	video communication
formation à distance	distance learning	video communication
montage de projet en visio	setting up a project by video	video communication
mooc	mooc	video communication
pas de déplacement : visio	no travel: video	video communication
projet sur site plus que par deplacement	project on site rather than by travel	video communication
une conférence en visio	a conference by videoconference	video communication
train	train	public transportation
avrion -> train	avrion -> train	public transportation
train au lieu de voiture	train instead of car	public transportation
avion -- train	plane -- train	public transportation
voyage en tran	travel by tran	public transportation
voiture pour train	car for train	public transportation
train au lieu d'avion	train instead of plane	public transportation
voiture ->train/vélo	car ->train/bike	public transportation
train (de nuit, confortable)	train (night, comfortable)	public transportation
dépalcement rain	depalcement rain	public transportation
alternative train	alternative train	public transportation
remplacement train	train replacement	public transportation
remplacement par du train	replacement by train	public transportation
voiture > train	car > train	public transportation
rempalcement avion par train	replacement plane by train	public transportation
en train	by train	public transportation
moyen courrier pour train	medium-haul to train	public transportation
rempalcer avion par train	repalcement plane to train	public transportation
train plutôt qu'avion	train instead of plane	public transportation
remplacer l'avion par le train	replace plane with train	public transportation
train ou train plus avion	train or train plus plane	public transportation
voiture ->train/vélo	car ->train/bike	public transportation
passage au train	switch to train	public transportation
remplacement	replacement	public transportation
faire du train au lieu de l'avion	use train instead of plane	public transportation
train plutôt qu'avion	train instead of plane	public transportation
voiture ou avion ->train	car or plane ->train	public transportation
convertir avion contre train	convert plane to train	public transportation
voiture -> train	car -> train	public transportation
train à l aplace avion	train instead of plane	public transportation
changement avion ->train	change plane -> train	public transportation
changement transport	change transport	public transportation
dépalcements France en train	transfer France to train	public transportation
transfert en train	transfer by train	public transportation
voiture =>train	car =>train	public transportation
remplacement par train	replacement by train	public transportation
voiture --> rer	car --> train	public transportation

avion vers train	plane to train	public transportation
avion > train	plane > train	public transportation
délégation (avion ->train)	delegation (plane ->train)	public transportation
interdire trajet en avion en France ou à moins de x heures	no air travel in France or within x hours	public transportation
train pour voiture	train to car	public transportation
voiture devient train	car to train	public transportation
mutualisation	mutualisation	mutualization
mission combinée	combined mission	mutualization
mutualisation des campagnes	mutualisation of campaigns	mutualization
1 déplacement pour 2 objectifs	1 trip for 2 purposes	mutualization
mutualiser les déplacements	pooling of trips	mutualization
regroupement missions	grouping of missions	mutualization
mutualisation campagnes chercheur/ingé	mutualisation of researcher/engineer campaigns	mutualization
mutualisation des campagnes en mer	pooling of campaigns at sea	mutualization
mutualiser les déplacements	pooling of trips	mutualization
regroupement	grouping	mutualization
mutualisation campagne	campaign pooling	mutualization
mutualisation des activités	activity sharing	mutualization
groupe les déplacements	group travel	mutualization
mutualisation déplacements	travel sharing	mutualization
mutualisation sorties en mer	mutualisation of sea trips	mutualization
mutualisation réseau conf	mutualisation network conf	mutualization
mutualisation campagne avec romain : 1 campagne collective	mutualisation campaign with romain : 1 collective campaign	mutualization
2 en 1	2 in 1	mutualization
combinaison de missions	combination of missions	mutualization
partage programme (mutualisation mesures en mer)	programme sharing (mutualisation of measurements at sea)	mutualization
mutualisation dépalcement	mutualisation depalcement	mutualization
mutualiser les simulations	pooling simulations	mutualization
regrouper missions de terrain	pooling field missions	mutualization
augmenter le personnel sur le bateau	increase staff on the ship	mutualization
combine montage projet/terrain/avec conf	combine project/field/conference set-up	mutualization
regroupement missions en mer	grouping of missions at sea	mutualization
mutualisé avec d'autres missions	shared with other missions	mutualization
mutualisation des trajets	pooling of trips	mutualization
réorganisation : regroupement	reorganisation: regrouping	mutualization
mutualisation projet	project pooling	mutualization
combinaison de déplacement	combination of trips	mutualization
cumul de missions	combining assignments	mutualization
combiner collaboration/jury?	combining collaboration/jury?	mutualization
groupement missions	grouping missions	mutualization
mutualisation avec antoine	mutualisation with antoine	mutualization
mutualisation conf/instruments	pooling of conferences/instruments	mutualization
mutualisation de réunions de projet	mutualisation of project meetings	mutualization
mutualisation des terrains	pooling of land	mutualization
mutualiser deux dépalcements	mutualisation of two depalings	mutualization
mutualiser les missions de terrain	mutualisation of field missions	mutualization

mutualisaiton externe	external mutualisation	mutualization
mutualisaiton avec charles	mutualisation with charles	mutualization
délégation avec doctorants qui sera présent	delegation with PhD students who will be present	mutualization
présentation d'un collègue en conférence	presentation of a colleague at a conference	mutualization
rempalcement bateau et mutualisation	boat repalcement and mutualisation	mutualization
mut. Terrain/projet	mutualisation. Field/project	mutualization
mutualisation déplacements	mutualisation of travel	mutualization
jury en visio	visio jury	mutualization
judith y va ça suffit	judith y va ça suffit	mutualization
combinaison réunion/jury	meeting/jury combination	mutualization
mutualisation formation/conf	mutualisation training/conf	mutualization
mutualisé avec d'autres missions	shared with other missions	mutualization
regroupement national	national grouping	mutualization
mutualise conf école d'été	mutualise conf summer school	mutualization
délégation	delegation	mutualization
mutualisation conférence	mutualisation conference	mutualization
délégation/formation	delegation/training	mutualization
mutualisation conf projet	mutualisation project conference	mutualization
mutualisation soutenance projet	mutualisation project defense	mutualization
combiner terrain conférence	combine field conference	mutualization
déplacements combinés	combined travel	mutualization
formation de vinh sur le terrain	vinh field training	mutualization
mission à la suite (2 tâches)	back-to-back assignments (2 tasks)	mutualization
mutualisation des dépalcements	mutualisation of depalletisations	mutualization
mutualisation des moments	mutualisation of moments	mutualization
mutualisation manip	pooling of handling	mutualization
regroupement d'activités	grouping of activities	mutualization
regroupement dépalcement	grouping of depalcement	mutualization
mutualisation cotutelle thèse	pooling of thesis co-tutoring	mutualization
fusion de mission	merger of missions	mutualization
je ne vais pas à la conf (david y va)	I don't go to the conference (David goes)	mutualization
missions regroupées	grouped missions	mutualization
mutualisation avec collègue	mutualisation with colleague	mutualization
mutualisation et délégation	mutualisation and delegation	mutualization
mutualisation formation terrain	mutualisation of training in the field	mutualization
coupler	coupling	mutualization
moitié presentiel moitié distanciel	half face-to-face and half distance learning	mutualization
deux missions en une	two missions in one	mutualization
choix doctorant ou encadrant	choice of doctoral student or supervisor	mutualization
mutualisation pour une conférence	pooling for a conference	mutualization
regrouper les missions	group the missions together	mutualization
plusieurs présentations sur meme conférence	several presentations at the same conference	mutualization
mise en commun formation	pooling of training	mutualization
représentation autre collègue	representation of other colleagues	mutualization
mutualisation avec collèuge/visio	pooling with colleague/visio	mutualization
en meme temps qu'une conférence	at the same time as a conference	mutualization
cobiner 2 terrains	cobining 2 fields	mutualization
avec le post doc sur le terrain	with the post doc in the field	mutualization
étudiant présentant les résultats	student presenting results	mutualization
héloise le représentera	héloise will represent him	mutualization

mission réalisée par étudiant	mission carried out by student	mutualization
mutualisation personnelle	personal sharing	mutualization
optimisation des activités	optimisation of activities	mutualization
rester plus longtemps sur place	stay longer on site	mutualization
le post doc assure le remplacement	the post doc provides a replacement	mutualization
regroupement de missions	grouping of assignments	mutualization
reorga des terrains	reorga of land	mutualization
vers julien	to julien	mutualization
annulation	cancellation	reduction cancellation
suppression	cancellation	reduction cancellation
annulation 1 conf internationale/personne	cancellation 1 international conference/person	reduction cancellation
supprimer	delete	reduction cancellation
annulé !	cancelled!	reduction cancellation
suppriession conférence	deletion conference	reduction cancellation
réduction activité	reduction of activity	reduction cancellation
renoncer aux dépalcements	no more depalletising	reduction cancellation
moins de simulations	fewer simulations	reduction cancellation
restriction activité	activity restriction	reduction cancellation
réduction nb conférences	reduction in number of conferences	reduction cancellation
suppression mais?	suppression but?	reduction cancellation
1 campagne tous les 2 ans	1 campaign every 2 years	reduction cancellation
quota	quota	reduction cancellation
renonce aux missions en mer	renounces missions at sea	reduction cancellation
une année sur deux	every other year	reduction cancellation
annulation(réduction de missions)	cancellation (reduction of missions)	reduction cancellation
alternance un an sur deux	alternating every other year	reduction cancellation
annulation de déplacement	cancellation of travel	reduction cancellation
partage ou réduit 50%	split or reduced by 50	reduction cancellation
retour à la mision ini	return to original assignment	reduction cancellation
diminution	reduction	reduction cancellation
règle 1 conf/an	rule 1 conf/year	reduction cancellation
partage 1 an / 2	sharing 1 year / 2	reduction cancellation
réduction	reduction	reduction cancellation
conf 1 an /2	conf 1 year /2	reduction cancellation
1an sur 2	1 year out of 2	reduction cancellation
1 année sur 2	1 year out of 2	reduction cancellation
1 fois sur 2	1 time out of 2	reduction cancellation
1 seul auteur à la foncérence	only 1 author at a time	reduction cancellation
report d'achat	postponement of purchase	reduction cancellation
suppression d'une présence sur manip, mutualisation encadrement	suppression of a presence on manipulation, mutualisation of management	reduction cancellation
abandon de conférence	abandonment of conference	reduction cancellation
mission à discuter si mainteanue ou pas	mission to be discussed whether to continue or not	reduction cancellation
consignes internes	internal instructions	reduction cancellation
report 1 sur 2	postponement 1 on 2	reduction cancellation
étaler dépalcements (1 an/2)	spread out the shifts (1 year/2)	reduction cancellation
règle : une conf long courrier par an	rule: one long-distance conference per year	reduction cancellation
suppression formation	suppression of training	reduction cancellation
abandon-délégation au doctorant	abandonment-delegation to doctoral student	reduction cancellation

compte rendu	report	reduction cancellation
supprime conference	delete conference	reduction cancellation
renoncement	waiver	reduction cancellation
espacement	spacing	reduction cancellation
idée du RE avoir 1 long courrier autorisé	idea of BR having 1 long mail allowed	reduction cancellation
conf->journal	conf->journal	reduction cancellation
activité une année sur deux	activity every other year	reduction cancellation
formation complète dans 2 ans	full training in 2 years	reduction cancellation
#ERROR!	#NAME?	reduction cancellation
1 année sur 2	1 year out of 2	reduction cancellation
moins de simus	less simus	reduction cancellation
renoncer au montage de projets nationaux	give up on national project development	reduction cancellation
terrain 1 année sur 2	field 1 year out of 2	reduction cancellation
datacenter responsable	responsible datacenter	Information technology
optimisation temps de calcul	optimise computing time	Information technology
chercher centre de calcul plus faible	look for a lower computing centre	Information technology
mutualisation ménage stockage	pooling of household storage	Information technology
faire durer le matériel/efficacité	make hardware last/efficiency	Information technology
cluster informatique	computer cluster	Information technology
mise en commun des simus	pooling of simus	Information technology
formation optimisation calcul	training in computing optimisation	Information technology
bonnes pratiques calcul	good computing practices	Information technology
formation pour optimisation du code	training for code optimisation	Information technology
importation des calculs au centre externe	importing calculations to the external centre	Information technology
rationnaliser	streamline	Information technology
partenariats et opti pour le calcul	partnerships and opti for computing	Information technology
améliorer la gestion des données	improve data management	Information technology
optimisation temps de calcul	optimisation of calculation time	Information technology
optimisation moins de calcul	optimise less computation	Information technology
optimisation de code	code optimisation	Information technology
réduction calcul	calculation reduction	Information technology
mutulasiation calculs	calculation mutulasiation	Information technology
optimisation calculs	optimisation calculations	Information technology
réduction/mutualisation calculs	reduction/mutualisation calculations	Information technology
amélioration calcul	calculation improvement	Information technology
transfert calcul intensif	transfer intensive calculation	Information technology
modèle plus rentable et plus efficace	more cost-effective and efficient model	Information technology
mieux préparer ses simulations	better preparation of simulations	Information technology
mutualisation de simulations	sharing of simulations	Information technology
mutualiser modélisation	mutualisation of modelling	Information technology
stockage sur le Laboratoire mixte international (quid de la sécurisation)	storage on the International Joint Laboratory (what about security)	Information technology
optimisation code info	optimisation of info code	Information technology
optimisaiton code/accélération	code/acceleration optimisation	Information technology
mutualisation heure de calcul	pooling of computing time	Information technology
non renouvellement	non-renewal	Information technology
optimisation de calculs	optimisation of calculations	Information technology
charte gestion données	data management charter	Information technology
mutualiation/optimisation	mutualisation/optimisation	Information technology

travail mutualisation calcul	work sharing calculation	Information technology
mix energetique meilleur	better energy mix	Information technology
utilisation rationnelle du réseau	rational use of the network	Information technology
optimisation code info	optimisation info code	Information technology
optimisation informatique	IT optimisation	Information technology
renoncement gros calculs	renunciation of large calculations	Information technology
data center plus écolo	greener data centre	Information technology
utiliser les serveurs locaux	use local servers	Information technology
covoiturage ou train	carpooling or train	others
covoiturage	carpooling	others
missions aux plus jeunes	missions to young people	others
mission bateau moins emettrice	less emissive boat mission	others
dans l'année pour échanger	in the year to exchange	others
avancée techno (capteurs)	technical progress (sensors)	others
mutualisation perso des déplacements	personal sharing of journeys	others
voiture	car	others
choix selon arbre de décision	choice according to decision tree	others
coivoiturage terrain	carpooling in the field	others
ordinateur plus éconoe en énergie	more energy efficient computer	others
télétransimission de données	remote data transmission	others
transport public	public transport	others
changement de techno	change of technology	others
vélo électrique (châteaux de la loire!)	electric bike (châteaux de la loire!)	others
transmission à Boris	transmission to Boris	others
innovation technologique	technological innovation	others
bénévole !	volunteer!	others
compensation (impact ?)	compensation (impact ?)	others
compensation (plantation miyawaki)	compensation (miyawaki plantation)	others
covoiturage mission	carpooling mission	others
déplacement domicile travail	commuting to work	others
prendre en compte le carbone projet lors soumission	take into account the carbon project when bidding	others
vacances ?!	holiday ?!	others
vélo électrique (châteaux de la loire!)	electric bike (châteaux de la loire!)	others
mission longue durée	long term mission	duration extension
mission longue durée	long term mission	duration extension
une année sur deux durée plus longue	every other year longer	duration extension
allongement travail terrain	longer field work	duration extension
rallongement timing mission (télétravail)	longer mission timing (teleworking)	duration extension
allongement de la durée sur place	extension of the duration on site	duration extension
plusieurs missions à mission longue durée	several long-term assignments	duration extension
ralllonger les missions	lengthen missions	duration extension
encourage la longue durée sur le terrain	encourage long duration in the field	duration extension
séjours longs	long stays	duration extension
missions plus longues dans le temps	longer missions in time	duration extension
rallonger les missions terrain	extend field missions	duration extension
allongement de mission	extension of missions	duration extension
passer un an de thèse en islande	spending a year of thesis in Iceland	duration extension

expatriation de trois ans	three-year expatriation	duration extension
optimisation travail terrain	optimisation of fieldwork	duration extension
misison longue durée (couplage terrain/conf)	long term mission (coupling field/conf)	duration extension
séjour plus long	longer stay	duration extension
long séjour	long stay	duration extension
allongement temps terrin	extension of field time	duration extension
rallongement mission	extension of mission	duration extension
train conf plutôt en europe	train conf rather in europe	relocation
tournée egu/agu et train	egu/agu and train tour	relocation
conférence plus proche	closer conference	relocation
conf locale	local conference	relocation
multi-localisation	multi-location	relocation
changement zone d'étude	change study area	relocation
échange pour proche	exchange for nearer	relocation
relocalisation	relocation	relocation
amplifer réseautage proche	amplify networking close by	relocation
conférence moins loin (europe)	conference less far (europe)	relocation
plus près !	closer !	relocation
utilisation cluster existant	use existing cluster	relocation
europe	europe	relocation
choi de conférence proche	choice of nearby conference	relocation
privilégier le "local"	focus on "local	relocation
conférence moins loin	conference less far away	relocation
changement par plus petit	change to smaller	relocation
vers plus proche	to closer	relocation
invitation network local	invitation network local	relocation
activité en local	local activity	relocation
changement de terrain d'étude	change of study area	relocation
changement lieu de manip	change of handling place	relocation
changement d'école d'été pour une destination plus proche	change of summer school to a closer destination	relocation
conference plus proche	closer conference	relocation
un projet moins loin, ou le spprimer	a project less far away, or compress it	relocation
hub local d'une conf lointaine	local hub of a distant conference	relocation
organiser des conférences en europe	organise conferences in Europe	relocation
remplacer en grenoble	replace in grenoble	relocation
conférence équivalente dans la région	equivalent conference in the region	relocation
soutien local	local support	local partners
transfert de compétences	transfer of skills	local partners
renforcement staff local	strengthening local staff	local partners
délégation à partenaires locaux	delegation to local partners	local partners
formation de partenaires locaux	training of local partners	local partners
formation à l'expertise sur place	training of local expertise	local partners
maintenance voyage un an sur deux	travel maintenance every other year	local partners
cotutelle	cotutelle	local partners
déléguer les tâches	delegate tasks	local partners
formation	training	local partners
développer webinar mooc	develop webinar mooc	local partners

quelqu'un sur place fera le terrain	someone on site will do the groundwork	local partners
collaboration partenaires locaux	collaboration with local partners	local partners
partenariat délégation	partnership delegation	local partners
renforcement foramtion locaux	strengthening local training	local partners
avec partenaire locale	with local partner	local partners
quelqu'un sur place	someone on site	local partners
participation terrain	field participation	local partners
quelqu'un sur place (prélèvement)	someone on site (sampling)	local partners
collaboration locaux	local collaboration	local partners
avec un partenaire local	with local partner	local partners
compétences sur site	on-site expertise	local partners
collaborateurs locaux	local staff	local partners
remplacer par moyen courrier	replace by mid-distance flight	local partners

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S3 Gender distribution by sessions : female and male for both facilitators and participants are reported in orange and green horizontal bars, respectively