Assessing the carbon footprint of a large international research program: study case of the BRIDGES kick-off meeting

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Abstract

There is a rising concern in the academic community about the environmental impact of research activities. Carbon footprints are typically evaluated at the laboratory or institutional level, but there are lacking an evaluations at the level where research is actually performed, i.e. at the level of research projects. In this work, we focus on the french BRIDGES international research program as a study case. We evaluate the carbon footprint of its kick-off meeting held in 2024 in the island of La Réunion, a French oversea territory located in the Indian Ocean. We report that the organization of the meeting emitted 100±37 t CO2eq. for 112 participants, mainly dominated by air travels. We then discussed that organizing this meeting in Paris would have emitted 2.5 times more greenhouse gas than in La Réunion. We discuss mitigation strategy for future meetings, including an optimized venue, where the location of the meeting is defined only after the participants are known, to minimize the carbon footprint of air travels. We also evaluate the carbon footprint of combining travels with other scientific objectives, by extending the duration of the accommodation and compared it with the one of doing a second air travel.

Author summary

BRIDGES is a large international research program, funded for ten years (2024-2034), which aims at studying the consequence of global warming and creating solutions against the environmental crisis on the marine biodiversity and fisheries in the Southwest Indian ocean. Our interdisciplinary team aims at monitoring and decreasing its carbon footprint over the duration of the project. This represents a challenge: studying the consequences and adaptation to global warming has a high societal impact, but it should be done by minimizing its contribution to global warming or other environmental impacts. The organization of scientific meeting, as detailed in this paper, is one of the important step of scientific research, as it allows partners to have face-to-face discussions, share their results, and brainstorm efficiently. However, this comes with a cost of a high climate impact, especially for such an oversea collaboration. In this paper, we are discussing the optimal organization of scientific meetings with respect to their climate impact. This work is a first study of the BRIDGES research project. Follow-up work will further evaluate the total carbon footprint of the whole program, and its mitigation strategy.

Introduction

The Intergovernmental Panel on Climate Change (IPCC) +1.5ºC special report [1] triggered a growing concern from the academic community about the environmental impact of their research activities [2, 3]. This response was particularly important in environmental sciences and research fields studying the consequences of climate change, but led to a growing awareness from the broader scientific community about the carbon footprint of their work [4–7], and more generally about the paradoxical adverse environmental impacts of their work [8]. From the travel required to participate to international academic meetings (an estimated 10,000-15,000 km/year/capita; [2, 9, 10]), to the use of large scientific equipment on the ground (e.g., ships in marine science [11], particle accelerators [12] and telescopes [13] in physics) or from space [14], the increasing use of artificial intelligence in many disciplines [15], and purchases made by scientists [16], the average carbon footprint of a scientist far exceeds that of an average citizen [17]. This disparity has been found to undermine the credibility of research related to climate change and its impacts [18].

The last decade witnessed the emergence of initiatives, groups, and tools that help measure and reduce the carbon footprint of academic research [19]. If some research organizations now regularly assess their annual carbon footprint, changing practices is not without obstacles and can require compromises and finding new ways to do science. Most carbon footprint assessments are conducted at the level of institutions [5], research laboratories [20], infrastructures [21], or individuals [7]. However, research is mostly organized into projects and programs, usually responding to specific funding calls. Thus, it would be useful to assess the carbon footprint of such projects and programs, not only to offer a more operational tool to project leaders, but also to inform the funders [22].

Here, we report on efforts done by the BRIDGES research program[1], one of 19 large "PEPR Exploratoire" funding from the French government that involves more than 150 scientists. BRIDGES is one of the few large French research programs that designs an explicit carbon reduction strategy and dedicates an entire work package in the targeted project BRIDGES-IMPACT. This 10-year interdisciplinary research program explores questions of transformations of marine social-ecological systems in the southwest Indian Ocean (SWIO) region, including France's overseas territories (i.e., La Réunion, Mayotte, and the Scattered islands), Comoros, Mozambique, and stakeholders from the SWIO in general. BRIDGES involves very diverse scientists (e.g., ecologists, sociologists, geographers, data scientists), requiring strong field work and data modeling for their activities.

Reducing the carbon footprint of such a research program contributes to the challenges of conserving coastal biodiversity and fisheries resources. Indeed, marine biodiversity is directly affected by human activities [23]. About two thirds of anthropogenic greenhouse gasses (GHG) released into the atmosphere are absorbed by the ocean, hence increasing its acidity [24]. This ocean acidification reduces the capacity of many marine species to form their calcium-based shell, including plankton, benthic mollusks, echinoderms, and corals [25]. Thus, ocean acidification disturbs the marine food chain and the overall

[1] https://www.bridges-wio.com/

biodiversity of the ocean. By absorbing approximately 90% excess heat trapped in the atmosphere of the Earth [26], the ocean is also heated up by a warmer climate, further perturbing the marine species. These effects impact fishing capacity, as well as the subsequent economic and social consequences for coastal populations that rely on it in their daily life [27]. The SWIO is also a hotspot for climate change [28], with increased air and water temperature, accelerated acidification, and intensification of heat waves, rainfall, and hurricanes. All of these are the consequences of extensive use of fossil resources by humans, which in turn destabilize the social-ecological systems of the region. In this context, the BRIDGES research program aims to find solutions to the conservation of biodiversity as well as to equitable and sustainable fishing in the SWIO.

Because most of BRIDGES' scientists are located in metropolitan France (i.e. mainland), it makes it challenging to create low-carbon project and sound, cooperative scientific partnership associated with the need to create meaningful connections with partners beyond academia (e.g., governments, non-governmental organizations).

One of the first actions of BRIDGES was to organize a kick-off meeting on the island of La Réunion in September 2024. Given the project's focus on the SWIO region, it was important to organize this meeting in the SWIO region and not in metropolitan France, such as Paris. Many BRIDGES members raised, prior to the event, the questions about the large carbon footprint related to such an overseas event, but it was thought that the benefits of doing it in La Réunion justified doing the event there. This paper presents the GHG emissions of the BRIDGES' kick-off meeting after a brief outline of the method used. Finally, it discusses a mitigation plan for the organization of future BRIDGES meetings and beyond.

Materials and methods

BRIDGES' kick-off meeting was held on September 25-26th 2024 in Saint-Paul, La Réunion (France). We evaluated its carbon footprint for the following sources of GHG emissions:

- Travel of the participants to the meeting venue;
- Accommodation of the participants;
- Catering;
- Videoconferencing for remote participants.

Other sources of GHG emissions, such as those associated with the building (e.g., electricity, construction), small purchases for the participants (e.g., goodies, name tags), were considered negligible. We gathered data from the meeting organizers, including the in-person and remote participants' list, and the number of meals served. The meals taken by the participants in local restaurants were not considered. In the following, we describe the method used to evaluate the GHG emissions for each of these sources.

Travels to the meeting venue

To evaluate the GHG emissions related to participants' travel, we followed the method adopted by Labos 1point5 [19]. From the list of in-person participants, we computed the great-circle distance from the city of their institute to La Réunion and added 95 km as recommended by the french norm *EN16258*. We assumed GHG emissions factors for air travel with condensation trails of 0.258, 0.187, 0.152 kg CO2eq.km^{-1}, for short (<1000 km), medium (<3000 km) and long-haul (>3000 km) flights, respectively. These emission factors have 37% uncertainty [19]. We assumed that the participants made a direct, dedicated round trip to La Réunion. Connecting flights are unknown and hence not considered here.

For the participants located in La Réunion, we computed the distance by road (i.e., the only transportation option) from Saint-Denis, the island's main city, to the meeting venue in Saint Gilles. We assumed that local participants came by car without carpooling for each day of the meeting. We used a GHG emission factor of 0.2156 kg CO2eq.km^{-1} (with 60% uncertainty [19]) of an average car [19].

The work location of the attendees in-person, their distance to the venue, together with the number of participants and their associated GHG emissions are listed in Table 1.

Table 1. Data for the in-person participants

City	Location	Distance [km]	#†	GHG emissions‡ [kg CO2eq]
Saint Denis	Réunion	41	68	35 ± 21
Saint Gilles		2	1	3 ± 2
Brest	Metropolitan France	9725	7	2985 ± 1105
Grenoble		8900	1	2734 ± 1012
Marseille		8777	1	2697 ± 998
Montpellier		8889	4	2731 ± 1011
Nantes		9472	2	2908 ± 1076
Paris		9367	8	2876 ± 1064
Sète		8885	2	2730 ± 1010
Strasbourg		9057	1	2782 ± 1029
Port-Louis	Mauritius	228	3	167 ± 62
Dzaoudzi	Mayotte	1409	3	562 ± 208
Moroni	Comoros	1653	3	654 ± 242
Cape Town	South Africa	3907	2	1216 ± 450
Dodoma	Tanzania	2679	1	1037 ± 384
Kuala Lumpur	Malaysia	5702	1	1762 ± 652
Madrid	Spain	9153	1	2811 ± 1040
Maputo	Mozambique	2399	1	933 ± 345
Nairobi	Kenya	2970	1	1146 ± 424
Washington DC	USA	15082	1	4614 ± 1707

†: number of in-person participants, ‡ value per participant

Accommodation

Of the 112 in-person participants, 69 were based in La Réunion. We expected those local participants to stay at their home overnight due to the short driving time required on the island. Hence, we considered no GHG emissions for their accommodation. For the 43 remaining in-person participants, we based our calculations on a 3 night accommodation (from September 24 to 27th, 2024). If some participants stayed longer, e.g. work visit or tourism, the extra GHG emissions were not considered as being directly related to the event and hence, were not considered here. We used the Cornell hotel sustainability benchmarking index 2024[2] [29], retrieved on October 29th, 2025. Their heat map indicated low carbon emissions per occupied room for the island of La Réunion, with emission factors ranging from 11.9 to 26.4 kg CO2eq per night and per room. Given

[2] https://www.hotelfootprints.org/

the venue was organized in a 3-star hotel, we used a value of 60 ± 15 kg CO2eq per non-local participant over the 3 nights.

Meal

A total of 450 meals were served by caterers over the duration of the event. The buffet menu offered a mix of meat, fish, and vegetarian dishes. Coffee breaks were also organized during the meeting. We conservatively used a unique GHG emission factor of 5.51 kg CO2eq (50% uncertainty) for each meal. This factor corresponds to red meat [19] and overestimates the GHG emissions associated with a mixed buffet by at least a factor two (GHG emission factor of vegetarian meal is 1.12 kg CO2eq). To compensate for this over-estimation, we did not include in the carbon footprint the GHG emissions of coffee breaks (4 during the 2-days meeting), estimated at the level of 0.36 kg CO2eq each, nor of other social event (e.g., cocktail) organized during the event.

Remote participation

A total of 60 participants attended part of the kick-off meeting remotely. However, about 30 participants were connected to the videoconferencing system at all times during the meeting. We used a value of 24.2 g CO2eq per hour of videoconferencing using Zoom application per remote participants from the estimation provided by Greenspector[3] in 2021. Another study found a higher value, up to 226 g CO2eq per hour, using another videoconferencing system [30], highlighting that this former value might be under-estimated. However, using a value even 100 times larger would not have changed the conclusions of this study. We assumed 8h of meeting per day over 2 days, hence 0.387 kg CO2eq per remote participant. We assumed 50% of uncertainty [30].

Results

The overall GHG emissions of the kick-off meeting are reported in Table 2 and displayed in Fig 1. We find a total of about 100 t CO2eq. Air travel is from far the largest contributor to the meeting's carbon footprint, with 93 t CO2eq. Ground travel by the local participants, accommodations for the non-local participants, and the meals account for about the same value, in the range 2.4 – 2.5 t CO2eq each. The videoconferencing system for remote participants only represents 0.012 t CO2eq, or about 0.01% of the total emissions. This is equivalent to about 0.9 t CO2eq per in-person participant and 0.2 kg CO2eq per remote participant.

Table 2. Carbon footprint from the various sources of GHG emissions for the kick-off meeting.

Source	GHG emissions [kg CO2eq]
Air travel	93208 ± 34487
Ground travel	2401 ± 1441
Accommodation	2580 ± 645
Meal	2480 ± 1240
Videoconferencing	12 ± 6
Total	100686 ± 37819

[3] https://greenspector.com/en/which-video-conferencing-mobile-application-to-reduce-your-impact-

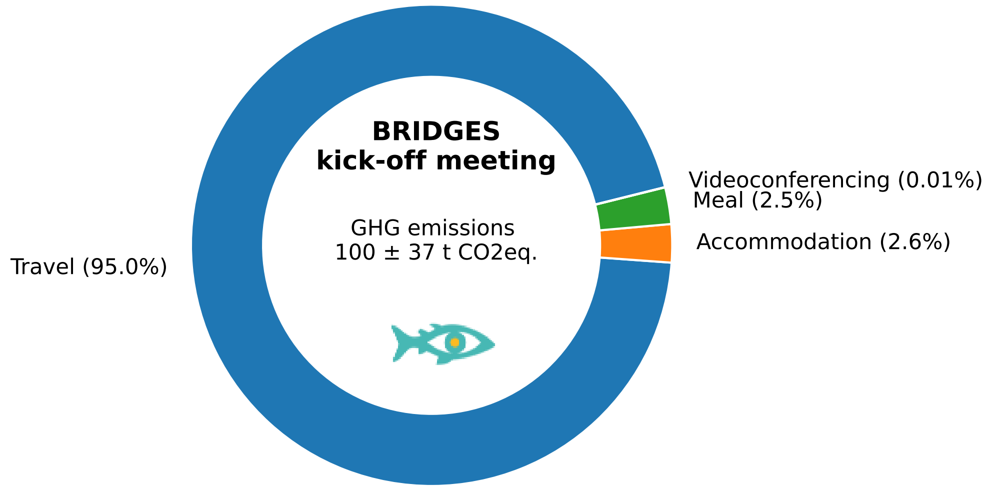

Fig 1. GHG emissions of BRIDGES' kick-off meeting. This figure shows the partitioning of the GHG emission: the travels are represented in blue (accounting for 95% of the carbon footprint), accommodation is in orange (2.6% of the total), meals are in green (2.5% of the total), and the videoconferencing system for remote participants (only 0.01%) is too small to be seen.

Discussion

The carbon footprint of BRIDGES' kick-off meeting is relatively large compared to the net-zero emission objective, as recommended by the IPCC to meet with the 2015's Paris agreement. Although the remote participant's emissions remain almost negligible, the in-person participants account for about half of the individual carbon-footprint annual budget one might reach by 2050. This motivates us to find mitigation scenarios to substantially decrease this value while maintaining the important research activities of a program like BRIDGES.

This value of approximately 0.9 t CO2eq / in-person participant is similar to those observed for international meetings and conferences in other scientific domains [31, 32]. These studies used different perimeters, but all included flights, which is the dominant source of carbon emission. It might be lower for local or national conferences where most participants travel by train [33].

A different venue?

The question of the kick-off meeting location (or to do it fully remotely) was strongly debated among its scientific leadership prior to the meeting, pointing by some people to a potentially much larger carbon footprint than holding it in, e.g. Paris. The decision to organize it in person and in La Réunion was largely based on (1) the fact that this may be the only large in person meeting over the 10 years of this research program, therefore offering a unique networking opportunity, and (2) the fact that it was key to involve regional partners meaningfully, as much of the research will be done with them to ensure tangible impacts from the program. To evaluate what the carbon footprint would have been if the event had been organized in metropolitan France, we simulated a kick-off meeting organized in Paris. We first assumed that the participant list was the same and that everyone would have traveled to Paris by train when possible or by plane. We assumed that the same menu would be requested from the caterers, and we used a GHG emission factor of 10 kg CO2eq per hotel night [29] (instead of 20 kg CO2eq) to account for the difference in the mix of electricity between metropolitan France and La Réunion. In that scenario, the carbon footprint would have risen to ∼ 246 t CO2eq, which is about 2.5 times higher than in La Réunion.

We have no information on the exact location of the remote participants, but many of them working the French institutes, one might expect that some of them would attend the meeting in person if it were organized in Paris. The reason for their remote participation is also unknown but could be motivated by various factors, such as teaching duties, personal constraints, time and money constraints, and awareness of their carbon footprint. While the first reason would likely not allow them to attend in person if it was organized in Paris, the latter reasons might have changed their participation status, whereas personal constrains reason is not unequivocal. However, in this scenario, some participants from La Réunion would also decide to attend the meeting remotely for the same reasons. To test this, we simulated an alternative participant list where only 50% (n=35), 33% (n=23), and 25% (n=17) of the 69 participants of La Réunion would have traveled to Paris. In these simulations, the remaining participants would have joined the meeting remotely. We find GHG emissions at the level of 146, 112 and 96 t CO2eq, respectively, as shown in Fig 2. The carbon footprint of a kick-off meeting held in Paris would have been equivalent to the actual meeting only if about 25% of the participants from La Réunion had traveled to Paris. In that last scenario, only 60 in person participants would have attended in person, hence nearly half of the actual participants.

The scenario with the lowest carbon footprint is obviously a fully remote meeting, which would have removed all the travel, accommodations, and catered meals. In that case, the GHG emissions would have been only ∼ 55 kg CO2eq, hence 1830 times less than the actual emissions.

Mitigation scenarios

In order to mitigate the climate impact of future BRIDGES' meetings, several options are possible:

- **Optimized venue:** if hybrid meetings, including both in-person and remote participants, are important, a solution would be to first survey potential participants and then define the venue to minimize the carbon footprint of travels. Given the list of participants for the kick-off meeting, the location on Earth minimizing travel distance and the carbon footprint is, in fact, in La Réunion.

- **Hub conference:** one option to decrease the carbon footprint of meetings while maintaining in-person attendance is to hold the conference in several interconnected hubs [34]. Such an option remains unusual and breaks out our traditional vision of a conference, with associated psychological barriers, but could combine low-carbon strategy and in-person social interactions and benefits. For the kick-off meeting, two hubs could have been set up: one Indian Ocean hub, held in La Réunion, and one Atlantic Ocean hub for the participants in metropolitan France, Spain, and the USA. Assuming that participants less than 1000 km away from the Atlantic Ocean hub would travel by high-speed train instead of planes, the travel footprint would decrease to ∼ 35 t CO2eq, which is about a third of the actual footprint. To allow some interaction between hubs during this decade-long project, some ambassadors from each hub could travel to the other hub at the cost of a few metric tons of CO2eq. However, this alternative would have prevented the desired networking between scientists from metropolitan France and scientists and partners from the SWIO region. Hub conferences not only have a positive impact on carbon footprint, but are also more inclusive than traditional conferences [35], so that a shift from traditional to hub conferences practices may operate in the future.

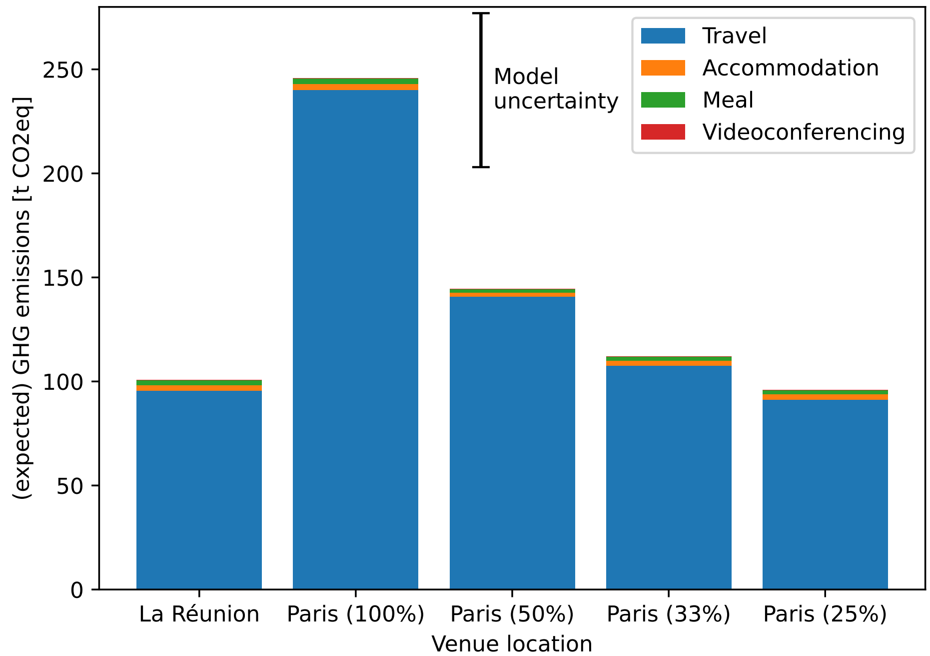

Fig 2. Comparison of GHG emissions of a kick-off meeting held in Paris. The GHG emission of the kick-off meeting in La Réunion is compared with the expected one if it was organized in Paris with 100%, 50%, 33%, and 25% of the participants from La Réunion to attend in person. The main difference is on the travels, even if the other sources are also varying with negligible impacts. The error bar is indicating the relative uncertainty on the emission factors that are used in the model and hence, is affecting the 5 scenarios.

- **Virtual meeting:** as mentioned previously, the solution that minimizes the meetings' carbon footprint is to organize fully virtual events. This substantially decreases the GHG emissions by a few thousand compared to a hybrid event. Emerging technologies such as those experienced, e.g., in astronomy [36], allow participants to have enhanced interactions without traveling.

An intermediate solution might be a mix of the above solutions: organize a hybrid meeting in an optimized venue in the first year, then a hub meeting in the second year, and the third one as a fully virtual meeting. This strategy could cycle every 3 years at a cost of $\sim$ 135 t CO2eq in total, or $\sim$ 45 t CO2eq per year. This would represent a 55% decrease in GHG emissions compared to a hybrid meeting yearly. Furthermore, some marginal mitigation solutions could be considered:

- **Combined travels:** If some participants plan a second travel to the meeting venue or its vicinity for a work visit, it would be best to join the two objectives in a single travel. This mitigation solution is the second most-popular lever to reduce the academic carbon footprint, after video communication [37]. In Table 3, we list the number of nights that are equivalent in GHG emissions to a round trip to La Réunion. In other words, if the combined-travel mitigation is extending the trip duration by more than the values reported in this Table, duplicating the travel would have a lower carbon footprint. Given that the carbon footprint is dominated by travel, the pooling activities would roughly halve their carbon footprint. However, this might come at the cost of an extended duration, hence more GHG emissions due to the accommodation.

- **Vegetarian menu:** Shifting the menus requested to caterers to be only vegetarian can decrease food-related GHG emissions by a factor ~ 5 compared to meals with red meat. This mitigation remains small compared to travel, but is easy to implement in the BRIDGES meeting, with no downside.

Table 3. Number of nights in an average hotel in La Réunion that have the same GHG emissions as one round trip.

Origin	# of nights
Port-Louis, Mauritius	8
Dzaoudzi, Mayotte	28
Moroni, Comoros	33
Maputo, Mozambique	47
Dodoma, Tanzania	52
Nairobi, Kenya	57
Cape Town, South Africa	61
Kuala Lumpur, Malaysia	88
Paris, France	144
Madrid, Spain	141
Washington DC, USA	231

Caveats and future work

The results presented in this study have large uncertainties (37%). They are due to the large uncertainties in the physical processes that lead to GHG emissions. For example, the carbon footprint of a flight depends, e.g. on the fuel consumption of the plane, the actual distance flown [38], as well as the production of contrails which increase the radiative forcing in the atmosphere [39]. Although these uncertainties are large, they affect the various scenarios discussed in section in a similar manner. Therefore, they have no impact on the discussion and conclusion of this paper.

This study also focuses on the impact on climate, neglecting other environmental impacts, such as impacts on biodiversity, resources, and human health. The various scenarios discussed to mitigate carbon emissions are leading towards sufficiency in traveling. Decreasing the number of flights within the projects will also have positive impacts on these other environmental impacts. Therefore, we expect that our conclusions are also valid for all environmental effects.

This work only considers GHG emissions and ignores the local socio-economic benefits of organizing a meeting in a remote venue or in a Global South country, which is also a key component of international dialog and arena of decisions.

Meetings are an important element of worldwide research projects such as BRIDGES. The evaluation of the carbon footprint of the kick-off meeting and the discussion of mitigation scenarios are an important first step to decrease the footprint of these research activities on the environment. We anticipate that this study will be completed in follow-up work, to further evaluate the carbon footprint of the project, including all related activities such as high-performance computing or field experiments. Travels are likely one of the main sources of GHG emissions, so the mitigation scenarios discussed here also apply beyond the kick-off meeting, to e.g. summer schools and field experiments.

Conclusion

In this paper, we evaluate the GHG emissions of the BRIDGES research program kick-off meeting, which gathered more than 100 participants on the island of La Réunion, a French overseas territory of the SWIO region. The event accounted for about 100 t CO2eq, dominated (93%) by air travel to the venue. Although this program is funded for ten years (2024-2033), it is anticipated that meetings might be organized in the future. We have shown that organizing such a meeting in metropolitan France (e.g., Paris), one of the options considered, would probably have increased the carbon footprint of the event, as most participants were located in the SWIO. We thus suggest that future meetings (or other community activities such as workshops or summer schools) be either organized with an optimized venue, minimizing the GHG emission of participants' travels, in several hubs, with ambassadors or completely remotely. This mitigation has the potential to decrease GHG emissions by 65% (hub), 99.94% (remote), or 55% in the case of a cycle over the three options. We also evaluated the benefit for individual participants of combining this event with other travel objectives, such as a work visit or field experiment. The benefits of such an approach could be limited in the case of short-distance travel, which might quickly be compensated for by the GHG emissions of extending the duration of accommodations, but could be interesting for participants coming from farther away. For example, a return trip from Mauritius to La Réunion is equivalent to about one week in an intermediate 3-star hotel.

The study presented in this paper might be applied to research projects and consortia beyond BRIDGES. In particular, when in-person meetings are mandatory, the concept of an optimized venue could be applied. It requires asking potential participants to register first, well in advance, and then to decide where to organize the meeting. This is the opposite of what is commonly done.

This study is the first of series that will focus on monitoring the carbon footprint of the BRIDGES research program over one decade, and suggest transformation to mitigate the environmental impact of research projects.

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