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An evidence-based approach to accelerate flight reduction in academia

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On the path towards net zero emissions in academia, reducing flight emissions is of high importance, yet particularly difficult to achieve. Flight emissions have a major share of the total greenhouse gas (GHG) emissions of research institutions but reducing them is challenging, because flying has become an essential part of academic culture. While there is a large amount of literature on the relevance of flight reduction in academia, very little data and hands-on experience exists on what a successful reduction process might entail. This paper contributes to closing this gap by presenting data from interviews and surveys from eight academic institutions on reasons for air travel and alternatives, showing how a transdisciplinary approach can support a transformation from a high to a low flying culture, and suggesting a practical path forward with the aid of an open-access toolbox on how to reduce flight emissions in academia.

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INTRODUCTION

Recent reports of the Intergovernmental Panel on Climate Change (IPCC) send a clear message: the international community is not on track to achieving the 1.5 degrees Celsius goal, which is set out in the Paris Agreement from 2015[1]. Extreme weather events, such as heat waves or floods, and in particular trends regarding planetary boundaries or so-called climate tipping points, give an idea of the enormous challenge the international community is facing[2,3]. Despite the fact that the international community has much more profound knowledge about the implications of climate change and about the mitigation measures required to address the root causes of climate change and other sustainability challenges, a large action gap remains[4]. This has been powerfully demonstrated once more at COP 27 in Sharm El Sheikh, where public speeches and official negotiations were dominated by policymakers recalling the urgency to act, but ultimately failing to agree on stronger and more effective climate action on the international level.

Looking at current emission pathways and the small amount of carbon emissions left for humanity to reach the Paris Agreement, it becomes clear that we need a new approach for managing the transformation towards net zero emissions. Net zero refers to a balance between the amount of GHGs emitted to and the amount removed from the atmosphere[5]. The emphasis hereby lies on reducing emissions as much as possible and removing or offsetting only what can absolutely not be reduced at a given point in time.

Based on current emission trends and climate policies, traditional policy learning and innovation processes will most likely not suffice to reach net zero. We need true transdisciplinary research to identify potential gamechangers and leapfrog innovation and learning processes. To contribute to a better understanding of how this could be facilitated for one specific aspect, we zoomed-in to a particularly difficult sector in a challenging environment: aviation emissions and academia.

Aviation plays a special role for the path to net zero. Flights have increased substantially over the last decades[6,7]. COVID-19 has briefly interrupted this massive growth of overall flights[6,8,9], but emissions are on the way back to pre-COVID-19 levels[9,10]. Interestingly, during the breakdown of flights in 2020, the number of total passenger flights were still as high as those in 2000[10]. No specific data exist about flights in academia back to 2000, but the situation is most likely comparable. In academia, flights contribute to a major share of total GHG emissions[11–16], partly due to the increasing availability of cheap flights and the goal of internationalisation[17]. Flying is often seen as normal[18,19] or even as a necessity for successful academic careers[20]. At ETH Zurich, total flight emissions show a positive trend from 2006 until 2018[21].

Business flights in academia constitute a strong example for major barriers for reducing the knowledge action gap in climate change mitigation. This refers to the challenge of translating scientific knowledge and understanding of climate change into effective actions that reduce GHG emissions[4]. Various studies showed that key factors contributing to the existing knowledge action gap include awareness, the willingness to act, limited resources, uncertainties regarding the effect of certain action, lacking coordination and strategies, social and cultural barriers, and the absence of effective communication[4,22,23].

For universities and research organisations, reducing flight emissions is of high importance for several reasons: (i) researchers fly more than the average person[24–26], (ii) they are (mostly) (co-) financed by public funds and are therefore subject to the social and political framework conditions[27] (including net-zero targets), (iii) they risk losing credibility if they do not follow their own advice[28], and (iv) air travel has a major share of an organisation's total GHG emissions, contributing up to about 60%[11,12,14–16,29]. In addition, various studies in recent years have shown that flying is very unevenly distributed among academic groups[13,14,30]. In a study from the University of British Columbia, 50% of the flight emissions were caused by 8% of the flyers[11].

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At the same time, while it holds great potential for meeting institutional emission targets, reducing flights in academia is particularly difficult[31]. International exchange and distribution of knowledge is at the heart of science. Moreover, flying as a means to an end has become deeply engrained in the scientific culture in the last few decades[18,20,32]. It is normal to frequently travel[18,19] to attend international conferences, give talks, join committees, do field work overseas, etc[16,33–35]. Since flying is often perceived as a cheap and easy travel option, most trips are relatively short – shorter than 10 days, with a peak at 1-2 days at a university in Finland[12] and with a median of 5 nights at a university in Canada[11]. Frequent flying is also fostered by the evaluation of scientific merits of individuals and organisations, where internationalisation and hence (overseas) travel have sometimes become a value of its own[15]. Increased air travel has also increased inequality as not everyone has the same opportunities to travel (finances, visa requirements, remote regions, caring responsibilities), negatively affecting the social dimension of sustainable development[18,36–38]. A frequently used argument is that (unlimited) flying is essential for scientific success[20,39,40]. However, there are a number of papers that find no or only a small impact of air travel on scientific success as measured by the h-index[40], the number of citations[41], or academic social capital, i.e., beneficial academic relationships[42,43]. In contrast to Wynes et al.[40], Berné et al.[44] found a correlation between flights and the h-index, but rose the question, if there is also a causality: 'Is it that scientists who travel more obtain more scientific visibility and hence get more citations, collaborations and papers (exposure effect), or is it instead that scientists who are more visible because of their work get to travel more (reputation effect)?'.

Many academic organisations have set themselves ambitious net zero targets, including flight emissions[15,16]. However, to reach net zero, keeping the current system, reducing a few flights, and relying on technology will not be enough. Instead, we need to rethink and redesign the scientific system, its values and culture, and the way scientists interact. This includes conferences, teaching, evaluation criteria and the role of policymakers and funders. As a consequence, the interests of different stakeholders need to be understood and managed to facilitate a smooth and effective transformation. We therefore present evidence from more than seven years of experience of working with academic institutions on reducing their flight emissions, as well as lessons learned from a comprehensive transdisciplinary project (www.flyingless.de/en) with interviews at four and surveys at eight academic institutions, which resulted in the development of a toolbox on reducing flight emissions in academia (see also method section at the end of this paper). Thereby, this paper seeks to contribute to a better understanding of why researchers travel by plane, how the current structures and processes could be transformed, and what research institutions can do to effectively reduce their flight emissions.

RESULTS

What is the status quo of flight reduction? – Aggregated interview results covering different fields of activity

At all FlyingLess partner institutions, flight emissions play an important role as the share of total emissions attributable to business-related air travel ranges from 11% to almost half of the total institutional emissions. The topic of flight reduction is embedded differently at the institutions, either as part of the discussions within the sustainability group, integrated into the sustainability strategy or climate action concept, or as a university-wide project located at management level and the sustainability unit, independently of a conceptual framework (Table 1). The intensity of implementation of the topic therefore ranges from soft informal to structural involvement at management level (Table 1). All institutions have a sustainability group with members of (all) status groups, which are embedded in different ways and engaged in varying degrees of activity. There was a sustainability manager at three of the four academic institutions who was also responsible for the flight reduction project. The involvement of other entities such as administration, management level, an international office or student initiatives differed between the institutions (Table 2).

The flight reduction project has progressed differently at all institutions. Looking at the business travel management, which is important for a consistent monitoring of the flight emissions, the interviews showed that there is a great demand for a uniform and easy-to-use interface to the flight data of the members of the institution. Therefore, some institutions already planned to improve the data situation and its handling, so that flight emissions can be calculated directly from the collected travel data.

Three institutions had already implemented a reduction target for flight emissions. All measures that were implemented so far were on a voluntary basis or in the form of recommendations. All institutions already had a report on their flight emissions started to raise awareness on the topic. Information events or discussions in sustainability meetings are examples that were mentioned (Table 1). The interviewees also named specific challenges for the implementation of flight reduction such as the lack of networking due to less social interaction, their small but globally connected research community and remote places for field work (see Table 1).

What is the behaviour and attitude towards flight reduction in academia?

Based on the sample size of all participating institutions combined, the per capita flight rate of professors & group leaders (5.8) was about four times that of scientists without professorship / group lead (1.5). This per capita flight rate corresponds to the estimated average number of academic plane trips per year before COVID-19. For scientists, the primary reason for business air travel were by far conferences including a presentation (87% 'very' or 'rather important'), followed by strategic collaborations (52%) (Fig. 1). Field research was rated as ('very' or 'rather') important by 40% with 30% of all respondents rating it as 'very important'.

More than 80% of all scientists surveyed rated conference attendance as well as networking and collaboration for their career development as very or rather important factors when deciding for a long-distance trip, whereas two thirds (68%) even saw the latter as requirement to do their job properly. Nevertheless, about 70% stated their willingness to reduce their academic air travel by making greater use of videoconferencing or choosing another mode of transport (e.g., train for a distance less than 1000 km; Fig. 2). More than half would even reduce their air travel in the future by not attending events that they consider as not very relevant (Fig. 2). In addition to their individual willingness to reduce air travel, in all status groups, a majority agreed that measures for reducing flight emissions are very or rather important, with strongest support from scientists without professorship and group lead (Fig. 3). The respondents also agreed to varying degrees with different flight reduction measures (Fig. 4): The refund of (more expensive) train journeys (incl. first class tickets and sleeper cars) found most consent (90%) among the given examples of flight reduction measures. More than two thirds of the scientists strongly or rather agreed with an expansion of virtual infrastructure (72%) and the provision of information to support the booking of bus and train travel (67%).

Among the group of 525 students, 77% had never taken a flight as part of their studies. The most recent flight of 15% of the students surveyed was continental and of 8% intercontinental. About two-third of the reported air travel was part of the bachelor's program (69% of continental plane trips, 60% of

Table 1. Aggregated interview results on the status quo of flight reduction at higher education institutes covering different fields of activity and the respective concluded findings.

Fields of activity	Aggregated status quo results from the interviews	Concluded findings
Implementation of the topic of flight reduction	Flight reduction as… - …part of a sustainability strategy - …part of the focus field of mobility within the climate action concept - …topic of discussion in the sustainability group (not formally embedded) - …a university-wide project located at management level and the sustainability unit, independently of a conceptual framework	➔ The intensity of implementation of the topic of flight reduction at academic institutions ranges from soft informal to structural involvement at management level
Involvement of different institution members	Flight reduction is driven by… - …sustainability officer - …a scientist's initiative - …the cooperation with administration/travel department - … legitimacy through management level - …discussions in a working/sustainability group (for mobility) consisting of different institutional members - …incentives by the international office - …involvement of student initiatives	➔ The types of involvement on the issue of flight reduction are different at each institution and, above all, vary in intensity
Monitoring + Reporting	- No standardised collection of business trip data - Travel reason is collected by a free text entry (hard to analyse/quantify) - Manual transfer of travel data to calculate emissions - Tool to measure flight emissions from business trips: atmosfair - No collection of data from student air travel - Aim to use new tool that facilitates monitoring of business trips/emissions	➔ The lack of digitisation and standardised collection and storage of flight data challenges the process of continuous monitoring
Flight reduction measures	- No implementation of any flight reduction measures - Implemented air travel policy including next steps on developing measures for flight reduction - Reduction targets for flight emissions - Carbon offset payment for flight emissions to the federal state - Voluntary carbon offset payment to an internal climate action fund - Continuing expansion of virtual infrastructure	➔ No mandatory flight reduction measures are implemented yet by any of the institutions studied
Communication	- Reporting of flight reduction data within the framework of the sustainability report - No information about the methodological approach of calculating the emissions - Free available paper (incl. number of flight emissions and methodology) - Different formats for information and awareness making events on the topic of flight reduction - Discussions on the topic of flight reduction in regular meetings	➔ Education and communication on the topic of flight reduction with all member groups of the institution promote the transformation process in various ways
Challenges	- Fostering scientific success/career/quality and simultaneously reduce flight emissions - Very small but globally connected research community - Fieldwork at remote places - Costs for flights vs. train - Long travel times are not family-friendly - Scientific communities' culture of presence - Possibility of networking or informal exchange is missing in virtual formats	➔ Individual challenges at each institution need to be faced

intercontinental), and one-quarter to one-third was part of the master's program (26% of continental plane trips, 30% intercontinental). The results of the student survey show high endorsement for different measures to reduce study-related air travel. More than three quarters (76%) assented to an increased number of study-related trips in the curriculum that are reachable by train, as well as to the provision of information and links to support the booking of rail and bus travel (77%). Also, they approved recommendations, e.g., for train or bus rides to destinations reachable within a certain travel time (78%). With regards to their future job, almost three quarters of the students (74%) stated that they would prefer to work for an employer who aims to reduce GHG emissions by reducing business air travel (Fig. 5).

Table 2. Overview of the topics and key questions for the implementation checklist (Module 2).

Topic	Key questions
Governance	⟩ Is there an institutional/structural embedding? ⟩ Is it part of the overall strategy? ⟩ Are there goals, targets and rules? ⟩ What about sanctionability? ⟩ Where is the personnel responsibility for implementation located? ⟩ What is the responsibility of the individual, what is that of the organisation? ⟩ How are the different groups involved? ⟩ Are there internal steering committees or groups at different levels?
Operationalisation	⟩ How to set up a database of flight emissions? ⟩ What is the reduction target? ⟩ Is there a predefined reduction path?
Measures	⟩ How are the measures selected (top-down, bottom-up)? ⟩ Do the same measures apply to everyone? ⟩ How, by whom and to whom are the adopted measures communicated? ⟩ How and by whom are the measures implemented, who is responsible? ⟩ Are there incentives for sustainable travel? ⟩ How are role models and multipliers recruited and involved? ⟩ Are the measures sufficient to achieve the goal?
Communication	⟩ Is there a communication concept? ⟩ Who is the target group for internal and external communication? ⟩ Who communicates regarding the goals, measures, successes/failures? ⟩ What and how often is the topic communicated? ⟩ How is communication done? ⟩ How often do major events on the topic take place?
Reporting	⟩ How frequently are emissions reported? Is there information/reporting on progress, resistance and best practices? ⟩ Are there any guidelines for the format of the reporting? ⟩ Who is responsible for this? ⟩ What happens if targets are not met (sanctions?) ⟩ How much transparency is there inside and outside the organisation?
Schedule, Networks, Evaluation	⟩ Timetable of implementation ⟩ Who sets the schedule? ⟩ Who supports the implementation? ⟩ Who controls the timely and targeted implementation? ⟩ Networks: is there good networking with other universities (national and international)? ⟩ Evaluation: is there regular evaluation, assessment and possible adjustment of the goals, measures and their implementation?

The FlyingLess toolbox

Based on the results of the FlyingLess interviews and surveys, a comprehensive literature review, and the in-depth experience in flight reduction in academia, both in a single organisation (ETH Zurich) and from working together with several other organisations, the FlyingLess toolbox was developed. The toolbox aims at supporting universities and other research institutions in implementing effective and participatory air travel reduction measures.

The toolbox has six modules, which contain a set of slides and, in the case of the 'Checklist' (Module 2) and 'Success factors and stumbling blocks' (Module 3.4) also texts in the form of PDF files. In addition, an explanatory video is provided for Module 3.5. There is also a video explaining the purpose and use of the toolbox[45].

The modules cover the following topics (see also Fig. 6):

- Module 1 is an introduction on *how to use* the toolbox with a flowchart as an orientation map for all modules and a short description of each module.
- Module 2 is a *checklist* with guiding questions for the implementation of a flight reduction project. The questions help the organisation to obtain an overview where they stand in terms of flight emissions and what steps should be taken by whom. For more information, see Table 1.
- Module 3 provides detailed *background information* and supporting arguments for the implementation within the organisation and contains six submodules about the *relevance of the topic, travel reasons, internal and external framework conditions, success factors and stumbling blocks and sufficiency*. For more information, see Table 3.
- Module 4 gives guidance what *methods and tools* are available to support the transformation process, covering project and stakeholder management and strategy development on the way to net zero.
- Module 5 provides suggestions for concrete *measures* and guiding questions how to reduce flight emissions.
- Module 6 deals with *next steps* to ensure an efficient implementation process at the institution.

The modules can be used independently of each other and in any order. However, it is recommended to start with Module 1 to get an overview and continue with the checklist (Module 2). If no background information or methods and tools are needed, one can take a shortcut and go immediately to potential measures (Module 5).

We used the first prototype of the toolbox in live workshops with the four FlyingLess partners (two German universities and two international research organisations). The participants of the workshops came from different levels of the institution, including the leadership level, senior and junior researchers, and administration. The toolbox was distributed to the participants in advance. They appreciated the wealth of useful information but requested more guidance about how best to use it. The material was seen as

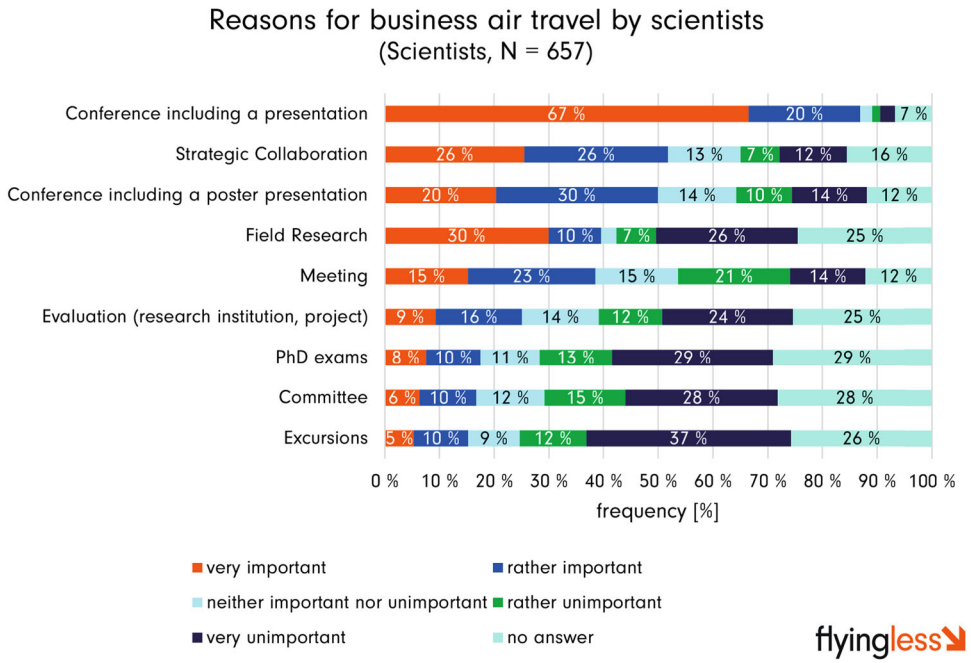

Fig. 1 Reasons for business air travel by scientists. Status group: Scientists, $N = 657$ (aggregated from professors & group leaders, $N = 218$ & scientists without professorship/group lead, $N = 439$). Relative frequency of mentions (level of importance, X-axis) per response option (reason for an academic flight; Y-axis). Results from the FlyingLess online survey 2022. (Original wording of the corresponding question in the survey: 'What are important reasons for your business air travel?').

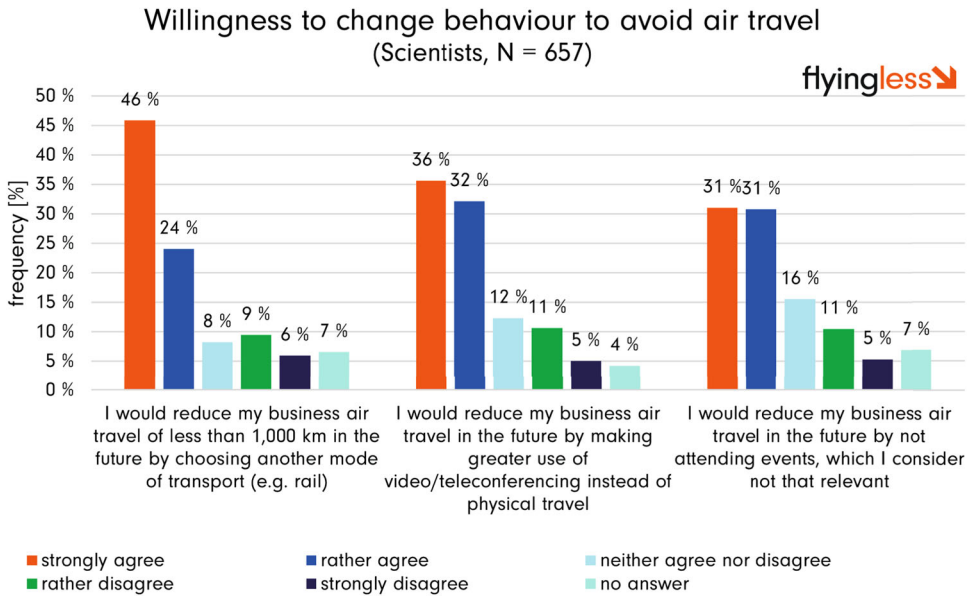

Fig. 2 Willingness to change behaviour to avoid air travel. Status group: Scientists, $N = 657$ (aggregated from professors & group leaders, $N = 218$ & scientists without professorship/group lead, $N = 439$). Relative frequency of mentions (level of agreement, Y-axis) per response option (agreement with statements about future mobility behaviour to avoid official air travel; X-axis). Results from the FlyingLess online survey 2022. (Original wording of the corresponding question in the survey: 'When you think about your business air travel over the past few years: Do you agree with the following statements?').

insightful but also as overwhelming. We therefore revised the toolbox in several iterative loops to make it more intuitive and tailor it even better to the needs of the target group. The toolbox[16] and an explanatory video[45] are available on a repository and the FlyingLess website. Furthermore, the toolbox will be available as an interactive tool, and we will provide videos, a webinar and virtual training workshops within the next few months to support and guide users how to make best use of the toolbox.

DISCUSSION

The FlyingLess partner institutions interviewed represent a broad spectrum of academic institutions dealing with the topic of flight reduction. The interview results indicate an overview of different levels of progress achieved so far in the process of flight reduction at academic institutions. Besides the mandatory carbon offset payment to the federal state for air travel at (some) universities, there were no mandatory measures

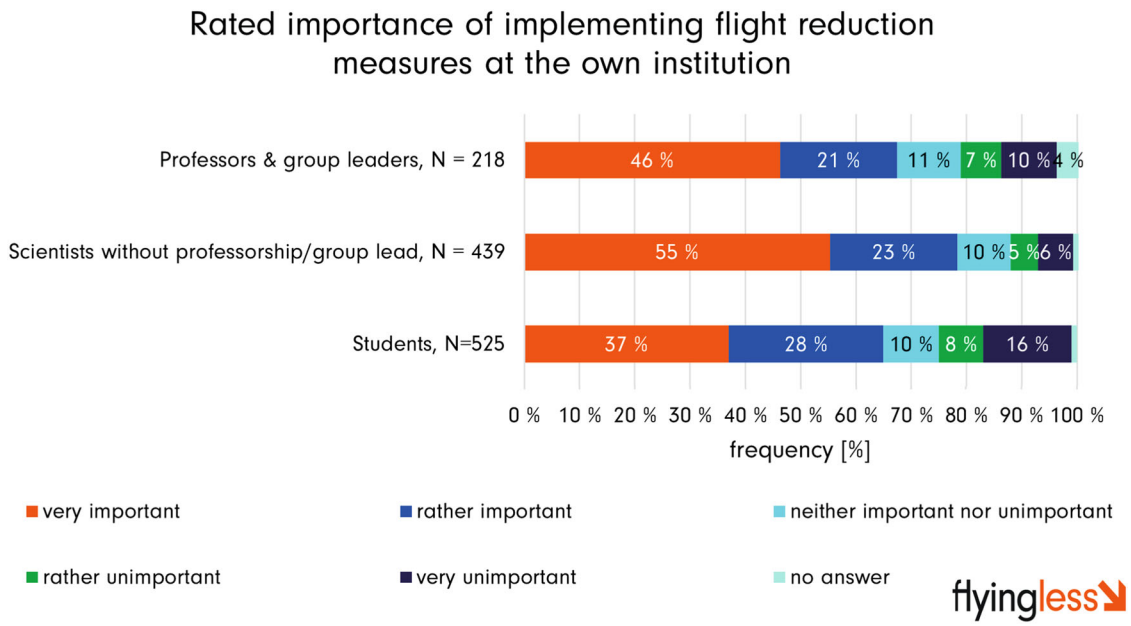

Fig. 3 Rated importance of climate action measures for the reduction of flight emissions at the own institution. Relative frequency of mentions (X-axis) per status group: Professors & group leaders, $N = 218$ & Scientists without professorship/group lead, $N = 439$ and Students, $N = 525$ (Y-axis). Results from the FlyingLess online survey 2022. (Original wording of the corresponding question in the survey: 'How important is it to you that your institution takes measures to reduce emissions from air travel for climate protection reasons?').

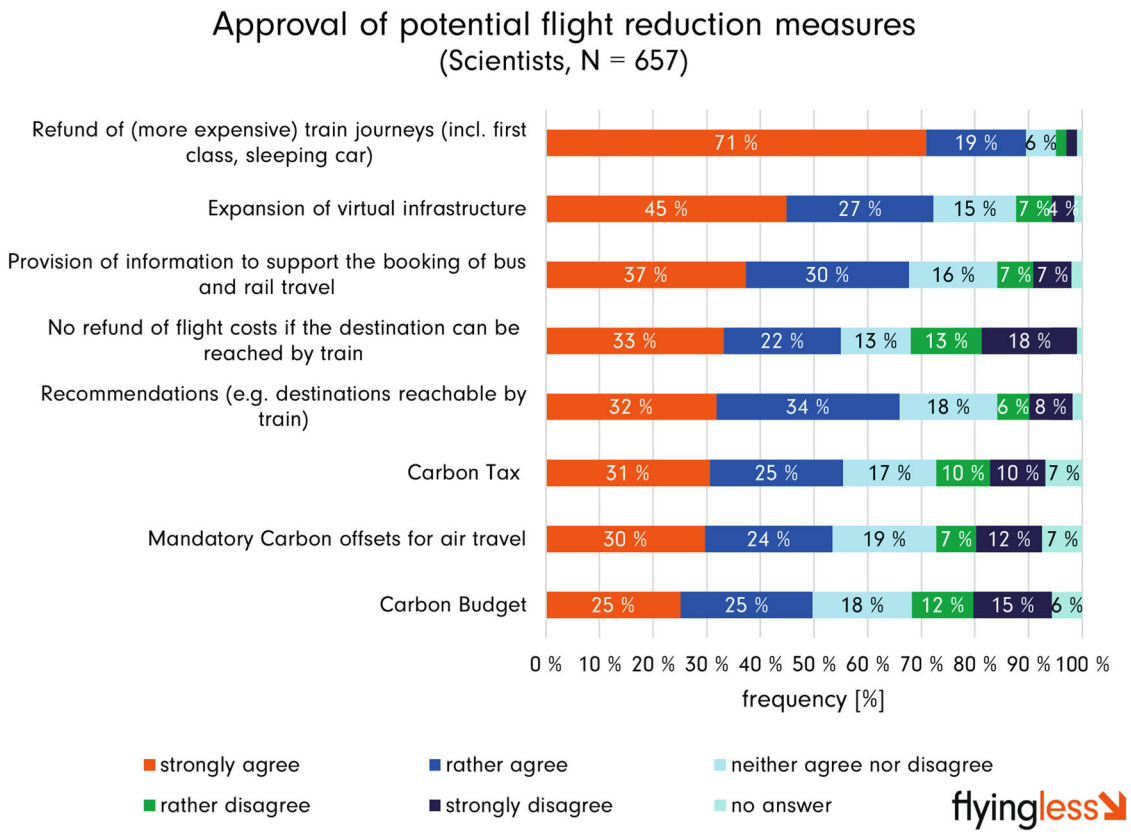

Fig. 4 Approval of potential flight reduction measures. Status group: Scientists, $N = 657$ (aggregated from professors & group leaders, $N = 218$ & scientists without professorship/group lead, $N = 439$). Relative frequency of mentions (level of agreement, X-axis) per partial answer (flight reduction measures; Y-axis). Results from the FlyingLess online survey 2022. (Original wording of the corresponding question in the survey: 'Which of the following types of emission reduction measures would you agree with at your institution?').

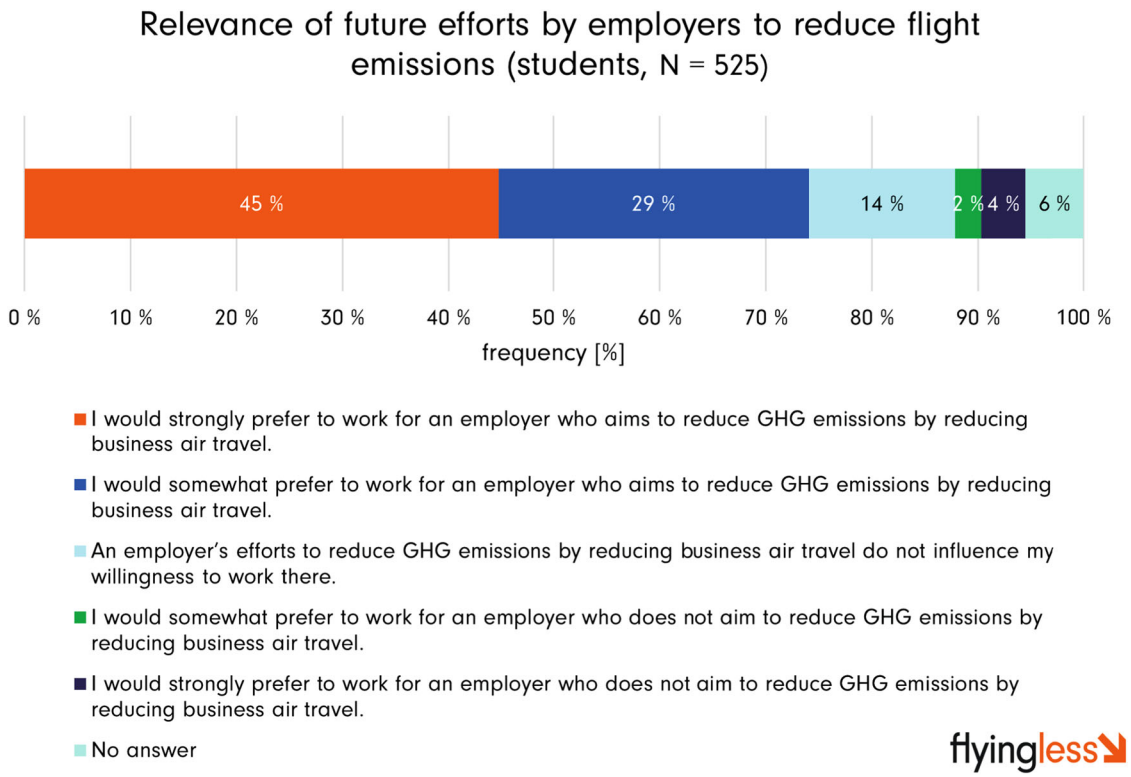

Fig. 5 Relevance of future efforts by employers to reduce flight emissions. Status group: Students, $N = 525$. Relative frequency of the stated preferences regarding the employer (X-axis). Results from the FlyingLess online survey 2022. (Original wording of the corresponding question in the survey: 'How would you rate a future employer's efforts to reduce greenhouse gas (GHG) emissions by reducing professional air travel?').

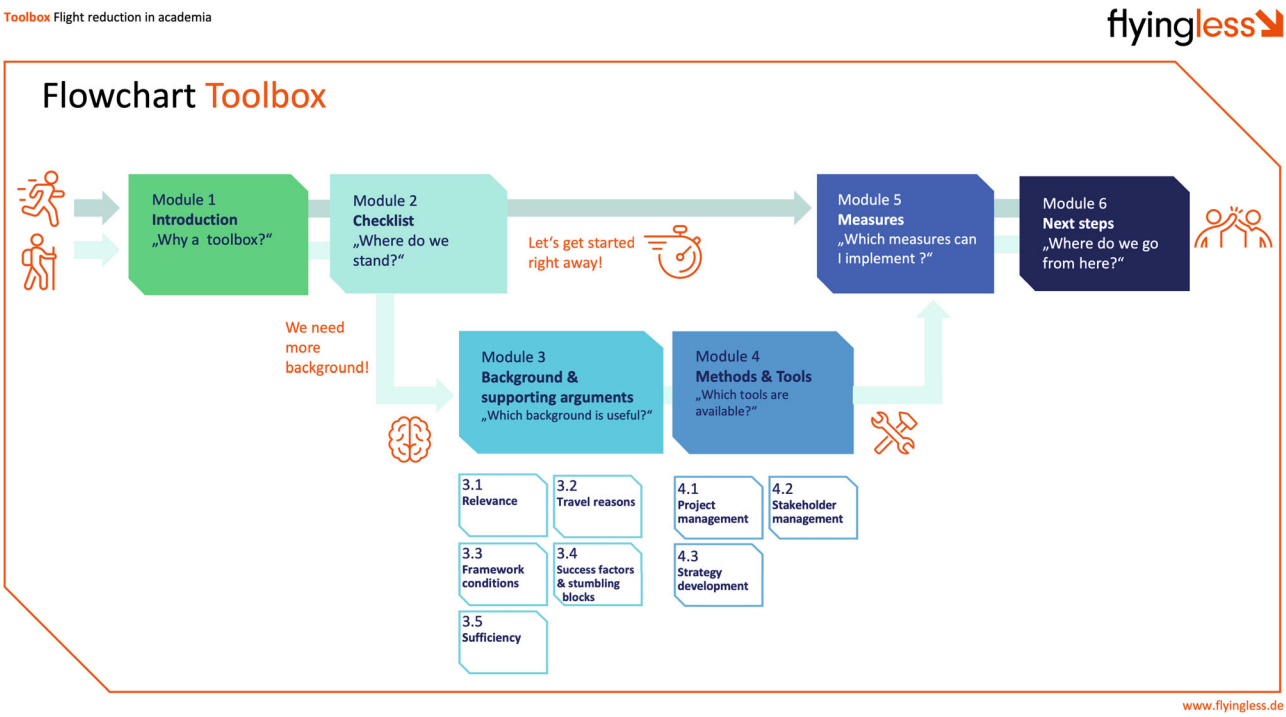

Fig. 6 Flowchart of the FlyingLess toolbox. The toolbox provides an overview on the toolbox modules.

implemented yet, i.e., most measures were voluntary (Table 1). Additionally the lack of digitisation[46] as well as standardised collection and storage of flight data as part of the latter challenges the process of continuous monitoring (Table 1). However, it is important to point out that the progress of individual transformation processes cannot be quantified solely on the basis of implemented flight reduction monitoring and measures. For example, informal discussions and awareness

Table 3. Content of Module 3 – Background information and supporting arguments.

Module	Main Objectives/Content
3.1 Relevance	〉 Addresses the relevance of the topic 〉 Provides information and arguments 〉 Why academia needs to reduce flight emissions 〉 How much emissions are caused by flights 〉 How net zero targets affect flights 〉 How science will need to adapt to become more sustainable 〉 Who has what responsibility on the way towards net zero 〉 How emotional the topic and process is, and 〉 What role technology could play
3.2 Travel Reasons	〉 Lists travel reasons 〉 Highlights the purpose, costs and benefits of travel 〉 Contrasts in-person vs. virtual conferences and 〉 Provides food for thought on alternatives
3.3 Framework Conditions	〉 Provides insights into the internal and external framework conditions 〉 Highlights possible courses of action
3.4 Success factors and Stumbling blocks	〉 This module is based on the implementation list (module 2) and provides tips how to navigate through the change process, based on previous experience
3.5 Sufficiency	〉 Shows the need for sufficiency as part of the sustainability strategy

making on the topic can also add enormous value to the (learning) process of transformation (Table 1, Communication).

Our survey finding, consistent with previous studies[13,14], that the flight emission footprint is larger for professors and group leaders than for scientists without professorship or group lead, questions the current scientific culture of mobility. This result supports the impression that those least reliant on career progression are those who fly most, which is also supported by other studies[14,30,47]. This inequality of flight emissions is furthermore not specific for academia and part of a broader debate about fairness and climate policies[48,49]. Besides the career stage, there are noticeable differences in disciplinary affiliation when it comes to academic mobility. The quantitative survey data on the importance of air travel for field work combined with our qualitative interview results (Table 1, Challenges) suggest that the dependence on distant field work locations as well as a (small but) highly globally connected research communities influence the amount of academic air travel[27,47].

At the same time, the (high) willingness to change mobility behaviour and for instance increasingly use virtual formats (see Fig. 2), which depends on the scope of behaviour change[47], facilitates the process of flight reduction. In contrast the lack of networking due to a lack of social interaction was a counter-argument for virtual formats (Table 1). However, there are already best practice examples that effective networking is also possible virtually[50]. The study by Wenger (2023) systematically structures those factors that influence the effectiveness of networking at virtual conferences. Furthermore, the experience with virtual communication during the pandemic can be used to further develop the exchange format and optimise it for specific requirements in the scientific context (as well as in teaching).

Noting that the majority of students prefer to work for an employer who aims to reduce business air travel, the transformation process needs to accelerate to meet the expectations of the next generation entering the labour market – including jobs within academia. Moreover, the (high) consent on flight reduction measures in general by all status groups surveyed helps to advance the process. To develop the appropriate measures, the survey results on travel decisions can be used as a basis, together with the background information and checklist provided by the toolbox. Nevertheless, to assess the significance of the survey results, the limitations and scope needs to be taken into account: Even though different types of academic institutions were included in the survey, the distribution of disciplinary affiliation is influenced by core fields of research, especially in non-university research institutions. The distribution of the survey may also have depended on committed individuals that promoted the survey at different levels. Furthermore, the student response rate was low, which questions the results' significance for this status group. On top, it needs to be considered that the survey links had no individual key restriction, which holds the option that one could have answered the survey more than once.

The results of the interviews and surveys, as well as the findings from literature on reducing air travel, reveal the important parameters for the transformation towards climate-friendly mobility in academia. Through the transdisciplinary involvement of stakeholders from the various status groups, it was possible to obtain evidence about the levels at which change processes are necessary if air travel reduction is to succeed. On the one hand, the presented toolbox builds on current scientific and societal discourses on tackling the climate crisis and, on the other hand, offers practice-oriented material for the concrete implementation of air travel projects. The results show that transformation processes need to take place not only within individual research institutions, but also at the level where framework conditions are regulated.

Framework conditions shape the environment that organisations and individuals act within, but they can also be shaped and changed (to varying degrees) by organisations and individuals. Specific framework conditions influence travel decisions in academia by fostering or limiting physical mobility, in particular flying. Framework conditions can be differentiated into (i) internal framework conditions, which can be influenced by the organisation or individual actors and (ii) external framework conditions, which can be influenced only indirectly by academia, such as politics, funding organisations, conference organisers or ranking agencies. To reduce flight emissions, both internal and external framework conditions need to be addressed in parallel. In the following paragraphs, we briefly discuss the most important aspects.

When looking into the *internal framework* conditions, the following questions may be helpful: what framework conditions are set by your organisation? How can they be made more sustainable? What scope do the framework conditions offer for sustainable individual decisions (e.g., virtual instead of physical participation, train instead of flight)? Which external players influence your travel decisions (e.g., travel expenses laws, funding organisations, conference organisers)? Which external framework conditions can be (indirectly) influenced by your organisations? Who could do this in your organisation? Who is a member of committees, societies, and advisory boards? What other organisations could you partner with? Who could provide support? This theme is discussed in more detail in the toolbox module about framework conditions.

The survey results give a broad overview on the preferences of the members of the institutions regarding internal framework conditions. With 64% approval, the survey shows a strong demand for clear responsibilities when shaping the process of flight reduction. According to our experience, leadership engagement, commitment and support are essential, as also shown by Schreuer et al.[51].

Governments, funding organisations, ranking agencies and conference organisers all shape the *external framework conditions*

Table 4. Example of concrete actions of funding organisations in the categories funding, evaluation, and requirements for proposals.

Funding	Evaluation	Requirements for proposals
⟩ Special funding for surcharges for train journeys ⟩ Allow funding for virtual infrastructure (also for partner organisations if they are from developing countries)	⟩ Include sustainability aspects in the evaluation criteria (especially for flights as the biggest lever) ⟩ Equivalence of virtual and face-to-face presentations in evaluations ⟩ Equivalence of national and European versus oversea conferences ⟩ Number of conference visits should not be considered in evaluations	⟩ Estimation of GHG emissions in the proposals and the final report, at least for flight emissions as this typically has the greatest impact ⟩ Limitations (if more than is required, a justification is needed) ⟩ Number of project meetings ⟩ Number of (inter)continental flights ⟩ GHG emissions through a carbon budget ⟩ Number of conferences organised as part of the project ⟩ At least some or the majority of project meetings must be accessible by train and/or virtually ⟩ All meetings should be offered as hybrid meeting

for air travel and partly influence each other. In the past, policies, such as subsidies and tax reliefs enabled the enormous growth of the aviation industry. To foster more sustainable behaviour, also in academia, a new set of policies is needed. For instance, public and private actors can revise their funding guidelines.

There is a long-standing debate as to which extent governments should set rules and regulations, for example to reach agreed climate targets such as net zero – or not. We have encountered this debate at academic institutions in connection with flight reduction as well. Most measures are voluntary which so far did not result in the significant reduction of flight emissions needed for the ambitious net zero targets the academic institutions committed themselves to. Further research is needed to explain why mandatory measures seem to be very unpopular. The arguments developed by Lepenies[52] against rules and regulations could be used as hypotheses for empirical investigations in the academic context. Lepenies puts forward four typical arguments against political actions when it comes to sustainability issues. The first three arguments are based on Hirschman[53], who argues that: (i) regulations are against the natural behaviour of human beings and are therefore perverse, (ii) regulations are ineffective, and therefore futile, (iii) regulations destroy the established order because they cost more than they benefit and are therefore dangerous, and (iv) regulations are seen as an intervention into the private lives of people and therefore illegitimate[52].

However, there are important counterarguments, as also discussed by Lepenies (2022), which resonates with our long-standing experience in flight reduction projects, for instance: (i) political action is not perverse, because human behaviour is shaped by social framework conditions. Modified framework conditions can promote other behavioural tendencies than personal short-term advantage, which is currently often favoured. For flight reduction at universities, important examples are reduction targets with a reduction path and a carbon budget. (ii) Political action is not futile, because individual contributions are indispensable for cumulative effects. Furthermore, for social innovations, individuals play an important role. Experience from current flight reduction projects in academia emphasises the importance of role models who trigger discussions and set an example. (iii) Political action is not dangerous, on the opposite, the continuation of the current business as usual is dangerous as it supports the externalisation of environmental costs. To counteract this argument in academia, it is essential to involve the young generations of scientists to ensure that their academic careers are not endangered when reducing air travel. This is clearly a particularly critical aspect that requires changes in academic culture and framework conditions. And (iv) political action is not illegitimate. As we know from other fields, such as road traffic, rules and regulations can be indispensable for safety reasons. Lepenies (2022) argued that freedom has been predominantly defined as the freedom to consume, however, freedom should also include consensus about regulations that guarantee the protection of the common good. This may be reflected by our survey where the majority of students indicated that they prefer working for an employer who aims to reduce GHG emissions by air travel.

We therefore argue that policies at both the governmental and university level (cf. external and internal framework conditions) can have an important impact when it comes to climate action, in particular flight reduction, which could be a topic for further research. In the past, policies, such as subsidies and tax reliefs enabled the enormous growth of the aviation industry. Now, a new set of policies is needed, which foster decisions towards sustainability, also in academia. The often-cited argument that the freedom of science should not be endangered does not mean that there is a right to conduct science in a way that endangers our future. Political guidelines change the discussion from 'if' we need to change the way science is conducted to 'how' academia can be more sustainable in its actions. Specifically, politics can set rules for funding organisation and influence the conference business, as discussed below.

Funding organisations distribute mostly public money and are hence subject to climate goals, such as the Paris Agreement. Rules and regulations imposed by funding agencies are nothing exceptional. In other fields, like finances, ethics, gender etc., guidelines and regulations are already implemented. Table 4 lists potential action points for funding organisations to stimulate the discussion how they can contribute to reducing flight emissions in academia.

Academic conferences are a multi-billion business, mostly paid with public funding. Yet research in the field is scarce, and there are no real parameters by which to assess the efficacy, intended impact, and actual outcomes on scientific communication, knowledge exchange and networking[54]. Furthermore, conferences are the most common reason for academic travel (see Fig. 1). Consequently, they contribute significantly to global GHG emissions, as seen at the example of the AGU from 2019[55]. Klöwer et al. provided several scenarios how to reduce conference GHG emissions, ranging from multi-hub, bi-annual to partially and fully virtual conferences. However, without guidelines from those who fund conference attendance, i.e., politics and funding agencies, it is unlikely that a significant reduction of GHG emissions from conference attendance will happen in the near future.

Finally, ranking agencies can also influence the travel behaviour in science. Universities compete amongst each other for excellent scientists, staff and also students, and therefore rankings have become increasingly important. In particular for students, whether a university 'walks the talk' is an evaluation criterion. To increase visibility and move it higher on the agenda, not only indicators

such as strategies, publications, reputation and student supervision, but also concrete measures and actions that result in the reduction of GHG emissions of universities' own operations could be taken into account.

We conclude that reducing flight emissions in academia is complex and characterised by conflicting goals, most notably climate action versus international exchange. The transdisciplinary involvement of stakeholders in the development of policies and measures significantly increases the practicability and acceptance of transformation processes. However, the necessary change triggers emotional reactions, because it involves individual choices and affects the way science will be done in the future. Nevertheless, if we want to reach net zero in all fields of academia, including flights, we need to go beyond reducing some flights and strive for an adaptation of the current framework conditions. Based on our empirical findings, we would argue that we need a transformation of the academic system to keep the excellence and the necessary exchange amongst scientists but with strongly reducing the negative effects. This transformation needs creativity and innovation, which is inherent to science and now also needs to be applied to the way science operates.

We also argue that tackling flight reduction is, beyond the reduction in emissions, worth the effort, as it can serve as a blueprint for other transformation processes towards sustainability. It is on the one hand a clearly defined field, with quantification of emissions in one organisation and a test case for different measures. The academic organisations are similar enough to learn from each other. On the other hand, flight reduction in academia goes beyond the individual organisation and involves individuals as well as society via the external framework conditions.

With this paper, we want to provide specific qualitative and quantitative information and practical help, based on interviews, surveys and previous experience to significantly reduce flight emissions in academia. The data collected and the toolbox provided serve as a basis for an evidence-based implementation of a flight reduction process at individual organisations and contribute to the evolution of a new mobility culture within academia and beyond.

METHODS

The transdisciplinary framework

To investigate how GHG emissions from air travel in academia can be effectively reduced, this paper builds on theoretical assumptions from stakeholder theory[56,57], perspectives from transdisciplinary research[58–60], and practical experience with flight reduction programs in academia. To bridge the knowledge action gap regarding aviation-based emissions in academia, it is essential to understand potential barriers to developing strategies and implementing measures to reduce emissions. According to stakeholder theory, both internal and external stakeholders are relevant for the success of such transformation projects and programs, which can include employees, managers, shareholders, customers and partners, legislators, society, media, and many other actors[61]. While several analysis tools can help to identify stakeholders and analyse their influence, relevance, and interest[62], we can learn more about the successful design and implementation of projects at the interface of science and society by applying transdisciplinary research approaches.

The lack of success in implementing effective measures in climate action and in meeting other societal challenges have shown that systems knowledge (knowledge about the current state) and target knowledge (knowledge about the state to be achieved) alone are not sufficient, but that transformation knowledge (knowledge about action and change)[63,64] is needed. Transformation knowledge can be generated by involving actors from the relevant fields of action in research and implementation processes from the very beginning. A characteristic of transdisciplinary research is the co-design of questions and the co-production of action-relevant knowledge. Applied to the topic of reducing air travel in academia, this means that the members of the institutions must be involved in flight reduction projects with all their concerns and motivations. On this basis, the most effective and most widely accepted measures can be developed within the institution, potentially also in interaction with other institutions.

The FlyingLess surveys and interviews

As part of a publicly funded project in Germany (FlyingLess), we performed 20 interviews in total at four partner institutions – two non-university research institutions and two universities in Germany – to identify the status quo on the flight reduction topic in early 2022 (Supplementary Methods). In addition, a survey led to quantitative information about the behaviour and attitudes towards academic air travel by the broader scientific community (Supplementary Methods).

At each institution one individual from four different status groups was interviewed, plus the person responsible for sustainability. The status groups were the (i) leadership level, (ii) senior scientists, (iii) administration and (iv) Bachelor/Master or PhD students. One interview guideline per status group was created to gain knowledge on, e.g., the institutional embedding of the topic of flight reduction, flight reduction measures, business travel management, calculation and reporting of flight emissions, the involvement of and communication with the institution's members/entities, and challenges in reducing air travel. The information collected in interview protocols were summarised in a table for each partner institution. Thematically structured, these show the status quo on the process of flight reduction until early 2022. Table 1 shows aggregated findings of these results, which are further outlined in the results and discussion section.

The interviews were followed by an online survey in summer 2022 among scientists and students at eight German academic institutions, consisting of two highly internationally networked non-university research institutions, five universities and one university of applied sciences. Since there were no students at the two non-university research institutions, the results for this status group are only available from six institutions. The participants of the survey were subdivided into the following status groups:

- Scientists
  - Professors and group leaders
  - Scientists without professorship/group lead (incl. PhD students)
- Students (Bachelor and Master or similar)

Since the mobility behaviour of PhD students is much closer to academic staff than to Bachelor or Master students, PhD students were asked the same questions as scientists. The differentiation of status groups allows for the subsequent comparison of status groups within and between the institutions surveyed.

The questionnaire was distributed by the partner institutions themselves. It covered questions about the mobility behaviour regarding academic long-distance travel as well as student air travel, reasons for this behaviour and other factors related to travel (mode) decision, the evaluation of potential flight reduction measures and internal framework conditions as well as the intention of the members of the institutions concerning their future academic air travel. In total, the sample size of the FlyingLess survey includes 657 scientists (218 professors & group leaders and 439 scientists without professorship/group lead) and 525 students. Since not every institution could provide exact and up to date numbers of the respective status groups the response rates are rough estimates: ca. 17% for professors and group leaders, ca. 7% for scientists without professorship/group lead and about 1% for students.

The design of the FlyingLess Toolbox

Based on the results of the interviews and surveys, the most relevant literature already summarised above and on transformation knowledge gained from practical work, we designed a so-called toolbox to facilitate the complex endeavour of implementing an efficient flight reduction pathway at an academic institution. The development of the toolbox methodically followed a transdisciplinary co-production process as outlined above. The starting point was the systems knowledge on the climate crisis and climate action, especially on the reduction of air travel in academia (see introduction). The internationally agreed climate targets result in the need to reduce greenhouse gas emissions in all sectors (target knowledge). The transformation knowledge required to create an action-oriented toolbox was generated through close involvement of stakeholders from the research institutions. The toolbox is a comprehensive collection of material that responsible persons at the institution can use and modify to their own specific needs, and which supports them in setting up their own flight reduction project. To design the toolbox, we used the current literature and provided it for the users in the respective modules of the toolbox. The content of the toolbox was directly influenced by the outcome of the interviews and surveys, which highlighted specific challenges and the need for quantitative information. From the results of the stakeholder engagement, a need for concrete methodological knowledge to support air travel projects was derived. These aspects were particularly addressed in Modules 4–6 (Fig. 6).

DATA AVAILABILITY

All interview and survey results from the FlyingLess partners are available as part of the master thesis of C. Merrem (Merrem, C., 2022: Auf dem Weg zu einer nachhaltigen Mobilität in der Wissenschaft. Eine Analyse im Rahmen des NKI-Projekts FlyingLess anhand von Interviews und Umfragen. Master-Arbeit, Geographisches Institut, Fakultät für Chemie und Geowissenschaften, Universität Heidelberg). The FlyingLess toolbox (https://doi.org/10.5281/zenodo.7876517) and an explanatory video (https://doi.org/10.5281/zenodo.8335785) are available on the zenodo repository.

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AUTHOR CONTRIBUTIONS

C.M. designed and performed the interviews and surveys, supervised by N.A. and S.G. S.G. and N.A. co-designed the toolbox, S.G. was responsible for its realisation, M.J. contributed to the usability of the toolbox. All authors contributed to the concept and the writing of the paper, except the discussion, which was written by S.G., N.A. and C.M.

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The authors declare no competing interests.

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