Monitoring Air Miles at the Faculty of Science (MNF) to reduce CO₂ emissions according to the University of Zurich (UZH) climate goal emissions

GEO 885, Group 1

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Abstract

To counteract the effects of climate change, a radical reduction of greenhouse gas emissions is essential. Reducing emissions is necessary for all areas of society, which includes the scientific community. Sustainable policies are being introduced progressively at universities, and for this paper relevant, the University of Zurich. The University of Zurich has actively chosen a more sustainable path and implemented "Strategy 2030" in 2022, which calls for climate neutrality until 2030. A flight emission reduction of 53% by 2030 is indispensable to achieving this goal. The first steps in the right direction have already been taken by the Faculty of Science (MNF). The MNF collected relevant information about all their paid flights from 2018 to 2020, including flight numbers, IATA codes of the origin and destination airports, booked service class (economy, premium economy, business, and first-class), and emission of greenhouse gas per flight. This study aims to provide the MNF with concrete approaches to reduce their air travel emissions and help them reach the climate goal of the University of Zurich. Thus, we conducted an R analysis with the provided dataset and quantified the emission impact of different flight classes. Further, the effect and gravity of short-haul flights (< 1000 km) were examined. We found that changing the flight class to the economy is an essential and easily realizable step. In addition, reducing 96% of short-haul flights until 2030 enables the MNF to implement the sustainability goals of the University of Zurich and reach the emission reduction target by 2030.

Keywords: academic flying, carbon emission, sustainability, environmental protection

1. Background

In today's world, the topic of emissions reduction is omnipresent and is being addressed in ever-larger circles. Statistically, aviation emissions are responsible for 2.4% to 3.8% of the total global emissions (Graver et al., 2019; Klöwer et al., 2020), yet they are reduced at a relatively low cost. Reducing aviation emissions is also an important goal at the global level and therefore embedded in the Sustainable development goals (SDG) 15 and 17 (Dib, 2021). An essential part of those emissions is caused by researchers, who frequently fly to foreign universities due to conferences, guest lectures, and fieldwork. In recent years, air travel done by academic staff received growing attention (Achten et al., 2013; Biørn-Hansen et al., 2021; Borgermann et al., 2022). Especially as universities worldwide incorporate sustainable development strategies (Borgermann et al., 2022). Similarly, the University of Zurich is setting an example, defining climate goals to be carbon neutral and reduce air traveling by 53% by 2030, using the SDGs as a framework (University of Zurich, 03.06.22). The MNF would like to achieve the university's goals and therefore change its flying behavior.

Although the majority in academic circles favor this development, questions have arisen as to whether this might not harm academic work as flying and face-to-face interactions play a vital role in an academic career (Klöwer et al., 2020; Kreil, 2021). Thus researching the relationship between academic flying and academic work and finding approaches to reducing emissions via air travel became the subject of multiple studies. The study of Kreil et al. (2021) proved that reducing air travel would affect scientific work and be beneficial. Possible alternatives to long-duration flights were shown in the study by Klöwer et al. (2020). They demonstrated that virtual conferences have a higher attendance rate and how annual global meetings could be held physically only every second year. For this paper, the study from Ciers et al. (2019) is relevant. They conducted a case study in Switzerland at the ETH of Lausanne (EPFL), proving that simple measures such as changing to economy class and replacing short-haul flights with an alternative travel option can reduce emissions by 36%. Contrary to other papers, which thematize the problem on a more global scale, this paper aims to find, similar to Ciers et al. (2019), easy and applicable solutions to reduce air travel emissions at the faculty and university level, which are easier to implement.

2. Research goal

This study aims to provide the MNF with an analysis of all flight emissions by flight journeys that the MNF funded. The goal is to present concrete propositions on how the MNF can reduce its flight emissions by 53% by 2030.

First, exciting flight patterns will be discussed, on which two complementary strategies will be investigated. How strong is the impact of the various flight classes, and how impactful is the shift to solely economy flights? Further, the effect and gravity of short-haul flights in Europe will be assessed to recommend reducing the number of flights to achieve the climate targets. Last, but not least the impact of the possible approaches and measures on the per capita employee of the MNF will be quantified and discussed.

3. Methods and data

3.1 Data

The dataset containing all flights at the MNF consists of 7018 individual flight segments, where connecting flights and outbound and return flights are listed separately. The flight number or the IATA codes of the departure and arrival airports were recorded. Likewise, the cabin class and the year the flight was boarded were noted for an individual segment.

Table 1. Summary of all flights between 2018 and 2020 divided by cabin class and total flights per year

Year	Economy	Premium	Business	First	Flights
2018	2892	21	120		3033
2019	3083	23	141		3247
2020	703	6	28	1	738

3.2 Preprocessing

The pre-data processing was done using Python. As most of the dataset contained missing values, the first step was to complete these NA values for the flight numbers and the IATA codes for the arrival and departure airports. For this, one parameter was essential: the IATA flight destination for each flight. The former parameter refers to the identification of the airline and the latter to the number of the specific flight. To link these IATA codes to each flight number, a Python script was written using an API developed by Aviation Edge (AviationEdge, 2022). The API retrieved the corresponding IATA departure and arrival codes for each IATA flight code and IATA flight number and read them

into the record set. For the request function, the airline-IATA codes and flight numbers were used.

Further, these new values were compared with the existing IATA destination codes, and in case of a missing value, it was replaced by the API's query. The same procedure was carried out with the emission calculations in the second step, using an API from GoClimate (GoClimate, 2020). The request for this API server used the parameters "Segments" consisting of departure and destination and the flown cabin class. It returned the emissions for each flight segment in kg of CO_2 and the estimated price. The previously mentioned steps were repeated for the identical dataset, but all cabin classes were changed to the economy, and the emissions were calculated again. From the 7018 original flights, 5463 could be matched, resulting in a 78% completeness.

3.3 Analysis

The data were first aggregated and supplemented with variables for statistical analysis. This included the flight distance for each flight (km), as well as the kg CO_2 consumption per flight kilometer for each respective flight segment. For easy identification of the two datasets, the term "Observed" was used for the original dataset. The word "Economy model" was used for the newly calculated dataset with only economy class flights. The analysis was then divided thematically according to spatial and statistical analysis. For the first part, all flight paths were mapped spherically, and the number of arrivals was calculated for each country.
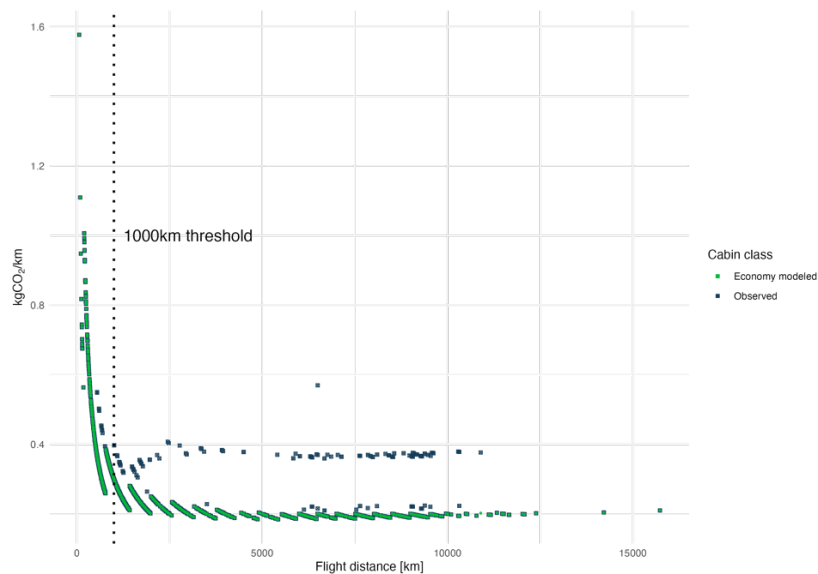

Figure 1. Emissions per flight km in kg CO_2 are plotted against each flight's flight distance, divided by cabin class, economy (green), and the observed flights (blue).

In the statistical part, the density of isolines was interpolated for all flights that arrived in Europe and departed in Switzerland. For the short-haul analysis, the previously calculated values for the number of landings per country were used and calculated with a flight radius of 1000 km from Switzerland. The threshold of 1000 km was set as flights shorter than 1000 km are responsible for the highest emissions per kilometer (Figure 1). As shown in Figure 1, the emissions remain constant for the same flight class from a flight distance of 5000 km. Thus, the emissions for a flight of 5000 km are not higher per kilometer than a flight of 15'000 km.

In a further step, the 3-year average of the emissions of all flights was calculated, as well as the emission reduction target of the MNF with a minus of 53% compared to the 3-year average. This difference in emissions was then calculated per capita so that the emissions over the next eight years for each employee at MNF could be determined. Finally, the annual reduction rate was calculated in percentage, once for the current state and the modeled economy flights. The annual reduction in short-haul flights was calculated using the average emissions per flight with less than 1000 km flight distance.

An apparent problem of our approach is the complex replication of the methods. Our script was designed explicitly for our question and could not be easily adapted for new data. Alternative ways of answering the research questions are sparse since it is a purely statistical research picture.

4. Results

The subtitles of the results take up the research questions posed at the beginning. First, the most interesting spatial distributions and patterns of the flights will be given, followed by the influence of cabin class (1st measure), reduction of short-haul flights (2nd measure), and, last but not least, the effects of the measures on the MNF and its employees.

4.1 Spatial flight patterns

Figure 2 shows all flights from Switzerland to foreign countries from 2018 to 2020. It highlights the extent of the air travel done by the MNF over a period of 3 years. The minimum distance flown is 63.41 km, while the maximum distance is 15'731.34 km. On the other hand, the mean is 2800 km, while the median is 1100 km for all 7018 flights. This significant difference in the median and mean shows that most flights were short-distance flights. The same result was derived from an analysis of the distance distribution, where 48% of all flights were less

than 1000 km. Nevertheless, the favorite long-distance destinations are most often in the United States, followed by Asia, with Japan, India, and Thailand. There are also occasional flights to South America, Africa, and Australia, but drastically fewer compared to North America.
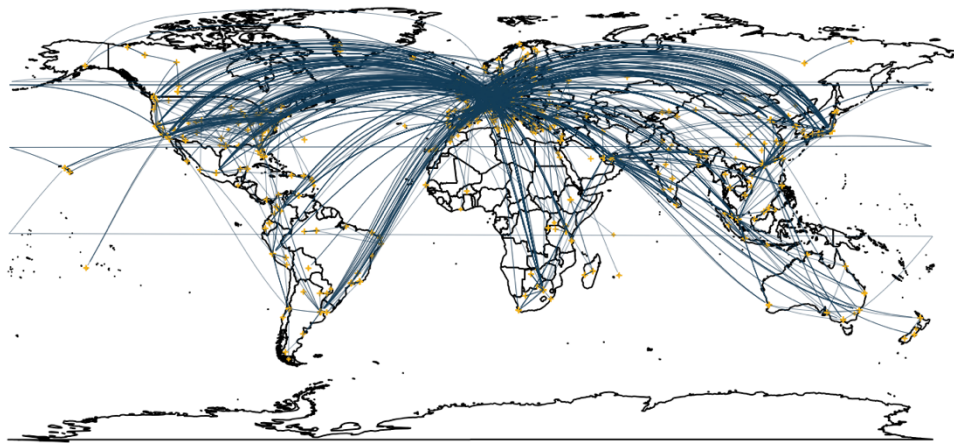

Figure 2. Flight paths for all flights at the Faculty of Science between 2018 and 2020. Flightpaths are blue, and arrival and departure airports are colored in dark yellow.

4.2 Flying economy class (Measure 1)

The analysis of the flight classes showed that the MNF already flew economy for the most part. Business-class was flown second most frequently, followed by premium economy. In the analyzed period, only one flight was registered as first-class in 2020. The plot (Figure 3) compares the observed and the calculated economy model. In other words, it represents the emission scenario if the MNF had only flown economy. As expected, the emissions are lower in the economy model than in the observed data over the whole period, but the difference seems to be smaller than anticipated. With a class change, 72'800 kg CO_2 would have been saved in 2018, 107'000 kg CO_2 in 2019, and 22'400 kg CO_2 in 2020. In total, 202'200 kg CO_2 emissions would have been saved; this equals 0.06% fewer emissions than the observed data. To meet the University of Zurich's climate goal, the faculty would still need to cut emissions by 6.3% each year. This corresponds to 0.03 % less compared to the observed scenario (Figure 4, Table 2).
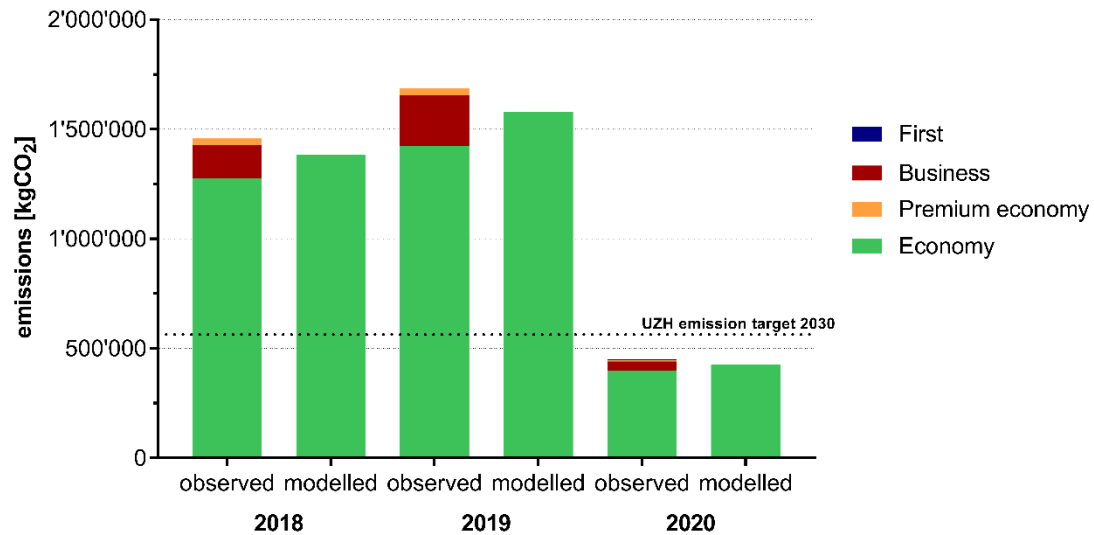
Figure 3. Emissions per cabin class (kg CO2) for the category "Economy model" and "Observed" with the cabin class first (blue), business (red), premium economy (orange), and economy (green).
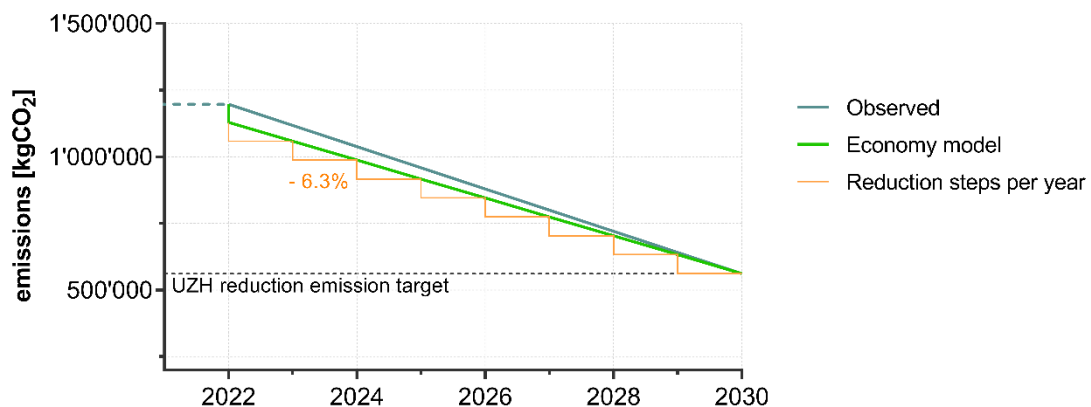

Figure 4. Measure 1: Comparison of reduction steps until 2030 between the economy model and observed. Necessary flight reduction of 6.3% per year by flying economy.

4.3 Reduction of short-distance flights

There are two possibilities on how to define and reduce short-haul flights, either by reducing based on flight emission zones (Figure 5) or by distance in km (Figure 6). Based on the first measure, the second measure calculates whether the climate target can also be achieved if the annual 6.3% emissions reduction is

fulfilled by eliminating only short-haul flights (< 1000 km). We analyzed only the reduction based on distance.
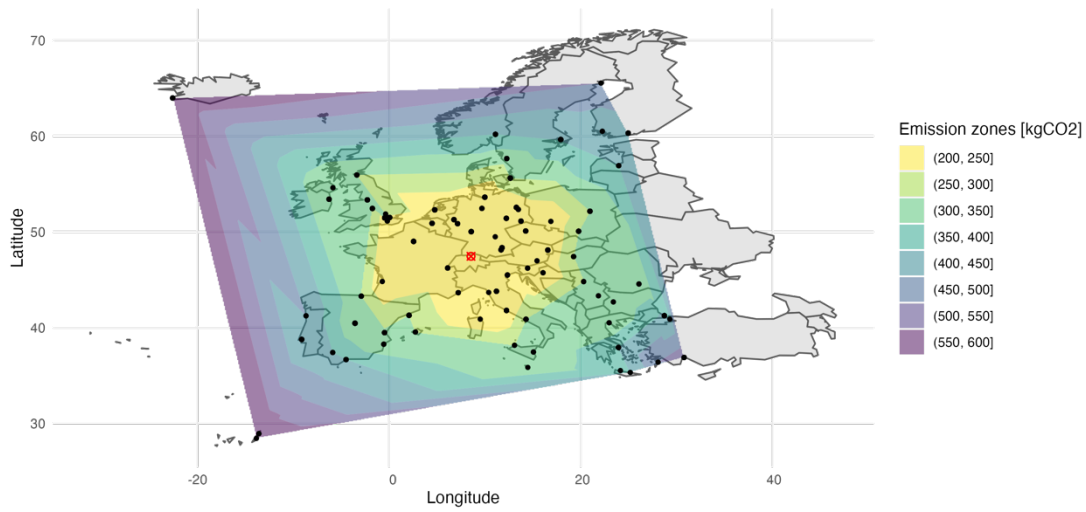

Figure 5. Model 1: Reduction of short-distance flights based on emissions. Emission isolines for European flights departing from Zurich, Switzerland.
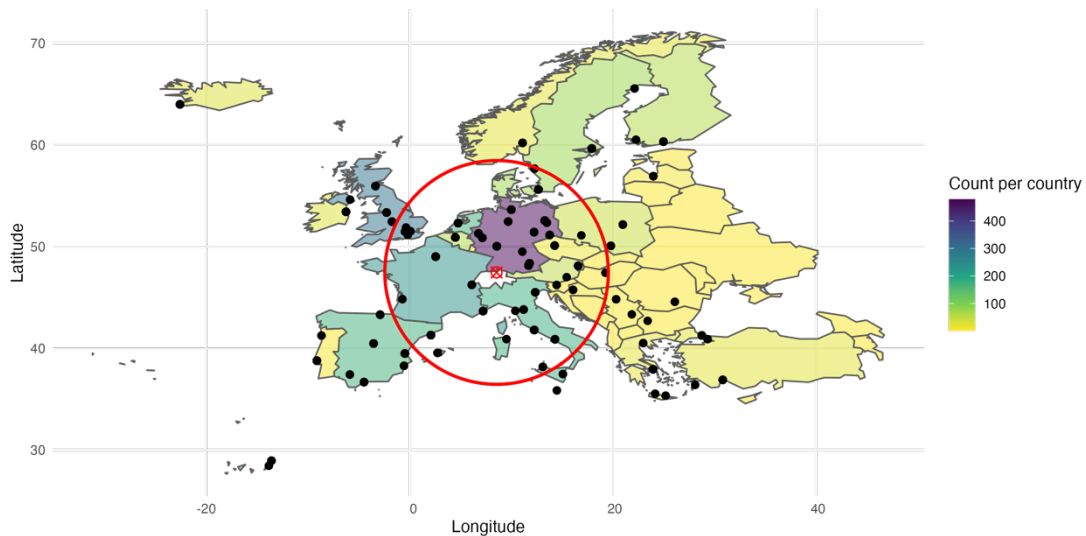

Figure 6. Model 2: Reduction based on distance (km). Red circle indicating a 1000 km distance radius from Zurich. Flight arrivals counted per country which departed from Zurich, Switzerland.

The MNF can meet the climate goal if 12.3% of all short-haul flights are eliminated each year. This corresponds to about 312 flights per year. Thus, by 2030, 96% of all short-haul flights are no longer available (Figure 7, Table 3). This measure would particularly affect flights to Switzerland's neighboring

countries. Especially Germany will be affected, having the highest flight counts (Figure 6).
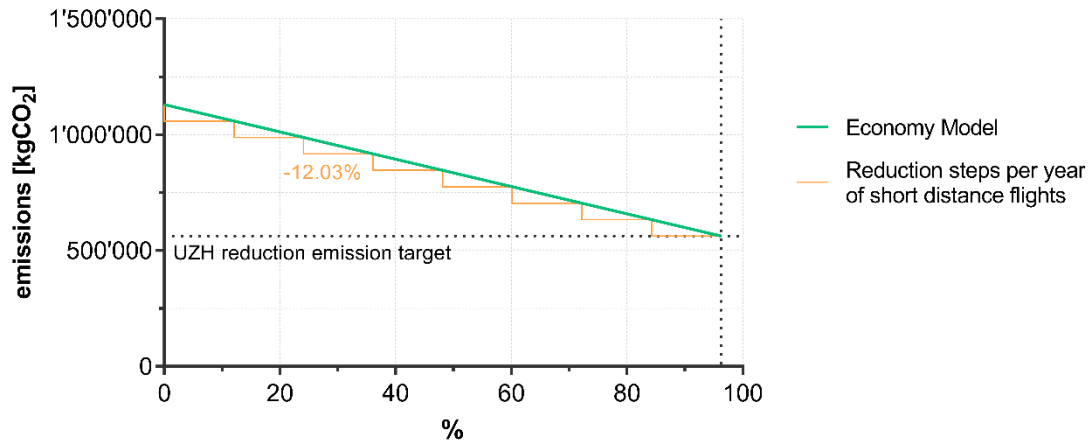

Figure 7. Measure 2: Reduction [%] of short-distance flight (< 1000 km) based on emissions [kg CO_2].

4.4 Impact of the measures per capita

The impact on MNF employees of switching cabin classes to economy does not show much difference. No matter which reduction scenario, each year until 2030, every fifth employee has to decline one flight (see Number of flights, Table 2). This simple measure is particularly interesting for faculty from a cost perspective, as flying economy class is in most cases cheaper. For the individual employee, on the other hand, there is no significant impact of changing cabin classes.

Table 2. Comparison of total reduction until 2030 and reduction of emissions and number of flights per year and per capita/per year between observed and economy model.

Reduction per year until 2030				Reduction per capita/ per year	
Model	Reduction until 2030 [%]	Reduction per year [%]	Reduction in flights per year	Emissions [kg CO_2]	Number of flights
Observed	53.05	6.63	362	144.13	0.22
Economy	50.25	6.3	343	128.97	0.21
	2.80	0.33	19	15.16	0.01

The reduction of only short-haul flights suggests that per capita, 0.19 flights per year cannot be flown (Table 3). The impact on the employees has not changed

much compared to the first measure since every fifth person could still not attend one flight per year. However, this measure allows employees to reach their destinations with an alternative travel option, assuming the destination is in Europe.

Table 3. Reduction per year until 2030 and reduction of emissions and number of flights per capita/per year of only short-distance flights.

Reduction per year until 2030 of short-distance flights			Reduction per capita/ per year	
Model	Reduction until 2030 [%]	Reduction per year [%]	Reduction in flights per year	Emissions [kg CO_2]	Number of flights
Economy	96.25	12.03	312	42.98	0.19

5. Discussion

The results about the effect of cabin class suggest no drastic change between the observed and the economy model. However, the easy realizable measure combined with the second measure, i.e., the reduction of short-haul flights, constitutes an essential step to reaching the climate goal of 2030. Thus, the recommended approaches align with the findings of the case study of Ciers et al. (2019), who proved that switching to economy class and inserting alternative transport options can save up to 36% of the emissions. Yet, such comparisons with other case studies must be taken with caution, as the MNF's flight habits may differ from other universities. Furthermore, it is necessary to quantify the consequences of reductions in short-haul flights and to investigate them more deeply. Simply eliminating 96% of all short-haul flights by 2030 has some problematic aspects, as these are also connecting flights for long-haul flights, and alternative transport solutions such as public transport result in possible higher monetary and time costs for the faculty. Building on the recommended measures, different solutions can be offered and investigated. Achten et al. (2013) proved switching to online conferences has a significant impact on reducing flight emissions. Online conferencing provides environmental benefits, has higher participation, and costs less (Klöwer et al., 2020). For this reason, it would be interesting to have a more comprehensive package of measures, which would give MNF greater scope for implementation. For example, it would be interesting to see what the impact of a reduction scenario might look like if long and short flights were alternately canceled and participation in online conferences were to be increased.

6. Conclusion

This study clearly showed that the potential for reducing emissions caused by university flights is significant. Thus, changing the flight class to economy is an essential and easily realizable step, which is further supported by the reduction of domestic short-haul flights to reach the climate target. Furthermore, the analysis of emissions shows how serious short-haul flights are in terms of their emissions per flight kilometer and that their reduction is a practical step towards the climate targets of the MNF. Nonetheless, by 2030, 96% of all short-haul flights must be canceled to achieve the climate goal. The spatial analysis of flights shows clear patterns of individual flights focusing on Europe and North America. However, further investigation of the data is necessary to develop different approaches to reduce emissions, moderate their practical impact, and detect other spatial patterns. For this, sufficient data and a wide range of variables are of enormous advantage to planning specific and compelling steps to achieve an emission reduction of 53% by 2030 at MNF. By reducing emissions and meeting climate targets, we are contributing to protecting the climate and enabling future generations to experience the same quality of life as we do.

7. Author contribution

Both team members worked equally on this paper. At the same time, Gregory Biland focused on the programming, visualization, and formal analysis part, and Simona di Vincenzo worked in-depth on visualization and writing. The conceptualization, methodology, and validation were done equally.

Acknowledgments

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