**Monitoring Air Miles at the Faculty of Science (MNF) to reduce CO2according to UZH climate goal emissions**

GEO 885, Group 1

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## Abstract

critic: more focus on research

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. Analyzing the provided dataset, we were interested in how a chosen service class impacts flight emission. As a result, we conducted an R analysis to quantify the impact of selecting a lower service class on future flight emissions. The goal is to provide the MNF with concrete approaches, starting with choosing lower service classes and thus implementing the sustainability goals of the University of Zurich.

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

## 1. Background

critic: Write abo the research gap. -> Simona

According to Dib (2021), writing for Uniting Aviation, reducing flight emissions would be covered by the SDGs 15 and 17 (Dib, 2021).

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 only 2.4% to 3.8% of the total global emissions (Graver et al., 2019; Klöwer et al., 2020), yet they are straightforwardly reduced at a relatively low cost. An essential part of those emissions is caused by researchers, who due to conferences, guest lectures, and fieldwork frequently fly to foreign universities. In recent years, travel by airplanes done by academic staff received growing attention. Especially as universities worldwide incorporate sustainable development strategies (Borgermann et al., 2022). This is also what MNF in Zurich has decided and would like to change its flight behavior.

Similarly, the University of Zurich is setting an example to be carbon neutral and reduce air travelling by 53% by 2030. Although the majority in academic circles are in favor of 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 a reduction in air travel would not affect scientific work but also 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 such annual global meetings could be held physically, only biennially. Contrary to other papers, which thematize the problem on a more global scale, this paper aims to find easy and applicable solutions to reduce air travel emissions at the 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 and the influence of flight classes on this reduction target.

Essentially, 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.

## 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 in which the flight was boarded were noted for an individual segment.

Table . 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 CO2 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 supplementary variables for statistical analysis. This included the flight distance for each flight (km), as well as the kgCO2 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.

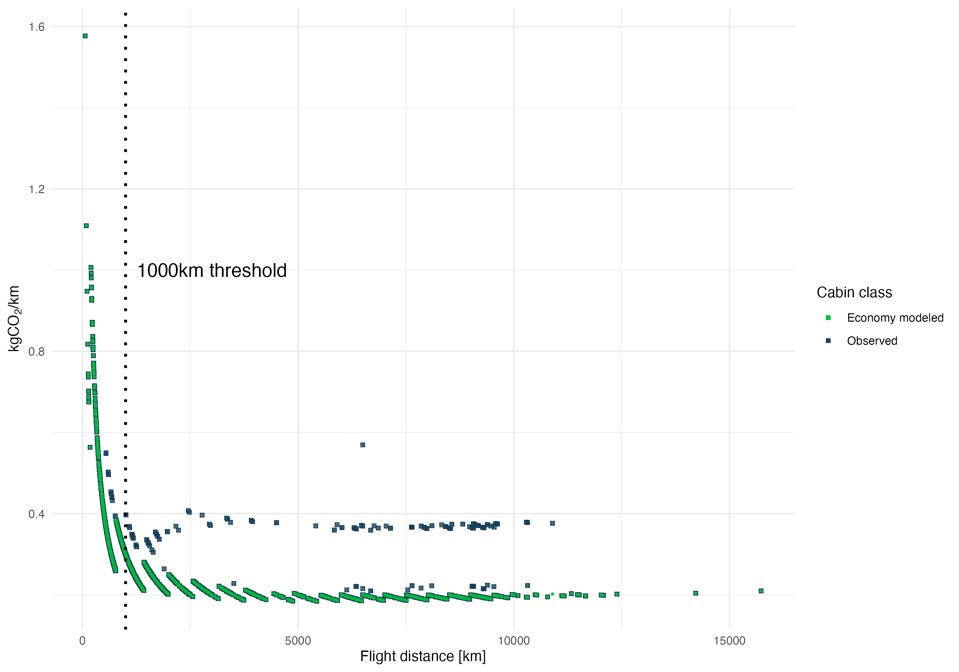


Figure . Emissions per flight km in kg CO2 are plotted against each flight's flight distance, divided by cabin class, economy (green), and the observed flights (red).

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 1000km from Switzerland. The radius of 1000km was obtained from the values of kgCO2/km, which were plotted against the total flight distance of the flight, from which a threshold was selected. 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 modelled economy flights. The annual reduction in short-haul flights was calculated using the average emissions per flight with less than 1000km flight distance.

A clear 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 in a time period of 3 years. The minimum distance flown is 63.41km, while the maximum distance is 15’731.34km. On the other hand, the mean is 2800km, while the median is 1100km for all 7018 flights, which the MNF between 2018 and 2020 paid. 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 1000km. Nevertheless, the favourite 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.

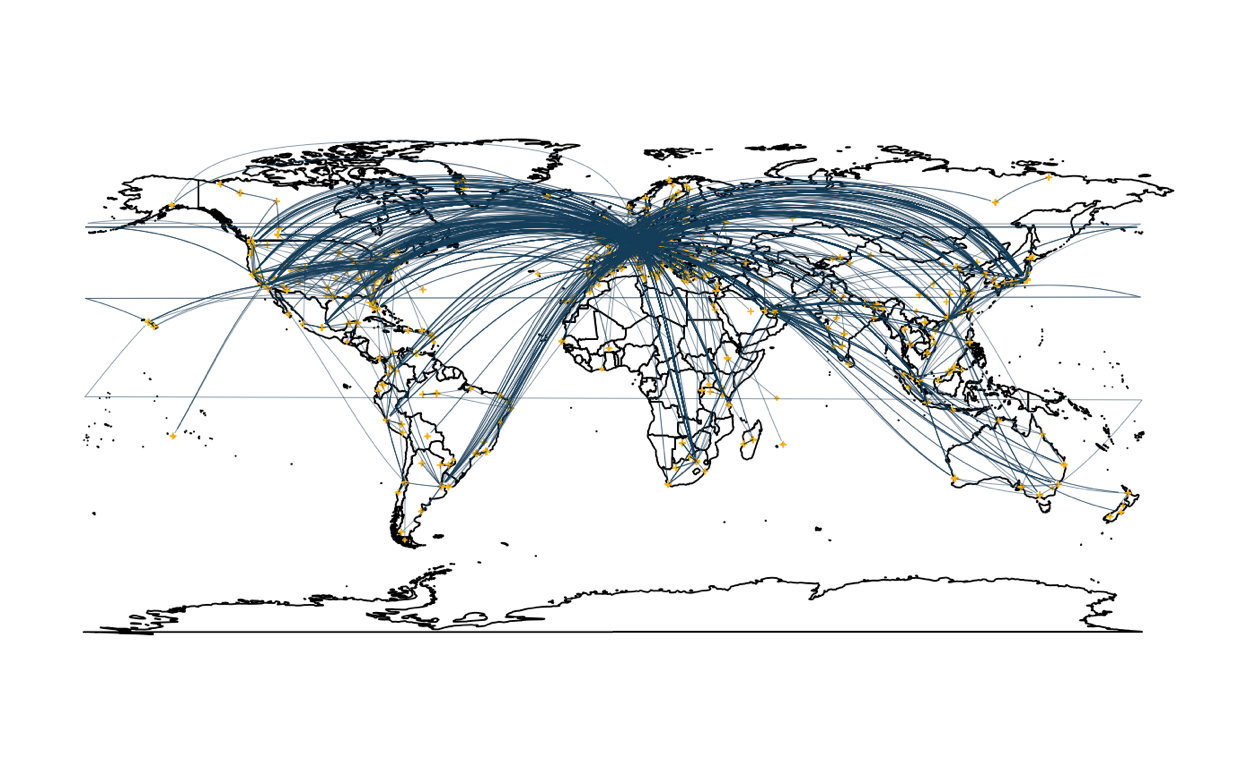
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Figure . Flight paths for all flights at the Faculty of Science between 2018 and 2020. Flightpaths are blue and arrival and departure airports are coloured in dark yellow.

### 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) represents the observed and the calculated economy model in comparison. 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 time period, but the difference seems to be smaller than we hoped for. With a class change, 72'800 kgCO2 would have been saved in 2018, 107'000 kgCO2 in 2019, and 22'400 kgCO2 in 2020. In total, 202'200 kgCO2 emissions would have been saved, this equals 0.06% fewer emissions compared to 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 (see figure 4, table 2).

Chart, bar chart

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Figure . Emissions per cabin class (kgCO2) for the category "Economy model" and "Observed" with the cabin class First (blue), business (red), premium economy (orange), and economy (green).

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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 the flying economy.

### 4.2 Reduction of short-distance flights

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 achieved by eliminating only short-haul flights (< 1000 km). There are two possibilities to define short-haul flights, either by reducing based on flight emission zones (figure 5) or by distance in km (figure 6). We will only focus on reduction based on distance.

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

As shown in Figure.1, flights of less than 1000 km are responsible for the highest emissions per kilometer flown. 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.



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

The MNF can meet the climate goal if 12.3% of all short-haul flights are eliminated each year. This means that by 2030, 96% of all short-haul flights can are no longer available (figure 7).

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Figure . Measure 2: Reduction in short distance (<1000km) flight based on emissions [%].

### 4.3 Impact of measure per capita

There were 5463 flights, of which 5162 were economy and 262 were business class. However, as visible in Figure 1, the preliminary results show that the space and CO2 intensive flight classes cause only a tiny portion of the emissions. Thus, it can be hypothesized that the emission targets of MNF cannot be achieved with a mandatory booking of only economy class tickets.

The mean emissions in kgCO2/km for modelled economy flights is 0.311, while it is 0.317 kgCO2/km for the observed flights.

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Figure 7. Scenario 2: Reduction of short-distance flights (<1000km) per capita.

Table . Comparison of reduction of flights per year until 2030 and reduction of emissions and number of flights 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** flightsperyear | Emissions [kgCO2] | 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 |

Table . 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** flightsperyear | Emissions [kgCO2] | Number  of flights |
| Economy | 96.25 | 12.03 | 312 | 42.98 | 0.19 |

## 4. Discussion

Wouter Achten and his colleagues also analyzed the potential for reducing emissions caused by flight behavior in academic circles. It showed an essential counterpart to our proposed reductions in the number of flights, namely how these reductions affect direct behavior in research. From switching to online conferences, emissions in the study can already be reduced by only 44 (Achten et al., 2013).

-> Neglected emissions of an alternative mode of transport

-> Changing cabin class and flying less also saves a lot of money

## 5. Conclusion

This study clearly showed that the potential for reducing emissions caused by university flights is significant. Thus, the change of 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 need to be cancelled 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 and moderate their practical impact, as well as to detect other spatial patterns. For this, sufficient data and a wide range of variables are of enormous advantage to plan specific and compelling steps to achieve an emission reduction of 53% by 2030 at MNF. By reducing emissions and meeting climate targets, we are making an indispensable contribution to protecting the climate and enabling future generations to experience the same quality of life as we do.

## 6. Author contribution

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

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