Aligning old and new ETH Zurich flight emission estimates: 2006-2019

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1 Original Data

ETH flight emission data (Fig. 1) include greenhouse gas emissions (in tons of CO_2 equivalents, t CO_2e) from flights taken by ETH staff (including doctoral students), students (BSc, MSc, MA, CAS, MAS, MBA) and guests, provided that their travel expenses are covered by ETH. These emissions are estimated using different methods for different periods. For the period 2006 - 2016, emissions were estimated using a conversion factor between the emissions and the cost of the ticket according to Räber (2017) (hereafter referred to as EarthEffect data, and indicated with *e* after the year in Fig. 1). For the period 2016 - 2019, the emissions for each flight were estimated based on actual flight information, according to the method of Atmosfair GmbH (atmosfair, 2011; Althaus and Graf, 2019) (hereafter referred to as Atmosfair data, and indicated with only year in Fig. 1). Additionally, for the period 2016-2018, INFRAS estimated emissions using the EarthEffect method but with a slight correction (Althaus and Graf, 2019) (indicated with year and *i* in Fig. 1). The Atmosfair method is regarded as the most accurate of the three methods and will be used for estimating future ETH flight emissions.

*For the ETH air travel project (www.ethz.ch/airtravel), January 2021

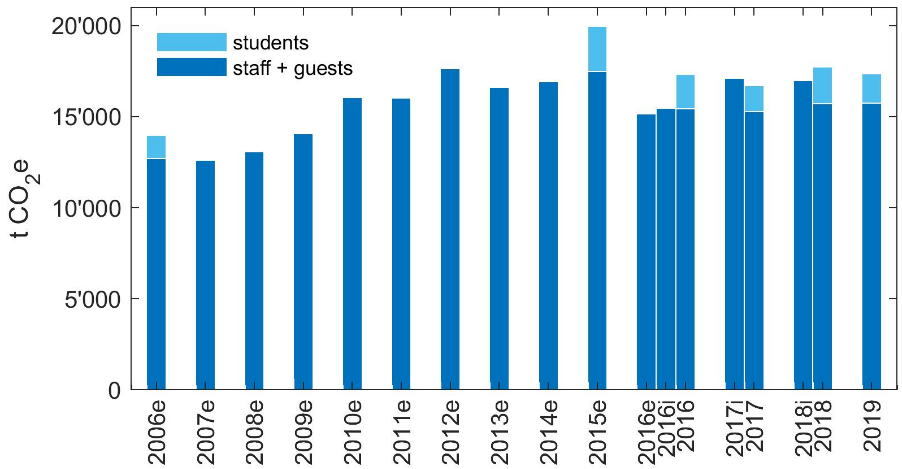


Figure 1: Total annual ETH flight emissions (in t CO_2e) for the period 2006-2019 for ETH staff and guests (dark blue) and ETH students (light blue). Year followed by *e* indicates emissions estimated using the EarthEffect method, *i* indicates INFRAS estimated data using the EarthEffect method. Where only the year is provided, the emission data are estimated using the Atmosfair method.

Student flights were only routinely included in the ETH flight emissions from 2016 onward, but additional estimates have been made for the years 2006 and 2015 using the EarthEffect method (Mobilitätsplatform ETH Zurich, 2017). Student flights are highlighted in light blue in Figure 1.

2 Aligning Procedure

The three methods provide slightly different estimates of the flight emissions. To account for this and adjust the data to be consistent with the Atmosfair method, we scale the EarthEffect data for the period 2006 - 2015 based on differences between the datasets in the overlapping periods using ETH staff and guest flight emissions. The scaling factors are given in Table 1. Student emissions are estimated separately.

The scaling factor between EarthEffect and INFRAS-EarthEffect is based on 2016, the only year of overlapping data between the two methods. INFRAS-EarthEffect is 1.9 % higher than EarthEffect, giving a scaling factor of 1.0191. The scaling factor between INFRAS-EarthEffect and Atmosfair is based on the emissions for the period 2016-2018, where the Atmosfair emissions are on average 6.72 % lower than INFRAS-EarthEffect. This results in a scaling factor

Table 1: The steps involved in scaling the 2006-2015 EarthEffect emissions to be aligned with Atmosfair. The scaling factor (*sf*) indicates what the EarthEffect has to be multiplied with account for the differences (Diff.) between the datasets for the overlapping period (Period). 1 and 2 are calculated using ETH staff and guest emissions, and 3 is calculated from student emissions.

Basis	**Period**	**Diff.**	***sf***
Staff and Guest:			
1. INFRAS-EarthEffect vs EarthEffect	2016	+1.91 %	1.0191
2. INFRAS-EarthEffect vs Atmosfair	2016-2018	-6.72 %	0.9371
Students:			
3. Atmosfair	2016-2019	+10.06 %	1.1119

of 0.9371 (resulting from 1/(1+0.0672)). In total, this leads to the adjusted EarthEffect staff and guest emissions to be reduced by 4.72 % compared to the original EarthEffect data (light magenta bars relative to magenta line in Fig. 2 and 3).

Student emissions are estimated as the fraction of the total emissions for the period 2016-2019. On average, the student flights account for 10.06 % of the total annual ETH emissions, which leads to a scaling factor of 1.1119 (resulting from 1/(1-0.1006)). In total, this leads to the adjusted EarthEffect staff and guest emissions to be increased by 6.19 % compared to the original EarthEffect data when also adjusting for student flights (light blue bars relative to magenta lines in Fig. 2 and 3).

3 Results

Figure 4 shows the evolution of the ETH emissions after adjusting the EarthEffect estimates to the Atmosfair data for the total emissions and when shown as emissions per full-time-equivalent (FTE). The data indicate that both the total emissions and emissions per FTE peaked in 2012. The total emissions are more or less constant while the emissions per FTE have steadily decreased sine 2012. Hence, this decrease is due to the gradual increase in FTEs at ETH over this period.

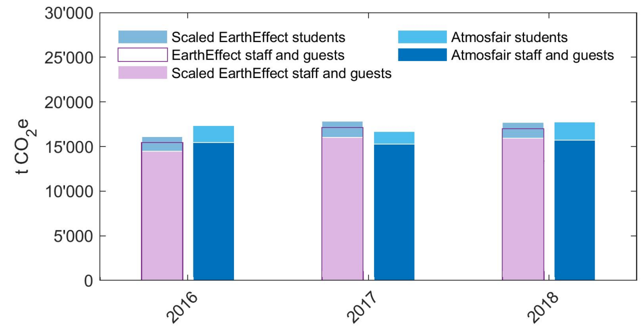


Figure 2: The original INFRAS-EarthEffect (magenta line), scaled staff and guest (light magenta) and student (light blue) together with the Atmosfair staff and guest (dark blue) and student (cyan) estimates for the overlapping period of the two time series.

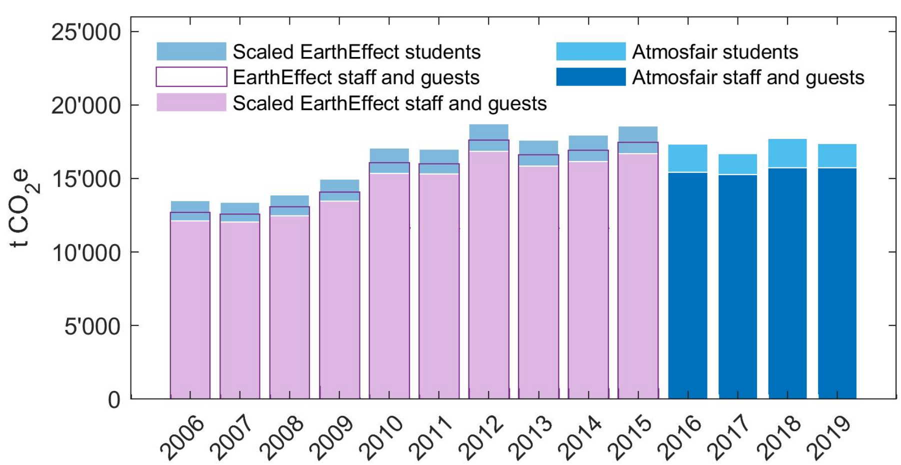
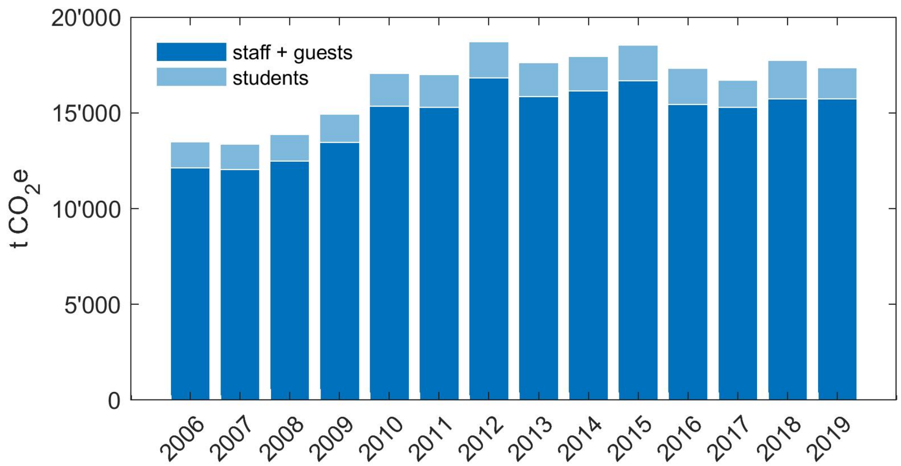


Figure 3: The original EarthEffect (magenta line), scaled staff and guest (light magenta) and student (light blue) together with the Atmosfair staff and guest (dark blue) and student (cyan) estimates for the overlapping period of the two time series.

a)



b)

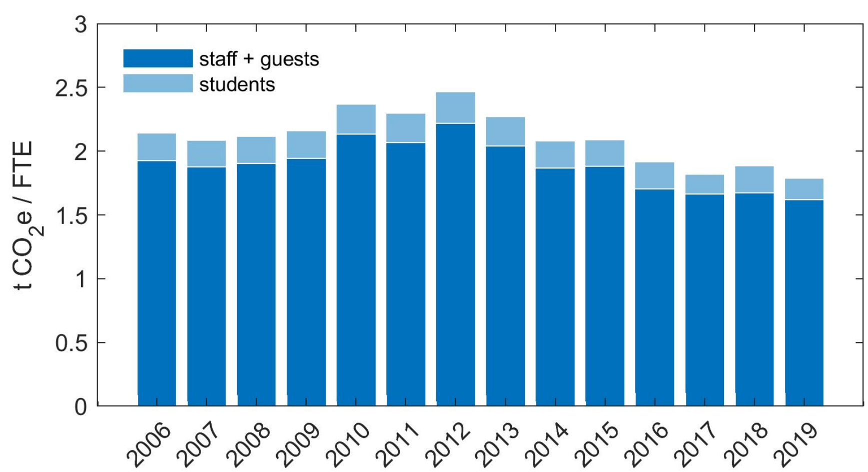


Figure 4: Aligned EarthEffect data for the period 2006-2015 and Atmosfair data for the period 2016-2019 for a) total emissions and b) emissions per FTE. The dark blue shows the contribution of ETH staff and guest, and light blue shows the contribution of the students.

4 Assumptions and Implications

The corrections made to the EarthEffect data are subject to several assumptions:

- The difference between the EarthEffect and INFRAS-EarthEffect is constant over time.
- The relationship between INFRAS-EarthEffect and Atmosfair is constant over time.
- The fraction of emissions from flights by students is constant.
- There are no biases in recording of data.

The difference between EarthEffect and INFRAS-EarthEffect should ideally be 0. It is not clear whether the differences occurring in 2016 between these two estimates are systematic, or whether the correction to the INFRAS-EarthEffect calculations occurs in other years too.

Over the reference period (2016-2018), the difference between INFRAS-EarthEffect and Atmosfair varies between 0.15 and 11.98 %. Hence, using one value to adjust for the difference could lead to a considerable uncertainty in the corrections made EarthEffect data for the period 2006-2015.

For the period 2016-2019, the fraction of total emissions caused by student flights varied between 8.5 and 11.4 %. The estimates made for student emissions in 2006 and 2015 using the EarthEffect method, indicated a student fraction of 9 % and 12.5 % for 2006 and 2015, respectively (Mobilitätsplatform ETH Zurich, 2017). Therefore, we assume that the assumption of student flights made in the adjustment of the EarthEffect data is reasonable.

Biases in recording of data will only affect the estimated student fraction in the above calculations since the same flights are used when calculating emissions using both methods for the overlapping period. However, if there are biases in the recorded data, no statements can be made about trends and evolution of emissions from Figure 4. Biases in recording of flights also exist for the period 2016-2018[1] (and later, since the recording is not done automatically), and hence one should interpret these numbers with care.

[1] In late 2020, duplicate flight entries were detected in the INFRAS-Atmosfair data. These lead to the flight emissions presented in Fig. 4 being too high for the years 2016-2018. In the future, the duplicates will be removed. The duplicates have been kept in the alignment because both the INFRAS-EarthEffect and INFRAS-Atmosfair should contain the same data. Hence, the calculated scaling factors calculated from the data shown in Fig. 1 should not be affected.

References

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