# Calculations in the GoClimateNeutral Flight Footprint API

2019-04-08
Version 1.0


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# 1. Introduction

The GoClimateNeutral Flight Emissions API calculates an approximation of the amount of $CO_2$-equivalents a future flight emits per person. We wanted to build the GoClimateNeutral.org Flight Emissions API to educate people searching for future flights what the flights environmental impact is per person, and thereby enabling people to choose less environmentally damaging flights or ways of travel.

## 1.1. Climate Change and Flying

Climate change is real and the time to drastically lower our total Greenhouse Gas-emissions is now. Even though flying is a small part of the global emissions (2-5% of global emissions), it is a very large part of an individual's carbon footprint. Lowering your personal flight emissions is often one of the most climate friendly actions you can do as an individual.

## 1.2. Exact Calculations of Future Emissions

Our calculation is an estimation of the flight emissions. It is not possible to calculate a future flight's exact emissions due to several reasons:

- Many parameters affecting the emissions cannot be known beforehand. These parameters include wind, number of taken seats, freight weight, fuel load, holding patterns and the possibility that the scheduled aircraft type is changed between booking and lift off.
- Up to date data about individual aircrafts engine type and their real world fuel consumption across distances are not publically available for all aircrafts. The European Environment Agency (EEA) has generated estimations of fuel consumption (1), but these are not made for comparing individual flight models. The UN-agency International Civil Aviation Organization (ICAO) has collected the data but have not released it other then in pdf-format with unclear licenses for public use (2).
- Data with good enough coverage for what aircraft and engine type a specific future flight number has is not available. This is available for past flights, but a requirement of the API is to also be able to calculate emissions of future flights.
- Public data with good enough coverage on seating plans on flights is not easily available. This can be seen on sites like seatguru.com (3), but the data has not full coverage and is also not publicly available. Number of seats can also be changed before lift off i.e. to include more business class seats lowering the total amount of passenger seats.

- Research is not conclusive on the relation between emissions on high altitude and climate impact, varying between a factor of 1.5 and 2.7.

Calculations on climate impact for one person being on a specific future flight therefore needs to be based on assumptions - each assumption with different drawbacks. In this document we try to explain the reasoning behind the assumptions we have made.

# 2. Objective

The objective of the GoClimateNeutral.org Flight Emissions API is to illuminate people searching for future flights what the flights environmental impact is per person, and thereby enable people to choose less environmentally damaging flights or ways of travel.

This means that the calculations need to be good enough to make it possible to compare flights and to make it possible for a consumer to choose the least $CO_2$eq-emitting flight among many flights or the least $CO_2$eq-emitting mean of transport from point A to B.

# 3. Principles

Since there are many ways of reasoning about the assumptions needed to be done when estimating future flight emissions, we have chosen a couple of principles to guide us.

## 3.1. Underestimation vs. Overestimation

We don’t want to underestimate emissions and thereby risk guiding consumers to make the wrong decisions based on flights being more climate friendly than they are. Future research could show that high altitude emissions have a higher climate impact than we think today. But we also don’t want to overestimate, giving the consumers the wrong impression of the actual emissions.

## 3.2. Approximately right vs. exactly wrong

We prefer to be approximately right than exactly wrong. This means that we rather answer with less significant digits in our response than too many significant digits.

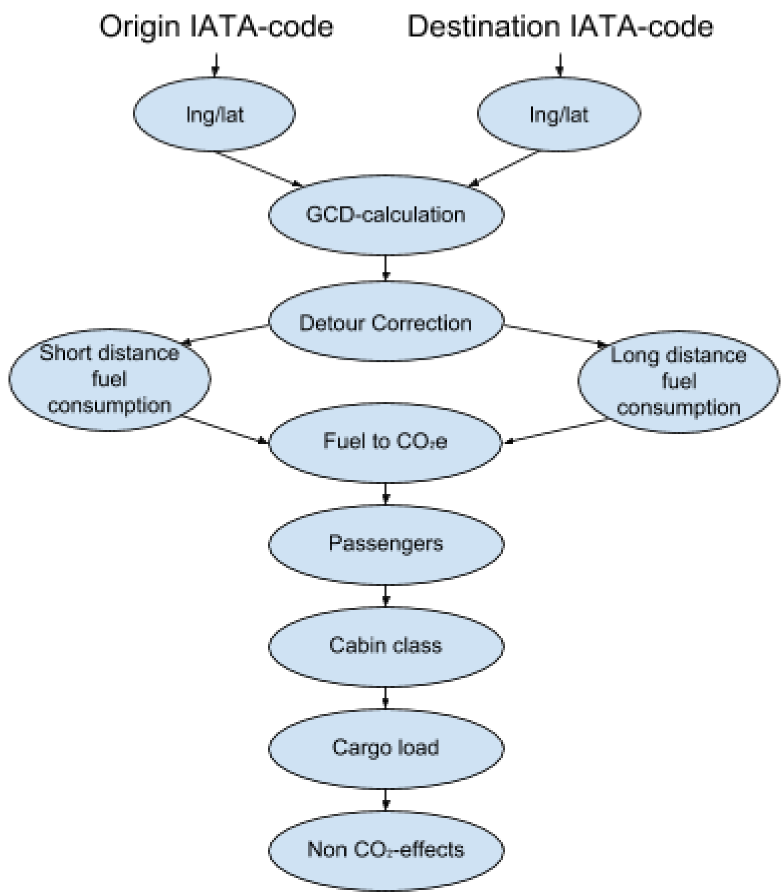
## 3.3. Incomplete datasets

We don’t want to use incomplete datasets that results in different calculation-models for different flights. That would risk misleading the consumer when comparing flights where the largest explanation for the difference in flight emissions is that we have different data for different flights when doing the calculations. We could be ok with almost 100% coverage leading to some different calculation models in edge cases, but not where using different calculations would be the norm.

## 3.4. Insignificant parameters

Some parameters simply doesn’t affect emissions that much, and can therefore be ignored.

# 4. Method




## 4.1. Flight Distance

Given origin and destination IATA-code, the distance between airports are calculated based on the great circle distance (4) using the Haversine formula (5). In case of non-direct flights, the route segments are treated as individual flights.

## 4.2. Detour Correction

The actual flight between airports is often longer than the great circle distance between airports. The difference can be due to air traffic control systems, weather events and holding patterns before landing.

We have not found any reliable global statistics on the extra distance and they seem to differ quite a lot between routes and individual flights (6).

We are using the GCD correction factor that ICAO (7) suggests for this purpose:

- Distance less than 550 km: +50 km
- Distance between 550 km and 5500 km: +100 km
- Distance above 5500 km: +125 km

## 4.3. Fuel consumption

Our calculation for fuel consumption is based on a model suggested by myclimate (8) defining fuel burn rates for a hybrid short distance (<1500 km) and long distance (>2500 km) aircraft.

Fuel consumption for the hybrid aircraft is based on a weighted average of fuel burn rates for different well used short respectively long distance aircraft types. A generalized function for the climb, cruise and descent-phase (CCD) fuel consumption is approximated with a second-order polynomial fit. The fuel consumption for distances between short and long distance is linearly interpolated.

The fuel burn rates weighted into the hybrid aircrafts are based on the EEA Air Pollutant Emission Inventory Guidebook (9). A constant fuel amount is also calculated for the hybrid aircrafts and added to the fuel consumption in order to account for the usage of the aircraft during landing, take-off and taxi (LTO).

To use real world fuel consumption numbers would be more reliable, but as stated earlier, data with good enough coverage is not available. In an ideal world airlines would release real world data flight by flight.

## 4.4. Fuel to $CO_2$

The combustion of 1 kilogramme (kg) of jet fuel in an aircraft engine produces approximately 3.15 kg of carbon dioxide ($CO_2$) (10).

## 4.5. Emissions per passenger

The emissions per aircraft are distributed among the number of passengers. The number of passengers is defined as the average number of seats per aircraft type (ICAODATA 2012) multiplied by the passenger load factor published by the International Air Transport Association (IATA 2012).

## 4.6. Cabin class weighting scheme

There are often different cabin classes in an airplane, and different cabin classes take up different amount of space in the airplane. If a plane only had economy class, more passengers would fit into the airplane and the emissions per passenger would be lower. The weighting factor comes from the myclimate calculation model (8) and has been calculated and weighed in for each hybrid aircraft type.

## 4.7. Cargo Load

Aircrafts often transport considerable amounts of cargo and revenues from cargo are a significant source of income for most large passenger carriers. It is therefore fair to allocate some of the aircraft emissions to the cargo load as suggested by SEI (11).

There are different approaches to allocate emissions between passenger and cargo load. We use the monetary approach, distributing the emissions according to the revenue from the passenger and freight business. According to ICAO this is 95.1% from passenger and 4.9% from cargo business.

## 4.8. Accounting for non-$CO_2$ effects of aviation

There is still uncertainty related to quantifications of the climate impacts of non-$CO_2$ air travel emissions. Clearly, more research and more sophisticated models are needed. Although there is no simple answer to what the overall impact of aviation is, it is clear that total contribution to climate change is greater than that of $CO_2$ alone. SEI advocates to use a multiplier of at least 2 for air travel emissions calculators to account for non-$CO_2$ warming effects (12).

Some are arguing for lower multipliers, and some are arguing for higher. An aspect here is the time frame you are looking at, where some GHG are more damaging in the short term but have climate effects that are near zero after a couple of years, while other gases, like $CO_2$ are around for hundreds of years.

We have chosen to use a factor 2 for $CO_2$ from combustion in our calculations which is based on the most recent scientific publications (13). We are following the research closely and are ready to update the multiplier if more conclusive research is presented.

# 5. References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