Transportation sector:
Domestic Aviation
International Aviation

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1. Introduction

The aviation sector is considered to be part of the top ten global emitting sectors and emissions are expected to climb due to increased demand for aviation fuel (Perlman, 2018; IEA, 2019). Unfortunately, aviation, along with other transportation sectors, was exempted from the Paris treaty and not considered on track to decrease emissions (Twidale and Saul, 2015; Edie, 2020, Climate Action Tracker, 2020). As a result, current efforts to reduce aviation emissions have proven woefully inadequate (Perlman, 2018).

To improve the monitoring and measuring of global aviation greenhouse gas (GHG) emissions, as well as serving as an input for the environmental management of the sector, Climate TRACE employs the International Civil Aviation Organization's (ICAO) methodology to estimate both domestic and international aviation emissions.

The ICAO methodology uses a Tier 3a approach defined by the Intergovernmental Panel on Climate Change (IPCC). The Tier 3a method, which is more detailed, considers information about aircraft movement, such as origin and destination aerodromes (locations where aircraft operations occur) and aircraft model. This method was applied to estimate fuel consumption and emissions of atmospheric pollutants and GHG, allowing for their discrimination based on type of movement, domestic or international.

2. Materials and Methods

Climate TRACE used ICAO Carbon Emissions Calculator Methodology, Version 11 along with Official Airline Guides (OAG) Historical Flight Status Data for all domestic and international passenger, commercial, private flights and general aviation starting from January 1, 2015, to July 31, 2021. The emissions estimates, based on fuel consumption, include direct GHG emissions: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

This sector does not include the following:

- Primary pollutants emissions (carbon monoxide, volatile organic compounds, nitrogen oxide, sulfur dioxide and particulate matter);
- Ethanol-powered aircraft; and

- The calculations are made for each flight between a origin and destination pair for all national aerodromes, except those referring to helicopters, military aircraft and agricultural aircrafts.

2.1 Datasets employed

The Official Airline Guides (OAG) air traffic movement database provides the main source of information for the ICAO method. Additional information was used, such as fuel consumption factors for specific aircraft types and flight distance provided by ICAO, and geographic coordinates of aerodromes from OurAirports.com (https://ourairports.com/) and airport data from the Aviation Stack API (https://aviationstack.com/).

2.1.1 Activity data: aircraft movement

Historical flight records were obtained from OAG (https://www.oag.com/). The data (covering historical flight departures and arrivals) was available on an annual time scale. Additionally, OAG data allows for the creation of a database containing flights from 2015 to 2021. The following attributes were available:

- The annual frequency of a particular flight between a pair of origin and destination airports (2015-2021);
- ICAO aircraft code;
- ICAO code of origin and destination airports;
- Airline/flight operator; and
- Flight origin and destination which can be used to classify into domestic or international trips

2.2 Model

Figure 1 provides an overview of the model applied by Climate TRACE along with the main data sources to calculate GHG emissions by domestic and international aviation.

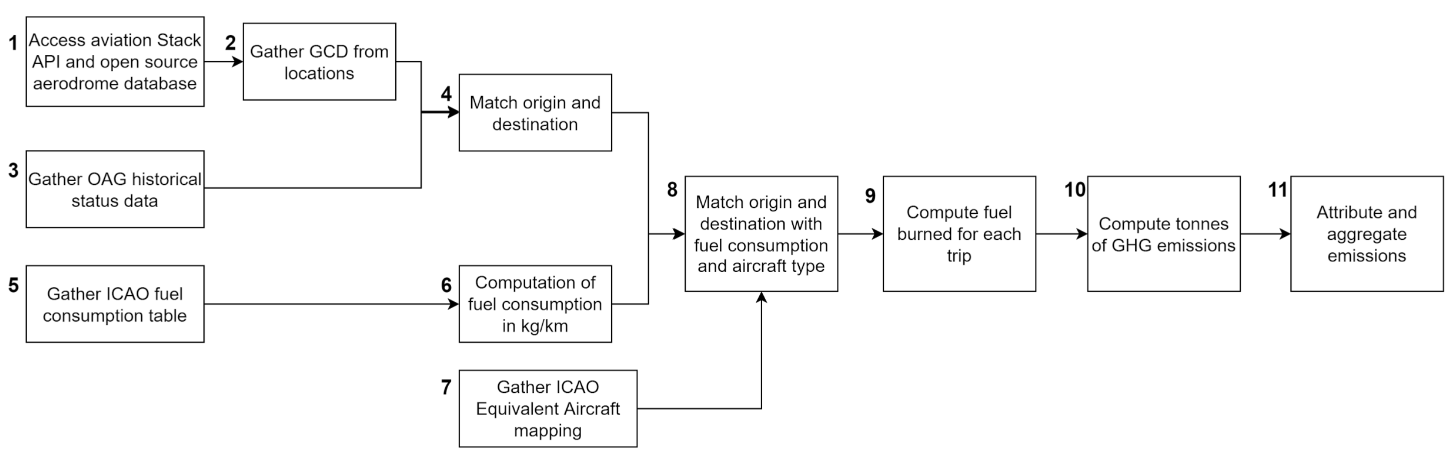

Figure 1 Flow of inputs and outputs to generate aviation emissions. Steps are described in section 2.3.

2.3 Methods

The following was performed to estimate aviation emissions.

The 1) aviation stack API and open source aerodrome database and 2) OAG historical status data were used to calculate 3) the Great Circle Distance (GCD) between every 4) origin and destination pair using airport location data (latitude and longitude) from these sources. A correction factor was applied to the GCD to account for distance flown in excess of the GCD due to stacking, traffic and weather-driven factors. The specific aircraft type used historically for every route was mapped to an equivalent aircraft type using ICAO's Equivalent Aircraft Mapping (see Appendix B: ICAO Carbon Emissions Calculator Methodology).

Next, 5) ICAO fuel consumption table (Appendix C: ICAO Carbon Emissions Calculator Methodology) was used to 6) estimate fuel consumption by aircraft type (kg/km). Step 6 was combined with 7) ICAO Equivalent Aircraft mapping to 8) match the origin and destination to the aircraft, the aircraft type and to estimate 9) the fuel consumption. Then the fuel consumption was used in 10) to compute fuel burned for each trip based on the aircraft travel origin and destination, and the aircraft type. Lastly, the fuel burned for each trip was converted to the equivalent GHG emissions using an aviation fuel emissions factor from ICAO Carbon Calculator methodology.

As a last step, 11) the resulting GHG emissions were either attributed fully to a country, if the route was domestic, or divided in half between countries in case of an international route. For airport emissions attribution, the GHG was divided in half between airports and the trip was classified into domestic or international category. The emissions for each country and airport were then aggregated by year to give the total aviation emissions by country and airport for 2015-2021.

3. References

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