TECHNICAL NOTE

Airport Emissions Tracker Data

The International Council on Clean Transportation

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The data used for the airport emissions tracker were derived from the Global Aviation Carbon Assessment (GACA) model developed by the International Council on Clean Transportation (ICCT). An in-depth methodology for passenger carbon dioxide (CO_2) estimation is included in the following report:

> Graver, B., Rutherford, D., and Zheng, S. (2020). *CO_2 emissions from commercial aviation: 2013, 2018, and 2019*. Retrieved from the International Council on Clean Transportation website: https://www.theicct.org/sites/default/publications/CO2-commercial-aviation-oct2020.pdf

The airport emissions tracker contains information for the 1,300 largest global airports, based on total revenue passenger kilometers (RPKs). This covers 99% of global airline passenger traffic.

Revenue passenger kilometers (RPKs) represents an airline's passenger traffic. It is derived by multiplying the number of fare-paying passengers on a flight by the flight distance.

Passenger transport carbon dioxide (CO_2) emissions represents the apportionment of total CO_2 emissions to passenger transport only.

Carbon intensity, in grams CO_2 per RPK, is the total passenger transport CO_2 emissions divided by the total RPKs.

Revenue freight kilometers (RFKs) represents an airline's freight traffic. It is derived by multiplying the mass of cargo carried on a flight by the flight distance and summed up for both belly cargo and dedicated cargo.

Freight carbon dioxide (CO_2) emissions represents the apportionment of total CO_2 emissions to both freight carried on passenger aircraft ("belly freight") and freight carried on dedicated freighters.

Carbon intensity, in grams CO_2 per RFK, is the total freight transport CO_2 emissions divided by the total RFKs.

ABRIDGED METHODOLOGY

CO_2 emissions

Global passenger airline operations data were sourced from OAG Aviation Worldwide Limited. The OAG dataset contained the following variables: air carrier, aircraft type, departure airport, arrival airport, departures (number of flights), and capacity in available seat miles.

Payload associated with the transport of passengers and their luggage was estimated using the number of aircraft seats, a passenger load factor, and a default passenger mass. If passenger load factors for an airline were not publicly available, a region-specific passenger load factor published by the International Civil Aviation Organization (ICAO) was used.[1] Total traffic, in revenue passenger kilometers (RPKs), was estimated by multiplying seat capacity by the passenger load factor, and associated unit conversions.

Global dedicated freighter operations data were also sourced from OAG Aviation Worldwide Limited, except for flights operated by UPS and FedEx. UPS and FedEx flight schedules were compiled from two sources:

(1) U.S. DOT Bureau of Transportation Statistics Form T100 Traffic and Capacity Statistics Segment Report[2], a publicly available dataset processed by Airline Data Inc., covering flights to, from, and within the United States; and
(2) Flight Radar 24 flight schedules[3], purchased directly from the vendor, covering flights outside of the United States.

Payload associated with the transport of cargo on a passenger aircraft was estimated using either publicly available data or an ICAO region-specific passenger-to-freight factor. For dedicated freighters on US-departing and US-arriving flights, great circle distance (GCD) and cargo mass carried are available in Form T100 for each route-airline-aircraft combination. We used the payload data as is and applied a distance correction factor[4] to account for deviation from GCD in real-world flight paths.

Flight Radar 24 flight schedules do not contain information about flight distance or payload. Great circle distances were calculated based on departure and destination airports.[5] Average payload for each route-airline-aircraft combination was estimated based on average weight capacity and average weight load factor specific to each carrier and each aircraft type. These average capacity values and average load factors were calculated using payload data of 2019 global freighter operations downloaded from the International Civil Aviation Organization's (ICAO) Data+ platform.[6]

For each combination of route, airline, and aircraft type, GACA modeled fuel burn based on the summation of passenger and cargo payload. Fuel burn was apportioned to passenger and cargo carriage using the following three equations:

Equation [1]

$$Total\,Passenger\,Fuel\,Use\,[kg] = \left(\frac{Total\,Passenger\,Weight\,[kg]}{Total\,Weight\,[kg]}\right)(Total\,Fuel\,Use\,[kg])$$

[1] International Civil Aviation Organization. (2017). ICAO carbon emissions calculator methodology, version 10. Retrieved from https://www.icao.int/environmental-protection/CarbonOffset/Documents/Methodology%20ICAO%20Carbon%20Calculator_v10-2017.pdf

[2] US DOT Bureau of Transportation Statistics. (2019). Form T100 Traffic and Capacity Statistics Segment Report. Retrieved from https://esubmit.rita.dot.gov/QaA/T100-Segment.pdf

[3] https://www.flightradar24.com/

[4] International Civil Aviation Organization. (2017). ICAO carbon emissions calculator methodology, version 10. Retrieved from https://www.icao.int/environmental-protection/CarbonOffset/Documents/Methodology%20ICAO%20Carbon%20Calculator_v10-2017.pdf

[5] Great Circle Mapper: http://www.gcmap.com/

[6] ICAO Data+. (2023). Traffic by Flight Stage. Retrieved from https://data.icao.int/newDataPlus/Tools

Equation [2]

$$Total\ Passenger\ Weight\,[kg] = (Number\ of\ Aircraft\ Seats)(50\,kg) + (Number\ of\ Passengers)(100\,kg)$$

Equation [3]

$$Total\ Weight\,[kg] = Total\ Passenger\ Weight\,[kg] + Total\ Freight\ Weight\,[kg]$$

Thus, total fuel use is proportional to payload mass after taking into account furnishings and service equipment needed for passenger operations. For dedicated freighters, for each combination of route, airline, and aircraft type, aircraft performance modeling software PIANO was used to model flight fuel burn based on the total cargo mass carried and the adjusted GCD. For all flights, CO_2 emissions were estimated using the accepted constant of 3.16 tonnes of CO_2 emitted from the consumption of one tonne of aviation fuel.[7]

Passenger operations and fuel burn were characterized by flight distance3:

- Short-Haul: Shorter than 1,500 km
- Medium-Haul: 1,500 to 4,000 km
- Long-Haul: Longer than 4,000 km

A conversion factor of 4 million tonnes CO_2 per coal-fired power plant was used to compare the CO_2 emissions of each airport. This is based on data reported by the United States Environmental Protection Agency.[8] Alternatively, for smaller airports emissions were normalized to the global average passenger car of 2 tonnes/CO_2 per year.

Air pollution

To estimate air pollution from landing and takeoff (LTO) operations at airports, data were sourced from GACA, T100, Flight Radar 24, the Aircraft Engine Emissions Databank[9] plus the Air Quality Manual provided by the International Civil Aviation Organization (ICAO)[10], and fleet data sourced from IBA.[11]

Estimates are provided for emissions of nitrogen oxides (NOx), fine particulate matter ($PM_{2.5}$), hydrocarbons (HC), and carbon monoxide (CO) for both passenger and freighter flights.
To model air pollution, the Engine Emissions Databank was supplemented with estimated non-volatile PM (nvPM) data where missing. nvPM emissions indices were derived from the Smoke Number (SN) convention of the aircraft engine, as directed in ICAO's Air Quality Manual. Non-volatile mass concentration and corrected engine-out emissions for nvPM, sulfur volatile PM, and organic volatile PM in four different modes (approach, taxi and ground idle, take off and climb) and summed all up to generate $PM_{2.5}$ emissions.

The supplemented Engine Emission Databank was then matched to IBA fleet information to enable the calculation of air pollution for each unique combination of route, airline, and aircraft type. To match operations data in the Global Aviation Carbon Assessment (GACA) to IBA emissions data we employ the concept of 'Aircraft/Aircraft Family Representative Engine

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[7] International Civil Aviation Organization. (2020). 2019 Environmental Report. Retrieved from https://www.icao.int/environmental-protection/Documents/ICAO-ENV-Report2019-F1_WEB%20(1).pdf
[8] See https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and- references
[9] European Union Aviation Safety Agency. (2023). ICAO Aircraft Engine Emissions Databank. Retrieved from https://www.easa.europa.eu/en/downloads/131424/en
[10] International Civil Aviation Organization.(2015). Airport Air Quality Manual. Retrieved from https://www.icao.int/environmental-protection/Documents/Doc%209889.SGAR.WG2.Initial%20Update.pdf
[11] IBA Group Limited.

Emission.' This representative emission value is computed as a weighted average based on specific pairings considering the Airport, Operator, Aircraft Family/Aircraft Model, and the corresponding weighted average emission value within each pair.

To normalize air pollution to passenger vehicles, we assumed an average per mile NOx and exhaust nvPM2.5 emissions rate for US gasoline cars in 2019 as published by the US Department of Transportation.[12] A global average of 9600 miles per car per year was applied.[13] An equivalent number of passenger vehicles was calculated for NOx and for PM2.5 at each airport, and then a simple average was reported.

[12] https://www.bts.gov/content/estimated-national-average-vehicle-emissions-rates-vehicle-vehicle-type-using-gasoline-and
[13] https://www.fhwa.dot.gov/ohim/onh00/bar4.htm