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An analysis of the greenhouse gas emissions profile of airlines flying the Australian international market

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ABSTRACT

International commercial flights (with the exception of flights between countries in European Union including Iceland, Norway and Liechtenstein) are currently not subject to greenhouse gas emission reduction regulation. To formulate effective and efficiency policy to manage greenhouse gas emissions from air transport, policy makers need to determine the emissions profiles of all airlines currently flying into their country or region. In this paper, we use 2012 data on airlines' aircraft characteristics, passenger load and cargo load (obtained from statistics reported by Australian Government Bureau of Infrastructure, Transport and Regional Economics) to estimate the volume and carbon efficiency on each international route flying to and from Australia. This is the first study to use actual passenger and cargo load data to determine the greenhouse gas (specifically CO_2) efficiency of airlines operating in the Australian international aviation market. Airlines' CO_2 emission profile is dependent on many factors including but not limited to the aircraft used, payload, route taken, weather conditions. Our results reveal that the airlines' CO_2 emission profile is not only dependent on the aircraft used and the number of passengers but also the amount of cargo on each flight.

1. Introduction

Aviation accounts for 2% of the total global greenhouse gas (GHG) emissions according to the United Nations (UN) Intergovernmental Panel on Climate Change (IPCC) (Barker et al., 2007; IPCC, 1999). Over the next two decades passenger traffic and air cargo is expected to increase at a rate of 4.5%–5.0% per year (Airbus, 2014b; Boeing, 2014b; Kahn Ribeiro et al., 2007) with GHG emissions growing at between 3 and 4% per year (Barker et al., 2007; International Civil Aviation Organization (ICAO), 2010). Owen et al. (2010) modelled the global aviation carbon dioxide (CO_2) emissions under the four Intergovernmental Panel on Climate Change/Special Report on Emission Scenarios (IPCC/SRES) plus one additional mitigation scenario and predicted that aviation CO_2 will grow to between 2.4% and 4.1% of the projected 2050 global CO_2 emissions.

Unlike other industries, international flights generate emissions across many countries and legal jurisdictions, with the effects both visible (e.g. con trails) and invisible (e.g. carbon dioxide (CO_2), mono-nitrogen oxides (NO_X)). Only flights within New Zealand and the European Union (EU) are subject to some form of GHG emissions regulation (Braathen et al., 2012). International aviation emissions were not included in the Kyoto protocol (United Nations (UN), 1998). Article 2.2 directed The Parties in Annex I of the protocol to work through International Civil Aviation Organisation (ICAO) in limiting and reducing GHG emissions. At the 2013 38th session of the ICAO Assembly, members agreed to develop and present recommendations on a global Market Based Measure (MBM) scheme for reducing international aviation GHG emission at the 39th session in 2016, with the goal of implementing MBM scheme from 2020 (International Civil Aviation Organization (ICAO), 2013a). The MBM is likely to also include alternative fuels, and improvements in technology and operations. Currently international aviation outside of the EU is not subject to any form of GHG emissions regulations. Aircraft emissions are not only made up of CO_2 but also black carbon (soot), sulphur oxides (SO_X), water vapour and NO_X. To account for the effects of non-CO_2 emissions, a multiplier of emitted CO_2 such as Radiative Forcing Index (RFI), Global Warming Potential (GWP), and Global Temperature Potential (GTP) is used. Marbaix et al. (2008) recommended using a GWP-based multiplier of between 1.5 and 4.1 with a best estimate of 2.4, which includes the effects of NO_X, contrails and induced cirrus clouds. Lee et al. (2009) suggested using 3.5% of global climate

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forcing (4.9% anthropogenic forcing including non-CO_2 and cirrus cloud). Some airlines and many companies have produced aviation carbon emission calculators that allow individuals and businesses to offset their carbon emissions from air travel (Carbon Footprint, 2014; Carbon Neutral, 2014; Kling and Hough, 2011; myClimate, 2014; Qantas, 2014). These calculators use different methodologies and produce different estimates of GHG emissions equivalent (CO_2e) for the same flight (Table 1). There is currently no consensus on which multiplier to use or how to include non-CO_2 aviation emissions. ICAO recommends focusing only on CO_2 aviation emissions since it is the largest component (International Civil Aviation Organization (ICAO), 2008).

The right to fly between an airlines' home country and any city of a foreign country or region (like the EU) is subject to negotiated bilateral or multilateral air service agreements. Most bilateral and multilateral Air Service agreements and Open Skies agreements will specify all or a subset of the nine Freedoms that will be granted (International Civil Aviation Organization (ICAO), 2013b; Vasigh et al., 2013). Prior to developing policies (such as economic, emissions and/or command and control policies) to manage and reduce CO_2 emissions from international aviation, policy makers in each country need to assess the amount of CO_2 emitted and the efficiency of all airlines on their international routes using actual load factors, flight schedule and aircraft characteristics.

Flight emissions calculators developed by various groups - International Civil Aviation Organization (ICAO) (2014b); Jardine (2009); Kling and Hough (2010); Miyoshi and Mason (2009) - all follow similar methodologies and estimate the amount of CO_2 apportioned to a passenger based on the seat class, aircraft type, distance flown, average load factor on the route and may include the average cargo load on the route. The carbon calculator presented in Miyoshi and Mason (2009) used the actual airlines routes, load factor, aircraft type and cabin configuration but not cargo to highlight each airline's CO_2 emission performance in the UK market. In this paper we use a modified version of the International Civil Aviation Organization (ICAO) (2014b) Carbon Calculator Methodology to determine the CO_2 emissions profile of airlines that fly the Australian International aviation market using the airline's aircraft type, passenger and cargo load in 2012. For benchmarking to be effective, ICAO recommends that benchmarking (performance) parameters should be independent of different airline business model (International Civil Aviation Organization (ICAO), 2008). In this paper, we do not take into account the seat class that is usually attributed to the different airline business models (i.e. low cost, traditional network). We demonstrate that an airline's choice of aircraft; seat density (i.e. number of seats in each aircraft), passenger load factor (i.e. % of occupied seats) and the amount of cargo transported on each flight can affect the CO_2 efficiency on Australian international routes.

2. Methods

The CO_2 estimates presented in this paper were derived using the CO_2 Profile Calculator shown in Fig. 1. This CO_2 Profile Calculator is a modified version of the ICAO Carbon Calculator Methodology that calculates the amount of CO_2 emitted on each flight (International Civil Aviation Organization (ICAO), 2014b). Unlike the ICAO Carbon Calculator, the algorithm used in this paper does not take into consideration the class of travel. The calculator used in this paper determines the amount of CO_2 emitted for an aircraft flying the great circle distance route between two cities. Passengers are treated as weighted payload and combined with the weight of freight to form the total payload on each flight. The amount of CO_2 emitted is then apportioned to each kg of payload km flown.

2.1. Input

2.1.1. Airport Details

Airport Details contains the airport's geographic location in latitude and longitude plus the three-letters International Air Transport Association (IATA) airport code, city, country name of the airport that each airline is flying to and from. This information was used to convert the airport/city pairs in the Airline Flight Schedule to geographic locations in latitude and longitude.

2.1.2. Airline Flight Schedule

Airline Flight Schedule contains the departure airport, arrival airport, aircraft equipment used, number of flights per month and the number of seats on the flight. This information can be obtained from each airline or purchased from companies that sell aviation information and analysis services (e.g. Innovata (2014); Official Airline Guide (OAG) (2014)).

2.1.3. Fuel burn tables

Fuel Burn Tables map the amount of fuel used by each aircraft type to fly a given distance. Most airlines have more detailed information on the fuel burn for each aircraft in their fleet but this information is not publicly available. In the algorithm used in this paper, Core Inventory of Air Emission (CORINAIR) fuel burn tables are used to determine the fuel burnt on each flight (European Environment Agency, 2006). The fuel burn table maps the fuel used for each phase of the flight namely; taxi out, take off, climb out, climb/cruise/descent, landing approach and taxi in. Horton (2010) recommend using the CORINAIR fuel burn tables but with a few modifications listed in Table 2. These modifications improve the accuracy and create new fuel burn tables for newer aircraft like the B777-300 ER and A380. For each fuel burn table, a quadratic function is also used to extrapolate and create additional table entries at intervals of 500 nm (Appendix Table B)

Table 1
GHG Emissions (CO_2e) estimates using four different carbon calculators.

Trip (one way)	myClimate[a] tCO_2e	Qantas[b] tCO_2e	Carbon Footprint[c] tCO_2e	Carbon Neutral[d] tCO_2e
Sydney-Los Angeles (SYD-LAX)	2.373	1.616	0.96	2.18
Brisbane-Los Angeles (BNE-LAX)	2.256	0.955	0.92	2.08
Sydney-Abu Dhabi (SYD-AUH)	2.379	1.561	0.96	2.18
Sydney-Auckland (SYD-AKL)	0.430	0.114	0.18	0.44
Perth-Kuala Lumpur (PER-KUL)	0.782	NA	0.33	0.75
Sydney-Hong Kong (SYD-HKG)	1.379	0.818	0.59	1.33

[a] myClimate, 2014. Offset your flight emissions, Zurich, Switzerland.
[b] Qantas, 2014. Offset My Flight, Sydney, Australia.
[c] Carbon Footprint, 2014. Flight carbon footprint calculator.
[d] Carbon Neutral, 2014. Air Travel Carbon Calculator.