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# The carbon footprint of air travel to UN climate conferences has increased 25-fold over three decades

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The annual United Nations Framework Convention on Climate Change Conference of the Parties convenes thousands of delegates from around the world to negotiate international climate policy, with participation relying heavily on long-distance air travel. Here, we estimate greenhouse gas emissions from travel by Party and Observer State attendees to every conference from 1995 to 2024 using the carbon R package and two datasets: a complete list of individual attendees from the first through the twenty-ninth conference, and global flight-route data (OpenFlights, 2014). Indirect emissions and well-to-tank emissions were included. Total emissions per conference were estimated by multiplying emissions per person per country by the total number of attendees and summing across countries. Emissions totalled 710,282 tonnes of carbon-dioxide equivalent over the study period, increasing by 2500% from the first conference (2959 tonnes) to the twenty-ninth (76,931 tonnes). Emissions per attendee were higher for conferences farther from Europe.

The annual Conference of the Parties (COP) is the main decision-making body of the United Nations Framework Convention on Climate Change (UNFCCC), where countries that have ratified the agreement (called Parties), as well as those that have not (called Observer States), gather to negotiate actions to tackle climate change. COPs have negotiated key international treaties, including the legally binding Kyoto Protocol (COP3, 1997) and the Paris Agreement (COP21, 2015) – the latter representing a crucial commitment to limit global warming to well below 2 °C while pursuing efforts to limit the increase to 1.5 °C. These conferences bring together thousands of delegates, including representatives of Parties and Observer States, United Nations officials, non-governmental organisations (NGOs), activists, business representatives, academics, and journalists. Reflecting on the complexity of participation at COP, a growing body of academic literature has examined trends in overall attendance<sup>1,2</sup>, stakeholder representation (e.g., by civil society<sup>3,4</sup>, health actors<sup>5-7</sup>, business<sup>8</sup>, and NGOs<sup>9</sup>), and attendance patterns by geography<sup>10</sup> and gender<sup>11,12</sup>.

Transportation is a large contributor to climate change, accounting for approximately 15% of global greenhouse gas (GHG) emissions<sup>13</sup>. While carbon dioxide (CO<sub>2</sub>) is the biggest contributor to climate change, a range of

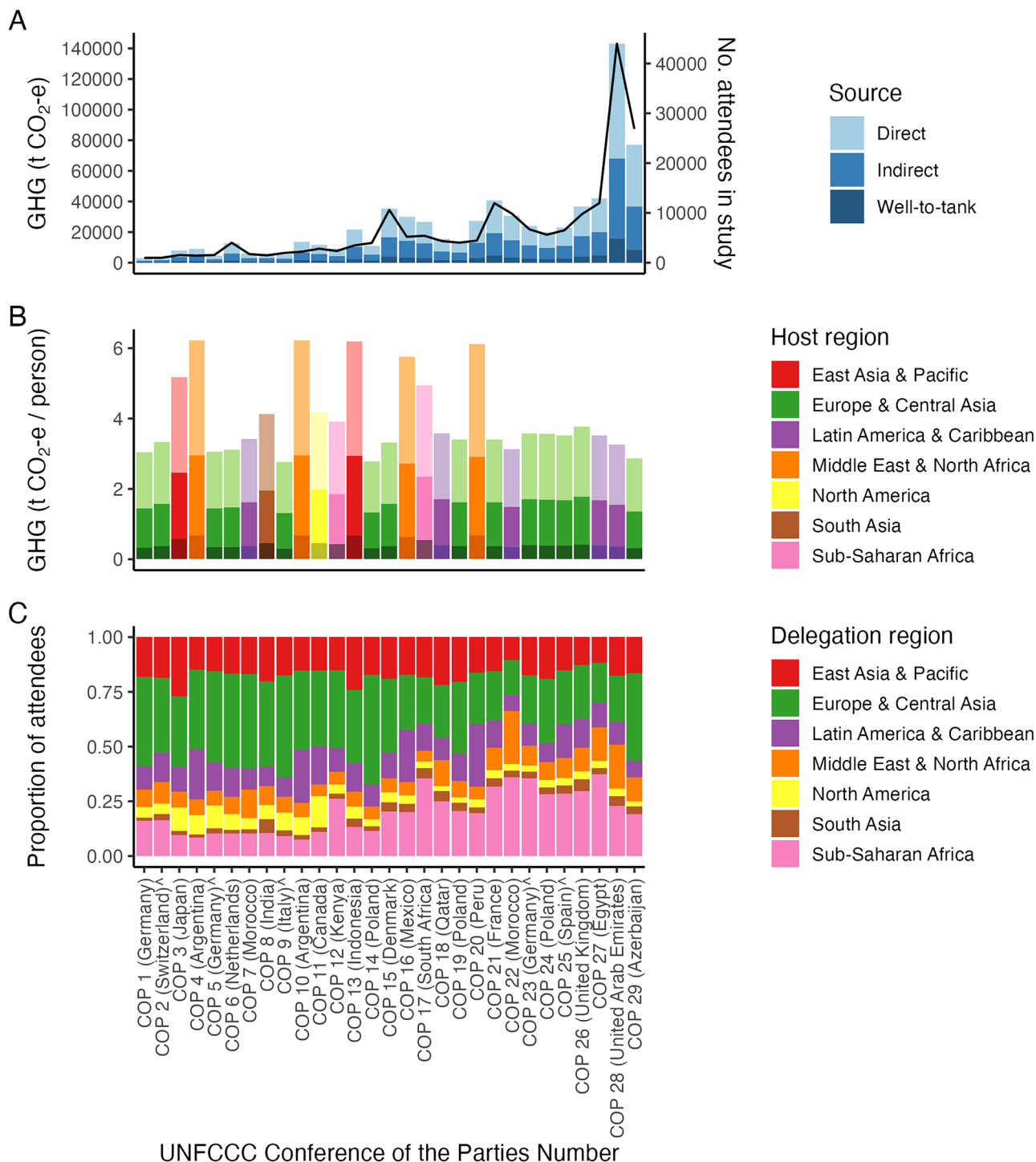
other GHGs, including methane, nitrogen oxides, and fluorinated gases, also contribute to warming. Within the transport sector, aviation is particularly emissions-intensive with its high energy demands currently met almost entirely by fossil fuels<sup>14,15</sup>. This presents a challenge for high-profile events like COP that rely heavily on long-haul air travel for international participation.

The UNFCCC Secretariat notes the scrutiny over emissions caused by air travel and encourages COP hosts to offset these emissions<sup>16</sup>. Total conference emissions have been reported by the hosts of several COPs, with up to 92% of emissions being attributable to travel (Supplementary Table 1). To date, the GHG emissions from travel to all COPs have not been systematically quantified. We present, to the best of our knowledge, the first comprehensive assessment of GHG emissions from return air travel by attendees to COP1 through COP29, addressing an unexamined gap in the climate policy literature.

## Results and Discussion

A total of 367,747 people attended COP1-29, of which 54% (197,566) were in-person Party or Observer State attendees (referred to as Party attendees for the remainder of this Brief Communication). This analysis

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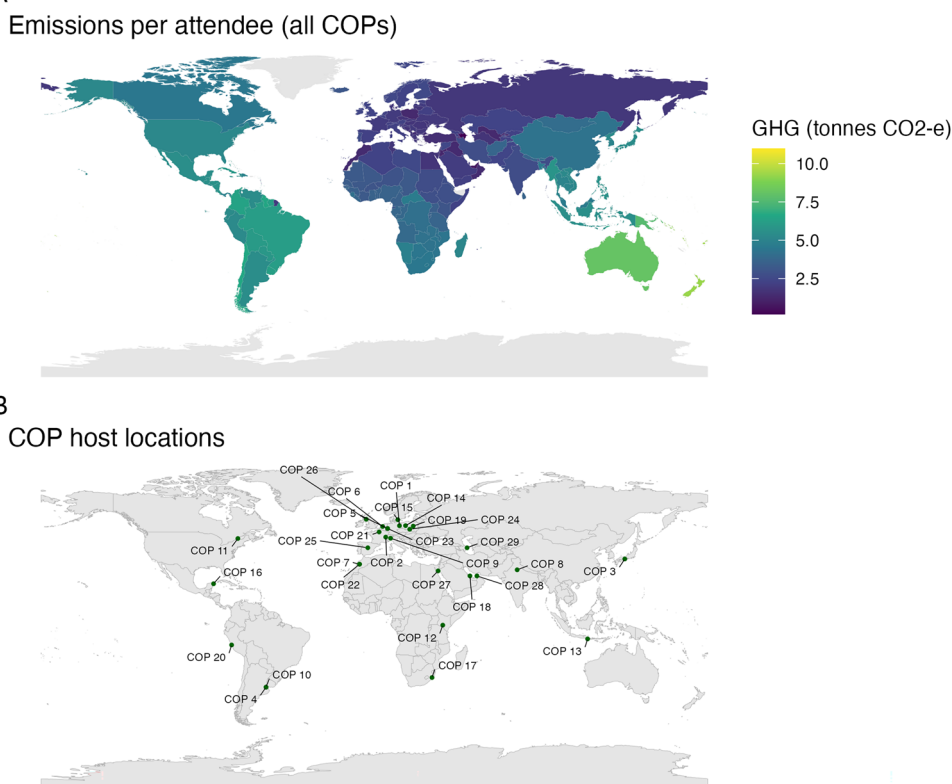
**Fig. 1 | Air travel-related greenhouse gas emissions and regional representation of Party and Observer State delegates at UNFCCC COP1-29 (1995–2024).** **A** Total greenhouse gas emissions (tonnes CO<sub>2</sub>-e) from air travel by Party and Observer State attendees at UNFCCC COP1-29 (1995–2024) (left y-axis, bar chart). Total number of Party and Observer State attendees at UNFCCC COP1-29 (1995–2024) (right y-axis, line chart). Emissions reported by source, as either direct, indirect, or well-to-tank. **B** Average greenhouse gas emissions (tonnes CO<sub>2</sub>-e) from air travel per Party and Observer State attendee at UNFCCC COP 1-29 (1995–2024). Colours represent the World Bank region of the host country. Emissions reported by source, as either

direct, indirect, or well-to-tank. The colour reported in the key is the mid-value for that colour and refers to indirect emissions. Lighter shades refer to direct emissions and darker shades refer to well-to-tank emissions, consistent with Fig. 1A. **C** Proportion of Party and Observer State attendees from different World Bank regional groupings. Note that these regions do not have equal populations (Supplementary Table 4). The host country was different from the COP presidency for COP2 (Zimbabwean presidency), COP5 (Polish presidency), COP9 (Hungarian presidency), COP23 (Fijian presidency), and COP25 (Chilean presidency) (indicated with ^).

excludes attendees not nominated by a Party, as data on their country of affiliation was not available. Further details are provided in Supplementary Methods. Party attendees were responsible for 710,282 tonnes of carbon dioxide equivalents (tCO<sub>2</sub>-e) from air travel to attend COP. GHG

emissions increased 2500% between COP1 (2,959 tCO<sub>2</sub>-e) and COP29 (76,931 tCO<sub>2</sub>-e), proportional to the increase in Party attendees over the same period (Fig. 1A). Attendance and total emissions peaked at COP28 in Dubai, the United Arab Emirates.

**Fig. 2 | Per-attendee greenhouse gas emissions by A nominating Party and geographical distribution of UNFCCC COP1-29 (1995–2024).** A Greenhouse gas emissions per COP attendee across UNFCCC COP1-29 (1995–2024) by nominating Party. Emissions are calculated as the sum of all emissions divided by the sum of all attendees per Party. B Geographical location of UNFCCC COP1-29 (1995–2024). The host country was different from the COP presidency for COP2 (Zimbabwean presidency), COP5 (Polish presidency), COP9 (Hungarian presidency), COP23 (Fijian presidency), and COP25 (Chilean presidency).



GHG emissions per COP per attendee ranged from 2.77 tCO<sub>2</sub>-e (COP9, Italy) to 6.22 tCO<sub>2</sub>-e (COP4, Argentina) (Fig. 1B). COPs with the highest emissions per attendee were held in Argentina (COP4, COP10), Indonesia (COP13), Peru (COP20), and Mexico (COP16). COPs with the lowest emissions per attendee were held in Italy (COP9), Poland (COP14), Azerbaijan (COP29), and Germany (COP1, COP5). Detailed results are reported in Supplementary Table 8.

Lower emissions per attendee for COPs hosted in Europe and Central Asia may reflect greater flight connectivity, meaning more attendees take shorter flights. Visa and financial barriers have limited participation from low- and middle-income countries to COPs held in Europe<sup>17,18</sup>, which may also contribute to the lower emissions per attendee for these COPs. However, there was no obvious pattern in attendance numbers by region or country grouping observed in this study (this conclusion is based on visual interpretation of Fig. 1C and was not formally tested). Almost half of all COPs (14 of 29) have been in Europe and Central Asia, resulting in overall high per-attendee COP travel emissions by Parties more distant from this region (Fig. 2A, B).

Our main analysis includes both well-to-tank emissions from the extraction, refining, and transportation of fuel, and indirect emissions from water vapour, contrails, and nitrogen oxides. These indirect emissions are associated with uncertainty and are an active area of research. To test the sensitivity of our results, we assessed how total emissions change when these components are excluded. When only well-to-tank emissions are excluded, total emissions decrease to 632,502 tCO<sub>2</sub>-e. When indirect emissions are excluded, total emissions decrease to 451,136 tCO<sub>2</sub>-e. Excluding both reduced total emissions to 373,357 tCO<sub>2</sub>-e (Supplementary Table 9). These results highlight that our analysis is sensitive to the inclusion of indirect emissions.

Our main analysis used the 2024 emissions factor for all COP meetings. However, aircraft energy intensity has declined by an average of 1% per year since 1970. To assess the robustness of our main conclusions, we conducted a sensitivity study which increased emissions by 1% per year from COP29 to COP1 (Supplementary Table 7). This demonstrated the soundness of our

conclusion that GHG emissions increased substantially between COP1 and COP29 (an increase of 2500% versus 2000%, not accounting for and accounting for energy intensity changes, respectively).

Our findings are largely consistent with existing work on this topic. Travel-related GHG emissions were previously estimated for COP15, 21, 23, and 26 (Supplementary Table 1). Our results are mostly consistent with these published reports, except for COP23, which reported about 43,000 tCO<sub>2</sub>-e for all travel compared to our result of 40,714 tCO<sub>2</sub>-e for Party attendees only. These discrepancies are likely due to methodological differences and the scope of emissions, as demonstrated by our sensitivity analyses. Calculators have been developed to estimate GHG emissions from transport between the United Kingdom and COP27 and COP29<sup>19,20</sup>. Results of these calculators vary depending on user inputs and flight layover locations, and do not account for radiative forcing (i.e., the greater global warming potential of emissions released at higher altitudes).

The emissions of air travel must be weighed against the potential benefits of the COP process. Face-to-face interactions play a critical role in international diplomacy, helping to build trust, foster empathy, and facilitate informal negotiations that may be harder or not possible in virtual settings<sup>21</sup>. Furthermore, implementation of the Paris Agreement (negotiated at COP21) has the potential to avoid exponentially greater emissions than those generated by the conference itself<sup>22</sup>.

Our analyses reveal that GHG emissions from COP travel are rising largely due to increases in attendance. There are calls for reforming the UN climate conferences, as critics argue that rising attendance dilutes the effectiveness of negotiations<sup>23,24</sup>. For example, COP28 saw the largest number of attendees in COP history and, with that, the largest number of delegates with fossil fuel interests<sup>25</sup>. Efforts to reduce emissions associated with COPs could focus on managing the overall scale of participation.

At the same time, participation must remain inclusive and centred on those most affected by the climate crisis. Prioritising participation from Parties, climate-vulnerable nations, Indigenous groups, youth, and civil society can help ensure that the conference remains focused on advancing equitable climate solutions. Rather than focusing on individual travel

choices or host country location, reform should begin by rethinking the scale and composition of participation itself. Complementary strategies to reduce travel-related emissions should also be considered. These may include shifting from air travel where feasible and supporting the transition from conventional jet fuel to low-carbon alternatives such as sustainable aviation fuel.

Equity must remain central to any COP reform. This includes recognising disparities between nations in terms of their historical and current contributions to global GHG emissions, as well as the right to sustainable development that enables climate-resilient communities. Although COPs held farther from Europe tend to generate higher emissions per attendee, excluding countries outside Europe from hosting due to travel-related emissions alone risks reinforcing existing geopolitical and structural inequities. Our analysis indicates that the recent COP30 conference in Brazil will be associated with high travel emissions. Yet this location offers a platform to elevate voices from Latin America and strengthen their influence in negotiations. An alternative model has been instituted on five occasions, whereby the country elected to the COP Presidency chooses to host the UN climate conference in another country<sup>26</sup>.

In conclusion, our estimates show that GHG emissions from air travel for COPs over the last three decades have totalled 710,282 tCO<sub>2</sub>-e for official Party delegates. Emissions per COP have increased, driven primarily by rising delegate numbers, with the highest per attendee emissions for conferences farthest from Europe. These emissions must be weighed against the importance of rotating COP locations to promote equitable representation and ensure that climate-vulnerable regions are meaningfully included. To reduce emissions, future efforts should limit overall attendance—particularly from delegates with interests contrary to the aims of the climate negotiations—and prioritise participation from those most affected by climate change.

## Methods

A full description of the methodology has been provided in Supplementary Methods, Supplementary Tables 2–6, and Supplementary Fig. 1, 2. Briefly, this analysis estimates the GHG emissions of travel to attend COP. It relies on two existing datasets: one comprising all individual attendees from COP1 (1995) to COP29 (2024)<sup>1</sup>, and another detailing global flight routes, published by OpenFlights in 2014<sup>27</sup>. The most direct flight routes from the biggest and/or busiest airport in each nominating country to the primary airport serving the COP host city were identified using OpenFlights data. We assumed all attendees nominated by a given Party travelled the same route and did not account for individual differences in start, end, or layover airports. We assumed that no flights were taken for attendees nominated by the COP host country. GHG emissions per attendee were calculated using the carbon R package, which relies on the United Kingdom GHG conversion factors for company reporting. Indirect emissions (water vapour, contrails, and nitrogen oxides) and well-to-tank emissions were included in the primary analysis. Total emissions per COP were estimated by multiplying emissions per person per country by the total number of attendees and then summing across all countries.

## Data availability

The code for all analyses conducted in R and R Studio is available in a public GitHub Repository (<https://github.com/jathwawi/cop-carbon-travel/>).

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## Author contributions

Jake T. W. Williams contributed to: conceptualization, methodology, software, validation, formal analysis, investigation, data curation, writing (original draft), writing (review and editing), visualisation, and project administration. Philomena Colagiuri contributed to: conceptualization, methodology, investigation, data curation, writing (original draft), writing (review and editing), and project administration. Paul J. Beggs contributed to: conceptualization, writing (review and editing), supervision, and funding acquisition. Kim Robin van Daalen contributed to: writing (review and editing), visualisation. Aditya Vyas contributed to: conceptualization, writing (review and editing). Arunima Malik contributed to: conceptualization, writing (review and editing). Ying Zhang contributed to: conceptualization, writing (review and editing), supervision, and funding acquisition.

## Competing interests

The authors declare no competing interests.

## Additional information

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