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Estimating the global warming emissions of the LCAXVII conference: connecting flights matter.

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Abstract Conferences are an important element of scientific activity but also one of the major causes of environmental burden. In this conference report, we analyse the carbon footprint of the annual conference of the American Center for Life Cycle Assessment, as well as some of the potential ways to reduce it. The average emissions per participant are estimated to be 952 kg CO_{2eq}, but with a large variability due to differences in travelled distance. Results indicate that studies should use distance-dependent flight emissions to increase the accuracy of the assessment. Connection flights are found to increase emissions up to 32 % compared with direct flights, due to the increased number of take-offs and landings. A method to calculate the ideal location is proposed, which can be used to identify unreasonably distant conference locations. Some of the measures taken to reduce the impact, such as meat-free menus, had a relatively minor contribution to emissions reductions, but could be important, as scientist advocating for the reduction of environmental burden should lead by example.

Keywords LCA · conference footprint · travel footprint

1 Introduction

The objective of organizing scientific conferences is to bring a community of scientists together to solve specific problems and updating the current state of the knowledge. Although it is remarked that participating in a conference plays an essential role on the scientific endeavour, many scholars have argued of the importance of minimising the footprint of scientific conferences Favaro (2014); Spinellis and Louridas (2013). Indeed, conference participation is one of the most substantial burdens associated with research.

Previous estimates of the carbon footprint vary widely, from 92 to 3000 kg CO_{2eq}/participant Bossdorf et al (2010); Stroud and Feeley (2015). Transport related emissions tend to dominate in most of the LCA indicators, including global warming (GW) emissions Hischier and Hilty (2002). Notwithstanding, food and accommodation has been reported to be responsible of 31 % of total conference CO_{2eq} emissions Bossdorf et al (2010) and therefore mitigation strategies should consider them. A thorough review of the literature is provided as supplementary material (SI).

In this conference report, the potential carbon footprint of the LCAXVII conference organized by the American Center for Life Cycle Assessment (ACLCA) was evaluated to suggest effective means for establishing sustainable academic practices. This event was held on October 3-5, 2017 at a hotel in Portsmouth, NH with the participation of 228 delegates to share knowledge, expertise and update the science and application of life cycle assessment (LCA). In this conference, 41 sessions were held, and 40 poster presentations were included in the conference program. The conference had a number of measures to reduce environmental impact, such as serving meat-free menus only, and not using PET water bottle or canned sodas during the conference. LCA was employed to assess the contribution of round-trip transportation to the conference, as well as food provision and accommodation.

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2 Methods

2.1 Goal and scope

The goal of this conference report is to better understand the environmental burden of an international conference and explore some potential ways to reduce it. The LCA method is used to give a comprehensive view of the emissions attributable to the conference. The focus is on emissions from transport as it is known to be the primary source of emissions. The accuracy of the estimate is improved considering factors that are usually neglected in the literature such as:

- The multimodal nature of transport (car, train and plane).
- How travelled distance affects the average emissions per flight
- Differences between travelled and as the crow flies distance.
- The potential effect of connecting flights.
- The optimal location of the conference.

We use the CO_{2eq} emissions as indicator for environmental burden using GWP100 characterisation factors. Despite its limitations, the carbon footprint is considered to be a good proxy for energy-related activities Kalbar et al (2017). For validation, we studied the correlation between CO_{2eq} emissions and other environmental indicators from a widely used impact assessment method (ReCiPe Goedkoop et al (2009)). Fig. A1 (in SI) show that for all indicators of the ReCiPe methodology are strongly linearly correlated with GW emissions for the flight-related burden. Therefore, we consider CO_{2eq} as a good proxy for environmental burden in this context. For consistency, all the sources used in this conference report use the GWP values provided in the IPCC 2007 report.

The emissions associated with the accommodation are taken from the literature and emissions from food provision are calculated based on the menu. All sources used in the inventory use cradle-to-grave accounting. Scientific conferences can be combined with other professional and personal activities. In such a case part of the emissions of travel could be allocated to other activities, reducing the burden of the conference. Maximise the utility of the travel could be a way to reduce emissions, but in this case, all emissions from travel were attributed to the conference, as we only had anecdotal evidence of multi-purpose travels.

2.2 Inventory

The environmental burden from transport is based on responses to an online questionnaire sent to all participants before the conference. We collected 122 responses, albeit some incomplete, which represented 54 % of the participants. In some instances, it was required to make a series of assumptions to fill data gaps. These are documented in the SI.

The origin of participants was geolocated, and the travel as the crow flies distance (i.e. geodesic distance) to the conference estimated using geocoding tools Geopy (2015). For those travelling by car, the travelled distance was estimated using the google maps API (n.d.). The estimated road travelled distance was strongly linearly correlated ($p=1.8e-28$ $R2=0.97$) with the geodesic distance, and about 30% larger. For those travelling by plane, the geodesic distance was scaled to take into account real-world flying constraints that deviate planes from optimal routes. Scaling factors were obtained from Reynolds (2014). For flights from US and Canada we used US estimates, and for transoceanic flights, values of flights across the Atlantic. Distances from the airport to the conference venue were also estimated using Google maps API.

The life-cycle CO_{2eq} emissions of flight transport are taken from Cox, Jemiolo, and Mutel (2018). This publication is the state of the art in air transport emissions, and it accounts for several issues rarely addressed in the literature such as the GWP of NOx, water vapour and aviation-induced cloudiness. It also models separately landing, cruise and take-off. The inventory distinguishes between different years of construction, and the average age of the US air fleet was used for this study. The publication reports emissions for travelled distances between 100-1200 km which were used to fit a power function ($p=1.08e-7$, $R2=0.96$) (Fig. A2 in SI). In case connexion flights were reported, the average EF was estimated assuming the connexion divided the flight into two equidistant flights. We note that for any given distance, a 50-50 split results in maximum emissions for the modelled function. For the rest of the transport modes (train, car and bus), life cycle emissions were obtained from the dataset reports of the ecoinvent 3.4 database (cut-off version). We assume that the participants returned to the same location using the same transport modes.

Other studies assessed optimal locations restricting the potential locations to origins of participants Stroud and Feeley (2015). In our case, we did not impose such a limitation, and the optimal conference location was estimated as the geometric median (i.e. the point that minimizes the total Euclidean distance for all participants). We used an implementation of the algorithm proposed by Vardi and Zhang (2000) provided by Orson Peters (Pers. Comm).

The conference gave a vegetarian menu plus some local seafood, such as crab and fish. The details of the conference menus were obtained from the organizer, including breakfast, lunch, and two coffee breaks. Emissions from food provision were estimated using the CarbonScopeData database. This LCI database provides data on embodied CO_{2eq} for a broad range of agricultural processes and food products in the North American context. The required energy for cooking the conference menu was extracted from Hager and Morawicki (2013) using liquefied petroleum gas as a fuel for heating energy. Quantifying potential emissions reductions with respect to a meat-based menu requires estimating the likely changes in production systems due to a change in demand (consequential LCA). The potential emissions reductions due to dietary change are derived from Goldstein, Hansen, Gjerris, Laurent, and Birkved (2016).

According to the survey, 82% of the delegates stayed at a hotel. In addition, 15% of the participants stayed in households, using systems such as Airbnb. We assumed that three persons were accommodated in each house. An average electricity consumption of 604 kWh/month was considered for household stays according to the consumption regime in New Hampshire (EIA Average Monthly Bill- Residential 2016). For the delegates, who stayed at hotels, the inventory was adopted from the literature Filimonau et al (2011), including energy consumption for hotel operational processes, such as air conditioning and hot water, as well as non-operational processes, such as laundry. The heat and electricity grid mixes for New Hampshire state were extracted from EIA, and US Census Bureau websites, respectively and the obtained values were included in the analysis of the accommodations for hotels and houses. The inventories of all the background processes, such as infrastructures, were obtained from the ecoinvent v.3.4 database.

3 Results and discussion

3.1 Transport

The average GW emissions per participant due to transport are 883 (s=824) kg CO_{2eq}/participant. Taken as reference median per capita GW emissions from 2010 Blanco et al (2014), the average emissions per participants are around 6% and 57% of the annual per capita emissions in high-income and low-income countries respectively. Average emissions are similar to those estimated by Spinellis and Louridas (2013) but much higher than in other conferences where few participants came by plane (e.g. Bossdorf et al (2010)). As illustrated in Fig. 1, the CO_{2eq} emissions vary considerably between participants, mainly because of the variation in distance travelled. Among those travelling shorter distances, there is a wide variability of emissions. For instance, travelling alone by car (the worst non-flying option) has lower CO_{2eq}/km than flying for trips of less of 750 km but around 5 times more emissions per km than buses or trains. 20% of participants with the highest emissions accounted for 50% of total emissions (Fig. A3 in SI).

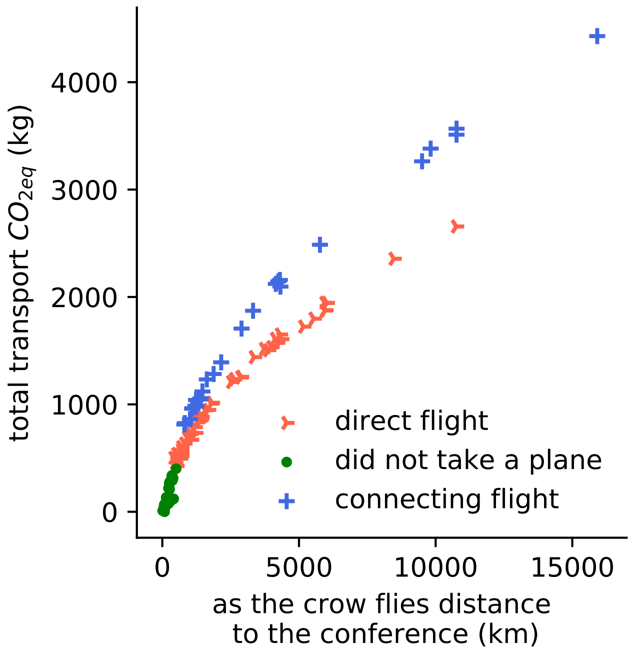

Fig. 1 total CO_{2eq} emissions per participant as a function of geodesic distance to the conference. Participants who took a connection flight are marked with a different colour.

Fig. 1 also shows how taking connection flights may have a detrimental environmental effect. Taking several flights means more take-offs and landings, increasing emissions per km flown. The finding suggests that conferences should prioritise locations that minimise the need for connecting flights, possibly close to big airports. Flight emissions as a function of distance were compared with reference values of intercontinental and intracontinental flights from ecoinvent database (Fig. A2). For distances shorter than 5000 km applying a constant emission from literature can considerably underestimate emissions from flights.

If the same participants would have come to the optimal conference location (i.e. the location that minimizes -Euclidean- distance) the average distance would have been 1913 km/participant. This is 6% lower than the actual average distance travelled. We note that this potential for reduction assumes that conference location does not affect origin of attendees. This is a potentially unrealistic assumption, but the proximity of the ideal and actual conference location suggests distance to the conference is an important factor for participation. A more reliable estimate could be calculated using participation data from multiple years, which would give a more representative sample of the participants that go to ACLCA annual conference. We also note that conferences should encourage participation. Using emission footprint as the sole criteria to choose a location could impede the participation of regions with lower density of potential participants. Carbon codes of conduct have been proposed for researchers Favaro (2014), and such an indicator could facilitate the identification of unreasonable distant conference locations.

3.2 Food and accomodation

The average of carbon footprints from the hotel and house accommodations are estimated to be 6.85 and 5.12 kg CO_{2eq}/pers/night, respectively. For the homestay participants, similar result is reported by Tsai, Lin, Hwang, and Huang (2014), where they reported a 6.3 kg CO_{2eq}/pers/night emission for an average of 2.76 tourists in household side activities in Taiwan. For the hotel accommodation, there is a wide range of results in the literature. As reported by De Grosbois and Fennell (2011), the variety of results can be from 6.04-23.7 kg CO_{2eq} /pers/night in studies with similar scope but with different room type (luxury, economy, etc.) and different locations.

The LCAXVII conference provided vegetarian food as means to reduce the environmental impact of the conference. Provision of breakfast, breaks, and lunch accounted for 1.3 kg CO_{2eq} /person/day, which is slightly higher than the results of other studies, such as Leuenberger, Jungbluth, and Büsser (2010) (0.9 kg CO_{2eq} /person for an average of five vegetarian main courses). The higher emissions of the conference can be attributed to the coffee breaks (0.08 kg CO_{2eq} /person per break) and breakfast menu (0.34 kg CO_{2eq} /person). Results from Goldstein, Hansen, Gjerris, Laurent, and Birkved (2016) indicate a change to the vegetarian menu from an omnivorous diet would reduce GW emissions by 46%. Thus, the omnivorous diet is about 1.85 more GW intensive. Therefore, the decision to serve vegetarian menu has avoided about 3 Kg CO_{2eq} / person for the three days of the conference. The relative contribution of food-related emissions in this study is about 1%, lower than in Bossdorf, Parepa, and Fischer (2010). The difference can be explained partially because it was a vegetarian menu but mostly because transport emissions to this conference are much higher. We note that these ignores some of the participants may have already a vegetarian diet, and that testing vegetarian diets may have knock-on effects on changing dietary habits.

Although some measures have a relatively small impact, conferences should try to reduce impact in the measure of their abilities. If scientists do not lead by example, they could be seen as hypocritical. With a public perception on climate change sharply influenced by motivated cognition Kahan et al (2012), practices perceived as hypocritical could have an adverse effect on GW mitigation efforts.

4 Conclusion:

This study quantifies the life-cycle emissions of an LCA VXII international scientific conference using the state of the art in LCA modelling. Results indicate that transport choices have a substantial impact on the emissions per participant. Applying distance-dependent emission factors for flights show emissions from short flights would have been considerably underestimated using a constant emission factor. Use distance-independent emission factors ignores the impact of taking connection flights, which turns out to be a very relevant factor in the estimation of transport CO_{2eq} footprint. Many participants do not use flights as main transport mode, and use means with considerably different emissions. The distance to the location that would minimise the total distance travelled by potential participants can be used as an indicator of the suitability of conference locations. Such an indicator can also be used to discard unreasonable distant conference locations.

Accommodation and (vegetarian) food accounted for a relatively minor share of total CO_{2eq} emissions (1% and 2%) respectively. Despite the small contribution, they should not be disregarded as levers to reduce the impact of a conference, as transport-related emissions are conditioned by the countrys transport infrastructure. However, conference organisers may have more choices when it comes to select venues and menus for the conference.

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References

Blanco G, Gerlagh S, Suh S, Barrett J, de Coninck H, Diaz Morejon C, Mathur R, Nkicenovic N, Ofosu Ahenkora A, Pan J, Pathak H, Rice J, Richels R, Smith S, Stern D, Toth F, Zhou P (2014) Climate Change 2014: Mitigation of Climate Change: Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on. In: Edenhofer O, Pichs-Madruga R, Sokona Y, Farahani E, Kadner K, Seyboth A, Adler A, Baum I, Brunner S, Eickemeier P, Kriemann B, Savolainen J, Schomer S, Von Stechov C, Zwikel T, Minx J (eds) Cambridge University Press, . . . , Cambridge University Press, Cambridge, UK, chap 5, URL http://www.isciences.com/spotlight/COP20_Road_to_Lima/SYR_AR5_LONGERREPORT.pdf%5Cnhttp://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Climate+Change+2014:+Mitigation+of+Climate+Change.+Contribution+of+Working+Group+III+to+the+Fifth+Assessment+Re

Bossdorf O, Parepa M, Fischer M (2010) Climate-neutral ecology conferences: just do it! Trends in Ecology and Evolution 25(2):61, DOI 10.1016/j.tree.2009.09.006

Cox B, Jemiolo W, Mutel C (2018) Life cycle assessment of air transportation and the Swiss commercial air transport fleet. Transportation Research Part D: Transport and Environment 58:1–13, DOI 10.1016/j.trd.2017.10.017, URL http://linkinghub.elsevier.com/retrieve/pii/S1361920917300482

De Grosbois D, Fennell D (2011) Carbon footprint of the global hotel companies: Comparison of methodologies and results. Tourism Recreation Research 36(3):231–245, DOI 10.1080/02508281.2011.11081669

Favaro B (2014) a carbon code of conduct for science. Science 344(6191):1461–1461

Filimonau V, Dickinson J, Robbins D, Huijbregts MA (2011) Reviewing the carbon footprint analysis of hotels: Life Cycle Energy Analysis (LCEA) as a holistic method for carbon impact appraisal of tourist accommodation. Journal of Cleaner Production 19(17-18):1917–1930, DOI 10.1016/j.jclepro.2011.07.002, URL http://dx.doi.org/10.1016/j.jclepro.2011.07.002

Geopy (2015) GeoPy. URL https://geopy.readthedocs.io/en/1.10.0/#

Goedkoop M, Heijungs R, Huijbregts M, De Schryver A, Struijs J, van Zelm R (2009) ReCiPe 2008. URL https://www.leidenuniv.nl/cml/ssp/publications/recipe_characterisation.pdf

Goldstein B, Hansen SF, Gjerris M, Laurent A, Birkved M (2016) Ethical aspects of life cycle assessments of diets. Food Policy 59:139–151, DOI 10.1016/j.foodpol.2016.01.006, URL http://dx.doi.org/10.1016/j.foodpol.2016.01.006

Hischier R, Hilty L (2002) Environmental impacts of an international conference. Environmental Impact Assessment Review 22(2002):543–557

Kahan D, Peters E, Wittlin M, Slovic P, Ouellette L, Braman D, Mandel G (2012) The polarizing impact of science literacy and numeracy on perceived climate change risks. Nature Climate Change 2(10):732–735, DOI 10.1038/nclimate1547, URL http://dx.doi.org/10.1038/nclimate1547

Kalbar PP, Birkved M, Karmakar S, Nygaard SE, Hauschild M (2017) Can carbon footprint serve as proxy of the environmental burden from urban consumption patterns? Ecological Indicators 74:109–118, DOI 10.1016/j.ecolind.2016.11.022, URL http://linkinghub.elsevier.com/retrieve/pii/S1470160X16306598

Leuenberger M, Jungbluth N, Büsser S (2010) Environmental impact of canteen meals : comparison of vegetarian and meat based recipes. Tech. rep., URL http://esu-services.ch/fileadmin/download/leuenberger-2010-meals-LCAfood.pdf

Reynolds TG (2014) Air traffic management performance assessment using flight inefficiency metrics. Transport Policy 34:63–74, DOI 10.1016/j.tranpol.2014.02.019

Spinellis D, Louridas P (2013) The Carbon Footprint of Conference Papers. PloS one 8(6):6–13, DOI 10.1371/journal.pone.0066508

Stroud JT, Feeley KJ (2015) Responsible academia: Optimizing conference locations to minimize greenhouse gas emissions. Ecography 38(4):402–404, DOI 10.1111/ecog.01366

Tsai KT, Lin TP, Hwang RL, Huang YJ (2014) Carbon dioxide emissions generated by energy consumption of hotels and homestay facilities in Taiwan. Tourism Management 42:13–21, DOI 10.1016/j.tourman.2013.08.017, URL http://dx.doi.org/10.1016/j.tourman.2013.08.017

Vardi Y, Zhang CH (2000) The multivariate L1-median and associated data depth. Proceedings of the National Academy of Sciences of the United States of America 97(4):1423–1426, DOI 10.1073/pnas.97.4.1423, URL http://www.pnas.org/content/97/4/1423