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THE INTERNATIONAL CLIMATE FOOTPRINT OF A COSMOPOLITAN CITY: MAGNITUDE AND TRENDS OF BRUSSELS'S AIR TRAVEL BURDEN

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Abstract

In its recent publications, the Brussels Centre Observatory attached particular importance to the way in which daily mobility is organized in and towards Brussels's hypercentre. However, to date no attention has been paid to the impact of international mobility that is generated by the Brussels-Capital Region, i.e. travelling for business and leisure. Nevertheless, many activities that develop in the hypercentre have a strong international character, and the climate impact of long-distance travel cannot be underestimated.

In the Spring of 2019, Brussels was startled by the manifestations of Youth for Climate, the student movement that is campaigning for more vigorous climate policies. Youth for Climate's actions were quickly joined by numerous related initiatives, all of which are committed to drastically shrinking the climate footprint of our societies, in particular in the Global North.

In the present chapter we argue that it is not by chance that these types of actions concentrate in a strongly internationally networked city such as Brussels. Within Europe, Brussels offers a highly suitable forum for internationally relevant political debates. Being a European centre of decision making, Brussels could be seen as part of the solution to the climate problem. The other side of the coin, however, is that holding an important internationally networked position goes hand in hand with a strong dependence on international mobility, which results in impressive volumes of air transport and the associated consumption of large quantities of fossil fuel.

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At the same time, aviation is strikingly often left off the hook in the climate debate. The climate impact of international air transport is only partly included in the official national and regional reporting schemes towards the UN and the EU, or in other words: it is not territorialized. If we look specifically at the Brussels-Capital Region, we can even say that the regional climate registry externalizes the vast majority of climate emissions for which Brussels's economy is responsible. Officially, the Brussels-Capital Region is accountable for 3.7 megatonnes of CO_2 equivalent (Mtonne CO_2eq) per year (in 2017), which represents just 3.2% of the total Belgian greenhouse gas emissions. These numbers compel us to look outside the box.

In this chapter we explore the knowledge gap with respect to the climate impact of international travel (by car, bus, train or air) towards the Brussels-Capital Region. Based on existing data on the origin of trips and the means of transport used by tourists and business overnight visitors heading to Brussels, we arrive at a number of striking observations. In 2018, the total estimated climate impact induced by the journeys studied was 2.7 Mtonne CO_2eq, which equals about three quarters of the impact of the official emissions of all other territorial activities (including heating of buildings, local traffic, industrial production, etc.) in the Brussels-Capital Region together. What is even more worrying is that this figure seems to grow continuously by around 4% per year, which means that the climate impact of Brussels-bound long-distance travel will very soon exceed the official, territorial emissions.

We conclude that the long-distance journeys to Brussels make an underestimated but very important and problematic contribution to climate change. Nevertheless, Brussels is particularly strongly networked within Europe, and therefore generates fewer air kilometres than comparable European cities such as Zurich or Seville that either have more intercontinental relationships or are less centrally located in Europe.

1 > CLIMATE WARMING ON THE POLITICAL AGENDA: WORLDWIDE, BUT CERTAINLY IN BRUSSELS

In the Spring of 2019, a global wave of high school student protests placed the issue of global warming at the top of (at least some) political agendas. The impetus for this was given by the then-fifteen-year-old Swedish student Greta Thunberg, who, on 20 August 2018, refused to continue attending school as long as inaction continued (Marris, 2019). Her individual demonstration did not pass unnoticed, partly because she was granted the opportunity to deliver a fiery speech at the UN Climate Change Conference in Katowice and at the World Economic Forum, both in December 2018.

On Thursday 10 January, Belgian students Anuna De Wever and Kyra Gantois, later accompanied by Adelaïde Charlier, started the first actions of 'Belgian Youth for Climate' in Brussels (De Wever et al., 2019). Inspired by the Swedish example, the Belgian campaigns also took the form of school strikes. The actions were repeated weekly and were unexpectedly successful. The third day of action, 24 January, saw around 35,000 demonstrators participate. On Sunday 27 January, a national climate rally gathered around 70,000 people (BBC News, 2019).

The Belgian movement could count on large amounts of sympathy from, among others, the rectors of five universities and the nation's king. At the end of January, the Belgian Panel for Climate and Sustainability was founded by Leo Van Broeck, the official Flemish government architect, and Jean-Pascal Van Ypersele, climate expert at the Université catholique de Louvain. The panel was intended to offer scientific support to Belgian Youth for Climate. Anticipating the regional, federal and European elections, on 14 May 2019 the panel's findings were presented to Belgian policymakers at various levels in the form of a memorandum.

Parallel to the actions of Belgian Youth for Climate and the Belgian Panel for Climate and Sustainability, two enthusiastic entrepreneurs started the 'Sign for my Future' campaign, based on the idea that the engagement of a number of industry leaders would aid the mainstreaming of climate action, and would encourage the government to organize the required mitigation efforts in an equitable manner.

Although the rise of climate demonstrations in Brussels was not of the same order of magnitude as the legendary anti-missile demonstration of 23 October 1983 (around 400,000 participants), or the White March of 20 October 1996 (around 300,000 participants), its persistent and structural nature was remarkable, with 21 climate marches being held from January to September 2019, according to Schoolstaking voor het Klimaat – Wikipedia, 2020, even from the perspective of historical manifestations in Belgium. The actions of Youth for Climate were widely picked up by foreign media, and were replicated outside of Belgium. Nevertheless, the climate school strike campaign of 24 January 2019 remains one of the largest of its kind.

It is no coincidence that some of the largest climate actions have been conducted in Brussels. The presence of the European institutions, lobbies, NGOs and international media, the geographically central position in Europe, and the cosmopolitan character of the city make Brussels a forum perfect for international societal debate (Vandermotten, 2013; Van Parijs and Van Parys, 2010). It was not a coincidence either that in February 2019 Greta Thunberg travelled to Brussels by train, not only to support Belgian Youth for Climate, but also to meet Jean-Claude Juncker, the then-president of the European Commission.

Optimists will see the cosmopolitan nature of Brussels, which facilitates internationally oriented social and political debate, as part of the solution. But at the same time, it is hard to deny that the internationalization of society, from which a city like Brussels is reaping the economic benefits, has become an important part of the climate burden itself. To keep their ecological footprint as low as possible, Greta Thunberg and her fellow campaigners travel by train and sailing ship, but they are exceptions. A significant share of international visitors to Brussels arrives by plane, which is the least climate-friendly option (Borken-Kleefeld et al., 2013).

2 > THE PITFALL OF A TERRITORIAL APPROACH TO EMISSIONS REGISTRIES

However, the ‘climate footprint’ of international mobility, which goes hand-in-hand with internationalization, is not particularly prominent within the debate on global warming. In the national greenhouse gas registries, which must be maintained by every industrialized country (i.e. ‘Annex I country’) under the Kyoto Protocol, neither international air traffic nor international sea shipping needs to be included according to current agreements (emissions related to domestic traffic, however, are reported). The current logic applies the assumption that these emissions should not be allocated to individual countries.

In addition, emissions related to the production at distance of imported goods, so-called embedded emissions, are not included in the national greenhouse gas registries either. These embedded emissions include the production of finished products (such as clothing, household supplies, or imported food), but also semi-finished products such as steel (Davis and Caldeira, 2010). These emissions are only registered by the countries that produce these goods (if at all), and not by those who consume them.

Such a territorial approach to the allocation of greenhouse gas emissions causes an important bias in the way in which the media reports on climate issues. In reality, emissions from international transport are caused by consumers, citizens or organizations that are established in certain, identifiable, countries, just as consumers that are at least partly responsible for the emissions related to the initial production of imported products.

In fact, the territorial focus of the climate registries ignores the internationalization of production chains, and the structural shift towards service industries (tertiarization) of the economy of the most developed countries. Emissions are viewed as soil-bound affairs, while economic activities are increasingly becoming footloose. Within the theme of embedded emissions, for example, this approach explains why the closure of the last blast furnaces in Wallonia in 2011 has led to a decrease in the industrial emissions registered in Belgium (FPB et al., 2018). In contrast with what appears from the statistics, however, there is no indication that less steel has been consumed in Belgium and, consequently, that emissions associated with steel use have reduced.

With regard to international long-distance transport, the aforementioned bias is at least as problematic. The shift from manufacturing to a service economy is clearly accompanied by a shift of the centre of gravity of emissions, away from geo-localized production processes, and toward the more-or-less ‘footloose’ sector of long-distance transport. Reductions within national industrial production are clearly visible in the national climate registries. However, increases in international travel associated with the rise of the service industry remain invisible in these registries. It is nevertheless quite possible that the tertiary sector, which includes the knowledge economy, the tourism industry and logistics services, is almost as carbon-dependent as the traditional manufacturing industry. Discussing the tourism industry specifically, Gössling et al. (2005: 432) already stated that 'tourism is not necessarily environmentally more beneficial than other economic activities, as claimed by the tourist industry'.

3 > THE CLIMATE FOOTPRINT OF INTERNATIONALIZATION: INVISIBLE, BUT STRUCTURAL

The impact of the territorial approach to emission registration upon debate is also clear from the memorandum of the Belgian Panel for Climate and Sustainability (Van Broeck and Van Ypersele, 2019), which supports the actions of Youth for Climate. It is striking how the emphasis in the memorandum is put on 'traditional' mitigation measures such as urban and regional planning, sustainable local and regional mobility, transition in the field of domestic energy use, expansion of natural and forested areas, and developing a more sustainable agricultural and food sector. With regard to international transport, only two measures are proposed, namely (1) 'Reduce the rampant growth of air traffic' and (2) 'Tackle emissions from maritime transport' (Van Broeck and Van Ypersele, 2019: 77).

Despite the good intentions behind the recommendations on aviation and shipping in the report, the Panel tends to ignore the high degree of complexity that lies behind the continuous growth of international transport and logistics. The tertiarization of the economy of the Global North, and the growth of the knowledge industry in the same part of the world, may be equally dependent on fossil fuels as the manufacturing industry. This is due to the fact that tertiarization is partly driven by the possibility of outsourcing core manufacturing activities to remote low-wage countries. However, the carbon required for this outsourced production is not visible in the national climate registries of the Annex I countries (David and Caldeira, 2010), and neither are the emissions associated with shipping the products. Moreover, part of the production chain, including research and development and commercial activities, often remains located in the importing countries, which means that numerous air trips are made to support this internationally integrated production system.

But aviation does not only support the manufacturing industry. The knowledge industry is also an important consumer of air kilometres, as are international politics, sports, culture, tourism, and all kinds of visits between families and friends across state boundaries. Within the academic sector, Erasmus programmes financially support European students' studies far away from home, with support increasing parallel to the travel distance. Researchers are encouraged to develop international networks and are therefore supposed to travel on a regular basis, often by aeroplane. Although Wynes et al. (2019) state that there is no direct link between frequent flying and academic productivity, they do find in their research a link between the level of salary among academic staff and their air travel frequencies (in the specific context of the University of British Columbia, Canada). In a different Canadian case, Arsenault et al. (2019) found that international students emit an average of 3.85 tonnes of CO_2eq per capita per year during their journeys, and professors no less than 10.76 tonnes. Impressive figures, certainly if you put them in the perspective of the official total emissions of the Belgian economy, which for 2017 amounted to 10.1 tonnes of CO_2eq per capita.

But international politics, including the European institutions and the many lobbying organizations present in Brussels, also have their own ecological footprint. Moreover, the relocation of families within which one member is active in the international sector often entails additional journeys, for example by relatives and friends who visit them. This final category of journeys falls under the category of 'tourism', which in the Global North comprises the bulk of all international journeys (Dobruszkes et al., 2019).

The emissions associated with such trips are not presented in the national climate registries. Boussauw and Vanoutrive (2019) calculated that the emissions associated with flights departing from Brussels Airport are equivalent to 5.7% of the total official emissions of Belgium, and almost as high as those of the most important industrial emitter in Belgium (the ArcelorMittal steel manufacturing plant in Ghent). The emissions from international transport are not only absent from the climate registry, but are also underexposed in the climate debate itself. Typical of this situation is the observation that Arnaud Feist, the CEO of Brussels Airport Company, could in 2019 publicly cynically subscribe to the 'Sign for my Future' campaign without much resistance, while the CEOs of the registered major industrial greenhouse gas emitters, including ArcelorMittal, Total and BASF, wisely chose not to engage in this campaign, probably well aware that public opinion might denounce such an act as hypocritical.

4 > BRUSSELS'S CLIMATE FOOTPRINT

In 2017, according to the Belgian greenhouse gas registry, total greenhouse gas emissions amounted to 114.5 Mtonne CO_2eq (FPS Public Health, Food Chain Safety and Environment, 2018), of which only 3.7 Mtonne CO_2eq (3.2%) was attributed to the Brussels-Capital Region (Bruxelles Environnement, 2019). This remarkably modest contribution stands out even more when we consider the fact that in 2017 the Brussels-Capital Region not only housed 10.5% of the Belgian population, but also generated 17.8% of the Belgian gross domestic product (GDP). These figures are grist to the mill of those who claim that city dwellers, by definition, live more sustainably than suburban or rural dwellers, or, as Banister (2008: 73) puts it: 'The city is the most sustainable urban form'.[3] Indeed, the official carbon intensity of the Brussels economy is around 5.5 times smaller than that of the Belgian average.

Nevertheless, the territorial pitfall is once more not far away. The Brussels-Capital Region is an important consumer of food and industrial products, almost none of which are produced upon its own territory. The emissions from traffic located within the boundaries of the region are also rather limited, given its modest surface area. And even if the emissions of planes and ships fuelling in Belgium were to be included in the territorial climate registry in the future, Brussels would still score very well, since no airport is located in the Brussels-Capital Region, likewise seaports.

Just as Belgium is externalizing an important part of the emissions for which the Belgians are responsible to low-wage countries and to all sorts of foreign travel destinations, Brussels is externalizing an even larger part of its emissions to its hinterland.

5 > METHODOLOGY

Mapping the entire, actual climate footprint of the Brussels-Capital Region is beyond the scope of this chapter, although such an endeavour would be of high interest for further enquiry. Rather, what we aim to do in this paper is explore the magnitude and trends of emissions associated with the long-distance travel involved in the international activities that are hosted in Brussels, and which currently lie at the core of Brussels's economy. This concerns all international journeys to and from Brussels, taking into account both inward and outward trips regardless of the purpose of the trip (business, politics, science, education, tourism), and will focus on direct emissions only, which result from combustion in vehicles, not taking into account indirect emissions linked to, for instance, to oilfield exploitation, fuel refining, or the manufacturing of vehicles.

In this way, we subscribe to an existing tradition of research into sustainable tourism. In that context, Peeters and Schouten (2006), for example, already investigated the ecological footprint of tourism to Amsterdam. A similar assessment was recently carried out for Barcelona (Rico et al., 2019). In both cases, the results show that the overwhelming share of tourist visits' climate impact is attributable to travel to the destination, in particular to long-distance air travel.

Various methods have been developed to assess the importance of the climate footprint of tourist trips to specific destinations, which usually and deliberately exclude outward trips made by residents of the city or region in question. Most studies combine data on the number of international overnight visitors (or 'tourists'

3 More recent literature reveals that the daily travel patterns of city dwellers are indeed relatively local, but that the positive environmental effects of it are compensated for by more frequent non-daily trips over long distances, see e.g. Longuar et al, 2010.

according to definition of the World Tourism Organization[4]) with modal split figures that vary according to their origin, trip length, and standardized emission rate per passenger kilometre (for a summary, see Peeters et al., 2007). In what follows, we will use the terms 'overnight visitor' and 'tourist' as synonyms for one another. When making a distinction between overnight visitors or tourists who are visiting for holiday or business purposes, we will use the concepts of 'leisure' versus 'business'.

Table 1 presents the data used and the processes employed to compute the indicators required for the analysis. Various sources and methods were used to develop two components of our assessment, respectively (1) measuring the climate impact related to international travel to and from Brussels in 2018, and (2) comparing the case of Brussels with a number of other European cities.

Table 1. Methodology: dimensions, scope, indicators and data sources

Dimension	Scope	Indicators	Data sources
Number of international tourists	Brussels case study	International tourist arrivals (for at least one night) in registered collective accommodation establishments. Arrivals by purpose of the trip (leisure vs business) and country of residence of the guest.	Statbel : https://statbel.fgov.be/en/themes/enterprises/tourist-accommodations
	Comparison with other European cities	International tourist arrivals (for at least one night) in registered collective accommodation establishments.	Tourmis database : https://www.tourmis.info
Travel mode	Brussels case study	Travel modal split according to country of origin. Based on surveys.	For leisure purpose : Art Cities Research, a survey conducted between April 2017 and April 2018 among 1,400 people staying in Brussels for the purpose of leisure (https://www.toerismevlaanderen.be/sites/toerismevlaanderen.be/files/assets/documents_KENNIS/onderzoeken/Art_citiesresearch_18.pdf). For business purpose : Adaptation of Art Cities Research results taking into account the annual Travel Survey conducted by Statistics Norway (Trips by mode of transport. type of trip and contents : https://www.ssb.no/en/reise)
	Comparison with other European cities	Travel modal split according to country of origin. Based on a logistic model.	Gunter and Wöber (2019) and Tourmis database

4 See the Glossary of Tourism Terms (https://www.unwto.org/fr/glossary-tourism-terms).

Distance between origin and destination	Brussels case study	Distance between the centre of Brussels and centroid of each country of origin weighted by the spatial distribution of the population.	Own calculations based on gridded population datasets (https://www.popgrid.org) provided by The Center for International Earth Science Information Network (CIESIN) (http://www.ciesin.org). For air travel, distance between origin and destination was multiplied by a coefficient to take into account the existence of detours (i.e. longer itineraries than the great-circle distance). We used the coefficients computed by Dobruszkes and Peeters (2019): 1.143 for distances less than 1000 km. 1.073 for 1000-4000 km and 1.048 for more than 4000 km.
	Comparison with other European cities	Distance between the centre of Belgium and centroid of each country of origin.	Gunter and Wöber (2019) and Tourmis database.
Greenhouse gas emissions	Brussels case study	Greenhouse gas emissions per passenger kilometre. class of distance and travel mode.	For airplanes: own calcuations based on CO_2 emissions for all the flights to/from Brussels airport in 2018. The data on the provision of regular air services in Brussels Airport have been extracted from the 2018 OAG Schedules Analyser (https://www.oag.com). For each flight. CO_2 emissions were calculated by using EUROCONTROL small emitters tools (https://www.eurocontrol.int/publication/small-emitters-tool-set-2019). Based on the World airline rankings 2018 (https://www.flightglobal.com), a seat occupancy rate of 80% has been used to estimate the number of passengers for each flight. The calculated emission factors by classes of distance (expressed in kg CO_2 pkm) are: 0.144 for distances less than 500 km. 0.108 for 500 - 1000 km. 0.090 for 1000 - 1500 km. 0.084 for 1500-2000 km and 0.093 for more than 2000 km. In a second time, according to the literature (DEFRA. 2016), the emission factors were multiplied by 1.9 to convert CO_2 emissions into CO_2eq ('climate impact'). For car : 0.102 kg CO_2 pkm (Christensen. 2016). For rail : 0.027 kg CO_2 pkm (Peeters et al.. 2007). For coach : 0.022 kg CO_2 pkm (Peeters et al.. 2007).
	Comparison with other European cities	Greenhouse gas emissions per passenger kilometre. class of distance and travel mode.	Peeters et al. (2007).

Several of the choices made in order to develop the first component need to be outlined. Firstly, we used survey data to estimate the distribution of international arrivals in Brussels by travel mode in 2018 according to the overnight visitors' origins. Although this data relates only to a limited number of origins and does not resolve the complicated question of multi-destination tours in which tourists from distant markets take part, it offers the advantage that it represents real trips instead of a model, an approach taken by Gunter and Wöber (2019), among others.

Secondly, for the computation of the distances between Brussels and the countries of origin of the overnight visitors, we have taken into account the intra-national spatial distribution of the population, which provides the basis of persons that will potentially travel. The measured distance therefore corresponds to the distance between Brussels and the centroid of each country weighted by the spatial distribution of population based on 2015 data, aggregated in a 1 km² rectangular grid. In the case of air travel, we have been paying attention to the fact that in practice, for various reasons (technical, environmental, political or social), aircraft routes usually do not follow the so-called ‘great circle distance’, which is the shortest path from a geometrical perspective (Dobruszkes, 2019). So, for each origin-destination pair, we have corrected the ‘shortest distance’ using the coefficients per distance class as provided by Dobruszkes and Peeters (2019).

Thirdly, we distinguished between modes of transport with respect to emission rates per passenger kilometre travelled. We started from the figures provided by Peeters et al. (2007), a well-cited source that has nevertheless become slightly outdated. Since the published rates were calculated in 2004, they needed to be updated with respect to air and car travel. Indeed, both modes have faced fleet renewal that has led to lower emissions per passenger kilometre during operations. In the case of air transport, we have updated the rates ourselves, based on real aircraft fleet in use for air services at Brussels Airport in 2018 (Table 1 shows more details). Depending on the distance, the obtained rates are 15% to 30% lower than those calculated back in 2004. With respect to car transport, we used the results of a recent study in Denmark (Christensen, 2016), which show that emissions per passenger kilometre were 25% lower in 2015 compared to 2004. Updating was not necessary, however, for emissions from trains and buses, as the current figures are very close to those measured in 2004 (see for example Prussi and Lonza, 2018, for trains, and DEFRA, 2016, for coaches). Finally, in order to estimate the total climate impact of air travel, effects caused by emissions of other gases (e.g. NO_x, water vapour) at high altitude should be added to CO_2 emissions. For this purpose, we have weighted CO_2 emissions through the application of a multiplier of 1.9, as suggested in the literature (DEFRA, 2016), in order to convert CO_2 into CO_2eq. Such a correction pertains to air travel only, and not to other modes of transport.

We can state that our method will result in an underestimation of the climate impact of international travel to and from Brussels for two reasons. Firstly, a portion of international tourist arrivals is not included in our statistics. According to our calculations (see Wayens et al., in this book), based on the AirDNA database, which lists the assets leased on the Airbnb and Home Away platforms, in 2017 nearly 34,000 beds, amounting more or less to the same number of beds in registered accommodation, would be absent from official registries. According to the same study, failing to take into account this vast set of unregistered accommodation would lead to an underestimation of tourist arrivals by around 30%. Furthermore, it should be borne in mind that these figures do not cover informal accommodation such as beds offered by friends and family members. However, this offer is probably important in Brussels, considering the high proportion of foreign residents, particularly those originating from wealthy states such as the European Union, North America and Japan. Additionally, a survey that was carried out in 2018-19 across Brussels’s museums showed that one-fifth of all international overnight visitors in Brussels were staying with friends or family members (Decroly and Tihon, 2019).

Another source of underestimation of climate impacts concerns the itineraries of air travellers. Indeed, our calculations do not account for the impact of stopovers in air trips to Brussels. Yet many passengers do not employ direct flights to Brussels, either because their desired connection is simply not offered as a direct flight (e.g., Sydney-Brussels or San Francisco-Brussels), or because an indirect route might be cheaper. This approach causes some bias, since the climate impact of take-off is proportionally higher than that of an aircraft while cruising (Baumeister, 2017).

On the other hand, our calculations attribute the entirety of emissions associated with travel to Europe to the Brussels-Capital Region. Yet, most intercontinental leisure tourists take advantage of the opportunity to visit multiple destinations when travelling to Europe. This is the case for tourists that travel in groups, using the format of the low-cost coach tours that are offered by many non-European tour operators and have become popular among, in particular, Chinese tourists (Arlt, 2013; Bui and Trupp, 2014; Xiang, 2013). This is also a common practice for Japanese, Korean or Chinese tourists travelling independently (Pendzialek, 2016). Although less well documented, this phenomenon is probably also common among individual tourists from other distant markets, such as the United States, Canada and Australia.

We decided to maintain this choice for two reasons. Firstly, among intercontinental overnight visitors, almost half of individuals came to Brussels for business reasons. In this case, it is likely that most stays in Europe do not include travel to other cities. Secondly, at present there are no quantitative studies on the distribution of intercontinental tourists coming to Europe in terms of number of cities visited and respective lengths of stay. We therefore have no solid empirical basis that would allow for a redistribution of the emissions related to tourist stays in Europe across several destinations.

For this first part of the analysis, we conclude that some of the choices we made contributed to an underestimation of the climate impact, while another choice leads to a 'maximum' estimation that could be considered an upward bias. Although these contrasting effects partly compensate for each other, it is important to stress again the exploratory nature of our study, and to place the results obtained from our calculations in the right perspective.

For the second part of our analysis, which comprises a comparison with other European cities, we relied exclusively on the data on arrivals and associated CO_2 emissions, as provided by the TourMis database (https://www.tourmis.info). These statistics also underestimate the numbers of international arrivals in the cities studied, but overestimate CO_2 emissions, since they are based on higher (outdated) rates of emissions per passenger kilometre. Finally, it should be noted that the emissions measured comprise CO_2 only, since no multiplier has been applied to account for non-CO_2-related climate effects.

6 > A DETAILED ANALYSIS OF THE BRUSSELS CASE IN 2018

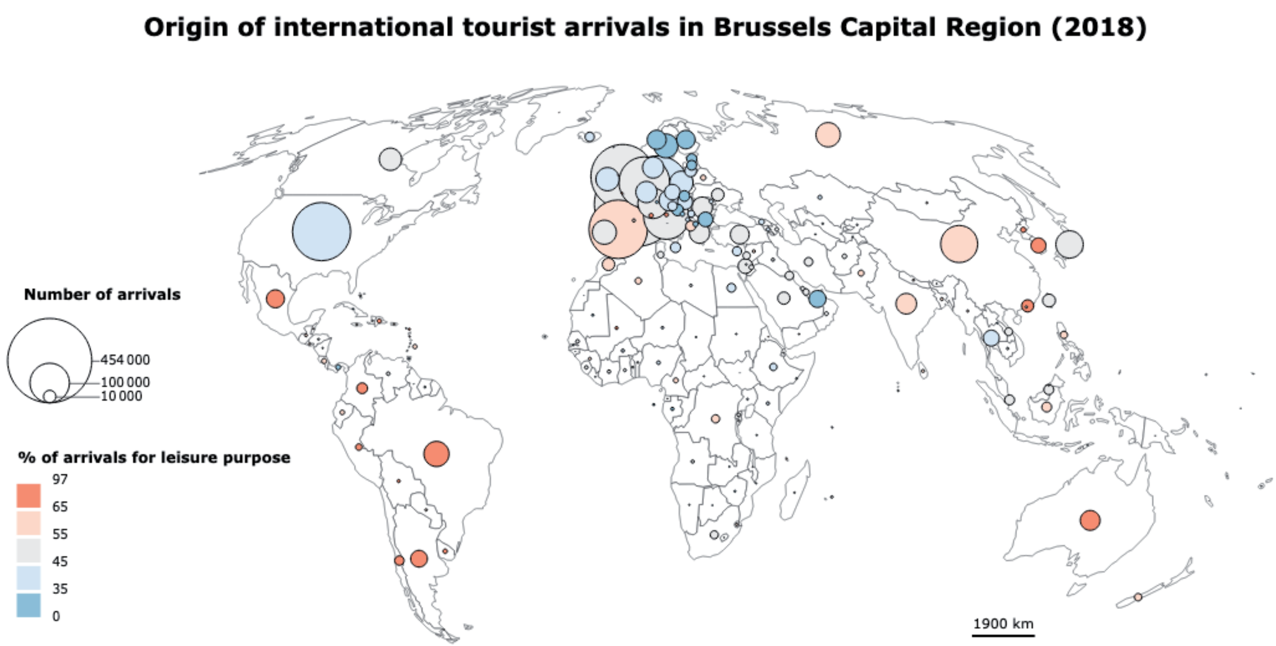
In 2018, the Brussels-Capital Region registered around 2.9 million international arrivals in recognized tourist accommodation. As such, Brussels represents an important, although not a major, urban destination in Europe. Its attractiveness remains modest compared to Paris and London (approximately 13 million international arrivals for each city), the two main poles of urban leisure and business tourism in Europe. The same applies when compared to cities that are well established as destinations for tourists from distant markets, both as city-trip destinations and as part of intra-European tours, be it individually visited or as part of a group (Rome, 9.6 million arrivals; Barcelona, 7.4 million; Amsterdam, 6.9 million; Prague, 6.7 million; Vienna, 6.3 million; Madrid, 5.2 million; Berlin, 4.9 million; Lisbon, 4.3 million; Venice, 4.3 million; Budapest, 3.8 million). Even Munich and Copenhagen, which are less well known as international tourist attractions, welcome more international overnight visitors than Brussels. The situation does not change if we account for the size of the city. Indeed, the number of international arrivals per inhabitant is lower in Brussels than in all the cities listed above, with the exception of Budapest.

In Brussels, as in other European metropolises, a very large majority of accommodations and overnight stays are located within the city centre. The Pentagon (hypercentre) alone accounts for around 40% of the registered rooms and overnight stays. Taking into account the Louise district, Northern quarter and Leopold districts, the city centre alone accounts for no less than 70 to 80% of the officially registered accommodation capacity and associated overnight stays. Therefore, the overwhelming majority of the carbon footprint linked to tourist travel to Brussels is directly attributable to the use of the city centre.

As shown in Figure 1, the vast majority of international overnight visitors staying in Brussels arrive from a limited number of states, with 70% of arrivals originating from the 12 most important ones. European states (70.5% of arrivals), especially neighbouring countries (41%), are the main source of overnight visitors, whether for leisure or for business purposes. Among the most distant origins, the United States (217,000 arrivals, 7.7% of the total), China (88,000, 3.1%) and, to a lesser extent, Japan (48,000, 1.7%), Brazil (41,000, 1.4%) and Russia (38,000, 1.3%) stand out clearly. The map also highlights not-insignificant volumes of arrivals from Canada (32,000), India (27,000) and Australia (25,000).

Given the important presence of international public bodies and the rather limited attractiveness of Brussels as a leisure destination, the number of arrivals with a leisure purpose has been significantly lower than the number of business trips for many decades. However, since the early 2000s the proportions of the two types of travel have gradually become more balanced. Currently, overall shares are more-or-less equal, although relative importance still depends largely on the country

Figure 1. Number of international arrivals in the Brussels-Capital Region by country of residence and by purpose (2018)



Source: StatBel

of origin (Figure 1). Business overnight visitors arriving from Europe (except for Spain), the United States, Arabian/Persian Gulf countries and Southeast Asia (including Japan) are generally overrepresented, while the reverse is true for arrivals from Latin America, Russia, India, China, Australia and New Zealand.

The geography of the origin of the flows of international overnight visitors staying in Brussels results from the combined effects of distance, the economic and population-based potential of origin countries for generating tourists, and local preferences in terms of destination choice behaviour. In an attempt to disentangle the influence of these different factors, we have broken down international arrivals by distance class (Table 2). The results show that the volume of flows decreases rapidly with distance: nearly 50% of arrivals come from within a radius of less than 1,000 km from Brussels, 20% from a radius between 1,000 and 2,000 km, while barely 2.5% originates from countries located at a distance between 2,000 and 3,000 km. Beyond 3,000 km, the relationship between distance and number of arrivals is adjusted according to variations in population size and per capita income between distance classes. The two distance classes between 7,000 and 9,000 km each produce more international overnight visitors to Brussels than those between 2,000 and 7,000 km, because they respectively include India and the United States (7,000 to 8,000 km) and China and Brazil (8,000 to 9,000 km). The expected negative relationship between distance and number of arrivals is only partly compensated for by the larger population in more remote distance classes, as shown by the number of arrivals in Brussels per 100,000 inhabitants in the origin classes (Table 2). Indeed, if the relative volume of flows to Brussels decreases steadily to a distance of 5,000 km, it increases between 5,000 and 8,000 km, then again between 9,000 and 10,000 km. These variations result in part from differences in per capita income in proportion to number of tourists generated. It is clear that those intermediate distance classes, which are characterized by a lower number of arrivals per 100,000 inhabitants, are generally characterized by a fairly modest per capita GDP (see for example the classes of 4,000 to 6,000 kilometres).

Table 2. International tourist arrivals and associated climate impact upon the Brussels-Capital Region (2018), by distance class

Distance class (km)	International tourist arrivals				Greenhouse gases emissions						
					For all transport modes		By travel mode (% of total GHG emission)				
	number (x 1,000)	%	per 100,000 inh.	per x10^9 US$ of GDP in PPP	Total (kT CO_2 eq)	By tourist arrival (kg CO_2 eq)	Airplane	Train	Car	Coach	Total
< 1,000	1,330	47.3	486	96	108	81	2.4	0.6	0.9	0.0	4.0
1,000 - 1,999	639	22.7	179	62	242	378	8.1	0.3	0.5	0.1	8.9
2,000 - 2,999	71	2.5	52	23	61	868	2.3				2.3
3,000 - 3,999	67	2.4	20	10	85	1,265	3.1				3.1
4,000 - 4,999	32	1.1	5	5	54	1,677	2.0				2.0
5,000 - 5,999	30	1.1	6	11	59	1,975	2.2				2.2

6,000 - 6,999	40	1.4	12	15	95	2,372	3.5				3.5
7,000 - 7,999	251	8.9	13	8	680	2,707	25.2				25.2
8,000 - 8,999	155	5.5	8	5	503	3,246	18.6				18.6
9,000 - 9,999	119	4.2	21	10	419	3,523	15.5				15.5
> 10,000	81	2.9	14	8	396	4,911	14.7				14.7
Total	**2,814**	**100.0**	**37**	**21**	**2,701**	**960**	**97.6**	**0.9**	**1.4**	**0.1**	**100.0**

Sources: StatBel World Population Prospects (2019), World Development Indicators database (World Bank, 2019), Art Cities Research (2017-18); Peeters et al. (2007); Christensen (2016), own calculations based on OAG data and EUROCONTROL small emitters tools

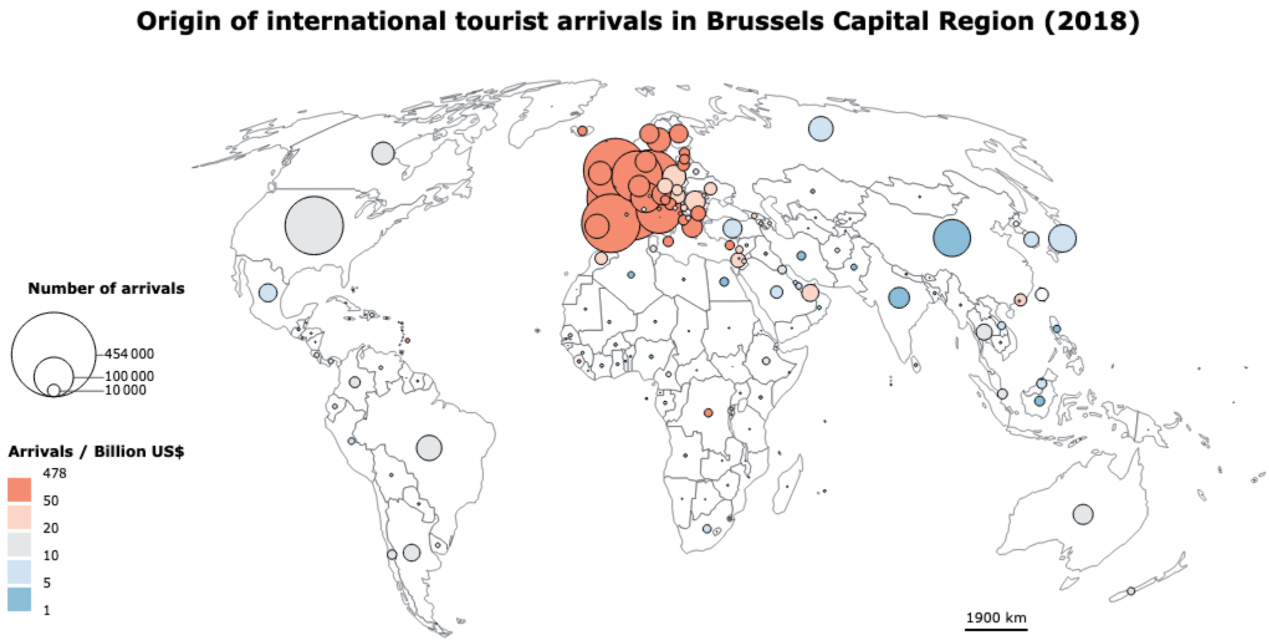
Then, we also calculated the ratio between tourist arrivals and GDP in PPP[5] (Table 1). Taking into account GDP in PPP will, in principle, neutralize the effects of population size and per capita income upon the number of tourists generated. The result shows a steady decrease of the relative volume of flows with distance, with a few exceptions. These exceptions result from particularities of the origin countries, such as the absence of the right to paid leave, the right to leave the country for leisure purposes, or the presence of effects of economic or cultural thresholds upon travel. For example, the class of 4,000 to 5,000 kilometres is characterized by a very modest number of tourist arrivals per billion dollars of GDP. In this group we find a number of countries which, while having a high GDP, still send a very low number of tourists (Iran, Nigeria), or clearly favour destinations other than Belgium (Saudi Arabia). Conversely, the 6,000 to 7,000 km class shows a relatively high number of tourists because it includes the Democratic Republic of the Congo, Burundi, Rwanda and Canada. The three African countries mentioned here have privileged links with Belgium that were inherited from the colonial period, while Canada's tendency to generate tourists may be related to relatively strong links between Francophone regions.

To conclude the current section, in Figure 2 tourist arrivals to Brussels have been correlated with the GDP of origin countries. In the Balkans, Ukraine and Belarus, lower propensities to travel to Brussels can be observed relative to Scandinavia, Greece and the Eastern Mediterranean islands (Cyprus, Malta). The map also shows the unique situations of Israel, the United Arab Emirates, the Democratic Republic of the Congo and Hong Kong, for which the relative volume of arrivals to Brussels is significant, at least in relation to the distance travelled and the respective levels of GDP. The same is true, albeit to a lesser extent, for Brazil and the southern part of Latin America, and for Australia and New Zealand.

According to our calculations, international tourist travel to the Brussels-Capital Region generated a total of 1,452 kilotonnes of CO_2 (or 1,452 Mtonne CO_2) in 2018, when considering both inbound and outbound trips. It should be noted that this estimate is 15% lower than that provided by TourMis database (1,670 kilotonnes of CO_2). The difference is mainly due to the updated coefficients used here to calculate CO_2 emissions per passenger kilometre in air transport. This observation calls

5 Gross Domestic Product based on Purchasing Power Parity. used as a standardized metric of a country's wealth.

Figure 2. Number of international tourist arrivals in the Brussels-Capital Region by origin (2018): absolute number, and per billion USD GDP in PPP in the country of residence



Sources: StatBel and World Development Indicators database (World Bank, 2019) for the regular updating of emission coefficients, in order to take into account the improved energy efficiency of air transport.

After applying the 1.9 multiplier to air trips, the climate impact of all international travel to Brussels in 2018 amounts to around 2,701 kilotonnes of CO_2 equivalent (i.e. 2.70 Mtonne CO_2eq), or approximately 73% of the entirety of all greenhouse gas emissions (all activities combined, including the residential sector and internal transport, but obviously excluding international travel) that were officially reported by the Brussels-Capital Region in 2018.

Examination of the distribution of tourism-induced climate impacts reveals a geography that is radically different from that of tourist arrivals. In fact, while the number of arrivals sharply decreases with distance, the amount of emissions increases with distance (Table 2). Thus, while overnight visits from Europe account for 70.5% of arrivals, they generate barely 15% of emissions, while arrivals from outside Europe, accounting for less than 30% of tourists (leisure and business combined), are responsible for nearly 85% of emissions.

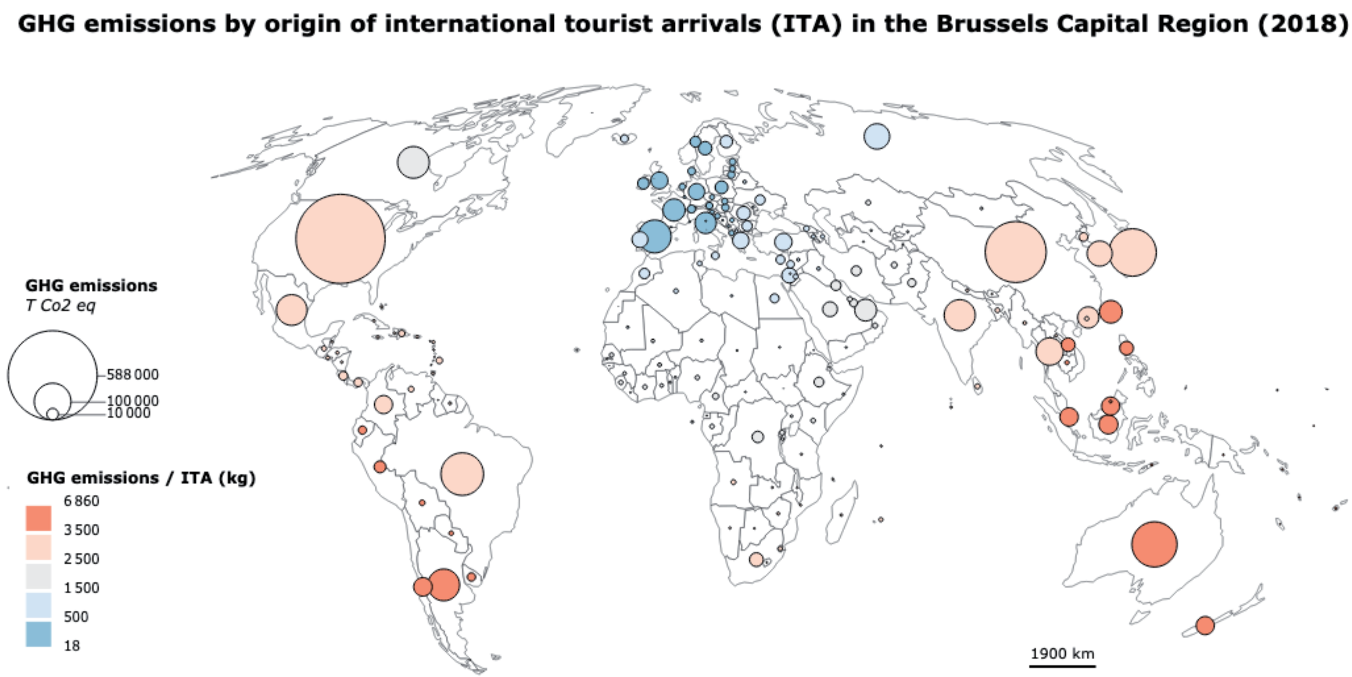
This striking result can be explained by the specific relationship between air transport and climate impact, which is brought forward by Figure 3, a map linking emissions by origin country to journeys to Brussels. The very significant climate impact of flows from the United States (21% of impact for 7.6% of flows) and China (10% versus 3%) stand out, as do those of Japan (6% versus 1.7%) and Australia (5.5% versus 0.9%). Only one European state is present among the top ten countries in terms of emissions, Spain, which is the only origin country that combines a very large number of overnight visitors to Brussels with a significant share of air travel.

7 > A COMPARISON WITH OTHER EUROPEAN CITIES

In the current section, we use data collected by TourMis to first examine the evolution of CO_2 emissions linked to tourist arrivals in Brussels from 2000 on, and then compare the 2018 figures for Brussels with those observed in other urban destinations in Europe.

In less than twenty years, CO_2 emissions caused by tourist trips to Brussels have more than doubled (Table 3). This strong increase results less from a generalized growth in international arrivals (which only increased by 33%) than from the accretion of tourist flows originating from distant markets, especially from eastern Asia (+66% from South Korea since 2010, +38% from China since 2005) and southern Asia (+374% from India since 2005), but also from Russia (+181% since 2000), Brazil (+99% since 2010) and Argentina (+250% since 2010). At the same time, flows originating from Europe grew only a little (+14%), but with very contrasting trends between origins (since 2000: +61% from France, +97% from Spain, +143% from Poland, but -36% from the United Kingdom and -30% from

Figure 3. Climate impact of international travel towards Brussels-Capital Region (2018), by country of origin: absolute number, and per international tourist arrival



Sources: StatBel Art Cities Research (2017-18); Peeters et al. (2007); Christensen (2016), own calculations based on OAG data and EUROCONTROL small emitters tools

Sweden). These trends are the result of a multitude of factors, the analysis of which is beyond the scope and objectives of the current chapter.

Table 3. Development of international tourist arrivals in the Brussels-Capital Region and of CO_2 emissions linked to these arrivals (2000–2018)

	International tourist arrivals in the Brussels-Capital Region						CO_2 emissions (kT)
	Europe	Asia	America	Africa	Oceania	Total	
2000	1,810	87	195	15	10	2,161	813
2018	2,057	281	357	44	29	2,867	1,677
Growth index	**114**	**323**	**183**	**292**	**295**	**133**	**206**

Source: TourMis (2019)

While the CO_2 emissions of tourist travel to Brussels have sharply increased since 2000, they remain quite modest compared to those observed for the main urban destinations in Europe (Table 4).[6] Overall, the observed emission volume in Brussels is 7.9 times less than of Paris, 6.4 times less than of London and 2.0 times less than of Barcelona.

Table 4. International tourist arrivals in a number of European urban destinations and volumes of CO_2 emissions associated with these arrivals (2018)

Cities	International tourist arrivals (x 1,000)	CO_2 emissions	
		Total (kT)	Per international tourist arrival (kg)
Paris	13,217	13,236	1,001
London	13,037	10,866	833
Barcelona	7,408	4,994	674
Amsterdam	6,922	4,908	709
Prague	6,671	4,764	714
Vienna	6,288	4,358	693
Madrid	5,205	5,207	1,000
Lisbon	4,295	3,859	898
Budapest	3,823	2,970	777
Munich	3,758	3,237	861
Brussels	2,867	1,677	585

6 Due to data constraints, this table is limited to CO_2 emissions, to which no multiplier for air transport was applied. Consequently, the climate impact of those cities with an above-average share of air transport (and therefore only a small share of other modes of transport, i.e. train, bus and car) will be underestimated compared to those cities that are less dependent on air transport.

Zurich	2,051	2,062	1,005
Seville	1,722	1,448	841
Hamburg	1,605	849	529
Tallinn	1,463	555	379
Salzburg	1,369	959	701
Warsaw	1,365	828	607
Dubrovnik	1,217	1,274	1,047
Helsinki	1,199	791	660
Zagreb	1,178	1,103	936
Valencia	1,131	766	677

Source: TourMis (2019)

Although this modest impact is partly due to the limited volume of tourist arrivals in Brussels, it is also the result of the relatively low level of CO_2 emissions associated with these arrivals. When comparing twenty destinations. each of which welcomes more than a million international arrivals per year. Brussels is among those cities with the most climate-friendly tourists. In order to explain this peculiar situation, we have examined arrivals by geographical origin in four destinations which have a number of international arrivals comparable to Brussels's figure (i.e. Budapest, Munich, Zurich and Seville) but report much higher climate emissions per arrival (Table 5). Unsurprisingly, the results show that tourist arrivals in Brussels from distant markets are proportionally less numerous. A comparison with Zurich, where CO_2 emissions per arrival are by far the highest, helps clarify this further. While in Brussels the European market provides 70% of arrivals, Europe only represents 49% of arrivals in the economic capital of Switzerland. The opposite situation prevails in distant markets: in Zurich 28.5% and 19.2% of arrivals originate from Asia and America respectively, compared to 9.8% and 12.4% for the Brussels-Capital Region.

Table 5. International tourist arrivals in 5 European urban destinations and volume of CO_2 emissions associated with these arrivals (2018)

Origin	International tourist arrivals (2018)									
	Budapest		Munich		Brussels		Zurich		Seville	
	Number (x 1,000)	Share (%)	Number (x 1,000)	Share (%)	Number (x 1,000)	Share (%)	Number (x 1,000)	Share (%)	Number (x 1,000)	Share (%)
Europe	2,551	66.7	2,193	58.4	2,057	71.8	1,008	49.1	1,046	60.7
Asia	712	18.6	764	20.3	281	9.8	584	28.5	145	8.4
of which ...										
China	200	5.2	191	5.1	88	3.1	128	6.2	49	2.8
India	49	1.3	41	1.1	27	1.0	105	5.1	0	0.0
Japan	49	1.3	93	2.5	48	1.7	46	2.3	28	1.6
South Korea	140	3.7	50	1.3	14	0.5	33	1.6	28	1.6
America	478	12.5	660	17.6	357	12.4	394	19.2	362	21.0
of which ...										
United States	341	8.9	496	13.2	217	7.6	304	14.8	192	11.2

Canada	46	1.2	49	1.3	32	1.1	15	0.7	20	1.2
Brazil	26	0.7	47	1.3	41	1.4	33	1.6	25	1.4
Other origins	82	2.2	140	3.7	172	6.0	66	3.2	169	9.8
of which ...		0.0		0.0		0.0		0.0		0.0
Australia	48	1.3	68	1.8	25	0.9	41	2.0	17	1.0
Total	3,823	100.0	3,758	100.0	2,867	100.0	2,051	100.0	1,722	100.0
CO_2 emissions of international tourist travel to specified destinations. per arrival (kg)	777		861		585		1005		841	

Source: TourMis (2019)

8 > CONCLUSION

Territorializing the international share of Brussels's climate impact is not an easy task. In our analysis, numerous methodological choices had to be made, and, furthermore, the scarce availability of data imposed additional limitations. In our calculation, we chose to only include the climate impact of overnight visitors with Brussels as a destination, assuming that the climate impact of journeys undertaken by Brussels residents would likewise be allocated to the destination territory. However, we were unable to cover international overnight visitors who stayed in unregistered accommodation, which means that our analysis significantly underestimates the total number of tourists (leisure and business combined) to Brussels. Furthermore, we were not able to redistribute the climate impact of overnight visitors arriving in Brussels among the multiple destinations they often visit as part of a single European trip, which implies that we overestimated the climate impact of a portion of the tourists, notably those arriving from countries that were not specified in the Art Cities Research. We are also aware that the climate impact as calculated by us covers only one, albeit an important, climate aspect of Brussels's international position. Emissions created in the supply chain of imported products were not calculated, nor was the share of Brussels's economy in the climate footprint of international sea shipping. Another comment that must be made is the significant degree of uncertainty associated with the multiplier that was used to translate CO_2 emissions of aircraft into overall climate impact (defined as 1.9 in the current study).

Despite all reservations that need to be taken into account, and the exploratory nature of our calculations, we can still report a number of striking findings. The calculated climate impact of international journeys with Brussels as a destination equalled 2.7 Mtonne CO_2eq in the year 2018, which is equivalent to about three quarters of the official total amount of emissions of the Brussels-Capital Region as recorded by the Belgian national climate registry (3.7 Mtonne CO_2eq in 2017).

Moreover, emissions from international journeys are increasing at a rapid pace, with an average growth of more than 4% per year over the past 18 years. If the current growth rate persists, by 2036 the climate impact of international travel to Brussels will be more than double the official amount of greenhouse gas emissions attributed to Brussels, even more if the emission reduction targets in several other sectors are achieved. The problematic nature of this finding is nuanced only to a limited extent by the finding that the climate impact of international journeys to Brussels is smaller, both counted per trip and in total, than that of comparable cities such as Munich, Budapest or Zurich.

Nevertheless, the climate debate itself is shaped only within the framework of the currently existing institutions. This means that conferences and events are organized in central and visible locations worldwide, and that personal interaction between the protagonists of the climate debate is of great importance. The frantic attempts of young climate activists to participate in all of these spatially separated events without boarding a plane has involved multi-day train trips and adventures with transatlantic sailing ships. Since such endeavours are not possible for most official negotiators, the climate debate itself is almost as dependent on fossil fuel as many other international decision-making and knowledge development processes. On the other hand, from a climate perspective, some locations may be better positioned than others to serve as hosts for international discussion forums. Our analysis shows that Brussels is in fact doing remarkably well, since the climate impact of international travel to Brussels is considerably lower than that of other cities with a strong international position. This is partly due to its central location in Europe, which means that the impact of business travel in particular is rather modest. On the other hand, we should not forget that the strong overall score of Brussels compared to cities such as Barcelona, Prague or Amsterdam is largely due to the relatively limited touristic appeal of Brussels in comparison to them.

From a wider perspective, we can conclude that in a rapidly globalizing and – at the same time – warming world, failing to territorialize the climate impact of international transport it is no longer tenable, especially considering such territorial attribution has become common practice for emissions caused by industrial activities, agriculture, buildings and domestic transport. Not including these emissions in climate registries leads to major biases in the climate debate itself. Climate movements such as 'Youth for Climate' and 'Sign for my Future' argue for adaptations to our Global Northern consumption patterns and production processes. It is becoming increasingly clear, however, that the real threat lies in the increasingly globalized and networked nature of our society. Dependence on long-distance travel not only makes our economy more carbon intensive, but also our education, research, culture and leisure activities, and even our family visits, rely ever more on the consumption of tremendous amounts of kerosene. Long distance travel patterns seem to be increasingly embedded in society, and less and less reversible. At the same time, in the Global South, the rapid growth of international mobility is strongly welcomed and regarded as a strict precondition for societal development. And even as less-carbon-intensive alternatives such as trains and buses are available for many medium-distance journeys in Europe, an absolute reduction in the number of aircraft kilometres travelled remains an unattractive idea for most citizens, businesses and organizations, for which broad societal support is virtually non-existent. Nevertheless, it is clear that a carbon neutral future must be one in which jet aircraft will no longer play a substantial role.

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