COVID-19 disruption demonstrates win-win climate solutions for major league sports

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ABSTRACT

Unlike other greenhouse gas sources associated with professional sports, team air travel is highly visible, under direct league control, and extremely difficult to decarbonize with technological advancement alone. In an analysis of air travel emissions from the four largest North American sports leagues, I estimate that teams traveled a combined 7.5 million kilometers in 2018, generating nearly 122,000 tonnes of carbon dioxide emissions. But the 2020 season saw major declines in travel as teams and leagues adjusted for the pandemic. Scheduling changes with co-benefits for player health and performance were central to this strategy including increased sorting of schedules by region and more consecutive repeated games ("baseball-style" series). If the scheduling changes implemented in 2020 were maintained in future years, air travel emissions reductions of 22% each year could be expected. Additional reductions in air travel emissions could also be achieved by using more fuel-efficient aircraft and shortened regular seasons.

SYNOPSIS

Maintaining policies implemented during the COVID-19 pandemic would greatly reduce greenhouse gas emissions from major league air travel.

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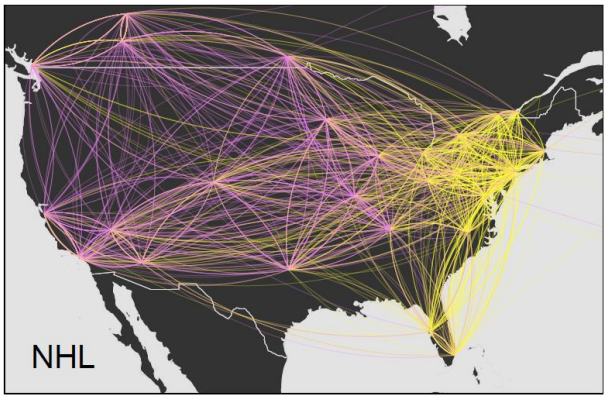

1. INTRODUCTION

By interrupting routine business practices, the COVID-19 pandemic has allowed companies and employees to evaluate which customs are constructive or necessary and which are dispensable. During the pandemic, many companies reduced their climate impact by replacing office labor with remote work and long-distance business travel with videoconferencing. But virtual solutions are not feasible in some industries, such as major league sports, where teams must be physically present in stadiums around the world.

While some transport emissions can be decarbonized through technological change alone, poor rail networks and low population densities prevent sports teams in North America from using decarbonized, overland travel. In the near-term, climate solutions are unlikely to come from the aviation industry itself which has demonstrated inadequate governance[1] in an already hard to decarbonize sector.[2] Prospects for technological solutions are weak: electric aircraft are expected to only be available for short flights[3] while the most promising path to decarbonization, non-biogenic synthetic fuels, will not eliminate non-CO_2 warming[4] and may compete for resources with other sectors.[5] For these reasons and others,[6] achieving international climate goals will require less air travel.[7]

Less air travel is desirable as a climate solution, but would leagues be better off focusing their mitigation efforts elsewhere? In 2016, 28% of all emissions tracked by the National Hockey League (including Scope 1, 2 and 3) were attributable to business air travel[8] with a majority of all emissions attributable to purchased electricity.[9] While technically not under their purview, leagues could also attempt to track and incentivize reductions in fan travel. However, unlike air travel, there are readily available technologies for decarbonizing energy grids and personal vehicles. 20% of teams in the four major leagues are based in jurisdictions with plans to ban new sales of internal combustion vehicles by 2035 (California and Canada)[10-11] while 32% of teams are in a jurisdiction with clean/renewable energy targets of 90-100% for 2030-2045.[12-13] Regulations governing aviation emissions in these same regions are much weaker; states are not permitted to set their own aircraft emissions standards, yet the Environmental Protection Agency's own standard for new aircraft (set for 2028) is not expected to reduce emissions.[14] Looking at future scenarios, in the IEA's optimistic "net zero 2050" scenario, 75% of new vehicles in advanced economies are electric in 2030 and electricity grids in those nations decarbonize by 2035, but even by 2050, only 75% of aviation fuels could be expected to come from kerosene alternatives.[15] There is every indication that technological and policy change will abate emissions from stadiums and personal vehicles while the fraction of emissions from air travel grows for the foreseeable future.

As high-profile businesses with employees who act as defacto role models,[16] there is an opportunity for professional sports teams and leagues to lead by example in reducing their air travel and thereby the most visible and intractable emissions in their industry. In recent years, leagues and teams commonly participated in social justice causes[17] including the provision of arenas as polling places for the 2020 United States election.[18] Meanwhile environmental efforts have been limited and instead luxury emissions are often promoted.[19-21] But climate-driven natural disasters[22-23] have begun to affect both leagues and individual athletes,[24-25] incentivizing a shift from the status quo. Fortunately, a range of win-win solutions can reduce emissions from major league sports travel.

Here, I analyze emissions from team air travel during 2018 and 2020 in the National Basketball Association (NBA), National Hockey League (NHL), Major League Baseball (MLB) and the National Football League (NFL), demonstrating the extent to which policies enacted during the COVID-19 pandemic could be maintained to permanently cut air travel emissions in this industry.

2. METHODS AND DATA

League schedules were taken from a variety of online sources. Relevant information (such as location of a preseason game) was occasionally unavailable, in which case information was obtained on an ad hoc basis (e.g. online video highlights of the game in question). A full list of scheduling sources is available in the Supplementary Text. For the 2020 schedule a number of games were cancelled or rescheduled. I relied on the original schedule since the purpose of analyzing the 2020 schedule is not to determine emissions in that year but to ascertain what could realistically be achieved through policy changes. For this reason, and due to some shortened seasons in 2020, the emissions in 2020 were calculated on a per game basis. Additionally, only the first half of the 2020 NBA schedule was included since the second half of the schedule was not available at the time of analysis. Similarly, only the regular season was analyzed for 2020 (only a small portion of emissions are attributable to the preseason and playoffs for each league).

As a simplifying assumption, I ignored air travel to All Star games, assuming that individual players traveled to their homes, the game, and the subsequent game by commercial carriers. Similarly, I assumed players took commercial flights to their first preseason/spring-training game but returned to the home team's city at the end of the season. I also excluded player movement from in-season trades. For the MLB and NHL, all split-squad Away games during Spring Training in 2018 were assumed to be played by the franchise's "B-team" without a charter aircraft and were excluded from the away team's

97 itinerary. For the NFL I assumed that each away game was followed by a return flight to the home
98 team's city due to the larger gaps between NFL games.

99 For each game I found major airports near the origin and destination stadium and determined flight
100 distance based on the coordinates of the two airports. The distance of each journey was estimated using
101 a great circle distance calculation with a correction factor recommended by the International Civil
102 Aviation Organization to account for additional travel due to traffic, weather corrections and so forth.[26]
103 Distance was then converted into a quantity of CO_2 emissions using a carbon calculator coded in R
104 (Version 4.0.2). Fuel burn rates were taken from the International Civil Aviation Organization carbon
105 calculator methodology which provides rates for various aircraft flown at discrete distances.[26] Because
106 only certain data points are provided (e.g. fuel burn at 125, 250, 500 nautical miles etc.) I fit the points
107 with a quartic function (increased emissions for takeoff and landing create a non-linear relationship).
108 This allows for interpolation of fuel burn at any given distance. Since 3.16 kg of CO_2 are produced for
109 every kg of jet fuel that is burned, the mass of fuel was then multiplied by the constant 3.16 to find the
110 mass of carbon dioxide released.[26] Note that values provided only include carbon dioxide emissions, not
111 carbon dioxide equivalents: the warming caused by league air travel would be about twice as large due
112 to the radiative forcing of non-CO_2 emissions from the aircraft.[27-28] To find the climate warming (or
113 carbon dioxide equivalents) associated, interested readers can multiply the CO_2 emissions by two to find
114 the Global Warming Potential of those emissions.[28]

115 Where specific information on a team's aircraft was available, I made use of that and otherwise made
116 the conservative assumption of a 737 (a commonly used charter aircraft on the lower end of emissions
117 intensity for chartered jets). The carbon calculator assumes that all flights beyond an aircraft's maximum
118 range (e.g. rare international flights for exhibition games) are taken on a larger 767 aircraft. I assumed
119 that all trips are direct flights, except for the few cases where a flight is outside the range of a 767,
120 where I instead assumed two equidistant legs in the 767 (see Table S3 in the Supporting Information for
121 full list of teams and corresponding aircraft). Flights that are shorter than 200km (e.g. Philadelphia to
122 New York), are assumed to be taken over ground and are not counted towards the emissions total.
123 Emissions are only calculated for those trips assumed to be on charter or private jets: emissions from
124 transport to the airport, hotel stays, stadium attendance and so forth are beyond the scope of the
125 paper. For values from individual trips see Dataset S1.

126 To provide an upper estimate of emissions reductions for the various policies (Table 2) I selected the
127 league where the policy best applied. For regionalized schedules, both the NHL and MLB took significant

steps in grouping teams during the 2020 season, however the NHL's schedule was not optimized for emissions reductions because it grouped all Canadian teams together, despite the large distances separating them. I therefore examine the MLB as a case of maximum efficacy. For consecutive repeated games ("baseball-style series"), the NHL was chosen for having the largest increase in consecutive repeats. The NFL was chosen for cancelling overseas games because the largest fraction of its emissions were derived from trips overseas. The NBA was chosen as the case for shortening of the regular season schedule since the policy has actually been considered by the NBA.[29]

To calculate the emissions associated with adding consecutive repeated games in the NHL, I determined the quantity of emissions that would have been produced in 2018 if the number of games and the emissions per trip remained the same, but the number of trips per game during the regular season took on the value from the 2020 regular season (about 0.9 trips per game) instead of the 2018 regular season (about 1.4 trips per game). By preserving the 2018 term for emissions per trip this calculation retains the influence of high emissions trips that took place in 2018 due to the lower levels of geographic sorting and the presence of longer overseas flights. This ensures that the estimate for the efficacy of geographic sorting only reflects changes from that policy.

Similarly, to calculate the emissions saved from increased geographic sorting, I took the number of games and the number of trips per game from 2018 but multiplied them by the emissions per trip during the 2020 regular season (15.1 tCO2) as opposed to the 2018 regular season (19.2 tCO_2). The MLB had no games coded as "overseas" in 2018 but did have one series played in Puerto Rico and another in Mexico. The effect on the results is negligible (emissions per trip drop by 0.4% when removing these trips from the 2018 sample). Likewise, although the Toronto Blue Jays moved home stadiums in the 2020 season to Buffalo this change is minor (the Great Circle Distance between airports is only 110km).

3. RESULTS

3.1 2018 Season

For all four major leagues, seasons beginning in 2018 were unaffected by the COVID-19 pandemic. During those seasons I estimate that the teams in these leagues traveled 7,500,998 km by air on 5655 flights taken on private jets and chartered aircraft. Emissions from these flights totaled 121,841 tonnes of carbon dioxide (tCO_2). Assuming a typical flight carries between 40 and 80 passengers, emissions per passenger kilometer range from 0.20-0.41 $kgCO_2$/pkm which is consistent with those of first-class passengers on commercial aircraft.[30]

Total emissions from air travel varied considerably between leagues (Figure 1). Emissions were lowest in the NFL which only holds 16 regular season games per team per year. Emissions in the MLB were only 1.6 times higher than in the NFL (22,966 tCO_2 compared to 14,743 tCO_2) despite having ten times as many regular season games (162). This is partially because NFL teams only play once a week and return home after every game, and also because MLB games tend to take place in series where the same two teams play consecutive games in the same arena ("baseball-style" series). Though the regular season is the same length (82 games) in the NBA and NHL, emissions from NBA air travel were estimated to be higher than emissions from the NHL because most NBA teams travel in larger aircraft with higher rates of fuel burn. Note that the four leagues have roughly the same number of teams (30 in the MLB and NBA, 31 in the NHL and 32 in the NFL).

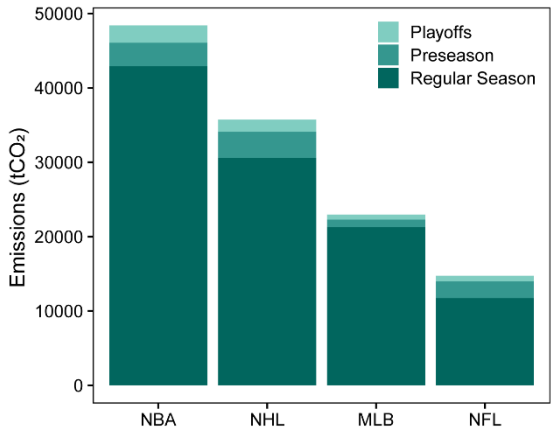

Figure 1: Emissions from air travel in 2018 for the four major North American sports leagues: the National Basketball Association (NBA), National Hockey League (NHL), Major League Baseball (MLB) and National Football League (NFL). See Table S1 in the Supporting Information for data breakdown.

Emissions from air travel in the major leagues are also dependent on the distances between team locations. The NBA and NHL are organized into Eastern and Western Conferences and teams in the same conference play one another more frequently which creates efficient geographic sorting (Figure 2). In the MLB and NFL, historical mergers of two separate leagues have resulted in teams being grouped into a National League/Conference and an American League/Conference. In both the MLB and NFL, teams in the same League/Conference play more games against one another, but since these groupings are not based on any geographic division, there is limited advantage in terms of reduced travel. This points to the potential for leagues to reduce emissions by rearranging their scheduling practices.

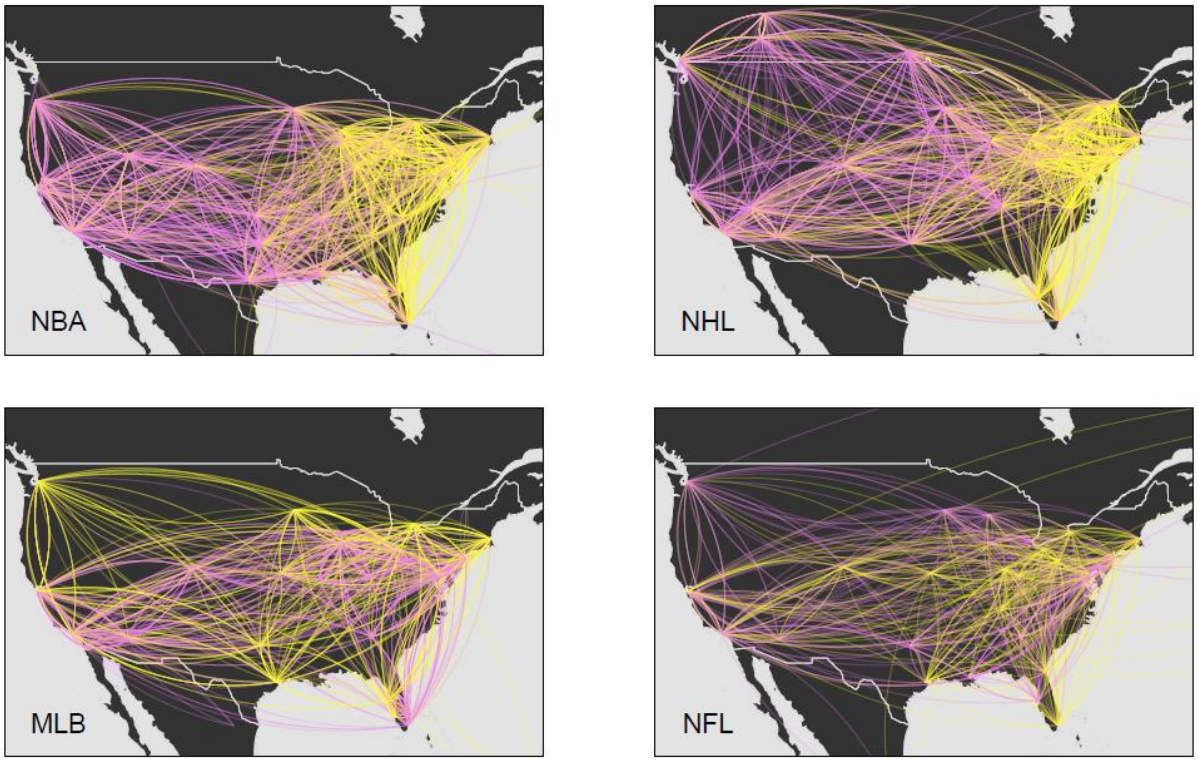

Figure 2: All trips taken during the full 2018 season (preseason, regular season and playoffs). Each line represents one trip, including flights and shorter journeys assumed to be taken over land. Yellow lines represent trips by teams in the Eastern Conference, American Football Conference or American League while purple lines represent trips by teams in the Western Conference, National Football Conference or National League.

The greater density of teams based on the East Coast creates disparities in the travel burden experienced by players. Teams in the Northeast and in more central locations tend to travel substantially less than teams on the west coast (Figure S1 in the Supporting Information), who therefore face a competitive disadvantage from increased fatigue. For instance, in the 2018 NHL regular season, when teams travelled between games the mean distance for Western Conference teams was 1324 km (SD = 988 km) compared to 1015 km (SD= 945 km) for Eastern Conference teams. According to a Welch's two sample t-test this is a significant difference ($t(1764.3) = -6.7727$, $p < .001$). In the NBA, mean distance for Western Conference teams was 1336 km (SD = 812 km) compared to 1141 km (SD = 785 km) for Eastern Conference teams ($t(1779.3) = -5.1579$, $p < .001$). Introducing scheduling changes that increase geographic sorting may also create opportunities to address a competitive imbalance.

3.2 COVID-19 disruption

In attempts to reduce potential staff and player exposure to the COVID-19 virus, the four major leagues implemented a series of procedural and scheduling changes which can be used as natural experiments to understand policies that could reduce emissions from air travel. During the pandemic, leagues shortened schedules, shifted arena locations, cancelled overseas games, introduced baseball-style series, and increased geographic sorting of team schedules. Table 1 describes the most relevant scheduling practices held before and after the pandemic by the four leagues.

Table 1

Policy	NBA		NHL		MLB		NFL	
	2018	2020	2018	2020	2018	2020	2018	2020
Schedules sorted by region	Moderate	Moderate	Moderate	Strict	Minimal	Strict	Minimal	Minimal
Consecutive repeating games	0%	10%	0%	42%	68%	67%	0%	0%
Overseas Games*	3	0	7	0	0	0	3	0
Regular season length (games)	82	72	82	56	162	60	16	16

*Does not include games played in Puerto RIco

Geographic Sorting

Though the NHL already sorted teams by conference in previous seasons (Figure 2), in order to reduce travel and isolate potential outbreaks, the NHL created four groupings in 2020 such that teams in a group only played one another during the regular season (Figure 3). The groupings were not geographically optimal since Canadian teams, which are broadly spaced across the country, were grouped together to eliminate the need for United States-Canada border crossings. Still, combined with the elimination of overseas games this had the effect of reducing the average distance per trip by 21.4% from 2018 to 2020.

The MLB previously had poor geographic sorting in 2018 and likewise grouped teams by region for the 2020 season. They did this without rearranging the traditional American and National Leagues but instead simply altered the schedule so that teams only played in their own Division (a smaller group within the American and National Leagues) or in the Division from the corresponding region in the other

League. This greatly increased geographic sorting such that distance per trip decreased by 30.0% from the 2018 to the 2020 season.

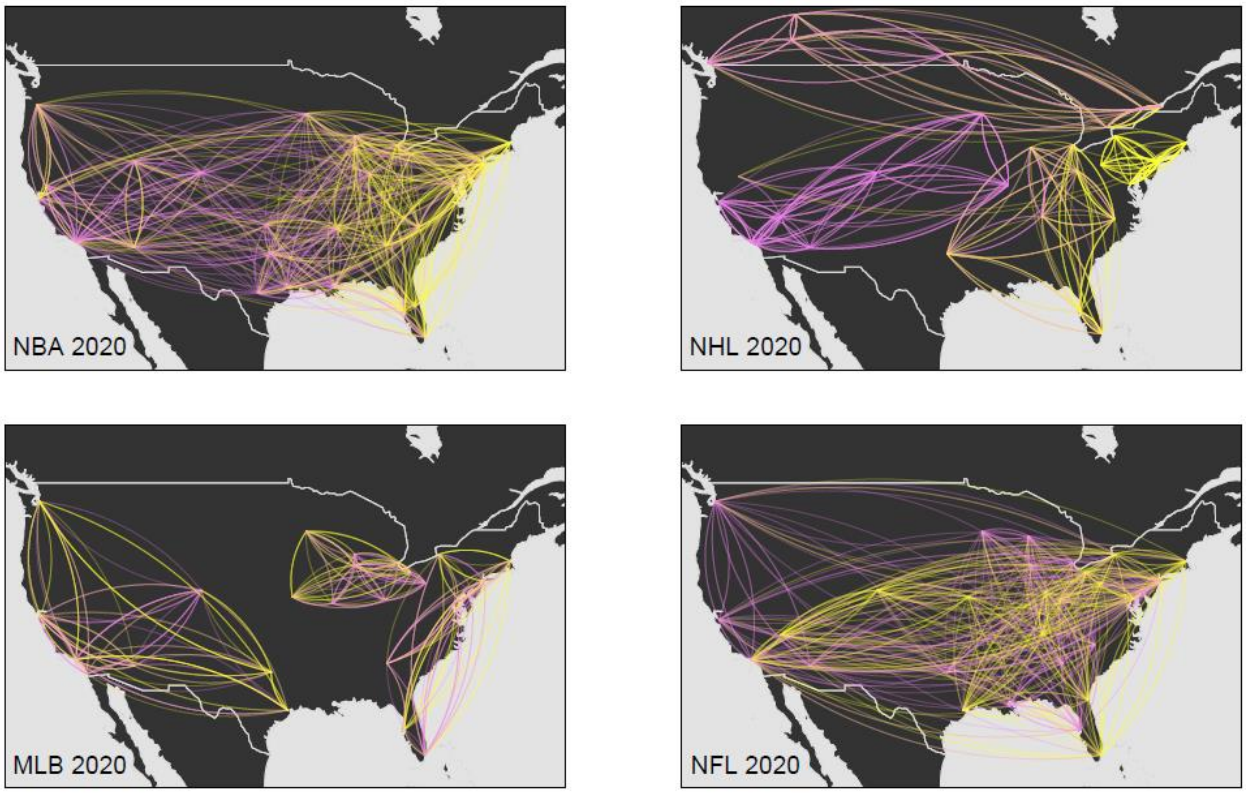

Figure 3: Trips taken for team travel during the regular season in 2020. Each line represents one trip, including flights and shorter journeys assumed to be taken over land. Yellow lines represent trips by teams in the Eastern Conference, American Football Conference or American League while purple lines represent trips by teams in the Western Conference, National Football Conference or National League. The NBA 2020 panel displays trips from the first half of the season only.

Consecutive repeating games

Both emissions and player travel were also reduced in 2020 due to a smaller number of trips taken (Figure 4). In 2018, only the MLB held games with repeated matches between teams in the same location during the regular season. But in 2020 the NBA introduced occasional baseball-style series such that 10% of regular season games in the first half of the season were consecutive repeats: the same two teams playing an additional game in the same location. The NHL implemented the same policy more aggressively: 42% of regular season games in 2020 were consecutive repeats. Major League Baseball continued this practice with 68% of regular season games occurring as consecutive repeats in 2018 and

67% in 2020. The NFL held no baseball-style series games in either season (though they did cancel overseas games in 2020).

Overseas games

Teams occasionally play games abroad. Due to the greater distances traveled I assume that these trips are taken in larger aircraft with greater ranges, thus increasing their climate impact. Additionally, because neither team is playing "at home" these games can require more trips per game since both teams take flights to and from the game. By substituting the emissions of each overseas flight (those over 5000 km) with the average emissions of non-overseas flights I estimate that replacing all overseas games with exhibition games at non-home-team locations in North America would have reduced emissions in 2018 by 3.3%. Note that the number of international games varies substantially between leagues and between seasons, and that this estimate includes pre-season overseas games.

We can use the emissions per game from each league in 2020 to estimate the emissions reductions that would be expected if the same policies (baseball-style series, geographic sorting and cancellation of overseas games) were implemented in a typical, regular length season. Even without making changes to the 2018 preseason or playoffs, I estimate total air travel emissions in 2018 would have decreased by 26,814 tCO_2 under such policies or 22% of air travel emissions that year.

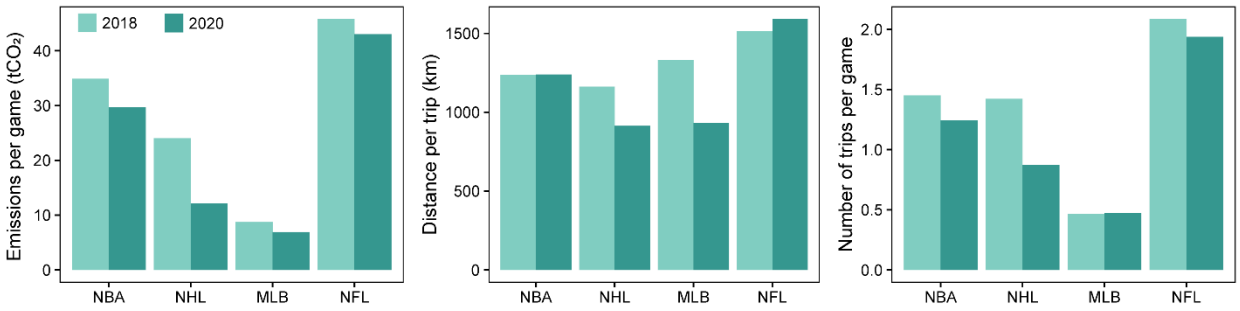

Figure 4: Emissions per game, distance traveled per trip and number of trips per game in the four major league sports during the 2018 and 2020 regular seasons. See Table S2 in the Supporting Information.

3.3 Additional policies

Although the type of aircraft used by each team is not always public knowledge, there are cases when this information is available and can be used to assess mitigation options. For instance, most teams in the NBA fly 757s to games, which are substantially larger than the aircraft previously chartered by the

264 league.[19] I estimate that switching NBA league aircraft from 757s to smaller A319s would have resulted
265 in league-wide air travel emissions reductions of 25.5% in 2018.

266 Finally, leagues could reduce air travel emissions simply by playing fewer games. The NBA at one point
267 considered shortening their season and adding an in-season tournament; both policies have broad
268 support amongst fans.[29] Dropping four games from the regular season (an option considered by the
269 NBA) would have reduced 2018 emissions by 2093 tCO_2, or 4.3% for the whole season (including playoffs
270 and preseason). Reducing the regular season by 10 games would reduce 2018 air travel emissions by
271 5232 tCO_2 or by 10.8% for the season. But if the league created a new, in-season tournament to
272 compensate for lost revenue, emissions reductions from the shorter season could be partially offset or
273 eliminated. For instance, a tournament played in Las Vegas where every team takes a return flight from
274 their home stadium would produce 2214 tCO_2 (though a more centrally located tournament in Chicago
275 would only produce 1576 tCO_2). For an overview of each policy and their relative mitigation potential
276 see Table 2.

277 **Table 2**

Policy	Co-benefits	Upper estimate of potential CO_2 reductions*
Cancel overseas games*	-Reduced player fatigue/injuries -Cost savings (fuel)	7.8% (NFL)
Reduce regular season	-Reduced player fatigue/injuries	10.8% (NBA)
Sort schedules by region	-Reduced player fatigue/injuries -Reduced competitive disadvantages -Cost savings (fuel)	19.9% (MLB)
Right-size aircraft	-Cost savings (fuel)	25.5% (NBA)
Increase consecutive repeating games	-Reduced player fatigue/injuries -Cost savings (fuel)	33.0% (NHL)

*Relevant league in parenthesis, provided as a percentage of that league's 2018 air travel emissions
**Does not include games played in Puerto Rico

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279 ## 3.4 Policy Implications

280 In 2020 the four major leagues adopted policies in response to the pandemic which would reduce air
281 travel emissions by an estimated 22% per year in a normal season. Additional policies could extend
282 these reductions even further. For instance, the NHL's scheduling changes were comprehensive (both in
283 terms of geographic sorting and consecutive repeated games) and cut emissions per regular season
284 game in half (Figure 4). The NBA experienced a much smaller decline in emissions but could achieve
285 greater cuts by increasing the number of consecutive repeated games. Likewise, the NFL, with relatively

low overall air travel emissions, could still take steps to improve geographic sorting. Leagues (especially the NBA) could also consider booking more right-sized, fuel-efficient aircraft. At one point the NFL investigated buying or leasing its own fleet of jets as a cost-saving measure:[31] such a league-wide standard would avoid incentivizing teams to compete for free agent players by offering increasingly luxurious (and inefficient) aircraft. Finally, shortened seasons would reduce player fatigue and could be adopted by any league seeking to cut back on air travel.

The absolute emissions from major league sports are globally small. Air travel from the four major leagues would only constitute 0.3% of emissions from private aviation, which is itself only 4% of global emissions from aviation.[1] Still, there would be considerable value in teams, leagues, and players acting as climate messengers in a region where much of the public remains skeptical of climate action.[32] Whereas emissions from stadium operations or spectator travel will drop as the energy and transport sectors decarbonize, flight emissions will remain high. Provided that the stated reductions are not cancelled out by other policies that grow emissions, taking steps to reduce air travel could signal genuine climate engagement.

The lessons learned from major league sports have possible carbon reduction implications in other industries. Medical residency interviews and major conferences can be regionalized to reduce emissions, for instance.[33-34] In some cases organizations will continue allowing remote work after the pandemic but may fly team members to one location for occasional, in-person meetings. Whether meetings are geographically optimized could determine if emissions saved from reduced commuting are cancelled by the increased emissions from air travel. Still, these changes involve many passengers dispersed on many commercial aircraft whereas this study evaluates the movement of entire aircraft and is therefore more analogous to corporations chartering aircraft or the wealthy flying in private jets.

Industry proponents claim that chartered aircraft and private jets are an “essential tool” of companies and organizations,[35] but it is difficult for researchers to evaluate the degree to which these flights are actually essential; Data on private aviation is quite limited[1], partially because of high levels of privacy not afforded to commercial travel.[36] But the findings of this study suggest that, at least in the sports industry, many flights could be eliminated or made more efficient. The trend of teams opting for increasingly larger aircraft, with one franchise owner going so far as to purchase multiple aircraft as backups for the same team[37] indicates a relative indifference to the costs of air travel. If sports teams can take on additional travel costs, they could voluntarily form partnerships with airlines to purchase

sustainable aviation fuels, thereby helping to grow a nascent technology[38] which could prove to be a critical tool in decarbonizing aviation.[39]

In addition to purchasing sustainable aviation fuels, sizeable reductions in emissions could be achieved without sacrifice by making fewer, shorter trips. For teams in the NBA, NHL and MLB, reduced air travel presents major benefits for player performance and injury prevention.[40] In the NBA, the negative impact of injuries and the discretionary resting of star players has already prompted the league to improve scheduling by restricting back to back game nights.[41] While a variety of policies can improve player health, the 2020 season demonstrated that sorting league schedules by region and using baseball-style series to reduce trips taken and kilometers traveled offer win-win solutions for players, fans and the climate.

Supporting Information

Supporting Information Text: Sources for league schedules; Figure S1: Cumulative distance flown by teams; Table S1: Data for Figure 1; Table S2: Data for Figure 4; Table S3: List of teams and corresponding aircraft; Dataset S1: Trip data

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