Journal of Interdisciplinary Science Topics

How many Formula One races would it take to raise the temperature of the Earth by 1°C?

Eleanor Davies
The Centre for Interdisciplinary Science, University of Leicester
26/03/2018

Abstract
This paper investigates the number of Formula One races it would take to raise the Earth's global temperature by one degree Celsius. This was done by calculating the carbon dioxide emissions of a Formula One Grand Prix and then comparing it to carbon dioxide ppm levels and corresponding global temperatures. It was calculated that 6.54×10^{10} races would need to take place to raise the temperature of the Earth by 1°C, which is the equivalent of 3,100,000,000 years.

Introduction
Formula One (F1) is the highest standard of motor racing, in which its seasons consist of grand prix. Each grand prix is set in a different location world-wide and spans an entire weekend, with the main event happening on the Sunday. The race weekend also involves free practice sessions and qualifying laps which determine the starting place of each driver in the final race [1].

F1 cars run on petrol [1] which consists of a mixture of hydrocarbons. Most cars, including F1 cars, have an internal combustion engine where the petrol is ignited and combusted, to ultimately power the vehicle [2]. The equation for the combustion of octane, a component in petrol, is:

$$2C_8H_{18} + 25O_2 \rightarrow 18H_2O + 16CO_2 \quad (1)$$

The carbon dioxide (CO_2) released in this combustion adds to the CO_2 in the atmosphere which in turns enhances the greenhouse effect [3]. The greenhouse effect is the process of keeping the earth warm due to greenhouse gases trapping UV radiation. This mechanism occurs because the Earth radiates wavelengths longer than those absorbed, causing the atmosphere to radiate some of the heat back to Earth [3].

Theory
Water vapour and clouds account for 75% of the greenhouse effect, however it is the 25%, primarily made up of CO_2 that sustains this effect [4]. From 1960 to 2010, the Earth's temperature has risen by 0.5 °C and CO_2 levels have risen by 75 parts per million (ppm), (using figure 1) [5]. Therefore, an increase of 1 °C is caused by $2 \times 75\ ppm = 150\ ppm$.

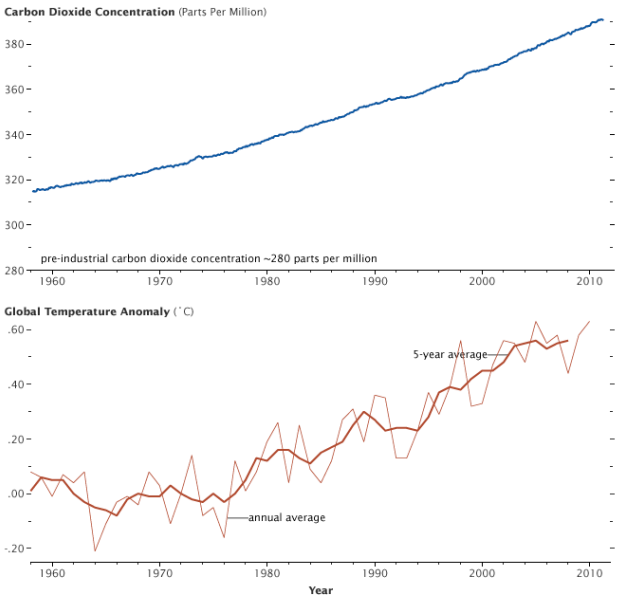

Figure 1 – Graphs showing the increase in carbon dioxide concentration and increase in temperature since 1960 [5].

The increase of other greenhouse gases contribute to global warming, however for the purpose of this

paper, carbon dioxide is assumed to be the sole factor.

For the 2018 season, there are 21 Grand Prix [6] with 10 teams competing in every race [1]. Each team enters two drivers and so two cars, totalling 20 cars. The most recent data available is for a 2007 naturally aspirated 2.4 litre V8 spec F1 car which emits 1.5 kg of CO_2 per 1 km [7]. Each race is a minimum of 305 km long, therefore this value will be used for this paper [8]. For the race weekend, each car will take part in qualifying and practice sessions as well as the grand prix itself. This distance covered over the weekend is likely to amount to a minimum of two race distances (305 km), therefore the total distance for each car per grand prix weekend will be approximately 610 km.

The total CO_2 emissions for a grand prix will be equal to the CO_2 emitted per kilometre multiplied by the distance travelled, multiplied by the number of cars. This equals $1.5\ kg\ km^{-1} \times 610\ km \times 20 = 18300\ kg$. To convert 18300kg of CO_2 into number of moles, equation 2 is used:

$$moles\ (mol) = \frac{Mass(g)}{Molar\ mass\ (gmol^{-1})} \quad (2)$$

Taking the molecular mass as 44.01 g mol^{-1} for CO_2, the number of moles is $18300/44.01 = 415814.6\ mol$. Then to convert this number to molecules, it is multiplied by Avogadro's number which gives 2.5×10^{29} molecules.

There are approximately 1.09×10^{44} molecules of gas in the atmosphere [9], so to convert 150 ppm of CO_2 to number of molecules, the following equation is used:

$$\frac{Molecules\ of\ gas\ in\ atm}{1\ million} \times CO_2\ ppm \quad (3)$$

This is equivalent to 1.635×10^{40} molecules of CO_2. In order to raise the Earth's temperature by 1 °C, $1.635 \times 10^{40}/2.5 \times 10^{29} = 6.54 \times 10^{10}$ F1 races must take place. If there are 21 races a year, then it would take 3.1×10^{9} years.
However, there are other factors that contribute to the overall emissions, such as:

- Manufacture of the car and spare parts- teams will bring enough parts to replace any that are heavily worn.
- Manufacture of the tyres – rules allow 12 sets of tyres per weekend. These will almost certainly all be used as fresh tyres result in faster lap times.
- Transportation of the cars, team members and spectators – the different location of each grand prix means that teams of around 30 people travel around the globe. The popular sport attracts people from various countries which also contributes to travel emissions.

Conclusion

Carbon dioxide is a greenhouse gas that is emitted by car engines. The 2007 specification F1 cars release 1.5 kg of CO_2 per km which totals 18300 kg of CO_2 for all cars in a grand prix. 1.635×10^{40} molecules of CO_2 are needed to be released in order to raise the temperature of the Earth by 1 °C. This is equal to 6.54×10^{10} F1 grand prix. If the emissions from the manufacture and transportation of race equipment as well as the travel of people were accounted for, then the number of races is likely to be significantly less.

References

[1] Formula One World Championship Limited (2018a) *Formula 1® - The Official F1® Website*. Available at: https://www.formula1.com/ [Accessed 21 February 2018].

[2] Energy.gov (2013). *Internal Combustion Engine Basics.* Office of Energy Efficiency and Renewable Energy. Available at: https://www.energy.gov/eere/vehicles/articles/internal-combustion-engine-basics [Accessed 5 March 2018].

[3] US EPA (2017). *Overview of Greenhouse Gases | US EPA.* Available at: https://www.epa.gov/ghgemissions/overview-greenhouse-gases [Accessed 5 March 2018].

[4] Hansen, K. (2010). *NASA - Carbon Dioxide Controls Earth's Temperature.* Nasa.gov. Available at: https://www.nasa.gov/topics/earth/features/co2-temperature.html [Accessed 21 February 2018].

[5] Earthobservatory.nasa.gov. (2018). *The Carbon Cycle: Feature Articles | Effects of Changing the Carbon Cycle.* Available at: https://earthobservatory.nasa.gov/Features/CarbonCycle/page5.php [Accessed 21 February 2018].

[6] BBC Sport (2018). 2018 Formula 1 calendar. Available at: http://www.bbc.co.uk/sport/formula1/race-calendar [Accessed 21 February 2018].

[7] Ornstein, D. (2007). *Formula One: Earth car will emit over 50 tonnes of CO_2.* The Guardian. Available at: https://www.theguardian.com/environment/2007/mar/02/formulaone.sport [Accessed 21 February 2018].

[8] Formula One World Championship Limited (2018b) *Points, classification and race distance.* Formula 1® - The Official F1® Website. Available at: https://www.formula1.com/en/championship/inside-f1/rules-regs/Classification_Race_distance_and_Points.html [Accessed 21 February 2018].

[9] Haby, J. (n.d.). *How many molecules of air are in the atmosphere?* Theweatherprediction.com. Available at: http://www.theweatherprediction.com/habyhints3/976/ [Accessed 21 February 2018].