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

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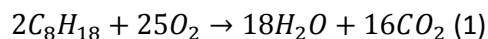
### Abstract

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  $6.54 \times 10^{10}$  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:



The carbon dioxide (CO<sub>2</sub>) released in this combustion adds to the CO<sub>2</sub> 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<sub>2</sub> that sustains this effect [4]. From 1960 to 2010, the Earth's temperature has risen by 0.5°C and CO<sub>2</sub> levels have risen by 75 parts per million (ppm), (using figure 1) [5]. Therefore, an increase of 1°C is caused by  $2 \times 75 \text{ ppm} = 150 \text{ ppm}$ .

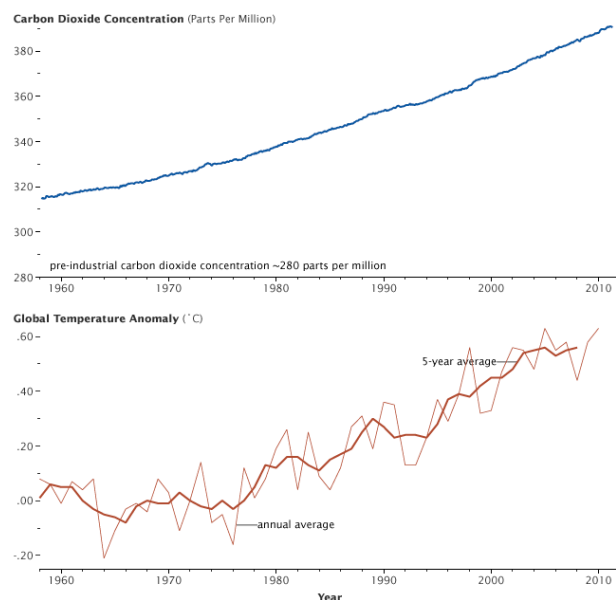


Figure 1 – Graphs showing the increase in carbon dioxide concentration and increase in temperature since 1960 [5].

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

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

Taking the molecular mass as 44.01 g mol<sup>-1</sup> for CO<sub>2</sub>, 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<sup>29</sup> molecules.

There are approximately 1.09×10<sup>44</sup> molecules of gas in the atmosphere [9], so to convert 150 ppm of CO<sub>2</sub> to number of molecules, the following equation is used:

$$\frac{\text{Molecules of gas in atm}}{1 \text{ million}} \times \text{CO}_2 \text{ ppm} \quad (3)$$

## References

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This is equivalent to 1.635×10<sup>40</sup> molecules of CO<sub>2</sub>. 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<sup>9</sup> 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<sub>2</sub> per km which totals 18300 kg of CO<sub>2</sub> for all cars in a grand prix. 1.635×10<sup>40</sup> molecules of CO<sub>2</sub> are needed to be released in order to raise the temperature of the Earth by 1 °C. This is equal to 6.54×10<sup>10</sup> 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.

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