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Radiative Forcing of Air Travel

What it is and why we do not account for it at Carbon Responsible

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Executive summary

- **Radiative forcing** is the change in the global warming effect of greenhouse gases when they are emitted at high altitudes (e.g., from planes)
- Many **offset providers** suggest also paying for radiative forcing when offsetting the emissions of a flight.
- There is **high uncertainty** around the additional global warming effect of greenhouse gases when they are emitted higher in altitude, so every measure of the emissions due to radiative forcing is highly estimated.
- Because of this high uncertainty, at Carbon Responsible we do not include the effect of radiative forcing when measuring air travel emissions.

If you offset the emissions of your flights with a carbon offset provider, your emissions might be divided into three categories: direct emissions (i.e., the gases that your plane emitted during your flight); indirect emissions (i.e., the well-to-tank ones, relative to the production and transport of fuel); and indirect effects (radiative forcing). This article will attempt to explain what radiative forcing is, especially in relation to air travel, and to provide the reasons why we do not include it in our analyses of our clients' air-travel emissions.

Global Warming Potential of Greenhouse Gases

The presence of certain gases, called greenhouse gases (or GHGs), in the atmosphere has a warming effect, because GHGs trap part of the outgoing longwave radiation emitted by the Earth, preventing it from going back to space. Depending on several properties of each greenhouse gas, the amount of heat absorbed by a GHG is different from the one absorbed by the same mass of another one. The global warming potential of a gas is a measure of the heat absorbed by that gas in the atmosphere as a multiple of the heat absorbed by the same mass of carbon dioxide.

Radiative Forcing

The warming potential of a flight is, however, not limited to the heat-trapping effect of the GHG molecules emitted during that flight. Airplanes produce water vapour as a biproduct of burning fuel and this water vapour condenses at high altitudes forming contrails, i.e., air traffic condensation trails. Contrails are line-shaped clouds and, as the other high-altitude clouds[1], have several effects on atmospheric energy balance. An effect is that they trap part of the longwave radiation coming from the Earth and prevent it from going back to space – this is an additional effect to the one of the emitted GHG molecules and tends to warm the planet. Contrails also reflect part of the radiation coming from the sun, which instead has a cooling effect on the Earth. These two effects, sometimes referred to as contrail and cloud albedo forcing, respectively, are two examples of radiative forcing.

[1] Hartmann, D. L., Ockert-Bell, M. E. & Michelsen, M. L. The effect of cloud type on Earth's energy balance: global analysis. J. Clim. 5, 1281–1304 (1992).

Radiative forcing of flights is expected to be positive, that is, to warm the planet overall. Accounting for radiative forcing would be ideal to have a more accurate and complete measure of the impact of air travel which, as we saw, does not only depend on GHG emissions. However, since the quantification of the effect of radiative forcing on the flight's overall global warming potential is highly uncertain, any estimation of such impact would be likely to be far from accurate. Moreover, radiative forcing strongly depends on the season, on whether the flight occurs at night or during the day[2], and on whether the planes travel mostly in areas where traffic is intense – these are the areas where the formation of contrails is more likely. Night-time flights during winter are responsible for most of the contrail radiative forcing (60 to 80 percent), despite only accounting for 25 percent of daily air traffic[2]. Daytime shortwave forcings are, instead, smallest in summer because "the combination of low solar zenith angles and smaller chances of forming a contrail dominates the effect of comparably higher summertime air traffic and longer daytime hours"[2]. In brief, even if we had a good knowledge of air-travel radiative forcing – which we do not have – an accurate estimation of radiative forcing would still require much more details about the flight that we can possibly ask our clients to provide.

Uncertainty in measuring radiative forcing

In conclusion, the global warming potential of flights is likely to be greater than the one that we can estimate by only considering the GHG emissions from that airplane. However, uncertainty is too high for us to quantify this additional forcing while guaranteeing a sufficient level of accuracy. It is convenient for companies selling carbon offsets to include radiative forcing with the risk of overestimating the emissions of a flight, as it means they get more money to offset the emissions for the same flight. It might also be argued that overestimating emissions leads to more serious emission reduction practices – you pollute more, you should reduce more. However, transparency and data accuracy are at the basis of what we do, and we believe that we should not ask our clients to also account for something that is still so uncertain for the scientific community. We will keep following the relevant research and, if science finds an accurate way of quantifying the radiative forcing of air travel, we will make sure to also consider adding it to our system.

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[2] Stuber, N., Forster, P., Rädel, G. et al. The importance of the diurnal and annual cycle of air traffic for contrail radiative forcing. Nature 441, 864–867 (2006).