IEAGHG Information Paper: 2017-IP16; Impacts of Non-CO_2 GHGs from Aviation

In a recent Information Paper (2016-IP37: Emissions from Aviation the Next Challenge?) we discussed the efforts underway to mitigate CO_2 emissions from aviation. Updating that paper, in October 2016, the 191 member states of the United Nation's International Civil Aviation Organization (ICAO) agreed to a new deal to cap international aviation emissions using a carbon offset approach[1].

Whilst welcoming the deal as progress, environmental pressure groups point to 2 issues that cause concern[2]. First, the offsetting nature of the ICAO scheme means countries still need to translate exactly how a deal – which doesn't actually stop aircrafts emitting more CO_2 and only begins in four years – will be able to align itself with the limits in global temperature rise set out in the Paris Agreement. Secondly they point out that the ICAO deal only addresses CO_2 emissions, and that Non-CO_2 GHG emissions from the aviation sector have so far been ignored.

The new ICAO deal only addresses CO_2 emissions, ignoring other emissions from planes which research has shown could result in warming several times greater than for CO_2 alone.

Non-CO_2 GHG emissions

Globally, aviation is responsible for around 2% of global anthropogenic CO_2 emissions, but its impact is projected to rise by 200% - 360% by 2050, even when the maximum use of lower-carbon alternative fuels is factored in. An environmental pressure group in the UK has estimated that the aviation sector could contribute as much as two-thirds of the UK's carbon budget for 1.5°C by 2050.

Significantly, these calculations don't take into account the radiative forcing caused by non-CO_2 GHGs such as water vapour, aerosols and nitrogen oxides. Apparently, the impacts of non-CO_2 GHG emissions from aviation at high altitudes was first highlighted in 1999 following publication of a special report by the International Panel on Climate Change (IPCC) on aviation. This estimated the total historic impact of aviation on the climate to have been two to four times higher than for CO_2 emissions alone. But, they argue that whilst it has been well established for more than a decade that air traffic affects the climate through emissions other than just CO_2, quantifying the effect is not easy. For example, the contribution of aircraft emissions to the formation of additional cirrus clouds formed by aircraft contrails – has proven extremely difficult to quantify. Contrails, for example, form when water vapour condenses on aerosol emissions. They are thought to have a significant warming effect. But, typically, they only last a few seconds in specific conditions of coldness and humidity.

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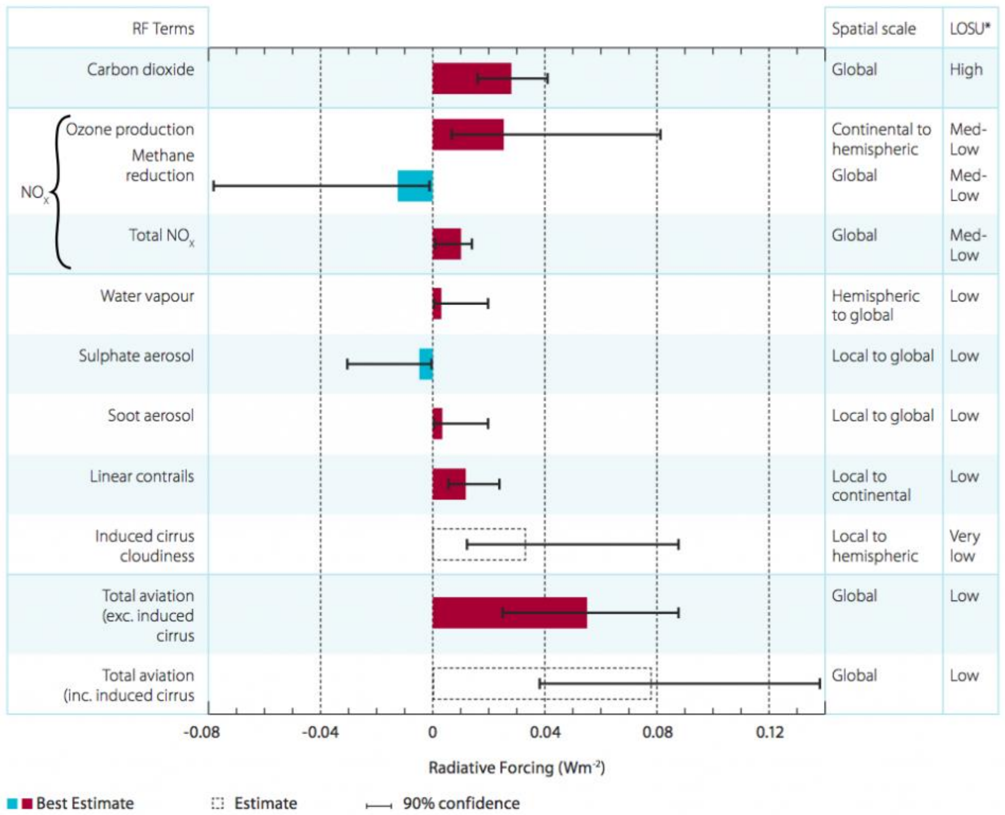
[1] http://www.icao.int/Meetings/a39/Documents/WP/wp_462_en.pdf

[2] https://www.carbonbrief.org/explainer-challenge-tackling-aviations-non-co2-emissions?utm_content=buffer3b879&utm_medium=social&utm_source=twitter.com&utm_campaign=buffer



Estimates for radiative forcing from global aviation in 2005. The induced cloudiness (AIC) estimate includes linear contrails. Error bars represent the 90% likelihood range for each estimate. The level of scientific understanding (LOSU) is shown on the right. Source: CCC (2009), reproduced from Lee et al. (2009)

Apparently, most of the impact of these non-CO_2 GHG emissions comes from the "cruise phase" of a flight when the plane is at high altitudes. Importantly, though, this impact depends largely on atmospheric conditions, such as temperature and the background concentrations of water vapour and nitrogen oxides.

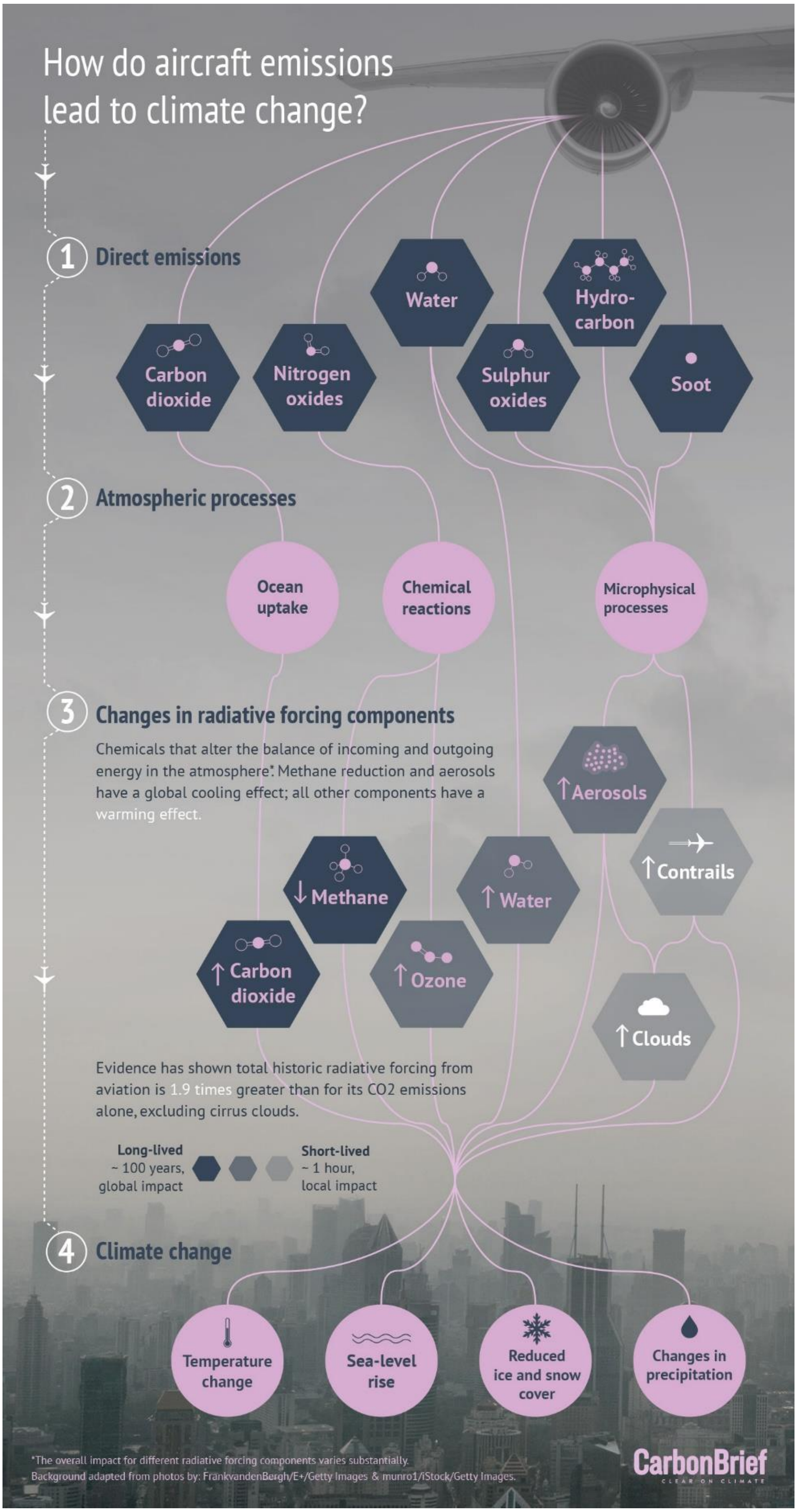
Reducing the impacts of Non-CO_2 GHG emissions

In its 1999 special report on aviation, the IPCC set out four broad areas where greenhouse gas emissions could be reduced from flights:

- technological improvements, such as light weighting;
- changes to (or replacements for) jet fuel;
- operational changes;
- and regulatory or economic options.

It is considered that reducing CO_2 emissions using these methods is challenging but is even more challenging for non-CO_2 GHG emissions. The reason for this is the short atmospheric "lifetime" of many of these pollutants which makes their climate impact highly dependent on the location, season and time of day of emissions.

However, the short lifetime of non-CO_2 GHG emissions, it is theorised, could also be a benefit since changes in operational procedures, such as air traffic management, could reduce their impact more than for CO_2 emissions.



How do aircraft emissions lead to climate change? Infographic by Rosamund Pearce for Carbon Brief. Data from Brasseur et al (2009) and Lee et al (2009), and the IPCC.

A study in Nature, published in 2006[3], found that night-time flying accounts for 60% - 80% of all contrail forcing from planes, despite accounting for just a quarter of flights. This is because while contrails trap warming infrared energy during both day and night, this is offset somewhat during the day by a cooling effect as they reflect sunlight back into space. The study also found winter flights have a far bigger overall warming effect than those taken during the rest of the year, since contrails are more likely to form when it is cold. Therefore, adjusting the times and seasons when flights are taken could cut their non-CO_2 GHG emissions impact significantly.

Studies in 2014 suggested that:

- lowering the altitude of aircrafts by around 2,000 feet (610 metres) could reduce the radiative forcing from emissions of nitrogen oxides (NOx) by two-fifths[4].
- re-routing flights to avoid climatic regions which are particularly sensitive to the effects of non-CO_2 GHG emissions could lower their climate impact by a quarter, at a cost increase of just 0.5%[5].

However, it must be noted that altering flight trajectories to limit climate impacts presents some significant challenges. For example, at a time when government policy and airspace regulators are already working to free up more airspace capacity, rerouting would instead create a new source of congestion. The possibilities for designing altered routes could be hindered by air traffic service routes and national airspace boundaries. Procedures to ensure there is enough space between planes could also force planned climate-friendly trajectories to be changed. And there remain significant barriers to providing the required accuracy in predictions of wind, temperature and weather predictions. Also, the new routes would have to be carefully balanced to ensure the resulting reduction in radiative forcing from non-CO_2 GHG emissions is not offset by the increased CO emissions of flying longer routes. Longer routes would mean a bigger fuel cost for airlines, which currently don't pay any penalty for their non-CO_2 GHG emissions.

However, a new paper released recently proposed an alternative form of flight rerouting using a regulatory approach to overcome some of the barriers. Rather than optimising the routes of individual aircrafts, it proposes restricting planes from flying in whole regions of airspace. The system would force aircraft to fly around regions where non-CO_2 GHG emissions would have a large impact on radiative forcing. The proposal would see a threshold value of climate costs set by policymakers, with airspaces which passed this value being closed until they had slipped below it again. The paper argues this option, which could see airspaces closed for hours, days or even months in a situation akin to military restricted airspace, could be easily implemented by air traffic controllers and could be used as an interim solution to longer term proposals to cut non-CO_2 GHG emissions from air travel. It finds the climate impact of flights could be cut by 12% at no extra cost to operators using such an approach. However, larger route changes could increase fuel costs and CO_2 emissions, though still resulting in less forcing overall.

Research into other ways of reducing non- CO_2 impacts is also ongoing. In a paper published in Nature recently, scientists used small, instrumented planes flying directly in the exhaust plume of jet plane to measure the emissions of various fuel mixes. Their results showed use of a 50/50 conventional fuel and biofuel blend could reduce aerosol emissions by 50% - 70% compared conventional fuels alone.

[3] http://www.nature.com/nature/journal/v441/n7095/abs/nature04877.html
[4] http://www.sciencedirect.com/science/article/pii/S1352231014004956
[5] http://www.sciencedirect.com/science/article/pii/S1352231014004063

Conclusion
However, despite the on-going research, this is a difficult area to tackle; first and foremost, quantifying the precise magnitude of their impact of the non-CO_2 GHG emissions from aviation - the difficulty in this would seem to be the starting point to get this issue on the policy makers agenda again.

However, the underlying concern of ignoring the issue of non-CO_2 GHG emissions from the aviation sector is not a good way to proceed in a world attempting to fulfil its collective commitment, agreed in Paris in late 2015, to limit temperature rise to “well below” 2^oC.

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