Future air quality implications of decision-making for sustainable aviation

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Aviation emissions lead to **degraded air quality and cause adverse human health impacts**. They have been estimated to result in ~16,000 early deaths globally every year [1]. **Aviation emissions have been growing steadily over the past decades**, and it is estimated that, despite the current hindrance in air traffic, they will continue to grow. As a result, mitigating aviation's adverse air quality impacts is an increasingly pressing challenge for the aviation industry. At the same time, the **aviation sector has inherently long-timelines** and inertia, indicating that **sustainability decisions made presently will take effect over the next 30+ years**. Recent work has shown that the **atmospheric response to a unit of emission changes over time**, due to the changing atmospheric composition, driven by meteorological and background (non-aviation) emissions [2-4]. This highlights the need to **take this evolving atmospheric response into account when assessing the air quality effects and costs/benefits of future mitigation scenarios**.

$$\frac{\partial\,(\text{Concentration})}{\partial\,(\text{Emission})} \times \Delta\,(\text{Emission}) \simeq \text{Air quality impacts of emissions scenario}$$

ATMOSPHERIC RESPONSE TO EMISSIONS

- Primarily **non-linear processes** between aviation emissions and the formation of $PM_{2.5}$ and ozone pollutants. They depend on atmospheric composition & meteorology
- *E.g. #1*: The atm. sensitivity to NO_x changed by 20% in the US between 2005-2011, driven by non-aviation emissions changes [2]
- *E.g. #2:* This atm. sensitivity differs by up to 50% between regions globally [4]
- It is critical that **future atmospheric conditions** are taken into account when assessing future mitigation scenarios **over the entire lifetime of the aircraft fleet scenario**.

AVIATION EMISSIONS

- Aviation fuel use is growing in the long term (despite setbacks)
- This growth is non-uniform globally
- Emissions indices are changing over time with evolving aircraft fleet [5]
- LTO and non-LTO emissions should be estimated for mitigation scenarios [1,4]
- When assessing the effects of mitigation/sustainability scenarios, emissions inventories that characterize **the spatial distribution of those emissions, as well as their temporal evolution over the entire lifetime of the aircraft fleet**, are needed.

References:
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