

AVIATION CO₂ REDUCTIONS



STOCKTAKING SEMINAR
TECHNOLOGY · OPERATIONS · SUSTAINABLE AVIATION FUELS

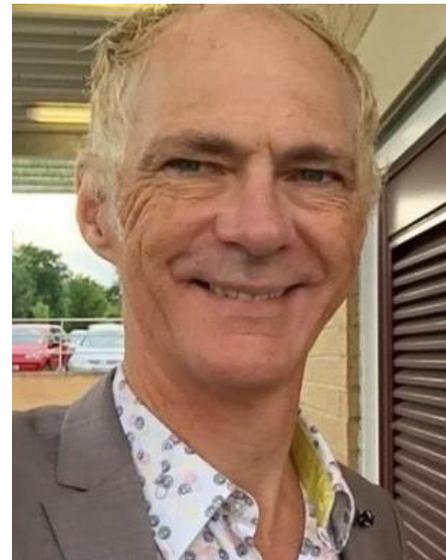


Impacts of aviation on climate



David S Lee

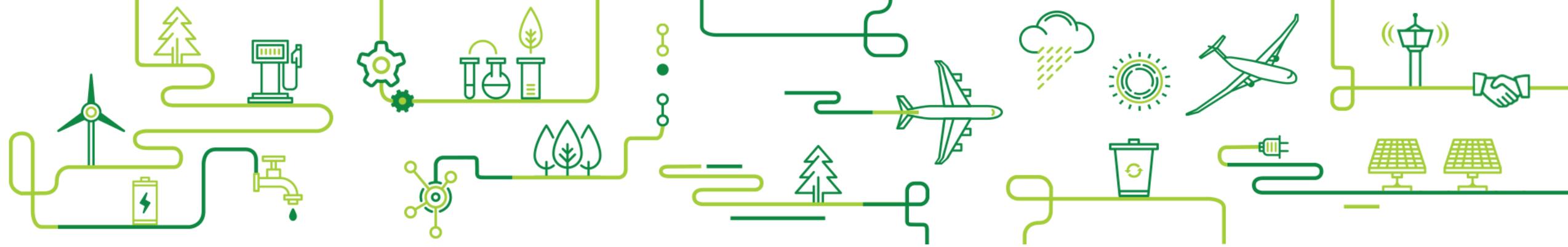
Manchester Metropolitan University, UK



with

Daniel Jacob

US Federal Aviation Administration



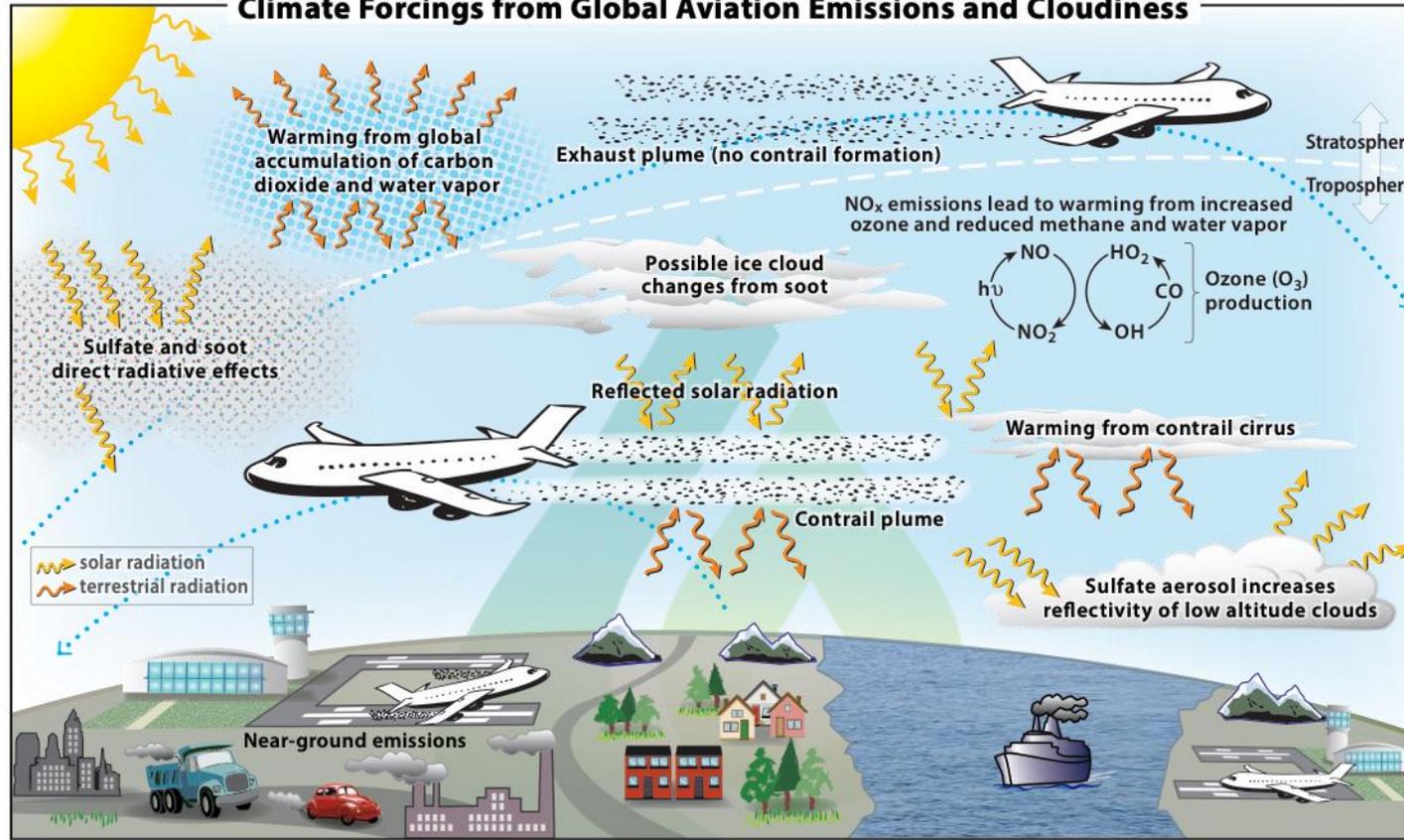
Global¹ aviation and climate – vital statistics²

- ~1,000 Million Tonnes of CO₂ in 2018 (based on IEA/IATA data)
- 2.4% of 2018 global annual emissions of CO₂ from fossil fuel combustion, cement manufacturing and land use change (based on above and Global Carbon Budget project)
- 32.6 billion tonnes of cumulative CO₂ since 1940, ~50% of which in the last 20 years
- CO₂ is the principal greenhouse gas emitted by aviation but there are important non-CO₂ effects that cause additional warming
- The metric used to assess present-day impacts is called ‘Effective Radiative Forcing’ (ERF), where positive = warming
- Non-CO₂ impacts represent around 66% of the net ERF; cumulative CO₂ emissions represents around 34% of the net ERF
- The major forcings from global aviation come from contrail cirrus clouds, CO₂ and the ‘net NO_x’ effect, with minor contributions from water vapour, soot and sulfur aerosol-radiation interactions
- The non-CO₂ effects contribute 8 times more than CO₂ to the uncertainties of net global aviation ERF in 2018
- Together, aviation impacts on forcing are 3.5% of total anthropogenic forcing

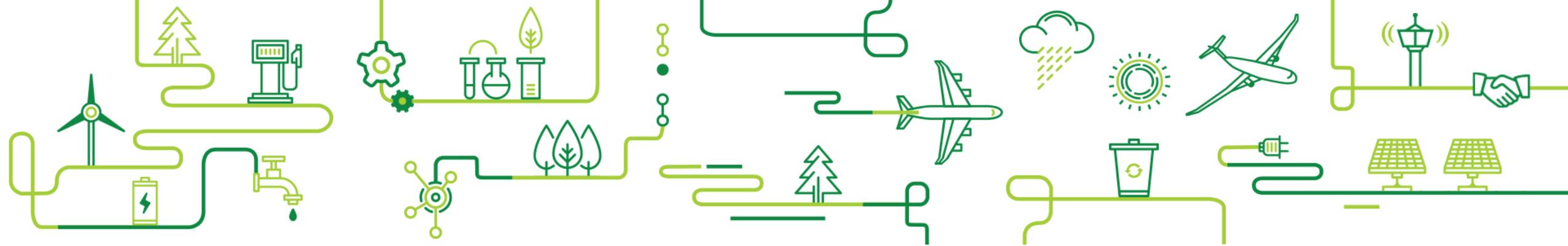
¹note that sectoral climate impacts are based on global (international + domestic)

²statistics/data from Lee et al. (2020), *Atmospheric Environment*

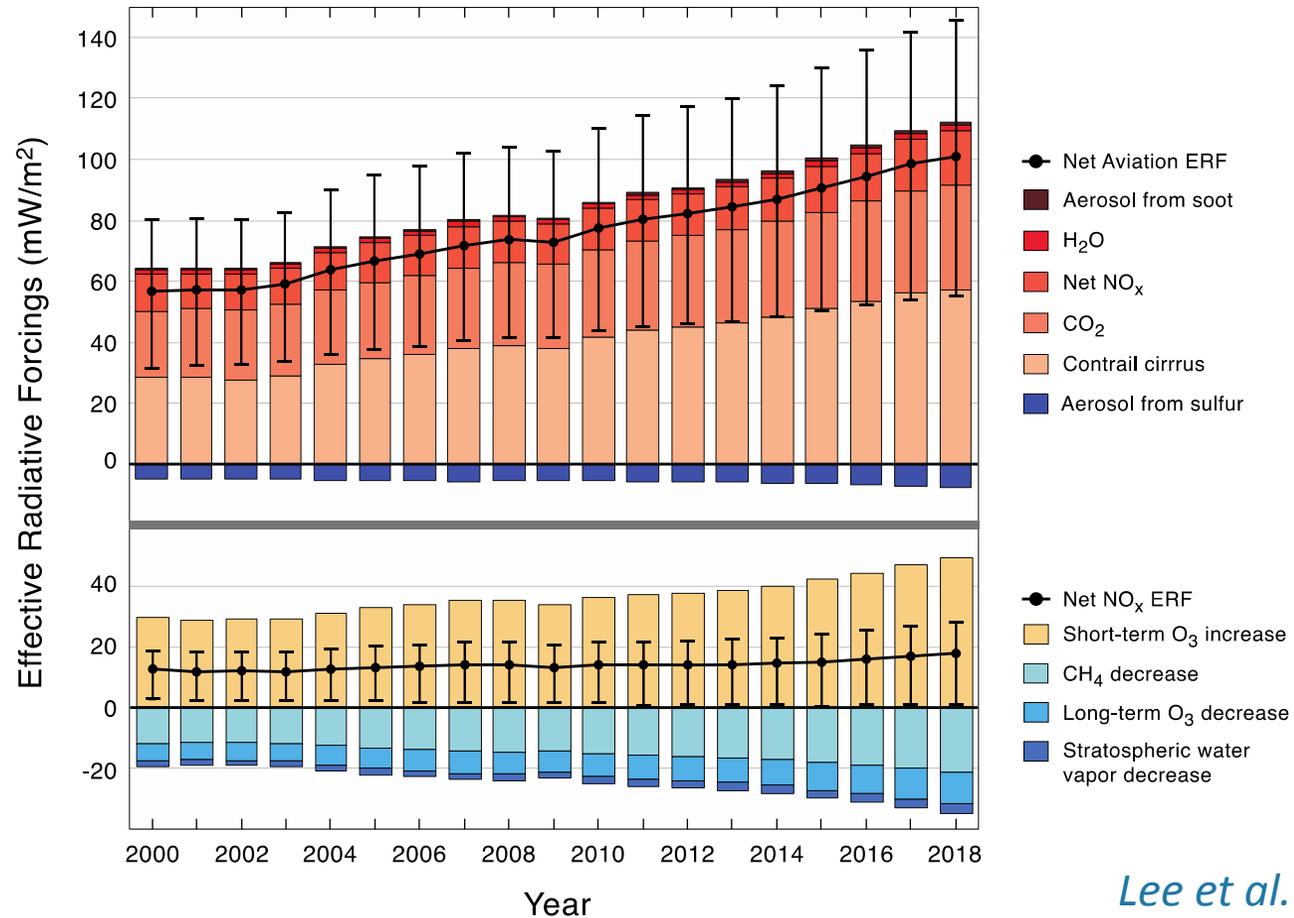
Climate Forcings from Global Aviation Emissions and Cloudiness



Jet Engine Combustion	Exhaust Plumes	Plume Composition	
Air: nitrogen (N ₂) + oxygen (O ₂)	No contrail formation	Gases	Aerosol Particles
Kerosene fuel: carbon (C _n), hydrogen (H _x), sulfur, aromatics	Contrail formation in low-temperature ice-supersaturated air	Carbon dioxide (CO ₂)	Cloud condensation nuclei
		Nitrogen oxides (NO _x)	Ice nuclei
		Carbon monoxide (CO)	Contrail ice
		Water vapor (H ₂ O)	Others
		Sulfur compounds	
		Unburned hydrocarbons (HC)	

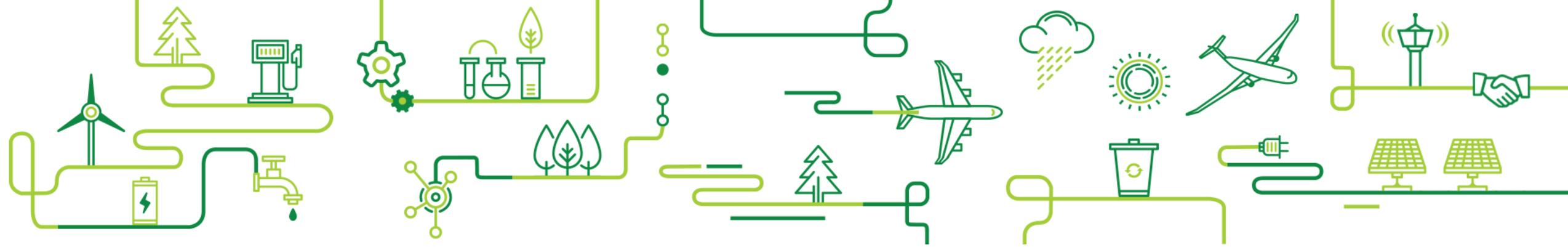


Global Aviation ERFs from 2000 to 2018



Global aviation represents 3.5% of anthropogenic forcings (for 2011, IPCC AR5 total forcing of 2.29 W m⁻²)

Lee et al. (2020) Atmospheric Environment



What of the future?

For CO₂, what matters most of all are the cumulative emissions over time, since CO₂ has very long lifetimes in the atmosphere, to millennia for a fraction of an emission (20%)

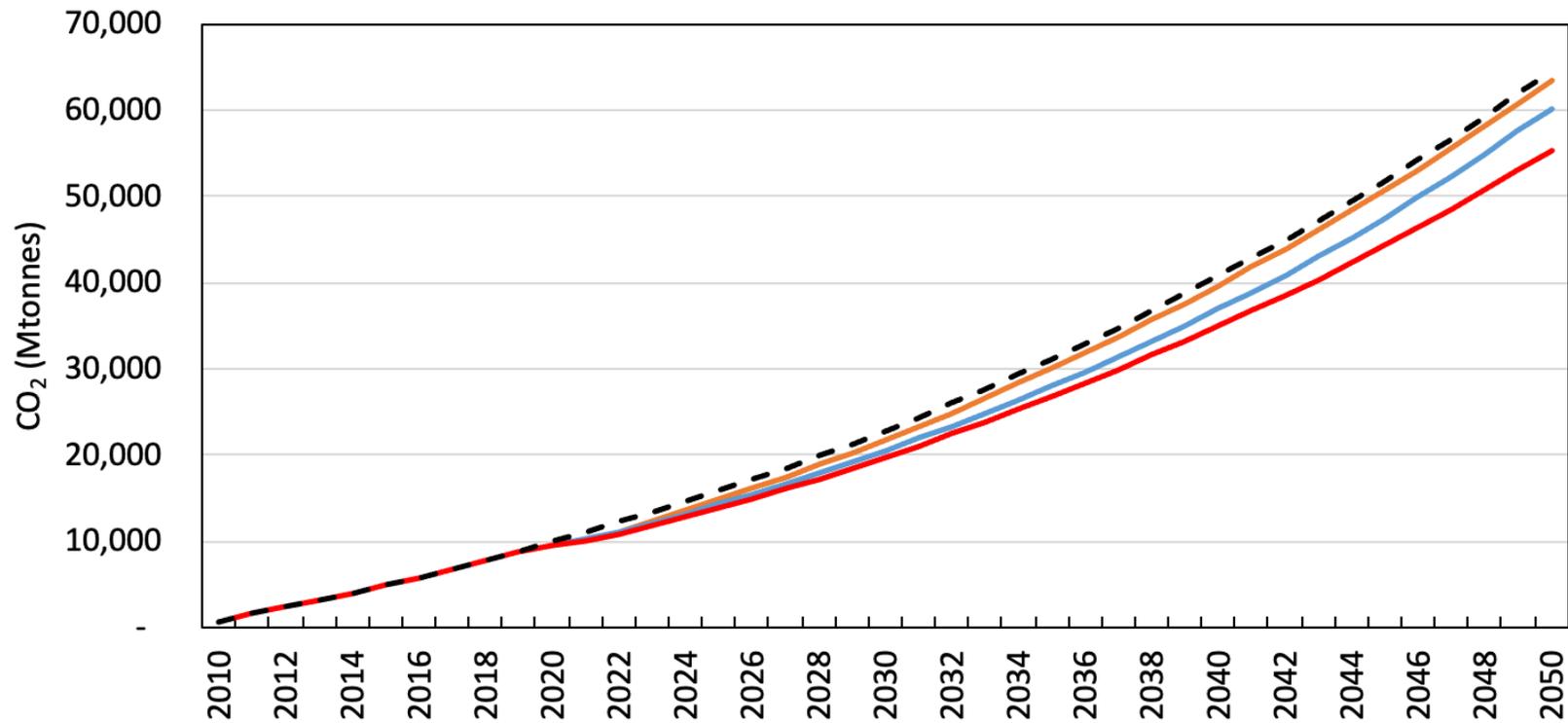
From the science, the Intergovernmental Panel on Climate Change (IPCC) has shown that there is a robust approximately linear relationship between increases in cumulative CO₂ emissions and global mean surface temperature change

The COVID-19 pandemic has seen dramatic reductions in air traffic and in-year emissions (see later talk of Roger Schauffele)

However, if traffic recovers in a few years time to former levels and then grows, the *impact* of aviation CO₂ emissions on climate will only be reduced marginally, or “*the problem hasn’t gone away...*”



Global Scenarios: Cumulative CO₂ (2010 to 2050)



Approximately 10% difference between base case counterfactual and 'worst case' scenarios for entire history (1940 – 2050) aviation CO₂ emissions

- Rebound (meet base case by 2023)
- Blue (extrapolate to 2050 to meet base case by 2050)
- Red (extrapolate to 2050 with constant percentage offset to 2050 from 2025)
- - BAU (CAEP11 Sc 3)

Lee et al., work in progress



Thank You

