State of Consensus Climate Science

By ICAO Secretariat

Introduction

The International Civil Aviation Organization continues to keep abreast of developments in other United Nations (UN) bodies, including the work of the Intergovernmental Panel on Climate Change (IPCC). According to the IPCC Sixth Assessment Report (AR6)[1], it is unequivocal that human influence has warmed the atmosphere, ocean and land: widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred. From a physical science perspective, the global surface temperature will continue to increase until at least mid-century under all emissions scenarios considered. Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in carbon dioxide (CO_2) and other greenhouse gas emissions occur in the coming decades.

The IPCC AR6 states that limiting human-induced global warming to a specific level requires limiting cumulative CO_2 emissions, reaching at least net zero CO_2 emissions, along with strong reductions in other greenhouse gas emissions. Strong, rapid and sustained reductions in methane (CH_4) emissions would also limit the warming effect resulting from declining aerosol pollution and would improve air quality.

IPCC AR6 Emissions trends and Continuing Challenges

According to the IPCC AR6[2], the rate of global greenhouse gases (GHG) emissions growth has slowed in recent years, from 2.1% per year between 2000 and 2009, to 1.3% per year in between 2010 and 2019. Nevertheless, GHG emissions have continued to grow at high absolute rates. Emissions increased by 8.9 $GtCO_2eq$ from 2000-2009 and by 6.5 $GtCO_2eq$ 2010-2019, reaching 59 $GtCO_2eq$ in 2019.

Aviation grew particularly fast on average at 3.3% per annum between 2010-2019. During that period, transport emissions have remained roughly constant, growing at an average of 2% per annum due to the persistence of high travel demand, heavier vehicles, low efficiencies, and car-centric development. Globally, energy efficiency has have improved but carbon intensities have not. The full decarbonisation of e-vehicles requires that they are charged with zero-carbon electricity, and that car production, shipping, aviation and supply chains are decarbonized.

Lockdown policies in response to COVID19 led to an estimated global drop of 5.8% in CO_2 emissions in 2020 relative to 2019. Energy demand reduction occurred across sectors, except in residential buildings due to teleworking and homeschooling. The transport sector was particularly impacted and international aviation emissions declined by 45%. However, atmospheric CO_2 concentrations continued to rise globally in 2020 and emissions have already rebounded as lockdown policies are eased. Economic recovery packages currently include support for fossil fuel industries.

IPCC AR6 Scenarios and ICAO Long Term global Aspirational Goal (LTAG) Observations

The emission scenarios considered by IPCC in AR6 are presented in Figure. 1. Based on the assessment of multiple lines of evidence by IPCC, under the five illustrative

1 IPCC Sixth Assessment Report: https://www.ipcc.ch/reports/
2 Table TS.1: Signs of Progress and Continuing Challenges , https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_FullReport.pdf

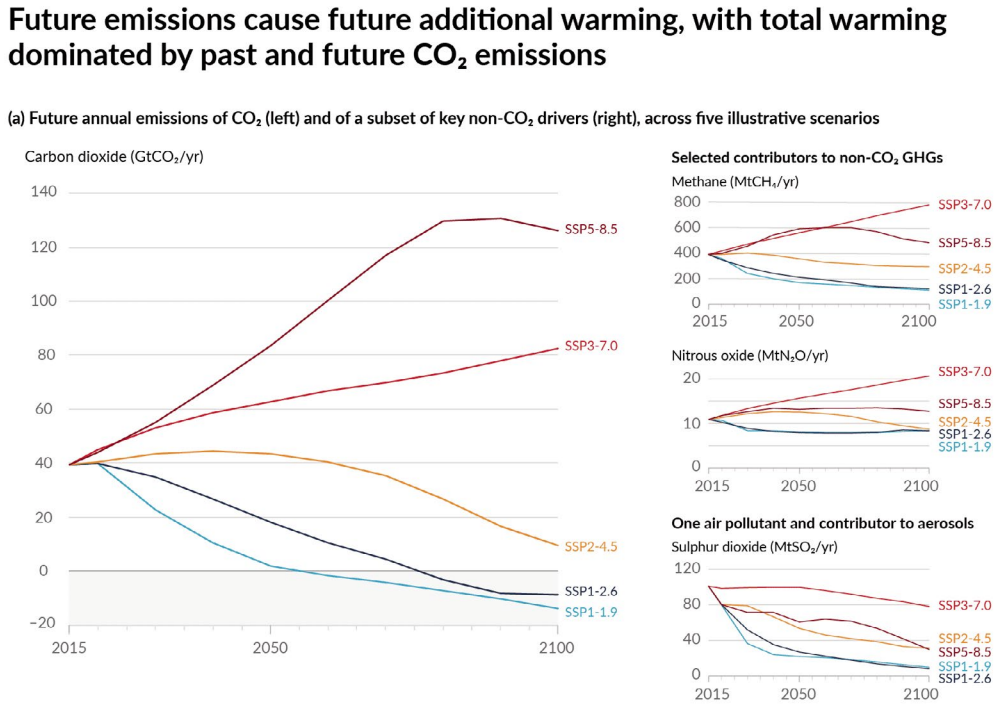

FIGURE 1: Future annual emissions of CO_2 (left) and of a subset of key non-CO_2 drivers (right), across five IPCC AR6 illustrative scenarios (Figure SPM.4 (part of) from IPCC AR6 WG1, 2021).

scenarios, in the near term (2021-2040), global warming of 2°C, relative to 1850–1900, would be exceeded during the 21st century under the high and very high greenhouse gas (GHG) emissions scenarios considered (SSP3-7.0 and SSP5-8.5, respectively). Global warming of 2°C would extremely likely be exceeded in the intermediate scenario (SSP2-4.5). Only under the very low (SSP 1-1.9) and low (SSP 1-2.6) GHG emissions scenarios, global warming of 2°C is extremely unlikely to be exceeded or unlikely to be exceeded, respectively.

For the ICAO Long-Term Aspirational Goal (LTAG) feasibility study[3], ICAO used the "very low GHG emissions scenario", under which it is more likely than not that global temperature would decline back to below 1.5°C towards the end of the 21st century, with a temporary overshoot of no more than 0.1°C above 1.5°C global warming.

The IPCC AR6 utilized an approach based on the carbon budget, which is the maximum amount of cumulative net global anthropogenic CO_2 emissions that would result in limiting global warming to a given level with a given likelihood, taking into account the effect of other anthropogenic climate forcers. For the IPCC AR6 estimated cumulative residual global anthropogenic CO_2 emissions (400 $GtCO_2$ at 67% probability) from the start of 2020 to limit global warming to 1.5°C, the international aviation share varies between 4.1 and 11.3%, depending on the LTAG Integrated Scenarios in the ICAO LTAG Report[4]. Similarly, for a warming limit of 2°C with the remaining allowed carbon emissions estimated to 1150 $GtCO_2$ at 67% probability, the international aviation share is between 1.4 and 3.9%, according to the ICAO LTAG Report.

Non-CO_2 effects (e.g., largely from methane, nitrous oxide[5], and fluorinated gases) are included in the above estimates and introduce in an uncertainty in the allowed CO_2 emissions for a given temperature limit and probability for staying at or below this limit. The total aviation forcing effect was approximately 3.5% of the total anthropogenic

3 ICAO Environmental Report 2022, LTAG Special Supplement.
4 ICAO LTAG Report: https://www.icao.int/environmental-protection/LTAG/Pages/LTAGreport.aspx
5 ICAO Environmental Report 2022. Chapter 3 – Local Air Quality. Impacts of Aviation NOx Emissions on Air Quality, Health, and Climate.

climate forcing in 2011. Aviation non-CO_2 climate effects are currently estimated to be about 2/3 of the total aviation forcing based on historical data although future projections are uncertain.

Achieving net zero global CO_2 emissions by around 2050 will provide the best chance to keep the global average temperature increase below 1.5°C, and that the 1.5°C temperature goal is beyond reach without immediate and deep emissions reduction across all sectors, while achieving net zero global CO_2 emissions by around 2070 will provide the best chance to keep the global average temperature increase below 2°C. Accelerated and equitable climate action in mitigating, and adapting to, climate change impacts is critical to sustainable development.

IPCC AR6 and Aviation Sector

The IPCC AR6 states that demand-side options and low-GHG emissions technologies can reduce transport sector emissions in developed countries and limit emissions growth in developing countries. Demand-focused interventions can reduce demand for all transport services and support the shift to more energy efficient transport modes.[6]

The IPCC AR6 also states that while aircraft efficiency improvements (e.g., optimised aircraft designs, mass reduction, and propulsion system improvements) can provide some mitigation potential, additional CO_2 emissions mitigation technologies for aviation will be required. For the aviation sector, such technologies include high energy density biofuels, and low-emission hydrogen and synthetic fuels, while electrification could play a niche role for aviation for short trips and can reduce emissions from airport operations. Improvements to national and international governance structures would further enable the decarbonisation of aviation. Such improvements could include, for example, the implementation of stricter efficiency and carbon intensity standards for the sector.[7]

According to the IPCC AR6, international environmental and sectoral agreements, institutions, and initiatives are helping, and in some cases may help, to stimulate low GHG emissions investment and reduce emissions. Current sectoral levels of ambition vary, with emission reduction aspirations in international aviation and shipping lower than in many other sectors.[8]

Many regulatory and economic instruments have already been deployed successfully. Such instruments could support deep emissions reductions and stimulate innovation if scaled up and applied more widely. Policy packages that enable innovation and build capacity are better able to support a shift towards equitable low-emission futures than are individual policies. Economy-wide packages, consistent with national circumstances, can meet short-term economic goals while reducing emissions and shifting development pathways towards sustainability.

In light of the IPCC's latest assessment, it is clear that while current ICAO global aspirational goals for international aviation in Assembly Resolution A40-18 (i.e. fuel efficiency improvements and carbon neutral growth) will keep the net CO_2 emissions from international aviation at a certain level, these goals will not align with a path in support of the 1.5°C temperature goal or the 2°C temperature goal.

Conclusion

According to the IPCC AR6, global warming, reaching 1.5°C in the near-term, would cause unavoidable increases in multiple climate hazards and present multiple risks to ecosystems and humans. The level of risk will depend on concurrent near-term trends in vulnerability, exposure, level of socioeconomic development and adaptation. Near-term actions that limit global warming to close to 1.5°C would substantially reduce projected losses and damages related to climate change in human systems and ecosystems, compared to higher warming levels, but cannot eliminate them all.

6 C.8 section, https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_FullReport.pdf
7 C.8.4. section, https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_FullReport.pdf
8 E.6.4 section, https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_FullReport.pdf

The evidence of observed impacts, projected risks, levels and trends in vulnerability, and adaptation limits, demonstrate that worldwide climate resilient development action is more urgent than previously assessed in AR5. Comprehensive, effective, and innovative responses can harness synergies and reduce trade-offs between adaptation and mitigation to advance sustainable development. The cumulative scientific evidence is unequivocal: climate change is a threat to human well-being and planetary health; and any further delay in concerted anticipatory global action on adaptation and mitigation will miss a brief and rapidly closing window of opportunity to secure a liveable and sustainable future for all.

Therefore, ICAO enhances cooperation with other UN bodies and international organizations involved in policy making on climate change, notably with the United Nations Framework Convention on Climate Change (UNFCCC). The ultimate objective of the UNFCCC is to achieve stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

Under ICAO's continuous leadership, Member States work together to limit or reduce emissions from international aviation, including the adoption at the 2010 Assembly of the ICAO global aspirational goals for the international aviation sector of improving fuel efficiency by 2 per cent per annum and keeping the net carbon emissions from 2020 at the same level.

Due to the cross-national-boundary nature of international aviation emissions, the ICAO global aspirational goals including a potential LTAG set out the international aviation sector's collective goals, without attribution of specific obligations in the form of emissions reduction goals to individual States, and Member States contribute to the achievement of collective goals by planning and implementing different sets of measures to reduce CO_2 emissions from international aviation, under the umbrella of ICAO coordination.