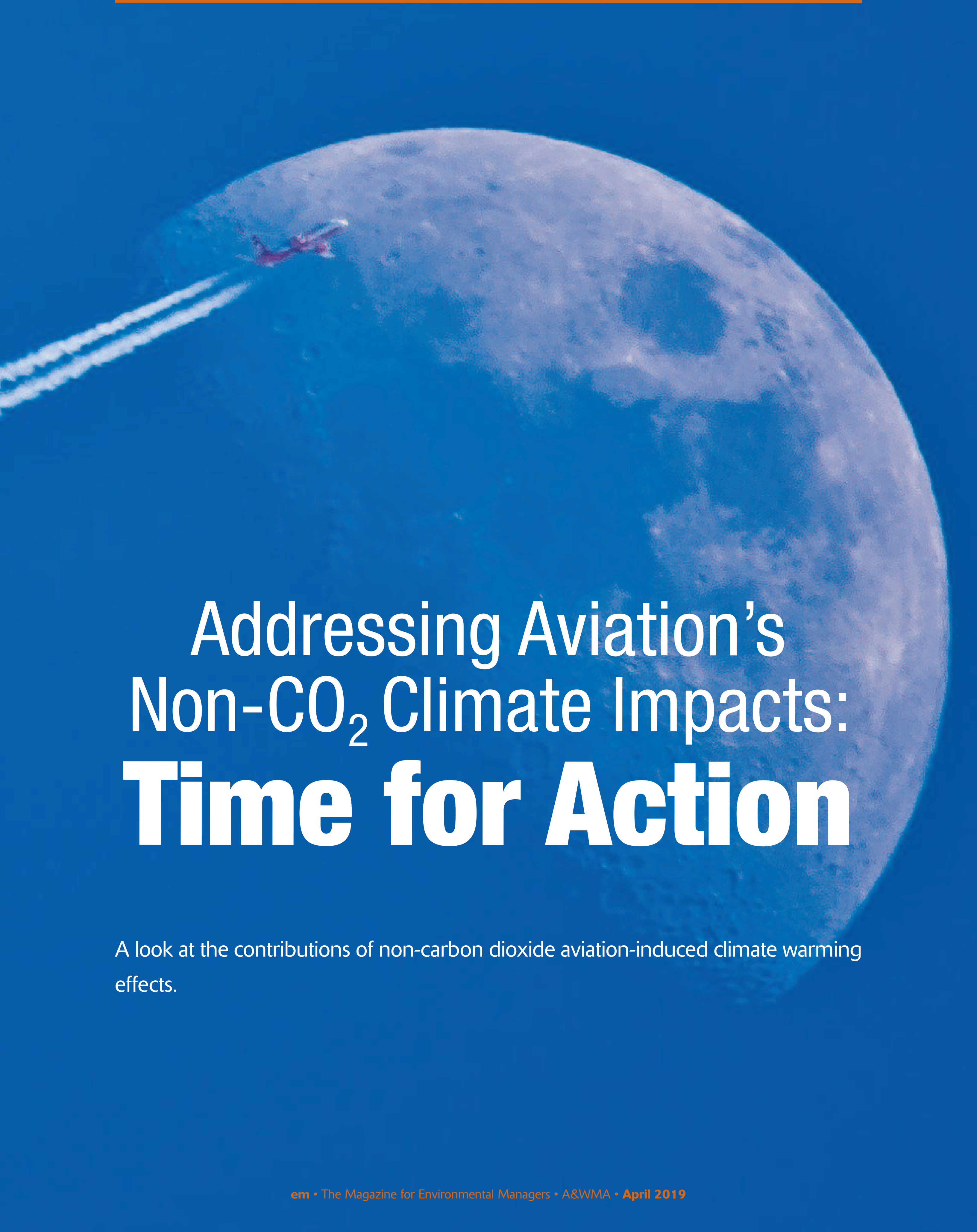

Addressing Aviation's Non-CO_2 Climate Impacts: Time for Action

A look at the contributions of non-carbon dioxide aviation-induced climate warming effects.

Aviation is commonly believed to account for 2% of the world's climate problem because the sector emits approximately 2% of global carbon dioxide (CO_2) emissions.[1] International aviation—flights between different countries—contributes about 1.3% of CO_2 emissions, while domestic emissions—flights within individual states—account for the remaining 0.7% of global aviation CO_2. But all this is only part of the picture. Aviation in fact accounts for about 5% of man-made global warming because in addition to emitting CO_2, aircraft flying at altitude impact the atmosphere in various ways and these impacts have a large, albeit transient, additional warming effect.[2]

Contributors to Aviation Non-CO_2

The main contributors of aviation-induced warming are contrail/cirrus cloud formation, CO_2, nitrogen oxides (NOx), water vapor, sulfur oxides (SOx), and aerosols. Contrails—the streaks in the sky comprising ice crystals formed around the escaping engine exhaust—and the resultant cirrus cloud formation, traps radiation escaping from the earth and again has a warming impact. NOx emitted at altitude by incomplete jet engine combustion enhances ozone formation on a timescale of weeks to months as well as depletes methane. Overall, NOx emissions have a net warming effect.

The climate impacts of CO_2 emissions are well known. CO_2 accumulates and has a very long life in the atmosphere (well over a 100 years). On the other hand, the climate impact of aviation aerosols is not currently well understood. Sulfate aerosols have a cooling effect and soot/black carbon a warming effect, while in general aerosols impact the climate by perturbing cloud formation. Overall the non-CO_2 climate impacts—NOx, contrails, cloud formation, water vapor, black carbon, etc.—have a transient lifespan, from minutes to hours/days/months. Yet, they are so powerful that, combined, they heat the planet far more every day than all the aviation CO_2 that has so far accumulated in the atmosphere since the Wright Brothers first took off.

If we accept that the world must decarbonize, then aviation must decarbonize as well. Indeed the Paris Agreement requires all Parties to reduce all emissions. This means addressing both aviation's CO_2 and its short-lived but potent atmospheric climate effects as well. Regrettably, this statement remains an assertion only. Industry, the United Nation's aviation body the International Civil Aviation Organization (ICAO), and even the European Union remain either in denial that aviation's non-CO_2 effects need addressing, or are unwilling to expend the political capital necessary to start a process of mitigation.

There is certainly agreement all round that more research into these impacts is needed. A paper published in 2009 by D.S. Lee et al.[2] remains the principal estimate of non-CO_2 effects, which were shown graphically and are reproduced in Figure 1. Figure 2 is a more recent (2017) version[3] of Lee's table, showing the different components of aviation-induced radiative (climate) forcing. It incorporates some updates.

Research but Act

While considerable uncertainties over impacts remain, the message is not unclear and research both in North America and Europe is ongoing to better understand and reduce the uncertainties. The U.S. Federal Aviation Administration (FAA), for instance, is directly involved through its Aviation Climate Change Research Initiative (ACCRI).[4] Work is concluding at ICAO to agree to engine standards for soot/black carbon (non-volatile particulate matter), including a no-backsliding standard for existing engines and one for new engine types. But the issues for new engines are complex—there is a trade-off with NOx when redesigning engines to reduce particulate matter. Cost is also an issue.

One relatively straightforward way to reduce aviation particulate matter is to reduce the sulfur content in jet fuels.[5] Surprisingly, the average sulfur content in jet fuel in the United States has been estimated at 544 parts per million (ppm) by the FAA,[6] way above that of road diesel. A similar situation exists in Europe. Some transatlantic discussion about reducing the sulfur content of jet fuel took place about a decade or so ago and efforts should be restarted. At about a 1% fuel cost premium, the move is feasible particularly when set against the substantial action that has been taken on health grounds to reduce sulfur in road fuels and now in shipping.[7]

Avoiding Climate Sensitive Flight Regions

Research is ongoing into the feasibility and impacts of avoiding contrail formation by rerouting aircraft around climate sensitive areas and atmospheric conditions that give rise to this phenomenon. Accurate weather forecasting up to 12 hours before a flight would be needed to enable flight plans

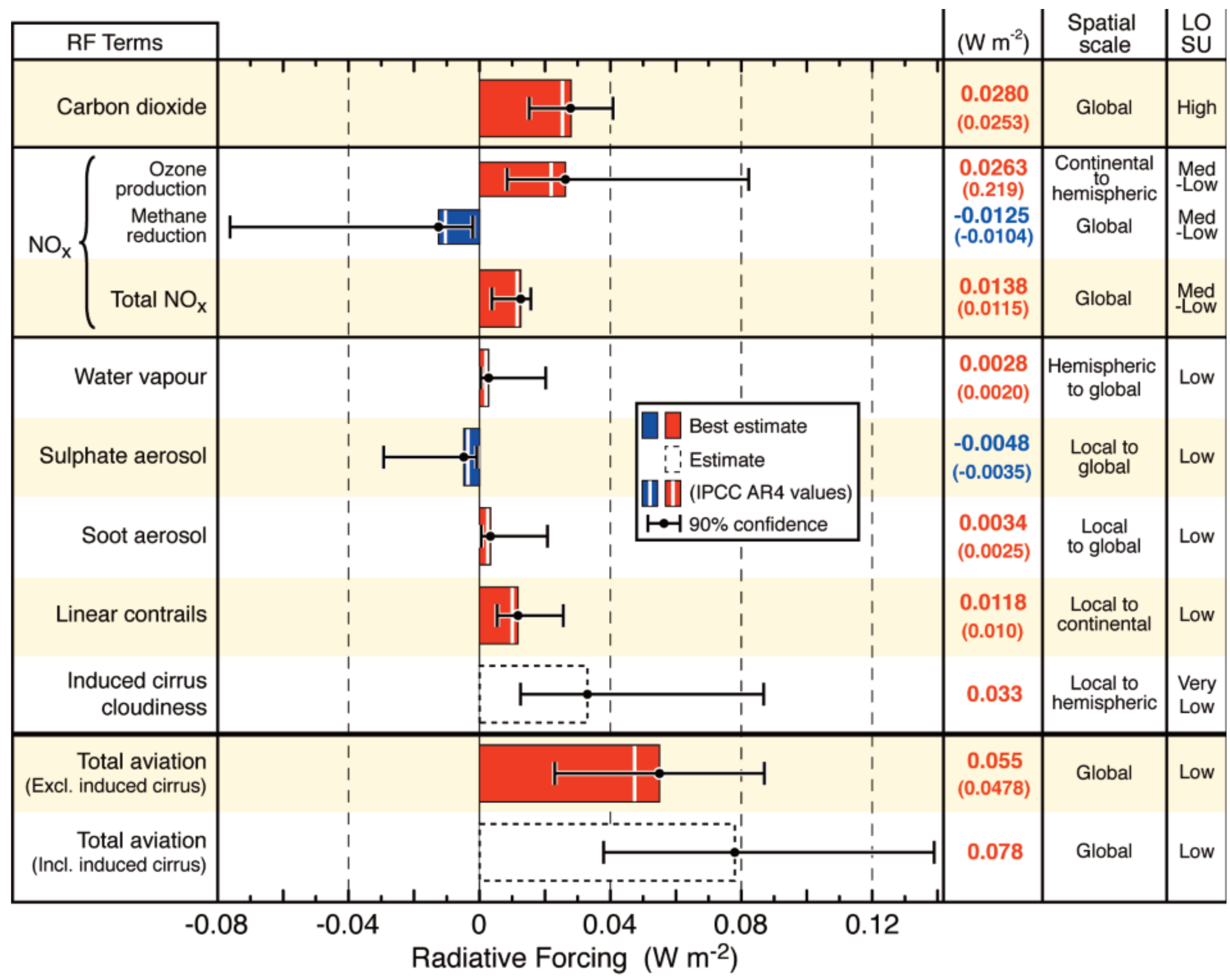

Figure 1. Components of aviation-induced radiative (climate) forcing (2005).[2]

and traffic systems to adjust. Air traffic control systems would need to be coordinated to cope with the changes and above all airlines would need to accept to implement the operational changes and the added costs brought about by additional fuel burn. According to leading expert, Prof. Volker Grewe, "with a little bit of a detour, flying a bit higher or lower or north or south of that region, you can change the climate impact of aviation via the non-CO_2 effects dramatically, for example by more than 10% with a cost increase of less than 1%."[8]

Even if such an approach is feasible and would reduce climate warming impacts, others argue that given the longevity of CO_2 in the atmosphere, no CO_2 penalty can be justified. That debate has however yet to be properly had among regulators at national level and internationally at ICAO. Not the least because effective international action to address aviation CO_2 is hardly underway either. The ICAO offsetting scheme, CORSIA, won't mitigate aviation kerosene usage and thus CO_2, as it relies on funding emissions reduction (offsetting) projects in other sectors in developing countries. And the

It's high time that research into aviation non-CO_2 impacts was accelerated and work started on developing policy options and procedures for addressing their impacts.

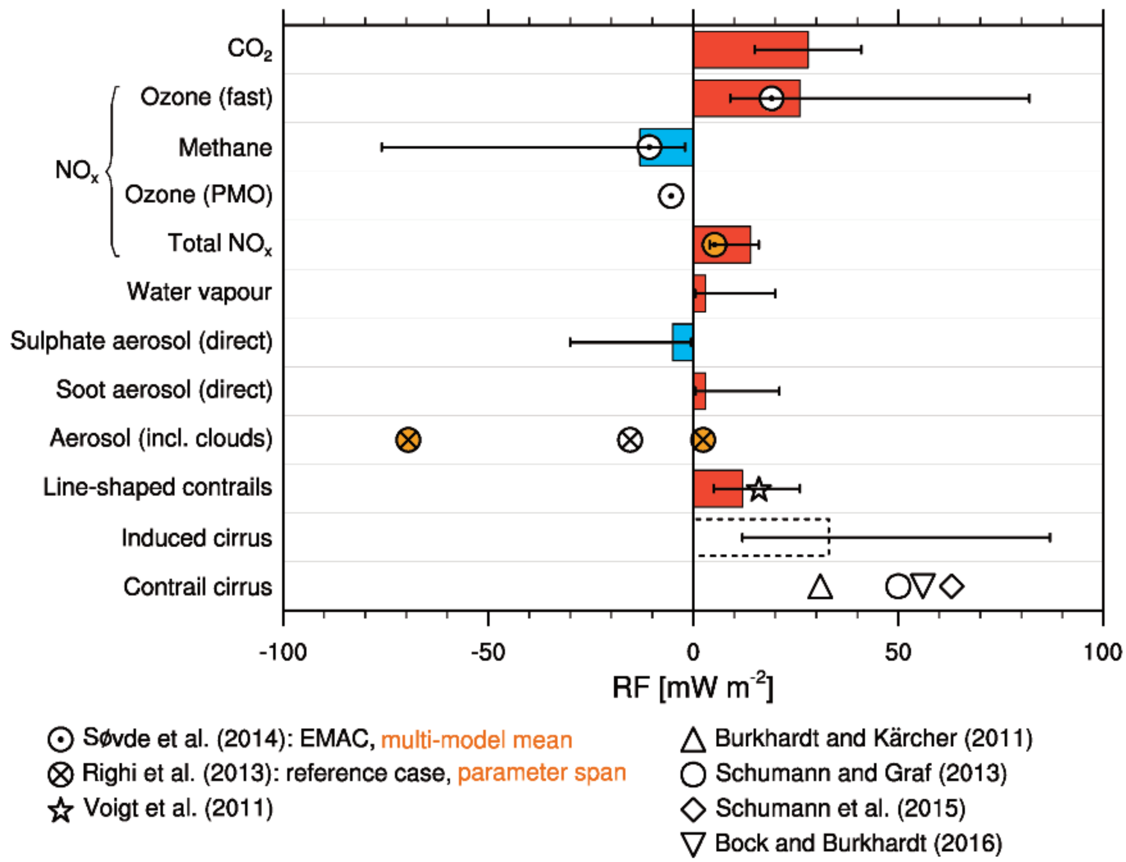

Figure 2. Components of aviation-induced radiative (climate) forcing (2017).[3]

rules governing the environmental quality of these offset projects together with safeguards against double counting of emissions or crediting the use of unsustainable biofuels remain unresolved. At best, the CORSIA could see potentially questionable offsetting projects address some 6% of international aviation emissions from 2015 through 2050.[9]

The EU Has Faltered on Non-CO_2

When the European Union decided in 2008 to include aviation in its Emissions Trading System (ETS), attempts were made to add a non-CO_2 multiplier, which would have required airlines to purchase additional emissions reduction allowances to account for non-CO_2 impacts. The proposal was dismissed as scientifically unsound and instead a study was undertaken for the European Commission, which recommended that a cruise NOx charge with a distance factor be introduced.[10] Unfortunately, that report is still sitting on Commission shelves. A second attempt came when revising the ETS for the period beyond 2021 through a call in late 2017 for the Commission to again assess non-CO_2 impacts, and if appropriate, come up with a mitigation proposal by January 2020. Regrettably, the European Commission admitted to the European Parliament last November that it hadn't yet acted on this latest request nor indeed the one made in 2008.

It's high time that research into aviation non-CO_2 impacts was accelerated and work started on developing policy options and procedures for addressing their impacts. The recent Intergovernmental Panel on Climate Change (IPCC) 1.5 °C report stressed that non-CO_2 emissions in pathways that limit global warming to 1.5 °C need to show deep reductions that are similar to those in pathways limiting warming to 2 °C.[11] It would help if the scientific debate over climate metrics for aviation CO_2 and non-CO_2 could be resolved. Meantime, there are no specific incentives or regulations requiring airlines to implement measures to minimize non-CO_2 impacts.

Aviation Emissions Threaten the Paris Agreement

The continued strong growth of aviation traffic and emissions shows no signs of easing up. Far more robust measures to reduce CO_2 impacts—accelerated uptake of technology and forcing standards, operational measures, the removal of the sector's tax subsidies, and regulatory and industrial initiatives to drive a move to using very low carbon drop-in electro-fuels[12] are urgently needed. Offsetting in other sectors above 2020 levels is clearly insufficient. Governments need to show the way on accelerating action on both CO_2 and non-CO_2 impacts if the aviation sector is not to present a real and present threat to achieving the goals of the Paris Agreement. **em**

William (Bill) Hemmings is director of aviation and shipping at Brussels-based Transport & Environment, the leading nongovernment organization working on sustainable transport issues across Europe. E-mail: **bill.hemmings@transportenvironment.org.**

References

1. ATAG Facts and Figures. Air Transport Action Group (ATAG), Geneva, Switzerland. See https://www.atag.org.
2. Lee, D.S.; Fahey, D.W.; Forster, P.M.; Newton, P.J.; Wit, R.C.N.; Lim, L.L.; Owen, B.; Sausen, R. Aviation and Global Climate Change in the 21st Century; *Atmos. Environ.* **2009**, 3520-3537.
3. Grewe, V., et al. Mitigating the Climate Impact from Aviation: Achievements and Results of the DLR WeCare Project; *Aerospace* **2017**, *4* (3), 34; https://doi.org/10.3390/aerospace4030034.
4. Brasseur, G.P., et al. Impact of Aviation on Climate; U.S. Federal Aviation Administration's (FAA) Aviation Climate Change Research Initiative (ACCRI), Phase 2, 2016.
5. Unger, N. Global climate impact of civil aviation for standard and desulfurized jet fuel; *Geophys. Res. Lett.* **2011**, *38;* doi:10.1029/2011GL049289.
6. *Aviation Emissions; Impacts and Mitigation. A Primer,* 2015; U.S. Federal Aviation Administration. See https://www.faa.gov/regulations_policies/policy_guidance/envir_policy/media/Primer_Jan2015.pdf.
7. Sofiev, M., et al. Cleaner fuels for ships provide public health benefits with climate tradeoffs; *Nature Communications* **2018**, *9* (406).
8. Prof Dr Volker Grewe speaking to Transport & Environment, February 2018. See https://www.transportenvironment.org/news/aviation-2-3-times-more-damaging-climate-industry-claims.
9. International Coalition for Sustainable Aviation. See https://icsaaviation.org/wpcontent/uploads/2018/06/ICSA-views-LTG-June-2018.pdf.
10. Faber, J., et al., Lower NOx at Higher Altitudes; CE Delft; https://www.cedelft.eu/publicatie/lower_nox_at_higher_altitudes/916.
11. Global Warming of 1.5 ºC – Intergovernmental Panel on Climate Change (IPCC); https://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf.
12. Transport and Environment detailed roadmap for decarbonizing European aviation, October 2018. See https://www.transportenvironment.org publications/roadmap-decarbonising-european-aviation.