Examining the role of stakeholders in the assessment of the climate effects of aviation - a stakeholder workshop report

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Both carbon dioxide (CO_2) emissions and non-CO_2 emissions from aviation (such as contrails and nitrogen oxides) can affect climate. A workshop held on the 9th of June at the UK's Royal Society bought together scientists, policy-makers, aviation industry, civil society and the aviation-related media to discuss the state of knowledge on the climate impacts of aviation and how this science could best inform climate-related policy and industry needs. Key recommendations emerged from the day. First and foremost, we found that a lack of appropriate communication between climate scientists and stakeholders remained an obstacle to progress. In particular, stakeholders found it difficult to assess the implications of newly published peer reviewed literature and wanted more assessment from the scientists themselves. They found "consensus" assessment reports such as Intergovernmental Panel for Climate Change Reports extremely useful but felt that such reports were not updated frequently enough for their needs. Stakeholders also wanted to see improvements to our basic understanding of the science, more applied science and to be more directly involved. The need to manage the expectations from the science was also apparent, as from a stakeholder perspective scientific progress can seem slow. To aid this progress stakeholders could, and should, do more to both directly and indirectly support the needs of climate science. These include providing global flight data to climate scientists and supporting commercial aircraft-instrumentation campaigns.

Introduction

Flying emits carbon dioxide and also has other effects on climate, principally via generating contrails and thereby altering clouds, and also through emissions of nitrogen oxides that effect two other important greenhouse gases (ozone and methane) (Lee et al., 2009). There is an ongoing debate as to whether such effects should be included in climate policies and, if so, how best to include them. This has previously led to discussion on the utility of metrics to account for the varying lifetime and effects of these emissions within a basket of greenhouse gases framework (Fuglestvedt et al., 2010, Wuebbles et al., 2010, Forster et al., 2006;2007). For this debate to be effective it needs to account properly for both science and policy considerations. The workshop aimed to foster communication between climate scientists and stakeholders to help frame this important debate. The workshop invited around 30 stakeholder and 10 climate scientists to discuss aviation-cloud-climate effects, their role in climate policy, aircraft design and operation. It focussed on the role of contrails, as these are probably the largest non-CO_2 climate driver from aviation (Lee et al., 2009), yet much of the discussions were also found to be applicable to the other non-CO_2 drivers.

Table 1 shows the representative stakeholders at the workshop. There were also about 10 climate scientists present that were working on aspects of the aviation-climate problem.

Table 1. Stakeholders

Theme	**Area**	**Example Stakeholders**
Industry	Airlines	British Airways, International Air Transport Association
	Aircraft manufacturing, engine and fuel suppliers	Airbus, Rolls Royce, Shell
	Aircraft operations	Airport Operators Association, NATS
	Trade Organisations	Advancing UK AeroSpace, Defence and Security Industries
Policy	Regulators	Civil Aviation Authority
Civil Society	Campaign groups	Transport & Environment, Green skies, Aviation Environment Federation
Media/Web		Greener by design, Green Horizon Aviation

The workshop was divided into morning presentations, an examination of pre-conceived ideas and an afternoon panel discussion session.

Presentations

Bernd Kärcher, an atmospheric scientist from the German Aerospace Centre (DLR) began with an introduction to aviation effects on climate and the mechanisms by which aviation can affect clouds. This highlighted that we have good understanding of the processes governing contrail formation and that soot particles from aviation fuel combustion are key contrail forming agents (e.g., Kärcher and Yu, 2009). Contrails would still form when reducing soot emissions but their optical properties would likely change. Furthermore, soot and other particulate emissions could affect other high clouds, but this science remains extremely uncertain.

Jim Haywood, a scientist from the Met Office/University of Exeter discussed satellite analysis of a spreading contrail case over the North Sea (see Haywood et al. 2009). This one case exhibited significant contrail spreading, contributing a large perturbation to the Earth's radiative balance over its lifetime of several hours. This work made the point that the key to determining the global impact of contrail spreading was to discover the frequency of such large-scale spreading events.

Ulrike Burkhardt, a scientist from DLR discussed their recent first climate model estimate of the climate forcing of spreading contrails (Burkhardt and Kärcher, 2011). Their study has a number of advantages over previous work. In particular, it was the first to account for all contrail-cirrus, not just the part that is observable as thin line-shaped contrails. They estimated the climate forcing both from spreading contrails and also calculated how creating contrails can lead to a small reduction in background cirrus. Their preliminary estimates of these global climate forcings are in Figure 1.

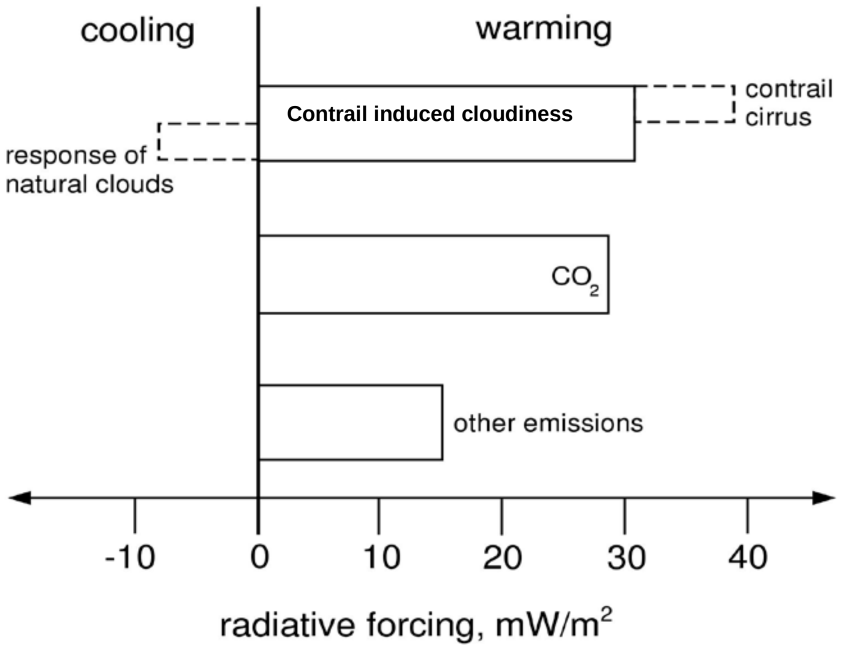

Figure 1. *Radiative forcing in the year 2002 from contrail-induced cloudiness, comprising the direct warming effect of contrail cirrus and the response of natural cirrus clouds introducing a cooling [Burkhardt and Kärcher, 2011]. The radiative forcing from accumulated aviation CO_2 emissions and the net radiative forcing from other aircraft exhaust species (comprising the effect of nitrogen oxide emissions on ozone and methane as well as direct radiative effects from emissions of water vapour and soot particles) are shown for comparison for conditions in the year 2005 [Lee et al., 2009]. The radiative forcing from contrail induced cloudiness likely exceeds the radiative forcing from past CO_2 emissions from aviation which makes contrail-cirrus the largest single climate forcing component of aviation. Figure courtesy of Ulrike Burkhardt.*

In the final talk, Paul Madden from Rolls-Royce presented on engine emissions from an engine manufacturers point of view. His presentation included advanced combustion technologies, new particulate matter measurements, and it discussed environmental trade-offs for example between particulate matter and nitrogen oxides. One slide also showed a reduction in particulate matter when an engine was run on an alternative fuel. He used his presentation material to frame questions that he was asked to develop to aid discussions on the current status of contrail/cirrus science (see Table 2).

Table 2. Example stakeholder questions to contrail scientists.

Theme	Example question
Significance of Climate Effect	• **Is the evidence for contrail-cirrus strong enough to drive avoidance measures?** • **What about water vapour in the stratosphere, is it better or worse than contrails**
Role of different emissions	• **What is the effect of particulates?** • **How important are engine sulphur emissions?** • **Can engine emissions produce cirrus clouds, even when contrails do not form?**
Future effects	• **As the amount of aviation grows in the tropics is the problem heightened?**

Aviation Futures and their Barriers

To asses preconceived ideas we asked stakeholders and scientists to imagine how they would you like to see civil aviation evolving within the context of a changing climate. Then we asked them to identify what decisions would need to be made and/or barriers overcome to bring about their chosen scenario. Firstly, no one imagined a business-as-usual future, i.e. rapid growth with little account of aviation-climate impacts in policy: all imagined a future where aviation was regulated for its impact on climate. Industry generally imagined futures where aircraft design changes to the aircraft body, engine or fuel, as well as changes to aircraft operations and routing, could make aviation more sustainable, allowing for continued expansion of passenger km. The civil society groups proposed similar futures and additionally suggested reducing demand for flying as a way to limit growth, although industry agreed it needed to internalise its impacts on the environment which could lead to higher costs and potentially reduced demand. Some scientists took a more system-wide approach, placing aviation in the context of total human emissions, imagining futures where aviation could increase its emissions provided other sectors of society compensated for this. Despite the presence of different stakeholder communities, the various futures and barriers identified were similar.

Barriers to achieving these futures were identified through stakeholder pair discussions, key findings are presented below

1) **Climate policy**. Key barriers here were the uncertainty in future regulatory regimes with a particular issue in the uncertainty of how to, and whether to, account for the non-CO_2 effects of aviation. On the regulatory side, stakeholders identified the slow pace of international climate-change regulation and how regulation for climate change impacts could conflict with regulations for air quality, noise and safety.
2) **Aircraft Design.** The slow pace of bringing new aircraft designs to market and the long service life of older less efficient aircraft were identified as key barriers. Linking to the policy barriers, although investment in low emission technologies were seen as desirable,

uncertainty in what designs should be optimised for and the possibility of making mistakes were an issue, especially if manufacturers try to optimise their designs to reduce an uncertain non-CO_2 climate effect at the expense of CO_2 emissions. As well as the non-CO_2 effects of aviation, science uncertainties also existed in the lifecycle emissions and food security issues surrounding biofuels. The feasibility and climate impact of hydrogen fuel was also presented as an issue.

3) **Aircraft operations.** Improved flexibility in air traffic management and airport operations were seen as important to reduce the climate impact per passenger km. Policy related issues principally concerned possible mismatched climate and safety pressures, such as reducing distances between aircraft so more can fly in optimum conditions where their climate impact are minimised. International agreements allowing better coordinated air traffic control was also identified as important, such as agreements on the single European sky, whereby national borders are removed from air traffic control decisions (http://www.eurocontrol.int/dossiers/single-european-sky).
4) **Climate Science.** Barriers from uncertainty in the climate science were concentrated on uncertainties in the non-CO_2 climate effects of aviation. Uncertainties in wider climate science and general climate-change scepticism was only seen as an obstacle in as much as it could slow the pace of international agreements on climate change. The rate and ability of the science to reduce key uncertainties was also indentified as a barrier.
5) **Media and public relations**. Sound-bites from media and press release channels were often seen to over-simplify and polarize the wider debate on aviation and climate. Also indentified as a barrier was a lack of a clear channel for speedy dissemination and assessment of the latest science. This made it difficult for non experts to interpret the significance of new findings.

Panel discussion findings

The first panel discussion led by Jonathon Counsell (British Airways), Ben Combes (Civil Aviation Authority) and Tim Johnson (Aviation Environment Federation) discussed how climate science currently informs decision making and how the science should be informing such decisions. A discussion on how decisions are made in practise showed that climate-science is only one of several factors that enter the debate and often the impact of complexities in the science is either not understood or ignored. Also debated was the degree of certainty needed in the science before policy should be introduced. For example, would it be better to avoid introducing policy that reduces contrail coverage until we have a better understanding of the contrail-climate impact? Or would it be better to introduce a sub-optimal policy today that could be refined or changed as the science evolves?

These discussions identified some key needs of decision makers from climate science and how this science is most appropriately communicated. Reducing uncertainties in estimates of the cloud and NOx impact of aviation were seen as a foremost priority. Help was particularly needed to identify climate mitigation measures that could effectively reduce both CO_2 emissions and the non-CO_2 effects. As biofuels are beginning to be introduced research on both lifecycle emissions and contrail/ozone formation potential was urgently needed. When communicating the science, expectations needed to be managed as to what answers climate science could give, and when it could give them. Often research papers themselves were not understandable to policy makers and/or did not directly address their decision-making needs. IPCC report type assessments were seen as very useful by policy makers, but their relatively infrequent publication made understanding and incorporation of the latest science into policy difficult and slow.

The second panel discussion led by Keith Shine (University of Reading) and David Lee (Manchester Metropolitan University) examined how the aviation industry could support the progress of climate science. Uncertainties in the aviation impact of climate arise from many factors but it was felt that science could progress with support from the aviation industry. Better information on flight routes and engine emissions at cruise would help constrain radiative forcings. Also, improved measurements of the background atmosphere would help climate science generally.

Discussion and recommendations

The workshop was oversubscribed and well received, indicating a clear need from the stakeholder community to hear and quiz climate scientists directly about their results. The workshop made it apparent that the communication between the two communities should be improved. A clear need was identified for more applied research addressing specific aircraft design, aircraft operations and climate policy issues (see Table 2 for examples). Following on from this ways need to be found to more directly and effectively communicate results back to industry and the policy makers. Distilling messages to an appropriate level whilst retaining enough complexity where appropriate is a difficult but necessary task if scientists what to see their findings being applied. There is a growing dedicated aviation and environment media such as “Greener By Design” that could be used to help this dialogue. Training of policy makers in the science background was also seen as a gap that Universities could easily fill by providing short relevant courses or seminars targeted at the stakeholder community.

Specific policy targets for climate change are needed to design appropriate metrics to assess the CO_2 effects of aviation together with its other effects on climate. Policy makers, industry and the wider civil society should come together internationally to discuss such targets. The International Civil Aviation Organization (ICAO) is the obvious vehicle to support this debate but is often seen as overly bureaucratic and slow.

The aviation industry could also do more itself to support science directly and indirectly (via lobbying etc.). Enhancing support for In-Service Aircraft for a Global Observing System (IAGOS) type programs would directly benefit many areas of atmospheric science and climate change science. Such programs instrument commercial aircraft to record the state of the atmosphere in a region of data scarcity, supplying this data to scientists. This extra data would help scientists assess the climate impact of aviation within the wider context of climate change. Stakeholders agreed to raise the issue of how industry can help collect data to support the scientific community in researching non-CO_2 effects at the upcoming IATA Environment Committee meeting in October, 2011. There could also be a greater international effort to collect and distribute real flight paths to climate modellers. The current datasets used are often for too short a time period and/or make crude assumptions about flight paths. To help narrow existing uncertainties more could also be done to collaborate with scientists to help characterise emissions from different engine types, especially when at cruise altitudes.

Lastly, we note that such a discussion would also be very applicable to other industries and in many ways the climate impact of aviation is better understood and better constrained than other sectors that contribute much more to climate change, such as agriculture. Yet, as the aviation industry itself is global, it is also perhaps best placed to take the lead in helping to assess its own climate impact, continuing and strengthening its strong relationship with climate scientists.

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