ENVIRONMENTAL RESEARCH
LETTERS

PURPOSE-LED PUBLISHING™

Celebrating the 20th anniversary of Environmental Research Letters

LETTER • OPEN ACCESS

Quantifying expert consensus against the existence of a secret, large-scale atmospheric spraying program

To cite this article: Christine Shearer *et al* 2016 *Environ. Res. Lett.* **11** 084011

View the article online for updates and enhancements.

You may also like

- Contrail or chemtrail? Challenges and opportunities for educators
Vojtch Tupec, Leontýna Šlégrová and Jan Šlégr

- The importance of assessing and communicating scientific consensus
Edward W Maibach and Sander L van der Linden

- On the detectability by uninvolved parties of covert stratospheric aerosol injection programs producing transboundary impacts
Wake Smith, Matias Alberola, Jasper G Boers et al.

This content was downloaded from IP address 176.84.245.226 on 19/10/2026 at 08:38

Environmental Research Letters

CrossMark

OPEN ACCESS

RECEIVED
7 October 2016

ACCEPTED FOR PUBLICATION
21 October 2016

PUBLISHED
22 November 2016

Original content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence.

Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

CORRIGENDUM

Corrigendum: Quantifying expert consensus against the existence of a secret, large-scale atmospheric spraying program (2016 *Environ. Res. Lett.* **11** 084011)

Christine Shearer[1,2], **Mick West**[3], **Ken Caldeira**[4] **and Steven J Davis**[1,2]

[1] Department of Earth System Science, University of California, Irvine, Croul Hall, Irvine, CA 92697, USA
[2] Near Zero, Carnegie Institution for Science, Stanford, CA 943053, USA
[3] Metabunk.org, Shingle Springs, CA 95682, USA
[4] Department of Global Ecology, Carnegie Institution for Science, Stanford, CA 94305, USA

Corrigendum

Unfortunately there was an error in figure 2. The number (n) for the pie charts (a)–(d) should have read 49—the number of respondents to the question of whether a secret, large-scale atmospheric spraying program was the most parsimonious explanation for the photos. Additionally, in figure 2(a), two of the blocks in

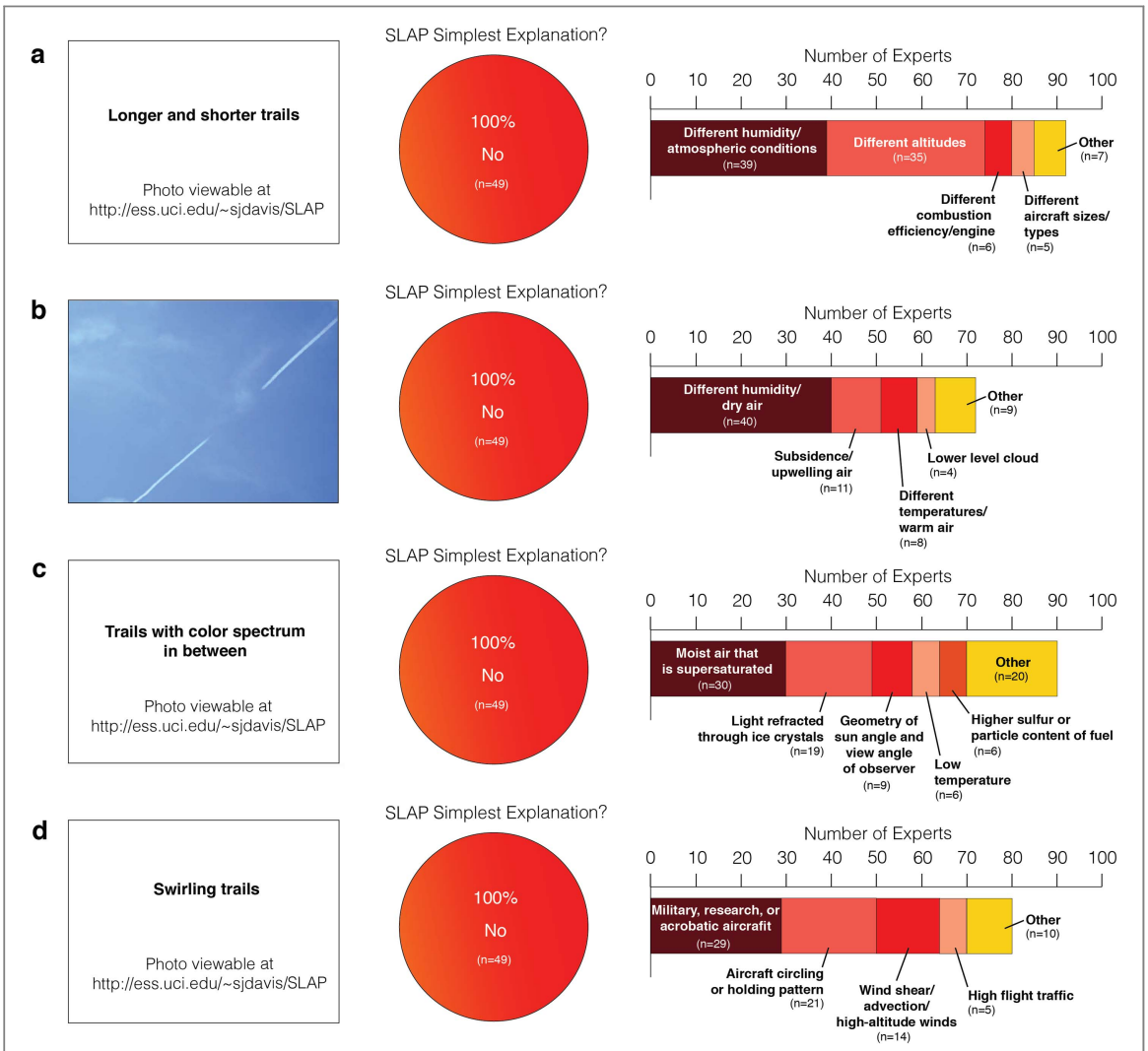

Figure 2.

© 2016 IOP Publishing Ltd

the bar chart had the same label 'Different combustion efficiency/engine'; the block for $n = 5$ should have instead read 'Different aircraft sizes/types'. Figure 2 with the correct number and label is above. All other data remains the same. Original photos can be viewed at www.ess.uci.edu/~sjdavis/SLAP/.

Introduction

The first line should have read: 'In a recent international survey of 3105 people,' not 3015 people.

Atmospheric deposition

The discussion of the third sample in the section on atmospheric deposition should have read: 'Twenty-three experts (82%) rejected the results as evidence of SLAP, while four (14%) did not know or were unsure.'

The Nguyen *et al* 1998 reference and citation should have read:

Minnis P, YoungDF, GarberDP, Nguyen L, SmithWL Jr and Palikonda R 1998 Transformation of contrails into cirrus during SUCCESS *Geophys. Res. Lett.* **25** 1157–60

Environmental Research Letters

CrossMark

OPEN ACCESS

RECEIVED
19 April 2016

REVISED
21 June 2016

ACCEPTED FOR PUBLICATION
18 July 2016

PUBLISHED
10 August 2016

Original content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence.

Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

LETTER

Quantifying expert consensus against the existence of a secret, large-scale atmospheric spraying program

Christine Shearer[1,2], **Mick West**[3], **Ken Caldeira**[4] **and Steven J Davis**[1,2]

[1] Department of Earth System Science, University of California, Irvine, Croul Hall, Irvine, CA 92697, USA
[2] Near Zero, Carnegie Institution for Science, Stanford, CA 943053, USA
[3] Metabunk.org, Shingle Springs, CA 95682, USA
[4] Department of Global Ecology, Carnegie Institution for Science, Stanford, CA 94305, USA

E-mail: sjdavis@uci.edu

Keywords: contrails, chemtrails, atmospheric deposition, secret large-scale atmospheric spraying program, geoengineering

Abstract

Nearly 17% of people in an international survey said they believed the existence of a secret large-scale atmospheric program (SLAP) to be true or partly true. SLAP is commonly referred to as 'chemtrails' or 'covert geoengineering', and has led to a number of websites purported to show evidence of widespread chemical spraying linked to negative impacts on human health and the environment. To address these claims, we surveyed two groups of experts—atmospheric chemists with expertize in condensation trails and geochemists working on atmospheric deposition of dust and pollution—to scientifically evaluate for the first time the claims of SLAP theorists. Results show that 76 of the 77 scientists (98.7%) that took part in this study said they had not encountered evidence of a SLAP, and that the data cited as evidence could be explained through other factors, including well-understood physics and chemistry associated with aircraft contrails and atmospheric aerosols. Our goal is not to sway those already convinced that there is a secret, large-scale spraying program—who often reject counter-evidence as further proof of their theories—but rather to establish a source of objective science that can inform public discourse.

Introduction

In a recent international survey of 3015 people, 2.6% of the respondents said it was 'completely true' that there is a secret government program that uses airplanes to put harmful chemicals into the air, and 14% said this is 'partly true' (Mercer *et al* 2011). The existence of such a program, popularly referred to as 'chemtrails', has gained a passionate following of people who link sprayed chemicals to negative impacts on human health and the environment. As described below, much of the support for 'chemtrails'-related theories has appeared on the internet, and not in peer-reviewed contexts. Social scientists have noted parallels between belief in claims of a secret, large-scale atmospheric spraying program (SLAP) and growing public distrust of elites and social institutions (Cairns 2014, Cairns and Stirling 2014, Bakalaki 2016).

Individuals who assert the existence of such a SLAP assume different purposes of the program. Initially, the most commonly inferred goals were control over population, food supply, and/or the weather. However, with the emergence of research on climate geoengineering in the early 2000s (Crutzen 2006), SLAP has also been increasingly explained as geoengineering of the Earth's climate system (Cairns 2014). SLAP activists can be aggressive, and academics assessing climate geoengineering using computer models have been subjected to threats for their alleged role in a secret spraying program (Keith 2013).

The existence of actual research programs that involve spraying or dispersing material in the atmosphere is seen, by some, as evidence in favor of SLAP theory. For example, cloud seeding entails spraying small particles of substances, such as dry ice or silver iodide, onto clouds in order to increase precipitation. The technique has been used by some states and countries, with modest results: the California Department of Water Resources has estimated a four percent annual precipitation increase attributable to the combined state seeding projects (Hunter 2007).

© 2016 IOP Publishing Ltd

Despite the prevalence of the SLAP theory, there here have been few attempts to seriously and scientifically evaluate the claims of its proponents. In 2000, the US Environmental Protection Agency, Federal Aviation Administration, National Aeronautics and Space Administration, and the National Oceanic and Atmospheric Administration posted a fact sheet to assure the public that the government is not operating a large-scale atmospheric spraying program (EPA, FAA, NASA and NOAA 2000). There have been no peer-reviewed studies in the scientific literature addressing SLAP claims. Meanwhile, a growing number of studies have shown that quantifying and communicating the scientific consensus on contested issues such as vaccine safety and climate change can help lower public misperceptions and uncertainty (Myers *et al* 2015, van der Linden *et al* 2015, van der Linden *et al* 2015).

Here, therefore, we report the results of an expert survey in which we asked experts on atmospheric chemistry and atmospheric deposition to scientifically evaluate the claims of SLAP theorists. We find broad scientific consensus against the existence of a secret, large-scale atmospheric spraying program. Our goal is not to sway those already convinced that there is a secret, large-scale spraying program—who often reject counter-evidence as further proof of their theories—but rather to establish a source of objective, peer-reviewed science that can inform public discourse in the future by seriously addressing the underlying concerns of science, governance, and public trust (Cairns 2014).

Methods

There are multiple websites dedicated to exposing the existence of SLAP, including 'Geoengineering Watch' (geoengineeringwatch.org) and 'Global Sky Watch' (globalskywatch.com). These websites collect and display data in support of the SLAP theory. This data most commonly falls into two categories: (1) photographs of trails left behind by airplanes and (2) elemental analyses of water, soil, and snow samples. The websites claim condensation trails, or contrails, should evaporate right away, and therefore persistent trails are evidence of chemical spraying. They also post test results suggesting above normal levels of elements —particularly strontium, barium, and aluminum— which they argue also indicates chemical spraying.

In order to evaluate these data, we developed two surveys (the complete survey protocols are available at: http://nearzero.org/elicitation/review/a2592e56-cb21-4849-baa2-560d456707c8 and http://nearzero.org/elicitation/review/d172e2d8-89fa-4bcc-a90f-c28a58bc7cf0) and administered each survey to a different group of experts: (1) atmospheric scientists with expertize in condensation trails and (2) geochemists working on atmospheric deposition of dust and pollution on the Earth's surface.

Expert participants were selected by using the ISI Web of Science to identify the authors of the most-cited peer-reviewed publications covering these topics that have been published in the past 20 years (1994–2014). In the first case, we searched for papers with the topic 'contrail'. For experts on atmospheric deposition, we used the search terms 'atmospheric deposition' AND ('aluminum' OR 'barium' OR 'strontium'), which narrowed the results to experts working on the elements most frequently pointed to as evidence of spraying by the analyses of SLAP proponents, and excluded other types of deposition events such as acid rain and nitrogen run-off. For the purposes of this study, we define 'contrail expert' and 'atmospheric deposition expert' to be a person who has co-authored one or more of the 100 most-cited papers in each search.

Using these criteria, we identified 220 contrail experts and 255 atmospheric deposition experts. A survey invitation was sent out: 49 contrail experts and 65 atmospheric deposition experts could not be reached with our contact information or explicitly disqualified themselves as experts on the survey topic. This left a total sample population of 171 for contrails and 190 for atmospheric deposition. Of these, 49 experts completed the contrail survey and 28 completed the atmospheric deposition survey—a response rate of 29% and 15%, respectively. The lower response rate for deposition may have in part been due to the wider breadth of knowledge covered in the survey leading more people to disqualify themselves as experts. All invited experts were informed that the survey would be confidential: participant names are listed, but responses are not attributed to specific experts. Contrail experts had an average of 26 years professional experience in their field (with a median of 26 years), and deposition experts 22 years (with a median of 20 years).

The surveys asked the two groups of experts to assess data that have been presented on websites as evidence of SLAP. In both surveys, the first question asked was: 'Have you, in your work or personal life, ever come across evidence that you think indicates the existence of a secret large-scale atmospheric spraying program?' Participants could choose either yes or no, or write in their own response.

Trails behind aircraft

SLAP proponents argue that condensation trails, or contrails, should evaporate quickly after the passing of an aircraft, and that more persistent trails are evidence of chemical spraying. Our contrail survey consisted of four pictures taken from SLAP websites that have been cited as evidence of a SLAP. In each case, the experts were first asked whether they thought the most parsimonious (i.e. simplest) explanation involved a SLAP. They were then asked to explain the photo and offer a reference to the scientific literature that best

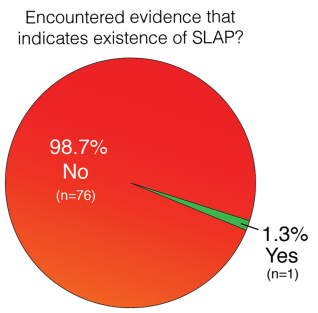

Figure 1. Of 77 experts surveyed, 98.7% (76) said they had not encountered evidence that indicates the existence of a secret, large-scale atmospheric spraying program (SLAP), and 1.3% (1) said they had.

described the mechanism(s) that account for the phenomena shown in the photo. They were also asked whether trails behind aircraft persist for longer time periods today than when air travel first began, and the factors underlying any change.

Atmospheric deposition

SLAP proponents argue that seemingly abnormal concentrations of elements such as strontium, barium, and aluminum in water, soil, and snow samples are the result of sprayed chemicals. Our survey asked experts to evaluate photocopies of three different laboratory analyses of elemental concentrations in samples of pond sediment, filter media, and snow that were posted on the SLAP website, Geoengineering Watch. Additionally, experts were asked to evaluate the appropriateness of the sampling methods recommended by SLAP websites, and whether they have observed any secular changes in the environmental concentrations of strontium, barium, and aluminum over their careers, and the factors underlying any change.

Results

In response to the general question of whether they have ever encountered evidence that indicates the existence of SLAP, 76 of the total 77 expert respondents (98.7%) answered no (figure 1). Further, when asked about their degree of confidence that they would have come across such evidence, the average confidence levels were 86% and 55% for contrail and atmospheric deposition experts, respectively. The one participant who answered yes said the evidence s/he had come across was 'high levels of atm[ospheric] barium in a remote area with standard 'low' soil barium'.

Trails behind aircraft

Figure 2 shows the four photos assessed by contrail experts. In each case, 100% of the experts indicated that the simplest explanation of the trails in the photo was *not* a secret, large-scale atmospheric spraying program. To the contrary, the experts often agreed about the physical mechanisms on display in each photo, and indicated that none were out of the ordinary or explained by events outside of normal contrail formation. There were also many common citations, suggesting the mechanisms behind the contrails shown are well documented in the peer-reviewed literature.

The first photo showed three trails in the sky, one thick and long and the other two thinner and shorter (figure 2(a)). SLAP proponents have argued that condensation trails should evaporate quickly, and therefore persistent trails of varying lengths indicate differences in how much and/or how long aircraft have been spraying chemicals. In contrast, 39 (80%) of the contrail experts stated that the larger trail in the photo was likely in an area of higher humidity, while 35 experts (71%) indicated that the thicker and longer size of the larger trail was related to greater altitude. Some experts also suggested that different types of aircraft may have made the trails and that their fuel efficiencies may have differed (10% and 12%, respectively), either of which could also affect the size and density of the condensation trail. The most common citation was Schumann's 'On conditions for contrail formation from aircraft exhausts' (Schumann 1996), cited by nine (18%) of the experts.

The second photo showed a trail broken by a gap (figure 2(b)). SLAP proponents have argued that such a gap reflects that chemical spraying was turned on, then off, then on again. Forty (82%) and eight (16%) of the contrail experts explained the gap as an area of particularly dry or warm air, respectively, which made it more difficult for the condensation trail to persist. Eleven experts (22%) also suggested the gap could be due to subsidence or an upwelling of air. Citations for this phenomenon were diverse, with the most common reference being again Schumann's 'On conditions' (Schumann 1996) and Schumann's 'Formation, properties, and climate effects of contrails' (Schumann 2005), both cited by 6% of experts.

The third photo showed a plane with thick, dense trails behind each wingtip and spanned by a color spectrum (figure 2(c)). SLAP proponents have argued such phenomena—thick, persistent contrails and rainbow colors—are both evidence of heavy chemical spraying. Thirty contrail experts (61%) instead explained the dense trails by the presence of moist air that was supersaturated, with the colors due to light refracting through ice crystals (19 experts, or 39%) or diffusion or scattering by small water droplets or ice crystals (11 experts, or 22%). The most common reference was Gierens *et al*'s 'Aerodynamic contrails: phenomenology and flow physics' (Gierens *et al* 2009), cited by 11 (22%) of the experts.

The fourth photo showed a swirling sky of trails, spanning different densities and lengths (figure 2(d)). SLAP proponents have argued such a thick patchwork of trails suggest widespread spraying. Contrails experts

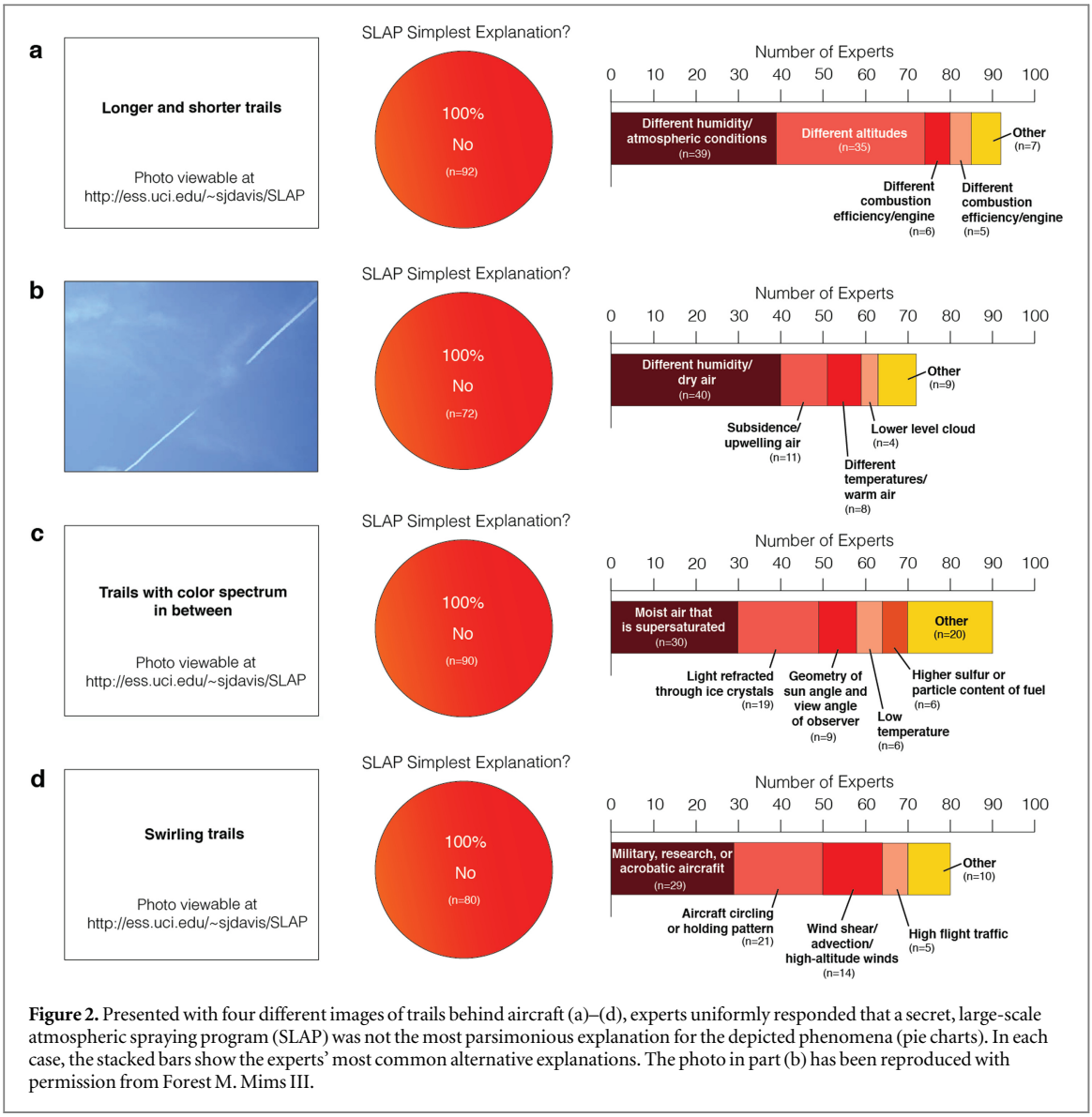

Figure 2. Presented with four different images of trails behind aircraft (a)–(d), experts uniformly responded that a secret, large-scale atmospheric spraying program (SLAP) was not the most parsimonious explanation for the depicted phenomena (pie charts). In each case, the stacked bars show the experts' most common alternative explanations. The photo in part (b) has been reproduced with permission from Forest M. Mims III.

suggested the depicted were likely related to military, research, or acrobatic aircraft (29 experts, 59%), or aircraft circling in a holding pattern, perhaps near an airport (21 experts, 43%). The different trail sizes were also attributed to wind shear, advection, or high altitude winds (14 experts, 29%). The most common reference was 'Transformation of contrails into cirrus during SUCCESS' (Nguyen *et al* 1998), cited by four (8%) of respondents.

In response to the question of whether trails behind aircraft are persisting for longer periods of time now than they did when plane travel first began, 23 experts (47%) answered no, 18 experts (37%) answered yes, and 8 experts (16%) offered no response. Among those indicating they thought trails are now lasting longer, the top reasons given were: Aircraft flying higher (17 experts, 35%), modern and larger engines that produce more water vapor (11 experts, 22%), more plane traffic leading to planes flying at higher altitudes where contrails are more likely to form (nine experts, 18%), higher water vapor content of the atmosphere due to climate change (six experts, 12%), and decreased temperature of aircraft exhaust related to improved fuel efficiency (five experts, 10%).

Atmospheric deposition

Figure 3 shows the responses to photocopies of three different laboratory analyses that SLAP proponents argue show high and abnormal concentrations indicative of chemical spraying. For each analysis, experts were first asked if the simplest explanation of the trails in the photo was a secret, large-scale atmospheric spraying program. They were then asked to write in how they interpreted the results.

The first lab result on the survey showed the concentrations of aluminum, barium, and strontium measured in a sample of pond sediment/sludge: 375 parts per million (ppm) for aluminum, 3.1 ppm for barium, and 345 parts per billion (ppb) for strontium (figure 3(a)). Twenty-four atmospheric deposition experts (86%) responded that the simplest explanation of these results did not involve a SLAP, and four

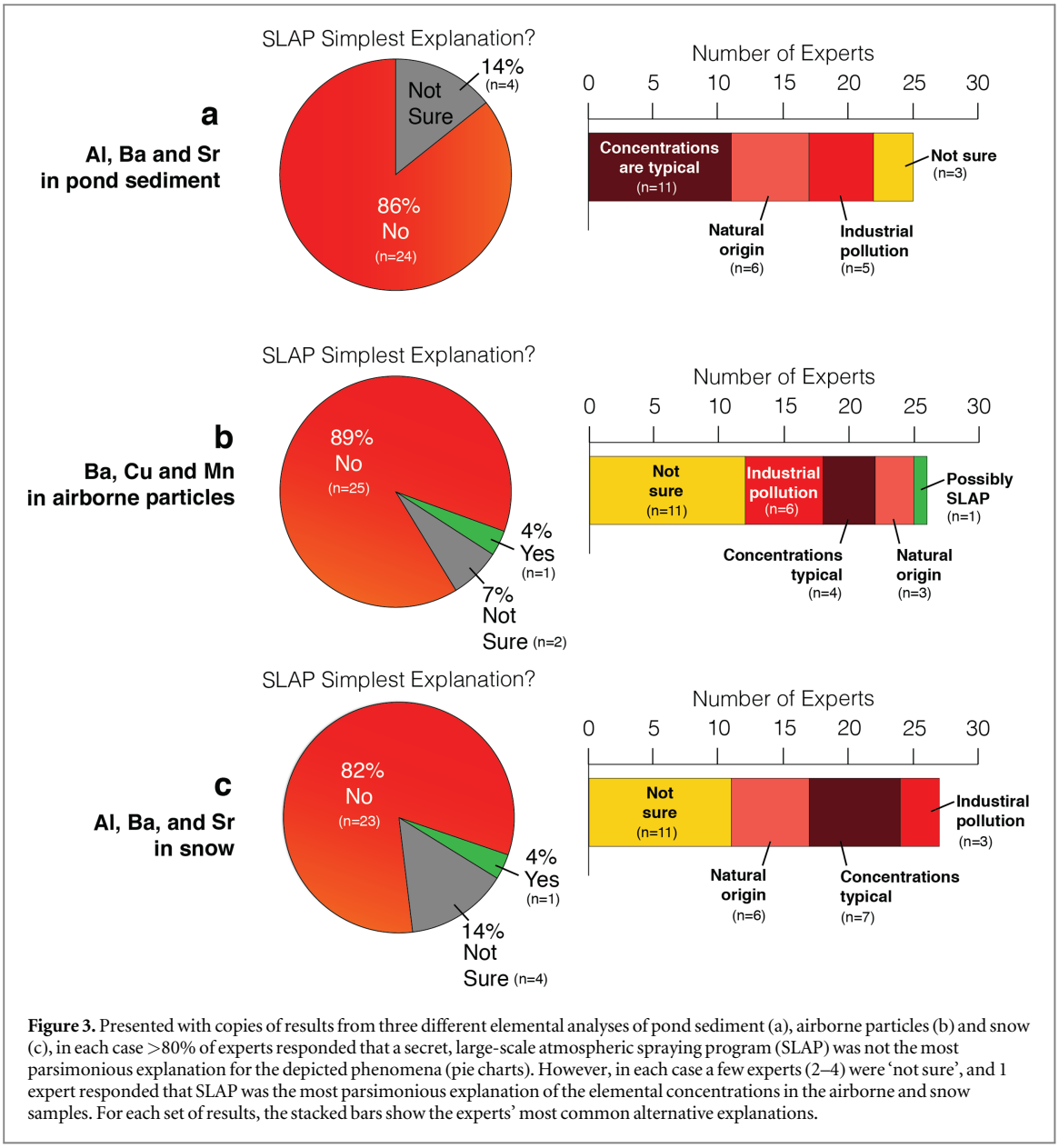

Figure 3. Presented with copies of results from three different elemental analyses of pond sediment (a), airborne particles (b) and snow (c), in each case >80% of experts responded that a secret, large-scale atmospheric spraying program (SLAP) was not the most parsimonious explanation for the depicted phenomena (pie charts). However, in each case a few experts (2–4) were 'not sure', and 1 expert responded that SLAP was the most parsimonious explanation of the elemental concentrations in the airborne and snow samples. For each set of results, the stacked bars show the experts' most common alternative explanations.

experts (14%) said they did not know how to interpret the results. Eleven experts (39%) indicated that the lab results showed typical concentrations of aluminum in sediment/sludge, and six (21%) said they were likely of natural origin (e.g. minerals in sludge). As summarized by one expert, 'All three of these elements are major constituents of crustal material. The concentrations reported for the three elements are much less than what is present in average upper continental crust'. Another stated: 'It looks like about five grams of average soil or desert dust in a liter of sludge, quite reasonable'.

The second sample showed the concentrations of elements in a sample of airborne particulates taken in May 2008 in Phoenix, Arizona (figure 3(b)). Barium is reported at 556 000 ppb, copper at 197 000 ppb, and manganese at 562 000 ppb. The results appear to show concentrations of all three elements far beyond their maximum contaminant levels (MCLs), which are listed on the results as 2000 ppb for barium and copper, and 100 ppb for manganese. One expert (4%) said the results may be evidence of a SLAP—the same expert who said s/he had previously come across high levels of atmospheric barium. Twenty-five experts (89%) rejected the results as evidence of SLAP, while two (7%) did not know or were unsure. When asked to write in their interpretation, 12 experts (49%) said they wanted more data first, such as atmospheric conditions and proximity to industry. Four experts (14%) said the concentrations were average or typical. As stated by one expert: 'The concentrations per unit mass look like average soil or desert dust. The MCL values are not relevant, and look to be based on drinking water standards'. The MCL values used were indeed based on drinking water, and not airborne particulates.

The third sample showed the concentration for the elemental make-up of metals from a snow surface sample taken in July 2008 on Mount Shasta, California

(figure 3(c)). Aluminum is measured at 611 ppm, barium at 83 ppb, and strontium at 383 ppb. Twenty-three experts (82%) rejected the results as evidence of SLAP, while fourteen (14%) did not know or were unsure. When asked to interpret the results, many experts (eleven, or 39%) again said they were not sure and wanted more data, while seven experts (25%) said the concentrations were average or typical. A different expert (4%) said the result may be evidence of a SLAP, writing 'Unless, there is some kind of Al[uminum] pollution source in the direct neighborhood, the results for are ridiculously high and indeed suspicious'. Another expert who rejected the sample as evidence of a SLAP said the results did show 'very high Al concentrations for a snow sample' which 'makes me think it cannot just be snow'. Indeed, the sample was not just snow, but snow surface. One expert explained: 'As before, these data are actually low relative to crustal composition' while another described the sample as showing 'normal dust fall'.

We also asked experts to evaluate the advice of one SLAP website on how non-specialists can collect samples of surface water to obtain evidence relevant to 'aerosol geoengineering':

> *If you are testing a pond, then the only thing different is how you collect the sample. The very bottom of the pond is where the elements stack up. Turn your jar upside down and get the mouth to the bottom of the pond or still water….the older the pond the higher the readings. Turn the jar over and collect both the water and a LITTLE of the bottom sediment.*

Twenty of the deposition experts (71%) either disagreed or strongly disagreed with the instructions, with 17 (61%) explaining that collecting the 'bottom sediment' would contaminate the water sample (figure 4(a)). The remaining eight respondents (29%) were neutral; no expert said they agreed with the instructions. As stated by one expert: 'The non-specialist is instructed to add sediments to the water which will not give an accurate measurement of metal concentrations in surface water itself—soils/sediments/sludge are more concentrated in these elements than water and will contaminate the water sample'. Another stated: 'The sampling will entrain both sediments and water; sediments are naturally high in trace metals and will not reveal anything about concentrations in the overlying water'.

The same website also has step-by-step instructions for how to collect samples of rain and snow, recommending the use of mason jars to collect the samples, and then to shake or stir the samples:

(1) If you can get brand new, never used mason jars, but clean used jars and lids will work.

(2) Place as many of these into the rain or snow as possible (you can pour all their contents into one jar).

(3) When transferring from one container to another, IT IS CRITICAL TO RE-SUSPEND the sample... shake the jar with the lid on, or stir with a sterilized instrument. Alternatively, you can 'back and forth' the samples, allowing a little 'fall' to create enough turbulence to re-suspend any contaminants that may be stuck to the glass.

(4) Seal with the lid and ring and place into the refrigerator. Take to the lab as soon as possible, preferably the next morning.

(5) Take the sample to your local lab, use a lab that tests 'well water'…they are certified and this is easy for them. Call them first, make sure you have the right lab. You ARE NOT looking for something like a 'well analysis'…which is pretty expensive…you just want to test a rain sample, in a sterile mason jar for specific metals.

Six experts (23%) were neutral and three experts (11%) agreed with the instructions; none strongly agreed (figure 4(b)). Nineteen experts (68%) disagreed or strongly disagreed with those instructions, with over half (15 experts, 54%) saying a jar glass and metal lid would likely contain trace elements that would contaminate the sample. One expert who strongly disagreed with the instructions wrote: 'the jar will contaminate the sample, as will the metal lid, particularly if you shake it! I cannot imagine a worse protocol for collecting a sample, the data would be totally worthless'. Another said: 'To analyze metals in environmental samples, glass needs to go through an acid wash to remove any residual metals. Otherwise, plastic should be used'.

Finally, we asked the deposition experts if they have noticed a general increase in environmental concentrations of aluminum, barium, and/or strontium over their careers. Only six (21%) thought concentrations of aluminum had increased, and three each (11%) barium and strontium. Of the experts who thought that concentrations might have increased, the increase was primarily attributed to changes in industrial, agricultural, or natural processes.

Both contrail and deposition experts were allowed to rate their level of expertize and confidence for each survey question, an option used by less than a third of participants in either survey. For the contrail survey, experts reported the lowest level of confidence for the question regarding duration of contrails, and the highest level of confidence and expertize for their assessment of the photos. Deposition experts were more likely to report lower levels of confidence regarding their analysis of the test samples, and higher levels of confidence and expertize in their assessment of the sampling instructions.

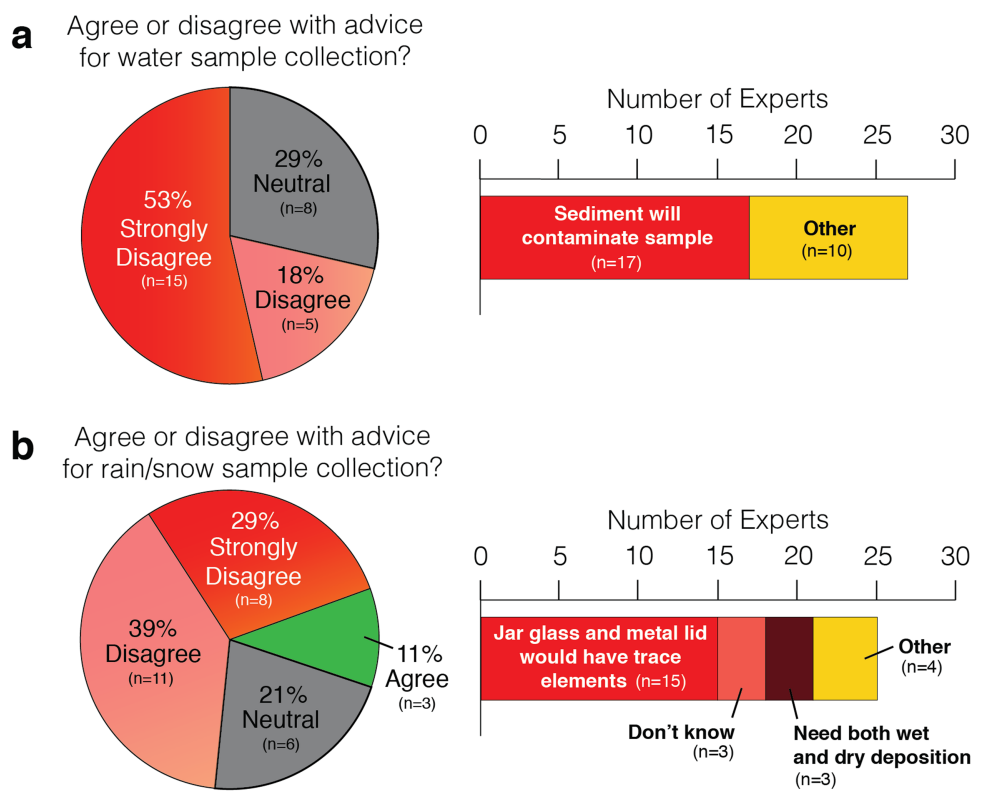

Figure 4. Presented with the sampling instructions offered on a SLAP website for collecting surface water (a), and rain and snow (b) samples, >60% of surveyed experts disagreed with the advice, in each case expressing concerns about contamination of samples.

Discussion

For the contrail survey, no expert thought they had ever come across evidence of a SLAP. Further, no expert thought any of the four photos in the survey—cited as evidence of chemical spraying on SLAP websites—were best explained by chemical spraying. On the contrary, there was a high degree of consensus on the natural mechanisms accounting for the phenomena in each photo. For many photos, there was also overlap on the peer-reviewed studies that best explained each photo.

Where there may be some slight agreement with SLAP theorists was with the 18 experts (37%) who thought trails may now be persisting for longer periods of time. However, they attributed the longer duration of trails to known factors such as larger engines and fuel efficiencies that create cooler water vapor and allow increased plane traffic to fly at higher altitudes, leading to more persistent condensation trails.

For the deposition survey, 80%–89% of respondents for each of the three samples presented did not think the simplest explanation involved chemical spraying. It should be noted, however, that eleven experts (39%) were not sure how to interpret the results from either the airborne particulates or snow surface samples (figures 3(b) and (c), respectively), saying they wanted more information and context. Yet while SLAP proponents argue all the samples show abnormally high levels of metal concentrations, the experts who did offer an analysis mostly said the samples showed average concentrations given the fact that they were not simply water, air, snow but sludge, sediment, and dust samples.

Although many experts were not sure how to interpret the second and third samples, most disagreed or strongly disagreed with the sampling instructions offered on the SLAP website for collecting surface water, rain, and snow testing (figure 4). The main reason offered for disagreeing with the surface water sample instructions is that adding sediments would increase measurement of metal concentrations, as levels are higher in sediment than water. There was also concern that the instructions for rain and snow samples did not include sufficient information for preventing contamination.

Conclusion

A small but vocal group of people have been advocating that there exists a SLAP that is spraying dangerous chemicals from aircraft. Some people believing these theories have constructed websites that purport to show evidence of ongoing widespread spraying. With the exception of a fact sheet presented by government agencies in year 2000 (EPA, FAA, NASA and NOAA 2000), these claims have not been addressed by the scientific community, which may lead the broader

Table 1. Expert participants in contrails survey (alphabetical order).

Name	Institution
Andrew Carleton	Penn State University
Andrew Heidinger	National Oceanic and Atmospheric Administration
Andrew Heymsfield	National Center for Atmospheric Research
Andrew J Weinheimer	National Center for Atmospheric Research
Brian A Ridley	National Aeronautics and Space Administration
Bruce Anderson	National Aeronautics and Space Administration
Bryan Baum	University of Wisconsin-Madison
Charles A Brock	National Oceanic and Atmospheric Administration
Charles E Kolb	Aerodyne Research
Christine Fichter	German Aerospace Center (DLR)
Christos Zerefos	University of Athens
Cynthia Twohy	NorthWest Research Associates
Darrel Baumgardner	Droplet Measurement Technologies
David Doelling	National Aeronautics and Space Administration
David Kratz	National Aeronautics and Space Administration
David Lee	Manchester Metropolitan University
David Lewellen	West Virginia University
David J Travis	University of Wisconsin-Whitewater
Donald P Garber	National Aeronautics and Space Administration
Eleftheratos Konstantinos	University of Athens
Gaby Radel	University of Reading
Guy Febvre	Observatory of Atmospheric Physics at Clermont-Ferrand
Hartmut Grassl	Max Planck Institute for Meteorology
Jack Dibb	University of New Hampshire
Karen Rosenlof	National Oceanic and Atmospheric Administration
Klaus Gierens	German Aerospace Center (DLR)
Larry Miloshevich	Milo Scientific
Markus Garhammer	Ludwig-Maximilians-University
Matthias Tesche	Stockholm University
Michael Ponater	German Aerospace Center (DLR)
Michael Prather	University of California, Irvine
Otto Klemm	University of Muenster
Patrick Minnis	National Aeronautics & Space Administration
Piers Forster	University of Leeds
R Paul Lawson	Stratton Park Engineering Company
Rabi Palikonda	National Aeronautics & Space Administration
Reinhold Busen	German Aerospace Center (DLR)
Robert Sausen	Institute of Atmospheric Physics
Robert Talbot	University of Houston
Ru-Shan Gao	National Oceanic and Atmospheric Administration
Sonia M Kreidenweis	Colorado State University
Stephan Bakan	Max Planck Institute for Meteorology
Tatiana Khokhlova	University of Washington
Thilo Stilp	European Aviation Group for Occupational Safety and Health
Tove Svenby	Norwegian Institute for Air Research
Ulrich Schumann	Institute of Atmospheric Physics
Ulrike Burkhardt	German Aerospace Center (DLR)
Volker Grewe	Institute of Atmospheric Physics
William L Smith	National Aeronautics and Space

Table 2. Expert participants in atmospheric deposition survey (alphabetical order).

Name	Institution
Anne-Catherine Pierson-Wickmann	University of Rennes 1
Carmen Nezat	Eastern Washington University
Carol Kendall	US Geological Survey
Chris Measures	University of Hawaii
Christopher Hissler	Gabriel Lippmann Public Research Centre
Clifton Buck	Franklin College
Daniel Engstrom	University of Minnesota
David Grantz	University of California at Riverside
Dominik Weiss	Imperial College London
Heleen de Wit	Norwegian Institute for Water Research
Jan Kramers	University of Johannesburg
Jill Schrlau	Oregon State University
Joanna Clark	University of Reading
Josef Hejzlar	Institute of Hydrobiology
Kiminori Shitashima	Kyushu University
Lubos Boruvka	Czech University of Life Sciences Prague
Marjorie Schulz	US Geological Survey
Mark Smits	Hasselt University
Matt Kulp	US National Park Service
Nicolas Belanger	University of Quebec
Pavel Rosendorf	T. G. Masaryk Water Research Institute
Robert Duce	Texas A&M University
Rolf David Vogt	University of Oslo
Scott Bailey	US Forest Service
Steve Howell	University of Hawaii
Tomas Navratil	Czech Geological Survey
William Landing	Florida State University
Wim de Vries	University in Wageningen

public to be confused or uncertain about the validity of the claims and data.

We therefore offer the first peer-reviewed expert response on SLAP data, from both atmospheric scientists with expertize in condensation trails and geochemists working on atmospheric deposition of dust and pollution. Results show that 76 out of 77 (98.7%) of scientists that took part in this study said there was no evidence of a SLAP, and that the data cited as evidence could be explained through other factors, such as typical contrail formation and poor data sampling instructions presented on SLAP websites.

The number of aircraft contrails has been increasing. There have been revelations over the decades of governments undertaking action in secret without the informed consent of the population. It is reasonable that ordinary citizens should want questions answered

concerning health, climate change, and pollution. While we understand that many of the fears underlying SLAP theories may be legitimate, the evidence as evaluated here does not point to a secret atmospheric spraying program. Changes in aircraft technologies may be causing contrails to persist longer than they used to, and changes in industrial development could potentially be increasing aerosol deposition in some areas. But the focus on a secret, large-scale atmospheric spraying program may be taking attention away from real, underlying problems that need addressing.

References

Bakalaki A 2016 Chemtrails, crisis, and loss in an interconnected world *Vis. Anthropol. Rev.* **32** 12–23

Cairns R 2014 Climates of suspicion:'chemtrail'conspiracy narratives and the international politics of geoengineering *Geogr. J.* **182** 70–84

Cairns R and Stirling A 2014 'Maintaining planetary systems' or 'concentrating global power?' High stakes in contending framings of climate geoengineering *Glob. Environ. Change* **28** 25–38

Crutzen P J 2006 Albedo enhancement by stratospheric sulfur injections: a contribution to resolve a policy dilemma? *Clim. Change* **77** 211–20

EPA, FAA, NASA, and NOAA 2000 Aircraft Contrails Factsheet (www.faa.gov/regulations_policies/policy_guidance/envir_policy/media/contrails.pdf) (accessed 12 November 2015)

Gierens K, Kärcher B, Mannstein H and Mayer B 2009 Aerodynamic contrails: phenomenology and flow physics *J. Atmos. Sci.* **66** 217–26

Hunter S M 2007 Optimizing cloud seeding for water and energy in California *A Pier-Final Project Report* California Energy Commission, CEC-500-2007-008 (www.energy.ca.gov/2007publications/CEC-500-2007-008/CEC-500-2007-008.PDF)

Keith D 2013 *A Case for Climate Engineering* (Cambridge, MA: MIT Press)

Mercer A M, Keith D W and Sharp J D 2011 Public understanding of solar radiation management *Environ. Res. Lett.* **6** 044006

Myers T A, Maibach E, Peters E and Leiserowitz A 2015 Simple messages help set the record straight about scientific agreement on human-caused climate change: the results of two experiments *PloS One* **10** e0120985

Nguyen L, Smith W L Jr and Palikonda R 1998 Transformation of contrails into cirrus during SUCCESS *Geophys. Res. Lett.* **25** 1157–60

Schumann U 1996 On conditions for contrail formation from aircraft exhausts *Meteorol. Zeitschrift* **5** 4–23 (http://elib.dlr.de/32128/1/mz-96.pdf)

Schumann U 2005 Formation, properties and climatic effects of contrails *C. R. Phys.* **6** 549–65

van der Linden S L, Clarke C E and Maibach E W 2015 Highlighting consensus among medical scientists increases public support for vaccines: evidence from a randomized experiment *BMC Public Health* **15** 1

van der Linden S L, Leiserowitz A A, Feinberg G D and Maibach E W 2015 The scientific consensus on climate change as a gateway belief: experimental evidence *PloS One* **10** e0118489