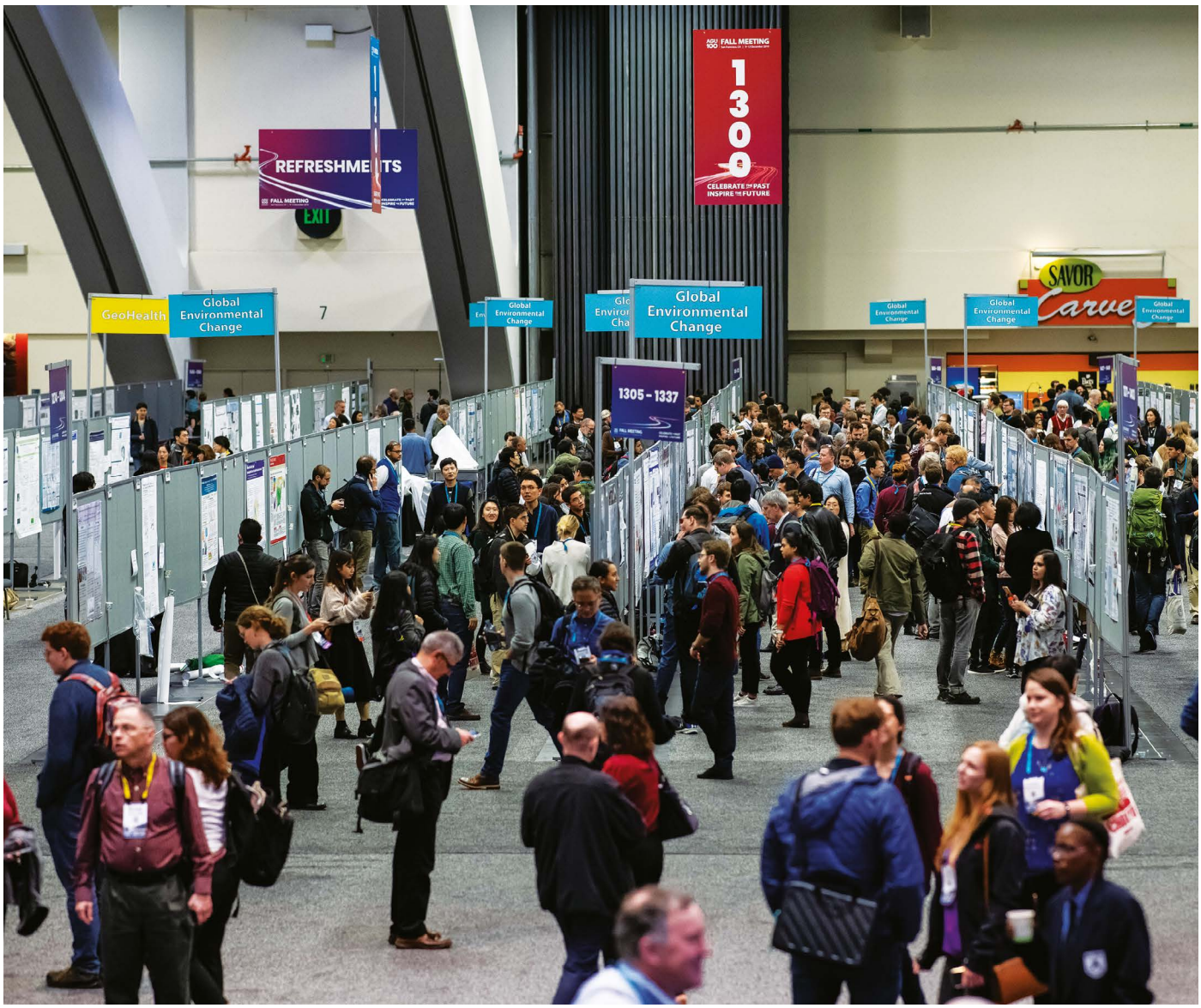


AGU

Some 28,000 people travelled to the American Geophysical Union's 2019 Fall Meeting, resulting in 80,000 tonnes of carbon emissions.

An analysis of ways to decarbonize conference travel after COVID-19

Milan Klöwer, Debbie Hopkins, Myles Allen & James Higham

Emissions associated with large academic meetings could be slashed by boosting virtual attendance and regional hubs, new calculations suggest.

Before the pandemic, many academics were frequent flyers. We travelled to conferences and board meetings, to conduct fieldwork, to visit collaborators and to give seminars and lectures. Many of us took multiple long-haul flights per year and have accrued thousands of air miles.

Yet we are also acutely aware of the negative impacts of travel. Before the outbreak of COVID-19, the transport sector as a whole accounted for 24% of annual global emissions of carbon dioxide. Aviation was responsible for about 3%, road transport 18% and rail less than 1% (ref. 1).The vast majority of flights were taken by a small minority of frequent flyers. In the United Kingdom, 15% of the population was responsible for 70% of the flights[2]. There are clear inequalities in who travels by air[3].

Academics are part of this hypermobile lifestyle. The sum total of travel associated with attendance at one large academic conference can release as much CO_2 as an entire city in a

week. Take the Fall Meeting of the American Geophysical Union (AGU) – the world's largest Earth- and space-science conference – held in San Francisco, California, last December. We calculate that its 28,000 delegates travelled 285 million kilometres there and back – almost twice the distance between Earth and the Sun. In doing so, they emitted the equivalent of about 80,000 tonnes of CO_2 (tCO2e). This is about 3 tonnes per scientist, or the average weekly emissions of the city of Edinburgh, UK[4]. Other big conferences will have had similarly large carbon footprints.

The COVID-19 pandemic has forced us to rethink what constitutes necessary travel. Many of this year's conferences have been cancelled. Some have gone virtual. For example, in May, the annual meeting of the European Geosciences Union (EGU) ran its sessions and panels online. It is the largest European meeting of geoscientists, with 16,000 attendees in a typical year. There was an upside to making it virtual – attendance rose to 26,000. Some climate and sustainability conferences have long been held online, including the Virtual Island Summit and Virtual Blue COP25.

Of course, for some academics, especially in their early career stages, occasional face-to-face interactions are likely to remain important, for example to aid networking.

Here, we present an original analysis of the potential emissions savings of doing things differently. We compare several actions that, by our calculations, can reduce conference travel emissions by up to 90%, including holding a conference biennially in accessible locations, having regional hubs, and increasing virtual presentations.

Long-haul aviation

To learn more about transport emissions from major conferences, we analysed the travel patterns of delegates to the AGU's 2019 Fall Meeting. We located the affiliations of all 24,008 presenters of talks and posters at the conference and estimated how far each had travelled from their home institution. We scaled up the result for all 28,000 attendees (see 'Emissions en route').

We assumed a typical mode of transport for each attendee, depending on the distance they travelled to San Francisco. Around 92% travelled more than 400 kilometres and were assumed to have flown. A car, bus or train journey was assumed for the remaining 8%.

We assigned average emissions rates to each transport type. Car, bus and train journeys were averaged into a single emission category, because their respective share among attendees is unknown. Flights produce three to five times more emissions per kilometre per person than does overland transport. These emission factors take into account the average fuel consumption, fuel weight, deviations from the shortest distance, the number of passengers per vehicle and indirect CO_2 effects caused by aircraft emitting at high altitudes (see Supplementary information for details, including the sensitivity to our assumptions, such as those for emissions factors).

Intercontinental flights are the main source of emissions: one return flight between Hong Kong and San Francisco releases more CO_2 than does the average British person's activities over an entire year, or than those of ten people living in Ghana.

"The sum total of travel to one large academic conference can release as much CO_2 as an entire city in a week."

Seventy-five per cent of the AGU 2019 emissions were generated by intercontinental flights for one-way distances greater than 8,000 km, made by 36% of the attendees (about 10,000 people), who travelled from outside North America. The highest emissions were due to 17% of the attendees (about 5,000 people) and account for 39% of the total emissions (see Fig. S1 in Supplementary information). These people had travelled the farthest – mostly from India, Australia and China (see Fig. S2).

By contrast, only 2% of the AGU 2019 emissions were caused by the 22% of delegates who took flights of less than 1,500 km one way (see Fig. S1). Changing their mode of transport would therefore make little difference to total emissions. Even if all 22% were to use trains, buses or carpools instead of aeroplanes, this would reduce total emissions by only 1%. Similarly, even for regional conferences that can be accessed by a well-connected rail network, such as the EGU meeting held each year in Vienna, a switch from plane to train reduces emissions by 10% at most (see Fig. S3).

We also assessed the impact on emissions of moving the AGU Fall Meeting to a different location in the United States. Holding the conference in the middle of the country, rather than on one coast or the other, would reduce travel emissions. Chicago in Illinois emerged as an optimum location, saving 12% in emissions (Fig. S4). Moving it to Hawaii, by contrast, would increase emissions by 42%, because almost everyone would need to fly more than 4,000 km to attend.

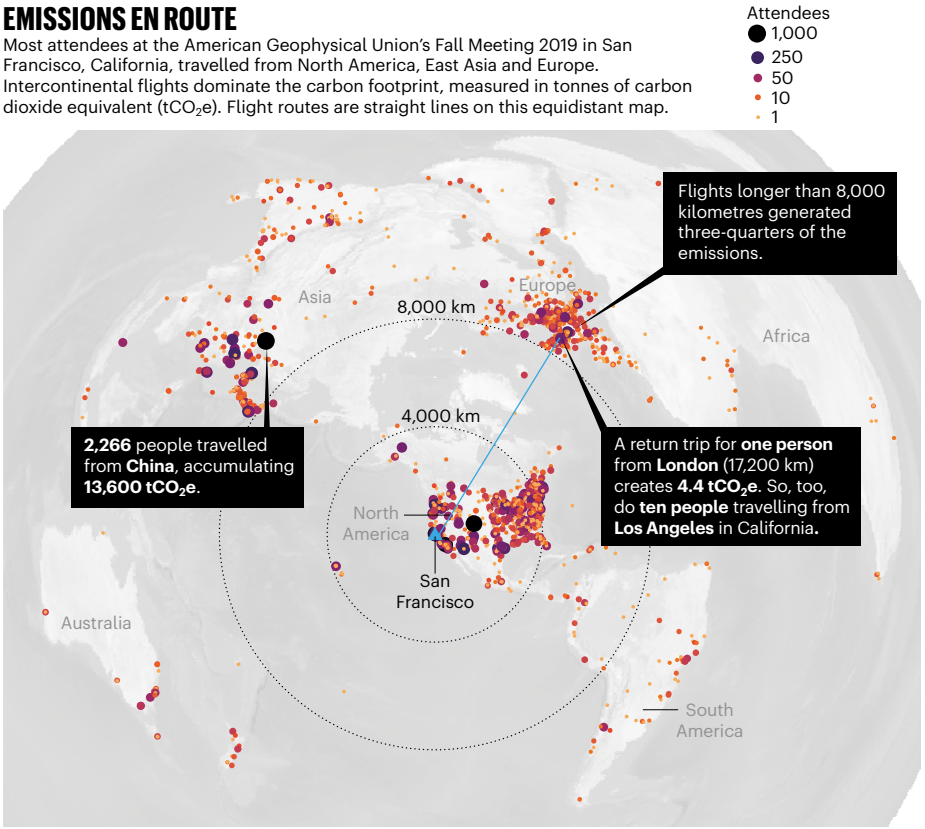
Conferences reimagined

The following three measures would reduce travel emissions associated with international conferences.

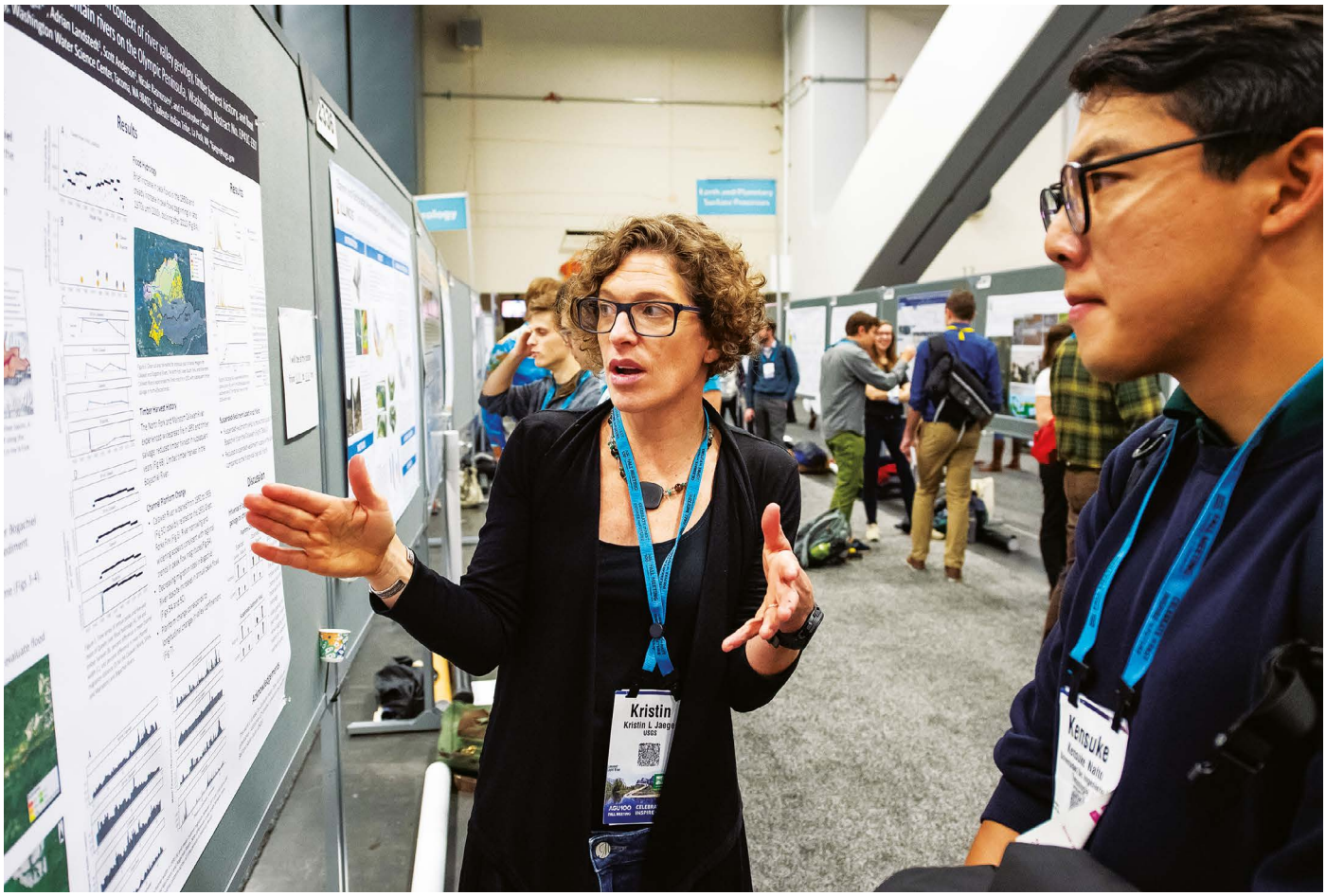
Choose accessible venues. Future conference locations should be selected, in part, to minimize transport emissions. Decisions could be informed by modelling delegates' journeys, as we did. Because air travel would still be necessary for most participants, virtual attendance should be considered instead of long-haul trips whenever possible. Low-carbon alternatives to air travel, such as trains, buses or carpools should be encouraged

EMISSIONS EN ROUTE

Most attendees at the American Geophysical Union's Fall Meeting 2019 in San Francisco, California, travelled from North America, East Asia and Europe. Intercontinental flights dominate the carbon footprint, measured in tonnes of carbon dioxide equivalent (tCO_2e). Flight routes are straight lines on this equidistant map.



SOURCE: M. KLÖWER HTTPS://DOI.ORG/10.5281/ZENODO.3553784 (2019)



AGU

In-person poster presentations at scientific meetings could be replaced by digital posters and online discussions.

for those who are able to use them, and for regional meetings.

Increase virtual attendance. Virtual conferences should do more than replicate an in-person conference online. Text-based online forums allow discussions to continue for days or weeks in any time zone, and increase the participation compared with in-person question-and-answer sessions. Virtual content should be archived and made open access to increase outreach. Lower fees will boost virtual attendance. For example, the EGU's virtual meeting in May was free to attend and attracted 60% more participants than last year's in-person conference.

Become biennial. Some major conferences, such as the AGU's Ocean Sciences Meeting, are held every other year. All things being equal, this immediately cuts a conference's annual travel emissions by 50%. Biennial meetings could be complemented by a fully virtual conference in alternate years.

By following all three steps, we calculate that travel-related carbon emissions for the AGU Fall Meeting could be reduced by more than 90% if the meeting were held biennially in Chicago, and with about one-third of the participants, those responsible for most of the emissions, attending virtually.

The downside is that this would exclude many scientists based outside the United States from attending in person, potentially resulting in a two-tier conference system and conflicting with aspirations for a global scientific community. Ways of improving opportunities for a wide range of researchers to participate are therefore needed.

Three-hub model

Merging regional annual conferences is a possible way of reducing emissions and improving equity. For example, the EGU meeting (held in April), and the Japan Geoscience Union (JpGU) meeting (held near Tokyo in May) complement the AGU Fall Meeting. These conferences often have sessions on similar themes and are already developing collaborative links. Before the pandemic, the AGU and the JpGU were planning a joint in-person conference in Japan in May this year.

We propose combining these conferences. A single global 'World Geosciences Union' conference would take place simultaneously in three hub locations, linked by dedicated virtual-room facilities to allow anyone to participate in any session. Attendees would travel only to their nearest hub. On the basis of current attendance patterns, Chicago, Tokyo and Paris would be suitable host cities (see Supplementary information). Such a three-hub model could reduce the combined total travel emissions of the three meetings by about 80%. (See 'Shrink the footprint' for a comparison of emissions from the AGU Fall Meeting and various other options.)

Time differences would have to be accommodated. A global meeting might open on a Monday morning in Tokyo and run for five days continuously until Friday evening in Chicago. Sessions with high attendance could be held in each hub in the afternoon, to allow live late-evening and early-riser participation at the other two hubs. Participants would have to accept sessions occurring at unconventional hours, but this is likely to be less stressful than back-to-back intercontinental flights[5].

Critics might counter that such a model would still disadvantage academics in parts of the world remote from these hubs, such as the Southern Hemisphere. Academics based in the Northern Hemisphere are more likely to reap the benefits of increasing their contacts, building trust and sharing informal knowledge in person, even under our three-hub model. Fully virtual conferences might provide more equality in this respect (see go.nature.com/38de0sr).

Further regional meetings might join and complement the main three. Virtual attendance could help early-career researchers to gain exposure to the entire global community at one meeting. People who might have struggled to attend for personal reasons, such as lack of childcare, low travel budgets or visa restrictions, could take part. For example, the Virtual Island Summit connects more than 250 island communities worldwide, especially from the global south, which would not be possible in person because of the vast distances and travel costs. Questions of equity are important, and need more consideration to avoid exacerbating existing inequalities.

Another issue is that the software currently used for running virtual conferences remains basic[6]. Although no more than a laptop or tablet with an Internet connection is required to participate, Internet connectivity can be a bottleneck for streaming video presentations. Uploaded recordings, digital posters and text-based discussions would reduce pressure on the technology. To enhance the virtual experience without limiting access, conferences should offer platforms for both low- and high-bandwidth connections. In addition, online community platforms such as Discord and Slack are essential to provide virtual attendees with opportunities to network and socialize at coffee and lunch breaks and other social events.

Action points

Recurrent in-person conference attendance is one of the least-necessary reasons for academics to travel. Scholarly success generally does not increase in line with air miles[7]. But the current move to online conferences in response to COVID-19 will not become the norm by default. Many actors need to be mobilized to transform the shift to a fair conference model for a net-zero carbon future.

Academic associations and professional bodies. Such groups should support the reorganization of conferences around emissions, virtual participation and inclusivity. They should set criteria for funding conferences — those that ignore emissions targets should not be supported. As a first step, there should be an immediate move to biennial conferences, with fully virtual meetings in alternate years.

Funding bodies. These should consider low-carbon and open-access dissemination of research output, support virtual conference presentations rather than conference travel, and reward regional attendance. They should consider carbon budgets as well as financials in grant applications and in contractual terms and conditions.

> **"Money saved by going virtual should be used to increase the participation of scientists from the global south."**

Academic institutions. Universities and others should reallocate conference funding from travel and accommodation to the costs of virtual hosting, including investment in virtual technologies, technical support and conference social-media engagement. Funding should cover expenses for virtual attendance, and there should be mechanisms for requesting 'conference leave' to allow full virtual participation. Promotion and research-assessment exercises should recognize conference contributions under the new model. Just as academics have an annual travel budget, institutions should look to implement differentiated carbon budgets (by career stage and other criteria)[8].

Researchers. Participants should promote and support virtual conferences wherever possible. Opportunities to present at virtual conferences should be accepted and virtual presentation should be demanded if it is not offered. Role models will be crucial, and senior scholars should insist on delivering invited keynote speeches virtually[9], or should pass on those opportunities to scientists from groups that are under-represented in their fields[10].

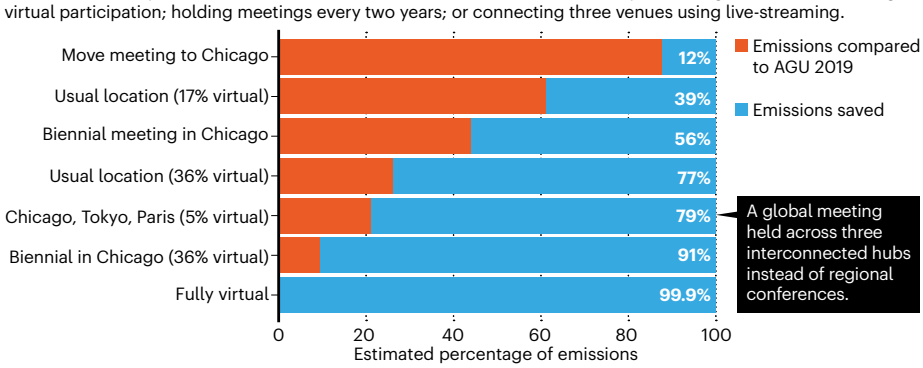
Conference organizers. When selecting a host city, event organizers should consider the emission profile of delegate travel. Conference hubs should be created to minimize the need for long-haul flights. Most aspects of conference participation should be moved online, including the live-streaming and recording of presentations, digital posters with discussion channels and virtual social events. Virtual presentation should be encouraged and time-slot preferences accommodated. Connections between similar conferences should be established. Money saved by going virtual should be used to increase the participation of scientists from the global south.

Virtual-technology providers. These should be funded to develop online conferencing solutions for the academic community. Open-source virtual technologies should be prioritized to avoid further dependence on expensive licensing, which creates and perpetuates exclusion.

Only through a concerted and coordinated effort will the transition towards a decarbonized model of academic conferencing gain traction. As COVID-19 has taught us, changes to deeply embedded and seemingly intractable practices can happen in a global emergency with remarkable speed.

SHRINK THE FOOTPRINT

The travel-related carbon footprint of the American Geophysical Union (AGU) annual meeting is equivalent to the average weekly emissions of Edinburgh, UK (80,000 tonnes of CO_2 equivalent). It is the largest yearly conference in the field, usually held in San Francisco, California. Emissions could be cut by relocating the event; increasing virtual participation; holding meetings every two years; or connecting three venues using live-streaming.



SOURCE: M. KLÖWER HTTPS://DOI.ORG/10.5281/ZENODO.3553784 (2019)

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