



Reducing the Carbon Footprint of Academic Conferences

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Télécom Paris

Who am I?

- **Researcher** and teacher in **theoretical computer science**
- Trying to **modernize academia** from the inside
 - Wrote a long guide, “**What’s wrong with academia**”
- **Concerned** about the climate crisis:
 - Since 2020: **vegetarian**, no **plane travel**
- Trying to **limit the carbon footprint of academia**
 - TCS4F, ICDT climate chair (2021), ACM DEBS panelist (2022)



Goals and limits of this talk

- Review the **climate crisis** and efforts to **address it**
- Explore the footprint of **academic research** and **plane travel**
- Focus on **conference travel** in **computer science**
- Illustrate **initiatives** to change the academic conference system

Limits of the talk:

- **Not an expert** in the scientific area of climate change, environmental research, etc.
- **Not a wide view** of the academic world across different scientific fields
- **Taking place online** with a diverse audience and unfamiliar context

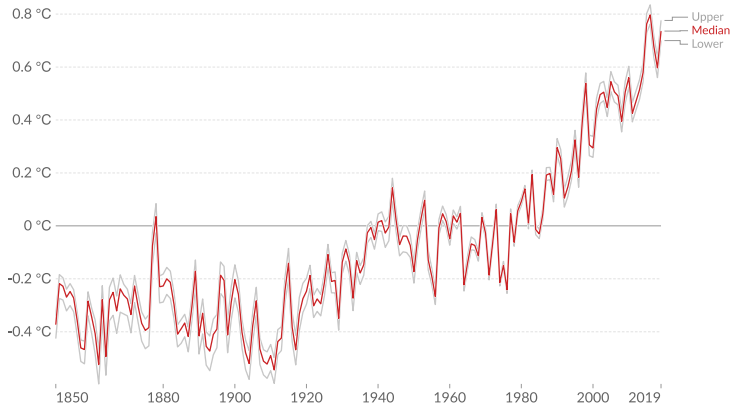
The Climate Crisis

Problem: Temperatures are increasing (among other things)

Average temperature anomaly, Global

Global average land-sea temperature anomaly relative to the 1961-1990 average temperature.

Our World
in Data



Source: Hadley Centre (HadCRUT4)

OurWorldInData.org/co2-and-other-greenhouse-gas-emissions • CC BY

Note: The red line represents the median average temperature change, and grey lines represent the upper and lower 95% confidence intervals.

Higher **average temperatures** means higher **extreme weather events**

Main cause: CO₂ concentrations are increasing

Global atmospheric CO₂ concentration

Atmospheric carbon dioxide (CO₂) concentration is measured in parts per million (ppm). Long-term trends in CO₂ concentrations can be measured at high-resolution using preserved air samples from ice cores.

Our World
in Data



Source: National Oceanic and Atmospheric Administration (NOAA)

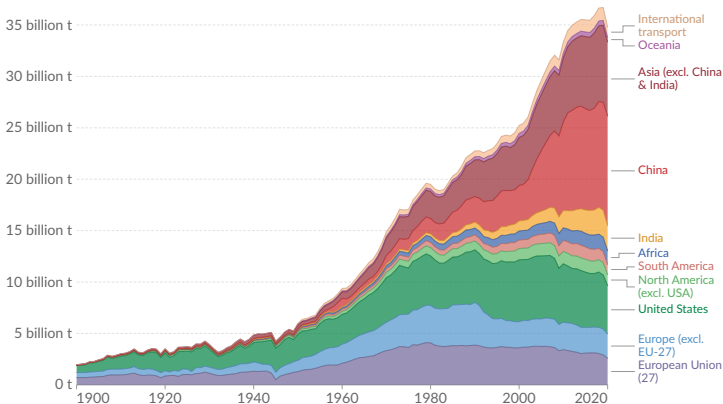
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Also **other greenhouse gases**: methane, nitrous oxide, haloalkanes (CFCs, etc.)

Main cause: Fossil fuel emissions are increasing

Annual CO₂ emissions from fossil fuels, by world region

Our World
in Data



Source: Global Carbon Project

OurWorldInData.org/co2-and-other-greenhouse-gas-emissions • CC BY

Note: This measures CO₂ emissions from fossil fuels and cement production only – land use change is not included. 'Statistical differences' (included in the GCP dataset) are not included here.

Emissions from **burning fossil fuels** (oil, coal, gas), not including land use change etc.

Solution: Lower the emissions

Global greenhouse gas emissions and warming scenarios

Our World
in Data

- Each pathway comes with uncertainty, marked by the shading from low to high emissions under each scenario.
- Warming refers to the expected global temperature rise by 2100, relative to pre-industrial temperatures.

Annual global greenhouse gas emissions
in gigatonnes of carbon dioxide-equivalents

150 Gt

100 Gt

50 Gt

Greenhouse gas emissions
up to the present

0

1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100

No climate policies

4.1 – 4.8 °C

→ expected emissions in a baseline scenario
if countries had not implemented climate
reduction policies.

Current policies

2.5 – 2.9 °C

→ emissions with current climate policies in
place result in warming of 2.5 to 2.9°C by 2100.

Pledges & targets (2.1 °C)

→ emissions if all countries delivered on reduction
pledges result in warming of 2.1°C by 2100.

2°C pathways

1.5°C pathways

Data source: Climate Action Tracker (based on national policies and pledges as of November 2021).
OurWorldinData.org – Research and data to make progress against the world's largest problems.

Last updated: April 2022.
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Goals and orders of magnitude

- Emissions per person in 2020¹:
 - World: **4.5 tons CO₂e**
 - Europe: **6.6 tons CO₂e**
- Paris Agreement (2015): “**Keep global warming well below 2°C, aim for 1.5°C**”
- Target emissions per person in 2030 worldwide: about **2.2 tons CO₂e**²
- Impact of flights: a Paris–New York economy round-trip emits **2.7 tons CO₂e**³
→ More than your sustainable yearly footprint!

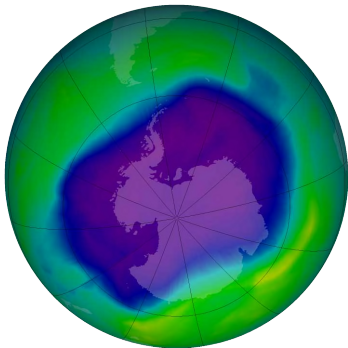
¹<https://ourworldindata.org/co2-emissions#per-capita-co2-emissions>

²Oxfam study <https://www.oxfam.org/en/research/carbon-inequality-2030>

³Estimation by atmosfair.de: the ICAO calculator estimates 660 kg CO₂e (large difference!)

Addressing the Climate Crisis

Success story: The Montreal protocol



- 1980's: **decline of the ozone layer** identified and attributed to **chlorofluorocarbons** (CFCs)
- 1985: **Montreal protocol**, an international agreement phasing out the use of CFCs
- 2019: ozone hole **smallest since discovered**
- 2075: ozone layer back to **pre-1980 levels** (forecast)

Can we do the same for **climate change** and **greenhouse gases** (GHGs)?

Scale of the GHG problem

Unlike CFCs, the production of GHGs is part of **almost all fields** of the economy:

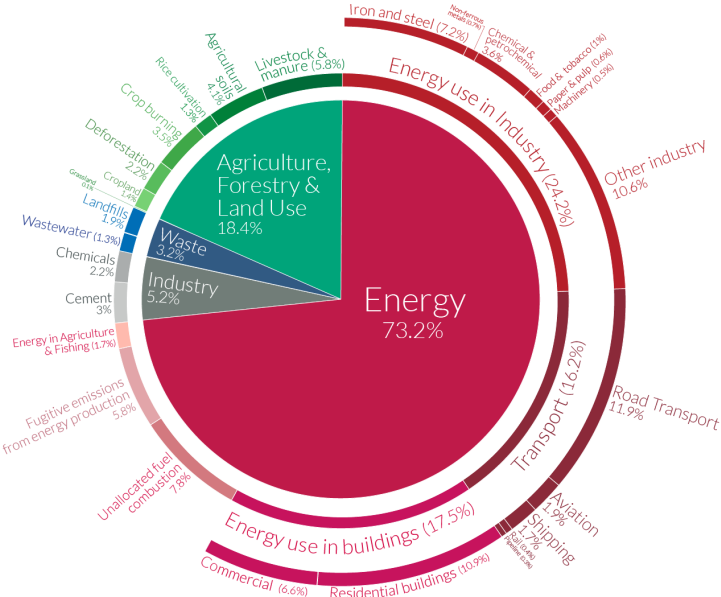
- **Electricity production:**
 - overall **2/3rd of produced electricity** comes from fossil fuels⁴ including all **dispatchable production** (except nuclear, hydro)
- **Transportation:** mostly reliant on fossil fuels (except electric cars, biking)
- **Heating buildings:**
 - overall **2/3rd of heating energy in Europe** is from fossil fuels⁵
- **Construction:** the production of cement is a large emitter of CO₂
- **Agriculture:** land use change (deforestation), methane and NOx from livestock

Overall **85% of total energy (electricity, transport, heat) comes from fossil fuels**⁴

⁴<https://ourworldindata.org/electricity-mix>

⁵https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_consumption_in_households

Emissions by sector (source: Our World in Data)



Global greenhouse gas emissions by sector

This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO₂eq.

OurWorldinData.org – Research and data to make progress against the world's largest problems.

Source: Climate Watch, the World Resources Institute (2020).

Licensed under CC-BY by the author Hannah Ritchie (2020).



Conflicting needs

To fix anthropogenic GHG emissions we need two conflicting trends:

- **Do more:** electrify transportation and heating, develop carbon-free electricity, recycling, insulation, etc.
- **Do less:** consume less carbonated goods and services, consume less energy

The difficult part is “do less”:

- Making something cheaper can increase demand: **rebound effect**
 - Worldwide economic mentality centered on **growth**
 - **Unclear** if we can decarbonize while maintaining the same production of energy and the same current standards of living/production
- Maybe progress since the Industrial Revolution was caused by **abundant fossil energy** and this is over? (cf. Energy return on investment)

Fixing climate change with individual action!

The most immediate way to address climate change is at the **individual level**:

- **Estimate** your GHG footprint (tons of CO₂-equivalent per year)
- **Reduce** your main sources of emissions

Common actions:

- Become **vegetarian** or **vegan** (around 1 tCO₂e/year⁶)
- Avoid **flying**, avoid **thermic cars**
- Change your **heating** or **insulation**, increase density
- Controversial: Have less **children**
- **Other**: Save energy, avoid food waste, packaging, disposable items, recycle, no pets, ethical investments, etc.



⁶<https://shrinkthatfootprint.com/food-carbon-footprint-diet/>

Limits of individual action...

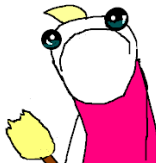
- People often focus on **small actions** with little or no **quantified benefits**
- Puts all the **responsibility** on individuals
 - Politically convenient!
- Can be **frustrating** if others do not change
 - Puts you at a **disadvantage** (coordination problem)
 - You will always see some people **care less** than you do

→ Your **individual contribution** always seems negligible

“Even if academics don’t fly to conferences, the scheduled flights are still going to fly”

- Many people **cannot afford** to change! (inequalities)
- Climate change is not an **individual problem** but a **political problem**!

clean all the things?



Summary on addressing the climate crisis



- We have a **large problem** which requires **fast** and **worldwide** action to avoid **dire consequences**
 - (Note: also other ecological problems (e.g., biodiversity))
 - Things are **moving** but not **fast enough**
 - Individual action is **not the answer**
- So **why act?!**
- Less **frustrating** than doing nothing
 - Necessary to be taken **seriously**
 - Can **influence** others
 - Can help create a **movement**

Impact of Academia and Air Travel

Academic research and climate change

- **Academia**: the field of higher-education **teaching** and **research**
- Academic **research**: creating **new knowledge**
- Done by **researchers** in **universities** and other **research institutions**
- Fields: STEM (science, technology, engineering, mathematics), HASS (humanities, arts, social sciences), etc.
 - I will often focus on **my field**: (theoretical) computer science



How does academic research contribute to climate change?

- **Business travel**, in particular by plane
- **Field-specific** emissions: lab equipment, materials, etc.
- Also usual **office emissions**: heating, electricity, commuting, food, etc.

Focus: flights

We focus on the **flights**. This is important at a **global scale**:

- Flights overall cause an estimated **3.5% of total man-made radiative forcing**⁷
- Traffic **doubles every 15 years** and trend is expected to continue⁸

And also at an **individual level**:

- For the **few people** that fly often, flights are the **main** emission source (tons of CO₂e!)
- Reducing the number of flights is comparatively **easy**

⁷Lee; et al. (2021), *The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018*, Atmospheric Environment

⁸Airbus Global Market Forecast, 2019

Why do academics fly?

From personal experience:

- **International conferences**, workshops, other events
- **Research visits**, sabbaticals
- Participation to **meetings**, project meetings, committees, etc.
- Interviewing for positions
- **Field trips**, in some areas



Flying believed to be **necessary for success**⁹ but in fact this is **unclear**¹⁰

⁹Eriksson et al., *On the Necessity of Flying and of not Flying: Exploring how Computer Scientists Reason about Academic Travel*, ICT4S'2020

¹⁰Wynes et al., *Academic air travel has a limited influence on professional success*, Journal of Cleaner Production, 2019; Chalvatzis and Ormosi, *The carbon impact of flying to economics conferences: is flying more associated with more citations?*, Journal of Sustainable Tourism, 2021

Intermission: I could have flown for this talk!

From: *** <***@uhasselt.be>

To: a3nm@a3nm.net

Subject: Invitation keynote speaker as part of course
"Globalisation & Sustainable Development"

Dear Antoine,

[...]

If you agree to do the lecture there would be two possibilities:

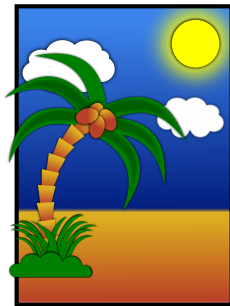
1. You can come to Belgium for the lecture and **we can fund your flight ticket**, and accommodation.
2. We can organize the class online.

[...]

Goals of academic conferences

We focus on **conferences**. They have many goals:

- **Peer review**: evaluate submissions for correctness and interest
- **Selection** of the best submissions of the year
- **Presentation** of the best contributions, and discussions
- **Informal networking**, allowing the community to meet
- **Tourism** (perk of academic life)



Conferences can be:

- **formal**: they “count” as a publication
- **informal**: can present already “published” work, unfinished work, etc.

Role of conferences in computer science

Research in **computer science** has a unique focus on conferences:

- Appeared in the **second half of the 20th century** with plane travel available
- The field structured around **conferences** (1960's-1970's), with journals for the **extended versions** of the articles
- The conferences are **selective** and usually **more prestigious** than the journals
- Perceived as a **problem** already in the late 2000's, e.g., Lance Fortnow, "Time for computer science to grow up", CACM 2009.

Conferences in computer science serve **two roles**:

- the **preferred way** to publish;
- the place where the community **meets**

The Carbon Footprint of Conferences

Example: Highlights'22

Example of an **informal European** conference which we organized this year in **Paris**

Carbon footprint

To estimate the carbon footprint of this edition of Highlights, please give us some information about your travel

Arriving from...

London, United Kingdom

Which city and country are you arriving from

Arriving by...

- Aucun(e) -



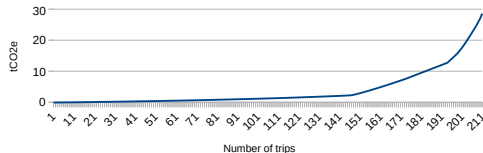
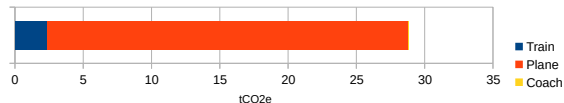
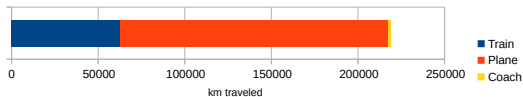
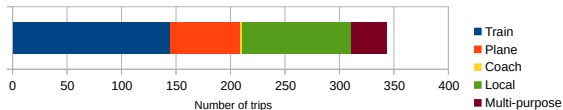
What is your main mode of transportation to arrive?

Leaving to...

Brussels, Belgium

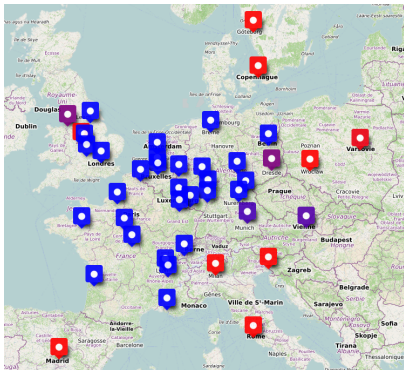
Footprint of Highlights'22

We have **173** registered participants



- **29 tCO₂e** — the yearly footprint of **6.5 people** today, **13 people** in 2030
- What matters is **flights**, especially **long flights**

Perspectives and lessons



- Substituting **plane trips** by **train trips** helps and is already **underway**
- However, the problem is **long flights**, which cannot be substituted
- International conferences have **more impact**, e.g., 710 kgCO₂e par participant for **ICALP 2022**¹¹
- Other conferences have quantified their impact¹²

¹¹https://icalp2022.irif.fr/?page_id=1092

¹²Neugebauer et al., *How sustainable are sustainability conferences? – Comprehensive Life Cycle Assessment of an international conference series in Europe*, Journal of Cleaner Production, 2020

Reducing the Impact of Conferences

Small improvements to conferences

- Substitute **train travel** to plane travel where possible
- Carefully choose the **location** of conferences
 - Problem: what about **remote universities**?
 - At least, avoid choices motivated by **touristic appeal**
- Optimize **on-site arrangements**: transportation, food, catering, etc.¹³
- **Co-location**: multiple conferences in one place (e.g., Federated Computing Research Conference, Federated Logic Conference...)
- **Bi-location**: multiple places for one conference (e.g., MFPS'22, Paris and New York)

¹³See for instance the handbook of the ICEP'19 conference

Radical change: make conferences virtual!

- **Suddenly became reality** because of the COVID-19 pandemic
- Have of course a **much lower** carbon footprint (at least 10-fold)¹⁴
- Complicated to draw **conclusions** from this “experiment”:
 - Online conferences during COVID-19 were prepared on **short notice**
 - We were missing the right **software**, skills, and practices
 - Tendency to **reproduce exactly** the format of in-person conferences
- The **outcome**:
 - **Talks** worked fine, but they were not the most important
 - People soon stopped **attending** talks given by others
 - For socializing, networking, etc.: **missing the right solutions**
 - breakout rooms? online spaces (WorkAdventure, Gather.town)? virtual reality? metaverse?

¹⁴Tao et al., *Trend towards virtual and hybrid conferences may be an effective climate change mitigation strategy*, Nature Communications, 2021

Drawbacks of in-person conferences

These were not widely discussed before:

- **Travel time** (hours or days per participant)
 - **Cost** (hundreds or thousands of dollars per participant)
 - **Inclusiveness** towards:
 - **Underfunded** participants, e.g., students, developing countries
 - **Visa restrictions**, e.g., developing countries
 - **Caretaking obligations**, in particular affecting **women**
- “Attendance by women increased **between 60% and 260%** at ICLR, AAS and NAMS VCs compared to the [in-person conference] baselines”¹⁵

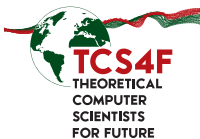
Online conferences are **worse** for the privileged few and **better** for those who wouldn't attend otherwise!

¹⁵Skiles et al., *Conference demographics and footprint changed by virtual platforms*, Nature Sustainability, 2021

Our action: TCS4F

In 2020 we started an **initiative** to reduce the footprint of our conferences:

THE EARTH IS WARMING UP!
THEORETICAL COMPUTER SCIENCE
SHOULD NOT BE PART OF THE PROBLEM!



SIGN THE TCS4F PLEDGE
AND COMMIT TO REDUCING
YOUR GREENHOUSE GAS EMISSIONS

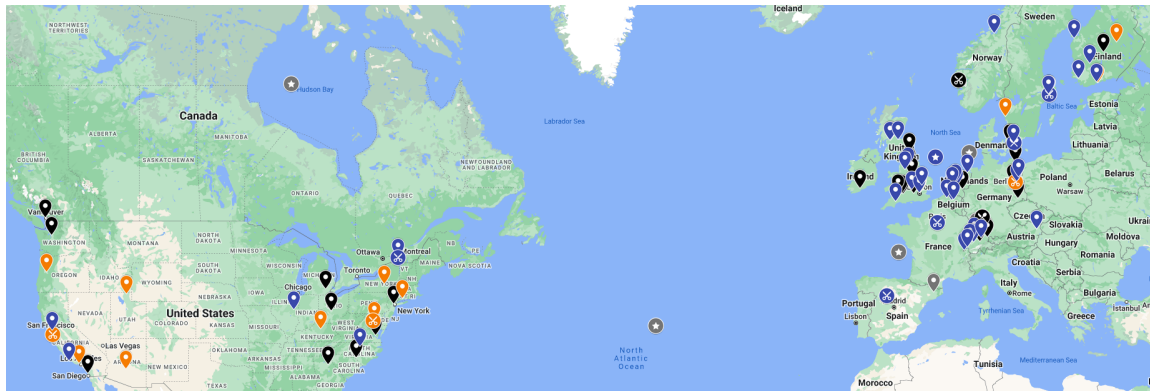
TCS4F.ORG

- **TCS4F**: Theoretical Computer Scientists for Future
- A **pledge** to commit to a 50% decrease of emissions by 2030
 - 4 signing conferences
 - 3 signing research groups
 - 191 individual signers
- Monitoring how TCS conferences are **resuming** after COVID:
[https://tcs4f.org/
how-are-tcs-conferences-adapting-after-covid-19](https://tcs4f.org/how-are-tcs-conferences-adapting-after-covid-19)

Similar initiatives in **many other fields**: Astronomers for Planet Earth, No Fly Climate Sci, Faculty for a Future, Scientists for Future. More pointers on flyingless.org and flyinglessresourceguide.info

Local actions

More and more **universities** measure their CO₂ footprint and commit to reducing it



Source: <https://www.google.com/maps/d/viewer?mid=1v49WXCeLrpWkeQFv12xIak8qrTvV7jGe>

Inspiring examples: ETH Zürich, University of Montreal

Actions at other levels

allea | All European Academies



**Towards Climate
Sustainability
of the Academic System
in Europe and beyond**

ALLEA Report | May 2022

- **Conferences:** at least preserving a **hybrid** component, or allowing **publication without travel** (Moshe Vardi's proposal)
- **National communities**, e.g., **Labos1point5** in France
- **Funding agencies** could measure the impact of the research that they finance

More pointers: *Towards Climate Sustainability of the Academic System in Europe and beyond*, report by ALLEA (European Academies of Sciences)

A personal perspective

- COVID-19 forced a **change** and left **technical skills** but not a **willingness to change**
- Formal conferences will resume, but we can hopefully make participation **optional**
- Some travel now seen as **unnecessary**, e.g., committee participation
- We can advocate for **positive action** like new seminars (researchseminars.org), local conferences, etc.
- It's harder to sell **negative action**, and conference boycotts are **invisible**
- Mentalities have **not evolved**: people boast about travel, they aren't ashamed of it
- Unfortunately academics are **slow to adapt**: can change come **from outside**?

A personal perspective

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Thanks for your attention!

Thanks to Louis Jachiet and Tristan McCowan for feedback on the slides.

Supplementary Material

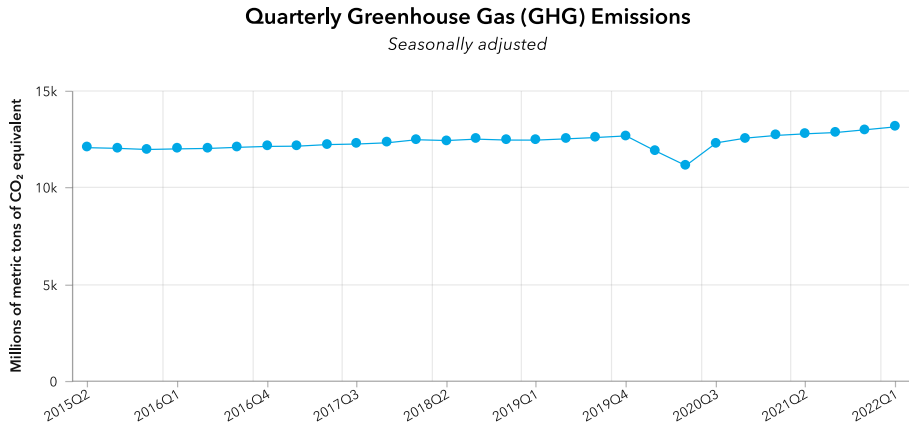
Image sources

- Slide 9: https://en.wikipedia.org/wiki/File:NASA_and_NOAA_Announce_Ozone_Hole_is_a_Double_Record_Breaker.png (public domain)
- Slides 13–14: Allie Brosh, Hyperbole and a Half:
<http://hyperboleandahalf.blogspot.com/2010/06/this-is-why-ill-never-be-adult.html>
- Slide 15: [https://commons.wikimedia.org/wiki/File:Protester_holding_a_banner_with_the_message_%22System_change,_not_climate_change%22_\(51525653745\).jpg](https://commons.wikimedia.org/wiki/File:Protester_holding_a_banner_with_the_message_%22System_change,_not_climate_change%22_(51525653745).jpg) (cropped), Ivan Radic
<https://www.flickr.com/people/26344495@N05>, CC BY 2.0
- Slide 16: <https://openclipart.org/detail/202668/academic-cap> by pnx, public domain.
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- Slide 20: <https://openclipart.org/detail/27362/postcard>, by coredump, public domain.

Supplementary slides:

- Slide 8: <https://openclipart.org/detail/314662/us-bombers-scale-chart> by GDJ, public domain
- Slide 10: <https://www.flickr.com/photos/purpleslog/2881603057>, User “Purple Slog” on Flickr, CC-BY

What about the COVID-19 pandemic?



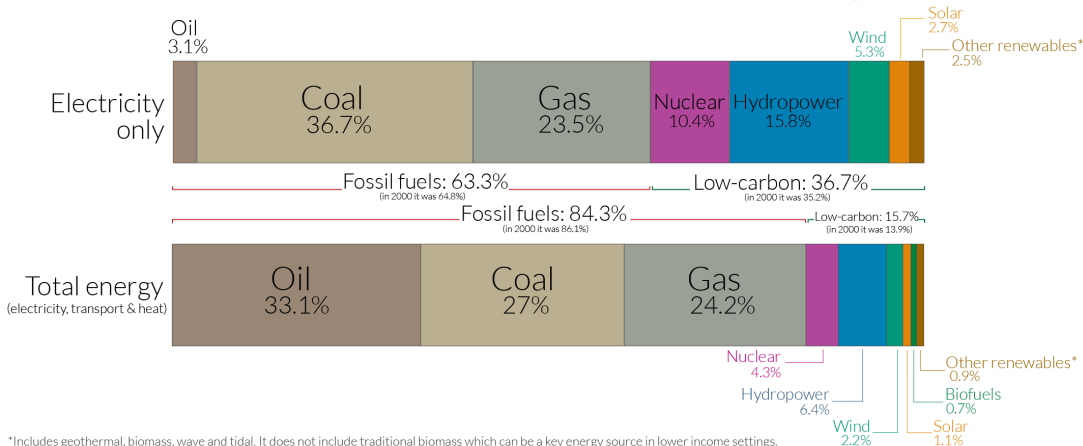
Sources: OECD Air Emission Accounts; UNFCCC; EDGAR; WRI, CAIT; IEA; OECD Quarterly National Accounts.

<https://climatedata.imf.org/pages/re-indicators>

Reminder: for 1.5°C warming, we must **divide by two** by 2030

Electricity and energy (source: Our World in Data)

More than one-third of global electricity comes from low-carbon sources; but a lot less of total energy does



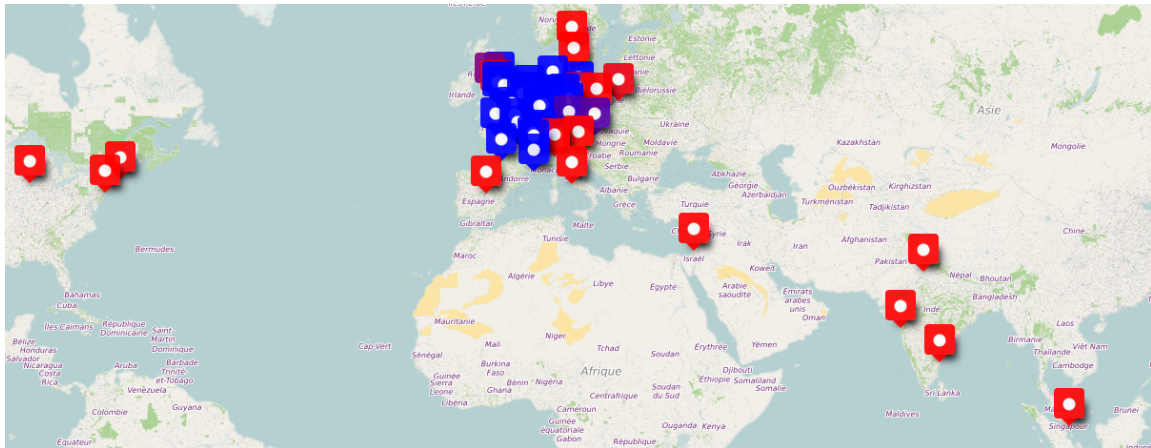
*Includes geothermal, biomass, wave and tidal. It does not include traditional biomass which can be a key energy source in lower income settings.

OurWorldinData.org – Research and data to make progress against the world's largest problems.

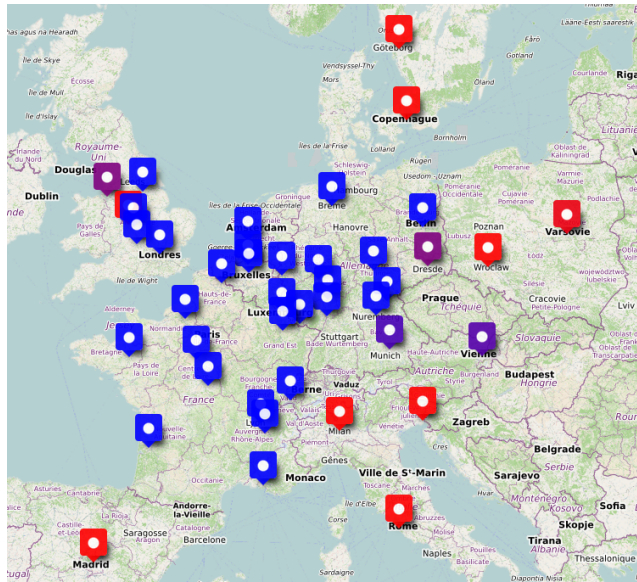
Source: Our World in Data based on BP Statistical Review of World Energy (2020). Based on the primary energy and electricity mix in 2019.

Licensed under CC-BY by the author Hannah Ritchie.

From where and how did participants travel?



From where and how did participants travel? (zoom on Europe)



Carbon footprint of plane travel

Why does **plane travel** emit greenhouse gases?

- Immediate: **burning fuel** (often the only thing considered):
 - 3.16 tonnes of CO₂ for 1 tonne of aviation fuel burned¹⁶
 - Consumption per trip depends on engine model, winds, plane weight, distance...
 - Consumption per passenger depends on **load factor** and **class** (economy, business...)
 - Also: **indirect emissions** from fuel production (refining)
 - Also: **life-cycle emissions** of producing the aircraft, other airline operations...
 - Also: other effects such as **nitrogen oxide** emissions and **contrails** (water vapor)
- Several methodologies, more or less precise¹⁷

As of 2021, total emissions estimated at about **3 times** the effect of CO₂¹⁸

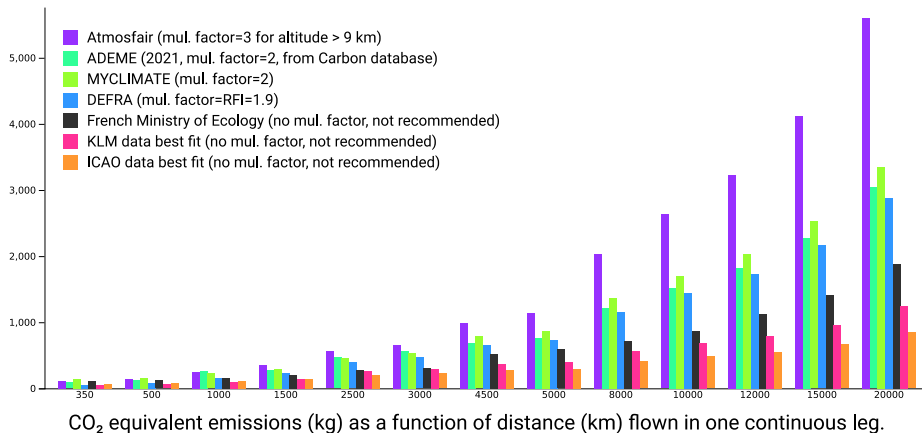
¹⁶ICAO Carbon Emissions Calculator Methodology v11

¹⁷See the notion of “Tier” in the 2006 ICPP Guidelines, Volume 2, Chapter 3, Section 3.6.

¹⁸Lee et al., The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018, Atmospheric Environment, 2021

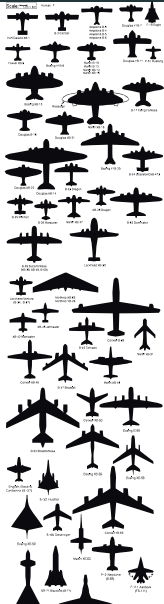
Carbon footprint of plane travel: uncertainty

Considerable difference in estimates! **More research** needed!



Source: <https://travel-footprint-calculator.irap.omp.eu/>

Cleaner aviation prospects



- Continuous **efficiency gains** on fuel consumption (but already heavily optimized)
- **Aviation biofuels**, partly based on non-fossil biomass, not always sustainable
- **Electrofuels**, using **renewable** electricity to produce standard fuels
- **Further prospects**: electric aircraft, hydrogen-powered aircraft
- Design alternatives, e.g., composite aircraft
- Other marginal gains: route optimization, ATC optimization, ground operations, etc.

Opinion: this is **encouraging** but **unlikely to matter much by 2030** → we must fly less

Overall impact of air travel

- Overall estimated contribution: **3.5% of total man-made radiative forcing**¹⁹
- 11% of international transportation is **business and professional travel**²⁰
- Traffic **doubles every 15 years** and trend is expected to continue²¹
- The emissions of international flights are not part of **national emissions targets**²²
- Also **inequalities**: many people do not fly, reducing flights is easier than, e.g., food
- Plane technology can **improve** but probably not much by 2030

→ We must fly less!

¹⁹Lee; et al. (2021), "The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018", Atmospheric Environment

²⁰<https://www.e-unwto.org/doi/pdf/10.18111/9789284422456>

²¹Airbus Global Market Forecast, 2019

²²Peeters et al., "Are technology myths stalling aviation climate policy?"

Problems of political action

- **Global problem:** must get countries to agree to large and individually disadvantageous measures
- **International meetings:** problems of **representativity** and **transparency**
- **Technically complex problem:** often poorly understood by citizens and decision-makers
- **Long-term issue:** other more pressing problems (COVID pandemic, energy crisis, war in Ukraine, etc.)
- **Gradual problem:** no clear tipping point (“boiling frog”)
- **Greenwashing:** difficult to identify real impact



Other difficulties

- Sometimes **debate** on the best solutions (e.g., nuclear power vs renewables)
- **Rebound effect**: efficiency gains sometimes cause larger consumption
- **Carbon offsets**: “reducing” emissions by sponsoring actions that presumably reduce carbon emissions elsewhere
- There is more to **ecology** than GHG emissions and climate change: biodiversity, pollution...

See for instance Lamb et al., “Discourses of climate delay”, Global Sustainability, 2020

Other in-system approaches

- **Fossil fuel divestment:** organizations that commit not to fund fossil fuel projects
→ But how to identify them? Precise accounting required!
- **Carbon emission trading:** give a price to GHG emissions and make emission quotas tradeable, to make it economically valuable to emit less
- **Other effects:** instability of fossil fuel prices, geopolitical aspects (e.g., gas during the Ukraine war)

Academic publications

A reminder about how **academic research** works nowadays:

- Researchers develop new **knowledge**, e.g., via experiments or proofs
- The knowledge has to be **published** for it to “count”
 - Usually “publish” means **making publicly available**
 - Here it means **accepted for publication** in a **peer-reviewed** journal or conference
- Professional researchers are **almost exclusively** evaluated by:
 - Their **number of publications**
 - The **prestige** of where they are published (according to some opaque rankings)
 - The **number of citations** that they attract (h-index etc.)