Climate Change and Computing: Introduction

Antoine Amarilli

June 27, 2022

Télécom Paris

The Impact of Our Research

Two ways to study the climate impact of our research:

- How will our research results help mitigate the climate crisis?
  - Positive: more efficient algorithms, new climate-aware applications…
  - Negative: other applications (proof-of-work, internet of things), rebound effect…
  - Overall information and communication technology is a high emitter:
    2.5% of GHG emissions in 2013, 4% in 2020, 8% in 2025 (forecast)[1]

- How do our research practices worsen the climate crisis?
  - Focus on academic conferences and other forms of travel

  → This is what the rest of the talk is about

[1] The Shift Project, Lean ICT – Towards Digital Sobriety, 2019

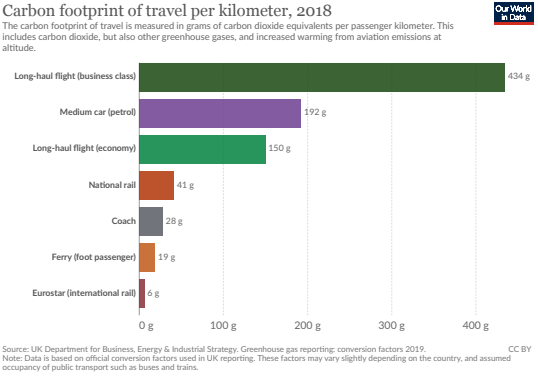
Goals and Orders of Magnitude

- Emissions per person in 2020[2]:
  - World: 4.47 tons CO_2e
  - Europe: 6.61 tons CO_2e
- 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 CO_2e[3]
- By comparison, a Paris–Copenhagen return flight is 0.5 tons CO_2e[4]

[2] Our World in Data
https://ourworldindata.org/co2-emissions#per-capita-co2-emissions
[3] OXFAM study *https://www.oxfam.org/en/research/carbon-inequality-2030*
[4] Source: *https://labos1point5.org/ges-1point5*

How Do Conferences Emit CO_2?

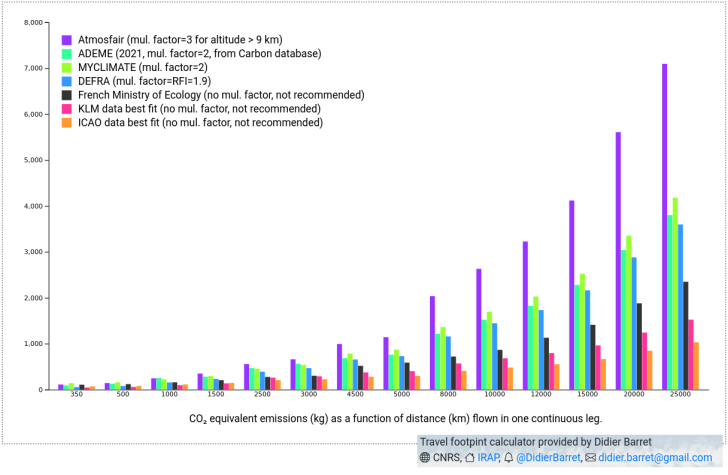
Main factor by far: flights by conference participants



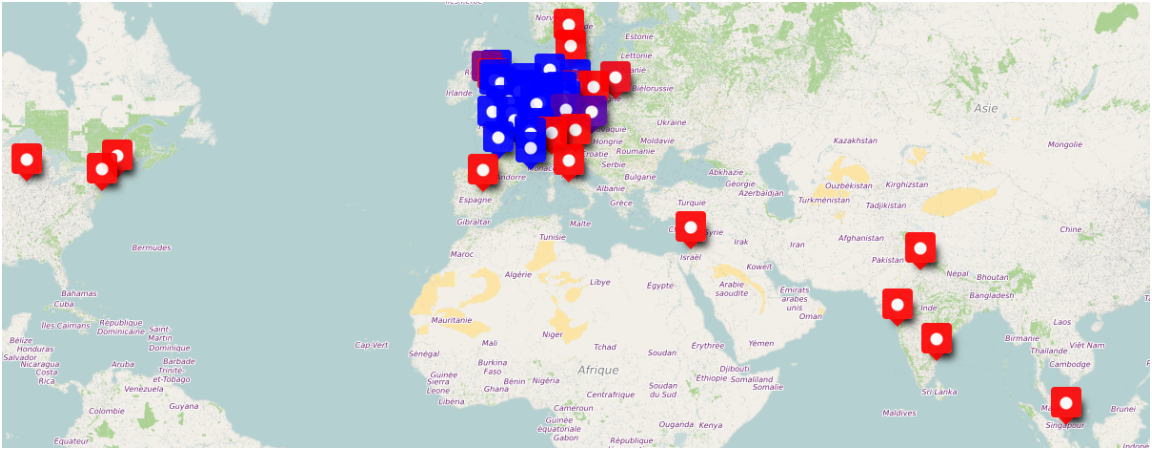
- Reduce the total distance flown by remote participants who need to fly
- Use trains/coaches instead of planes when possible

Estimating the Carbon Footprint

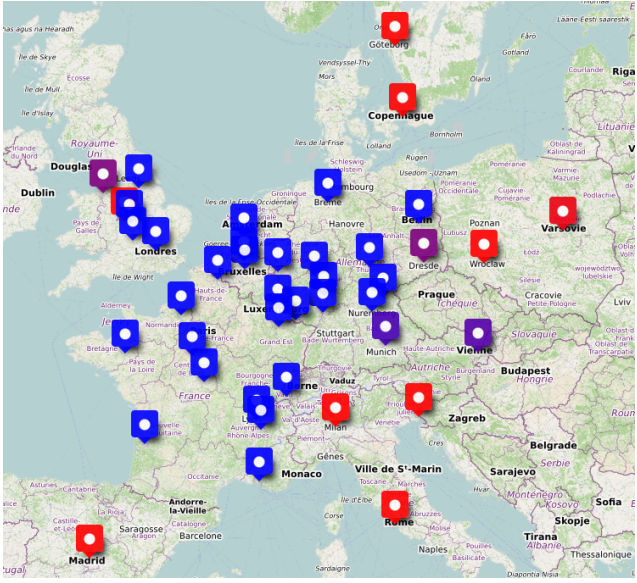
Large uncertainty on plane emissions! (and on rail). We use Labos1point5/Ademe data



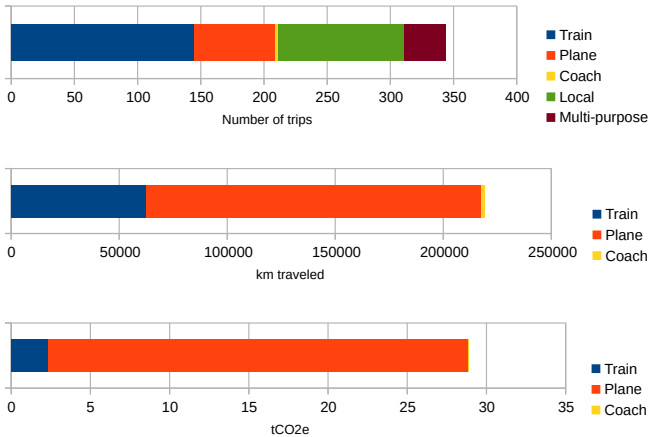
Places for CSConf'22 (172 participants, in Paris)



Places for CSConf'22 (172 participants, in Paris)

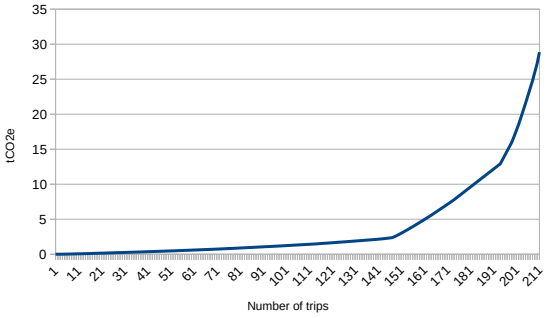


Results for CSConf'22 (172 participants, in Paris)



- 29 tCO_2e — the yearly footprint of 6.5 people today, 13 people in 2030
- What matters is flights, especially long flights

Cumulative Emissions for CSConf'22



To divide the carbon footprint by 2:

- Remove the 15 most emitting trips (out of 344)
- Reduce by 66% on the 40 most emitting trips

What Can We Do?

Step 1: Commit to a Goal

tcs4f.org

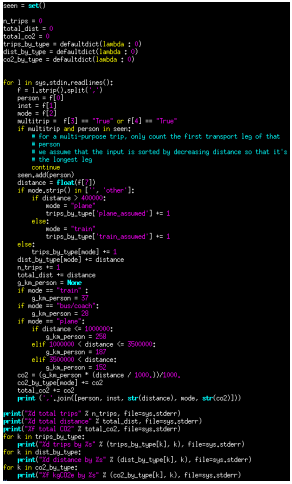
- IPCC goal: reducing our emissions by at least 50% before 2030
- TCS4F: a manifesto for (theoretical) computer science conferences
- Idea: commit to an objective, then discuss on the means
- Can be signed by ACM DEBS or by individual researchers
- (Disclaimer: I am a maintainer of TCS4F.)

The following conferences have committed to the 50% objective:

Name	Full name
CSL	Annual Conference for Computer Science Logic
HIGHLIGHTS	Highlights of Logic, Games and Automata
ICALP 2022	49th EATCS International Colloquium on Automata, Languages and Programming
STACS	International Symposium on Theoretical Aspects of Computer Science

Step 2: Measure Emissions

- You can't reduce what you don't measure
- Make methodology and anonymized data public
  - Ensures reproducibility across editions
  - Can revise previous computations
  - Can inspire other conferences



```
seen = set()

n_trips = 0
total_dist = 0
total_co2 = 0
trips_by_type = defaultdict(lambda : 0)
dist_by_type = defaultdict(lambda : 0)
co2_by_type = defaultdict(lambda : 0)


for l in sys.stdin.readlines():
    f = l.strip().split(',')
    person = f[0]
    inst = f[1]
    mode = f[2]
    multitrip = f[3] == "True" or f[4] == "True"
    if multitrip and person in seen:
        # for a multi-purpose trip, only count the first transport leg of that
        # person
        # we assume that the input is sorted by decreasing distance so that it's
        # the longest leg
        continue
    seen.add(person)
    distance = float(f[5])
    if mode.strip() in ['', 'other']:
        if distance > 400000:
            mode = 'plane'
            trips_by_type['plane_assumed'] += 1
        else:
            mode = 'train'
            trips_by_type['train_assumed'] += 1
    else:
        trips_by_type[mode] += 1
    dist_by_type[mode] += distance
    n_trips += 1
    total_dist += distance
    g_km_person = None
    if mode == 'train' :
        g_km_person = 57
    if mode == 'bus/coach':
        g_km_person = 28
    if mode == 'plane':
        if distance <= 1000000:
            g_km_person = 258
        elif 1000000 < distance <= 3500000:
            g_km_person = 187
        elif 3500000 < distance:
            g_km_person = 192
    co2 = (g_km_person * (distance / 1000.))/1000.
    co2_by_type[mode] += co2
    total_co2 += co2
    print (','.join([person, inst, str(distance), mode, str(co2)]))

print('%d total trips' % n_trips, file=sys.stderr)
print('%d total distance' % total_dist, file=sys.stderr)
print('%f total CO2' % total_co2, file=sys.stderr)
for k in trips_by_type:
    print("%d trips by %s" % (trips_by_type[k], k), file=sys.stderr)
for k in dist_by_type:
    print("%d distance by %s" % (dist_by_type[k], k), file=sys.stderr)
for k in co2_by_type:
    print("%f kg/CO2 by %s" % (co2_by_type[k], k), file=sys.stderr)
```

Step 3: Change

- Have hybrid conferences, like DEBS'22
  - → Complicated! Timezones, audio/video, social interaction...
  - → Host meetups for virtual conferences or distant conferences? (like NeurIPS)
- Have virtual conferences, e.g., every other year
  - → How good can they become?
- Co-locate with a relevant conference
- Encourage participants to stay longer (research visits, etc.)
- For conferences with formal proceedings: allow remote presentations
  - → Other reasons for this: inclusivity, etc.
- Formal proceedings: publish less in conferences and more in journals
  - → Or have journals that work like conferences

Bad Idea: Carbon Offsets

- An alluring idea: pay money (around 23 EUR/tCO2e) to reduce emissions elsewhere
- In practice, many problems:
  - No guarantee on emission decrease
  - No satisfactory oversight
  - Mostly repackaging of existing savings

Questions for discussion

- Should we turn formal conferences into journals?
- Which hybrid models work well?
- How should we co-locate conferences?
- Are you ready to reduce your plane travel?
- What do you think online conferences will become?
- Will the world need CS research in 2050? in 2100?