

INTERACTIVE

POSTER

# CO<sub>2</sub> Emissions from Theoretical Physics Research?

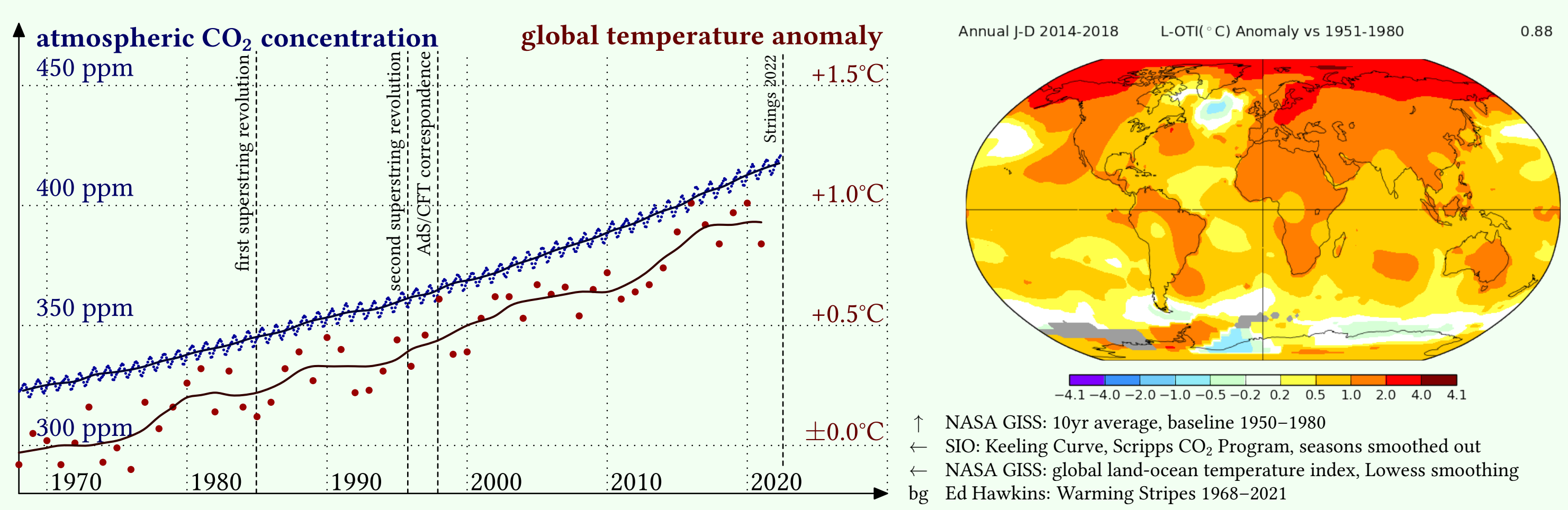
YOUR THOUGHTS?

Niklas Beisert (Zürich), Nils Carqueville (Wien) et al.  
Strings 2022 Poster Session – 18 July 2022

**Abstract:** Global Warming is a clear and present danger for humankind. Halting it in time will require technological advances and societal changes at impressive scales and rates. Both, Global Warming and mitigation efforts will have an impact on the way we conduct research. What should we do? What will you do?

## Global Warming (GW) in a Nutshell

**Data:** Keeling Curve, Temperature Anomaly



### Basic Mechanism of Global Warming:

- Combustion of fossil fuels leads to CO<sub>2</sub> emissions (underground → atmosphere).
- CO<sub>2</sub> is long-term stable in atmosphere (integral of emissions matters).
- Greenhouse effect: atmospheric CO<sub>2</sub> (and other greenhouse gases) cause GW.

Other relevant contributions: land use, deforestation, livestock, tipping elements, ...

**Detailed Climate Research, Summary:** IPCC Assessment Reports; latest: AR6 (2021/22)

## Budgeting CO<sub>2</sub>-eq Emissions Towards Net-Zero

**Paris Agreement (2015):** International agreement to take all necessary steps to keep GW below +1.5°C or at most +2.0°C. It is based on negotiations and compromises.

**Climate Impact Research:** IPCC SR1.5 (2018), AR6/WG2 (2022).

Expected consequences: • extreme weather events • infrastructure damage • loss of harvest • mass migration • social unrest • armed conflicts • ...

GW can be halted by **net-zero emissions** only.  
1.5°C / 2.0°C goal still within reach; **requires:**

- immediate emission reductions;
- net-zero by around 2035 / 2050;
- negative emissions: CO<sub>2</sub> capture and storage.

How about **Theoretical Physics research** context?

Some **rough estimates** for emissions (CO<sub>2</sub>-eq):

computer hardware	0.2–1 t
computer operation	0.0002–0.5 t/yr
European return flight	0.3–1.5 t
intercontinental return flight	2–12 t
infrastructure, buildings, catering	...

<b>emission budget figures</b> (CO <sub>2</sub> -eq)	
total remaining budget	300–1000 Gt
– per capita (global)	<b>50–150 t</b>
total emission rate	~ 40 Gt/yr
– per capita (Austria)	7–11 t/yr

<b>electricity emission estimates</b>	
fossil	500–800 g/kWh
renewable	10–50 g/kWh

<b>travel emissions comparison</b>		
mode	1000 km	annotations
flight	0.2–0.3 t	RFI factor 2
car	0.1–0.2 t	single, fossil fuel
train	0.001–0.08 t	power source

## If Wishes were Fishes... What are your Suggestions on Sustainability Aspects of Theoretical Physics (TP) Research?

- **Invitation:** Consider and/or discuss with people around you any of the following aspects.
- **Activity:** Write your thoughts or suggestions on a sticky note and paste it into the blanks. Agree / disagree with other notes by adding green / red dots, respectively (max. 3 each).
- **Definitions:** Below, “we”, “our” refers to: scientists in a field of Theoretical Physics (TP) conducting research (including all related activities).
- **Disclaimer:** Provided replies may be reproduced, reused or recycled in aggregated and anonymised form.

### 1. Impact of GW on TP Research

Will progressing Global Warming or mitigating efforts have a detrimental impact on Theoretical Physics research? Why (not)? • Do you consider Theoretical Physics research resilient in this regard?

Handwritten sticky notes in heart shapes. One says: "I consider Theoretical Physics to be resilient because it can be done from almost anywhere. There will be no impact, but it will affect the environment." Another says: "Global warming is a threat to all of us, even if it doesn't affect evenly everyone." A third says: "However, string theorists will be highly flexible to switch to another job, which might be more helpful." A fourth says: "We are absolutely not resilient! In a few years, nobody will care about string theory, so what is our work worth then?"

### 2. Impact of TP Research on GW

Do you think research in Theoretical Physics causes relevant amounts of CO<sub>2</sub> emissions? Why (not)? • Are we on track towards net-zero CO<sub>2</sub> emissions? When and how should this be achieved?

Handwritten sticky notes in heart shapes. One says: "We could reach net 0 CO<sub>2</sub> 1) no flights anymore, as soon as possible? 2) no only possible if conferences can be held online, such that it makes sense." Another says: "NOT MORE THAN MOST OTHER 'OFFICE JOBS'. I BELIEVE LARGE SCALE CHANGE IN LAWS REGARDING TRAVEL, LEADERSHIP INDUSTRY AND MOBILITY ARE OF MORE IMPORTANCE." A third says: "Large conferences are CO<sub>2</sub> inefficient. Maybe their time is over?"

### 3. Realised Steps in TP Research

What steps have you / your group / institution taken to reduce the climate impact of your research? • Do you think the heads, leaders, or organisers in our field approach sustainability issues well? Why (not)?

Handwritten sticky notes in heart shapes. One says: "Limitation of emissions for private flights." Another says: "I can do and I really do 1) reduce the amount of travel (avoid flights) 2) use public transport 3) use all shared resources." A third says: "Rules can still be set by the heads of departments."

### 4. Sustainable Research Activities in TP

How would Theoretical Physics research be different in a society at net-zero CO<sub>2</sub> emissions? Describe your thoughts / vision. • What roles do you attribute to change of habits, reduction, compensation and CO<sub>2</sub>-capture? What about scalability and time frames?

Handwritten sticky notes in heart shapes. One says: "x86 → RISC-V". Another says: "We need a 'Unified Field Theory' of action on climate change. And we need it soon!" A third says: "I don't think cutting down on office conference activity is feasible. There should be an emphasis on increased productivity and adoption of remote work." A fourth says: "Maybe students / postdocs should be allowed to work from home / during the week. The remaining time to the supervisor is probably just contributing to a waste."

### 5. Steps to be Taken in TP Research

What steps are yet to be taken to align our research culture with climate sustainability requirements? • Who should bring forward / impose rules towards limiting CO<sub>2</sub> emissions in our research activities?

Handwritten sticky notes in heart shapes. One says: "Good online conferences, no coffee breaks online & interaction with talks." Another says: "USE OUR CREATIVE & COMPUTATIONAL SKILLS TO CREATE GOOD ONLINE CONFERENCES." A third says: "We could try to limit wasteful behaviour such as cooling or heating offices the whole day." A fourth says: "Why restricting to the conferences? Our skills can be helpful in a much broader sense."

### 6. Responsibility to Research and Society

Which CO<sub>2</sub> reduction measures should we not impose on ourselves? Can you provide equally effective alternatives? • What exceptions can we claim to retain / obtain higher than average CO<sub>2</sub> budgets? We would need solid arguments.

Handwritten sticky notes in heart shapes. One says: "I think we should be willing to sacrifice more than others because of the privilege we have." Another says: "TP researchers are privileged, we should try to go forward in a good example."

### 7. Comments and Feedback

Should sustainability issues play a more prominent role in our professional life? Why (not)? • Do you have any other related remarks?

Handwritten sticky notes in heart shapes. One says: "Yes, I think more people do not mind about their emissions caused by conferences." Another says: "Not, we can set a good example?" A third says: "Thanks for identifying clearly a few points about personal contributions to the cause." A fourth says: "Damn, it is so dangerous! And everybody tries to calm themselves and not to think about it! We are analytic thinking people. If we cannot convince ourselves of investigate the problem, often nobody can! So let us start solving the problem now! And not put it aside as we do so far!"

### References

Selected sustainability references and efforts (further references therein):

- IPCC Reports (e.g. SR1.5, AR6; SPMs)
- Sustainable HEP Workshop 2021 & 2022
- White Paper: Sustainability in HECAP (in preparation)
- ALLEA: “Towards Climate Sustainability of the Academic System in Europe and beyond” (2022)
- “Towards Sustainability in Research at D-PHYS/ETH”
- “Estimate of the carbon footprint of astronomical research infrastructures”, Nature Astron. 6, 503 (2022)
- “An approach to less climate-impactful conferencing”
- ... many more individual & institutional initiatives.

