Being Green

Musings on sustainable computing & research

Sadie Bartholomew

CMS Weekly Meeting 20/06/2025

National Centre for Atmospheric Science
NATURAL ENVIRONMENT RESEARCH COUNCIL

1. Why is it important (read: why bother)?

(here I mean, of course, green as in ***sustainable***, and ***with respect to our work*** as opposed to reducing food waste at home or going vegan, etc.)

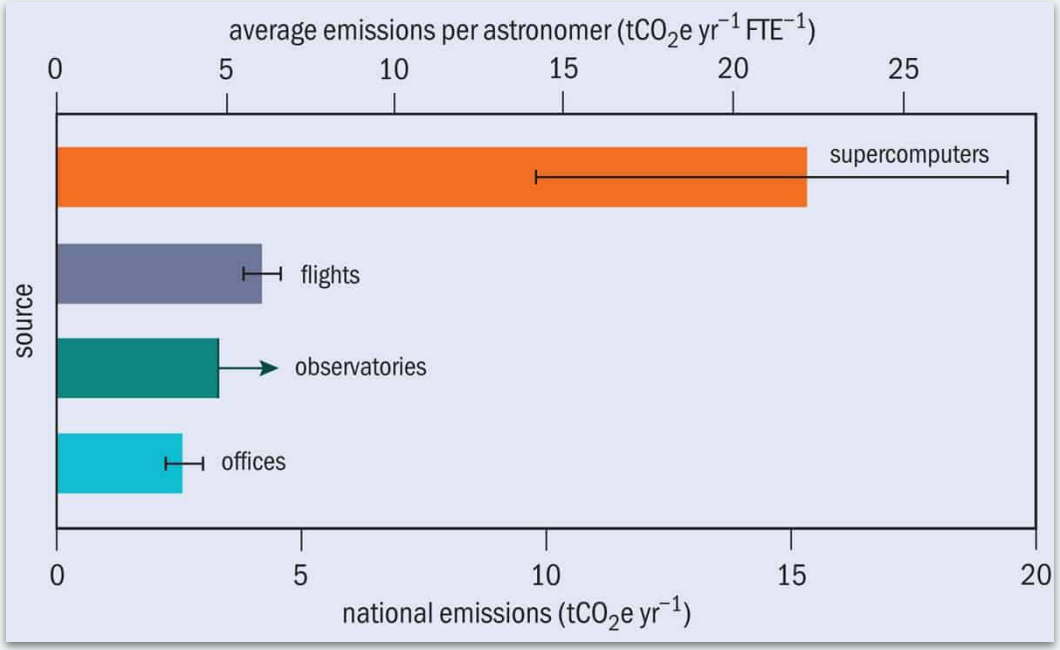
(Super)computer use: possible relative scale of environmental impact

- More need for HPC → more systems built, at larger scale → higher carbon footprint of HPC:

"For example, the *Summit supercomputer built in 2017 has a peak power consumption of 13 MW, while in 2021, the next-generational Frontier supercomputer has more than doubled the peak power to 29MW*"*

- Energy demands of data centers and HPC systems are expected to continue to increase significantly over the next few decades, driven partly by growing use of cloud services, AI, and machine learning models plus more need for data centers which are power hungry:

*"It is estimated that by 2030, datacenters and HPC systems may account for up to 8% of the worldwide emissions if not intervened"**



*Breakdown of the four sources of **Australian astronomers' emissions** considered in one study from 2019 †*

* B. Li et al., 2023, Toward Sustainable HPC: Carbon Footprint Estimation and Environmental Implications of HPC Systems
† A. Stevens et al, 2019, The imperative to reduce carbon emissions in astronomy

Digital research infrastructures and their impact: case study of UKRI as a whole

Emissions per year for digital research infrastructure

Large scale computing facilities: 40 kiloton CO2e/yr

UKRI DRI facilities average estimate

Server rooms and laptops: 35 kiloton CO2e/yr

Non-facilities equipment average estimate

15 kiloton CO2e/yr
(UKRI funded equipment)

plus:

20 kiloton CO2e/yr
(not UKRI funded equipment)

Both are equally important contributors to emissions from UKRI funded research.

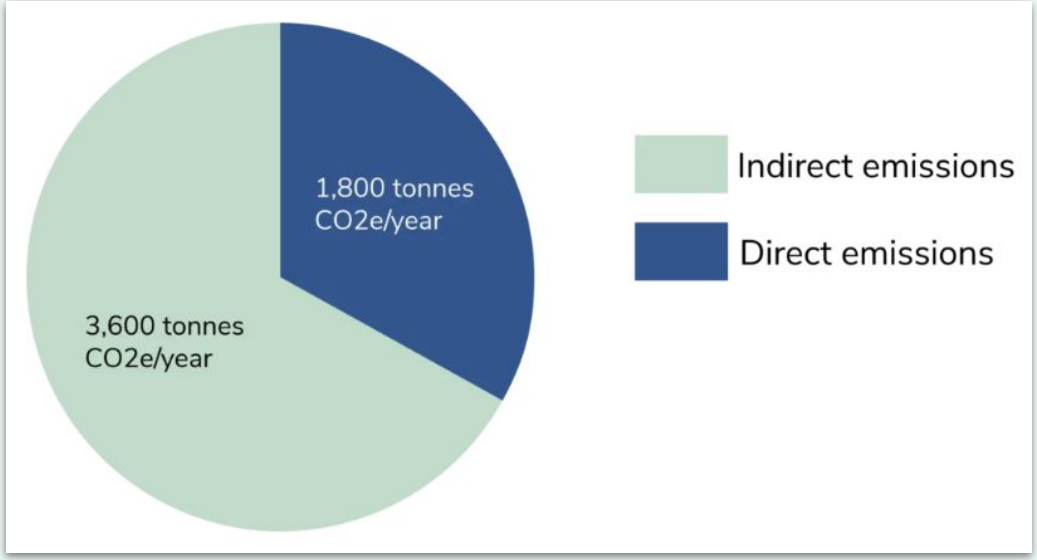
There is a large uncertainty on these figures.
Averages have been used for the purpose of this infographic.

"The operation of digital infrastructure is not carbon neutral, and the carbon emissions associated with its expansion and use are significant and growing."

*Source: Sustainability in Digital Research Infrastructure UKRI Net Zero DRI Scoping Project final technical report, 2023, Juckes et al.

Carbon footprint of NCAS specifically

~5 years ago, as quoted from NCAS comms piece of ~ 2 years ago (Feb. 2023)*: "Using data collected for 2019, the current estimate for the NCAS baseline carbon footprint is 5,400 tonnes CO_2e a year"



- ⅔ of total 'indirect' vs. ⅓ of total 'direct' emissions, see left
- "The majority of our energy consumption emissions are indirect, as we have extremely limited operational control over energy demand and supply at most of our sites. We have included these emissions as leased assets. "
- Caveat: "Our carbon footprint assessment provides insights, but is by no means a complete picture."
- Of this, unclear how much pertains to computing/DRI usage from the piece at least

*Source: Review of carbon footprint of NCAS as described at: https://ncas.ac.uk/national-centre-for-atmospheric-science-carbon-footprint/

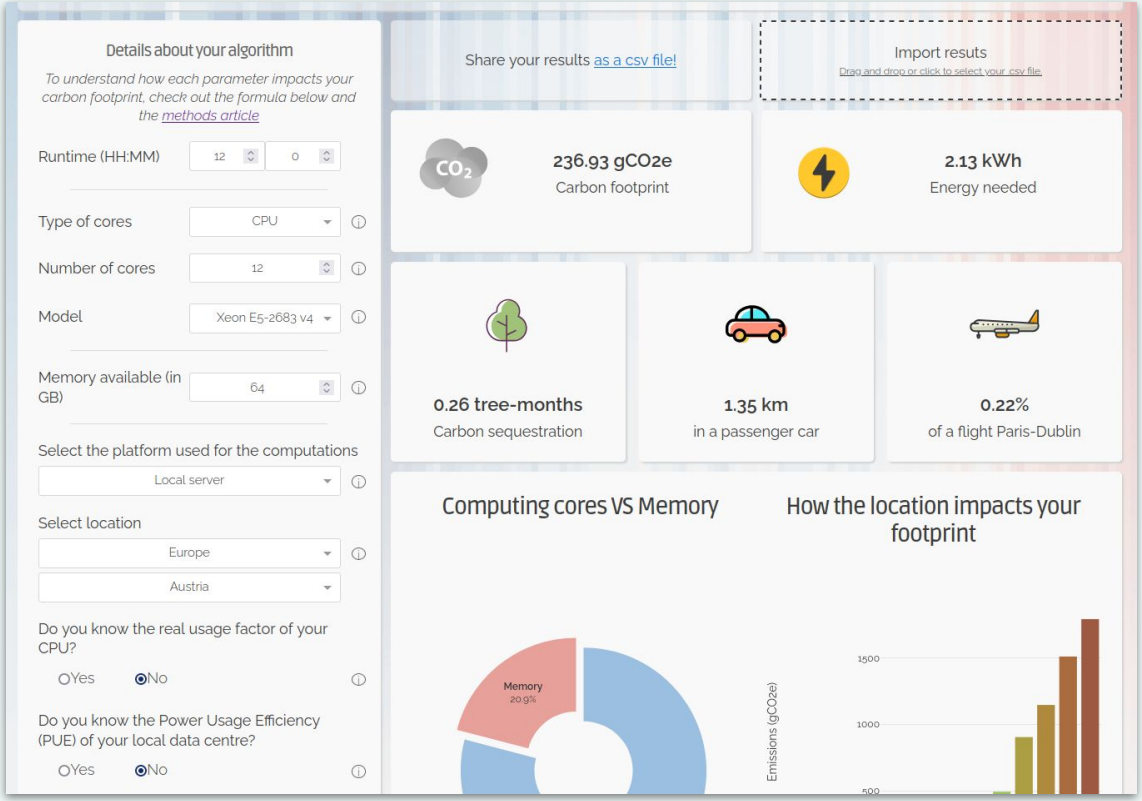
2. Initiatives to be aware of

Photos of trees around the Harry Pitt building from Jonathan Gregory's 'Whiteknights Trees Gallery' with photos from 2018–2025 (fantastic resource - I highly recommend a look): https://www.met.reading.ac.uk/~jonathan/trees/

Initiatives relating to sustainability in the research and RSE communities

1. The Environmental Sustainability Concordat: https://wellcome.org/about-us/positions-and-statements/environmental-sustainability-concordat
    - Wellcome Trust initiative signed by UKRI
    - ”The concordat represents a shared ambition for the UK to continue delivering cutting-edge research, but in a more environmentally responsible and sustainable way.”
2. Green DiSC: a Digital Sustainability Certification, https://www.software.ac.uk/GreenDiSC
    - “a new certification scheme which provides a roadmap for research groups and institutions who want to tackle the environmental impacts of their computing activities”

3. The Green Algorithms project, https://www.green-algorithms.org/: shown left is a screenshot of the ‘carbon footprint calculator’ tool distinguishing given algorithms run on given hardware
4. UKRI Net Zero Digital Research Infrastructure Scoping Project: https://net-zero-dri.ceda.ac.uk/:



- Led by a project team at CEDA!
- Scoping project funded by UKRI for £1.8 million to investigate how UKRI can achieve net zero computing
- The final technical report has now been published and is freely available for anyone to make use of: https://zenodo.org/records/8199984
- Six elements of the sustainable computing strategic toolkit: Mission Focus, Recognition of shared responsibility, Action-based-research, Work with peers and suppliers, Build and Share Knowledge, Green Software Engineering

What is NCAS doing regarding sustainability?

- The reading I did towards this presentation is the first step to my informal understanding and reviewing of what we are doing at NCAS on the subject
- I will talk more with Sophie Clay, our sustainability officer - hopefully at the Staff Meeting in a few weeks
- At NCAS: you can explore comms pieces on the subject which cover a lot of work: https://ncas.ac.uk/news-events/page/2/?category_name&tag=environmental-sustainability (uses tag ‘Environmental Sustainability’)
- For one, we are part of the Concordat for the Environmental Sustainability of Research and Innovation as of late 2024 and folk at CEDA co-authored the NERC DRI Scoping Project aforementioned

3. What I am doing on this topic (not just preaching)!

Photos of trees around the Harry Pitt building from Jonathan Gregory's 'Whiteknights Trees Gallery' with photos from 2018–2025 (fantastic resource - I highly recommend a look): https://www.met.reading.ac.uk/~jonathan/trees/

Specifically, 1. part of the Green RSE Special Interest Group (SIG)

- On the steering committee of a relatively new group, the Green RSE SIG, spun up late 2024 and officially launched in January 2025 with a dedicated online event bringing together a diverse group of voices from across the research software community
- See https://socrse.github.io/green-sig/, recently added website for the SIG
- 7 ‘GREENER Principles for Sustainable Computing’ have been devised by SIG member Loïc Lannelongue which are used to structure the aims and activities of the group:

  Governance, **R**esponsibility, **E**stimation, **E**nergy and embodied impacts, **N**ew collaborations, **E**ducation and **R**esearch

- I’ve taken the lead on *Governance* principle

Specifically, 2. Co-developing/maintaining the tool CATS

- CATS is a CLI tool that intelligently time shifts compute jobs to run them at the time that minimises carbon footprint across their expected duration, using real-time carbon intensity data from the National Grid ESO API
- Prototyped at SSI Collaborations Workshop 2023 Hack Day and the team continued our development with further funding from the SSI
- See codebase with links at: https://github.com/GreenScheduler/cats

```
~                                                    ✔ | cf-env-312  19:00:35
date
Mon  2 Dec 19:00:38 GMT 2024
~                                                    ✔ | cf-env-312  19:00:38
cats -d 30 --loc RG1

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WARNING:root:config file not found
WARNING:root:Unspecified carbon intensity forecast service, using carboninten
sity.org.uk

Best job start time                    = 2024-12-03 00:00:42.252413+00:00
Carbon intensity if job started now    = 270.48 gCO2eq/kWh
Carbon intensity at optimal time       = 192.91 gCO2eq/kWh
```

- I presented about CATS at a previous CMS weekly meeting and recently at CIUK in December 24 and Durham HPC Days earlier this week (slides available*)
- v1 targeting local workflows released last year, v2 for HPC/HTC application due for release this summer
- JOSS paper in review!

*E.g. see: https://github.com/sadielbartholomew/sadielbartholomew/blob/master/talks-and-workshops/CATS_Durham_HPC_Days.pdf

…and in general, aiming to raise awareness: Green DiSC site contact etc.

Bronze Criteria	Last updated: 20/11/2024
For research groups:	**For central teams:**
General	**General**
Nomination of a Green DiSC representative	Nomination of a Green DiSC representative
Computing sustainability is part of the induction procedure	Computing sustainability is encouraged to be included in induction procedures
Information and resources are shared with other groups engaging with sustainability.	There is a central institutional repository for sustainability resources
Dissemination of this program in the institution	Dissemination of this program in the institution
Offices	**Offices**
Inventory of office computing hardware	Inventory of the different purchasing streams for computing hardware
Identification of electronic waste processing streams	Identification of electronic waste processing streams
Identification of unused computing equipment	
Data Storage	**Data Storage**
Inventory of main data resources	Inventory of main data storage solutions
Implement regular cleaning of users own data directories	Regular cleaning of centrally-managed data storage
	Template and training resources for data management are made available centrally to all
Compute	**Compute**
Inventory of computing infrastructures used	Inventory of computing infrastructures
Inventory of the most demanding computing pipelines	Training on green computing best practices is offered centrally
Training on (green) computing best practices is provided	

- NCAS is evaluating the feasibility of joining the Green DiSC scheme s covered in section (2) of this presentation. First step is Bronze certification (criteria to left)
- I volunteered to be the ‘Green DiSC representative’ for CMS and NCAS@Reading - a contact to spread the word and in time understand what we are doing and what we need to work on for this

Summary: It's not easy bein’ green… but it is very important

- Be mindful that our environmental impact from our work may be more, or even dwarf, that from our home lives - even if we jet off to various lovely locations in holiday - remembering the UKRI and NCAS case studies and Australian astronomers’ emissions plot
- Can be seen as a ‘necessary evil’ for our line of work, but that doesn’t mean we can’t make (a bit of) effort to reduce the GHG emissions resulting from our work
- There is lots of work on this by various people and groups e.g. I outlined initiatives such as Environmental Sustainability Concordat, UKRI Net Zero Digital Research Infrastructure Scoping Project, Green DiSC and Green Algorithms
- I covered some work I am doing in this area - please come and talk to me about it if you want to discuss being green esp. in relation to your own particular line of work
- Let’s keep the conversations going on sustainability of computing and research!