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Responsible computing: minimising the environmental impacts of research

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NCAS Harmony in the Skies: Bridging Horizons in Atmospheric Science
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Context

Still image sourced from: The IT Crowd (TV show), Channel 4

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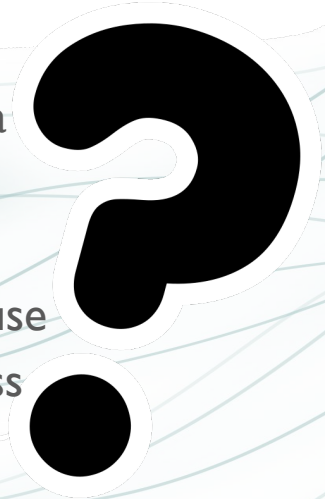
Overview

- Understand that **computing contributes significantly to climate change**
- Appreciate reasons that atmospheric and aligned research requires advanced infrastructure, high data volume and high power input
- Understand that integrity in research therefore involves being *wary about* our carbon footprint from computing and *careful not to heighten it, at least, and ideally reduce it*
- **Learn some general approaches to reducing our carbon footprint** from use of software (code), hardware (computers/machines) and data

Did you know ?

Related to the **greenhouse gas (i.e. CO_2e) emission from computing**:



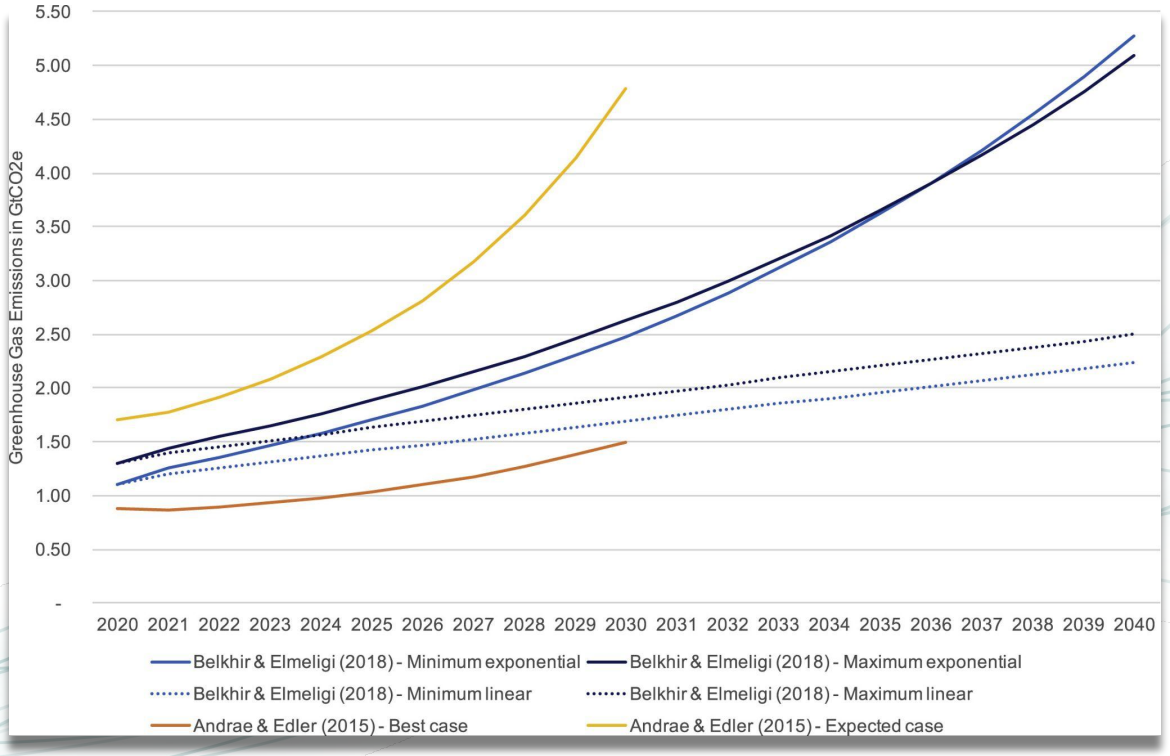
- IT sector was responsible for 2 - 6% of global CO2 emissions in 2020*, a share that could grow to 20% by 2030*
- UK power grid uses renewables but their availability varies so the 'cleanliness' of energy consumed depends on location and date/time of use
- Carbon footprint of an email: 0.3 gCO_2e if short and send to one address or 26 gCO_2e if taking 10 mins to write and sent to 100 people✝

For reference: CO_2e = 'carbon dioxide equivalent', amount of CO_2 with same global warming impact as a set mix of greenhouse gases, for ease of comparison. A European car emits an average of 175 gCO_2e per km, and flying from Paris to London emits 50,000 gCO_2e *.

*: Lannelongue L, Grealey J, Bateman A, Inouye M (2021) Ten simple rules to make your computing more environmentally sustainable. PLoS Comput Biol 17(9): e1009324. https://doi.org/10.1371/journal.pcbi.1009324

✝: The Carbon Literacy Trust, https://carbonliteracy.com/the-carbon-cost-of-an-email/

The consumption of computing: significant & increasing!



- Computing's global share is modest but growing at a much faster rate than many other energy-consuming sectors
- "ICT's footprint has likely grown faster than global emissions, with a very uncertain best estimate of twice as fast" † (though it is hard to estimate accurately, see plot †)

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† Source: 'The real climate and transformative impact of ICT: A critique of estimates, trends, and regulations', Freitag et al., https://doi.org/10.1016/j.patter.2021.100340

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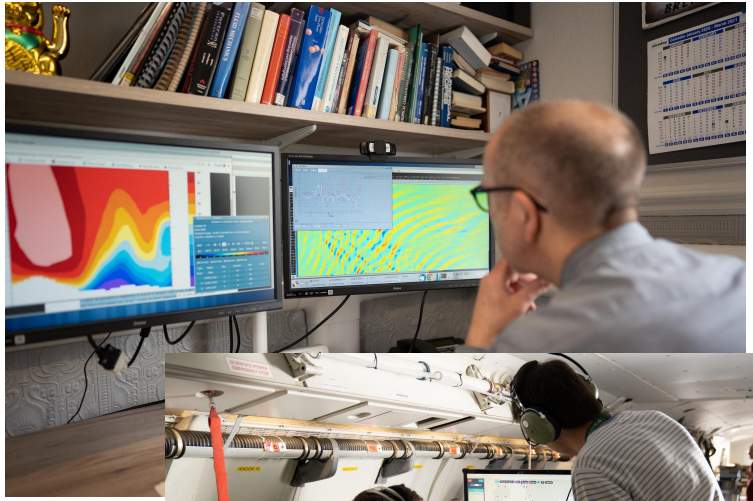
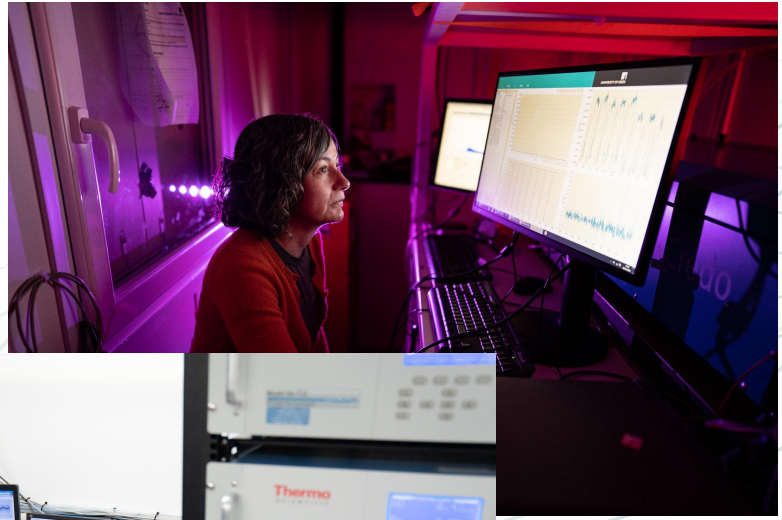
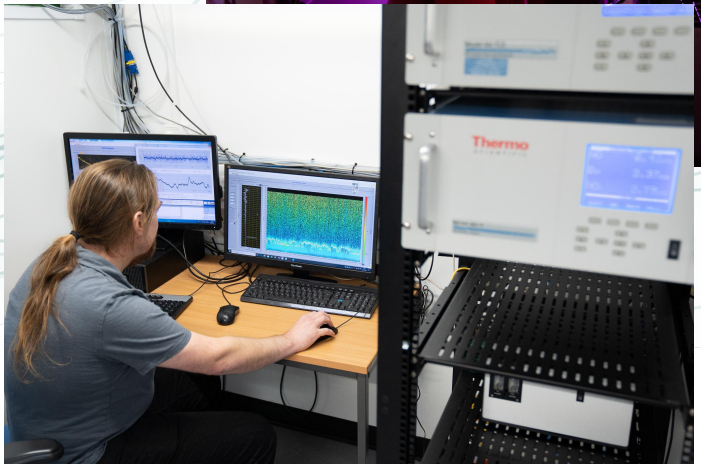
Many different forms of computing in (atmospheric) research







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Images from the NCAS flickr photo library: https://www.flickr.com/photos/195788208@N07/

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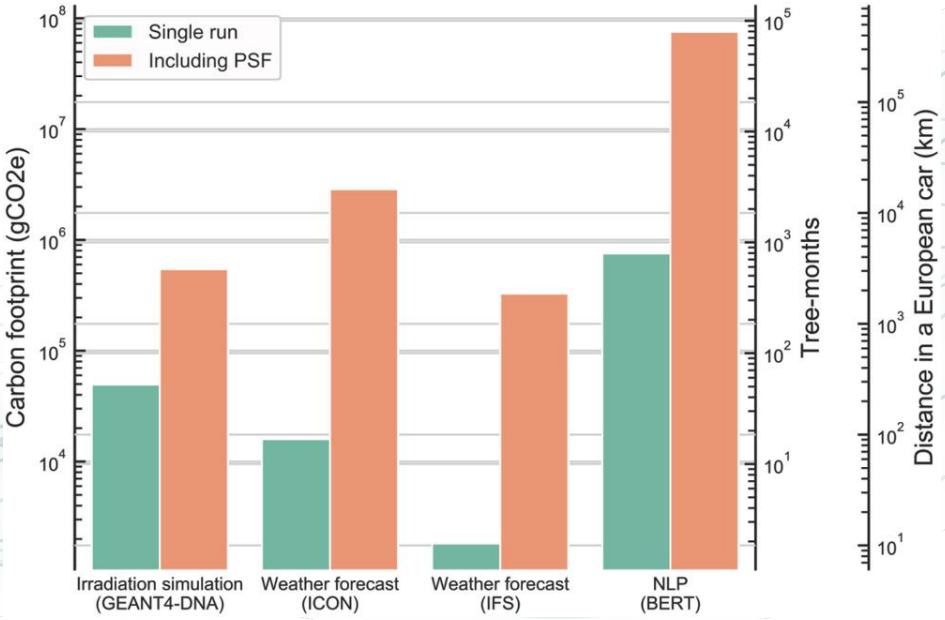
Computing in (atmospheric) research

Atmospheric science & similar research (earth sciences etc.) requires particularly sophisticated and intensive computing:

- observing, modelling and accurately simulating the Earth, a vast highly interconnected system, to high resolution, requires large amounts of data and modern supercomputers and therefore power consumption and storage etc.
- the domain is generally at the forefront of use of software (code), hardware (computers) and data (including storage e.g. data centers)



Carbon footprint (gCO2e) for a selection of algorithms. Source: 'Green Algorithms: Quantifying the Carbon Footprint of Computation' Lannelongue et al., https://doi.org/10.1002/advs.202100707

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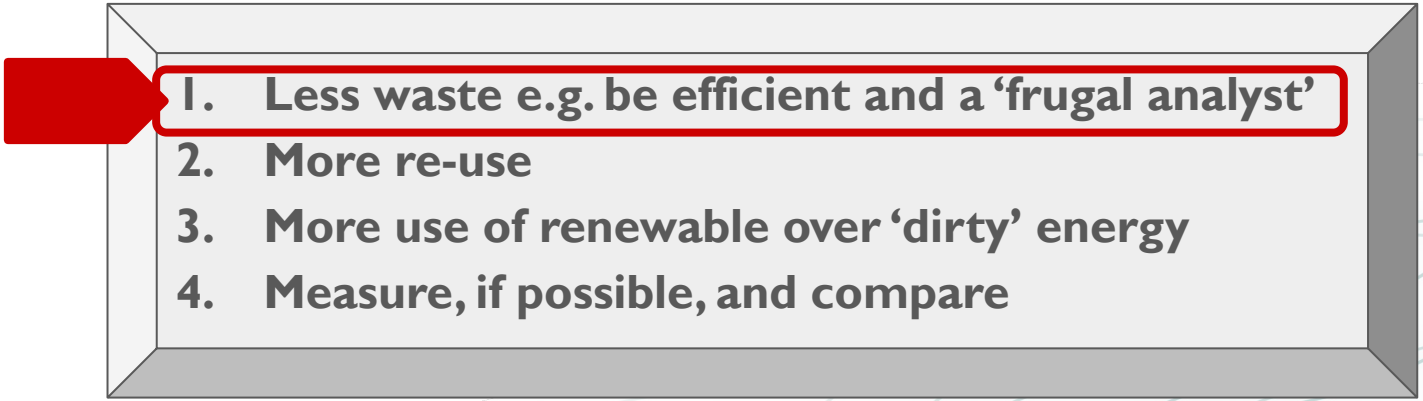
Green practice: approaches to reducing our impact

1. Less waste e.g. be efficient and a ‘frugal analyst’
2. More re-use
3. More use of renewable over ‘dirty’ energy
4. Measure, if possible, and compare

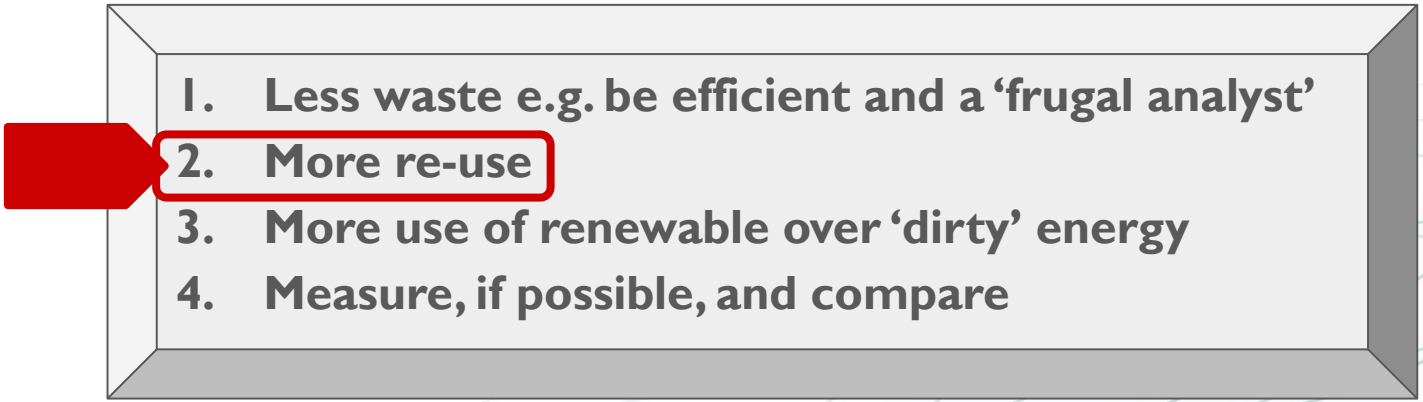
Green practice: approaches to reducing our impact



- **Be frugal**: only run jobs (e.g. code, commands) when you need and are ready to
- Design/validate to **fail early** with any issues in a workflow to avoid running jobs with bad output
- **Only use ML when necessary** (e.g. for AI chatbots, would a Google search suffice instead?). AI tools tend to have a huge carbon footprint to train and 'learn' as they are used (each ChatGPT query is estimated to produce 0.382 g CO2e per query*)

*: Pointon, C. The carbon footprint of ChatGPT (2022)

Green practice: approaches to reducing our impact



- Consider **manufacturing costs**: choose your machine well and keep, repair and re-use it where possible, with the help of your uni/organisation IT services
- Improve the **efficiency of your code(s)**, if feasible: often there can be small changes that make a big difference!
- Use **checkpointing and writing/storing of outputs** to make use of results from previous code or workflow runs instead of re-running them

Green practice: approaches to reducing our impact

1. Less waste e.g. be efficient and a ‘frugal analyst’
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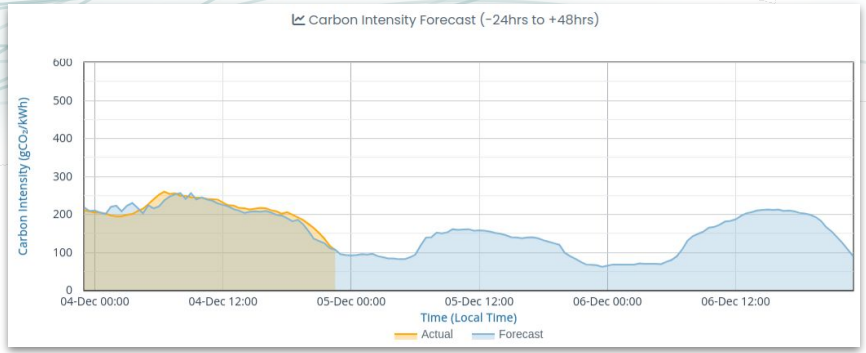
- Force **more use of renewables vs. ‘dirty’ energy**: run (or schedule) jobs for times when the carbon intensity of the power grid is lower…
- … or use machines which draw from cleaner energy (e.g. ARCHER2 is supplied by 100% certified renewable energy)



Plot: Carbon Intensity Forecast (-24hrs to +48hrs), from the Carbon Intensity API https://carbonintensity.org.uk/

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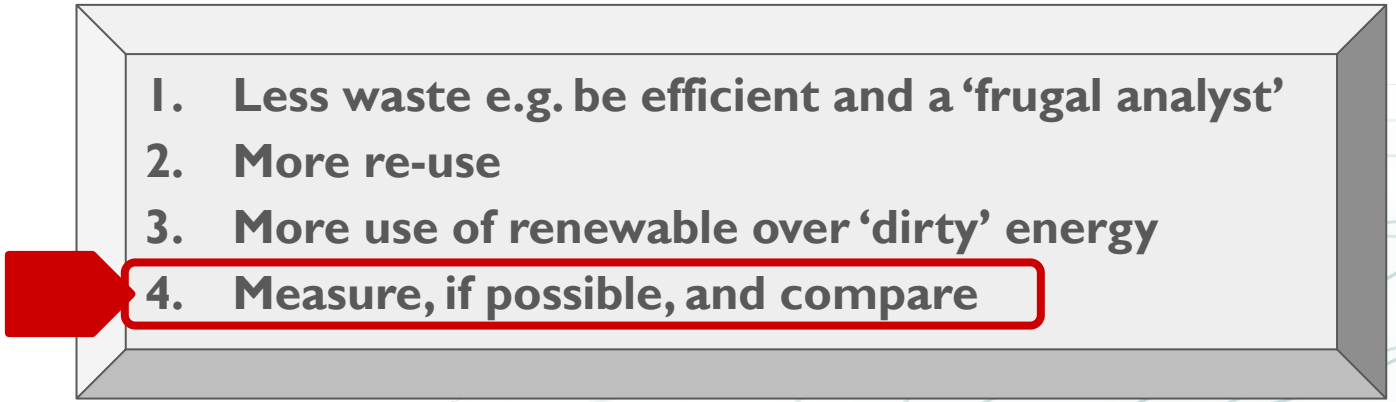
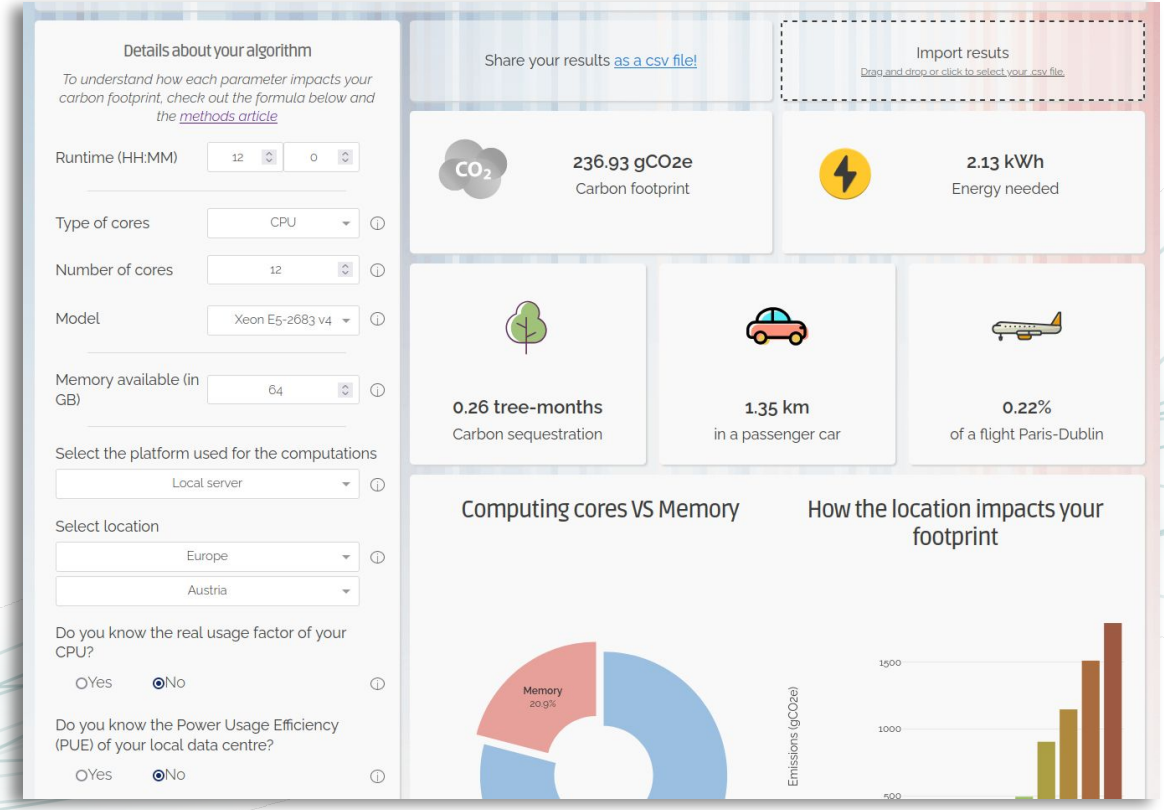


- In general, the **best way to keep your carbon impact low or reduce it is to understand and monitor it**: be able to measure it and compare it to the impact from other activities
- Unfortunately it is usually hard to measure accurately, but rough approximations are still very useful. Tools such as the The Green Algorithms calculator (see next slide) can allow you to get reasonable estimates if you can provide certain details of your software/algorithms and hardware
- On a personal/simple level, even counting the amount of times you run your script could count

Resources for learning more…



- There are now numerous initiatives, groups and research dedicated to greener / more sustainable (research) computing practice
- For example, The Green Algorithms calculator (shown left) is a freely-available tool to allow you to evaluate your computations: see http://calculator.green-algorithms.org/
- 'Green DiSC: a Digital Sustainability Certification' is a certification scheme that anyone working in research in any domain can complete in their own time to aim to be more sustainable: https://www.software.ac.uk/GreenDiSC
- Many other sustainable computing resources!
- For an introductory post to the topic, see: https://www.software.ac.uk/blog/tracking-environmental-impact-research-computing

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Summary

- **Computing contributes significantly to the climate crisis**
- Atmospheric/aligned research requires advanced infrastructure (supercomputers etc.) high data volume & power input, due ultimately to the complexity of modelling the earth
- Integrity in research therefore involves being *wary about* our carbon footprint from computing and *careful not to heighten it, at least, and ideally reduce it*
- We covered some general approaches to reducing our carbon footprint from use of software (code), hardware (computers/machines) and data:
  - 1. Less waste e.g. be efficient and a 'frugal analyst'
  - 2. More re-use
  - 3. More use of renewable over 'dirty' energy
  - 4. Measure, if possible, and compare
- **To learn more: https://www.green-algorithms.org/ is a great place to start!**

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