Results of the SEA sustainability survey 2024

The carbon footprint of Spanish Astronomy and ways to reduce it

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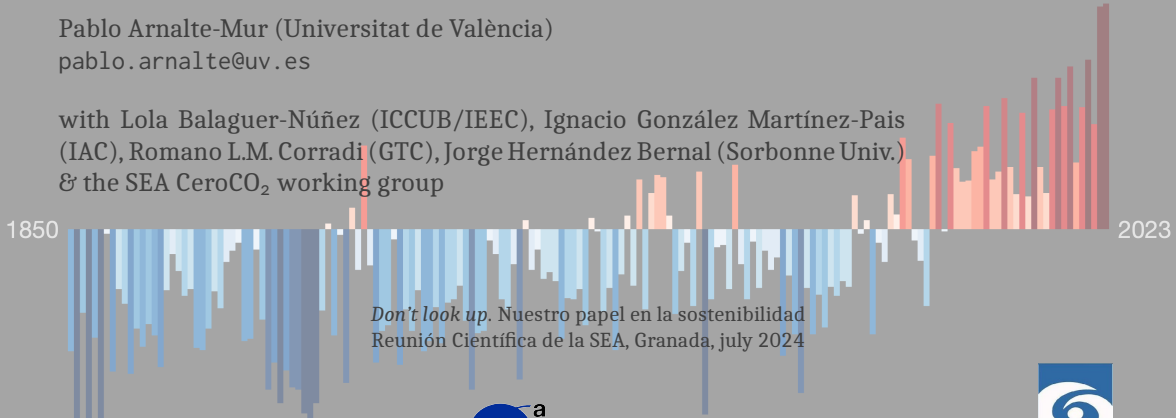

Don't look up. Nuestro papel en la sostenibilidad
Reunión Científica de la SEA, Granada, july 2024

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SEA

Aims

- Estimate the carbon footprint of professional Spanish Astronomy *within a limited scope*
- Compare with the results of the 2020 survey (E. González Egea et al.) $\longrightarrow$ effects of the pandemic (?)
- Survey the opinion of Spanish astronomers about possible actions to reduce our environmental impact
- Contribute to the collective reflection on the community about the climate emergency

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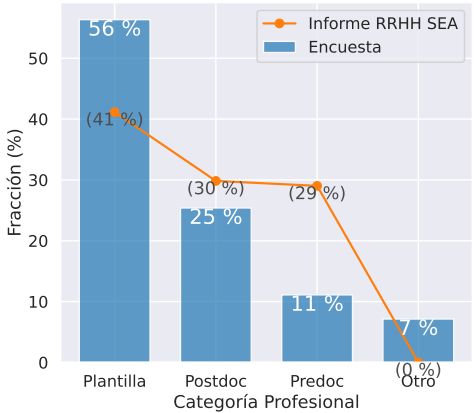
Disclaimer

We are not Social Scientists. Design and analysis of the survey was done as well as we could.

Demographics of the survey

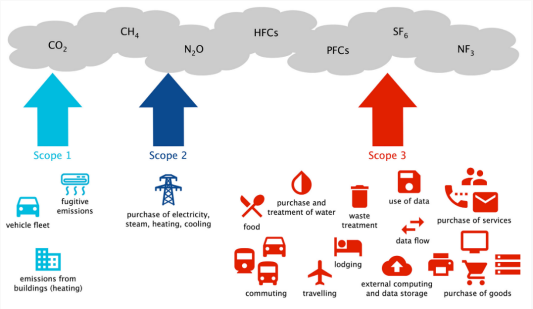
- Survey conducted in March-May 2024. Announced via `sea-anuncios` and SEAMOS.
- Completed by $N = 126$ individuals ($\simeq$ 10% of Spanish Astronomers)[a]
- Very probably a *biased sample*
- Permanent staff over-represented, pre-doctoral researchers under-represented

[a] Compared to data from the *Informe de RRHH SEA 2024*



Estimation of the carbon footprint of astronomical research

- *Carbon footprint*: amount of GH gases than activity adds to the atmosphere
- Several studies (pre-pandemic) of carbon footprint of Astronomy in different institutes/countries (incl. IAC)
- We consider **only three areas**: commuting, work travels, supercomputing
- Period considered: 2022 — 2023



[Knödlseder (2024)]

- For reference:
  - Spanish average: $5.2\,\mathrm{tCO_2eq/yr/person}$
  - World average: $4.7\,\mathrm{tCO_2eq/yr/person}$

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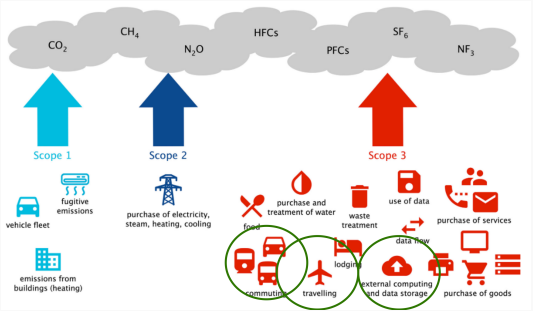

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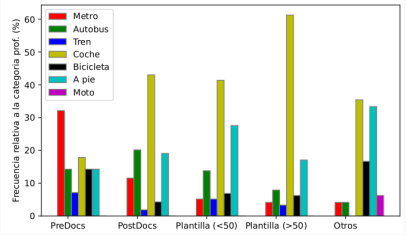
Commuting

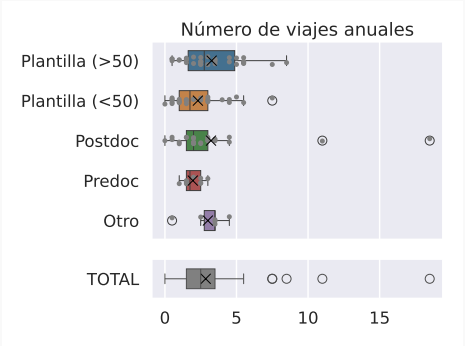
- Car is the most used mean of transport for daily commuting
- Car use more prevalent among Staff/Postdocs. Predocs use more public transport
- Carbon footprint estimate: $\simeq 0.54\,\mathrm{tCO_2eq/yr/person}$ (taking into account remote work)
  - Without remote work: $\simeq 0.76\,\mathrm{tCO_2eq/yr/person}$
- 2020 estimate: $\simeq 0.8\,\mathrm{tCO_2eq/yr/person}$

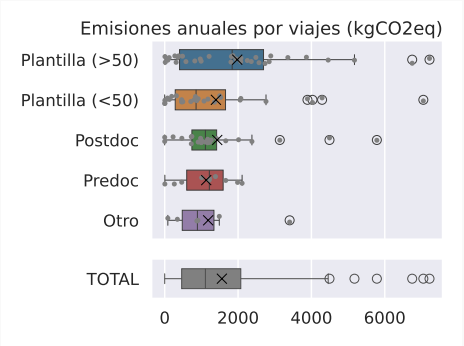


- Remote work reduces commuting emissions by $\sim 30\%$
- BUT: it may induce larger emissions in other areas (e.g. heating/cooling)

Work travel

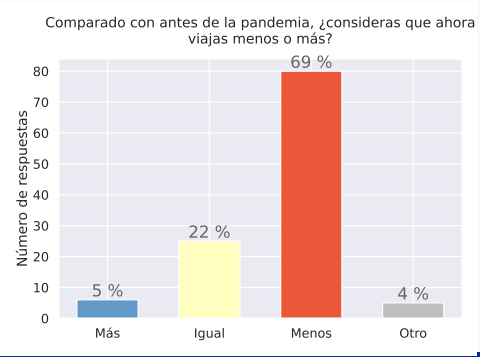
- Large dispersion on number of trips/distances/emissions
- Significant differences between professional categories (also gender differences for junior staff)
- Carbon footprint estimate: $1.46 \pm 0.23\,\mathrm{tCO_2eq/yr/person}$

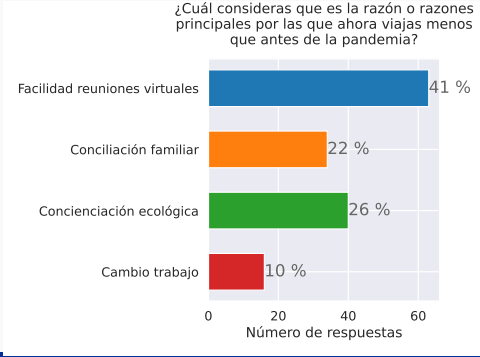




Work travel: changes from 2020

- 2024 estimate: $1.46 \pm 0.23\,\mathrm{tCO_2eq/yr/person}$
- 2020 estimate: $\simeq 5\mathrm{tCO_2eq/yr/person}$
  - At face value: reduction of $\sim 70\%$
  - $\sim 50\%$ reduction in number of trips
- 70% of respondents claim they travel now less than before the pandemic





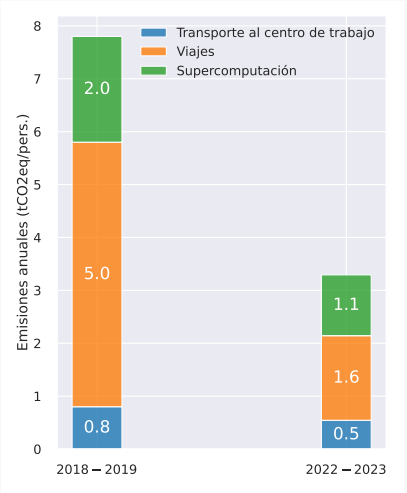
Supercomputing

- $\simeq$ 17% of Spanish astronomers are supercomputing users $\longrightarrow$ low number of answers $\longrightarrow$ large uncertainty in estimates
- In total: $\simeq$ 170MCPUh/yr used by Spanish astronomers ($\simeq$ 135kCPUh/yr/person)
- Carbon footprint estimate: $1.15^{+1.45}_{-0.97}$ $\mathrm{tCO_2eq/yr/person}$[a]
- 2020 estimate: $\simeq$ 2 $\mathrm{tCO_2eq/yr/person}$, but large uncertainty and different efficiency/emission factors assumed

[a] We assume 53 W/CPU (Stevens et al., 2020), 160 $\mathrm{gCO_2eq/kWh}$ for Spain (`electricitymap.org`)

Summary of estimated footprint

- Total estimated footprint **(commuting + travel + supercomputing)**: $\simeq 3.2^{+1.5}_{-1.0}\,\mathrm{tCO_2eq/yr/person}$
- Significant reduction compared to 2020, but difficult to quantify



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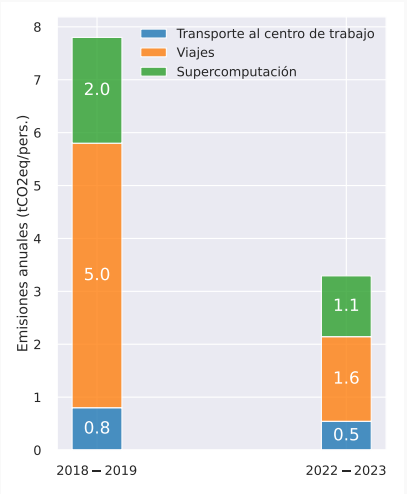
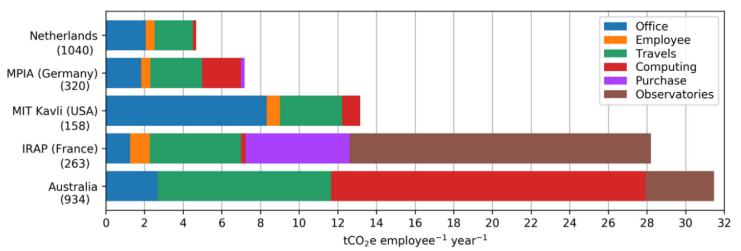
Can we trust the 70% reduction in travel footprint?

- Different biases and/or ways of collecting/analysing data in 2020 vs. 2024 samples?
- Early 2022 still "in pandemic"?
- 2020 over-estimation? (e.g, IAC, 2018; $\sim 6\mathrm{tCO_2eq/yr/person}$ (RFI = 2))



Is this the full footprint?

- Our estimate covers a **small part** of the astronomical research footprint
- Other important contributions:
  - Institute's heating/cooling and electricity consumption
  - Purchases
  - Observatories: probably the most important contribution (e.g. $\simeq$ 15 $\mathrm{tCO_2eq/yr/person}$, IRAP, Martin et al. 2022; $\simeq$ 37 $\mathrm{tCO_2eq/yr/person}$, world, Knödlseder et al. (2022))
- Detailed studies needed at the institute level



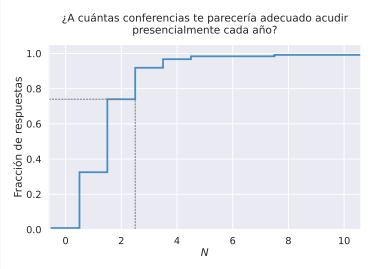
[Knödlseder (2024)]

Survey on possible actions to take

- The survey also included several opinion questions about possible actions to reduce the footprint of astronomical research
- Main focus on travel and conferences
- Some questions similar to those in 2020 survey $\longrightarrow$ no significant differences observed

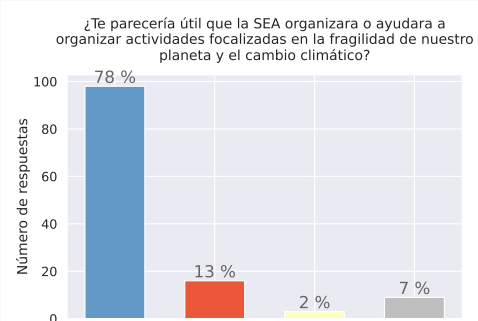
Survey on possible actions to take (Selection)

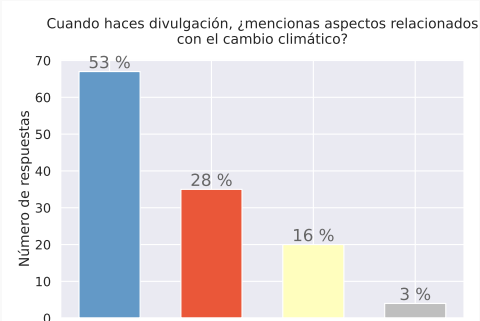
- 74% consider 2 (or less) in-person conferences/year appropriate
- 76% *in favour* of making the RC-SEA hybrid (but 74% *against* making them fully online)
- 60% *in favour* of including a carbon budget in grants/projects



Outreach

- The most effective action we can take as astronomers to tackle the climate emergency is to take about it
- 53% of astronomers already talk about climate change when doing outreach/University lectures
- 78% agrees with SEA organising outreach activities about it





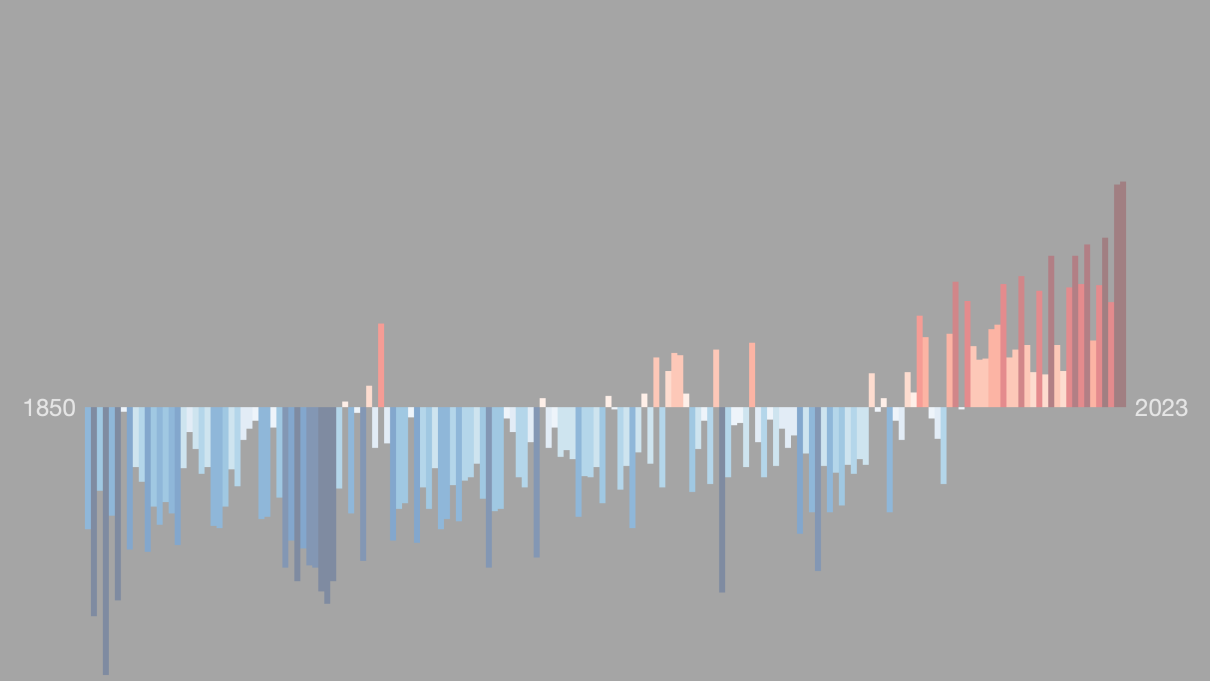
Other actions

Some other actions proposed (and comments) from answers

- Awareness-raising among the astronomical/research community
- Institutions: energy consumption and general $\longrightarrow$ all the institutions should have a de-carbonisation plan
- Conferences/travel:
  - Discussions about when in person conference/meetings are important, relevance for ECRs
  - Sustainability measures in conferences
  - Imposed limit on travel
  - Remote observing
- Link to light pollution
- ...

Conclusions

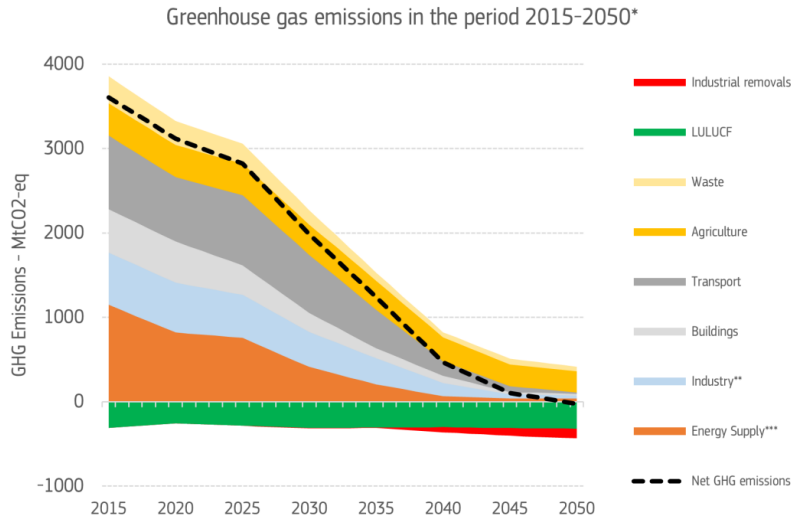
- Important reduction of carbon footprint due to work travel, commuting (and supercomputing) after the pandemic (but difficult to quantify exactly) $\longrightarrow$ $\simeq 3.2^{+1.5}_{-1.0}\,\mathrm{tCO_2eq/yr/person}$
- Work to do: do a more detailed analysis of the survey and share it with the SEA
- This is still a **small part** of the full carbon footprint of astronomy research $\longrightarrow$ need an institutional effort to quantify it and make plans for reduction
- Most important action as astronomers: raise awareness, put pressure on institutions, serve as an example (?)


1850
2023

Some bibliography

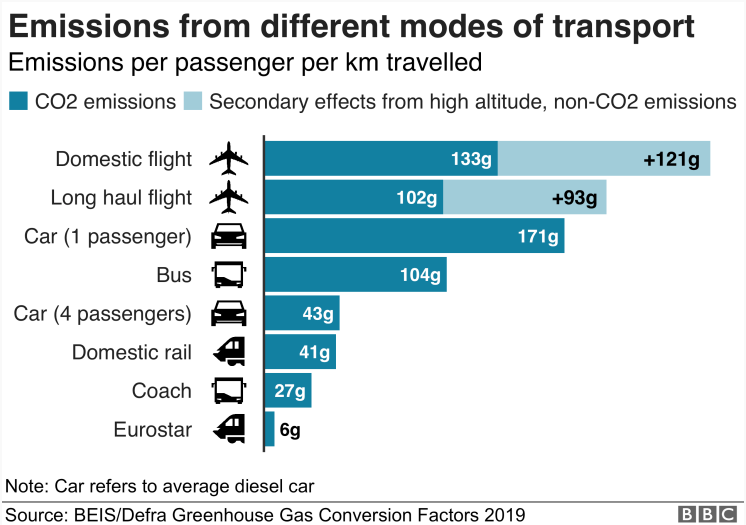
- T. Rector (ed.): *Climate Change for Astronomers: Causes, consequences and communication*, IOP (2024) (link)
  - J. Knödlseder: *Chapter 18: The Carbon Footprint of Astronomy Research*
- A. Stevens et al.: *The imperative to reduce carbon emissions in astronomy*, Nature Astronomy, 4:843 (2020) (link)
- M. Blanchard et al.: *Concerned yet polluting: A survey on French research personnel and climate change*, PLOC Climate, 1:e0000070 (2022) (link)
- A. Gokus et al.: *Astronomy's climate emissions: Global travel to scientific meetings in 2019*, PNAS Nexus, 3:143 (2024) (link)
- P. Martin et al.: *A comprehensive assessment of the carbon footprint of an astronomical institute*, Nature Astronomy, 6:1219 (2022) (link)

EU Climate Targets

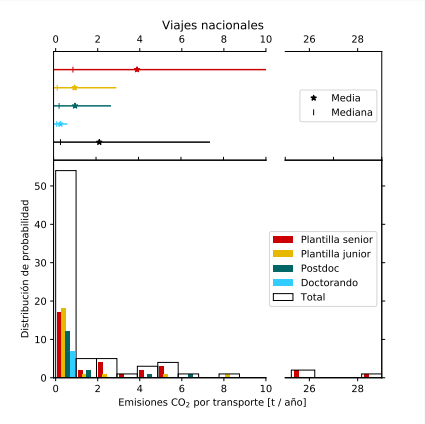


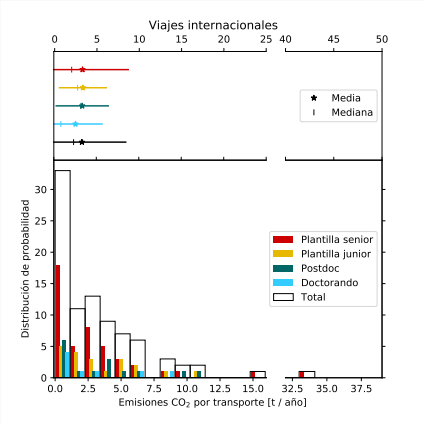
*Source: PRIMES, GAINS, GLOBIOM

Emission factors assumed



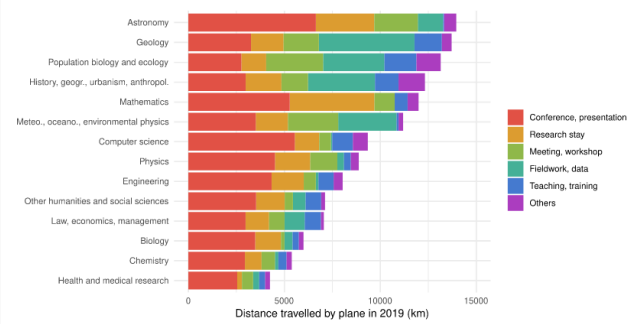
Emissions from work travel - 2020





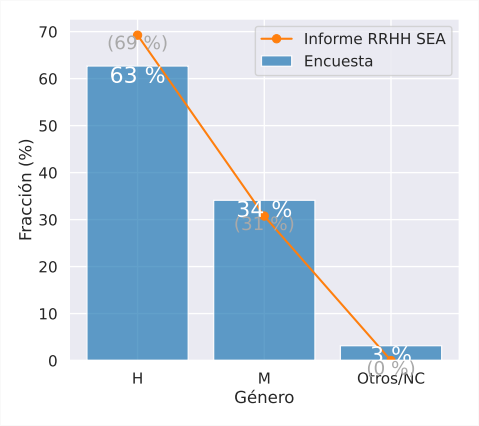
Estimation of the carbon footprint of astronomical research

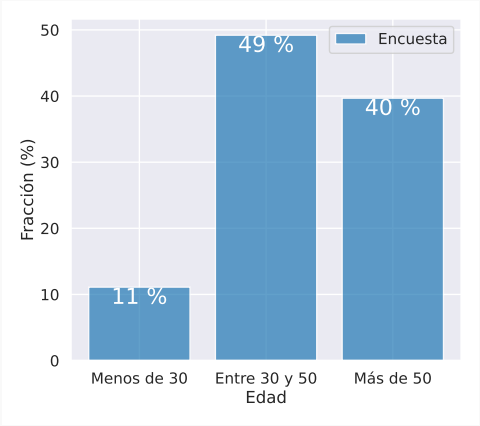
- Several studies (pre-pandemic) of carbon footprint of Astronomy in different institutes/countries
- In Spain: IAC study (A. Mampaso & I. García de la Rosa)
- Survey of French researchers (2020): Astronomers are among those travelling the most



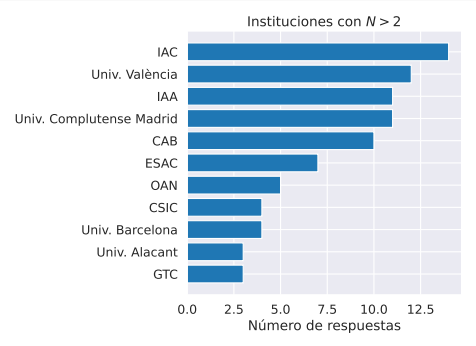
[Blanchard+ (2022)]

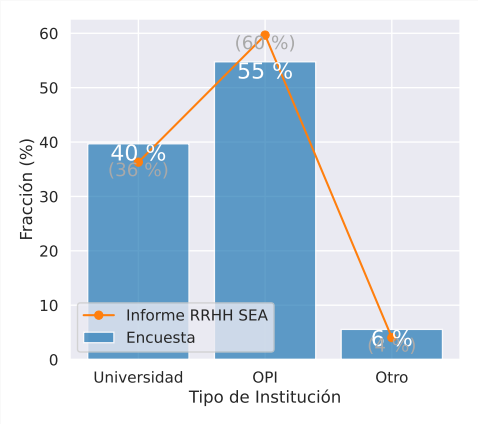
Demographics of the survey





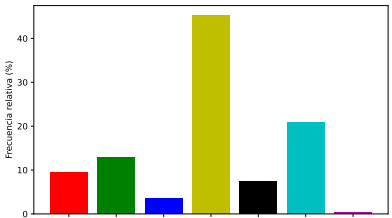
Demographics of the survey (institutions)

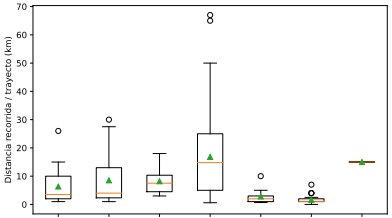


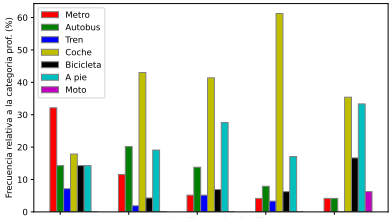


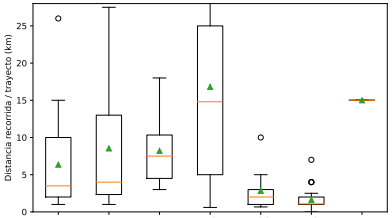
Commuting - extra plots

Desplazamientos trabajo-domicilio (frecuencias y distancias recorridas)



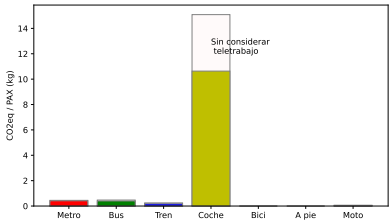


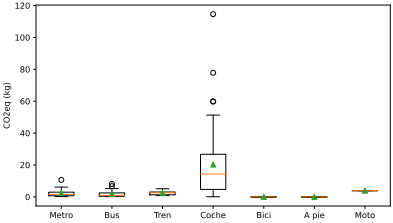


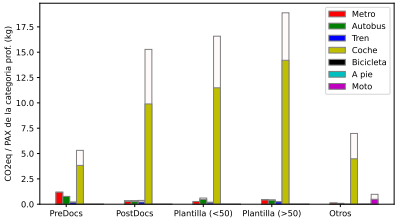


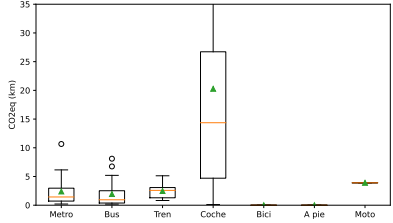
Commuting - extra plots

Desplazamientos trabajo-domicilio (Huella de Carbono semanal)



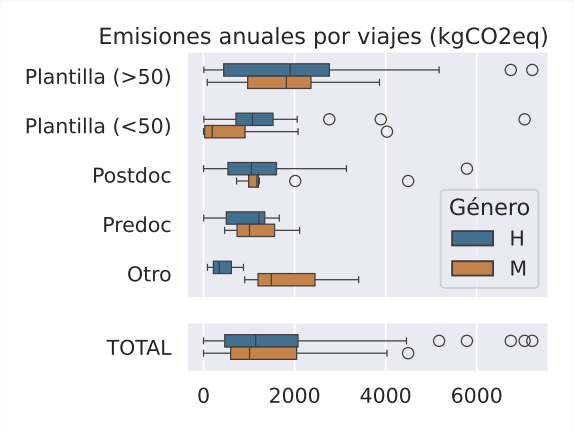




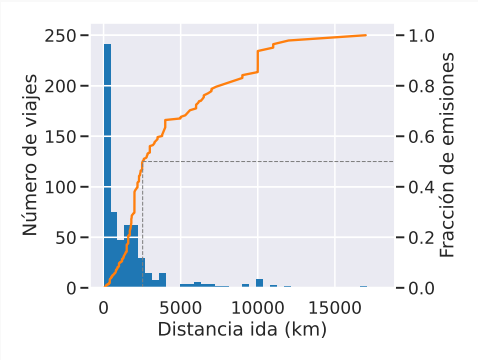


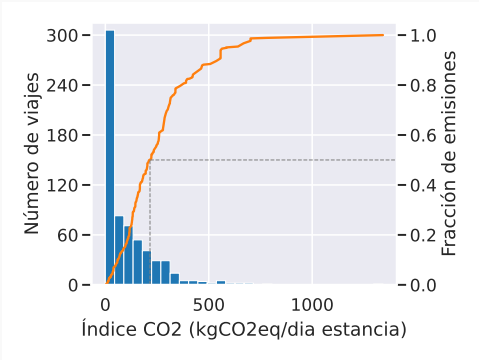
Work travel: gender differences

- No clear gender difference for the full sample
- Noticeable gender difference for junior staff $\rightarrow$ family care?

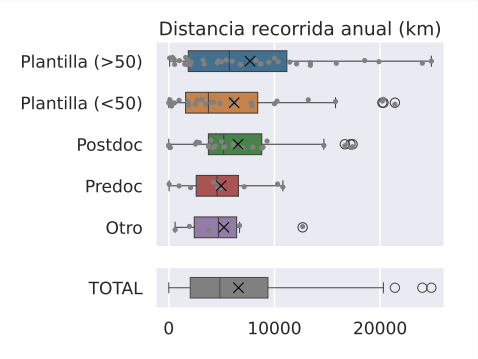


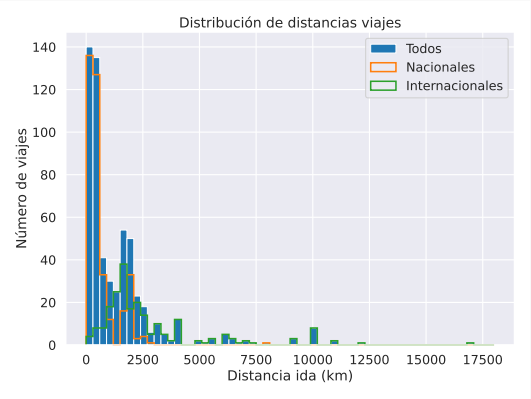
Work travel: distance, length of stay





Work travel - extra plots





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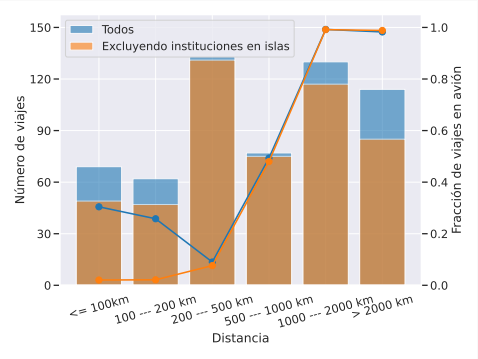
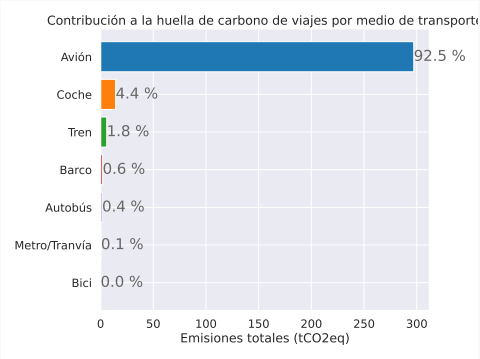
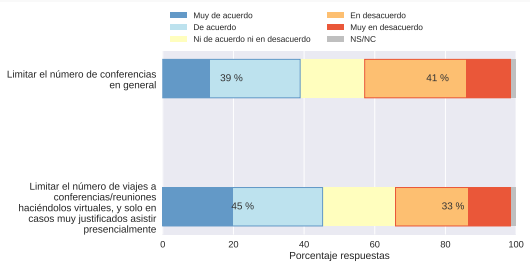
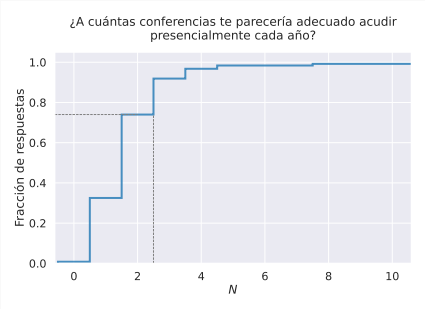


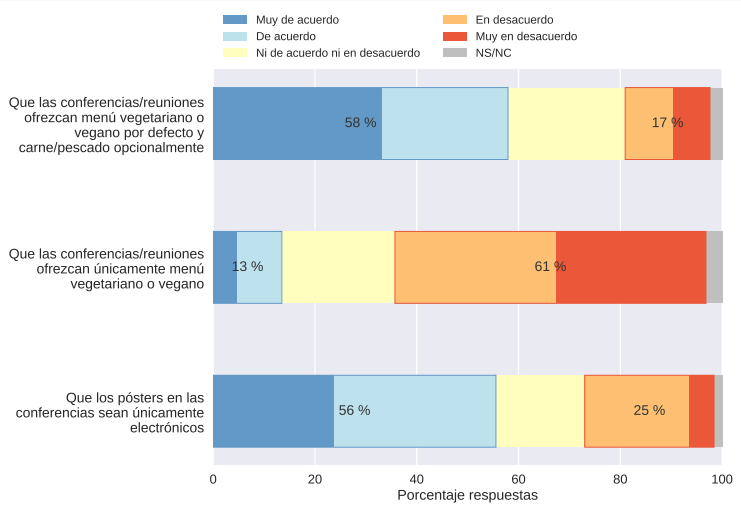


Reducing the number of (in person) conferences

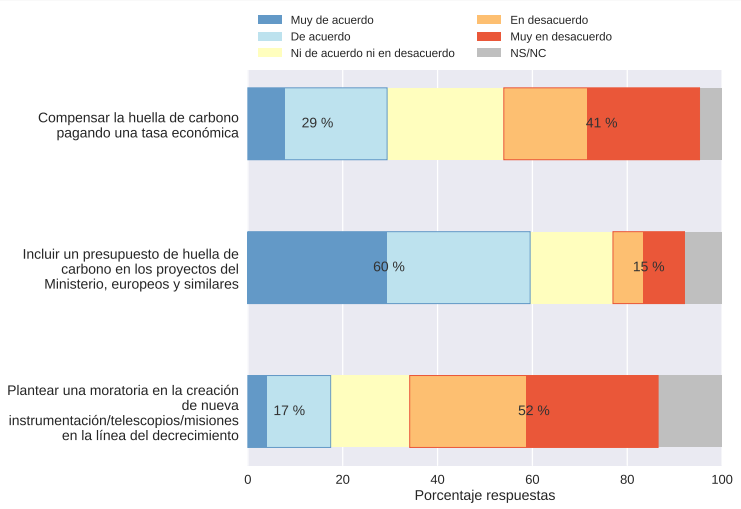




Conference organisation



General actions in research



Reuniones Científicas SEA