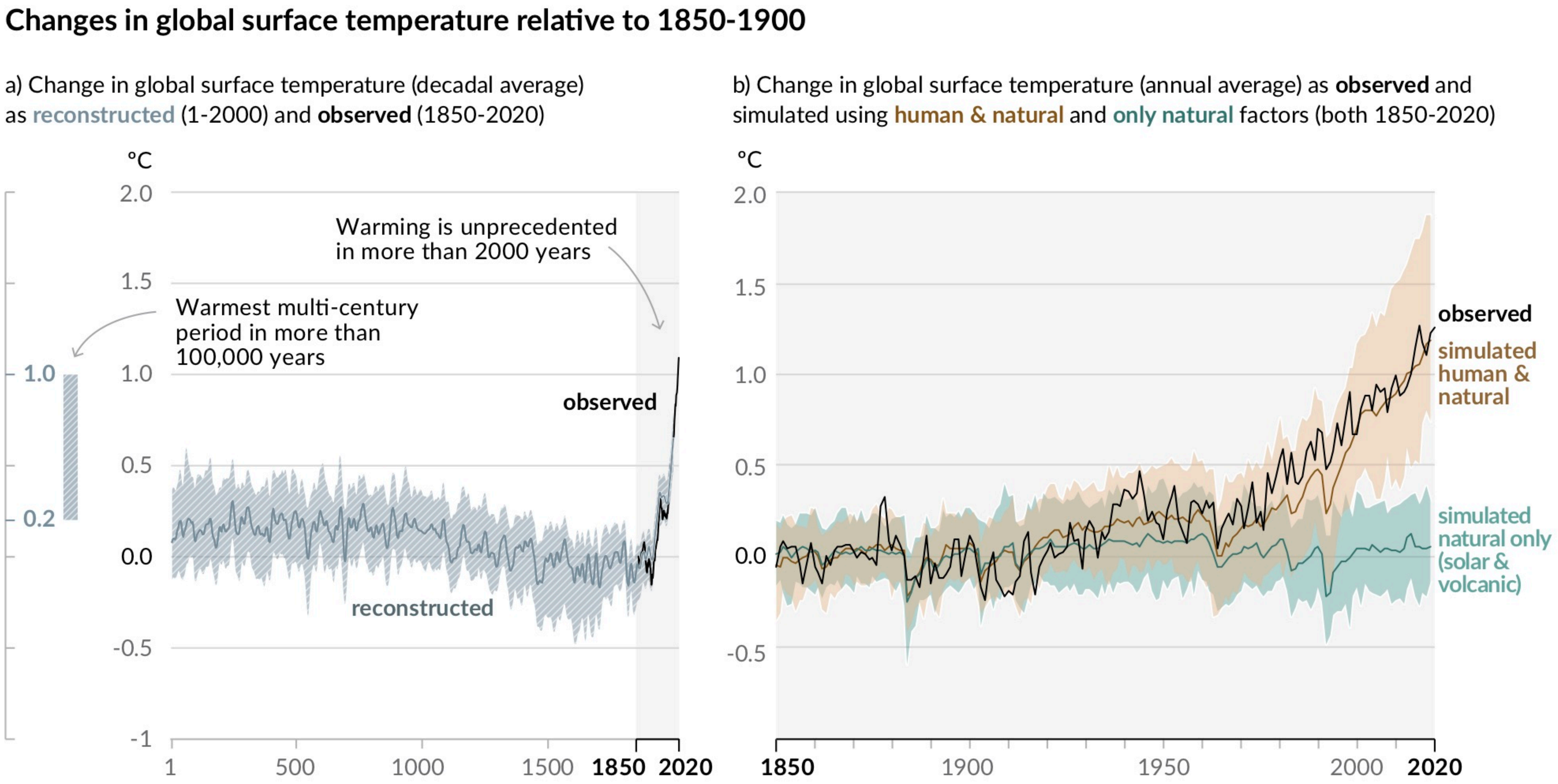
A paradigm shift in Astronomy and Astrophysics?
Lessons learned from the carbon footprint evaluation of IRAP

Victor Réville, Pierrick Martin, Angèle Mouinié et la commission environnement de l'IRAP

Journée Sciences Bas Carbone du 26 mai 2023

Global warming…

Summary Report for Policy Makers
of the IPCC 6th assessment report of Working Group 1

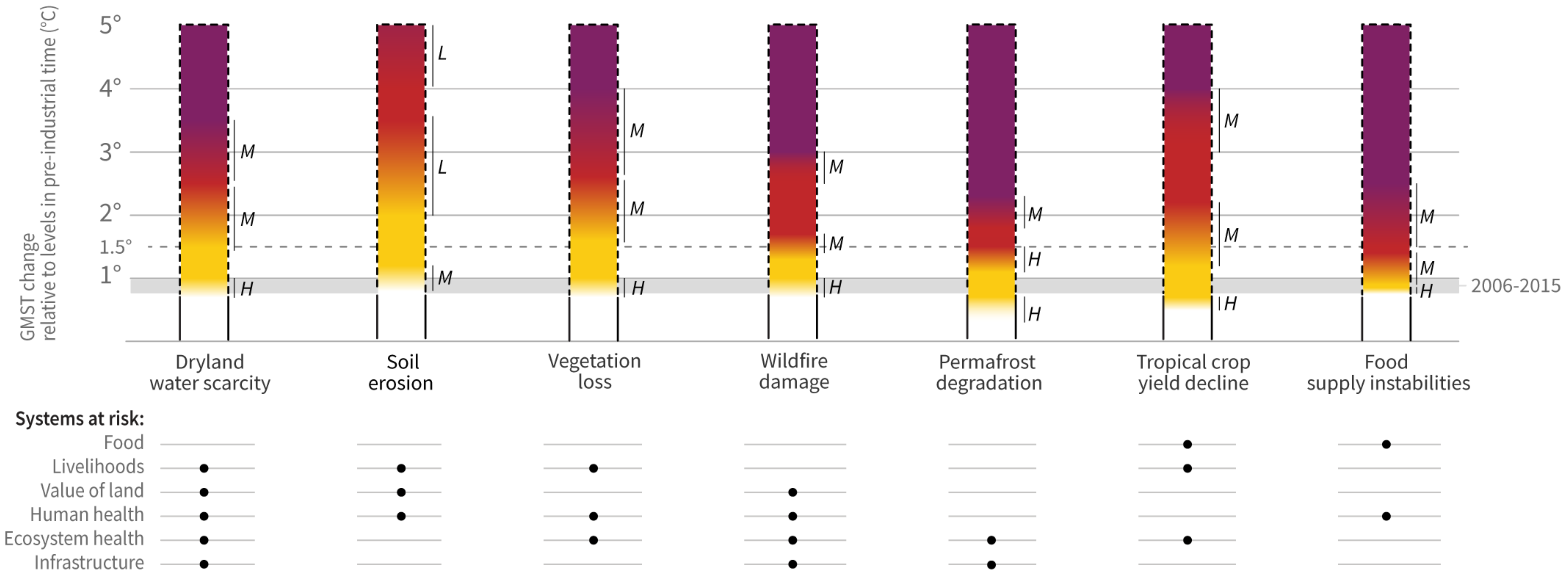


The risks

IPCC Special Report
on Global Warming of 1.5°C

A. Risks to humans and ecosystems from changes in land-based processes as a result of climate change

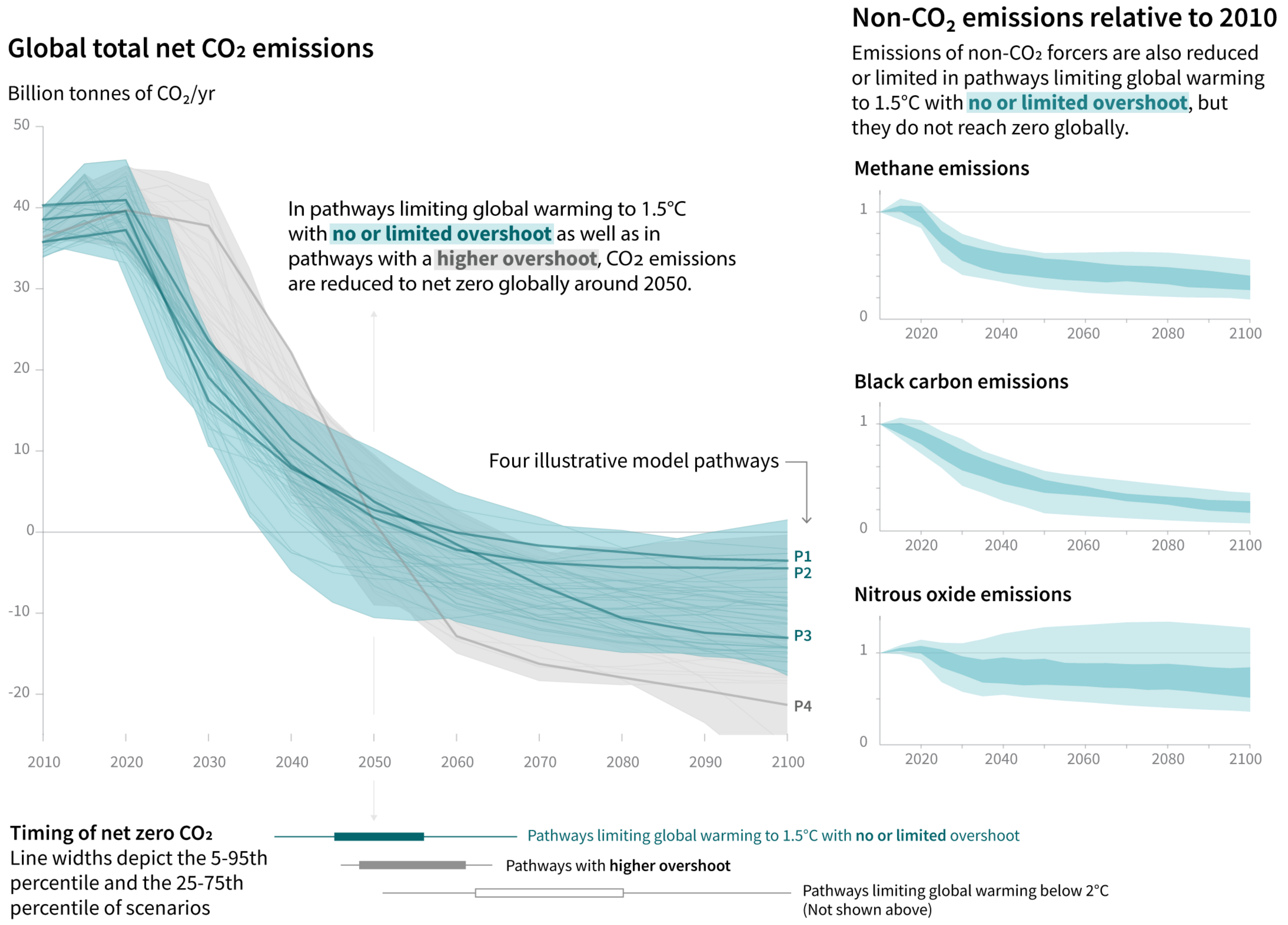
Increases in global mean surface temperature (GMST), relative to pre-industrial levels, affect processes involved in **desertification** (water scarcity), **land degradation** (soil erosion, vegetation loss, wildfire, permafrost thaw) and **food security** (crop yield and food supply instabilities). Changes in these processes drive risks to food systems, livelihoods, infrastructure, the value of land, and human and ecosystem health. Changes in one process (e.g. wildfire or water scarcity) may result in compound risks. Risks are location-specific and differ by region.



Effects are already there - Major risks for future - Every 0.5°C counts

Possible ways out

IPCC Special Report
on Global Warming of 1.5°C



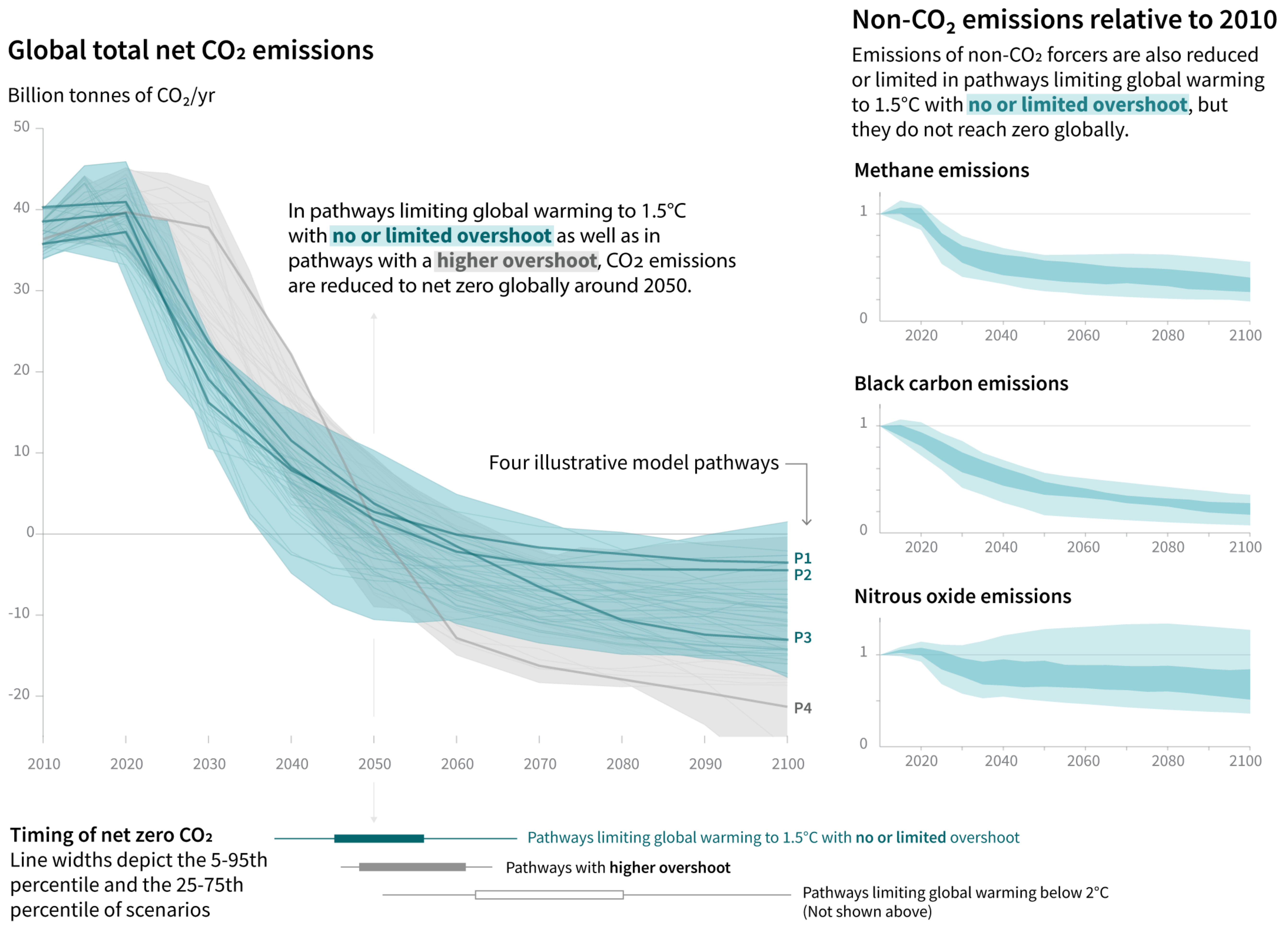
Coming decade is crucial

Need to engage <u>systemic</u> changes

IPCC studied pathways to remain <1.5°C
Reducing GHG emissions by 40-60% by 2030 (with respect to **2010 !**)
Carbon neutrality by 2050

Possible ways out

IPCC Special Report
on Global Warming of 1.5°C



7.6%/yr reduction every year
over next decade

Covid-19
global lockdown
6.4% reduction
in 2020

IPCC studied pathways to remain <1.5°C
Reducing GHG emissions by 40-60% by 2030 (with respect to **2010 !**)
Carbon neutrality by 2050

Carbon footprint of IRAP

Comment

https://doi.org/10.1038/s41550-022-01771-3

A comprehensive assessment of the carbon footprint of an astronomical institute

Pierrick Martin, Sylvie Brau-Nogué, Mickael Coriat, Philippe Garnier, Annie Hughes, Jürgen Knödlseder and Luigi Tibaldo

The development and use of research infrastructures accounts for more than 70% of the carbon footprint of the Institute for Research in Astrophysics and Planetology. Our community needs to rethink this crucial facet of astronomical research to engage in effective and perennial reduction strategies.

and the Australian[7] and Dutch[8] astronomy communities. While these studies have identified professional air travel and supercomputing as significant sources of GHG emissions, potentially large sources of GHG emissions such as the consumption of goods and services and the use of space- and ground-based astronomical observatories were excluded from these analyses. A much wider scope of an astronomical research institute's activities was investigated for a comprehensive assessment of GHG emissions at the Institute for Research in Astrophysics and Planetology (IRAP) for the reference year of 2019[9].

IRAP is the largest astronomy research institute in France with 116

For more details:
arxiv:2204.12362

Commission environnement IRAP since 2018
Training to Bilan Carbone™ in 2020
Most of the data collection and calculations in 2021

Carbon accounting

- Key principles
  - Decision-making tool in view of low-carbon transition strategy
  - Identify emissions an activity depends on/generates while running
  - Determine maximum leverage for action (on input and output flows)

Can I still perform my activity according to current standards if a certain source of emissions is removed ?

In practice:

GHG amount = activity data (AD) x emission factor (EF)

Example: 120 kg CO_2eq = 2000 kWh x 0.06 kg CO_2eq/kWh

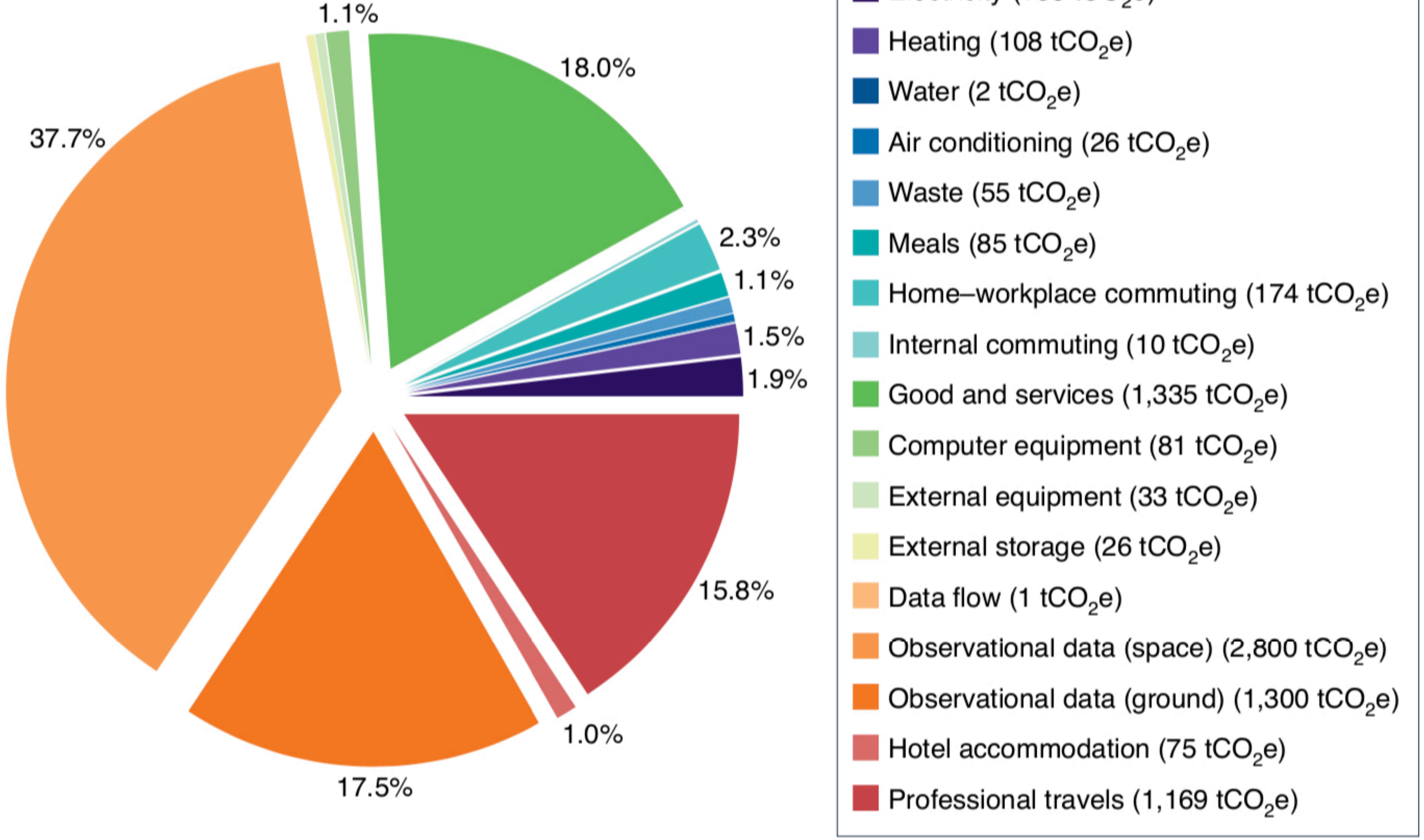
Main difficulties: AD not always accessible or accurate
major uncertainties on some EF

Note:
CO_2eq includes gases other than CO_2: CH_4, N_2O,…

Scope

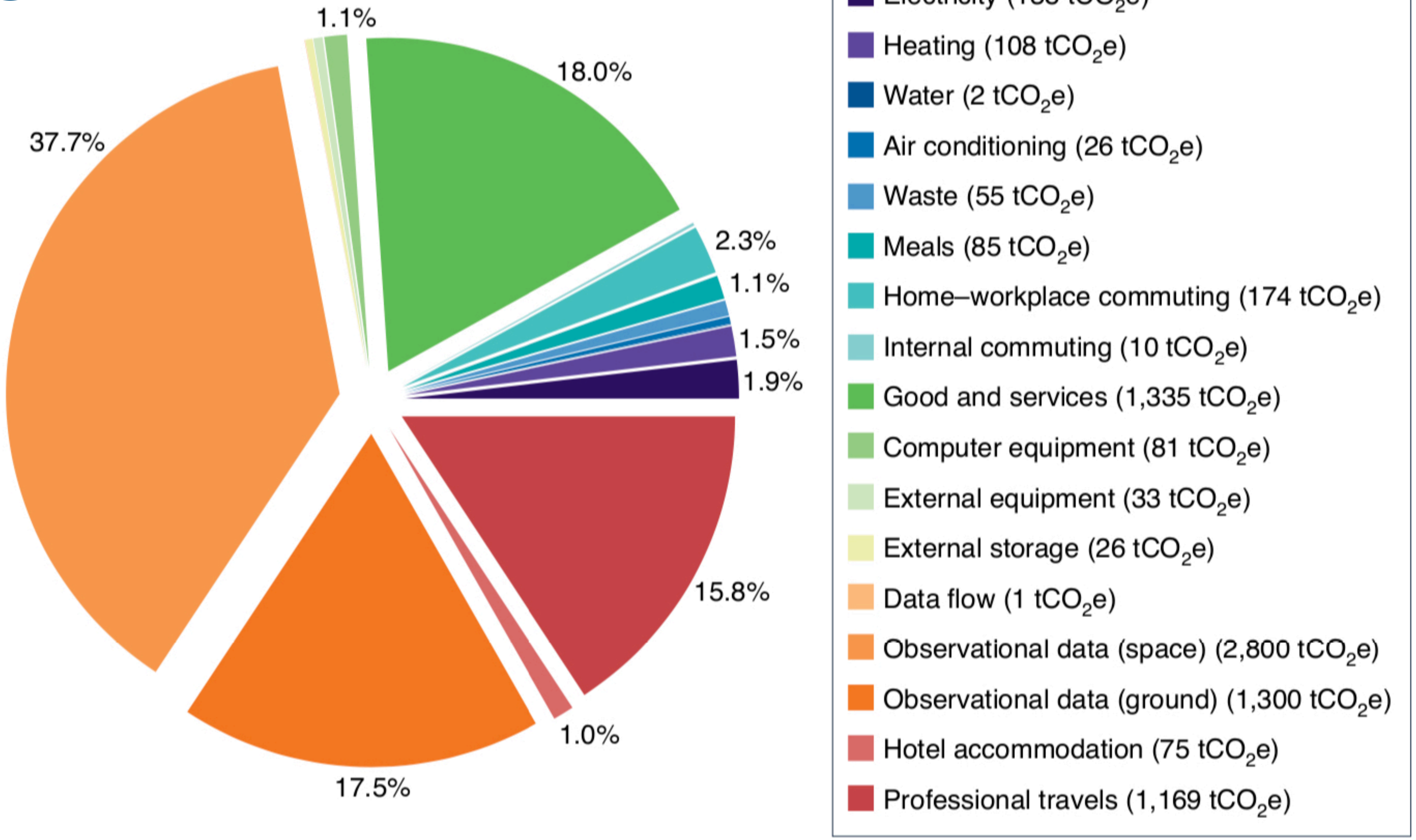
- Reference year: activity period concerned
  - 2019 (pre-covid)
- Organisation: facilities, staff, and activities concerned
  - Sites: Belin, Roche, Tarbes
  - People: 116 C/EC - 78 ITA/CDD - 69 PhD/Postdocs = 263 pers.
  - Activities: all except most of teaching and some support services
- Operations: GHG-emitting operations concerned
  - Direct emissions (ex: own vehicles) - Scope 1
  - Indirect emissions from energy (ex: electricity) - Scope 2
  - Other indirect emissions (ex: travels, purchases) - Scope 3

Results



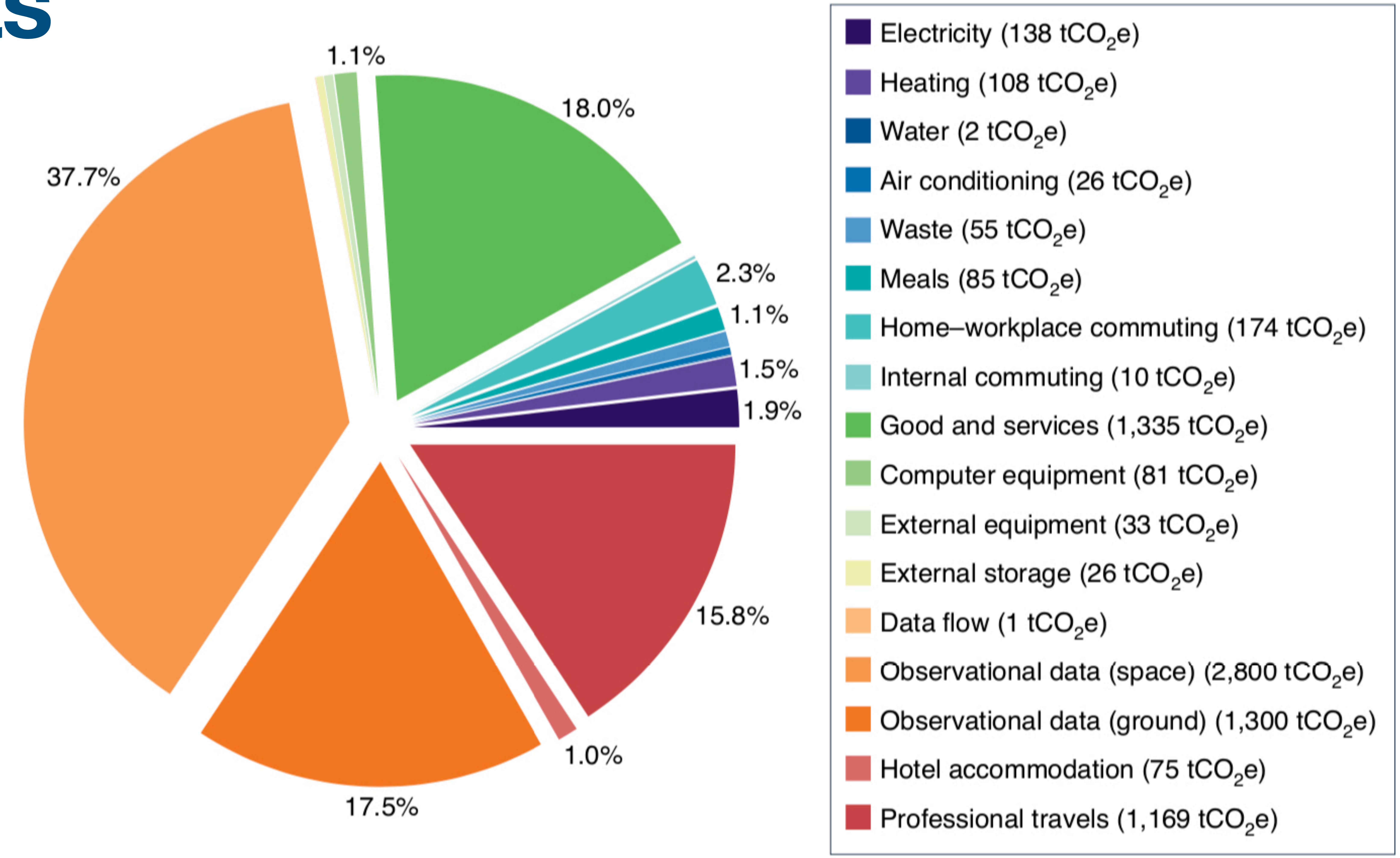
Total **7400 +/- 900 tCO_2e** for 260 persons in 2019

Results



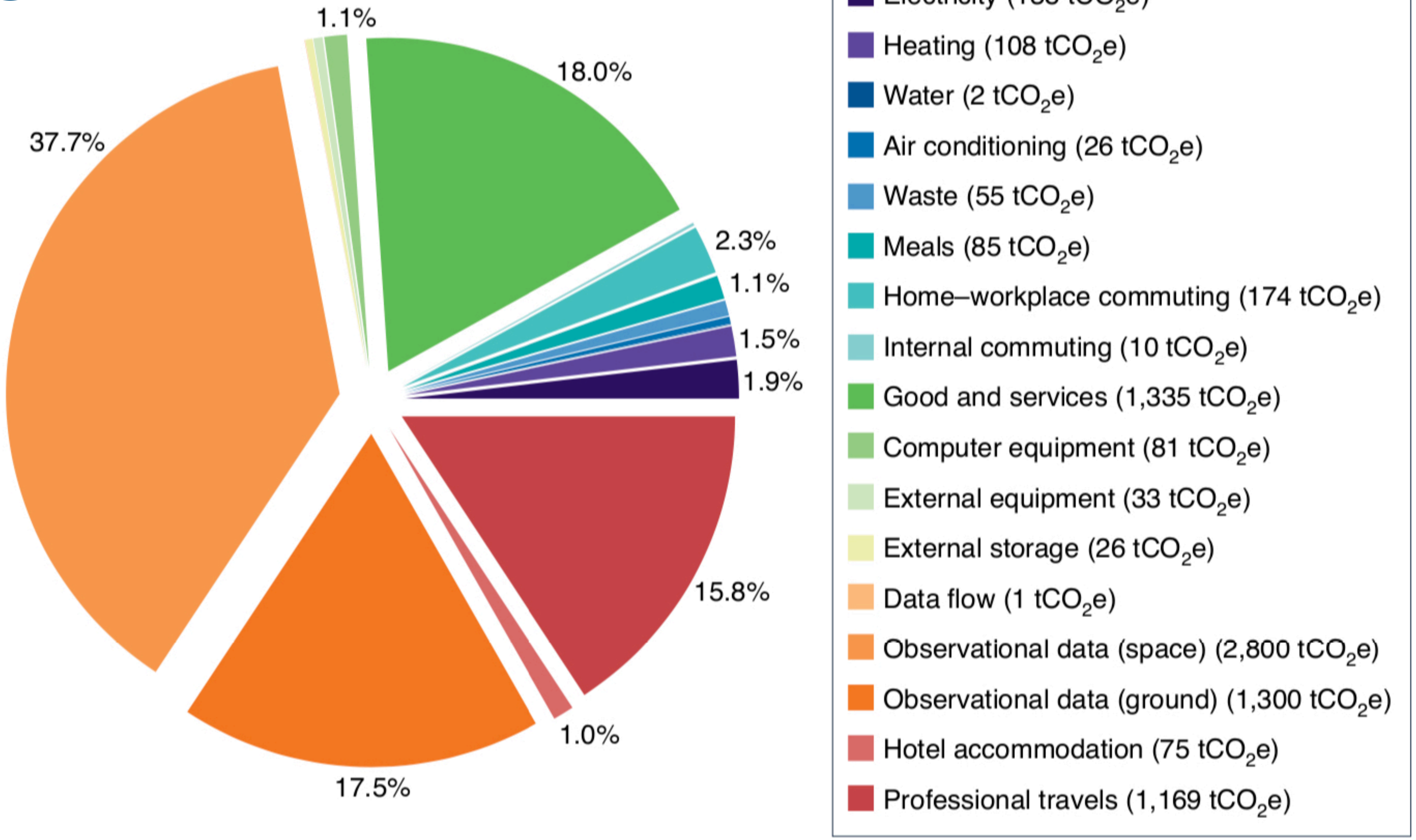
~55% of the footprint
Use of **observational data from** space mission/ground-based observatories
(see Knödlseder et al. 2022 for the method)

Results



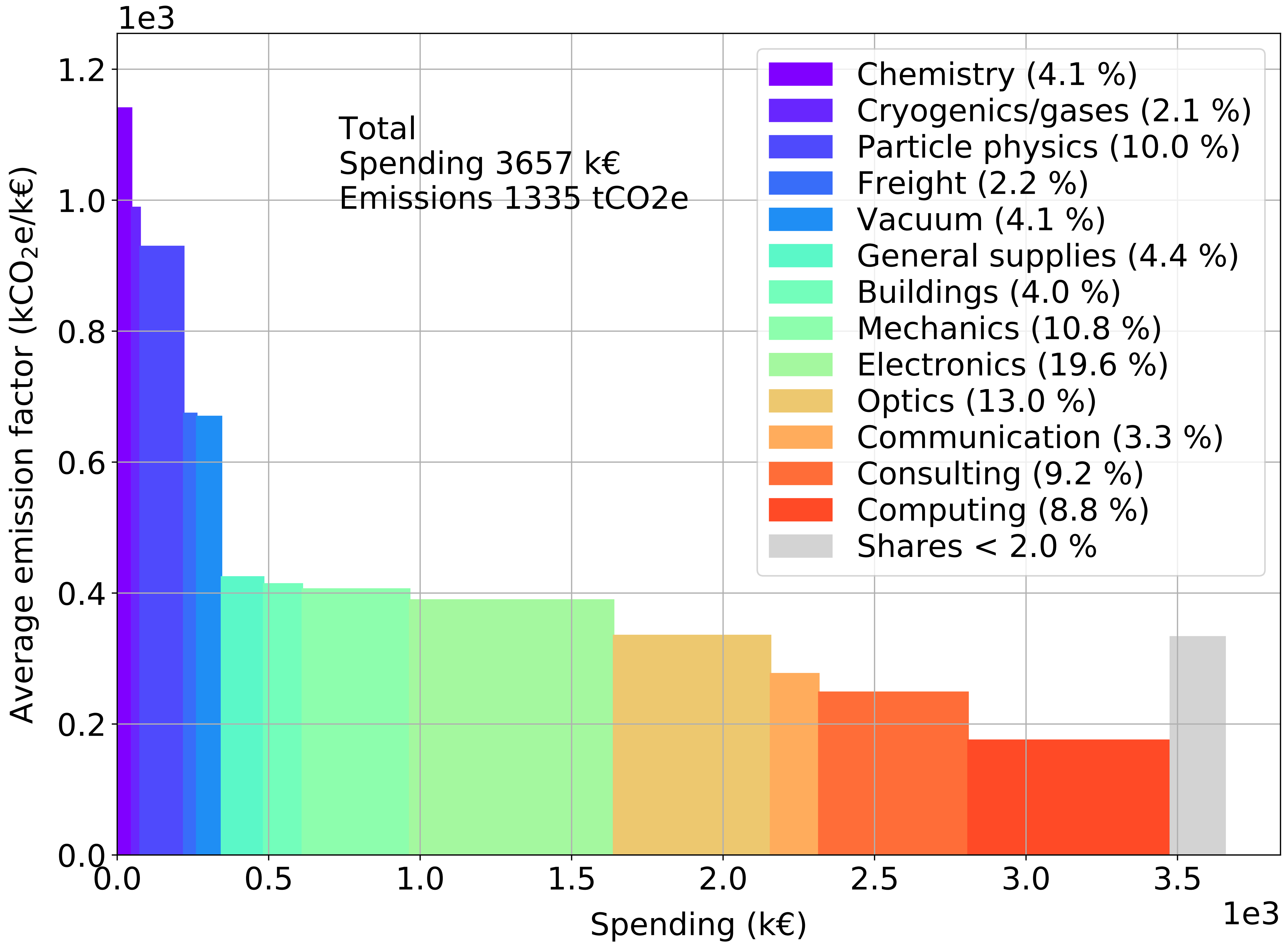
~20% of the footprint
Purchase of **goods and services**
(85-90% of which feeds instrumental development)

Results



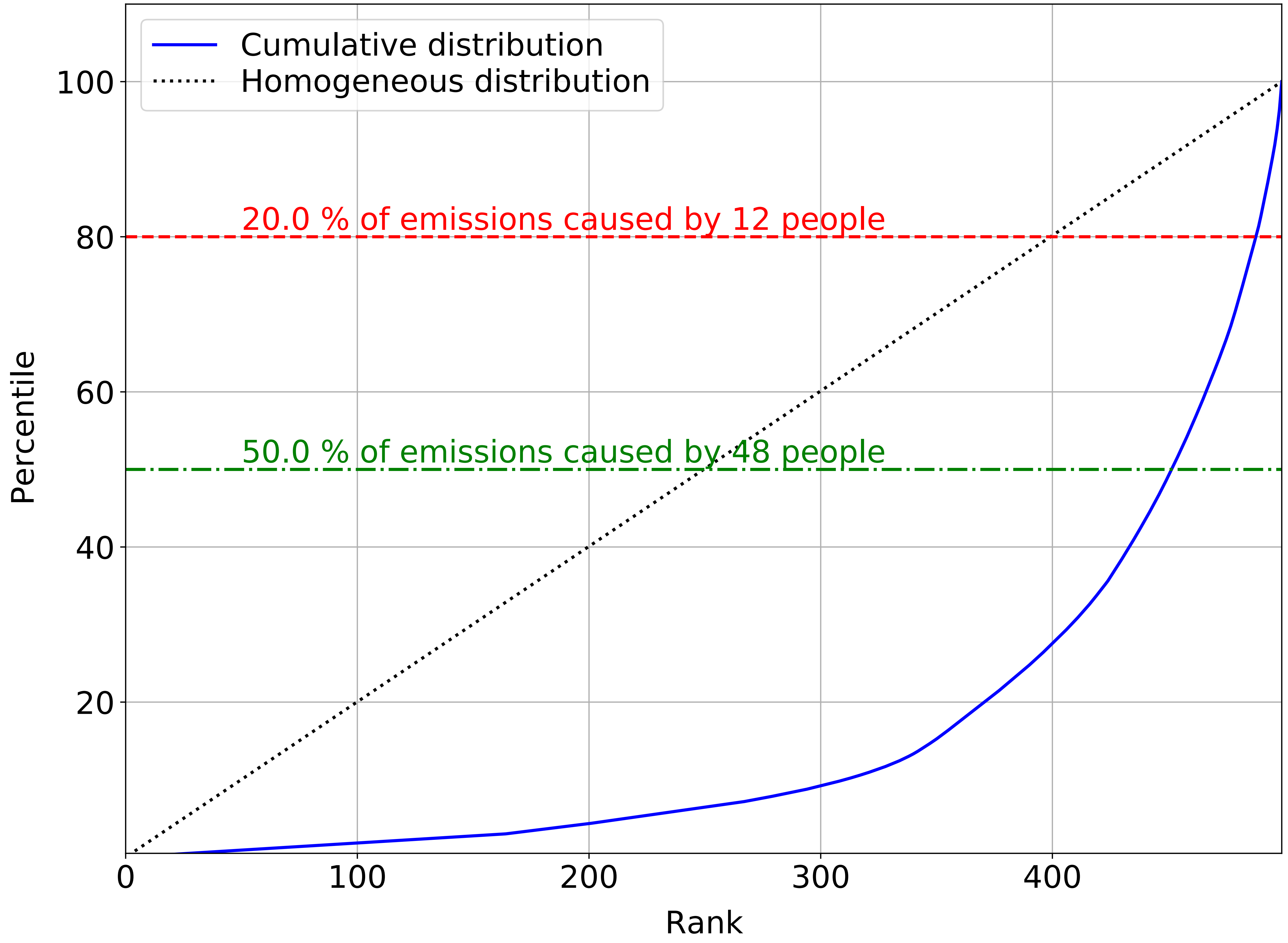
~10% of the footprint
Local infrastructure incl. part of purchases
(nuclear-powered electricity + biomass burning for main site)

About purchases



85-90% of purchases in connection to instrumental development and experimentation

About professional travels



Very **uneven** distribution

Should make it easy
to achieve significant
reductions
while preserving the
possibility to meet/interact
with external colleagues

Effect of gender:
92% (87%) of those responsible for 20% (50%) of GHG are male
General population at IRAP 75% of male

Towards significant reduction

- What is the reduction target ?
  - Ultimate global goal: ~2tCO_2e/yr/capita
  - For each sector, consider social benefits, technological constraints,…
  - A political question not to be decided by researchers alone
  - Factor ~2 by 2030 and ~5-10 by 2050 would be fair
  - Let's just start and achieve -25% first… then we will see
- Lessons from IRAP
  - Research infrastructures account for >70% of our footprint
  - (Air) travels for about 15%
  - The local infrastructure only 10%
  - -10% achievable by changing traveling/commuting habits

To achieve significant and long-lasting reductions
research infrastructures cannot be left out of the equation

Reduction strategy at IRAP

4 working groups dedicated to different reduction paths

1) Lab life (ref. Katia Ferrière)

2) Professional travels (ref. Luigi Tibaldo)

3) Purchase (ref. Jürgen Knödleseder)

4) Low carbon science (ref. Victor Réville)

About **60 measures** proposed for the three first working groups with quantified associated GES emissions reductions

These measures apply to the IRAP structures and personals but not projects and observations infrastructures

Reduction strategy at IRAP

Example of reduction measures

1) Lab life (ref. Katia Ferrière)

- Setup more protected bike parking spot
- Improve waste management

2) Professional travels (ref. Luigi Tibaldo)

3) Purchase (ref. Jürgen Knödleseder)

4) Low carbon science (ref. Victor Réville)

Reduction strategy at IRAP

Example of reduction measures

1) Lab life (ref. Katia Ferrière)

2) Professional travels (ref. Luigi Tibaldo)

3) Purchase (ref. Jürgen Knödleseder)

4) Low carbon science (ref. Victor Réville)

- Favor train for short trips / allow 1st class to improve working conditions on trains
- Replace IRAP vehicles with electric
- A pool of IRAP bicycles for short commute (CNES, UPS)

Reduction strategy at IRAP

Example of reduction measures

1) Lab life (ref. Katia Ferrière)

2) Professional travels (ref. Luigi Tibaldo)

3) Purchase (ref. Jürgen Knödleseder)

- Integrate environmental clauses in calls
- Extend life cycle of computers and screens

4) Low carbon science (ref. Victor Réville)

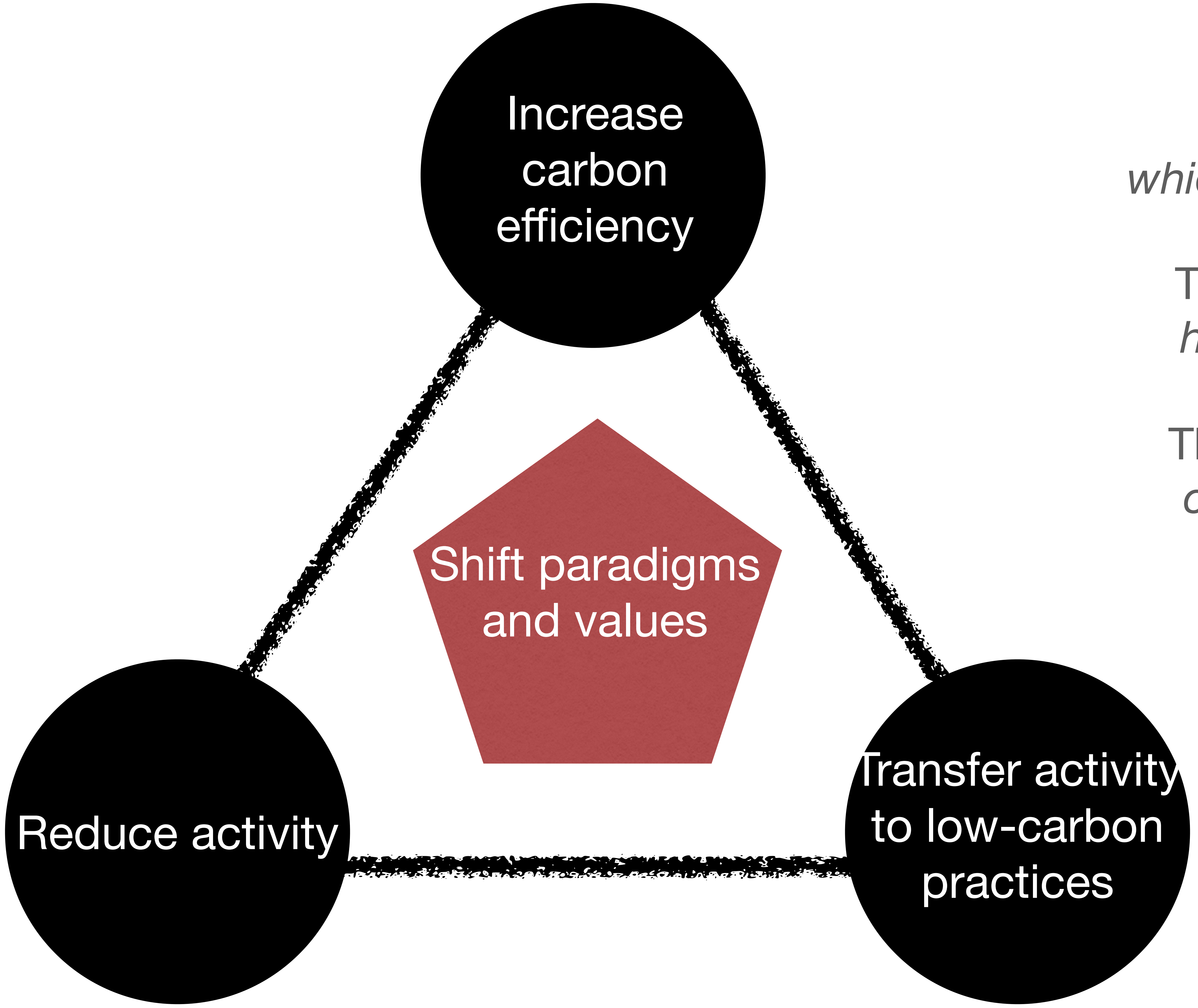
???

Reduction strategy at IRAP

Angèle Mouinié has joined us as « chargée de transition »

- Work at organizing and implementing a strategic reduction plan
- Propose training for IRAP people on climate matters
- Review and prepare potential low carbon development (e.g. electronic chips)

Avenues for reduction

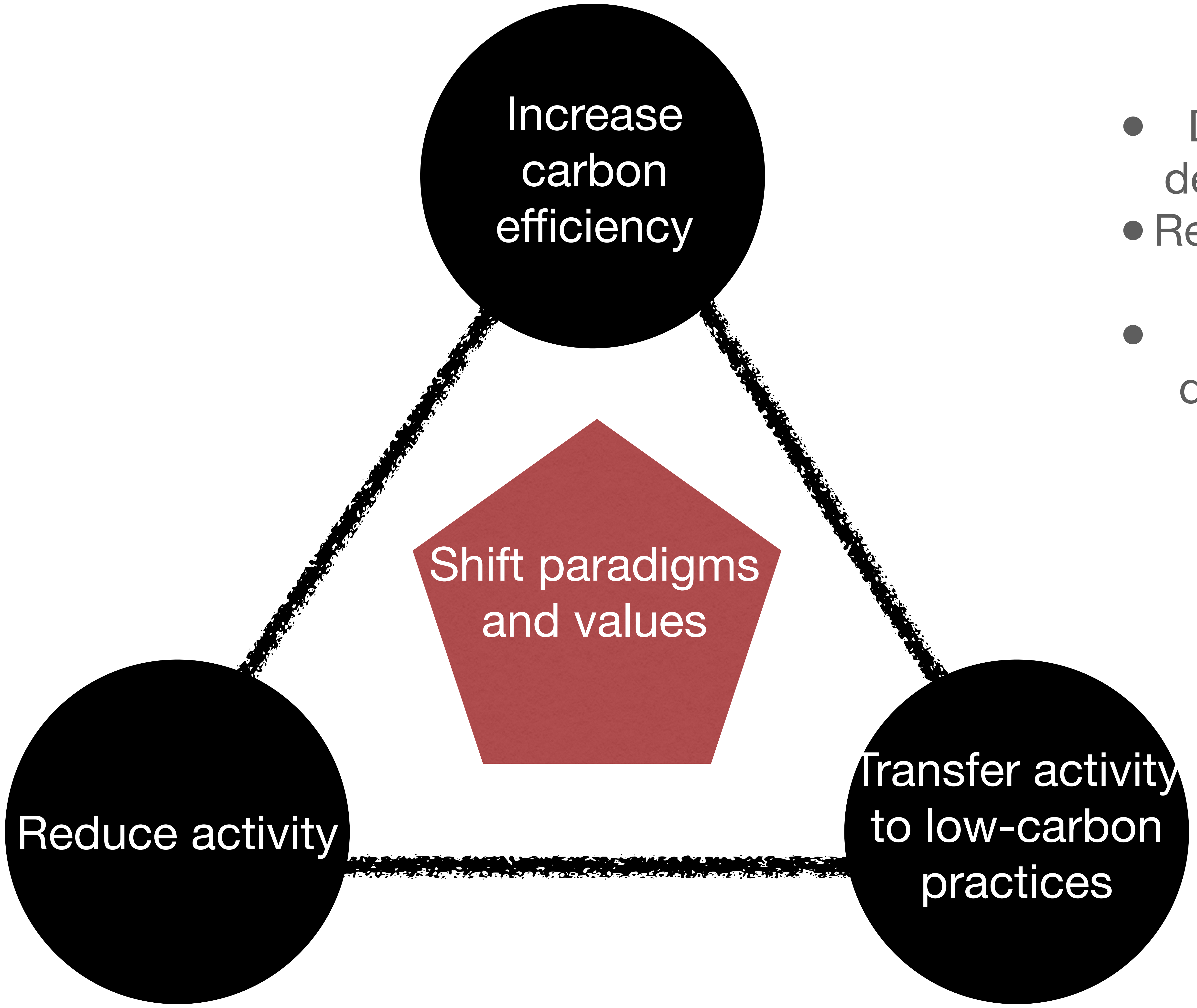


Think operational **control**
which measure can have direct effects

Think data/procedure **availability**
having them ready will take years

Think **magnitude** of the challenge
clock is ticking: act on all levers !

Avenues for reduction



Our **recommandations**:

- Divert growing fraction of funds to decarbonize existing infrastructures
- Research/development in low-carbon technologies for future projects
- Reduce cadence and scale of deployment of new infrastructures

Program

I] **Introduction aux enjeux, rappel des initiatives nationales, locales** (9h – 10h30)

– Présentation des actions et outils développés par Labo 1.5 (Olivier Berné, IRAP, 30 min)

– Retour sur le bilan GES de l'IRAP et spécificité de la recherche en Astrophysique (Victor Réville, IRAP, 30 min)

– Discussion

Pause café

II] **La science dans la société et liens avec l'industrie** (11h – 12h30)

– La science, supplément d'âme du spatial ? (Arnaud Saint Martin, CESSP, 30 min)s

– Urgence écologique, responsabilité de la communauté scientifique et pertinence de l'engagement des chercheurs (Odin Marc, GET/Atécopol, 30 min)

– Discussion

Pause déjeuner

III] **Initiatives bas carbone à l'IRAP** (14h00 – 16h00)

– Réutilisation d'instruments: le cas de l'experience ballon PILOT (Jean-Philippe Bernard, IRAP, 20 min)

– The value of exploiting archival data – An example of reducing our dependency on new research infrastructures (Jürgen Knödlseder, IRAP, 20 min)

– Futurs du calcul numérique (Pierre Marchand, IRAP, 20 min)

– Discussion

Pause café

IV] **Valoriser et financer la recherche bas carbone** (16h30 – 17h30)

– Auto-évaluation des scientifiques sur les bilan GES de leur recherche

– Rôle des agences et tutelles : CNES, INSU, CNRS, SNO, écoles doctorales

– Discussion