# Monitoring and minimising the travel footprint associated with the development of the Athena X-ray Integral Field Unit

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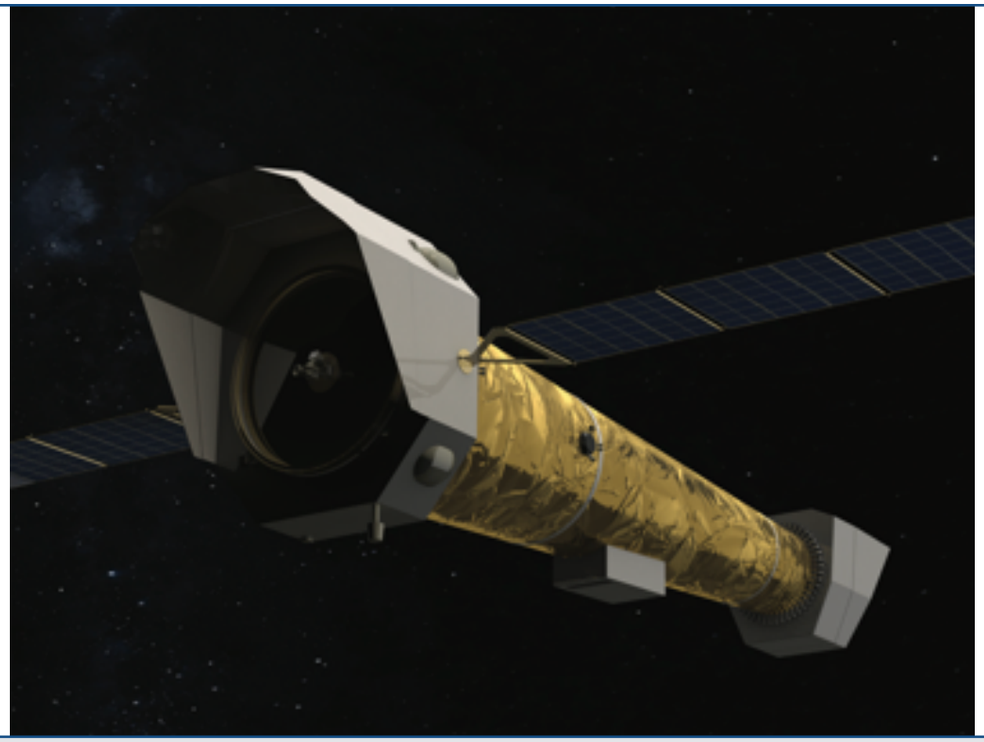
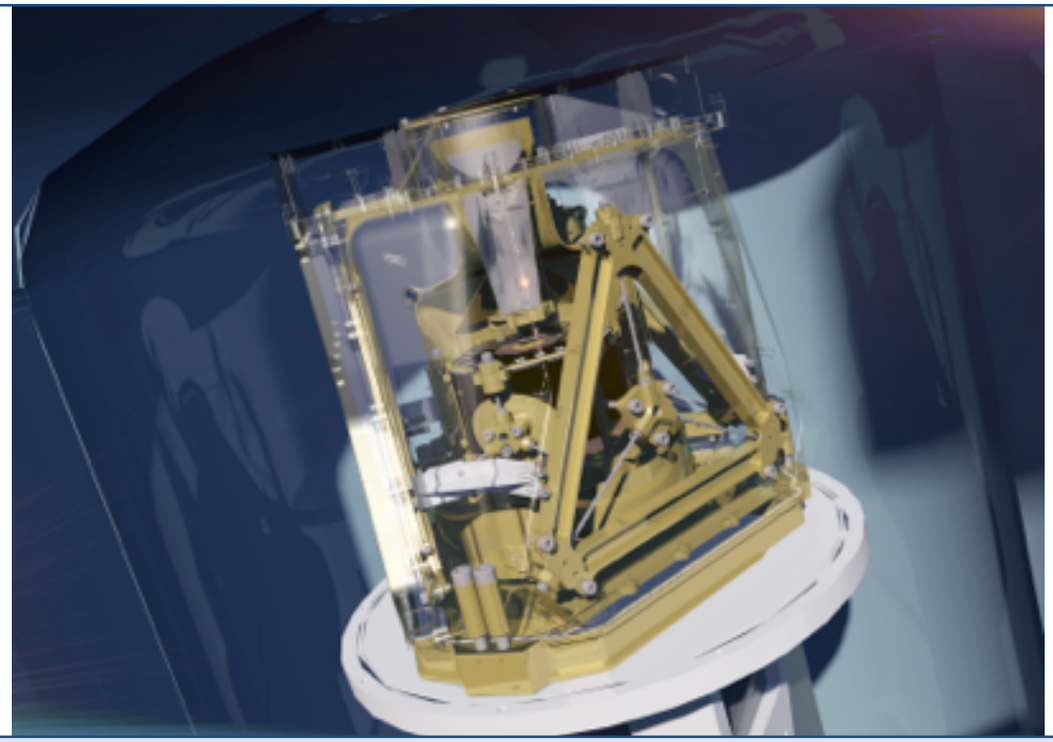
# What is X-IFU?

- X-IFU is the high-resolution X-ray spectrometer of the ESA's Athena Space X-ray Observatory: the second large mission of the Cosmic Vision Science Program
  - Overall footprint expected to be large
- The X-IFU is developed by a large international consortium spread over 12 countries, gathering about 60 institutes and institutions from Europe, Japan and the United States
  - Travel footprint expected to be large



The Athena space observatory (Credits ESA/X-IFU)



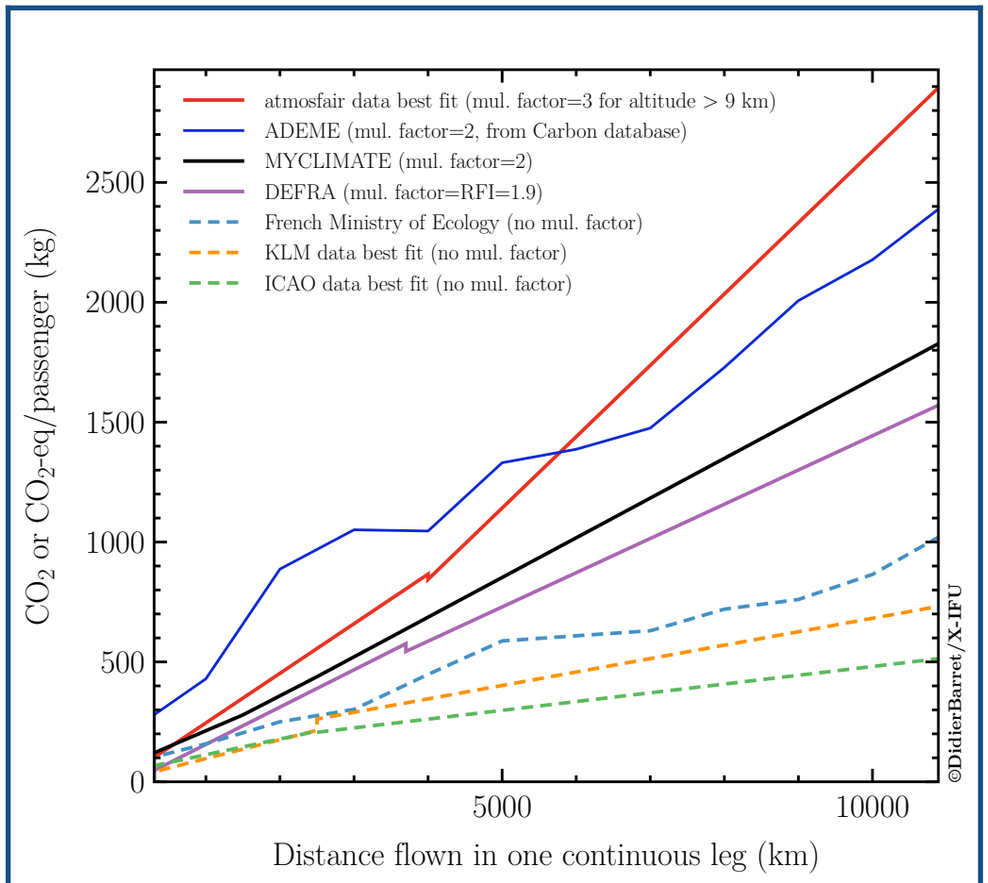
The X-IFU Focal Plane Assembly (Credits X-IFU)

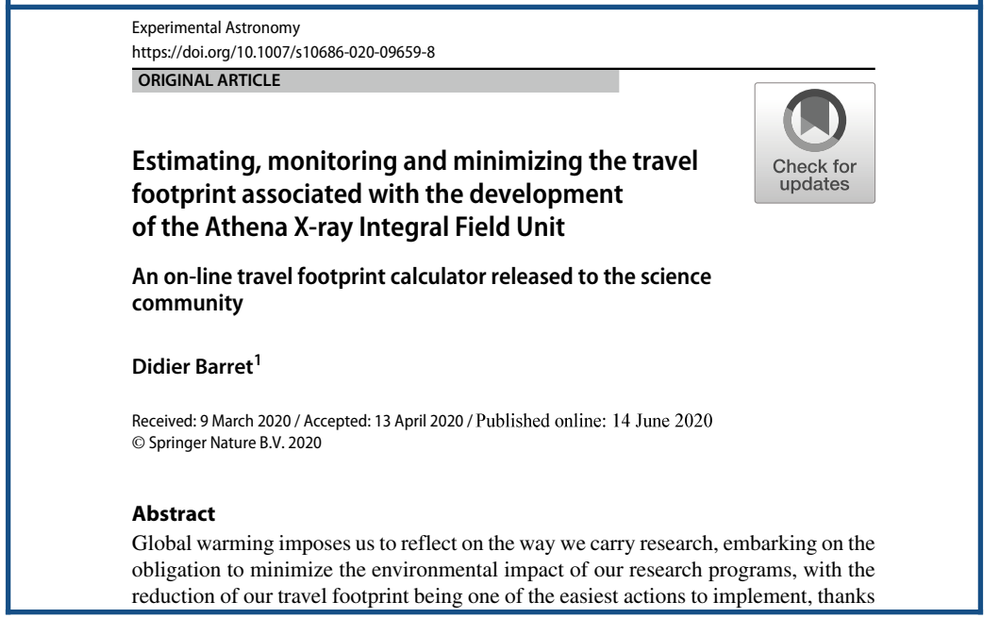
# How did I get there ?

- Stimulated by several initiatives (like this special session, thanks Leo and colleagues for setting this up !) and several publications from academia, I realised that I ought to do something urgently for X-IFU
  - How best to reduce the environmental impact of the X-IFU project?
    - ➡ The obvious answer was reducing first our travel footprint
- However, I soon realised that facing real numbers would be more efficient to convince people to change their habits than just talking about the mandatory need to do so.
- What was needed was to :
  - compute the overall travel footprint of X-IFU related activities
  - present the actual numbers to the Consortium
  - propose ways to reduce the X-IFU travel footprint, not being dogmatic
  - offer a tool for each member of the Consortium to compute its own footprint
    - ➡ This led to the development of a travel footprint calculator

# Need for a standardisation

- Unfortunately, this led me to discover that there is no commonly accepted methodology to compute flight emissions
  - Difference occurs in accounts of non-$CO_2$ effects (conversion factors from $CO_2$ to $CO_2$-eq ranging from 1 to ~3), in plane emission factors (fuel consumptions, seating configurations, passenger loading factors…), in perimeters considered (include the infrastructures, the plane maintenance…)
  - This leads to variation by up of ~5 for $CO_2$-eq emissions of long distance flights !
    - ➡ Calls for a standardisation, regulation
- Nevertheless a travel footprint calculator was developed and released to the members of the Consortium (and then to the community)
  - ➡ Barret (2020, Exp. Astr, arXiv:2004.05603)





Experimental Astronomy
https://doi.org/10.1007/s10686-020-09659-8

ORIGINAL ARTICLE

**Estimating, monitoring and minimizing the travel footprint associated with the development of the Athena X-ray Integral Field Unit**

**An on-line travel footprint calculator released to the science community**

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**Abstract**

Global warming imposes us to reflect on the way we carry research, embarking on the obligation to minimize the environmental impact of our research programs, with the reduction of our travel footprint being one of the easiest actions to implement, thanks

# Travel footprint calculator

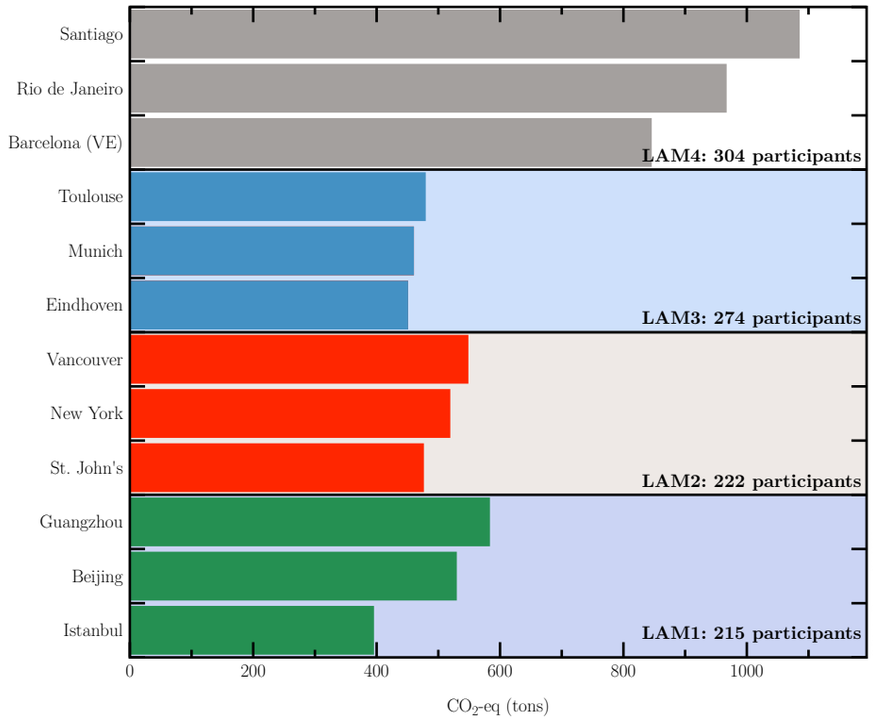
https://travel-footprint-calculator.irap.omp.eu


- The tool computes the carbon footprint associated with round trip flights, according to the methodology of several publicly available calculators.
  - From a given city of origin to a set of destinations,
  - For a larger set of trips, corresponding to a conference, a meeting and so on,
  - If multiple destination cities are provided, the tool ranks those cities according to the associated travel footprint.
- Freely available, user friendly and used 100s times already !

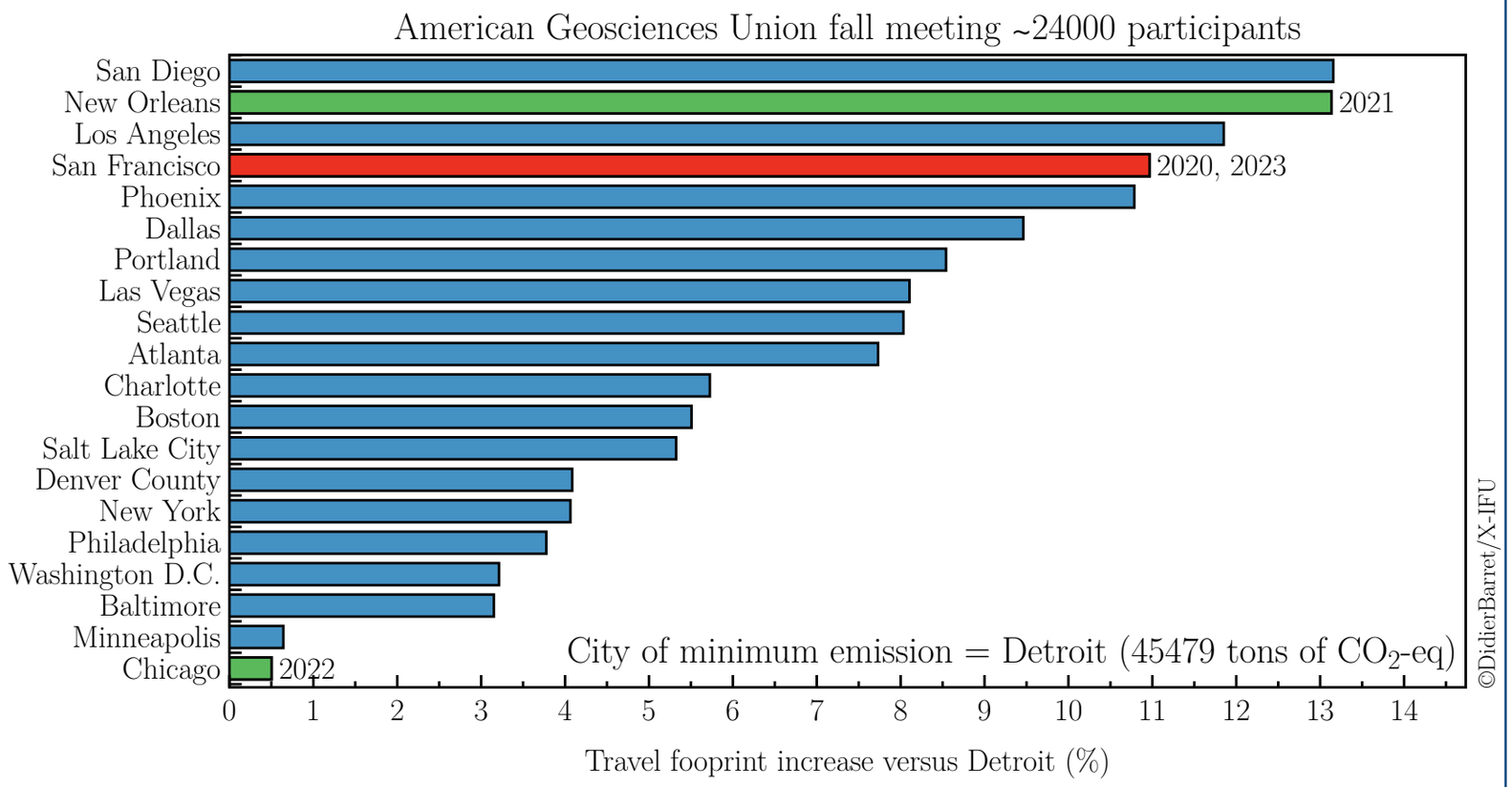
https://travel-footprint-calculator.irap.omp.eu

# Application to IPCC/AGU meetings

- The calculator enables to search for the city of minimum emission for large conferences/meetings…
  - Just needs an file (csv or xlsx format) with templates provided
  - It provides also inputs files with the lists of large airports by continent and world wide
  - Minimum travel distance for flying can also be selected (train journeys are then considered)

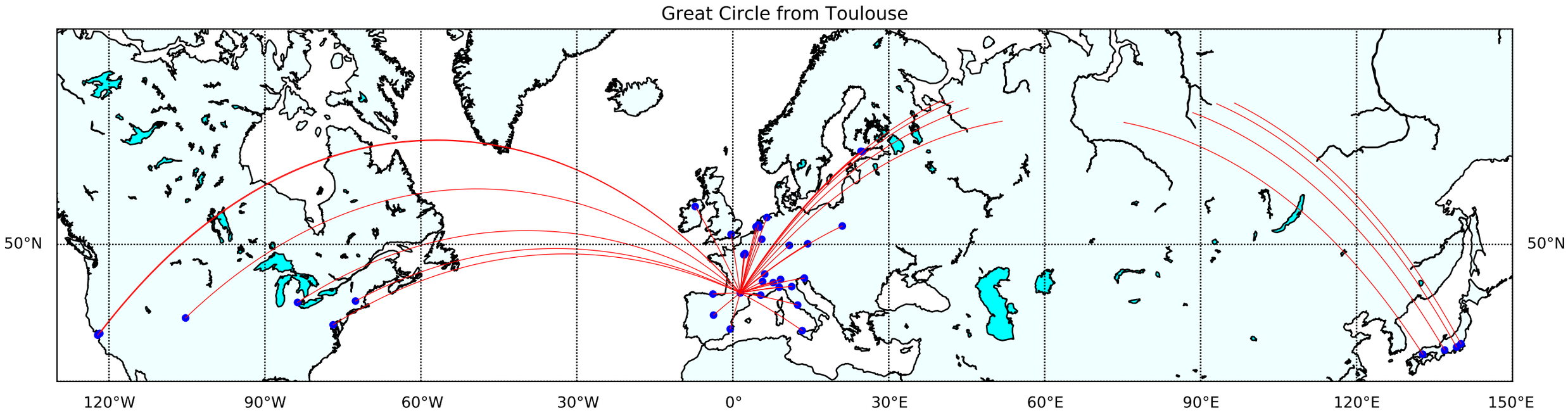



Outputs for 4 IPCC lead-author meetings to take place in 4 different continents.




Outputs for AGU fall meetings with Detroit the city of minimum emission (close to Chicago). San Francisco is 11% higher.

# Application to X-IFU




- Assumptions:
  - ~250 consortium members
  - a representative set of meetings with different attendances
  - integrated over ~15 years, which is the development time of the instrument
    - ➡ The grand total is ~7000 tons of $CO_2$-eq (~500 tons/yr) or 1/10th of an annual AGU meeting
- However, specific to running a project like X-IFU, the covid-19 pandemic revealed
  - that it was possible and effective to hold important meetings virtually/remotely (while it was generally thought that the urgent matters would require physical presence)
  - that virtuality increases inclusivity, removing the burden, constraints, funding issues of traveling

# Conclusions

- Reducing our travel footprint is mandatory: this can be achieved easily
  - First actions implemented already: e.g. moving to 1 consortium meeting per year
- The pandemic has shown that most meetings can be done virtually
  - We may now set a goal of reducing our travel footprint by at least 50% from now on
- Still in long lifetime projects like X-IFU, physical interactions are mandatory
  - Special care will be taken to optimise each travel, select the site of minimum emission, privilege train travels…
  - Optimise the presence to conferences, e.g. solicit the closest possible speakers
  - Yet privilege the youngest members to do their necessary networking
- Making the reduction of the environmental footprint of space activities a key requirement for developing a mission like Athena is also mandatory
  - Framework exists, e.g. the clean space initiatives of ESA and CNES,
  - Favouring green technologies whenever possible…
- The advance of knowledge is vital for humanity, but cannot be done at the expense of contributing to the destruction of our planet

# Backup slide

- Total footprint estimates using approximate relations

# What about the overall footprint

- No life cycle assessment of X-IFU and Athena exist yet
- Athena is ~2 B€ mission (spacecraft, payload, launcher, ground segment)
- First very crude estimate consists of taking the cost multiplied by the mean carbon intensity of Europe, being the total emission divided by the Gross Domestic Product (GDP) — *adapted from Knödlseder+2020 for the Cerenkov Telescope Array (internal report)*
  - Mean carbon intensity in Europe (source World data) ~ 0.237 kg/k€ of CO2
    - ➡ Total footprint (assuming Athena is built entirely in Europe) : ~ 800 ktons of CO2-eq
- Another crude estimate consists of decomposing the activity into, e.g. Services, R&D, Construction, Electronics, computers, optics, Metal products,…
  - Metal products has an intensity of 600 kg $eCO_2$/k€
  - Split the total cost into various components, e.g. assuming services are 40% of the costs
    - ➡ Total footprint (assuming ADEME French numbers): ~ 900 ktons of CO2-eq over 20 years
    - ➡ Assuming a mean worldwide emission of ~7 tons of CO2-eq/yr per capita, this represents the annual emission of ~6500 world citizens for 20 years at the current rate