Carbon footprint of numerical simulations

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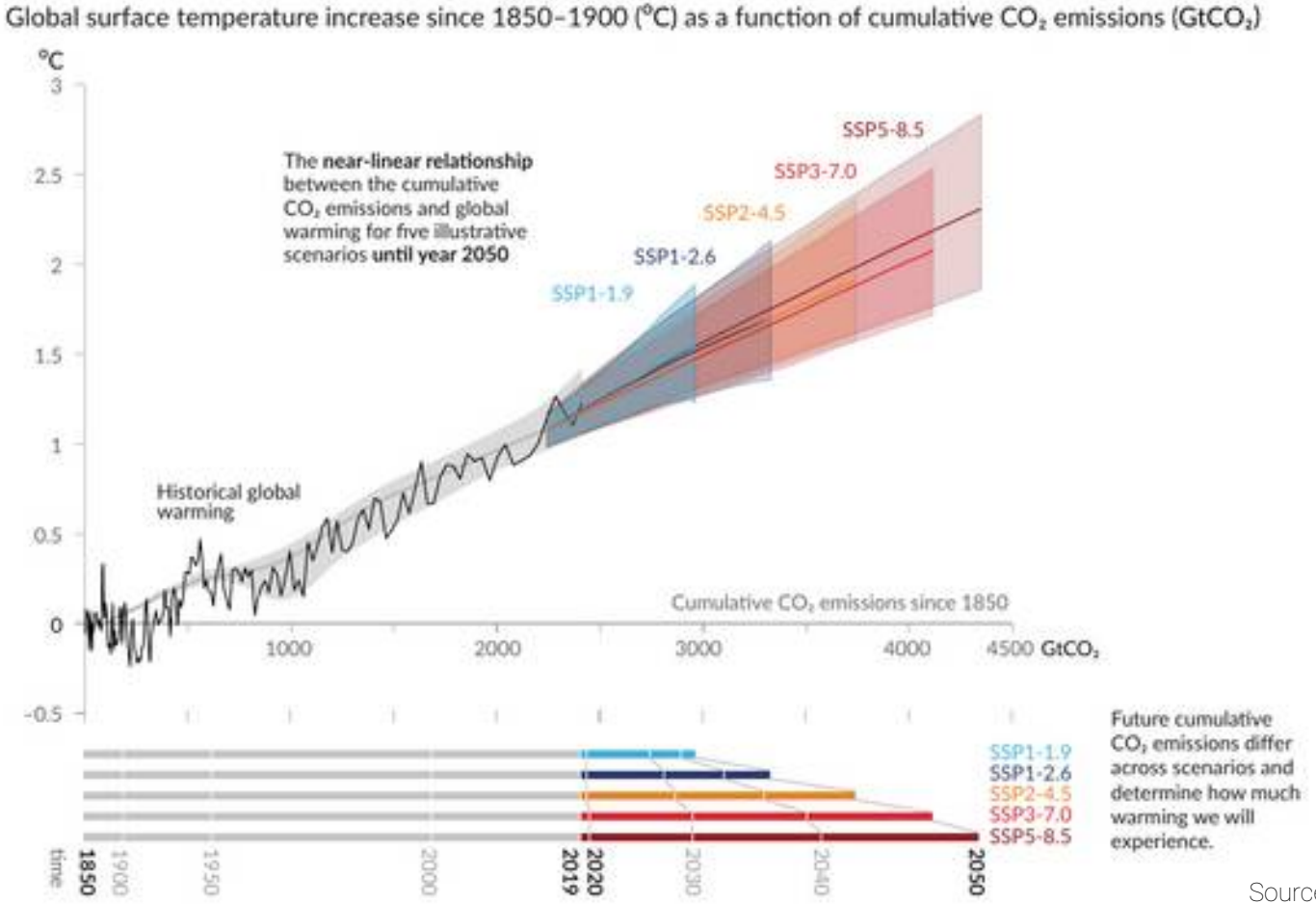
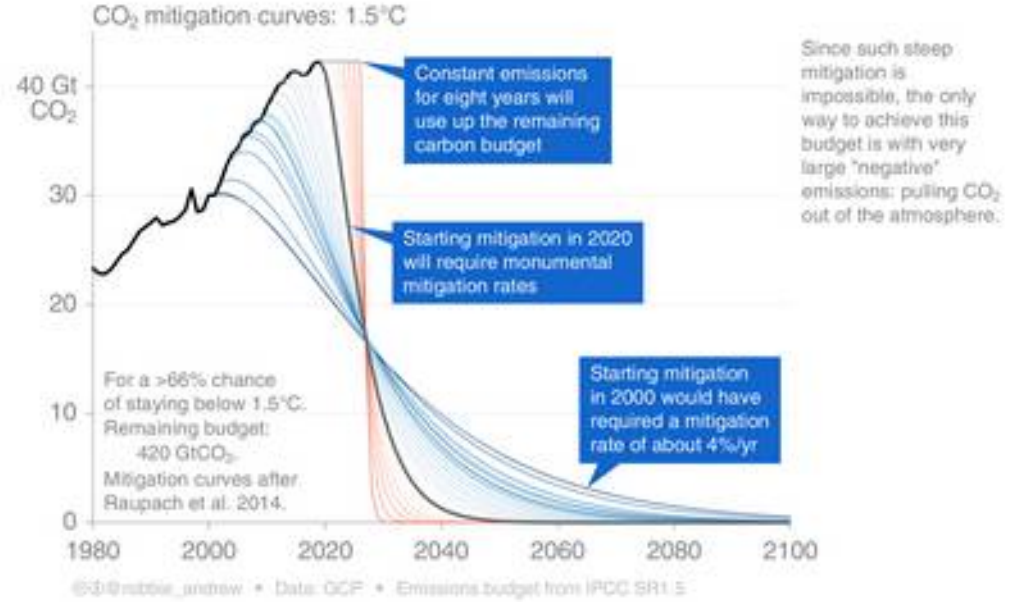
Why ?

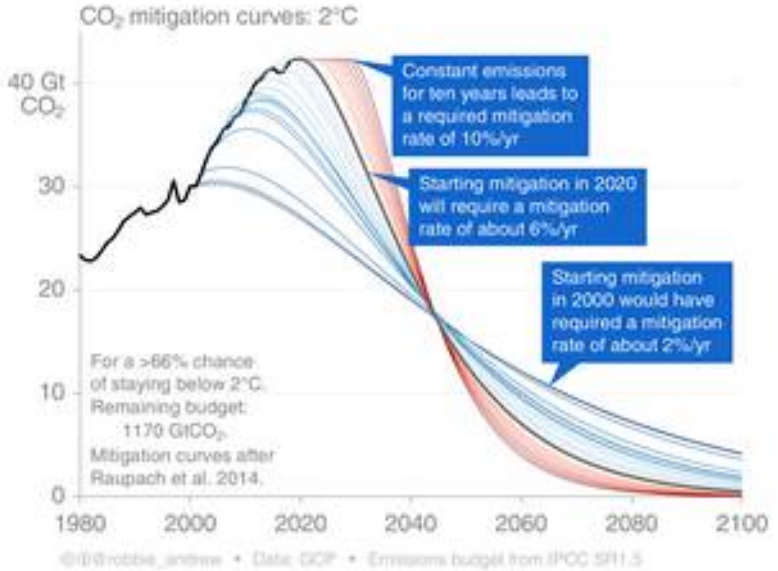


Source : GIEC/AR 6 2021

Why ?

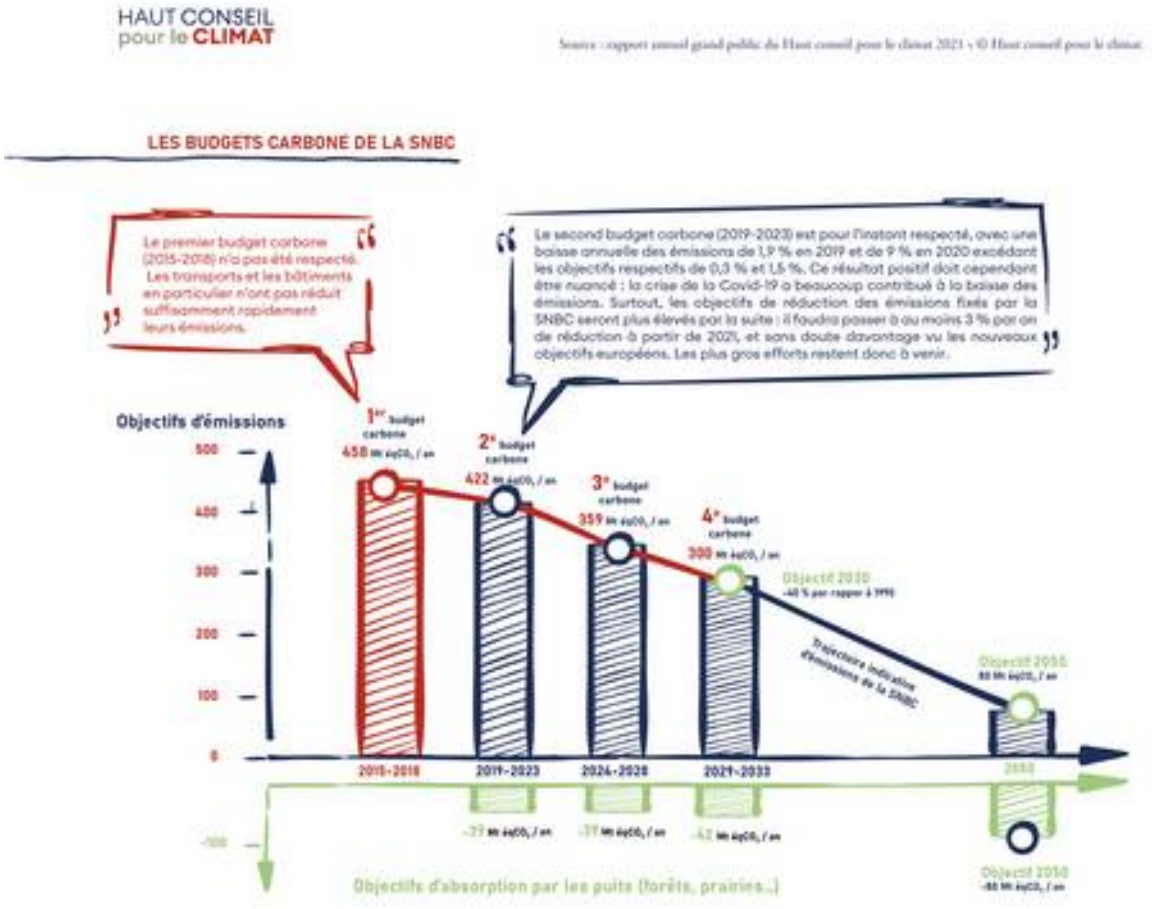
- Carbon budget
  - Remaining budget
  - Population : up to 8.8M
- 1,5 or 2 tCO_2^{eq}/yr/capita
- Today mean carbon footprint in France : ~9tCO_2^{eq}/yr/capita





Models from Raupach, Nat. Climate Change 2014

Why ?



Source : Haut conseil pour le climat & Stratégie Nationale Bas Carbone (SNBC)

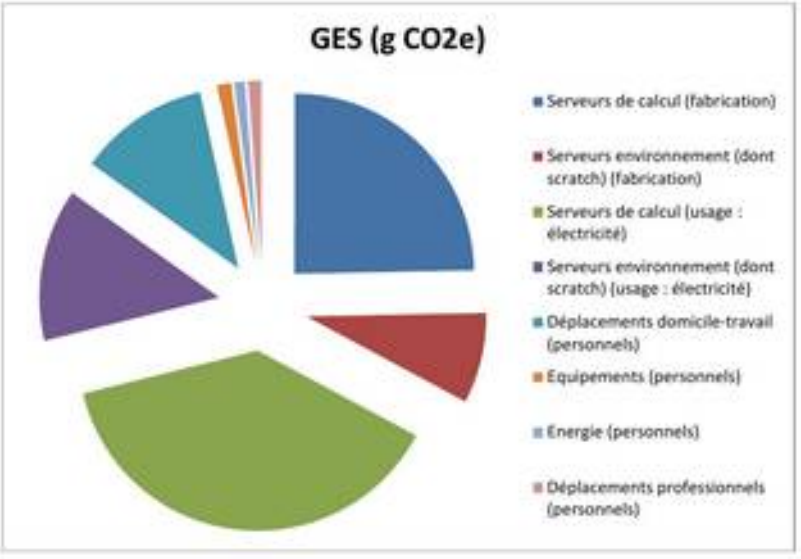
Some assumptions

- Paris agreement and french pledge
- Numerical simulations in astrophysics
- Efficiency vs. Frugality

Carbon footprint of a numerical simulation

- Include (Life cycle analysis)
  - Energy consumption of the cluster
  - Power carbon intensity - France :
    - 34g/kWh for RTE
    - 68g/kWh for Ember
    - *85gCO2/kWh for International Energy Agency*
    - *108gCO2/kWh for European Life Cycle Data*
  - Construction of the cluster (no recycling)
  - Buildings & human ressources
- Results : 4.68gCO2/hCPU (GRICAD Local cluster)
  - Lifetime of the servers
  - PUE (Power usage efficiency)

Sources : https://ember-climate.org, https://www.rte-france.com,

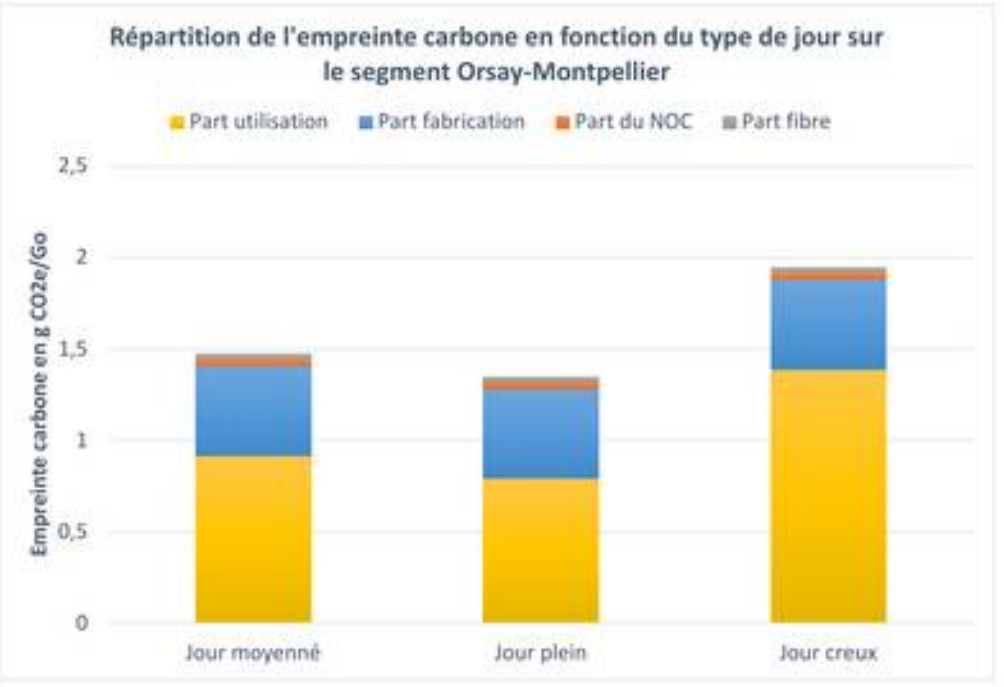


Sources : ECOINFO, https://hal.archives-ouvertes.fr/hal-02549565v4

Carbon footprint of storage : transport

- Include (Life cycle analysis)
  - All elements of network
  - Construction
- Results
  - Transport Renater (1.4gCO2 for 1Go for Orsay/Montpellier)
  - Transport France : 9gCO2/Go (ADEME/ARCEP)
  - Transport France home usage 18gCO2/Go (check your bills !)

Sources : EcoInfo/Renater & Ademe/Arcep



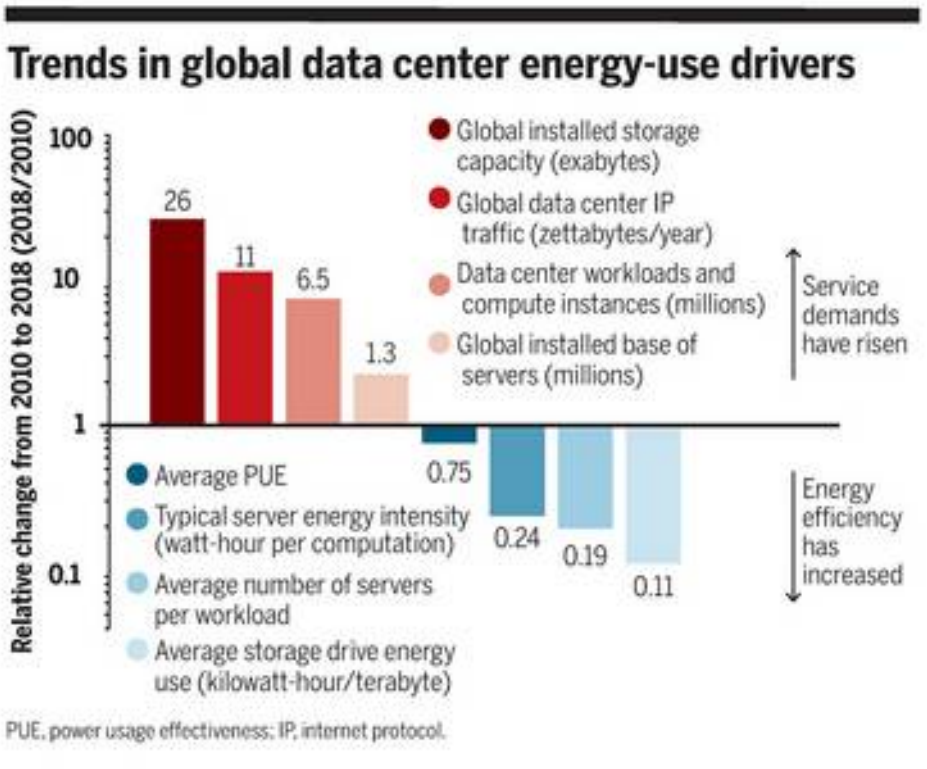
Carbon footprint of storage : datacenters

- Include (Life cycle analysis)
  - Servers
  - Power
  - Cooling
- Results
  - 135kg/To/an ?

Sources : ADEME/ARCEP, 2022

Some general good practices

- Use french and shared facilities
- Optimize your codes (avoid unoptimized Python)
- Code adapted for any platform including old ones
- Open source codes with documentation
- Perform simple tests before heavy runs
- No unnecessary runs to finish your time allocation



Masanet et al. 2020

Some conclusions

~ 4 tCO2/MhCPU

~ 135kgCO2/To/yr

~ 2kgCO2/To/download

- Efficiency
  - France / Shared facilities
  - Life-time of the clusters
  - PUE & usage
  - Rebound
- Sobriety

- Other environemental impacts
- Accessibility
  - High-level (reduced) data to be shared
  - Low level data accessible on demand