



**Barcelona
Supercomputing
Center**

Centro Nacional de Supercomputación

The BSC Earth Sciences Department and the Development of Services

Francisco Doblas-Reyes

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27 February 2024



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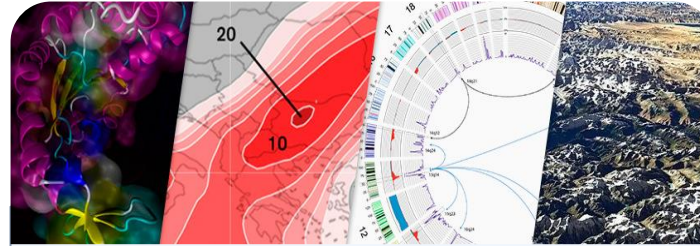


Barcelona Supercomputing Center Centro Nacional de Supercomputación

BSC-CNS objectives



Supercomputing services
to Spanish and EU researchers



R&D in Computer, Life, Earth and
Engineering Sciences



PhD programme, technology
transfer, public engagement

**BSC-CNS is
a consortium
that includes**

Spanish Government



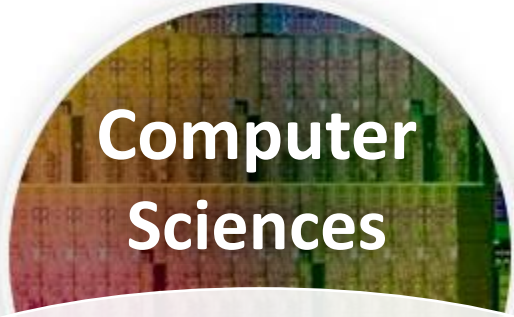
Catalan Government



Univ. Politècnica de Catalunya (UPC)

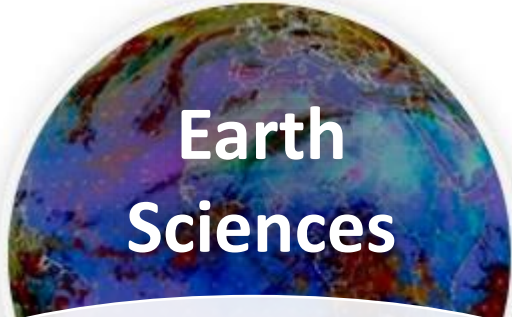


Mission of the BSC scientific departments



Computer Sciences

To influence the way machines are built, programmed and used: programming models, performance tools, Big Data, Artificial Intelligence , computer architecture, energy efficiency



Earth Sciences

To develop and implement global and regional state-of-the-art models for short-term air quality forecast and long-term climate applications



Life Sciences

To understand living organisms by means of theoretical and computational methods (molecular modeling, genomics, proteomics)

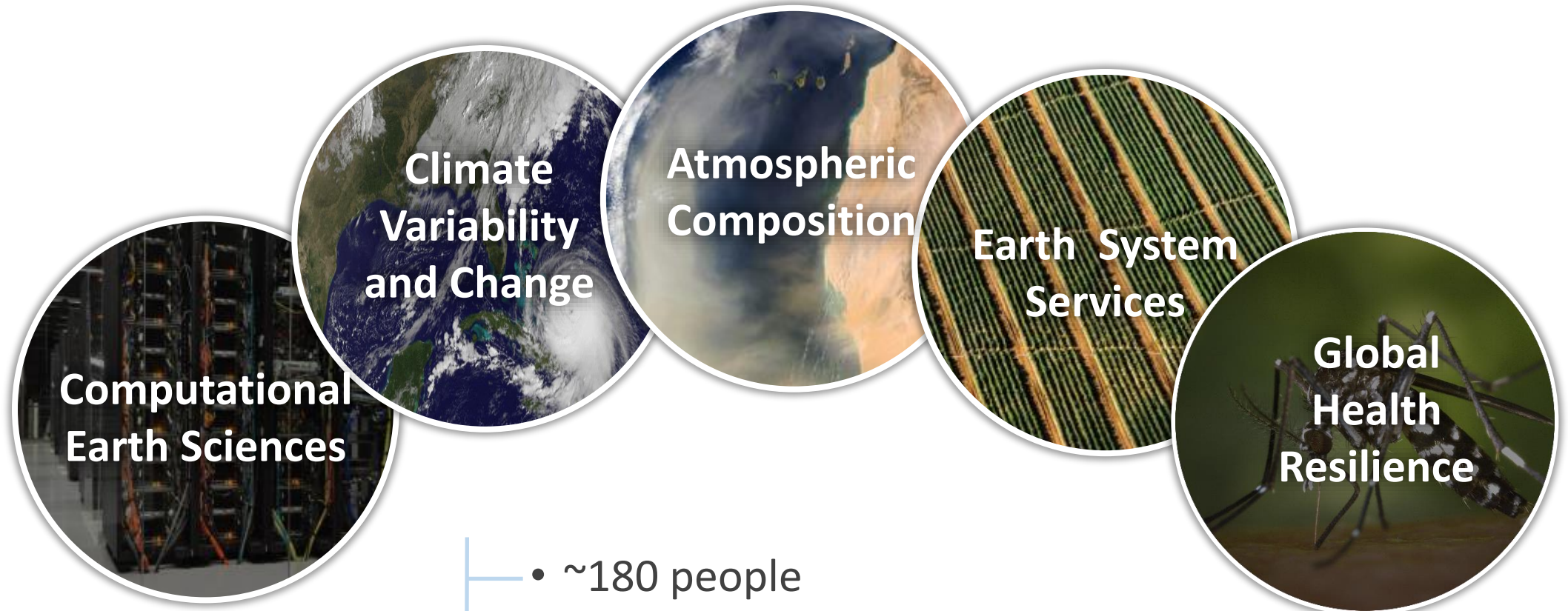


CASE

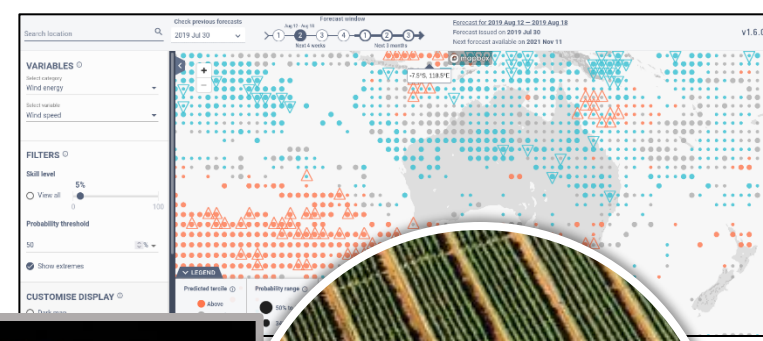
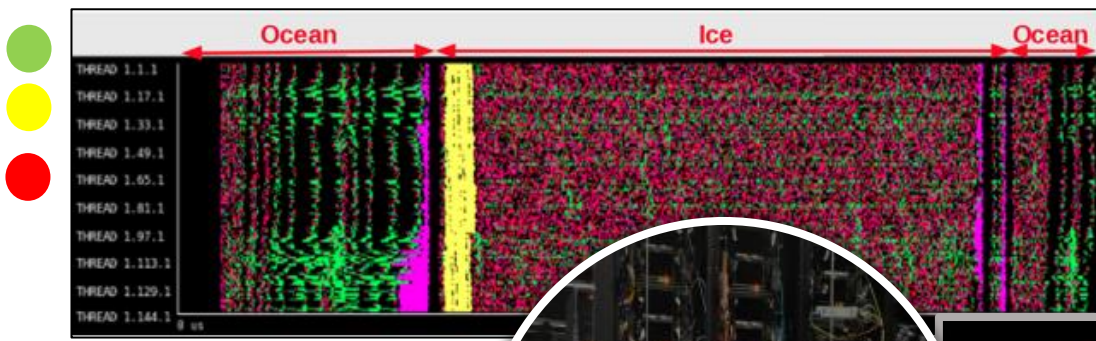
To develop scientific and engineering software to efficiently exploit super-computing capabilities (biomedical, geophysics, atmospheric, energy, social and economic simulations)

Earth Sciences Department

Environmental modelling and forecasting using process-based and artificial intelligence models, with a particular focus on **weather, climate and air quality**. This includes **transferring solutions** to support the main societal environmental challenges through data applications



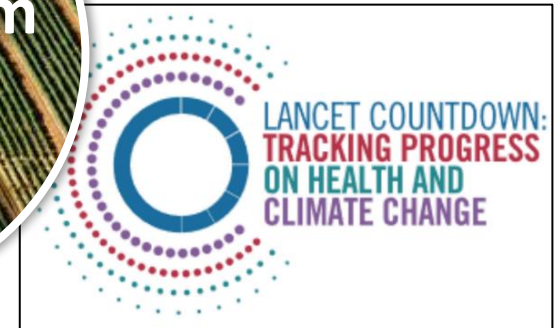
- ~180 people
- Funding from EC, Copernicus, private sector, ESA, Spanish and regional governments
- Four ICREA, close link to local universities



Visualisation



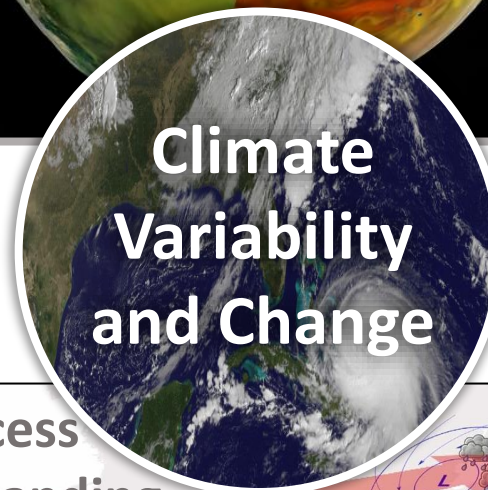
Climate impacts



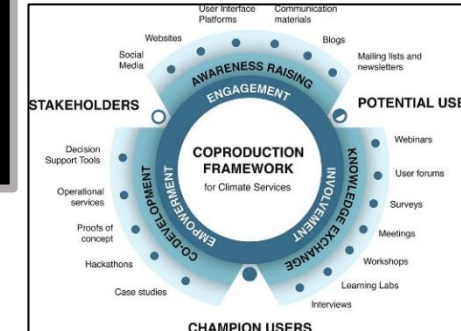
Earth System Services



Digital Twin Earth



Climate Variability and Change



User engagement



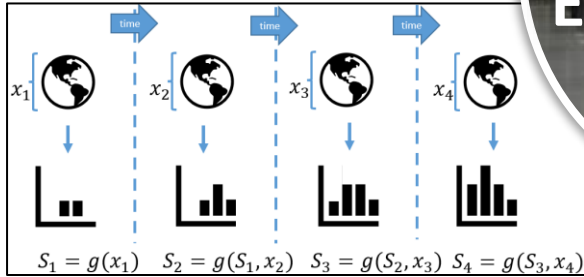
Process understanding



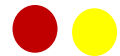
Computational Earth Sciences



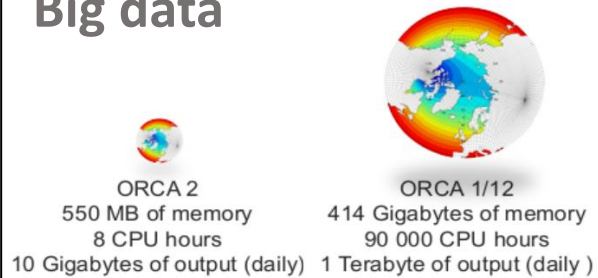
Code development



Data workflows

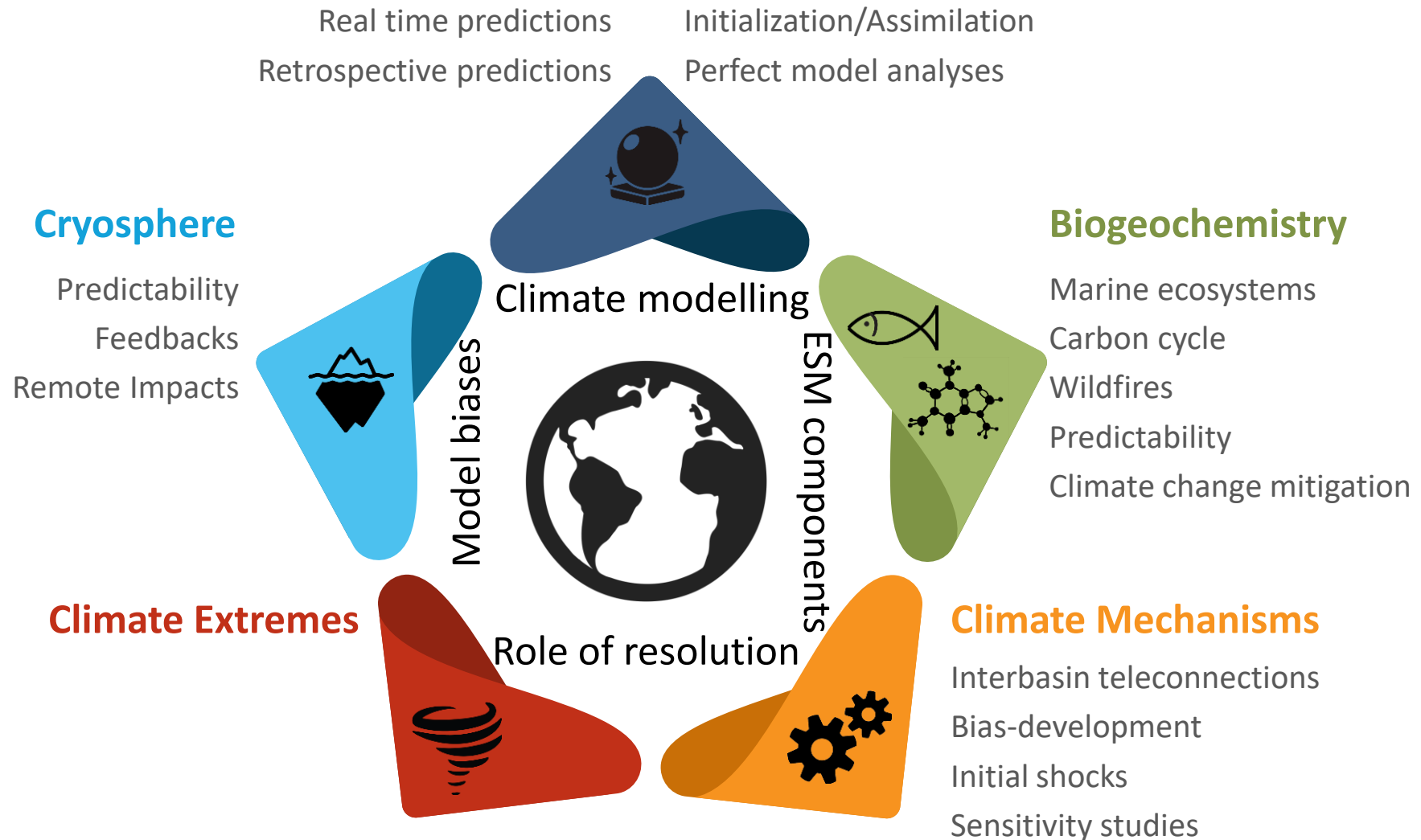


Big data



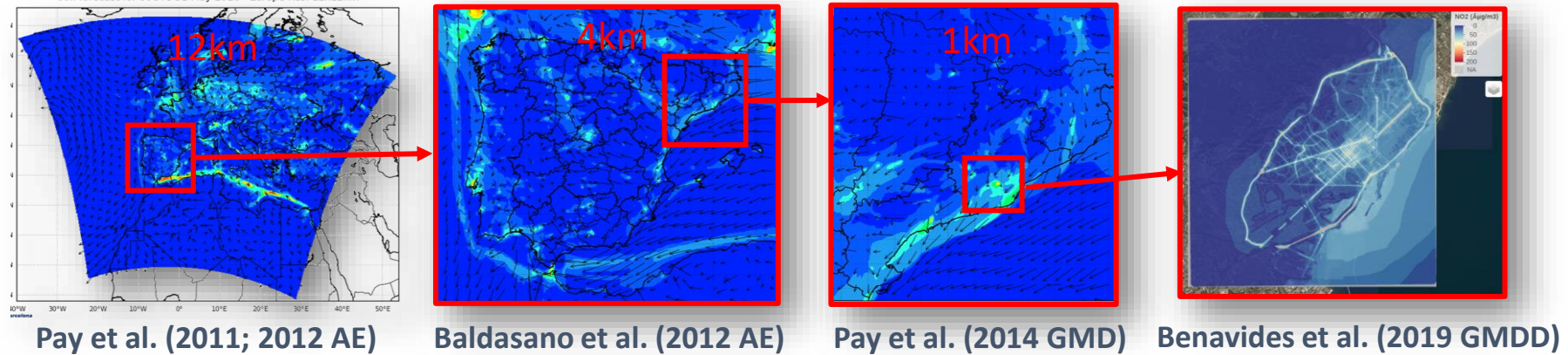
- Data science
- Physics
- Chemistry
- Applied mathematics
- Software engineering
- Environmental science
- Climatology
- Social science
- Humanities
- Environmental economy

Global climate modelling



Multiscale air quality forecasts

- Air quality forecasts produced every day with the forecast system developed at the BSC.

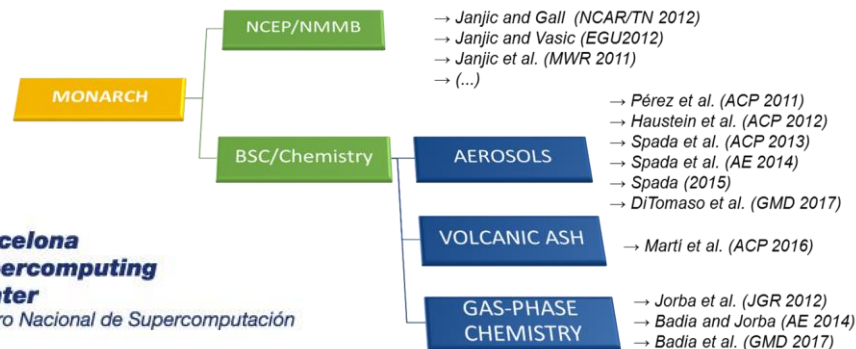


← CALIOPE system: air quality forecasts from regional to urban scales →



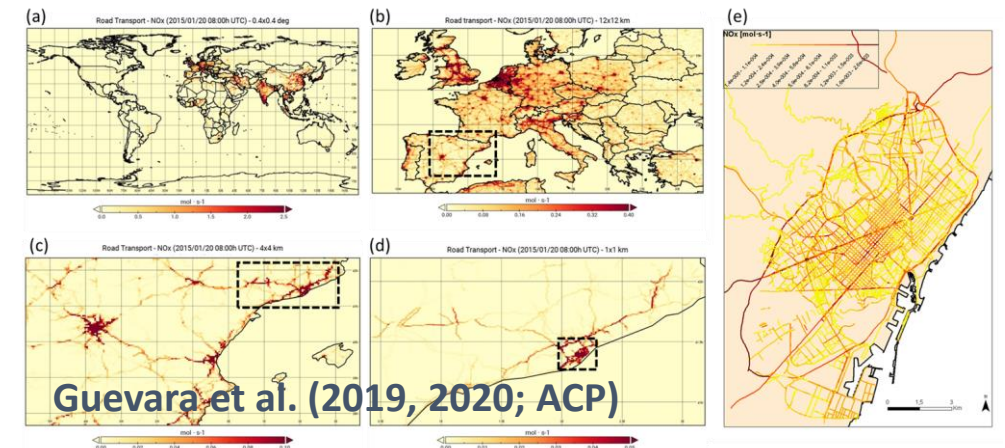
MONARCH model

Multiscale Online Nonhydrostatic Atmosphere Chemistry model
Global to regional (up to 1km) scales allowed with full on-line coupling, including data assimilation and machine learning



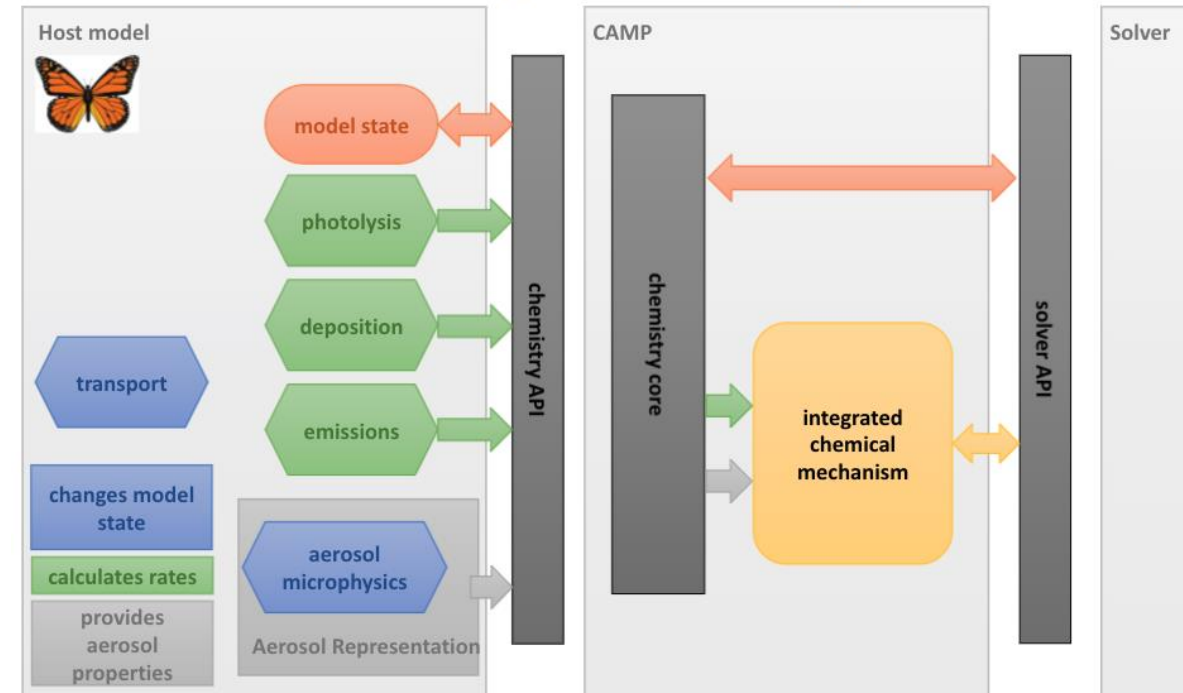
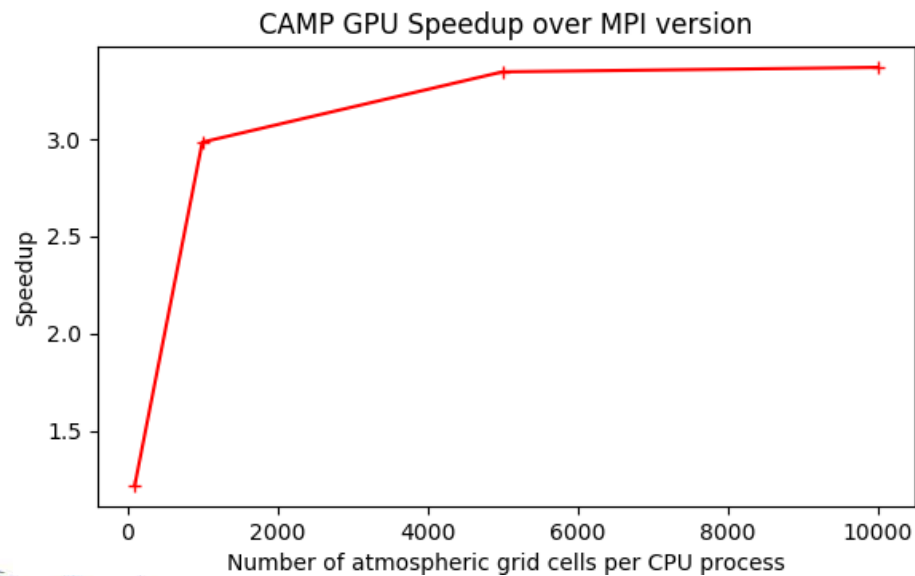
HERMES3 emission model

Open source, parallel and multiscale emission modelling framework for gas and aerosols



Atmospheric chemistry modelling

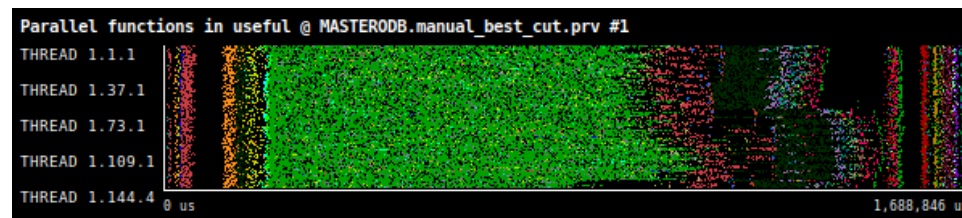
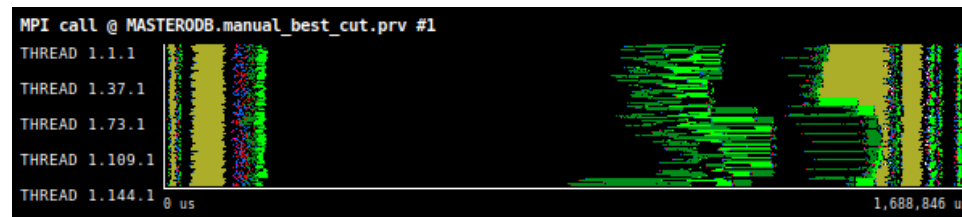
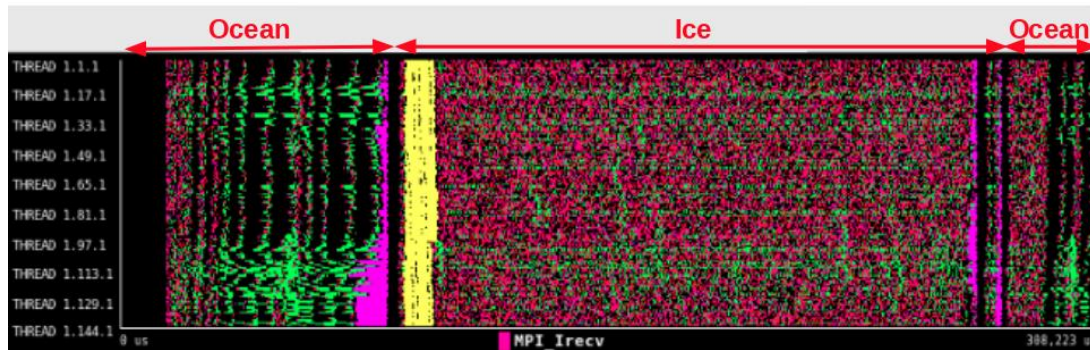
- An object-oriented gas- and aerosol-phase chemistry solver built on a framework with a flexible interface that allows changing the chemical mechanism without recompiling and varying the mechanism complexity based on conditions/location.
- Chemistry Across Multiple Phases (CAMP) brings flexibility to the modelling side (via APIs and chemical mechanisms described in JSON files) and portability.
- Chemistry models involve calculations from hundreds of individual reactions -> accelerators.



Computational efficiency of community models

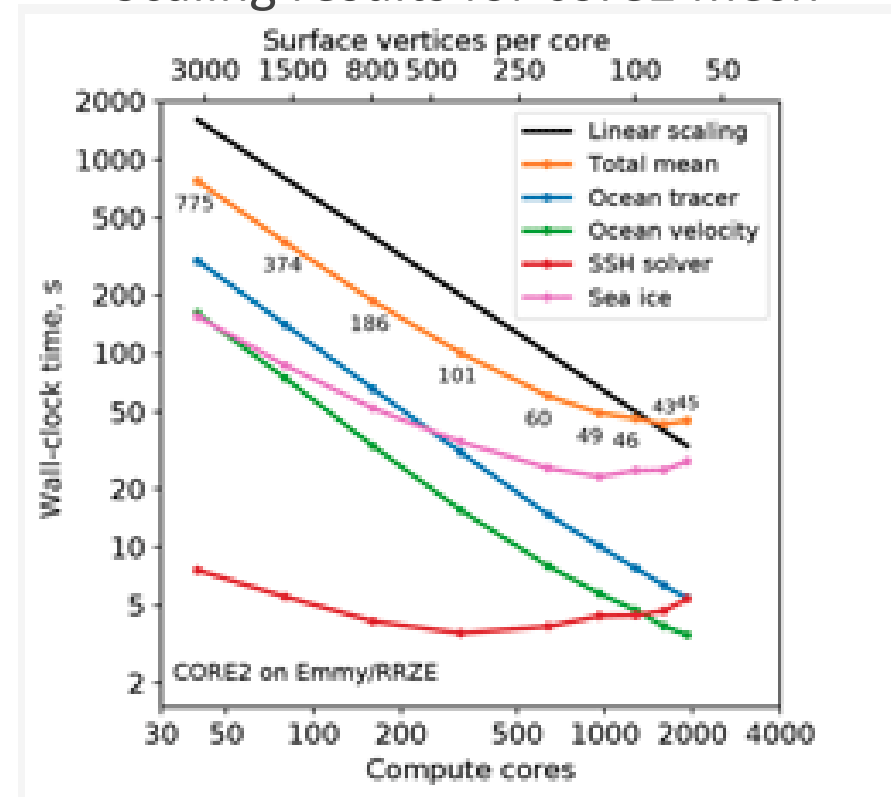
The aim is to help the community to run better and faster experiments and forecasts enhancing the community capability to use heterogeneous architectures (GPU, RISC-V).

FESOM2 ocean model



HARMONIE weather
forecast model

Scaling results for core2 mesh

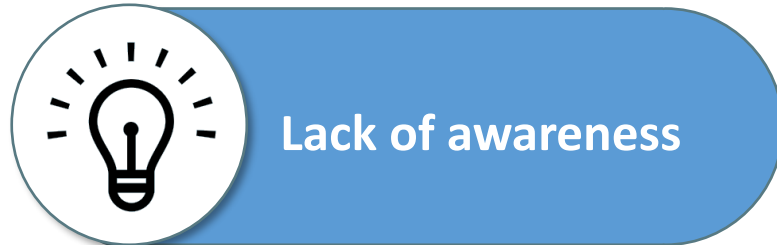


Breaking barriers for decision making

Some **limitations** for the use of environmental data in different socio-economic sectors.



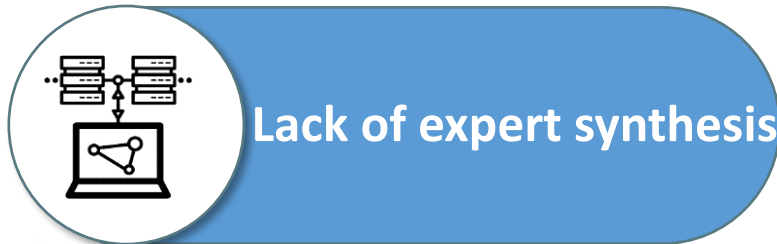
Possible solution: to distil the information from existing sources to be integrated in decision-making.



Lack of awareness



Difficult interpretation



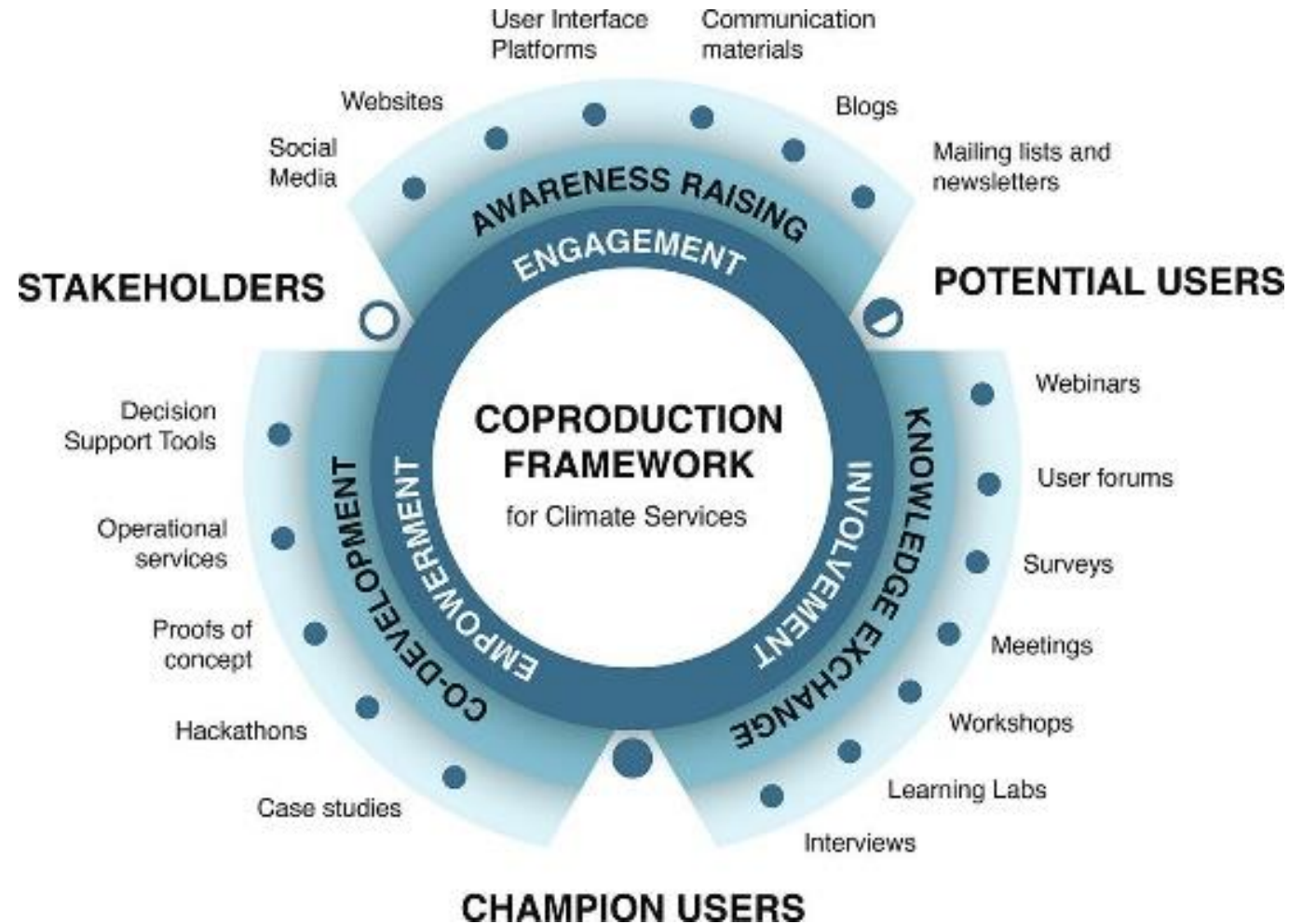
Lack of expert synthesis

Environmental services

- **Goal:** the development and incorporation of environmental data for planning, policy-making and practice at the global, regional and national scale.
- **Implementation method:** co-production and co-design.

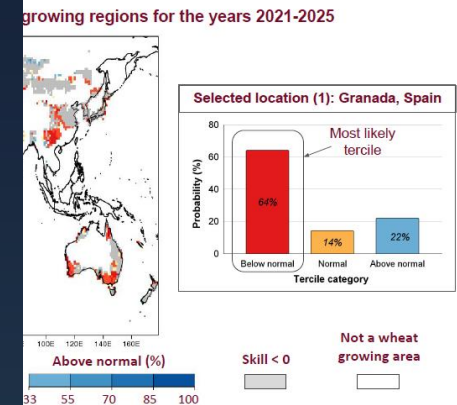
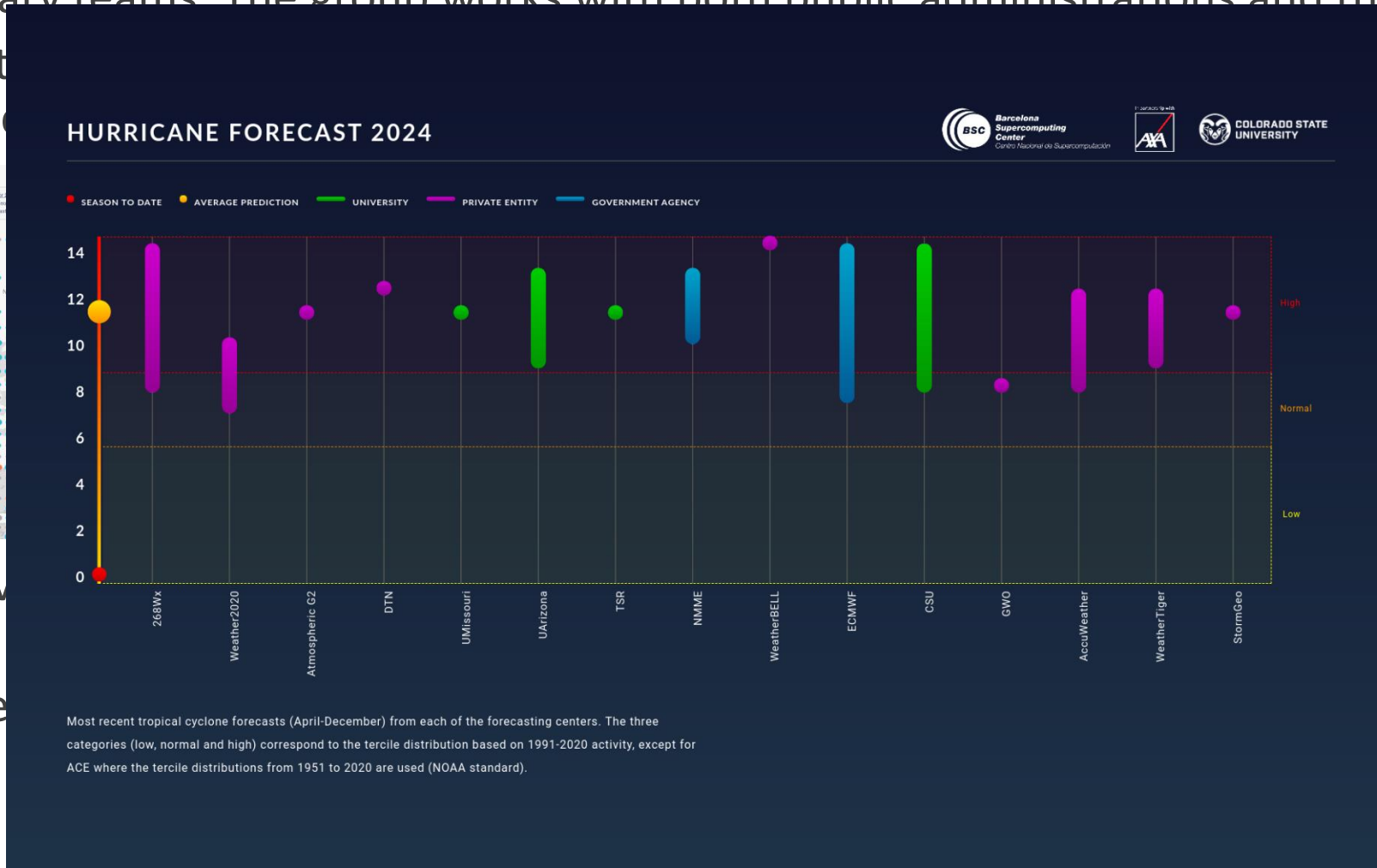
Social sciences and humanities

Increased trans-disciplinarity enhancing the participation of researchers from social sciences (including environmental economics) and humanities in technology-based environmental research to better reach users, policy makers and citizens.



Working with the users

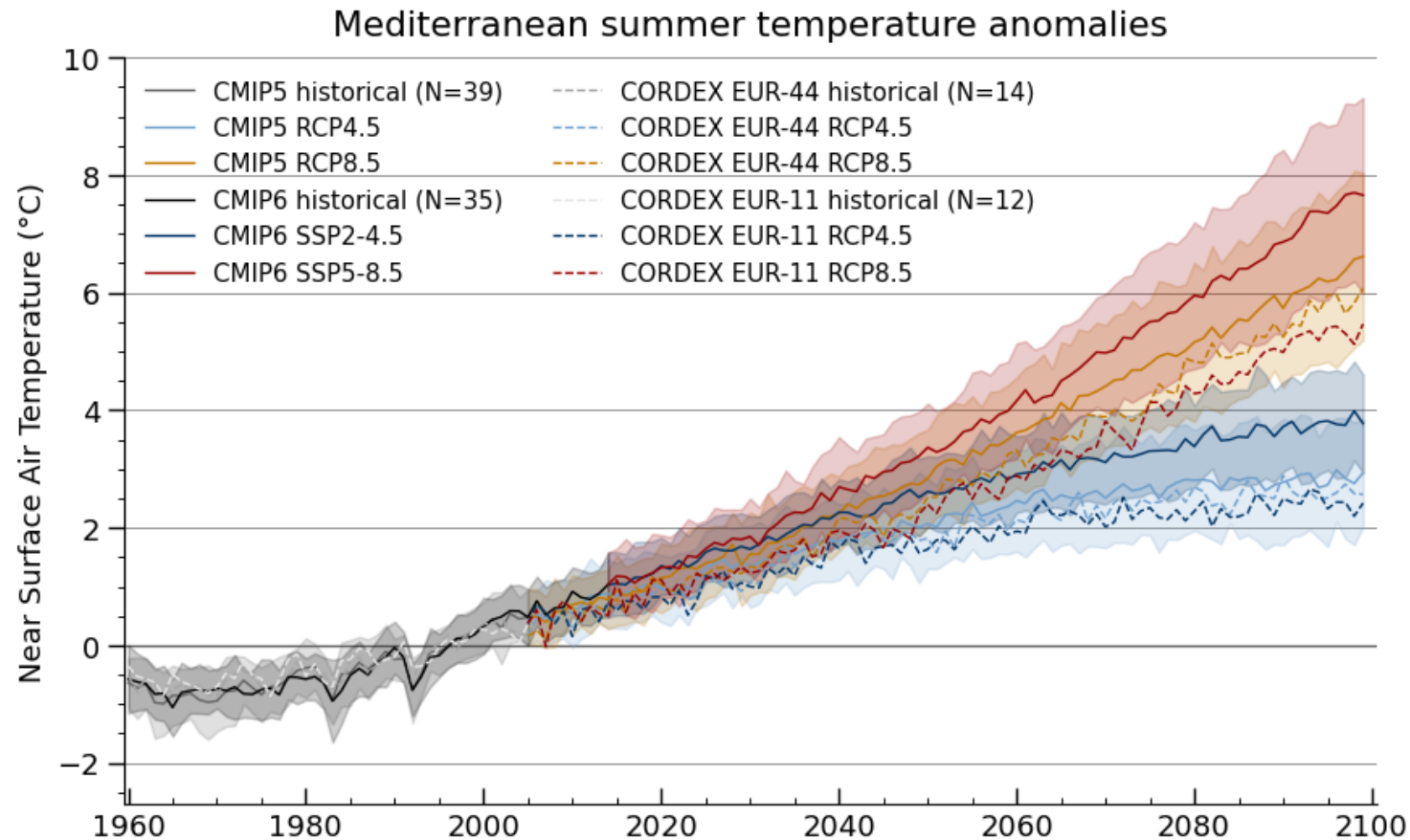
- Research in climate services, bridging the gap between research and actual applications requires trans-disciplinary teams. The group works with both public administrations and the private sector.
- Tailored climate services for short-term, seasonal, decadal, projection



Wind forecasts available from S2S4E DST for 30 days from March 2018, issued three times a week

Use of all climate public information sources

- All sources of climate information (both global and regional) are used to estimate the impact of climate change on the Mediterranean region.
- In a collaboration with **Meteocat** BSC replicates its comprehensive climate database, procedures to distil climate information and capability to engage with society and the industry.



CLIMATE ADAPTATION DIGITAL TWIN (CLIMATE DT)

Climate DT is a new type of climate information system funded by the Destination Earth programme that focuses on **assessing the impacts of climate change and different adaptation strategies** at **local and regional levels with a global perspective** using a strategy where **user requests drive the production chain**.

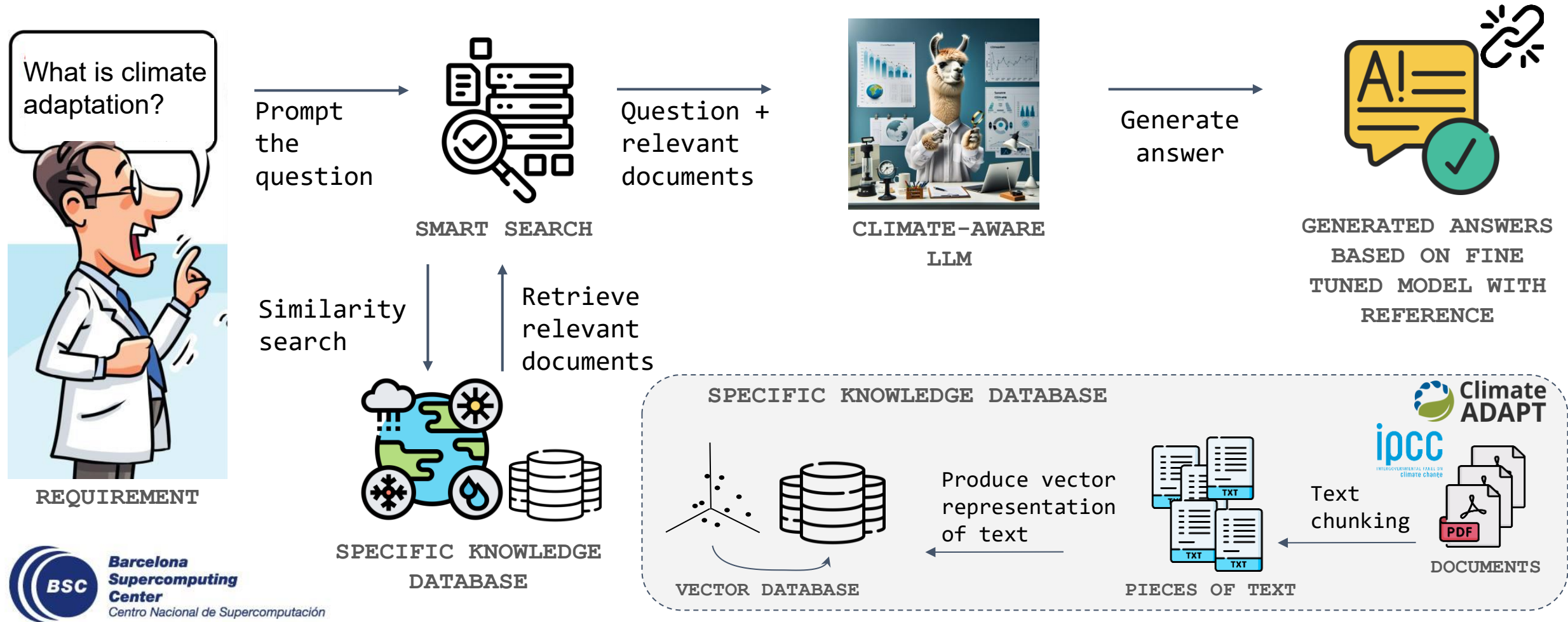
The Climate DT includes

- **Global climate models** with unprecedented resolution
- **Quality assessment and uncertainty quantification**
- Deployment on **EuroHPC pre-exascale computers** (LUMI, Leonardo and MareNostrum5)
- Relevance of both **climatic and non-climatic drivers**
- **Integration of large amounts of relevant European R&D**



Scalable targeted climate information in context

Climate adaptation is a specific domain. More salient results are sought with a fine-tuned LLM and retrieval augmented generation.



Quality assurance to increase robustness

The **Climateurope2** project develops recommendations for the standardisation of climate services by identifying and working with the community. The EC has requested the European normalisation body to start the process of standardising climate services.

The screenshot shows a 'Health Navigator' page for 'Paracetamol'. It includes brand names (Panadol, Paracare, Pacimol), a pronunciation guide, and detailed usage instructions. A prominent red box at the bottom states: 'Paracetamol overdose is a medical emergency. If you realise you have taken too much paracetamol (including from other products with paracetamol in them), immediately call your doctor, nurse or the Poisons Centre 0800 POISON (0800 764 766)'. It lists symptoms of overdose and advises not to wait for signs.

Paracetamol
Sounds like 'paa-ra-SEE-ta-mol'

Brand names include:

- Panadol®
- Paracare®
- Pacimol®

Paracetamol is used to treat fever and pain including headache, and aches and pains associated with COVID-19. It begins to work about 30 minutes after a dose is taken, and the effects usually last for about 4 to 6 hours.

When taken as directed, paracetamol works well. However, it is important not to take more than the daily recommended dose. If you take too much – all at once or over a period of days – paracetamol can damage your liver.

How to take paracetamol

- Paracetamol tablets are commonly available as 500 mg tablets or caplets.
- The **usual dose for adults** is 1 or 2 tablets every 4 to 6 hours as needed for pain or fever.
- Always **wait at least 4 hours** between doses.
- Do not take** more than 8 tablets in 24 hours OR 4 grams in 24 hours.
- Keep a record of how many doses you have taken.

Many other medicines have paracetamol in them

Some pain, cold and flu medicines also have paracetamol in them, eg, Coldral®, Nuromol®, Lemsip®, and Maxigesic®.

Check the ingredients of medicines carefully before you take them.

If you do take other medicines that have paracetamol in them, do not take more than the recommended maximum dose of paracetamol each day.

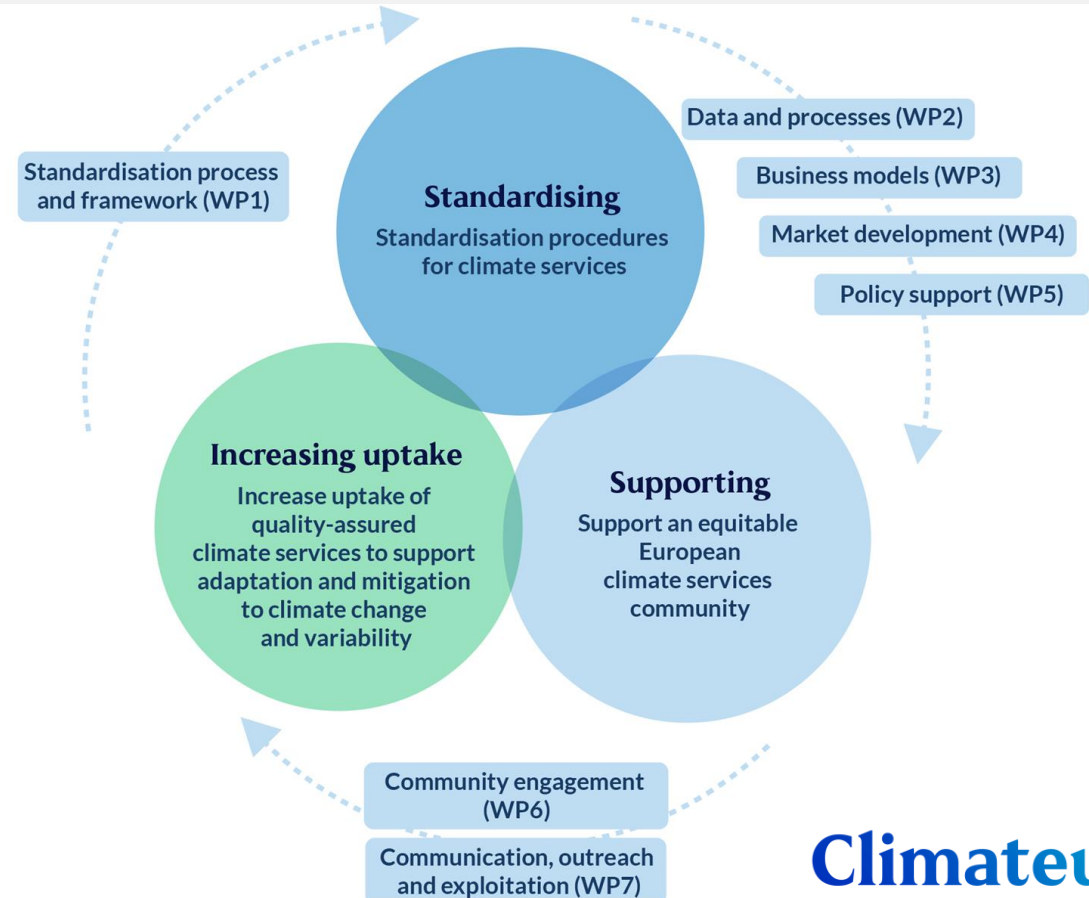
Ask your pharmacist if you are not sure.

Paracetamol overdose is a medical emergency

If you realise you have taken too much paracetamol (including from other products with paracetamol in them), immediately call your doctor, nurse or the Poisons Centre 0800 POISON (0800 764 766)

- **DO NOT WAIT** for signs of overdose as these appear when the damage to your liver is already done.
- Signs of overdose include nausea (feeling sick) or vomiting (being sick), diarrhoea (runny poo), yellow skin or eyes, poor appetite, confusion or extreme sleepiness.
- Older people are most at risk, so should take extra care.

For more information about paracetamol, visit hn.org.nz/paracetamol





(Sample divider)



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