



**Barcelona  
Supercomputing  
Center**

*Centro Nacional de Supercomputación*

# A Digital Twin for Climate Adaptation

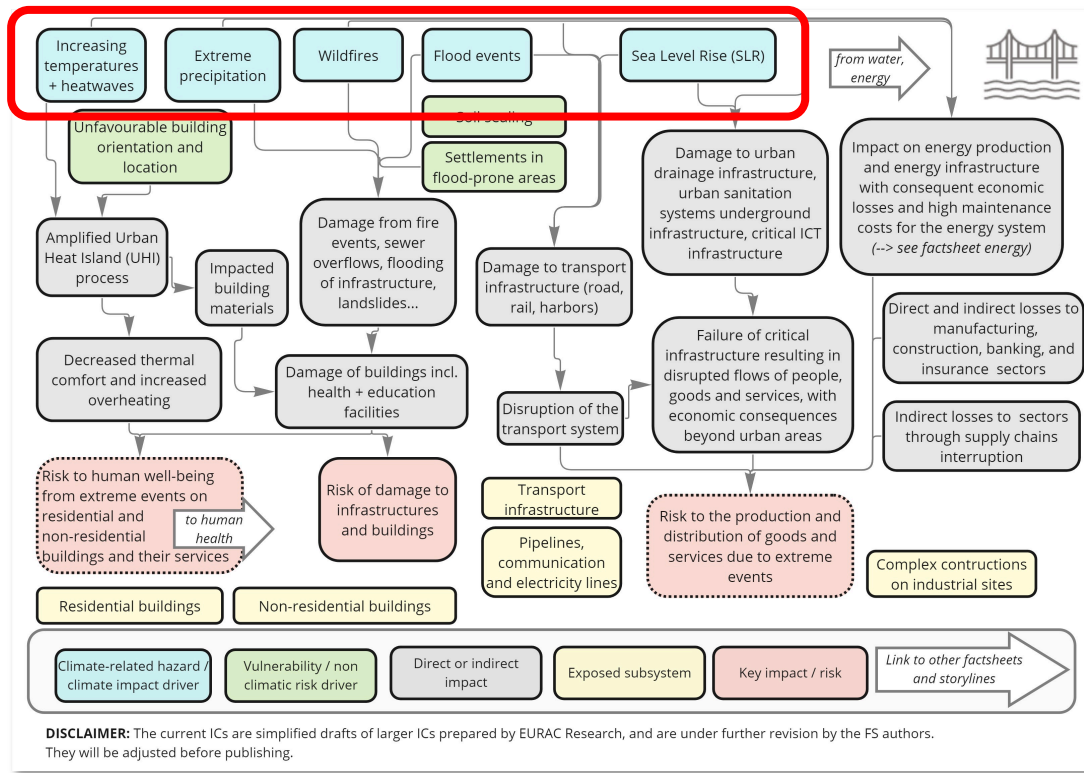
**F.J. Doblas-Reyes**

21 March 2024

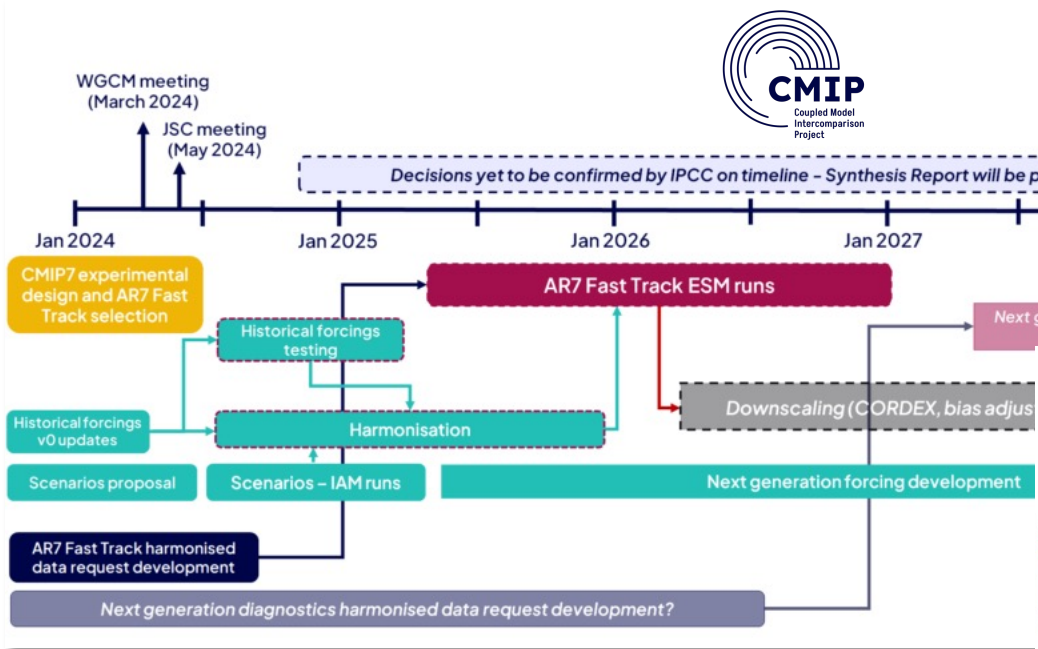
# Climate adaptation in context

**Adaptation** is the action that leads to limiting the consequences of a warming climate and requires, among many other elements, **climate information** about climate hazards.

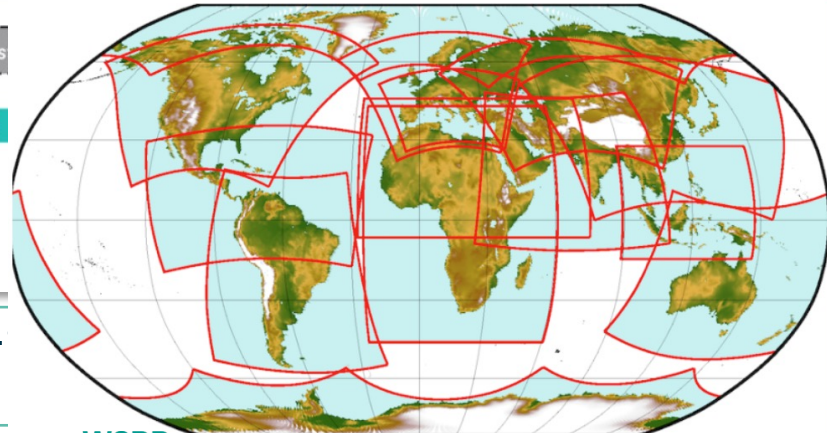
Other challenges that require climate information are climate mitigation, disaster risk reduction, and climate risk assessment.



# Current climate information sources



Many regional models, research driven, resolution 10-50 km, long time between cycles, often no ocean, inconsistent across regions, static archive



Many global models, research driven, resolutions 50-many years between update cycles, static archive

# Current climate information sources serve a purpose

AR6 Synthesis Report

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## UN Climate Change Conference – United Arab Emirates

30 Nov – 12 Dec 2023

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### Reports and decisions

[Access the reports here](#)

AR6 Synthesis Report  
Climate Change

# But operational climate projections needed

Are all the relevant needs taken care of? Are timing, quality, adequacy, and authority addressed?

The digital twin emerges as an alternative to **operationalise** the on-demand production of climate information.

Comment | [Published: 02 November 2023](#)

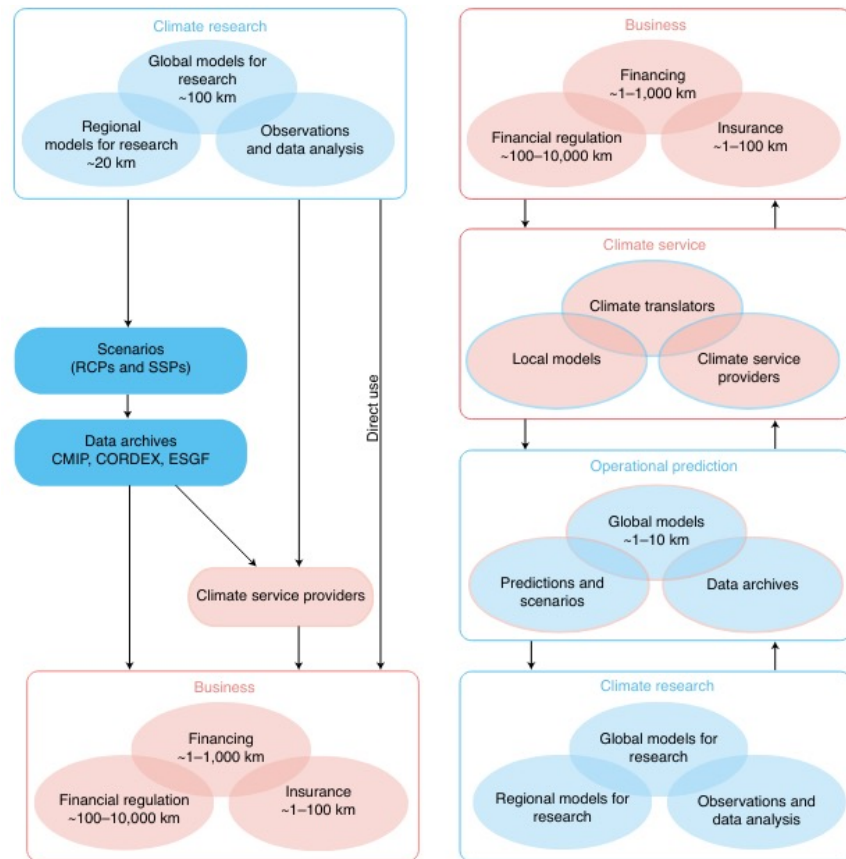
## The need to **operationalize** climate modelling

[Christian Jakob](#) , [Andrew Gettelman](#) & [Andrew Pitman](#)

[Nature Climate Change](#) 13, 1158–1160 (2023) | [Cite this article](#)

2168 Accesses | 35 Altmetric | [Metrics](#)

Climate models have evolved from research tools to underpin decision-making across the globe. To provide optimal value for society in the future, the models need to be made operational.

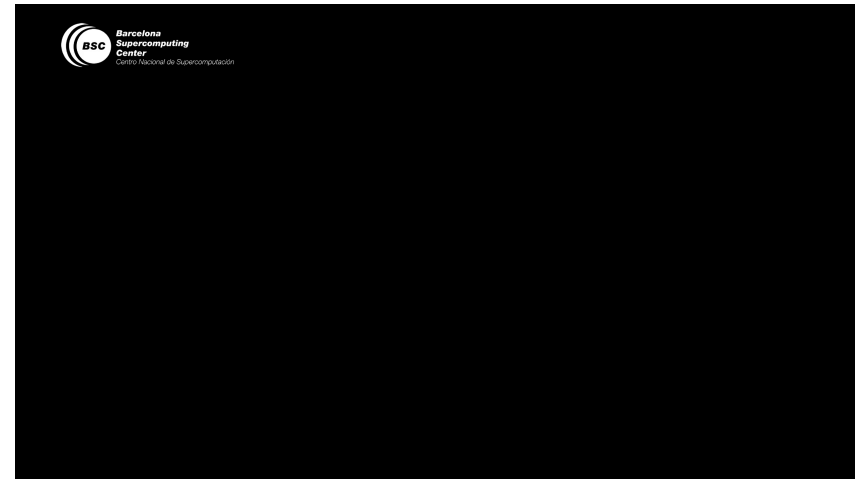


## CLIMATE ADAPTATION DIGITAL TWIN (CLIMATE DT)

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**.

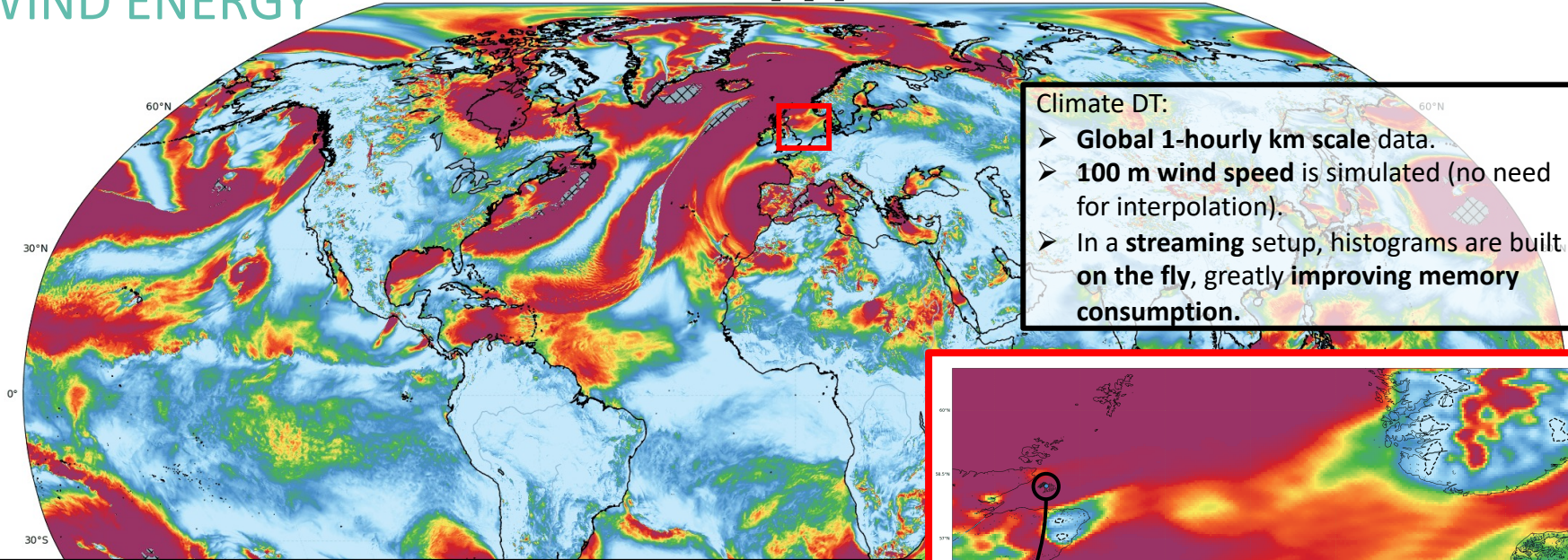
The Climate DT includes

- **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**

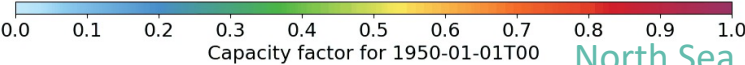
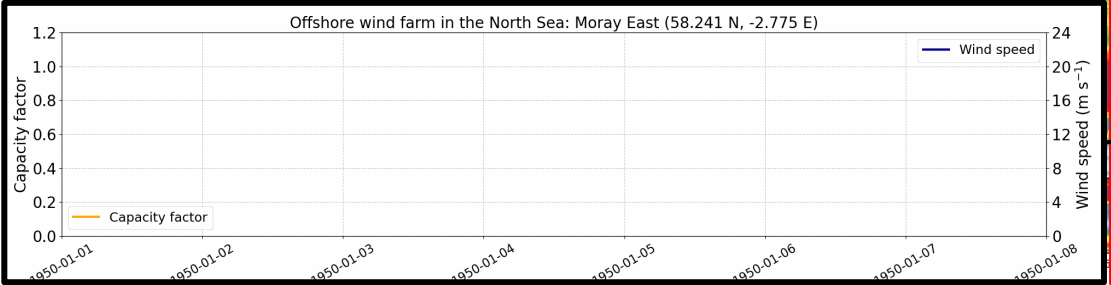
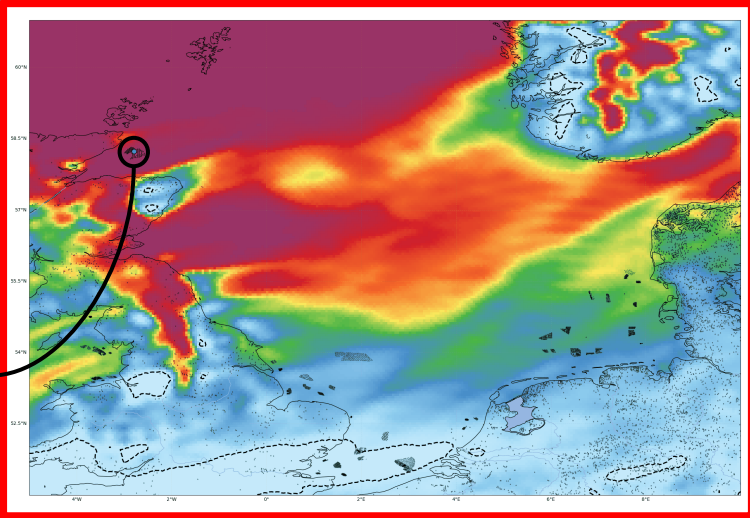


# WIND ENERGY

ClimateDT control simulation (IFS-NEMO\_2D\_1h\_0.05°) - Class S (Vestas V164/9.5MW)

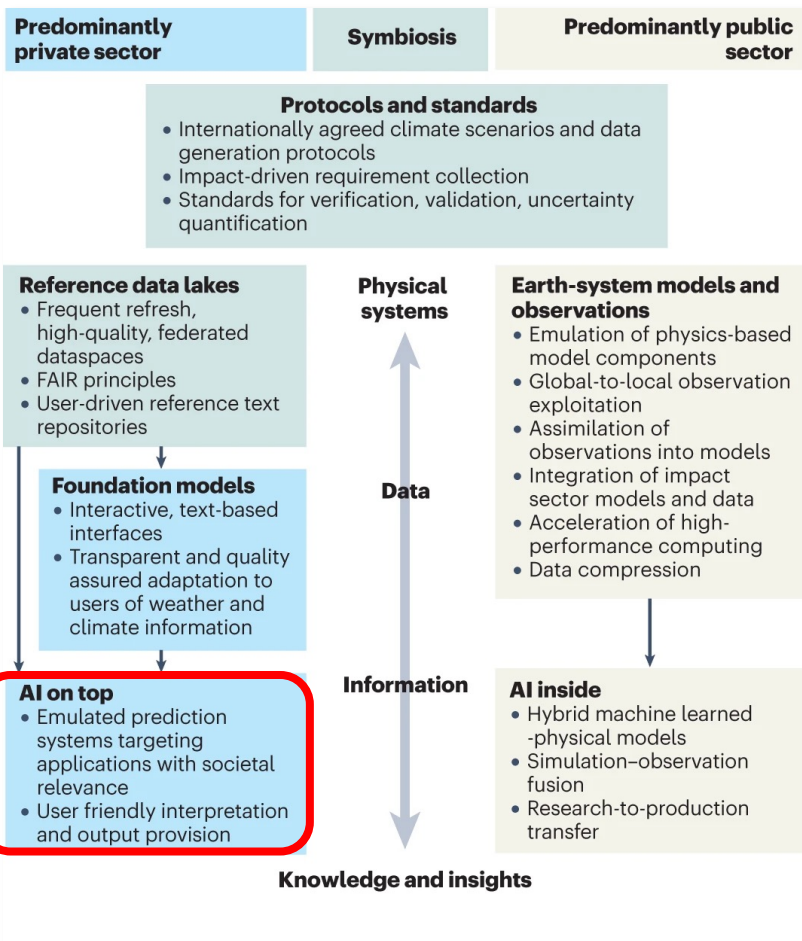


- Climate DT:
- **Global 1-hourly km scale data.**
  - **100 m wind speed is simulated (no need for interpolation).**
  - **In a streaming setup, histograms are built on the fly, greatly improving memory consumption.**



North Sea - Moray East wind farm: 58°N, -2°E

# What role for AI?



## Deep learning and a changing economy in weather and climate prediction

[Peter Bauer](#) ✉, [Peter Dueben](#), [Matthew Chantry](#), [Francisco Doblas-Reyes](#), [Torsten Hoefler](#), [Amy McGovern](#) & [Bjorn Stevens](#)

*Nature Reviews Earth & Environment* 4, 507–509 (2023) | [Cite this article](#)

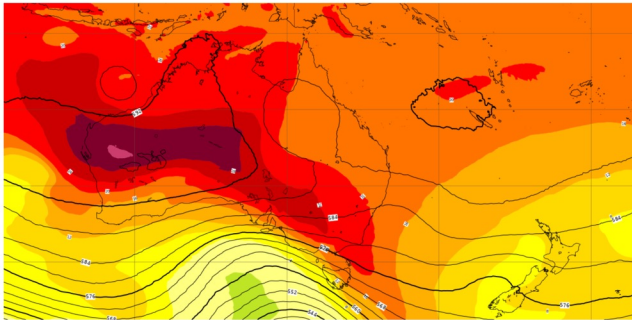


# More efficient climate data services

- GenAI weather forecast systems emerged in the last couple of years. They are competitive (and at times considered better) with traditional (first principles) systems.
- Climate data for the atmosphere can be recreated and quickly served for any model trajectory by interpolating (**tethering**) between checkpoints (every five days, 15 GB each) stored during the simulation. **Model training needs to be done while streaming!!**

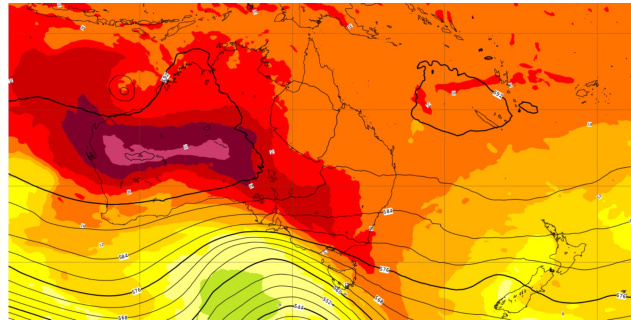
Experimental: GraphCast ML model: 500 hPa geopotential height and 850 hPa temperature

Base time: Tue 20 Feb 2024 12 UTC Valid time: Thu 22 Feb 2024 12 UTC (+48h) Area : Australasia



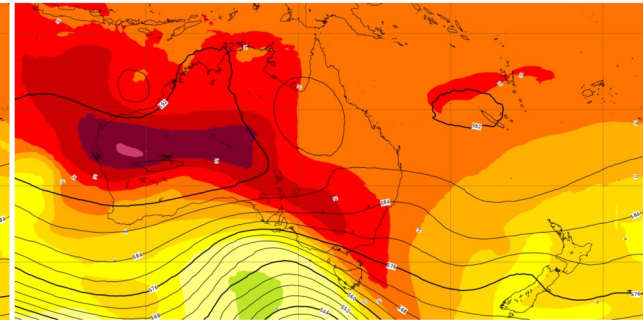
500 hPa geopotential height and 850 hPa temperature

Base time: Tue 20 Feb 2024 12 UTC Valid time: Thu 22 Feb 2024 12 UTC (+48h) Area : Australasia



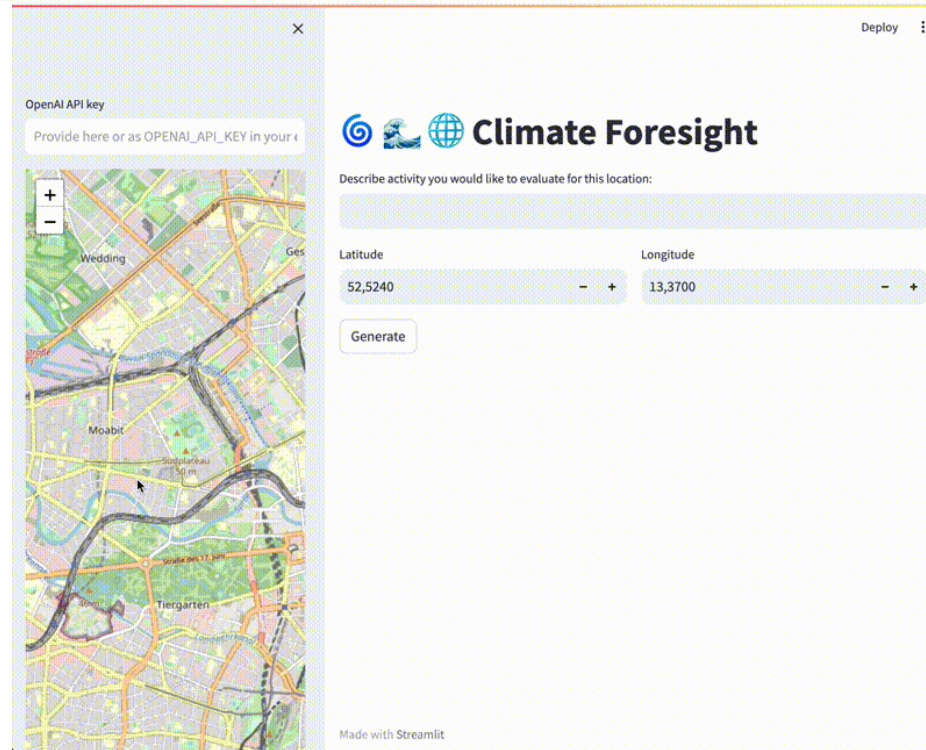
Experimental: Pangu-Weather ML model: 500 hPa geopotential height and 850 hPa temperature

Base time: Tue 20 Feb 2024 12 UTC Valid time: Thu 22 Feb 2024 12 UTC (+48h) Area : Australasia



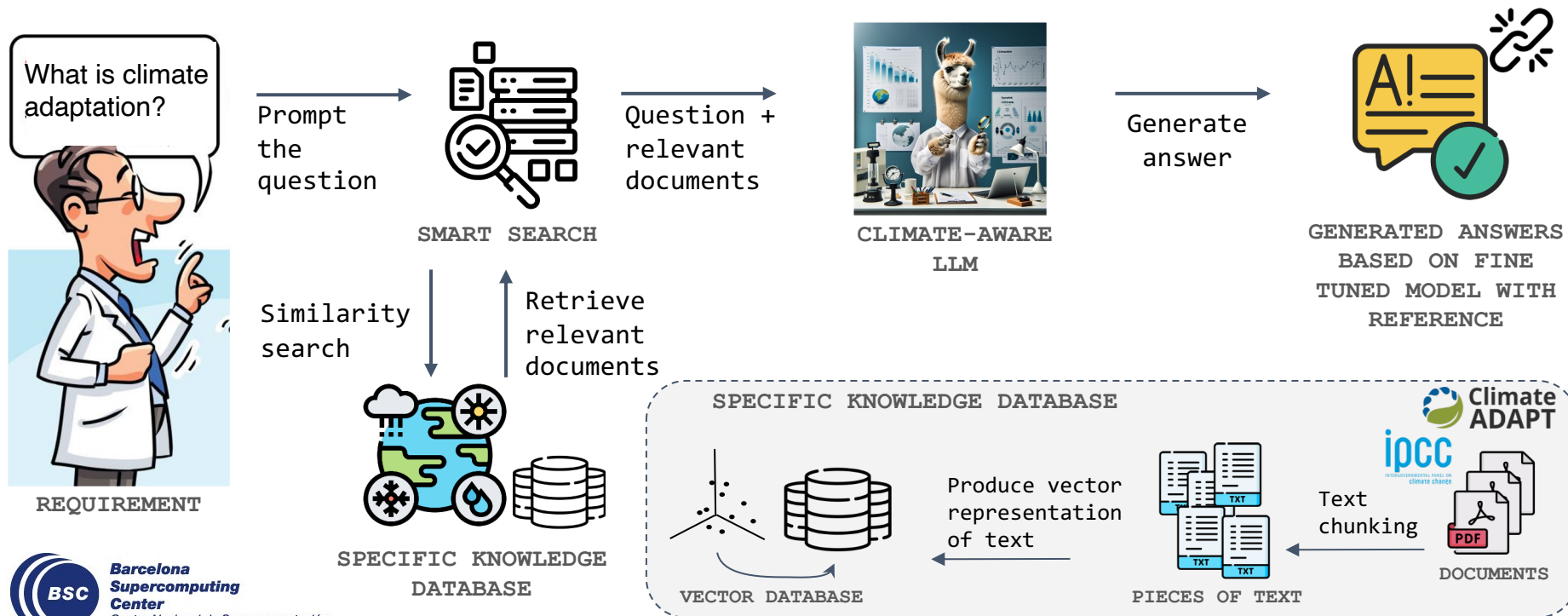
# Scalable targeted climate information in context

**ClimSight** is a prototype tool for a climate information system that uses ChatGPT to provide structured reports on local climate changes and their impacts.



# 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 of climate services

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), usage instructions, warnings, and a section on paracetamol overdose. The page is in English and features a blue header with the Health Navigator logo.

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

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<sup>®</sup>, Nuroamol<sup>®</sup>, Lemsip<sup>®</sup>, and Maxigesic<sup>®</sup>.

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.

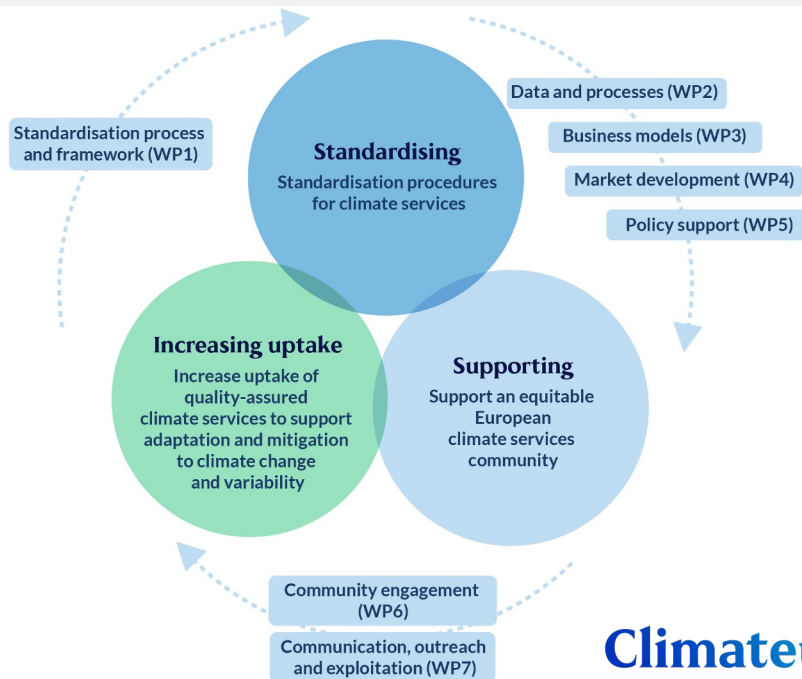
Ask your pharmacist if you are not sure.

**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](http://hn.org.nz/paracetamol)



# A digital twin for climate adaptation

- **A new information system for climate adaptation**: operational, user relevant, adapted to decision making; technology at the service of society.
- **AI serving specific scaling needs**: data service, faster and more complex models, public-private partnerships.
- **Synthesis and narratives**: how to deal with multiple lines of evidence in the climate adaptation information construction.
- **Traceability and quality control**: quality control and data reproducibility as a key element to develop a European-led robust market.