



**Barcelona  
Supercomputing  
Center**  
*Centro Nacional de Supercomputación*

# The Barcelona Supercomputing Center

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Earth Sciences department

22<sup>nd</sup> November de 2020

Modelling for Science and Engineering - UAB

# The MareNostrum 4 supercomputer

Total peak performance:

**13,7 Pflops/s**



Access: [prace-ri.eu/hpc-access](https://prace-ri.eu/hpc-access)



RED ESPAÑOLA DE  
SUPERCOMPUTACIÓN

Access: [bsc.es/res-intranet](https://bsc.es/res-intranet)



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# The MareNostrum 4 Supercomputer

The most heterogeneous cluster in the world aimed at generating scientific knowledge

Nearly  
165,888 cores

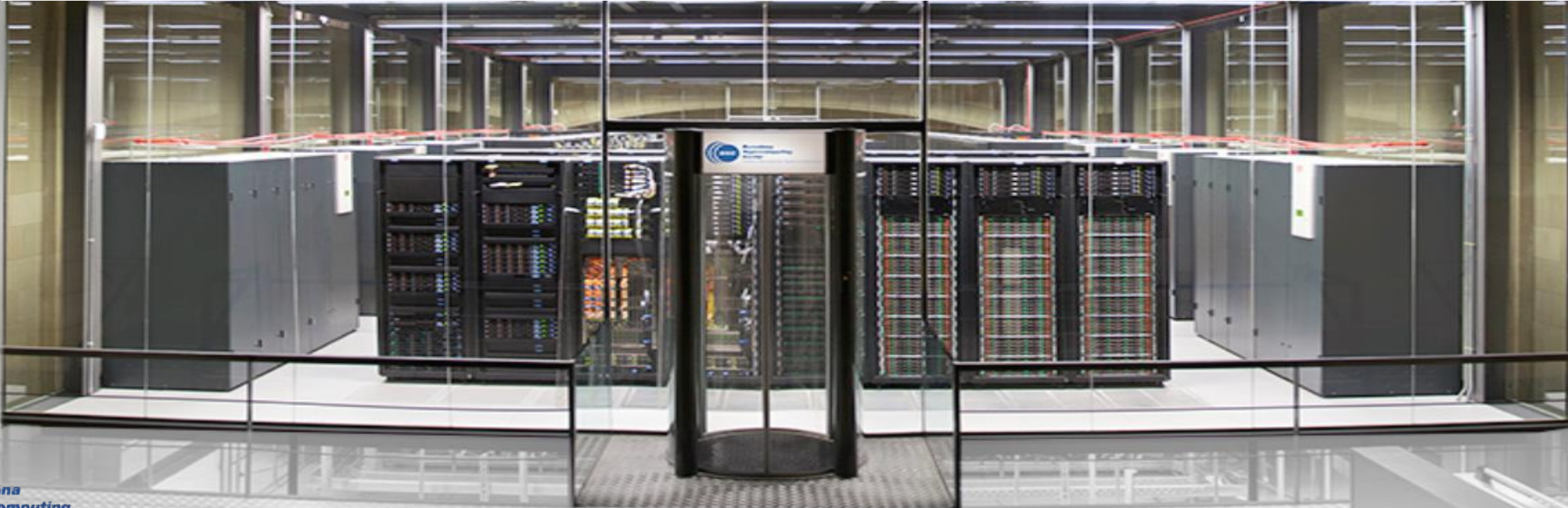
390.8 TB  
of main memory

3 PB  
of disk storage

80% PRACE

16% RES

4% BSC-CNS

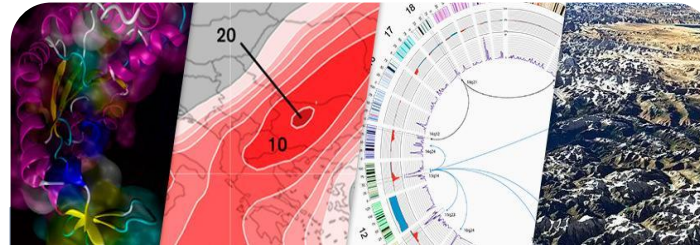


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## BSC-CNS objectives



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

60%



Catalan Government

30%

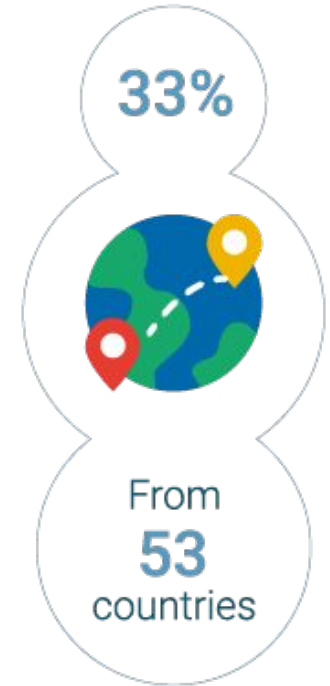
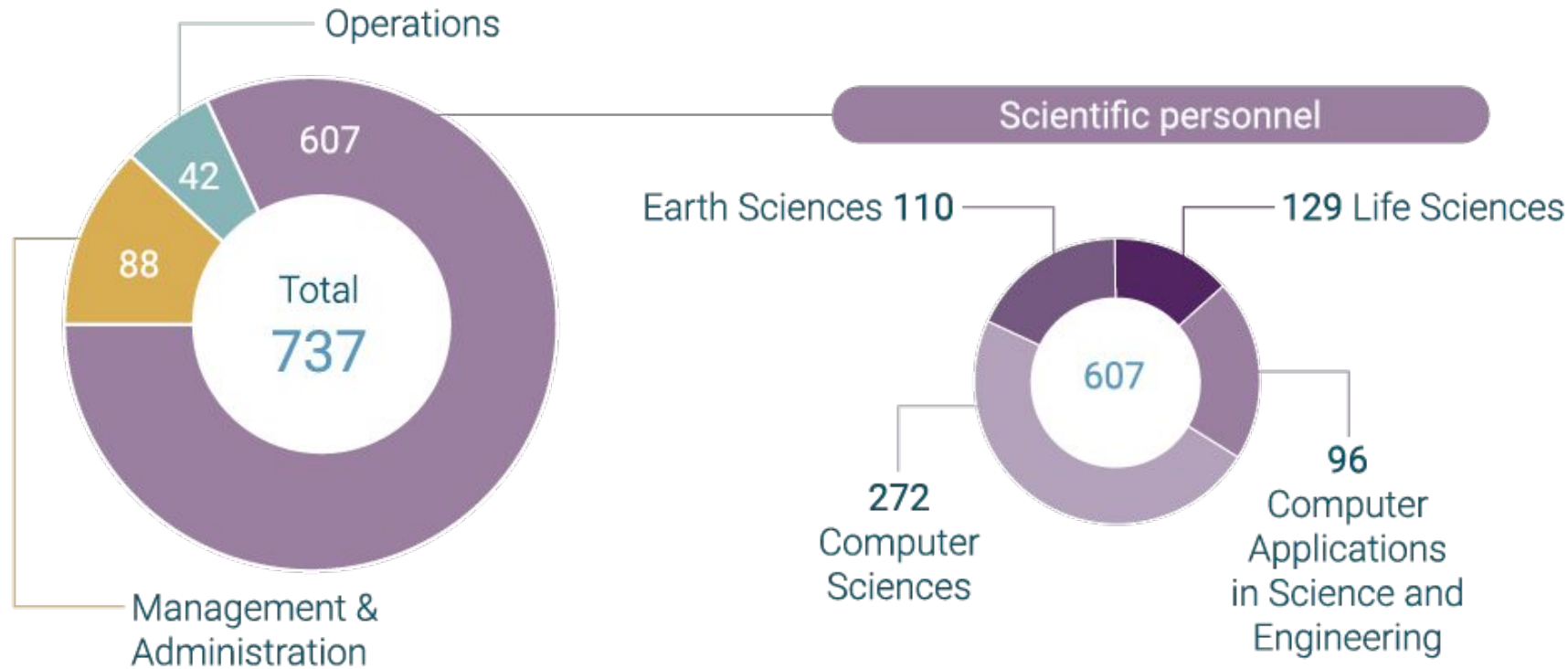


Univ. Politècnica de Catalunya (UPC)

10%



# BSC in numbers



# BSC Scientific Departments

A circular graphic for the Computer Sciences department. The top half shows a colorful, abstract pattern of vertical lines in shades of green, yellow, and red. The bottom half is a light blue gradient.

## Computer Sciences

Shape the way supercomputers are built, programmed and used

A circular graphic for the Earth Sciences department. The top half shows a satellite-style image of Earth with various colors representing land, water, and ice. The bottom half is a light blue gradient.

## Earth Sciences

Environmental modelling: climate and air quality

A circular graphic for the Life Sciences department. The top half shows a 3D molecular model with various colored atoms and bonds. The bottom half is a light blue gradient.

## Life Sciences

Computational genetics, personalized medicine, bioinformatics, drug discovery...

A circular graphic for the CASE department. The top half shows a colorful, abstract pattern of swirling lines in shades of green, yellow, and red. The bottom half is a light blue gradient.

## CASE

Aerodynamics, structures, engineering...

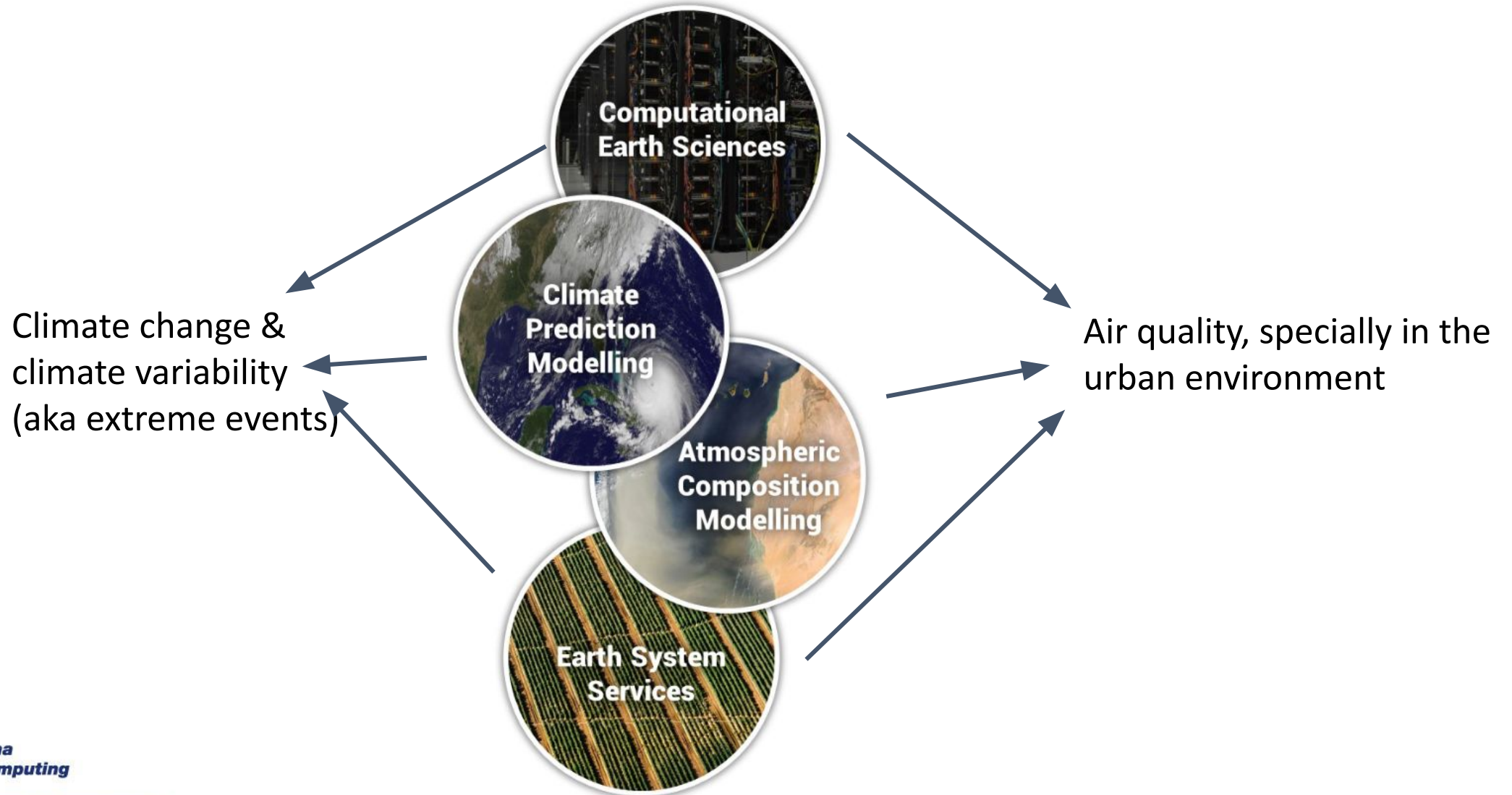
# Earth Sciences department



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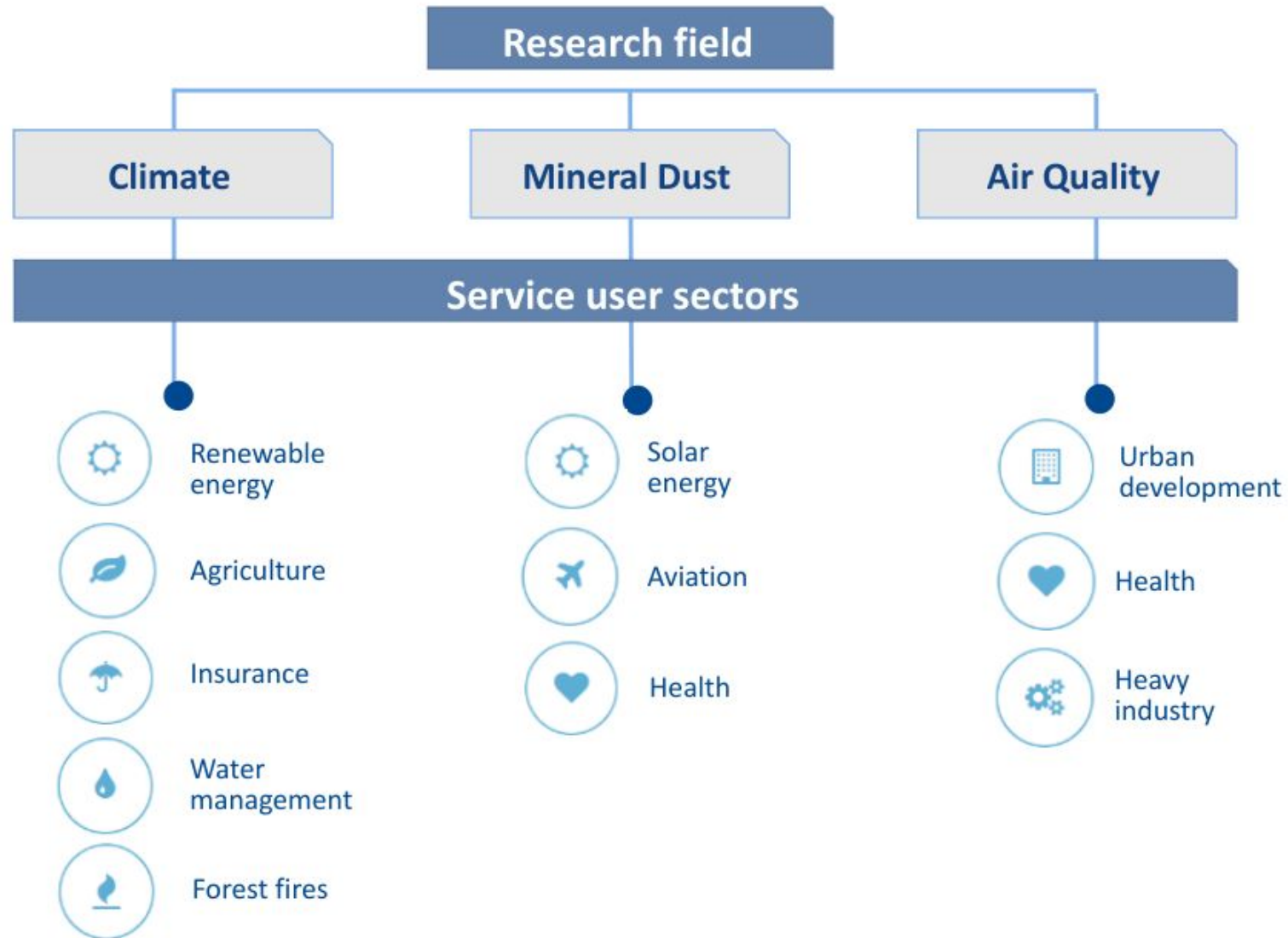
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# Addressing two big challenges of our time





# From Research to Services



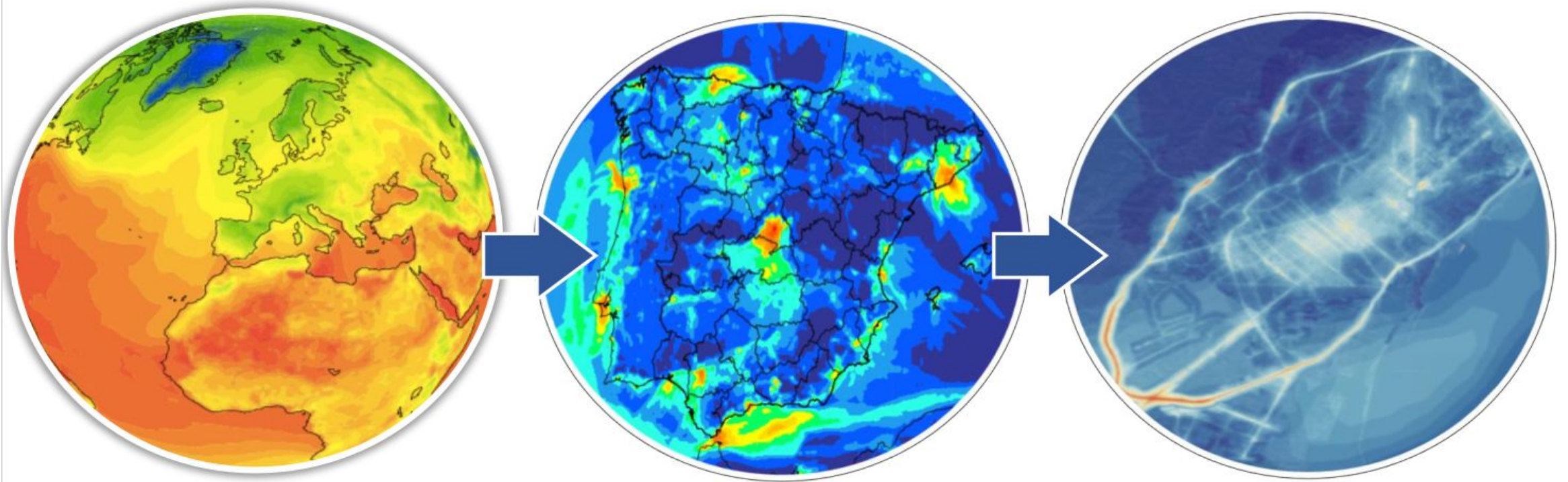
# What models we use?



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# Air quality: info is needed at urban scales!



## CALIOPE:

- WRF-ARW (meteo)
- HERMES (emissions)
- CMAQ (photochemical)
- DREAM (dust)

NMMB/MONARCH (meteo+sand+dust)

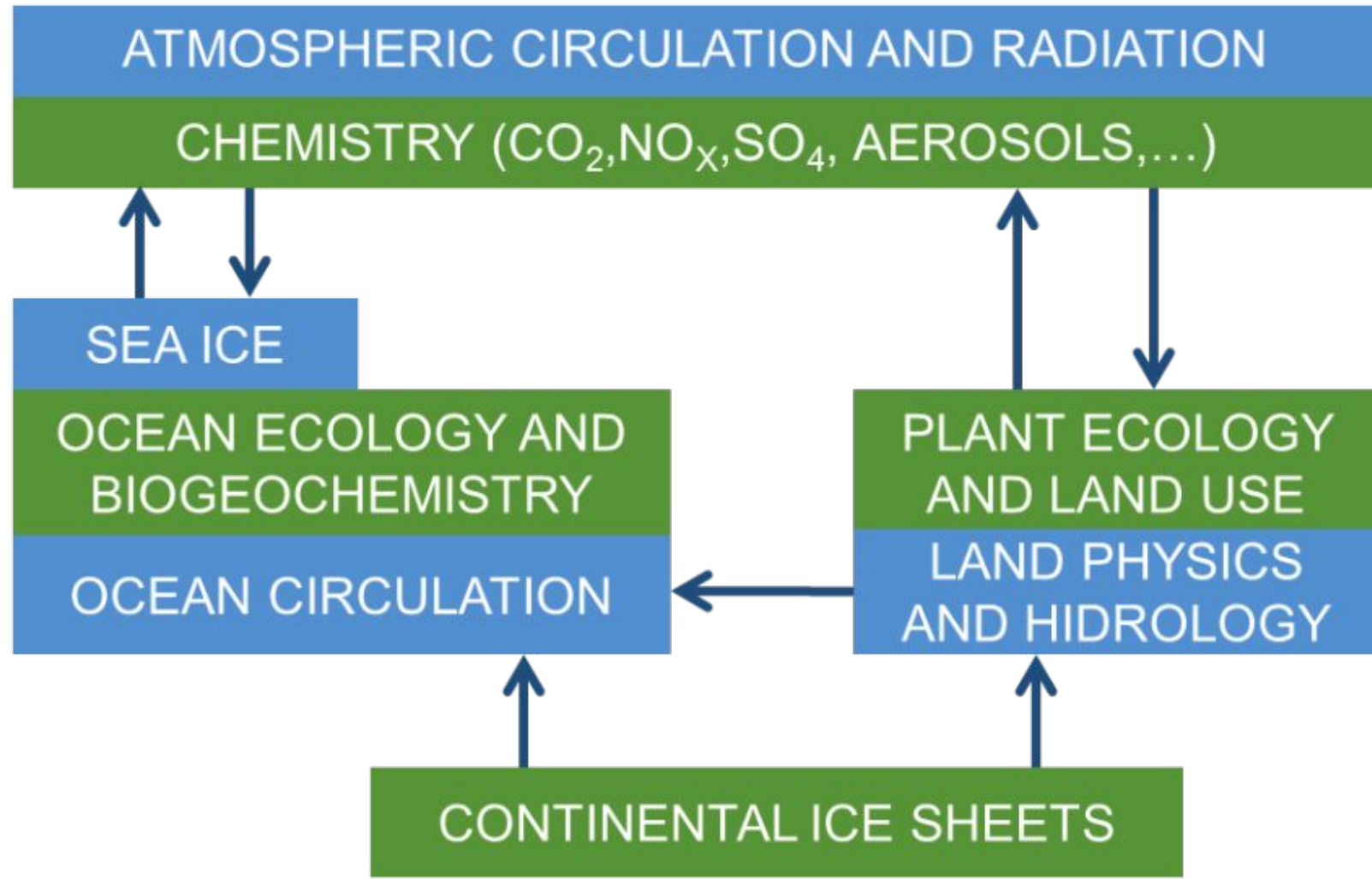
CAMS (AC reconstructions w data assimilation)

# Climate: Earth System Models



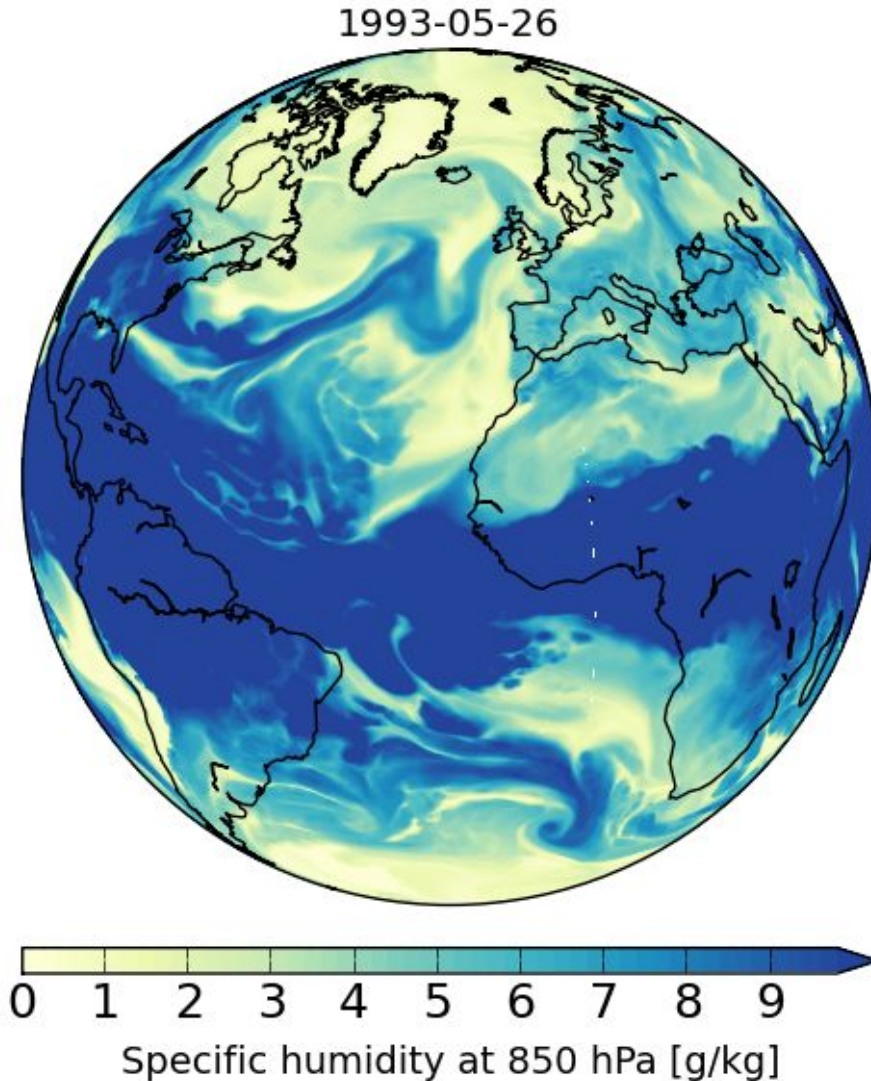
## EC-EARTH

- IFS (atmosphere)
- TESSEL (land surface)
- NEMO (ocean)
- LIM (sea ice)
- PISCES (bio-geo-chemistry in the ocean)
- TM5 (aerosols, AC)
- PISM (continental ice)
- GUESS (dynamic vegetation)

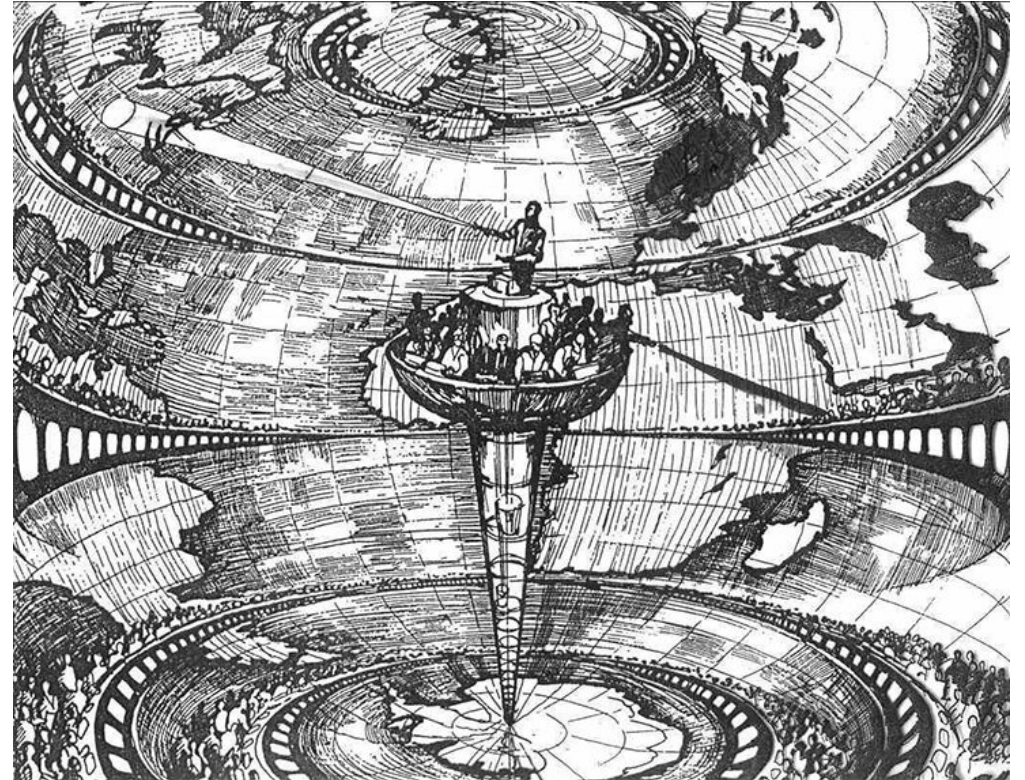
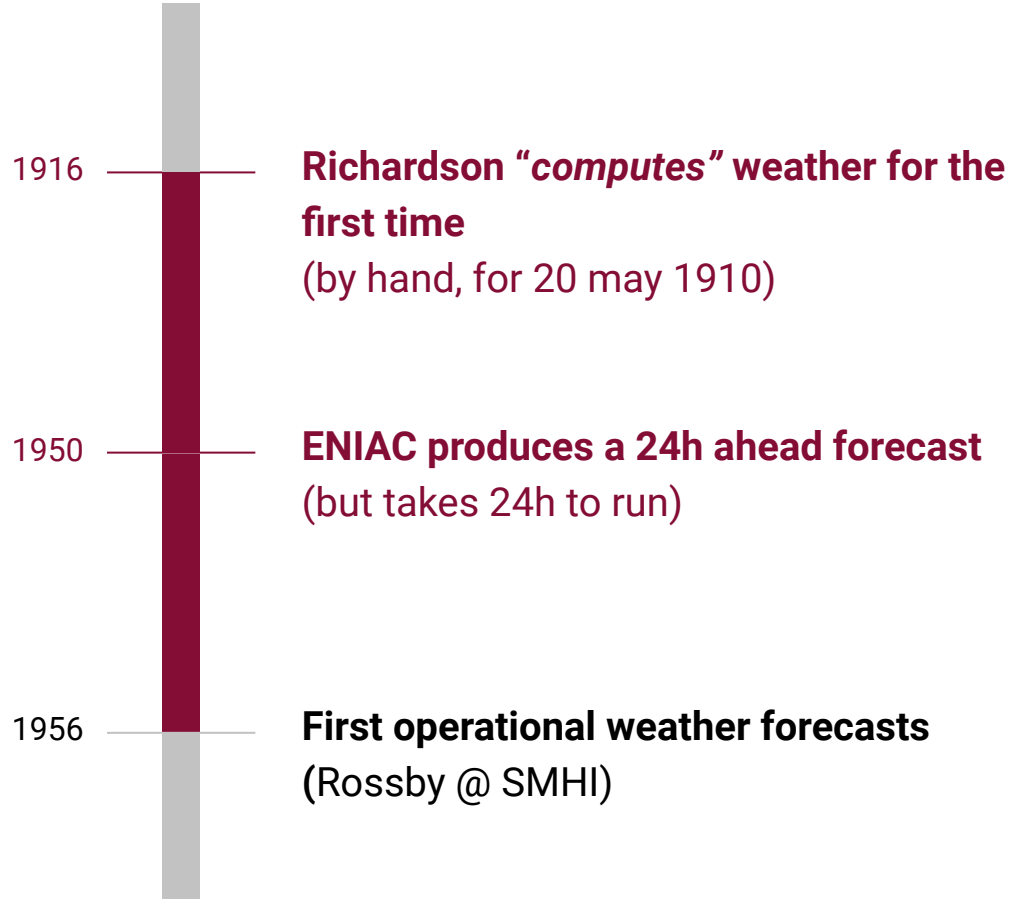


# Atmosphere and ocean: fluid dynamics

1. Differential equations describe fluid motions  
(primitive equations of atmosphere,  
Navier-Stokes, etc...)
2. Analytic solution impossible but can be numerically  
integrated
3. Discretization and parallelization in  
supercomputers
4. Parametrizations needed for sub-grid processes



# Richardson experiment

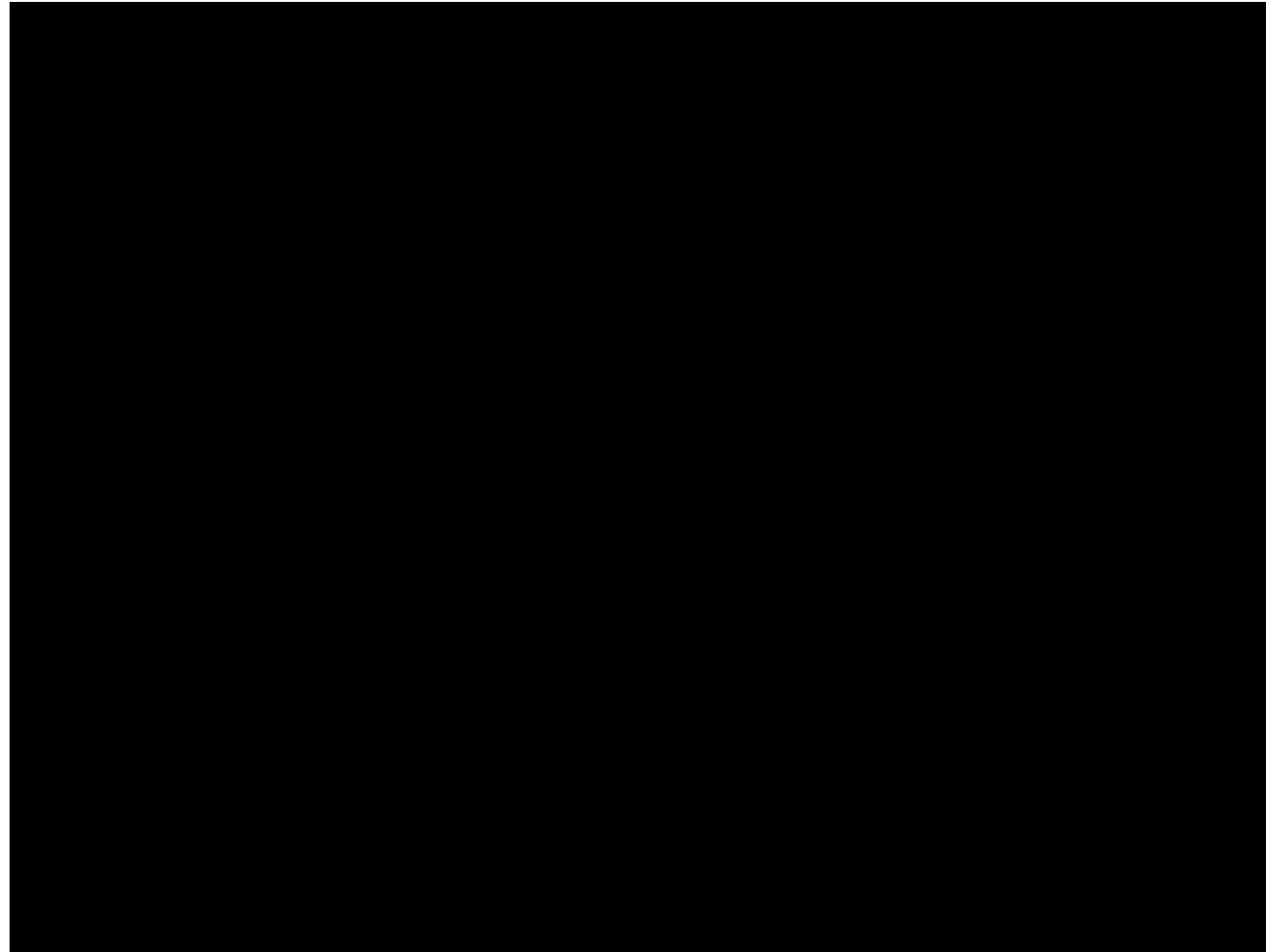


*Weather Prediction by Numerical Process (1922), Lewis Fry Richardson*

He imagined a large theater with 64,000 humans, each in charge of computing the weather of an Earth's portion, while a leader, “like a conductor of an orchestra” combined their results and interactions, decades before “parallel computing”.

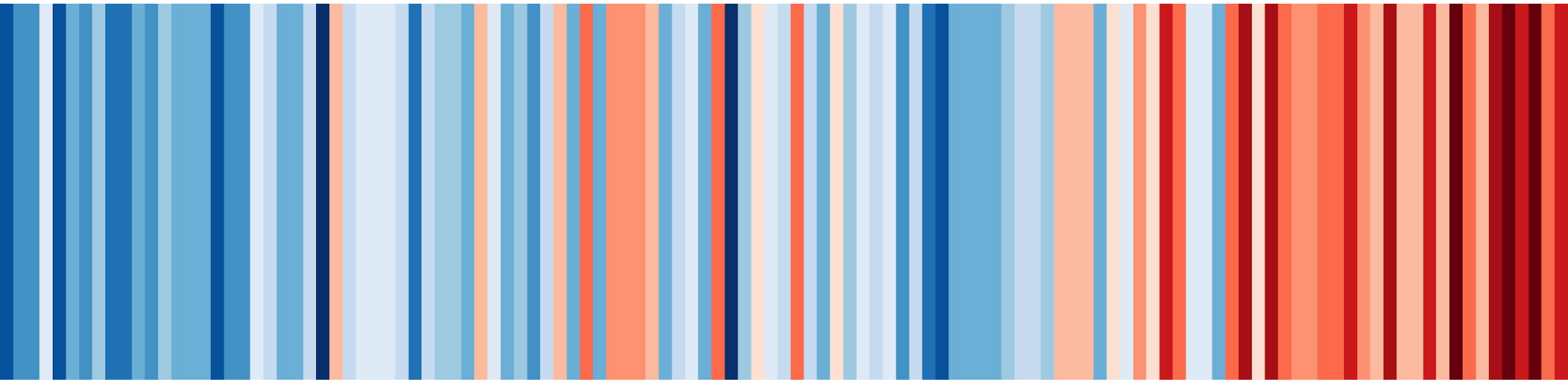
*the quiet revolution of NWP*

# Are meteorologists always wrong?



# The challenge of climate prediction

Yearly anomalies of temperature in Spain



1910

1930

1950

1970

1990

2010

Evident long-term trend

Substantial variations between consecutive years





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# Gràcies

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