

# 2024 OCEAN DECADE CONFERENCE

Ocean Decade  
Marine Protected Areas Forum  
8-9 APRIL 2024  
BARCELONA, SPAIN

As part of the Ocean Decade Week (8-12 April 2024)

## Digital Twins of the Ocean: Predicting Changes

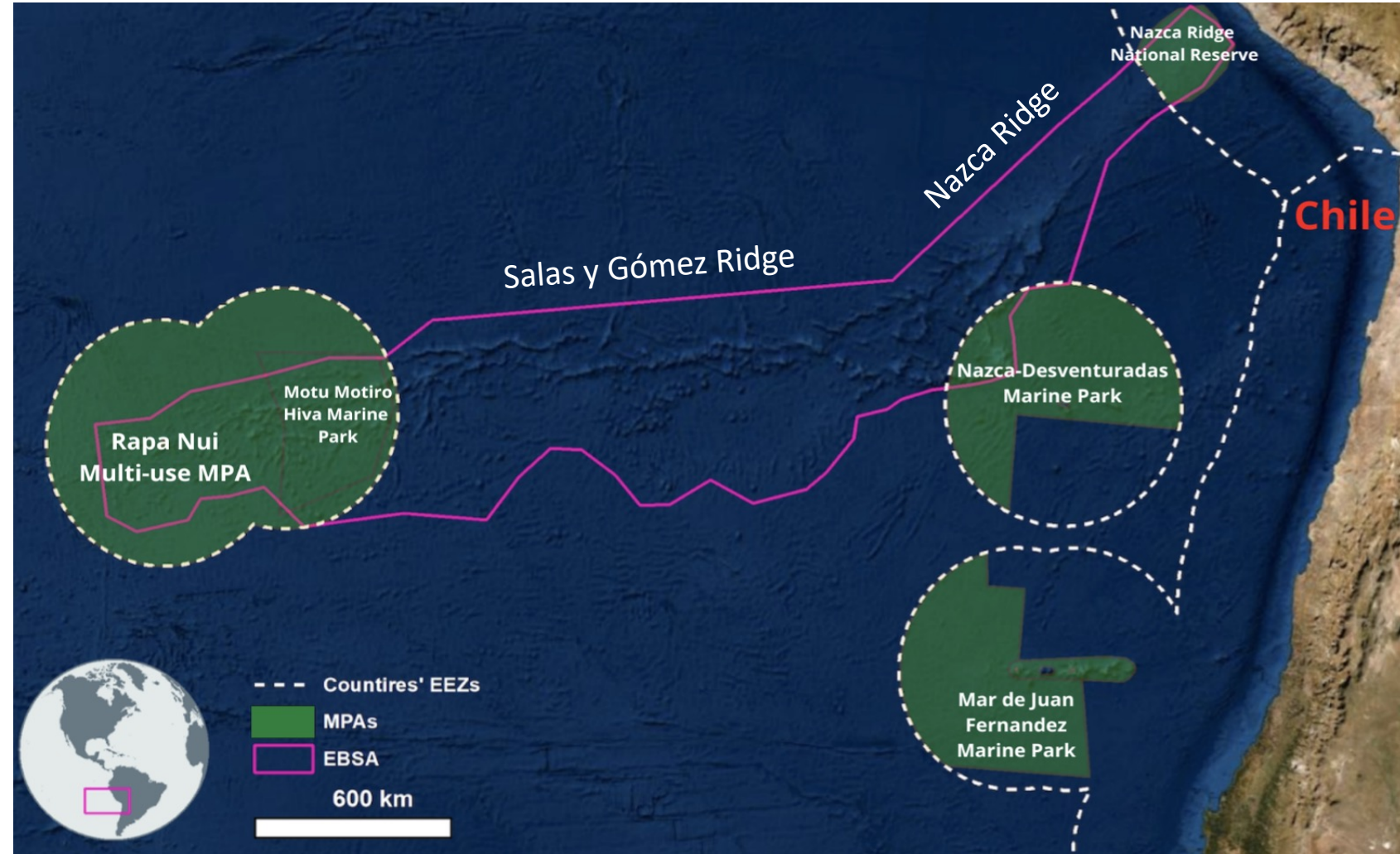
Pablo Ortega (BSC)



2021 United Nations Decade  
2030 of Ocean Science  
for Sustainable Development



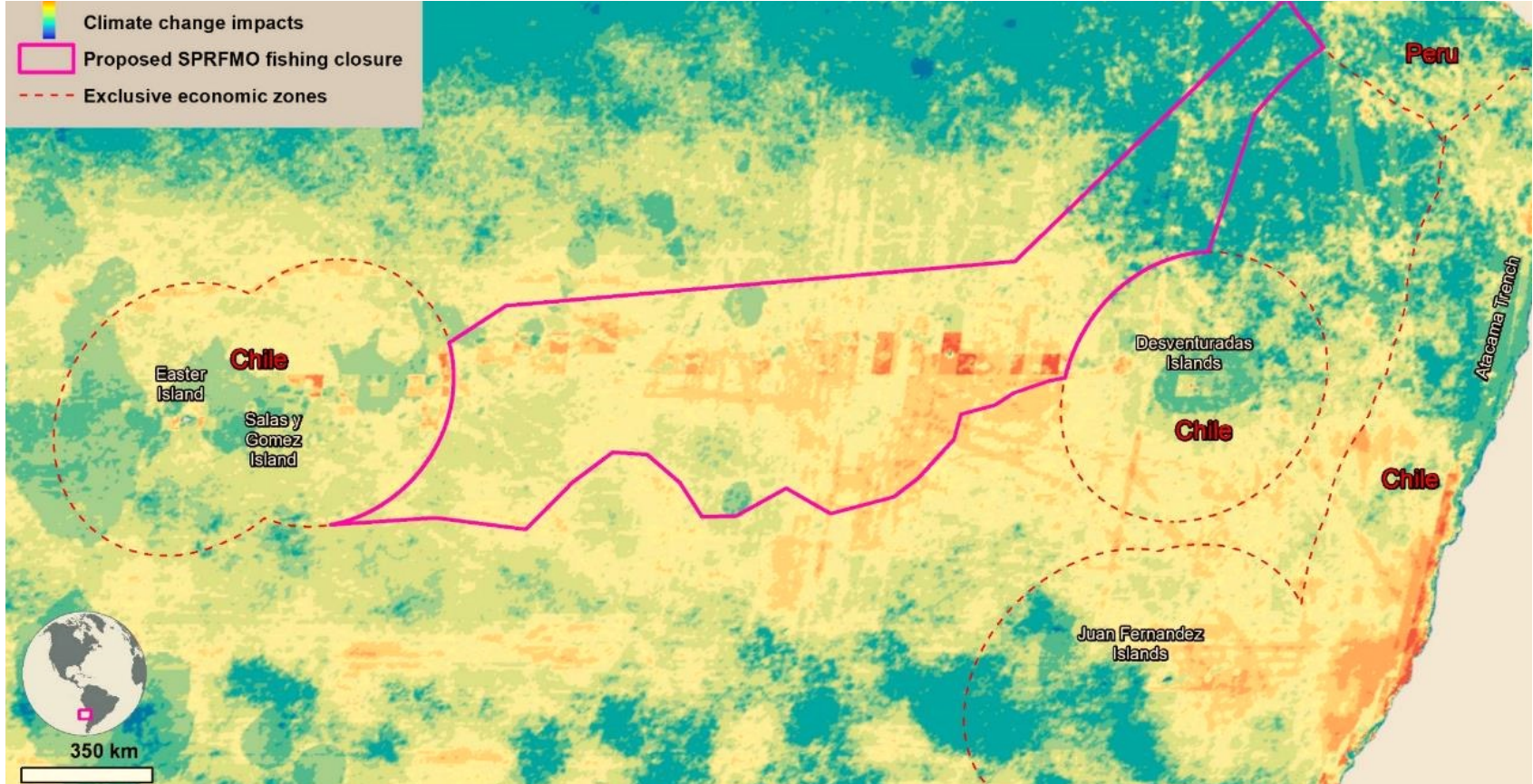
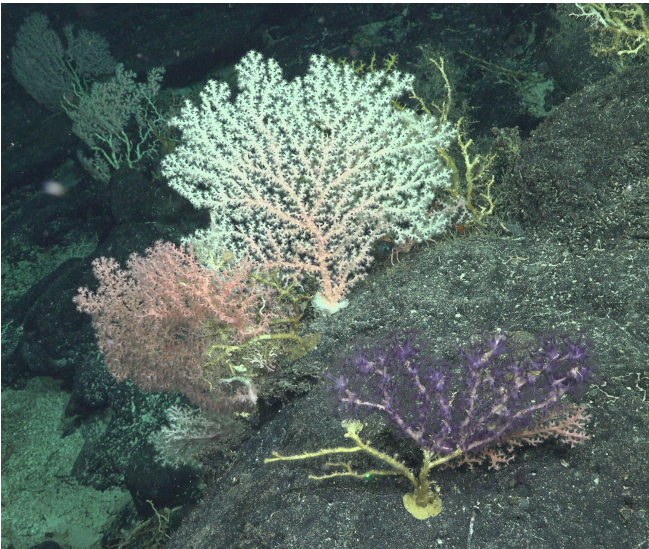
# Salas y Gómez Ridge



A volcanic seamounts chain that extends 2,300 km between the **Nazca Ridge** and **Rapa Nui**.

# Salas y Gómez Ridge

## Major Threats



Warming

Deoxygenation

Acidification

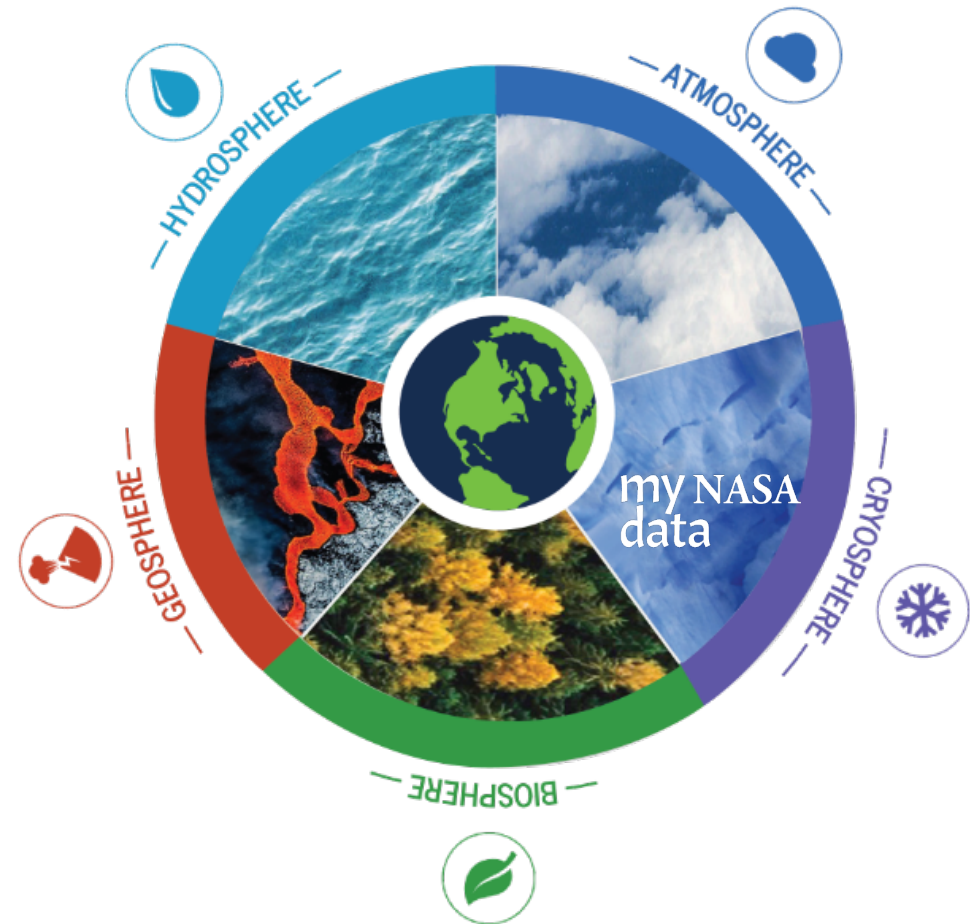
MPA survivability relies on the availability of reliable information on near-term environmental changes

# Earth System Models

(our research labs)

*In essence*

Mathematical representation of the Earth system through the fundamental laws governing the evolution within and interactions between the different Earth system components.



# Earth System Models

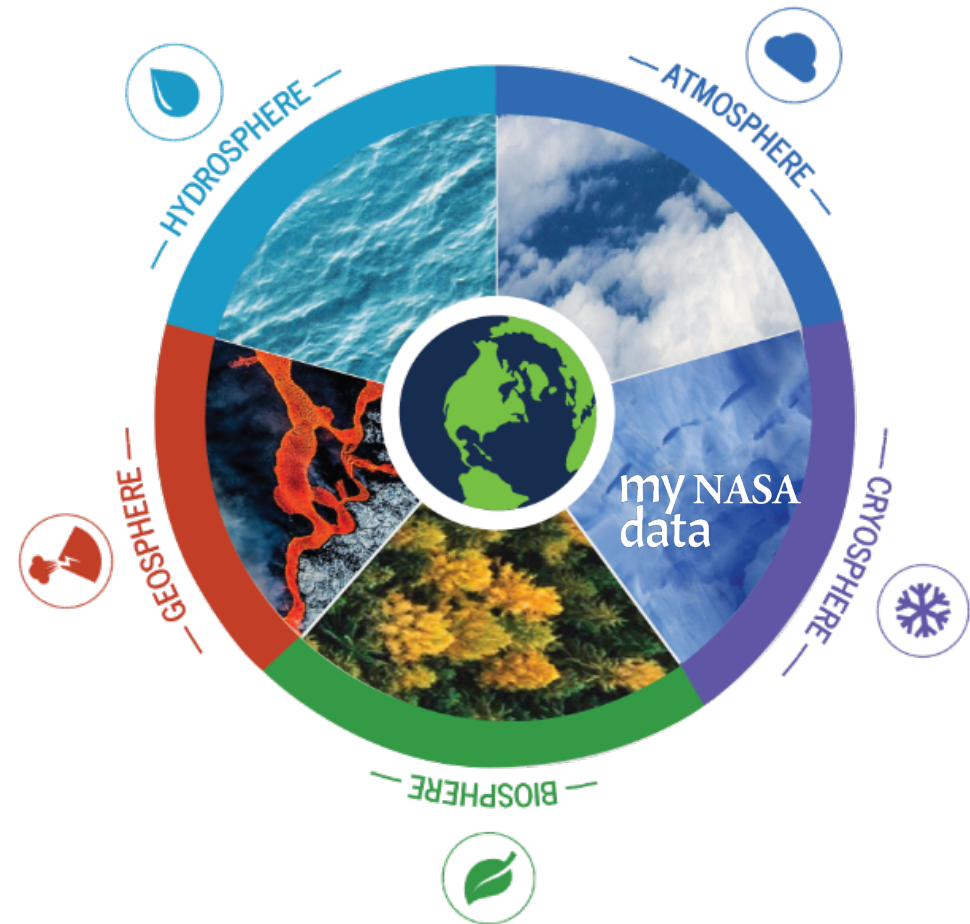
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*In Practice*

ESMs are our **key tool** to generate scientific understanding via hypothesis testing on topics as diverse as:



# Earth System Models

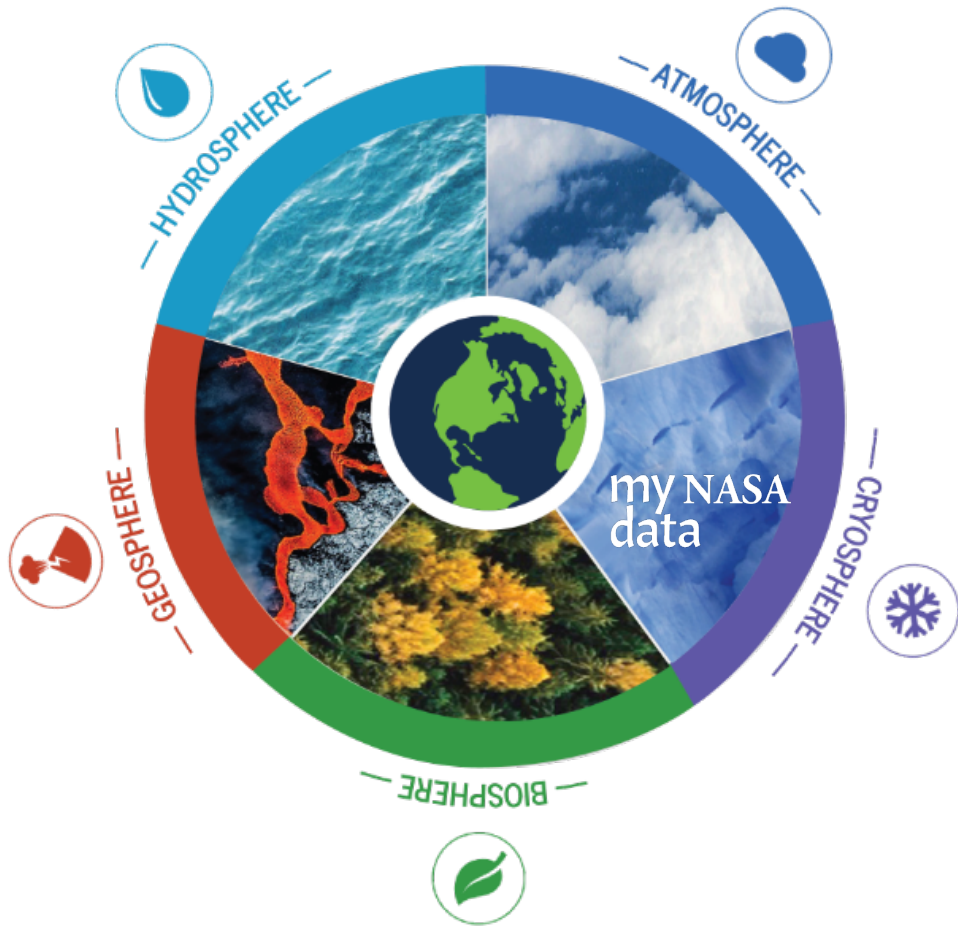
(our research labs)

*In essence*

Mathematical representation of the Earth system through the fundamental laws governing the evolution within and interactions between the different Earth system components.

*In Practice*

ESMs are our **key tool** to generate scientific understanding via hypothesis testing on topics as diverse as:



Attribution of past climate changes



Adaptation/Mitigation of future climate change

Risk of tipping (Irreversible Changes)

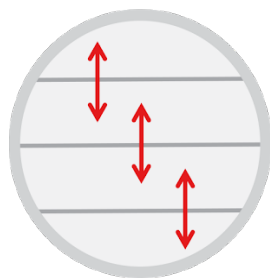
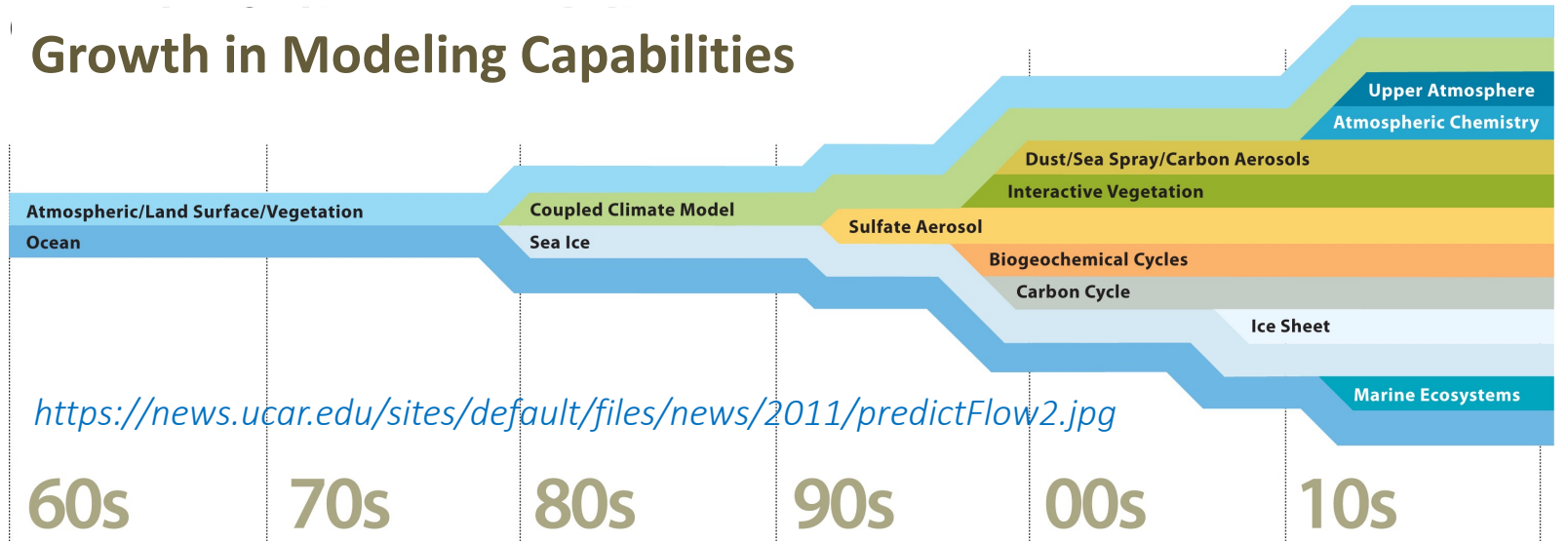


Near-term climate prediction

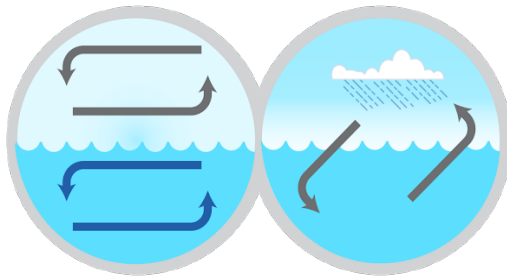
# Model Complexity

(a timeline)

## Growth in Modeling Capabilities



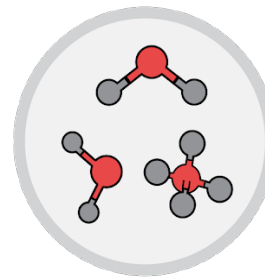
1890s  
Radiative  
Transfer



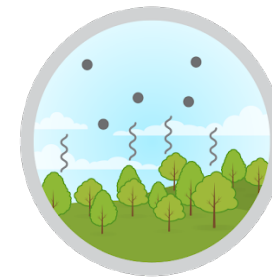
1960s  
Non-Linear  
Fluid Dynamics      Hydrological  
Cycle



1970s  
Sea Ice and  
Land Surface



1990s  
Atmospheric  
Chemistry



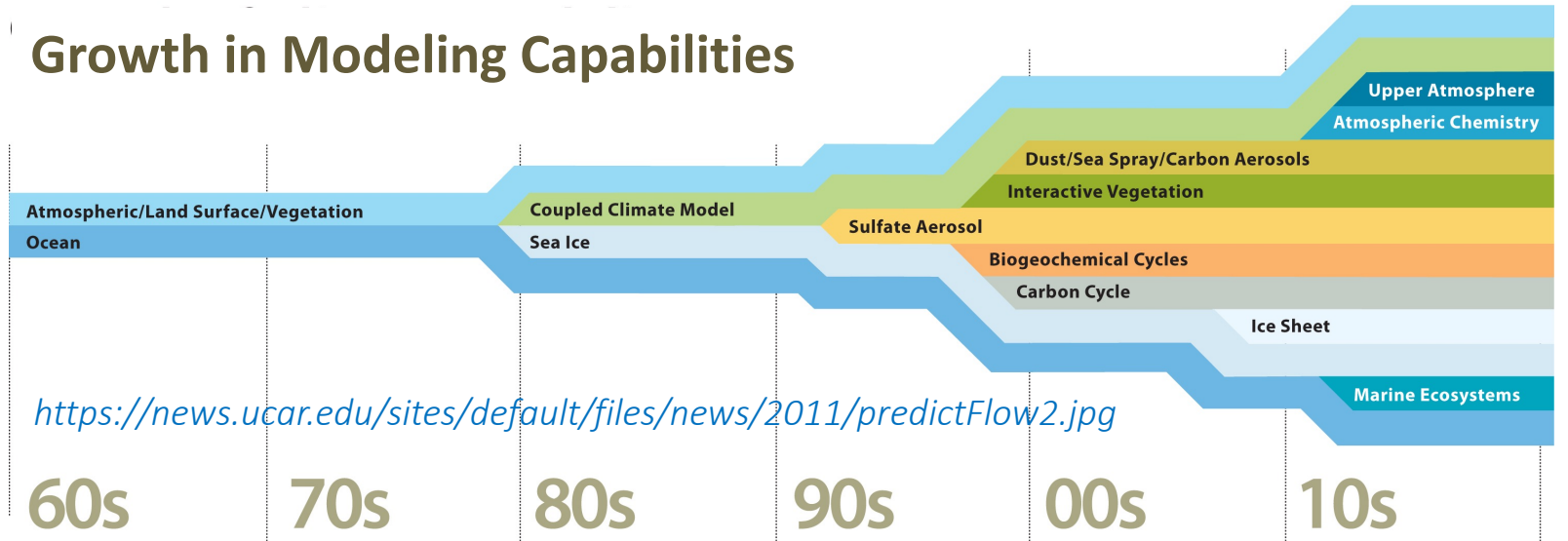
2000s  
Aerosols and  
Vegetation



2010s  
Biogeochemical  
Cycles and Carbon

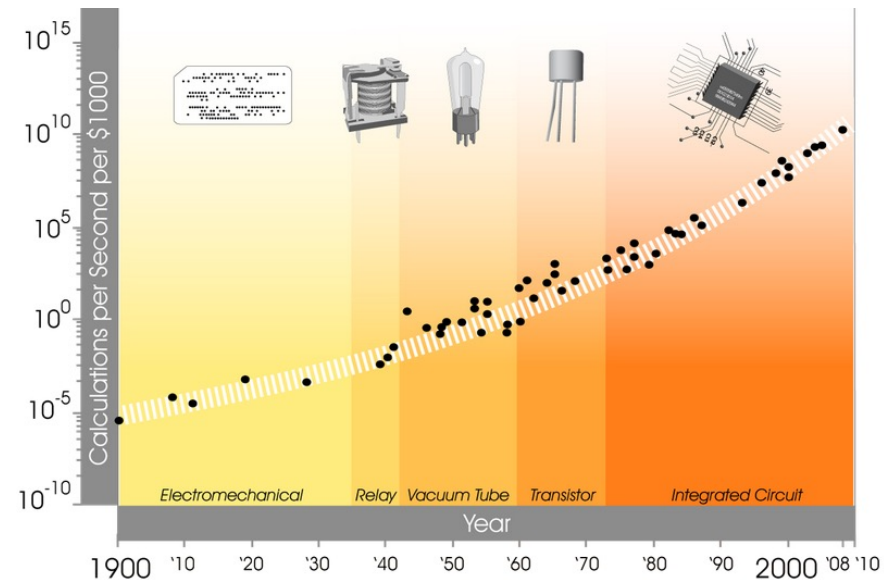
# Model Complexity (a timeline)

## Growth in Modeling Capabilities



<https://news.ucar.edu/sites/default/files/news/2011/predictFlow2.jpg>

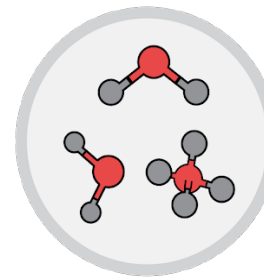
## Growth in Supercomputing Power



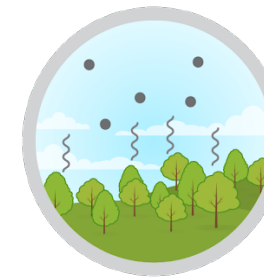
Hydrological  
Cycle



1970s  
Sea Ice and  
Land Surface



1990s  
Atmospheric  
Chemistry



2000s  
Aerosols and  
Vegetation



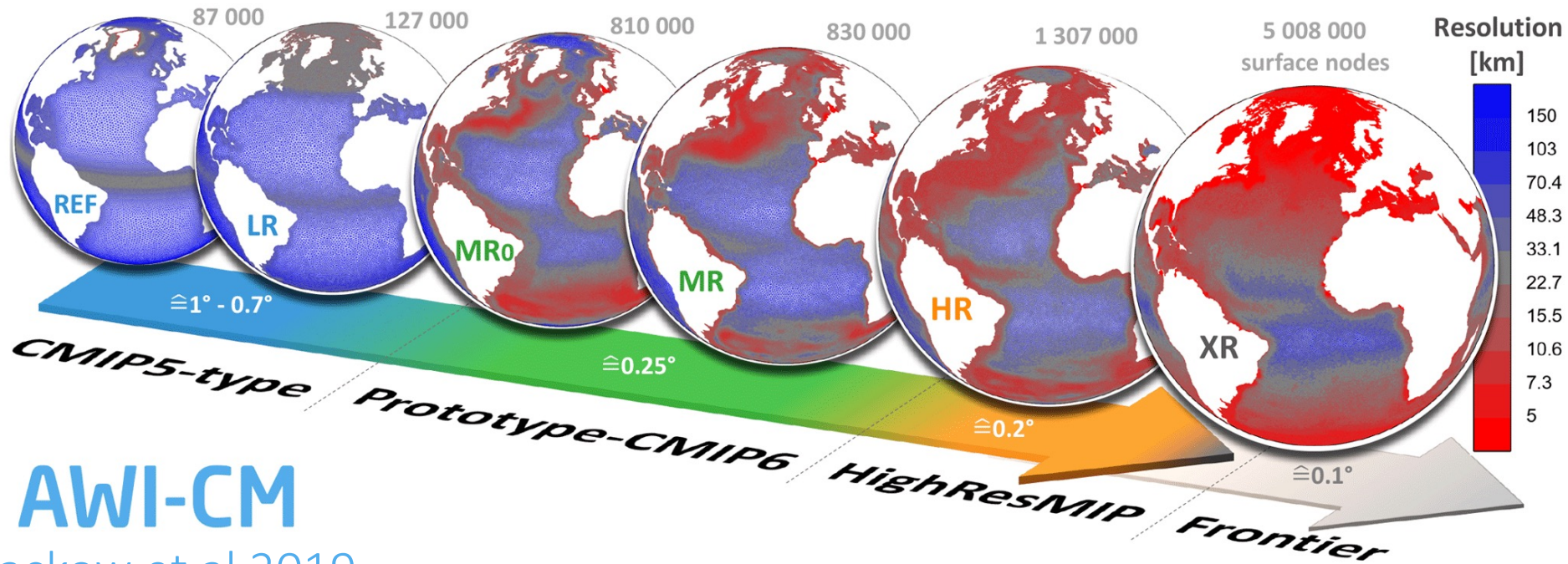
2010s  
Biogeochemical  
Cycles and Carbon

4<sup>th</sup> National Climate Assessment (US), Volume I



# Model Resolution

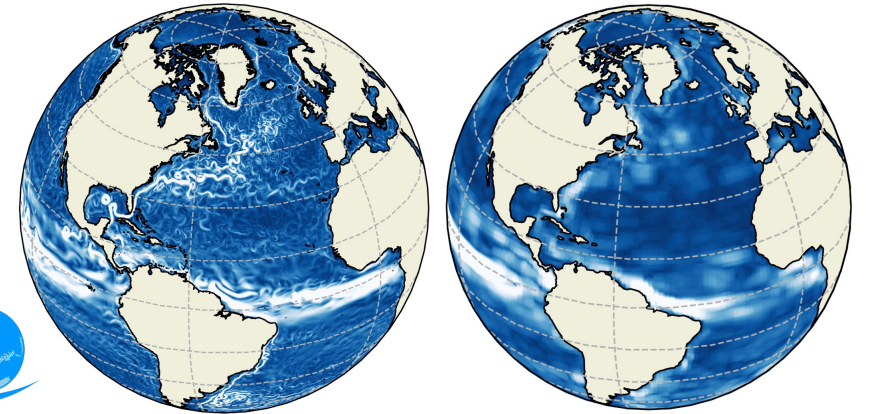
(a timeline)



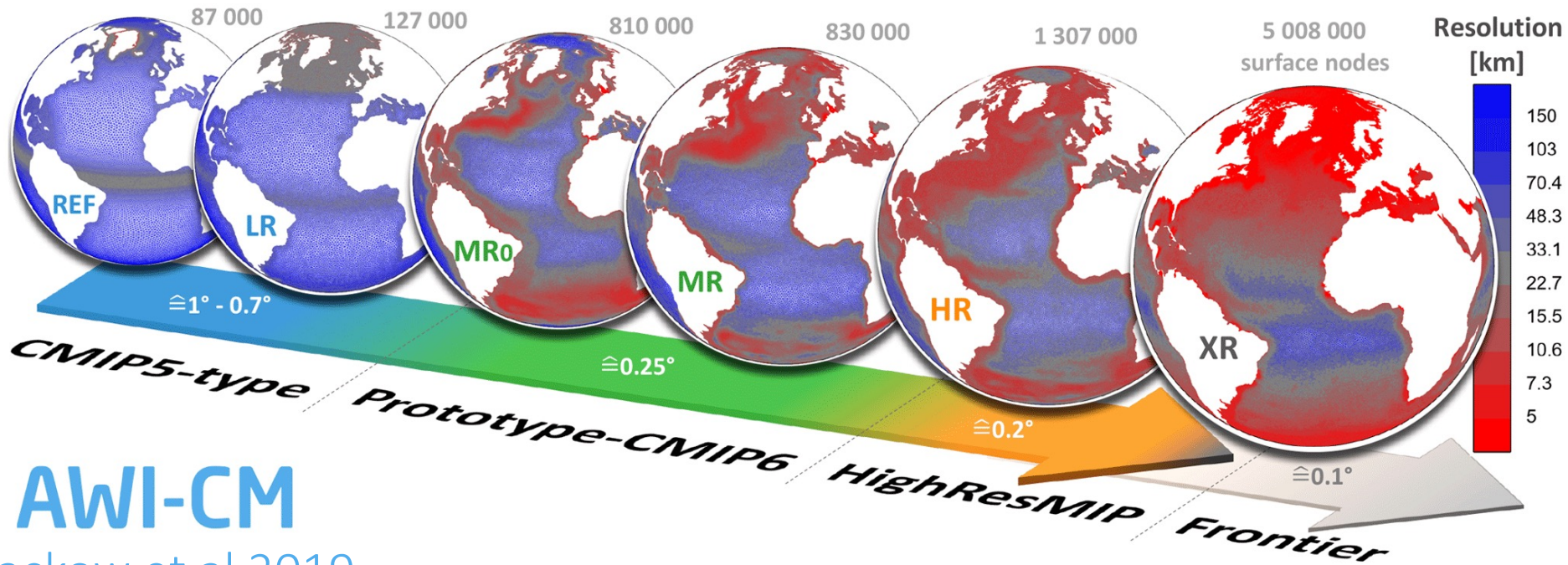
AWI-CM

Rackow et al 2019

# Model Resolution (a timeline)



[https://nemo-related.readthedocs.io/en/latest/nemo\\_notes/orca\\_config.html](https://nemo-related.readthedocs.io/en/latest/nemo_notes/orca_config.html)

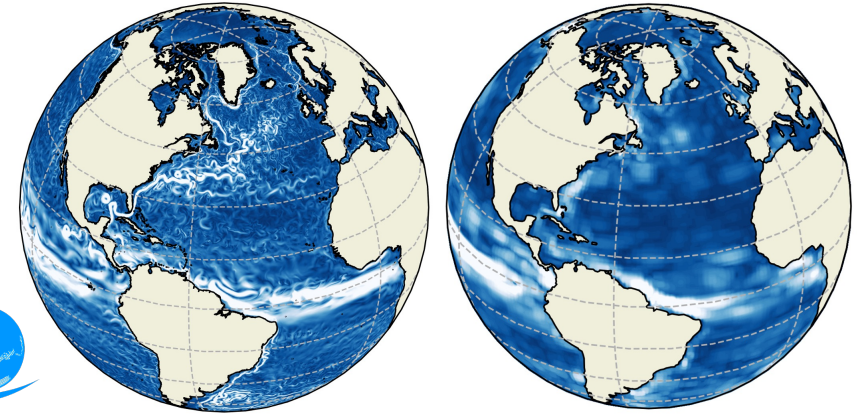
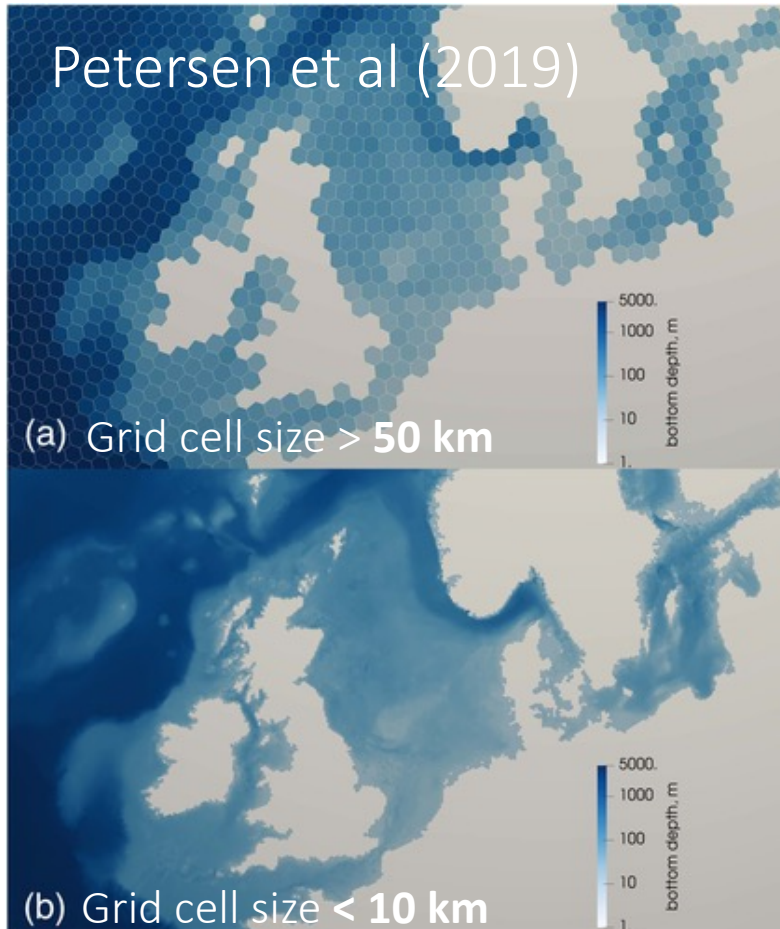


AWI-CM

Rackow et al 2019

# Model Resolution

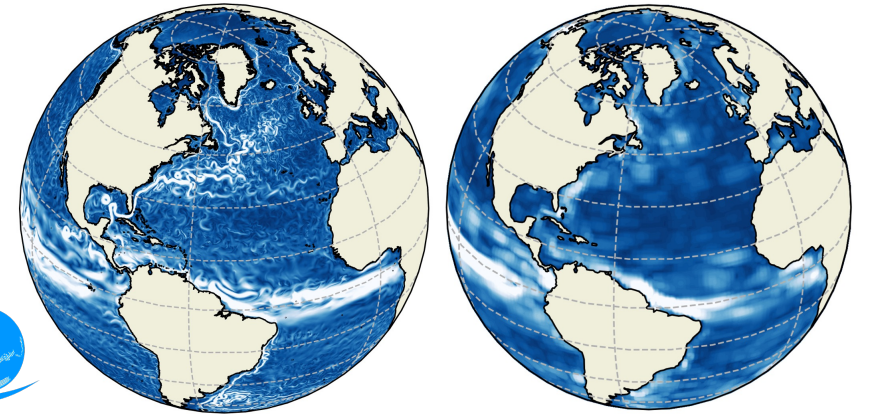
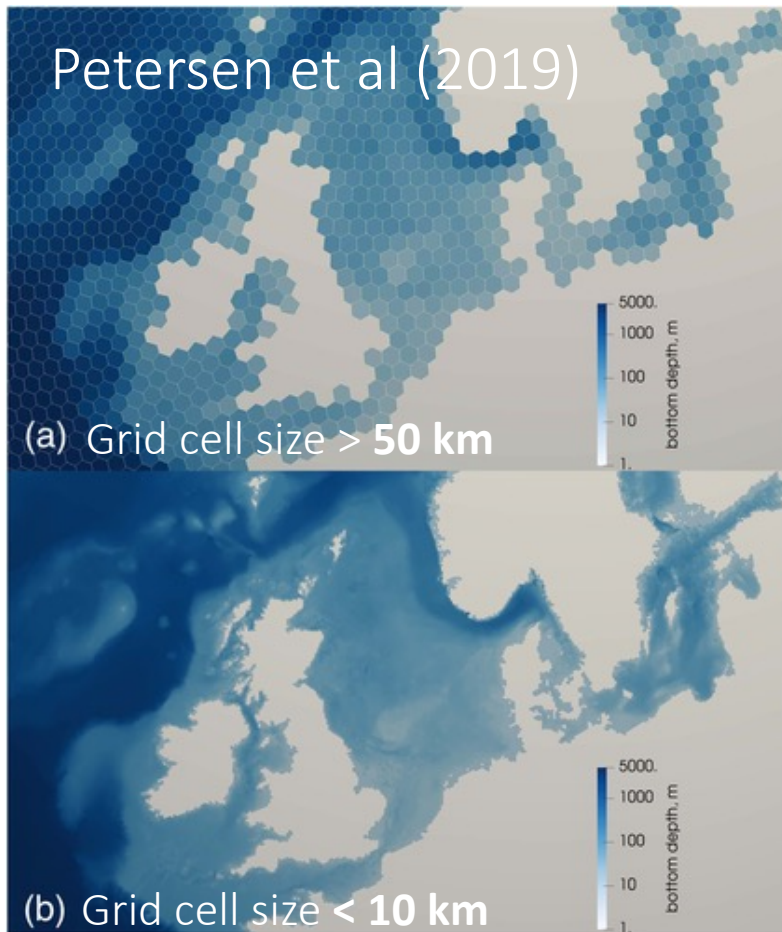
(a timeline)



[https://nemo-related.readthedocs.io/en/latest/nemo\\_notes/orca\\_config.htmlv](https://nemo-related.readthedocs.io/en/latest/nemo_notes/orca_config.htmlv)

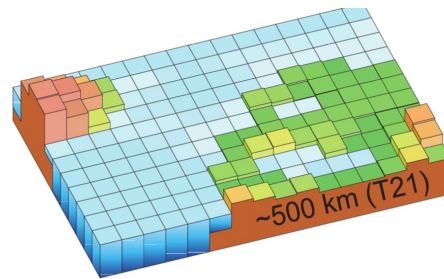
# Model Resolution

(a timeline)

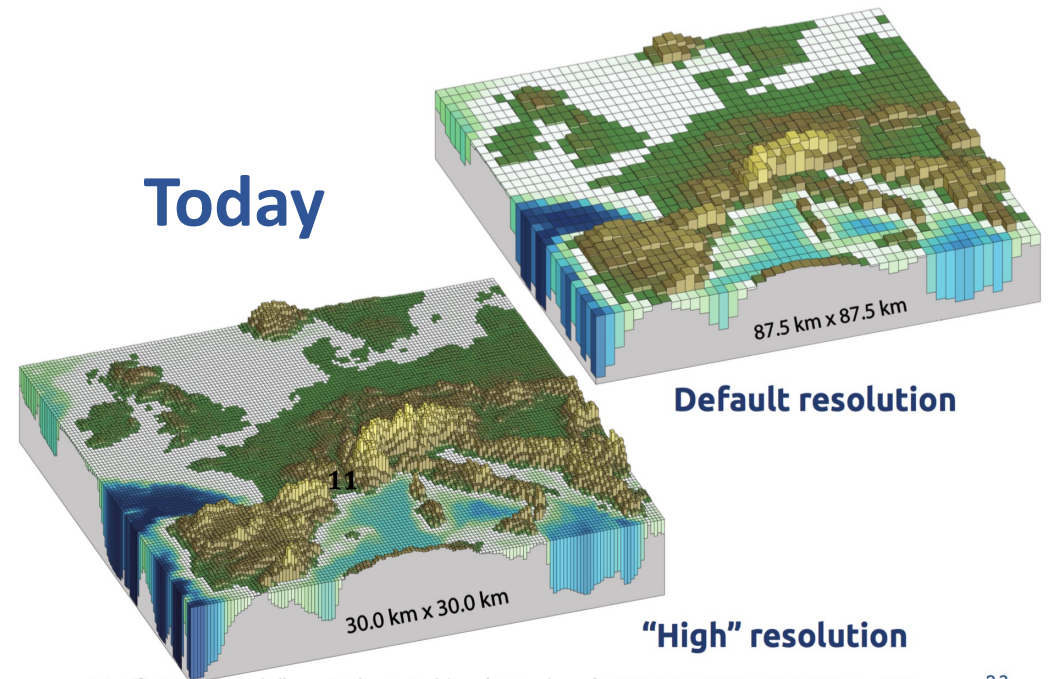


[https://nemo-related.readthedocs.io/en/latest/nemo\\_notes/orca\\_config.htmlv](https://nemo-related.readthedocs.io/en/latest/nemo_notes/orca_config.htmlv)

Typical resolutions  
in the 90s

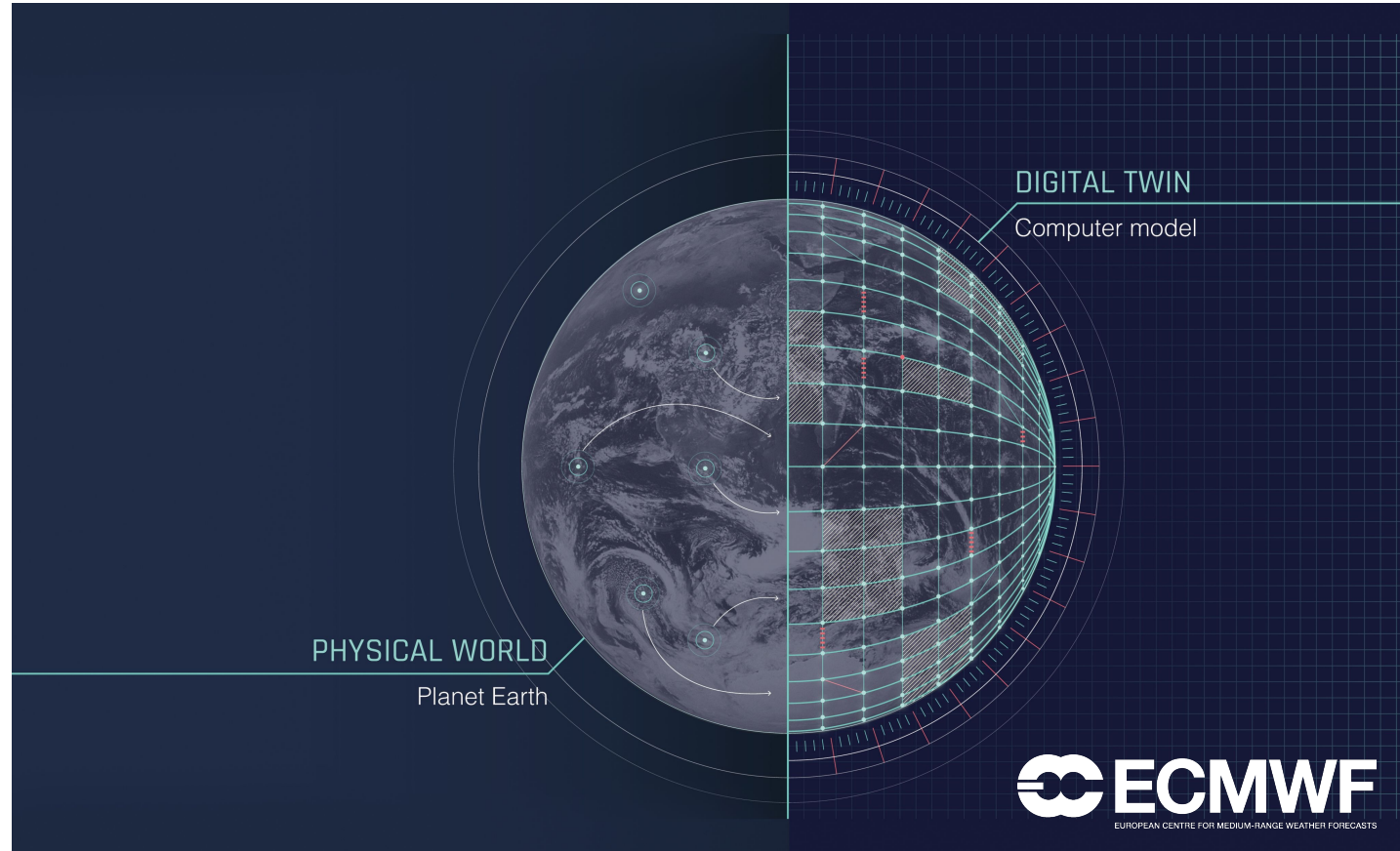


Today



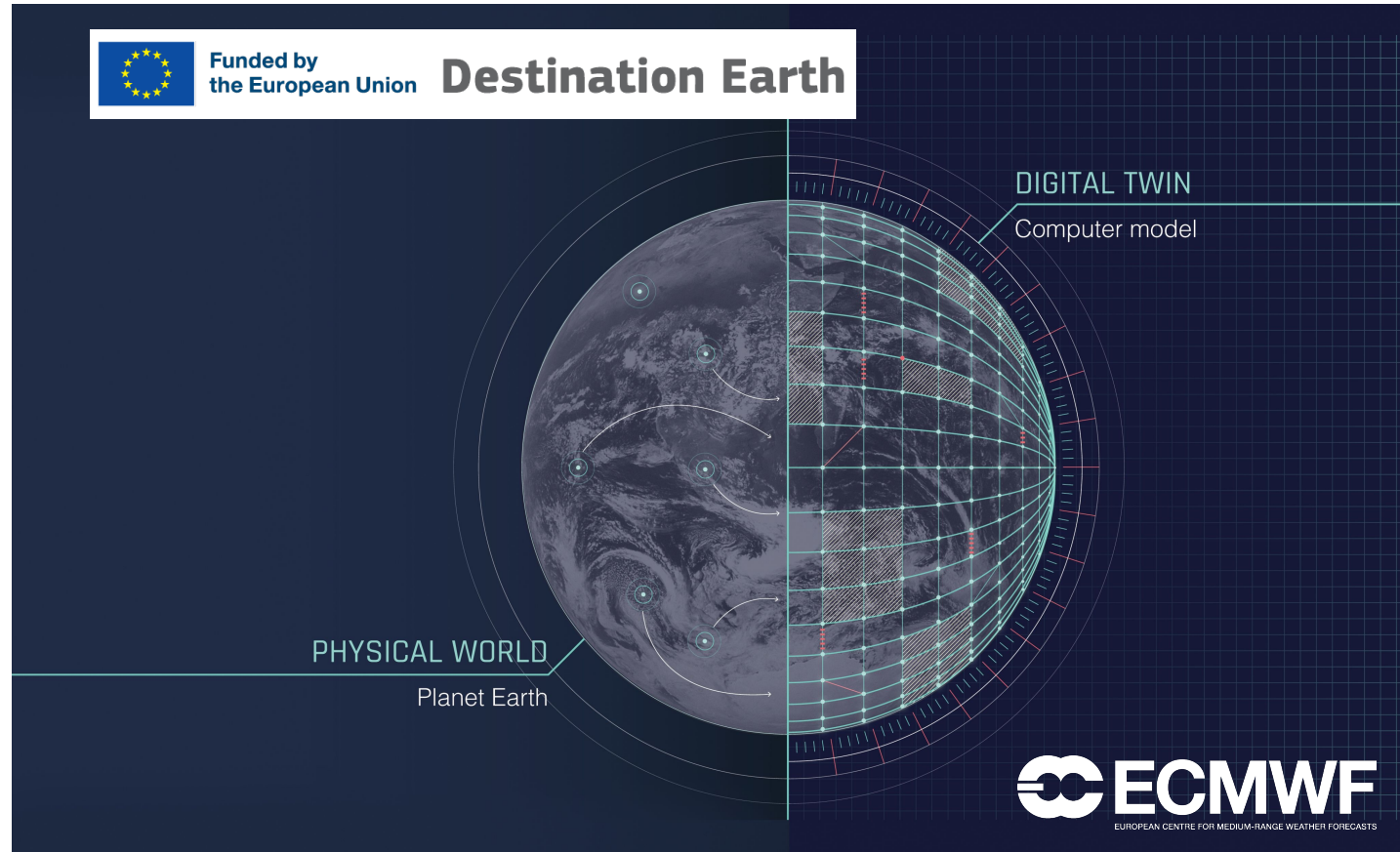
# Digital Twins

(one step further)



# Digital Twins

(one step further)



Destination Earth is developing a new type of climate information system tailored to **assess the impacts of climate change and different adaptation strategies** at local and regional levels over multiple decades using a strategy where **user requests drive the whole production chain**.

# Digital Twins

(one step further)



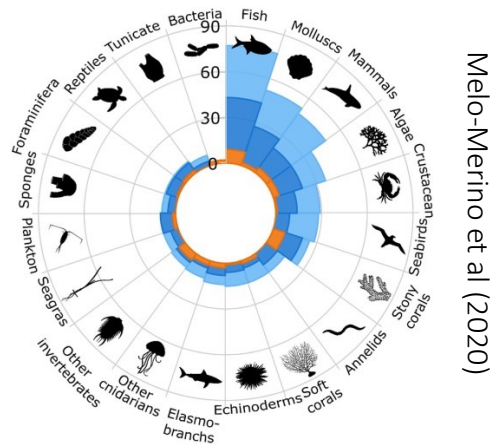
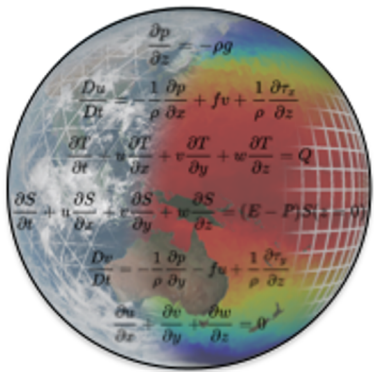
**EDITO-Model Lab** will connect on a common platform, a large variety of ocean and coastal numerical models, allowing for global, regional-to-coastal model configuration and the **co-development** of **new simulations** and **what-if scenarios** for a **more sustainable management of marine environments**.

# A Practical Example

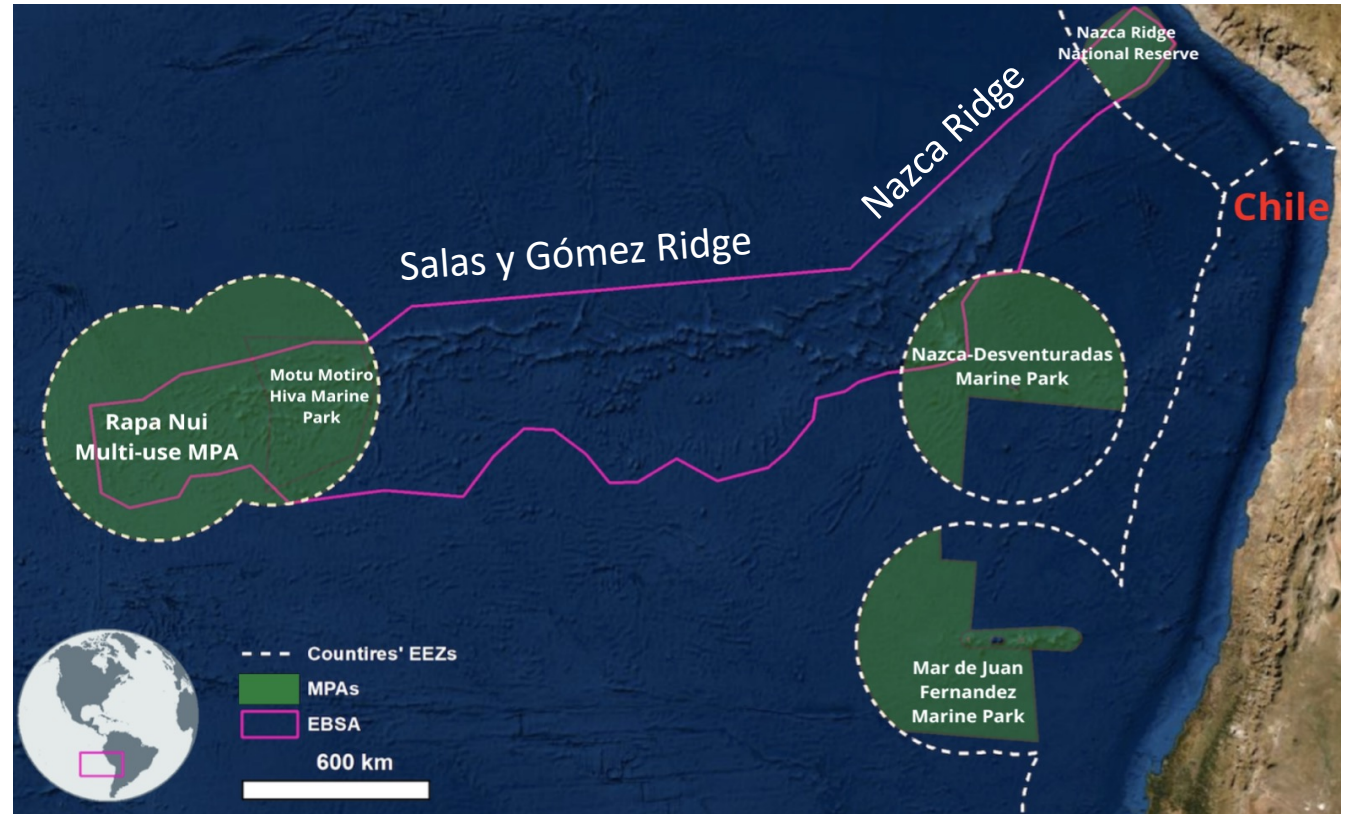
(one step further)

**MOANA** | Marine climate change refugia for insular mesophotic ecosystems in the South Pacific ocean

Ariadna Mecho



Melo-Merino et al (2020)



Earth System Models of different complexity

Species Distribution Models



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## ACKNOWLEDGEMENTS

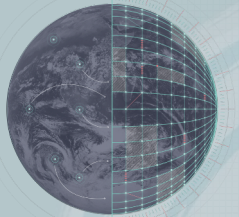
*Destination Earth is a European Union funded initiative and is implemented by ECMWF, ESA, and EUMETSAT.*



Funded by  
the European Union

**Destination Earth**

implemented by  **ECMWF**  **esa**  **EUMETSAT**



*The research leading to these results has received funding from the EU HE Framework Programme under grant agreement n° 101093293 and 101081383*



Funded by  
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European Eddy-Rich ESMS

European Digital Twin Ocean



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# Booth 11 Host

JOIN US!!

Earth Sciences  
Department



**Barcelona  
Supercomputing  
Center**

*Centro Nacional de Supercomputación*



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