



Optimal high resolution **Earth System Models**  
for exploring future climate change

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#### EARTH SYSTEM MODELS (ESMs)

- EC-Earth (SMHI, DMI, KNMI, BSC, ULUND, CNR, FMI)
- UKESM (METOFFICE, UNIVLEEDS, NOC, UoB, UREAD, UNEXE)
- CNRM-ESM (MF-CNRM, CERFACS)
- IPSL-ESM (CNRS)

#### REGIONAL CLIMATE MODEL

- WRF (THE CYPRUS INSTITUTE)

#### INTEGRATED ASSESSMENT MODELS (IAMs)

- REMIND-MAGPIE (PIK)

#### SIMPLE CLIMATE MODELS (SCMs)

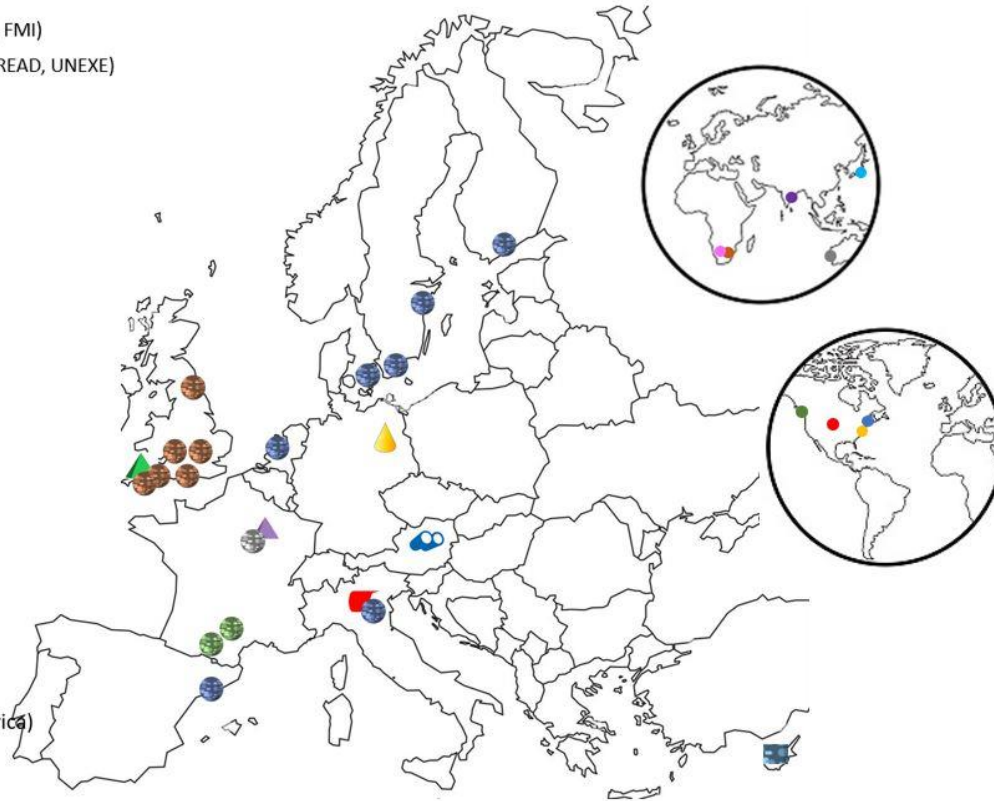
- ACC2 (CNRS)
- FAIR (METOFFICE)

#### OBSERVATIONS (B.GEOS)

- DATA (CINECA)

#### INTERNATIONAL COLLABORATIONS

- NOAA-GFDL (USA)
- CCCma (Canada)
- LDEO Columbia University (USA)
- University of Pretoria (South Africa)
- University of the Witswatersrand (South Africa)
- IITM (India)
- University of Western Australia (Australia)
- JAMSTEC (Japan)



**20 partners, 11 countries**

**9 international partners**  
USA, Canada, South Africa,  
India, Japan

**Project duration: 2023-2027**



This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101081193.



# Main goal of OptimESM



The **primary goal** of OptimESM is to develop the **next generation of ESMs**, **bringing together increased model resolution and process realism**, and to deliver **long-term climate projections** that better support policy and societal needs, providing guidance on **regional climate change at different levels of global warming**, the **risk of abrupt Earth system changes** at these warming levels and the **regional impacts** arising from such events.



# Motivation



OptimESM

## Need full Earth System Models:

Interactions and feedbacks between Earth system components

Carbon cycle

Tipping points/ abrupt changes

carbon cycle

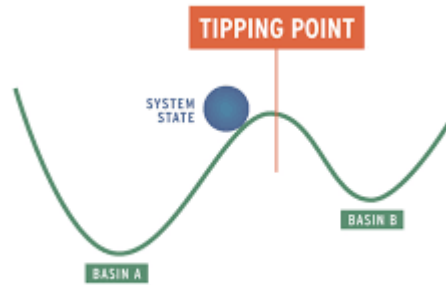
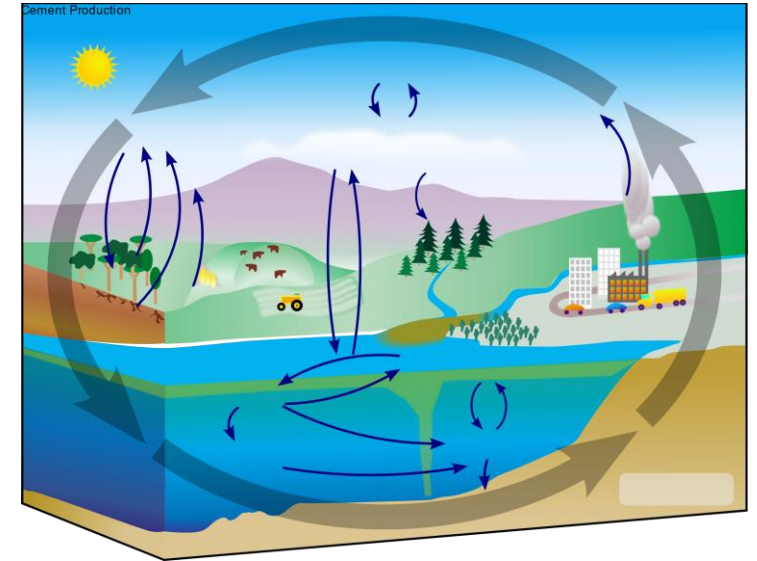


Illustration by Andrew Senior, adapted from Malm, B. & Daly, D. (2000) Resilient Training: Sustaining Ecosystems and People in a Changing Arctic. Island Press, Washington, DC.

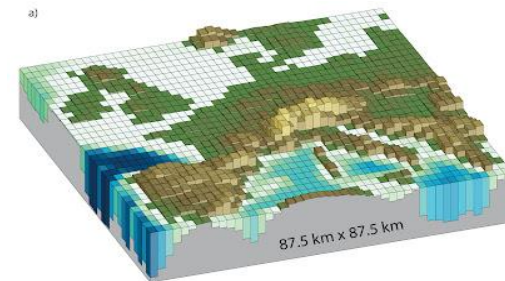
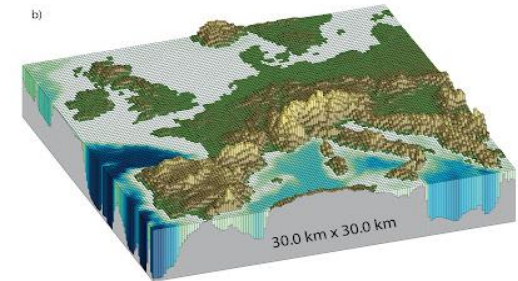


## Need high resolution:

Clouds and interaction with radiation

Extremes

Small scale processes and complex topography

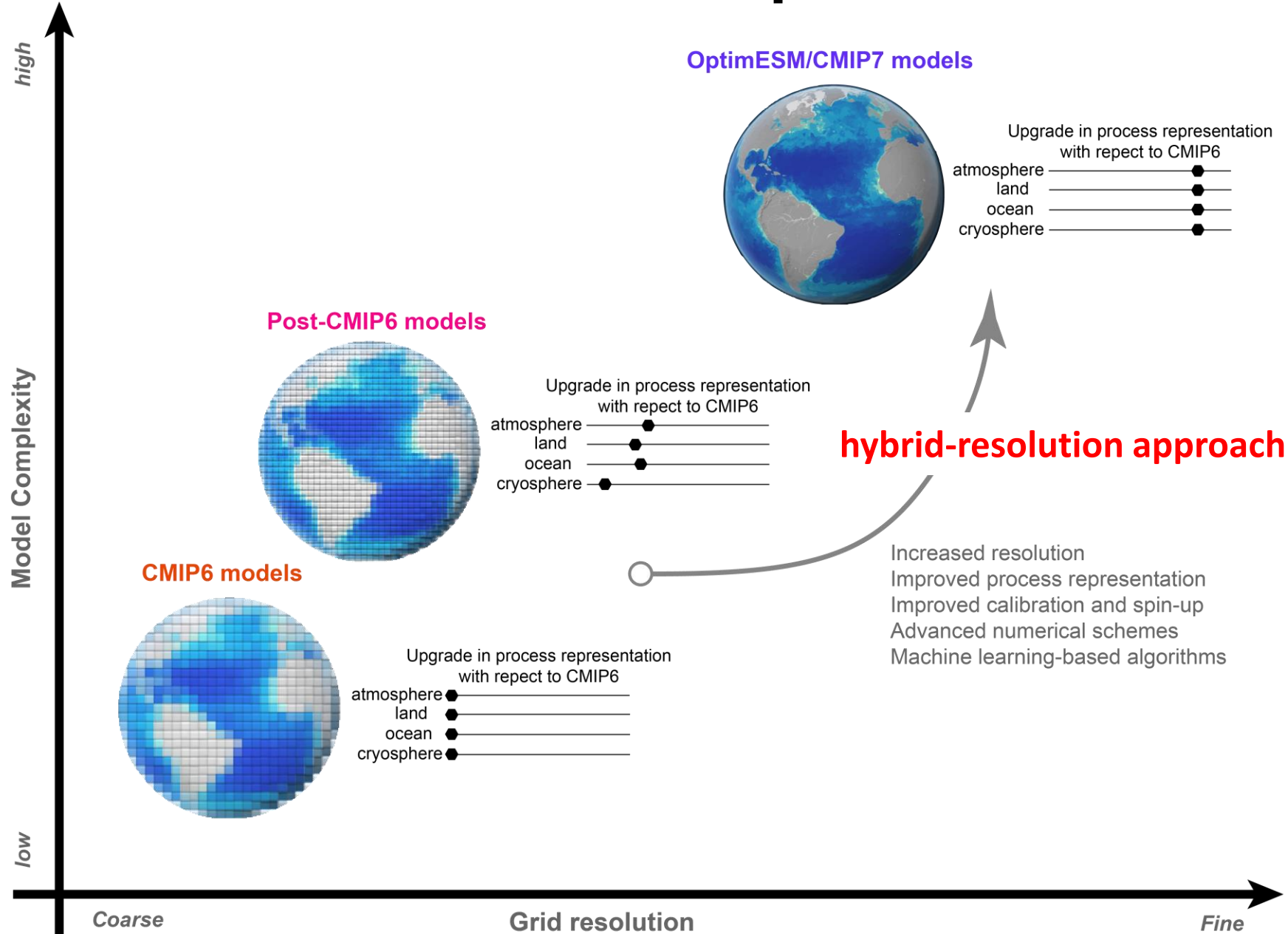




# Concept



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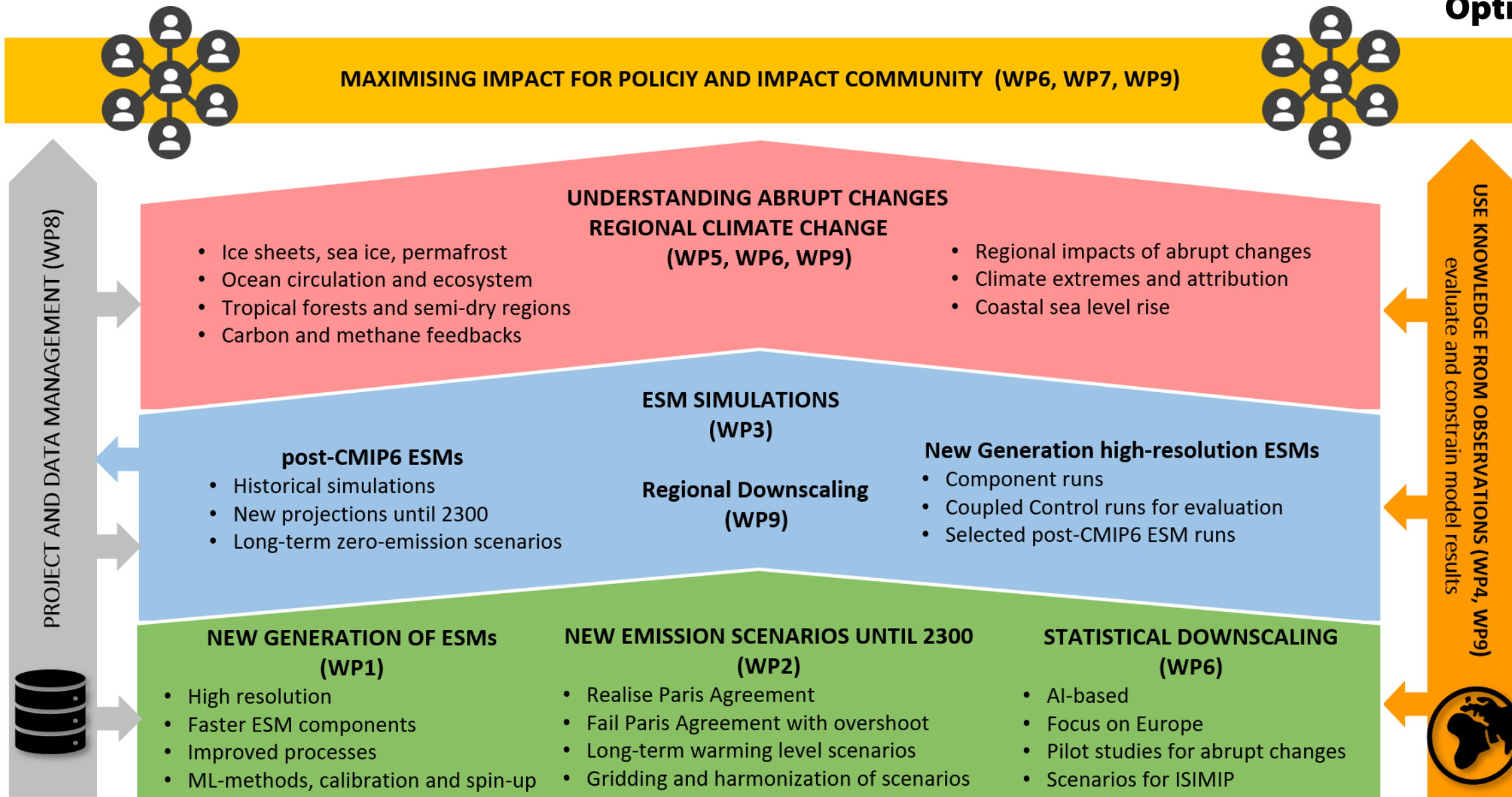




# Structure



OptimESM



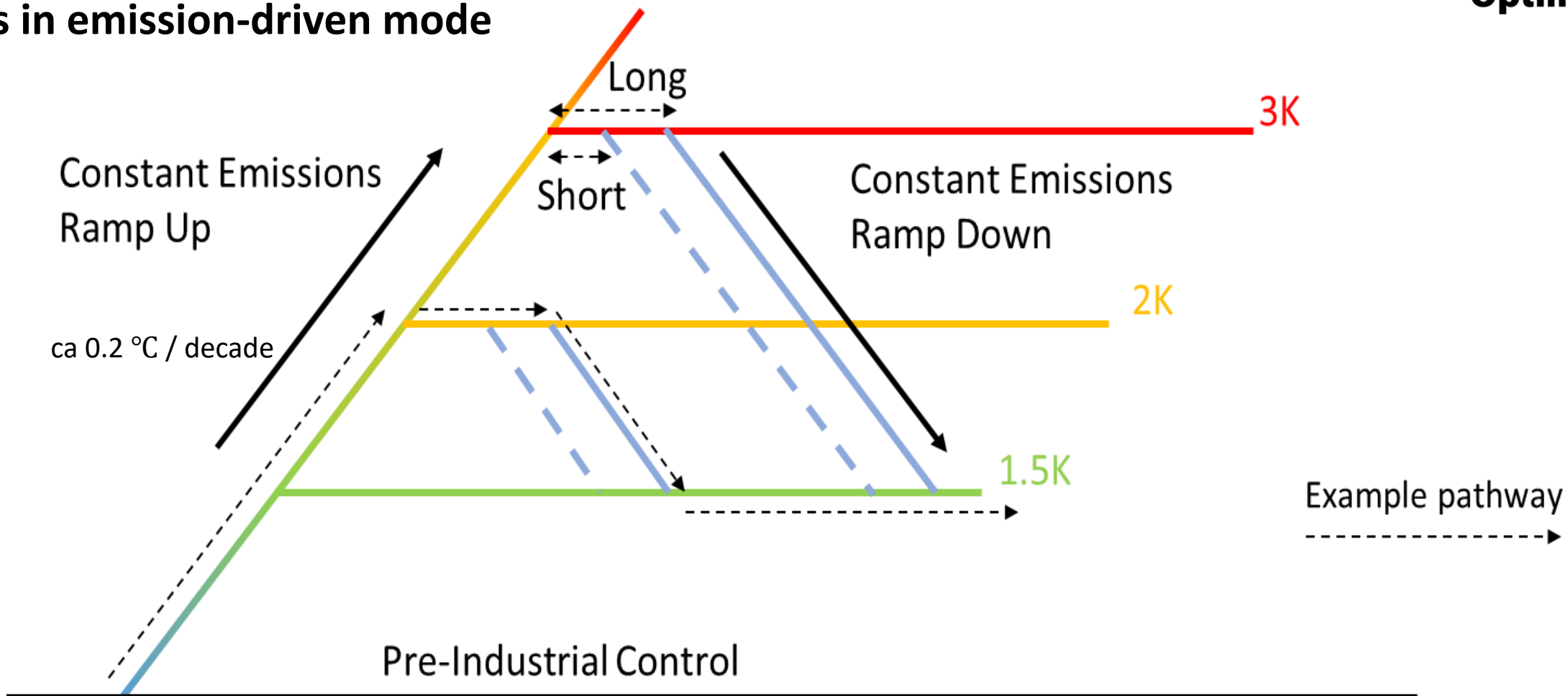


# Idealized Scenarios



OptimESM

## ESMs in emission-driven mode





# New Emission and Land-Use Scenarios

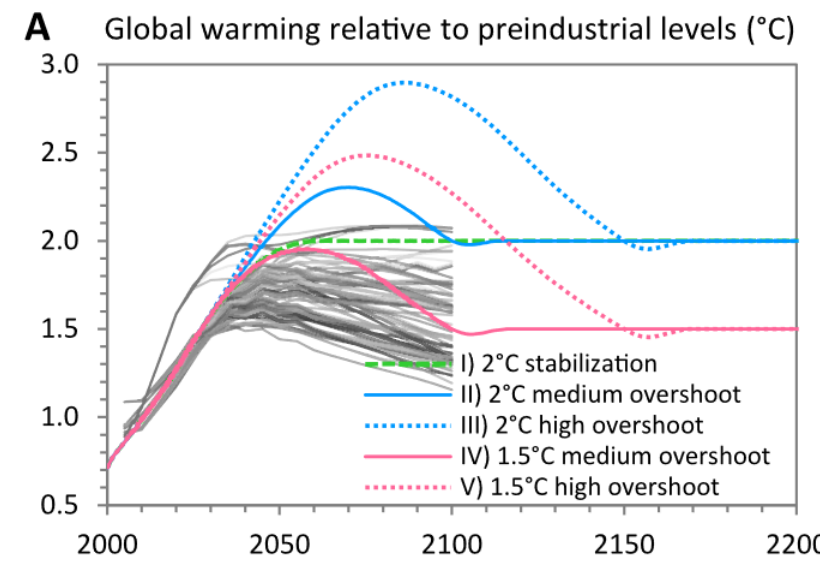
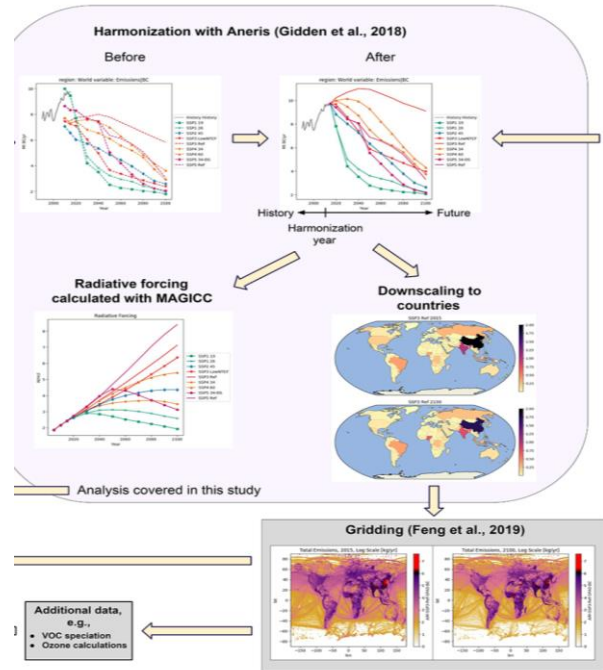


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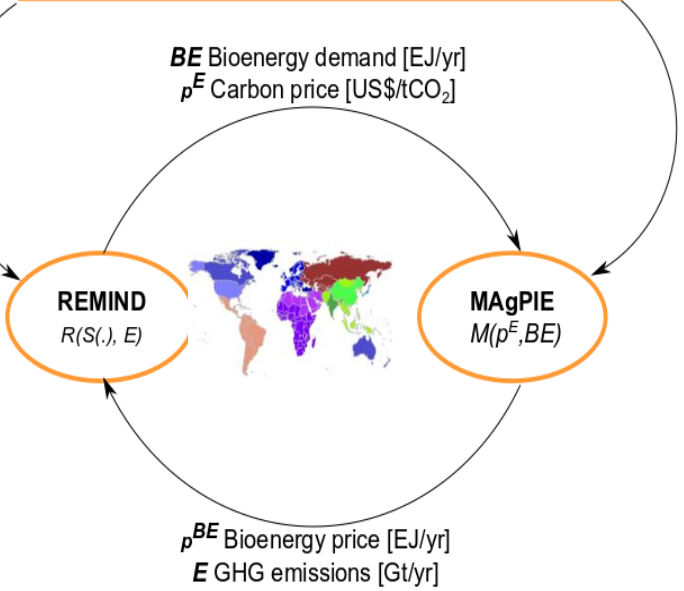
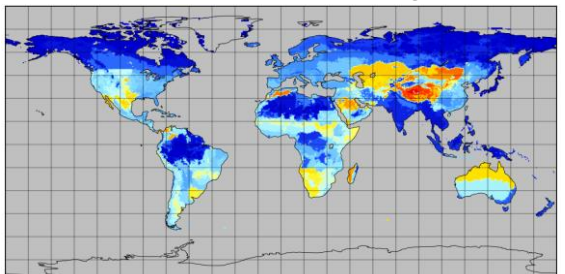
New scenarios w/ and w/o overshoot (2020-2100)

Harmonization and Gridding of emissions and land-use (CMIP6-like)

Extended scenarios until 2300



Pasture & Rangeland Shares 2015 (200 Cluster in MAgPIE)



Dietrich et al. (2019), Baumstark et al (2017), Bauer et al. (2020)

Tanaka et al. (2021)



# ML-based downscaling for Europe

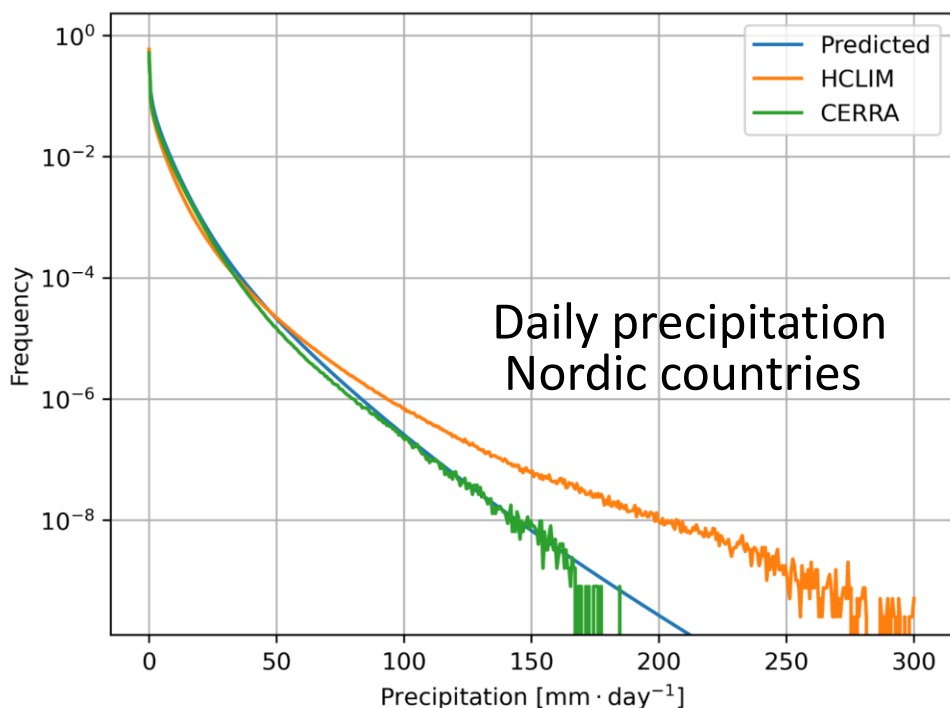
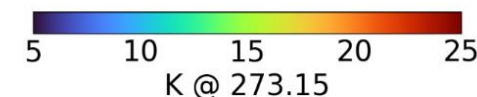
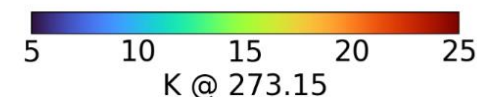
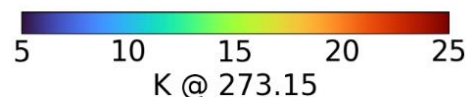
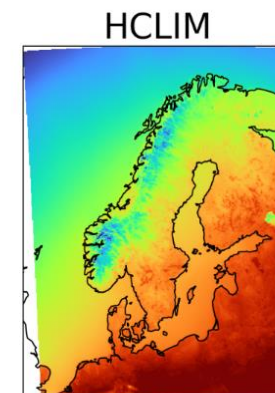
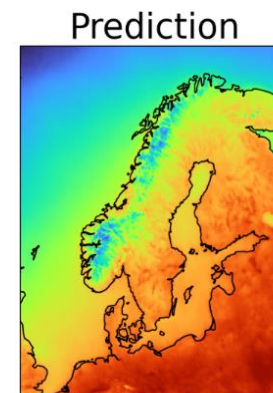
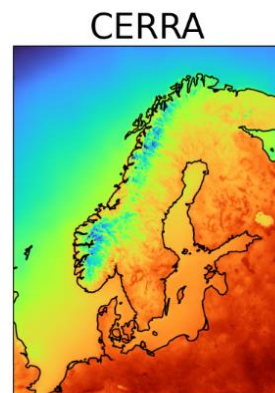


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<b>ERA-5 (input)</b>	<b>CERRA (ground truth)</b>
Low-res (0.25°)	High-res (5.5 km)

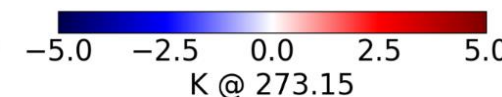
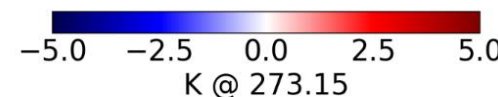
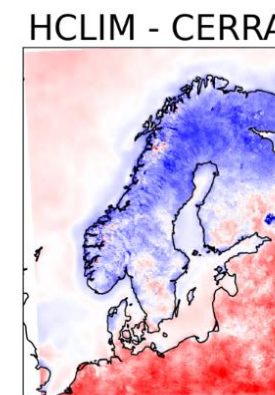
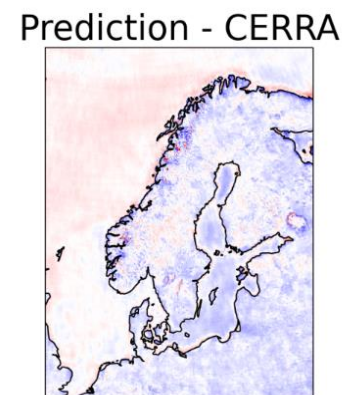
- Air temperature and precipitation
- Training period: 1985–2012
- Validation period: 2013–2020

Mean yearly t98, T2m



Daily precipitation  
Nordic countries

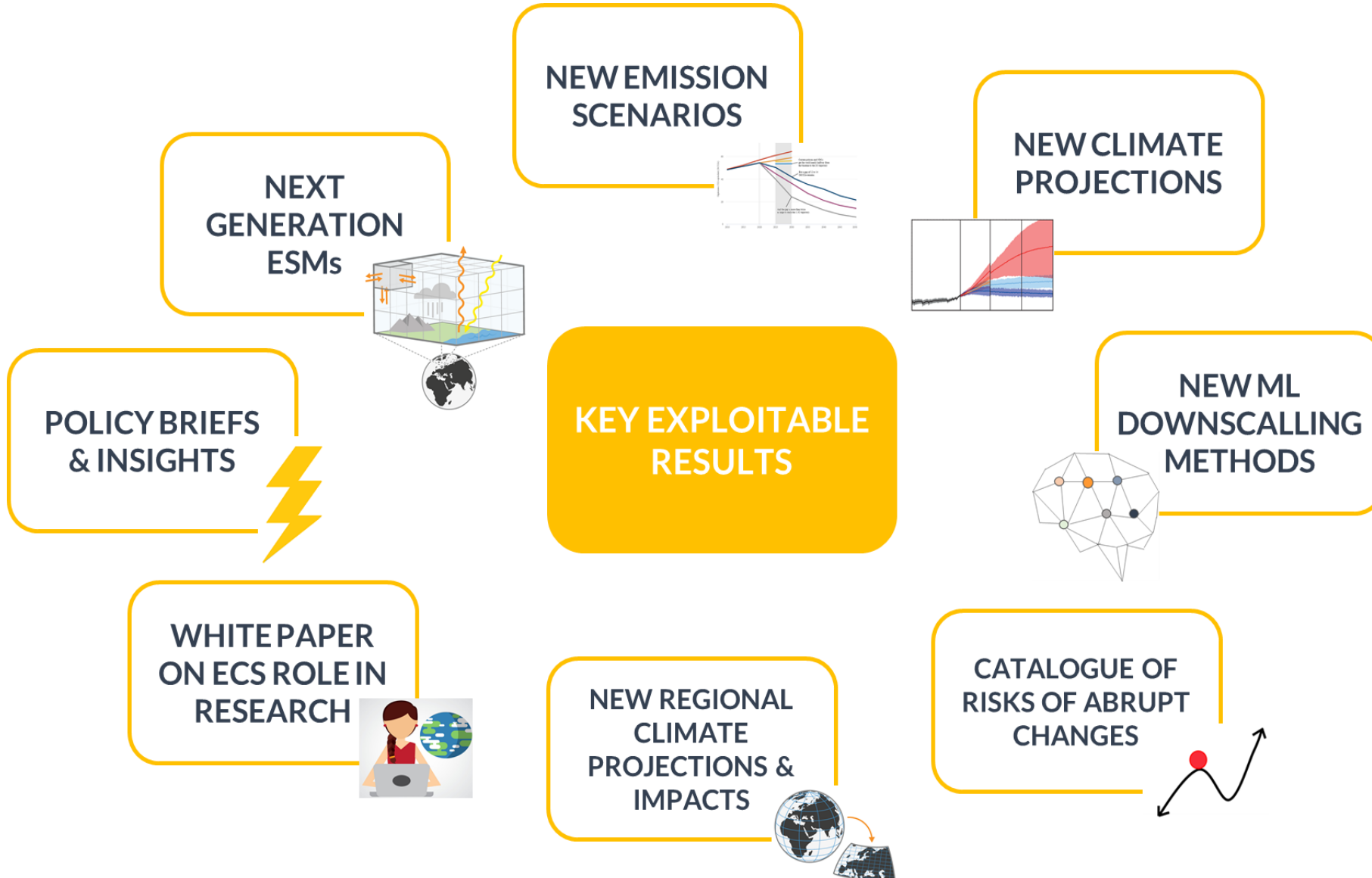
Comparison to  
2.5 km dyn.  
reg. model  
HCLIM



Krus et al., in prep



# Expected key results





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**OptimESM**

Optimal high resolution **Earth System Models**  
for exploring future climate change

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# Optimal high resolution Earth System Models for exploring future climate change

*Coming soon!*  
[optimesm-he.eu](http://optimesm-he.eu)

OptimESM will develop a novel generation of Earth system models to deliver cutting-edge and policy-relevant knowledge around the consequences of global warming, including the risk of rapid change in key Earth system phenomena and regional impacts.

[Learn more](#)