OptimESM has received funding from the European Union's Horizon innovation programme under grant agreement No 101081193.

Optimal high resolution Earth System Models for exploring future climate change

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OptimESM

Motivation

- Earth System Models (ESMs) are essential to study the **interactions and feedbacks** between Earth system components and **abrupt changes** in the Earth system
- Simulations of clouds and their interaction with radiation, small scale processes, complex topography and climate extremes require **high resolution** in ESMs.

Goals

- develop a **new generation of ESMs** with both **increased resolution** (25-50 km) and **process realism**
- deliver **long-term climate projections** that better support **policy and societal needs**
- provide guidance on **regional climate change**, the **risk of abrupt Earth system changes** and the **regional impacts** arising from such events **at different levels of global warming**.

OptimESM in numbers

SMHI Coordination
20 European partners
9 International collaborations

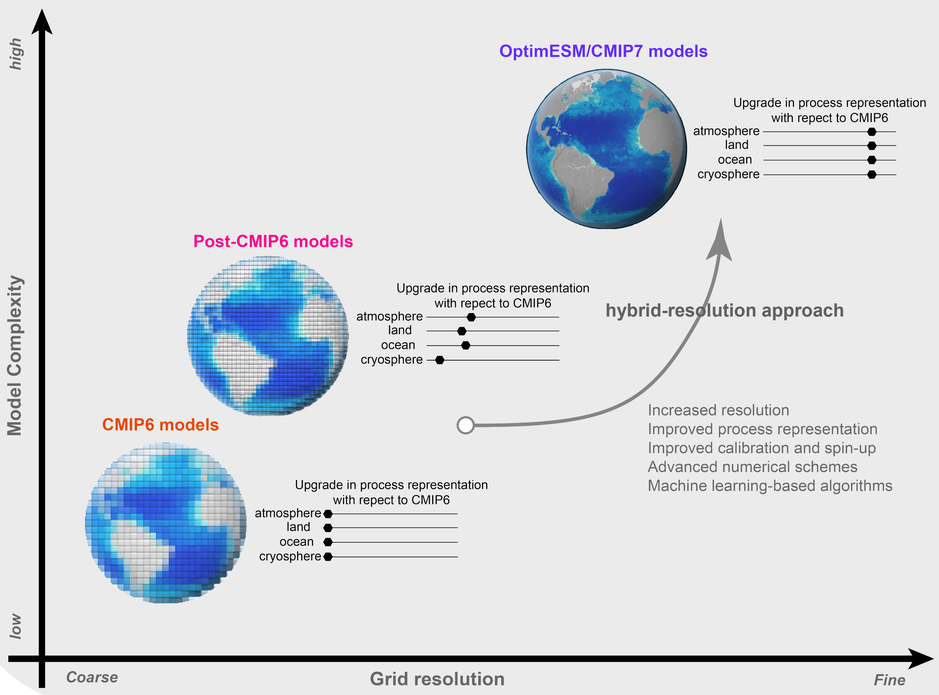
4 Earth System Models
1 Integrated Assessment Model
2 Simple Climate Models

Dynamical & statistical downscaling
Observations
Data
Communication & Dissemination

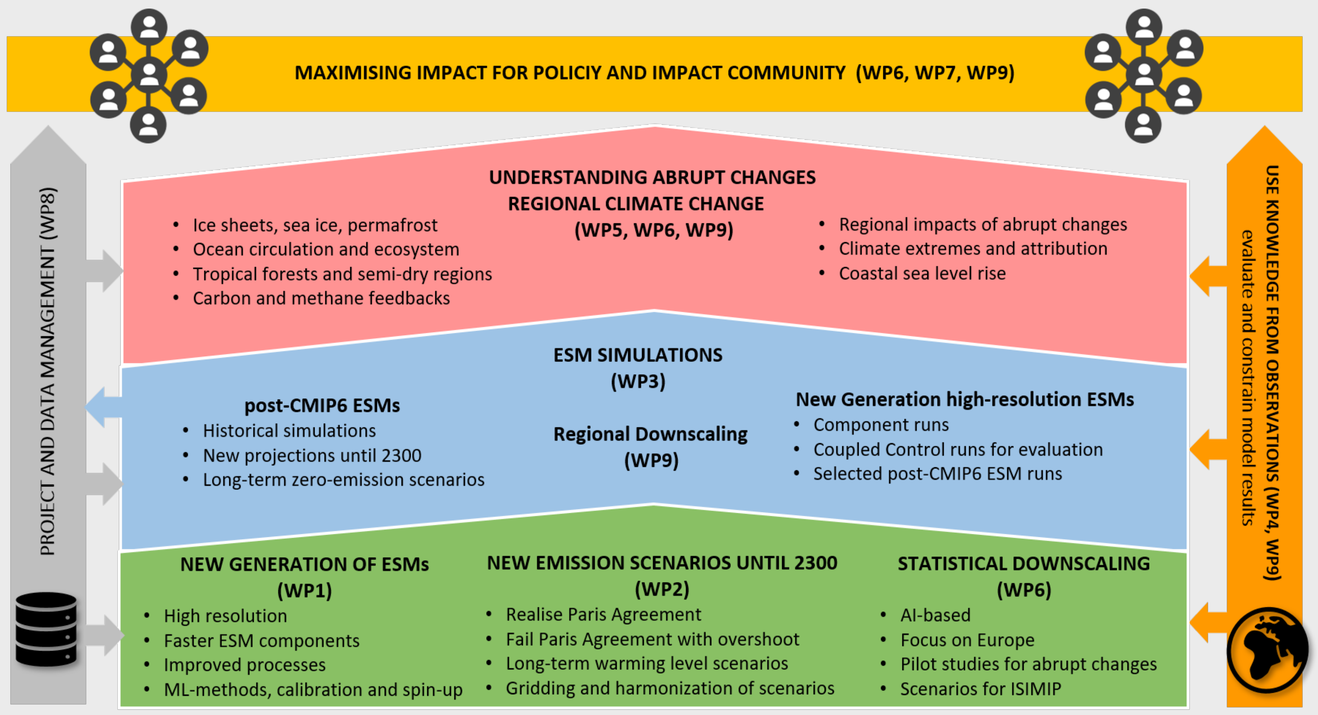
5 years (Jan 2023 – Dec 2027)
Horizon Europe

Concept

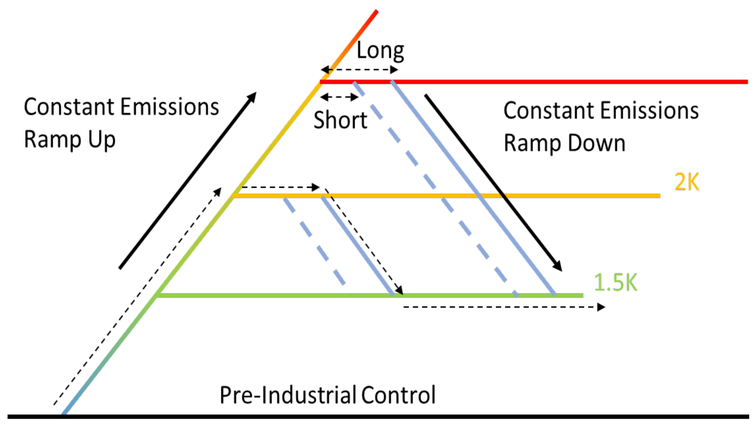
Bridging the gap between process-realism and high resolution



Structure



Protocol for idealized scenarios simulations

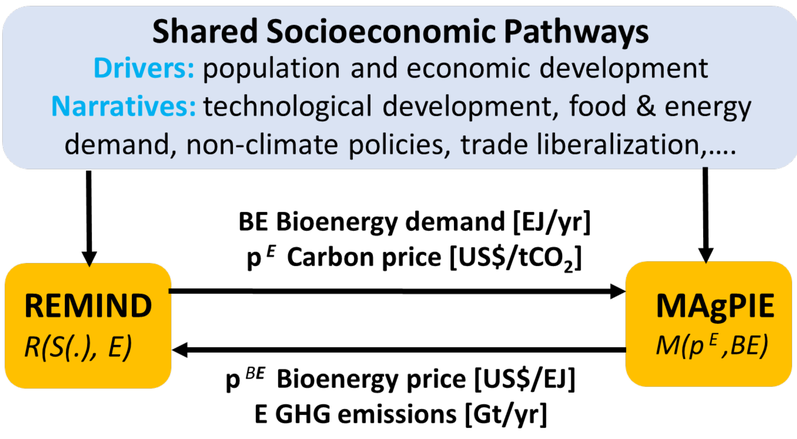


OptimESM will use ESMs in emission driven mode.

- ***Ramp-up:*** Starts from PI Ctrl and ramps-up with 0.2K/decade.
- ***Stabilisation runs:*** Emissions are set to zero when the targeted warming is reached.
- ***Ramp-down***: Fast and slow rate of ramp-down down to pre-industrial.

New Emission and Land-Use Scenarios

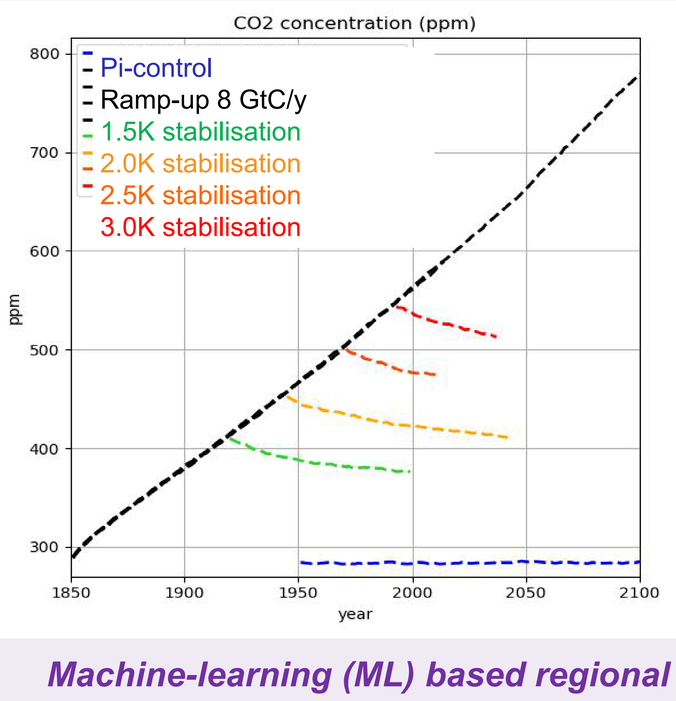
Shared Socioeconomic Pathways
Drivers: population and economic development
Narratives: technological development, food & energy demand, non-climate policies, trade liberalization,….

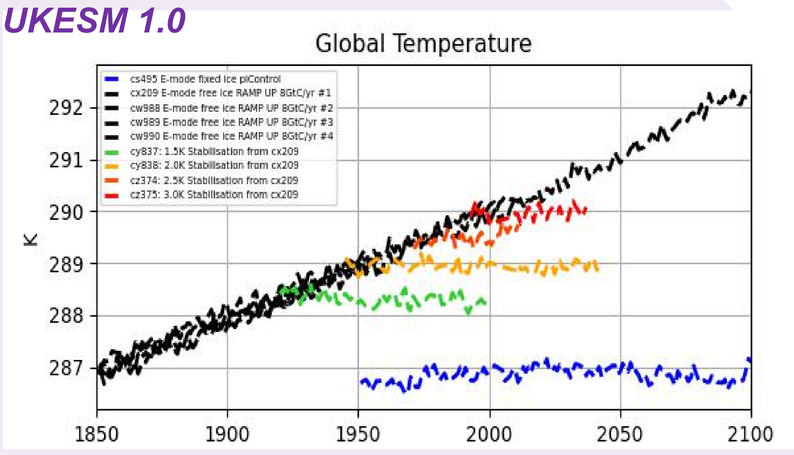


- a new set of emission and land-use scenarios (2020-2100)
- overshoot and no overshoot
- extended scenario to 2300 using a simple climate model

Some initial results

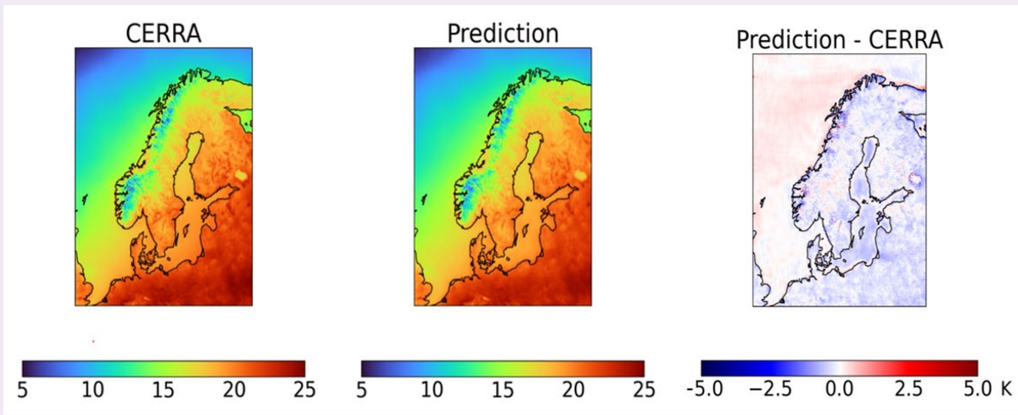
First results from ramp-up simulations with UKESM 1.0





- Ocean, land and vegetation continue taking up CO_2 after zeroing emissions.
- The cooling effect of the reduced atmospheric CO_2 concentration balances the warming effect from the oceans.
- Global temperature is almost stable after zeroing emissions.

Machine-learning (ML) based regional downscaling
Downscaling of ERA5 data (25 km resolution) to 5.5 km using convolutional neural networks.



- CERRA data served as training data for the period 1985-2012.
- Shown is the 98 percentile of T2m in the CERRA-data, in the downscaling (prediction) and the difference for the time period 2013-2020.
- The ML based downscaling (prediction) represents well observed temperature and precipitation extremes over northern Europe.

OptimESM maintains a close collaboration with CMIP and CORDEX, as well as with the global climate impacts community through the Inter-Sectoral Impact Model Inter-comparison Project (ISIMIP).