PRIMAVERA

PRocess-based climate sIMulation: AdVances in high-resolution modelling and European climate Risk Assessment

How do climate models work?

Climate models are mathematical representations of the climate system, its components and their interactions. Climate models represent the earth and the atmosphere on a three-dimensional grid of boxes, where the size of a single box represents the spatial resolution of a model. Smaller scale processes are often represented by means of parameterizations. To simulate future climate characteristics, different Representative Concentration Pathways (RCPs) (or concentration scenarios) are used that correspond to storylines of future societal and technological development, including incorporation of climate mitigation policies. High-resolution climate information is needed for climate risk and impact assessments and adaptation planning. The PRIMAVERA project high resolution Global Climate Models (GCMs) are expected to provide credible information in support of climate risk assessments in Europe.

What is a climate model?

A climate model is a mathematical representation of the climate system and the physical, biological and chemical processes that exemplify the various interactions and relationships between the different elements of that system. The climate system consists of the atmosphere, land, snow and ice cover, the plant cover and ocean life, and the oceans and surface water. The evolution of the system depends on (i) the internal interactions between its elements and (ii) the external drivers, such as solar radiation or greenhouse gases, acting on it.

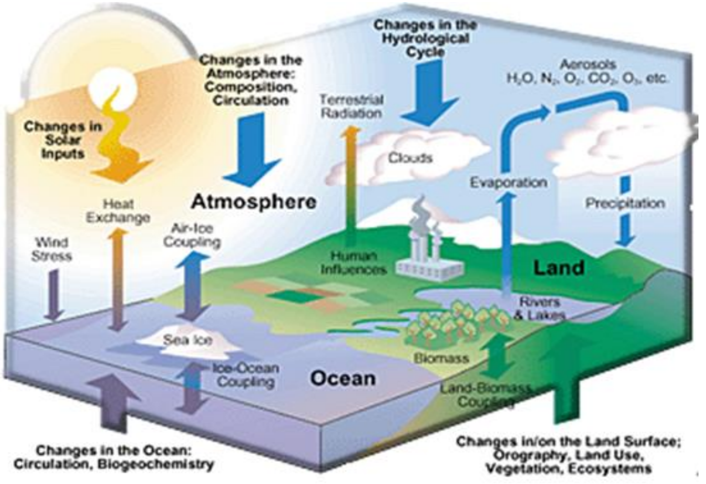

Fig 1.Global climate system (Source:www.era-clim2.eu/about)

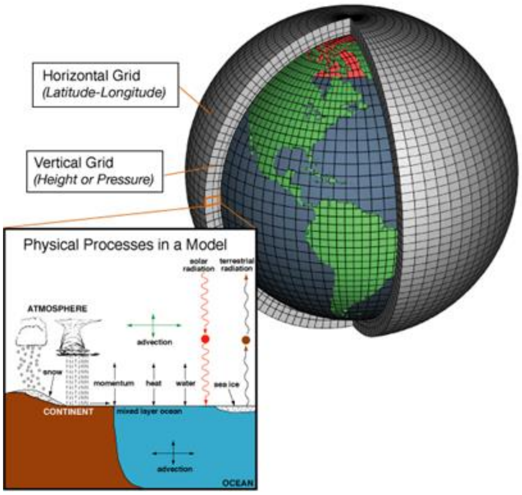

Fig 2. Atmospheric model schematic, (Source: NOAA)

How do climate models work?

Climate models simulate the transfer of energy, matter and momentum using mathematical equations. The models represent the Earth and the atmosphere with a three-dimensional grid of boxes. The mathematical equations are solved within each box, over sequential time steps that march forward in time. To model the future, different concentration (forcing) scenarios are used. Information from one box is passed to the surrounding ones, to simulate the exchange of matter or energy. The main equations represent the fundamental laws of physics, such as the law of conservation of energy. The grid box size represents the resolution of the model: the smaller the grid boxes, the greater the detail of the simulations, and the larger the computing power that is needed to run them. Different climate models will give somewhat different current climates. This depends on the model set-up and complexity, and how some processes are represented.

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Info

PRIMAVERA is a collaboration between 19 leading European research and technology organisations with complementary expertise in climate science, climate change modelling, and high performance computing.

The project is led by the Met Office and the University of Reading.

Media

www.primavera-h2020.eu

Watch the project video →

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Types of climate models

A **coupled global ocean-atmosphere climate model** contains atmospheric, land, ocean, and sea-ice components, coupled together. Such climate models are also known as **General Circulation Models** (GCMs), and are often called Global Climate Models. More comprehensive models that represent the carbon cycle are called **Earth System Models** (ESMs). Models that represent a smaller region at higher resolution, and receive information at their boundaries from a GCM, are called **Regional Climate Models** (RCMs). These models are faster, require less computing power compared to GCMs - but cover a limited area of the earth's surface. In addition to coupled models, **atmosphere-only models** which are forced with sea surface temperature information are also used in climate research. Such models can be useful in understanding various climate processes.

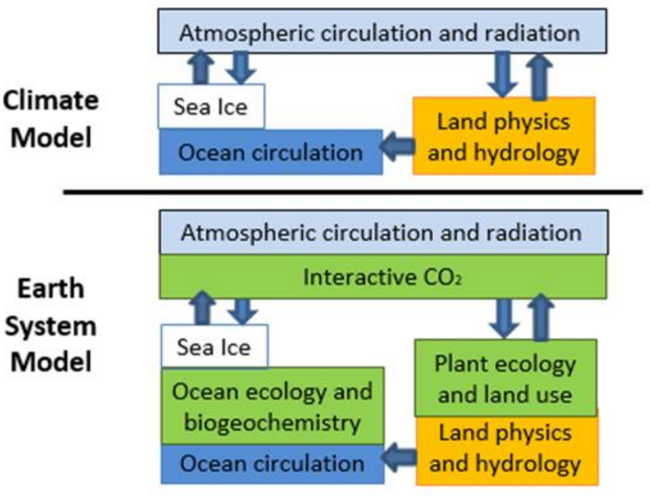

Fig 3. Basic structure of a GCM and an ESM (image courtesy of J. Bessembinder)

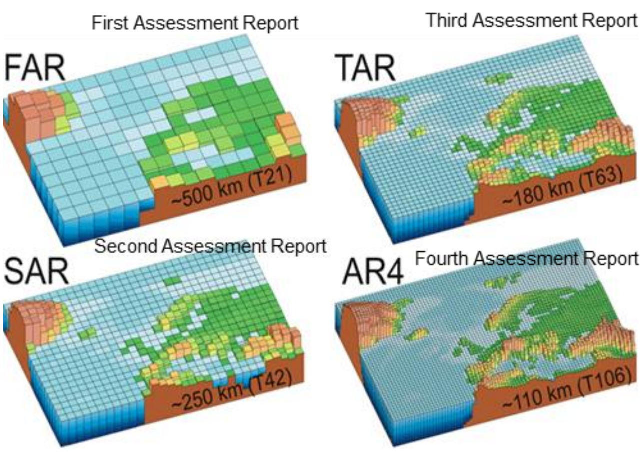

Fig 4. Increase in model resolution of the GCMs used in the IPCC Assessment reports (1990-2007; image courtesy of UCAR, from IPCC AR4)

Do current global models have high enough resolution?

Some processes and phenomena – such as precipitation, thunderstorms, clouds and cloud formation – cannot be modelled explicitly in most current GCMs, either because they occur on spatial scales smaller than the models' resolution, or because they may not be sufficiently well-understood. These have to be parameterized (estimated using observations, theory and simulations). A range of parameterization schemes exists and different schemes are used by different modelling groups currently. However, even the current high resolutions can challenge the expectations of users of climate model information, for whom spatial and temporal detail is important. The PRIMAVERA project has developed a new generation of high resolution global climate models aiming to provide a more credible representation of extreme events that impact society.

References

IPCC AR4 (2007) – Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change; Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.) Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

Atmospheric model schematic from NOAA https://www.climate.gov/maps-data/primer/climate-models

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