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Unparalleled accuracy for European climate projections

An international team including CNRS, Météo-France, CEA, UVSQ and INERIS¹ has carried out and analyzed² an ensemble of climate projections for the whole of Europe at an unprecedented resolution of 12 km, by downscaling the global simulations performed for the 5th IPCC report. These simulations for the 21st century now provide a much more detailed representation of local phenomena and extreme events. Initial analyses confirm that there will be a significant increase in the frequency of extreme events, such as heavy rainfall, heatwaves and droughts. Data from the EURO-CORDEX project have just been published and made available to scientists. This should lead to more detailed studies of the impact of climate change in Europe on air quality, hydrology and extreme events, all of which affect key sectors such as energy, health and agriculture.

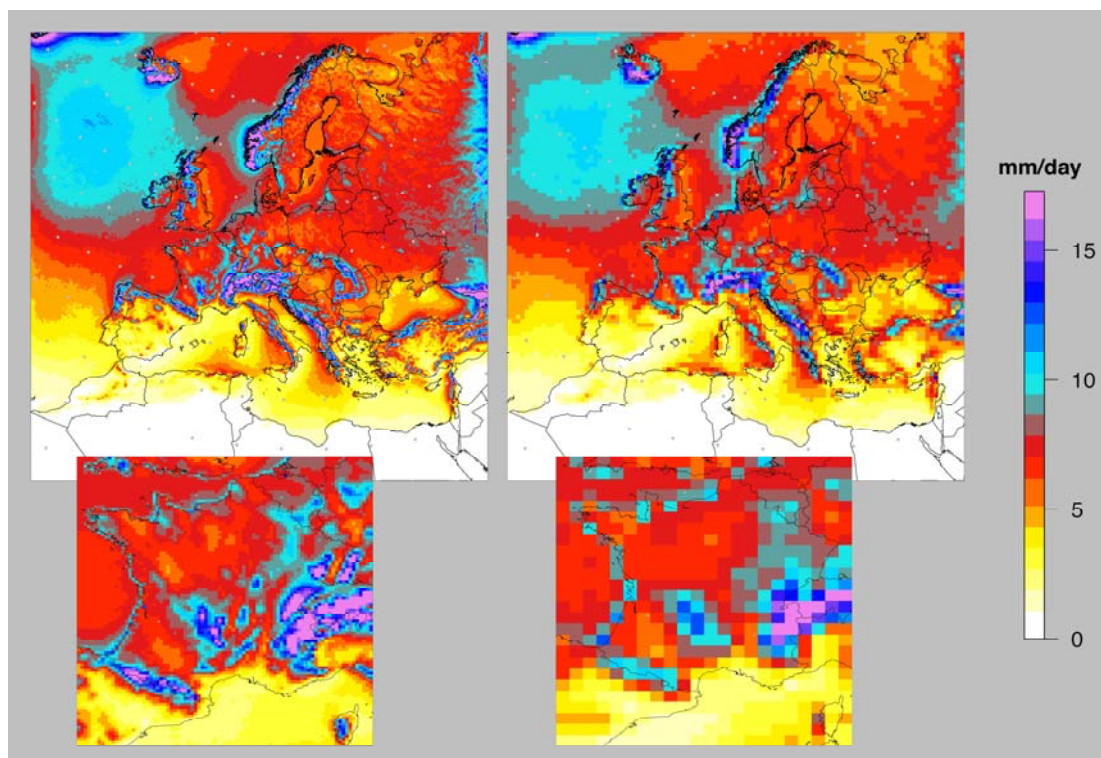
EURO-CORDEX: more detailed forecasting of Europe's climate

The new simulations confirm the projections published last September³ for the whole planet, while providing a far more accurate picture for Europe. They forecast an increase in temperatures of 1°C to 5°C in Europe by the end of the 21st century, with differences between one region and season to another. Southern Europe is likely to undergo far more rapid warming in summer than northern Europe, while warming in winter will probably be faster in eastern and northern Europe. Precipitation is likely to be heavier in northern Europe and lighter in the south. In practically every European country, the simulations predict that heavy precipitation will become more frequent, with such phenomena being shown much more clearly than previously thanks to the high resolution obtained. Longer droughts and more frequent heatwaves are forecast. Predictions for France are more diverse, with a pronounced overall increase in precipitation in winter, together with more frequent droughts in summer, especially in southern France. High-resolution simulations make it possible to show phenomena such as heavy precipitation in mountain areas (see image below).

¹ The French laboratories concerned are the Laboratoire des Sciences du Climat et de l'Environnement (LSCE/IPSL, CNRS/CEA/UVSQ) and the Centre National de Recherches Météorologiques - Groupe d'Etude de l'Atmosphère Météorologique (CNRM-GAME, Météo-France/CNRS), together with the Institut National de l'Environnement Industriel et des Risques (INERIS).

² The analyses appear in particular in three recently published articles: Vautard, R. et al., 2012: The simulation of European heat waves from an ensemble of regional climate models within the EURO-CORDEX project. *Climate Dynamics*, doi:10.1007/s00382-01-1714-z; Jacob, D. et al., 2013, EURO-CORDEX: New high-resolution climate change projections for European impact research, *Regional Environmental change*, doi:10.1007/s10113-013-0499-2; Colette, A. et al., 2013: European atmosphere in 2050, a regional air quality and climate perspective under CMIP5 scenarios. *Atmos. Chem. and Phys.*, doi:10.5194/acpd-13-6455-2013

³ Volume 1 'Climate Change 2013: the Physical Science Basis' of the IPCC Fifth Assessment Report was presented on 27 September 2013 following the adoption of the Summary for Policymakers.



Mean annual distribution of heavy rainfall simulated for the present climate by one of the EURO-CORDEX high-resolution (12 km) models (left), corresponding to the new generation of simulations, and at low (50 km) resolution (right). Note in particular the differences in mountain areas in Corsica.

These distributions are the result of simulations, not observations, and therefore contain inaccuracies.

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Ten regional climate models

Launched in 2011 as part of the international CORDEX initiative, the EURO-CORDEX project has produced an ensemble of climate projections for Europe in the 21st century at very high spatial resolution. To do this, ten regional climate models were used, including two by the French community⁴. The projections were carried out according to three baseline scenarios selected from the four scenarios in the 5th IPCC report. These are three more or less optimistic pathways⁵ for change in greenhouse gas concentrations from now until the end of the 21st century. Coordinated by a German team, EURO-CORDEX involves more than 20 European research organizations, including CNRS, Météo-France, CEA, UVSQ and INERIS. French teams played an extremely active role in the initiative. They were able to use CEA and Météo-France's supercomputers, as well as being allocated time on the French National Supercomputing Facility GENCI.

⁴ ARPEGE-Climat developed by CNRM-GAME and IPSL-CM5A-MR-WRF developed by the Institut Pierre-Simon Laplace (IPSL), which brings together several environmental science laboratories attached to CNRS, including LSCE.

⁵ The three scenarios selected are RCP2.6, 4.5 and 8.5. RCP stands for 'Representative Concentration Pathways'. Scenario RCP8.5 is an extreme scenario with a major increase in greenhouse gases. The most optimistic scenario (RCP2.6) corresponds to virtuous behavior, with very low greenhouse gas emissions. RCP4.5 is an intermediate scenario.



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Around 100 simulations of Europe's climate in the 21st century

In all, around 100 simulations were carried out for EURO-CORDEX. Approximately 20 of them are unique in that they reach an unprecedented resolution of 12 km for projections covering the whole of Europe. This degree of accuracy makes it possible to show in greater detail local phenomena such as heavy rainfall that are crucial to climate change. Better information is thus available for future studies into adaptation to climate change in Europe. It is now planned to study the impact of climate change on air quality and on other key sectors of the economy such as energy and agriculture. CNRS, CEA, Météo-France, UVSQ and INERIS are participating in the analysis of the simulations, all of which were published on 1 December 2013. The data has now been made available in particular to the scientific community and to climate services, with the aim of providing climate information to economic, industrial and political stakeholders. The simulations will also be supplied to the French national DRIAS portal, which collects data about predicted climate change in France.

From global to local

Global climate models are used to produce climate projections on the scale of continents, like those presented last September in the first volume of the 5th IPCC report. However, given the current power of supercomputers, their resolution remains limited to 200 km, preventing the description of phenomena that take place on the kilometer scale, such as torrential autumn rainfall, high wind episodes, and events occurring near coasts and higher ground. Using regional models makes it possible to increase resolution. Such models show specific regions of the world in more detail by using global simulations, especially to describe conditions at the edges of the regions. In this case, supercomputing power is primarily used to improve spatial resolution.

In France, simulations for the EURO-CORDEX initiative were carried out with the help of CEA and Météo-France's supercomputers and allotted time on the French National Supercomputing Facility GENCI, as well as the European FP7 IMPACT2C project and the Salut'AIR project supported by ADEME and the French Ministry of Ecology, Sustainable Development and Energy. Data processing and placing of information online was made possible thanks to the FP7 IS-ENES2 and E3P Climate Knowledge and Innovation Community projects.

CORDEX: an international program of regional simulations

In parallel with the global climate simulation project CMIP5⁶, another international simulation program seeks to produce high-resolution regional simulations. Called CORDEX, it is coordinated by the World Climate Research Program. Launched in 2010, it focuses on 13 predefined regions at a maximum resolution of 50 km. French climatologists are especially involved in CORDEX in seven regions: the Arctic, Africa, North America, South America, southern Asia, Europe and the Mediterranean. EURO-CORDEX is the component of CORDEX that focuses on Europe.

To find out more about CORDEX: <http://wcrp-cordex.ipsl.jussieu.fr/>

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⁶ The international scientific community has taken action, especially through the World Climate Research Program (WCRP), to design and carry out a simulation exercise of past and future climate covering the entire planet: CMIP5.