



POLICY BRIEF | COMBINED CLIMATE AND SOCIO-ECONOMIC SCENARIOS FOR EUROPE

INTEGRATED SOLUTIONS TO ADDRESS HIGH LEVELS OF CLIMATE CHANGE

The IMPRESSIONS project examines the implications for Europe of future changes in both climate and socio-economic drivers. Many natural and human systems are sensitive to changes in climate variables such as temperature, rainfall, wind and humidity (their averages as well as their extremes). Socio-economic factors determine the greenhouse gas emissions and land use changes that cause anthropogenic climate change, but also affect our exposure, vulnerability and capacity to adapt to these climate hazards.

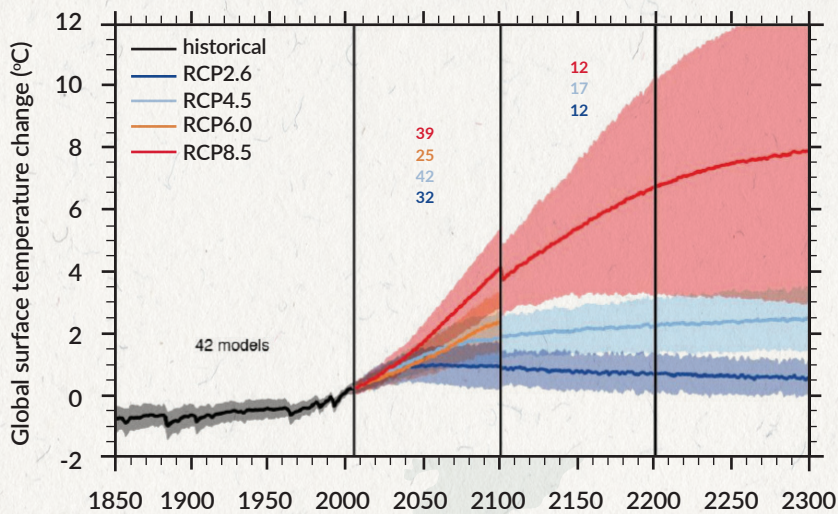
Climate and socio-economic scenarios in IMPRESSIONS are based on a globally agreed set of pathways developed by the international research community for use in climate change assessments: the Representative Concentration Pathways (RCPs) and Shared Socio-economic Pathways (SSPs). These were downscaled to a set of European scenarios, and then downscaled further to provide detailed scenarios for the case study areas of Iberia, Scotland, Hungary and Central Asia (see Case Study briefs).

Global climate scenarios

The RCPs describe different ways in which atmospheric greenhouse gas and aerosol concentrations might change up to the year 2100, with extended versions to the year 2300. Concentrations are expressed according to their warming effect on the atmosphere ('radiative forcing') in Watts per square metre (Wm^{-2}) by 2100 relative to pre-industrial levels (defined as 1850-1900). Temperature estimates are derived from an ensemble of climate models run by different research groups, so that each pathway spans a range of possible values.

- **RCP8.5** assumes that no further mitigation policies are adopted after the year 2005. The average projected global temperature rise in 2100 is $+4.3^{\circ}\text{C}$ relative to pre-industrial times, though five out of 39 climate models project more than $+6^{\circ}\text{C}$. Even if emissions were subsequently to fall to zero by 2250, average global warming is projected to reach $+8.6^{\circ}\text{C}$ by 2300 (within a range of $+3$ to $+12^{\circ}\text{C}$). RCP8.5 was adopted as the highest climate change scenario in IMPRESSIONS.
- **RCP6.0** (not used in IMPRESSIONS) represents a pathway assuming weak mitigation measures, leading to an average projected rise of 2.8°C by 2100, continuing to rise after 2100.
- **RCP4.5** requires strong mitigation action to limit the average global temperature rise to 2.4°C in 2100, continuing to rise slowly to reach $+3.1^{\circ}\text{C}$ by 2300. It was adopted in IMPRESSIONS as the main alternative scenario to RCP8.5, displaying global warming on average somewhat above the 2°C policy target.
- **RCP2.6** requires very strong climate mitigation action, with emissions peaking in 2020 and falling to zero by 2100, resulting in an average temperature rise of 1.6°C by 2100, and declining temperatures after that. Few downscaled climate projections were available for Europe at the time of scenario selection so RCP2.6 was not included as a core scenario in IMPRESSIONS, though it was used in the European case study.
- **RCP1.9** was developed to represent the pathway needed to give a 66% chance of achieving the Paris Agreement goal to limit the global temperature rise to well below 2°C and ideally 1.5°C above pre-industrial levels (which is not quite achieved by RCP2.6). This is a very challenging pathway which requires emissions to peak by 2020 and decline to zero by 2050, after which there must be significant negative emissions. Climate projections for this pathway are still in progress, so it was not used in IMPRESSIONS.

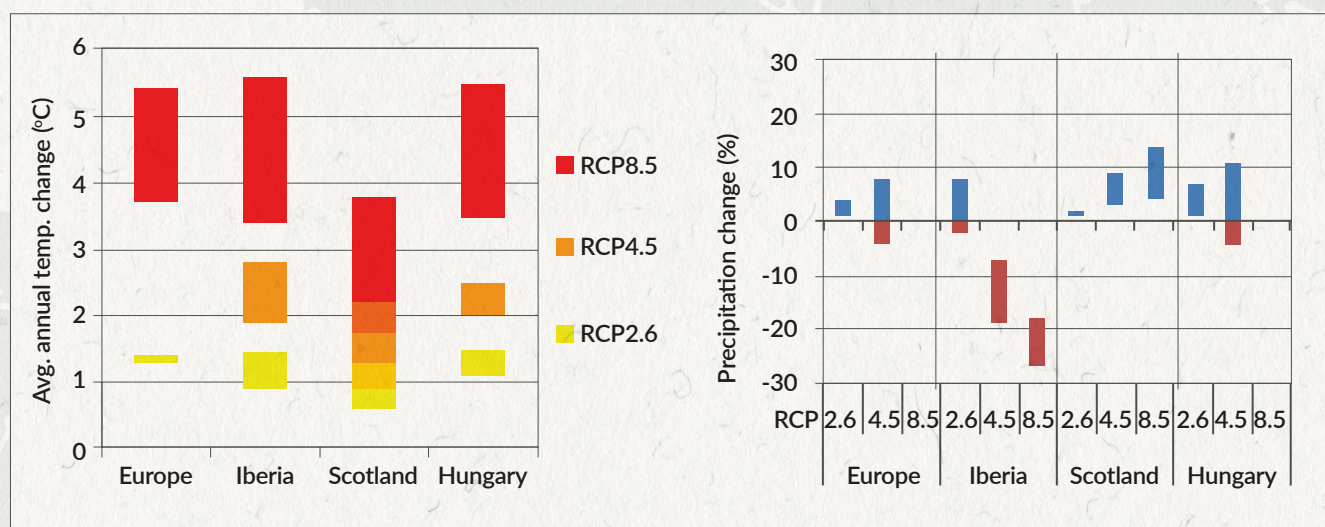
Following the Paris Agreement, countries pledged to reduce their emissions by promising a set of 'Nationally Determined Contributions' (NDCs). Some of these were promised unconditionally, and some were conditional on actions by other countries. The pledges only guarantee emission reductions up to 2030, so it is not possible to estimate what impact they would have in 2100. However, although the NDCs will certainly reduce emissions below the RCP8.5 trajectory, they would not put us in line with RCP6.0, let alone deliver the Paris target.



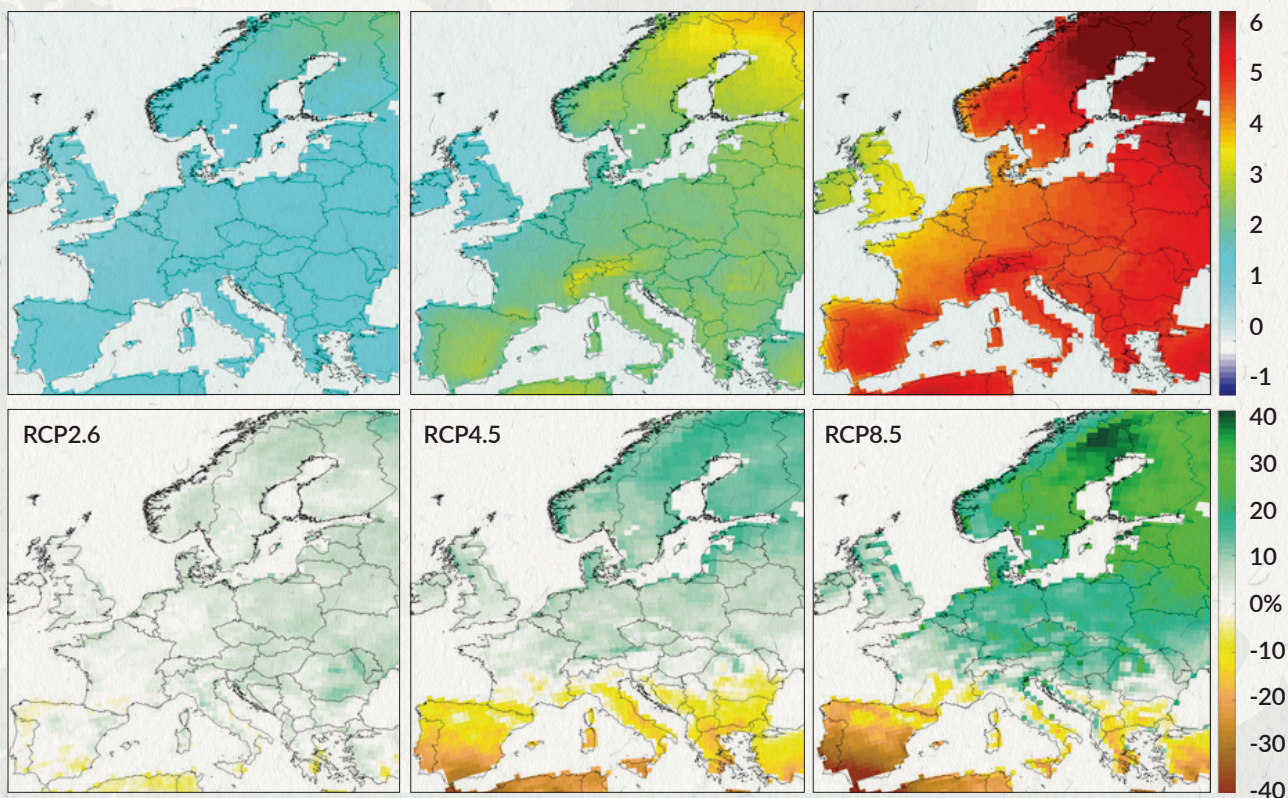
Projected global annual mean surface air temperature anomalies (relative to 1986-2005; add 0.6°C to compare to pre-industrial). Solid lines are multi-model means (coloured numbers show how many models were used) and shading shows the likely range (5th to 95th percentile). [IPCC, 2013, based on CMIP5]

European climate scenarios in IMPRESSIONS

For Europe, a subset of ten climate models was selected to span the range from the very low end of the RCP2.6 projections to the high end of the RCP8.5 projections. Although there are some differences, the models agree that southern Europe will become hotter and drier under climate change, while northern Europe becomes warmer and wetter. In a +4°C world (RCP8.5), extreme long-term drought conditions are expected to occur more frequently throughout southern Spain, southern Italy, southern Greece and Cyprus.



Change in annual average temperature (left) and precipitation (right) in 2071-2100 relative to 1961-1990 for the RCP2.6, RCP4.5 and RCP8.5 climate change scenarios in IMPRESSIONS showing the range for different climate models



Projections of changes in average annual temperature (top) and precipitation (bottom) for RCP2.6, RCP4.5 and RCP8.5 from 1961-1990 to 2071-2100 (mean outputs from the IMPRESSIONS subset of climate models).

Socio-economic scenarios

The international research community has defined five global Shared Socioeconomic Pathways (SSPs 1 to 5), which seek to explore future development pathways with differing challenges to adaptation and mitigation. We worked with stakeholders to create socio-economic scenarios based on four of these SSPs (omitting the 'middle of the road' SSP2). SSPs were created for Europe as a whole, and separate sets consistent with these European SSPs were created for each of the IMPRESSIONS case study areas (see Case Study policy briefs).

Each SSP was paired with the most relevant RCP. The two fossil-fuel dependent scenarios (SSP3 and SSP5) were paired with the higher warming scenario (RCP8.5), and two low carbon scenarios (SSP1 and SSP4) were paired with the lower warming scenario (RCP4.5).

The socio-economic scenarios determine how society might respond to climate change. SSP1 represents a sustainable and co-operative society with a high capacity to adapt, and low vulnerability to food and water stress. Combined with lower warming, this presents fewer challenges for adaptation. In SSP3, social and political fragmentation combined with high climate change (RCP8.5) poses challenges for adaptation. In SSP4, even with lower warming (RCP4.5), high levels of inequality mean that only the elite can adapt effectively. SSP5 features heavy reliance on technological solutions, but with high climate change (RCP8.5) resulting from dependence on fossil fuels, parts of southern and eastern Europe collapse under severe environmental stress.

SSP	Global name	IMPRESSIONS name for Europe	Paired RCP	Description
SSP1	Sustainability – taking the green road	SSP1 – We are the world	RCP4.5	Low challenges to mitigation and adaptation. High development, low inequality. Sustainable and inclusive development, respecting environmental boundaries with emphasis on health, education and human wellbeing rather than growth at all costs.
SSP3	Regional rivalry – a rocky road	SSP3 – Icarus	RCP8.5	High challenges to mitigation and adaptation. Low development, high regional inequality. Nationalism, regional conflicts and low co-operation between regions. Low technological innovation, resource-intensive consumption and environmental degradation.
SSP4	Inequality – a road divided.	SSP4 – Riders on the storm	RCP4.5	Low challenges to mitigation, high challenges to adaptation. Unequal development, high within-country inequality. Power and knowledge concentrate in a small international elite who invest in low-carbon energy. The rest of society is poorly paid and poorly educated; social unrest and conflict is high.
SSP5	Fossil fuelled development – taking the highway	SSP5 – Fossil fuelled development	RCP8.5	High challenges to mitigation, low challenges to adaptation. High development, low inequality. Reliance on competitive global markets and participatory societies to produce rapid technological development, which underpins investment in human capital (health and education). High fossil fuel consumption and reliance on technology (e.g. geoengineering) to fix problems.

IMPRESSIONS used a range of models to explore the impacts of these paired climate and socio-economic scenarios on urban development, water resources, flooding, human health, agriculture, forestry and biodiversity, and how adaptation actions could reduce adverse impacts or exploit opportunities. For example, the IMPRESSIONS Integrated Assessment Platform was used to model future water stress based on the effects of changes in rainfall and temperature on water resources and crop water needs, combined with changes in competing water demands due to population change, changing lifestyles and technology (see Water and Agriculture briefs).

The project outputs can be used to guide efforts to adapt to the increasingly likely consequences of failing to meet our climate targets, but they also show that there are limits to adaptation: some impacts are unavoidable under the higher warming scenarios. This highlights the benefits of shifting to lower emissions pathways and the urgency of much stronger action to meet climate targets. IMPRESSIONS therefore developed integrated pathways that prioritise options with benefits for both adaptation and mitigation, avoiding lock-in to adaptation options that increase greenhouse emissions (see Pathways policy brief).

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Find out more: www.impressions-project.eu.