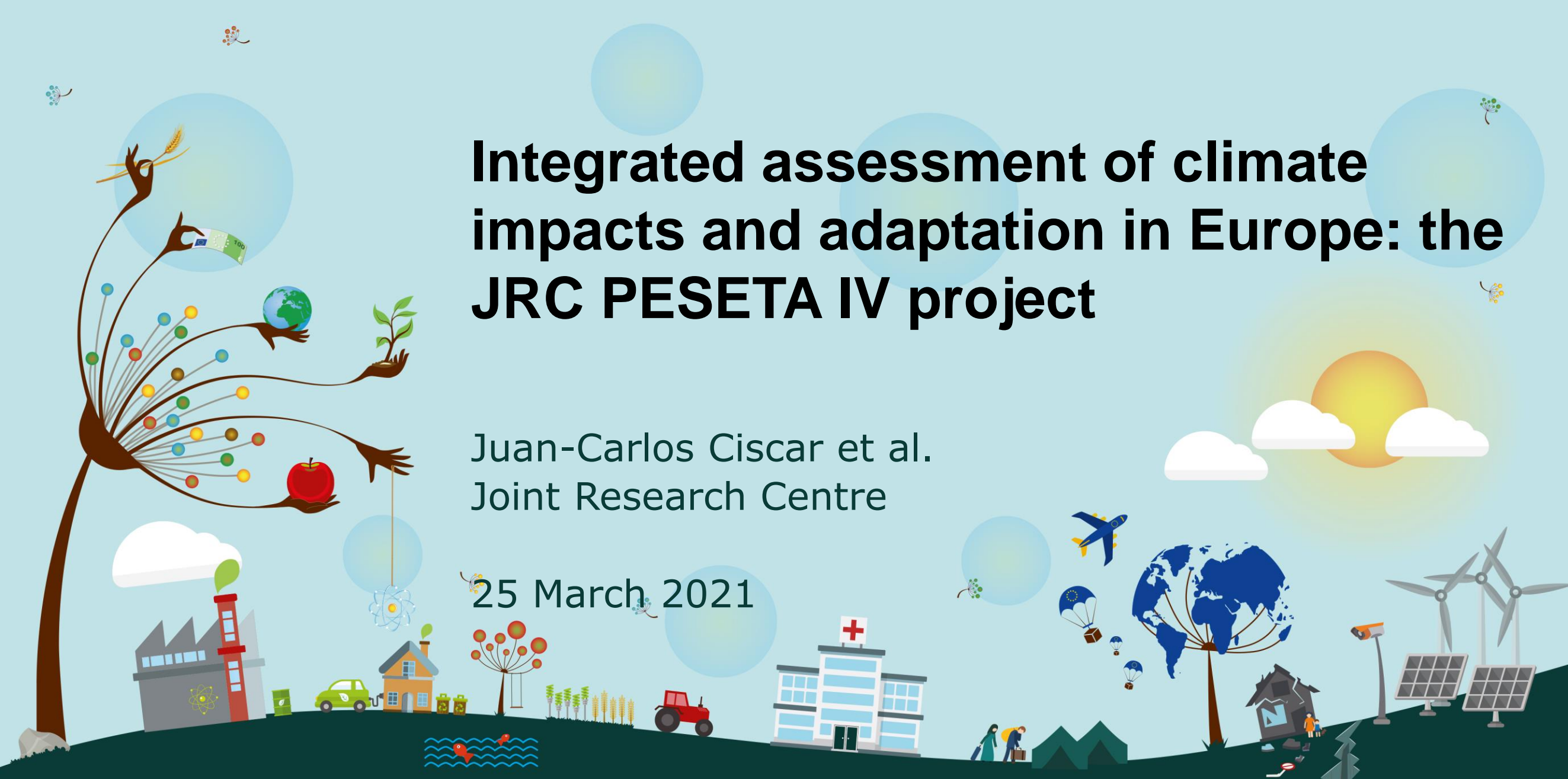


Integrated assessment of climate impacts and adaptation in Europe: the JRC PESETA IV project

Juan-Carlos Ciscar et al.
Joint Research Centre

25 March 2021



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ECFIN Webinar on the economics of climate change:
Towards a climate neutral economy - what role for economic policies?



Climate change impacts and adaptation in Europe: the JRC **PESETA** studies

*Projection of
Economic impacts
of climate change in
Sectors of the
European Union
based on bottom-
up Analysis*

What are the most important climate impacts in Europe?

Is there a regional pattern in impacts?

How much climate impacts are avoided with mitigation?

How much climate impacts are avoided by adaptation?

Policy context

2007 Green Paper on Adaptation

...

2015 The Paris Agreement

...

2020 The European Green Deal

2021 New EU Strategy on Adaptation

Methodology

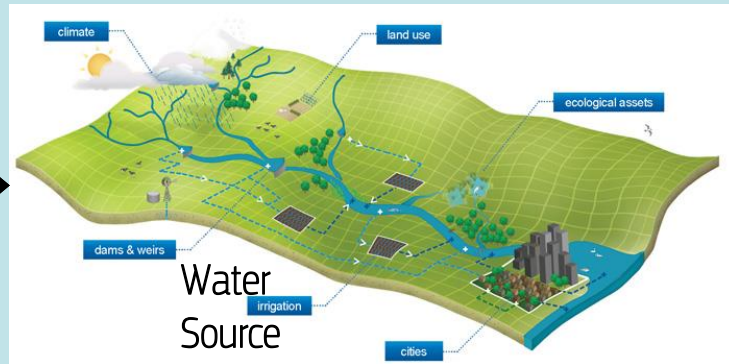
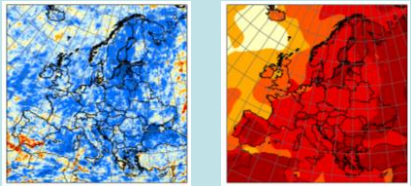
Multi-disciplinary, integrative methodology

- Results are mostly based on bottom-up, process-based impact models
- Consistency: common, high-resolution climate scenarios; same socio-economic scenarios (ECFIN Ageing Report)

Focus on **1.5C, 2C and 3C warming levels** (average of RCP4.5 and RCP8.5)

Example impact modelling: river floods

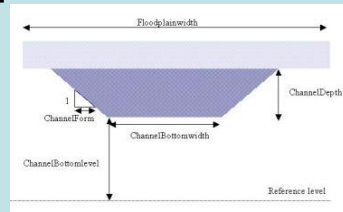
high-resolution climate information



data on soils, land cover, river basins, ...

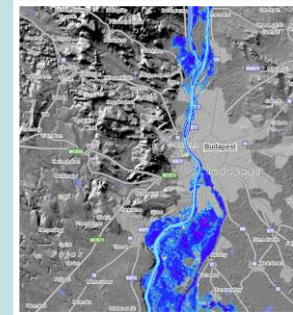


data on river dimensions, discharges, etc



Hazard analysis

Hazard

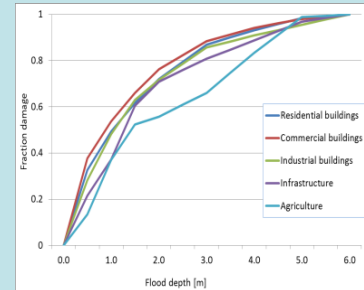


Exposure



Impact

Vulnerability



PESETA climate impact categories



agriculture



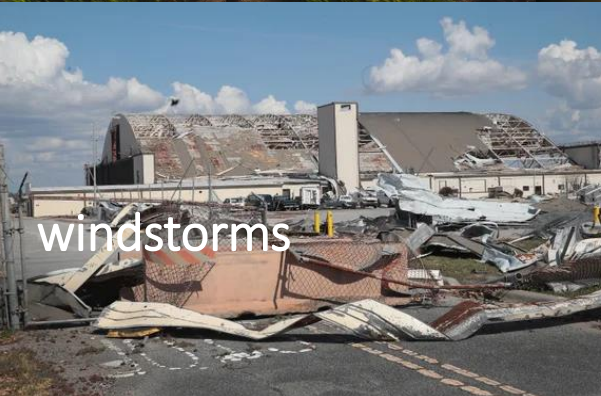
energy



transport



temperature extremes



windstorms



river flooding



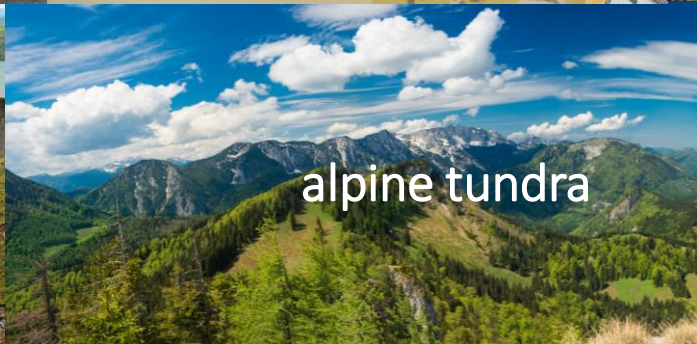
forest ecocystems



wildfires



water resources



alpine tundra



drought

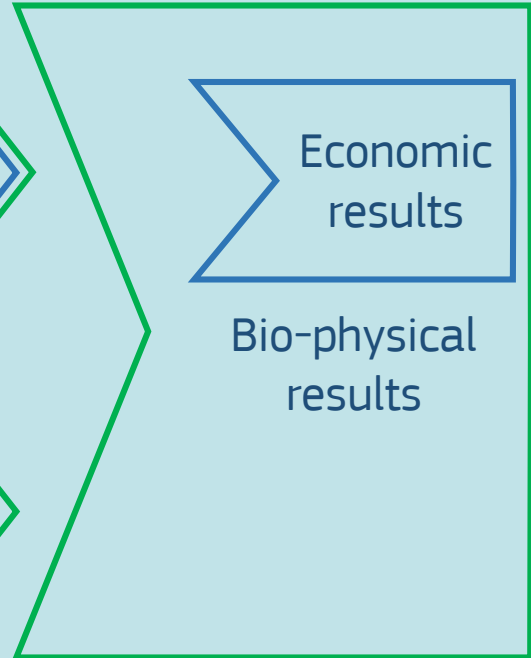
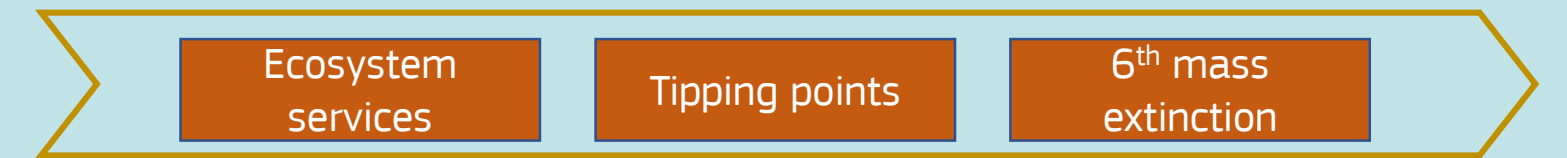
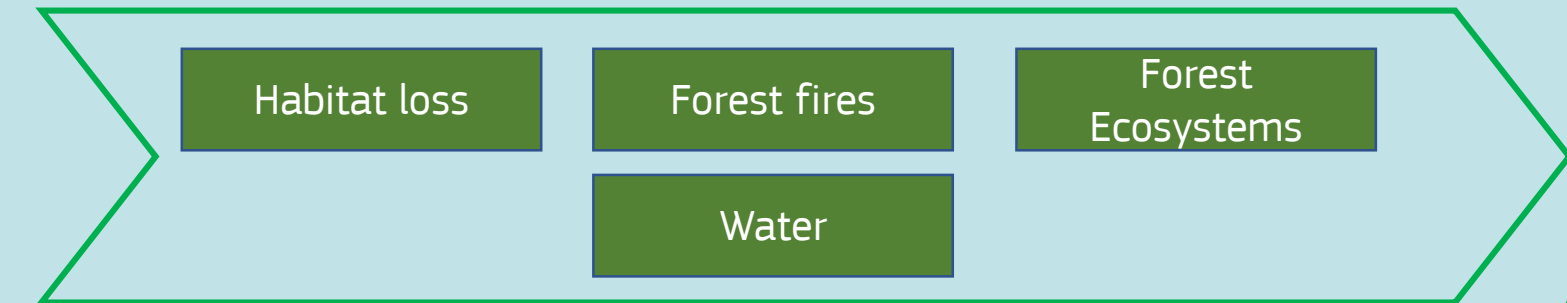
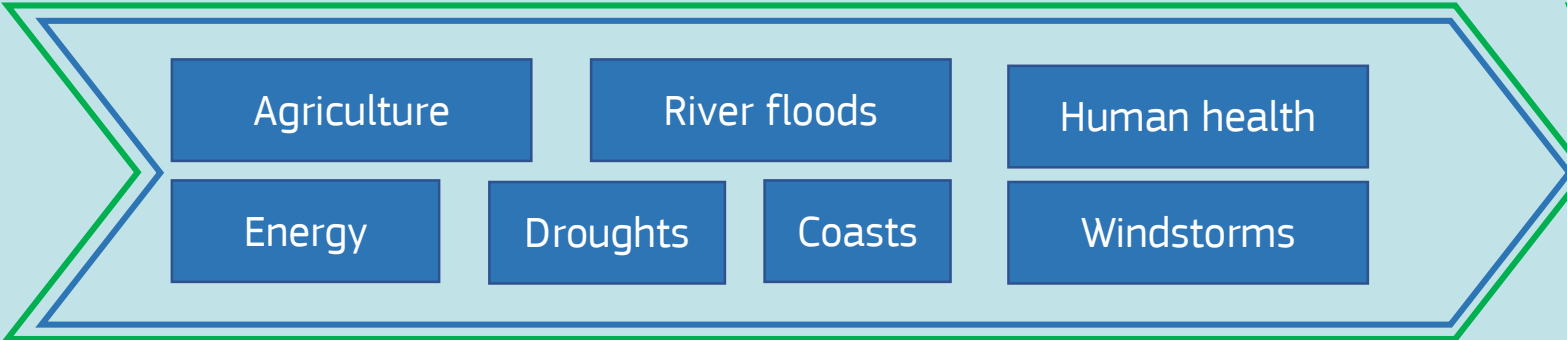
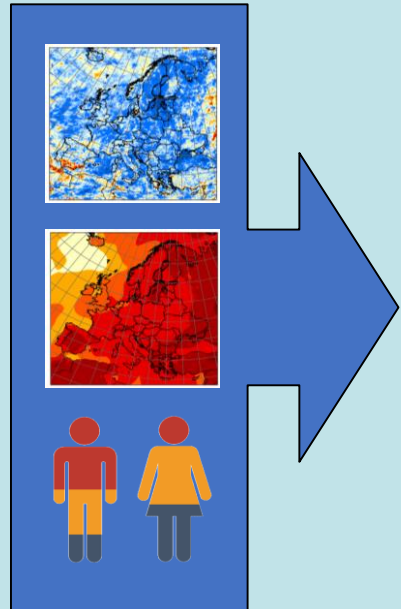


coastal flooding

JRC PESETA IV project

Climate change and socioeconomic data

Bio-physical modelling



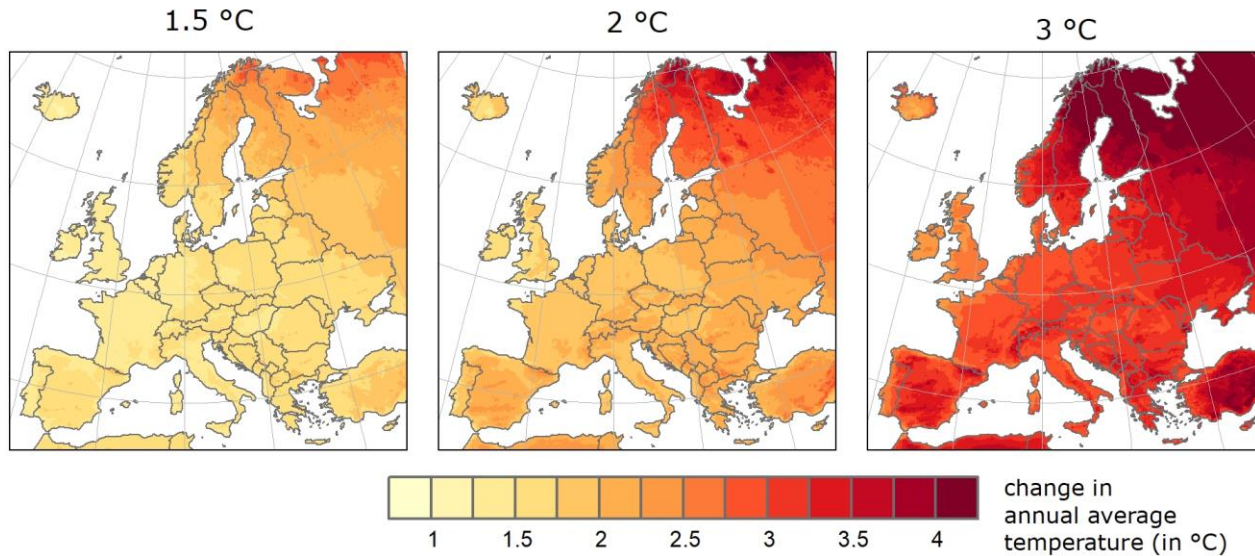
Stage 1. Climate change scenarios

RCP4.5 and 8.5

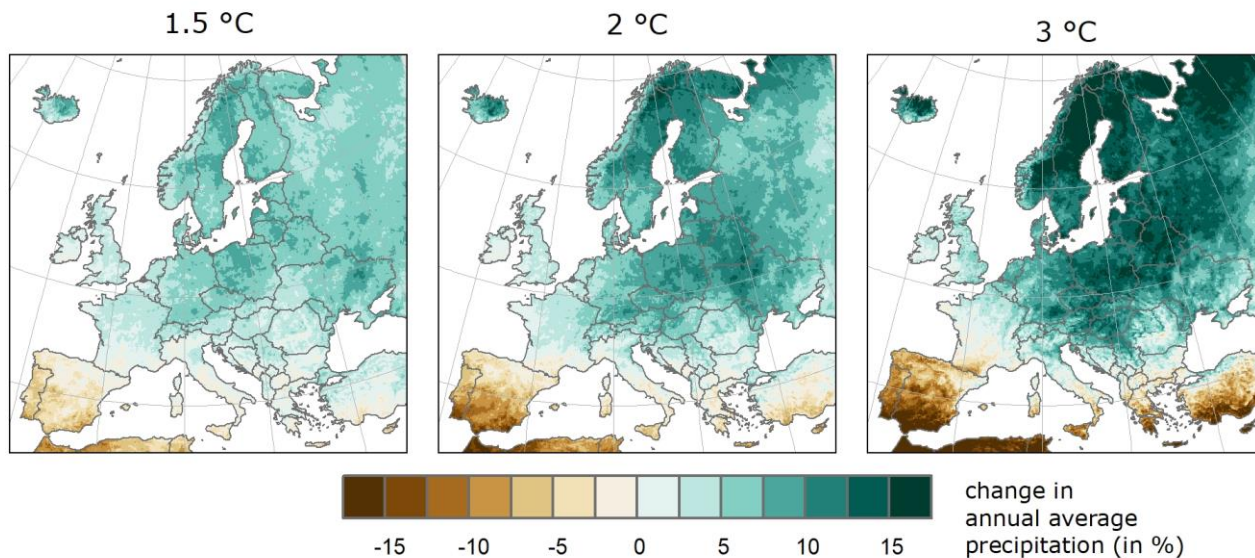
11 climate runs for each RCP (EUROCORDEX, 11km)

Focus on 1.5C, 2C and 3C global warming levels

Climate change in Europe with global warming

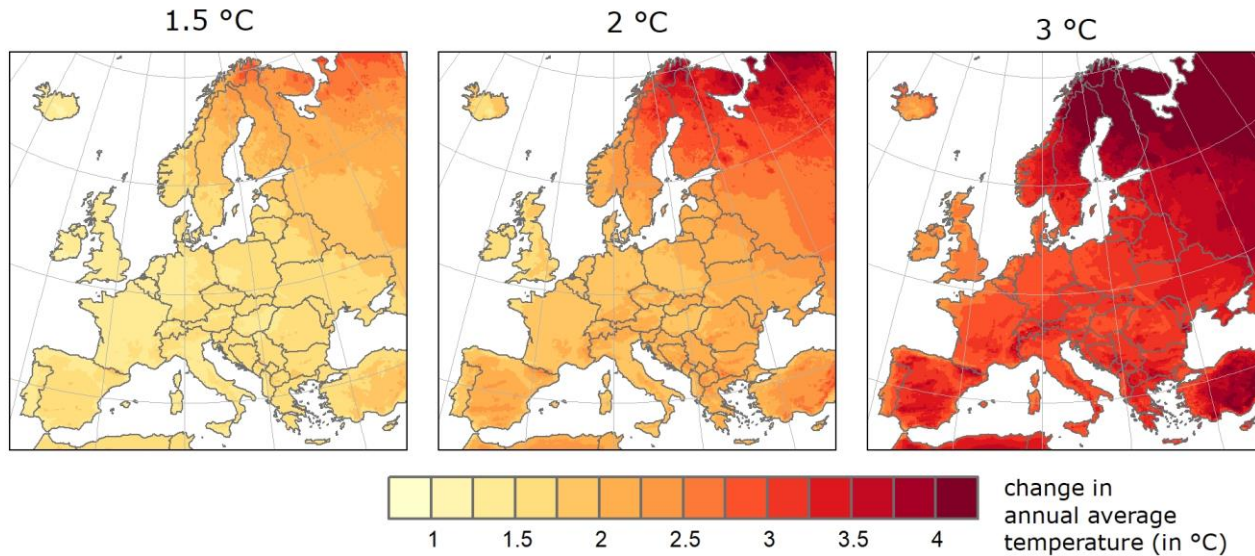


Projected change (°C) in annual average temperature compared to pre-industrial times

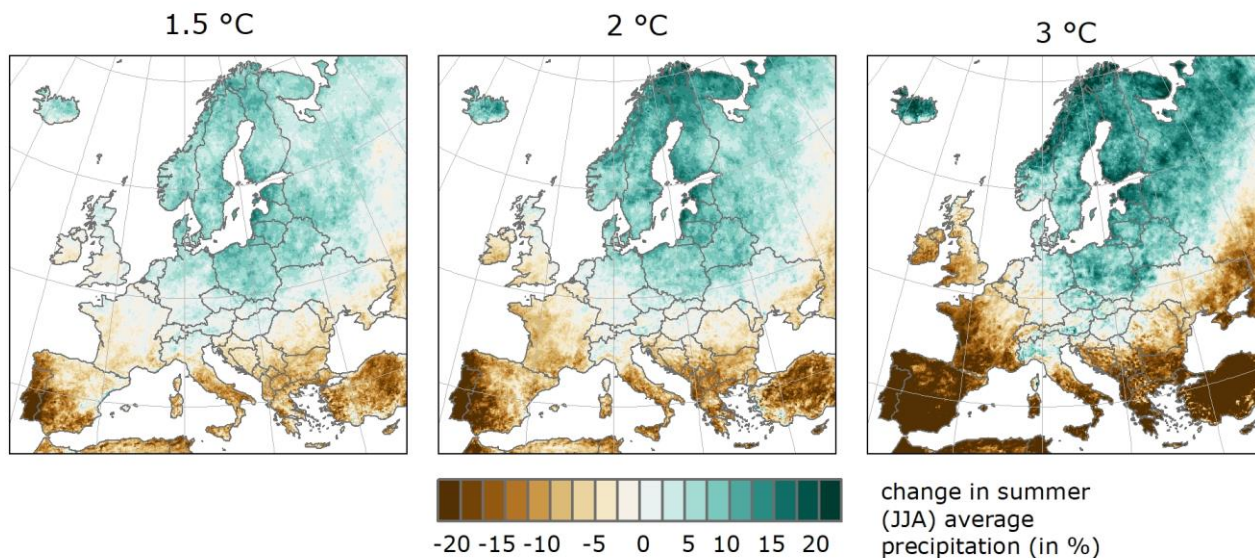


Projected change (%) in annual average precipitation compared to 1981-2010

Climate change in Europe with global warming



Projected change (°C) in annual average temperature compared to pre-industrial times



Projected change (%) in summer average precipitation compared to 1981-2010

Stage 2. Biophysical impact modelling

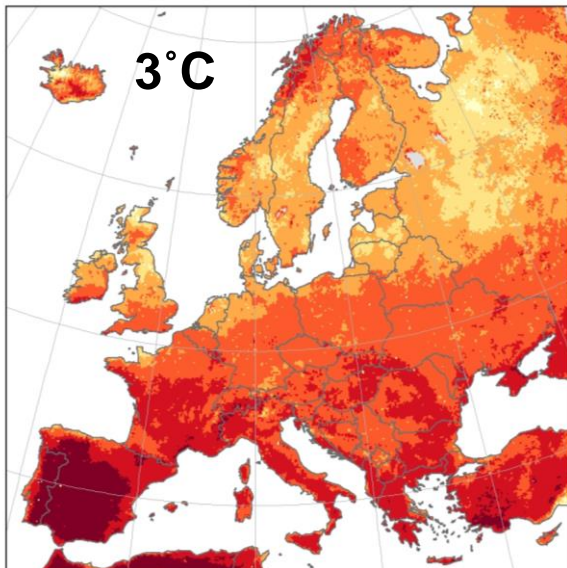
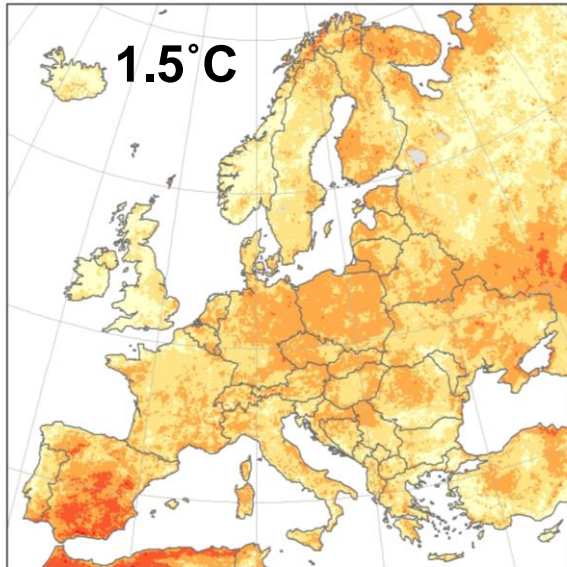
Direct damage results (dynamic)

Expected annual losses

Impact on EU population of extreme heat



Occurrence frequency in years of heat waves that now happen once every 20 years

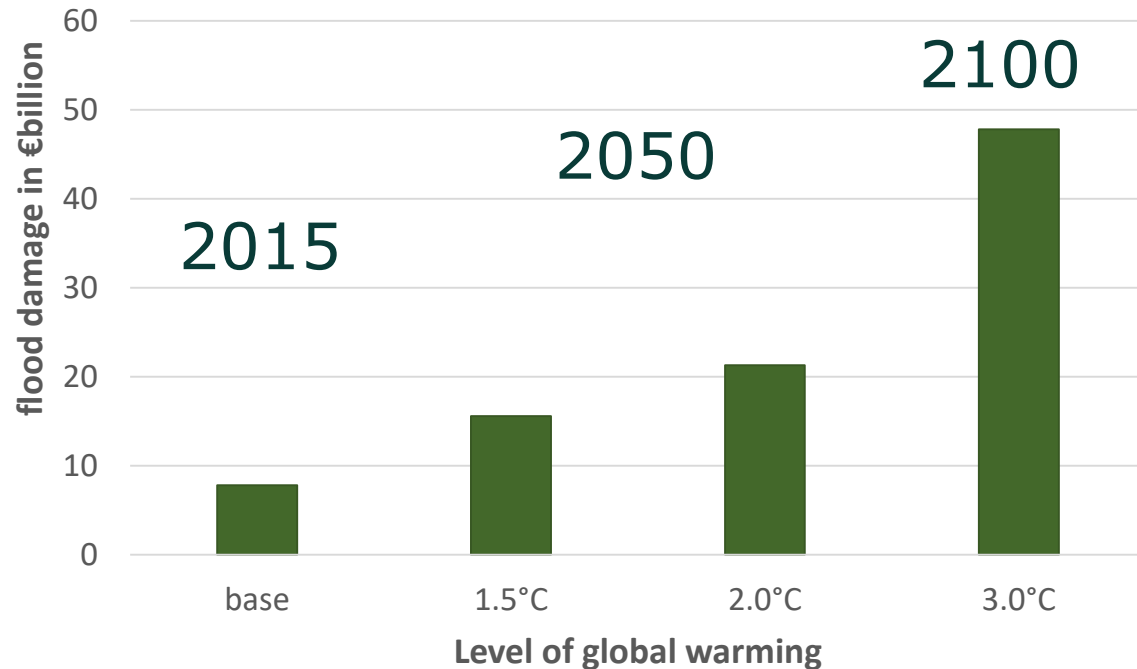


Human exposure to and fatalities from heat waves in Europe

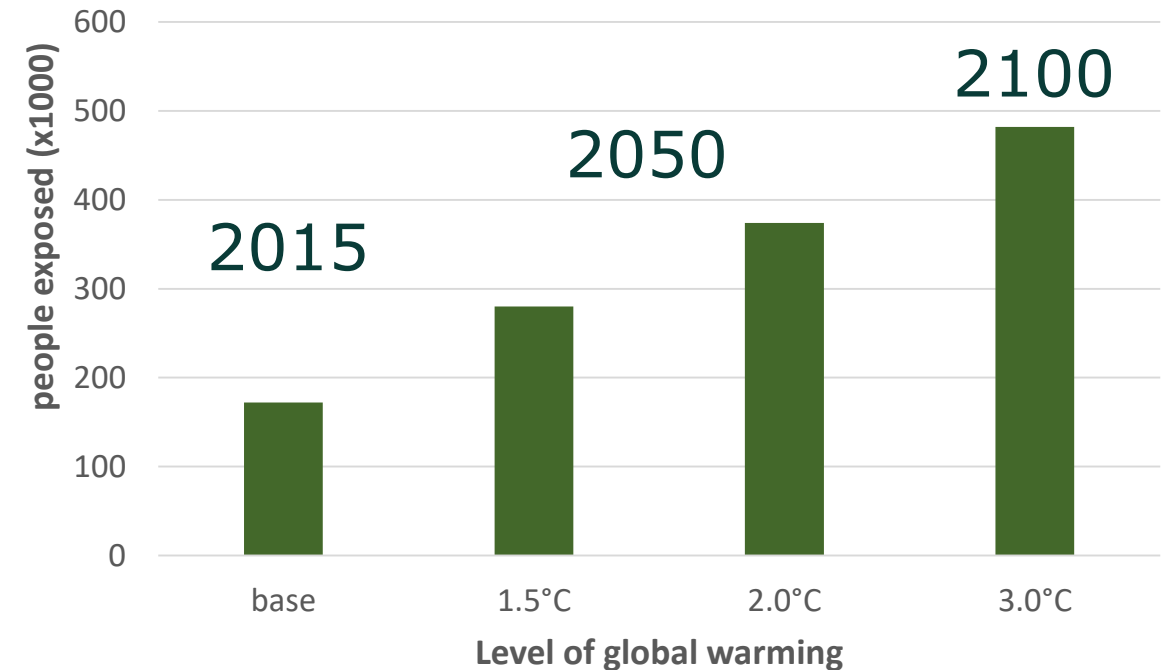
base	1.5°C	2.0°C	3.0°C
People annually exposed to a 50-year heat wave (million)			
9.6	103	168	288
Annual fatalities from heat waves (x1000)			
2.7	28.8	49.4	89.0

River flood risk in Europe

Annual flood losses in EU + UK



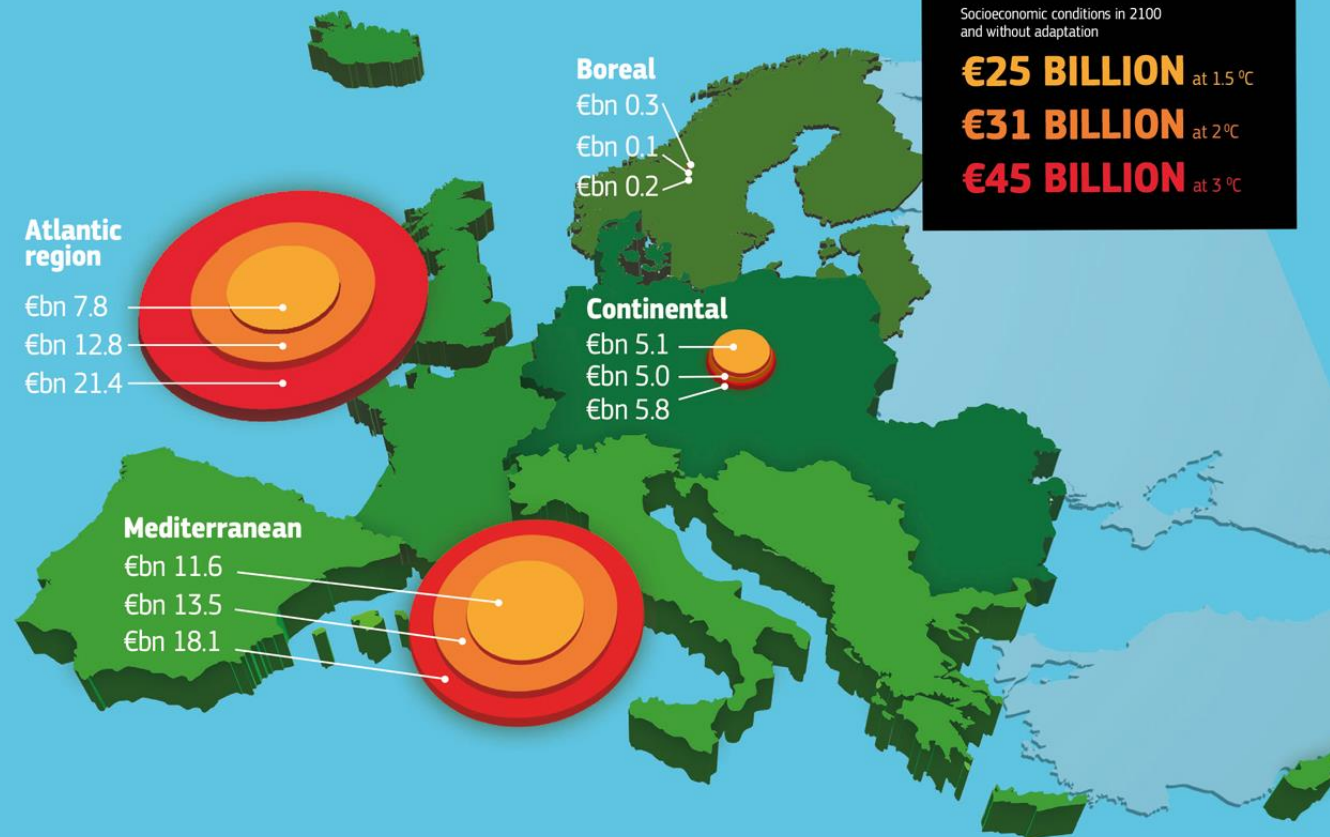
Population annually exposed in EU + UK



River risk in Europe will increase with global warming

Drought in a changing climate

A **first-ever** pan-European quantitative assessment of the economic impacts of drought in Europe.



Modelled expected annual losses (billion €) for the present (1981 - 2010)				Projected expected annual damages (billion €) based on socioeconomic conditions in 2100 and without adaptation, at:		
Mediterranean	Atlantic region	Continental	Boreal	1.5 °C	2 °C	3 °C
3.6	2.5	2.6	0.3			

IMPACT ON SECTORS CONSIDERED



Agriculture

- Damages to crops and livestock losses
- Irrigation restrictions due to water scarcity



Power generation

- Reduction in hydroelectricity production
- Reduced capacity of cooling systems
- Possible shutdown of thermal and nuclear power plants



Public water supply

- Decreasing water availability
- Increasing competition amongst different sectors



Commercial shipping

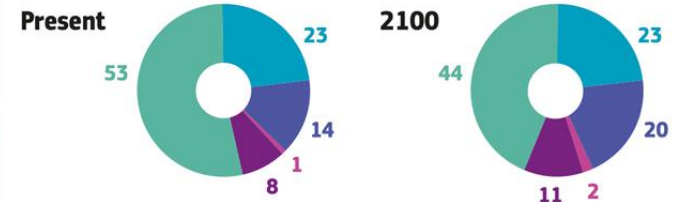
- Interruption of navigation
- Reduction in cargo maximum capacity
- Transfer to other means of transportation



Buildings and infrastructure

- Damages due to soil subsidence
- Aquifer over-exploitation may aggravate damage to buildings from subsidence

Share of drought losses per socioeconomic sector (%)



KEY SUMMARY

- Drought will be more severe and persistent in southern and western Europe, whereas it will become less intense in northern and eastern Europe.
- Mediterranean and Atlantic regions are already contributing to about 68% of present losses, and this share will become 87% at 3 °C.
- Agriculture sector is most affected now and in the future, even if its economic importance is reduced in future European economies.

NO-ACTION SCENARIO

Global warming is driving sea-level rise and intensifies coastal storms, resulting in more frequent flooding. If no action is taken, coastal flood impacts will be severe.

year 2100 HIGH EMISSIONS

SEA LEVEL +85 cm
[47 cm – 198 cm]

NOW

2.2 million
PEOPLE EXPOSED
per year

239 billion €
ECONOMIC LOSSES
per year

170-fold increase in economic losses
22-fold increase in exposed population

130 Gt
of CO₂eq
emissions*

25 Gt
of CO₂eq
emissions*

MITIGATION AND ADAPTATION SCENARIO

Mitigation means limiting sea level rise by reducing emissions. **Adaptation** includes all measures to protect coastal communities through nature-based and engineered physical measures.

year 2100 WITH MITIGATION

SEA LEVEL +51 cm
[21 cm – 84 cm]

NOW

552 thousand
PEOPLE EXPOSED
per year

12 billion €
ECONOMIC LOSSES
per year

95% reduction of economic losses
73% fewer people exposed

100 thousand
PEOPLE EXPOSED
per year in present

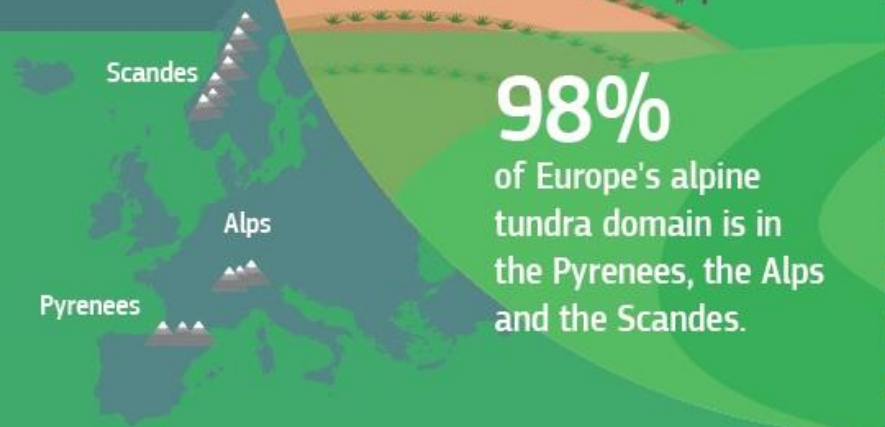
1.4 billion €
ECONOMIC LOSSES
per year in present

Raising flood defenses
will cost up to 2 billion € per year

*CO₂eq is a metric measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential, by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential (definition from Eurostat).

Alpine tundra in Europe in a changing climate

Present



98%
of Europe's alpine
tundra domain is in
the Pyrenees, the Alps
and the Scandes.

The domain is projected
to shrink by
84%
across Europe in a
3 °C warming scenario.

Future

The treeline is projected to move vertically upwards by up to 8m every year in a 3 °C warming scenario.

Tundra area loss

Region	Global temperature increase		
	1.5 °C	2 °C	3 °C
Alps	-36%	-50%	-75%
Scandes	-50%	-61%	-87%
Pyrenees	-74%	-91%	-99%

The projected changes affect vital ecosystem services, such as the provision and regulation of freshwater from melting snow. They also diminish valuable habitats, biodiversity, and recreational uses such as skiing.

Stage 3. Economic integration

Welfare results

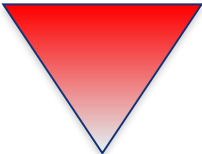
Static (economy as of today)

Approach to integration with economics

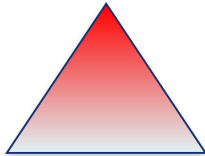
- Economic model to integrate the biophysical impacts (making them *comparable*)
- *Model*: Multi-sector, multi-country Computable General Equilibrium (CGE) (CAGE-GEME3 with 19 sectors and 25 regions)
- CGE as an accounting framework: direct and indirect effects; includes cross-sectoral and cross-country effects
- *Comparative static* framework: impact of future climate change on today's economy.

Climate impacts interpretation

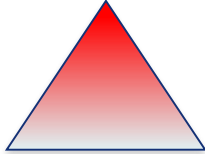
Productivity
shocks



$$\text{Supply} = \text{Demand}$$

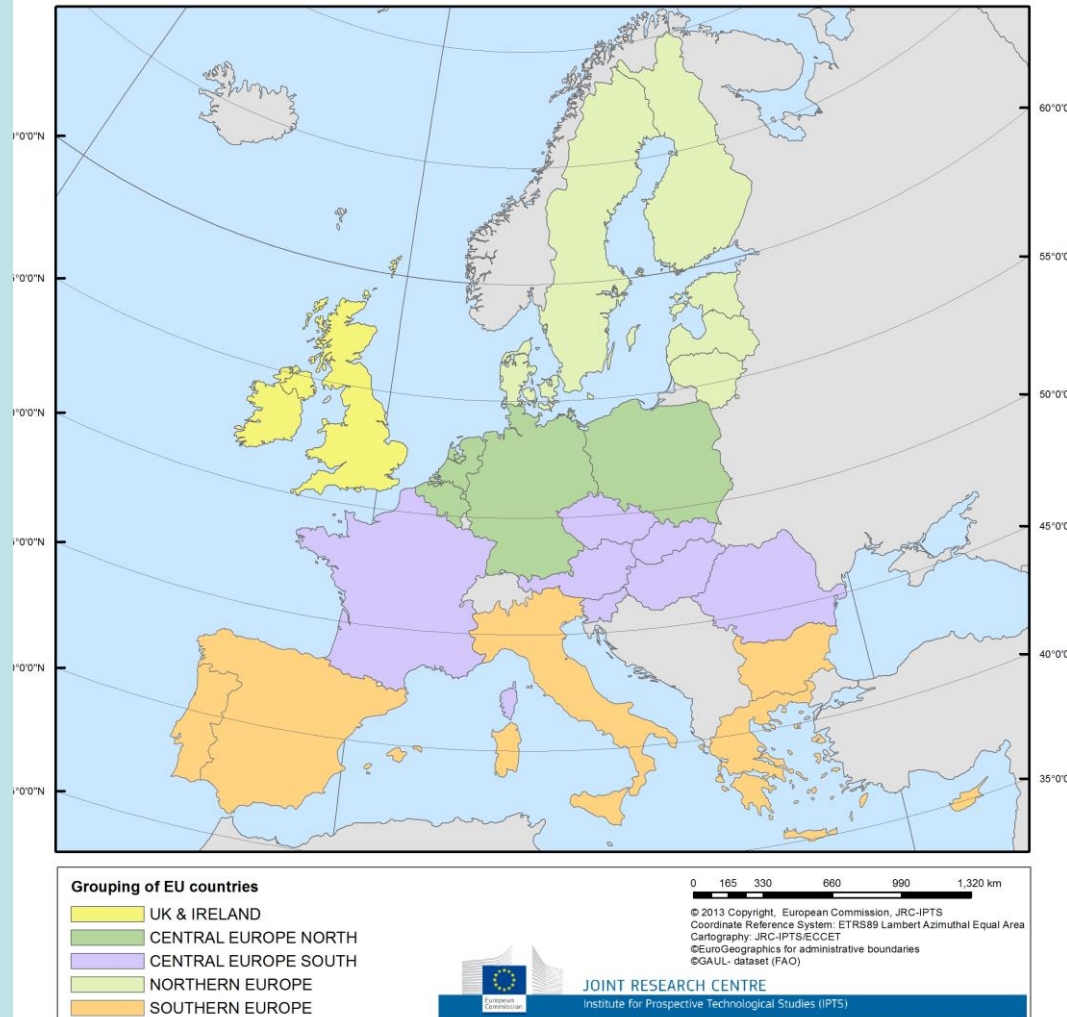


Capital
losses



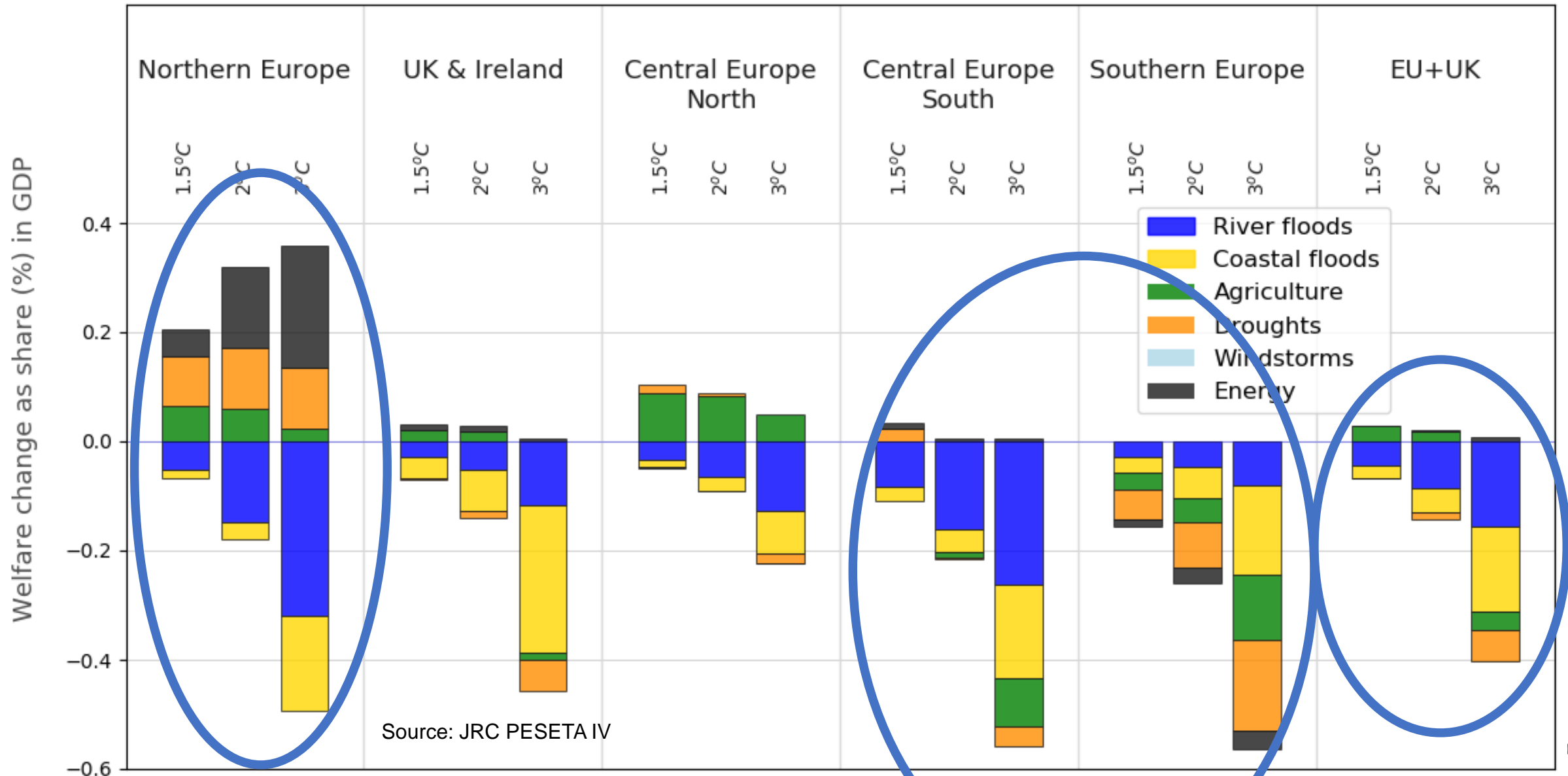
Forced
consumption
for residential
repair

Grouping of EU countries

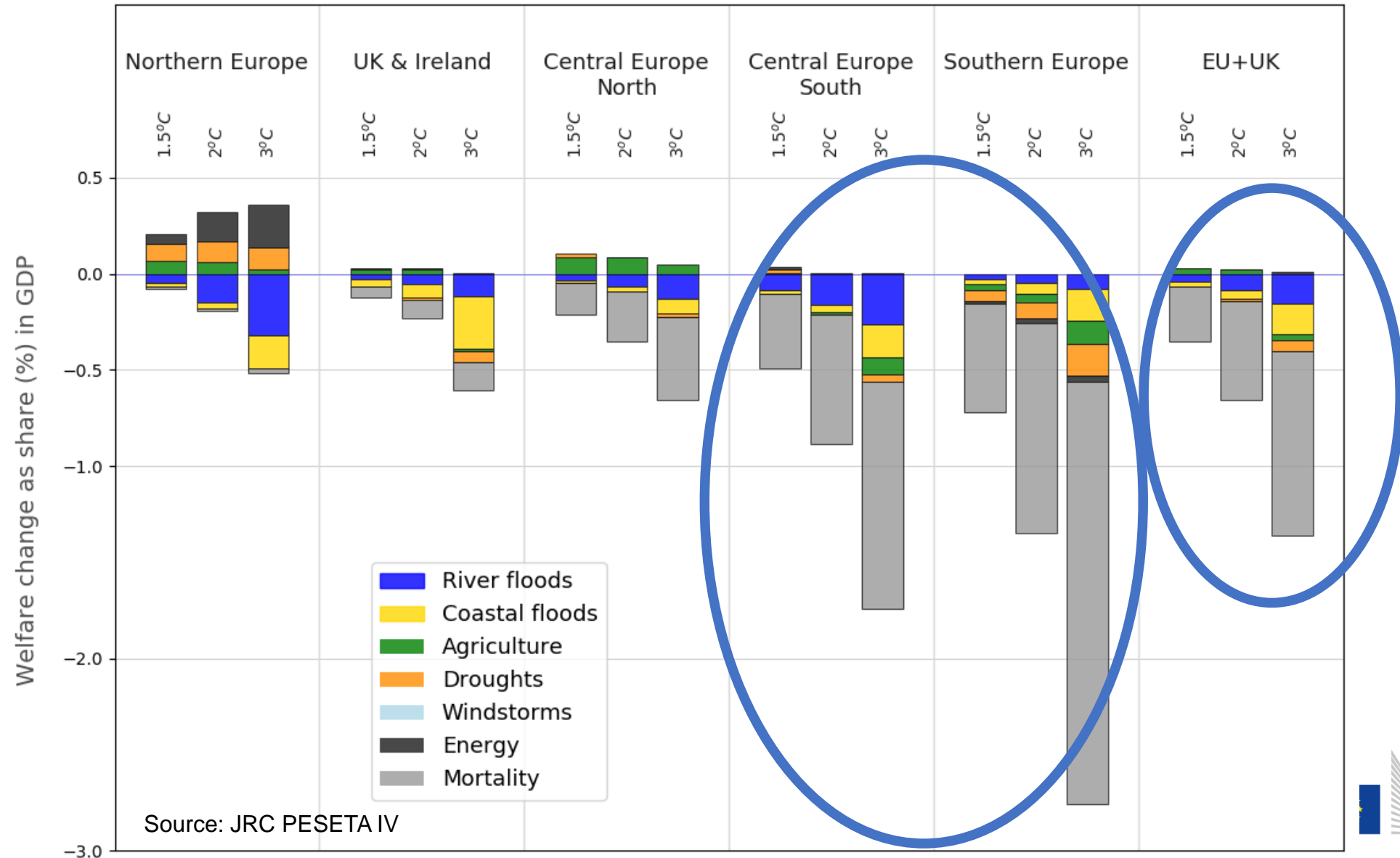


- **Northern Europe:** Sweden, Finland, Estonia, Lithuania, Latvia and Denmark
- **UK & Ireland:** UK and Ireland
- **Central Europe North:** Belgium, Netherlands, Luxemburg, Germany and Poland
- **Central Europe South:** France, Austria, Czech Republic, Slovakia, Hungary, Slovenia and Romania
- **Southern Europe:** Croatia, Portugal, Spain, Italy, Greece, Malta, Cyprus and Bulgaria

Distribution of Welfare damages, without mortality

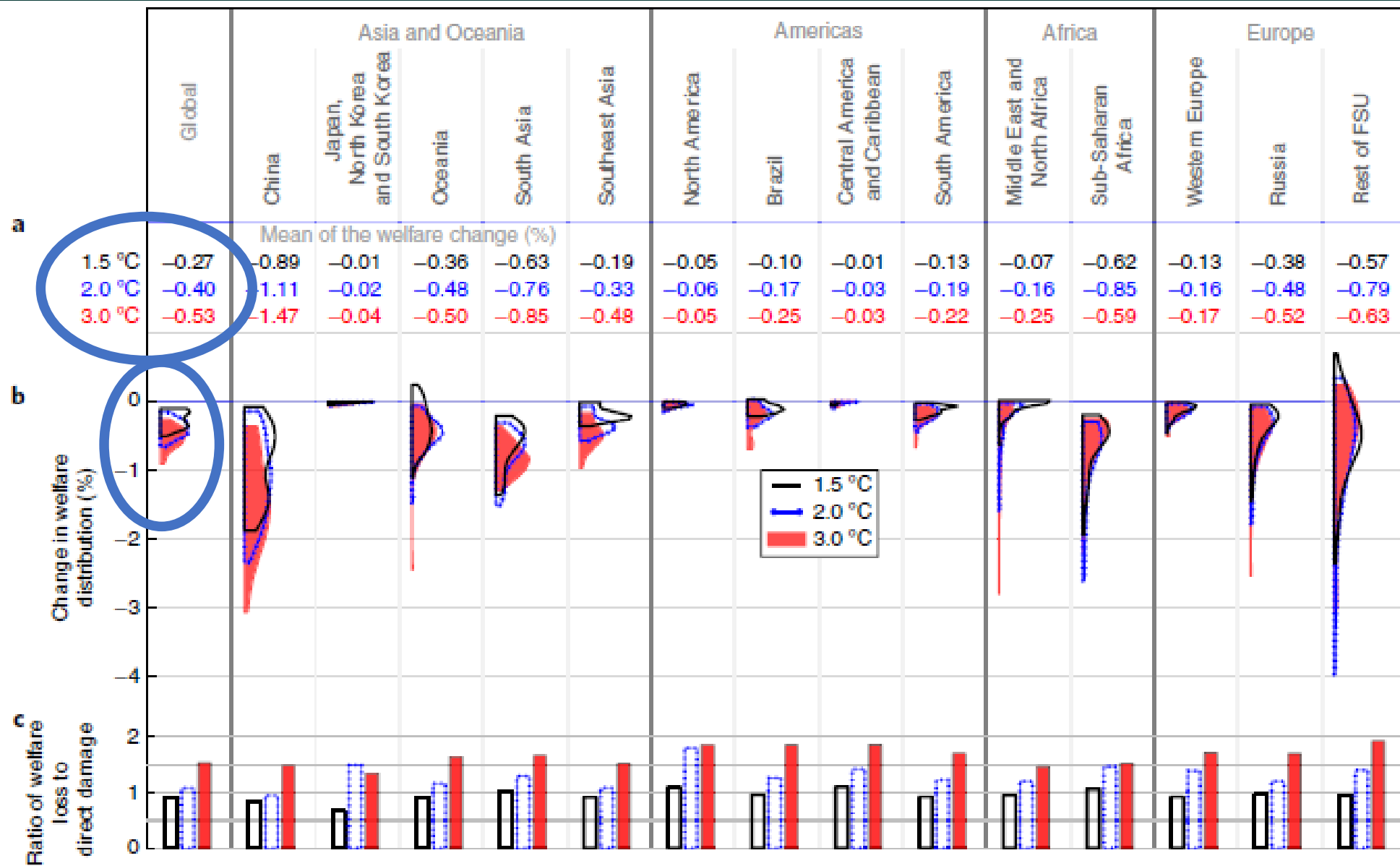


Distribution of Welfare damages, with mortality



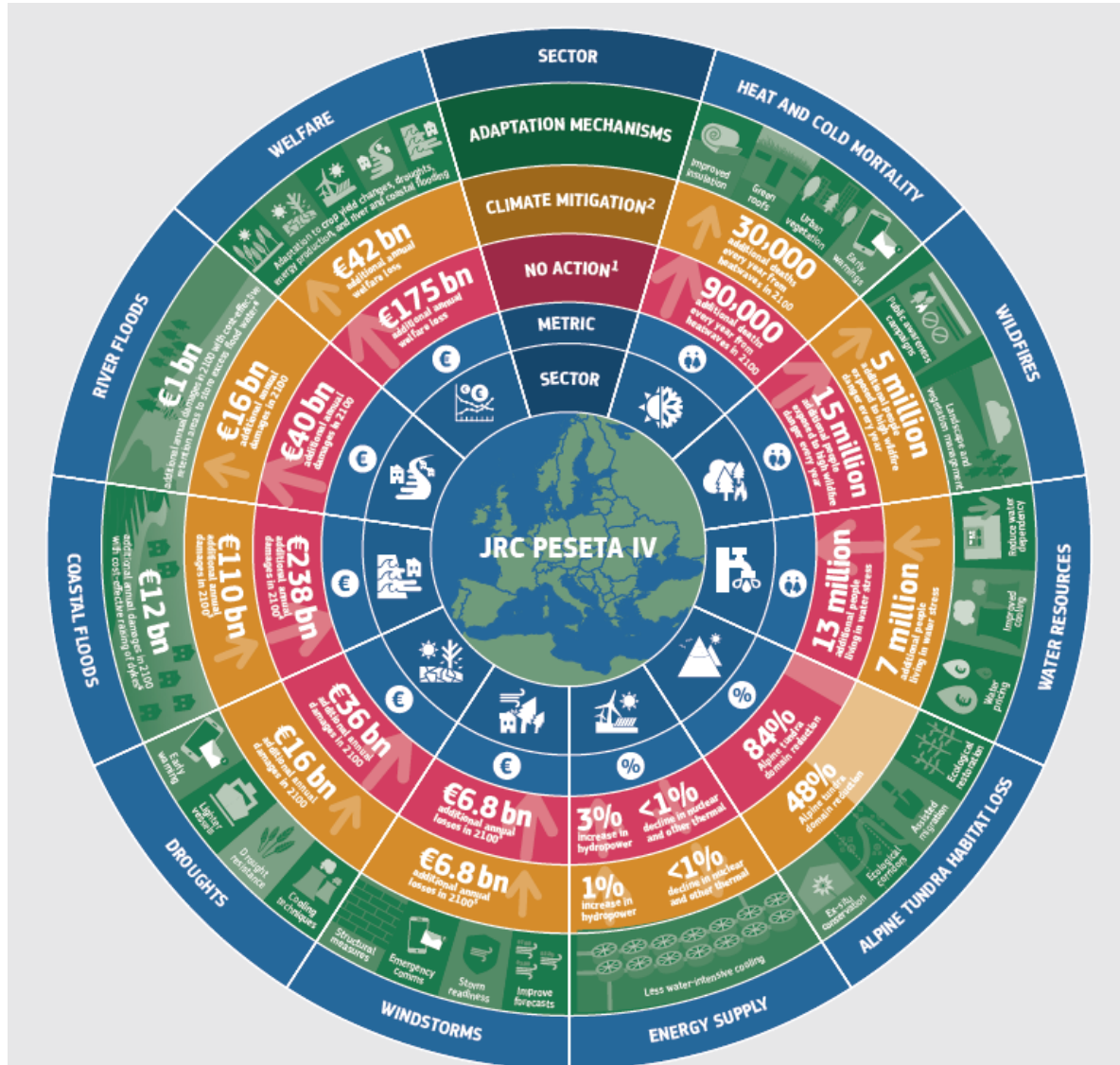
Source: JRC PESETA IV

Global analysis of river floods, Welfare effects



Dottori et al (2018), Nature Climate Change

Dissemination



- Technical reports
- Scientific reports

- Infographics
- Summary cards
- [Video](#)

<https://ec.europa.eu/jrc/en/peseta-iv>

Dissemination

LETTERS

<https://doi.org/10.1038/s41558-018-0260-4>

nature
climate change

Climatic and socioeconomic controls of future coastal flood risk in Europe

Michalis I. Vourdoukas^{1,2*}, Lorenzo Mentaschi¹, Evangelos Voukouvalas³, Alessandra Bianchi⁴, Francesco Dottori¹ and Luc Feyen¹

Environmental Research Letters

LETTER

Assessing future climate change impacts in the EU and the USA: insights and lessons from two continental-scale projects*

Juan-Carlos Ciscar¹, James Rising², Robert E Kopp³ and Luc Feyen⁴

¹ Joint Research Centre, European Commission, Spain

² The Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science, United Kingdom

³ Institute of Earth, Ocean, and Atmospheric Sciences and Department of Earth and Planetary Sciences, Rutgers University, New Brunswick, NJ, United States of America

⁴ Joint Research Centre, European Commission, Italy

Earth's Future



RESEARCH ARTICLE

10.1029/2019EF001170

Key Points:

- Unique concurrent spring and summer climatic anomalies affected Europe in 2018
- 2018-like droughts could become a common occurrence as early as 2043
- Climate change adaptation strategies for agriculture in Europe cannot count on recurrent water seesaws

Supporting Information:

- Supporting Information S1

The Exceptional 2018 European Water Seesaw Calls for Action on Adaptation

Andrea Toreti¹, Alan Belward¹, Ignacio Perez-Dominguez², Gustavo Naumann¹, Jürg Luterbacher³, Ottmar Cronie⁴, Lorenzo Seguíni¹, Giacinto Manfron¹, Raul Lopez-Lozano¹, Bettina Baruth¹, Maurits van den Berg¹, Frank Dentener¹, Andrej Ceglar¹, Thomas Chatzopoulos², and Matteo Zampieri¹

¹European Commission, Joint Research Centre (JRC), Ispra, Italy, ²European Commission, Joint Research Centre (JRC), Seville, Spain, ³Department of Geography, Climatology, Climate Dynamics and Climate Change, Centre for International Development and Environmental Research, Justus-Liebig University of Giessen, Giessen, Germany,

⁴Department of Mathematics and Mathematical Statistics, Umeå University, Umeå, Sweden



Dissemination

European Commission

JRC TECHNICAL REPORT

Analysis of climate change impacts on EU agriculture by 2050

JRC PESETA IV project – Task 3

Jordan Hristov, Andrea Torelli, Ignacio Pérez Domínguez, Francisco Dentener, Thomas Fellmann, Christian Elbery, Andrej Ceglár, Davide Fumagalli, Stefan Niermeyer, Jacopo Cerrari, Lorenzo Panamello, Marian Bratu

2020

Joint Research Centre

EUR 30079 EN

European Commission

JRC Science for Policy Report

Climate change impacts and adaptation in Europe

JRC PESETA IV final report
Feyen L., Ciscar J.C., Gosling S., Barrera D., Soria A. (editors)
Full list of authors in Acknowledgments

Joint Research Centre

EUR 30180 EN

Extreme heat and cold in a changing climate: Impacts on human health in the EU & UK

A grim future
The area of the red and blue circles represents fatalities from extreme heat and extreme cold respectively.

Projected annual deaths due to extreme heat in 2100 without adaptation

- 3 °C rise: 90,000
- 2 °C rise: 49,000
- 1.5 °C rise: 29,000

Projected annual deaths due to extreme cold in 2100 without adaptation

Present day: 2,700 annual deaths

With unmitigated climate change human exposure to severe heatwaves could be around 50 times greater than present at higher latitudes, while it could be 40-50 times greater in countries in southern Europe.

Adaptation options

- Stay cool
- Stay hydrated
- Stay informed
- Sustainable Green Cities: green roofs, parks, shaded areas

A north-south divide
The heat is expected to be fatalities from extreme heat is most pronounced in southern European countries and the highest number of fatalities occur in France, Italy and Spain.

Urban heat island
During hot spells, temperatures can be several degrees higher in cities compared to surrounding rural areas.

Vulnerable people
Sensitivity or vulnerability to harm and lack of capacity to cope and adapt, the elderly.

Proportion of population aged over 65 years
The share of people older than 65 will increase from 19% now to 26% by end of this century.

For more information, including assumptions of the modelling framework used, see: JRC PESETA IV project <https://ec.europa.eu/jrc/pejeta-iv>

Agriculture in a changing climate

Climate change may trigger yield losses and shocks in European agriculture markets, especially in the south, with trade acting as an important adaptation mechanism for dealing with variability in yields.

Pure biophysical effects of climate change

Wheat yield	Maize yield ¹
1.5 °C: +5% (Northern Europe), -7% (Southern Europe)	1.5 °C: -3% (Northern Europe), -7% (Southern Europe)
2.0 °C: +5% (Northern Europe), -12% (Southern Europe)	2.0 °C: -5% (Northern Europe), -11% (Southern Europe)

Mitigation
Keeping global warming below 2 °C reduces the risk and facilitates adaptation.

Adaptation mechanisms
Market adjusted effects of climate change²
For some crops improvement of agro-management practices, and introduction of new varieties may protect against climate change. A novelty of this study is that global market demand may spur adaptation in Europe with advantages for the European farming sector.

2 °C warming in year 2050

Wheat yield	Maize yield
+3% (Northern Europe), +1% (Southern Europe)	+4% (Northern Europe), +1% (Southern Europe)

Impacts
Markets: Potential price spikes & volatility; global markets may offer opportunities for European agriculture if physical and socio-economic factors are well-managed.
CO₂: Some positive effects on wheat productivity but negative on nutritional aspects.

Farm management
Copiesias: Digital transformation of agriculture holdings using earth observations.
Climate services: Climate-informed agro-management planning and anticipation of unfavorable conditions.
CAP: Support climate action, increase resilience and sustainability.

Without mitigation and adaptation, wheat and maize yields will decrease in southern Europe and the crops produced will have reduced nutritional value.

For more information, including assumptions of the modelling framework used, see: JRC PESETA IV project <https://ec.europa.eu/jrc/pejeta-iv>

<https://ec.europa.eu/jrc/en/peseta-iv>

Conclusions

- Asymmetric geographical pattern of impacts
- Large potential to reduce impacts with mitigation
- Adaptation can also play a key role

Limitations/next steps

- Need to enlarge coverage of sectors (e.g. *European Climate and Health Observatory*)
- Better know impacts facts in Europe
- Adaptation modelling
- European climate risk assessment
- International scientific diplomacy and cooperation

Thank you !

L Feyen, JC Ciscar, S Gosling, D Ibarreta, A Soria, A Dosio, G Naumann, S Russo, G Formetta, G Forzieri, M Girardello, J Spinoni, L Mentaschi, B Bisselink, J Bernhard, E Gelati, M Adamovic, S Guenther, A de Roo, C Cammalleri, F Dottori, A Bianchi, L Alfieri, M Vousdoukas, I Mongelli, J Hinkel, P Ward, H Costa, D de Rigo, G Libertà, T Houston Durrant, J San-Miguel-Ayanz, JI Barredo, A Mauri, G Caudullo, G Ceccherini, P Beck, A Cescatti, J Hristov, A Toreti, I Pérez Domínguez, F Dentener, T Fellmann, C Elleby, A Ceglar, D Fumagalli, S Niemeyer, I Cerrani, L Panarello, M Bratu, J Després, W Szewczyk, A Matei, E Mulholland, M Olariaga