IMPACT2C: Quantifying Projected Climate Impacts Under +2 °C Warming

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Economic Commission for Europe, Inland Transport Committee Meeting
UN, Geneva, 27-28 March, 2017
Climate Service Center Germany (GERICS)

- **Founded in 2009** by the German Federal Ministry of Education and Research
- Since June 2014 **scientific organizational entity** of Helmholtz-Zentrum Geesthacht
- Financed by **programme-oriented funding** of Helmholtz Association
- Director is **Prof. Dr. Daniela Jacob**
- Based in Hamburg’s **Chilehaus**
- **Interdisciplinary team** of natural scientists and socio-economists (approx. 40 staff members)

www.climate-service-center.de
www.gerics.de
IMPACT2C – aim and approach

Research questions
1. What are the potential climate impacts in Europe in a 2 degree (compared to pre-industrial) warmer world?
2. What are the differential impacts between 1.5, 2, and 3 degree C worlds?
3. Are there any hotspot areas in Europe which may be particularly negatively or positively affected by multiple climate impacts?

Sectors
Water, ecosystems, agriculture, health, air quality, energy, tourism, coasts (SLR), cross-sectoral impacts.

Quantifying uncertainty
Multiple climate models, and multiple impact models.
What do we mean by +2 °C?

- ‘Pre-industrial’ period 1881-1910 (GISS LOT1, HadCRUT3, NOAA NCDC
- Base period 1971-2000
- Temperature threshold periods (1.5, 2, 3 °C), determined by year in which GCM 30 year running mean crosses the temperature threshold starting from base period warming
When might we reach +2°C?

Evolution of global temperature. Observed historical (black line) and future projections from different GCMs (CMIP5). Time series are smoothed using a 30-year running mean. The 2°C threshold is marked in red.

Pre-industrial time: 1881-1910; baseline period: 1971-2000

RCP4.5 ~2050
RCP8.5 ~2040

Source: Vautard et al. 2014
What does +2 °C global warming mean for Europe?

- Most regions in Europe warm more than global average; exceptions are British Isles, France, Germany and surrounding area;
- Most pronounced warming in the north and east in winter and in the south in summer;
- More precipitation in the north and more severe heavy precipitation extremes in most of Europe.

Results for 12 EURO-CORDEX simulations (EUR-44)
For the RCP4.5 scenario.
Source: Cathrine Fox Maule and Ole Bøssing Christensen, 2014.
Seasonal mean temperature changes in Europe in a +2 °C world

- Enhanced summer heat in Mediterranean regions (+3 °C)
- Enhanced winter warming in Northern and Eastern Europe (+4 °C)
- Robust agreement among climate models

*Source*: Sobolowski et al. In prep.
Daily maximum and minimum temperature in Europe in a +2 °C world

- Daily max. temp. 3-4 °C over S, SE, Europe
- Daily min. temp. 3-6 °C in more northerly latitudes

Source: Sobolowski et al. In prep.
Mean precipitation changes in Europe in a +2 °C world

- Increases in winter ppt. of +10-20% over central and northern Europe
- Decreases in summer ppt. of -10 to -20% for central and southern Europe
- Results not as robust as for temperature based indicators

Source: Sobolowski et al. In prep.
Intense rainfall (1 in 10 year RP) in Europe in a +2 °C world

Source: Roudier et al. 2016
Cold day duration index (southern Finland)

The number of days where, in intervals of at least 6 consecutive days the daily minimum temperature is five degrees lower than the long term mean minimum temperature. The dashed line indicates the historical 95th percentile. stefan.sobolowski@uni.no
Heatwave duration index (central France)

The number of heatwave days per year (May-Sep) in intervals of at least six consecutive days which are at least 5 degrees over the climatological Tmax 5-day running mean. The dashed line indicates the historical 95th percentile. stefan.sobolowski@uni.no

Source: Sobolowski et al. In prep.
Growing season length (Brandenburg, Germany)
The number of days between the first occurrence of 5-day where $T > 5^\circ C$ and the last occurrence within a calendar year. The dashed line is the median from the historical simulations.

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Source: Sobolowski et al. In prep.
Floods – 1 in 10 year RP

Source: Roudier et al. 2016
Floods – 1 in 100 year RP

Source: Roudier et al. 2016
Hydrological drought - low flow duration

Source: Roudier et al. 2016
Hydrological drought – magnitude of low flow

Source: Roudier et al. 2016
Multi-sector “winners” and “losers” in a +2º C world

Impacts: water (hydrological drought, floods, cooling water), agriculture (crop yield), ecosystems (NPP, SOC), tourism (summer and winter VaR)

Published in ‘Climate change, impacts and vulnerability in Europe 2016’ EEA 2016 (https://goo.gl/qZvavi)
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Project outputs
IMPACT2C policy briefs

Policy Update on 2°C Warming
Analysis of early IMPACT2C climate modelling results

goo.gl/gSkc6P

Effects of 2°C Warming
IMPACT2C modelling results: climate change and sea-level rise from a 2°C climate

Policy Brief Nº2

goo.gl/bBgzeQ

Effects of 2°C Warming
IMPACT2C modelling results for a 2°C climate for key global vulnerable regions

Policy Brief Nº3

goo.gl/wNell4
IMPACT2C atlas: www.atlas.impact2c.eu

By presenting a wide variety of potential climate change impacts, the IMPACT2C atlas aims to serve various audiences in gathering information for the development of recommendations on possible adaptation strategies on national and international levels.
IMPACT2C Atlas example: freeze-thaw days (1971-2000 absolute)

Freeze-Thaw Days

Key messages:
- Number of freeze-thaw days decreases almost everywhere under a +2°C global warming
- Exceptions are modest increases at high altitudes and latitudes

Why is the context of this map important?
Freeze-thaw days are days during which temperatures cross the 0°C threshold. There can be serious and costly impacts on aviation, roadways and railways. It is largely due to the expansion/contraction of materials, which leads to cracking and deformation. On roadways and runways, the most dangerous ice conditions also occur around the 0°C threshold.

Which sectors are affected by this result?
The results are important for the transportation sector, especially transport infrastructure design and maintenance, particularly road, rail and air. The projected changes are actually good news for most of Europe, whereas the 0°C crossings are problematic under present conditions.

What is shown on the maps?
The current map shows that freeze-thaw days are most common in northern Europe with anywhere from 30-60 freeze-thaw days per year. The +2°C global warming period already shows decreases, on average, of over 15 days per year in northern Europe and the near disappearance of the phenomenon at lower latitudes. The few areas that do show an increase are modest, only being a handful of days.

Details and further information:
We have defined freeze-thaw days following the description given by Schmeltz et al. (1988). A day is considered as a freeze-thaw day if the daily minimum temperature is less than or equal to -2°C and the maximum temperature is equal to or greater than 0°C. The number of these days is then calculated over each year. There are many alternative definitions. The arguments for our approach is that temperatures between zero and -2°C do not constitute a hard freeze and impacts on vegetation and infrastructure are modest. Nevertheless, certain impacts might depend on more detailed indicators, which are not considered in this study, such as the number of crossings of 0°C per day.

Additional information: >
IMPACT2C Atlas example: freeze-thaw days (+2 °C absolute)
IMPACT2C Atlas example: freeze-thaw days (change in a +2 °C world)

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Details and further information:
We have defined freeze-thaw days following the description given by Schmidlin et al. (1986). A day is considered as a freeze-thaw day if the daily minimum temperature is less than or equal to -2.2°C and the maximum temperature is equal to or greater than 0°C. The number of these days is then calculated over each year. There are many alternative definitions. The argument for our approach is that temperatures between zero and -2°C do not constitute a hard freeze and impacts on vegetation and infrastructure are modest. Nevertheless, certain impacts might depend on more detailed indicators, which are not considered in this study, such as the number of crossings of 0°C per day.

Additional information: 
Overview (for this story) | More topics (for this story) | More stories
IMPACT2C Atlas example: freeze-thaw days (model agreement in a +2 °C world)

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Additional information:
Using climate information in the transport sector

- Climate risk screening and risk analyses
- Testing current design standards against climate change - new updated standards needed?
- Examining current business goals and objectives and how a changing climate may affect the ability to meet these → climate risk management in the transport sector.
Using climate information in the transport sector

<table>
<thead>
<tr>
<th>Phenomenon</th>
<th>1\textsuperscript{st} threshold: harmful impacts possible</th>
<th>2\textsuperscript{nd} threshold: harmful impacts are likely</th>
<th>3\textsuperscript{rd} threshold: harmful impacts are certain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind (gust speed)</td>
<td>&gt;= 17 m/s</td>
<td>&gt;= 25 m/s</td>
<td>&gt;= 32 m/s</td>
</tr>
<tr>
<td>Snowfall</td>
<td>&gt;= 1 cm/day</td>
<td>&gt;= 10 cm/day</td>
<td>&gt;= 20 cm/day</td>
</tr>
<tr>
<td>Rain</td>
<td>&gt;= 30 mm/day</td>
<td>&gt;= 100 mm/day</td>
<td>&gt;= 150 mm/day</td>
</tr>
<tr>
<td>Cold (mean daily temp.)</td>
<td>&lt; 0 °C</td>
<td>&lt; -7 °C</td>
<td>&lt; -20 °C</td>
</tr>
<tr>
<td>Heat (mean daily temp.)</td>
<td>&gt;= 25 °C</td>
<td>&gt;= 32 °C</td>
<td>&gt;= 43 °C</td>
</tr>
<tr>
<td>Blizzard</td>
<td>When threshold values of wind, snowfall, and cold are realised simultaneously</td>
<td></td>
<td></td>
</tr>
</tbody>
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\textit{Source:} adapted from Leviakangas and Saarikivi, 2012
Acknowledgement

Stefan Sobolowski, Abdulla Sakalli, Alessandro Dosio, Alessandro Cescatti, Andrea Damm, Wouter Gruell, Oskar landgren, Franz Pretenthaler, Nikola Rogler, Christoph Toegelhofer, Chantal Donnelly, Philippe Roudier, Dieter Gerten, Giovanna Pisacane, Daniela Jacob, Lola Kotova, Robert Vautard, and the whole IMPACT2C team.

EU FP7 IMPACT2C grant agreement no. 282746
Thank you

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Spare slides
We are…

Project Coordinator: Dr. Daniela Jacob
Climate Service Center Germany

Researchers from **29** different **institutions** and **16** different **countries**
Number of days with >30 cm snow per year

Scandinavia

Alps

Days per year with >30 cm snow

Altitude [m ASL]
Water

- Projected change in mean annual total runoff
- 5 HMs (E-Hype, Lisflood, LPJmL, VIC, WBM)
Example in Finland

Avg daily discharge (55 members), lon=24.6; Lat=65.75 (Finland, Kemijok river)

- 1971/2000
- +2C period

Discharge (m³/s)

Day of the year
Winter tourism demand

- Natural snow conditions in Europe
- Weather value at risk (VaR) resulting from adverse weather conditions
- VaR is change in number of overnight stays
- Regression model between number of overnight stays and a snow index (fraction of days SWE $\geq 120$mm)
- VIC and E-Obs (1958-2010)
- VIC and RCP8.5 simulations
- Socio-economic factors: GDP per capita, population
Ecosystems

- Projected change in NPP
- CLM4.0-CN, LPJmL
Ecosystems (NPP)

Difference 2°C - 1.5°C

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Electricity demand

- Temperature related impact on electricity load
- Load data corrected for non-climate factors e.g. weekday effects, summer holidays, industrial production
- Regression between corrected historical load data and daily mean temperature
- Historical relationship used with RCPs
Electricity demand
Sources of uncertainty in climate model projections

Source: Hawkins & Sutton 2009
Reasons for concern, informing climate policy goals

Source: Oppenheimer et al. 2014
Key findings

- A global warming by 2°C substantially affects a wide range of sectors and regions throughout Europe.
- Some regions or sectors will benefit from a future warming, but some will experience disadvantages.

- To assess the impacts of climate change on specific sectors, cross-sectoral relationships have to be included into the analysis.

- In most regions of Europe, the projected regional warming is more pronounced than the global mean warming.
- Projections for annual mean precipitation show wetter conditions in northern Europe and drier conditions in southern Europe.

- Under a 2°C global warming, a European-wide increase in the frequency of extreme events is expected.
- Heatwaves are projected to double while extreme precipitation events tend to become more intense.

- A limitation to 2°C global warming will not stop sea-level rise due to the delayed reaction of the oceans. Therefore costs due to coastal flooding will incur even with adaptation measures.

- Bangladesh and the low-lying islands like Maldives are expected to feel the consequences of climate change, due to the continuous rise of sea-levels enhancing the risk for storm surges and flooding.

- For West and East Africa, the warming is above the global temperature increase.
- West Africa could experience a modest increase in rainfall, whereas for East Africa no clear trend is projected.
Summary

Based on the evidence presented:

- Some appreciable changes in climate impacts at 1.5C
- Differential impacts between 1.5C and 2C worlds, are, on the whole, not considerable for Europe, more pronounced at 3C
- Find out more: [www.impact2c.eu](http://www.impact2c.eu)
- Online atlas available at: [www.atlas.impact2c.eu](http://www.atlas.impact2c.eu)