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Policy brief summarising assessment of impacts of SWLS in Europe including uncertainties

October 31

2017

Policy Brief

Assessment of impacts of SWLS in Europe including uncertainties

Summary of results from the FP7 Project HELIX - High-End cLimate Impacts and eXtremes

Human influence on the climate system and its effects on global warming are clear and unequivocal. At present, global surface air temperature has risen by almost 1°C since the pre-industrial era. Under a high-end emissions scenario corresponding to Representative Concentration Pathway (RCP) 8.5 Wm^{-2}, the average surface air temperature in Europe is projected to rise by 4°C before the end of the century. The projected warming may profoundly affect the distribution of freshwater resources, increase the intensity and frequency of weather-related extremes, and result in rising sea levels along European coastlines. This will likely have a broad range of consequences for our societies, including impacts on food production and agriculture, energy supply and demand, critical infrastructures, health, transportation and tourism, among others. The aim of WP7 of HELIX was to understand these potential impacts for Europe and propose measures to limit the future burden on society.

Impacts

Climate and hydrological models used in HELIX project that under +4°C global warming mean river flow increases in northern Europe and decreases in most of southern Europe and parts of eastern Europe. Broad agreement between several sets of models simulations gives high confidence to this assessment - an example of one set of projections is given in Figure 1, other sets give similar results. The projected increase in mean river flow can be up to +75% in Scandinavia, whereas reductions can be up to 50% in the Iberian Peninsula. At lower levels of warming, this trend is more uncertain, especially towards the south and east, and small to moderate negative changes in mean river flow are only projected for scattered regions in the Iberian Peninsula, south Balkans and eastern Europe. Central Europe is a region with small average changes in mean river flow and high uncertainty in the projections. The basins located here, such as the Rhine, Elbe and Danube, can show ambiguous signals in future river flow regime because their river basins extend over large domains that may contain areas subject to opposite changes in flow characteristics.

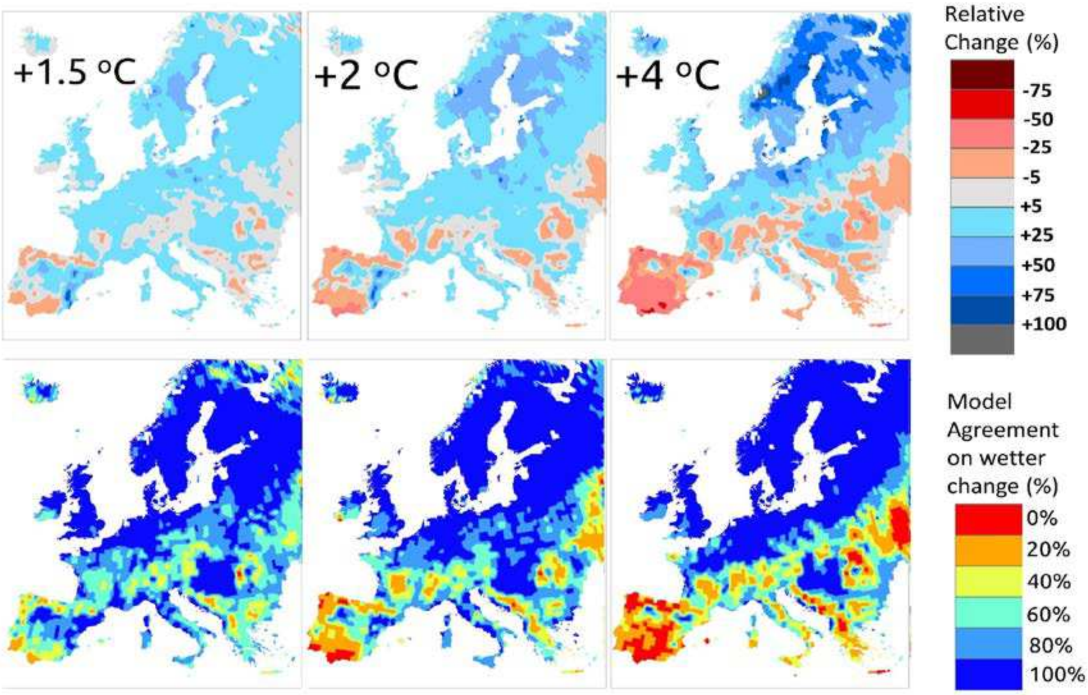

Figure 1. Ensemble-average changes in mean annual runoff at different warming levels (top row) and the corresponding degree of agreement towards a wetter change (bottom row) for a set of high-resolution climate projections.

Under +4°C global warming, there is high confidence that low river flows will reduce in most of southern and western Europe as well as the Alps, with low flow reductions up to 80% (Figure 2). In northern parts of Europe, low flows will significantly increase. At lower levels of warming similar patterns of change in low river flows are projected, yet changes are less pronounced and more uncertain. Apart from the magnitude, also the duration of drought conditions is projected to increase with warming in the Mediterranean region (south Spain, south Italy, south Greece and Cyprus).

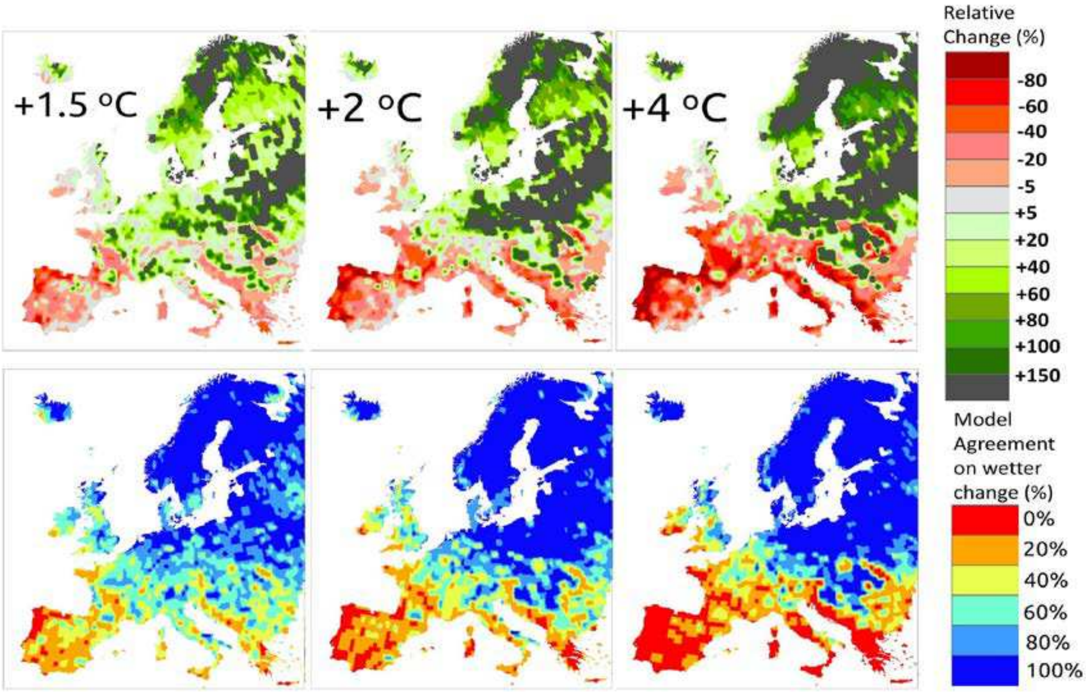

Figure 2. Ensemble-average relative changes in low runoff at different warming levels (top row) and the corresponding degree of agreement towards a wetter change (bottom row) for a set of high-resolution climate projections.

Although socio-economic developments are likely to dominate the dynamics of water scarcity, decreasing water availability could exacerbate water stress and intensify problems of water scarcity and irrigation shortfall, particularly in the southern and south-eastern European regions. For agriculture, more frequent and prolonged periods of low water availability in combination with heat stress is estimated to be the major limiting factor on crop yield. Reduced summer river flow in combination with higher water temperatures and increased cooling demands is projected to affect the European power generating capacity. The overall decline in summer river flows is expected to increase the vulnerability of the power supply.

Maximum daily precipitation is projected to increase for most of Europe, especially moving towards eastern and northern Europe. The expected annual frequency of very extreme events (with peak discharge above the 100-year return period) is projected to rise significantly in most of Europe. On average over Europe, flood peaks with return periods above 100 years are projected to double in frequency by 2050.

At present the expected annual people exposed (EAPE) to flooding in Europe is nearly 250,000 and the expected annual damage (EAD) is around €6 billion. Under 4°C global warming and assuming present socio-economic conditions prevail into the future, flood risk will nearly triple (EAD = €17 billion) if we do not adapt to the projected changes in flood hazard. Under the 2°C scenario, the impacts are projected to reach €12.5 billion of damage each year and 510,000 people exposed. Hence, relative to 4°C global warming, annual damages of around €4.5 billion could be avoided under the 2°C scenario across Europe. Even more impacts could be avoided under a more ambitious scenario that limits global warming to 1.5°C, in line with the aspirational objective of the Paris Agreement. Under this scenario, 500,000 people would be exposed annually, with direct damages amounting to €11 billion each year.

Under high-end climate change, Italy, Hungary, Austria and Slovakia are expected to face an increase in EAPE in excess of 500% by 2080, while Belgium, Austria, Slovenia and Slovakia are expected to face a similar increase in EAD, with maximum values roughly at +750% for Austria. By 2080, negative changes in river flood risk are found only in Finland (-8% in EAPE and -15% in EAD) and in Lithuania (-30% in EAPE and -28% in EAD) due to a reduction in snowmelt-driven floods (Figure 3).

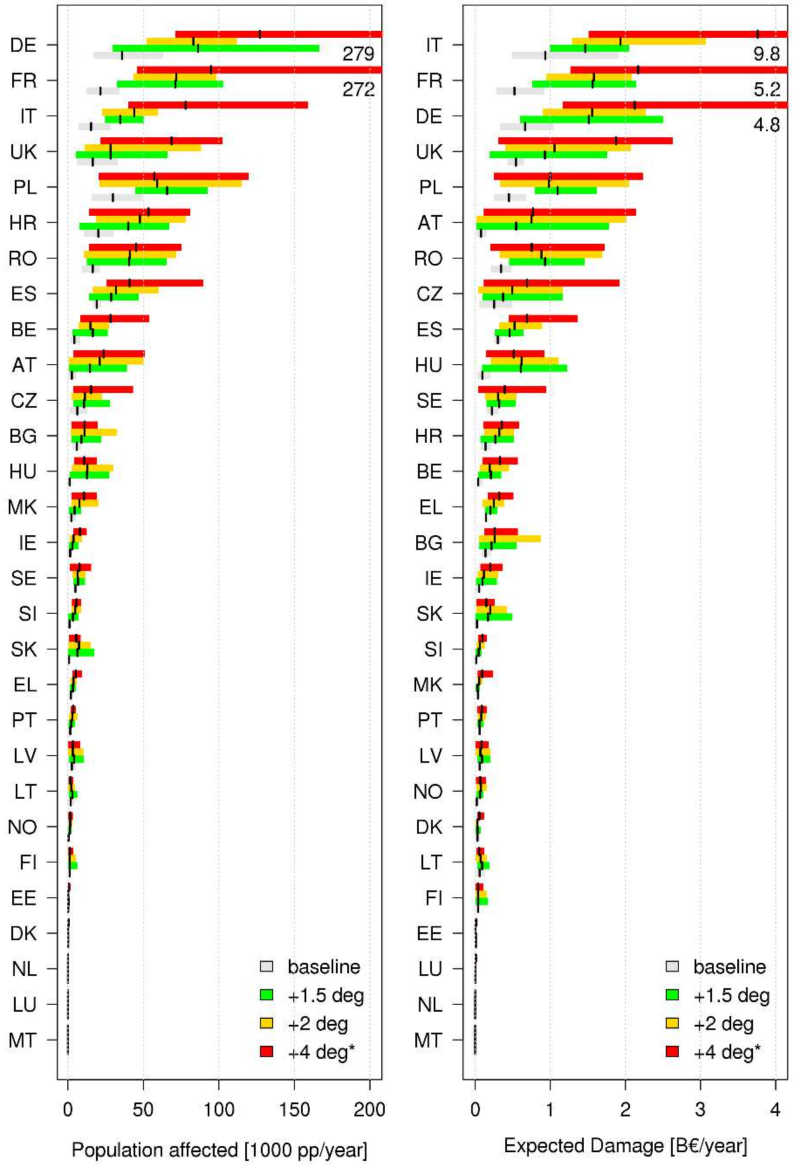

Figure 3. National estimates of population exposed (left) and economic damages (right) from flooding, for present (baseline) and global warming of 1.5, 2 and 4°C respectively. Black lines represent ensemble mean estimates, the bars denote the climate uncertainty range. Estimates assume present socio-economic conditions prevail and that no adaptation is undertaken. *Note that the 30-year time window centred on 4°C does not end before 2100 for some climate realizations; for these models the period 2071-2100 was taken, hence representing conditions with warming slightly less than 4°C.

When coherent projections of socio-economic growth are included in the assessment, central estimates of population annually exposed in Europe are within 520,000 and 590,000 by 2050 and within 530,000 and 975,000 by 2080. Absolute flood damages are considerably larger when accounting for socio-economic dynamics, with central estimates of €19 to €26 billion per year in 2050 and €29 to €112 billion per year in 2080, yet a richer society has a higher capacity to absorb the rise in flood losses and take action to prevent or reduce them.

Coastal flooding is driven by extreme sea levels, being the result of the mean sea level, astronomical tide and episodic water level fluctuations due to climate extremes (waves and storm surges). All of these components are subject to change in a warmer world. There is no one-to-one mapping between a given level of global warming (such as 2°C or 4°C) and a particular level of sea level rise, because sea level takes a very long time to respond to warming. Hence we present time-dependent projections. By the end of this century, the 100-year extreme sea level will on average increase between 57 and 81 cm along European coastlines. The North Sea region is projected to face the highest increase, amounting to nearly 1 m under a high emission scenario by 2100, followed by the Baltic Sea and Atlantic coasts of the UK and Ireland. Sea level rise is the main driver of the changes, but intensified climate extremes along most of northern Europe can have significant local effects.

At present, damages from coastal flooding are around €1.25 billion/year and approximately 100,000 people are annually exposed. The HELIX coastal impact assessment shows that coastal flood losses in Europe will likely rise at a much greater rate due to global warming than previous studies portrayed. Assuming present socio-economic conditions prevail into the future, hence only due to the effects of climate change under a RCP8.5 scenario, coastal flood impacts could rise to €60 billion/year of damage and 2.1 million people annually exposed (Figure 4). This implies that when flood protection standards are not upgraded along Europe's coasts and rivers, total flood risk in Europe will increasingly be dominated by coastal flood hazard from mid-century onwards. When accounting for socio-economic projections, economic impacts are projected to range between 93 and 961 billion € by the end of this century, depending on the considered concentration pathway and socioeconomic development. The number of people exposed is projected to reach between 1.5 and 3.7 million people by that time. Overall, country-level projections follow the continental trend, with the UK, France and Norway showing the highest absolute increase in coastal impacts towards the end of the century.

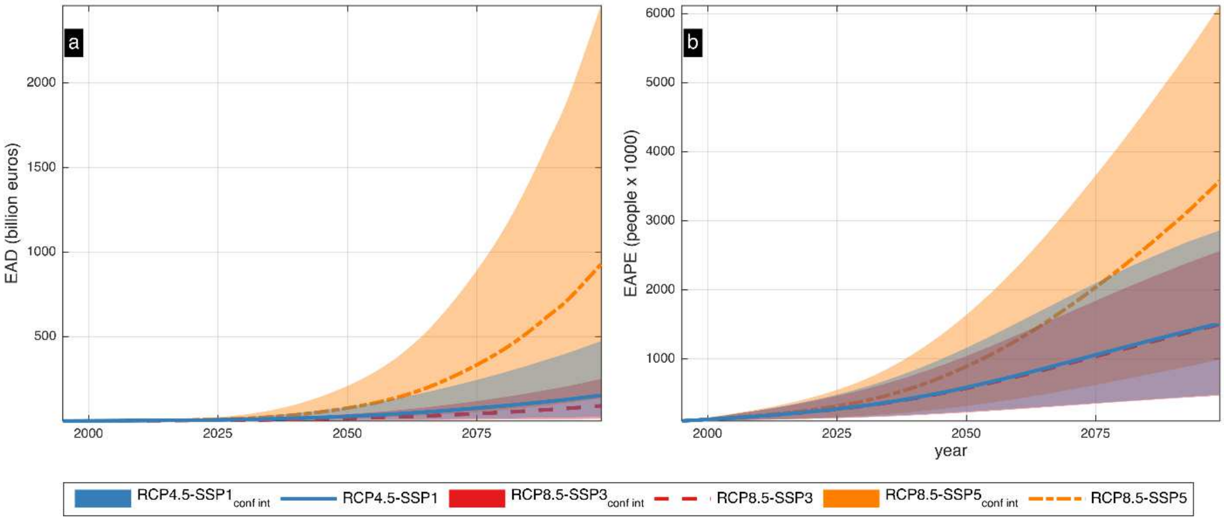

Figure 4. Projected evolution in time of coastal flood impacts aggregated at European level: Expected Annual Damage from coastal flooding (a; EAD: billion €), Expected Annual number of People Exposed to coastal flooding (b; EAPE: thousands). RCP4.5-SSP1 (blue line), RCP8.5-SSP3 (red dashed line), and RCP8.5-SSP5 (orange dash-dot line). Lines express the ensemble mean projections, and patches express the intra-ensemble variability.

Results further show that climate change is the main driver of the future rise in coastal flood losses, with the importance of coastward migration, urbanization and rising asset values rapidly declining with time. This is mainly caused by the uplift of extreme sea levels by relative sea level rise. Permanent inundation by rising sea levels only emerges by the end of the century, while changes in climate extremes have an increasingly marginal effect with time.

Adaptation

HELIX impact projections for Europe advocate for coordinated and effective climate mitigation and adaptation plans to limit the impacts on future societies. While mitigation efforts to reduce atmospheric concentrations rely on international agreements involving all world countries (e.g., the Paris Agreement at the 21st Conference of the Parties in 2015), national and regional plans need to focus on dedicated adaptation measures to compensate for the increasing climate impacts at local to regional scales.

Resource efficiency is very important in the context of the EU's policy recommendations of the "Blueprint to safeguard Europe's water". However, it should be noted that water savings due to higher efficiency in absence of adequate water allocation mechanisms do not necessarily lead to a decrease in water use. A potential way to save freshwater is to reuse treated wastewater, especially in water stressed regions. Increased tourism activity over the water scarce Mediterranean region during dry periods could further increase treated water volumes and thus the potential benefits of reuse. Water reuse is an accepted practice in several EU Member States, and the Urban Wastewater Treatment Directive (UWWTD) pushed Member States to reuse treated wastewater “whenever appropriate” but without setting any guidelines and legal definition of the term “appropriateness”.

Proposed adaptation actions further include rain-water storage expansion, desalination, use of more efficient/smart irrigation systems, introduction of drought resistant crops and changes to the cropping calendar (for example the use of early ripening cultivars to avoid heat or drought stress) and agriculture based natural water retention measures. Adaptation strategies for the energy sector should aim at raising the share of renewable energy resources as well as replacing recirculation (tower) cooling systems and coal-, lignite- and oil-fuelled power plants by gas-fired power plants.

For river and coastal floods, the projected increase in frequency and magnitude of extreme flood events shows that traditional approaches based only on raising flood protections are not sustainable in the long term. It will likely exacerbate the “levee effect” by reducing the frequency of moderate events and exposing the society to fewer but more catastrophic floods, which could result in potentially long and painful post-event recovery.

We recommend that future adaptation strategies are based on a combination of different measures working in synergy and optimized at the level of river basins, estuaries and coastal systems, rather than through independent actions over isolated river or coastline reaches. Adaptation efforts should give priority to measures targeted at reducing the consequences of hazardous events, rather than trying to avoid their occurrence. In particular, relocation and vulnerability reduction measures should be further investigated, due to their two key features of 1) lowering the impacts of all floods without reducing their frequency, thus strengthening the resilience of societies and ultimately the “adaptation effect”; and 2) reducing the effects of uncertainty in future climate on the consequent risk reduction due to adaptation measures. Raising flood protection should be seen as last resort to compensate for the residual risk in areas where other options cannot be implemented. In the latter case, best practice in the realisation of new structures include 1) the need for gradual and non-catastrophic failure in case of overload, and 2) building in redundancy, so that a single failure in the system would not compromise the overall flood risk protection capacity.