IPCC AR5 - WG II
EUROPA

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“Southern Europe is particularly vulnerable to climate change (*high confidence*) as multiple sectors will be adversely affected:

Tourism
Agriculture
Forestry
Infraestructure
Energy
Population health”

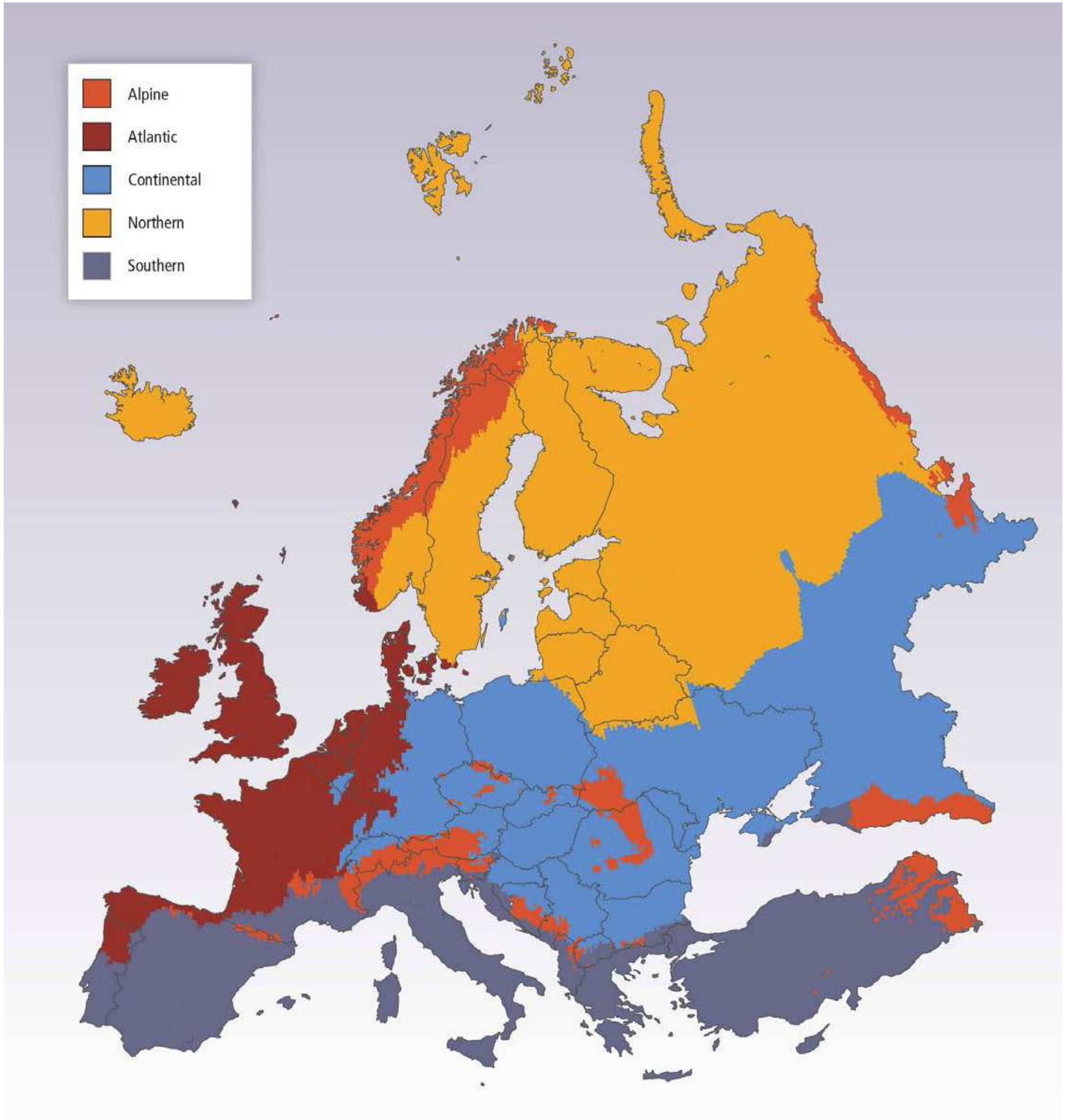
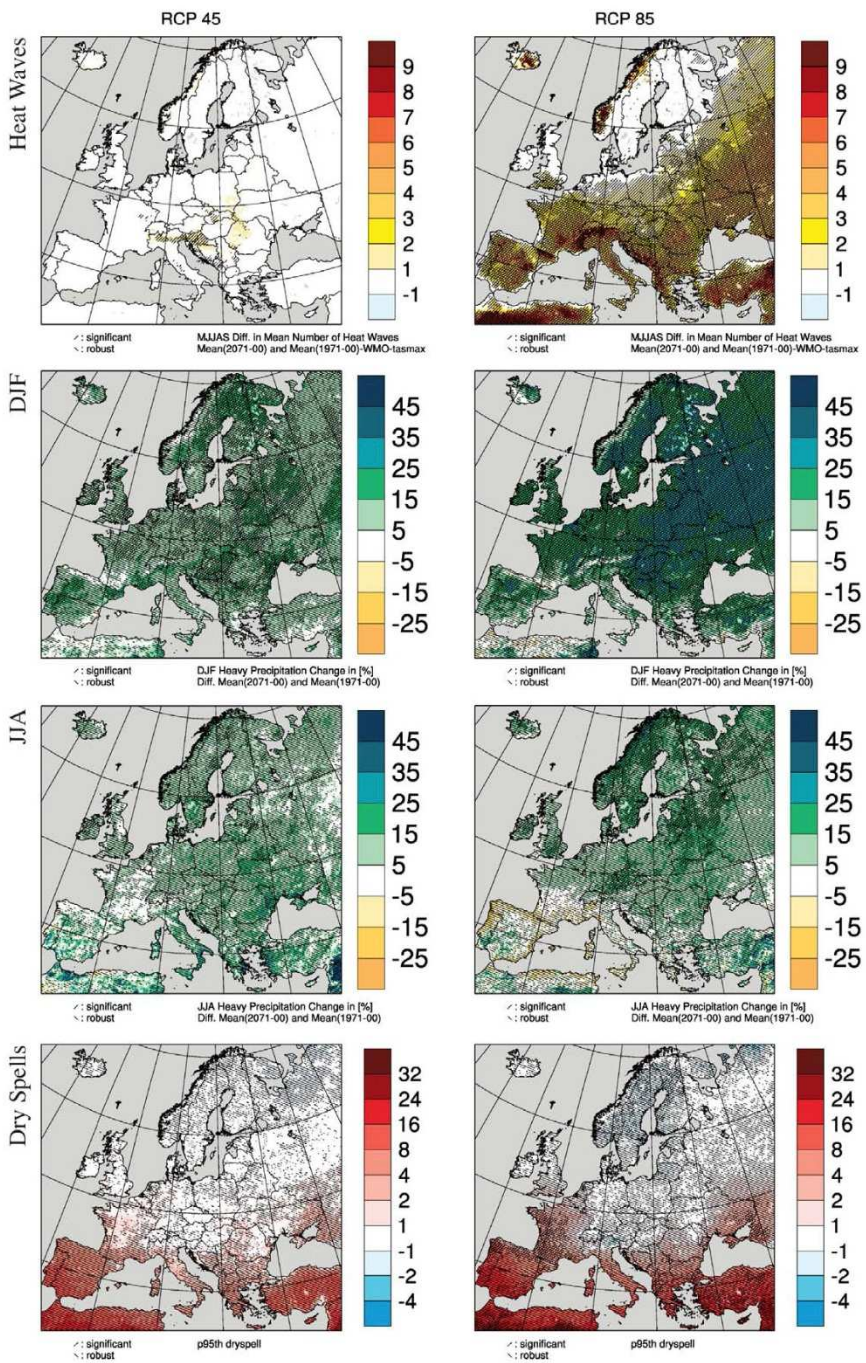


Figure 23-1: Sub-regional classification of the IPCC Europe region. Based on Metzger et al., 2005.



OBSERVED & PROJECTED CHANGES

Figure 23-2: First row: Projected changes in the mean number of **heat waves** occurring in the months May to September for the period **2071-2100** compared to 1971-2000 (number per 30 years). Heat waves are defined as periods of more than 5 consecutive days with daily maximum temperature exceeding the mean maximum temperature of the May to September season of the control period (1971-2000) by at least 5℃. Second and third rows : Projected seasonal changes in **heavy precipitation** defined as the 95th percentile of daily precipitation (only days with precipitation > 1mm/day are considered) for the period 2071-2100 compared to 1971-2000 (in %) in the months December to January (DJF) and June to August (JJA). Fourth row: Projected changes in the 95th percentile of the length of **dry spells** for the period 2071-2100 compared to 1971-2000 (in days). Dry spells are defined as periods of at least 5 consecutive days with daily precipitation below 1mm. Hatched areas indicate regions with robust (at least 66% of models agree in the sign of change) and/or statistical significant change (significant on a 95% confidence level using Mann-Whitney-U test). Changes represent the mean over 8 (RCP4.5, left side) and 9 (RCP8.5, right side) regional model simulations compiled within the EURO-CORDEX initiative. Adapted from Jacob et al. (2013).

Table 23-1: Impacts of climate extremes in the last decade in Europe.

IMPACTS

Year	Region	Meteorological Characteristics	Production Systems and Physical Infrastructure, settlements	Agriculture, Fisheries, Forestry, Bioenergy	Health and Social Welfare	Environmental Quality and Biological Conservation	Mega-fire
2003	Western and Central Europe	Hottest summer in at least 500 years (Luterbacher *et al.*, 2004)	Damage to road and rail transport systems. Reduced/ interrupted operation of nuclear power plants (mostly in France). High transport prices in Rhine due to low water levels.	Grain harvest losses of 20% (Ciais, et al. 2005)	35,000 deaths in August in Central and Western Europe, (Robine *et al.* 2008)	Decline in water quality (Daufresne et al. 2007). High outdoor pollution levels (EEA 2012)	Yes
2004/ 2005	Iberian Peninsula - Portugal	Hydrological drought	-	Grain harvest losses of 40% (EEA, 2010c)	-	-	
2007	Southern Europe	Hottest summer on record in Greece since 1891 (Founda & Giannakopoulos 2009)	1710 buildings burned down or rendered uninhabitable in Greece (JRC, 2008)	Approx. 575,500 hectares burnt area (JRC, 2008)	Significant mortality impact: 6 deaths in Portugal, 80 deaths in Greece.	Several protected conservation sites (Natura 2000) were destroyed (JRC, 2008)	Yes, - Greece
2007	England and Wales	May–July wettest since records began in 1766.	Estimated total losses £4 billion (£3 billion insured losses) (Chatterton et al. 2010). Failure of pumping station led to 20,000 people without water for 2 weeks	78 farms flooded. Impacts on agriculture £50 million (Chatterton et al. 2010)	13 deaths and 48,000 flooded homes (Pitt, 2008). Damage costs for health effects, incl. loss of access to education £ 287 million (Chatterton et al. 2010)		
2010	Western Russia	Hottest summer since 1500 (Barriopedro *et al.*, 2011)		Fire damage to forests (Shvidenko et al., 2011). Reduction in crop yields (Coumou and Rahmstorf, 2012)	Estimated 10,000 excess deaths due to heatwave in Moscow in July and August (Revich and Shaposhnikov, 2012)	High outdoor pollution levels in Moscow (Bondur, 2011, Revich and Shaposhnikov, 2012)	Yes
2011	France	Hottest and driest spring in France since 1880	Reduction in snow cover for skiing	8% decline in wheat yield (AGRESTE, 2011)			

* Extreme events derived from Coumou and Rahmstorf, 2012.

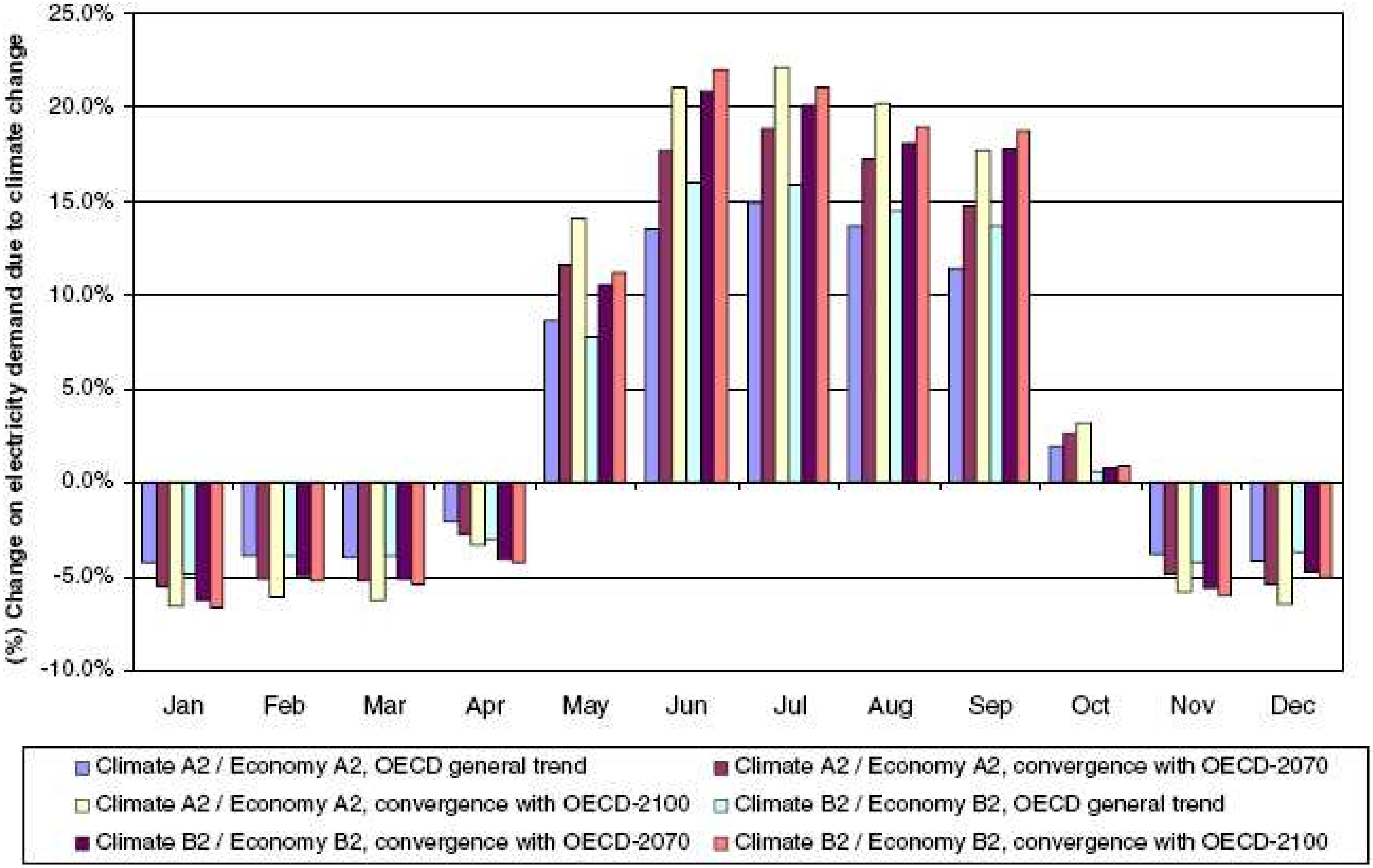


Fig. 8. Percentage change of electricity demand in Greece attributable to climate change as applied to the model.

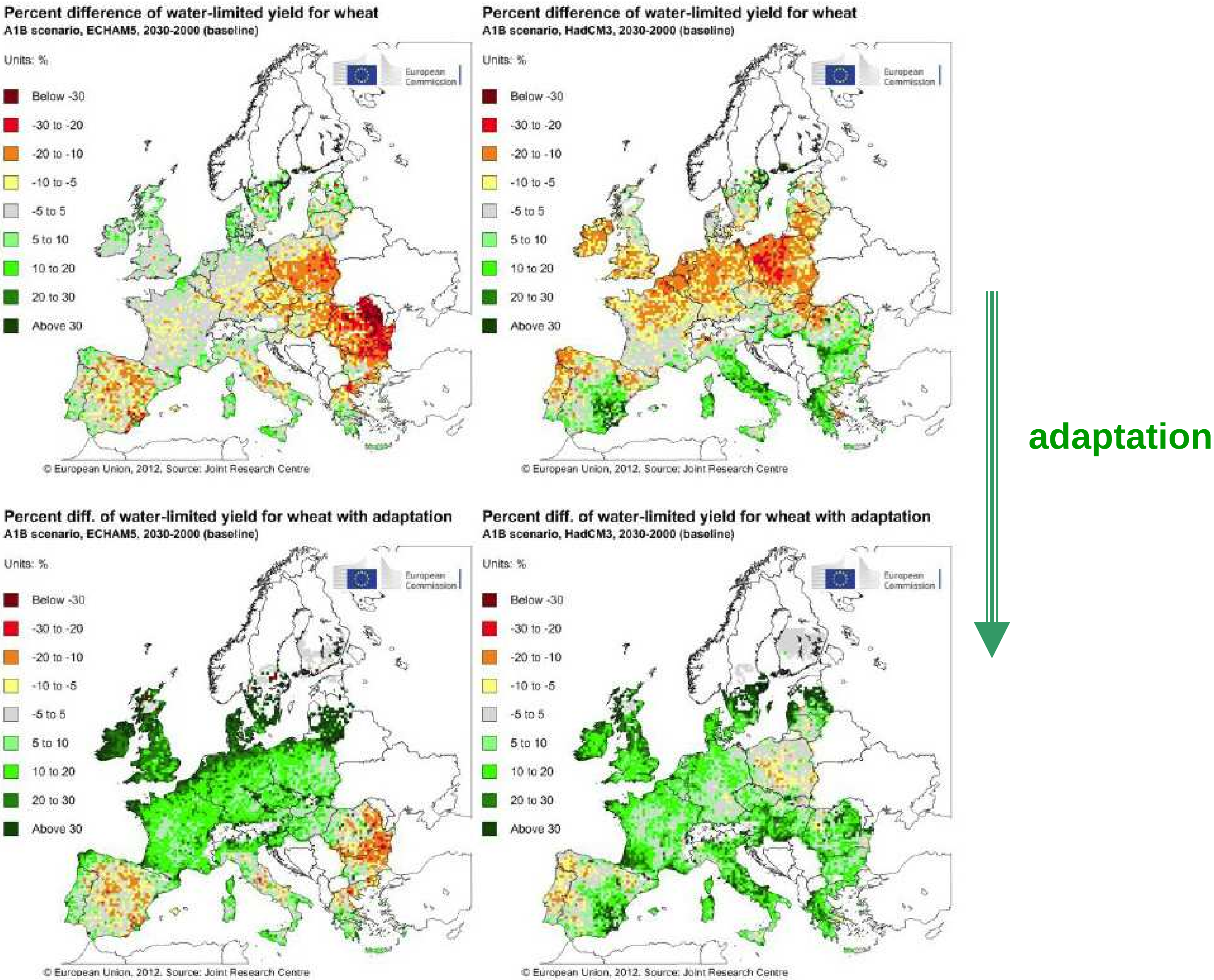


Figure 23-4: Percentage change in simulated water-limited yield for winter wheat in **2030 with respect to the 2000** baseline for the A1B scenario using **ECHAM5 (left column) and HadCM3 (right)** GCMs. Upper maps to do not take adaptation into account. Bottom maps include adaptation. Source: Donatelli et al., 2012.

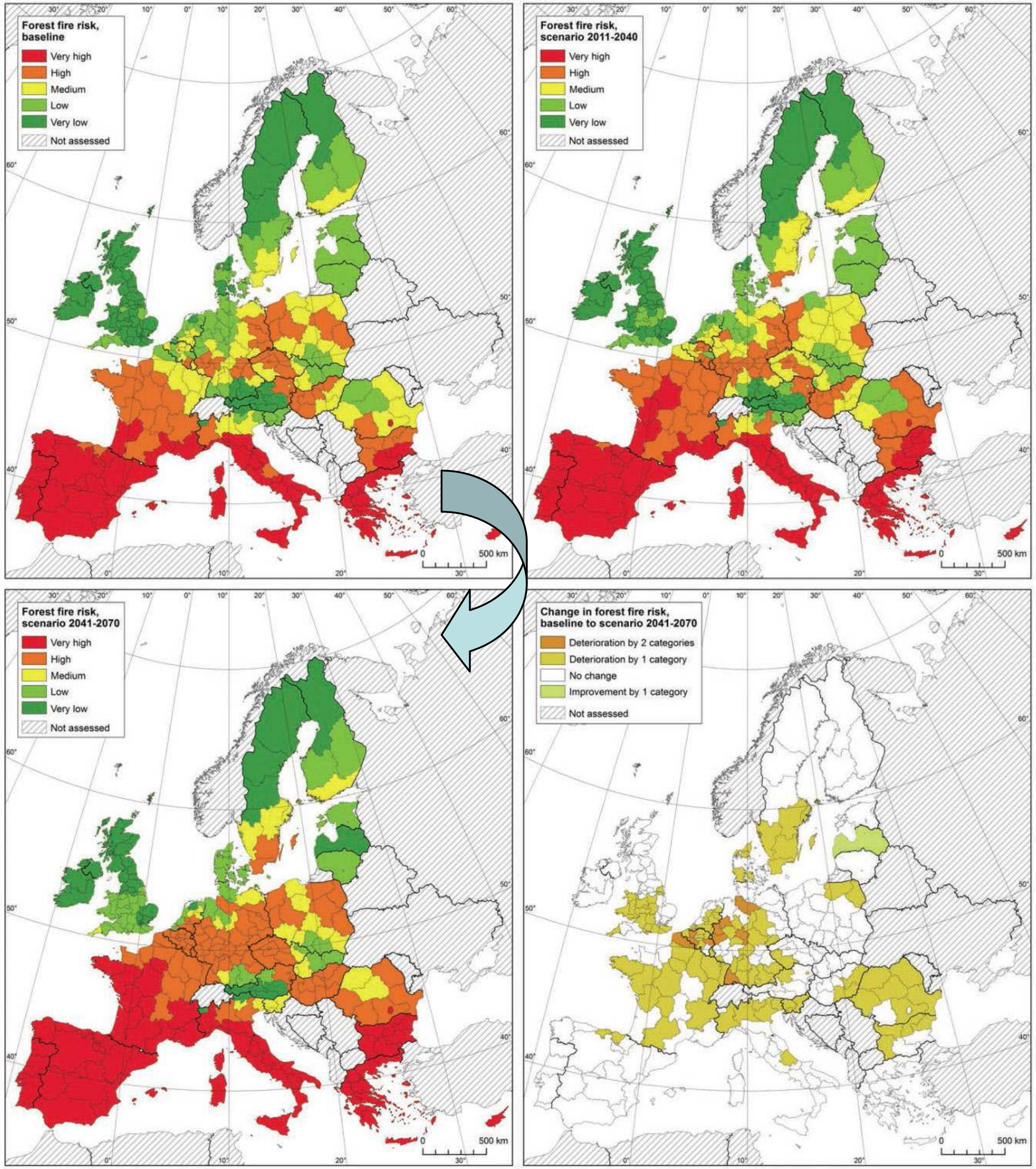


Figure 23-5: Changes in **forest fire risk** in Europe for three time periods: **baseline (left) , 2011-2040 (right),** and **2041–2070 (below-left)** based on high-resolution regional climate models and the SRES A1B emission scenario. Source: Lung et al., 2013.

BOX 23-1 TABLE

ECOSYSTEM SERVICES 2050s

	Alpine	Atlantic	Continental	Northern	Southern
Provisioning services:					
Food production	No (1) ∨ (4)	∨ (1)	∨ (1)	∧ (1) ∨ (1)	∨ (1)
Livestock production	No (1) ∨ (1)				
Fibre production	∨ (1)				
Bioenergy production	∧ (1)			∧ (1)	∨ (1)
Fish production		No (1) ∨ (1)	∨ (1)	No (1) ∨ (1)	No (1) ∨ (2)
Timber production	∧ (5) No (2) ∨ (5)	∧ (2) No (3)	∧ (1) No (2) ∨ (1)	∧ (6) No (1)	V (2)
Non-wood forest products				∧ (1) No (1)	∨ (1)
Sum of effects on provisioning services	∧ (6) No (4) ∨ (11)	∧ (2) No (4) ∨ (2)	∧ (1) No (2) ∨ (3)	∧ (9) No (3) ∨ (2)	No (1) ∨ (7)
Regulating services:					
Climate regulation (carbon sequestration)					
- General/forests	∧ (4) No (1) ∨ (3)	∧ (4) No (1)	∧ (3) No (1)	∧ (4) No (1) ∨ (1)	∧ (3) ∨ (1)
- Wetland		No (1) ∨ (1)	∨ (1)	No (1) ∨ (1)	No (1) ∨ (1)
- Soil carbon stocks	No (1) ∨ (2)	No (1) ∨ (2)	No (1) ∨ (1)	∨ (3)	No (1) ∨ (1)
Pest control	∧ (1)		∧ (1)	∧ (1)	∨ (1)
Natural hazard regulation*					
- Forest fires / wildfires		∨ (1)	∨ (2)		∨ (1)
- Erosion, avalanche, landslide	∧ (2) ∨ (1)				
- Flooding	∨ (1)				
- Drought			∨ (1)		No (1) ∨ (1)
Water quality regulation		∨ (1)		∨ (1)	
Biodiversity	∧ (2) ∨ (4)	∧ (2) No (1) ∨ (4)	∧ (2) ∨ (4)	∧ (3) ∨ (2)	∧ (1) ∨ (8)
Sum of effects on regulating services	∧ (9) No (2) ∨ (11)	∧ (6) No (4) ∨ (9)	∧ (6) No (2) ∨ (9)	∧ (8) No (2) ∨ (8)	∧ (4) No (3) ∨ (14)
Cultural services:					
Recreation (fishing, nature enjoyment)		∨ (1)		∧ (1) ∨ (2)	∨ (1)
Tourism (skiing)	∨ (1)			∨ (1)	
Asthetic/heritage (landscape character, cultural landscapes)	∧ (1)	∨ (1)	No (1) ∨ (1)		∨ (1)
Sum of effects on cultural services	∧ (1) ∨ (1)	∧ (1) ∨ (1)	No (1) ∨ (1)	∧ (1) ∨ (3)	∨ (2)

∨ = decreasing impacts
∧ = increasing impacts
No = neutral effect

IMPLICATIONS OF CLIMATE CHANGE FOR EUROPEAN WINE AND VINEYARDS

- Europe produces > 60% of global total wine
- ↑ T^e may change yield and quality (e.g. ↑ sugar/acids)
- New potential areas for viticulture

- **Adaptation** already occurring, but … some barriers:
    - geographical displacement & change varieties,
        - but this may affect prices associated to regions (e.g. Burgundy)
        - and regulation problems with D.O.

⇒ flexibilize regional identity concept?

ADAPTATION
Relatively high capacity
In Europe

Table 23-2: Selected published cost estimates for planned adaptation in European countries.

Region	Cost estimate	Time period	Sectors/Outcomes	Reference
Europe	€2.6-3.5 billion/a	In 2100	Coastal adaptation costs	Hinkel et al. 2010
Europe	€1.7 billion/a €3.4 billion/a €7.9 billion/a	By 2020s By 2050s By 2080s	Protection from river flood risk for EU27	Rojas et al., in press
Netherlands	€1.2–1.6 billion/a €0.9–1.5 billion/a	up to 2050 2050–2100	Protection from coastal and river flooding	Delta Committee, 2008
Sweden	total of up to €10 billion	2010-2100	Multi sector	Swedish Commission on Climate and Vulnerability, 2007
Italy	€0.4-2 billion Up to € 44 billion	By 2080s	Coastal protection Hydrogeological protection	Bosello et al. 2012, Medri et al. 2013.
Greece	€0.4-3.3 billion	Up to 2100	Coastal protection	Bank of Greece, 2011
UK	€1.8 billion €2.2 billion €7-8 billion	Until 2035 2035-2050 At 2100	Maintain and improve Thames flood protection Renew and improve Thames flood protection New Thames barrier for London	EA, 2011

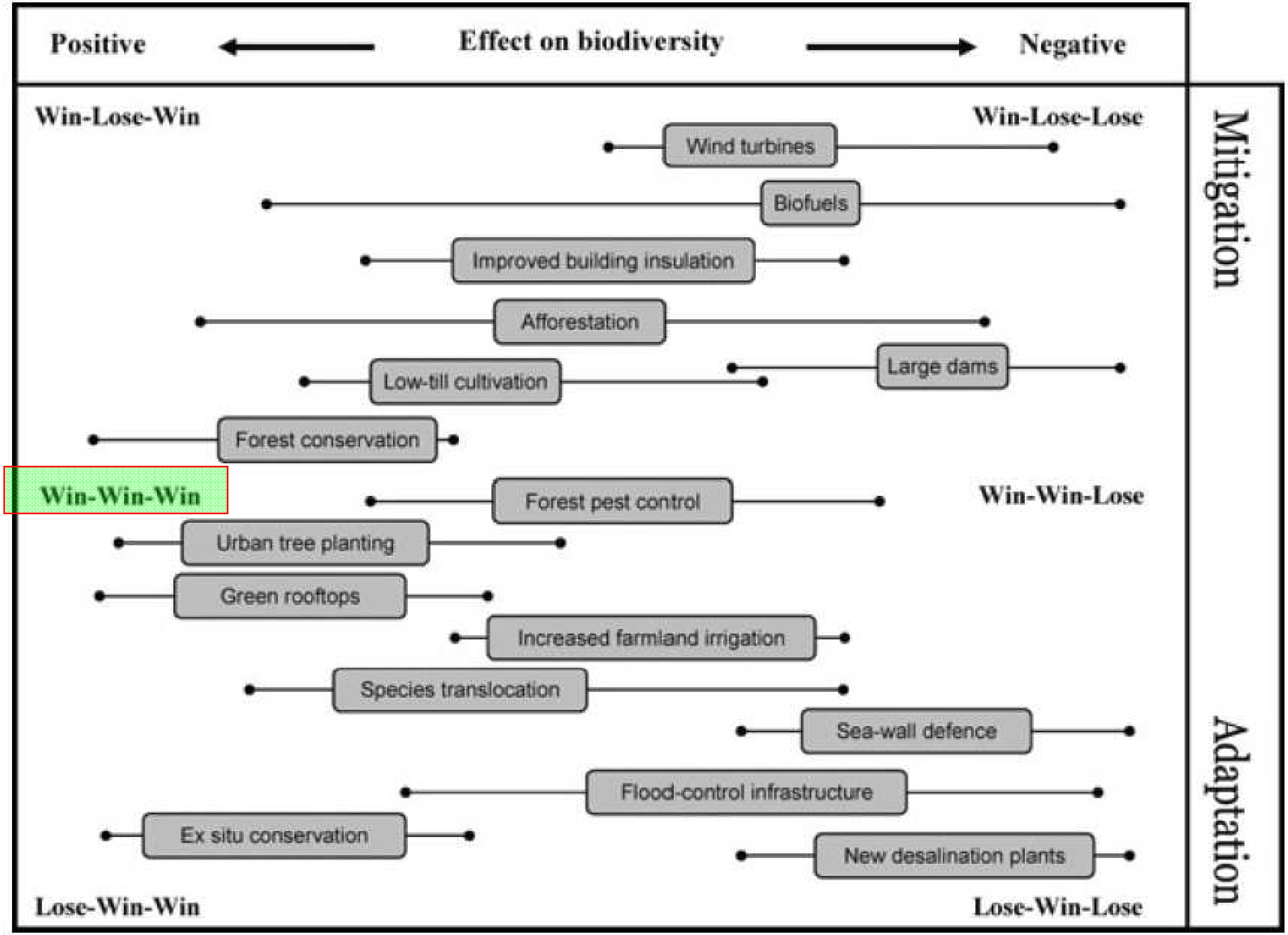


Figure 23-6: Adaptation and mitigation options and their effects on biodiversity.

KEY VULNERABILITIES

Table 23-4: Assessment of climate change impacts by sub-region by 2050, assuming a medium emissions scenario,
and no planned adaptation.

	Alpine	Southern	Northern	Continental	Atlantic	
Energy						
Wind energy production	→	↗ (green) → ↘ (red) [1]	↗ (green) →	→	↗ (green) → ↘ (red)	23.3.4
Hydropower generation	↗ (green) ↘ (red) [2]	↘ (red)	↗ (green) →	↘ (red)	↗ (green) ↘ (red)	23.3.4
Thermal power production	→ ↘ (red)	→ ↘ (red)	→	→ ↘ (red)	→ ↘ (red)	23.3.4, 8.2.3.2
Energy consumption (net annual change)	↘ (green)	↗ (red)	↘ (green)	↘ (green)	↘ (green)	23.3.4, 23.8.1
Transport						
Road accidents [3]	→ ↘ (green)	↘ (green)	→ ↘ (green)	→ ↘ (green)	→ ↘ (green)	23.3.3
Rail delays (weather-related)	?	?	↗ (red)	?	↗ (red) ↘ (green) [4]	23.3.3, 8.3.3.6
Load factor of inland ships	?	?	?	→ ↘ (red)	→ ↘ (red)	23.3.3
Transport time and cost in ocean routes	?	?	↘ (green)	↘ (green)	?	23.3.3, 18.3.3.3.5
Settlements						
River flood damages	→	→	→	↗ (red) ↘ (green)	↗ (red) ↘ (green)	23.3.1
Coastal flood damages	n/a	↗ (red) →	↗ (red) →	↗ (red) →	↗ (red) →	23.3.1
Tourism						
Length of ski season	→ ↘ (red)	?	↘ (red)	↘ (red)	?	23.3.6, 3.5.7
Human health						
Heat wave mortality and morbidity	→	↗ (red)	↗ (red)	↗ (red)	↗ (red)	23.5.1
Food safety	→	↗ (red)	↗ (red)	↗ (red)	↗ (red)	23.5.1

Table 23-4: Assessment of climate change impacts by sub-region by 2050, assuming a medium emissions scenario, and no planned adaptation.(2)

	Alpine	**Southern**	Northern	Continental	Atlantic	
Social and cultural Impacts						
Social costs of floods	→	→	→	↗ (red) ↘ (green)	↗ (red) ↘ (green)	23.5.3
Damage on cultural buildings	↗ (red)	↗ (red) ↘ (green)	↗ (red)	↗ (red)	↗ (red)	23.5.4
Loss of cultural landscapes	↗ (red)	?	↗ (red)	↗ (red)	↗ (red)	23.5.4
Environmental quality						
Air quality (ozone background levels)	?	↗ (red) ↘ (green)	↗ (red) ↘ (green)	↗ (red) ↘ (green)	↗ (red) ↘ (green)	23.6.1
Air quality (particulates)	?	→	→	→	→	23.6.1
Water quality	→	↘ (red)	→	→	↘ (red)	23.6.3

Key:
Green means a "beneficial" change
Red means a "harmful" change
? means no relevant literature found

Table 23-5: **Key risks** from climate change in Europe and the potential for reducing risk through mitigation and adaptation.

Key risk	Adaptation issues and prospects	Climatic drivers	Supporting ch. sections	Timeframe	Risk for current and high adaptation
Increased economic losses and people affected by flooding in river basins and coasts, driven by increasing urbanisation and by increasing sea-levels and increasing peak river discharges (*high confidence*)	Adaptation can prevent most of the projected damages (high confidence). The experience in hard flood protection technologies is significant. Main issues include the high costs for increasing flood protection demand for land in Europe, and environmental and landscape concerns.		23.2.3, 23.3.1, 23.7	Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low / Medium / Very high
Increased water restrictions. Significant reduction in water availability from river abstraction and from groundwater resources, combined to increased demands from a range of sectors (irrigation, energy and industry, domestic use) and to reduced water drainage and run-off (as a result of increased evaporative demand) (*high confidence*)	Proven adaptation potential from changes in technologies and adoption of more water efficient technologies and of water saving strategies (irrigation, crop species, land cover, industries, domestic use). Further adaptation possible through solar desalinization (to limit fossil fuel demand).		23.4.3, 23.4.4, 23.7.2	Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low / Medium / Very high
Increased economic losses and people affected by extreme heat events: impacts on health, welfare (overheating in buildings), labour productivity, crop production, reduced air quality (*medium confidence*)	Implementation of warning systems, adaptation of dwellings and work places, and transport and energy infratructure. Reductions in emissions to improve air quality. Improved wild fire management.		23.3.2, 23.3.4, 23.3.3, 23.5, 23.6.1, 23.6.3, 23.7.4	Present Near-term (2030-2040) Long-term (2080-2100) 2°C 4°C	Very low / Medium / Very high

Climatic drivers of impacts

Warming trend · Extreme temperature · Extreme precipitation · Damaging cyclone · Sea level

Risk & potential for adaptation

Potential for adaptation to reduce risk

Risk level with **high** adaptation · Risk level with **current** adaptation

Table 23-6: **Observed changes** in key indicators in ecological and human systems attributable to climate factors.

Indicator	*Change in indicator*	*Confidence in detection*	*Confidence in attribution to change in climate factors [**]*	*Key references*	*Section*
		Bio-Physical Systems			
Glacier retreat	Fast mass loss of 30 Swiss glaciers since the 1980s	High confidence	Medium confidence	Huss, 2010	18.3.1.3 WG1 10.5
		Infrastructure			
Storm losses	Increase since 1970s	High confidence	No causal role for climate	Barredo, 2010	23.3.7
Hail losses	Increase in parts of Germany	Low confidence	Low confidence	Kunz *et al.*, 2009	23.3.7
Flood losses	Increasing general trend in economic losses in Europe since 1970s; none in some locations	Medium confidence	No causal role for climate	Barredo, 2009; Barredo et al., 2012	23.3.1
		Agriculture, Fisheries, Forestry, and Bioenergy Production			
C3 crop yield	CO_2 induced positive contribution to yield since preindustrial for C3 crops	High confidence (high agreement, robust evidence)	High confidence (high agreement, robust evidence)	Amthor, 2001; Long *et al.*, 2006; McGrath and Lobell, 2011	7.2.1
Wheat yield	Stagnation of wheat yields in some countries in recent decades	High confidence	Medium confidence	Lobell *et al.* 2011 ; Brisson et al., 2010; Kristensen et al., 2011	23.4.1
Phenology –leaf greening	Earlier greening, Earlier leaf emergence and fruit set in temperate and boreal climate,	High confidence (high agreement, robust evidence)	High confidence (high agreement, robust evidence)	Menzel *et al.*, 2006	4.4.1.1
Phytoplankton productivity	Increased phytoplankton productivity in NE. Atlantic, decrease in warmer regions, due to warming trend and hydroclimatic variations	High confidence	Medium confidence	Beaugrand *et al.*, 2002; Edwards and Richardson, 2004	6.3.2
Ocean systems	Northward movement of species and increased species richness due to warming trend	High confidence	Medium confidence	Philippart *et al.* , 2011	6.3.2
		Environmental quality and biodiversity			
Biodiversity	Increased number of colonization events by alien plant species in Europe	Medium confidence (high agreement, medium evidence)	Medium confidence	Walther *et al.*, 2009	4.2.4.6
Migratory birds	Decline over the period 1990-200 of species that did not advance their spring migration	Medium confidence (medium agreement, medium evidence)	Medium confidence	Moller *et al.*, 2008	4.4.1.1
Tree species	Upward shift in tree line in Europe	Medium evidence (medium agreement, high evidence)	Medium confidence	Gehrig-Fasel *et al.*, 2007, Lenoir *et al.*, 2008	18.3.2.1
Forest fires	Increase in burnt area	High confidence	High confidence (high agreement, robust evidence)	Camia and Amatulli 2009; Hoinka et al., 2009; Carvalho et al., 2010; Salis et al., in press; Pereira et al., 2005; Koutsias et al., 2012	23.4.4