# Impacts of climate change in Europe

Europe’s climate shows regional variability. The sensitivity to climate change in Europe has a north-south gradient; many studies indicate that southern Europe will be more severely hit than northern Europe. In Europe, climate change will affect more than 830 million people through reduced provisions of agriculture, forestry, fisheries, infrastructure, and tourism; changes in weather and biodiversity; effect on human health, society and economy. (EEA 2010, EC 2007) The annual average temperature is projected to rise this century by 1-5.5 degrees Celsius (best estimate, EEA 2008) with the largest warming over eastern and northern Europe during winter, and over south-western and Mediterranean Europe during summer.

### Observed climate change impacts

European land areas have warmed up by more than 1.2 degrees Celsius (IPCC 2007) above pre-industrial levels, with a further increase expected by the end of the 21st century. Eight of the 12 years between 1996 and 2007 were among the warmest years since 1850. For Europe as a whole heavy rain events have increased in the past 50 years and are projected to continue to become more frequent, while dry periods are projected to increase in length and frequency in southern Europe. Since 1850, glaciers in the European Alps have lost approximately two thirds of their volume, with clear acceleration since the 1980s (EEA 2008). Snow cover in the northern hemisphere has fallen by 1,3% per decade during the past 40 years. There is evidence that the flowering and maturity of several species in Europe occurs two to three weeks earlier than in the past.

Further climate change in Europe in expected to bring about an increase in frequency of extreme weather conditions:

* Extreme seasons, especially exceptionally hot and dry summers in southern Europe.
* Short-duration events such as wind storms, heavy rains, floods, droughts.
* Long term changes in climate which will put particular pressure on coastal areas (f.ex. through sea level rise)

### Most sensitive regions in Europe

* Coastal zones, low lying areas, deltas, due to sea level rise combined with increased risk of storms.
* South and southeast Europe, the Mediterranean Basin, due to high temperature increases and reduced precipitation.
* Mountain areas, where temperatures increase rapidly leading to widespread melting of snow, changing river flow and loss of biodiversity.

(EEA 2008, EC 2007)

## Impacts on biodiversity

Climate change impacts plant and animal species and their habitats. Changes to local conditions and resources will influence a species’ ability to survive. Directly or indirectly, climate change produces effects on:

* Habitat loss, relocation, changes in dispersal and diversity of species. Changes in the structure, function and composition of ecosystems.
* Changes in timing of life stages, mismatching of species life-cycle events and food sources, decoupled predatory-prey relationships
* New invasive alien species
* Terrestrial and marine ecosystems currently absorb roughly half of anthropogenic CO2 emissions. Loss of ecosystems would reduce the capacity of Earth’s carbon sinks.

In Europe biodiversity is in decline due to urbanization, industrialization, modification of rivers, agricultural and forest management and fragmentation of habitats between infrastructure. The fragmentation of habitats may restrict movement of species which will reduce their ability to adapt. Further climate change will change and reduce the adaptive capacity of ecosystems. Milder winters will result into northward shifts of many European plants. Mountain ecosystems in many parts of Europe are changing as alien pioneer species invade and expand uphill and cold-adapted species are driven out of their ranges. Forests are likely to contract in the south and expand in the north. European birds, insects, and mammals are moving northwards, but are not necessarily keeping in pace with the climate. Europe’s birds are projected to shift nearly 550km to the northeast by the end of the century (EEA 2008). There are several examples of research that studies the already observable results to biodiversity in Europe, few examples from the EEA 2010 publication ’ 10 Messages for 2010 - Climate Change and Biodiversity’ :

* Alpine plants represent a large proportion of Europe’s native plant diversity. Alpine plants are a sensitive and vulnerable indicator group of global warming impacts. Observations taken during 1994-2004 as part of the GLORIA observation network clearly show a shift of plants towards higher altitudes. The populations of subnival and nival species, dwelling near a mountain’s peak and therefor unable to move upwards, were declining.
* Regular monitoring of butterflies in three countries (Finland, Netherlands and the UK) and analysis of butterfly climatic envelopes, reveals changes in butterfly communities during the period 1990-2005, with significant trend towards higher proportion of ‘warm’ species relative to ‘cool’ species.

Timing of seasonal events in plants is changing across Europe, 78% of leaf unfolding and flowering records show advancing trends and only 3% a significant delay. The average advance of spring and summer has been 2.5 days per decade, during the last 30 years. The pollen season starts on average 10 days earlier and is longer than 50 years ago. Healthy ecosystems can significantly mitigate the effects of climate change, impact on animal and plant species and human quality of life. Healthy biodiversity and ecosystems provide fresh air and water, reduce wind speed and erosion, regulate the nitrogen and carbon cycles, and provide a genetic resource for environmental adaption. (EEA, 2010)

There are signs that 19% of habitats and 12% of species of European interests are potentially threatened by climate change over their natural European range. Bogs, mires and fens are the most vulnerable habitat types. Species of greatest threat include specialists, animals at the top of the food chain and animals with poor dispersal abilities or demanding habitat requirements. Of the species groups, amphibians are worst affected. (EEA, 2010) Breeding seasons are lengthening, allowing extra generations of temperature-sensitive insects such as butterflies and pest species to be produced during the year. Pest species population, variety and distribution may explode if the young are not exposed to normal predatory or environmental pressures.

The length of the growing season of several agricultural crops in Europe has changed and will continue to change. A longer growing season increases crop yields, but also the insect and pest populations in areas that were not previously capable of radiating to the area. The increase in length of the growing season and change in insect species are observed mainly for the northern latitudes, at southern latitudes the trend is towards a shorter growing season and high risks of drought and frost damage due to delayed spring frosts. Farm practices will need to adapt to avoid negative impacts of crop-cycle changes.

## Risks of non-linear climate change

Perhaps better known as ‘Abrupt Climate Change’ it is a forced transition to a new state at a rate that is determined by the climate system itself and which is more rapid than the rate of change caused by external forcing.

Global systems are inherently complex, consisting of multiple interacting sub-units with more than one equilibrium state. They exhibit “emergent properties” that do not exist in any one unit alone due to complex interaction between the sub-systems, resulting in non-linear behavior. Crossing a tipping point, or other threshold can lead to unpredictable and even irreversible changes. (OECD, 2003)

### Global tipping points:

* Possible deglaciation of the West Antarctic Icesheet and Greenland. Sustained warming of 1-2 degrees Celsius is a threshold beyond which there will be a commitment to a large sea-level rise due to the partial deglaciation of both sheets. Sea levels may rise over the next 1000 years.
* Under slowing or full shut-down of the thermohaline circulation, temperatures on Europe’s western margin would be most affected, together with further rises in relative sea level on European coasts.
* Progressive emission of methane from permafrost melting.
* Rapid climate-drive transitions from one ecosystem to another.

### Thermohaline circulation

The thermohaline circulation is a large ocean circulation that is driven by global water density gradients created by surface heat and freshwater or saltiness. Warm water travels on the surface heading polewards from the equatorial Atlantic Ocean, cooling all the while and eventually sinking at high latitudes. The dense, cold water then flows into the ocean basins. If warming reduces the ability of surface water to sink in the north, this interferes with the inflow of warm water from the south. Slowdown of the thermohaline circulation in the North Atlantic may counteract the global warming trends in Europe, but have serious consequences for the behavior of the world’s climate system with exacerbated impacts elsewhere. The IPCC Fourth assessment report states several impacts on European climate due to the slowdown of the thermohaline circulation:

* + - Reductions in runoff and water availability in southern Europe; major increase in snowmelt flooding in western Europe.
    - Increased sea-level rise on western European and Mediterranean coasts.
    - Reductions in crop production with consequent impacts on food prices.
    - Changes in temperature affecting ecosystems in western Europe and the Mediterranean (e.g., affecting biodiversity, forest products and food production).
    - Disruption to winter travel opportunities and increased icing of northern ports and seas.
    - Changes in regional patterns of increases versus decreases in cold- and heat-related deaths and ill-health.
    - Movement of populations to southern Europe and a shift in the centre of economic gravity.
    - Requirement to refurbish infrastructure towards Scandinavian standards.

## Economic impacts

Extreme weather events have direct impact on human health and indirect costs for the economy. For instance, a series of major windstorm catastrophes caused losses of EUR 17.8 billion in central Europe during 1990-2007 and flood catastrophes in central Europe in 1993-2006 caused overall losses of up to EUR 85.8 billion. (EEA, 2010) The costs of adaptation are estimated to be significant, but we can assume that the longer we wait before taking action the higher the costs will be.

### Northern Europe

* Decreased winter heating benefit and reduced energy costs.
* Increased tourism opportunities but reduced ski season
* Increased forestry and agricultural production (short-term)
* Increased winter storm risk and economic damages
* Rainfall and snowfall significantly increased

### Central Europe

* Rising risk of sea level rise and coastal floods to European coastlines or rising costs of coastal protection
* Increased frequency and magnitude of winter floods
* Reduced alpine snow and winter sport tourism and revenues

### Southern Europe

* Rising summer electricity use and increased energy costs
* Reduced water availability and losses or increased costs of supply, more frequent droughts
* Increased forest fire risk
* Reduced agricultural yields
* Reduction in peak summer tourism
* Increased health effects of heat-waves
* Impacts on ecosystem services

## Adopted policy

The EU has set a target to limit global temperature rise to 2°C above pre-industrial level. The target was set from a perspective of reducing non-linear climate change with potentially very large consequences. Beyond 2°C change, the risk of dangerous and unpredictable climate change increases significantly and costs of adaptation escalate. The target maximum of 2°C will limit risk, but not avoid all impacts. The European Commission adopted a Green Paper, ‘Adapting to climate change in Europe — options for EU action', in June 2007. (EC, 2007) It proposes four pillars of action:

* Early action. Integrate adaptation when implementing and modifying existing and forthcoming legislation and policies
* Integrating adaptation into EU external actions.
* Expanding knowledge base through integrated climate research.
* Involving European society, business and public sector in the preparation of coordinated and comprehensive adaptation strategies.

The EU target of limiting global average warming to not more than 2°C above pre-industrial level is projected to be exceeded between 2040 and 2060, for the all six IPCC scenarios.

### Under 2C degrees warming

- Melting of the Greenland ice sheet can be initiated by a global temperature rise between 1 and 2 degrees Celsius and could be irreversible if temperature rise is sustained.

- Increase of less than 2C is likely to allow adaption to climate change for many human systems at moderate human/economic cost. (In Europe)

- Many natural ecosystems have limited capability to adapt to rapid climate change and their limits might be exceeded before 2C is reached.

### Over 2C degrees warming

- At a temperature rise of more than 2 C above pre-industrial levels, there is an increase in the risk of a range of severe large-scale events, such as shutdown of the thermohaline circulation.

- Beyond 2C major increases in vulnerability, considerable impacts, costly adaptation needs, risk of large-scale irreversible effects, substantial increase in the uncertainty of the impacts.

(IPCC 2007, EEA 2008)

## Sources:

**Green Paper from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions - Adapting to climate change in Europe – options for EU action {SEC(2007) 849} /\* COM/2007/0354 final \*/**

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