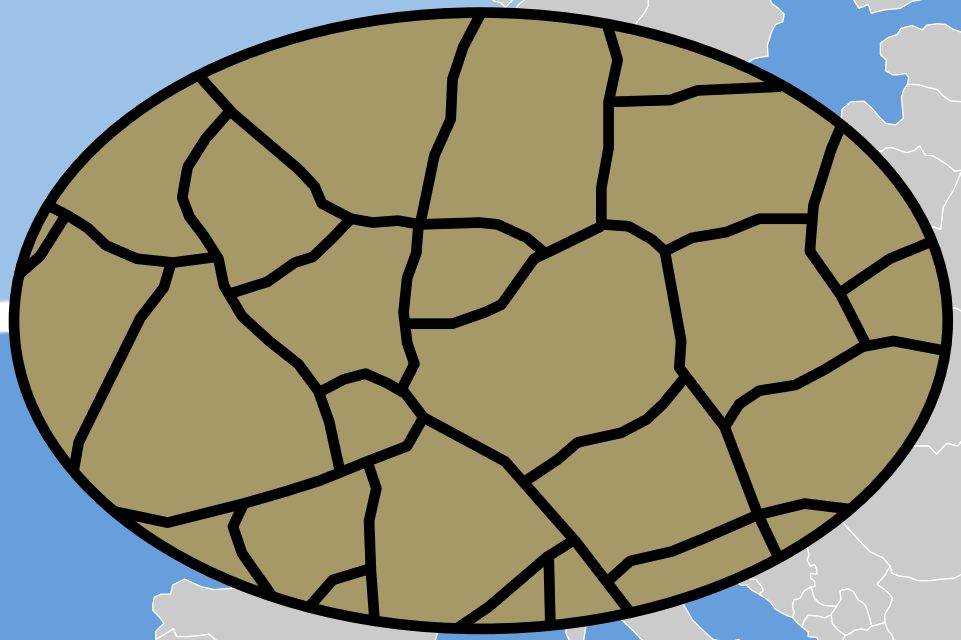
Europe's droughts in a changing climate



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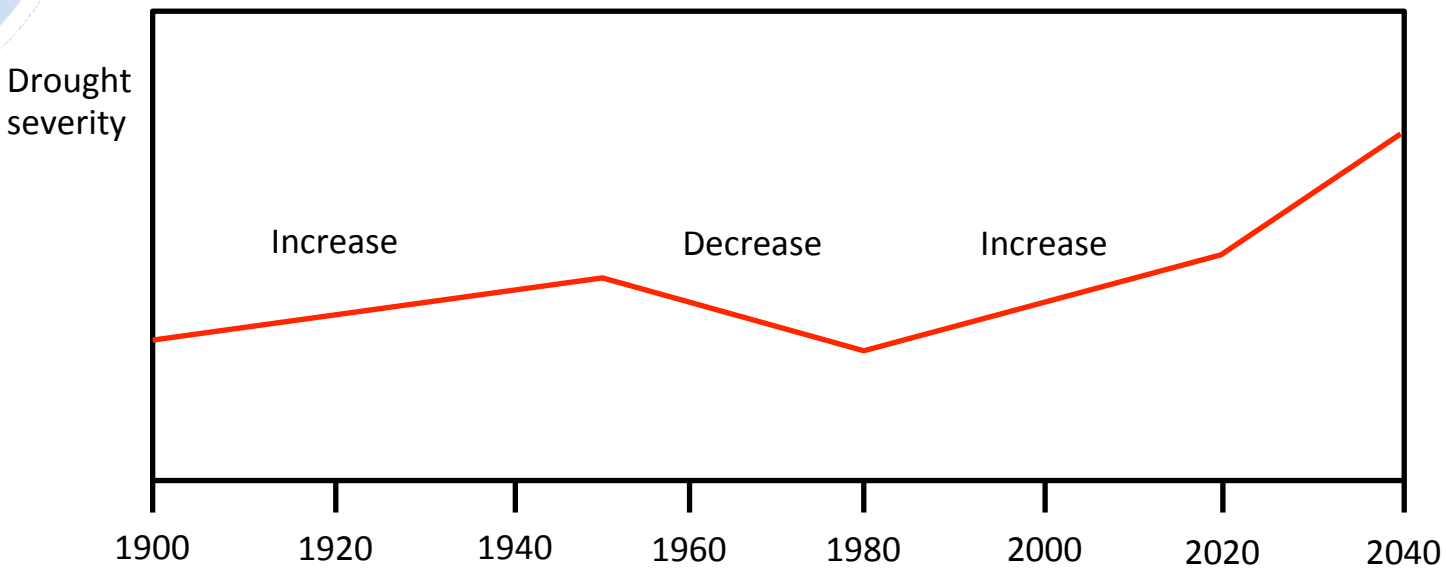
Droughts: Global annual trends



Two conclusions:

- Man-made climate change has increased droughts for already 100 years. But: no continuous trend. From 1950 to 1975 decrease: it looks like air pollution (aerosols) and volcanic eruptions blocked sunlight and influenced rainfall such that the drought trend was reversed.
- Clear signals of drought increase, and decrease around mid-century, are only revealed by looking at the global scale. On a regional scale, for instance Europe, natural variability is too large compared to the signal we're looking for.

Source: Marvel et al. (2019)

Droughts

Definition

Four types of droughts

Meteorological droughts relate to a deficiency of precipitation.

Hydrological droughts reduce stream flow and low water levels of reservoirs and lakes, affecting water resources management, power plant cooling, irrigation, and inland navigation.

Agricultural droughts are characterized by low soil water availability for plants, potentially leading to reduced biomass and yield or crop failure.

Socioeconomic droughts can emerge from all of the aforementioned drought types. It is characterized by a shortfall of water supply (water scarcity) leading to monetary losses.

Droughts

The cost of droughts

The cost of droughts in Europe over the past thirty years was € 100 billion. Total economic damage of the drought of 2003 in around twenty European countries was over €13 billion.

Main impacts are losses for the agricultural sector, especially in the southern half of Europe.

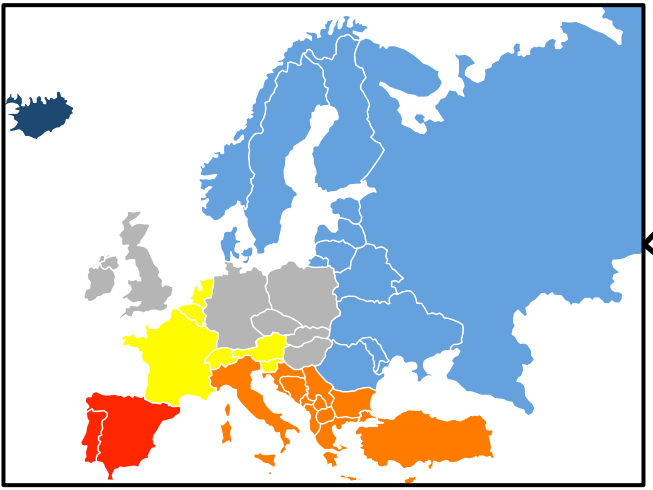
Additional socioeconomic impacts are those on navigation, hydropower, water supply.

Droughts may also strongly affect biodiversity.

Droughts are the second most important natural disaster after floods. From 2006-2010, on average **15% of the EU territory and 17% of the EU population have been affected by meteorological droughts each year**. In the 1990s and 2000s the drought hotspots were the Mediterranean area and the Carpathian Region.

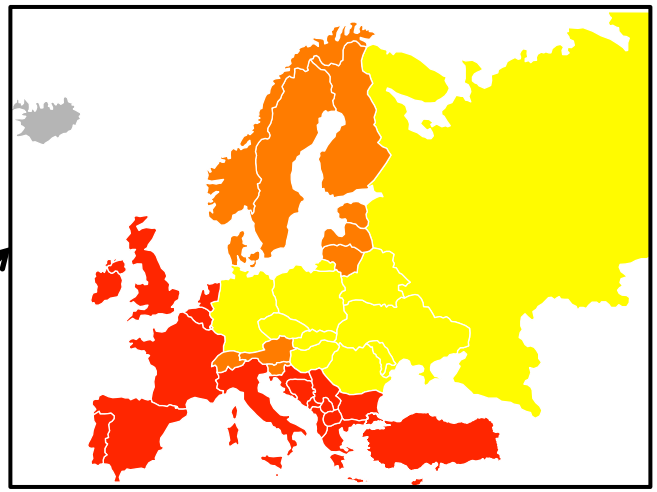
Droughts: annual trends

Observed trends 1951-2010



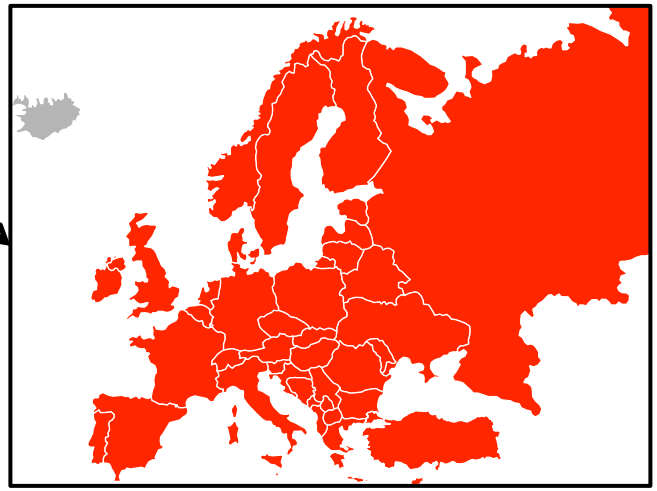
Moderate scenario of climate change

Projected trends 2011-2100



High-end scenario of climate change

Projected trends 2011-2100



Drought frequency trends
(source: Spinoni et al., 2018)

- Strong increase in most of the region
- Increase in most of the region
- Moderate increase in most of the region
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- Decrease in most of the region
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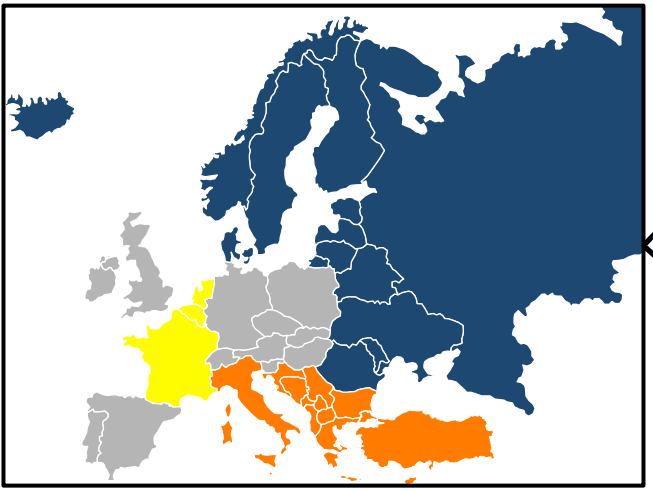
Droughts: winter trends

Observed trends 1951-2010



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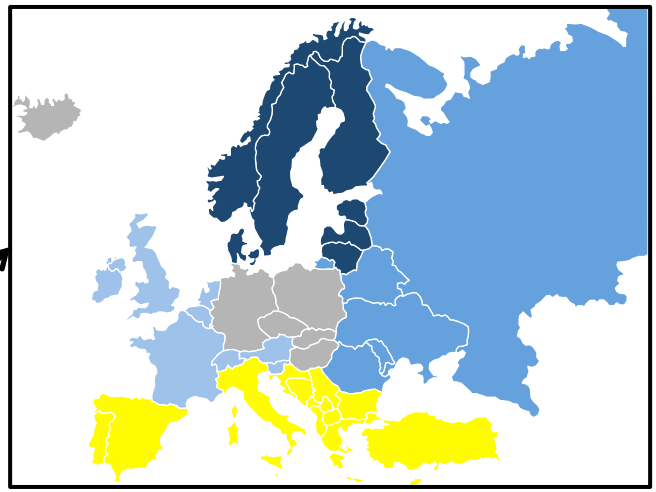

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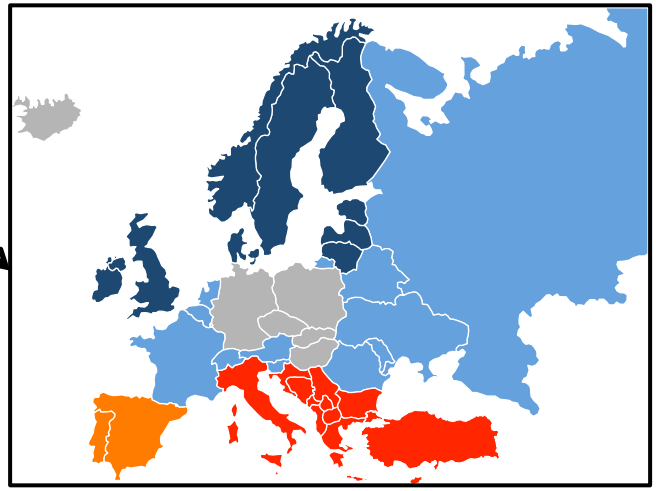

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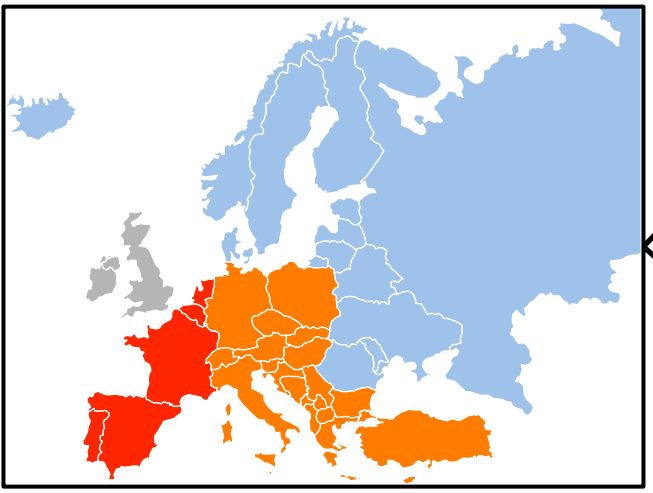
Droughts: spring trends

Observed trends 1951-2010



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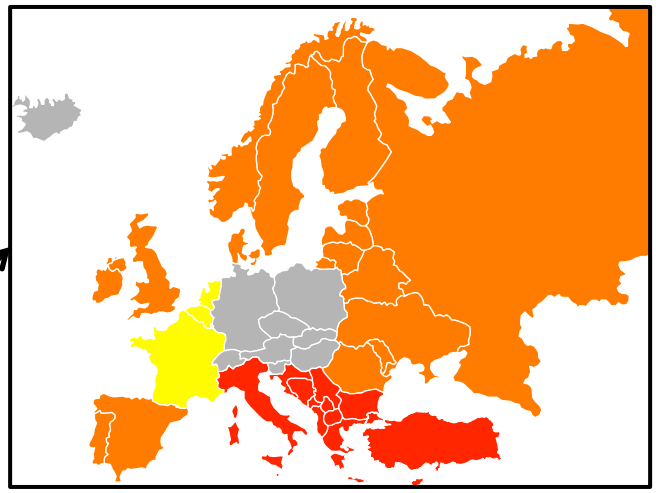

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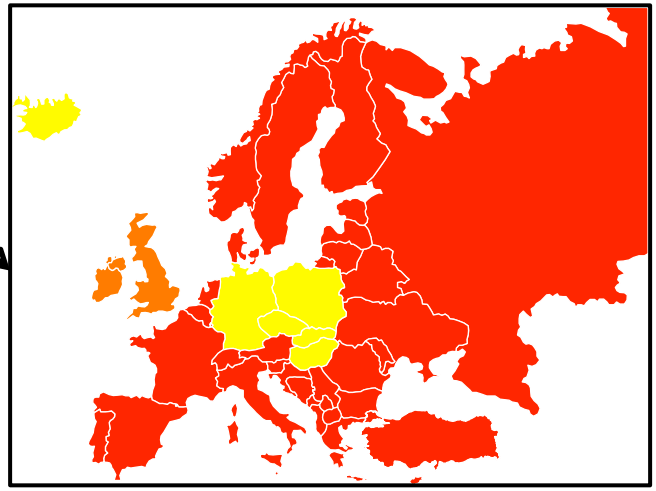

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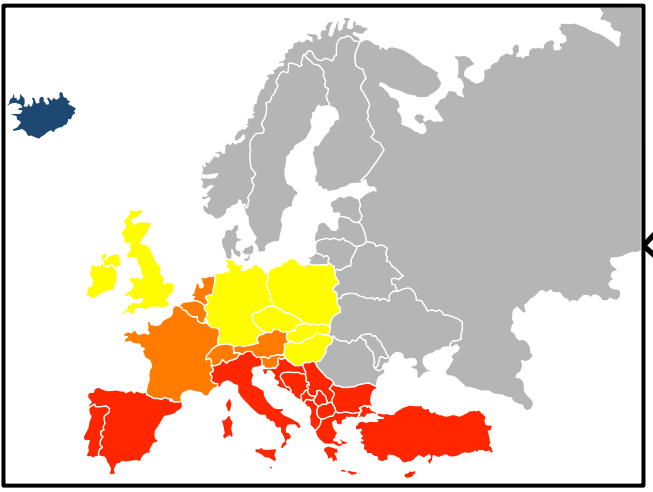
Droughts: summer trends

Observed trends 1951-2010



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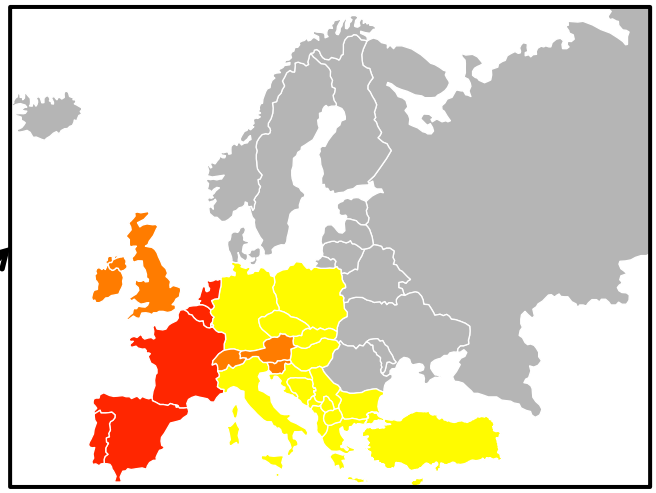

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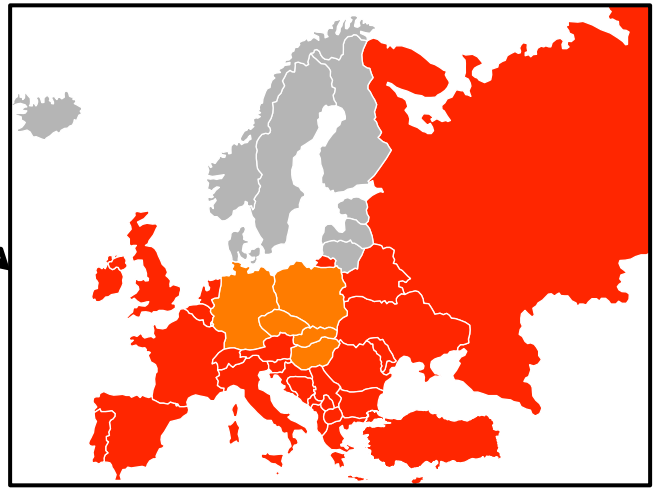

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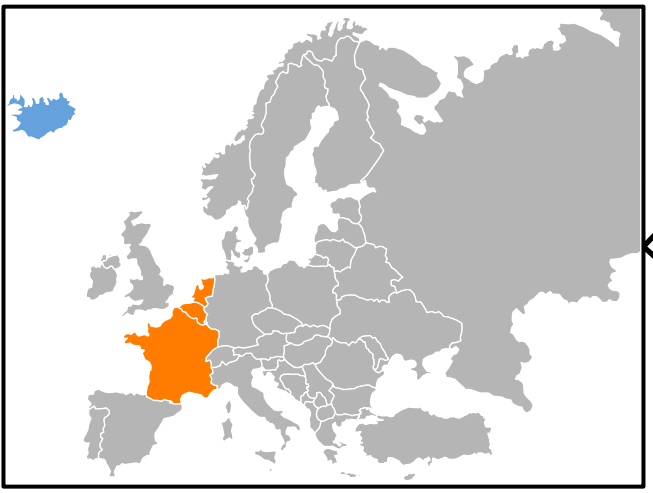
Droughts: autumn trends

Observed trends 1951-2010



Moderate scenario of climate change

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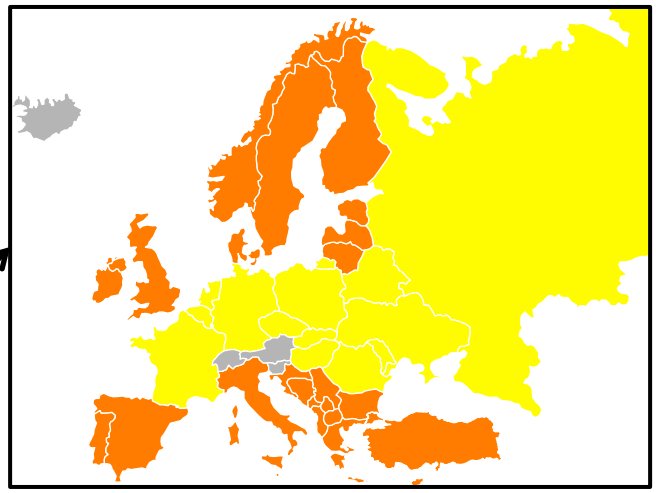

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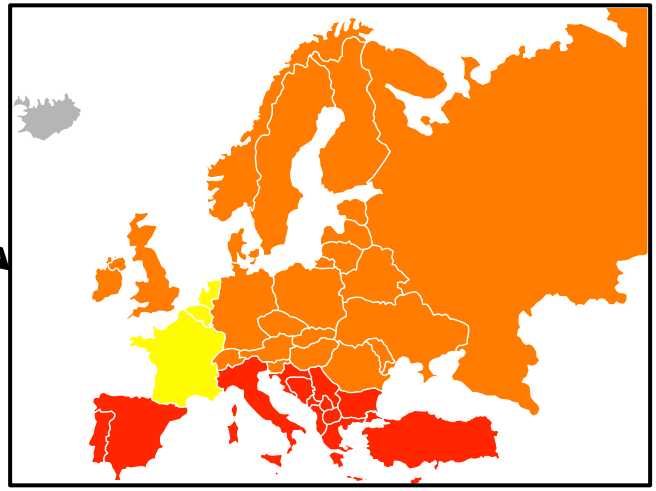

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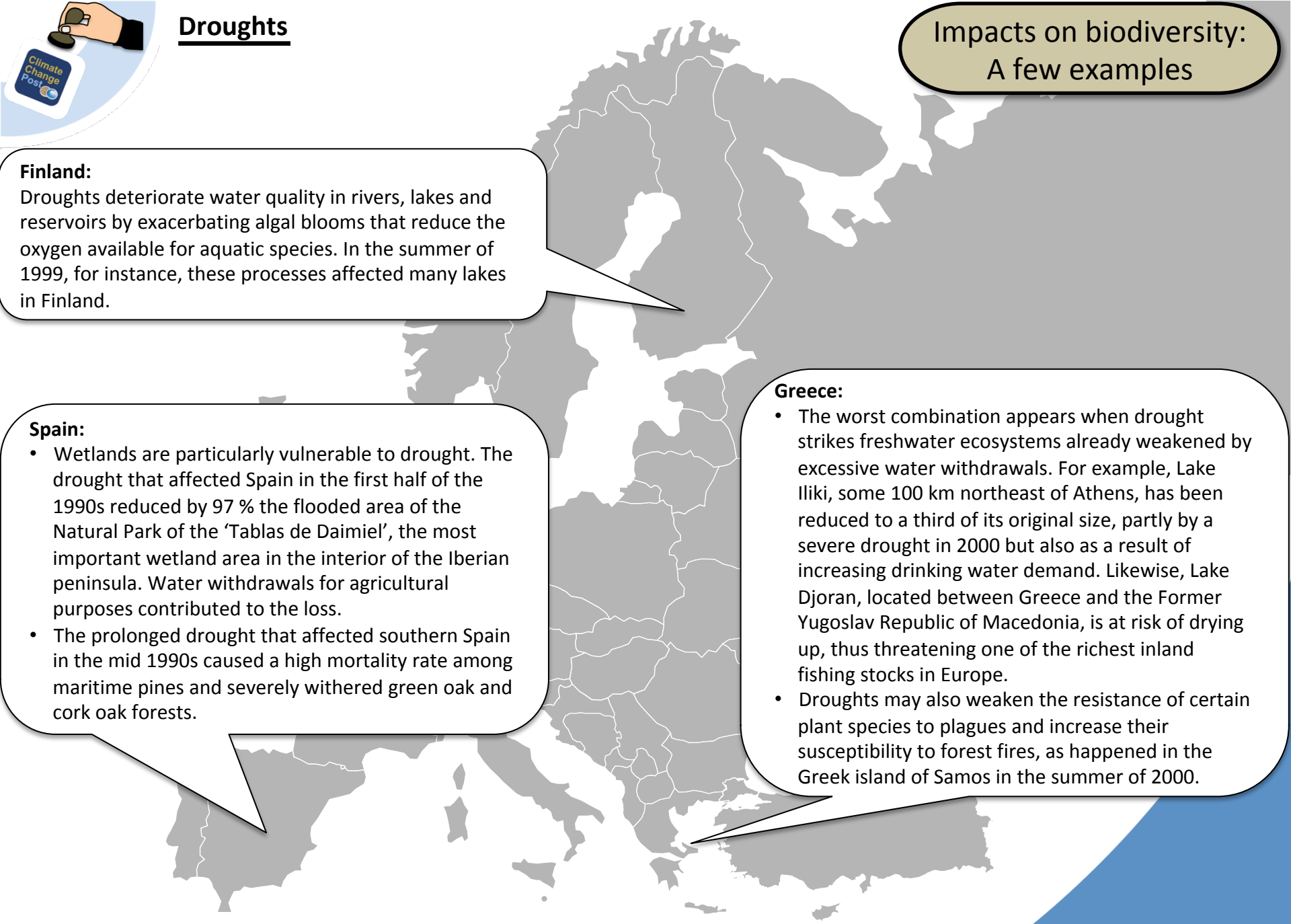
Droughts

Impacts on biodiversity: A few examples



Finland:
Droughts deteriorate water quality in rivers, lakes and reservoirs by exacerbating algal blooms that reduce the oxygen available for aquatic species. In the summer of 1999, for instance, these processes affected many lakes in Finland.

Spain:

- Wetlands are particularly vulnerable to drought. The drought that affected Spain in the first half of the 1990s reduced by 97 % the flooded area of the Natural Park of the 'Tablas de Daimiel', the most important wetland area in the interior of the Iberian peninsula. Water withdrawals for agricultural purposes contributed to the loss.
- The prolonged drought that affected southern Spain in the mid 1990s caused a high mortality rate among maritime pines and severely withered green oak and cork oak forests.

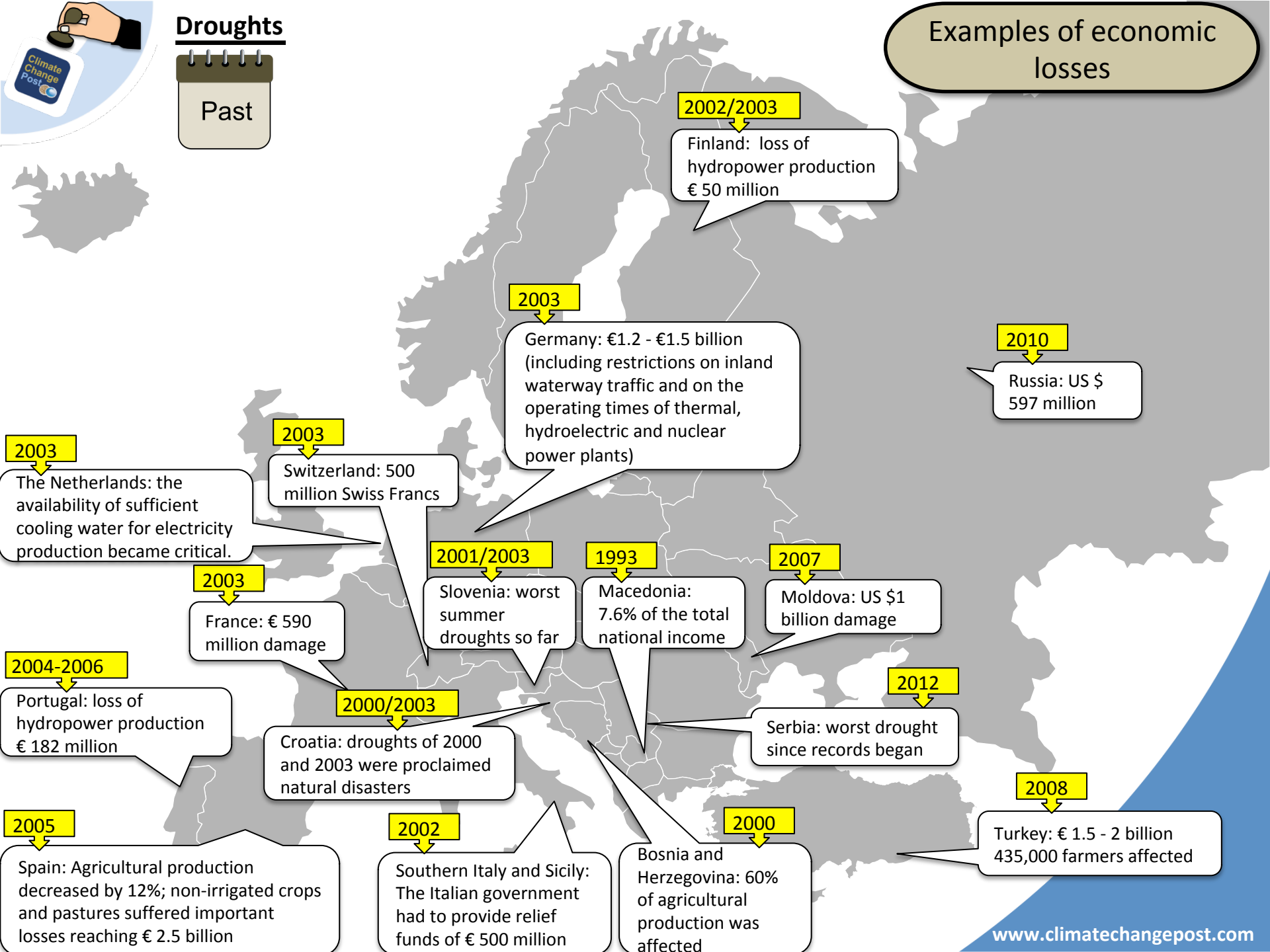
Greece:

- The worst combination appears when drought strikes freshwater ecosystems already weakened by excessive water withdrawals. For example, Lake Iliki, some 100 km northeast of Athens, has been reduced to a third of its original size, partly by a severe drought in 2000 but also as a result of increasing drinking water demand. Likewise, Lake Djoran, located between Greece and the Former Yugoslav Republic of Macedonia, is at risk of drying up, thus threatening one of the richest inland fishing stocks in Europe.
- Droughts may also weaken the resistance of certain plant species to plagues and increase their susceptibility to forest fires, as happened in the Greek island of Samos in the summer of 2000.

Droughts

Past

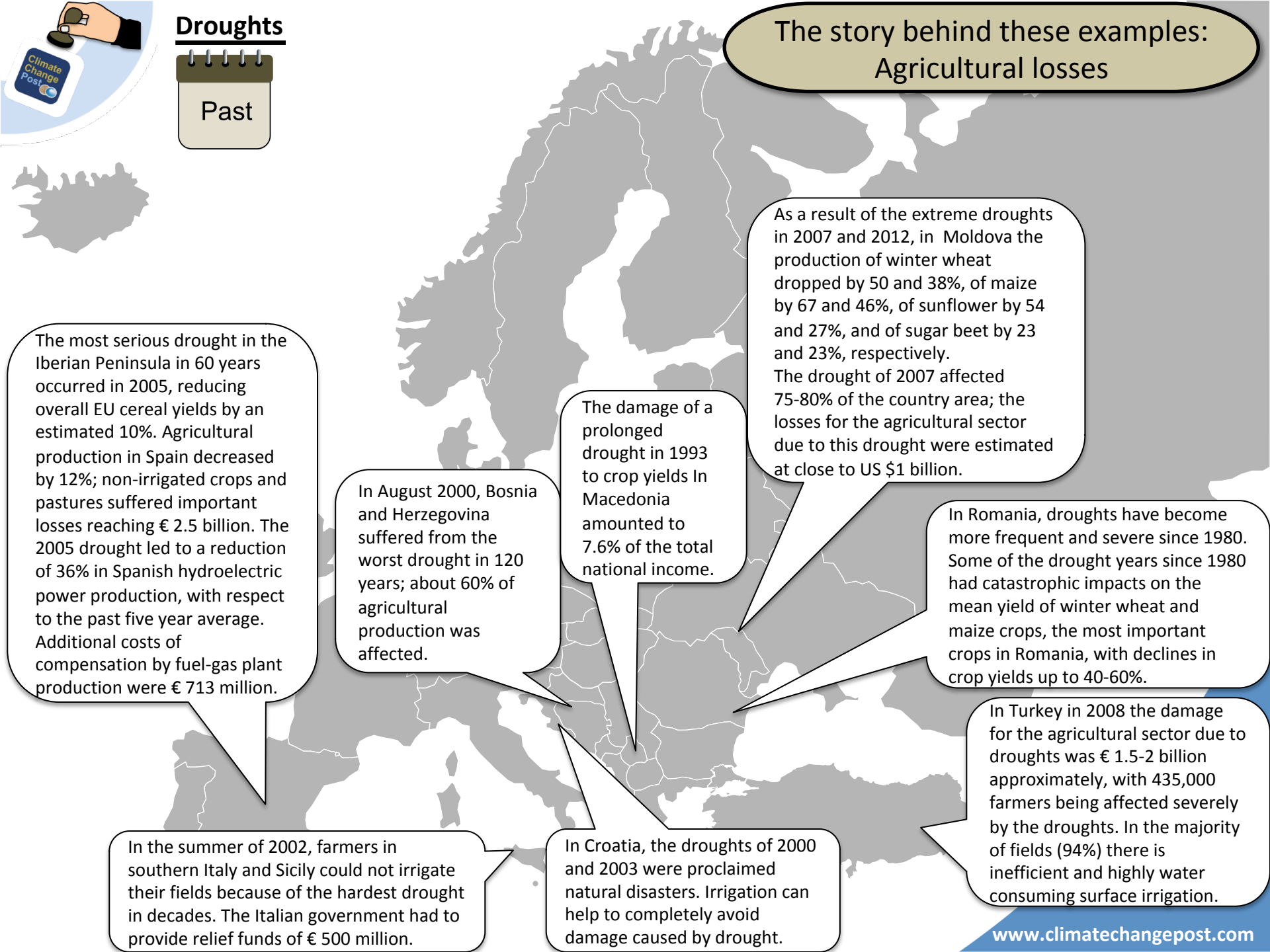
Examples of economic losses



Droughts

Past

The story behind these examples: Agricultural losses



The most serious drought in the Iberian Peninsula in 60 years occurred in 2005, reducing overall EU cereal yields by an estimated 10%. Agricultural production in Spain decreased by 12%; non-irrigated crops and pastures suffered important losses reaching € 2.5 billion. The 2005 drought led to a reduction of 36% in Spanish hydroelectric power production, with respect to the past five year average. Additional costs of compensation by fuel-gas plant production were € 713 million.

In August 2000, Bosnia and Herzegovina suffered from the worst drought in 120 years; about 60% of agricultural production was affected.

The damage of a prolonged drought in 1993 to crop yields In Macedonia amounted to 7.6% of the total national income.

As a result of the extreme droughts in 2007 and 2012, in Moldova the production of winter wheat dropped by 50 and 38%, of maize by 67 and 46%, of sunflower by 54 and 27%, and of sugar beet by 23 and 23%, respectively.
The drought of 2007 affected 75-80% of the country area; the losses for the agricultural sector due to this drought were estimated at close to US $1 billion.

In Romania, droughts have become more frequent and severe since 1980. Some of the drought years since 1980 had catastrophic impacts on the mean yield of winter wheat and maize crops, the most important crops in Romania, with declines in crop yields up to 40-60%.

In Turkey in 2008 the damage for the agricultural sector due to droughts was € 1.5-2 billion approximately, with 435,000 farmers being affected severely by the droughts. In the majority of fields (94%) there is inefficient and highly water consuming surface irrigation.

In the summer of 2002, farmers in southern Italy and Sicily could not irrigate their fields because of the hardest drought in decades. The Italian government had to provide relief funds of € 500 million.

In Croatia, the droughts of 2000 and 2003 were proclaimed natural disasters. Irrigation can help to completely avoid damage caused by drought.

Droughts

Past

The story behind these examples: Impacts on navigation, hydropower, water supply

In the Netherlands, the droughts of 1976 and 2003 caused considerable damage to especially agriculture and forests (wildfires). In 2003 also the availability of sufficient cooling water for electricity production became critical.

A lot of the dikes near canals and lakes in the low-lying parts of the Netherlands are made out of peat. In the summer of 2003 one of the dikes dried out, become unstable and burst, and several houses behind the dikes were flooded.

The costs of the heat wave of 2003 in Germany has been estimated at more than €1.2 billion (losses in the agricultural sector, restrictions on inland waterway traffic and on the operating times of thermal, hydroelectric and nuclear power plants). Others report an agro-economical impact of this drought event for Germany of €1.5 billion.

Hydropower production has been reduced due to drought events in Finland; € 50 million was lost in Finland due to the droughts in 2002-2003.

If a 1976 drought event occurred under current circumstances of water demand, navigation would be made impossible on the Belgian canal system during 115 days, resulting in a cost to the navigation sector of €123 million.

In France the electricity sector encountered difficulties in the dry and hot summer of 2003: low level of water in the reservoirs leading to a loss for hydroelectricity power of about 1,600 MW, and loss of thermal electricity potential production up to 16,000 MW due to decrease in the cooling power of rivers (high water temperature and low river flows).

The 2004-2006 drought in Portugal was the most severe in the last 60 years in terms of land area affected. The country spent € 23.2 million in urban water supply. Loss of hydropower production in this period was € 182 million.

Droughts

Present

Trends from observations

In the Netherlands **no trend has been observed** in the yearly maximum cumulative precipitation deficit over the last 100 years. Water shortages during the summer are a common phenomenon in the Netherlands and are generally not considered to be problematic. Crop loss due to an extreme drought can be € 150 million to € 700 million per year.

It is not yet clear whether droughts in Hungary are affected by climate change already; **there were always heavy drought periods** in Hungary.

Northern half of Europe and parts of eastern Europe: Trend?

The longest periods without significant recorded precipitation show **no major change** since the early 20th century for Belgium.

Droughts are a major problem for Moldova. Since the 1980s, droughts increased in intensity and persistence compared to the past. Between 1990 and 2007, nine droughts were registered in the country. Only 13% of the arable land in Moldova is irrigated. This makes the agriculture sector highly dependent on natural precipitation.

In the wettest parts of Mediterranean France, during the period 1971-2006, drought intensity has increased while droughts on average now last about 1 month longer.

Dry episodes were rarely observed in the mountainous regions over the period 1961-2014.

Droughts are common in continental Portugal. However, its frequency and intensity have increased in the last decades of the 20th century.

Southern Europe and central Europe:

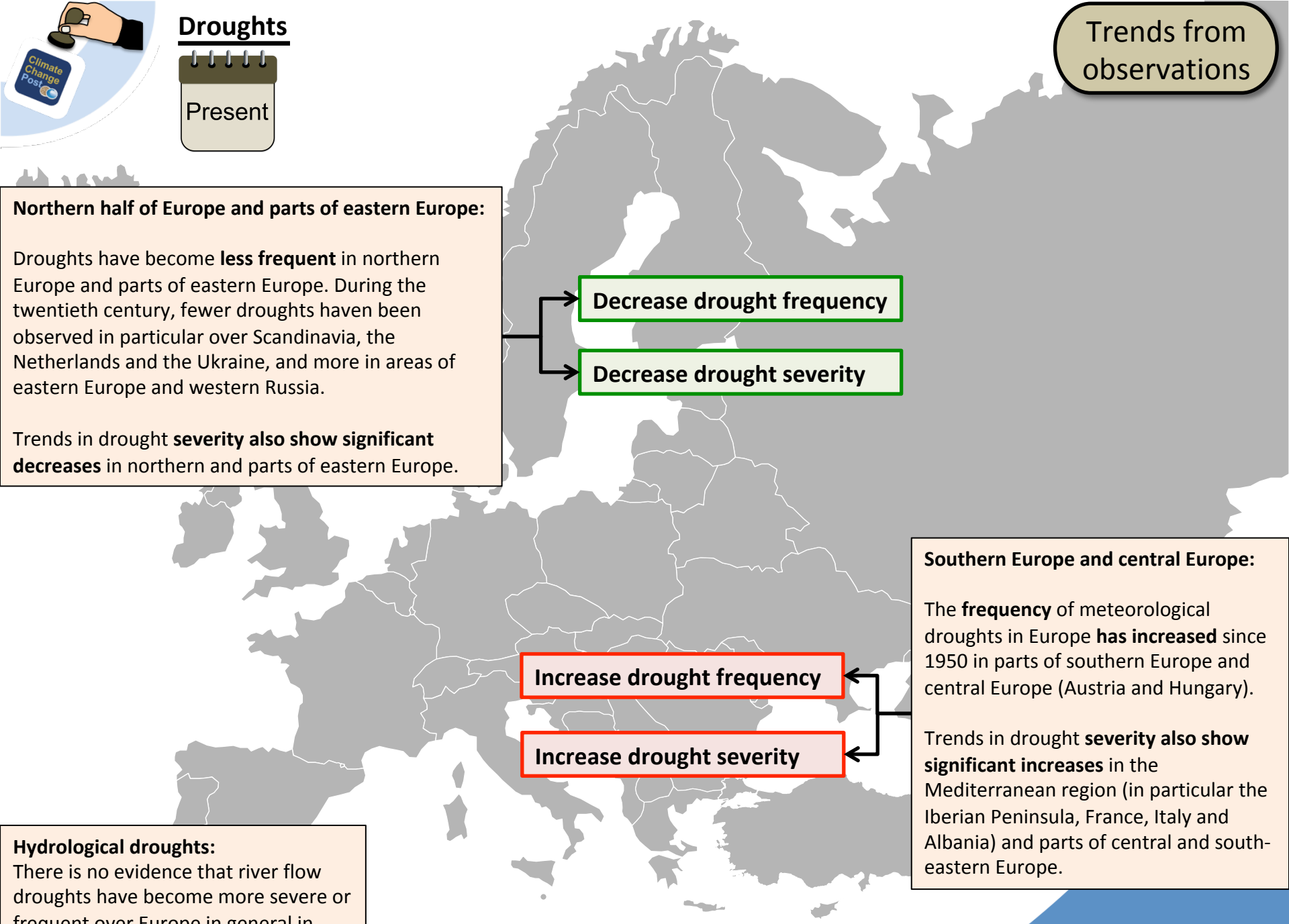
- **Increase drought frequency**
- **Increase drought severity**

There is a clear drying trend for most of the Iberian Peninsula in the period 1906-2010 with maximum rates of change in the south, south-eastern and central Iberia as well as in the Ebro basin. Drying trends are largest for summer. This increase in drought severity was caused by greater atmospheric evaporative demand derived from temperature increase. No significant trend in precipitation was found.

Droughts

Present

Trends from observations



Northern half of Europe and parts of eastern Europe:

Droughts have become **less frequent** in northern Europe and parts of eastern Europe. During the twentieth century, fewer droughts haven been observed in particular over Scandinavia, the Netherlands and the Ukraine, and more in areas of eastern Europe and western Russia.

Trends in drought **severity also show significant decreases** in northern and parts of eastern Europe.

Decrease drought frequency

Decrease drought severity

Increase drought frequency

Increase drought severity

Southern Europe and central Europe:

The **frequency** of meteorological droughts in Europe **has increased** since 1950 in parts of southern Europe and central Europe (Austria and Hungary).

Trends in drought **severity also show significant increases** in the Mediterranean region (in particular the Iberian Peninsula, France, Italy and Albania) and parts of central and south-eastern Europe.

Hydrological droughts:
There is no evidence that river flow droughts have become more severe or frequent over Europe in general in recent decades.

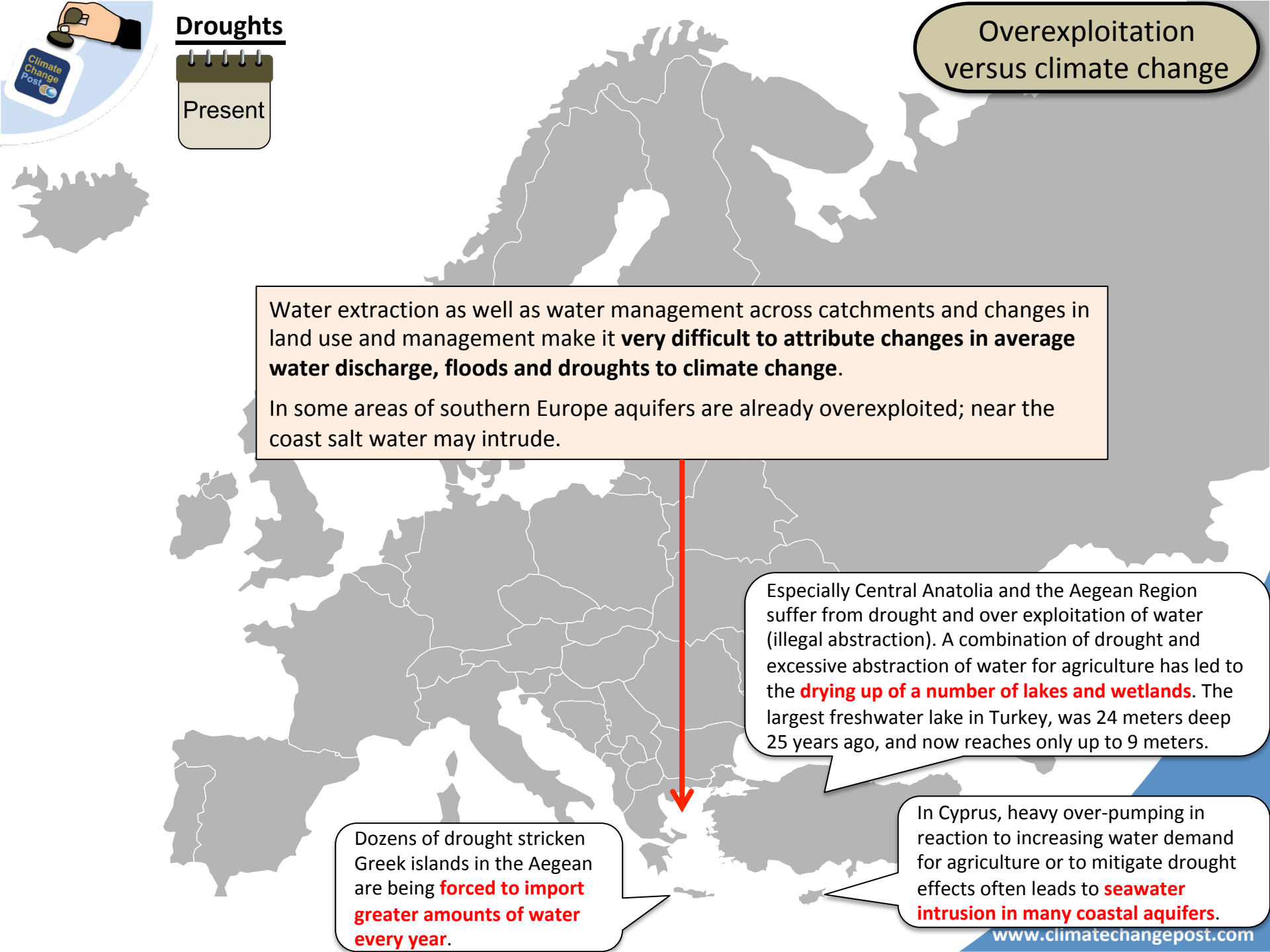
Droughts

Present

Overexploitation versus climate change

Water extraction as well as water management across catchments and changes in land use and management make it **very difficult to attribute changes in average water discharge, floods and droughts to climate change**.

In some areas of southern Europe aquifers are already overexploited; near the coast salt water may intrude.



Especially Central Anatolia and the Aegean Region suffer from drought and over exploitation of water (illegal abstraction). A combination of drought and excessive abstraction of water for agriculture has led to the **drying up of a number of lakes and wetlands**. The largest freshwater lake in Turkey, was 24 meters deep 25 years ago, and now reaches only up to 9 meters.

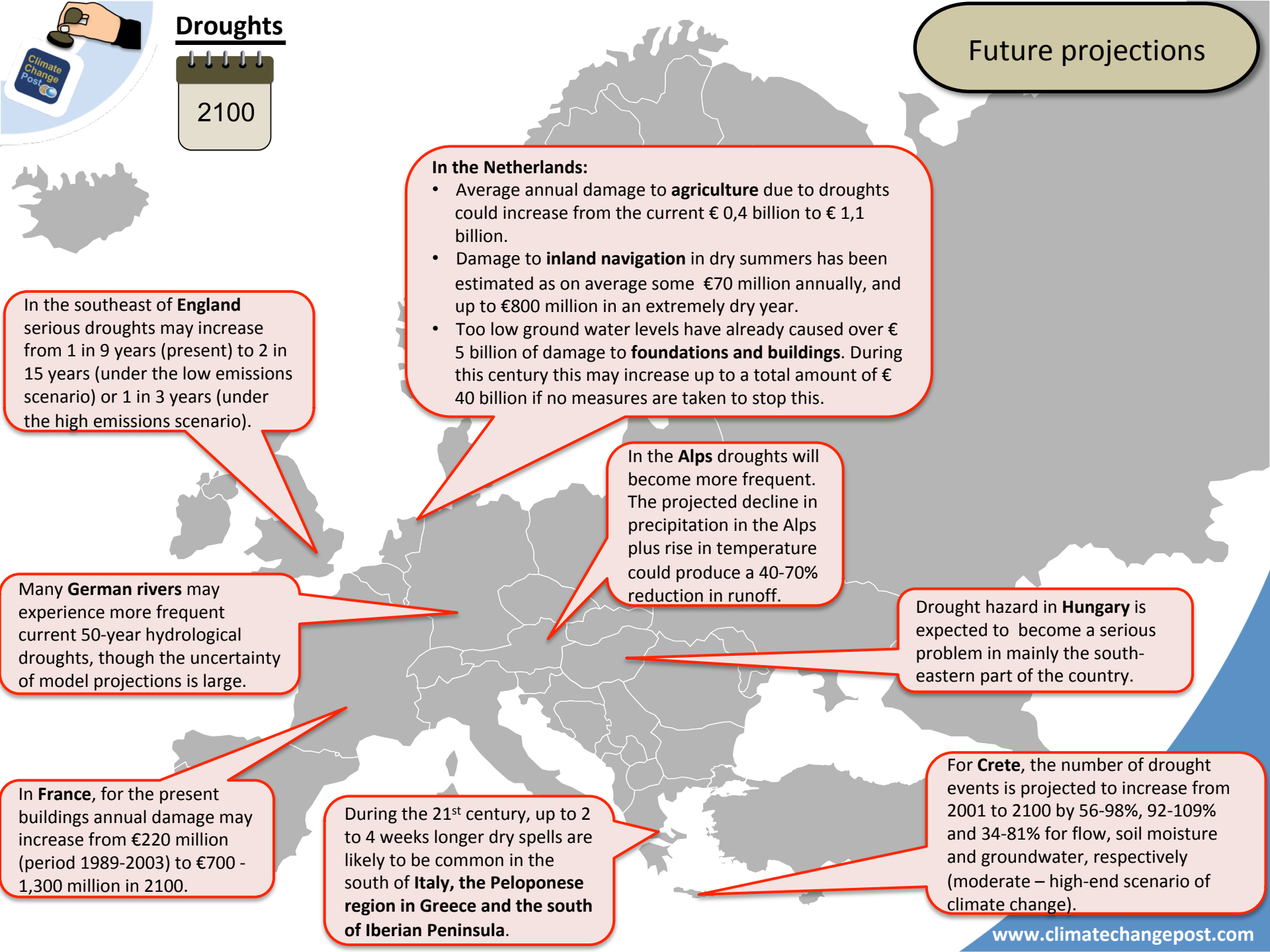
In Cyprus, heavy over-pumping in reaction to increasing water demand for agriculture or to mitigate drought effects often leads to **seawater intrusion in many coastal aquifers**.

Dozens of drought stricken Greek islands in the Aegean are being **forced to import greater amounts of water every year**.

Droughts

2100

Future projections



In the Netherlands:

- Average annual damage to **agriculture** due to droughts could increase from the current € 0,4 billion to € 1,1 billion.
- Damage to **inland navigation** in dry summers has been estimated as on average some €70 million annually, and up to €800 million in an extremely dry year.
- Too low ground water levels have already caused over € 5 billion of damage to **foundations and buildings**. During this century this may increase up to a total amount of € 40 billion if no measures are taken to stop this.

In the southeast of **England** serious droughts may increase from 1 in 9 years (present) to 2 in 15 years (under the low emissions scenario) or 1 in 3 years (under the high emissions scenario).

In the **Alps** droughts will become more frequent. The projected decline in precipitation in the Alps plus rise in temperature could produce a 40-70% reduction in runoff.

Many **German rivers** may experience more frequent current 50-year hydrological droughts, though the uncertainty of model projections is large.

Drought hazard in **Hungary** is expected to become a serious problem in mainly the south-eastern part of the country.

In **France**, for the present buildings annual damage may increase from €220 million (period 1989-2003) to €700 - 1,300 million in 2100.

During the 21st century, up to 2 to 4 weeks longer dry spells are likely to be common in the south of **Italy, the Peloponese region in Greece and the south of Iberian Peninsula**.

For **Crete**, the number of drought events is projected to increase from 2001 to 2100 by 56-98%, 92-109% and 34-81% for flow, soil moisture and groundwater, respectively (moderate – high-end scenario of climate change).

Droughts

2100

Future projections

Meteorological droughts:
Climate models project **longer and more severe droughts in the Mediterranean and Southern and Central Europe**, and **shorter, less severe, events for Scandinavia** with greater uncertainty as to the direction of change for the rest of Europe.

The largest increases in frequency of extreme droughts are projected for parts of the Iberian Peninsula, southern Italy and the eastern Mediterranean.

Hydrological droughts:
River flow droughts are projected to increase in frequency and severity in southern and south-eastern Europe, the United Kingdom, France, Benelux, and western parts of Germany over the coming decades.

The impacts of a +2°C global warming (upper limit Paris Agreement) indicate more extreme hydrological droughts (low river discharge) in magnitude and duration for Spain, France, Italy, Greece, the Balkans, south of the UK and Ireland. For the rest of Europe, the projections generally show a decrease of drought magnitude and duration.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