



Umberto Fratino : Impact des changements climatiques sur les bassins versants méditerranéens

Résumé

The Mediterranean is home to more than 510 million people and this region is warming 20% faster than the global average. By 2050, water demand is projected to double or even triple. The related impacts will exert additional pressure on already strained ecosystems and on vulnerable economies and societies. Many areas, mainly coastal zones, face heightened disaster risks, including flooding and erosion, and the salinization of river deltas and aquifers that sustain food security and livelihoods. Water resources in the Mediterranean are scarce. They are limited, unevenly distributed and often mismatching human and environmental needs. Three quarters of the resource are located in the northern Mediterranean while three quarters of the needs are in the south and east. As a consequence, 180 million people in the southern and eastern Mediterranean countries suffer from water scarcity. On the other hand, northern countries face additional risks in flood prone areas where urban settlements are rapidly increasing. Climate change, in interaction with other drivers (demographic and socio-economic developments), has mainly negative consequences for the water cycle in the Mediterranean, including reduced runoff and groundwater recharge, increased crop water requirements, increased conflicts among users, and increased risk of overexploitation and degradation.



GID –CIHEAM

Parmenides IX Conference



Sustainable management of Mediterranean watersheds faced with the impacts of societal and climate change

Bari (ITALY) - 19 - 21 October 2021



IMPACT OF CLIMATE CHANGE ON MEDITERRANEAN WATERSHEDS

Politecnico di Bari

UMBERTO FRATINO



Marocco, 2014



Sicily (Italy), October 5, 2021



Greece, October 14 - 15, 2021



**The Arabian Desert is covered with rivers.
Oman (cyclone Shaheen), July 2021**

Not only floodings. What's about droughts?



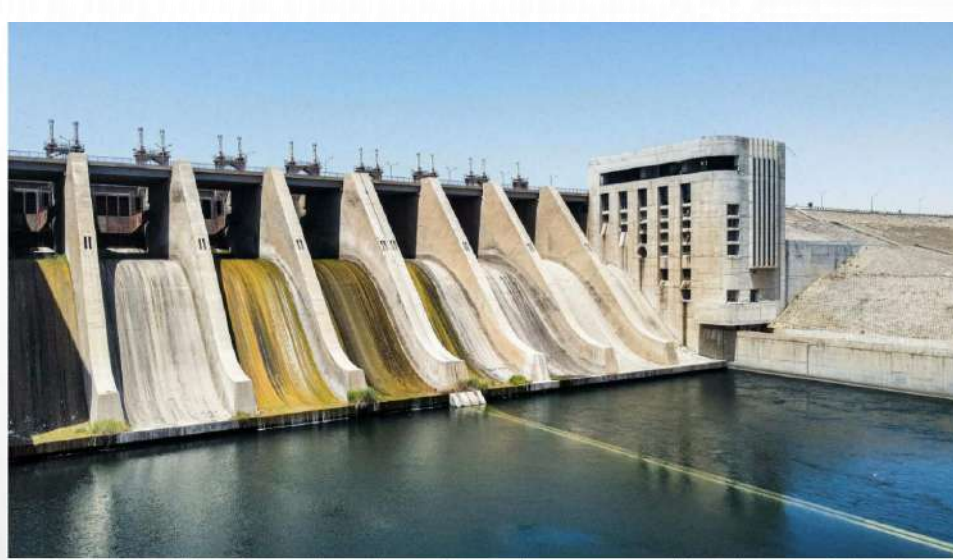
The Entrepeñas reservoir in Guadalajara (Spain) during a drought in 2017



SYRIA: Severe drought in Euphrates River – 2021

Hydrological drought or geopolitics related issues?

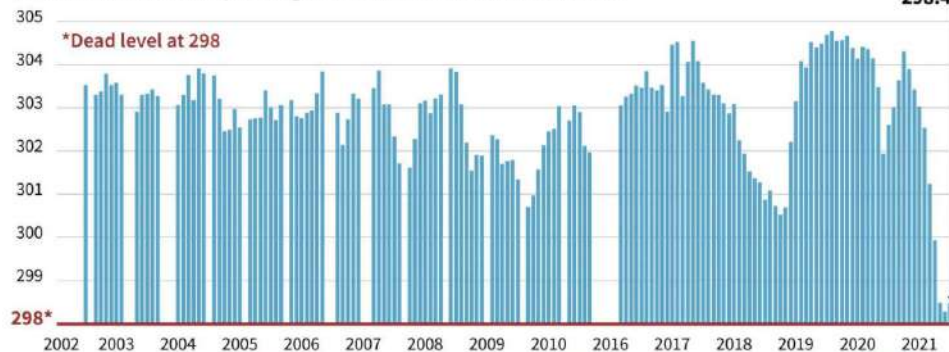
Discharge drops from 500 to 200 m³/s of water across the border



Water levels at Syria's Tabqa dam

Water levels in metres at Syria's largest dam for months recorded since 2002

July 14, 2021
298.47



*level at which electricity production is halted

Source: NES Forum AFP

Water levels at Syria's Tabqa dam AFP



Elsewhere in EUROPE



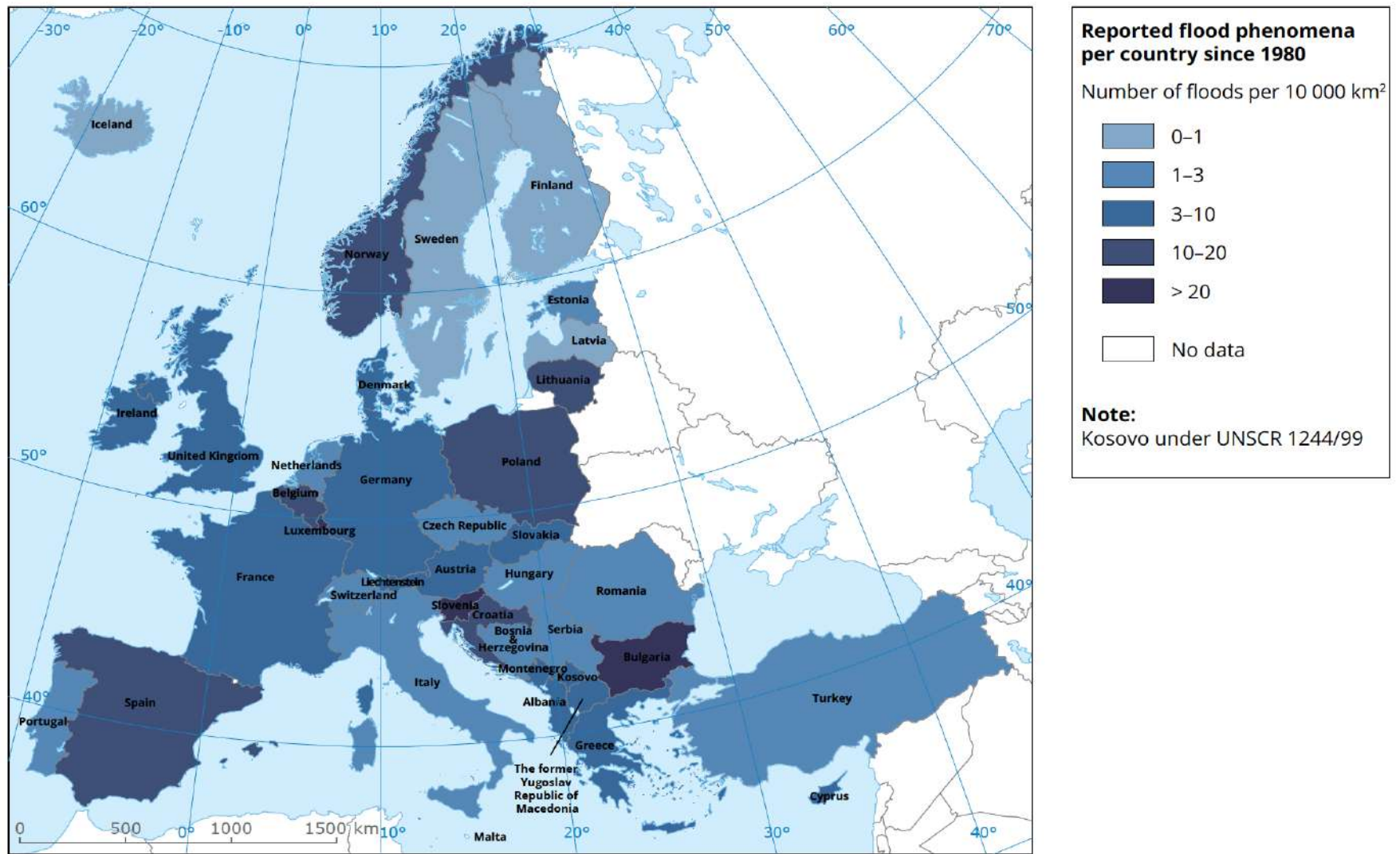
Cyclists ride through the flooded
Danube River
(Budapest, Hungary, June 7, 2010)

In Germany, more
than 120 people dead
for flooding during the
summer 2021



Massive sinkhole caused by a flood event
(Erftstadt, Germany, July 16, 2021) <#>

A CLEAR EVIDENCE



EEA report, Flood risks and Environmental vulnerability, 2016

WHAT IT HAPPENS? WHY IT OCCURS?



Major flood events in Québec
1996/2011/2017



Major flood events in Bavaria
1999/2002/2005/2013/2016

« Extreme precipitation events over most of the mid-latitude land masses and over wet tropical regions will *very likely* become more intense and more frequent. » - IPCC AR5 report



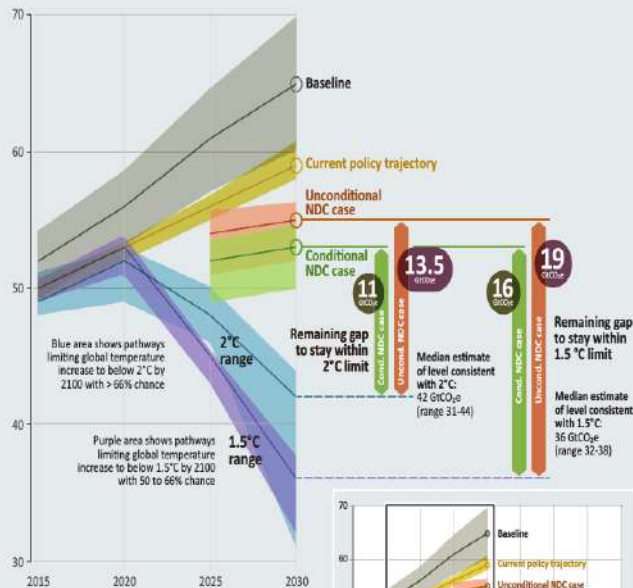
Armin Laschet blamed the devastating weather on global warming. *"We will be faced with such events over and over, and that means we need to speed up climate protection measures ... because climate change isn't confined to one state,"* he said.



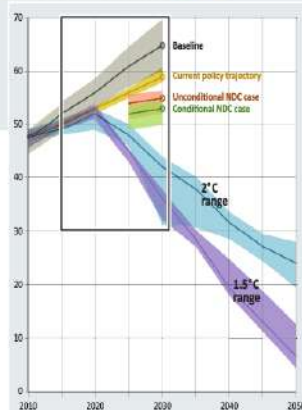
CLIMATE CHANGE?



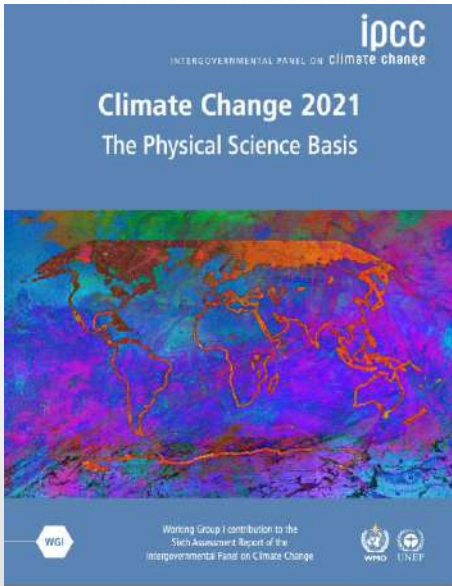
Annual Global Total Greenhouse Gas Emissions (GtCO₂e)



Note: the emissions range for 1.5°C is smaller than for 2°C, as a smaller number of studies for 1.5°C are available. For current policy, the minimum-maximum across all assessed studies are provided.



A SCIENTIFIC CERTAINTY



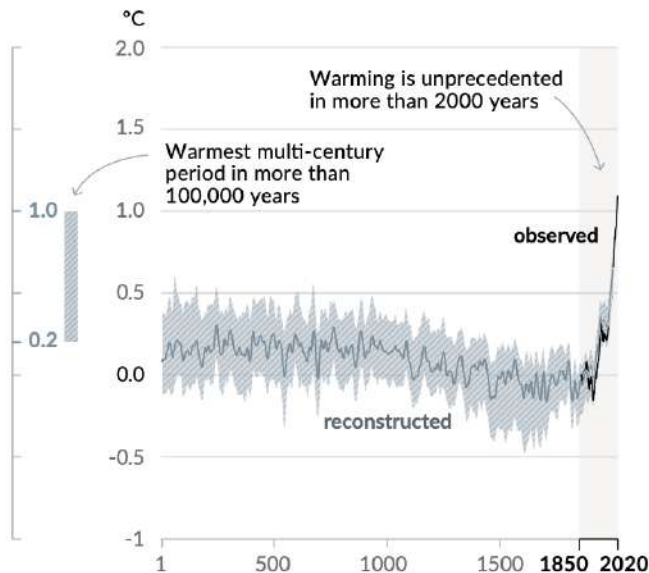
It is unequivocal that human influence has warmed the atmosphere, ocean and land.

Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred.

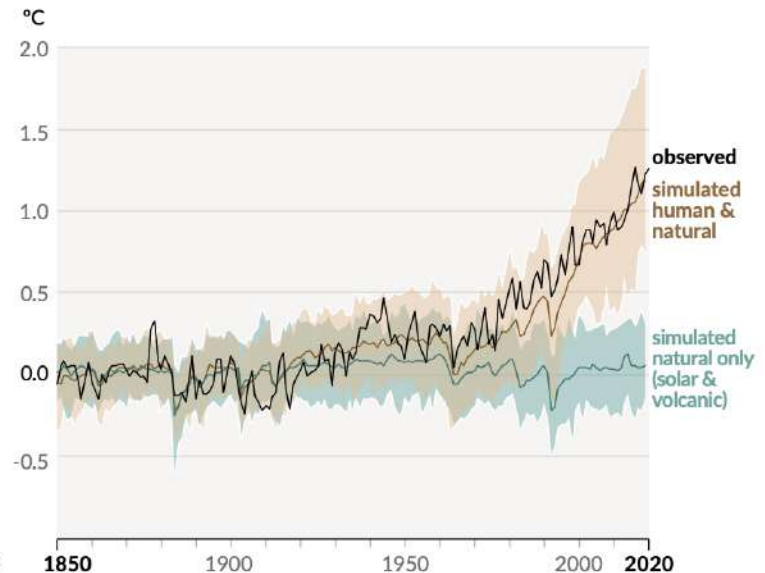
Human influence has warmed the climate at a rate that is unprecedented in at least the last 2000 years

Changes in global surface temperature relative to 1850-1900

a) Change in global surface temperature (decadal average) as **reconstructed** (1-2000) and **observed** (1850-2020)



b) Change in global surface temperature (annual average) as **observed** and simulated using **human & natural** and **only natural** factors (both 1850-2020)

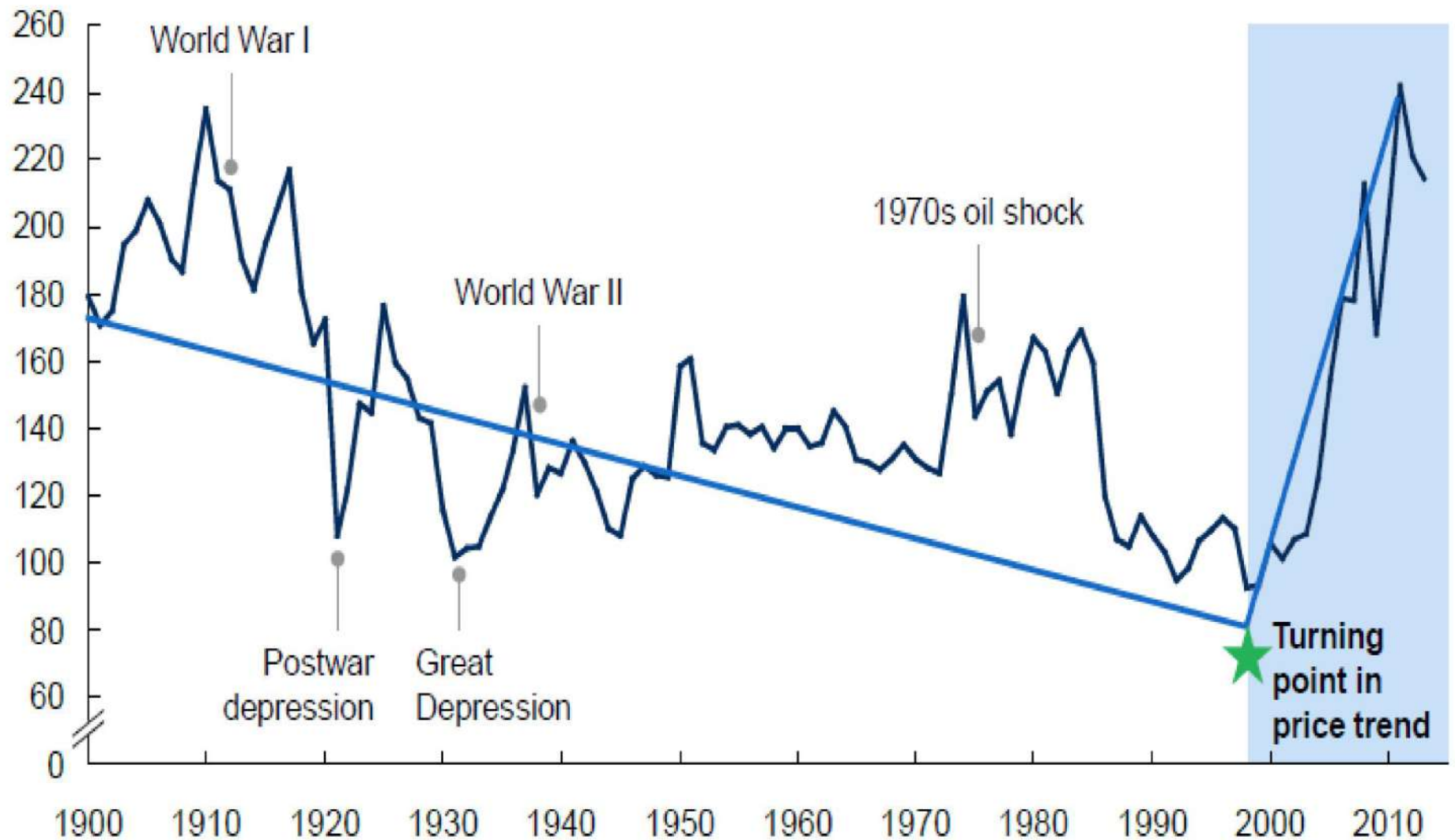


IPCC _ AR6 report
August 7, 2021

UNTIL 2100
FLOOD RISK ←
MAY INCREASE BY
50% AND EROSION
RISK BY 13%

A DOUBT:

could it be related with the cost of the natural resources?



About the Mediterranean Region

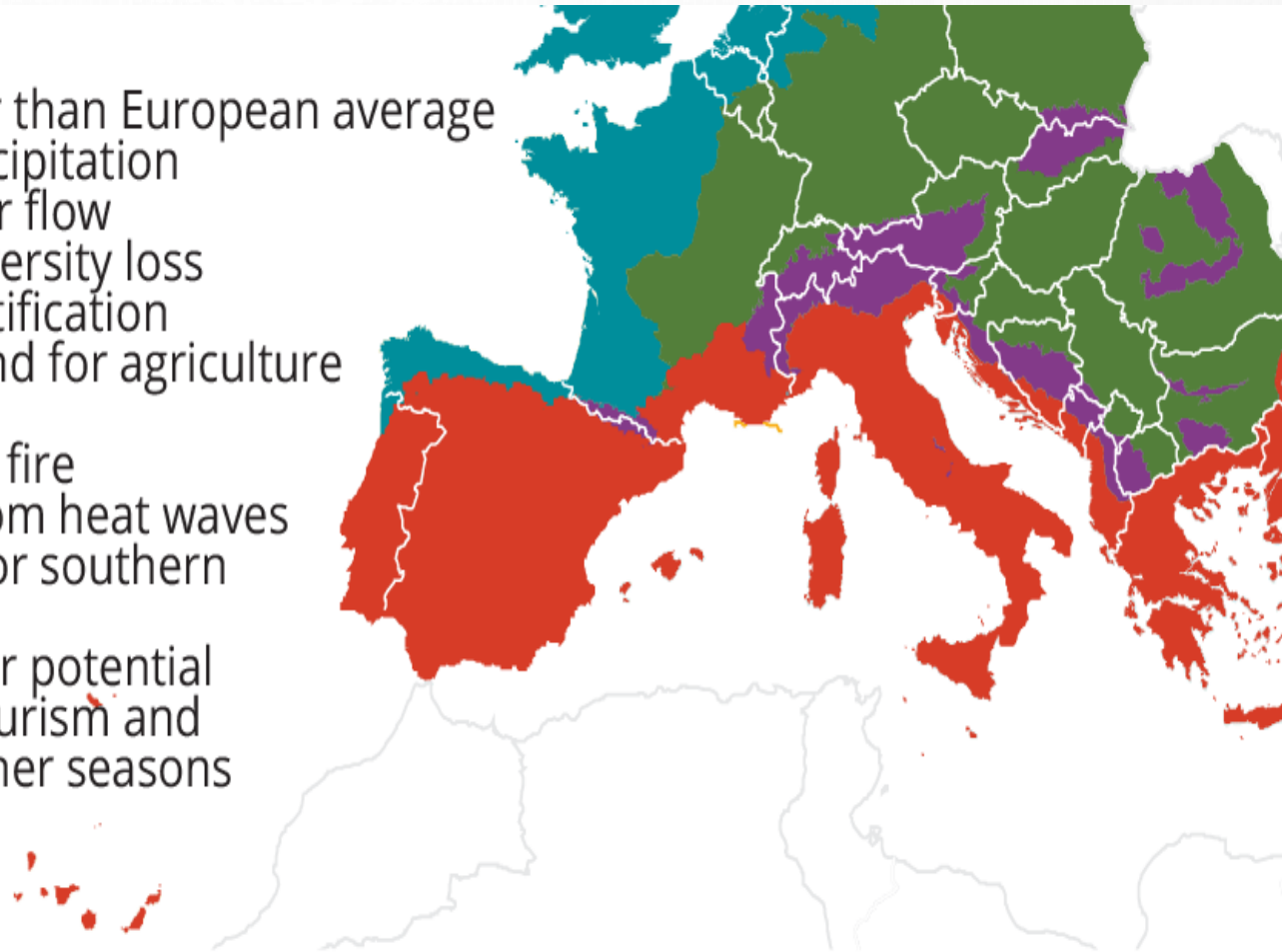
The Mediterranean sea is surrounded by 23 countries and it's home to around 510 million people, corresponding to about 7,5% of the global population



What does the CC in Mediterranean region imply?

Mediterranean region

- Temperature rise larger than European average
- Decrease in annual precipitation
- Decrease in annual river flow
- Increasing risk of biodiversity loss
- Increasing risk of desertification
- Increasing water demand for agriculture
- Decrease in crop yields
- Increasing risk of forest fire
- Increase in mortality from heat waves
- Expansion of habitats for southern disease vectors
- Decrease in hydropower potential
- Decrease in summer tourism and potential increase in other seasons



Source: EEA report, 2018

The Mediterranean a climate change hotspot where vulnerabilities are exacerbated

SoED
2020

State of the Environment and
Development in the Mediterranean



Warming
20%
faster than global average

Increased fire risk
through a longer
fire season, increasing
heatwaves and drought



#SustainableMED

Already
0.4°C

increase in seawater temperature
(up to +3.5°C by 2100)



Low-lying coastal
cultural heritage sites
are threatened by
flooding and erosion



A decrease of
-0.1

in the pH of the ocean since
the pre-industrial period, and
a forecast of -0.4 by 2100



Sea level rise

between 0.43 and 2.5 m by 2100, depending on
scenarios and projections. Increased risk for the
20 million people living below 5m of current sea level

+1.54°C

increase in air temperature:
above the global average
(projection in 2040: +2.2°C
versus +1.5°C global level)



-30%

of rainfall in spring/summer
by 2080 and +10/20% of heavy
rainfall events outside of summer

Consequences

- ⊕ heat waves
- ⊕ coastal erosion
- ⊕ fires
- ⊕ invasive species
- ⊕ acidification of the sea
- ⊕ floods
- ⊖ modification of migrations and
risk of extinction of certain species
- ⊖ quality aquaculture fishing
- ⊖ agriculture production



To consult the full report on the State of the Environment and Development in the Mediterranean and its information sources : www.planbleu.org/scod2020

WITHOUT ADDITIONAL MITIGATION
REGIONAL **TEMPERATURE**

INCREASE WILL BE **2.2°C**
→ IN 2040
POSSIBLY **EXCEEDING**
3.8°C IN SOME REGIONS
IN 2100



FRESH WATER AVAILABILITY
IN THE **MEDITERRANEAN REGION**
IS LIKELY TO **DECREASE** SUBSTANTIALY

By **2 to 15%**
for **2°C**
warming

AMONG THE **LARGEST**
DECREASES IN THE WORLD

85 scientists from 20 countries of the Network of Mediterranean
Experts on Climate and Environmental Change (MedECC) present:

1st

SCIENTIFIC ASSESSMENT REPORT ABOUT CLIMATE AND ENVIRONMENTAL CHANGE IN THE MEDITERRANEAN

FOOD SECURITY

Food demand is set to increase as yields of crops, fish and livestock decline

90% of commercial fish stocks are already overfished, with the average maximum body weight of fish expected to shrink by up to **half** by 2050

WATER RESOURCES

Within 20 years, 250+ million people will be classified as 'water-poor'

Fresh water availability is to decrease by up to 15% among the largest decreases in the world

SEA LEVEL

Sea level rises may exceed 1 metre by 2100, impacting 1/3 OF THE REGION'S population

Half of the 20 global cities set to suffer most from sea level rises by 2050 are in the Mediterranean

ECOSYSTEMS

The Mediterranean basin is **ONE OF THE MOST PROMINENT hotspots of climate and environmental change**

700+ non-indigenous animal species recorded due to warmer conditions

Increasing water acidification causes **mass deaths of marine species**

Mega fires have destroyed record areas of forest due to climate change

The Mediterranean
REGION IS WARMING
20% faster
than the global average

Regional temperature
increase of

→ **2.2°C**
by 2040 with current policies
→ Paris Agreement's target of 1.5°C

HEALTH AND SECURITY

Increase in frequency, intensity and duration of **HEAT WAVES** imply significant **health risks** for vulnerable populations, especially in cities

Increasing frequency in droughts since the 1950s has played a significant role in the current regional crisis

Conflicts concerning limited natural resources may increase large-scale human migrations

MedECC
Mediterranean Experts on Climate and Environmental Change

United Nations
Environment Programme
Unité pour le Méditerranée
الوحدة من أجل المتوسط

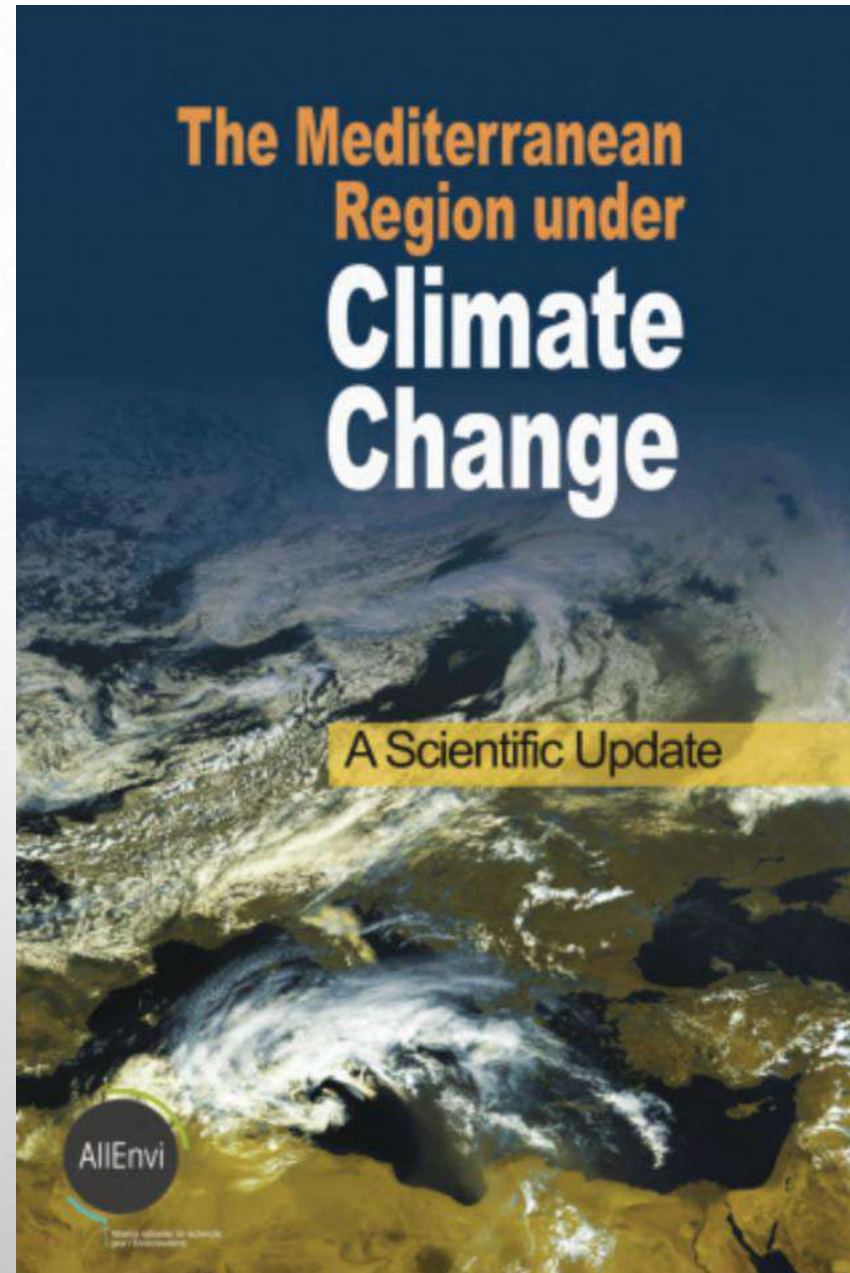
UN
environment
United Nations
Environment Programme

World Economic Forum
Global Agenda Council on the Environment

Plan
B
i

source: (MedECC, 2019)

Mediterranean climate change has been observed at a magnitude exceeding global means, despite the fact that the emission of greenhouse gases (GHGs) in Mediterranean countries lies at relatively low levels



A Mediterranean basin without a Mediterranean climate?

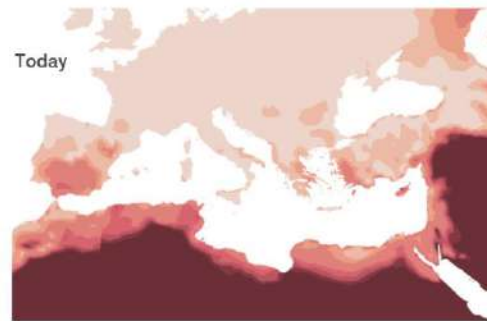
The number of days above 37°C in southern Spain, Turkey, and Egypt is expected to double by 2050, from about 30 to 60.

Number of days with maximum temperature above 37°C

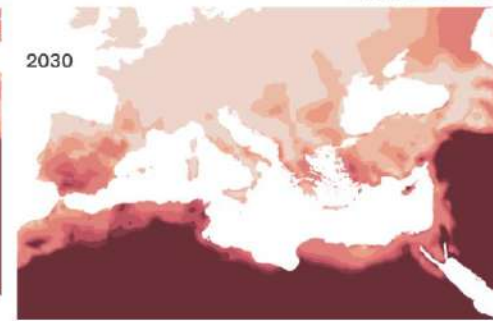


Based on RCP 8.5

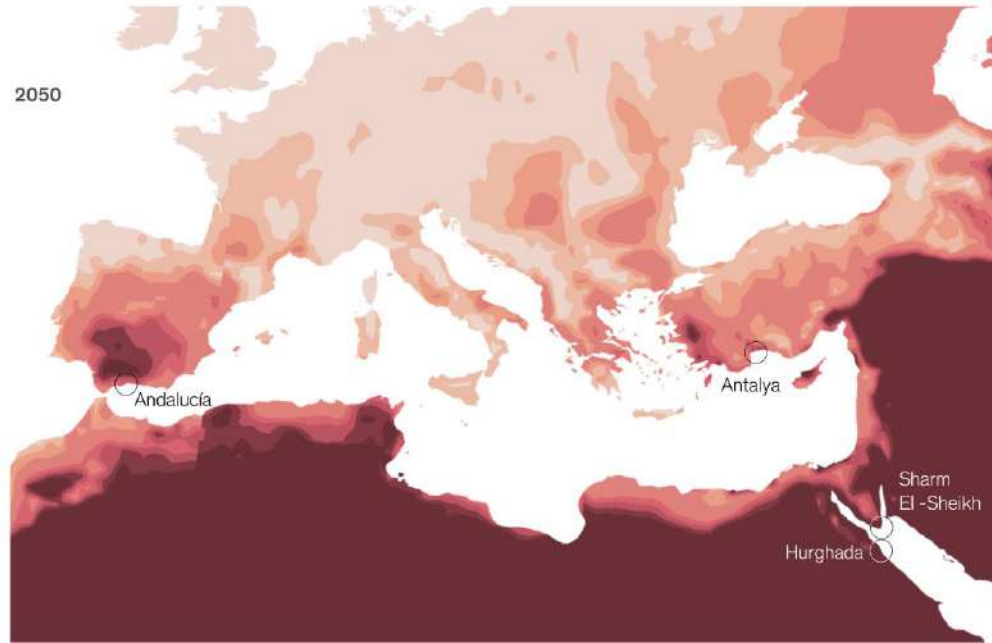
Today



2030



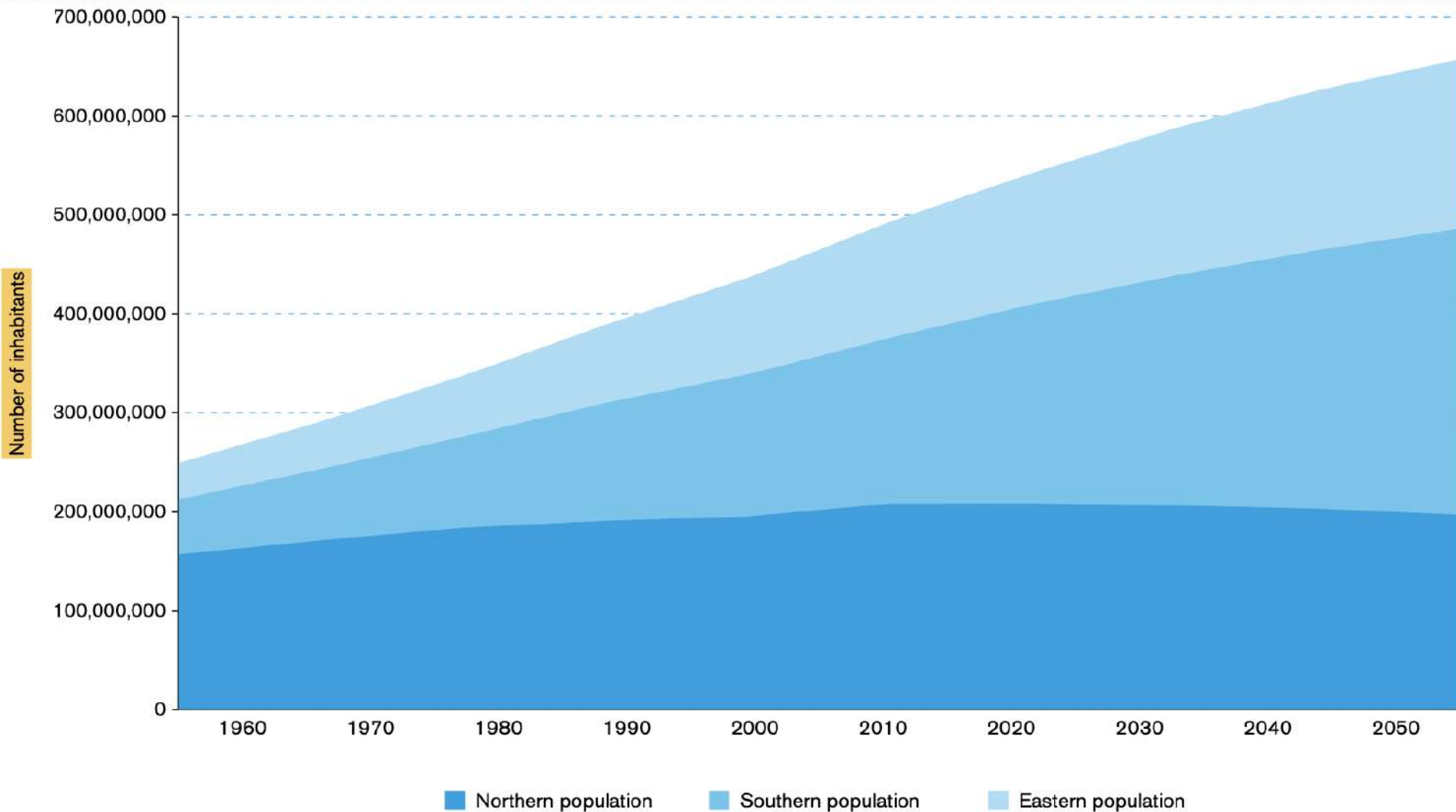
2050



Source

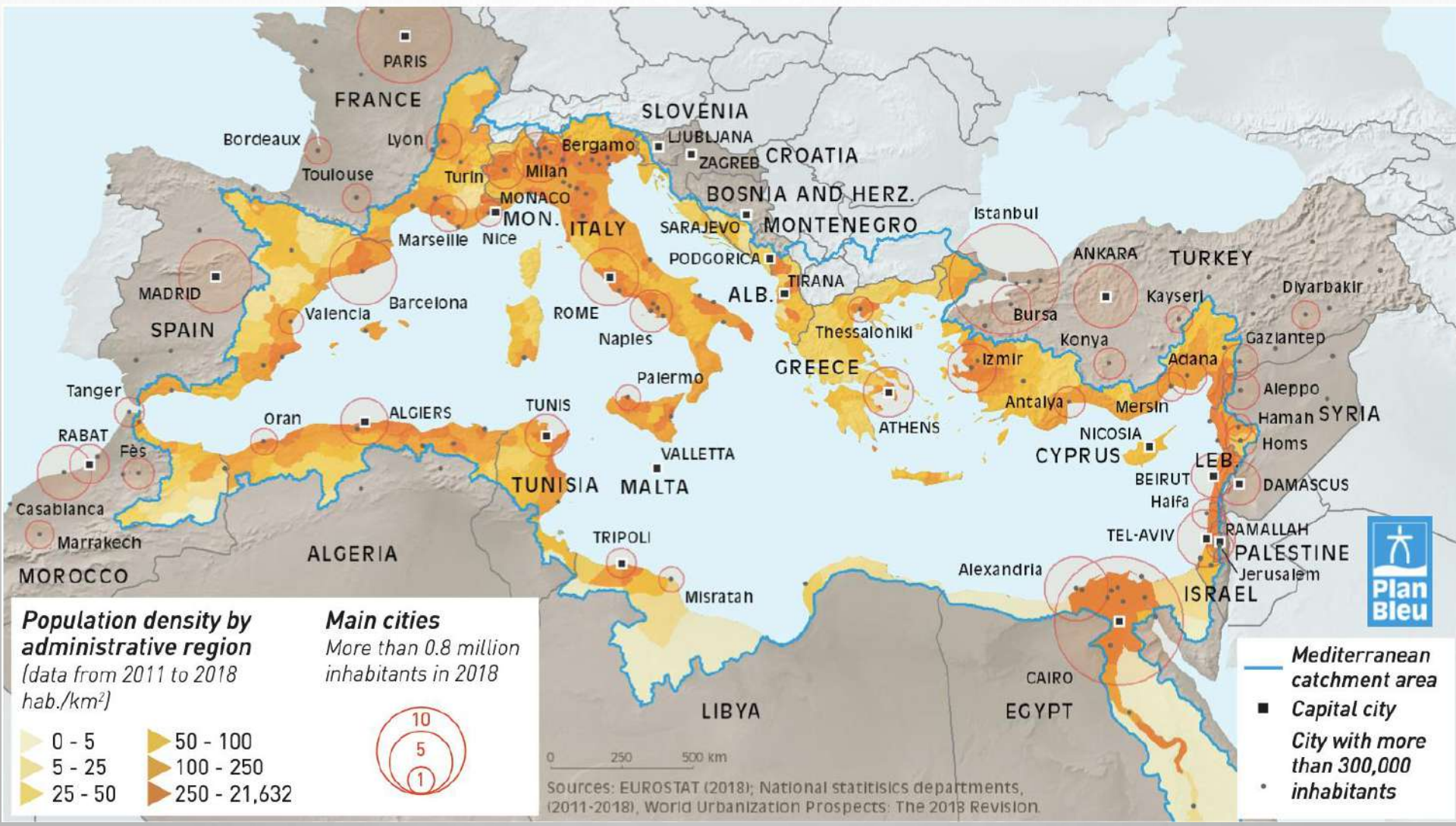


IS THE MEDITERRANEAN REGION OVERCROWDED?

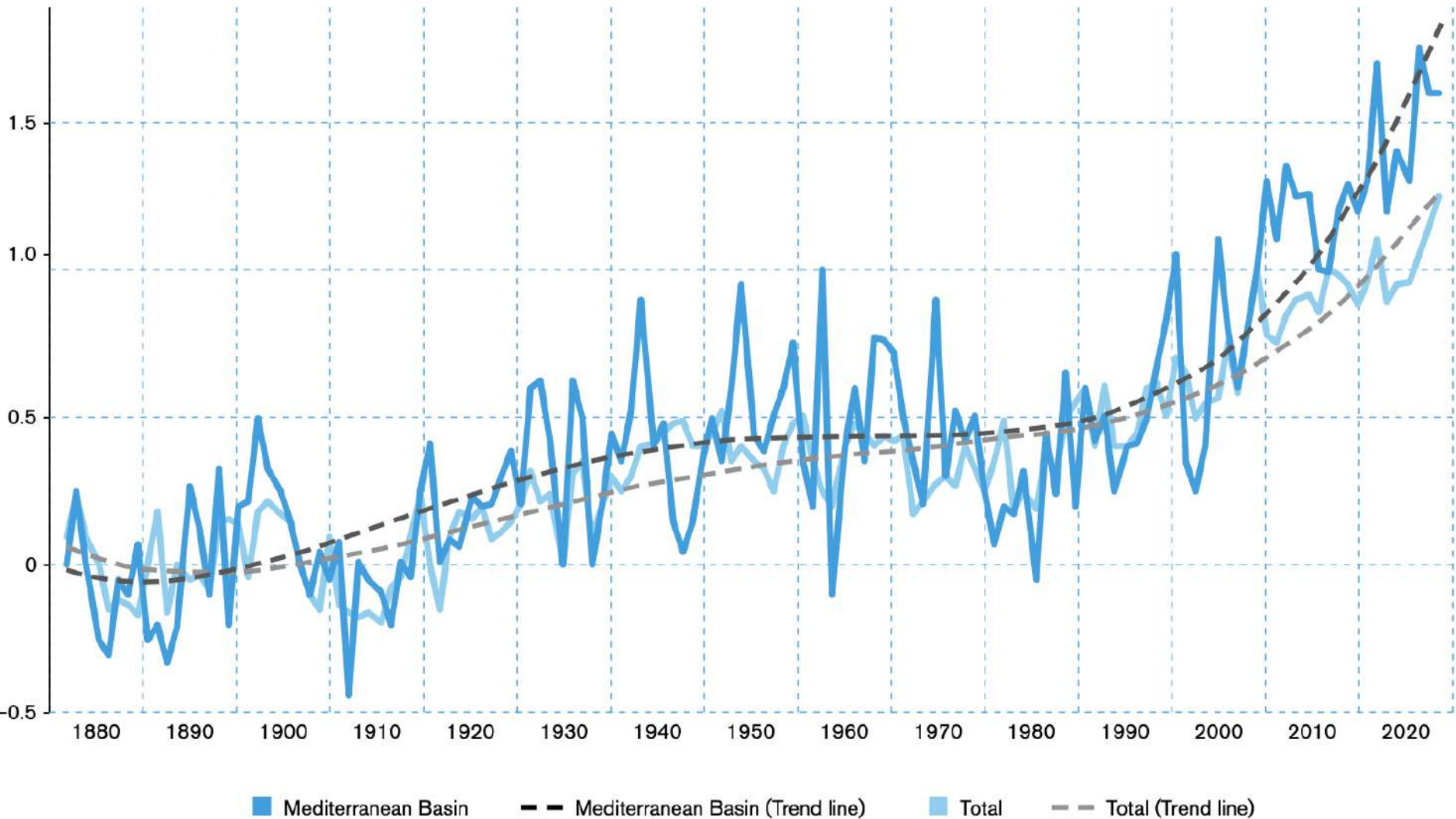


Source: FAO 2018 based on World Bank data (2015)

ANTHROPIC PRESSURE ON COASTAL AREAS OF MEDITERRANEAN SEA



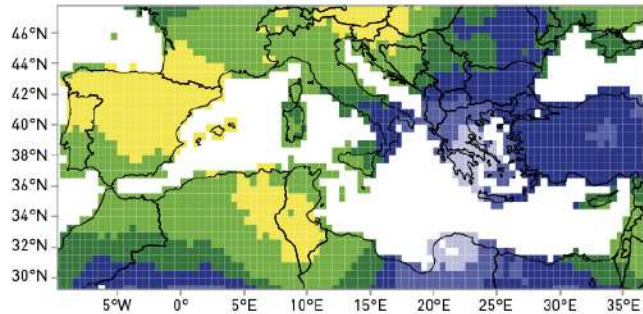
AIR TEMPERATURE : observed trend



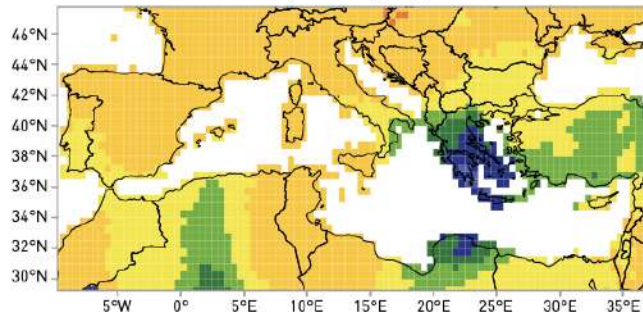
Source: Cramer et al. (2018)

More in details

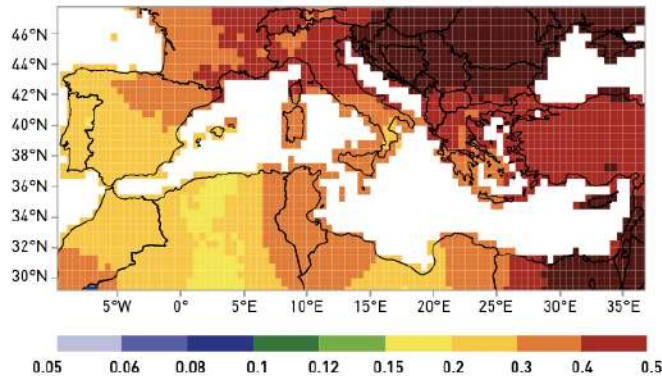
Annual trend ($^{\circ}\text{C } 10 \text{ yr}^{-1}$) 1901-2018



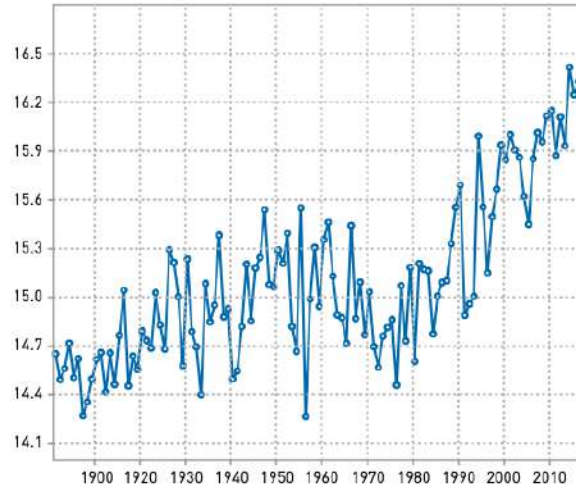
Annual trend ($^{\circ}\text{C } 10 \text{ yr}^{-1}$) 1950-2018



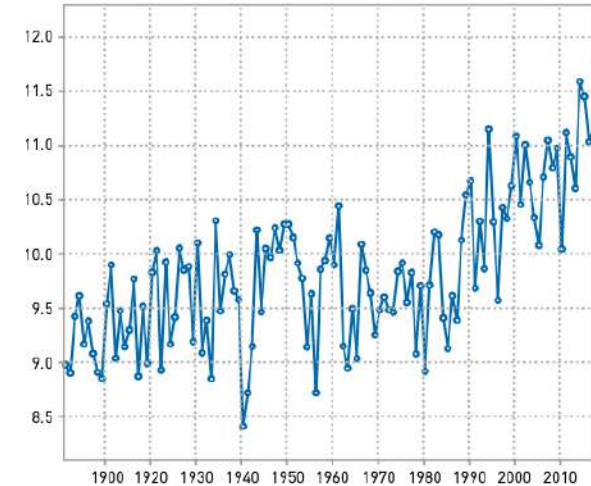
Annual trend ($^{\circ}\text{C } 10 \text{ yr}^{-1}$) 1980-2018



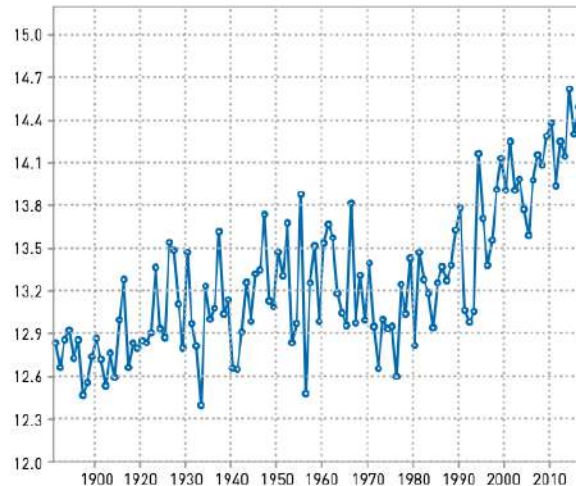
Annual temperature for the Mediterranean Basin



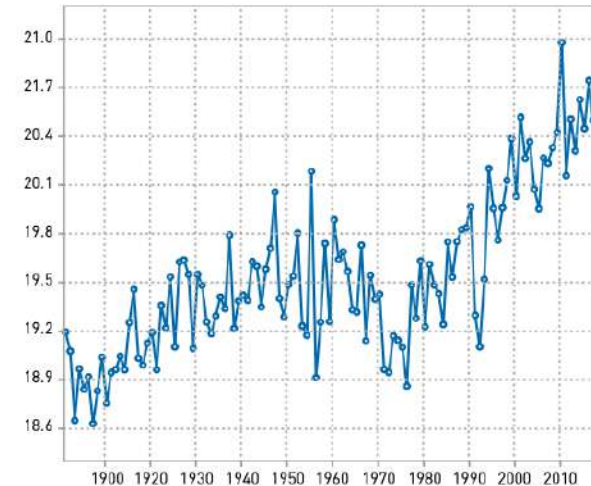
Annual temperature for the North Med



Annual temperature for the Central Med



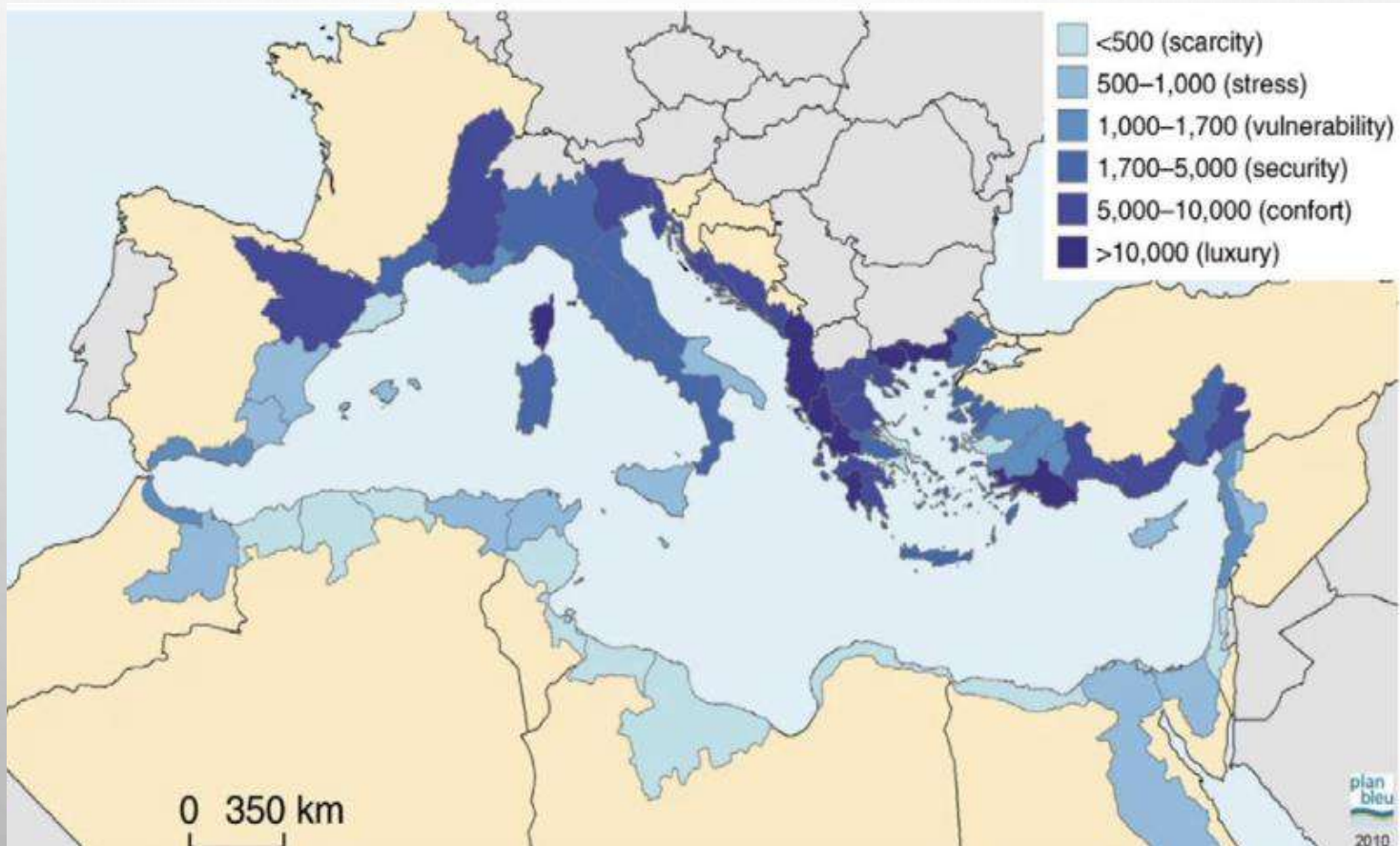
Annual temperature for the South Med



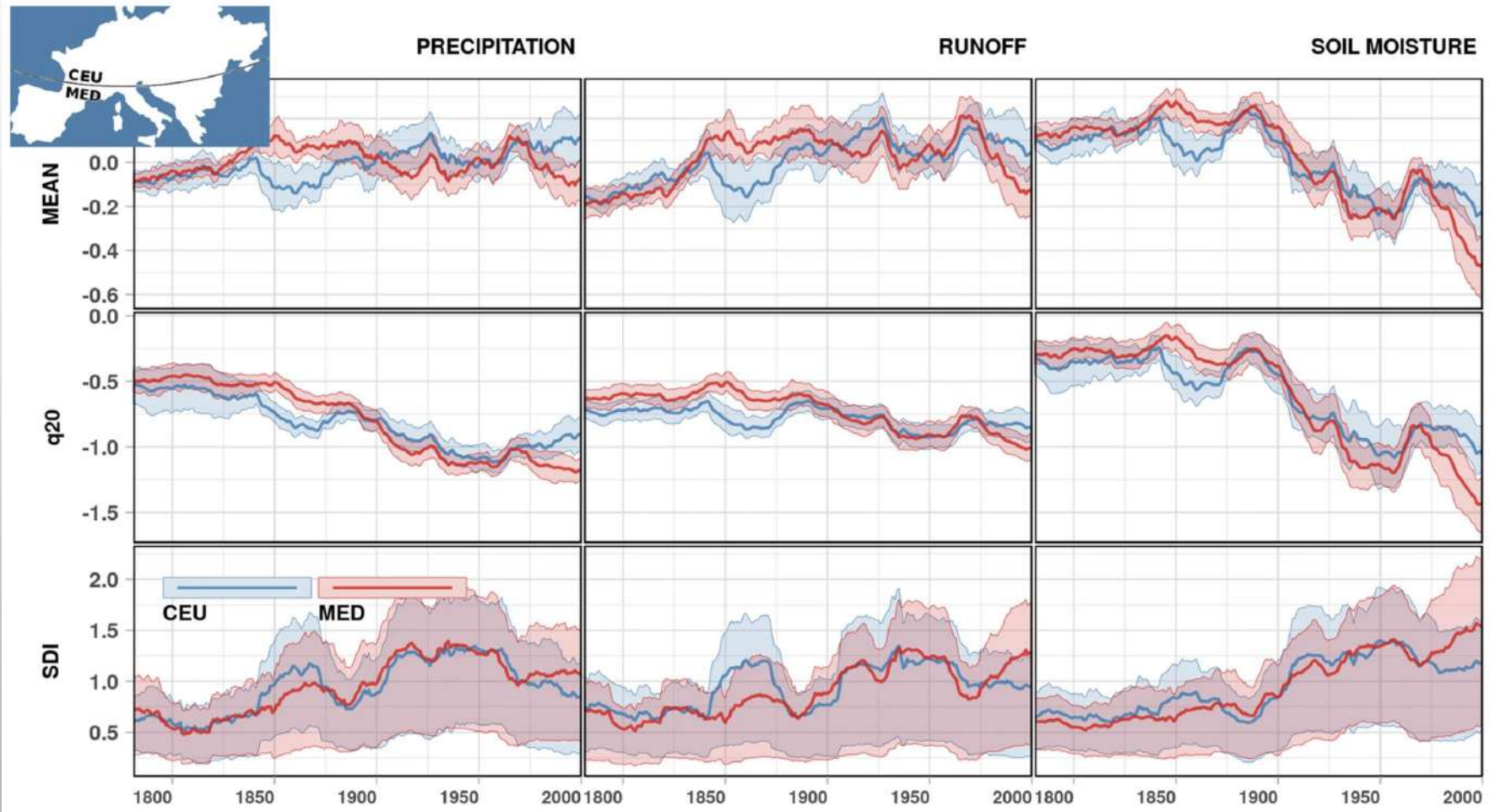
WATER RESOURCES

They are limited, unevenly distributed and often mismatching human and environmental needs.

Three quarters of the resource are located in the northern Mediterranean while three quarters of the needs are in the south and east.



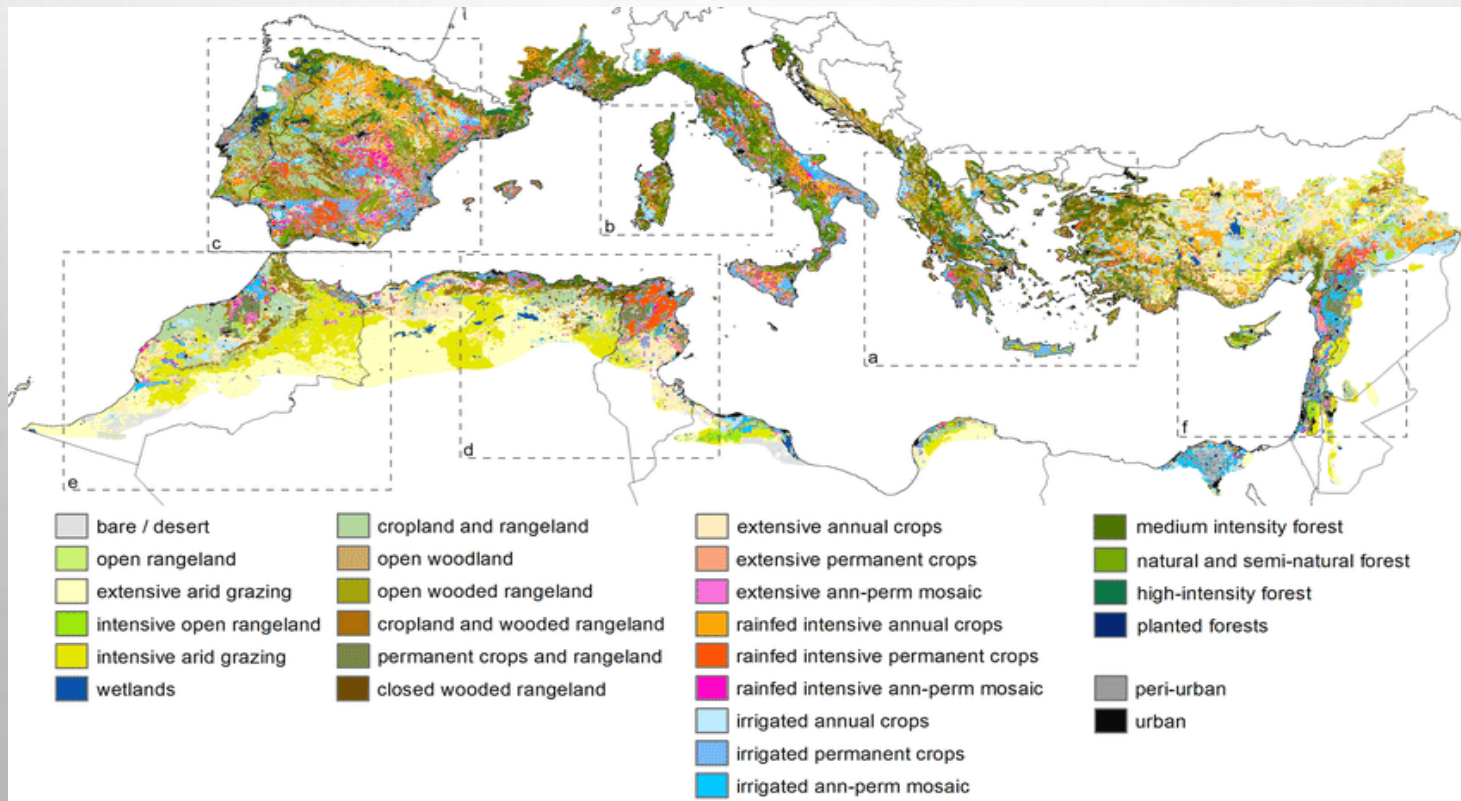
In the Mediterranean region, **water availability** will reduce as a consequence of three main factors: (i) precipitation decrease, (ii) temperature increase, and (iii) population growth.



Source: Hanel, M., Rakovec, O., Markonis, Y. *et al.* Revisiting the recent European droughts from a long-term perspective. *Sci Rep* 8, 9499 (2018).

IRRIGATION NEEDS

Irrigation is between 50% and 90% of the Mediterranean water demand. Irrigation water requirements in the Mediterranean region are projected to increase between 4 and 18% by the end of the century due to climate change alone (for 2°C and 5°C warming, respectively).



SOCIETAL AND ECONOMIC ASPECTS RELATED TO THE AGRICULTURAL SECTOR

Agriculture and population in the Mediterranean basin

People employed in agriculture

Per 10 000 people living in rural areas



1990

2011

- Decreasing from 1990
- Stable or increasing from 1990
- Trend not available

Agricultural land

- Dry cereal farming
- Pastureland or natural areas
- Hill and mountain farming

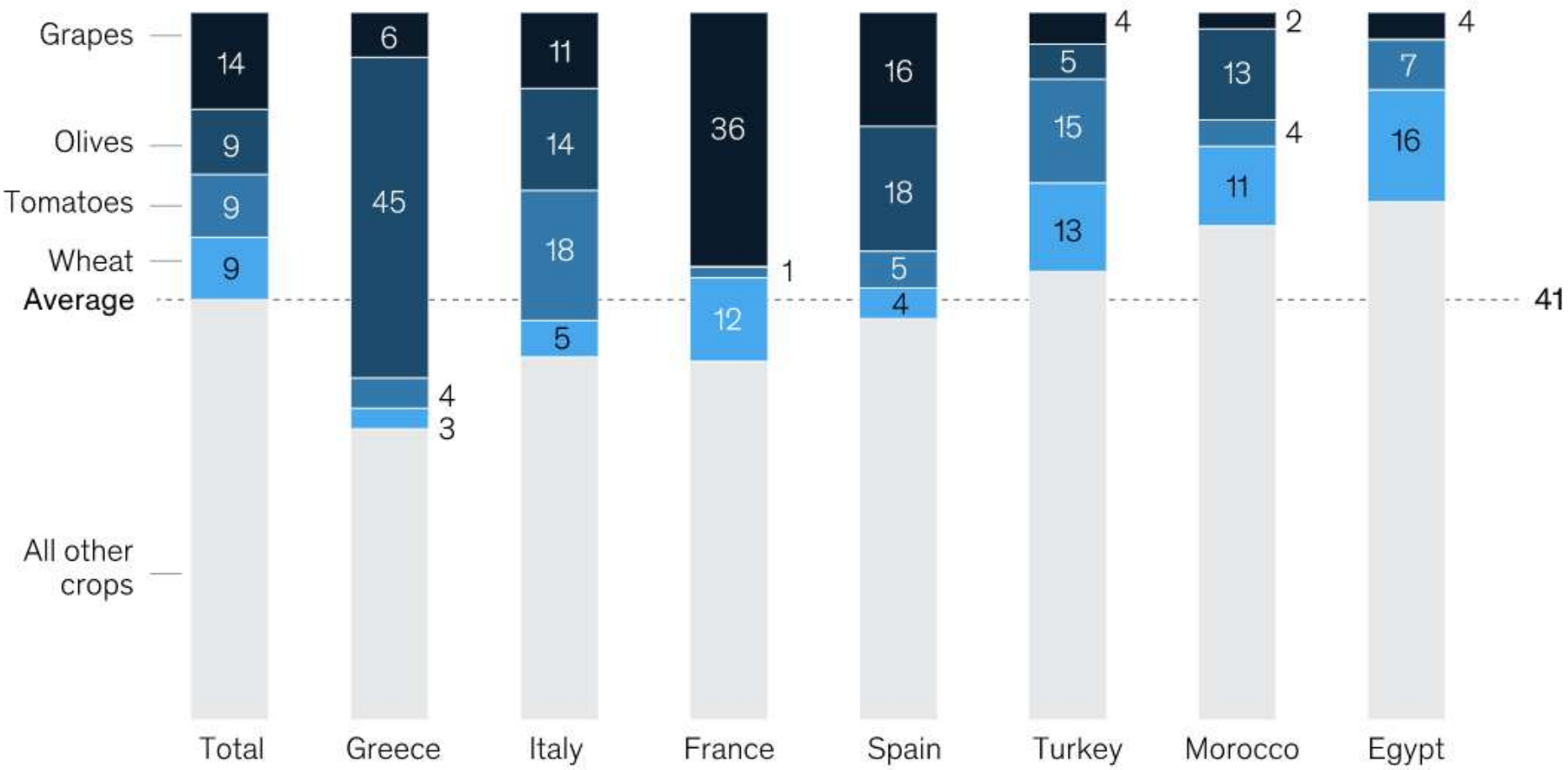
- Olive growing areas
- Viticulture areas
- Irrigated areas

Sources: World Bank, World Development Indicators, on line database, accessed October 2011; Beilstein, M., Bournay, E., Environment and Security in the Mediterranean: Desertification, ENVSEC, 2009.



About 40 percent of the Mediterranean region’s agricultural production value comes from just four crops: wheat, tomatoes, olives, and grapes.

Crop production value in the Mediterranean region, 2016,¹ % of total gross production value



¹Albania, Algeria, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Malta, Morocco, Portugal, Slovenia, Spain, Tunisia, Turkey.
Source: FAO; McKinsey Global Institute analysis

FERTILIZER AND NITROGEN USE HAVE A SIGNIFICANT ENVIRONMENTAL IMPACT

Fertilizer use and nitrogen release in the Mediterranean region

Fertilizer consumption

Kilograms per hectare of arable land, 2008

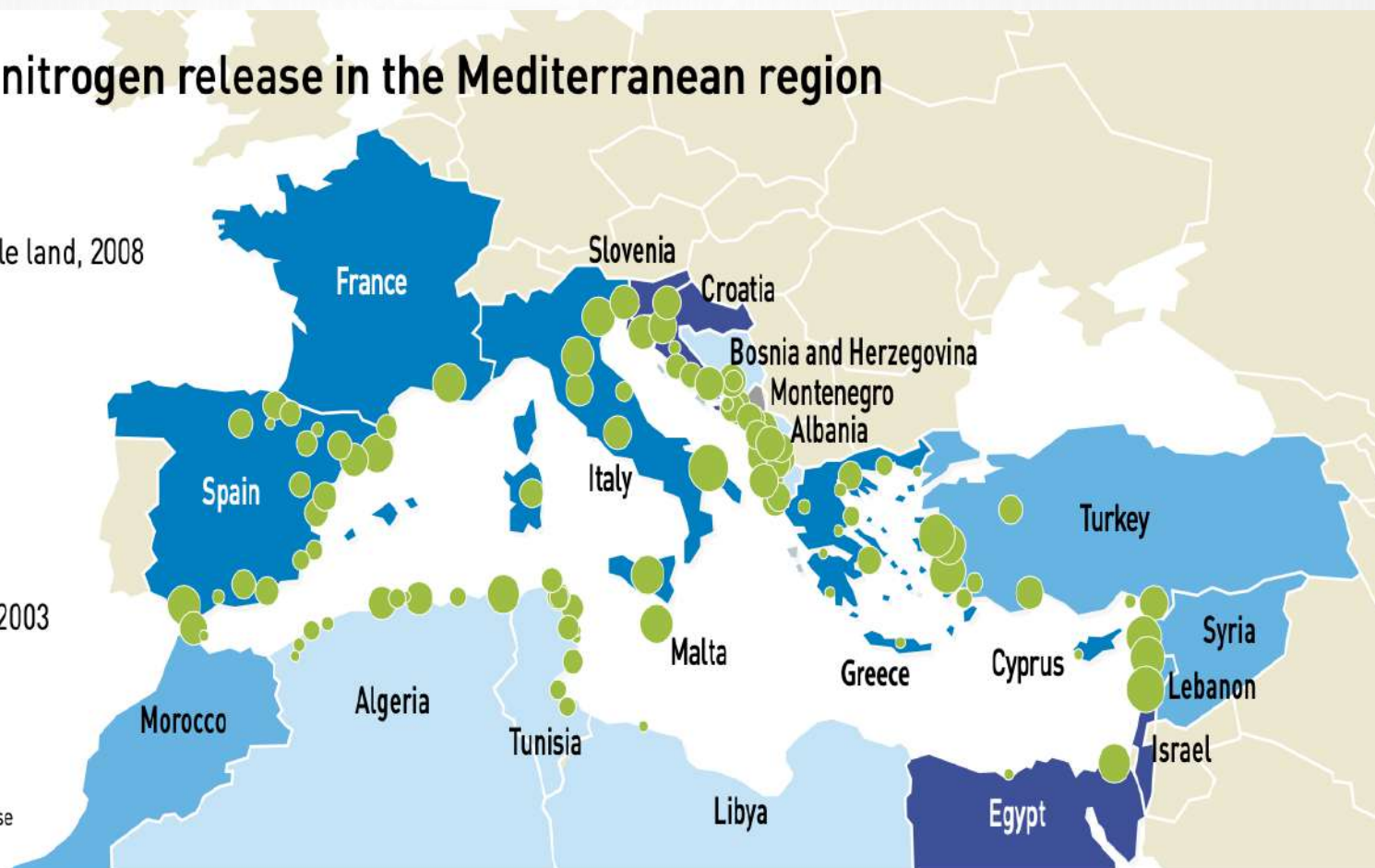
- 6 to 50
- 50 to 100
- 100 to 200
- More than 200
- No data

Nitrogen release from point source

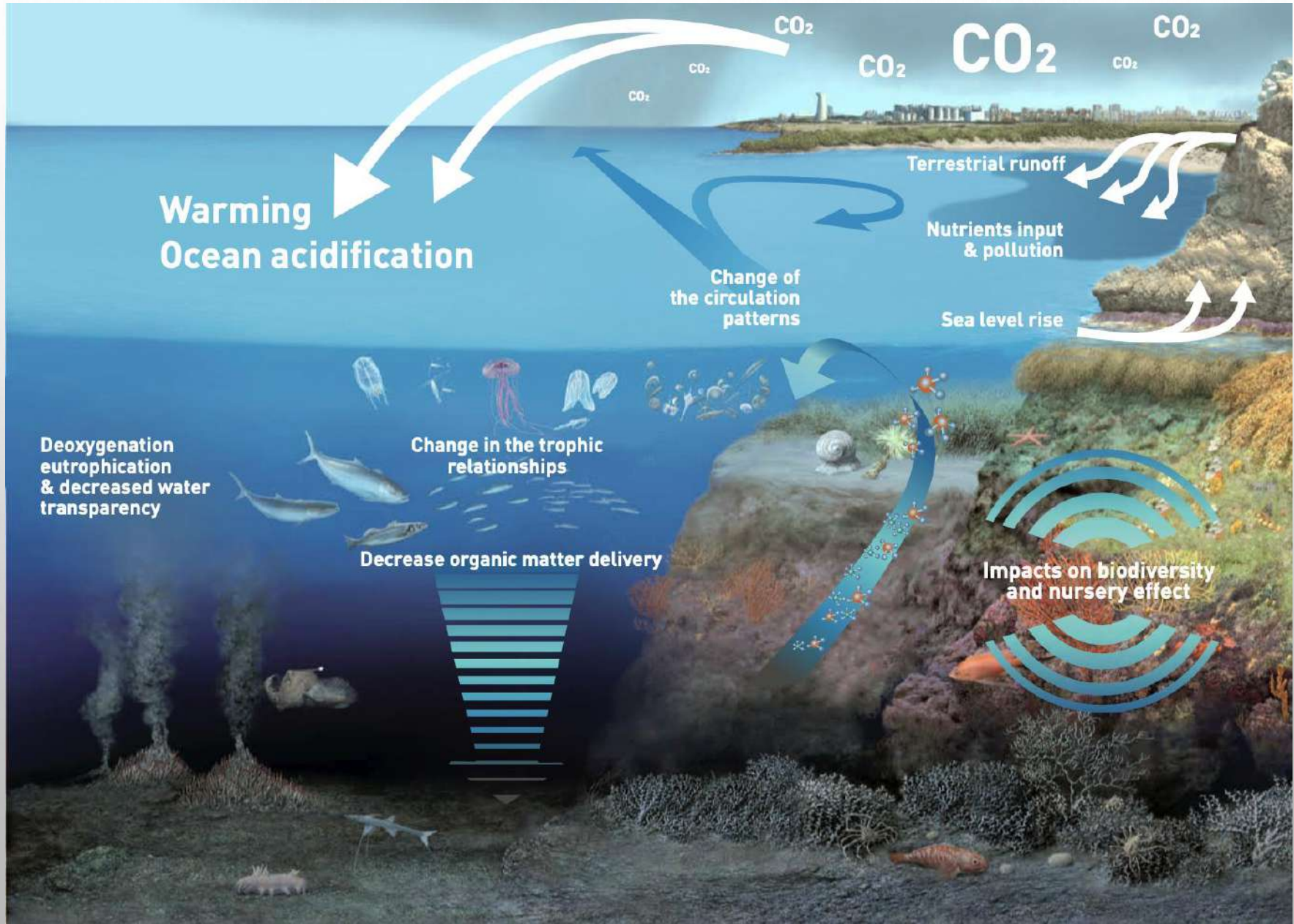
Thousand kilograms per year, 2003

- 0.3
- 7 240

Sources: UNEP Mediterranean Action Plan
(MAP)/MED POL; World Bank online database

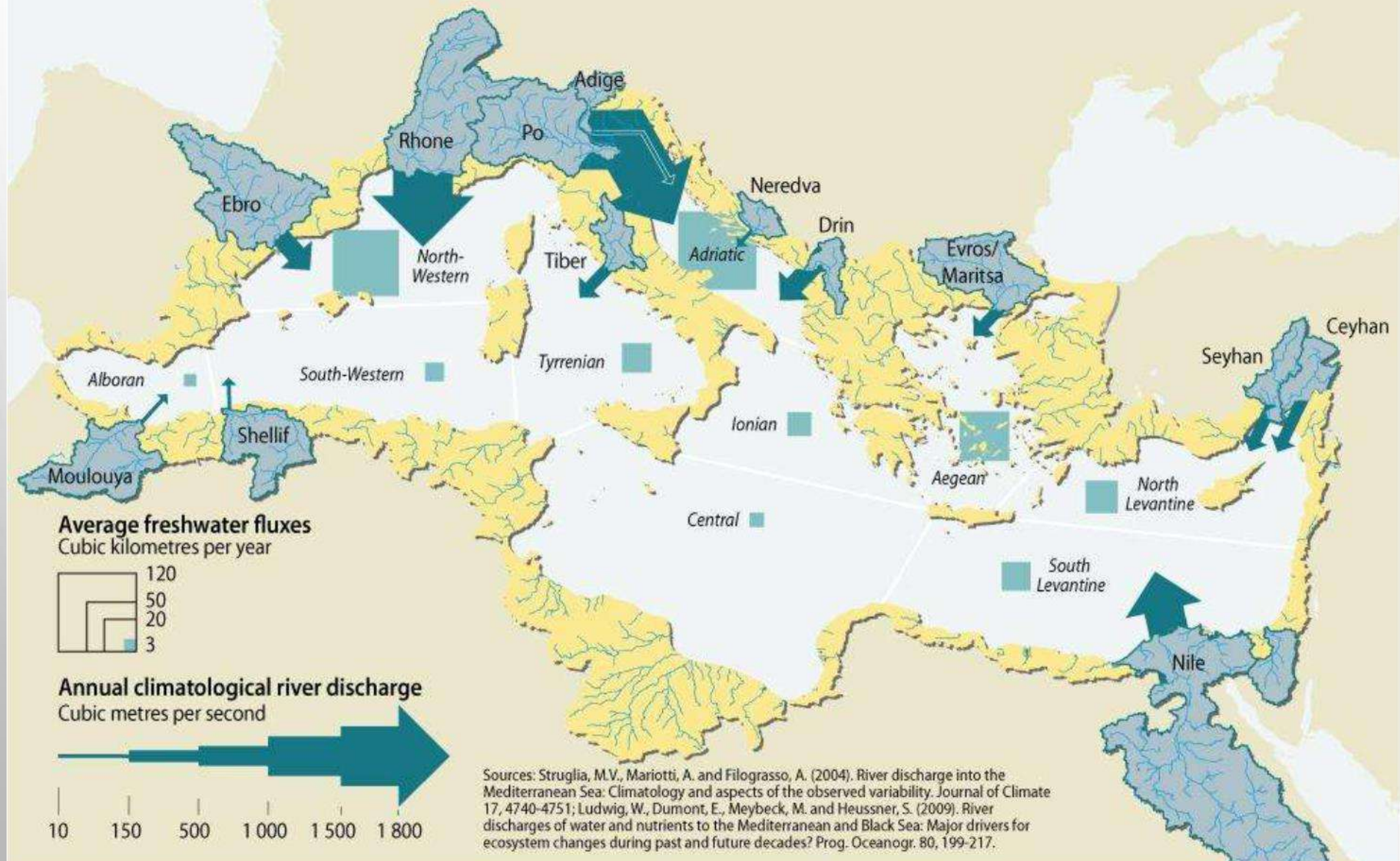


CC AND HUMAN ACTIVITIES IMPACT THE INTEGRITY OF MARINE ECOSYSTEMS

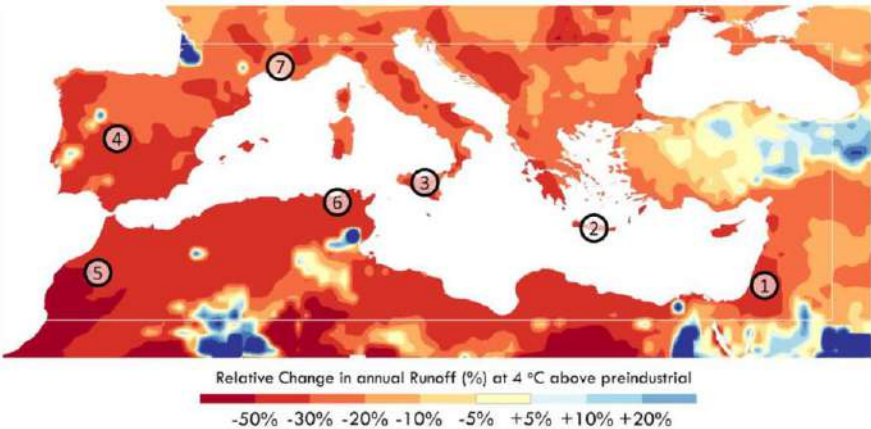


FRESHWATER AVAILABILITY

River discharge of freshwater into the Mediterranean

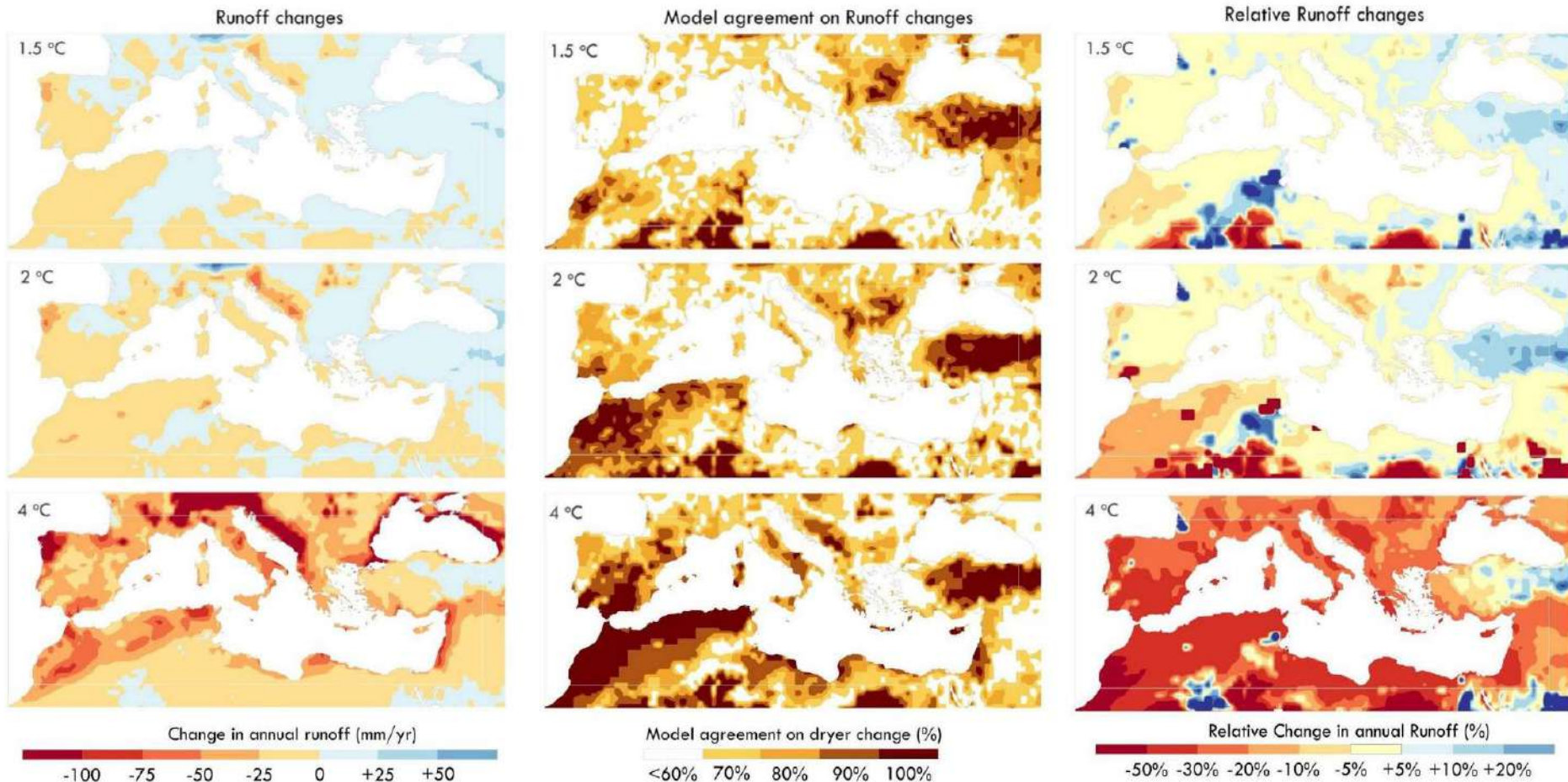


Source: Fader M, et al., 2020: *Climate and Environmental Change in the Mediterranean Basin – Current Situation and Risks for the Future. First Mediterranean Assessment Report*
UNEP/MAP



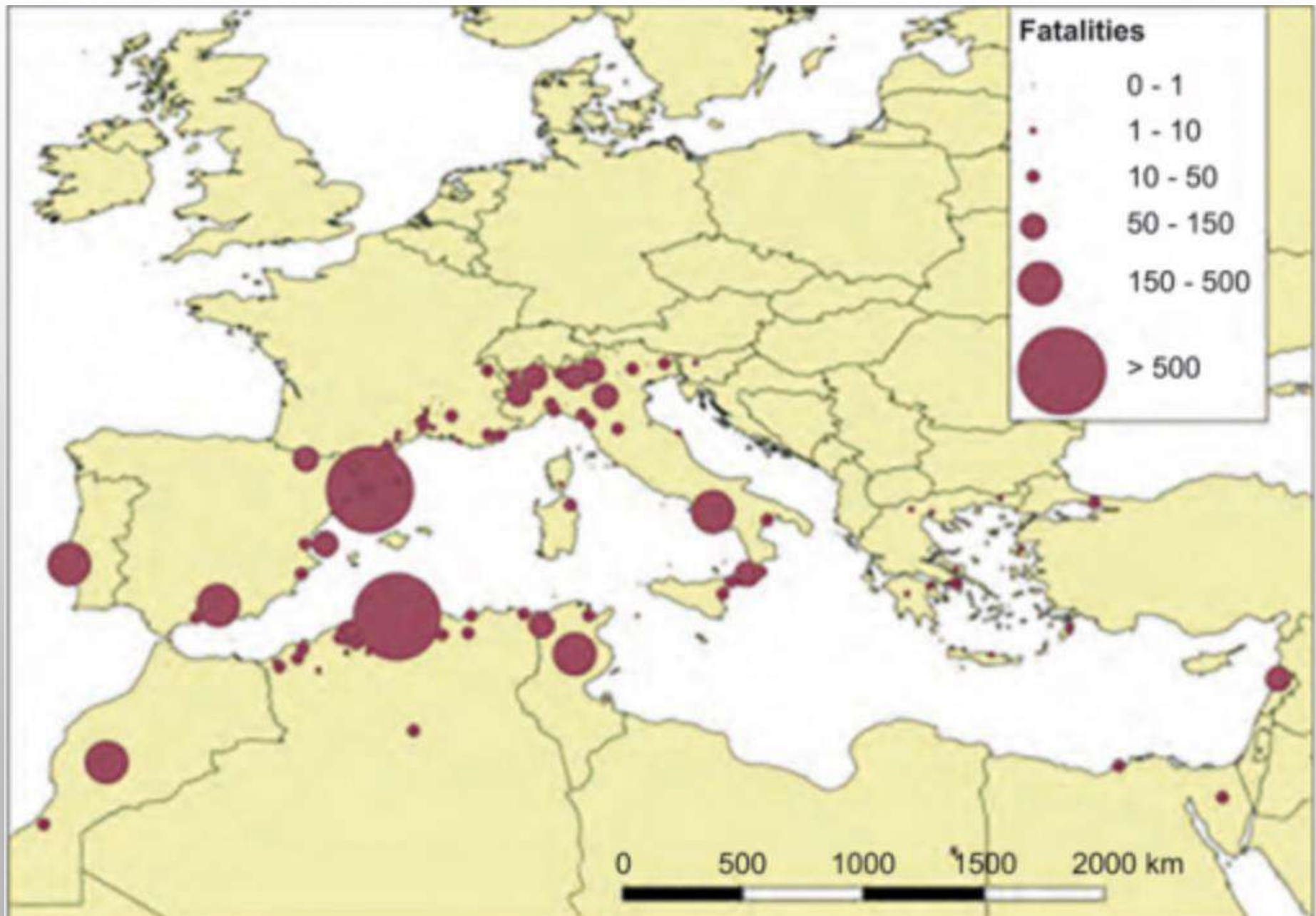
Ref. No Fig. 3.7	Country	Watershed /Region	Size (km ²)	Future/baseline pe- riod of reported changes	No of cli- mate models	Relative changes			Reference
						Mean	Max	Min	
1	Israel	Lake Kinneret wa- tershed	800	2050-2079/ 1979-2005	15	-35%	-9%	-51%	(Givati et al. 2019)
2	Greece	Crete	8320	2047-2076/ 1990–2011	5	-27%	-37%	-3%	(Koutroulis et al. 2016)
3	Italy	Imera Meridionale river basin	1782	2080-2100/ 1990-2010	32	-50%	-25%	-80%	(Viola et al. 2016)
4	Spain	Tagus	80000	2071-2100/ 1971-2000	5	-60%	-50%	-75%	(Lobanova et al. 2016)
5	Morocco	Rheraya catchment (high Atlas)	225	1979–2005/ 2049-2065	5	-50%	-35%	-65%	(Marchane et al. 2017)
6	Tunisia	North Tunisia (5 catchments)	81-315	1970-2000/ 2070-2100	8	-50%	-37%	-57%	(Dakhlaoui et al. 2019a, 2019b, 2020)
7	France	Rhône at Beaucaire	98000	1970-2000/ 2070-2100	8	-17%	-30%	-5%	(Dayon et al. 2018)

Model prediction

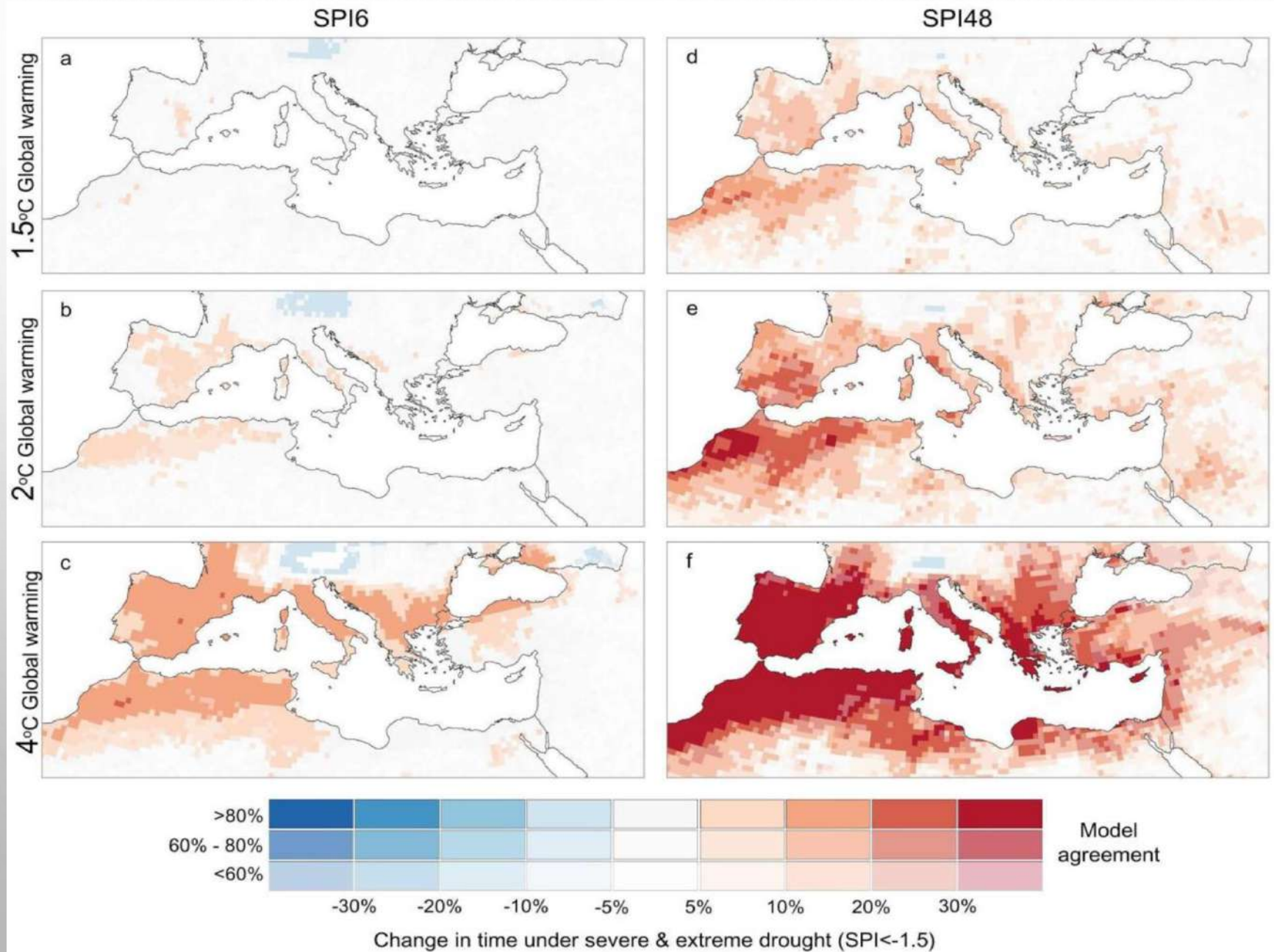


Source: Fader M, et al., 2020: *Climate and Environmental Change in the Mediterranean Basin – Current Situation and Risks for the Future. First Mediterranean Assessment Report UNEP/MAP*

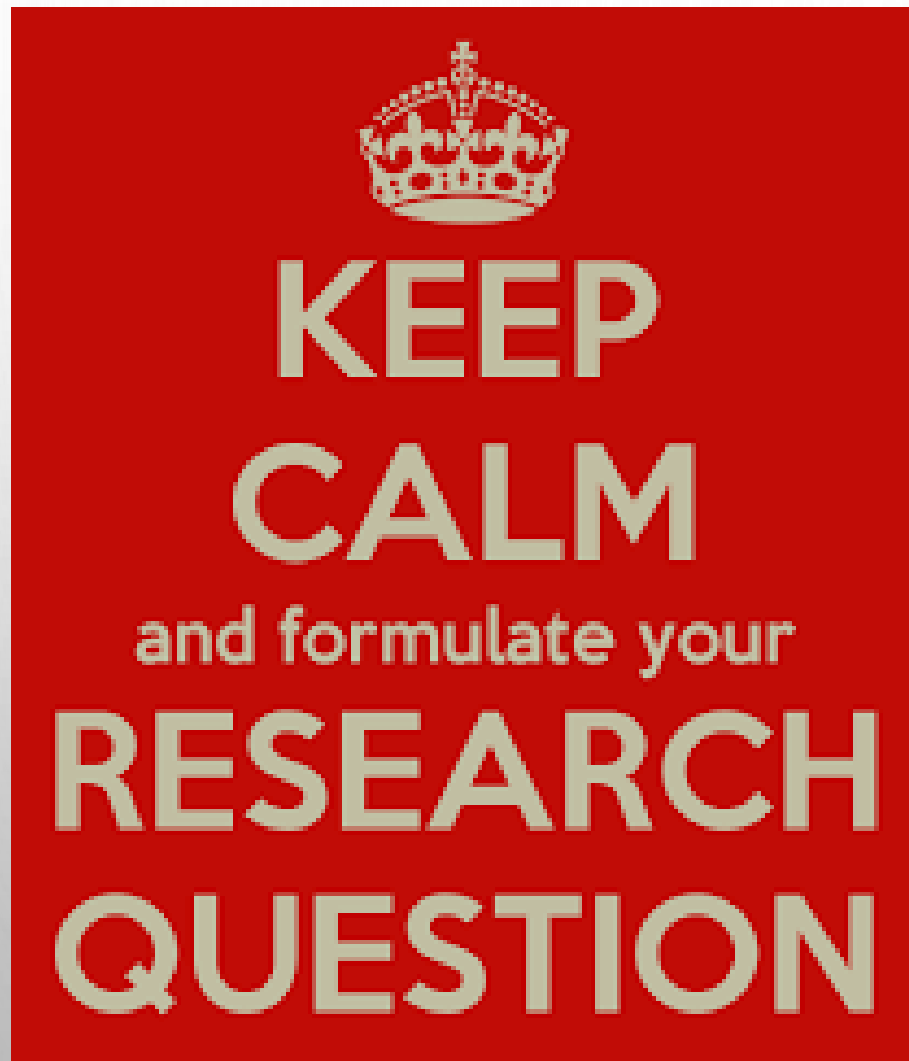
FLOOD FATALITIES



DROUGHT FORECAST



HENCE?

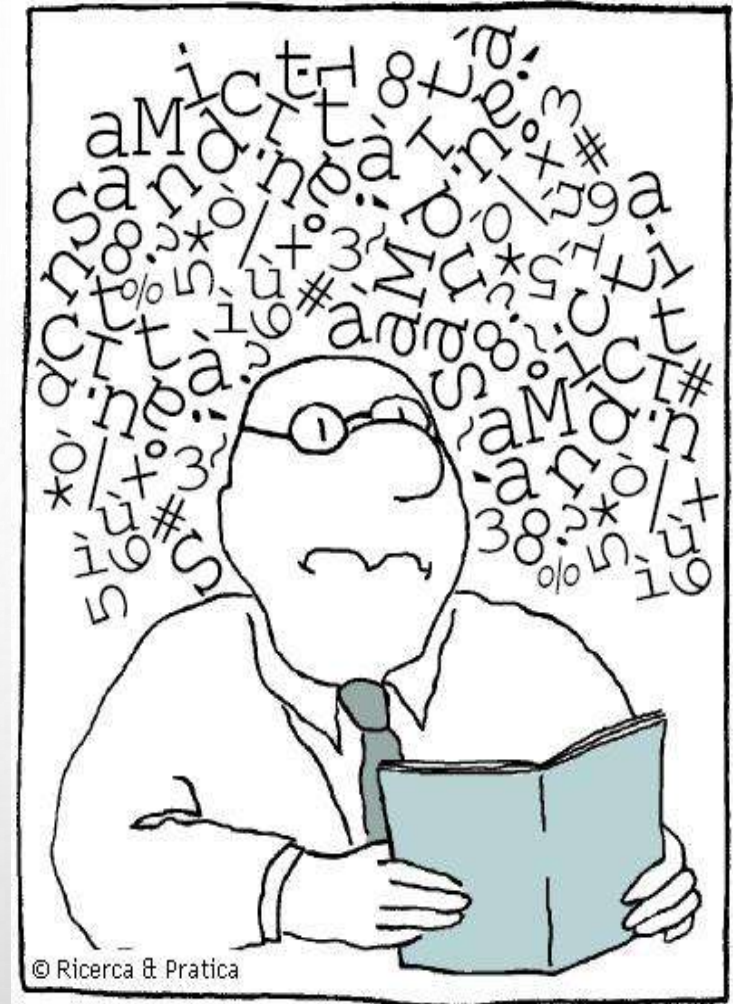


RESEARCH GAPS

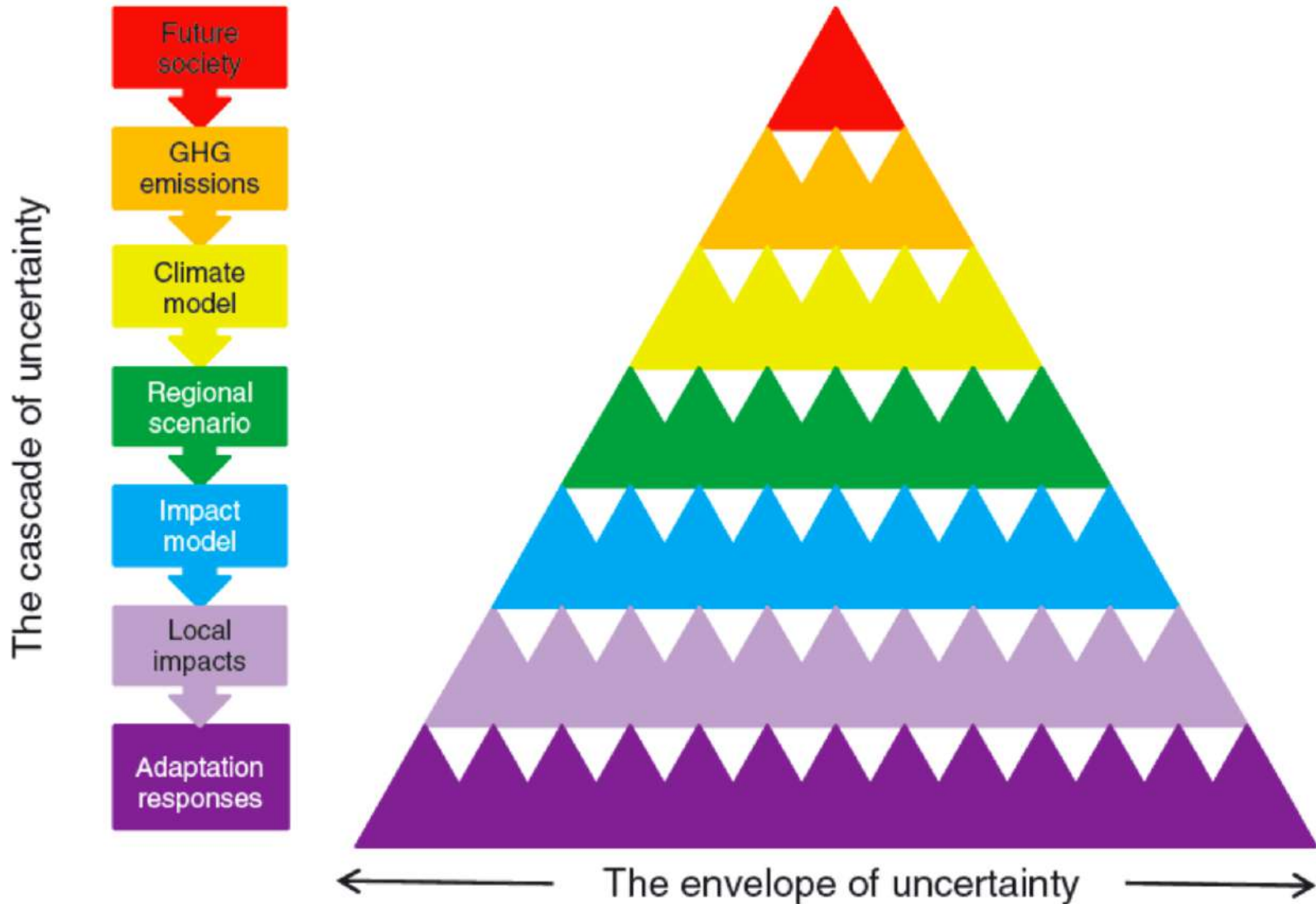


1. Analysis of extreme hydrological events in the CC context
2. Bridging the knowledge gap on IF and HOW CC modifies the size and frequency of extreme events, taking care to recognize the intrinsic effects of natural variability and separate them from those connected to the CC
3. Adapt risk management to the new dynamism at regional level

MEANWHILE.....











THE UNCERTAINTY PYRAMID



DOWNSCALING AT REGIONAL LEVEL

Common regional changes

-  Regardless of future levels of global warming, temperatures **will rise** in all European areas at a rate exceeding global mean temperature changes, **similar to past observations** (*high confidence*).
-  The frequency and intensity of hot extremes, including marine heatwaves, **have increased** in recent decades and **are projected** to keep increasing regardless of the greenhouse gas emissions scenario. Critical thresholds relevant for ecosystems and humans **are projected to** be exceeded for global warming of 2°C and higher (*high confidence*).
-  The frequency of cold spells and frost days **will decrease** under all the greenhouse gas emissions scenarios in this report and all time horizons, **similar to past observations**. (*high confidence*)
-  Despite strong internal variability, **observed** trends in European mean and extreme temperatures cannot be explained without accounting for anthropogenic factors. Before the 1980s, warming by greenhouse gases **was** partly offset by anthropogenic aerosol emissions. Reduced aerosol influence in the recent decades **has led to** an observable positive trend in shortwave radiation. (*high confidence*)
-  **Observations** have a seasonal and regional pattern consistent with **projected** increase of precipitation in winter in Northern Europe. A precipitation decrease **is projected** in summer in the Mediterranean extending to northward regions. Extreme precipitation and pluvial flooding **are projected** to increase at global warming levels exceeding 1.5°C in all regions except the Mediterranean. (*high confidence*)
-  Regardless of level of global warming, relative sea level **will** rise in all European areas except the Baltic Sea, at a rate close to or exceeding global mean sea level. Changes **are projected** to continue beyond 2100. Extreme sea level events **will become** more frequent and more intense, leading to more coastal flooding. Shorelines along sandy coasts **will retreat** throughout the 21st century (*high confidence*).
-  Strong declines in glaciers, permafrost, snow cover extent, and snow seasonal duration at high latitudes/altitudes **are observed** and **will continue** in a warming world (*high confidence*).
-  Multiple climatic impact-drivers **have already** changed concurrently over recent decades. The number of climatic impact-driver changes **is expected** to increase with increasing global warming (*high confidence*).

Revisiting the Concepts of Return Period and Risk for Nonstationary Hydrologic Extreme Events

Jose D. Salas, M.ASCE¹; and Jayantha Obeysekera, M.ASCE²

Abstract: Current practice using probabilistic methods applied for designing hydraulic structures generally assume that extreme events are stationary. However, many studies in the past decades have shown that hydrological records exhibit some type of nonstationarity such as trends and shifts. Human intervention in river basins (e.g., urbanization), the effect of low-frequency climatic variability (e.g., Pacific Decadal Oscillation), and climate change due to increased greenhouse gasses in the atmosphere have been suggested to be the leading causes of changes in the hydrologic cycle of river basins in addition to changes in the magnitude and frequency of extreme floods and extreme sea levels. To tackle nonstationarity in hydrologic extremes, several approaches have been proposed in the literature such as frequency analysis, in which the parameters of a given model vary in accordance with time. The aim of this paper is to show that some basic concepts and methods used in designing flood-related hydraulic structures assuming a stationary world can be extended into a nonstationary framework. In particular, the concepts of return period and risk are formulated by extending the geometric distribution to allow for changing exceeding probabilities over time. Building on previous developments suggested in the statistical and climate change literature, the writers present a simple and unified framework to estimate the return period and risk for nonstationary hydrologic events along with examples and applications so that it can be accessible to a broad audience in the field. The applications demonstrate that the return period and risk estimates for nonstationary situations can be quite different than those corresponding to stationary conditions. They also suggest that the nonstationary analysis can be helpful in making an appropriate assessment of the risk of a hydraulic structure during the planned project-life. DOI: 10.1061/(ASCE)HE.1943-5584.0000820. © 2014 American Society of Civil Engineers.

Hydrol. Earth Syst. Sci., 18, 649–671, 2014
www.hydrol-earth-syst-sci.net/18/649/2014/
doi:10.5194/hess-18-649-2014
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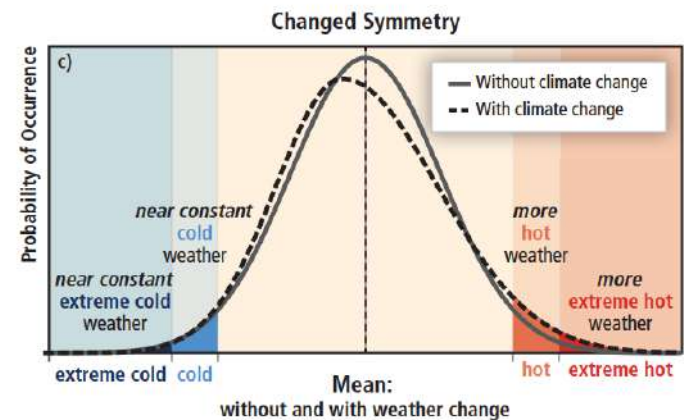
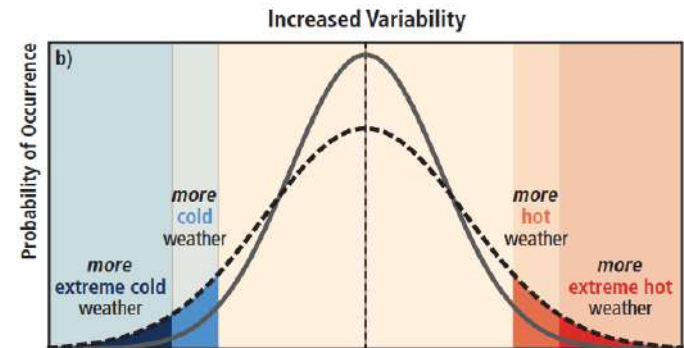
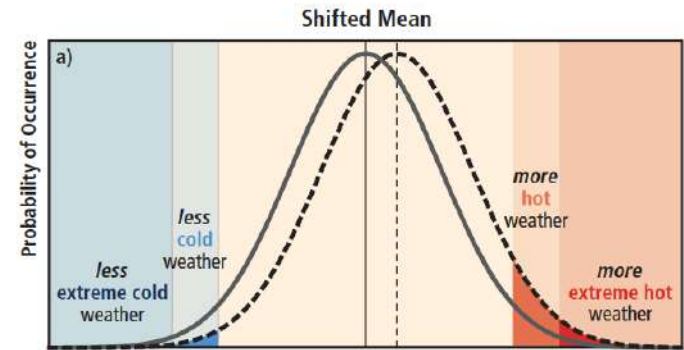
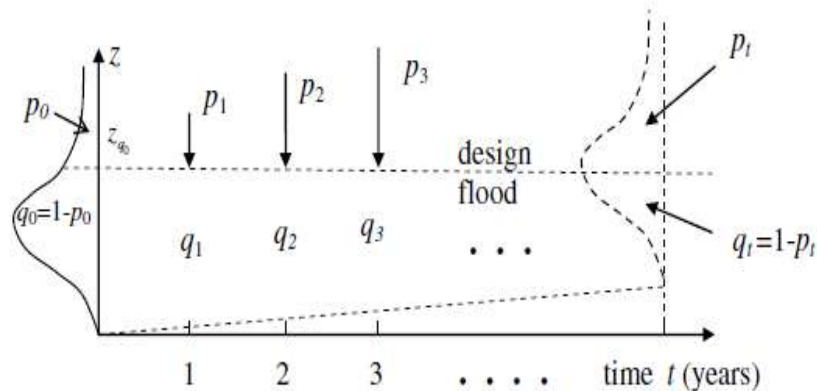
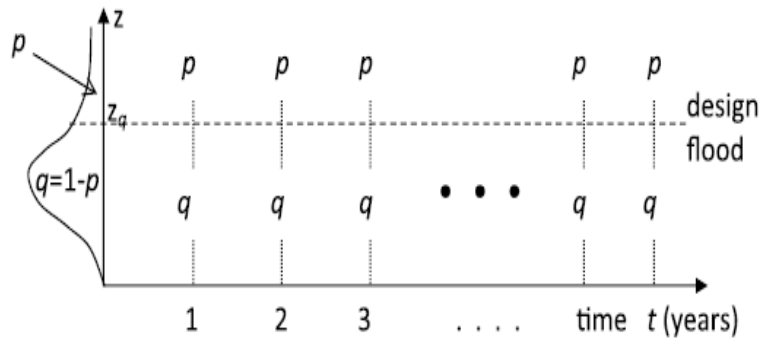
Hydrology and
Earth System
Sciences



Advancing catchment hydrology to deal with predictions under change

U. Ehret , H. V. Gupta , M. Sivapalan , S. V. Weijjs , S. J. Schymanski , G. Blöschl , A. N. Gelfan , C. Harman , A. Kleidon , T. A. Bogaard , D. Wang , T. Wagener , U. Scherer , E. Zehe , M. F. P. Bierkens , G. Di Baldassarre , J. Parajka , L. P. H. van Beek , A. van Griensven , M. C. Westhoff , and H. C. Winsemius

EFFECTS



CONCLUSIONS

THE ASSESSMENT OF THE CLIMATIC IMPACTS ON THE MEDIUM-LONG TERM FORECAST REQUIRES:

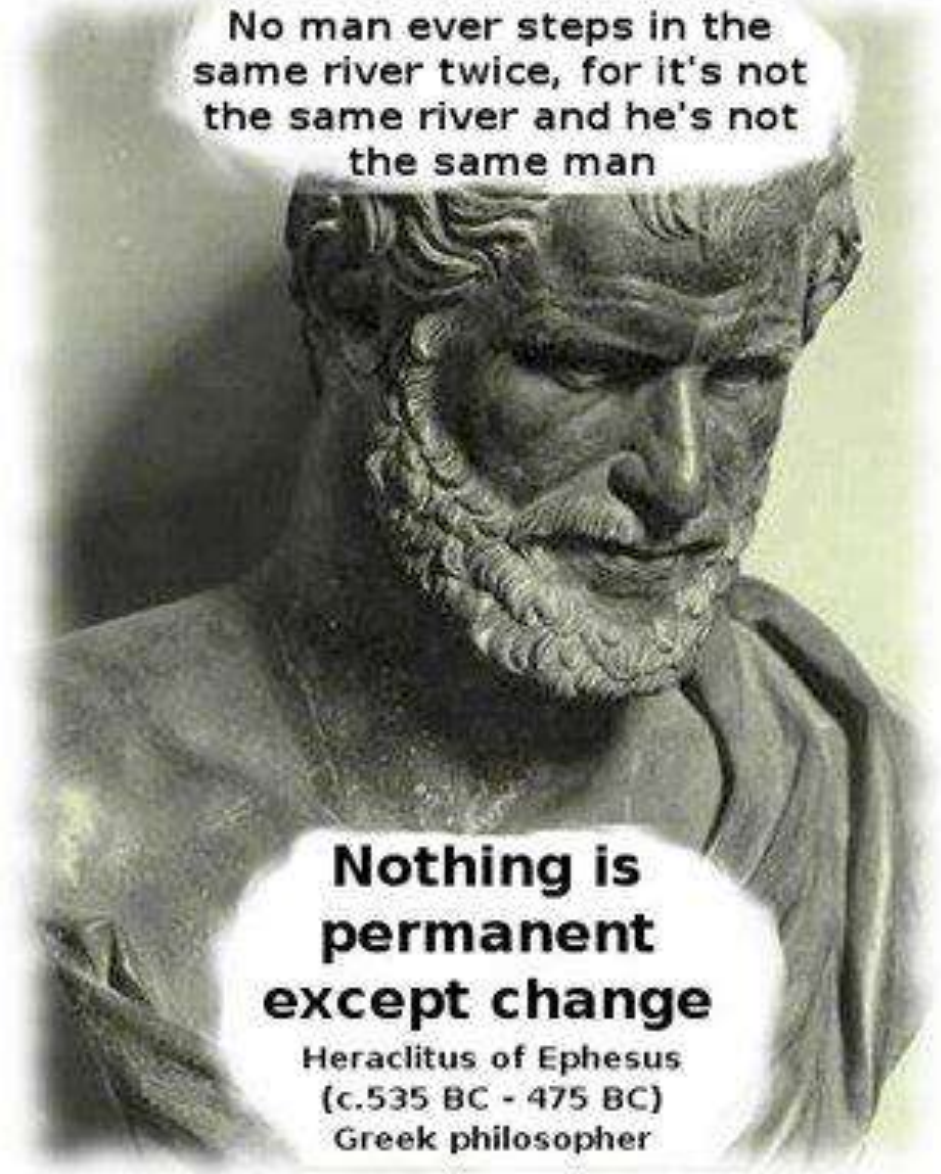
A rigorous evaluation of the observed trends;

An effective regional analysis;

Probabilistic models capable in representing non-stationary phenomena

Promote the rainfall data collection and the river discharge measurements



A detailed marble bust of the Greek philosopher Heraclitus of Ephesus. He is depicted with a full, curly beard and hair, and a serious, contemplative expression. He is wearing a draped garment, likely a chiton or himation.

No man ever steps in the
same river twice, for it's not
the same river and he's not
the same man

**Nothing is
permanent
except change**

Heraclitus of Ephesus
(c.535 BC - 475 BC)
Greek philosopher

THANKS

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