Expert 2 – Dr. Antonio TRABUCCO

Scientific researcher

at the Euro-Mediterranean Center on Climate Change (CMCC)

**“Climate change and challenges on water resources in Mediterranean areas”**

# CAUSES OF CLIMATE CHANGE

**Anthropic Activities**

**Greenhouse gas and aerosol emissions**
Since the industrial revolution, emission of greenhouse gases into atmosphere from industrial and intensive activities has increased exponentially:

fossil fuels, farming, fertilization

**Land Use Changes**
Important changes already from Roman Empire, but prevalent from industrial era, conversion from forests to agriculture.

Carbon release from plant biomass and into the soil

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# CAUSES OF CLIMATE CHANGE

**Natural Activities**

Solar energy - Earth's orbital components (axial tilt, orbital eccentricity, etc.) vary by affecting the amount of incident solar energy

Volcanic eruptions - emission of gases and dust particles, causing a partial block of the sun's rays for a few years.

Oceanic Currents - Blocking of the tropical current in the Pacific (el Niño / la Niña)

Plate tectonics - land movement / blocks and alteration of atmospheric and oceanic cycles

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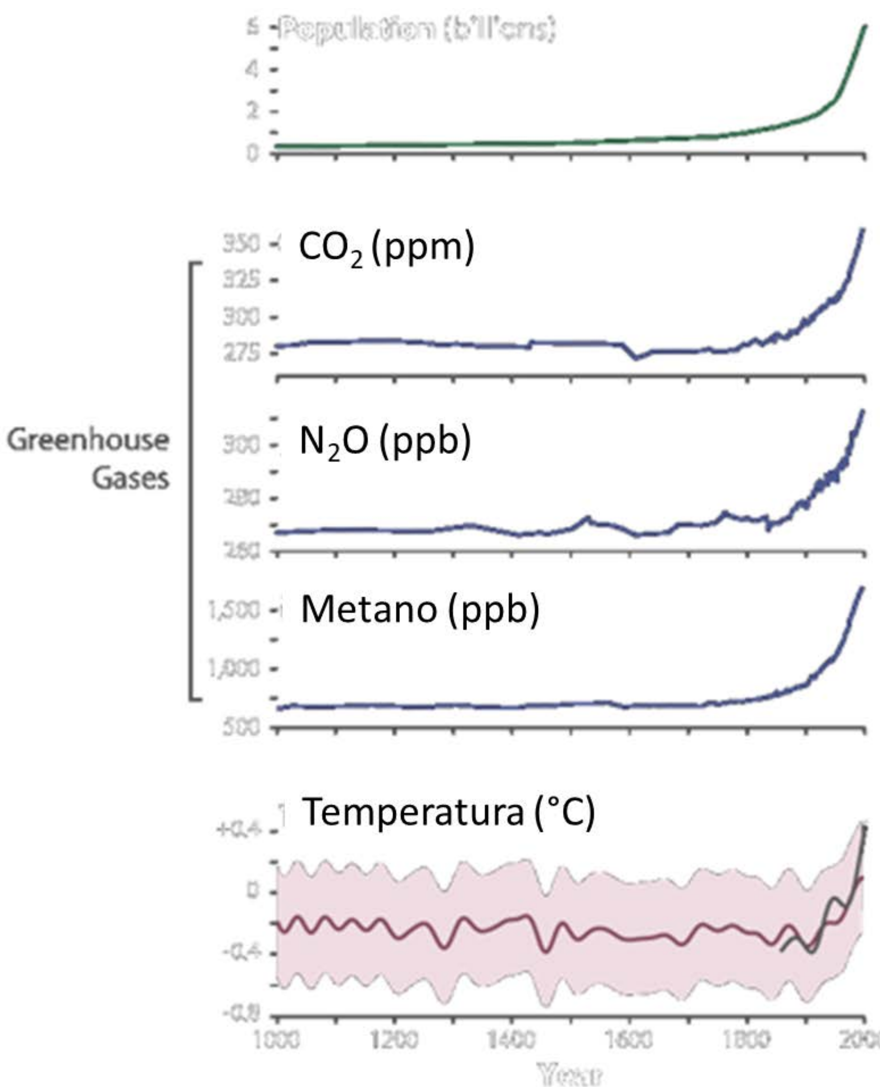
# CAUSES OF CLIMATE CHANGE



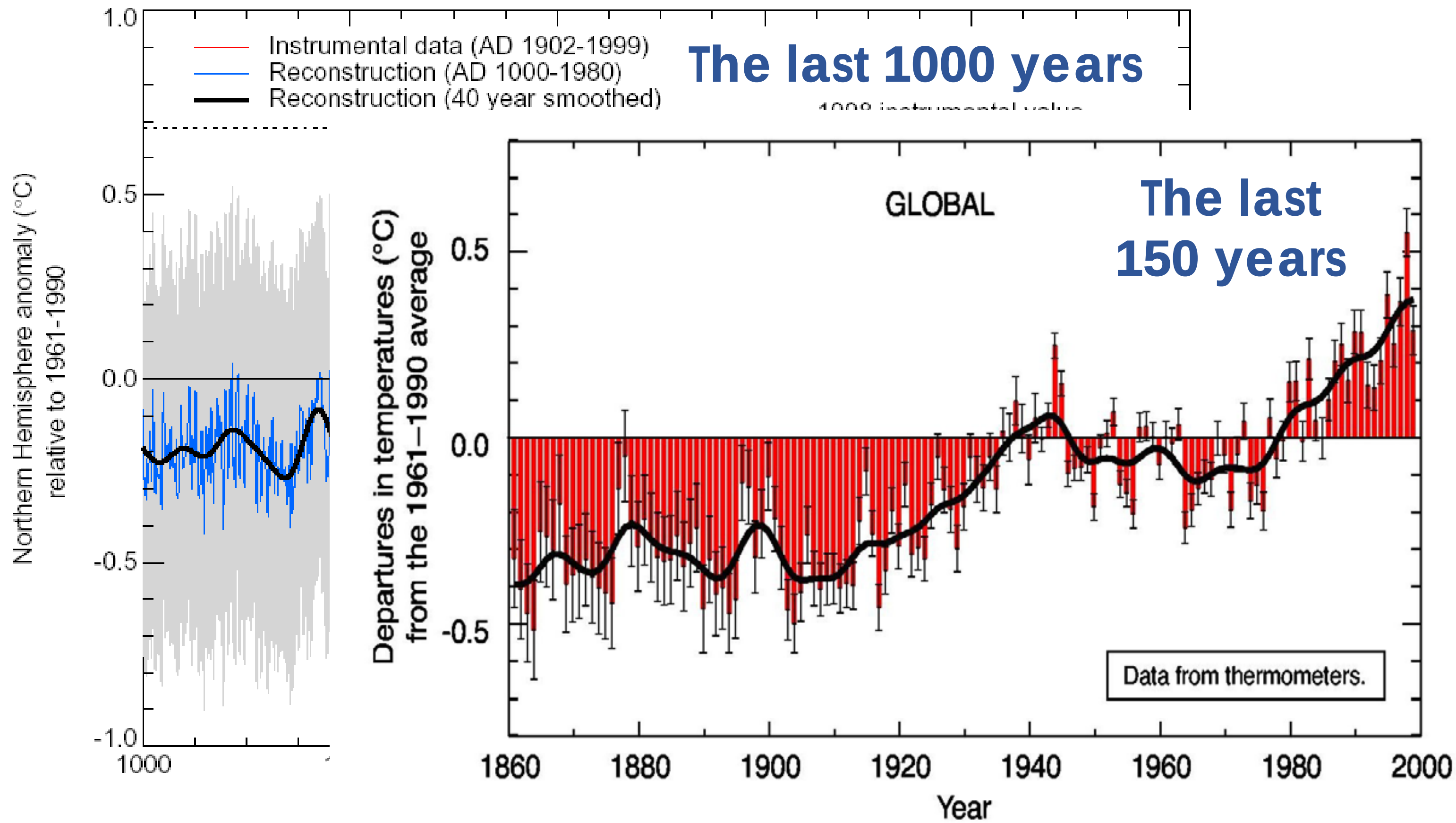

Population has increased from 1.65 billion to over 7 billion inhabitants

Over the same period, increase in three of the most abundant GHG emitted by man, reflecting the growth of the human population

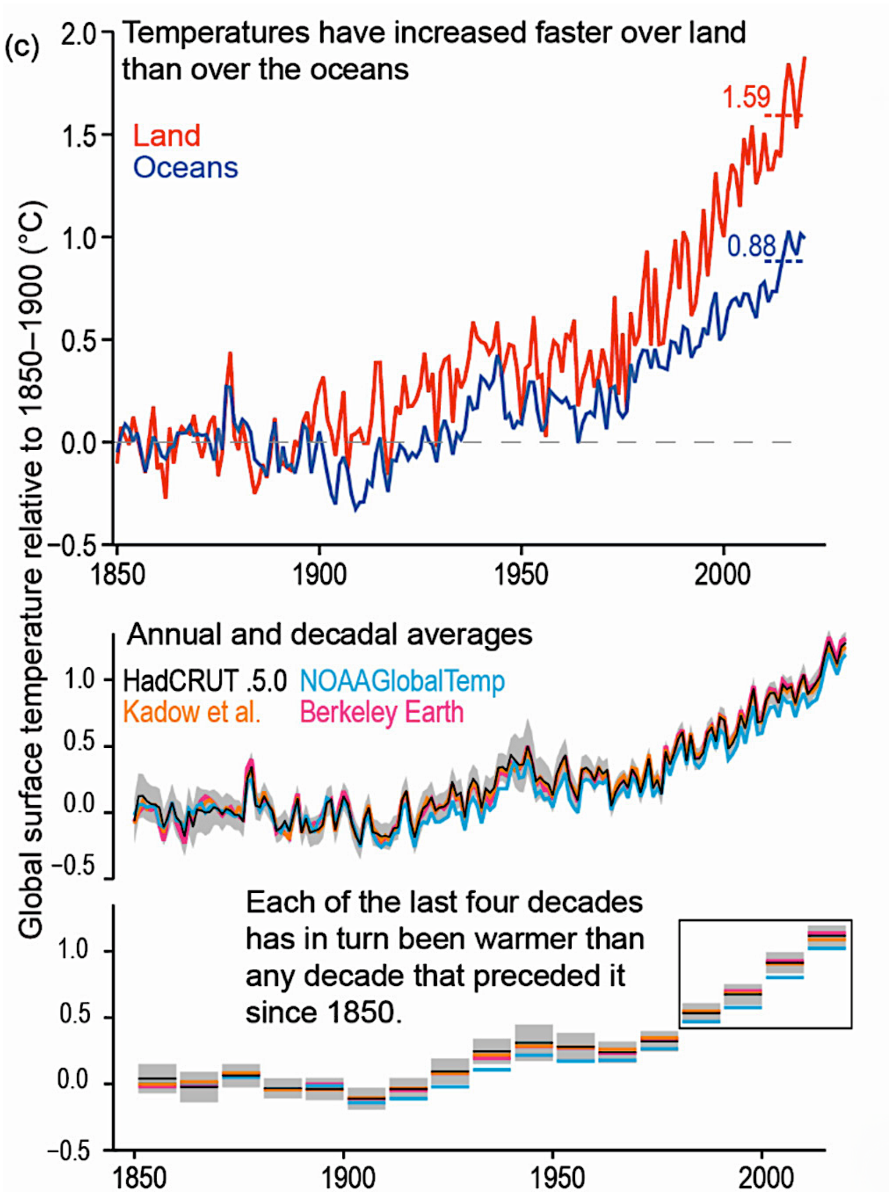
As those GHG increased, Earth experienced an unusually rapid rise in its average temperature, increasing by 0.8 °C since 1880

# CLIMATE CHANGE

## The climate of our planet is dynamic and it is therefore constantly evolving



# The recent warming




+ 1.59°C

+ 0.88°C

In recent decades, key indicators of the climate system have risen to levels never seen in centuries and millennia and are changing at unprecedented rates.

The last seven years since 2015 have all been the warmest recoded; the top three being **2016, 2019 and 2020**

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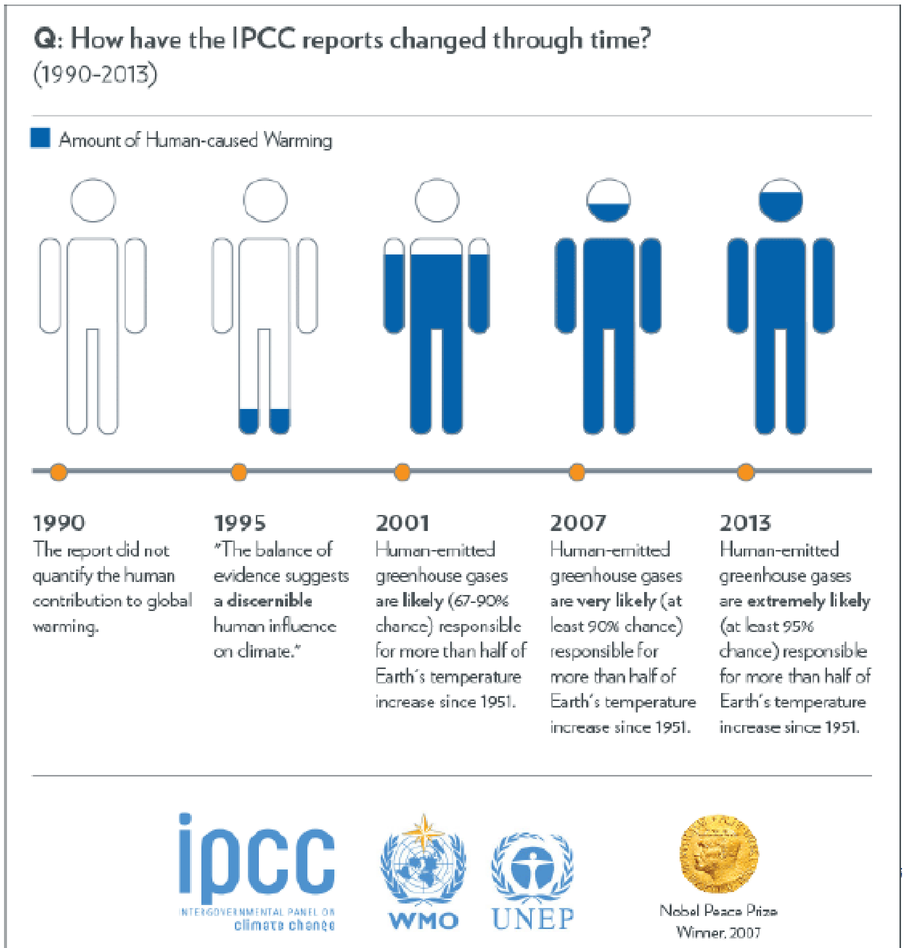
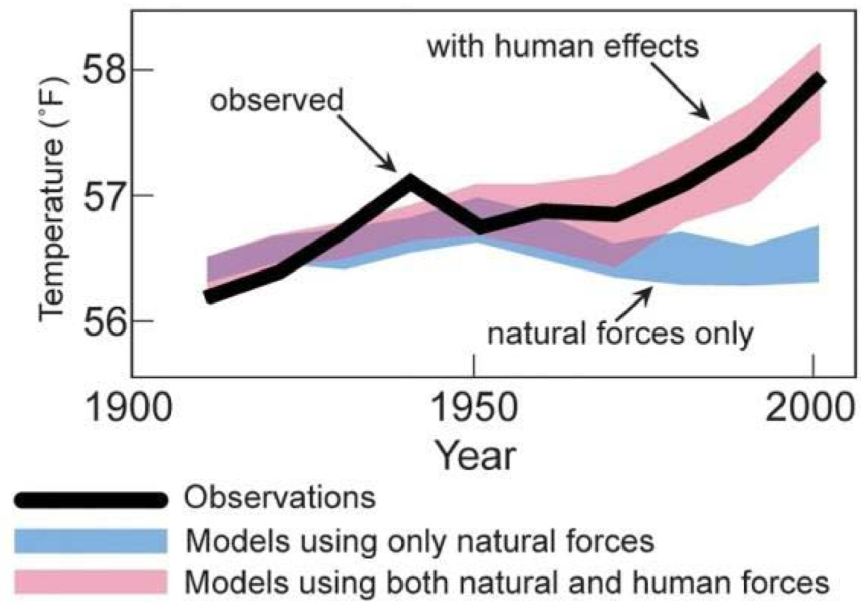
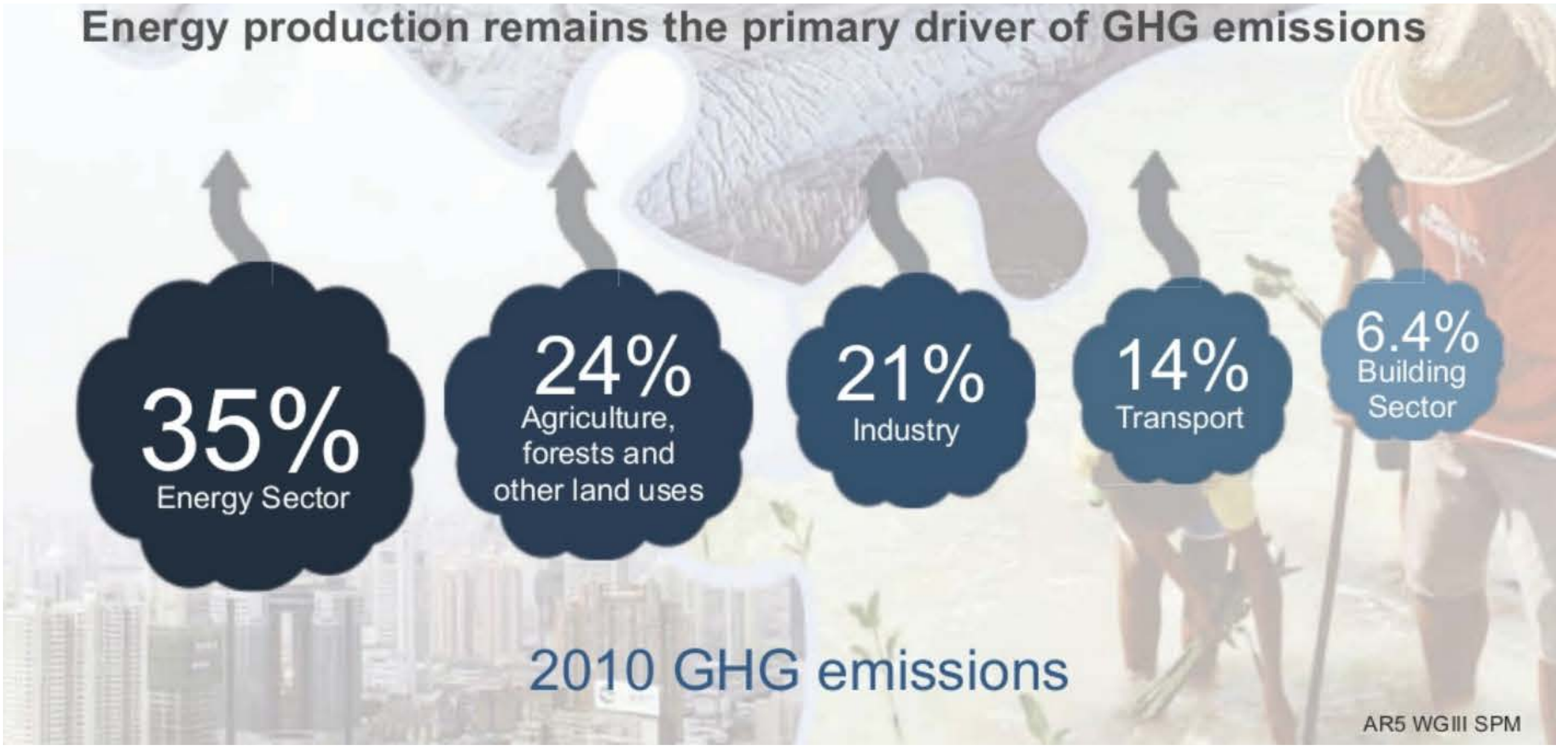
# Anthropic influence on climate change



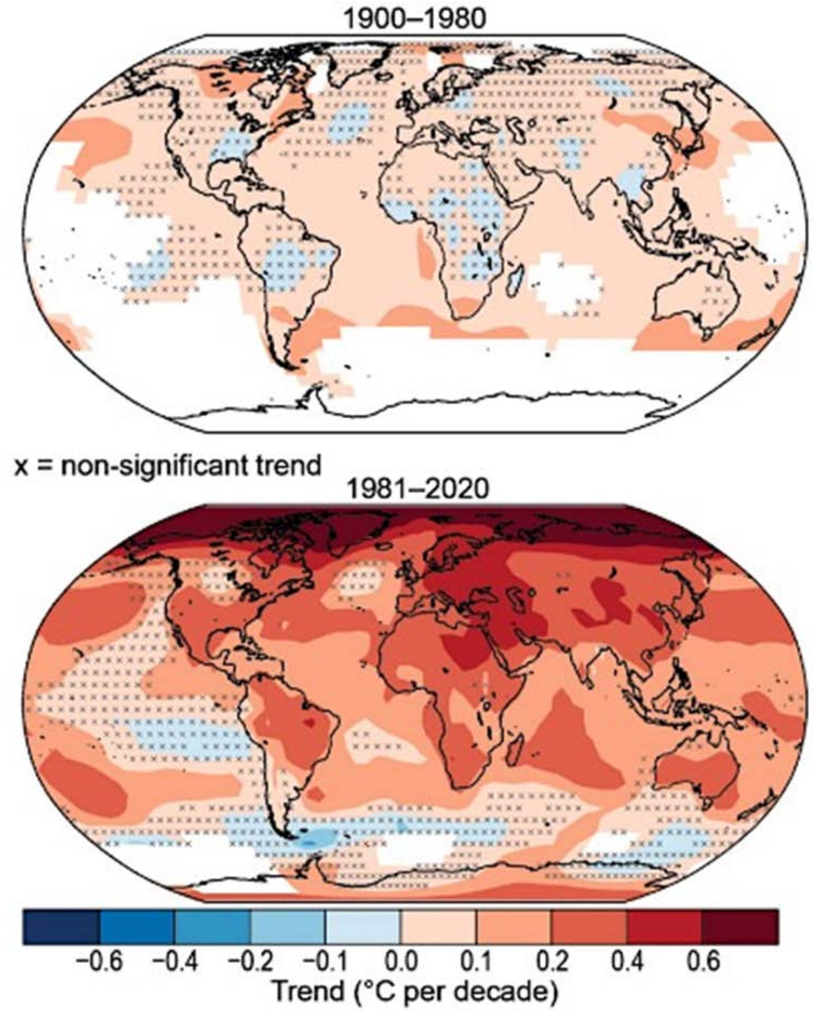
# The causes of global warming




The main sources of emissions are energy sources (35%), agriculture, forests and other land uses (AFOLU, 24%), industry (21%), transport (14%), and buildings (6.4%).

# The recent warming

Temperatures have risen faster than in previous IPCC assessment rounds (AR6, 2021)




Temperature variations (° C per decade) for the periods 1900-1980 (top map) and 1981-2020 (bottom map).
"X" indicates an insignificant trend.

# The recent warming

The impacts of observed climate change are **widespread** and **relevant**

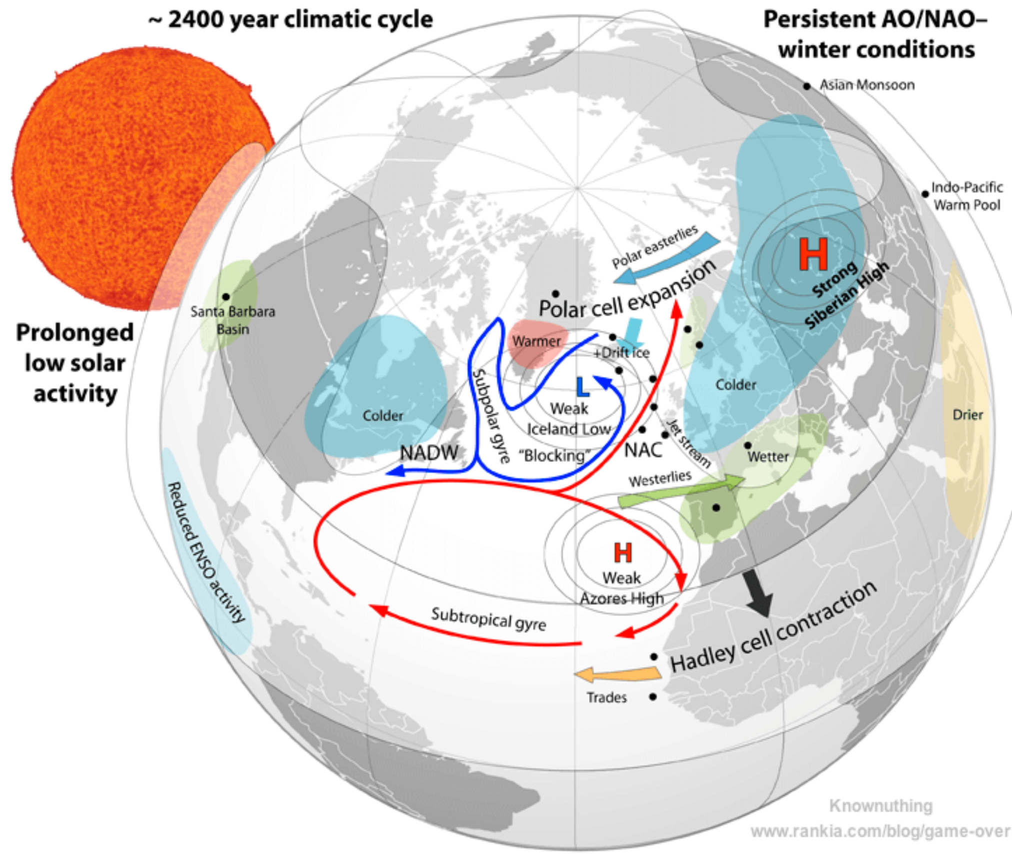
**Faster speed** of climate changes that took place in the past, largely a consequence of the concurrence of human activity

Heating that causes accelerations in the hydrological cycle and air flows causing high variability and more extreme event

Heat Waves, Strong precipitation events

Mediterranean hotspot of climate change

# The Mediterranean climate




Proximity to Atlantic and Indian Oceans and surrounding massive land areas, with diverse climate characteristics -> crossroads of many global climate patterns and processes of tropical and extra-tropical origin

**Observed changes:**

Basin-wide, annual mean temperatures are now 1.5°C above the preindustrial.

After the 1980s, warming has accelerated at higher rates than global average

Hot and cold extremes have also become warmer, while in particular there is strong evidence and consensus that heat waves more frequent and severe

Average length of heat waves has doubled, while the frequency of hot days has tripled

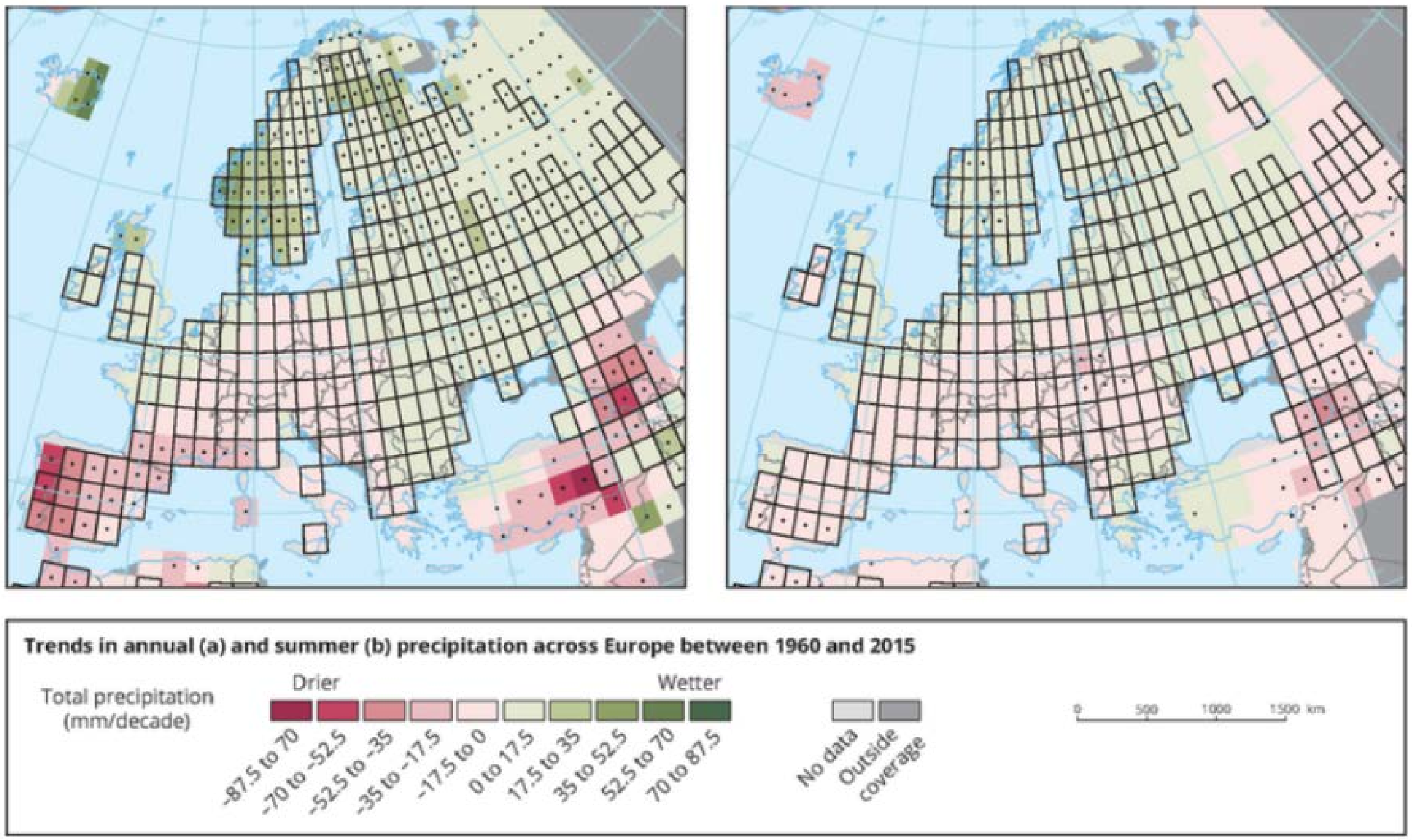
Increased frequency of heavy rainfall events

higher Sea surface temperature might derive to stronger medicanes cyclones.

# Changes observed in Europe

Scandinavia + > 17 mm/decade
Penisola Iberica - 90 mm/decade

N. Europa + 18 mm/decade
S. Europa - 20 mm/decade

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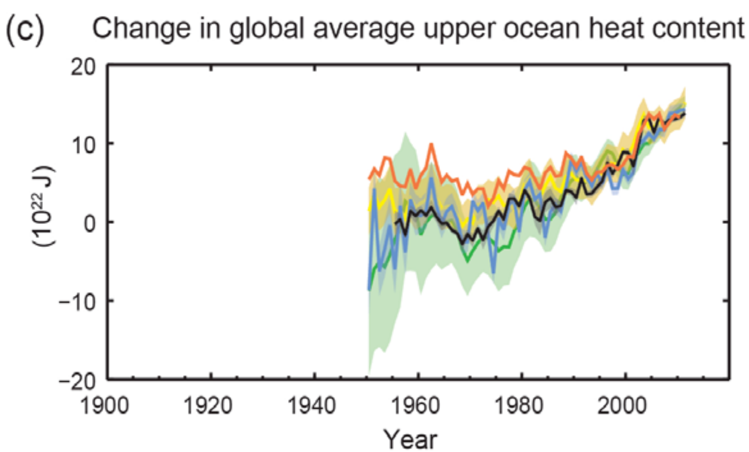
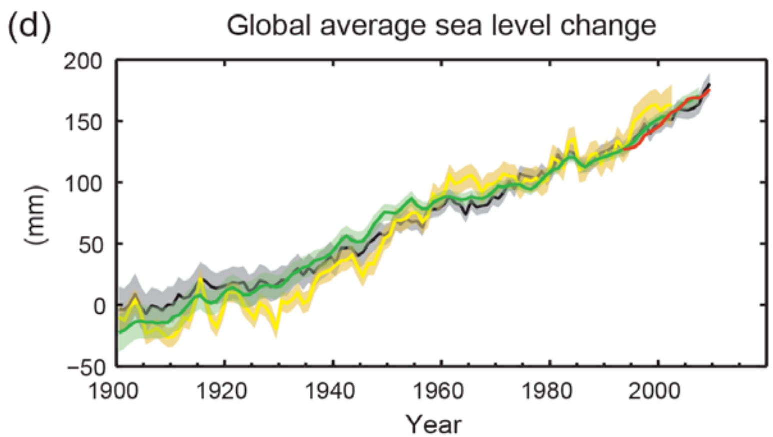
# Sea level rise

- The oceans have absorbed up to 80% of the heat added to our planet
- Average ocean temperat increased to a depth of 3000 m
- The sea surface is warming at a rate of 0.11 C per decade over the period 1971-2010.
- Sea heating causes water expansion and sea level rise.
- Glaciers and snowpack decreasing → sea level rise..

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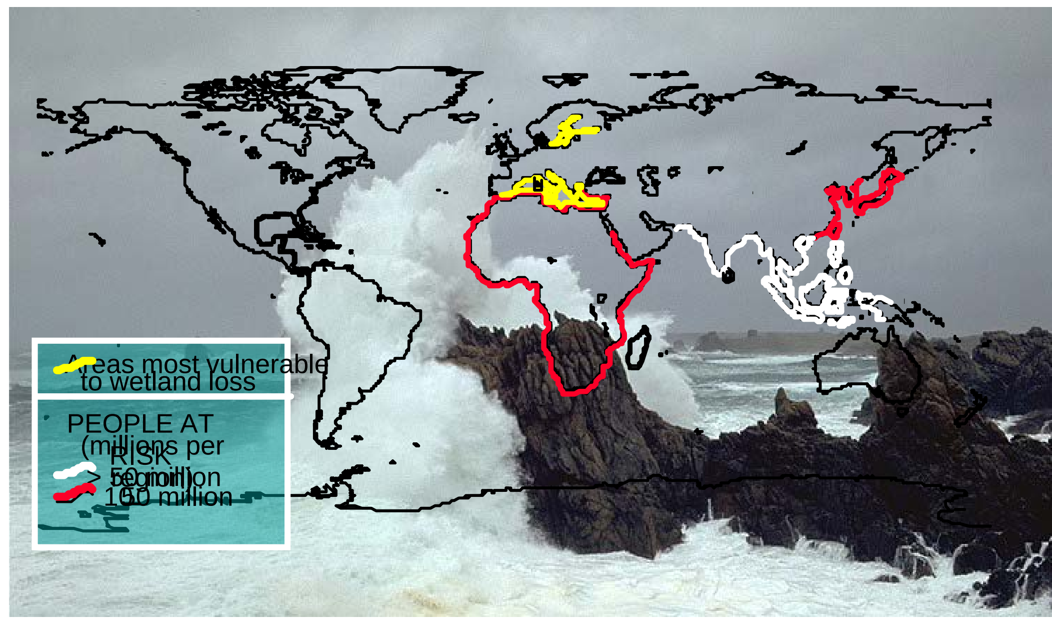
# Sea level rise

- Coastal **erosion** risk
- Modification of the current **structure** of the coasts, its **habitats**, activities and **infrastructures** that contribute to well-being and social subsistence
- Alteration of **nutrient cycles** with consequent repercussions on food production and activities related to fishing and aquaculture
- Increased **annual floods** affecting millions of people



# Intergovernmental Panel on Climate Change (IPCC)

1988 United Nations (UNEP & WHO) form the IPCC

Provides policy makers with a scientific assessment of the technical-scientific and socio-economic literature on climate change, impacts, adaptation and mitigation. It is not a research organization!

Report: 1990-1995-2001-2007-2014


Working Group I Report
"Climate Change 2013: The Physical Science Basis"

Working Group II Report
"Impacts, Adaptation and Vulnerability"

Working Group III Report
"Mitigation of Climate Change"

http://www.ipcc.ch/

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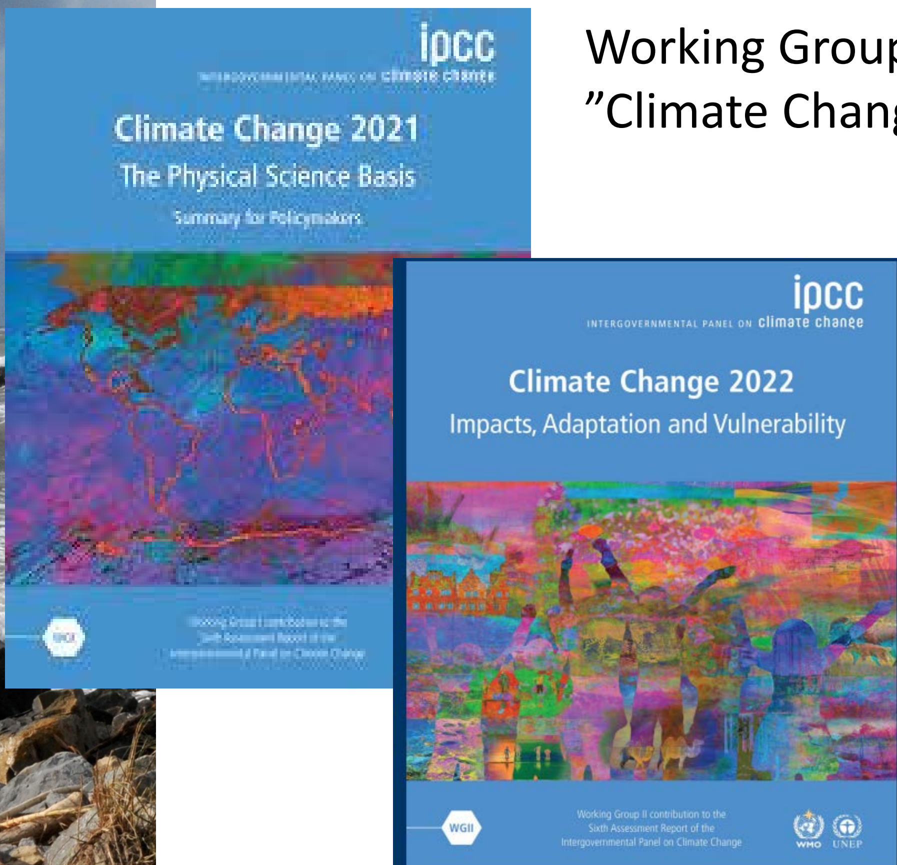
# Intergovernmental Panel on Climate Change (IPCC)

## IPCC Assessment Reports (2021) – AR6




Working Group I Report
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Working Group III Report
“Mitigation of Climate Change"

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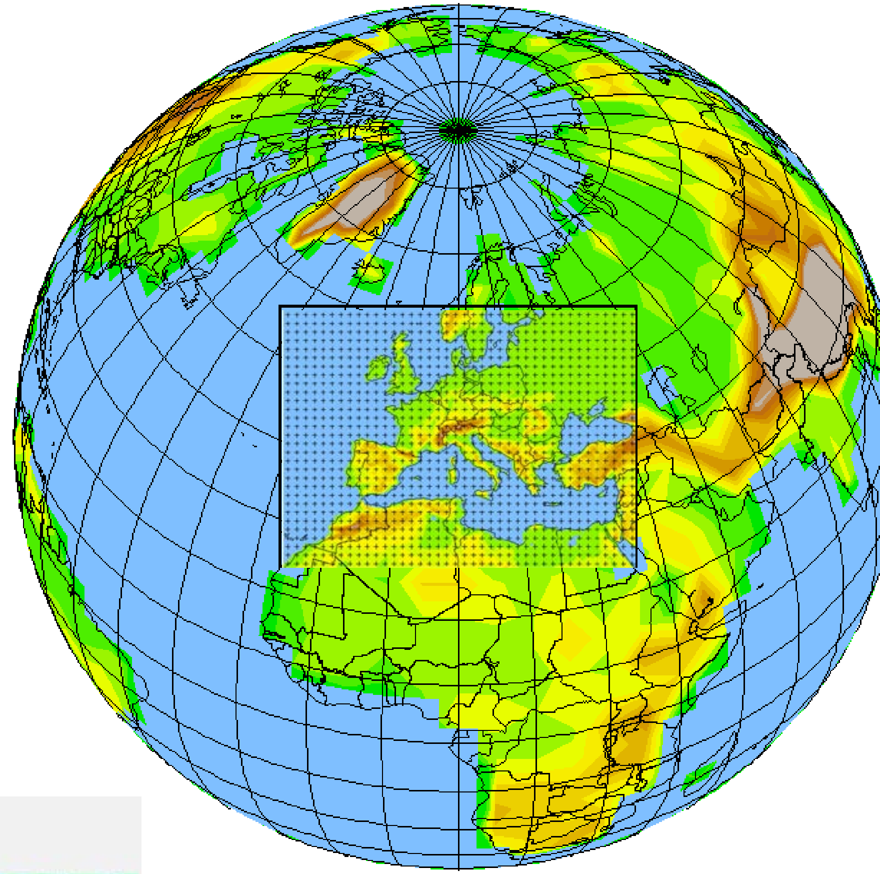
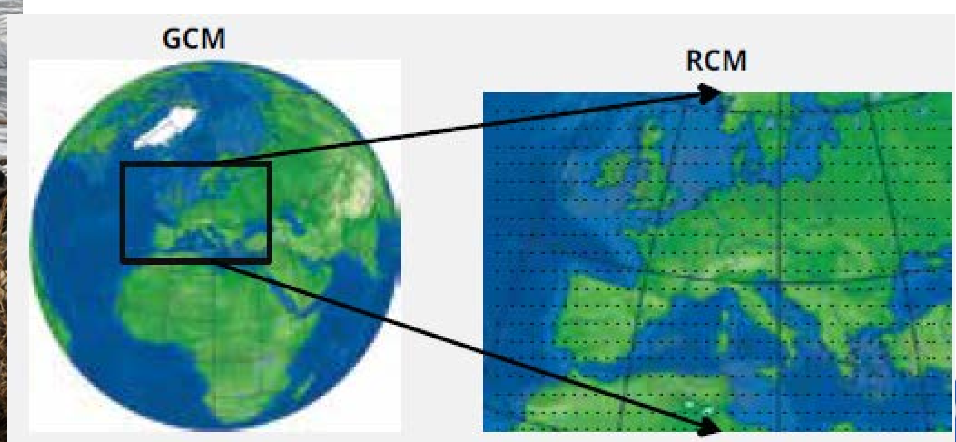
# The expected climate changes

Numerical mathematical models: they are called "general circulation models of the atmosphere and ocean" or "regional climate models"



Global Circulation Model

Regional Circulation Model



# Numerical simulations

| | |
|---|---|
| **Reanalisi climatiche** | Periodo storico |
| **Numerical Weather Predictions (NWP)**<br>*Meteorological Prediction Centers* | da poche ore a 10 gg |
| **Sub-seasonal predictions** | da 10 a 45 gg |
| **Seasonal predictions** | da 1 a 6 mesi |
| **Decadal predictions (or short term projections)** | da 2 a 20 anni |
| **Climate (or long term) projections** | da 30 a +100 anni |

Forecasts

Projections

# Climate Scenarios

the scientific community has defined a set of four scenarios, referred to as the “**Rapresentative Concentration Pathway**” (RCP).

The scenario is an assessment of future changes in greenhouse gas emissions and aerosol based on certain assumptions

| Nome | Forzante | CO2 equiv. (ppm) | Anomalia T (°C) |
|---|---|---|---|
| RCP2.6 | 3 Wm2 prima del 2100, decremento al 2.6 Wm2 dopo il 2100 | 490 | 0.3-1.7 |
| RCP4.5 | 4.5 Wm2 dopo il 2100 | 650 | 1.1-2.6 |
| RCP6 | 6 Wm2 dopo il 2100 | 850 | 1.4-3.1 |
| RCP8.5 | 8.5Wm2 nel 2100 | 1370 | 2.6-4.8 |

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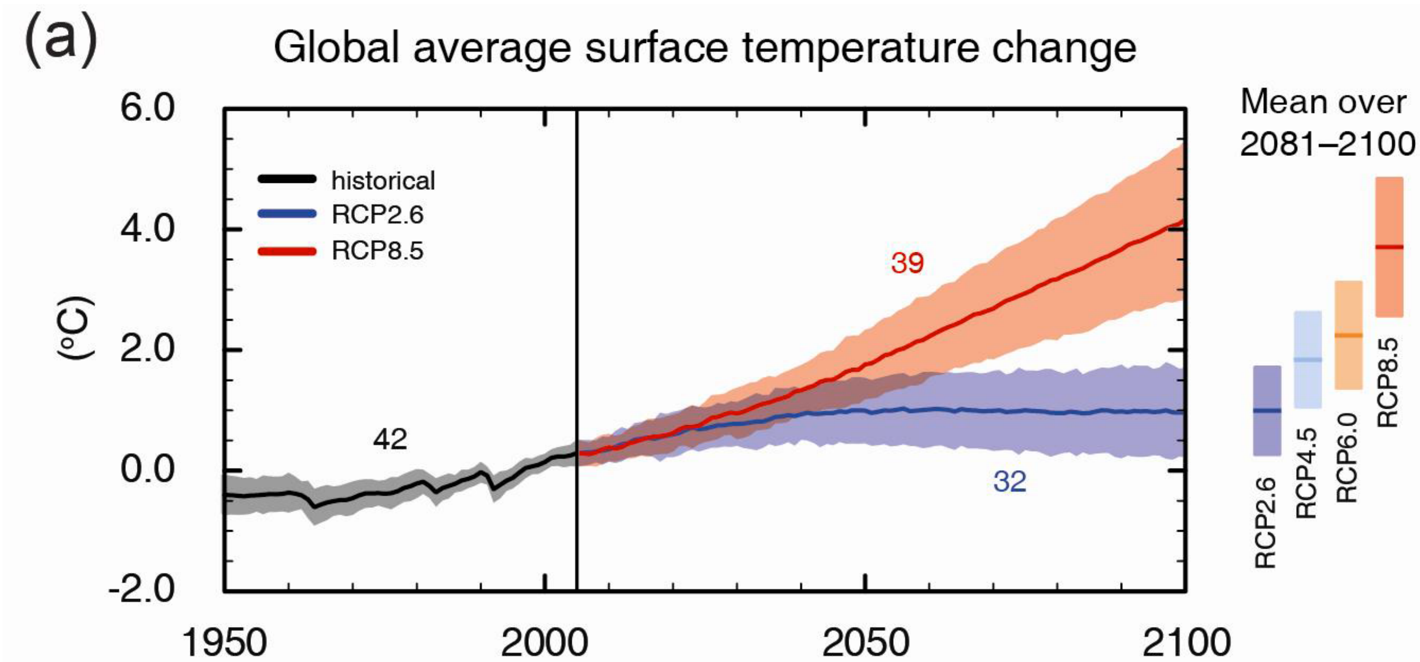


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| | | | malia T |
|---|---|---|---|
| | | | 1.7 |
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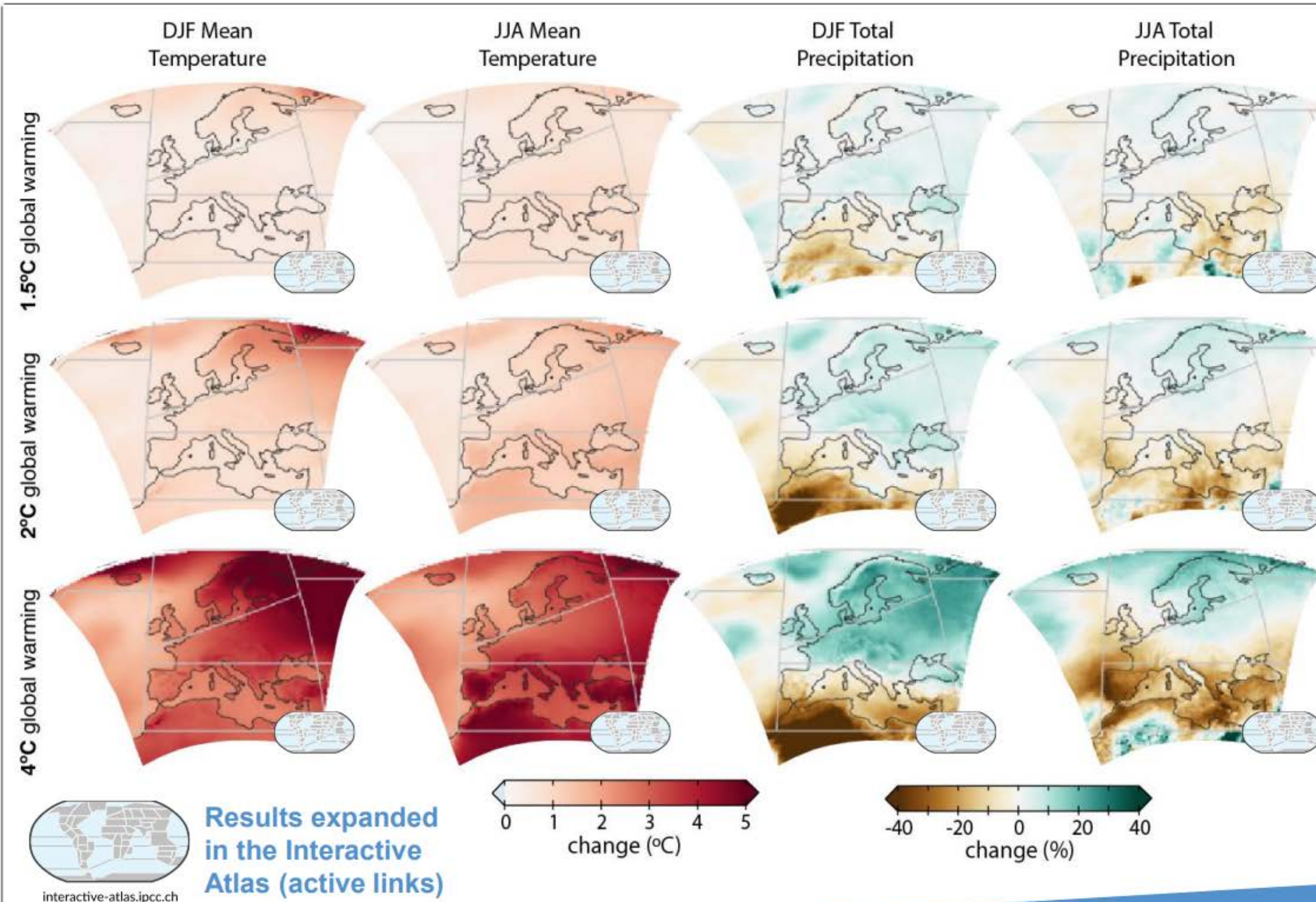
# Climate Change in the Mediterranean




**Projected changes in seasonal (Dec–Feb, DJF, and Jun–Aug, JJA) mean temperature and precipitation at 1.5°C, 2°C, and 4°C global warming relative to 1995-2014.**

Based on EURO CORDEX (40 models) using the SSP5-8.5 scenario to compute the warming levels.

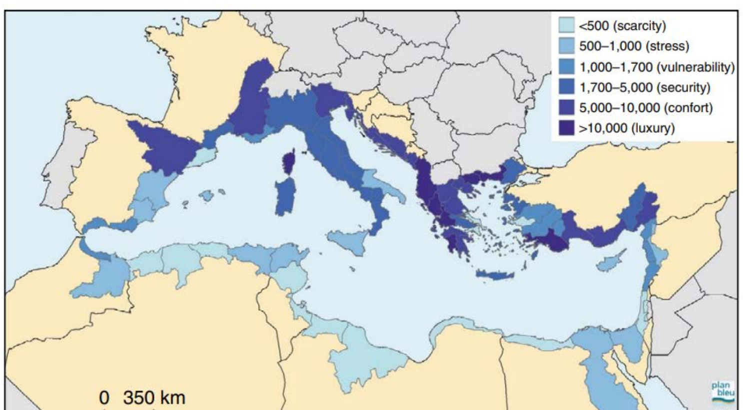
IPCC - SIXTH ASSESSMENT REPORT

# Climate Change in the Mediterranean

- Recent increases in temperatures in the Mediterranean exceed global averages
- More marked temperature increase in summer and lower in winter
- Heat waves can be amplified by drier ground conditions, which amplify the intensity and frequency of heat waves
- High uncertainty of rain forecasts (high spatial and temporal variability). On average, a slight decrease in the total annual precipitation is expected
- Likelihood of falling precipitation in spring / summer and a slight increase in autumn / winter (associated with more extreme precipitation events)
- Concomitance of temperature increases and decreases in rainfall leads to greater risks of drought

# Climate Change & runoff in the Mediterranean

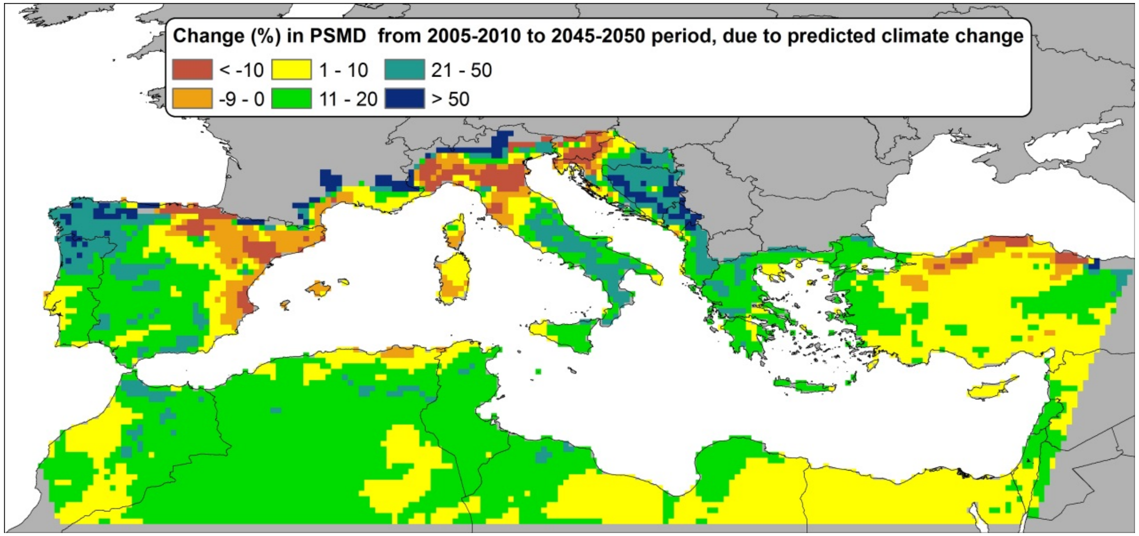
- Fresh water availability is likely to decrease substantially (by 2–15% for 2 °C of warming)
- Seasonality of streamflows very likely to change, with earlier declines of snow melt in spring, intensification of low flows in summer and greater and more irregular winter discharges
- The eastern and southern rim countries, as part of the MENA region, will see particularly severe shortages of river flow.
- Water levels in lakes and reservoirs will probably decline



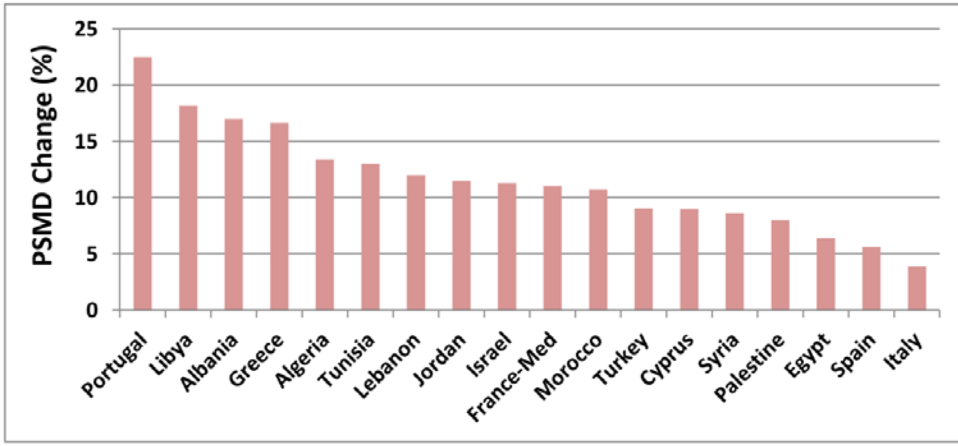

Annual natural renewable water resources in the main Mediterranean watersheds. Plan Bleu

# Climate CC & Irrigation requirements

## Irrigation Water requirements – Potential Soil Moisture Deficit



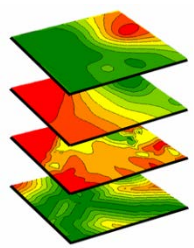

The change of PSMD indicator due to climate change in the Euro-Med indicates criticalities and hazards to agriculture sector, correlated with changes of crop water requirements (i.e. irrigation requirements)



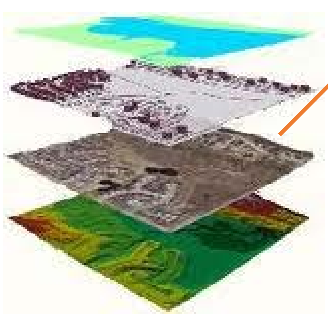
# **Irrigation requirements** - SIMETAW GIS-Platform

The **SIMETAW GIS-Platform (**Masia et al., 2018**)**

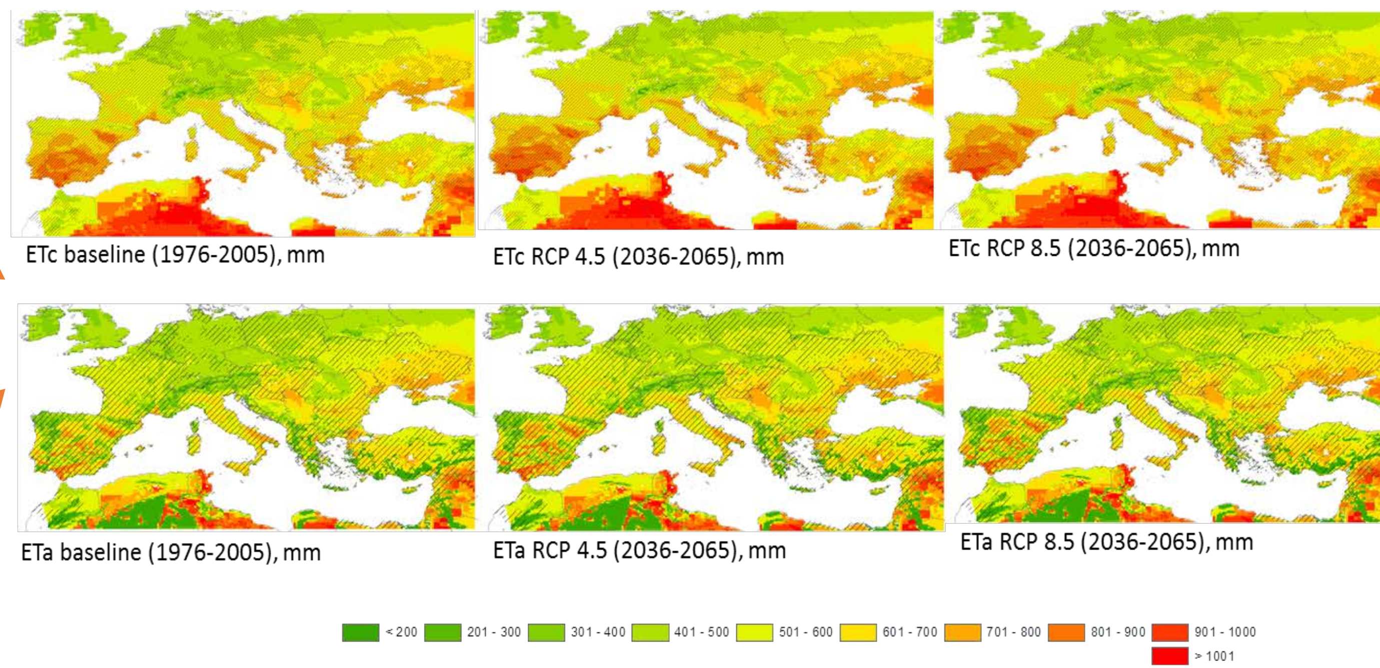
**Input NETCDF Daily Climate time series**



**Input Soil properties Crop management**



**Spatial modelling Output (NETCDF)**
**Reference/Actual evapotranspiration; Irrigation Requirements**



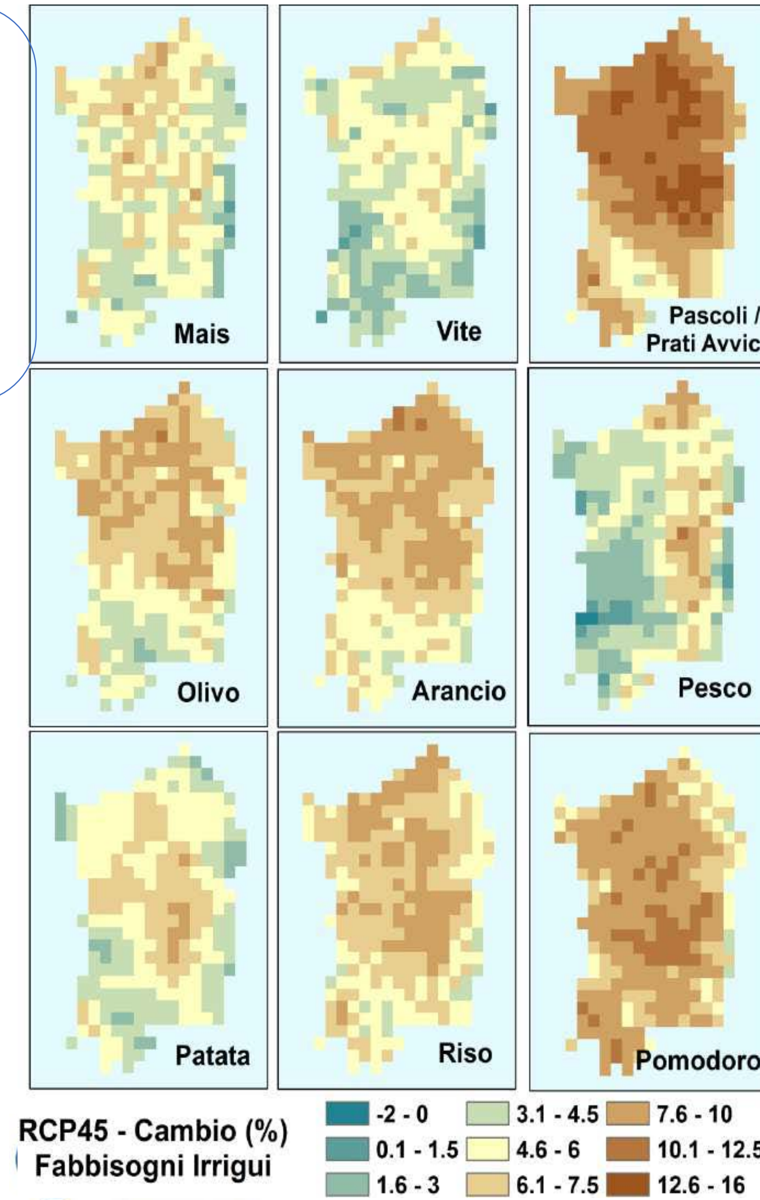

Masia et al., 2018

# Climate risk: change of irrigation requirements (%)

## SIMETAW-GIS TOOL

Expected changes in irrigation requirements for different crops in Sardinia under climate change

- ❑ Crop types most affected are those with winter/spring season growth (pastures, orange, rice and olive)
- ❑ Crop types with late summer growth suffer lowest anomalies in irrigation requirements
- ❑ Expected changes in crop distribution following CC



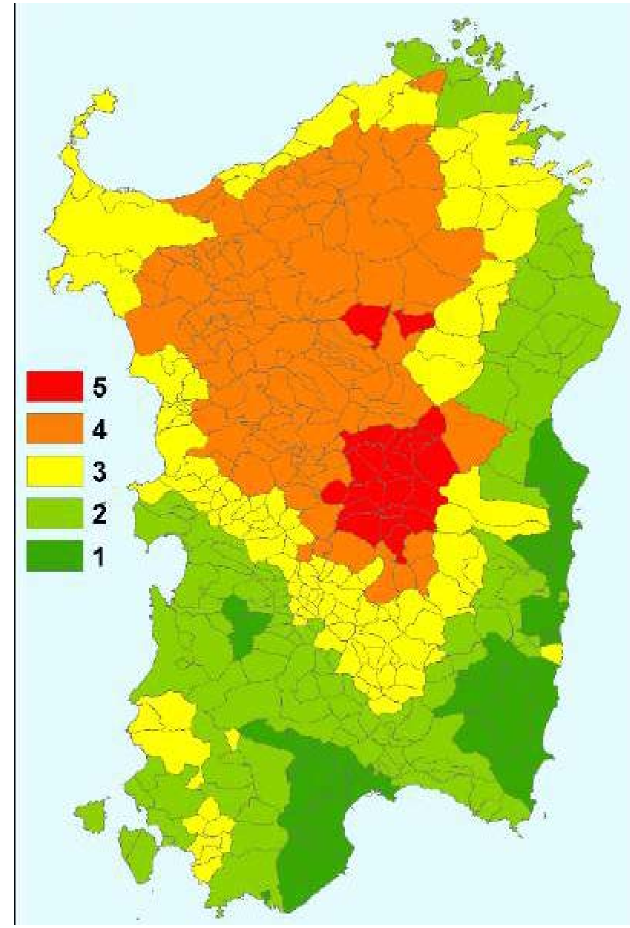
# Climate Risks on water resources

Aridity Index (UNEP, 1997) integrates precipitation, water availability, over water demand from vegetation:

Classes of risks (1-5) of increasing aridity, due to climate change in 2050, RCP 45.

Higher class of risk in the central zones and generally at higher elevations («mountains as sentinel to climate change»)

Highest levels of hazards occur in the most internal areas where majority of water resources, on which coastal areas depend

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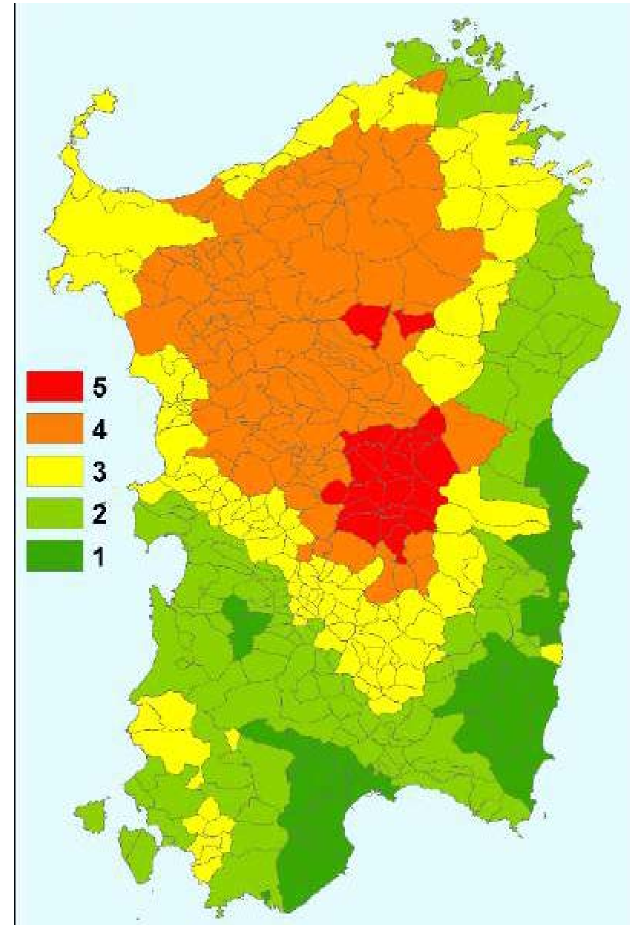


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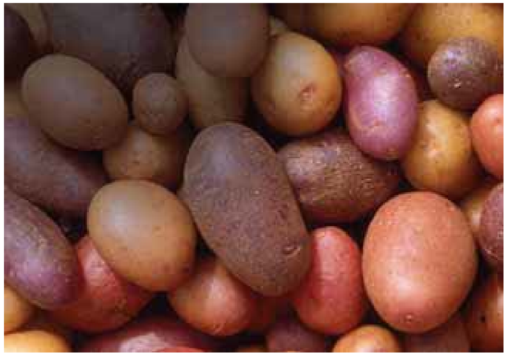
# Climate Risks on water resources

Climate change without adaptation measures will lead to significant yield losses due to rising temperatures, not compensated by increased rainfall

Some crops that grow mainly in southern Europe will become more suitable for northern latitudes or higher elevations



In southern Europe, irrigation will be the main limiting factor for crop productivity

- High variability of water resources following drought (climate change will increase variability) will emphasize expansion and contraction of irrigated areas
- Mechanization and abandonment of agriculture area will worsen land degradation and desertification, together with climatic factors

# Climate Risks on water resources

- Water resources in the Mediterranean are scarce, unevenly distributed and often mismatching human and environmental needs.
- Most (3/4) water resource are located in the northern Mediterranean while three quarters of the needs are in the south and east.
- Around 180 million people in south and east Mediterranean suffer from water scarcity (<1000 m3 capita-1 yr-1).
- The main water user is agriculture, and in particular in southern and eastern parts.
- Irrigated land account for 25% of the total cultivated area for Mediterranean Basin and currently increasing, likely with higher rates under future projected drier climate conditions.
- Water demand for both tourism and agriculture peak in summer, potentially enhancing tensions and conflicts in the future.
- Municipal water use is particularly constrained in the south and will likely be exacerbated in the future by demographic and migration phenomena.

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# Increasing demand for Resources

Demand for freshwater, energy and food will increase significantly under the pressure of population growth and mobility, economic development, international trade, urbanisation, diversifying diets, cultural and technological changes, and climate change.

At the same time, the food production and supply chain consumes about 30 % of total energy consumed globally. Energy is required to produce, transport and distribute food as well as to extract, pump, lift, collect, transport and treat water.

Cities, industry and other users, claim increasingly more resources, and at the same time, face problems of environmental degradation and resources scarcity.

Loss of marine ecosystems, ecosystems in wetlands, rivers and even mountain areas, many of which are already endangered by unsustainable practices (e.g. overfishing, land use change).

# The NEXUS

Land, food, energy, water and climate are interconnected, comprising a system (the ‘Nexus’), dominated by complexity and feedback. For water management and CC adaptation are strongly interconnected within a Water-Energy-Food-Ecosystem Nexus

- Bonn2011 Conference: "The Water, Energy and Food Security Nexus: Solutions for the Green Economy" presented initial evidence on how a nexus approach could enhance water, energy and food security.
- 'Agenda for Change' in 2011 which allowed us to concentrate on the poorest communities and to improve their access to land, food, water and energy without damaging effects on the environment
- The 2011/2012 EU Development Report urging the international community to radically transform approaches to managing water, energy and land
- Work by EU Member State Development Agencies to mentor 'regional organisations' and country processes towards operationalisation of the Nexus perspective

Systemic approaches for integrated management and governance of resources and interconnected sectors (i.e. the Water-Energy-Food-Climate-Land use-Nexus) are increasingly considered, but several challenges remain for an effective operationalization of such frameworks into practice

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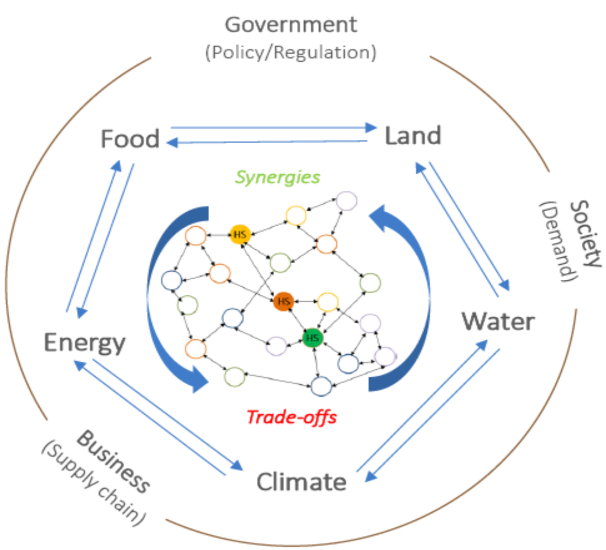
# The NEXUS

Silo-thinking

Integrated Approach




Sectors and resources are linked, in such a way that action on a sector may easily impact other sectors.

Es. Water and Energy are nowadays highly interlinked; Water is used for energy production, while energy is required in water extraction, deploymnet and treatment.

Increase efficiency of resource use to grant a sustainable managemnt of scarse resources.

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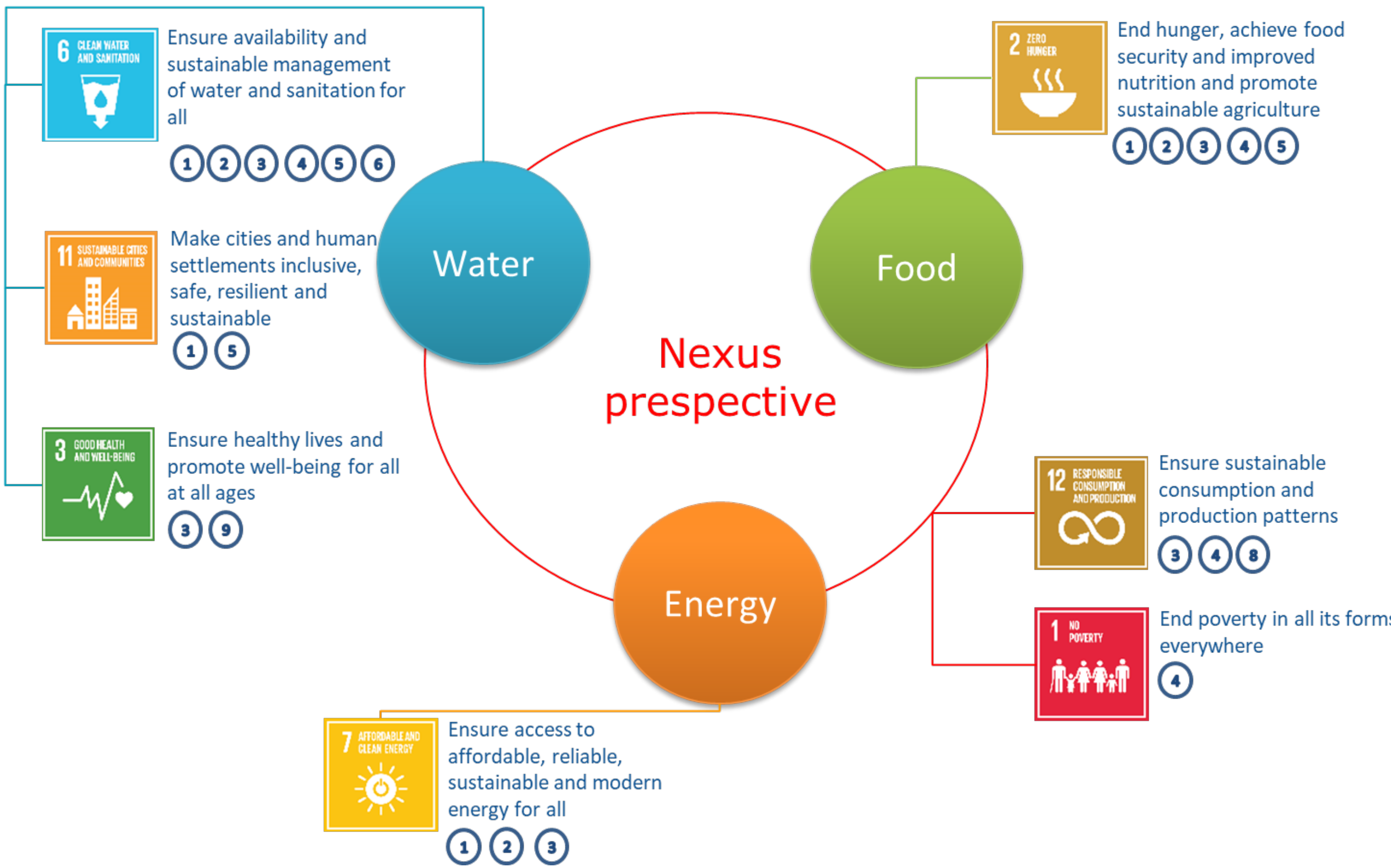
# The NEXUS and SDGs

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# NEXUS & Ecosystems

- The Nexus perspective accounting for different sectors is applied to improve integrated resource management and relevant policy.
- Irregularities in fluvial regime (due to climate change) and increase in water demand by different sectors adds new challenges to management of water resources
- The resilience of vulnerable reservoirs should be verified in detail to prepare for and mitigate potential impacts of these changes within the Nexus
- The importance of meeting environmental flow requirements to ensure the healthy functioning of aquatic ecosystems will require certain amounts of water to be retained in these systems, further limiting availability for human uses

# Conclusions:

Need to limit temperature rise: target at 1.5C, instead of 2C to limit risks on water resources in the Mediterranean, and alleviate conflicts and social risks.

Limiting rise in temperatures requires mitigation: greater efficiency in the use of natural resources, which could actually benefit the economy by reducing costs

However, this requires changes in mentality / habits in the production / consumption system

Water conflicts are highly seasonal!!!

Ethical responsibility that does not "threaten" political sovereignty

Increase capacity and commitment to dialogue for a long-term future.

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# Thanks for the attention

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