Climate Change in the Mediterranean. The Jucar River Basin Case

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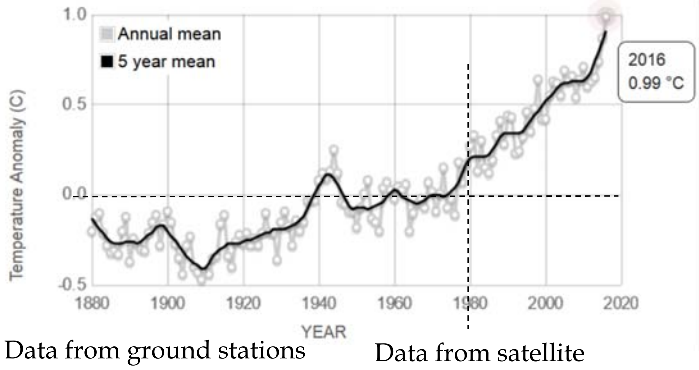
Malta 23 March 2017

I) Observed data

Temperature and sea level anomaly

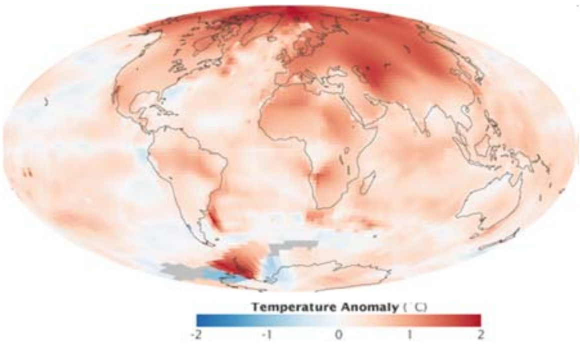
Mean global Temperature ocean-land
Reference Period 1960-1990
2015 +0,87ºC Record
2016 +0.99ºC Record

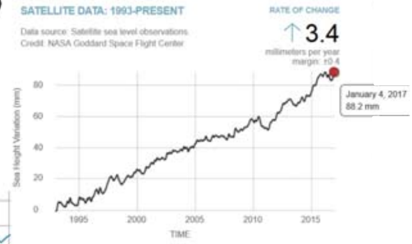


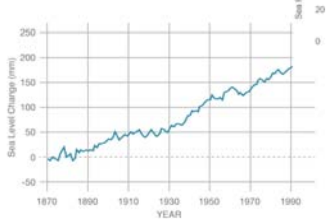
Earth observatory NASA
http://climate.nasa.gov/
http://earthobservatory.nasa.gov/

Data from ground stations
1870-2000 (130 years)
Increase of 20 cm, from 1870
1.5 cm per decade CSIRO

Data from satellite
6 cm from 2000
3.5 cm per decade (NASA)





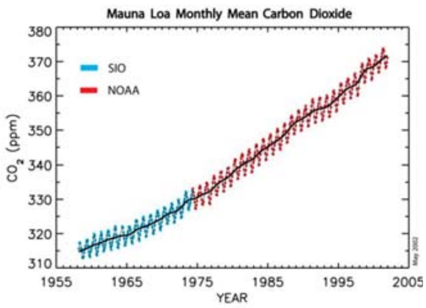


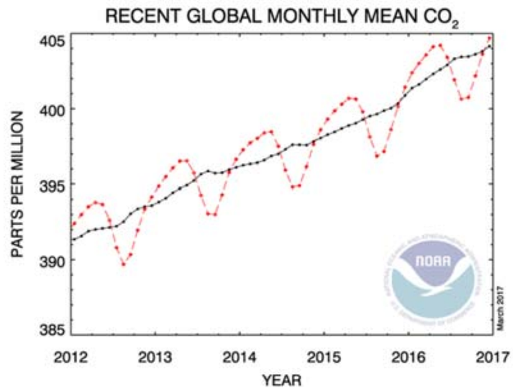
Mean Temperature Anomaly 2000-2009

CO2 and Methane levels in the atmosphere

CO2
Half-life
100 years

Year 1960 (320 ppm).
Year 2017 (>400 ppm)

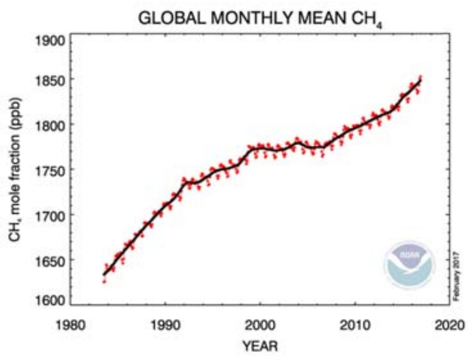


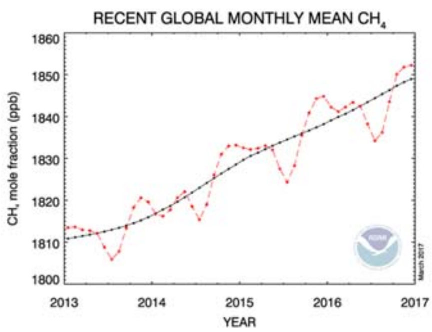


http://www.esrl.noaa.gov/gmd/ccgg/trends/

Methane
Half-life
12 years

Year 1980 (1650 ppb)
Year 2017 (1850 ppb)





http://www.esrl.noaa.gov/gmd/ccgg/trends_ch4/

CO2 Reconstruction last 2.000 years (Roman Age)

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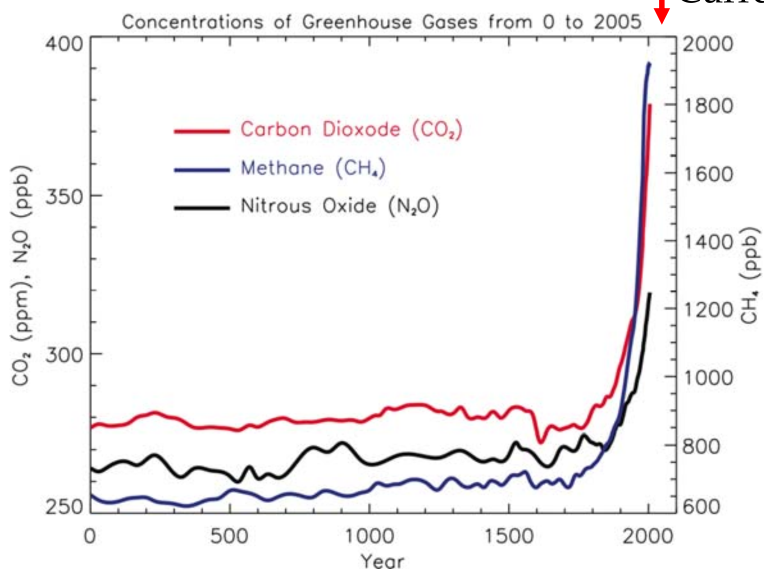
Main Greenhouse Gases:

- Carbon Dioxode CO_2
- Methane CH_4
- Nitrous Oxide N_2O

Third Report 2001

Current Day



CO2 Preindustrial (270 ppm). Year 1960 (320 ppm). Year 2017 (>400 ppm.)

Paleoclimate: 600.000 years Reconstruction (Discovery of Fire)

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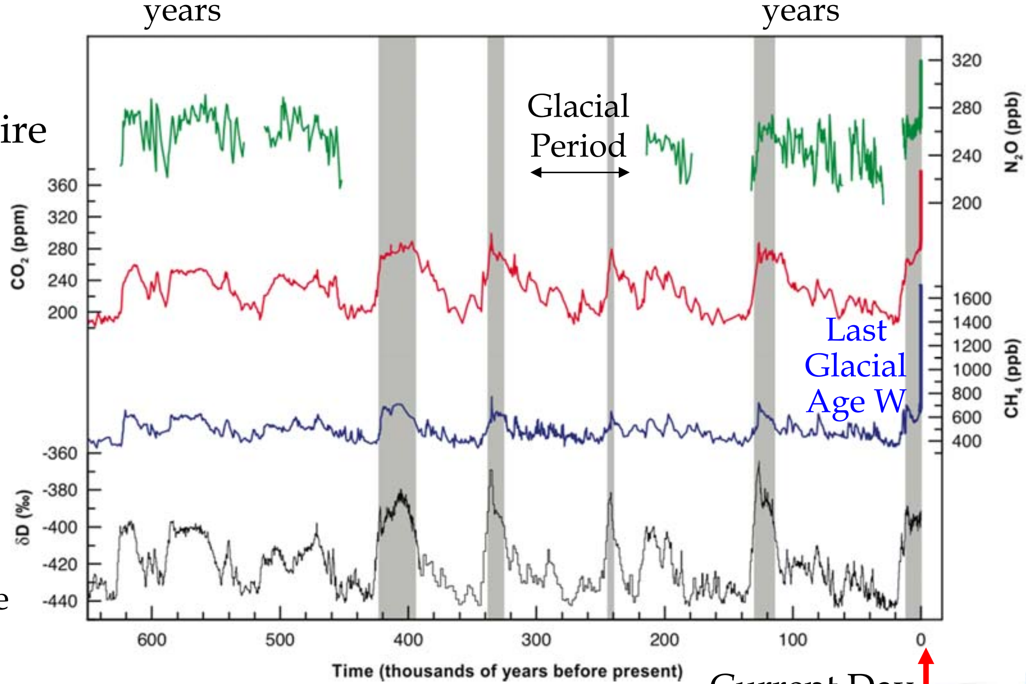
Quaternary 2.6 Millions of Years

Discovery of Fire by Humans 400.000 years

600.000 years

130.000 years



Deuterium δD Hydrogen Isotope

Current Day

- Temperature an CO2 well correlated.
- Calide Periods: 240-300 ppm. Glacial Periods: 180-200 ppm

Paleoclimate: 400 Millions Years Reconstruction

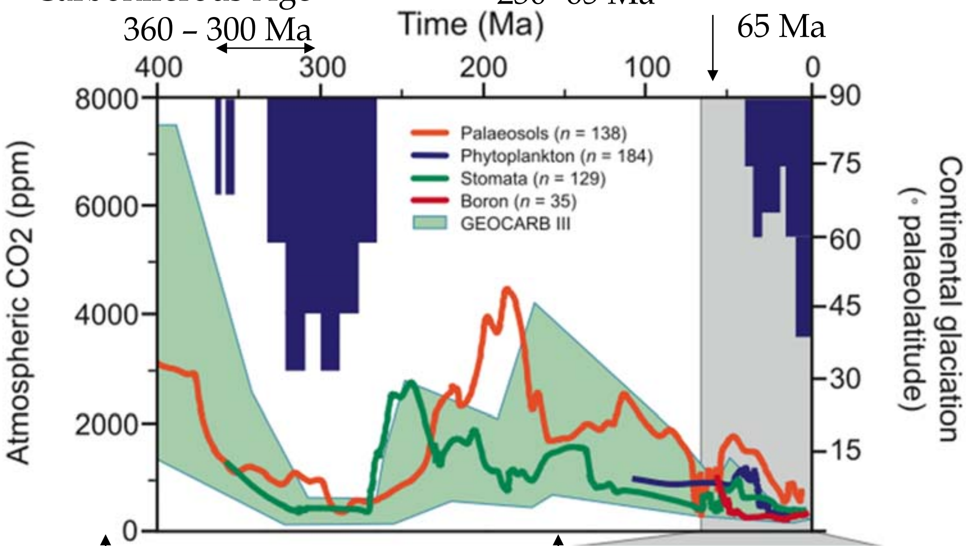
Karoo Glacial Age

Quaternary Glacial Age

Dinosaur Age 230- 65 Ma

Carboniferous Age 360 – 300 Ma

Dinosaur End 65 Ma



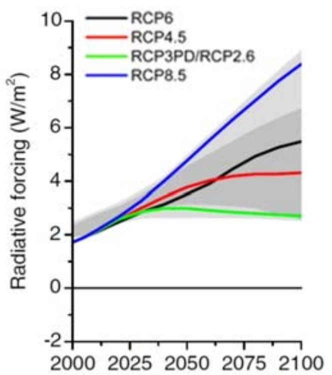
Cambrian 550 - 500 Ma
CO_2 6000 ppm

Jurassic 200 - 150 Ma
CO_2 1200-1500 ppm

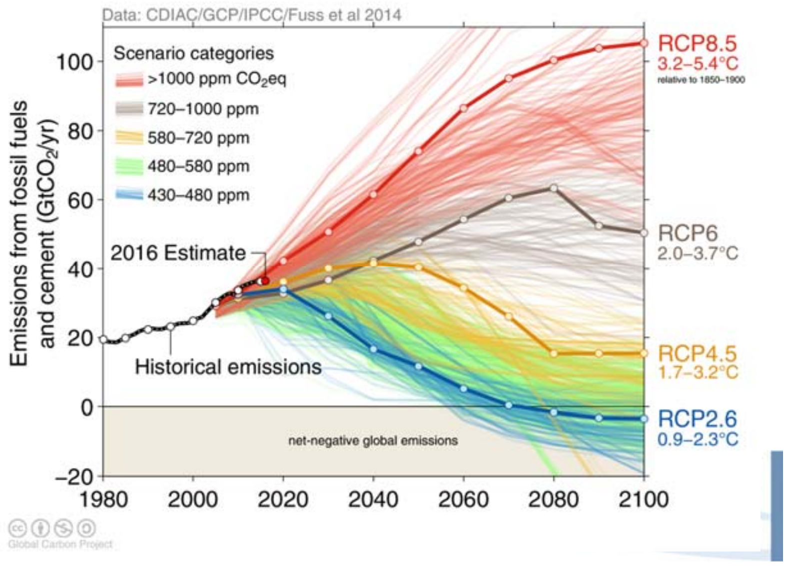
II) Scenarios and models

Schenarios RCP (Representative Concentration Pathways) (AR5)

Name	Radiative Forcing[1]	Concentration[2]	Pathway shape
RCP8.5	>8.5 W/m² in 2100	> ~1370 CO_2-eq in 2100	Rising
RCP6	~6 W/m² at stabilization after 2100	~850 CO_2-eq (at stabilization after 2100)	Stabilization without overshoot
RCP4.5	~4.5 W/m² at stabilization after 2100	~650 CO_2-eq (at stabilization after 2100)	Stabilization without overshoot
RCP3-PD[3]	peak at ~3W/m² before 2100 and then decline	peak at ~490 CO_2-eq before 2100 and then decline	Peak and decline

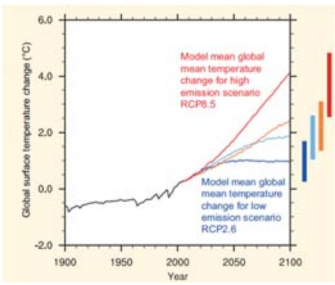


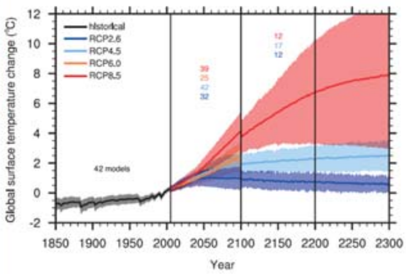
Radiative Forcing of the Representative Concentration Pathways. van Vuuren et al (2011) The Representative Concentration Pathways: An Overview. Climatic Change, 109 (1-2), 5-31.

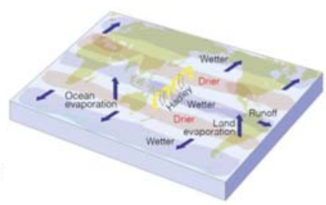


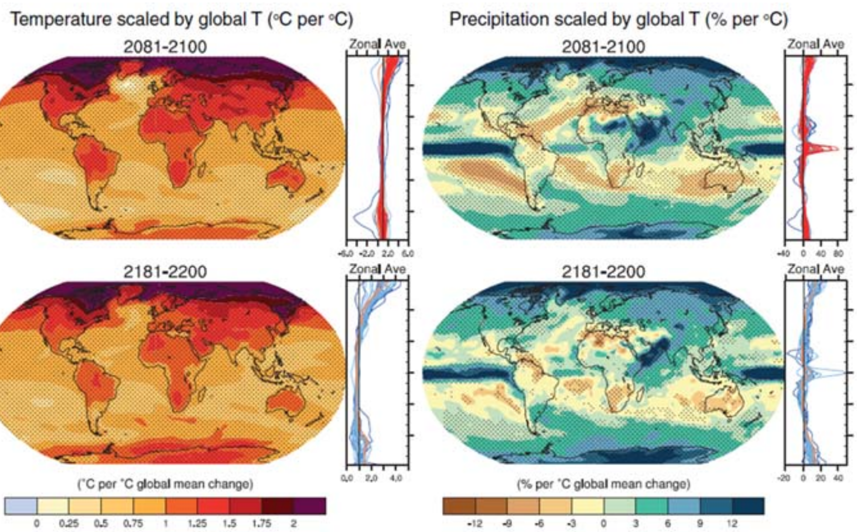
Temperature and sea level results

Temperature:
RCP2.6 1ºC
RCP4.5-6 2ºC
RCP8.5 4ºC

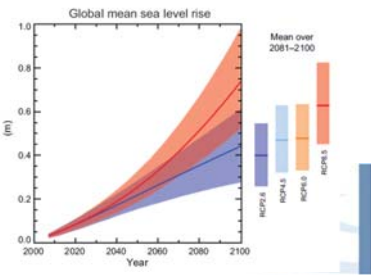








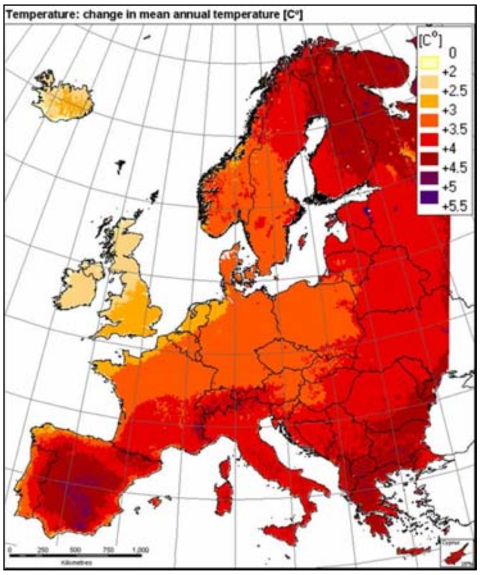
Sea level increase
40 cm RCP2.6
60 cm RCP8.5
Max 1.0 m



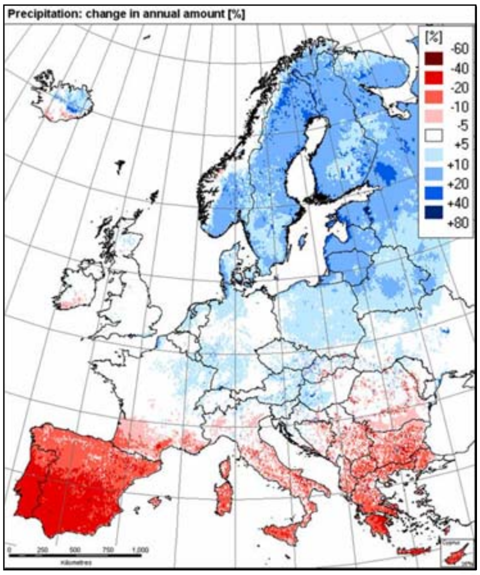
European Union and the Mediterranean

EC 2007. 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

Cambios en la temperatura



Cambios en la precipitación

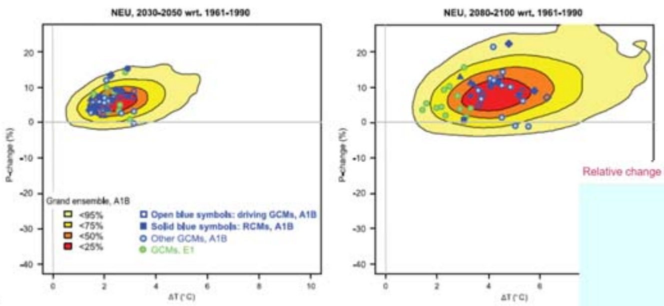


Previsiones de variación para 2071-2100 referido al periodo 1960-1990
Basado en: IPCC SRES scenario A2. Proyecto PRUDENCE

European Union and the Mediterranean

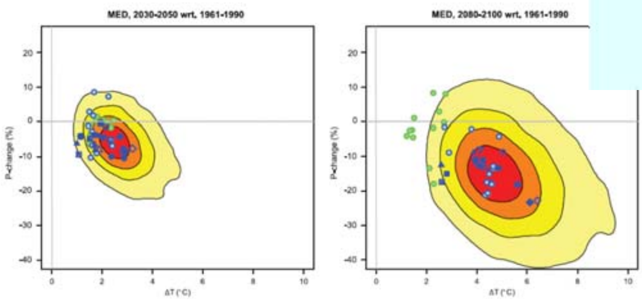
Scenario A1B

North Europe:
2030-2050: ΔT 2ºC ΔP +5+10%
2080-2100: ΔT 4ºC ΔP +10+15%

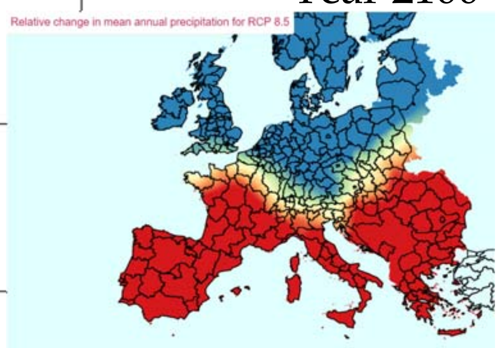


Projected mean annual temperature (°C) and precipitation (%) chang relative to 1961-1990

Mediterranean Area:
2030-2050: ΔT 2ºC ΔP –5-10%
2080-2100: ΔT 4ºC ΔP –15-20%



European 0 Precipitation Line
Scenario RCP 8.5
Year 2100



White Zone: -5% a 5%
Change in Precipitation

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III) Impacts in the Júcar River Basin

- Reduction in the natural water resources (average conditions)
- Increase of number and intensity of Droughts (extreme conditions)
- Increase in the Risk of Wildfire in the river basin (extreme conditions)
- Water needs for crops (average conditions)

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Water Balance Model Patrical

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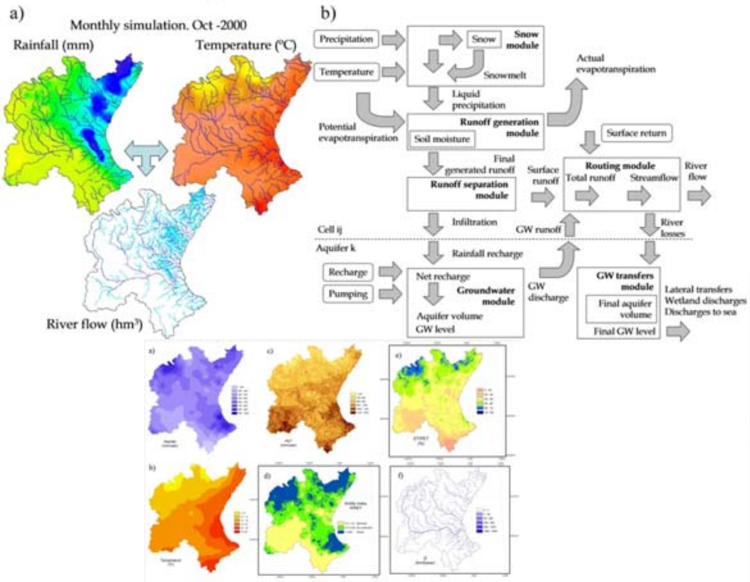
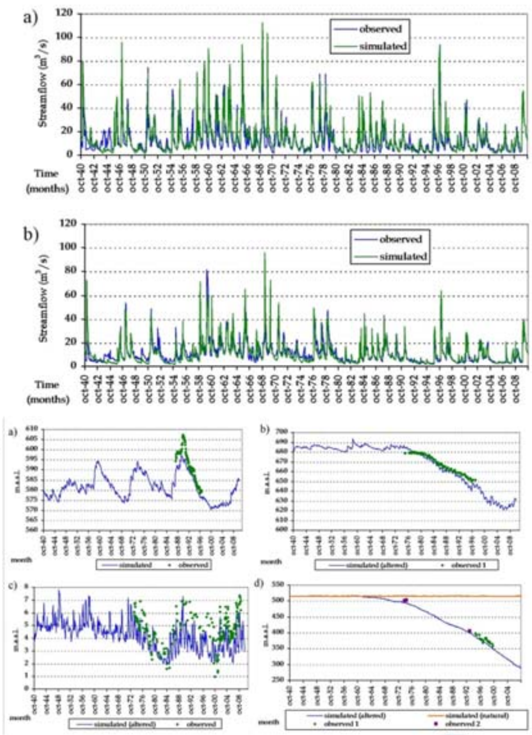
Monthly Distributed Water Balance Model

Surface+ Groundwater+
River-aquifer interaction





Pérez-Martín MA, Estrela T, Andreu J and Ferrer J. (2014) Modeling Water Resources and River-Aquifer Interaction in the Júcar River Basin, Spain. Water Resour Manage (2014) 28:4337–4358 DOI 10.1007/s11269-014-0755-3

RCP scenarios (AR5)

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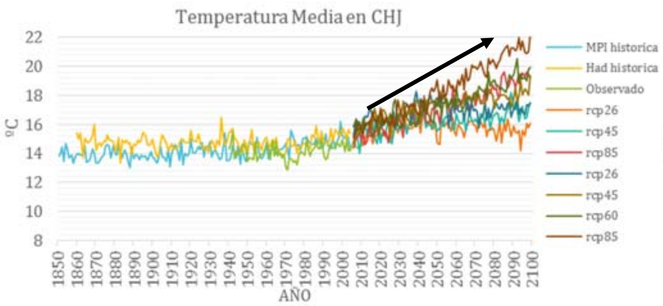

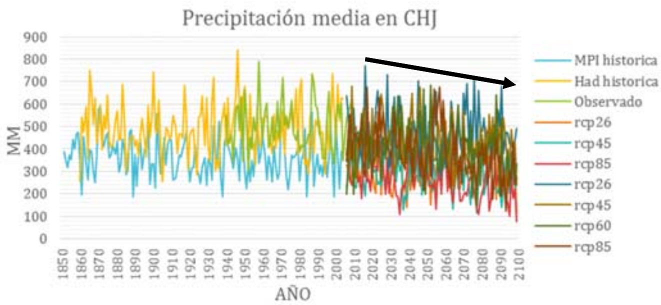

- **MPI-ESM-MR.-** Max-Planck-Institut-Earth System Model running on médium resolution grid
- **HadGEM2-ES.-** Hadley Global Environment Model 2 – Earth System

Temperature and Precipitation Anomalies refer to 980-2005 period

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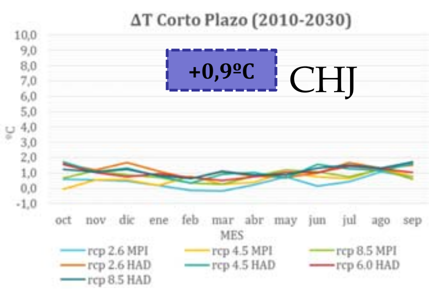
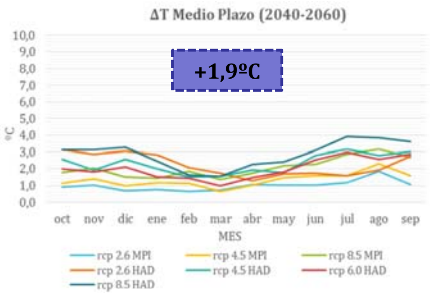
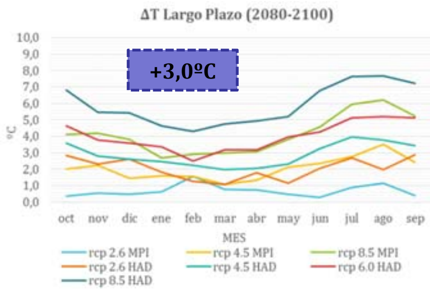


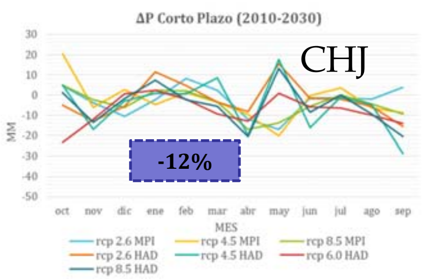
Escenario	MPI-ESM-MR	HadGEM2-ES
rcp 2.6	0,40	1,19
rcp 4.5	0,60	1,12
rcp 6.0		1,00
rcp 8.5	0,80	1,14



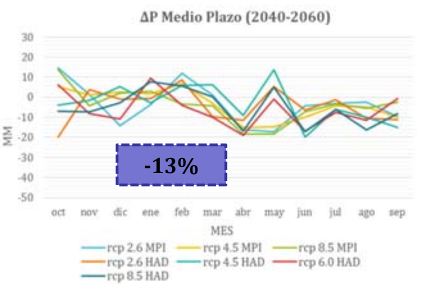
Escenario	MPI-ESM-MR	HadGEM2-ES
rcp 2.6	0,40	1,19
rcp 4.5	0,60	1,12
rcp 6.0		1,00
rcp 8.5	0,80	1,14



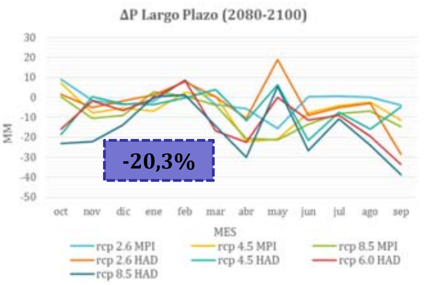
Escenario	MPI-ESM-MR	HadGEM2-ES
rcp 2.6	0,70	2,04
rcp 4.5	2,04	2,87
rcp 6.0		3,98
rcp 8.5	4,12	5,90



Escenario	MPI-ESM-MR	HadGEM2-ES
rcp 2.6	-9%	-7%
rcp 4.5	-9%	-12%
rcp 6.0		-18%
rcp 8.5	-15%	-13%



Escenario	MPI-ESM-MR	HadGEM2-ES
rcp 2.6	-12%	-12%
rcp 4.5	-13%	-8%
rcp 6.0		-15%
rcp 8.5	-14%	-13%



Escenario	MPI-ESM-MR	HadGEM2-ES
rcp 2.6	-5%	-6%
rcp 4.5	-23%	-14%
rcp 6.0		-26%
rcp 8.5	-30%	-39%

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Short-time 2010-2040

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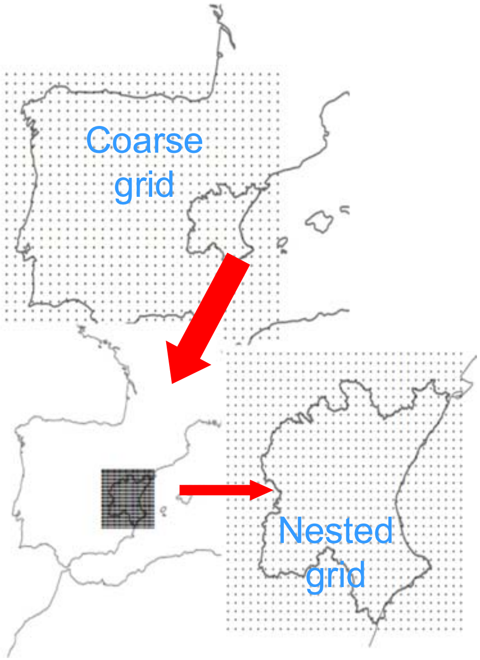
- Based on: **AR4 IPCC, 2007**.
- Dynamic downscaling: **ECHAM5**, T63 (1.9º) L31
- Scenario: **A1B**
- Regional model: **RegCM3**
- Control period: 1990 – 2000
- **Future period: 2010 - 2040**



Reduction natural resources:
River flows 21%
In the headers (Alarcón 26%, Contreras 28%)
Rainfall recharge into aquifers: 19%

Doctoral Thesis: "Caracterización de los futuros escenarios climáticos en la Comunidad Valenciana: propuestas de mejora para la evaluación de la oferta y demanda de recursos hídricos". Chirivella Vicente, 2010. Directores: José Capilla y Miguel Ángel Pérez

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Long-time 2070-2100

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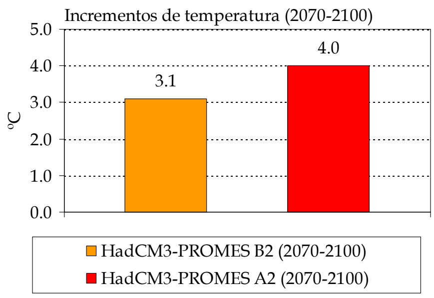
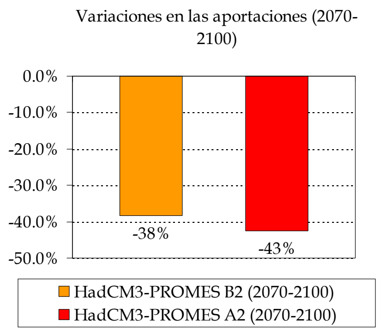
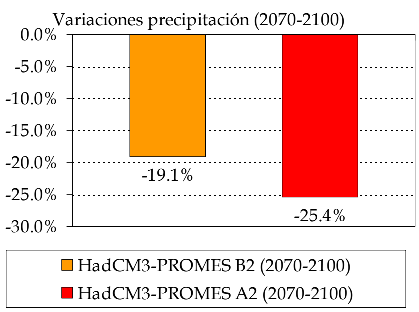
Temperature





SRES A2. 2070-2100

Precipitation

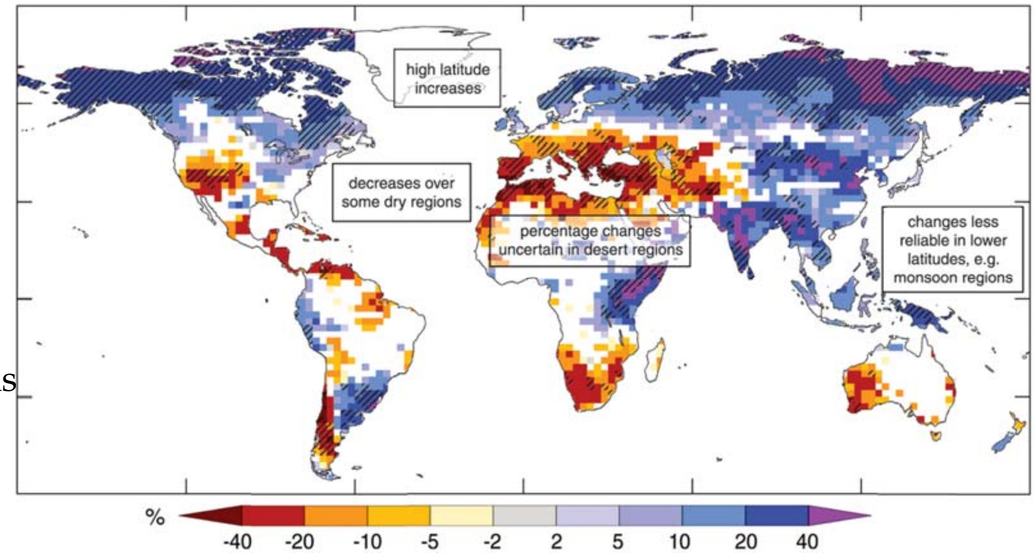


Escenarios hidrológicos futuros:
Escenarios climáticos 2070-2100:
$\Delta T \approx +3$ ºC, $+4$ ºC
$\Delta P \approx -15\%$, -25%
Efectos escenarios hidrológicos 2070-2100:
$\Delta Q \approx -30\%$, -40%

Doctoral Thesis: "Efectos del cambio climático en los sistemas complejos de Recursos Hídricos. Aplicación a la cuenca del Júcar". Hernández Barrios, 2007. Directores Joaquín Andreu y Miguel Ángel Pérez

Mediterranean one of the most vulnerable areas

Variaciones porcentuales en las escorrentías anuales periodo 2090-2099, respecto periodo 1980-1999. Escenario A1B

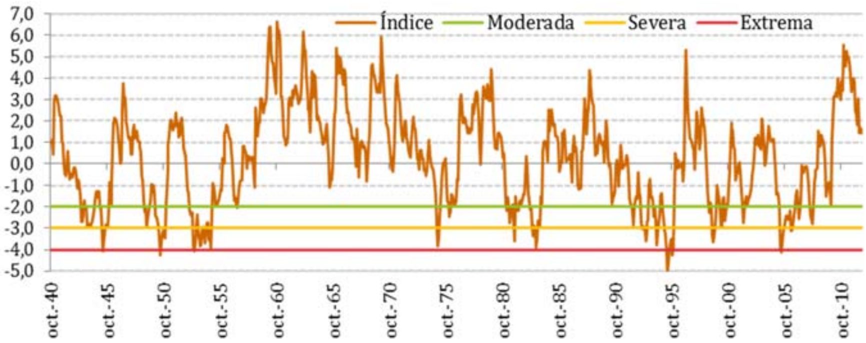


Spain reductions around 40% 2090-2099

Zonas ralladas: más de un 90% en la concordancia de los modelos en el signo del cambio

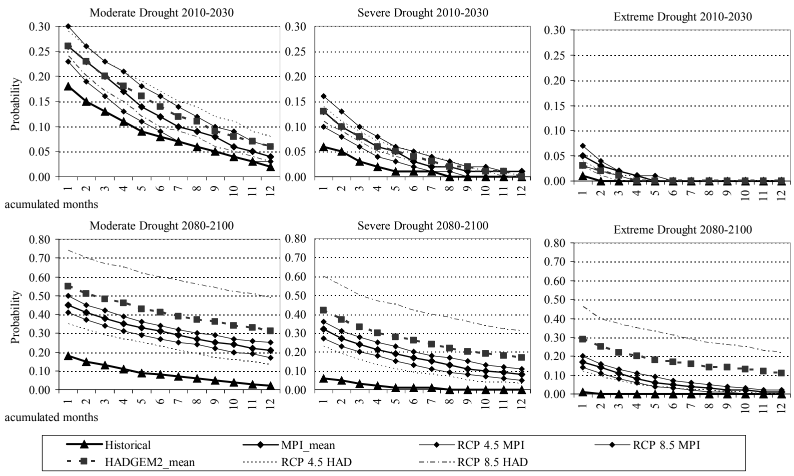
"Climate Change and Water", IPCC Technical Paper VI. IPPC", june 2008

Increase of number and intensity of Droughts



Palmer Index

Drought Definition
Moderate (-2)
Severe (-3)
Extreme (-4)

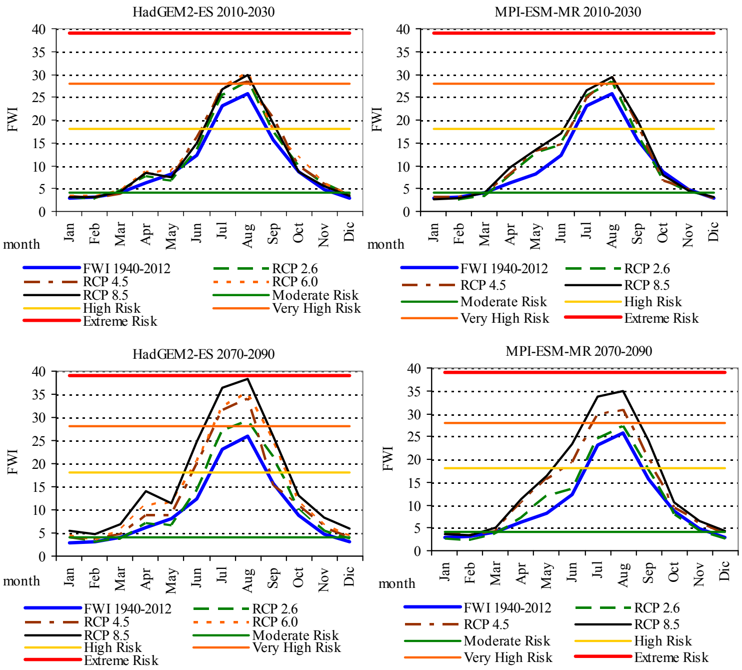


Probability of Drought with Socio-Economical Consequences (Severe):

- Double in the short-term (2010-2030)
- 6-9 times in the long-term (2080-2100)

Climate Change Impact on Water Resources and Droughts of AR5 scenarios in the Jucar River, Spain. Pérez-Martín, Batán, del-Amo and Moll. ICDrought 2015

Risk of Wildfires and Potential number



Canadian Fire-Weather Index (FWI) (Van Wagner, 1974)

Increase in the number of potential Wildfires per year:

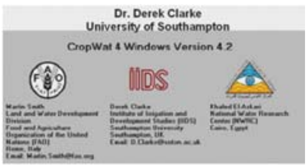
- 40% in the short-term
- Doubling in the long-term

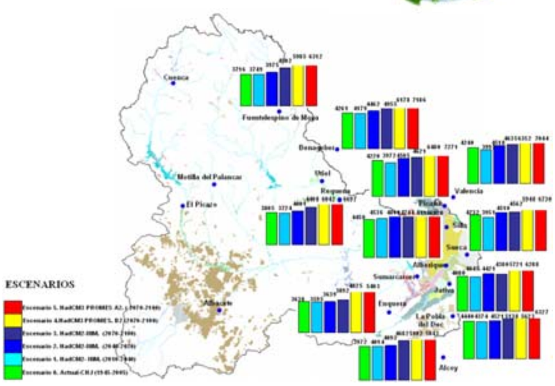
Risk level	FWI	KBDI	Potential number of Wildfires per season
Low	0 – 4	0 – 40	0
Medium	4 – 18	40 – 180	20 – 60
High	18 – 28	180 – 280	60 – 150
Very High	28 – 39	280 – 390	150 – 300
Extreme	>39	>390	+300

Pérez-Martín, M.A., Vinces, F., del-Amo, P., Batán, A. ***2015. Climate Change and the Increase of Wildfire Risk*** *in the Upper Jucar River Basin, Spain. Drought: Research and Science-Policy Interfacing - Proceedings of the International Conference pp. 91-96*

Water needs for Crop Irrigation

Cropwat software
Penman-Monteith method





Alfalfa

Wheat

Corn

Citric

Onion

Vineyard

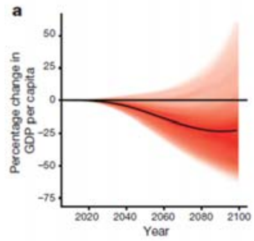
Citric: current: 4.000-4.500 m3/ha/year
Future: 6.000-6.500 m3/ha/year
increase: 40%-50%

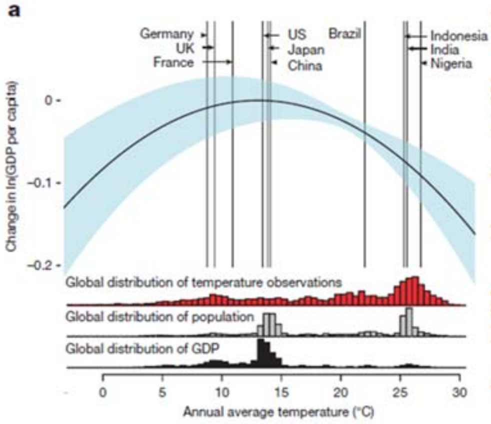
Mean water needs increase for all irrigation crops 2100: **30% - 40%**

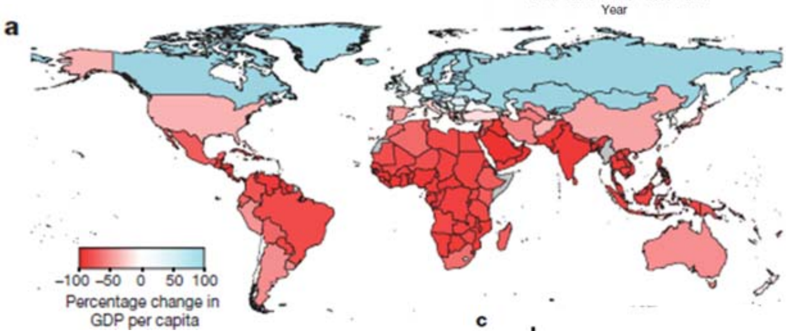
Doctoral Thesis: "Efectos del cambio climático en los sistemas complejos de Recursos Hídricos. Aplicación a la cuenca del Júcar". Hernández Barrios, 2007. Directores Joaquín Andreu y Miguel Ángel Pérez

Economical impact of Climate Change

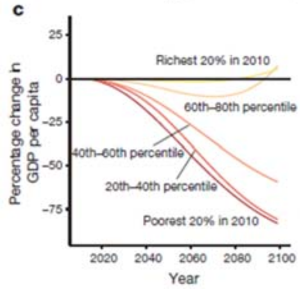
Productivity Increase in Cold Regions (T<15ºC)
Productivity Reduction in Warm Regions (T>15ºC)
Spain: Tmean 15ºC. North 14ºC, Mediterranean 15-18ºC







Based on:
Laboral supply
Labour Performance
Agricultural Yield



Marshall Burke, Solomon M. Hsiang & Edward Miguel 2015. Global non-linear effect of temperature on economic production. Nature

IV) Conclusions

Conclusions about future scenarios

- Changes in climate in the Mediterranean area, Jucar Basin:
  - Temperature Increase: **1ºC next decades** (2010-2030) and **3 - 5 ºC at the end of the century**.
  - Rainfall Reductions: **10% next decades** (2010-2030) and 20% at the end of the century.
- Impacts:
  - Natural Water Resources will be reduced, **20% next decades** (2010-2030) and more than **40%** (aprox. 50%) (2070-2100).
  - **Droughts will be increased** in number and severity: **doubling** in short-term and 6 or more times in long-term
  - The **Number of Wildfires per year** will be **increased 40%** next decades (2010-2030) and doubling at the end of the century.
  - **Irrigation water requirements will increase around 40%.**
- **Mediterranean area** is one of the more **vulnerable** areas to the Climate Change in relation with the Water Resources

Conclusions about future scenarios

- Current CO2 level 400 ppm future levels from 600-1200 ppm. Return to 60-100 Millions of Years
- Current carbon emissions is curving but is far of the 2º increase pathway. (Curving US gas, and Chine carbon reduction aerosols)
- **Mediterranean. Jucar River Basin:**
  - **Natural water resources reduction** and **irrigation** water **demand increase** (with the same crops) will contribute to a **more stressed River Basin**.
  - **Gradual reduction of the Natural Resources**. It is necessary to learn how to preserve the environment and produce the same with the half of water. Increase the efficiency in the water use.
  - **Adaptive measures are required**. Also, **permanent monitoring** of the climate change evolutions is required to reduce the vulnerability of the system.

Turia river

Thank you for your attention

Albufera wetland

Júcar river