Impacts of anthopogenic climate change in Europe

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GUTTA opening conference| Lecce| 06 February 2019

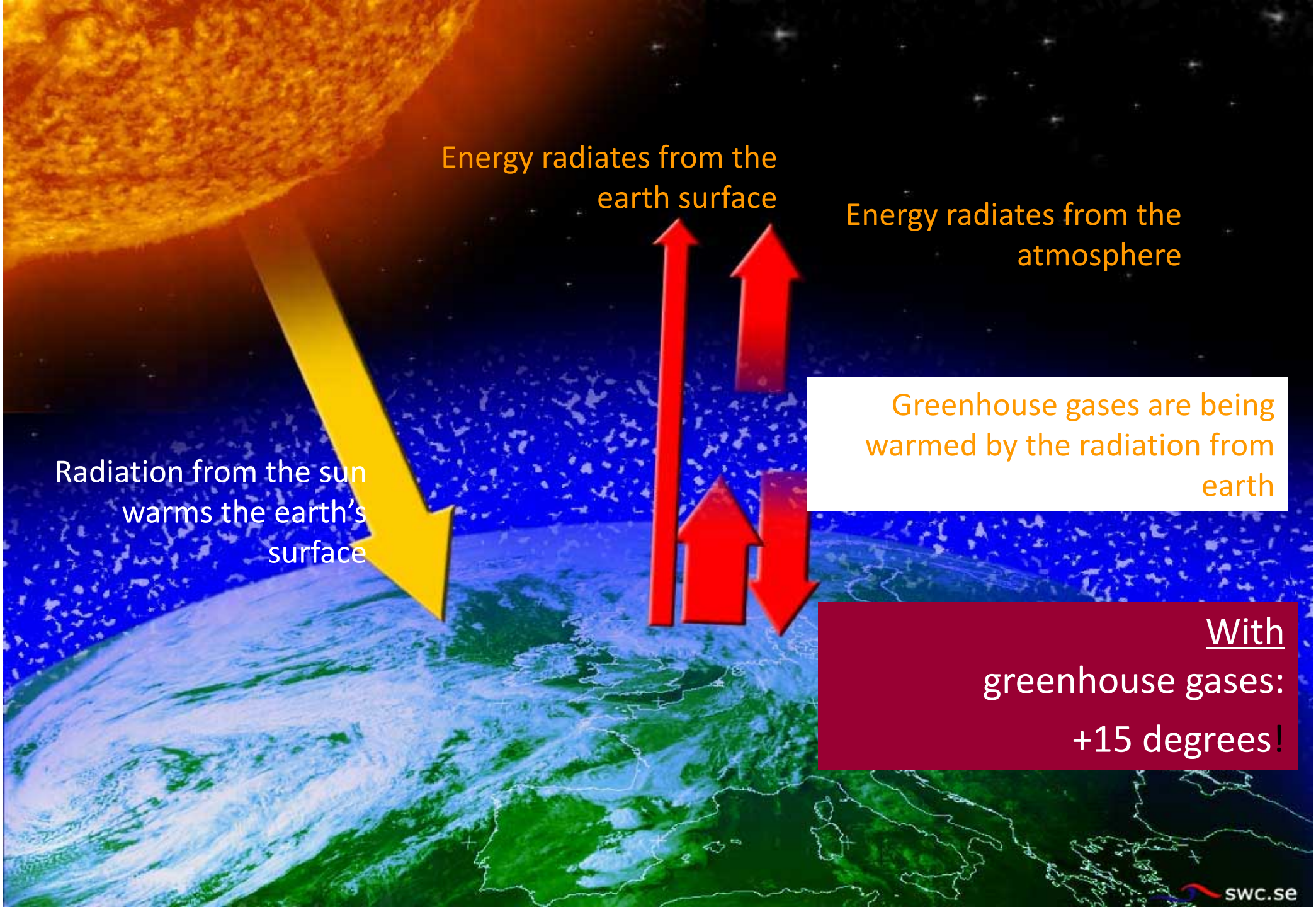
European Regional Development Fund

Outline

- Evidence of anthropogenic effects on climate.

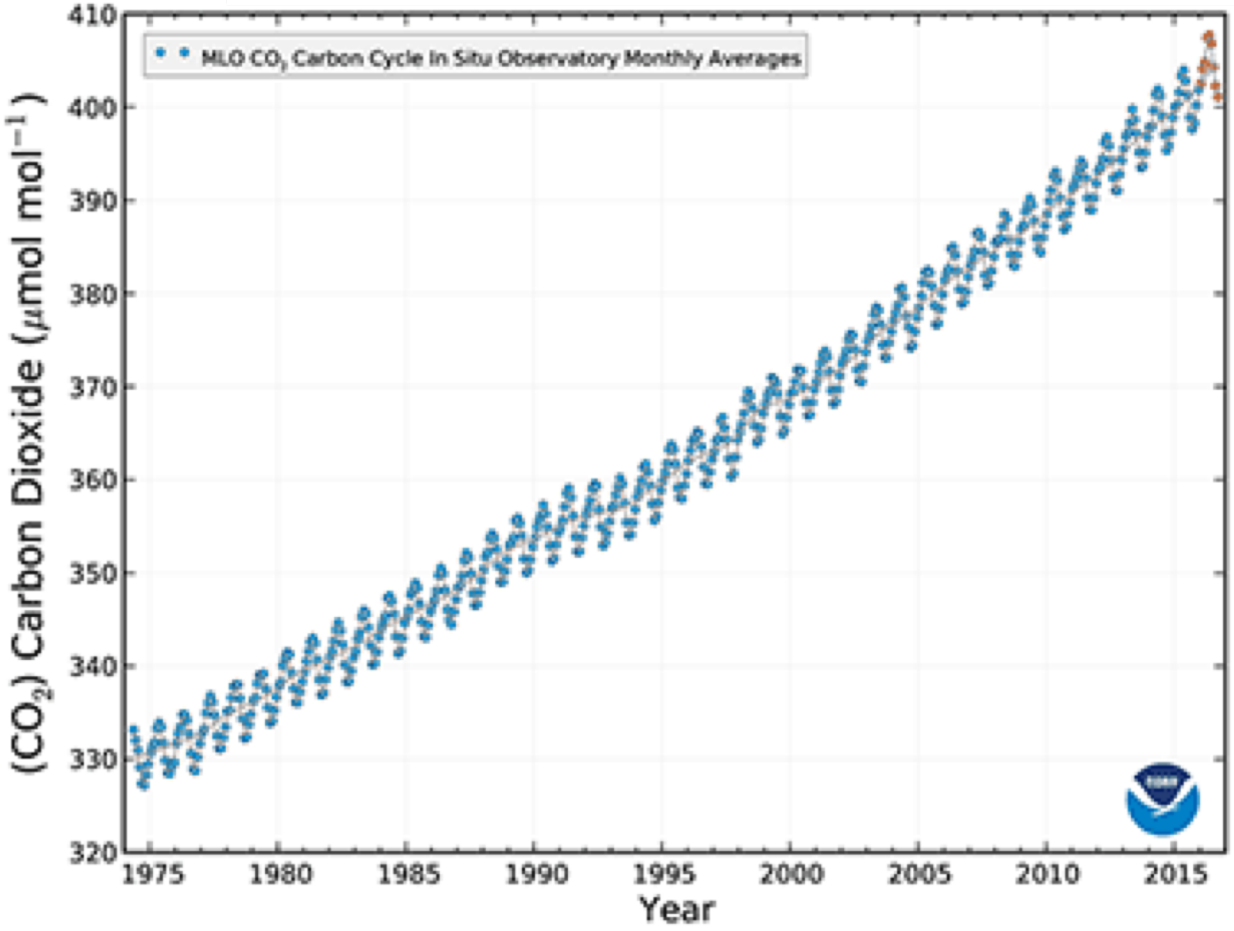
- Climate Models as a tool to investigate the impact on climate of different potential GHGs Representative Concentration Pathways.

- Projections of **Precipitation** and **Perceived Temperature** over Europe: changes in extreme events at the end of the current century.


Energy radiates from the earth surface
Energy radiates from the atmosphere
Radiation from the sun warms the earth's surface
Greenhouse gases are being warmed by the radiation from earth
With greenhouse gases: +15 degrees!
swc.se

Changes in atmospheric CO_2 concentration

main GHGs are : CO2, CH4, H2O



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

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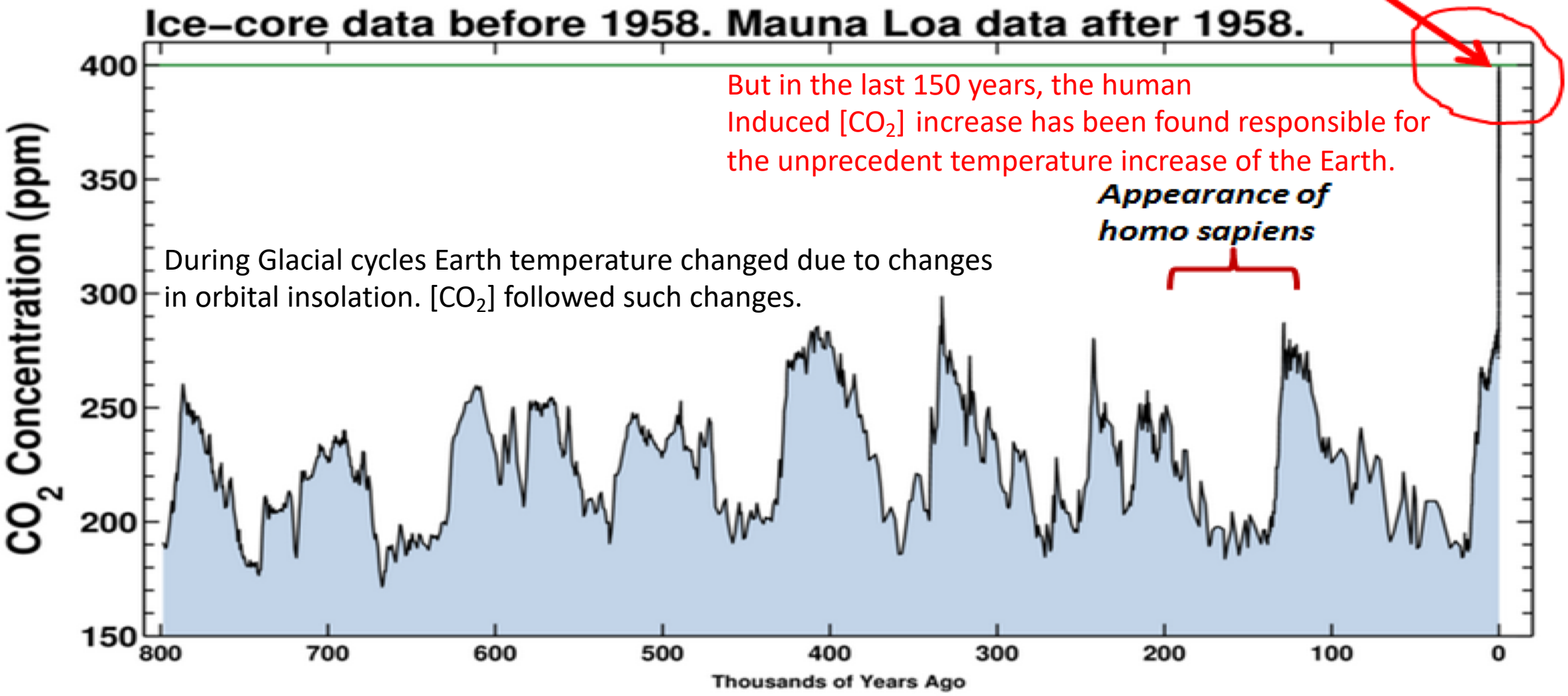
410.92 ppm

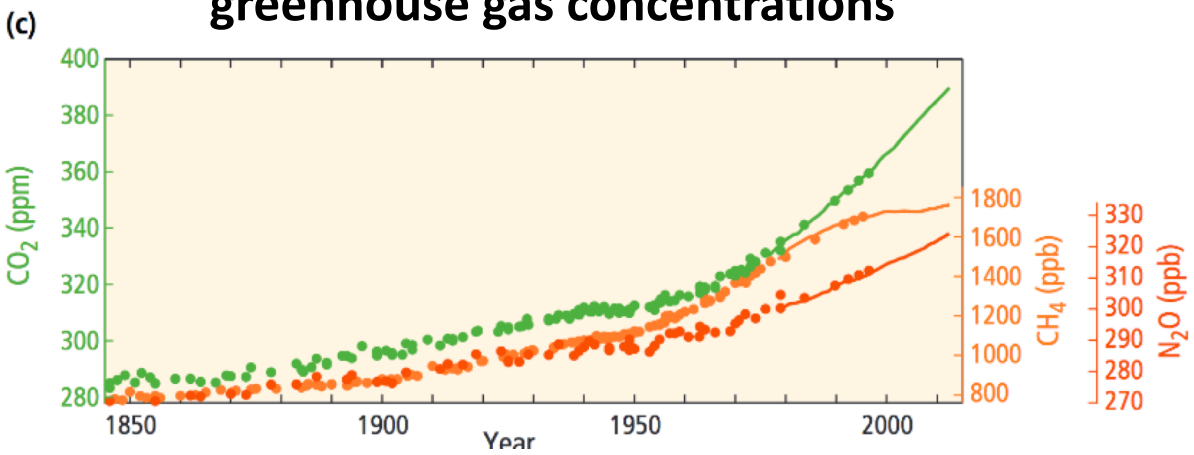
Why "unprecedented perturbation"?



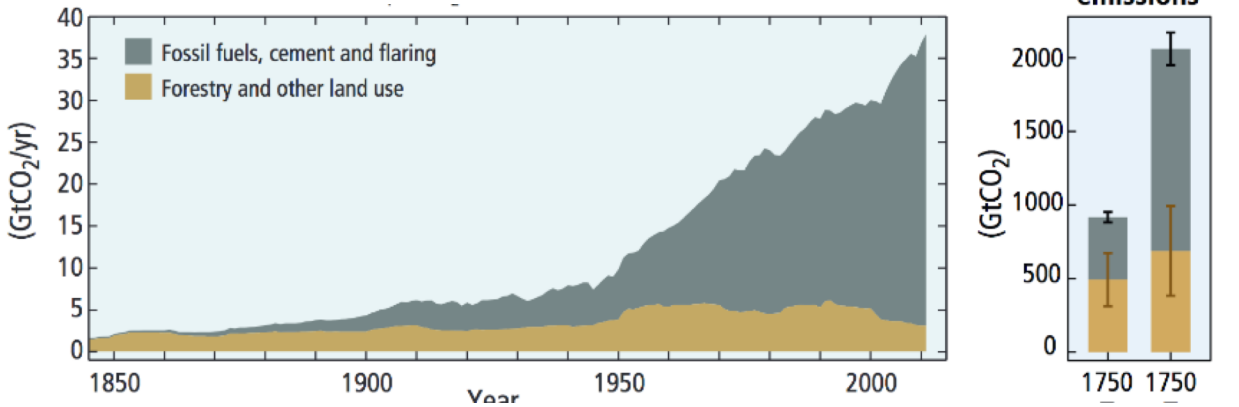
Source: http://keelingcurve.ucsd.edu/

Climate Change in the recent past

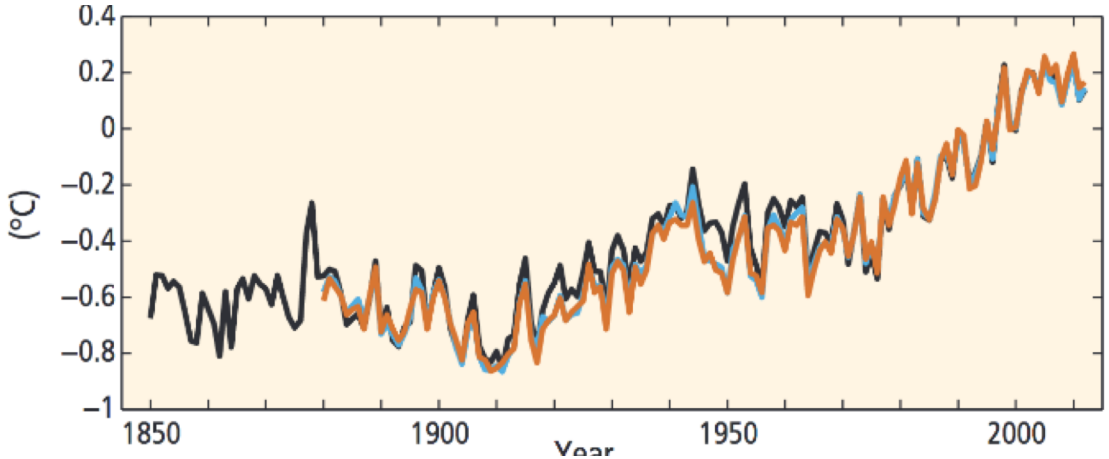
greenhouse gas concentrations



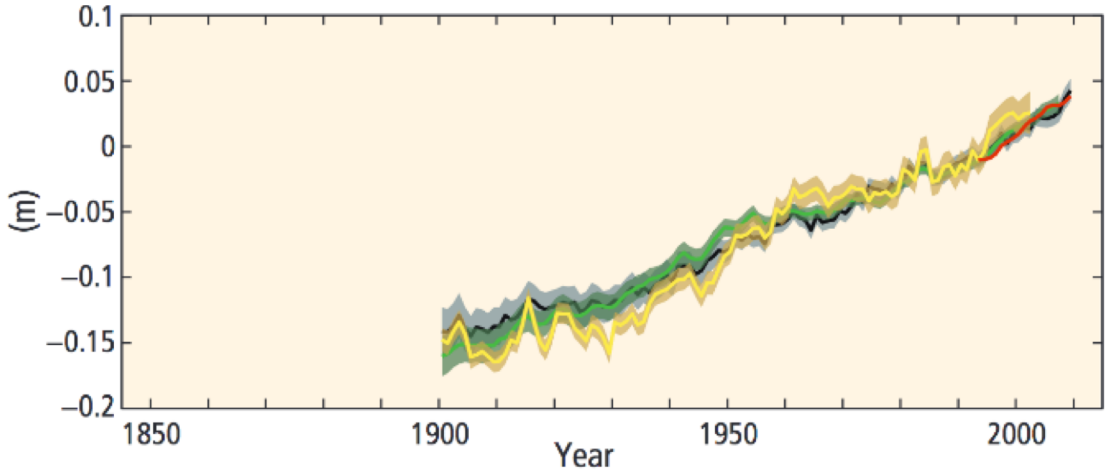
anthropogenic CO2 emissions



Temperature Anomalies wrt 1986:2005



Sea Level Anomalies wrt 1986:2005

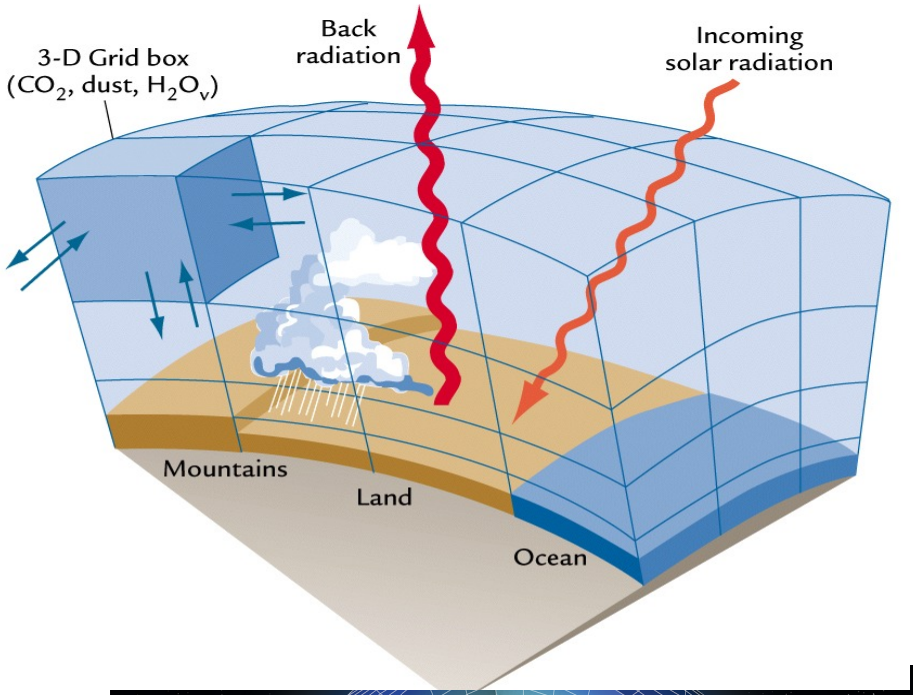


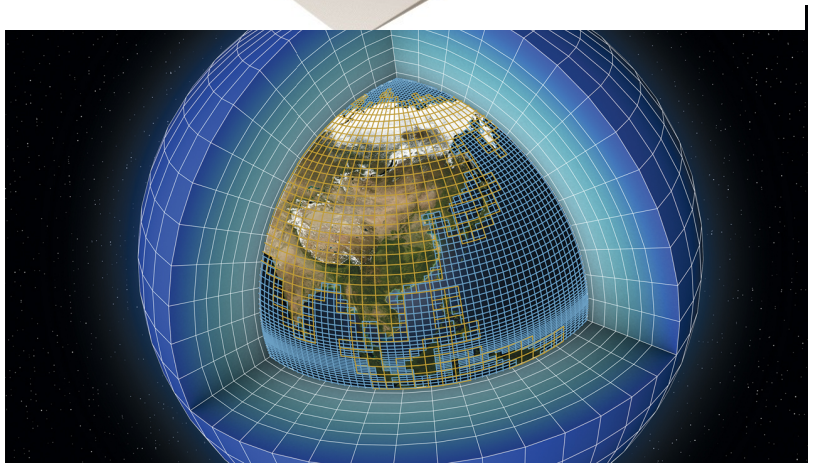
Human influence on the climate system is clear, and recent anthropogenic emissions of green-house gases are the highest in history.

Ref: IPCC AR5 Summary for Policy makers

Climate Models as a tool to investigate potential future GHGs Repr. Conc. Pathways

- Investigation tools
- Prognostic models of the general circulation of the ocean and atmosphere
- Based on physical equations of mass and energy balance
- Discretized numerical solutions on given spatial grids





An educational climate model can be found at http://edgcm.columbia.edu/

An example of Fully Coupled GCM: CMCC-CM2

River routing

River Transport Model RTM (0.5°)

Atmosphere

Community Atmosphere Model*
CAM4 (FV, 1° & 1/4° , 26 levels, interactive & prescribed aerosols)

Coupler / Driver

CPL7

Sea Ice

Community Ice CodE CICE4 (multi-category, same resolution as ocean)

Land/ Vegetation

Community Land Model CLM4.5

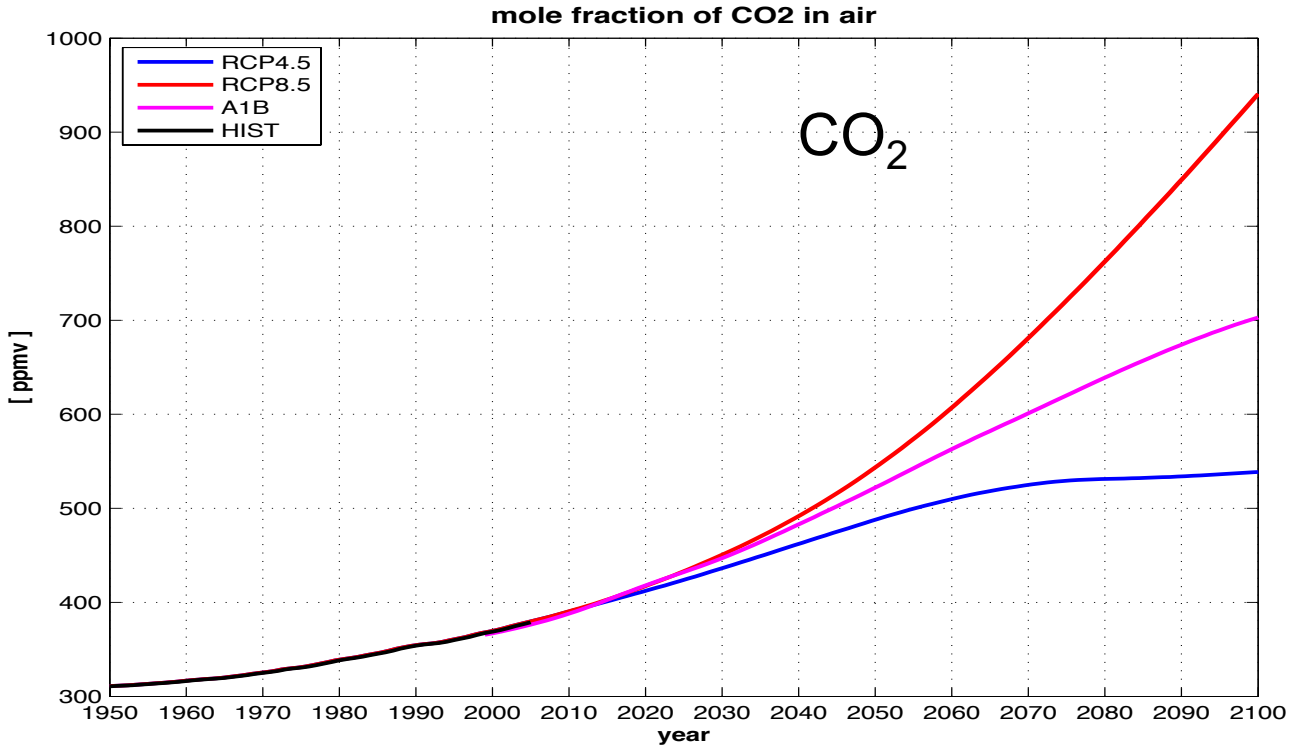
Ocean

Nucleus for European Modelling of the Ocean NEMOv3.6 1/4° ; 50 levels)

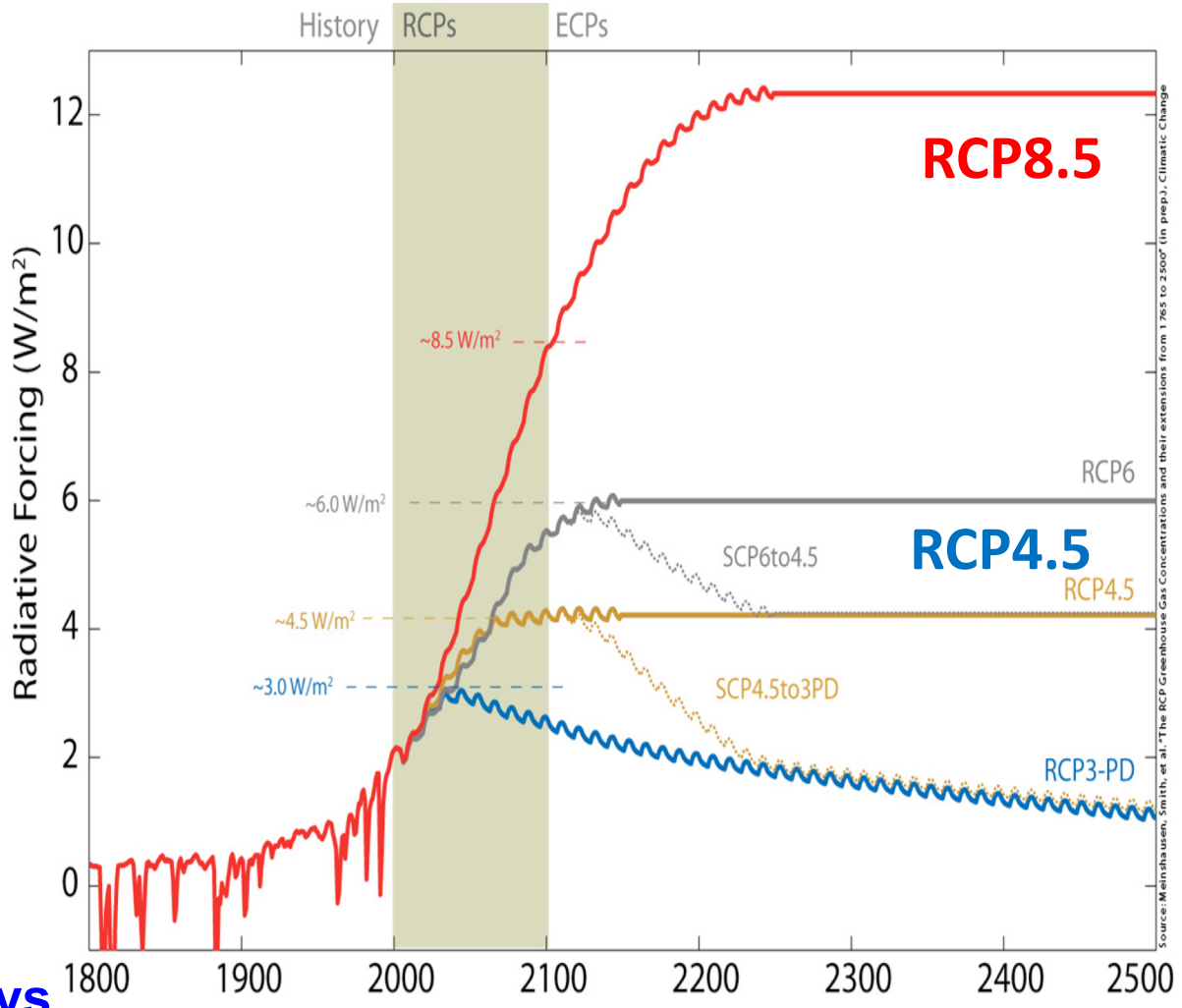
Climate Models can be used to investigate different radiative forcing paths in terms of: GHGs (CO2, CH4, H20) Aerosols, Ozone etc. emissions or concentrations

Ref: Fogli et. al 2014, Scoccimarro et al. 2017, Cherchi et al. 2018

Future potential radiative scenarios



The Representative Concentration Pathways (RCPs) describe a wide range of potential futures for the main drivers of climate change: greenhouse gas and air pollutant emissions and land use.



The scenarios cover the range from high emission futures to scenarios consistent with the 2°C target.

RCP = CMIP5 Representative Concentration Pathways

Future potential radiative scenarios

Different modelig groups worldwide provide simulations for the past and for the future scenarios, following common protocols defined by the Coupled Model Intercomparison Project (CMIP, last available CMIP5) to create a dataset useful for the preparation of the Intergovernmental Panel on Climate Change Assessment Report (AR, last avaliable AR5)

Based on the different RCP chosen, different global temperature Increases are expected:

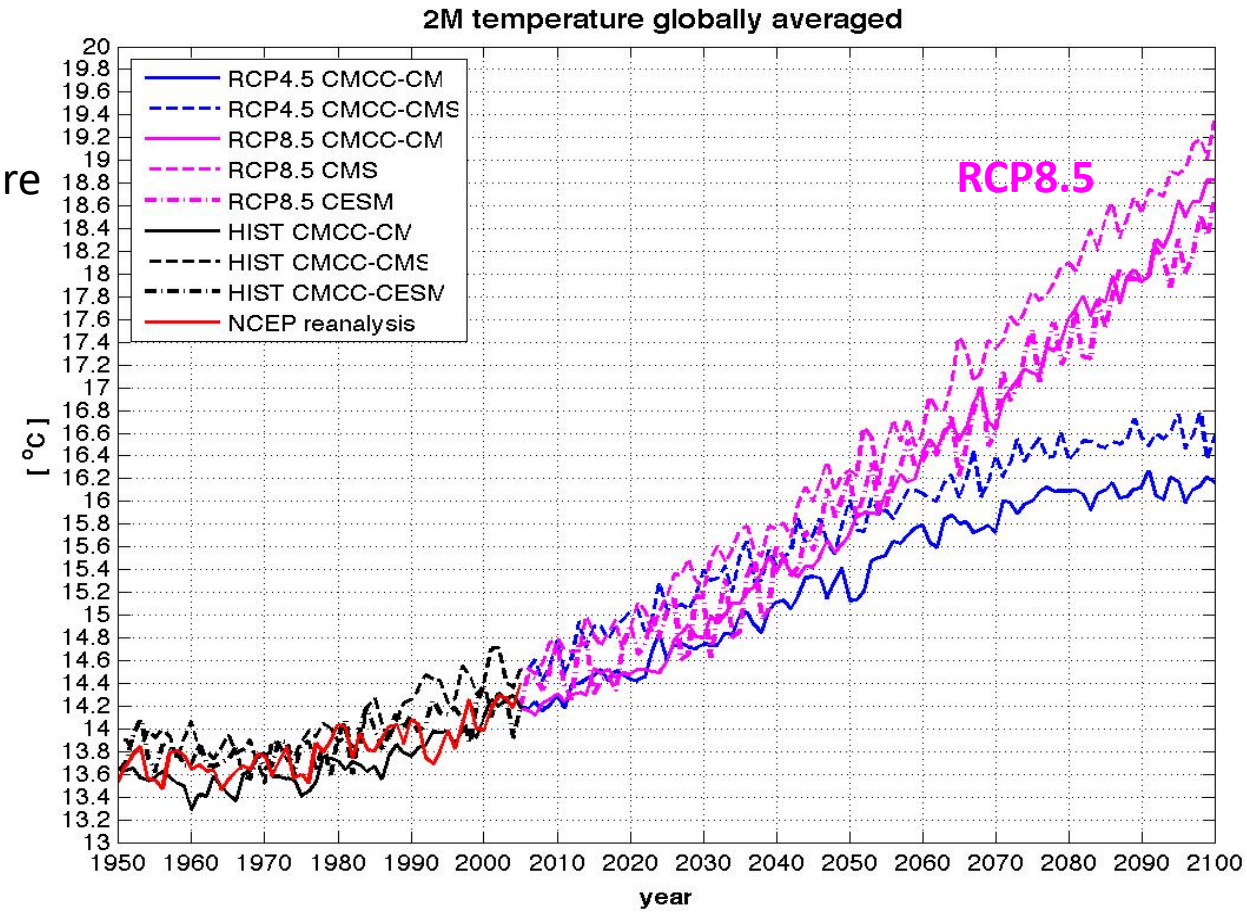
as an example

RCP4.5 leads to about 2.5°C Increase

and

RCP8.5 leads to more than 5°C increase.

Next slides will focus on the worst scenario, the RCP8.5, based on multi model averages



Projections of **Precipitation** over Europe: changes in winter extreme events.

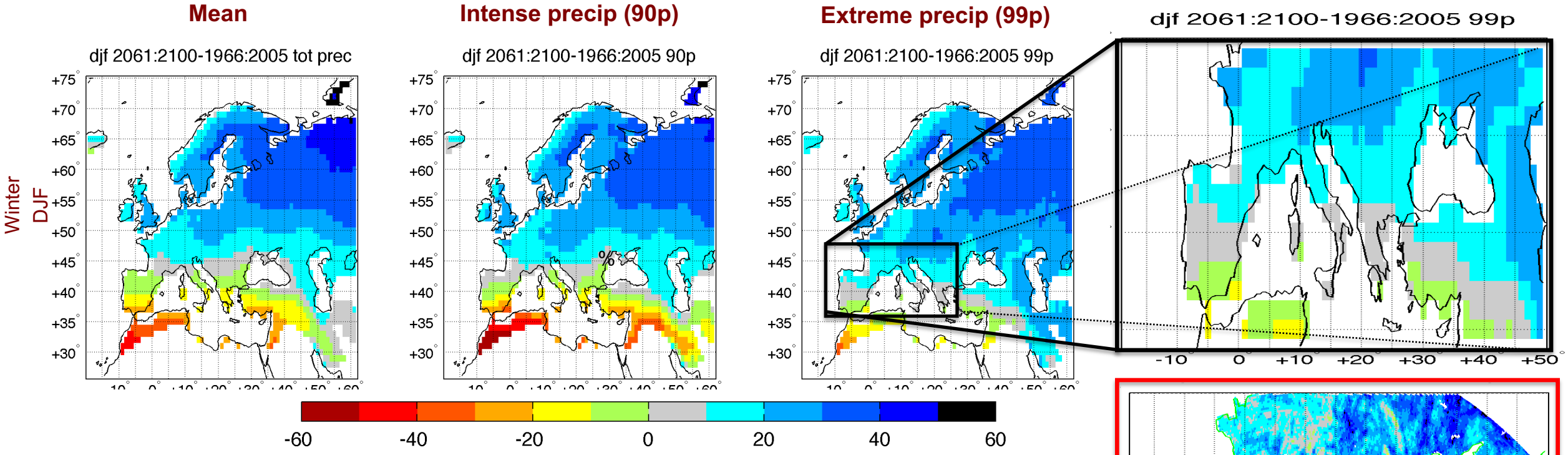
Daily
Precipitation
as from
CMIP5 models

- HISTORICAL 1966-2005
- RCP8.5 scenario 2061-2100

Model name	Lat x Lon (degrees)	Institute (Institude ID)
BNU-ESM	2.8 x 2.8	College of Global Change and Earth System Science, Beijing Normal University (GCESS)
CCSM4	**0.9 x 1.5**	National Center for Atmospheric Research (NCAR)
CMCC-CESM	3.7 x 3.7	Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC)
CMCC-CMS	1.9 x 1.9	Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC)
CMCC-CM	**0.8 x 0.8**	Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC)
CNRM-CM5	**1.4 x 1.4**	Centre National de Recherches Meteorologiques / Centre Europeen de Recherche et Formation Avancees en Calcul Scientifique (CNRM- CERFACS)
CSIRO-Mk3-6-0	1.9 x 1.9	Commonwealth Scientific and Industrial Research Organization in collaboration with Queensland Climate Change Centre of Excellence (CSIRO-QCCCE)
CanESM2	2.8 x 2.8	Canadian Centre for Climate Modelling and Analysis (CCCMA)
FGOALS-s2	1.6 x 2.8	LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences (LASG-IAP)
GFDL-CM3	2.0 x 2.5	NOAA Geophysical Fluid Dynamics Laboratory (NOAA GFDL)
GFDL-ESM2G	2.0 x 2.5	NOAA Geophysical Fluid Dynamics Laboratory (NOAA GFDL)
GFDL-ESM2M	2.0 x 2.5	NOAA Geophysical Fluid Dynamics Laboratory (NOAA GFDL)
HadGEM2-CC	**1.2 x 1.8**	Met Office Hadley Centre (MOHC)
HadGEM2-ES	**1.2 x 1.8**	Met Office Hadley Centre (MOHC)
INM-CM4	**1.5 x 2.0**	Institute for Numerical Mathematics (INM)
IPSL-CM5A-MR	**1.2 x 2.5**	IPSL-CM5A-LR Institut Pierre-Simon Laplace (IPSL)
MIROC5	**1.4 x 1.4**	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology (MIROC)
MPI-ESM-MR	1.9 x 1.9	Max Planck Institute for Meteorology (MPI-M)
MRI-CGCM3	**1.1 x 1.1**	Meteorological Research Institute (MRI)
NorESM1-M	1.8 x 2.5	Norwegian Climate Centre (NCC)

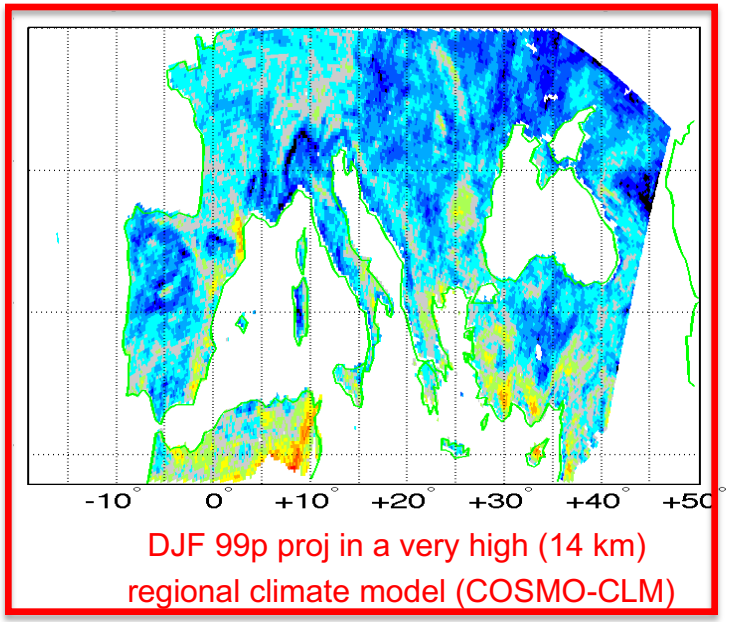
Projections of **Precipitation** over Europe: changes in winter extreme events.

Mean | **Intense precip (90p)** | **Extreme precip (99p)**



90p= 90mo percentile
99p= 99mo percentile

Results from 10 CGCMs



DJF 99p proj in a very high (14 km) regional climate model (COSMO-CLM)

References::

- Scoccimarro E. et al. 2016: Heavy precipitation events over Europe: future projections. *Regional Environmental Change*, DOI:10.1007/s10113-014-0712-y

- Scoccimarro E., et al., 2015: Projected changes in intense precipitation over Europe at the dailyand sub-daily time scales *Journal of Climate*, DOI: 10.1175/JCLI-D-14-00779.1.

- Scoccimarro E. et al. 2013: Heavy precipitation events in a warmer climate: results from CMIP5 models. *Journal of Climate*, DOI: 10.1175/JCLI-D-12-00850.1

Projections of **Perceived Temperature** over Europe: changes in extreme events.

- Once human body temperature higher than 37°C is reached, internal **heat needs to be released** from the body into the environment, **via evaporation of sweat. In high humidity conditions**, however, is much **less efficient than under dry conditions**, and any other physiological changes cannot prevent the core body temperature from reaching a dangerous level.

- This is suggesting that it is important to consider not only the **Air Temperature** but also the environmental **Relative Humidity** to **quantify the heat disease for the human body** especially under extreme conditions.

Perceived Temperature can be represented as HUMIDEX index

$$HUMIDEX = T + 5/9 * (e-10)$$

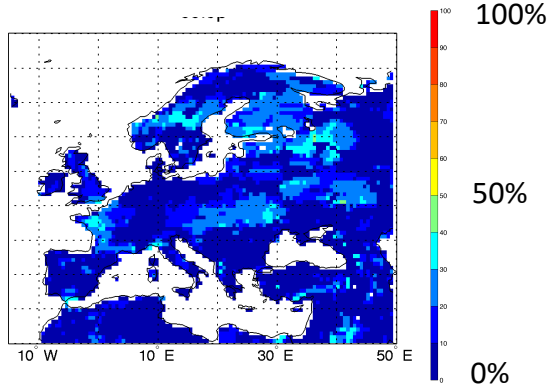
where: e ={6.112*10^(7.5***T**/[237.7+**T**]) ***RH**/100}

T = 2-meter air temperature [°C]

RH = 2-meter relative humidity [%]

Masterton and Richardson, 1979)

Results from 4 Regional Climate Models Over the EUR-11 EURO-CORDEX domain



100%

50%

0%

Observed fraction of extreme events of **perceived temperature** (considering temperature and relative humidity) contemporaneous to extreme events of temperature only.

Projections of **Perceived Temperature** over Europe: changes in extreme events.

Five main **HUMIDEX** categories are defined to represent different level of ***heat disease***:

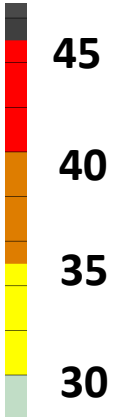
I) ***HUMIDEX*** >= 45 Really Dangerous, Heat Stroke possible

II) 40 <= ***HUMIDEX*** < 45 Huge Discomfort, avoid exertion

III) 35 <= ***HUMIDEX*** < 40 Great Discomfort

IV) 30 <= ***HUMIDEX*** < 35 Some Discomfort

V) ***HUMIDEX***< 30 No Discomfort



Moderate to Extreme HUMIDEX values have been computed based on **30 year of daily data** over the different periods, as:

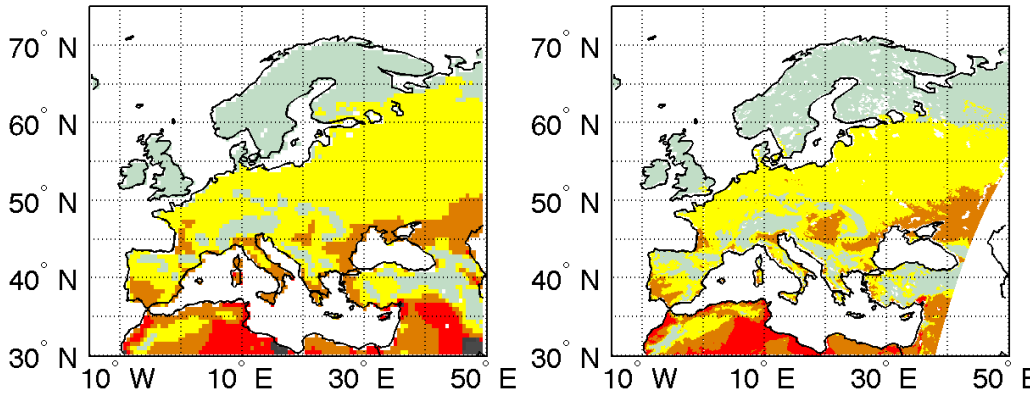
90 percentile of the 30 year daily time series (90p) -> **Moderate Events**

99 percentile of the 30 year daily time series (99p) -> **Intense Events**

99.9 percentile of the 30 year daily time series (99.9p) -> **Extreme Events**

Results from 4 Regional Climate Models Over the EUR-11 EURO-CORDEX domain

OBSERVATIONS **MODELS**

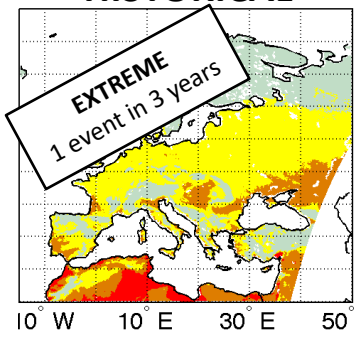


Ref :
Scoccimarro et al., accepted Sept. 2017.
"The role of humidity in determining perceived temperature extremes scenarios in Europe"
Environmental Research Letters doi: 10.1088/1748-9326/aa8cdd.
Available online at: http://iopscience.iop.org/article/10.1088/1748-9326/aa8cdd/pdf

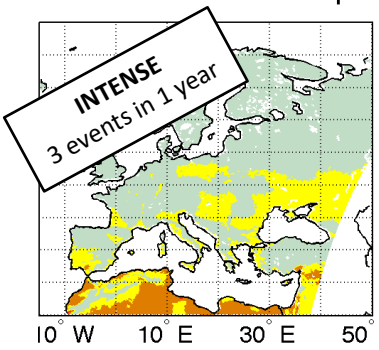
Projections of **Perceived Temperature** over Europe: changes in extreme events.

Far Future Projections (2066:2095) following the business as usual **scenario RCP8.5**

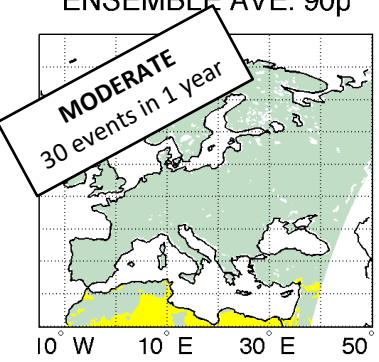
HISTORICAL



ENSEMBLE AVE. 99p



ENSEMBLE AVE. 90p



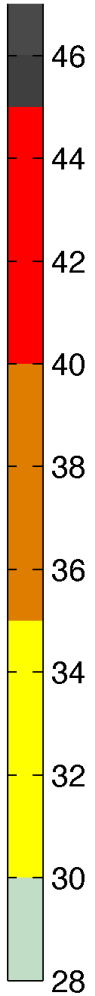
Really Dangerous

Huge Discomfort

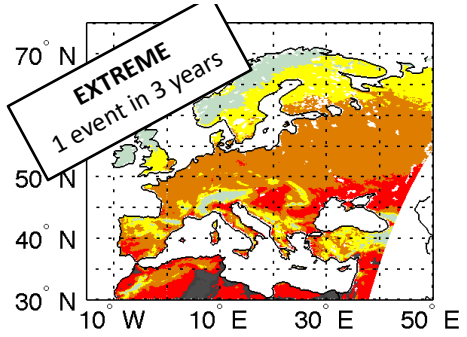
Great Discomfort

Some Discomfort

No Discomfort

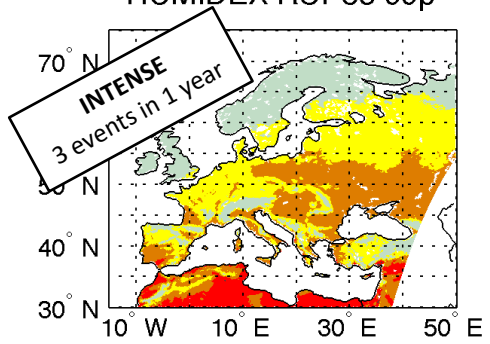


2066:2095 PERCEIVED TEMPERATURE



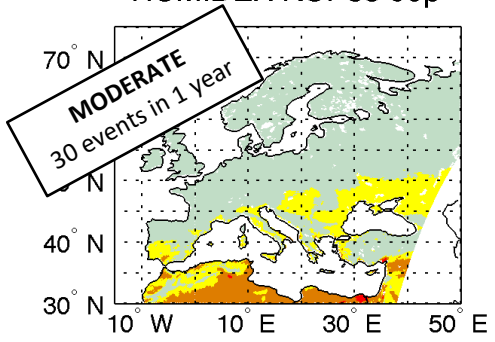
Under **EXTREME** conditions
Huge discomfort is expected over southern plains.
Great discomfort is expected for the end of the century over most of the EU domain.
Some discomfort will appear north of 60°N.

HUMIDEX RCP85 99p



Under **INTENSE** conditions
Great discomfort is expected for the end of the century over most of the EU domain and
Some discomfort is expected over western Europe and between 50°N and 60°N.

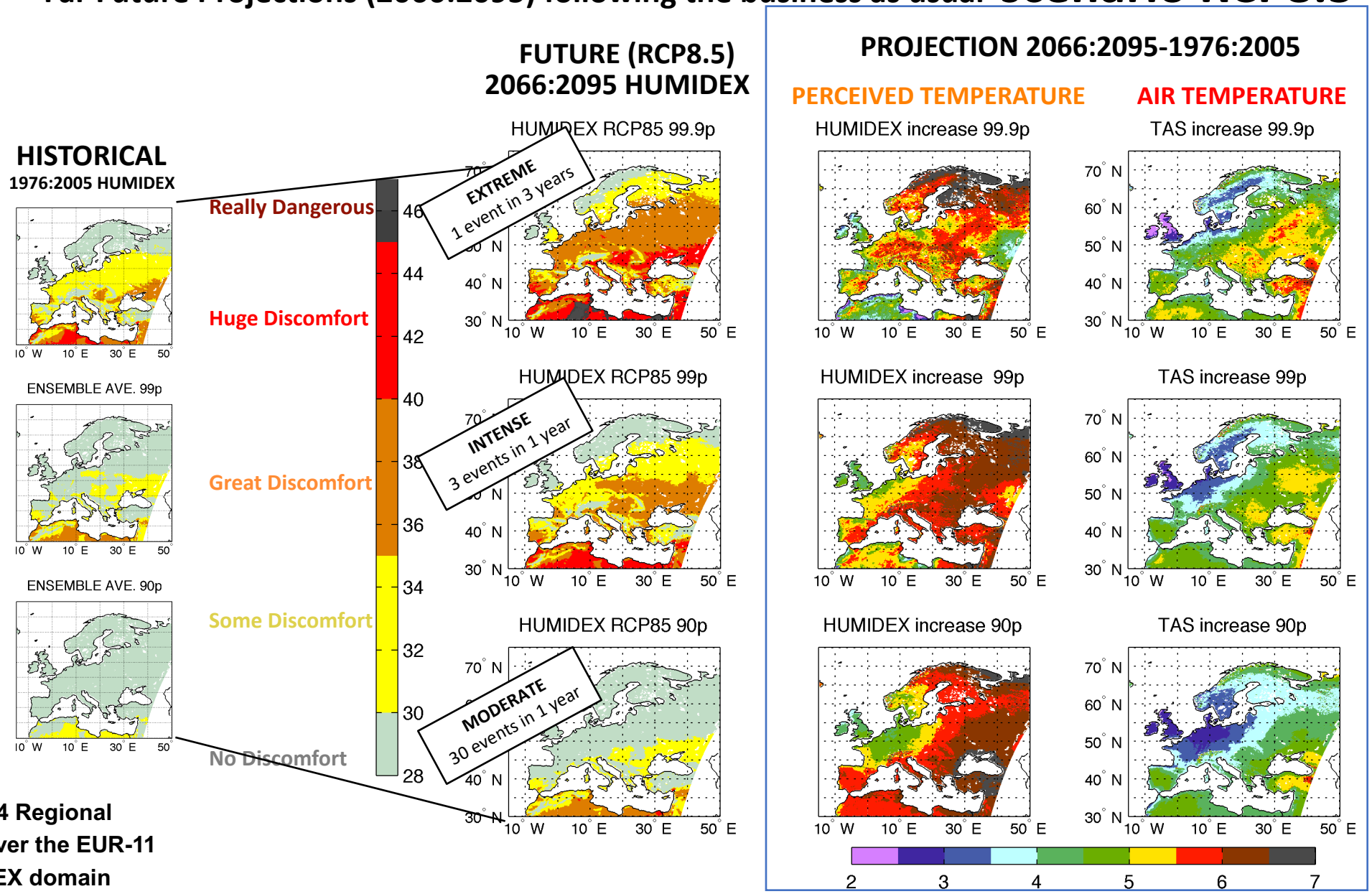
HUMIDEX RCP85 90p



Under **MODERATE** conditions
Some discomfort is expected over southern plains.

Future Projections

Far Future Projections (2066:2095) following the business as usual scenario RCP8.5



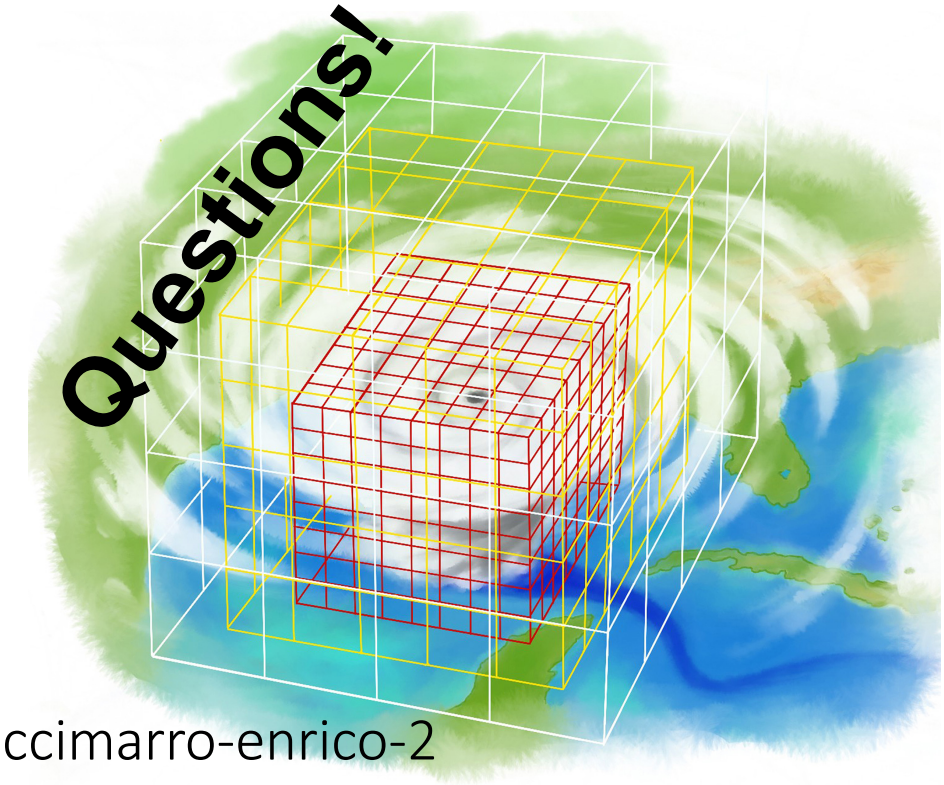
Results from 4 Regional Climate Models over the EUR-11 EURO-CORDEX domain

Impacts of anthopogenic climate change in Europe

Summary of projections over EU for the end of the century following RCP8.5

- **Precipitation** is expected to increase over Northern Europe and to decrease over the southern EU domain .
- The whole EU domain will be affected by an increase of **Extreme Precipitation** events.
- Extreme Events of **Air Temperature** and **Extreme Events** of **Perceived Temperature** (HUMIDEX) over Europe are not synchronous.
- When focusing on Extreme Events, projections on **Perceived Temperature** are more pronounced than projections of **Air temperature** only**.**
- The Relative Humidity under warmer conditions tends to decrease, but less over the north-eastern Europe, due to the pronounced **projected increase of Specific Humidity** over the region.

Impacts of anthopogenic climate change in Europe



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www.italy-croatia.eu/gutta

Interreg Italy - Croatia GUTTA
European Regional Development Fund

EUROPEAN UNION

cmcc

MARE NOSTRUM

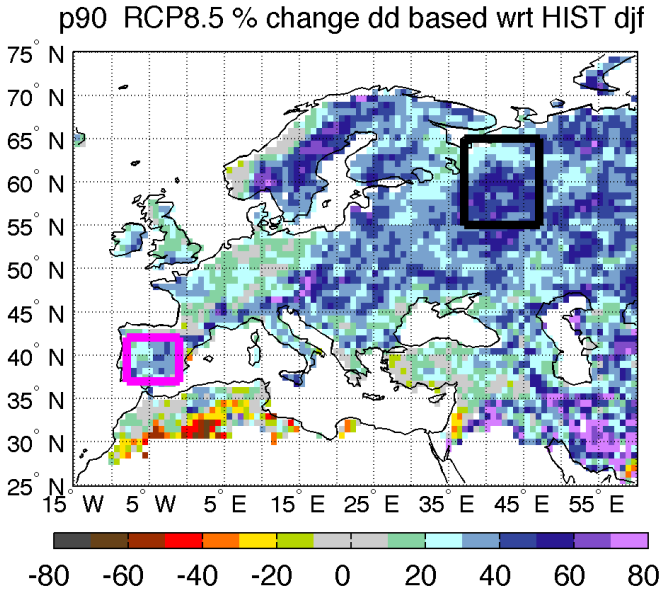
Republika Hrvatska
Ministarstvo Mora, Prometa i Infrastrukture

Autorità di Sistema Portuale del Mare Adriatico Meridionale
Bari, Brindisi, Manfredonia, Barletta, Monopoli

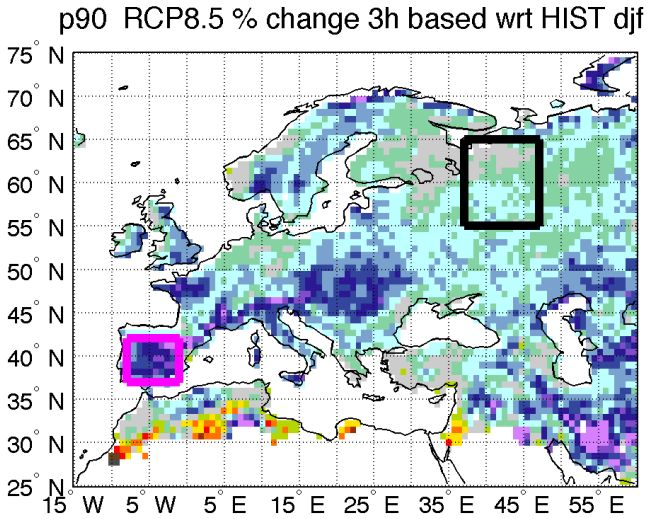
Projections of **Precipitatoin** over Europe: changes in winter extreme events based on **daily** or **3h** time series.

90th percentile (90p) precipitation projection during DJF

DAILY Based projections



3 HOURLY Based projections



Difference between 3 HOURLY and DAILY projections