Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile

EARTH TECHNOLOGY EXPO

Proiezioni climatiche future in area Mediterranea:

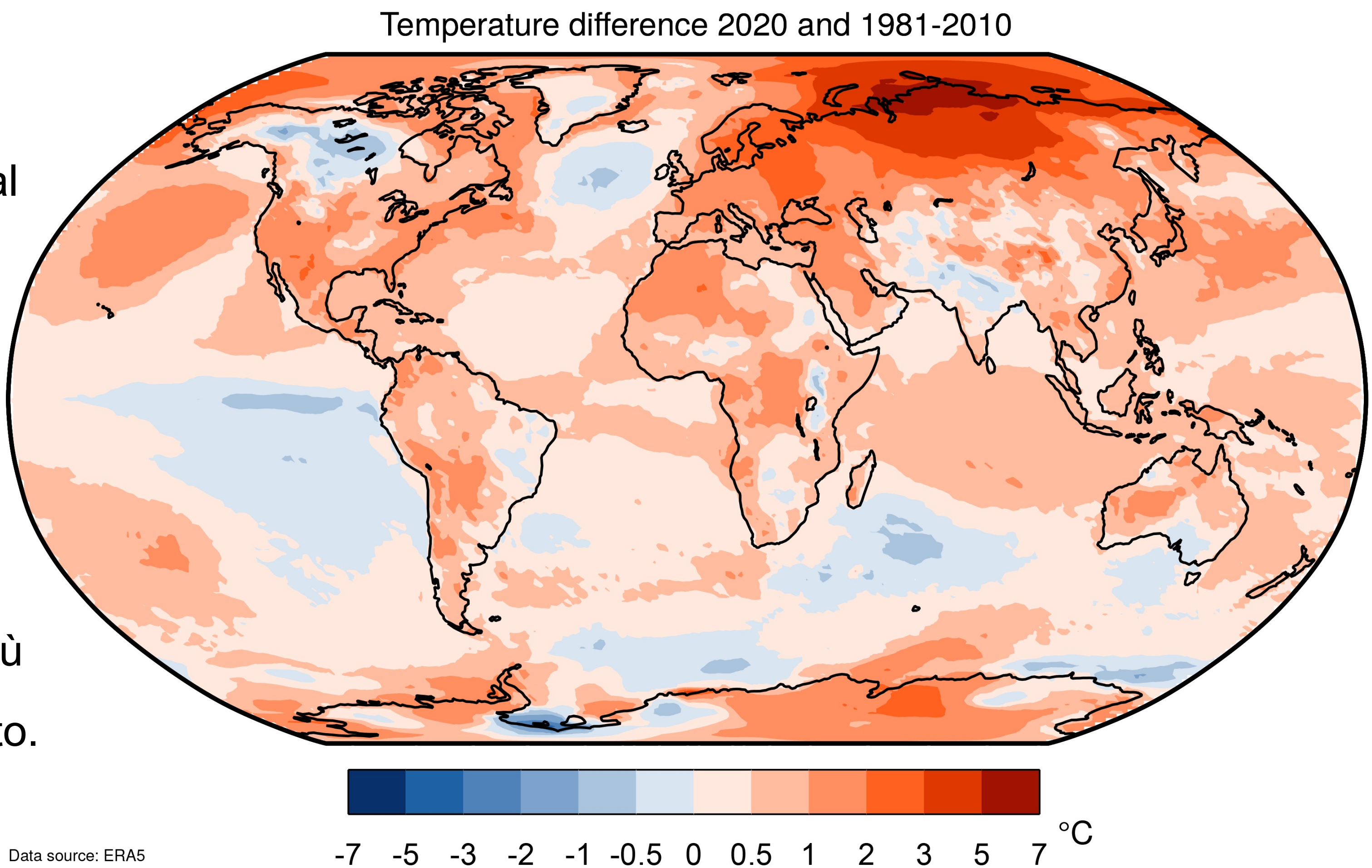
Firenze - 13 ottobre 2021

Gianmaria Sannino – Laboratorio di Modellistica Climatica e Impatti (ENEA)

https://impatti.sostenibilita.enea.it/structure/clim

2020 secondo anno più caldo dal 1860

Il 2020 è stato l'anno più caldo dal 1860 per l'Europa; a livello globale, il 2020 si attesta al secondo posto, a breve distanza dal 2016, l'anno più caldo mai registrato.



Air temperature at a height of two metres for 2020, shown relative to its 1981–2010 average. Source: ERA5. Credit: Copernicus Climate Change Service/ECMWF

Temperature superficiale globale: anni più caldi dal 1880

RANK 1 = WARMEST PERIOD OF RECORD: 1880–2020	YEAR	ANOMALY °C
1	2016	1.00
2	2020	0.98
3	2019	0.95
4	2015	0.93
5	2017	0.91
6	2018	0.83
7	2014	0.74
8	2010	0.72
9	2013	0.68
10	2005	0.67

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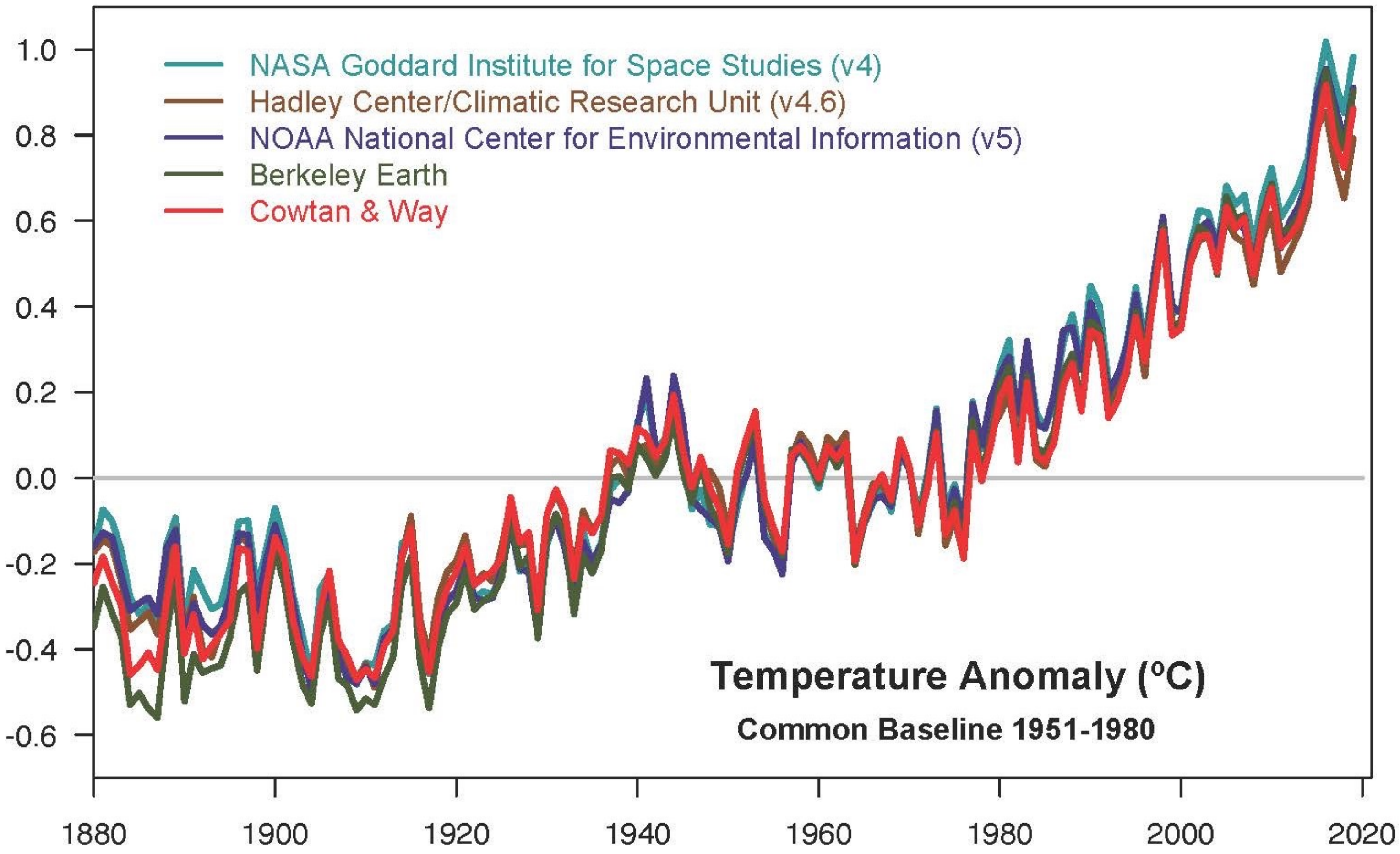
Global combined land and ocean annually averaged temperature rank and anomaly for each of the 10 warmest years on record (1910–2000) [cit. NOAA]

Andamento temperatura globale superficiale

Change in global surface temperature relative to 1951-1980 average temperatures



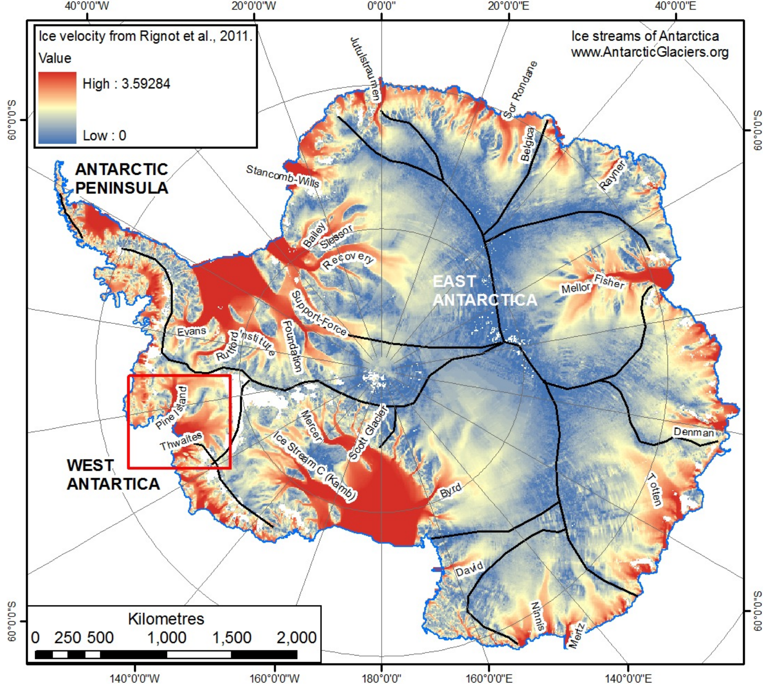
Incendi in Australia, Siberia, California e Amazzonia

Inondazioni in Cina, Bangladesh e India

Ondate di calore in tutto l'emisfero nord

In Siberia, il permafrost fonde ad una velocità senza precedenti

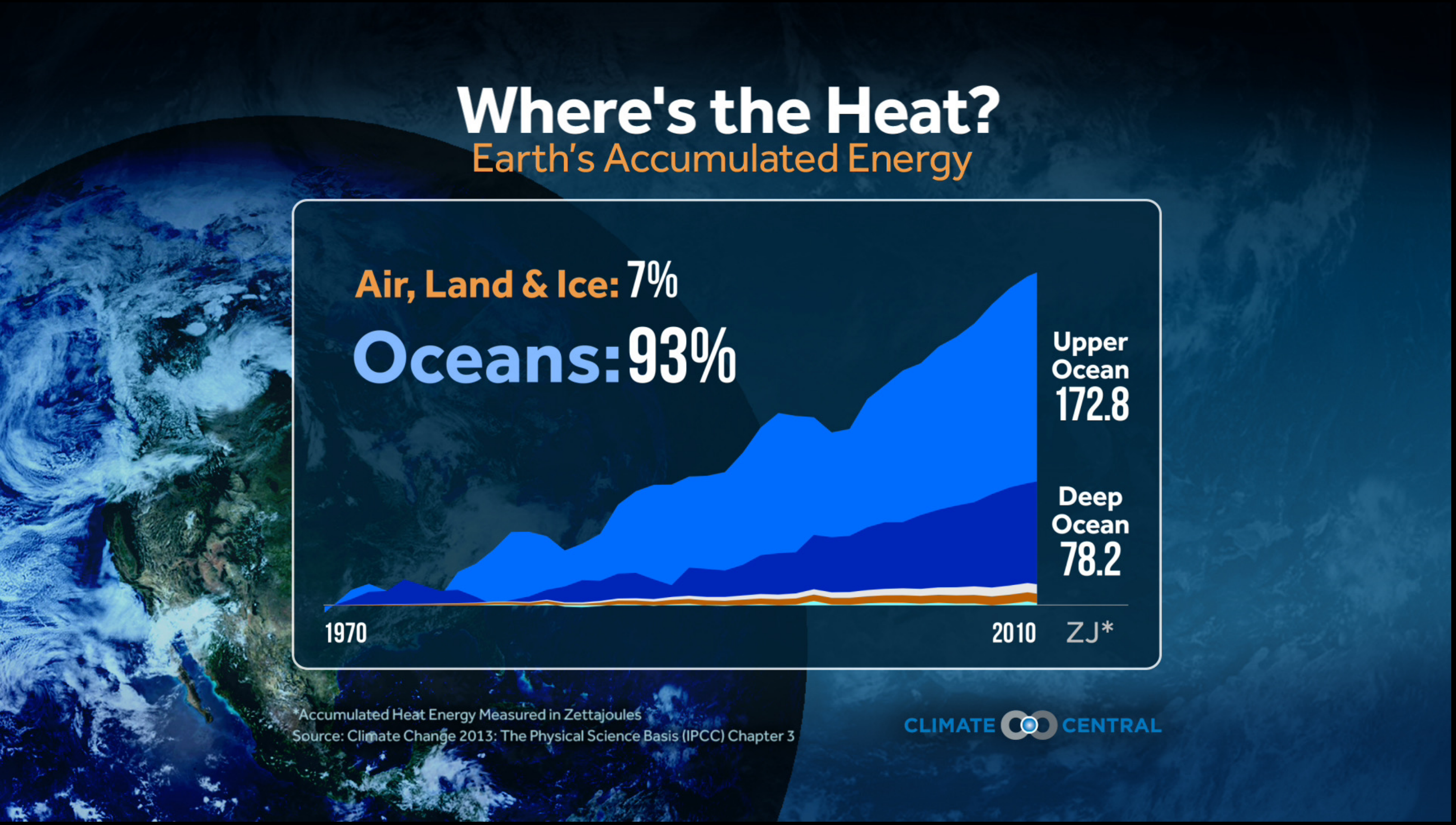
La Groenlandia sta perdendo miliardi di tonnellate di ghiaccio ogni anno



L'Antartide occidentale fonde a ritmi impressionanti

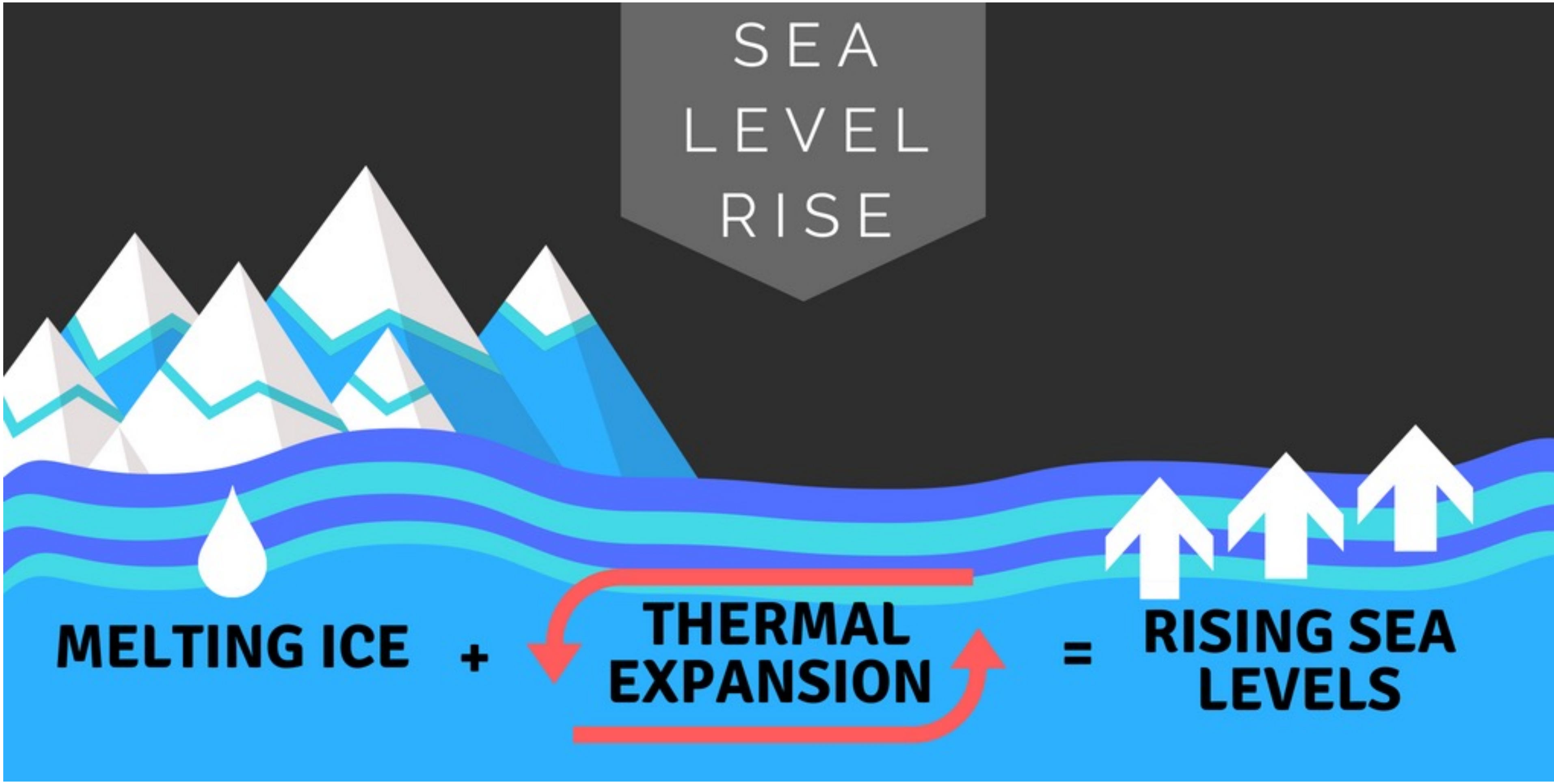
E ora, il ghiacciaio più solido della terra, l'Antartide orientale, sta diventando instabile

Gli oceani si stanno riscaldando

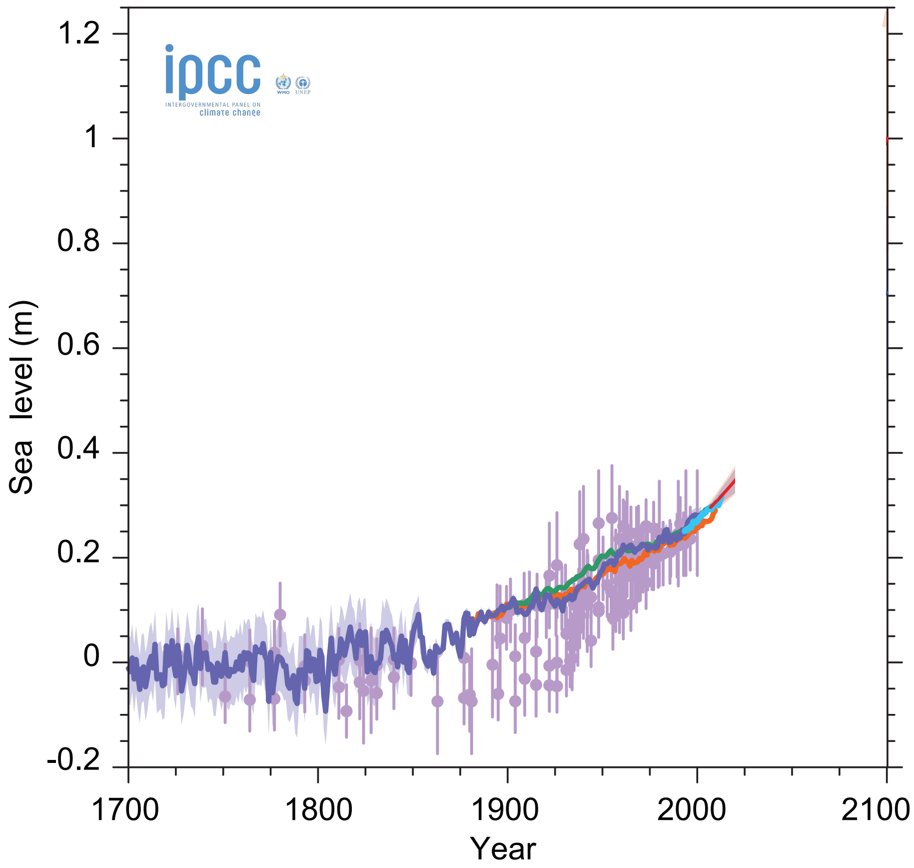


- La maggior parte del calore è finito negli oceani, non nell'atmosfera.
- Gli oceani assorbono il 25% della CO2 emessa in atmsfera

Causes of Sea Level Rise



Global sea level since 1700



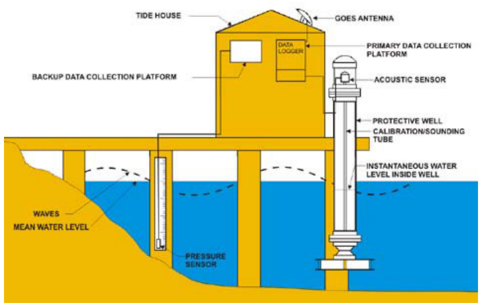
Rate during 1901-1990 was 1.50 ± 0.2 mm yr^{-1}

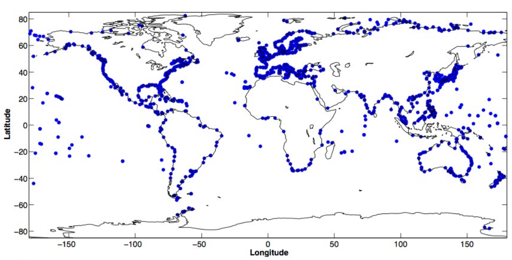
Rate during 1993-2010 was 3.07± 0.37 mm yr^{-1}

Rate during 2005-2017 was **3.50± 0.2 mm yr^{-1}**

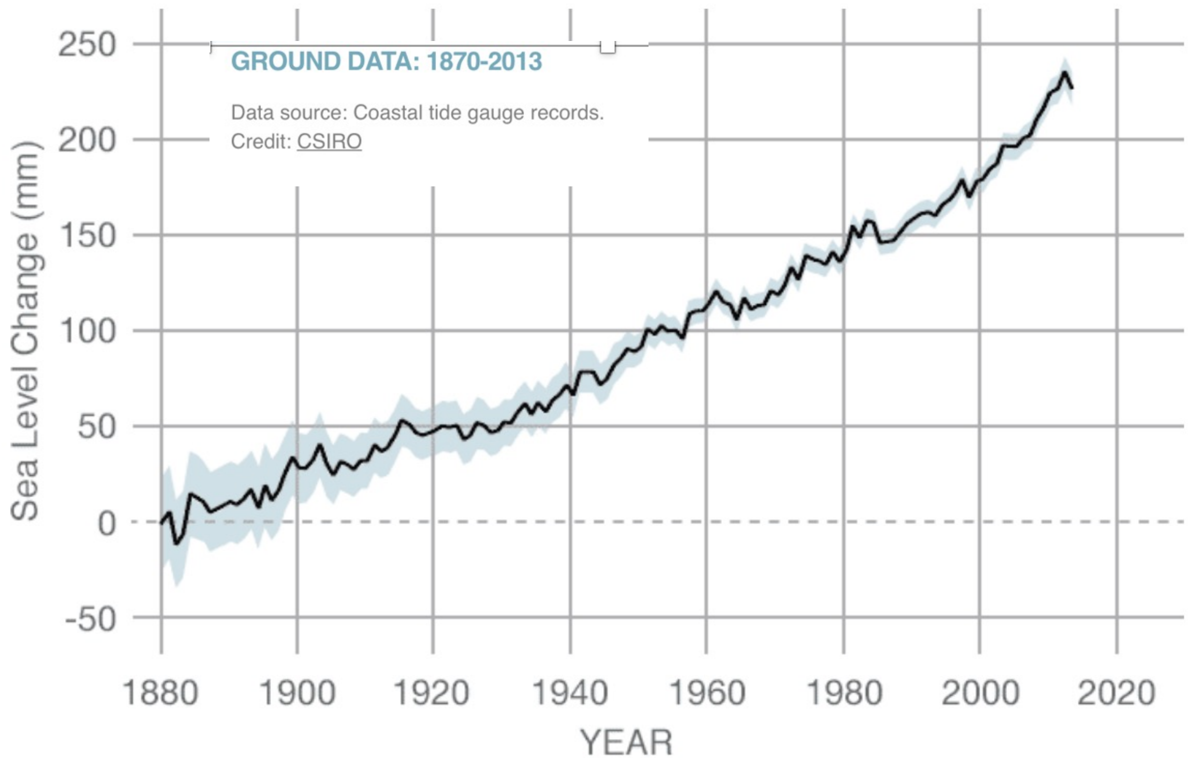
Compilation of paleo sea level data, tide gauge data, altimeter data.

Global sea level since 1880





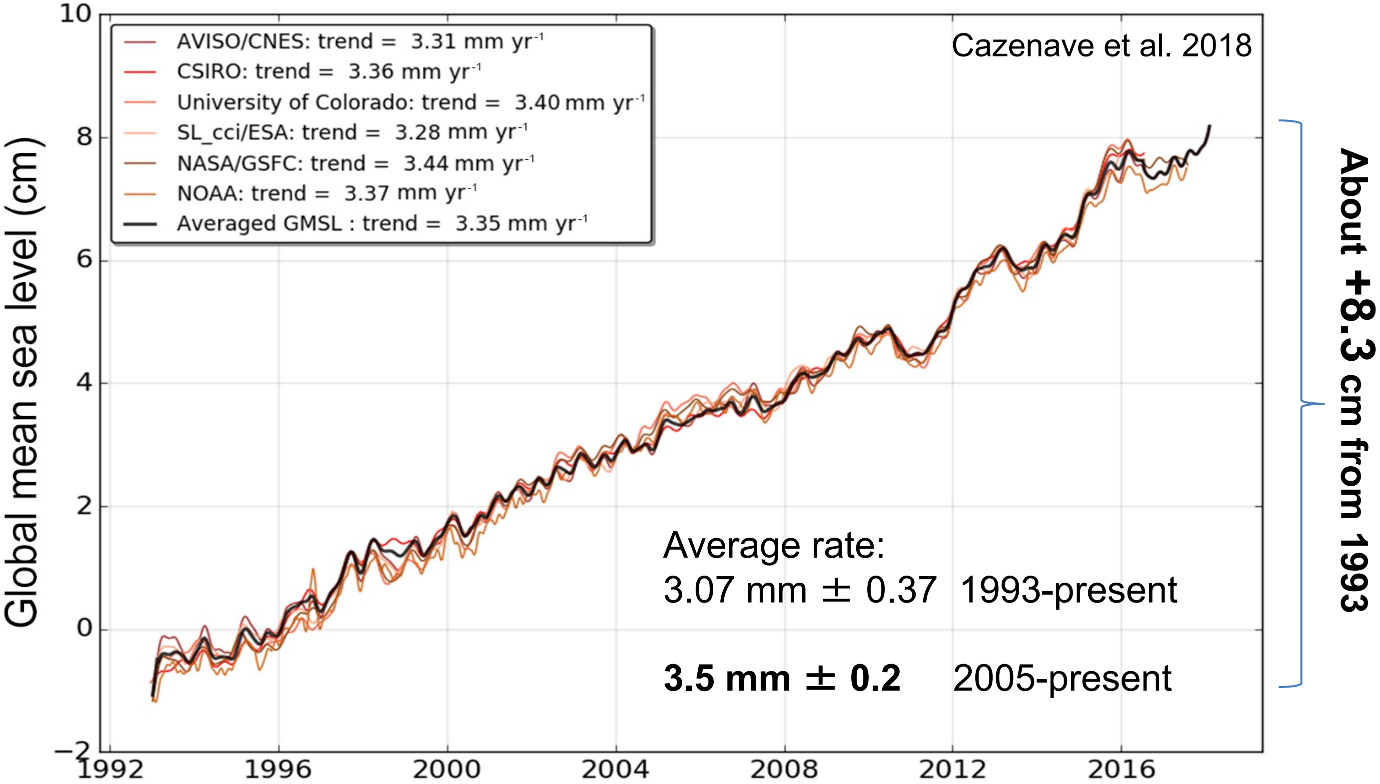
Spatial distribution of the **1420** tide gauges



Change in sea level since 1880 as observed by coastal tide gauge*

About +25 cm from 1880

Global sea level since 1993



Change in sea level since **1993** as observed by satellites.

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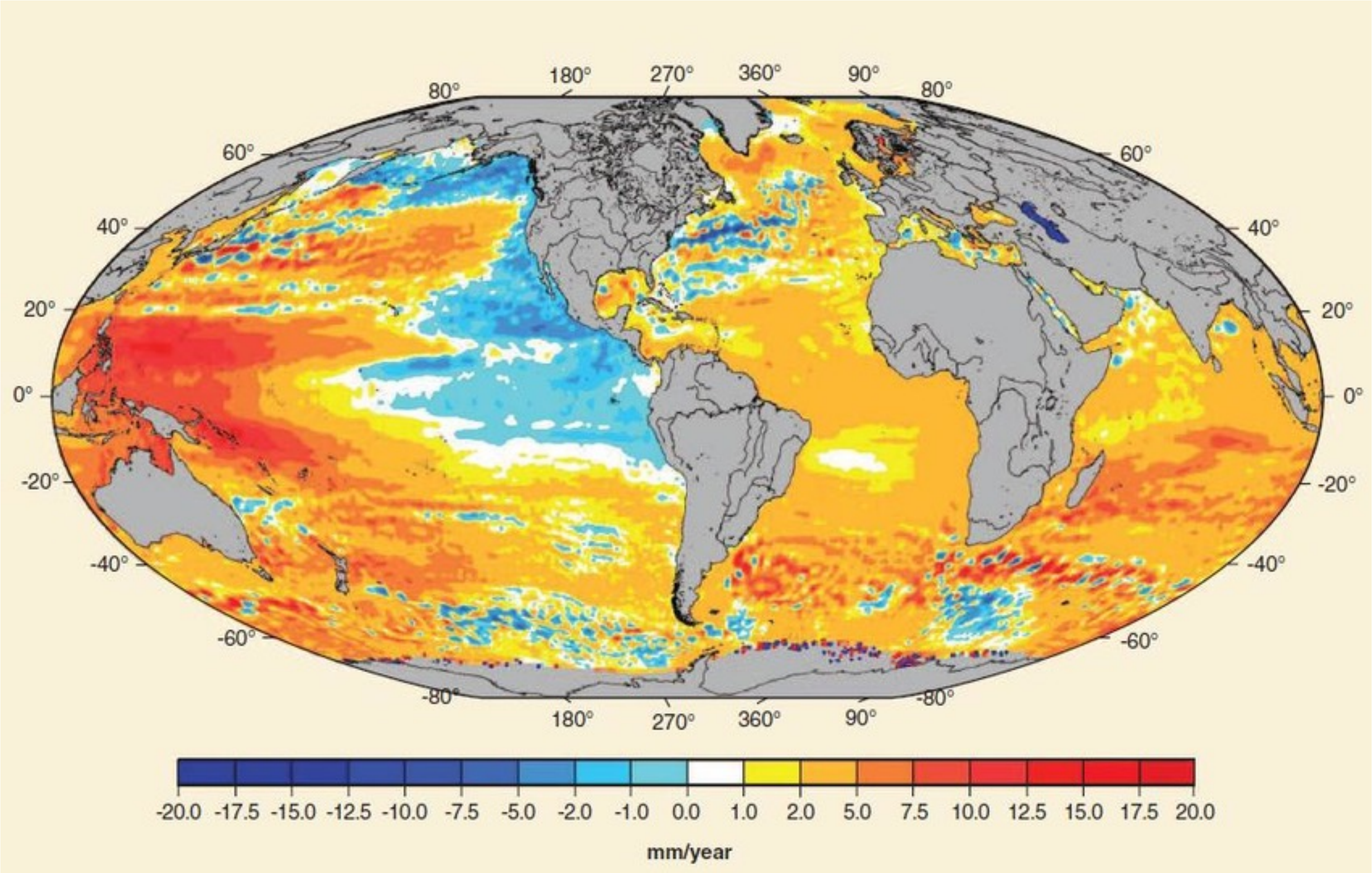
Regional Sea Level

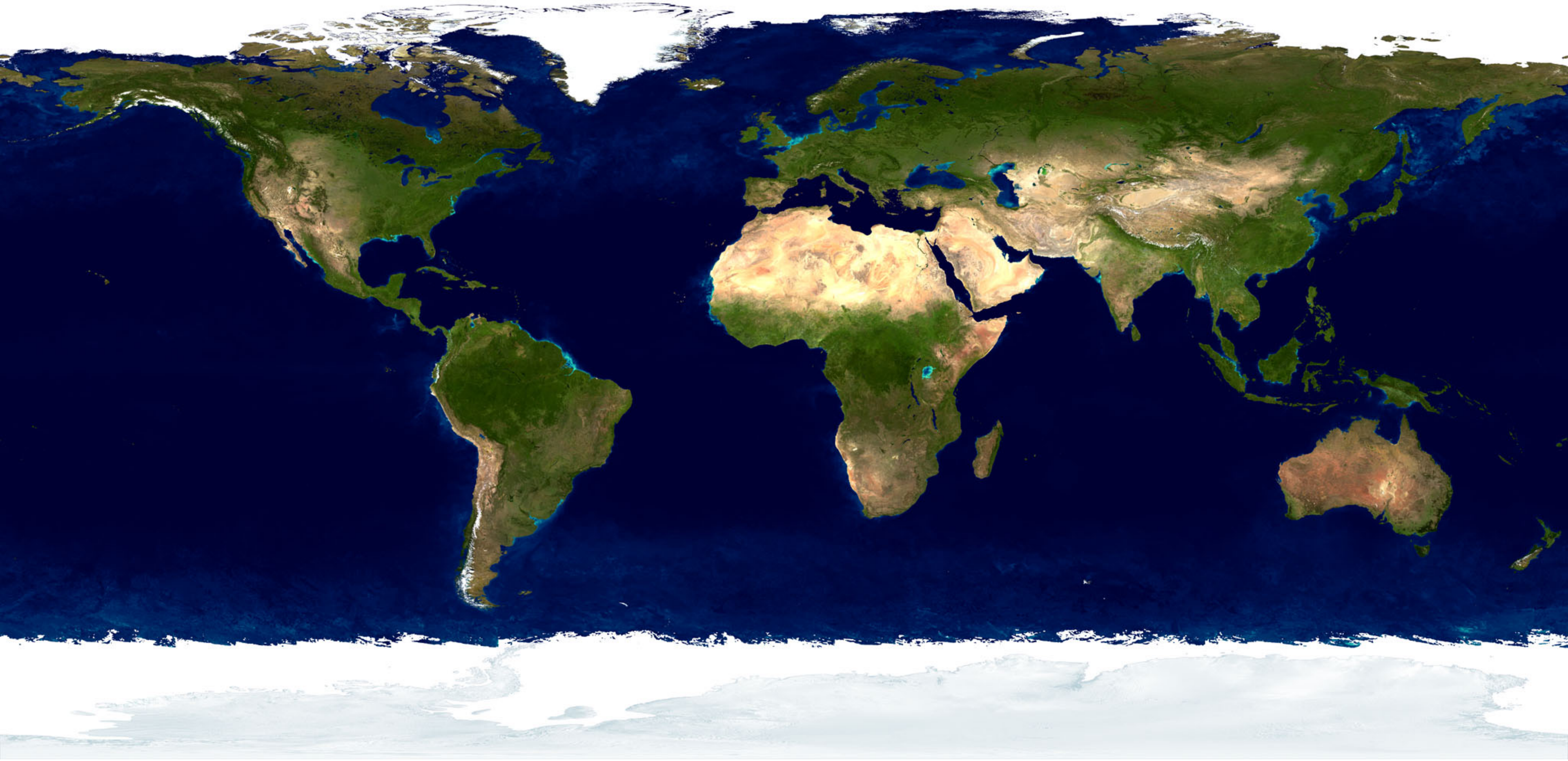


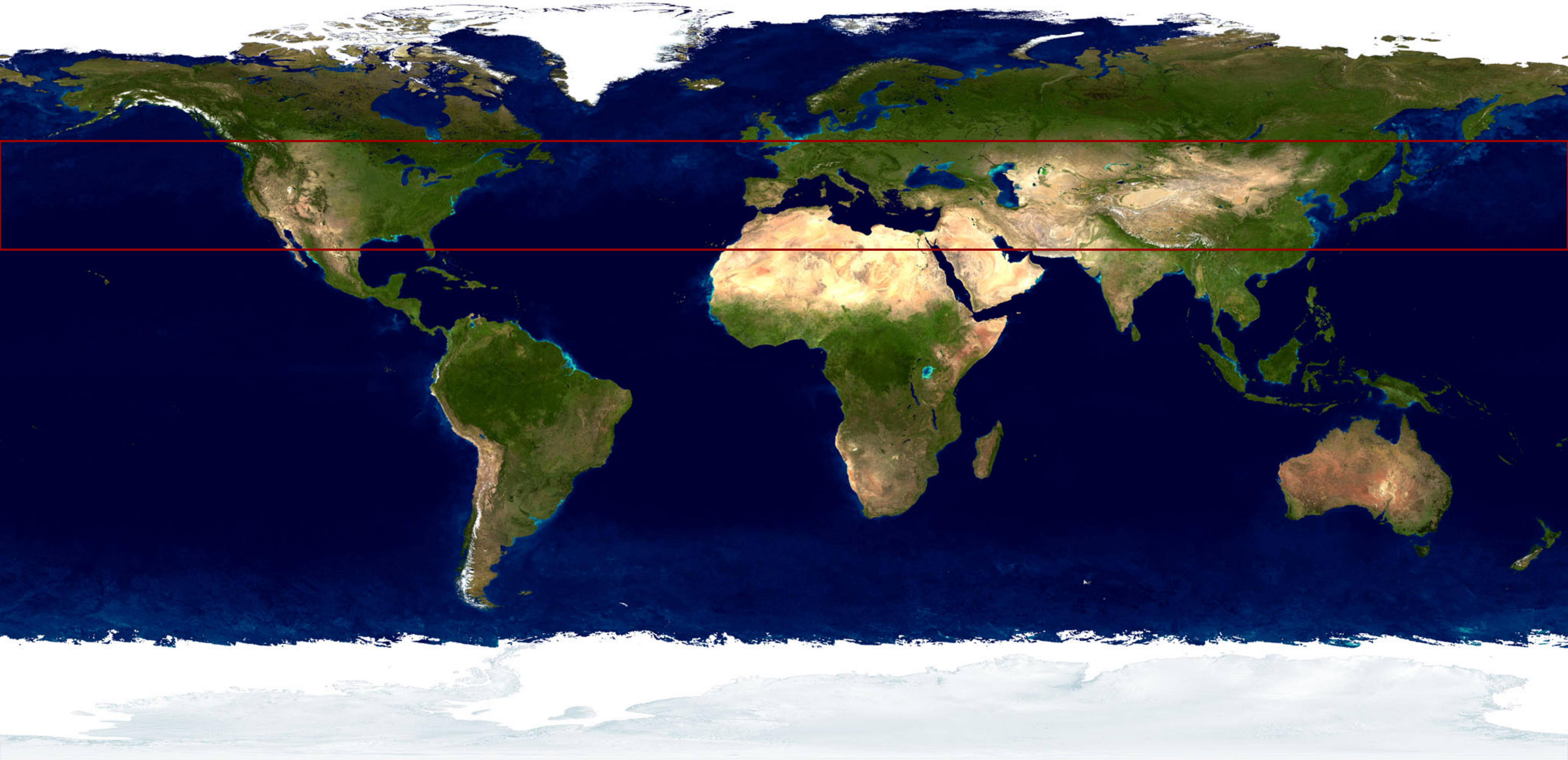
Regional sea-level trends from satellite altimetry for the period: **October 1992 to July 2009**

Spatial differences are due to the steric effect. Nicholls & Cazenave, 2010

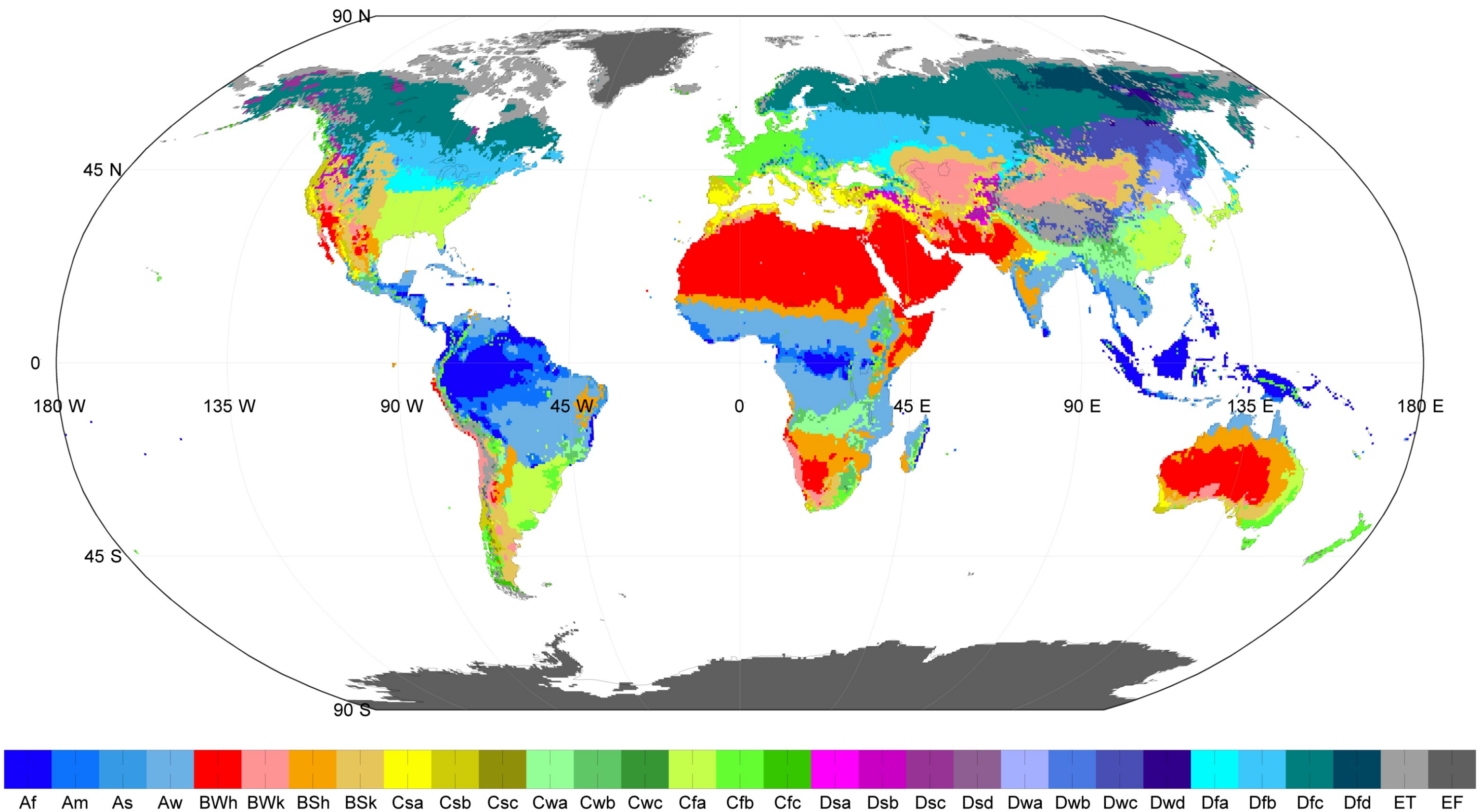
Causes of R-SLR at Gobal, Regional and Local scale

	G	R	L
Melting Greenland and Antarctica	●	●	○
Melting Glaciers and ice caps	●	●	○
Ocean Thermal expansion	●	●	○
Ocean Circulation	●	●	○
Postglacial rebound, self-attraction and loading	○	●	●
Land Hydrology	○	○	●
Tides, Storm surge, Subsidence	○	○	●





World map of Köppen climate classification for 1901–2010



First letter	Second letter		Third letter
A: Tropical	f: Fully humid	T: Tundra	h: Hot arid
B: Dry	m: Monsoon	F: Frost	k: Cold arid
C: Mild temperate	s: Dry summer		a: Hot summer
D: Snow	w: Dry winter		b: Warm summer
E: Polar	W: Desert		c: Cool summer
	S: Steppe		d: Cold summer

Data source: Terrestrial Air Temperature/Precipitation: 1900-2010 Gridded Monthly Time Series (V 3.01)

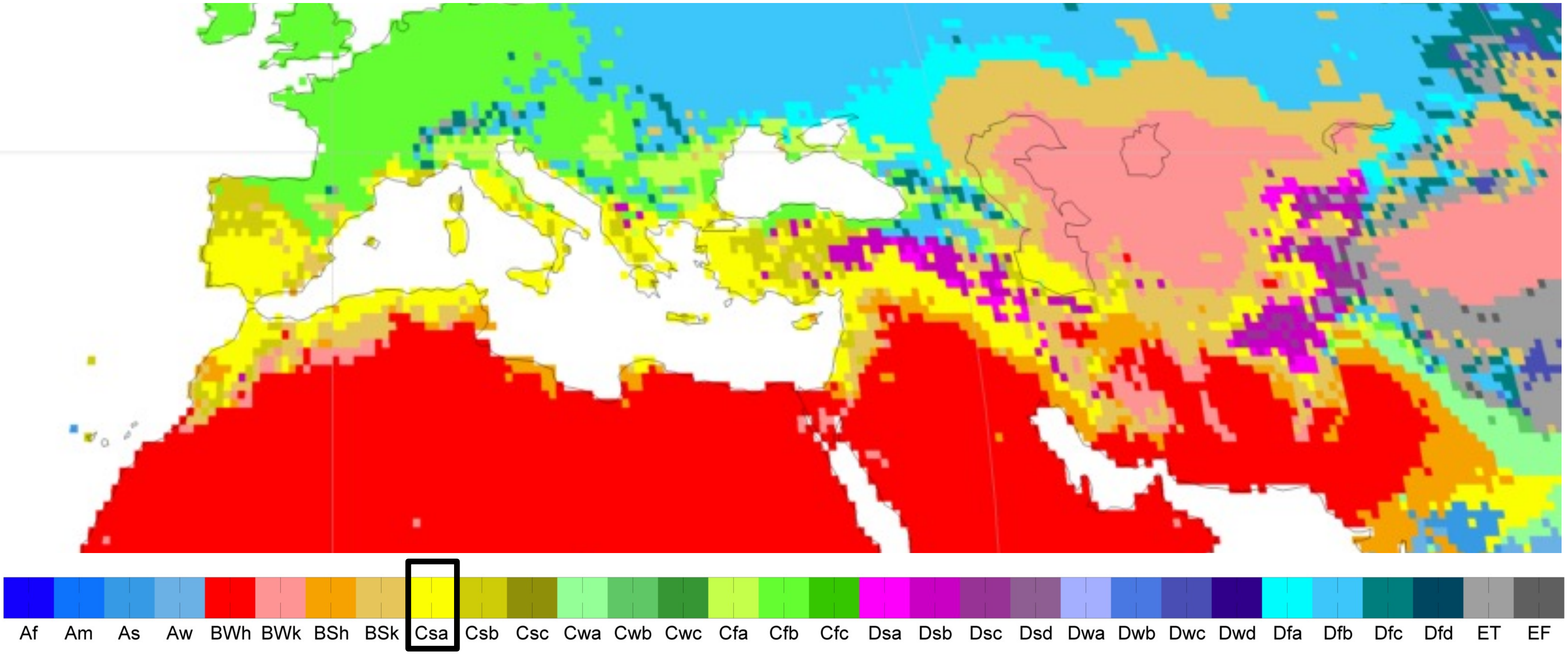
Resolution: 0.5 degree latitude/longitude

Website: http://hanschen.org/koppen

Ref: Chen, D. and H. W. Chen, 2013: Using the Köppen classification to quantify climate variation and change: An example for 1901–2010. Environmental Development, 6, 69-79, 10.1016/j.envdev.2013.03.007.

The **Köppen climate classification** was first published in 1884, with several later modifications by Köppen, notably in **1918** and **1936**. Later, the climatologist Rudolf Geiger (1954, 1961) introduced some changes to the classification system, which is thus sometimes called the **Köppen–Geiger climate classification system.**

The Köppen–Geiger climate classification system



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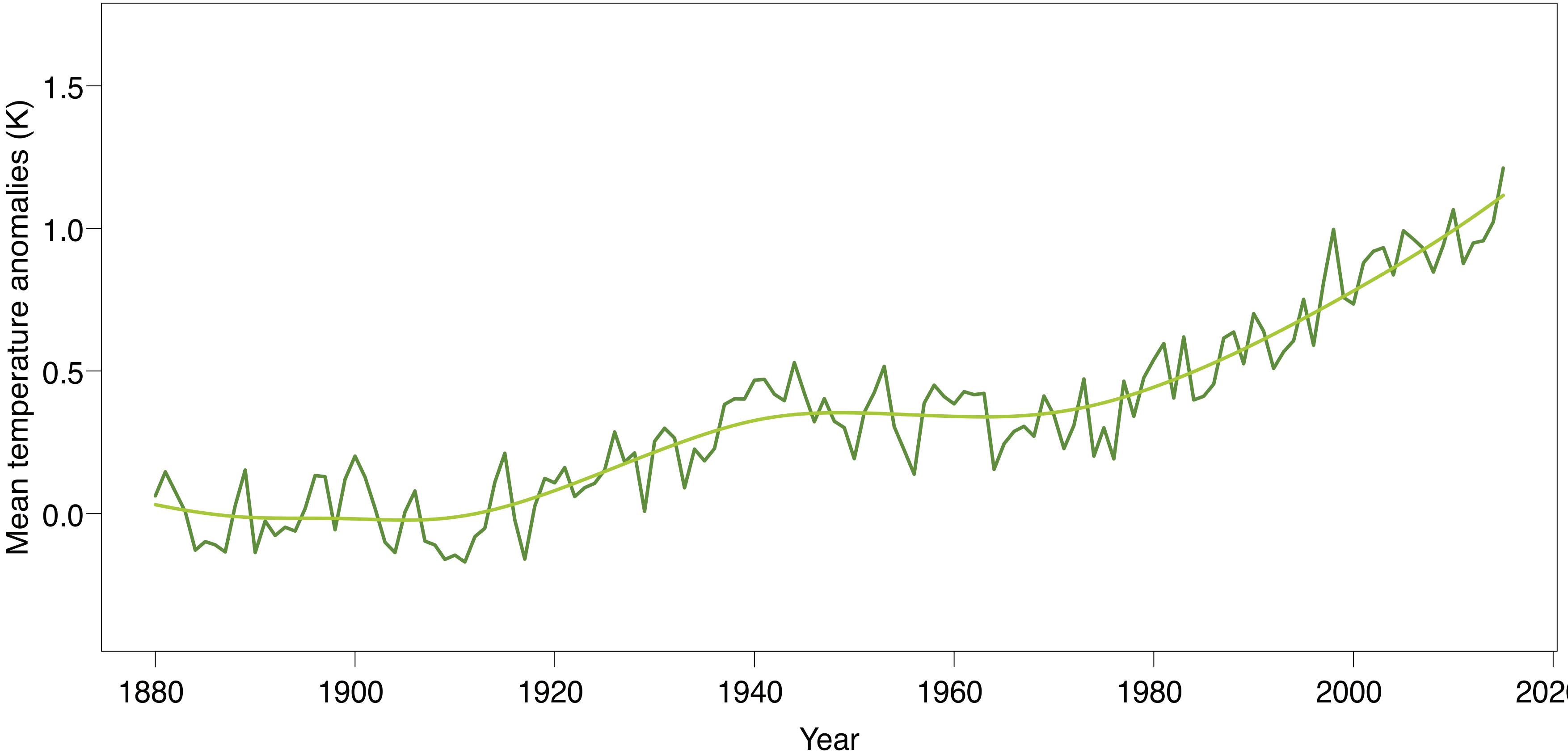
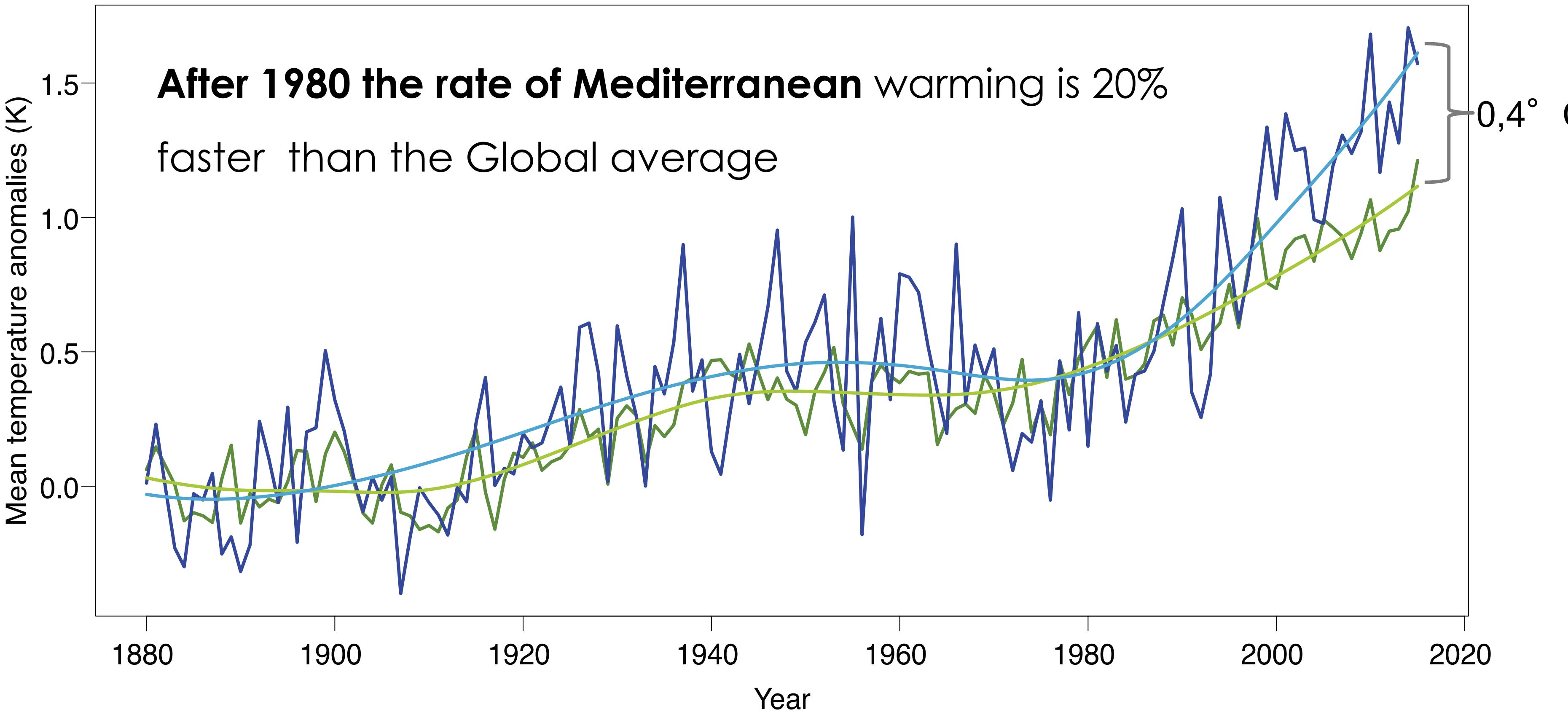
Historic Global Surface Air Temperature



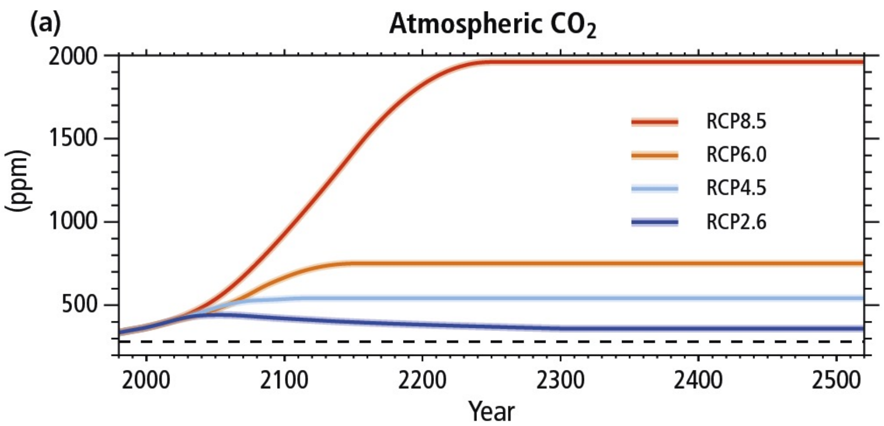
Historic warming of the atmosphere at Global scale**.** Annual mean air temperature anomalies are shown with respect to the preindustrial period (**1880–1899).** Cramer et al. 2018 (NCC)

Global vs Mediterranean Surface Air Temperature



Historic warming of the atmosphere at Global and Mediterranean scale. Annual mean air temperature anomalies are shown with respect to the preindustrial period **(1880–1899).** Adapted by Cramer et al. 2018 (NCC)

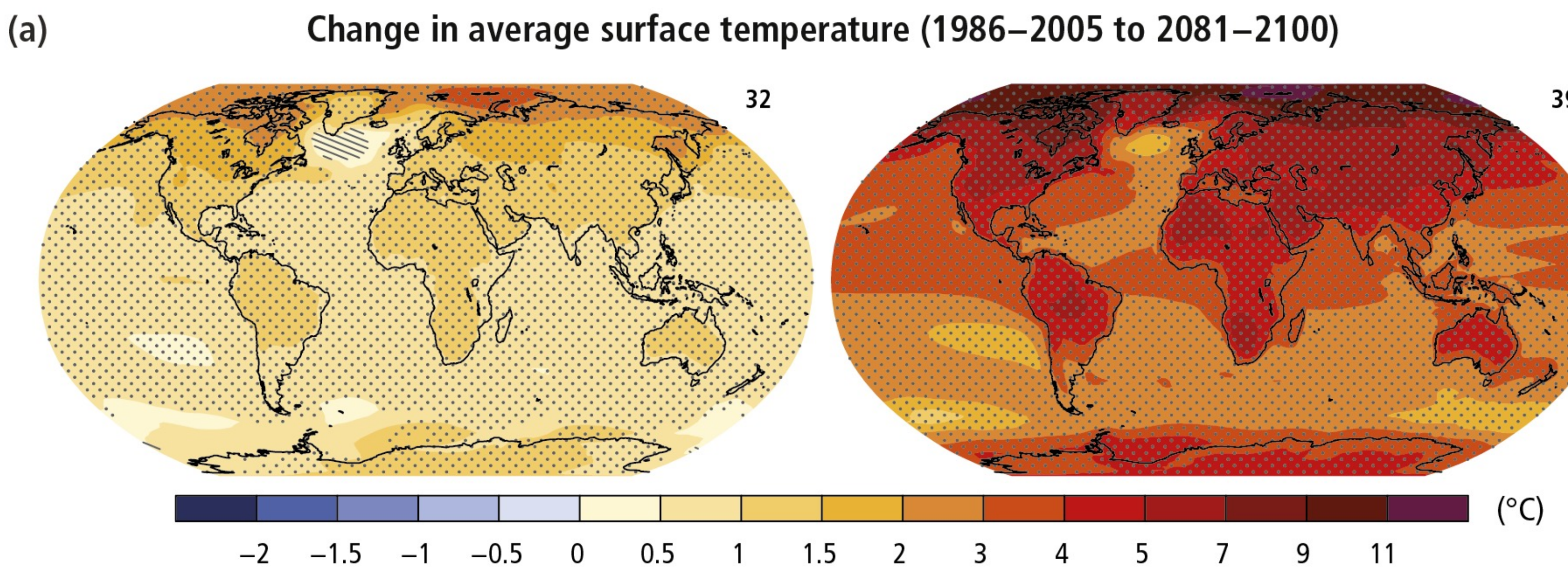
IPCC Assessment Report 5 - Projected Climate Change: surface



Future Climate Changes, Risks and Impacts

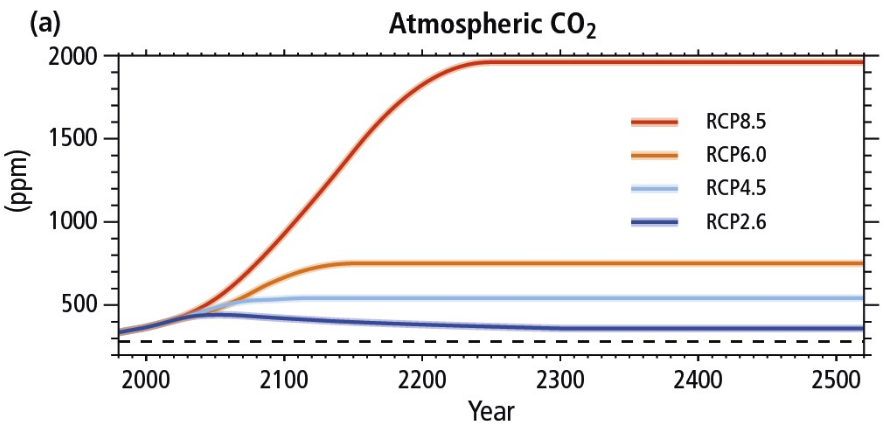
Representative Concentration Pathways (RCPs) are four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its fifth Assessment Report (AR5) in 2014

RCP2.6 RCP8.5



Projected Change in Average Surface Temperature

IPCC Assessment Report 5 - Projected Climate Change: precipitation



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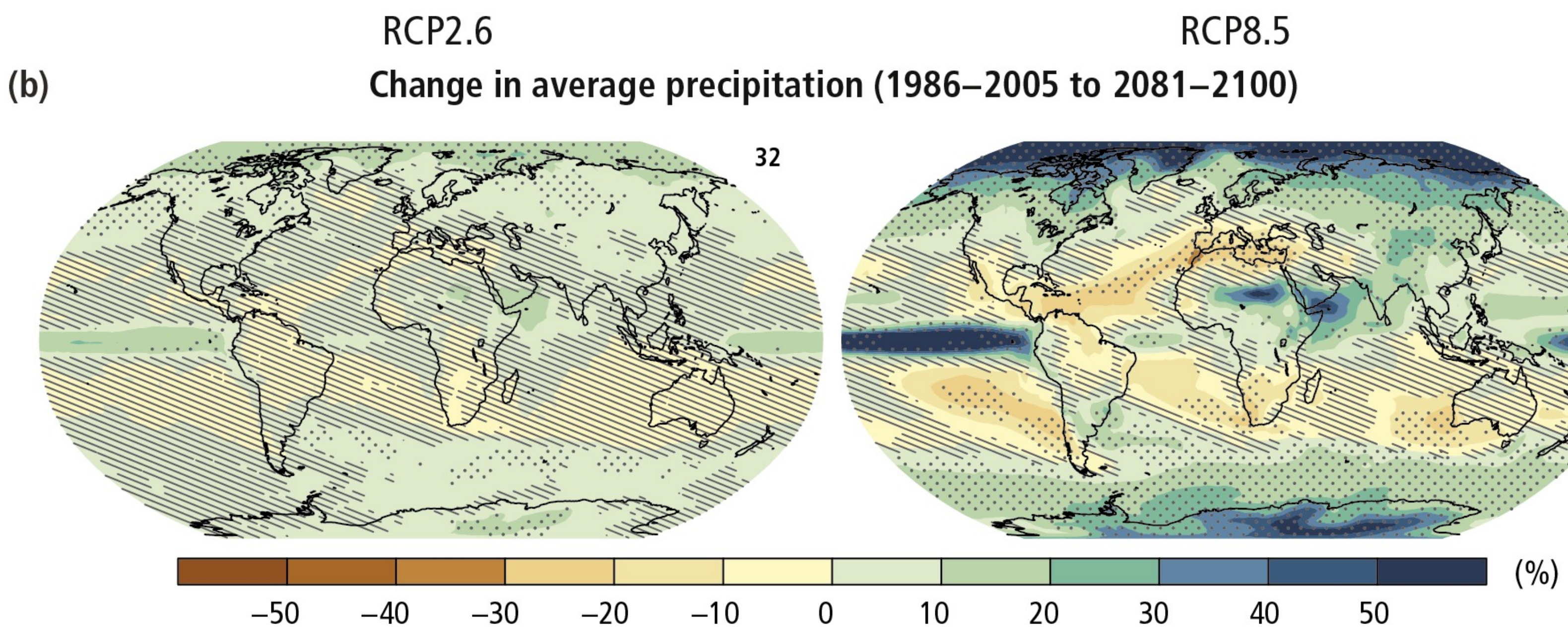

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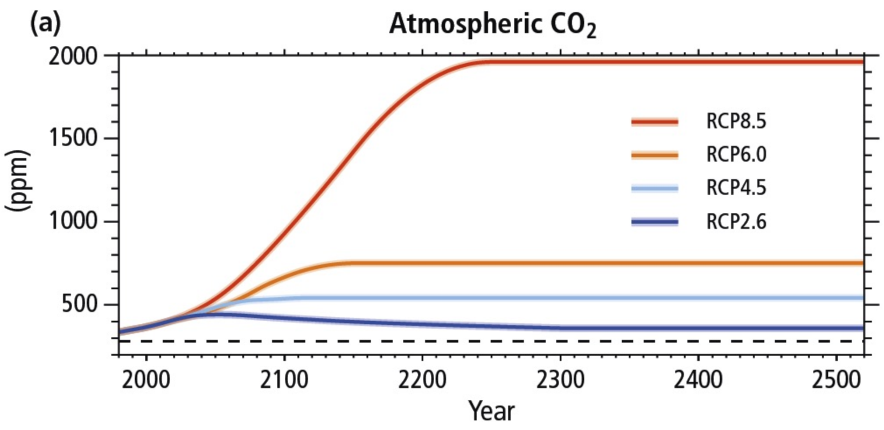

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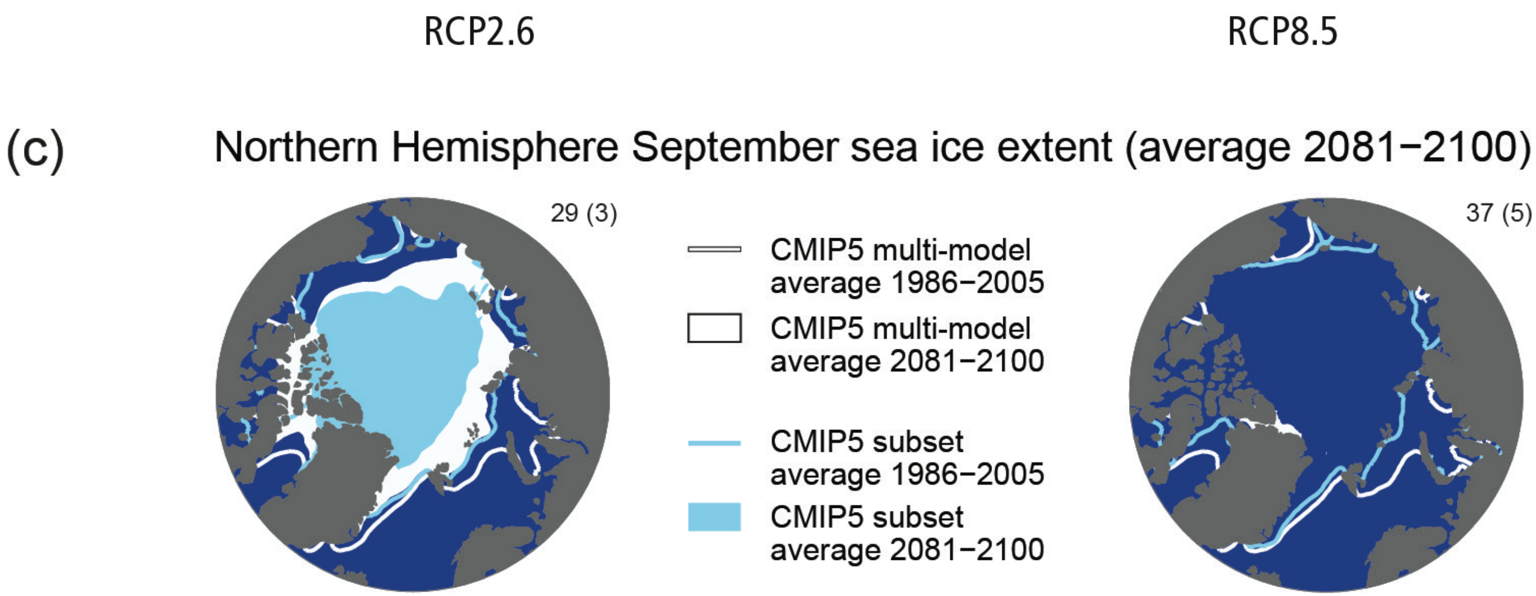
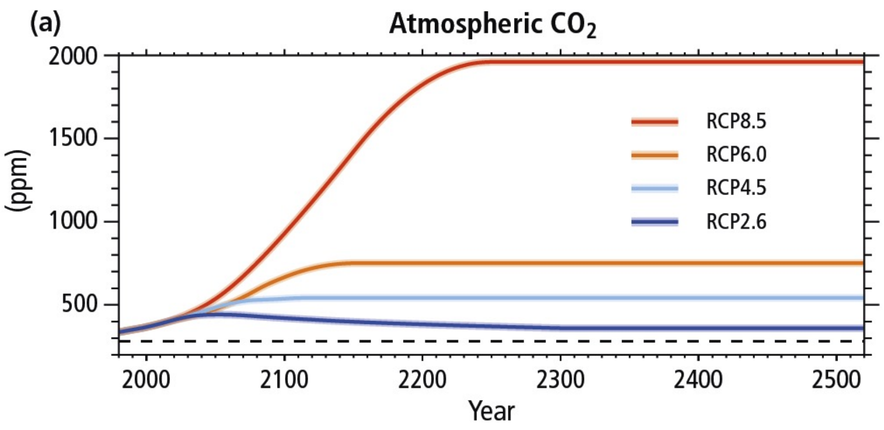


Projected Change in Artic sea ice extent

IPCC Assessment Report 5 - Projected Climate Change: precipitation



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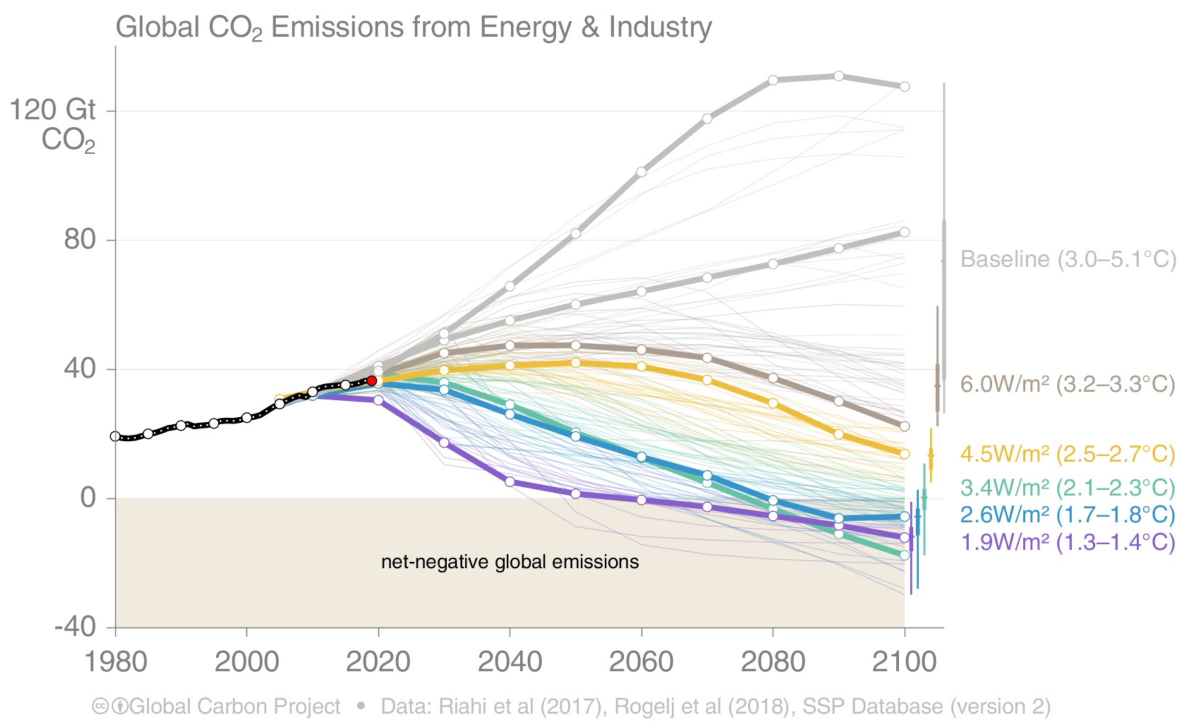
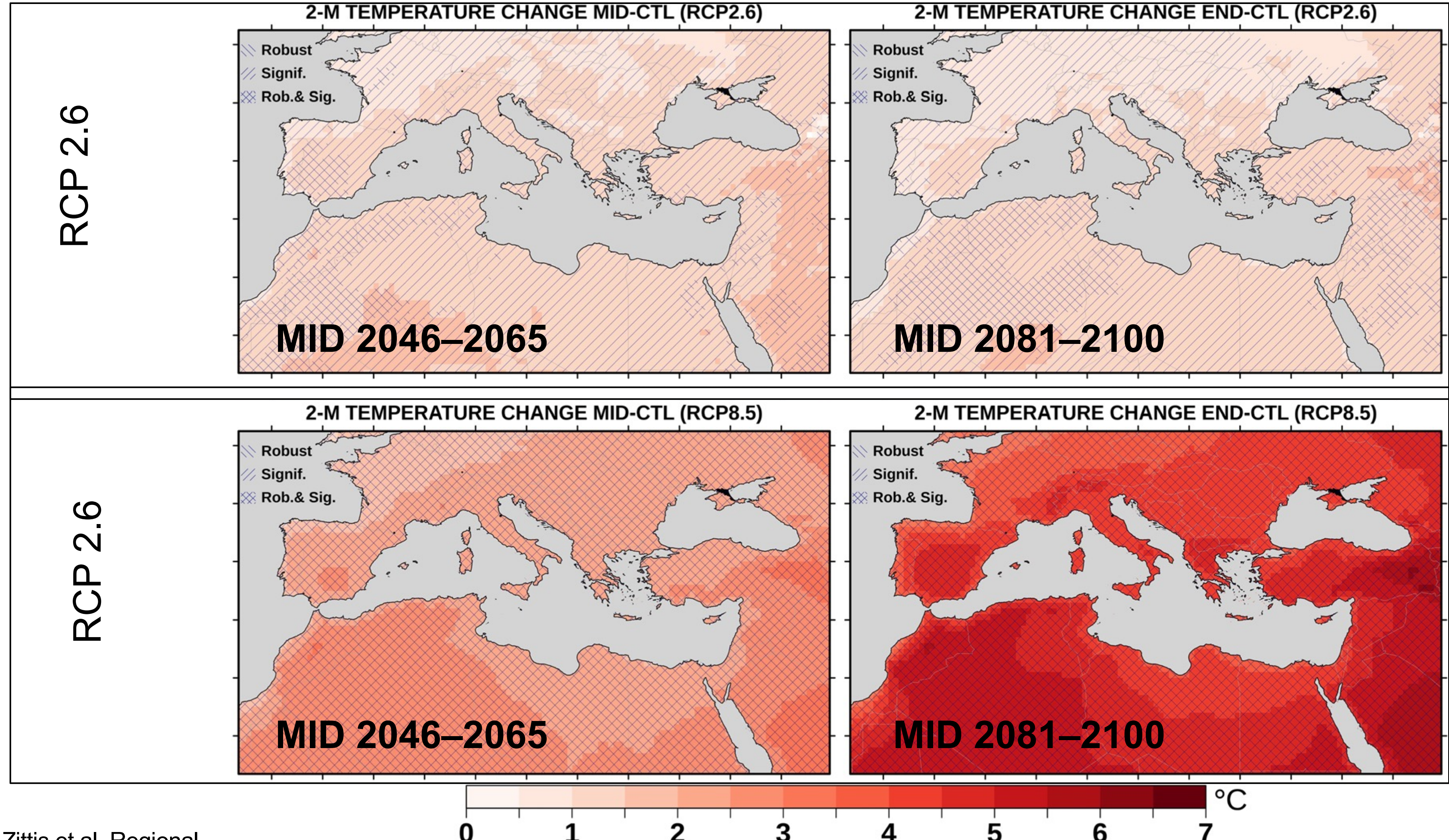


This set of quantified SSPs are based on the output of six Integrated Assessment Models (AIM/CGE, GCAM, IMAGE, MESSAGE, REMIND, WITCH). Net emissions include those from land-use change and bioenergy with CCS.
Source: Riahi et al. 2016; Rogelj et al. 2018; IIASA SSP Database; IAMC; Global Carbon Budget 2019

Future Mediterranean Surface Air Temperature



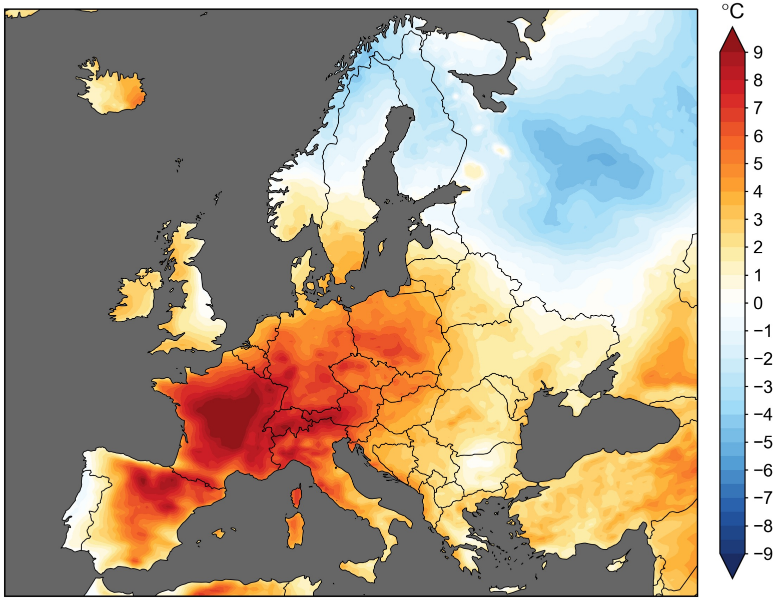
Zittis et al. Regional Environmental Change, 2019

Projected changes of **mean annual temperature** for mid (**MID 2046–2065**) and end (**END 2081– 2100**) of twenty-first century with respect to the reference period (CTL 1986–2005), for three RCP pathways (**RCP2.6**: top row, **RCP8.5**: bottom row). Robustness and significance are indicated c

Future (2100) Mediterranean Surface Air Temperature

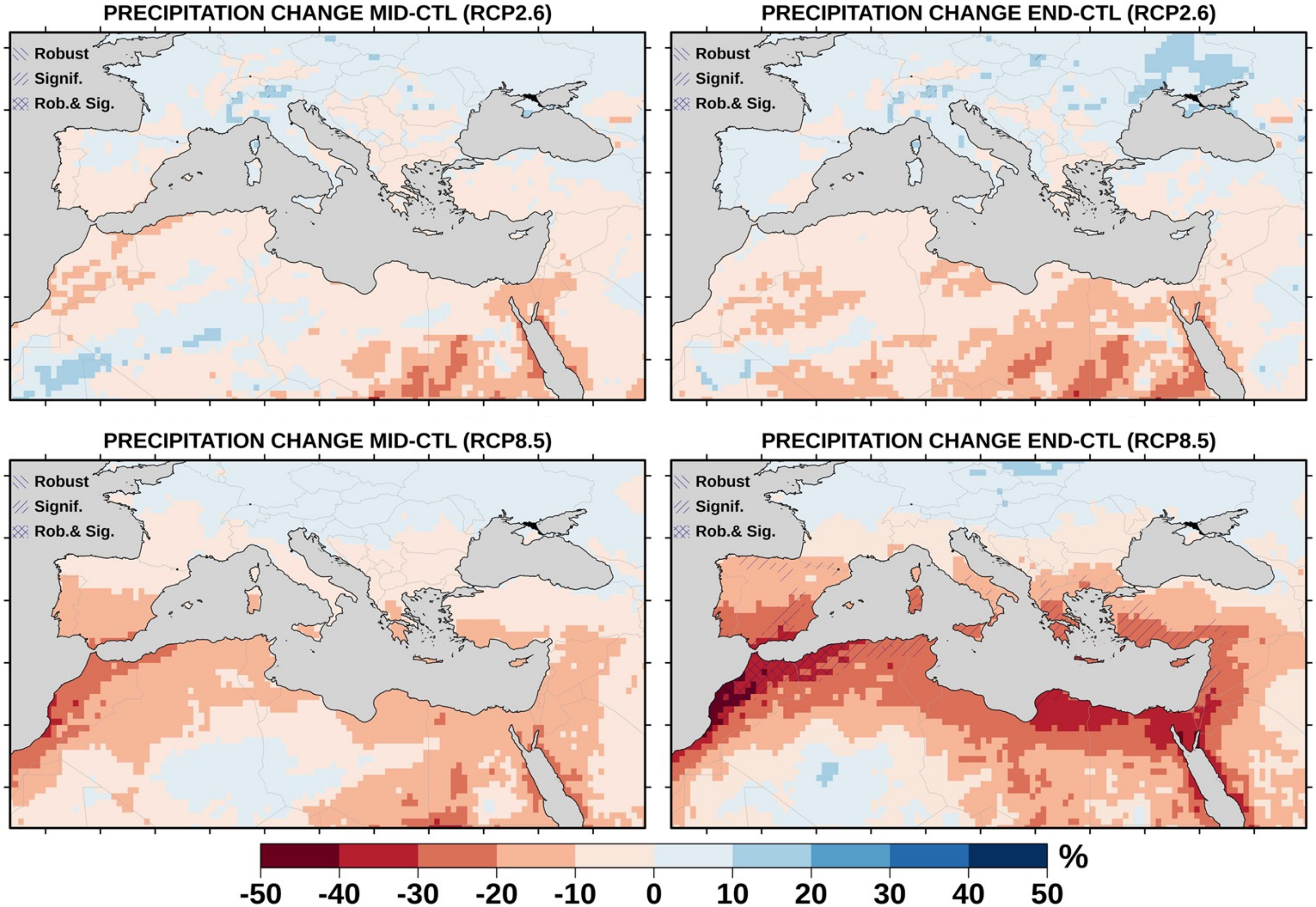
Summers will likely warm more than winters. High temperature events and **heat waves** (periods of excessively hot weather) are likely to become more frequent and/or **more extreme**.

Average 2m temperature anomaly for 25-29 June 2019



European Commission · Copernicus Europe's eyes on Earth · Climate Change Service climate.copernicus.eu · IMPLEMENTED BY ECMWF

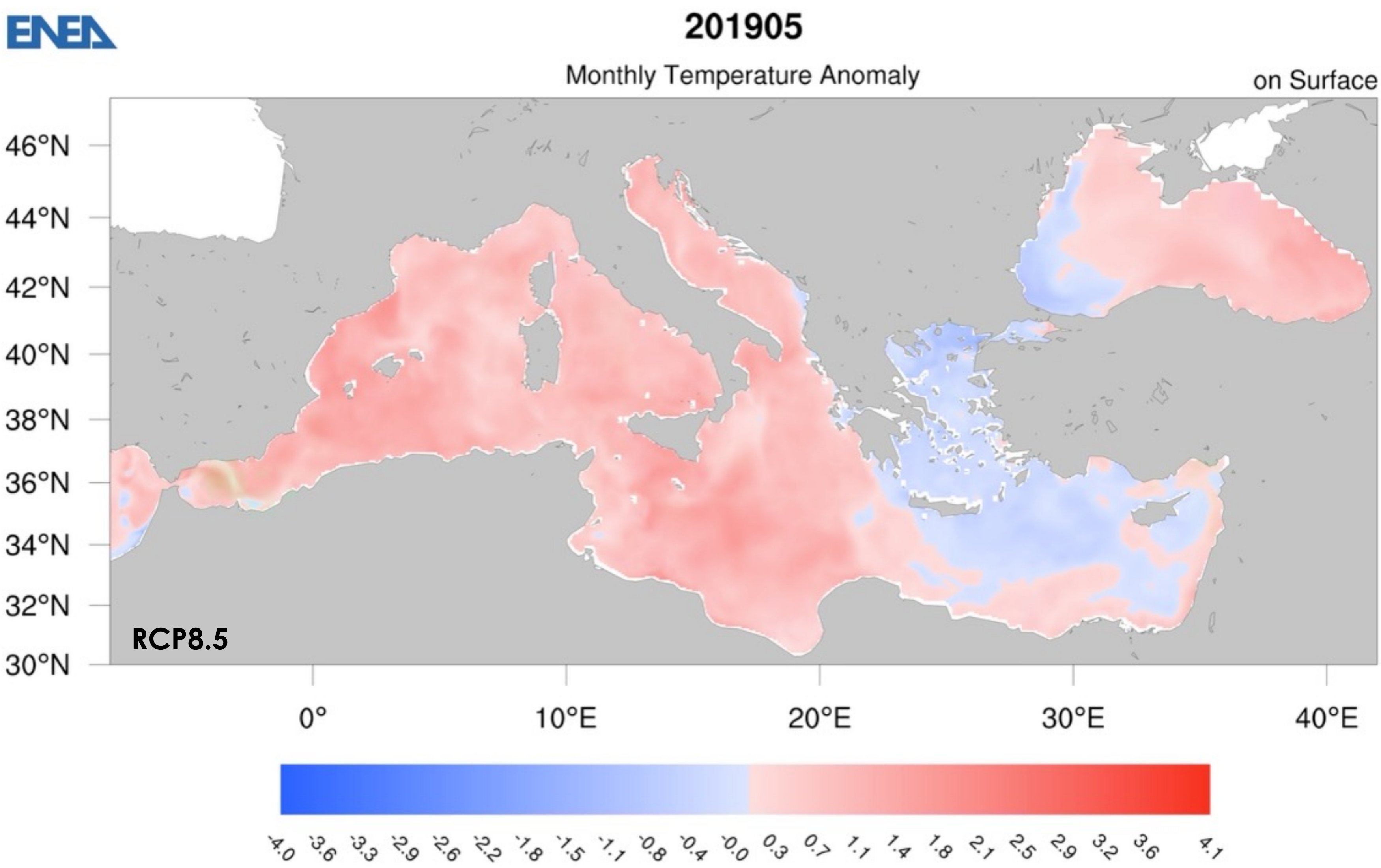
Future Mediterranean Precipitation



Zittis et al. Regional Environmental Change, 2019

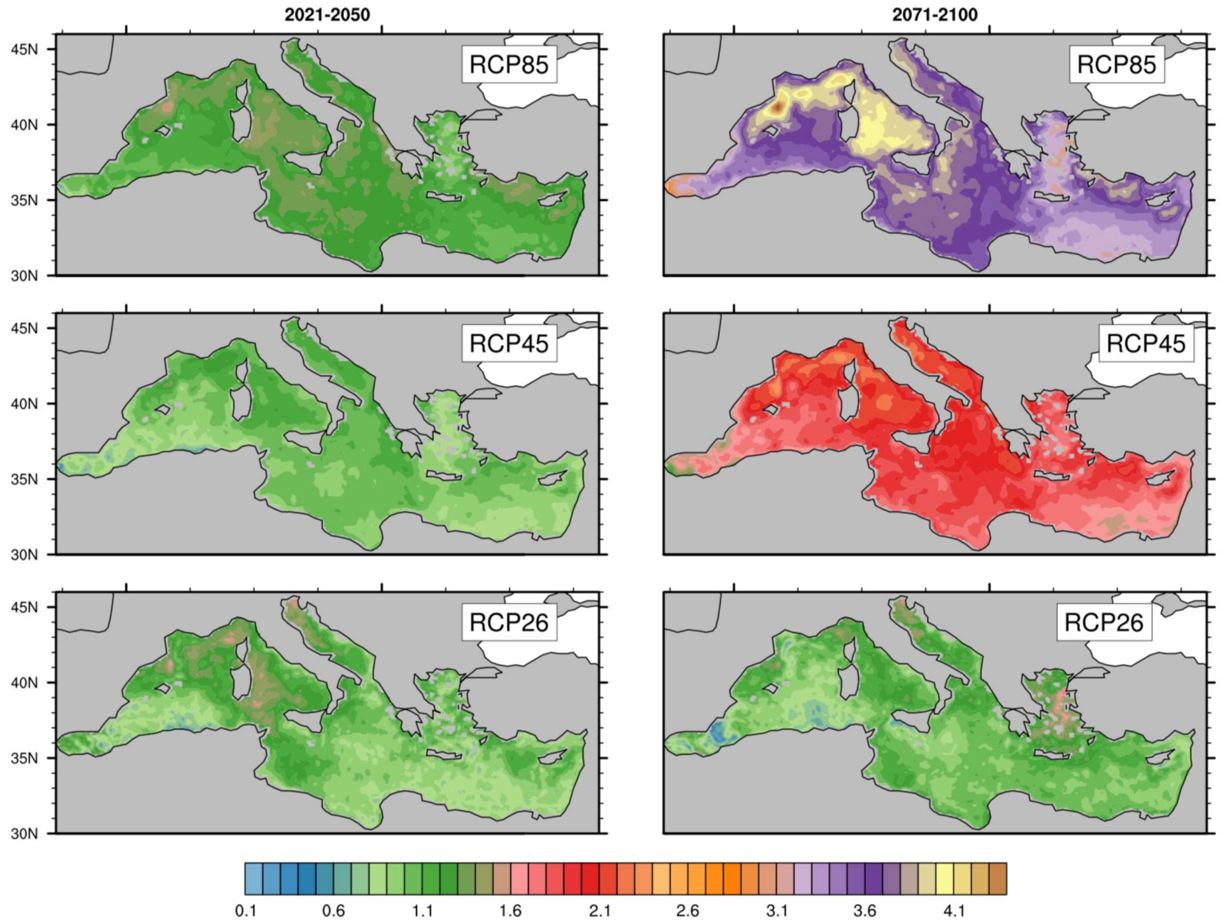
Projected changes of **mean annual precipitation** for mid (**MID 2046–2065**) and end (**END 2081– 2100**) of twenty-first century with respect to the reference period (CTL 1986–2005), for three RCP pathways (**RCP2.6**: top row, **RCP8.5**: bottom row). Robustness and significance are indicated c

Future (2100) Mediterranean Heat Waves



Future (2100) Mediterranean Heat Waves

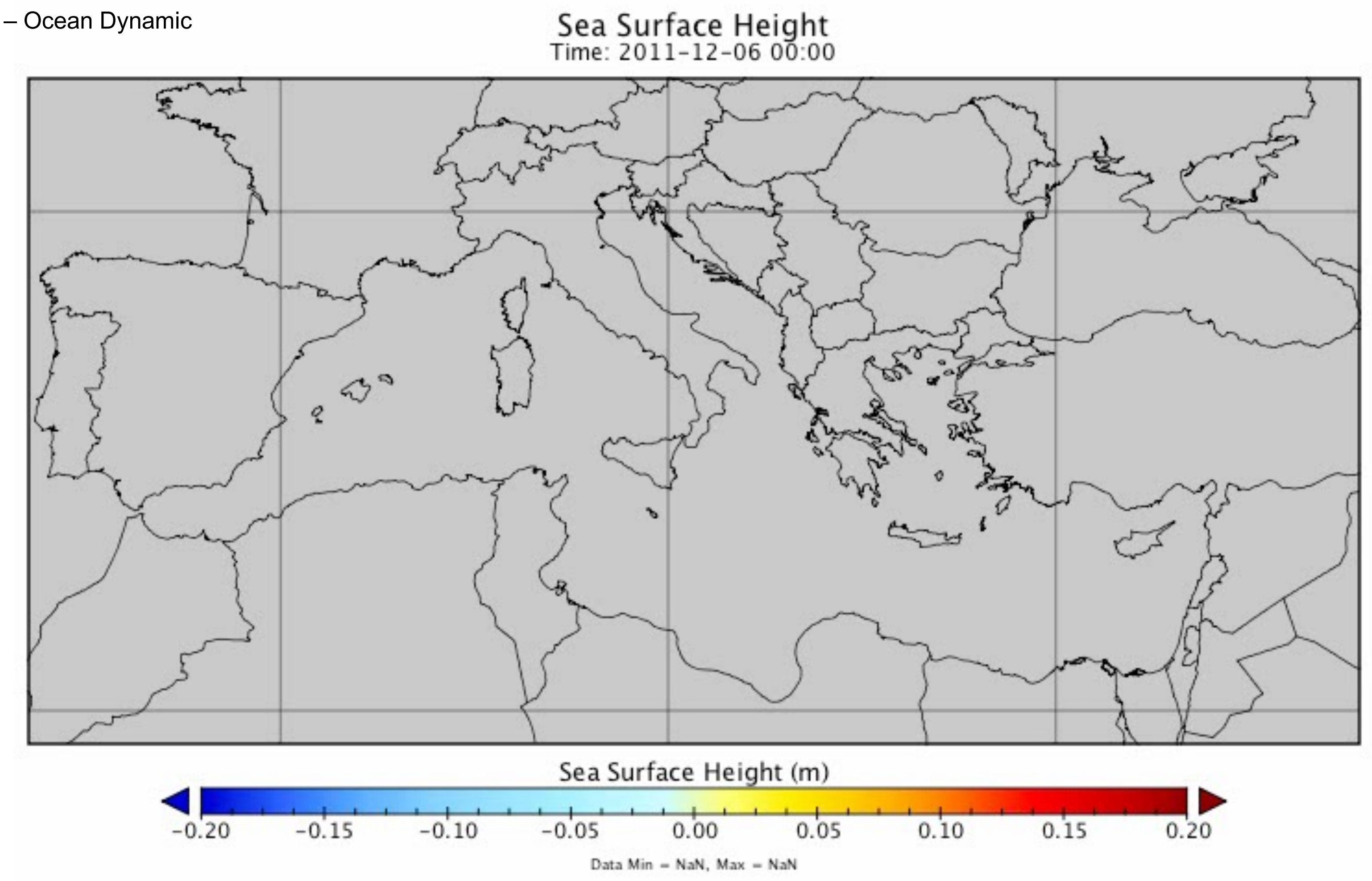
Multi-model average anomaly of extreme *SST99Q* (° C) with respect to corresponding ensemble mean HIST (**1976-2005**) of each scenario, for the near and far future. The RCP2.6 scenario has only one simulation (CNRM) . Darmaraki et al. 2019



In response to increasing green-house gas forcing, the HW events become stronger and more intense. By 2100 and under RCP8.5, simulations project at least **one long-lasting MHW every year**, up to three months longer, about **4 times** more intense than present-day events. They are expected to occur from June-October and to affect at peak the entire basin.

ENEA Climate Model

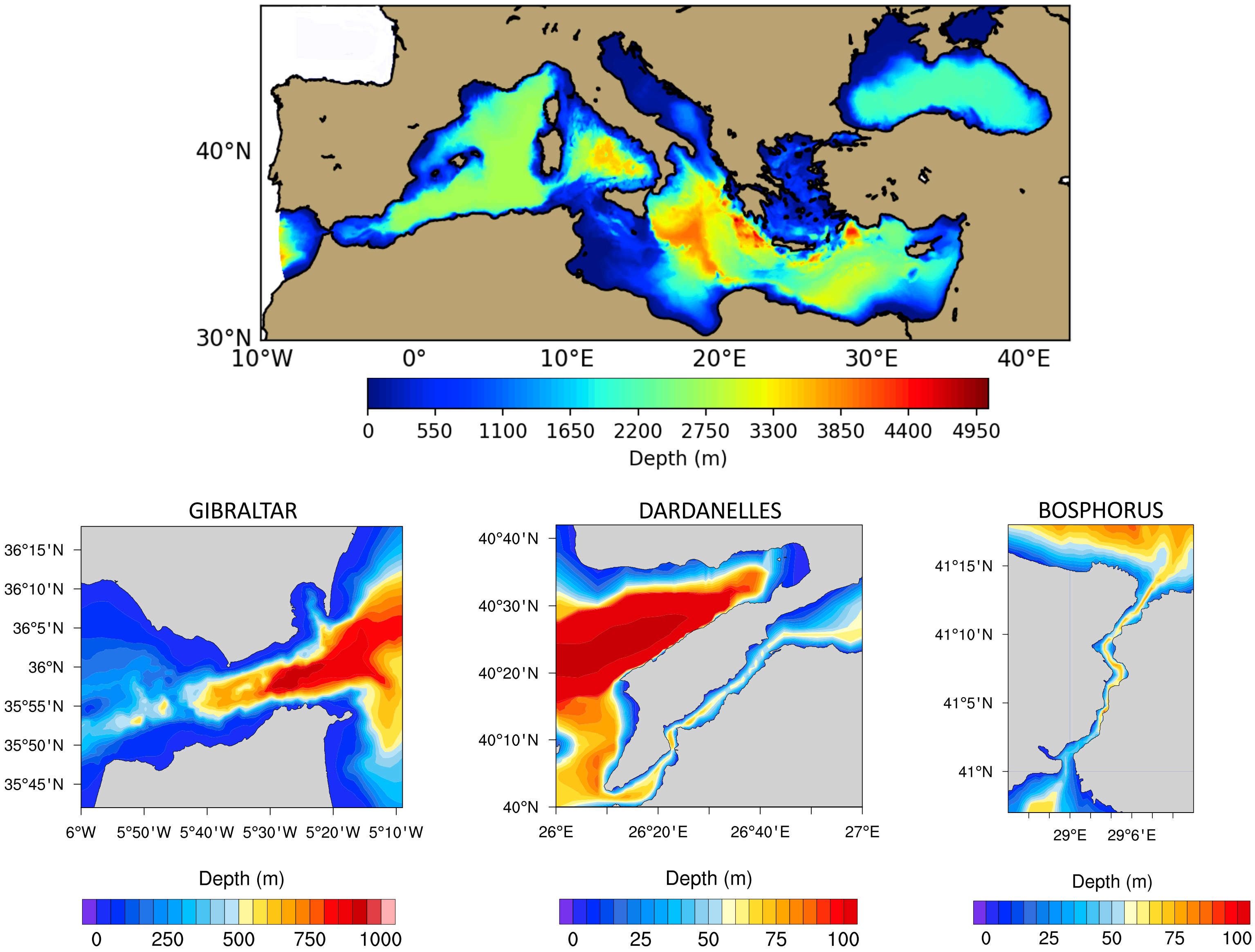
Palma et al 2019 – Ocean Dynamic



MITgcm – Explicit Tides (M2,S2, K1, O1) – Lateral Tide + Tidal Potential
Average resolution 1/16° (7 Km)
Minimum resolution at Gibraltar (230m) and Turkish Straits (90m)
100 Vertical Levels

ENEA

ENEA Climate Model



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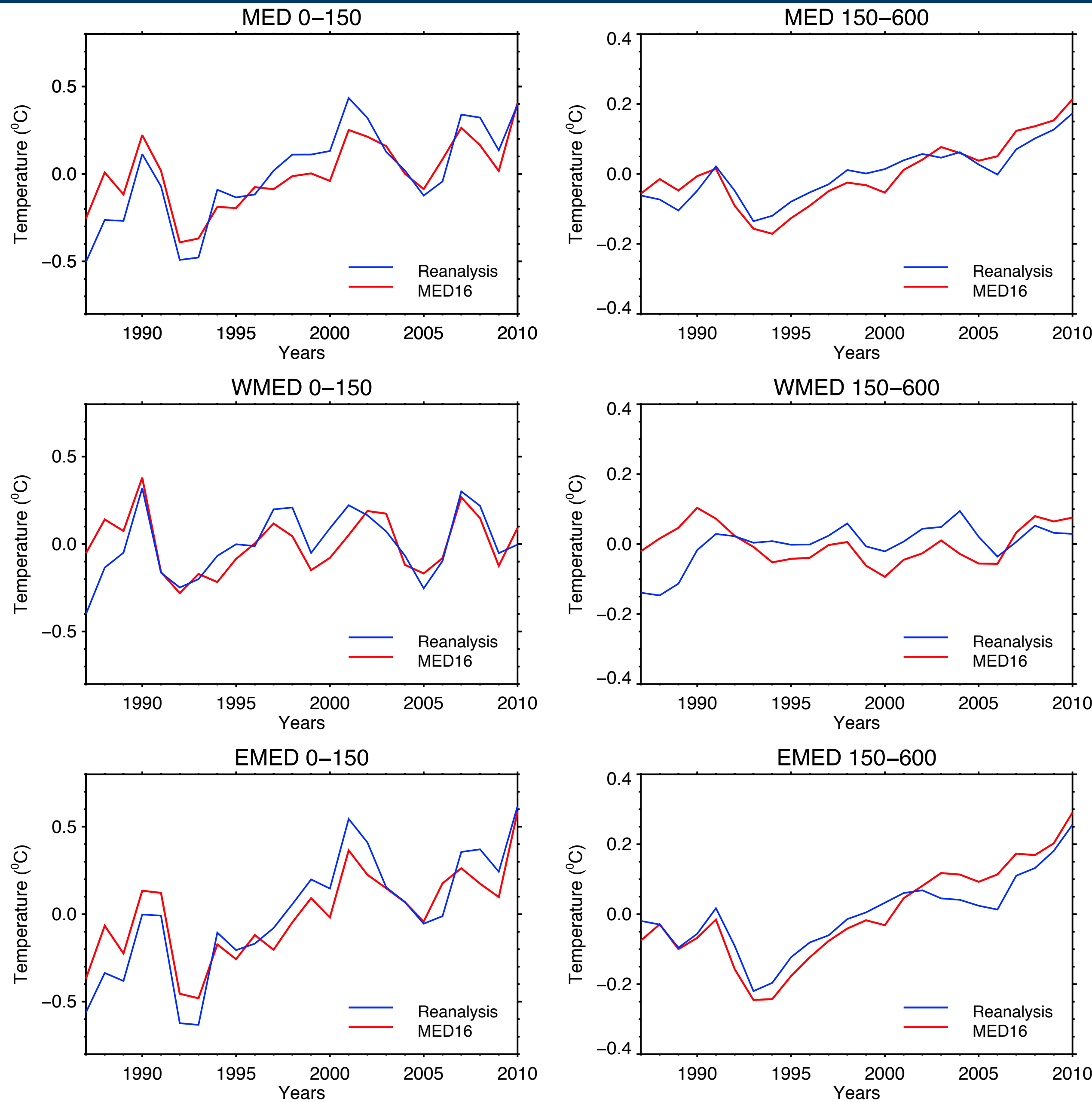
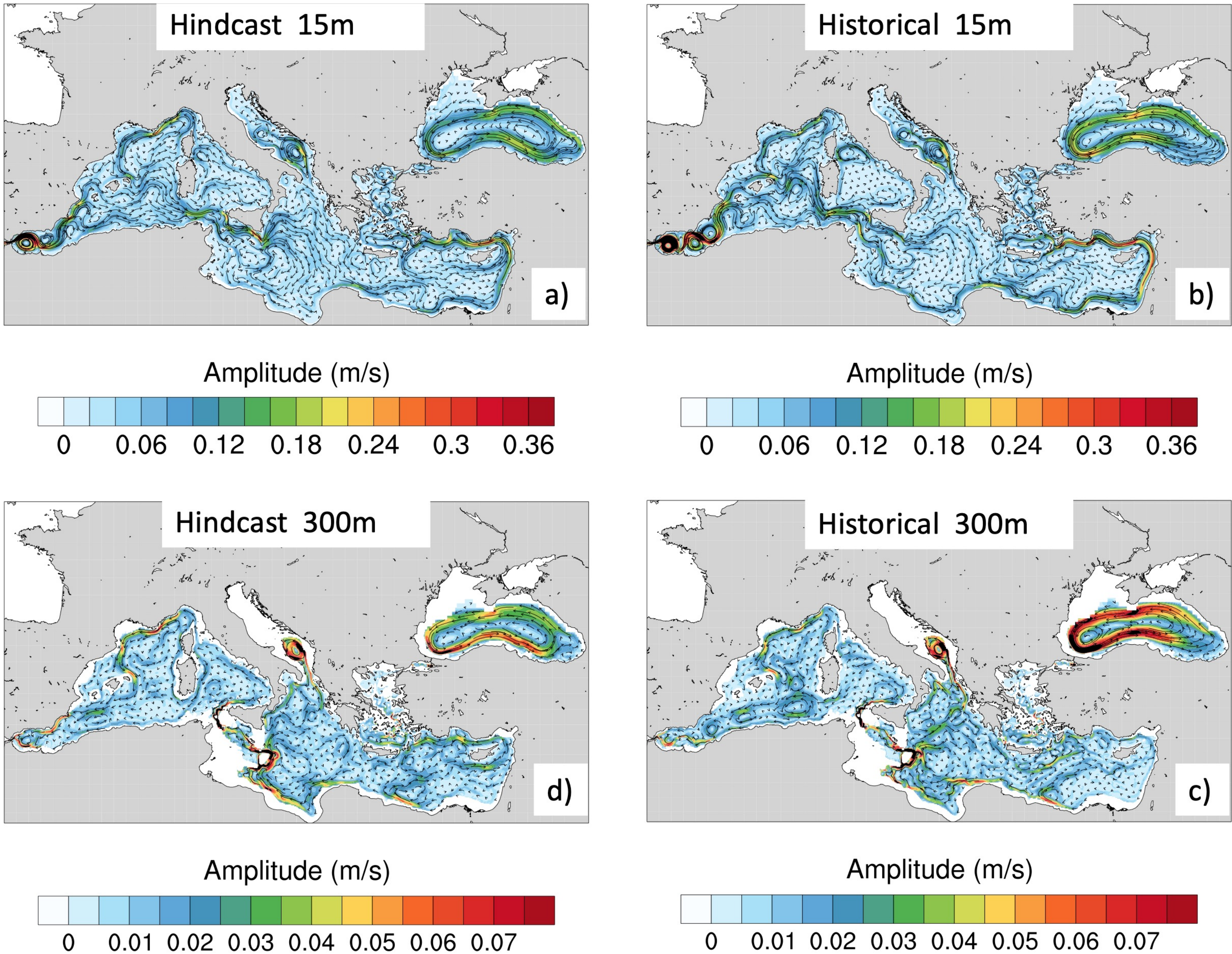
ENEA Climate Model

Reanalysis (blue) and hindcast (red) time series of temperature anomalies (° C ; annual values) for the upper (0-150 m) and intermediate (150-600 m) layers, for the Mediterranean Sea, and the western and eastern sub-basins



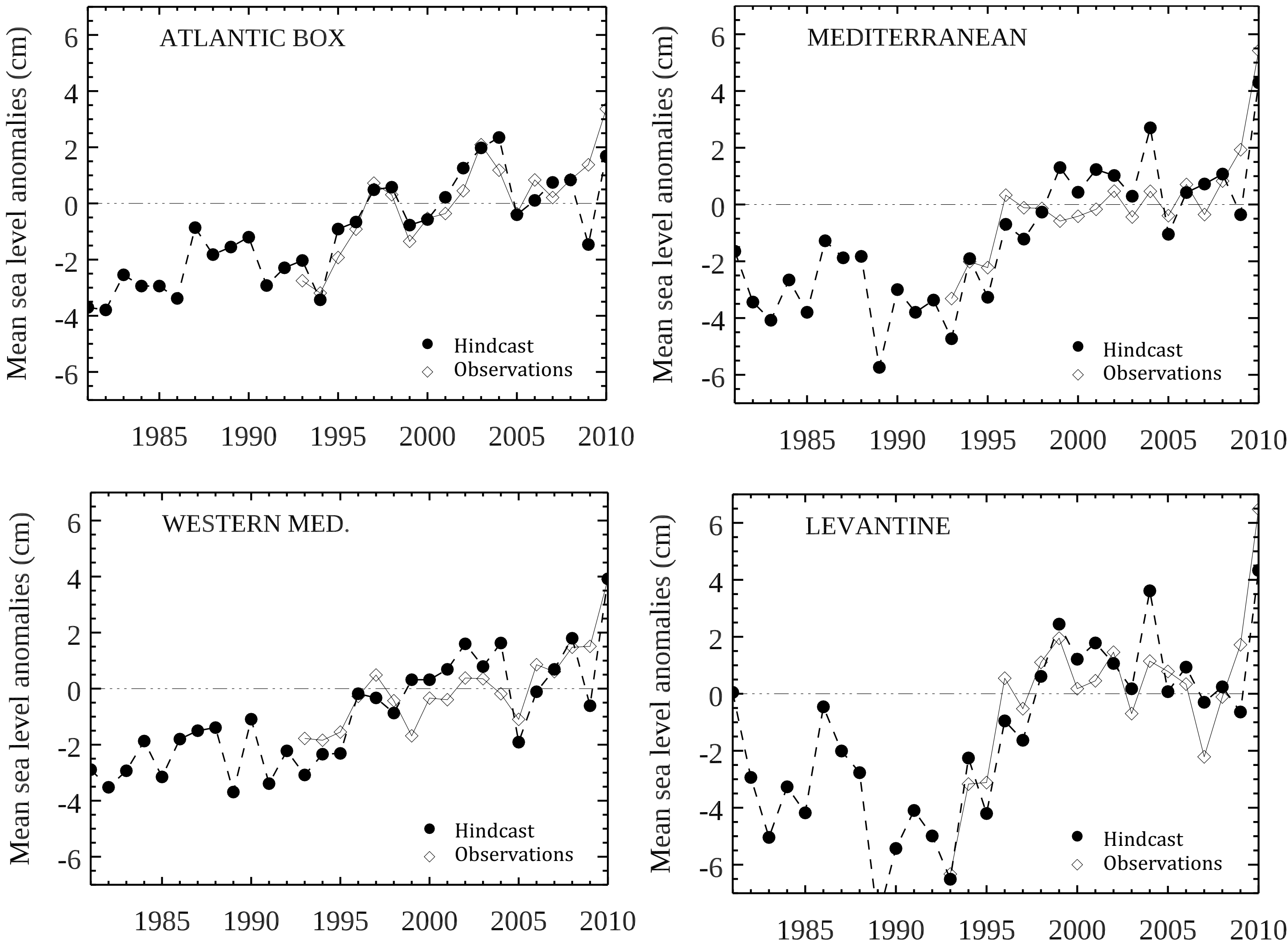
ENEA Climate Model

Surface (15 m of depth) and intermediate (300 m of depth) circulation, averaged over the simulation periods of the hindcast (left panel) and of the historical (right panel) experiments



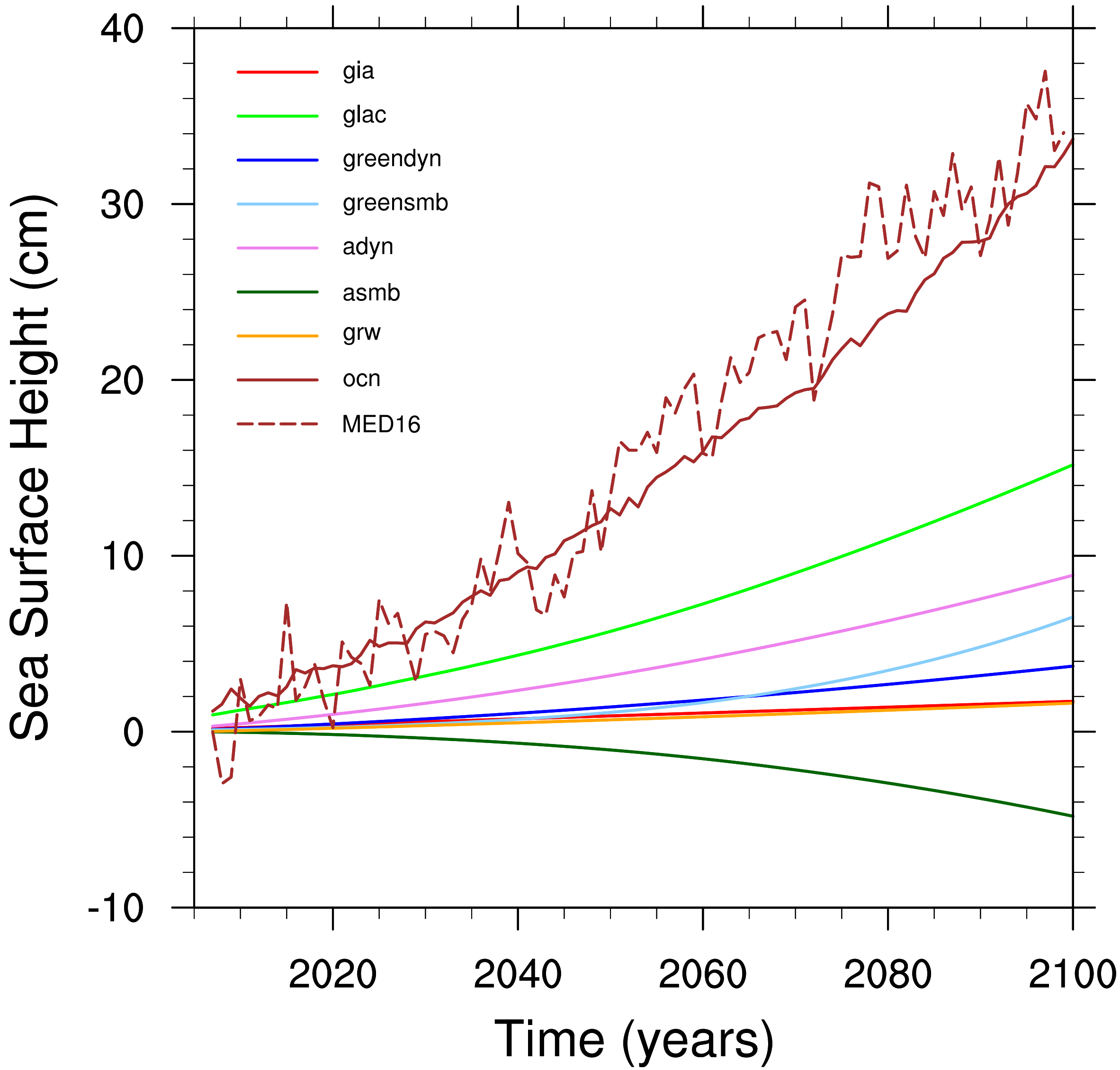
Future (2100) Mediterranean Sea Level

Interannual variability of the sea-level anomaly in different basins: whole Mediterranean (panel a), western and eastern sub-basins (panels b-c). Black dots denote values computed from the hindcast simulation, and diamonds those from the observations



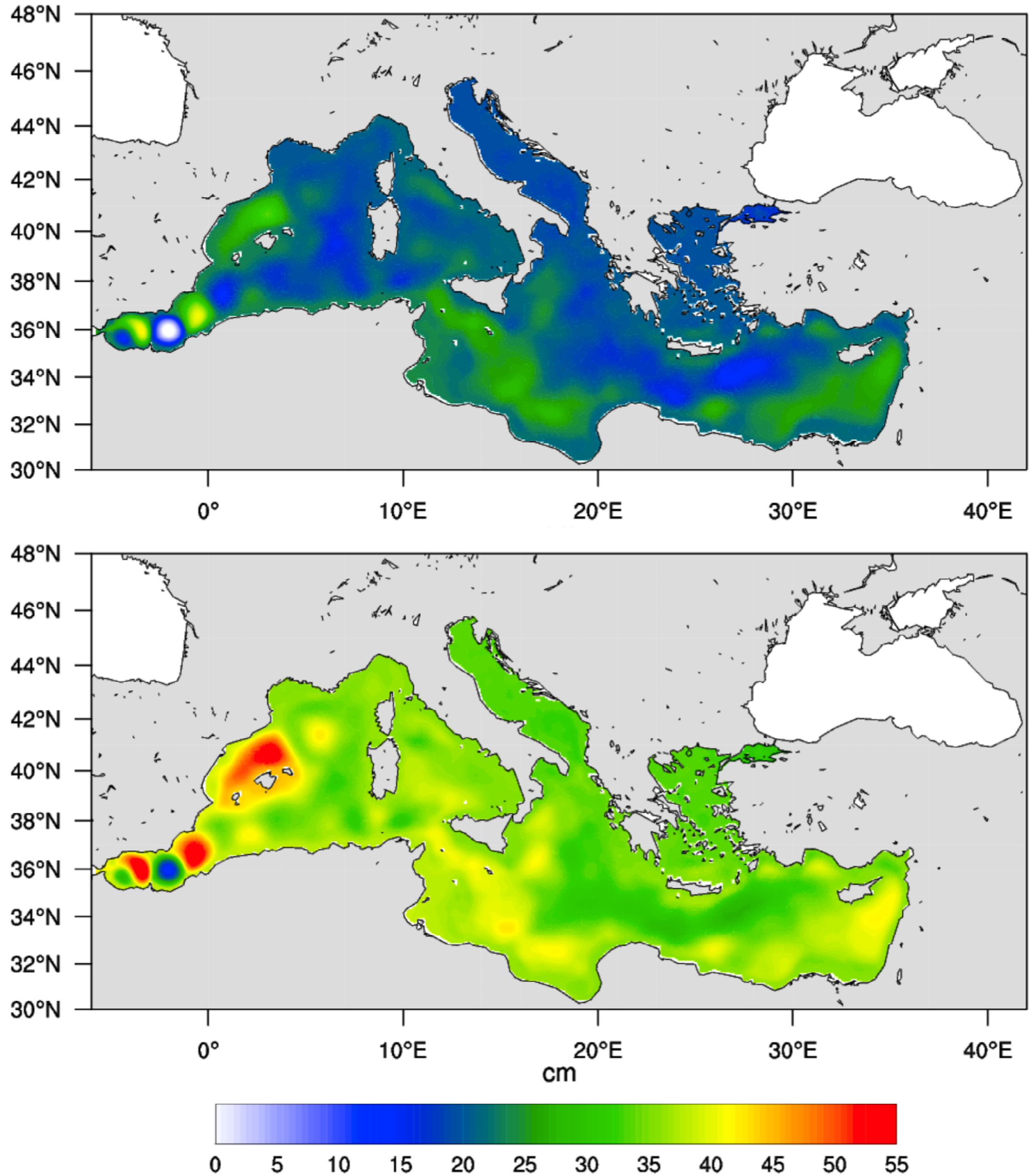
Future (2100) Mediterranean Sea Level

Time evolution of the components contributing to the projected mean sea level in the Mediterranean under the RCP8.5. Solid lines represent the central estimate over available models



Future (2100) Mediterranean Sea Level

Difference in the MED16 sterodynamic SLC computed over the period 2046-2065 (upper panel) and over the period 2080-2099 (lower panel) relative to the historical period. (scenario rcp 8.5).



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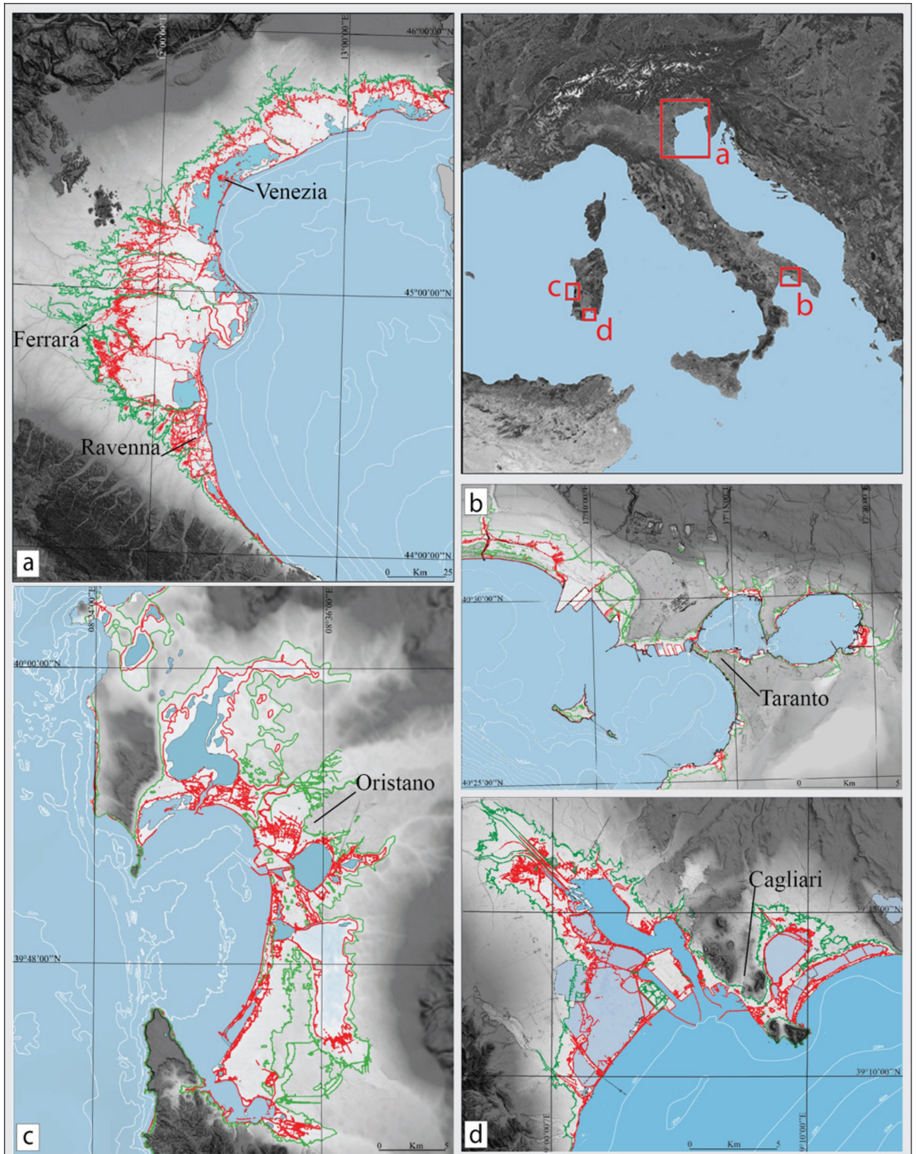
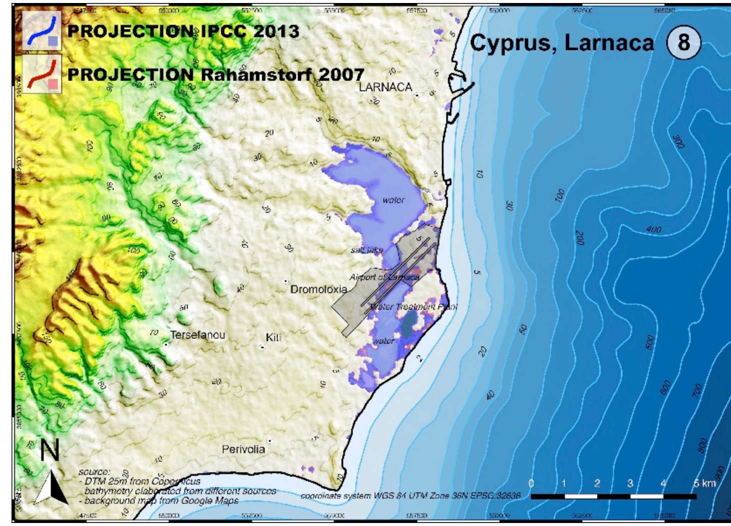
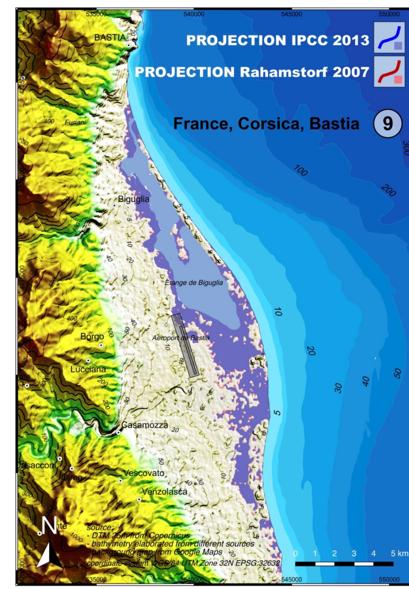
Future (2100) Mediterranean Sea Level







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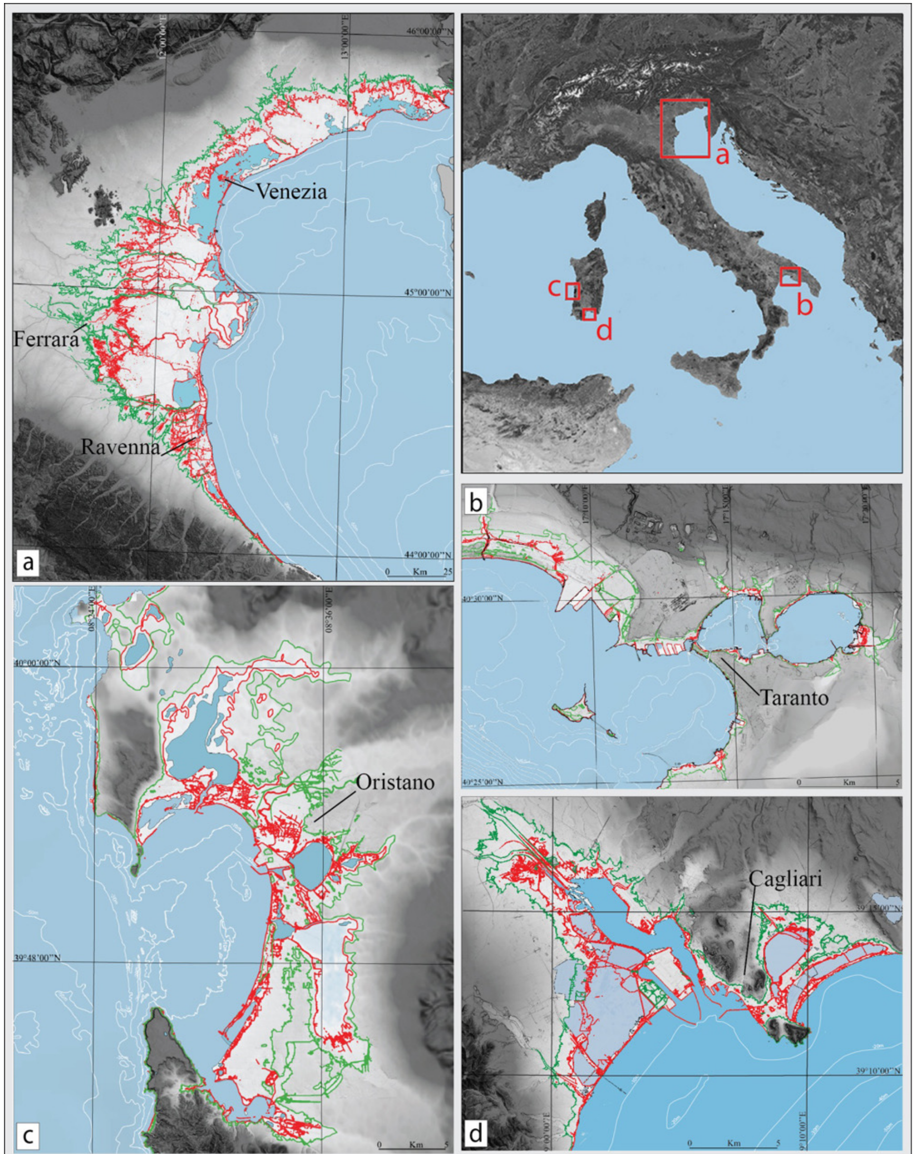
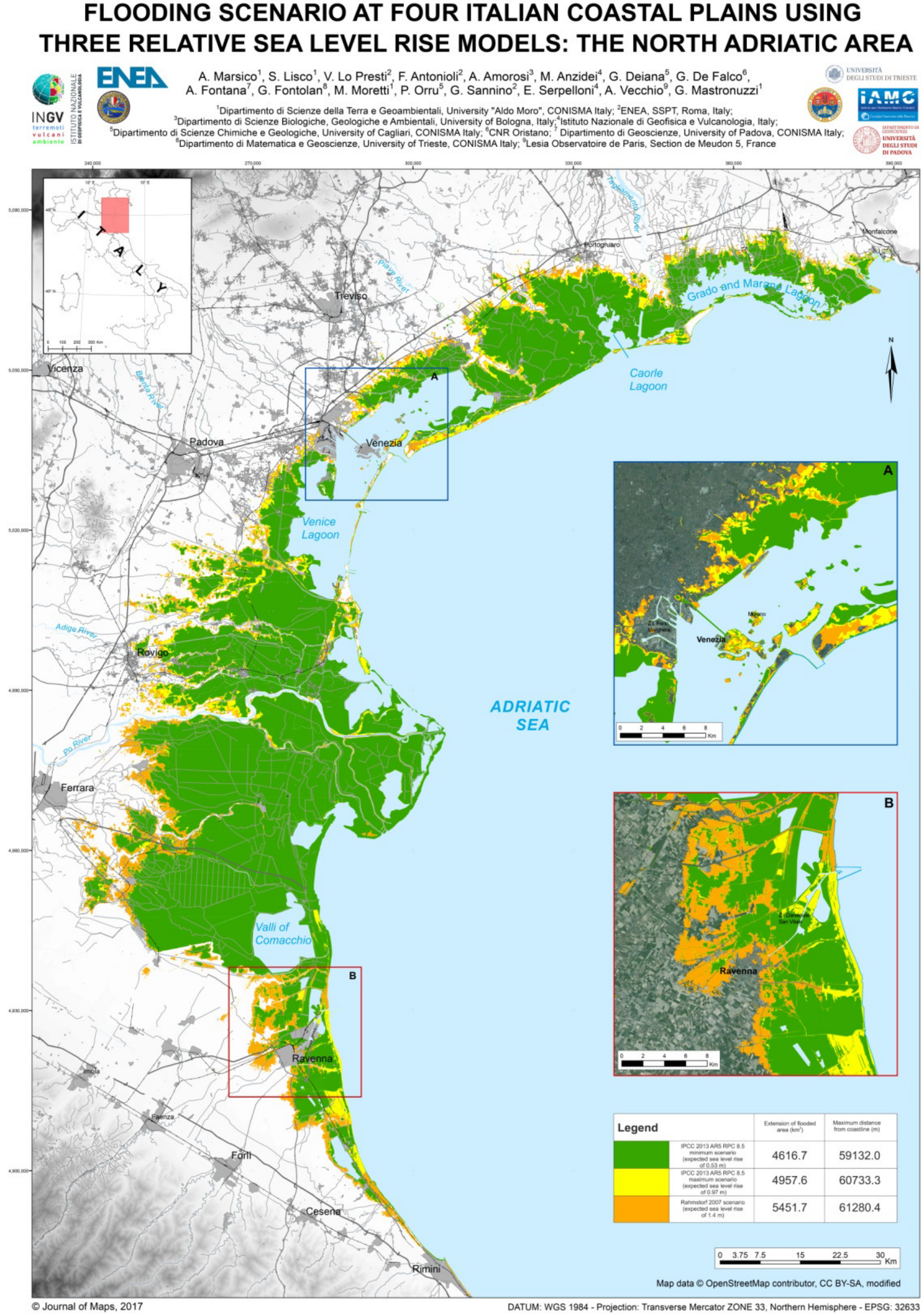


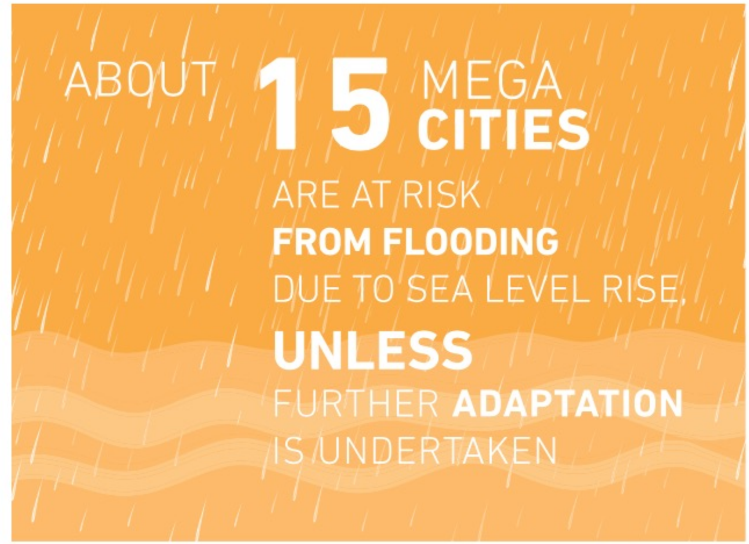
ABOUT **15** MEGA **CITIES** ARE AT RISK **FROM FLOODING** DUE TO SEA LEVEL RISE, **UNLESS** FURTHER **ADAPTATION** IS UNDERTAKEN

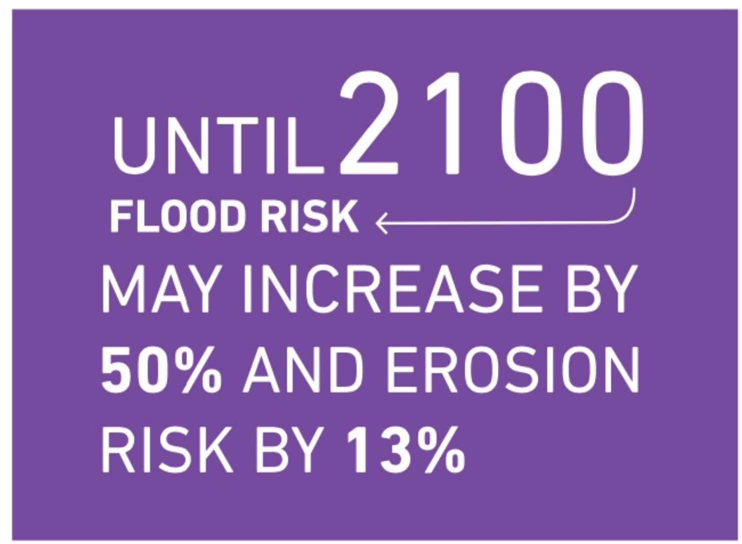
UNTIL 2100 **FLOOD RISK** MAY INCREASE BY **50%** AND EROSION RISK BY **13%**

ENEA

Future (2100) Mediterranean Sea Level rcp 8.5







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