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The plausible future climates: from the global to the city scale

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GEOSUSTAINED

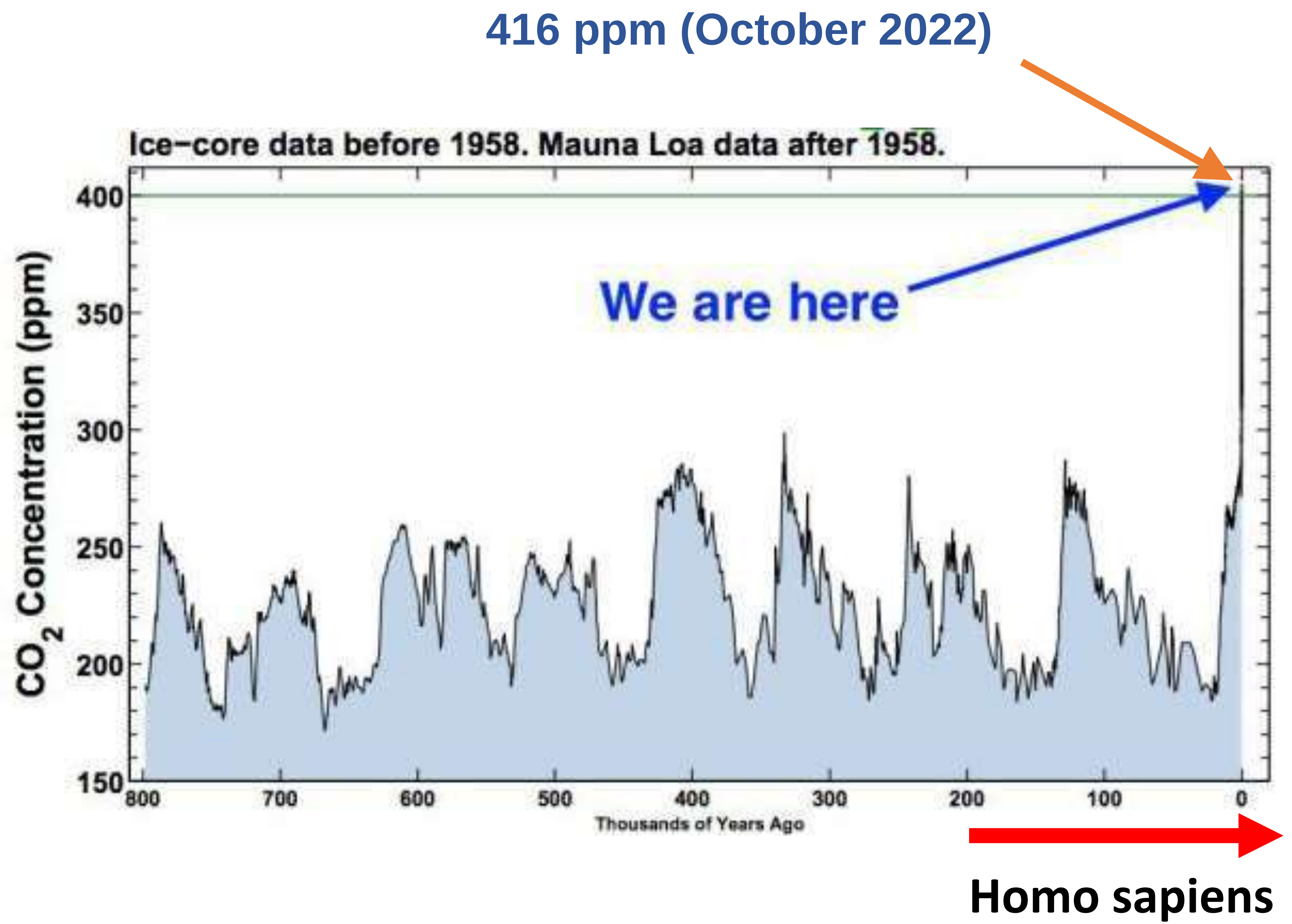
GEOTERMIA SUPERFICIAL

Perspetivas de aplicação em contexto urbano

06.12.2022

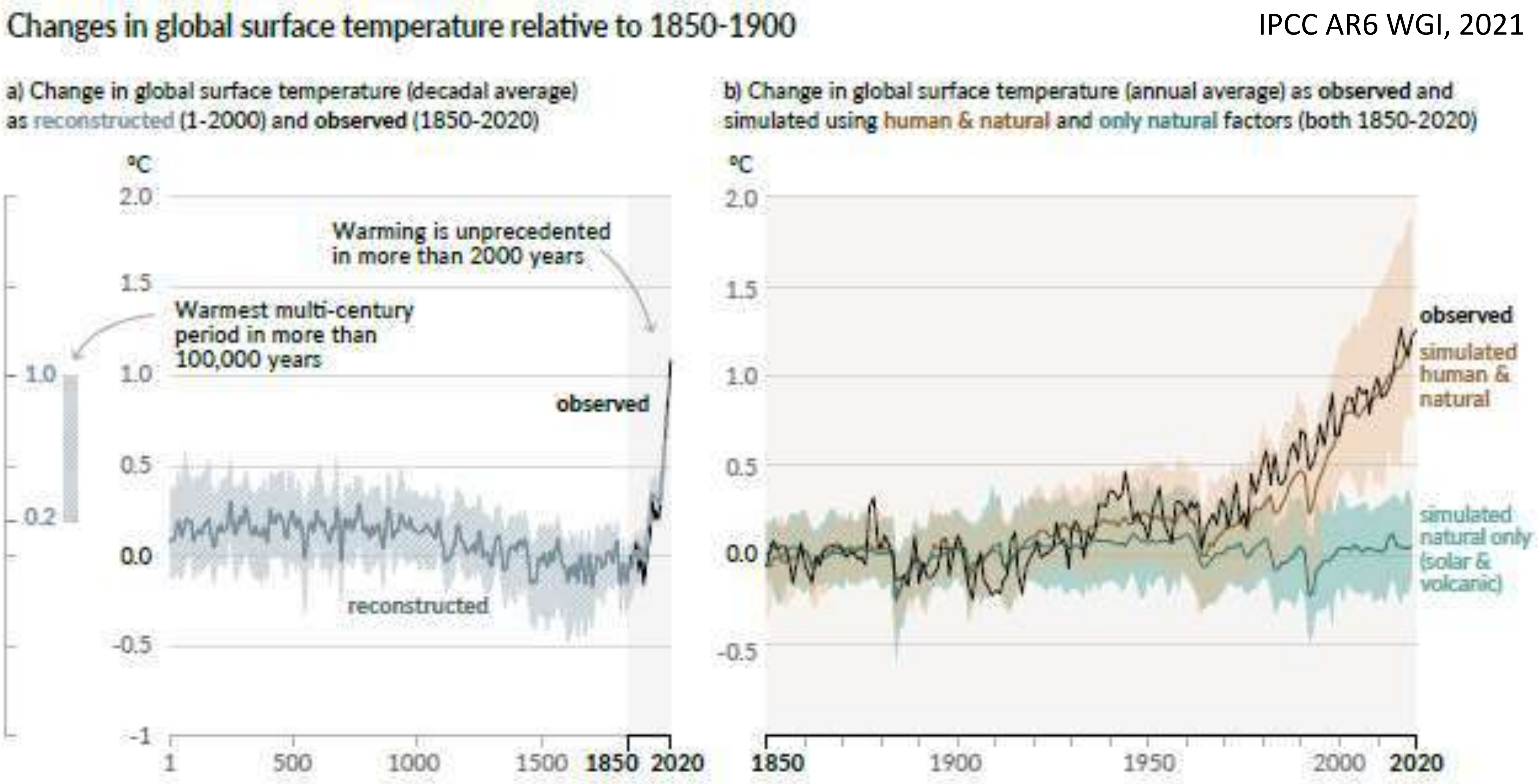
The world we live

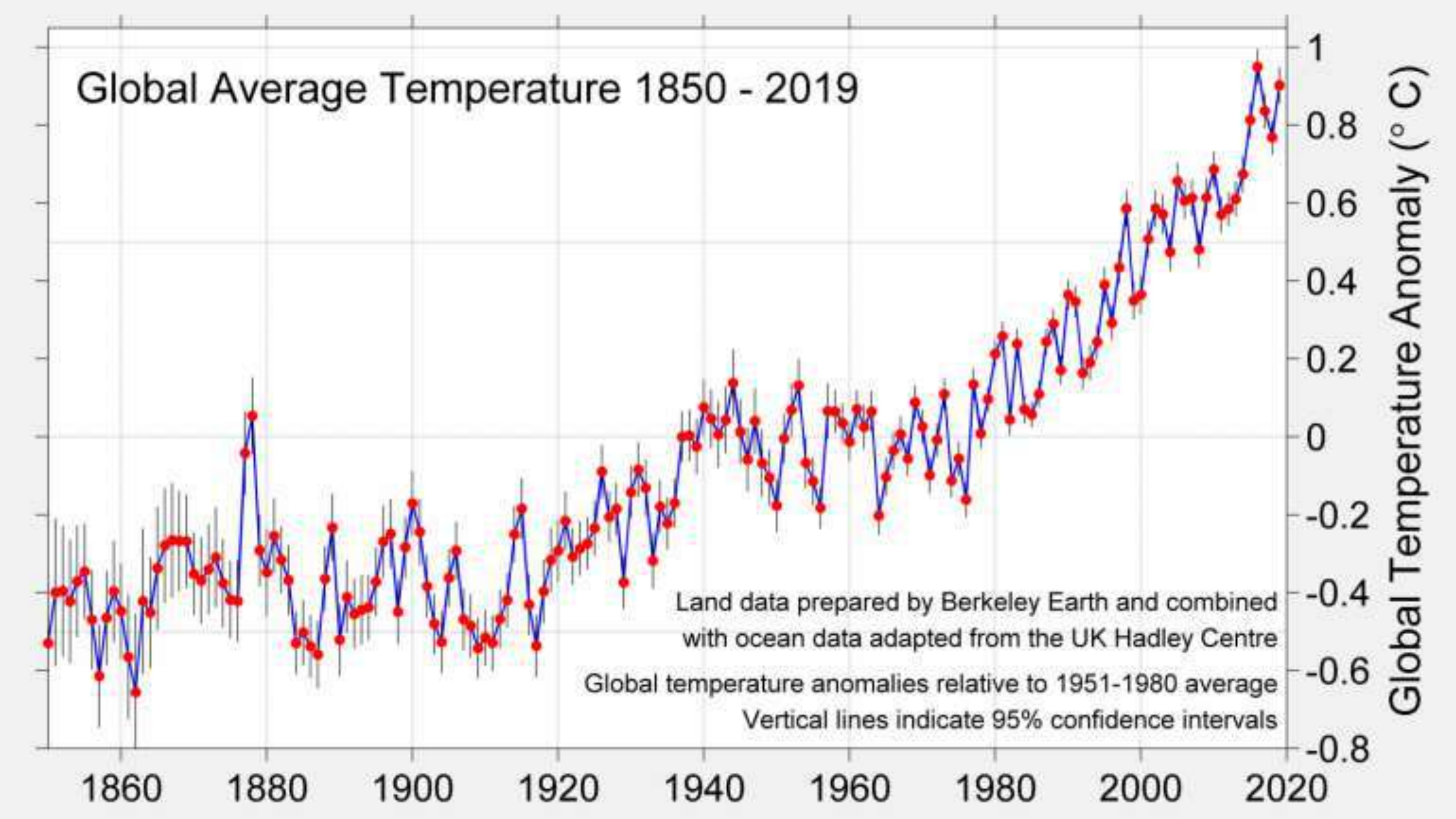
all impacting negatively natural and cultural sites

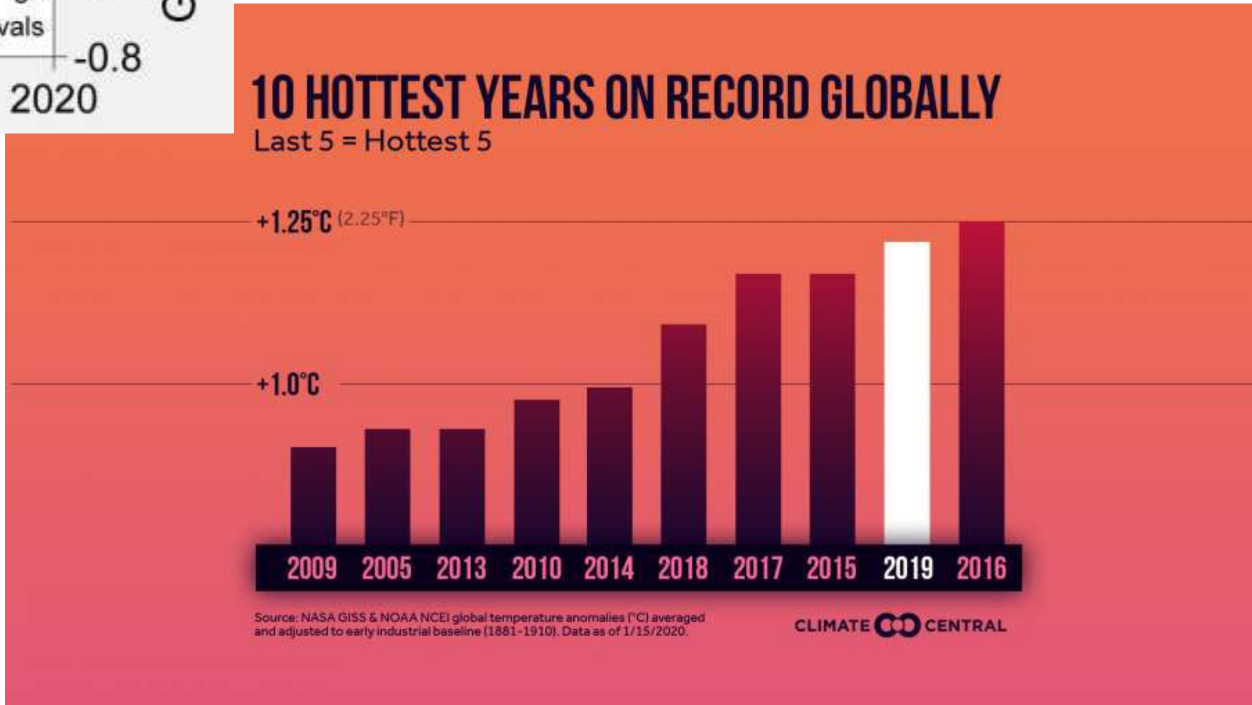

416 ppm (October 2022)
Ice−core data before 1958. Mauna Loa data after 1958.
We are here
CO_2 Concentration (ppm)
400
350
300
250
200
150
800
700
600
500
400
300
200
100
0
Thousands of Years Ago
Homo sapiens

Human influence has warmed the climate at an unprecedented rate in at least the last 2000y

IPCC AR6 WGI, 2021



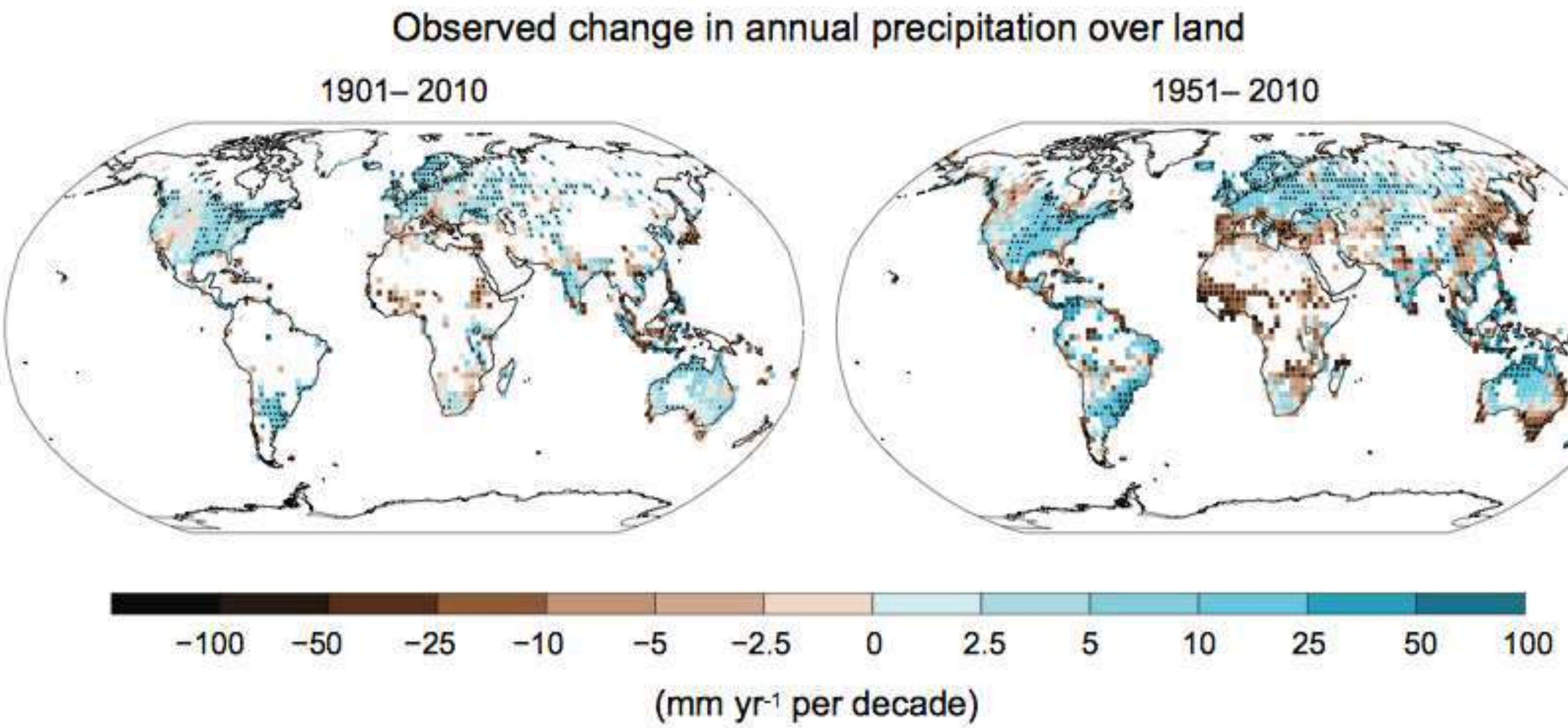




the 19 warmest years occurred since 2000!

Precipitation

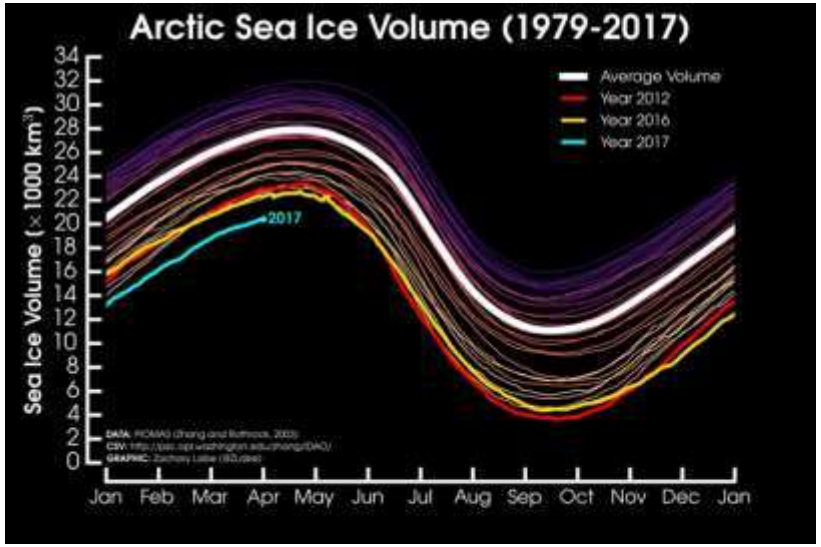
IPCC - 2013



Extremes

- More land regions where heavy precipitation has increased than where it has decreased.
- The frequency or intensity of heavy precipitation has likely increased in North America and Europe.

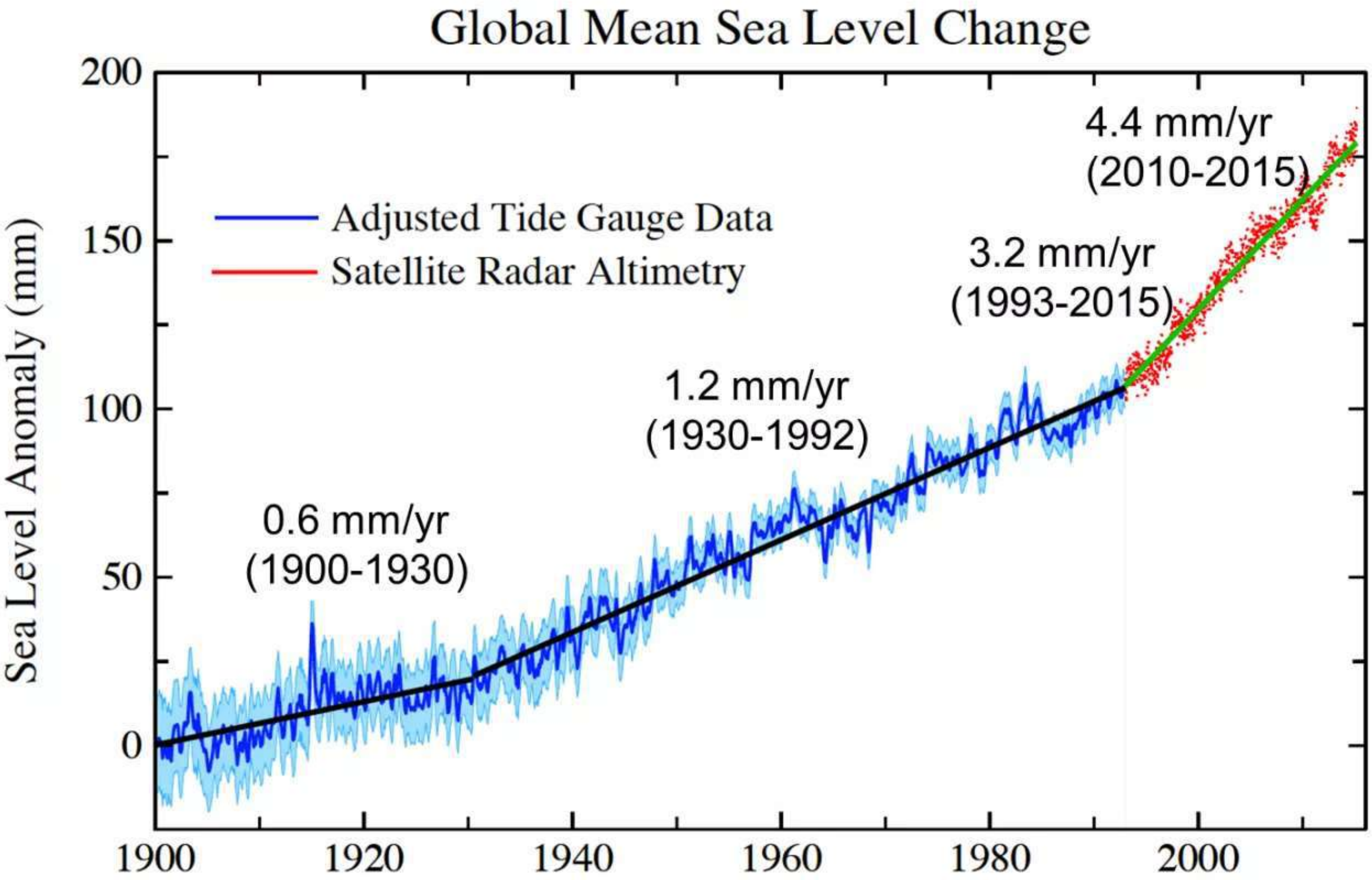
Ice melting



Since 1979, the volume of Summer Arctic Sea Ice has declined by more than 80% and is accelerating…

National Snow and Ice Data Center

waming (expation) + melting = sea level rise

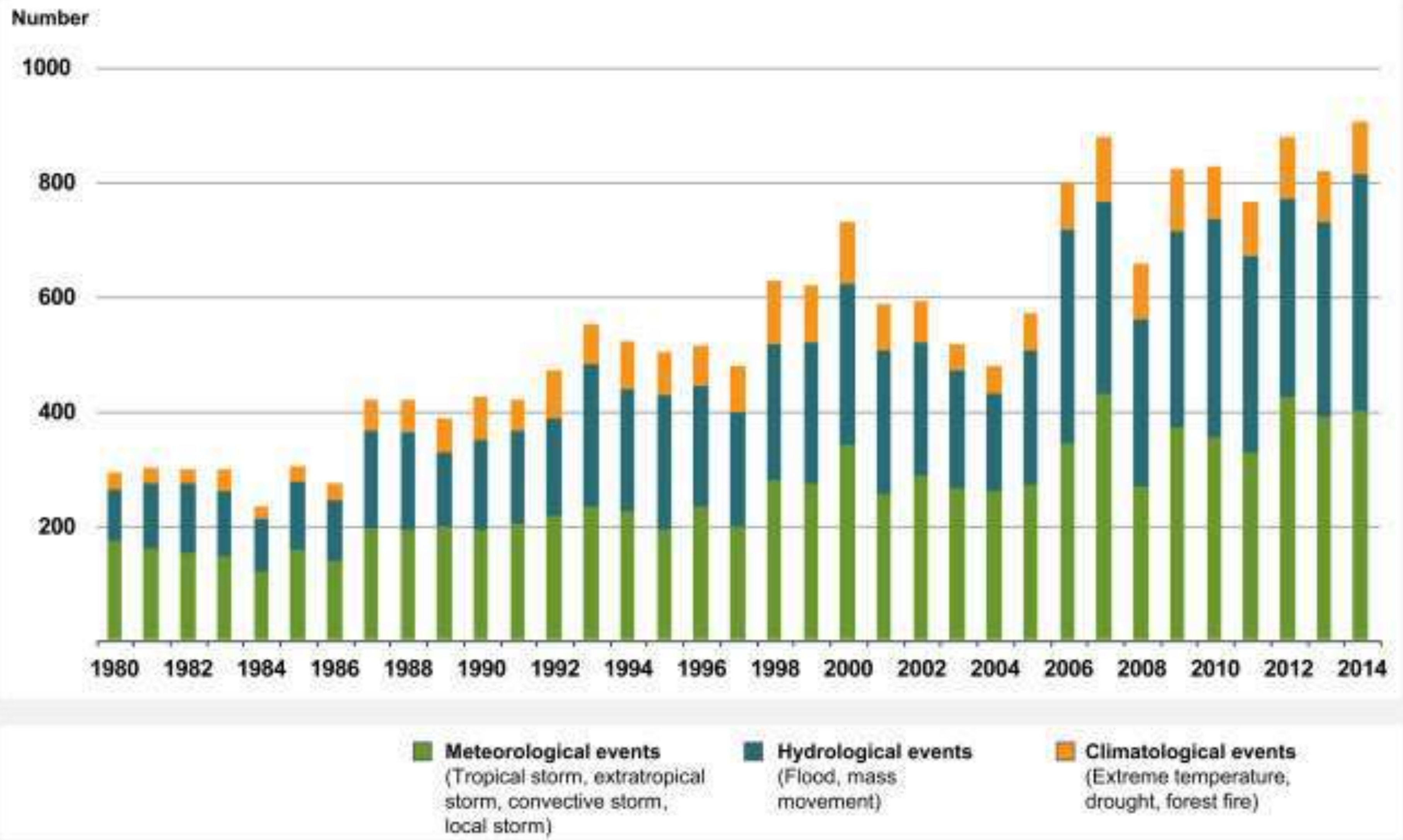


NatCatSERVICE

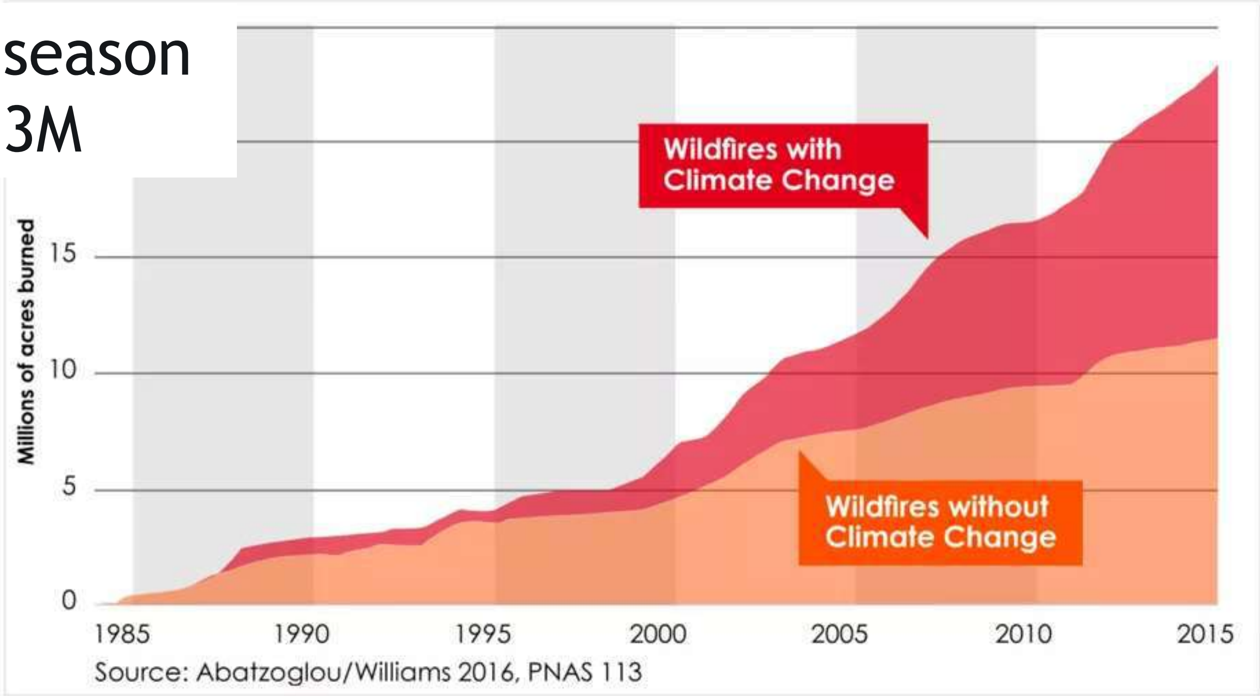
Weather related loss events worldwide 1980 – 2014

Number of events

Munich RE



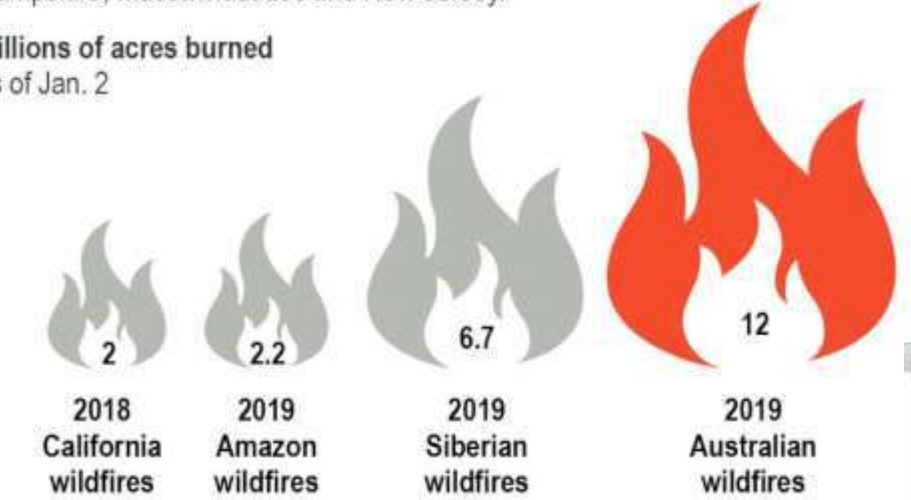
2020 worst fire season
California – 3M



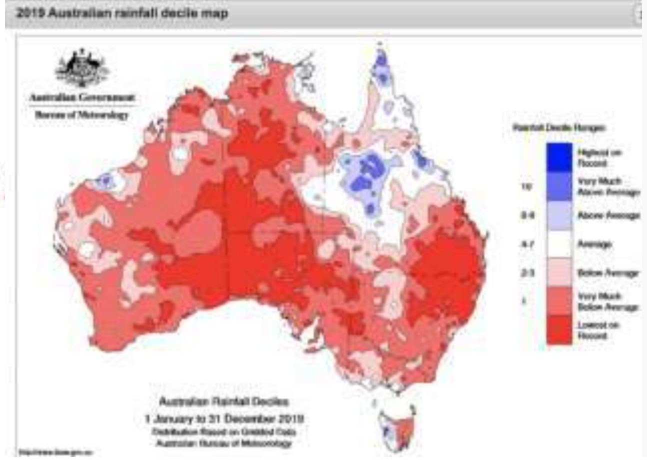
Australia fires dwarf other major wildfires

The wildfires burning in Australia, covering roughly 12 million acres, are as large as the state of Maryland and bigger than several other states including Vermont, New Hampshire, Massachusettes and New Jersey.

Millions of acres burned
as of Jan. 2



SOURCE: Statista



Australia fires compared to other major fire events

FIRE NAME	YEAR	NUMBER OF ACRES BURNED
Australia bushfires*	2019–20	25.5M
Brazilian Amazon fires over 12 months	2019	17.5M
Siberia fires in July	2019	6.4M
Alaska fires over the summer	2019	2.5M
Worst California wildfire season	2018	1.9M
Peshtigo fire: Worst fire in US history	1871	1.2M
Australia's Black Saturday bushfires	2009	1.1M
Latest California wildfire season	2019	260K
California Camp Fire	2018	153K

*As of January 7, 2020

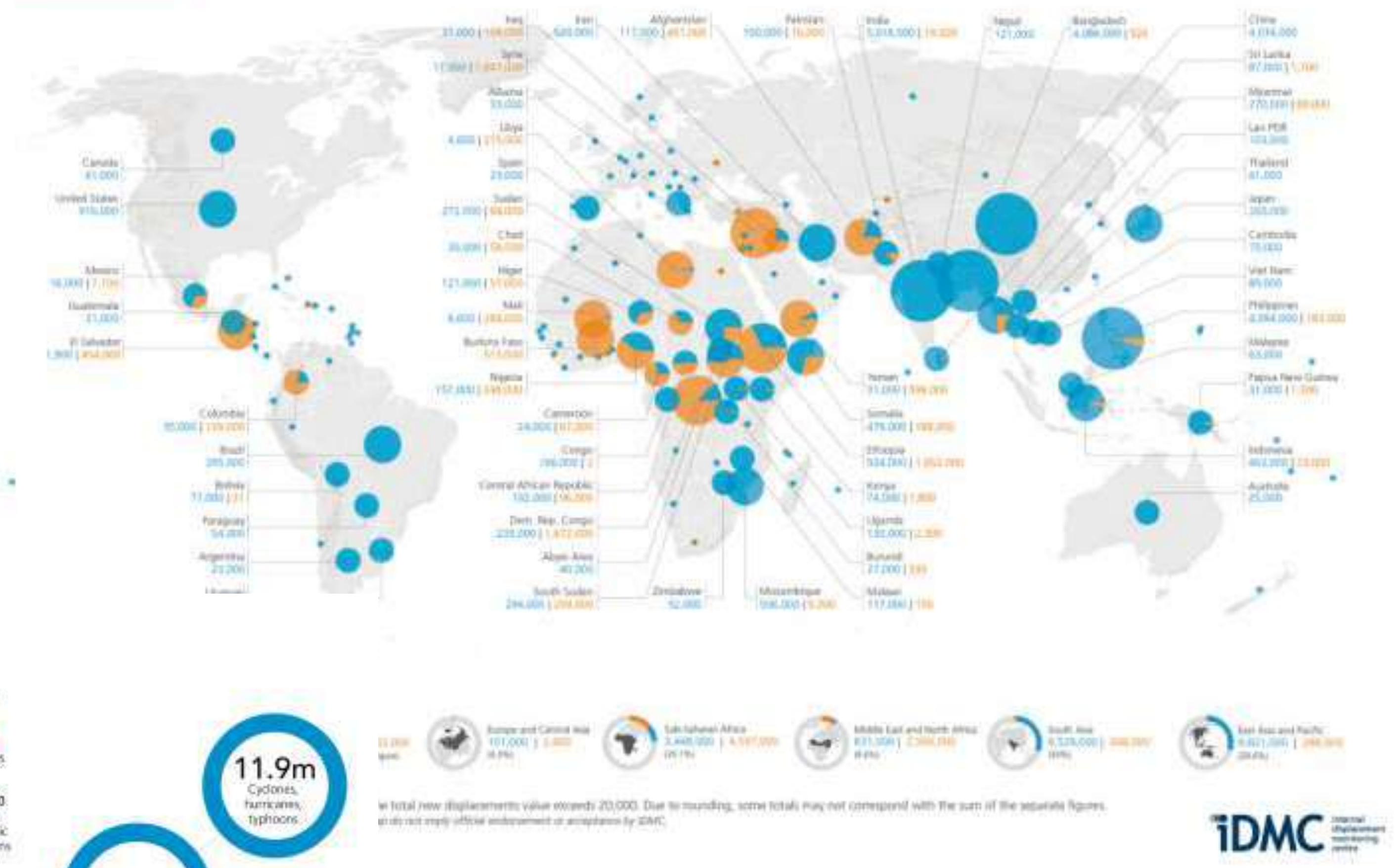
Sources: Reuters; IPNE; NASA; Cal Fire; Weather.gov; National Museum Australia

INSIDER

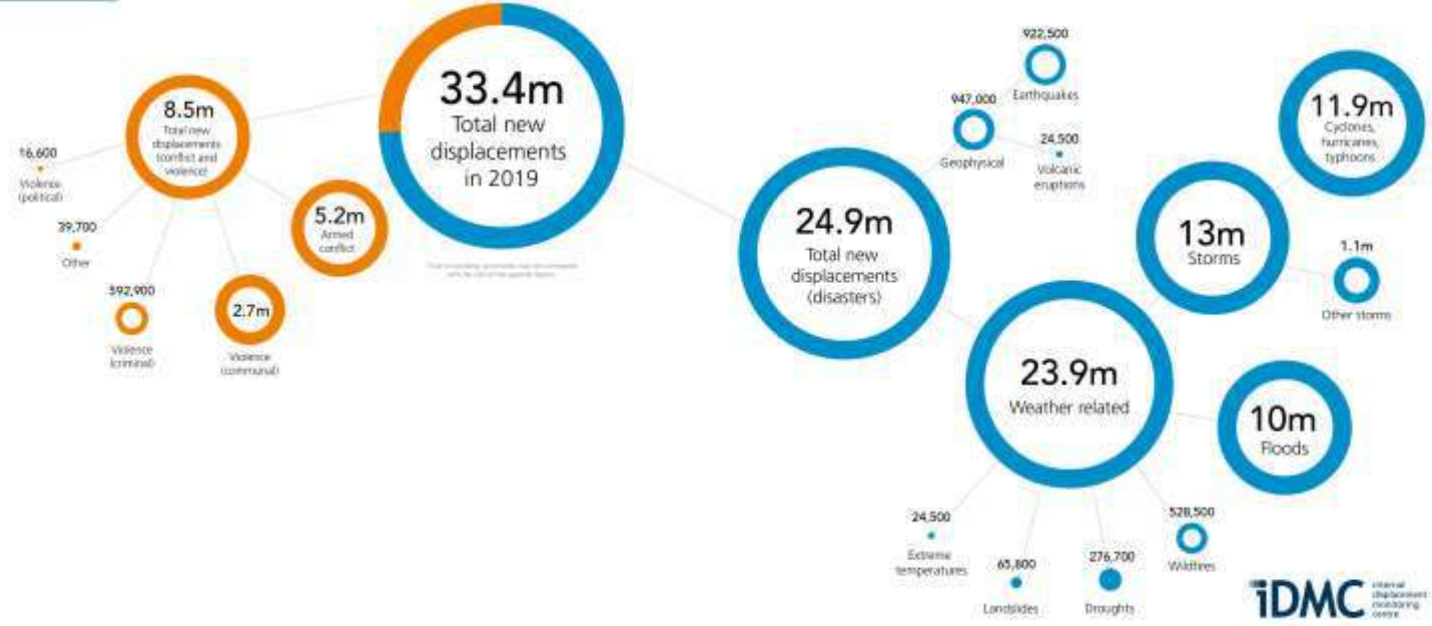
Displacements

Total 33.4 M
Disasters 24.9M
Conflicts 8.5 M

New displacements by conflict and disasters in 2019



New displacements in 2019: breakdown for conflict and disasters



How do we study the <u>present</u> climate and project the **future climate?**

Present:

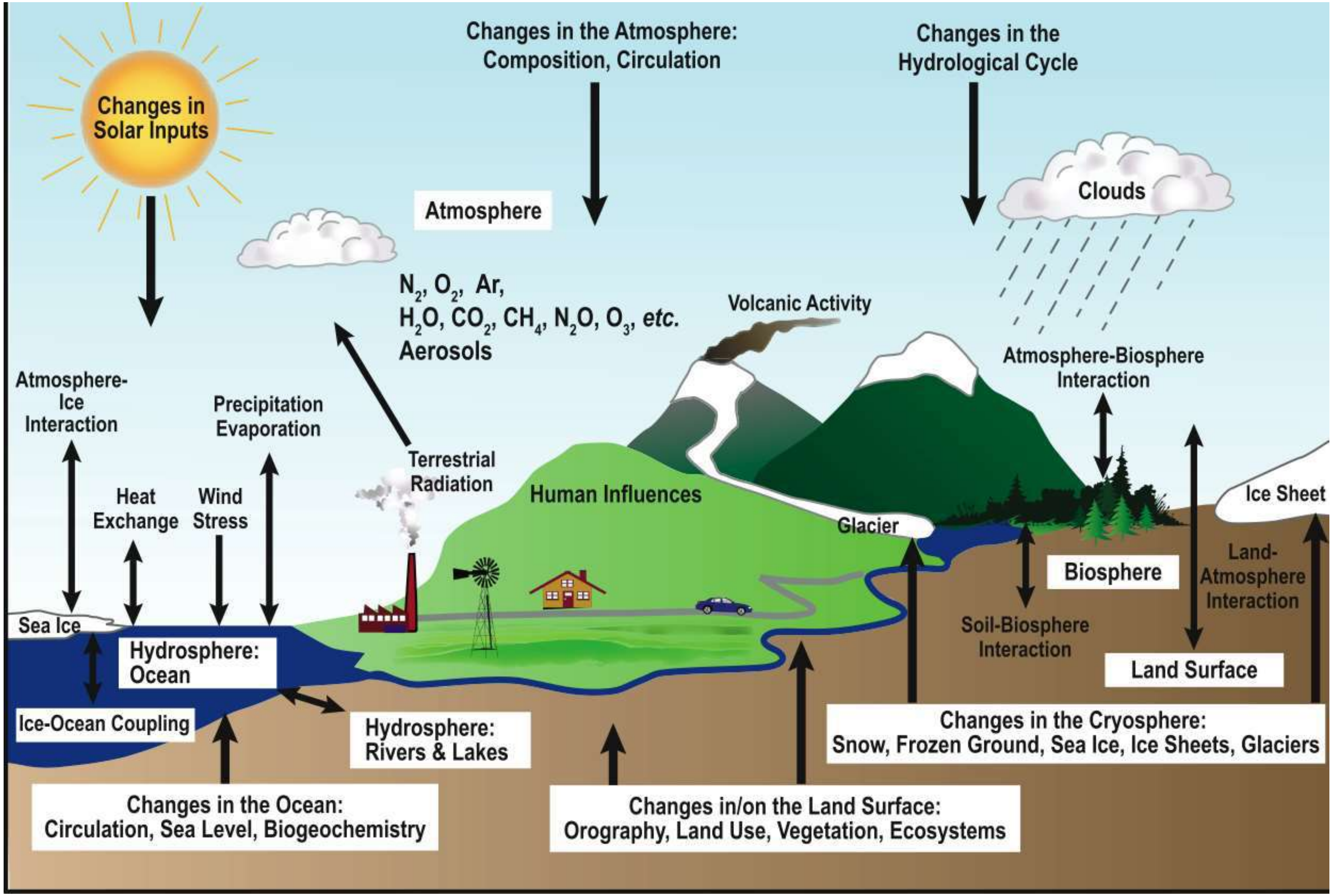
Observations
Climate Models
Reanalisys

Future:

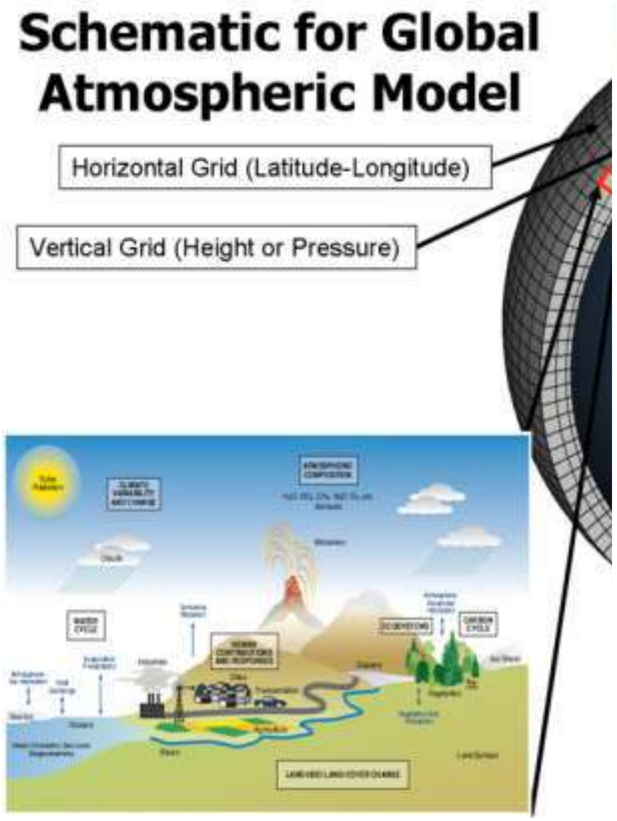
only Models →

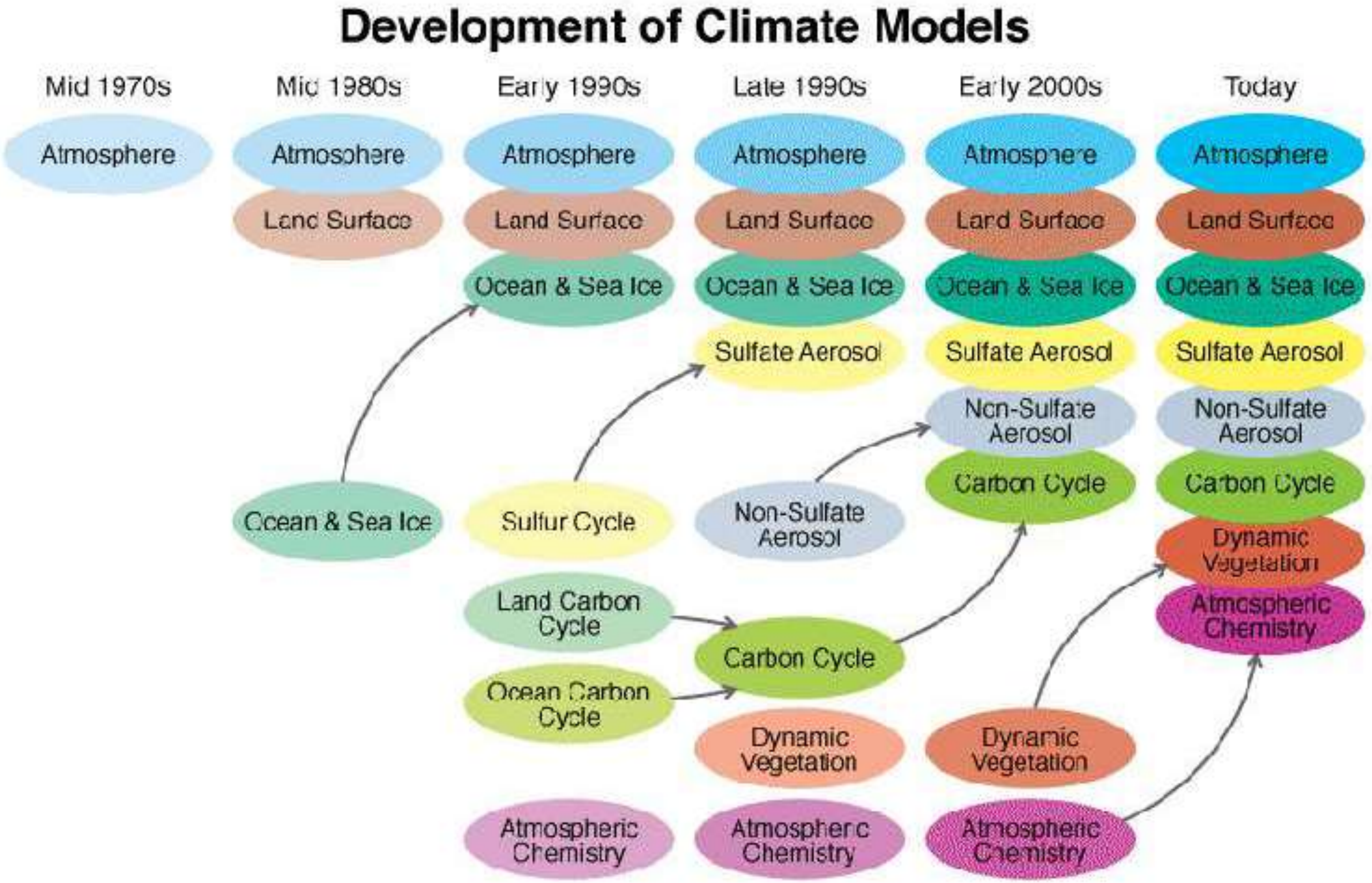
Global Climate Models
GCMs
Earth System Models
ESMs

The climate system



Global Climate



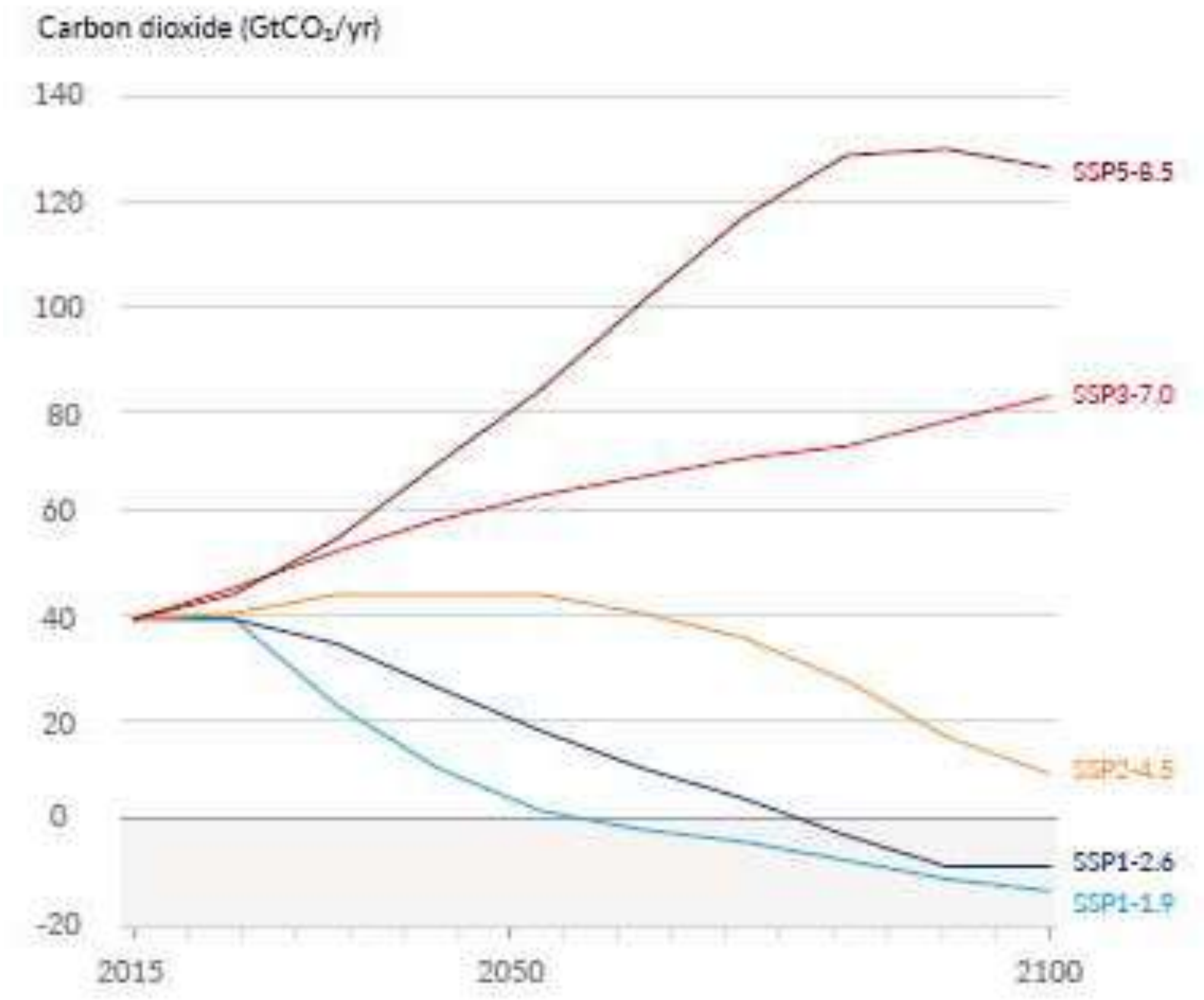


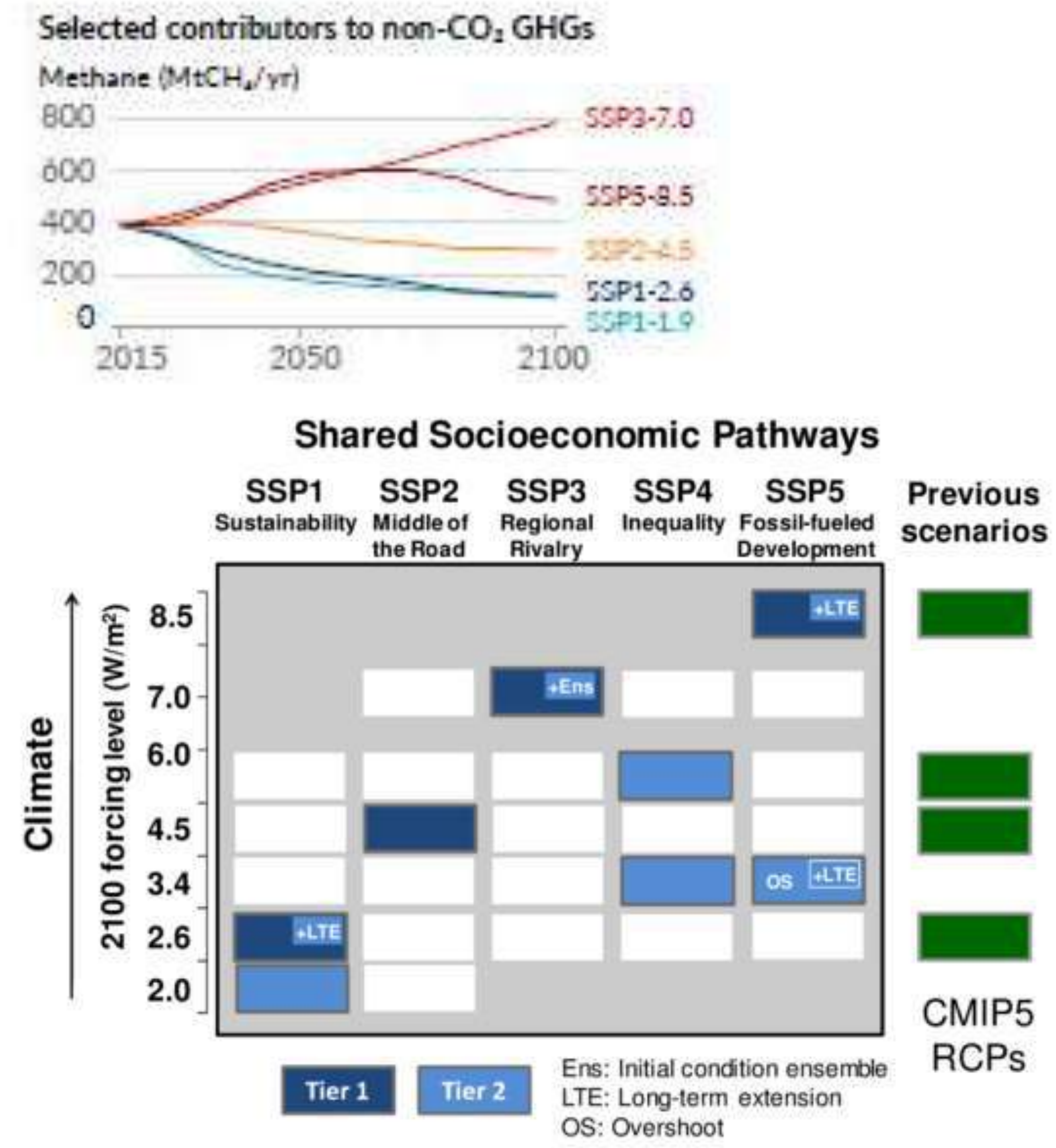
IPCC AR6 CMIP6
Eath System Modelling
Future climate

IPCC - Intergovernmental Panel on Climate Change
AR6 – Assessment Report 6
CMIP6 - Coupled Model Intercomparison Project Phase 6

Shared socioeconomic pathways and Future emissions

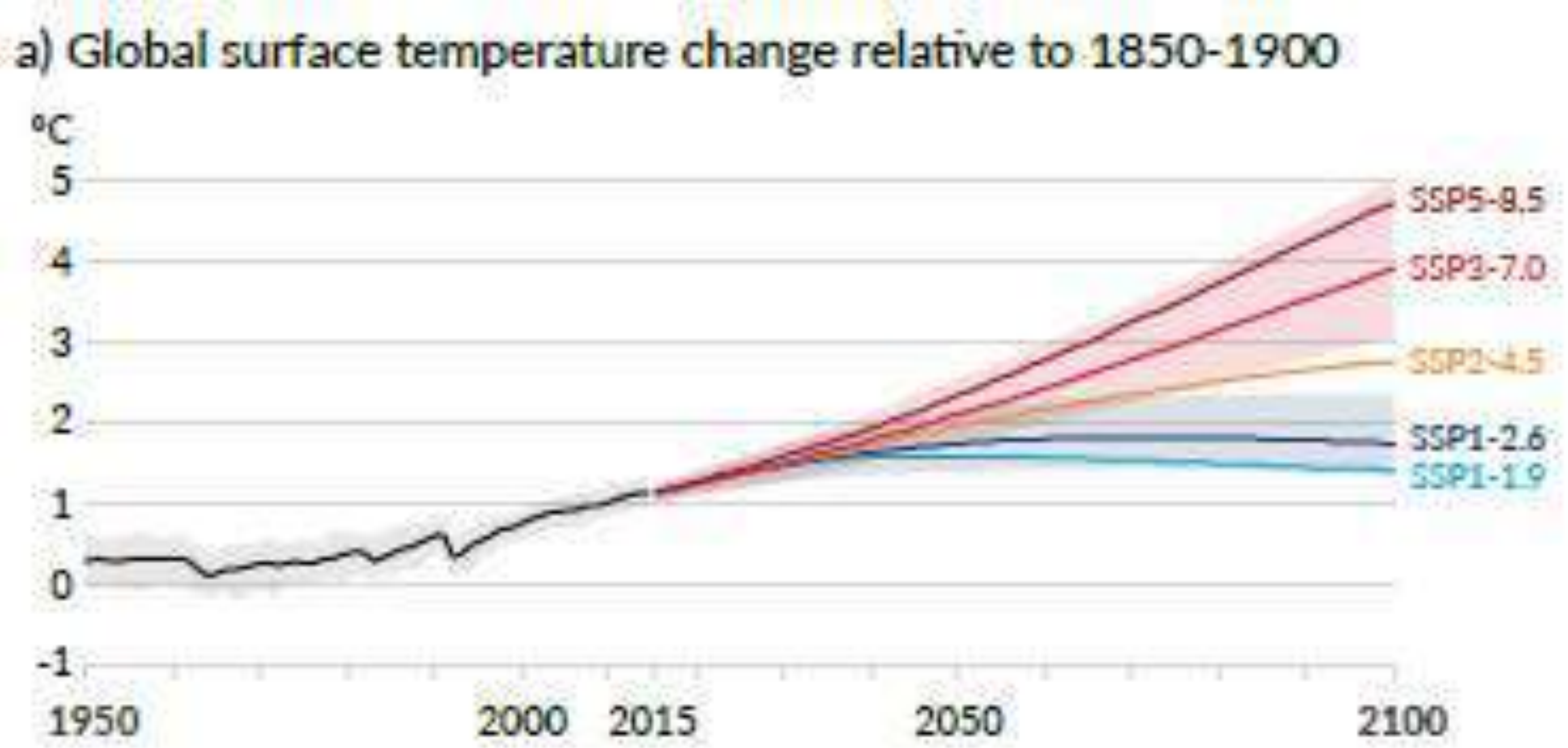
a) Future annual emissions of CO_2 (left) and of a subset of key non-CO_2 drivers (right), across five illustrative scenarios





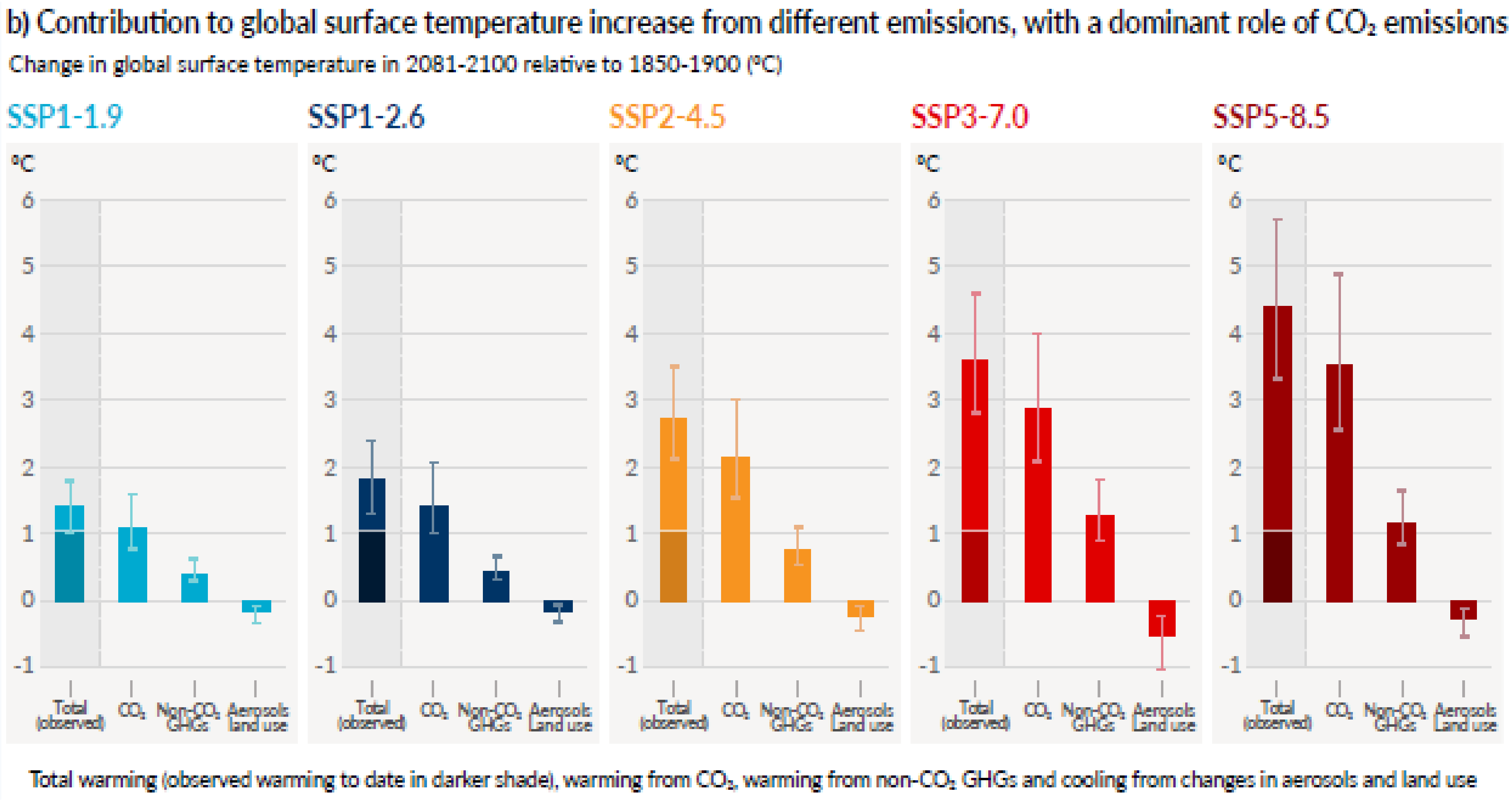
IPCC AR6 WGI, 2021

Human activities affect all the major climate system components, with some responding over decades and others over centuries

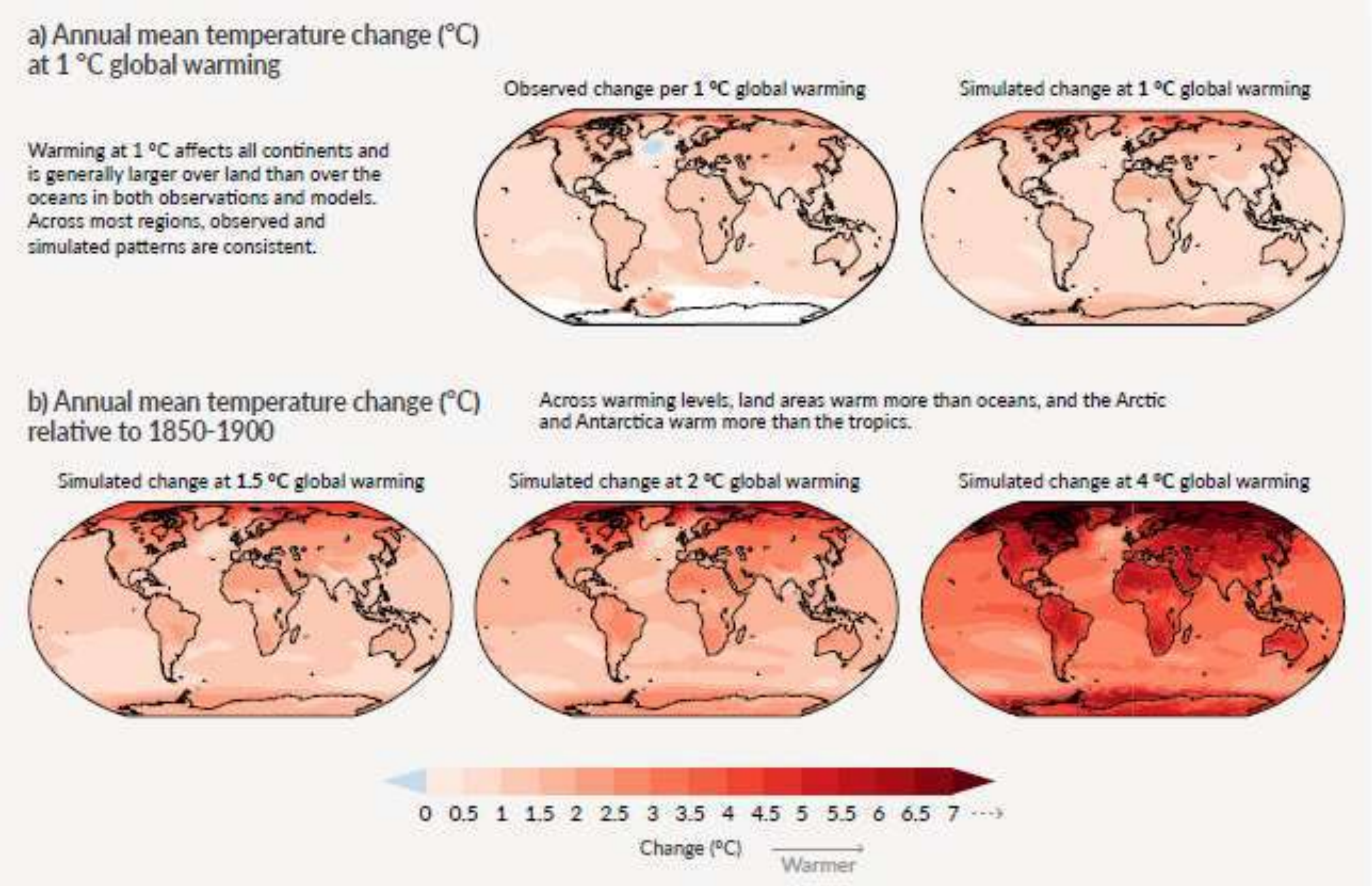


IPCC AR6 WGI, 2021

Mitigation is vital

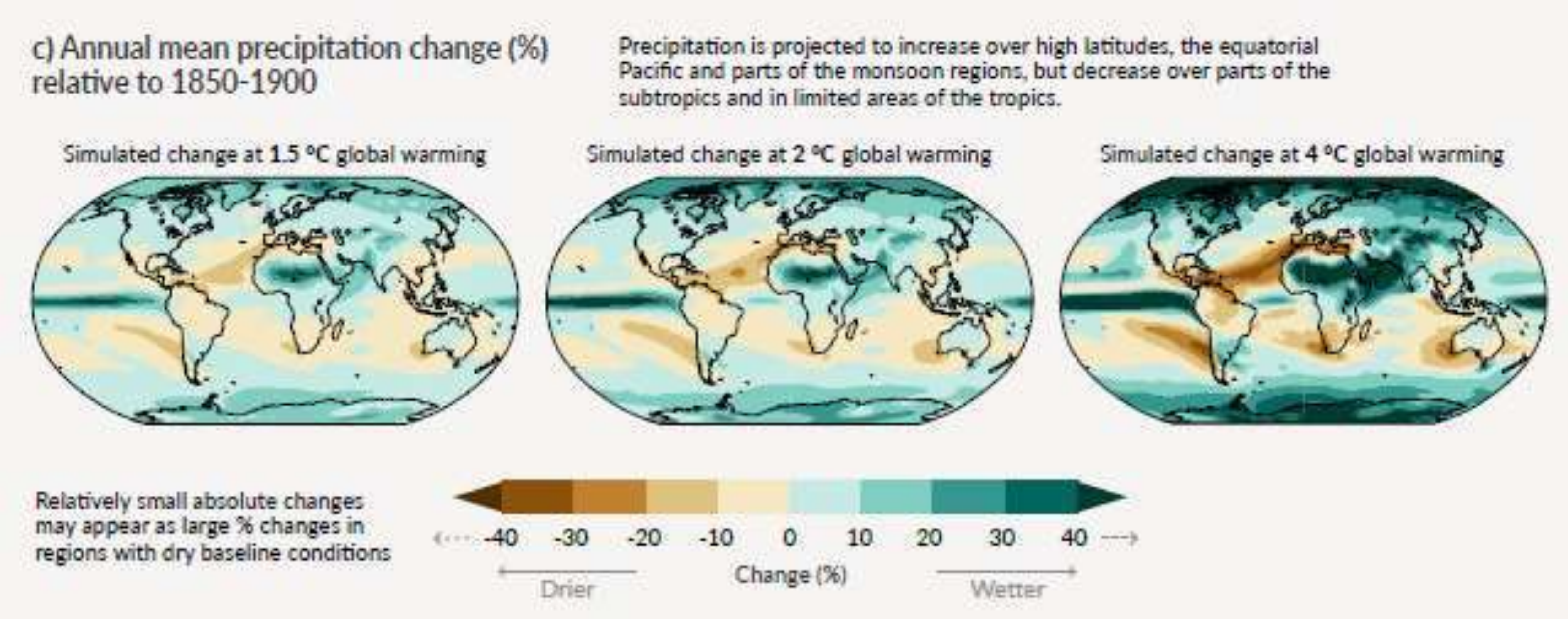


IPCC AR6 WGI, 2021



With every increment of global warming, changes get larger in regional mean temperature, precipitation and soil moisture

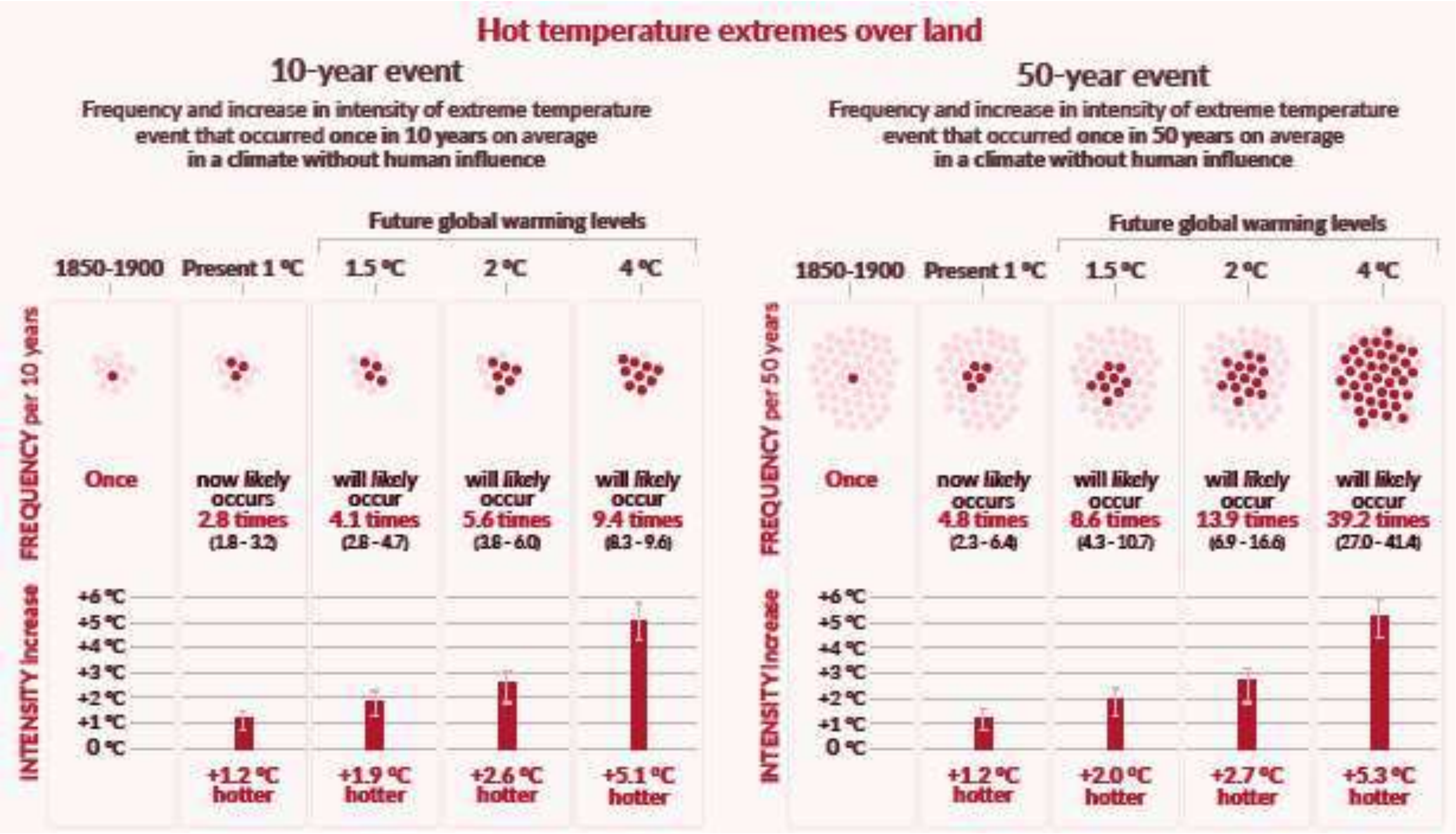
IPCC AR6 WGI, 2021



IPCC AR6 WGI, 2021

Projected changes in extremes are larger in frequency and intensity with every additional increment of global warming

Mitigation is vital



IPCC AR6 WGI, 2021

Global to regional (and local)

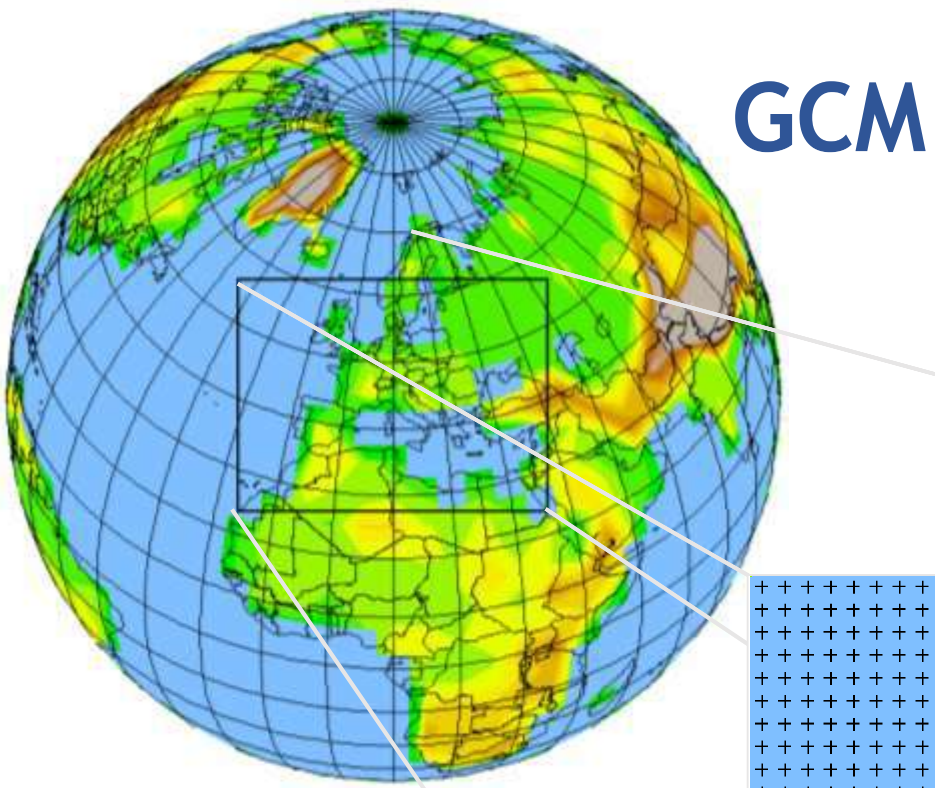
Climate change impacts are felt at the regional and local scales!!!

Climate information at local scales is essencial to assess climate change impacts

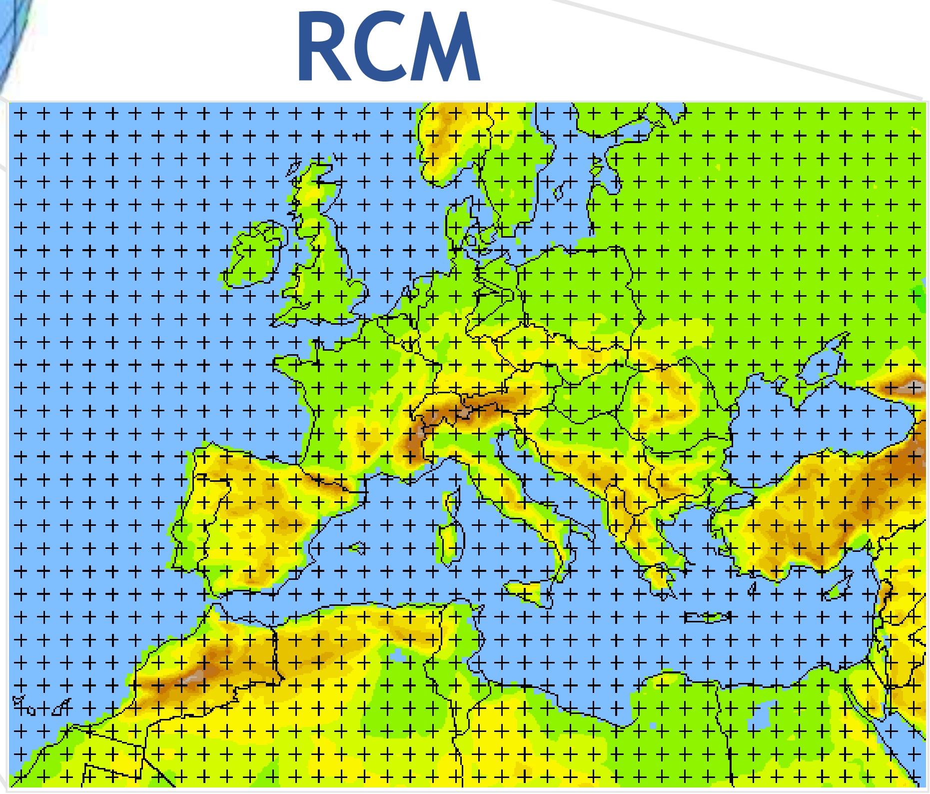
Statistical downscaling

Dynamical downscaling

Regional Climate Modelling



RCM Nesting
GCM força o RCM na fronteira lateral e superfície oceância (~12km)



WCRP CORDEX
Coordinated Regional Climate Downscaling Experiment

WCRP CORDEX
FLAGSHIP PILOT STUDIES

WRF
Weather Research & Forecasting

Regional Climate Models
EURO-CORDEX
~12km resolution
…km -scale~2-3km

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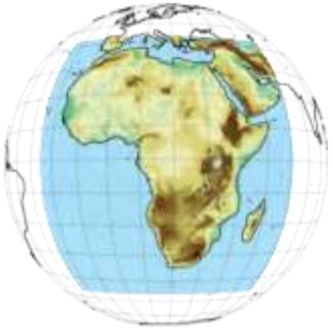

Objectives

To characterize the climate change signal on the precipitation, temperature and renewables, and sectoral impacts: water, fires, droughts and agriculture.

Methods

- Using the newest and highest resolution regional climate simulations available
- Evaluate extensively RCMs results against observations
- Model ranking based on model performance
- Multi-model ensembles – full, selected and weighted
- Assess the climate change signal, impacts and adaptation

Climate Change Impacts in Portugal

National Roadmap for Adaptation XXI - Portuguese Territorial Climate Change Vulnerability Assessment for XXI century 2021-2023

EEA project

apa agência portuguesa do ambiente

Iceland Liechtenstein Norway grants

Ciências ULisboa

dgTerritório Direção-Geral do Território

cE3c centre for ecology, evolution and environmental changes

Universitas Olisiponensis Ad Lucem

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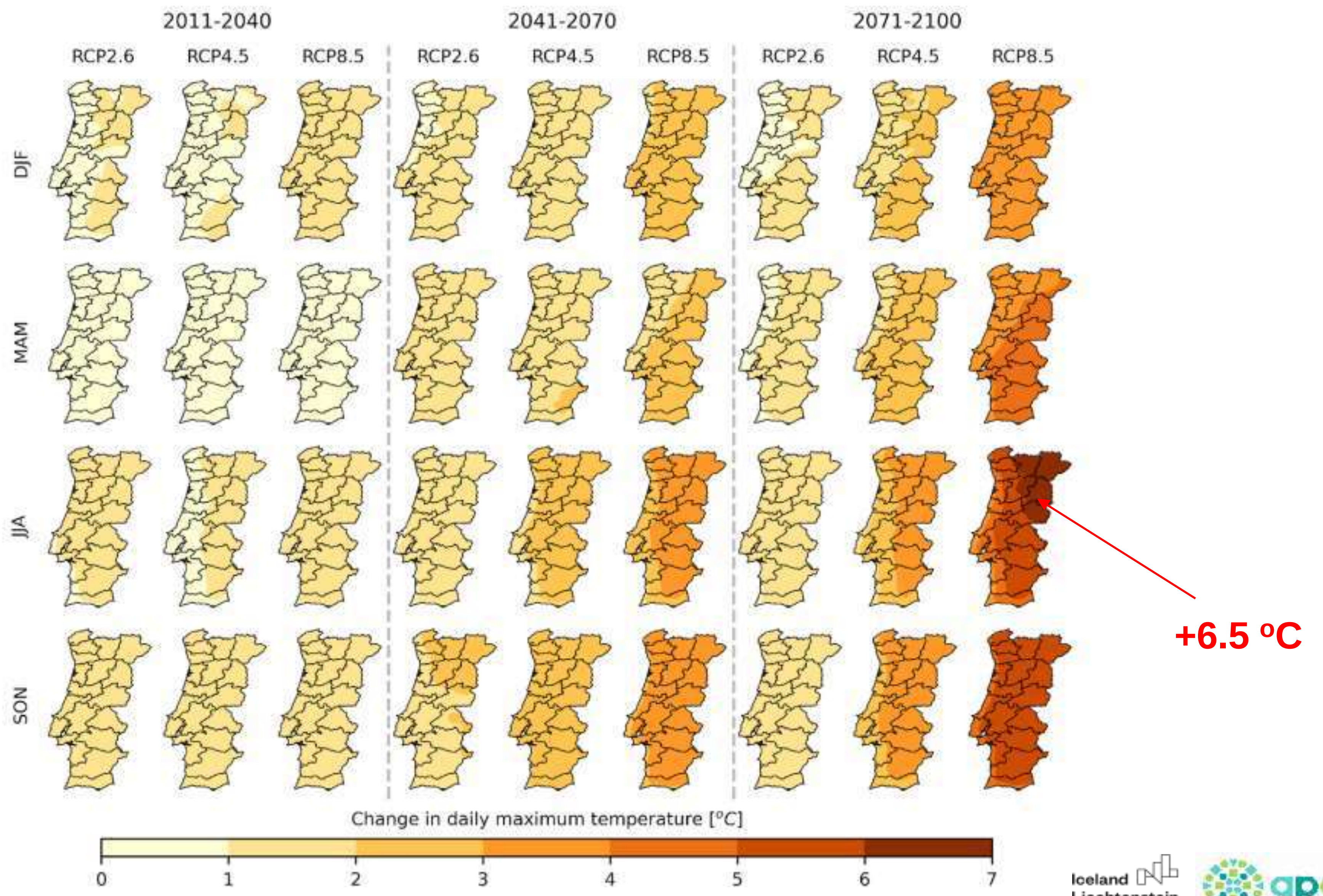
BANCO DE PORTUGAL EUROSISTEMA

IPMA

WP2 - Climate Projections, Extremes and Indices

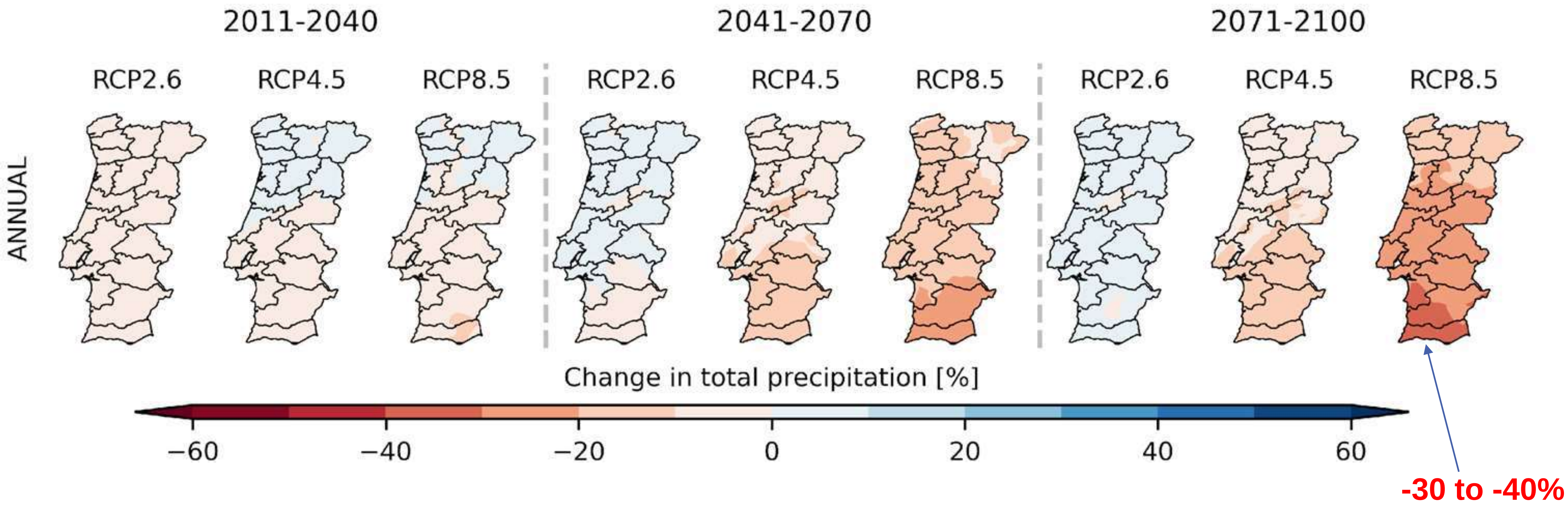
Seasonal Maximum Temperature



Lima et al. (2022)

WP2 - Climate Projections, Extremes and Indices

Annual Precipitation



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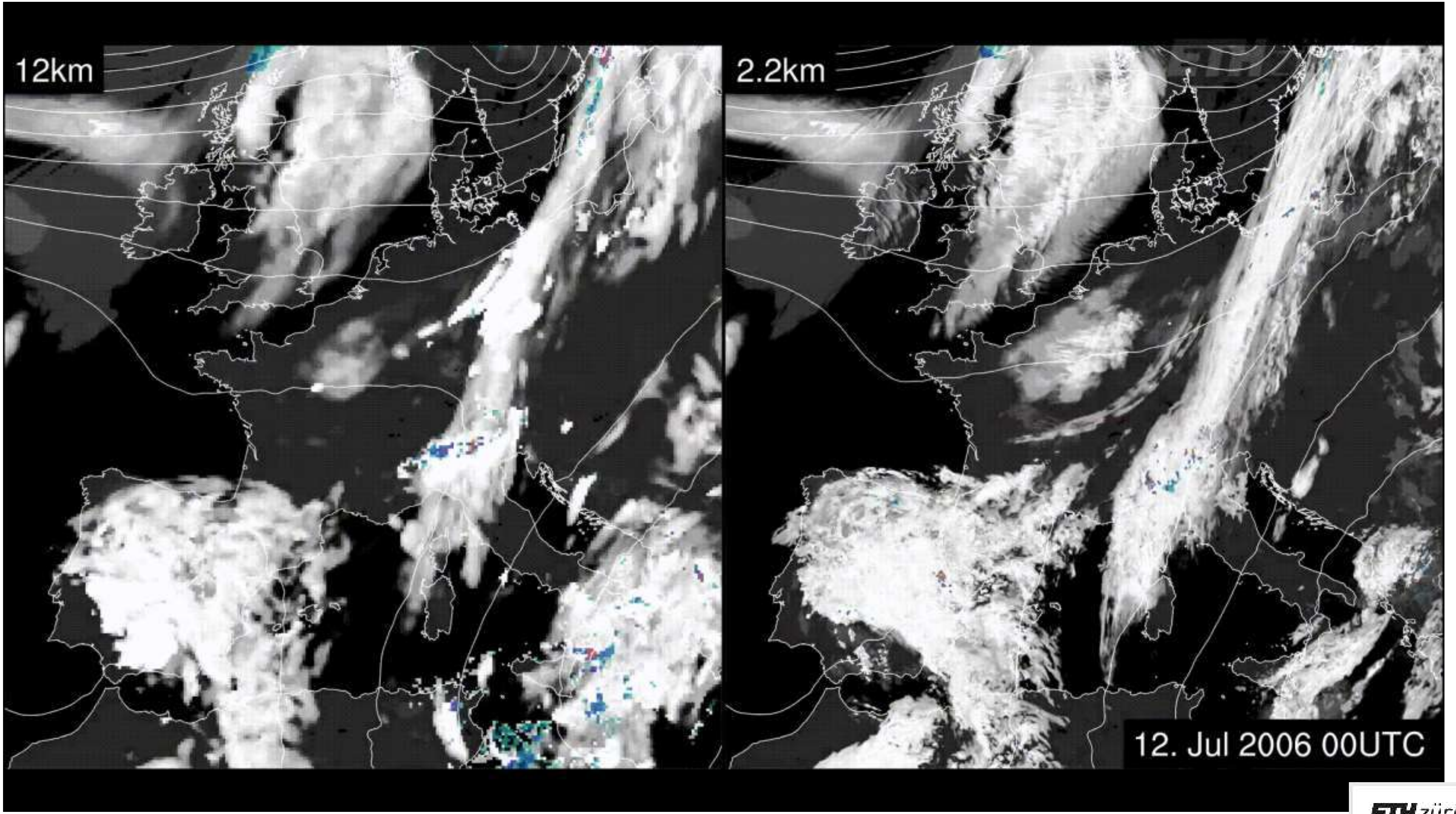
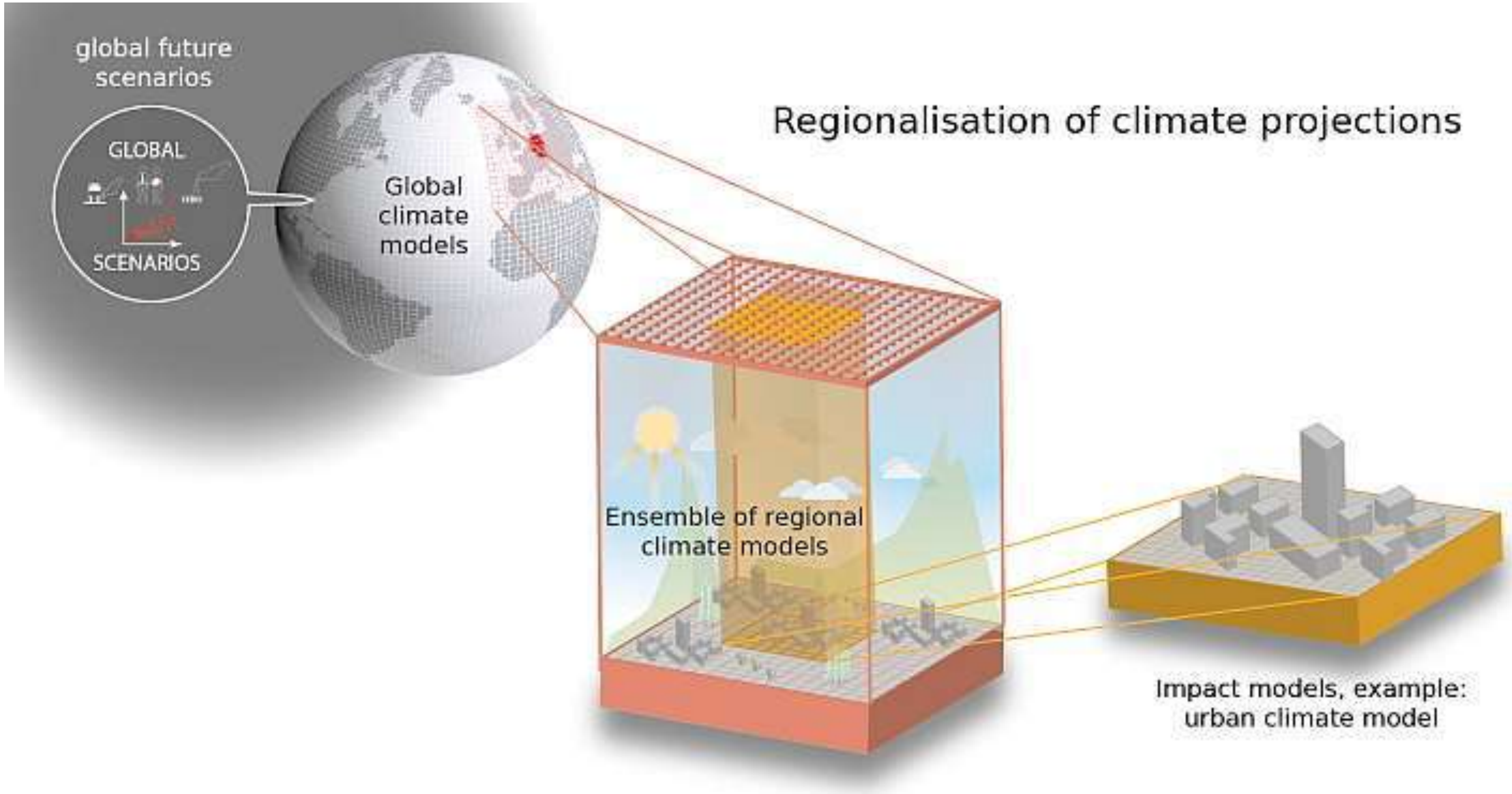


ETH zürich

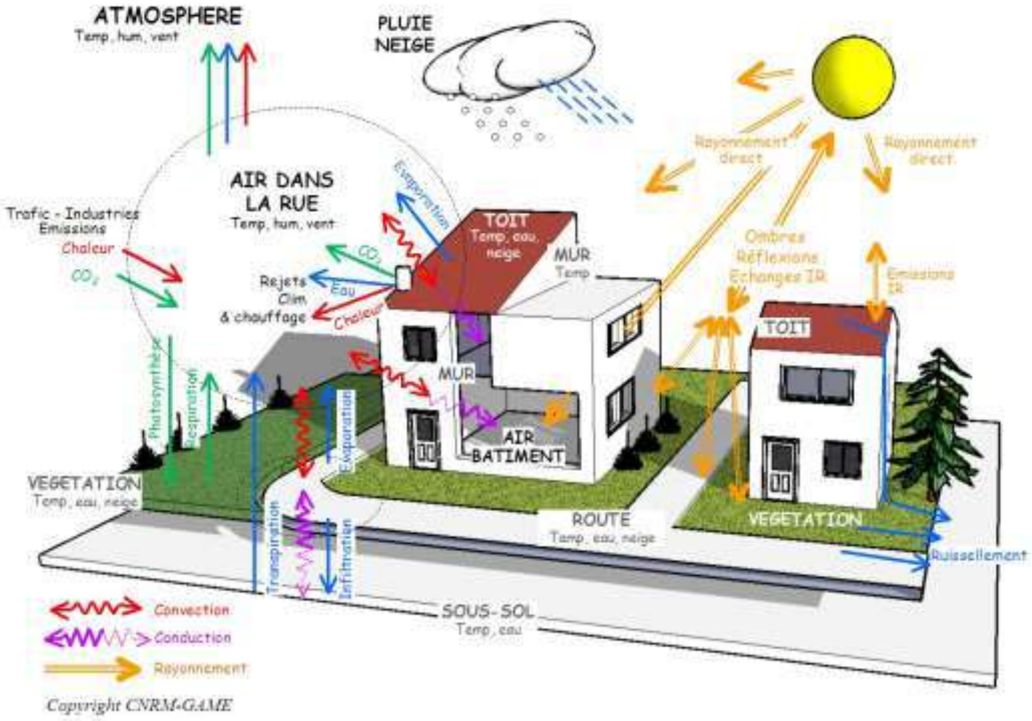
Urban climate simulation

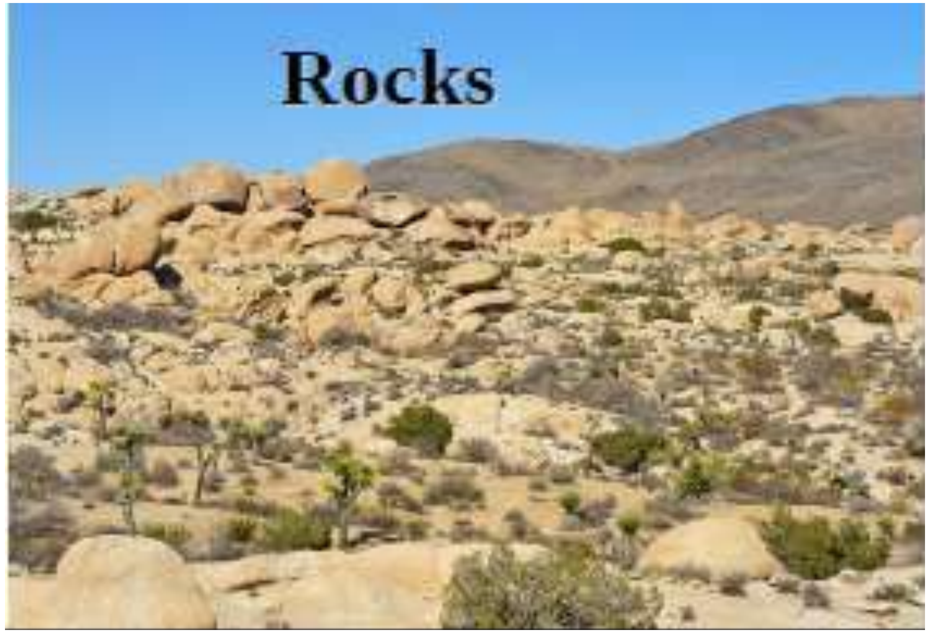


Computational Power limits:

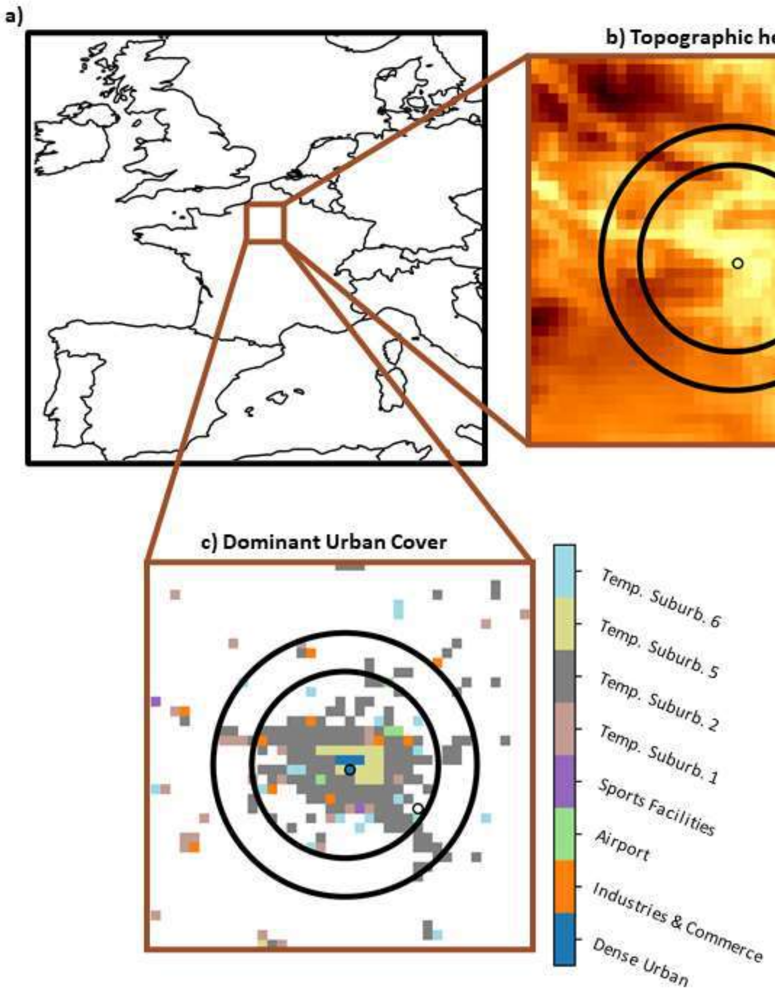
- Domain size
- Grid resolution
- Detail of urban schemes/parameterizations
- **<u>Number of experiments</u>**

Urban Climate Simulations





Offline SURFEX simulations



Name	SFX-TEB	SFX-ROCK
Period	2003-2018	
Space res.	0.05ºx0.05º	
Timestep	30 min	
Forcing	ERA5 hourly (surface and z=40m)	
LSM	ISBA (soil Diffusion, 14 layers, 12 patches)	
Urban	TEB+BEM	Rock

- **ERA5 0.25º -> nearest neighbor forcing!**
- **Analysis 2004-2018**
- **Single layer UCM setup**
- **2-meter air temperature UHI & Surface UHI (SUHI)**

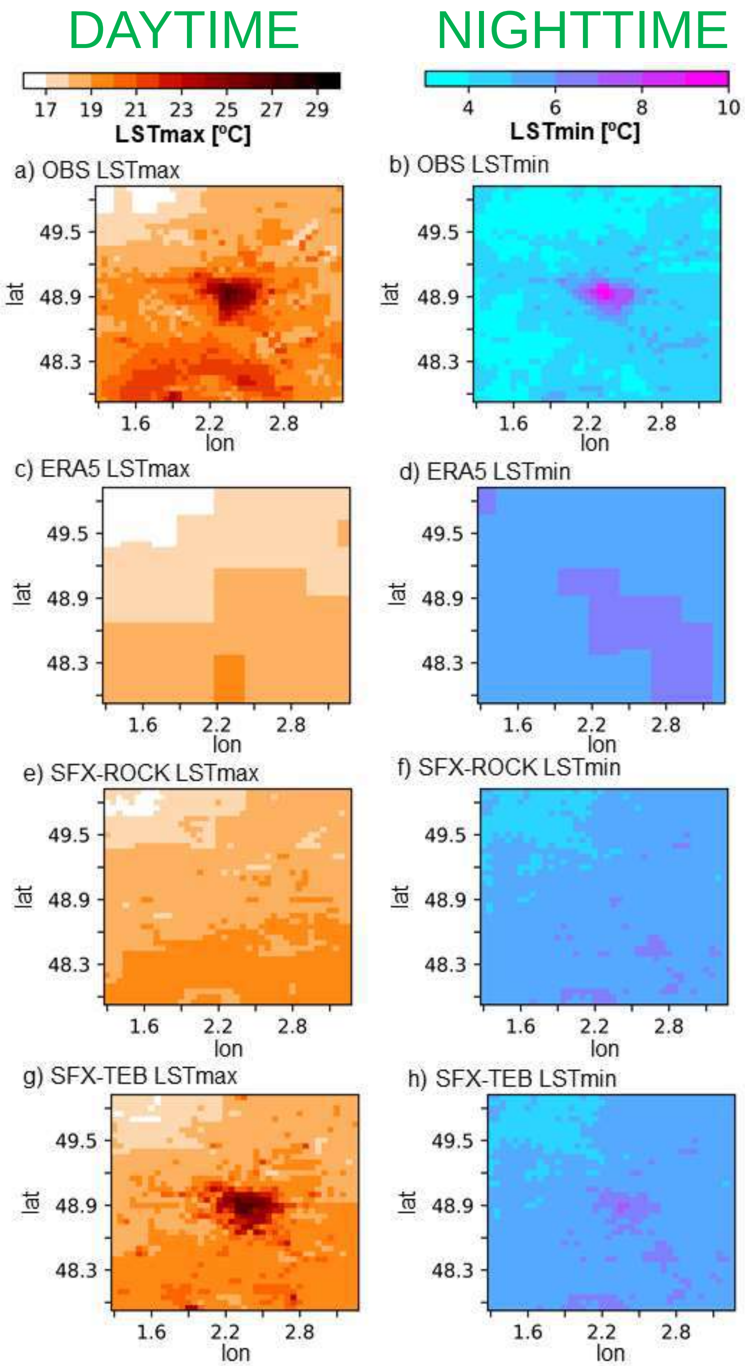
Offline urban simulation

OBSERVED UHI (LSA-SAF LST)

NO UHI in ERA5

NO UHI IN SFX-ROCK

UHI in SFX-TEB

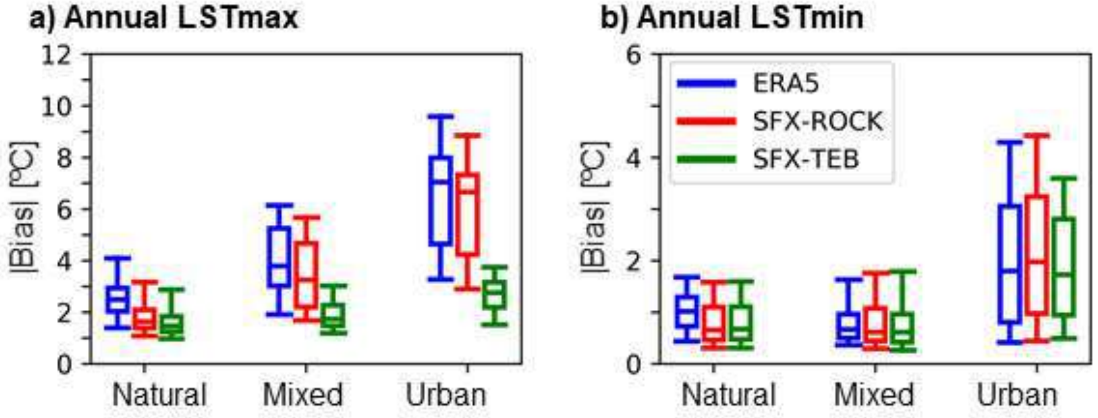


Offline urban simulation

Systematic error

DAYTIME

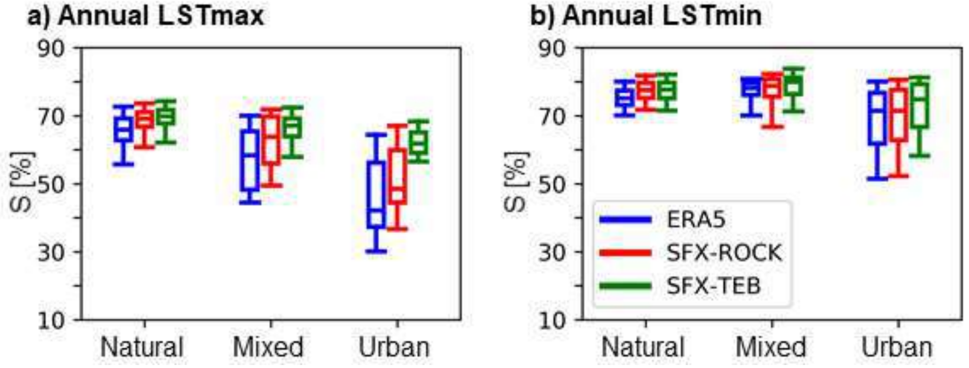
NIGHTTIME



PDF assessment

DAYTIME

NIGHTTIME



DAYTIME

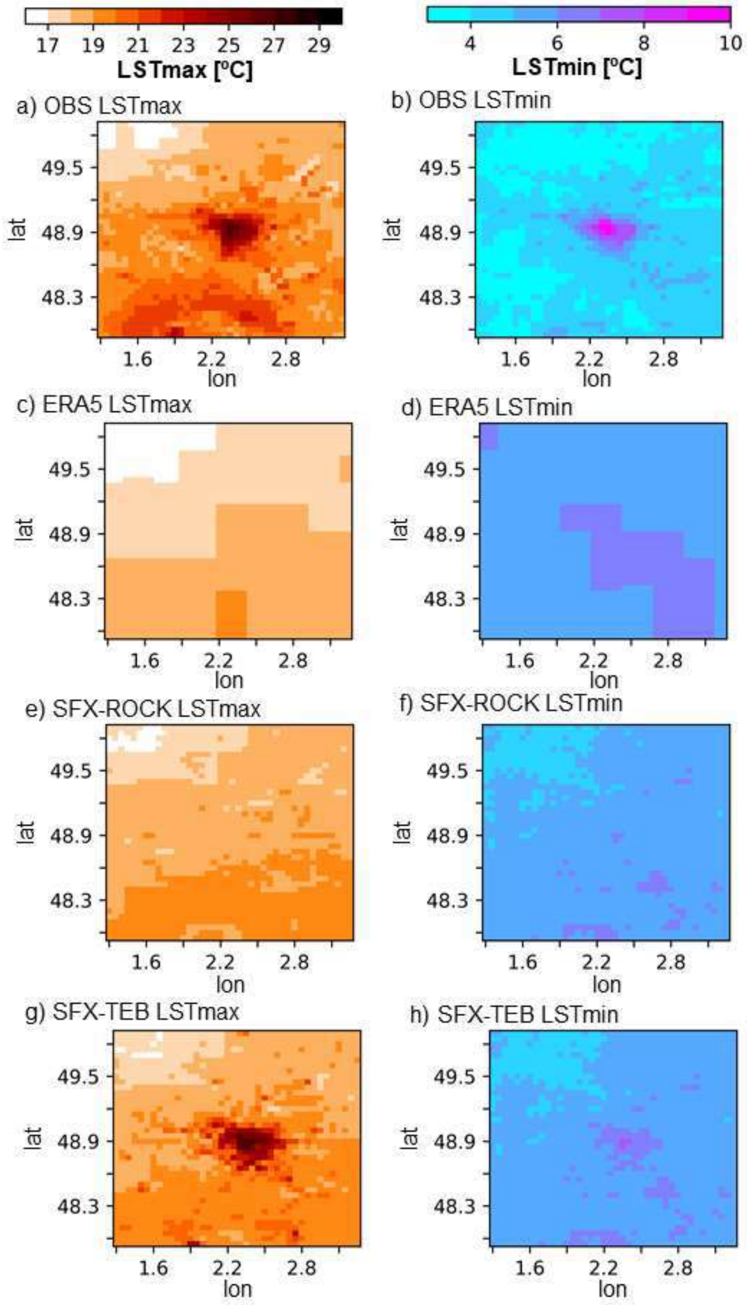
NIGHTTIME

OBSERVED UHI (LSA-SAF LST)

NO UHI in ERA5

NO UHI IN SFX-ROCK

UHI in SFX-TEB



Thanks