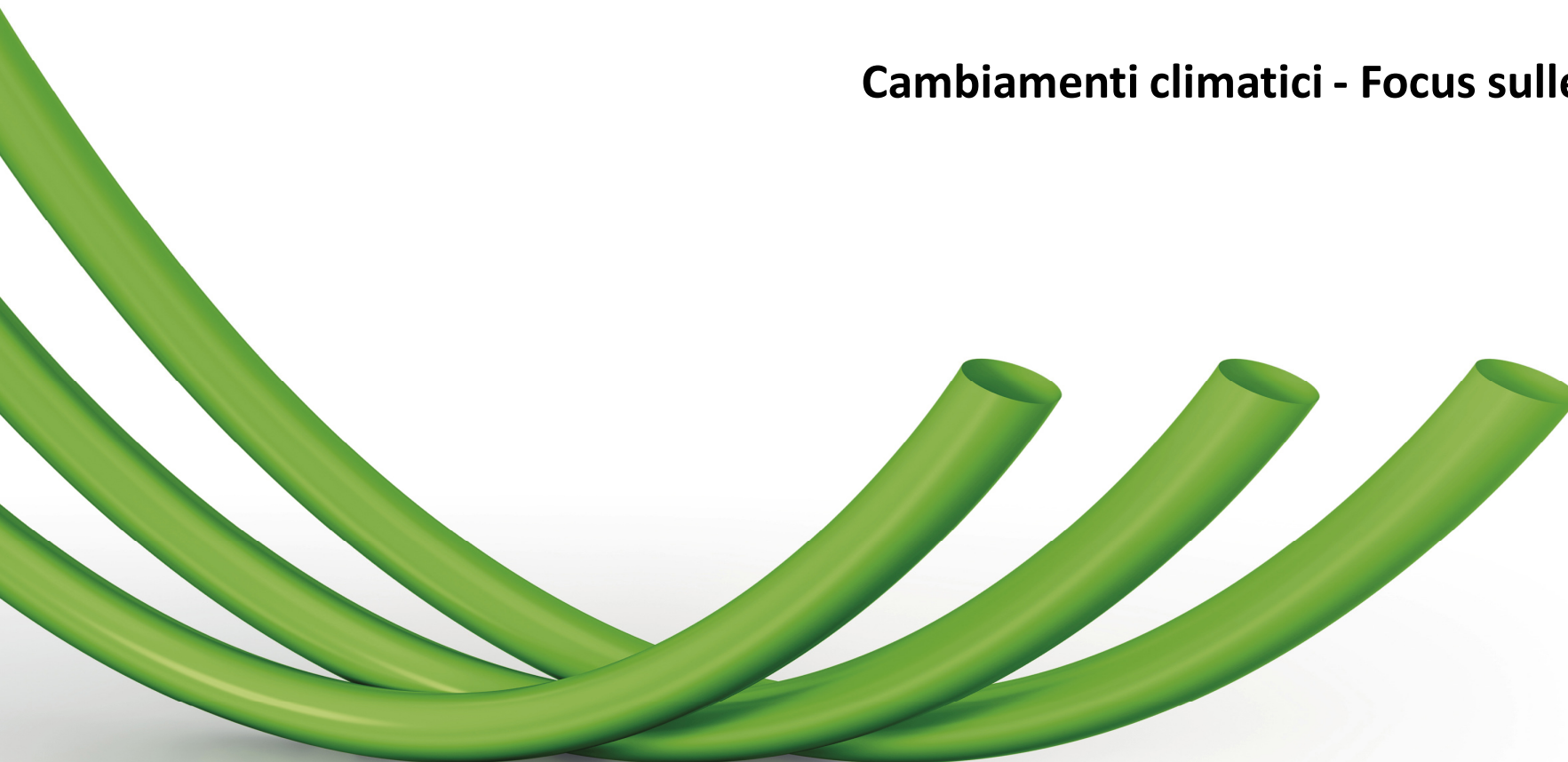




30 September 2020

Cambiamenti climatici - Focus sulle Precipitazioni

Paola Faggian



Ricerca sul Sistema Energetico

develops applied researches in the electro-energetic sector



www.rse-web.it

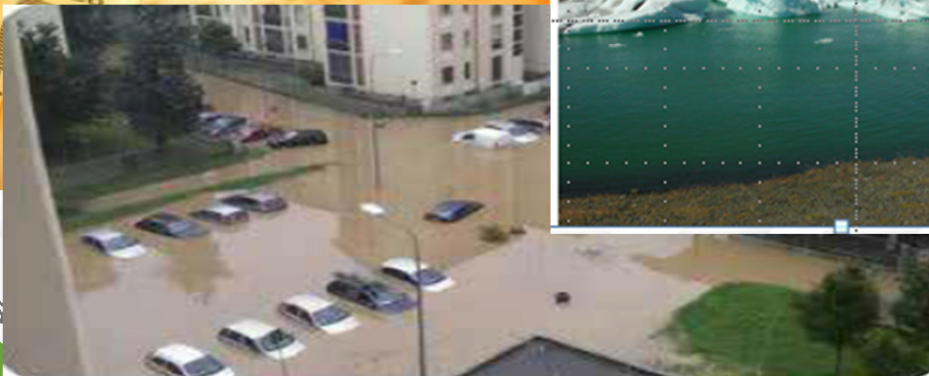
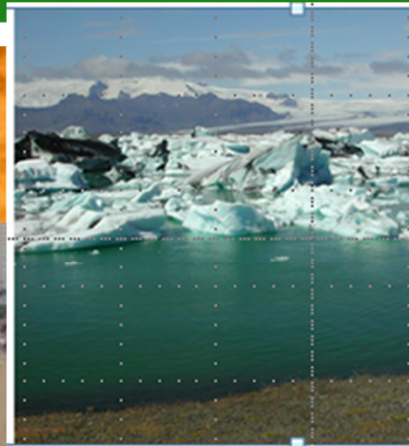
In the Sustainable Development and Energy Sources Department (SFE) some activities involve:

- application of meteorological models to assess renewable energy capability;
- Application of meteorological models to forecast the meteorological variables influencing the management of the electrical system at short/medium term;
- application of meteorological and chemical models to assess the electricity system impacts on the air quality;
- ***Climate model analysis to investigate the climate change impacts on the electro-energy system.***



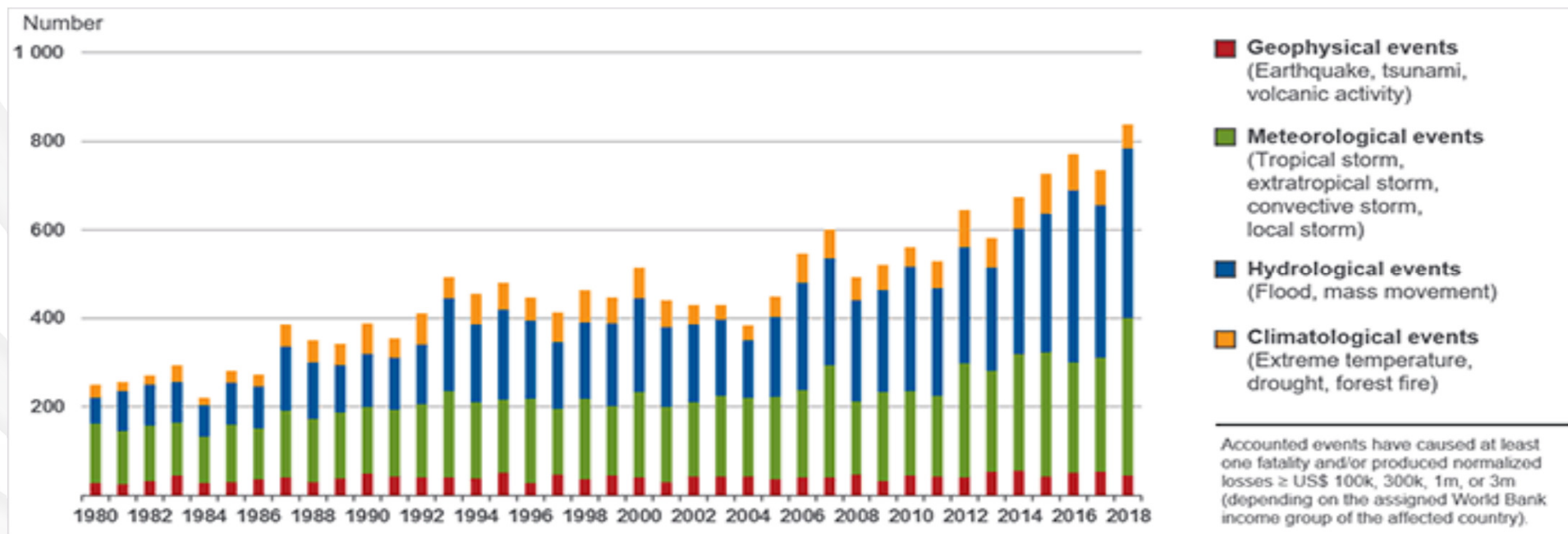
Outline

1. Climate Changes: cosa sta succedendo?
2. Data-set
3. Metodologia di analisi
4. Analisi dei risultati: variazioni graduali, estremi climatici
5. Conclusioni



1. Introduction

Loss events worldwide (1980-2018): number of relevant events by peril



Source: © 2019 Munich Re, Geo Risks Research, NatCatSERVICE. As of March 2019.

Climate-related hazards are at historically high levels

References



Intergovernmental Panel of Climate Change (IPCC)

<http://www.ipcc-data.org/>

Copernicus Climate Change Service (C3S)

<https://climate.copernicus.eu/about-c3s>

EU Reports (i.e. European Environmental Agency)

Regional Climate Model (RCM) results (EU Projects)

PRUDENCE 2001-2004

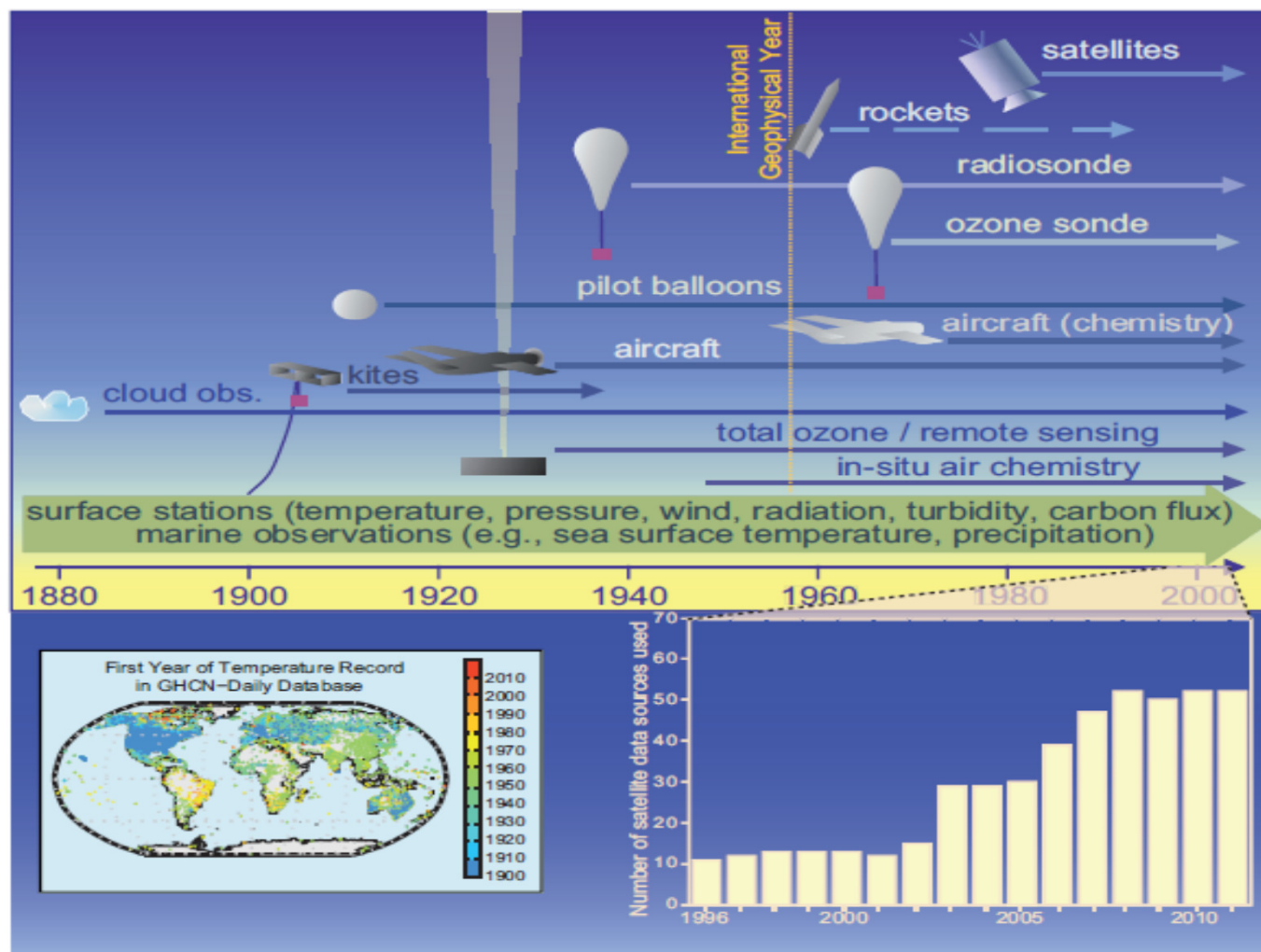
ENSEMBLES 2004-2009

CIRCE 2007-2010

ACQWA 2008-2012

CORDEX (Euro-CORDEX, Med-CORDEX)

Development of observations



IPCC, AR5 WGI

The development of Climate models

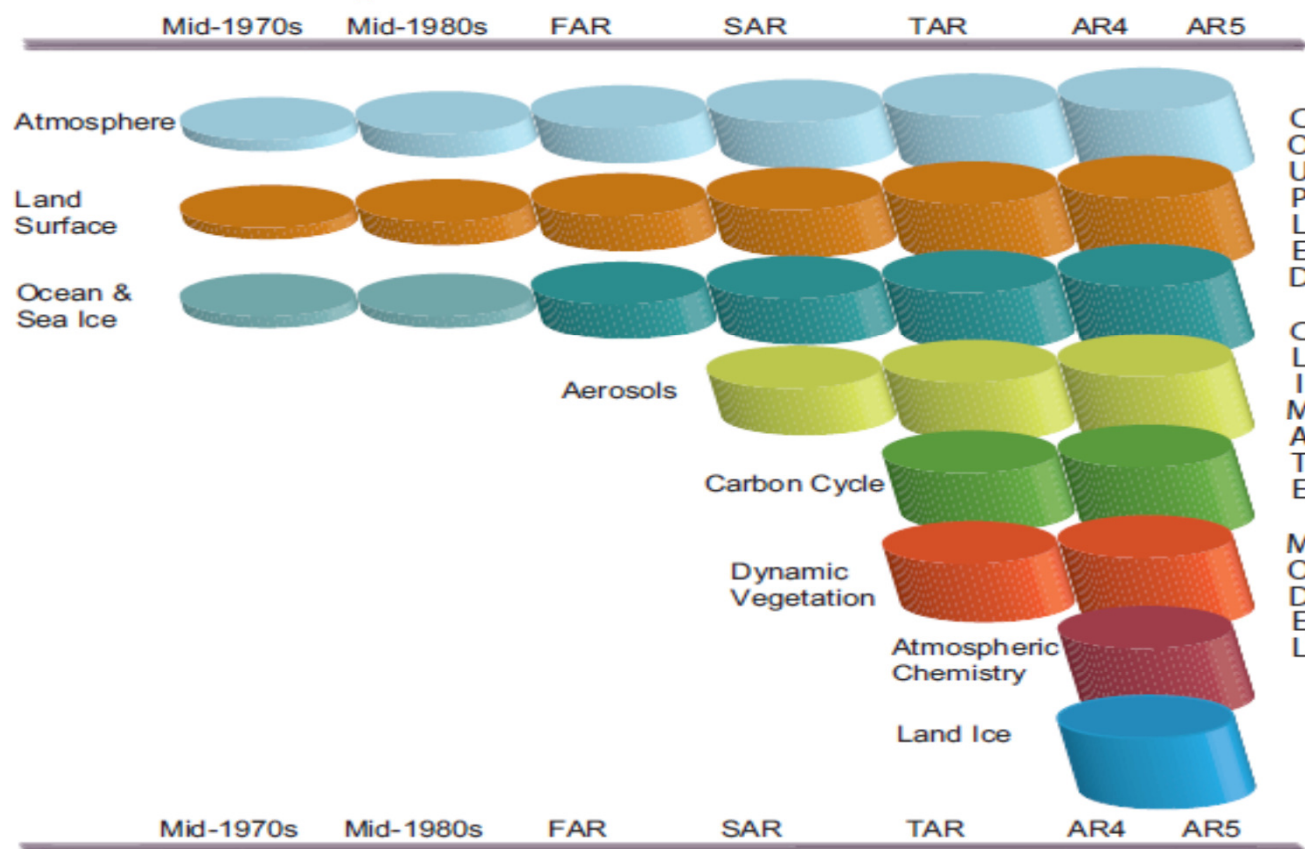
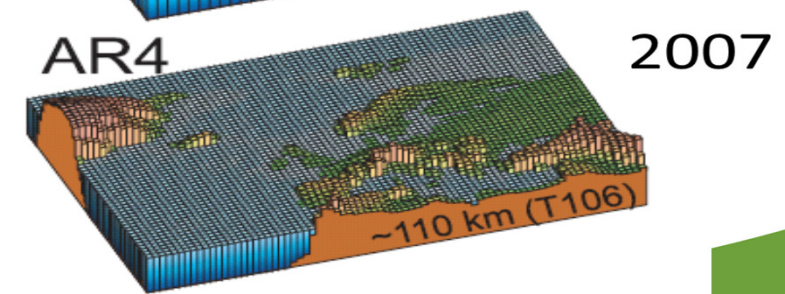
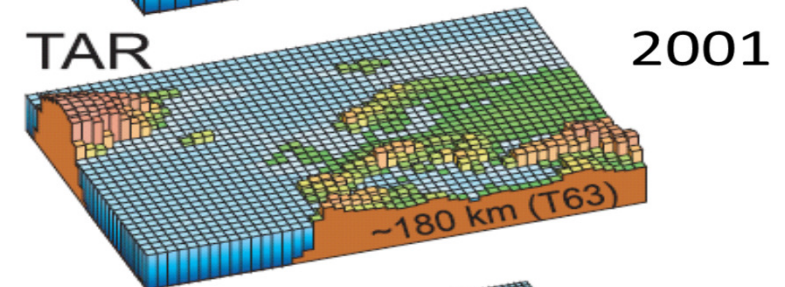
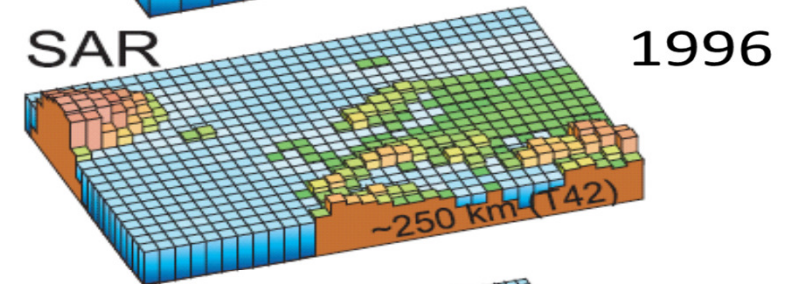
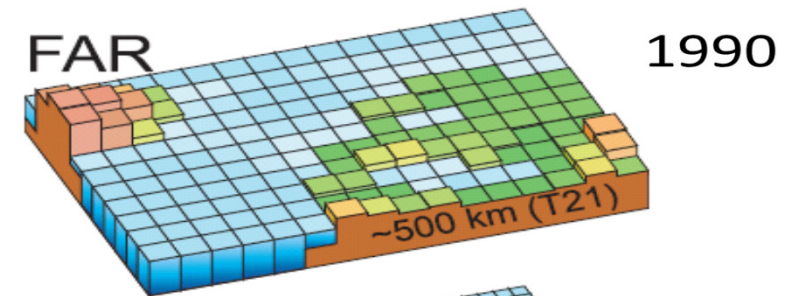
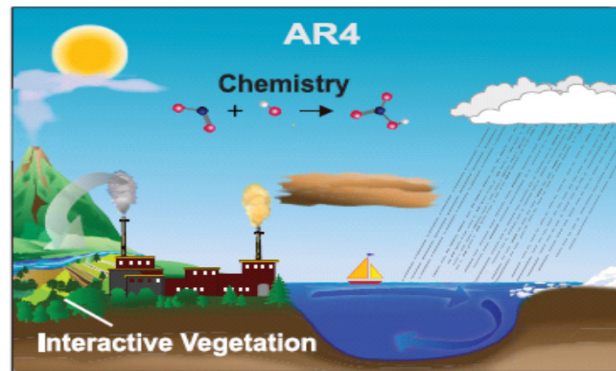
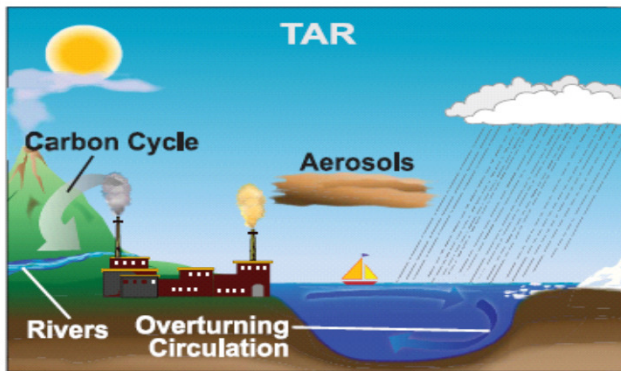
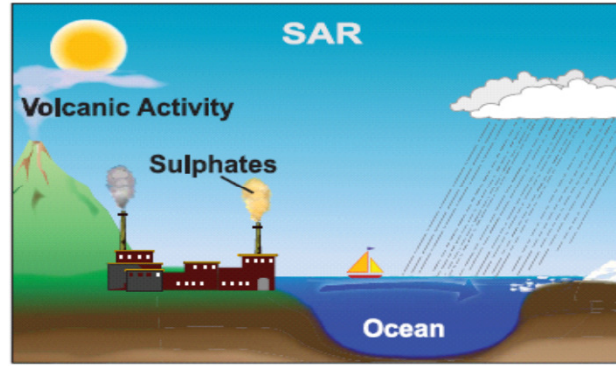
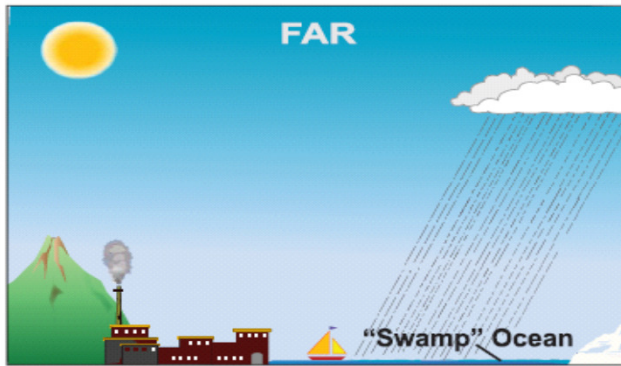
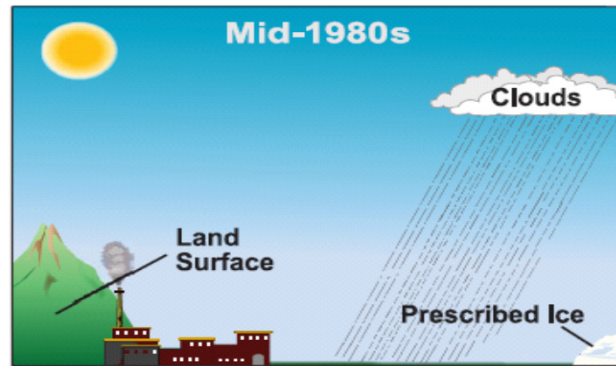
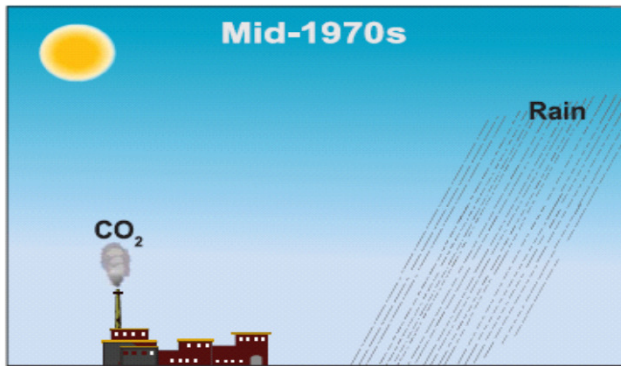
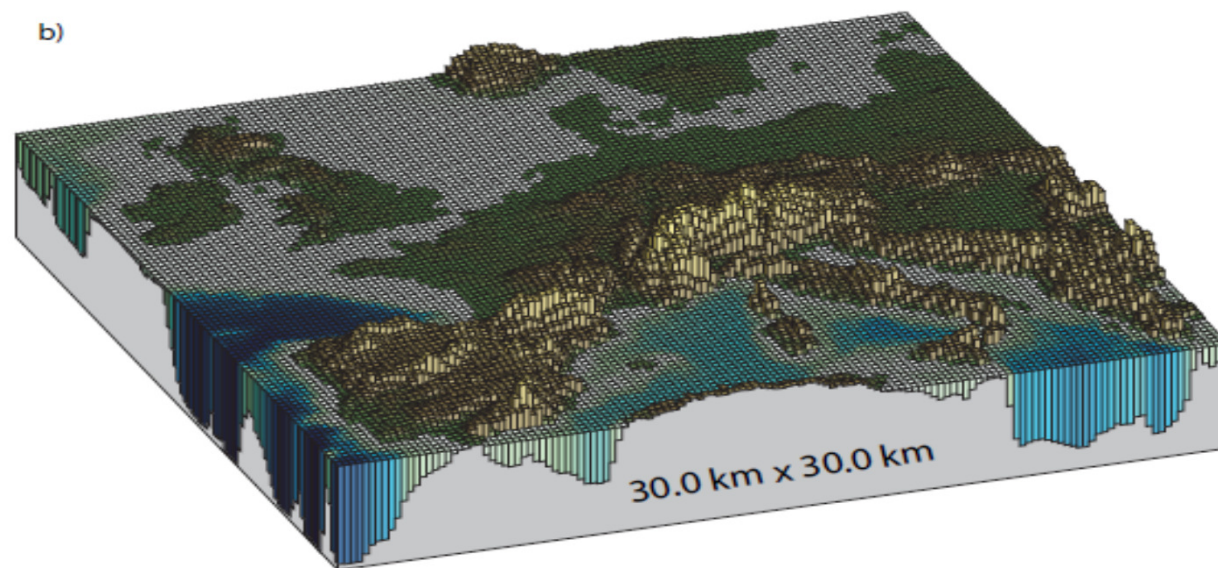
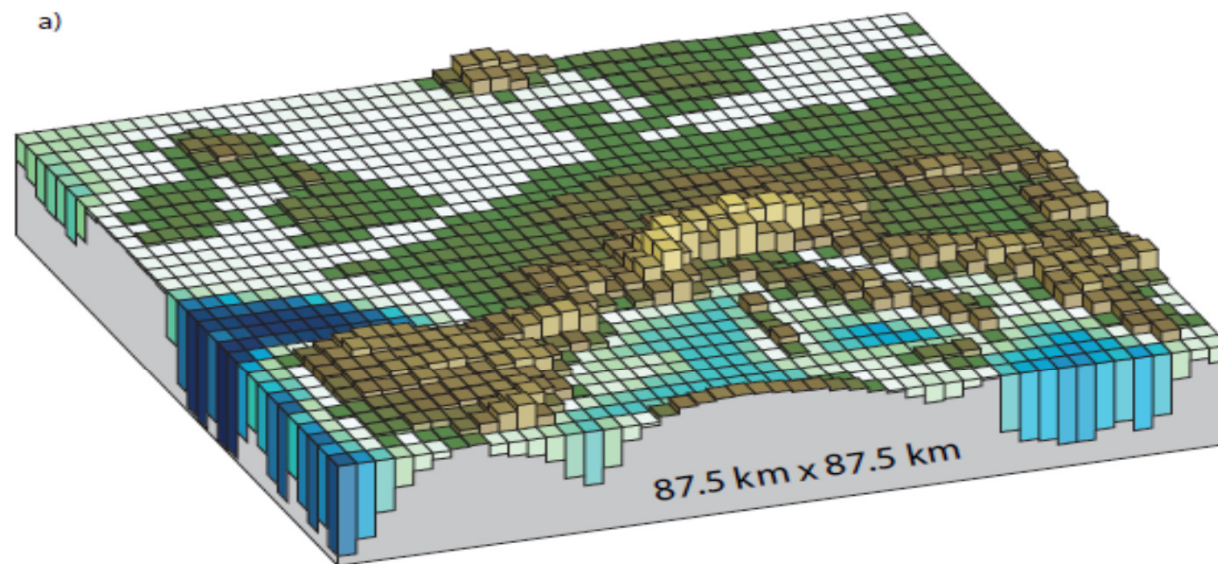


Figure 1.13 | The development of climate models over the last 35 years showing how the different components were coupled into comprehensive climate models over time. In each aspect (e.g., the atmosphere, which comprises a wide range of atmospheric processes) the complexity and range of processes has increased over time (illustrated by growing cylinders). Note that during the same time the horizontal and vertical resolution has increased considerably e.g., for spectral models from T21L9 (roughly 500 km horizontal resolution and 9 vertical levels) in the 1970s to T95L95 (roughly 100 km horizontal resolution and 95 vertical levels) at present, and that now ensembles with at least three independent experiments can be considered as standard.

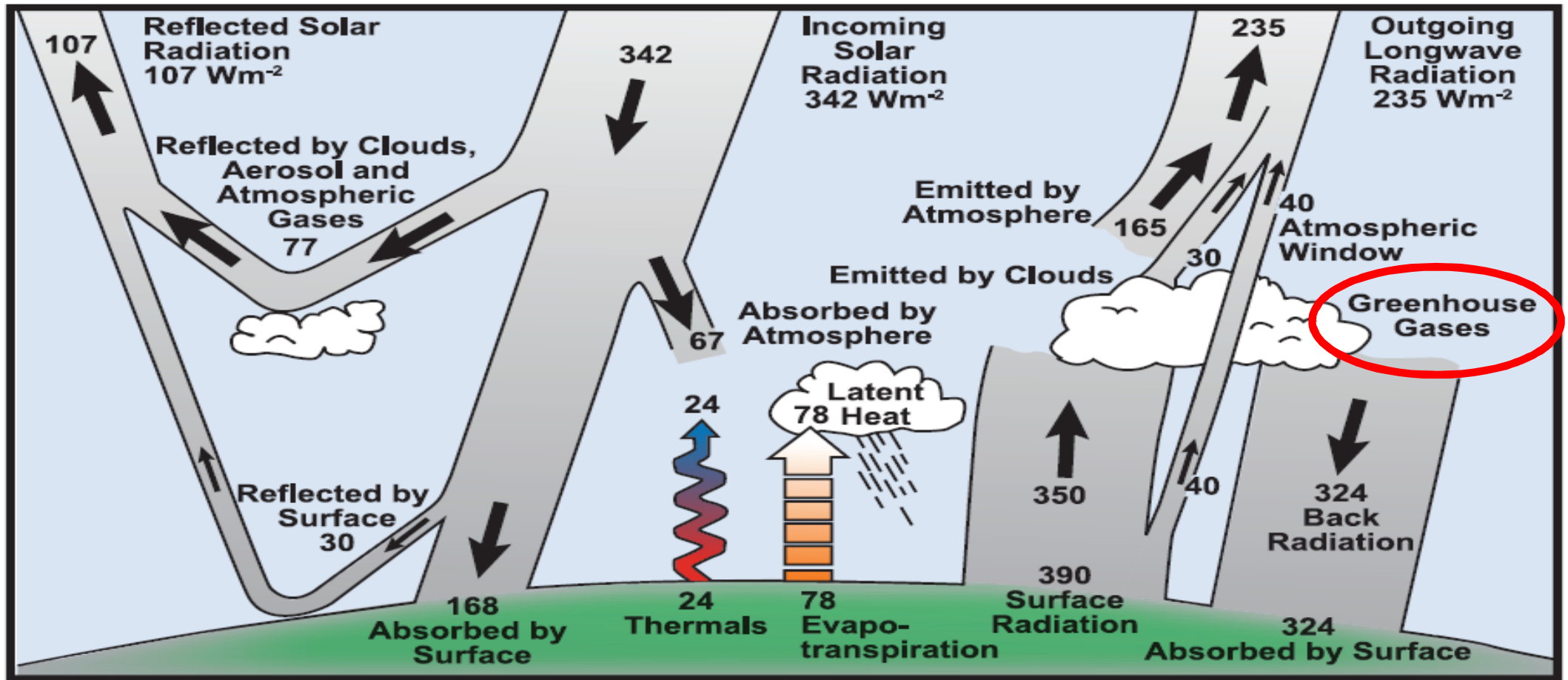
Climate models development



Horizontal resolution AR5 models



Global Mean Energy Balance

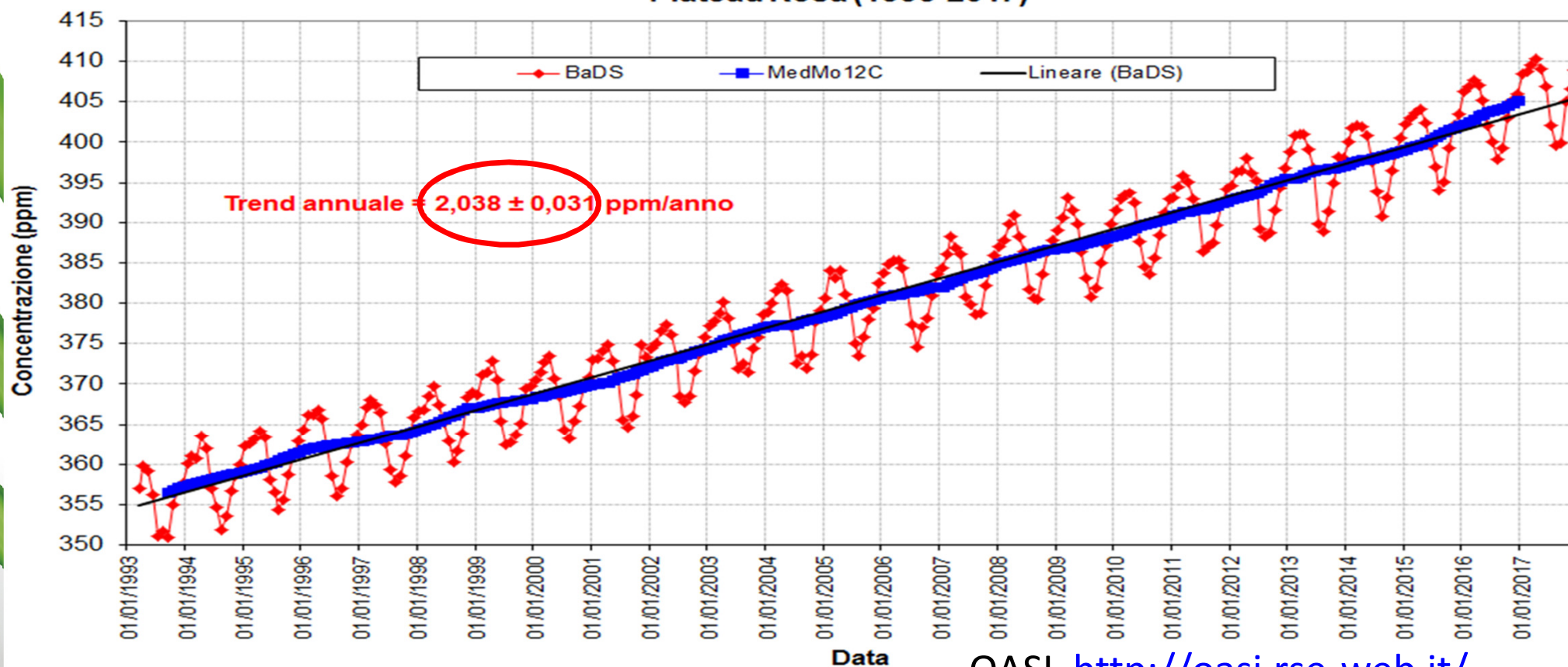


FAQ 1.1, Figure 1. Estimate of the Earth's annual and global mean energy balance. Over the long term, the amount of incoming solar radiation absorbed by the Earth and atmosphere is balanced by the Earth and atmosphere releasing the same amount of outgoing longwave radiation. About half of the incoming solar radiation is absorbed by the Earth's surface. This energy is transferred to the atmosphere by warming the air in contact with the surface (thermals), by evapotranspiration and by longwave radiation that is absorbed by clouds and greenhouse gases. The atmosphere in turn radiates longwave energy back to Earth as well as out to space. Source: Kiehl and Trenberth (1997).

IPCC AR4, 2007

Monitoring Station Plateau Rosa CO2 BaDS (Background Data Selection)

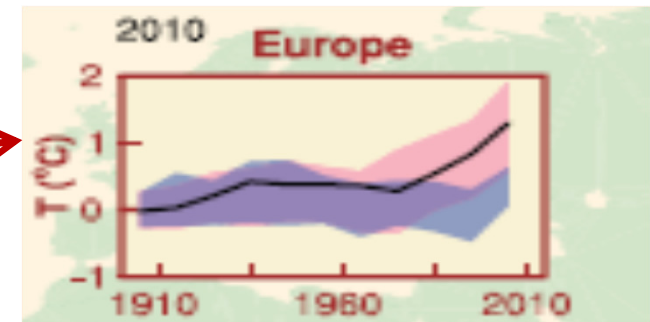
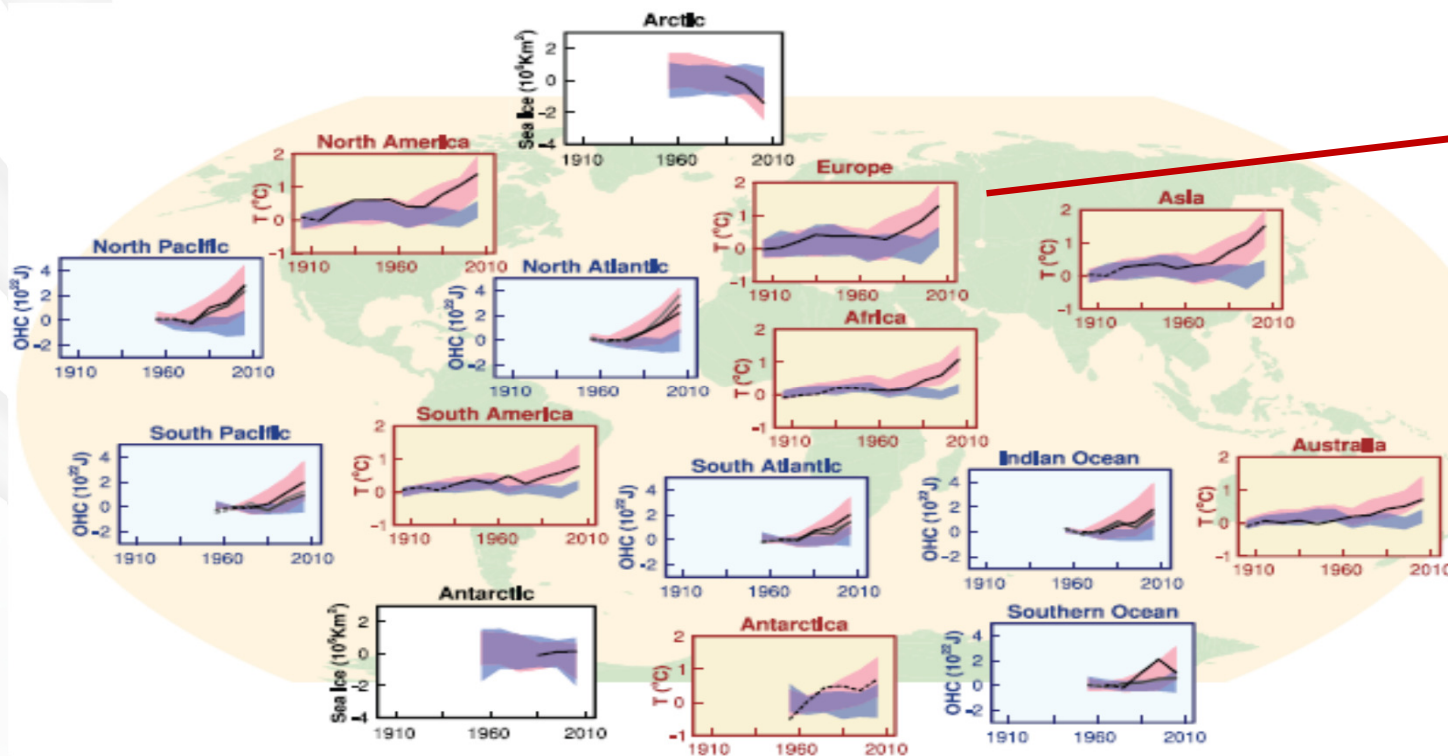
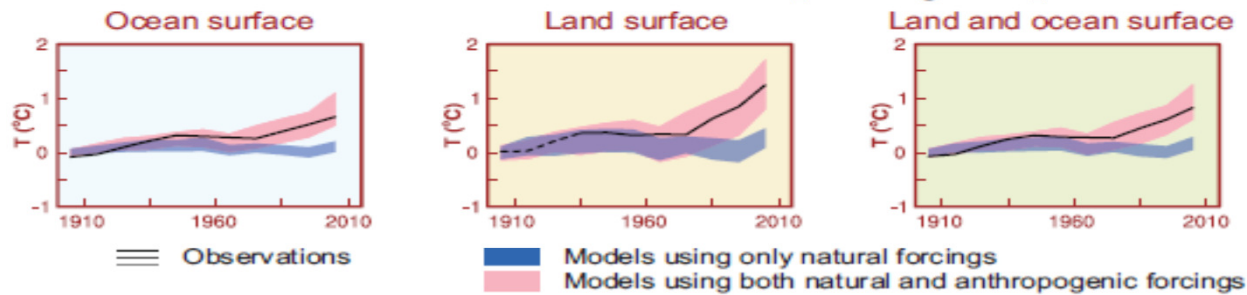
Andamento del valore medio mensile della concentrazione atmosferica di fondo
Plateau Rosa (1993-2017)



OASI <http://oasi.rse-web.it/>

IPCC AR5 (2013)

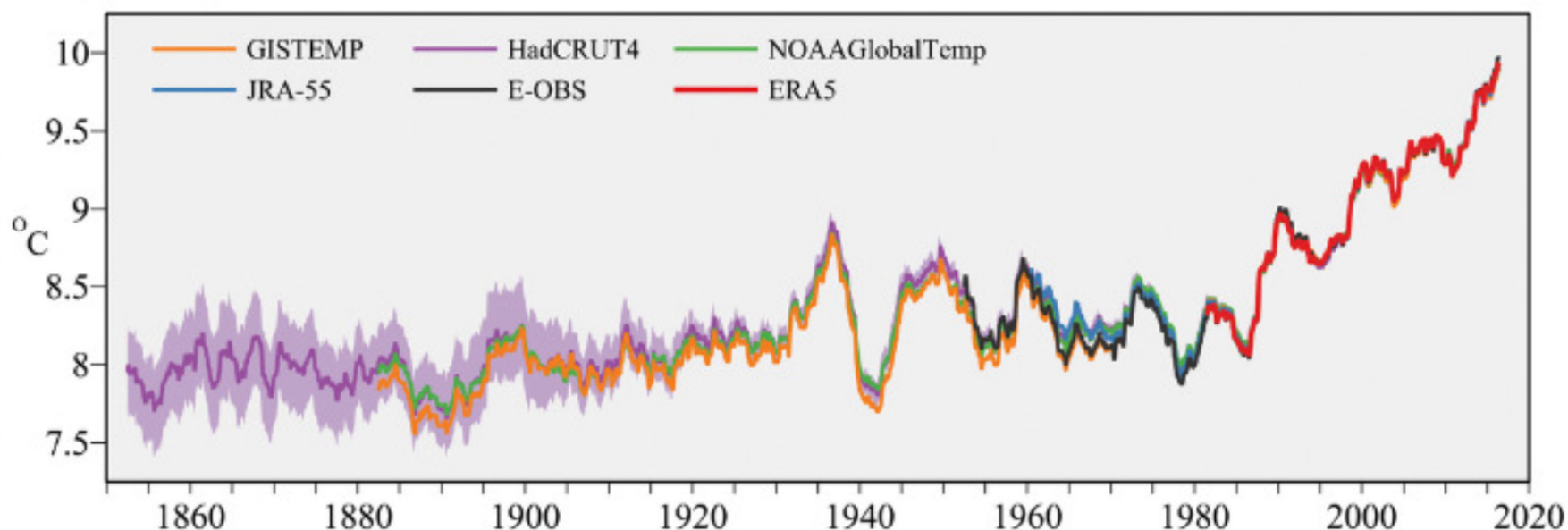
Global Averages



**Mediterraneo
Hot Spot**

Surface European Air Temperature over land

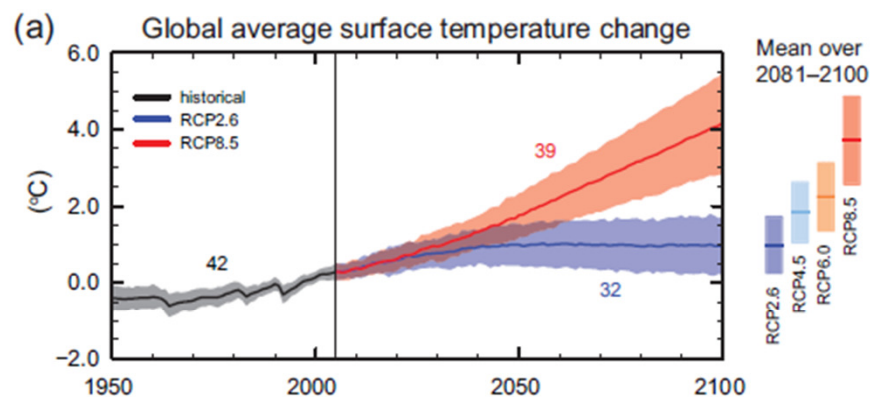
60-month average
European temperature



<https://climate.copernicus.eu/surface-temperature>

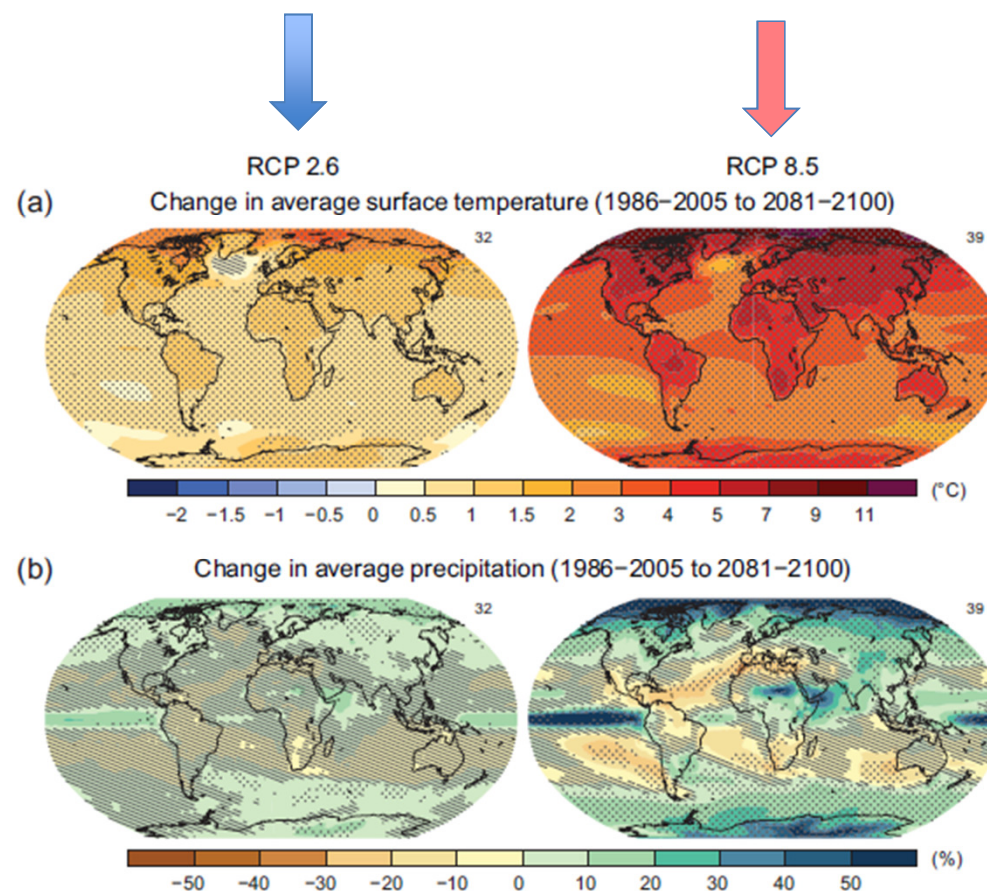
In Europe: an increase of almost 2°C since the latter half of the 19th century

Projected changes in annual average and



surface temperature →

total precipitations →



2. Data-sets



Euro-CORDEX models

(spatial res: 12km x 12 km)

ID Mod	Climate model Simulation
1	KNMI_EC-EARTH_RACMO
2	CLMcom_EC-EARTH_CCLM
3	CLMcom_MPI-ESM-LR_CCLM
4	CLMcom_CNRM-CM5_CCLM
5	KNMI_HADGEM2-ES_RACMO
6	CLMcom_HADGEM2-ES_CCLM
7	SMHI_CM5A-MR_RCA
8	SMHI_CNRM-CM5_RCA
9	SMHI_MPI-ESM-LR_RCA
10	SMHI_EC-EARTH_RCA
11	SMHI_HADGEM2-ES_RCA

The names of simulation identify:
the Research Institute,
the Global Circulation Model
the Regional Climate Model

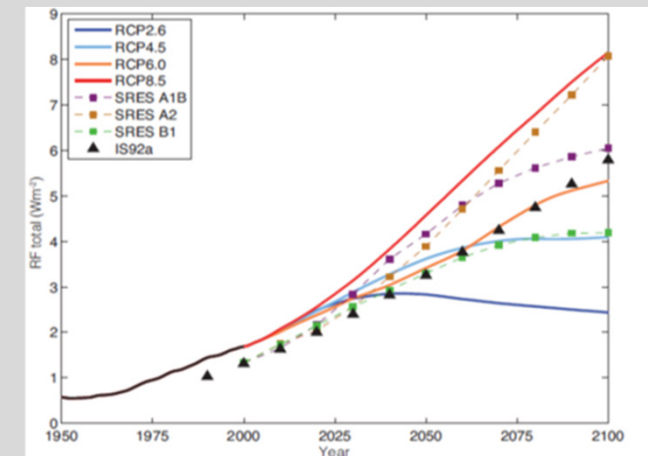
Ricerca sul Sistema Energetico - RSE S.p.A.

3 different socio-economic pathways (Detlef et al., 2011) Representative Concentration Pathway

RCP 8.5

RCP 4.5

RCP 2.6



(Source: Detlef et al, 2011)

RCP 8.5 : BAU

RCP 4.5: partial mitigation

RCP 2.6: mitigation according to Paris Agreement

3. Methodology



- gradual changes

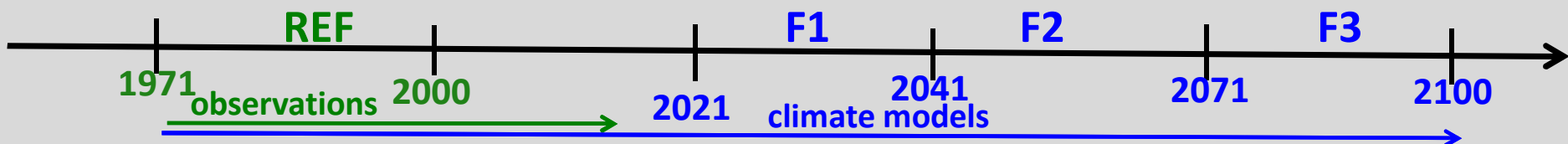
temperature
total precipitation

for different 30y periods

- *extreme weather events*

Droughts
Extreme precipitations

Baseline period	REF = 1971-2000	reference scenario
Future periods	F1 = 2021 – 2050	future scenario at short term
	F2 = 2041 – 2070	future scenario at medium term
	F3 = 2071 – 2100	future scenario at long term



3. Methodology



Climate analysis at annual and seasonal scale

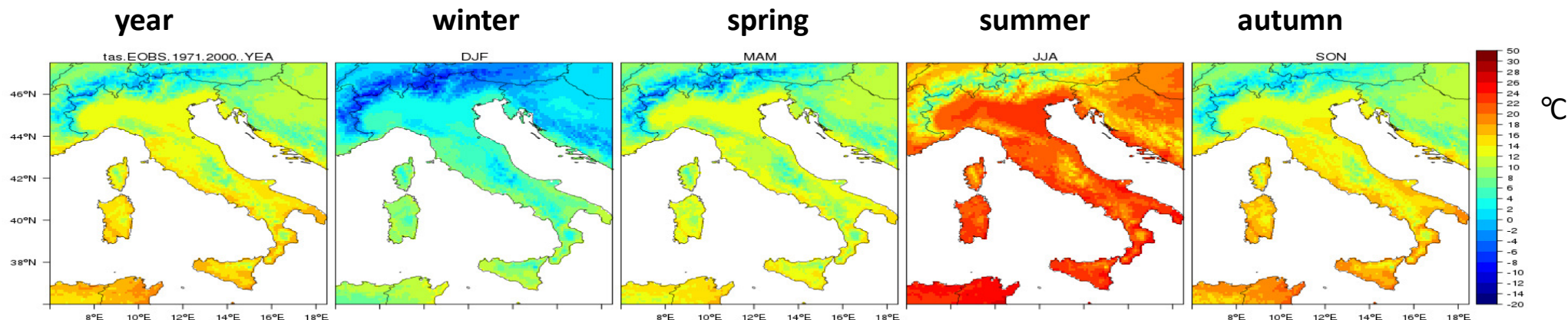
DJF = winter
MAM = spring
JJA = summer
SON = autumn

Reference scenario: Comparison between $V_{mod}(REF)$ and $V_{obs}(REF)$

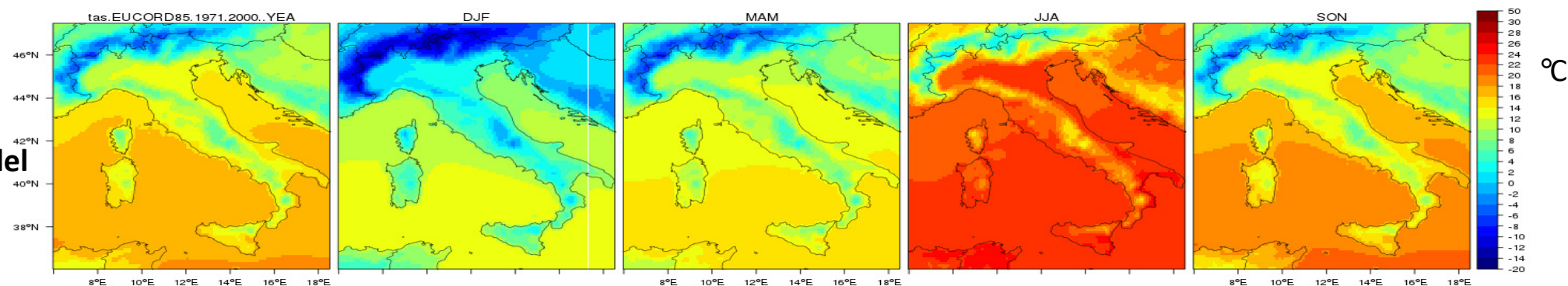
Future scenarios: $V_{mod}(FUT) - V_{mod}(REF)$

Temperature – Reference values 1971-2000

E-OBS
Ref
Scenario



ENS
Multi-model
scenario



Future Temperature Anomalies against Ref Scenario (1971-2000)

Anomalies: ΔT

RCP 8.5

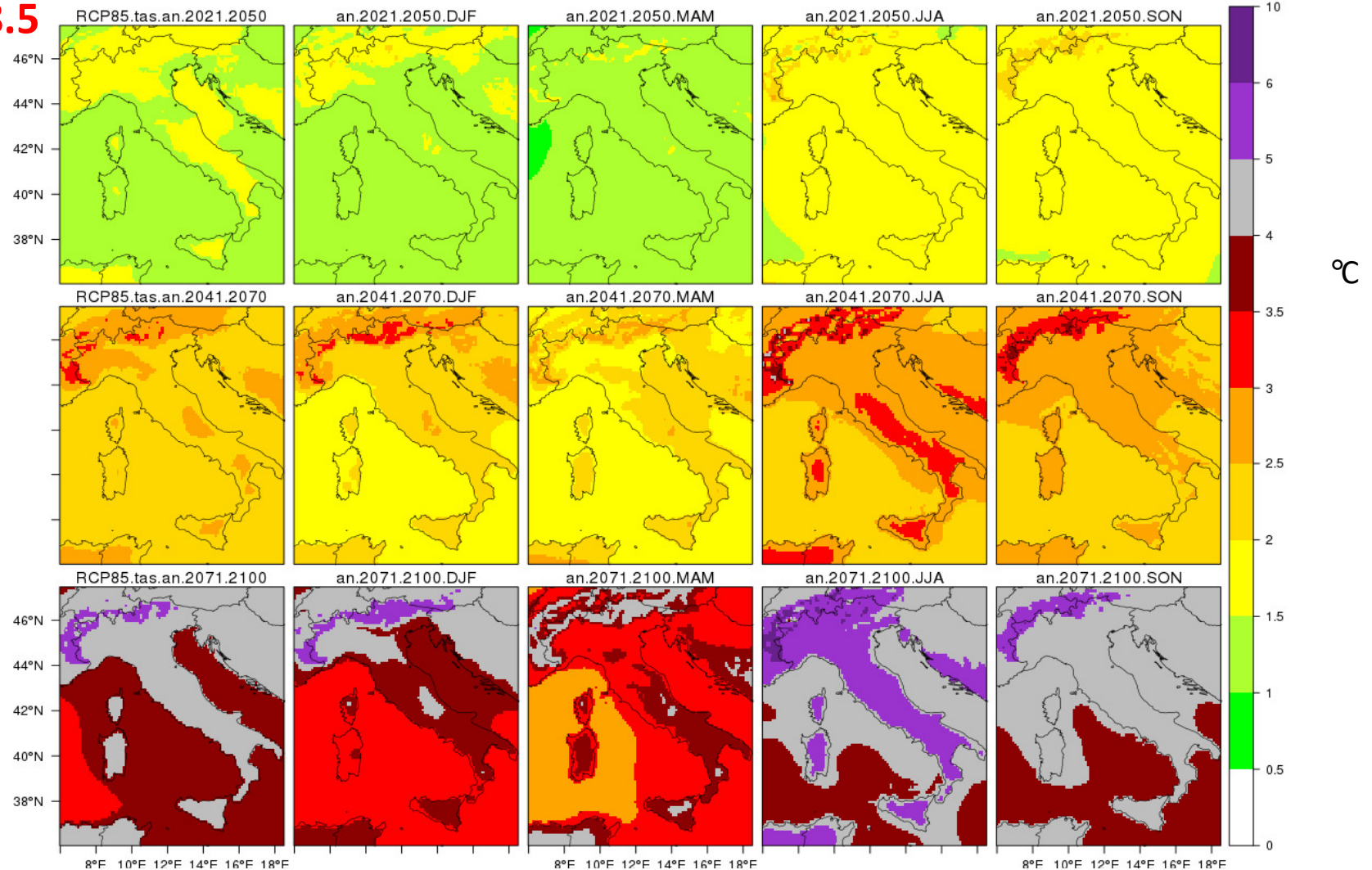
annual

winter

spring

summer

autumn



Ricerca sul Siste

Warming of about 2°C in the next decades, 3°C in the mid of the century, and more than 5°C in the last thirty-years period

Future Precipitation Anomalies against Ref Scen.1971-2000

Anomalies: %

RCP 8.5

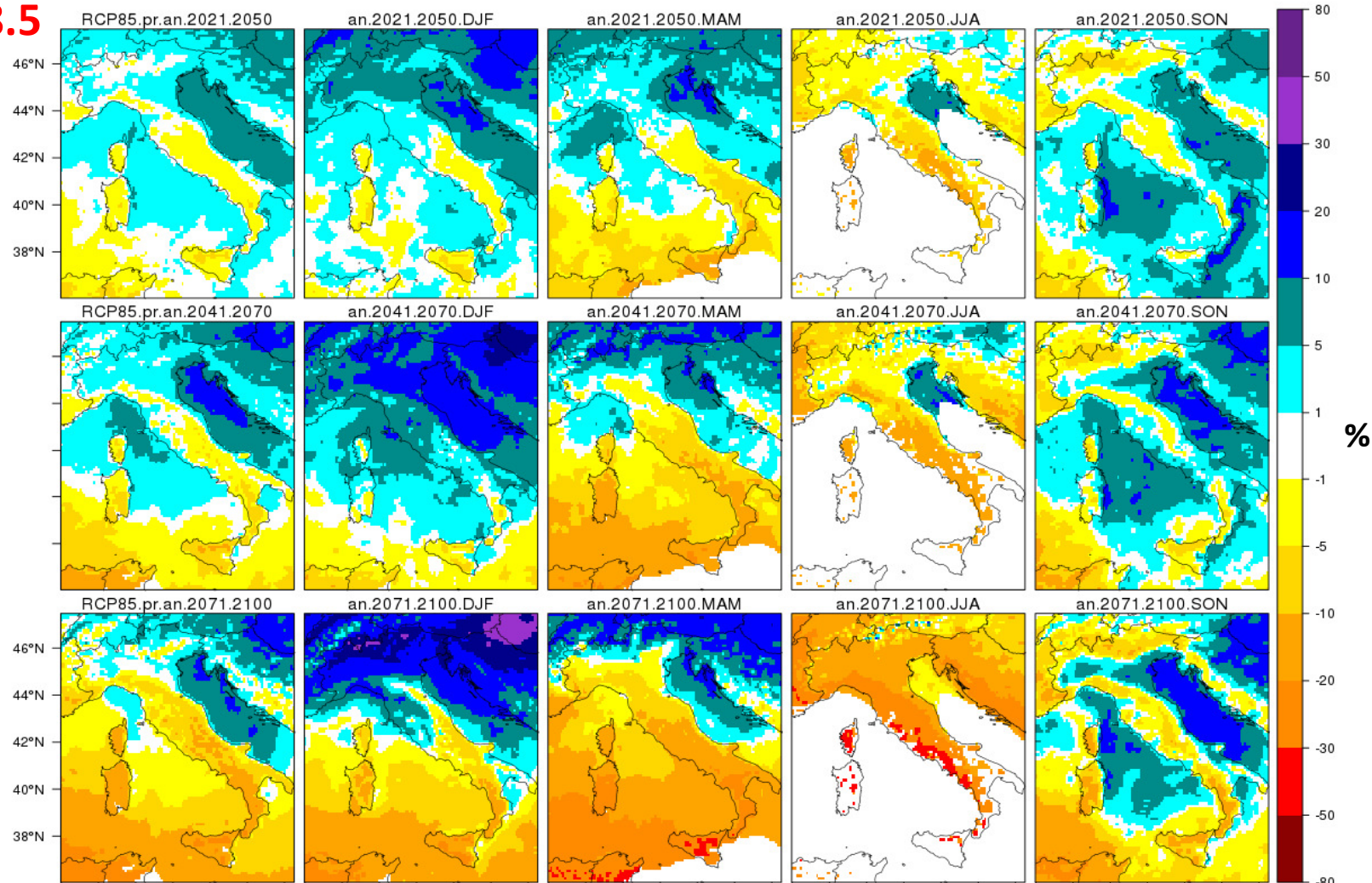
annual

winter

spring

summer

autumn



F1= 2021-2050

F2= 2041-2070

F3= 2071-2100

Ricerca sul Siste

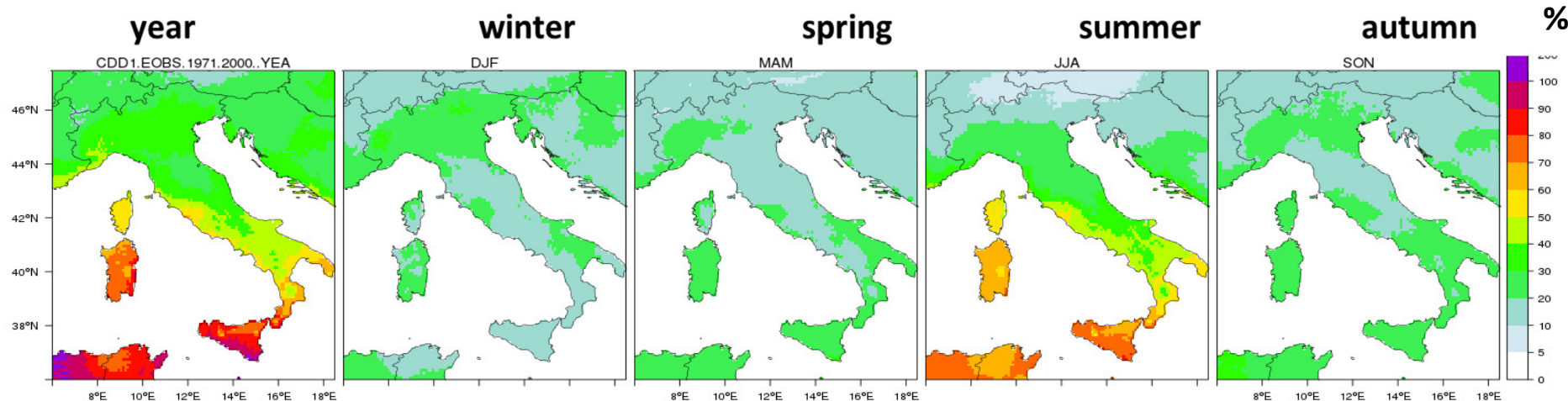
Significant pr reduction in spring/summer ranging in 5 - 10% in the first half of the 21 century until 30-50% at the end of it

Droughts REF

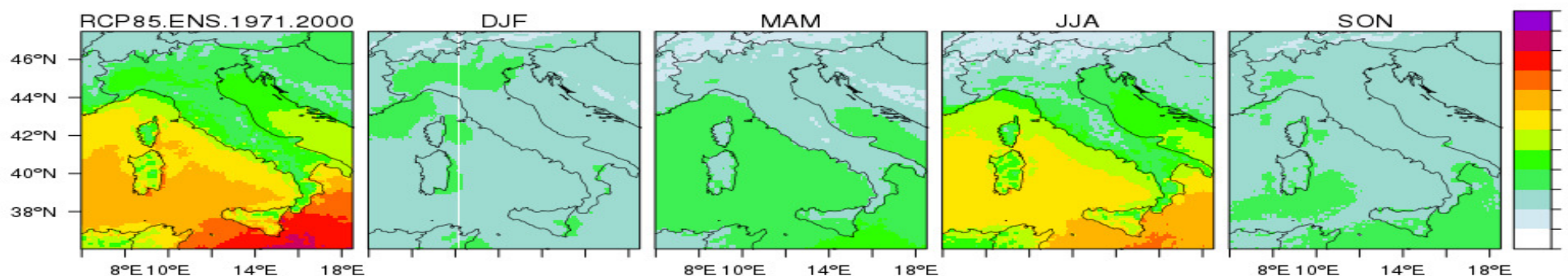
Consecutive Dry Days (CDD) - maximum length of dry spell ($pr < 1 \text{ mm}$)



E-OBS



ENS



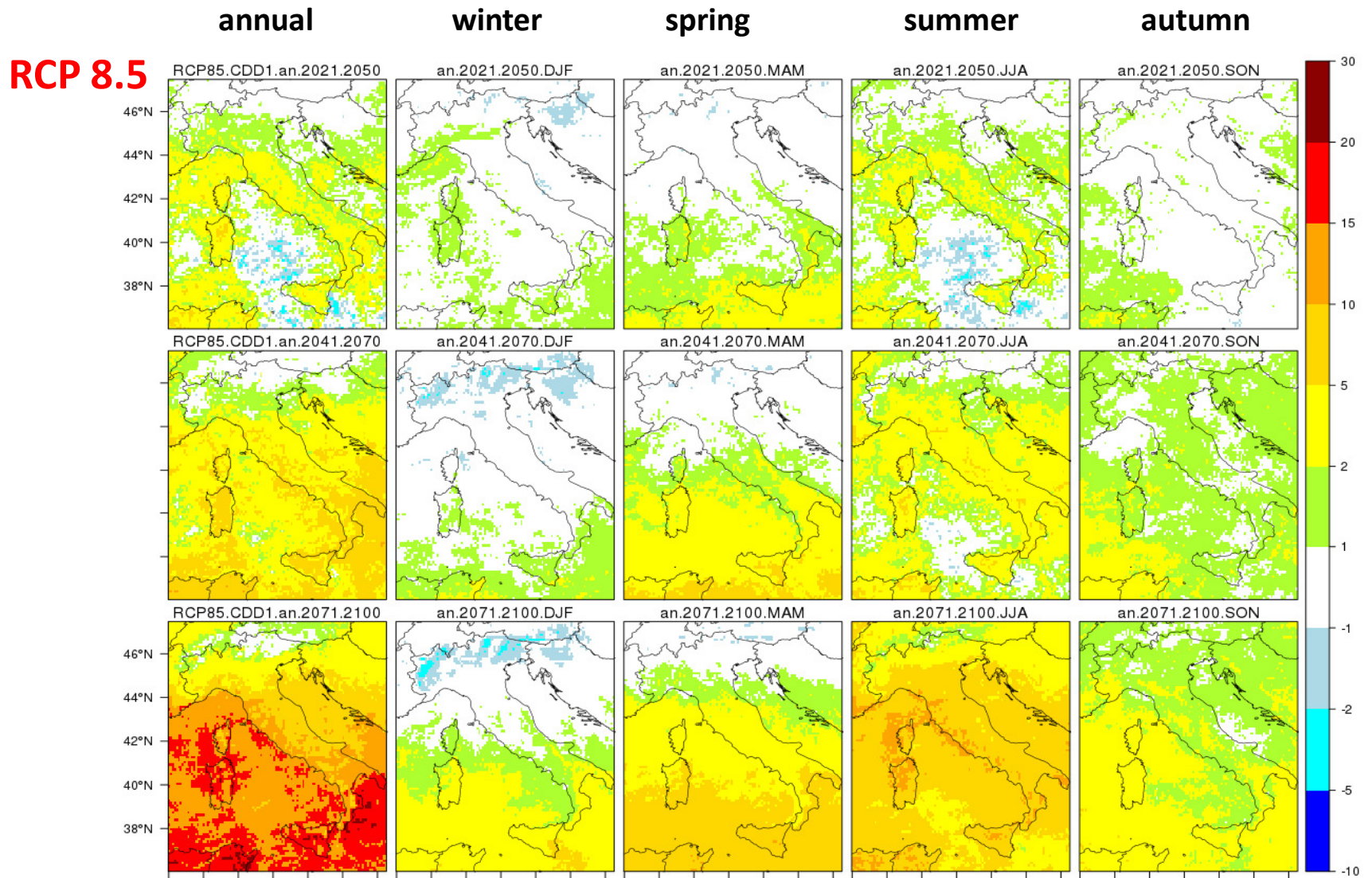
Changes of Droughts against Ref Scen. 1971-2000

max lenght CDD
Anomalies: ΔN

F1= 2021-2050

F2= 2041-2070

F3= 2071-2100



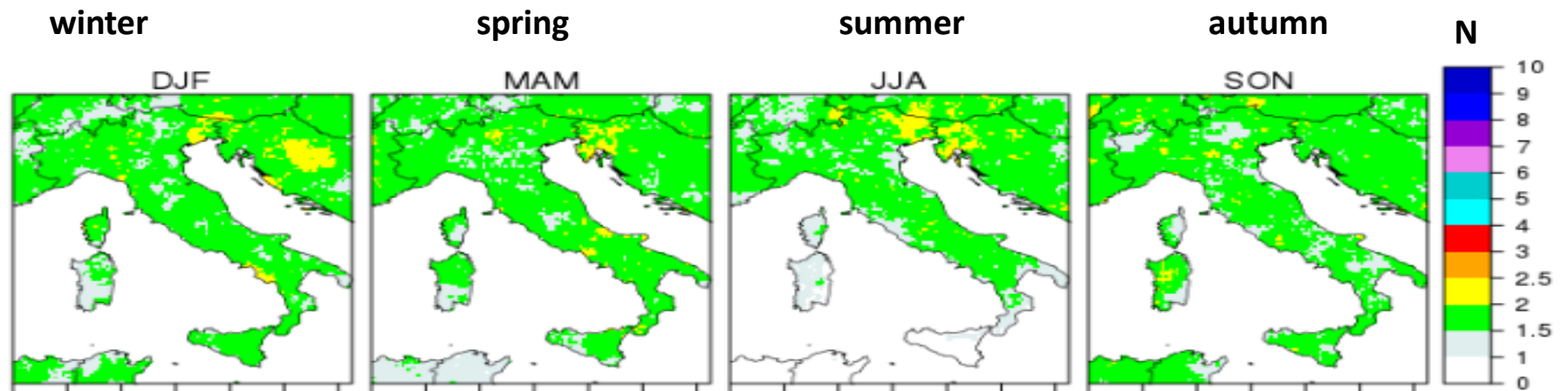
Significant CDD lenghting in spring/summer of about 2-5 days in the next decades, till 5-10 days in the last period of the century

Extreme Precipitations

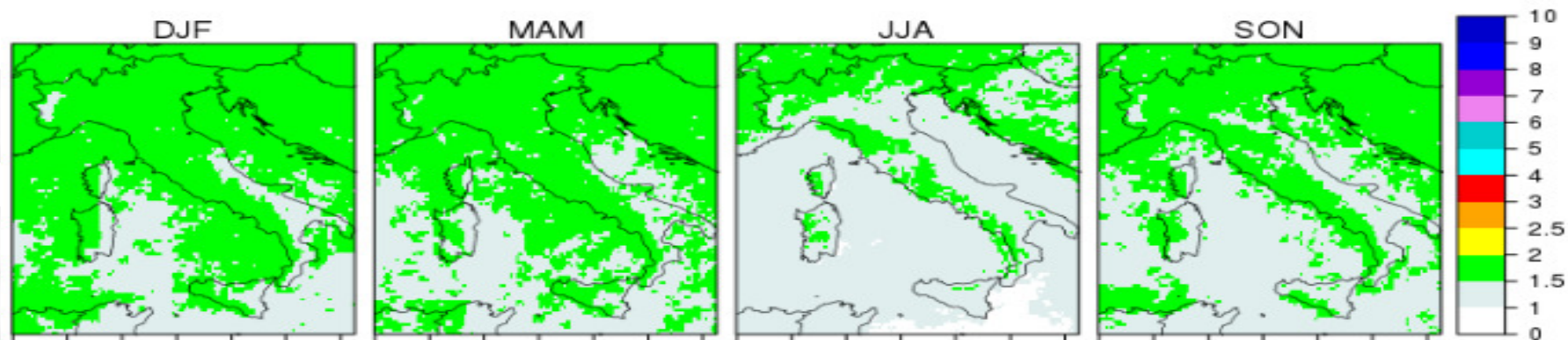
1. $99^{\circ}P$
2. $RR > 99^{\circ}p$



E-OBS



ENS



Changes of Extreme Precipitation against Ref Scen. 1971-2000

R99P: RR > 99^op
Anomalies: ΔN

RCP 8.5

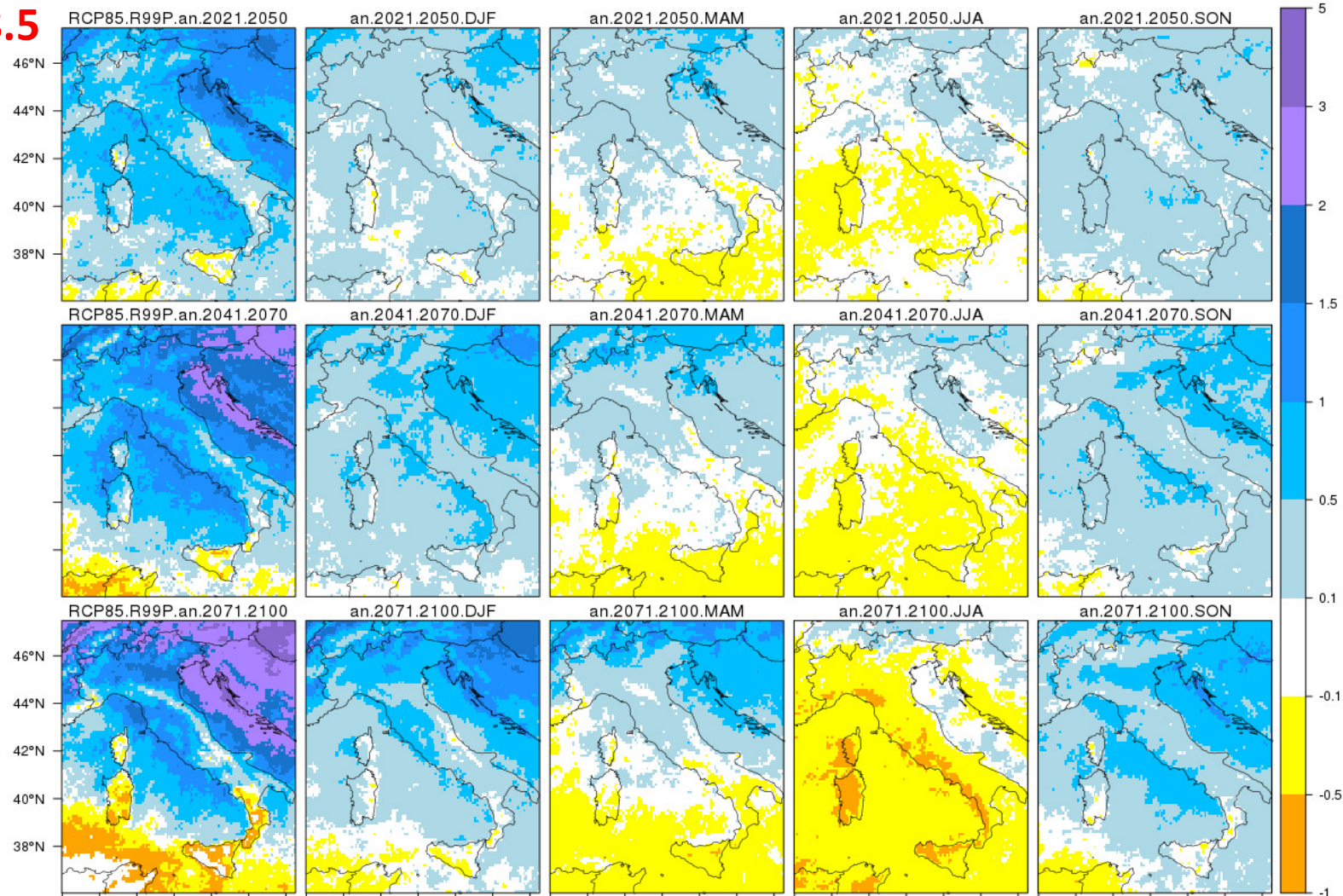
annual

winter

spring

summer

autumn



Extreme precipitations show a serious rise, their danger will depend on both the season and the area

4. Lessons learned

In Europe the frequency of occurrence of climate hazards show significant changes throughout the 21st century (JRC Report, 2016)

Over Italy, too, it is likely an exacerbation of the climate hazards, projected to become more serious in the second part of the century

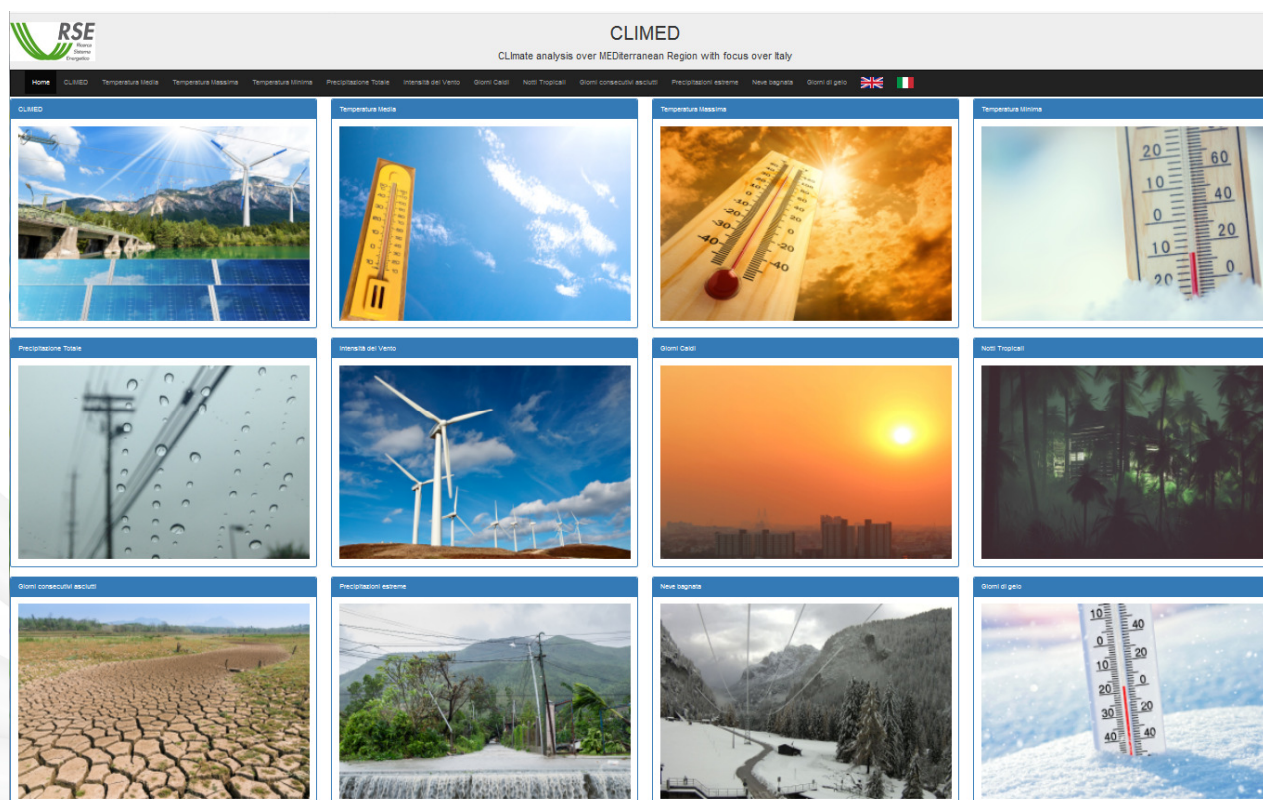
Without mitigation actions, the more significant results highlight:

- Warming of about 2 °C in the next decades, 3 °C in the mid of the century, and more than 5 °C in the last thirty-years period.
- Precipitation decrease is expected, with significant reduction in the summer ranging in between 10 and 20% in the first half of the century, until 50% at the end of it.
- Drought conditions are projected to increase in spring/summer of about 2-5 days in the next decades, till 5-10 days in the last period of the century.
- extreme precipitations show a serious rise, but their danger will depend on both the season and the Italian region.

In the case of a socio-economic pathways RCP2.6, compatible with 1.5 °C increase of the mean air temperature, climate changes are projected to be much lower.

CLIMED CLimate analysis over MEDiterranean Region

<http://climed-rse-web.it>



Thank you for your attention

This work has been financed by the Fund for Research on the national Power System (RdS) under Programme Agreements between RSE and the Italian Ministry for economic development (MiSE).