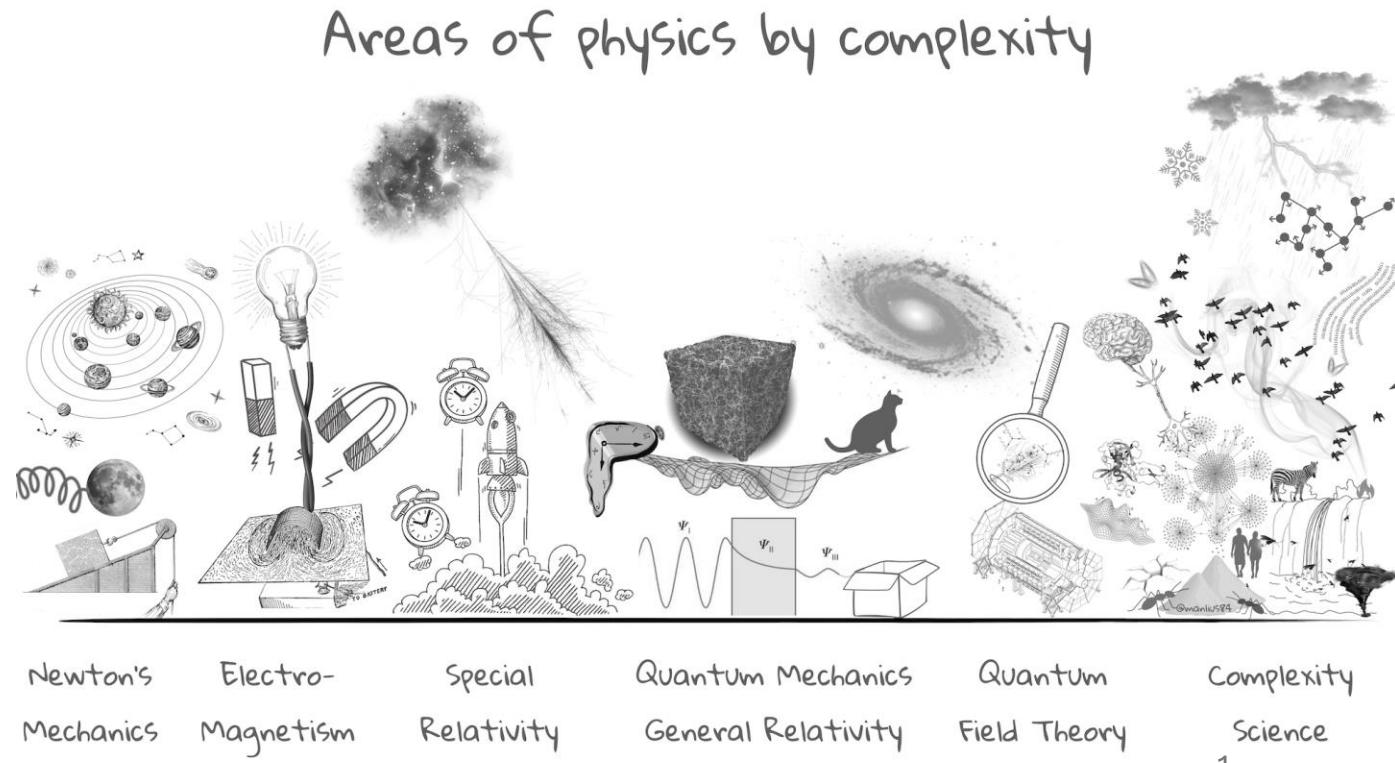


Prof. De Domenico Manlio
Dott. Scagliarini Tomas

CLIMATE NETWORK

Fiaschi Gabriele

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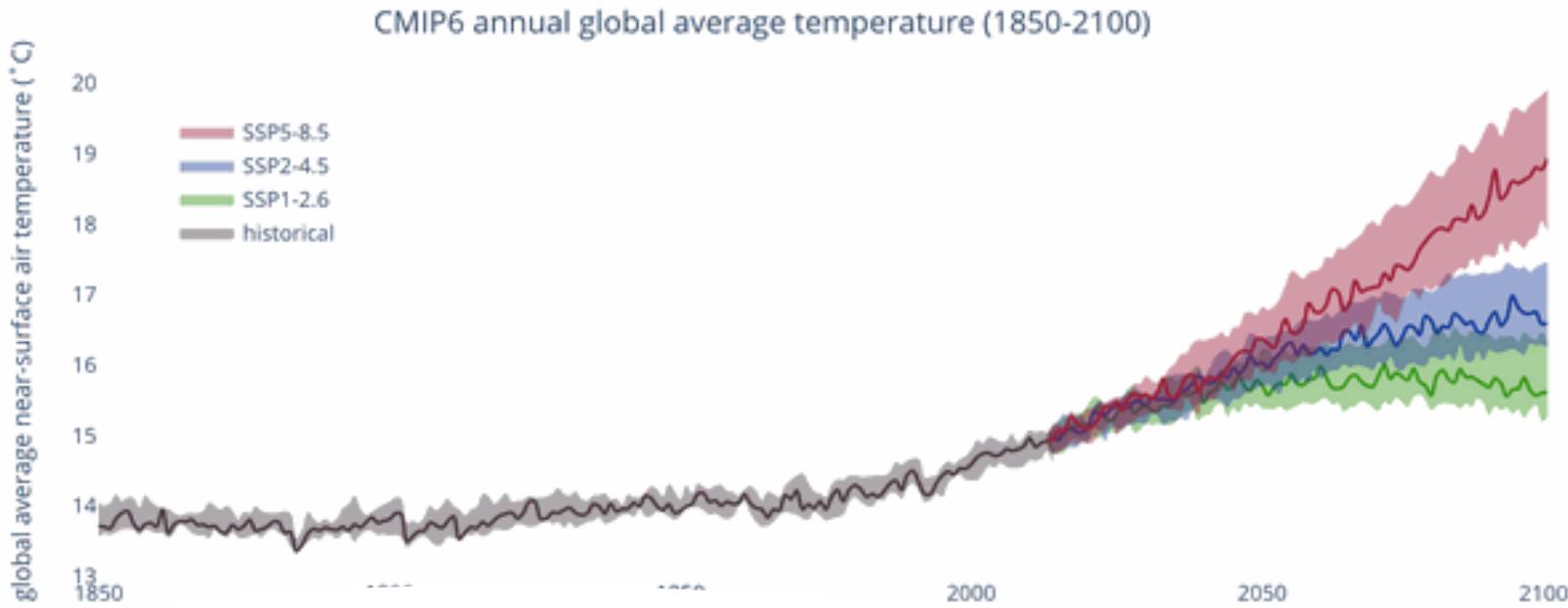
INTRODUCTION



- Earth system is one of the most impressive example of a complex system
- Scientists focus on the coupled dynamics of **land, ocean and atmosphere: GENERAL CIRCULATION MODEL**
- Due to its complexity, the time evolution of the system can be described only with numerical methods

CMIP6 PROJECTIONS

- CMIP6 is the main dataset to do the computational analysis
- It is an "ensemble" of multiple models and scenarios

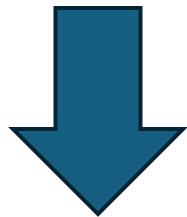


- By considering different models, we can extract a "mean model" and how strong are the dispersion, as a error bar (the grey one)
- In picture we have **SSP**, hypothetical scenario based on the political choice for socio-economic system
- **RCP** the remaining quantity links to the CO₂ emission



COMPUTATIONAL ANALYSIS

PRE-PROCESSING of raw data

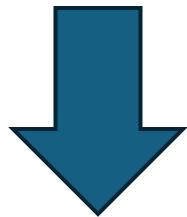


- Importing data and unzip procedure

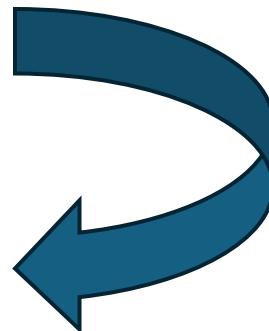


COMPUTATIONAL ANALYSIS

PRE-PROCESSING of raw data

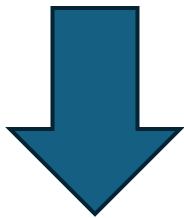


- Importing data and unzip procedure
- ❖ First selection of models and scenarios, during internship was chosen: **awi**, **cmcc**, **cesm** model in **SSP1** and **SSP5** scenarios



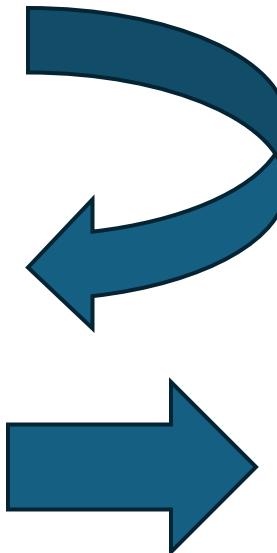
COMPUTATIONAL ANALYSIS

PRE-PROCESSING of raw data



- Importing data and unzip procedure

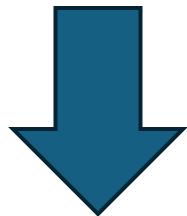
❖ First selection of models and scenarios, during internship was chosen: **awi**, **cmcc**, **cesm** model in **SSP1** and **SSP5** scenarios



❖ We focus on **near surface air temperature**, **air temperature at different pressure level**, **precipitation**

COMPUTATIONAL ANALYSIS

PRE-PROCESSING of raw data

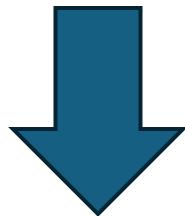


- Importing data and unzip procedure
- Regrid procedure



COMPUTATIONAL ANALYSIS

PRE-PROCESSING of raw data



- Importing data and unzip procedure
- Regrid procedure

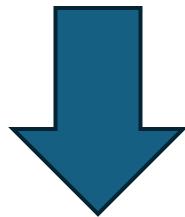


- ❖ Each geographical point in the system is mapped through coordinates (grid)
- ❖ The procedure consists in a sort of **coarse grain**



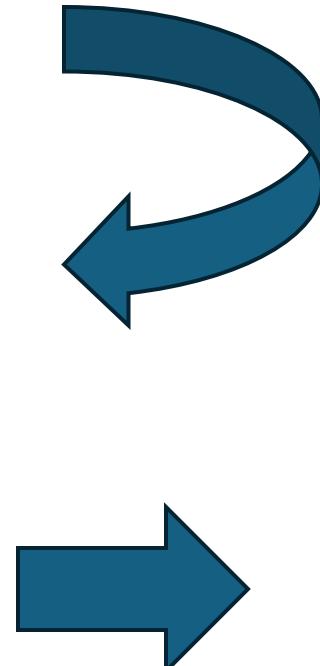
COMPUTATIONAL ANALYSIS

PRE-PROCESSING of raw data



- Importing data and unzip procedure
- Regrid procedure

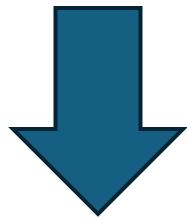
❖ Each geographical point in the system is mapped through coordinates (grid)
❖ The procedure consists in a sort of **coarse grain**



❖ First of all we sample the geographical point then we evaluate the mean behaviour of selected variable taking into account the neighbors' point

COMPUTATIONAL ANALYSIS

PRE-PROCESSING of raw data

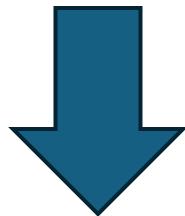


- Importing data and unzip procedure
- Regrid procedure
- Extract anomalies



COMPUTATIONAL ANALYSIS

PRE-PROCESSING of raw data



- Importing data and unzip procedure
- Regrid procedure
- Extract anomalies

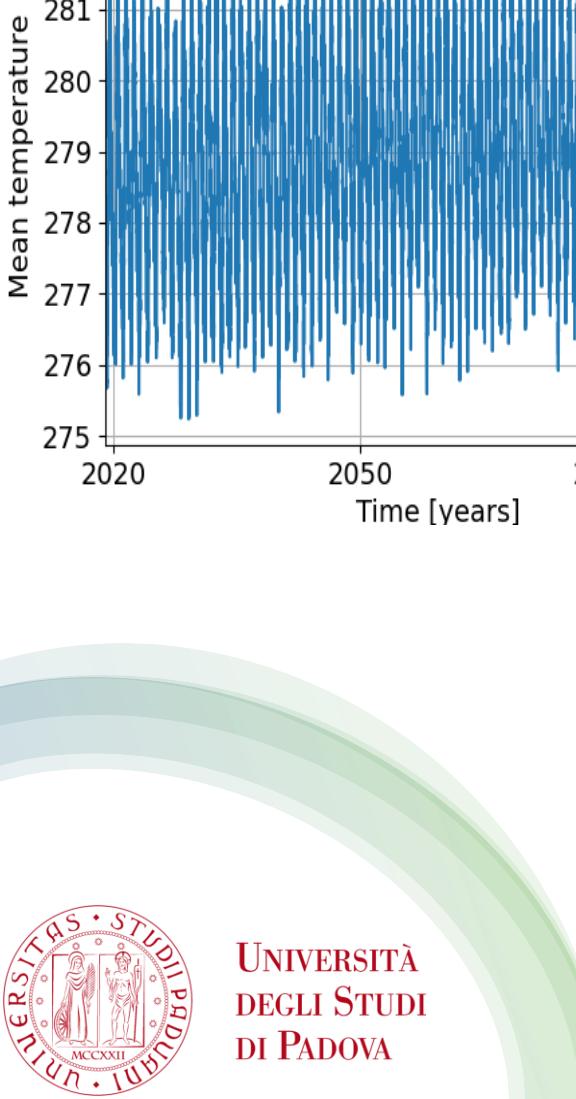


❖ Here we evaluate the discrepancy or **deviation** with respect to the **historical mean temperature**

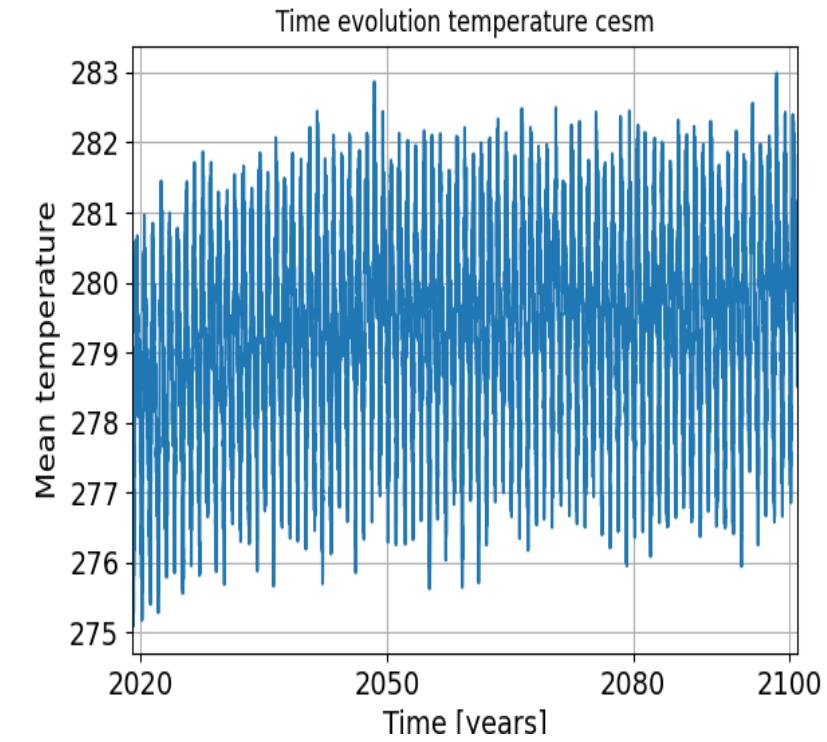
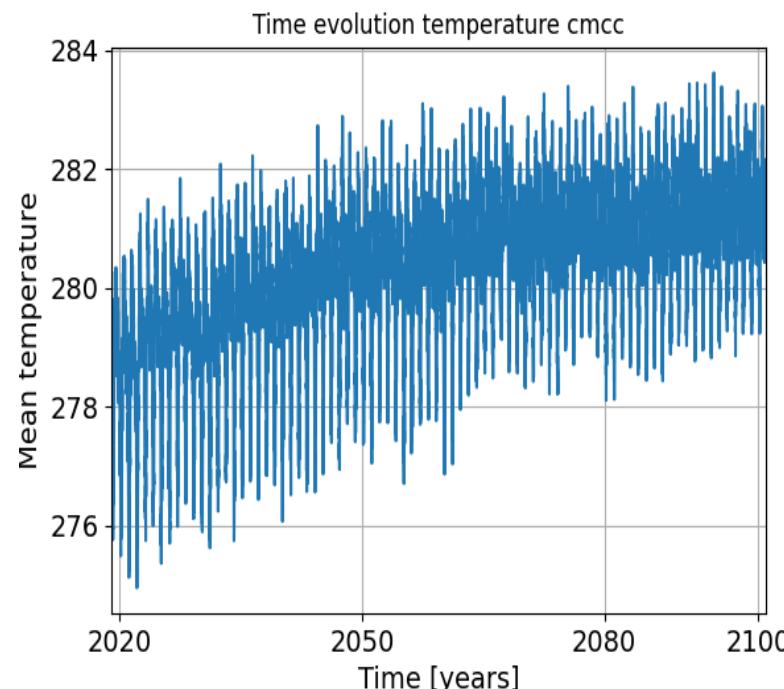
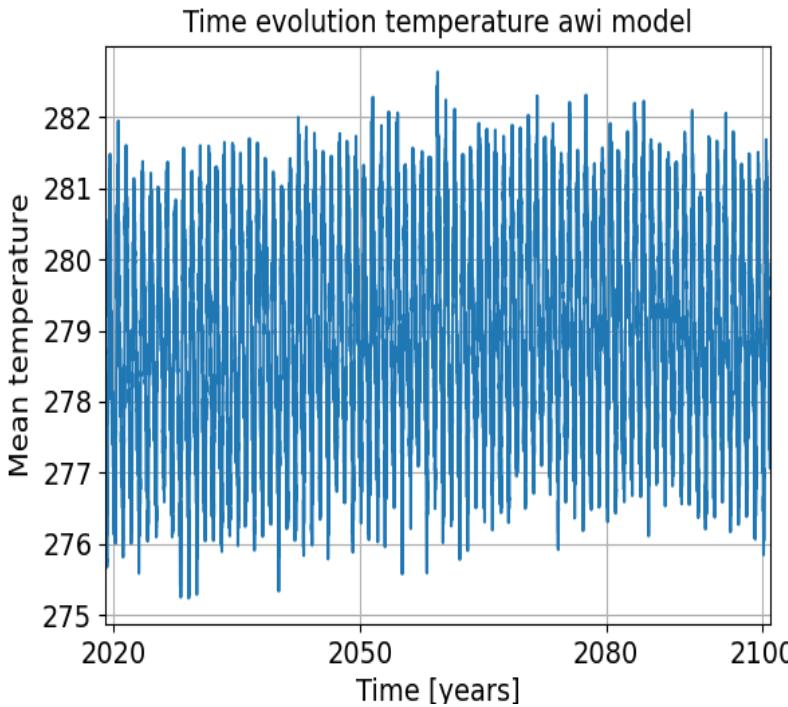


VISUALIZATION OF RESULTS

it is presented
mean temperature
evolution for **SSP1**
scenario for all selected
models



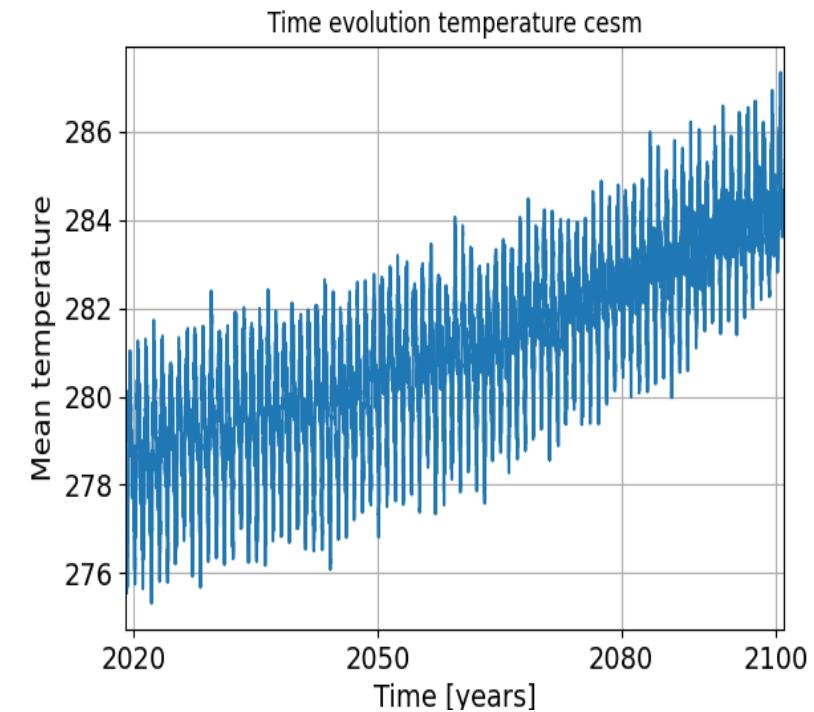
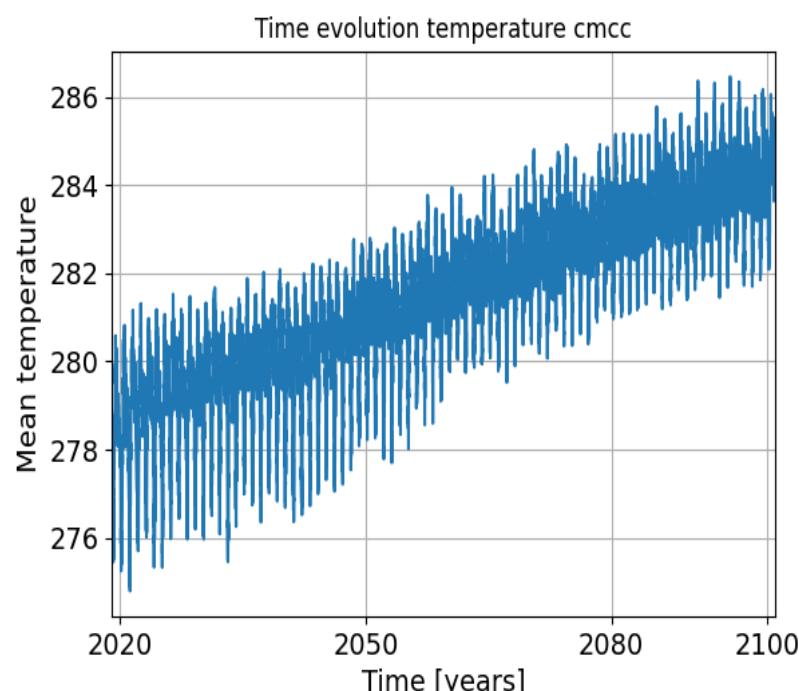
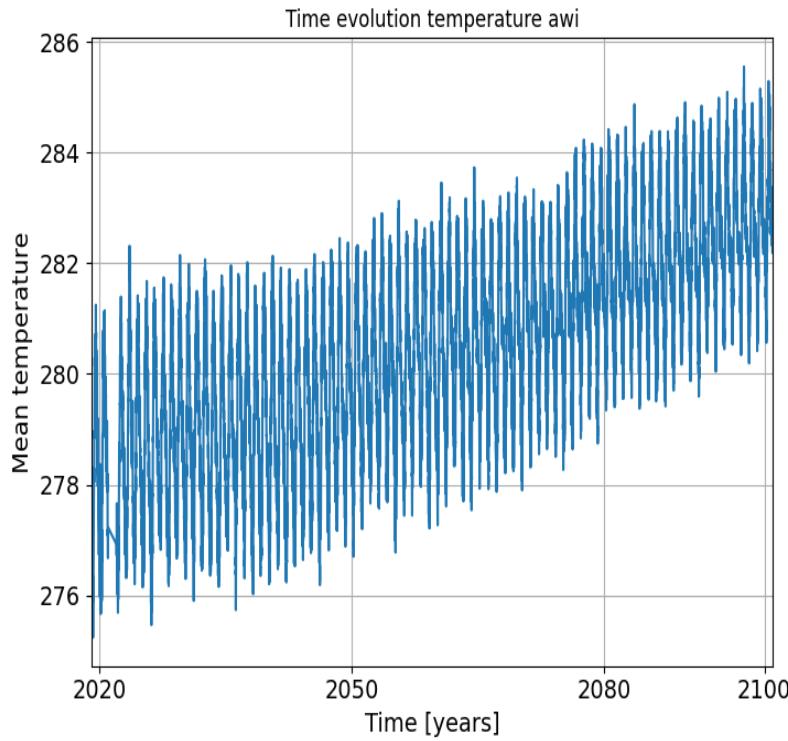
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Notice: there isn't a
specific trend in this
scenario

VISUALIZATION OF RESULTS

it is presented
mean temperature
evolution for **SSP5**
scenario for all selected
models

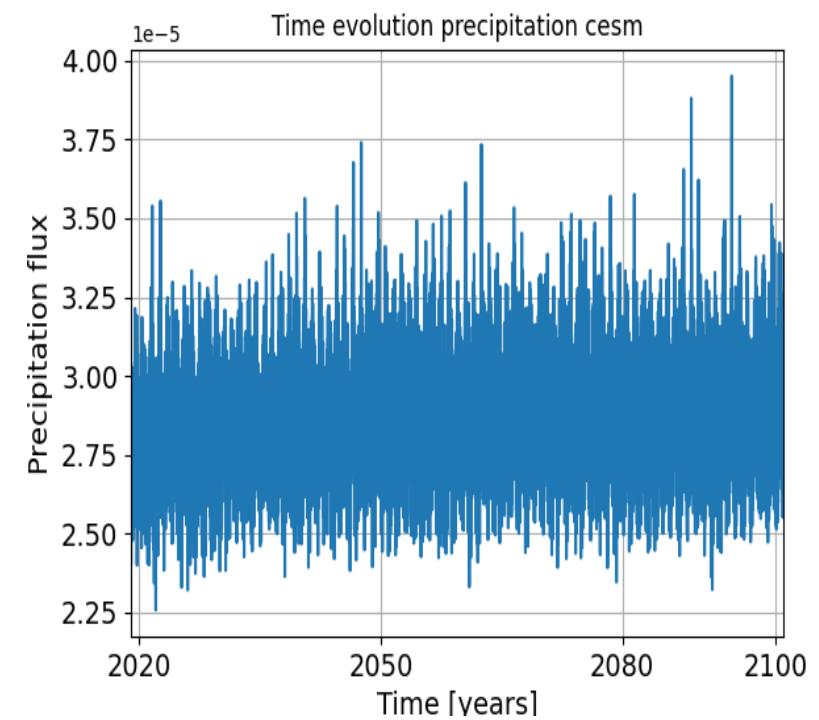
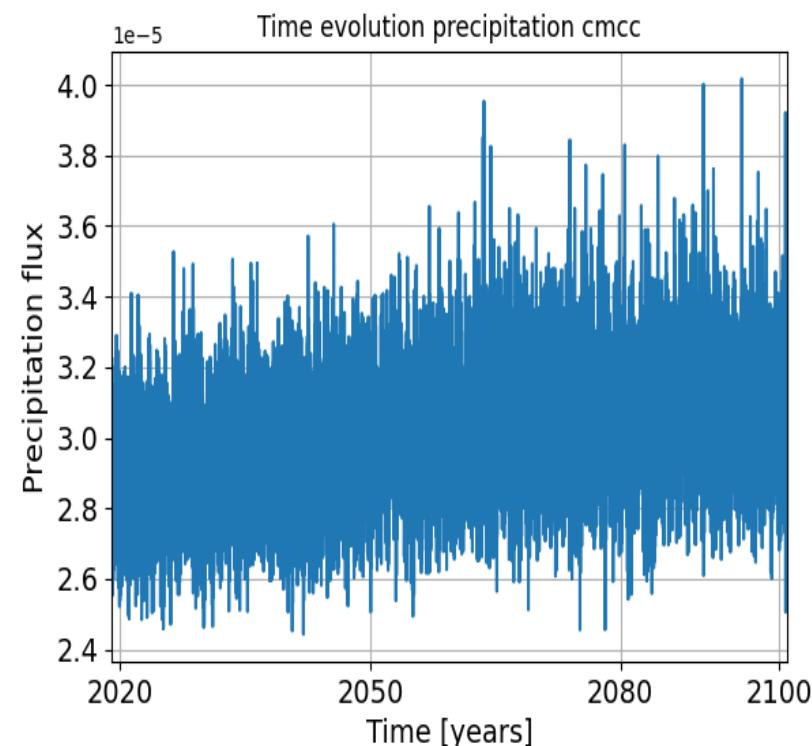
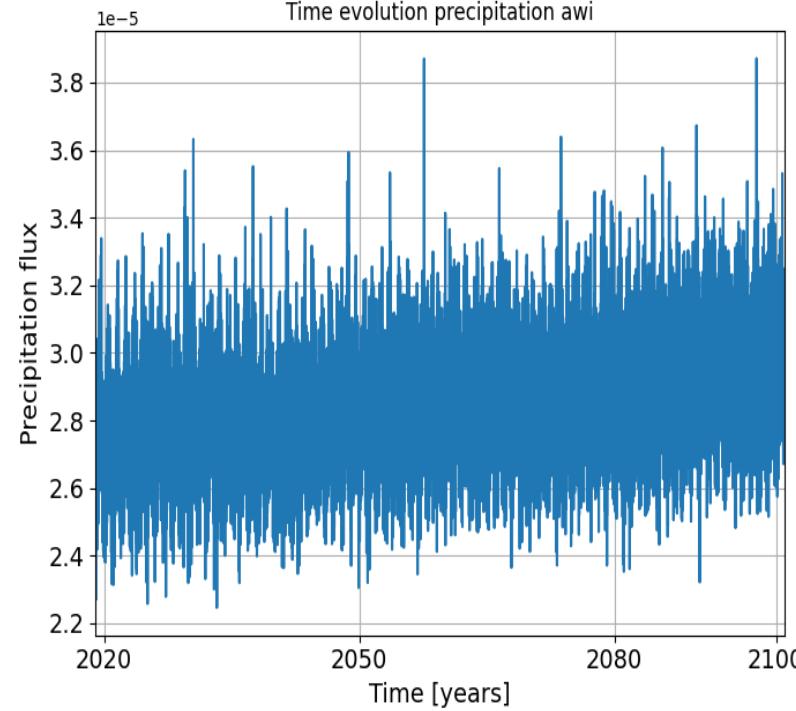


Notice: growth of
mean temperature
across years



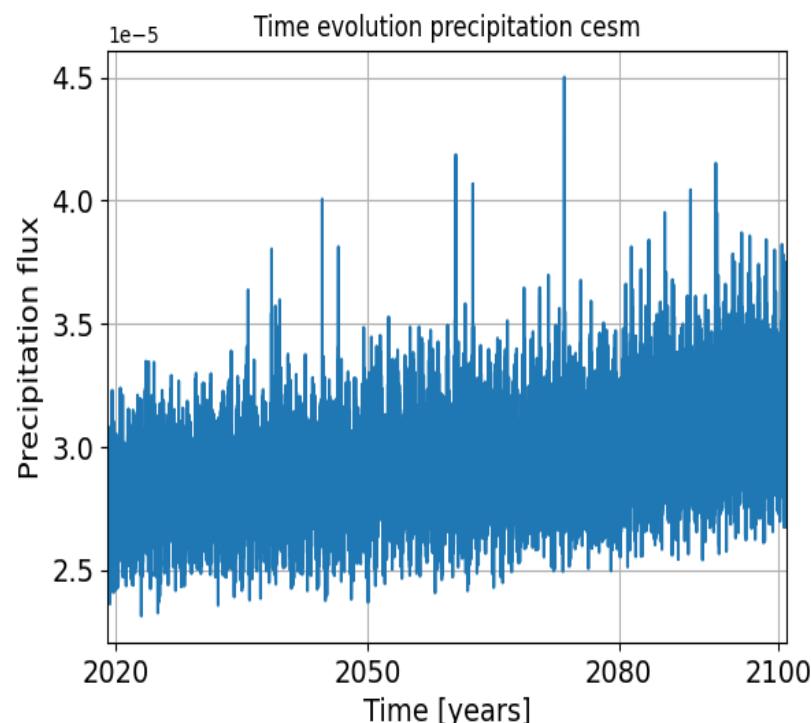
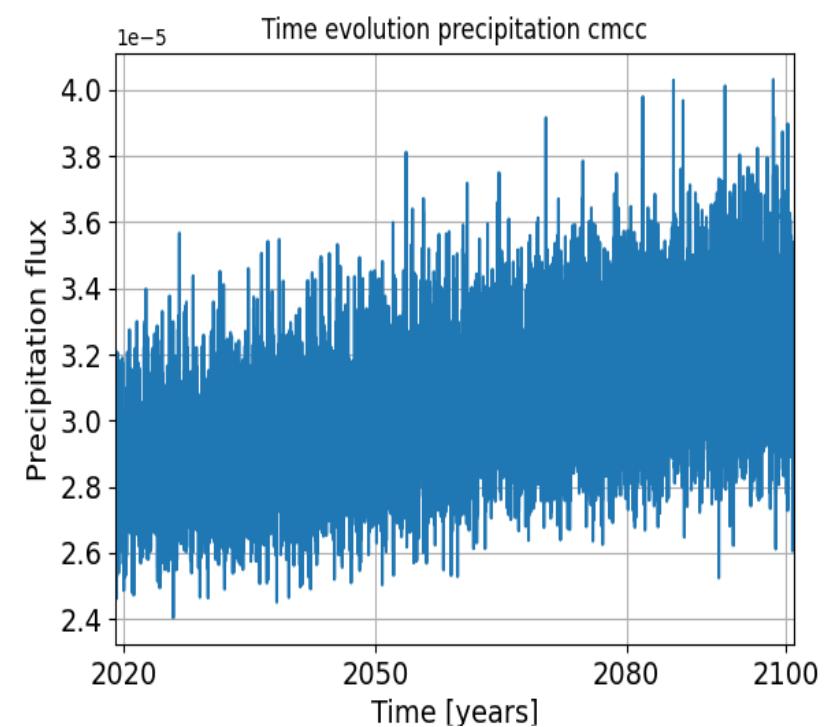
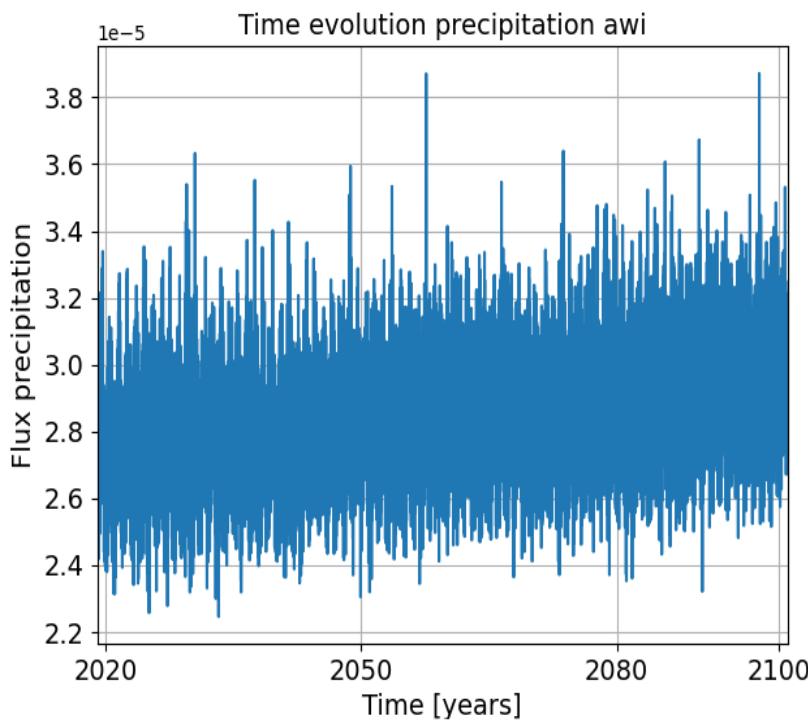
VISUALIZATION OF RESULTS

it is presented
flux precipitation
evolution for SSP1
scenario for all selected
models

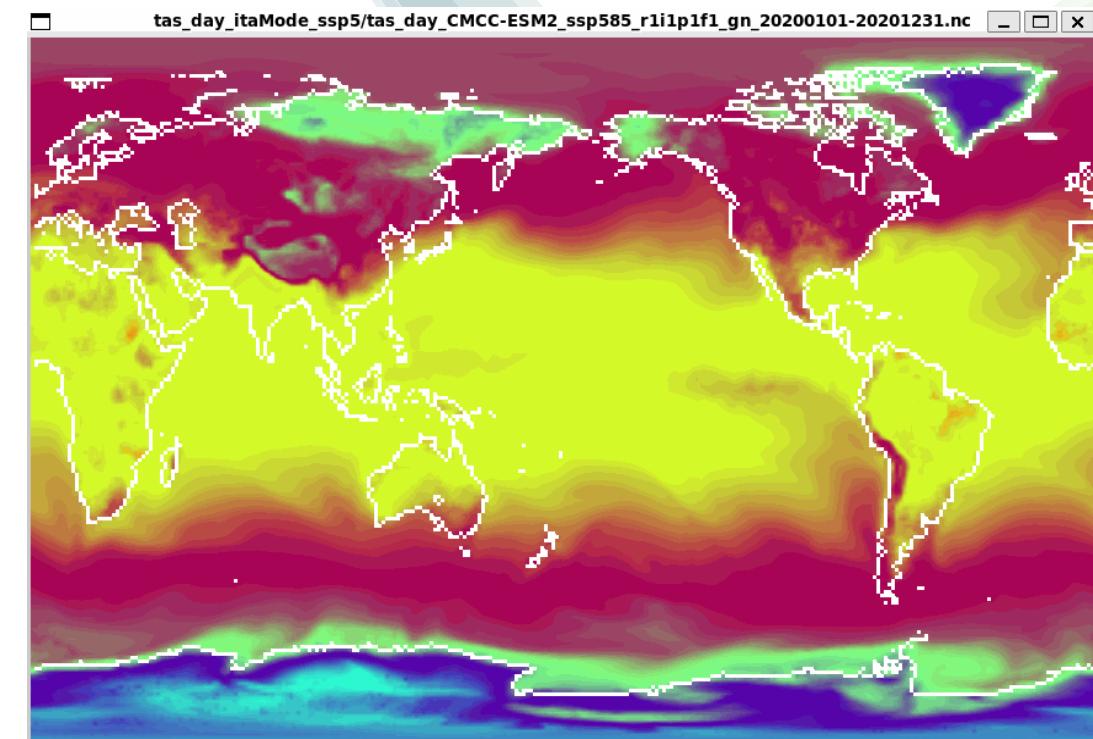
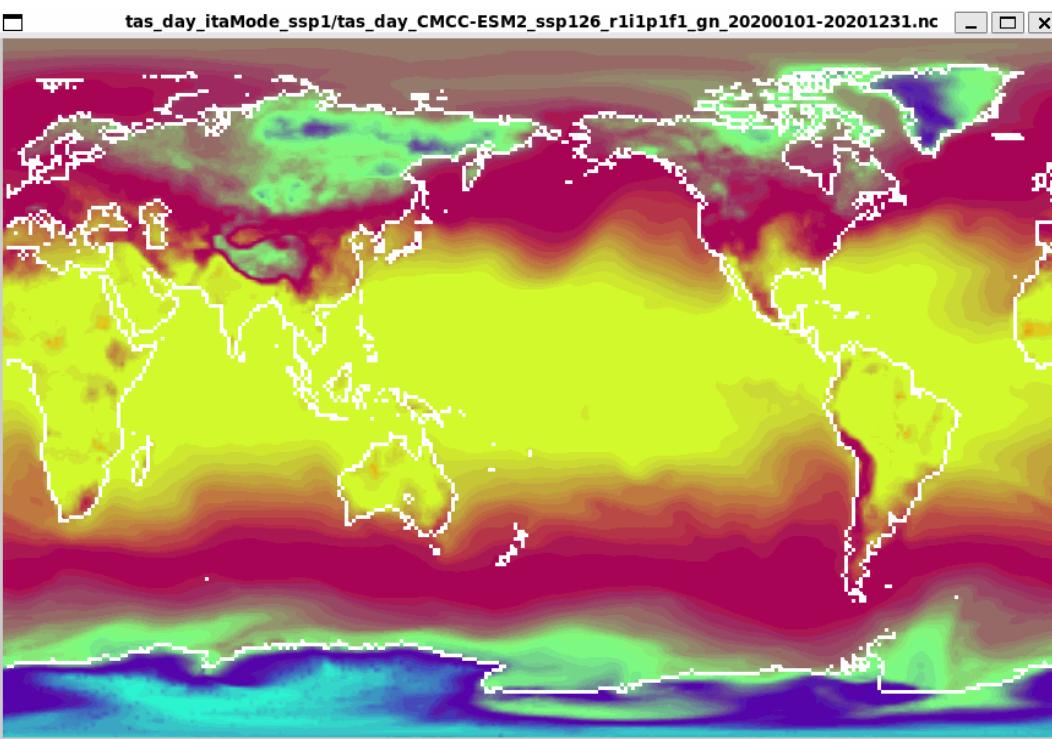


VISUALIZATION OF RESULTS

it is presented
flux precipitation
evolution for SSP5
scenario for all selected
models



VISUALIZATION OF RESULTS

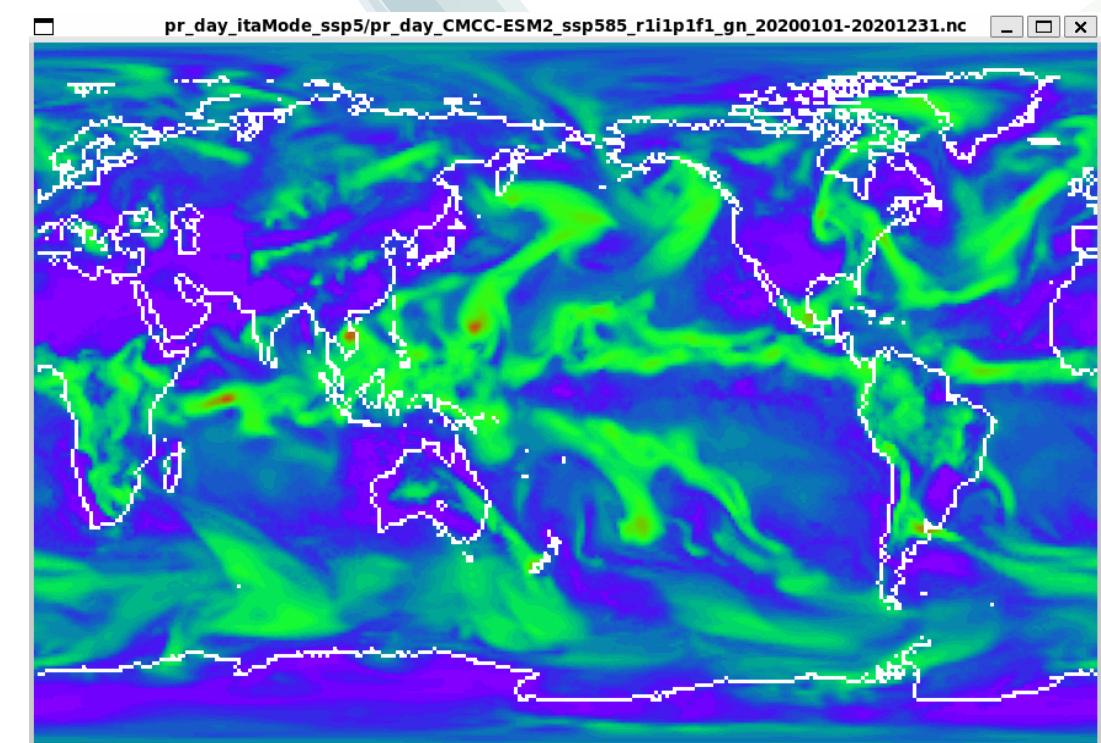
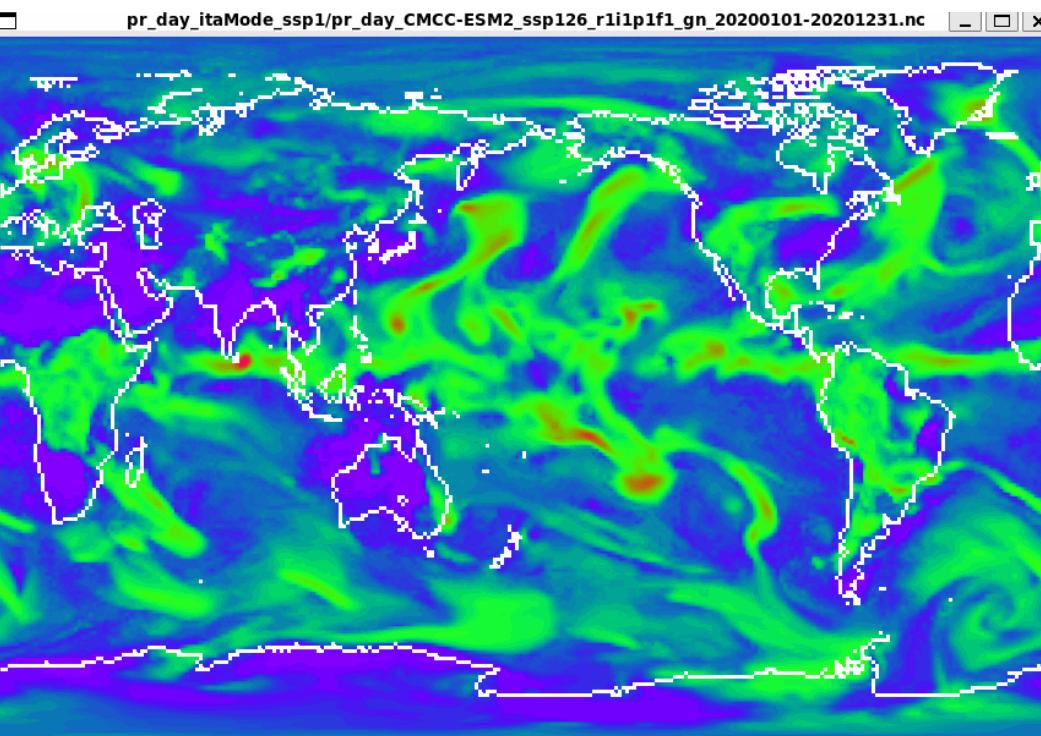


Comparison mean temperature time evolution
from 21 October 2024 to 21 October 2100



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VISUALIZATION OF RESULTS



Comparison precipitation time evolution
from 21 October 2024 to 21 October 2100



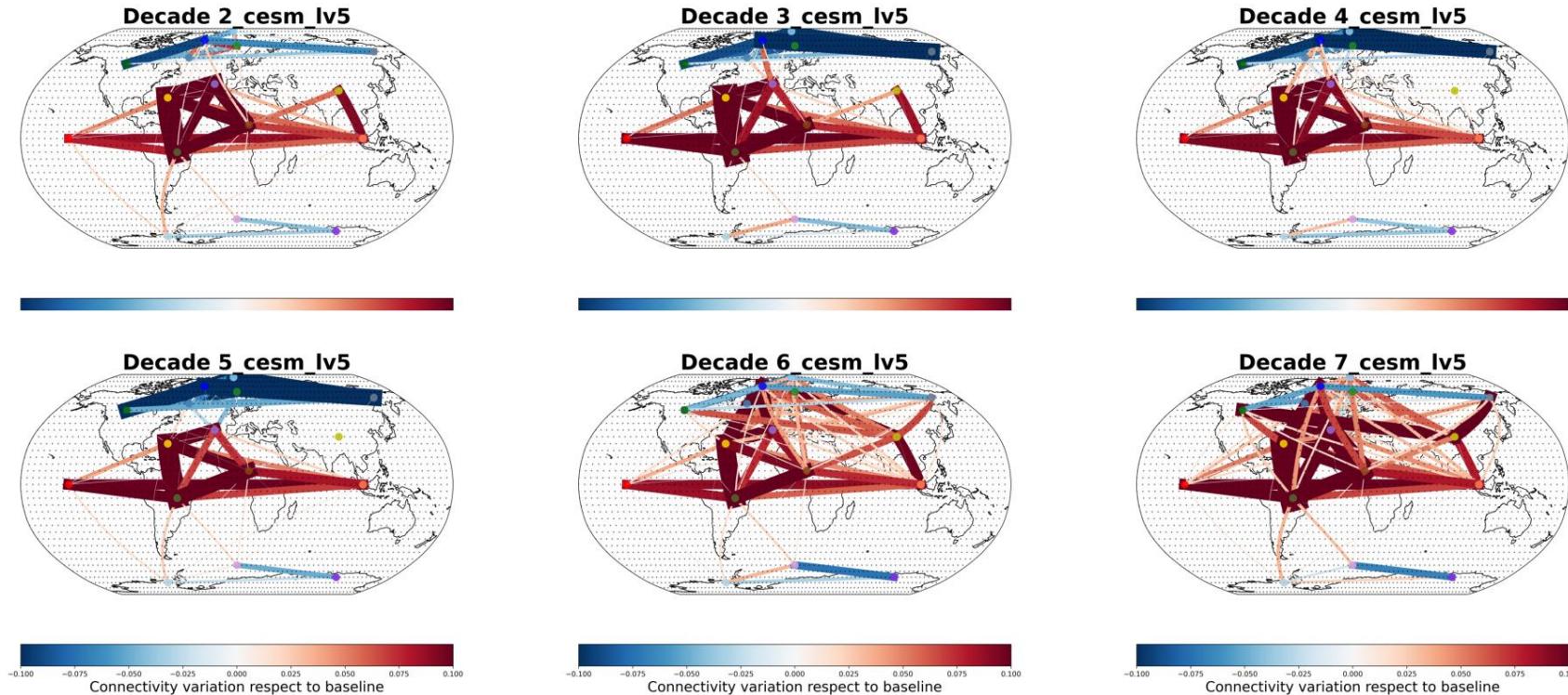
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MULTILAYER NETWORK

- The first step to create the multilayer network is the evaluation of **cross-correlation** between geographical points (**tipping points**)
- It is repeated at different pressure level and the resulting matrix, C, is the adjacency matrix related to the specific level so that creates the structure of the network.
- We do a **reshuffling procedure** to destroy information between nodes' temporal series.
- The last step is the comparison with **null hypothesis** from which we extract Z_score matrix and finally P_value matrix whose values are the entries of **FUZZY matrix**.



ANALYSIS



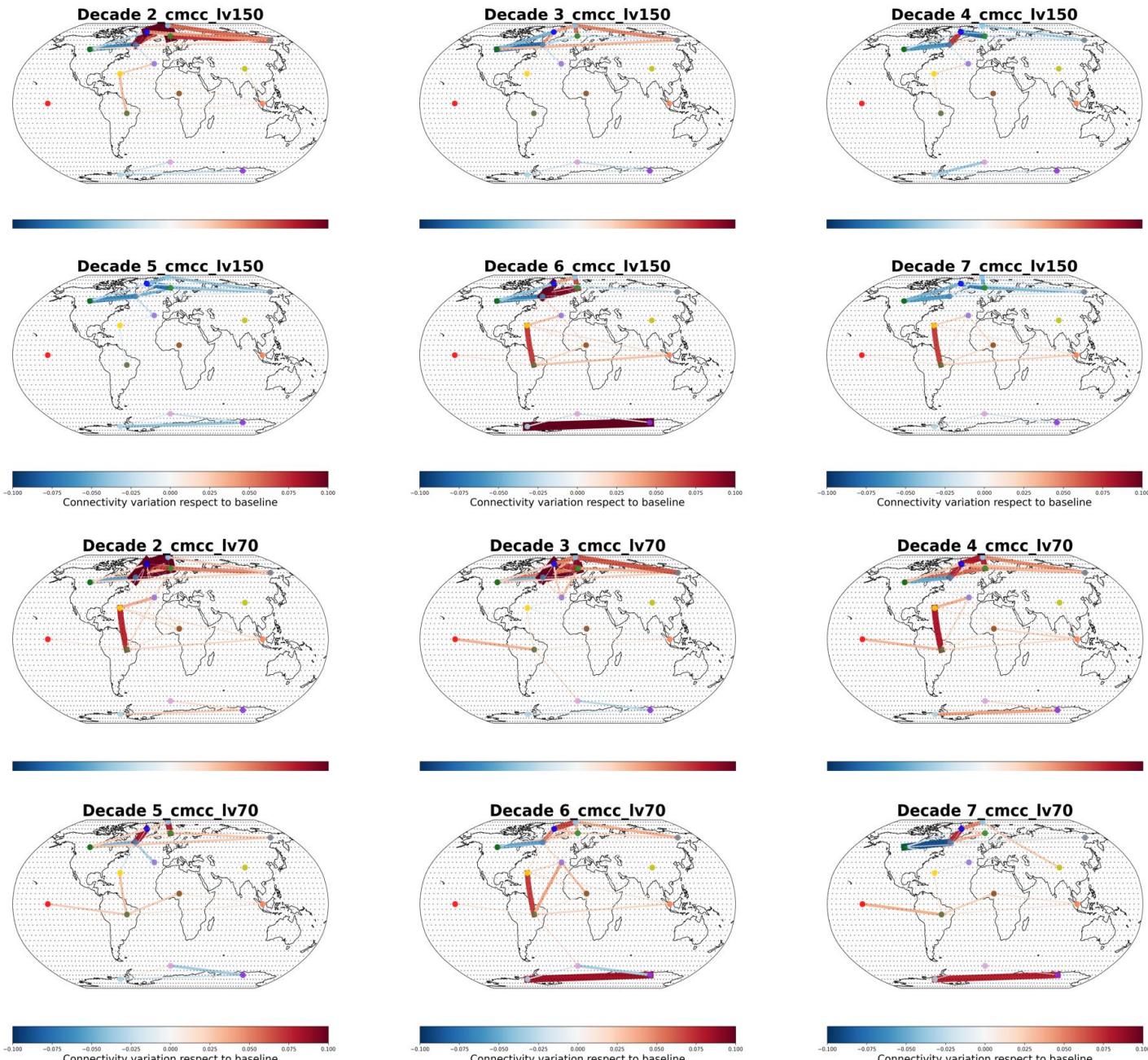
➤ Example of computational analysis done for **cesm model** across the decades for **SSP1 scenario** and **level 5 hPa**

- The analysis is based on the variation of connectivity between tipping points with respect to the baseline (2020-2030).
- We can observe cluster formation on the network



ANALYSIS

- This is an example of clustering research across the pressure levels.
- The pictures depict the survive of cluster formation across the pressure levels in the North area of the globe.

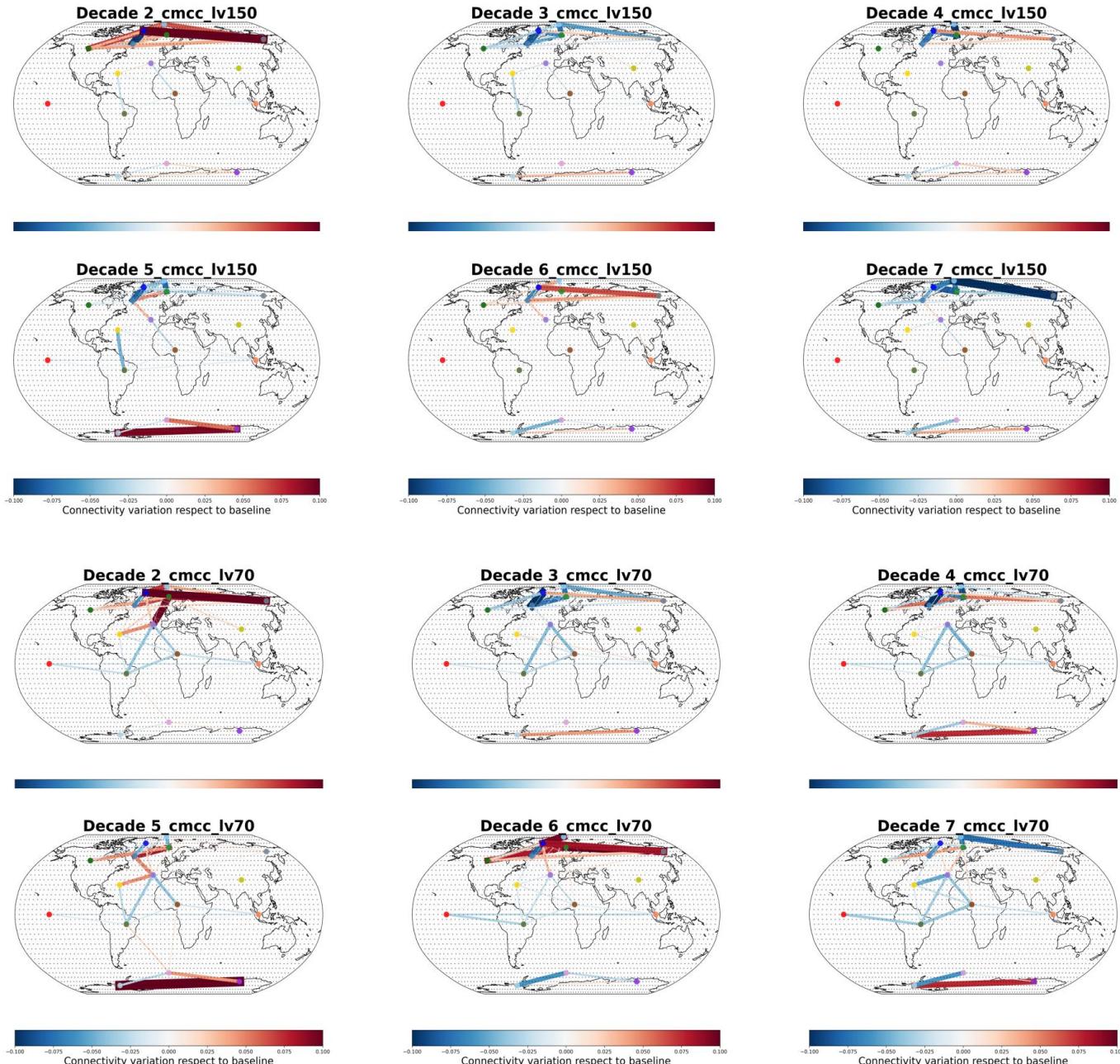


- I focus on the **Cmcc** model at **150 hPa** and **70hPa**



ANALYSIS

- Finally I present the **SSP5** scenario fixing the same levels and model (cmcc) as done in the previous slide



- We can observe a different cluster in the Antarctica's area



WILL WE DIE ?

- We can't predict what is the physical effect of an increase or decrease of connectivity behaviour within the network layer.
- We can investigate about cluster or triadic closure formation (the simplest cluster).
- This kind of analysis on single layer can be extended to finally create and investigate multilayer climate networks dynamics and structure.
- To answer the question, hopefully at the end of the century we will die !



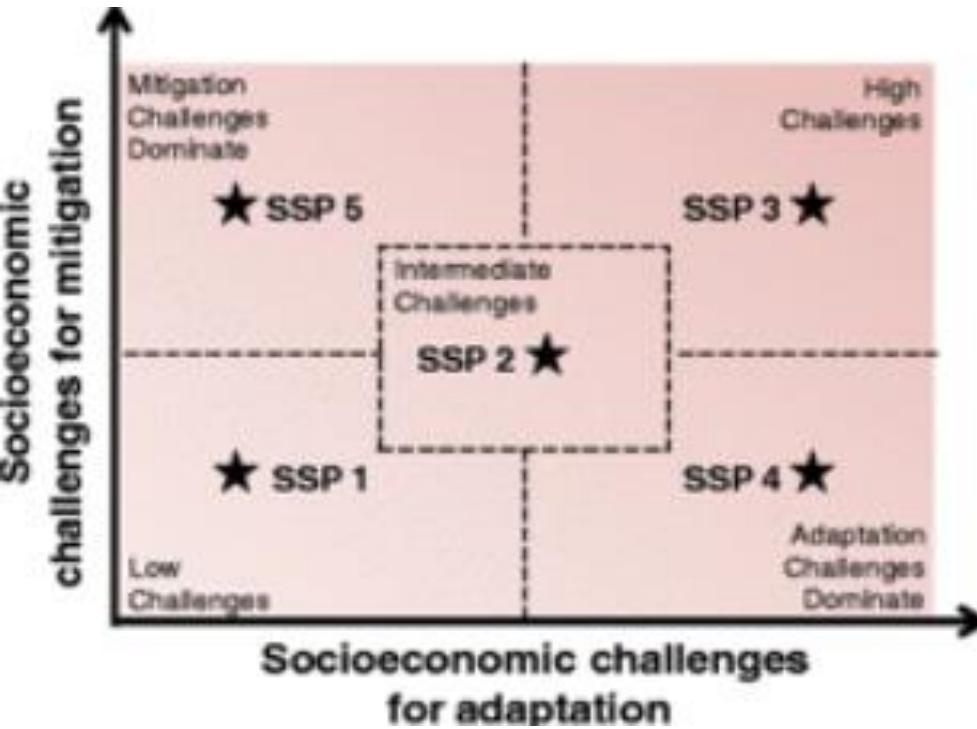


THANKS FOR THE ATTENTION



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FOCUS ON THE MODELS



- SSP identify **Shared Socioeconomic Pathway**.
- That is a **hypothetical scenario** based on the political choices about sustainability of socioeconomic system.
- SSP1 is the sustainable scenario
- SSP5 is the extreme one
- To complete the description it is associated quantity related to **C02 emission (RCP)**

