DESTINATION EARTH

CLIMATE DT: SIMULATIONS

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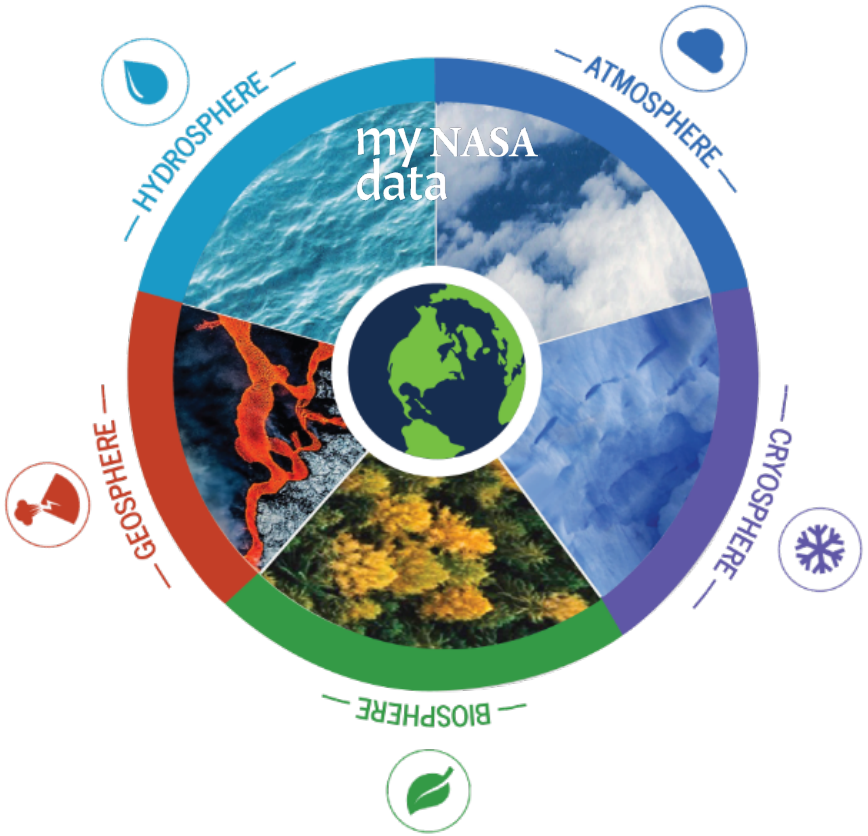
Centro Nacional de Supercomputación

Funded by the European Union

Destination Earth implemented by ECMWF esa EUMETSAT

EARTH SYSTEMS MODELS (THE PHYSICAL CORE OF THE DT)



In essence

Mathematical representation of the Earth system through the fundamental laws governing the evolution and interactions between its different components.

In Practice

ESMs are our major tool to generate scientific understandig on topics as diverse as:

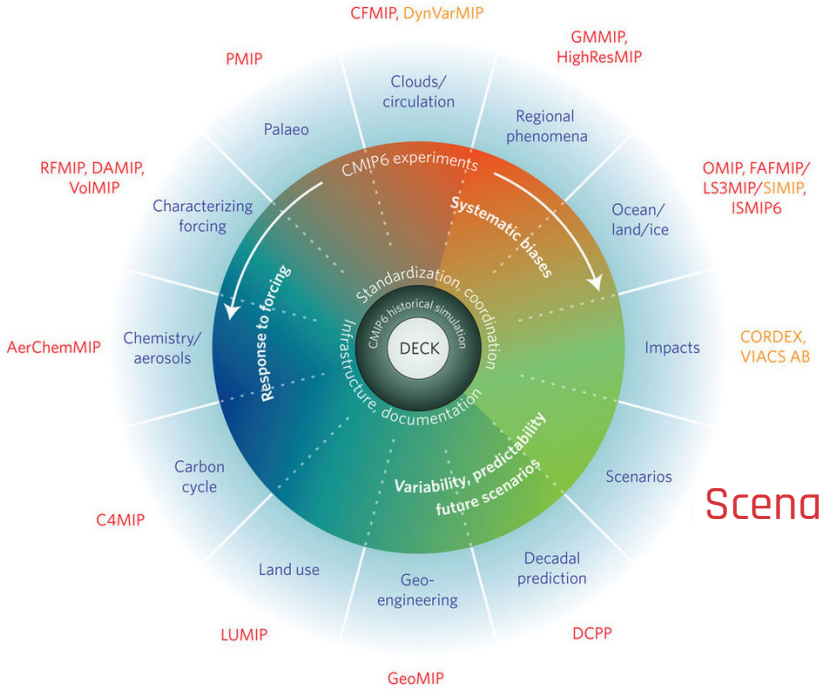
Attribution of past climate changes

Adaptation/Mitigation of future climate change

Risk of tipping (**Irreversible Changes**)

EARTH SYSTEM MODELS: OUR MAIN SCIENTIFIC LABORATORY

CMIP6 Activity Overview

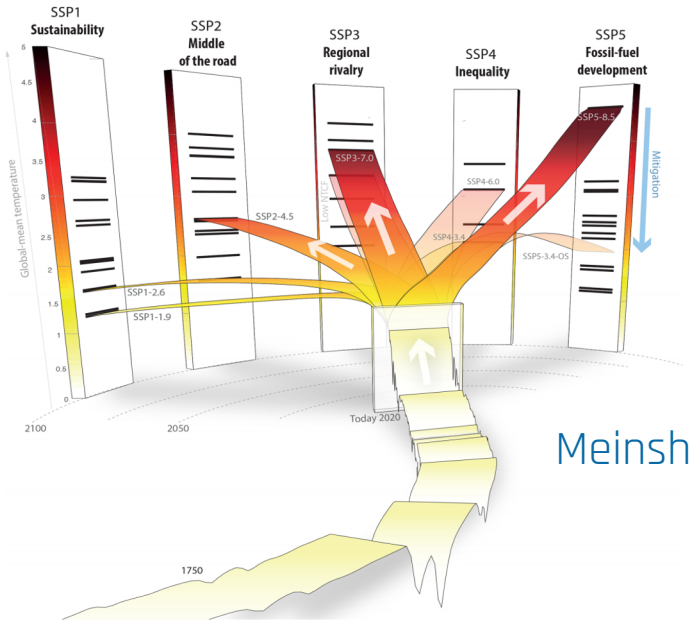


Simpkins et al (2017)

ScenarioMIP

Each CMIP6 activity and type of experiment has a purpose or several

Exploring our possible future climates



Meinshausen et al. (2020)

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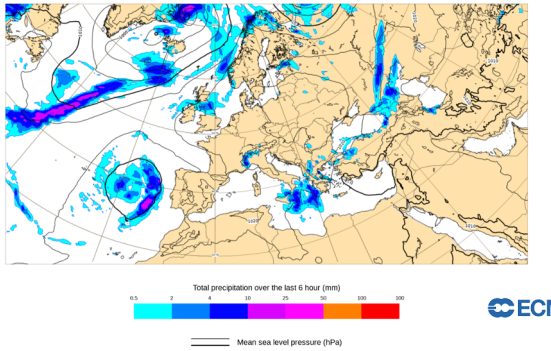
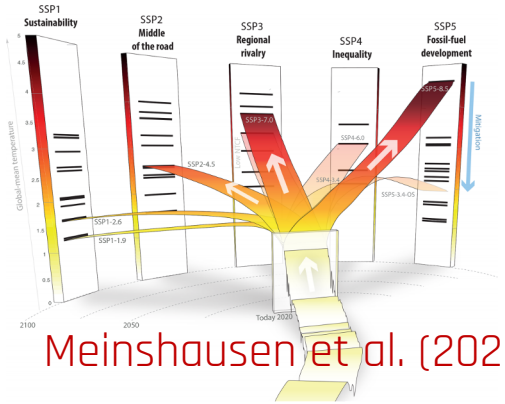
⚠ CLIMATE PROJECTIONS ARE NOT PREDICTIONS

Weather forecasts



Climate projections

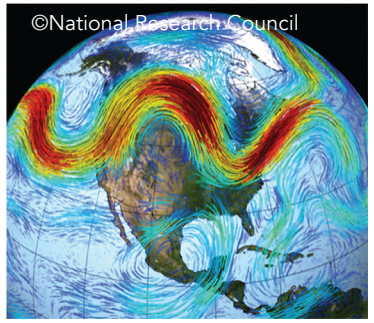


Meinshausen et al. (2020)

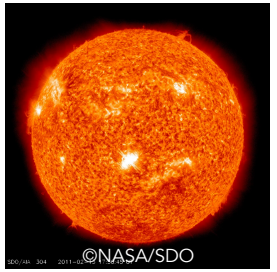
Climate Predictions

Both contributions matter!!

Days | Weeks | Months | Seasons | Years | Decades | Centuries



Models are **initialized with observations** to leverage the predictability of internal variability sources



The **projected evolution** in the **forcing factors** dictates the simulated future changes

EARTH SYSTEM MODELS: OUR MAIN SCIENTIFIC LABORATORY

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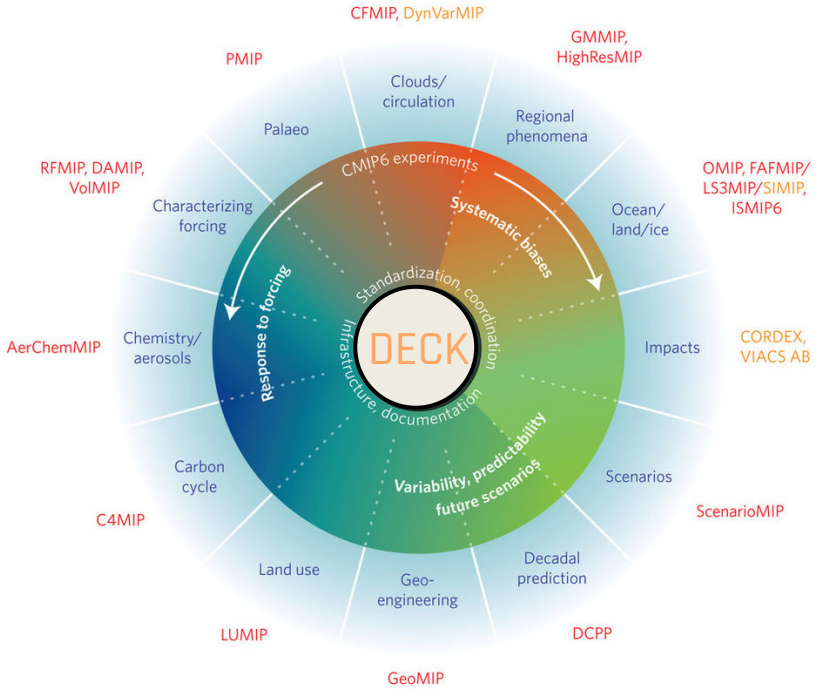

Simpkins et al (2017)

Each CMIP6 activity and type of experiment has a purpose or several

Determining baseline model features

DECK+historical
spinup: 200+ years
Equilibrate the model's climate
picontrol: 500+ years
Internal model variability
historical: 165 years (1850-2014)
Model validation vs observations *Role of historical forcings*

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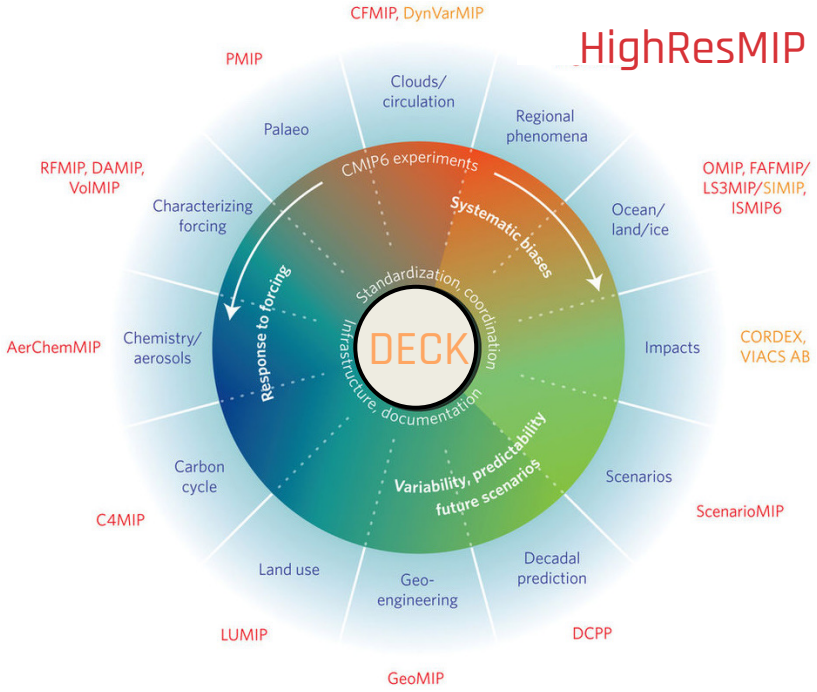
CMIP6 Activity Overview



Simpkins et al (2017)

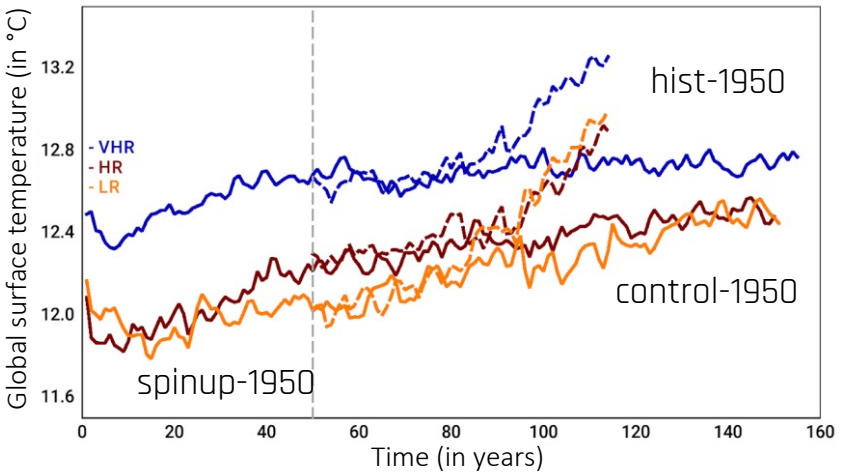
Each CMIP6 activity and type of experiment has a purpose or several

Determining baseline model features

DECK+historical	HighResMIP
spinup: 200+ years	spinup-1950: 50+ years
Equilibrate the model's climate	*Equilibrate the model's climate*
picontrol: 500+ years	control-1950: 100+ years
Internal model variability	*Internal model variability*
historical: 165 years (1850-2014)	hist-1950: 65 years (1950-2014)
Model validation vs observations *Role of historical forcings*	*Model validation vs observations* *Role of historical forcings*

EARTH SYSTEM MODELS: OUR MAIN SCIENTIFIC LABORATORY

Example of HighResMIP runs with EC-Earth3P



Moreno-Chamarro et al (under review)

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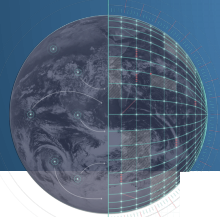
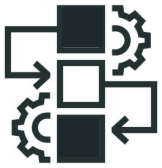


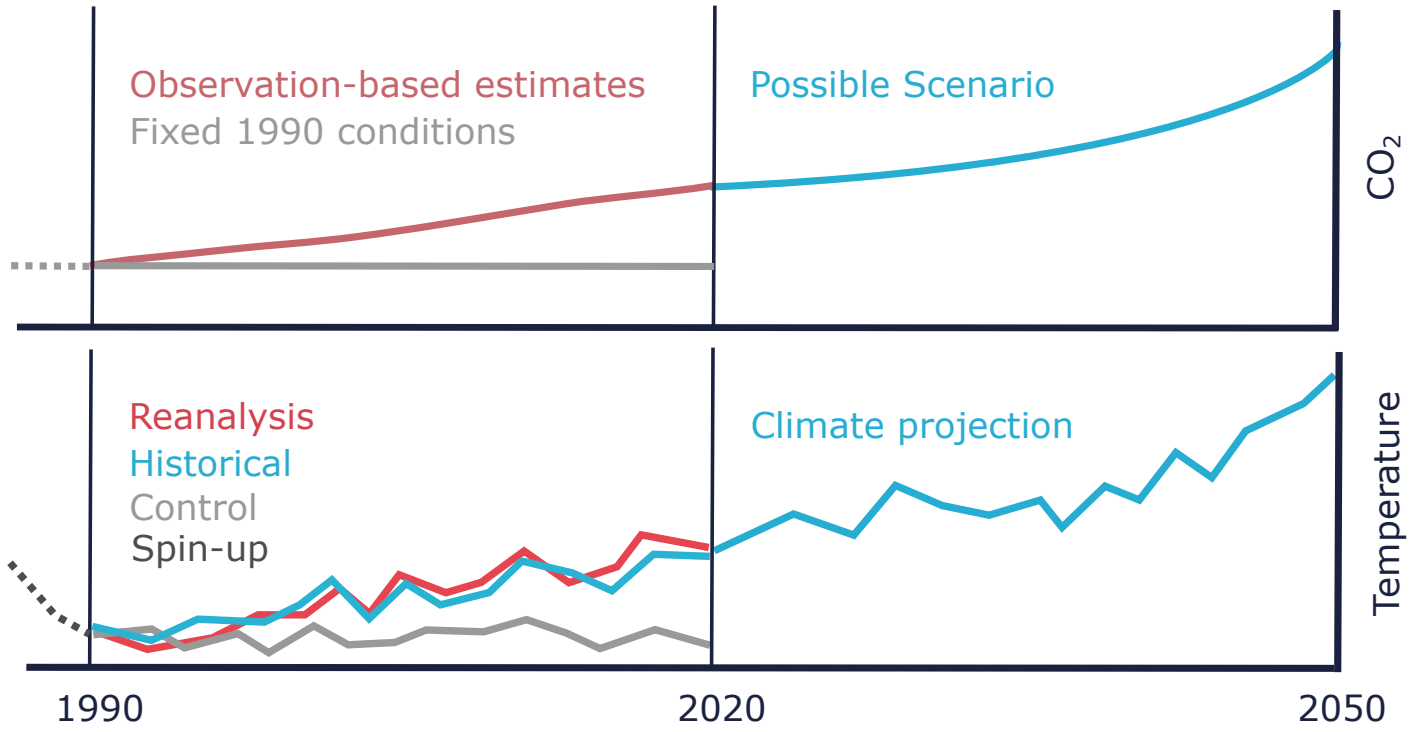
CLIMATE DIGITAL TWIN - COMPLETE SIMULATION PROTOCOL



CMIP6	HighResMIP	Destination Earth
spinup: 200+ years	spinup-1950: 50+ years	spinup: 5-yr ocean+ 2-yr coupled
Equilibrate the model's climate	*Equilibrate the model's climate*	*Equilibrate from initial shocks*
picontrol: 500+ years	control-1950: 100+ years	control-1990/2020: 60/30 years
Internal model variability	*Internal model variability*	*Internal model variability* *Diagnose & correct remaining drifts*
historical: 165 years (1850-2014)	hist-1950: 65 years (1950-2014)	historical: 30 years (1990-2019)
Model validation vs observations *Role of historical forcings*	*Model validation vs observations* *Role of historical forcings*	*Model validation vs observations* *Role of historical forcings*
ssp585: 86 years (2015-2100)	highres-future: 36 years (2015-2050)	ssp370: 30 years (2020-2049)
Assess long-term future	*Assess near-term future*	*Assess near-term future*
Typical resolutions: 100 kms	Finest resolutions: 10 kms (ocean) 20 kms (atmos)	Resolutions: 10 kms (ocean) 5-10 kms (atmos)

CLIMATE DIGITAL TWIN - COMPLETE SIMULATION PROTOCOL

Schematic of climate DT simulations

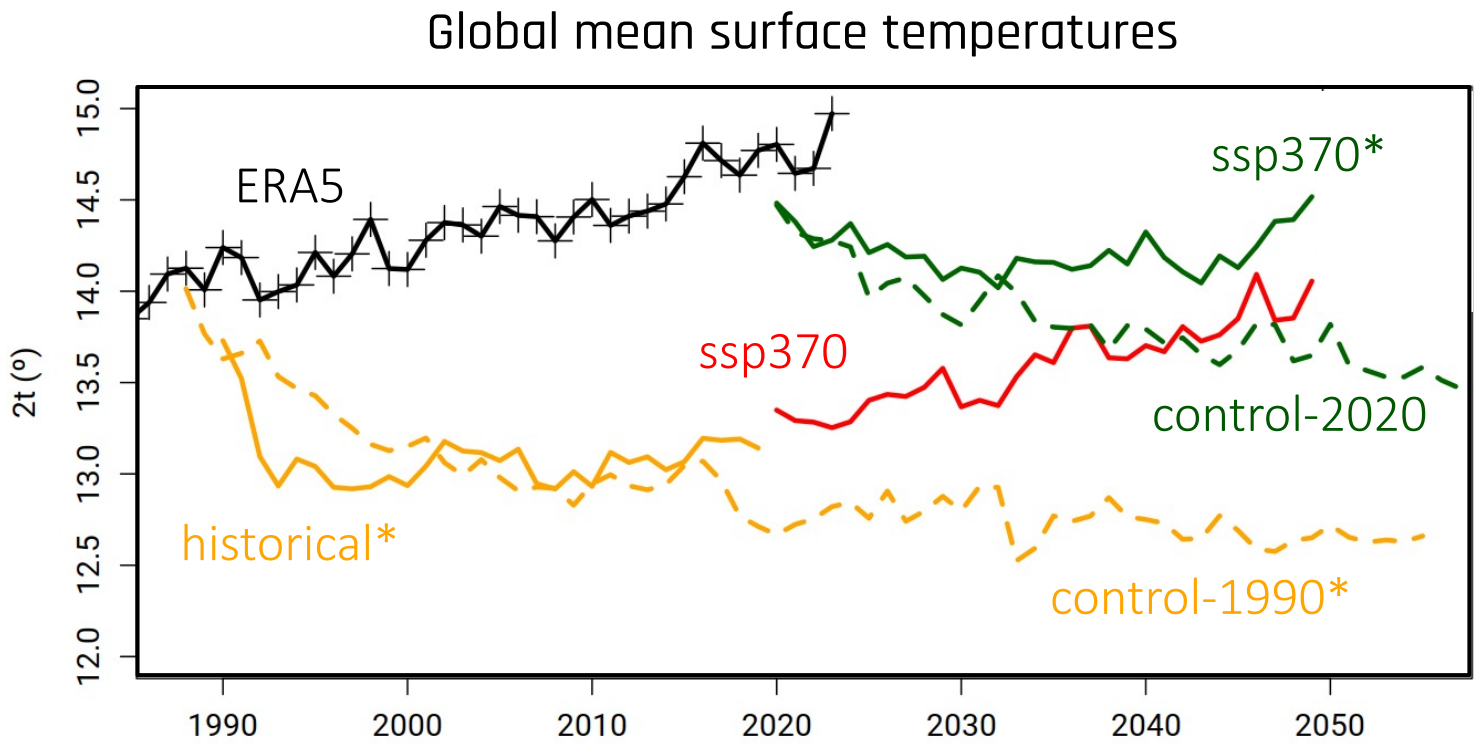


Destination Earth
spinup: 5-yr ocean+ 2-yr coupled
Equilibrate from initial shocks
control-1990/2020: 60/30 years
Internal model variability *Diagnose & correct remaining drifts*
historical: 30 years (1990-2019)
Model validation vs observations *Role of historical forcings*
ssp370: 30 years (2020-2049)
Assess near-term future

Resolutions: 10 kms (ocean)
5-10 kms (atmos)

CLIMATE DIGITAL TWIN - COMPLETE SIMULATION PROTOCOL

Example of DE simulations with IFS-NEMO at LR



** Experiments produced in phase-I*

Destination Earth
spinup: 5-yr ocean+ 2-yr coupled
Equilibrate from initial shocks
control-1990/2020: 60/30 years
Internal model variability *Diagnose & correct remaining drifts*
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CLIMATE DIGITAL TWIN - COMPLETE SIMULATION PROTOCOL

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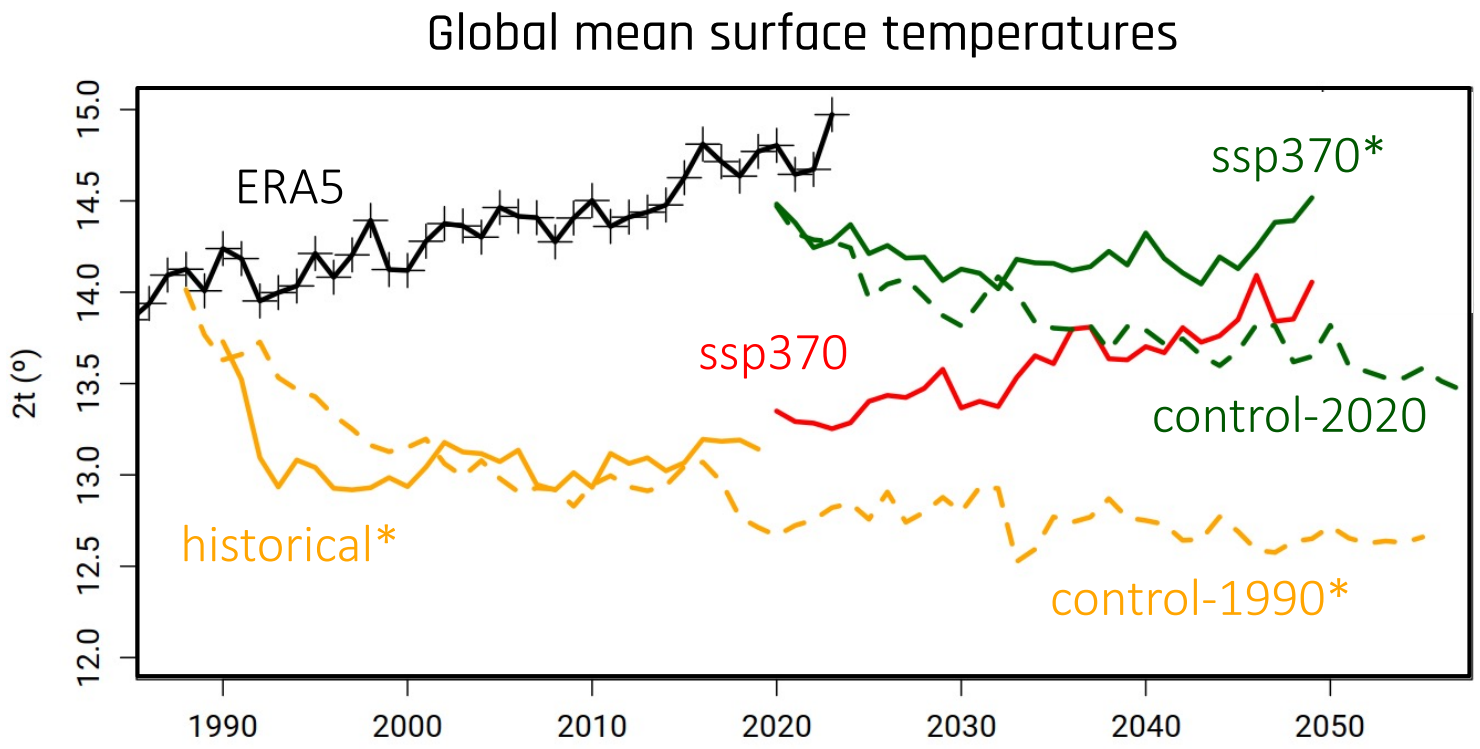
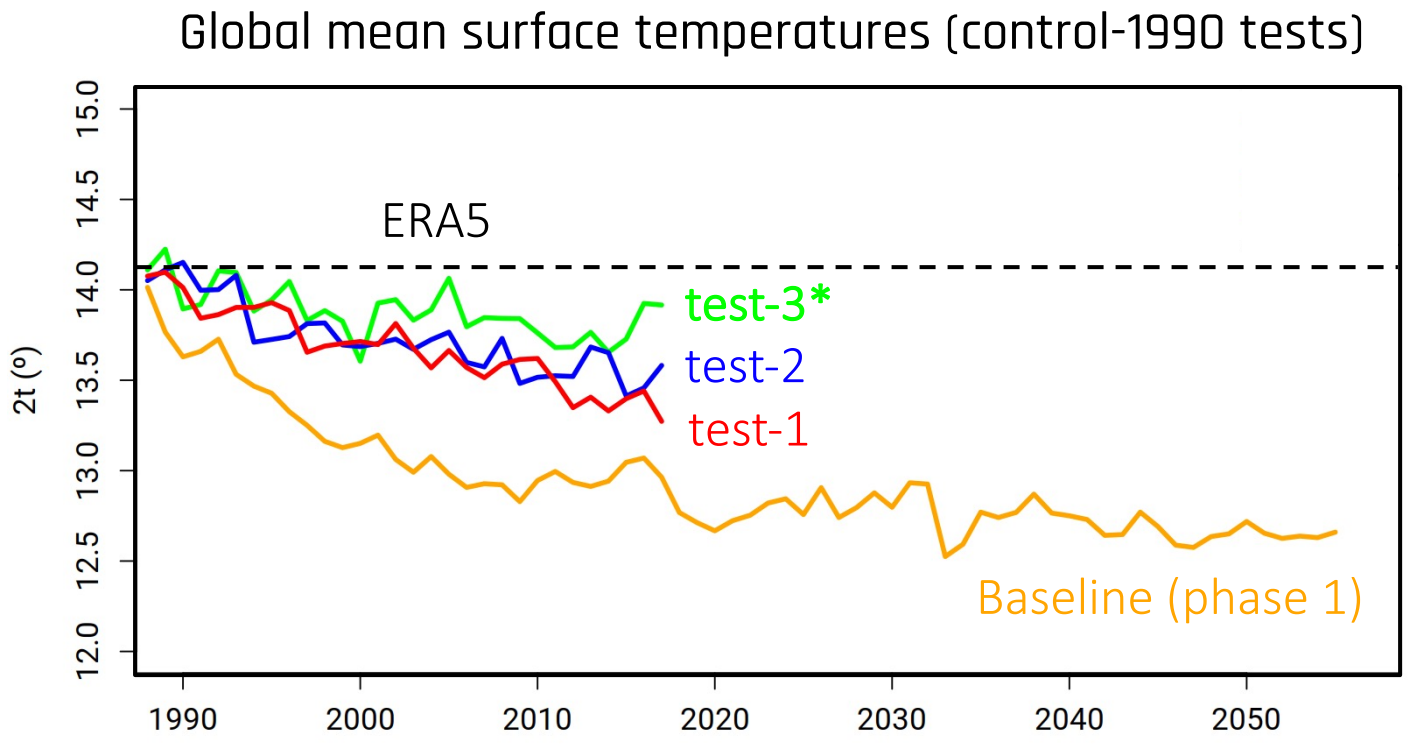


** Experiments produced in phase-I*

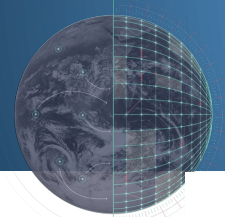
- The **spin-up strategy** might need to be **revised** to mitigate the initial shocks
- The underlying problem is that the **model's** mean state is **too cold**. Cooling trends are substantially reduced in a newly tuned version of the model

CLIMATE DIGITAL TWIN - COMPLETE SIMULATION PROTOCOL

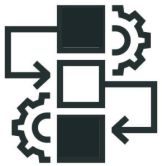
Example of DE simulations with IFS-NEMO at LR



- The **spin-up strategy** might need to be **revised** to mitigate the initial shocks
- Through in-depth analyses and several tests a new version with **substantially reduced initial shocks** is available, also **validated at higher resolution**



CLIMATE DT SIMULATIONS – TAKE HOME MESSAGES



- The **experimental protocol** for the climate DT is a streamlined version of the HighResMIP protocol **conceived to ran at km-scale resolutions**
- **All experiments produced** (spin-up, control, historical, scenarios) have their purpose and **ultimately seek to produce trustworthy climate projections** to support climate change adaptation
- Main **issues affecting phase-I simulations** have been **carefully addressed** for the **second phase of the climate DT**.