Avoiding the curse of opportunity: best practices from the EURO-CORDEX community

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(special thanks to Jesus Fernandez, Samuel Somot)

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Motivations:

- Stop the “ensemble of opportunity” approach used in the RCM community since the 90s. Improve upon GCM selection routines from CMIP5
- Make CMIP6/EURO-CORDEX ensemble more reliable to explore future climate change and therefore a better climate information source for adaptation strategies
- Avoid to run “useless” simulations (picking implausible GCMs without knowing it)
- Better explore the range of plausible futures
- Create an a ”balanced” matrix subset of simulations for practitioners and VIACS community

Goals of the “Task Team”:

- Develop a set of best-practice guidelines
- Base these on existing literature & expert judgment following internal discussions
- Execute design of RCM-GCM ensembles (i.e. “The Matrix”) in less of an ad-hoc manner

Note that the proposed protocol is strongly influenced by the spirit of McSweeney et al. 2015

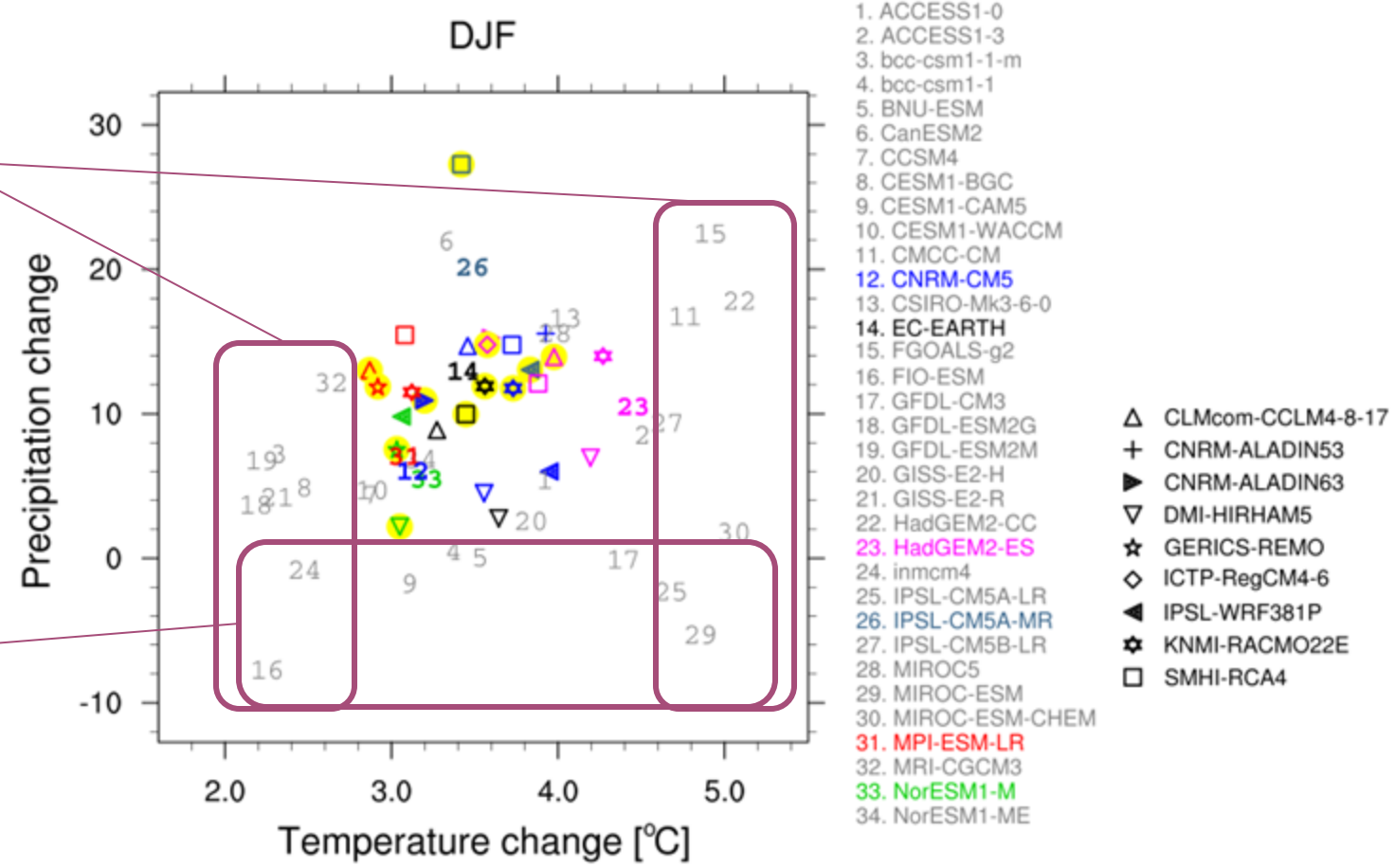
We need to better explore the range of plausible futures : illustration with the current Euro-CDX ensemble for France in Winter

Future change in precipitation (%) and near-surface temperature (°C)

(France, DJF, 2071-2100 vs 1976-2005)

The GCMs with most and **least** warming in CMIP5 are missing in Euro-CDX forcing

The GCMs with **Winter** drying in CMIP5 are missing in Euro-CDX



Figures: L. Corre, Meteo-France: figure done with 6 most used driving GCMs in Euro-CORDEX among the 9 driving GCMs

Three approach: 3(4) selection criteria families

Data availability/ quality

- CORDEX-MIP
  - Availability of scenario so balanced ensembles can be produced (e.g. ssp126 and ssp585)
  - Availability of variables to (1) evaluate the GCM in step 2 and 3, (2) drive the RCMs and (3) use ESD or hybrid approaches
- Basic QA (missing values, suspect values)
- FAIR meta-data (Lars can maybe say something about this?)

Eliminate Implausible GCMs

- Global climate criteria (e.g. ECS, TCR, past trend representation of the global-mean temperature, known strange behaviour such as spurious ocean trends or breaks)
- Favour model (bio-)diversity : independence criteria (https://esd.copernicus.org/preprints/esd-2020-23/esd-2020-23.pdf), etc.
- European large scale performance criteria (.e.gg. 850hPa winds, Stormtracks, Jet stream (strength/position), trend reproducibility, low frequency variability such as NAO or weather regimes, Hadley circulation, ECS, Low-level humidity advection, African and Asian monsoon
- European forcing performance criteria: AOD, regional SST and SIC, IWV, etc. [key here is to think of factors that will influence the RCM]

Explore the range of future outcomes

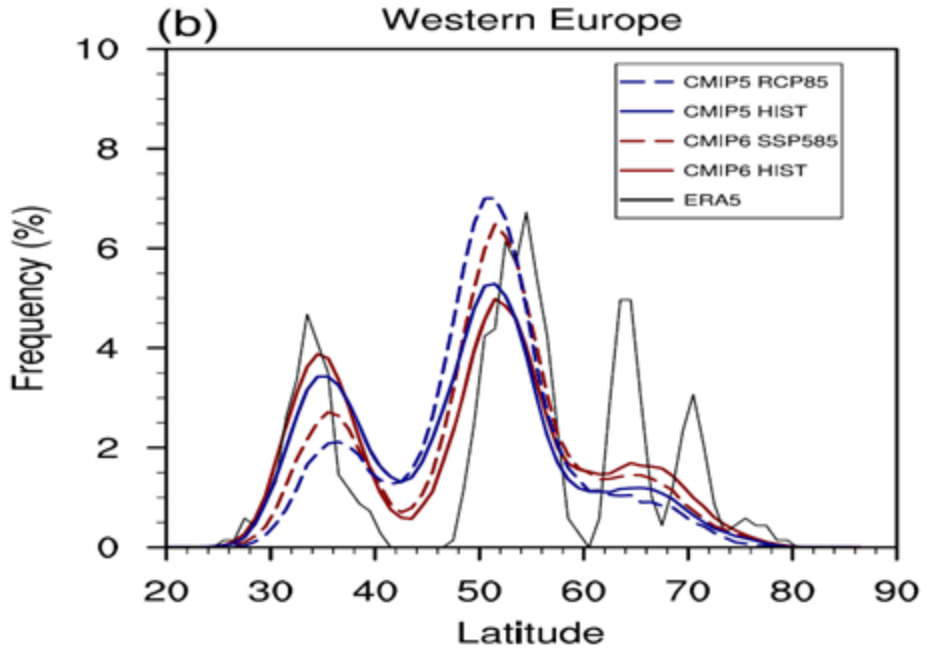
- European TAS response (delta-T spread) à la McSweeney et al. 2015, Spread in ECS or TCR (low, medium, high), Spread in GCMST for e.g. ssp585?
- Spread in future response of circulation pattern or large-scale features controlling European climate change (e.g. robust storm track shifts as in Oudar et al., 2020: https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2019GL086695), Polar vortex strength and Tropical amplification (see storyline's paper by Zappa and Shepherd), and/or other emergent constraints
- Spread in other forcings: regional SST and SIC, regional AOD trend,

Large-scale performance criteria: illustrations by the North-Atlantic storm track

Bias in the storm track north position for CMIP6 GCMs
(ONDJFM, position in °N)

CMIP6 models	Jet Bias
BCC-CSM2-MR	-1.49
CAMS-CSM1-0	-1.91
CESM2	1.42
CESM2-WACCM	0.28
CNRM-CM6-1	-2.79
CNRM-ESM2-1	-3.02
CanESM5	0.9
EC-Earth3	-0.26
EC-Earth3-Veg	-0.69
FGOALS-g3	-0.43
GFDL-CM4	-2.1
GFDL-ESM4	-3.4
INM-CM4-8	1.01
INM-CM5-0	0.03
IPSL-CM6A-LR	-1.53
MCM-UA-1-0	-0.39
MIROC6	-3.31
MIROC-ES2L	-6.97
MPI-ESM1-2-HR	-3.1
MRI-ESM2-0	-2.66
NESM3	-2.03
UKESM1-0-LL	-0.43

Maximum wind position distribution
for CMIP6 GCMs
(ONDJFM)

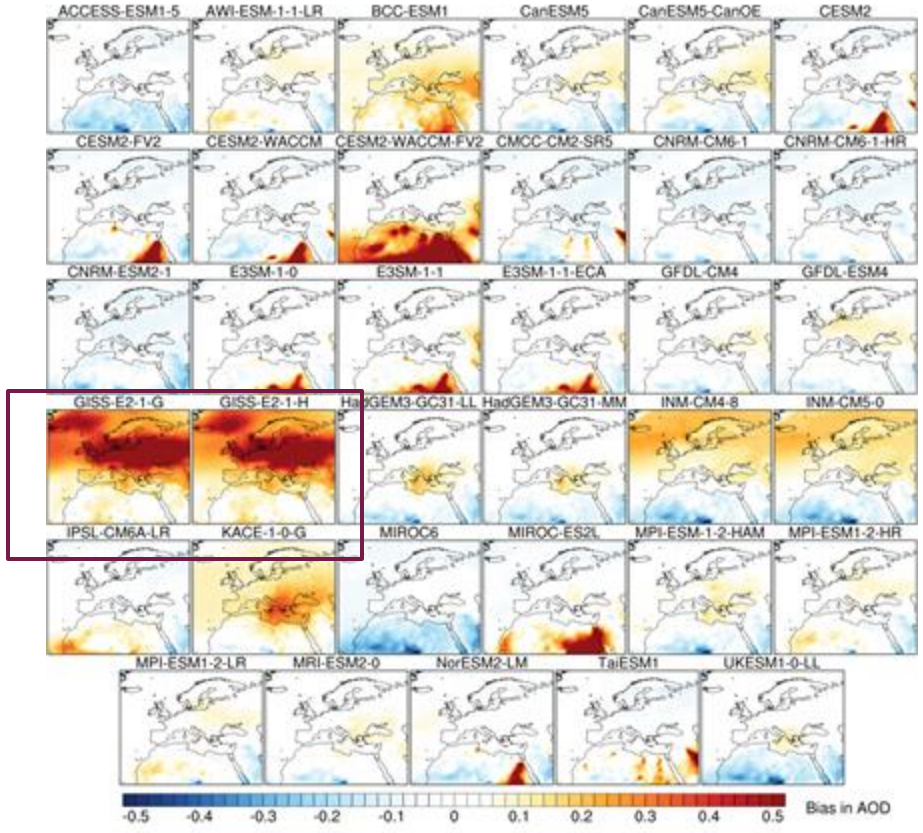


Implausible driving model
7° too far south!

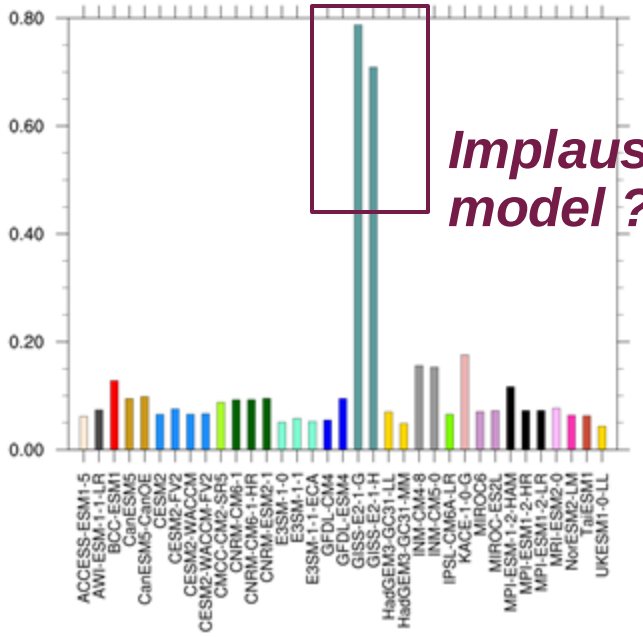
Oudar et al. 2020

Regional forcing performance criteria: illustrations by the European Aerosol Optical Depth

Yearly-mean AOD bias for CMIP6 GCMs
(yearly-mean, 2000-2014, wrt satellite data)



RMSE (yearly-mean, 2000-2014, wrt satellite data)



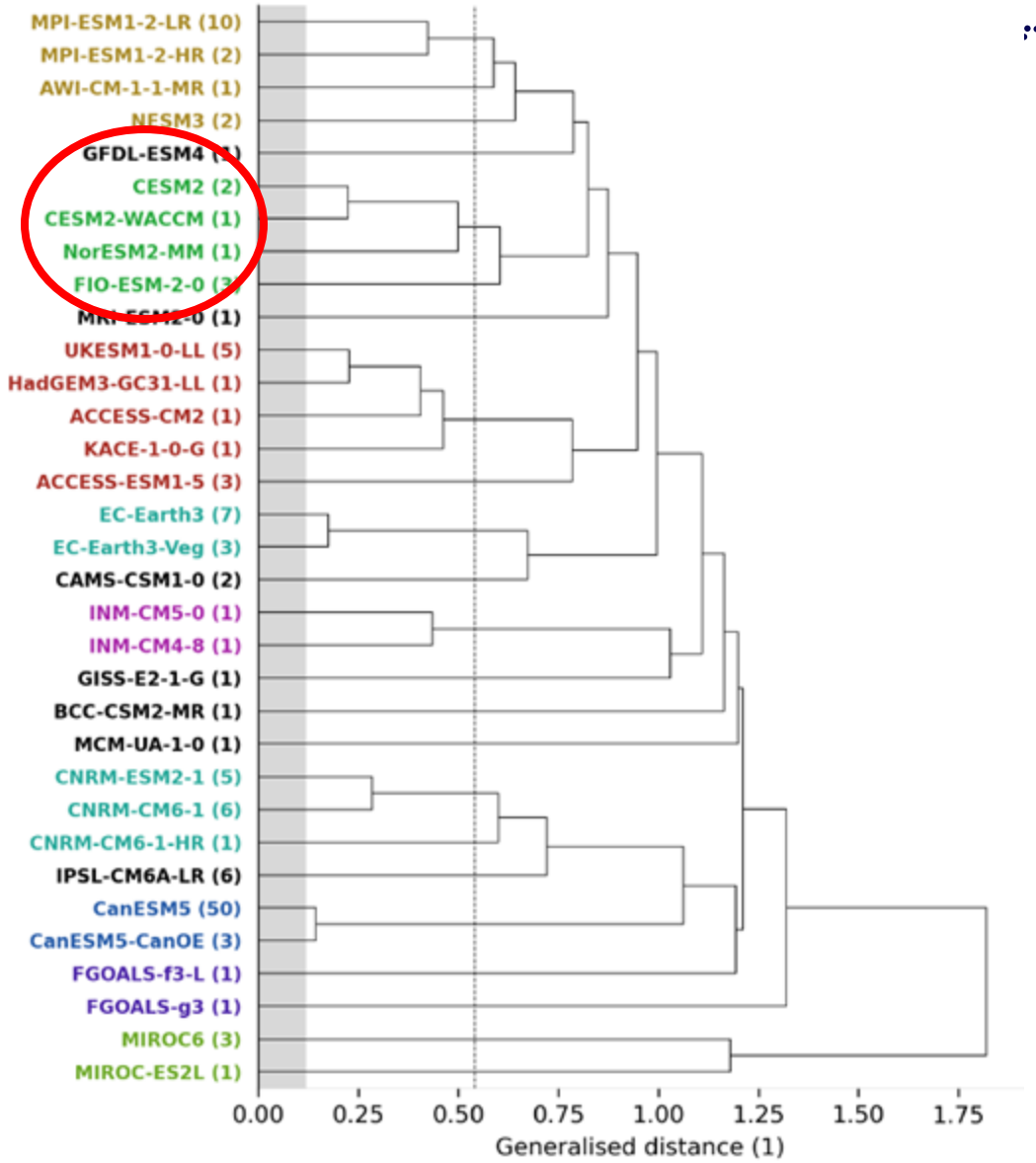
Implausible driving model ?

P. Nabat (CNRM) , pers. comm.

Global/Other criteria: model (bio-) diversity

GCM are not independent
they can be gathered by families
“End of the model democracy”. R. Knutti

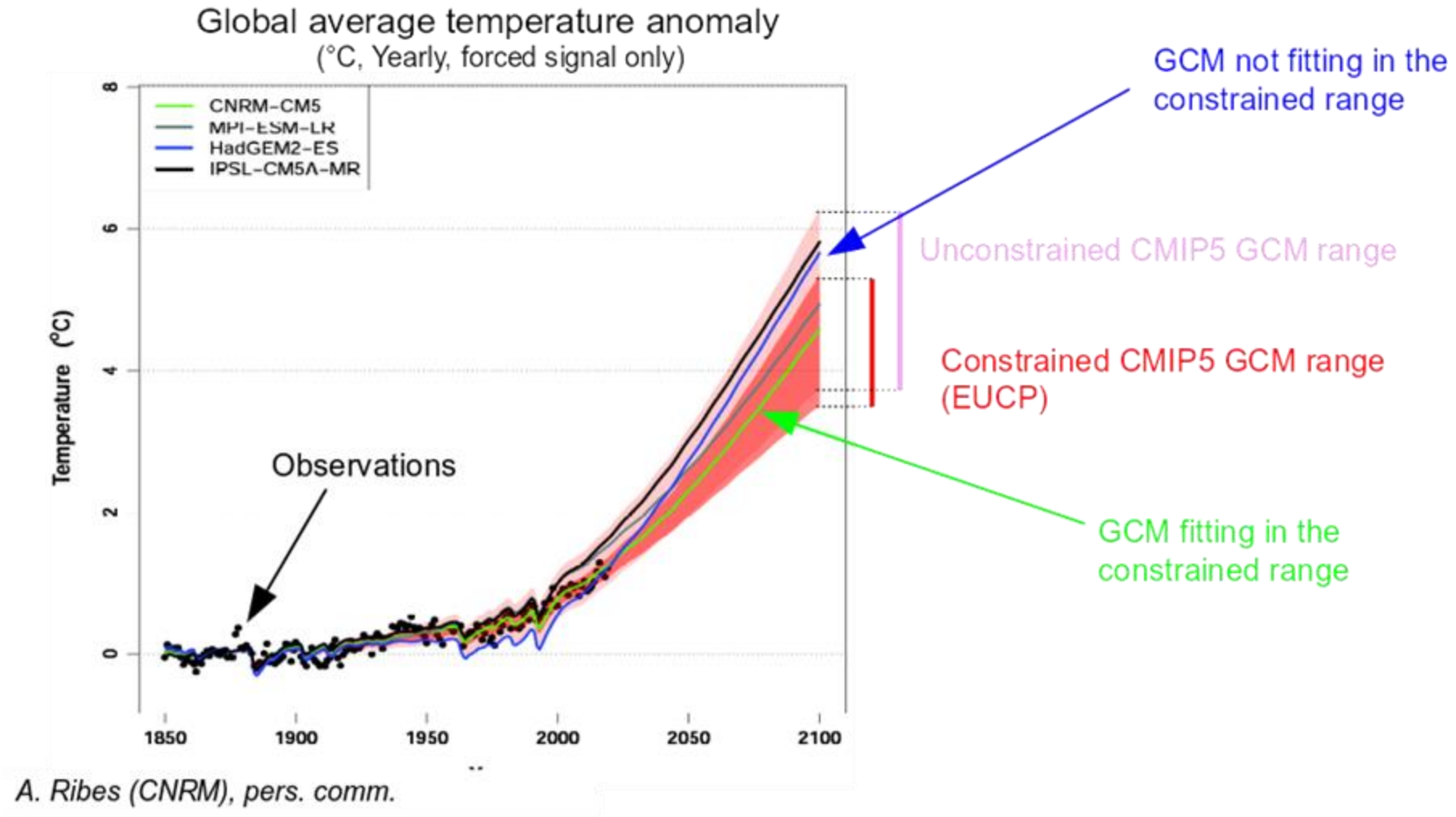
(Here similarity criteria based on global tas and psl field
1980-2014)



Brunner et al. 2020

Global criteria: constraint on the global average temperature past trend

In this example, only 2 CMIP5 GCMs out of 4 (used as drivers in Euro-CORDEX) fits the observational constraints → meaning that at least 2 Euro-CORDEX driving GCMs are implausible wrt this specific metric!



A. Ribes (CNRM), pers. comm.

How this works in practice: move to a traceable, transparent, extendable approach

New implementation to collect GCM information:

- based on published scientific literature
- extended by author contributions
- described by more than just numbers, incorporating decision thresholds
- human readable
- machine readable
- extendable (e.g. to other CORDEX domains)
- traceable, recording the decision process and alternative decisions
    - Open & collaborative
    - Version control
    - Text files
    - Programming to process the information in different ways
    - Issues to store the decision process

GitHub

Outcomes: GCM recommendations for EURO-CORDEX

Table 1. *Most strict; GCMs which are available for all four scenarios (ssp126, ssp245, ssp370,ssp585) and are deemed "plausible" for each evaluated criteria. To qualify models must be evaluated for at least one criterion per score family. The third column shows the number of failed criteria over the total number of criteria for each model. Models that are also part of institutional commitments are highlighted. The fourth column shows an illustration of future spread categories for the selected GCMs (here based on TCR values).*

GCM name	Run	Marks/Criteria	TCR Plausible range (1.2K-2.4K)[12]
MPI-ESM1-2-LR	r1i1p1f1	0/18	1.84

Table 2. *Less strict; same as Table 1 except for GCMs which are "available" for all four scenarios. Scores are based on all evaluated members of a model even if only one member is "available". Only one model per family is kept in most cases and in the event of a tie criteria such as complexity and resolution may play a role as tie-breakers. Explanations appear in footnotes.*

GCM name	Run	Marks/Criteria	TCR Plausible range (1.2K-2.4K)
NorESM2-MM[13]	r1i1p1f1	1/17	1.33
MIROC6[14]	r1i1p1f1	1/20	1.55
MPI-ESM1-2-HR	r1i1p1f1	1/20	1.66
CNRM-ESM2-1	r1i1p1f2	1/19	1.86
CESM2[15]	r11i1p1f1	1/18	2.06
CMCC-CM2-SR5[16]	r1i1p1f1	1/15	2.09
IPSL-CM6A-LR[17]	r1i1p1f1	2/16	2.32
EC-Earth3-Veg[18]	r1i1p1f1	2/15	2.62
UKESM1-0-LL[19]	r1i1p1f2	2/19	2.79

Outcomes: CMIP6 - EURO-CORDEX “balanced” matrix: first final version

RCM \ GCM	EC-Earth3-Veg (*) r1i1p1f1	MPI-ESM1-2-HR r1i1p1f1	CNRM-ESM2-1 r1i1p1f2	NorESM2-MM r1i1p1f1	MIROC6 r1i1p1f1	CMCC-CM2-SR5 (*) r1i1p1f1
WRF		✗		✗		✗
ALADIN6x			✗	✗		✗
COSMO/ICON-CLM	(✗)	✗			✗	✗
HCLIM43-ALADIN	(✗)	✗	✗	(✗)	✗	
RegCM5	✗	(✗)	✗	✗		
REMO	✗	✗			✗	
RACMO23E	✗		✗	✗		

✓ At least 3 runs by RCM and 4 runs by GCM

? GCM/RCM compatibility?

Color = TCR Plausible range

✗ **planned**

✗ **still to be placed**

(*) only total aerosol forcing available on ESGF (**od550aer). (2022.05.17 for EC-Earth3-Veg)**

CORDEX-CMIP6 downscaling plans summary tables

https://wcrp-cordex.github.io/simulation-status/CORDEX_CMIP6_status.html#EUR-11

Based on Eivin et al., 2021

Summary

- Tables to summarize the 4-step GCM selection process are ready to be used and completed with
    - Additional model runs
    - Additional studies
    - Refined decisions on thresholds, preferred metrics for a given aspect

Citable documentation link

https://wcrp-cordex.github.io/cmip6-for-cordex/CMIP6_studies_table_EUR.html

Link to GitHub pages

Please, explore the GitHub site and contribute

https://wcrp-cordex.github.io/cmip6-for-cordex/

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Thank you. Takk. Merci. Gracias. Obrigado.

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