Assessing mean climate change signals in the global CORDEX-CORE ensemble

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Outline and Research question

- Short introduction to CORDEX CORE
- GCM-RCM Mean climate change signal at global scale
- GCM-RCM Mean climate change signal in regions
- Conclusions and Outlook

How does the global 25km-resolution CORDEX-CORE ensemble compare with the AR5-GCM-ensemble and the driving GCMs?

CORDEX CORE - Main ideas

Purpose:

Provide a foundation of high-resolution regional climate model projections to improve the understanding of local fine scale phenomena and to allow ensemble-based vulnerability, impact, adaptation and climate services research world-wide.

CORDEX CORE:

- ... aims to create an initial homogeneous downscaled ensemble
- ... aims at covering the major populated areas of the world
- ... will be extended by further simulations in the regions
- ... will allow new research:
  - to assess future climate (mean, extremes and hazards, ...)
  - to study one phenomena across multiple domains (e.g., monsoons, tropical cyclones)
  - to assess consistency of climate change signals and possible added value (in comparison with coarser resolution)

CORDEX CORE - Main ideas

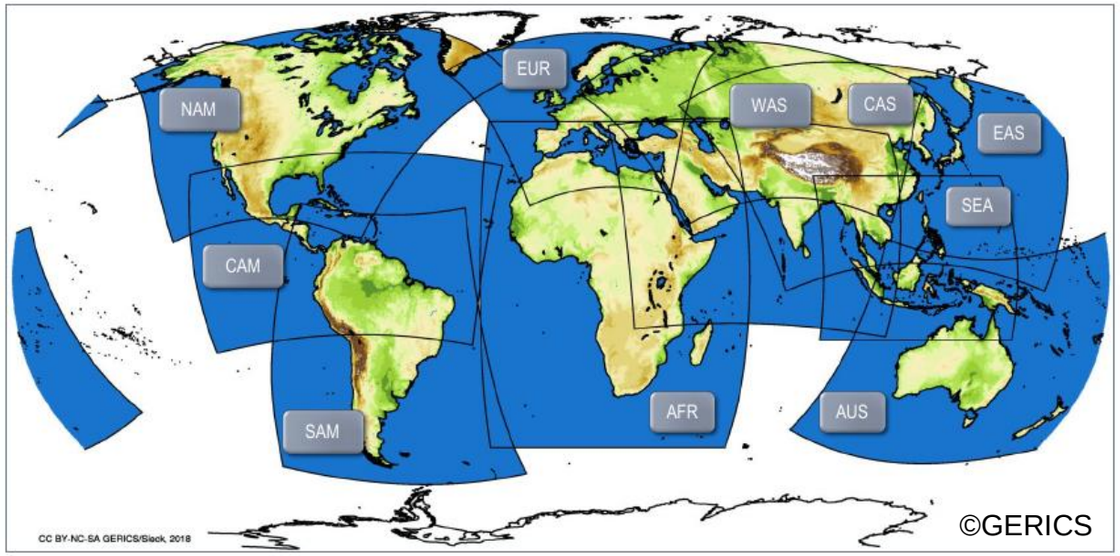
Method:

CORDEX CORE is designed

- to use a core set of RCMs
  - RegCM and REMO (so far)
- to downscale a core set of GCMs with high, medium and low Climate Sensitivity
  - **HadGEM** (backup: MIROC5)
  - **MPI-ESM** (backup: EC-Earth)
  - **NorESM** (backup: GFDL-ESM)
- to have a validation simulation and use different representative concentration pathways
  - **ERA-Interim**, **RCP2.6** and **RCP8.5**
- to be incrementally extended with further contributions by additional models/experiments

- CORDEX CORE (**25km**) is extending the CORDEX (50km) regional climate information

CORDEX-CORE Simulation matrix



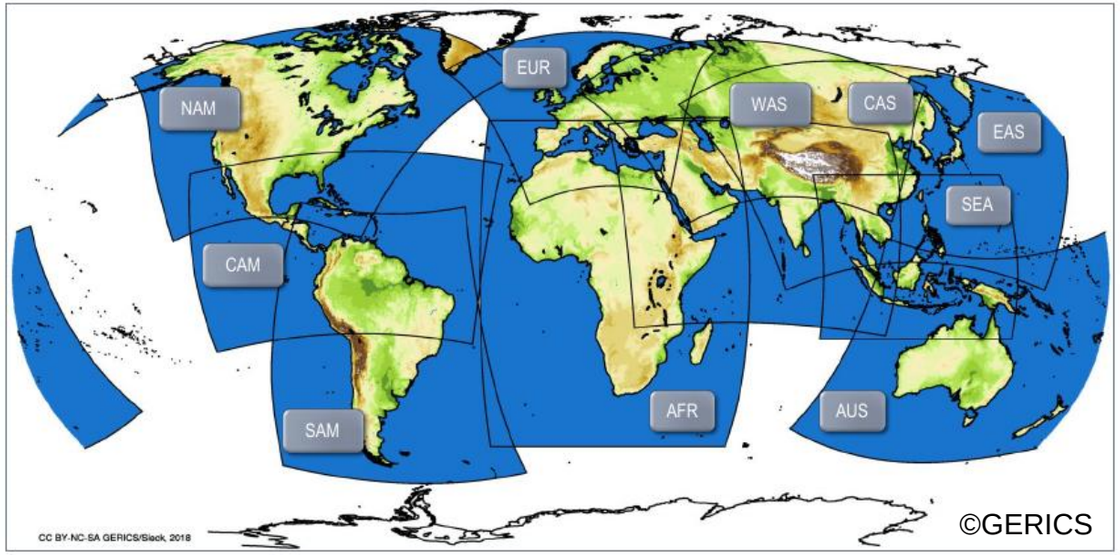
(CORDEX-CORE domains, see Gutowski et al., 2016 and www.cordex.org)

Domains	ERA-Interim	NCC-NORESM	GFDL-ESM2M	MPI-ESM-LR	MPI-ESM-MR	HadGEM-ES	MIROC-MIROC5
EUR-11/22	ICTP	ICTP		ICTP		ICTP	
AFR-22	ICTP	ICTP			ICTP	ICTP	
CAM-22	ICTP		ICTP		ICTP	ICTP	
SAM-22	ICTP	ICTP			ICTP	ICTP	
WAS-22	ICTP	ICTP			ICTP		ICTP
EAS-22	ICTP	ICTP			ICTP	ICTP	
SEA-22	ICTP	ICTP			ICTP	ICTP	
AUS-22	ICTP	ICTP			ICTP	ICTP	
NAM-22	ICTP		ICTP		ICTP	ICTP	©GERICS

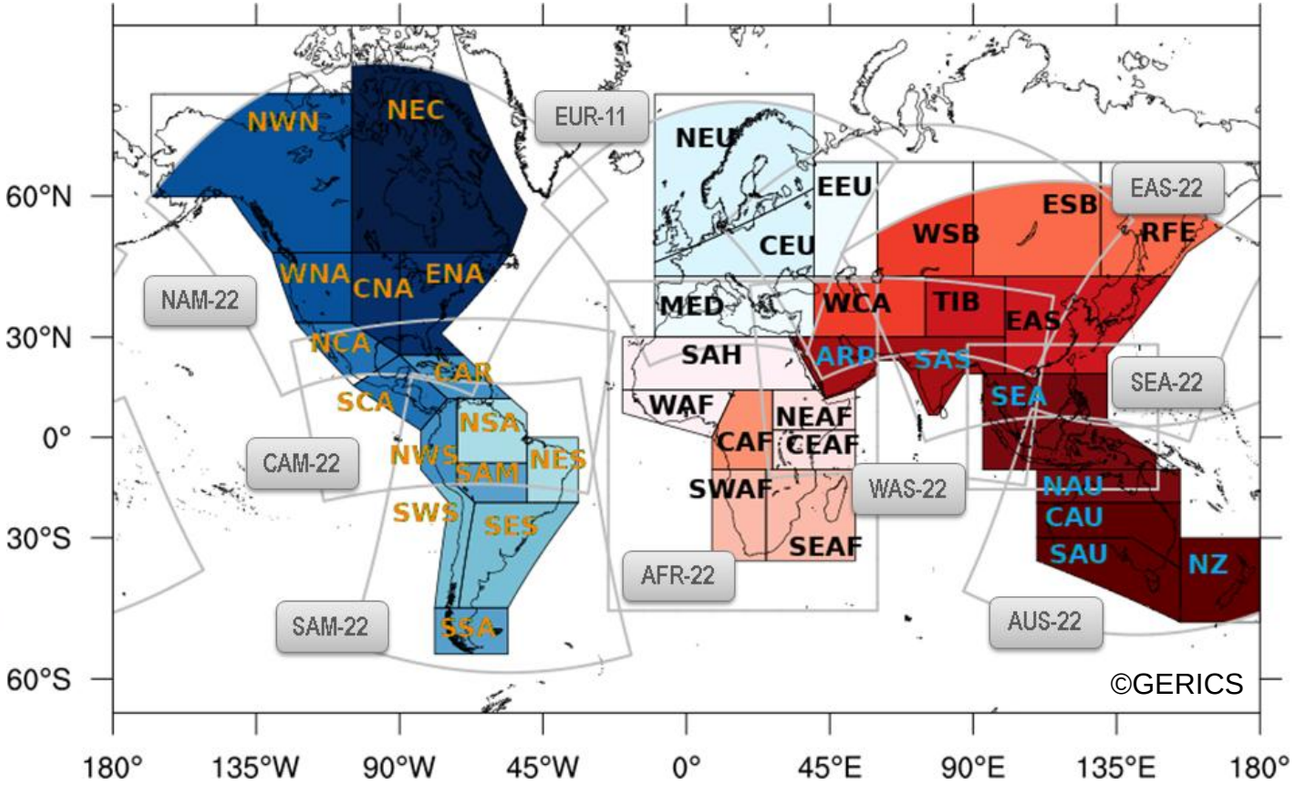
- **Experiments:**
  - evaluation: reanalysis, 1979 to 2017
  - historical, rcp2.6 and rcp8.5: GCMs, 1950 (1970) to 2100
- **Variables to be stored:**
  - 8 Mandatory variables: tas, tasmax, tasmin, pr, ps, hurs, sfcWind, rsds
  - 19 Recommended variables: sfcWindmax, rlds, hlfs, hfss, rsus, rlus, evspbsl, mrro, mrso, snw, prc, ua200, va200, ta200, zg500, ua850, va850, ta850, hus850

- **Additional simulations:**
  - CAS-22 (using REMO in the frame of the AFTER project)
  - Upcoming CLM simulations from selected domains
- **Evaluation of CORDEX-CORE simulations using REMO:**
  - Remedio et al., 2019, Atmosphere: *https://doi.org/10.3390/atmos10110726*

CORDEX-CORE Simulation matrix



(CORDEX-CORE domains, see Gutowski et al., 2016 and www.cordex.org)

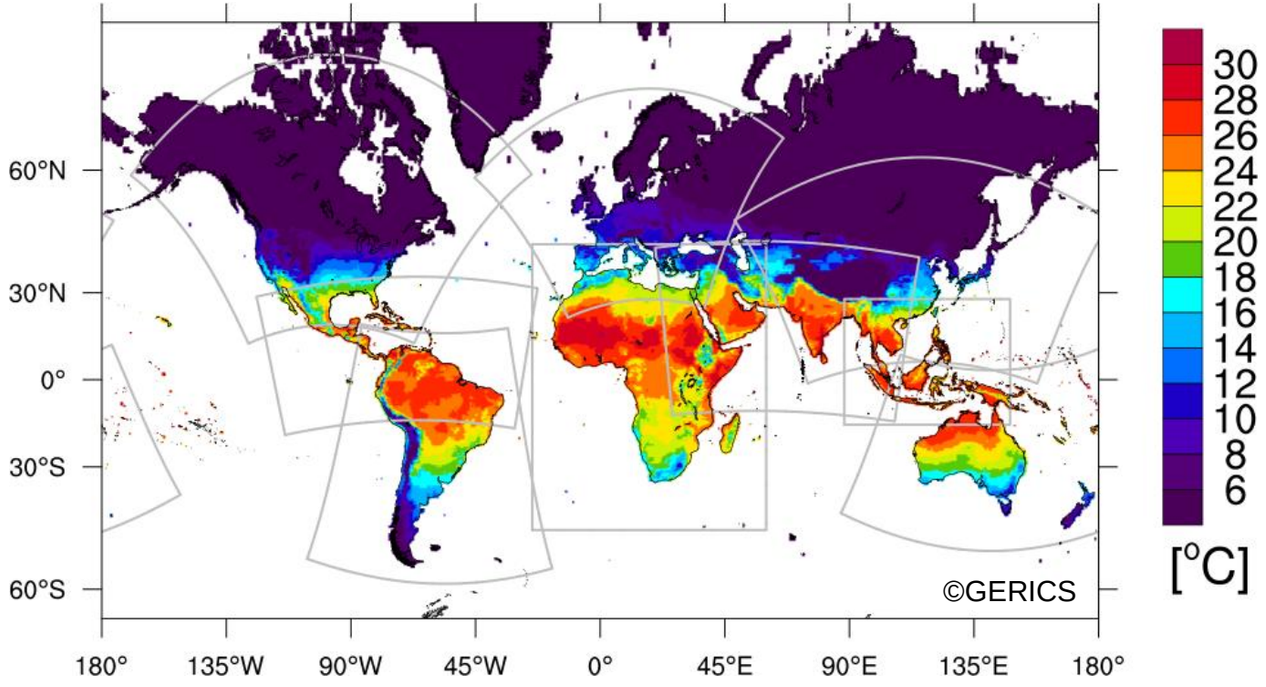


Our analysis is based on 39 analysis domains based on the AR6 IPCC physical climate reference regions

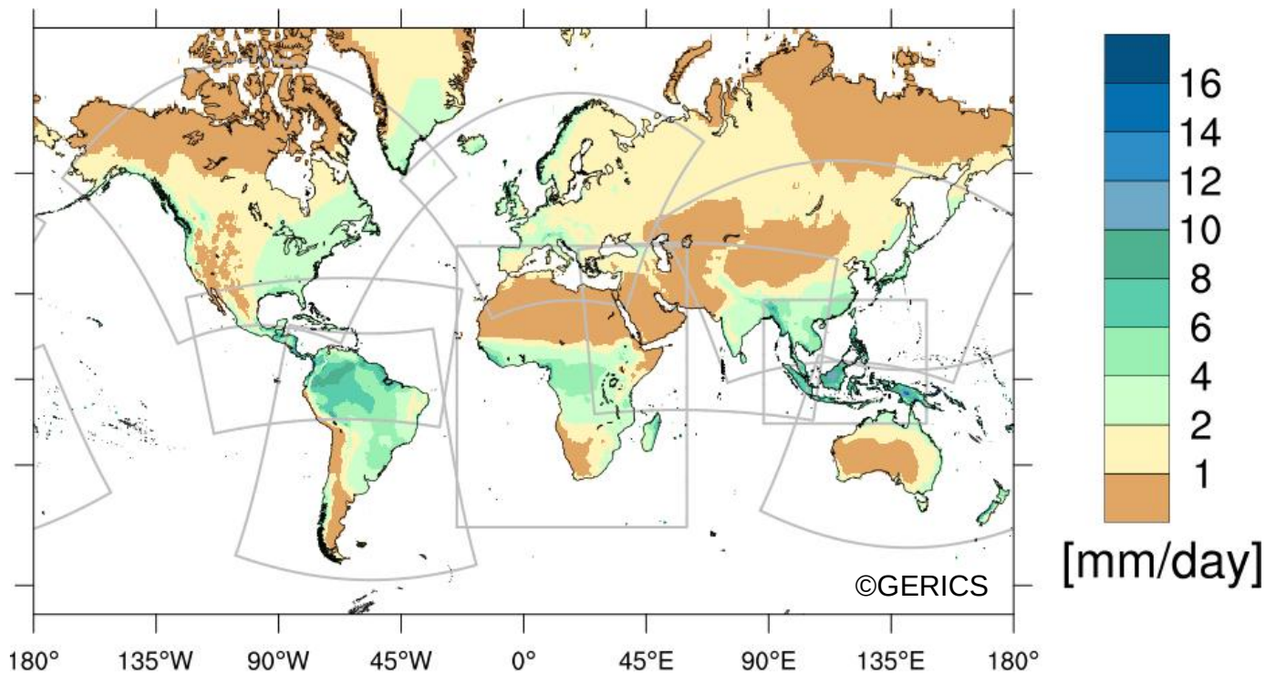
(Iturbide et al., 2020, Earth System Science Data (ESSD), https://doi.org/10.1175/JCLI-D-19-0084.1)

Observed temperature and precipitation based on CRU TS 4.02, 1971 to 2000

Temperature



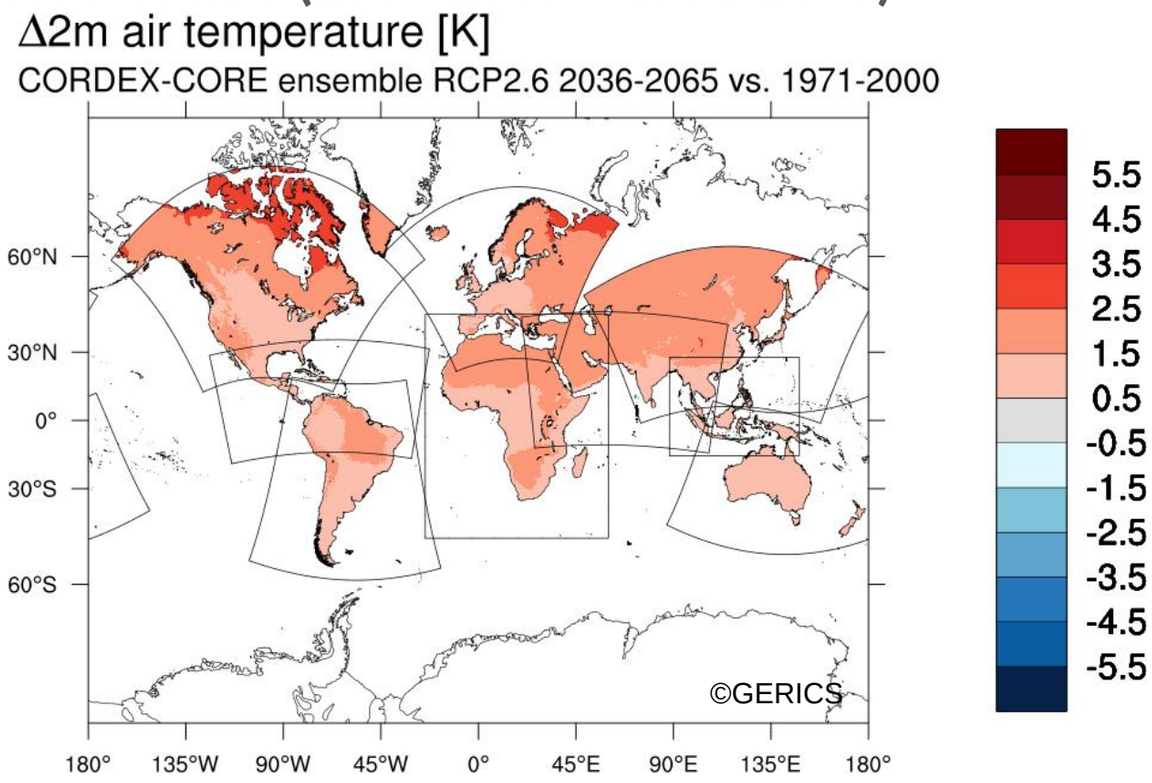
Precipitation



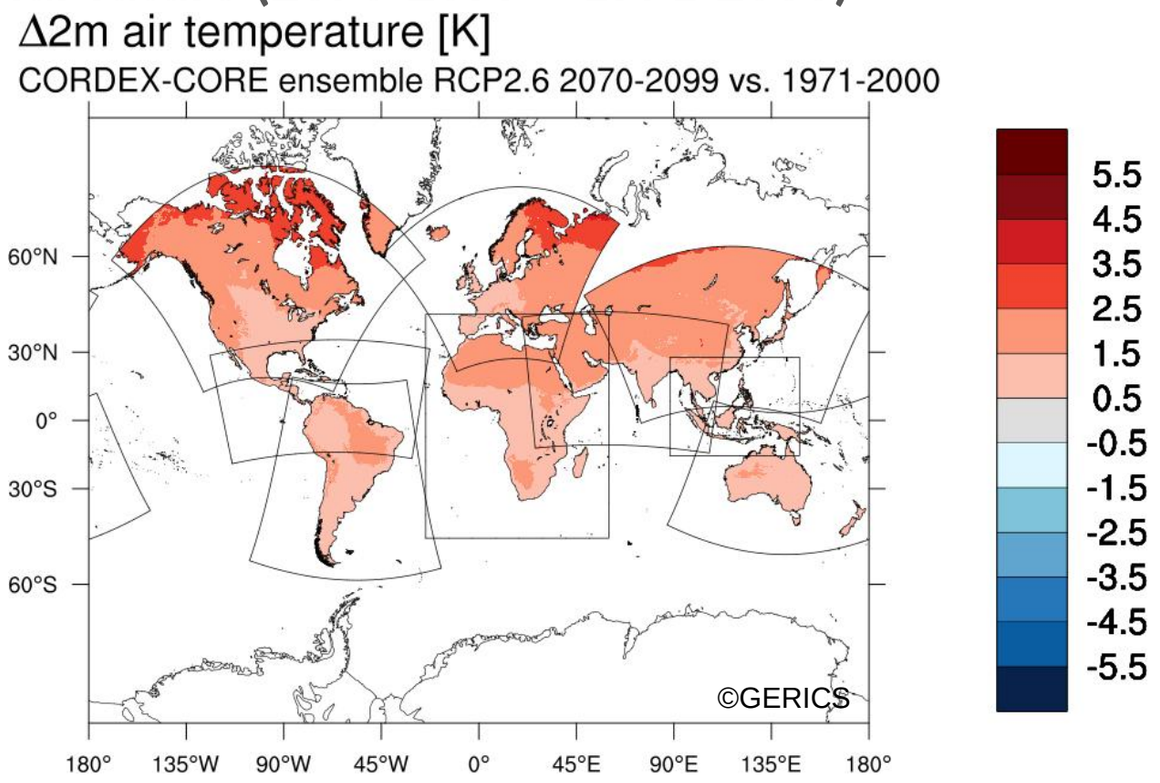
Observed temperature and precipitation as a reference for follow-up climate change signal plots.

Mean annual temperature climate change signal at RCP2.6

near future (2036-2065 – 1971-2000)



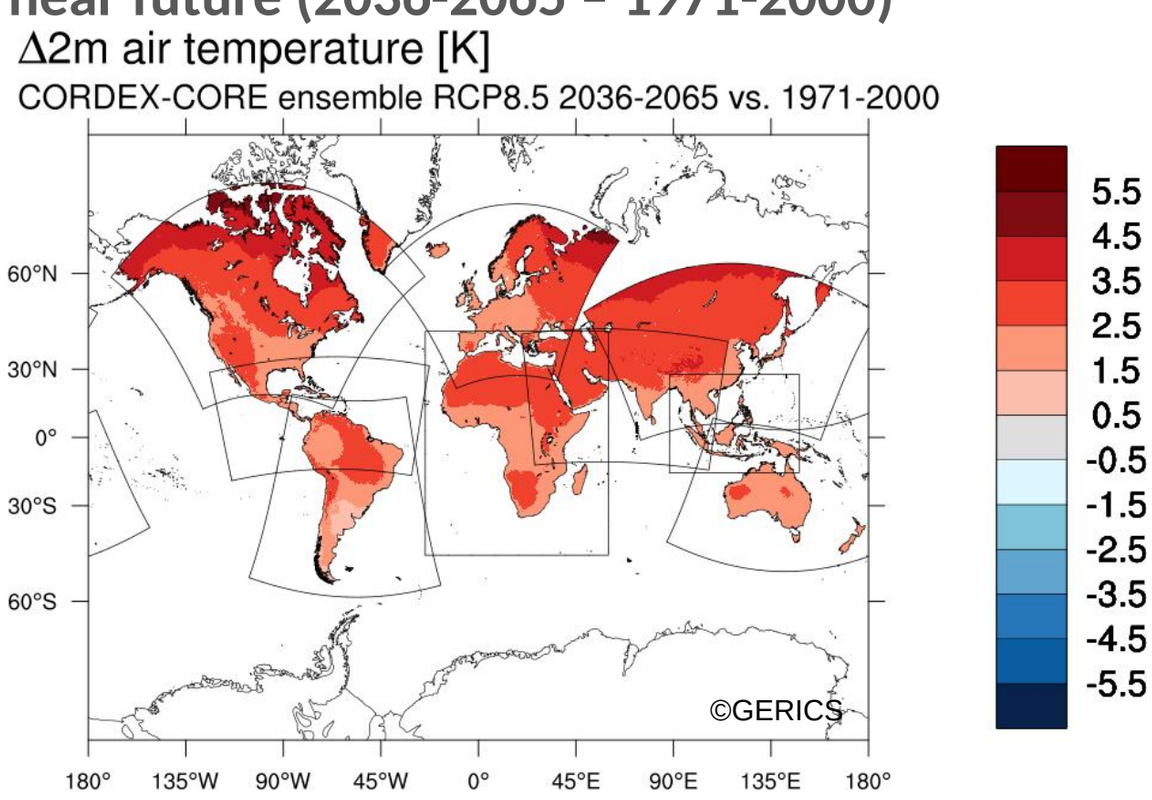
far future (2070-2099 – 1971-2000)



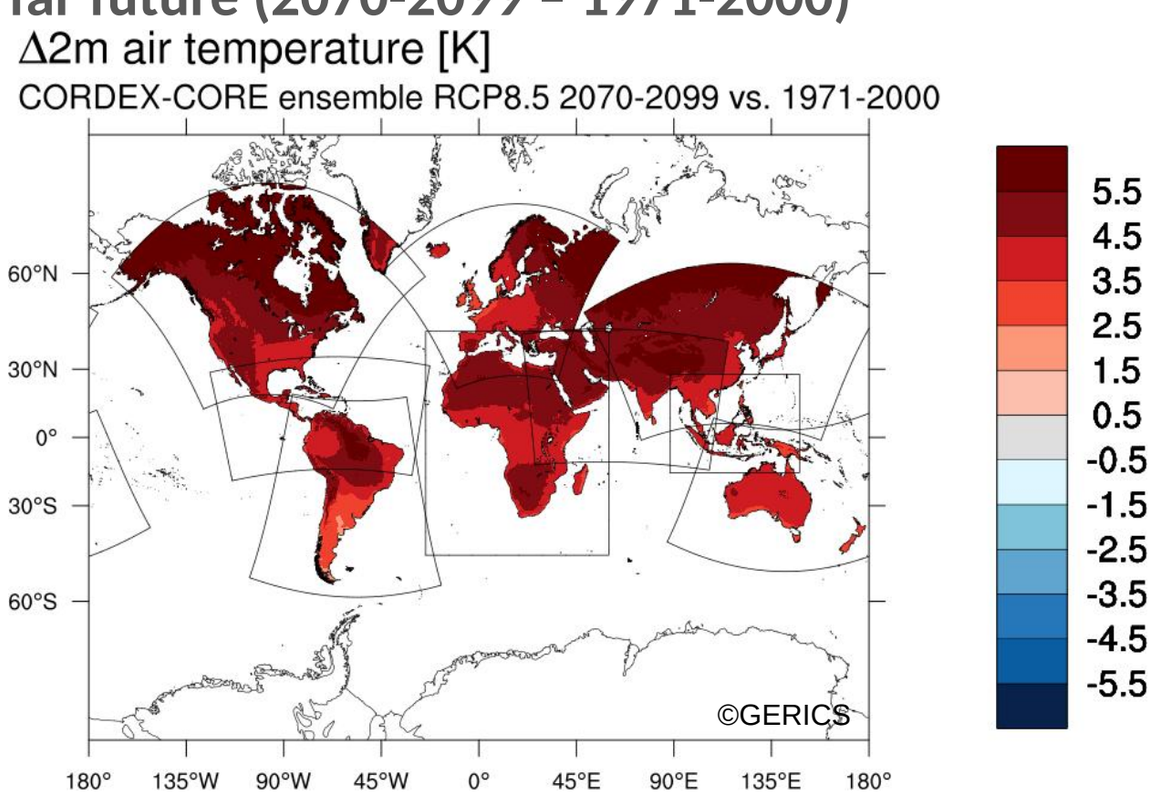
- Ensemble mean temperature climate change signal: about +0.5 to +3.5 K (high CCS over North America and European domains)

Mean annual temperature climate change signal at RCP8.5

near future (2036-2065 – 1971-2000)



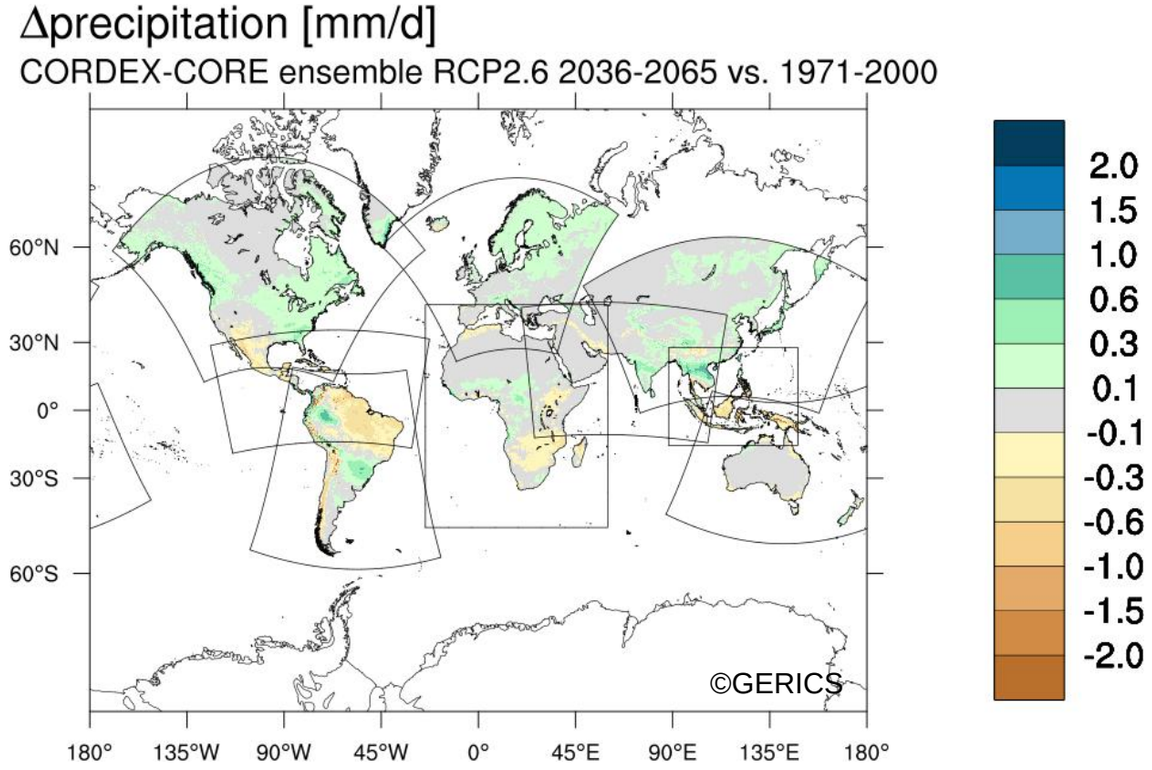
far future (2070-2099 – 1971-2000)



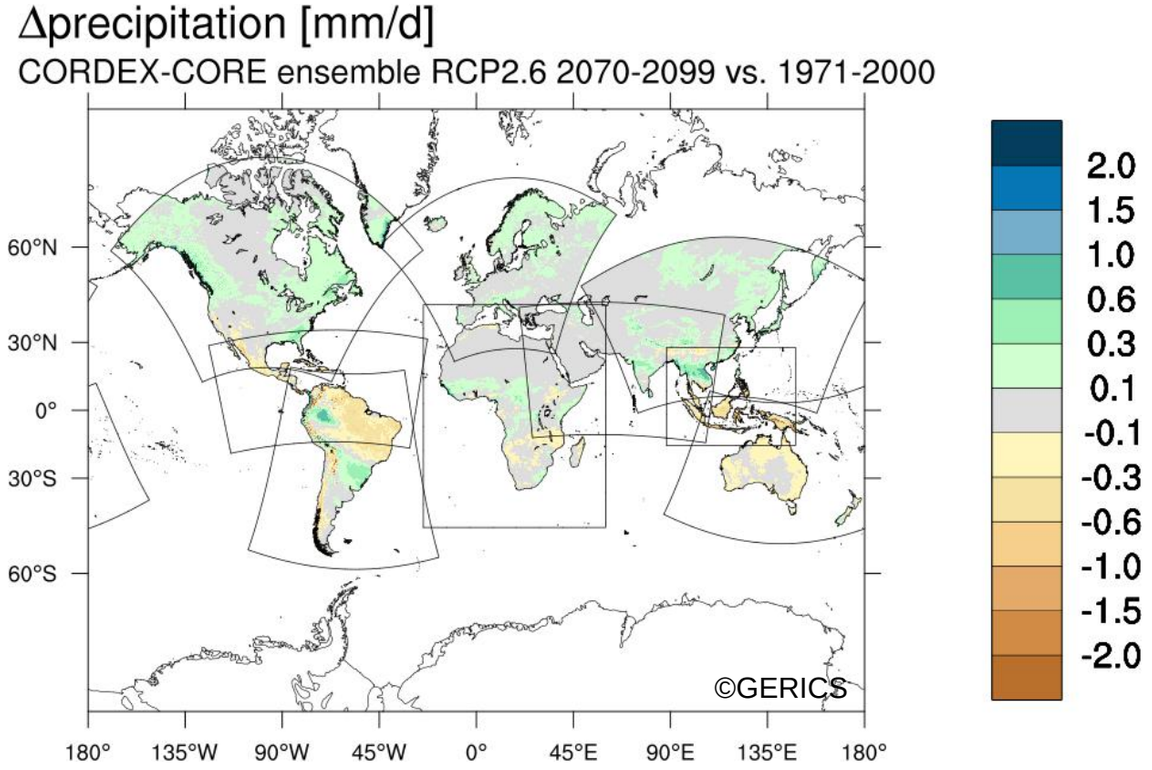
- Ensemble mean temperature climate change signal: about +0.5 to +4.5 K (about +1.0 K increase of CCS at the end of the century)

Mean annual precipitation climate change signal at RCP2.6 (abs)

near future (2036-2065 – 1971-2000)



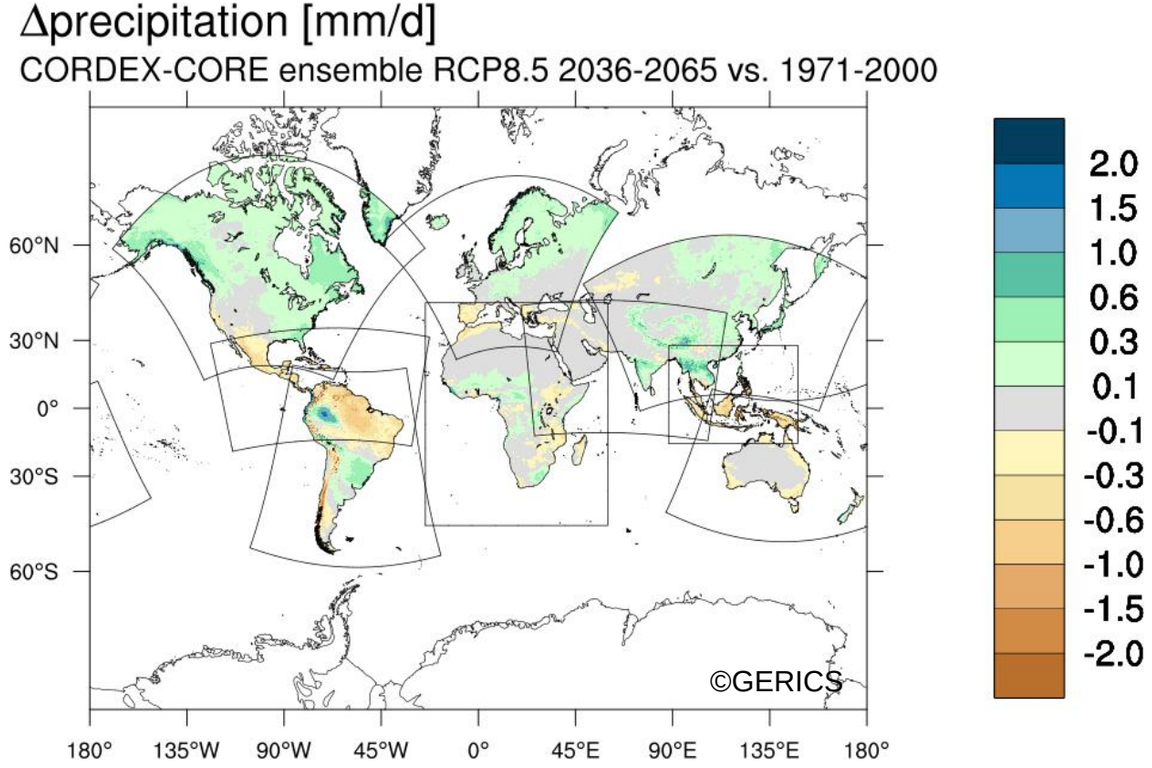
far future (2070-2099 – 1971-2000)



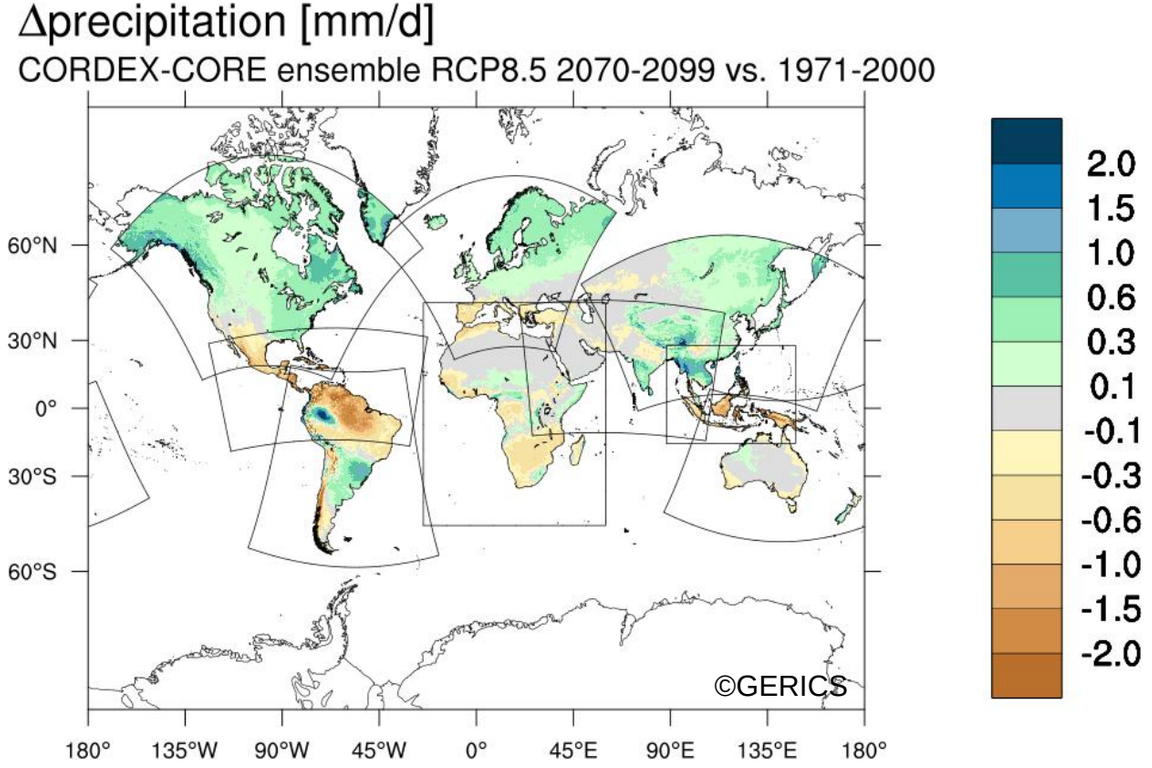
- Wet CCS: north of NAM, EUR, and EAS domains (5 to 15%), Southeast South American (SES) region
- Dry CCS: Central America, Northeast of Brazil, northern and southern parts of Africa (-5 to -15%), AUS domains (weak, but spreads to the continent at the end of the century)

Mean annual precipitation climate change signal at RCP8.5 (abs)

near future (2036-2065 – 1971-2000)



far future (2070-2099 – 1971-2000)

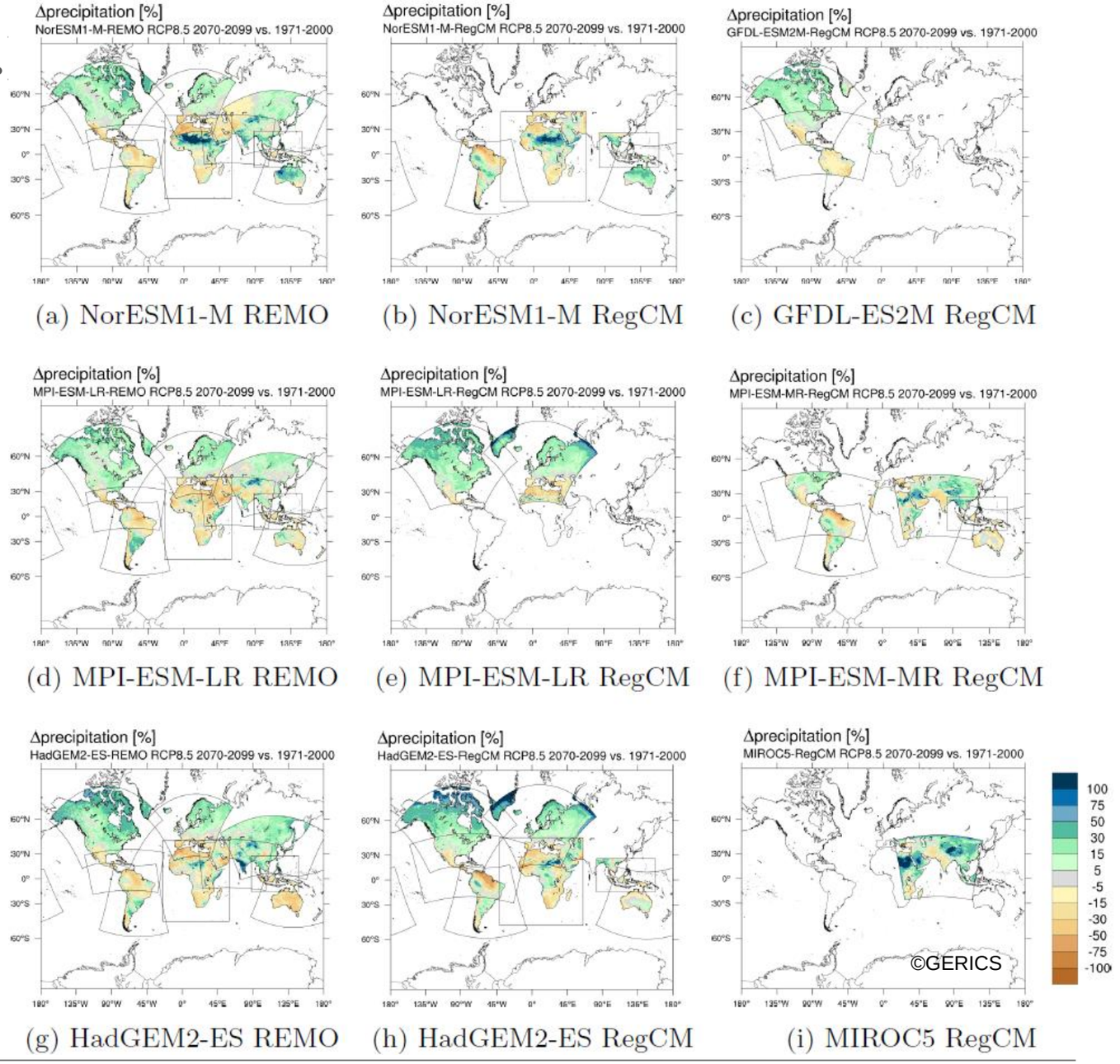


- Wet CCS: NAM and EUR domains (+15 to +50%)
- Dry CCS: CAM, north and south of SAM, north and south of AFR (-15 to -50%)
- Weak dry CCS over AUS and increasing wet signal over Central Australia (CAU) region

Precipitation CCS at RCP8.5 (end cent.

- **Relative precipitation Changes** are plotted for different driving GCM-RCM combinations.

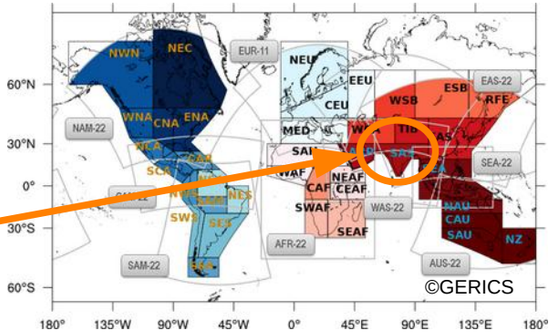
- wetting signal in the NAM-22 – present in all RCMs
- drying signal over the Amazon – present in all RCMs except the emerging wet signal over the Northwest South America (NWS) region in the medium and high ECS GCMs (Figure d to h)
- strong wetting signal over AUS-22 is mainly due to the RCM simulations driven by the NorESM1
- strong wetting signal over Southern India originates from REMO simulations, in contrast to the drying depicted by the RegCM simulations

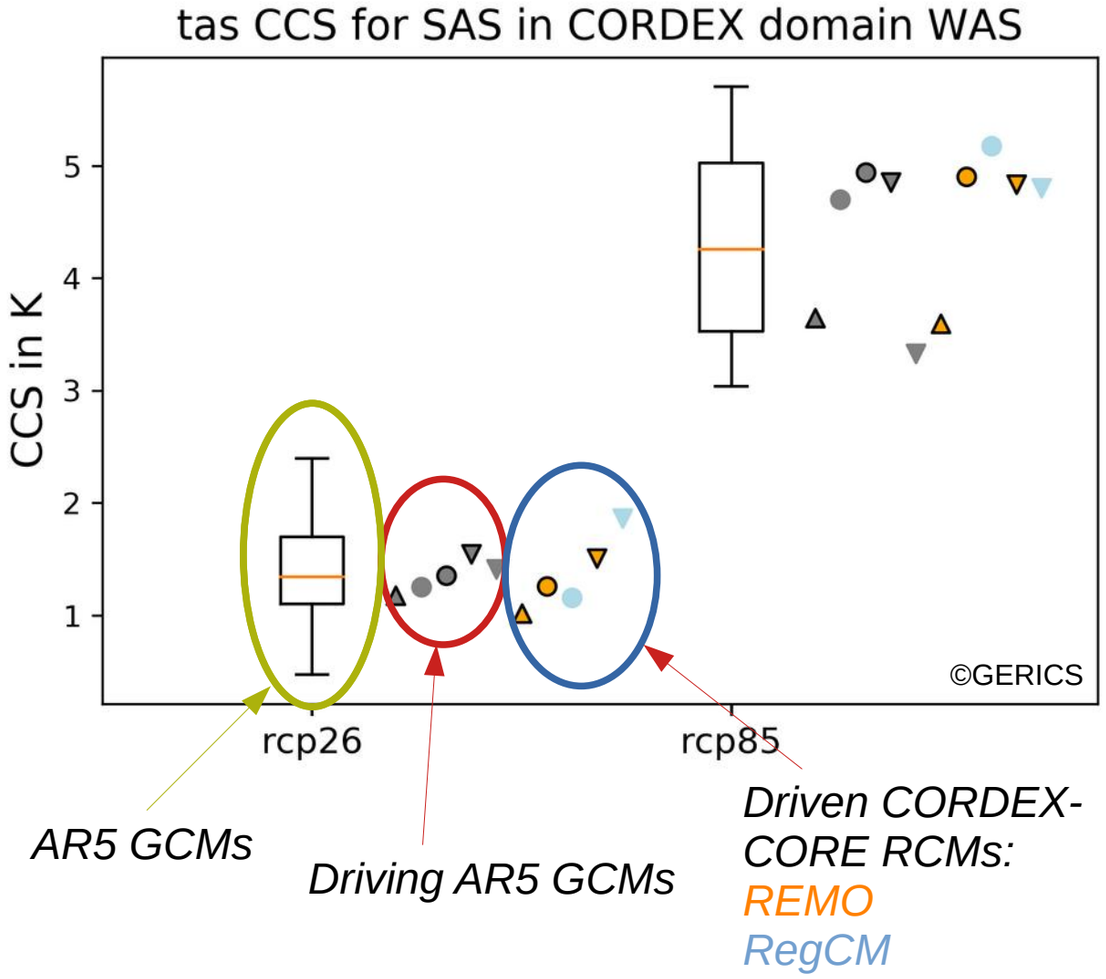


GCM-RCM Mean climate change signal in regions

Methodology

IPCC physical reference region: SAS

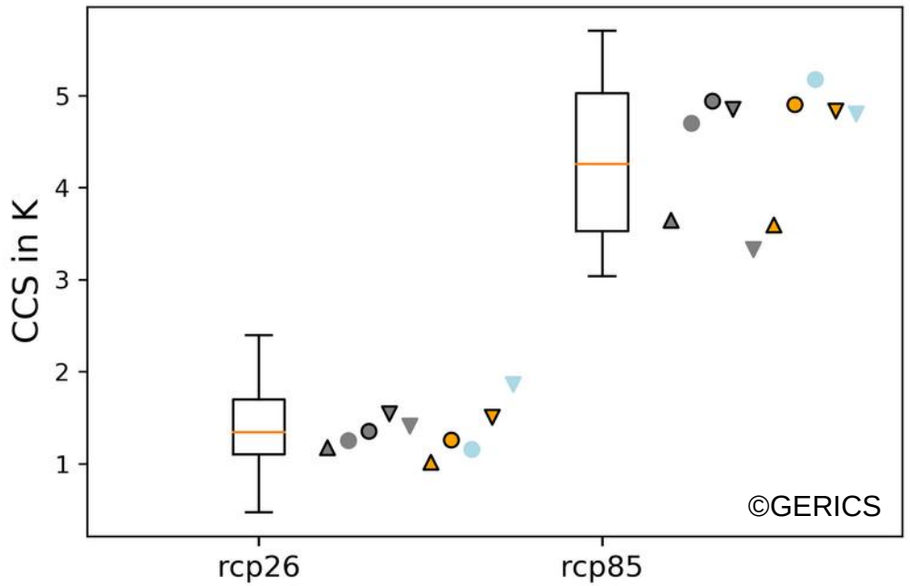




- Temperature climate change signals for AR5-GCMs and CORDEX-CORE RCMs in selected IPCC reference regions for **RCP2.6 and RCP8.5** at the end of the century **(2070-2099)** for the entire AR5-GCM ensemble, the CORDEX-CORE driving GCMs of the respective CORDEX-CORE domain and the CORDEX-CORE RCMs.
- The climate change signal of the AR5-GCM ensemble is depicted as a **box-whisker plot**.
- The driving AR5-GCMs with low, medium and high equilibrium climate sensitivity are plotted as **gray** triangles pointing upwards, circle and triangle pointing downwards, respectively. Primary GCMs are marked with a solid border.
- The RCMs driven by low, medium and high equilibrium climate sensitivity GCMs are drawn using the same symbols as before, but in **orange** for REMO and in **blue** for RegCM. Primary driving GCMs are again marked with a solid symbol border.

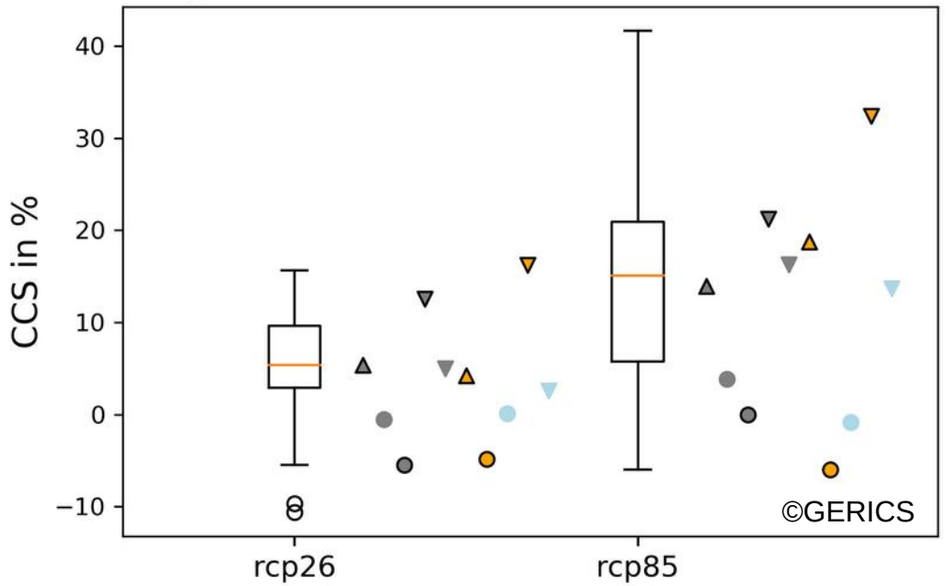
GCM-RCM Mean climate change signal in regions

Temperature climate change signal
tas CCS for SAS in CORDEX domain WAS



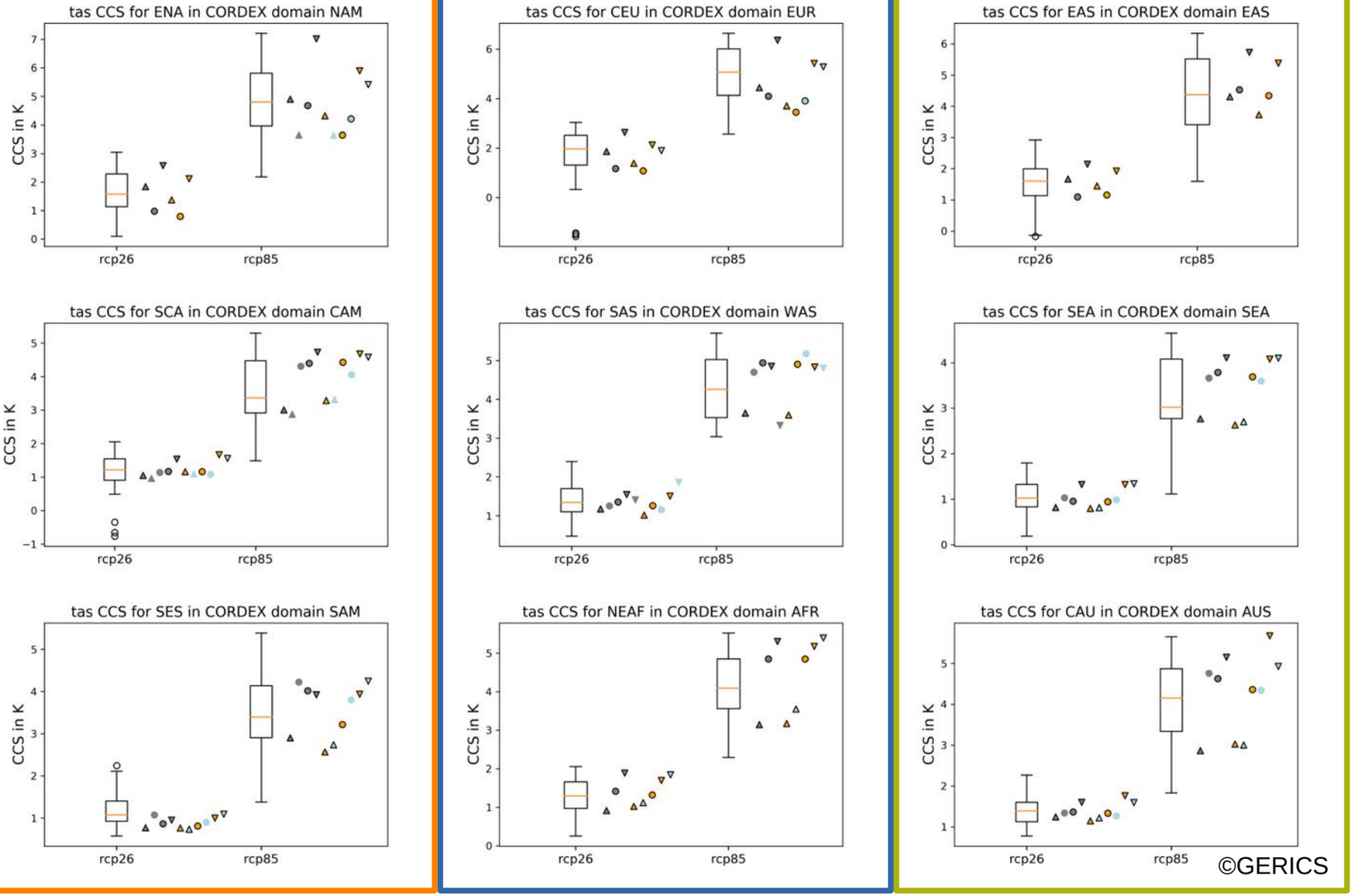
- AR5-GCM interquartile range is covered by the CORE GCMs and CORE RCMs
- Similar CCS for the CORE GCM and CORE RCM (0.5 K)
  - except for high ECS GCM (CCS of 3.4 K), its RCM (CCS of 4.8 K)
- Order of low, medium and high ECS GCMs and CORE RCMs are preserved

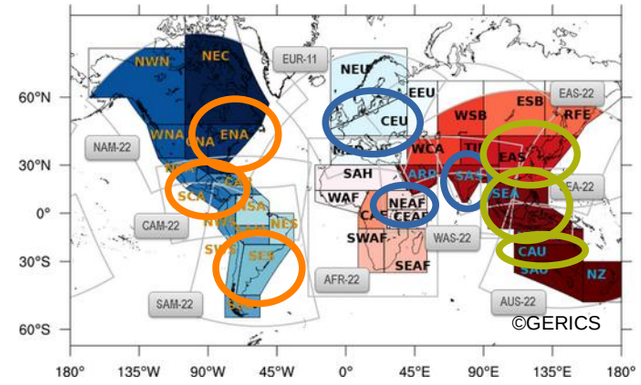
Precipitation climate change signal
pr CCS for SAS in CORDEX domain WAS



- AR5-GCM interquartile range is covered by the CORE GCMs and CORE RCMs
- Similar CCS for the CORE GCM and CORE RCM (-5 to 13%) for rcp2.6
  - for rcp8.5, large spread of AR5-GCMs
- CORDEX-CORE RCMs reproduce the GCM CCS but the extremes are more amplified

GCM-RCM Mean climate change signal in IPCC physical reference regions

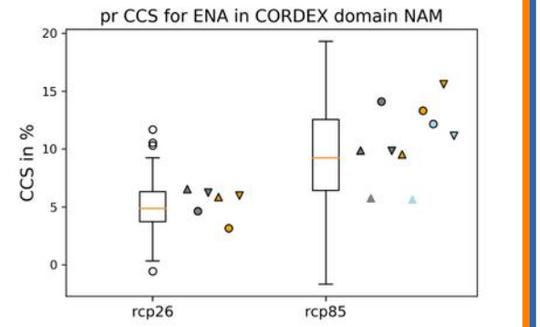


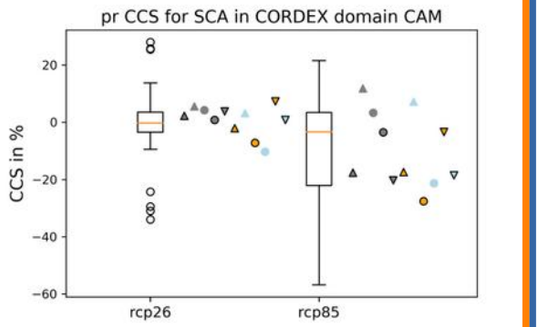


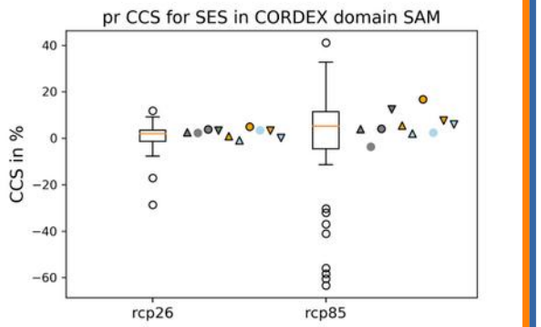
Temperature climate change signals for different IPCC physical reference regions for six CORDEX-CORE domains

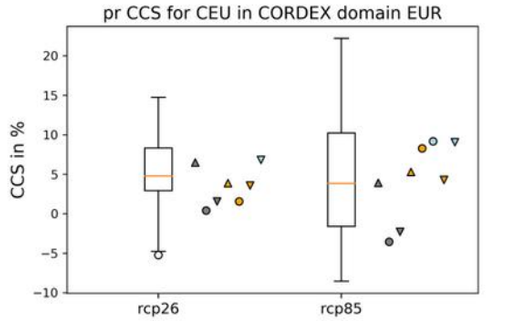
- AR5-ensemble climate change signals interquartile range is well covered for most of the domains by selected CORDEX-CORE GCMs and RCMs
- Global driving GCM climate sensitivity order is not necessarily preserved.
- Tropical regions show quite similar CCS for CORDEX-CORE GCMs and RCMs (and thus generally preserve the ECS-order)

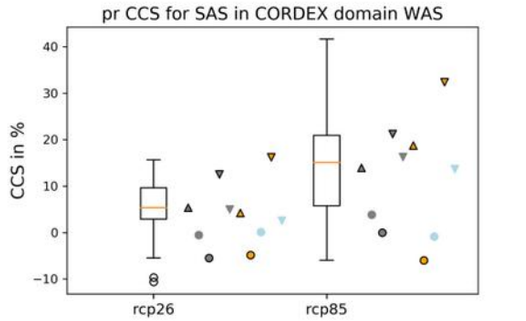
GCM-RCM Mean climate change signal in IPCC physical reference regions

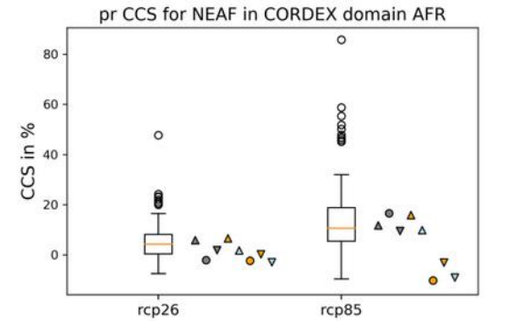


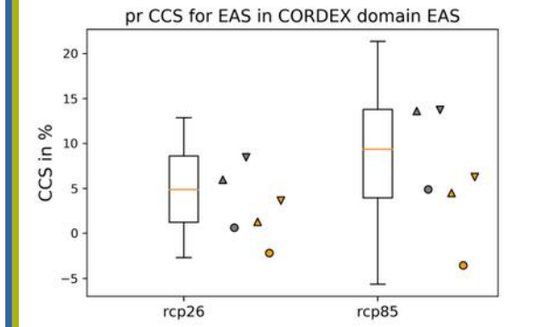


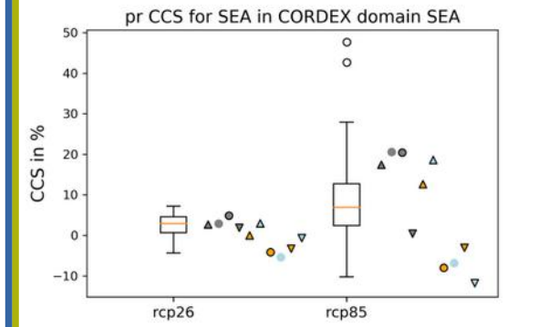


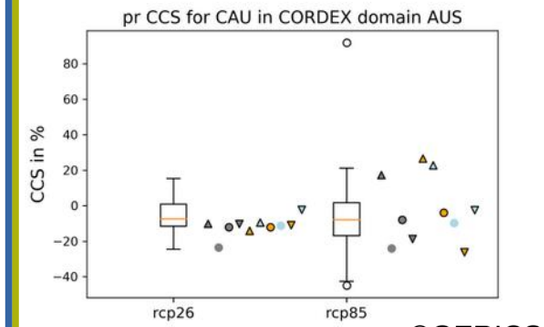












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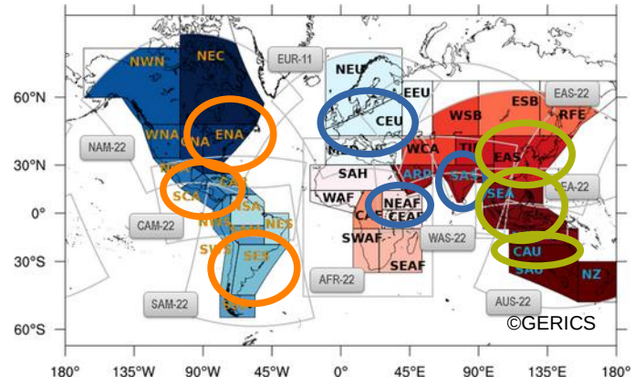

Precipitation climate change signals for different IPCC physical reference regions for six CORDEX-CORE domains

- AR5-ensemble climate change signals interquartile range is well covered for most of the domains by selected CORDEX-CORE GCMs and RCMs, but not for all.
- Oposite Climate change signals in some regions (e.g., NEAF where medium and high ECS GCM project a precipitation increase, while RCM project a precipitation decrease)
- Larger spread of CCS for RCP8.5 compared to RCP2.6 (for GCMs as well as for RCMs)

Conclusions and Outlook

- The mean climate change signal based on the 39 regions of analysis were calculated in the CORDEX-CORE ensemble and compared with the AR5-GCM ensemble as well as the GCMs driving the CORDEX-CORE ensemble.
- The CORDEX-CORE ensemble represents the AR5-GCM ensemble of temporal and spatial mean climate change signals for most IPCC reference regions of the world.
- In some regions, the AR5-GCM ensemble of climate change signals is not represented to the full extent by the CORDEX-CORE GCMs and RCMs.
- Futher individual assessment in each region is necessary before applying CORDEX-CORE simulations to VIACS applications

- Upcoming reference papers submitted in Climate Dynamics:
  - Assessing mean climate change signals in the global CORDEX-CORE ensemble (Teichmann et al., 2020)
  - Climate hazard indices projections based on CORDEX-CORE, CMIP5 and CMIP6 ensemble (Coppola et al., 2020)
- CORDEX phase I + CORDEX CORE contributes to the AR6 IPCC Atlas

- Data are CMOR-ized and distributed on the ESGF archive (CINECA Italy & DKRZ Germany nodes)
- We encourage the use of CORDEX-CORE for any scientific studies by the entire CORDEX research community
- **Data Policy**: we strongly encourage people using the data from the CORDEX-CORE database to contact the model data producers in order to give feedbacks on the model simulations, interact on the scientific studies and/or propose co-authorships.

Thank you for your interest in this study!