CORDEX climate forcing datasets requirements

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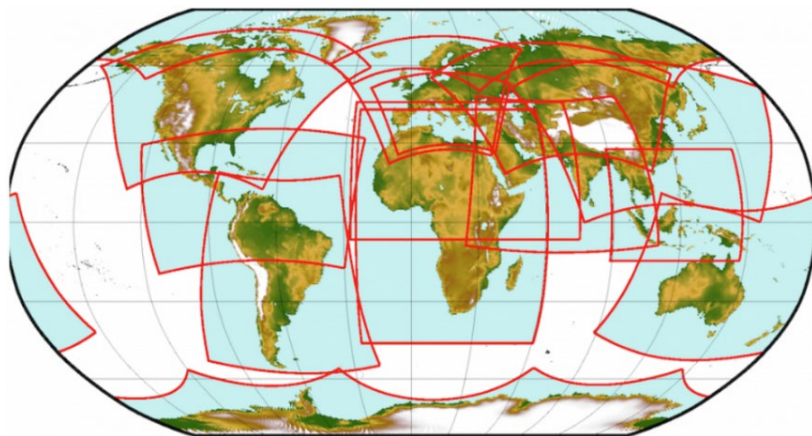Instituto de Física de Cantabria (IFCA), CSIC-Universidad de Cantabria, Spain

appointed by CORDEX SAT

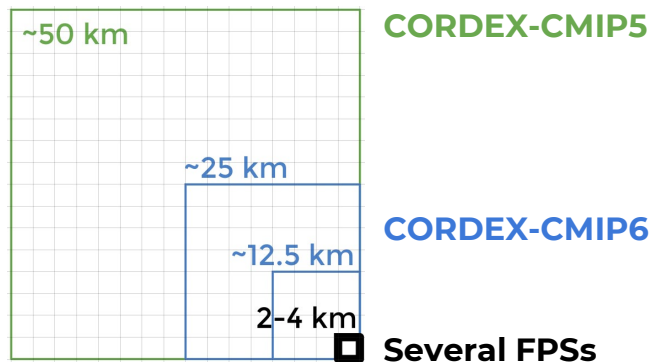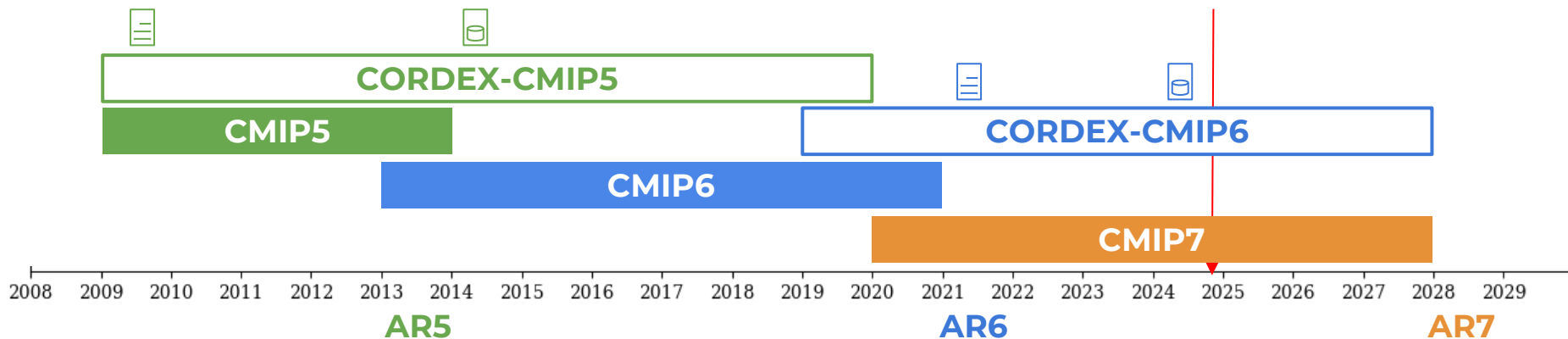with inputs from: D. Rechid, P. Nabat, S. Somot, E. Katragkou, P. Hoffmann

CORDEX

Coordinated Regional Climate Downscaling Experiment

- Regional Climate Models (RCMs)
- Convection-permitting (km-scale) RCMs
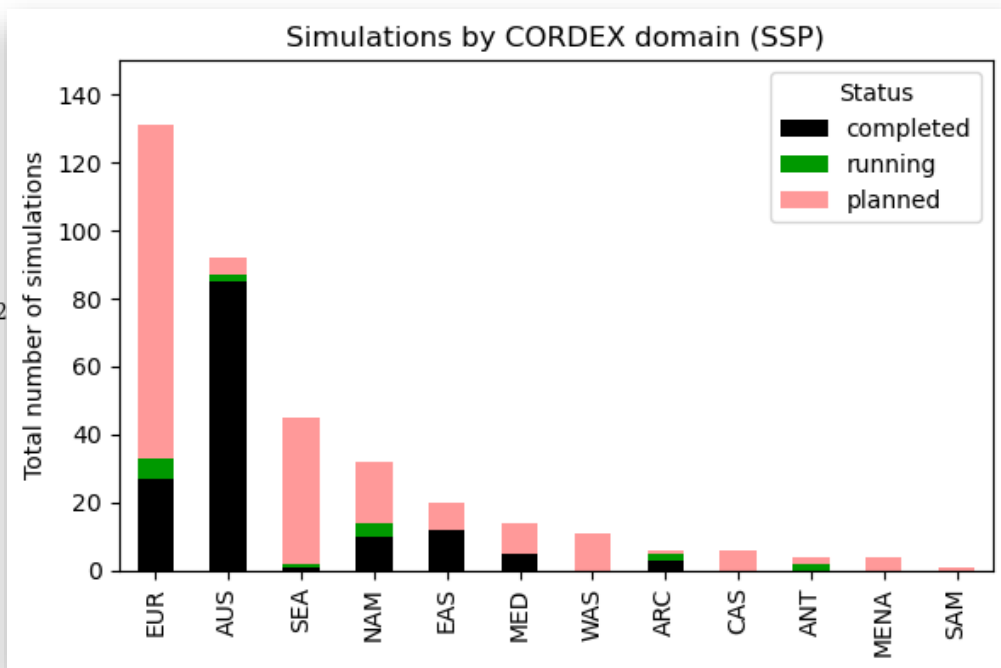- Empirical-statistical downscaling (ESD) and ML RCM Emulators

- Regional communities
  - Continental-scale downsc.
  - Flagship Pilot Studies (FPS)
- CORDEX-CORE

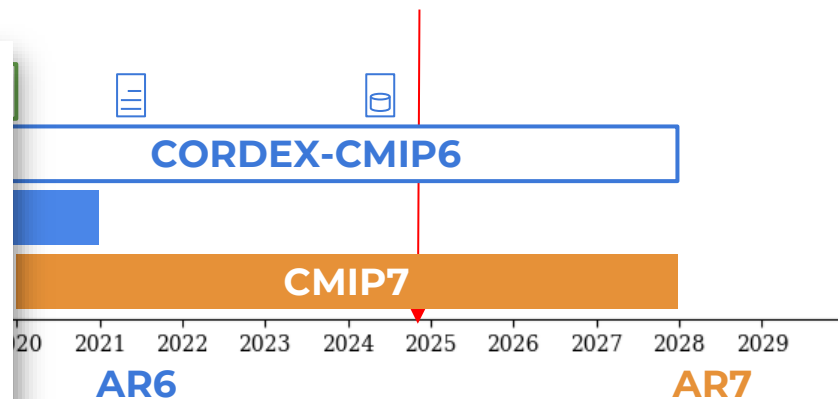# CORDEX and CMIP

CORDEX-CMIP6 status

Simulations by CORDEX domain (SSP)

https://wcrp-cordex.github.io/simulation-status/CMIP6_downscaling_plans.html

CORDEX-CMIP6

CMIP7

AR6   AR7

Size of the scenario ensemble
(mostly SSP3-7.0 and SSP1-2.6)

Climate forcings sustained mode
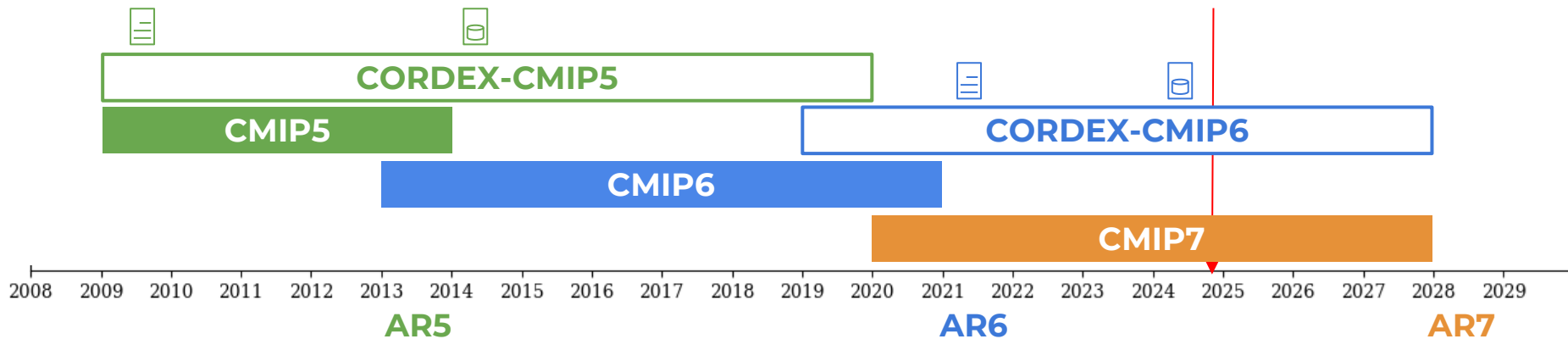
With these timelines, CORDEX seems:

- less concerned with extensions (1 yr) / updates (3 yr)
- and more with support (5-10 yr)

FPS might benefit from these, though

emulators!

Climate forcings in CORDEX

- Lateral boundary conditions from the driving GCM as the main forcing

- Consistently incorporating climate forcings is still a pending subject. CORDEX-CMIP6 discourages, but allows:

  - Static land use   **→ FPS-LUCAS**

  - Basic aerosol treatment (e.g. fixed climatology)   **→ FPS-Aerosol**

- CORDEX-CMIP7 envisioned to use forcings fully consistent with the driving GCMs

FPS-Aerosol
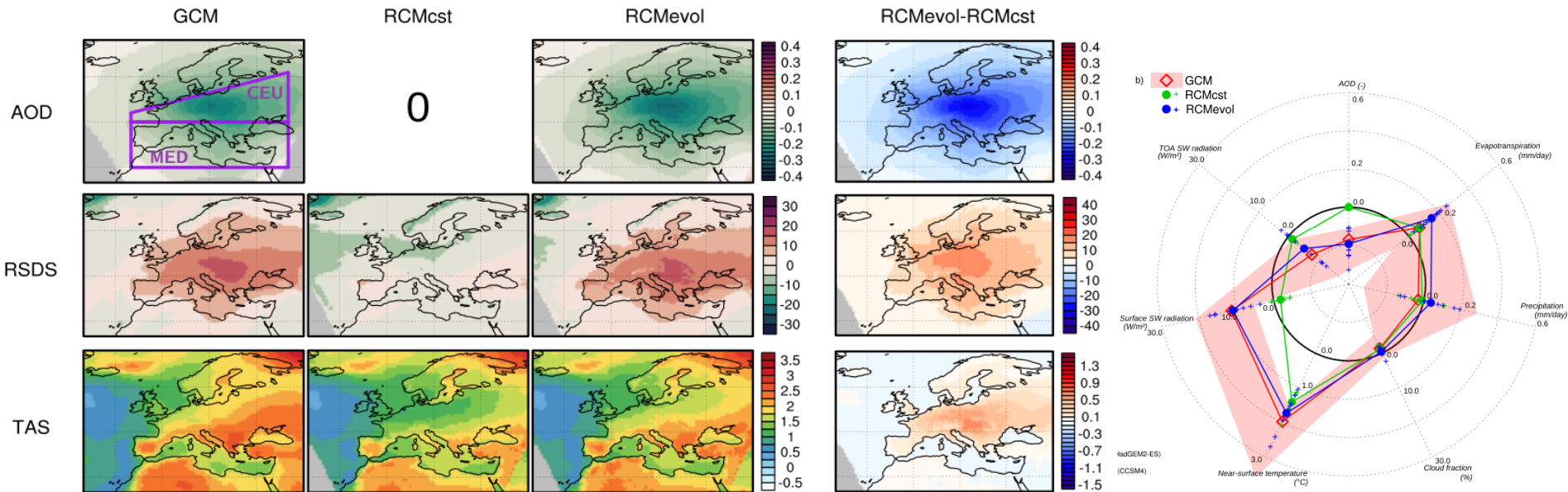
Nabat et al. (2024, submitted to GRL) "Multi-model assessment of the role of anthropogenic aerosols in summertime climate change in Europe"

See also:
Gutiérrez et al. (2019) https://doi.org/10.1088/1748-9326/ab6666
Boé et al. (2020) https://doi.org/10.1007/s00382-020-05153-1
Taranu et al. (2023) https://doi.org/10.1007/s00382-022-06540-6

Institute	RCM	Grid	Driving GCM	Aerosols
AUTH	WRF[a]	50 km	CCSM4 (r6i1p1)	From GCM[g]
CNRM	ALADIN63[b]	12.5 km	CNRM-CM5 (r1i1p1)	From GCM[h]
CNRM	ALADIN63[b]	12.5 km	HadGEM2-ES (r1i1p1)	From GCM[g]
CNRM	ALADIN63[b]	12.5 km	NorESM1-M (r1i1p1)	From GCM[g]
CNRM	ALADIN63[b]	12.5 km	MPI-ESM-LR (r1i1p1)	From GCM[i]
ETH	COSMO-crCLIM[c]	12 km	MPI-ESM-LR (r1i1p1)	Clim[j]+trend[h]
GERICS	REMO2015[d]	12 km	EC-Earth (r12i1p1)	Clim[k]+trend[h]
KNMI	RACMO22E[e]	12 km	EC-Earth (r3i1p1)	From GCM[g]
LAERO	RegCM[f]	50 km	EC-Earth (r12i1p1)	Clim[i]+trend[i]

LANDMATE Plant functional type (PFT) map 2015 based on ESA-CCI LC

- ESA-CCI LC: global land cover dataset (~300 m)

- Cross-walking tables refined for climatic conditions to convert ESA-CCI LC classes into 16 PFTs

Holdridge Life Zone map:
- CRU rainfall and temperature
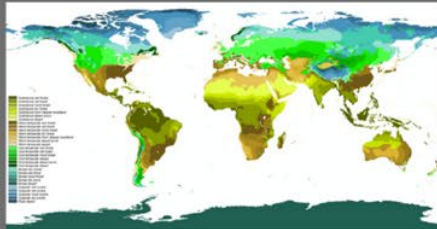- E-OBS for Europe

Figure: Holdridge Life Zone Map

- **0.1° and 0.018°** PFT map 2015 (LANDMATE PFTs) evaluated for Europe with ground truth data

- *by Reinhart et al. 2022, Earth Syst. Sci. Data, 14, 1735–1794, https://doi.org/10.5194/essd-14-1735-2022, 2022.*

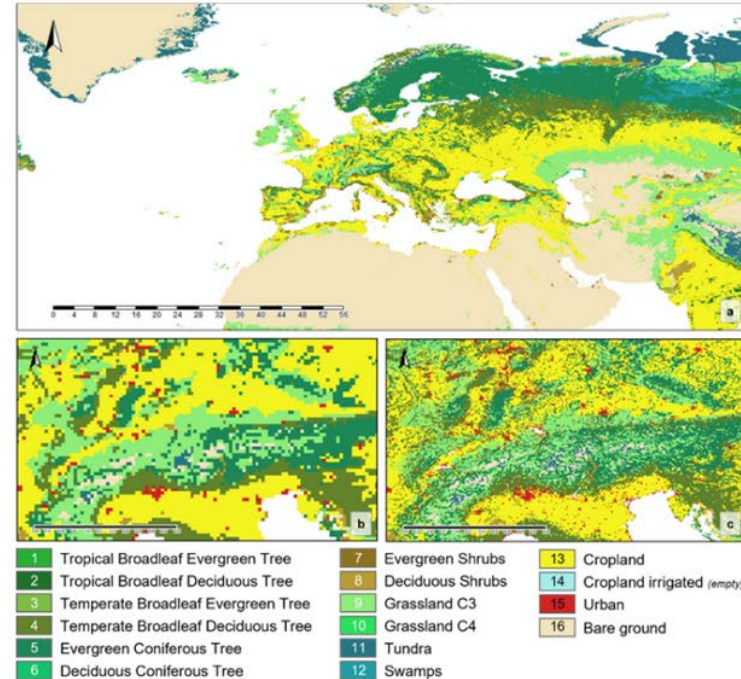|			
1 Tropical Broadleaf Evergreen Tree	7 Evergreen Shrubs	13 Cropland	
2 Tropical Broadleaf Deciduous Tree	8 Deciduous Shrubs	14 Cropland irrigated *(empty)*	
3 Temperate Broadleaf Evergreen Tree	9 Grassland C3	15 Urban	
4 Temperate Broadleaf Deciduous Tree	10 Grassland C4	16 Bare ground	
5 Evergreen Coniferous Tree	11 Tundra		
6 Deciduous Coniferous Tree	12 Swamps		

Figure: LANDMATE PFT map for Europe for 2015 (a). Alpine region 0.1° (b) and 0.018° (c). For visualization all maps show the majority PFT per grid cell.

High-resolution land use land cover change datasets for use in RCM experiments and for downscaling CMIP6 simulations over Europe
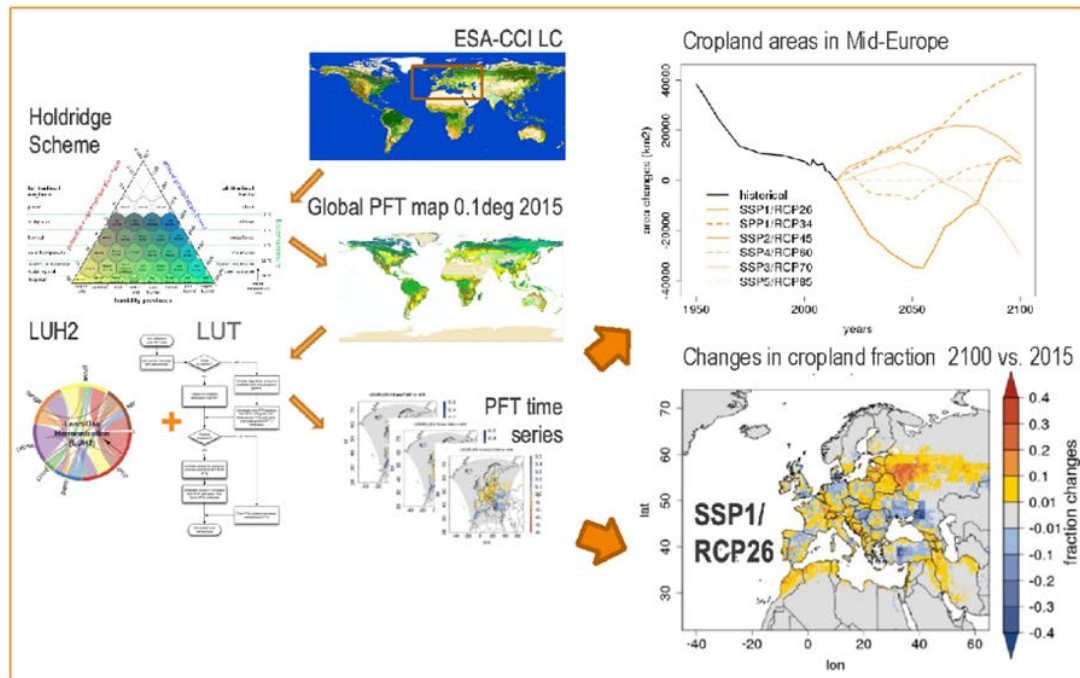
LANDMATE PFT land cover dataset for Europe 2015 V1.0 (Reinhart et al., 2021)

- PFT map 2015 on **0.1°** and **0.018°** for EURO-CORDEX domain

LUCAS LUC historical land use and land cover change dataset V1.0 (Hoffmann et al., 2021)

- annual PFT maps on **0.1°** for EURO-CORDEX domain for past period 1950-2015

LUCAS LUC future land use and land cover change dataset dataset V1.0 (Hoffmann et al., 2021)

- annual PFT maps on **0.1°** for EURO-CORDEX domain for multiple SSPs 2016-2100 based on LUH2, following LUMIP/CMIP6

The method could be extended to all continents. Transferred to CORDEX-NA: see Hoffmann et al. 2024 *published at WDCC / DKRZ (see below)*

Hoffmann, P., Reinhart, V., Rechid, D., de Noblet-Ducoudré, N., Davin, E. L., Asmus, C., Bechtel, B., Böhner, J., Katragkou, E., and Luyssaert, S.: High-resolution land use and land cover dataset for regional climate modelling: historical and future changes in Europe, Earth Syst. Sci. Data, 15, 3819–3852, https://doi.org/10.5194/essd-15-3819-2023, 2023.

- Recent results from FPS LUCAS phase 1 show the impacts of land use change driven modifications of small scale soil, vegetation and snow patterns on atmospheric processes and local climate conditions *(e.g. Sofiadis et al. 2022; Daloz et al., 2022; Mooney et al. 2022)*

- FPS-LUCAS phase 2 provides a framework to incorporate land use change forcings consistent with CMIP6 SSP scenarios at high spatial resolutions

- LULCC data sets on 0.1 deg resolution for use in RCM experiments for downscaling CMIP6 GCM simulations have been generated for Europe, the method could be extended to all continents

- A protocol for implementing the new LULCC maps into RCMs has been developed to represent LULCC consistently among models, and can be accessed by CORDEX FPS LUCAS

- High resolution land use change experiments with RCMs on convection permitting scales (< 4 km resolution) require higher resolution data on land use transitions including high resolution future scenarios and resulting LULCC maps.

D. Rechid et al., Land use forcing for RCMs

CORDEX climate forcings requirements

- Higher resolution spatialization of the forcings extracted from the SSP scenario. In particular having the land-use-land-cover (but also water use, waste) evolution forcings at the RCM resolution.
  - ~10 km for CORDEX continental domains worldwide
  - ~1 km for CPM
- Also for aerosol emissions maps, need to be adapted to CORDEX resolutions.
- This work has been done partially by FPS LUCAS over Europe for the LULC scenarios. Need of a global approach to cover all CORDEX domains.
- FPS-URB-RCC also requiring urban evolution scenarios (e.g. LCZ or other urban subtype transitions)

Additional material

LCZ scenarios example   (Hong Kong Greater Bay Area)
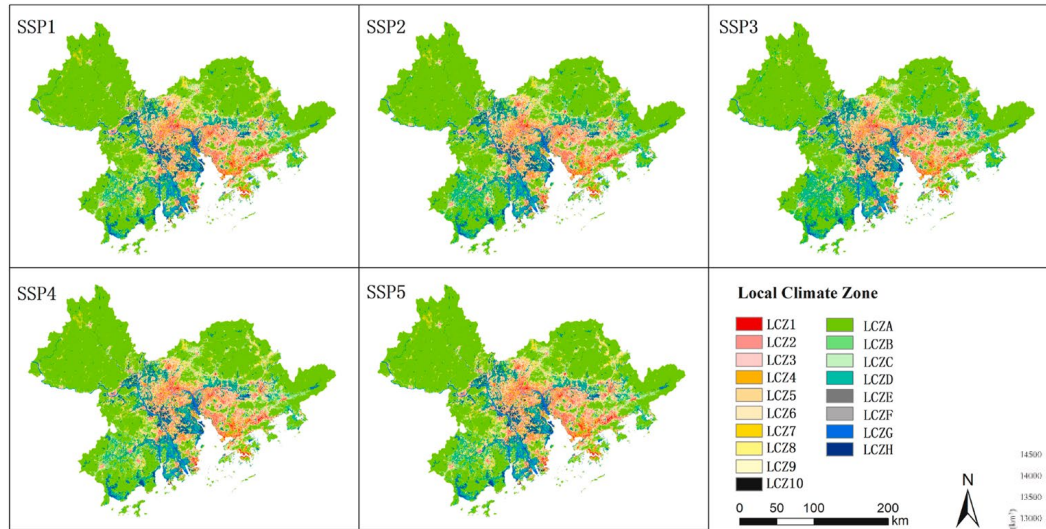
Chen et al. (2021) Future "local climate zone" spatial change simulation in Greater Bay Area under the shared socioeconomic pathways and ecological control line
https://doi.org/10.1016/j.buildenv.2021.108077

CORDEX-CMIP6 status

CORDEX-CMIP6

CMIP7

AR6

AR7

Also represents the current number of different RCMs (and configurations) per domain

CORDEX-CMIP6 status
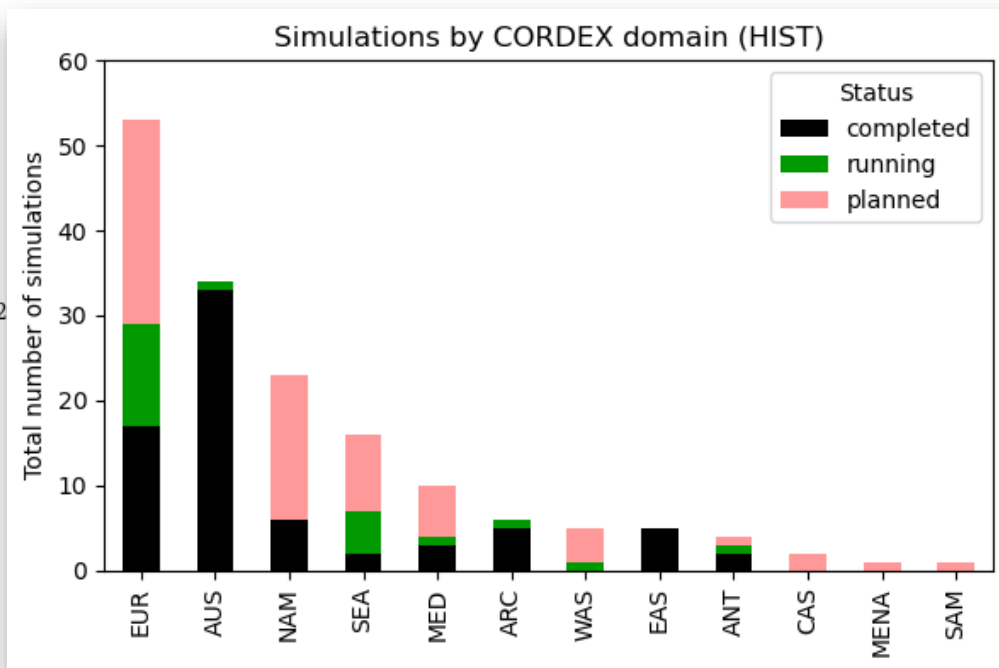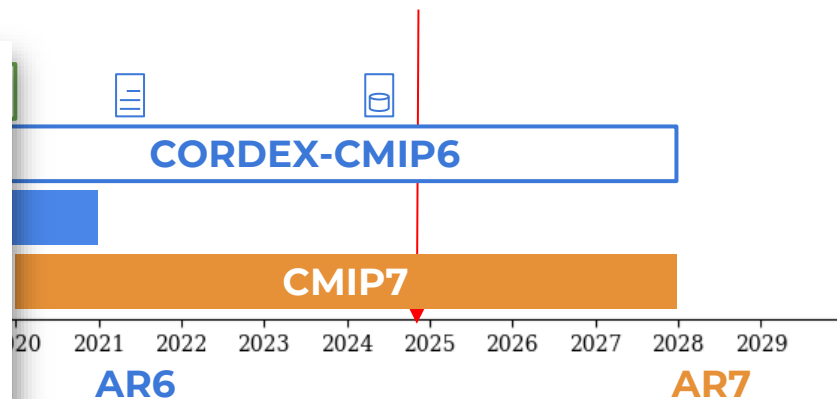
Also represents the current number of GCM-RCM combinations per domain

https://wcrp-cordex.github.io/simulation-status/CMIP6_downscaling_plans.html