Statistical disaggregation and bias-adjustment of CMIP6 variables for climate change impact studies at global and regional scales

OVERVIEW

The recent IPCC Summary Report for Policymakers based on the analysis of climate data and model simulation output provided by an ensemble of tenths of Earth System Models, CMIP6, corroborates that anthropogenic GHG emissions induce climate change. Geo-climatic crisis is manifested in more frequent and severe extreme weather events in several regions around the planet. Systematic biases introduced to the global climate model data, mainly due to the under-representation of orographic forcing, limits their suitability for climate change impact assessments, especially at regional scales, unless further steps are taken to account for these biases. We present an actionable state-of-the-art procedure to statistically downscale and bias-adjust CMIP6 model data.

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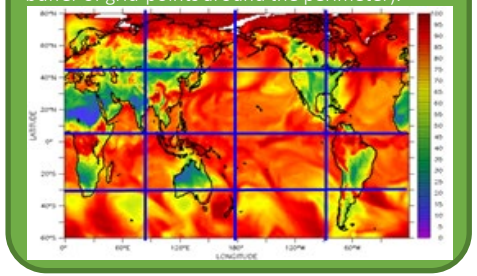
BIAS-ADJUSTMENT METHODOLOGY

Step 1: Data pre-processing

Merging of historical GCM data with projections in a single file (1980-2100); needs calibration period (1980-2005).

Step 2: Split the global domain

In rectangular, equal in size, subdomains (gcd method, this is necessary because we remove a buffer of grid-points around the perimeter).



Step 3: The CI/QDM procedure*

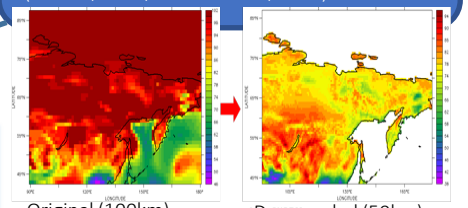
(a) *Climate Imprint* - CI: performs statistical disaggregation on the GCM data (coarse sp. resolution) and transfers information on the OBS grid (finer sp. resolution; e.g., 100 km → 50 km)

(b) *Quantile Delta Mapping* - QDM: performs the bias-adjustment using the statistically downscaled data generated by CI.

*(Li et al., 2010; Cannon et al., 2015)

$$\delta_f(t) = \frac{Q_{s,f}(t)}{F_{s,r}^{-1}[F_{s,f}[Q_{s,f}(t)]]}$$

$$Q_m(t) = F_o^{-1}[F_{s,f}[Q_{s,f}(t)]] \times \delta_f(t)$$

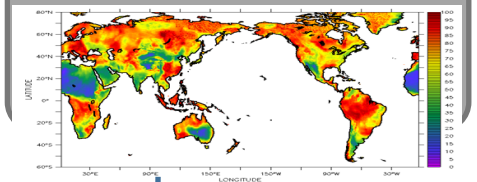


Original (100km)

Downscaled (50km)

Step4: Collect subdomains …

and reconstruct the bias-adjusted global domain. We end up with 80 files corresponding to four SSPs and two meteorological parameters (i.e., tas and hurs).



The bias-adjusted CMIP6 data, against WFDE5 (v1.0), span the period 1980-2100 or 121 years of daily values!

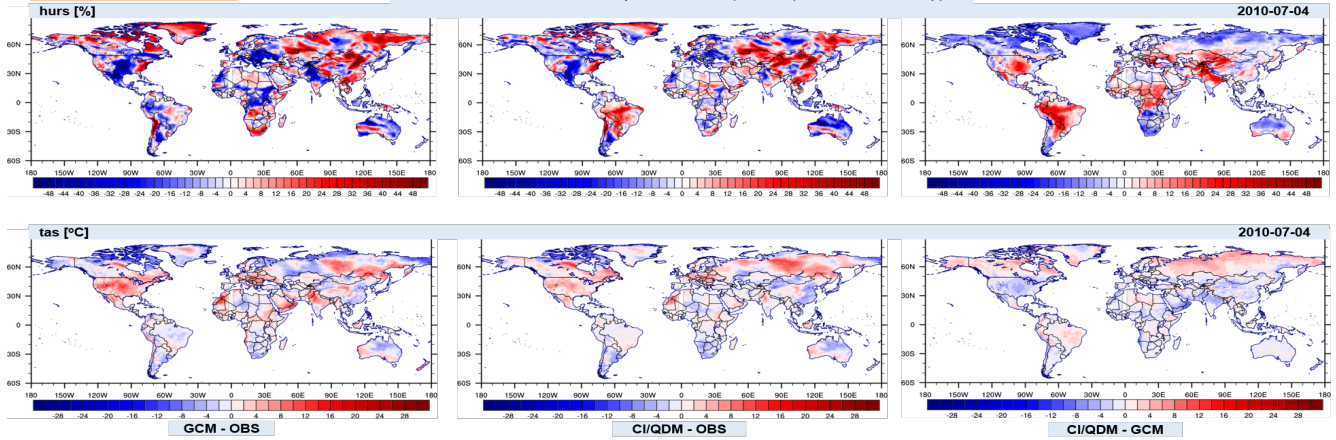
The CI/QDM code has been optimized to run in parallel (openMPI) on the Cyl HPCF systems. Significantly faster than the serial case.

SAMPLE RESULTS

Ten CMIP6 models with nominal resolution of 100 km were selected, and four IPCC Shared Socioeconomic Pathway (SSP) scenario experiments (SSP1-26, SSP2-45, SSP3-70, and SSP5-85) that span the period 1980-2100. For the bias calibration of the original CMIP6 simulations, we used the global daily, 50 km, WFDE5 (v1.0) reanalysis (proxy observations) data over 1980-2014. Selected sample results are shown below.

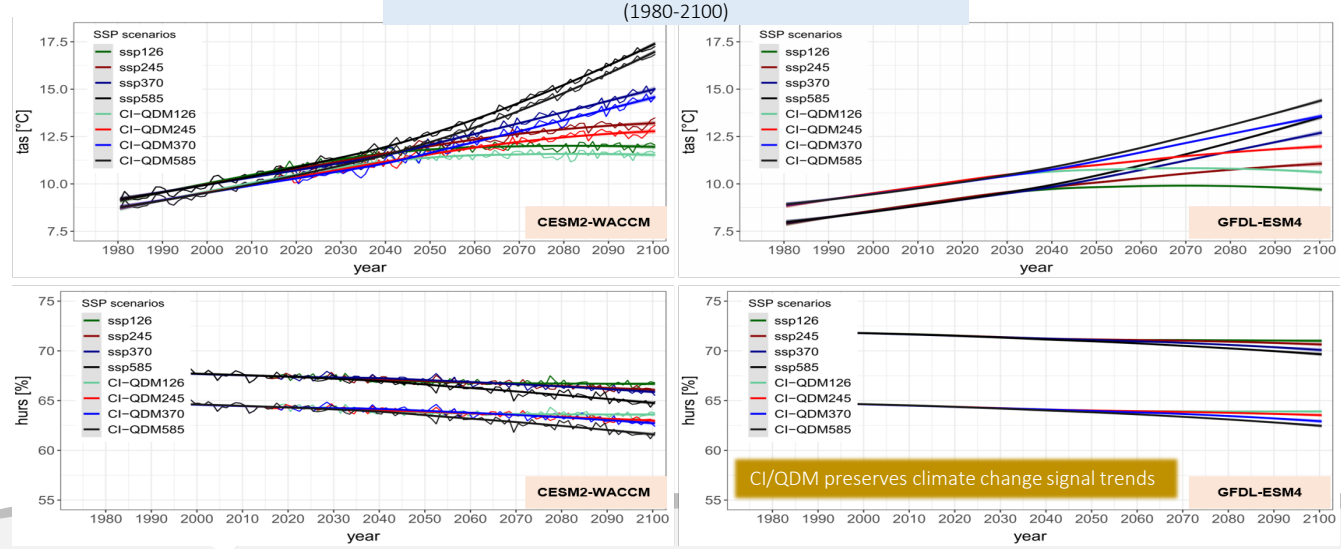
GCM: CESM2-WACCM

Differences between OBS, GCM and CI/QDM (... a summer day)



- For the chosen summer day, the bias-adjusted **hurs** data has noticeable differences compared to the OBS and GCM data (maps on top row). For the case of **tas** variable there are changes but less pronounced, overall; differences varying between -6 and 6 degrees centigrade can be seen on the third map of bottom row.

Future projections – area-weighted mean value time series (1980-2100)



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