Evaluating state-of-art statistical downscaling and analogs approaches on historical climate statistics over European regions

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Abstract

Climate change impacts assessment crucially relies on climate information at high temporal and spatial resolutions, not available from global climate models (GCMs) involved in the coupled model intercomparison project (CMIP). At the same time, dynamically downscaled regional climate model simulations do not provide global-scale coverage and in several cases are computationally too expensive. For this reason, downscaling techniques are commonly applied to bridge the resolution gap between GCM simulations and impact studies. The most common methodology is the statistical downscaling approach. However, statistical downscaling fast computation comes at a price, it does not account for physical and dynamic processes potentially inflates temporal variability of the original simulations' resolution. Given this limitation, the analogs technique may represent a valuable alternative since it considers both large and local scales dynamics balanced by a reasonable increase in computational costs. The present study explores differences, added value, and limitations characterizing state-of-the-art bias adjustment/statistical downscaling based on a stochastic quantile mapping approach and the analogs technique. In particular, the comparison applies to the data computed in the inter-sectoral impact model intercomparison project (ISIMIP) and data obtained by applying the analogs method based on the same ISIMIP reference dataset. The two approaches are compared and evaluated in terms of the historical period observed statistics reproduction for a few climate variables over European regions. This study is performed in the framework of GoNEXUS and NEXOGENESIS European projects.

Method

➢ **Data**

The GCMs used in CMIP6 cover a large variety of spatial scales going from 25 km to about *150 km*.
In this study, a low resolution GCMs has been selected to maximize the downscaling operation:

IPSL-CM6A-LR

This GCMs is downscaled to a resolution of 50km using an high-resolution observational dataset:

W5E5

Surface atmospheric temperature (**tas**) over the historical period **1979-2014** is evaluated in this study.

➢ **Statistical downscaling**

The Inter-Sectoral Impact Model Intercomparison Project (**ISIMIP**) provides a state-of-the-art statistical downscaled product of a set of CMIP6 data.

In particular, the **ISIMIP3BASD** method by Lange (2019) is used in ISIMIP.

➢ **Analogs**

Analogs search for days with similar large scale conditions to downscaled fields to a local scale based on *Minimum Euclidean distance* in the large scale pattern (Yiou et al, 2013, Perez-Zanon et al, 2022, and Rpackage CSTools).

Lange (2019) https://doi.org/10.5194/gmd-12-3055-2019
Perez-Zanon et al. (2022) https://doi.org/105194/gmd-15-6115-2022
Rpackage CSTools https://CRAN.R-project.org/package=CSTools
Yiou, et al. (2013) https://doi.org/10.1007/s00382-012-1626-3

Annual

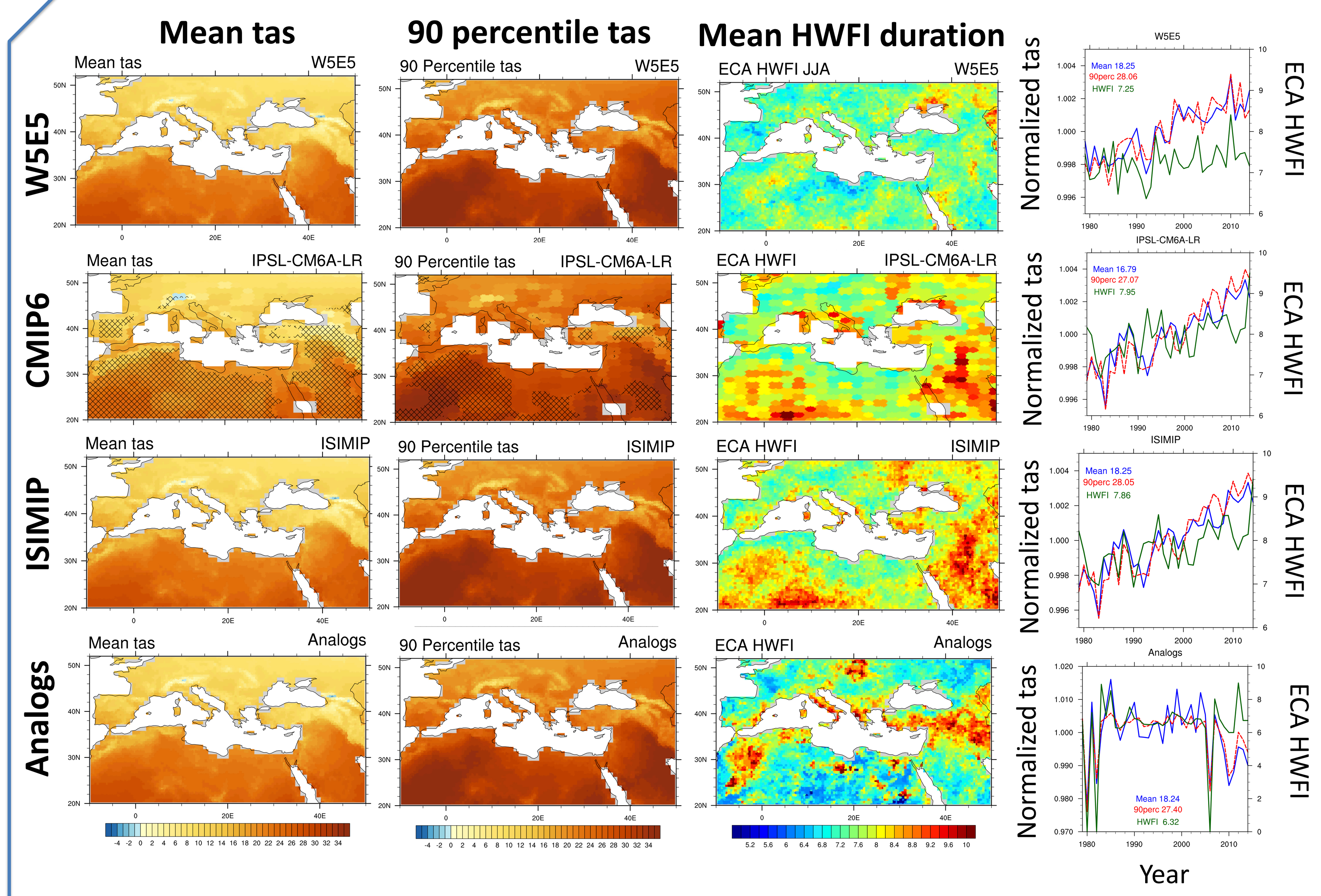

Figure 1: Annual mean and 90 percentile near-surface temperature averaged over 1979-2014. Crossed regions are areas where the difference between model and observation is larger than the sum of model and observation interannual variability (i.e. standard deviation). The mean warm spell days index (ECA-HWFI) duration is calculated using the values of the total number of events and event duration computed with CDO. The time series show the normalized tas (absolute value divided by time-series mean value) and standard ECA-HWFI. Analogs are computed using the large-scale field of SLP in the region -10W to 50E and 20N to 52N.

Summer

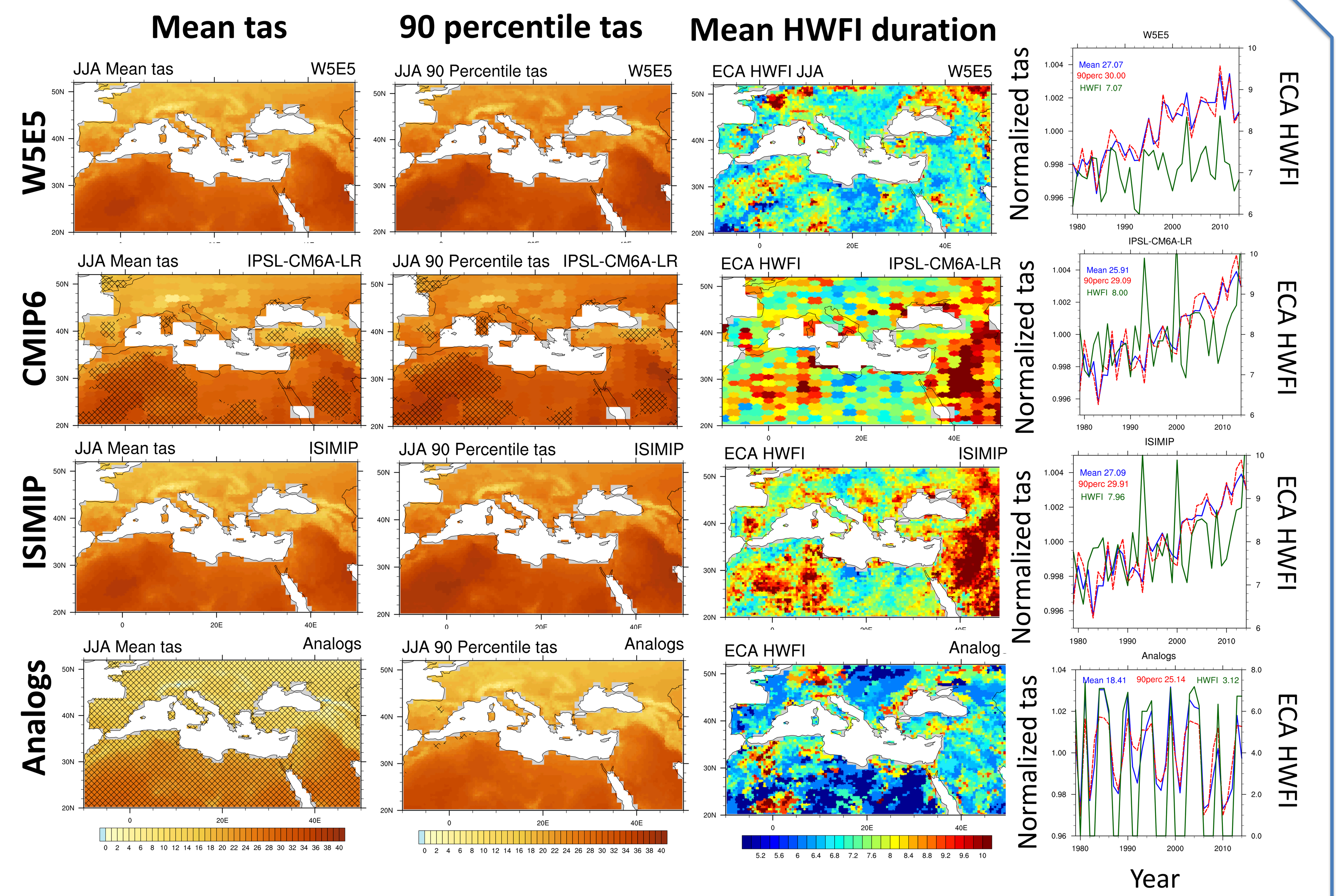

Figure 2 : Summer (JJA) mean and 90 percentile near-surface temperature averaged over 1979-2014. Crossed regions are areas where the difference between model and observation is larger than the sum of model and observation interannual variability (i.e. standard deviation). The mean warm spell days index (ECA-HWFI) duration is calculated using the values of the total number of events and event duration computed with CDO. The time series show the normalized tas (absolute value divided by time-series mean value) and standard ECA-HWFI. Analogs are computed using the large-scale field of SLP in the region -10W to 50E and 20N to 52N.

Summary

- ➢ Both downscaling methodologies improve the mean and the 90 percentile fields compared to the original CMIP6 data in annual values;
- ➢ Statistical downscaling preserves the original interannual variability and spatial distribution of the extreme events;
- ➢ Analogs present colder condition in summer and extreme events with a spatial distribution closer to CMIP6 case at annual scale and observation in summer season.

Outlook

- ➢ Further calibration of Analogs options will be performed;
- ➢ Further variables and indexes will be investigated to assess the difference between Analogs and Statistical downscaling methods;
- ➢ Further seasonal analysis will be performed;
- ➢ Validation will be performed on a larger set of observational datasets.