Anonymous Referee #1

RC: This paper quantifies the performances of several combinations of regional climate models (RCMs) driven by different general circulation models (GCMs) in two regions of southern Italy. The GCM-RCM combinations are part of the Coordinated Regional Climate Downscaling Experiment (CORDEX) initiative in the European domain (EURO- CORDEX). Performances are evaluated in the ability to capture the spatial variability of mean annual and seasonal precipitation (P) and temperature (T), as well as three drought metrics derived by applying the run theory. I enjoyed reading this paper, which is well written; presents rigorous analyses; critically discusses the results; and has practical utility for impact studies in the study regions, since it provides a list of best GCM-RCM combinations. I recommend its publication and I only have a few minor requests and suggestions.

AC: *Thanks for your positive comments.*

RC: The authors should provide more details on how they applied the principal component analysis (PCA): Was it applied on monthly or annual P? The PCA returns spatial patterns that explain most of the P variability. How did the authors derive the subregions within these spatial patterns? This should be clarified.

AC: *Thank you for this comment, which allowed us to improve the description of the PCA. At this regard, we will add further information to the manuscript as follows:*

<u>Author's changes to the manuscript (LL 148-170):</u> *"The precipitation patterns obtained by the interpolation procedure were analyzed adopting a methodology based on the Principal Component Analysis (PCA) to distinguish zones with rather independent climatic variability within the area under investigation. PCA is a well-known statistical tool used to transform an original set of intercorrelated variables into a reduced number of new linearly uncorrelated ones explaining most of the total variance (Rencher, 1998). The latter, derived as linear combinations of the original variables, are the principal components (PCs), while the coefficients of the linear combinations are the loadings, which in turn represent the weight of the original variables in the PCs. From a procedural standpoint, PCA consists of solving an eigenvalue-eigenvector problem applied to the covariance matrix. The eigenvectors, properly normalized, are the loadings of the principal components, while the eigenvalues provide a measure of the total variance explained by each loading (Bordi and Sutera, 2001 and references therein). Under this decomposition, the loadings represent the correlation between the associated PCs and observed time series. Mapping the loading patterns of each PC among the ones selected, based on the percentage of the total explained variance of the process, largely allow to identify independent climatic areas within the study region. Moreover, it may be useful to apply a rotation operation to the eigenvectors, so that the corresponding loadings are more spatially localized. In other words, the rotation leads to loadings with a high correlation with a smaller set of spatial variables and a low correlation with the remaining variables. Here, only orthogonal rotations were considered, computed by the varimax algorithm in Matlab® R2016. Clearly, each rotated pattern will not explain the same variance of the unrotated one, although the total variance explained remains unchanged.*

In the present study, the first nine rotated PCs both at the annual and seasonal (DJF, MAM, JJA, SON) scales were investigated. Regardless of the considered period, the selected PCs always explain more than 78% of the total variance, with a maximum of 85% in the winter season (DJF). The loading patterns of these rotated PCs were mapped for each considered period to identify climatically homogeneous regions. Homogeneous sub-regions were detected at the annual scale and in autumn and winter seasons, whereas a confusing picture *arose in spring and summer seasons. Furthermore, since about 75% of the total annual rainfall of the case-study area occurs between autumn and winter (as a result of cyclonic storms), the climatically homogeneous sub-regions identified at the annual scale approximately overlap with the ones identified at seasons SON and DJF. Isolated grid cells showing a different PC correspondence with respect to the surrounding cells, were manually corrected to simplify the delimitation of the homogeneous sub-regions. This approach led in dividing the whole area into six climatically homogenous zones, three for Sicily and three for Calabria (Fig. 1), for which separate performance assessments were carried out. Concerning Sicily region, the three identified sub-regions roughly coincide with the ones detected by Bonaccorso et al. (2003), who investigated the spatial variability of droughts in Sicily region based on SPI series computed on monthly precipitation observed in traditional rain gauges and on NCEP/NCAR reanalysis data from 1926 to 1996. In particular, three distinct areas, namely North-Eastern (identified in the PCA as zone 5, Fig. 1b), South-Central Eastern (zone 4), and Central-Western (zone 1), were identified. Also in Calabria, three main zones were determined, namely North-Western (zone 2), North-Eastern (zone 3) and South-Eastern (zone 6), broadly corresponding to climatic homogenous areas found in previous studies (e.g., Versace et al., 1989). Interestingly, the South-Western tip of Calabria is identified as a part of a broader area (zone 5) extending over the North-Eastern Sicily."*

RC: When ranking the models based on performance in reproducing annual P, the authors find that nine models have similar error metrics. Have they tried to compute the mean rank of each model across the zones and even across the five time scales considered (annual and the four seasons)? There may be some models that are consistently in the top (lowest ranks) and these should be mentioned.

AC: *Thank you for this useful suggestion. Indeed, this aspect was already partially investigated and some details are drawn in LL379-384 of the manuscript, where we pointed out that the models Had-RACM, ECE-CCLM and Had-CCLM have the overall better performances at both annual and seasonal time scales. Thus, we propose to enlargen and make clearer the discussion in the revised version of the manuscript. We may also add the figure below, which highlights deviations in the performances of some models (e.g., CM5-ALAD), considering both the annual scale and the average behaviour at the seasonal scale (the higher the deviation, the higher the distance from the bisector).*

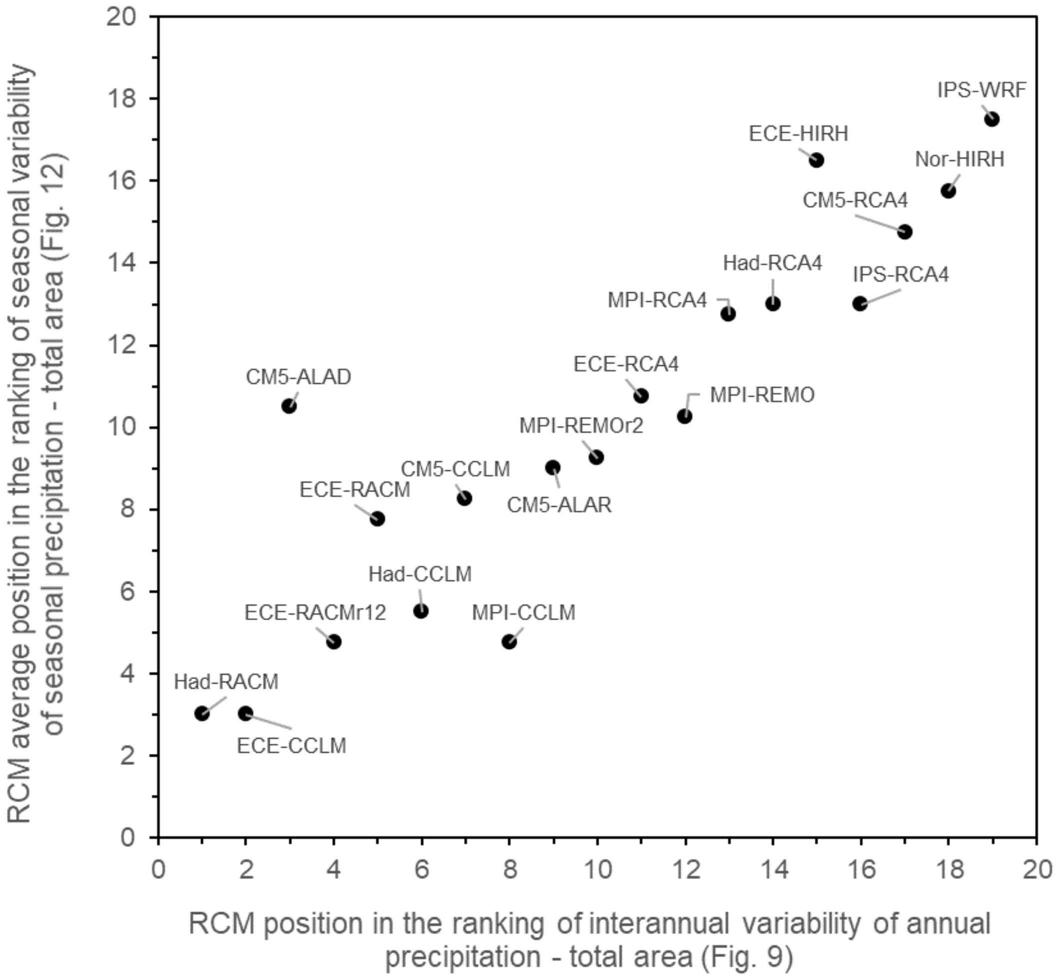

Fig. R1. Comparison between the RCM position in the ranking of interannual variability of annual precipitation versus the average position in the ranking of seasonal variability of seasonal precipitation. Data concerns the whole study area (Calabria and Sicily).

RC: Line 45: Extremes occur everywhere. I suggest changing to "... occurrence of particularly intense extreme events, …". If this is what the authors mean, a reference is also needed.

AC: *That's correct, this is in fact what we meant. The sentence will be changed according to the suggestion and proper references will be added (concerning droughts: Bonaccorso et al., 2013; Bonaccorso et al., 2015a and 2015b; concerning floods: Llasat et al., 2016; Senatore et al., 2020)*

RC: Line 55: CMIP5 has been already defined; just use the acronym.

AC: *We will revise accordingly.*

RC: Line 61: I suggest adding "historical" before simulations.

AC: *We will revise accordingly.*

RC: Line 326: it should be “show”.

AC: *We will revise accordingly.*

References to be added in the new version of the manuscript:

Bonaccorso, B., Peres D.J., Cancelliere A., Rossi G. (2013). Large Scale Probabilistic Drought Characterization Over Europe. Water Resources Management, 27 (6), pp. 1675-1692, ISSN: 0920-4741, DOI: 10.1007/s11269-012-0177-z.

Bonaccorso, B., Peres, D.J., Castano, A., Cancelliere, A. (2015a). SPI-Based Probabilistic Analysis of Drought Areal Extent in Sicily. Water Resources Management, Volume 29(2), pp. 459-470, ISSN: 09204741, DOI: 10.1007/s11269-014-0673-4.

Bonaccorso., B., Cancelliere, A., Rossi, G. (2015b). Probabilistic forecasting of drought class transitions in Sicily (Italy) using Standardized Precipitation Index and North Atlantic Oscillation Index. Journal of Hydrology, Volume 526, pp. 136-150, ISSN: 00221694, DOI: 10.1016/j.jhydrol.2015.01.070.

Llasat, M.C., Marcos, R., Turco, M., Gilabert, J., and Llasat-Botija, M.: Trends in flash flood events versus convective precipitation in the Mediterranean region: The case of Catalonia, J. Hydrol., 541, 24-37, 10.1016/j.jhydrol.2016.05.040, 2016.

Senatore, A., Furnari, L., and Mendicino, G.: Impact of high-resolution sea surface temperature representation on the forecast of small Mediterranean catchments' hydrological responses to heavy precipitation, Hydrol. Earth Syst. Sci., 24, 269–291, https://doi.org/10.5194/hess-24-269-2020, 2020.