Supplementary materials of paper "Evaluation of convection-permitting extreme precipitation simulations for the south of France"

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We make a few tests on the effect of sizes and positions on precipitation simulation results. These results can help to select an optimal configuration to conduct simulations at climate scale. We only discuss the figures to make decision rather than explaining the underlying factors that make a configuration better than others. We first set up a EURO-CORDEX (EUR-11) domain forced by ERA-Interim similarly to what is described in Section 2.1 except that spectral nudging method is applied to prevent the regional information from going far away the driving reanalysis. The nudging terms are only added to the five longest waves of upper zonal and meridional winds in the prognostic equations. We expect the technique can produce boundary conditions for CPS domains as close as possible to the real state of the atmosphere. This simulation is conducted for the autumn of 2014 with its boundary condition updated every 6 hours.

Next, four different convection-permitting (CPS) domains nested inside the EUR-11 domain are designed with the horizontal resolution and time step of a fourth of the parent domain (i.e. dx = 3km and dt = 15s). All physics parameter, map projection, number of vertical levels and time of updating boundary in these nested domains remain the same as the EUR-11 domain except that either cumulus parameterization or spectral nudging are switched off. Three out of four d02s including WRF-01, WRF-02 and WRF-03 (see Figure S1) have the same size of 301 by 301 grid points but they are located at different places. The WRF-01, whose centre of the domain located roughly over the country of Andorra, covers a part of the north-western Mediterranean Sea and a small part of the eastern Atlantic. The WRF-02 moves north-eastward from ERAI-01 and covers mainly continent and the western part of the Alps. The WRF-03 moves south-eastward from the WRF-01 and therefore it contains a larger part of the Mediterranean Sea including Corsica. This helps in evaluating the effect of position of the domain and the presence of the Mediterranean Sea in the domain in reproducing heavy rainfall events in the Cévennes mountain range. The last nested domain (i.e. WRF-003) has a smaller size of 201 by 201 grid points which helps investigating how size of domain affects simulation of extreme rainfall events.

We use the same methods and observations as described in Section 2.2 to evaluate the simulated from those four CPS domains. These methods incorporate the maximum daily/3-hourly rainfall and distribution of wet daily/3-hourly events.

Figure S2 shows the maximum daily rainfall of the autumn 2014 from observation at stations all CPS simulations. In general, those simulations have a good agreement with observations in terms of spatial distribution of extreme values. The most extreme value occurs in the north upwind-side of the Cévennes range, meanwhile the less heavy (but still extreme) precipitation occurs in the south of the mountain. WRF-02, WRF-03 and WRF-003 (Figure S2 b-d) reproduce the intensity of Rx1day closely to observations with the mean absolute bias at 14 stations of 32%, 49% and 44%, respectively. The WRF-03 and WRF-003 are the two cases that are able to reproduce 3 stations with rainfall amount higher than 200 mm per day (compared to 4 stations from observations) even though their intensities are lower than those from observations and the places of occurrence are different from observations. The result from WRF-01 underestimate the precipitation value (mean absolute bias among 14 stations is 54%).

The maximum 3-hour rainfall in the autumn of 2014 from observation and simulations are plotted in Figure S3. The coverage of stations with availability of hourly data over the Cévennes mountain range is restricted to the southern part (Figure S3e). Therefore, we only focus on the evaluation for Rx3hour in the southern part of the mountain (i.e. from the latitude of 44°N to the south). The Rx3hours at some observed stations in the southern part of the Cévennes and near the coast exceed 180 mm with the maximum value of 252 mm in 3-hour. The WRF-01 and WRF-03 reproduce well this spatial distribution of Rx3hour with their mean absolute bias of all stations within the Cévennes box of 30% and 50%, respectively. The WRF-02 and WRF-003 tend to show more intensified rainfall over the middle and the northern part of the Cévennes. The mean absolute bias of stations from these two cases are 68% and 53%, respectively. Figure S4 shows the comparison of simulations and observations in terms of distribution of pooling 14 stations as used in Vautard et al. (2015). The distribution of wet daily events from the simulations of four CPS domains are comparable to each other and underestimate observations in either the middle or the right tail of the distributions (Figure S4a). To be more specific for the right tail of the distribution, the WRF-01, WRF-03 and WRF-003 reproduce extreme values closest to observations. Their mean and median biases ranged from -30% to 20%. The WRF-03 and WRF-01 seem to be the best case because their range of bias is the smallest. However, the box from WRF-03 is closer to 0 compared to WRF-01. The WRF-02 case underestimates the observations. We also find similar pattern for the distribution of 3-hourly rainfall events (Figure S5).

These results enable us to select the domain WRF-03 for the simulations at climate scale.

References

Vautard, R., Yiou, P., van Oldenborgh, G.-J., Lenderink, G., Thao, S., Ribes, A., Planton, S., Dubuisson, B., and Soubeyroux, J.-M.: Extreme fall 2014 precipitation in the Cévennes mountains, Bulletin of the American Meteorological Society, 96, S56–S60, 2015.

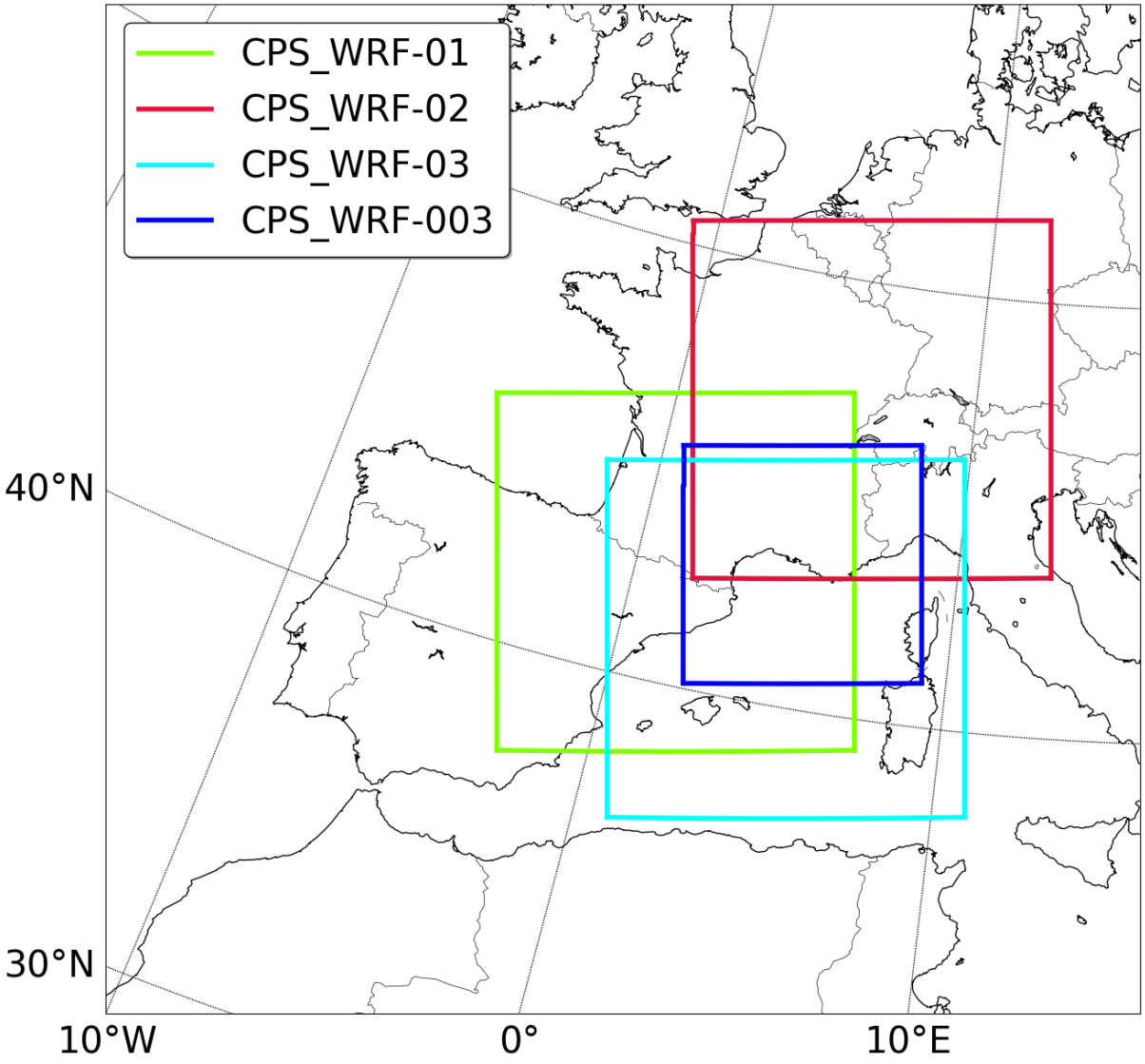

Figure S1. The position of four CPS domains. Note that the EURO-CODEX showed here is reduced to better focus on the area of interest and the four CPS domains.

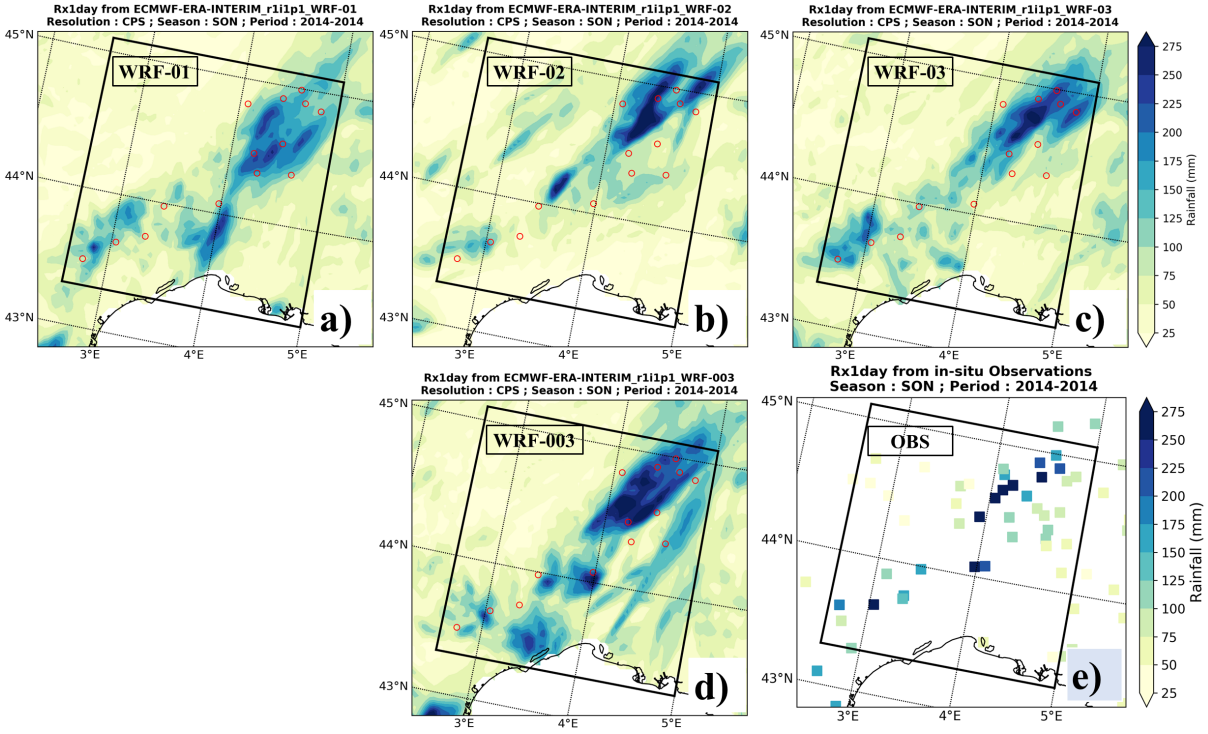

Figure S2. The maximum daily rainfall (Rx1day) of autumn 2014 from four CPS domains and in situ observations; The red empty circles inside the Cévennes box from panel a to d denote 14 stations used in Vautard et al. (2015).

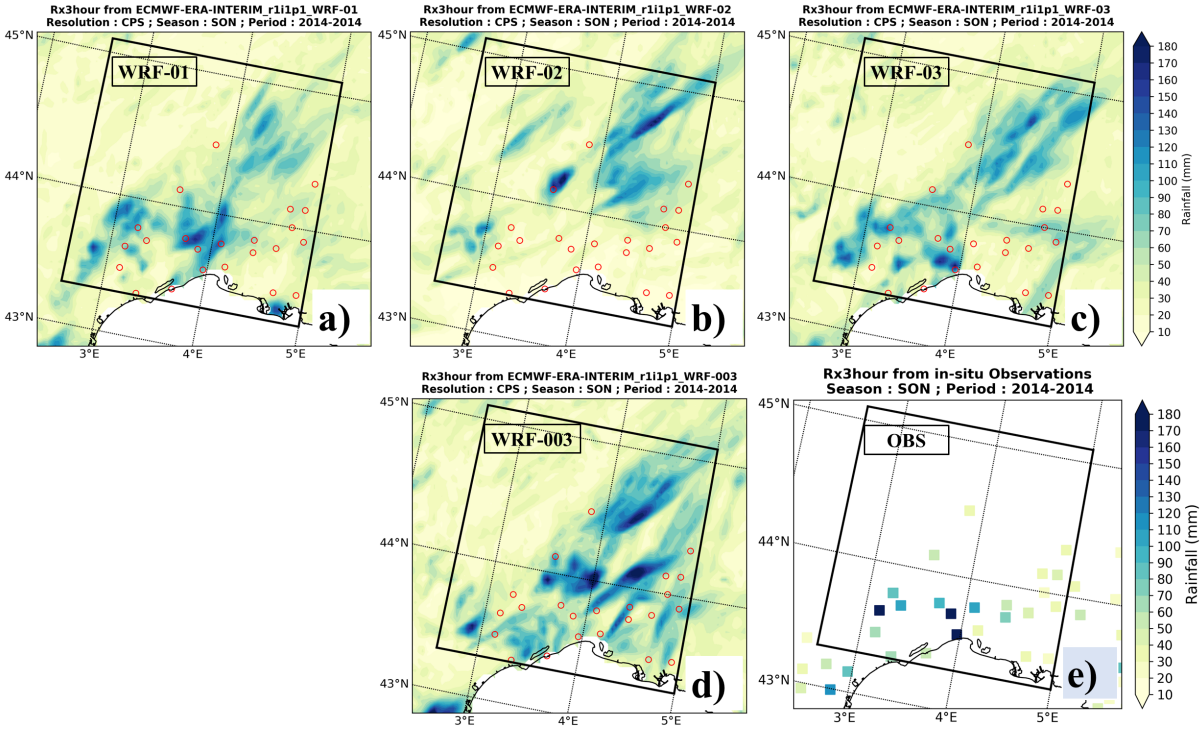

Figure S3. The maximum 3-hourly rainfall (Rx1day) of autumn 2014 from four CPS domains and in situ observations; The red empty circles inside the Cévennes box from panel a to d denote 23 stations that 3-hourly data is available.

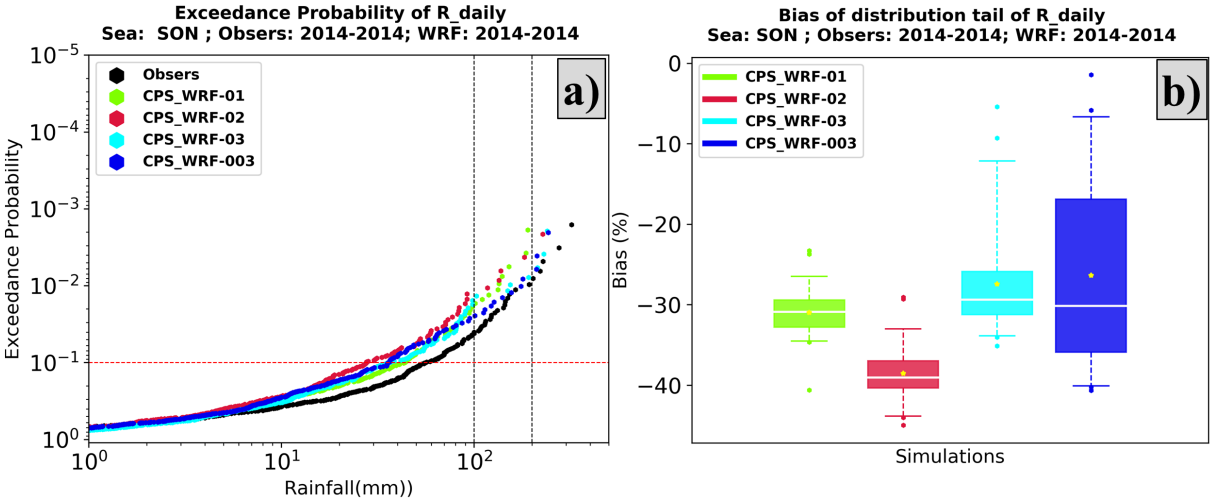

Figure S4. Exceedance probability distribution (a) for daily rainfall in the autumn 2014 from in-situ observations and four CPS domains and the bias (b) of 10% in the tail of the distribution from each simulation against in situ observations. The red dotted line on panel a denotes the exceedance probability of 0.1 above which the simulated rainfall values are used to estimate the bias of the distribution tail on panel b.

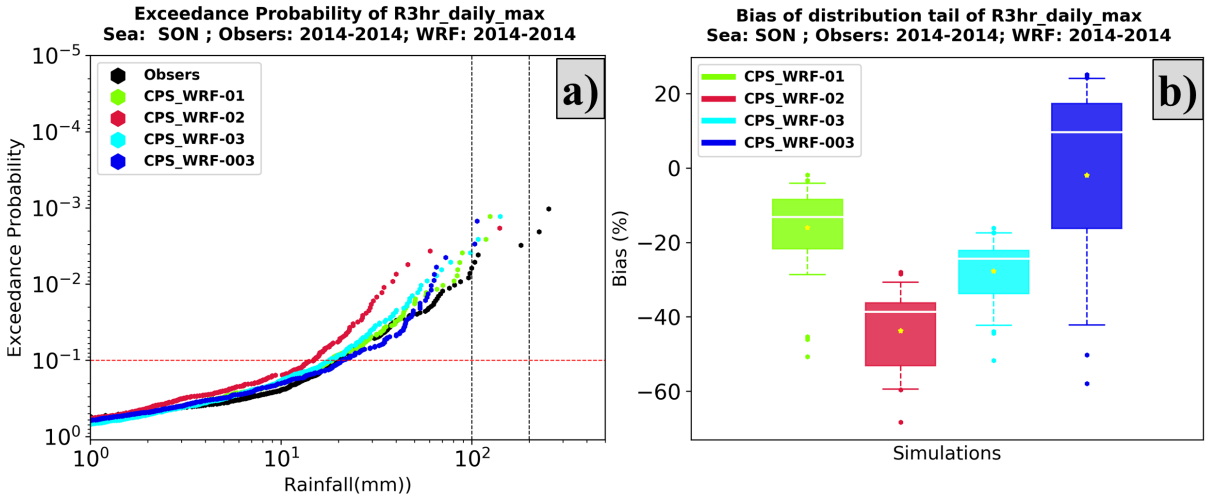

Figure S5. Exceedance probability distribution (a) for 3-hourly rainfall in the autumn 2014 from in-situ observations and four CPS domains and the bias (b) of 10% in the tail of the distribution from each simulation against in situ observations. The red dotted line on panel a denotes the exceedance probability of 0.1 above which the simulated rainfall values are used to estimate the bias of the distribution tail on panel b.