A flexible methodology to evaluate natural variability in ClimaMeter: Supplementary materials

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We report here the results that were not explicitly discussed in the main part of the article. They show all the steps of the natural variability gauge computation for the three pre-industrial events (heat wave in Paris, Storm Hans and Storm Ciaran) applied to the three climate models (IPSL, CNRM, and MPI). The results are consistent with those discussed in in the section of the article dedicated to the stationary pre-industrial experiment (section 5). For the CNRM and MPI models, the procedure applied is the same as that described in Section 3 for the IPSL model. The only difference lies in the length of the available simulations. While the full 2000-year piControl run is available for IPSL, only 500 and 1000 years are available for CNRM and MPI, respectively. This allows analogue searches over 40-year factual and counterfactual periods to be performed 11 times for CNRM and 24 times for MPI. Although this results in lower statistical robustness, it enables us to test the new methodology on models whose representation of natural variability differs from that of IPSL. The consistency of the results across models provides important evidence supporting the robustness of the new methodology.

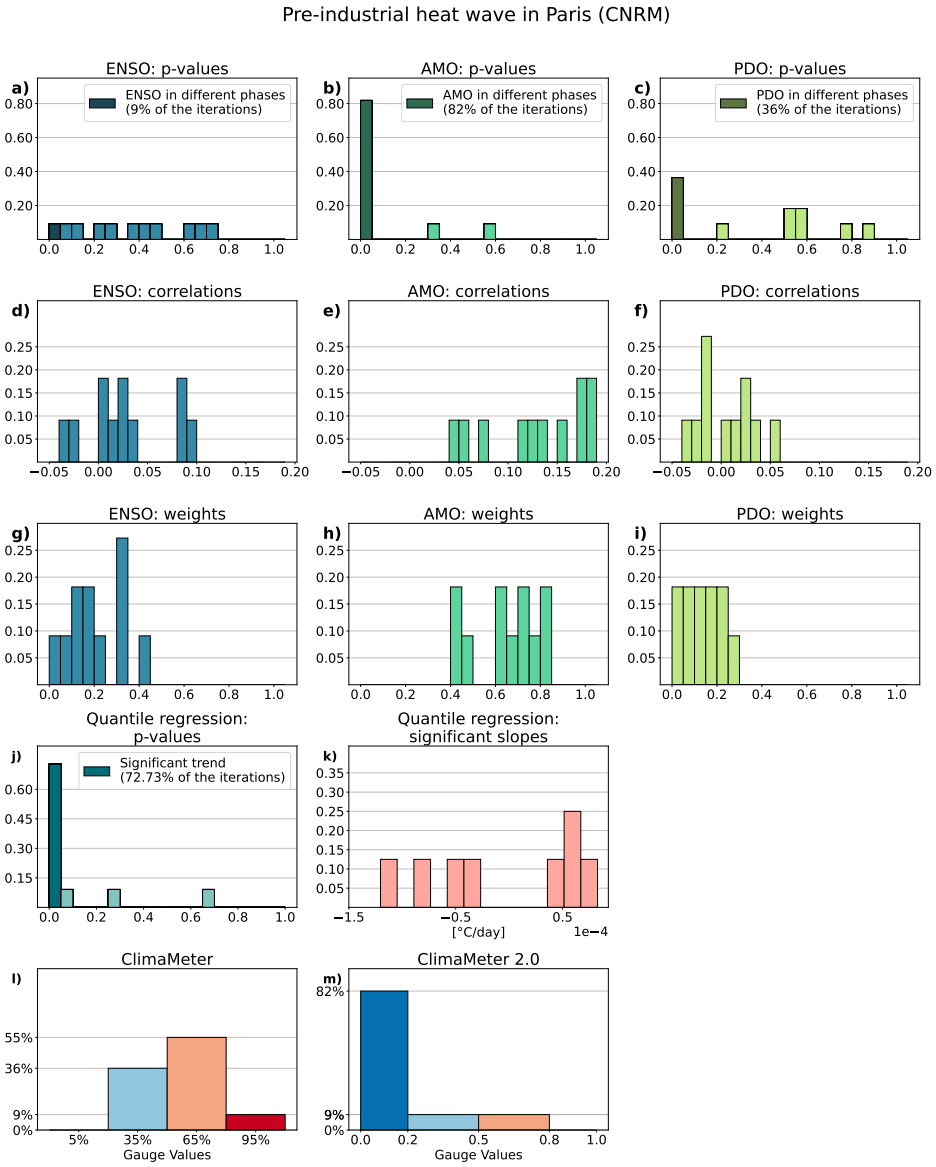

Figure S1. Pre-industrial heat wave in Paris: natural variability gauge computation for the 11 iterations of the analogues search applied to the *piControl* simulation of the CNRM model. The first row of plots illustrates the results of the Cramér–von Mises test applied to the counterfactual and factual sets of indices on analogue dates. When the p-value is smaller than 5 %, we conclude that the mode was in different phases between the two periods. The second row shows the distributions of the linear correlation coefficients between the hazard, spatially averaged over the target region, and the natural variability indices. The third row summarizes the values of the weights computed from these correlations. The previous results are shown for the three modes of variability: ENSO (first column), AMO (second column), and PDO (third column). Histogram j) represents p-values associated with the quantile regression of temperature anomalies in the target region. Since the null hypothesis of the test is that the regression slope is zero, p-values smaller than 5% (first bin in a darker shade of green) are associated with significant trends. Histogram k) depicts slopes associated with significant regressions. The last row of plots illustrates the results of the gauge based on the l) ClimaMeter and m) ClimaMeter 2.0 methodologies. Low gauge values are associated with events "Influenced by Natural Variability", while high values to events "Influenced by Climate Change". In histogram m), bin limits are chosen so as to have the minimum distance between the possible values of the original ClimaMeter gauge.

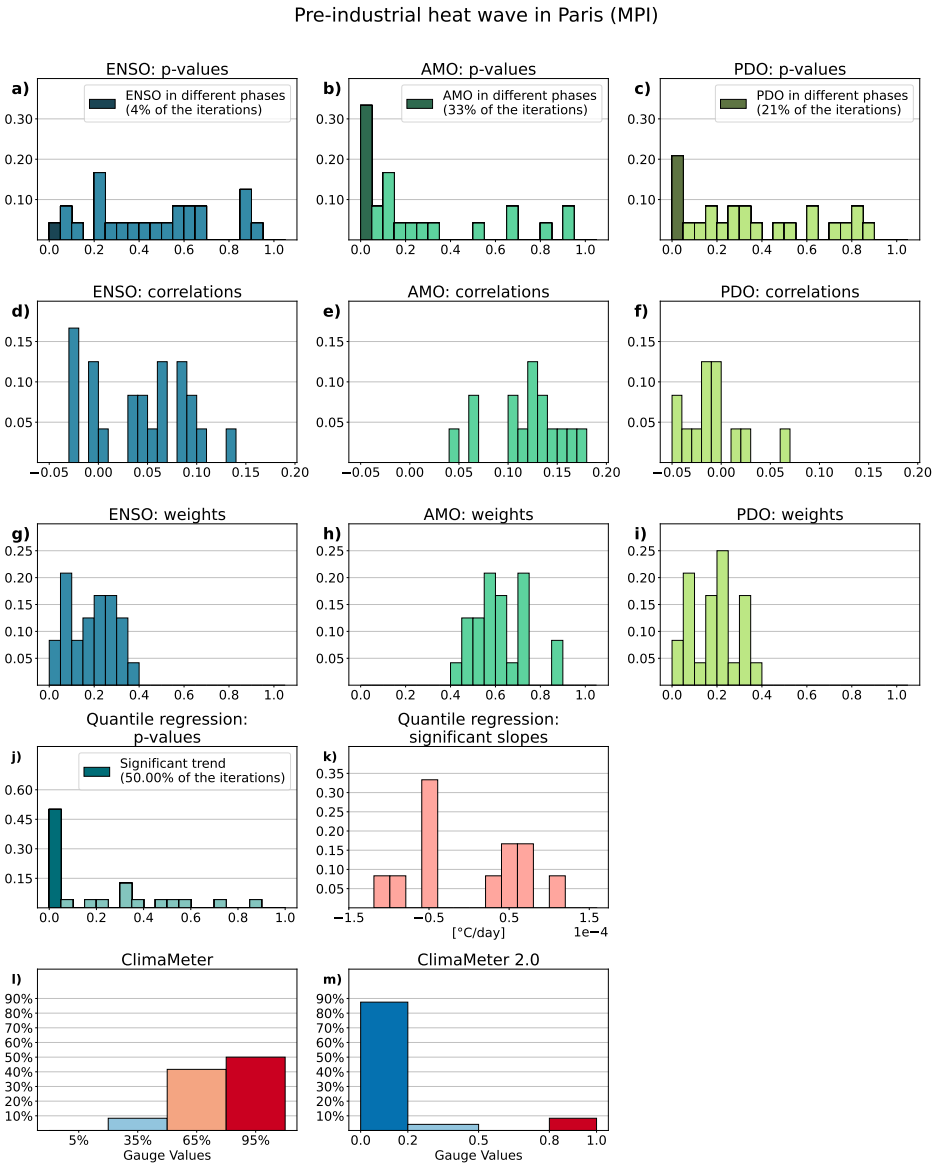

Figure S2. Pre-industrial heat wave in Paris: natural variability gauge computation for the 24 iterations of the analogues search applied to the *piControl* simulation of the MPI model. The plots description is the same as in Fig. S1.

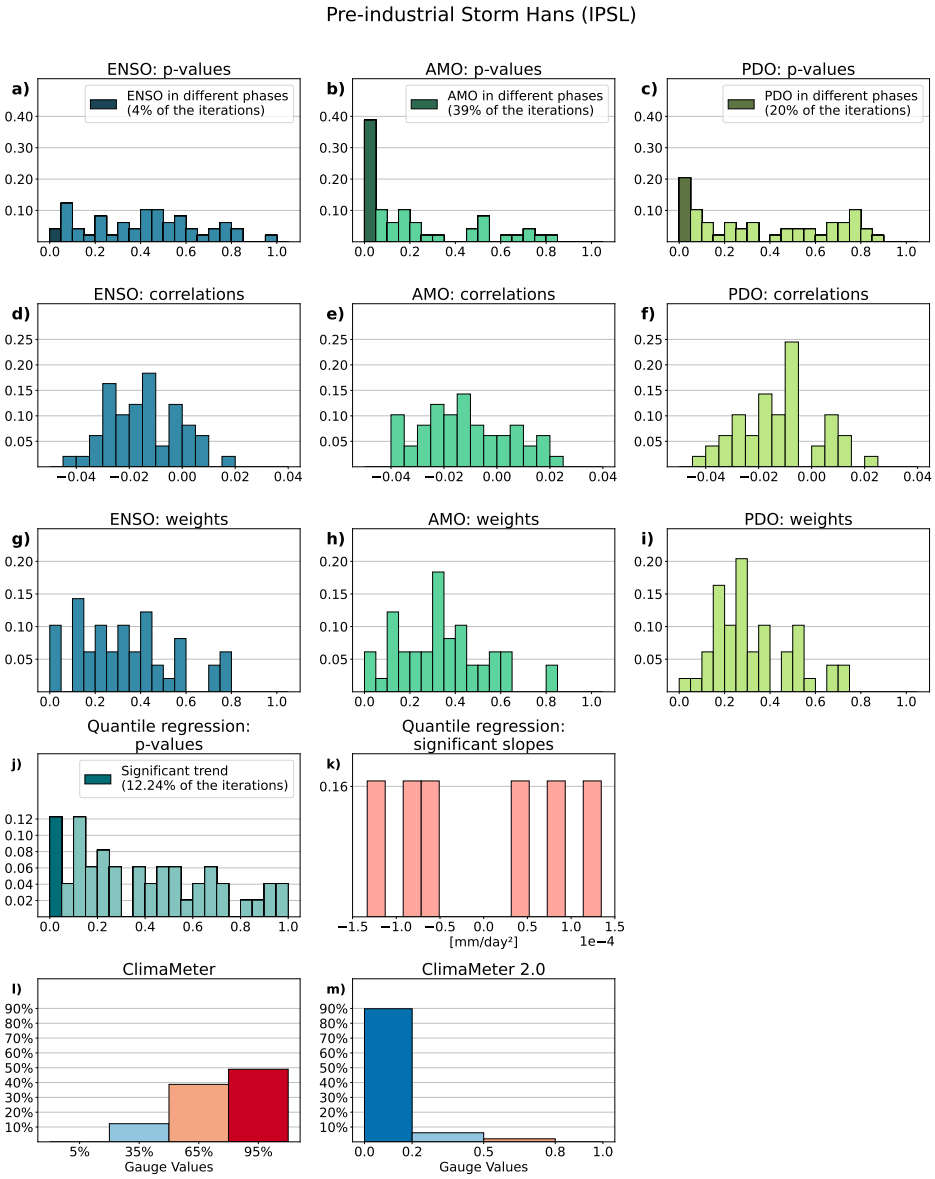

Figure S3. Pre-industrial Storm Hans: natural variability gauge computation for the 49 iterations of the analogues search applied to the *piControl* simulation of the IPSL model. The first row of plots illustrates the results of the Cramér–von Mises test applied to the counterfactual and factual sets of indices on analogue dates. When the p-value is smaller than 5 %, we conclude that the mode was in different phases between the two periods. The second row shows the distributions of the linear correlation coefficients between precipitation, spatially averaged over the target region, and the natural variability indices. The third row summarizes the values of the weights computed from these correlations. The previous results are shown for the three modes of variability: ENSO (first column), AMO (second column), and PDO (third column). Histogram j) represents p-values associated with the quantile regression of precipitation in the target region. Since the null hypothesis of the test is that the regression slope is zero, p-values smaller than 5% (first bin in a darker shade of green) are associated with significant trends. Histogram k) depicts slopes associated with significant regressions. The last row of plots illustrates the results of the gauge based on the l) ClimaMeter and m) ClimaMeter 2.0 methodologies. Low gauge values are associated with events "Influenced by Natural Variability", while high values to events "Influenced by Climate Change". In histogram m), bin limits are chosen so as to have the minimum distance between the possible values of the original ClimaMeter gauge.

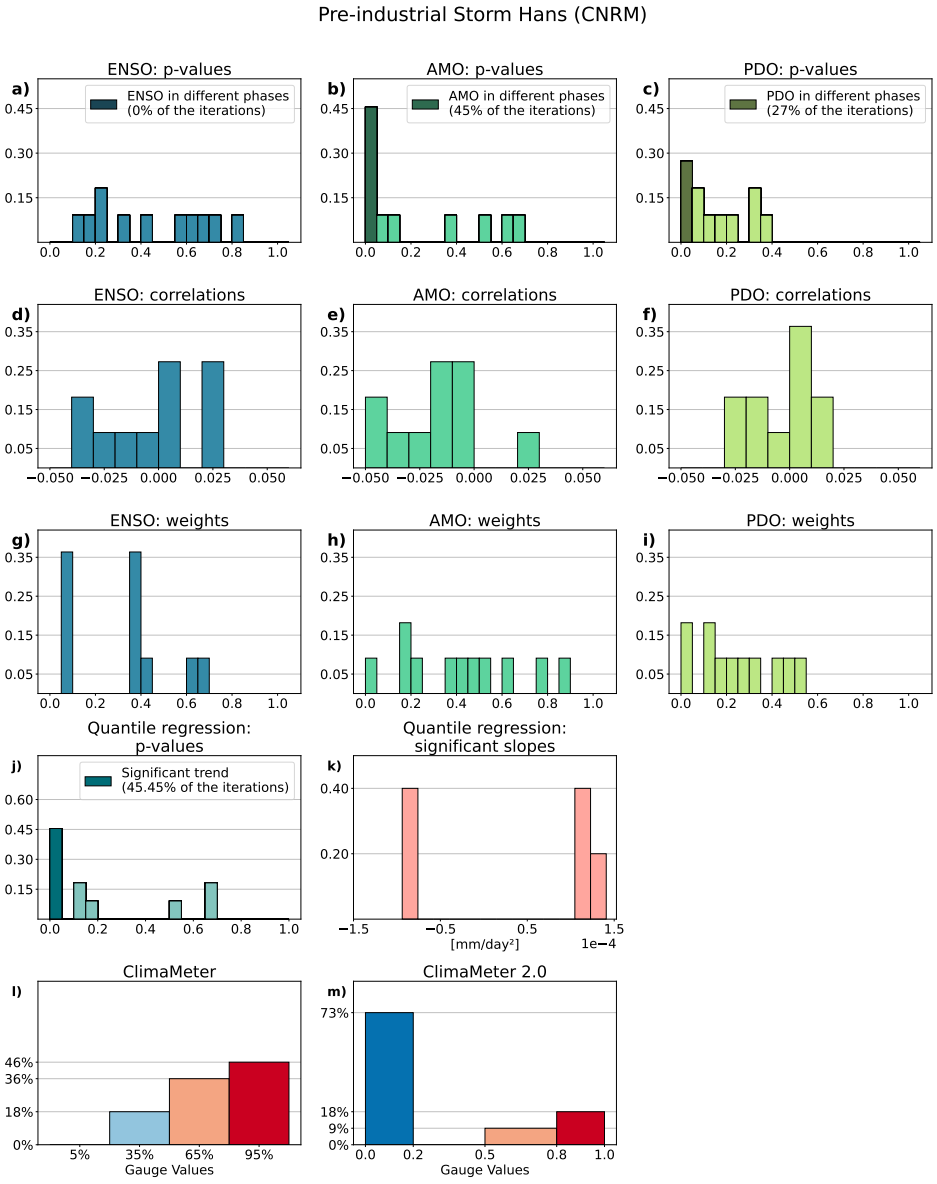

Figure S4. Pre-industrial Storm Hans: natural variability gauge computation for the 11 iterations of the analogues search applied to the *piControl* simulation of the CNRM model. The plots description is the same as in Fig. S3.

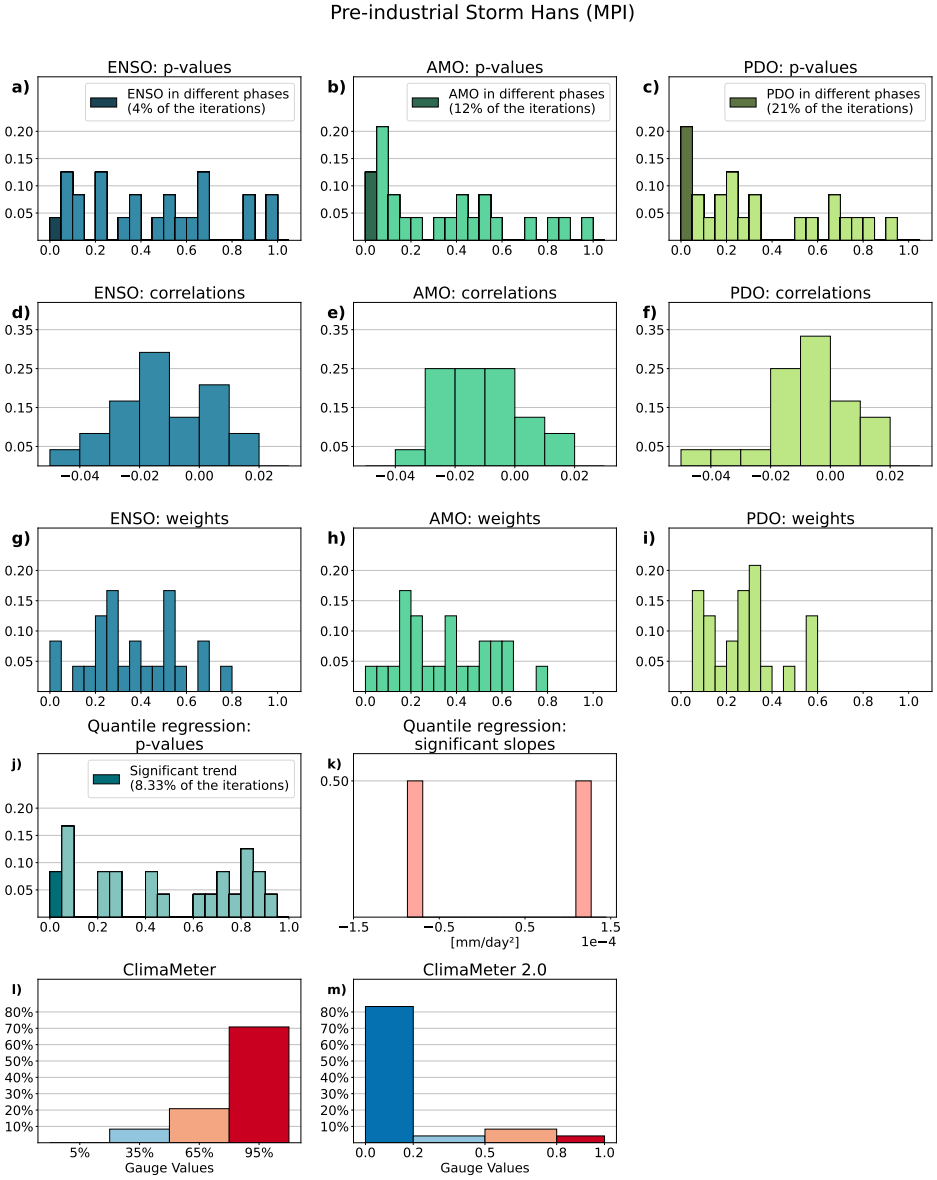

Figure S5. Pre-industrial Storm Hans: natural variability gauge computation for the 24 iterations of the analogues search applied to the *piControl* simulation of the MPI model. The plots description is the same as in Fig. S3.

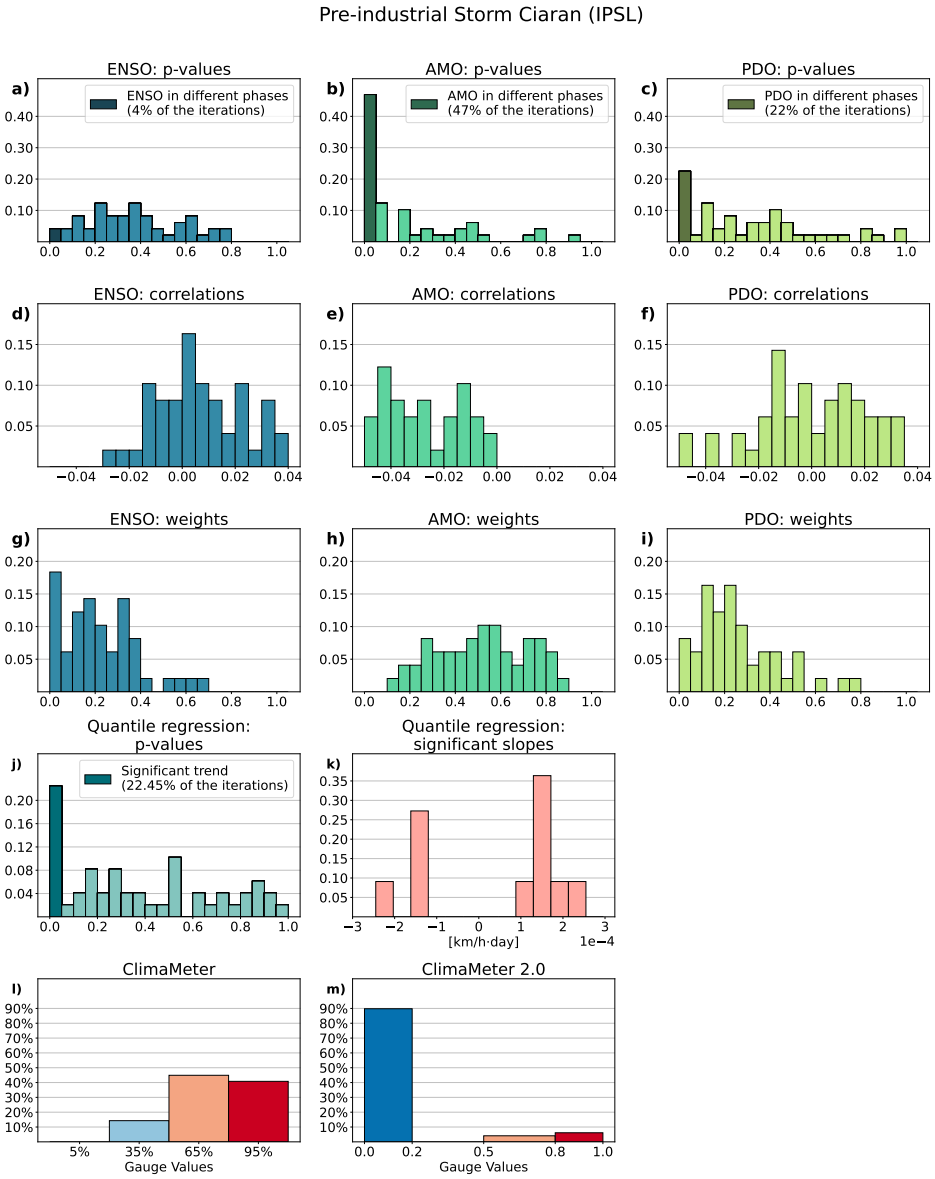

Figure S6. Pre-industrial Storm Ciaran: natural variability gauge computation for the 49 iterations of the analogues search applied to the *piControl* simulation of the IPSL model. The first row of plots illustrates the results of the Cramér–von Mises test applied to the counterfactual and factual sets of indices on analogue dates. When the p-value is smaller than 5 %, we conclude that the mode was in different phases between the two periods. The second row shows the distributions of the linear correlation coefficients between wind speed, spatially averaged over the target region, and the natural variability indices. The third row summarizes the values of the weights computed from these correlations. The previous results are shown for the three modes of variability: ENSO (first column), AMO (second column), and PDO (third column). Histogram j) represents p-values associated with the quantile regression of wind speed in the target region. Since the null hypothesis of the test is that the regression slope is zero, p-values smaller than 5% (first bin in a darker shade of green) are associated with significant trends. Histogram k) depicts slopes associated with significant regressions. The last row of plots illustrates the results of the gauge based on the l) ClimaMeter and m) ClimaMeter 2.0 methodologies. Low gauge values are associated with events "Influenced by Natural Variability", while high values to events "Influenced by Climate Change". In histogram m), bin limits are chosen so as to have the minimum distance between the possible values of the original ClimaMeter gauge.

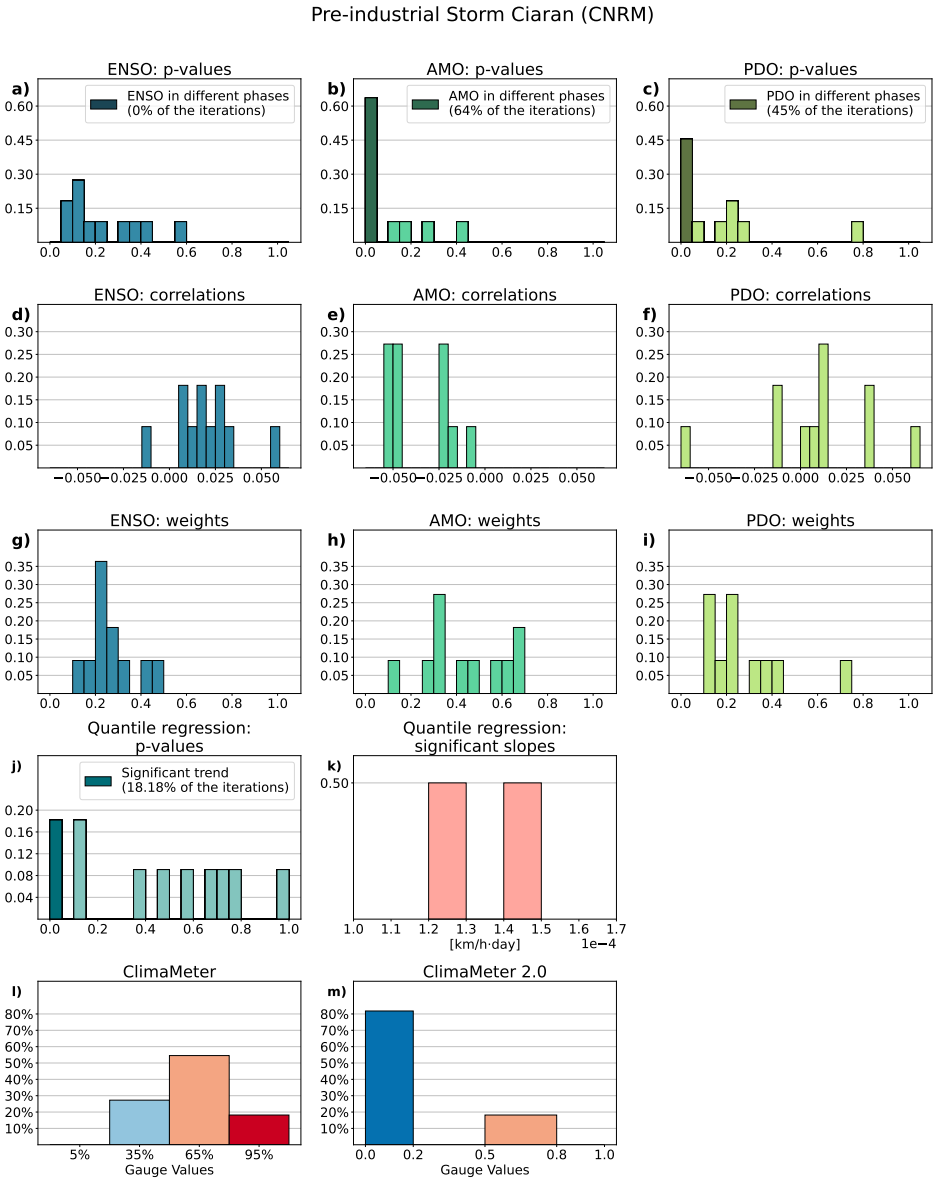

Figure S7. Pre-industrial Storm Ciaran: natural variability gauge computation for the 11 iterations of the analogues search applied to the *piControl* simulation of the CNRM model. The plots description is the same as in Fig. S6.

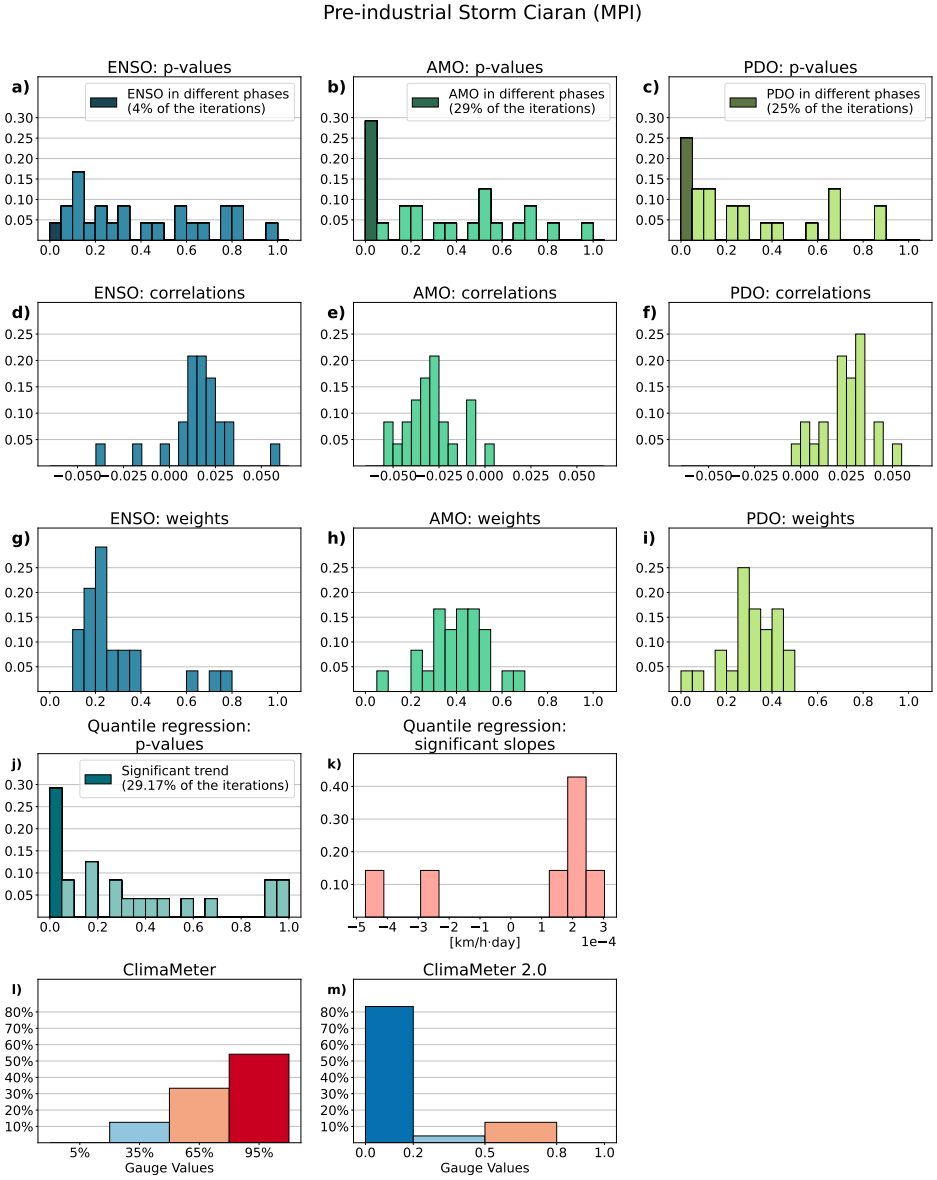

Figure S8. Pre-industrial Storm Ciaran: natural variability gauge computation for the 24 iterations of the analogues search applied to the *piControl* simulation of the MPI model. The plots description is the same as in Fig. S6.