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Selection of Representative Measuring Points for Temperature Field Reconstruction using a Metaheuristic approach

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Currently the atmosphere is scrutinized using a number of systems ranging from conventional meteorological stations, to geostationary and polar orbiting satellites. These observations are then assimilated in models for meteorological forecasting or climate reanalysis. The increasing availability of these products should not hide the need of keeping and improving the operation of weather and climate stations, which can be compromised due to constraints in the budget of the operating agencies. In this context, it is highly relevant to identify which are the stations producing the most relevant data for a given variable or process. This can be formulated as an optimization problem, in the aim of finding the ideal subset of points that best reproduces the characteristics of a certain region.

Recent developments in Evolutionary Algorithms have validated the performance of biologically-inspired operators to solve an extensive collection of optimization problems. Specifically, the Coral Reef Optimization (CRO) algorithm has provided efficient solutions to the Representative Selection problem, outperforming other well-known methodologies. Here, we combine the CRO algorithm with the widely-used Analog Method in order to identify the most representative set of monthly average temperature time series for Europe from gridded (ERA Interim) and un-gridded (ECA) datasets.

Our approach exhibits good performance and shows similar results in both cases. Moreover, the best solutions obtained with this methodology are climatologically consistent, and include points from Scandinavia, Central and Southern Europe, Eastern Europe and the Black Sea. Interestingly, once the number of selected locations reaches a certain threshold, the improvement in the temperature reconstruction is achieved by adding points nearby the previously-identified zones and not by reshaping the number of sub-regions. Therefore, a reduced subset of original points over key areas is enough to capture the climate variability of the entire region. Furthermore, our method excels by reducing the reconstruction misfit up to 28% when compared with other metaheuristic procedures, such as the greedy algorithm, based on individual selections.

These results are just an example of the multiple applications of this methodology, which range from the identification of best located climate proxies to the design of operational meteorological networks. Besides, they also stress the need for further studies where evolutionary algorithms can shed light on the dynamics of several climate variables by providing the minimum number of sampling locations to obtain spatially-resolved climate fields.