Evaluation and applicability of the spatio-temporal complementarity of the solar and wind resources for the optimized design of renewable energy scenarios

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We present and test a parsimonious model to help designing optimized wind and photovoltaic fleets, e.g. guaranteeing that the renewable production closely follows the electricity demand curve or any other optimization criteria. First, time-series of weather variables, from high-resolution gridded datasets, are transformed into time-series of wind and PV power potential production, which can be seen as capacity factor (CF) estimates. Second, a combination of hierarchical and non-hierarchical clustering is performed to identify regions with similar temporal variability of the CF series. Third, a linear combination of the resulting mean regional CF series is constructed to be fitted, for instance, to get the best production-demand adjustment, or under alternative optimization criteria such as minimum cost of installations that guarantee a certain supply. The coefficients obtained for each CF series after the fitting or optimization exercise, to which the condition of being zero or positive must be imposed and which, optionally, could be individually forced to vary within a certain range, will indicate the optimum amount of installed power capacity needed in the each region under the chosen optimization criteria. Illustrating the method, it has been applied over Europe at the monthly time-scale using the ERA5 reanalysis, but its applicability in other spatial and temporal scales is immediate. The results support its utility to design optimized renewable energy scenarios.

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