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Temporal and spatial complementarity of the wind and the solar resources in the Iberian Peninsula

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Both Iberian countries (Portugal and Spain) are investing considerably in new wind and solar power plants to achieve a sustainable future, both in environmental and economic terms. Resource evaluation, aimed at optimizing the power generation according to the energy demand, is a mandatory requisite for the success of such a large amount of investments. However, this aim is difficult to attain due to the lack of lengthy and reliable observational datasets, implying poor spatial coverage. Hence, here we rely on a hindcast simulation spanning the period 1959-2007 and covering the whole Iberian Peninsula with resolution of 10 km, to retrieve the primary meteorological variables from which estimations of wind and solar power are done. Based on that, we have investigated the temporal (at the monthly timescale) and spatial complementarity of the wind and the solar resources in the Iberian Peninsula.

The annual cycle of energy demand in Iberia shows two maxima centered in winter and summer and relatively smaller loads during the transitional seasons, with both the shape and the monthly values of this cycle having experienced small changes in the recent years. Since the annual cycle of wind (solar) power presents a clear maximum in winter (summer), it is immediate to infer that both cycles could be combined in order to achieve the shape required by the annual cycle of energy demand.

Interannually, both resources show large variability in the winter months. Nevertheless, our results indicate that the monthly series of wind and solar power are strongly anticorrelated during winter and thus, both series could be also combined in order to achieve minimum interannual variability in the resulting wind-plus-solar production output. Moreover we found that this interannual complementarity is related, at least partially, to the multiple influence of the three main large-scale modes of climatic variability affecting Europe (NAO, EA and SCAND) since while their positive phases enhance one of the resources, reduces the other.

Motivated by the potential temporal complementarity, both intra and interannually, between the solar and the wind power series, we have developed an algorithm to identify those large areas within Iberia where either wind or solar plants should be installed so that the spatially aggregated monthly values of wind+solar power generation satisfies two conditions, namely (1) staying always above a predefined minimum threshold according to the annual cycle of energy demand, and (2) presenting the minimum values of combined (wind+solar) interannual variance. Obtained results highlight the spatial complementarity of both resources. The approach is exportable to other timescales than monthly and to whatever region, supporting any restriction, condition or assumption.