Modelling the dependence of energy droughts from variable renewable energies over Europe

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Meeting carbon-reduction targets will require to consider climate variability and climate change due the increasing share of climate-sensitive renewable energy sources (RES). In particular, wind and solar power are an important contribution within the energy mix in Europe. However, the strong dependence of RES on weather conditions poses a great challenge to the European power systems. One of the main concerns arises from situations of low production and high demand that can further aggravate the energy system. The purpose of the present study is twofold. Firstly, we characterize energy droughts, identified as periods of low wind and solar production (PWS) and periods of high energy residual load (RL)(i.e. energy demand minus wind and solar production). For that, a bivariate copula modelling approach is used to construct the joint probability distribution of two main characteristics of droughts: duration and severity. Secondly, we examine energy compound events defined as episodes of low PWS and high RL occurring simultaneously. A least absolute shrinkage and selection operator (LASSO) logistic regression is used to model the frequency of energy compound events using relevant meteorological drivers as covariates. Our results show that energy droughts derived from RL are less frequent but last longer than the droughts obtained from PWS that are more frequent although generally shorter. The bivariate frequency analysis indicates that severe droughts of PWS occur less frequent with large return periods at most of the countries. Shorter return periods are found in the case of RL, which points out that European countries experience more often severe droughts of RL. Results from the LASSO logistic regression indicate that temperature plays a relevant role on the occurrence of energy compound events. Overall, a higher likelihood of the occurrence of energy compound events is associated with extreme low wind speeds and low temperatures (<10th), accompanied by varying conditions of solar radiation (5th-30th).