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Spatial and temporal wind variability over Spain and its relationship with synoptic weather types

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The knowledge of the spatial and temporal variability of the wind over a given area is crucial for multiple purposes, like wind power generation, pollutant dispersion, risk evaluation, hydrological processes, etc. On the other hand, the assessment of the synoptic conditions related to wind behavior can be very useful for several applications. In the framework of wind power, integrating the effects of large-scale on wind behavior could improve the scheduling of the power generation, as well as to avoid damage in wind turbines due to extreme wind events. In this work, we present a methodology which contributes to the improvement in wind energy profits manly in two aspects. By one hand, performing an objective wind regionalization of an extensive area allows the identification of complementary regions. On the other hand, the association of wind field to WT can be used as a convenient tool for medium-range weather forecast, as well as to perform future wind projections under different climate change scenarios.

We have analyzed the wind variability using a network of 448 wind observations evenly distributed over Spain (except Canary Islands). The first step was to obtain regions with similar temporal behavior. This was performed by using a clustering method based on the main principal modes of variability, obtained through PCA analysis. The hierarchical Ward‘s method is used to provide the initial seeds to a subsequent no-hirarchical k-means method. The analysis was carried out for daily mean series of wind speed encompassing the period 2001-2007, considering each season separately.

The number of regions obtained with a similar wind speed behaviour depends on the season (8 in winter, 7 in spring, 6 in summer and autumn, and 13 for the whole year). The common regions in all seasons can be roughly associated to the following areas: High Ebro Valley, Low Ebro Valley, the Mediterranean Basin, the Guadalquivir Valley, the Cantabrian Coast and the Iberian Plateaus. It is found that, in some seasons, some of these areas exhibit no correlation or even are anticorrelated to others.

In a second step, the mean spatial regional series are related to the synoptic conditions. The Weather Types (WT) classification used (García-Valero et al, 2012) consist on 12 WT for each season, accounting for SLP and Z500 obtained from ERA40 reanalysis and ECMWF analysis. The wind climatology of every region is associated to each WT. Therefore, the weather situations involving extreme events, calms or regular winds are characterized.