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Causal discovery among wind-related variables in a wind farm under extreme wind speed scenarios: Comparison of results using Granger causality and interactive k-means clustering

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Using the era5 meteorological reanalysis data from 2000 to 2020 [1], we investigate temporal effects of ten wind related processes in time intervals of extreme wind speed values, extracted and corrected towards wind turbine locations for a wind farm in Andau, Austria. We approach the problem by two ways, by the Granger causal inference, namely by the heterogeneous Graphical Granger model (HMML) [2] and by clustering, namely by the interactive k-means clustering (IKM) [3].

We investigate six scenarios based on the hydrological half-year, a moderate wind speed and time intervals of low or high extreme wind speed in the farm. In case of HMML, we discover causal variables and their values for each scenario. Regarding the method IKM, it is used for three clusters (clusters for a moderate wind speed and for a low and high extreme wind speed) to find coefficient representations of each interacting variable with respect to the wind speed in each of the six scenarios. We compare the results of both methods in terms of the values of causal variables and of the values of the coefficients of representation and evaluate the interpretability of the discovered causal connections with the expert meteorological knowledge.

[1] <https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-pressure-levels?tab=overview>

[2] Hlaváčková-Schindler, K., Plant, C. (2020) Heterogeneous graphical Granger causality by minimum message length, *Entropy*, 22(1400). pp. 1-21 ISSN 1099-4300 MDPI (2020).

[3] Plant, C., Zherdin, A., Sorg, C., Meyer-Baese, A., Wohlschläger, A. M. Mining interaction patterns among brain regions by clustering. *IEEE Transactions on Knowledge and Data Engineering*, 26(9):2237–2249, 2014.