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Multivariate calibrated ensemble forecasts of wind and waves

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A number of offshore meteorological applications involve decision-making under uncertainty e.g. ship routing, offshore platform operations, or the optimal management (trading, maintenance planning) at offshore wind/wave energy instalments. The decision-making problems are then solved within a complex stochastic optimization framework, over multiple periods and with correlated random effects impacting the potential costs of decisions. For the specific case of offshore renewable energy, which is our primary focus, the corresponding monetary costs often are enormous, potentially also involving personnel safety. For this family of problems, the must-have input consists in multivariate ensemble forecasts of wind and wave characteristics. This is since they optimally describe the temporal interdependence structure of relevant uncertainties, as well as wind-wave dependencies.

The aim of this work is to discuss the quality of ensemble forecasts of wind and wave characteristics, to be used as input. Calibration aspects (univariate and multivariate) are analysed in detail, from overall methodological aspects to various possible assumptions about the generating processes (e.g. Gamma for wind ensembles and Rayleigh for wave height). In parallel the fact that certain approaches to calibration may distort or even destroy some of the nice features of ensemble predictions is shown and discussed. Especially there, the temporal correlation structure and wind-wave dependencies may be lost in the case where calibration approaches are not designed carefully. In addition, we analyse how these aspects may (or may not) be visible when evaluating known skill scores.

An illustrative example application is presented based on ECMWF ensemble forecasts of wind and wave characteristics at the FINO site in the German bight, for lead times up to 7 days and over a period of 2 years covering 2010-2011.