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Probabilistic forecasting of wave height for offshore wind turbine maintenance. (English)

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Summary: Wind power continues to be the fastest growing source of renewable energy. This paper is concerned with the timing of offshore turbine maintenance for a turbine that is no longer functioning. Service vehicle access is limited by the weather, with wave height being the important factor in deciding whether access can be achieved safely. If the vehicle is mobilized, but the wave height then exceeds the safe limit, the journey is wasted. Conversely, if the vehicle is not mobilized, and the wave height then does not exceed the limit, the opportunity to repair the turbine has been wasted. Previous work has based the decision as to whether to mobilize a service vessel on point forecasts for wave height. In this paper, we incorporate probabilistic forecasting to enable rational decision making by the maintenance engineers, and to improve situational awareness regarding risk. We show that, in terms of minimizing expected cost, the decision as to whether to send the service vessel depends on the value of the probability of wave height falling below the safe limit. We produce forecasts of this probability using time series methods specifically designed for generating wave height density forecasts, including ARMA-GARCH models. We evaluate the methods in terms of statistical probability forecast accuracy, as well as monetary impact, and we examine the sensitivity of the results to different values of the costs.

MSC:

90B25	Reliability, availability, maintenance, inspection in operations research	Cited in **1** Document
62G07	Density estimation	
62M20	Inference from stochastic processes and prediction	
62P30	Applications of statistics in engineering and industry; control charts	

Keywords:

OR in energy; offshore wind operations and maintenance; wave height; probabilistic forecasting

Software:

expsmooth

Full Text: DOI

References:

[1] Azzalini, A.; Genton, M. G., Robust likelihood methods based on the skew-t and related distributions, International Statistical Review, 76, 106-129, (2008) · Zbl 1206.62102

[2] Baillie, R. T.; Bollerslev, T., Prediction in dynamic models with time-dependent conditional variances, Journal of Econometrics, 52, 91-113, (1992) · Zbl 0850.62902

[3] Bollerslev, T.; Engle, R. F.; Wooldridge, J. M., A capital asset pricing model with time varying covariances, Journal of Political Economy, 96, 116-131, (1988)

[4] Caroll, J.; McDonald, A.; McMillan, D., Failure rate, repair time and unscheduled O&M cost analysis of offshore wind turbines, Wind Energy, 19, 1107-1119, (2016)

[5] Catterson, V. M.; McMillan, D.; Dinwoodie, I.; Revie, M.; Dowell, J.; Quigley, J., An economic impact metric for evaluating wave height forecasters for offshore wind maintenance access, Wind Energy, 19, 199-212, (2016)

[6] De Menezes, L. M.; Taylor, J. W.; Bunn, D. W., Review of guidelines for the use of combined forecasts, European Journal of Operational Research, 120, 190-204, (2000) · Zbl 0962.91531

[7] Dinwoodie, I. A.; Catterson, V. M.; McMillan, D., Wave height forecasting to improve off-Shore access and maintenance scheduling, (2013 IEEE power \& energy society general meeting, (2013))

[8] Genre, V.; Kenny, G.; Meyler, A.; Timmermann, A., Combining expert forecasts: can anything beat the simple average, International Journal of Forecasting, 29, 108-121, (2013)

[9] Garrad Hassan, G. L., A guide to UK offshore wind operations and maintenance, (2013), Scottish Enterprise and The Crown

Estate

[10] Gneiting, T.; Balabdaoui, F.; Raftery, A. E., Probabilistic forecasts, calibration and sharpness, Journal of the Royal Statistical Society, Series B (Statistical Methodology), 69, 243-268, (2007) · Zbl 1120.62074

[11] Gneiting, T.; Ranjan, R., Combining predictive distributions, Electronic Journal of Statistics, 7, 1747-1782, (2013) · Zbl 1294.62220

[12] Gourieroux, C., ARCH models and financial applications, (1997), Springer New York · Zbl 0880.62107

[13] Hyndman, R. J.; Koehler, A. B.; Ord, J. K.; Snyder, R. D., Forecasting with exponential smoothing: the state space approach, (2008), Springer-Verlag Berlin, Heidelberg, Germany · Zbl 1211.62165

[14] Irawan, C. A.; Ouelhadj, D.; Jones, D.; Stålhane, M.; Sperstad, I. B., Optimisation of maintenance routing and scheduling for offshore wind farms, European Journal of Operational Research, 256, 76-89, (2017) · Zbl 1394.90278

[15] Irawan, C. A.; Song, X.; Jones, D.; Akbari, N., Layout optimisation for an installation port of an offshore wind farm, European Journal of Operational Research, 259, 67-83, (2017) · Zbl 1394.90391

[16] Jeon, J.; Taylor, J. W., Short-term density forecasting of wave energy using ARMA-GARCH models and kernel density estimation, International Journal of Forecasting, 32, 991-1004, (2016)

[17] Kapetanios, G.; Mitchell, J.; Price, S.; Fawcett, N., Generalised density forecast combinations, Journal of Econometrics, 188, 150-165, (2015) · Zbl 1337.62292

[18] LeClerc, J.; Joslyn, S., The cry wolf effect and weather-related decision making, Risk Analysis, 35, 385-395, (2015)

[19] Lichtendahl, K. C.; Grushka-Cockayne, Y.; Winkler, R. L., Is it better to average probabilities or quantiles, Management Science, 59, 1594-1611, (2013)

[20] Miller, A. R., The effects of winds on water level on the new england coast, Limnology and Oceanography, 3, 1-14, (1958)

[21] Reikard, G., Forecasting Ocean wave energy: tests of time-series models, Ocean Engineering, 73, 168-178, (2009)

[22] Reikard, G.; Robertson, B.; Bidlot, J. R., Combining wave energy with wind and solar: short-term forecasting, Renewable Energy, 81, 442-456, (2015)

[23] Rieder, K. F., Analysis of sea-surface drag parameterizations in open Ocean conditions, Boundary Layer Meteorology, 82, 355-377, (1997)

[24] Roulston, M. S.; Ellepola, J.; von Hardenberg, J.; Smith, L. A., Forecasting wave height probabilities with numerical weather prediction models, Ocean Engineering, 32, 1841-1863, (2005)

[25] Shyshou, A.; Gribkovskaia, I.; Barceló, J., A simulation study of the fleet sizing problem arising in offshore anchor handling operations, European Journal of Operational Research, 203, 230-240, (2010) · Zbl 1176.90384

[26] Staid, A.; Guikema, S. D., Risk analysis for US offshore wind farms: the need for an integrated approach, Risk Analysis, 35, 587-593, (2015)

[27] Taylor, J. W., Probabilistic forecasting of wind power ramp events using autoregressive logit models, European Journal of Operational Research, 259, 703-712, (2017) · Zbl 1395.62350

[28] Ursavas, E., A benders decomposition approach for solving the offshore wind farm installation planning at the north sea, European Journal of Operational Research, 258, 703-714, (2017) · Zbl 1394.90307

[29] Winkler, R. L., The importance of communicating uncertainties in forecasts: overestimating the risks from winter storm juno, Risk Analysis, 35, 349-353, (2015)

[30] Yoder, M.; Hering, A. S.; Navidi, W. C.; Larson, K., Short-term forecasting of categorical changes in wind power with Markov chain models, Wind Energy, 17, 1425-1439, (2014)