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- towards climate change services

Offshore Wind Power Integration in severely fluctuating Wind Conditions

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Strong power fluctuations from offshore wind farms that are induced by wind speed fluctuations pose a severe problem to the save integration of offshore wind power into the power supply system. Experience at the first large-scale offshore wind farm Horns Rev showed that spatial smoothing of power fluctuations within a single wind farm is significantly smaller than onshore results suggest when distributed wind farms of 160 MW altogether are connected to a single point of common-coupling. Wind power gradients larger than 10% of the rated capacity within 5 minutes require large amount of regulation power that is very expensive for the grid operator. It must be noted that a wind speed change of only 0.5m/s result in a wind power change of 10% (within the range of 9-11 m/s where the wind power curve is steepest). Hence, it is very important for the grid operator to know if strong fluctuations are likely or not.

Observed weather conditions at the German wind energy research platform FINO1 in the German bight are used to quantify wind fluctuations. With a standard power curve these wind fluctuations are transfered to wind power. The aim is to predict the probability of exceedence of certain wind power gradients that occur in a time interval of e.g. 12 hours.
During 2006 and 2009 the distribution of wind power fluctuations looks very similar giving hope that distinct atmospheric processes can be determined that act as a trigger. Most often high wind power fluctuations occur in a range of wind speeds between 9-12 m/s as can be expected from the shape of the wind power curve.

A cluster analysis of the 500 hPa geopotential height to detect predominant weather regimes shows that high fluctuations are more likely in north-western flow. It is shown that most often high fluctuations occur in non-stable atmospheric stratification. The description of stratification by means of the vertical gradient of the virtual potential temperature is chosen to be indicative for convection, i.e. it can be assumed that a negative gradient indicates convection which leads to strong wind fluctuations in the updraft and downdraft of the cloud.
Neural Networks are used to determine the probability of exceedence of wind power gradients from a set of atmospheric parameters that are taken from Numerical Weather Prediction Models. Parameters describing atmospheric stability, that are related to convection (e.g. rain rate) and that forecast wind gusts tend to carry most information to estimate expected wind power fluctuations.