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On the Effect of Offshore Wind Parks on Ocean Circulation

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The interest of renewable energy sources grew during the last years and especially the increasing interest in wind energy induced a strong demounting of wind parks. Due to a less reduced wind speed over ocean which leads to a higher energy production than over land companies started to invest in offshore wind parks (OWPs). For example it is planned to built for Germany‘s energy supply around 8700 MW in North Sea and Baltic Sea (source:IWR) which is in accordance with more than 20 OWPs composed of 80 turbines.

As known in literature such wind parks excite the so-called wake-effect which impacts the atmospheric turbulence; disturbed wind fields again affects the ocean circulation.

To analyze the influence of OWPs on the ocean circulation we evaluate model simulations using the Hamburg Shelf-Ocean-Model (HAMSOM). The simulations are driven with a wind forcing produced by the Mesoscale Atmosphere Model of the Hamburg University (METRAS) which has implemented wind turbines (courtesy of the Meteorological Institute of the University Hamburg, department Technical Meteorology, Numeric Modelling).

In a sensitivity study we defined a virtual ocean of 60m depth with a flat bottom and a warmer and fresher surface layer according to North Sea’s conditions. Main results show that already a small OWP of 12 turbines with a rotor diameter of 80 m, arrangement of turbines is based on wind park Alpha Ventus, lead to a complex change in the ocean circulation. Due to the wake-effect zones of upwelling and downwelling are formed already shortly after turning-on rotators. The dimension of these cells sizes around 30x30 kilometers with a vertical velocity in the order of 1μm/sec influencing the dynamic of an area being 160 times bigger than the wind park itself. The emerged vertical structure results in a change of sea level of some millimeters. This disturbance of the upper layer show a dipole structure across the main wind direction. Additional the upwelling and downwelling patterns around the wind park and a changed vertical mixing cause a tilt of the thermocline which can also affect the lower levels.

The physical process behind the formation of these vertical patterns is a combination of Ekman Pumping and a changed vertical exchange both due to an induced divergence in the wind field.

Considering that wind turbines work only in a special window of wind speed, rotors will stop in case of too weak or too strong wind speeds as well as in case of technical issues, the dimension and intensity of upwelling and downwelling cells induced by OWPs depends on the number of rotors and the wind speed.

Finally we will focus on realistic simulations of the North Sea to estimate the dynamic changes due to OWPs. These results will be helpful for ecosystem modeling analyzing the question of reef’s development within OWPs. If we assume a continuous operation of North Sea’s OWPs in future we would expect a fundamental change in ocean dynamics connected with a possible change of the ecosystem behavior.