A new 2D velocity deficit computation

The computation of the velocity deficit of wakes behind the offshore windparks requires the better knowledge of the undisturbed or freestream wind field. The estimation of the background wind field is performed using the undisturbed winds fields on both side of the wake area through filtering method (e.g. Kaiser window $K_c$). It takes into account the width of the wake ($\xi$) and the wind direction. The background wind $V_{\text{freestream}}$ is obtained through the convolution of the filter and the original SAR wind field. This procedure enhances the wind speed in the wake areas. Finally, the velocity deficit $V_D$ is estimated without any manual intervention. The filter emphasizes visually the 2D view of the wake.

$$V_D = 100 \frac{V_{\text{freestream}} - V_{\text{wake}}}{V_{\text{freestream}}}$$

Estimation of $V_{\text{freestream}}$ by 2D convolution of the SAR wind field with tailored filter

$$K_c(x) = \begin{cases} \frac{I_0(a)}{I_0(a)} e^{-|x|^2 / a^2}, & |x| < \xi/2 \\ 0, & |x| \geq \xi/2 \end{cases}$$

Statistical wake occurrence analysis

The velocity deficit computed from the filter technique is used as a tool to analyse the detection of wake behind any wind park in the German Bight in the year 2017. The statistics of appearance of wakes is based on the morning and evening SAR overflights for the same frame geometry. High percentage of wake is found from March-August (62% / 59%) for Evening/morning passes. This results correlate with the thermal stratification from FINO-1.

Conclusions

- The spectral analysis revealed that spectral slope of the wind field for all stability conditions are generally close to k-5/3. The spectral energy decreases with the atmospheric stability.
- The new filter method improves the 2D view and detection characteristics of wakes behind the windparks. This eases the estimation of the velocity deficit behind offshore wind parks from SAR imagery without any subjective and arbitrary manual interventions. It also allows error estimates for deficits based on spectral properties of the background wind field.
- Seasonal distribution of wake is displayed, which is coherent with the thermal stratification from FINO-1.

References


