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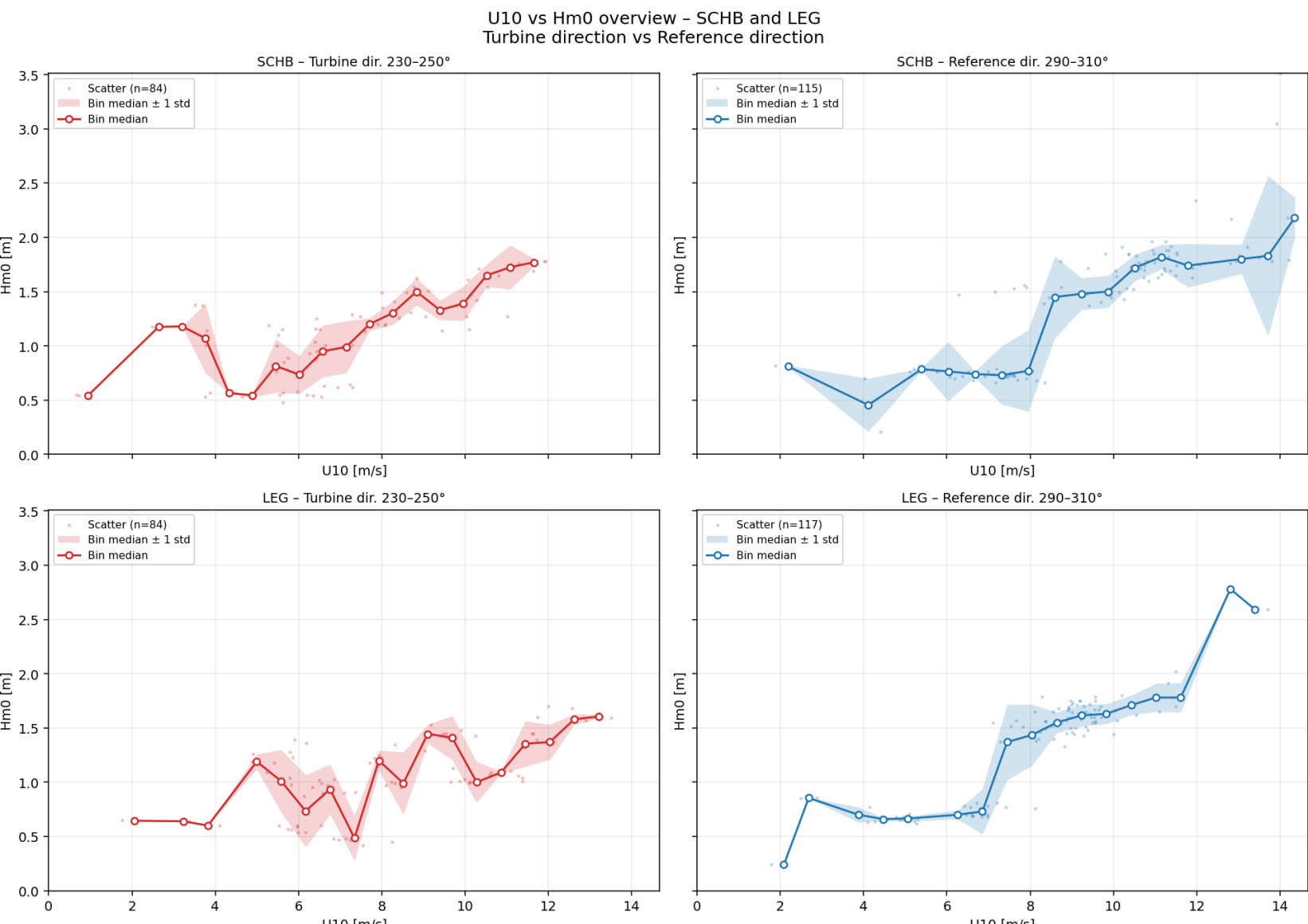
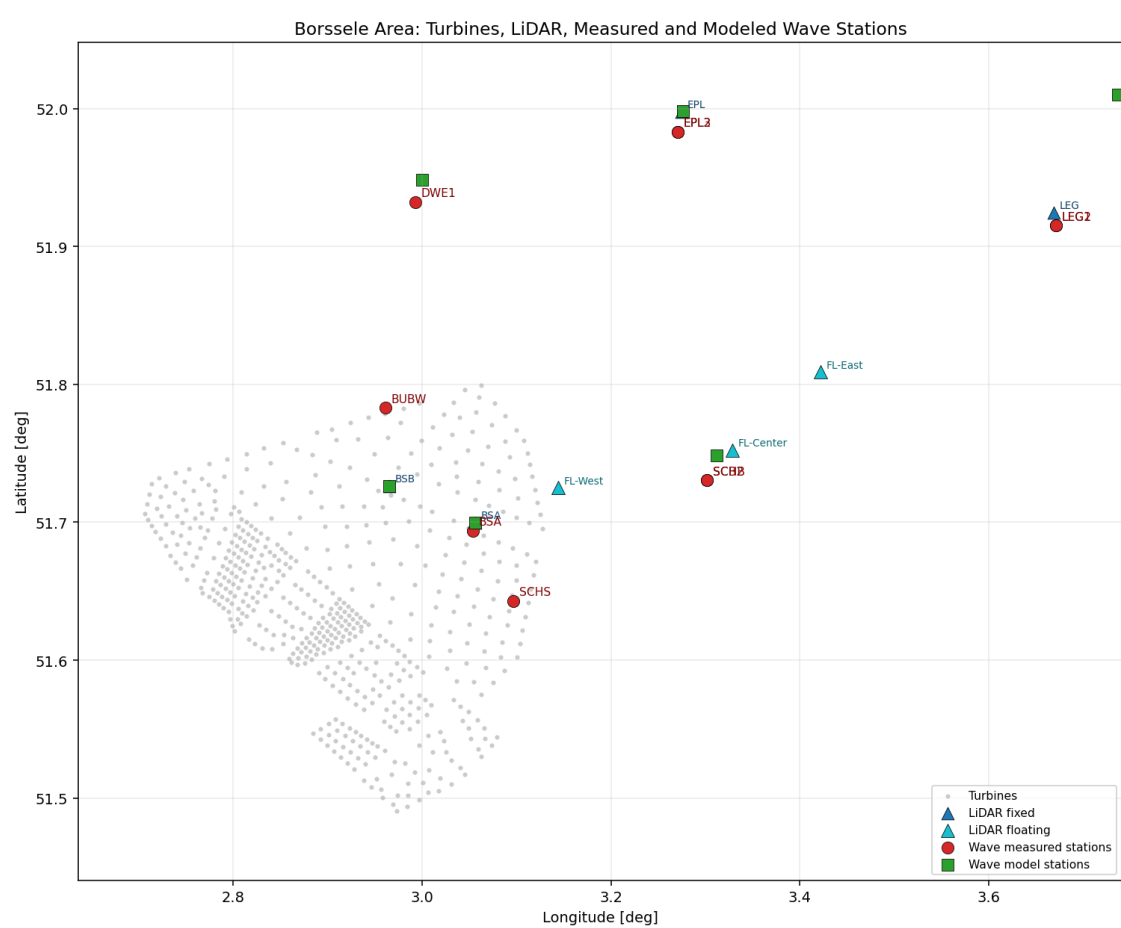
Wind farm wakes affect high-freq wave generation downwind, but measured effects are minimal

PROJECT SITE

The BeneWakes project, coordinated by the Netherlands Enterprise Agency (RVO), is a combined atmospheric and oceanographic measurement campaign around the Borssele offshore wind farm cluster. It integrates waveriders, wave radars, floating lidar buoys and array of fixed and scanning lidars deployed around and downstream of the cluster. In this initial assessment, the objective is to assess how atmospheric wake conditions translate to modifications of the local wave climate.

WIND DEFICIT

Wind turbines extract momentum from the atmospheric flow, reducing wind speed and increasing turbulence downstream. These wake effects decrease with distance from the wind farm.



Hm0 vs U10

Lidar wind speeds at stations SCHB and LEG were extrapolated to 10m height. At these stations the U10 has been plotted against the measured wave height. A downstream directional sector of 230-250° and a reference sector of 290-310° have been defined. The reference sector was chosen to have similar fetch lengths to the downstream sector.

SCHB is closer to the wind farm and the effect on the wind speed is expected to be stronger. At station SCHB we do see slightly lower wind speeds than at LEG.

We expect the lower wind speed to affect the wave height to wind speed relationship in the downstream sector compared to the reference sector but from the data any effect is very minor.

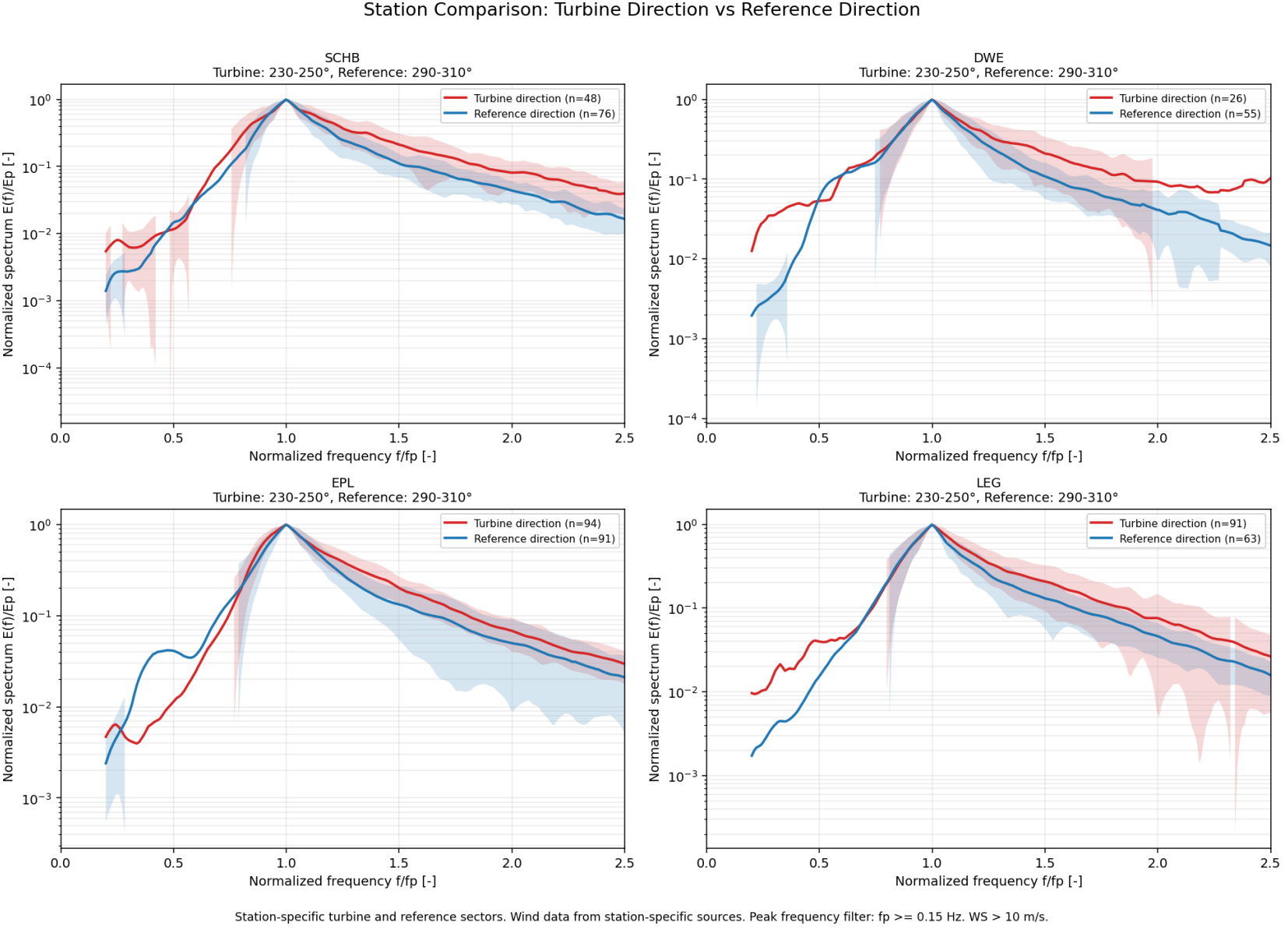
WAVE SPECTRA

We expect that reduced wind speed would mainly affect the high frequency part of the wave spectrum. We therefore looked for an effect on the spectral form in the downstream spectra compared to the reference sector.

We first removed swell dominated sea states by excluding sea states with a peak frequency < 0.15 Hz.

Stations SCHB and LEG are downstream of the wind farm, while stations DWE and EPL are unaffected for both direction sectors.

Our initial expectation was a reduction in the surface wind speed due to the wind park that causes a reduction in the wave energy at the higher frequencies. What we actually see, is that at all stations the wave energy at these frequencies is higher for the winds coming from the turbine direction, suggesting that any differences are related to climatic aspects.



FUTURE WORK

Our initial analysis so far does not indicate that wind farm wakes have an effect on the wave conditions downstream of the wind farm. However, we note that the current data set contains very few periods with winds above 10 m/s in the critical direction sector. This limits the possibilities to select data and compare it statistically.

However, a framework has been set out to make the relevant comparisons. As more measurements become available, we expect that more periods will occur with a strong wind deficit. This will enable us to further select relevant data to draw statistically reliable conclusions.

It does seem likely, however, that any effect on the waves downstream is relatively minor. This could be related to a wind deficit at hub height not being reflected by strong wind deficits at the sea surface e.g. because the wakes cause more wind energy to be brought closer to the sea surface. It could also be because a more turbulent wind gives more energy input to the waves than a stable wind.

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