



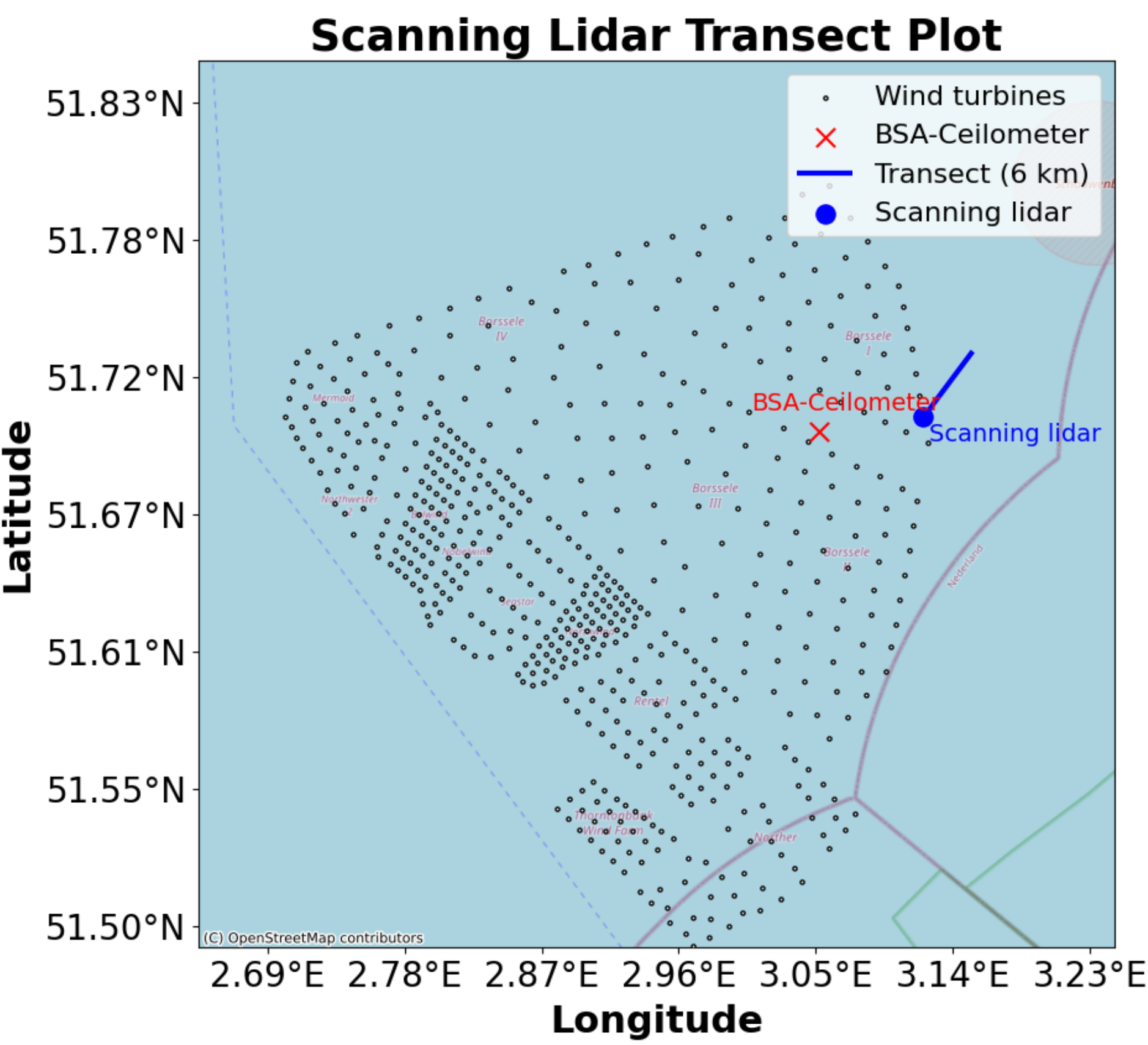
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Scanning LiDAR unlocks spatial ABL height estimation for blockage effects

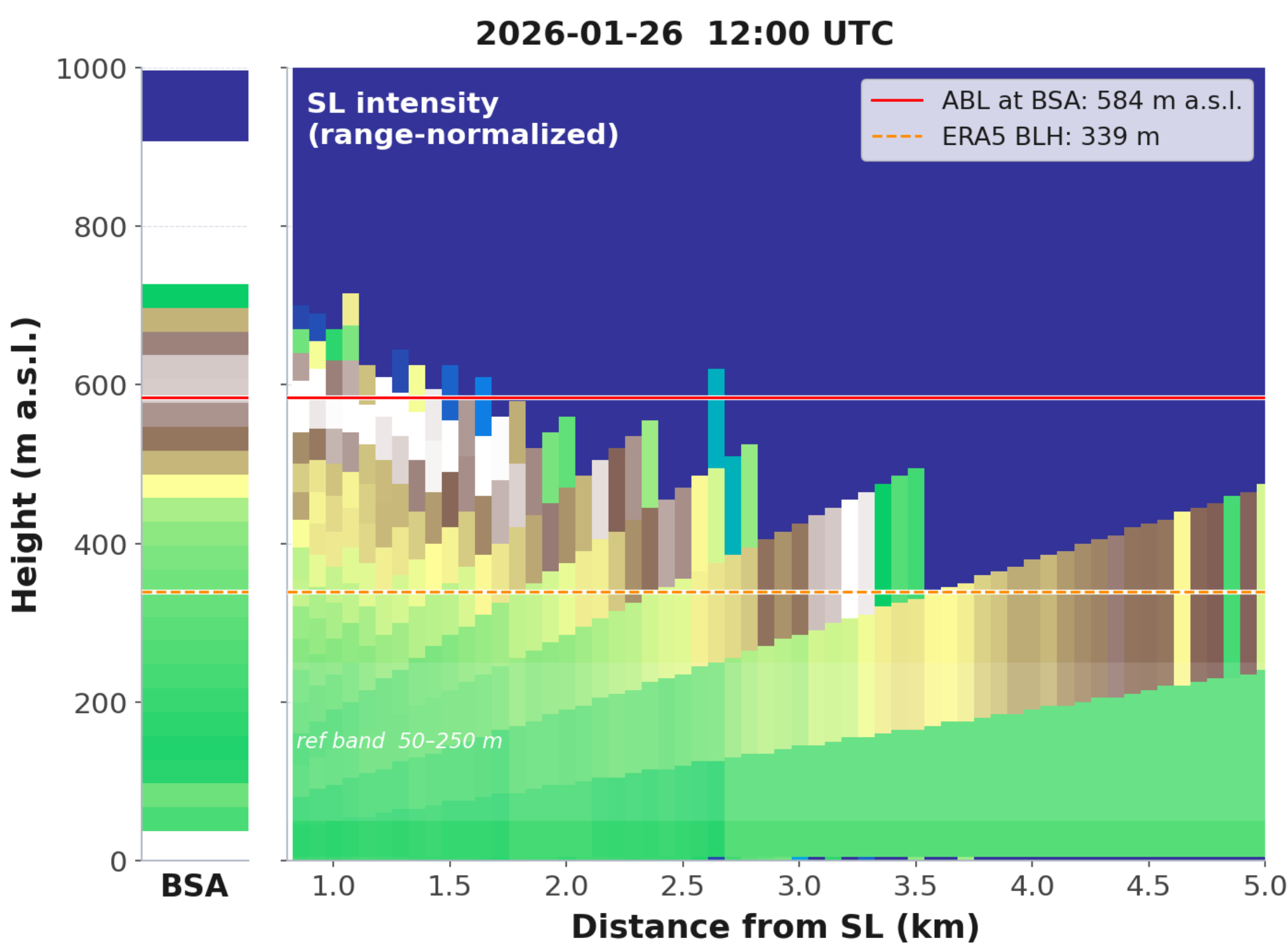
The campaign setup

As part of the BeNeWakes projects a Scanning LiDAR (SL, Galion G6000) was installed on the transition piece of a wind turbine in the North-Easterly outer row of the Borssele wind farm. We also retrieved data from the KNMI operated ceilometer backscatter LiDAR (Lufft CHM15k) at the BSA transformer station. ERA5 reanalysis data was used as an additional reference for ABL height estimate (based on the bulk Richardson number) at 0.25° horizontal resolution and 1-hour temporal resolution.

The project area is indicated herebelow:



When looking in upwind direction (f the SL along the transect), a following image appears:



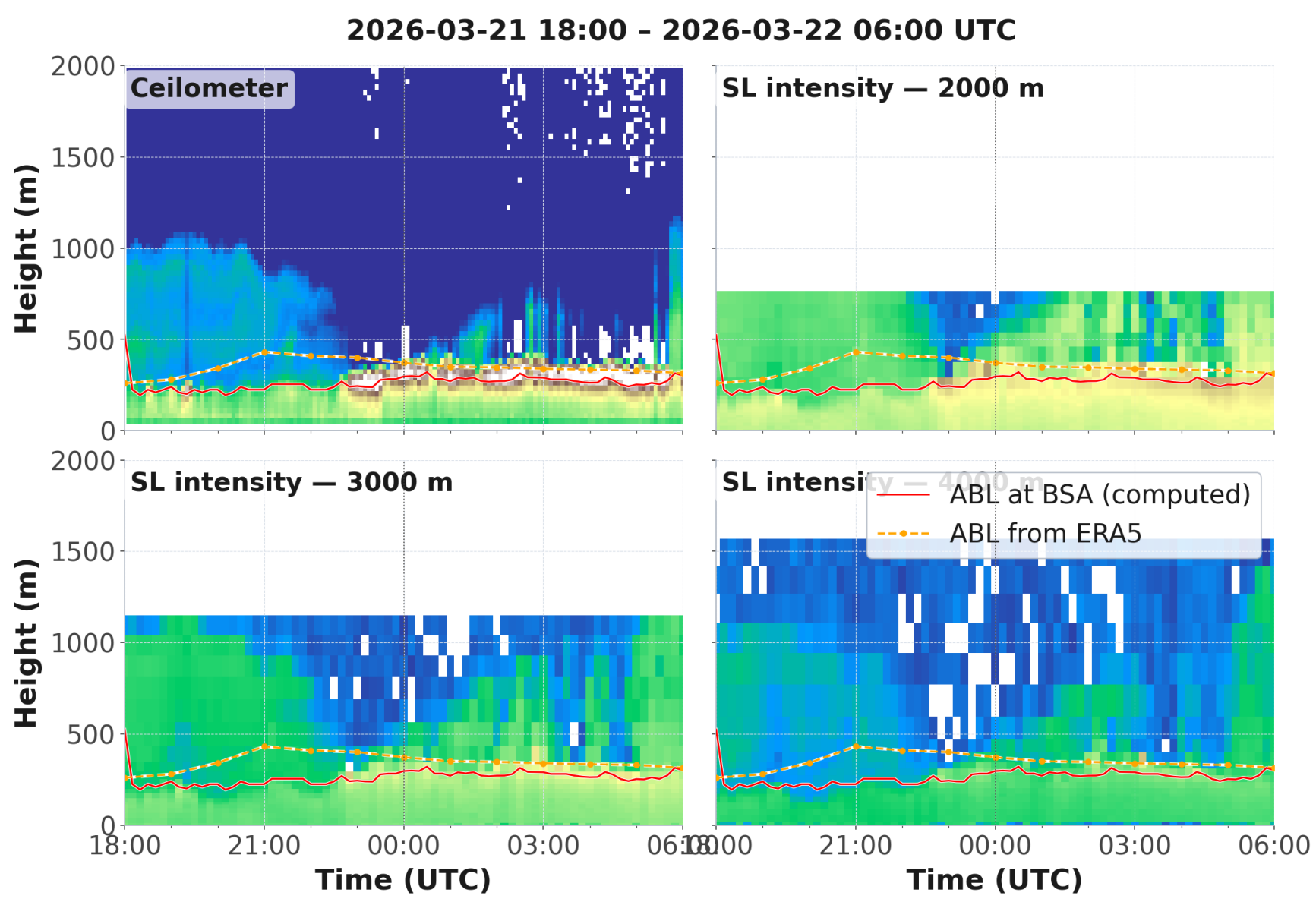
This graphic shows (a for single 10 min time-step) the range-normalized boundary layer heights as derived from the Ceilometer (left) and SL (right). This is plotted with the KNMI-derived ABL-height (red line) over the wind farm. Though just a single instance, the theoretically expected ‘growth of the ABL can be seen.

Why does it matter?

Wind farms modify the Atmospheric Boundary Layer (ABL) through upstream blockage, downstream wakes, and turbulent mixing — effects that vary strongly with atmospheric stability. Scanning lidar intensity transects allow these spatial signatures to be observed directly at the heights most relevant to wind farm interaction. The ABL height can be derived from the lidar backscatter data, as explained by Kotthaus et al 2023 (Atmos. Meas. Tech., 16, 433–479)

Comparing scanning LiDAR w Ceilometer

SL backscatter intensity profiles are compared against co-located ceilometer measurements to validate ABL height detection. Validation is performed at ranges of 2, 3, and 4 km from the lidar, covering a representative cross-section of the scan domain. The time series figure shows that ABL height estimates remain consistent across all three ranges and agree well with the ceilometer, confirming that range-dependent signal attenuation does not significantly affect the results. This gives confidence in the scanning lidar as a tool for spatially resolved boundary layer observations.



RESULTS

Several timesteps show a clear increase in ABL height when winds approach from the north-east, consistent with upstream blockage effects induced by the wind farm. Notably, the lidar-derived ABL height increases progressively as you approach the wind farm, converging towards the BSA estimate — behavior that aligns with theoretical expectations of boundary layer growth upstream of a large wind farm. However, the number of qualifying cases captured during the campaign remains too limited (for now) for statistical analysis.

Going further

Extending the measurement period will increase the number of usable cases, and using modelled ABL heights would increase quality. Systematic screening could identify additional blockage and wake events, and atmospheric stability classification can be added to stratify results. This would ultimately enable a robust statistical analysis of wind farm–ABL interactions.

See for more on the BeNeWakes project:
[BeNeWakes – project status update 2](#) · [Offshorewind RVO](#)



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