PO.165

Which lidar system should be used for offshore wind resource assessments in the Greek market?

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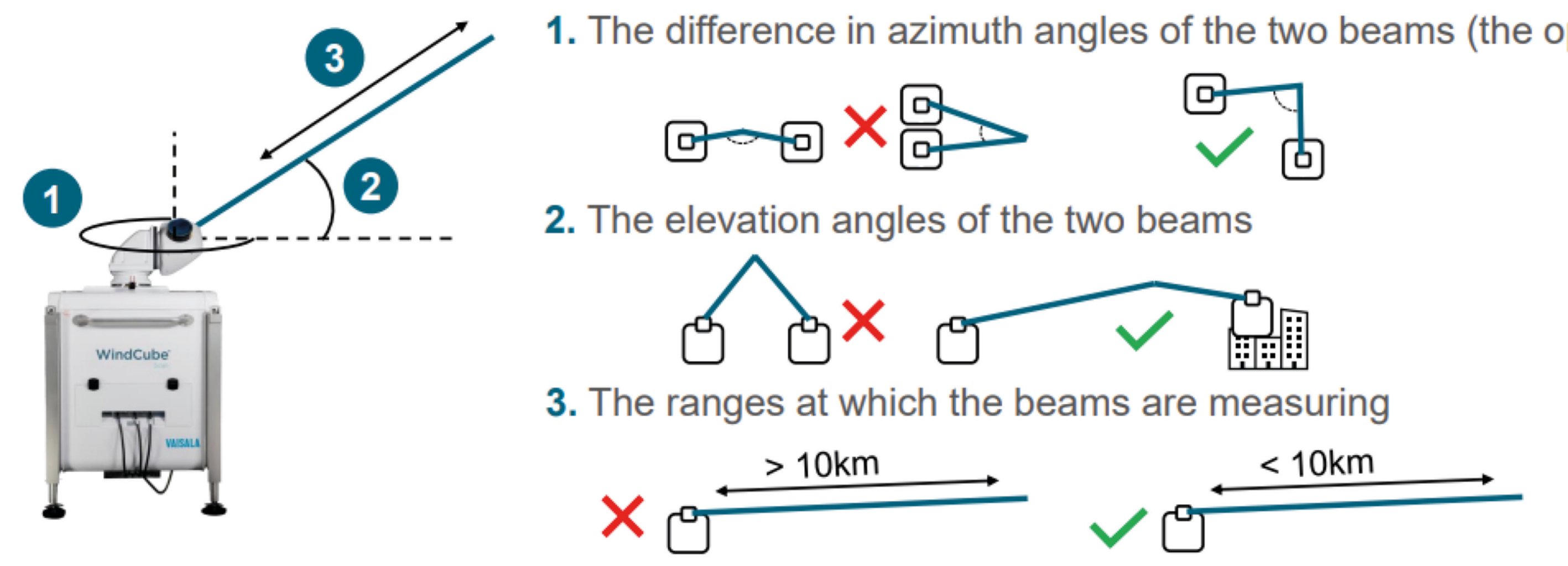
Abstract

The Greek Parliament approved Greece's first Offshore Wind Law in 2022 and is targeting to build a total of 9 GW of offshore wind energy by 2023, set to increase in later revisions of their National Energy and Climate Plan [1]. The expected proximity of prospective wind farm development to the Greek coastline present an opportunity for dual scanning lidars to be used for the wind resource assessments of those developments, in addition to the now commonly used floating lidar. A theoretical model of the uncertainty of dual scanning lidar measurements, combined with a high-resolution coastline dataset, is used to create a map of dual scanning lidar uncertainty across the Greek offshore region. This is compared to the uncertainty of a stage 2 floating lidar to provide information on where each type of instrument is preferable to be used for an offshore wind resource assessments.

Dual scanning lidar geometry and uncertainty

The uncertainty of a dual scanning lidar (DSL) measurement depends on the geometry between the beams of the two lidars. The key geometric factors that affect the measurement uncertainty are summarized below:



1. The difference in azimuth angles of the two beams (the opening angle)

2. The elevation angles of the two beams

3. The ranges at which the beams are measuring

Methods

Vaisala has developed a theoretical model of DSL measurement uncertainty as a function of beam geometry, among other inputs. It takes into account the three main sources of DSL measurement error:

- The base uncertainty of the individual scanning lidars
- Assumptions made when reconstructing the horizontal wind speed
- Measuring the wrong part of the shear profile due to pointing inaccuracy

This error model has been presented and validated in [2].

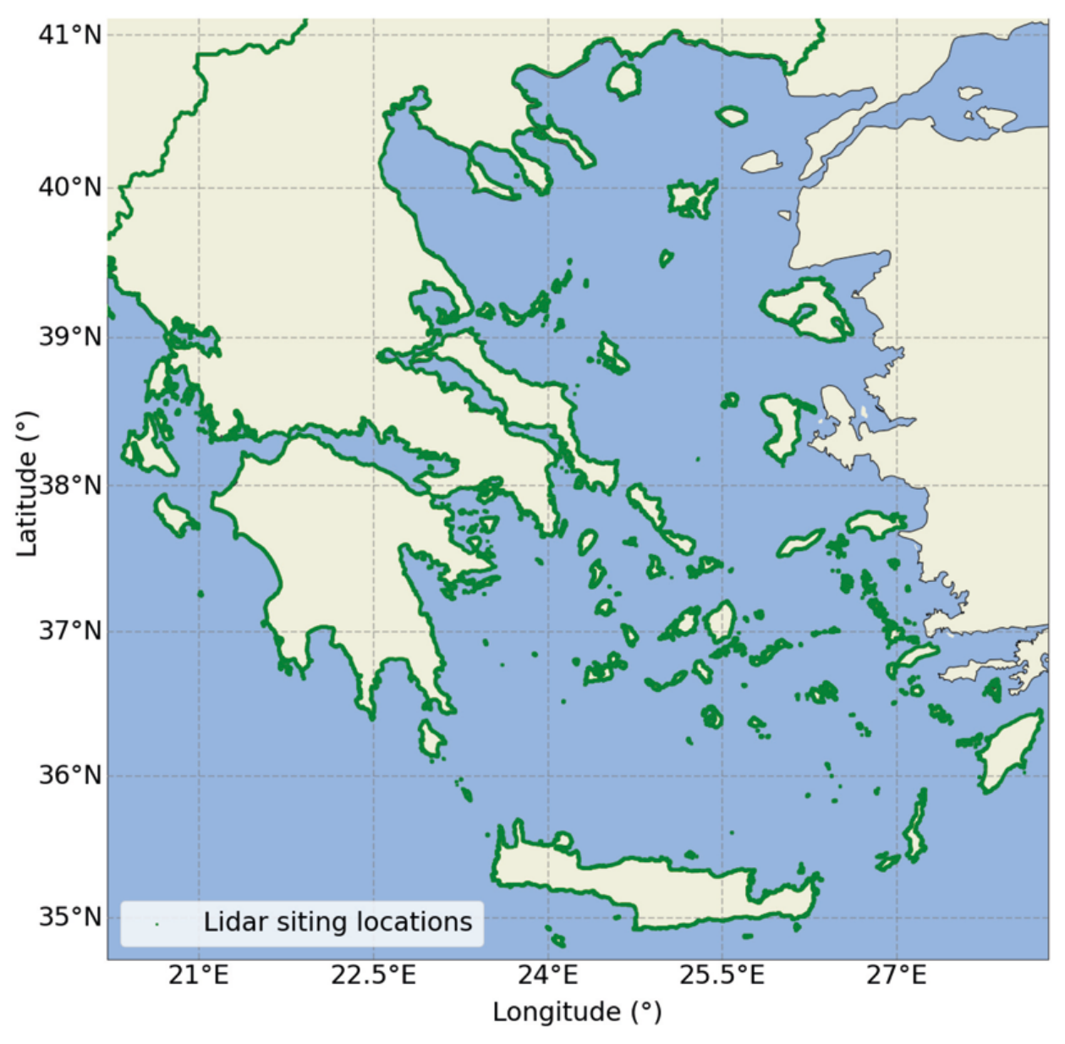


Figure 1: The locations considered for the installation of scanning lidars

Data on where the lidars could be installed to measure over the sea was retrieved from an open source, high resolution data base of the Greek coastline, provided by the Greek open data catalogue Geodata.gov.gr [3].

The considered siting locations are shown as green points in Figure 1. Note that only sites in Greece were considered and sites in other countries (notably in Türkiye) were neglected.

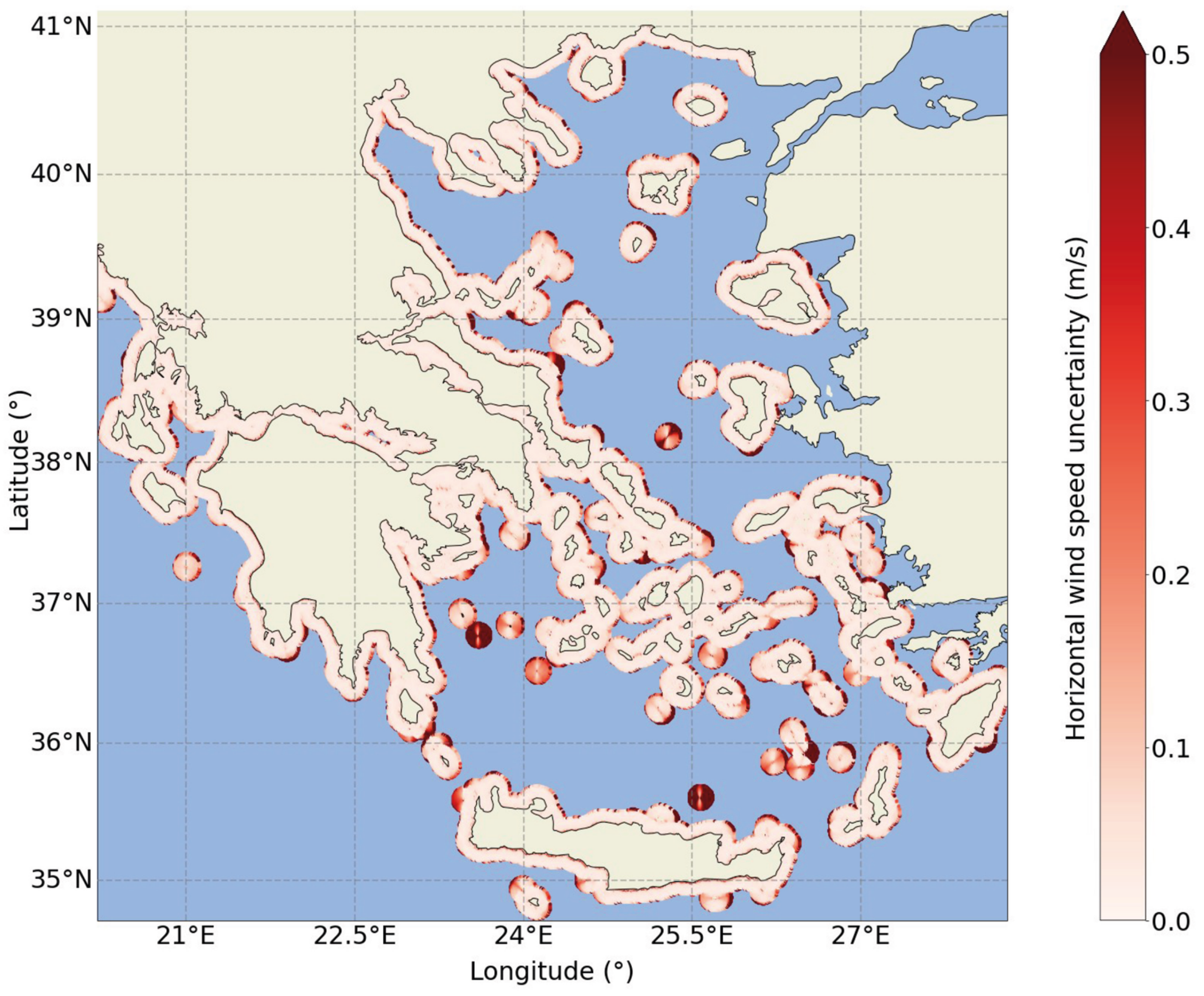
All maps in this poster were created using the Python library Cartopy [4].

A fine grid of potential measurement locations was defined and a quad trees algorithm used to link each to nearby sites within the range of the lidar. The pair of sites which combined gave an azimuth opening angle the closest to orthogonal were used by the error model to calculate the measurement uncertainty which was plotted on the map.

To do a geographical comparison of where DSL can achieve lower uncertainty than floating lidar systems (FLS) in the Greek offshore region, a typical FLS measurement uncertainty was assumed. As a conservative estimate for a stage 2 FLS, 3.5% is taken [5].

Results

Figure 2: All possible DSL measurement locations plotted over a map of the Greek offshore region. The colour of the points shows the modelled DSL measurement uncertainty with the best possible beam geometry according to the available SL installation sites.



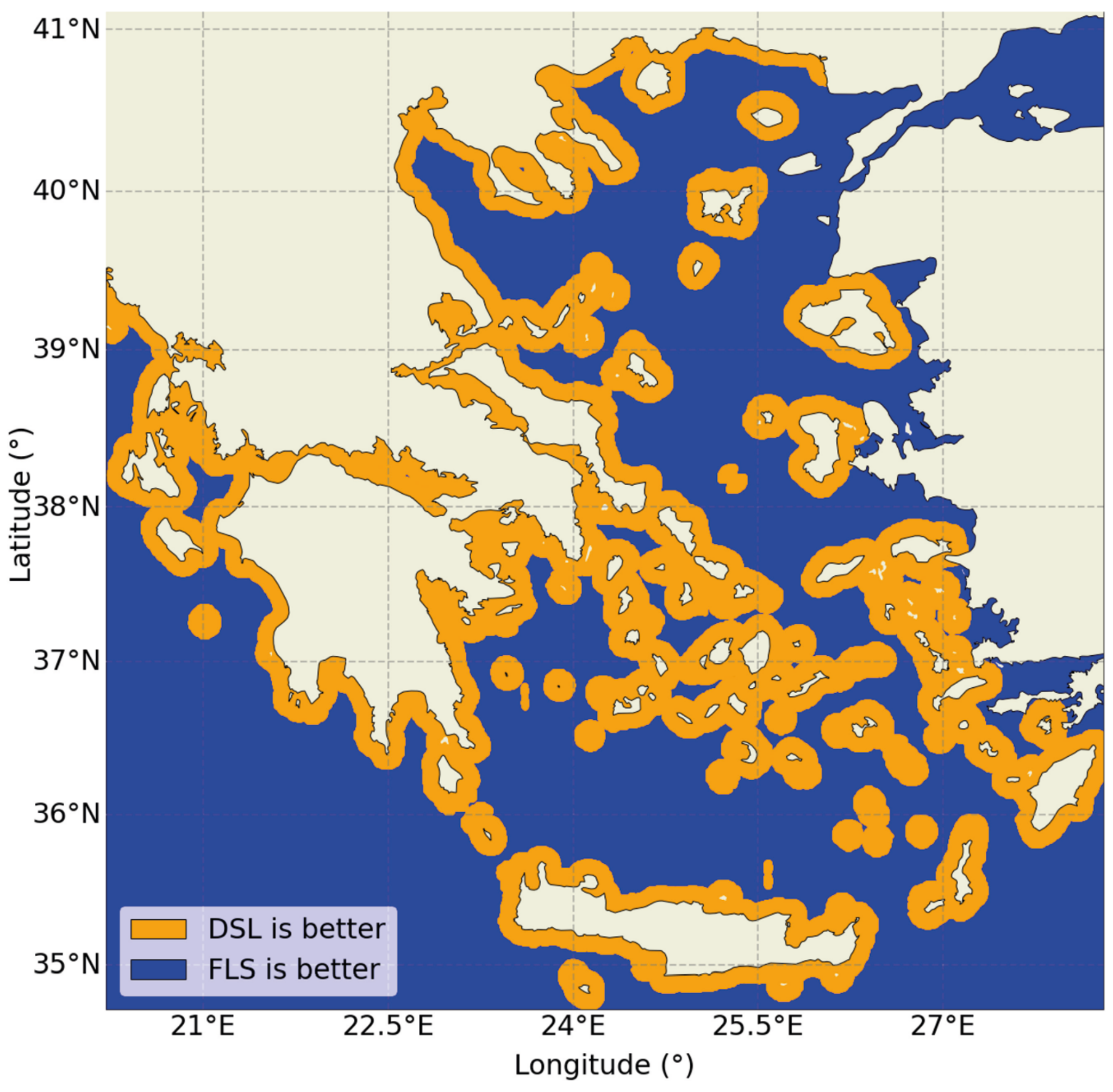


Figure 3: Comparison of where, in terms of measurement uncertainty, it is better to use DSLs or a FLS for an offshore WRA. Locations where the DSL setup with the best possible beam geometry has lower uncertainty are shown in Orange and locations where a stage 2 FLS has lower uncertainty are shown in blue.

Conclusions

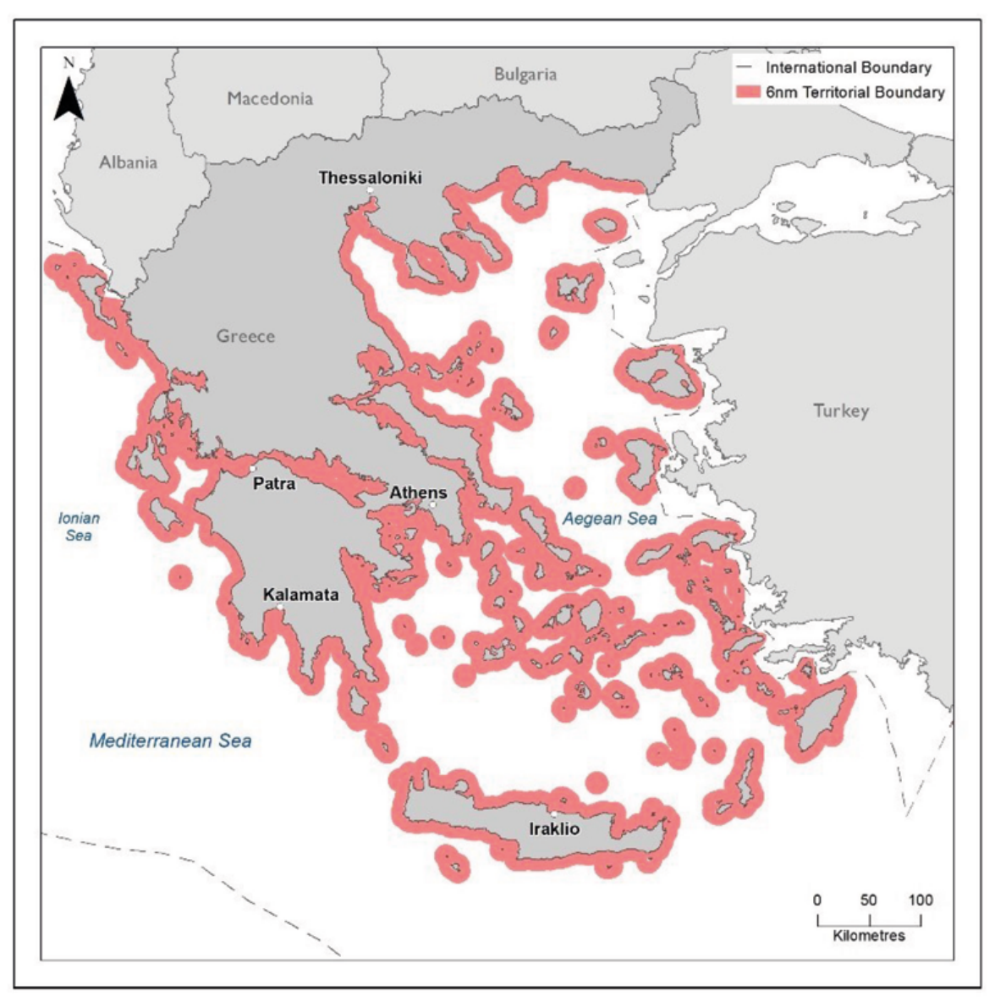


Figure 4: The limits of Greece's territorial sea [6]

When suitable sites are within range of a particular measurement point and allow for good beam geometry, DSL typically outperforms FLS in terms of measurement uncertainty often achieving less than 0.1 m/s. FLS has the advantage of being applicable almost anywhere – even above the deep ocean, far from any landmass, whilst still achieving a suitable uncertainty for the wind resource assessment. Given the limits of Greece's territorial sea only extend 6 nautical miles (11.1 km) from the coast into the Aegean sea, as seen in Figure 4, the suitable areas for DSL measurement correspond well with the likely positions of future wind farm development. The technology therefore presents a good option for offshore wind resource assessments in the Greek offshore market.

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