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This work presents validation for continuous wave lidar TI transfer function METICE, developed by ZX Lidars to address systematic differences between lidar-derived turbulence intensity and traditional cup anemometer measurements. Sound performance is demonstrated under unstable, neutral, and stable atmospheric conditions, and for a range of operational turbine heights showing that the transfer function successfully compensates for strong height- and stability-dependent differences.

Problem

Turbulence Intensity (TI) as measured by continuous wave lidar (TI_{CW}), produces differences compared with cup anemometers (TI_{CUP}), with differences maximised in stable conditions and at higher heights due to volume and probe averaging effects.

Solution

Transfer functions can be deployed to produce cup equivalent TI (TI_{CE}) to minimise these differences. ZX Lidars' Multisite Ensemble TI_{CE} transfer function (METICE) was developed for this purpose [1].

Method

To validate METICE, 63 lidar/cup pairs in simple terrain are evaluated using the site suitability framework outlined in the CFARs criteria [2]. Representative TI difference (REP TI) and mean bias error (MBE) are assessed in each case. Where a temperature gradient was available at a mast, the stability class is determined using the bulk Richardson number (Rn), with $Rn < -0.02$ classified as unstable, $-0.02 \leq Rn \leq 0.02$ classified as neutral, and $Rn > 0.02$ classified as stable [3].

Results

The results are shown in 1 m/s each wind speed bins in Fig 1.

- Across all wind speeds (4–14 m/s) and stability classes, MBE and

REP TI differences are tightly clustered around 0%, indicating minimal systematic bias.

- MBE mostly within $\pm 1\%$ across all regimes.
- REP TI mostly within $\pm 2\%$ across all regimes.

Continuous Development

This ensemble represents an evolving and adaptive framework. Future development will focus on maximising the model's envelope of validity, particularly for complex sites. This will also include load validation for evaluation analysis through improving damage index performance across the full range of exponents.

References

- [1] Macdonald, E. and Woodward, A. 2025. Introducing METICE: Multi-Site Ensemble Turbulence Intensity Cup Equivalent from ZX Lidars, <https://www.zxlidars.com/media/publications/>
- [2] St. Pé, A., et al., 2021. CFARS Site Suitability Initiative: An Open Source Approach to Evaluate the Performance of Remote Sensing Device (RSD) Turbulence Intensity Measurements & Accelerate Industry Adoption of RSDs for Turbine Suitability Assessment, <https://doi.org/10.5281/zenodo.5529750>
- [3] Pérez Albornoz, C., et al., 2022. Review of atmospheric stability estimations for wind power applications, Renewable and Sustainable Energy Reviews, <https://doi.org/10.1016/j.rser.2022.112505>

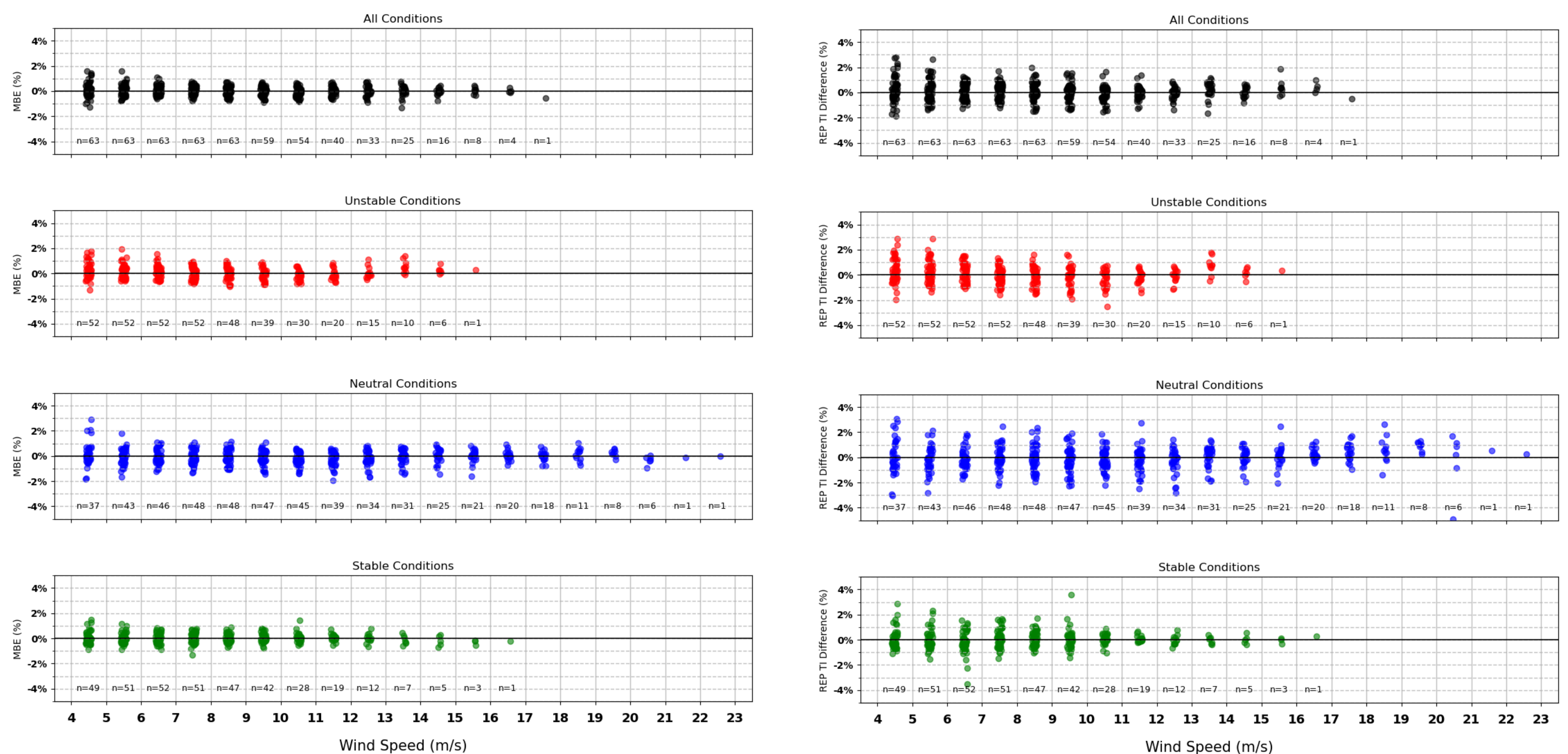


Fig 1. Representative TI difference and mean bias error binned by windspeed for test set of 63 unique lidar/cup pairs for different stability conditions. The count n , is shown within each bin.

