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CFARS Site Suitability Initiative:

Accelerating Data-Driven Guidance on Remote Sensing Device Turbulence Corrections

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Introduction

A pressing question in the wind industry remains - how can we reduce the cost of wind energy and de-risk future projects? In 2017 an industry consortium, Consortium For Advancing Remote Sensing (CFARS), launched to take on this cardinal question, focusing on remote sensing devices (RSDs) as a viable solution to reduce costs and risk in the realm of pre-construction wind resource assessment. CFARS is comprised of nearly 30 diverse wind energy stakeholders, including developers, consultants, turbine manufacturers, and RSD manufacturers.

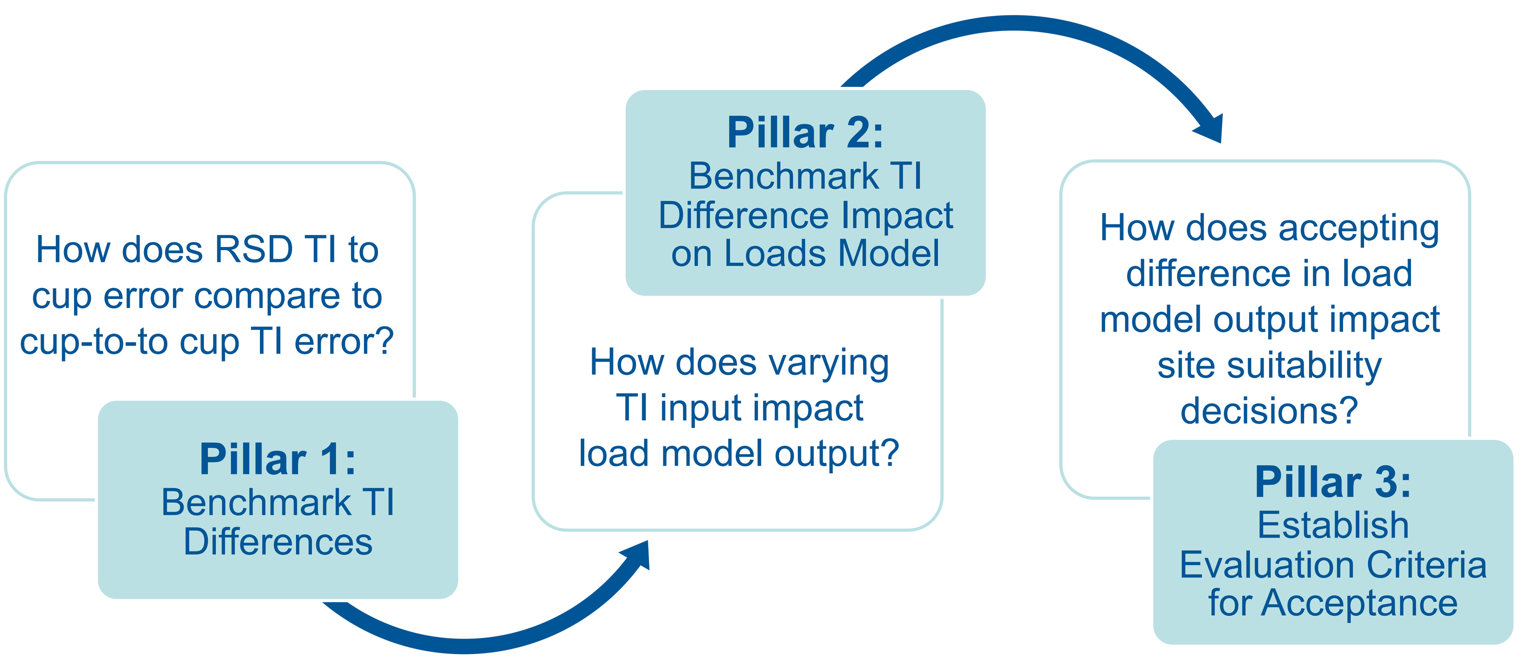
Within CFARS, the Site Suitability (SS) subgroup aims to increase the acceptance of RSDs for turbine site suitability assessment. The subgroup focused on turbulence intensity (TI) measurements, which describe how much the wind speed at a given height varies over a 10-minute period within a given wind speed bin. So why do we care about TI? High turbulence can generate excessive fatigue loads on major components in a turbine. This is a problem because it reduces turbine performance and energy yield, increases operation and maintenance costs related to unanticipated repairs, and potentially decreases the turbine's overall lifespan. Therefore, it is imperative that we accurately measure and understand a project site's TI conditions during a pre-construction site suitability assessment, to make sure we are choosing a suitable turbine — a turbine that will not endure disproportionate fatigue loads once operational.

Today, the industry's understanding, methodology, and models for turbine site suitability assessment originate from cup anemometer wind speed measurements on meteorological masts. While trusted cup anemometry remains invaluable, the growing demand to meet new market requirements, coupled with more than a decade of RSD wind measurement improvement, is motivating broad industry desire and momentum towards integrating more agile and advanced measurement techniques from RSDs into site suitability assessment.

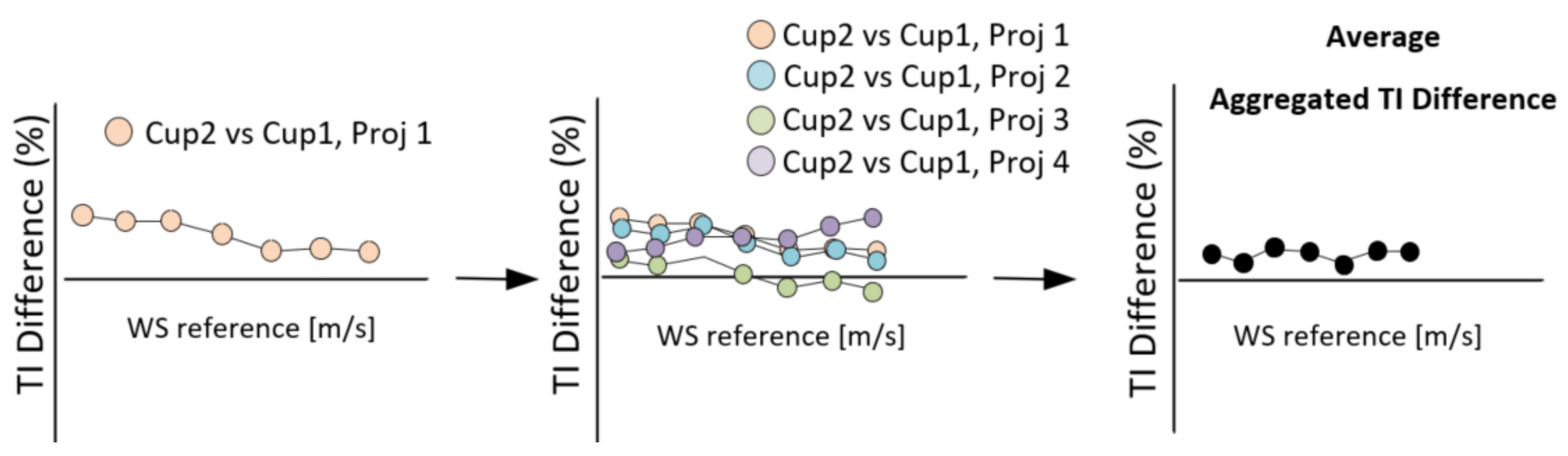
Nonetheless, two compounding challenges lay ahead on the road to RSD derived turbine site suitability decisions. The first challenge is the fundamental difference between cup anemometer and RSD wind measurement principles. The second, perhaps more formidable challenge, is centered on *what we do as an industry about the inherent cup to RSD measurement differences*. The CFARS Site Suitability subgroup formed with the **mission to frame the discussion on how best to increase confidence in single-profiling, ground-based, RSD use for onshore site suitability assessments and build consensus on RSD use as collocated and a standalone device.**

R&D Framework

The SS subgroup established an open and novel R&D framework to achieve its mission and support the industry's desire for alignment on best practice guidance to resolve the inherent differences between cup anemometers and onshore, single-profiling, ground-based, RSD TI measurements. The site suitability R&D framework consists of three pillars, each founded with the objective to provide data-driven answers to persistent RSD measurement questions.



Pillar 1 & 2 - Methods



The first pillar of the framework is a benchmarking exercise, which measures the magnitude of TI measurement differences between a reference cup and a redundant cup as well as between an RSD and a reference cup within a collocated, concurrent, dataset for several independent projects. the CFARS stakeholders agreed there is value in performing the first industry-wide round-robin evaluation of inherent cup-to-cup measurement discrepancies and elucidating how the cup-to-cup discrepancies compare to the magnitude of uncorrected and corrected RSDs' measurement discrepancies from cups. Several RSD TI correction methods, both site-specific and global, are tested in this benchmarking activity.

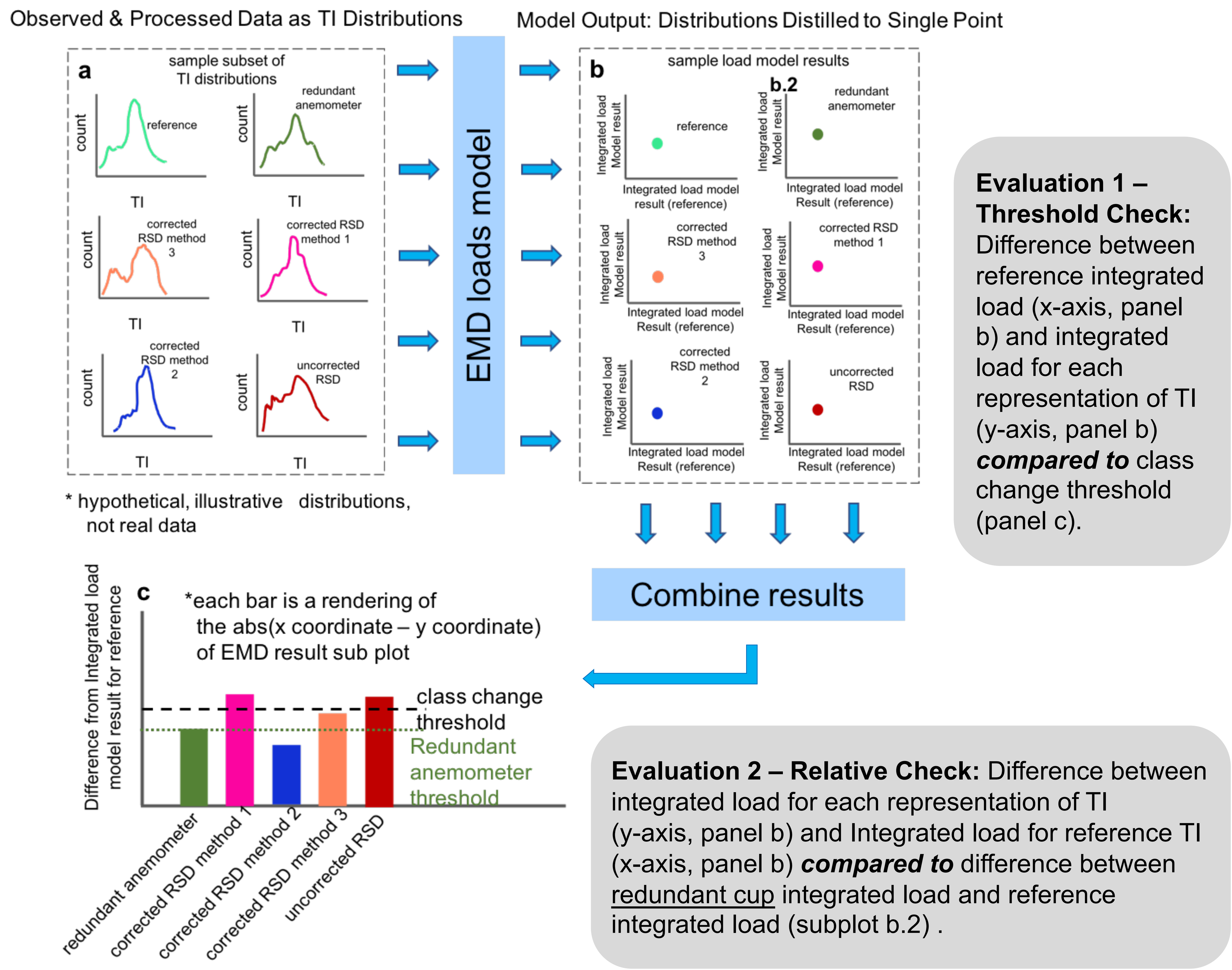
The second pillar benchmarks the sensitivity of various TI measurement sources on turbine fatigue loading, using a generic loads model and the NREL 5MW reference turbine. This benchmarking measures loads model differences based on changing the TI input data only; using data from the reference cup, the redundant cup, uncorrected RSD measurements and corrected RSD measurements.

The schematic above summarizes how the participants' data were combined to generate result from the TI difference benchmarking activity, and the same logic is applied for all aggregated group statistics.

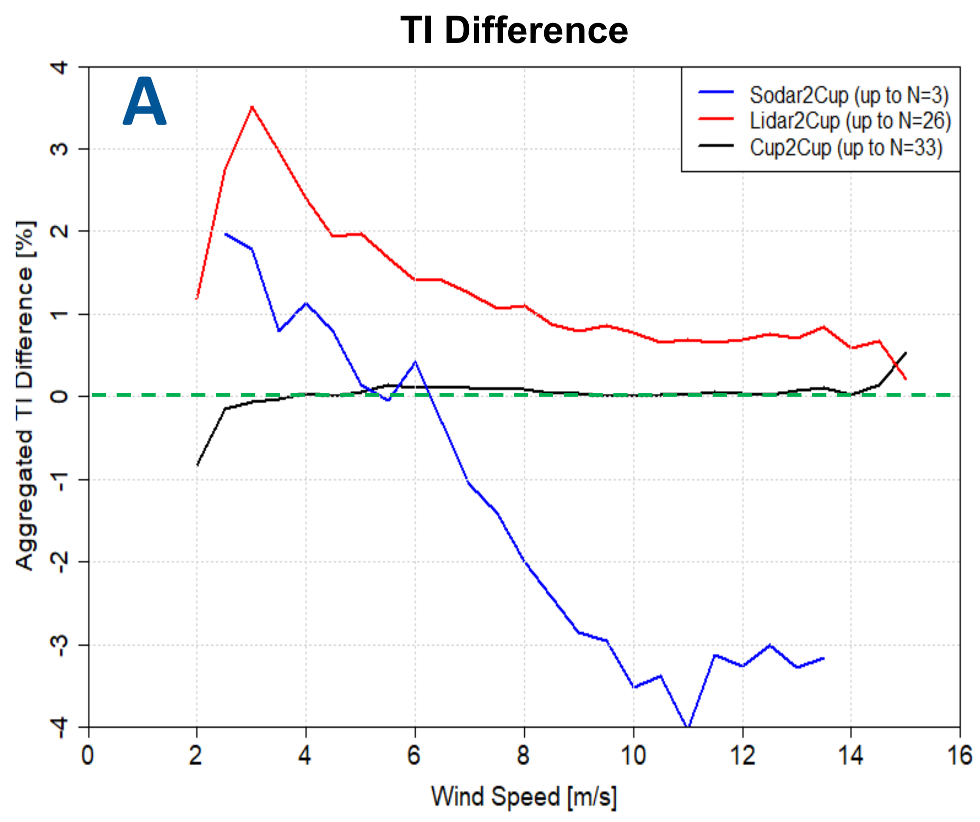
Pillar 3 - Methods

The final pillar establishes a direct link between the benchmarking activities in pillar one and two and site suitability decision-making. Specifically, the SS subgroup has developed a **evaluation criteria to help stakeholders make more-informed decisions on acceptance of corrected RSD measurements for site suitability assessment by elucidating the downstream impacts of discrepancies in TI measurements on turbine fatigue load model output.**

Schematic of Evaluation Criteria Methodology for Site Suitability Acceptance
(for a given project)

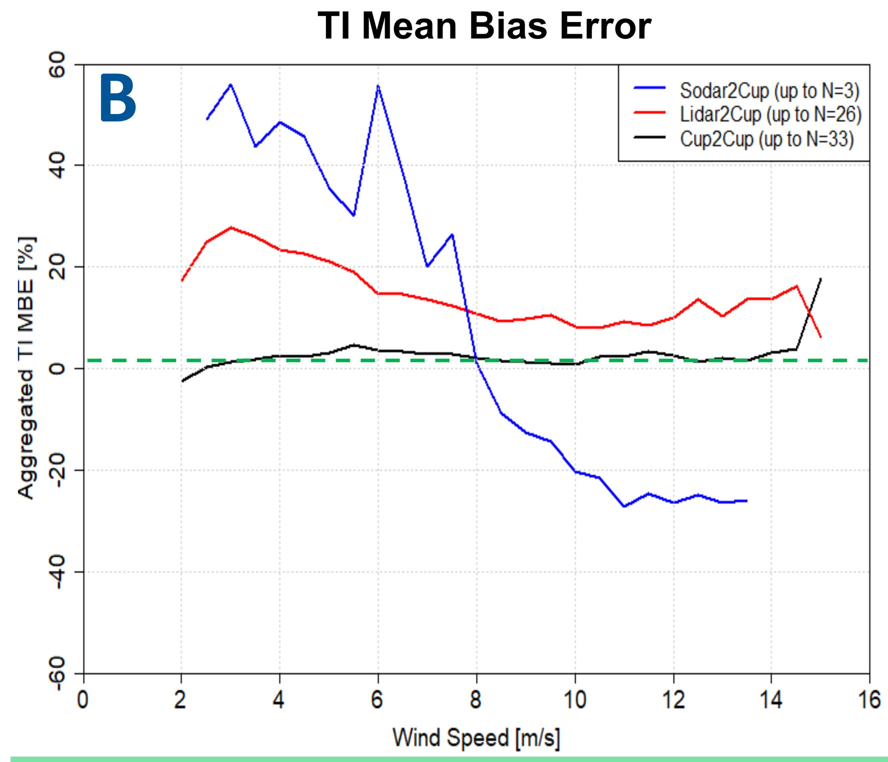


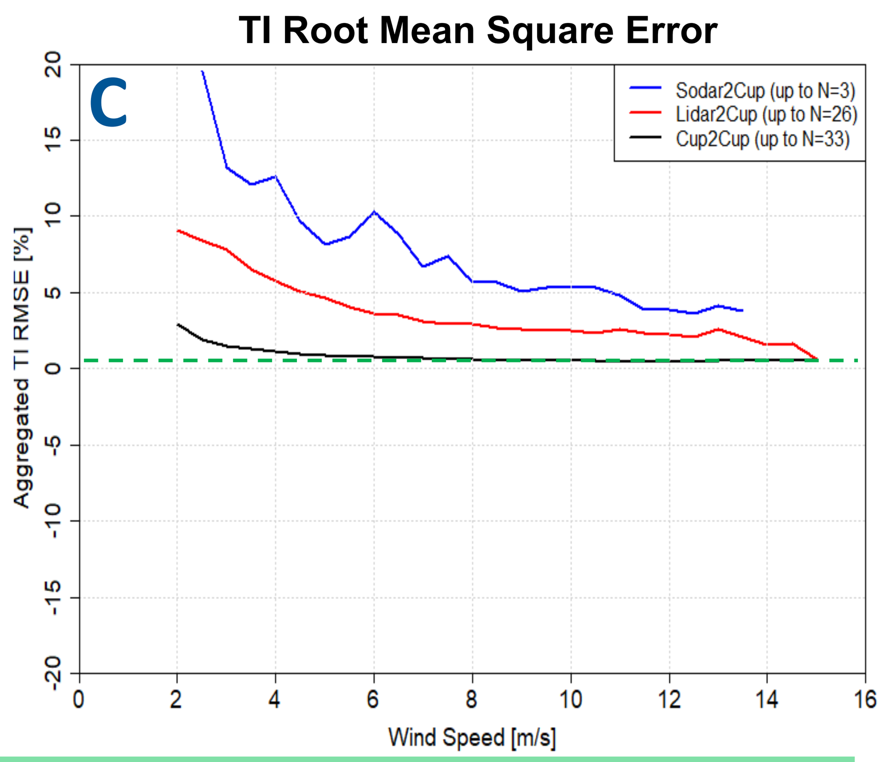
Results



Datasets to execute the R&D framework came from more than 10 organizations, and comprised of more than 30 collocated, concurrent, RSD and mast projects across North America and Europe. Panel A-C illustrate the preliminary (first round) results from the TI benchmarking exercise with **uncorrected RSD measurements** (Pillar 1).

On average, a small magnitude of difference, bias, and error in reference up to redundant cup TI measurements is found. In general, uncorrected lidar-to-reference cup results show decreasing TI positive difference and error over increasing speeds (A,C), with a slight increase in bias at higher wind speeds (B). Sodar results display similar trends to lidar in TI error (C); however, an interesting flip from positive to negative TI difference and bias around speeds of 6 m/s and 8 m/s respectively (A,B).





Next Steps

Final benchmarking of corrected RSD and cup TI measurements and testing of the evaluation criteria for RSD TI acceptance are underway. Details of the subgroup's analysis methods and results will presented in a white paper, to be released industry-wide Fall 2020. The CFARS SS subgroup does not endorse or recommend any particular RSD, nor correction method, over another. Rather, the SS subgroup hopes the collaborative framework and forthcoming results further initiate open, thought-provoking discussions and can illuminate one viable path to frame future decisions on RSD acceptability for site suitability assessment.

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