Measuring 3D Wind Velocity Using a Self-Built Load Cell Anemometer

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Introduction & Objectives

The purpose of this research was to study wind speeds on the Arctic Sea ice in Utqiagvik, Alaska, in March 2024, using a self-built vertical anemometer post. This was done to better understand the boundary layer, as well as to attempt to develop a novel method for measuring wind velocity.

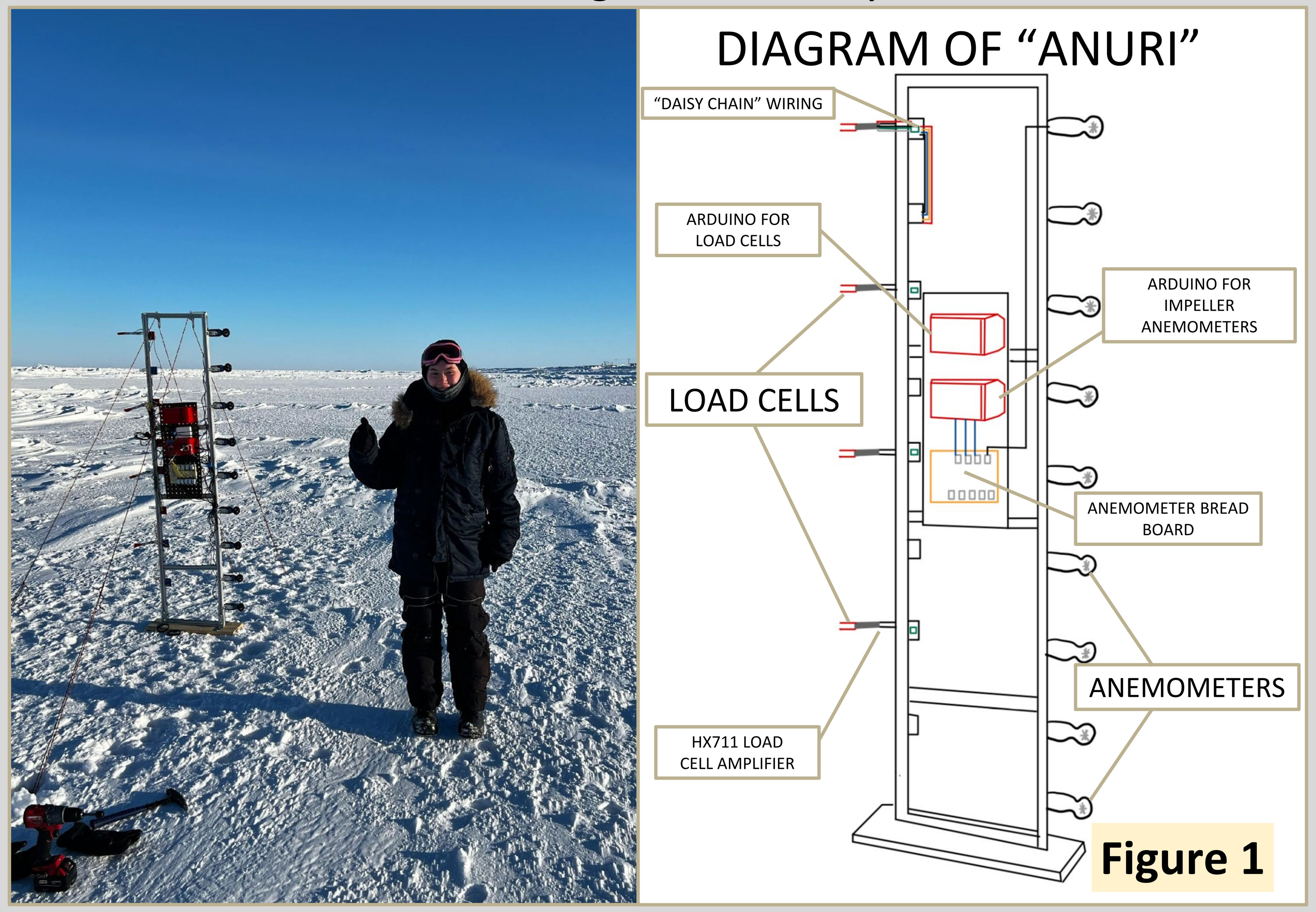

Figure 1

This work included the development of a self-built, 3D anemometer utilizing three inexpensive load cells. Load cells are transducers converting force into an electrical signal and are ubiquitous in scales. Anemometers, such as the industry-standard 3-cup instrument, measure the magnitude of wind speeds but not direction, necessitating an additional sensor. Load cells read force in two directions through positive and negative outputs, yielding both magnitude and direction. Note that ideation for this project came before the knowledge of two related works on measuring 3D wind speeds (Ref. 1,2).

While commercial ultrasonic anemometers yield both speed and direction for wind, they are much more expensive than this approach based on load cells.

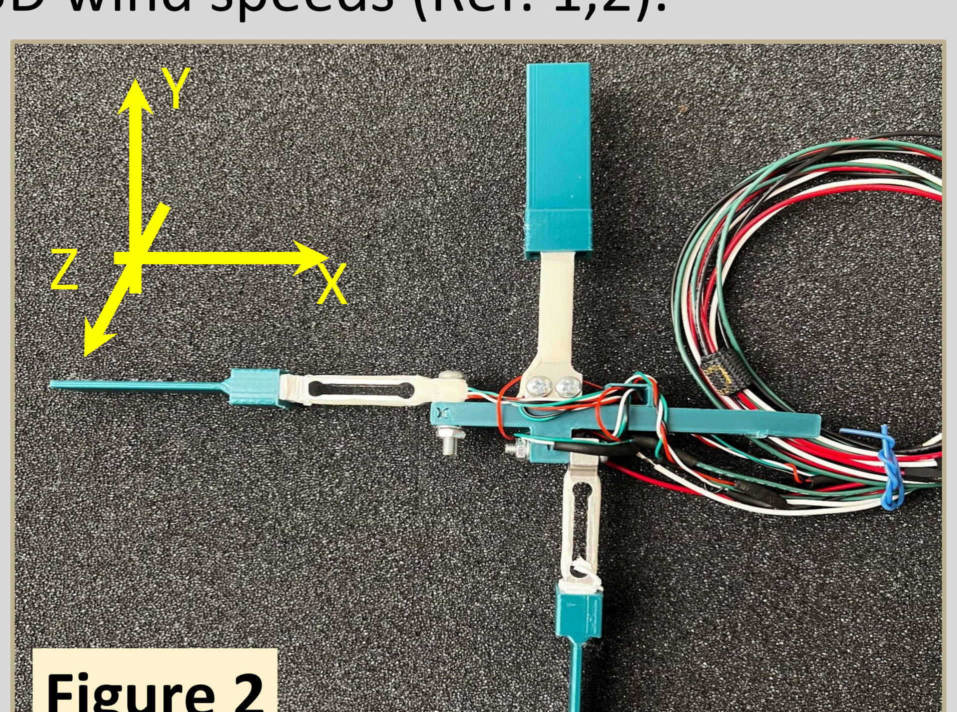

Figure 2

Equipment & Methods

Materials include an Arduino Mega 2560; twelve HX711 load cell amplifiers, twelve 500-gram load cells, twelve self-curated 3D printed "wings," twelve 3D holders, and screws/nuts/wires. Three load cells were attached orthogonally to the holder (Fig. 2). 20mm wings were attached to the ends to increase sensitivity. Each load cell was calibrated using a wind tunnel following Bernoulli's Theroem: $v \sim \sqrt{\Delta P} = \sqrt{F} \rightarrow v = \alpha\sqrt{F}$

The factor **α**=0.075 was determined from the graph in Fig. 3 and was added to the velocity calculation in the Arduino code. Wind speed was collected with one 3D load cell anemometer (Fig. 7). As a test case, four 3D load cell anemometers mounted on a vertical post (Fig. 3) collected data on wind speed and direction.

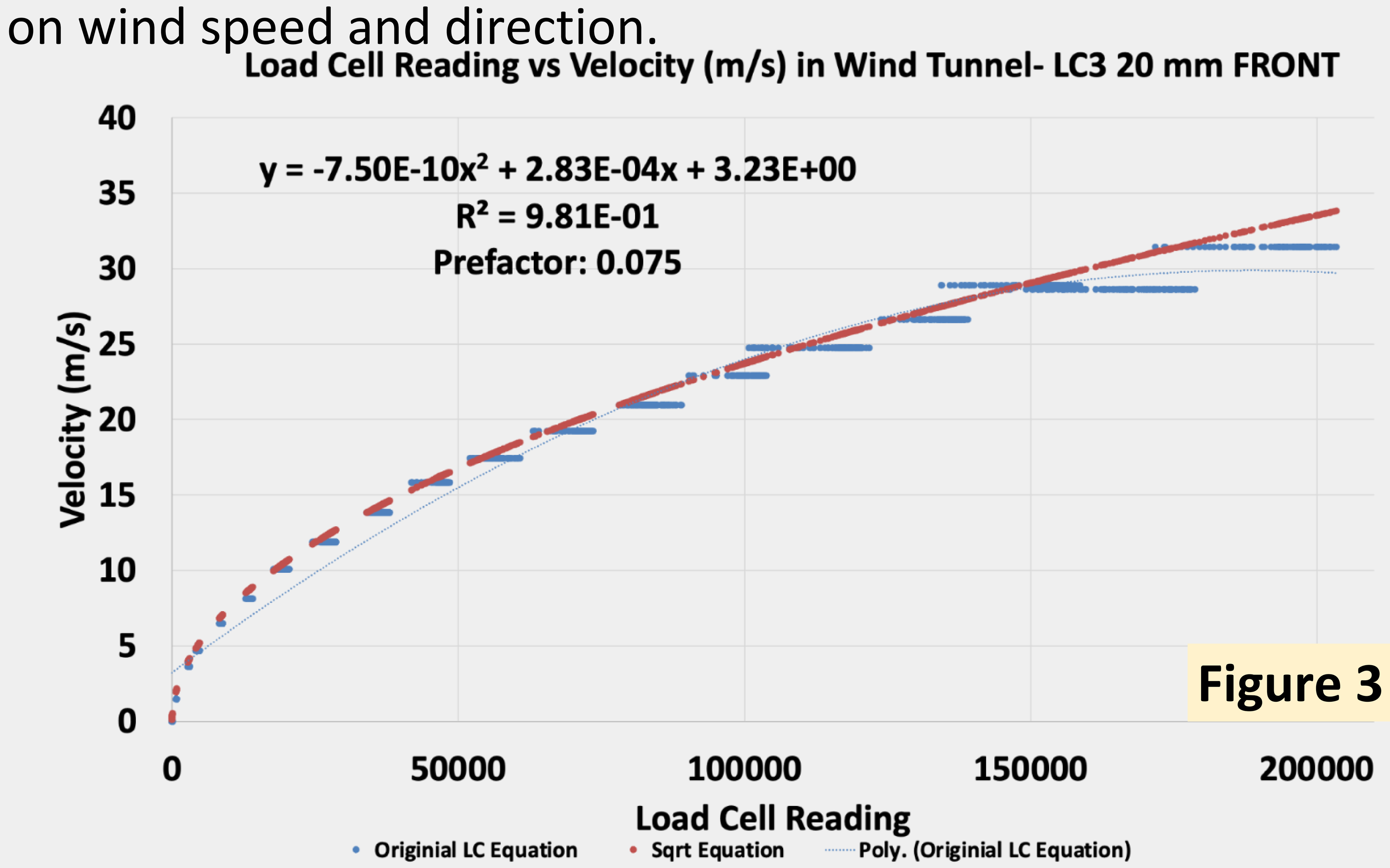

Figure 3

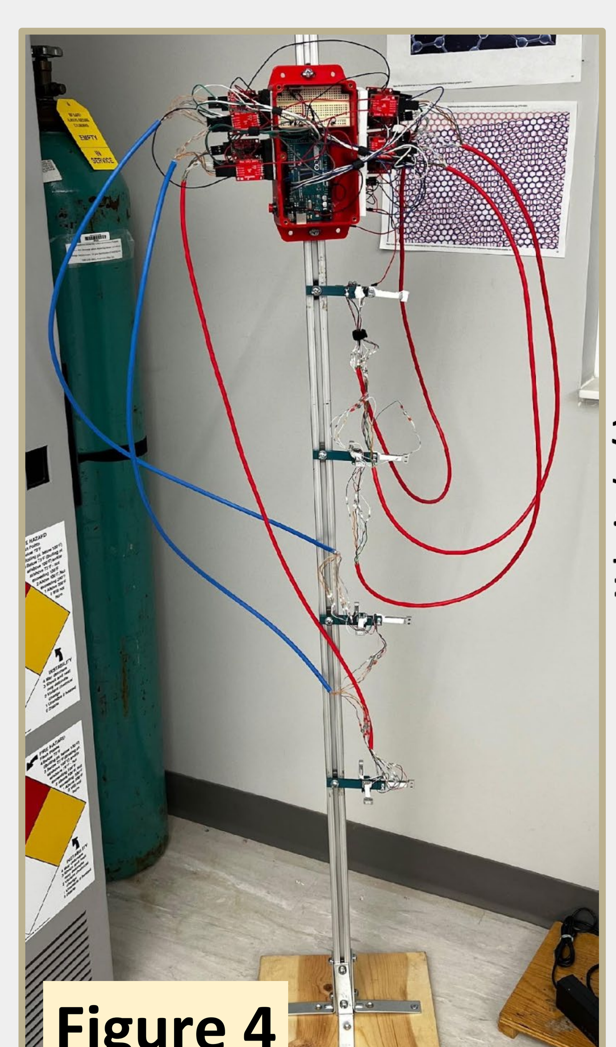

Figure 4

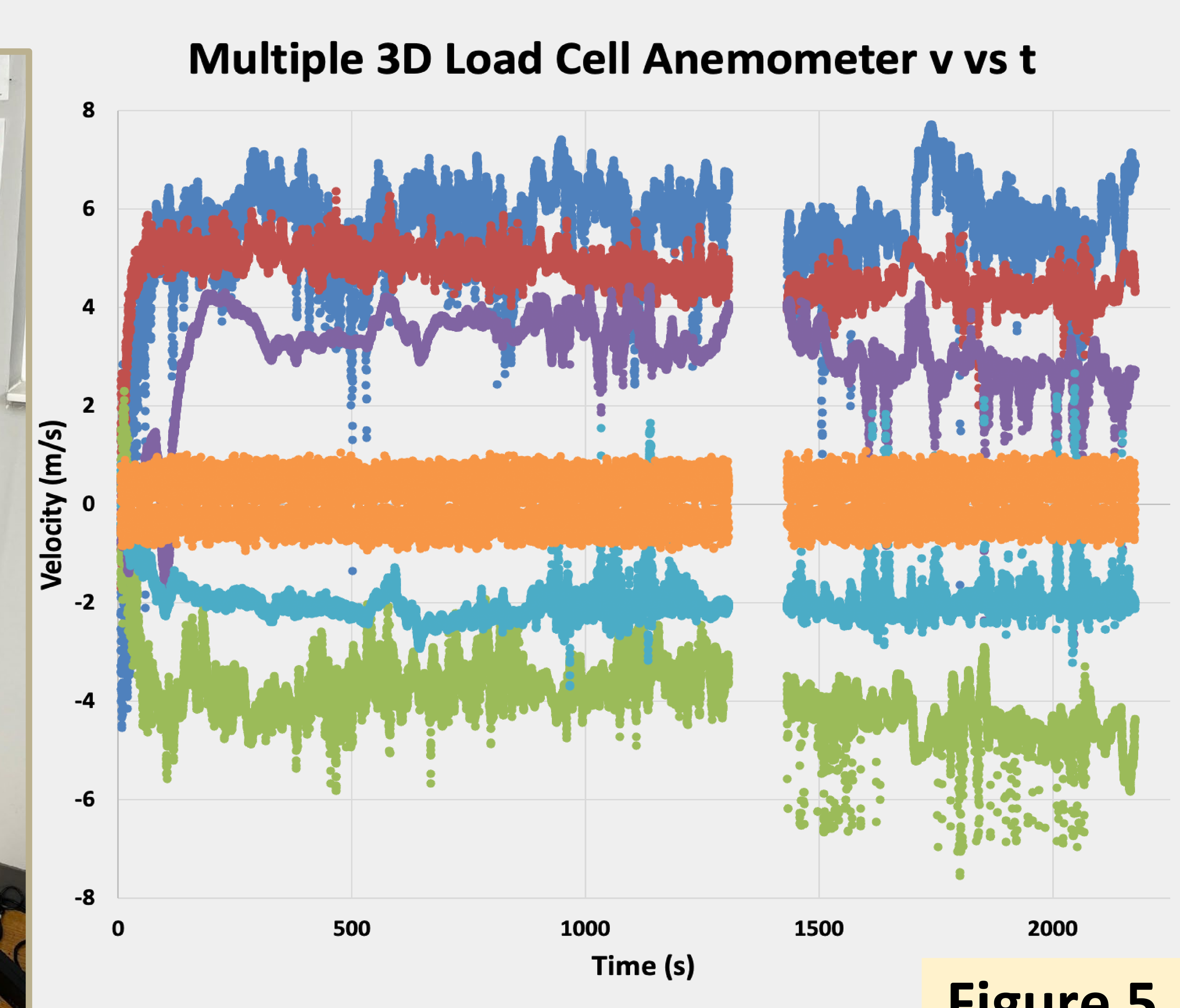

Figure 5

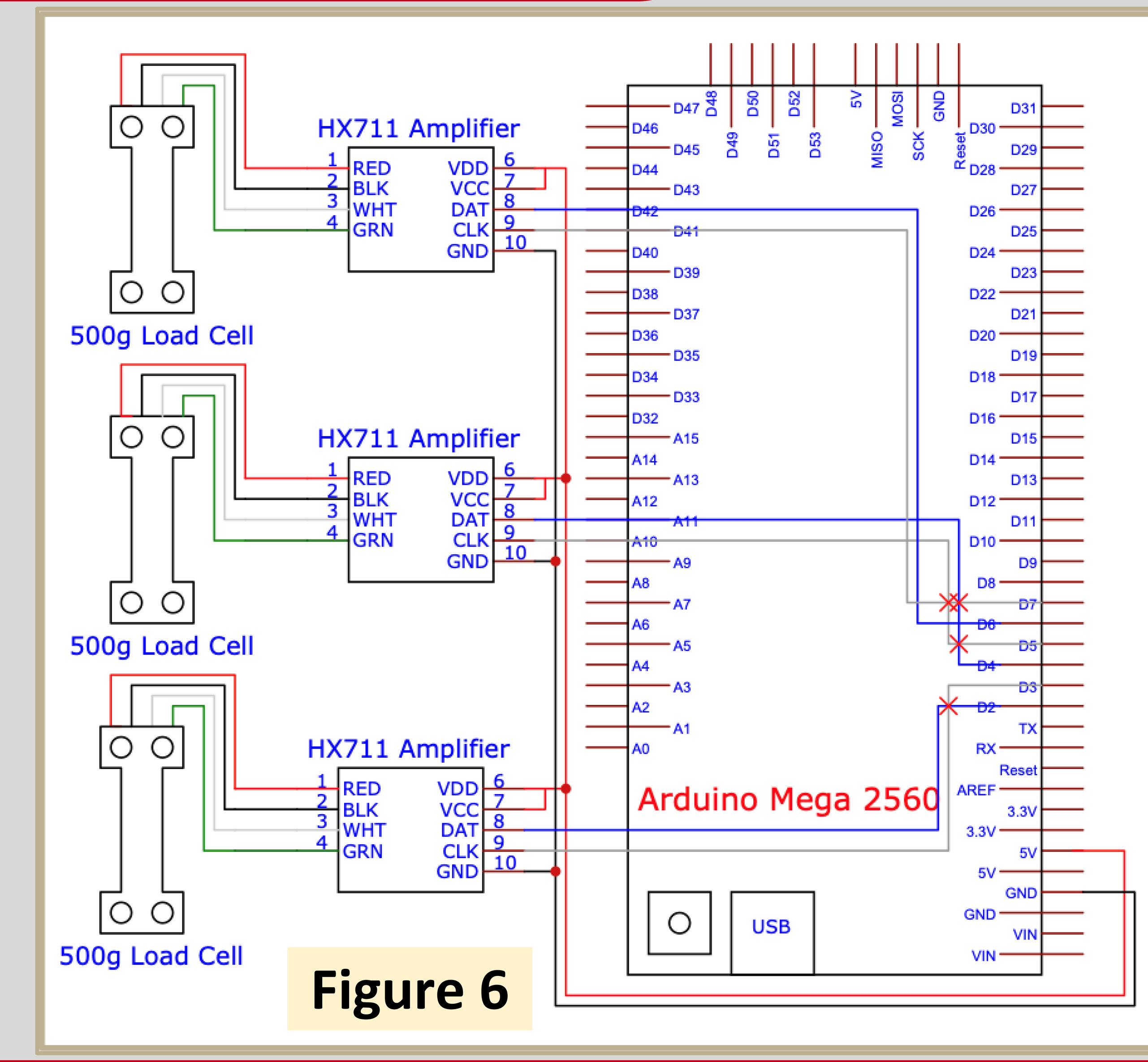

Figure 6

General Applications & Conclusions

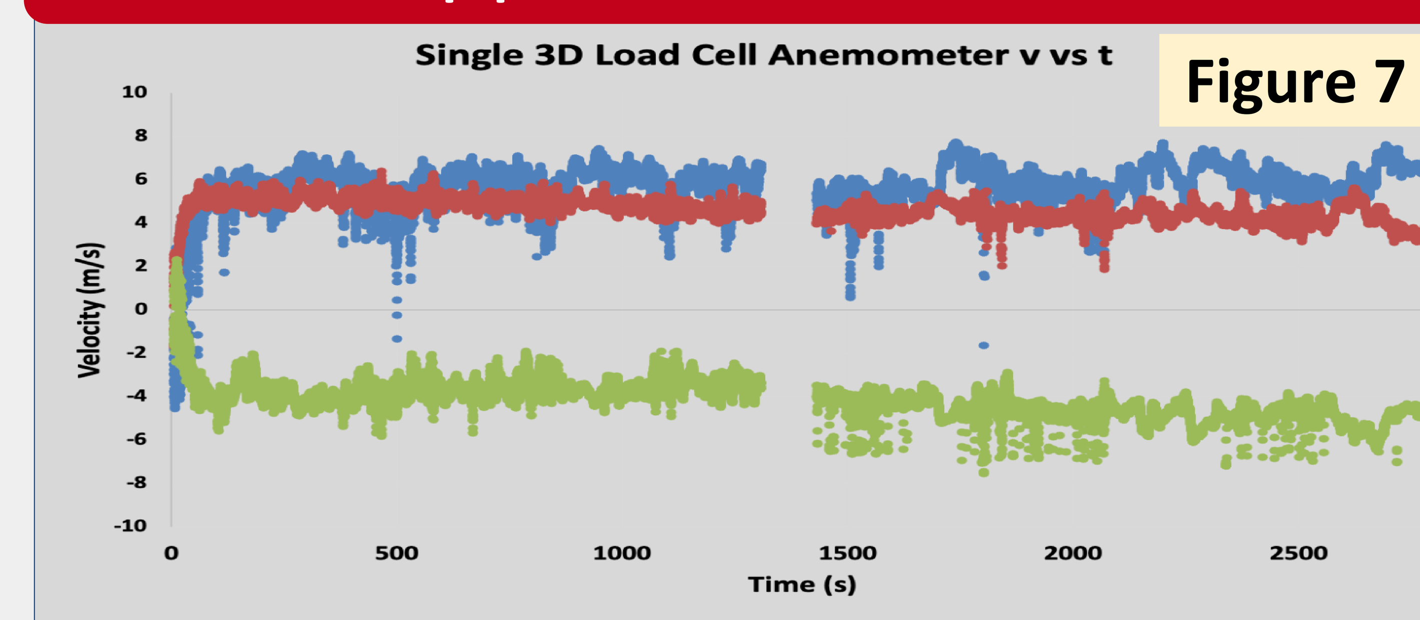

Figure 7

The general application for this work is to provide an inexpensive yet reasonably accurate device for measuring wind velocity. The load cell's bi-directional nature is well suited for this so that those on a budget can also study wind kinematics - including laminar and turbulent flow - in more complicated situations.

Acknowledgements & References

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2. Yakunin, A G. "3D Ultrasonic Anemometer with Tetrahedral Arrangement of Sensors." *Journal of Physics: Conference Series*, vol. 881, Aug. 2017, p. 012030, doi:10.1088/1742-6596/881/1/012030.

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