Pressure-Based Wind-Profiling

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Abstract

In infrasound work, we typically try to filter the noise due to the winds blowing above an infrasound sensor. In this work we seek to exploit the wind noise to infer wind speeds at multiple heights above the sensor. That is, we seek a pressure-based wind profiler whereby a single infrasound sensor placed on the ground is able to infer the winds at multiple heights above the ground. The advantage of such a wind profiler over traditional microwave, laser, and acoustic wind profilers is that it would work via "passive listening," emitting no potentially interfering signals, and it would have all-weather capability, able to profile the winds in both precipitating and "clear-air" conditions.

Research Objectives

- Proof-of-concept that infrasound wind noise can be used to obtain wind profiles.
- Wind generates turbulent eddies which have different sizes and move with the wind. As eddies move past pressure sensors, they produce pressure fluctuations at a frequency proportional to their size and speed.
- We are trying to prove that eddies of different sizes give information about wind speeds at different heights — small ones about wind speeds close to the ground — large ones about wind speeds higher up above the ground.

Progress and Results

We designed, built, and deployed a 30 foot tower with two Paroscientific DigiQuartz 6000-16B barometers and two Vaisala WXT510 weather stations. One barometer, weather station pair at 1 meter and another barometer, weather station pair at 10 meters. The tower logs infrasound and wind speed data at the two heights. At the base of the tower, there is a box which contains a Raspberry Pi running software (written in C) that samples the instruments at 25hz and 1hz respectively. We are also developing a supervised machine learning system to learn whatever relationships exist between the infrasound recorded at the two sensors and the wind speeds at the two heights. We are using TensorFlow to explore various neural network architectures, including traditional 2-layer networks and "deep" many layer convolutional networks.

Sample Weather Station Data

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Table 1: Sample Barometer Data

Barometer and Weather Station at 10 meters
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<table>
<thead>
<tr>
<th>Sensor</th>
<th>Data</th>
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</thead>
<tbody>
<tr>
<td>Barometer</td>
<td>Weather Station</td>
</tr>
<tr>
<td></td>
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<tr>
<td>Value</td>
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Hardware Block Diagram

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Barometer and Weather Station at 1 meter
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Barometer and Weather Station at 10 meters
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Sample Barometer Data
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Table 2: Sample Weather Station Data

Hadley Farm Field Deployment
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<table>
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Ongoing and Future Work

Remote access to the Raspberry Pi as well as scheduled data backup to an offsite server will be set up in the near future. Data analysis will involve using machine learning to determine if there are relationships between the pressure detected by the barometer at 1 meter and the winds at 1 meter and 10 meters. If there is a strong relationship, future work will seek to understand how high the winds can be measured, to what vertical resolution, and to what accuracy they can be measured. It would also be necessary to understand to what degree training at one location transfers to other locations and how to best determine wind direction in addition to wind speed.

Current and Planned Industrial Collaboration

Wind profiling has important applications in aviation and wind energy. In aviation, wind profiles can improve aircraft safety and increase airport runway usage through its potential to provide real-time measurements of wind shear and wake vortices. While in wind energy, wind profiles can be used to improve turbine output and protect vortices. While in wind energy, wind profiles can be used to improve turbine output and protect turbines.

Publications

- “Highlights from the 2011 CASA Infrasound Field Experiment,” 16th AMS Conf. on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans, and Land Surface (IOAS-AOLS), New Orleans, LA, January 2012.

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