Investigating Effect of Wind on Anisotropy using a Hartman Turbulence Sensor

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Abstract:
A Hartmann Turbulence Sensor (HTS) was set up with a Helium-Neon laser (632.8 nm) over a 1000 meter path to measure the turbulence over an asphalt runway (figure below). Measurements of the turbulence-aberrated wavefront of the laser beam taken at different times of the day, and a sonic anemometer was used to measure wind direction and speed. Previous data collected from a 200 meter path over grass (figure at right) showed a strong correlation between the tilt of the major axis of the anisotropy of the turbulence and the direction of the wind blowing across the beam path. This correlation was most prominent during the day and when the wind speed was relatively high. This correlation is being investigated further using data collected this summer. This research will help in understanding the nature and cause of anisotropy in turbulence near the ground.

Results:
A correlation between the wind direction and the angle of the major axis of anisotropy was observed during the day with wind speeds around 3 mph or higher. Specifically, the angle tended to be close to 45° or -45° (see left column of plots) and it tilted in a different direction depending on which way the wind blew across the path. When the wind switched directions the angle of the major axis of anisotropy also changed sign (see middle column of plots). During the night leading up to dawn and when the wind speed was low there was not a strong correlation with the wind (see right column of plots). The wind angles for the summer of 2017 have higher resolution because a sonic anemometer was used to collect data, while the wind data for 2016 was obtained from www.wunderground.com.

Conclusions:
Analysis of the turbulence data collected by the HTS over two different paths indicates that the direction in which the anisotropy of the turbulence across the path is the greatest is strongly correlated with the direction the wind blows across the path. This correlation is most noticeable in the daytime and when the wind speed is not low. In addition to this, the angle of the major axis of anisotropy tends to be closer to 0 or 90 degrees at quiescent periods, suggesting structural anisotropy that is not caused by the wind. These results may be very helpful in trying to characterize and predict the anisotropic nature of turbulence near the ground.

Possible Future Work:
- Compare anisotropy to anemometer data over the 40 second data captures from the HTS to get better resolution comparison.
- Investigate effects of wind speed on the angle of anisotropy.
- Investigate how the wind is related to the Greenwood frequency and the inner scale.
- Try the experiment over a different path or at different times of the year.
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References:
- https://www.google.com/maps

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- Try the experiment over a different path or at different times of the year.
- Use differential tilt analysis to investigate anisotropy.