Low-level Wind Comparisons Using Multiple Sensing Technologies

ATMOSPHERIC SCIENCES
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Background

As part of the 2015 Summer Student Operational ADRAD Project (SOAP) program and the TAMU Gulf Coast Research Experience for Undergraduates (REU), undergraduate students were provided with a unique opportunity to work with different technologies to compare for consistent measurement, as well as identify their strengths and weaknesses in their abilities to detect low-level winds. The students worked with a SODAR (Sonic Detecting and Ranging), which is a remote sensing instrument that uses the scattering of an emitted high intensity sound wave to derive wind speed and direction at multiple heights. Wind profiles from the SODAR were compared to 3 different rawinsonde soundings using a simple python program. The students also used a DOW (Doppler on Wheels) and the fixed ADRAD (Aggie Doppler Radar), technologies which use the radial doppler velocity determined from an emitted radio wave from multiple radar scans to build a wind profile of the atmosphere. The VAD (Velocity-Azimuth Display) profiles from ADRAD and the DOW were compared to the soundings in a similar fashion, using a different simple python program. The SODAR time-height plots were created by the software PADS provided by the manufacturer. The data was collected in College Station, TX as part of the SOAP Intensive Operation Periods as well as in Galveston, TX as part of a combined SOAP/REU field experience.

Sensing Technologies

SODAR: ASC 3000we SODAR
- Configured for 10 meter Resolution up to 200 meters
- 2 Solar Panels provide power with a backup gas generator
- 32 speaker array provides the sound for the separate u,v, and w components of the wind
- Data sent via cellular modem to the internet, where it can be accessed from any computer with the SodarView program installed
- Heater allows for use during snow events
- Able to run without any user intervention for long periods of time

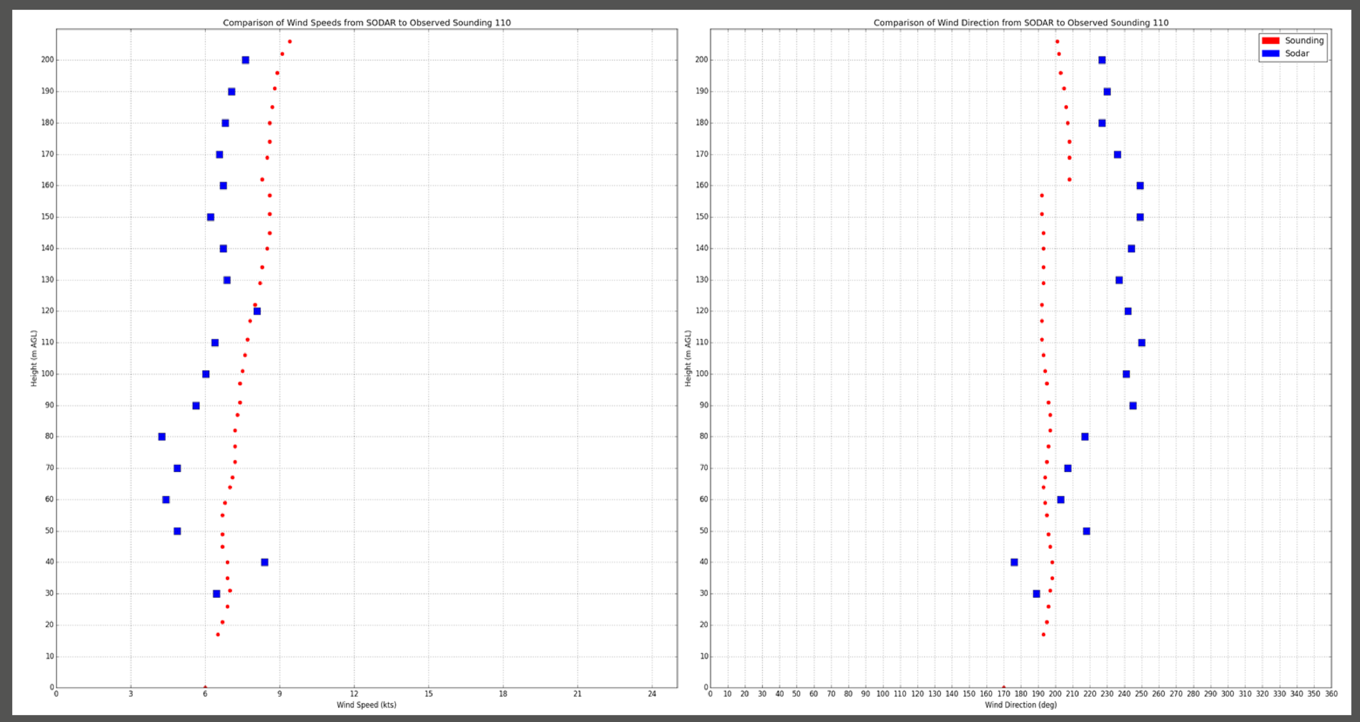
Upper Air Equipment: I-MET Model 3050 fixed/3150 Ultra-Portable Rawinsonde Ground System x2
- 3150 – 403 MHz Radios, Laptops and Modem
- 3050 – Semi-fixed antenna atop the Oceanography and Meteorology Building on Texas A&M Campus

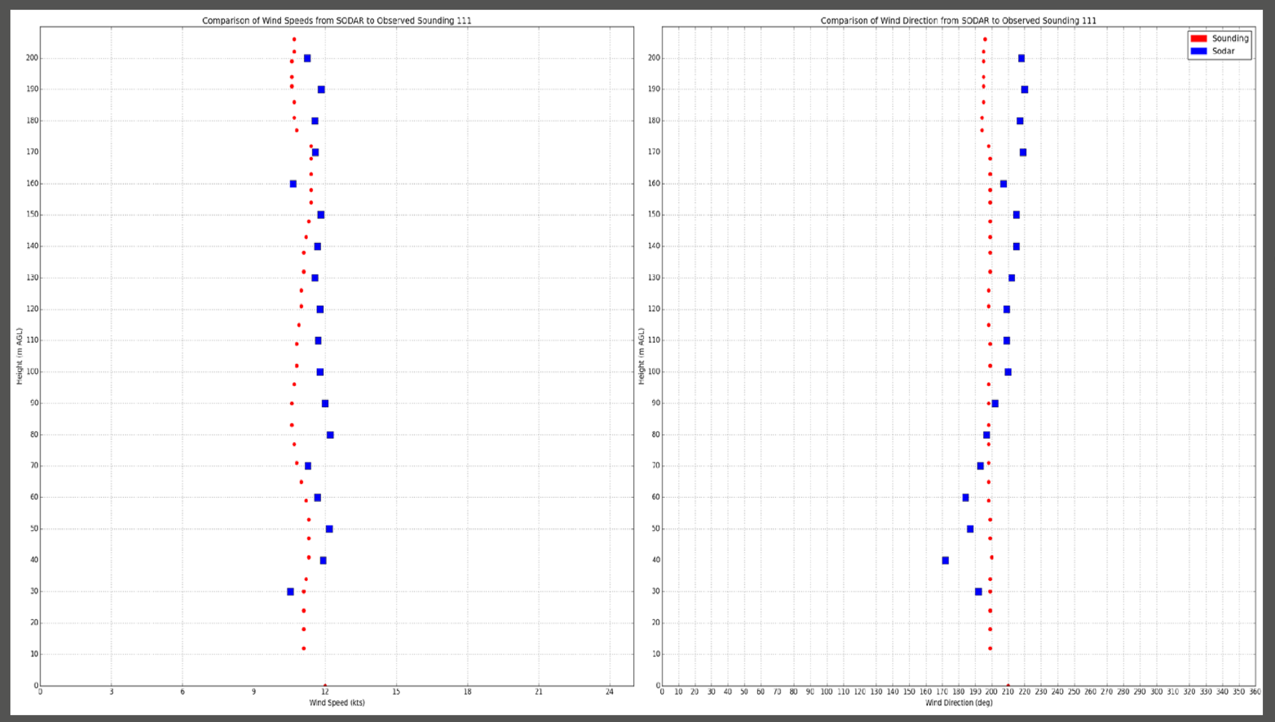
DOW: NCAR Center for Severe Weather Research (CWSR) Doppler on Wheels 7
- 500 kW Dual-Frequency, Dual-Polarization X-Band 1 degree beam width radar

ADRAD: Aggie Doppler Radar
- 1 megawatt, 10 cm wavelength S-Band radar

SODAR vs. Rawinsonde

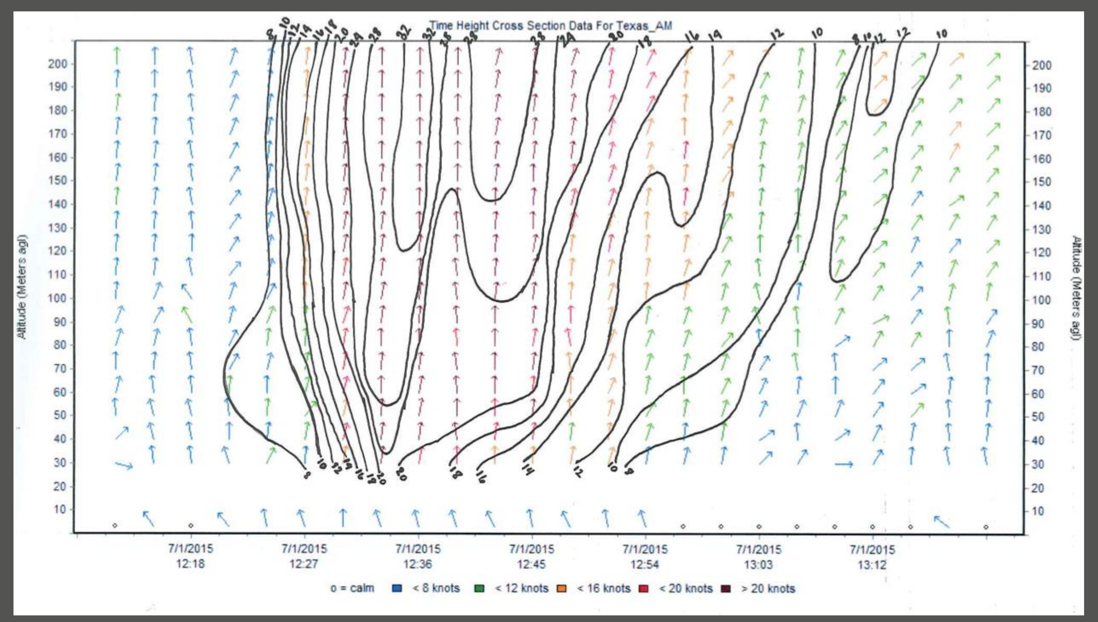
Date of observation: 7/1/2015, 19:59 Z

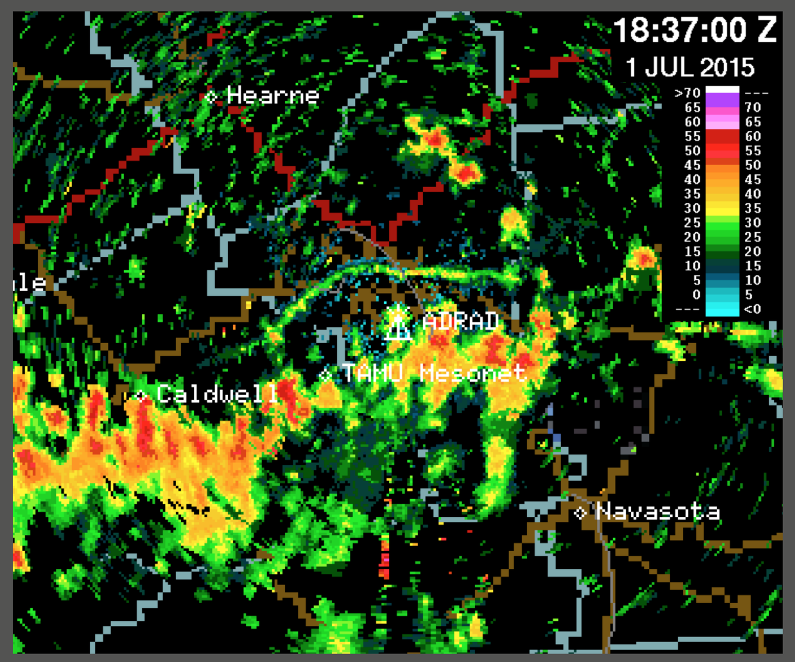


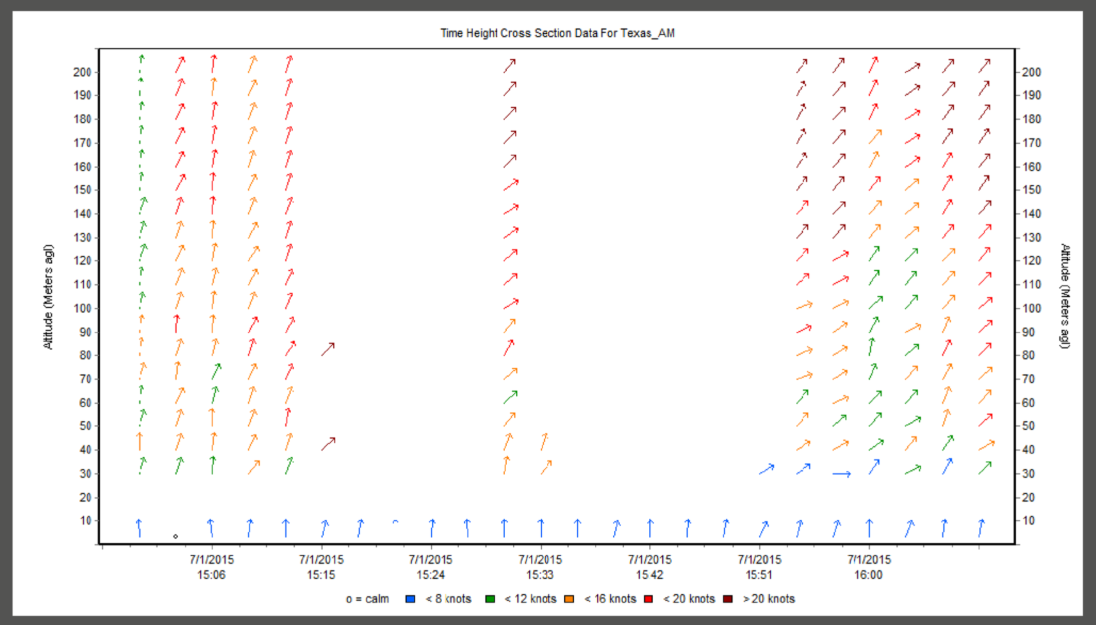


Date of observation: 7/22/2015, 16:33 Z

- In our comparisons, we found that when dealing with a SODAR, it's all about location. In College Station, TX, the SODAR was placed in a parking lot surrounded by tall buildings and very noisy construction within 100 feet of the instrument. We found that the data recovered was reasonably close to the rawinsonde's measurements, however, error due to the noisy location was evident as seen by the graph on the left.
- In Galveston, TX, where the observation area was much quieter and more apt for hearing sound returns, the data recovered from the SODAR was very similar to the data produced by the rawinsonde, as seen on the image to the right. While this is the optimal result, we can see a few limitations to the technology. To be able to get reliable results from the SODAR, it must be placed in an isolated area away from any noisy disturbances.
- While the rawinsonde took an instantaneous measurement of the wind, the SODAR required a 3-minute average to retrieve a quality profile.

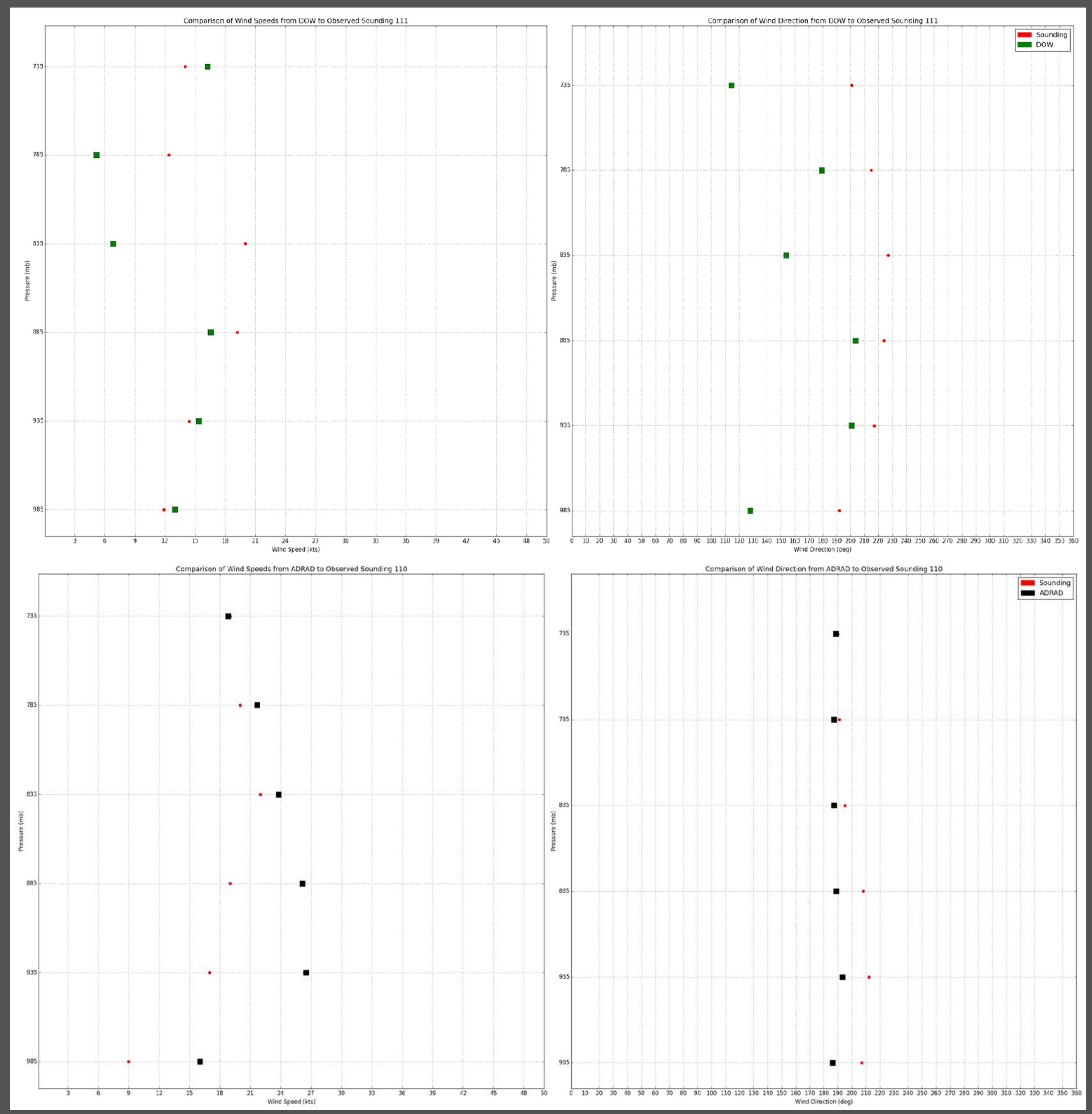






- During one intensive observation period, we took data during the passage of a gust front and contoured the measurements recorded from the SODAR. The SODAR time-height plot on the left is a great example of one of the instrument's capabilities. The data received from the SODAR allows the structure of this gust front to be shown in more detail than other remote sensing technologies could produce. An interesting detail during this period was when a second gust front associated with heavy rainfall came later in the day, the SODAR could not recover any data due to possible disturbances from the strong downward motion associated with the heavy thunderstorm and precipitation interference. This data gap is shown in the plot on the right where observations are absent for about 30 minutes. Both observations took place on 7/1/2015. The plot on the right was about 3 hours later in the afternoon than the plot on the left.

ADRAD and DOW VAD vs. Rawinsonde



VAD wind profiles are created by analyzing the velocities from a volume scan, but to get a high enough signal-to-noise ratio, the data must be averaged over a large time period. Since the radar scan gives velocities at different heights and distances from the radar site, there is inherently a large amount of spatial averaging as well. For this poster, the VAD method developed by Brian Mapes was used.

The VAD derived winds from the DOW, shown in the top plots, matched the sounding well in the cases examined, but it generally had a larger error than the fixed ADRAD did.

The ADRAD VAD, shown in the bottom plots, matched the sounding exceptionally well, but the limitation of the 1 hour averaging time is evident. The case shown is on the same date as the lower portion of the SODAR section, where a gust front moved through the observation area. The one hour averaging shows this in the plots, as an increased wind speed up to 835 millibars and a slightly more southerly wind direction.

Conclusions

Given the limitations and differences of the sensing technologies, our results showed mutually consistent wind profiles. While comparing the different technologies, we found each instrument to have its own set of advantages and disadvantages. Since the SODAR has a better time resolution than the VAD, averaging winds over a 3-minute time period rather than a 1 hour period, the SODAR is able to produce higher quality data in the lower levels. Also, the DOW and ADRAD have poor vertical resolution, providing values for the wind at only 50 millibar increments whereas the SODAR records values every 10 meters. However, the VAD will show winds at much greater heights than the SODAR, which is limited to 200-400 meters and is still able to pick up data during severe weather disturbances unlike the SODAR.

In terms of cost efficiency and portability, the SODAR is much more affordable and is deployable in just about any location whereas the ADRAD is expensive and fixed in a single spot. Although the DOW is also portable, the instrument itself is much larger and more difficult to travel with than the SODAR. A SODAR can be placed near trees and other small obstacles without much issue, unless there are loud sounds in the instrument's audible frequency, but the DOW requires a large open area, otherwise beam blocking will affect the data. DOW and ADRAD cannot be located next to people due to the dangerous radiation emitted, so they must be located where they cannot affect human health. Although the SODAR does not immediately affect human health, it creates very loud sound pulses that can be intrusive.

Each remote sensing technology has its own advantages and disadvantages, and the choice of which technology to use really depends on project needs and funding levels.

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