Sodar Data from Oyster Bay at Winyah Bay National Estuarine Research Reserve in South Carolina

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Introduction

The SecondWind Triton® is a SODAR (SOnic Detection And Ranging) sonic wind profiler (Triton® sodar) system capable of profiling the wind characteristics up to 200m above the instrument. SODAR systems transmit acoustic chirps into the atmosphere and measure the backscattered signal returned to the device. The primary source of acoustic scattering is variations in air temperature, which cause changes in the refractive index of sound. By measuring the Doppler-shifted frequency of these returned signals, the Triton® can calculate the wind's speed and direction for the volume of air above the instrument, measured at ten fixed heights, known as station heights. The Triton® is specifically designed for the purpose of wind energy resource assessment as it can remotely capture wind data at heights above ground where wind turbine rotors operate.

The Triton® uses a phased array of 36 acoustic transducers (i.e. speakers) to produce an audible chirp, and then capture backscattered signals from the wind. Second Wind's hexagonal speaker array pattern allows for precise beams of sound to be transmitted while keeping off-beam side energy to an absolute minimum. The Triton® array is monostatic, meaning that the same set of transducers is used as both speakers and microphones.

During transmit, all 36 speakers in the array are excited to produce an audible chirp at a frequency of ~4500 Hz*. The array consists of seven rows of speakers. Each row is phased to steer the beam of sound to a precise location without need for calibration. This beam is reflected off of an acoustic mirror (aluminum plate) inside the instrument and is sent upwards at a slight angle from vertical, to backscatter from moving wind above the Triton. The Triton® cycles through three unique, yet precise beam directions; A then B and then C as shown in Figure 1. Each of the chirps produce one of these A, B or C beams. The Triton® repeats this chirping cycle. Over a 10-minute interval, the Triton® will chirp approximately 100 times in each beam direction. *Actual transmit frequency depends on ambient temperature.

The Triton® collects 10-minute averaged intervals of the following measurement types at all ten heights:

- Horizontal Wind Speed
- Vertical Wind Speed
- Horizontal Wind Direction
- Turbulence

Figure 1 Beam pattern generated by phased array of 36 acoustic transducers in Triton®.

Integrated sensors also collect operational data for use in data analysis. Theses sensors include the following:

GPS

All Triton® data is stamped with Universal Time Coordinates (UTC), elevation, and coordinates for latitude and longitude. This information is maintained through the Global Positioning Satellite (GPS) system. The Triton® is equipped with a GPS receiver, which regularly accepts updates from the satellite network. System time is backed up with a real-time clock on the on-board CPU, so that even if the GPS signal is unavailable, the time is kept accurate.

Barometric Pressure

A barometric pressure sensor chip is installed on a circuit board in the ventilated sensor box near the speaker array. The pressure sensor is accurate to +/- 5mbars and automatically corrects for temperature.

Humidity

A relative humidity sensor chip is installed on a circuit board in the ventilated sensor box near the speaker array. The relative humidity sensor is accurate to +/- 5% relative humidity. 3.2.2.4 Temperature The Triton® contains three temperature sensors, which are potted thermistors accurate to +/-0.5° C. These sensors measure the ambient (aka external) temperature, the temperature of the acoustic mirror, and the temperature of the battery compartment (aka internal).

Tilt

Even if the Triton® is not perfectly leveled at the time of installation, it is still possible to measure highly accurate wind data. Tilt in the North-South and East-West directions is measured by the Triton® using a built-in dual-axis accelerometer. These measurements are then used to compute the absolute tilt of the speaker array, so that the Triton® knows the precise orientation of the speakers. The Triton® can compensate for tilt angles of +/- 3° in both directions. The tilt sensor is accurate to +/- 0.5°.

The amount of usable data available at any measurement height is a function of the quality of the shots collected at those heights. Each chunk of data is assigned a quality factor between 0% and 100%, which is based upon the signal to noise ratio (SNR) of the shots within the chunk. SNR is the determining factor of how accurate the wind data is for each shot recorded by the Triton. High levels of atmospheric absorption, or atmospheric stability at the measurement site, can decrease the signal strength. Generally, there are diurnal and seasonal trends in the levels of absorption or stability in the atmosphere.

With the Quality Factor set to 90%, the Triton® can deliver the following:

• Horizontal wind speed measurements accurate to +/- 0.5 m/s, range from 0 m/s to 25 m/s
• Vertical wind speed measurements accurate to +/- 0.5 m/s, range from –5 m/s to 5 m/s
• Horizontal wind direction measurement accurate to +/- 1.5°, range from 0° to 359°
• Triton® correlates to within R=0.98 of cup anemometers
• 95% availability of high quality, filtered wind data at 60m
• 90% availability of high quality, filtered wind data at 80m

Site Description

The study area is located east of Georgetown, South Carolina in North Inlet - Winyah Bay National Estuarine Research Reserve. The Reserve includes portions of two separate but connected estuaries: North Inlet a small ocean-dominated estuary and Winyah Bay, a classic estuary fed with freshwater by four major rivers. The Triton® was located on a thin strip of land in the tidal marsh of Oyster Bay west of North Inlet between the coastline and forested upland of Hobcaw Barony, Figure 2. The Triton® was located at N 33.33188 W -79.19872. The fetch in the southwest to northeast direction from the tower consists of low marsh emergent wetland dominated by cordgrass bordered by the waters of Winyah Bay to the south and the Atlantic Ocean to the North. The fetch from the northwest to the southeast of the tower transitions from forested upland to low marsh emergent wetland dominated by cordgrass to the open water of the Atlantic Ocean.

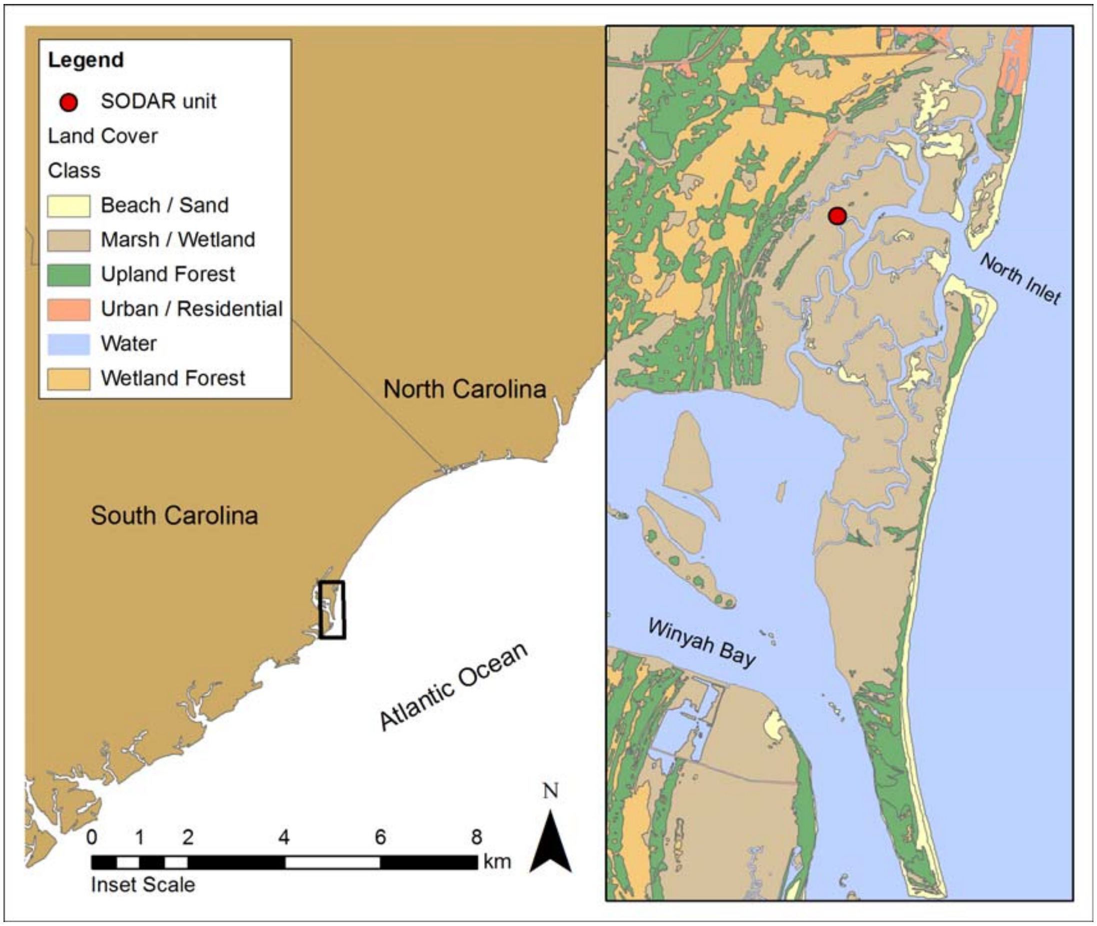

Figure 2 Location map for Triton® located in Winyah Bay National Estuarine Research Reserve.

(a)

(b)

Figure 3 View of Triton® in Winyah Bay National Estuarine Research Reserve looking west-northwest (a) and looking north-northeast (b).

Data

The monitoring period for data in this report begins 5/14/2009 9:30:00 AM EST and ends 8/2/2010 11:40:00 AM EST. All reported values represent an average results collected in a 10 minute interval and are included in the report in a comma separated variable (CSV) text file in the attached CD, Attachment 1. The direction observations were corrected by shifting all readings 18 degrees west to align direction with a meteorological tower co-located with the SODAR unit. Table 1 contains a list of data on the attached CD.

Table 1 Measurements made and recorded by Triton® sodar.

Measurement	Description	Unit
Date_Time_EST	Not corrected for daylight savings time	
C##mDir	Corrected wind direction at ## meters	Degrees east of north
##mSp	Horizontal wind speed at ## meters	m/s
##mVert	Vertical wind speed at ## meters	m/s
Q##m	Wind speed quality factor at XX meters	Percent
#mTurb	Turbulence at ## meters	
TurbQ##m	Turbulence quality at ## meters	
Date_Time_UTC	Original time recorded by Triton,	Universal time coordiantes
TAmb	Ambient temperature	Celesius
P_mBar	Atmospheric temperature	MilliBar
Humidity	Relative humidity	Percent
Noise-A	Noise for signal A	Decibels
Noise-B	Noise for signal A	Decibels
Noise-C	Noise for signal A	Decibels
##mSigA	Signal strength at ## meters for beam A	Decibels
##mSigB	Signal strength at ## meters for beam B	Decibels
##mSigC	Signal strength at ## meters for beam C	Decibels
##mSNRA	Signial to noise ratio at ## meters for beam A	Unitless
##mSNRB	Signial to noise ratio at ## meters for beam B	Unitless
##mSNRC	Signial to noise ratio at ## meters for beam C	Unitless
TInt	Internal temperature	Celsius
TMir	Mirror temperature	Celsius

Acknowledgements

Work on this project is sponsored by the South Carolina Renewable Energy Infrastructure Fund Grant #MG-08-05 and USDoE SEP Grant #DE-FG26-08NT05560. The authors would like to express their gratitude to the Belle W. Baruch Foundation for allowing the installation of the sodar in Hobcaw Barony located in Georgetown, SC.

Attachment 1

For a copy of the data please contact:

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