SODAR OBSERVATIONS IN URBAN ATLANTA

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INTRODUCTION

The troposphere is the lowest region of the planetary atmosphere. Located at the bottom of the troposphere is the subregion known as the atmospheric boundary layer (ABL). The (ABL) owes its existence to two factors: (1) the viscosity of air as a fluid, and (2) the input of solar energy to the earth system. Fluid motions are characterized in the ABL primarily by turbulence, although convection, advection, and laminar flow can contribute to the transport of scalars through the ABL and into the free troposphere.

One of the best remote sensors for visually depicting the evolution of the ABL throughout the day and night is the sodar (SOund Detection and Ranging), an acoustical device that operates like a radar (RAdio Detection and Ranging). Sodars are also known as acoustic radars, acoustic sounders, echosondes, and acdars. Sodars have been used for three decades to track the height of the boundary layer for use in air pollution, turbulence, frontal passage, and dispersion studies.

WHAT IS A SODAR?

A sodar is a tool used to obtain continuous remote information about the mixing height and the turbulence field in the atmosphere from a height up to couple of kilometers down to ground level. The sodar record has many applications. The air pollution engineer can document the ability of the atmosphere to mix specific pollutants. The research meteorologist can analyze wind and temperature turbulence in the ABL. The weather forecaster can observe frontal passages and rain events. The airport meteorologist can use the record to observe and forecast the top of a fog layer.

PURPOSE

The purpose of this project is to set up, calibrate, obtain and analyze data from an Aerovironment 300C monostatic sodar at an urban site on top of the Research Center for Science and Technology building at Clark Atlanta University.

COMPONENTS OF A SODAR

The Aerovironment 300C monostatic sodar consists of three basic systems: (1) a reflecting dish antenna (Figure 1) which focuses the transmit pulse from the loudspeaker transducer and the receive signal from turbulence backscatter, (2) an acoustical enclosure (Figure 2) to shield the sodar from ambient noise and to aborb the loud transmit acoustic pulse, and (3) a remote recorder (Figure 3) to produce a visual image of the acoustic record. A fourth component can be added to this list: a remote digital data acquisition system. Quantitative information about vertical wind speeds and turbulence can be obtained from the digital record.

Component (3) amplifies the received sodar signal and delivers it to a stylus which moves across the recording paper from bottom to top. The vertical distance on the paper chart represents the height in the atmosphere, while the darkness of each vertical line is proportional to the strength of the signal received. This signal strength is a function both of temperature gradient and turbulence intensity (see Neff, 1986).

This instrument emits a brief (0.2 sec) pulse at a frequency of 1600 Hz and listens for faint echoes to scatter back from turbulence aloft. As with any radar system, the sodar works best in an environment with minimal ground clutter: e.g., buildings, smoke stacks, and trees. Much ground clutter can be avoided by locating the sodar on a rooftop.

In general, turbulent eddies act as scatterers to generate the echo signal detected by the sodar. A return echo can be produced wherever the speed of sound changes, and since the speed of sound is a function of temperature, the echo usually originates in regions of strong temperature gradient or strong turbulence intensity. The energy received back at the sodar is very weak (several orders of magnitude less than the energy transmitted) for detection by the human ear, but it can be detected electronically if the antenna system is sufficiently sensitive. Narrow-band filtering and well-designed acoustical shielding allow the sodar to produce good data even in the presence of urban ambient noise.

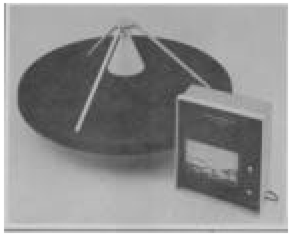


Figure 1

Figure 2

Figure 3

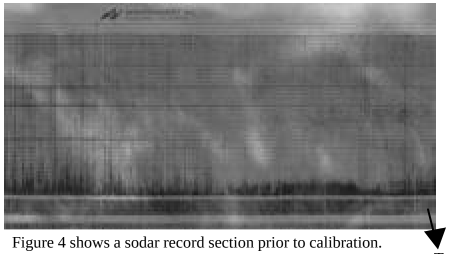
CALIBRATION

Calibration is fundamental to obtaining good-quality sodar records calibrated. The sodar used in this study had been in storage for 10 years and because of this calibration was suspect. It was as part of the study in order to adjust the span of the record and check for proper voltages and timing values. The calibration report is shown in Table 1.

Table 1: Calibration Report

MEASURED VARIABLE	VALUE		
	Should Be	Was	Is
Transmitter Output Voltage	90 Vpp	90	90
	50 ms	50	50
Transmit Pulse Length	100 ms	100	100
	200 ms	200	200
Write Amp Out	16 Vpp	16	16

Sodar Record Section Before Calibration



Transmit pulse

Figure 4 shows a sodar record section prior to calibration.

Note that the transmit pulse is shown in its entirety, and the span is short of reaching the top of the chart.

Sodar Record After Calibration

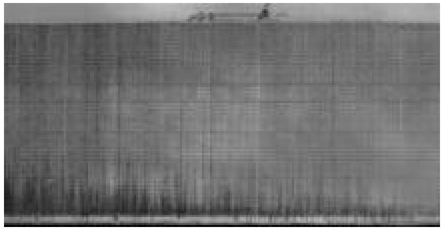


Figure 5 shows a sodar record after calibration.

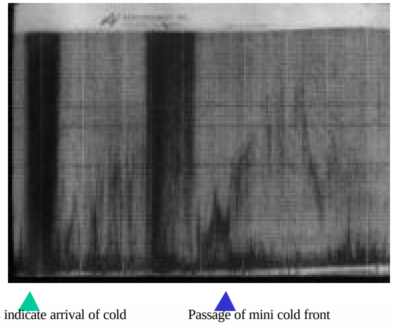
The transmit pulse has been lowered off the chart, and the span reaches the top of the record.

RESULTS

I learned how to prepare and interpret sodar record charts. For example, the rise of thermal plumes in the morning normally indicates the upward evolution of the ABL as the sun rises and heats the ground. The descent of thermal plumes in the evening usually shows the descent of the top of the ABL as the sun sets and the ground cools. A daytime record that rises very slowly or appears somewhat wavy can indicate the presence of cloud cover.

Figures 6 and 7 show other typical sodar record types on the dark bands on the left side of Figure 6 indicate heavy rainfall. The first band to the left arrives at the same time as the sudden decrease in air temperature at about noon on Julian Day 205. The rising echo pattern just to the right of center coincides with the passage of the mini cold front shown at 1600 hr in Figure 7.

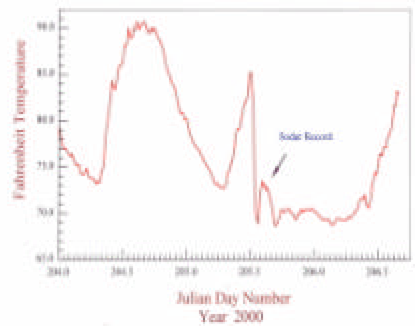
Sodar Record Section of a Cold Front Passage



Rain bands indicate arrival of cold front

Passage of mini cold front

Figure 7: Temperature record from CAU rooftop meteorological station



I also learned that because the make-shift acoustical shield now enclosing the sodar is only half as high as it should be, the generally dark character of the sodar record is a result of ambient noise contamination.

SUGGESTIONS FOR FUTURE WORK

Digital data acquisition is the top priority for future work. This will provide a quantitative analysis capability that can only enhance sodar record interpretation. Vertical wind speeds and variances, C_V^2 (structure parameter for wind turbulence), and perhaps C_T^2 (structure parameter for temperature turbulence) may be calculated from digital data.

The sodar operating parameters, such as pulse length, filter width, sensitivity, and ramp start, must be studied in greater depth so that better contrast can be achieved in the chart records.

A better acoustical enclosure must be built.

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Neff, W.D., and R.L. Coulter, 1986: Acoustic remote sensing. In Probing Atmospheric Boundary Layer, Amer-meteorol. Soc., Boston, Mass. Pp. 202-236.