

# Intercomparison of an ADCP, ADP, standard and long-range HF RADAR: Influence of Horizontal and Vertical Shear

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**Abstract**—A nested HF radar network has been deployed along the New Jersey coast as part of the New Jersey Shelf Observing System (NJSOS). A standard range (about 50 km) system setup for continuous operation since 1999 includes two sites in Brant Beach and Brigantine, New Jersey. A second longer range system (about 170 km) includes four New Jersey sites set up in Wildwood, Tuckerton, Loveladies, and Sandy Hook. The first of the long-range sites was deployed in Spring 2000. Both the long-range and standard-range systems provide real-time maps of surface currents, with resolutions of 1.5 km (standard) and 6 km (long-range). During the summer of 2001, three Workhorse ADCPs and two SonTek ADPs were deployed along a line perpendicular to the coast. All of these in situ current meters were deployed for six weeks within the footprints of the two CODAR networks. Comparisons were made between the ADCP/ADP time series and radial CODAR time series provided by the long-range and standard-range sites closest to the line of current meters. Additional comparisons were drawn between the total current fields of the standard and long-range CODAR systems with the in situ current meters. Several forcings were examined to explain the differences in the observations including vertical and horizontal shears.

## I. Introduction

HF radar utilizes a high frequency radio wave to be reflected and Doppler shifted by a surface ocean wave precisely one half the wavelength of the transmitted radar wave. The radar derives a vertically averaged quantity over a depth of  $\lambda/12\pi$  or possibly less, where  $\lambda$  is the radar wavelength [1]. Expected differences between the surface HF radar measurement and current meters depend on numerous sources of error and differences, such as geophysical variability [2]. The research conducted here on the geophysical variability may help to explain the RMS difference between HF Radar and more conventional and often-accepted techniques (i.e.

current meters, drifters, ADCPs, etc.) that remains a crucial measurement issue [2].

This paper will provide the details of how the data was analyzed and compared between the ADCP and CODAR system, discuss the implication and meaning of the comparison and lastly detail future analysis and comparisons.

The first of five long-range CODAR systems was installed in the spring of 2000. The last planned system will be installed in the spring of 2003. See Figure 1 for a map indicating the location the four long-range CODAR sites (white circles along the New Jersey coastline) along with a typical total vector current map. The data from the Tuckerton CODAR site was first utilized. This system operated at 5 MHz with a range of 180 km and a resolution of 6 km.

During the summer of 2001, three Workhorse ADCPs and two SonTek ADPs were deployed along a line perpendicular to the same coastline. Out of the five current meters, this analysis concentrated on the current record from the ADCP furthest offshore. An RD 600 kHz ADCP was deployed in 22 m of water for a period of six weeks. The water column was divided into 22 bins (Bin 1 closest to the ADCP and bin 22 closest to the surface) each with a length of 1 m. The ADCP recorded continuously for the six-week period at frequency of 0.2 Hz.

## II. Data Analysis

The first comparison point is an ADCP 23.4 km offshore in 22 m of water. The shallowest bin that could be used was 4.4 m below the surface. Both the radial currents from the Tuckerton CODAR site and ADCP data were center-averaged over a 3-hour period. The ADCP measurements were then rotated into a radial and cross radial coordinate system to match the Tuckerton radial data. Figure 2 shows the

comparison between the CODAR surface radial velocity and the radial current in Bin 16 of the ADCP. The RMS difference between the measurements was 6.3 cm/s over the entire record.

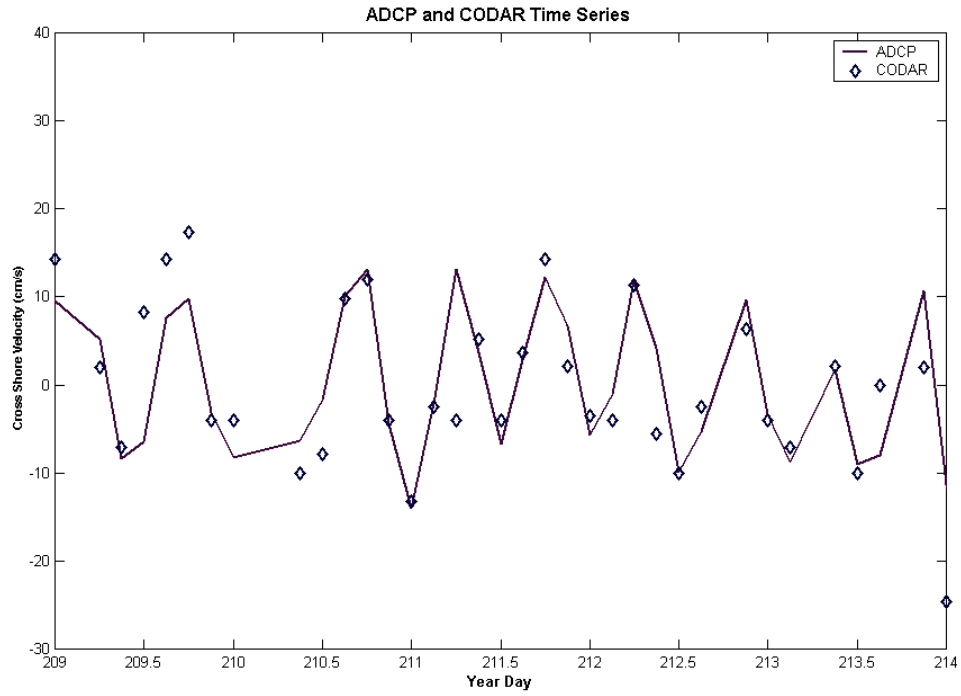
A closer examination of the comparison shows that the correlation between the two data sets varies with time. As discussed in the

introduction there are several possible causes of this difference. Since system error should not vary over these time scales, shear in the water column was first tested.

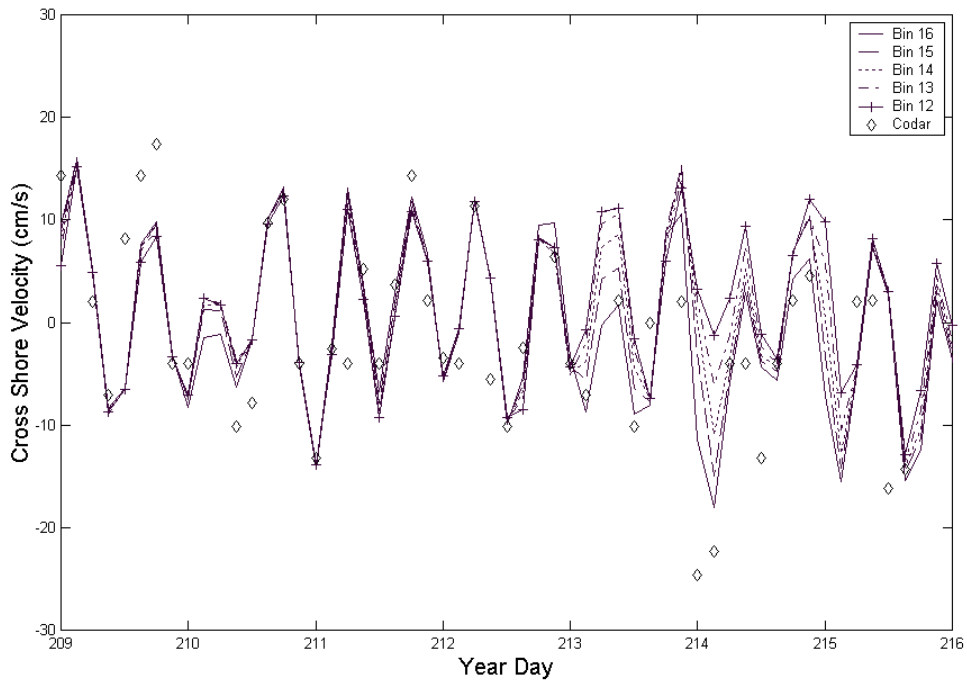
The velocity measurements from Bins 16 through 12 were plotted along with CODAR radial measurements, as seen in Figure 3.

Tuckerton

**Figure 1: Location of long-range codar along New Jersey Coast**



**Figure 2: Comparison of long-range CODAR radial velocity with ADCP measurement**



**Figure 3: Long-range CODAR measurements along with ADCP measurements from 5 ADCP bins**

From Figure 3, velocity shear is present in the water column at the beginning of days 210 and 214. The Codar data point's magnitude follows this shear trend. An underwater jet (Magnitude of Bin 12 > Magnitude of Bin 16) is present at the end of day 214 and CODAR follows that trend (CODAR point < Bin 16). Looking at the latter half of day 210, there is no shear in the water column leading to closer CODAR and ADCP measurements. Therefore, the observed RMS difference is influenced by the physical environment in which the measurements are being made.

The physical shear in the water column is shown to contribute to the difference observed in the measurements of the HF radar and ADCP. There was no clear correlation between increased shear and the local wind field, indicating that the shear may not always be wind driven.

#### IV. Future Analysis

There are several analysis options that can be examined to try and narrow the difference between CODAR and ADCP measurements.

- Bins closer to the surface can be used. The data analysis is simplified if the 99999 readings from the ADCP are ignored.
- Horizontal shear can be analyzed by comparing the current measurements between the 5 acoustic current meters installed.

The comparison presented here will be expanded to include data from other higher resolution (25 MHz) HF radar systems and additional in situ current meters. With this larger spatial data set, the contribution of horizontal and vertical shear to the time dependent comparisons will be explored.

#### V. References

- [1] Stewart, R.H. and Joy, J. W. (1974). "HF radio measurements of surface currents." *Deep-Sea Research*, Vol. 21, 1039-1049
- [2] Graber, H.C., Haus, B.K., Chapman, R.D., and Shay, L.K. (1997). "HF radar comparisons with moored estimates of current speed and direction: Expected differences and implications." *Journal of*