Surface Current Mapping in the Lower Chesapeake Bay

INTRODUCTION

High frequency RADAR antennas are used to observe the surface circulation patterns in the lower Chesapeake Bay and provide near real-time hourly surface current velocity maps to the public, maritime and scientific communities. This velocity data may be applied to search and rescue operations, maritime navigation, pollution tracking, recreational activities, fishing and research of coastal ocean processes.

The most widely used current meters to date have gathered velocity data at a single point or along a vertical/horizontal profile in the water column. The radio surface mapping of a wide coverage area offers a unique perspective allowing for development of new data products to a wider range of users. This project aims to facilitate the use of this data by identifying potential users and incorporating their input into the development of data products.

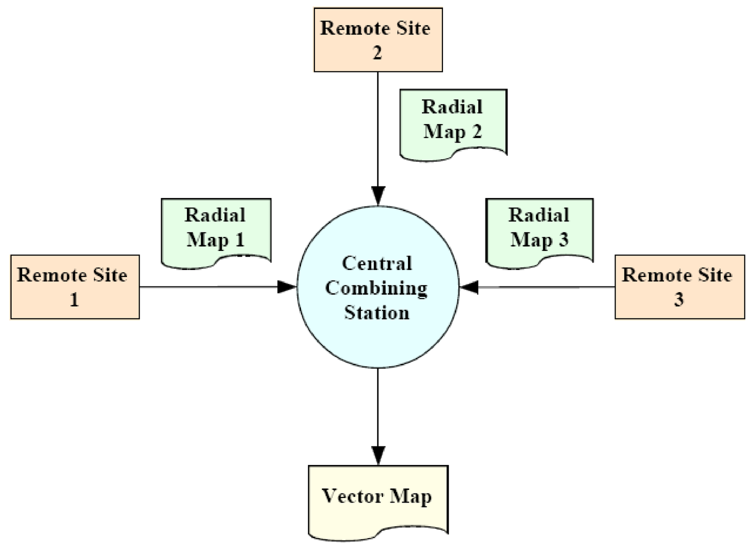
The Center for Coastal Physical Oceanography at Old Dominion University operates two CODAR standard range (25 MHz) HF RADAR antennas in the lower Bay: one at Norfolk's Ocean View Community Beach (Fig. 1, "VIEW" in Fig. 3) and another on the 4th island of the Chesapeake Bay Bridge Tunnel (Fig. 2, "CBBT" in Fig. 3)

Figure 1. CODAR Antenna located on the Community Beach at Ocean View.

Figure 2. CODAR Antenna located on the 4th Island of the Chesapeake Bay Bridge Tunnel.

HF RADAR MAPPING

The antennas transmit radio signals and listen for strong returns reflected off of sea waves. The speed derived from the Doppler shift of the return signals represents the combined speed of the wave *and* the surface current underlying the wave. Using the principles of Bragg scattering and the deep-water dispersion equation, the theoretical phase speed of the wave is calculated and subtracted out, leaving the speed of the surface current.



In an HF RADAR network, radial maps (Fig. 3) from two or more remote sites are combined at a central station to make a total current vector map (Fig. 4).

Communication between the remote site and the central site is through a computer modem or Ethernet network (CODAR manual).

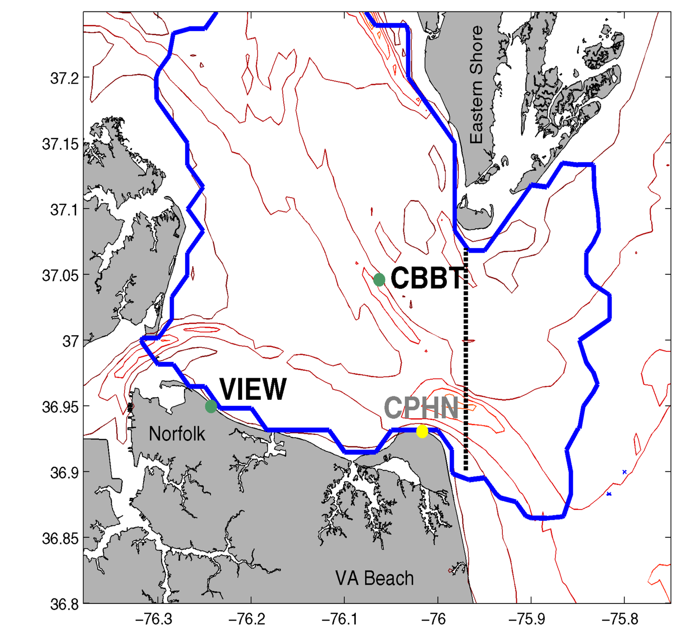


Figure 3. Station location map. CPHN indicates the future site of a NOAA antenna at Cape Henry. Outlined in blue is the area of 90% total vector coverage over a 48-hour period. Land interference and range limitations reduce data quality in the area to the right of the dashed line.

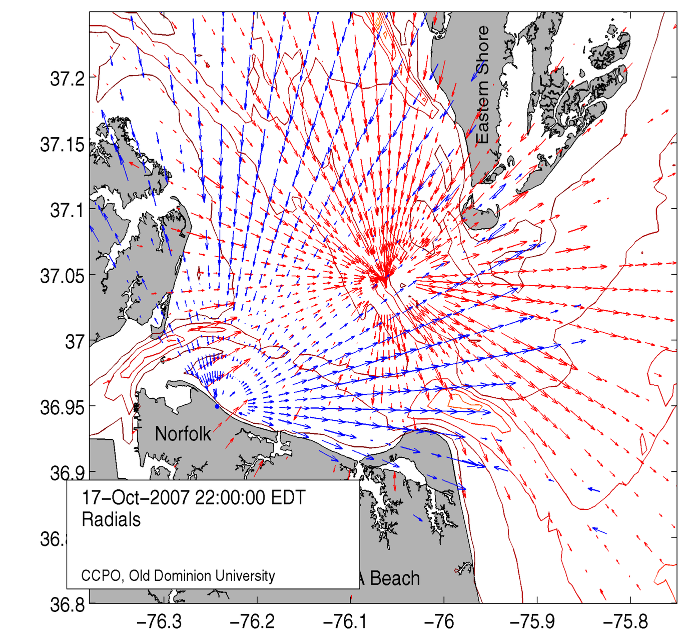


Figure 4. Radial vector data from each antenna site is plotted (CBBT in red, VIEW in blue). Radial velocity information is combined to produce total vector current velocity maps such as those seen in Figure 5 below.

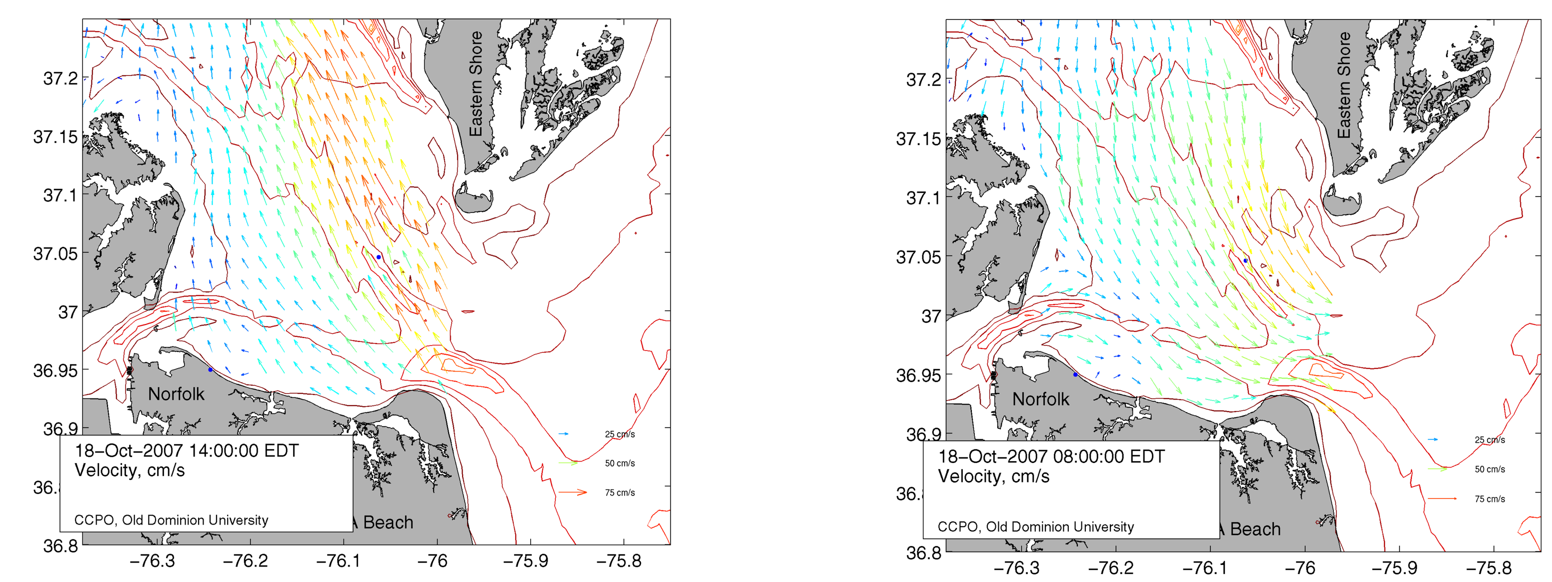


Figure 5. Examples of hourly average surface current vectors during flood tide (left) and ebb tide (right).

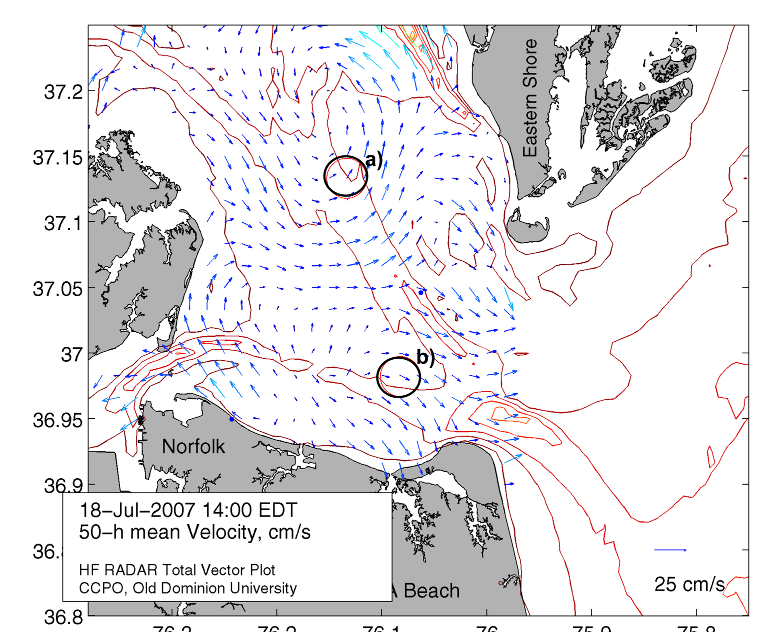


Figure 6. Sub-tidal (residual) surface current in the Lower Chesapeake Bay (50 hours average). The flow shows a counter-clockwise recirculation in the north area and a clockwise recirculation in the south area. At the Chesapeake Bay mouth, the currents show typical estuarine outflow. During the averaging period, the dominant winds were 10 knots from the SSW.

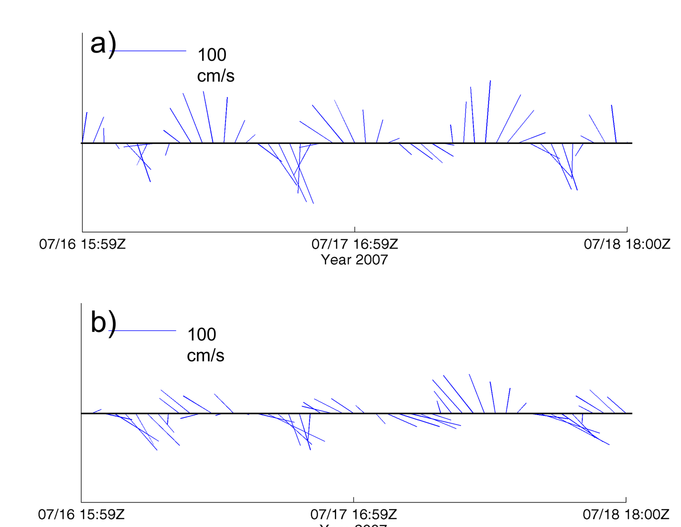


Figure 7. Time series current velocity for 50 hours at the two points marked on Figure 5 (black circles). The flow shows the semidiurnal component of the tide and indicates a maximum speed of 71 cm/s during ebb. The tidal current at point (a) shows a nearly 1 hour delay with respect to point (b).

DATA PRODUCTS & RESEARCH OPPORTUNITIES

The basic products are hourly surface velocity maps (Fig. 5). Other data products include 50 hour averaged (sub-tidal) currents (Fig. 6), time series (Fig. 7), particle trajectories (Fig. 8), and tidal ellipses. We can also create special data product maps tailored to specific users such as shipping channel currents for pilots (Fig. 9). Combining the velocity data with concurrent observations such as wind and water level measurements from the National Oceanic and Atmospheric Administration and river discharge from the U.S. Geological Survey will allow the study of how circulation patterns vary under different forcing conditions.

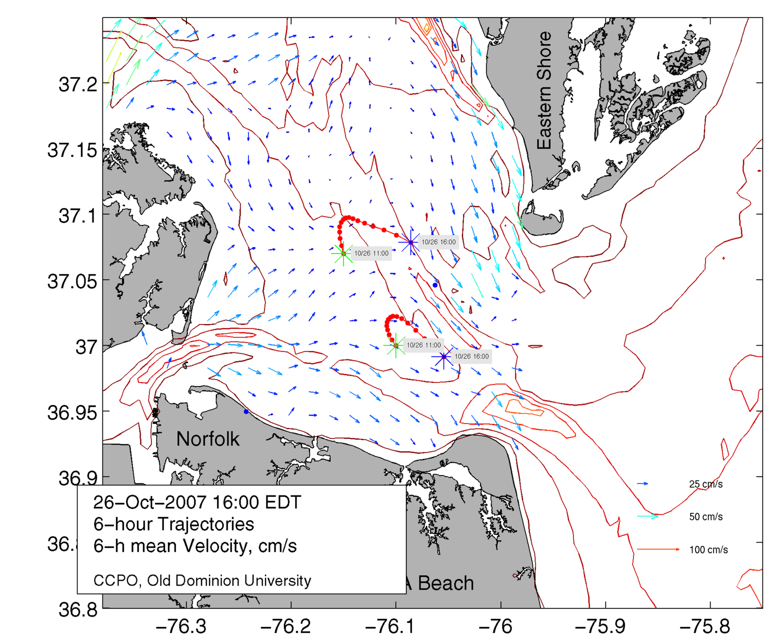


Figure 8. Particle trajectories calculated from observed current speeds for a 6 hour time period.

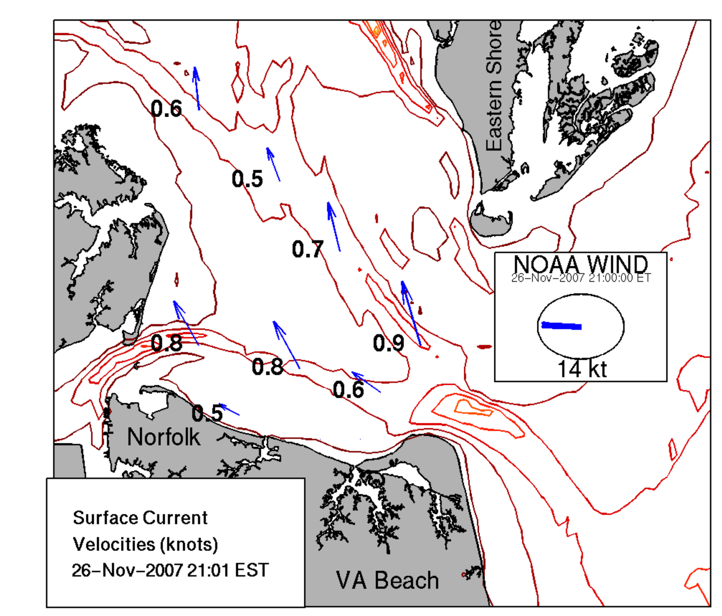


Figure 9. HF RADAR surface current velocities within the Thimble Shoals and Chesapeake shipping channels displayed with wind data from NOAA's PORTS Bay Bridge Tunnel station.

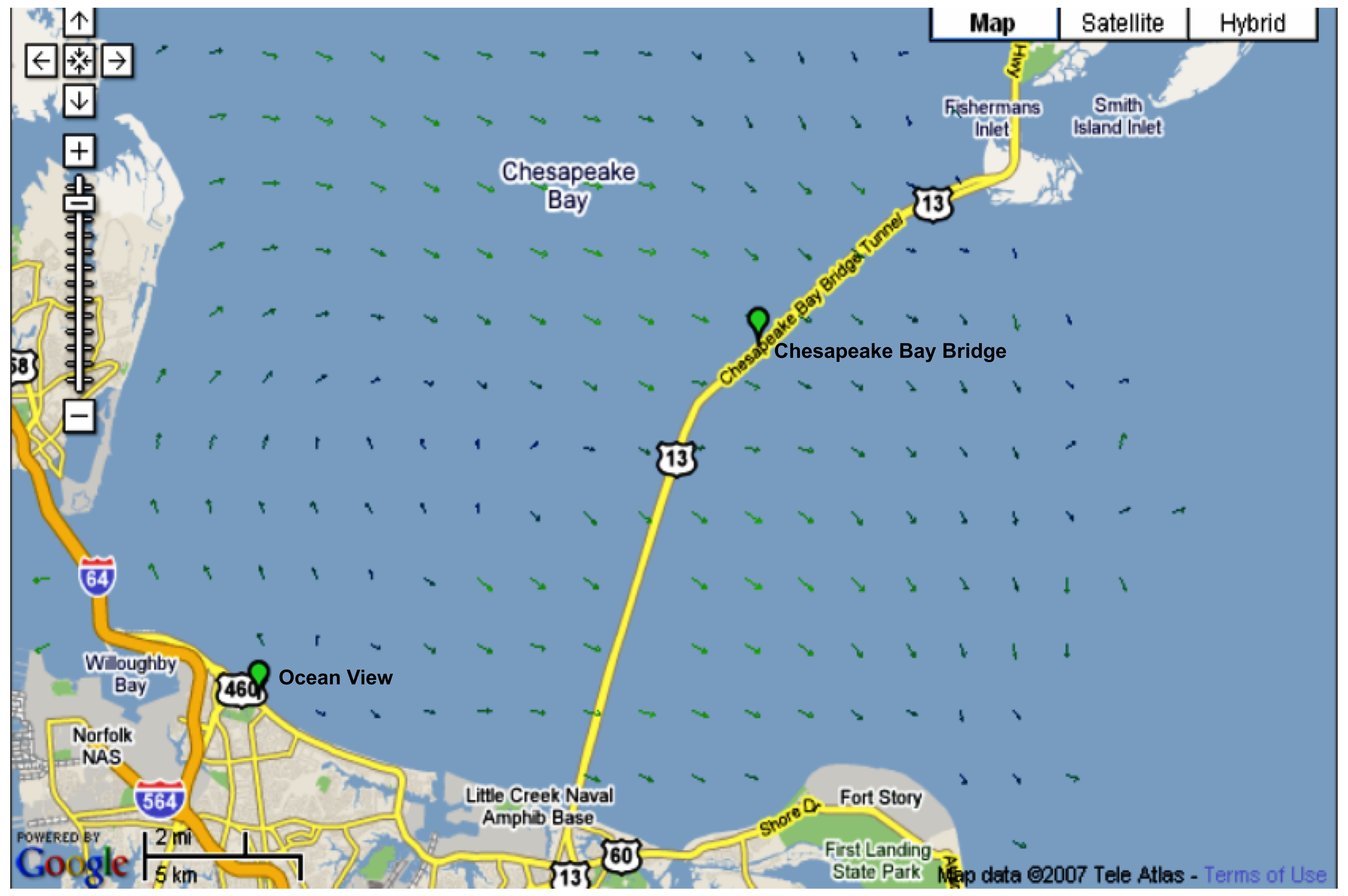


Figure 10. Mean flow over 25 hours (sub-tidal flow) shows surface outflow in the study area that is typical of estuarine circulation. This is an example of the near real time visualization through the National HFRADAR Network Gateway.

ACKNOWLEDGMENTS

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ACCESS TO DATA

Data are freely available to anyone on the project website (www.lions.odu.edu/org/cbc) or on the National HFRADAR Network Gateway (http://cordc.ucsd.edu/projects/mapping/).

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