

Final report for COI funded project 27100111: Uncovering the Lagrangian template of the stirring on the Martha's Vineyard inner-shelf using a combination of surface drifters, high-resolution HF radar systems, and techniques from the dynamical systems theory

In August 2011, a mass drifter experiment was conducted in coastal waters south of Martha's Vineyard, MA, releasing 80 CODE-type surface drifters in close proximity to the coast and partially within the footprint of the Martha's Vineyard HF radar. Drifters were deployed inside a rectangular 8 km x 6 km domain and then recovered 3 days later (Figure 1). Drifter GPS positions were logged at 1-min intervals and transmitted on-shore via Iridium-based text messaging every 5 minutes. The results of this mass drifter release provided a rich dataset to: 1) examine the accuracy of the HF radar system and its abilities to predict particle trajectories, 2) investigate the effects of the radar resolution on the resulting velocities and trajectories, and 3) study the relative importance of different flow components in a coastal ocean.

Using this drifter dataset, discrepancies between the drifter and MVCO HF radar-based velocities were found to be among the lowest reported in literature. The drifter/radar comparisons revealed that surface velocities estimated from the MVCO HF radar system were unbiased in direction but biased in magnitude with respect to drifter velocities. The radar was found to systematically underestimate drifter-based velocities by 2 cm/s, likely as a result of the smoothing effects of the spatial and temporal averaging employed by radar systems. The domain-averaged difference between the radar- and drifter-based velocity magnitudes was found to be 3.8 cm/s. Over the course of the 10 hrs when the surface drifters were within the HF radar domain, real drifter trajectories separated from simulated trajectories based on HF radar velocities by an average of 1 km. At an equivalent separation speed of 2.8 cm/s, these separation rates are among the lowest documented for a coastal HF radar system.

Our work suggests that additional improvements to the radar-based trajectory predictions could be achieved by correcting the radar velocity magnitudes for the mean bias. For the MVCO radar system, adjusting the radar velocity magnitudes to account for the 2 cm/s mean underestimate led to a roughly 18% decrease in the separation velocity between the real and simulated trajectory pairs. We expect that for typical operational long-range radar systems that are in use by the U.S. Coast Guard at many locations around the U.S. and the world, the mean velocity underestimate (bias) could be even more severe and thus the simple adjustment of velocity magnitudes could lead to even more significant improvements in the radar performance.

Due to the large number of drifters deployed and the high temporal and spatial resolutions of the MVCO HF radar system, the experiment was uniquely suited to investigate the effects of the temporal and spatial resolution of the radar on the resulting drifter/radar correspondence. By degrading the native, high resolution radar velocities to coarser temporal and spatial scales, we showed that critical spatial and temporal resolutions existed for the dataset considered. Radar observations degraded to length/time scales longer than about 1.5-2 km and 3 hours incurred markedly higher discrepancies between simulated and real trajectories, suggesting that resolving these critical spatio-temporal scales is crucial for the good performance of the HF radar system.

Finally, we have looked at the relative importance of the different flow components present during the experiment – mean, tidal, locally-wind-driven currents, and the residual velocities. We concluded that a minimum combination of tidal and residual currents was necessary to reproduce trajectories of drifters with minimal degradation. The importance of the residual velocities, which by definition, cannot be predicted from local measurements alone, is potentially important for the short time prediction systems used for search-and-rescue operations as it suggests that a combination of the tidal and locally-wind-driven currents, commonly proposed as a way to forecast future currents, are not always likely to significantly improve forecast estimates. Based on our results, improved long-term trajectory forecasting will likely require the inclusion of a fully coupled, assimilative, regional forecasting model guided by the surface current observations.

This work has been presented at several scientific conferences in the US and abroad. The manuscript describing our findings has been submitted to JAOT and is currently in review. This project has also leveraged additional funding from the National Science Foundation.

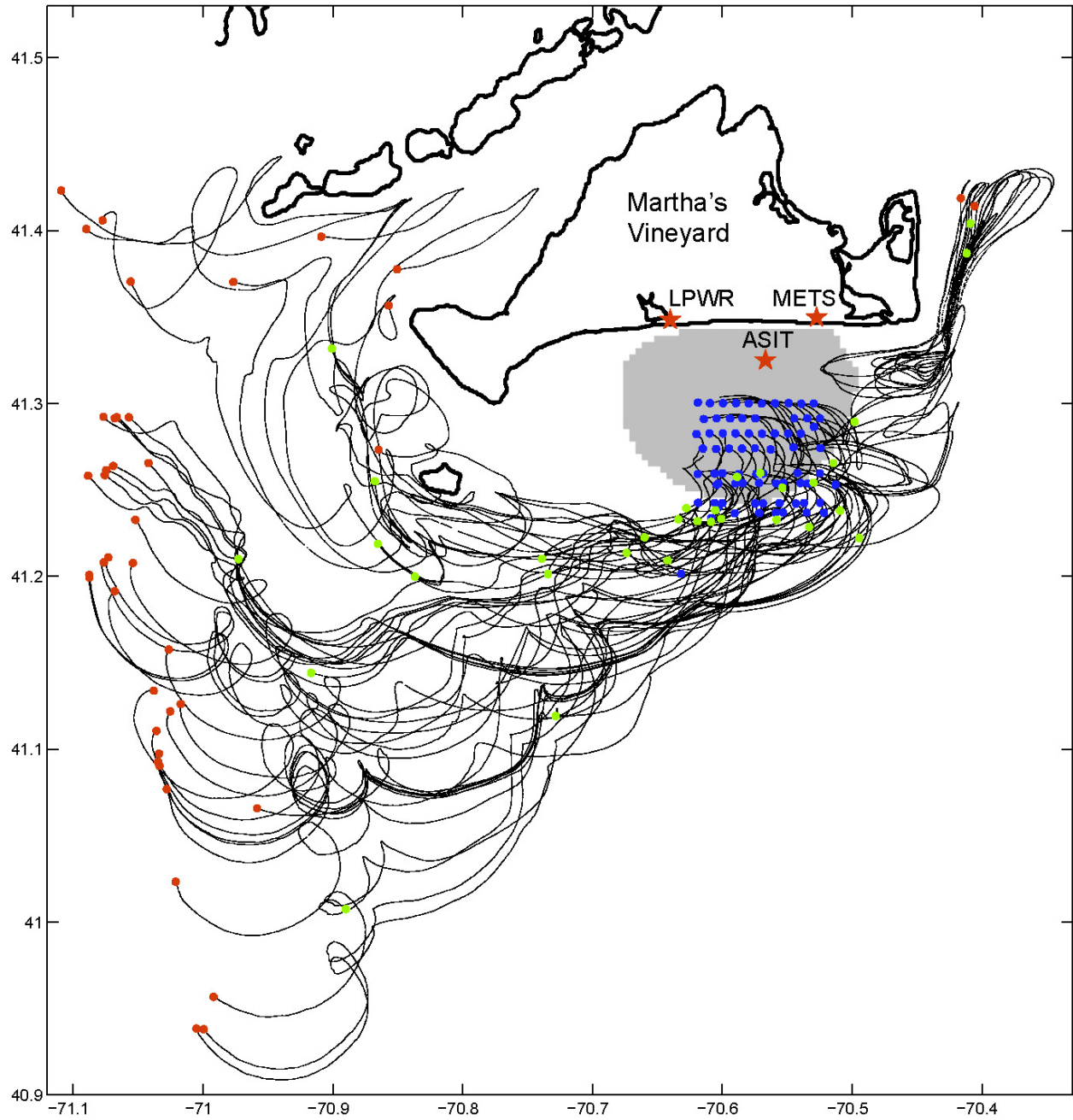


Figure 1. Drifter trajectories from the mass drifter experiment. The first position fix for each trajectory is shown in blue, last – in green/red for faulty/normal-performing drifters. Grey shaded area shows the HF radar footprint, red stars show positions of the three HF radar sites, thick black curve indicates land.