An assessment of operationally available hydrodynamic models for the NE Caribbean using CARICOOS regional observations: potential applications and challenges toward the implementation of high resolution coastal ocean current forecasting system

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BACKGROUND

"Provide data for decision making." has been the Caribbean Coastal Ocean Observing System (CARICOOS) motto and mission for the last decade. Good decisions require great and reliable data. Since its commencement CARICOOS ability to observe the ocean (with discrete and continuous measurements) has steadily increased in priority areas: wind, wave and currents. While its ability to forecast wind and waves has remarkably improved, forecasting currents has remained a challenge. In part, the challenge has come from an operational numerical modeling dichotomy of either being able to resolve and forecast the small high-frequency inshore dynamics (well inside the shelf platform) or the large low-frequency open ocean dynamics; another part comes from the physical constraints imposed by the Parent Model (PM, AMSEAS NCOM_4.3 1/30 degree & HYCOM GOFS 3.0 with OSU tides 1/12 degree). In order to forecast inner-shore and shelf dynamics it is necessary that the initial boundary conditions are taken from a PM capable of accurately resolving low-frequency open ocean dynamics. This work focuses on assessing the performance of operationally available PMs best aggregates in forecasting low-frequency open ocean surface dynamics. Said assessment relies on the use of HFR derived surface currents. HFR's have shown to be able to measure these as shown in previous validations efforts (Corredor et al., 2011) which highlight their reliability and robustness. With the incorporation of long-range High-Frequency Radar (HFR) antennas in the south coast of Puerto Rico CARICOOS has emplaced the capability to observe and assess surface mesoscale circulation processes in the region against the global Ocean Surface Current Analysis Real-time (OSCAR) 1/3 degree product and PMs output.

IMPORTANT FEATURES & DETAILS

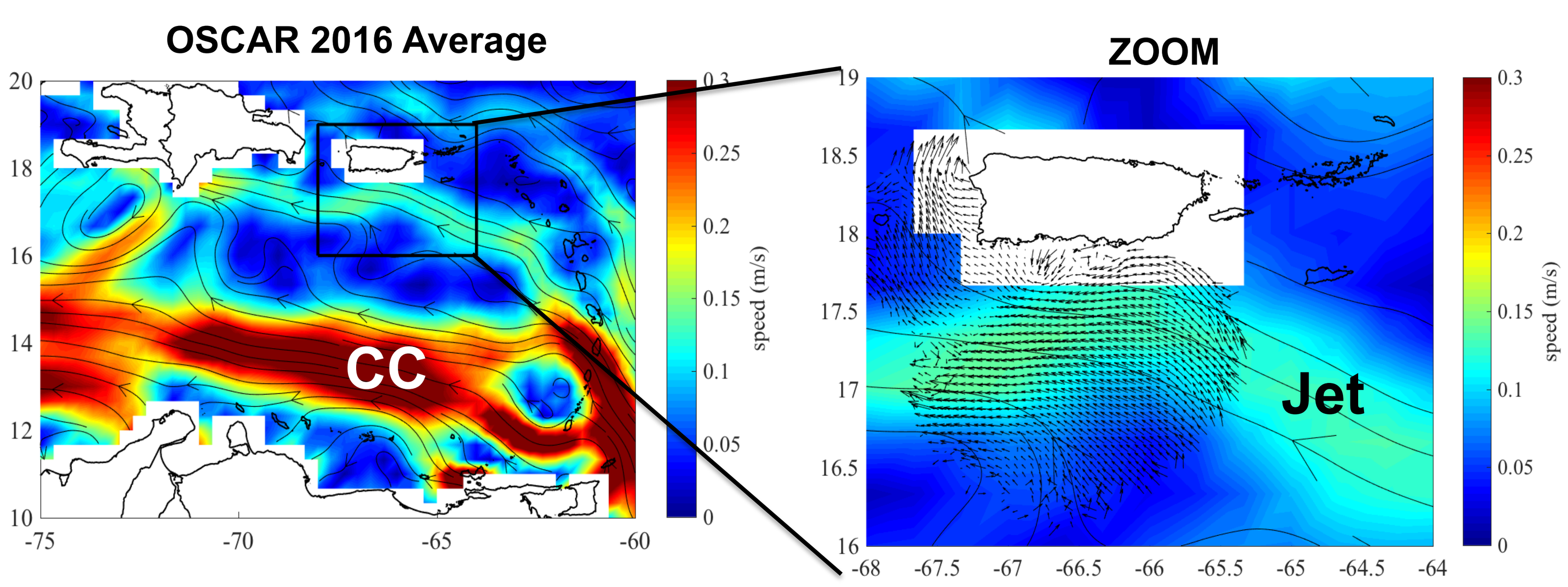

Fig 1. Important open ocean large and mesoscale circulation features, such as the Caribbean Current (CC, [80 cm/s]) and the bifurcation of a Eastern Caribbean jet in the 17N (Richardson 2005, [15 cm/s]) respectively. ZOOM in view illustrates the high correlation mean-flow of the HFR field and OSCAR for 2016.

DATA TREATMENT

- HFR data was used to validate the surface currents estimates from the PMs AMSEAS & HYCOM best aggregates, and OSCAR dataset (@15m) for the year 2016.
- HFR data filtered by:
  - Geometrical Dilution of Precision equal or less than unity
  - High temporal data density of 75% or greater
- Bounding box: [67.4WW – 65.6W]; [16.6N – 17.7N]
- All datasets where averaged to 5-day time intervals matching OSCARs output time steps.
- Linear regressions where force to zero intercept, b = 0

VALIDATION RESULTS

In short: *Large open ocean low-frequency surface dynamics are better represented by OSCAR than by validated operational PMs*

I.

Time series qualitative comparison

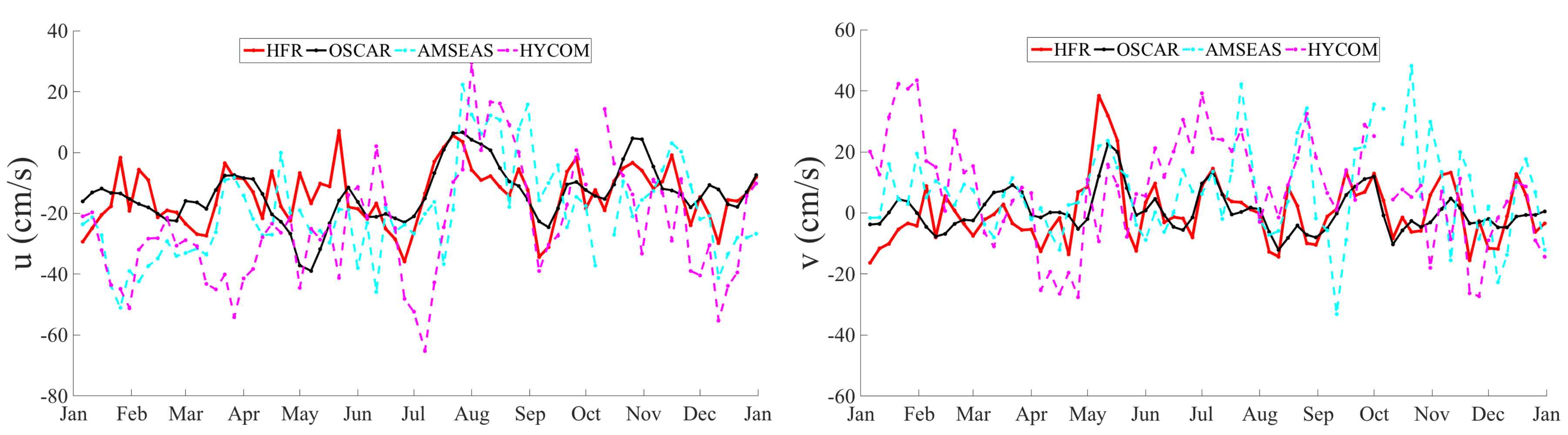

Fig 2. 5-day averages time series of u & v velocity components for the compared datasets during the 2016 year at, [66.5W; 17.4N], the current regional model nested boundary. It conveys an example of the boundary conditions available, with their overestimated fluctuations and skewness.

II.

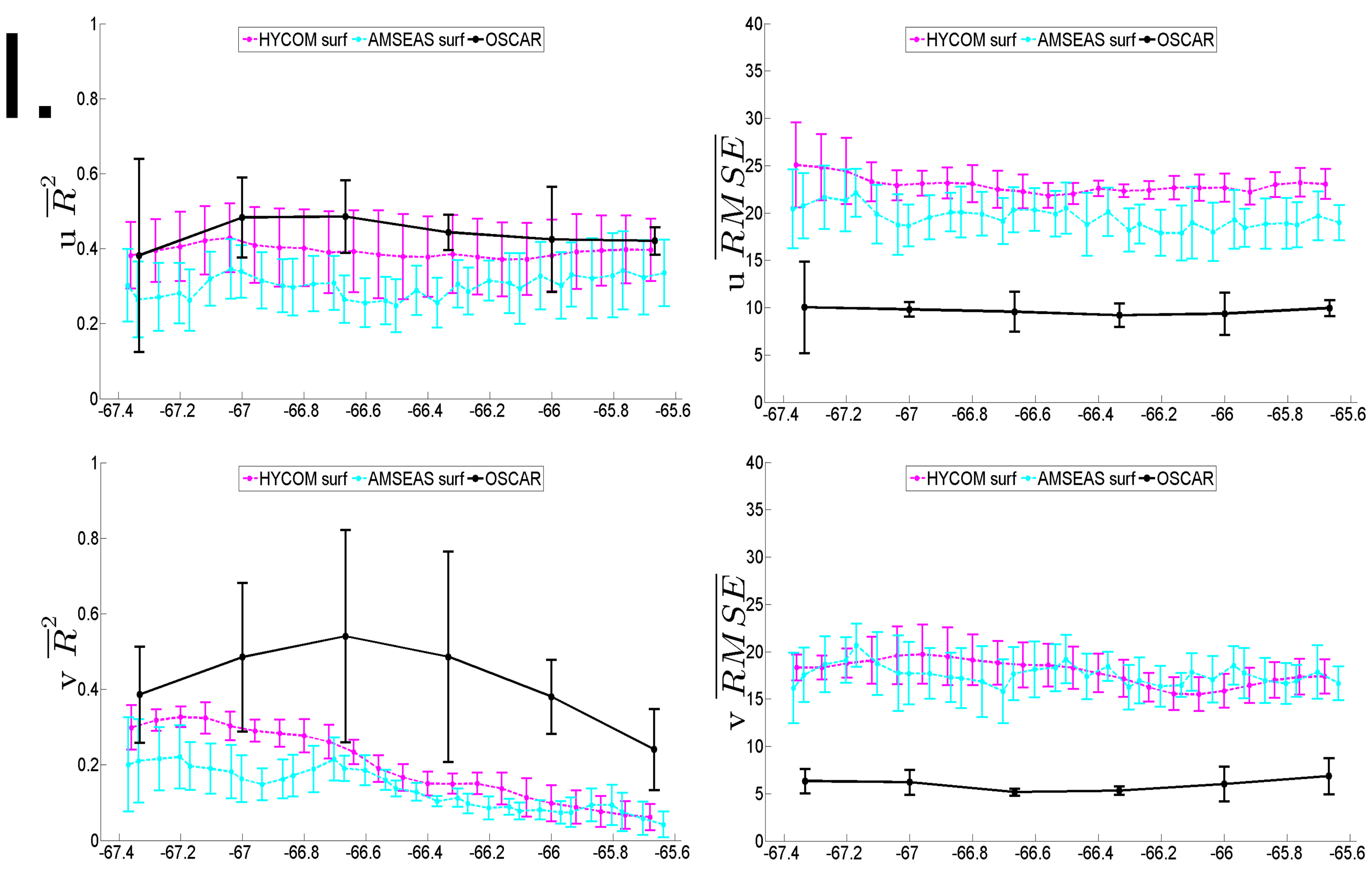

Fig 3. Meridionally averaged R^2 and RMSE values for grid point time series velocity components u & v, computed out of 5-day means from the 2016 year.

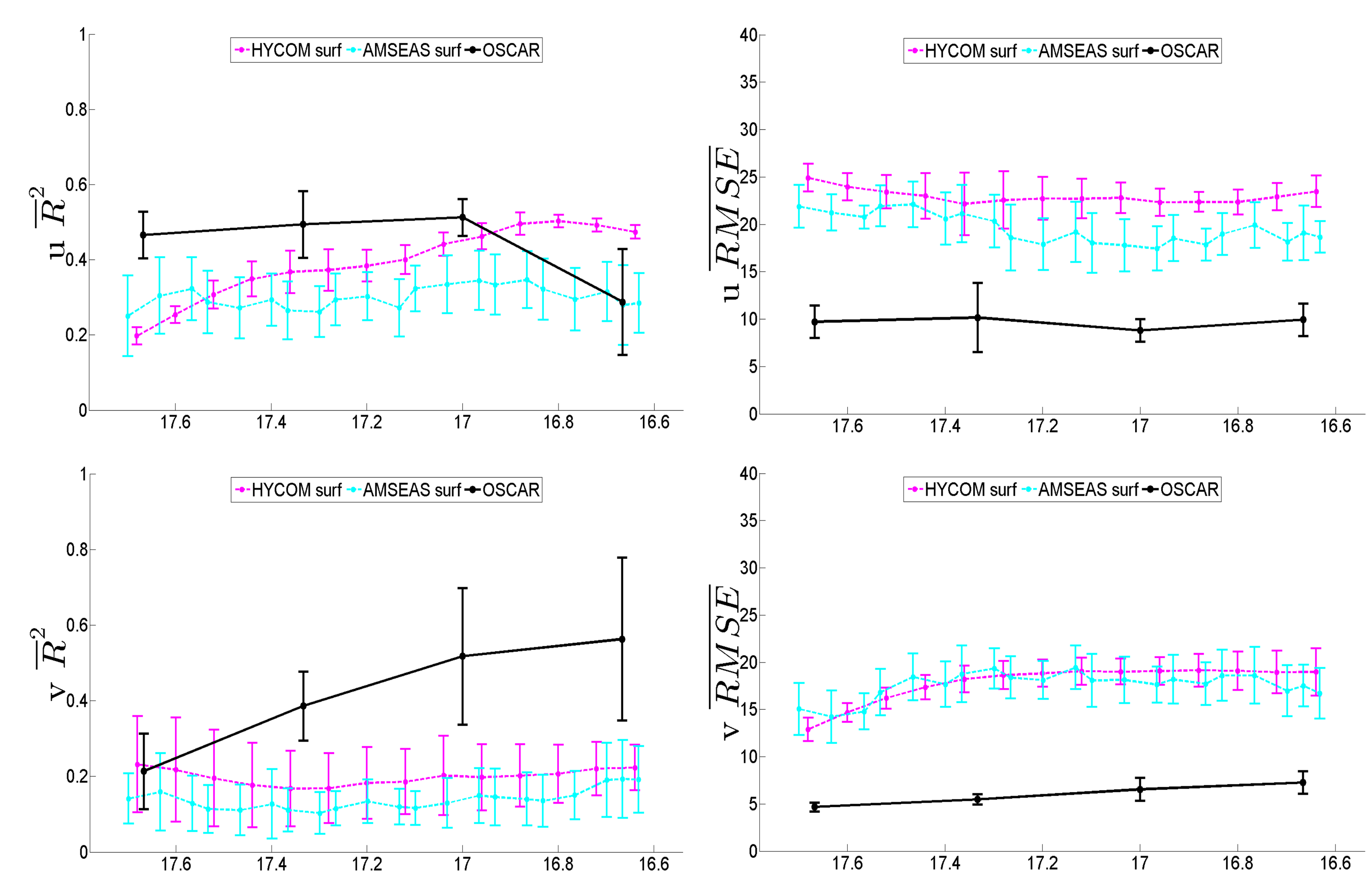

Fig 4. Zonally averaged R^2 and RMSE values for grid point time series velocity components u & v, computed out of 5-day means from the 2016 year.

Findings!

- OSCAR correlates better with HFR data than the models currently being used.
- OSCAR produces half the error of the validated PMs

III.

From an unexpected result... A possible atypical/impure approach?

The analysis summarized in Figs 3 & 4 shows us that OSCAR provides the best estimate for 5-day average surface currents out of the 3 validated datasets. So, how about using OSCAR for operational modeling? As an exercise, we analyzed what would be like to use OSCAR as the main source of large open ocean low-frequency surface dynamics for our predictions. And compared it to HFR data and the PMs. The table below illustrates the process in t days from 0 to 4.

	DAYS	t0	t1	t2	t3	t4	t0	t1	t2	t3	t4
SPEED	OSCAR	15 cm/s	15 cm/s	15 cm/s	15 cm/s	15 cm/s	21 cm/s	21 cm/s	21 cm/s	21 cm/s	21 cm/s
	HFR	17 cm/s	19 cm/s	12 cm/s	14 cm/s	18 cm/s	20 cm/s	23 cm/s	27 cm/s	24 cm/s	20 cm/s
	AMSEAS	27 cm/s	30 cm/s	16 cm/s	18 cm/s	23 cm/s	22 cm/s	26 cm/s	34 cm/s	22 cm/s	18 cm/s
	HYCOM	23 cm/s	26 cm/s	14 cm/s	14 cm/s	19 cm/s	19 cm/s	24 cm/s	30 cm/s	25 cm/s	22 cm/s

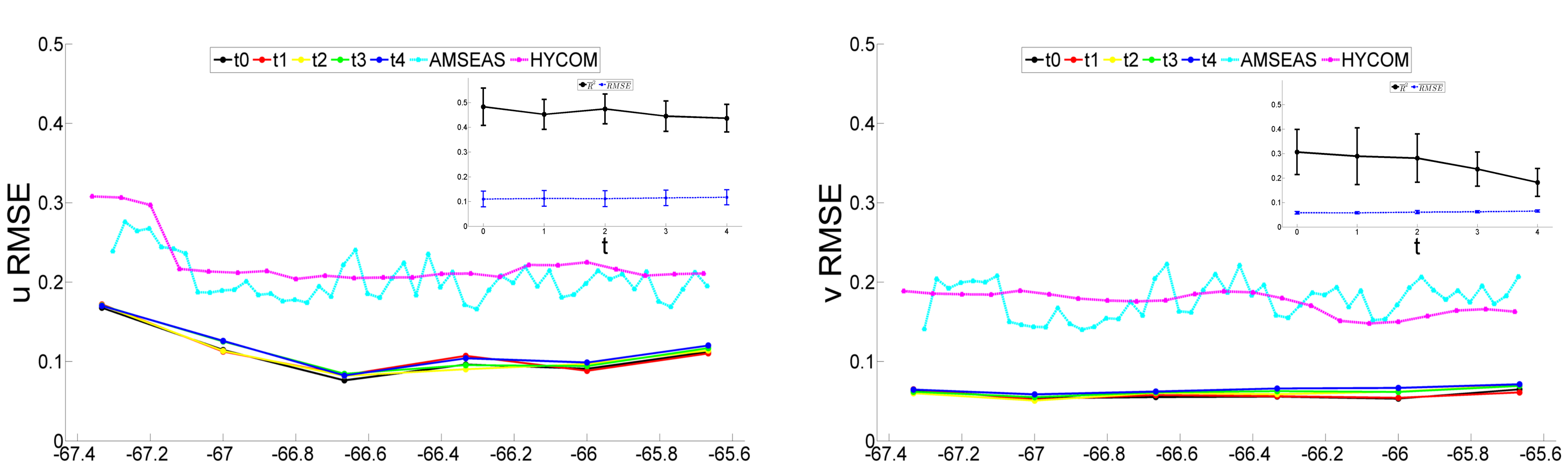

Fig 5. RMSE values for grid point time series in the CARICOOS regional model south boundary, at 17.4N. The small graph illustrates OSCARs diminishing correlation values and its RMSE rise in t day.

FUTURE WORK

- Use OSCAR as a proxy of reliable currents outside the HFR coverage area by establishing an empirical correlation with HFR inside its current domain. Then use that to validate PMs outside the HFR coverage area – mainly south of Puerto Rico.
- Through the proxy, find where lies the best available data from PMs that can be used as initial boundary conditions for the in-house CARICOOS model.
- Future work includes a time series temporal assessment of the CARICOOS Ponce Buoy at the south coast shelf break against the datasets used here. With the objective of studying the open ocean jet temporal variation and influence (if any) on the shelf break. This would provide ample evidence on the skill and need of PMs at predicting this phenomena.

REFERENCES

- Richardson, P. L. (2005). Caribbean Current and eddies as observed by surface drifters. Deep-Sea Research II 52, 429-463
- Corredor, Jorge & Amador, Andre & Canals, Miguel & Rivera, Samuel & E. Capella, Jorge & Morell, Julio & Glenn, Scott & Roarty, Hugh & Handel, Ethan & Rivera Lemus, Erick. (2011). Optimizing and Validating High-Frequency Radar Surface Current Measurements in the Mona Passage. Marine Technology Society Journal. 45. 49-58. 10.4031/MTSJ.45.3.6.