An overview of recent Wave Glider® field programs

Pat Fitzpatrick 1)
1) Mississippi State University, Stennis Space Center, MS
*Corresponding author: fitz@gri.msstate.edu

1. Introduction. Developed by Liquid Robotics, Inc., Wave Gliders® (WGs) use wave energy for propulsion through the synergistic alternating thrust of wave action on the floating vehicle and mechanical wings 6 m below the vehicle. WGs provide dynamic environmental monitoring in the maritime environment with weeks-to-months-long deployments using solar panels to power sensors, and satellite and cell communication channels for data delivery. Some data is transmitted real-time or in bulk at more infrequent intervals, while other data is archived on-board for extraction after a mission.

Example field programs include: wave, ocean, and PBL measurements in tropical cyclones; algae bloom monitoring; satellite ground truthing; active and passive acoustics; marine mammal monitoring; carbon cycle studies; geodesy marine magnetics; hydrocarbon seep mapping; and marine surveillance. Instrumentation to support these missions are different combinations of the following: anemometer; towfish; fluorometer; ADCP; acoustic modems; acoustic recorders; directional ocean wave sensor; CTD-DO; magnetometer; and camera.

The presentation overviews recent WG field programs, including the 2014 Mississippi State University mission ([1], [2]). MSU deployed 3 WGS from Aug.-Nov. 2014 (Fig. 1), validating the instruments during buoy loitering exercises for surface meteorology, SST, and wave data. MSU also intercepted Tropical Storm Hanna's fringes.

2. MSU field program results. The oceanography validation compared well to the buoys. ADCP SSTs showed biases (WG minus buoy) between -0.24 and 0.18°C, absolute errors 0.06 to 0.27°C, and correlations r=0.88 to 0.98. Wave statistics were performed in two stages: Oct. during relatively low wave conditions, and in Nov. with vigorous frontal passages. 7-day Oct. statistics for average period, peak period, and peak direction, respectively, were: biases of 0.36 s, -0.34 s, and -0.72 deg; absolute errors of 0.40 s, 0.61 s, and 12.7 deg; and r^2 of 0.55, 0.44, and 0.94. Significant wave height bias was 0.08 m, absolute error was 0.10 m, and r^2=0.91. In Nov., the wave parameters again validated well, with high correlations for significant wave height, peak direction, and average period. The correlation is lower for peak period but still respectable at r=0.84 for buoy 42036, and r=0.92 for buoy 42099. Significant wave height, peak direction, and average period showed little or no bias, and absolute errors were 0.1 m, 11-15 deg, 0.2-0.3 s, and 0.4-0.5 s, respectively.

The meteorology validation did well for atmospheric pressure, but exhibited issues with wind and temperature. The WG showed the atmospheric tide diurnal pressure oscillation with a bias of 0 to -0.5 mb, absolute error of 0.4 to 0.55 mb, and r^2=0.94. The validation for sustained wind was partitioned into Oct. and Nov. datasets. Oct. showed a bias of 0.48 ms^{-1}, absolute error of 0.76 ms^{-1}, and a variance r^2=0.87. However, Nov. fronts increased the bias to 1.5 ms^{-1}, absolute error to 1.7 ms^{-1}, and r^2=0.72. Errors increased when wave heights > 1.8 m. It's clear a WG anemometer provides decent observations in low wave heights, but as waves exceed 2 m, obstructed wind flow introduced negative wind biases.

The Airmar air temperature sensor was susceptible to solar radiation heating as it isn't shielded nor equipped with a fan aspirator, hence daytime comparison were sometimes poor. Nocturnal summertime validation also presented problems with sharp PBL vertical gradients between the WG platform and buoy thermometer heights, so those results could not be corroborated. In contrast, Nov. WG air temperature and pressure validated better, with r ≈1.0, no bias, and absolute errors of 0.5°C and 0.4 mb. The Airmar sensor may represent the marine boundary layer better in windier late fall conditions due to less intense insolation and a well-mixed 4-m PBL layer.

3. Conclusions. These results provide assurance that WG ocean observations will benefit filling in data gaps, as short-term substitutes for buoys, for targeting observations, and for high-impact, difficult-to-measure weather events. More research is required to understand instrument niches. It is recommended these validation experiments continue in extended time periods and extreme weather events. Furthermore, WG field experiments which validate ocean current profiles, salinity, and dissolved oxygen have been neglected, and require future support.

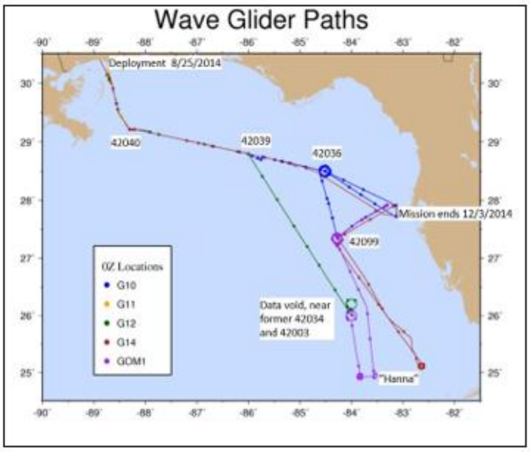

Fig. 1 Paths of the WG deployments. Locations of buoy loitering are shown, as well as open water monitoring to demonstrate data-gap filling. Deployments to capture the northern fringes of Tropical Storm Hanna's (denoted as "Hanna") are also shown.

References

[1] Fitzpatrick, P. J., et al., 2015: A review of the 2014 Gulf of Mexico Wave Glider® field program. *Marine Technology Society Journal*, **49**, 64-71.

[2] Fitzpatrick, P. J., et al., 2016: Further analysis of the 2014 Gulf of Mexico Wave Glider® field program. *Marine Technology Society Journal*, **50**, 72-75.