Using Slocum Gliders with Nontraditional Flight Behaviors to Accommodate Unique Sampling Requirements

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Abstract

Slocum gliders are autonomous profiling units with vertical speeds averaging 5-15 cm/s. In this work, we present the use of "hover" (fixed-depth) missions to better sample localized fixed-depth events for adaptive sampling needs.

These flight behaviors allow for long-term monitoring within specified depths in the water column using software controls within the Slocum glider software (v 10.08). We present a series of field trials within a deep-water floating seaweed farm as well as in near-coastal waters on the NJ shelf. We demonstrate the ability to hover at depth and detect localized events not easy to document with traditional glider flight behaviors.

Background

Slocum glider uses:

- Autonomous and cost-effective
- Long-duration ocean observing (30-90 days)
- Cross ocean basin or localized region

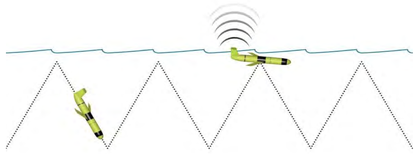

Figure 1: Traditional glider flight pattern with comms surfacing.

Traditional flight:

- Moves in a triangle pattern using a buoyancy (ballast) pump and a pitch battery [1]
- Consistent profiles with matched speeds (5-15 cm/s).

Hover flight:

- Hovers at specified depth(s) inputted by the user with no speed or speed from thruster
- Seed file with user predicted pump usage needed to ballast at various hover depths
- Linear fit for auto-ballast pump adjustments from seed file [2]
- Glider learns its environment as it flies more without continuous input from the user.

Methods

Field Trial 1 with RU44 Glider:

- Deep 1000-meter G3s Slocum glider – CTD, ECO-puck, oxygen, and nitrogen
- Surveyed the Climate Foundation's seaweed farm from March-July 2025
- Seaweed farm raised and lowered on a 12-hour schedule
- Difficult to navigate moving structure
- Hover missions used with and without thruster above and below farm

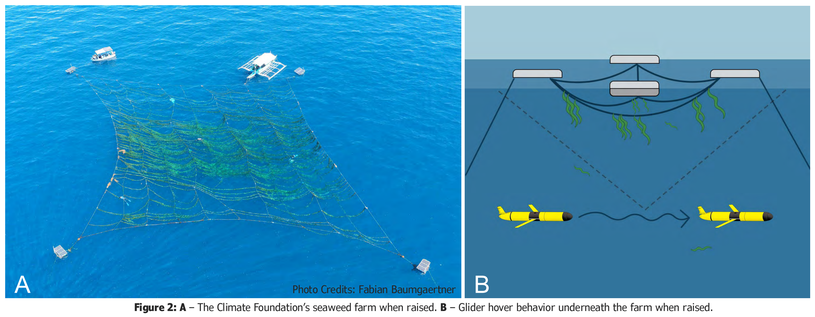

Figure 2: A – The Climate Foundation's seaweed farm when raised. **B** – Glider hover behavior underneath the farm when raised.

Field Trial 2 with RU39 & RU43 Gliders:

- 2 shallow 100-meter G3s Slocum gliders – CTD, ECO-puck, pH (RU39), oxygen (RU43)
- Surveyed New Jersey coast for seasonal variability in May (RU39) and June (RU43)
- Hover missions used to observe isolated events within a strong thermocline

Results

Field Trial 1 with RU44

Traditional Flight	Hover Flight	Thrust Hover Flight
• 5-15 cm/s vertical speed • Higher chance of hitting structures • Moves through smaller observing areas too quickly • Lots of profiles in a larger observing area	• "Hovers" (no speed) • If it hits an obstacle, very low impact • Surveys tight depth range in observing area directly for an extended period of time. • Good for localized observing area	• 20-40 cm/s moving horizontally • Easier to navigate through structures and in strong currents • Surveys exact depth across distance for extended period of time.

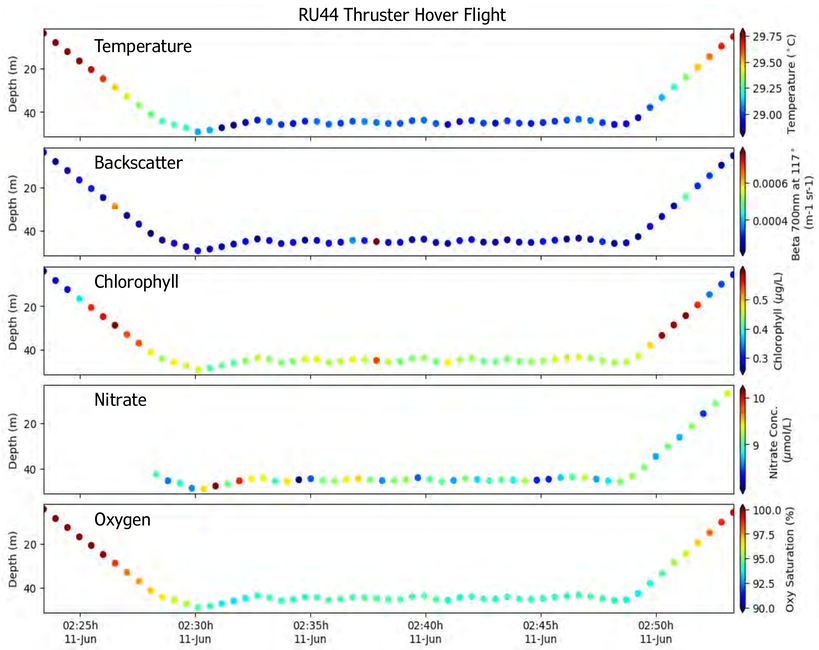

Figure 3: Glider flight plots showing depth maintained, under the seaweed farm, while thruster hovering with steady sensor measurements. Glider detects slight fluctuations in variables at depth. Plotted measurements are from the raw real-time dataset, full resolution dataset available at https://slocum-data.marine.rutgers.edu.

Field Trial 2 with RU39 & RU43

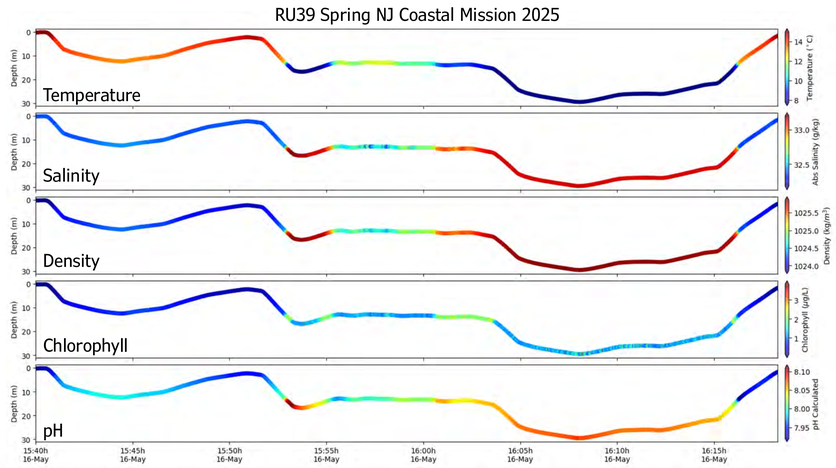

Figure 4: Glider flight plots from RU39's spring NJ mission. Glider detects variation in thermocline depth. Plotted measurements are from the raw delayed-mode dataset available at https://slocum-data.marine.rutgers.edu.

RU39 Glider

- 3 depths in a step-down motion: above, within, and below thermocline
- Hover depth is maintained within a meter while in the thermocline
- A shift in measurements towards the end of the within thermocline hover likely due to internal waves

RU43 Glider

- 3 depths in a step-up motion: near-bottom, at the end of, and at the start of the thermocline
- Sits on the bottom while trying to hover, no density change
- Slow profile climb while getting trapped in the thermocline

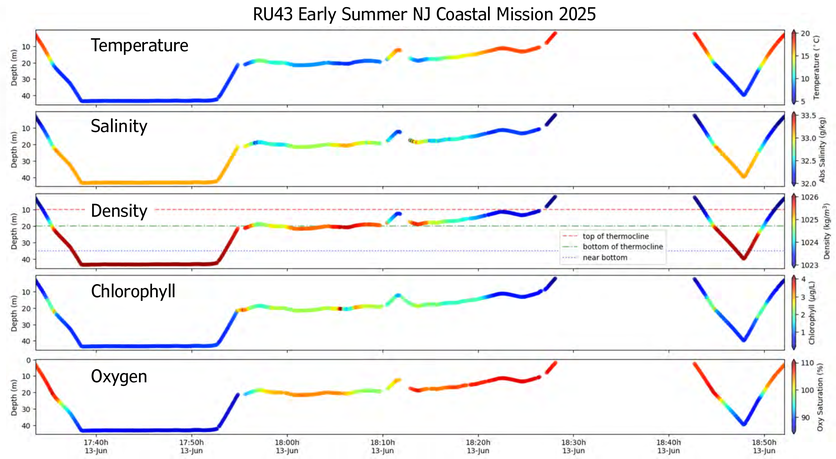

Figure 5: Glider flight plots from RU43's summer NJ mission. Plotted measurements are from the raw real-time dataset available at https://slocum-data.marine.rutgers.edu.

Conclusion

- Easy to implement but requires more attention from the pilot in comparison for traditional glider flight
- Can be autonomous, but in the case of event specific detections or flying in urban waters, glider data would need to be analyzed for adjustments
- Hover missions with complex sensors could increase glider capabilities as new technologies emerge
- Use of a thruster allow gliders to fly in more urbanized waters
- Observing highly specified events within certain ocean regions can
- Better understanding of sub-ocean processes that affect the greater climate
- Hover Manual on GitHub: *Using Hover Missions with Slocum Gliders* [3]

References

[1] O. Schofield et al, "Slocum Gliders: Robust and ready," J. Field Robotics, vol. 24, pp. 473–485, 2007. Available: https://www.researchgate.net/publication/220648215_Slocum_Gliders_Robust_and_ready. DOI: 10.1002/rob.20200.

[2] "Slocum Masterdata 11.01," Available: https://gliderfs.coas.oregonstate.edu/gliderweb/masterdata/display.php?fn=masterdata_11_01.txt.

[3] jleonard-marine. hover-missions. Available: https://github.com/jleonard-marine/hover-missions/.

Acknowledgements:

This work was done in collaboration with the Climate Foundation. I would like to thank my fellow RUCOOL glider team and those at the Climate Foundation in Compostela, Cebu, Philippines for their continuous field support. Shallow glider observations made possible thanks to NJDEP's RMI initiative. Piloting support and assistance courtesy of David Aragon and Cordielyn Goodrich.