# Wind/Wave/Current co-variability in two Southern Ocean autonomous surface vehicle surveys

**Poster 5198**

**Session PSP02 (PS02+PS07)**

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## Introduction

Two long-duration missions (Dec 2016 – Mar 2017 and Oct 2019 – Feb 2020) with a wave-propelled and solar-powered Wave Glider autonomous surface vehicle in the vicinity of Drake Passage and the Antarctic Peninsula (Fig. 1) were conducted to investigate wind-wave-current relationships in different environments. The vehicle occupied both timeseries stations and spatial surveys, open ocean and continental margins, broad frontal zones and sharp ACC jets, and periods with both weak winds and strong storms (Figs. 2 and 3). Taken together, the observations span the typical range of Southern Ocean conditions, allowing for analysis of processes driving co-variability in these quantities in addition to data quality evaluation at different headings, sea states, and current speeds.

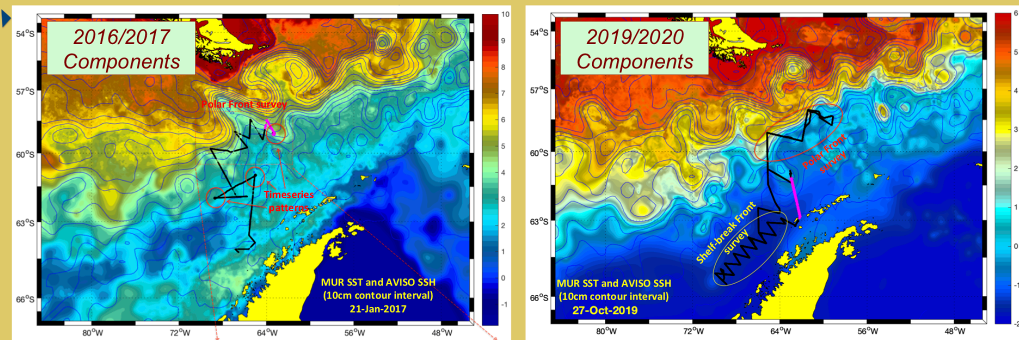
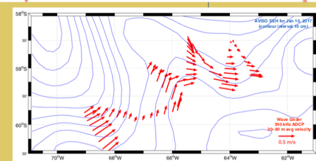



*Figure 3: Oceanographic setting of the two Wave Glider surveys. ACC jets and surface fronts are visualized using satellite SST (colors) and SSH (contours) from a single day during each survey. Vehicle position over the 3 days leading up to the image is shown in green.*

## Surveys and timeseries

Timeseries stations (generally implemented as octagonal loops) allow estimation of synchronization between wind and wave quantities while also capturing spatial variability over small scales. Spatial surveys (Fig. 4) allow estimation of current gradients and ocean dynamics via repeated transects across coherent jets, but may alias tides or high-frequency wind-forced ocean variability. Comparison of wavenumber spectra with vessel crossings (e.g., the route of the R/V *Laurence M. Gould* across Drake Passage) allow separation by frequency due to different speeds.



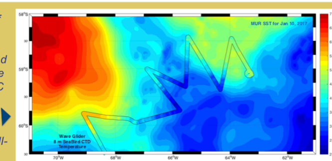



*Figure 4: Magnified view of Polar Front survey from 2017, showing wave glider currents and SST compared with satellite estimates. The overall structure of the ACC jet and temperature front are well captured in both datasets, but the in-situ measurements reveal small-scale structure missed by the satellites.*

## Flux impacts and coupled air–sea interactions

Analysis of data from the two wave glider missions is under way, focusing on wind–wave–current co-variability and hypothesized causes. Wind–SST correlation has been seen in the 2016/17 dataset (Thomson et al 2018). Simultaneous sampling of wind, waves, and currents allows evaluation of the contributions of coherent and incoherent influences to air–sea fluxes (Fig. 5), as well as known responses such as mixed-layer inertial oscillations and Ekman transport. Wave spectra allow estimation of the effects of currents on long-range propagating waves (swell) vs. wind waves.

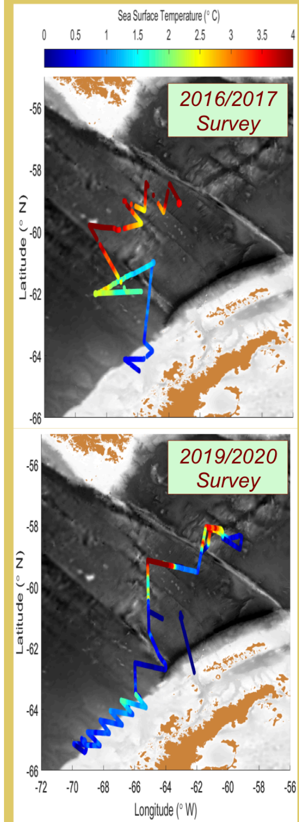



*Figure 1: Location and geographical setting of the two Wave Glider surveys, plotted over seafloor bathymetry—showing the series of basins and ridges encountered by the Antarctic Circumpolar Current (ACC) in Drake Passage. Color coding along the tracks indicate sea-surface temperature (SST) measured by sensors mounted under the Wave Glider float (Aanderaa CT in 2016/17 and ADCP thermistor in 2019/20).*

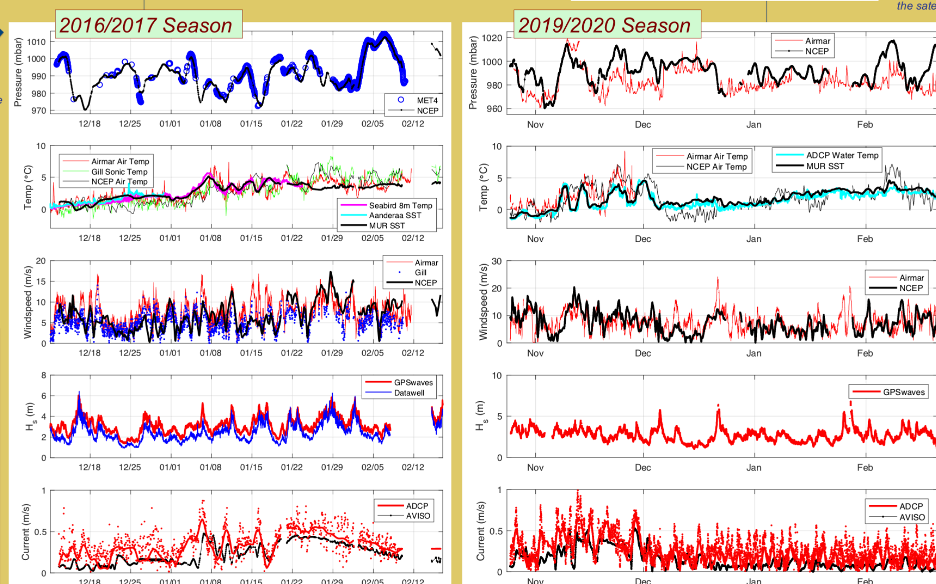



*Figure 2: Timeseries of measured quantities from the two Wave Glider surveys, along with comparison data from NCEP reanalysis, MUR SST (merged infrared and microwave product), and AVISO altimetry.*

### 2 years—Two Configurations

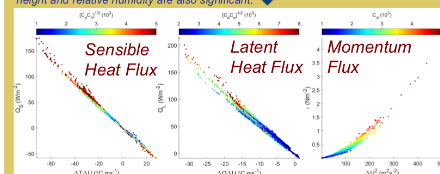
- 2016/17 integrated new instruments: Gill 3-axis anemometer (for turbulent wind stress), GPSWaves, Aanderaa CT, and Paroscientific MET4 (air pressure, temperature, humidity).
- Planned launch and initial calibration period at OOI Southern Ocean array—prevented by customs strike and shipping delays.

- 2019/20 integrated Nortek Signature ADCP and new LRI profiling winch with 150 m wire.
- Winch profiling scripts developed using python for automated operation.
- Coordination planned with Slocum gliders near Palmer Station—prevented by sea ice.

### Key Lessons Learned:

- Solar power limits high-latitude work to 5 summer season months (Oct–Feb)
- Limited Sensor Durability. Season 1 failures before end of mission included Gill 3-axis sonic anemometer Aanderaa CT, and MET4. Season 2 failures included CTD winch sinker (early), Aanderaa CT (on launch), Gill (intermittent), and Airmar air temperature.
- Profiling CTD winch needs sinker improvements (hydrodynamics and durability).
- GPS heading sensor would improve ADCP accuracy.

*Figure 5: Air–sea flux dependency in the COARE 3.5 algorithms, illustrating the range of values sampled by the Wave Glider surveys. First order dependence of fluxes is on wind speed and air–sea temperature difference, but additional dependence on wave height and relative humidity are also significant.*




## Conclusions

- Sustained presence by autonomous surface vehicles allows simultaneous measurements of wind speed, wind stress (from high-frequency 3-D wind sampling), air–sea heat flux, directional wave spectra, and surface currents.
- Surface vehicle motion is critical to estimate and correct for in most of these measurements.
- Sensor durability is particularly challenging for relative humidity, air pressure, and profiling CTD measurements.

### References

1. Thomson, J., and J. Girton. 2017. Sustained measurements of Southern Ocean air-sea coupling from a Wave Glider autonomous surface vehicle. Oceanography 30(2):104–109, https://doi.org/10.5670/oceanog.2017.228.
2. Thomson, J., Girton, J. B., Jha, R. and Trapani, A., 2018. Measurements of directional wave spectra and wind stress from a wave glider autonomous surface vehicle. Journal of Atmospheric and Oceanic Technology, 35(2), pp.347-363, DOI: 10.1175/JTECH-D-17-0091.1.

### Acknowledgments

1. Funding for this work was provided by NSF grants PLR-1558448 and PLR-1853291.
2. The assistance of the captains and crews of the R/V *Laurence M. Gould* and R/V *Nathaniel B. Palmer*, as well as the many excellent people who support the US Antarctic Program, was invaluable throughout this work.
3. Critical assistance was also given by Liquid Robotics, Inc. (LRI) and the APL-UW wave glider team (including Alex DeKlerk, Ryan Newell, Avery Snyder, and Joe Talbert).