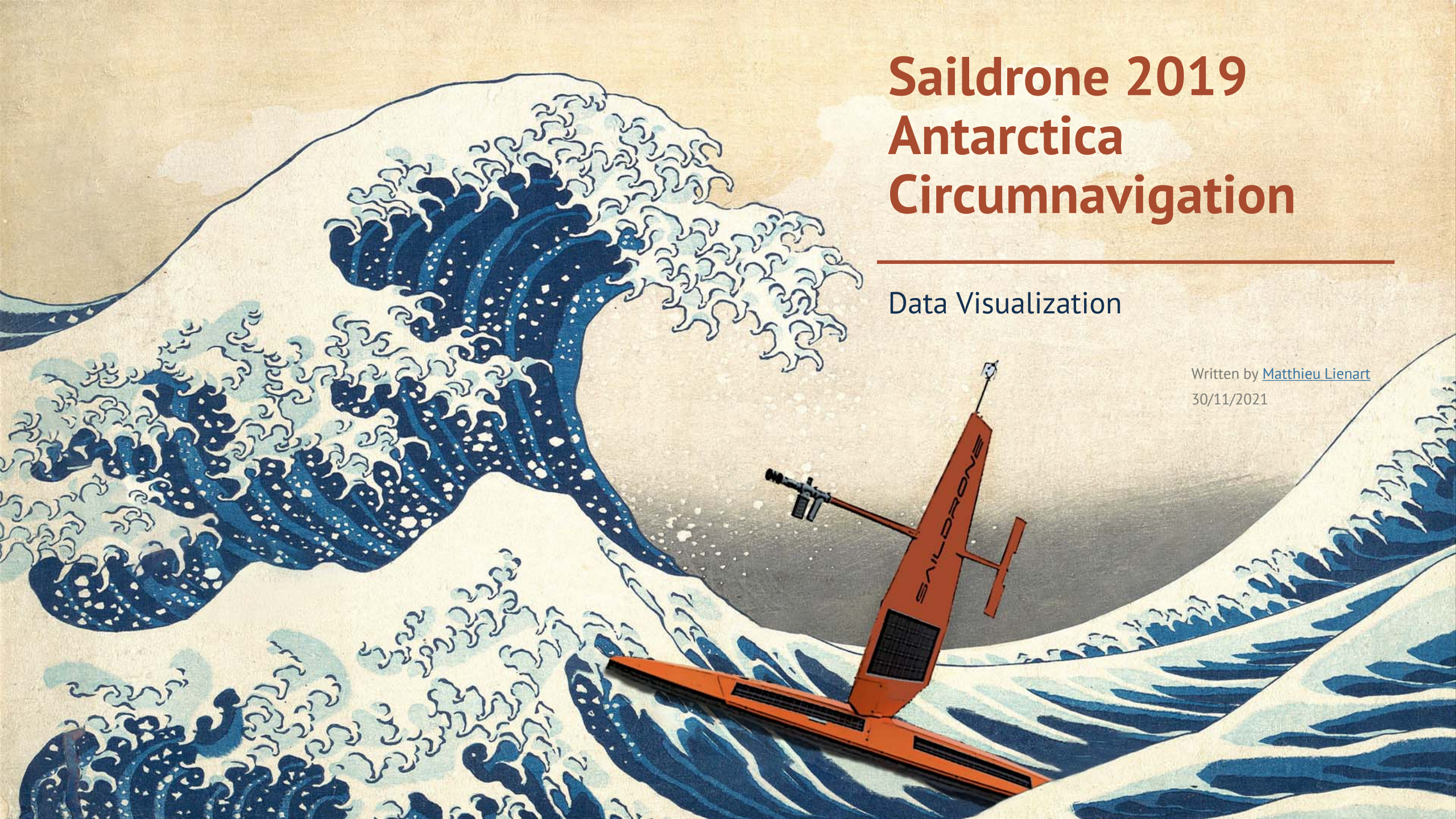
Saildrone 2019 Antarctica Circumnavigation

Data Visualization



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The Mission

Disclaimer

This work is not a scientific research study based on the data collected during the Saildrone mission in Antarctica. It is only a short data visualization project.

This project is also entirely personal. It does not involve or engage the responsibility of any organizations including:

- Saildrone
- My company Amanox Solutions

The Antarctica Mission

In 2019 Saildrone deployed a fleet of three unmanned surface vehicles (USV) around Antarctica. One of the objective of the mission was to gather data for scientists to better understand the Southern Ocean and build better weather and climate models; in particular, measuring the ocean's uptake of CO_2 emissions during the winter months.

Conditions are too harsh in the Southern Ocean during the winter months for scientific expedition ships. The use of Saildrone USVs was thus a unique opportunity to collect new data for scientists in places and times ships cannot visit, "enabling new key insights into ocean and climate processes."[2]

Want to know more about the mission? Read this article.

The Datasets

I used 3 datasets:

- Both the Saildrone USV SD 1020 1-hour and 1-minute surface datasets. They contain the measurements from Saildrone's standard atmospheric and oceanographic sensor suite. They are available here.
- The NOAA dataset. It contains measurements from NOAA's pCO2 sensor suite. It is available here.

Data Manipulation

Data points with missing latitude, longitudes or observations have been ignored.

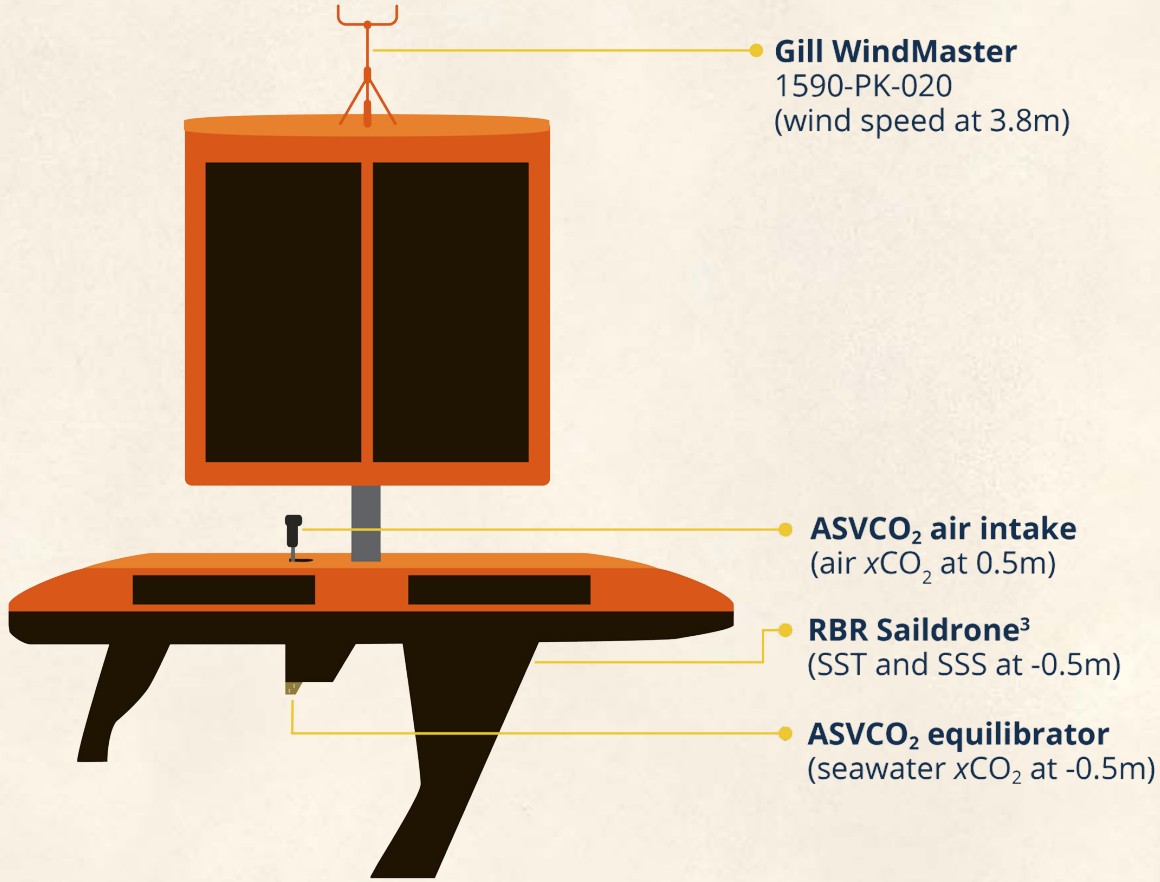
About This Work

Unless mentioned, all the visualizations, graphical design, image and color editing are my own. Visualizations and calculations were computed using python in a Jupyter notebook available here.

How USVs Measure CO_2 Flux

There are several techniques to measure or estimate the CO2 flux, each having a different level of uncertainty.

The ocean's CO_2 flux is best measured by calculating the difference between direct sea and air CO_2 pressure measures. Saildrone USVs "address these observational challenges through remote surveying in harsh conditions with direct measurements of air-sea CO_2 pressure and wind speed"[3].



This Schematic diagram of the 2019 Southern Ocean Saildrone Unmanned Surface Vehicle (USV) is from Geophysical Research Letters, volume 48 publication[3]

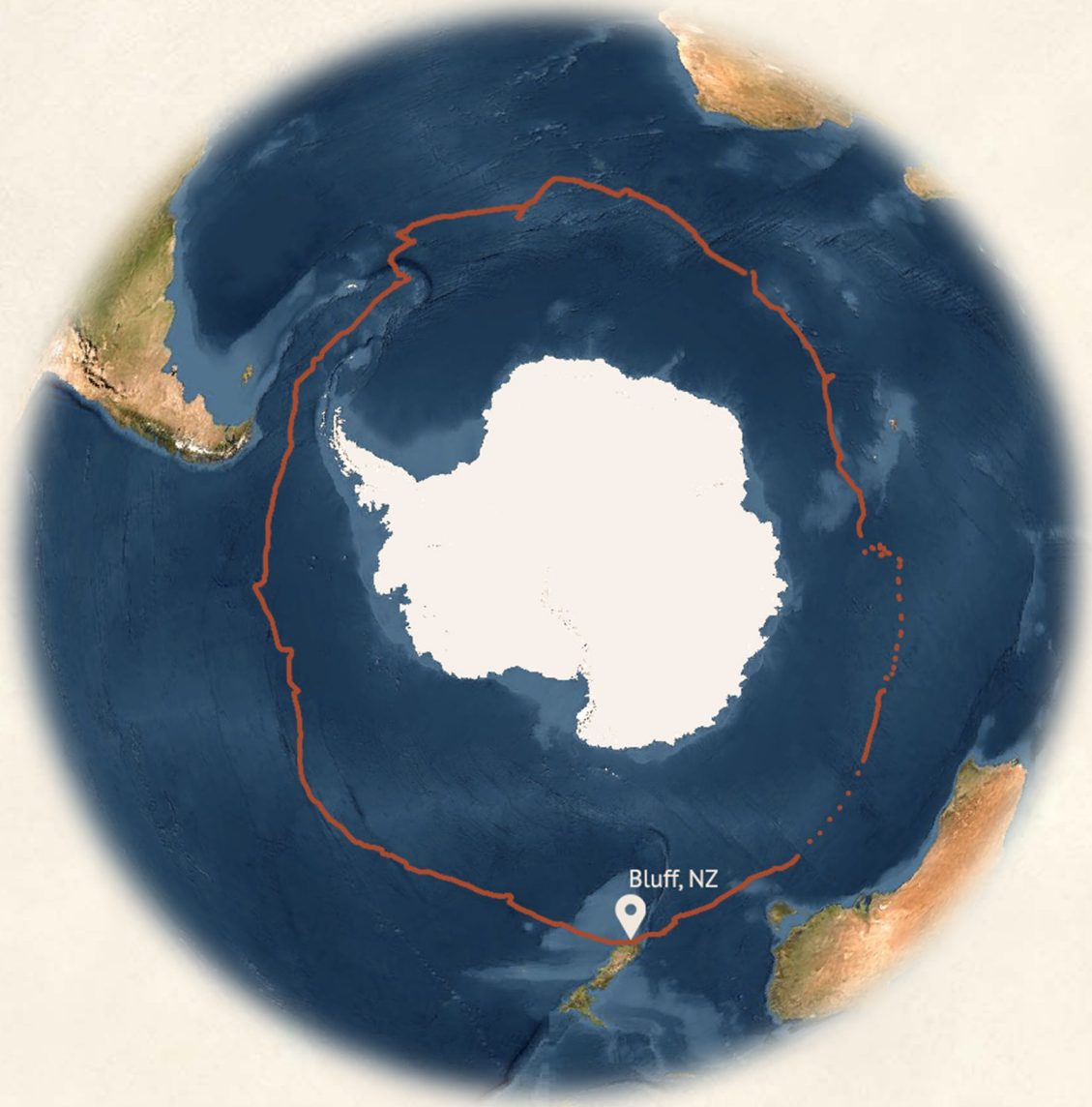
The Sailing Cruise...

The 3 Saildrone USVs left Southport in Bluff, New Zealand on January 2019. While 2 USVs had to quickly turn around for repair, the remaining one returned to port in August of the same year completing the first unmanned circumnavigation around Antarctica.

28,328* kilometers

196 days

* Calculated by summing the pairwise haversine distance between all the data points. Due to the coastline paradox, it makes a big difference compared to the announced 22,000 km.



… Was a Tough Journey

When launched, one of the USV was equipped with a rugged square wing specially designed “to deal with the huge forces of being rolled and submerged” [2] by the Southern Ocean’s breaking waves.

The other two USVs were equipped with the toughened regular Saildrone wing. In the first few days of the mission, they both suffered storm damage and had to sail back to port for repair before being redeployed with square wings.

Storms, howling winds, giant waves, freezing temperatures, the data show that the mission around Antarctica was not a pleasant cruise, even for drones.

5*

number of storms faced

31.9 m/s*

max gust wind speed

= “violent storm” on the Beaufort scale[4]

11.95 m

max wave height

-0.76°C

min air temperature

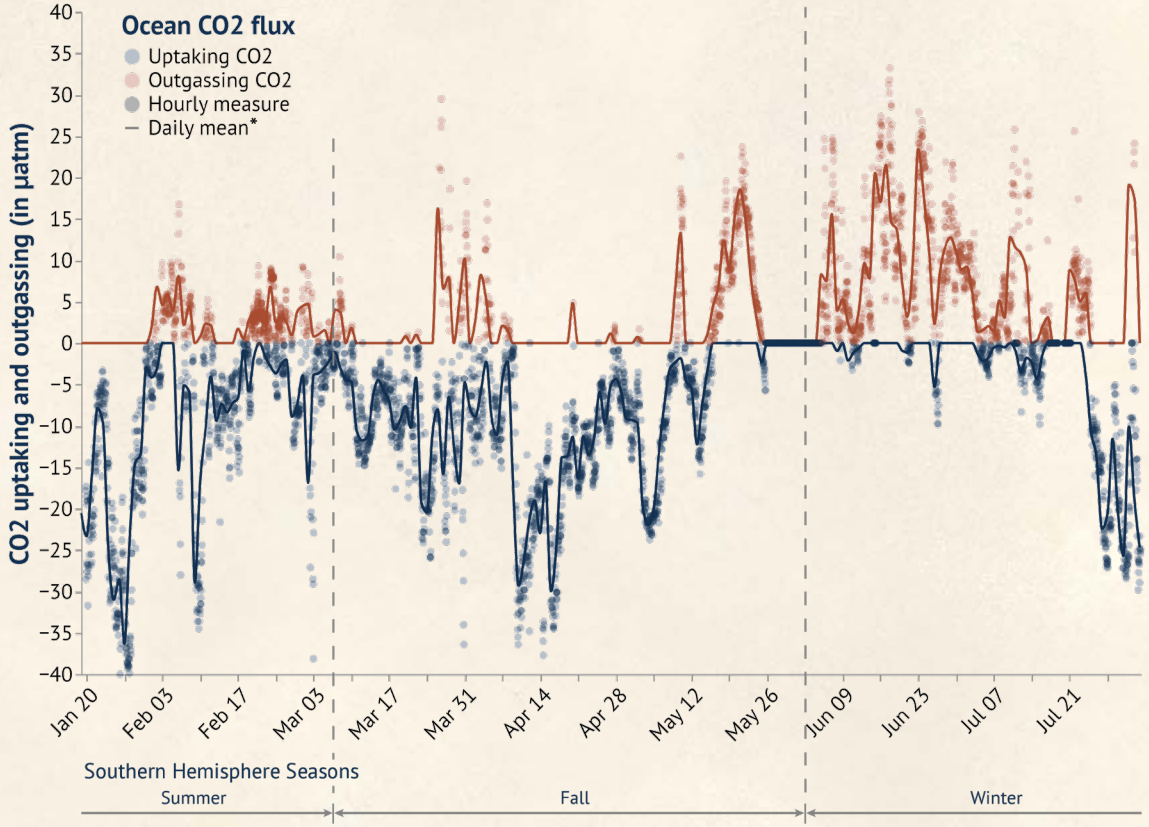
* The USV anemometer was damaged in March 2019, providing only 3 months of wind speed measurements. The number of storms was thus calculated based on the number of periods with wave height > 9 meters (according to Beaufort scale)

Southern Ocean CO_2 Flux

The data collected during the mission, show CO_2 outgassing throughout, but was prevalent during the southern hemisphere late fall and early winter.

According to A. J. Sutton et al. [3], the measures performed by the Saildrone USV, challenge the idea that the Southern Ocean is as a strong carbon sink than traditionally considered.

The Southern Ocean was Outgassing CO_2 Mainly During Late Fall and Early Winter



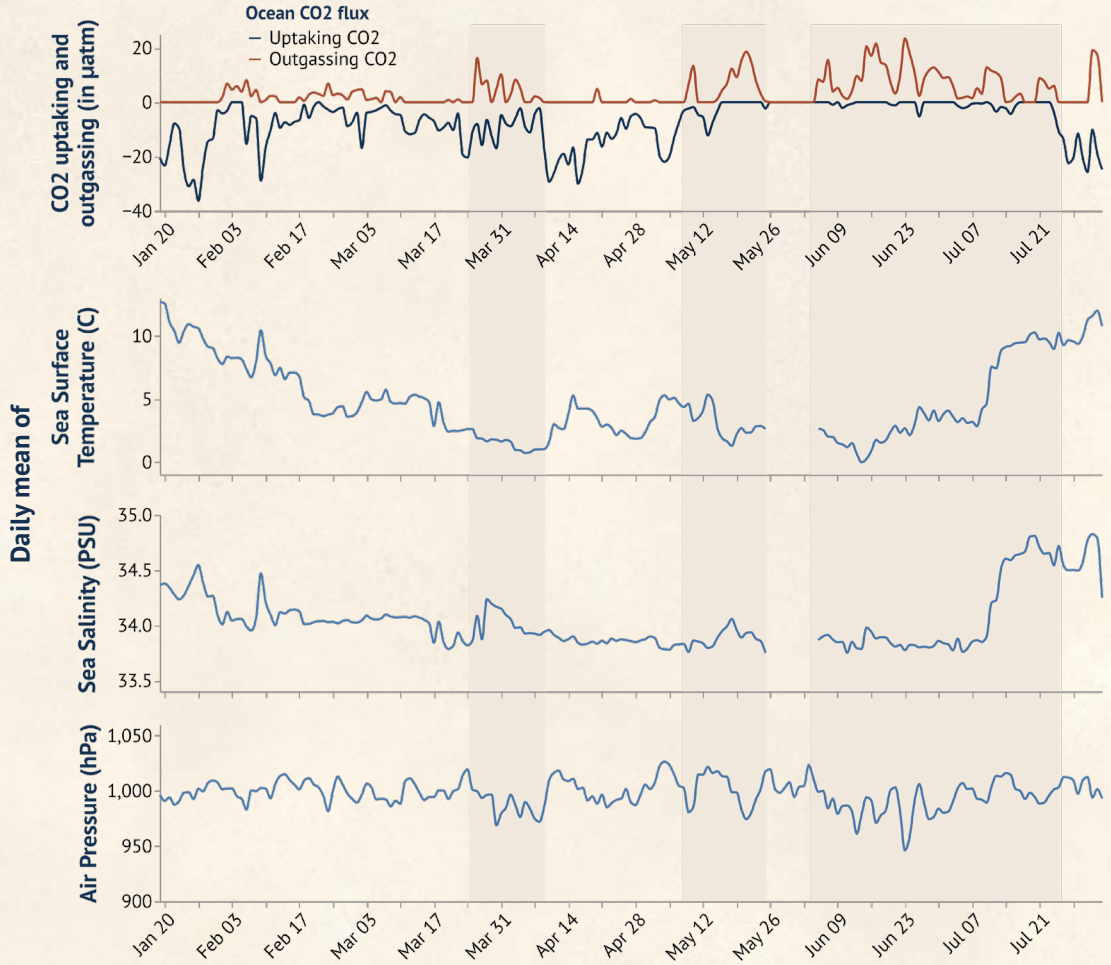
* For the mean lines, missing data points are zeroed-out

Factors Influencing CO_2 Flux

Although CO_2 outgassing appears prevalent during colder seasons the correlation between CO_2 outgassing and sea temperature is not obvious. A simple comparison of the variation of CO_2 flux with other environment factors show no obvious correlation with any of them. The question remains thus opened.

The Southern Ocean is estimated to account for 40% of the global ocean carbon uptake, and climate change is predicted to further impact the ocean's role of a carbon sink[3]. Getting more insights through such missions, into the oceans' role in the climate system, seems crucial for scientist to better understand and model the changes that await us.

No Clear Correlation With Other Factors



* CO_2 uptaking and outgassing daily means have been zeroed-out for missing data points

References & Credits

References

1. “Saildrone in the Southern Ocean”. *Saildrone*. https://vimeo.com/565674133. Accessed on 21st November 2021.
2. “Unmanned Vehicle Completes Antarctica Circumnavigation”. *Saildrone*. http://www.saildrone.com/news/unmanned-vehicle-completes-antarctica-circumnavigation. Accessed on 21st November 2021.
3. A. J. Sutton, N. L. Williams, B. Tilbrook. “Constraining Southern Ocean CO2 Flux Uncertainty Using Uncrewed Surface Vehicle Observations”. *Geophysical Research Letters*, 48, e2020GL091748. https://doi.org/10.1029/2020GL091748. 19 January 2021.
4. “Beaufort scale”. *Wikipedia*. https://en.wikipedia.org/wiki/Beaufort_scale. Accessed on 21st November 2021.

Credits

- The front page and graphical theme of this presentation is a personal edit of the woodblock print 神奈川沖浪裏 (Under the Wave off Kanagawa) by ukiyo-e artist Hokusai
- The schematic diagram of Saildrone on page 3 is from A. J. Sutton et al. Geophysical Research Letters (2021) publication[3]
- Icons come from Microsoft PowerPoint standard icon library, except for the buoy which comes from Font-Awseome icon library