Application of the Cloud-based Data Match-up Service to examine the dependence of surface wind speed and wind curl on the intensity of marine heat waves

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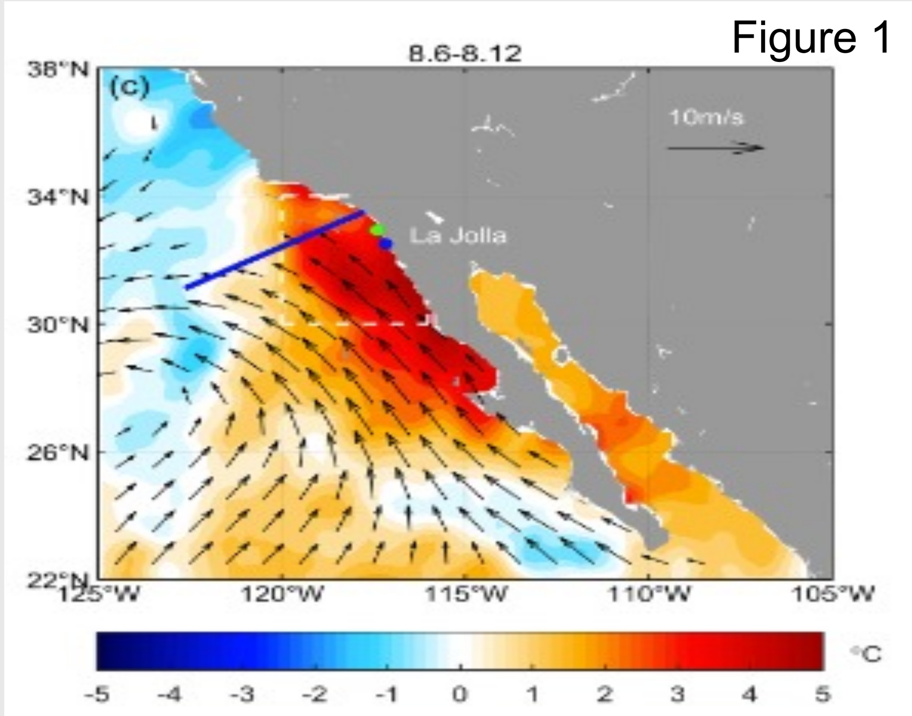
MOTIVATIONS

I. In the summer of 2018, a marine heat wave of anomalously warm sea surface temperatures (SSTs) persisted for several months in the Pacific near Baja California.

Figure 1



SST anomalies demonstrating the heat wave, overlayed by the MERRA-2 derived wind anomaly in August of 2018 [from Wei et. al, 2021]

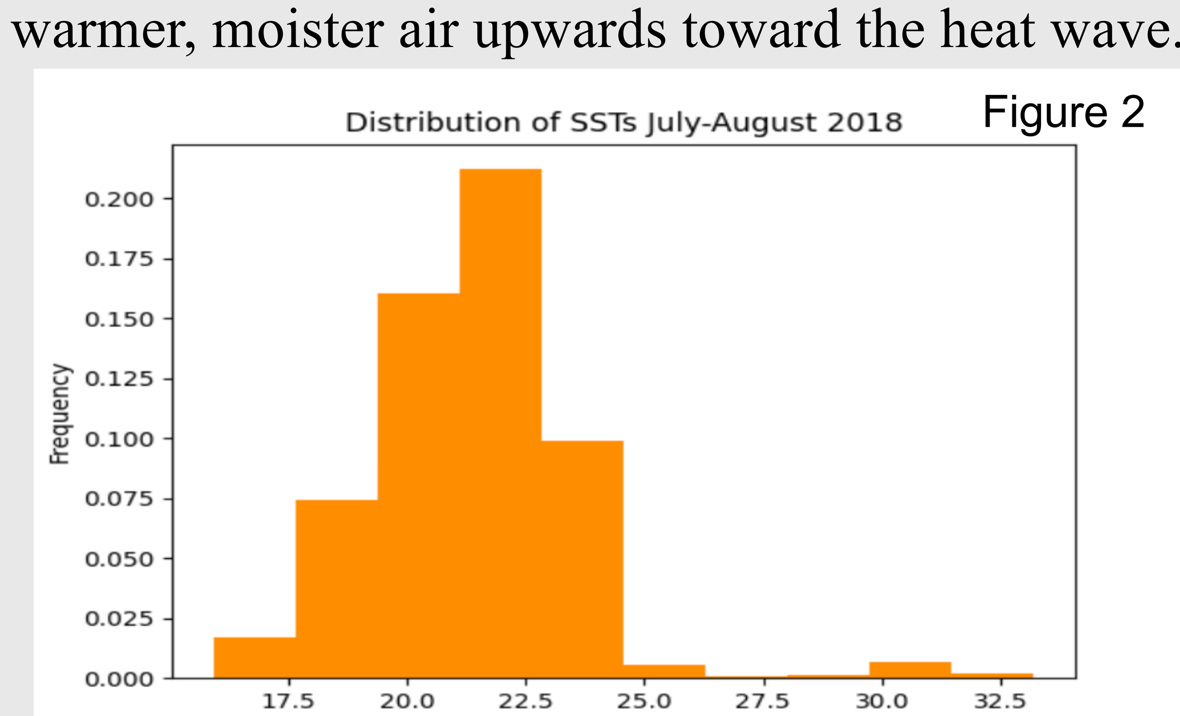
II. These anomalies can cause harmful algal blooms, fishery disasters, and disrupt marine ecosystems.

III. Using a collocated dataset of SST points and their corresponding wind points, we can investigate a possible dependence between this anomalous heating and two different weather processes:

1.) **Wind speeds:** Light winds could play a role in positive SST anomalies due to reduced upwelling and mixing of cooler waters and increased solar heating relative to heat loss from evaporation.

2.) **Vorticities:** Anomalous negative wind circulation could lead to the advection of warmer, moister air upwards toward the heat wave.

Figure 2



This PDF represents the recorded SST values in the time and spatial range of the datasets used for this investigation.

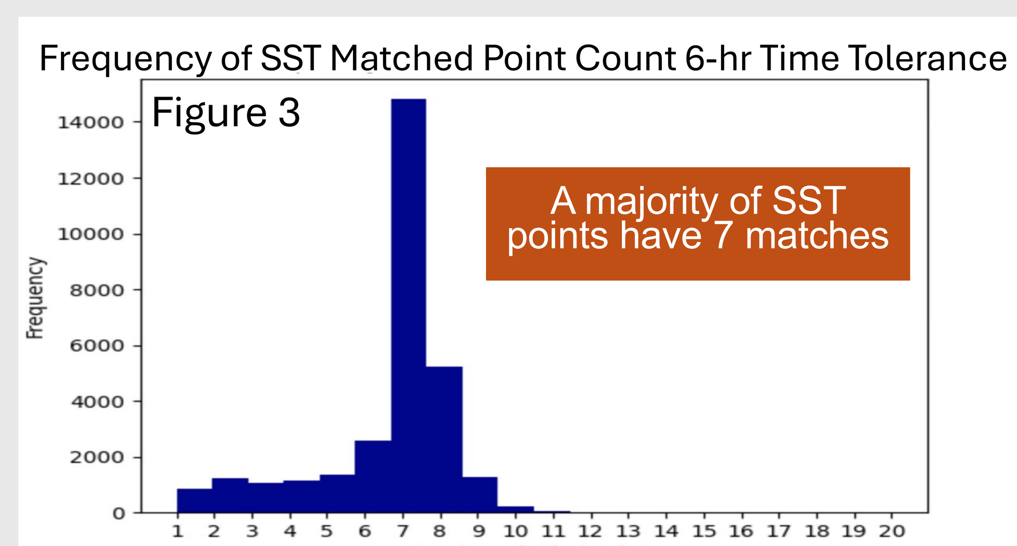
METHODS

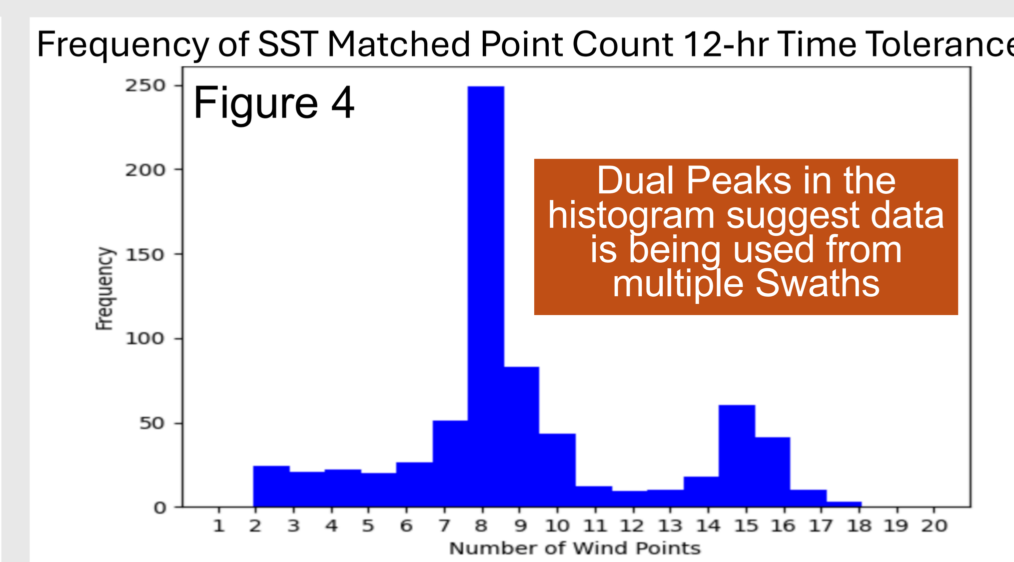
COLLOCATION

I. CDMS data are used to match satellite wind and SST data near the coast of Baja California; wind data are collected from KNMI's ASCAT-B dataset, and SST data are collected from GHRSST's MUR L4 dataset. The following criteria are used to match data in this investigation:
- Dates between 07/01/2018 - 09/30/2018
- Located from 26˚N – 24˚N and 114˚W-122˚W
- A time tolerance of 6 hours
- A radius tolerance of 18.75 km from the SST point

II. All data points that meet this criteria are determined to be relevant to the collocated dataset and are matched into a "one-to-many" array of multiple winds to one SST.

III. The 6-hour time tolerance avoids the matching of wind points from multiple swaths to one SST point because winds from different swaths led to poor vorticities. See figs. 3 and 4.

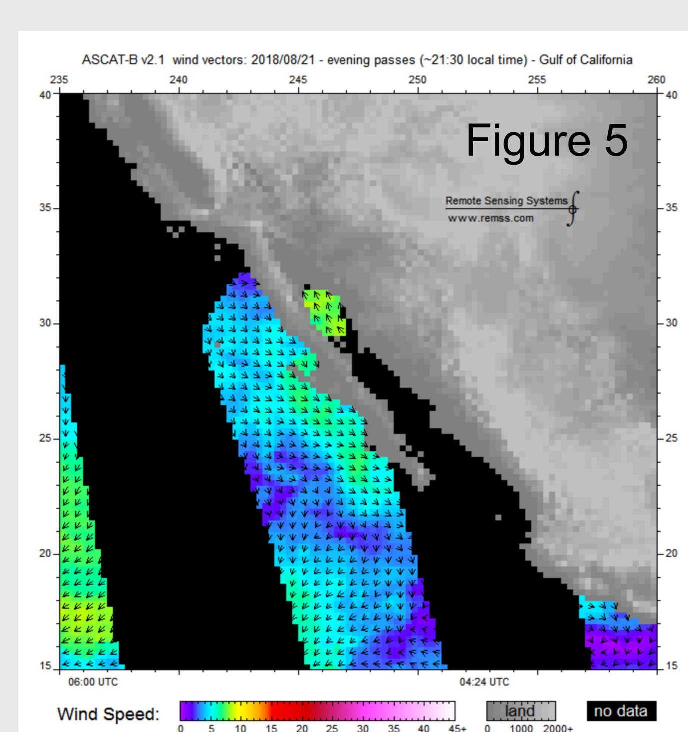


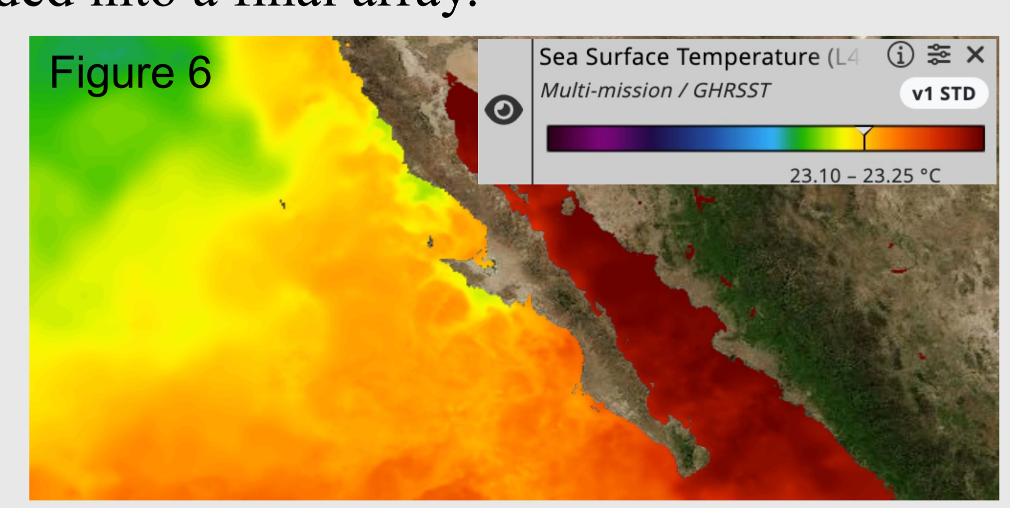


VORTICITY CALCULATION

I. The code iterates through each matched set and starts by choosing the four closest wind points to the SST point and assures that their locations enclose said SST point. It then orders the wind points in a clockwise rotation based on their coordinates and calculates the circulation around the SST point. Vorticity is calculated as circulation divided by the area of the shape the wind points make around the SST point.

II. All these vorticities are then added into a final array.





These two images show examples of the data being matched by CDMS. Fig.5 shows the wind speeds recorded from satellite swaths, fig.6 shows the SST data on the same day.
Fig.5 from: https://www.remss.com/missions/ascat/
Fig.6 from: https://soto.podaac.earthdatacloud.nasa.gov/

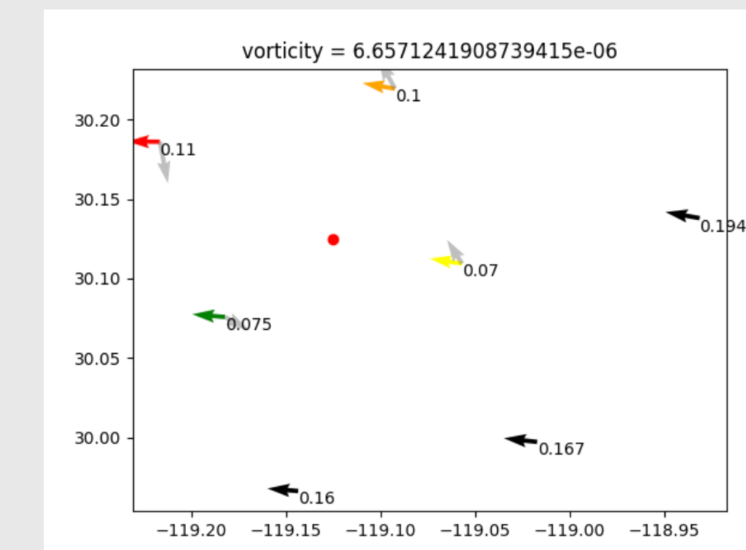
COMPARISON

I. Two sets of probability distribution functions of SST are made, one displaying PDFs for ranges of wind speeds, and the other displaying PDFs for ranges of vorticities. The different variable ranges are indicated by color.

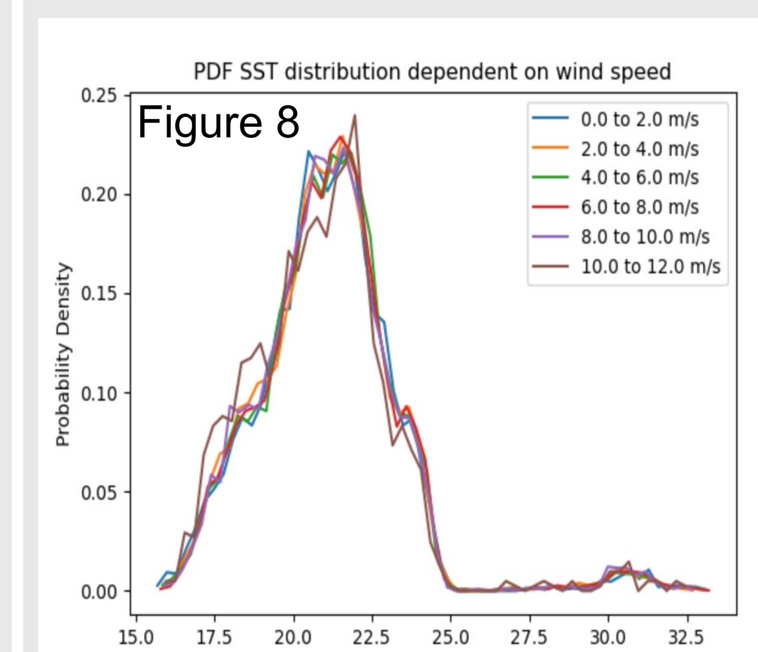
II. Shifts of these curves across the ranges of variables will demonstrate any dependence between the variables and increasing SSTs.

METHODS CONTINUED

I. Fig. 7 displays the program's process for calculation:
- Only the four closest points to the SST are colored
- They are ordered in a clockwise rotation (red to green)
- The grey vectors represent the anomaly of each vector based on a subtraction of the average of all four chosen vectors.

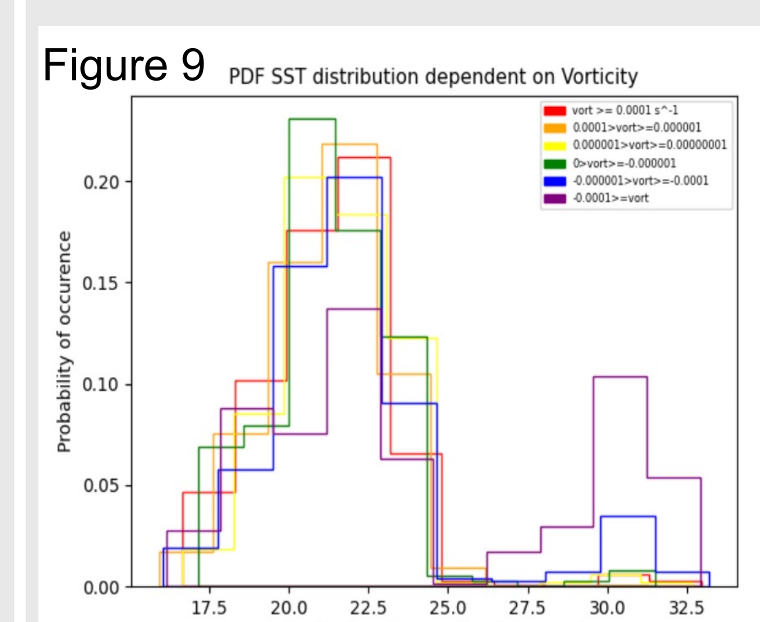


CONCLUSION



I. There is no dependence on wind speed (fig.8): the SST distributions are similar for all wind speeds.

II. There is a shift in the curves at the most extreme SSTs (fig.9): the negative vorticities increase in magnitude and the corresponding SSTs have more positive extremes.



III. Increasingly negative vorticity could be due to either high pressure systems or, (more likely based on fig.1) increased offshore winds combined with coastal friction.

Vision for the future: This case study of the marine heat wave in Baja California can be repeated for other heat wave events.

ACKNOWLEDGEMENTS

Thank you to Mark Bourassa and Shawn Smith for guiding this research and giving me the opportunity to be a part of this project.
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REFERENCES

Wei, X., Li, K., Kilpatrick, T., Wang, M., Xie, S., 2021, Large-Scale Conditions for the Record Setting Southern California Marine Heat Wave of Augus 2018, *Geophysical Research Letters*, **48**, 3, https://doi.org/10.1029/2020GL091803.