Ground Validation of Remotely Sensed Sea Surface Temperature Data

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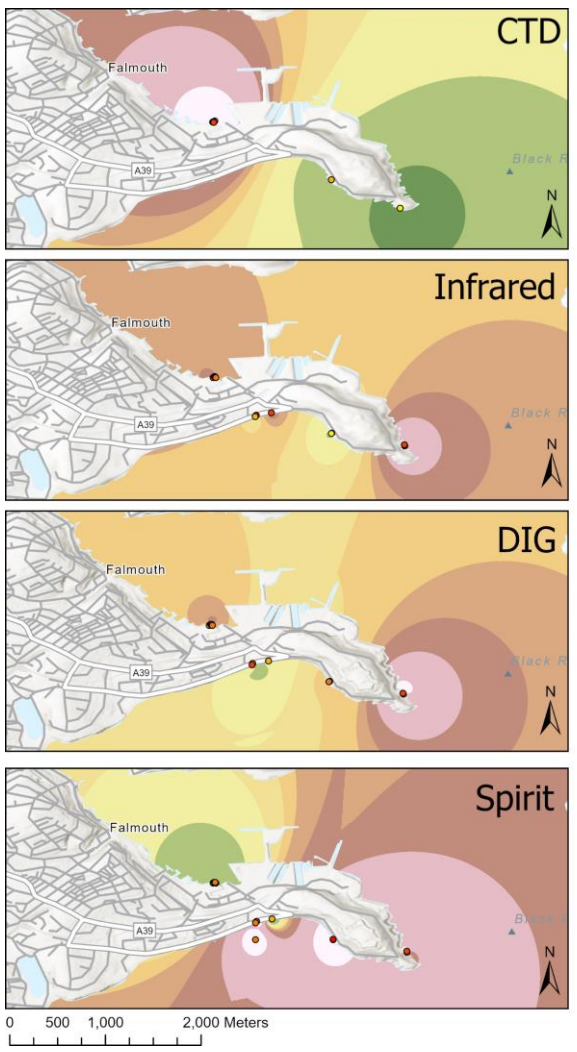


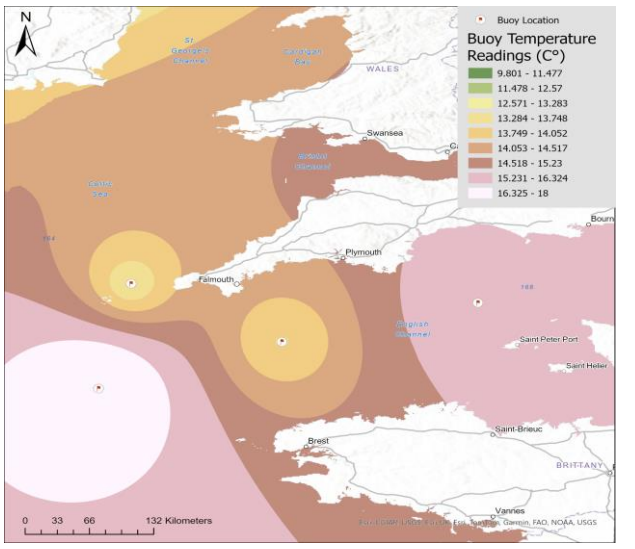
Aims & Introduction

Within remote sensing there is no such thing as 'truth', only validated data. The quest in remote sensing is to determine how well the data represent real processes aka "the truth". (Braun, 2024)

Sea surface temperature (SST) has been used as an indicator for the planet's warming due to the ocean's ability to capture and re-distribute heat energy. (Embury, 2024) Validating the methodologies used to capture SST is essential. To do this, we compared remotely sensed SST readings from satellites and buoys, as well as field captured readings from canvas buckets, spirit thermometers, infrared thermometers, digital temperature probes, and a CTD, and then compare the accuracy and precision of each method against each other to highlight discrepancies and similarities. Both methods record SST but through different means.

Method

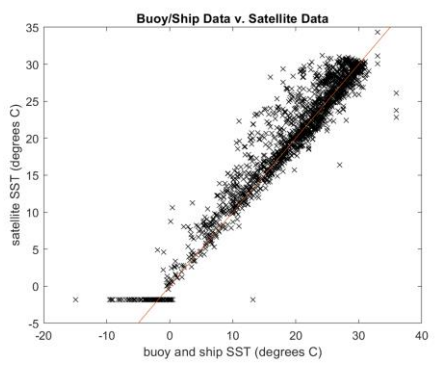
1. Ingest data remote sensing data from satellites and buoys into MATLAB and generate baseline values and infographics.
2. Process field data from multiple groups using Excel. Import processed data into ArcGIS, plot each method's temperature readings onto a map, then utilize spatial analysts' interpolation method to generate heatmap based on each point data's temperature value.
3. Compare each individual method's figure to visualize temperature measurement discrepancies.

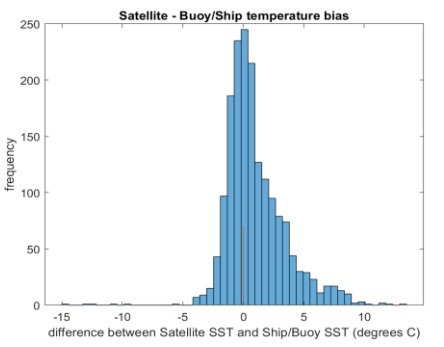


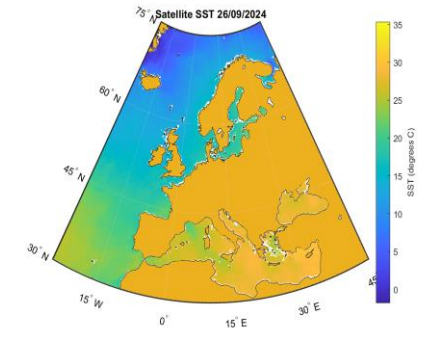
Results

Satellite readings indicate a temperature of 16.9 C offshore of Falmouth on the day of ground validation. Comparing this to the Buoy readings which report between 14.1-14.5 C. The digital probe (DIG) delivered an average of 16.6 C, The IR readings averaged 16.40, and the spirit 15.4. The CTD returned an average 16.5 but had the greatest variability in site readings, the first test site measured much hotter than the second and third.

The digital and infrared temperature probes were the closest results to the satellite data and looking at the consistency of their readings on the map we can see that they are somewhat similar to each other over the study area. The CTD while similar in average temperature does show a different story of high variability between testing sites compared to the other methodologies. The spirit thermometer trended much hotter later in the day compared to the first testing sites.







Precision & Accuracy

- The CTD measurements showed higher accuracy but lower precision.
- The infrared and digital were somewhat accurate and precise.
- The spirit thermometer lacked accuracy and precision for this experiment.

(Helmenstein, 2014)

Conclusion

Different field validation techniques exhibit significant variability between methods, and more metadata is required while working in the field to better process and visualize results after collection. Satellite and buoy methods are more accurate but lack granularity especially when dealing with areas as small as the AOI for this experiment. The process for presenting this data would work better with far more data points, when translating point values to visual georeferenced ones more data helps reduce inaccuracies.

Discussion

Remote Data

- Captured using Microwave-IR radiometer at 9km resolution. Microwave radiometry improves through-cloud measurements and is combined with the higher spatial resolution of Infrared. (Wentz et al, 2000)
- Diurnal warming is estimated and removed using 'baseline SST' to lessen the impact of daytime-nighttime temperature biases, which can reach almost 3C in difference. (REMSS, no date)
- Buoy temperature data is harvested from moored buoys with probes located at about 1 meter depth placed in regular intervals; ships of opportunity also help deliver readings. (Elipot et al, 2022)
- Both datasets interpolate data into a continuous grid from point values. This introduces error the further distance a reading is from a point value. (Reynolds et al, 1994)

Ground Validation Data

- Canvas bucket depth and time in the water was not recorded
- Metadata was lacking on some data points, specifically on whether readings were gathered from the canvas bucket or not. Data that could not be collated into one category or the other was omitted.
- Some data points were improperly georeferenced, those were omitted for this analysis.
- For interpolation between data points of each ground truthing method, the Empirical Bayesian method was deployed to account for error in the heat map visualizations. (Gribov et al, 2019)

References

- Alexander Gribov a, et al. "Empirical Bayesian Kriging Implementation and Usage." *Science of The Total Environment*, Elsevier, 15 Feb. 2020, www.sciencedirect.com/science/article/pii/S0048969720308007.
- Braun, Adreas Christian. *Sage Journals: Discover World-Class Research*, 2024, journals.sagepub.com/doi/10.1177/16094069231205789.
- Elipot, Shane, et al. "A Dataset of Hourly Sea Surface Temperature from Drifting Buoys." *Nature News*, Nature Publishing Group, 14 Sept. 2022, www.nature.com/articles/s41597-022-01670-2.
- Embury, Owen, et al. "Satellite-Based Time-Series of Sea-Surface Temperature since 1980 for Climate Applications." *Nature News*, Nature Publishing Group, 29 Mar. 2024, www.nature.com/articles/s41597-024-03147-w.
- Helmenstine, Todd. "What Is the Difference between Accuracy and Precision?" *Science Notes and Projects*, 16 Aug. 2021, sciencenotes.org/what-is-the-difference-between-accuracy-and-precision/.
- "Microwave Oi SST Product Description." *Remote Sensing Systems*, www.remss.com/measurements/sea-surface-temperature/oisst-description/. Accessed 14 Nov. 2024.
- Reynolds, Richard W., and Thomas M. Smith. "Improved Global Sea Surface Temperature Analyses Using Optimum Interpolation." *AMETSOC*, American Meteorological Society, 1 June 1994, journals.ametsoc.org/view/journals/clim/7/6/1520-0442_1994_007_0929_igssta_2_0_co_2.xml.
- Wentz, Frank J., and Dudley Chelton. *Satellite Measurements of Sea Surface Temperature through Clouds*. 2000.