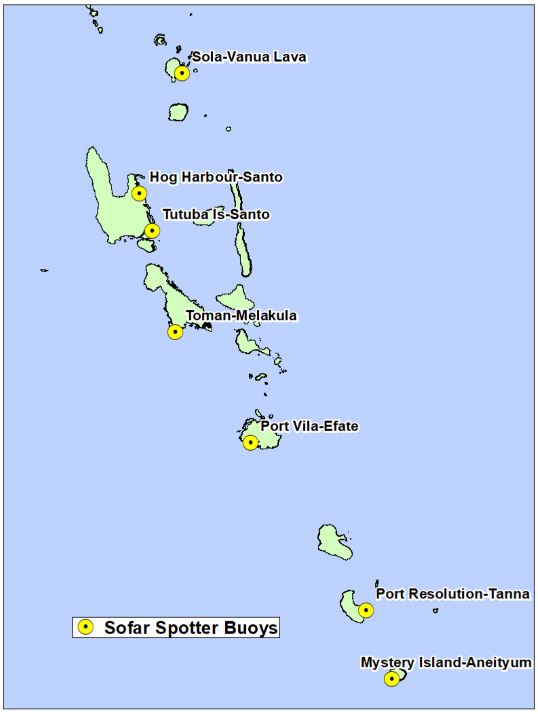
Ocean monitoring: Sofar Spotter buoys

FACTSHEET

This factsheet provides technical information on Sofar Spotter buoys and how they are used in Vanuatu for ocean monitoring to generate real-time observational data and information on key physical climate and environmental conditions such as wave height.

An ocean monitoring buoy network has been deployed across the Vanuatu archipelago by the Van-KIRAP project to monitor how climate change is affecting the ocean; in particular the inshore coastal environment.

This network serves multiple purposes including to provide early warning to communities and key agencies of impending climate-related events[1], as well as to provide real-time observational data to validate climate and ocean model outputs, and to generate application-ready future climate data for informing hazard-based impact assessments. Critical data and information on ocean, wave and surface temperature conditions is disseminated by Van-KIRAP and the Vanuatu Meteorology and Geo-hazards Department (VMGD) in the form of Climate Information Services (CIS) products to a wide range of sectors like fisheries, aquaculture, maritime transport, tourism and natural disaster management for policy development, management planning and associated decision-making purposes.



The buoys have been deployed at inshore coastal sites around the Vanuatu archipelago including Sola, Vanua Lava; Hog Harbour, Santo; Tutoba Is, Santo; Toman, Melakula; Port Vila, Efate; Port Resolution, Tanna; Mystery Island, Aneityum.

Sofar Spotter buoys

The Van-KIRAP project identified the 'Sofar Spotter' ocean monitoring equipment as fit-for-purpose technology and, in 2023, commissioned six of these buoys as the country's first ocean coastal climate hazard monitoring network. The data gathered by the buoys allows the VMGD and the Department of Fisheries to issue early warnings to sectors and local communities on ocean conditions, especially for ocean waves and marine heatwaves. However, the data from this monitoring network will also improve understanding of future climate change impacts, including projections of extreme sea level events and coastal inundation (e.g. wave-driven storm surge) and erosion. In practice, real-time data and information from the buoys is sent to the Vanuatu Department of Fisheries and VMGD via satellite. These data are also shared with climate change researchers, engineers and other technical specialists for undertaking more detailed, spatially explicit analysis of current and future climate change impacts.

The buoys have been deployed following the practical guidelines developed by CSIRO for the Australian defence force [2], with the mooring consisting of various buoys and tether lines connected to anchors on the sea floor.

---

[1] Recognising the critical requirement for high-resolution, real-time ocean monitoring, many countries have been investing heavily in coastal ocean data buoy networks for many years. For example, the United States National Buoy centre has hundreds of active coastal ocean buoys (ndbc.noaa.gov), and Australia has also recently coordinated its coastal buoy network (imos.org.au), with observations available from online databases. The Data Buoy Cooperation Panel (DBCP) is an official joint body of the World Meteorological Organization (WMO) and the Intergovernmental Oceanographic Commission (IOC). It consists of the data buoy component of the Global Ocean Observing System (GOOS).

The Pacific, the Earth's largest and most climatically important ocean, has remained a relative "blind spot" to ocean data networks. PacIOOS and other organisations have been working towards fixing the Pacific "blind spot", though efforts remain heavily weighted towards northern hemisphere and/or developed country-affiliated Pacific states.

In the past, wave buoys have been briefly deployed in Vanuatu national waters. In the early 1990s buoys supported a Norwegian study, and more recently a study on coastal processes in Erakor Lagoon, Efate Island 1. But these buoys were not owned by Vanuatu and no long-term monitoring was established.

Faivre, G., et al., Coastal processes within a coral reef lagoon system: Erakor lagoon, Efate Island, Vanuatu. *Journal of Coastal Research,* 2020. 95(SI): p. 1427-1432.

Below is a photo of the mooring builds ready for deployment in Mandurah.

Figure A.1 Mooring build ready for deployment

2.2 S-Tether Mooring Configuration and Sizing

Below is a diagram of the main features of the mooring configuration developed, with the main sizing considerations.

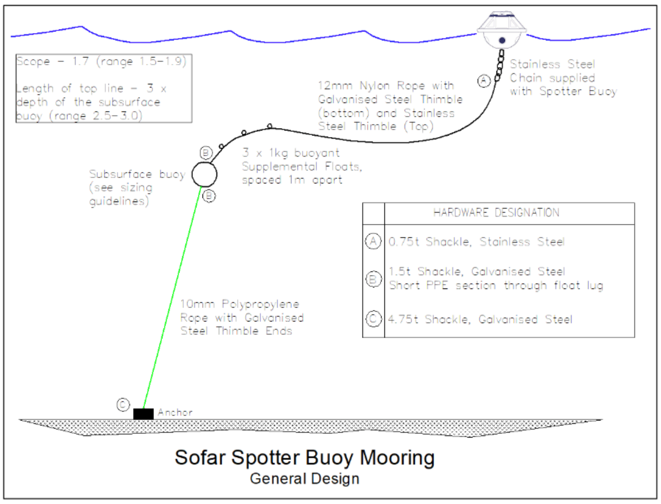


Figure 1 Van-KIRAP and Department of Fisheries staff deploying the buoy (top), The Sofar Spotter Buoy (bottom). Source for Sofar Spotter Buoy Mooring general design: Sofar dashboard

Ocean observation data output

Sofar Spotter buoys measure various observational data featuring a complete description of wind-waves (height, period, direction, etc.), sea surface temperature (SST), and atmospheric (barometric) pressure, and can be integrated with other sensors. The data are transferred in near-real-time via satellite and can be accessed via a customised, digital web-based dashboard being developed by Van-KIRAP for VMGD, Department of Fisheries and other Vanuatu stakeholders.

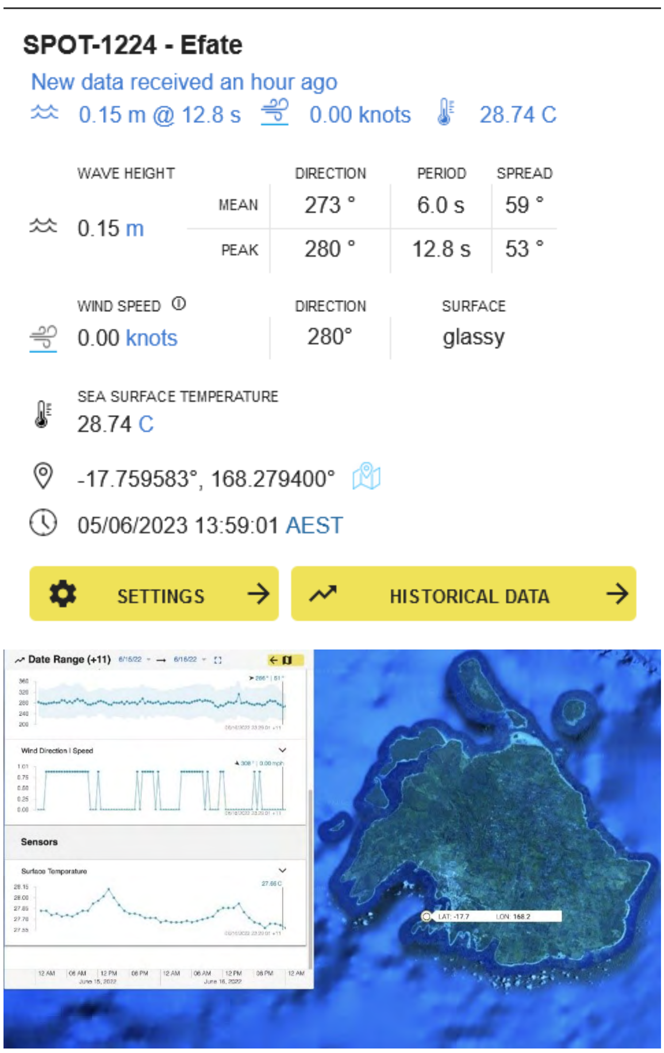


Figure 2 Spot-1224 Efate spotter buoy data records wave height, wind speed and sea surface temperature (right). Source: Sofar dashboard

A recent example of wave height data relating to tropical cyclones (TCs) was recorded by the Sofar Spotter buoy deployed off Port Resolution, Tanna. This captured the 2023 TCs Judy and Kevin compound extreme events (both Category 4 storms tracking more-or-less identically through Vanuatu within a couple of days of each other), noting the twin peak wave heights recorded of between 4–5 metres (Figure 3).

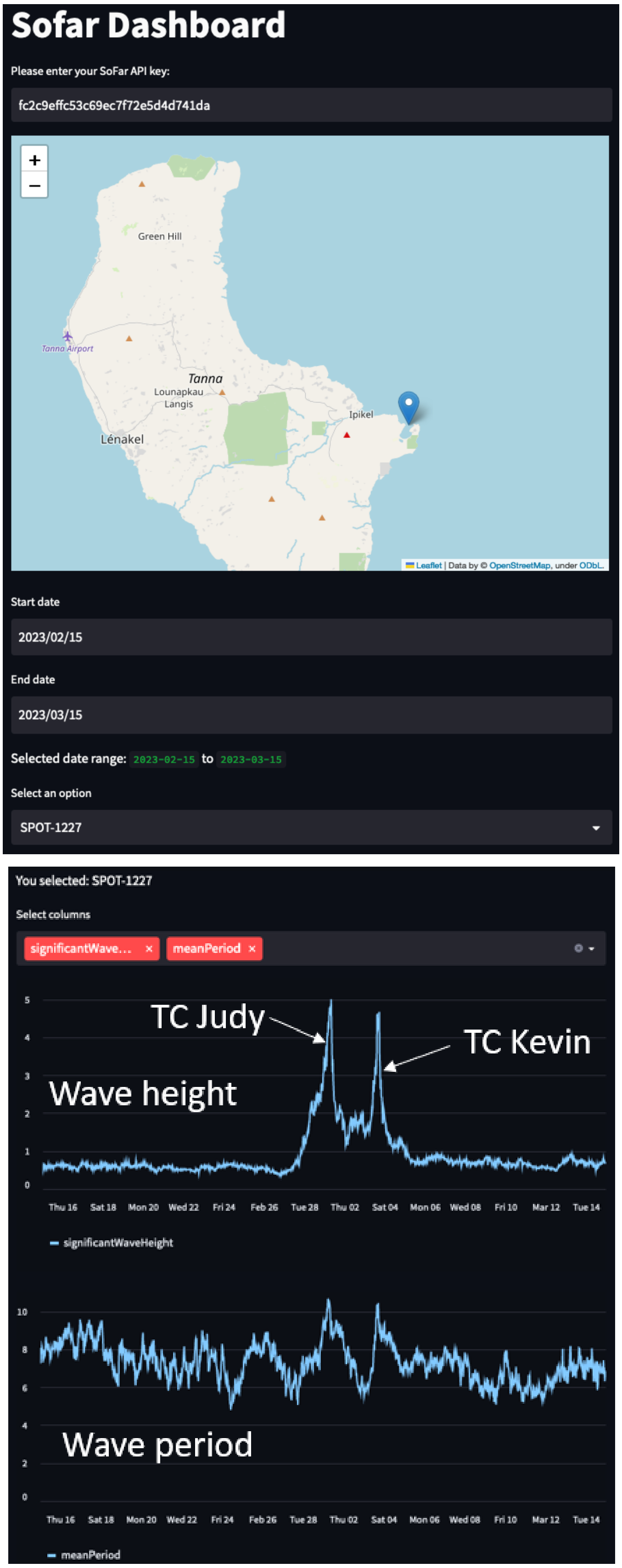


Figure 3 Sofar Spotter buoy (SPOT-1227) wave height and wave period output for Port Resolution, Tanna for the period 15th March–15th April, 2023 recording impact from TCs Judy and Kevin. (Credit: software being developed by CSIRO).

In future, integration of Sofar Spotter buoys could be undertaken with other sub-surface instruments being deployed as part of 'smart moorings' (where all of the attached instruments are connected via the Sofar Spotter buoy to the same satellite link), e.g. higher accuracy water temperature, chemistry and/or water level sensors, to make the monitoring more comprehensive, accurate and fully integrated. In particular, ocean chemistry monitoring such as for pH, turbidity/Chlorophyll a, dissolved oxygen etc., will become increasingly more important for understanding vulnerability of ocean organisms to climate change, including the effects of marine heatwaves, ocean acidification and coral bleaching in the Pacific [3] (see [Ocean acidification factsheet]).

Comparing monitoring buoy data with other observational data sources

Ocean observations provided by monitoring buoys enable more spatially explicit, higher resolution climate information and data to be produced and compared with similar observational data from other sources (e.g. global gridded satellite-derived data). Many different weather and climate models are being run by different scientific institutions around the world to generate forecasts and projections of future climate over different timescales, but the models' output data are required to be validated by observational information. For instance, model simulated storm wave and storm surge data can be used to assess how much worse sea level rise and coastal inundation may be in the future. These types of events have been simulated for TC Pam across Vanuatu using a model developed for the Van-KIRAP project (Figure 4). Without reliable, high resolution ocean observations for validation, it is difficult to know if the model is working correctly and the level of confidence in the projections of future climate and associated impacts.

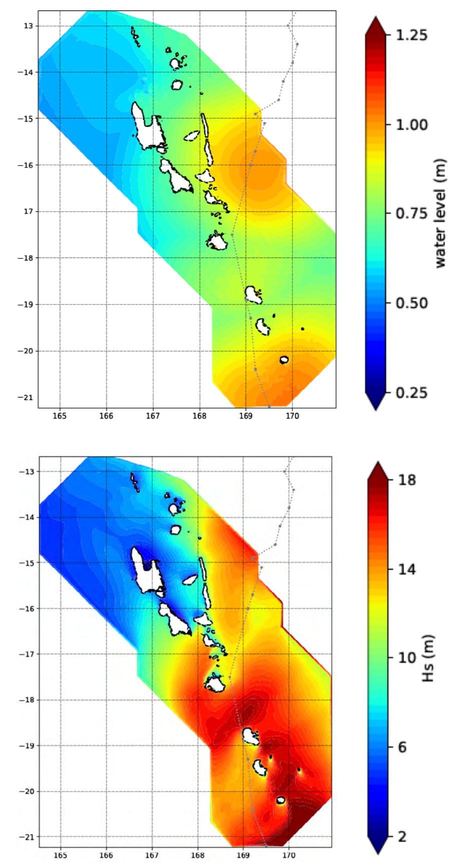


Figure 4 Maximum storm tide (storm surge+tide) heights (left panel) and storm wave heights (right panel) which occurred during the passage of TC Pam through Vanuatu (6–17 March, 2015), as simulated by the Van-KIRAP national SCHISM-WWMIII model. TC Pam's track ([https://www.ncei.noaa.gov/products/international-best-track-archive]) is plotted in grey.

Comparison of hourly Sofar Spotter buoy SST measurements with the larger scale, global gridded SST observations (OISSTv2.1; [4]) confirm the accuracy of latter values obtained at the monitoring buoy locations for Vanuatu (Figure 5). The hourly Spotter buoy data show the density of data that are available, the daily variability, and that the OISST daily mean data largely sit in the middle of the spread of the Sofar Spotter buoy data range (which is expected if they are both appropriately correlated). Comparisons have previously been undertaken with monitoring buoy data for other reefs in the Pacific [5], giving scientists more confidence in the global gridded satellite derived observational data sets used in the related climate model experiments.

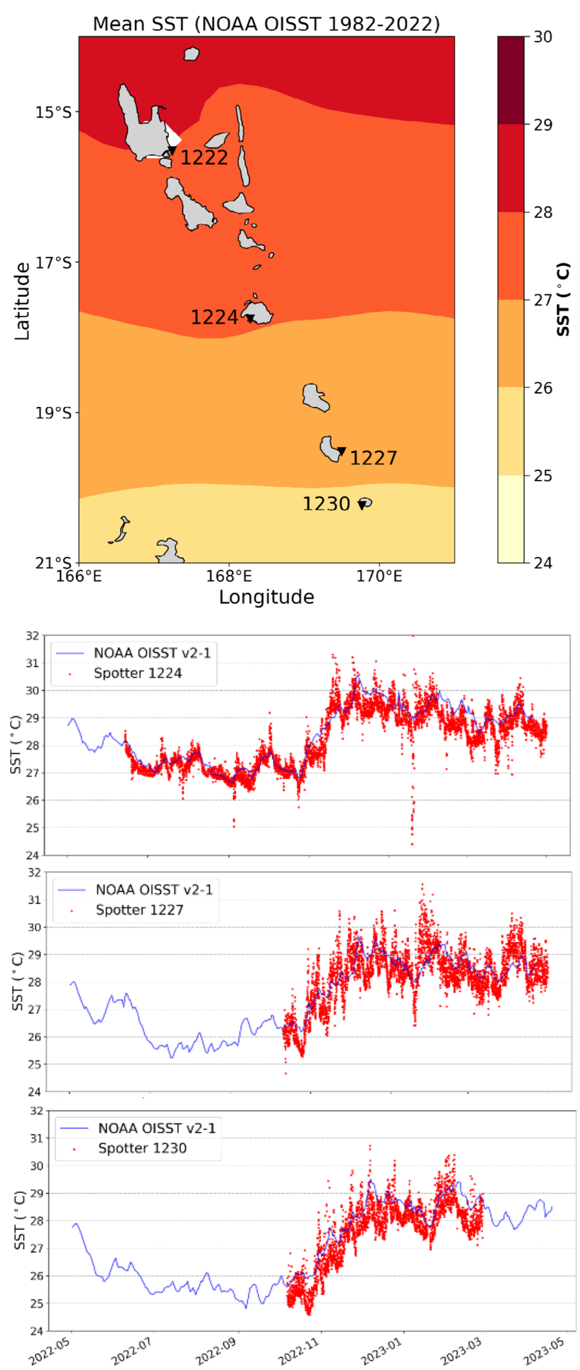
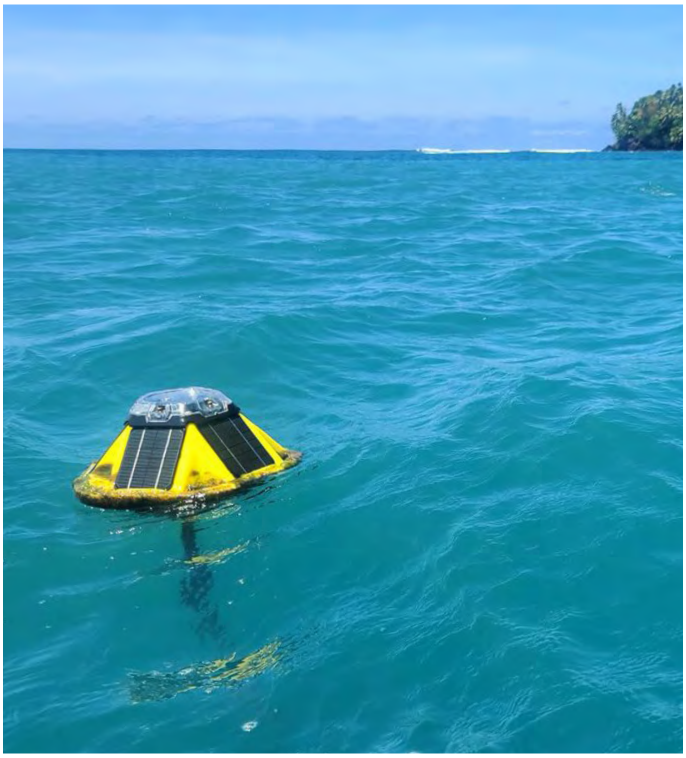


Figure 5 Timeseries (May 2022 to May 2023) of sea surface temperature extracted from the OISST global data set at Spotter 1224, 1227, and 1230 location (blue line), compared with corresponding buoy data (red dots) for four Sofar Spotter buoys in Vanuatu. Data are plotted from buoys deployment date.

For Van-KIRAP, the Sea Turtle, Seagrass, and Coral bleaching infobytes are all informed by global gridded OISST data, with future monitoring work around these species and systems benefitting from the Van-KIRAP monitoring buoy network.



References

1. Faivre, G., et al., Coastal processes within a coral reef lagoon system: Erakor lagoon, Efate Island, Vanuatu. *Journal of Coastal Research,* 2020. 95(SI): p. 1427-1432.
2. Martini, A., et al., *Mooring Design and Operational Guidelines for Lightweight Wave Buoys.* Australia Available from: https://publications.csiro.au/publications/publication/PIcsiro:EP2021-2941
3. Gregor, L. and N. Gruber, OceanSODA-ETHZ: a global gridded data set of the surface ocean carbonate system for seasonal to decadal studies of ocean acidification. *Earth System Science Data Discussions,* 2021. 13(2): p. 777-808.
4. Huang, B., et al., *NOAA 0.25-degree daily optimum interpolation sea surface temperature (OISST),* version 2.1. 2020 Available from: https://psl.noaa.gov/data/gridded/data.noaa.oisst.v2.html
5. Holbrook, N.J., et al., Impacts of marine heatwaves on tropical western and central Pacific Island nations and their communities. *Global Planetary Change,* 2022. 208: p. 103680.

Van-KIRAP Resources

Vanuatu Climate Futures Portal

Guidance Material

Case Studies

Videos

Fact Sheets