IMOS Integrated Marine Observing System

marinematters

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IMOS is extending our monitoring of extreme marine events

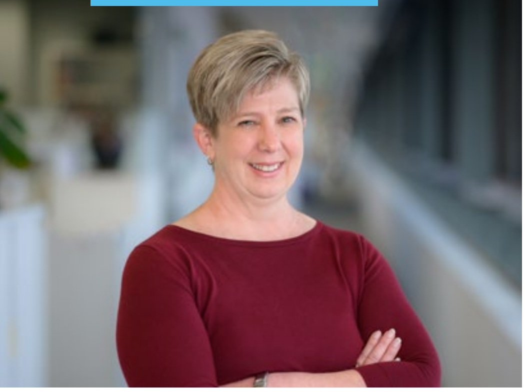
Introducing Tonya Grant: our new Indigenous Partnerships Coordinator

Introducing the Fishing Vessels as Ships of Opportunity sub-Facility

Small scale variability in the wet troposphere impacts the interpretation of SWOT satellite observations

Credit: Nick Thake

director's corner



IMOS acknowledges the Traditional Custodians and Elders of the land and sea on which we work and observe, and recognise them as Australia's first marine scientists and carers of Sea Country. We pay our respects to Aboriginal and Torres Strait Islander peoples past and present.

Welcome to the May 2025 edition of *Marine Matters*

It is a pleasure to provide some exciting updates to the program. The first thing is to welcome our new Indigenous Partnerships Coordinator, Tonya Grant, to the IMOS family. You can learn more about Tonya in this issue – she started in March and is very busy getting to know IMOS as she settles in.

Other new additions to IMOS include transitioning the pilot FishSOOP project into an IMOS sub-Facility. This project began as a collaboration funded by IMOS and the Fisheries Research Development Corporation (FRDC) to deploy temperature/depth recorders on fishing equipment to increase subsurface data. The pilot was a great success and we are now looking at how we can facilitate and scale the collaboration with industry in IMOS. The AODN has also developed a new AusTemp product as part of our drive to uplift our data tools and products for the community. We look forward to seeing its use and uptake in the community.

Recent weather events have helped highlight the value of understanding long-term and episodic ocean changes. In this issue we shed some light on the Ocean Glider Event-Based Sampling sub-facility which is focused on helping understand the implications of events such as marine heatwaves. The agility to collect data during episodic events is critical to understanding the extent and impact of marine heatwaves like the ongoing event in WA. In conjunction with event-based sampling, we also have fantastic tools like OceanCurrent to help visualise changes, including recent monitoring of wave height during TC Alfred which hit the east coast earlier this year. While operating at a longer scale, the recent SOTS voyage brings back much needed data on the state and trends of the Southern Ocean which unpin our understanding of climate and sea level rise. We need to understand open ocean changes to help predict and anticipate changes at the coast, so all of these activities are interconnected and critical to our holistic understanding of state and trends.

In this issue we also highlight research publications, including a recent Science paper revealing the value of plankton to help understand marine biodiversity and relationships between biomass and species diversity. The importance of IMOS satellite calibration and validation infrastructure is also highlighted through a recent publication outlining its use in the recently launched Surface Water Ocean Topography (SWOT) mission. Keeping with the satellite theme, we would like to draw your attention to the student spotlight featuring Andrea Hay's PhD work using satellite calibration and validation data.

Finally, I want to thank everyone who has taken time to contribute and share your stories, updates and information with us. Your efforts and engagement exemplify the relevance and success of IMOS.

I hope you enjoy this edition of *Marine Matters*.

Dr Michelle Heupel
IMOS Executive Director

NEWS

AIMS

Introducing **Tonya Grant**: IMOS' new Indigenous Partnerships Coordinator

I was raised in Ayr Burdekin area (approximately 85kms south from Townsville) known as the sugar cane capital of Australia. Having Yuru, Yidinji and Australian South Sea Islander ancestry drives my efforts in helping First Nations people to meet their local needs. Supporting local Aboriginal and Torres Strait Islander peoples' aspirations is a goal that I hope to achieve working in my role. I believe working in the Australian Institute of Marine Science (AIMS) Indigenous Partnerships Team, in collaboration with IMOS, provides a wonderful opportunity to work in partnership closely with mob to help support them in their responsibility to care for their sea country.

My role as the IMOS Indigenous Partnerships Coordinator will be to actively work with the Indigenous Partnership Team and other staff at AIMS to implement agreed workplans that promote engagement and partnerships within IMOS. I will be working to integrate IMOS into Traditional Owner engagement and partnership work within the AIMS Indigenous Partnership Team. The position will facilitate a two-way communication between IMOS participants and Traditional Owners about marine ecosystems, coastal habitats, ocean processes and Indigenous Knowledge, perspectives and priorities in ocean observing. The role will facilitate Free Prior Informed Consent for IMOS projects and help broker meaningful marine science and IMOS delivery partnerships between Traditional Owners and IMOS.

FUN FACT: I enjoy spending hours sitting with Elders hearing and learning about their stories. You get an insight into how change and progress benefits future generations.

Sentinel-2 Satellite image from 19 February 2025, demonstrates the results of rain from Tropical Cyclone Zelia and its effects on the De Grey River catchment in the Pilbara region of Western Australia.

IMOS is extending our monitoring of extreme marine events

As our oceans continue to change at unprecedented rates, the data collected by IMOS is increasingly important in helping to understand the state and trends of our environment.

The impact of natural disasters currently cost the Australian economy at least $38 billion per year and is projected to rise to $73 billion per year by 2060. However, the environmental impacts are incalculable.

IMOS monitors marine heatwaves in Australian coastal waters with ocean gliders through our Event Based Sampling sub-Facility. IMOS is extending the scope of the sub-Facility to observe marine events beyond marine heatwaves to include river outflows due to floods, marine cold spells and extreme weather events such as tropical storms and cyclones. The number of ocean glider deployments is also increasing from four to eight possible deployments per year.

The ocean gliders provide high-resolution temporal and spatial observations of sub-surface ocean temperature, and their relative portability make them a valuable tool for monitoring extreme marine events. The ocean gliders not only measure temperature but also key bio-physical variables (including oxygen, chlorophyll, salinity) which aids in understanding the growth, peak and decay of these events and their potential impacts on the marine environment.

NEWS

IMOS has set up a national steering committee for the Event Based Sampling sub-Facility who meet monthly to discuss a list of priority indicators, data sources, and tools for monitoring marine heatwaves and now other events, through their growth, peak, and decay phases. The committee reviews and evaluates available evidence and indicators to assess the likelihood of marine heatwave events and the likely geographic regions to be impacted.

The committee has developed a set of principles to aid in the prioritisation of the potential deployment locations and the timing of ocean glider deployments per year.

This priorisation is based on criteria including: predicted impacts including ecological consequences; gaps in our knowledge of the underlying processes; the potential consequences for fisheries, aquaculture and the broader community; likely scale of potential events in both space and time; accessibility to facilities to enable deployment, and the availability of existing and supporting meteorological and oceanographic observations and models.

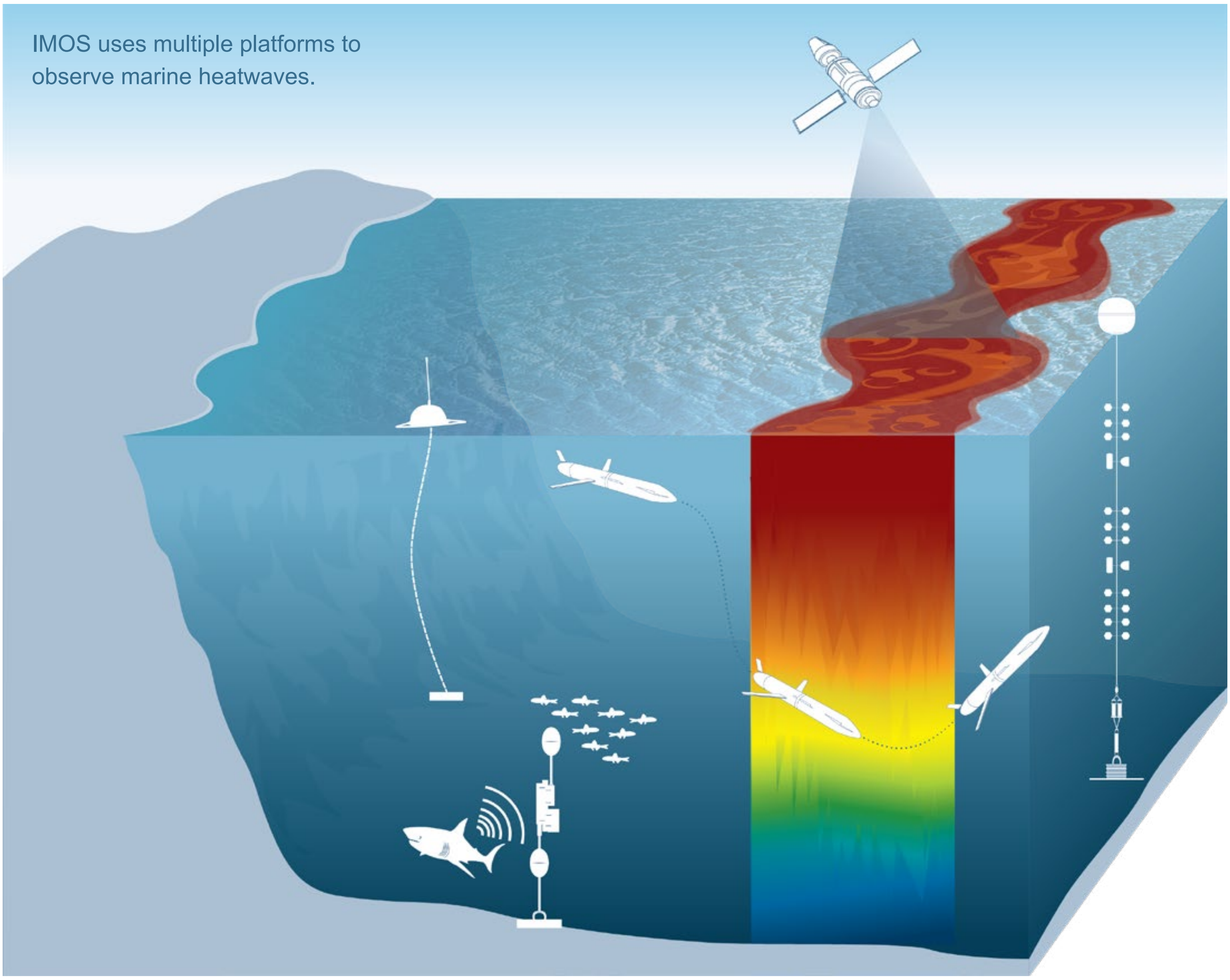
With a high occurrence of marine heatwaves and large-scale river runoff events in recent years the sub-Facility has deployed gliders around the country, with some leveraging routine deployments of the fleet of gliders that IMOS has in the Ocean Glider Facility.

The frequency and scale of these events are increasing with the most recent summer seeing marine heatwave conditions around the country simultaneously impacting several critical ecosystems, fisheries and other biodiversity.

The data collected by the gliders complements data streams from other platforms such as moorings, wave buoys, and remotely sensed data products, to provide a four-dimensional picture of the extreme event by increasing spatial and temporal resolution.

The national Steering Committee includes key stakeholders to ensure representation that captures the complete information pipeline from data creation to end-use. These stakeholders also represent the views of their own stakeholders ensuring the produced data is user-friendly.

The Committee composition provides a pathway for easier and deeper engagement between meetings, ensuring data providers and scientists can be more responsive and provide tailor-made knowledge in near real-time. The Committee is currently growing the number of stakeholders in its membership to build on this approach.



NEWS

IMOS revives and expands ReefTemp as "IMOS AusTemp" for nationwide marine management.

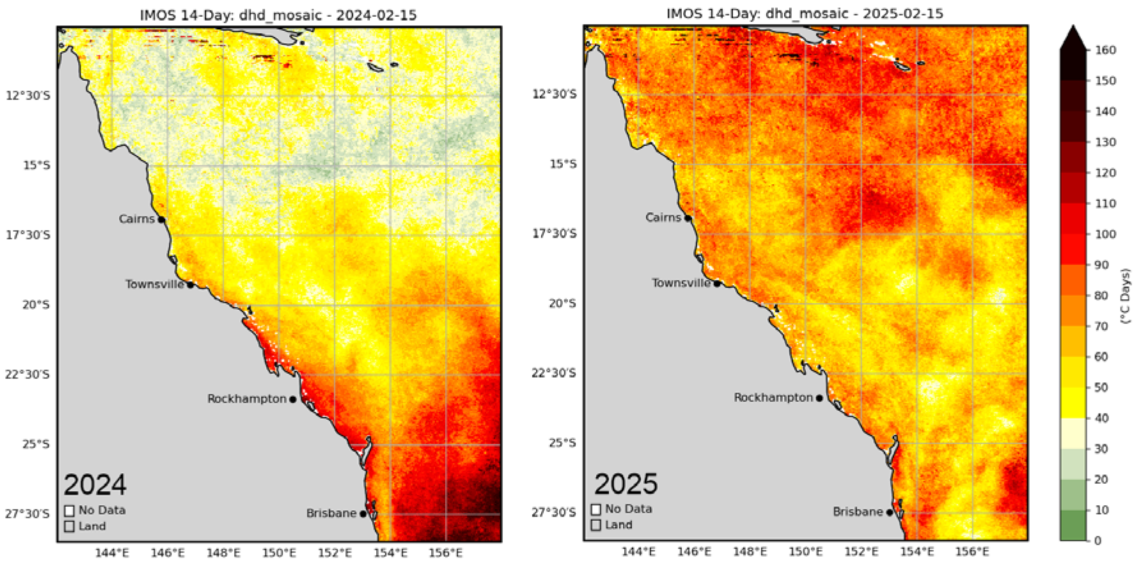
ReefTemp Next Generation was an operational remote sensing application developed by the Bureau of Meteorology to provide sea surface temperature anomalies (SSTa) and a heating stress indicator (Degree Heating Days, DHD). These products were used to assess the risk of coral bleaching over the Great Barrier Reef (GBR). However, ReefTemp was decommissioned in May 2024, leaving a community of users without a valuable tool for managing the GBR.

Starting this past summer, IMOS has re-launched the production of ReefTemp, now called IMOS AusTemp. This product has been expanded to cover the entire Australian marine region. The collection features two main products: Sea Surface Temperature anomaly (SSTa) and Degree Heating Days (DHD), both at a 2 km pixel resolution. These indicators are used to evaluate the heating conditions of the ocean's surface. The DHD measures the accumulation of degrees Celsius above expected climatological values; the more hot days there are—meaning days with temperatures exceeding expected levels—the higher the DHD value. This indicator clearly shows the recent massive marine heatwave affected half of the Western Australia coast over the summer. Additionally, the heating of the Southern Great Barrier Reef in 2024 was also evident.

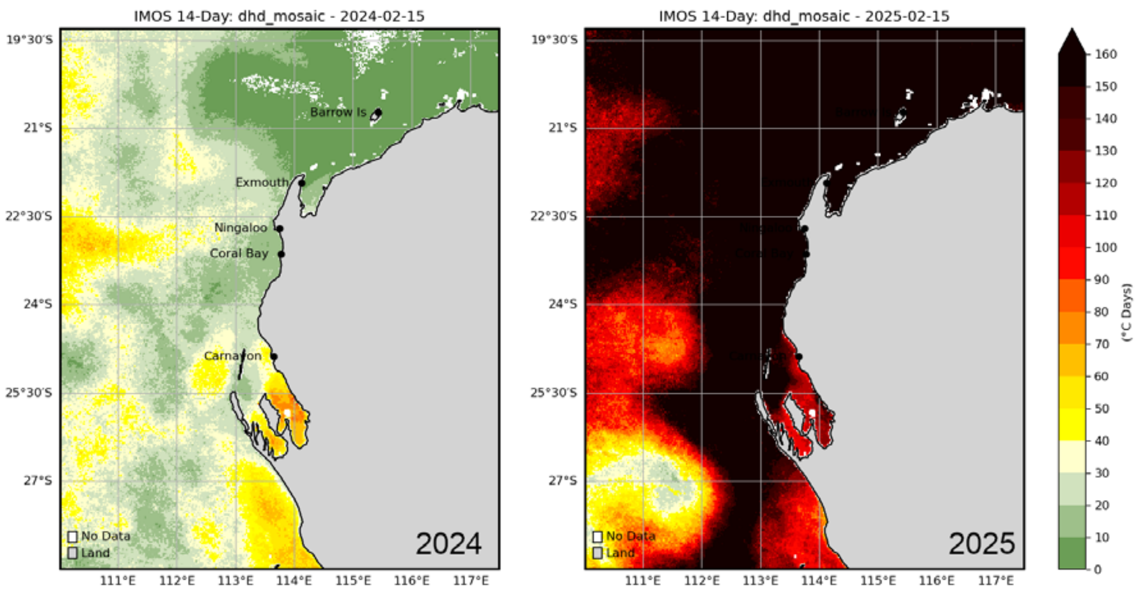
The IMOS AusTemp product is a vital tool for monitoring the state of the ocean and is one of the metrics used to assess the impact of global changes in marine communities. It is available as standard daily netCDF files and in a cloud optimised format. IMOS is dedicated to maintaining this product under its Data Uplift program and generating historical datasets that can be used for managing marine areas and conducting scientific research.

Complete metadata records for SST and Degree Heating Week are available in the AODN catalogue.

Degree Heating Days for the Great Barrier Reef Region. The 2024 showed an extreme heating of the Southern GBR, triggering a massive coral bleaching.



Degree Heating Days for Central Western Australia Region. During the summer of 2025 a massive heat wave impacted most of the area. Field surveys reported massive bleaching of the corals.



Introducing the Fishing Vessels as Ships of Opportunity sub-Facility

MetService NZ

This new IMOS Fishing Vessels as Ships of Opportunity sub-Facility works with the fishing industry to collect near real-time subsurface sea temperature measurements by installing equipment on fishing gear deployed by a network of commercial fishing vessels.

Every day, fishing vessels operate broadly across coastal, shelf and offshore waters within Australia's Exclusive Economic Zone. This IMOS sub-Facility utilises this opportunity to fill data gaps cost-effectively and increase the spatial and temporal resolution of subsurface sea temperature observations in Australia's marine estate.

IMOS is building on the observations originally collected as part of the successful Fisheries Research and Development Corporation (FRDC) funded pilot project FishSOOP (2022-007), which was a partnership between the University of New South Wales, Fishwell Consulting, and IMOS. ■

Making waves in ocean temperature observations

Written by Matt Irwin, Dr. Véronique Lago, and Prof. Moninya Roughan

Large waves off New South Wales in early April gave the surfing community plenty to talk about, including what's thought to be the largest ever wave surfed at Sydney's iconic Bondi beach. Wave monitoring buoys in the region recorded wave heights of 6.3m (Eden), 5.9m (Port Kembla), and 5.1m (Bateman's Bay) (This wave buoy data can be accessed from the AODN Portal). The waves, combined with a king tide and storm surge, also caused damage to properties along the Sydney coastline, forcing some residents in Botany Bay to evacuate their homes.

The increased wave height also showed in some sub-surface observations from the IMOS Fishing Vessels as Ships of Opportunity (FishSOOP) sub-Facility (Figure 1). FishSOOP uses high resolution temperature and pressure (TP) sensors attached to fishing gear to record sub-surface ocean data. The TP sensors were attached to commercial fish traps deployed off Sydney and were submerged before, during, and after the heavy weather (Figures 2–4).

Initially, the data show bottom temperatures warm, but within range for this region and time of year, with modest temperature variation at ~42m depth, and the semi-diurnal cycle of the tides visible as pressure changes corresponding to 1–2m depth change (Figure 1).

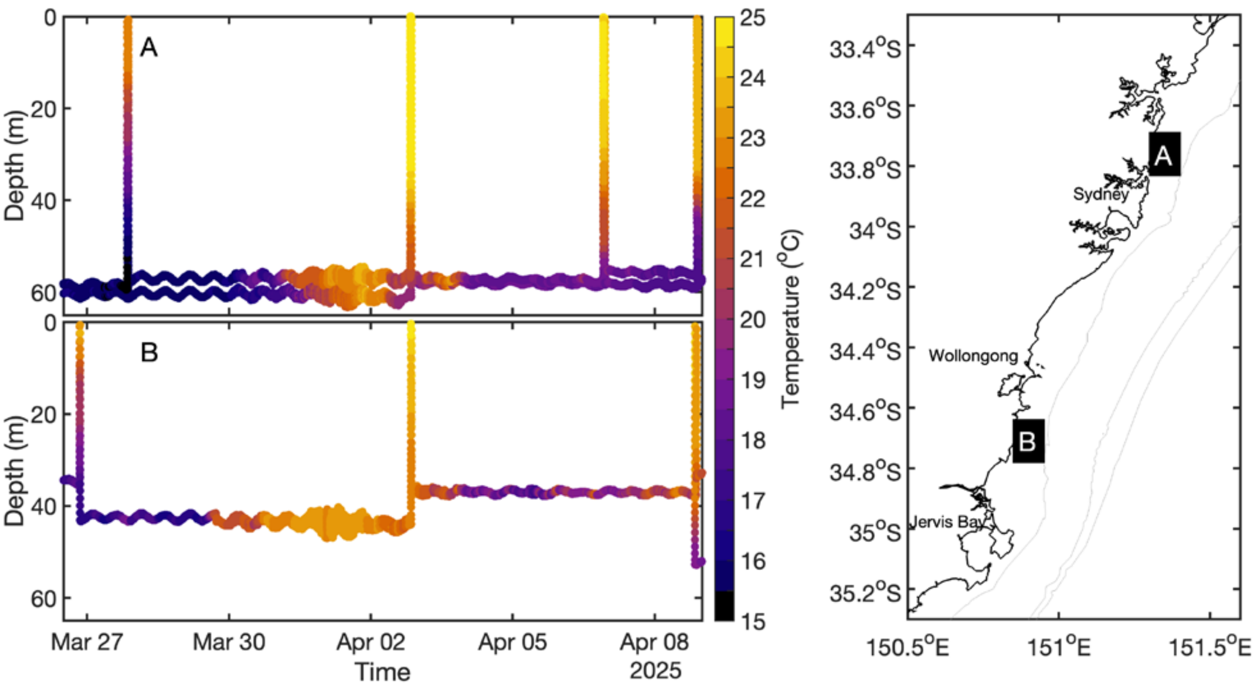


Figure 1. Temperature and depth time series data measured off Sydney's Northern Beaches (A) and Kiama (B) regions.

Figure 2. Temperature and pressure (TP) sensor (Moana) attached to fish trap.

From 30th March onwards however, three interesting changes are associated with the heavy weather:

- Firstly, the bottom temperature increased from 16–17˚C to 23˚C.
- Secondly, there was an overall trend of increasing pressure, indicating that the water column above the sensor was becoming thicker i.e. deeper. This is attributed to the compounding effect of the storm surge (a phenomenon caused by the onshore wind and falling atmospheric pressure), the king tide, and the presence of a large warm core eddy offshore (Figure 3).
- Finally, the variability in pressure readings increased, indicating greater changes in the thickness of the water column above the sensor, which can be attributed to the increased wave height and tide (Figure 4).

The temperature throughout the water column remains warmer following the storm. At the time of writing (late April), the region is still experiencing a marine heatwave along the coast, which began in early March. Following the storm-induced mixing, the water column remains less stratified and bottom temperatures stay warmer then prior to the storm, providing an important insight into the depth penetration of the marine heatwave.

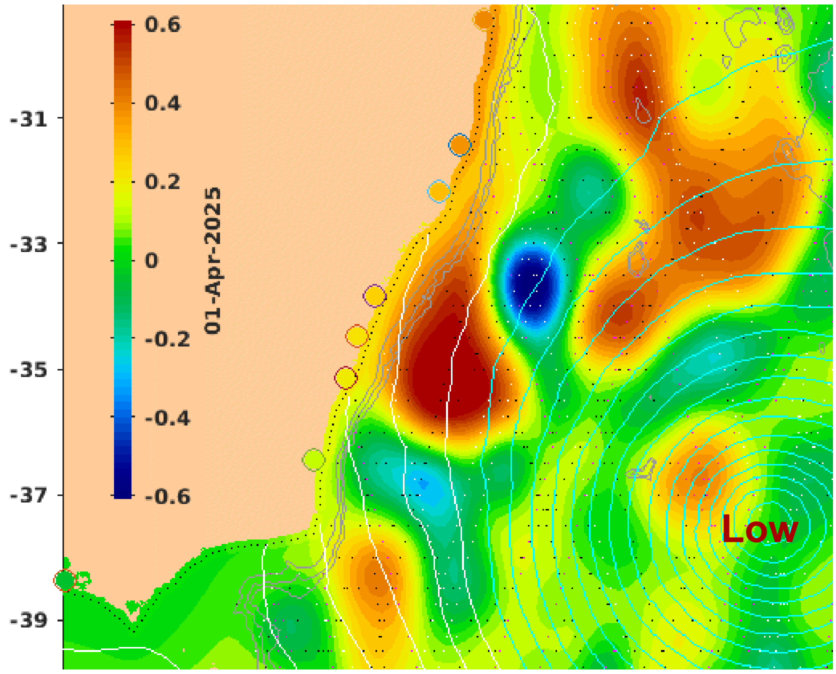


Figure 3. Sea level anomaly data for 1st April 2025 showing an increase in sea level height of 20-30cm close to the NSW coast (and 60cm offshore) due to the storm surge. The centre of the low-pressure system responsible is visible in the bottom right of the image, along with 2hPa isobars. Sourced from IMOS OceanCurrent.

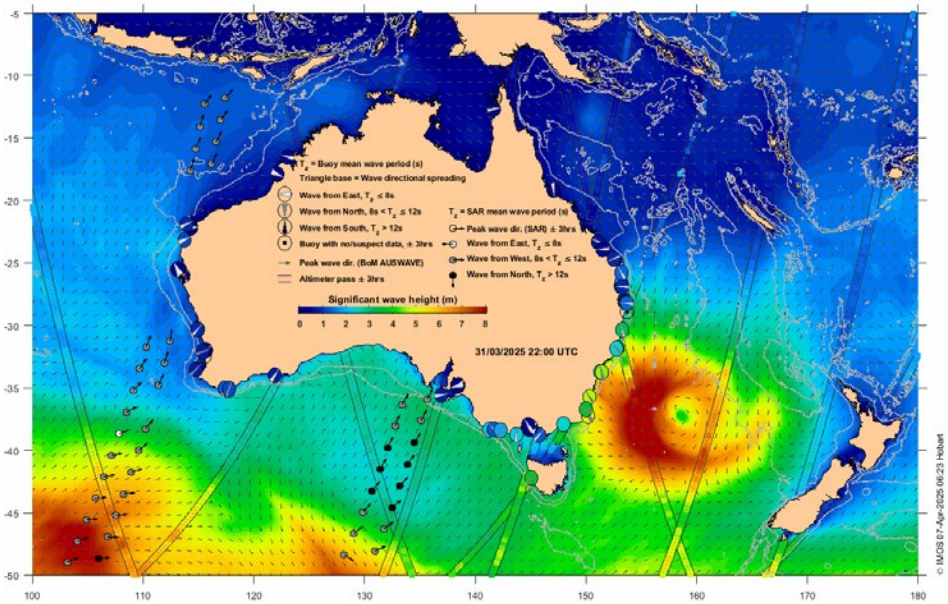


Figure 4. Significant wave height for 31st March 2025 showing signifcant wave heights of 5-6m close to coast (and 8m offshore).

The IMOS Fishing Vessels as Ships of Opportunity (FishSOOP) sub-Facility has instrumented more than 50 fishing vessels around Australia and further afield to gather sub-surface ocean temperature and pressure data. Recent data from the programme is forwarded to the Global Telecommunication System for inclusion in weather models to improve forecasts.

This example indicates the potential insights available through sub-surface ocean observations of pressure and temperature, for example in predicting the depth penetration and impact of storms, and their potential effects on bottom-dwelling marine life. ■

IMOS OceanCurrent wave tool monitors high waves from TC Alfred

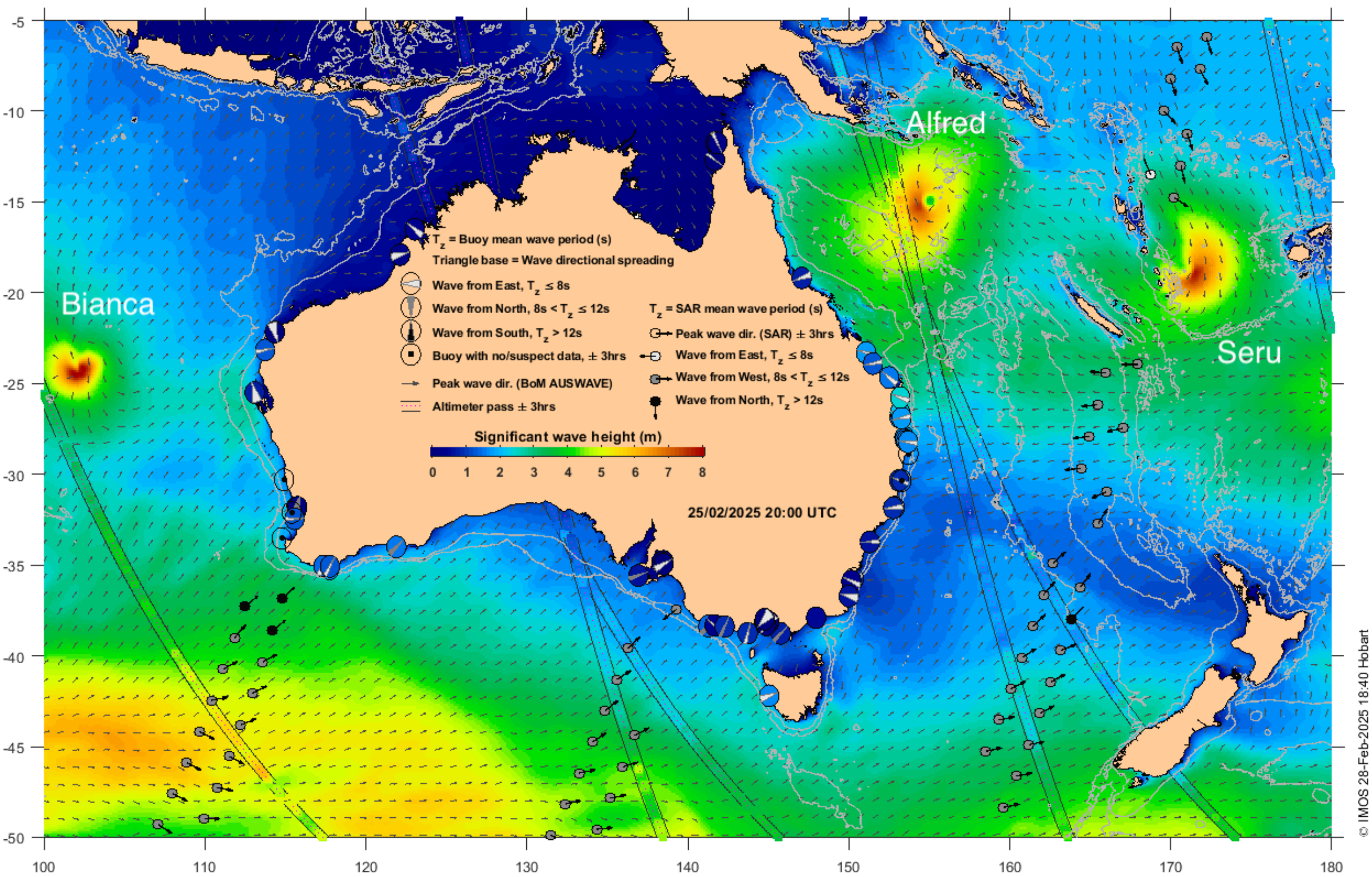
Written by Salman Khan, Marites Canto, Mark Hemer, and Hamish Ramsay

In late February there were four tropical cyclones lurking to the west and east of Australia: Bianca in the South Indian Ocean, and Alfred, Seru, and Rae in the South Pacific. The wave fields from Bianca, Alfred and Seru captured simultaneously by the IMOS OceanCurrent wave tool below is a unique occurrence.

Ocean observing satellites are well suited to capturing the broad geographical scales of these systems with several passing close to the tropical cyclones, and sampling important attributes of the observed wave field in the time snapshot shown. Wave heights of Bianca and Alfred, and swell periods and directions of Seru match well with the background modelled wave field from the Bureau of Meteorology.

TC Alfred was a persistent and slow-moving system. Initially heading in the Southerly direction, it made a dramatic right turn towards the Southeast Queensland (SEQ) coast. It was forecast to make landfall somewhere between Brisbane and Sunshine Coast with impacts warnings from K'gari (Fraser Island) to as far south as Coffs Harbour, NSW.

TC Alfred's near surface wind speeds as observed through a combination of SAR satellites (Sentinel-1, Radarsat-2, Radarsat Constellation Missions1+2+3) revealed detailed structure of the storm and its wind speed characteristics (radii of maximum winds and their decay profile in each quadrant, storm asymmetry, storm centre, etc.), thanks to the unprecedented sub-kilometre spatial resolution of SAR technology (~500m in this case). Such data are invaluable for collecting detailed information on tropical cyclones at broadscale and have the potential to improve storm forecasts and help prepare for their impact.

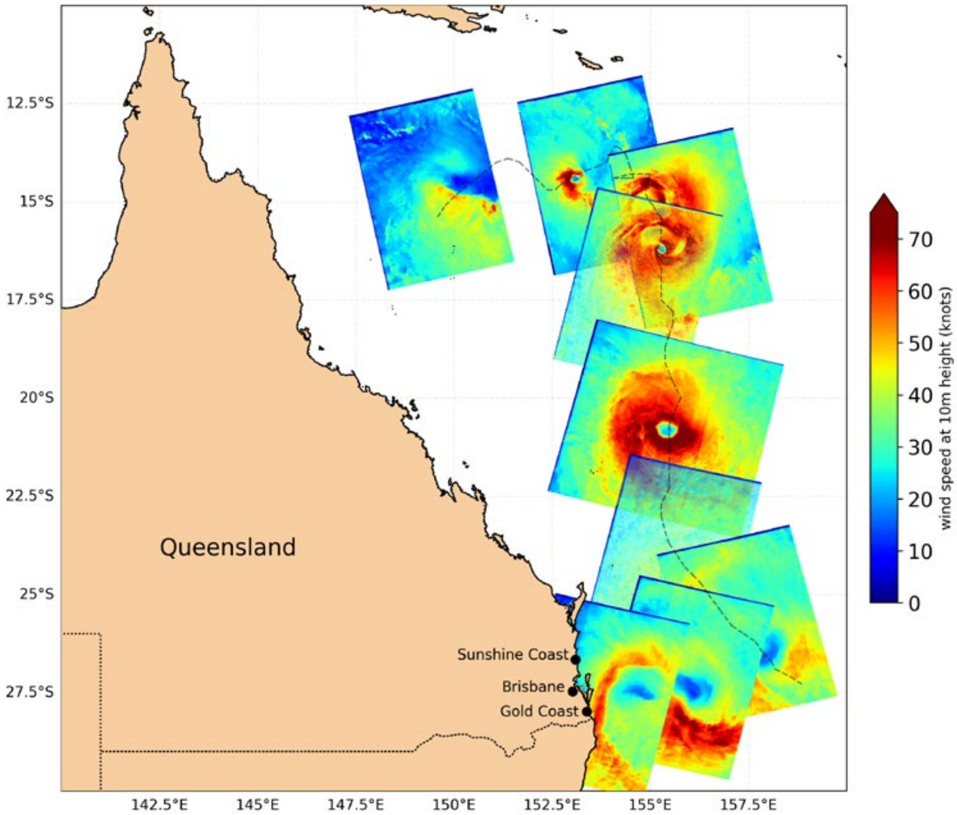


Wave field from TCs Bianca, Alfred, and Seru as observed by the wave monitoring tool on the 25th of Feb 2025 20:00 UTC.

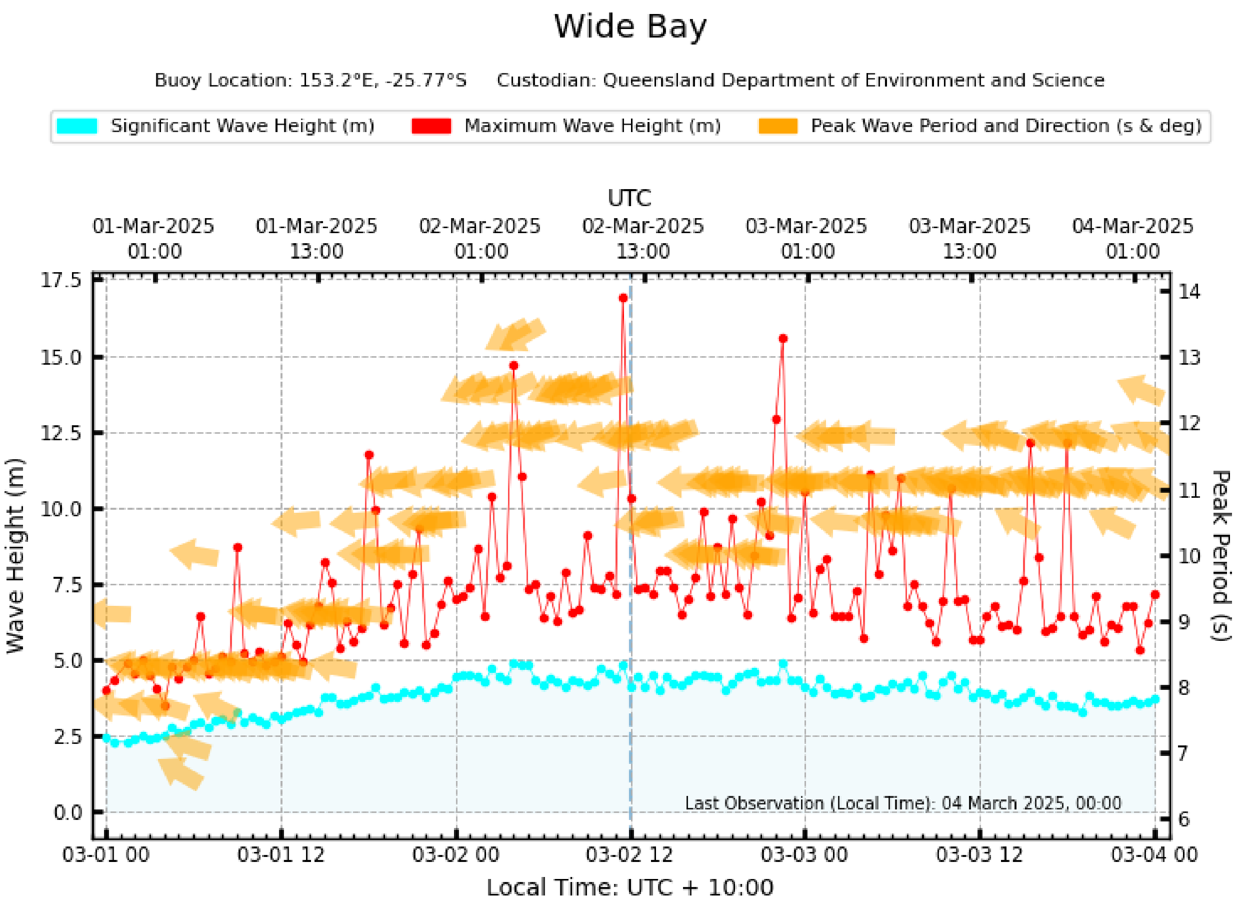
While satellites sampled the extreme waves offshore, coastal wave buoys measured the waves in-situ along various parts of the coastline. Watch a short animation (from IMOS OceanCurrent) with the wave conditions along the South East Queensland coast from the IMOS wave visualisation tool as TC Alfred made its way towards the coast here.

The time series plots of wave information measured at Wide Bay, Tweed Offshore, and Gold Coast confirmed high wave conditions and increasing in magnitude (at Tweed offshore and Gold Coast) ~5-9m significant wave heights, maximum wave height upwards of 15m (Wide Bay), and predominantly ~12 sec long Easterly wave systems generated by TC Alfred.

The conditions were sustained over several days leading to significant stress on coastal systems. Thanks to the Queensland Department of Environment and Science for making these data easily available.



TC Alfred near surface wind speed as imaged by several SAR satellites (Sentinel-1, Radarsat-2, and Radarsat Constellation Mission 1+2+3). Data sourced from NOAA.



Deep-sea sediment traps are a key focus of the Southern Ocean Time Series

Written by Gemma Woodward

Each year, members of the IMOS Southern Ocean Time Series (SOTS) Facility embark on the CSIRO research vessel Investigator to recover deep-sea moorings and deploy new instruments for the year ahead. The SOTS observatory is one of the few comprehensive Southern Ocean sites globally for measuring continuous ocean and atmosphere data.

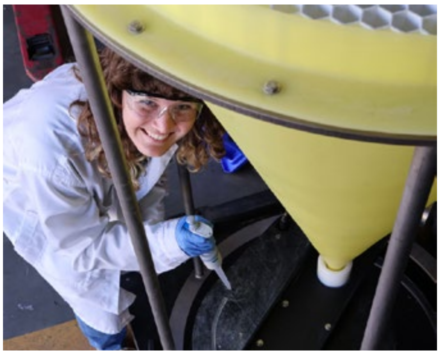
Located about 500km south-west of Hobart, the SOTS observatory is in the sub-Antarctic zone, a region of the Southern Ocean known for extreme weather conditions including large waves, strong currents, and severe storms. Here processes controlling the air-sea exchange of heat, moisture, and carbon dioxide are both intense and relatively poorly understood.

A lot of hard work goes on during the voyage to make sure everything goes off without a hitch, but before the voyage there are months of work that goes into preparing the equipment to spend 12 months thousands of metres below the ocean surface.

Three deep-sea sediment traps are a main aspect of the SOTS program and the longest running component, having first been deployed in 1997. They are stationed at 1000m, 2000m, 3800m below the ocean's surface at the SOTS site (nominal location of 47oS, 142oE).

The traps are large funnels designed to collect sediment sinking from the ocean surface to the deep ocean, with a rotating carousel that allows the collection of multiple samples. This enables study of the transfer of carbon and nutrients to the ocean interior via sinking particles, also known as the biological carbon pump. Researchers are also interested in the 'transfer efficiency', which is the fraction of organic matter that remains after being consumed as it travels between the surface layers and depth.

To keep the sediment traps working for another 25 years, they go through various preparation and maintenance steps before being deployed into the deep ocean. That's the job of Gemma Woodward, Australian Antarctic Program Partnership's Marine Carbon Analytical Chemist. Read more about how the sediment traps are prepared for deployment here. ■



Mark Horstman, AAPP

Gemma Woodward prepares a sediment trap for deployment.

Elizabeth Shadwick, CSIRO

Deployment of the 27th (SAZ-27) sediment trap mooring at the SOTS site in early April 2025

Small scale variability in the wet troposphere impacts the interpretation of SWOT satellite observations

IMOS Satellite Calibration and Validation GNSS buoys in the Bass Strait and a high-resolution atmospheric model were used to assess small scale wet troposphere signals near the coast.

The new Surface Water and Ocean Topography (SWOT) mission is the first satellite altimeter to observe changes in the height of the sea surface over broad swaths at high resolution.

To obtain high accuracy measurements various corrections are needed for the raw radar measurements. One of the required corrections accounts for the water vapor in the atmosphere which delays the radar signal.

Although SWOT sea surface measurements are at high resolution, the correction available for the water vapor in the atmosphere is at a lower resolution, which could possibly affect interpretation of SWOT observations.

A recent study used a high-resolution atmospheric model (ACCESS-NRI's model ACCESS-C) and an array of IMOS Global Navigation Satellite System (GNSS) buoys in Bass Strait to investigate the variations of atmospheric water vapor over shorter distances in Australian coastal waters.

The study found that the variation is higher than the SWOT error budget and that a higher-resolution correction for moisture in the atmosphere is often needed to ensure the correct interpretation of SWOT observations. ■

> Read the full paper

Macroecological rules predict how biomass scales with species richness in nature

Researchers identify a new fundamental rule governing how ecosystems are assembled, that reveals how and why biomass increases with the number of species.

Professor Anthony Richardson, IMOS Australian Plankton Survey sub-Facility lead, emphasises that while experimental studies have shown biodiversity enhances biomass and energy fluxes, a key challenge remains in understanding how these relationships function in complex natural ecosystems, particularly in the face of climate change.

“In this unique global comparative analysis, we leveraged data from thousands of diverse species of trees, birds, land mammals, moths, earthworms, phytoplankton, forams, copepods, and fish.”

The IMOS National Reference Station copepod data set was integral to this study because of its consistent long-term sampling approach, enabling the calculation of robust indices of both species’ richness and biomass. ■

> Read the full paper

Copepod *Oithona plumifera*

Andrea Hay

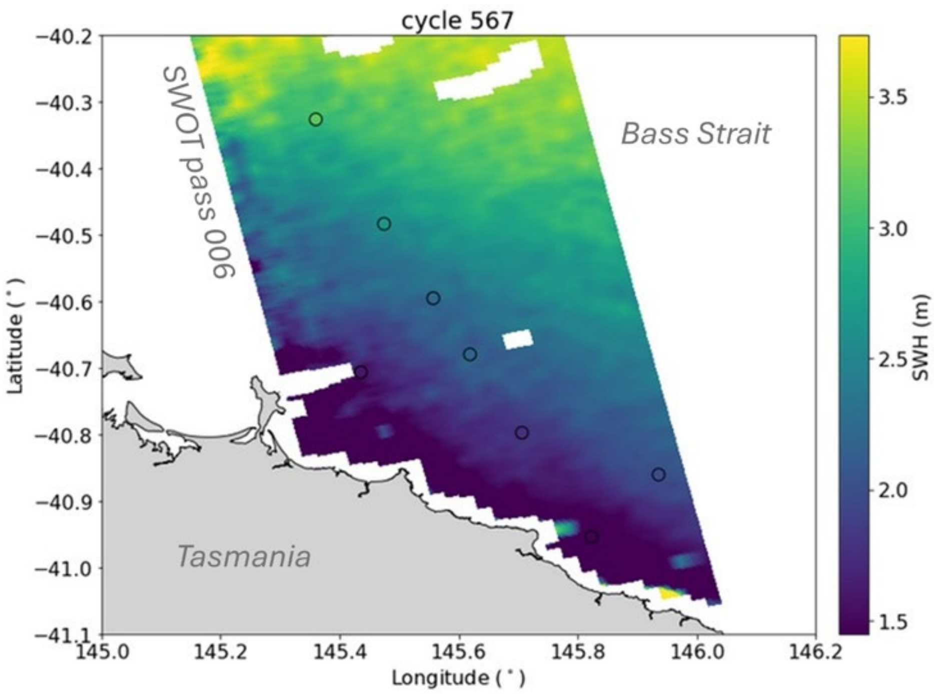
University of Tasmania, CSIRO

A Contribution to the Geometric Validation of the SWOT Mission

Andrea onboard the RV *Investigator* during the FOCUS voyage in 2023, collecting in situ validation data for the SWOT satellite mission in the Southern Ocean.

In December 2022, the Surface Water and Ocean Topography (SWOT) mission was launched to map the sea surface from space at an unprecedented resolution and precision. As a pathfinder mission, validation of this completely new measurement type is critical to confirm the accuracy of the new features in ocean topography being revealed. To achieve a robust validation, a diverse range of globally distributed sites is required.

Andrea has contributed to the global effort to validate this new mission using Global Navigation Satellite System (GNSS) data from both the IMOS Southern Ocean Flux Station mooring in the Southern Ocean and an array of nine buoys deployed in Bass Strait (as part of the IMOS Satellite Altimetry Calibration and Validation sub-Facility).



Significant wave height from GNSS buoys and SWOT wave product on a day with large variation in wave height across Bass Strait. SWOT wave heights are displayed as the colored grid and GNSS buoy wave heights are shown as colored circles. The color scale is the same for both datasets.

These data provide insights into not only the sea surface topography, but also surface waves, and the signal path delay caused by the wet troposphere which affects both the altimetry and GNSS measurements.

Using the buoy array in Bass Strait and a high resolution atmospheric model, errors due to wet path delay from the troposphere were found to exceed to SWOT error budget over less than 80 km scales (Hay et al., 2025). These errors could affect the interpretation of sea surface height fields from SWOT data over small scales. The buoy array was also used to quantify the precision of sea surface height measurements from SWOT, with SWOT precision found to fall in a band between 1.7 mm and 5.6 mm, far exceeding the mission requirements.

Both the buoy array in Bass Strait and the SOFS mooring also validated the new two-dimensional wave fields from SWOT. The buoy array showed large gradients in wave height over 80 km are well captured by SWOT in a coastal environment (see figure). Comparisons to the SOFS dataset confirmed a low bias in SWOT wave estimates (Bohé et al., 2025), providing valuable data for algorithm optimization in high wave environments. ■

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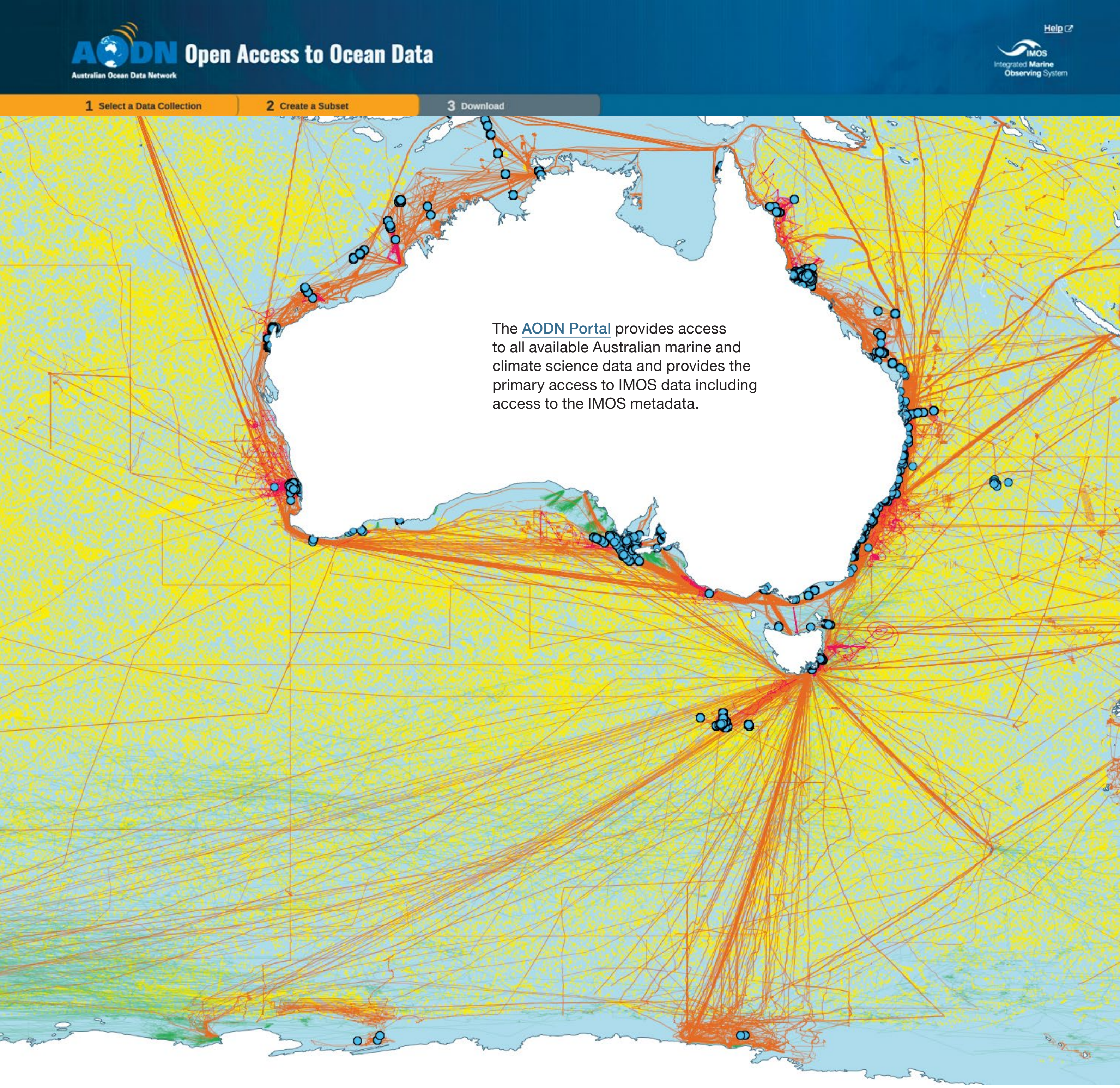

The AODN Portal provides access to all available Australian marine and climate science data and provides the primary access to IMOS data including access to the IMOS metadata.

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NCRIS
National Research Infrastructure for Australia
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For more information about IMOS please visit the website www.imos.org.au