INDIAN OCEAN DIGITAL ATLAS

An interactive tool to explore ocean features and trends in the Indian Ocean

USER MANUAL

Version 1.0

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Link : https://ioda-atlas.gov.sc

Note

All terms with the asterisk symbol * are explained in the Glossary, Section 7 of this document. The symbol is associated to the first occurrence of the term in the text.

IODA, version 1.0 ©

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1. Introduction

1.1 Purpose

Nowadays, there is a range of climate or ocean datasets compiled by various organisations and projects. Access to the data is often free, however the formats available are very diverse, and some tools are required to tailor the data to the user's needs. Producing the information and the figures that you need for your study requires some expertise in writing scripts.

The Indian Ocean Digital Atlas (**IODA**) is an ensemble of scripts and datasets packaged into a web platform that can facilitate the exploration of ocean features and climate-related trends for general users. Outputs are easy to handle, they can be exported and pasted in reports and research papers.

The availability of ocean and climate data is needed to complement fish stock assessments, as the environmental changes have become a prominent issue in fisheries management. For many years, the environmental variability has been considered as a white noise neglected in fish stock analyses. Under the evidence that climate change reshapes ocean conditions affecting fish stocks and their ecosystems, given that it happens at a fast pace, the Regional Fisheries Management Organisations (RFMO) have promoted the integration of climate change related stressors into fisheries management and have agreed on management measures for that purpose. The WCPFC initiated the process in 2019 with Res. 2019-01, followed in 2022 by the ICCAT (Res. 22-13) and the IOTC (Res. 22/01), and by IATTC in 2023 (Res. C-23-10). Overall, the resolutions support further development of scientific research on the relationship between climate change and target stocks and species belonging to the same ecosystems as the target stocks.

IODA is a tool designed to meet the objectives of the climate-related resolutions of the IOTC in the Indian Ocean, in terms of supporting scientific studies between oceanography, climate trends and variability, and tuna stocks through diverse visualisations. It will also be conducive to develop a dedicated IOTC webpage on climate change and its impacts on IOTC fisheries.

1.2 Main capabilities

The IODA generates **four thematic products**: maps, time and space profiles, Hovmöller* diagrams and depth profiles, for 16 variables (8 physical, 8 biogeochemical) along 20 depth levels (0 to 900 m). Anomalies and climatology (1993-2016) also exist for each variable and they can be represented. Additionally, four climate indices can be processed in time series. Finally, the GEBCO bathymetry is included to produce maps of the seabed.

The **maps** can cover the whole area of competence of the IOTC (which is the Indian Ocean basin between 45°S and 30°N) or a specific region defined interactively by the user. Once a map is produced, overlays can be activated to add contours, EEZ boundaries, and to plot external data. External data mean a georeferenced data file prepared by the user (e.g. catch, effort, …) that can be overlaid on the map.

The **time and space profiles** include four kinds of plots: time series, including climate indices, longitude and latitude transects. Time series of ocean variables can be calculated for a single point, or for an area, as defined by the user in an inset map. In case of an area selection, the spatial variability (25th and 75th percentiles) is represented as a shaded area around the median line. Series of climate indices are represented either as simple lines, or with filled coloured areas above and

below the 0 baseline. The transects are drawn on the inset map by the user, either along longitudes or latitudes, then the selected variable along that transect is plotted.

The **Hovmöller diagrams** are space-time diagrams, with one spatial dimension on one axis (generally longitude in X and latitude in Y) and time (year/months) on the other axis. The user can draw an elongated rectangle (in longitude or in latitude) in the inset map, where the values will be averaged and displayed for each month at each grid point, forming a continuous field of values just like a map

The **depth profiles** draw the variable along the depths, between two selected depth levels. The location of the profile is selected in the inset map. Optionally, the envelope of the profiles located in the neighbour grids, at distances of 25, 50 and 100 km around the selected location, can also be plotted.

1.3 Intended users

As IODA has been developed under the auspices of the IOTC, the primary users are fisheries scientists and fleet managers. They can explore how the environmental conditions could impact fishing success of their fleets, and include the most significant variables into statistical models to establish relationships. However, the range of outputs can also serve a broader community, such as:

- agencies involved in **marine spatial planning**, to characterize local patterns of environmental variability and assist in the selection of specific areas for economic activities.
- **meteorological services**, as ocean parameters (e.g. temperature, salinity, mixed layer* depth, currents) are required to improve coastal weather forecasts and enhance seasonal climate forecasts.
- **Educators and students,** as a resource for explaining how the ocean works and how anomalies affect life .

1.4 System requirements

IODA can be accessed from desktop and laptop computers, tablets, and smartphones running a current version of Windows, macOS, Linux, Android, or iOS. Use a recent version of Chrome, Edge, Firefox, or Safari with JavaScript enabled. A stable internet connection is required. A larger screen is recommended for a better viewing of interactive maps and detailed plots.

2. Installation

No installation is required on computers, tablets, or smartphones. IODA runs directly in the web browser, and all datasets are accessed online through the application. Therefore, no datasets need to be downloaded. Ensure you have a fast Internet connection to minimize the response time of the app.

Open the link to begin: https://ioda-atlas.gov.sc

3. User interface overview

3.1 IODA home page

The home page opens directly on the plotting functions (Plots), with the four modules shown on the right side of the screen (Fig. 1)

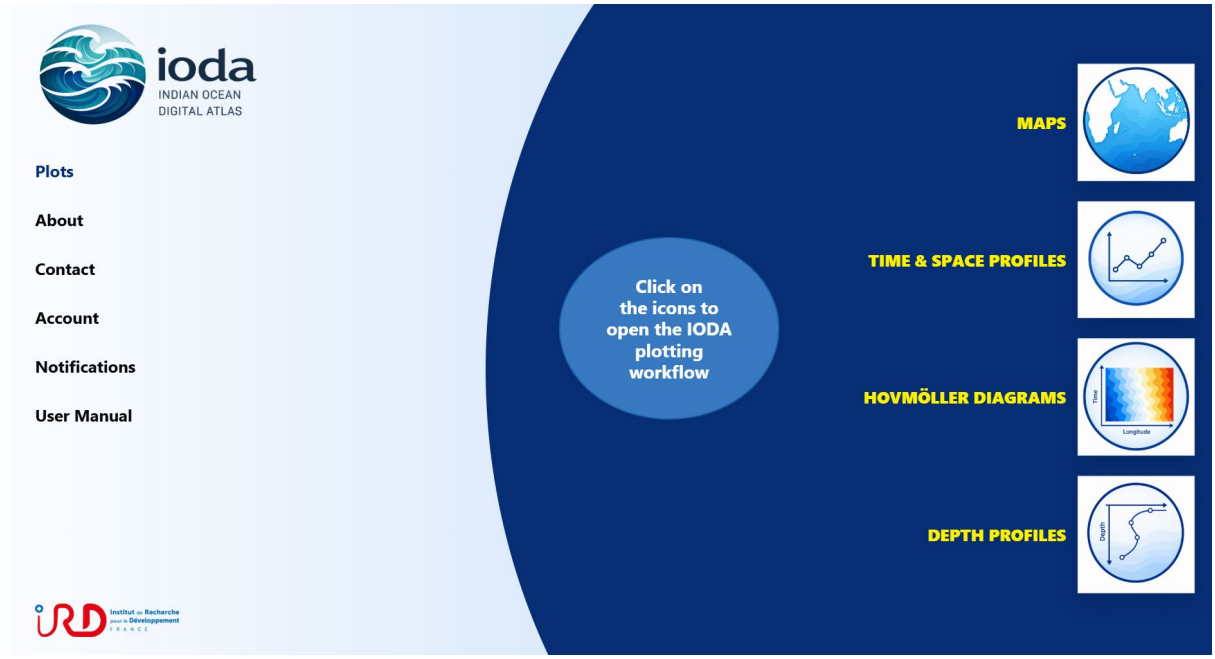


Fig. 1 – IODA home page

About – Provides an overview of the atlas, acknowledgements, and description of the datasets and their sources, including their DOIs. It also explains how to cite IODA.

Contact – opens a form through which users can submit requests, comments or bug reports. The IODA team will respond to the feedback.

Account – created at the first login. Users are required to register by providing a username, password, email address, professional sector, and country of origin. Plots saved within IODA can be accessed in the *Plots* folder associated with the user's account, thereby creating an image repository that can be built up over successive sessions.

Notifications –opens a window displaying the latest news about software and data updates.

User Manual –provides a link to download the IODA User Manual

3.2 Getting registered

You need to register (free of charge) and create an account on the first-time use of the atlas. Click Account in the home page.
You will be prompted to enter a username, an email address, your full name, country, and profession and password (Fig. 2). As for the profession, find which situation suits you best.

3.3 Signing in / Signing out

To start a new session, enter your email address or username and password, then click **Sign in**. You can then start using the atlas by clicking on Plots.

To log out at the end of your session, click Account on the home page, then select **Sign out**.

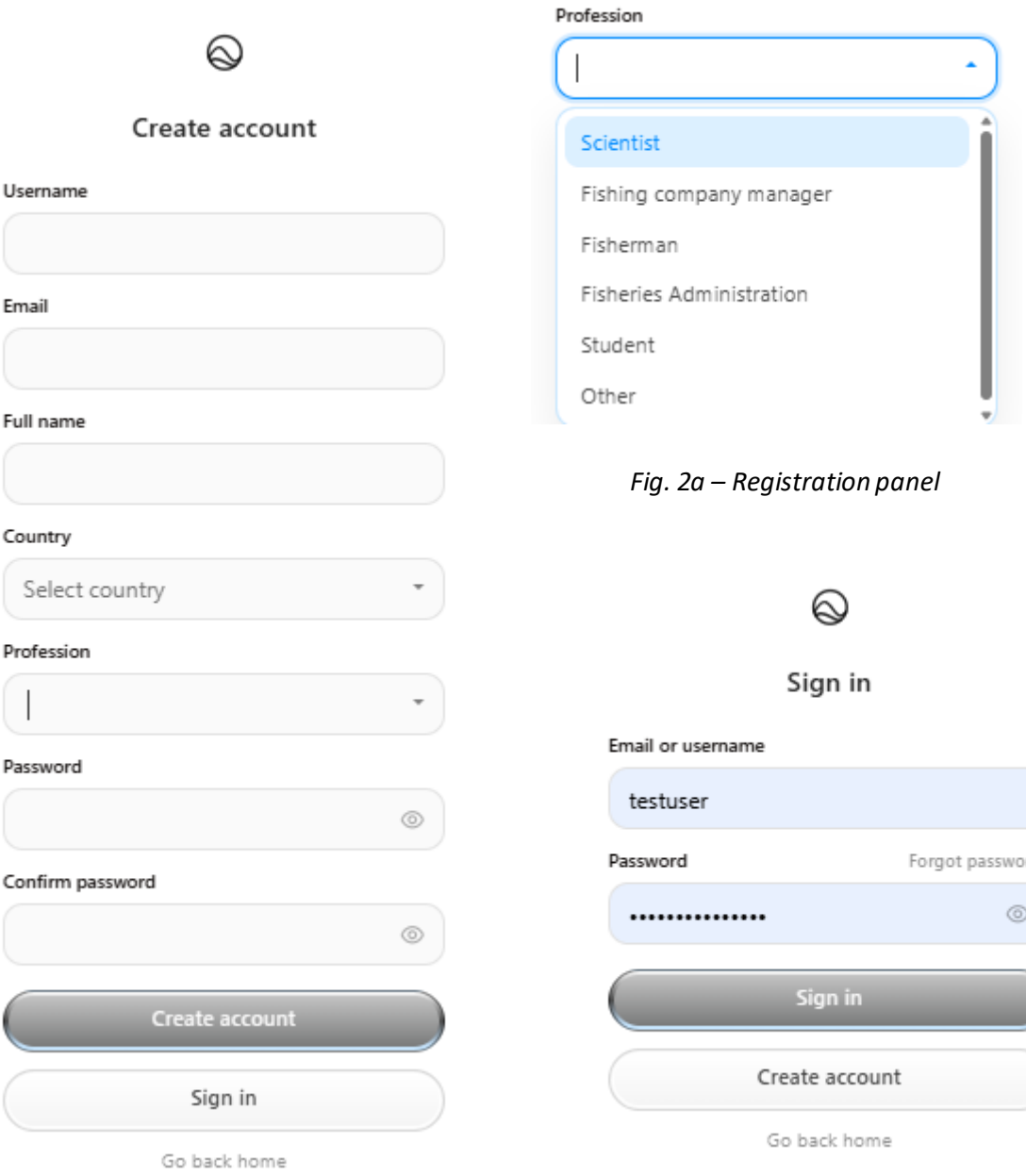


Fig. 2a – Registration panel

Fig. 2b – Signing in

3.4 Getting familiar with the IODA plot screens

The IODA screen is divided into four areas (Fig. 3):

- a parameters pane on the left
- a plotting window
- a general statistics window
- control buttons (up to three, depending on the module)

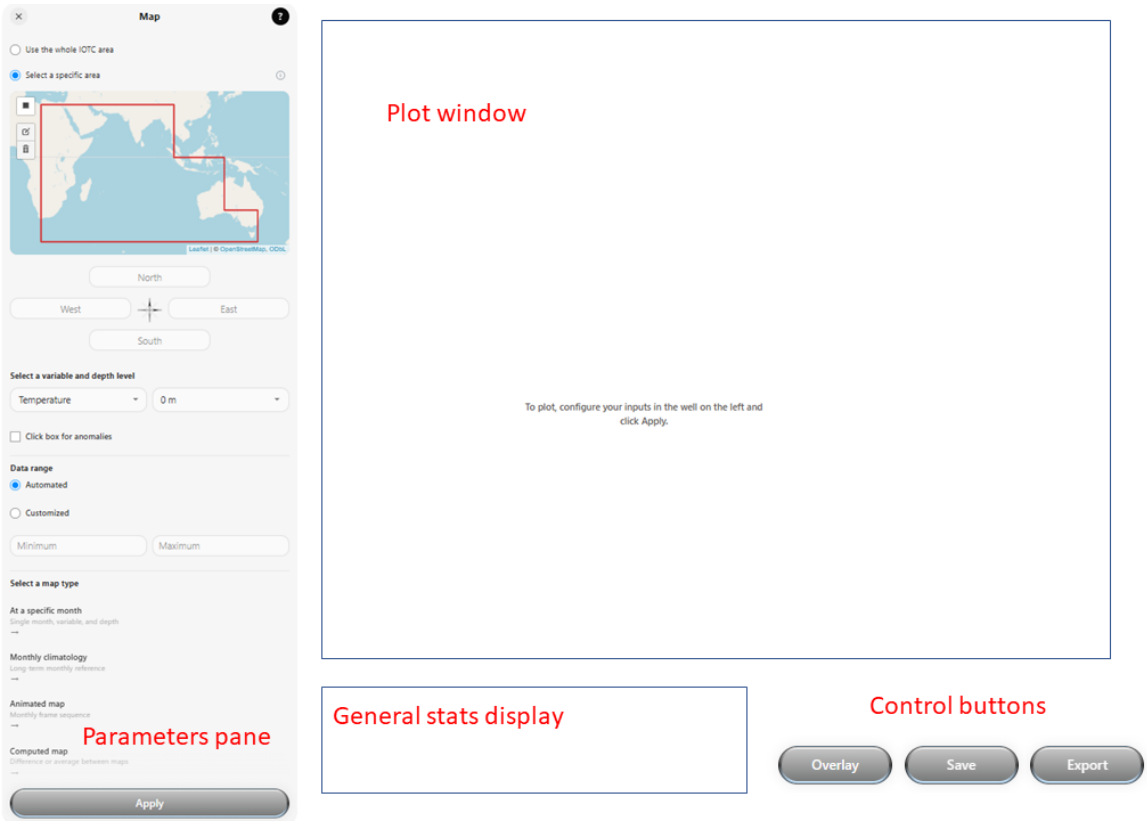
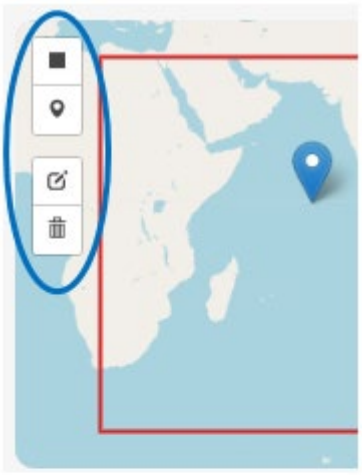


Fig.3 – Layout of the IODA plot screen

Parameters pane. The pane contains an **inset map**, where the area selections are made interactively with the mouse. There are different ways of defining a location or an area by using the symbols set on the left of the inset map and dragging the mouse on the map, or by manually entering coordinates in the text boxes under the inset map



Available symbols:

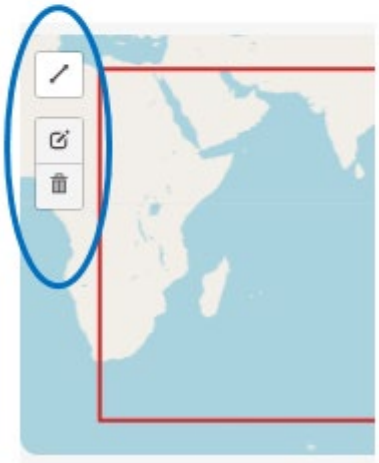
■ to draw a rectangle on the inset map

a locator to point a specific position on the map

to draw the longitude and latitude transects on the map

to edit (move or change size) of the rectangle, locator or transect (all modules)

to delete the area selections (all modules)



When a rectangle, a location or transect is drawn on the map, the coordinates appear in the four text boxes under the map. They can be changed manually if needed.

The selection of **variable** and **depth level** are common to all modules, but the rest of the pane depends on the active module. Once the selections are made, click **Apply** to generate the plot.

Plot window. All maps and profiles are displayed here.

General Stats display. Summary statistics for the plot are shown in this window.

Control buttons. Up to three buttons may be available: **Overlay** (MAPS module only: adds contours, EEZ boundaries and external data); **Save** (saves the plot in the Plots repository of your account); and **Export** (exports a Summary of the statistics and the data used to generate the plot in various formats).

At the top of the pane, ? gives a quick help for the active module, and × closes the pane and take you back to the home page.

4. The IODA variables

IODA includes 20 variables: eight physical ocean variables, eight biogeochemical variables, and four climate indices.

4.1 Physical variables

The **physical variables** (shown in blue in Table 1) are available at two different spatial resolutions, 8 km (1/12°) and 12 km (1/8°). Six variables directly sourced from the European Copernicus Marine Service (https://marine.copernicus.eu): Sea water potential temperature, Sea water salinity, Eastward sea water velocity, Northward sea water velocity, Ocean mixed layer thickness, Sea level anomalies*. The products consist of outputs from data-assimilative ocean models, downloaded for the IOTC area of competence.

4.2 Biogeochemical variables

The **biogeochemical variables** (shown in green in Table 1) are available at a spatial resolution of 25 km (1/4°) for coupled ocean models data, and 4 km (1/24°) for *Level 4* satellite-derived sea colour *chlorophyll-a* composites.

For both categories, other variables were calculated from the core Copernicus datasets. They are qualified as "Derived" in Table 1.

- the 20°C isothermal depth (also referred to as Thermocline depth*), the vertical current shear*, among the physical variables (1/8°)
- the depth of the 2.5 ml/l dissolved oxygen concentration (a lower threshold delimiting tuna habitat), the depth of the maximum fluorescence (Fmax*) and the Integrated Chlorophyll content in the upper 300 m*, among the biogeochemical variables (1/4°).

4.3 Climate indices

Climatic indices (shown in red in Table 1) form the third data component of IODA. Four indices with long-term time series have been included to track large-scale oscillations in the ocean–climate system: the Dipole Mode Index (DMI), the Southern Oscillation Index, the Multivariate ENSO index (MEI.v2) and the Niño-4 index

The last data component, the **seafloor topography**, is planned for inclusion in a future database update. These data originate from the GEBCO 2026 database, with a spatial resolution of 463m (15 arcs-second).

Except for the climate indices which are provided in CSV* plain text format, the data files were created using the Network Common Data Form (NetCDF; Unidata, DOI:10.5065/D6H70CW6). They are organised by variable and year. Each variable also includes anomalies (difference from the climatology) and climatology (calculated over 1993-2016). The variables are also organised into two categories: **three-dimensional** (longitude, latitude and depth), and **single layer** (one value per longitude/latitude grid cell). The 3D files include 20 depth levels, from the surface to 900 m (0, 10, 25, 40, 56, 78, 92, 110, 130, 156, 186, 222, 266, 318, 380, 454, 541, 644, 763 and 902 m). The overall size of the dataset is approximately 250 GB for the period from January 1993 to December 2025. The IODA database is expected to grow by approximately 10 GB per year.

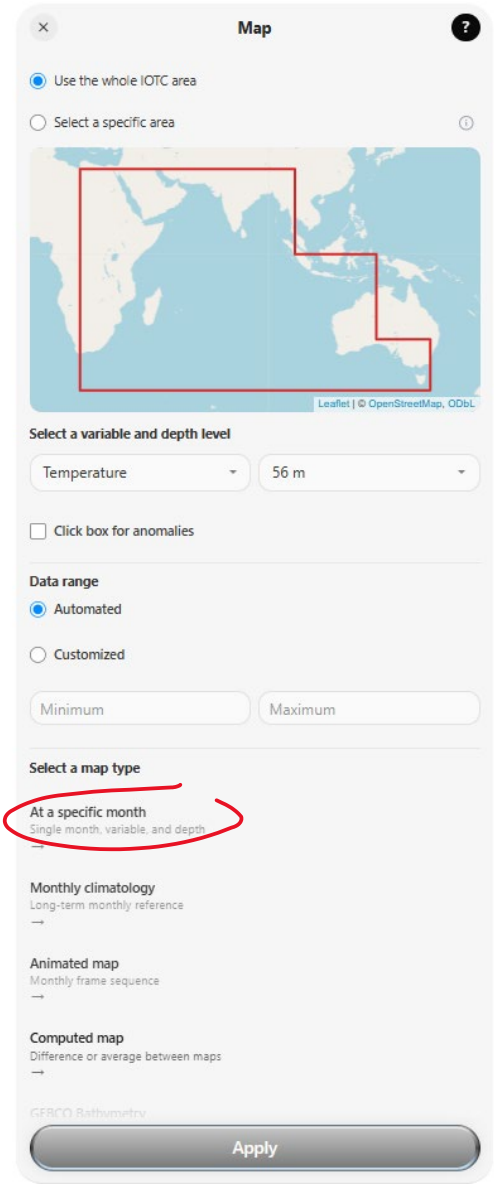
	Variable	Depth range	Start year	Source	Spatial resolution	Product ID
PHYSICAL	Temperature Salinity Current	0-902 m (20 levels)	1993 - Jan	Ocean model	0.083° x 0.083° (~8km)	GLOBAL_MULTIYEAR_PHY_001_03
	Sea level anomaly	single-layer	1993 - Jan	Satellite altimeter	0.125° x 0.125° (~12km)	SEALEVEL_GLO_PHY_L4_MY_008_047
	Mixed layer depth Thermocline depth Current shear 0-130m Current shear 0-450m	single-layer	1993 - Jan	Ocean model Derived Derived Derived	0.083° x 0.083°	GLOBAL_MULTIYEAR_PHY_001_03
BIOGEOCHEMICAL	Depth of 2.5 ml/l DO	single-layer	1993 - Jan	Derived	0.25° x 0.25°	GLOBAL_MULTIYEAR_BGC_001_029
	Dissolved oxygen Chlorophyll-a Net Primary Prod pH	0-902 m (20 levels)	1993 - Jan	Ocean model	0.25° x 0.25° (~25km)	
	Surface chlorophyll	single-layer	1997 - Sep	Satellite obs.	4 x 4 km	OCEANCOLOUR_GLO_BGC_L4_MY_009_104
	Fmax depth Integrated chl content		1993 - Jan 1993 - Jan	Derived Derived	0.25° x 0.25°	GLOBAL_MULTIYEAR_BGC_001_029
CLIMATE	Dipole mode index Southern oscillation Index Multivariate ENSO index Nino-4 index	single-layer	1870 - Jan 1866 - Jan 1979 - Jan 1870 - Jan	Observations	n/a	n/a
BATHY	Seafloor bathymetry	single-layer	n/a	Composite	~ 500 m	GEBCO 2026 Grid (Sub-ice topo/bathy)

Table 1 –IODA datasets summary, with depth range, start of period covered, data source, spatial resolution and product reference.

5. Functional modules

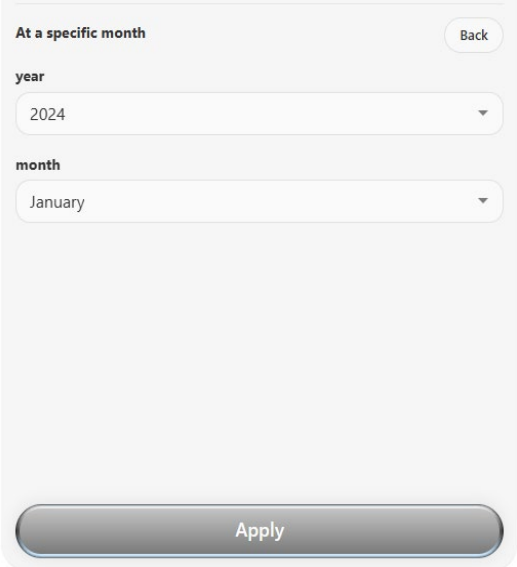
Choose the product you want to generate, by clicking MAPS, TIME & SPACE PROFILES, HOVMÖLLER DIAGRAMS or DEPTH PROFILES.

5.1 The MAPS module



To get started:

- use the **whole IOTC area**
- select a **variable** (here temperature) and a **depth level** (here 56 m).
- note you can also display the variable's **anomaly** (the difference from the climatology) by ticking the Anomaly check box.
- keep the **Automated range**
- select the first map type At a specific month
- then, select the **Year** (e.g. 2024) and **Month** (e.g. January) in the drop-down lists



- Then, submit the query with a click **Apply**.

A temperature map is produced (Fig. 4), using a coloured range between the minimum and maximum temperature found in the selected area. By clicking the **Overlay** button, you can enhance your map with additional features: plotting contours (with or without labels), drawing the EEZ boundaries and adding external data.

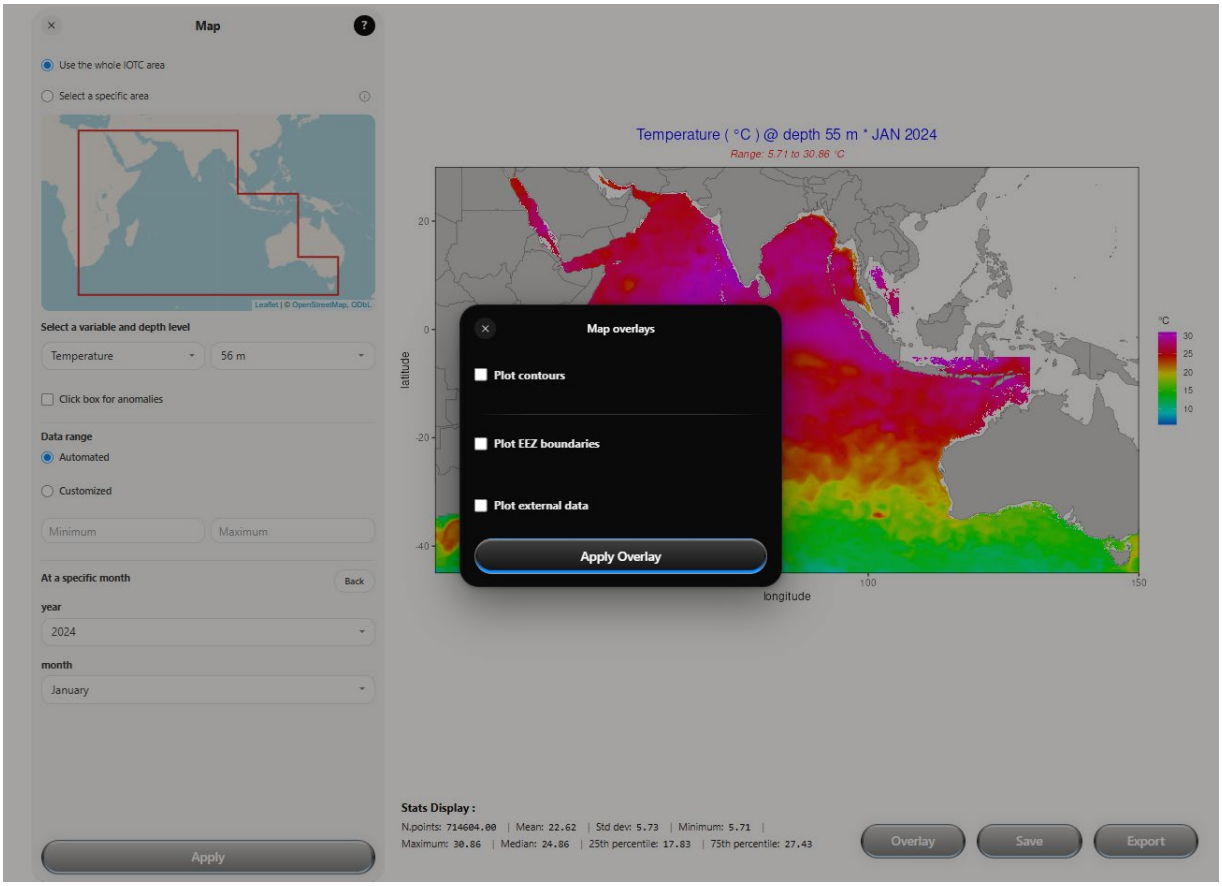
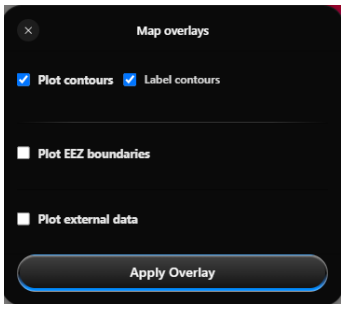
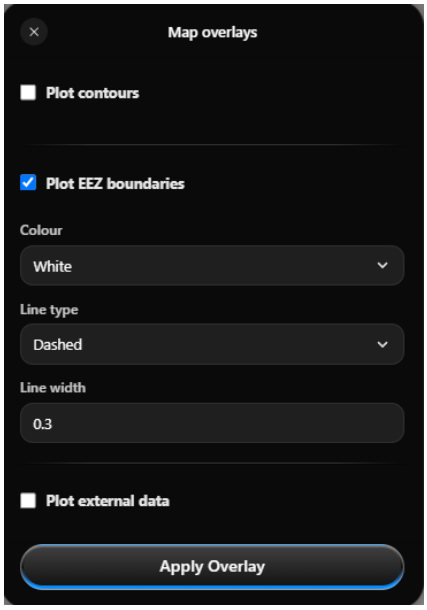


Fig. 4 – Temperature map with the Overlay panel opened



- Plot contours (and labels). This is activated by ticking the corresponding check box, then click **Apply Overlay**



- Plot EEZ boundaries. The default settings are a white line, a dashed type line, and line width of 0.3. These settings can be changed by the user in a drop-down list. Then click **Apply Overlay**.

The result is shown in Fig. 5.

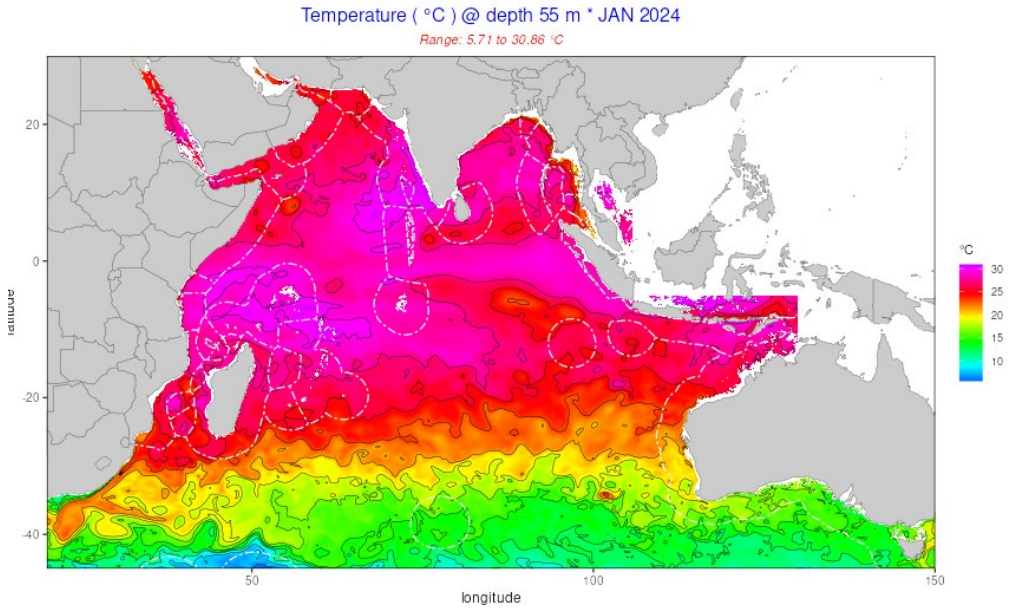
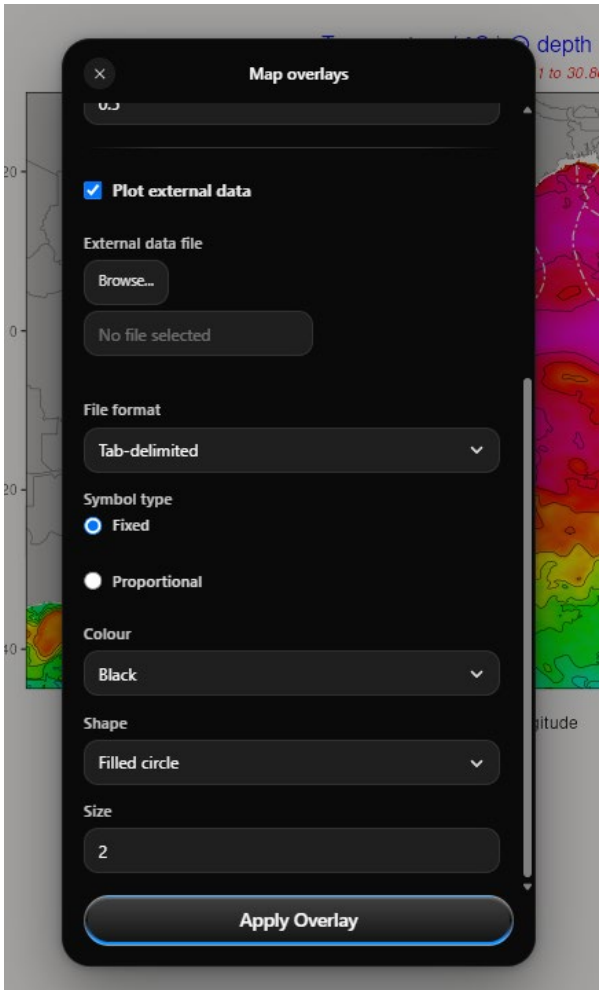


Fig. 5 – Temperature map with contours and EEZ boundaries overlaid

Now you can add your own data layer on the map, for instance location of buoys, catch or effort data, etc... This can be made by ticking Plot external data (see below).

The Overlay panel contains the following fields:



- *External data file*. Browse to select the file from your computer.
- *File Format*. Select a file format: Comma-separated*, Tab-separated* or Space-delimited* values.
- *Symbol type*. With two columns in the file (X and Y), select **Fixed** (only location will be plotted); with three columns (X, Y and Z), select **Proportional** (a circle with size proportional to the value will be plotted)
    - If Fixed: you can define a colour (choice of 9), a symbol shape (a choice of 8) and a size. See an example with black-filled circles of size 1 on top of the temperature map (Fig. 6)
    - If Proportional, you can define a colour and a map scaling factor to control the size of the circle (the larger the factor, the smaller the symbol). See an example with black circles with a scaling factor of 0.006 on top of the temperature map (Fig. 7). A range of different circle size is set in the right margin to indicate the magnitude of the values represented.

- *Colour*: a selection of 9 different colours are displayed in the drop-down list
- *Shape*: a selection of 8 different shapes are displayed in the drop-down list
- *Size*: the value is proportional to the scale of the map. Start with one value (2) and fine-tune by changing the value if needed.

Click **Apply Overlay**.

How do you prepare a file containing your own data?

Your data must contain two or three columns, in plain text data format. The first two columns are for Longitude and Latitude (decimal data) in this order. This will indicate the coordinates or your observations to be added on the map (for instance, location of moored buoys). A third column (optional) is used to enter a value at each location (for instance, catch data) which will be represented with a proportional circle. Enter the labels X, Y and Z as column headings, like in the example below:

```
X       Y       Z
65.5    14.5    7.4
63.5    12.5    19.28
64.5    12.5    0
66.5    12.5    0.49
67.5    12.5    5.03
```

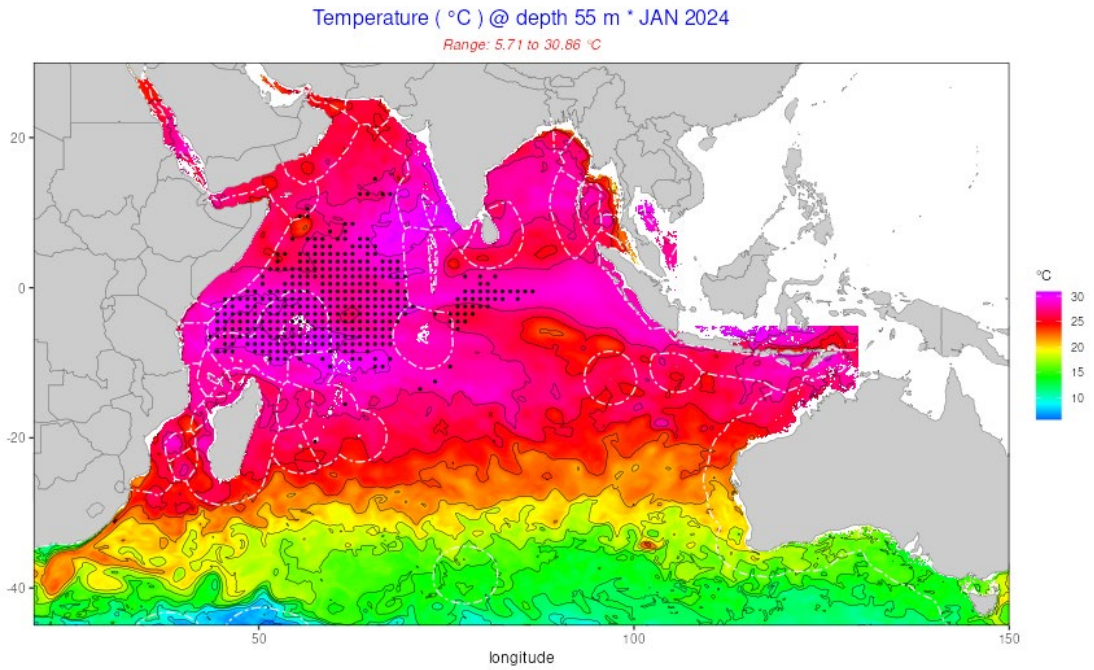


Fig. 6 – Temperature map with contours, EEZ and external data (fixed plot) added

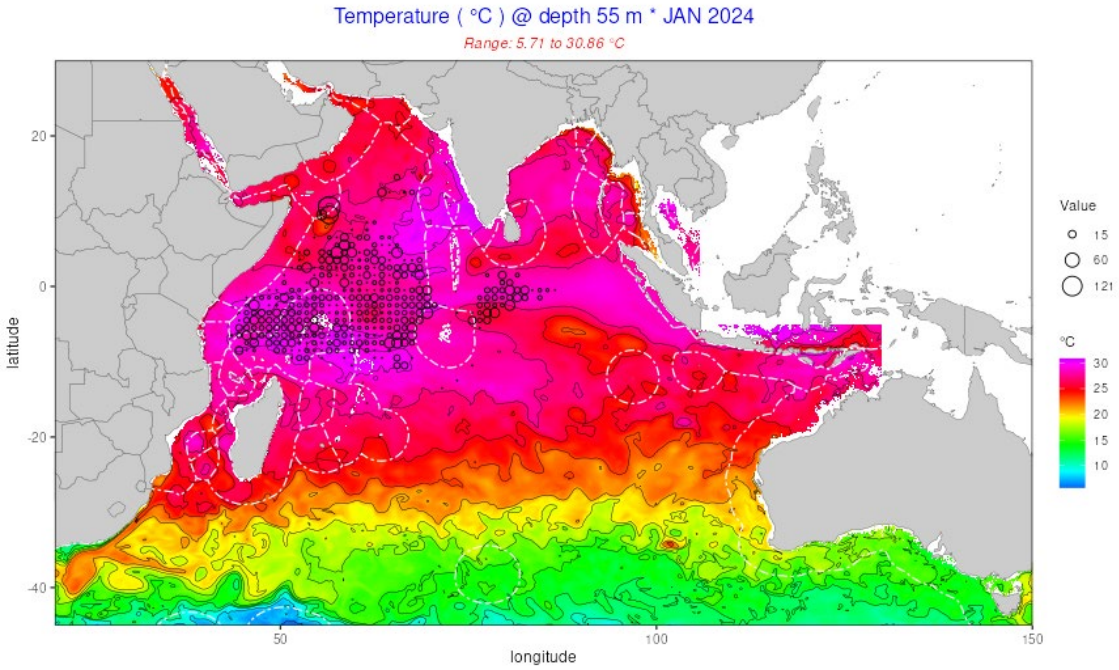
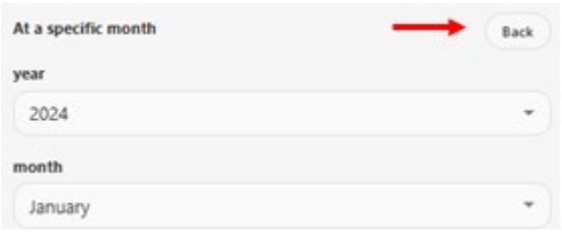


Fig. 7 – Temperature map with contours, EEZ and external data (proportional plot) added

The maps shown so far represent a specific month and year

Other types of maps can be produced. The catalogue is listed in the parameters pane. Should you have already activated a map type, just click **Back** to return to the main MAPS page, and be able to select another map type.



Monthly climatology. This provides a map of the climatological mean (1993-2016) of the variable and depth selected. By default, the area, variable, depth level and data range selections remain the same as in the previous plot. The overlay options are also kept active, and you can deactivate them. You must select a **month** in the drop-down list, then click **Apply**. You can customize the map with the **Overlay** options, just like in the previous map.

Animated maps. Maps of consecutive months are generated and packaged in an animated sequence. In order to have a proper representation of the sequence, you have to set the **Data range** to **Customized**. Doing so, you must enter the minimum and maximum values that will force the colour palette to be identical on each map (= frame). You can start with guess minimum and maximum values, then you can refine afterwards. Start and end **year** and **month** have to be entered to set the time sequence. The result is shown in Figure 8. In the example shown, a range of 10 to 30°C was set for the temperature at 56 m, from January 2021 to December 2023 (making a sequence of 36 frames). Clicking **Play** starts the movie. It is also possible to animate manually with **Prev** and **Next**. Overlays can be added.

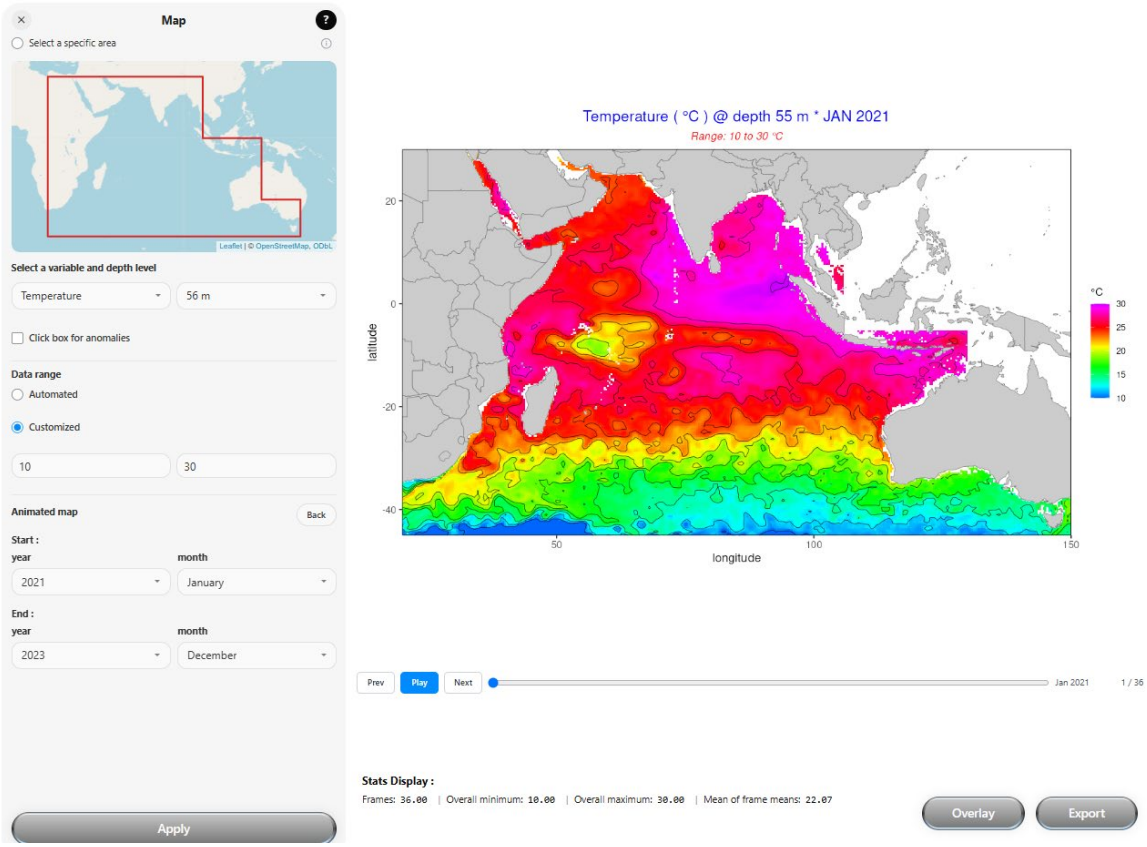
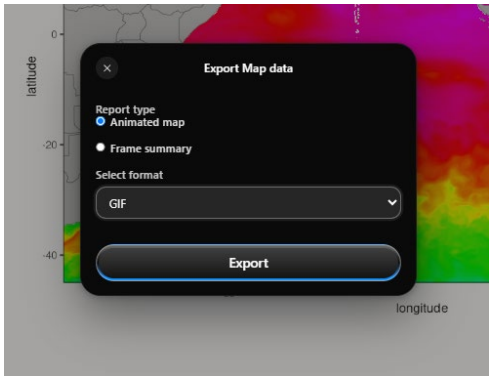


Fig. 8 – Animated maps screen, with the horizontal scroll bar to animate the sequence. Here, the temperature range is customized to 10°C - 30°C

The **Export** button provides several output options:

- *Animated map*, creating an external animated gif that can be run externally, in either GIF or ZIP-compressed forms
- *Frame Summary*, in CSV, XLSX* or JSON*, giving the general statistics of each frame



Computed map. This provides a map which is either the difference between two monthly maps, or the average through a period of time. This works better with an **Automated** data range.

- *Difference*: Figure 9 shows the temperature difference calculated in November, between 2022 and 2023 (i.e. 2022 minus 2023). Along Indonesia, the temperature at 56 m was up to 10°C higher in Nov 2022 compared to 2023, whereas Nov 2022 was cooler than 2023 of more than 5°C in the Western Indian Ocean, at around 65°E and 5°S, an illustration of the 2023 positive dipole.

- *Average*: Figure 10 shows the average temperature calculated for July, considering the years 2021 and 2022. This panel is slightly different than the differential temperature's panel. Here, the start and end years for the average, as well as the selected month, must be entered.

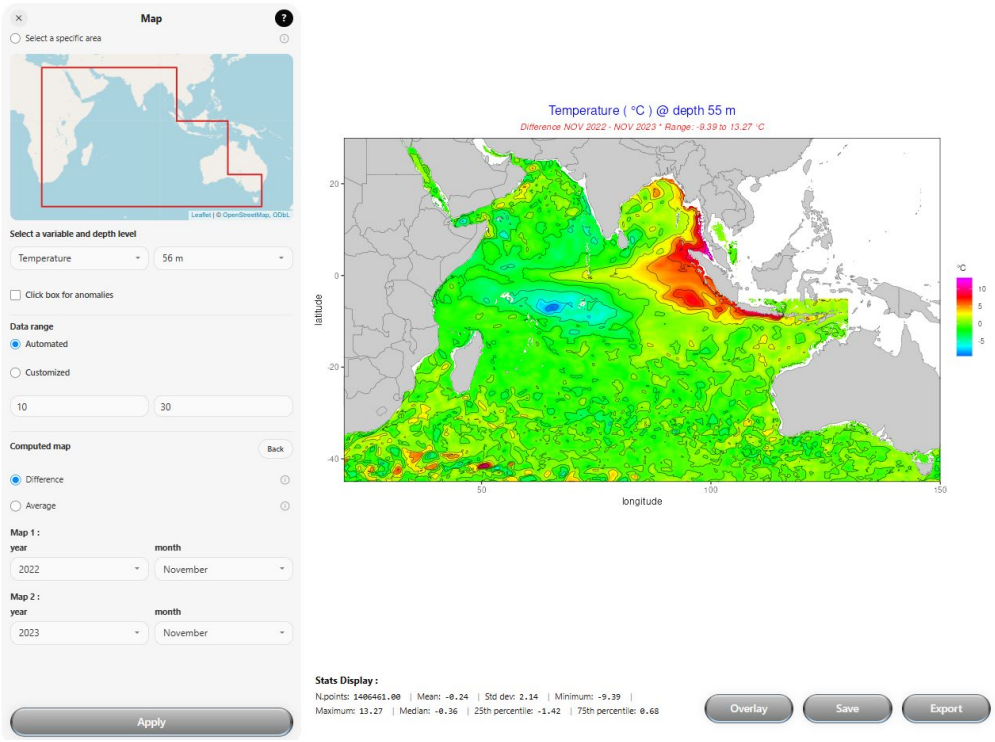


Fig. 9 – Differential temperature map in November, between 2022 and 2023

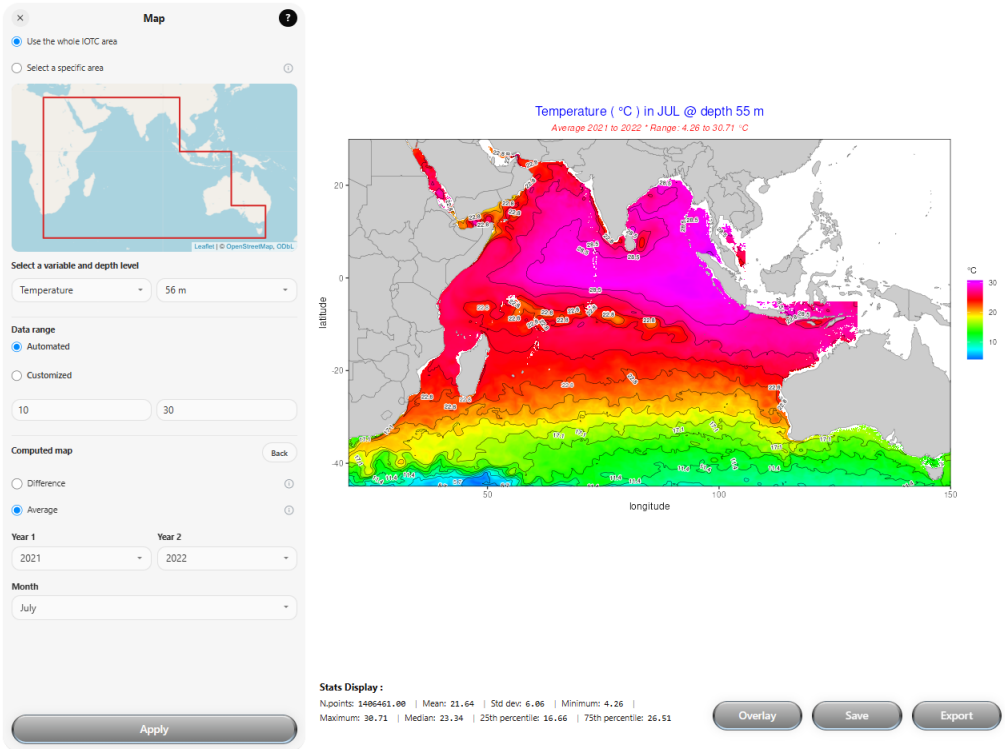


Fig. 10 –Average temperature map for July over 2021-2022

5.2 The TIME & SPACE PROFILES module

The four plot types available in this module are described below.

5.2.1 Time series

The first action is to select a particular location on the inset map, a single point using 📍 or a box area using ■ as shown in section 3.4 (Fig. 11). A series built for a single point will use the data of the corresponding grid cell. In the case of a box area the series will be computed from all grid cells inside the selected area.

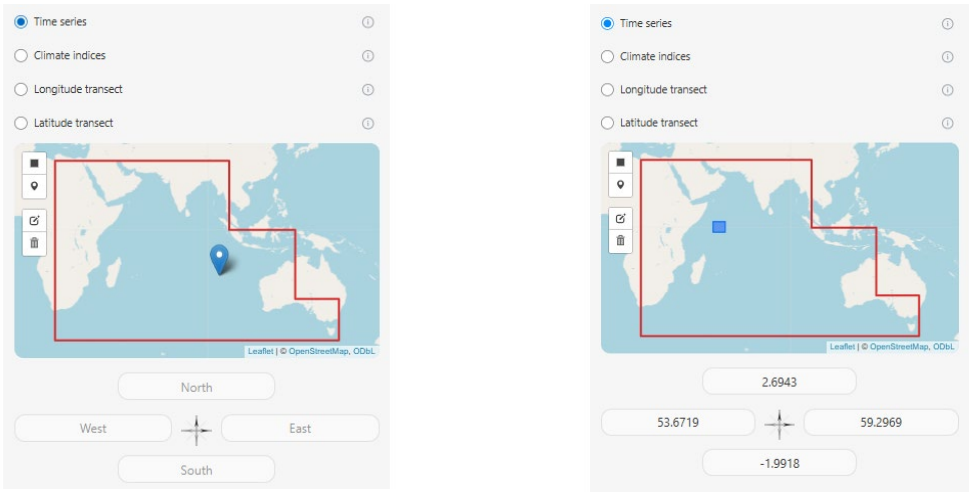
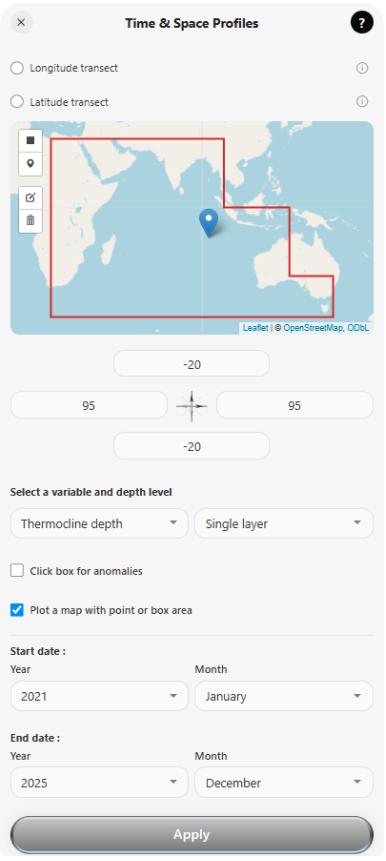


Fig. 11 - Area selection with a point marker (left) or by dragging the box area marker



The coordinates of the selected location are displayed belowthe inset map. They can be changed manually if needed. Then, the **variable** and **depth level** must be selected (here, the thermocline depth, which is a single layer variable without depth level).

You can select anomalies to be plotted, and if a map showing the location of the selected area can be shown below the graphs, by ticking the appropriate check boxes.

Finally, select the start and end **years** and **months** from the drop-down lists, then click **Apply** to generate the plot.

For a single point plot, the profile displays a single line (Fig 12a). For a rectangular area, the profile displays the median (black line) surrounded by a blue shaded area representing the 25th and 75th percentile of the distribution of the values in the box area (Fig. 12b).

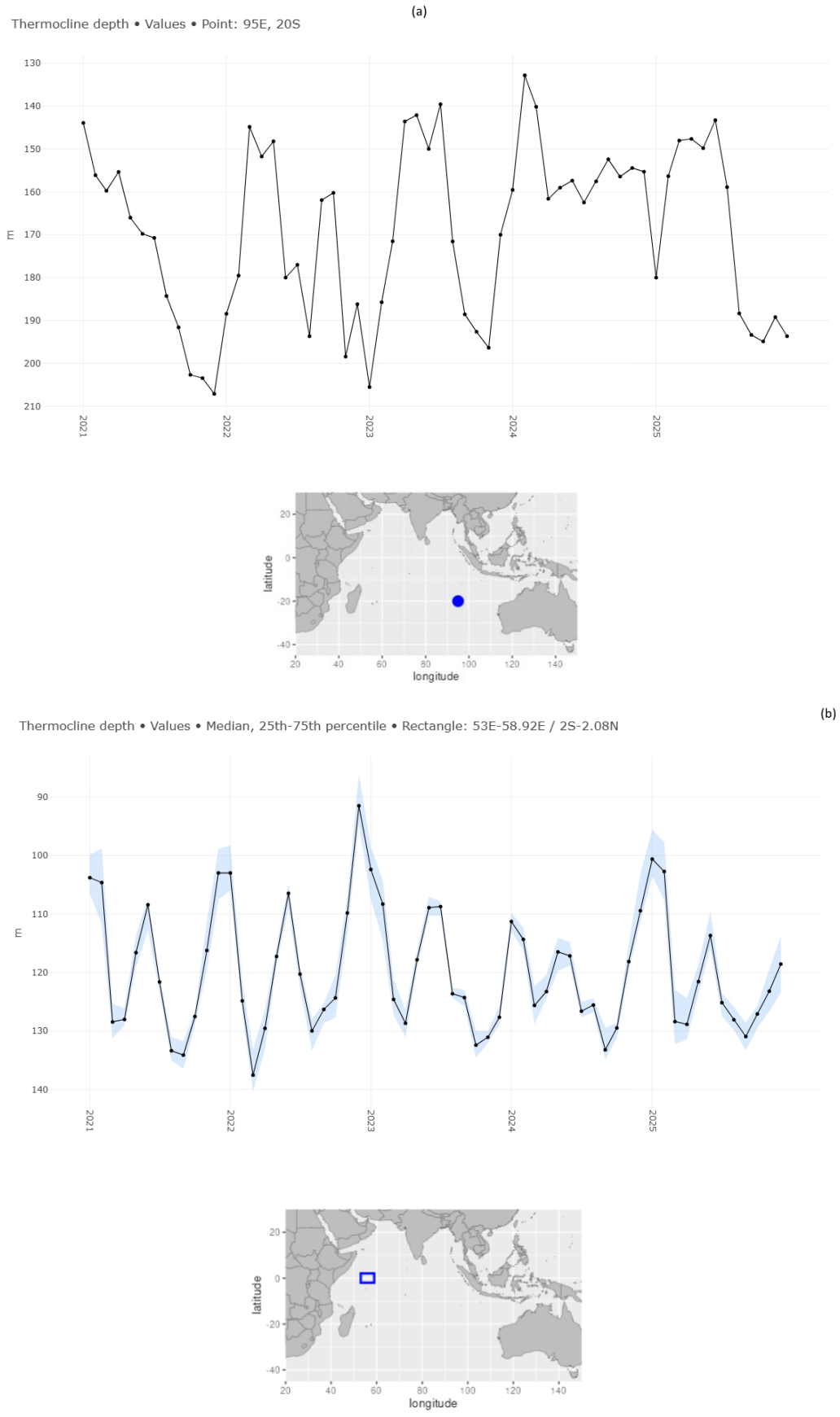


Fig. 12 – Times series of the thermocline depth a) for a single coordinate, and b) for a box area. The map shows the location of the point or the box area selected

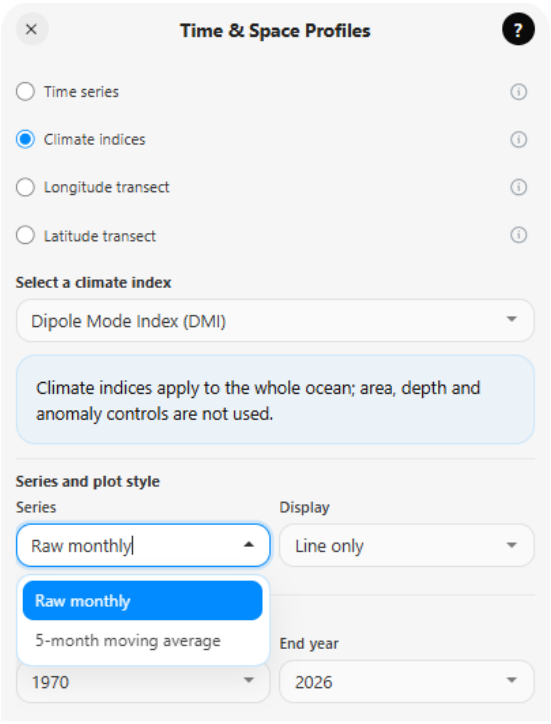
5.2.2 Climate indices

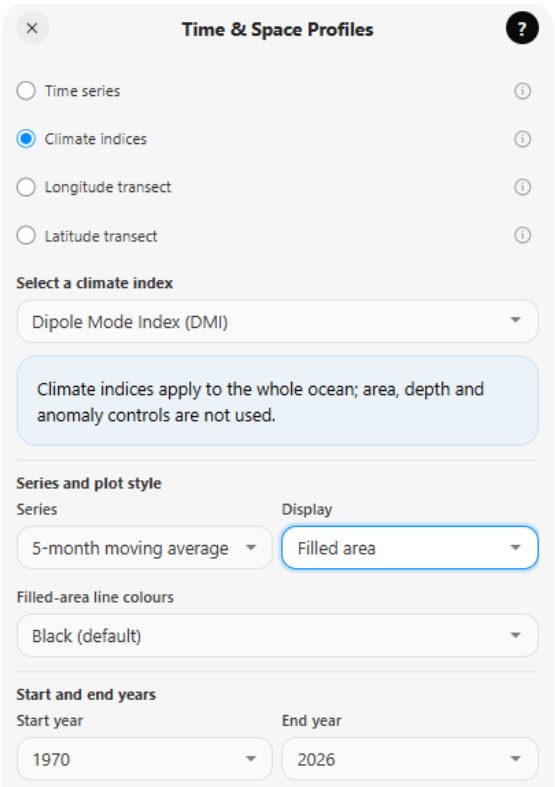
There is no inset map (in the parameters pane) associated to climate indices, as they apply to the whole ocean (even beyond the Indian Ocean). The monthly time series for four different climate indices can be plotted:

- the **Dipole Mode Index** (DMI), a tracer of the Indian Ocean Dipole based on the SST gradient between West and East of the Indian Ocean (1870 to present)
- the **Southern Oscillation Index**, a tracer of the El-Niño Southern Oscillation (ENSO) and a predictor of global climate disruptions (1866 to present)
- the **Multivariate ENSO index** (MEI.v2), another tracer of ENSO combining five variables (1979 to present)
- the **Niño-4 index**, based on temperature anomalies in the Western Pacific, also related to the ENSO cycle (1870 to present)

Several display options are available for these time series:

- raw (monthly) or smoothed with a 5-month moving average
- display a line only, or colour-filled areas above and below the 0 baseline
- for filled areas, the line colour can be either uniform (black) or red and blue to delineate to coloured areas





Then the start and end years must be selected. Click **Apply** to render the plot. The result is shown in Figure 13.

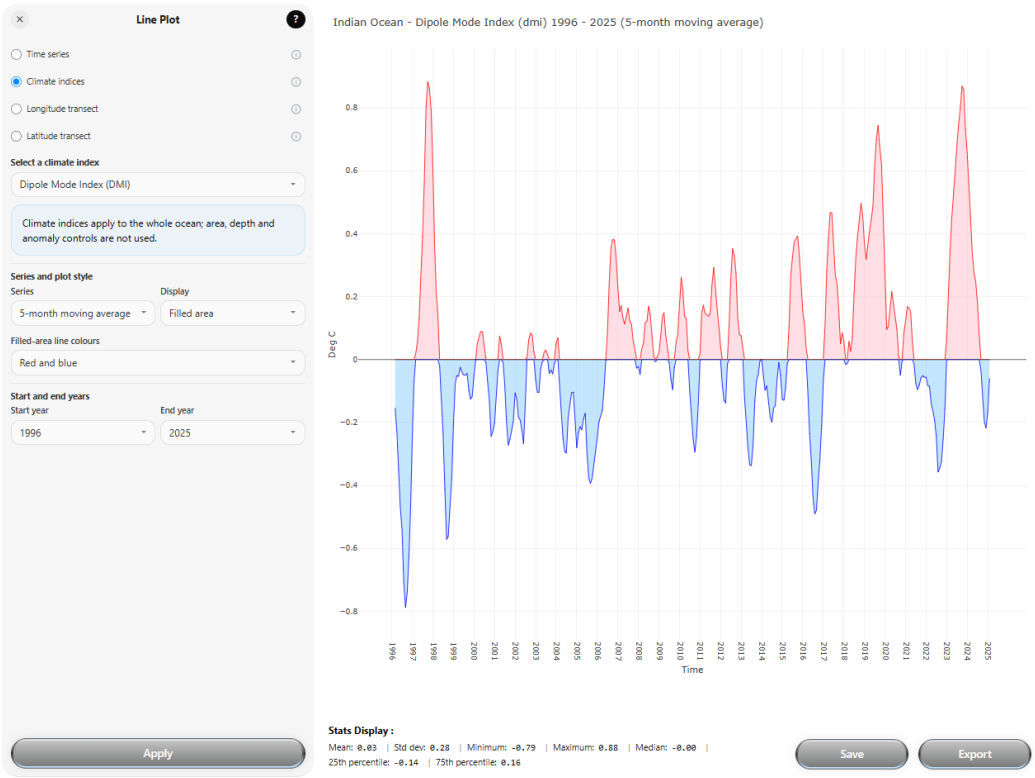


Fig. 13 – Times series of the Dipole Mode Index, 1996-2025.

5.2.3 Longitude transect

The profile will display how a variable is changing along longitudes, at a fixed latitude. Use the ╱ marker to draw a horizontal line on the inset map. A first click to start the line, a second click to finish it and a third click to validate the transect line. The coordinates will be displayed under the inset map.

Select a **variable** (here, temperature **anomaly**, by checking the anomaly box), **depth level** (here, 25 m), with a **map** showing the transect line under the profile (check box 'Plot map with transect line'). Submit the query with a click **Apply**. The result is shown in Figure 14.

5.2.4 Latitude transect

Operate similarly to longitude transect, but the transect must be drawn as a vertical line across the inset map. As an example, Figure 15 is the latitudinal profile of anomalies of the chlorophyll-integrated content (0-300 m) from 15°N to 25°S at the longitude 60°E, with an inset map under the profile showing the transect line studies.

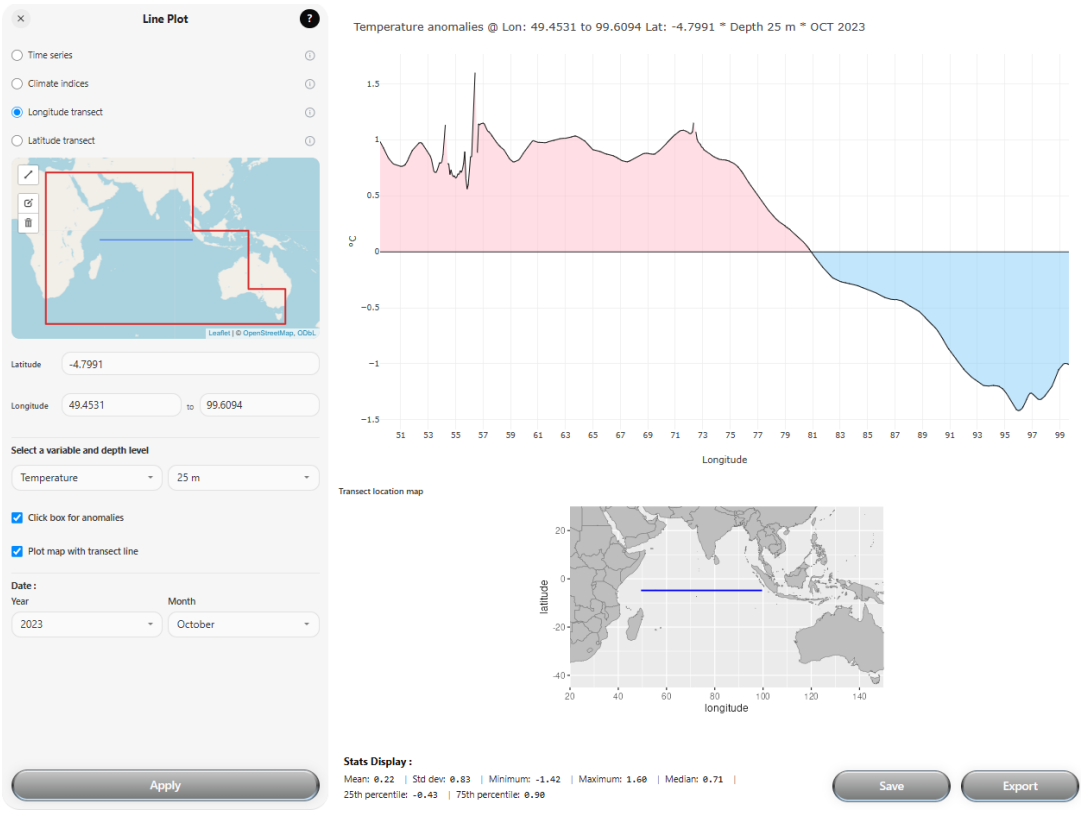


Fig. 14 – Longitude transect of the temperature anomaly at latitude 4.8°S, in October 2023.

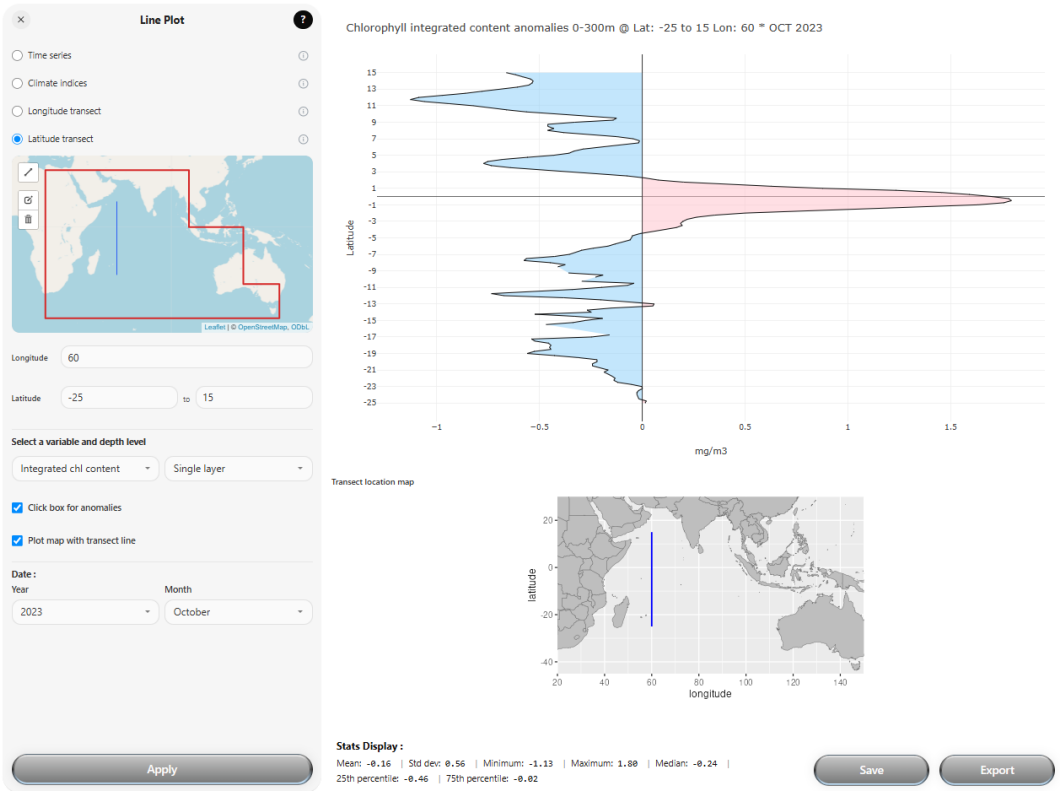


Fig. 15 – Latitude transect of the anomalies of integrated chlorophyll content at longitude 60°E, in October 2023.

5.3 The HOVMÖLLER DIAGRAM module

Hovmöller diagrams inform on the changes of a variable in both space and time. It is a common way of plotting environmental data to highlight the behaviour of waves and cycles.

The spatial dimension is either longitude or latitude. An area must be drawn on the inset map, as a horizontally-oriented rectangle in the case of a **Longitude-time diagram**, or as a vertically-oriented rectangle in the case of a **Latitude-time diagram**. Use the ■ marker to draw an elongated rectangle on the inset map. In case of longitude (latitude), the plot will be a heat map of the average value at each longitude (latitude) grid cell inside the box area.

Select a **variable** and a **depth level**, with **anomalies** optionally, then select a start and end **year**. Submit your query by clicking **Apply**. For longitude diagrams, the spatial dimension (longitude degrees) is along the X axis and the time is along the Y axis. For latitude diagrams, the spatial dimension (latitude degrees) is along the Y axis and the time along the X axis. The result using the anomalies of temperature at 10 m is shown in Figure 16 for Longitude-Time, and Figure 17 for Latitude -Time diagrams.

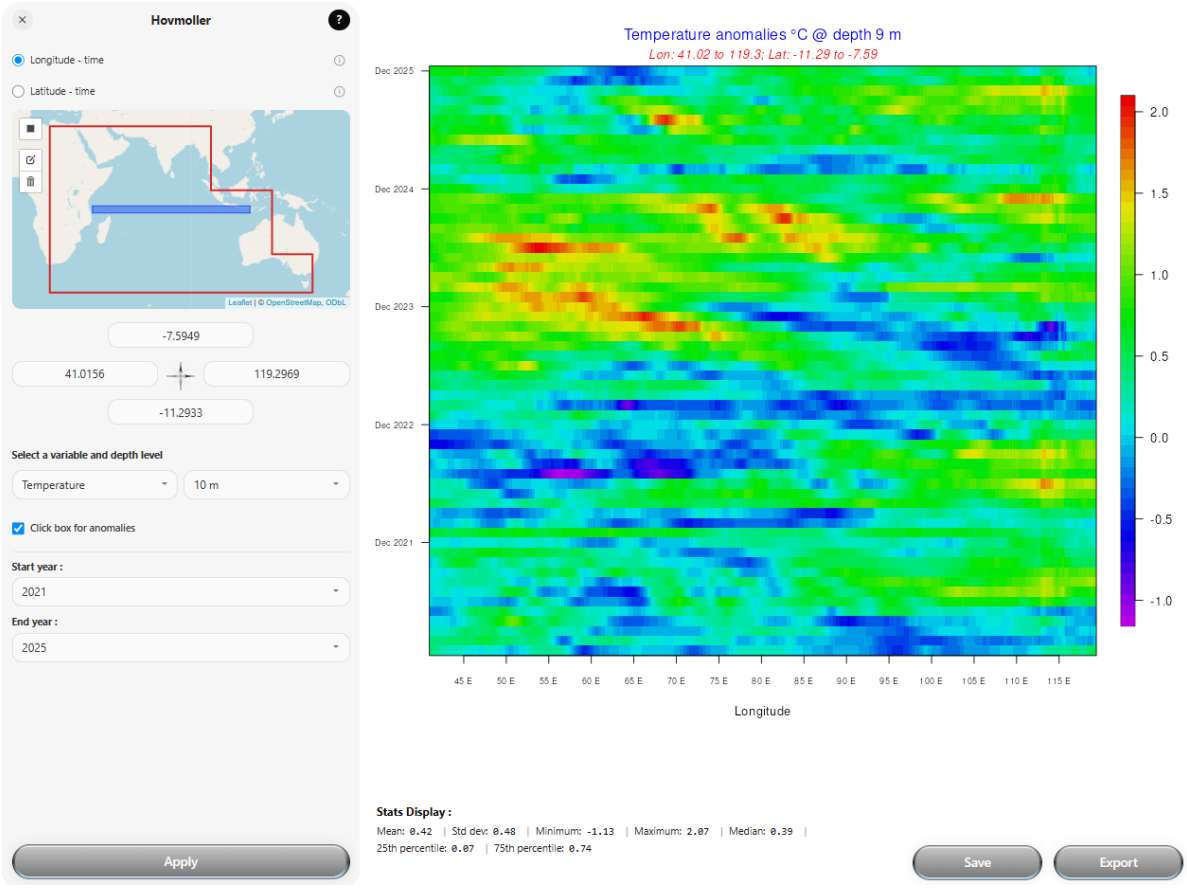


Fig. 16 – Longitude-time Hovmöller diagram of temperature anomalies at 10 m, 2021 to 2025

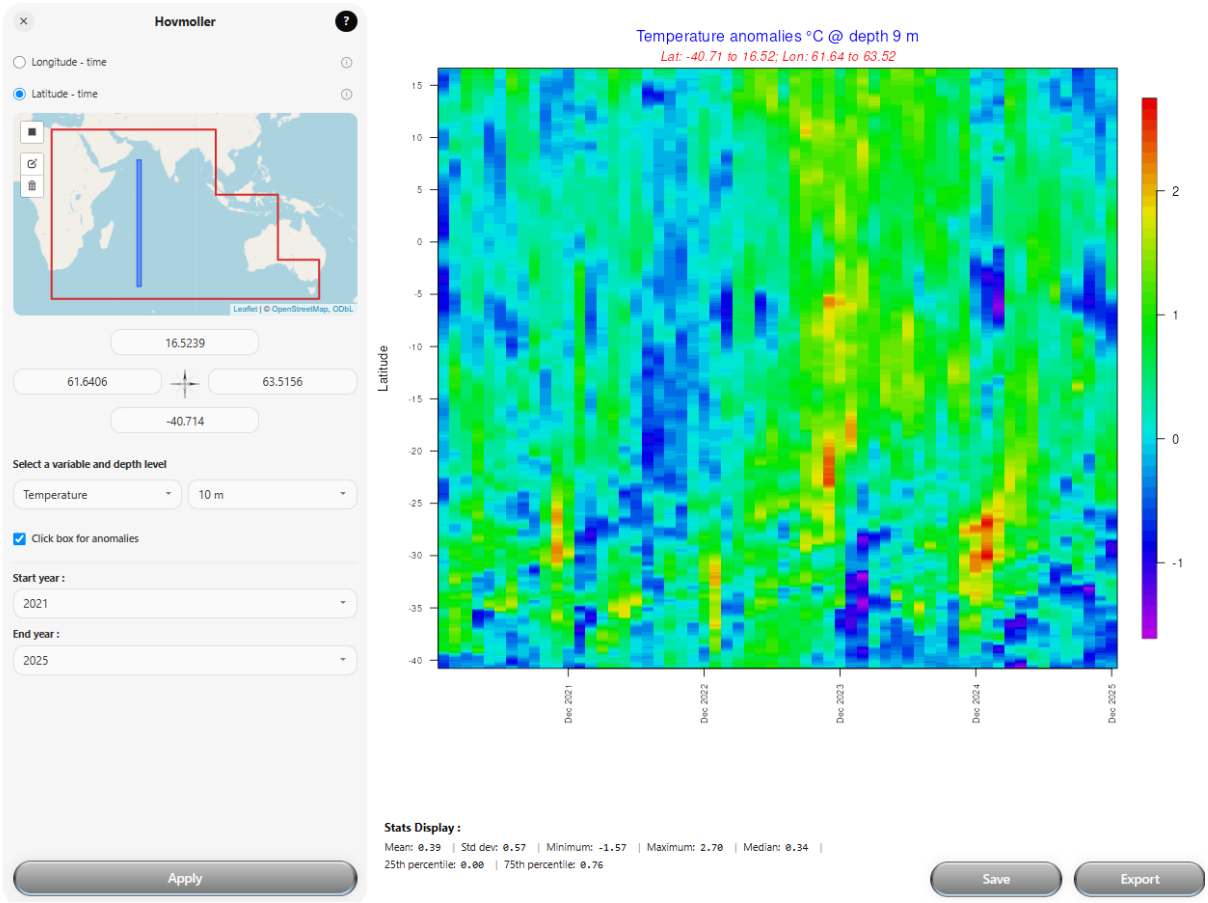


Fig. 17 – Latitude-time Hovmöller diagram of temperature anomalies at 10 m, 2021 to 2025

5.4 The DEPTH PROFILES module

Depth profiles are plotted for the variables having a "depth" dimension, such as temperature, salinity, current, dissolved oxygen, chlorophyll a, net primary production* and pH*.

Click on the pointer (*Draw a marker*) and drag it on the inset map to select a location. The coordinates of the point will appear below the inset map. Select a **variable**, **anomalies** (check box if wanted) then the **maximum depth** of the profile. Eventually, you define a **year** and **month** for the profile.

By default, you plot a single profile at the selected location. Alternatively, you can make a combined plot pooling all grid cells around the selected location, within a radius of 25, 50 or 100 km. In that case, select the radius in the drop-down list of "**Include neighbour profiles**". In that case, the maximum and minimum values at each depth around the profile will be represented by a shaded pink ribbon. Click **Apply** to submit the query. An example for a temperature profile is given in Figure 18.

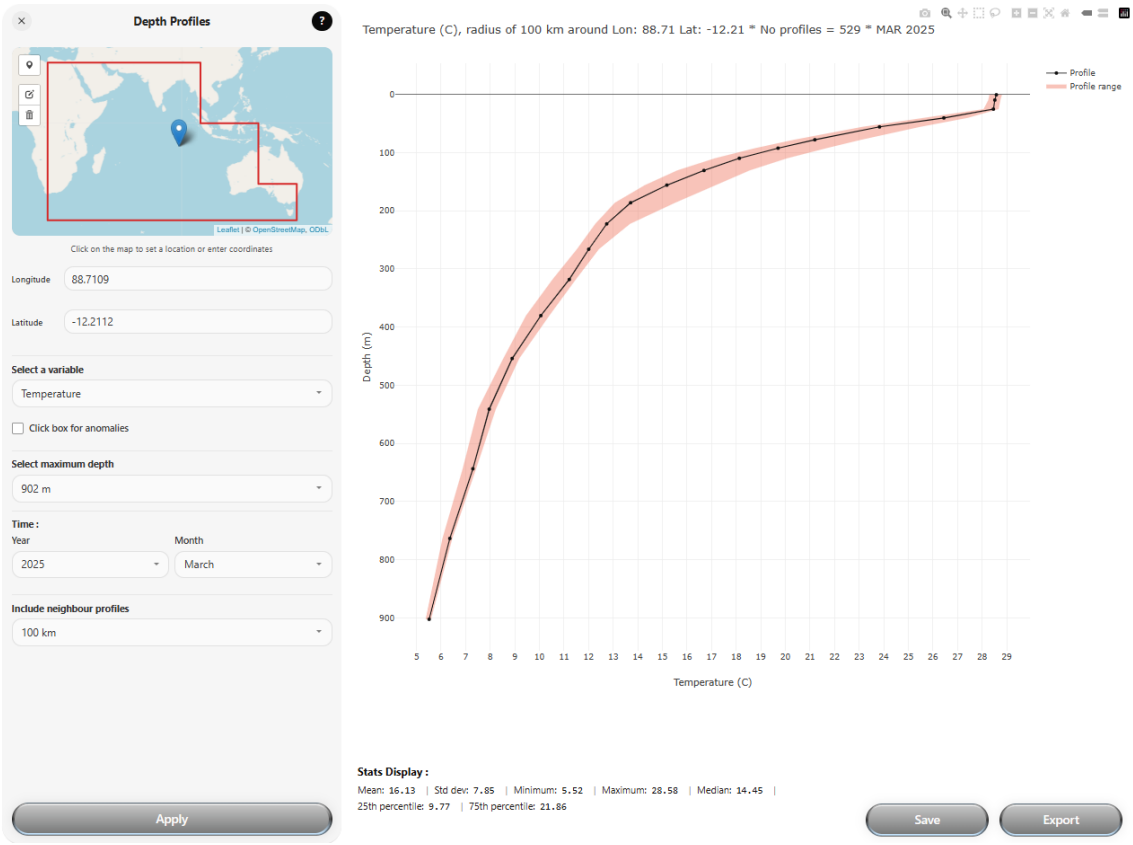
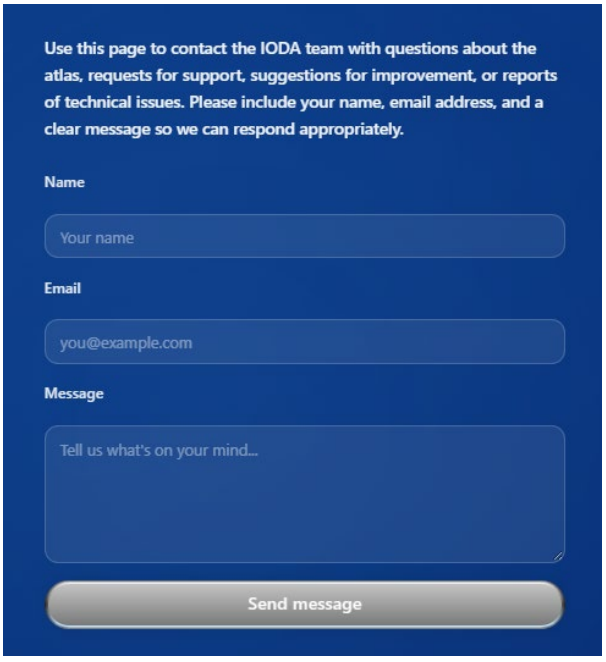


Fig. 18 – Temperature depth profile to 900 m (black line) and temperature range in the surrounding 100 km (shaded area) around the selected profile position.

6. Reporting bugs and comments

IODA is not guaranteed 100% bug-free. Therefore, reporting bugs is much welcome to correct the tool. Similarly, suggestions are also useful to devise on future versions of the atlas.



To report any comment, click **Contact** in the IODA home page. You will see the screen shown on the left

Enter your name, email contact, write your message and send it. It will be processed by the IODA management team.

2

7. Glossary of terms

The terms below are listed in alphabetical order

Comma-separated values (CSV): a plain text data format for storing tabular data where the fields (values) of a record are separated by a comma as the delimiter and each record is a line.

Current shear: integration in the water column of the zonal (north-south) and meridional (east-west) velocity components of each layer *n* between the surface and a given depth *z*. The shear calculated in IODA is the log-transformed value of this integration. It is provided for two different depth ranges, 0-130 m (shallow) and 0-450 m (deep). Shear can be used to study (to some extent) the performance of the drifting longlines, as the shear can affect the gear shape when deployed. The shallow shear could be applied to the swordfish longline fishery whereas the deep shear would refer to the tuna longline fishery.

Fmax: the maximum fluorescence intensity emitted by photosynthetic organisms in the ocean's water column. In IODA, the Fmax depth corresponds to the depth of the Deep Chlorophyll Maximum (DCM) calculated from vertical profiles of *chlorophyll-a* of the coupled NEMO-PISCES biogeochemical model.

Hovmöller diagram: A cross between a map and a graph, which allows to condense a multiyear series of observations into a single picture. It is used to trace in a static way the temporal evolution of spatial patterns in the ocean or the atmosphere.

Integrated Chlorophyll content: the sum of chlorophyll-a concentration (mg m^{-3}) at depth in the upper 300 m of the ocean calculated from vertical profiles of *chlorophyll-a* of the coupled NEMO-PISCES biogeochemical model.

JSON (JavaScript Object Notation): an open standard file format and data interchange format that uses human-readable text to store and transmit data objects consisting of name–value pairs and arrays

Mixed layer: a layer in which active turbulence has homogenized some range of depths. The ocean mixed layer is a layer subject to turbulence generated by winds, surface heat fluxes, or evaporation which results in an increase in salinity. The mixed layer depth represented in IODA (sourced from Copernicus Marine Environment) is the depth where the density increase compared to density at 10 m depth corresponds to a temperature decrease of 0.2°C in local surface conditions.

Net primary Production (NPP): the balance between the carbon gained by photosynthesis and the carbon released by plant respiration. Applied to the ocean, NPP measures the amount of biological material produced primarily by phytoplankton to support the consumers of the sea.

pH: a numeric scale that measures the acidity of basicity of a solution (concentration of hydrogen H+ ions). A pH of 7 indicates a neutral solution; values below 7 are acidic while values above 7 are basic of alkaline. The pH scale ranges from 0 to 14. The scale is logarithmic, meaning that each whole number change represents a tenfold difference in H+ concentration (e.g. pH 5 is ten times more acidic that pH 6).

Sea level anomaly (SLA): the deviation of the sea surface height from the mean sea surface (SLA = SSH – MSS). This product is derived from satellite observations. Positive (negative) anomalies indicate downwelling (upwelling) in the ocean mixed layer. SLA can be used to identify sea level rise trends.

Space-separated values (SSV): a plain text data format for storing tabular data where the values of a record are separated by space as the delimiter and each record is a line.

Tab-separated values (TSV): a plain text data format for storing tabular data where the values of a record are separated by a tab character as the delimiter and each record is a line.

Thermocline: a distinct layer in a body of water where temperature decreases rapidly with depth, forming a sharp thermal gradient that separates warm surface waters from colder deep water. The thermocline depth calculated in IODA is the 20°C isothermal depth.

XLSX: tabular data format managed by Microsoft Excel©