PRODUCT USER MANUAL

GLIDER TOOLBOX

From EOVs to geostrophic transport estimations

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Balearic Islands Coastal Observing and Forecasting System

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Description:	This document describes the toolbox for the automatic visualization of physical and biogeochemical variables, as well as the operational production of geostrophic transports in the Balearic Channels from SOCIB glider observations.
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1. Introduction

1.1. SOCIB objectives

SOCIB contributes to respond to science and society needs monitoring the ocean through multi-platform observational network in the western Mediterranean and providing quality-controlled data (Tintoré *et al*., 2013, 2019). Efficient tools are also developed to monitor and visualize Essential Ocean Variables (GOOS, https://www.goosocean.org/eov) and derived indicators (https://apps.socib.es/subregmed-indicators/; https://apps.socib.es/subregmed-marine-heatwaves/), and to analyse and understand the ocean state and variability (Juza and Tintoré, 2021; Juza et al., 2022).

In particular, SOCIB has implemented an open access toolbox for the computation and visualization of physical/biogeochemical variables from gliders, as well as derived variables and indicators (Juza and Tintoré, 2021) that are relevant for both science and society. This work is also a contribution to the JERICO-S3 project, Task 7.5.2.: "*Estimation of sea water masses types and transport monitoring D2PTS: will develop physical oceanography products from glider data that may be combined with biogeochemistry observations*".

1.2. SOCIB glider monitoring

The Ibiza Channel (IC) is considered as a choke point of the western Mediterranean Sea (Heslop *et al*., 2012; Juza *et al*., 2013) where the topography and circulation are complex, where most of the meridional exchanges of water mass occur and where the high ocean variability strongly affects the marine ecosystem. SOCIB is monitoring the IC quasi-continuously through the deployment of gliders along an endurance line since January 2011. The repeated glider sections enable a high-resolution monitoring to describe and understand the ocean processes involved in the ocean circulation variability from daily/weekly to interannual scales. Semi-permanent glider sections are becoming available in different coastal to ocean areas, and tools such the one developed will facilitate understanding the circulation in key ocean areas and its relation to water masses driving these changes.

1.3. Computation and visualization support

An effective tool has been developed processing the SOCIB glider data to monitor and visualize the ocean circulation and variability as observed by the glider measurements. The developed metrics and diagnostics are: (1) vertical sections of temperature (T), salinity (S), density (ρ) and geostrophic velocity (GV), (2) T/S diagrams and water mass identification, and (3) geostrophic transports (total and per water mass).

The tool also allows the use of biogeochemical (BGC) data from glider measurements (chlorophyll-a concentration, oxygen concentration and saturation, and turbidity). The data processing applied to the BGC data is the same as for the hydrographic variables (T, S) in order to be able to relate BGC values to the GV and associated water mass transports.

2. Toolbox description

2.1. Datasets

The glider data used are the L1 delayed time (DT) or delayed mode (DM) glider products, which are quality-controlled and distributed by SOCIB. The potential temperature θ is computed with 0 for the reference pressure.

2.2. Scripts

The complete time series (all glider missions) from a given date are processed executing the general script:

General script: launch/ script_glider_transports_period_glider.sh

The three principal steps of the general script are:

1. launch/generate_SOCIB_glider_data_file_list.sh [loading glider data]
Generates the sorted list (by time) of "correct glider files (discarding "bad" missions) from SOCIB thredds for a given deployment ("Canales" or "all").

2. launch/compute_transports_glider.m [processing data & computing transports]	
- matlab/processing_transect_glider.m (1st data processing) *T/S QC, vertical interpolation, glider potential T (θ) computation, transect detection.*	
- matlab/processing_transport_glider.m (2nd data processing) *Projection on standard line, horizontal interpolation, filling, smoothing, water mass detection, geostrophic velocity (GV) and transport computations.*	
Additional sub-routines (in matlab/)	
- binHoriz.m, binHoriz_bgc.m	- *horizontal bin interpolation*
- binVert.m, binVert_bgc.m	- *vertical bin interpolation*
- calculate_geostrophy(_commonDepth).m	- *geostrophy computation*
- colorlist.m	- *colors*
- findGliderType.m	- *find glider type*
- get_bathymetry_sections.m:	- *interpolate bathymetry to standard line*
- get_bathymetry_Smith_Sandwell.m	- *read bathymetry (Smith & Sandwell)* **

- get_logo.m	*- load logo*
- get_glider_transects_IC.m	*- detection glider transects* **
- initfigall.m	*- figure adjustment for print*
- interpHoriz.m, interpHoriz_bgc.m	*- horizontal interpolation*
- interpVert.m, interpVert_bgc.m	*- vertical interpolation*
- medcoast_huge_noriv.mat	*- Mediterranean coast line* **
- plot_glider_bgc_individual_sections.m	*- plot biogeochemical data*
-plot_glider_geostrophy_individual_sections.m	*- plot geostrophic velocity*
- plot_glider_trajectory.m	*- plot glider surface trajectory*
- plot_glider_ts_individual_sections.m	*- plot TS vertical section*
- plot_glider_ts_sections.m	*- plot all TS vertical sections*
- projectPointsOnLine.m	*- projection into standard line*
- redbluelio.mat	*- color map*
- stdLineProjection.m	*- creation standard line*
Data processing (quality control, interpolation on regular grid, transect detection), geostrophic velocity and transport computations.	

** Specific function or file for the Balearic Channels in the western Mediterranean

3. matlab/plot_glider_model_transports.m	[visualization]
- get_logo.m - initfigall.m	*- read logo* *- figure configuration for print*
Plots time series of geostrophic transports for glider (total & per water mass).	

2.3. Data processing

2.3.1. First step (processing_transect_glider.m)

Input	Glider file (L1)
Profile identification	Find profiles (profile_index)
Data sampling conditions	Number data>10, data gap<5 db, length>20 db (per profile)
Linear interpolation into vertical grid	- Depth resolution = 1m (~glider sampling) - From 0 to max(mission pressure) - Profile position (lon,lat,time)=mean(lon,lat,time)
Outputs	Figures (see section 3.1) - Positions of glider profiles - Detected transects in the selected channel - Vertical sections of θ, S, BGC (optional) for all the mission

	- θ/S diagram distinguishing channels for all the mission Matfile - Structure *dataTS* with processed profiles and transect index

2.3.2. Second step (processing_ transport_glider.m)

Input	Output matfile from 1st step
Projection on standard line	Projection of longitude and latitude on fitted line
Filling surface gaps	Horizontal linear interpolation of surface values + extrapolation
Bin data / linear interpolation	5m/2km bins in vertical/horizontal
Fill to channel bottom	Interpolate bathymetry into standard line + extrapolation
Horizontal smoothing	Moving average filter: 24km
Geostrophic transports	Compute GV from binned/interpolated/smoothed T/S + total and water mass transports
Outputs	Figures (see section 3.2) For each individual transect in channel: - Vertical sections of θ, S, density, BGC (optional), GV - θ/S diagram distinguishing the identified water masses Matfile - Structure *dataGV* with GV and transports

2.3.3. Transport visualization (plot_glideronly_transports.m)

Inputs	Output matfiles from 2nd step for processed missions over selected period
Outputs	Figures (see section 3.3) - Time series of total geostrophic transports (net, northward, southward) - Time series of water mass geostrophic transports (northward, southward)

2.4. Specific options

Smoothing parameter	- Initial value: 6 km (Heslop et al., 2012) - Recommended value: 12 or 24 km (~Ro)
Criterion for WIW	Article (Juza et al., 2019)
Biogeochemical data	- BGC data: chlorophyll-a concentration, oxygen concentration / saturation, turbidity - Additional vertical sections of BGC data (sections 3.1.4/3.2.3)
Ibiza / Mallorca Channels	- Some missions monitor both channels - Automatic detection of transects distinguishing each channel

3. Visualization

3.1. *Figures (1st data processing)*

3.1.1. Glider mission

First, the characteristics of the mission are displayed: the trajectory of the glider (Fig. 1) as well as the transects in IC as detected by the tool following the longitude variations (Fig. 2).

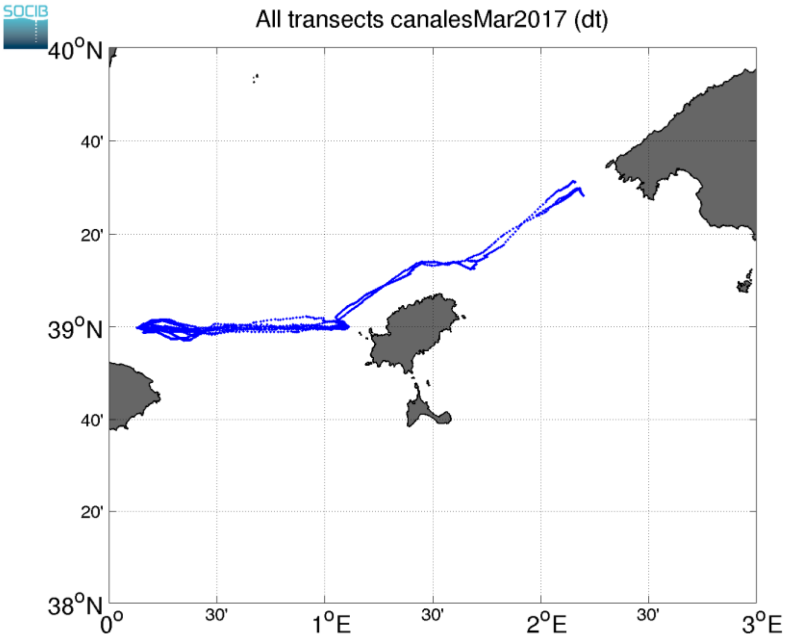

Figure 1: Profile positions during the glider mission deployed in March 2017.

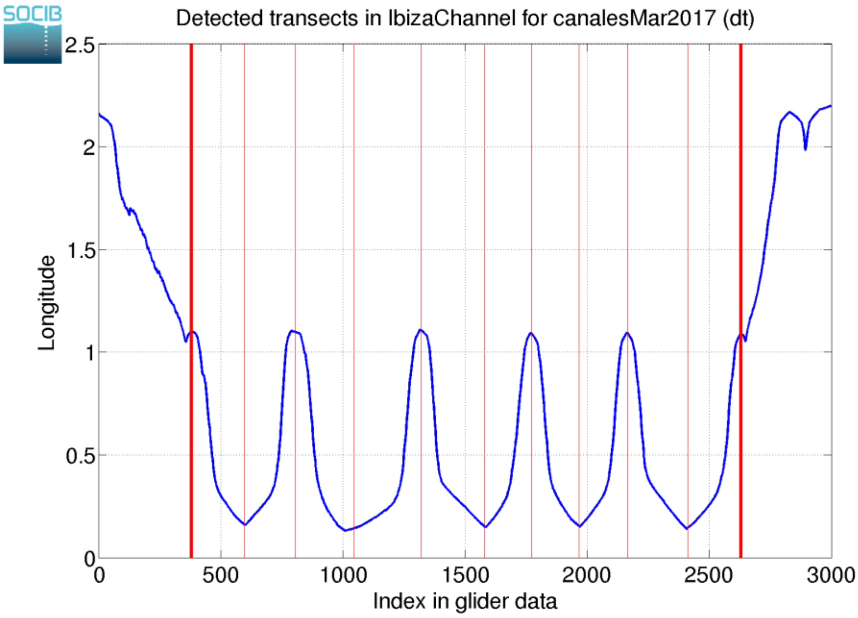

Figure 2: Longitudes (blue) and detected transects (between two red lines) for the glider mission deployed in March 2017

3.1.2. Vertical sections (all transects)

All available vertical profiles of θ and S data from glider are shown as function of time. Sections for glider are illustrated in Fig. 3.

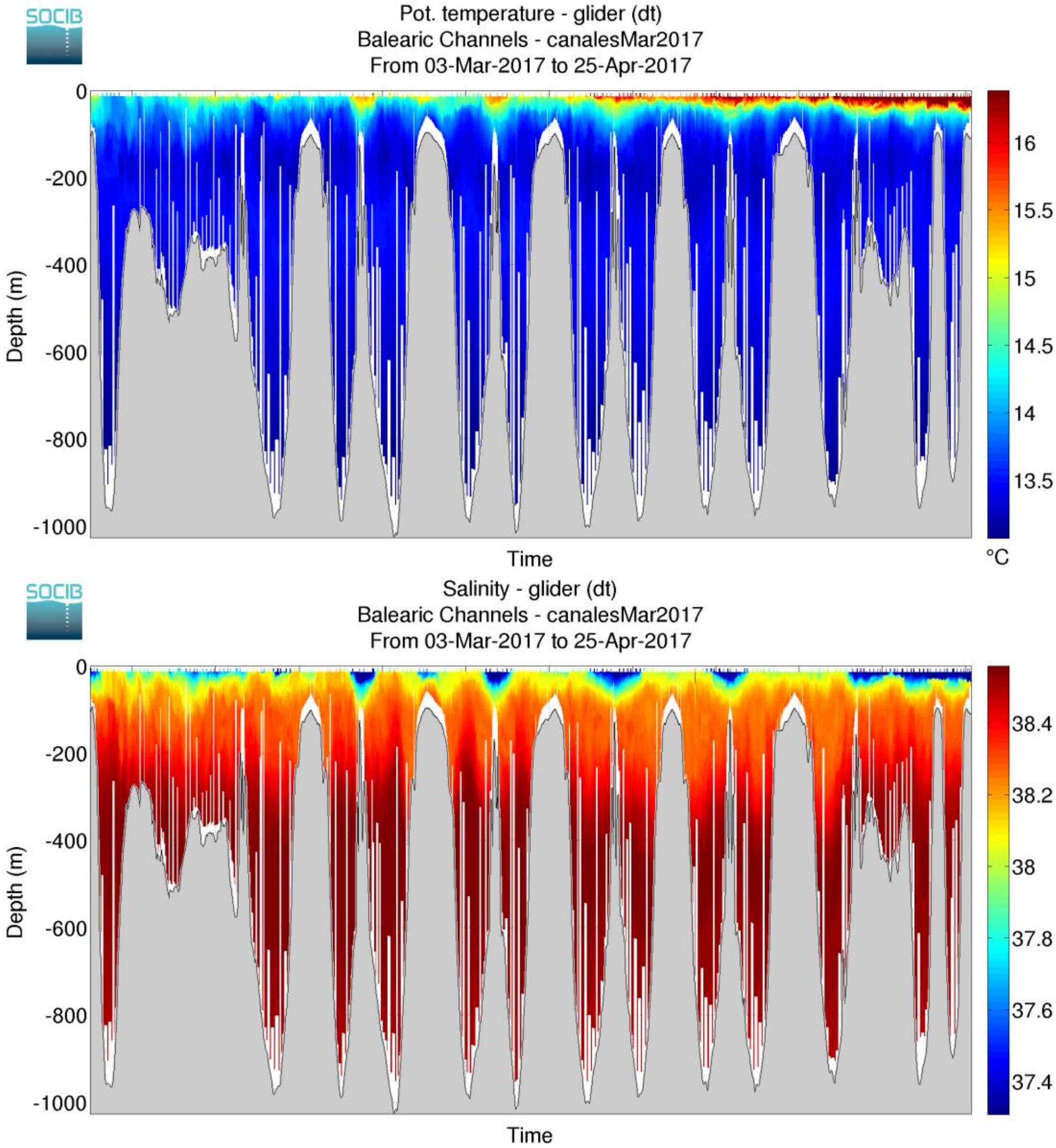

Figure 3: Quality controlled and vertically interpolated θ and S profiles for all transects of the mission in March 2017 (Mallorca and Ibiza Channels).

3.1.3. T/S diagram

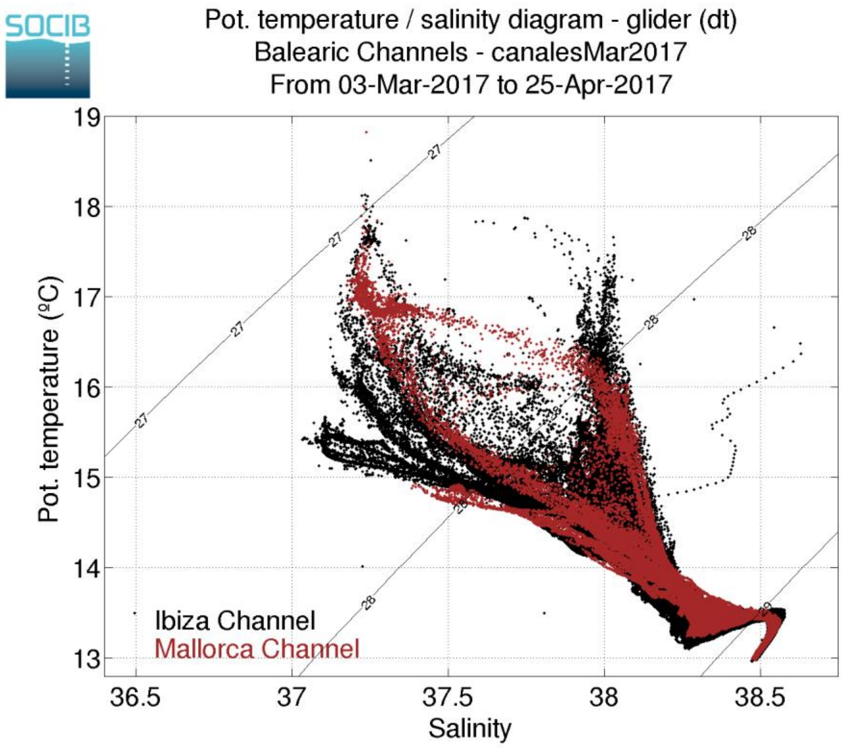

Figure 4: θ/S diagram for all the profiles of the missions distinguishing the channels.

3.1.4. Optional figures (BGC data)

Vertical profiles of BGC data are displayed as function of time (as done for θ and S). Illustrations in Fig. 5 are given for the mission in November 2015. Note that no data of Chlorophyll-a and turbidity were collected during this mission.

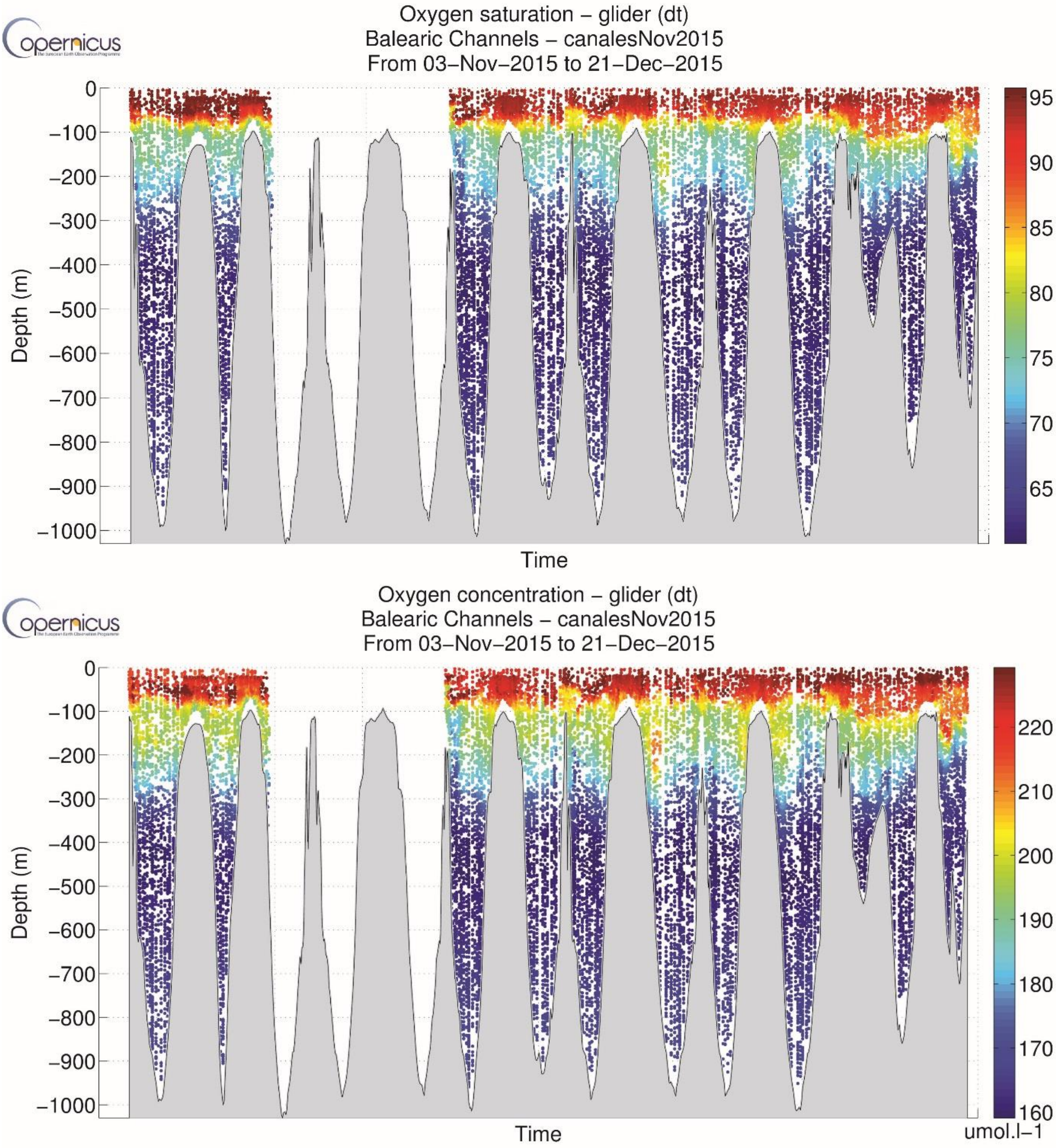

Figure 5: Vertical sections of oxygen concentration and saturation from glider for all monitored transects, plotted as a function of time, during the mission in November 2015.

3.2. *Figures (2nd data processing)*

3.2.1. Vertical sections (individual transects)

Illustrations are given for the 4th transect of the mission in March 2017.

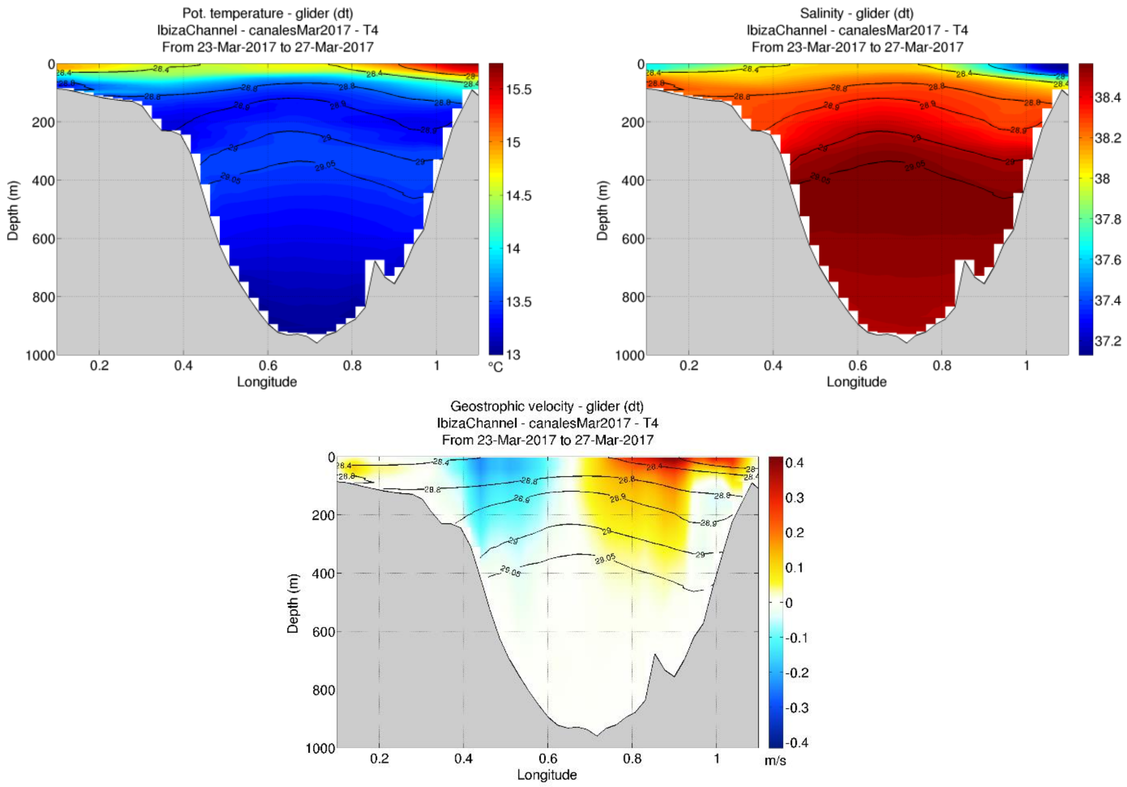

Figure 6: Vertical section of glider θ, S and GV for the 4th transect in IC of the mission.

3.2.2. T/S diagrams (individual transects)

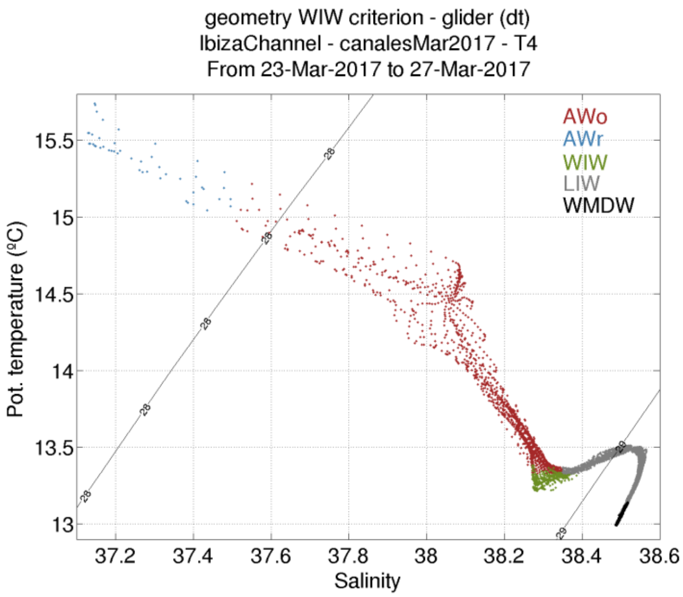

Figure 7: θ/S diagram for the profiles of the 4th transect in IC of the mission.

3.2.3. Optional figures (BGC data)

Illustrations are given for the mission in November 2015.

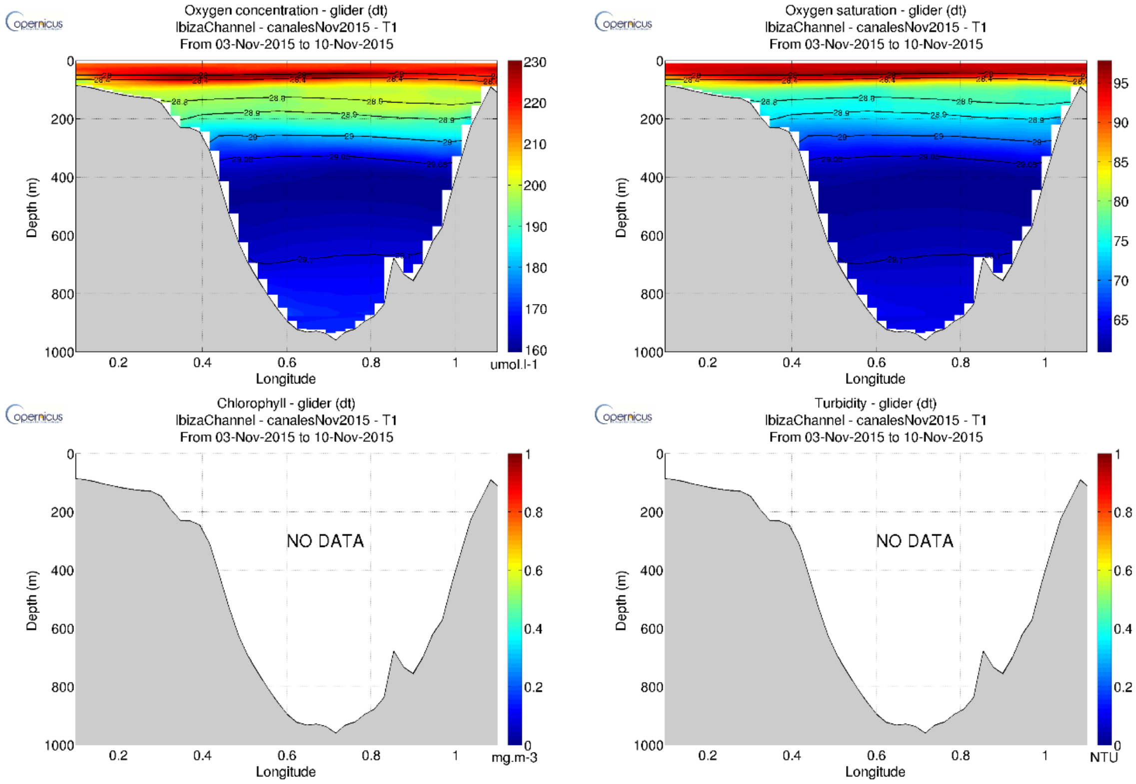

Figure 8: Vertical section of glider oxygen concentration and saturation, Chlorophyll-a concentration and turbidity for the 1st transect in IC of the mission.

3.3. Figures (transport visualization)

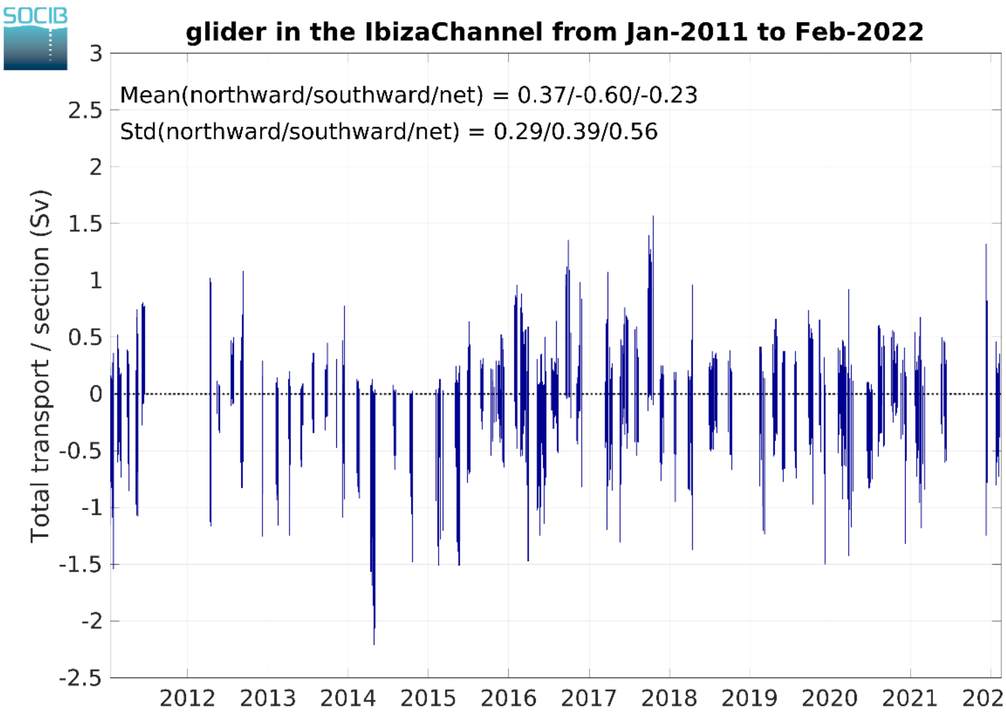

Figure 9: Total geostrophic transports (northward & southward) in the IC for all the missions since 2011.

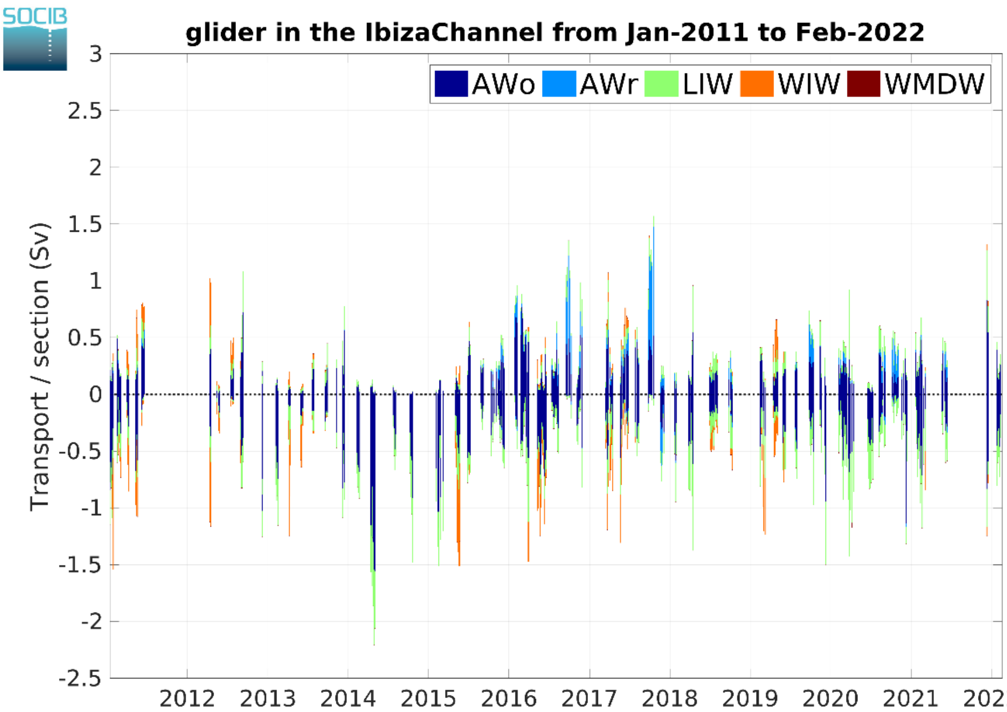

Figure 10: Water mass geostrophic transports (northward & southward) in the IC for all the missions since 2011. Source: https://apps.socib.es/subregmed-indicators/transports.htm

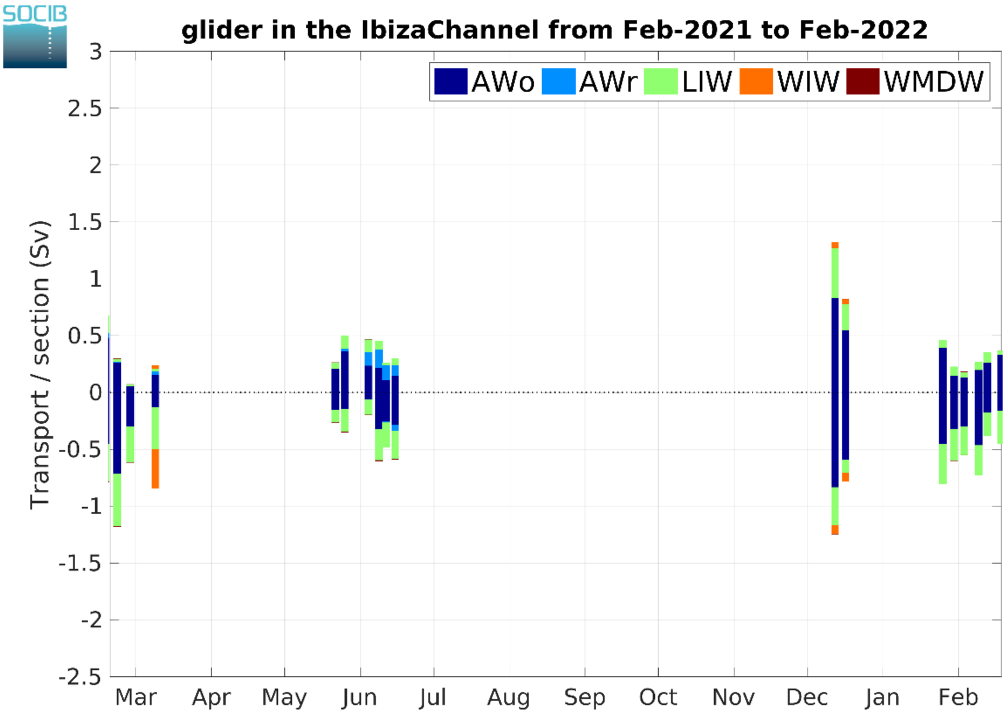

Figure 11: Same as Figure 10 over the last year.
Source: https://apps.socib.es/subregmed-indicators/transports.htm

4. Conclusion and perspectives

An automatic tool has been developed to process the L1 product from SOCIB glider observations in the Balearic Channels in order to compute and visualize key variables and indicators (geostrophic transports), flowing three steps:

- 1st data processing: building QC L2 product, identifying transect, generating files/figures
- 2nd data processing: computing geostrophic transport per transect, generating files/figures
- Final visualization: displaying time series of geostrophic transports in the Channels.

As future works, it could be performed the following:

- **Netcdf files**: the toolbox generates, as added-value products from glider data, figures (in png) and files containing the derived variables (in mat). The generation of these files in netcdf is planned.
- **Programming language**: the launch scripts are written in bash. Then, most of the computational codes are written in matlab. The conversion in python is planned, under the condition of finding human resources.
- **Extending/exporting the toolbox**: the structure of the toolbox allows adapting the codes through the modifying of specific/individual function. In particular, the toolbox can

be extended to:

- Model data interpolated at the glider space-time positions
- Gliders deployed in another channels (such as in Gulf of Finland)

Acronyms

AWo	Atlantic Water “old”
AWr	Atlantic Water “recent”
BGC	Biogeochemical data
DM	Delayed mode
DT	Delayed time
D2PTS	Data to product thematic service
EOV	Essential ocean variable
GOOS	Global ocean observing system
GV	Geostrophic velocity
IC	Ibiza Channel
LIW	Levantine Intermediate Water
NW-MED	North-western Mediterranean
PSS	Pilot Super Site (JERICO-S3)
T	Temperature
θ	Potential temperature
S	Salinity
SOCIB	Balearic Islands Coastal Observing and Forecasting System
WIW	Western Intermediate Water
WMDW	Western Mediterranean Deep Water

References

Heslop, E., Ruiz, S., Allen, J., López-Jurado, J.L., Renault, L., Tintoré, J. (2012). Autonomous underwater gliders monitoring variability at “choke points” in our ocean system: a case study in the western Mediterranean Sea”. *Geophys. Res. Lett.*, 39(L20604), doi:10.1029/2012GL053717.

Juza, M., Renault, L., Ruiz, S., & Tintoré, J. (2013). Origin and pathways of Winter Intermediate Water in the North-western Mediterranean Sea using observations and numerical simulation. Journal of Geophysical Research: Oceans, 118(12), 6621-6633, doi:10.1002/2013JC009231.

Juza, M., Escudier, R., Vargas-Yáñez, M., Mourre, B., Heslop, E., Allen, J., & Tintoré, J. (2019). Characterization of changes in Western Intermediate Water properties enabled by an innovative geometry-based detection approach. Journal of Marine Systems, 191, 1-12, doi:10.1016/j.jmarsys.2018.11.003.

Juza, M. and Tintoré, J. (2021). Multivariate sub-regional ocean indicators in the Mediterranean Sea: from event detection to climate change estimations, Frontiers in Marine Science, 8:610589, doi.org:10.3389/fmars.2021.610589.

Juza, M., Fernández-Mora, A., and Tintoré, J. (2022). Sub-regional marine heat waves in the Mediterranean Sea from observations: long-term surface changes, sub-surface and coastal responses, Front. Mar. Sci., doi:10.3389/fmars.2022.785771.

Tintoré, J., et al. (2013). SOCIB: the Balearic Islands Coastal Ocean Observing and Forecasting System responding to science, technology and society needs. Mar. Techn. Soc. J., 47(1), doi:10.4031/MTSJ.47.1.10.

Tintoré, J., et al. (2019). Challenges for sustained observing and forecasting systems in the Mediterranean Sea. Front. Mar. Sci. 6:568, doi.org:10.3389/fmars.2019.00568.

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