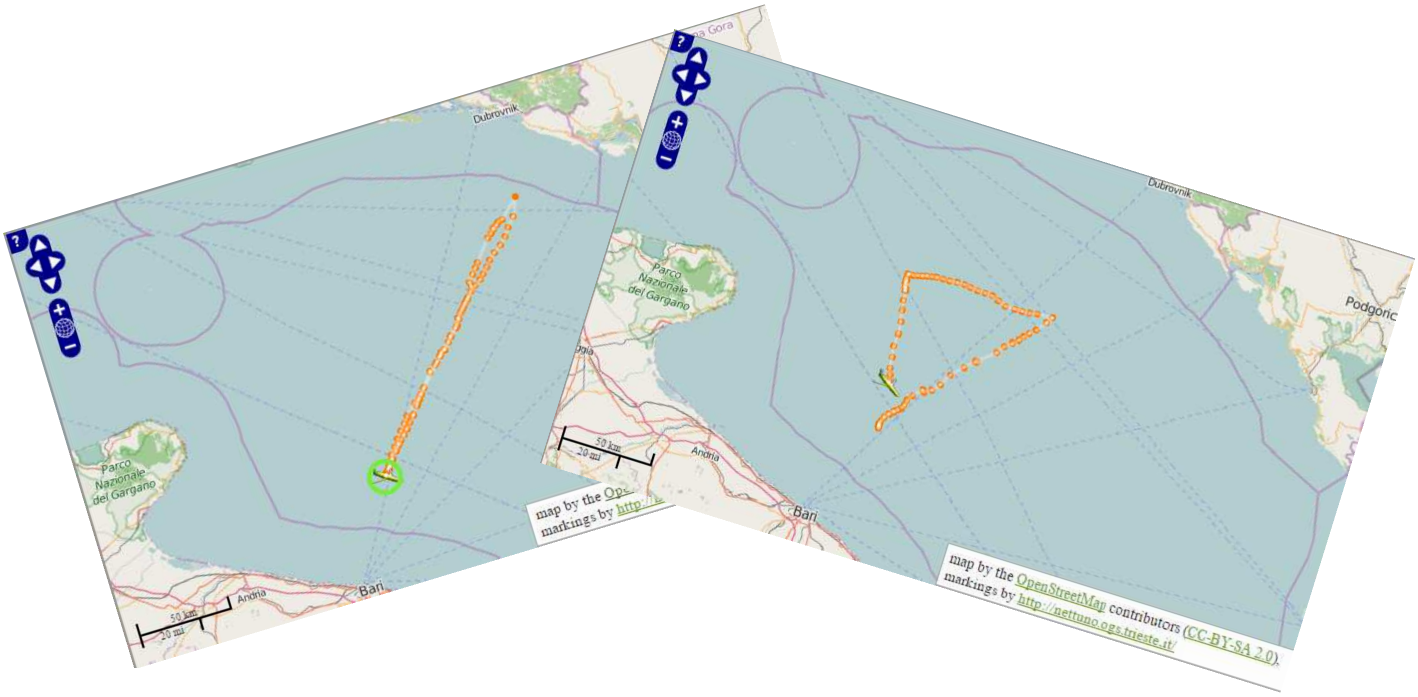

The PreConvex16 and Convex16 glider missions in the South Adriatic Sea (November 2015 and April 2016)

R. GERIN, E. MAURI, A. BUSSANI, P. ZUPPELLI, S. KUCHLER,
Z. KOKKINI, M. PACCIARONI and P.-M. POULAIN

Approved by: ……………………………

Dr. Paola Del Negro

INDICE:

1. Introduction

As part of the South Adriatic monitoring program, the Slocum glider 403 was deployed in the Southern Adriatic Sea from November 20 to December 1, 2015 (PreConvex16 mission). The mission had the aim to assess the hydrographical characteristics of the study area in November. During winter (February-March), if the weather conditions are favorable, the area is interested by the deep convection process and the November characteristics will strongly influence the process.

The same glider was deployed again in the same area from April 22 to May 1, 2016 (Convex16 mission) to explore the hydrographical characteristics after the convection.

During both missions the glider was equipped with a Sea-Bird GPCTD sensor for temperature, salinity and pressure, an Aanderaa Optode 4831 oxygen sensor to measure dissolved oxygen and a WetLab ECO Triplet FLBBCD-SLK sensor to measure chlorophyll fluorescence at 470/695 nm, back-scattering at 700nm and Colored Dissolved Organic Matter (CDOM) at 370/460 nm.

2. PreConvex16 mission

The mission started with the deployment of the glider on November 20 at 10:32 UTC at 41.506°N and 17.090°E. The instrument was steered along the Bari-Dubrovnik transect to the first waypoint toward the Croatian waters at 42.333°N and 18.085°E (reached on Nov 26 at 02:54 UTC). The glider then was headed to the Italian Coast and recovered on December 1 at 08:36 UTC at 41.505°N and 17.097°E (Fig.1).

The glider performed about 214 dives with maximum depth varying from 20 to 950 m. The WetLab sensor was programmed to record the optical parameters from the surface down to 600 m (400m starting from 26/11).

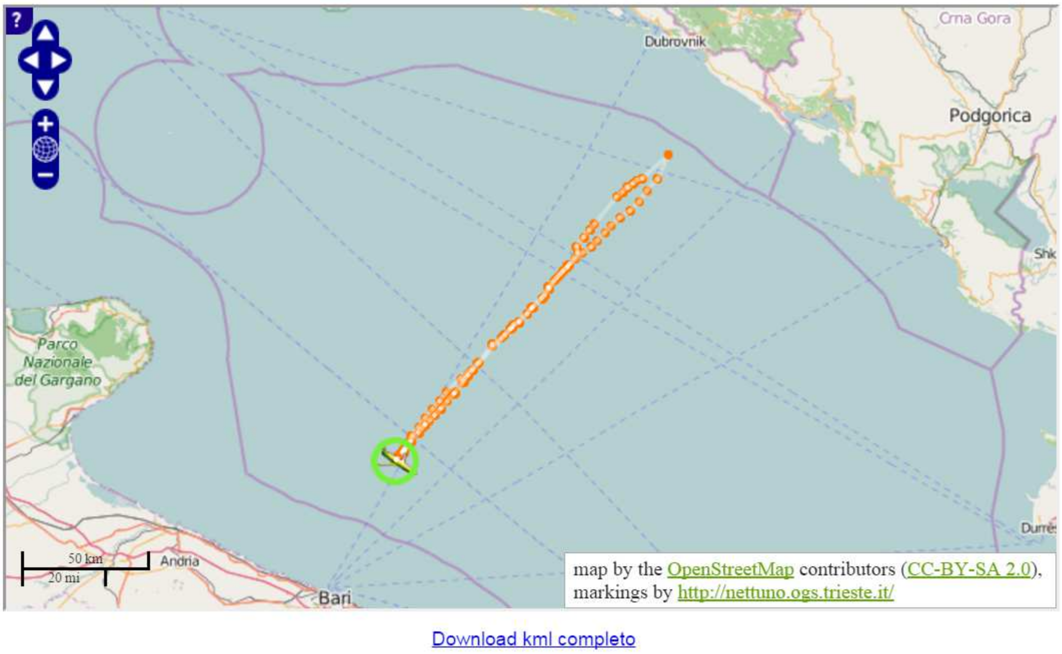

Fig.1 The glider trajectory, along the Bari-Dubrovnik transect, the deployment and recovery was performed off the Italian Coast.

2.1. Scientific data

The temperature data collected during the mission showed well stratified conditions in the top 100 m (Fig.2). Filaments of cold water were crossed along the coastal Italian water. A maximum salinity layer is present at around 100 m (Fig.3). A nucleus of low salinity, located in the center of the pit between 200 and 400m, was crossed on November 23. Other deep low salinity nucleuses were also sampled along the Italian coast. A second high salinity layer is present between 400 to 600 m.

The maximum oxygen concentration is observed on top the sub-surface salinity maximum layer (Fig.4).

Fluorescence depicts patchy distribution of chlorophyll in the top 80 m (Fig.5). The back-scatter plot (Fig.6) displays high values in correspondence of the WAC along the Italian coast. Low CDOM values (Fig.7) are depicted along the glider transect on the way back (from Dubrovnik to Bari). The maximum depth of acquisition for the optical sensor was changed during the mission (from 600m to 400m), consequently the interpolation displayed from 26/11 below 400m is an artefact (Fig.5, Fig.6 and Fig.7).

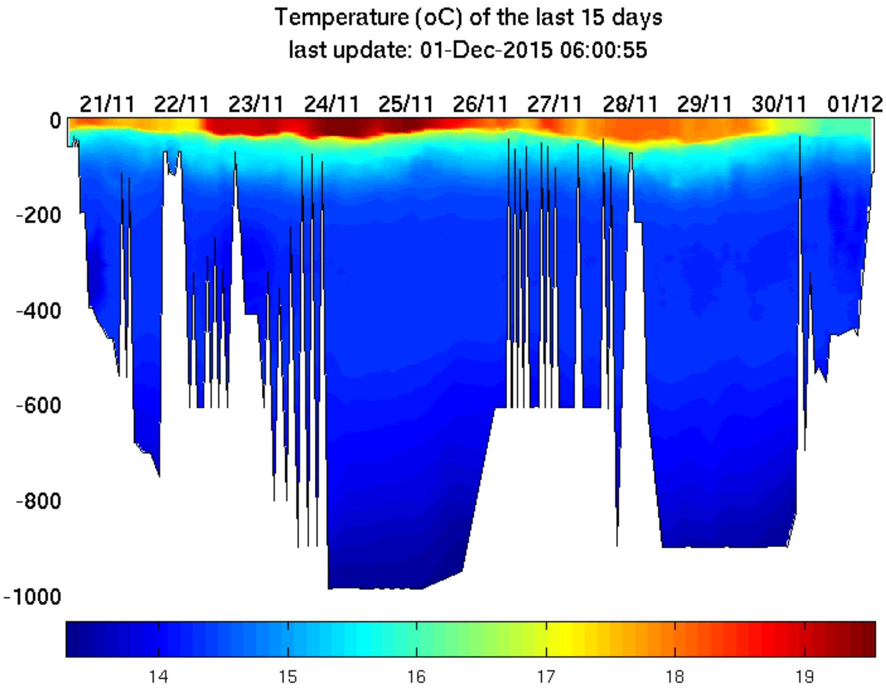

Fig.2 *Sea temperature versus time.*

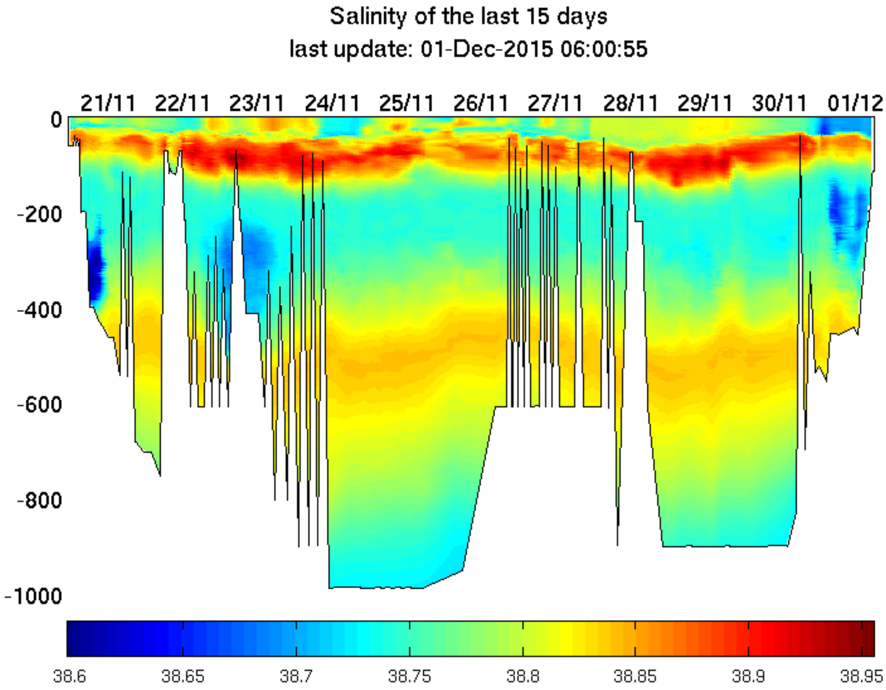

Fig.3 *Salinity versus time.*

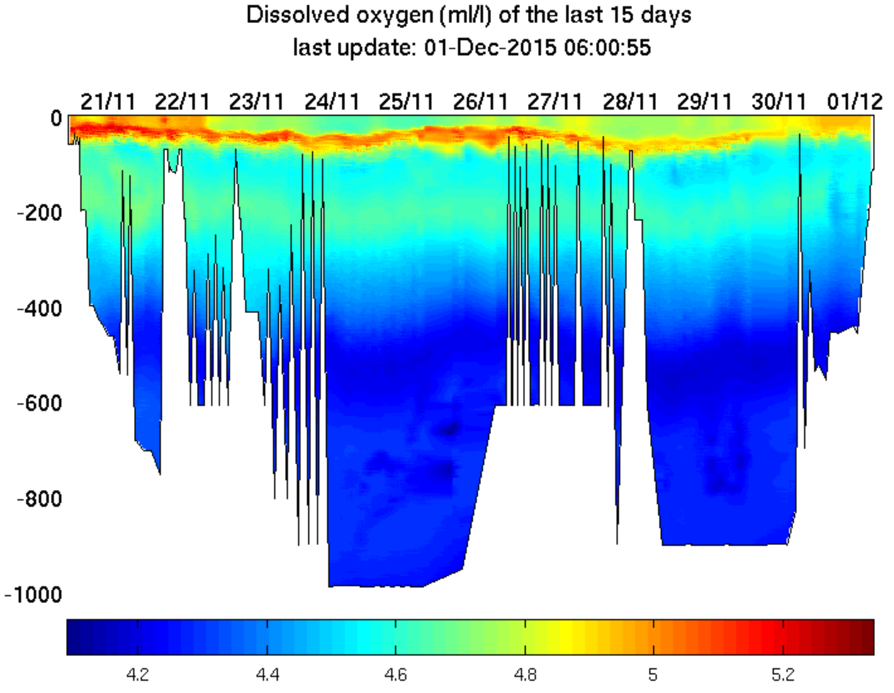

Fig.4 Oxygen versus time.

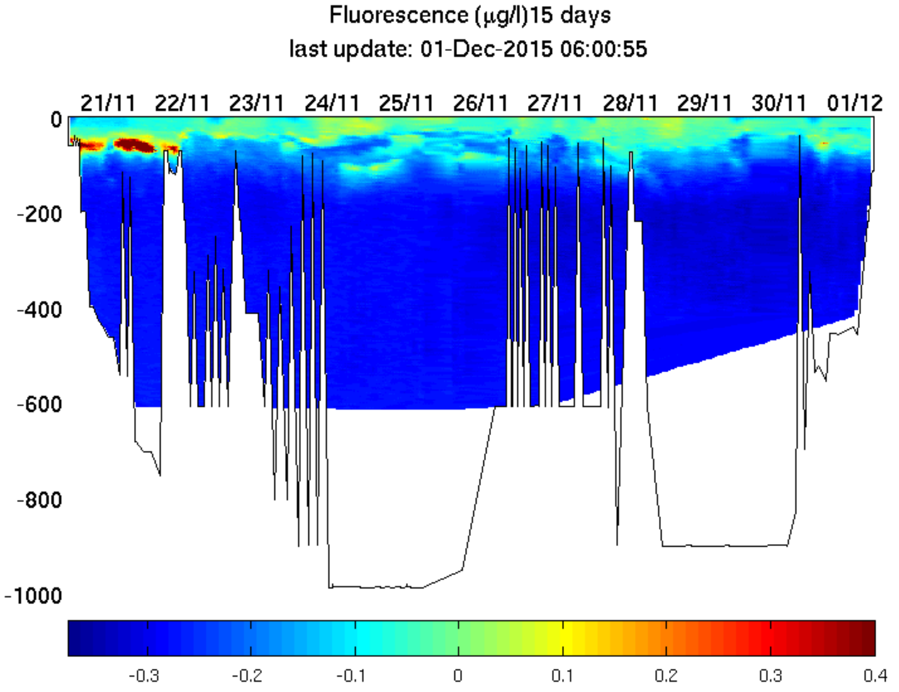

Fig.5 Fluorescence versus time.

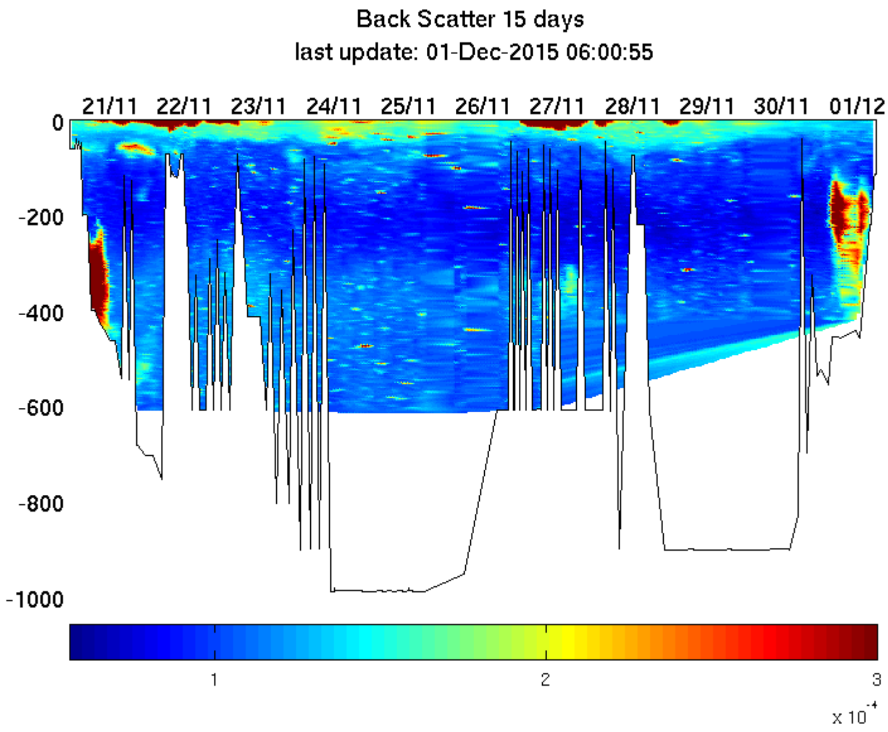

Fig.6 Back-scattering versus time.

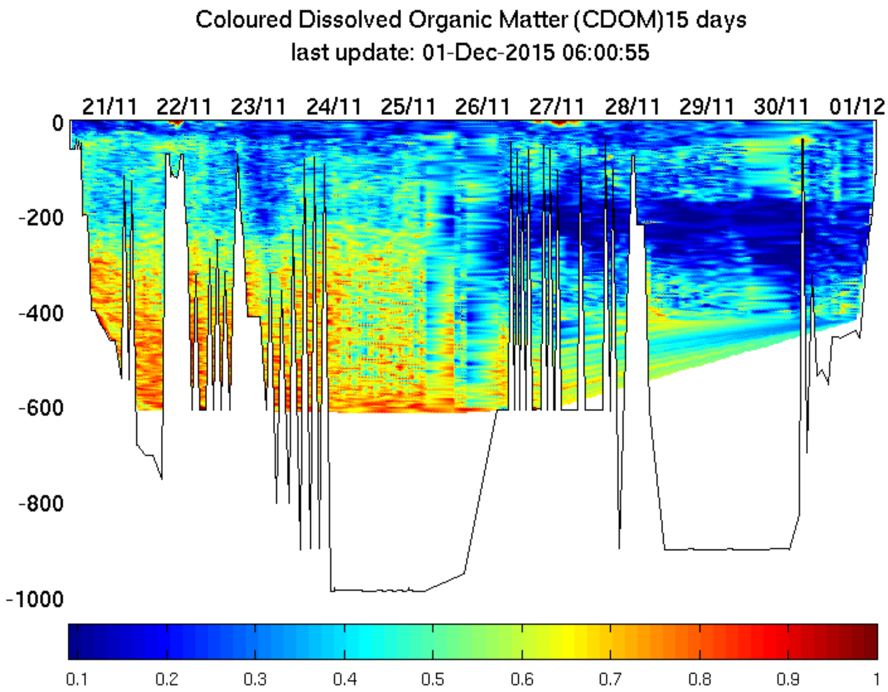

Fig.7 CDOM versus time.

2.2. Technical data

The technical data recorded during the mission are depicted in figures from Fig.8 to Fig.15. The glider altimeter detected the bottom several times (green dots in Fig.8) and the glider reacted correctly turning as expected. It looks that there is no risk of hitting the bottom even in case of damaged/uncalibrated depth sensor (see 3.3). Indeed, the interval between the bottom and the depth at which the glider begins its ascent due to the bottom detection (see for example what happened on 12/01) seems to correspond exactly to the d_target_altitude value set in the yo**.ma file (50 m). This means that the glider considers the distance from the bottom and not the depth of the bottom.

The battery consumption for the 10-day mission was about 85 A (Fig.9) and the voltage dropped from about 13.6 V to about 12.1 V (Fig.10). The measured heading varied within about 20 degrees from the commanded heading (Fig.11). The vacuum was between 7 and 7.5 inHg while the glider was navigating underwater and around 9 inHg when the glider was at surface (Fig.12). No leakage was detected during the mission (Fig.13). The pitch and vertical velocities plots (Fig.14 and Fig.15) show a glider finely ballasted.

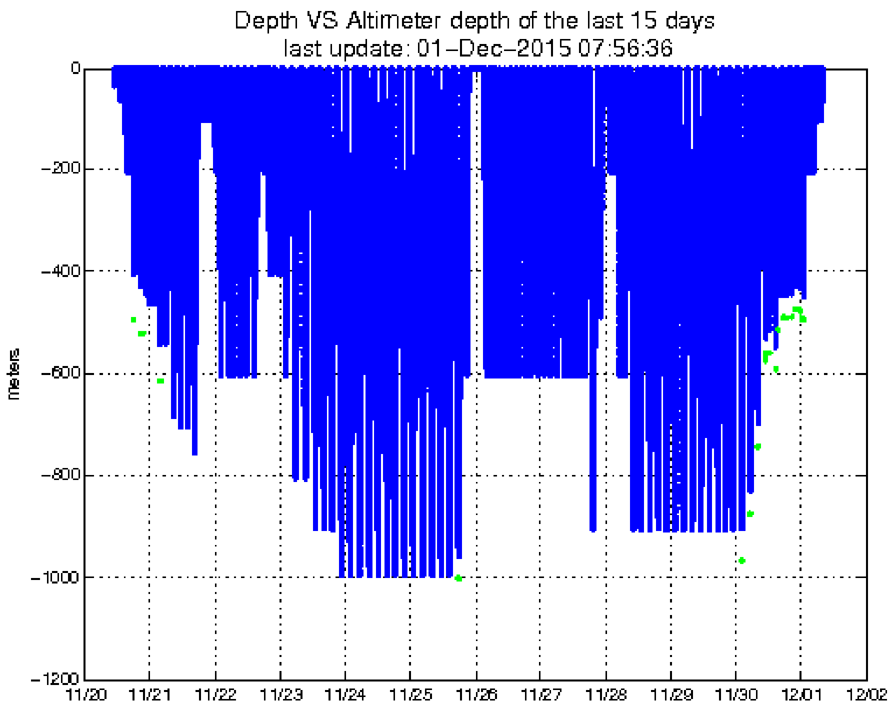

Fig.8 Glider depth (blue) and bottom (green) if recognized by the altimeter

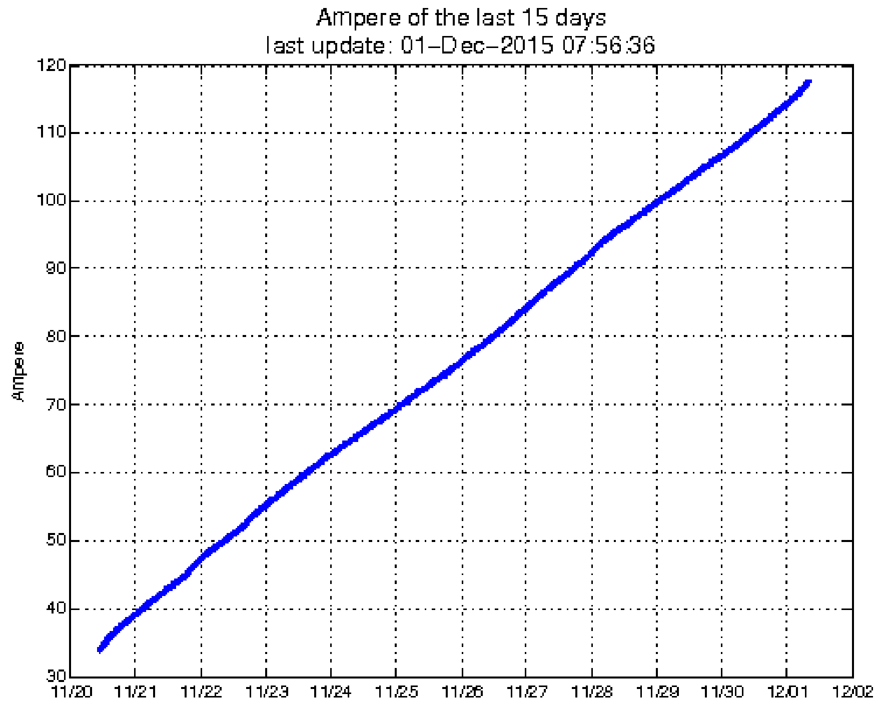

Fig.9 Ampere consumption of the glider during the mission.

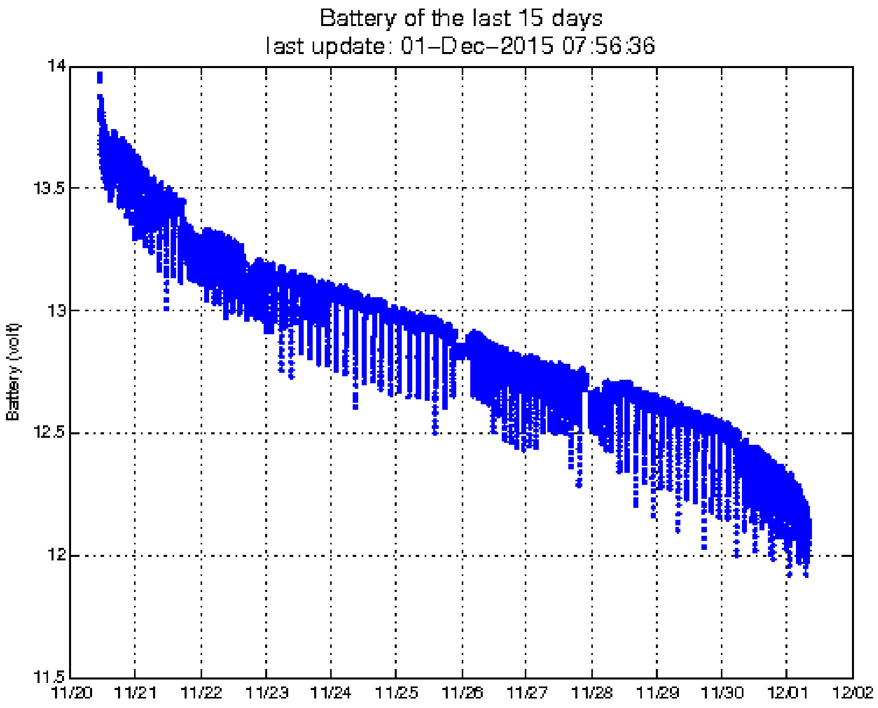

Fig.10 Battery consumption (voltage) of the glider during the mission.

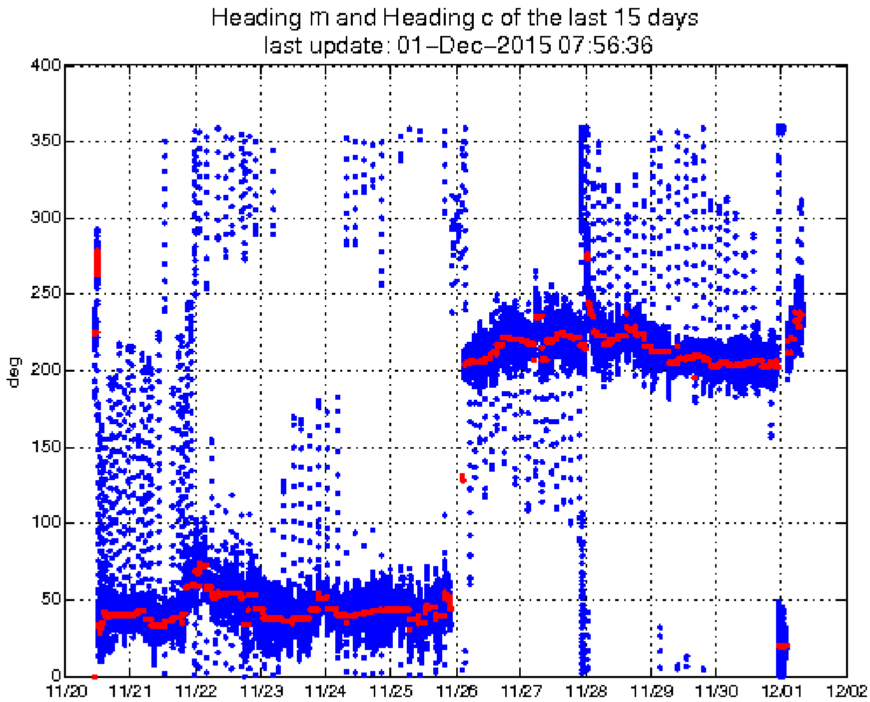

Fig.11 Commanded heading (red) and measured heading (blue).

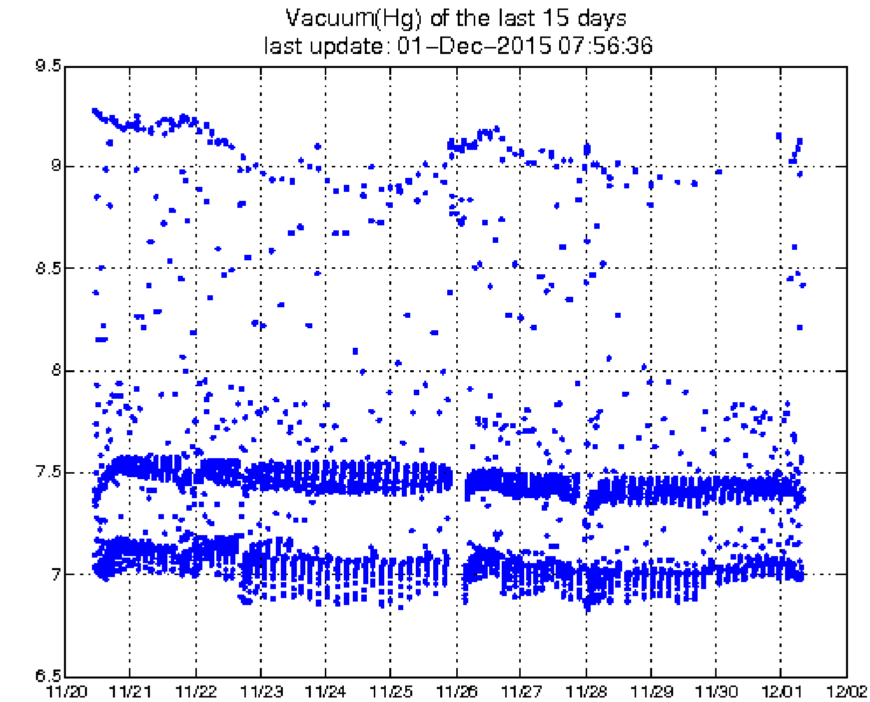

Fig.12 Internal vacuum of the glider during the mission.

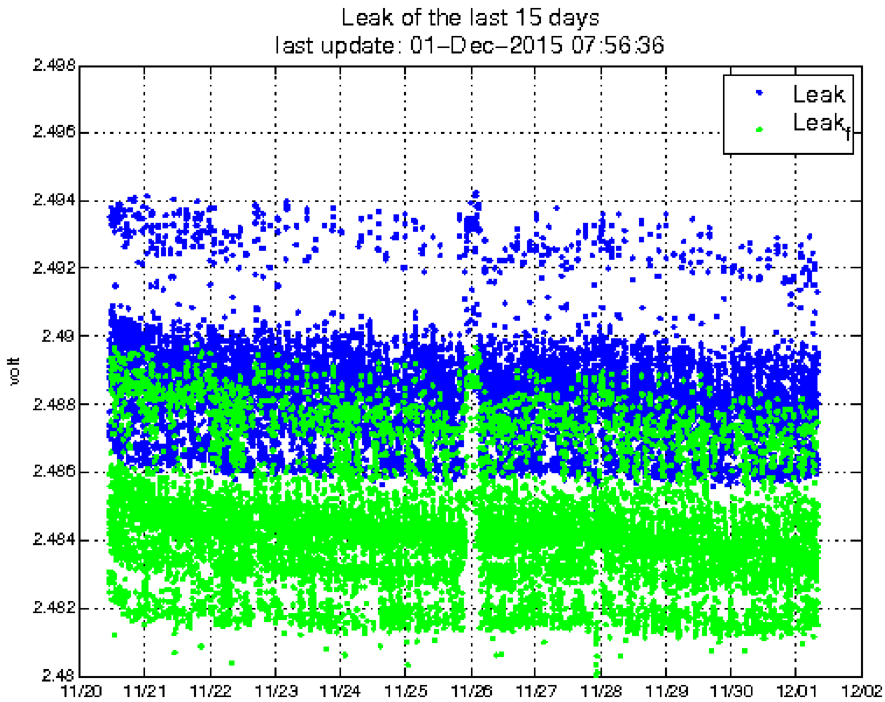

Fig.13 Voltage measurements as reported by the leakage detectors inside the glider: aft measurements (blue) and forward measurements (green).

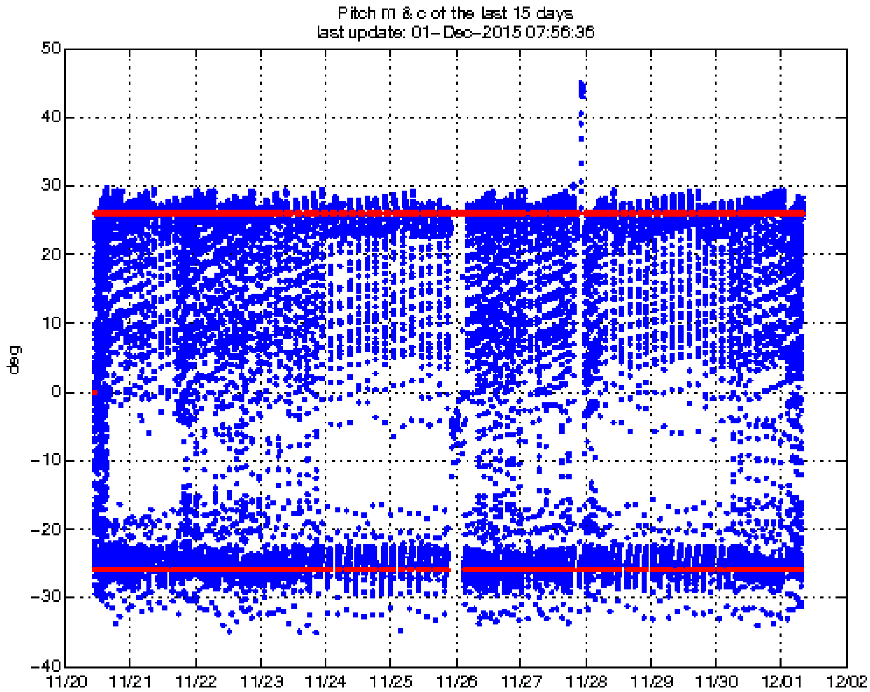

Fig.14 Commanded pitch (red) and measured pitch (blue).

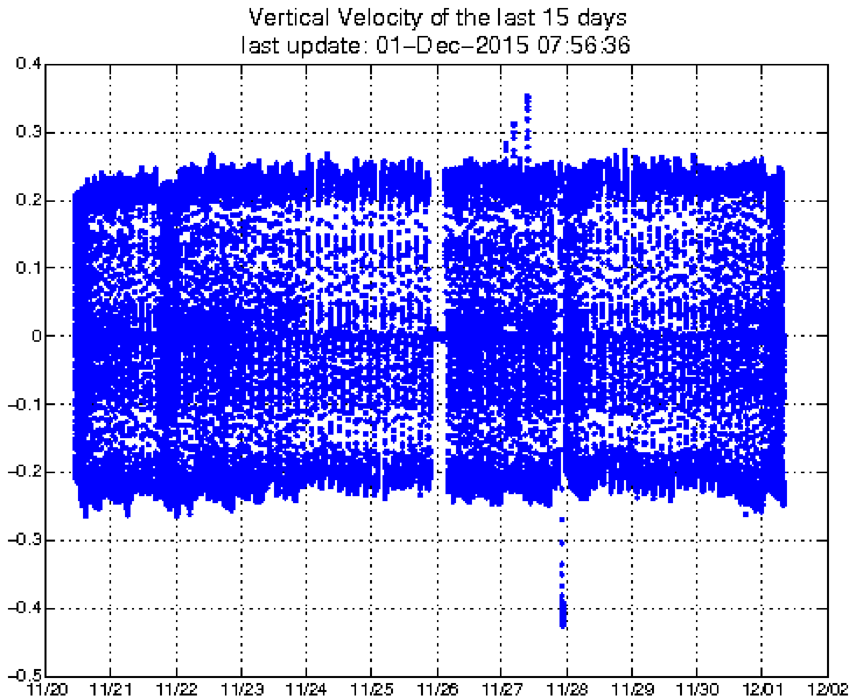

Fig.15 Vertical velocity of the glider as computed by the internal Persistor.

3. Problems faced during the PreConvex16 glider mission

3.1. Waypoints sequence

The initial setting of the initial_wpt parameter (-1) caused the glider to navigate toward the wrong direction. Indeed it initially come back to the Italian coast instead of navigating toward Dubrovnik. In order to head the glider toward the first waypoint of the list written in the goto_l**.ma file, the initial_wpt must be set to 0. Additionally, if the num_legs_to_run is set to 1, the glider does not complete the list of the waypoint as written in the goto_l**.ma file, but it stops the mission once it reaches the first waypoint of the list. In order to run all the waypoints of the list, the num_legs_to_run parameter must be set equal to -2, otherwise, if the operator wants to perform an infinite loop through the list, this parameter must be set to -1.

3.2. Basestation problems

The main Basestation showed connection problems reporting the "All available NetworkSerialConnections are in use" error. The problem was not solved even after having increased the networkSerialPorts max_num parameter (included in the dockserver.conf file) from 2 to 12. The dockServer_yyyymmdd.log file must be monitored to prevent the saturation of all the available ports. If this happens, the dockserver (and the dataserver) of the glider terminal client must be restarted.

Also the backup Basestation had some communication problems. The issue was deeply investigated and it was found that at the boot of the Basestation, the modem can be associated to the wrong port. The problem was fixed by modifying the gliderlink device parameter of the /var/opt/dockserver/dockServerState.xml file. Indeed, with all the gliderlink device parameters set to "freewave" (NOT to "modem"), the connection is ok independently of the port to which the modem is associated (the initial configuration of the dockServerState.xml file was usb0 = modem; usb1 and usb2 = freewave; usb3 = direct).

3.3. Aborts due to the depth sensor

During the mission the glider aborted several times. The abort reason was due to the depth sensor and the reported error was MS_ABORT_NOINPUT = 12.

The issue was initially solved by increasing the overdepth_sample_time from 15 to 25 (Ben Allsup suggestion), but unfortunately the abort occurred several other times during the mission.

After the mission the glider was sent to the factory for some replacements: batteries, impulse connector on the bulkhead, Aanderaa interface cable and alkaline batteries cable adaptor. During the check at the factory, the depth sensor was replaced, because it was found damaged.

A successive data analysis demonstrated that the damaged depth sensor was responsible for a shift as large as 25 m (Fig.16 and Fig.17).

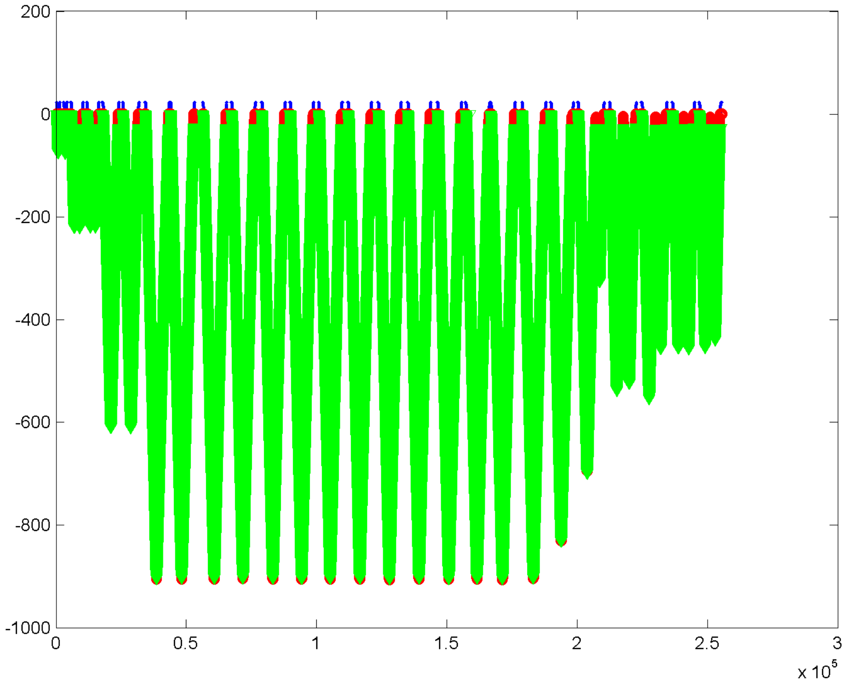

Fig.16 Shift of the depth sensor (green) with respect to the CTD pressure sensor (m_depth in red and m_pressure in blue).

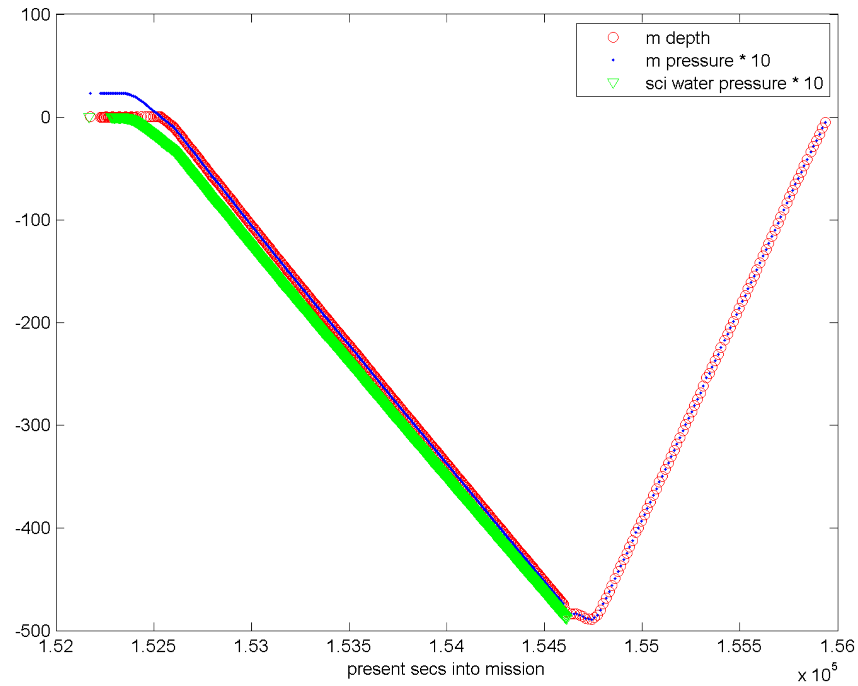

Fig.17 Shift of the depth sensor (green) with respect to the CTD pressure sensor (m_depth in red and m_pressure in blue). Example of one dive.

3.4. Aborts due to the attitude_rev sensor

During the mission the glider aborted also because of the attitude_rev sensor which was taken out of service and the reported error was MS_ABORT_DEVICE_ERROR = 16. The problem was solved by putting again all the devices in service with the command use all.

3.5. GPS fix

During the mission, many times the glider could not get a GPS fix and it used the old fix, obtained just before the beginning of the dive. This was due to the damaged depth sensor. Indeed, during the surfacing maneuvers, this sensor reported a depth of 0 meters while the glider was actually at a depth of 25 meters. The glider started acquiring the GPS fix while surfacing, but of course it could not obtain any GPS signal while underwater.

4. Convex16 mission

The mission started on April 22, 2016 and ended 9 days later on May, 1. The track of the glider, depicted in Fig.18, follows a triangle with the first lag along the Bari-Dubrovnik transect then the glider turned to the west heading to the Gargano Peninsula and finally it headed south to the deployment point.

The glider was deployed on April 22 at 08:43:09 UTC at 41.503°N and 17.087°E. At the beginning, the instrument was steered along the transect Bari-Dubrovnik to the first way point at 42.067°N and 17.744°E, reached on April 26 at 11:42:30 UTC. The glider was then headed to the second way point located at 42.063°N and 16.998°E. The point was reached on April 29 at 03:10:09. The third way point was set at the same location of the deployment, the glider was recovered on the way to the waypoint at 41.673°N and 17.069°E on May 1 at 07:53:33 (Fig.18).

During the mission, 170 dives with maximum depth varying from 20 to 950 m were performed. The WetLab optical data were recorded from the surface down to 200 m.

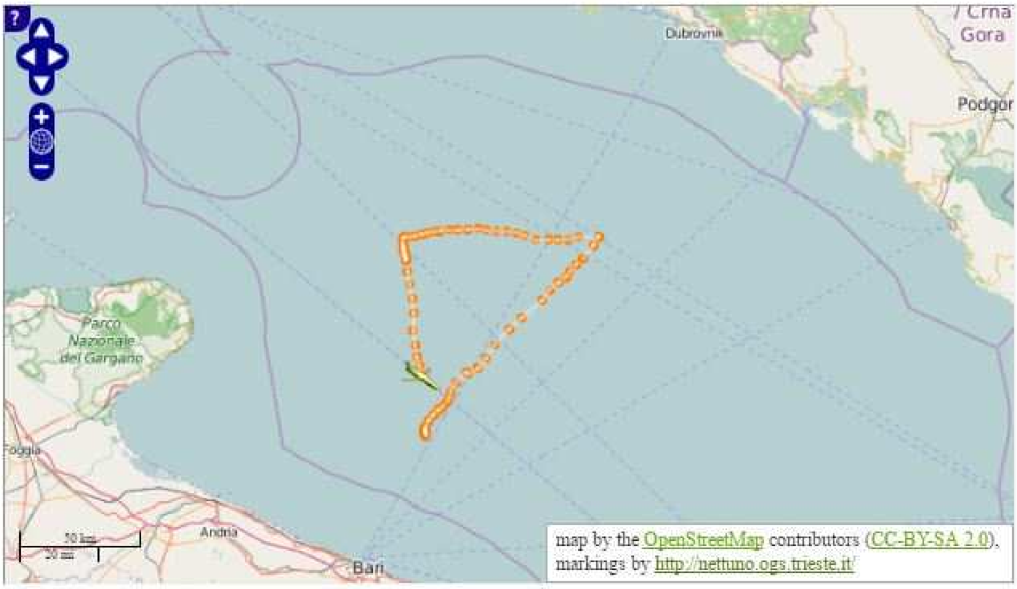

Fig.18 The glider trajectory; the deployment and recovery was performed off the Italian Coast. The glider icon indicates the recovery point.

4.1. Scientific data

The temperature data, collected during the mission, showed in the top 20 m the beginning of a stratified condition (Fig.19). On April 27 the breaking of the stratification was concomitant with a strong wind episode.

A double salinity maximum is evidenced. One maximum can be observed at around 100 m, while the second maximum is located between 400 to 700 m. (Fig.20).

Higher oxygen concentration is present at the surface while minimum values are correlated to the deep maximum of salinity (Fig.21). The fluorescence plot shows the presence of a chlorophyll maximum at about 50 m (Fig.22). The back-scattering plot (Fig.23) displays the highest values at surface on April 25 and 26. The maximum value of the back-scattering seems to follow the maximum of the fluorescence. Low CDOM values (Fig.24) were found in correspondence of the high fluorescence value.

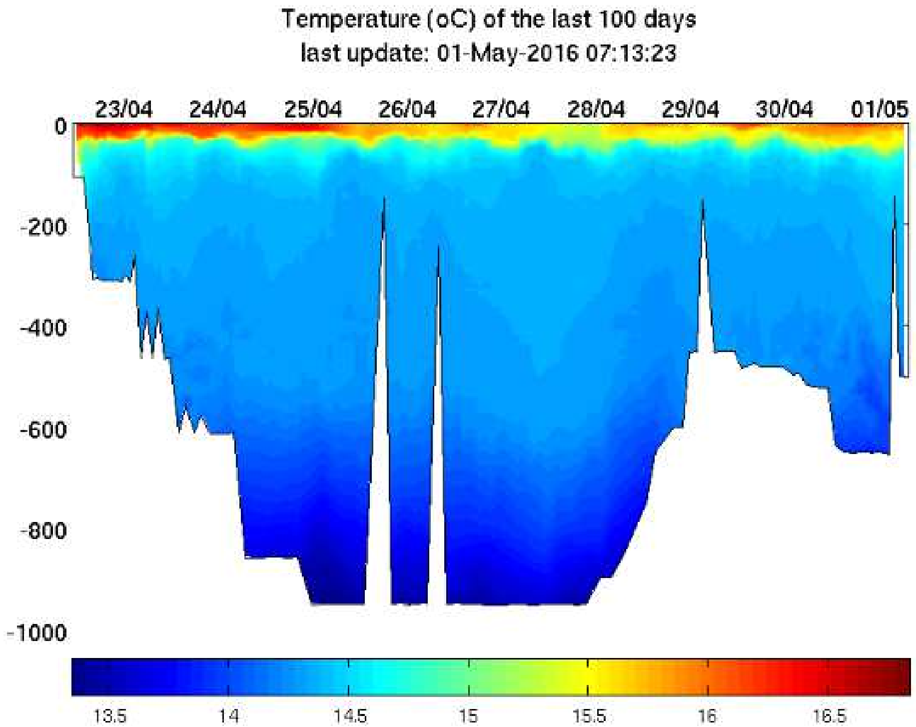

Fig.19 Sea temperature versus time.

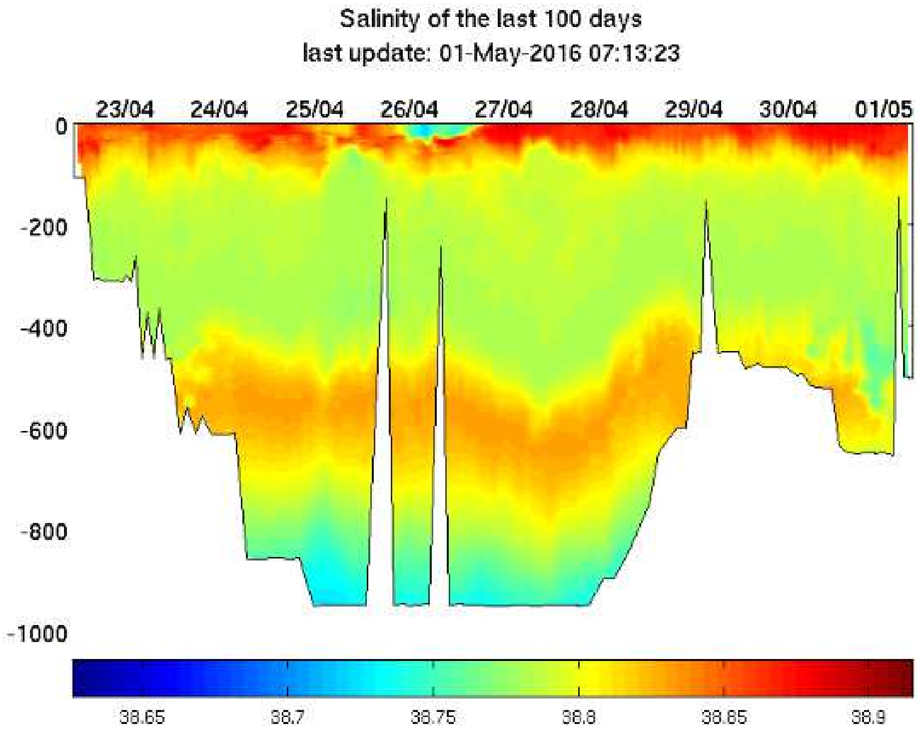

Fig.20 Salinity versus time.

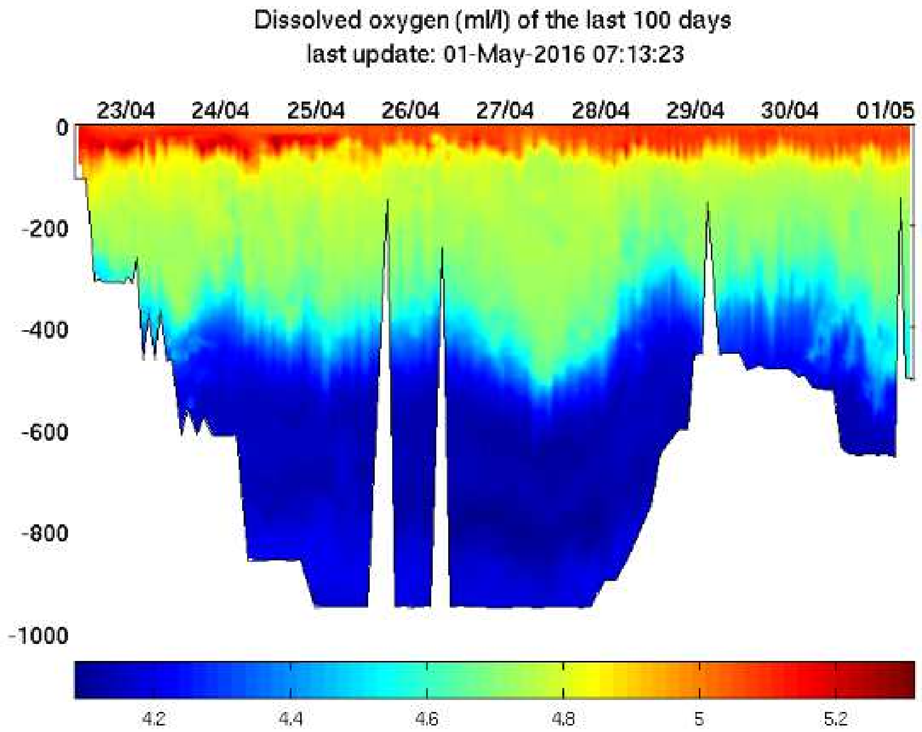

Fig.21 Figure 4: Oxygen versus time.

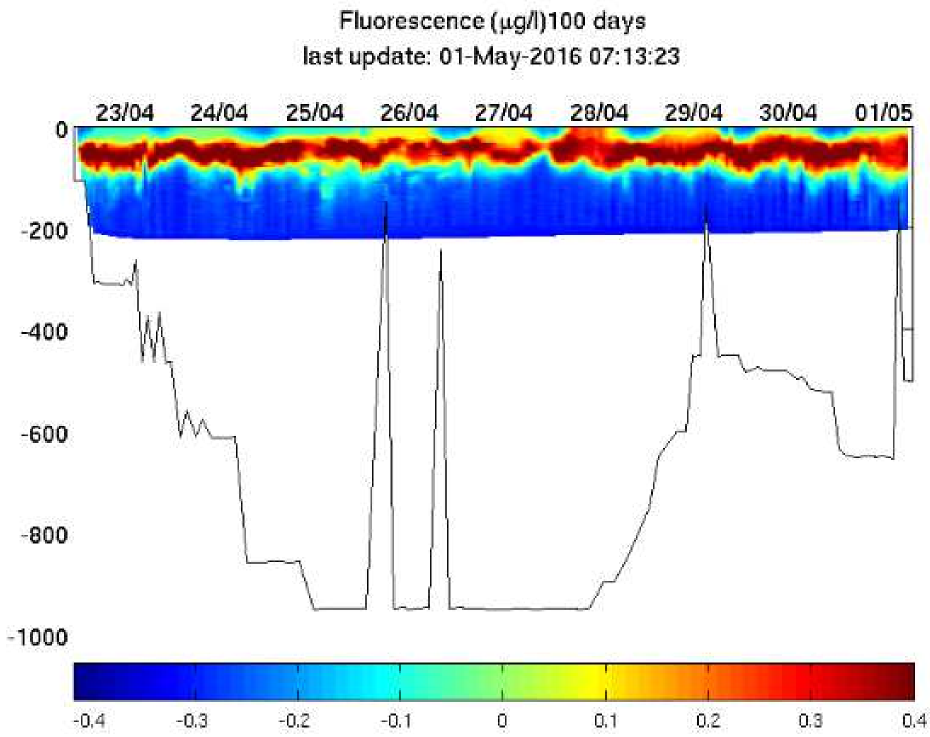

Fig.22 Fluorescence versus time.

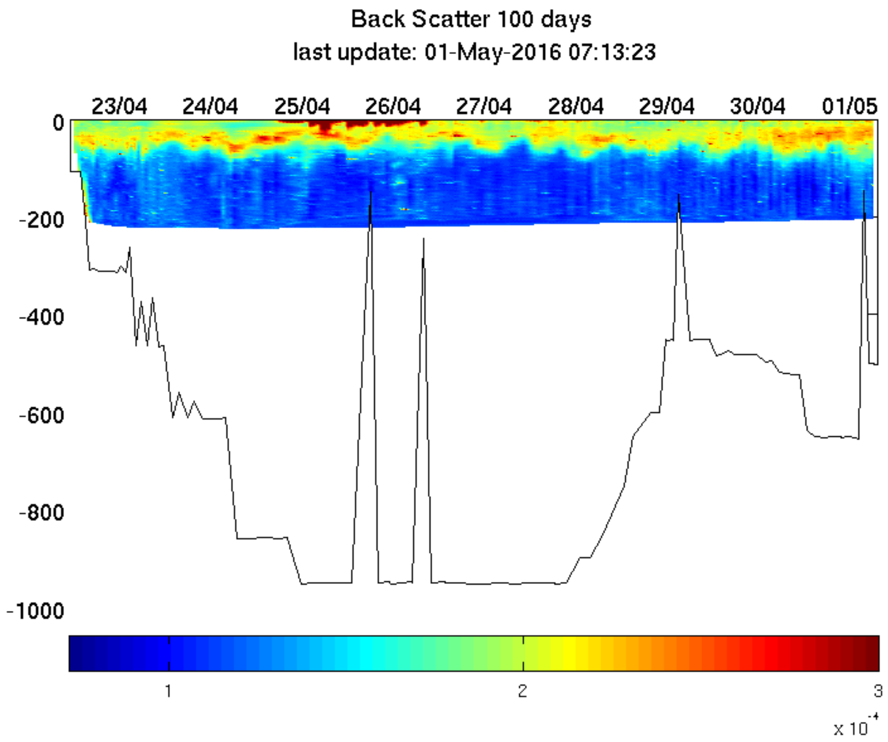

Fig.23 Back-scattering versus time.

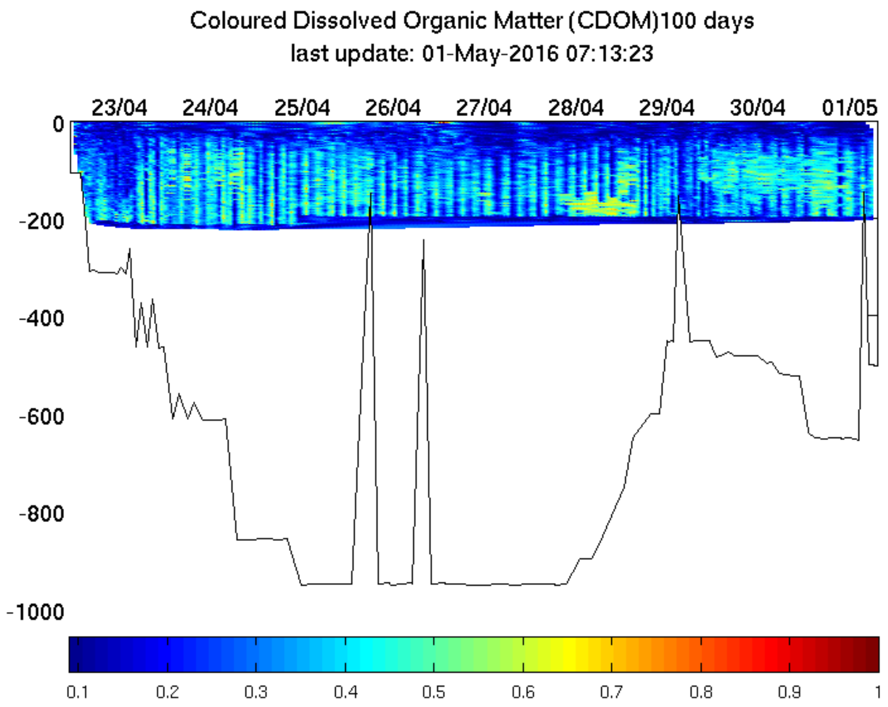

Fig.24 CDOM versus time.

4.2. Technical data

The technical data recorded during the mission are depicted in figures from Fig.25 to Fig.32. The glider altimeter detected the bottom several times (green dots in Fig.25). The glider turned most of the time because it reached the d_target_depth and not because of the d_target_altitude.

The battery consumption for the 9-day mission was about 55 A (Fig.26) and the voltage dropped from about 15.1 V to about 13.3 V (new batteries; Fig.27). The measured heading varied within about 15 degrees from the commanded heading (Fig.28). The vacuum ranged between 6.9 and 7.4 inHg while the glider was navigating underwater and around 9 inHg when the glider was at surface (Fig.29). No leakage was detected during the mission and a decreasing trend of the measured voltages was observed (Fig.30). The pitch and vertical velocities plots (Fig.31 and Fig.32) show a well ballasted glider, slightly faster during the diving phases (positive velocities).

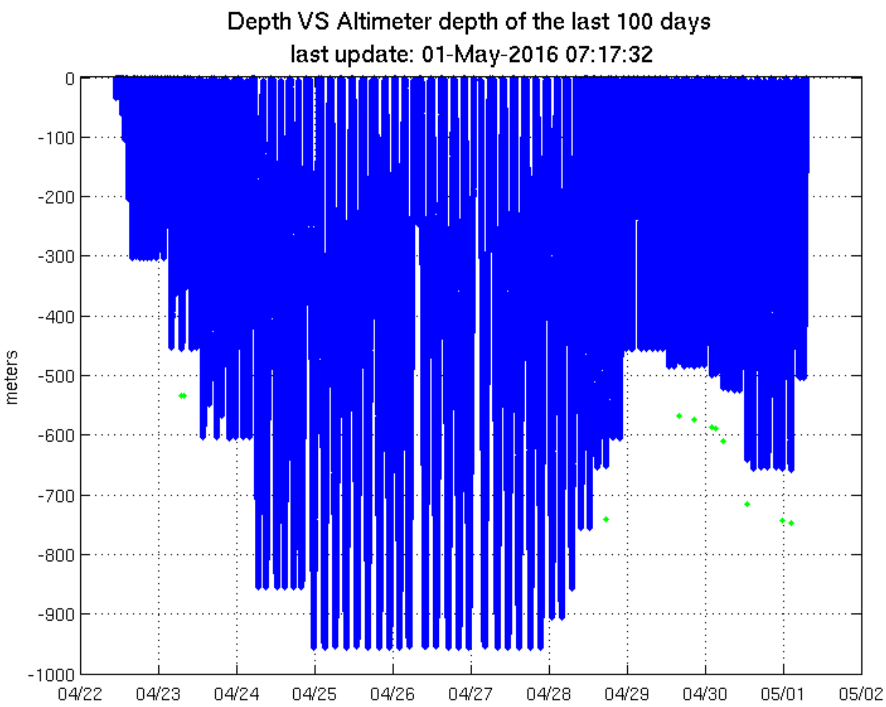

Fig.25 Glider depth (blue) and bottom (green) if recognized by the altimeter

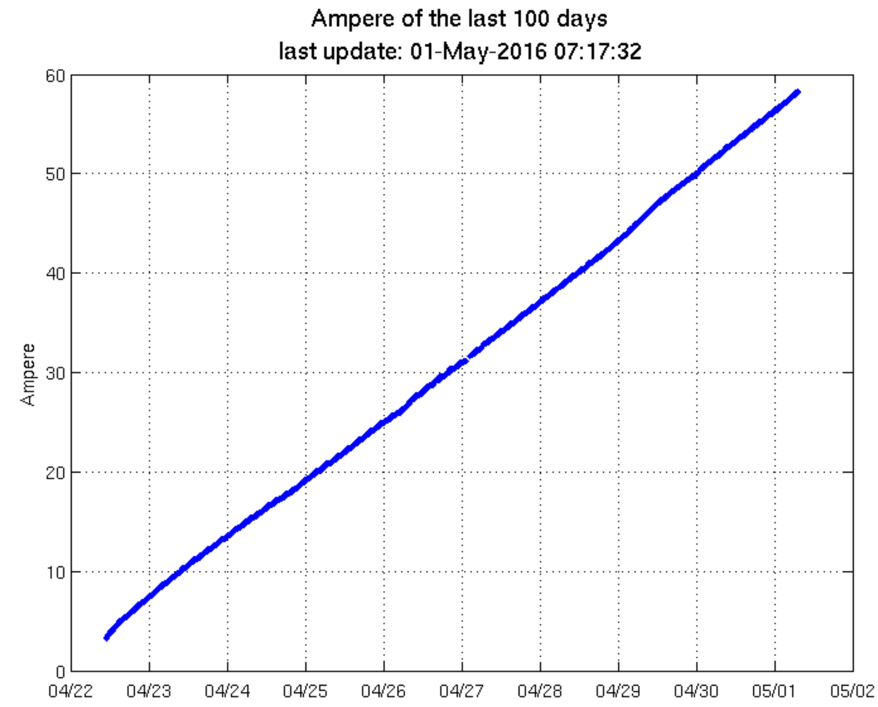

Fig.26 Ampere consumption of the glider during the mission.

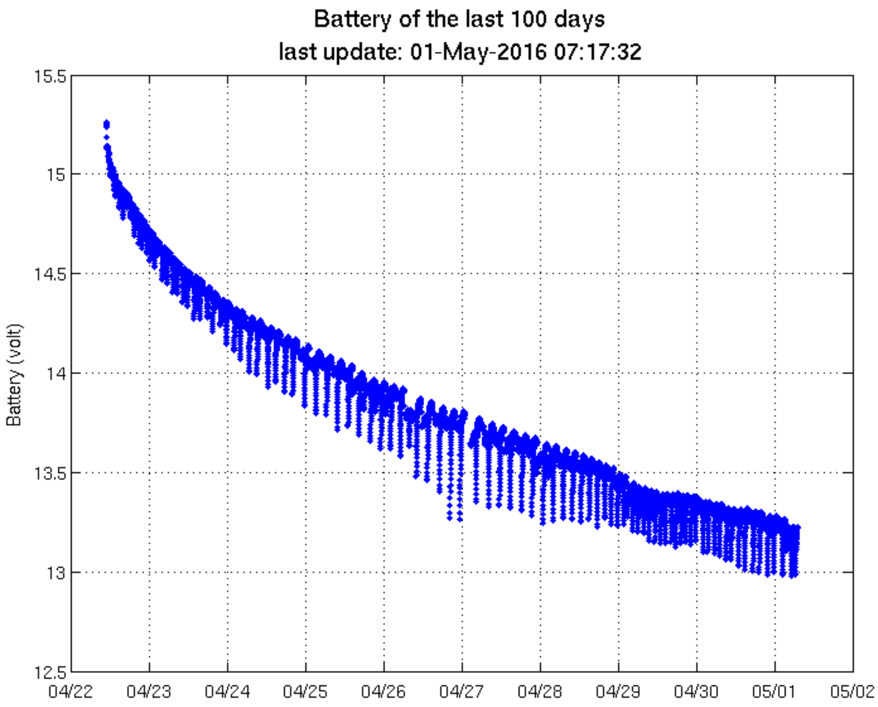

Fig.27 Battery consumption (voltage) of the glider during the mission.

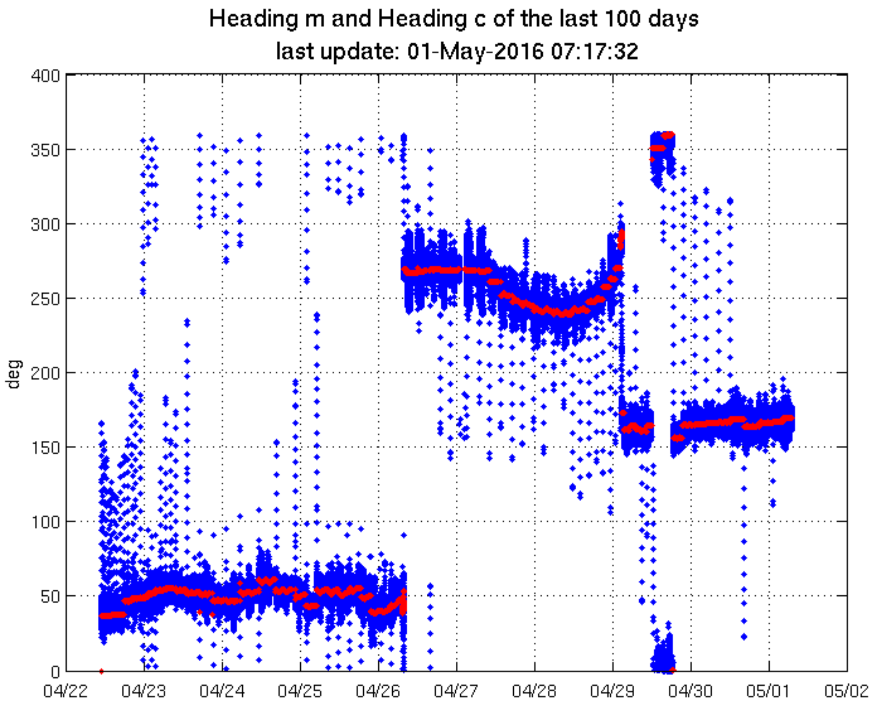

Fig.28 Commanded heading (red) and measured heading (blue).

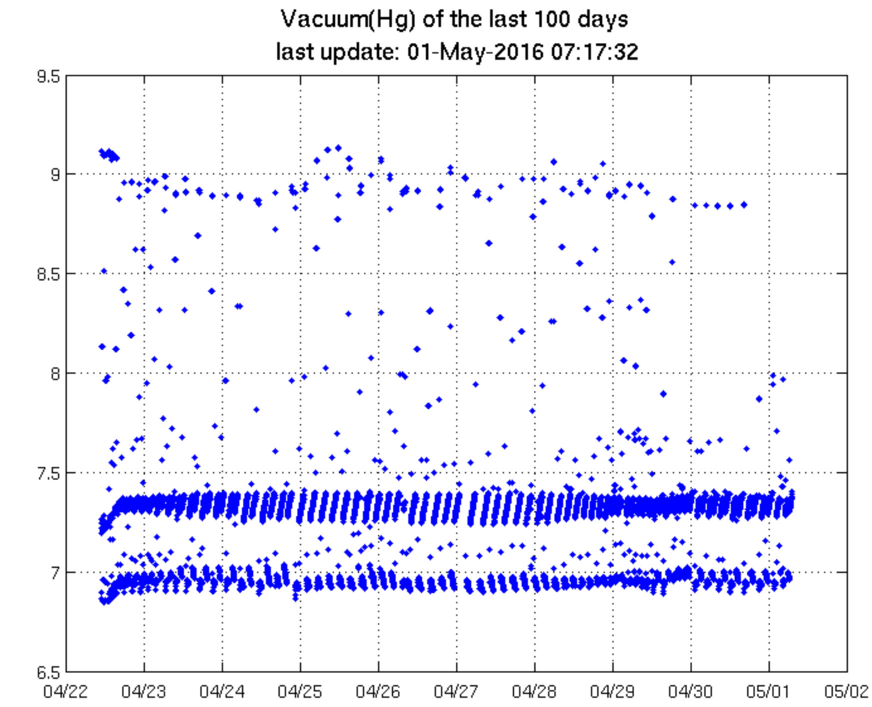

Fig.29 Internal vacuum of the glider during the mission.

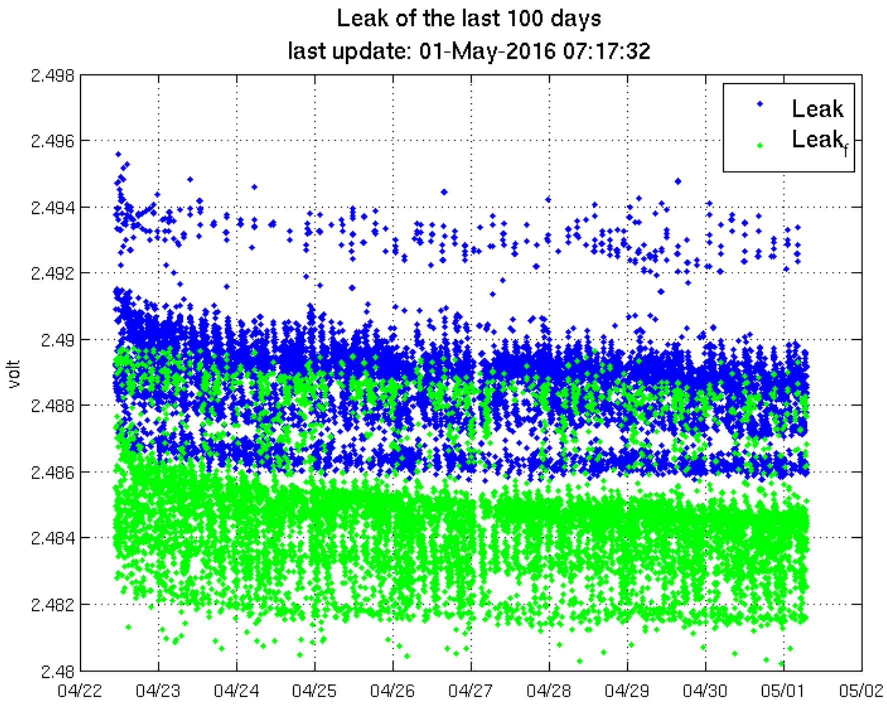

Fig.30 Voltage measurements as reported by the leakage detectors inside the glider: aft measurements (blue) and forward measurements (green).

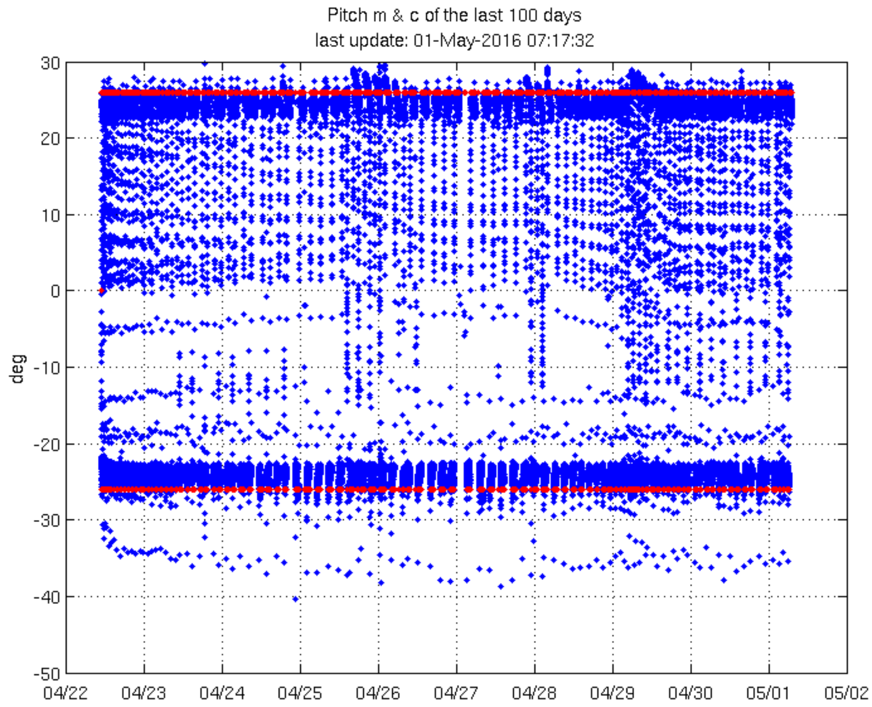

Fig.31 Commanded pitch (red) and measured pitch (blue).

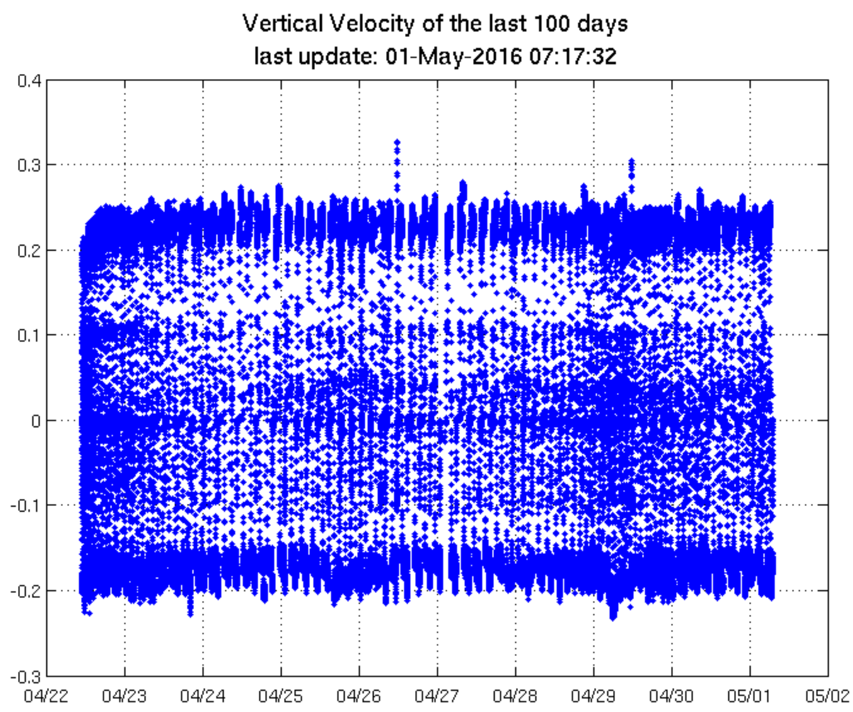

Fig.32 Vertical velocity of the glider as computed by the internal Persistor.

5. Problems faced during the Convex16 glider mission

5.1. Waypoints sequence

When dealing with the goto_l**.ma file, if the initial_wpt is set to 0 and the file is re-read by the glider (with a ctrl F command for example), the glider executes the *.ma files again and it heads toward the first waypoint of the list.

This may cause the glider to invert its route or to head toward an undesired route (extremely dangerous in presence of islands).

5.2. Aborts due to the depth sensor

The replacement of the depth sensor should have solved the error already reported during the PreConvex16 mission. Unfortunately, during the Convex16 mission the glider aborted again because of the depth sensor giving the error MS_ABORT_NOINPUT = 12.

The re-calibration (reset) of the depth sensor by using the ZERO_OCEAN_PRESSURE command worked fine, therefore, it is highly suggested to reset the depth sensor periodically during a mission (even at each surfacing).

5.3. Abort due to corrupted file

During the mission, the glider experienced an additional abort due to a corrupted file. The message was: MS_ABORT_INITIALIZATION_ERROR and it was due to a yo21.ma file with 0 byte. This file was generated in the glider by an unsuccessful transmission and the problem was solved by simply re-sending and re-executing (with ctrl F) the file.

6. Acknowledges

The authors would like to thank all the people who helped in all the phases of the deployment of the instrumentation; in particular, Caterina Fanara and the captains and the crews of the Pasquale Cristina boat involved in the experiment.