HOW TO TRIM A SEAGLIDER: DESCRIPTION OF USEFUL PARAMETERS AND THEIR EFFECTS ON THE GLIDER BEHAVIOUR

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1. Introduction

During the period between 15 and 22 May 2013 the SeaGlider "Amerigo" was operated in the Southern Adriatic Sea. This is the first "long" mission for Amerigo after the test in the USA and a short mission carried out in the same area in March. This short mission was aborted because of some malfunctions. In the May mission several problems were faced and solved. In particular, the glider team tackle with ballasting adjustment, optimization of glider speed, connectors leakage, altimeter false reading and data management. The glider team was engaged on 24h 7/7d shift of about 8 hours in order to trim the instrument and deal with the problems.

This report illustrates the commands used by the glider team during the mission and describes their effects on the glider behaviour.

2. General notes

To pilot a SeaGlider, three files are used. They contain the parameters that determine the glider behaviour.

The most complex file is the **cmdfile file** that is used for the general commands and will be deeply described in the next section. In this file, the ratio between the depth $D_TGT and the time $T_DIVE must always be 3:1 in order to have a correct fly of the glider.

The **targets file** contains the list of the waypoints and the radius center on the waypoint within which the glider consider a waypoint reached. It is very important to take into account the presence of islands in the area in order to set the radius large enough to allow the glider mission continuation even in case of a strong current that impedes the glider to reach the exact waypoints. The radius must be therefore, a compromise to allow to the glider to reach the waypoint without hitting the land.

Finally, the **science file** defines the acquisition rates of the scientific sensors from the surface down to 1000 m. The CPCTD is not fully integrated in the SeaGlider and its intervals are set in the cmdfile. Please note that the battery absorption of the fluorimeter is

quite high and normally it is use only during the first 200 m in stratified conditions, while in case of deep convection it should be activated even deeper.

During the mission the GPCTD was set:

- $PC_PROFILE,3

- $PC_XMITPROFILE,3

- $PC_INTERVAL,5

in order to collect data during the up- and down-cast every 5 seconds and to transmit to the dockserver all the acquired data.

The initial values of the parameters in the cmdfile were set equal to the values in the trim sheet provided by the factory. It is important to note that the Seaglider "Amerigo" is equipped with a standard buoyancy engine (SBE). SBEs are designed for normal dive operations, while the Enhanced Buoyancy Engines (EBEs) are designed for shallow water operations. The regular D_BOOST value for a SBE is set between 3 and 5 (Andrew Palmer personal communication), therefore we left D_BOOST set to 3.

- D_BOOST,3

3. Modification of the cmdfile parameters

Table 1 reports the values of the parameters of the cmdfile used during the first dive. These parameters produced a not optimized glider flight as depicted in Fig. 1. In particular, the depth of the glider (black line) or the vertical velocity in Fig. 2 denotes that the dive phase is much faster than the climbing phase and the apogee manoeuvre is uneven. This is due to the behaviour of a not properly ballasted glider. It looks very heavy indeed, the target depth was set to 75 m and the glider went deeper reaching 100 m.

$C_PITCH,2623	$RHO,1.030
$C_ROLL_CLIMB,2000	$SM_CC,650
$C_ROLL_DIVE,2000	$D_TGT,75
$C_VBD,2994	$T_DIVE,25
$MASS,54850	$T_MISSION,35
$MAX_BUOY,120	$AH0_10V,95
$PITCH_GAIN,40	$AH0_24V,145

$ALTIM_PING_DELTA,5	$T_GPS,15
$ALTIM_PING_DEPTH,20	$T_NO_W,120
$ALTIM_BOTTOM_TURN_MARGIN,15	$T_RSLEEP,3
$D_NO_BLEED,200	$T_TURN_SAMPINT,5
$D_SURF,3	$USE_BATHY,0
$KALMAN_USE,2	$VBD_CNV,-0.245296
$NAV_MODE,2	$VBD_MAX,3961
$HEADING,-1	$VBD_MIN,455
$N_NOSURFACE,0	$VBD_PUMP_AD_RATE_SURFACE,5
$D_FINISH,5	$VBD_TIMEOUT,720
$PITCH_AD_RATE,175	$XPDR_VALID,5
$PITCH_CNV,0.003125763	$LOGGERS,1
$PITCH_MAX,3914	$PC_RECORDABOVE,1000
$PITCH_MIN,90	$T_BOOST,0
$PITCH_TIMEOUT,16	$D_BOOST,3
$PRESSURE_SLOPE,0.00011686645	$PC_PROFILE,3
$ROLL_AD_RATE,350	$PC_XMITPROFILE,3
$ROLL_CNV,0.02827	$PC_INTERVAL,5
$ROLL_MAX,3816	$RELAUNCH,0
$ROLL_MIN,227	$QUIT

Table 1. cmdfile of the first dive.
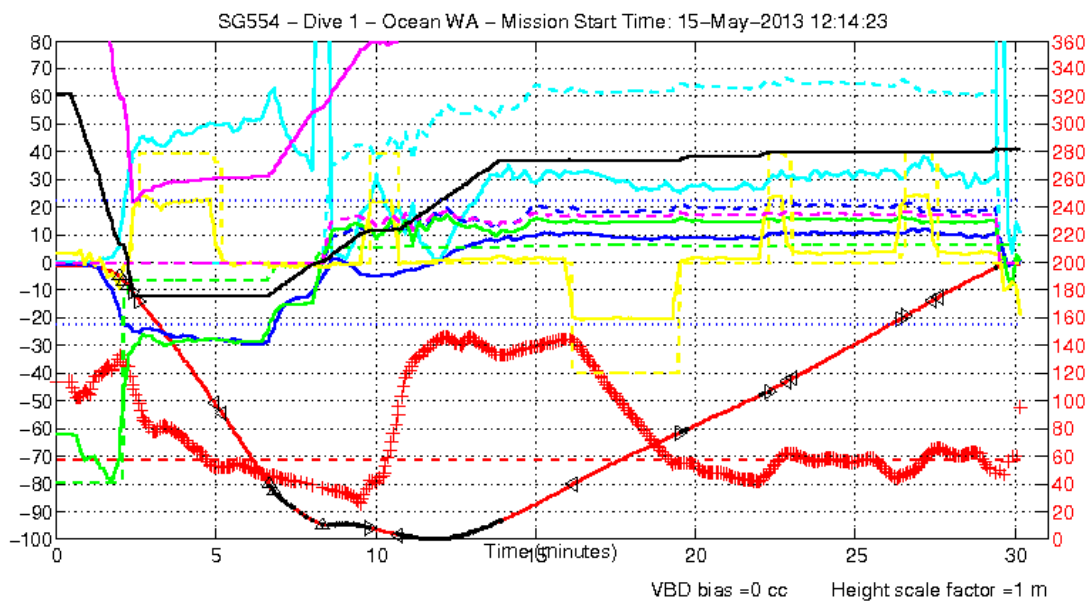
Fig. 1. Plot related to the first dive.

In order to make the glider lighter in water and decrease its speed during the diving phase, $C_VBD must be decreased. Remember that the values of the $C_VBD reported in Fig. 2 has to be neglected and the operator must change this value carefully by a tiny amount at the time.
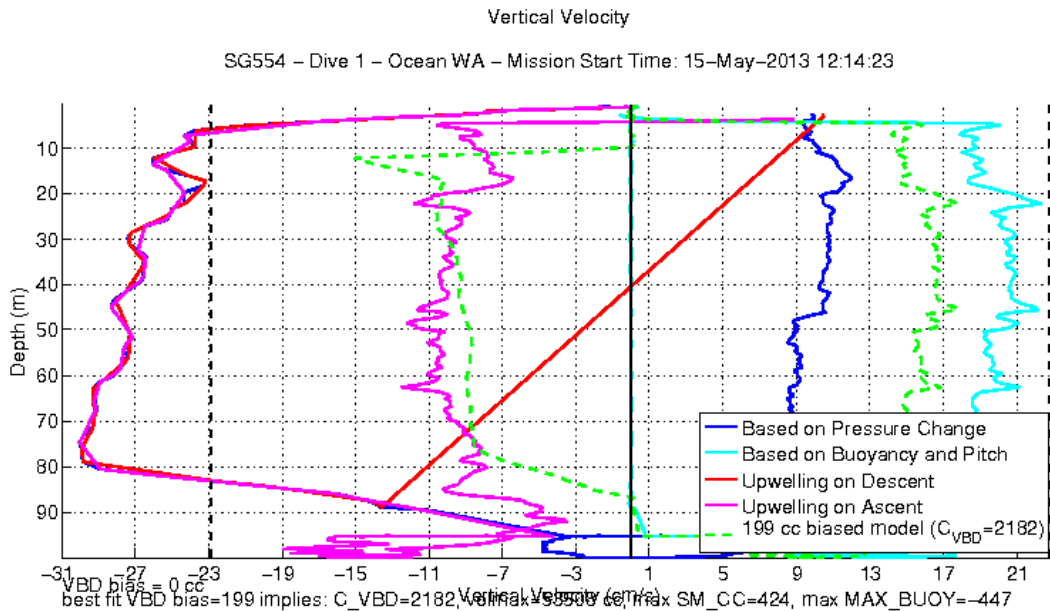
Fig. 2. Vertical velocity plot of the first dive.

The glider mission was slightly modified. The initial $C_VBD was decreased from 2994 to 2900 in the cmdfile.4 (see modifications in Table 2). No clear improvement can be seen in the plots of the dive 5 (Fig. 3 and Fig. 4), therefore the value of the $C_VBD was further decreased in cmdfile.5 ($C_VBD,2800, results in Fig. 5 and Fig. 6).

```
$C_VBD,2900
$D_TGT,45
$T_DIVE,15
$T_MISSION,25
```

Table 2. Changes in cmdfile.4.
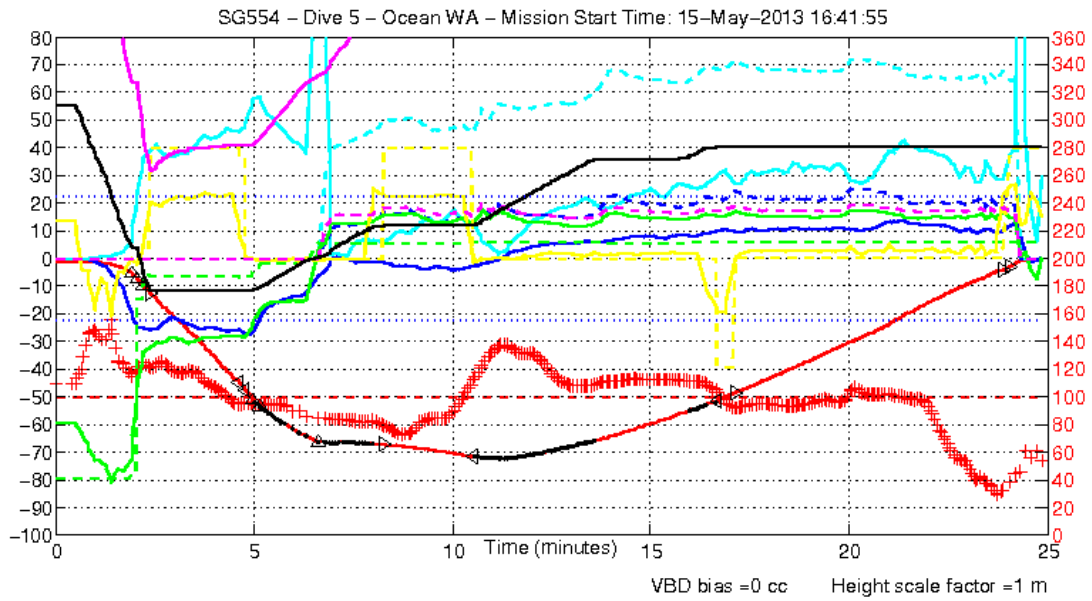
Fig. 3. Plot related to dive 5.
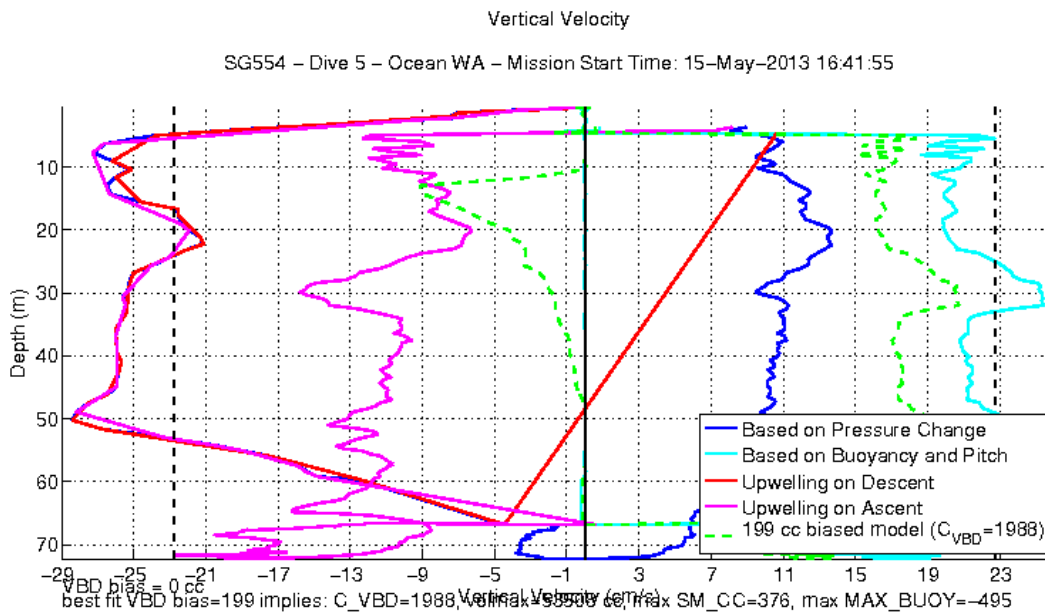
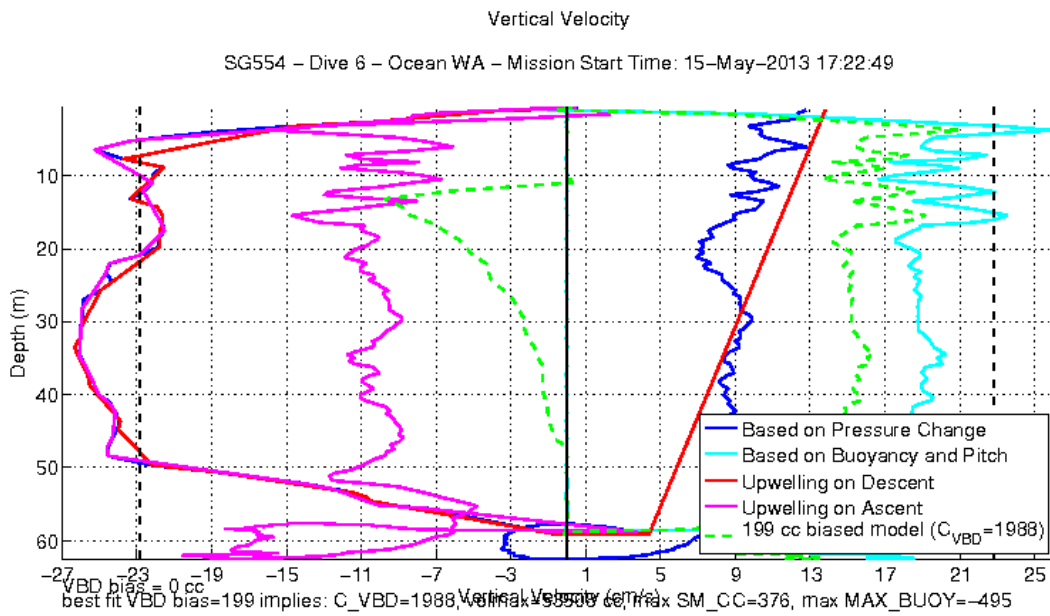Fig. 4. Vertical velocity plot of dive 5.
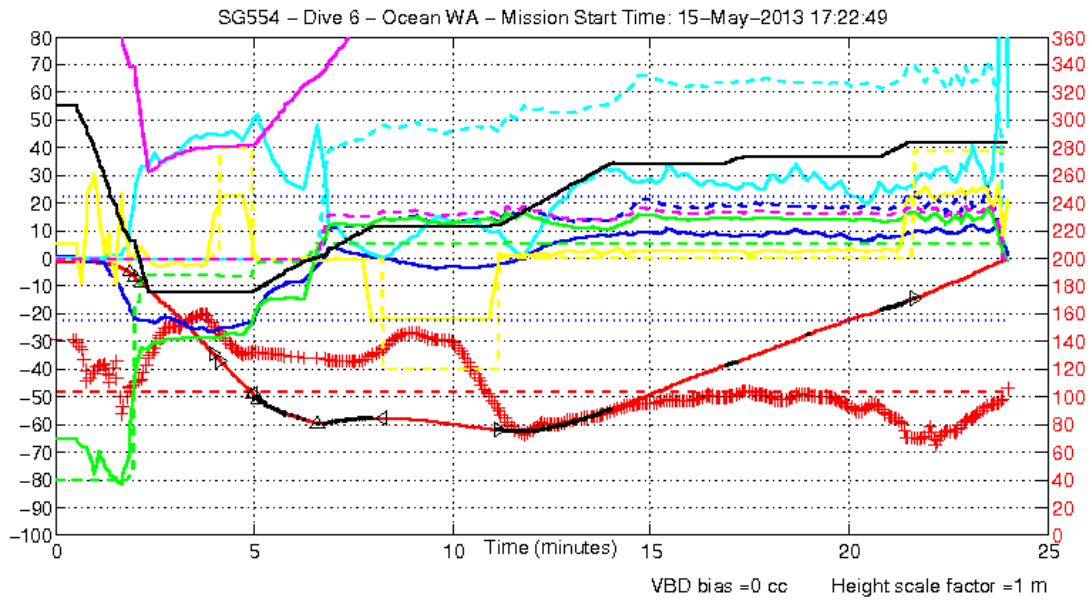
Fig. 5. Plot related to dive 6.

Fig. 6. Vertical velocity plot of dive 6.

The $C_VBD was further decreased to 2700 and the glider was commanded to go deeper in cmdfile.10 (see Table 3 and results in Fig. 7 and Fig. 8).

```
$C_VBD,2700
$D_TGT,60
$T_DIVE,20
$T_MISSION,30
```
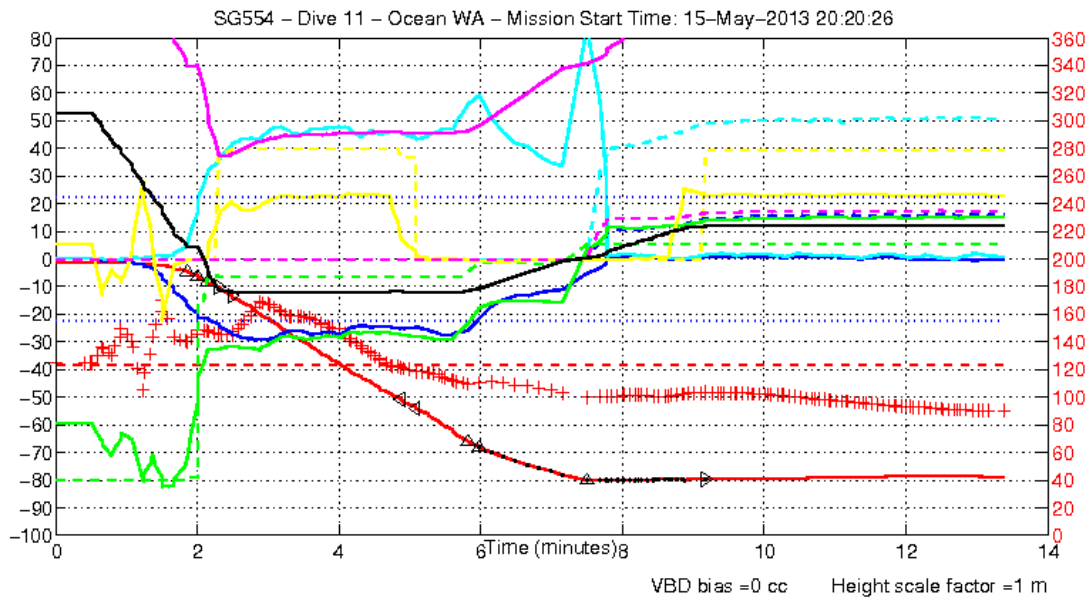
Table 2. Changes in cmdfile.10.
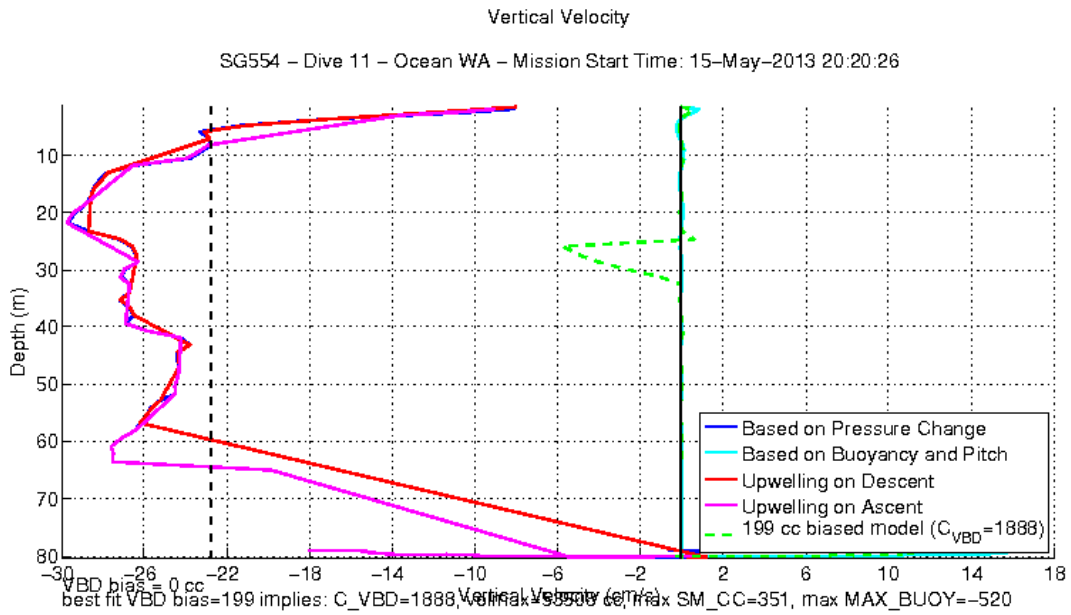

Fig. 7. Plot related to dive 11.

Fig. 8. Vertical velocity plot of dive 11.

The depth and the other variables in Fig. 7 and Fig. 8 are shown only during the down-cast phase, this happened during dive 11 and 12 but the problem did not occur anymore. There is not a clear explication for the lack of data during the ascent phase. Probably it is correlated to the double bump at the apogee, but it is unlikely linked to the changes of the values in the cmdfile.

Some improvements in the glider flight were obtained when the $C_VBD was changed to 2300 (Fig. 9). The apogee phase in Fig. 9 looks good, but the depth plot is still asymmetric.
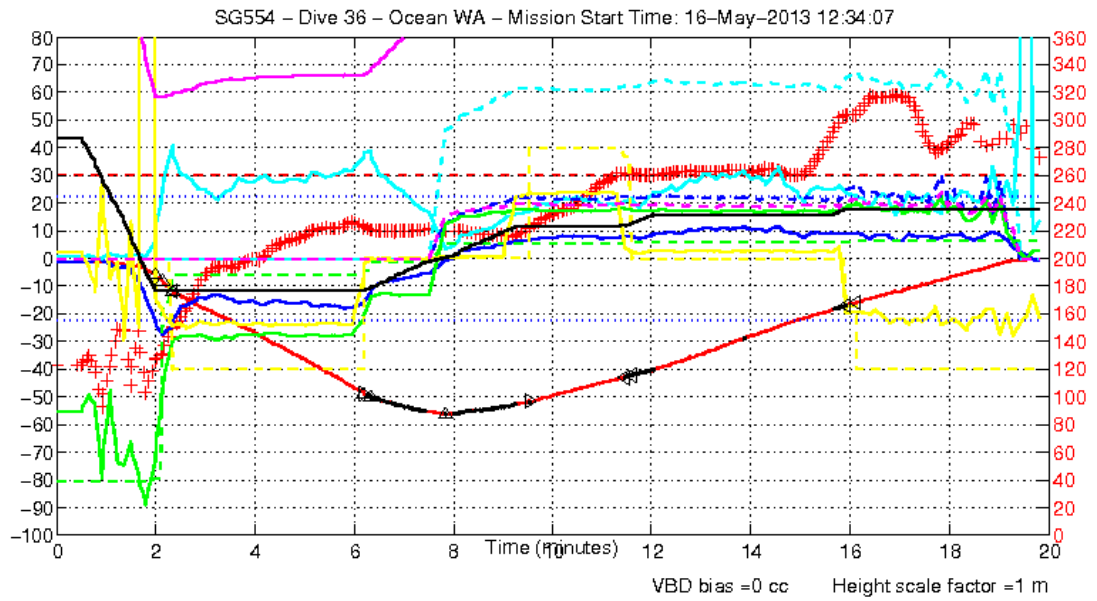
Fig. 9. Plot related to dive 36.

To go further in the trimming (from dive 37) the $PITCH_GAIN was decrease from 40 to 38, resulting in a much more stable glider flight. An important improvement is observable on the vertical velocity graphs, on the VBD and on the pitch and roll (compare dive 36 to dive 40; starting from Fig. 10 to Fig. 19).
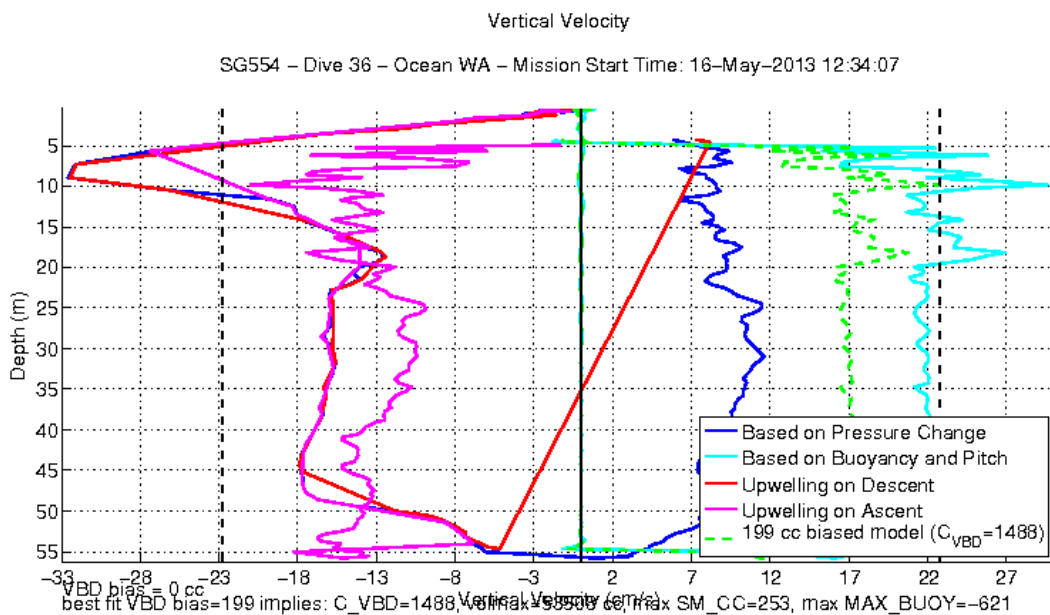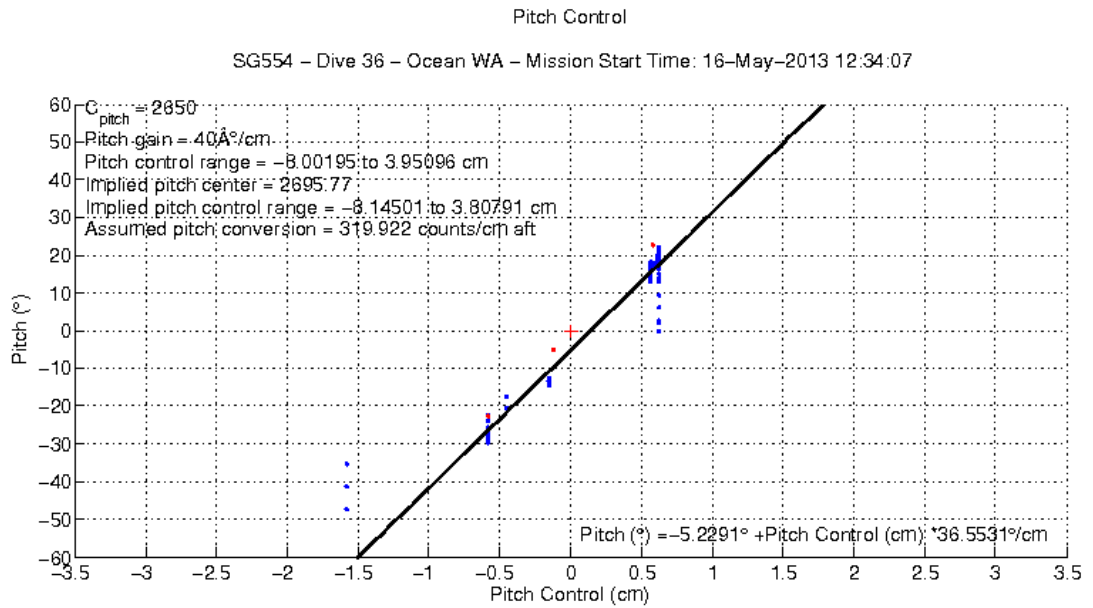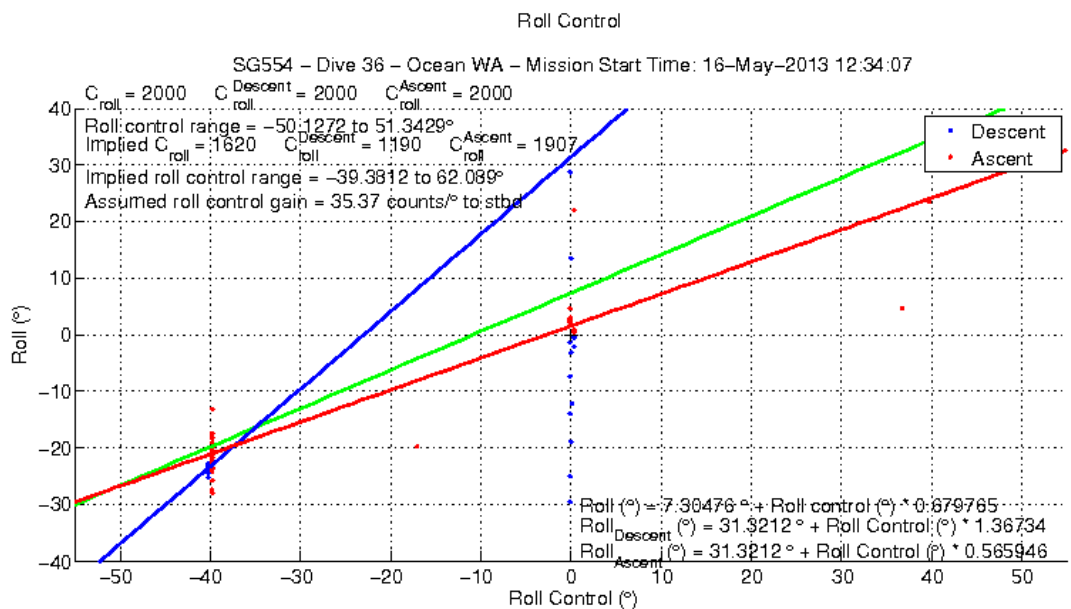

Fig. 10. Vertical velocity plot of dive 36.

Pitch Control

SG554 – Dive 36 – Ocean WA – Mission Start Time: 16–May–2013 12:34:07

Fig. 11. Pitch graph of dive 36.

Roll Control

SG554 – Dive 36 – Ocean WA – Mission Start Time: 16–May–2013 12:34:07
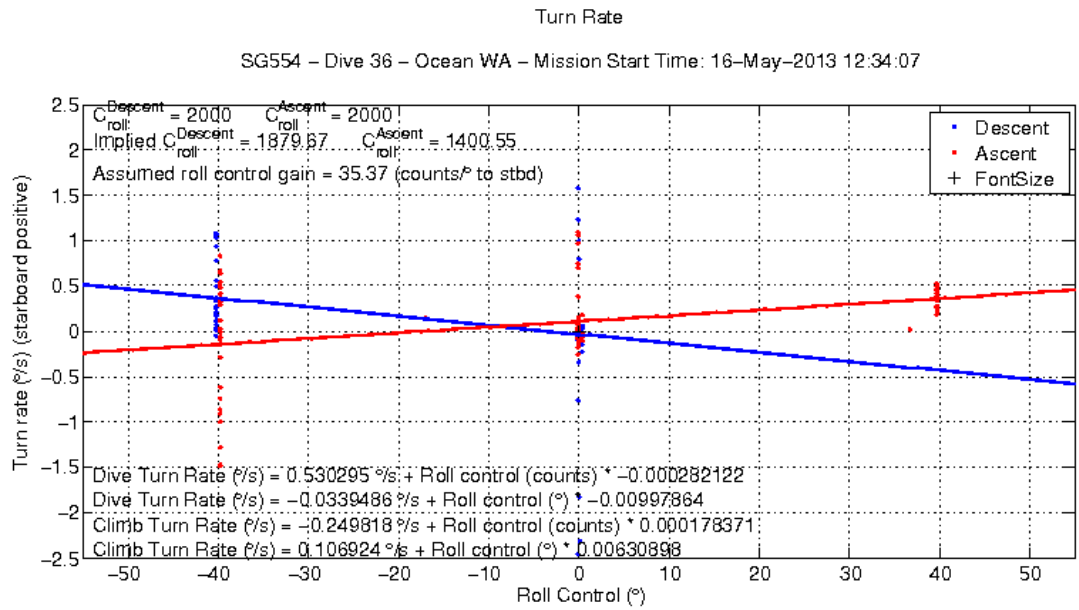
Fig. 12. Roll graph of dive 36.
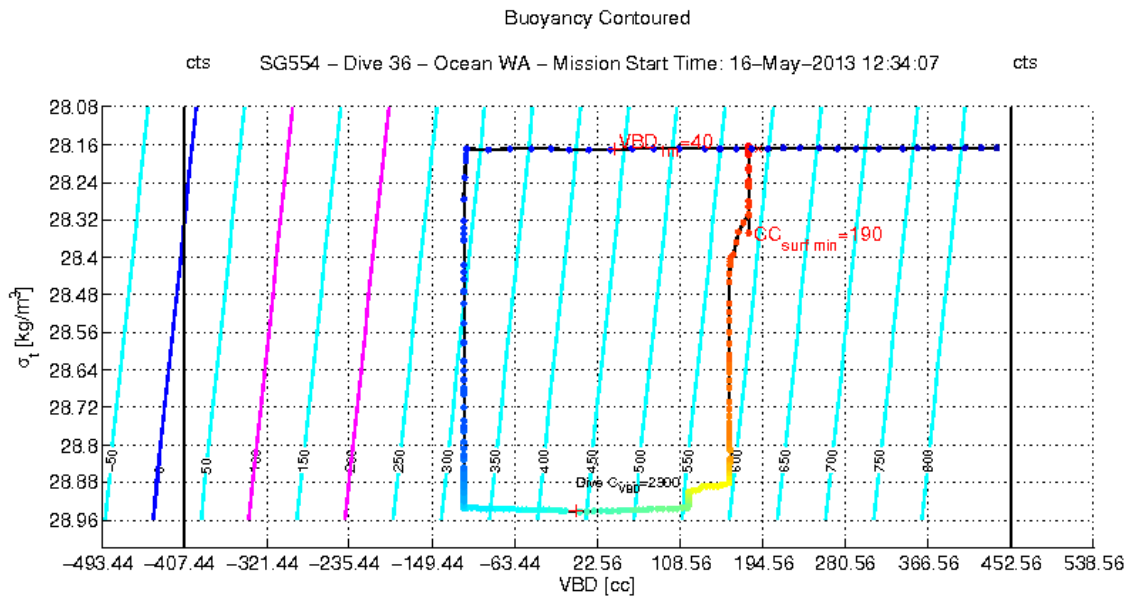
Fig. 13. Turn rate graph of dive 36.
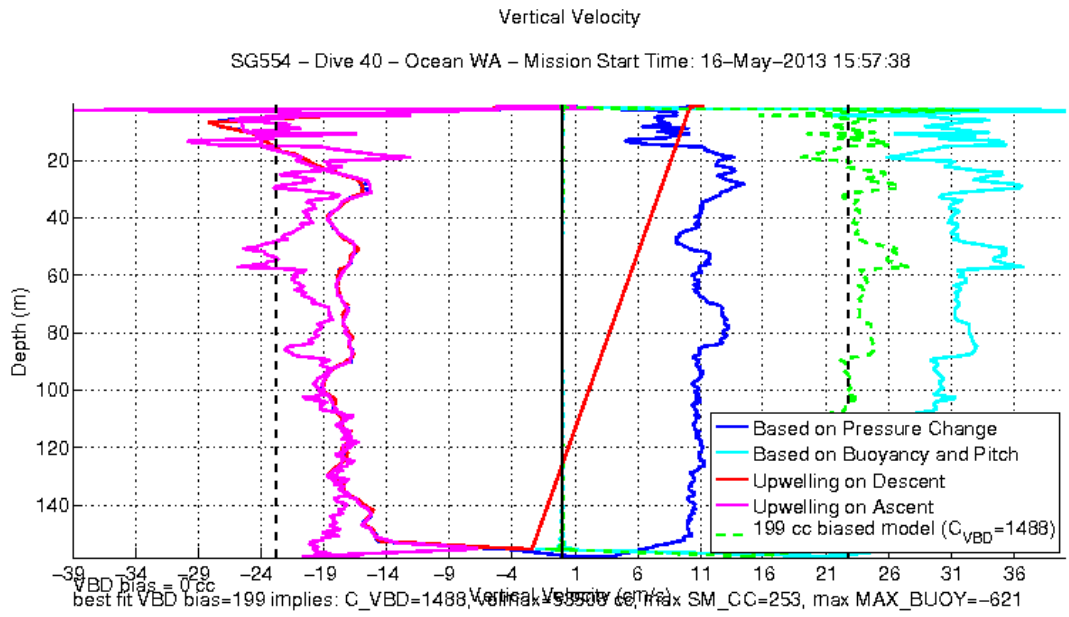

Fig. 14. VBD graph of dive 36.

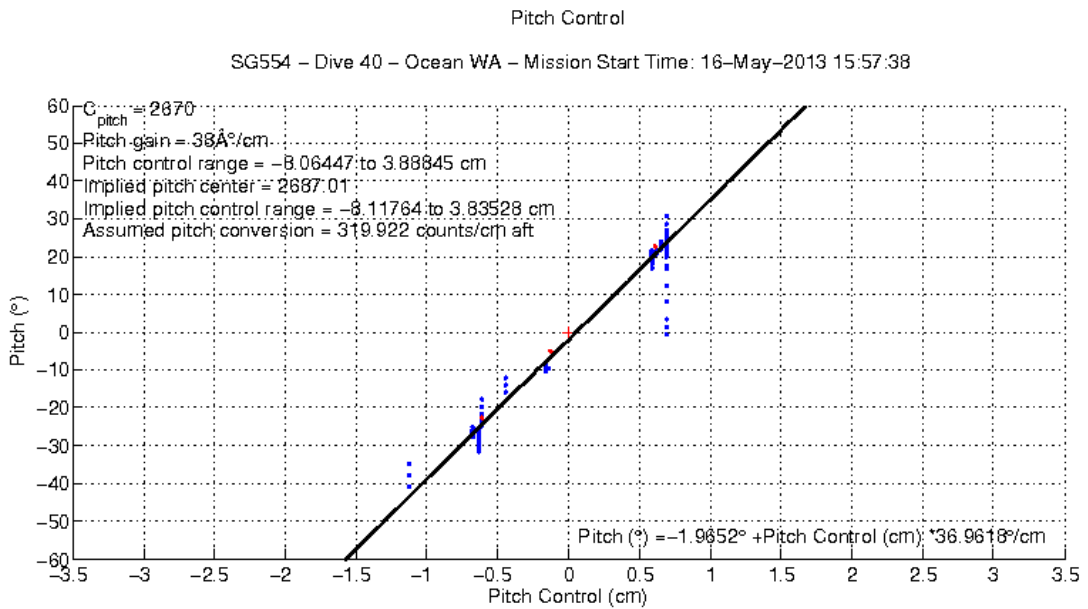Fig. 15. Vertical velocity plot of dive 40.

Fig. 16. Pitch graph of dive 40.

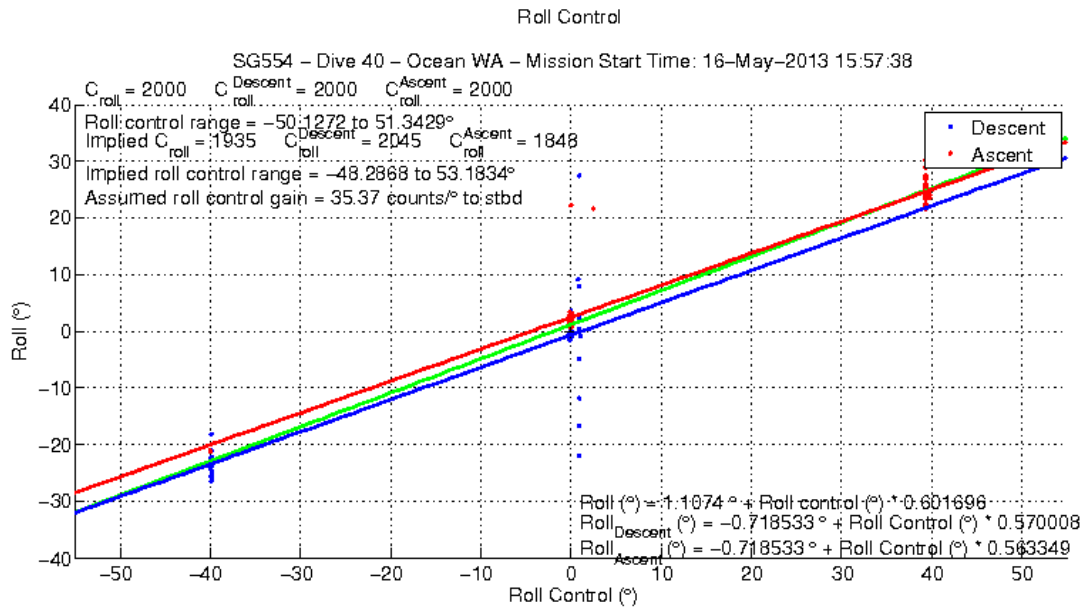Fig. 17. Roll graph of dive 40.

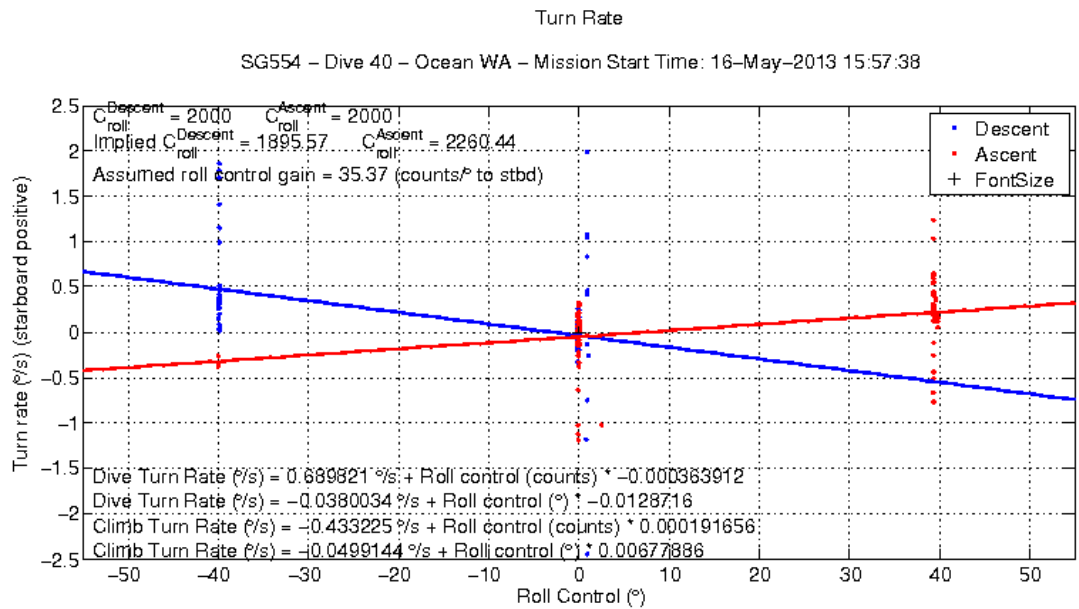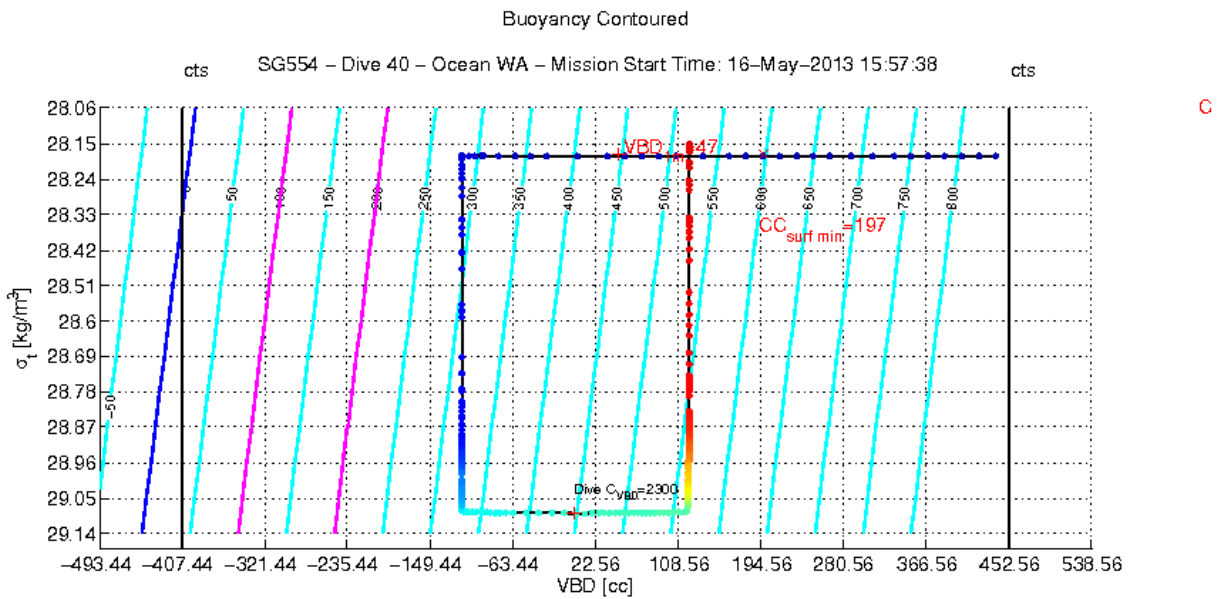
Fig. 18. Turn rate graph of dive 40.

Fig. 19. VBD graph of dive 40.

The $MAX_BUOY setting was changed starting from dive 68 to dive 71, the value was increased from 120 to 180 obtaining a much more symmetric flight, well described by the depth graph (Fig. 20).
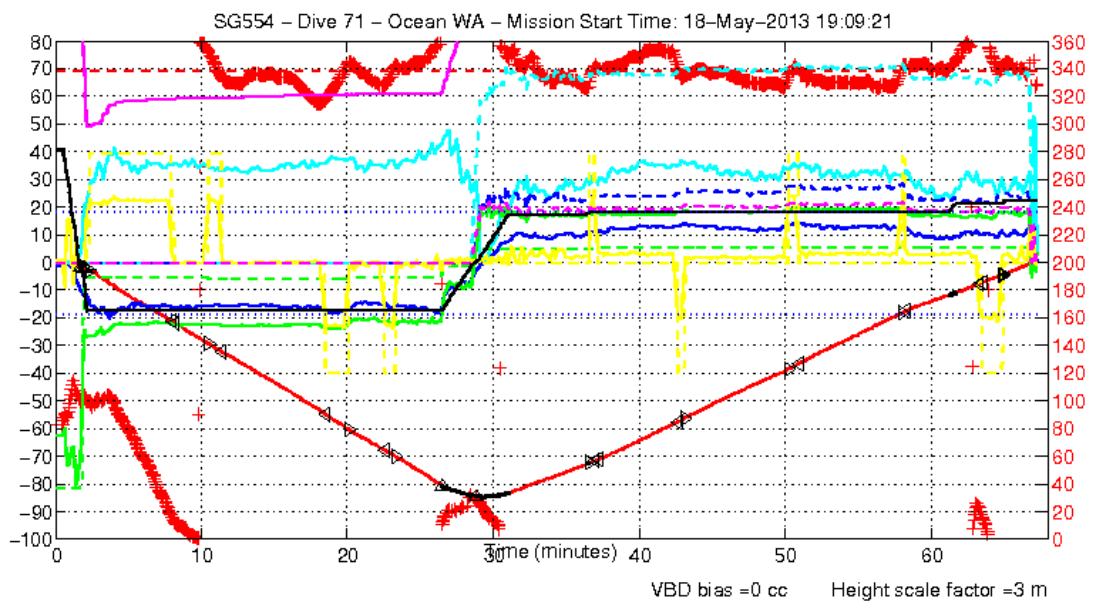

Fig. 20. Plot related to dive 71.

4. Some notions about the altimeter

False bottom readings can be relatively common. This can be a result of many reasons, a biomass layer, strong thermocline/halocline/pycnocline, wildlife (fish/mammals).The altimeter can be adjusted by the pilot as needed with two parameters:

- $ALTIM_SENSITIVITY is a voltage threshold the return signal has to remain above in order for the Seagliders altimeter to register the signal as a bottom reading.

- $ALTIM_PULSE is the length of the Seagliders altimeter pulse in milliseconds and a measure of how much acoustic energy is transmitted into the water.

These two parameters can be turned and adjusted as needed. It is important that the pilot don't adjust these parameters a lot. The best way to fine tune them is to adjust only one parameter at a time and by only a amount of 1.

During the mission in the Southern Adriatic Sea, we changed the $ALTIM_PULSE because we had a false bottom detection (in dives 95 and 97). Increasing the $ALTIM_PULSE from 3 to 4 generated a false bottom detection closer to the surface, while decreasing the parameter to 2, the problem was solved. Remember, never switch off the altimeter or make it insensitive to neglect the discontinuous layers, it can eventually result in the loss of the SeaGlider. Also in this case, a compromise between values that allow to cross some water discontinuities but not the sea bottom is needed.

5. References

iRobot 1KA Seaglider User's Guide, Revision: D