Project N. 037110

NEAREST

Integrated observations from NEAR shore sourcES of Tsunamis: towards an early warning system

Instrument: STREP

Thematic priority: 1.1.6.3 GOCE (GlObal Change and Ecosystems)

D15a: recovery cruise of the deep sea platform and data quality check

Due date of deliverable: September 2008

Actual submission date: September 30, 2008

Start date of the project: 01/10/2006   Duration: 36 months

Organisation name of the lead contractor for D15a deliverable: INGV

Introduction

The GEOSTAR multiparameter abyssal observatory was equipped with different sensors, that can collect a wide variety of different geophysical and oceanographic data. A complete list of the instruments installed on board the station is reported in the following table.

Sensor	rate	Acquisition
Triaxial broad band seismometer	100Hz - 3 comp. (0.016-100 Hz f.r)	Continuous + triggered events
Triaxial accelerometer	100Hz - 3 comp.	Continuous + triggered events
Hydrophone	100Hz	Continuous
Pressure sensor	15sec or 5 sec	Continuous
Accelerometer +Gyros (IMU)	100Hz - 6 comp. (0.3 mg at 2g)	Only on triggered events
Gravity meter	1Hz	Continuous
CTD + Transmissometer	1smp/hour	Continuous
ADCP	1profile/hour (40 layers/3 comp.)	Continuous
Currentmeter	5Hz	Continuous

ISMAR and INGV performed the first step of the bottom pressure data quality check. ISMAR analysed both the bottom pressure sensor data and the bottom pressure values acquired by CTD; the first operation performed was to fill the "holes" in the two time series due to missing data, using Harmonic Least Square Analysis (in order to extract the tide level) and linear interpolation techniques. The coherence of these just corrected data was then checked.
The same tsunami detection algorithm installed on the GEOSTAR CPU was applied to the corrected bottom pressure sensor data and the detected events were checked against the bottom pressure events reported on the log file stored on the GEOSTAR CPU.
In the following section a detailed, even if still in progress, data quality check on each devices installed in the abyssal observatory is reported. Also examples of periodic (data and status) and event messages are reported.

At this stage of work a further data quality check is still in progress. This release of the document describes the preliminary data analysis results.

Seismometer, Accelerometer and Hydrophone

Instruments:
GURALP CMG-40T 3 component 100 sps, 24 bit- OBS from hereon
GURALP CMG5T ACCELEROMETER 3 component 100 sps, 24 bit- ACC from hereon
HYDROPHONE OAS-E2PD- 100 sps, 24 bit HYD from hereon
GURALP DM-24 digitizer

Data quality check has been performed both in time and frequency domain. Traces are unfiltered unless otherwise stated and numbered from the top down in the figures.
The main problem, visible on all components of the OBS and ACC and somewhat on HYD, is a high amplitude disturbance (hereon D1) with period about 144 s lasting about 50 s (1 hour records FIG 1, traces 1-3 E N Z OBS, traces 4-6 E N Z ACC, trace 7 HYD). FIG 2 is a zoom of FIG 1

showing the shape of D1. D1 has a very sharp onset and in ACC there it has step-like behavior, with steps 1 s long (FIG 2 traces 4-6). The HYD signal in general presents a strange asymmetrical waveform influenced by the disturbance but in a less obvious way (FIGs 1 and 2 trace 7).
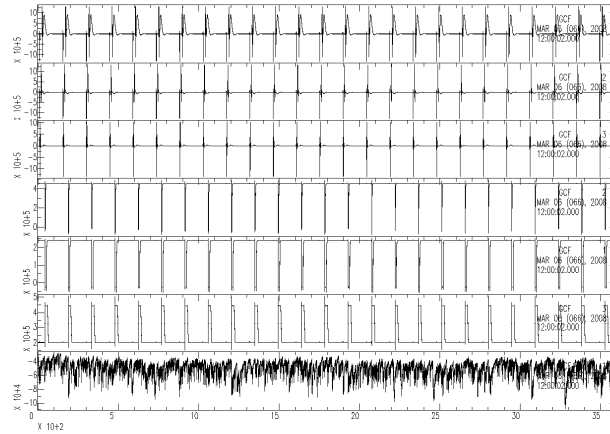D1 is present from the beginning of the mission till the end.

Figure 1 Noise signals on the seismometer
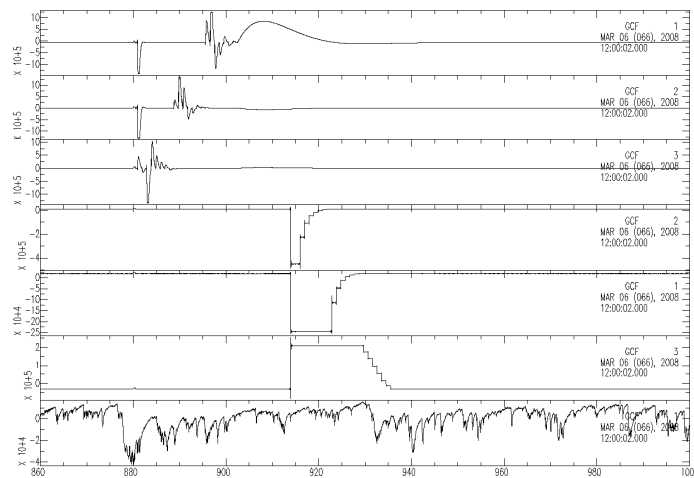
Figure 2 Noise signals on the seismometer (zoom of fig.1)

Further analysis are in progress also with the help of the seismometer system supplier (Guralp) in order to set up a procedure to clean up the data improving the signal to noise ratio.

Nevertheless we are able to well describe some seismic event detected: the following figure is an example of an event of magnitude 4 Mw 50 Km North from GEOSTAR site (11/1/2008 00:21:42 UTC) as was recorded by the abyssal station.

Figure 3 Seismic event, 4.4 Mw 50 Km North from GEOSTAR (11/1/2008 00:21:42 UTC)
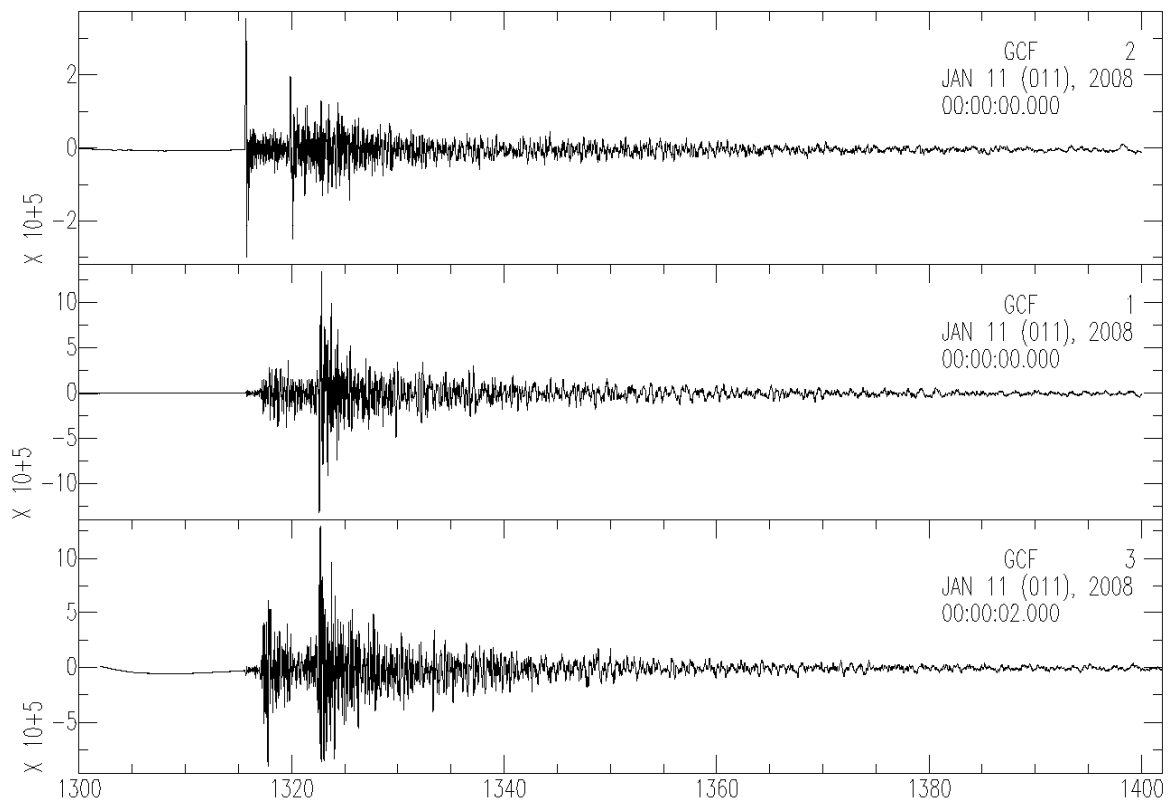
Pressure Sensor

First available data : 25/08 /2007 time 21:16:30 UTC
Last available data: 2008/04/06 time 17:55:30 UTC
Total number of pressure samples at normal sampling rate (15 sec.): 1290900 , which correspond to 224 acquisition days (322725 minutes, or 5378.75 hours)
Total number of pressure samples recorded at high sampling rate (5 sec.) : 455091, which correspond to 632 hours c.a.
Mean pressure value: 326449 mbar, which corresponds to 3262.46 m water depth.
In the following figures some examples of pressure data are reported. Pressure data from the Paroscientific devices (sampled at 15 sec) were compared to the ones recorded by the CTD (sampled at 1 hour) and shown a good agreement for large part of the acquisition time. Some discrepancy were found during the months October, November and December 2007, were also high frequency noise is present. Such noise is not present in all the remain mission time (see the following   Figure 4 and Figure 8). The noise in pressure data are highlighted in Figure 6 (differences between CTD data and Paroscientific ones) and Figure 7 (Pressure time derivative) and are limited to months October, November and December 2007.
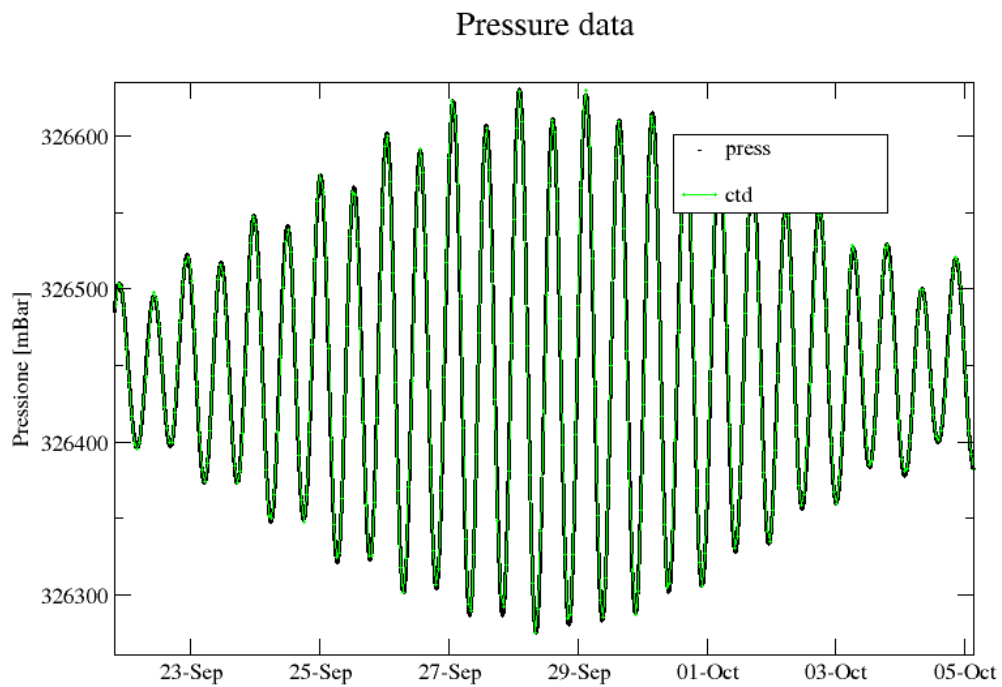
Figure 4 Pressure data in September 07 (black Paroscientific device sampled at 15 sec. green CTD data sampled at 1 hour)
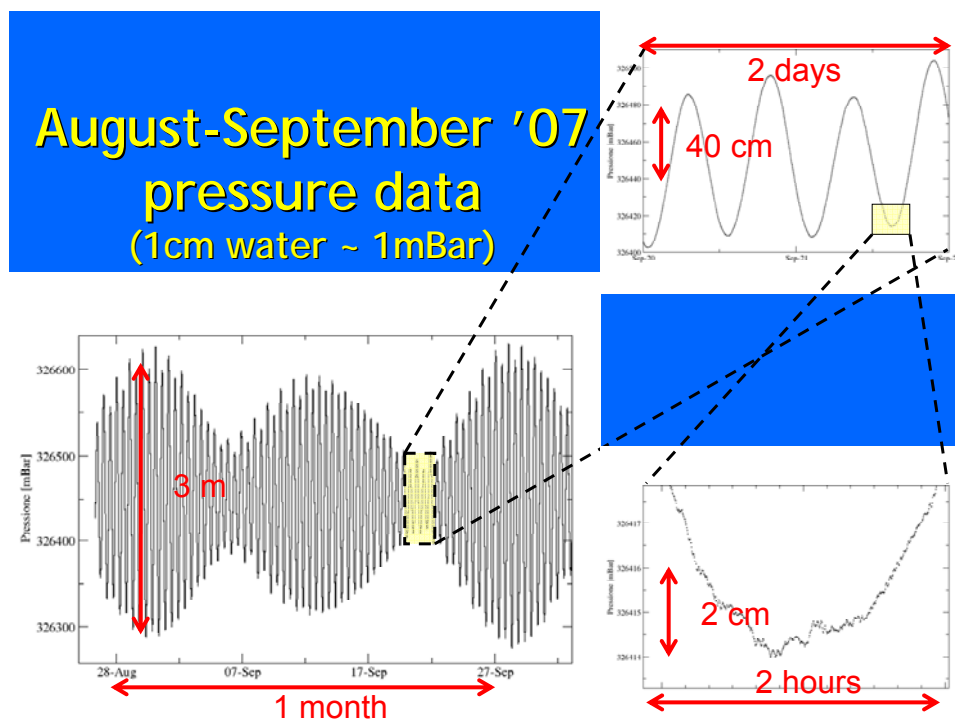
Figure 5 Example of pressure data recorded in September 2007

Difference between pressure and expected tide signal
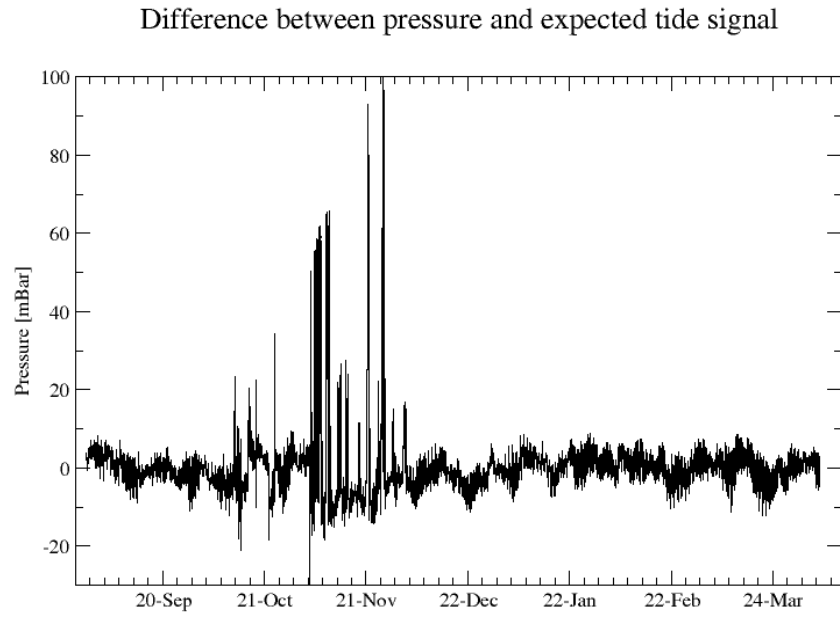
Figure 6 Difference between pressure data from Paroscientific device and expected tide signal. Large discrepancy mainly concentrate in October, November and December 2007.

Pressure data derivative
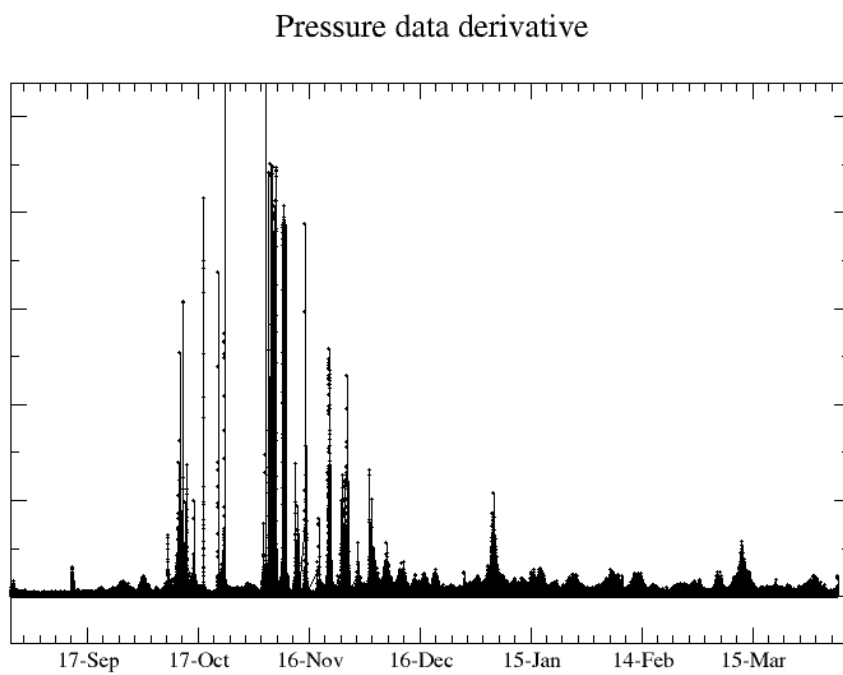
Figure 7 Pressure derivative (absolute value): high values in October, November and December corresponds to jumps in pressure data. Such jumps are no more present from January to April, even if the mean value of absolute derivative in the last months of the mission is larger than in the first three starting months.
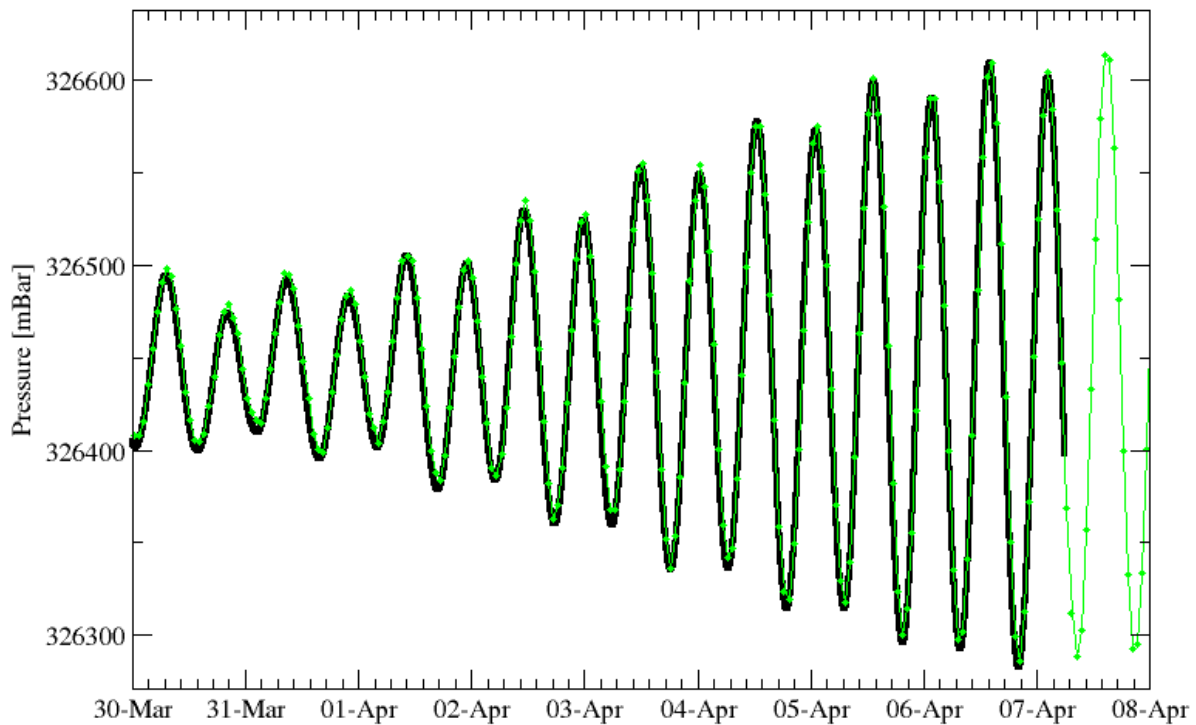
Figure 8 Pressure data from the Paroscientific device in the last month of acquisition (black) and comparison with pressure samples from the CTD device (green)

Accelerometer +Gyros (IMU)

IMU device was scheduled to acquire data only at the beginning of a detected seismic event. A detailed analysis is still in progress, but all data file were generated as expected.

Gravity meter

The analysis on gravity meter data are still in progress

Oceanographic devices

The first procedure after the GEOSTAR recovery consisted in a quality check of oceanographic data acquired during the NEAREST mission (20 August 2007 – July 2008).

The oceanographic dataset consists of:

1. Temperature, Conductivity, Pressure and Turbidity (CTD SBE16*plus* and BB WetLab)
2. 3D Current velocity along the water column above GEOSTAR station (ADCP 300KHz)

3. Punctual 3D speed intensity measured inside the observatory (3D Current meter (Nobska)

1. CTD SBE 16*plus* + turbidimeter

Sampling rate: 1 sample/hour.

The CTD worked properly during all the period of measurement (20 August 2007 - 18 July 2008). The dataset doesn't show any lack of data, evidence of noise or spikes. The only lacking period (it's not shown in the figure) starts at 4.00 PM of 17 October 2007 until 01.00AM of18 October 2007, it corresponds to the reboot command sent to the station.
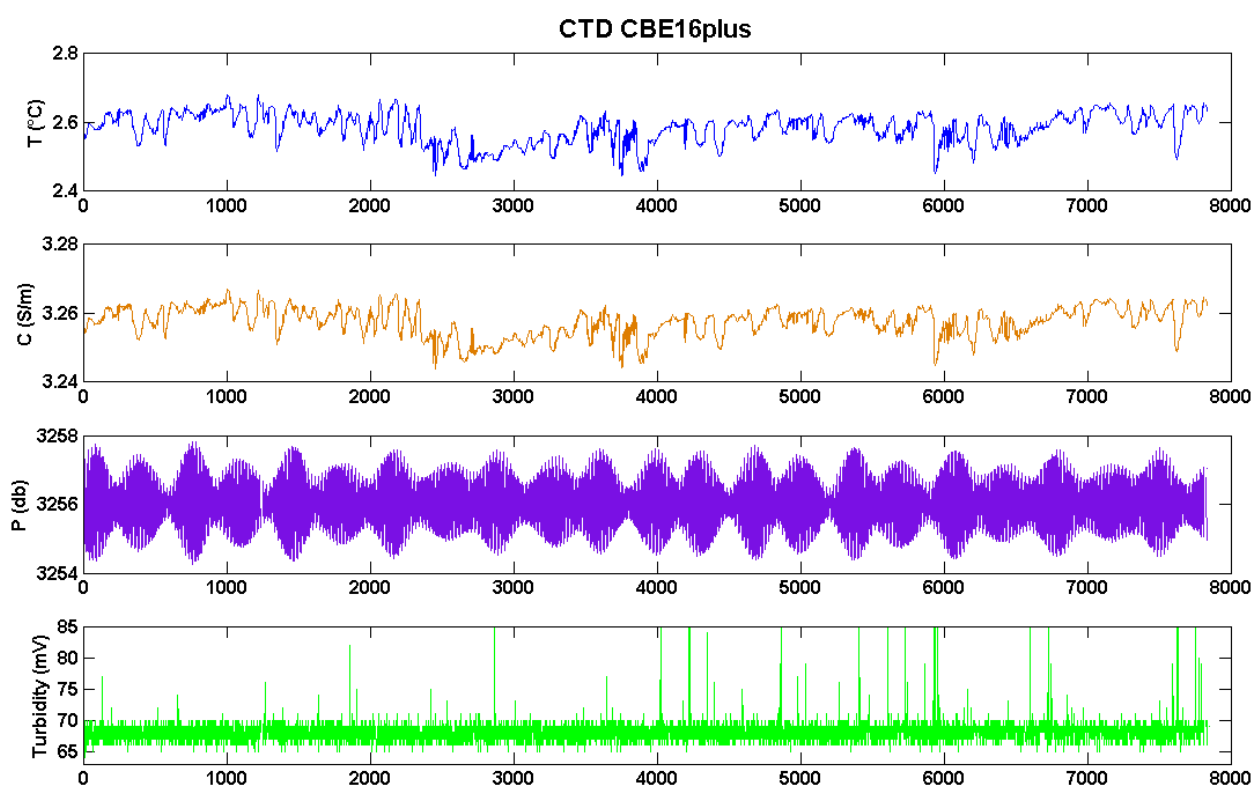
2. ADCP 300KHz

Sampling rate: 1 sample/hour.

The first "valid" sample starts the 1st September 2007. All data collected in August seem corrupted and unreadable with ADCP software. The whole dataset (1st September 07 – 18 July 08) doesn't present any problem (noise or missing data).
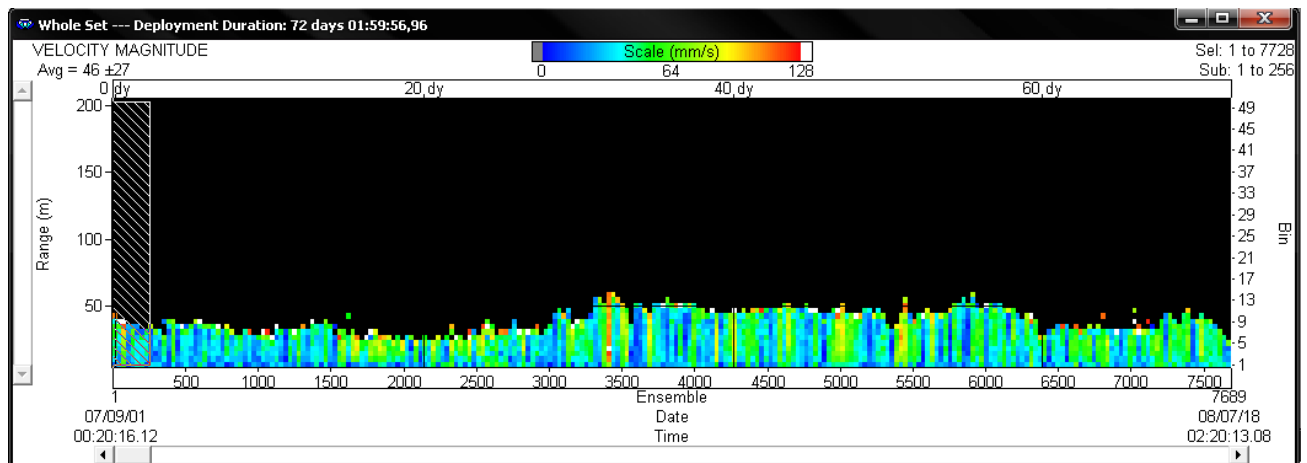
3. 3D current meter
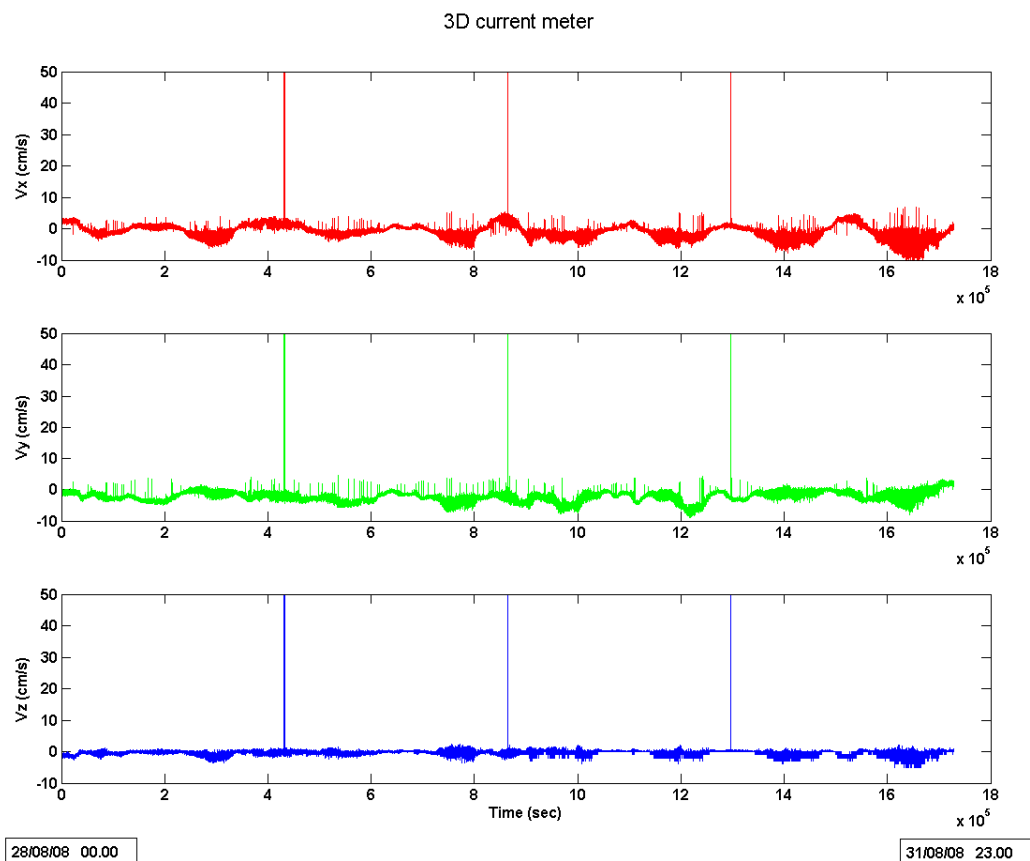
Sampling rate: 5 samples/sec.

The right sampling starts on 25/08/07 at 21 (last 16 minutes of this hour were also missed in data recorded).

Since 26/08/07, all dataset seems affected by periodic spikes 11 sec long each day at 00.00 AM. Also a lot of no periodic spikes are visible on all dataset (the image shows an example of 3 days long of continuous data) probably associated to some noise. Data since 17 October 15.00 PM to 18 October 01.00 AM was detected.

Periodic and event Messages

GEOSTAR Observatory was programmed to prepare one data message and one status message each mission hour. Data messages contains information on each sensor devices (samples values and status); Status messages contains information on the whole abyssal station (CPU status, battery, etc.) ; Event messages are generated only in the case an event was detected and contain information on the event (seismic or pressure and the time of detection for the first "starting event message") and pressure data sampled at 15 sec. (for the following data event messages, generated one each 10 minutes for the event mode duration). In the following tables examples of such messages are reported. They were generated and contain the all the information as expected.

Examples of DATA MESSAGES (25 Sept 2007)

Date-Time	SDU OBS NDataTot	NSeis	NSeisEvent	NAccAS	NHydro	NEv	NErr	LastPkt_Time
25/09/2007 0.00	6049	3030	0	1983	929	110	165	Tue Sep 25 00:59:56 2007
25/09/2007 1.00	5660	2829	0	1850	870	110	168	Tue Sep 25 01:59:58 2007
25/09/2007 2.00	6031	3028	0	1964	930	110	131	Tue Sep 25 02:59:56 2007
25/09/2007 3.00	5653	2828	0	1843	871	110	155	Tue Sep 25 03:59:58 2007
25/09/2007 4.00	6026	3022	0	1967	930	110	162	Tue Sep 25 04:59:56 2007
25/09/2007 5.00	5852	2930	0	1912	900	110	140	Tue Sep 25 05:59:58 2007
25/09/2007 6.00	5646	2830	0	1839	870	110	163	Tue Sep 25 06:59:56 2007
25/09/2007 7.00	6024	3030	0	1954	930	110	160	Tue Sep 25 07:59:56 2007
25/09/2007 8.00	5819	2919	0	1893	900	110	150	Tue Sep 25 08:59:58 2007
25/09/2007 9.00	5854	2931	0	1913	900	110	164	Tue Sep 25 09:59:58 2007

Date-Time	PDU PRESS Press_0 [mbar]	Press_1 [mbar]	Press_2 [mbar]	Press_3 [mbar]	Press_4 [mbar]	Press_5 [mbar]	IMU Gyro_x [deg]	Gyro_y [deg]	Gyro_z [deg]	Acc_x [g]	Acc_y [g]	Acc_z [g]	Temp [°C]
25/09/2007 0.00	326566.4	326555.6	326516.8	326459.2	326398	326348.9	-0.44	-1.01	1.54	-0.082	0.075	-1.217	2.73
25/09/2007 1.00	326544.6	326566.4	326555.6	326516.8	326459.2	326398	1.3	1.89	-1.21	0.085	-0.002	-1.348	6.5
25/09/2007 2.00	326496	326544.6	326566.4	326555.6	326516.8	326459.2	0.87	0.52	-1.61	0.065	-0.05	-1.124	4.4
25/09/2007 3.00	326434.1	326496	326544.6	326566.4	326555.6	326516.8	-1.51	-0.06	-0.77	-0.009	-0.111	-0.842	3.66
25/09/2007 4.00	326374.6	326434.1	326496	326544.6	326566.4	326555.6	0.46	0.81	-0.57	-0.049	0.009	-1.119	4
25/09/2007 5.00	326333.7	326374.6	326434.1	326496	326544.6	326566.4	-1.35	0.87	0.07	0.047	-0.135	-0.996	4.84
25/09/2007 6.00	326324	326333.7	326374.6	326434.1	326496	326544.6	2.61	0.33	-1.38	-0.02	-0.139	-1.002	3.12
25/09/2007 7.00	326346.3	326324	326333.7	326374.6	326434.1	326496	1.89	1.2	-1.39	0.052	-0.139	-1.037	4.29
25/09/2007 8.00	326398.2	326346.3	326324	326333.7	326374.6	326434.1	1.26	2.08	-0.55	0.035	0	-1.125	5.11
25/09/2007 9.00	326466	326398.2	326346.3	326324	326333.7	326374.6	1.56	0.6	0.99	0.013	-0.094	-1.007	6.77

Date-Time	DAU GRAV Empty values	Comm_errors/h	Media G [ng]	Media Temp [°C]	S.dev. G [ng]	S.dev Temp [°C]	CTD Temp [°C]	Conduct [S/m]	Press [dbar]	Transm [mV]
25/09/2007 0.00	0	0	14302552	-0.31	981.72	0.002	2.623	3.2613	3257.15	67
25/09/2007 1.00	0	0	14301818	-0.308	493.56	0.002	2.625	3.2615	3257.134	68
25/09/2007 2.00	0	0	14300278	-0.306	437.4	0.001	2.629	3.2618	3256.832	67
25/09/2007 3.00	0	0	14298887	-0.305	345.6	0.002	2.627	3.2616	3256.267	68
25/09/2007 4.00	0	0	14297727	-0.303	420.12	0.002	2.628	3.2617	3255.651	67
25/09/2007 5.00	0	0	14297373	-0.302	238.68	0.002	2.628	3.2618	3255.102	67
25/09/2007 6.00	0	0	14297161	-0.296	492.48	0.002	2.629	3.2618	3254.77	68
25/09/2007 7.00	0	0	14296958	-0.297	511.92	0.001	2.63	3.2619	3254.77	67
25/09/2007 8.00	0	0	14296798	-0.295	498.96	0.002	2.631	3.2619	3255.124	68
25/09/2007 9.00	0	0	14296070	-0.295	436.32	0.002	2.635	3.2624	3255.672	68

Date-Time	ADCP300 Heading [deg]	Pitch [deg]	Roll [deg]	Temp [°C]	3DACM mVe [cm/s]	mVn [cm/s]	mVw [cm/s]	mT [°C]	mMx	mMy	mPi [deg]	mRo [deg]
25/09/2007 0.00	224.89	0.25	0.41	2.43	1.7	1484.9	1485.1	2.81	0.89	148.09	1485.2	0.7
25/09/2007 1.00	224.88	0.25	0.41	2.44	1485	1483.7	1485.3	2.85	0.89	148.09	1485.2	0.7
25/09/2007 2.00	224.87	0.25	0.41	2.44	1484.7	1484.5	1485.1	2.85	0.88	148.09	1485.2	0.7
25/09/2007 3.00	224.87	0.25	0.41	2.44	1484.3	1484.7	1485	2.85	0.89	148.09	1485.2	0.7
25/09/2007 4.00	224.87	0.25	0.41	2.44	1484.6	1485.3	0	2.86	0.89	148.09	1485.2	0.7
25/09/2007 5.00	224.93	0.25	0.41	2.44	0.9	1485.3	1485.3	2.85	0.89	148.09	1485.2	0.7
25/09/2007 6.00	224.87	0.25	0.41	2.44	1.9	1484.6	1485	2.82	0.89	148.09	1485.2	0.7
25/09/2007 7.00	224.87	0.25	0.41	2.44	0.8	1483.5	1485.3	2.81	0.89	148.09	1485.2	0.7
25/09/2007 8.00	224.89	0.25	0.41	2.44	1.7	1484.6	1485	2.83	0.89	148.09	1485.2	0.7
25/09/2007 9.00	224.85	0.25	0.41	2.45	1.1	1484.8	1485.2	2.84	0.89	148.09	1485.2	0.7

Examples of STATUS MESSAGES (25 Sept 2007)

MCU

Date-Time	Reboots	OpMode	CF_Free [B]	Volt [V]	Curr [mA]	TiltX [deg]	TiltY [deg]	Heading [deg]	Settlem [mm]	Temp_B [°C]	Press_B [mbar]	Water_B	Temp_D [°C]	Press_D [mbar]	Water_D
25/09/2007 0.00	5	MISSION	499016	27.762	331	0.32	1.14	180.02	-140	3.32	781	OK	4.03	742	OK
25/09/2007 1.00	5	MISSION	499016	27.734	343	0.35	1.28	179.77	-140	3.3	781	OK	4.07	743	OK
25/09/2007 2.00	5	MISSION	499016	27.744	341	0.24	1.27	179.79	-140	3.32	781	OK	4.06	742	OK
25/09/2007 3.00	5	MISSION	499016	27.686	446	0.29	1.12	180.05	-141	3.32	781	OK	4.02	743	OK
25/09/2007 4.00	5	MISSION	499016	27.746	343	0.35	1.28	179.83	-140	3.32	781	OK	4.05	742	OK
25/09/2007 5.00	5	MISSION	499016	27.709	353	0.31	1.27	179.57	-140	3.29	781	OK	4.06	742	OK
25/09/2007 6.00	5	MISSION	499016	27.734	343	0.25	1.12	179.78	-140	3.34	781	OK	4.03	743	OK
25/09/2007 7.00	5	MISSION	499016	27.749	328	0.36	1.16	179.89	-140	3.3	781	OK	4.07	742	OK
25/09/2007 8.00	5	MISSION	499016	27.744	347	0.35	1.22	179.64	-140	3.33	781	OK	4.07	743	OK
25/09/2007 9.00	5	MISSION	499016	27.748	332	0.31	1.22	179.81	-140	3.31	781	OK	4.05	743	OK

SDU / PDU / DAU

Date-Time	Flags	Reb.	OpMode	CF_Free [B]	HD	HD_Part	HD_Free [kB]	HD_Size [kB]	Clock	Flags	Reb.	OpMode	CF_Free [B]	Flags	Reb.	OpMode	CF_Free [B]
25/09/2007 0.00	OK	27	MISSION	268656	BH_0	PART_D	1.14E+08	1.17E+08	OK	OK	5	MISSION	1708464	OK	5	MISSION	3887776
25/09/2007 1.00	OK	27	MISSION	262768	BH_0	PART_D	1.14E+08	1.17E+08	OK	OK	5	MISSION	1708463	OK	5	MISSION	3887488
25/09/2007 2.00	OK	27	MISSION	274536	BH_0	PART_D	1.14E+08	1.17E+08	OK	OK	5	MISSION	1708462	OK	5	MISSION	3887200
25/09/2007 3.00	OK	27	MISSION	268688	BH_0	PART_D	1.14E+08	1.17E+08	OK	OK	5	MISSION	1708461	OK	5	MISSION	3886912
25/09/2007 4.00	OK	27	MISSION	262832	BH_0	PART_D	1.14E+08	1.17E+08	OK	OK	5	MISSION	1708460	OK	5	MISSION	3886624
25/09/2007 5.00	OK	27	MISSION	256960	BH_0	PART_D	1.14E+08	1.17E+08	OK	OK	5	MISSION	1708459	OK	5	MISSION	3886336
25/09/2007 6.00	OK	27	MISSION	268688	BH_0	PART_D	1.14E+08	1.17E+08	OK	OK	5	MISSION	1708458	OK	5	MISSION	3886048
25/09/2007 7.00	OK	27	MISSION	262856	BH_0	PART_D	1.14E+08	1.17E+08	OK	OK	5	MISSION	1708457	OK	5	MISSION	3885760
25/09/2007 8.00	OK	27	MISSION	274568	BH_0	PART_D	1.14E+08	1.17E+08	OK	OK	5	MISSION	1708456	OK	5	MISSION	3885472
25/09/2007 9.00	OK	27	MISSION	268704	BH_0	PART_D	1.14E+08	1.17E+08	OK	OK	5	MISSION	1708455	OK	5	MISSION	3885184

Example of EVENT MESSAGE (15/09/2007 11.27 UTC) (start message and 10 following data event messages, one prepared to be sent each 10 minutes.

START EVENT
Msg

Time	Flags	Seism. Event ID	Press. Event ID	Seism Event Time	Press Event Time 00/00/00	Buoy Rx Time 00/00/00	Press [mbar]
15/09/2007 11.00	0x03	109	0	15/09/2007 11.26.48	00.00.00	00.00.00	326371.5

DATA EVENT
Msgs

Time	Flags	Seism. Event ID	Press Event ID	Sequence n°	Seism. Count	Num. Samples	Packet length	Start Time	Pressure values [mbar]		
15/09/2007 11.27	0x01	109	0	1	109	40	160	15/09/2007 11.27	326371.7	… …	326372.3
15/09/2007 11.37	0x01	109	0	2	109	40	160	15/09/2007 11.37	326378.1	… …	326378.6
15/09/2007 11.47	0x01	109	0	3	109	40	160	15/09/2007 11.47	326385.3	… …	326385.8
15/09/2007 11.57	0x01	109	0	4	109	40	160	15/09/2007 11.57	326393	… …	326393.6
15/09/2007 12.07	0x01	110	0	5	110	40	160	15/09/2007 12.07	326401.1	… …	326401.8
15/09/2007 12.17	0x01	110	0	6	110	40	160	15/09/2007 12.17	326409.4	… …	326410
15/09/2007 12.27	0x01	110	0	7	110	40	160	15/09/2007 12.27	326418.2	… …	326418.8
15/09/2007 12.37	0x01	110	0	8	110	40	160	15/09/2007 12.37	326427	… …	326427.7
15/09/2007 12.47	0x01	110	0	9	110	40	160	15/09/2007 12.47	326436.1	… …	326436.7
15/09/2007 12.57	0x05	110	0	10	110	40	160	15/09/2007 12.57	326444.9	… …	326445.6

↑

Here 40 column for the 40 samples of pressure data for each row (i.e for each message) are present