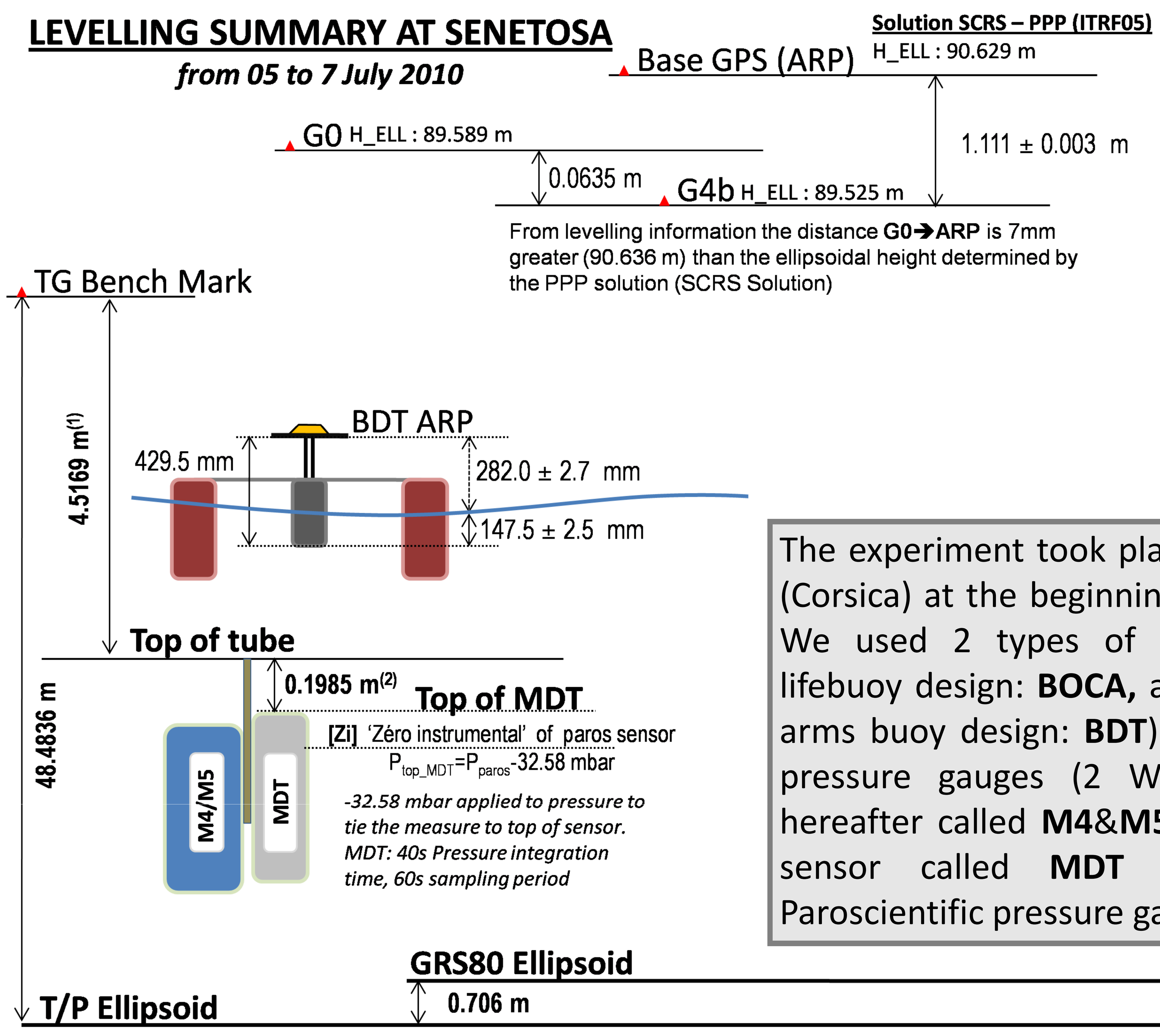
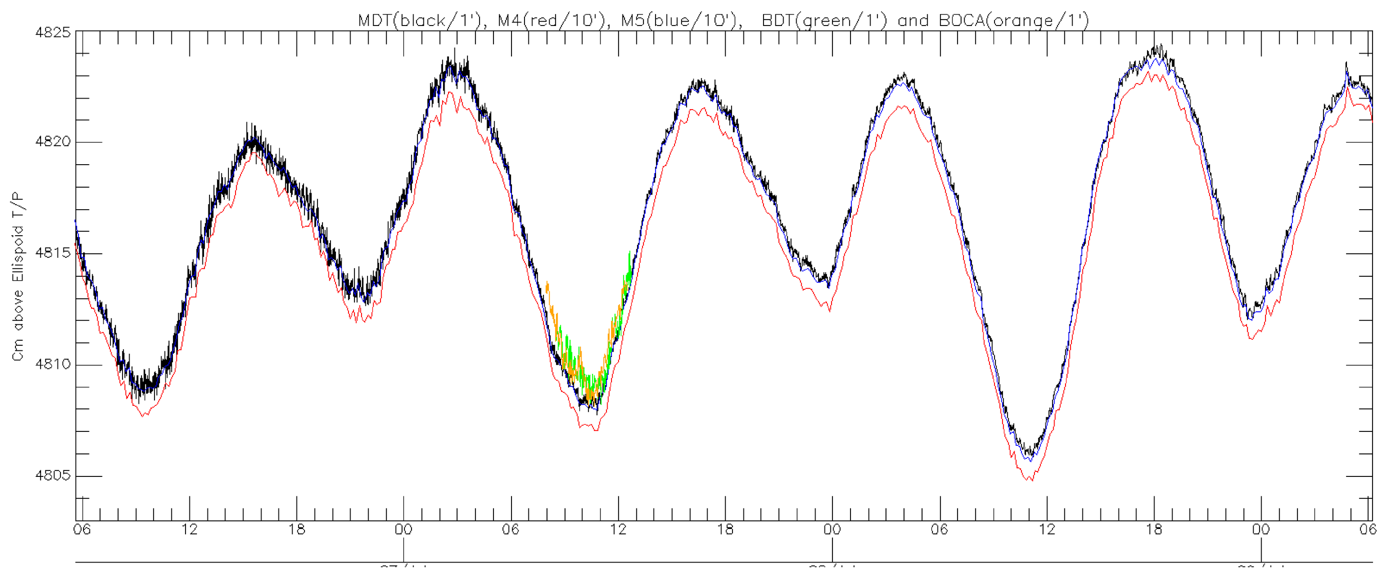
PRECISION AND ACCURACY OF GPS BUOYS: AN INTER-COMPARISON EXPERIMENT

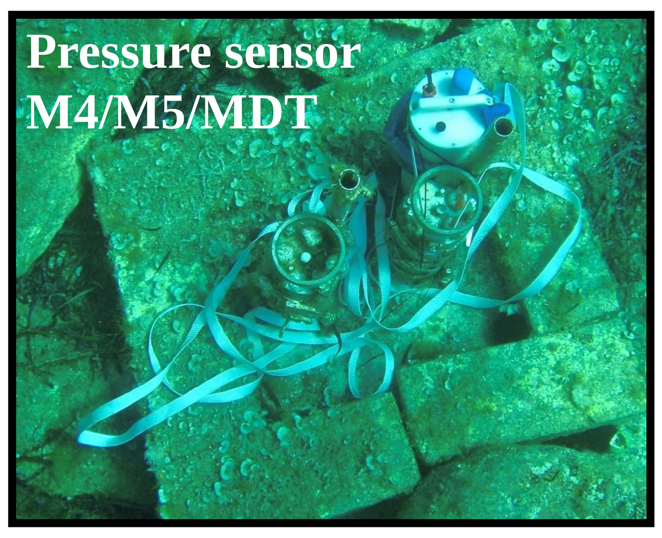
L. Testut(1), M. Calzas(2), C. Drezen(2), A. Guillot(2), P. Bonnefond(3), O. Laurain(3) and C. Gaillemin(4)

(1) LEGOS, Toulouse, France, laurent.testut@legos.obs-mip.fr
(2) DT/INSU, Brest, France
(3) OCA-GEOAZUR, Grasse, France
(4) PEM, Propriano, France

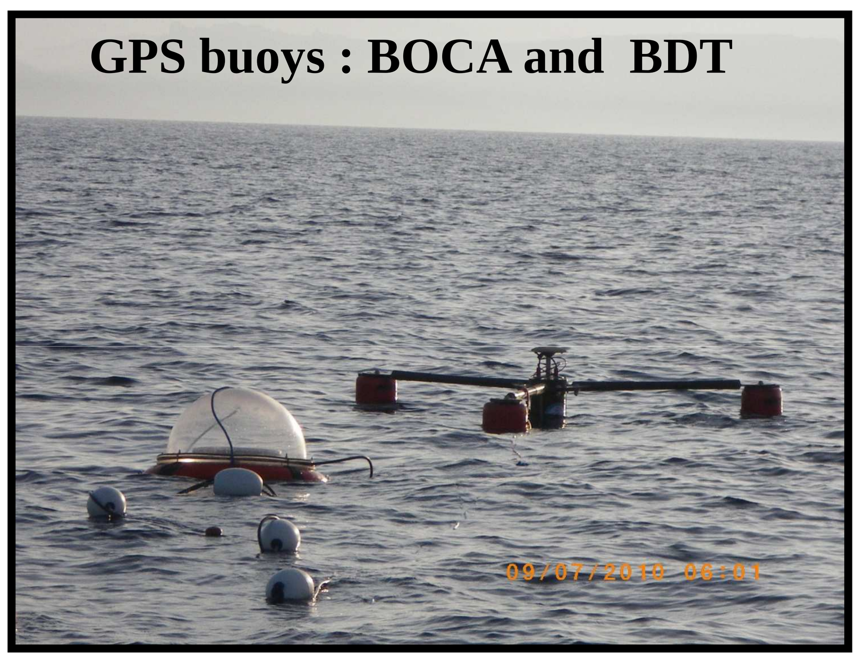
First experiments of sea level measurement using a precise GPS receiver onboard a floating buoy, start at the beginning of the 1990's. These GPS buoy systems are now routinely used by teams involved in cal/val activities, either to directly compare to the satellite measurements or to calibrate and tie a coastal tide gauge. Many different buoy designs are now used ranging from the classical lifebuoy design to the more sophisticated triangular system developed by the Australians (Watson et al., 2008). When used for lake or river cal/val activities, the design is not critical, but it becomes an important factor, when the buoy is used offshore under a satellite ground track, in rough condition. In 2009, we have designed a new GPS buoy in order to improve the stability, the robustness and the autonomy of the system. This system has been tested with different sensors (lifebuoy GPS design, different bottom pressure sensors) in a set of inter-calibration experiment in May and July 2010. We present here the first results of these experiments in terms of behaviour of the buoy at sea and in terms of precision and accuracy compared to the bottom pressure gauges.

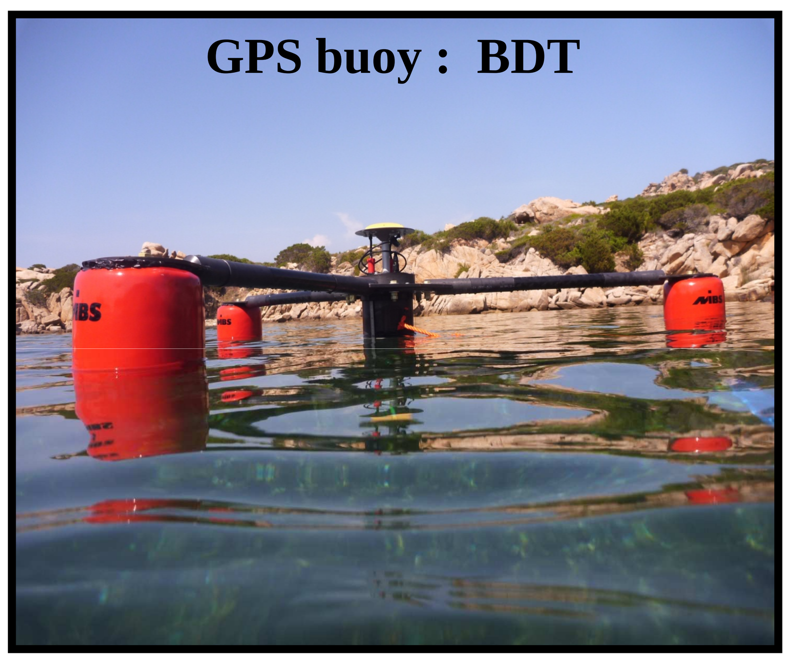






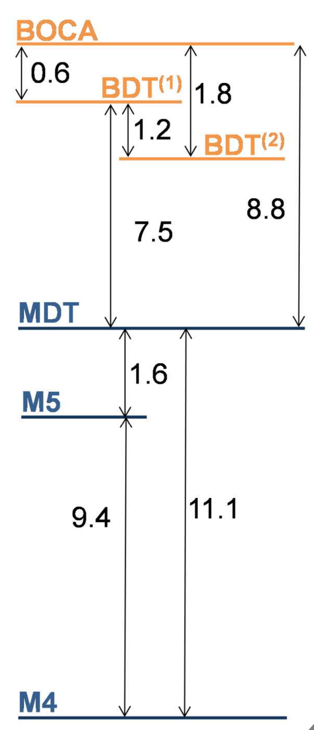
The experiment took place in Senetosa (Corsica) at the beginning of July 2010. We used 2 types of GPS buoys (1 lifebuoy design: **BOCA,** and the new 3-arms buoy design: **BDT**) and 3 bottom pressure gauges (2 WLR7 Aanderaa hereafter called **M4&M5** and our own sensor called **MDT** based on a Paroscientific pressure gauge.





INTERCOMPARISON TABLE

Offset (mm) / RMS (mm) / *Nbr of diff.*	MDT	M4	M5	BDT(2) TRACK	BOCA TRACK
MDT		-11.1 / 3.2 / *N=436*	-1.6 / 2.4 / *N=436*	+6.3 / 8.6 / *N=253*	
M4	+11.1 / 3.2 / *N=436*		+9.4 / 1.6 / *N=445*	+17.2 / 5.8 / *N=25*	
M5	+1.6 / 2.4 / *N=436*	-9.4 / 1.6 / *N=445*		+8.1 / 7.1 / *N=25*	
BDT(1) TTC	-7.5 / 7.7 / *N=253*	-18.4 / 5.3 / *N=25*	-9.5 / 6.2 / *N=25*	-1.2 / 6.2 / *N=15240*	0.6 / 91.7 / *N=14548*
BOCA TRACK	-8.8 / 6.4 / *N=277*	-19.5 / 4.1 / *N=28*	-11.3 / 4.8 / *N=28*	-1.8 / 91.7 / *N=14548*	



ANALYSIS OF THE SERIES

The 2 GPS buoys were processed in double difference kinematic mode with both TRACK (GAMIT) and TTC (Total Trimble Control) Software. The 3 pressure sensors are tied to the reference (the T/P ellipsoid) using classical leveling.

1) All the pressure sensors are comparable in term of precision (within a few mm), but the accuracy is of the order of ~1 cm due to bias between sensors (ex: M4/M5 > 1.cm offset).
2) The 2 GPS buoys give the same mean sea level at the mm level whatever the software used. But the impact of the design of the buoy is not negligible with a RMS close to 10 cm RMS due to different behavior at sea. The spectra of the difference exhibit significant energy below 10s with peaks at 3s and 6s (see figure below)
3) The impact of the GPS processing software is of 1.2 mm in term of bias and ~6 mm in term of RMS difference (the spectra is close to white noise. *not shown here*)

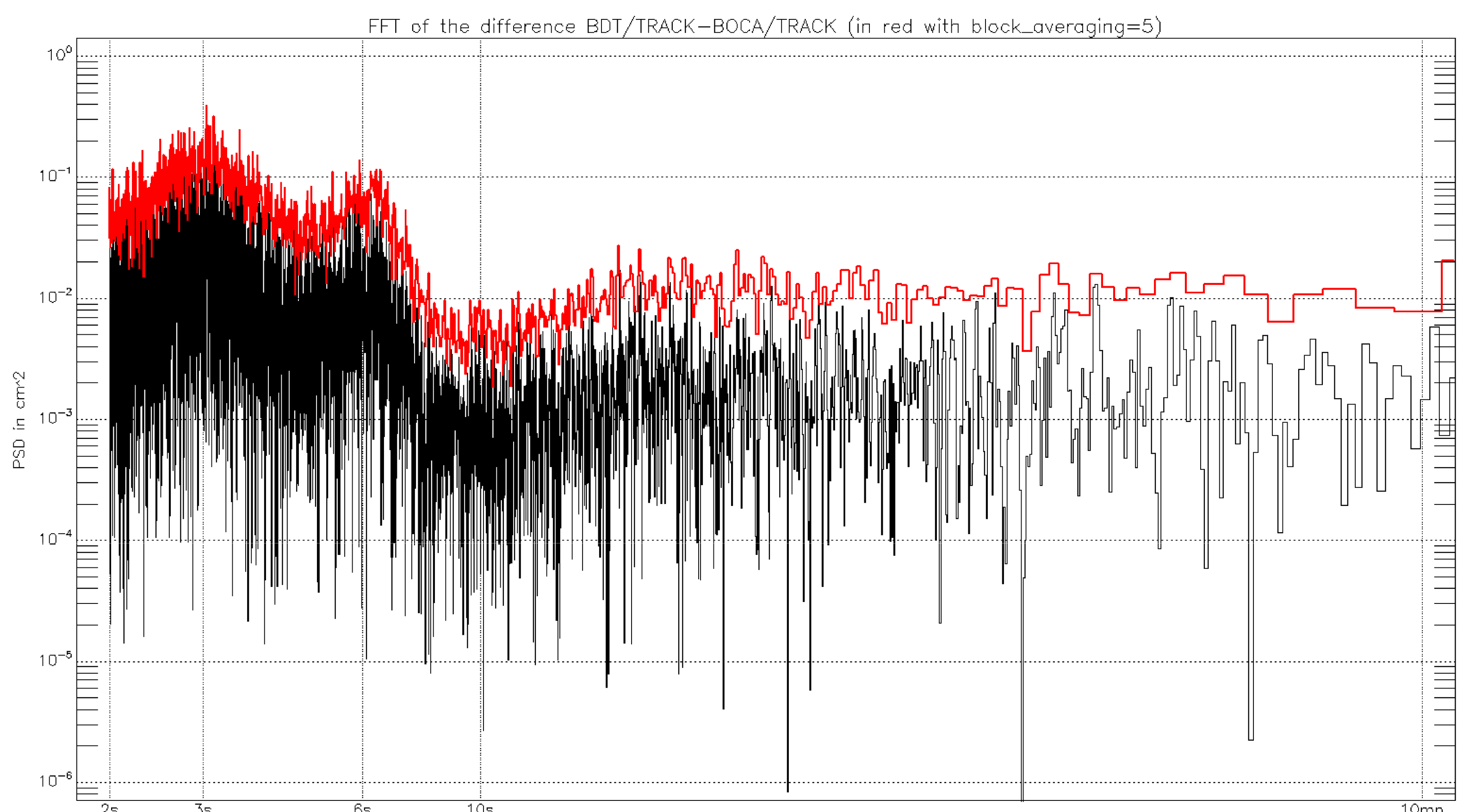


Figure : Spectrum of the difference between BDT and BOCA GPS buoys @1 Hz processed with TRACK

GPS-BUOY SWELL SESSION at 10 Hz

In order to test the ability of the GPS-Buoys to capture the high frequency ocean signal, a 4 hours session was done few kilometers away from the coast, during relatively high swell conditions (about a meter). The figures show that both buoys are able to capture the swell (Fig1). One can note also the strange 1s oscillation of the BDT@10Hz. This 1s peak is also present without strong swell (*not shown here*).

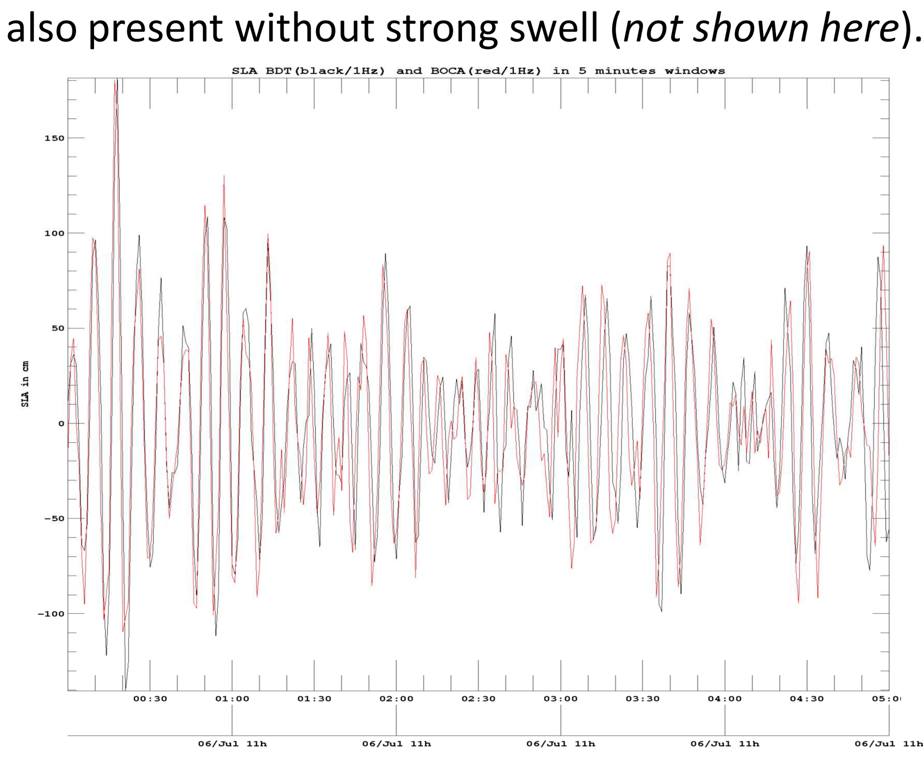


Fig 1 : High frequency sea level from the BDT@1Hz (black) and BOCA@1Hz (red) during the swell session.

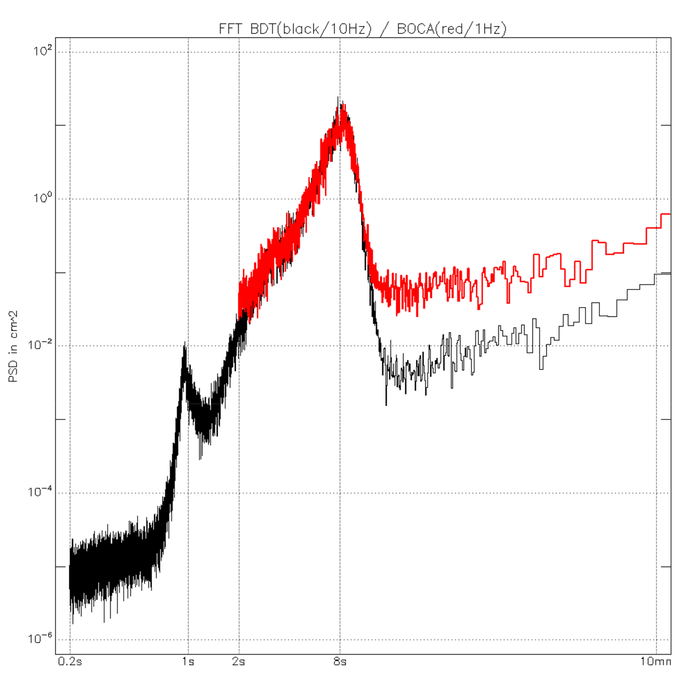


Fig 2 : Spectra of the BDT 10 Hz session (black) and the BOCA 1Hz session (red) during the swell session

CONCLUSION

The inter-comparison experiment has shown that:
•The pressure sensors are accurate at the cm level and precise at the mm level
•The GPS buoys are accurate and precise at the same level or better than the pressure gauges
•There are non negligible behavior differences between the two GPS-buoys at sea in the (0.1s to 10s) signal range
•It remains a dubious ~1s oscillation in the BDT that needs to be investigated further

References

Watson C.S. , Coleman R., Handsworth R. (2008). Coastal tide gauge calibration : A case study at Macquarie Island using GPS buoy techniques. *Journal of Coastal Research. 24(4) pp1071-1079 doi: 10.22112/07-0844.1.*

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Acknowledgment:

This research is supported by the French National Space agency (CNES) in the frame of the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) and CNES joint Ocean Surface Topography Science Team (OST-ST) Project.