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Oceanographic real time measurement on buoyancy beacon feedback in Rhone delta and Gulf of Fos

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Abstract:
The instrumentation implanted since 2003 on two buoyancy beacons in the Gulf of Fos-sur-Mer and in the delta margin provides local oceanographic and meteorological real time data. The device is based on Doppler technology sensors fixed on the beacon pipe. Meteorological sensors, acquisition and data transmission systems are clamped to the emerged structure close to Aide to Navigation (AtoN) and their energy systems. The monitoring of this equipment and analysis of recorded observations for nearly four years allows to specify uncertainties linked to this kind of measurement and provides a reliable feedback on the exploitation of the observatory. A data base of simultaneous measurements of beacons structure behavior (tilting measurement) and oceanographic and meteorological parameters have been used to design new buoyancy beacon (Lavezzi in Bonifacio Strait, Corsica; Marseille Port Authority; ...). The analysis of current measurement enables to characterize current profiles on the water column located above sensors, to distinguish flow stratification effects and wind-current correlations. Although originally designed to monitor the structure behavior and to supply wave climate to marine pilots, the system has developed deffered time applications. For example, sediment dredge bottom discharge has been optimized in the Gulf of Fos and frequency analysis of sea level has been compared to coastal tide gauge data for the historical Rhone flood in December 2003 (MAILLET *et al.* , 2006).

Keywords:
Buoyancy beacon – ADCP – Wavemeter – Metocean observatory – Gulf of Fos

1. Project presentation

The origin of the instrumentation of two buoyancy beacons in the Gulf of Fos came from different needs from two partners. On the one hand, the CETMEF (French Institute for Maritime and Inland Waterways) wanted to improve *in situ* knowledge of beacons structures behavior. On the other hand, Port Authority of Marseilles (GPMM: Grand Port Maritime de Marseille), owner of a wavemeter (Datawell type) in the Gulf

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of Fos often hit by ships, wanted to secure this equipment. In 2001, GPMM, CETMEF and Maritime Service of Bouches-du-Rhone (SM13) agreed to build a metocean observatory on two beacons (figure 1) located in the Golf of Fos.

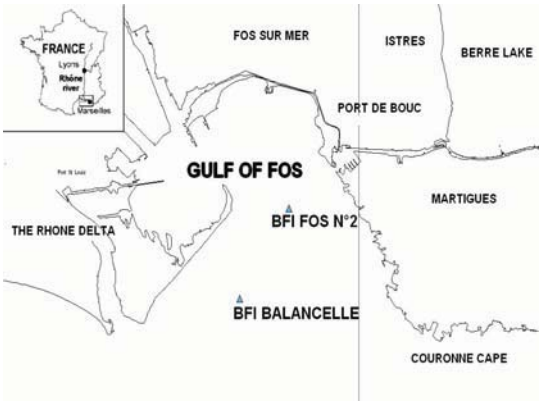

Figure 1. Situation of the buoyancy beacons in the Gulf of Fos (France).

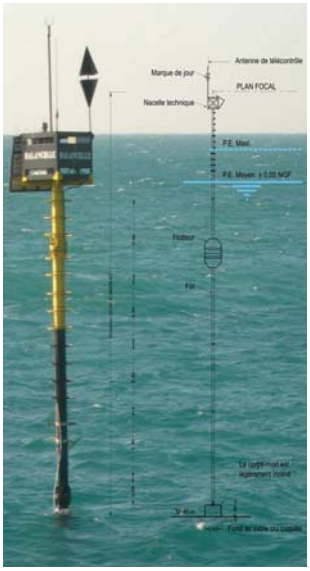

Figure 2. Buoyancy beacon equipped in its environment (left) and structure of the observatory moored on sea bed (right).

2. Instrumentation description

The current profiler is an Awac type from Nortek. ADCP (Acoustic Doppler Current Profiler) uses Doppler technology, based on phase difference calculation between the emitted and received frequencies. Phase difference is linked to particles speed in the water (plankton, sediments, ...) driven by currents. The instrument also measures sea level (pressure sensors), sea temperature and eventually wave parameters. The Awac is clamped on a supporting arms perpendicular to the beacon main pipe, see figure 3.

Figure 3. ADCP on the perpendicular arm during an inspection. Notice bivalve colonization after 6 months.

The arms were calculated as to install ADCP 3.5 m away from the main pipe so that Awac beams are not disturbed by beacon structure. Depths are 15.5 m for the Fos n° 2 ADCP and 14.5 m for the Balancelle one along the Rhone deltaic margin. Arms are East-West oriented in order to remove automatic magnetic North, otherwise sensors would have been influenced by the metallic pipe and beacon.
The ultrasonic anemometer is a Vaisala WS425 type fixed on the buoyancy beacon nacelle 7.0 m above average sea level (see figure 4). Metocean parameters are described in table 1.

Figure 4. Vaisala WS425 anemometer on the buoyancy beacon nacelle.

Table 1. Parameters.

Measure type	***Resolution***	***Accuracy***	***Range***
Current	*1 mm/s*	*+/- 5 mm/s*	*[-10 m/s;+10 m/s]*
Wave high	*1 mm*	*+/- 1 cm*	*[0 m; 20 m]*
Wave period	*0.01 s*	*+/- 0.1 s*	*[0.5 s; 100 s]*
Wave direction	*1°*	*+/- 2°*	*[0°; 360°]*
Sea level	*5/100000*	*0,50%*	*[0 m; 50 m]*

Values, given for fixed conditions are influenced by buoy movements around vertical axis (maximum pitch measured: 7.8°).

3. Data validation and processing

At the commissioning of the two buoyancy beacons, a data validation has been realized. Jointly made by GPMM, SM13 and the service provider. Awac profiler results were compared to Datawell wavemeter and atmospheric measures to Météo-France data basis. A Datawell buoy was specially installed near to the Fos n° 2 beacon. Observations showed significant wave (Hs) slight underestimation by Awac vs Datawell system and wave period underestimation as well (0.5 to 2 seconds). After tests, calibration of instruments has been made in order to identify and eliminate any bias.

4. Technical and maintenance restrains

Main missing data are due to unforeseen computer stops without any alarm (figure 5). Consequently computer maintenance needs to be well organized. The 5 years feedback shows that acquisition-transmission-archive chain is very secure over the time.

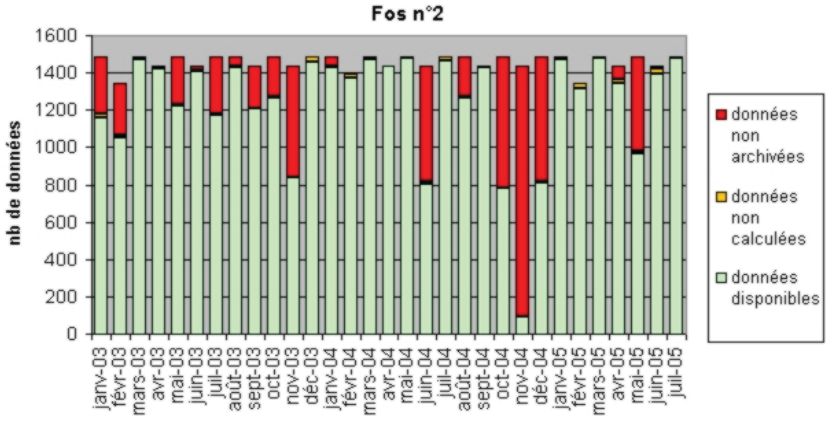

Figure 5. Missing data due to unforseen computer stops (2003-2005).

As to sensor maintenance, stains on the sensors disrupt the acquisition process and produce damaged data, even if recording is still active. We observed measurements sensibility depending on stains occurrence, see figure 6 (red line: sensors cleaned).

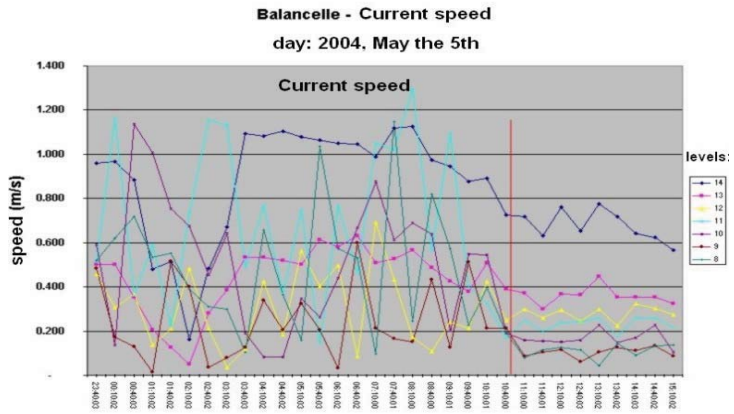

Figure 6. Sensors cleaning influence on current speed measurement.

Diving missions were periodically programmed to check and clean the sensors. The first dive took place in May 2004. We observed that the two sensors were covered by concretions and colonized by bivalvias and various algae, see figure 3. According to the first two dives, a quarterly inspection is the ideal frequency on Balancelle beacon. Fos system further away from Rhone mouth, with less nutriment is less impacted by bio-colonization. Regular sensor heads cleaning allows to optimize diving inspections and minimize data acquisition disruption.

5. Results

Correlations have been produced between wave height / wave direction, wind intensity / wave height and wind direction / current direction. Surface current and wind are well correlated, mainly during Mistral and storm events (135° and 315°) see figure 7.

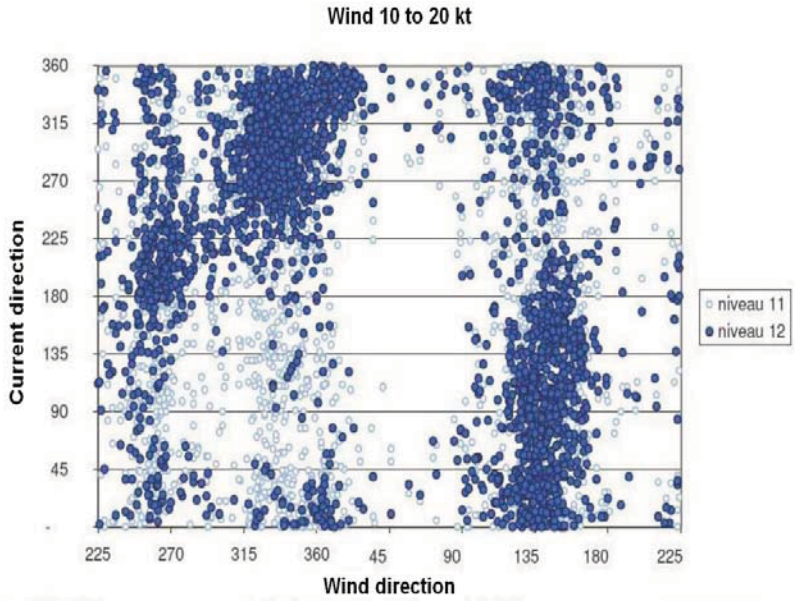

Figure 7. Wind /current directions correlation.

Inclination data (pitch, roll,...) observations enabled to improve beacon structure behavior and their design (figure 8).

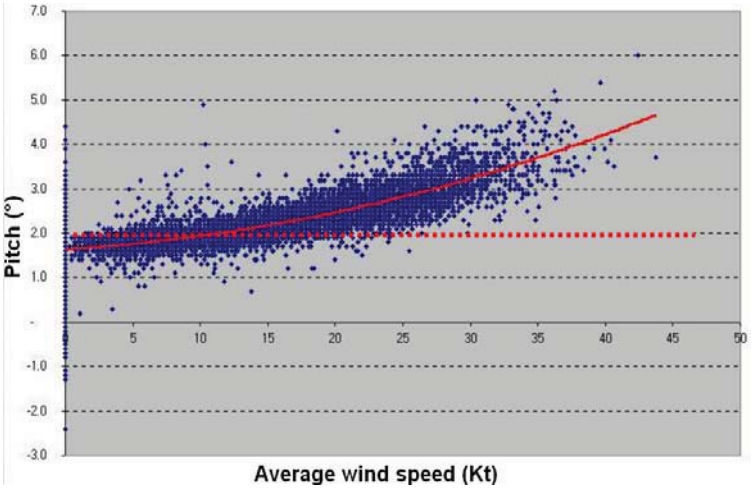

Figure 8. Pitch/wind correlation.

Subsurface shear current may be observed during episodes (figure 9).

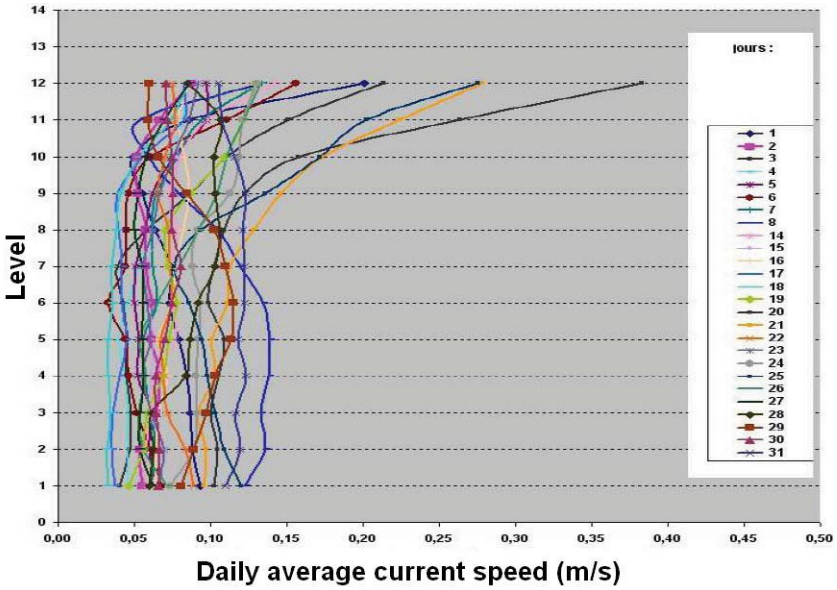

Figure 9. Daily average current profile.

6. Conclusion

Five years of real time data experience provided by profiler technology fixed on buoyancy beacons show the interest in coupling marine observatory to AtoN buoy : direct energy providing (solar or wind), localization, safety of the equipment,... Eventually we advise to keep the instrument in its original configuration - including magnetic North - independently positioned on sea bottom on a tripod and connected to the buoy by a short umbilical wire to avoid trawling.

MESURHO (web site) program (IFREMER, CNRS, CEREGE, SM13 and CETMEF), a new beacon observatory centered on the main Rhone, will benefit from the two beacons experience. Flow structure in the Rhone river mouth and hydro sedimentary processes off the coast of the Gracieuse They are the main study purposes.

Spatial altimetry projects, coastal oceanic modeling or any operationnal or research program interested in integrating those observations are welcome in order to enlarge partnership and maintain a sustainable equipment in marine conditions.

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