A practical comparison between Seabird SBE911 and Ocean Seven 320 CTD probes

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Introduction

Invented at the end of the 70's, the MK IIIB-CTD (see Brown and Morrisson, 1978) has been for many years the reference hydrographic profiler. At the launch of the WOCE programme in the early 90's, increased accuracy and resolution was requested for the hydrographic parameters. Careful laboratory calibrations and analysis of ***in situ*** data series revealed the limits of the NBIS MK-IIIB performances, most of which resulted from the limited technologies available at the time the device was conceived. Some remedial was proposed to improve the precision of the MKIIIB in order to comply with WOCE standards (Muller et al., 1994). However, such updates were not easy to apply, as all probes in the MKIII series were not identical, sometimes containing different electronic modules. One of the WOCE repercussions was thus to boost the development of a new generations of standardized CTD's, based on more recent 80'-90' technologies. These new CTD's can be classified in three categories, according to their principle of measurements and configuration:

a) The "free-flow" CTD's, system in which T,C,p and auxiliary sensors are in direct contact with the surrounding water, (like in the previous NBIS MK III probe) but with improved electronics.
b) The "inductive free flow" type, which includes a new inductive conductivity sensor also in direct contact with the surrounding water, but with some geometrical constraints and proximity effects (as in the Falmouth Scientific Instrument probe).
c) The "pump-circulated" system, in which the water is forced to run through an independent sensor's network as in the Seabird type probes.

In spite of significant skill and efforts, few manufacturers were able to meet the WOCE standards in the early 90's. Having been one of the first to be successful, because of a fast efficient market spreading and a first class services to customers, Seabird products rapidly took the lead in that field and became a worldwide reference for many years. However, in the meantime, many manufacturers proceeded with new developments, by taking into account customer's needs and experience, and by using emerging technologies in sensors, electronic design and signal processing. According to recent technical data sheets, the level of resolution and accuracy now achieved by the last generation of CTD's appears to be very close to the characteristics of the standard facilities used to calibrate the sensors, with precision/resolution 0.001-0.002°C in temperature and 0.002‰ in salinity.

Theoretical and practical performances

The commercial data sheets usually refer to ideal conditions and are sometimes over optimistic. Indeed, a calibration performed in a quiet laboratory does not always reflect performances under realistic fieldwork conditions. Field tests are the only way to verify and compare intrinsic performances of such devices. However, to be meaningful, comparison tests should ideally be carried out with instruments recently calibrated in the same facilities, in order to avoid any bias, which might result from different calibration procedures. Also, the probes must be mounted in a single frame to perform simultaneous measurements, possibly in rather homogeneous water to get rid of any steep gradient effect. The homogeneous Mediterranean deep water is one of the ideal environment to carry out precision tests: the variation of its physical properties over a few hundred meters above the bottom are of the same order of magnitude as the WOCE requirements for the basic hydrographic parameters.

A field intercomparison between Seabird 911 and Ocean Seven 320 CTD probes

The OCEAN SEVEN 320 multiparameter CTD (OS320) probe is the last product of IDRONAUT, a manufacturer of high quality marine instrumentation (http://www.idronaut.it). In the OS 320 probe, the array of redundant T and C sensors is in direct contact with the surrounding water, avoiding thus the need of an external pump and associated flushing delays, as well as manifold electrical connectors. Conductivity is measured according to the principle of the free flow cell as in the earlier NBIS MKIII probe, however with significant improvement in the design of a seven uncoated rings quartz cell (http://www.idronaut.it/multi_probes/320/main.html). The SEABIRD 911 probe is actually the world wide recognized high precision CTD oceanographic probe, in which an external pump circulates seawater across a network of external, high precision sensors.

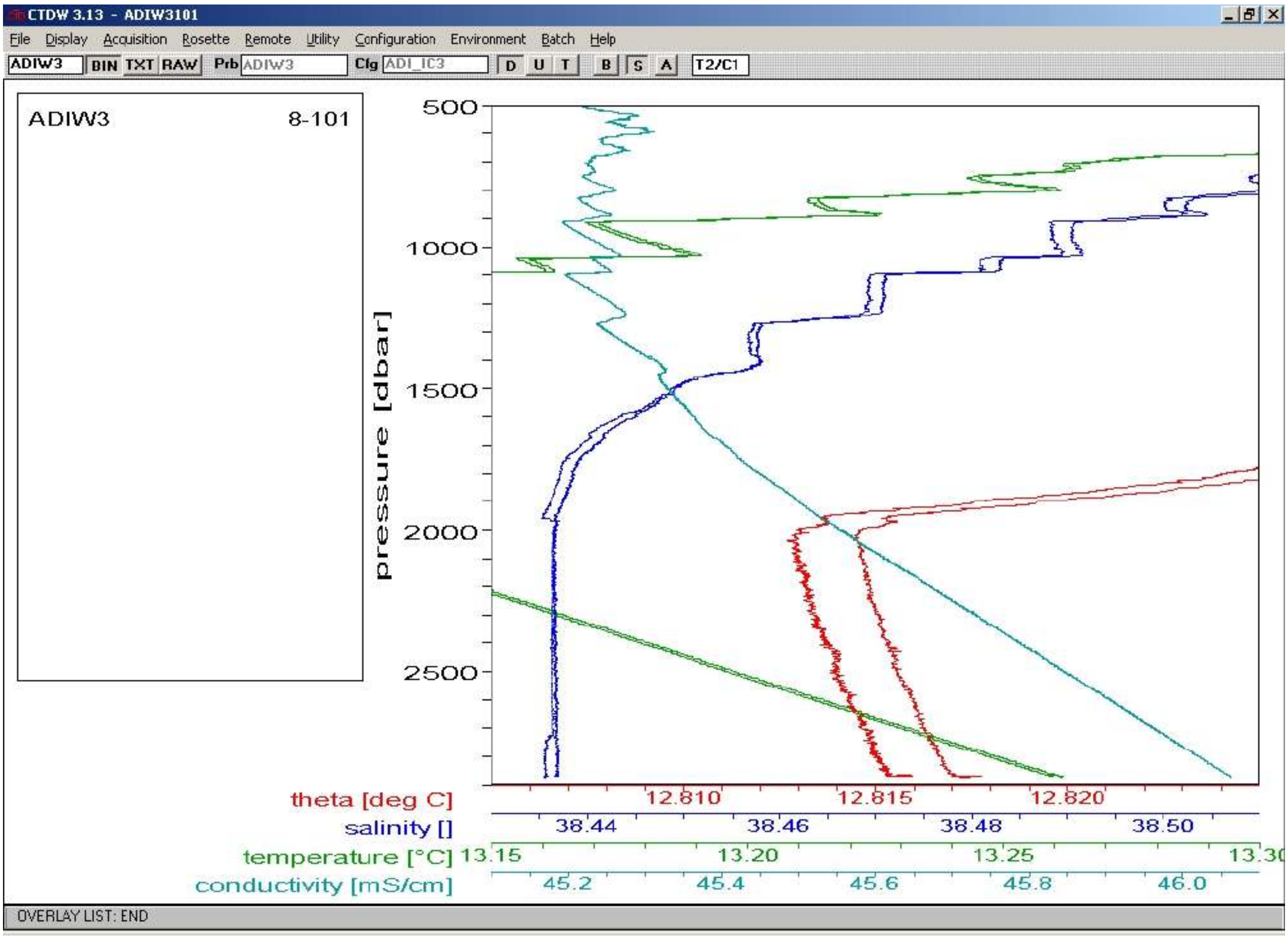
The ADIOS ADW3 cruise (24.5-2.6.2002) was a unique opportunity to compare the performances of the OS 320 probe and a Seabird 911 CTD, which is part of the permanent facilities available on board the R.V Urania ship. Due to time constraints, the OS 320 was rapidly factory calibrated just before the cruise, but a refined post-cruise calibration was performed at the Saclant's facilities in June 2002, which resulted in very small updates of the earlier factory calibration constants. The SBE 911 was last calibrated at the same Saclant's facilities in February 2002. The comparison between both devices was thus really meaningful. The work area was located around 39°25 N / 6°05E, where the water depth is more than 2800m, thus with a homogeneous bottom water more than 800m thick. In that area, some staircase like gradients in temperature and salinity were depicted at mid depth and are also relevant for such a comparison. Both devices were mounted close to each other in a rosette frame. The sea cable powered the SBE 911 and transmitted data, while an external battery was added to the OS 320, its data being stored in a 64 Mbytes internal memory. Because of an unexpected hardware failure of the SBE 911, only one deep cast is available for that intercomparison. However, that single cast illuminates the agreement between data provided by both devices, in spite of the conceptual differences in the measurement system. The OS 320 was used for the follow up of the cruise, and values obtained in the homogeneous deep water of the area remained within a range of 0.003°C for temperature and 0.006 psu for salinity.

Results

In order to compare performances and efficiency of different CTD probes under fieldwork conditions, and pending any universal standard, the Seabird products are actually recognized as reference in that field. Our comparison thus focused on the absolute values of the hydrographic parameters in the near bottom homogeneous layer, but also on the response of the sensors in the staircase like structure at mid-depth. The 500 dbar-to-bottom section of the cast is displayed in figure 1, with expanded scales for potential temperature and salinity. Indeed, by contrast with in situ temperature which varies significantly due to the pressure effect, potential temperature is very stable in the deep layer and its variations are < 0.005° C over 1000m thickness. The OS320's potential temperature is higher by 0.0015°C compared to SBE 911's temperature. That difference is constant over the last 800 dbar, and remains within the WOCE standards. Apart from the small jump in salinity for the OS320 around 2000 dbar, the calculated salinity only differ by dS=0.002-0.003 °/oo. The conductivity overlap with differences dC<0.003 mS/cm even in the staircase section (500-1500 dbar in fig. 2). The small jump in salinity at 2000dbar correspond to a step dC<0.001 mS/cm in conductivity. Such a jump was not observed in the subsequent deep casts of the cruise, and it is likely due to a small impurity temporarily trapped in the measuring cell. The differences between calculated salinities mainly result from the difference in temperature between the two probes.

Conclusions

The ADIOS W3 cruise was an opportunity to compare performances of two CTD's systems based on different concepts, the SBE911 and OS320 systems respectively. Although only one single twin cast could be performed, the results suggests that in spite of small discrepancies, the accuracy of both systems is rather close and remains within the uncertainties range included in the WOCE standards. The actual challenges for the end users might thus become to really choose their equipments according to their practical needs and resources, and also to take into account the most recent evolution of the technology in the field of sensors and CTD's concepts.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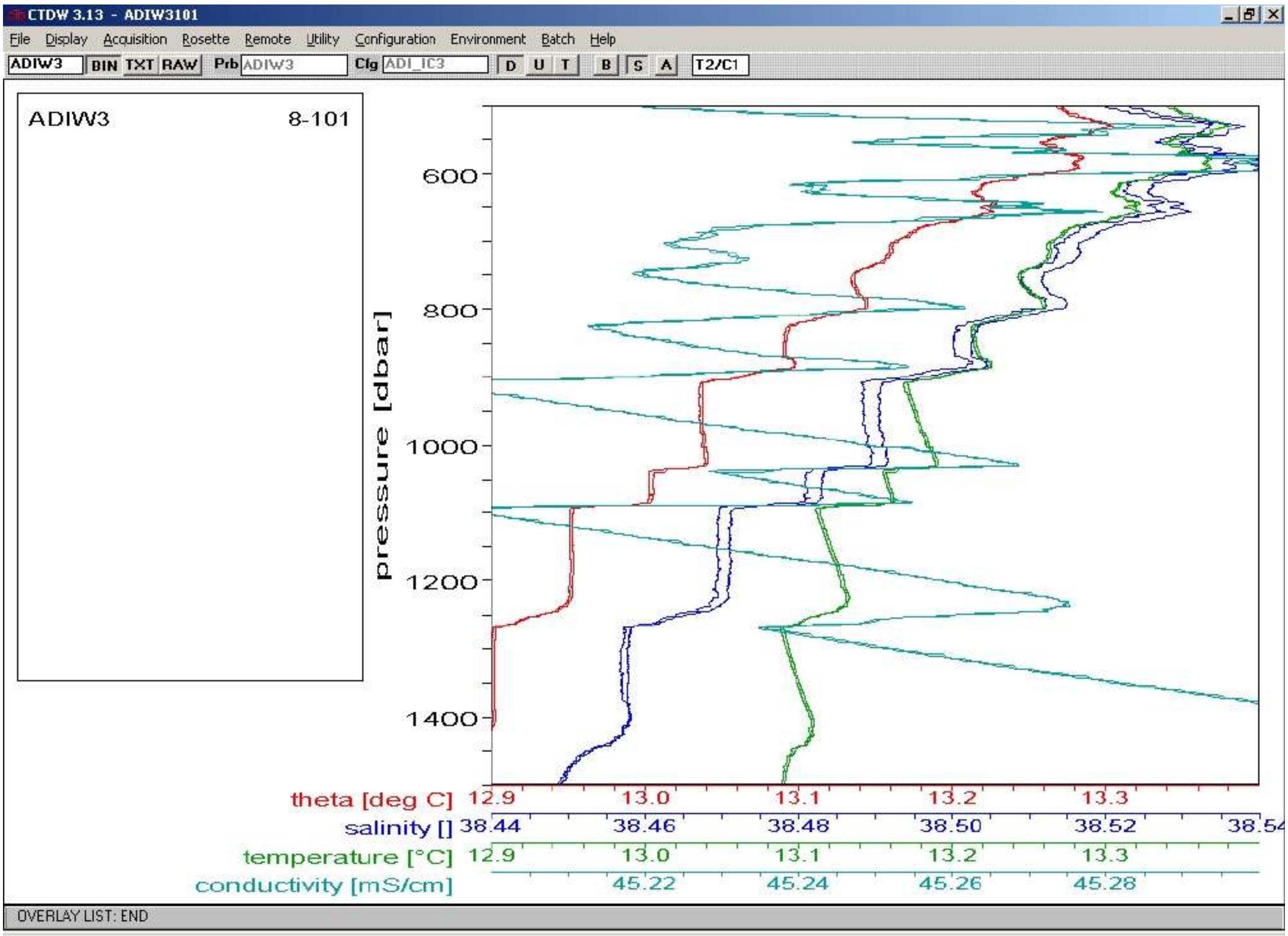
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