

Review of Hemming et al.: Measuring pH variability using an experimental sensor on an underwater glider

Special issue: REP14-MED: A Glider Fleet Experiment in a Limited Marine Area

#### GENERAL COMMENTS

This work is a contribution to a special issue about an observational experiment in a limited area in the western coast of Sardinia, where two research vessels collected high resolution oceanographic data using different observational systems as described in Onken et al. (same special issue). A fleet of 11 gliders was deployed. The current manuscript by Hemming et al. (OSD, 2016) deals with the results from one of them equipped with a pH sensor. The relevance of the manuscripts derives from the clear need by the biogeochemical community devoted to study the carbon cycle to implement reliable biogeochemical sensors in autonomous platforms. This sensors, pH included, should be developed and tested in the lab, and finally in a variety of ocean conditions, from coast to open ocean, surface to deep, high and low saline, etc..

To be concise I consider Hemming et al. (OSD, 2016) needs MINOR REVISION, the reasons are exposed below. My main concerns are the precalibration of the pH sensor, the adaptation to the high salinity conditions in the Western Mediterranean Sea and the comparison with ship based observations as detailed below.

#### SPECIFIC COMMENTS

##### 1. Introduction

I do not understand why the acronyms for dissolved oxygen and dissolved inorganic carbon widely referred as O<sub>2</sub> and DIC among others in the ocean biogeochemistry literature are here referred as c(O<sub>2</sub>) and c(DIC) .. why the "c"? I think is unnecessary and could be misinterpreted.

The only thing I miss in the introduction is short paragraph about the particular CO<sub>2</sub> chemistry characteristics in the Western Mediterranean Sea. Some information about this can be found in the literature, for example Rivarolo et al. (Mar Chem, 2010), Touratier & Goyet (DSRI, 2011), Álvarez et al. (OcSc, 2014), Yao et al. (Mar. Environ. Res., 2016) among others. The MedSea

is warm, salty, very high in alkalinity and high in pH compared to rest of the open ocean, concretely the adjacent Atlantic. This fact should be highlighted in my opinion.

## 2. Methodology ( I would change the title of this section to Data set and methodologies)

I would suggest a reorganization of this section. I think it can be improved and some more information should be given.

### 2.1. REP14-MED sea trial.

Despite the general overview of this trial is given in Onken et al (this issue). It might be good to just write a short paragraph about the general aim of deploying 11 gliders and concretely one with a pH ( and other biogeochemical ) sensors.

### 2.2 Glider sensors.

I am not an expert on the different types of ISFET sensors, so it is not clear to me if the glider had a pCO<sub>2</sub> sensor separated from a pH sensor, or is it a dual sensor?.

Please clearly separate the paragraphs according to the sensors described, first conductivity and temperature, then oxygen, then pCO<sub>2</sub> and finally pH. Give details about the quality control for each of them. For example no reference is given for the O<sub>2</sub>-glider calibration, I am sure this data is analysed in other manuscript, and if not please provide this information because the data is presented and discussed along with the final pH-glider data.

### 2.3. Ship based measurements ( I would change the current title "validation of ISFET pH measurements").

In this section I would also include for example a description of the oxygen winkler measurements if any done to calibrate the glider O<sub>2</sub> sensor.

During the CO<sub>2</sub> compiling exercise CARINA the Mehrbach et al. (1973) constants refitted by Dickson and Millero (1987) (see Key et al., 2010) were suggested to calculate pH from DIC and TA, as also concluded by Álvarez et al. (2014), specifically for the MedSea, however in GlodapV2 the ones used by Lueker et al. (2000) were used. Please comment about this.

Please clearly state that both pH from the ship and from the glider are expressed on the total scale and at in situ temperature.

## 3. Results and Discussion (the title "Results and corrections" is not very appropriate for a journal section).

I do not see a clear separation between the different sections included here, the pH corrections and validation are given in 3.1, 3.2 and 3.3. I suggest a reorganization of the whole section to make it more readable.

### 3.1. Ship based data (present and discuss the DIC, TA and pH derived ship based data)

TA and DIC measurements are expensive and time consuming, I think they deserve to be presented within a section from coast to open ocean ( and also the pHT in situ ) derived from them. Figure 4 a b and c are just showing vertical ranges of variability, but some coast-ocean variability should be also seen in the data. CTD hydrographic temperature and salinity data should also be included.

I do not understand the first paragraph in section 3.1... what do you mean with the standard deviation values, are you calculating bin averages and STD by depth intervals?.

Fig 4c is useless, are you showing pH total scale at in situ temperature?.. please adjust the pH range if you keep it.

### 3.2. Glider data

#### 3.2.1. Sensors validation

First comment on the Temperature and salinity glider data referring to the vertical distribution in Fig 4 e and f.

Secondly some words and maybe a figure (now missing) about the comparison between ship and glider O2 data.

Finally all your findings about the pH glider data.

I would start commenting Fig 4d.

#### 3.2.2. Coast to open ocean high resolution hydrographic and chemical variability from glider data

Here you should comment fig 8 & 9.

In general this section also needs some bibliography review. Please check the references given above that should be also included when discussing pH values and variability associated with distinct water masses in the MedSea.

## 4. Conclusions

Please the final phrase I think it should include "potential use of the corrected glider pH ....." as the pH sensors are still under development and in situ checking.

I hope to have been helpful.