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Processing BGC-Argo Radiometric data at the DAC level

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History of the document

Version	Date	Authors	Modification
1.1	October 2017	Catherine SCHMECHTIG, Antoine POTEAU, Hervé CLAUSTRE, Fabrizio D'ORTENZIO	Initial version

Preamble:

This document does NOT address the issue of radiometric parameters quality control (either real-time or delayed mode). As a preliminary step towards that goal, this document seeks to ensure that all countries deploying floats equipped with radiometric sensors document the data and metadata related to these floats properly.

If the recommendations contained herein are followed, we will end up with a more uniform set of radiometric data within the BGC-Argo data system, allowing users to begin analyzing not only their own radiometric data, but also those of others, in the true spirit of Argo data sharing.

1 Introduction

Presently, radiometers can be implemented on profiling floats to estimate some radiometric measurements. Hereafter, we briefly describe the principle of the method to evaluate radiometric variables, based on several configurations of the OCR500 series instruments. These measurements can be radiance or irradiance at different wavelengths and in different directions (upward or downward). The Photosynthetically Available Radiation (PAR) is also measured as it represents the solar radiation that photosynthetic organisms are able to use in the process of photosynthesis.

At the moment, all radiometric sensors implemented on floats are developed by the Satlantic Company and are of the OCR serie. These radiometers combine three wavelengths for irradiance measurements together with a measurement of the Photosynthetically Available Radiation. The present document is focused on the management of radiometric data flow acquired by those sensors (section 3). As soon as other sensors are implemented and successfully tested on floats, the present document will be accordingly updated.

2 Recommendations for addressing the radiometric data processing

The official BGC-Argo unit for:

- Irradiance is $W.m^{-2}.nm^{-1}$
- Radiance is $W.m^{-2}.nm^{-1}.sr^{-1}$
- PAR is $\mu molQuanta.m^{-2}.s^{-1}$

Presently, the radiometers implemented on floats provide counts as a measurement. The recommendations to address the radiometric data processing are listed here:

1. Store any raw data transmitted by the radiometer with meaningful names. It is important to store raw data, to recompute radiometric variables if changes occur in the calibration/conversion equations used to convert the sensor output in radiometric data. The proposed names for the counts transmitted by the radiometer are:

   RAW_DOWNWELLING_IRRADIANCExxx
   Downward irradiance measurements in counts at wavelength xxx (in nanometers)

   RAW_UPWELLING_RADIANCExxx
   Upward radiance measurements in counts at wavelength xxx (in nanometers)

   RAW_DOWNWELLING_PAR
   Downwelling PAR measurements in counts

2. Convert the counts in radiometric data, and store them with meaningful names. The proposed names for the radiometric variables are:

   DOWN_IRRADIANCExxx
   Downward irradiance measurements in $W.m^{-2}.nm^{-1}$ at wavelength xxx (in nanometers)

   UP_RADIANCExxx
   Upward radiance measurements in $W.m^{-2}.nm^{-1}.sr^{-1}$ at wavelength xxx (in nanometers)

   DOWNWELLING_PAR
   Downwelling PAR measurements in $\mu molQuanta.m^{-2}.s^{-1}$

3. Fill properly the metadata to document the calibration, the conversions equations and the fields to identify a sensor. In the metadata file, the configuration parameters must be also filled to characterize as precisely as possible the radiometric sensor (central wavelength, bandwidth)

The model number and serial number of the radiometric sensor must be stored. This tracking way can be essential if a specific failure concerns all the sensors from the same batch for instance, or if the manufacturing process changes after a certain serial number.

Note that indications provided in the two following sections, as well as the examples on how to fill metadata, are valid at the date of writing of this document. It is very likely that changes in calibrations and conversions equations will occur in the future. Metadata will then have to be filled accordingly with the new procedures.

3 OCR sensor

In the following, we will focus on measurements performed with an SATLANTIC_OCR504_ICSW, which means that is a radiometer of type OCR500, measuring irradiance in four wavelengths with a cosine detector in the water. We will focus on three wavelengths 380nm, 412nm, 490nm and PAR (400 to 700nm).

3.1 Measurements and Data processing

Raw data from the OCR radiometer are transmitted as counts. The basic equation allowing the retrieval of radiometric data from raw transmitted measurement is:

for example for the downwelling irradiance at 380nm:

DOWN_IRRADIANCE380 = 0.01*A1_380*(RAW_DOWNWELLING_IRRADIANCE380 - A0_380) * lm_380

where

DOWN_IRRADIANCE380 = downwelling irradiance at 380nm (W/m^2/nm)

RAW_DOWNWELLING_IRRADIANCE380 = raw counts output when measuring a sample of interest

A1_380, A0_380, lm_380 are calibration factors provided by the manufacturer on the instrument's characterization sheet, supplied by Satlantic and will be stored in the:
"PREDEPLOYMENT_CALIB_EQUATION" and in the
"PREDEPLOYMENT_CALIB_COEFFICIENT".

for example for the PAR:

DOWNWELLING_PAR = A1_PAR*(RAW_DOWNWELLING_PAR - A0_PAR) * lm_PAR

where

DOWNWELLING_PAR = photosynthetically available radiation (µmolQuanta/m^2/s)

RAW_DOWNWELLING_PAR = raw counts output when measuring a sample of interest

A1_PAR, A0_PAR, lm_PAR are calibration factors sent by the manufacturer on the instrument's characterization sheet and they will be stored in the "PREDEPLOYMENT_CALIB_EQUATION" and in the "PREDEPLOYMENT_CALIB_COEFFICIENT".

3.2 Sensor METADATA and Configuration parameters

3.2.1 Sensor and parameter metadata

This section contains information about the sensor and the parameters measured by the profiler or derived from profiler measurements that need to be filled. All the reference tables can be found in the Argo user's manual.

Sensor metadata	
SENSOR	RADIOMETER_DOWN_IRR<nnn>[1]
SENSOR MAKER	SATLANTIC
SENSOR_MODEL	SATLANTIC_OCR504_ICSW
SENSOR_SERIAL_NO	*To be filled*
SENSOR	RADIOMETER_PAR
SENSOR MAKER	SATLANTIC
SENSOR_MODEL	SATLANTIC_OCR504_ICSW
SENSOR_SERIAL_NO	*To be filled*

Parameter metadata	
PARAMETER	RAW_DOWNWELLING_IRRADIANCE<nnn>[1]
PARAMETER_SENSOR	RADIOMETER_DOWN_IRR<nnn>[1]
PARAMETER_UNITS	count
PARAMETER_ACCURACY	
PARAMETER_RESOLUTION	
PARAMETER	RAW_DOWNWELLING_PAR
PARAMETER_SENSOR	RADIOMETER_PAR
PARAMETER_UNITS	count
PARAMETER_ACCURACY	
PARAMETER_RESOLUTION	
PARAMETER	DOWN_IRRADIANCE<nnn>[1]
PARAMETER_SENSOR	RADIOMETER_DOWN_IRR<nnn>[1]
PARAMETER_UNITS	W/m^2/nm
PARAMETER_ACCURACY	
PARAMETER_RESOLUTION	
PARAMETER	DOWNWELLING_PAR
PARAMETER_SENSOR	RADIOMETER_PAR
PARAMETER_UNITS	microMoleQuanta/m^2/sec
PARAMETER_ACCURACY	
PARAMETER_RESOLUTION	

3.2.2 Configuration parameters

In order to characterize precisely the radiometric sensor, some configuration parameters can be filled using the calibration sheets of the manufacturer with the central wavelength and its bandwidth.

As an example, for nominal wavelength of 380nm, 412nm and 490nm:

CONFIG_OcrDownIrrWavelength1_nm = 380
CONFIG_OcrDownIrrBandwidth1_nm = 10

[1] <nnn> stands for the wavelength of the sensor in nanometers

CONFIG_OcrDownIrrWavelength2_nm = 412
CONFIG_OcrDownIrrBandwidth2_nm = 10

CONFIG_OcrDownIrrWavelength3_nm = 490
CONFIG_OcrDownIrrBandwidth3_nm = 10

Radiometric OCR sensors do not collect data at the same pressure as the CTD sensors. We define a configuration parameter to illustrate the offset in pressure due to the difference of the vertical alignment between the Ocr and the CTD. As the Ocr is about 8 cm above the CTD:

CONFIG_OcrVerticalPressureOffset_dbar=-0.08

Vertical pressure offset due to the fact that the sensor is not exactly at the CTD pressure

3.3 Radiometric data related parameters

During the ADMT13, the decision to separate data files for floats with biogeochemical sensors was taken. Then for biogeochemical floats, there are three files : one for P,T,S, one containing P and intermediate parameters (b-file) and one merged file containing P, T, S and ocean state variables.

3.3.1 Radiometric related parameters for the b-file

Raw data from the OCR sensor is output in counts from the sensor. These data will be stored in the b-file:

PARAMETER = "RAW_DOWNWELLING_IRRADIANCExxx"

PREDEPLOYMENT_CALIB_EQUATION = "none"

PREDEPLOYMENT_CALIB_COEFFICIENT = "none"

PREDEPLOYMENT_CALIB_COMMENT = "Uncalibrated downwelling irradiance measurement at xxx nm"

PARAMETER = "RAW_DOWNWELLING_PAR"

PREDEPLOYMENT_CALIB_EQUATION = "none"

PREDEPLOYMENT_CALIB_COEFFICIENT = "none"

PREDEPLOYMENT_CALIB_COMMENT = "Uncalibrated downwelling PAR measurement"

3.3.2 Radiometric related parameters for the b-file and the merged file

Every wavelengths of the measurements performed with a radiometer is considered as an ocean state variable and then will be stored in the merged file.

For example for the wavelength 380nm and for the PAR:

PARAMETER = "DOWN_IRRADIANCE380"

PREDEPLOYMENT_CALIB_EQUATION = "DOWN_IRRADIANCE380 = **0.01***A1_380 * (RAW_DOWNWELLING_IRRADIANCE380 - A0_380) * lm_380"

PREDEPLOYMENT_CALIB_COEFFICIENT = "A1_380 = 1.56541802179e-007, A0_380 = 2147954749.1, lm_380 = 1.161"

PREDEPLOYMENT_CALIB_COMMENT = ""

PARAMETER = "DOWNWELLING_PAR"

PREDEPLOYMENT_CALIB_EQUATION="DOWNWELLING_PAR = A1_PAR * (RAW_DOWNWELLING_PAR - A0_PAR) * lm_PAR"

PREDEPLOYMENT_CALIB_COEFFICIENT = "A1_PAR = 2.84829329483e-006, A0_PAR = 2147822280.4, lm_PAR = 1.359"

PREDEPLOYMENT_CALIB_COMMENT = ""

4 References

1. Operation Manual for the OCR-504 Document No.SAT-DN-00034 Revision G, 21 May 2013. http://www.seabird.com/sites/default/files/documents/Manual-OCR-504-SAT-DN-00034.pdf