Evaluation and scientific exploitation of CryoSat ocean products for oceanographic studies



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1. Introduction

Ocean products: CryoSat-2, launched 2010, is Europe's first ice mission featuring an advanced radar altimeter specifically designed to monitor the most dynamic sections of Earth's cryosphere. A dedicated operational ocean processor updated with an improved version of the processor (Baseline C) was introduced in November 2017 (further improvements are coming soon). CryoSat-2 is a huge asset to the oceanographic community, and the exploitation of its data over the ocean represents a welcome additional return for ESA's investment in the mission. Data are made available on a number of time scales Near real time Ocean Product (**NOP**), Intermediate Ocean Product (**IOP**) and Geophysical Ocean Product (**GOP**) with timescales of within 3 hours, within 3-days and about 30 days from acquisition respectively. Operational mode varies in space as Low Resolution Mode (LRM; conventional pulse limited altimeter), Synthetic Aperture Radar (SAR; enhanced along-track resolution also known as Delay Doppler Altimetry) or Synthetic Aperture Radar Interferometric mode (SARIn; primarily employed at ice sheet edges where SAR is enhanced by the use of a second antenna)

Assessment and validation: The UK National Oceanography Centre (NOC) has been tasked with the scientific quality control and validation within the CryOcean-QCV Project. Here we show selected results of a global assessment of the IOP/GOP sea surface height anomaly (SSHA) and significant wave height (SWH). We also present the highlights of the production and use of a gridded Level 3 SSHA product based on GOP.



valid SWH 06/10/202

Daily quality reports are available for NOP/IOP alongside more in-depth, monthly validation reports for all products. Samples of output from the reports can be seen in Figures 1, 2 and 3. <u>https://earth.esa.int/web/sppa/mission-performance/esa-missions/cryosat/quality-control-reports/ocean-product-quality-reports</u>.







Figure 2: GOP Wonting Report Example: Geographical Gistinguidon of science-valid SSHA (cm) for December 2020. Values shown in table refer to SSHA (calculated separately for LRM and SAR). Wmean/Wstd are spatial area-weighted mean/standard deviation.

3. Gridded Sea Level Anomaly Product (NOCSLA¹)

Data: Based on along-track, GOP (Baseline C) SSHA (LRM and SAR). Spatial-temporal weighted averaging (median) of Quality Controlled data excluding coastal regions.

Output: Gridded daily, ½° SSHA for 24 January 2011 – 8 October 2020 within 60° of poles for non-coastal oceans.

Technical Validation: Excellent agreement of timeseries with other data sources^{2,3,4,5} (Table 1 and Figures 4 and 5).

Figure 1: IOP Daily Report Example: Geographical distribution of science-valid SSH anomaly (left) and SWH (right) data over oceans and lakes for 06/10/2022. Values in the tables refer to the SSHA (cm)/SWH (m) calculated separately for LRM and SAR. Black lines mark outer limit of polar polygons.





Figure 4: (Top) Multivariate ENSO Index (MEI.v2; https://psl.noaa.gov/enso/mei/), >0 is *El Ninõ* whereas <0 is *La Niña*. (Bottom) Global mean sea level (GMSL): NOCSLA (black), ESA Climate Change Initiative v.2² (CCI; thin, solid, red), Colorado³ (dotted, blue), Becklev⁴ (thick, green) and AVISO⁵ (dashed, purple). End of CCI period (Dashed, black).

Table 1: Trend (mm/year) and amplitude of annual cycle (α ; mm) in GMSL for 2011–2020 (February 2011 – January 2020; shaded region in Figure 4) and 2011–2015 (overlap of NOCSLA with CCI). Numbers in brackets are the uncertainty at the 95% confidence interval.

	2011 – 2020		2011 – 2015	
Source	Trend	α	Trend	α
	(mm/year)	(mm)	(mm/year)	(mm)
NOCSLA ¹	4.07	5.08	6.11	4.52
	(0.77)	(1.01)	(1.18)	(1.33)
CCI ²	-	-	5.32 (1.52)	6.06 (0.90)
Beckley ⁴	4.56	4.81	6.02	4.80
	(0.71)	(1.02)	(1.46)	(1.37)
Colorado ³	4.76	5.80	6.05	5.61
	(0.55)	(0.93)	(1.26)	(1.26)
AVISO⁵	4.65	6.54	5.59	6.47
	(0.56)	(0.71)	(1.34)	(0.93)

References

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⁵ AVISO. Mean Sea Level product and image interactive selection,

https://www.aviso.altimetry.fr/en/data/products/ocear indicators-products/mean-sea-level/products-andimages-selection-without-saral-old.html (2021).



Figure 5: K²E¹/₂Conal se²⁰⁰/₂ level tre⁵⁰/₂ds from NOCSLA over the pe¹⁰⁰/₂d Febru¹⁵/₂ 2011–January 2020 (top), NOCSLA over the period January 2011–December 2015 (middle) and ESA Sea Level CCI January 2011–December 2015 (bottom). Colour scale is trend in mm/year. Hatching shows regions where the trend significantly different from zero (95% confidence).

